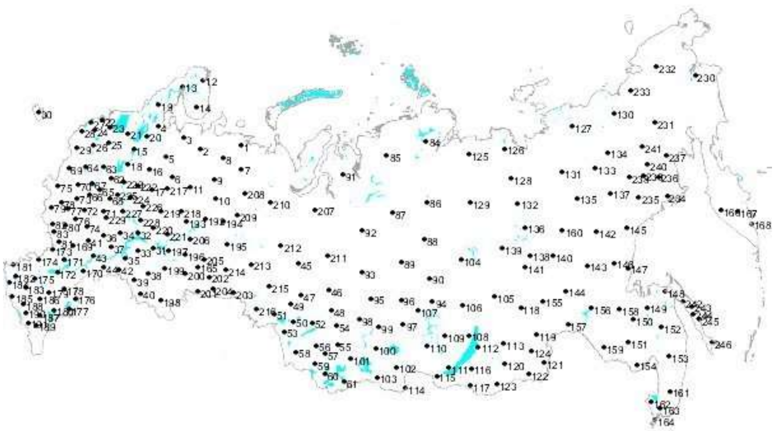
Friedrich- Schiller University Jena
Institute of Geography
Department for Geoinformatics

GMES-RUSSIA

Establishing a Thematic Network in Russia for Priority Themes A, B, C and E for GMES Strand 2 Assessment Activities

Final Report 2004



Authors: C. Schmullius (Project Leader), D.Denissov, V.Alexandrov, B.Belan, L.Bobylev, N.Dobretsov, G.Erokhine, D.Kovalevsky, G.Matvienko, N.Novikova, L.Permitina, S.Tashchilin

Date: 30 June 2004
EC Contract Number:
EVK2-2002-80022"GMES RUSSIA"
Area 2.0.0.0.2.3. - Accompanying Measure
Research Programmes EESD-ESD-3, ESD-ENV-2002 & GMES

Contents	**Page**

Foreword of Coordinator

This report completes the GMES RUSSIA Project. The project started in January 2003 and finished in Juni 2004. In accordance to project's methodology all work is broken down into Work packages that comprise the different aspects of the project's tasks. The latter presumes not only the introducing to the Russian partners the GMES concepts and ideas [7] and some preliminary introductory activities but the real intensive work in the field of technical-scientific assessments, socio-economic and institutional issues of GMES with regard to chosen GMES thematic priorities: A, B, C, E.

Since basically the work within work packages WP2000 – Technical-scientific assessments and WP 5000 – the cross analysis of research projects in Russia concerning the GMES thematic priorities has been done in 2003 and is described in details in our GMES Russia annual report [1], we present here these themes as extended (executive) summary.

Vice versa the socio-economic and institutional issues of GMES in Russia are described completely, with significant portion of details.

Thus we present here the results of our 18-month work that cover all our tasks formulated in the Work program within corresponding Work packages.

Since simultaneously with this project the cross-cutting assessment studies:

- **"BICEPS", Building an Information Capacity for Environmental Protection an Security [2]**
- **"DPAG", Data Policy Assessment for GMES [3]**
- "**GSeS" GMES Socio-economic Study [4,5]**

under guidance of EC started as well, we attempted not only follow the requirements and methodological principles of the latter but closely communicate with leaders of these projects- Dr. Barry Wyatt, Prof. Ray Harris and Dr. Nina Costa - in order to receive much helpful advice and provide information exchange.

Our project partners are prominent Russian organisations and Institutes having a great deal of expertise and experience in the field of Earth Observation and environmental sciences. To enable this expertise to benefit our project tasks it took some time to introduce and explain the peculiarity of GMES principles, objectives and commitments.

The GMES FORUMS in Noordwjik, Athens and Baveno and participation of the Russian partners in these conferences (as a result of coordinating activities of Friedrich Schiller University – Jena) played the crucial role in their understanding of what GMES means and how to cope with project's tasks.

List of Abbreviations

AARI – Arctic and Antarctic Research Institute
AIISA - Automated Ice Information System for the Arctic
AFTN - Aviation Federal Telegraph Network;
AMCS – Aviation Meteorology Civil Station;
ASDT - Automated System of Data Transfer;
AVC – Aerological Automated Computing Complex;
"AVIALESOKHRANA" - Aviation Forest Protection Office
BAMD - Bank of Aviation Meteorological Data;
BICEPS – Building an Information Capacity for Environmental Protection and Security;
DPAG – Data Policy Assessment for GMES
EMERCOM - Russian Emergency Committee
FKTs "ZEMLYA" - Federal Cadastral Centre "ZEMLYA"
GGI - State Hydrological Institute
GGO - Central Geophysics Observatory
GIPE – State Institute of Applied Environment
GMB – Hydrometeorology Bureau;
Goskomhydromet USSR - State Committee for Hydro Meteorology of the former USSR;
GOSKOMZEM - Russian Federal State Committee on Land Resources
HMTs - Hydro meteorological Centre of Russian Federation
IAO SB RAS – Institute of Atmospheric Optics, Siberian Branch of the Russian Academy of Sciences;
ICAO - International Civil Aviation Organization;
ICKC SB RAS - Institute of Chemical Kinetics and Combustion, Siberian Branch of the Russian
Academy of Sciences;
IGAN - Institute of Geography of Russian Academy of Science
IGCE - Global Climate and Ecology;
IGKE - Institute of Global Climate and Ecology
IKI – Institute of Space Research
KGI-4S — Heliogeophysical measurement instrumentation
MAMC - Main Aviation Meteorological Centre;
MD - Ministry of Defence;
MH - Ministry of Health;
MGO - Main Geophysical Observatory;
MIL - International Institute of Forest
MIVZA — Microwave radiometer for integral humidity sounding
MPR - Russian Ministry of Natural Resources
MOH - Marine Operations Headquarters
MSGI-5EI — Multi-channel system for measuring geo-active radiation
MSU-E — Multi-band optical-electronic scanner of high-resolution
MSU-SM — Multi-band scanner of medium resolution
MSU - Moscow State University;
MTVZA — Microwave radiometer for temperature and humidity sounding of atmosphere
NITs "PLANETA" – Research Scientific Centre "Planeta"
NPO "Tayfun"- Research Production Organization "Tayfun"
NRTsPOD - Novosibirsk Regional Centre for Data Acquisition and Processing
NSR – Northern Sea Route
NSRA - Northern Sea Route Administraiton
RAN – Russian Academy of Science
RF – Russian Federation

RFI - Russian Information Fund on Nature Management and Environmental Control
RIATs – Regional Information-Analytical Centre
ROSAVIAKOSMOS - Russian Aviation and Space Agency
ROSHYDROMET - Russian Federal Service for Hydrometeorology and Environmental Monitoring
RSBD - Regional Special-purpose Data Banks
SAGE-3 (US) – Instrument for measuring small gas components of the atmosphere
SFM-2 — Spectrophotometer for vertical distribution of ozone and other small gas components of the atmosphere
SSMAP - State Service for Monitoring of Atmospheric Pollution;
SES - Sanitary Epidemic Stations;
TsAO - Central Aerological Observatory
TsGMC – Territory Department of Hydrometeorology;
TSEM – Territorial Systems of Environment Monitoring
TsEPL - Centre of Ecology and Forest Productivity
TCCN - Transport Corporate Computer Network;
UGMC – Region Department of Hydrometeorology;
VNIIGMI-MTsD - All-Russian Research Institute of Hydro meteorological Data – World Data Centre
VNII of EMERCOM - All-Russian Research Institute of Emergency
VNIISKhM - All-Russian Research Institute of Agricultural Meteorology
WMO – World Meteorological Organisation

Introduction

GMES-RUSSIA establishes a first network of key data providers and users between the European component of GMES and Russia and contributes thus to the implementation of this specific EC programme. GMES-RUSSIA produces a current assessment of EO and in-situ data capabilities, on-going research activities and modelling approaches in Russia with respect to the GMES tasks. GMES-RUSSIA is a contribution of Russian expertise concerning technical and scientific issues for GMES cooperation and is assessing scientific-technical, socio-economic and institutional aspects. GMES-RUSSIA contributes to on-going European-Russian cooperation projects and is designed to meet the needs of long-term monitoring. The project establishes therefore a basis for future cooperation in the fields of environmental monitoring and climate impact studies.

The consortium consists of seven multi-disciplinary partners from Germany and Russia, who are linked to GMES-RUSSIA through their own interest. The team has a good spread of institutions: 1 university, 2 institutes of the Russian Academy of Sciences, 1 institute of the Russian Space Agency (Rosaviakosmos), 2 SMEs, 1 governmental agency.

GMES-RUSSIA is coordinated by the Department of Geoinformatics & Remote Sensing of the Friedrich-Schiller-University Jena which also maintains EU contacts. The FSU Jena established over many years well-known experience in coordination of large and complex projects (SIBERIA, SIBERIA-II, ARSGISIP) as well as EO missions (involvement in SRTM and airborne campaigns, e.g. TerraDew for TerrSAR).

The participation of the Russian institutions is critical for the successful implementation of GMES-RUSSIA and is hence in conformity with the interest of the Community policies.

The Russian participants are well recognised in their fields and are top-level specialists. Their institutions add substantial value to implement the EC´s GMES programme and are essential for achieving the objectives of the project.

FSU (Coordinator)	Friedrich-Schiller-University, Institute of Geography, Dept. of Geoinformatics and Remote Sensing Jena, Germany
NRCGIT	Novosibirsk Regional Center of Geoinformation Technologies, Akademgorodok, Novosibirsk, Russia
NIERSC	Nansen International Environmental and Remote Sensing Center, St. Petersburg
IAO	Institute of Atmospheric Optics, Russian Academy of Sciences, Tomsk, Russia
URIIT	UGRA Research Institute of Information Technologies, Khanty-Mansiysk, Russia
NTSOMZ	Research Centre for Earth Operative Monitoring, Russian Space Agency Rosaviakosmos, Moscow, Russia
ISZF	Institute of Solar-Terrestrial Physics , Russian Academy of Sciences, Irkutsk, Russia

It is presumed that project partners perform very close interaction with each other and attempt to extend the number of organisations to collect necessary information as well.

This final report has the following structure. We arranged the whole material into three sections:

- Technical –Scientific Assessment of GMES Capacity in Russia
- Socio-Economic Issues of GMES
- GMES RUSSIA Networking Component

The first section includes Chapter I, which is devoted to the description of the infrastructure of the environmental monitoring in Russia and presents our results within WP 2000. The emphasis here is given not only to our thematic priorities A, B, C, E but to GMES cross-analysis issues as well.

The second section consists of four chapters which present the detailed description of the four case studies with emphasis on socio-economic and institutional issues of GMES.

The third section includes chapter VI and is devoted to the description of the innovative technology for European-Russian communication and to our activities regarding the extension of the interested and relevant to GMES organisations, scientific groups and individuals in Russia and preparation of the new research initiatives within FP6 regulated by our work program and WP 6000 and WP 7000.

We would like to note some peculiarities. For convenience of reading some chapters (basically in Section 2) contain their own lists of references and references to the particular item of these lists are given in the text in the usual manner [in brackets]. At the same time there is the list of references to the whole report placed in the end. References to the items of this list are given in the text as upper index (for example, [1]).

Technical-Scientific Assessment of GMES Capacity in Russia

I. Infrastructure of the Environmental Monitoring in Russia

This chapter describes the common issues of the environmental monitoring infrastructure in Russia. Here we present not only which ministries, agencies and particular organisations and institutes are involved in this sort of activities but consider types of monitoring being done under guidance of particular ministry. Chapter also presents summary of user requirements to satellite sensors and instruments to provide effective high-quality monitoring of environment. Organisational features and the leading role of ROSAVIAKOSMOS in satellite remote sensing in Russia are pointed out. The paragraphs of the chapter present state-of-the-art with monitoring of the particular environmental components: atmosphere, oil pollution, soil degradation, forest fires. These thematic problems in our case are projected onto "assessment coordinates". Practically in every task we attempted to estimate users and user requirements to data and information, data quality and data quality control, data types and standards, data archives and data policy issues in accordance with DPAG methodology.

I.1 Organisational Structure of the Environmental Monitoring

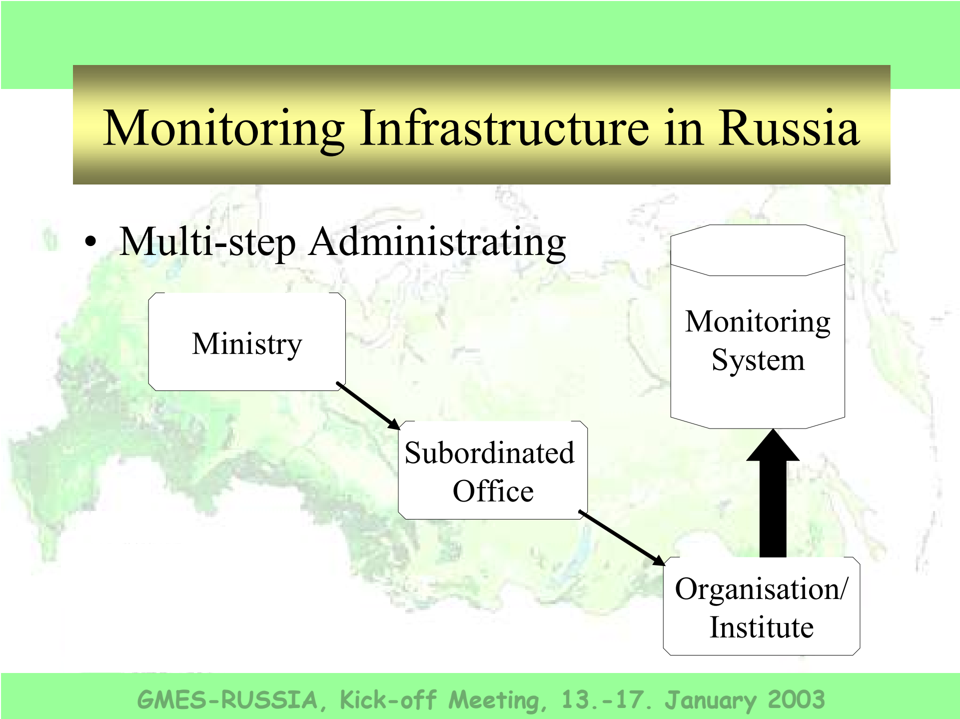
Monitoring infrastructure in Russia has multistep administrative structure (See **Fig.1.1**) The monitoring process is under the control of the corresponding ministry. The offices and departments of ministries are responsible for the particular monitoring type. The implementation of the monitoring is being done by the subordinated organisations and/or institutes that are responsible for collection, accumulation, processing, analysis and distribution of the monitoring data.

Five ministries and Russian Academy of Science (RAS) are involved in the Monitoring of Environment in Russia.

The ministries under the consideration are:

- Russian Aviation and Space Agency (**ROSAVIAKOSMOS**)
- Russian Ministry of Natural Resources (**MPR)**
- Russian Federal Service for Hydrometeorology and Environmental Monitoring (**ROSHYDROMET**)
- Russian Emergency Committee (**EMERCOM**)
- Russian Federal State Committee on Land Resources (**GOSKOMZEM**)

Some 31 Organisations and Institutes are involved in the development, production and exploitation of the monitoring networks and instruments. The detailed description of these organisations is presented in GMES RUSSIA annual report [1]. **Fig.1.2** gives the overview organisations of the corresponding ministries.



a) Fig.1.1 Monitoring Infrastructure in Russia

Fig.1.2 Overview of Russian Ministries

Below we summarise the activities of the key Russian ministries in the field of environmental monitoring.

I.1.1 ROSAVIAKOSMOS

The space monitoring as well as other space activities in Russia are being done under guidance and control of **ROSAVIAKOSMOS** ministry. The operative environment monitoring from space is coordinated by Office of Space Systems for Earth Remote Sensing of **ROSAVIAKOSMOS** and is carried out by Research Centre for Earth Operative Monitoring **(NTs OMZ**). The space instruments for the monitoring of environment that are under operation now and those expected in the nearest future are developed in accordance to the official *document "The Concept of Development of the Space Systems for monitoring of Environment"*. Here the main goals and objectives are grouped and categorized:

- Weather forecast and climate exploration
- Ecological monitoring
- Monitoring of emergency and risk situations
- Monitoring for sustainable development of natural resources
- Monitoring for Earth sciences and Atmospheric research

Naturally every group has different tasks and these tasks put different requirements to the parameters of the space instruments and sensors:

- Spatial resolution
- Radiometric accuracy
- Spectral content
- Timeliness/currency

As a result of thorough analysis of the monitoring tasks and objectives **ROSAVIAKOSMOS** specialists have developed the launch program of remote sensing satellites for the monitoring of environment presented in [1].

I.1.2 Ministry of Natural Resources (MPR)

Ministry of Natural Resources (MPR) carries out the coordinating functions to create complex system for monitoring of environment and use of the natural resources. It performs also the state control over water bodies, forests, land use, biosphere on the territory of Russia and together with other federal governmental executive organs regulates the activities of the third parties in the field of environmental policy.

It is the primary MPR commitment to coordinate the functioning of the different monitoring systems, to provide the communications and information exchange between monitoring systems belonging to other ministries and departments and guarantee the archiving of the monitoring data.

The MPR administrative structure has 3 levels.

The lowest level is the level of individual organisations; the territorial level is presented by special territorial offices subordinated to the local authorities and the federal level is presented by special analytical centres(within MPR) and other offices to form data banks on environmental monitoring and support decision making on environmental problems. Here recently was created the so called "Situational Centre" to support the decision making in environmental policy.

The information transfer between levels mentioned above is being carried out on a base of:

- Legislative acts and legal regulations
- Interdepartmental agreements
- Agreements between MPR and territorial bodies and authorities
- Licensing

The development and exploitation of the monitoring networks is being funded through interested organisations and institutes from:

- State federal budget
- Local budget (the budgets of subjects of Russian Federation)
- Free funds
- Commercial and non-state assets

I.1.3 ROSHYDROMET

The **ROSHYDROMET** - Russian Federal Service for Hydrometeorology and Environmental Monitoring- is responsible for monitoring hydro and meteo parameters of the environment and atmosphere. In Chapter 6 the detailed information about the Atmospheric monitoring, that is being done under **ROSHYDROMET** guidance, is presented.

Organizational structure of hydrometeorology and environmental monitoring under guidance of **ROSHYDROMET** is given in [1]. **ROSHYDROMET** system for acquisition of hydrometeorologal and environmental information is broken down into terrestrial, aerological and space subsystems.

The monitoring of the hydro-meteo-parameters from space is coordinated by Hydro meteorological Office of the ROSHYDROMET and is carried out by “NITs PLANETA” (Moscow) and Regional Centre for Data Acquisition and Processing “NTs RTsPOD” (Novosibirsk).

Territorial subsystems of ROSHYDROMET are based on network organizations:

- Centres for hydrometeorology and environmental monitoring (CHMS);
- Hydrometeorological observatories (HMO);
- Hydro meteorological bureau (HMB);
- Hydrological stations and posts;
- Environmental centres.

Territorial metrology is implemented on a base of uniform techniques and instruments being applied at specified time.

All terrestrial data are recorded into special-purpose data banks (RSBD). Every RSBD has its own data types and belongs to one of **ROSHYDROMET** organization. RSBD system was created on a base of unique techniques, instruction structure and language. All RSBD data is sampled and filled out by All-Russian Research Institute of Hydro meteorological Data – World Data Centre **(VNIIGMI-MTsD**).

Data quality control is carried out in accordance to **ROSHYDROMET** and Metrological Instrument Inspection techniques and instructions for all kinds of earth-based observations. Data processing is carried out also on a base of **ROSHYDROMET** techniques. The processing results are controlled on the base of permissible discrepancies. The processing results are presented in formats compatible with World Meteorological Organization (**WMO**) demands and requirements and being transferred to VNIIGMI-MTsD.

User Requirements depend on monitoring type and change with regard to region peculiarities, degree of details and time intervals. They must correspond to those published in “Primary sector of national economics and Weather Service demands to hydro meteorological data compound and spatial resolution” [GUGMS USSR, Obninsk, 1971].

Archive politics is realized in accordance to **WMO** demands [WMO-№784, 1992]. Data archiving is fulfilled in table letter-digital structure for easy access and satisfying customer needs.

Pricing policy of ROSHYDROMET

State Services are provided along with hydro meteorological data free of charge.

Scientific and research centres pay for software products only. Other customers could have hydro meteorological data and information on the conditions of transaction price.

I.1.4 EMERCOM

EMERCOM: the Ministry of Russian Federation for Civil Defence, Emergencies and Elimination of Consequences of Natural Disasters is a federal executive authority specially accredited for problem salvation in the fields of Civil Defence, the population and territories protection from natural and technological emergency situations. EMERCOM implements general state policy and state administration in the field of Civil Defence, emergency prevention and response, and coordination of federal executive authority’s activities on the population and territories protection from emergency situations.

EMERCOM principal activities in field of environment monitoring are the following:

- To ensure the Unified Emergency Prevention and Response State System (UEPRSS) operation;
- To control works on large accidents, disasters and other emergencies elimination;
- Coordination of federal executive authorities activities during search-and-rescue operations, oil and petrochemicals spills, harmful chemicals and radioactive substances emissions elimination on the sea and inland reservoirs.

Environmental monitoring is carried out by EMERCOM for the following purposes:

- for emergencies forecast;
- during a period of emergency situations;
- during a period of elimination of the aftermath of the emergencies.

The framework of emergencies and disasters forecast monitoring system is given in [1].

The information is transferred and processed at EMERCOM Agency on Emergencies Monitoring and Forecast established on the base of the All-Russian Research Institute for the problems of Civil Protection and Emergency Situations (VNII GOCHS, Moscow).

Floods and fires forecasts are based on the information given by the **ROSHYDROMET** and **“AVIALESOKHRANA”** (the Central Base for Forest Protection Aviation).

In emergency situations resulted in chemical, biological or radioactive environment pollution, the monitoring is carried out by the Observation and Laboratory Control System which comprises laboratories of other Ministries : MPR, ROSHYDROMET, Ministry of Health. The All-Russia Centre of Laboratory Control (VCNLC) is responsible for requirements to data measurements and measuring equipment.
There is a constantly working air-space monitoring system in EMERCOM that comprises satellite data receiving stations in Moscow, Krasnoyarsk and Vladivostok.

I.1.5 Russian Academy of Science (RAN)

The research in the field of Environmental Monitoring is being done in the research Institutes of the Russian Academy of Science in the corresponding departments such as: Department of Earth Sciences.
RAN preliminary infrastructure of Environmental Monitoring Research is given in Tabl.1.1.
Research funding goes on a base of research projects and grants.
RAN satellite data base and archive for research projects are presented in [1] .
The accumulation of the data of space monitoring in RAN is being done by special “Unified Information System of the Fundamental Space Research “(UISFSR). The System developers are IRE and IKI RAN.
This system has three levels:

- common catalogue and basic archive of space data
- catalogues and basic archives of individual Institutes (such as Institute of Space research, Institute of Radio electronics and other)
- catalogues and archives of the individual research projects

Ministry and Department	**Subordinated Offices**	**Organizations and Institutes**	**Archives, Funds, and Data Banks**

Russian Academy of Sciences (RAN) and Russian Aviation and Space Agency (Rosaviakomos)	Department of Physical Sciences Office of Space Systems for Earth Remote Sensing	Institute for Radio Engineering and Electronics (IRE), Fryazino, Space Research Institute (IKI), Moscow Research Centre for Earth Operative Monitoring, NTsOMZ (Moscow)	Integrated Information System of Basic Space Research (EIS FKI) consisting of Russian Catalogue and Basic Space Data Archive for Russian scientific space projects

Table 1.1 RAN satellite data Archives and Data Banks

The Institute of Geography (Moscow) performs the monitoring of the land cover on the territory of RF and makes inventories of the forest resources. The regular activity on forest monitoring performs The International Forest Institute (Moscow), Sukachev Forest Institute (Krasnoyarsk), Institute of Solar-Terrestrial Physics (Irkutsk).

I.2 Satellite Environmental Monitoring in Russia

In this paragraph the analysis of satellite remote sensing of environment is given. Taking into account the variety of environmental thematic tasks, multifaceted requirements to satellite sensors and instruments and different types of Earth surface under investigation, it seemed us reasonable to bring together and generalise the corresponding issues. The second objective was to make our analysis as close to topics relevant to GMES priorities as possible. That is why the paragraph includes issues on “users and user requirements”, “data quality”, ”data policy”, “ data archives and standards” etc. We attempted to emphasise the peculiarities of Russian situation, concerning management and administration points and specific geographical conditions.

I.2.1 Satellite receiving stations

As it was pointed above all kinds of space activities in Russia are being done under guidance and control of **ROSAVIAKOSMOS**. The main Operator of the remote sensing space systems is ***Space Observation Centre*** that guides programming and control of the systems and interacts with Mission Control Centre (TsUP) of **ROSAVIAKOSMOS.**
Operative environmental monitoring from space is coordinated by Office of Space Systems for Earth Remote Sensing of ROSAVIAKOSMOS and is carried out by Research Centre for Earth Operative Monitoring (NTs OMZ), which is the branch of Space Observation Centre. The role of NTs OMZ is receiving, processing, archiving and distributing of Russian and foreign satellite data.

The receiving stations of the remote sensing data in Russia belong to different ministries, agencies, organisations. Every station should receive the license from **ROSAVIACOSMOS** for its activity. The leading role here belongs to receiving station of NTsOMZ.
ROSHYDROMET has three big stations for receiving the remote sensing data, that are located in Moscow, Novosibirsk and Khabarovsk and several small stations in Russian regions.
Ministry of Natural Resources (MNR) became recently one of the active participants of Space data acquisition process. **EMERCOM** is one of the active remote sense data users and now has several small acquisition stations.

Russian Academy of Science is traditionally among other agencies that develop new techniques and methods for remote sensing data utilisation in the filed of environmental problems.
Locations of Russian receiving stations are shown on the **Fig.1.3**. The brief analysis of the deployment of the receiving stations over the territory of Russia allows draw the conclusion that huge territory of North Siberia is covered with receiving stations insufficiently.

I.2.2 User requirements to remote sensing data

To create the document *"The Concept of Development of the Space Systems for monitoring of Environment"* the thorough analysis of the "end user" requirements has been done by ROSAVIAKOSMOS specialists. These user requirements with regard to some environmental tasks are given below.

Monitoring of floods, snow and ice cover
The following requirements to Earth Observation data should be fulfilled.

Spatial resolution:	10 – 100 m
Spectral content:	0, 01 – 0, 04 μm (optical, IR)
Radiometric resolution:	0,1 – 1,0% (optical band); 0,1 -0,2K (IR); 1-2 DB (UHF)
Frequency:	1- 6 hrs
Timeliness:	0,5 – 1 hrs

Monitoring of forests

Spatial resolution:	2 – 3 m
Spectral content:	1- 20 nm (optical, IR)
Radiometric resolution:	1 – 5% (optical band); 0,1 -0,5K (IR);
Frequency:	1- 6 months
Timeliness:	10 – 20 days

Monitoring of agricultural fields and control of the field work

Spatial resolution:	10 – 20 m
Spectral content:	10- 20 nm (optical, IR)
Radiometric resolution:	1 – 5% (optical band); 0,1 -0,5K (IR); 0,5-1 DB (UHF)
Frequency:	10-20 days for agriculture
Timeliness:	5 -7 days

The user requirements relevant to GMES RUSSIA Project thematic priorities are summarised in the [1].

I.2.3 Data quality control

The BRS (Bitmap ReSource) file format is used for storage and processing of remote sensing data from Russian satellites: RESURS-O1, OKEAN-01, OKEAN-O, METEOR-3M №1. BRS format is an extension of standard BMP format. In addition the BRS file has a header for metadata storage. Software to handle the BRS files has functions for image import/export from/to BMP, GIF, LAN and other formats.
The purpose of data quality control is a verification of the received information with existing standards. Data quality control is divided on two basic groups: metrological certification and control of spacecraft orbital parameters.
Metrological certification
Metrological certification is a control of parameters which are recorded in a header of BRS-file and matching the latter with the same parameters that are obtained from operating mode monitoring data of MSU-E, MSU-SM, MSU-SK scanners. The aim of the processing of the monitoring data is an implementation of two types of control:

- comparison of actual equipment operating modes with pre-scheduled ones
- comparison of actual parameters of MSU-E, MSU-SM, MSU-SK scanners with spacecraft orientation parameters

Scanners variables under control are:

- amplification in each spectral band
- scanner mirror turning angle
- on/off calibration control and calibration levels

Spacecraft orientation variables under control are:

- Spacecraft angle of bank
- Spacecraft angle of pitch
- Spacecraft yaw angle
- Spacecraft velocity angle of bank
- Spacecraft velocity angle of pitch
- Spacecraft velocity yaw angle

Orbital data control.

Orbital data control aimed at more accurate rectification of scanner image gridding. The gridding accuracy improvement is implemented by means correction of some ballistic and spacecraft orientation parameters. For more accurate gridding rectification the following technological steps are foreseen:

- Displaying of vector map as a layer and scanner image as background one
- Ground control point entering
- Automatic correction of orbital parameters
- Automatic correction of a scanner mirror rotate angel
- Automatic correction of spacecraft orientation angels
- Saving the corrected values to a header of BRS-file

I.2.4 Archives and data standards

- **NTs OMZ archive infrastructure and data standards**

Hardware Servers:
SUN FIRE 280R (RDBMS, Web Server, Common User Interface system), 2CPU 850 MHz, RAM 2 GB, HDD 72 GB, 2 TP 100 Mbps cards - 1 unit,
Intel P4 (Mail Server, archive manager), P4 CPU 2.5 GHz, RAM 512 MB, HDD 120 - 480 GB, 1 TP 100 Mbps card, 1 TP 1 Gbps card, - 3 units,
Client workstations:
Intel P3-P4, CPU 1.5-2.5 GHz,, RAM 256-512, HDD 80-120 GB-10 units;
Tape drives:
DLT7000, LVD, external - 2 units
DLT8000, LVD, external - 2 units,
LTO ITANIUM, LVD, external - 1 unit
Software -
OS:
Solaris 8.x (SUN server),
RedHat Linux (P4 server),
MS Windows 98/ME/2000/XP (client workstations),
RDBMS:
Oracle for Solaris 9.x;
Development software:
MS Visual Studio 6
Borland C Builder
GCC development kit
PL/SQL developer
Perl interpreter with DBI and CGI modules
Web Server
Apache
LAN Topology
Workstation-sever links via TP 100 Mbps,
Server-server links via TP 1 Gbps links, 100 Mbps switches and hubs;
WAN Connection

Last-mile connection via 128 kbps copper cabling (bottleneck),
Gateway on CISCO 26xx router.

- **Data structures and compatibility with international standards**

Archive structure.
Archive is constituted from Data Collections that includes data retrieved within defined space mission by means of defined scientific instrument (remote sensing sensor) or group of instruments (sensors).
Archive Media.
All data is stored on magnetic tapes (as a rule DLT IV type) or CDs (CD-R, CD-RW).
Archive Utility.
The most part of existing collections is written by using CA ARC serve backup utilities in MS Windows environment. Therefore, to get access to data sets on these archive types in UNIX environment one should use additional utility (available by optional request for SOLARIS environment). Data from current project (such as TERRA MODIS, acquired by NTs OMZ receiving station) is stored on archive tapes by using standard UNIX tar utility. In addition the HDF as basic file format is being used.
File Format.
The most usable file format for early conducted missions (especially for RESURS and METEOR) is so called BRS format (extension of BMP format with additional specific set of tagged data objects which are necessary for describing multidimensional data sets obtained in multi-channel visible/IR observations).
Catalogue content
Catalogues contain descriptors of individual Granules (atomic, i.e. undivided, data set), Data Collections (data sets' aggregations), Browse Images (images, requested for data set browsing), File Descriptions (describing data set location vs file structure), Tape Descriptions (containing descriptions of tape as a whole).
Searchable attributes.
Searchable attributes include Date, Coordinates, Parameter, Sensor, Platform, Mission, and Data Centre attributes (similar to those used in EOSDIS and INFEO information systems).
International Standard Compatibility
Developed catalogue system complies with ISO 19115 requirements and could be considered as ISO 19115 profile. In addition it complies the requirements of CEOS Catalogue Interoperability Protocol (CIP) Specifications (V.2.4, June1998).
User service system
User public interface
User interface is integrated in NTs OMZ information portal (http://sun.ntsomz.ru) and could be used for data search and/order purposes, supported by guide services.
Catalogue Access
Remote on-line 24x7 for data search, estimation and ordering via public Internet, no authorization is required.
Massive data set distribution.
Off-line exchanges using tape or CD media (over 100 MB per day)
Medium or small data set distribution
On-line exchanges using ftp (up to 100 MB per day).

I.2.5 Data policy issues for satellite remote sensing data

- **Archive Politics and Pricing Policy of ROSAVIACOSMOS (NTs OMZ)**

In Russia all kinds of space activities are under **ROSAVIACOSMOS** control. That is why all acquisition ground stations should have **ROSAVIACOSMOS** license for such activities. In accordance to these licenses the organizations could have rights for archiving and distribution of satellite data. In this way the organizations are owners of their archives with shared participation of **ROSAVIACOSMOS**. In accordance to these regulations NTs **OMZ** implements its data policy.

NTs OMZ Satellite data archive content

NTs OMZ has the archives of data obtained from the following remote-sensing systems:
Russian:
RESURS-O1- archive data sets, descriptors, and browse images (MSU-SK, MSU-E, SRRB (France) instruments);
OKEAN-O - archive data sets, descriptors, and browse images (MSU-SK, MSU-V, RLSBO, RM-08, Delta instruments);
KOMETA - archive data sets (KVR-1000 and TK-350 cameras);
METEOR-3M №1- in progress (MSU-E, MTVZA, KGI, SAGE-3 (US) instruments)
Foreign:
TERRA -in progress (MODIS instrument) archives data sets, descriptors, and browse images;
ERS -in progress (SAR instrument) archive sampled data sets, descriptors, and browse images;
NOAA -in progress (AVHR instrument) archives data sets, descriptors, and browse images,
- Goscentr PRIRODA (over 24000 descriptors) - only granule (frame) descriptors.

The digital archive of images from the RESURS-O1 series spacecraft №2, 3, 4 that is generated by the NTsOMZ, contains more than 600.0 gigabytes of data from MSU-E (of 35 m in resolution) and MSU-SK (of 150 m in resolution). The archived 200.0 gigabytes of OKEAN-O data are presented as radar images (RLSBO — 2 km in resolution, RM 08 — 15 km in resolution), microwave images (DELTA), and optical images (MSU-V — 50 m in resolution, MSU-SK — 160 m in resolution) of the Earth.
The KOMETA KVR-1000 pictures have a 2-3-m linear resolution on ground and cover territories of 3 million square km in area. The TK-350 pictures have a 10-m linear resolution on ground. The TK-350 images archived at NTs OMZ provide a 5 million sq km coverage subject to overlapping.
The KVR-100 and TK-350 images are archived in a digital form. Moreover the NTs OMZ has access to all KVR-1000 and TK-350 archive images stored in other Russian organizations.
To enable obtaining data for ecological, hydrometeorological, and heliogeophysical monitoring the METEOR-3M №1 spacecraft is in operation now. METEOR-3M №1 launched on 10 December 2001 is a unified spacecraft equipped with on-board natural-resources instruments (MSU-E, MSU-SM), scientific instruments (MTVZA microwave scanning radiometer for temperature and humidity sounding of the atmosphere, MIVZA microwave scanning radiometer for integral humidity sounding of the atmosphere, KGI geophysical measurement complex, MSGI multi-channel system of geo-active radiation), and hydrometeorological instruments (MR-700m).
The METEOR-3M №1 data-based archive comprises 1000.0 gigabytes of optical images and about 180.0 gigabytes of scientific data.

The data from KGI geophysical measurement complex and MSGI multi-channel system of geo-active radiation are displayed on the NTs OMZ's website (www.ntsomz.ru\spacedata\ipg\index.html) in 30 minutes after the receipt session.
Within the framework of international agreements the NTs OMZ provides acquisition and archiving of data from foreign equipment installed on board Russian spacecraft. Today the data from SAGE instrument (USA) installed on METEOR-3M №1 are acquired and archived.
The TERRA MODIS data archive is under generation since 2003 based on operational data from the NTs OMZ receiving station.
The ERS SAR image data that have been acquired by the NTsOMZ within the framework of pilot projects are available as well.

NTs OMZ archive policy

The existing archiving system provides the following opportunities:
- Maintenance of operational magnetic disc archive and long-term DLT magnetic tape archive;
- Data cataloguing in an operational mode, their geographical referencing, “reduced” image generation, entering the information attributes and reduced images into the catalogue data base.
Consumer required data retrieval is made by means of the catalogue that provides computer-aided image selection from the archive using the geographical co-ordinates of a region required. At the same time the consumer requirements for such image attributes and quality indices as season and period of imaging, the Earth’s surface cloud cover, fail presence, etc. are allowed for. For quick overview and selection of images, quick-look tools are used.
Consumers may handle with catalogues via both the NTs OMz terminal and Internet communication links using the remote access to www.ntsomz.ru site.
Using the NTs OMZ’s catalogue consumer may draw up a request for purchasing copies of space data available in the archive.
The servicing system provides standard processing of data (Fig. 5.3) by consumer requests , digital data recording on magnetic media (tapes, discs and others), as well as image and graphical data preparation and printing on paper or film.
In addition to data products of standard processing levels, consumers may be provided with data products underwent value-added processing as an option.

Fig. 1.3 Remote Sensing Data Receiving Stations in Russia

I.3 Atmospheric Monitoring

I.3.1 Users of the Atmospheric Monitoring

All the branches of economy of the Russian Federation use the results of atmospheric monitoring. Some users have a need for urgent (actual) information and for short-term or long-term prediction of the state of air basin. The other users employ climatic (averaged, probabilistic and minimax) characteristics. In this section the basic “User” categories are enumerated:

- **Aviation.**

For this branch the actual information about the weather is necessary in the airport of departure, the weather forecast along the flying route - in the airport of landing and in the reserve airfield. To select a place or location of the new air enterprise the long term climatic characteristics are being used. When designing this enterprise the entire set of climatic characteristics is under consideration.

- **Building and ground transport.**

Climatic characteristics are mainly used here. Actual information involves the forecast of dangerous weather phenomena (gusty wind, ice-crusted ground, downpour, etc.).

- **Power engineering and communication.**

When designing objects and communications the different climatic characteristics are employed. Operative information includes the short-term weather forecast. This makes possible to choose the optimal temperature for the heat-transport medium and for a system of central heating, to dump in time the water from reservoirs of hydroelectric power stations. Naturally, this branch has a need for the forecast of the dangerous environmental phenomena.

- **Agriculture.**

Climatic characteristics are necessary for planning crop rotation. Prediction of dangerous nature phenomena makes possible to avoid the crop losses. In the present situation semi-operational characteristics such as: the sum of temperatures or solar radiation during decade, month, season- are being used. Today the air pollution is taken into account as well.

- **Industry.**

Earlier only climatic characteristics have been used for purpose of designing and constructing enterprises. Now-a-days the interest raised to the atmosphere operative temperature and wind stratifications that determine the scatter of pollutants emitted by plants.

- **Municipal services.**

All kinds of information about the state of air basin are being used in these services. For example, in the case of heavy snow forecast the cleaning of the territory should be prepared. The short-term forecast is necessary for subdivisions exploiting different city communications. The long-term forecast is necessary for planning seasonal repair measures. The actual air pollution is taken into account in control of traffic and work of plants located in the city territory. Climatic characteristics are being used when designing and creating new municipal projects.

As a rule, for solving most of problems in every branch the same parameters characterizing the state of air are used. Therefore it is convenient to classify these characteristics according to the goals, to which they are being used:

- long-term planning of the development of branches and planning of the arrangement of production resources;
- technical designing of the specific projects and specific measures;
- use of objects of national economy;
- forecasts of all types.

I.3.2 Demands and requirements to atmospheric information

At long-term planning the information is necessary about the future (for several decades or years) state of the environment, about expected standard values of hydro meteorological elements and about the probability of appearance of extreme or critical values of separate elements and their combinations.

The information is required for any “geographical point”, region, water area or route on the territory of the Russian Federation. In this case the concepts of “geographical point”, water area or route will be different for different branches of national economy. For example, the planning of the installation of a mast for radio retransmission requires the information about the region of an area of 0.01 km^2; the planning of agricultural production requires the information about the territory from several hundred to several thousand km^2; the planning of plants and towns requires the information about the territory of hundreds thousands km^2.

In technical design of the specific projects there is an urgent need for the same information as for the problems of long-term planning. However, there is significant difference in the requirements. Basically higher degree of spatial and temporal resolution and higher accuracy of measurements are required. The degree of measurement accuracy should correspond to the accuracy of project specifications.

The information must refer to definite and limited (not arbitrary) "geographical points", regions, water areas and routes on the territory of the Russian Federation, for which the projects are planned. The information can be based both on the accumulated statistics and on the observations collected specially during the limited time periods (2-3 years). The exploitation of the objects of national economy requires the following information:

a) specific expected in the future hydro meteorological phenomena for planning the certain actions and arrangements (flight of aircraft, sowing of agricultural crops, etc.) in the routine activity of industrial enterprises, building projects, transport and agriculture;
b) significance of several hydro meteorological elements or their combinations, actually taking place at definite locations, at definite instants and points in time. For example, whether or not the hailing is possible or the wind rush >25 m/s is observed, and so on. These data are necessary for estimation of efficiency, analysis of losses, etc.
c) critical values of hydro meteorological elements (wind velocity at a building area, water level at a dam during heavy shower, the visibility on the take-off and landing runway), occurring in the regions of activity of national economic objects, for immediate action.

The main and most important part of this information consists of short-term and long-term forecasts; consequently, the requirements to this information are the requirements to the forecasts.

The tables presented in [1] contain the detailed numerical criteria for the meteorological data used for designing and exploitation of the objects of national economy or for weather forecast. The criteria have been developed by State Committee for Hydro Meteorology of the former USSR (***Goskomhydromet USSR***) in accordance to the instructions of the Worldwide Meteorological Organization **(WMO)** and are still in operation.

I.3.3 Atmospheric Monitoring Infrastructure

The monitoring of the air quality in Russia is performed by the following ministries:

- Russian Federal Service fro Hydrometeorology and Environmental Monitoring ***(Roshydromet),***
- Ministry of Natural Resources ***(MNR),***
- Ministry of Emergency Situations ***(MES),***
- Ministry of Defence***(MD),***
- Ministry of Health ***(MH),***
- and the Institutes of the Russian Academy of Sciences ***(RAS)***

The overwhelming majority of data is obtained by ***Roshydromet*** and this information is the most accessible for a wide range of users. That is why in this section we consider the problem of the atmospheric monitoring in the system of ***Roshydromet.***

At present several measuring networks have been developed for the atmospheric monitoring. A basic network is the network of meteorological stations that are located relatively uniformly over the entire territory of Russia. This network includes: *actinometrical, ozonometric and agro meteorological networks.* In parallel with the *meteorological one* the *aerological network* is set up for radio sounding of the atmosphere. For monitoring the air quality three types of measurements were implemented in Russia:

  - determination of the level of air pollution in the cities,
  - system of background monitoring and
  - system of acid precipitation.

Besides, taking into account the specificity of the aviation demands, each airport has its own *avia* meteorological stations (***AMS***) and as a rule the meteorological radars. The information from all stations comes without delay to the ***Roshydromet*** local and central offices and to the corresponding department where the data are processed and accumulated. This does not happen with the data from other Ministries and departments.

Fig 1.4 gives the overview of the organisational structure of the Atmospheric Monitoring in Russia

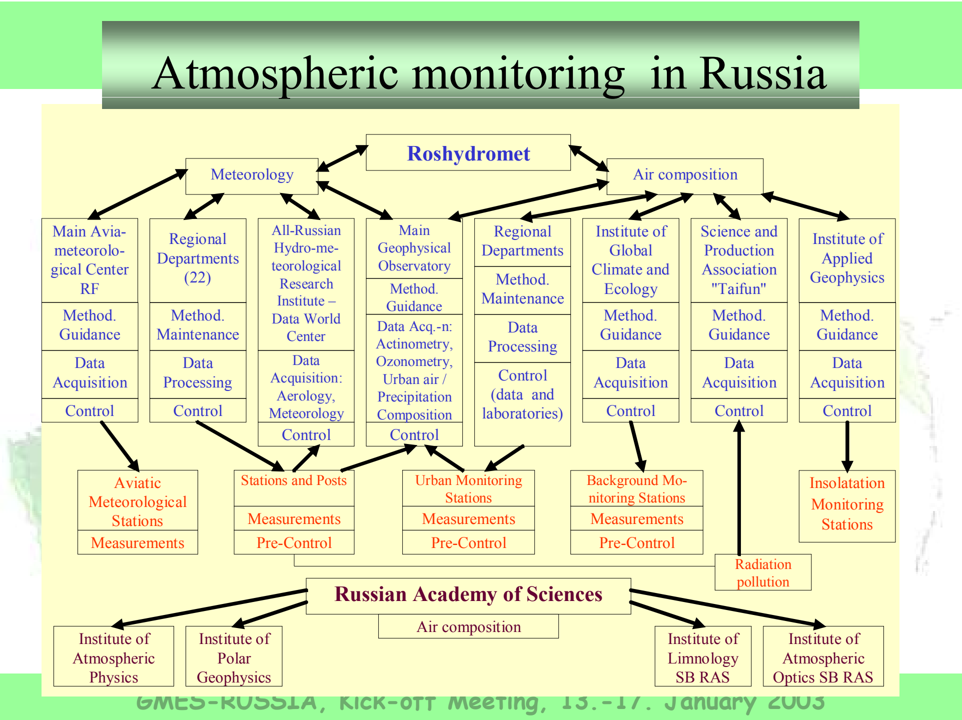


Fig. 1.4 Atmospheric Monitoring Infrastructure

Figure 1.4 shows that the atmospheric monitoring in Russia consists of two basic components: a “state component” headed by the ***Roshydromet*** and a “scientific” one organized in the Russian Academy of Sciences.

The “state component” of monitoring is strictly centralized. Each type of monitoring is checked by the appropriate office, which executes the scientific-methodological management of the entire system of data acquisition, collection and transfer. Fig.1.4 shows that there are two such basic offices. One is engaged in all the kinds of meteorological measurements, another one monitors the air composition.

The next level of organization of state monitoring of the atmosphere is represented by the regional departments (22), head institutes of the ***Roshydromet*** branch centres. Their functions are the development of methodological instructions in the particular types of data transfer and in the particular types of data measurements, collection and transmission to regional data users, control of data quality, creation of data bases and banks.

At the low level of the state monitoring there are stations and posts, which perform the measurements and observations. From Figure 1.4 it follows that these stations and posts can be subdivided into 5 categories. The aviatic meteorological stations located at airports carry out the measurements using the particular own program and provide operative data at the disposal of both their own enterprise and other airports, using the data channels. Due to the operative character of such stations, the original data control at these stations is only subjective. The full control is performed at the head AviaMeteoCentre ***(AMC)***.

The second type denoted as ‘stations and posts’, unites a wide range of measuring stations: meteorological, aerological, hydrological etc., which carry out the measurements of physical air parameters, and in some cases, the characteristics of radio active contamination of the environment. The information received at this type of stations is being used for weather

forecast, risk management and calculation of climate parameters. The preliminary data quality control is introduced here.
The urban monitoring stations work in accordance with specific program and perform basically the inspection of air composition. As a rule this is the collection of air samples followed by determination of ingredients by analytical techniques. 1-2 gas components and main meteo parameters are being measured in operative mode.
There are only few of background monitoring stations that located in the regions free from anthropogenic stress. These stations work in accordance with program developed in the Institute of Global Climate and Ecology. The latter performs also the acquisition, accumulation, testing and distribution of the information.
Finally the network of insolation monitoring stations carries out the tracking of the solar activity and consists of a few stations. These stations were developed in the Institute of Applied Geophysics and work in accordance with programs of this Institute.

The state network of atmospheric monitoring of the ***Roshydromet*** is a component of the global network of the World Meteorological Organization. Since the ***WMO*** regulations with regard to national networks dictate conformity with international standards, the Russian systems of observations meet all these requirements. The obtained information is used by the entire world community.

The disadvantage of this network is its ineffectiveness in operative monitoring of air composition. Therefore in a series of institutes of the Russian Academy of Sciences their own measuring networks have been developed. As a rule, the foreign instruments that are well recognised and employed in the monitoring of the environment, or domestic instruments with intercalibration with the best world standards are used here. Each this station works in accordance with its own program without centralized guidance. Sometimes the Institutes transmit the data to the Geophysical Committee at the Presidium of Russian Academy of Science and provide the free access to information through the Internet.
The difficult economical situation in Russia during last decades affects drastically the functioning of the atmospheric monitoring networks. Some stations work constantly, several stations work in regular intervals and some stations work irregularly. That is why it is difficult to estimate the state-of-the-art of the density of the functioning stations over the territory of Russian Federation.

Meteorological measurements

The currently available meteorological stations could be broken down into classes 1, 2, 3 and meteorological and agro meteorological posts, according to the work being carried out, staff and instrumentation. For comparison and unity all meteorological measurements, are being done at all the stations at unified time at 00, 03, 06, 09, 12, 15, 18 and 21:00 of Moscow time, by unified techniques, using 11 instructions and instruments of one type. Instruments, used in the network, are calibrated at the departments accredited by the Russian State Committee of Standards. Atmospheric phenomena and the weather changes between the observation periods are recorded by observer.

Since there is a lot of hand-operated functions that may cause the subjective errors, the multistage control and testing of the measurements is foreseen. The first check is performed at the station. After that the table of observations is aggregated and directed to the regional department. At this department the second level of testing is being done by comparison the measurements from neighbouring stations. Finally, at the third level, the information comes to the World Data Centre - Russian Research Institute of Hydrometeorological Information located in Obninsk, (Kaluga region), where the total data control is carried out. Only after these steps the data can be put down into the archives.

Meteorological information from 280 stations of Russia is available on-line on the server of Central Radiometcentre of ***Roshydromet:*** http://grmc.mecom.ru/info/index.html. Here the products of preliminary processing are presented. Russian Research Institute of Hydrometeorological Information is a **holder** of a long-term archive: http://www.meteo.ru/data.htm.

_ **i. Actinometrical measurements**

At a series of meteorological stations, along with meteorological measurements, the observations of the intensity of incoming solar radiation are made. The observations are performed every hour at day-time and at principal meteorological periods at night time. For these measurements an actinometer AT-50, a pyranometer M-80 and a national instrument -radiation balance gauge M-10- are used. The latter instruments are unified and being checked every year.

The following parameters are being measured every hour:

- *direct solar radiation* (integral over the spectrum) in the range 0-1400 W/m^2 within an error of ±5% (AT-50) ;
- *total (0-1400 W/m^2), scattered (0-1400 W/m^2) solar radiation* and short-wave (λ=0.4-2.3 μm) balance within an error ±5% using a pyranometer M-80 –;
- *a radiation balance* gauge M-10 enables to determine at day-time the radiation balance (±600 W/m^2) in the spectral range λ=0.4-14 μm within an error of ±15% and at night the effective radiation within an error ±20%.

Data holder: the World Centre of Radiation Data of the Main Geophysical Observatory ***(MGO):*** http://www.mgo.rssi.ru/nev/mgo-ru.htm.
At this Centre the control of the measurements results is performed.

Ozonometric network

The ozonometric network measures the total ozone content and spectral atmospheric transmittance at 6 spectral intervals λ=344; 369; 463; 530; 572 and 627 nm. The network consists of more than 30 stations on the entire territory of Russia and equipped by a national ozonometer M-124. The measurements are being done by the sun or by the scattered radiation in zenith. For measurements reliability and compatibility all the instruments are compared with the Dobson auxanometer every year. It is presumed that measurement error does not exceed 5 %.

The data are promptly passed to Hydrometcentre of Russian Federation where the daily map of total ozone content over the Russian territory is formed.

Data holder: the World Centre of Radiation data of the ***MGO***. This Centre controls the data quality

Aerological Measurements

The network consists of more than 100 stations intended to determine vertical profiles of pressure, temperature and humidity of the air and the wind direction and velocity using a radiosondes.

The traceability of measurements is achieved by a launching the weather balloon-sonde at the same dates and time and by common processing technique of the telemetric information with preliminary calibration of its sensors.

The network is equipped with different instruments. In the distant regions of ***RF*** the systems “Malakhit-A-22” are used. The other stations use the Systems “Meteor-RKZ” and “Titan-Mar2”. In the last few years the Aerological Automated Computing Complex (AVC) was developed, whose characteristics are close to those of the complex Vaisala “Digi Cora”.

Along with the producer calibrations the intercalibration tests with the foreign systems were made using this network.

The multistage monitoring is implemented in this network.

Data holder: World Data Centre of Russian Research Institute of Hydrometeorological Data ***(WDC ARSRIHD).***

Due to the expensive character of these observations the network is in the moment in deplorable condition. Instead of sounding 4 times a day as it is required for many problems, only two times sounding is being done. To preserve the equipment and staff, one radiosonde per day is launched at each station. The stations and time of launching vary within the regional department. For example, at the West-Siberian Department six stations operate as follows. At 00-00 of Moscow time the radiosondes are launched in Barnaul, Novosibirsk and

Kolpashevo. During 12hrs the closely located stations of Kosh-Agach, Barabinsk, and Aleksandrovskoye launch their radiosondes. As a result of the described situation, there is a lack of information for the detailed analysis of the altitude weather maps.

Support for Aviation.

The support for aviation is implemented at all large airports of Russia using the techniques agreed in the aviation. The **data holder** is the Main Aviation Meteorological Centre ***(MAMC):*** http://www.mecom.ru/roshydro/pub/servers/game.
To ensure the ***MAMC*** activities the Bank of Aviation Meteorological Data ***(BAMD)*** plays a crucial role. The data for more than 2000 airports of Russia and abroad is available in this bank. The information involves: the actual weather at the airport for the last three hours *(code MSTAR),* the latest weather forecast for the airport *(code TAF).*

The ***BAMD*** makes it possible to obtain, accumulate and distribute the aerometeorological data in real time.

This technology has developed for a qualitative and immediate meteorological service of aircraft flights. The structure of data bank and types of data processing correspond to the Russian and international meteorological standards.

The users are connected to the bank by direct communications through local and remote modems and also through the communications of ***Roshydromet*** (Automated System of Data Transfer, ***ASDT***) and civil aviation (Aviation Federal Telegraph Network, ***AFTN***).

The bank services are at full disposal for all countries - members of **WMO** and ***ICAO*** (International Civilian Aviation Organization)**.** Access is gained by ***AFTN*** according to the international communication procedures.

Our attempts to obtain any information from this databank by direct access through Internet have failed. Evidently the databank maintaince and services are carried out on a commercial basis. There is also uncertainty about data quality control.

Network of monitoring urban air quality

In 2000 the regular network of the State Service for Monitoring of Atmospheric Pollution ***(SSMAP)*** of ***Roshydromet*** on the territory of Russia consisted of 621 stations and was deployed in 220 cities. Together with services of the departments of industrial enterprises and services of sanitary epidemic stations ***(SES)*** the atmospheric pollution monitoring have been done in 253 cities with the help of 685 stations. The stations were located in housing estates, near highways and large industrial objects. According to the location of the station the latter are subdivided to the city background stations in the housing estates – 35%; industrial stations in the impact area of an enterprise – 32%, motor stations (close to large highways) – 28% and regional stations – 5%.
Today this network uses:

- the “POST-1” and “POST-2” stations equipped with the sampling units for gas components M-822 and EA-1;
- samplers for suspended matters EA-2C and EA-2;
- automatic sampler “Component”;
- gas analyzers “Palladii-3”; GMK-3;
- gas counters RG-7000 and GCB-400;
- meteosystem M-49.

As a result, only two gases SO_2 and CO, and their “meteovalues” at a point of measurements, pressure, temperature and air humidity, the wind velocity and direction are determined operationally. The other ingredients are determined either at peripheral or central *(“Taifun”)* laboratories. According to general instructions (PD5204186-89, Hydrometeo Publ., 1991’), the following requirements can be imposed upon the instruments and techniques for monitoring the atmospheric pollution. The detection threshold of any compound must be $\leq$0.8 of maximum permissible concentration of i-impurity. The error of its extraction must not exceed 25%.

The quantity of the determined substances at different stations varies and depends on the equipment of the analytical laboratory. At all stations only the mass concentrations suspensions (aerosol) as well as nitrogen dioxide and oxide, sulphur dioxide, carbon monoxide are determined. The measurements at the stations must be made 4 times per day at 01-00, 06-00, 13-00 and 19-00 of local time. In practice only 12% of posts operated on total program in 2000, 80% of posts operated three times per day and 8% of posts worked according to a limited program – 2 times per day. The data obtained in this network went through multiple control. To ensure the reliability and quality of the information, the Main Geophysical Observatory as a methodological centre performs every year analysis and estimates the quality of work of the network based on the check of calibration charts to determine the impurity concentrations, to fulfil the external control of the measurement quality, methodological inspections and analysis of the quality of information materials.

In the network laboratories the interior control of the measurement accuracy and the content of main and specific impurities in accordance to the requirements of RD 52.04.186-89 are performed. Besides, almost in all chemical laboratories the control of rough errors and the statistical control in accordance to the instruction №2335-95 are carried out.

The exterior periodic control of the measurement accuracy is carried out by central laboratories of regional departments by sending to network laboratories standard samples, check solutions and periodic testing of calibration diagrams. The same exterior control is carried out periodically by the MGO. In such a rigorous approach it is natural that all the network laboratories are accredited by the Russian State Committee of Standards. The instruments are regularly checked either by the department inspection or by local departments of the State Standard Committee.

As a rule, the information obtained using the network is not prompt. It is collected at the MGO, generalized, and then published in the year-book “State of Atmospheric Pollution in Cities on the Territory of Russia”. More information can be found on a site of the Service of Environmental Protection of Ministry of Natural Resources of Russia: http://www.eco/net.ru.

The main drawback of the described network is that it is bad deployed. 60% of all stations are located either in the vicinity of enterprises or along highways. Consequently, the obtained data show mainly not the condition of the city environment but the power of sources of industrial pollution.

Background monitoring

The *background state* of the environment means the state of ecological system at vast, not urban territories, under moderate anthropogenic impact due to contaminants from near and distant emission sources in the atmosphere.

For monitoring of *background atmospheric conditions* a network of background monitoring has been developed under the leadership of the Institute of Global Climate and Ecology ***(IGCE).*** At present this network consists of 18 stations at different regions of Russia. But not all of them perform the measurements in full. For example, only three stations: *Bering Island, Kotelnyi Island, and Teriberka* – measure carbon dioxide.

The program of measurements must include:

- the measurement of heavy metal concentration – Pb, CD, Hd;
- suspensions;
- chlororganic pesticides;
- sulphur and nitrogen dioxides;
- sulphates;
- nitrates, carbon dioxides and methane,
- total ozone content;
- atmospheric transmittance;
- electric characteristics of the atmospheric boundary layer.

In this case the analytical (not routine) methods of analysis are used. The data obtained are not routine. The data are collected and generalized at the ***IGCE***: http://www.igce.comcor.ru.

Based on these generalized results the yearbook “Overview of Back-ground State of the Environment on the territory of CIS countries” is issued in St-Petersburg, by Hydrometeo publishers. More detailed information was not found so far.

Monitoring of the Chemical Composition of Precipitation

In the 1990’s, the sampling of precipitation for chemical analysis or for measuring the acidity have been performed in Russia using more than 200 stations ,including 45 stations of the federal network of ***Roshydromet.*** The stations of the federal network are located outside the cities and they are far removed from the enterprises. The international system of the ***WMO*** includes 11 stations of the federal network. The selected samples are subdivided into the overall monthly, weekly and single. To single samples refer the single or daily precipitation.
At 114 points the value of pH is measured in a period of rainfall. The network is served by seven laboratories. From these laboratories the tables with the results of chemical analysis are being sent to the ***MGO***. Sampling and chemical analysis of samples are carried out using the unique methods with the use of samples from the State Committee of Standards. In the precipitation we determine $SO_4^{2-}, Cl^-, NO_3^-, HCO_3^-, NH_4^+, Na^+, Ca^{2+}, Mg^{2+}, Zn^{2+}$ the sum, PH. The measurement error for mean values is 5%. The **data holder** is the ***MGO***. The summarized data are published periodically. For example, the latest data were published in “Annual data on chemical composition of Atmospheric Precipitation for 1991-1995”. St.-Petersburg, “Hydrometeoizdat” Publ., 1998.

Supporting Monitoring Networks

This is the type of atmospheric monitoring which presents additional information about the atmospheric conditions. The Institute of applied Geophysics (http://www.mtcjVI.ru/roshydro/pub/servers/ipg_0303/ipg_home.htm) controls and summarizes the impact of heliogeophysical factors on the atmospheric conditions. Unfortunately, there is a lack of the description of the control system. The federal analytical centre “Taifun” (http://www.typhoon.obninsk.ru) controls the state of the radiation situation in the territory of Russia. The prompt information from this network arrives, apart from central departments of ***Roshydromet***, to MNR and to **MES** (Ministry of Emergency Situations) of Russia for undertaking urgent efforts to prevent emergencies.
The holder of information is Centre “Taifun”. The summarized information is published in the year-books “Radiation Situation in the territory of the CIS”.

Research in the field of Atmospheric Monitoring

Due to the fact that the national networks practically do not provide the information about the air composition in the vast territories of Russia, some organizations in early 1990’s, have developed the monitoring of the atmospheric state in background regions. All these organisations /institutes belong to the Russian Academy of Sciences (RAS).

Institute of Atmospheric Physics
The Institute of Atmospheric Physics carries out the monitoring of atmospheric composition using three stations:

- in Moscow - (the Lenin hills –Moscow State University ***(MSU)*** observatory);
- near Kislovodsk - the background station at 2000 m height;
- close to Zvenigorod, Moscow region – measurement site of the Institute of Atmospheric Physics

For monitoring the gas composition the foreign instruments are used. Aerosol and meteorological characteristics are determined by the instruments of national production.

Polar Geophysical Institute

The Polar Geophysical Institute carries out the monitoring of air composition on the Kola Peninsula. The idea of monitoring is the same as at the Institute of Atmospheric Physics.

Limnological Institute
The Limnological Institute carries out regular measurements of aerosol composition in the Baikal region and along the Baikal shore. The Limnological Institute has organized the background monitoring in the settlement Mondy (at the Mongolia border) and the gas and aerosol monitoring. The foreign instruments are used.

Institute of Atmospheric Optics
There are several instruments and installations being used in the Institute of Atmospheric Optics (Tomsk) in the monitoring regime.

Automatic post measuring the air composition (TOR-station).
An automatic post is intended for measuring gas and aerosol air composition and meteorological characteristics and it is mounted at a 5 tons railway container.

Technical characteristics of the post:

Gases:	sulphur dioxide	0.002…40.0 mg/m3±20%;
	Nitrogen peroxide	0.001…10 mg/ m3±15%;
	Nitric oxide	0.001…10.0 mg/ m3±15%.
	Carbon monoxide	0.10…20.0 mg/ m3±20%,
	Carbon dioxide	100…2000 ppm ±20%,
	Ozone	0.001…1.0 mg/ m3±12%.
Suspensions:		
	Dispersed composition	0.4…10.0 μm in 12 channels,
	Chemical composition:	filter sampling – and laboratory analysis;
	Mass concentration	0.01…60 mg/ m3.
Meteorological characteristics:		
	Air temperature	-50…+50°C±0.2°C,
	Air humidity	10…100%±3%,
Wind direction		0…360°±10%,
Wind velocity		1…40 m/S±1m/S,
Total solar radiation		0…1400 w/m2±20%,
Precipitation		yes/no,

Data access: http://meteo.iao.ru

2. Aircraft-laboratory AN-30 "Optic-E"

Figure 1.5 shows the location of instruments on the board of aircraft-laboratory. This aircraft-laboratory can be used to solve a wide range of problems: from sounding the atmosphere and water and ground surface to determining the state of biological objects, detecting fish shoals and so on.

The deploying of instrumentation on the board of the aircraft-laboratory AN-30 (Optik-E)

1 – blocks of air intake pipes and contact gauges;
2 – solar spectrophotometer;
3 – post for mounting of primary converters of gas-analysis and aerosol complexes;
4 – chromatograph;
5 – nephelometer with agents of thermo – and hydro optics;
6 – central computer;
7 – spectrophotometer meter;

8 – lidar meter;
9 - lidar;
10 – spectrophotometer;
11 – radiometer;
12 – infrared imager;
13 infrared imager recorder;
14 – board of airborne operator;
15 – navigation complex.

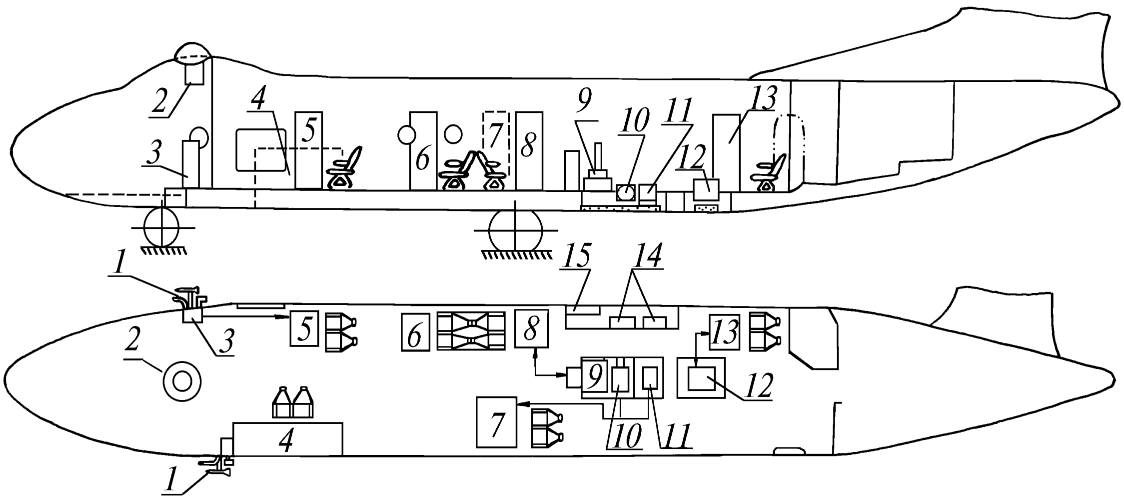


Fig. 1.5 The deploying of instrumentation on the board of the aircraft-laboratory AN-30 (Optik-E)

I.3.4 Understanding of Atmospheric Processes

In the 1980's when the meteorological and aerological networks worked in a full and all city posts and background monitoring of pollutions operated entirely, the correctness of short-term forecasts of weather exceeded 90% and the complete list of the most polluted USSR cities was made up.

The decrease of the station network and the observation programs in the 1990's has resulted in the reduction of the correctness of short-term weather forecasts up to 70% and the list of cities where the monitoring of atmospheric pollution takes place have been also reduced. It doesn't mean that the investigation and understanding of meteorological and weather processes became less. Simply there is a lack of initial data for the current atmospheric models and latter affects in turn the final product – the weather forecast.

Two ways to resolve the problem are possible:

- gradual reconstruction of the monitoring network;
- transit to other types of data, sensors and instruments (for example utilization of the space remote sensing data, updating current and developing new atmospheric models).

The understanding of the processes that determine the air composition in the territory of Russia (especially outside the cities), was not high in the 1980's. The reason - insufficient number of stations of background monitoring for the area of 22 million km2 (territory of the former USSR). This network could reflect only the most global changes of the air composition, since there exist vast regions where the information source on the air composition was not available.

In recent years the situation was not improved. If we exclude from consideration the network of air monitoring in the cities (these data are very much polluted in the information sense),

then the data on gas and aerosol composition can't be representative for the background conditions at two or three points in Russia. Evidently the use of such data doesn't allow saying much about atmospheric processes.
The lack of input data resulted in the fact that there is no specific and precise model for the forecast of air composition in the territory of Russia. The current existing models developed to describe a single source of pollution (case of accident) or for a specific city can not encompass the whole problem. <u>In this sense the problem of global climate change and environmental changes in the territory of Russia requires more efforts and resources that should be incorporated into the investigation of the atmospheric models.</u>
The way out is either in the creation of several mobile laboratories operating in its region and providing information about the air composition or in the creation of several tens of stationary ground stations of monitoring outside the cities in different regions. Otherwise we can obtain inadequate models of atmospheric processes.

If we compare the state-of-the-art of atmospheric monitoring in Russia with those in Europe (see BICEPS 2 Interim report), we can recognise the commonalities and distinguish the differences.
The important role of modelling to study the environmental processes is pointed out in BICEPS 2. For Russia it is only possible when study the meteohydrological processes. The modern models that are supported by data from monitoring networks exist for this field in Russia. In the field of air quality the approach on a base of models as a method of exploration looks at the moment inappropriate due to the lack of data from the vast territories of ***RF*** that significantly exceeds the territory of Europe. It doesn't mean that models of atmospheric processes are not under development in Russia. They are definitely under extensive development. However they have pure theoretical flavour and mainly based on data parameterisation, obtained in some few short-term experiments. That is why for GMES this modelling data could serve as evaluation trials rather than information source.

To fulfil the Kyoto protocol agreements it is suggested in BICEPS the modelling approach and direct measurements of emissions from big pollution sources. The modelling of this sort of emissions is being done in Russia as well, whereas the direct measuring of emissions is an open question. More over Russia with its huge forest funds represent on a global scale rather the <u>flow</u> of green gases than their <u>source</u>. The absorption coefficient of the Russian forests is estimated up to now with a big inaccuracy. Therefore GMES structure for Russian conditions should take into account this inaccuracy and for environmental monitoring and for modelling the global processes. At present the Siberian branch of Russian Academy of Science together with National Institute of Environmental Research (Japan) deploys 5 high altitude masts for estimating the $C0_2$ balance on the territory of the Western Siberia. In the future these masts could become basic instruments for modelling the global changes in environment.
Since huge funding is necessary for creating the really advanced air quality monitoring network in Russia and since this funding is not available, we have to find out non-standard approaches. The combination of the satellite remote sensing and small number of the good-equipped ground stations looks like a realistic and reasonable approach. Such a combination could allow a good verification of satellite data, followed by using this data for modelling the atmospheric processes.

I.3.5 Quality Control of the Atmospheric Data

The data quality of any monitoring type depends on:

- measurement techniques and instrumentation
- subjective errors of the attendants
- malfunctions in the transmission and communication channels

To exclude the random and systematic errors the multistep data quality system is set up in ***ROSHYDROMET***.

Firstly, all measurements are being done in accordance to ***WMO*** instructions in the same time, with the same techniques and unified instruments. In this way the comparability and synchronism of the observations is achieved.

Secondly, there exists the Main Technical–Scientific Office in ***ROSHYDROMET*** that defines the list of instruments admitted for exploitation, the rules and instructions of instruments utilization and periodicity of the instruments checking. Every *regional department* of ***ROSHYDROMET*** has special laboratory for instrument periodic checking. Every device that is under exploitation in the measurement network is being checked. The time interval for this checking varies and could be from 1 to 5 years. It is strongly prohibited to use the unchecked instruments in the state atmospheric monitoring network.

To exclude subjective errors of attendants the multiple testing of data is arranged. The first stage of testing is carried out on the station where this data is obtained. This is so called technical control. The particular operator and the head of the station perform this control. Next step is *regional department* where data go through critical control. The checking staff here estimates not only the absolute values of the parameters, their admissible limits and temporal variability but makes matching of the particular parameter with values received at all the stations within the region. Sometimes, when the station location has been chosen inappropriate, this station receives the status of “microclimatic”. It means that its measurements reflect only local climate conditions. Finally data are directed to the central Institutes of ***ROSHYDROMET***, where sophisticated evaluation methods are used to decide if data from ground stations could be used in the global monitoring network. Only after performing all control procedures the data could be inserted in the corresponding archive and/ or data bank.

Along with subjective and instrumentation errors the errors from transmission and communication channels could arise in the data. To avoid this sort of errors the special international compressing transmission codes are used: code KH-01 for meteorological data, code KH-04 for aerological data for example. On one hand these codes provide the reduction of the information to be transmitted and therefore the reduction of the transmission time, on the other – saving the costs on communication services.
On the receiving end the information is decoded and is tested with the help of the special software. This quality control system practically excludes the probability of the erroneous data in the output.

I.3.6 Data policy issues for atmospheric data

Here we consider data policy with regard to atmospheric data that exists today in **Russia.**
Our considerations follow the approach introduced in Data Policy Assessment study for GMES (DPAG cross-cutting assessment study and DPAG Interim report). That is why we take six data policy characteristics

- Ownership, privacy and confidentiality
- Intellectual property rights and associated legal frameworks
- Standards and metadata
- Licensing, distribution and dissemination
- Pricing policy
- Archiving policy

and attempt to trace them with regard to atmospheric data.

1. Ownership, privacy and confidentiality

All data that has been received in ***ROSHYDROMET*** is the state property and in accordance with legislative act: “Law of Russian Federation on Protection of Environment” this data is open. The results of measurements being done in the Institutes/Organizations of ***ROSHYDROMET are the property of*** the corresponding Institute/Organization and have as a rule the confidential character.

2. Intellectual property rights and associated legal frameworks

The intellectual rights with regard to atmospheric data belong to ***ROSHYDROMET.***
If data have been processed, analysed and generalized in some particular Institute, the property rights on these results belong to this particular Institute. The intellectual rights on a data, received in the Institutes of Russian Academy of Science belong to laboratories and groups that carried out the measurements and processing.

3. Standards and metadata

Roshydromet follows international standards recommended by World Meteorological Organisation **(WMO), ECOMET and ECMWF**. Such a policy ensures that weather observations and products are standardised. The latter is important and essential for effective monitoring of the global meteorological processes. The data produced by other environmental monitoring organisations cover a variety of environmental fields and topics, but not always correspond to international standards. The importance of metadata is also recognised by environmental organisations, and the majority of them maintain some type of metadata system.

4. Licensing, distribution and dissemination

Licensing and distribution of meteorological data and products is influenced by international agreements and organisations, basically by World Meteorological Organisations (***WMO***). Resolution No.40 is one of the key agreements of the ***WMO***, which requires that its members provide, on a free and unrestricted basis, 'essential data and products required to describe and forecast weather and climate, and to support WMO programmes'. ***WMO*** members must also provide data to the research and education communities on a free and unrestricted basis. In Russia only operative information such as weather forecasts, emergency warnings are distributed for free. Reference and hand-books are distributed on queries of organisations.
The organizations of Russian Academy of Science which receive funding from government and act in the public interest generally make their information and data as much available as possible. Many such organisations distribute their data free to interested parties with little or no licensing restrictions.

5. Pricing policy

The price for meteorological data is affected by international organisations and agreements. The ***WMO*** considers the meteorological data as essential component of humanity well being, and much of the data should therefore be exchangeable on a free and unrestricted basis. Practically, this means that basic meteorological information such as warnings, forecasts and observation data should be free for a wide range of public users. ***WMO*** Resolution No.40 also ensures that some meteorological data and products are provided free of charge to non-commercial research and educational users.
In other cases the prise depends on the service type:

- Information services (for example the weather forecast for some enterprise)
- Preparation of the reference data (for example data about climate and or air contamination in the spot of the future factory constructing)
- Providing data from archives
- Payment for communication services

As a rule the Institute of the Russian Academy of science distribute their data free within common research projects or sell this data within commercial projects.

6. Archiving policy

ROSHYDROMET as well as foreign partners create the data archives.Meteorological data is recognised as valuable historical and climate record, and most agencies have therefore compiled archives over many years. This has been in digital format over recent years. At the same time many meteorological organisations keep records and information in hard copy format dating back to many decades. The same situation is in the Institutes of ***RAS.***

In this paragraph the system of atmospheric monitoring in Russia is presented. We attempted to track different aspects of this particular monitoring type taking into account the GMES key principles and focuses. We also attempted to link our considerations with cross-cutting assessment studies that have been recently done within BICEPS and DPAG projects. The main conclusion that could be drawn is that advanced atmospheric monitoring system exists and is under operation in Russia. This system basically meets end user requirements to data and information and is a part of global international monitoring network under guidance ***WMO.***

The modern information technologies are used for data transfer, distribution and archiving. These technologies match the international standards.

Essential drawback of the atmospheric monitoring in Russia is insufficient density of background monitoring stations over territory of a country. The way out is the transit to combination of satellite remote sensing observations and creation of supporting ground stations.

I.4 Environmental Stress Monitoring in Russia

In this paragraph the problem of Environmental Stress Monitoring in Russia is considered with regard to particular region of Russian Federation – namely Khanty-Mansiysk Autonomous Okrug **(KMAO**)-where the environmental problems are strongly pronounced and where all significant environmental impacts are presented [1] . Chapter III of this report gives detailed description of this particular territory of Russian Federation and considers regional environmental stress regarding its socio-economic impact. Here we make emphasis on scientific and technological assessment of the existing in the region monitoring infrastructure.

Abschnitt 0.1 I.4.1 Soil degradation monitoring

<u>Soils and land resources</u>

Since Khanty-Mansiysk autonomous region is located in the central part of the West Siberian plain, the climate of the region's territory is sharp continental and is formed under influence of air masses of the Asian continent. The main features of the climate are:

- precipitation exceeds evaporation and
- insufficient warmth.

According to geographic and soils zonation, the territory of the Khanty-Mansiysk autonomous region belongs to the central taiga and mixed forest zone of the West Siberian province of gley-podsolic and podsolic alluvial-humus soils. A dense drainage system (Ob and Irtysh river basins) and a great number of lakes and bogs are the characteristic features of the landscapes. In general, the conditions of the natural environment can be characterized as rather severe for human activity of any kind and for land use.

The land cover/land use of the territory can be categorized as follows:

- Forests occupy 90.9 % (or 48602.2 thousand ha) of the total region area;
- Agricultural lands occupy 687.9 thousand ha (or 1.2 %);
- Urban territories – 487.4 thousand ha (or 0.9 %);
- Industrial, transport, communication lands – 130.8 thousand ha (or 0.3 %);
- l reserves lands – 874.4 thousand ha (or 1.6 %);
- odies – 501.8 thousand ha (or 0.9 %)
- – 2195.6 thousand ha (or 4.2 %)

The infrastructure of the land use management is depicted in graphic form in Fig. 7.2 of our annual report [1].

According to the valid state and regional environmental legislation, minerals and petroleum exploiters (holders of exploitation licenses) should develop systems for regular environmental observations (atmospheric air quality, surface water and underwater, soils) of the licensed areas and should carry out an environmental monitoring. Environmental monitoring of the licensed areas has the following objectives:

- Environmental control based on chemical, physical and biological characteristics for determination of the source of pollutants, a pollution level and the estimation o fenvironment protection effectiveness;
- To provide special accredited environment protection and resources exploitation supervising organizations with regular data on environment pollution level, forecast of its possible changes, and emergency information on abrupt increase in pollutant level in the environment.

Environmental monitoring of the areas under control should be a complex of connected, temporally and spatially synchronized observations of the environment and their quality assessment.

Development of local environmental monitoring systems should to be based on the results of previous studies of the oilfield areas and initial (background) pollution, regulated by the document:

"The main requirements for licensed areas initial (background) pollution appraisal of oilfields, gas-fields and other mineral resources of the Khanty-Mansiysk Autonomous Okrug".

As a result of this directive certain characteristics have been specified on the basis of a data analysis of sources and scale of technological impacts:

- Number and location of the environmental observation stations
- The list of quality indices to estimate the environmental stress
- Observation intervals for various environmental components and indices.

The set of ingredients and observation intervals (sampling intervals) for various observation stations for a monitoring network can differ, and they should be proved on a base of actual measurements in the area of initial pollution. The systematic control is required for all types of pollutants with concentration that exceeds environmental standards.

Requirements for an observation network

The observations of the environmental conditions are carried out through the observation network designed on the basis of a preliminary study of initial background pollutions, the nomenclature of pollutants and evaluation parameters.

The observation network is intended to provide the possibility for an all-round evaluation of all environmental components. The observation network project, comprising deployment of sampling and express-analysis stations, the list of controlled ingredients and observation intervals, is the subject for coordination with specially accredited environment protection and resources exploitation supervising organizations of the Khanty-Mansiysk Autonomous Okrug. The latter are responsible for termination of the observation process, change of the station location, change of the list of parameters and ingredients to be measured and so on. An unauthorized change of the location of sampling spots, observation intervals and controlled parameters is strongly prohibited. Sampling should be carried out according to the State Standards for atmospheric air and soils, surface water and underwater. The copies of the certificates are produced by "Specialized Inspection for Analytical Control of Khanty-Mansiysk Autonomous Okrug".

Requirements for soil monitoring

System of ecological observations of soil condition should be designed on the basis of landscape-geophysical differentiation of the territory taking into account the geochemical barriers and the most probable ways of the ground (under-soil) migration of pollutants.

Every year soil sampling is carried out on the previously chosen spots or profiles of the territory and the distribution of the principal pollutants is calculated. The observations should be done on unpolluted territories as well, for the estimation of the background

conditions. Together with chemical analysis, the control of hazardous land pollution sources is recommended to carry out through biological tests. Biological objects for testing are chosen on a base of natural and climatic conditions of the region.

Within ecological monitoring, an exploiter is forced to carry out, at least once in three years, remote sensing of the whole licensed area (air survey or spectrozonal high resolution snapshot from space) for evaluation of the spatially differentiated technological impacts on environment under intensive industrial exploration, in other cases – once in five years.

In the case of oil spills on regional or territorial scale the exploiters must immediately carry out an air survey or a snapshot from space of the adjacent territory. The exploiter of the territory should submit the report with the results of ecological monitoring to the corresponding authority. Information on pollutants and emissions (their volumes, location, and time) is immediately reported to the special accredited environment protection and resources exploitation supervising organizations.

The information obligatory to be reported by the land users on results of ecological monitoring:

1. For soils conditions – once a year;
2. For surface water and underwater – once a quarter;
3. For air – once a quarter (snow sampling – once a year);

The basic results of ecological monitoring are being produced for oil, gas and other mineral resources of the license areas on a base of data of contractor; accredited laboratories carry out air, water, sediments and soils samples analysis. All sampling sites should be shown on the maps attached to the report; for all sampling sites there should be geographical (or plane) coordinates.

4. The area map drawn at the 1:50 000 scale with observation points.
5. Table of observation points (sampling places) position data (in geographical values of 1942).

Space monitoring of soil degradation

Monitoring of soil with remote sensing techniques was developed by some organizations both governmental, scientific and commercial. The problem is that remote sensing data could not be used widely, because there are no techniques for data interpretation, authorized by the normative acts. There are some organizations that have been working successfully in the field of soil monitoring. A large amount of work have been done by Moscow State University, Institute of Edaphology and Agricultural Chemistry of Siberian branch of Russian Academy of Sciences (Novosibirsk), Institute of Land Monitoring of Federal Land Cadastre Service of Russia (Voronezh) and some non-governmental organizations.

Abschnitt 0.2 I.4.2 Oil pollution monitoring

The framework of oil pollution monitoring is presented in [1].

In 2000 the laboratory research has been done in KMAO with regard to biological activity of soils. The results of this research program allow establishing the precise correlation between the growth of contamination of soil and the petroleum concentration and how this concentration modifies the microbiological parameters. It was detected that in a range of petroleum concentration from 50 up to 300 ml/kgs the sharp modifications in microbiological system of soil take place.

The analysis of obtained outcomes allows to make the following conclusions:

- Floods of petroleum, burning of gas, the wood fires suppress biological activity and promote manifestation of toxicosis of soils.
- In the greater degree the biological activity of soils is suppressed by influence of floods of petroleum and wood fires. A little bit less the plume affects the soil parameters. It is connected, probably, to small factions of petroleum acting in aerosols.

- Due to the effect of the described factors the biological performance (mainly in upper horizons of soils) is worse, especially because of the effect of plumes and wood fires.

The research of the petroleum spills influence on soil contamination has shown that the majority of sectional platforms have high concentration of heavy liquid oil fraction. The traces of floods of petroleum at nearby territory had been observed. The big squares of contamination of ground happened to be from malfunctions and incidents on international oil pipelines.

The main results were achieved in the investigations of correlation between negative factors (pollutants) and real pollutions. Oil pollution monitoring should be based on steady flow of information.

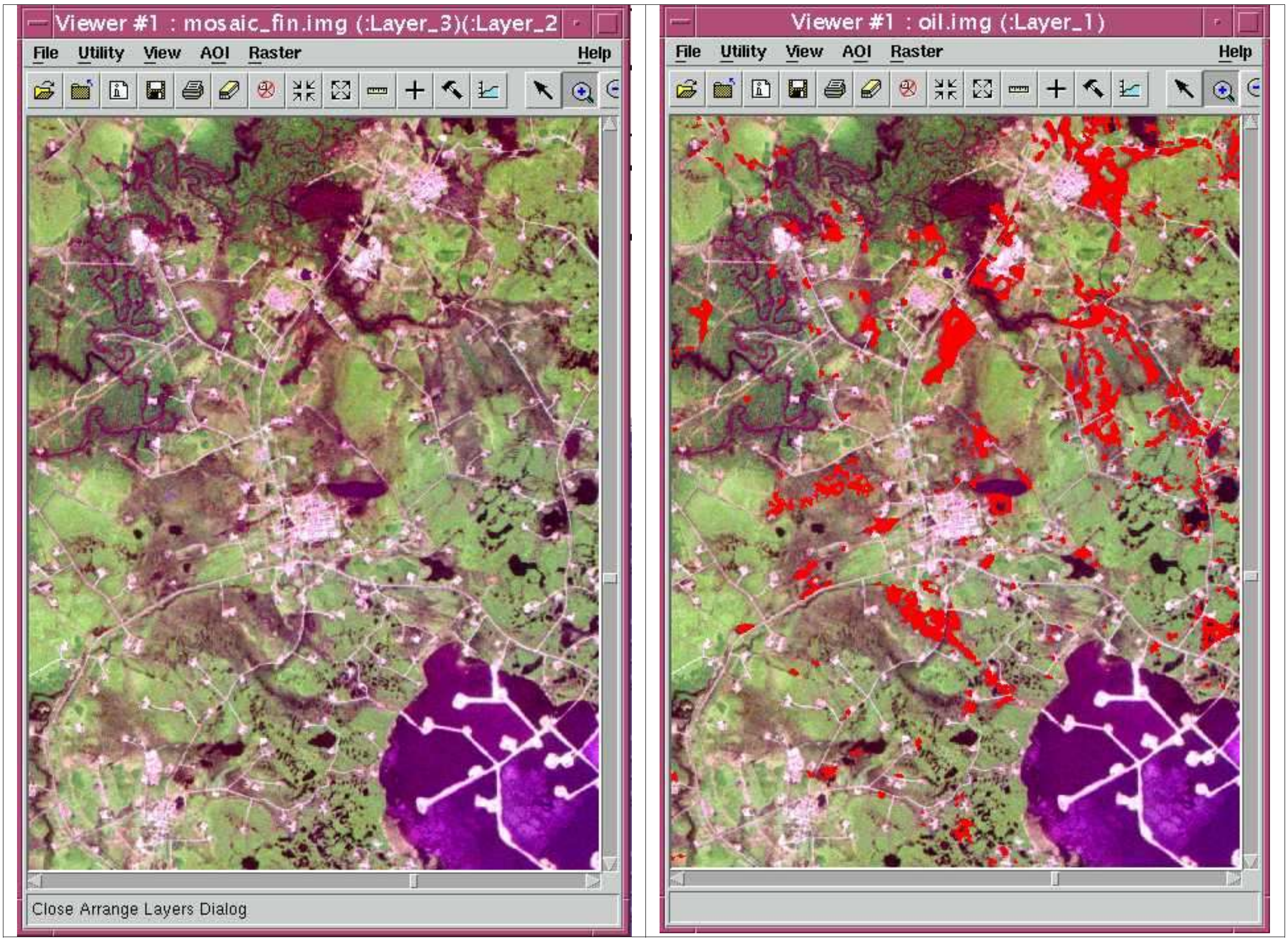
The only regular information sources are reports from oil extractive companies.

These reports include:

- the date and time of accident;
- the volume of outflow of oil;
- the square of territory damaged.

During the next years the extractive company should give reports about soil and vegetation restoring. The real picture of oil pollution can be only done with the use of remote sensing monitoring. Global remote sensing monitoring of oil pollution is necessary in the development of methodological recommendations and data processing on a base of GIS technologies. The research on oil pollution detection is being done in Governmental Enterprise NPC “Monitoring”. Ugra Research Institute on Information Technologies (URIIT) is involved in this sort of activities as well.

Fig.1.6 presents the example of oil pollution detection experiment. All experiments have been done using ERDAS IMAGINE 8.5 software. After multi-step processing, the territories with oil pollution were detected (**Fig 1.6.b**) .



a) the LANDSAT image of territory near Samotlor lake b) the result of image decoding.

Abschnitt 0.3 Fig.1.6 Results on oil pollution detection with the use of remote sensing imagery

Abschnitt 0.4 I.4.3 Atmosphere pollution through gas fire

Every year about 20 billions m3 of way petroleum gas is produced and more then 3, 5 billions were burned in gas plumes in **KMAO**.

The reasons of contamination of an atmospheric air – errors in design solutions and absence of funding of the programs connected with the reduction of ejections in atmosphere of polluting substances.

The negative effect of plumes on an environment is caused by consumption of a huge amount of oxygen, heat radiation, and contamination of atmosphere, vegetation and soils by products of partial combustion of hydrocarbon, carbon oxide and nitrogen and other harmful substances.

The plumes are intended for burning a gaseous mixture, however periodically the liquid factions of petroleum appear in plumes, resulting in an apart from all other to fall-out of heavy liquid oil fraction . The formation of an oxide of carbon is an intermediate stage of burning of gaseous fuel. Therefore defect of oxygen and the supercoolings of a zone of burning cause growth of CO concentration in products of combustion. The oxides of nitrogen in products of combustion of gaseous fuel have mainly thermal origin. If there are enough high temperatures (more than 1800 C) it should be the oxidation of nitrogen of an air up to a monooxide of nitrogen (~ 97-98 % volumetric NO). Then in atmosphere is oxidized up to NO_2, and their total concentration is recalculated on oxides of nitrogen frequently represented by a numeral NOx.

A source of thermal oxides of nitrogen is the high-temperature zones of a gas plume. Other component in volume of ejections of oxides of nitrogen is so-called «fast» oxides, which source is the active zone of fuel and oxidizer (described by high concentration of active radicals) due to the lack of the latter. The temperature level of process of formation of «fast» oxides of nitrogen (~ 1 200 C) is much lower, than thermal. Therefore it is impossible to avoid their formation.
The limits of extreme admissible ejections are placed for the extractive enterprises. It is the basis for payments. It is impossible to check up an actual condition by means of ground measurements.
The technique for calculation of the degree of contamination of atmosphere on a base of remote sensing data was developed in **URIIT**.

Data types for environmental stress monitoring

This data varies with respect to time character, timeliness requirements, form of submissions, level of privacy and source of reception. In this way the data could be divided into:
on a time character: -planned; not planned.
on timeliness requirements: current; operative; results
by the form of submissions: tables; raster; vectors; maps; reports.
on a level of privacy: open; confidential;classified.
on a source of reception: Federal level;Region level;Local level;level of particular Organization.

At the moment the uniform structure of a system of monitoring does not exist. The various transfer protocols of information and different data formats are used. The initial data depends on the object of measurement and the types of characteristics that have to be measured. The data obtained by means of ground measurements include physical, chemical, biological probes, tables and texts and the results of compararison of methods of investigations. The data obtained by means of air-space remote sensing may be accumulated in vector and raster formats, depending on software available.

Software for processing remote sensing data

The software for processing the remote sensing data allows making the preliminary and thematic data processing, development of applied modules, as well as the interactive work of users. The software packages ERDAS IMAGINE Pro 8.5 for SUN и ENVI (UNIX) are used for automation of the process of RS data processing, cataloging and storage. ENVI allows to process data in multiprocessor regime that speeds up the work. The ENVI IDL language and Imagine Developers Toolkit are being used for the development of software modules.
The license software ENVI, ERDAS IMAGINE Pro 8.5, ErMapper 6.2 is being used at the moment in URIIT and other organisaitons.

GIS software

Geoinformation systems and special-purpose applied packages are widely used in RUSSIA.
In **URIIT** the basic software is the full set of ArcGIS products by ESRI. This set of products includes the floating licenses of ArcMap, ArcCatalog, ArcTools, ArcEditor, as well as the fixed licenses of ArcMap, ArcCatalog, ArcTools. Additional modules are:

- 3D Analyst,
- Spatial Analist,
- Geostatistical Analyst,
- fully-functional GIS ArcInfoWorkStation for Windows and Solaris,
- programs for client-server and internet-solutions ArcSDE and ArcIMS.

I.4.4 On-going Projects on Environmental Stress Monitoring

An ENVISAT-AO Project (ID 635) *“Environmental pollution monitoring over the oil and gas exploitation regions (northern parts of Russia) using ENVISAT data”* has started in October 2002 and will be finished until December 2004. Along with NIERSC and URIIT teams, the following research institutes and organizations are involved in the project:

- Nansen Environmental and Remote Sensing Center (NERSC, Bergen, Norway);
- Scientific-Research Centre of Space Hydrometeorology "PLANETA" (Moscow, Russia);
- Centre for Space Monitoring of Siberia (CSMS, Novosibirsk, Russia);
- Institute of Terrestrial Magnetism, Ionosphere and Radio Wave Propagation (IZMIRAN) of Russian Academy of Sciences (Troitsk, Russia);
- and Yamal-Nenetz State Committee of Environmental Protection (YNSCEP, Salekhard, Russia).

The overall objective of the project is to demonstrate ENVISAT data applications for operational monitoring of the state of environment and its contamination in the regions of oil and gas exploration in Northern Russia (Hanty-Mansi and Yamal-Nenets Autonomous Districts).

The Northern Russian territories undergo now the peak of business activity due to exploration of oil and gas deposits by Russian and foreign companies. This region is characterized by extreme climatic conditions and under-developed infrastructure, as well as by very long time of nature's self-cleaning. Soil and water bodies contamination, degradation of vegetation cover, changes in soil chemical composition and permafrost structure, thermocarst and thermo erosion, changes in ground water level and hydrological regime, grave or irreversible changes in natural ecosystems **are consequences of anthropogenic industrial stress in these regions**. Today there is a need to fully assess the state of environment in the existing regions and to develop methodology for environmental protection.

Extensive coverage area and hard accessibility of the territory under study stipulate the use of remote sensing techniques as one of the main instruments for environmental monitoring for Northern Russia. Among potential users of such kind of information will be oil and gas companies, local and regional authorities, environmental protection agencies as well as many others. New approaches for study and monitoring of environmental conditions in the named regions are under development in the framework of ongoing project. Simultaneously the development of methods for synergistic use of

- data from various ENVISAT sensors (ASAR, MERIS, AATSR),
- sensors from other satellites
- field observations for environmental monitoring

is being done as well. The collection of in situ and remote sensing data will be done through exploitation of existing archives and databases, as well as by field surveys. New algorithms and methods of synergistic use of various ENVISAT and other satellites sensors having different spectral, temporal and spatial resolution will be elaborated. The remotely sensed parameters will be validated by field surveys data. All this will result in demonstration of benefits of use of ENVISAT data for environmental monitoring. The market analysis of potential users for such data and the development of strategy of operational monitoring of environmental pollution will be also done .

In the course of the project implementation historical in-situ data on natural parameters and data on industrial infrastructure for several regions of existing and planned oil and gas deposits exploration will be collected. All the information collected will provide the base for the analysis of current state of the environment for chosen regions. Seasonal and year-to-year variability of natural parameters will be taken into account. Special attention will be paid to the assessment and ranging of contamination risks under normal and accidental operating conditions. Such goal will be achieved through complex analysis of

- land cover and land use type,
- regional topography,
- pathways of pollution transport,
- ranging the territory from the viewpoint of promoting/hindering pollution transport,
- potential risk of accidents on the existing industrial oil and gas infrastructure.

Qualitative and quantitative changes in vegetation cover and forest landscapes, deforestation, changes in forest composition, biomass production variability are factors that will allow to estimate anthropogenic impact on surrounding nature.
The results of study such as :

- influence of oil and gas exploration on the environmental conditions
- assessment of pollution risks and transport pathways

will provide base for development of environmental and pollution monitoring strategy. Operational monitoring of petroleum release into the environment can be successfully made using high-resolution ASAR imagery. Regular mapping of “hot spots” areas and discrimination of radiometric changes within serial images will give information on potential release of hydrocarbons,that will be validated by utilization of additional information from other remote sensing and in situ data. If the identification of leak of contaminants or release will be approved, this information should be transferred to local and regional authorities. Project will demonstrate possibilities of ENVISAT data for pollution risk management assessment in such areas as:

- contaminant release identification;
- prediction of pollution transport and spreading;
- assessment of potential environmental impact and damage assessment;
- development of monitoring strategy and mitigation scenarios;
- study of changes in environmental conditions and self-cleaning processes after contaminants release;

The RFBR (Russian Foundation for Basic Research) Project no. 03-05-96831 “*Development of methodology of ENVISAT satellite data processing for monitoring of Northern Regions of Russia”* has started in 2003 and will be finished by the end of 2004. Along with NIERSC and URIIT teams, the following research institutes are involved in the project:

- IZMIRAN and Ugra State University (USU, Knanty-Mansijsk, Russia).

The project objectives are in many respects similar to those mentioned above but special emphasis will be done on satellite monitoring of environmental pollution by metallic trash. ASAR images with different polarizations will be used for the purpose of development of methodology of operational environmental monitoring.

I.5 Forest Monitoring in Russia

The Russian Federation possesses vast forested areas, containing about 23% of the world’s closed forest. The Forest Fund, which consists of both forested and non-forested land, takes up about 12 million. km^2.

I.5.1 Overview of the Forestry in Russia

Organizational structure of forest management

The history of forest management in Russia stretches for more than 200 year. According to the current legislation, the state forest administration includes forest use, monitoring and control activities, as well as protection and reforestation throughout the country. Management and administration functions are carried out by the President of the Russian Federation, the Government of the Russian Federation, executive bodies of the subjects of the Russian Federation, and specially authorized state forest administration bodies.
Specially authorized state forest administration bodies are represented by the Ministry of Natural Resources (MPR Russia) and the Federal Forest Service (FFS). The following departments constitute the FFS:

- Department of Forest Use;
- Department of the Forest Fund;

- Department of Control, Protection and Reforestation of the Forest Fund;
- Regional Forest Management Bodies in the subjects of the Russian Federation as well as Forest Management Units (leskhozes);

Also, the MPR Russia consists of:

- State Forest Planning and Inventory Enterprises (that were reorganized in the year 2002 and are currently titled "Forest Inventory and Planning Institutes");
- Airborne Forest Protection Service **("Avialesokhrana");**
- Science and Research ("Department of Research and Interaction with the Scientific Community");
- Education Institutes

Property rights on Forestry Fund

According to the Forest Code of the Russian Federation (1997). Forest Fund lands, including all forest, located on the defence lands, are under Federal jurisdiction. The federal law allows property rights transfer in favour of the subjects of the Russian Federation. Both the civil legislation and the Forest code guarantee the free access to the forest. There are Forest Fund allotments, which are available for lease by citizens and juridical persons. In addition to this, there is shot-term use; concession use and use of forest lands free of charge, which are all widely practiced. The Forest Fund and other lands constitute almost 69% of the total land area of the Russian Federation. MNR Russia controls and governs 95.83% of the Forest Fund area is governed and controlled by MNR Russia while other ministries and agencies manage the rest of the forest.

I.5.2 Forest resources assessment

The structure of forest resource assessment includes:

- State Forest Fund Account
- State forestry Cadastre;
- Forest Management and Planning;
- Forest pathology and other inspections;
- Inventory of current changes in the Forest Fund;
- Forest monitoring;

State Forest Fund Account (SFFA)

The primary responsibilities of the State Forest Fund Account (SFFA) are to ensure that there is:

- sustainable forest management;
- forest guard and protection;
- forest reproduction;
- systematic quality and quantity control;

Also, SFFA is required to provide federal and regional authorities, juridical persons, and other concerned parties the reasonable data and reliable information.

Up to the year 1999, the SFFA was carried out every five years. It was crucial to get region based summarized forestry characteristics and to present them by the start of each five-year plan. Presently, taking into account the dynamic character of civil society development and, also, the demand for actual and updated information, the State Forest Fund Account is conducted **annually.**

SFFA data is used for keeping the State forest cadastre.

Forest cadastre

The State Forest cadastre data is used for:

- state forest management;
- the practical implementation of forest management plans;
- the conversion of forest lands into non-forest lands to be used for purposes that not related to forest management and Forest Fund use;
- Forest Fund lands withdrawal;
- the establishment of timber prices and other forest payments;

- assessment of the forest user's economic activity

Forest inventory and Planning

An account of the forest in Russia is based on a periodic Forest Fund inventory conducted in accordance with forest inventory and planning procedures. Each territory must be inventoried every 10-15 years. The actual area of annual forest inventory and planning is about 30 mln.ha, which covers 3% of the Forest Fund area at the most. Thus, both the area and the quantity of sites that exceed the inspection period required by the guidelines are accumulating (Fig.6).

Forest inventory and planning has been carried on 61.4 % of the Forest Fund area. About 32.6% of the forest area has been thoroughly studied, while 6% of the area was inventoried by using simplified methods, such as aerial-visual inspection and remote sensing. Information about the scope and level of forest inventory and planning throughout Russia is presented in the Figure VIII.

At present, basic forest account information is gained from forest inventory and planning. Reliability of the data presented by administrative regions, regions of the Russian Federation and by the federal district is strongly dependent on the volume and quality of the forest account. Forest inventory and planning is comprised of a system of measures providing for sustainable Forest Fund use, higher efficiency in management, and common and unified policies in science, technology and research.

Forest inventory and planning throughout all the territories of the Forest Fund in Russia is conducted by state forest inventory and planning institutions that follow common and unified rules and approaches, which are established by the federal forest management body. The following parameters are taken into account by inventory and planning operations:

- species composition;
- age distribution;
- the health and condition of the forest;
- other quality and quantity indices;

In the year 2001, 108 forest management units located in 31 subjects of the Russian Federation were involved with the inventory and covered a total area of 28.3 mil. ha, while aerial photography covered an area of 16.8 mil. ha.

Inventory of Preserved Forest

Inventory of the preserved forest in Siberia and the Far East is conducted using aerial-visual inspection and remote sensing methods and covers the areas where there is no scheduled exploitation for the coming 15 – 20 years. These forests are mainly used for local needs in contrast with forest inventory and planning, the preserved forest inventory does not conduct forest management and state planning. All the boundaries are marked and determined by natural borders such as watersheds and rivers. In the year 2001, the preserved forest inventory covered an area of 5.1. mill.ha.

Forest pathology inspection

Forest pathology inspection is carried out to detect pests, diseases and other pathological damage and aims to assess the health and conduction of the Forest Fund. Forest pathology experts, working for the forest protection divisions of the MNR, implement the above-mentioned inspections. The inventory is conducted in:

- the areas which are under the mass outbreaks of pests and diseases;
- the sites damaged by windfalls, fires and other natural calamities;
- forest suffering from industrial pollution;

Efficient and flexible monitoring and control is annually performed over an area 7-9 mill. ha. In addition, forest pathology expeditions conduct surveys in the areas where there are complex and unfavourable pathology conditions (almost 8 Mio. ha). These expeditions are conducted in order to verify the size of outbreaks and look deeper into the influencing factors, as well as to define the forest protection measures, which are necessary to be implemented.

Inventory of current changes in the Forest Fund

An inventory of current changes in the Forest Fund is a permanent duty of the forest management until staff. The idea id to monitor the occurring changes resulting from both forestry measures and natural calamities and to reflect them in the reporting documentation. Documentation of the inventory of current changes consists of the basic statistic reported by the forest management units. It is annually submitted to the regional divisions of the MNR. The data can be obtained by using ground methods (regular surveys, sampling plots) or remote sensing.

For an inventory of the current changes in the presented forest, space and aerial photography of different scales is utilized.

Remote sensing interpretation is used in the forest management and planning procedures to reflect the spotted changes and trends.

Documentation of the current changes in the Forest Fund is widely used in monitoring and controlling the Forest Fund and is extensively employed in forest management and planning

I.5.3 Forest monitoring

Forest monitoring is a system to observe, assess, and forecast the Forest Fund dynamics and its condition for the purpose of the state forest management, guard and protection, which is aimed at the increase of the forest's ecological value.

In accordance to various goals and structural divisions, monitoring consists of different methods:

- forest resource monitoring;
- Forest Fund lands monitoring;
- forest fire monitoring;
- purpose-oriented, specific monitoring (including monitoring of the forest, subjected to industrial emissions and radioactive pollution);
- monitoring of remote and insufficient investigated forest (by means remote sensing);
- forest monitoring conducted within a framework of international agreements and conventions.

Taken as a whole, the structure of forest monitoring is reliable enough and meets the requirements, but its technical provision is quite low.

We shall not examine here the ground-based data that carry information on what has been said above. We can say with reasonable confidence that most ground-based information available to date does not correspond to the actual situation in RF forests. The source of new, unbiased information can be provided by satellite data of both high and low spatial resolution. It is necessary and, most importantly, possible modernize the system for monitoring and inventory of forests in the RF, based on existing information obtained through ground-based and aerovisual interpretation. In next paragraphs we will overview briefly the actual state-of-the-art in applied satellite remote sensing.

I.5.4 Satellite Remote Sensing for Forestry Monitoring

The difficult economic situation that emerged in Russia in the early 1990s has led to the fact that today only two orbiting Russian satellites are in operation: "Meteor-3M" (meteorological and natural-resource exploring spacecraft) and "Arkon" (dual-purpose spacecraft). The orbiting cluster of small spacecraft will" cover" the Earth in real time Anatoly Kiselev]. Furthermore, this information is virtually unused in forestry. One way out would be to make operational the "Monitor" program that was developed by specialists of the SM.V.Khrunichev Scientific and Production centre. This program provides the creation of an orbiting cluster of small spacecraft (four optico-electronic, and two radio locating) to acquire natural-resources information in real time. It is planned to incorporate in the "Monitor" system small regional sites for reception of information that would ensure direct reception of remotely sensed data on the Earth directly by customers using relatively small receiving stations [V. V. Lebedev, Problems of Creating Geoinformation Complexe, in Russian].

Companies of the USA, Canada, EU, and Japan have the leading role in the development of natural resources exploring satellites today.

With the advent and evolution of small regional sites for reception of satellite information in Russia, there emerged a tendency for the subjects of the RF to be independent as regards the acquisition and processing of satellite data. These sites are mostly equipped with receiving stations developed at the "Scanex" ITC; they also use existing stations located in the Regional Centres for Receiving and Processing Satellite Data in Moscow, Obninsk, Novosibirsk) and Khabarovsk. Today there exist about 30 operational sites in Russia for receiving and processing of satellite data. The bulk of operations correspond to reception of data from four satellite systems: METEOR 3M, NOAA, EOS, and IRS. In this case the data from NOAA and EOS are disseminated gratis. Data from the aforementioned satellites are received in real time.

Another method of acquiring real-time information is by making an order for a picture from the operational archive of organizations that disseminate remote sensing data. The RF-largest supplier of Russian and foreign remote sensing data is «SOVINFORMSPUTNIK Thus, on 4 June 2003, «SOVINFORNSPUTNIK» and the company «Space Imaging Eurasia» signed a memorandum about the dissemination, on the territory of the Russian Federation, of remotely sensed data on the Earth acquired by the ICONOS spacecraft. On the other hand, the company «DigitalGlobe» granted «SOVINFORNSPUTNIK» the rights for the dissemination of remotely sensed data space images in the Russian market. In addition to «SOVINFORMSPUTNIK», we must mention a young Russian commercial organization, «SOVZOND»

All archival and real-time satellite data of high spatial resolution (over 30 meters) are disseminated on a commercial basis. Below we give the list of the main satellite systems that are used in forestry of the RF and in a number of foreign countries.

Current satellite systems for forestry monitoring

NOAA AVHRR

With ~20 years of data record, the Advanced Very High Resolution Radiometer offers a unique opportunity for retrospective processing of 1-km data into time series of active fires and burned areas. AVHRR continues to provide useful information on board the current POES series. However, its instrument characteristics are inferior to the recent experimental and semi-operational systems. On the future NPOESS series AVHRR will be replaced by VIIRS.

EOS AM/PM (Terra/Aqua) MODIS

The Moderate Resolution Imaging Spectroradiometer is currently providing global, medium-resolution near-real time measurements useful for fire mapping. The improved geolocation accuracy and more suitable radiometric characteristics allow the production of higher accuracy active fire and burned area products.

DMSP OLS

Night-time visible data from the Operational Linescan System on board the Defence Meteorological Satellite Program can be used for global fire mapping at medium resolution.

TRMM VIRS

The Tropical Rainfall Measuring Mission Visible and Infrared Scanner provide medium resolution VIS, NIR, SWIR and IR measurements from a low inclination orbit. It can be used for the sampling of the burning activity in the tropical and sub-tropical regions at various local times.

ERS ATSR and ENVISAT AATSR

The Along Track Scanning Radiometer on board the ERS-1 and -2 satellites, and the Advanced ATSR on board ENVISAT are dual-view medium resolution sensors, which provide VIS, NIR and SWIR measurements for burnt area mapping and active fire detection.

ENVISAT MERIS

The Medium Resolution Imaging Spectrometer has 15 programmable channels to measure the reflected solar radiation in the VIS and NIR spectral region at 300 m resolution. Potential applications include burned area mapping.

SPOT VGT

The VEGETATION instrument provides medium-resolution, global VIS and NIR, high-quality measurements that are useful for burned area mapping.

LANDSAT TM, ETM+

The Thematic Mapper, which was replaced by the Enhanced Thematic Mapper Plus, provide high resolution imagery for burned area mapping and for the validation of medium-resolution burned area products.

EOS AM (Terra) ASTER

The Advanced Spaceborne Thermal Emission and Reflection Radiometer provides high resolution VIS, NIR and SWIR data coincident with MODIS observations near the centre of the swath. ASTER is a valuable tool for the validation of MODIS active fire products and burned area maps from various satellite systems.

BIRD satellite

The Bi-spectral Infrared Detection is a small satellite that provides VIS, NIR and SWIR data for burned area mapping and active fire detection at 185 m and 370 m respectively.

OrbView -2 , OrbView-3

The VHR satellite that provide 1 and 2 meter panchromatic resolution images and 4 meter multispectral resolution images on real-time basis worldwide.

Some of the uses for ORBIMAGE imagery include pipeline routing, new construction planning, farming, forestry, and travel planning, to name a few. Imagery adds an additional data layer for today's GIS systems to help organizations manage facilities and resources, make better decisions and save money. Applications for our imagery products detailed here include National Security, Commercial and Environmental. Also the OrbView-2 satellite carries the SeaWiFS sensor which provides 1km resolution data in 8 spectral bands.

IKONOS

The satellite equipped with very high resolution (VHR) optical sensor. It have both cross-track and along-track viewing instruments which will enable flexible data acquisition and frequent revisiting capability: 3 day at 1 meter resolution (for look angles < 260) and 1.5 days at 1.5 meter resolution. The near real-time programming capability will make possible to program acquisitions while taken the current weather conditions into account. The nominal width at nadir is 11 km.

QuickBird

The QuickBird satellite is intended for producing digital images of Earth cover at 0.64 meter in panchromatic resolution and 2.5 meter multispectral resolution images. The nominal width at nadir is 16.5 km. (scene size is 16,5 x 16,5 км) and very high metric accuracy.

Coming in the nearest future satellite systems for forestry monitoring

NPP/NPOESS VIIRS

The Visible/Infrared Imager Radiometer Suite will be first flown aboard the NPOESS Preparatory Project (NPP) and then on board the National Polar-orbiting Operational Satellite System (NPOESS). It will provide similar measurements to MODIS at higher resolution.

ADEOS-II GLI

The Global Imager on board the Advanced Earth Observation Satellite has 36 bands in the VIS, NIR, SWIR, MIR and TIR spectral regions which are useful for burned area mapping and active fire detection.

In Table 1.2 below we collected the mentioned above satellites and their capabilities.

Satellite	Bands (mkm)	Resolution (meter)	Width (Km)	Time resolution (Day)	Assess

NOAA/AVHRR	0.58 -0.68 0.725- 1.1 1.58 -1.65 3.55 -3.93 10.5 -11.5 11.5 -12.5	1100 m	2048	4-6 times/day	Free
EOSAM/PM (Terra/Aqua) / MODIS	Chanells 1,2 0.62 – 0.876 Chanells 3-7 0.45 – 2.155 Chanells 8-36 0.405 – 14.3 мкм.	250 500 1000	2048	2-4 times/day	Free
LANDSAT/ TM, ETM+	0,52-0,90 PAN 0,45-0,52; 0,52-0,61; 0,63-0,69; 0,75-0,90; 1,55-1,75; 2,09-2,35; 10,4-12,5	30 m VIS 60 m IR	183x172	16 days	Commerce
SPOT 5	0,50-0,59; 0,61-0,68; 0,78-0,89; 1,58-1,758	PAN - 5 m MS – 10 m Super PAN – 2.5 m	60	26 days	Commerce
SPOT 4	0,50-0,59; 0,61-0,68; 0,78-0,89; 1,58-1,758	PAN - 10 m MS - 20 m	60	26 days	Commerce
EOS AM (Terra) / ASTER	0,56; 0,66; 0,81 1,65; 2,17; 2,21; 2,26; 2,33; 2,40 8,30; 8,65; 9,10; 10,6; 11,3	15 m 30 m 90 m	60	16 days	Commerce/free
BIRD					
IRS-1D	0,50-0,75 PAN 0,52-0,59; 0,62-0,68; 0,77-0,86 1,55-1,75	6 m 24 m 71 m	70 142 810	24 days	
OrbView -2 , OrbView-3	0,40-0,42; 0,43-0,45; 0,48-0,50; 0,50-0,52; 0,55-0,57; 0,66-0,68; 0,75-0,79	PAN – 1m MS – 4 m			Commerce

IKONOS	0,45-090 PAN 0,45-052; 052-0,61; 0,64-0,72 0,77-0,88	1 m 4	11 km	2.9 days for getting ithe images with spatial resolution 1 m; and 1.5 days for 1.5 m resolution	Commerce
QuickBird	0,45-0,90 PAN 0,45-0,52; 0,52-0,59; 0,63-0,69; 0,76-0,89	0,5-1,25 2,5-3,3	16.5 km	1 – 3,5 days	Commerce

Table 1.2 The Capabilities of remote sensing based systems for forest monitoring

I.5.5 Demands and requirements to remote sensing data for forest monitoring

The classification of Users

We use some of the results and recommendations about users requirements for remote sensing information from [6].

Major users of remote sensing data for forestry analysis in Russia could be classified as follows:

- Local level (scales from 1:1000 to 1:50000): managers and professionals of forest enterprises, Nature Protection Committees of the administrative districts, etc.
- Regional level (scales 1:50000 to 1:1000000): regional bodies of Federal Forest Service, regional forest inventory and planning enterprises, regional offices of “Avialesookhrana”, regional Nature Protection Committees, regional governments, and NGOs.
- Federal level (scales 1:1000000 to 10000000): Federal Forest Service of Russia, other federal ministries, “Avialesokhrana”, Universities, and NGOs;
- Continental and global level (all Russia territory, scales above 1:2500000 to 1:5000000, but local to regional scale requirements could arise at the individual project level):international organizations and long-term scientific programs (such as IGBP, GOFC etc.,), global and continental environment studies, different companies, national and international financial institutions (e.g. in the framework of the post-Kyoto negotiation process), etc.

Organizations developing remote sensing methods for forestry monitoring

List of organizations developing and applying Remote Sensing Methods for forest monitoring is given in **Tabl.1.3**

Organization	
1	Centre on Problems of Ecology and Productivity of Forest RAS, Moscow
2	V. N. Sukachev Forest Institute, SB RAS, Krasnoyarsk
3	V. N. Sukachev Forest Institute Western Siberian Department, RAS Novosibirsk
4	Geographic Institute SB RAS, Irkutsk
5	Remote sensing centre, Institute of solar – terrestrial physics SB RAS, Irkutsk
6	Laboratory of remote sensing supply, Space Research Institute, RAS Moscow
7	Radiotechnic and Electronic Institute RAS, Moscow
8	Geographic Institute RAS, Moscow
9	Nansen International Environmental and Remote Sensing Center("Nansen-Center", St. Peterburg)
10	M. V. Lomonosov Moscow State University (MSU) geographic Department. Laboratory of Aerospace Methods, Moscow
11	Institute of Space Analysis of Forest attached to Moscow
12	St. Petersburg Scientific-research Institute of Forestry, St. Petersburg
13	All Russian Scientific-research and Information Centre for Forest Resource (VNIICLesresurs), Moscow
14	All –Russian Scientific-research Institute of Fire-Prevention Protection of Forest and Mechanization of Forestry (VNIIPMLeshoz), Krasnoyarsk

Tabl.1.3 List of organizations developing and applying Remote Sensing Methods for forest monitoring

I.5.6 Domestic and international projects and programs for forest monitoring

GOFC/GOLD

Several international programs have been established towards the goal of gaining complete information on fire activity around the world using satellite sensors. These include the International Geosphere Biosphere Program, Data and Information System's (IGBP-DIS) Global Fire Product initiative (Justice and Malingreau, 1993, 1996), the World Fire Web, the ASTR World Fire Atlas (Arino and Rosaz, 1999), the MODIS Fire Product (Kaufman et al., 1998a), and many other national and regional fire programs as summarized in Gregoire et al. (2000). These activities are among those endorsed by the Global Observation of Forest Cover program (Ahern et al. 1998).

The overall objective of GOFC is to improve our understanding of the impact of forest dynamics and forest fires on the global carbon budget. Since forest fires affect forest dynamics and the carbon budget, monitoring and mapping forest fire is a major component of GOFC. GOFC has two requirements 1) near-real-time detection and monitoring of fires during the fire season and 2) post-fire season mapping of the burnt areas. These requirements respond to the needs of three fire user groups: the global change research community, policy and decision-makers, and fire managers (Ahern 2000). Specific needs for fire information are diverse among these groups. For active fire detection, the main difference in request of fire information lies in the promptness of information delivery, with fire managers and climate research community being the most and least demanding user groups, respectively.

GOFC/GOLD (Global Observations of Forest and Land Cover Dynamics) is a project of the Global Terrestrial Observing System (GTOS) program, which is sponsored by the Integrated Global Observing Strategy (IGOS). The main goal of GOFC/GOLD is to provide a forum for international information exchange, observation and data coordination, and a framework for establishing the necessary long-term monitoring systems.

The GOFC/GOLD-Fire Mapping and Monitoring Theme is aimed at refining and articulating the international observation requirements and making the best possible use of fire products from the existing and future satellite observing systems, for fire management, policy decision-making and global change research.

GOFC/GOLD is promoting self-organized regional networks of data users, data brokers and providers, where closer linkages and collaborations are established with emphasis on an improved understanding of user requirements and product quality. GOFC/GOLD-Fire is pursuing, in a joint effort with the Committee on Earth Observing Satellites (CEOS) Working Group on Calibration and Validation (WGCV) Land Product Validation (LPV) subgroup, the coordinated validation of fire products by standardized protocols.

GOFC/GOLD-Fire is partnering with the Global Fire Monitoring Centre (GFMC), and the United Nations International Strategy for Disaster Reduction (ISDR) Working Group 4 on Wildland Fire

The speed of obtaining and disseminating fire information is dictated, to a large extent, by the fire monitoring systems that are reviewed in a separate paper in this book (Gregoire et al. 2000). The accuracy of fire information is a common concern for all user groups that is determined primarily by fire detection algorithms, which are the subject of this paper. The accuracy is measured in terms of levels of both commission and omission errors and the location of fires detected that should be well defined and documented.

Remote sensing of fires has been achieved using a variety of space-borne systems/sensors. The most widely used sensor for long-term and large-scale fire monitoring is the Advanced Very High Resolution Radiometer (AVHRR) aboard the National Oceanic and Atmospheric Administration's (NOAA) polar orbiting satellites [Flannigan and Vonder Haar 1986; Kaufman et al., 1990a; Arino and Mellinotte 1998; Justice et al. 1996; Li et al. 1997]. Measurements from many other sensors have also been employed such as GOES [Menzel et al., 1991; Prins and Menzel, 1994], LANDSAT [Chuvieco and Congalton, 1988], DMSP [Cahoon et al., 1992], ATSR (Arino and Rosaz, 1999), and in the recently launched MODIS (Kaufman et al., 1998a).

Developing of real-time monitoring systems of forest fire detection and forecast

The satellite remote sensing of fire began in the late 1970s (Croft, 1978; Matson et al., 1987). Since this time the global importance of fire has become internationally recognized. Fire has also escalated to the forefront in the global carbon budget discussions (e.g. Kurz et al., 1995; Kasischke et al., 1995; Stocks et al., 1998).

Based on experience of a large amount of work on the creation of regional sites for reception and processing of satellite information for purposes of a real-time monitoring of forest fires, the RF Ministry of Natural Resources (MPR) supported the project of the development and trial of the forest fire real-time monitoring system on the territory of the RF. The principal project participants are:

- Space Research Institute RAS;
- Centre for problems of ecology and productivity of forests RAS;
- Institute of Solar-Terrestrial Physics SB RAS;

The main goal of the project is: to create a single unified system for satellite monitoring of forest fires and their consequences on the territory of the RF as an ancillary tool among the traditional methods for detection, monitoring and management of forest fires. It is planned to use results from the project on both a regional and Federal level.

Today, to achieve the goal of the project, both ground-based data of aviation patrol and satellite data are used. Satellite information is represented by data from the NOAA weather satellites, as well as data from the EOS satellites (Terra and Aqua). The sites for reception and processing of satellite information are located in Moscow (Roshydromet), Moscow (SRI RAS, CB "Avialesookhrana), Irkutsk (Irkutsk Base of Aviation Protection of Forests), and Khabarovsk (FE RCRPSD). The meteorological data and the data on thunderstorm activity obtained recently in (**MSU**, Moscow) are used as well as. .

The main ministry that uses the information about forest fires in Russia is the Ministry of Natural Resources (MPR) (http://www.pripoda.ru).

The state forest departments and ministries together with branches of national economy that use the forest resources and/or being engaged in this activity are responsible for the forest fire protection functions in RF. Traditionally forest fire protection is being done in forest fire service, non-specialized branches of timber cutting, forest management and other enterprises.

A special place has been taken by specialized service – Aviation of forest fires protection (**“AVIALESOOKHRANA**”) (Pushkino) http://www.pushkino.aviales.ru.
Aviation forest protection is the composite part of the whole complex of activities on forest fire and insect protection. The 60% of the territory of Russia is under protection of “AVIALESOOKHRANA”. Aviation is used on the main part of this territory. Here aviation detects about 50% of fires and takes part in smoothing and removing of more then 30% of fires.
The structure of “AVIALESOOKHRANA” is as follows: 245 departments (avia branches, avia groups) and 9 mechanized detachments. The forest area of about 637,0 bln. is protected by the branches of „AVIALESOOKHRANA“. Each avia-branch serves one definite territory of forest (appr. 6 bln. hectare).

- Local subdivisions (aviabranches) of „AVIALESOOKHRANA“ ;
- Federal subdivisions (Regional avia-bases) „AVIALESOOKHRANA“ ;
- Central avia-base „AVIALESOOKHRANA“.

All data about forest fires received by aviation and ground methods are transferred to all organizations, which are interested in extinguishing the fires. They are:

- regional authorities,
- regional branches of Ministry for Emergency Situations (EMERCOM)
- Hydrometeocenter and
- mass media.

In Federal system of operational forest fire monitoring are two receiving stations (TACIS project). One station is located in Central base of Avia protection (Pushkino) and the second is located in Federal subdivisions (Irkutsk). All L1A, L1B satellite information belongs to these organizations. All the rights for thematic and results processing are reserved by designers from RAN, ISFZ, IKI.

I.5.7 Data Policy Issues

In this paragraph we consider the data policy issues not only with respect to forest fire satellite and ground data, but with respect to more wide areas including vegetation and land use maps.

<u>Satellite NOAA data</u>
<u>Ownership, privacy and confidentiality</u>
Formally the data belong to NOAA (USA). But NOAA data are free for all users who have ground receiving station. The receiving telemetry belongs to users who got these data.
Ground stations are distributed among the following ministries and organisations:

- **ROSHYDROMET** (5 stations including: Moscow, Obninsk, Dolgoprudniy, Novosibirsk, Khabarovsk)
- Ministry of Natural Recourses (**MPR**):
  - (5 stations: Moscow, Yakutsk, Ekaterinburg, Astrakhan’, Yuzno-Sakhalinsk)
  - 2 receiving stations in **“AVIALESOOKHRANA”** (Moscow, Irkutsk)
- Russian Academy of Sciences **(RAN**)
- Institute of Space Research(**IKI)**(Moscow)
- Institute of solar-terrestrial physics SB RAS **(ISFZ**) (Irkutsk)
- Institute of Atmospheric Optics SB RAS (**IAO**)(Tomsk)

and other commercial and educational institutions such as for example SCANEX and Tomsk state University.
In the Federal system of forest fire monitoring are two receiving stations (TACIS project). One station is located in **Central base of AVIALESOOKHRANA” (Pushkino)** and the second - in its **Federal subdivisions (Irkutsk).** All L1A, L1B satellite information belongs to these organizations. All the rights for the results of thematic processing are reserved by designers from RAN, ISFZ, and IKI.
<u>Standards and metadata</u>

Institute of solar terrestrial physics (Irkutsk) and Institute of Space Research (Moscow) using the L1B format have the biggest archive of NOAA telemetry in Russia. For fire detection AVHRR radiometer should have a spectral band in 3.75 mkm such as NOAA 12, 15, 16. The fire database is collected starting year 1994.

Licensing and distribution

NOAA users must have **ROSAVIACOSMOS** licence to deal with satellite information. The thematic results (maps of fire location) are distributed free to all users having emails and access to Internet.

Pricing policy

Overwhelming majority of NOAA users distribute NOAA telemetry (L1B) data free of charge. The cost on thematic processing (for example detecting forest fires) depends on data offers. The forest fires database of Russian territory produced by NOAA within 1994 –2002 distributed on a commercial base.

Satellite EOS (MODIS) data

Ownership, privacy and confidentiality

In case of MODIS, NOAA data are free and no restrictions on their use. In Federal operational system the MODIS “hot spots” received from NASA and University of Maryland, USA (WWW site - http://rapidresponse.umd.edu/) are used. The reference is obligatory on the source of data.

Standards and metadata

Standards on thematic results of EOS/MODIS produced by NASA & University of Maryland, (USA).

Licensing and distribution

The data are transfer on base of agreement included in the document «Development of an Integrated System of Ground-, Air- and Space-based Observations of Biomass Burning in Northern Eurasia». The latter is submitted to NASA Land Cover Land Use Change Program in support of the Northern Eurasian Earth Science Partnership Initiative (NEESPI).

Pricing policy

The data are free. But the payment is only for using NET.

Forest fires ground base data

Ownership, privacy and confidentiality

There is no free access to this data. There has been archive on the whole territory of Russia since 50-es last century. The authenticity of such characteristics as burned area, starting and finishing fire data is the reason for re-examination according to other sources. Data representation is 80%.

Standards and metadata

All ground information about fixed forest fires is gathered daily in central control spot of **“AVIALESOOKHRANA”** and is transferred to Emergency situation centres **of MPR** and to **EMERCOM**. Each fire has an identification number. The information is added daily during all forest fire season. The accuracy of fire location is determined during fire observation by avia navigation appliances and also by ground descriptions.

Licensing and distribution

The Data can be spread to all organizations dealing with extinguishing and to all authorities.

Vegetation, Land use maps

Ownership, privacy and confidentiality

The vegetation cover on Russia territory is done on the base of SPOT Vegetation data by Institute of Environment and Sustainability of JRC, Italy (http://www.gvm.sai.jrc.it/) in 1:1000000 scale.

Standards and metadata

The vegetation cover is classified into 22 types according to LCCS (Land Cover Classification
System - Antonio Di Gregorio, FAO)

Licensing and distribution

Data are available through Internet.

Forestry plans

Ownership, privacy and confidentiality

The system of presentation is forestry quarters. The representation is in map and plans in paper standard in the scale 1:10000, 1:50000. The statute of limitation of these data is from 10 to 20 years. All the information in 1:100000 scales can be found in the Central archive of Forest Department. The maps of smaller scales are kept in regional forestry.

Standards and metadata

The digital formats of forestry quarters are done in different formats by different organizations. The digital cover of Russia territory is done not evenly. The largest part of the material is done in logical coordinates. All forestry information corresponds ROSKARTGRAPHIA standards.

Licensing and distribution

To do this work on renewing forest husbandry license of ROSKARTGRAPHIA and 5 years experience are demanded.

Shared Information system of forest fires observation from satellites

Institute of Space Research (Moscow), Institute of solar-terrestrial physics (Irkutsk), International forest Institute and Maryland University have designed and are developing at the moment the system on **Operative forest fire monitoring on a base of satellite data**.
http://www.irkutsk.aviales.ru/engl/main.htm
All information that presented on this site is free.

I.6 Conclusions

The consideration of the infrastructure of environmental monitoring given above allow to make the following conclusions:

1. The current Russian monitoring systems provide monitoring of the basic environmental components such as:

- Water
- Air
- Forests
- Land resources
- Ecological situations

2. The monitoring of water bodies aiming at detection and prediction of floods and creating water cadastre, estimating of water quality performs State Water Service of MPR, the State Hydrological Institute (GGI)-St.Petersburg and Hydrometeocentre (Moscow) of **Roshydromet.**

3. The accumulation of the data of space monitoring in RAN is being done by special "Unified Information System of the Fundamental Space Research "(UISFSR).

This system has three levels:

a) common catalogue and basic archive of space data
b) catalogues and basic archives of individual Institutes (such as Institute of Space research, Institute of Radio electronics and other)
c) catalogues and archives of the individual research projects

4. All Russian monitoring systems are thought up as complex systems that use space, ground, airborne and aerological information in combination.

The data integration from these different information strata is being done on the base GIS technologies. The commercial software products ARC/INFO, ARC/VIEW, ENVI, ERDAS/IMAGINE, MAP/INFO are intensively used in the corresponding organisations.

The analysis of users and user requirements to satellite remote sensing sensors and instruments presented in Chapter I is a good overlook with regard to different sensor characteristics such as spatial, spectral and radiometric resolution, spectral range, data updating process and time of data delivery. The details on archives and archiving policy allow to realise the explicit picture of existing in Russia at the moment archives and data banks.

The main conclusion that could be drawn with regard to Atmospheric monitoring is that advanced atmospheric monitoring system exists and is under operation in Russia. This system basically meets end user requirements to data and information and is a part of global international monitoring network under guidance ***WMO.*** The modern information technologies are used for data transfer, distribution and archiving. These technologies match the international standards. Essential drawback of the atmospheric monitoring in Russia is insufficient density of background monitoring stations over territory of a country. The way out is the transit to combination of satellite remote sensing observations and creation of supporting ground stations.

The information for monitoring of environmental stress is being collected both by governmental and non-governmental organizations. Data that come to governmental structures has

a) periodical character (from holders of exploitation licenses)
b) irregular character (from state inspections).

The official databases include the results of ground and underground measurements existing in the form of in tables and text files.

Environmental stress monitoring system can be constructed on the base of new information technologies with intensive utilisation of remote sensing data. Some of Russian organizations are ready to develop such a system. The latter are:

- Moscow State University (methodological base of soil degradation problem),
- Ugra Research Institute of Information Technologies (methodological base of gas fire pollution, super calculations, data storage, GIS technologies)
- NPC "Monitoring" (ground measurement collection and mapping).

The uniform structure of a System for Environmental Stress Monitoring in RUSSIA does not exist but all necessary information can be obtained from existing monitoring systems by means of collecting the data from regional centers. It might be reasonable the next stage of GMES RUSSIA activities to direct toward implementation of pilot projects with focus on environmental stress monitoring on a regional scale.

The whole situation in Russia with satellite information for operational monitoring of forest can be considered as rather satisfactory. However, the questions on fire forecast, independence of weather conditions, early fire detection when the fires are small are still not solved so far. There exists an idea of broadening satellite data. It means the simultaneous utilisation of all-weather survey and forest fire controlling satellite systems. These systems must have supplementary radar sensors, that can also detect big forest fires, and theirs burned scars.

It should be stated that recently new developments in the field of portable satellites for forest fire observation («BIRD» of DLR, Germany) have been created. A steady operation of satellites "BIRD" with increased spatial resolution in IR spectral bands and practically with non-restricted temperature threshold is of great interest for Russia.

In monitoring of big fires the problem of fire propagation is still open. There are no good models of forest fires propagation that went through practical testing. This is the result of the fact that it is very difficult in Russia to make experiments with applying a wide range of ground data and foreign satellite systems. There is no good feedback to do the work on validation of satellite and ground information. Annual ground data about registered forest fires taken from Federal and regional subdivisions are very often falsified. The practical collaboration with Airbases in feedback regime shows that real area characteristics of fires may differ from reported several times.

Socio-Economic Issues of GMES

In this section we present our approach to Socio-economic assessments with regard to Russian conditions and the detailed description of the main case studies. We analysed carefully the cross-cutting assessment study (GMES Socio-economic Study) and give our acknowledgements to Mr. Jon Styles, Mrs. Pam Vass and Mr. Andrew Shaw who provided us with necessary information and their GSeS D4 report [4, 5].
The choice of the case studies for our project was influenced by those described in GSeS report [4].

We accepted the approach of cross-cutting assessment study team and have chosen several case studies to provide socio-economic assessments for Russian conditions. These case studies and the assessments are described explicitly in the consequent chapters.

II. Oil spill monitoring in Caspian Sea Region

II.1 Identification of the Caspian Sea environmental problems

Caspian Sea is the focus of attention of the environmentalists during many decades. The water –supply of the Sea constitutes 75 000 km^3 and is equal to 0,005% of the water reserve of the "world ocean"; area of the Caspian Sea is equal to 370000 km^2 and constitutes 0, 07% of the whole earth area. The Caspian Sea is the unique source of the sturgeon fish population (2/3 of the world reserve) and produces annually 250 million tons of the organic material. The richest oil deposit and oil extraction make an extreme anthropogenic stress on the regional environment. Oil spill in the marine environment is the severe problem of the region.

After disintegration of the USSR the Regional countries hadn't legal framework of the environmental control though the drafts of such acts were considered in Russia.

The Caspian offshore oil exploitation started in the begin of 19th century when mud oil was yielded from seabed at the Azerbaijan shelf zone. The first oil well was put in 1925. Since 1949 the "Neftyanyie Kamni" oil deposit has been exploited. In the forties the seabed oil production was in the progress in Dagestan in-shore, and in the next decade – in Turkmenian in-shore. Some elements of petroleum production took place in Iran. By 1972 there were more then 2000 exploratory islands and 300 km of offshore piers in the sea [2, 4]. New deposits are explored and pipelines are put in operation.

In the sixties the marine fleet including tankers became the main oil pollution source in the Caspian Sea as the result of ballast water discharge. When the USSR Council of Ministers adopted the Regulation on the prohibition of ballast water discharge from oil ships (1968), this kind of pollution had been substantially reduced. The main source of oil product inflow to the Caspian Sea as well as into the World Ocean is the surface run-off [5, 6]. A major portion of the petroleum hydrocarbon sinks with a suspended matters in shallows of confluent seashore. Oil inflow amount with wastewater and from oil fields constitutes some 20 tons per year.

Today the man-made environmental stress increased substantially. One of the most widespread pollutants is oil and oil processing products. Oil discharge into water bodies has an adverse effect on the environment. Oil slicks result in the decrease of water aeration and photosynthesis, loss of surface flora and fauna. Oil products occurrence at the bottom causes the death of near-bottom and bottom microorganisms. With the intensification of oil transportation and recovery, oil products emerge in those regions they have never been before, and the ecosystem is not adapted to such phenomena as it happens in the areas of inhabitancy of natural gryphons.

The following events may serve as examples of oil production influence on the environment:

- the oil storage fires during the war in Iran,
- the wreck of PRESTIGE oil ship in proximity of the coast of Spain in 2000,
- the accidents with VOLGONEFT-77 and VOLGONEFT-63 oil ships on 29 September 1973 in Makhachkala. More then 3000 tons of oil spilled into the sea [19],
- petroleum gas flares at the Gkhavar oil wells in Saudi Arabia [4],

Figures 2.1-2.3 demonstrate the oil and gas infrastructure in the Caspian Sea Region [http://karty.narod.ru].

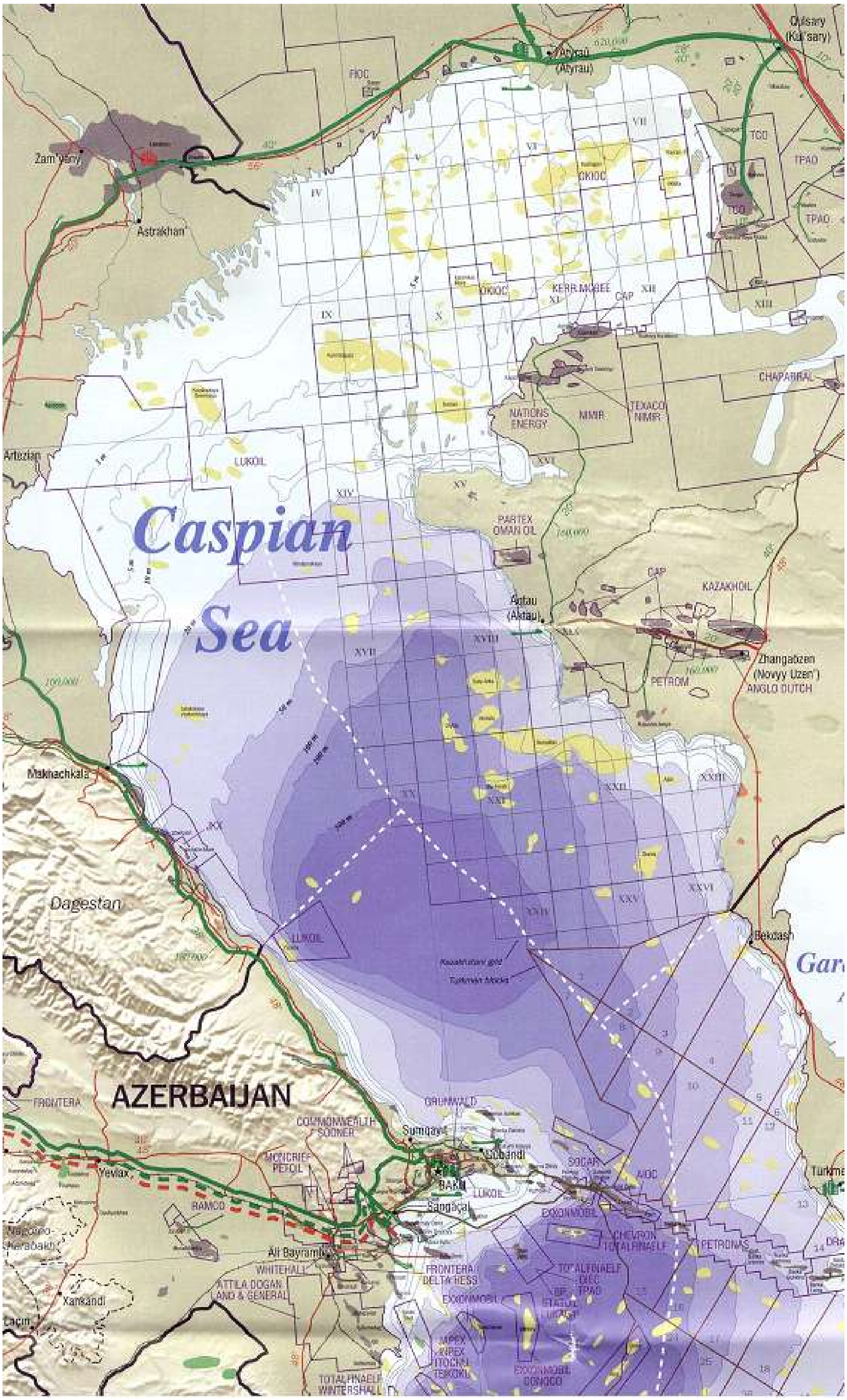


Fig.2.1: Oil and gas infrastructure in the Caspian Sea. The north and middle of the sea

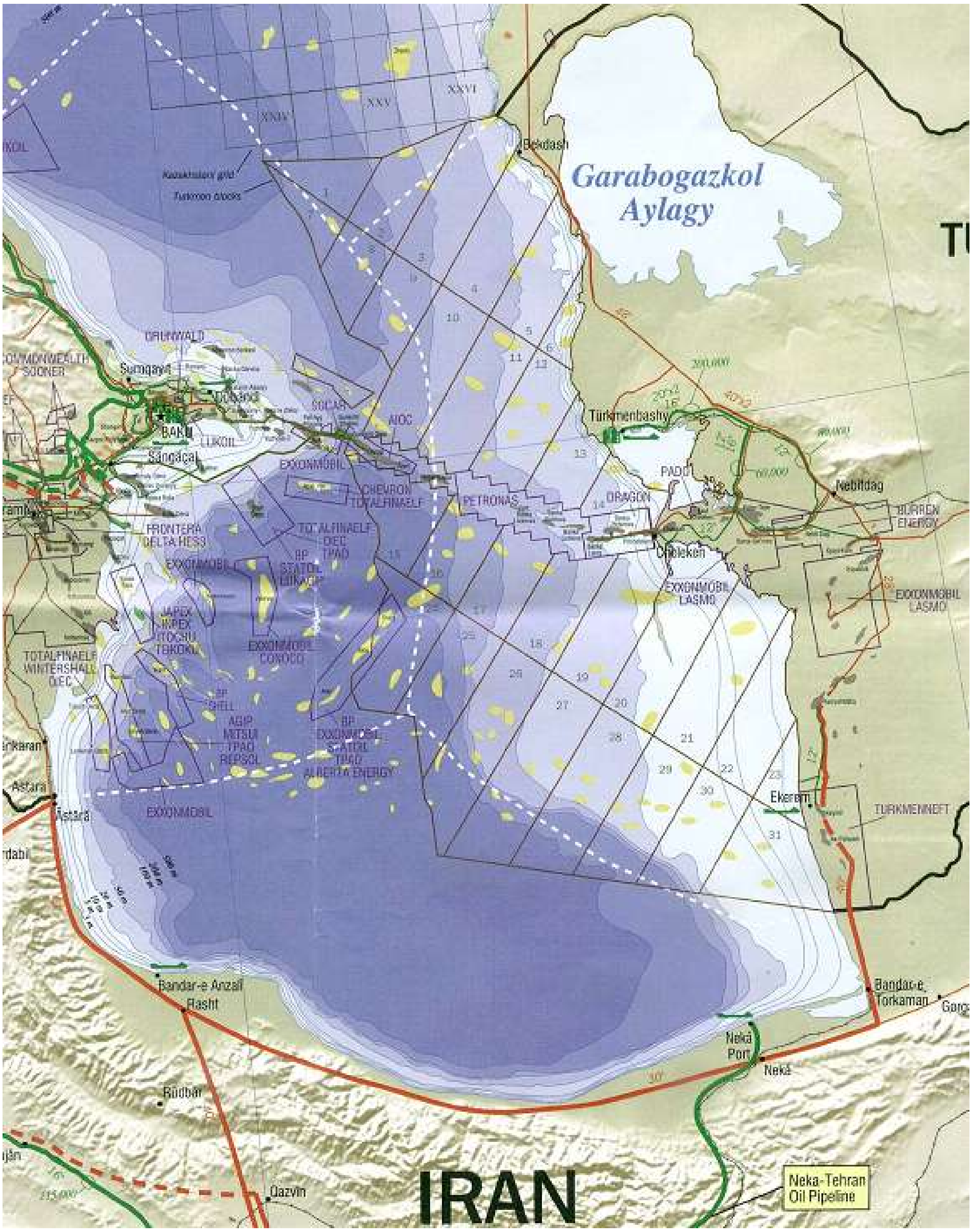


Fig.2.2: Oil and gas infrastructure in the Caspian Sea Region. The south of the sea

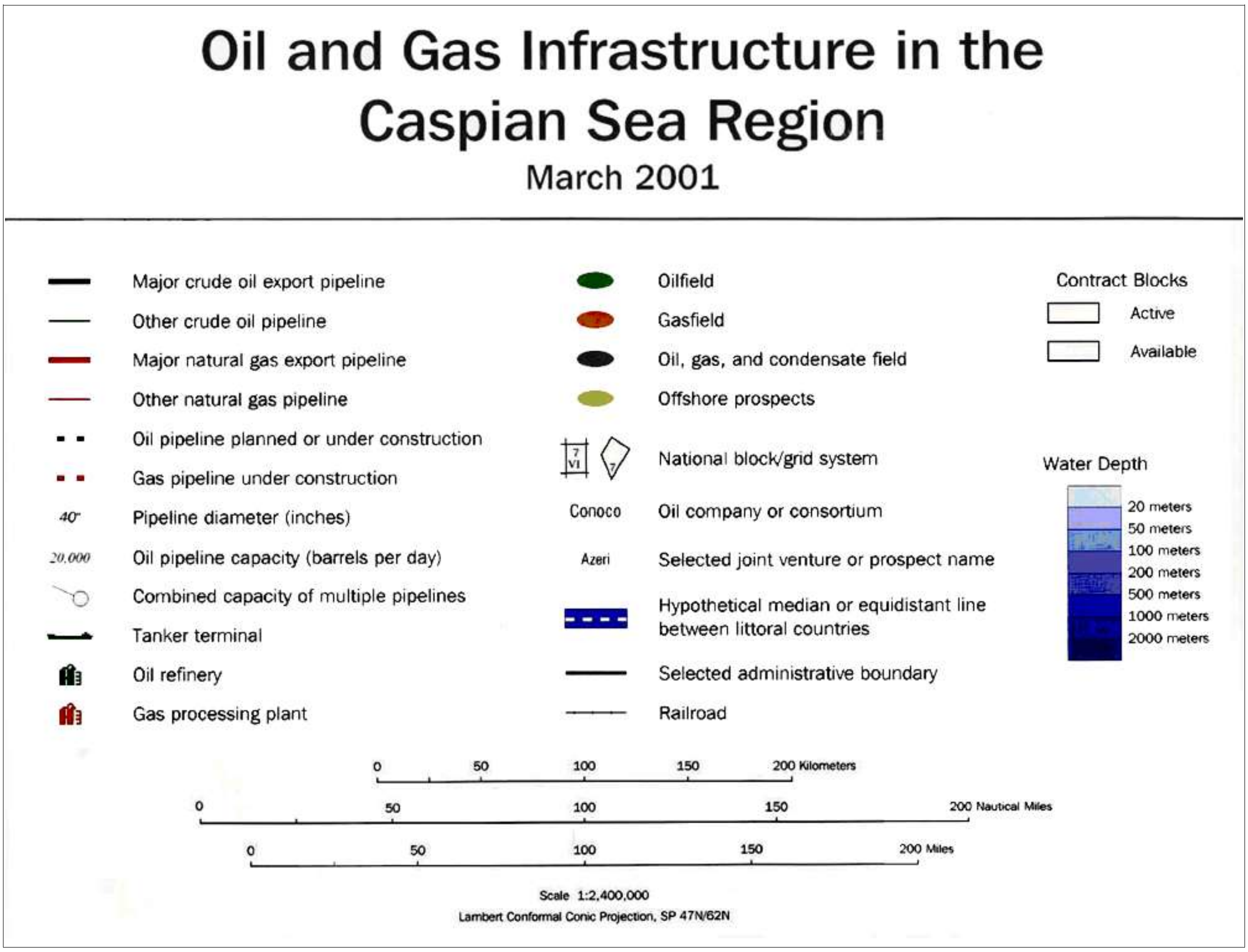


Fig.2.3: Legend for Fig. 2.1-2.2

The annual oil product discharge in oil fields is approximately 30 thousand tons of oil products. Oil is spilled into the sea from

- overfull oil storages installed on the artificial islands,
- leaky pipelines built at the sea bed
- piers, when loading and landing the oil ships [2, 26].

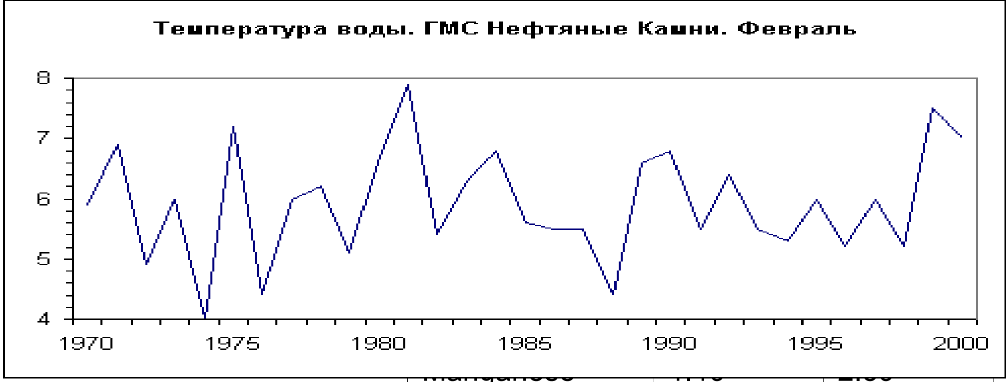
In the case of emergency and technological discharges of oil products, oil pollution has local character. For example, the Kalamkas, Karazhambas and Tengiz oil deposits (located in Kazakhstan) are separated from the sea by protruding dykes. However when wind-induced surges and floods occur, they destroy these dykes and water moves a great quantity of oil products in the sea. The latter results in the increase of the petroleum hydrocarbon concentration in coastal water near the East shore of the North Caspian Sea. Oil patch size may be as much as several hundred meters. When oil products along with wastewater inflow into the Caspian Sea, the petroleum hydrocarbon amount increases from 4 to 25 maximum permissible concentrations (MPC) in the vicinity of the Tengiz Deposit. Air pollution level in the vicinity of the Tengiz Deposit is 6-10 MPC for hydrogen sulphide, 4-6 MPC for sulphur dioxide gas with these gases concentration being more than 4 MPC within 30 km of the deposit. In Ural River and Emba River and in coastal waters of the northern shore of the Caspian Sea an average annual content of oil products is 13-27 MPC [3, 16]. Over the past 3 years 11 large-scale pollutions have been observed in the Kazakh part of the Caspian Sea [14]. The same situation takes place in the Bibi-Eibat Deposit (Azerbaijan), in oil lakes of the Pir Allakhi Island, near Sumgait, and in Kura River delta, close to Ogurginsky Island (Turkmenistan) [2, 3, 14-16]. Every year 20 tons of oil products along with wastewater are discharged to the Baku Bay and beyond 60 million tons of pollutants has

been already accumulated there. Household and domestic wastewater containing above 40000 tons of organic substances is discharged to Kura and Araz Rivers. The copper-molybdenum plant discharges several hundred tons of strong acid and heavy metals to Kura River. [2]. An average annual concentration of hydrocarbon in waters of the Turkmenbashi (Krasnovodsk) Bay and in the vicinity of Cheleken Island exceeds 1.5-2 MPC [15].
As a whole the problems concerning the biosphere are of a similar nature in Iran. For example, an uncontrolled enlargement of agricultural lands and residential areas, house and villa building particularly in the middle part of the Iranian Caspian coast resulted in the additional environmental stress because all these objects are located too close to the sea. All cities of the Iranian coast have no sewers or sewage purification facilities. The fertilizer quantity being used within the coastal territories is about 270000 tons per year. During recent years the alongshore forests are greatly reduced. Coastal highways, dams, canals, pipelines changed considerably a water regime of the drainage area that yielded floods, dump and slaughterhouse under-flooding, and impediments to fish migration [11].
A total volume of water discharged into the Caspian Sea is equal to approximately 180000 m3/day including raw municipal wastewater 30000 m3/day, a volume of industrial raw wastewater coming to the sea is as great as 1 million m3/day. About 100 thousand tons of oil is extracted from the sea daily [2,8].
It should be noted that oil spills caused by oil production and transportation have never been disposed in the official reports completely.

II.2 Description of environmental change in Caspian Sea Region

As a result of nature management already in sixties the benthos biomass decreased by ten times and its population by twenty times within the Apsheron Archipelago. The phytoplankton products decreased by 12-15 times during the sixties-eighties and a specific structure of super organisms changed drastically. A change of fish inhabitancy and breeding conditions due to both natural and anthropogenic factors for last 50 years resulted in a significant decrease of fishing. The content of heavy metals and hydrocarbon in fish tissues and soils increased more than by a factor of ten. Since 1981 in the neighbourhood of the Tengiz Deposit approximately 1 million waterfowls have been lost. Within oil-polluted areas a decrease in the canopy cover and a progress of marine and wind erosion are observed [3].

Among negative factors affecting the Caspian Sea ecosystem are also fish over catching, ecotope degradation, loss of spawning grounds resulted from the stream flow regulation of all large Caspian rivers, a rising of sea-water level during the period of 1978-1995, and agricultural lands flooding. The stream flow regulation led to water bloom of reservoir and to the turning the most of phosphorous and nitrogen into organic compounds. These organic compounds of phosphorous and nitrogen as well as ammonium and carbamide rather than phosphates and nitrates were carried out to the sea. Silicon brought by rivers in the form of suspension and colloid deposited substantially in the bottom sediment of reservoirs. The amount of organic matter carried out rose sharply and throughout the year. Instead of spring flood where 80-90% of annual runoff was carried out during a month, now 35% of water from reservoirs is discharged in winter resulting in winter blooming of rhyzosolenia. This diatom absorbs the remains of dissolved silicon acid in an euphotic layer. Since zooplankton does not use it, rhyzosolenia sinks to the bottom thus hiding a great deal of silicon, phosphorous and nitrogen [20-22]. All these factors brought to an excess of organic substances in the sea, and therefore to an eutrophication of the Northern Caspian Sea [25].
The Volga regulated flow, water pollution in the river, oil product and drilling waste discharge were the basic reasons of increase in heavy metal concentration in the sea water at the boundary of the North and Middle Caspian Sea (See Table 2.1 [26]).
In the USSR the Caspian Sea fishery was approximately 30% of total fish yield of inland water bodies. The largest fishing of the Caspian sturgeons took place in early decade and a half of the 20th century. They ranged up to 38 thousand tons. Then an exorbitant fishing occurred, and fish harvest was reduced to 10 thousand tons till the sixties. A prohibition of offshore net fishing and trap fishing (1964) had a profound impact in saving sturgeons. By 1976 fish harvest rose up to 23 thousand tons. The negative trends in productivity of fishing took place in Iran as well.



Manganese μg/l.	[illegible]	[illegible]
Zinc μg/l	3.58	3.24
Nickel μg/l	1.65	2.00
Lead μg/l	1.45	2.70
Cadmium μg/l	0.18	0.66
Barium μg/l	14.82	12.25

Table 2.1: Average (0-bottom) concentration of heavy metals in seawater in 1997-2000

Fish	Years							
	1981	1986	1991	1992	1993	1994	1995	1996
	Harvest, tons							
Sprat	1341	2384	1381	2152	2873	5100	4100	5700
Sturgeon (meat)	1625	1687	1789	1583	1312	1284	1163	1295
Other kinds of fish	7211	6200	1857	1687	2232	1700	1580	1550

Table 2.2: Fishery in Iran for the period 1981-1996 [11]

The global climate warming reduces the North Caspian Sea ice cover in winter. In spring the diatom population arises at the edge of melting ice thereby decreasing fish feed and zooplankton that uses the diatoms. A climate warming accompanied with a decrease in sea-surface wind tends to the reduction of sea aeration, oxygen starvation, and fish inhabitancy degradation. Besides the warmer is the water and the weaker is the wind, the longer oil slicks stay on the surface and hence the photosynthesis and sea aeration reduction go on further. The climate warming gives rise to the increased evaporation. **Fig.2.4-2.6** give the graphic description of some important sea surface parameters connected with climate warming effect.

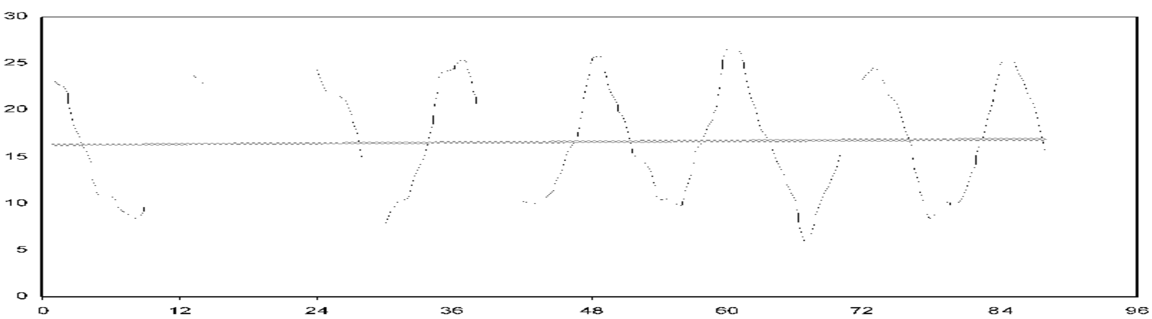


Fig.2.4: Average monthly variability of sea surface temperature (SST) of the Caspian Sea during the period January 1995 – January 2004 measured from AVHRR/NOAA. The straight line shows the SST trend in the Region [18].

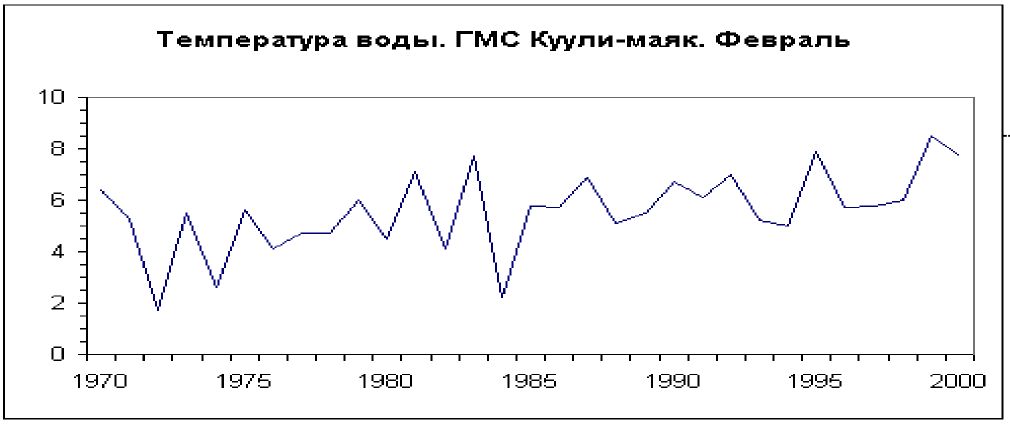


Fig.2.5: Sea surface temperature variability in the Caspian Sea hydro meteorological stations “Neftyanye Kamni” and “Kuuli Mayak” [7].

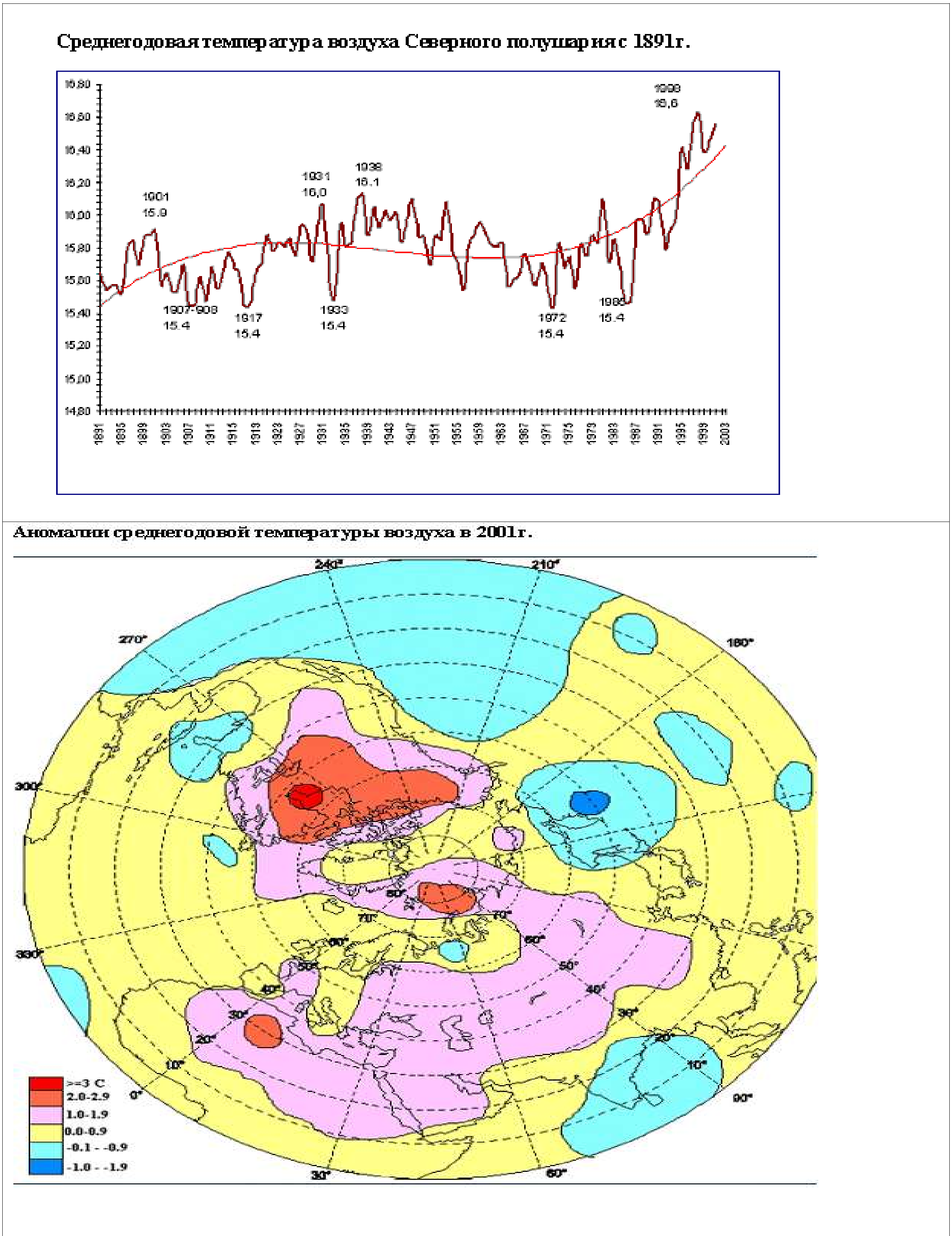


Fig.2.6: Average annual air temperature of the northern hemisphere since 1891 (top). Anomalies of average annual air temperature in 2001 (bottom) [7].

Figure 2.7 shows the global warming impact as a step-by-step north drifting of ice edge.

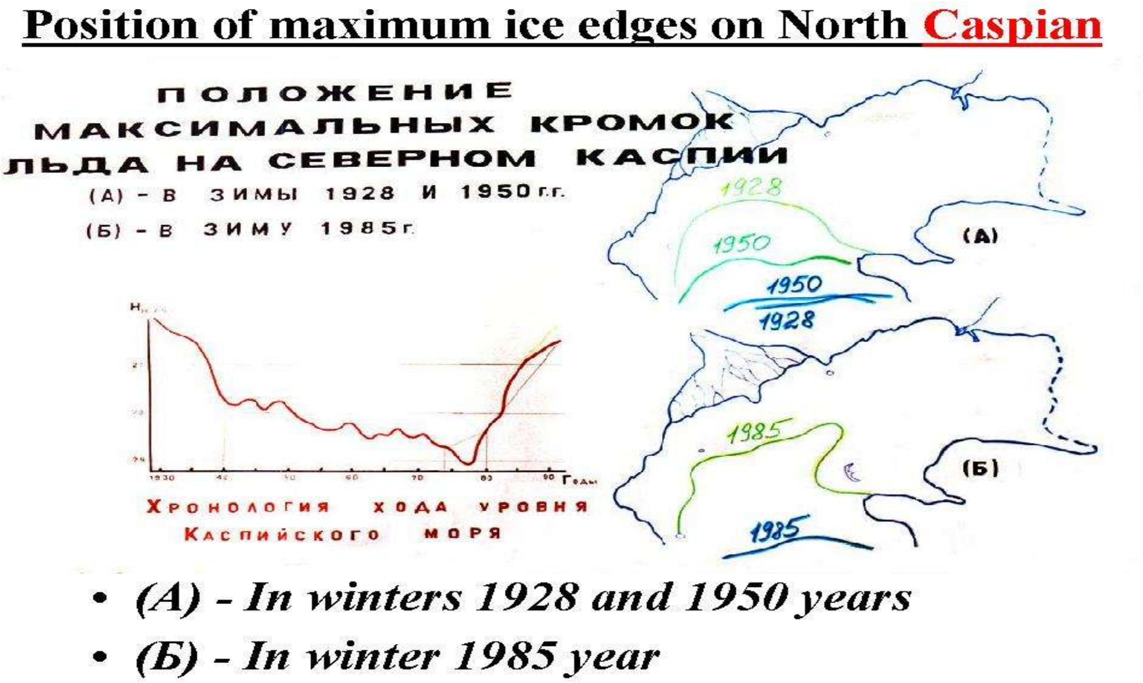


Fig.2.7: Position of maximum ice edges in the North Caspian Sea [5]

Winters at the end of the 20th century (1999-2000) were mild. This affected the ice distribution in the sea.

The whole description above gives the reason to state that the profound changes in the biosphere of the Caspian Region ecosystem happened. Both anthropogenic oil spill monitoring and detailed ecological monitoring of the Caspian Sea involving the SST, water clarity, and ice cover monitoring are of extreme need and importance.

II. 3 Environmental damage assessment

Economic loss from disasters and domestic oil product discharge is estimated with regard to:

- amount oil products lost and their cost [19];
- cost of lost property – sunk oil ships, burnt oil derricks, etc. [9];
- water areas lost for the biota breeding and fattening depending on their historical bio productivity and loss of the cost of profit [9];
- coastal zone areas with their values (forests, agricultural lands, aqua parks, beaches, reserves. tourism, etc.) put out of use;
- water and air pollution [3, 25], and
- losses of people health and lives. (For instance during flowing of oil well №37 in Tengiz accompanied with sulphurous gas and carbon release, the inhabitants morbidity increased by 2.5 times; 200 thousand people were influenced by negative factors and 200 thousand birds were perished).

The elimination oil blowouts requires significant money sums (from 5 to 20 million tenge in Kazakhstan). In 2004 Kazakhstan has allocated 719 million tenge for the Program of oil and gas wells elimination and conservation [9, 14]. The insurance of the local human and environmental inhabitants from negative environmental conditions is not widespread on the territory of the CIS countries. Therefore, the damage assessment caused by air and water degradation or loss of birds during trans-boundary migration is hampered. That is why we consider the assessment of irreparable losses from offshore oil field.

During recent years oil-and-gas companies put particular attention on environmental impacts of their activities. Among such companies is “Lukoil” Company that attempts to use the “dead discharge” concept. However, the putting out of use of some water area when installing offshore drilling rig is inevitable (See Table 10) [12, 26]. This gives rise to reduction of feeding areas for benthos and then for all biota beginning with fish and ending with seals. **Table II.3** represents damage assessment for fish recourses.

Damage area			Biomass of feeding organisms		Loss of fish resources, ton
Bottom area under holders, m2	Bottom deposit coverage, m2	Sea water volume in turbidity plume, thousand m3	Zooplankton,g/m3	Zoobenthos, g/m3	
233	610	117	0.7	54	0.2

Table 2.3 Damage assessment of fish resources caused by the loss of feeding organisms as a result of drilling platform installation

However the official documents do not give an overall estimation of the ecological damage. For example, fish resources damage from the navigation intensification in drilling rig area is not published. The reason for that is that in Russia the waterways including navigation canals, shipping locks, etc. are free of charge for ship-owners.

By multiplying 0.2 tones of irreparable fish resource loss (from Table 2.3) from one oil platform by 10000 (a knowingly small number of drilling platforms, loading docks, port structures for tanker fleet) we obtain 200 tones of fish loss. If the estimated losses due to navigation intensification in areas of oil recovery in shallow waters are greater by the order, then irreparable fish resource loss will be approximately 2 thousand toned. These losses constitute approximately 5 to 20% of the total amount of fishing in the country. Taking into account the real desertification of offshore oil producing areas, the irreparable fish resources loss could be increased in two-three times. Thus a total fish resource loss from marine crude oil production is some 15% of the total current fishing yield.

II.4 Organizations involved in environmental monitoring in the region

The Caspian Research Institute of Fishery (**KaspNIRKh**) provides a thorough monitoring of the Caspian Sea including a satellite component in collaboration with **NTs OMZ** (Moscow).
A partial monitoring of the Northern Caspian Sea is being done by

- the Caspian military flotilla,
- the Volga-Caspian Reserve,
- Lukoil Company,
- specialists from regional branches of hydro meteorological service,
- the Astrakhan navigation canal,
- IO of RAN, GOIN, IVP of RAN,
- the Astrakhan University

The Volga oil pollution monitoring is being done by experts from Ministry of Ecology and Natural Resources of Tatarstan (a direct contact and remote oil spills monitoring is performed on board of “FLAMINGO” patrol ship). The Service of Emergency Oil Spill Elimination is established in Makhachkala [10]. A partial land monitoring is performed by

- the Astrakhan Reserve,
- cadastral centres,
- and the EMERCOM centres.

In Iran there have been founded the National Oceanography Centre and the Caspian Regional Centre for the efficient estimation of pollution levels.

In Kazakhstan – Institute of Botany and Phytointroduction of Ministry of Education and Science, Institute of Hydrology and Hydrophysics of Academy of Sciences.
In Turkmenistan – National Service for Development of the Turkmen Section of the Caspian Sea, National Institute of Deserts, Vegetable and Animal Kingdom.
In Azerbaijan – State Committee on Ecology and Nature Management, Technical University.
Centres for acquiring satellite data to be used when assessing the ecosystems are started to establish recently in the Caspian Region (Kalmykia, Astrakhan, Kazakhstan).

II. 5 State-of-the-art with environmental monitoring in the region (Problems and Prospects)

The present departmental monitoring networks don't ensure adequate data acquisition both qualitatively and quantitatively. This happens because:

- The mechanism for a systematic data exchange between various organizations and departments as well as between various entities of the Federal Volga-Caspian Region has not been completed yet;
- The departmental disconnection of ongoing data acquisition, generalization, archiving, and processing networks creates data duplication on the one hand and data incompleteness and non-synchronous - on the other;
- The possibilities and conditions of water and in-situ observations became more complicated as a result of new country's boundaries and information barriers;
- There are no regional centres for data analysis and decision-making in the region for Caspian marine and coastal ecosystem management [13].

Nevertheless, the emergency centres, designed to overcome the oil spill accidents, are being established now in Kazakhstan and Russia (Makhachkala). The Russian ship-owners put out from exploitation the single-bull drill ships of the type of well-known "PRESTIGE" tanker. This is particularly important since the Russian tanker fleet to be prepared to join the International Convention on Demands to Oil Ships until April 2005. The routine actions for safety navigation are undertaken in Russian ports. For example, in Novorossiisk in December 2003 a unique laser system was put in operation to provide the safe ship mooring. The system cost was more than 500 thousand dollars. The expensive project on ship safety management system is implemented in Makhachkala [14]. Since 1897 the Caspian Research Institute of Fishery (**KaspNIRKh**) has provided the chemical and bacteriological monitoring of the Caspian Sea water and its biota, fish and mammals. The reserves and nature-conservative areas arranged in the Ramsar lands are in use and are being enlarged. These territories are destined to maintain the biota population. This state of the in-situ environmental monitoring makes the remote sensing (satellite) monitoring facilities are of extreme importance. Satellite monitoring enables detection of the redundant oil product discharge from ships **(Fig. 2.8)** (ballast water) or observation of the industrial pollutants. One can see flood effects with a significant portion of oil products washed away (**Fig.2.9**), oil platform and pipeline breakdowns, centres of disasters and oil leakage (discharge), and oil spill dynamics (**Fig.2.10-2.11**). The Figures2.8 – 2.11 illustrate the mentioned above effects and oil spill accidents.

Data from multiple satellite systems are used to reach the objectives and fulfil the tasks of monitoring. There are satellite systems of low resolution (above 500 m), medium resolution (up to 10 m), and high resolution (several meters) in visible, IR and microwave length bands. In microwave length band both passive and radar measurements are applied. The repetitiveness and frequency of space imaging is between an hour (geostationary satellites) and two weeks (satellites equipped with high and very high resolution instruments). Generally high-resolution data are used for oil spill monitoring. High- and very high-resolution radar data are used to distinguish oil pollution-free areas; this data enables observing decks, surfs, unspent fuel slicks.

In recent years satellite ecological centres are being established in the Caspian Region (Kalmykia, Astrakhan, Kazakhstan). These centres are intended to acquire and process the satellite data, to train regional authorities in fundamentals of ecological science i and to inform them about the necessity of ecological monitoring and about the role of satellites as an essential part of whole monitoring process.

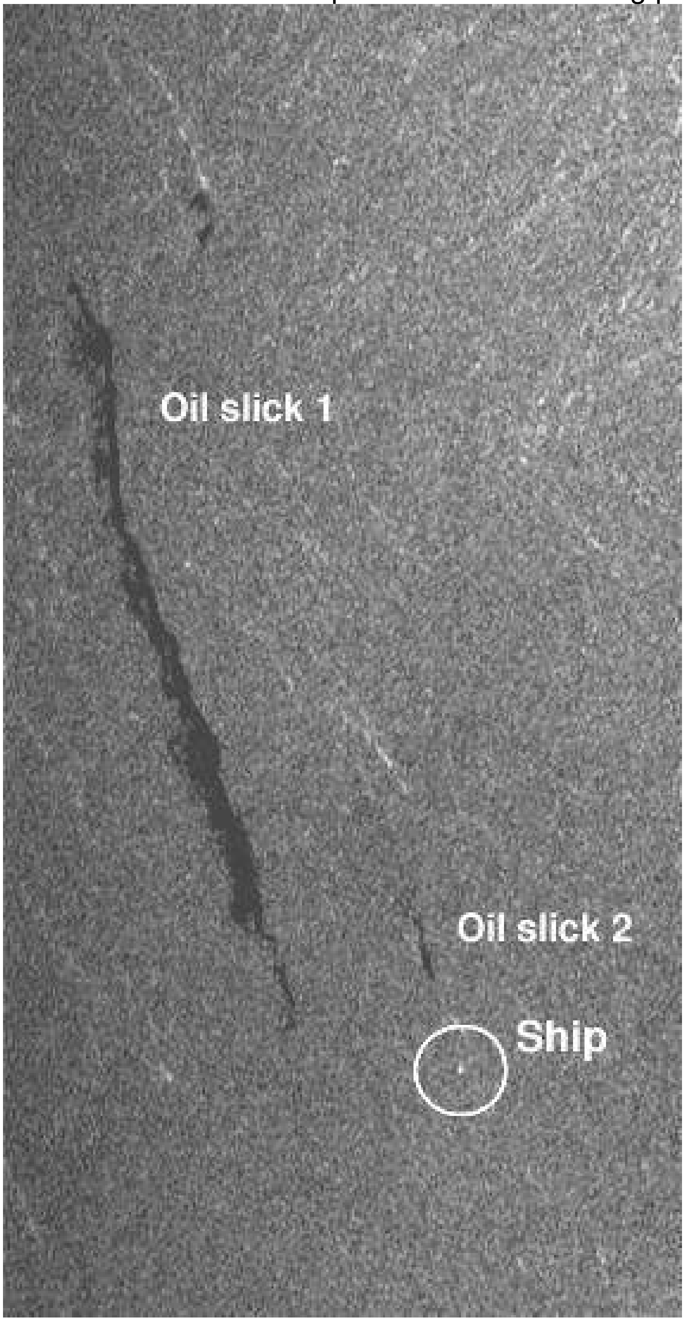


Fig.2.8: ERS-2 image of oil slicks in North Sea between Great Britain and Holland, 28 August 2001 (http://earth.esa.int/ers/)

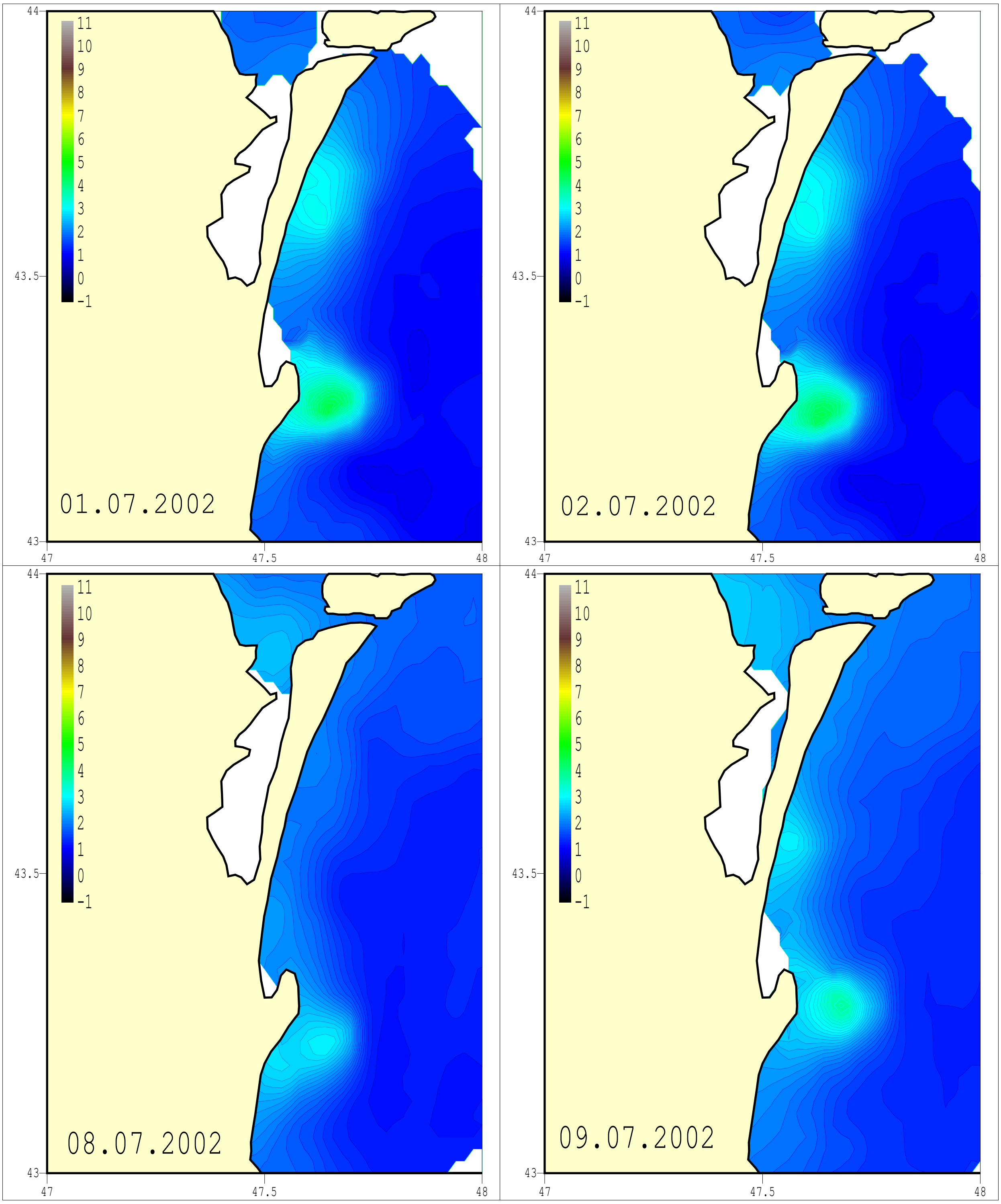


Fig 2.9: Disastrous flood resulted in the hydrosol spots with oil products at the sea surface in the vicinity of Terek and Sulak River mouths in the first decade of July 2002 [17]

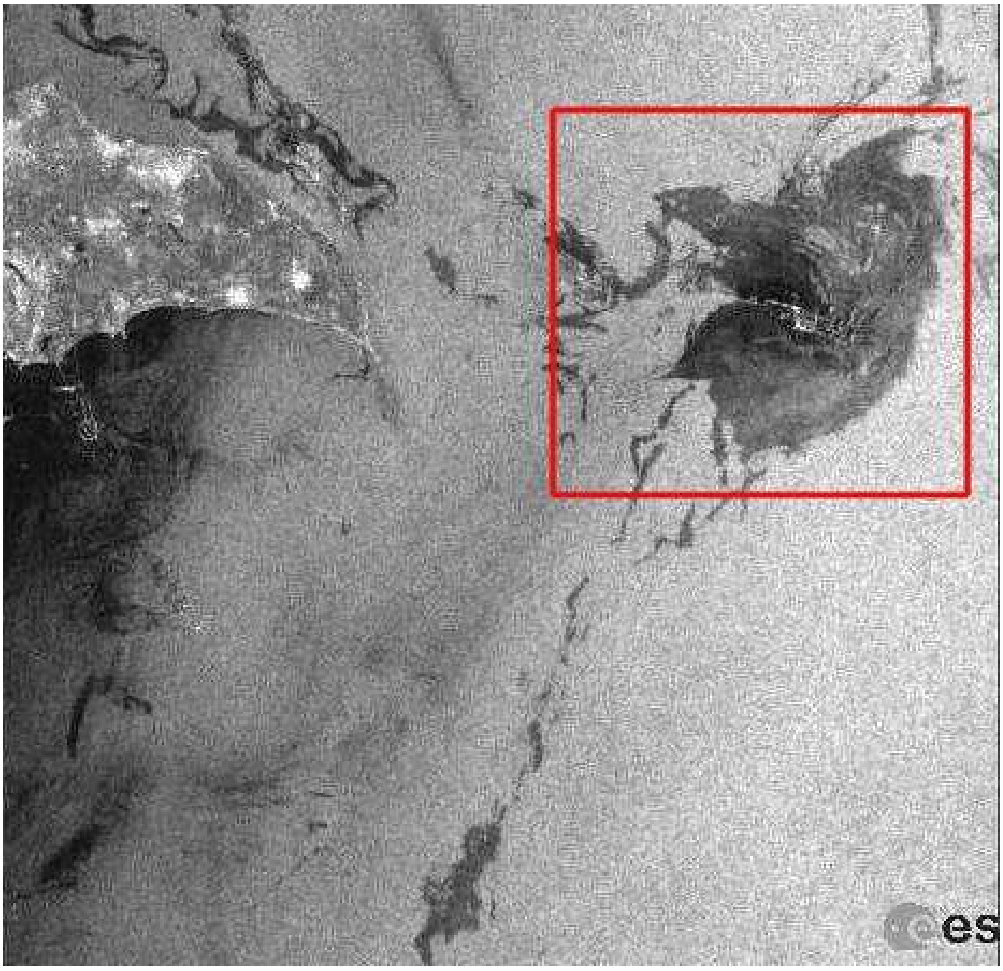


Fig.2.10: Sea pollution near „Neftyanye Kamni“ settlement [10]

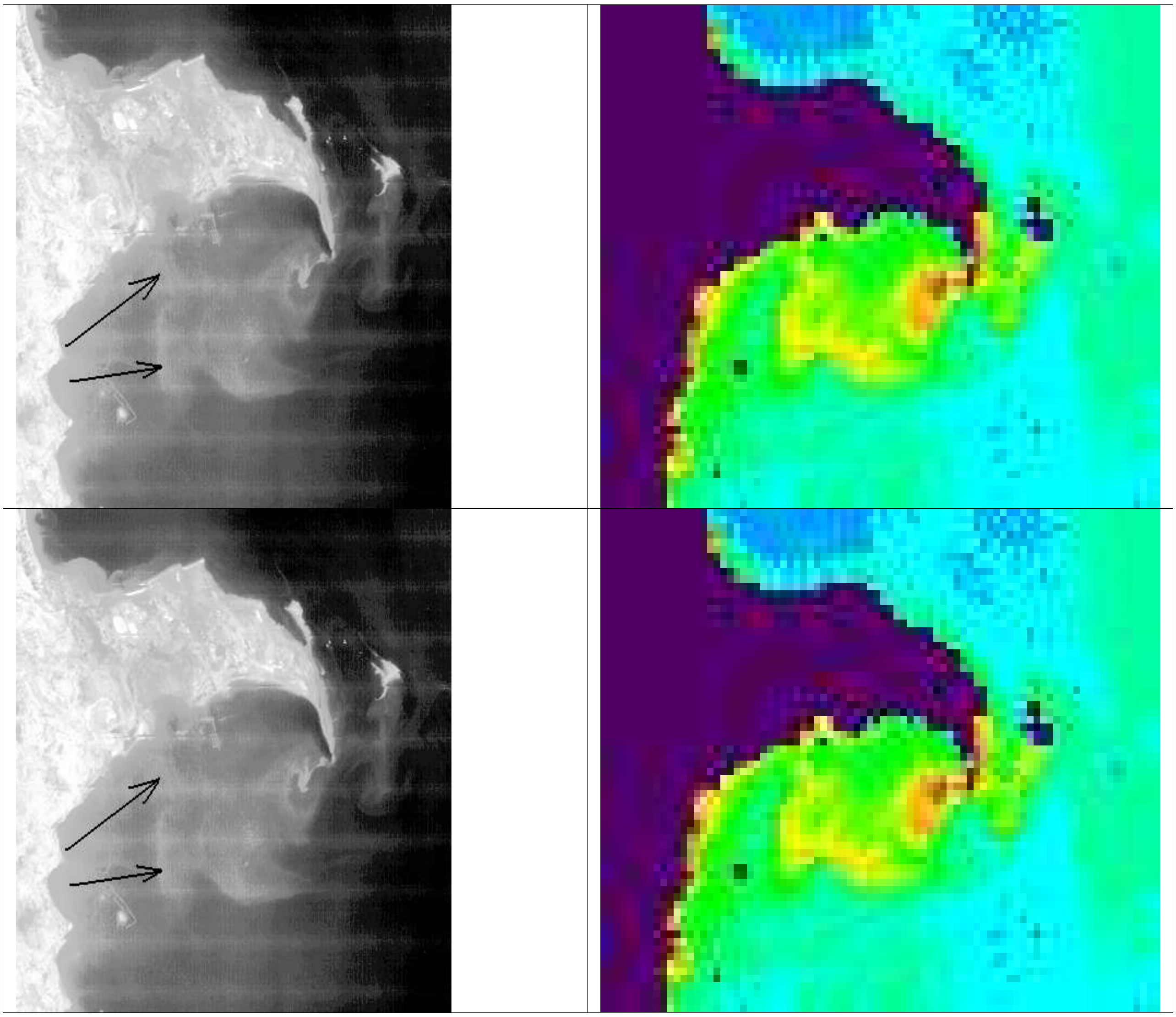


Fig.2.11: TERRA image of the Apsheron and ambient water (left – arrows mark turbid water flow from the Baku Bay) and hydrosol field (right) of the same area using the AVHRR/NOAA data, 10 September 200 [17]

Satellite background monitoring of oil spill is implemented by **KaspNIRKh** in collaboration with **NTs OMZ**. The monitoring scheme involves the following data and instruments:
METEOR-3M, AVHRR/NOAA, and MODIS/TERRA, AQUA low- and medium resolution data under assumption of cloud-free conditions [a) SST is below background; b) Sea surface roughness is less than for background; c) Hydrosol albedo is higher than that of clean water].
All these factors indicate a high probability of oil spill accident [18]. It should be noted that similar cases take place in shallow waters and river deltas. **Fig 2.12** illustrates the situation of 12 May 2004 when the Volga and Sulak water flows spread over the offshore along their beds in deltas. Wind-induced wave is observed in the sea whereas the river waters are calm **(Fig.2.12 right)**. On 17 May 2004 just an opposite situation took place (**Fig. 2.13**). The Volga waters in the offshore are driven to the eastern bank. The sea is calm; the northwest wind blows over the cold Volga waters. The analysis of the images **Fig.2.12 and Fig.2.13** shows that the surface turbid water movement is basically determined by a local wind condition (breeze, foehn). Hence in each such case the interaction with an operator is

foreseen. Otherwise, the calm sea areas erroneously fall in the “class” oil spills and practically the whole sea area appears to be oil-covered (**Fig. 2.14** [10]).

Because of low spatial resolution of spacecraft (METEOR, NOAA, TERRA, AQUA) only large oil spills could be detected in daylight and under cloud free conditions with several days delay after oil spilling. To provide a really efficient operative satellite monitoring of oil pollution, sea surface condition, and seawater level the multiple operational satellite high-resolution data along with in-situ data are required. Namely the radar data, TV and IR images of 4-30 m resolution from ALMAZ, RESURS-DK, SPOT, ERS, ENVISAT, RADARSAT are of particular importance. Moreover, data from constellation of high- and very high-resolution satellites are needed since the modern onboard high- and very high-resolution instruments have a restricted swath width and the dot-objects over the Caspian Sea may be imaged only once every decade.

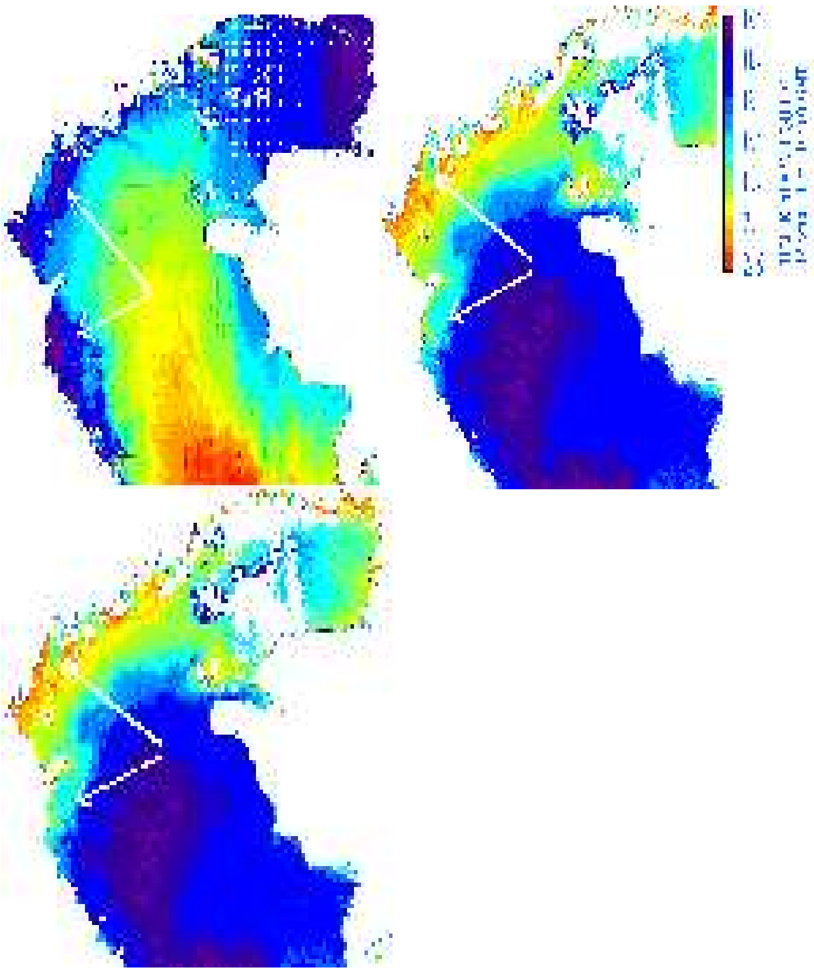


Fig.2.12: Left - Index of sea surface roughness, 12 May 2004.
Blue colour – calm, red colour – wind-induced wave
Central – Sea surface temperature (SST)

i. **Right – Hydrosol albedo. Dark-blue colour – clear water, red colour – turbid water**

White arrows show the Volga and Sulak water streams

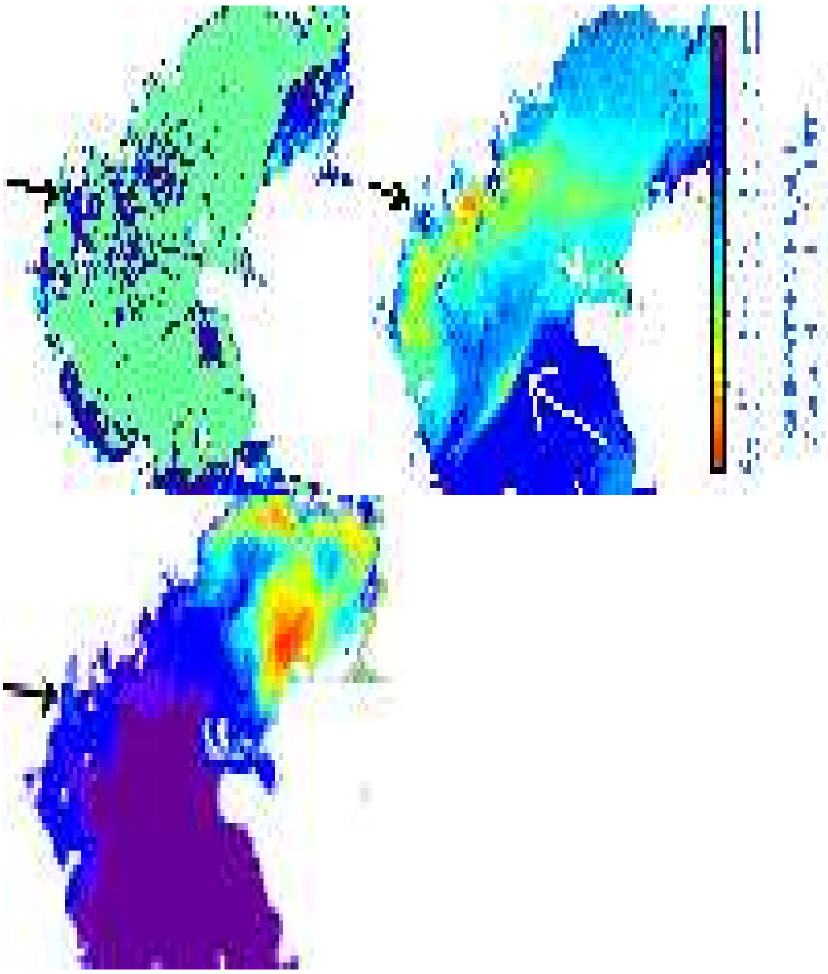


Fig.2.13: Left - Index of sea surface roughness, 17 May 2004.
Green colour – calm, blue colour – wind-induced wave
Central – Sea surface temperature (SST)
Right – Hydrosol albedo. Dark-blue colour – clear water, red colour – turbid water
A black arrow shows the Volga water stream in the sea, a white arrow shows the overheated oil slick area under calm conditions

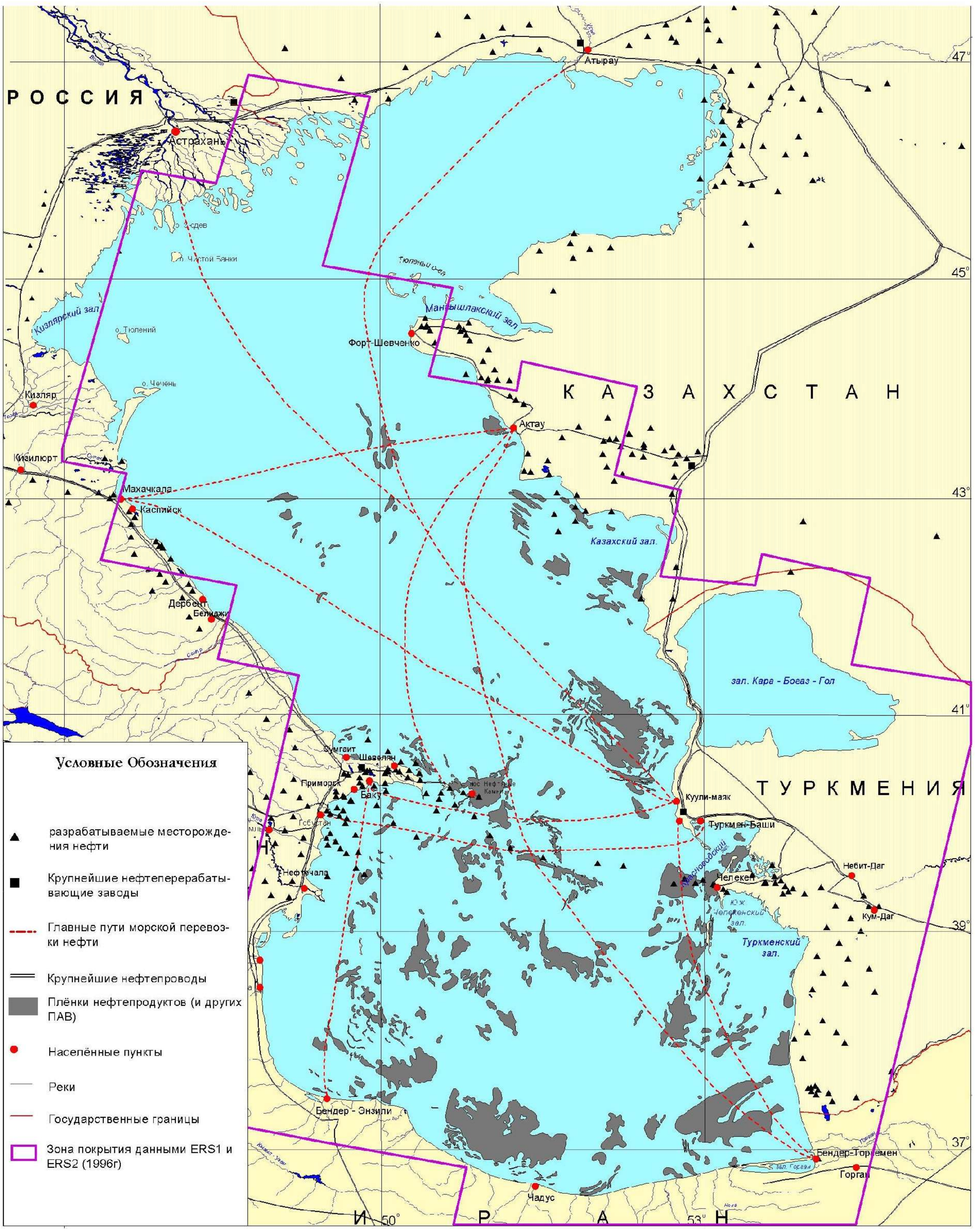


Fig. 2.14: Integral map of oil slicks, oil products and tamol distribution, May 1996 [10]

It should be noted once again that satellite monitoring of the Caspian Sea involves not only surface pollution monitoring, but the monitoring of SST, the upper water column clarity, sea surface (wind-induced wave parameters) and ice cover condition. It is well known that operational ice data is of great importance for navigation and drill personnel. When ships are ice-bound (**see Fig 2.15**) and drill platforms or pipelines are cut off by ice, sea oil pollution is inevitable. In the former USSR airborne ice reconnaissance was performed during the period November – April every decade. However, those activities were insufficient since the ice edge (fast ice) in the Caspian Sea dislocates for more than 100 km during several days
(**Fig. 2.16).** Now a day the ice reconnaissance is not performed in usual mode. Airborne and helicopter ice reconnaissance is often being replaced by satellite image analysis.

As for coastal objects, the Astrakhan Reserve provides the most consistent environmental monitoring. It provides the combination of in-situ and remote sensing monitoring and relies heavily on remote sensing data of all wavelength bands and spatial resolutions. In recent years the cadastral centres and the EMERCOM centres are involved in monitoring activities as well. These centres are engaged in constructing a regional GIS for the Astrakhan Region. The test sites have been chosen in near the Astrakhan gas-condensate field, Ilmen-Bugrovoy Reserve, and Gandurinsk fish bypass channel.

Fig.2.15: A ship frozen into ice [5]

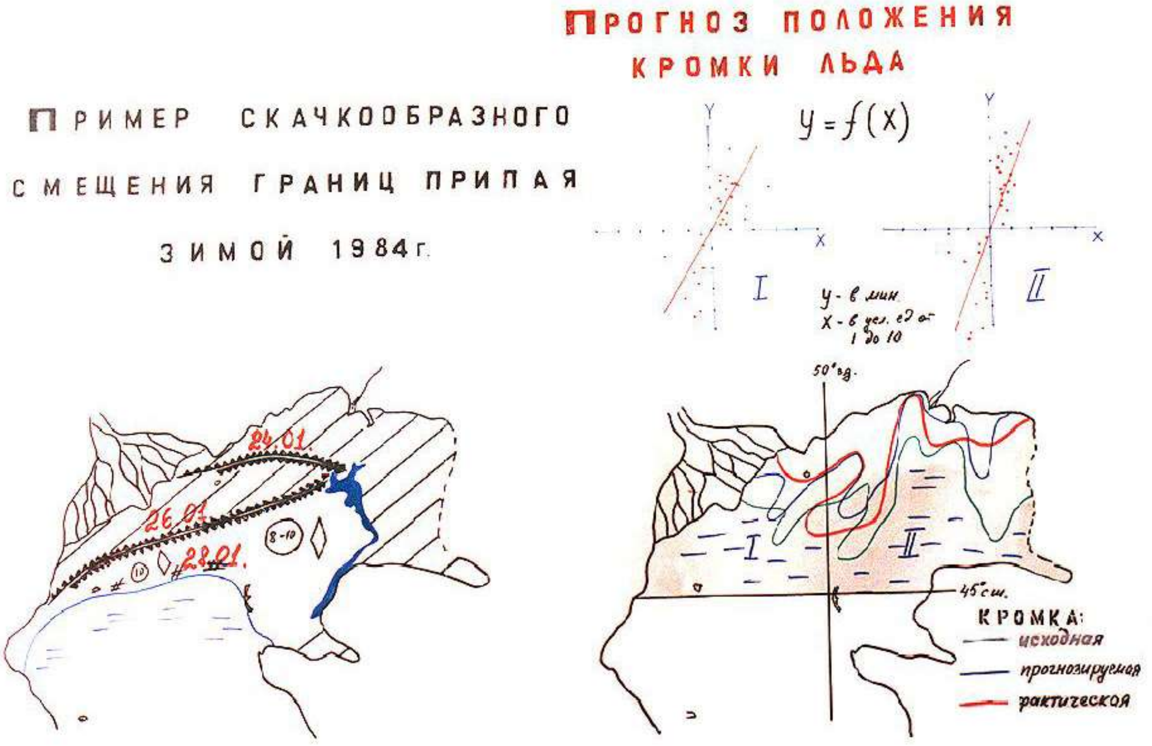


Fig.2.16: An example of discontinuous fast ice boundary displacement [5]

In 2004-2005 the powerful tools for improving the efficiency of the Caspian environmental monitoring should appear and be put in operation.

They are:

- the joint Russian/Ukraine SICH-1M spacecraft equipped with radar sensor (see **Table 2.4**),
- MONITOR spacecraft with multi-band optical equipment having 25 m resolution in 200 km swath width, and 8 m resolution in 80 km swath width in a panchromatic imaging mode,
- Meteor-M (**Table 2.5**)
- and RESURS-DK (**Table 2.6**) spacecraft with 1 m spatial resolution in panchromatic mode and 2-3 m resolution in narrow spectral bands.

Consumer	Rosaviakosmos & NKAU
Mission	To acquire remote sensing data in optical, IR and microwave regions
Payload	MSU-EU1/MSU-EU2 multi-band scanning instrument of high resolution: 3 spectral bands over the range of 0.5 – 0.9 µm, scanned area - 800 km, swath width of a scanner - 48 (63) km, two scanners – 80 (105) km, resolution – 24x34 (34x66) m at nadir (at the edge of scanned area) respectively. MSU-M multi-band scanning instrument of low resolution: 4 spectral bands over the region of 0.5 – 0.9 µm, swath width - 2000 km, resolution – 1.5 (1.8) km at the centre (at the edge) of the line respectively. RLSBO side-looking radar: operating wavelength – 3.2 cm; swath width: 450 km – standard, 700 km – wide; resolution: 1.7x1.3 (2.4x0.7) km at the beginning (at the end) of standard swath width, 2.8x0.7 km – for the end of wide swath width. RM-08 scanning radiometer: is designed to be used in conjunction with RLSB, operating wavelength – 0.8 cm, swath width - 550 km, average resolution within the swath - 25x25 km. MTVZA-OK module for temperature and humidity sounding of atmosphere: 4 bands in visible (0.37 – 0.78 µm), 1 band in IR (3.55 -3.93 µm), 11 bands in microwave regions (6.9 – 183.3 GHz); swath width - 2000 km; resolution in visible and IR regions – 1.1x1.1 km, in microwave range – between 112x260 and 8x19 km; the module has its own memory. “Variant” scientific equipment consists of: WZ-1 wave sounder (2 items), ZF Rogovsky belt, EZ electric sounder (4 items), FC Faraday cylinder (2 items), FZM magnetometer.
Ground segment for data acquisition and processing	The main centers for data acquisition and processing: Dunaevtsy (the Ukraine), Moscow, Obninsk. Novosibirsk (Russia), as well as RTsPODs and APPI.
Scheduled beginning of in-flight tests	2004

Table 2.4: SICH-1M Spacecraft Main Characteristics

Consumer	Rosaviakosmos, Roshydromet, Russian Federal Ministry of Defense
Missions	- Acquisition of multi-band images including radar ones, and measurements of the “Earth’s surface – atmosphere” system outgoing radiation in various regions of energy spectrum; - Obtaining of heliogeophysial data; - Acquisition and transmission of data from DCPs of different types (ground, ice, drifting)
Payload	1. MSU-MR Multi-band scanner of low resolution (2 packages, one package runs continuously): - resolution – 1000 m; swath width - 2800 km; spectral bands - 6: 0.5-0.7; 0.7-1.1; 1.6-1.8; 3.5-4.1; 10.5-11.5; 11.5-12.5 μm 2. KMSS Complex for multi-band spectral imagery of medium resolution has 3 cameras: - resolution - 70 m; swath width when 2 cameras run concurrently - 1200 km; spectral bands -4: 0.45-0.50; 0.535-0.575; 0.63-0.68; 0.76-0.90 μm 3. “Severyanin-M” Onboard radar complex (BRLK): - low resolution – 0.7-1.0 km; medium resolution – 0.4-0.5 km; swath width - 450 km 4. MTVZA Microwave radiometer: - horizontal resolution - 10-100 km (is channel dependent); vertical resolution - 4-5 km; channel number - 26; spectral range – 18.7-183.31 GHz; swath width - 2000 km 5. IKFS-2 Fourier spectrometer - resolution - 35 km; swath width - 2500 km; spectral range - 5-15 μm 6. RADIOMET Radio transillumination equipment: - atmospheric temperature error - 1°K; atmospheric pressure error - 3%; discreteness of measurement points by height – 1 km 7. GGAK-M Heliogeophysical equipment: MSGI-MKA spectrometer, SKL-M spectrometer, GALS-M detector, RIMS-M mass-spectrometer, IKOR-M advanced short-wave back-scattered radiation meter - electron and proton flux density measurements, atmospheric ion composition determination.
Ground Facilities for Data Acquisition and Processing	NTs OMZ’ Data Acquisition and Processing Complex; Roshydromet’ Ground Segment for Data Acquisition and Processing; APPI and MPPI network of Rosaviakosmos, Roshydromet, Moscow Region of Russian Federation, Roshydromet’ DCP network, Moscow Region of Russian Federation, and others.
Scheduled Start of In-Flight Tests	The 4th Quarter, 2005

Table 2.5: “METEOR-M” Spacecraft Main Characteristics

Information Density Figures

Resolution on ground, m	
In panchromatic range In narrow spectral ranges	No worse than 1 2.0-3.0
Scan width (at nadir), km Scan width when spacecraft turns away by roll, km Swath width, km	from 4.7 to 28.3 Up to 40 448
Spectral bands, µm panchromatic three narrow spectral bands	 0.58-0.8 0.5-0.6 0.6-0.7 0.7-0.8
Number of spectral bands read at one time	1-3

Table 2.6: "Resurs-DK1" General Characteristics

Comparison of Optoelectronic Equipment Characteristics for Different Remote Sensing Spacecraft

Spacecraft name Parameters	"Resurs-DK1"	"Ikonos"	"Quick Bird"
Resolution, m Panchromatic range (pixel) Spectral range	 0.79 2–3	 0.8 4	 0.61 2.44
Scan width, km Panchromatic range Spectral range	 28.3 28.3	 11 11	 16.5 16.5
Performance, pixel/s Panchromatic range Spectral range	 8.4·108 10.2·108	 1.05·108 0.2·108	 2.1·108 0.4·108
Relative scan width (relative to "Resurs-DK1")	1	0.38	0.58
Relative performance (relative to "Resurs-DK1")	1	0.122	0.244
Relative resolution (relative to "Resurs-DK1") Panchromatic range Spectral range	 1 1	 1 2	 0.78 1

"RESURS-DK1" having approximately the same resolution on ground exceeds "Ikonos" and "Quick Bird" instruments regarding

- Scan swath – by a factor of 2.5–1.3
- Daily relative performance – by a factor of 8–4

When the above satellite systems will be put in operation, the possibility of all-weather observation of the water areas with reduced roughness will be significantly increased. The data on the upper water column clarity, ice cover condition, floods, fires; agricultural lands may be obtained with the required spatial resolution and delivered to consumers within 1-3 hours after imaging. The promising Russian RESURS-DK1 spacecraft having a wide swath width will enable a repeated imaging of a region more often than from those as IKONOS or QUICK BIRD. The domestic satellite component of land cover monitoring will be feasible.

II. 6 Cost efficiency analysis of satellite monitoring

Cost efficiency of the Caspian Sea satellite monitoring is analysed by comparing satellite monitoring costs with those of ground-based (in-situ) monitoring.

1. Ground-based oil slicks monitoring requires a service consisting of approximately 10 high-speed sea vessels to observe the environment at roadstead, near oil fields, along pipelines and navigation routes, and in fishing areas (such survey takes place in Norway Sea and Barents Sea). Supervisors should be nominated for each vessel, timber ship, container ship, tanker, and ferry. Taking into account the current cost of the vessel rent and costs for monitoring operations, the total cost of ground-based monitoring will constitute some 2 million roubles per day (app. 700 thousand USD daily). The observation of the water areas of Caspian Sea where oil spill occurs frequently requires about 20 series of radar, visible, and IR multi-band 100x100 km images of up to 30 m resolution per day. Under assumption that the cost of an image is about 3-5 thousand roubles for governmental, scientific and environmental services, the total costs for satellite monitoring component will constitute 200-500 thousand roubles a day. Besides, to validate oil patches detected by satellite data the in–situ measurements and observations with the help of helicopter service are required. A rent for helicopter operation over sea is approximately 50 thousand roubles per hour. The flight cost of helicopter is approximately 500 thousands roubles (17 Thousands USD) if we take average figures for flight distance (1000 km) and flight speed 200 km/hour.

Our experience gained in the Caspian Sea pollution monitoring, shows that the detection of the polluted oil fields doesn't happen every decade. It could be related to a low activity of large-capacity ship traffic in the centre of the sea. In oil-producing regions in particular in the Paterson archipelago, oil escapes steadily. From the above estimates it follows that **the cost of satellite monitoring** together with helicopter component testing in situ pollution **is two – three times lower than those of vessel monitoring**. In addition, vessel monitoring is available exceptionally in daylight and under calm sea conditions. The radar satellite data that detect the patches of the reduced sea-surface roughness (the most important indicator of oil spill) are free from the above restrictions. The penalties and fines may partly compensate the costs for monitoring. This practice takes place in the developed countries. The penalty charge is imposed on ship-owners and oilmen who don't comply with the ecological standards of environmental services. These fines could be up to millions dollars. We would like to stress the point that vessel monitoring and satellite monitoring should be used in combination. For example, the vessel monitoring (in Norway Sea and Barents Sea) is combined with checking of quotas on catching, factual fish yields, fishing instruments, etc.

2. The use of satellite data for ice cover monitoring has strong justification. As it was mentioned above, operational ice cover data is of great significance for navigation and drill personnel. According to safety requirements the ice reconnaissance should be done every decade. Since a rent for helicopter operation over sea is approximately 50 thousand roubles per hour, the current cost of a single ice reconnaissance of the North Caspian Sea is close to 500 thousand roubles. Besides, airborne ice reconnaissance has some weather restrictions. Radar ice imaging may be done without care on weather conditions and daytime (**Fig. 2.17**). Satellite data on ice cover allow adapting the reconnaissance routes and excluding from the flight routes the wide areas where floating ice and hummocking appear rarely. Last winter in 2003-2004 the North Caspian Sea was free of clouds every week and even the METEOR, NOAA, and TERRA data showed no floating ice (except for original forms of ice being of no hazard to ships) along sea routes. The costs for acquisition of the above-listed satellite data are minimal (under 30 thousand roubles per a season). Thus, 5-8 million roubles have been saved during the Caspian Sea ice reconnaissance actions in winter of 2003-2004 due to reasonable cost of the radar data. We stress again that satellite images alone including radar ones cannot substitute completely in-situ ice reconnaissance. The information on ice hummocks, for example is difficult to extract only from satellite data. Besides the airborne reconnaissance could very helpful in calculation of the wild animals on ice and in tracking poaching.

3. The national fishery branch needs the forecast with regard to time and route of fish migration to spawn and back to the South Caspian Sea in autumn. Such forecasts are based on the maps of SST and upper water column clarity, which are an indicator of the North Caspian Sea fresh and salt-water distribution. The acquisition of such data by ground

facilities requires two-week operation of the three fish research vessels per year. The cost of this operation is 1-3 million roubles. The cost of satellite data used to produce maps of SST and upper water column clarity during the period of 3-5 days doesn't exceed 10 thousand roubles. The aggregate costs of the producing the necessary information based on satellite data are about 150 thousand roubles.

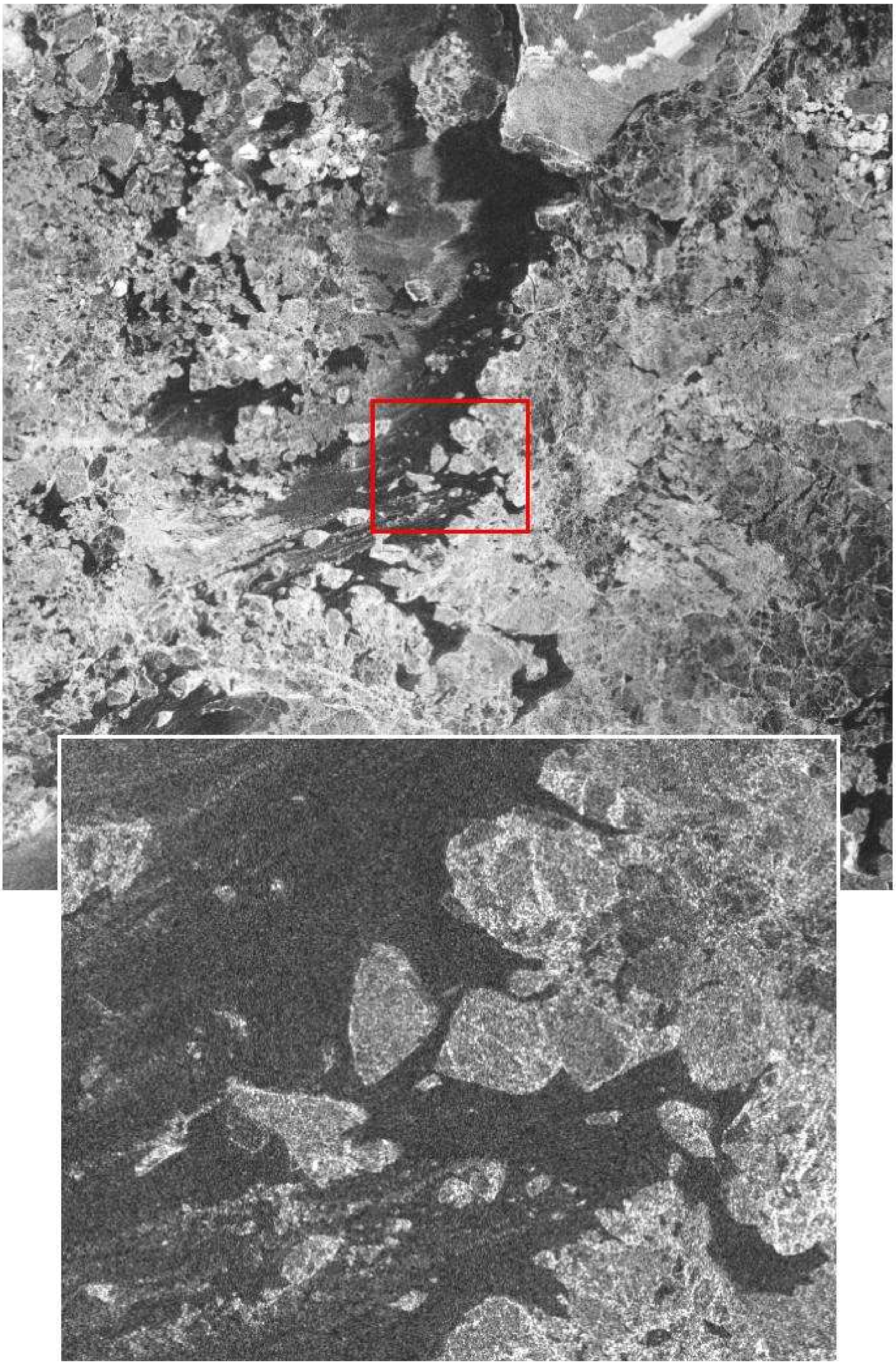


Fig. 2.17: RADARSAT radar image of the Caspian Sea ice cover, 13 January 2003. The enlarged sub-image has a pixel size of 25 m [23].

II. 7 Data policy of Russian Federal Space Agency (ROSAVIAKOSMOS) on supplying the Caspian Region end users with satellite data

The policy of remote sensing data distribution and utilisation in Russia as well as all over the world has two trends:

- A commercial trend implies acquiring and using data of very high spatial resolution (1-2 m and better (RESURS-DK));
- Non-commercial trend implies acquisition, storage, analysis, and use of the following remote sensing data:
  - Multi-spectral data of low, medium and high spatial resolution in all spectral bands ranging from ultraviolet to microwave;
  - Data of atmospheric sounding and near space monitoring in the interests of research activities and practical applications (METEOR-3M, SICH-1M, MONITOR-E).

All favourable conditions, scientific and industrial potential for further development of both trends for remote sensing data are available in Russia. The intensive cooperation with foreign countries in the field of remote sensing data takes place as well.

The Data Policy of Federal Space Agency (**ROSAVIAKOSMOS**) relies on public interests stated in legislative acts and regulations. The examples of these acts are given below.

- Federal Space Activity Act of 20.08 1993, №5663-1 with regard to the Acts supplements of 29.11.1996, №147-FZ, of 10.01.2003, 05.03.2004.
- The Russian Federal Information and Information Protection Act of 20.02.1995, №24-FZ.
- Regulation on the Russian Federal Archive Fund approved by Decree of President of RF of 17.03.1994, №522.

Consumers (end users) of satellite data products may be classified into the following categories:

- The Russian Federal ministries and departments, research bodies;
- Users with special permission from the Federal Space Agency;
- The Russian Federal Bodies with federal funding (including Russian Academy of Sciences, EMERCOM);
- The Russian Federal commercial enterprises;
- The Russian and foreign organizations involved in implementing of research and commercial projects over foreign territories;

Satellite data cost is different for different categories of consumers in Russia and abroad and is estimated using various principles based on the possibility of reducing costs for domestic consumers. These principles could be briefly characterised in the following way:

- For the Russian Federal consumers having state contracts the data price is fixed by data generation, duplication, and dissemination cost;
- For consumers whose activities are being done within the framework of the FKA permission, FKA-signed international agreements, joint programs, the data price is the same as above plus a minimal profitability and VAT;
- For the Russian Federal Bodies with federal funding such as RAN, EMERCOM and others) implementing governmental programs and agreements (without commercial profit), the data price is estimated as above with adding the possibility to receive discount;

- For the Russian consumers of image data taken over the Russian territory within the limits of commercial orders, the data price contains profitability, (which should not exceed 15% of the cost value and VAT);
- For consumers of image data on foreign territories when performing the commercial contracts, the price calculation is based on similarity estimation with data from foreign spacecraft of similar missions and characteristics with correction factors that show a comparative and actual quality and value of Russian satellites and onboard instruments;

The listed above principles give a possibility to sell data at reduced prices including cost compensation for data retrieval from archive, copying, media, transfer in case of repeat or regular requests for archived data.

Let us consider as example the Data Policy with regard to the Caspian Region regional users. The consumers of satellite data products of the Region are regional authorities, Hydro meteorological Service, the Caspian military flotilla, EMERCOM, cadastral centres, fishery industry (KaspNIRKh), environmental entities (the Reserve in the Volga delta), LUKOIL and KNK oil companies. Satellite monitoring centres have been established in Astrakhan and Elista. The establishment of a small acquisition centre in Makhachkala is under negotiation.

The data from geostationary satellites, METEOR-3M, NOAA, TERRA, and AQUA polar-orbits are the major data being supplied now. In 2004-2005 consumers will be provided with SICH-1M, MONITOR-E, RESURS-DK data as well. Under the Data Policy the regional receiving stations acquire data from METEOR-3M №1, SICH-1M free of charge. Considerable data flows of high- and very high resolution (MONITOR-E and RESURS-DK) will be acquired at NTs OMZ (Moscow) an in the centre of Khanty-Mansiisk and transferred to consumers by request. The European ERS-2 data are acquired at NTs OMZ but may be transmitted to consumers exclusively on the agreement with the European Space Agency. The foreign LANDSAT, ERS, ENVISAT, SPOT data of high resolution and especially the IKONOS and QUICL BIRD data of very high resolution are not available to Russian consumers on an operational basis because of high prices, particularly to organisations with federal funding.

As to new space technology and new remote sensing instruments, the Federal Space Agency will make wide use of small satellites. An important point is that the information flow from this kind of spacecraft will exceed those of current large spacecraft. A composite nature of space data will allow a wide range of consumers to use them. Here the users might be: different ministries, departments, and Federal services as well as others.

In Russia the ground-based infrastructure for space data acquisition processing, archiving, and use is being re-arranged and re-constructed (see **Fig. 2.18**).

The Moscow Federal Centre for Earth Remote Sensing (Centre for Earth Observation from Space, Research Centre for Earth Operative Monitoring), of Federal Space Agency follow a unified public policy in remote sensing system exploitation, space data acquisition, processing, archiving, and delivering to consumers (**Fig. 2.18**). The Centre exploits all Russian existing remote sensing space systems, co-ordinates the operation of the other centres, carries out a metrological control of space data quality, and provides all categories of consumers with satellite data. The standby remote sensing data acquisition centre is in Khanty-Mansiisk (West Siberia) is intended to provide an operational delivery of medium- and high-resolution data, the data acquisition and dissemination to departmental receiving centres (EMERCOM, MPR, ROSHYDROMET), regional receiving centres (Rostov, Astrakhan, Elista, Makhachkala, and others), and small receiving centres.

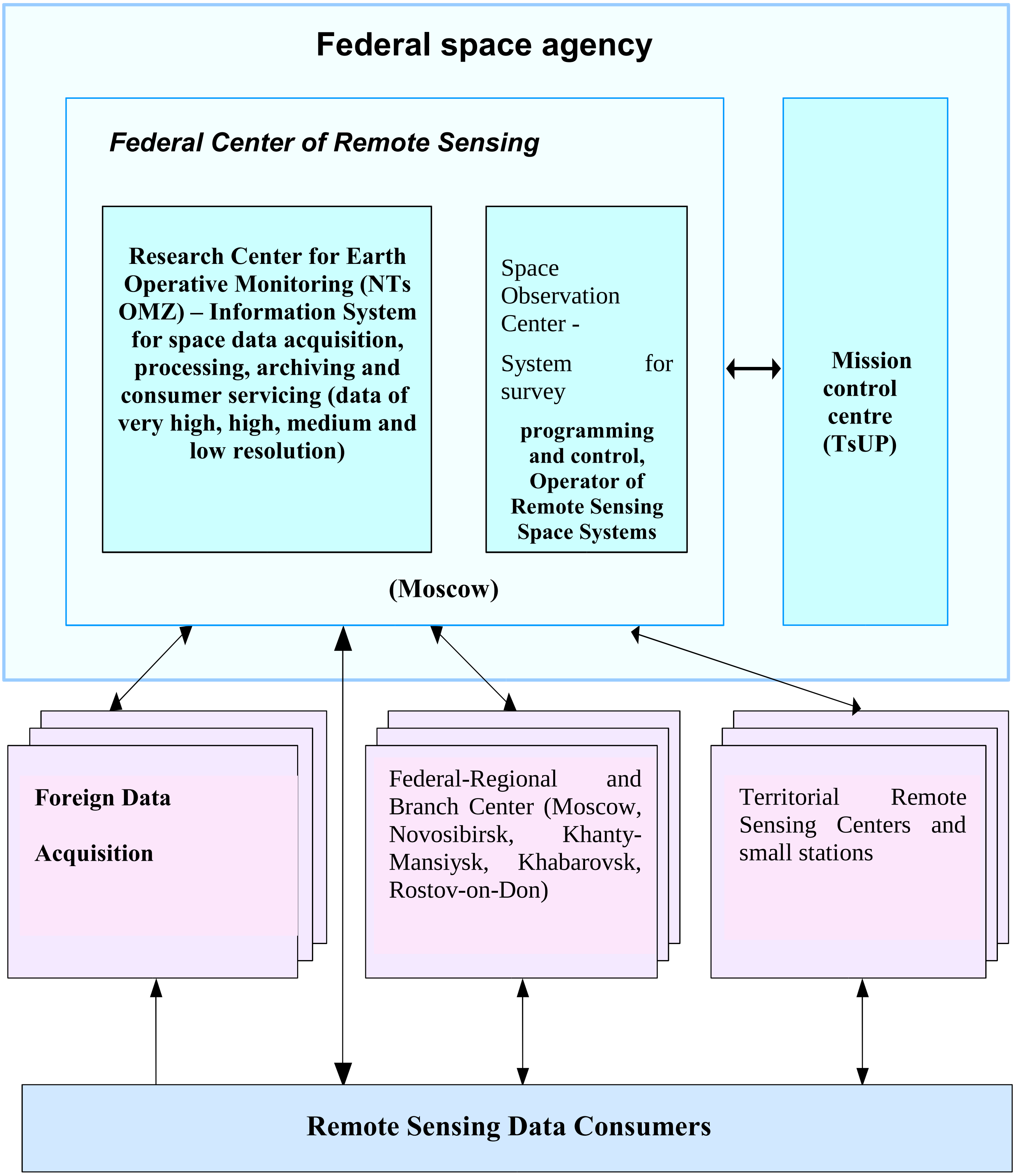

Federal space agency
Federal Center of Remote Sensing
Research Center for Earth Operative Monitoring (NTs OMZ) – Information System for space data acquisition, processing, archiving and consumer servicing (data of very high, high, medium and low resolution)
Space Observation Center -
System for survey
programming and control, Operator of Remote Sensing Space Systems
(Moscow)
Mission control centre (TsUP)
Foreign Data Acquisition
Federal-Regional and Branch Center (Moscow, Novosibirsk, Khanty-Mansiysk, Khabarovsk, Rostov-on-Don)
Territorial Remote Sensing Centers and small stations
Remote Sensing Data Consumers

Fig. 2.18 Russian Ground Information System for Space Environmental Monitoring

a) II.8 Conclusions

Fish resources and diversity of some populations of species are the important indicators of the ecosystem in the Caspian Region. The regional and planetary climate changes are responsible for sea level variations. The last water level rise of 2-3 meters late in the 20th century resulted in the degradation of fish living conditions including spawning conditions in shallows. It happened because newly flood-affected land areas - shallow spawning grounds, were brought to places with salt-affected soil. The man-made impacts on Caspian Sea environment resulted in the loss of sturgeons.

Among negative factors affecting the Caspian Sea ecosystem are the following:

- Predatory off-shore net and trap fishing (prohibited in 1964);
- The Volga flow regulation by dams. Building of the Volgograd dam, reduced by seven to ten times the sturgeon spawning grounds area. The volumes and time of water evacuation from reservoirs are not appropriate to a natural cycle of fish spawning. Such nutrients as silicon, phosphorous and nitrogen deposit or turn into organic matter in reservoirs.
- Ballast water or crude waste waters discharge especially from tanker fleet. It led to fish ecotype degradation. In the sixties the thickness of black oil layer was 15-20 cm in the waters of ports and oil fields. When in 1968 the USSR Council of Ministers adopted the Regulation on the prohibition of ballast water discharge from oil ships, this kind of pollution was not any more observed.

The environmental parameters to be monitored by satellite remote sensing, as showed above, are the following:

- Sea surface condition;
- Sea surface temperature;
- Upper water column clarity;
- Ice cover.

The analysis of these environmental characteristics enables detecting of probable appearance of areas of surface-active oil slicks, oil products and other pollutants on the sea surface. The in-situ testing of detected on a base of space data pollutions requires a ground monitoring service. This service will test pollutions using high-speed sea vessels and provide regional authorities with information on man-made pollutions.

Today the Caspian Sea environment is monitored using the METEOR, NOAA, TERRA, and AQUA instruments. The capacity of the Caspian Sea satellite monitoring based on domestic space sensors will increase when the following prospective instruments will be put in operation:

- SICH-1M spacecraft equipped with radar,
- MONITOR spacecraft with multi-band optical equipment having 25 m resolution in 200 km swath width, and 8 m resolution in 80 km swath width in a panchromatic imaging,
- and RESURS-DK spacecraft with a 1 m spatial resolution in panchromatic mode and 2-3 m resolution in narrow spectral bands.

The cost efficiency analysis of satellite data to provide the oil pollution indication, ice and fishery reconnaissance has shown that a satellite-monitoring component is independent from weather conditions, more operational and less expensive than the ground component. The combination of satellite and ground monitoring components should give significant results for the Caspian Sea monitoring. The ground-based monitoring has particular benefits. For instance, airborne reconnaissance could be helpful in counting the wild animals on ice and in poaching supervision.

List of Abbreviations to Chapter II

AVHRR - Advance Very-High Resolution Radiometer
CIS – Commonwealth Independent States
EMERCOM - Russian Emergency Committee
GOIN – State Oceanography Institute
IO RAN – Institute of Oceanology
IR – Infrared wavelength band
IWP – Institute of Water Problems
KaspNIRKh – Caspian Research Institute of Fishery
MPC – Maximum permissible concentration
MPR - Russian Ministry of Natural Resources
MSU-E — Multi-band optical-electronic scanner of high-resolution
MSU-M — Multi-band scanner of low resolution
NTsOMZ – Research Centre for Earth Operative Monitoring
RAN – Russian Academy of Science
RLSBO – Side-Looking Radar
ROSHYDROMET - Russian Federal Service for Hydrometeorology and Environmental Monitoring
SST – Sea Surface Temperature
TV – Television (visible) wavelength band
USD – United States Dollar
USSR – Union of Soviet Socialist Republics
VAT – Value Added Tax

b) References to Chapter II

1. Aladin, N.V., Plotnikov, I.S. (2000): Event chronology of the XX century that had an impact on exploitation of fish and other biological resources, and on exploitation oil and gas and other mineral resources. - Vestnic Kaspiya, 5(25): pp. 76-85.
2. Babaev, F.R. (1997): Possible ways of the Caspian Sea oil pollution. - Ecosystem and Caspian Sea Environment – Proceedings of Hydrometeorology and Environmental Control Center, Dagestan, 1: pp. 22-26, Makhachkala.
3. Baitulin, I.O., Ogar, N.P. (1997): Pollution sources of the Caspian Sea and coastal zone and their contribution to ecological characteristics and sea biological productivity degradation – the Caspian Sea Ecosystem and Environment – Proceedings of Hydrometeorology and Environmental Control Center, Dagestan, 1: pp. 146-149, Makhachkala.
Buzinov, B.I., Makarova, M.G., Skaryagin, V.D. (1997): The fundamentals of environmental remote sensing – Izd. of RUDN, p.102, Moscow.
5. Bukharitsin, P.I.: The Caspian Sea ice study — http://www.ecoline.ru/books/ed_catalogog/chart4/html.
6. Gargopa, Yu.M/ (2003): The large-scale changes in hydrometeorological conditions of the Azov biological productivity formation. Author's abstract: 46 pp., Murmansk.
7. Hydrometeorological Center of RF – http://hmc.hydromet.ru/.
8. Gumbatov, A.I. and Mamedov, R.M. (1989): Impact of physiographic factors on wastewater dissemination in Apsheron. – Izvestiay of AN of Azerb.SSR, Ser. nauk o Zemlye, 6: pp. 93-100.
9. Diarov, M. (1997): Assessment of relative ecological risk and possible damage of the North-East Caspian Sea. – Proceedings of Hydrometeorology and Environmental Control Center, Dagestan, 1: pp. 160-164, Makhachkala.
10. Ermoshkin, I. (2003): The Caspian Sea oil pollution. – ARCREVIEW, ДАТА+, 4, 16 pp.
11. Zomorrdian, X, Sheikholaslami, M.R. (1997): The Caspian Sea: a trend in the Environment and its stability, aspects of national priorities and strategies. – Proceedings of Hydrometeorology and Environmental Control Center, Dagestan, 1: pp. 133-145, Makhachkala.
12. Personal contractor design № 471 to sink an exploratory well № 3 of the Yu. Korchagin Deposit. Volume "Environmental Control", Appendixes, NF Ekotsentr "MTEA", 2002, Moscow.
13. Application of information technologies to the Caspian marine and coastal ecosystem management. Data from Integrated Management of the Volga-Caspian Environment, UNEP/TsMP, 2000, p. 26, Moscow.
14. The Caspian Information Center http://www.caspinfo.ru
15. Mamieva, I.D., Glazovsky, V.A., Atamuradov, X.I. (1997): Pollution sources of the Turkmenian section of the Caspian Sea - Ecosystem and Caspian Sea Environment – Proceedings of Hydrometeorology and Environmental Control Center, Dagestan, 1: pp. 87-90, Makhachkala.
16. Mukhamedzhanov, M.A. (1997): The Environmental control problems while marine oil operations in the North-East Caspian Sea shelf (the Kazakhstan section). - Ecosystem and Caspian Sea Environment – Proceedings of Hydrometeorology and Environmental Control Center, Dagestan, 1: pp. 71-76, Makhachkala.
17. Lyushvin, P.V., Tretiyakov, A.V. (2003): Inland reservoir satellite monitoring. - All-Russian Congress of Water Management Workers, Report theses, Moscow, pp. 148-149.
18. Pakhomov, L.A., Lyushvin, P.V., Chernyavsky, E.B. (2004): Taking into account the distorting atmospheric effect when estimating the albedo and surface temperature of the Caspian Sea using NOAA AVHRR data. – Issledovaniye Zemli iz Kosmosa, not published.
19. Postavik, P.V. (1997): An accidental oil spill at the Dagestan coast of the Caspian Sea occurred on 29 September 1973. - Ecosystem and Caspian Sea Environment – Proceedings of Hydrometeorology and Environmental Control Center, Dagestan, 1: pp. 101-106, Makhachkala.
20. Sapozhnikov, V.V. (2000): Current state of the Caspian Sea ecosystem and scenario of further event development. – Caspian Floating University, Scientific Bulletin, 1: pp. 64-71, Astrakhan, KaspNIRKh.

21. Sapozhnikov, V.V. (1997): Current state of the Caspian Sea ecosystem and scenario of further event development. – Ecosystem and Caspian Sea Environment – Proceedings of Hydrometeorology and Environmental Control Center, Dagestan, 1: pp. 52-59, Makhachkala.
22. Saipulaev, I.M., Gadzhiev, M.K., Dibirov, M.G. (2003): Problems of interstate apportioning of water in the boundary Samur River basin. – All-Russian Congress of Water Management Workers, Report theses, Moscow, pp. 94-96.
23. ScanEx - http://ckanex.ru.
24. Chuikov, Yu.S. (1997): Sustainable development and environmental safety in the Volga delta and Volga-Akhtubinsk flood-plain. - Ecosystem and Caspian Sea Environment – Proceedings of Hydrometeorology and Environmental Control Center, Dagestan, 1: pp. 38-46, Makhachkala.
25. Shagidullin, R.R., Trofanchuk, V.M., Tarasov, O.Yu., Petrov, A.M., Igonin, E.I. (2003): Econanalytical monitoring in Tatarstan. – All-Russian Congress of Water Management Workers, Report theses, Moscow, pp. 257-261.
26. Environmental Policy of LUKOIL Company in the Caspian Sea, Volume 1, The environmental conditions while exploration work in the Khvalynskaya structure in 1997-2000, Astrakhan, 2000, 133 pp.

III. Oil Spill Monitoring in Khanty-Mansijsk Autonomous Okrug (KMAO)

This chapter comprises the results of ecologic and socio-economic analysis that has been done with the aim to assess the damage of oil spills to both environment and human health. This particular anthropogenic load is a dominant in the regions of oil production and transportation. Much attention is paid to the existing and prospective systems of ground-based and space monitoring of oil spills. At the end of the chapter a scenario for assessment of ecological and socio-economic benefits of the regular space monitoring of oil spills, being developed within GMES, is given.

There is still no system of operative monitoring of local oil spills caused by pipeline and multiple well platforms faults on the territory of **KMAO** which would allow precise estimation and documenting of an accident site and duration of the accident event, amount of oil spilt, polluted site area and pollutants' streams into the atmosphere, soil and water.

The data on quantitative characteristics of oil spills marked in this chapter as "official data" is mainly based on statistics given in the reports of oil and gas production companies. Lack of proper operative oil spills monitoring system, results in:

- on one hand, doubts of "independent experts and state control services representatives" about reliability of the information on oil spills given by oil companies,
- and, on the other - leads to very uncertain quantitative estimation of oil spills ecologic and socio-economic damage, which can lead to unjustified legal administrative actions from the side of state control bodies to oil companies.

Thus, the state management, ecologic control bodies and oil companies are interested in making the data on oil spills and environmental and human health damage assessment more objective, which is possible if a proper space and ground-based monitoring system, will be developed and put in operation. The legislative act of the **Government of KMAO** N 302-п of July 29, 2003 [1] on creation of such a system regulates the efforts being undertaken in the region in this direction. The GMES principles give a good practical guideline how to achieve the goal.

III.1 Historic information of oil production and transportation in the Khanty-Mansiysk Autonomous Okrug

The area of the Khanty-Mansiysk autonomous region is 534.8 thousand km2, what is almost equal to the territory of France. Total population constitutes 1401.9 thousands.

The economic potential of the Khanty-Mansiysk autonomous region is one of the top ten in the Russian Federation and it holds the first position in oil production, the second - in electric-power generation, and the third - in gas production. Extracted oil output constitutes 58 % of the gross oil production in Russia. In sectional structure of industrial production of the region the petroleum extraction industry constitutes 80.5 %, power industry – 12.6 %, gas-processing industry – 5.6%, wood and wood processing industries – 0.4 %, building materials production – 0.4%.

There are immense resources of hydrocarbons, fresh and mineralised underwater. On the eastern slope and in the piedmonts of the Northern and Sub-polar Urals there are numerous deposits and prospects of minerals.

The oil production complex is the basis of the regional economy. During last decades, intensive exploitation of the natural resources has been accompanied by unprecedented environmental anthropogenic stress. Over 10 modern cities and dozens of small towns have been built, over thousand kilometres of railways and over 5 000 kilometres of roads, thousands kilometres of oil and gas pipelines, electric-power lines, etc. have been constructed.

That is why, the multifaceted problem of environmental stress monitoring can be considered for this region as a "representative example" of the common situation, existing at the moment in this field in Russia.

Fig. 3.1 presents the geographical location of the Khanty-Mansyisk Autonomous Region within the Northern Russia territory. The city of Khanty-Mansiysk is the regional centre and the UGRA Research Institute of Information Technologies (URIIT) is the leading organization, responsible for GIS and Remote Sensing applications development and for Rational Use of local Entrails.

Fig.3.1 The geographic position of the Khanty-Mansiysk Autonomous Okrug

At present, the Okrug is one of the major regions where raw hydrocarbons are being explored and produced; its contribution to annual Russian oil production makes more than 55%. The total oil amount produced from the beginning of commercial production of the pools on the territory of the Khanty-Mansiysk Autonomous Okrug had reached 7,574 mil tons by the beginning of 2003. There are 186 oil deposits with ongoing oil production [2]. Thus, in 2002, the oil companies of the Okrug produced 209.9 mil tons of oil, which is 57.3% of the total production volume of the Russian Federation and 5.8% of the total world oil production [3]. Oil production dynamics in KMAO and in Russia as a whole is shown in the **Fig.3.2** [3-10].

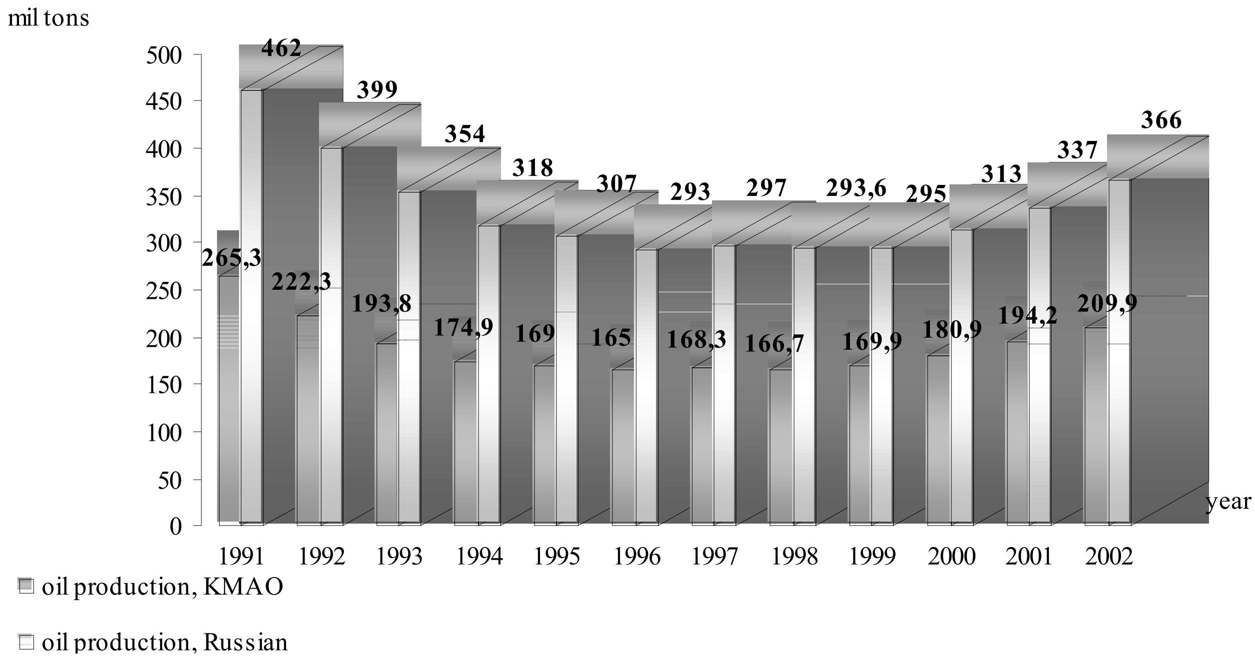


Fig.3.2 Comparative figures of oil production on the territory of Russia and KAMO

The increase of oil production volumes, putting into operation new hydrocarbons deposits and, as a result, the increase of pipeline transportation traffic requires more and more pipelines systems. It is necessary to take into account the fact that pipelines wear out very soon in the process of operation in remote Northern regions with severe environment and engineering-geological conditions. That is why they need recurrent renewal. Correlation between the total length of the pipelines in the Autonomous Okrug and the length of the pipelines, which require an urgent renewal (their lifetime determined by the official standards has already expired), is shown in **Fig.3.3** [3-12].

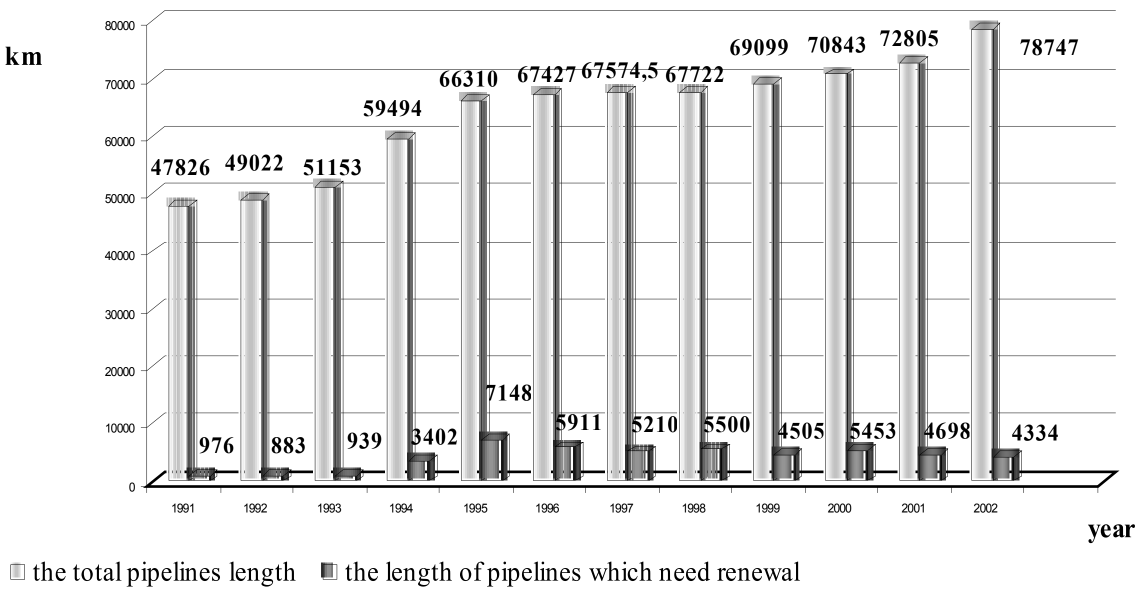


Fig. 3.3 Pipelines length in KMAO

III.2. Ecological, social and economic consequences of oil spill accidents

It is well known that the state policy of gas and oil deposits exploitation in the Khanty-Mansijsk Autonomous Okrug in 1960 – 1980 had met the requirement to achieve the **maximum oil production** as soon as possible with the **minimum extraction expenses**. Correspondingly, oil-field constructions were done with minimal possible expenses for high-volume pumping. There was practically no attention paid to environmental safety of the construction of gas-and-oil production objects. Measures for environmental security were mostly ignored and funding allocated for improvement of technological reliability of pipelines was in many cases just re-directed to other purposes. The first field pipelines outbreaks followed by significant oil spill accident happened soon after their construction. After 5-6 years of oil deposits exploitation, mass pipelines and oil-gathering systems began leaking due to acceleration in high-volume oil pumping. In fact, oil production companies did not concern themselves with elimination of ecological implications of the accidents. Some oil spilt in accessible places was pumped out; oil spills located in immediate proximity to oil field objects were covered with sand. Most of oil spills were left neglected or burnt off [13].

Ecological implications of oil ingress into environment depend on its component structure, its high mobility and ability to circulate between various components of the environment (including biota) and remain there for a long time [14]. Petroleum industry has a complex and concentrated impact on hydro-, litho-, atmosphere and biosphere, causing very often long and irreversible damage. Some of the consequences are the relief changes and soil erosion, the degradation of the vegetation cover, the air pollution and the deterioration of the underground water quality.

All these processes directly affect environmental conditions of the living organisms and cause observable decline in human health. In the regions of the most intensive emissions and discharges of the petroleum industry enterprises, the residents are noticed to have the higher incidence rate in tuberculosis, asthma, cancer, and also high infant mortality rate. The major reasons of the deterioration of the environmental conditions in the regions of intensive activity of the petroleum industry enterprises are the following:

- lack of proper technical control and support of the systems,
- depreciation and obsolescence of equipment,
- shortage of corrosion preventing agents.

In the years of the economic crisis in Russia, the number and scale of pipeline faults was significantly increased due to their depreciation and corrosion and the maintenance works were significantly decreased [15, 16].

The principal features of natural geo systems of the northern part of Western Siberia determining the conditions of penetration, spread and transformation of oil pollutions caused by accidents (and their consequences) in the regions of oil production are the following:

- predominantly sandy soils with low sorptive capacity and favourable conditions for pollutants penetration into the subsoil waters;
- significant water logging of the area and presence of a number of half-closed reservoirs which are characterized by low water rotation;
- widespread high-grade peat deposits which are a kind of geochemical barrier for diffusion of man-caused pollutants flow and a source of a wide range of natural organic compounds for the hydrosphere [14].

Dynamics of oil pollutants migration is mostly determined by interaction of the following ecological factors:

- multi-component structure, chemical and physical-chemical characteristics of oils;
- relief characteristics: complexity, heterogeneity composition and structure of any ecosystem which is in the process of constant change and development;
- variety and changeability of external environmental characteristics affecting the ecosystem.

Quantity and conditions of oil and oil products penetration into the environment and the distance from a discharge point are very important characteristics for oil pollution implications assessment.

As a whole, the structure of socio-economic consequences of oil spills can be represented by the following list:

<u>Social consequences:</u>

- increasing social tension among the population, living in the regions open to oil pollution;
- partial migration of the population into the towns and cities distant from pollution sources;
- life quality decrease (health deterioration, birth rate decrease, incidence rate increase, etc.)

<u>Economic consequences:</u>

- forest rehabilitation costs;
- water bodies rehabilitation costs;
- contaminated soil remediation costs, including second recuperation;
- animal and fish livestock reproduction costs;
- potential compensation costs for irretrievably lost ecological, social and resource functions of forests and water bodies;
- oil losses in the process of production and transportation.

III.3 Current and prospective monitoring of oil spill accidents in Khanty-Mansijsk Autonomous Okrug (KMAO)

III.3.1. Reasons and spatial-temporal characteristics of oil spills on the ground surface.

One of the main types of negative technological impacts of the petroleum industry on the environment is the oil spills accident and highly mineralised strata water spills. The major sources of environmental technological load are field and trunk pipeline communications. Their faults cause significant local oil pollution into soils and water. Number of annual pipeline faults is shown in **Fig.3.4** [3-12].

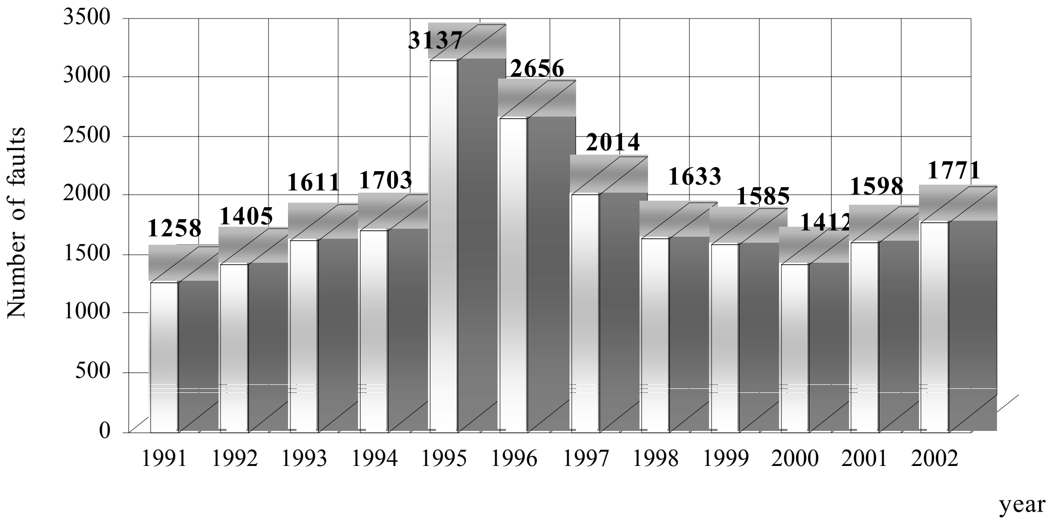


Fig.3.4 Number of pipeline faults in KMAO

The major reasons for the transmission pipelines faults are pipe corrosion, mechanical failure and construction defects. These reasons of pipelines faults (percentage of the total number of the faults) are shown in **Fig. 3.5** [3-12].

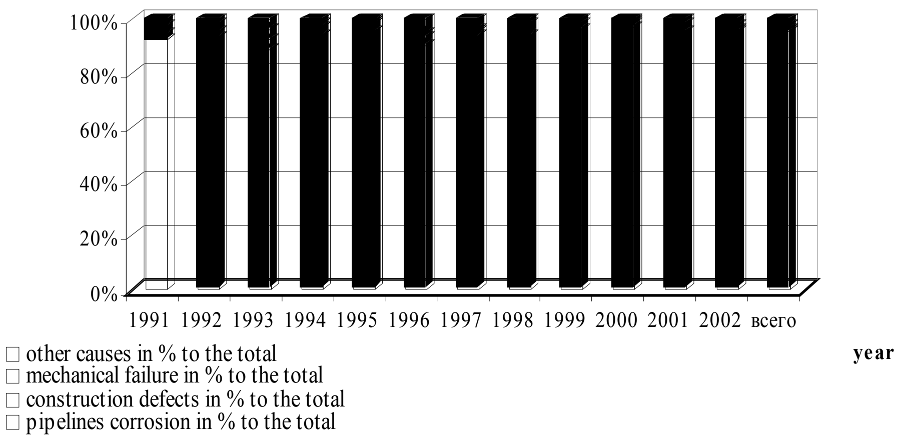


Fig. 3.5 Reasons of pipeline faults in KMAO

Oil pollution caused by a pipeline fault (depressurisation) differs from many other man-made impacts. It does not give a gradual environmental load but an immediate one. Today there is practically no possibility to foresee all necessary environmental measures along the whole length of pipelines which constitutes many thousands kilometres. For instance, the pipelines on the territory of the Okrug are very much worn out because many of them were built more than 20 years ago. Due to oil pipelines deterioration and high corrosion rate (severe northern environmental conditions), there is no good reason for optimistic forecast on significant decrease of oil spills number on the territory of the Okrug within the next few years.

Oil spills into rivers and inland water reservoirs are among the most dangerous kinds of environmental pollution. They are highly probable on water and mire areas, in places of oil pipeline crossings with rivers and reservoirs because pipelines are mostly laid in trenches at the bottom of the water bodies. Pipes depressurising may be caused both by inner defects (corrosion, joint opening, etc.) and outer effects. For example in those situations when the bed movement leads to pipeline uncovering and they break under non-steady-state flow pressure. In that case, there can be hundreds and even thousands cubic meters of oil spilt into the water environment. For instance, according to [17], in case of oil-trunk pipelines passages faults, oil emission into the Ob River can reach from 6 to 8 thousand tons, which will cause pollution over a 200 kilometres stretch of the riverbank.

Analysis of the surveys on environmental conditions in **KMAO** in 1996-2002, shows a stable high level of oil pollution (annual average concentrations exceed 10 maximum permissible concentrations for fish industry reservoirs) of small and medium rivers and the major water path of the regional territory – the river Ob, which is carrying the polluted waters into the Kara Sea. Thus, due to high migration speed of oil pollutions in the hydrosphere, the problem of local oil spills generates a serious ecological problem of a regional importance for the northern part of Western Siberia and potentially a global problem if we consider transition of oil and oil products to the Arctic Ocean.

According to expert estimation, about 30% of the total oil volume spilt in accidents penetrates into the water bodies [37]. There is a correlation of oil volumes penetrated into the water bodies and land sites (see **Fig 3.6**) that is based on the data on the total oil volumes incoming the environment [3-10,12].

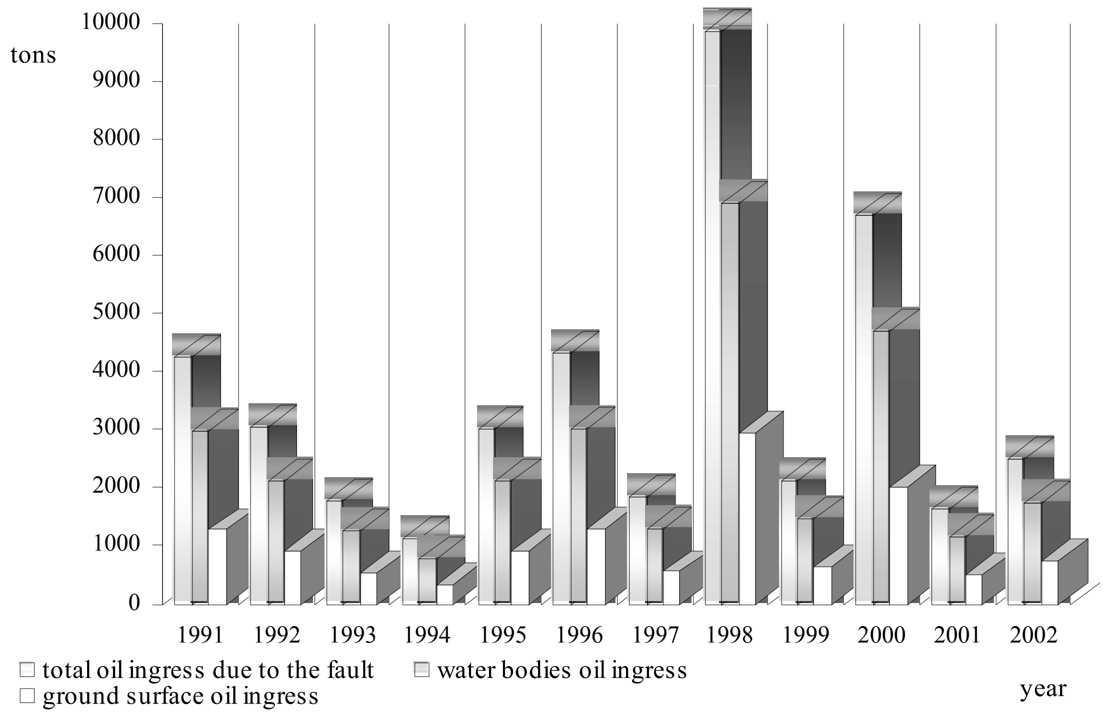


Fig. 3.6 Oil volumes ingress into the environment due to pipelines faults

According to official data, the average oil volume ingress into the water bodies reached 1,056 tons per year, and on the ground – 2,463 tons per year for the period of 1991-2002. Considering the land areas contaminated by oil spills according to the official data [3-10, 12] (see **Fig.3.7**) and oil volumes ingress to those lands, we can estimate that, on average, 1 ha of the ground surface is contaminated with 17.6 tons of oil.

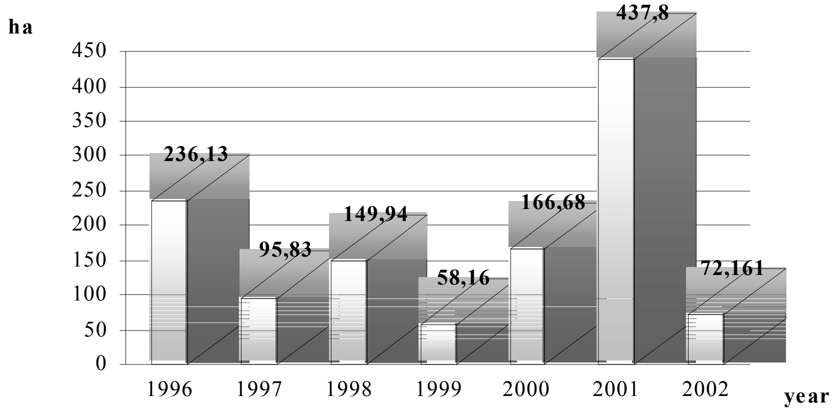


Fig.3.7 Land areas polluted by oil spills

As it was mentioned above, the statistic data on accident number on field pipelines, amounts of oil ingress into the environment and oil polluted land areas given by the oil companies can be significantly underestimated. In practice, the oil companies are not fast in reporting an accident to the state ecologic control and state management bodies hoping to manage oil spill themselves. This fact significantly prevents an emergency response in order to identify and eliminate the accident consequences.

According to various expert evaluations [18-33], about 3.5% of produced oil volume is lost in the processes of its production, preparation and transportation, which is, in average, 4,809 tons per year for **KMAO** during last 12 years.

III.3.2 Existing systems of ground-based and space monitoring of oil spills (Remote Sensing Methods for detection and assessment of oil polluted areas)

The following ground instruments are currently used by Environment Protection Board of the Khanty-Mansiysk Autonomous Okrug for the environmental oil pollution control:

1. KTC RMK-N – a portable radiometric complex. Detection and determination of oil film thickness and oil patch area on the water surface in the range of thickness from 0.2 mm to 12 mm. This method of oil film thickness determination on the water surface is based on dependence of the reflection coefficient of radio waves on mutually orthogonal polarizations on oil film thickness.
2. KT-3C - Oil film thickness determination on water and ground surfaces in the proximate oil spill area when it is necessary to assess volumes of pollutants. Its operation principle is bases on localization of the interfacial area by ultrasonic impulse.
3. APIN (autonomous station for oil indication):
    - measurement of mass concentration of oil dissolved in the surface waters;
    - detecting of threshold value exceeding of mass concentration of oil in the surface waters;
    - detecting of threshold value exceeding of mass concentration of dissolved oil;
    - automatic transmission of the measuring results by the radio channel into the processing centre.

Oil pollution indicator APIN is a highly sensitive impulse fluoriometer measuring fluorescence of oil in the ultraviolet spectrum, and is adapted for working in independent mode in a wide temperature range. Its threshold of sensitivity is 10 microgram per litre; dynamic range of measurements is up to 200 microgram per litre.

Space monitoring and mapping of oil polluted lands in the interests of Environment Protection Board of the Khanty-Mansiysk Autonomous Okrug is carried out on the basis of multi-timing analysis of both remote sensing and ground observations current and historic data in order to determine the tendency and intensity of changes in land cover conditions. The system is based on the principles of Geo Information Technologies.

The space images MSU-E from the satellite Resource-O-4 of 22.06.99, 02.06.2000 and 02.08.2000 on the territory of Nefteyugansk and Nizhnevartovsk regions of KMAO were used as test areas to debug the oil spills detection method. The satellite flight altitude was 650 kilometres; orbital inclination angle - 98 degree. The scanner MSU-E has a capture range of 45 kilometres and is able to survey the Earth surface in 3 spectral wavebands: channel 1 – 0.5-0.6 micrometer; channel 2 – 0.6-0.7 micrometer; channel 3 – 0.8-0.9 micrometer. The original images go through photometric correction and are georeferenced into Gauss-Kruger projection. The images are digital with spatial resolution 33 meters. The topographic maps of 1:100 000, 1:200 000, and 1:500 000 scales for the investigated territories were used as additional sources of information.

At the first stage of the data processing, the image coordinates were corrected because of insufficient spatial accuracy of the initial data. The spatial accuracy should be about 1 pixel, which is 33 meters in this case. Correction of the coordinates has been done with help ground control points with polynomials of the third degree in Arc View. The least-squares method was used for calculation of the conversion coefficients. The given technology of geographic reference provides necessary accuracy and allows receiving new information on the Earth surface condition when the thematic layers are superimposed onto the MSU-E images and the results of ground geochemical investigation taking from (GIS) are applied. The further image processing steps have been done with help of ENVI package, where

separate channels of the original images were merged in RGB image in the following way: R – channel 1, G – channel 2, B – channel 3 of the scanner.
This way synthesised images were used to identify hydrographic objects, forests, road network and industrial objects. The investigated territory is highly waterlogged. Within the mires there are lakes with stable shoreline. Petroleum industry objects are seen as light areas connected by communication lines and dumps; pipelines are seen as light straight lines. The road network can be well identified inside the forestlands and on waterlogged sites.
The vegetation cover analysis gives good discrimination to species diversity if the separate channels of the original images are synthesised in RGB in the following way: R – channel 3, G – channel 2, B – channel 1. The basic criterion for identification vegetation identification is, in this case, its biomass. As a result of the image classification procedure there can be identified deciduous and mixed (birch, aspen, pine-tree) forests, bush growth on the river and lake banks, forest bogs with suppressed vegetation, sparse growth of trees, and also reed, moss and grass vegetation in the flood-lands and waterlogged lands.
Drilling waters reservoirs are also identified at the images. The given objects can be identified only in the near infrared range (channel 3 of the scanner) because in the visibility range of electromagnetic spectrum (channel 1 and 3 of the scanner) the quantum spectral luminance factors (SLF) values of these objects are very high and lie in the range from 248 to 255 (white light). For instance, cloud clusters have the same range of luminance change. The most reliable way for the drilling waters reservoirs identification is synthesized image processing by the threshold contrast method when all other objects having SLF higher or lower than the given one (in this case, higher than 61 at the histogram) are not identified.
Oil polluted areas are identified around the oil production areas and along the pipelines. The most reliable way for oil polluted areas identification is the processing of synthesized image by the equidensitometry method when a part of the histogram of brightness distribution corresponding to SLF of oil (from 28 to 52) is cut out. In the result of such processing, oil patches are very well seen even on the water surface. Otherwise, such kind of pollution can be erroneously classified water bodies because their brightness values are very close. The brightness values on oil-polluted areas vary for different space images because the vegetation significantly contributes into the luminance and this considerably complicates the identification and area assessment of the polluted territories. The high reliability of space images identification was proved by comparative analysis of oil polluted areas obtained in MSU-E images with the help of ground-truth data.

Object's number	**Artikel I. Area, ha**		Object's number	**Artikel II. Area, ha**	
	MSU-E of 03.06.2000	Field measurements		MSU-E of 02.08.2000	Field measurements
1	93.7	110	1	152.8	138
2	52.06	60	2	89.24	95
3	76.15	75	3	33.04	38
4	90.71	93	4	95.29	90
5	2.89	4	5	144.62	138
6	132.75	140	6	51.46	55
7	254.07	265	7	465.87	450
8	229.58	245	8	145.06	145
9	496.5	510	9	539.76	540

Table 3.1 Oil polluted areas according to MSU-E and ground truth data

III.3.3. Prospective oil spills monitoring systems based on ground-based and space monitoring

When observing individual objects, it seems reasonable to compare successive images of the same region. That is why there is a growing necessity to form a database of space images obtained from various remote sensing systems. The database can be used for study of the dynamics of environmental processes. The following images are available at the moment: scanner images from the satellites KOSMOS-1939, RESOURCE-O, METEOR-3M, LANDSAT/ETM, SPOT, TERRA/ASTER, the photo-cameras CA-20M, KATE-140 and MK-4 from RESOURCE-F, the synthetic aperture radars ENVISAT/ASAR, ERS-2, RADARSAT. For some territories time period of image cover can be about 30 years. Using panchromatic and multi-spectral images with spatial resolution from 0.6 to 5 meters from the satellites QUICK BIRD, IKONOS, IRS-1D, IRS-P6 will allow identification of oil and mineralised drilling water spills areas from 10 square kilometres.

Ugra Research Institute of Information Technologies has the archive of space images from the satellites METEOR-3M, TERRA, NOAA received by its own receiving antennas and images from other satellites that were bought while working on individual projects. The images are processed and stored in the supercomputer SUN FIRE 15K.

At the research-and-production centre “MONITORING” (Khanty-Mansiysk), the map of oil pollutions on the territory of the Khanty-Mansiysk Autonomous Okrug was created. The map was produced with the help of data received by automatic classification of LANDSAT-7 images. At the same time, image mosaicing and geo-coding was done with 15 meters resolution and covering all the territory of the Okrug with the images of 1999-2001. The classifier was trained on the test areas with real oil spills. The utilisation of the repetitive survey of the territory of the Okrug by ETM scanner from LANDSAT-7 in 2002-2003 allowed finding the new oil spills, assessing eliminated old oil spills areas. The evaluation of the quality of recuperation of the damaged areas has been also done. The space survey data distinctly showed that oil polluted lands areas are 10-12 times more than it was officially reported by the oil companies.

There is a project to develop a subsystem for ecological monitoring on the territory of the Okrug that will operate in addition to space survey and ground-based observations for operative oil spills detection. This ecological monitoring subsystem will comprise search-and-rescue helicopters and aircrafts carrying remote sensing equipment and equipment for physical-chemical analysis on board. There is also a positive experience of the use of moto-hang-gliders on the territory of KMAO for digital air photography of small size oil spills.

Legal basis for local ecological monitoring

The legislative act of the Government of KMAO N 302-п of July 29, 2003 regarding the requirements to initial pollution level in the environmental components regulates ecological monitoring procedures for oil production companies.

Thus, the instrumental measurements of initial pollution into/on soils and rocks, zone of aeration, underground and surface waters, sediments, hydrodynamic characteristics of water bodies have been fixed by legislation only since the middle of 2003. While the license for deposit exploitation is valid, oil companies are to carry out ecosystem observations of the above mentioned environmental components for each kind of landscape at their own company’s expense. They have to produce electronic maps of the major ecologically dangerous technological objects; lands polluted with various chemical substances, degraded and disrupted landscapes, and geochemical anomalies.

After the license is expiration, the natural resource user has to submit information about the anthropogenic impact on the environment within the license area to the regional authorities.

Analysis of monitoring possibilities using radar satellites and satellites carrying visual and short infrared range sensors

Oil spills in pure form are quite easy to detect, but the analysis of the character of pollution for a number of Western Siberian oil deposits showed small number of objects entirely covered with oil. Oil pollution localization is mostly connected to the pipelines, drilling sites and accumulative areas around them, slush ponds and oil suspension collecting into exhausted quarries.

Polluted areas within drilling sites and ground containers look on satellite images like dot clusters against yellow-white sand fills and dams. Their identification is possible by reducing intensity in blue and red channels of the scanners. In case of high drilling fluid concentrations near ground container, the intensity level will fall only in the near infrared channel.

In the same way the diagnostics of oil spill along a broken pipeline is done, if the latter goes over disrupted mineral surface or sand fills. In the case when the broken section of the line goes over peat soils, it becomes more difficult to identify hydrocarbons spill. If the accident has been eliminated but no recuperation was done, the colour changes of peat-bog areas can be noticed in the pseudo-colour image. For high-moor sphagnum peat bogs, these colour changes demonstrate the transition from light yellow before the accident to bright green afterward. This happens due to sphagnum degrading and the polluted area periphery eutrophication.

Space multispectral images with 30 meters spatial resolution allow assessment of drilling sites and ground containers quite accurate on sandy fills pollution with oil fluids if the pollution cover is less than 0.5 mm thick and its size is less than 200 square meters. Other places of pollution localizations and sources are recommended to monitor using early winter and spring data.

From the methodological viewpoint, we can define the following two directions of oil pollutions monitoring:

1. Comparative analysis of the territory at the moment of snow covers setting with those shortly before the beginning of its intensive melting.
2. Analysis of pollution sources in the period of active vegetation.

The basic spectral channel for oil pollution diagnostics is the near infrared channel. The first direction is based on the significant spectral differences of the fresh snow and the polluted snow cover and on the difference in thaw through speed of clean snow and snow-oil mixture. The second direction is based on the peculiarities of spectral reflection of oil spots in blue and red parts of the spectrum.

Speckles, which are an integral feature of radar images, significantly interfere with oil spills detection on the ground surface. Irregularities and roughness of the open soil surface or soil covered with grass and bush growth contribute much more into satellite radar signal backscattering than the differences in dielectric characteristics of pure soil and oil do.

Oil patches on the water surface can be identified only if a spill area is several times greater than the synthesized pixels size. Spatial resolution of satellite images is from 8 to 25 meters, and air survey images have 3 cm resolution minimum. Oil film reduces water micro ripples what is the major identification feature when oil film thickness on the lakes and rivers is small.

Oil patches on the water surface and oil polluted lands are best identified at thermal infrared channels (TIR) in the range 8-12 micrometers. Spatial resolution of TIR channels on TERRA/ASTER and LANDSAT/ETM scanners is 90 m and 60 m correspondingly and it allows identification only of large areas of oil spills. It is advisable to use infrared channels for continuous monitoring of recuperated lands and repeated accidents on producing fields.

III.4 Socio-economic analysis of oil spill ecological impact

III.4.1 Comparative analysis of existing methods of oil spills economic damage evaluation

One of the most important problems and at the same time a bottleneck in the mechanism of ecologically safe and economically sustainable development of the region is the problem of economic evaluation of ecological damage. This problem is complicated because of variety of the forms this kind of damage and because this damage, as a rule, cannot be adequately measured in money terms. Ecological and economic damage value can be determined only with some degree of probability. The major complication in practical calculation of the economic losses is the lack of coincidence in time and place of the negative effects and their impact. This refers to ecological impact first of all.

Economic evaluations of ecological damage are the most important instrument of government regulation in the sphere of the conservation and management of the natural resources of the region. These evaluations are of extreme need to solve a wide range of planning, projecting and management tasks at macro- and micro economic levels. They are necessary, first of all, for the determination of the compensation allowance to recover the environmental damage.

There is a *legislative act in Russia under Section 78 of the Russian Federation Act on Environment Protection* (adopted on January 10, 2002; №7-Ф3), which states that environmental damage is determined by actual expenses on the damaged environment rehabilitation, considering sustained damages, including loss of profits, and in recultivation projects and other kind of rehabilitation measures.

Economic damage is a value of actual and probable loss to the national economy by environmental pollution or supplementary costs to recover losses from pollution accidents. This definition may be considered as the official one because it was included into *"Temporary typical method of environmental measures efficiency calculation and assessment of economical damage of the national economy by environmental pollution"* [34]. According to [34] "polluted environment affects recipients, it can cause the sickness rate increase, labour efficiency decrease, decline of the living conditions of the population, decline of natural resources productivity, accelerated depreciation of basic production assets…"

Environmental pollution leads to two kinds of expenses caused by negative effect on recipients:

- the costs of preventive measures on polluted environment effect on recipients (when such measures whether partial or full are technically possible),
- and the costs caused by polluted environment effect on recipients.

The last ones appear if full preventive measures are not possible or the costs of these measures are higher than the amount of the both costs type for partial prevention of polluted environment effect on people and various objects. Due to the fact that pollution accidents give as usual side effects the both types of costs usually occur at the same time.

Presently, there are no standards and methods of evaluation of consequences of pollution accidents approved at the Federal level in Russia, which are obligatory for use. At the same time there are methodological documents on economic evaluation of pollution for both environment as a the whole and separate environmental components approved by Ministry of Natural Resources, State Sanitary-Epidemiological Supervision, the Ministry of Fuel and Energy. These documents have recommendatory status and the corresponding measures on environmental protection are applied in practice with a permission of control and other executive bodies [34-51]. These documents were analysed and on the basis of this analysis the Methodology of calculation of environmental damage estimation was developed (the Methodology of KMAO) [52]. The latter was approved by Regulation №288-п of the Government of KMAO issued on July 17; 2003.The possibility to approve the Methodology at the Federal level is based on Sections 5 and 6 of the Federal Act on Environment Protection concerning the powers of the state authorities of the Russian Federation in the sphere of environment. These Sections state that economic evaluation of business activity impact on the environment falls under the jurisdiction of both Federal and Regional Authorities.

Let us see in brief advantageous and shortcomings of the principal standards and methodological documents used in this "Methodology" [52].

One of the most significant parts is the calculation of the state's losses inflicted by Water legislation abuse [37]. This act was firstly approved by the Ministry of Water Management, the Ministry of State Planning and the Ministry of Finance of the USSR in 1983. In 2002, All-Russia Research Institute of Mineral Resources (ARRIMR) prepared a re-draft of the method: "The Methodology of calculation the losses inflicted as a result of the damage to water bodies by the Russian Federation Water legislation abuse" (the Method-02) [38].

The Method-02 [38], with some corrections, was taken as a basis for the development the Methodology of KMAO [52]. Average damage rates for water body oil pollution, given hear, are calculated on the bases of the elimination costs of pollution consequences. That is why "average damage rates for water body oil pollution caused by accident or forbidden oil products discharge" (further - damage rates) are decreasing depending on the pollutants mass discharge as well as land recuperation costs are decreasing depending on the scale of pollution.

According to [37,38], the economic indicators of damage caused by 1 ton of pollutants discharge are rather high, especially comparing with pollution penalty rates, which regulate the claims for environment damage recovering under the Temporary Order of Accident Damage Assessment [44]. The standard fee for 1 ton of oil discharge over the limit, i.e. unsanctioned pollution, is 137,550 roubles according to Regulation №344 of the Government of the Russian Federation [53]. According to the Methodology [38], the damage rates are from 8 to 0.72 mil roubles/ton (the average value is **4.6 mil roubles/ton**) correspondingly. If the discharge is from 0.1 to 5,000 tons the fine exceeds up to 5 – 58 times. This approach seems to be quite reasonable and justified since it stimulates natural resource users not to set low pollution volumes. This is very important until there is no reliable state system of environment pollution monitoring.

According to the data given in the Surveys on the environmental conditions in the Khanty-Mansiysk Autonomous Okrug in 2001-2002, an average oil spill in the Okrug is about 1.025 ton per accident, so the damage rate per 1 ton of oil discharge is **3.4 mil roubles**. Besides, the Method-02 and the whole Methodology of KMAO introduce increasing coefficients depending on the water object category. In the Methodology of KMAO these coefficients are set from 1 to 1.5. In case of oil products discharge into sewage, the damage rates will be different. If oil products concentration at a test site is up to 50 maximum allowable concentrations the damage rate is 960 roubles/ton; if oil products concentration is over 50 maximum allowable concentrations the damage rate is 4,800 roubles/ton.

Besides the mentioned above methods of water bodies damage calculation (Water legislation abuse), was included in 1998 in the Methodology of damage calculation for underground waters pollution [39]. The given Methodology is officially approved by the State Committee on Ecology of the Russian Federation and the Ministry of Finance of the Russian Federation. It contains the recommendations on calculation of the damage value as a result of technological accidents in enterprise, transport, and etc. entailing the underground waters pollution. The Methodology is based on the method of direct losses calculation. Direct economic losses comprise the expenses and losses caused by this particular accident at given time and place. It is possible to use this "Methodology" for claiming purposes as well. The same can be said about other methodologies based on the methods of direct economic loss calculation.

III.4.2 Results of oil spills economic damage assessment

According to the inventory data made by Nizhnevartovsk Institute of Nature Management, there were about 28,000 ha of oil-polluted territory in KMAO in 2001. On a base of average annual data (for 12 years) some 17.6 tons of oil are spilt over 1 ha of the land (or 0.06 ha/ton). For the whole oil production period, about 466,667 tons of oil have been spilt what constitutes 0.3% (173.4 mil ton/year, 466,667 ton/year) of the average annual oil production for the last 12 years. Presuming that oil spills for the last 10-15 years can be visually traced the annual oil loss as a result of accidents and partial recuperation of the polluted lands is about 0.03% of the yearly produced oil amount or 5,202 ton/year. Considering that the area of 28,000 ha is the result of oil spills accidents during some years, the data on oil loss amounts are given as: from 1% to 7% of production output [18-33]. These figures are overestimated on our opinion since they include the data about not only oil spill accidents but about technological losses on the gas and oil wells, which are not necessarily, should be included in ecologic and economic damage calculations.

Average regional damage rate for land pollution, according to the Methodology of KMAO [52], is **1,076 thousand roubles/ha** (200 thousand roubles/ha * 1.5 * 1.3 * 4.6 * 0.6).

- 200 thousand roubles/ha – an average standard price of land exposed to oil pollution [51],
- 1.5 – the coefficient, taking into account the damage of the forest fond (Table 5.9. [52]),
- 1.3 - the coefficient depending on pollution depth (Table 5.8. [52]),
- 4.6 -the coefficient of standard land price recalculation depending on a recuperation period (Table 5.10. [52]),
- 0.6 - the coefficient depending on chemical pollution density (Table 5.6. [52]).

Average damage rate per a ton of oil penetrated into a water source as a result of oil spill is **5,668 thousand roubles**/ton in average for the given region.

The results of annual economic damage resulted in by oil spills are given in **Table 3.2**.

The calculation was done using average values of all variables in the formulas for water and land oil pollution assessment given in the Methodology of KMAO [52].

Number	Economic indicator	Value
1.	Average damage rate for water body pollution (thousand roubles/ton)	**4,360** **5,668** (4,360*1.3)
2.	Average damage rate for land pollution (Thousand rouble/ha)	**1,076**
3.	Average annual pollution amount penetrated into a water source (ton/year)	
3.1	a) by the official report data	**1,056**
3.2.	b) by URIIT expert estimation data	**15,606**
3.3.	c) by expert estimation data from [18-33] (3.5% of the oil produced)	**1,820,700**
4.	Lands areas polluted in the result of oil spills (ha/year)	
4.1.	a) by the official report data	**140**
4.2.	b) by URIIT expert estimation data	**2,069**
4.3.	c) by expert estimation data from [18-33] (3.5% of the oil produced)	**241,400**
5.	Annual damage from water objects pollution with oil and oil products (thousand roubles/year)	
5.1.	a) by the official report data	**5,985,408** (5,668*1,056)
5.2.	b) by URIIT expert estimation data	**88,454,808** (5,668*15,606)
5.3.	c) by expert estimation data from [18-33]	**10,319,727,600** (5,668*1,820,700)
6.	Annual damage from land pollution (Thousand roubles/year)	
6.1.	a) by the official report data	**150,640** (1,076*140)

6.2. 6.3.	b) by URIIT expert estimation data c) by expert estimation data from [18-33]	**2,226,244** (1,076*2,069) **259,746,400** (1,076*241,400)
7. 7.1 7.2. 7.3.	Total damage from water and land oil spills (thousand roubles) a) by the official report data b) by URIIT expert estimation data c) by expert estimation data from [18-33]	 **6,136,048** (5,985,408+150,640) **90,681,052** (88,454,808+2,226,244) **10,579,474,000** (10,319,727,600+ 259,746,400)
8. 8.1. 8.2. 8.3.	Specific weight of damage caused to water objects in the result of oil spills in the total damage, % a) by the official report data b) by URIIT expert estimation data c) by expert estimation data from [18-33]	 **97.5** **97.5** **97.5**
9. 9.1. 9.2. 9.3.	Specific weight of damage caused to land objects in the result of oil spills in the total damage, % a) by the official report data b) by URIIT expert estimation data c) by expert estimation data from [18-33]	 **2.5** **2.5** **2.5**
10.	Gross regional product (GRP) of KMAO in 2001 (thousand rouble)	**561,367,700**
11.	Specific weight of damage caused by oil pollution in GRP of KMAO, % a) by the official report data b) by URIIT expert estimation data c) by expert estimation data from [18-33]	 **1.1** **16.2** **1,889**
12.	Budget revenue of KMAO, thousand rouble, (plan of 2003)	**57,527,088**
13.	Specific weight of damage caused by oil pollution in budget revenue of KMAO, % a) by the official report data b) by URIIT expert estimation data c) by expert estimation data from [18-33]	 **10.6** **157.6** **18,390.4**

Table 3.2: Calculation of average annual damage caused by land and water oil spills

Thus, the specific weight of the total damage caused by oil pollution of water objects and lands in gross regional product (GRP) of the Okrug, according to URIIT expert evaluation, is about 16.2% (90,681,052 thousand roubles) while the corresponding specific weight of the total damage according to the official data is 1.1% (6,136,048 thousand roubles). These figures are comparable with those existing for the whole Russia.

III.4.3. Potential advantages from utilisation space monitoring system for oil spills detection within GMES

Oil spills space monitoring data will contribute to increase percentage of detected oil pollution accidents, which will make possible to increase amount and number of advanced and recovered claims to organizations responsible for oil pollution. This will also allow increasing of the budget revenue of the Okrug because claim amounts in recouping for damages are entered into the budget of the subject of the Russian Federation. However, recovered claims amounts are to increase gradually. It is possible that in the future, the Methodology of KMAO [52] will be corrected in the direction of the amounts reduction if a considerable number of the users of natural resources will not able to pay the advanced claims amounts.

Besides the direct financial benefits as increase of the budget revenue due to increase of amounts of claims to responsible organizations, there can appear also considerable indirect benefits as a result of use of space monitoring data. There may appear new possibilities for funding increase of the environmental activity in the Okrug, conducting of preventive health care for ecologically caused diseases, ecologically friendly technical re-equipment of oil-and-gas enterprises of the Okrug. Inevitable economical punishment will stimulate the enterprises to renew the worn-out pipelines in time. This measure can be seen as the most important environmental measure in the process of oil production and transportation. The facts that in the near future the state technical regulations for oil production and transportation will be adopted and Russia will join the World Trade Organization are to be followed by activation of market mechanism of nature management, and the most important element of this mechanism is ecological and economical damage assessment based on the data of the modern systems of ecological space monitoring developed within GMES project.

List of Abbreviations to Chapter III

KMAO - the Khanty-Mansiysk Autonomous Okrug
GIS - geo information system
SLF - spectral luminance factor
TIR - thermal infrared channel
GRP - gross regional product

References to Chapter III

1. Resolution of the Government of the Khanty-Mansiysk Autonomous Okrug № 302-п of 29.07.2003 “On approval of requirements to initial environment pollution determining, projecting and support of ecological monitoring within license areas on the territory of the Khanty-Mansiysk Autonomous Okrug” (in Russian)
2. Analytical survey. “Neftegazovaya vertikal”, № 13, 2003. (in Russian) (*There used the materials of Economic Policy Department of the Autonomous Okrug, Oil, Gas & Mineral Resources Department of the Autonomous Okrug, State Unitary Enterprise “V.I. Shpilman Scientific and analytical center of nature management”, gas and oil companies of the Okrug*)
3. Information bulletin “Environmental conditions of the Khanty-Mansiysk Autonomous Okrug in 2002”, Khanty-Mansiysk, RPC “Monitoring”, 2003 – 135 p. (in Russian)
4. Survey “Environmental conditions of the Khanty-Mansiysk Autonomous Okrug in 1995”, Khanty-Mansiysk, RPC “Monitoring”, 1996 – 125 p. (in Russian)
5. Survey “Environmental conditions of the Khanty-Mansiysk Autonomous Okrug in 1996”, Khanty-Mansiysk, RPC “Monitoring”, 1997 – 168 p. (in Russian)
6. Survey “Environmental conditions of the Khanty-Mansiysk Autonomous Okrug in 1997”, Khanty-Mansiysk, RPC “Monitoring”, 1998 – 168 p. (in Russian)
7. Survey “Environmental conditions of the Khanty-Mansiysk Autonomous Okrug in 1998”, Khanty-Mansiysk, RPC “Monitoring”, 1999 – 162 p. (in Russian)
8. Survey “Environmental conditions of the Khanty-Mansiysk Autonomous Okrug in 1999”, Khanty-Mansiysk, RPC “Monitoring”, 2000 – 129 p. (in Russian)
9. Survey “Environmental conditions of the Khanty-Mansiysk Autonomous Okrug in 2000”, Khanty-Mansiysk, RPC “Monitoring”, 2001 – 127 p. (in Russian)
10. Information bulletin “Environmental conditions of the Khanty-Mansiysk Autonomous Okrug in 2001”, Khanty-Mansiysk, RPC “Monitoring”, 2002 – 120 p. (in Russian)
11. Resolution of the Government of the Russian Federation “On the preventing and emergency response measures in oil and oil products spills on the territory of the Russian Federation” of 15.04.2002, № 240 (in Russian)

12. Official report on the environment condition of the Khanty-Mansiysk Autonomous Okrug in 2002; Khanty-Mansiysk, Central Administrative Board of Natural Resources and Environment Protection over the Khanty-Mansiysk Autonomous Okrug, 2003 – 57 p. (in Russian)
13. A. Filipenko “Future of space methods of ecological control”, the Novosti Yugry, 24.08.2000 (in Russian)
14. N.P. Solntseva. Oil production and natural landscapes geochemistry. – Moscow: Moscow State University publishing house, 1998 – 376 p. (in Russian)
15. Report of the working group of inter-departmental commission on environmental safety under Security Council of the Russian Federation (Yablokov’s commission). Moscow, 1995 (in Russian)
16. G. Vilchek. Oil and gas industry environmental impact., (typescript of IGAN, 1998) (in Russian)
17. “Technological pollution of natural waters with hydrocarbons and its environmental impact”. V.M. Goldberg, V.P. Zverev, I.A. Arbuzov and others. (in Russian)
18. Russian Arctic on the verge of a catastrophe / under the editorship of A.V. Yablokov, Moscow, 1996 (in Russian)
19. I.I. Mazur. Ecology of oil and gas complex. Moscow, 1993 (in Russian)
20. F.R. Khazifov. Technologies of raw hydrocarbons field loss reduction. Ufa, 1997 (in Russian)
21. S.G. Mironyuk. Draft concept of obligatory ecological insurance in the Khanty-Mansiysk Autonomous Okrug (typescript of IGAN, 1993) (in Russian)
22. A.Yu. Solodovnikov. Major principles of oil-field facilities//Neftyanoe khoziaystvo. 1997. № 9 (in Russian)
23. Yu. Yershov. Soviet export of fuel and energy // Vneshnaya torgovlya. 1990. №7 (in Russian)
24. Oil and gas production activity in the north-west of Russia, 1997 (report of Norwegian ecological organization “Bellona”) (in Russian)
25. The Green World. 1990. №5 (in Russian)
26. I.I. Mazur. Economics is to be ecological // Neft Rossii. 1997. №10 (in Russian)
27. N.A. Maltsev and others. “Oil industry of Russia in the post-war period”, Moscow, 1996 (in Russian)
28. The Nezavisimaya Gazeta. 1995. February 5
29. N.P. Kovalenko. Oil and gas pipeline transportation losses assessment. Tyumen, 1995 (in Russian)
30. O.N. Sheshina. Assessment of ecological impact on the cryolite zone surface in the process of Western Siberia developing: (the Materials of the II conference of geo-cryologists of Russia), Moscow State University, 2001 (in Russian)
31. Materials of the Parliamentary debates on oil and gas industry impact on the environment condition (05.12.2000) (in Russian)
32. Interview of the Governor of the Tyumenskaya Oblast // the Rossiyskaya Gazeta. 2000. October 5 (in Russian)
33. M. Goldberg and others. Technological pollution of natural waters with hydrocarbons and its environmental impact. Moscow, 2001 (in Russian)
34. Temporary typical method of environmental measures efficiency calculation and assessment of economical damage caused to the national economy by environmental pollution. – Moscow: Economika, 1986. – 92 p. (in Russian)
35. The Russian Federation Act on Environment Protection of January 10, 2002; №7-Ф3 (in Russian)
36. Methodology of prevented ecological damage calculation. – Moscow, 1999. – 92 p.
37. Methodology of calculation of the state’s losses inflicted by Water legislation abuse. – Moscow: Central Technical Research Institute of the Ministry of Water Management of the USSR, 1983. – 83 p. (in Russian)
38. Methodology of calculation the losses inflicted in the result of the damage caused to water bodies by the Russian Federation Water legislation abuse, Moscow: 2002, (draft). – 42 p. (in Russian)

39. Methodology of calculation of the damage caused by underground waters pollution (approved by the State Committee on Ecology of the Russian Federation and the Ministry of Finance of the Russian Federation on 11.02.1998, 31.05.1999, 01.06.1999) (in Russian)
40. Temporary Methodology of calculation of losses caused by air pollution by emissions of ferrous metallurgy enterprises/ Moscow: 1987(in Russian)
41. Methodological guidelines on assessment and indemnification of environmental damage caused by ecological offences (approved by the State Committee on Ecology of the Russian Federation on 06.09.1999) (in Russian)
42. N.V. Khilchenko, A.A. Litvinova. Methodology of aggregative economical estimation of ecological damage (for the Sverdlovskaya Oblast). – Ekaterinburg, 2002. – 36 p. (in Russian)
43. D.V. Moskovchenko. Oil and gas production and the environment. Ecological and geochemical analysis of the Tyumenskaya Oblast. – Novosibirsk: Nauka. Siberian enterprise of RAS. 1998. – 112 p. (in Russian)
44. Temporary Procedure of assessment and indemnification of environmental damage caused by accidents (approved by the Russian Ministry of Nature on 27.06.94, Order №87) (in Russian)
45. Procedure of damage calculation caused by land chemical pollutions. – Moscow: 1993
46. Methodology of damage assessment caused by soils and lands degrading (approved by the Ministry of Natural Resources and Environmental Protection), Moscow, 1994 (in Russian)
47. Standard costs of new lands developing instead of agricultural lands withdrawn for non-agricultural purposes (valid from 01.01.1996) (introduced by the Government Regulation № 1176 of 27.11.1995) (in Russian)
48. Methodology of environmental damage calculation caused by trunk pipelines breakouts (approved by the Ministry of Energy on 01.11.1995) (in Russian)
49. Government regulation № 3278 of 29.04.2002 "On the value, procedure of collection and record of payments for converting forest lands into non-forest and withdrawing of forest lands in 2002"
50. Rates for calculation of damage penalty caused to forestlands stock and other forestlands by abuse of the Forest Legislation of the Russian Federation (approved by Government regulation № 388 of 21.05.2001)
51. Regulation of the Government of the Khanty-Mansiysk Autonomous Okrug N 496-п of 16.09.2002 "On Standard land cost"
52. Methodology of calculation of environmental damage caused by the environmental legislation abuse (approved by Regulation of the Government of the Khanty-Mansiysk Autonomous Okrug N 288-п of 17.07.2003)
53. Regulation of the Government of the Russian Federation №344 of 12.06.2003 "On standard fees for air pollutants emission by fixed and movable sources, discharge of pollutants into the surface and underground waters, industrial and consumption waste disposal"

IV Sea Ice Monitoring

i. IV.1 Increasing industrial activities in the Russian Arctic

The Russian Arctic is a very important region for economics of the Russian Federation. Indeed, the most material wealth, very important for the Russian economic development, are concentrated in the Arctic, i.e. 80% of natural gas, 75% of oil, resources of strategically important nonferrous and precious metals. The Norilsk industrial region of the Taimyr Peninsula secures 20% of the world nickel production. The Arctic Ocean is the largest oil and gas province in the Earth. The oil and gas resources of Russian Arctic shelf are evaluated as 70 billion tonnes. During the last decade oil and gas industry in this region became the main competitor to the traditional resource use. The output of the oil achieved 4 million tonnes by the end of the year 2000 (Velikhov et al, 2001).

Apart from the pipelines, the transportation by ships along the Northern Sea Route (NSR) is an effective solution of the problems of transportation in the Arctic. **Figure 4.1** presents the map of the Northern Sea Route. The NSR is the world's longest sailing route in ice-covered waters. Most of the NSR cargoes after 2nd World War have either been inbound state-organized transport of supplies to the towns, settlements and industrial activities of the Russian Arctic, or outbound transport of timber and non-ferrous metals/ores. Almost all of this was transported westwards to Murmansk, Archangelsk or abroad. During the past decades the Soviet Union have invested heavily in the overall development of the Northern Sea Route and has succeeded in building of formidable arctic marine transportation system. Particularly costly have been the huge fleet of polar ships and the extensive infrastructure of port facilities, communications, and navigation systems (Brigham, 1996). The basis of this transport system is a powerful icebreaking fleet consisting of 6 nuclear and 6 linear icebreakers. The Arktika class ships are currently the largest and most powerful polar icebreakers in operation. These ships were the most important elements in extending the navigation season in several sectors of the Soviet maritime Arctic.

Traffic in the NSR peaked at 1987, when approximately 6.6 million tonnes of goods were transported in the NSR, and after that declined dramatically in the 1990s, but has been more or less stabilized since 1996 around 1.5-2.0 million tonnes per year. Only since 1994 has marine transport of hydrocarbons begun to play a role for the NSR. In recent years the amount of oil exported by Russia through the Barents and Baltic Seas has increased considerably. Among other things, the development of these oil transportation systems is caused by the fact that the existing system of export pipelines from Western Siberia to Southern and Western Russia has already reached the maximum of its throughput capacity (Frantzen, Bambulyak, 2003)

Industrial activities have increased in the Russian Arctic in recent years, and future increase is forecasted for forthcoming decades. Thus, in accordance with the Federal “Program of Timan-Pechora oil and gas complex development till 2010” the volume of extracted oil in this province will increase 5-6 times. Proved reserves of hydrocarbons in Timan-Pechora province consist of 1.5 billion tonnes of oil (Andreeva, 2000). By the end of 2005 according to plans Varandey terminal will have a capacity of between 5 and 7.5 million tonnes annually, with throughout capacity possibly increased further to 15 million tonnes at a later stage. In the nearest years oil and gas production will also increase in Prirazlomnoye and Kolguev deposits. Prirazlomnoye is situated in the Pechora Sea in 60 km from the coast at the depth of 18-20 m. Ice period in this region lasts for 7-8 months. Period of its field development was determined at 25 years at the maximum production of 6 million tonnes per year. Oil export will be carried out along the NSR by ice class shuttle tankers with intermediate oil overloading in the Pechenga Gulf. Development and attaining of oil production level scheduled 7 million tonnes per year will create the cargo flow on the NSR exceeding its maximal 6 million tonnes in the 1980s.

ii. IV.2 Traditional Russian scheme of sea ice monitoring in the NSR

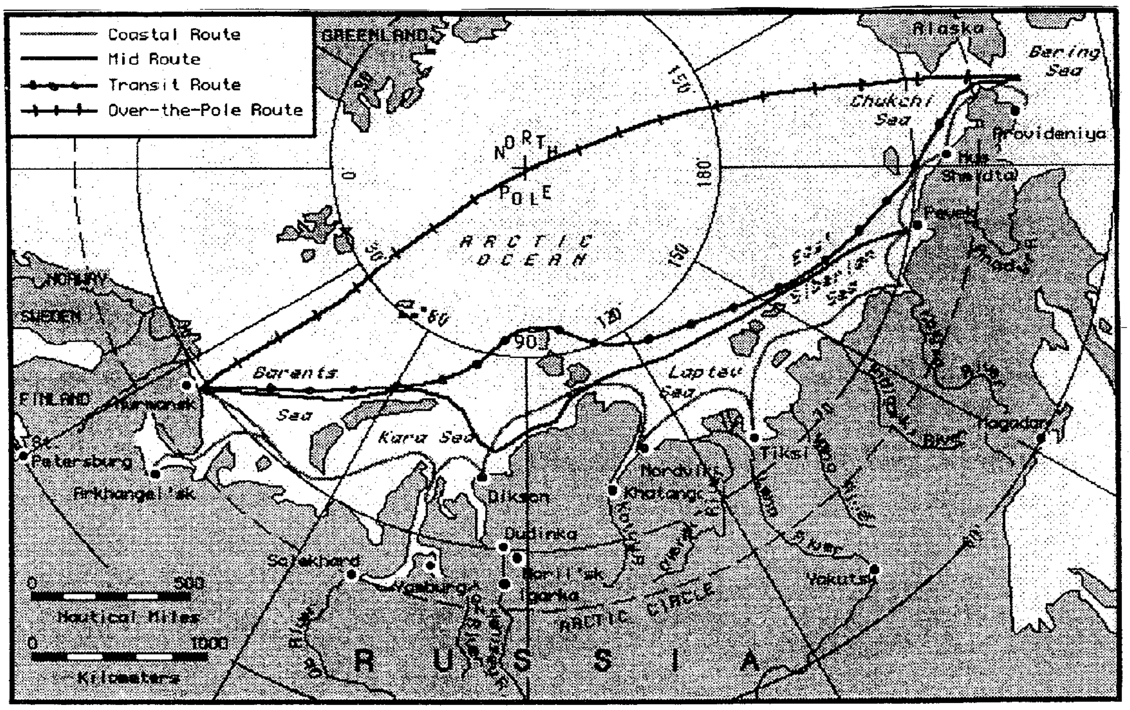


Fig.IV.1 Map of the Northern Sea Route with the main sailing routes (Mulherin, 1996)

IV.2.1. Introduction

The NSR is a national Russian transport communication in the Arctic, lying in the inner seawaters or in the economic zone adjacent to the northern coastline of Russia and the archipelagos and the islands of the Russian Arctic. The NSR includes the routes suitable for the ice navigation confined in the west to the entries to the Novaya Zemlya straits and to the meridian north of Cape Desire; in the east, in the region of the Bering Strait. It extends over a distance of between 2200 and 2900 nautical miles along Russia's northern coastline. Transit distances between North Pacific and European ports through NSR are 35-60% less than the traditional southerly routes (Mulherin, 1996).

At present, the different ship routes in the NSR are classified into coastal, high-sea; high-latitude and near-pole routes (see **Fig. 4.1).**

Of the various legs, only the westernmost to the port of Dudinka in Yenisey are normally used in late winter and spring. This route is kept open for transport of nickel from the major mining town of Norilsk. In years with difficult ice conditions, navigation along the whole NSR is only possible from about June to November, maybe until somewhat later (until February) in the western part.

The state supervision of the rational use of the NSR is realised by the NSR Administration (NSRA) of the Russian Federation Ministry of Transport. The NSRA executes its functions both directly and through special navigation services of the Murmansk and Far-East Shipping Companies - the so-called Marine Operations Headquarters (MOH) of the Western and Eastern regions of the Arctic respectively. The MOH directly carry out all sea ice operations along the NSR. For ensuring of safe and efficient navigation, protection of human life on the sea, prevention of marine environment from pollution by ships accurate and timely hydrometeorological information is required. Ensuring of safety in the arctic navigation stipulates for special demands for information about the distribution, conditions and dynamics of ice cover and on sea ice forecasts.

IV.2.2. Brief history of sea ice monitoring in the NSR

Hydrometeorological and sea ice observations in the Northern Sea Route are very important for Russia because of the ship traffic that requires icebreaker support. The possibility to obtain integral ice distribution and ice dynamics pattern of the Arctic Ocean appeared after the beginning of the Arctic study from the aircrafts. In 1932, after establishment of the NSRA, the system of hydrometeorological navigation support was formed, including a Polar Aviation group for navigational air reconnaissance, and the net of Polar stations. In 1938 a significant part of the Arctic seas was covered with visual air reconnaissance. The observations and mapping of sea ice in that period were carried out by means of visual methods. Ice observers estimated the main sea ice parameters, built ice chart onboard the aircraft and delivered them to serviced icebreakers and ships. Visual ice observations are subjective and quantitative estimates of sea ice parameters were not quite accurate. As a rule only 10-20% of studied area was observed, which leaded to significant errors in interpolation and extrapolation of sea ice boundaries.

Several major technological improvements of the ice observation capability were achieved in the 1960s. Side-Looking Airborne Radar (SLAR) "Toros", with a swath width of about 60 km, was constructed in 1968 especially for ice survey. SLAR surveys in the Arctic seas were carried out regularly since 1969 until 1991. In 1978 SLAR "Toros" was modernized: four polarizations (HH, VV, HV, VH) could be used for ice reconnaissance, and a special communication link for transmission of sea ice imagery to icebreakers was mounted. Experiments with multifrequency radar which operates in Ka, X, L, and UHF bands, conducted in 1992, revealed that use of these bands widens the radar capabilities for sea ice observations (Alexandrov et al., 1992).

Visible satellite images from the experimental system of meteorological satellites "Meteor" were used in sea ice monitoring since 1967. These images were received and processed in the regional centres for receiving, processing and transmission of meteorological information (Moscow, Novosibirsk, Khabarovsk), as well as in several autonomous centers. Since 1975 data of scanning visible (0.5-0.7 μm) and IR (8-12 μm) radiometers mounted onboard meteorological satellites of the second generation "Meteor-2" were used for mapping sea ice in the Arctic. These images covered a swath of 2000 km wide, with a 2 km resolution for visible and 8 km for IR images. Information received in regime of direct transmission was used for operative tasks. "Meteor-3" system have been launched since 1987. Scanning visual radiometer (0.5 – 0.7 μm) with swath width of 2600 km was mounted onboard these satellites.

Side-Looking Radar images from the "Okean" satellites were widely used in sea ice monitoring since 1983 until 2000. A radiophysical equipment which included side-looking radar with resolution of 2 km and wavelength 3.15 cm, and scanning microwave radiometer with resolution of 25 km and wavelength 0.8 cm, was mounted onboard these satellites together with a four-channel low resolution visible scanning radiometer (Mitnik, Viktorov, 1990). The superposition of swaths for all sensors, formation, storage and transmission of all images as a joint still in APT mode are the main features of this facility. Radar satellite images were received in three regional centers (Moscow, Novosibirsk, and Khabarovsk) and in a number of receiving stations, situated in different regions of the country and the Arctic coast.

Significant attention was paid to elaboration of image interpretation techniques and ice chart composition from various remote sensing data. The techniques of image interpretation were developed using sub satellite field experiments, when the results of image interpretation were compared with real sea ice conditions. The manuals on interpretation of sea ice conditions in Side-Looking Airborne and satellite radar, visible and infrared images were issued (Bushuev, Bychenkov, 1976; Bushuev et al., 1983). The techniques and technologies of preliminary and thematic processing of various satellite images and sea ice chart composition were elaborated, based on interactive image processing. The specialized software for interactive image interpretation and ice chart composition was elaborated at AARI (Arctic and Antarctic research Institute, St. Petersburg). The methodology of composition of photo mosaics from several sequential satellite images was elaborated at NPO "Planeta" (Mitnik, Viktorov, 1990).

A reorganization of the system of hydrometeorological support in the Arctic was done by means of putting "Automated Ice Information System for the Arctic (AIISA)" into operation. In 1983 the Commission of the Presidium of the Cabinet Council of USSR adopted a decision on creating this system, and appointed the State Committee of Hydrometeorology of USSR as a system customer, with AARI as a prime developer of the system (Frolov, 2002). A conception of AIISA system envisaged unification, coordinated elaboration and functioning of the following main systems of hydrometeorological support:

- information collection and receiving,
- processing, analysis, hind casts and forecasts,
- distribution and transmission of information to users.

In 1986 the AIISA was put into pre-production operation, and the Centre of sea ice and hydrometeorological information was organized at AARI. In 1989 the first stage of the AIISA system was put into an operation and maintenance phase. Organizationally, the ice information system is based on a spatially shared, regionally organized network for the collection, analysis and operational use of ice information with centres in Dikson, Tiksi and Pevek, and AARI engaged in studying problems with methodological supervision and coordination of efforts for problem-solving.

The composite sea ice charts of the Arctic Ocean are issued by the Ice Centre of AARI once per week. Their composition is based on a complex approach, when all available sea ice information is used, including data from satellite images, ships, icebreakers, drifting buoys and others. This information is analysed by experienced ice experts with the use of modern hardware and special software developed at AARI (Smirnov et al., 2000). AVHRR NOAA images in visible and IR bands with 1.1 km resolution regularly received by the Ice Centre, as well as visible band images from TERRA satellite (250 m resolution), are used in ice chart composition. The detailed ice maps are composed for selected regions to support concrete marine operations. RADARSAT and ERS SAR images were occasionally used during the implementation of several demonstration projects.

The AIISA system has a module for analysis and forecasting sea ice and hydro meteorological conditions. Stochastic and hydrodynamic models for predicting ice cover distribution from 1-7 days up to 3-6 months have been developed and are currently in use. Short-term (1-3 days) and medium-term (7-8 days) meteorological and ice forecasts are prepared. Ice data are presented in digital form in the regular grid points to solve operative and research tasks of forecast and analysis with the help of numerical methods. A numerical model for the evaluation of ice routing, with due regard to actual or predicted ice information and technical characteristics of icebreakers and ships, has also been developed (Maroon et al., 2002).
Nevertheless, the contemporary state of hydrometeorological support in the Arctic is characterized by significant negative tendencies. The following negative changes happened in the main system for receiving information (Frolov, 2002):

- the regular aerial ice surveys in the Arctic are absent since 1992;
- the drifting stations “North Pole” were not organized in the period since 1991 until 2002;
- the state budget practically does not fund organization of the complex Arctic marine expeditions;
- at present time the information from Russian satellites, which is necessary for mapping sea ice conditions in the Arctic and Antarctic, is completely absent,
- total amount of ground-based Polar Stations in the Arctic was reduced more than twice;
- the funding for supporting technical equipment of the Polar Stations is absent.

The negative changes in the Northern Sea Route also include absence of the coordinating power structure, which would be responsible for the development of the Arctic region (liquidation of Goskomsever, uncertainty in the areas of responsibility in the Ministry of Marine Fleet, between the Northern Sea Route Administration and joint-stock shipping companies, the abolishment of the Arctic and Antarctic Marine Administration in the State Committee for Hydrometeorology, an abeyance of operation of the Interdepartmental Committee on the Arctic and Antarctic, and others).

IV.2.3. User requirements to sea ice information

The most important part of the navigation ice information is the navigation ice reconnaissance and mapping of sea ice. The MOH, depending on the purpose, tasks and objectives, divides the navigation ice reconnaissance into (Johannessen et al., 1997):

• strategic (survey)
• operative
• tactical

The strategic (survey) ice information is used by the NSRA and MOHs to plan the fleet operation. The basic means of the strategic ice reconnaissance are space-borne devices with a low resolution (~5-10 km local) and maximum viewing bandwidth. The satellite data of higher resolution as well as the data from other sources can be used as additional information to obtain more detailed estimates of sea ice parameters. The strategic (survey) ice reconnaissance covers all water basins of the NSR routes, including the Barents and Bering Seas as well as the near-pole regions. Maps of different scales (1:5 mill, 1:7 mill, 1:2 mill) in azimuthally or conical projection are used as cartographic basis for plotting of the survey ice maps. The survey ice maps are usually plotted with a frequency of once in 10 days, in winter they may be drawn with the frequency once in a month.

These maps contain information on the location of the ice boundary and that of the open water, the boundaries of the fast ice zone and recurring flaw polynyas, the boundaries of ice massives and fields of different age (thickness) and concentration. In accordance with the scale of the chosen cartographic basis, the data of the survey ice maps should be averaged. The spatial scale of averaging of the ice cover characteristics constitutes from several thousand to tens of thousand square miles. The distance between the graphic elements (location of the boundaries of inhomogeneous ice and open water areas) on the map usually reaches from ten to hundreds of miles.

The operative ice maps and ice forecasts are transmitted to all the icebreakers and ships in relation to the region of their work. With the help of this information the navigators correct the routes, plan and take measures to ensure the safety of ice navigation. The finished-off operative maps are used in plotting of the composite ice maps, and for scientific-research purposes - to systematise the data on the regime characteristics of the navigation routes, to study general and regional laws of the ice regime.

Data sources of the operative ice reconnaissance are: satellites with an increased resolution (within tens or hundreds of meters local), the data of observations at polar stations, ships, and the data of expeditions. The contribution of the data of ice observations from polar stations and expeditions is quite negligible. The additional information includes weather forecasts from 1-3 to 7-10 days in advance; ice forecasts - the ice re-distribution, drifting and compression - 3 to 7 days in advance.

The operative ice reconnaissance is carried out in the period of navigation. This reconnaissance covers the areas of the arctic seas within the NSR routes on which concrete sea operations are executed. The results of the operative ice reconnaissance are formed as operative ice maps. Maps of the scale from 1: 2 mill to 1:7 mill of Mercator's or conical projection serve the cartographic basis for the operative ice maps. The operative ice maps are usually plotted with the periodicity once every 2-3 days, 5 days at most. The operative ice maps contain much more navigation-significant characteristics of the ice cover compared to the composite ice maps and include the following information: location of the ice and open water boundaries; the fast ice boundaries with an allocation of the areas of ice of different age (thickness), hummocking and destruction; flaw polynyas and clearings; the boundaries of ice fields of different thickness (age) and concentration; fractures and diffusion in more compact ice masses; orientation and extent of fractures, systems of cracks as well as individual cracks; the amount of prevailing forms of ice in points, separate huge or vast ice fields among smaller ice forms; local sites of increased hummocking, hummock ridges, grounded hummocks and icebergs; localisation of the zones of various orientation and compression in the ice cover; characteristics of the snow cover or destruction of the ice cover; man-made canals in the ice.

Major customers and users of the data of the tactical ice reconnaissance are the navigators of the icebreakers and ships. The tactical ice reconnaissance is carried out episodically in the process of accomplishment of each concrete sea operation - ship or convoy steering, autonomous voyage of the icebreaker, cargo operations away from the ports (ship - shore, ship - ship). The main goal of the tactical ice reconnaissance is to choose an optimal route of ice navigation, that is, the route that with the lowest expenditures of time and power resources provides the utmost safety of ice navigation.

At present time the major source of the data for the tactical ice reconnaissance could be high-resolution SAR imagery. The best result from the realisation of the data of the tactic ice reconnaissance is reached when it coincides with the accomplishment of sea operation in real time. Permissible delays in the data delivery should not exceed several hours. An experience in using of the images of the SLR "Nit' " and high-resolution satellites (from several meters to hundreds of meters local) has shown that the original images supplemented with the co-ordinate grid and shore outlines are sufficient to solve most of the tactical problems of navigation. The efficient use of such images depends on the resolution of the source of data and the quality of data receiving.

The requirements to strategic, operative and tactical sea ice information are summarised in **Table 4.1**.

	Strategic	Operative	Tactical
Users	NSRA, MOH	MOH, captains	Captains
Coverage	Global (the whole NSR)	Regional	Local
Spatial resolution	~ 10 km	< 1 - 2 km	< 100 m
Time delay	10 days	2 - 3 days	2 – 3 hours
Scale of ice chart	1:7 000 000 1:5 000 000 1:2 000 000	1:7 000 000 1:5 000 000 1:2 000 000	1:500 000 1:200 000

Table 4.1 Summary of requirements to sea ice information for ice navigation

Satellite imagery is the main source of information for obtaining strategic and operative sea ice information. Composite ice charts of the Arctic Ocean for strategic purposes are issued by AARI once per week. The main source of information for their composition is images from Meteor and NOAA satellites. From the formal point of view these charts satisfy user requirements for strategic ice information due to their coverage, spatial and temporal resolution. Nevertheless, in practice some areas of the Arctic Ocean cannot be covered with satellite images because of the following reasons:

- Sea ice information cannot be retrieved from Meteor and NOAA images in cloud conditions;
- Information from visible images cannot be obtained in winter due to lack of visibility;
- Information from IR images can be retrieved only when the temperature falls below (-10) degrees Centigrade;

The operative ice charts are characterised by the same disadvantages as strategic ice charts. User requirements to spatial and temporal resolution for operative ice charts are stricter than those for strategic ones. In our opinion, at present time these requirements can be satisfied with the use of Radarsat ScanSAR images.

During the last years NERSC in Bergen, NIERSC in St.Petersburg and Murmansk Shipping Company carried out pilot projects aimed on using high-resolution satellite SAR images for support of icebreakers with tactical sea ice information (Johannessen, Sandven, 1992; Johannessen et al., 1994; Johannessen et al., 1995; Alexandrov et al., 1998; Pettersson et al., 1999). In these projects geolocated SAR images with overlaid grid of geographical co-ordinates were transmitted to the icebreakers of Murmansk Shipping Company in quasi-real time and proved high effectiveness for selection of optimal ship route. Nevertheless, it is impossible to supply all ships in the Northern Sea Route with quasi-real time SAR images because of the gaps in spatial coverage of ERS SAR images.

Radarsat ScanSAR images should be used for the tactical purposes, but even these images cannot support all ships in the Northern Sea Route with 2 - 3 hours time delay. Therefore during subsatellite experiment it will be useful to estimate the possibility of using Radarsat ScanSAR images for the tactical purposes with larger time delay after satellite overpass. The possibilities of different satellites to satisfy user requirements for strategic, operative and tactical ice information are presented in **Table 4.2** (Sandven et al., 1999).

Sensor	Strategic	Operative	Tactical
SSM/I	Satisfy requirements	Poor spatial resolution	Can be used if there is no other possibility
Visible / IR (NOAA, Meteor)	Satisfy requirements	Satisfy requirements	Can be useful when received onboard the ship

ERS SAR	Can be used for detalisation of ice charts	Can be used if sufficient coverage is supplied	Satisfy requirements if transmitted to icebreaker in real time
RADARSAT SAR	Scansar satisfies all requirements	Scansar satisfies all requirements	Satisfy all requirements if transmitted to icebreaker in real time

Table 4.2 Use of satellite images for obtaining strategic, operative and tactical sea ice information

The major use of sea ice information is to optimise ship operations, both with respect to time and energy consumed by operations, to obtain the safest possible navigation and hence to reduce the risk for damage of escorted vessels. There is a need for detailed information in particular on the most hazardous sea ice phenomenon. This information includes ice edge location, ice type (or age) classification, ice movement, shear zones, leads, ice roughness and icebergs etc.

IV.2.4 Application of SAR data to sea ice monitoring

SAR images have proven to be capable of delivering much more information on sea ice conditions than currently used visible and IR images. Since 1991 ERS-1 SAR data have been introduced in ice monitoring in many research and demonstration projects around the world. The SAR has proven to be a very powerful instrument for sea ice observations and is at the stage to become the main instrument in operational sea ice monitoring. Systematic use of satellite SAR data can bring the quality of local and regional ice charts to a higher level and so reduce the risks of damage and accidents caused by sea ice. Our previous studies have also shown that significant economical benefits could be obtained by using SAR images in Ice Routing. Estimated increase of the convoy speed in this case amounted to 20-30%.

SAR ice monitoring for the whole Arctic has been demonstrated by R. Kwok, showing unique results on ice convergence, divergence, freezing ice thickness distribution and seasonal ice growth. Operational ice services using SAR have been established on regional basis, but there are large areas of the Arctic Ocean that are not covered by such a service yet. There is no service in Europe that provides SAR data and derived products from the whole Arctic region. The Canadian RADARSAT, operational from 1996, was the first satellite with sea ice monitoring as a prime objective. It provides SAR data for operational ice services in countries like Canada, USA, Denmark/Greenland and Finland/Sweden. With RADARSAT data, a new era in operational ice monitoring by satellites has begun. ENVISAT will contribute with more SAR data, improving the SAR data supply for navigation support.

In Russia, there is a pressing demand for cloud and daylight independent, high resolution SAR data, to support sea ice monitoring, and other environmental studies. The European Commission financed the Project for the implementation of the ERS data acquisition and processing station at Research Centre for Earth Operative Monitoring (NTsOMZ, Moscow), which lasted for 6 months from June to December 2001. During this period the ERS SAR ground station was installed at NTs OMZ quarters in Moscow. After the Project is finished, the system became operational and the antenna coverage reaches mid-Novaya Zemlya in the North, river Ob in the east, northern Caspian Sea in the south and France in the west (**Fig. 4.2**).

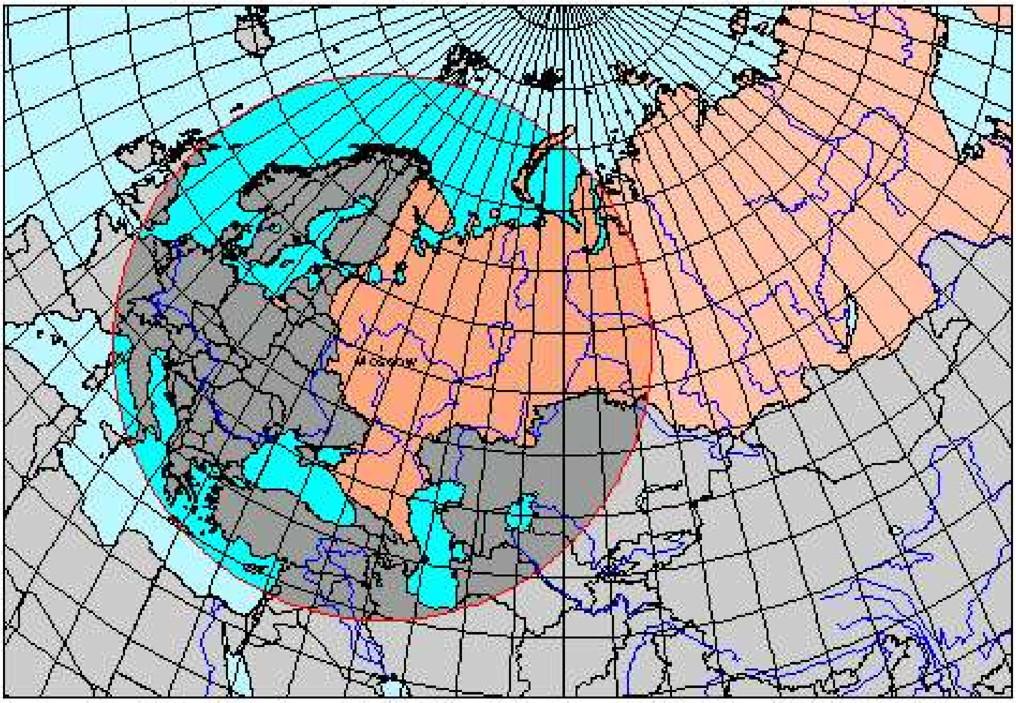


Fig. 4.2 The Moscow ERS ground station antenna coverage.

The proposal for ERS station deployment in Siberia was elaborated. In 2002 the scientific pilot project "Monitoring sea ice conditions in the NSR" has been fulfilled. During the project implementation series of ERS-2 SAR images have been acquired by Moscow receiving station, processed and transmitted to MOH of Murmansk Shipping Company.

It is foreseen that SAR images can be received directly by customers working at sea provided that the images are processed onboard the satellite, and derived products can be transmitted to the vessels and platforms in near-real time. The benefits of using SAR data onboard ships are not only related to safety but also can improve efficiency and time saving which has considerable economic importance. It is the requirement from several captains that future ice information should be included into electronic charts and be displayed together with bathymetric data and other relevant information on one terminal on the bridge.

The focus of the development of sea ice monitoring service should include implementation of SAR data as an addition to satellite data in visible and IR bands. The Main EO data will be SAR from ENVISAT and RADARSAT, supported by scatter meter products and other EO-data. Based on SAR data from ENVISAT/RADARSAT a number of products can be provided such as high-resolution maps of ice extent, concentration, age, freezing rate, deformation/ridging, drift, leads, and polynyas as well as processes in the marginal ice zone related to wind, waves, eddies, freezing and melting. The scheme of data flow in the operational system of sea ice monitoring with inclusion of SAR data is presented in Fig. 3. The maps can be provided for the whole Arctic Ocean, on regional and local scale at time intervals from daily to weekly coverage. The scatter meter products from Quickscat allow monitoring of the multiyear ice boundary. When CRYOSAT data becomes available in 2004-2005, Arctic ice thickness data will be incorporated as a new element in ice monitoring. The microwave satellite products will be integrated with existing marine and climate observing and modelling systems.

IV.3. Benefits of using SAR in ice navigation and icebergs monitoring

IV.3.1. Major problems caused by sea ice

Use of SAR data contributes to safer and more cost-effective sea transport in high-latitude ice covered waters. Considerable economic savings can be achieved by optimising ice navigation and reduce sailing times of ships. By providing sea ice information with SAR and other EO data the risk of ship damage and accidents such as oil spills in ice covered waters will be reduced. Safer operations in marine and polar environments, which are known to be particularly fragile and vulnerable to pollution and other man-made impact, will be provided. For example, oil spilled in these cold environments takes longer to disperse and break down, and even minor spills can cause long-lasting impacts to an area. Sea ice is a hazard for ship transport and other offshore activities, and poor information about ice conditions can lead to accidents that may cause severe environmental damage of this type. By improving Met-ice Ocean and other essential information used for decision-making in ice navigation in route planning onboard ships, the risk for harming the vulnerable environment in these regions could be reduced. Offshore activities in the NSR are expected to grow in the coming years and will require timely and accurate information about sea ice and weather conditions to plan and implement operations with minimum risk of harmful impact on the environment.

Polar water represent a significantly higher degree of risk to shipping than most other waters, by the presence of ice fields, wind-driven ice forces, cold isolation and lack of full support-services. The Arctic navigator may also face lengthy voyages in ice, possible entrapment in pressure ridges in confined areas, and deceptively interlaced areas of multiyear ice. Human error is acknowledged to be a major factor in some 80% of all marine accidents in polar waters and the risk of errors is increased by the high demands placed on mariners. Another risk is the possibility of oil spill and other pollution, which can cause severe damage to the environment. The presence of sea ice makes cleanup techniques normally employed in more temperate climates useless in ice-covered areas.

There is no doubt that improved and easily accessible ice information will improve safety and thereby reduce the risk for accidents, loss of life and equipment. If oil, gas and mineral exploitation in Arctic regions increases, accurate and timely ice information will become even more important for safe and economic operations.

In general, use of satellite data have demonstrated promising capability to improve the quality of all types of ice charts needed for safe and cost-effective operation in ice areas. Systematic use of satellite SAR data can bring the quality of local and regional ice charts to a higher level and reduce he risks of damage and accidents caused by sea ice. The benefits of using SAR data onboard ships are not onl ve efficiency and time saving, which has considerable eco

Land-based users
MURMANSK, MSC
MOH

The benefits of SAR images for mapping the ice co en SAR data become available on an operational basis, bu for use in ice monitoring is not yet resolved. Vast areas of the Arctic Ocean, the Barents Sea and the Russian coastal seas have only used SAR data occasionally in connection with expeditions or research projects.

IV.3.2. Improvement made by SAR applicatio

Users at sea
ICEBREAKERS, SHIPS

The key question is how use of satellite data can contr ed safety for all users of ice information (users who wo for icebreakers, cargo ships, offshore platforms, as well as

First, systematic use of satellite data, especially SAR data, will contribute to better quality local and regional ice maps and should be used to make high resolution maps or interpreted images for smaller regions (straits, harbours) of particular importance for ice navigation. The satellite data will thus contribute to better quality ice data, but also to more cost-efficient data if satellite data can replace some of the aircraft observations. The benefits will be:

- better quality in the ice information delivered to users
- lower costs for the ice centres in data acquisition

Secondly, SAR data can be used directly by customers working at sea provided that the images and derived products can be transmitted to the vessels and platforms in near real time. Images available in near real time can help ship captains find the best sailing routes through the ice pack and avoid dangerous areas. In combination with better quality ice maps from the ice centres this will contribute to more cost-effective and safer operations in ice. The benefits are:

- minimum time delay in receiving ice information in near real time
- minimise the risk for accidents in ice
- use of the most cost-effective sailing route

Thirdly, SAR data can contribute to better knowledge of the ice conditions, which will be useful in making better prediction models. The benefits will be:

- both the ice centres and the users will increase the ice knowledge which is necessary for safe and cost-effective operations
- the ice forecasting will be improved which is necessary for short-term as well as long-term planning of operations.

iii.

iv.

v. IV.3.3 Iceberg monitoring in the Eurasian Arctic

Introduction

Icebergs are a serious threat to maritime activities in many regions of the Arctic and Antarctic. Their formidable presence makes icebergs an obstacle to shipping, offshore oil production, and commercial fisheries activities. Consequently, it is extremely important that the iceberg danger be identified, tracked, and reported to the mariner. After the “Titanic” wreck in 1912 iceberg observations were initiated in the frames of the International Ice Patrol (IIP). The International Ice Patrol's role is to establish the limit of all known ice south of 52o N, and transmit iceberg information to shipping. The IIP monitors and broadcasts the south-eastern, southern, and south-western limits of icebergs in the vicinity of the Grand Banks of Newfoundland. Reports of ice in this area will originate from passing ships and IIP reconnaissance flights. The addition of the SLAR tremendously improved the Ice Patrol's reconnaissance efficiency. Since 1983, IIP's primary detection radar has been the AN/APS-135, Side-Looking Airborne Radar (SLAR). In 1993, the IIP added the AN/APS-137, Forward-Looking Airborne Radar (FLAR) as an additional sensor. The Ice Patrol was then able to get the same amount of patrols in a week as two weeks without the SLAR. Even using present day technology, icebergs are not easily detected by mariners. The smaller pieces of icebergs and growlers are difficult to detect either visually or by radar.

Berg Analysis and Prediction System (BAPS) under the Canadian Ice Service implement the icebergs monitoring and modelling their movements. The method involves locating the position of the icebergs using visual observations (aerial, ships and if possible satellites). Then using the CIS drift model, iceberg movement is predicted for up to maximum 30 days. The model incorporates i.e. sea currents at 50 m depth, wave heights, wind data, and sea surface temperature (Sandven et al., 1997).

Iceberg distribution in the Eurasian Arctic

In the Eurasian Russian Arctic, icebergs are calved mainly from the outlet glaciers, located in Franz-Joseph Land, Novaya Zemlya, and Severnaya Zemlya. The very approximate assessment of total ice calving for Novaya Zemlya is 2 km3 of ice per year (Govorukha, 1989). These icebergs melt in Novaya Zemlya fjords and were not frequently observed in the open sea. According to air reconnaissance data the southern boundary of their distribution in the Kara Sea is situated in 75-76oN. Along the eastern coast of Novaya Zemlya icebergs did not occur. The probability of their appearance near the western coast of Yamal is almost zero. The annual iceberg calving in Franz-Joseph Land amounts to 2.26 km3 from total outflow of 6.5-7.5 km3 (Abramov, 1996). The large icebergs can be calved from the glacier on George Land. According to Kloster, Renown Glacier on Vilczek Land is the main source of very large icebergs up to 1.4 km long. The large icebergs (with length of some hundred meters and thickness of 60-100 m) were observed in the straits and gulfs of Franz-Joseph Land: in British Channel, Cambridge, Ermak, Austrian Channel, Zubova and several other straits. Usually the large icebergs are anchored on banks near to frontal cliffs of glaciers. As a rule, they do not reach area southward from 74o N, but in extreme years, for example in 1929, they appear even at Murmansk coast and entrance to the White Sea (Abramov, 1996). The amount of icebergs does not remain stationary in time, and in some years suddenly increases.

Due to exploration of oil fields in the Eurasian Arctic Shelf the interest to the iceberg studies in this region increased significantly. Icebergs there present a threat for the oil platforms and underwater communications. At present time the system of their monitoring is absent, but a number of studies of their distribution and size were conducted. In iceberg monitoring particular attention should be drawn to use of Remote Sensing techniques for their detection.

Experience in iceberg detection using SAR

The Eurasian Arctic icebergs are significantly smaller than those are in the Antarctic and Greenland and therefore high spatial resolution of satellite sensors is necessary for their detection. Our studies were conducted using ERS, RADARSAT and ENVISAT SAR images. Icebergs in SAR images were detected by means of visual inspection due to their higher backscatter as compared with surrounding ice. Nevertheless even in SAR images their detection is ambiguous and their signatures could be similar to those for the small floes of multiyear ice. Therefore expert knowledge about the iceberg distribution in different regions of the Arctic and sub satellite data is necessary. Studies were conducted in the regions near Novaya Zemlya, Severnaya Zemlya, Franz-Joseph Land, and Scabbard.

Novaya Zemlya. Glacier boundaries and areas of iceberg calving were detected from ERS-2 SAR images for September 4 and 7, 2001, covering the northern part of Novaya Zemlya. A significant amount of small icebergs and bergs bits were observed from the ship near Petersen, Bunge, Vera, Pavlova, Inostrantseva, Karbasnikova, Vize and Anuchina glaciers. Single icebergs were not detected in SAR images, but areas near the glacier boundaries have specific SAR signature.

Severnaya Zemlya. From ERS SAR images for August 1993 icebergs were identified in the western part of the Laptev Sea to the east of Red Army strait (Kolatschek et al., 1995). More than 100 icebergs were observed in this area from helicopter in September 1993 (Eicken et al., 1994). Also in October 1995 more than 100 icebergs were observed in this area from icebreaker and helicopter. Some of them were more than 1 km long (Alexandrov and Kolatschek, 1997).

From RADARSAT ScanSAR images, acquired in March 1997, September 1997, and March 1998, icebergs were detected in different parts of Severnaya Zemlya. In March 1997 icebergs were identified in the eastern part of Shokalsky Strait, near Matusevich fjord (more than 20 icebergs), and in the different parts of Red Army Strait – to the north of Pyatnistyi gulf, near Visokiy island, and to the south of Diabazovie islands. In March 1998 icebergs were found in Shokalsky Strait in its eastern part and near Marat fjord, to the east of Matusevich fjord (more than 10 icebergs), in Red Army Strait, and to the east of it.
An iceberg recognized in RADARSAT ScanSAR image for September 7, 1997 to the east of Vilkitsky Strait was observed from the icebreaker “Sovetsky Soyuz” and its estimated length amounted to 100 m (Sandven et al., 2001).

In ERS-2 SAR images, acquired in September 2001, several tens of icebergs were detected in different parts of Red Army Strait, and to the east of Matusevich fjord (more than 10 icebergs).

Franz Josef Land. From RADARSAT ScanSAR images for March 1997 and 1998, and November 1997, several areas of iceberg distribution were detected.

Between Wilczek Land and Klagenfurt island. Coordinates of the area with high concentration of icebergs are the following – 80o26N', 60o11'E; 80o24'N, 60o17'E; 80o22'N, 60o11'E; 80o23'N, 60o02'E; 80o 22'N, 59o 59'E; 80o24'N, 59o 55'E. This area was delineated from ScanSAR image for March 13, 1998. More or less similar iceberg distribution was found in this area from analysis of ScanSAR images for March 1997, and in February 1992 from analysis of airborne multifrequency radar images (Alexandrov et al., 1992). Several icebergs were detected in the Austrian channel (to the west of Wilczek Land), and in the Yelena Guld Gulf (to the north of Cape Vailas, Vilczek Land).

George Land area. In Essen Gulf icebergs were located in the area with the coordinates (80o22'N, 49o12'E; 80o 17'N, 49o 17'E; 80o18'N, 49o27'E; 80o20'N, 49o29'E), and several icebergs could be identified near Cape Piterhead. Icebergs in this area were also detected in SLAR images for February 1992. About 10 icebergs were detected in Geographov Gulf from ScanSAR image.

Solsberry Island area. Icebergs were detected in Brown and Rods straits.

Rainer Island area. Icebergs were recognized in Ruslan and Bashmakova straits.

Jackson Island area. Several icebergs were identified in the Italian Strait.

The area between Bruce and Prichett Islands. Several icebergs were detected in Sadko Strait.

Svalbard. In March 2003 and April 2004 series of ENVISAT ASAR images were acquired in the area around Svalbard, and subsatellite sea ice observations were conducted from ships and helicopters. During the experiments geographical coordinates of several icebergs were determined. Size of several icebergs and bergy bits was measured during in situ observations. The analysis of the possibility of iceberg detection from SAR data is analyzed.

Conclusions

Analysis on using SAR for iceberg detection is conducted in different parts of the Eurasian Arctic. It is shown that icebergs could be detected and mapped using SAR images from ERS, RADARSAT, and ENVISAT satellites. Areas of iceberg discharge were found in Severnaya Zemlya and Franz Josef Land Archipelagos. Nevertheless, the problem of iceberg detection from SAR images needs further investigations. It is necessary to clarify the possibility of their identification depending on their size and characteristics of surrounding sea ice, as well as open water.

vi. IV.4. Possible integration of Russian and European Ice services

Sea ice in the Arctic is very important for marine operations and climate. Sea ice monitoring and forecasting of sea ice conditions, as well as related meteorological and oceanographic parameters, is important for ensuring safe operations with minimum risk for accidents and negative impact of human activities on the environment. Increased activity in oil and gas exploration in the Eurasian Arctic shelf needs more accurate data on sea ice parameters. Global Climate Change is expected to be most pronounced in the Arctic regions, where the ice cover is quite sensitive to these changes Therefore a necessity for better quality Ice Services becomes quite actual.

At present time the concept of integrated European Ice Service is elaborated in the frames of ICEMON Project (i.e. one of the GMES activities). This service will support different user segments, such as climate and weather services, safety of sea transportation and fisheries, management of marine environment and others. In ICEMON the plan is to design and implement a monitoring service for all ice areas in the Northern Hemisphere, using SAR in combination with other EO- and in situ data.

Sea ice monitoring in the major part of the Arctic is implemented by the Russian Ice service. Therefore the consolidation of the Russian Ice Service with the proposed integrated

ICEMON service is of major importance. Advanced remote sensing techniques, such as SAR and radar-altimeters could significantly improve sea ice monitoring in the Northern Sea Route. Plans for launching satellites with sensors in microwave and visible bands exist in Russia ("Sich" satellite). An experience, accumulated by Russian ice observers in interpretation of satellite images in different spectral bands, as well as knowledge of sea ice conditions in the Eurasian Arctic, could be successfully used in interpretation of SAR images. The infrastructure for receiving satellite images is developing, and includes data from the European and American satellites. The databases of sea ice parameters, accumulated in Russia during the decades of active Arctic exploration, could significantly support climate studies in regional and global scales.

vii. IV.5. Economic framework of SAR application to sea ice and icebergs monitoring

viii. IV. 5.1. Data policy aspects

The economic aspects of using satellite data in ice monitoring can be discussed at three different levels:

- Space agency level
- National ice centre level
- End user level

The cost-benefit of using satellite data is totally determined by the data policy of the space agencies (ESA, NASA, NASDA, etc.) or national space programmes (NOAA, SPOT, IRS, etc.). The decisions made by member states of these organizations (who can receive data free-of-charge, who must pay for the data, and what is the price for different users) define the economic framework for the use of satellite data. Satellite systems for earth observation are usually financed by national governments through the space agencies, space programmes or through organizations such as WMO, but commercial space programmes using more dedicated and low-cost satellite systems are expected to become more important in the future.

The use of satellite data in ice monitoring is different from use of data in land applications. Operational applications, like ice services and meteorological services, use data every day, and as soon as they have been used they have only historical value. In ice monitoring all available data, including space-borne data, are collected, analysed and made available to users through various products (reports, charts, forecasts, etc.). This also means that operational ice services use large volume of data and the data costs are large compared to terrestrial uses. The data policy for SAR data is not designed to make large quantities of space-borne data available in operational ice monitoring.

Due to different data policy, we have a situation that some types of satellite data used in ice monitoring are free-of-charge such as NOAA AVHRR and SSM/I data, while other data such as SAR (RADARSAT), SPOT, IRS and Landsat have to be purchased at commercial terms. The commercial data are usually high-resolution images which provide much more detailed information than the free-of-charge data with coarse resolution. ESA's delivery of SAR data includes both a commercial and a free-of-charge policy, because a large amount of SAR data are being provided free-of-charge for research and demonstration purposes, while commercial users such as oil companies have to pay for the SAR data. There is an increasing demand that ESA need to sell data, implying that the possibilities to get large amounts of free-of-charge data will be more restricted. RADARSAT, which also supplies SAR data for ice monitoring, has a clearly more commercial data policy than ESA. On the other hand, the main users of RADARSAT data in ice monitoring, the national ice centres in Canada and USA, receive data at a fraction of the official price. This is because these users are governmental institutions and the RADARSAT programme is financed by significant investment from these governments.

The national ice centres in Europe are the main users of satellite data for ice monitoring. The cost-benefit of satellite data form their point of view is mainly determined by the price they have to pay for the data compared to the price of other sources of information. In many cases, there is a trade-off between use of aircraft surveys and satellite data, especially SAR data. The ice centres have limited budgets and there is often a demand to reduce costs as well as to increase the quality of the ice monitoring service. User payment for the ice information has been introduced for some services, but since basic ice information is a public service it should be available free-of-charge or at a modest cost. It would not be possible to provide a basic ice service without considerable funding from the national governments. A full commercial ice service would only be possible for specific customers such as shipping companies, oil companies and other offshore industry which need more extensive and focused ice information than the basic public service can provide. ERS SAR data can be cost-effective if the data provide important ice information and the price is realistic. Acquisition of RADARSAT data for operational services at the nominal price is not realistic within the budget of the national ice centres.

However, with a strongly reduced price for RADARSAT data, this situation may change. In Russia, use of SAR data in the national ice services is unrealistic due to the severe budget cuts in recent years. The main possibility to use SAR data for ice monitoring in the Northern Sea Route, is to make data available free of charge, such as ESA has done in the ICEWATCH demonstration project. Another possibility is that oil companies or other industries, which need ice information, may pay some of the costs for SAR data as part of their investments in a better ice service.

The most important economic aspects are those from the end users point of view. It is the end users who are the driving force for the national ice services, and it is the benefit and cost-savings for the end users that determine the acceptable cost of ice monitoring. If there is a large number of end user, who need ice information and are willing to share the costs, it is possible to increase the quality of the ice service by introducing more expensive satellite data. On the other hand, if there are only a limited number of users and they expect the ice service to be free-of-charge, it is not realistic to introduce additional satellite data on fully commercial terms to improve the ice service.

Ice monitoring is traditionally a public service financed by the governments through their national ice centres. Users of ice information consider standard ice information products to be free-of-charge or available at a low cost. As the need for more specialized ice information develops, first of all due to requirements from the offshore industry, financing of specialized products by the customers increases. This development is clearly seen in many European ice services.

Today the ice services have the basic governmental funding supplemented by customer funding of up to 50 % of the total budget of the ice centres. However, many of the customers are other governmental institutions, so it is a question of how public funding is channelled. There is also varying degree of financing from industry and private funding sources. The exact figures for how much public and private customers contribute to the financing is difficult to assess because expenses of the ice services are also part of for example the coast guard air surveillance, public rescue services and the general meteorological services.

It is foreseen that the trend of decreasing public funding and increasing private funding will continue. The specialized needs from different customers, the availability of better space-borne data, the improvements in global communication, and last but not least the importance of computer technology to produce new ice products will stimulate a market where several companies and institutes will offer data and services related to ice monitoring.

There has also been a change in governmental policy towards reducing the free-of-charge public services. Therefore some of the products, which were formerly free-of-charge or very cheap, have been re-priced, including the products and services delivered to the other governmental institutions. The ice services have been able to sell their products to a larger number of customers and thus the funding by customers has increased. However, the number of driving users such as ship traffic and offshore oil activities limits the market.

The shipping companies are not fully aware of possibilities of operating ships more economically in ice-covered areas by using more high-resolution satellite data. On the other hand, public ice services cannot and are not willing to finance the use of expensive SAR data alone, since it is the private sector that will benefit from improved ice information. If ice navigation could be made more efficient, it is the shipping companies which will save costs and the price per transported ton would decrease. The overall result of this cost saving is to the benefit of the whole national economy.

The user investigations suggest that the major component of the ice services will also be a public responsibility in the future, but it will be supplemented by the private financing. The questionnaire sent to the users in the private sector suggests that the ice services could be funded 3/4 from public sector and 1/4 from the private sector.

IV.5.2. Effectiveness of sea ice monitoring of NSR

The Marine Operations Headquarters in Dikson, which provides ice maps and ice forecasts for the western part of the Northern Sea Route, is partly financed by the Murmansk Shipping Company, which is in turn financed by the Russian government to provide icebreaker service in the area.
The Northern Sea Route is the longest and most difficult sailing route in sea ice. Lack of adequate ice information can therefore have severe economic impact for ships in terms of damage to ships and time loss due to difficult ice navigation. Satellite data is considered to play an increasingly important role to provide the ice information, first of all because use of aircraft for ice monitoring has decreased in recent years.
NOAA AVHRR data are, in spite of the cloud limitation, the most used remote sensing data in sea ice monitoring due to its low cost. SAR data have proven to be the most powerful tool for ice monitoring, but operational use has not been possible due to high cost of data and insufficient coverage. With RADARSAT and ENVISAT the coverage will be significantly improved, but the data cost will still be a problem.
The price levels for SAR data must be adapted to operational use in order to be used by MOH on regular basis. This can be achieved if the data providers offer lower prices and data purchase is subsidised by the government. The MOH has limited budgets, and if there is a need for improved quality of the ice monitoring services by use of SAR data, it is expected that the users must pay for this.
Availability of SAR images and derived sea ice information may replace parts of the expensive and in periods extensive need for use of helicopters for local reconnaissance of the sea ice conditions.

Use of SAR images in near real time can help ships avoid heavy ice and save sailing time by following the optimal route. With a daily cost of $ 50 000 for icebreaker assistance from NIB Vaygach to foreign vessels this demonstrates that significant savings can be made by using real-time ice images to select the optimal sailing route.

It has been estimated by N. Babich (Babich, pers. comm.) that with SAR coverage from RADARSATs ScanSAR it will in theory be possible to double the productivity of the icebreaker fleet of Murmansk Shipping Company. This is illustrated in **Fig. 4.4** showing the mean icebreaker speed will increase from the present situation with no use of SAR (bold line) to the dotted line representing a situation with use of RADARSAT images. The hatched area represents the improvement in productivity as a function of season.

For instance, if we assume that the velocity of a ship without using SAR data is 5 knots on the average then it is easy to obtain that 120.000 $ will be saved for each 1.000 km of the route in case of application of SAR data.

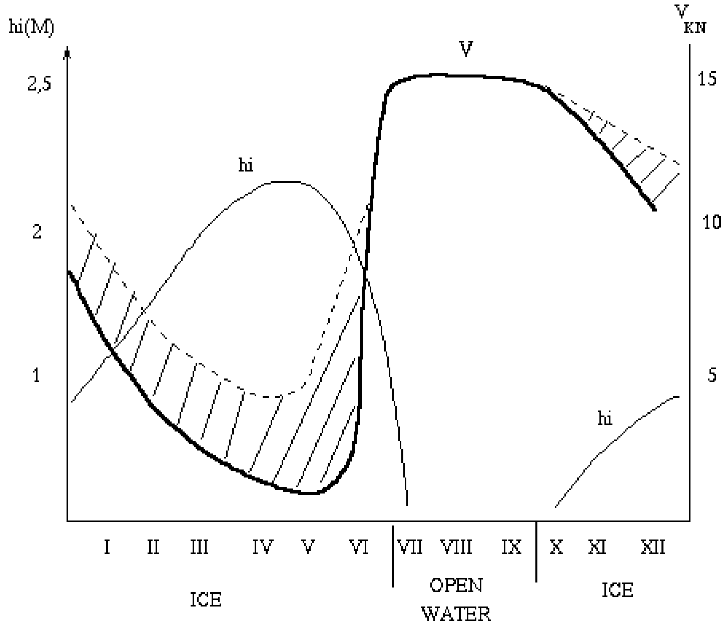


Fig. 4.4. **Mean icebreaker convoy speed (V) and mean ice thickness (hi) as function of month in the Northern Sea Route. (N. Babich, pers. communication).**

Additional quantitative information on the subject could be extracted from **Fig. 4.5.**

Accurate and timely sea ice information is important not only for the economy, but also for safe navigation to avoid accidents with loss of human lives and pollution (oils spills, etc.), which harms the Arctic environment. The regulations of ship transport in the Northern Sea Route, which require extensive hydrometeorological and sea ice information, are made to minimize the risks for pollution of the environment. Transport of oil and gas, which is currently performed by pipelines, can be shifted more to tankers in the future as production moves offshore. Also the prospect of international ship traffic between Europe and East Asia/North America will have impact on the environment.

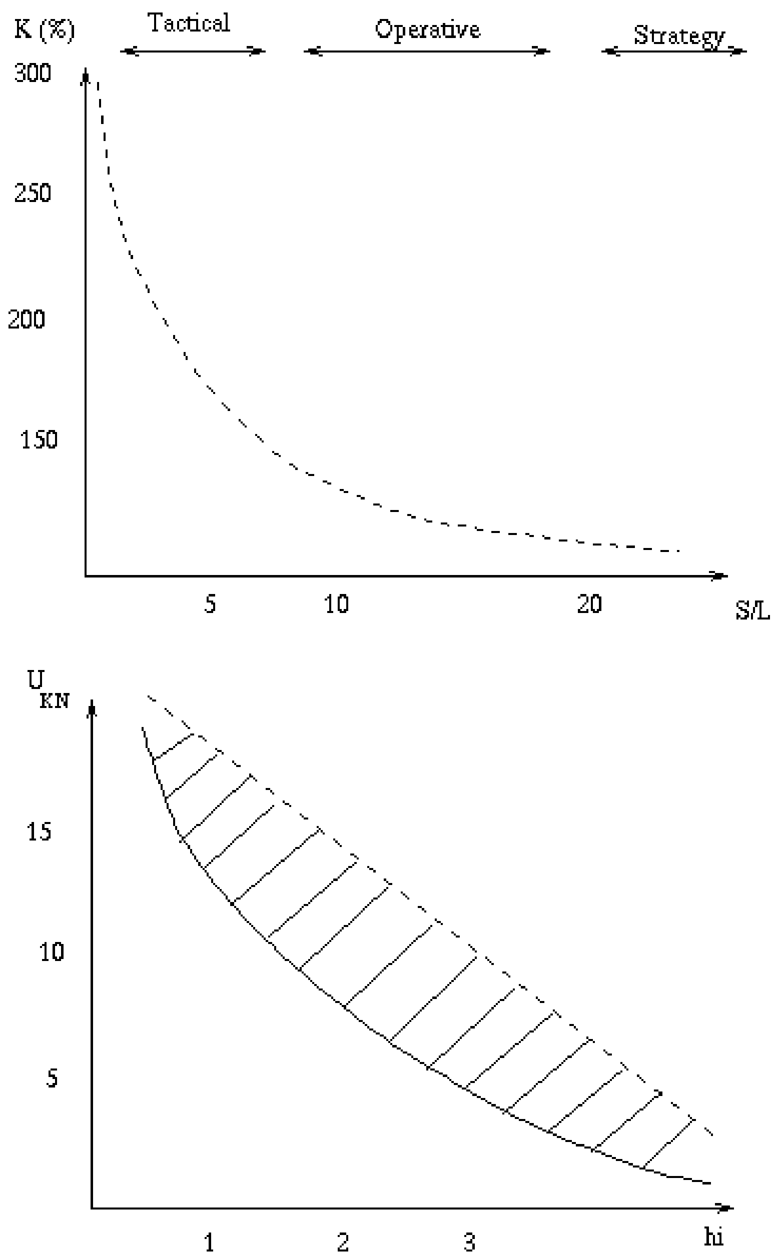


Fig. IV.5. Top: dependence of coefficient of increase of ship velocities in ice conditions (K %) on linear scale of resolution of source of data of ice reconnaissance. Bottom: ship velocity U (knots) as a function of ice thickness hi (meters) (N. Babich., pers. communication).

ix. References to Chapter IV

Abramov V.A. Atlas of Arctic Icebergs, The Greenland, Barents, Kara, Laptev, East-Siberian seas, and the Arctic Basin, Ed. By A. Tunik, Backbone Publishing Company, 1996, 70 pp.

Alexandrov V.Y., Blinkov A.N., Kolpak V.V., Loshchilov V.S., Savich V.A., Torokhov G.A., Fomin V.A. Multifrequency radar signatures of ice cover. In: Proceedings of the 18th Annual Conference of the Remote Sensing Society, University of Dundee, 15-17th September 1992, pp.35-46.

Alexandrov V.Yu., Kolatschek J. Sea-ice remote sensing – in Berichte zur Polarforschung, 248, 1997, pp. 28-29.

Alexandrov V.Y., Melentyev V.V., Bobylev L.P., Korotkevich O.E., Bogdanov A.V., Zaitsev L.V., Zemeszirks K.E., Babicg N.G., Gorshkovsky A.G., Sandven S., Dalen Ø., Pettersson L.H., Kloster K., Lundhaug M. Satellite SAR Ice Charting and Routing Validation and Assessment, NIERSC Technical Report No.12, St.Petersburg, 1998, 77 p.

Andreeva E.N. Methods of study of socio-economics problems of the Russian Arctic Coastal Zone. In: Abstracts of the Third Workshop on Land Ocean Interactions in the Russian Arctic (LOIRA), Moscow, 5-8 December 2000, pp. 7-9.

Brigham L.W. Technical development and the future of Soviet Arctic marine transportation. Polar Record, 1996.

Bushuev A.V., Bychenkov Y.D. Studies of sea ice cover distribution and dynamics from visible images of "Meteor" satellite. A temporary instruction, Leningrad, Gidrometeoizdat, 1976, 132 p.

Bushuev A.V., Bychenkov Y.D., Loshchilov V.S., Masanov A.V. Studies of sea ice cover with the use of side-looking airborne radar, Leningrad, Gidrometeoizdat, 1983, 120 p.

Eicken H., Alexandrov V., Bogdanov V., Martin T., Reimnitz E., Syrtsov S. Iceberg observations, In: Berichte zur Polarforschung. The expedition ARCTIC'93 Leg ARK-IX/4 of RV "Polarstern" 1993, edited by D.K. Fuetterer, vol. 149, 1994, pp. 76-78.

Frantzen B., Bambulyak A. Oil transport from the Russian part of the Barents Region (on July 1, 2003). Svanhovd Environmental Centre, 2003.

Frolov I.E. Hydrometeorological support of the Northern Sea Route: history and perspectives/ In: Reports of the Scientific-practical conference "Hydrometeorological support of the economical activity in the Arctic and freezing seas", St.Petersburg, March 27-29, 2002, pp. 45-50.

Govorukha L.S. Modern glaciation of the Soviet Arctic, Hydrometeoizdat, L., 256 p., 1989.

Johannessen O.M., Sandven S., Kloster K., Miles M., Melentyev V.V., Bobylev L.P. A Sea Ice Monitoring System for the NSR using ERS-1 SAR data, Technical report N 103, NERSC, September 1995, 50 p.

Johannessen O.M., Volkov A.M., Grishenko V.D., Bobylev L.P., Asmus V., Hamre T., Haugen V.J., Kloster K., Melentyev V.V., Pettersson L.H., Sandven S., Smirnov V.G., Alexandrov V., Milekhin O.E., Krovotyntsev V.A., Solhaug J., Zaitsev L. ICEWATCH: Real-Time Sea Ice Monitoring of the NSR using Satellite Radar Technology, Technical report N 113, NERSC, May 1997.

Johannessen O.M., Pettersson L.H., Sandven S., Melentyev V., Miles H., Kloster K., Bobylev L., Stette M., Drottning A., Kondratyev K. Real-Time Sea Ice Monitoring of the NSR using ERS-1, Project report for ERS AO PP2-N1, NERSC, July 1994, Technical Report 1/94

Johannessen O.M., Sandven S. ERS-1 SAR ice routing of L'Astrolabe through the Northeast Passage, Arctic News-Record, Polar Bulletin, Vol. 8, No.2, 1992, pp. 26-31.

Kolatschek, J., Viehoff T., Eicken H., Nagelsbach E., Alexandrov V. Ice dynamics in the southwestern Laptev Sea as derived from ERS1 SAR images. In: Berichte zur Polarforschung, RussianGerman Cooperation: Laptev Sea System, edited by H. Kassens, D. Piepenburg, J. Thiede, L. Timokhov, H.-W. Hubberten, S.M. Priamikov, vol. 176, 1995, pp. 20-24.

Mironov E.U., Brestkin S.V., Smirnov V.G. Ice information system for the Arctic and development of hydrometeorological support technologies. In: Reports of the Scientific-practical conference "Hydrometeorological support of the economical activity in the Arctic and freezing seas", St.Petersburg, March 27-29, 2002, pp. 130-136.

Mitnik L.M., Viktorov S.V. (eds) Radiolocation of the Earth from Space, Album-monography, Gidrometeoizdat, 1990, 199 p.

Mulherin N.D. The Northern Sea Route. Its development and evolving state of operations in the 1990s, CRREL Report 96-3, 1996, 77 p.

Pettersson L.H., Sandven S., Dalen Ø., Melentyev V.V., Bogdanov A.V., Kloster K., Lundhaug M. Arctic Demonstration and Exploratory Voyage (ARCDEV), The Nansen Centre contribution to WP3: Ice conditions and WP10: Remote Services and Maintenance, NERSC Technical Report No.167, Bergen, June 1, 1999, 49 p.

Sandven S., Dalen O., Lundhaug M., Kloster K., Alexandrov V.Y., Zaitsev L.V. Sea ice investigations in the Laptev Sea area in late summer using SAR data, Canadian Journal of Remote Sensing, vol. 27, No. 5, 2001, pp. 502-516.

Sandven, S, Groenvall, H., Seina, A., Valeur, H.H., Nizrovsky, M., Gill, R., Andersen, H. S., Haugen, V.J., Kloster, K. 1997. Operational Sea Ice Monitoring by Satellites in Europe OSIMS Report No. 2, NERSC Technical Report No. 129.

Sandven S., Maekynen M., Hallikainen M., Similae M., Gronvall H., Cavanie A., Ezraty R., Maroni C., Gill R., Valeur H.H., Pedersen L.T., Alexandrov V., Andersen S., Lundhaug M., Bjørgo E., Dalen Ø., Kloster

K. Integrated use of new microwave satellite data for improved sea ice observation, IMSI Final Report, IMSI Report no.8, NERSC Technical Report N 145, July 1999, 140 pp.
Smirnov V., Frolov I., Grishchenko V., Mironov E. Russian Ice Information Services in the Future, In: Proceedings of the Northern Sea Route User Conference, Oslo, 18-20 November 1999, Kluwer Academic Publishers, 2000, pp. 169-176.
Velikhov E., Pahsaev D., Kuznetsov V. Russia in the process of Arctic shelf hydrocarbons fields development: state, perspectives, problems. In: Symposium of European Community countries, Russia, Canada and USA “Common approach to collaborative technological research for Arctic development”, Brussels, 25-27 October 2001, pp. 32-50.

V. Air Quality monitoring. Social-economic aspects

V.1 Natural Hazards and Disasters in Russia

It is impossible today to find the human's activities, which are free from the influence of the environmental and meteo-climatic factors. The environmental processes make significant impacts on agriculture, transport, fishery, power engineering, building and trade.
The territory of Russia possesses the variety of geological, climatic and landscape conditions and there are more than 30 types of natural hazards observed [3]. The most damaging are:

- Earthquakes
- Floods and under flooding
- Forest Fires
- Draughts
- Landslides and mudslides
- Soil erosion
- Karsts
- Suffusions
- Hurricanes, Storms, Tornadoes
- Snow avalanches

Whereas one group of hazards consists of sudden and momentary events (earthquakes, avalanches, hurricanes, mudslides) and entails serious consequences including people deaths. Other- such as under flooding and soil erosion - are long-term processes, which don't threaten the human's life directly but give the dramatic damage to environment and national economy.

The zones of the seismic danger constitute one fifth of the territory of Russian Federation. The most seismically dangerous territories are:

- North Caucasus
- Baikal Lake region
- Kamchatka peninsula
- Sakhalin island
- Kurill islands

The seismic activities in Russia in 2002 have been registered in:

- North Caucasus (Dagestan republic)
- Baikal seismic zone (Buryatia republic and Irkutsk region)
- Far East (Kamchatka peninsula, Sakhalin island, Kurill islands

The intensity of some earthquakes was 5-6 grades.

The floods became the most repetitive natural disaster that brings the hardest economic loss and destroys the huge territories of the country. Some 400 000 km^2 in Russia is the territory of the potential flooding risk. Some 50 000 km^2, over 300 Cities with population over 4, 6 millions are being flooded annually. The economic damage and loss from the floods is estimated as 43 Bln. roubles (1, 43 Bln. USD).
The most dramatic situation occurred in summer 2002 in southern Russia. As a result of heavy floods 114 people were killed and some 329 000 people were affected with hard economic consequences. The damage of settlements (1863 living houses were completely destroyed), roads, electric supply lines, bridges was enormous.

Forest Fires

Ministry of Natural Resources and State Statistics Agency registered 43 400 Forest fires in Russia in 2002. The figure exceeds those of 2001 in 1, 8 times. The fire sized 1, 37 million hectares of forest and 0, 76 millions hectares of populated areas. The regular forest fire monitoring is being performed only on a 60% of the forest fund territory. In the northern Siberia and Far East (30% of national forest fund) the operational monitoring and active anti fire fight is practically absent. Despite of the number of forest fires in Russia on 1 million hectares of forest territory is several times less than in Europe and Northern America, the average area of fire spot is significantly bigger. The damage from forest fires in 2002 in accordance to data from Russian State Statistics agency and Ministry of Natural Resources was estimated as 4, 9 billions roubles. 32 351 200 m^3 of wood were completely eliminated and 105 600 hectares of the young forest were destroyed. The costs for fire extinguishing constituted 1079, 5 millions roubles.

Draughts

The draughts are large - scaled and long-term disaster. In the Volga region and in North Caucasus the draughts occur every 2 or 3 years. In accordance to data of the Ministry of Agriculture some 2 276 000 hectares in 32 federal districts of Russian Federation were affected by draught in 2002. The agricultural crops were killed by the draught and total economic lost was estimated as 6628, 8 millions roubles.

The dangerous meteorological events

In accordance to ROSHYDROMET records some 258 emergency events are registered in 2002 in Russia that caused significant economic damage. These events were connected with strong winds, rainfalls, snowfalls and spring floods. The maximum of these events are registered in the southern federal district (78), in Siberia (67), in Volga region (12) and in Ural region (16).

The hurricane winds have caused the significant damage to national economy in Krasnodar, Stavropol, Altai, Kaliningrad, Kemerovo regions and Hakassia republic.

The strong snowfalls and storms damaged electricity supply networks and collapsed the transport and industry in Krasnoyarsk, Kemerovo, Tomsk and other regions of the federation.

The strong and long term rainfalls caused the loss of the harvest in Kaliningrad, Tyumen, Irkutsk regions.

The large number of the emergency situations is caused by the high frosts. The strong frosts (-45º - -55º Celsius) were registered in 2002 in Yamal, Taimyr, Evenkyjski autonomous okrugs and in Krasnoyarsk. These strong frosts paralysed in some cases the activities of the city services, transport, central heating etc.

Table 5.1 summarises the valuations of the economic losses regarding to natural disasters mentioned above [4].

Natural disaster	**Number of Cities affected**	**Annual Economic loss in Bln . rub.**	
		One-time estimations	**Average estimations**
With people deaths			
Floods	746	7.2	13.5 – 14.625
Hurricanes and storms	500	0.135	0.36
Tsunamis	9	0.675	0.2025
Landslides and crumbling	725	0.135	8.1 – 13.5
Earthquakes	103	135	6.75 – 10.35
Avalanches	5	3.375	0.0675
Mudslides	9	0.675	0.00675
Without people deaths			
Surface erosion	734	2.025	23.85 – 28.8
Under flooding	960	0.675	16.2 – 20.25
Erosion (Rivers)	442	0.00675	13.5
Karsts	301	0.02025	3.375
Suffusion	958	0.135	>= 3.37
Forest slump	563	0.09	1.935 – 2.636
Thermo-karsts	62	0.0675	1.35 – 1.935
Thermo-erosion	72	0.0675	0.675
Total		**150.282**	**100.000 – 140.000**

Table 5.1 Socio-economic damage from natural disasters

V.2 Risk assessment for human's health as a result of atmospheric pollution

Losses caused by the atmospheric pollution and led to worsening of the human's health, can be presented in the form of three components:

- underproduction of the national income as a result of diseases of persons;
- pecuniary aid for temporary disability ;
- expenses for health services.

Expenses for treatment include the cost of medicines, cost of a call for a doctor, expenses for treatment in the hospital, expenses for inspection and treatment.
All the population of the region affected by air pollution could be divided into three age groups:

- till 19 years
- 20 – 60 years;
- over 60 years

The losses from the sick rate of the population of the first age group consists of the expenses for health services, and in part of those connected with underproduction of national income and payment of medical certificates. The illness of the population of the second group leads to the expenses that are completely above those of the first group. The losses from the third group consist of expenses for health services.

Table 5.2 shows the supposed costs of losses for every age group depending on the concentration in the air of different harmful ingredients. All figures for costs are given in thousands roubles.

Specific damage roubles/(year• persons)	Annual mean ash concentration, mg/m3							
	0.3	0.45	0.6	0.75	0.9	1.05	1.3	1.35
From worsening the population health	13	20	24	28	31	33	34	35
Specific damage roubles/(year• persons)	Annual mean ash concentration, mg/m3							
	0.3	0.45	0.6	0.75	0.9	1.05	1.3	1.35
From worsening the population health	13	20	24	28	31	33	34	35
Specific damage roubles/(year• persons)	Annual mean concentration of nitric oxides, mg/m3							
	0.17	0.225	0.34	0.425	0.51	0.593	0.68	0.765
From worsening the population health	16	24	31	35	38	40	43	41

Table 5.2 Costs from worsening the human's health and costs of municipal services as a result of air pollutions

The present overview combines elements of traditional methodology of the risk evaluation and the model of ecological damage from burning of mineral fuels developed by the Department of the environmental protection of the World Bank.

According to this model the risk for the human's health, arising as a result of emissions of harmful substances in the urban atmosphere, is an important category of damage accompanying the use of various fuels. The examples of such risks include

- the increase of frequency of respiratory diseases,
- acute attacks of cardio-vascular diseases

- and additional or premature death rate of the population connected with these diseases.

It also gives the increase of the probability of the development of malignant tumours (carcinogenic effects).

These negative effects directly depend on emissions of suspended matters (TSP) in the atmosphere, and to be exact, on concentrations of the most dangerous fractions of the suspended particles in air-particles of diameter less than 10 μm (PM10) and less than 2.5 μm (PM2.5), emissions of nitrogen peroxide, sulphur dioxide, soot benzopyrine, volatile organic compounds heavy metals. These emissions are inevitable in the process of burning of mineral fuels.

In the USA the wide experience is gained in the application of the methodology of risk assessment and risk control for estimating concurrent benefits in ecological policy. This methodology was successfully tested in Russia as well [10]. The results of the performed investigations have shown the advantages of the risk evaluation for human's health when making the decisions on a base of economically effective nature protection and sanitary actions. For estimating we shall use the latest data on the air pollution in cities of Russia published in [10].

According to [10], in 2002 Russian cities (what constitutes the 80% of the cities under the experiment) the annual mean concentrations of harmful substances in the air exceeded the maximum permissible concentration. These cities have the total population of 64.5 million people.

The risk evaluation is made on a base of the criteria given in [9]. The growth of common mortality due to the influence of sulphuric dioxide **is 0.72 %** for every extra 10-mkg/m3 concentration and **is 0.4 %** for every 10 mkg/m3 of PM_{25} particles contained in the ash of coals. The increase of frequency of respiratory diseases as a result of influence of nitric dioxide is
6.6 % for every 10 mkg/m3 of this substance. The increase of duration of attacks of bronchial asthma **is 6/5 %** with the growth of nitric dioxide for every 10 mkg/m3 and **is 5 %** with growth the concentration of sulphur dioxide for every 10 mkg/m3. The average estimations for Russia are given in **Table 5.3**. The figures represent thousands persons.

Unfavourable effect	NO_2	SO_2	Suspended matters	Total
General mortality	-	210.2	678.4	888.6
Increase of frequency of respiratory diseases	3110.6	-	-	3110.6
Increase of duration of attacks of bronchial asthma	3063.0	1502.6	-	4565.6

Table 5.3 the population in Russia exposed to the risk of health (thousand persons)

Table 5.3 shows that almost one million persons in Russia live in a zone of a possible lethal outcome and more than 3 millions people have such a risk because of the increased level of air pollution. More than 4.5 millions people turned out to be in the risk area of acute attack of bronchial asthma. The above data represent the forecast that has been made on a base of the methodology given in [10]. Below we give the actual estimates presented in [11].

Mortality

Rank	Factor	Reason of death	Number	Source
1	Road and transport incidents	accidents	Up to 30	The Ministry of Internal affairs of Russia
2	Atmospheric air pollution by suspended matters	Diseases of organs of breathing and cardiovascular diseases	Up to 40	On the basis of use of methodology of risk evaluation
3	Microbe water pollution and food products pollution	All intestinal infections	1.1.	(Revich, Bychkov; 1998, with additions). Goskomstat of Russia
4	Dangerous natural phenomena	Fatal outcomes	0.08-0.94	Goskomstat of Russia

Sick rate

Rank	Factor	Diseases	Number of thousands cases per one year	Source
1	Microbe water pollution and food products pollution	Sharp intestinal infections caused by agents of indefinite etiology	399, including 232 children	Federal centre of state Sanitary Epidemic Supervision (FCSSES)
2	Atmospheric air pollution by suspended matters and nitric dioxide	Diseases of organs of breathing	240-370 of pulmonary diseases (chronic bronchial asthma, etc.) among children	Estimation based on the VOZ calculations

Table 5.4 Estimates of unfavourable factors and their influence on human's health
(The numbers are given in thousands of cases).

V.3 Assessments of the damage for the national economy caused by the atmospheric pollution

The damage to housing and municipal services from the **atmospheric pollution** consists of expenses for compensation and preservation of the capital assets affected by the pollution and the growth of capital investments and accompanied costs, connected with elimination of consequences of the pollution.

Tables 5.5 and 5.6 show the calculation of estimates of the damage for "averaged statistical city" of Russia with the population of one million inhabitants.

Indicator	Unit	Value
Quantity of removed dust In the polluted region In the control region	 t (ha/year) t (ha/year)	 2.6 1.7
The area of a polluted region subjected to cleaning	ha	273
Quantity of the dust cleared away in addition	t	246
Cost of cleaning of one ton of dust	roubles	10.5
Operational expenses for daring away the dust	roubles/year	2580
Overall expenses for cleaning away the dust in the city	roubles/year	29976
Specific weight of additional expenses for clearing away the dust	roubles/year	0.086
The given capital investments in harvest equipment in the city	roubles/year	25206
The given capital investments in the transport depot for harvest equipment	roubles/year	5174

Table 5.5 Estimates of expenses for cleaning of the extra dust as a result of atmospheric pollution.

The expenses for additional service include the expenses for additional washing and, cleaning of clothes, additional capital investments into laundries and dry-cleaners.

Kinds of expenses	Total expenses for the city, (thousands roubles)	The percentage of additional expenses	Additional expenses, roubles
Maintenance of metal buildings	117,2	67%	784,0
External repair of buildings	851,6	36%	306,57
Internal repair of buildings	2060,0	22%	453,2
Maintenance of an external network (street illumination, electro trans-mission lines, bus pavilions, equipment of parks and gardens	259,7	36%	93,5
Total			931700

Table 5.6 Estimates of additional costs for maintenance of housing and other elements of municipal economy

The damage to city vegetation areas (parks, boulevards, barrage bushes, etc.) consist of additional operational costs for cultivation of new plants instead of lost ones.

Name	Unit	Value
The quantity of trees in the city	Thousand(s)	36
Cost of planting and service for 1000 trees	Roubles/thousand of trees	4510
Factor of premature annual destruction of trees	-	0.17
Additional expenses for planting and servicing of trees	Roubles	27600
The quantity of bushes in the city	Thousand(s)	112
Cost of planting and servicing of bushes	Roubles/thousand	1450
Factor of premature annual destruction of bushes	-	0.15
Additional expenses for planting and servicing of bushes	Roubles	21000
The quantity of flowers	Thousand	120
Cost of planting and servicing of 1000 flowers	Roubles/thousand	150
Factor of premature annual death of flowers	-	0.3
Additional expenses of planting and servicing of flowers	Roubles	5400

Table 5.7 Estimates of the additional costs for the maintenance of vegetation areas in the cities

The damage to the forestry because of the pollution of air basin, water sources and soil consists of losses of commercial forestry products as a result of the destruction of the forest plants instead of expenses for cleaning of the forest.

Table 5.8 Calculation of the damage because of the loss of commodity quality of timber and additional expenses for forest cleaning as a result of atmosphere by emissions

Fo-res-try	Volume of shri-vedel timber, м3	Area of pollution, ha	Output of business wood on the average on a forest area, %	Average output of business wood at sani-tary cutting, %	Cost of burned timber rouble/m 3	Cost of business wood, rouble/m3	Cost of cleaning rouble/m 3	Total damage, rouble
1	67440	2032	79	15.5	1.4	6.97	1.25	629700
2	49010	2280	78	20.3	1.3	7.50	1.60	428820
3	59820	1905	78	20.3	1.3	7.50	1.60	521200
4	63210	1576	70	19.2	1.2	6.00	1.15	388500
To-tal								1968200

Forestry	Area of plantations, ha	Cost of preparation of soils, roubles	Cost of planting material, roubles	Cost of planting, roubles	Cost of care, roubles	Damage of the forestry, roubles
1	455	1068	13104	8312	2521	25005
2	57	719	1716	-	4273	6708
3	922	803	31451	6568	18990	117812
TOTAL						149520

Table 5.9 Calculation of the expenses for reforestation of the damaged forest areas caused by the pollution of atmospheric emissions

Damage to the industry from air pollution includes additional capital investments and costs due to the increased deterioration of main industrial funds, taking place in a zone of air pollution, losses of valuable raw materials and losses from the increased personnel migration in enterprises located in the polluted areas.

Assessment of the damage from atmospheric emissions of copper-melting enterprises

Because of complicated multicomponent structure of the dust and gas emissions of copper industry, its influence on the atmospheric air is done with regard to radial zones which centre is the location of the pollution source. These zones have the following radii:
Zone 1 - 0-5 km;
Zone 2 - 5.1-7.5km;
Zone 3 - 7.6-10km;
Zone 4 - 10-13 km).
The radii of zones are chosen on the basis of the change of values of average-annual concentrations of harmful emissions at various distances around the copper plant(**Table 5.10).**

Local economic loss	Unit	Zone			
		I	II	III	IV
Damage to human's health	roubles/ thousand persons	237	49	41	-
To municipal services	roubles/ thousand persons	44	15	8	-
To agriculture	roubles/ha	0.6	0.4	0.3	0.1
To forestry	roubles/ha	0.7	0.5	0.4	0.2
As a result of the increased deterioration of capital assets	roubles/million roubles of capital assets	10	5	3	1

Table 5.10 Specific economic losses on 1 thousand tons of harmful atmospheric emissions of copper plant

The supposed zone of pollution is the territory, in which the concentration of a prevailing component exceeds the value of the maximum permissible concentration (damages from worsening the health of population, losses of municipal services and industry. According to the A.T. Miroshnikova and V.S. Nikolaevskii [8] for sulfurous anhydride the threshold concentration is lower than the maximum permissible concentration for people and animals and can be taken to be equal to 2.0 mg/m3.

Damage assessment for the enterprises of thermal-power engineering

To determine the local damages the above method of zones had been used.
The figures represent thousands roubles expended during one year for every hectare of the polluted area.

Region	Ingredient	Annual mean concentration, mg/m3						
		0.02	0.05	0.1	0.15	0.2	0.25	0.3

Donetsk-Pridneprovsk	Ash	-	6	11	18	15	31	36
	Sulphurous anhydride	3	8	16	24	32	39	45
	Nitric oxides	-	14	28	42	55	72	81
Ural	Ash	-	3	6	9	13	17	20
	Sulphurous anhydride	2	5	10	14	18	23	26
	Nitric oxides	-	7	14	21	30	43	48
Kazakhstan	Ash	-	2	3	5	7	8	10
	Sulphurous anhydride	2	2	5	8	10	13	15
	Nitric oxides	-	4	7	11	15	21	25
Kuzbas	Ash		4	7	11	15	21	25
	Sulphurous anhydride		6	12	18	23	28	33
	Nitric oxides		10	21	31	42	53	59

Table 5.11 Specific damage to the agriculture,
roubles/(ha/year)

Local damage	Unit	Value
From worsening the human health	Rouble/1000 persons	12110
To the municipal services (objects necessary for residing 1000 persons)	Rouble/1000 persons	1160
Agriculture	Roubles/ha	265
Forestry	Roubles/ha	126
Industry (per 1 million roubles of annual mean cost of capital assets	Roubles/million roubles	85

Table 5.12 Specific damage caused by annual mean concentrations of fluoride compounds

The average figures of the economic losses for different harmful components of the atmospheric pollutions are presented in the **Table 5.13** [8].

Dust	120-180	Hydrocarbons	180-270
Sulphurous anhydride	135-200	Carbon monoxide	70-100
Nitric oxides	200-300		

Table 5.13 Average damage assessment.

V.4 Conclusions

In the last few years due to global warming and climate change it became warmer in all the territory of Russia. Most precisely this trend is observed in the Asian part of Russia where exists the danger of droughts and forest fires. It could be distinctly seen the increase of unfavourable meteo short-term phenomena (periods of abnormal warm weather and frosts, strong winds and snowfalls, etc.) as well as the increase of their repetitiveness.

Reduction of the time interval of weather change, observed in the last years, 3-4 days against usual 6-7 days creates the certain difficulties in forecasting the spontaneous hydro meteorological phenomena. The latter affects the degree of efficiency of weather forecasts and meteo warnings.

The danger of flooding in the Russian Federation exists for more than 500 cities and tens of thousand of other settlements. The area about 500 thousand square kilometres is the subject to periodic flooding. Every year about 50 thousand square kilometres are being flooded. The average size of economic losses from the flooding is evaluated **as 100 billion roubles per year.**

Analysis of emergency situations caused by forest fires in Russian Federation over a period from 1999 to 2002 has shown that, as a whole, the list of regions where the forest fire conditions are dangerous remains stable. However the number of forest fires is significantly increased. The principal reason for that is the absence of the early forest fire forecast. Actual frequency rate of air patrolling, which is one of basic tools to prevent and detect the forest fires is considerably decreased.

A tendency of increasing of the risk from natural disasters in Russia is caused both

by natural and social-economic reasons. Below we enumerate some of them:

- The slow localization of emergency events and insufficient funding of the prevention measures;
- the migration of the population from the zones of extreme environmental conditions (Russian north territories, for example);
- the development of territories, which don't have sufficient infrastructure for living;
- the development of a specific complex dangerous technogenic natural processes produced by the human activity (flooding of territories, destruction of coasts of water basins, landslips, etc.);
- strategic, mistakes at regional levels in a policy of safety of the population and objects of national economy.

References to Chapter V

1. Zhukovskii E.E. Meteorological information and economic decisions. 1: Gidrometeoizdat, 1981, 304 p.

2. Monokrovick E.I. Hydrometeorological information in the national economy. 1: Gidrometeoizdat, 1980, 176 p.
3. Khandozhko S.A. Meteorological maintenance of the national economy. 1: Gidrometeoizdat, 1981, 232 p.
4. Bruskin M.I. Statistics of Sea Transport. M.: Transport, 1971, 248 p.
5. The state report “About the state of protection of the population and territories of the Russian Federation from extreme situations of natural and technogenic character in 2002” M.: MUS, 2003, 172 p.
6. Faleev M.I. Protection of the population and territories in extreme situations. Kaluga, GUP “Oblizdat”, 2001, 480 p.
7. Delyatitskii C., Zaionts I., Chertkov S., Ekzar’yan V. Ecological dictionary. Moscow, Konkord, STD Ekoprom, 1993, 202 p.
8. Balatskii O.F., Mel’nik S.G., Yakovlev A.F. Economics and quality of the environment, L., Gidrometeoizdat, 1984, 191 p.
9. Davidov-Danil’yan V.I. Ed., Climatic changes a view from Russia. M.:TEIS, 2003, 416 p.
10. Bezuglaya E. Yn. Ed., State of atmospheric pollution in cities in the territory of Russia in 2000. St. Peterburg: Gidrometeoizdat, 2001, 182 p.
11. Chiburaev V.I., Revich B.A. About a national plan of actions on hygiene of the environment of the Russian Federation: // Protection of health of the Russian Federation. 2001, No 3.

Artikel III.

Artikel IV.

Artikel V.

Artikel VI.

Artikel VII.

Artikel VIII.

Artikel IX.

Artikel X.

Artikel XI.

Artikel XII.

Artikel XIII.

Artikel XIV.

Artikel XV.

Artikel XVI. GMES-Russia Networking Component

VI. New Initiatives and Extension of the Russia-Europe Co-operation

One of the critical topics existing at the moment between Russia and EU is the problem of miscommunication. Most people and RTD organizations from both sides don't know the real expertise of each other. While the main goal of the GMES RUSSIA Project is to establish the first network of key data providers and users between the European component of GMES and Russia then the real networking mechanism is important.

It was initially suggested that the results of GMES-Russia Project will be published in the printed form and then distributed between both Russian and European organizations. However, the results and public discussions in the GMES Forums (Noordwijk, Athens, and Baveno) have shown the great interest to closer communication and detailed information about data providers in Russia, results of their research, existing monitoring systems, etc. This actual information can be given only by the data providers themselves. That is why the idea to establish self sufficient networking between different organizations was discussed during the GMES-Russia Project meeting which took place in September, 2003 (St. Petersburg, Russia).

The GMES RUSSIA project partners agreed to establish one or few Internet portals where data providers and interested organizations could send information to store it as open database. The main principles of this Data Base are given below in VI.1. The full description can be found in GMES RUSSIA annual report [1].

Another direction of our activities was the extension of the team of Russian partners and partners form CIS countries (namely Ukraine) aiming at the preparation of the new research projects within FP6. The results of these activities are described in paragraph VI.2 of the current chapter.

VI.1 GMES Interactive Data Base

The **GMES-Russia Database** and server should provide information about both GMES activities and the goals of the GMES-Russia Project. Russian WEB site portal should be localized to be understood by Russians. The role of the WEB site is to promote EU and GMES activities between Russian organizations and help them in understanding of the role of GMES as a whole. Each organization and or single researcher could provide information about their activity, data and information products they have and the complete addressing information as well. The first version of the GMES-Russia Database server was established in Novosibirsk, Russia, and can be reached under the URL address:
http://www.giscenter.ru/GMES

Fig.6.1 shows how the home page looks like

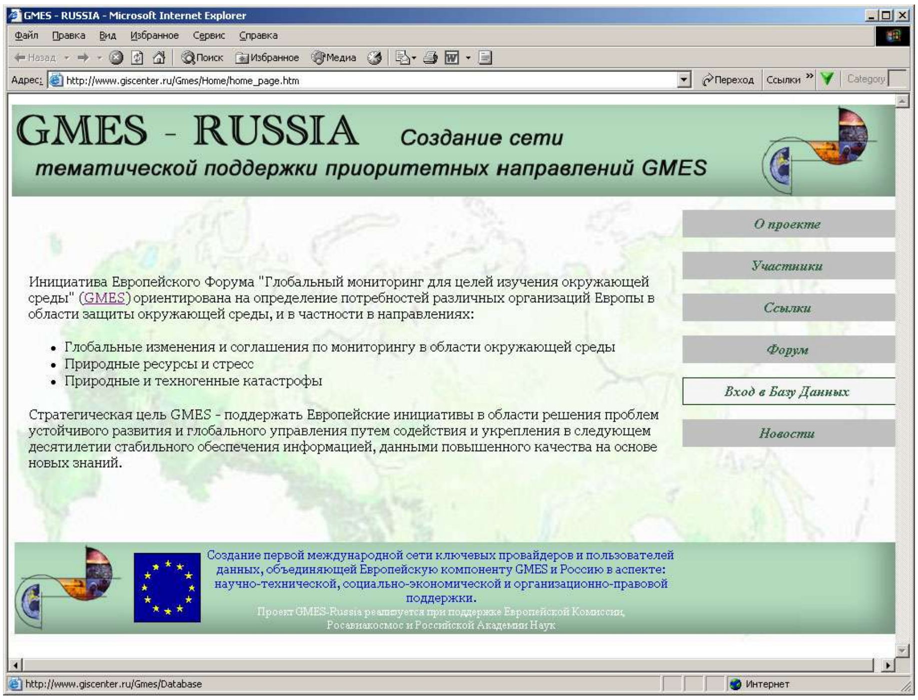


Fig.6.1 GMES RUSSIA Home page (Russian)

The Database contains records in a metadata form (according to the ISO 23950 Standard). There are three main blocks of data collected in the database: (see Fig.6.2)

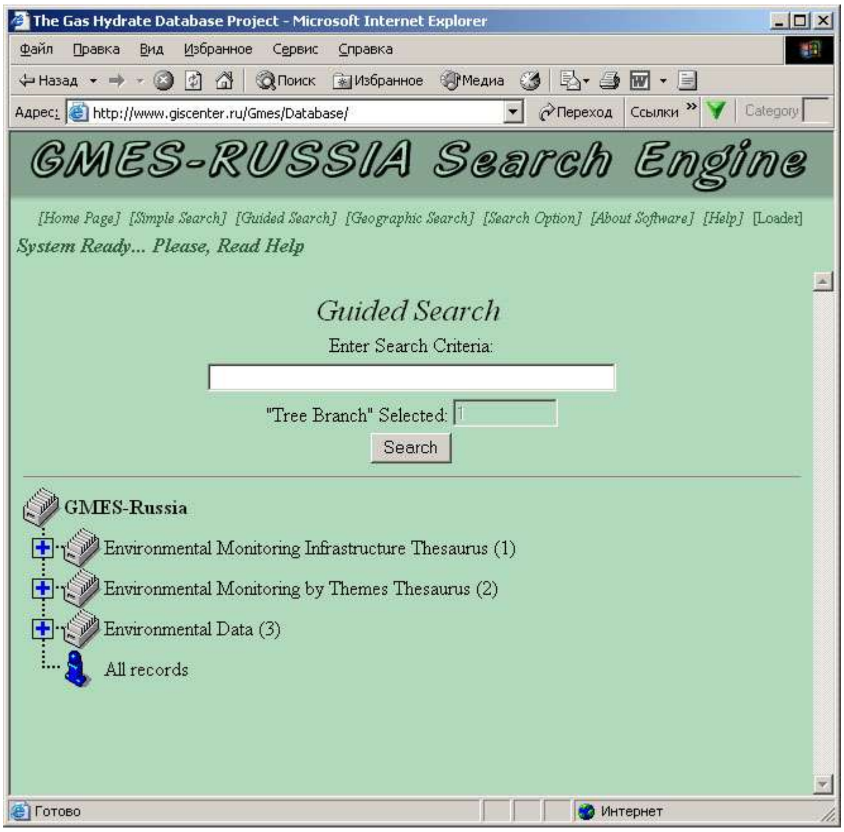


Fig.6.2 Main blocks of data collection

- Environmental Monitoring Infrastructure
- Environmental Monitoring by Specific Areas of the Research and Technology
- Environmental Data

The simple and flexible metadata protocol (see detail description below) allows enter all required information to the database. The remote (client-side) interface allows enter records for the registered Database users. The registration is allowed for free for any research, commercial, etc. organization. The language of the User Interface is English, and the link to Database could be established in any European WEB site:
http://www.giscenter.ru/Gmes/Database/

Abschnitt XVI.1General information about the Database system

The GMES-Russia Database is operational on a so-called "fully relational, client-server system". It means that the installed server software assures the access to the database from any computer connected to the internet and having a web browser.

The design of the system is based on distributed database concept, best described as "hub and spoke". The advantages of this conceptual system could be formulated as follows:

- The data input is open for everybody, although standardized. The data will consequently be submitted from the entire scientific community.
- The distributed structure of the database system, linking several remote data collection sites is an optimal system for interactive data retrieval and exchange.
- The term "hub and spoke" refers to how the conceptual system components interact to create the distributed database system. Just as in the case of a wheel, there is the need to have a central "hub" or portal where the information that should be managed is coordinated. This portal essentially contains the connections (links) to the individual "spokes" or participating data providers. Fig.6.3 illustrates the idea of the "hub and spoke" design principle

Fig. 6.3 The ‘hub and spoke” design principle.

The central portal ("hub") that coordinates the information at meta-data level combines WWW. It is hosted by the Novosibirsk Regional Centre of GI Technologies for SB RAS (Novosibirsk, Russia) and some mirrors are to be established soon in both Russia and Europe.

Individual data components ("spokes") that contain [meta]database(s) are located on the remote systems of each partner; the latter being responsible for the data provided to the system, for local data entry and quality assurance. Each spoke operator populates the database and whenever new data sets are introduced or updated, the meta information is automatically being sent to the hub portal.

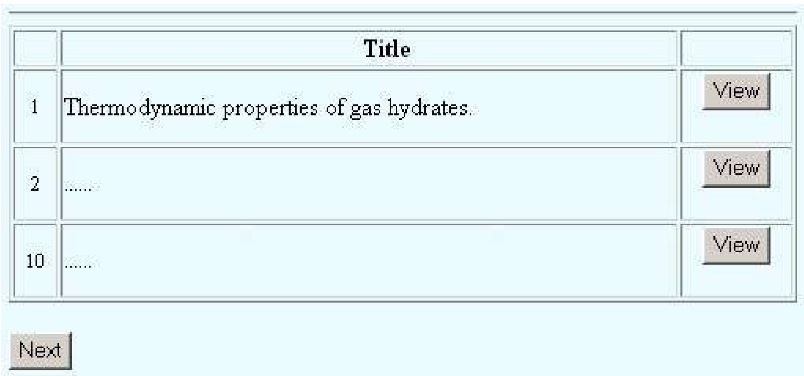
Abschnitt XVI.2Navigating through the Database

The structure of the GMES-Russia Database allows navigate through the data in different ways, making it convenient for a wide range of users. When entering the Database Search Engine, the user can choose between the following three options:

Simple Search	Permits to search the whole Database by entering criteria
Guided Search	Allows navigating through the index-tree structure of the Database
Geographic Search	Is a GIS based search of data for a specific area?

- The "Simple search" is intended for the user who knows what he is looking for, and who wants to do a sampling of all data using a specific keyword, or to search by criteria - a combination of several keywords or a name of a geographic location.
- The "Guided search" allows the user to navigate through the index-tree structure of the Database. The user will be guided towards the data along different GMES related research disciplines and subsidiary research topics up to records stored in the deepest level. It offers also searching by criteria within records of the selected structural level.
- The "Geographic search" is based on a specially designed Geographical Information System (GIS) where the spatially related data records and locations of the referenced organizations are shown. It offers a wide range of map tools as zooming, dragging, moving of the map centre etc. and allows searching of data within a chosen area or single point.

The result of the search will tell how many datasets on the requested topic have been found in the GMES-Russia Database displaying them in series of ten by title only as it's shown below. The user can then browse the records describing the tagged datasets, and select and retrieve the data of interest to him. Fig.6.4 illustrates how search results could be displayed.



	Title	
1	Thermodynamic properties of gas hydrates.	View
2	......	View
10	......	View

Next

(a) Fig.6.4 Example of the search results displaying

There is an opportunity to Refine Search within the Dataset by entering additional criteria.

Abschnitt XVI.3Data Search Interfaces

- **Simple Search**

"Simple Search" Engine allows to search Database by entering one or few search criteria. It works similar to many well known Internet search engines (http://www.google.com http://www.yahoo.com , etc.), except the search is performed in predefined Database.

The main advantages of the Simple Search option are:

- User doesn't need to know: "How database works?" "How and where data are stored?" "What field the database contains?", and so on …
- User doesn't need to know: "How to build query?"
- User uses simple, intuitive and vivid interface …

We omit enumerating of the possible disadvantages. Simple is simply …

There is one active window to start search. It contains one field to enter customer's query (see, Fig.10.6)

Fig.6.5 Query Input Interface

... and two search options:

- Search within the whole record (by Default)
- Search within KeyWords, only (if checked)

By Default, the entered criteria will be used to search within the all fields of record available (All: Title, Abstract, etc.).
However, if you want to search fast, choose "Keywords" option. Case of this option, only specific field "Keywords" will be searched.
There are many ways to enter search criteria you want use. The most simple is "One word" or "One Phrase" search query.
Just type word or phrase you want, and push the Search button. System will try to find exact phrase you entered.
Another option is to use logical search. Current version of the Search Engine supports the logical "AND".
ust use + symbol in front of each word/phrase You entered.

Guided Search

One of the most useful and flexible engines of the GMES-Russia Database is the Guided Search Interface. It allows query information by the exact theme defined by the database hierarchy tree. Fig.6.6 – Fig.6.9 illustrate Guided Search Interface

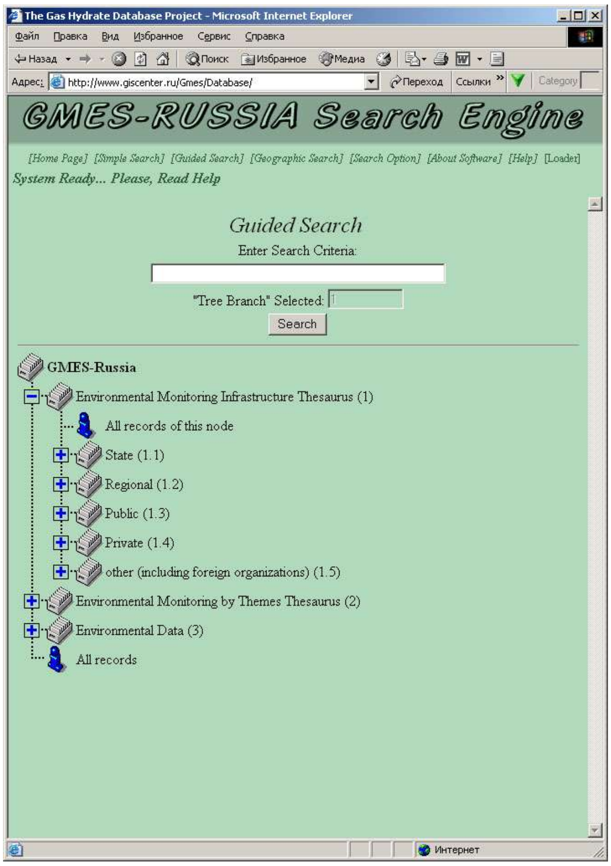


Fig. 6.6 Guided Search Interface (organisations)

There are three levels of data hierarchy supported:
Environmental Monitoring Infrastructure, which contains the list of Russian organizations by the status:

- State Organizations of the Federal Level (Ministries, etc.)
- Regional Organizations
- Public Organizations (Foundations, Committees, etc.)
- Private Organizations (Companies)

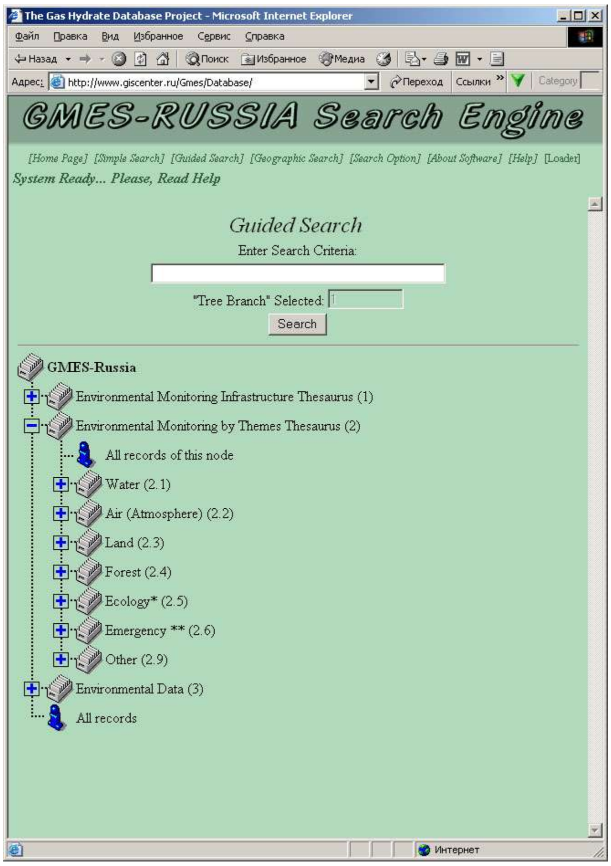


Fig.6.7 Guided **Search Interface (Thematic areas)**

Environmental Monitoring & Researches by the field and/or theme:

- Water related Researches and Monitoring
- Air (Atmosphere) related Researches and Monitoring
- Land (Land cover) related Researches and Monitoring
- Forest related Researches and Monitoring
- Ecology related Researches and Monitoring
- Emergency (catastrophic events) related Researches and Monitoring

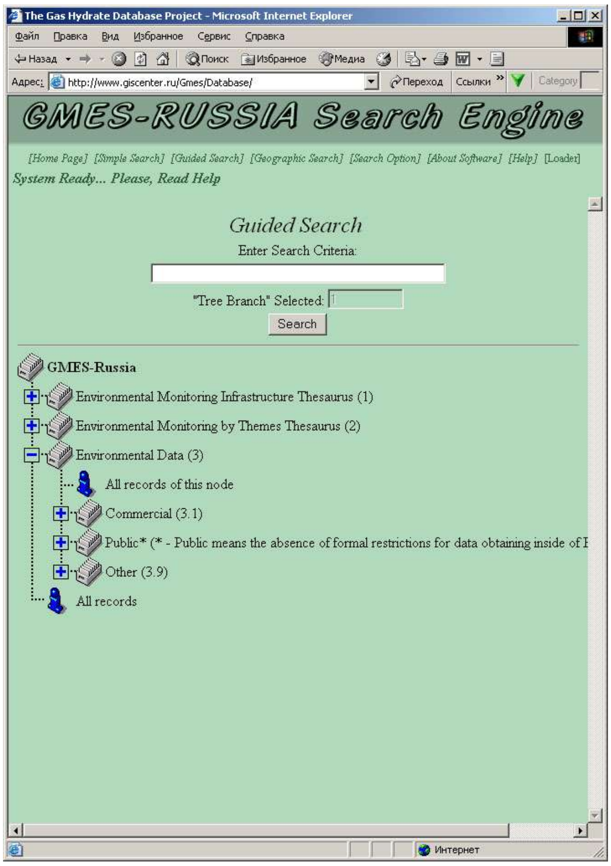


Fig.6.8 Guided Search Interface (Resources)

Environmental Monitoring Data:

- Commercial resources
- Public domain resources
- Other resources

The interface window allows check any appropriate branch of the Database hierarchy tree and then enter the search criteria. The search will be performed within the chosen branch only:

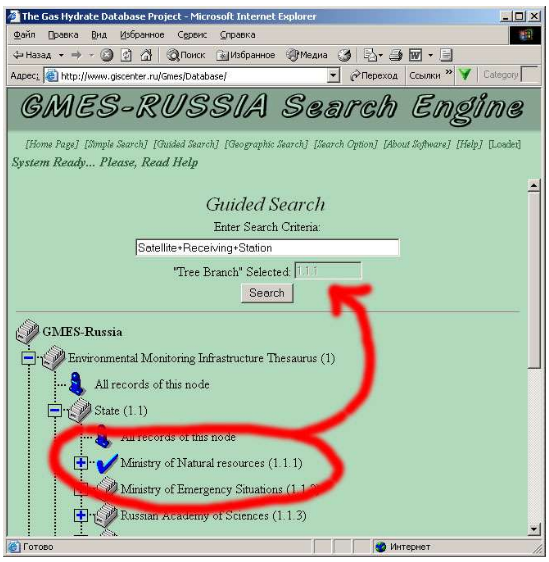


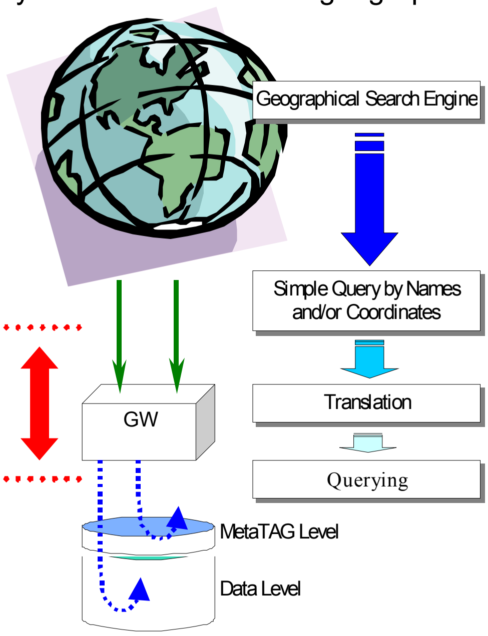
Fig.6.9 Guided Search Interface (choosing the tree branch)

- **Geographic Search**

Any distributed network system with databases related to spatial data needs to perform the search by geographical parameters (spatial queries). The problem is how the query is “constructed” and how each database processes that query. The first means some step of processing which could be not strictly related to the searched data.

The traditional solution is to develop either geographical search “engine” within the each concrete database (GIS approach), or use exact fields with the spatial attributes within the database to answer query from external search.

Both solutions are quite complex case of existing database use. For example, there are many databases contained geographical names, only.



The appropriate solution could be to split the processes of spatial query formation and its transfer to real database. It means performing three major stages of querying (in general sense):

1. All complex procedures of navigation, overlaying, logical operations should be done within the separate tool (engine), which has some GIS functionality;
2. Generated Query should be “simplified” to either list of geographical names, or to the coordinates string;
3. “Simplified query” is to be send to the database directly or via specified Gateway Engine which is responsible for both query’s compatibility (translation) and for the answer.

(See Fig.6.10)

(i) … **following:**

- Sys… l as within geographic search engine func…
- System … DBMS and database structure (data formats …
- The Query … so there are no problems with the “backward” …

(ii) … **be:**

- The … ase data can produce the problem of syn…
- Each se… generation and processing.

(iii)

… nd processes it locally. The query is

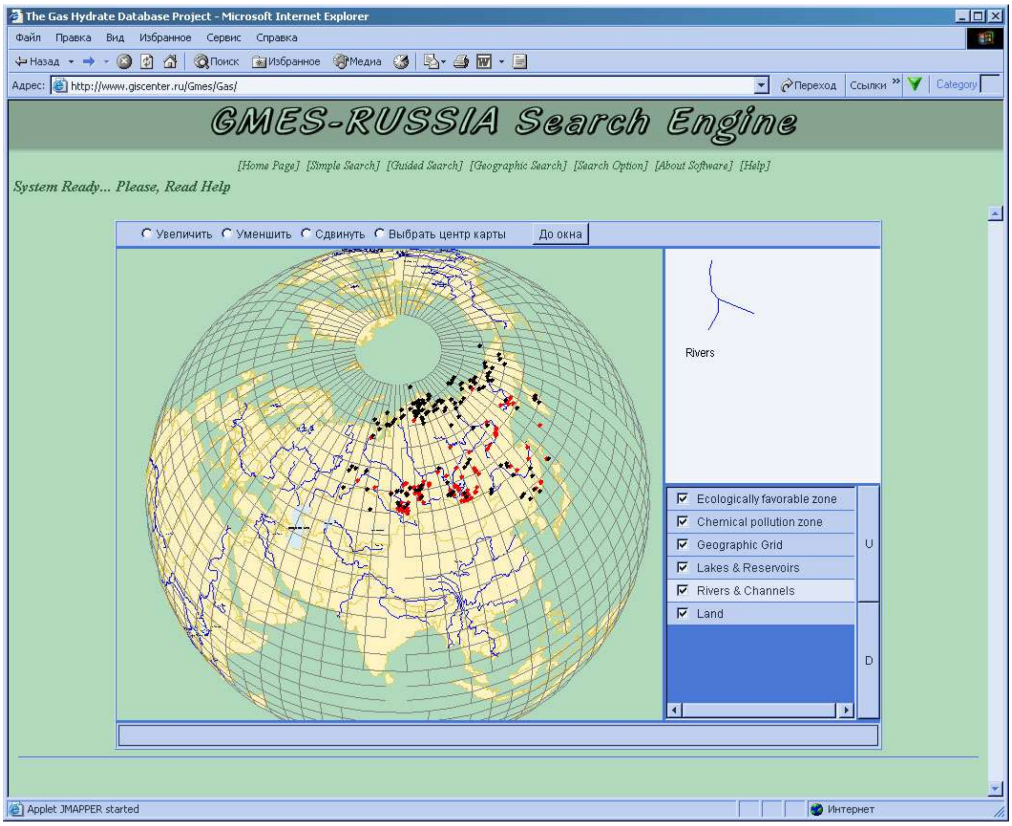


Fig.6.11 Geographic search (main menu)

VI.2 New Research Initiatives

As a result of our search activities and establishing contacts with new scientific groups, individuals and organisations relevant to GMES, the following scientists and research organisations in Russia and Ukraine have been found.

1. Irkutsk Science Centre (ISC), Irkutsk, Russia

Irkutsk Science Centre is subordinated to the Presidium of the Siberian Branch of Russian Academy of Sciences (SB RAS) and is a prominent scientific foundation. The Department of Regional Economic and Social Problems has the following fields of expertise:

- regional socio-economic policy,
- economic federalism,
- territorial systems stability.

The central themes are the programs and mechanisms of the development of regions, inter-budget relations in the region, and links in the system "Economy and Environment". Currently, the Department works on creation of model of regional and branch systems analysis and forecasting as a basis for development of the strategy of local regional management. The methodological propositions of economic zoning, Territorial Production Complexes formation (1970s), programs of complex development of Angara-Enisey region,

and economical development of Baikal-Amur Railway zone on base of mathematical modelling (1980s) are worked out. Upon the analysis of institutional changes of economy in transition we substantiated directions of Irkutsk region production structure improvement, foreign economic activity influence on regional socio-economic development. International contacts related to regional researches in collaboration with Birmingham and Bonn Universities were established. (www.oresp.irk.ru)
Department's leader – **Dr.Dumova** is simultaneously a member of regional administration as well.

2. Centre for Aerospace Research (CASRE), Kiev, Ukraine

Centre for Aerospace Research of the Earth IGN NAS of Ukraine was established in 1992 according to the Decree of Presidium of National Academy of Sciences of Ukraine as a legal entity at the Institute of Geological Sciences of Ukraine. At present the Centre staffs is about of one hundred employees, including 2 Corresponding Members of NAS of Ukraine, 3 Doctors of Sciences (Professors) and 31 Candidates of Sciences (PhDs). The Centre is specialized on remote sensing (RS) data acquisition and thematic interpretation, focusing on processing of air- and space borne images, and preparation of geoinformation products as well. The parameters of energy mass exchange in geosystems and their impact onto very sensitive to natural and technogenic factors various physical, chemical and biological processes responsible for spectral response of natural objects are under investigation. The models of general spectral signatures for natural objects are elaborated, and their relations with attributes of the environment are evaluated. New techniques and technologies for acquisition and thematic interpretation of RS data are being developed. The Centre is authorized by NAS of Ukraine and National Space Agency of Ukraine as a leading organization for integrated development of remote sensing scientific and methodical basics to survey natural resources and monitor the environment. Pursuing this scientific goal **CASRE** works along with other institutions and agencies in Ukraine and abroad.
CASRE is a first scientific organization in Ukraine that joined European Association of Remote Sensing Laboratories (EARSeL). The Centre develops international contacts and actively cooperates with European Space Agency (ESA), Space Agencies of Germany (DARA-DLR), France (CNES), International Institute for Applied System Analysis (IIASA), and many other institutions and organizations in Europe.

One of the main directions of activity of the Centre is forests monitoring, forests vegetation species classification and analysis on dynamic of forests vegetation state using modern software for satellite images processing (ERDAS Imagine, ArcView etc.). **CASRE** has the experience on monitoring of forests within Ukraine (Chernobyl exclusive zone) and boreal forests of Central Siberia (together with IIASA). Different approaches to forest state analysis on the basis of multispectral space imagery are developed by the Centre. The approaches of numerical modelling of energy-mass exchange in water-soil-vegetation-atmosphere system within forests using satellite data are developed in **CASRE** as well.
Professor Vadim I. Lyalko - Director, Centre for Aerospace Research of the Earth, Institute of the Geological Science, National Academy of Science of Ukraine.
Dr. Alexey I. Sakhatsky - senior research associate, Department of Energy Mass Exchange in Geosystems,

3. Ukrainian Centre of Environmental and Water Resources (UCEWP), Kiev, Ukraine

UCEWP is consulting and software development company, specializing in environmental risk assessment, radiation safety, environmental and water management, environmental hydro thermo dynamics, river and marine computational hydraulics, physical oceanography, coastal engineering and development of environmental modelling software and data bases (http://www.ucewp.kiev.ua). UCEWP has been established at the end of 1999 by the Academy of Technological Science of Ukraine and by the scientists of the Institute of Mathematical Machines and Systems Problems (IMMSP) of National Academy of Science of Ukraine to involve the experts in information technologies, radiation safety, environmental risk assessment, environmental engineering, ecology, hydrology, oceanography, meteorology, environmental and water management, into the national and international interdisciplinary projects in these fields. A group of scientists comprising the

UCEWP team in the proposed project has been created at IMMSP in 1986 immediately after the Chernobyl accident to support counter-measures and predict the radionuclide dispersion in the water system. Within the Fourth, Fifth and now Sixth Framework Programs, this group participates in the development of an EU Real time, On-line, Decision Support (RODOS) system for the off-site management of nuclear emergencies and customisation of this system in the Ukraine and other European countries. Now the main fields of the activities include the development and implementation of models of watershed hydrology and river hydraulics, 1-D, 2- D and 3- D models of the currents, thermodynamics, sediment transport an waves in rivers, reservoirs, lakes, cooling ponds of the power plants, coastal areas of the seas, 2-D runoff model for small watersheds, models of the radionuclide uptakes in the marine and freshwater organisms. The most important recent projects in the Ukraine are "Environmental Impact Assessments of the new navigation channel to be dredged in the Bystry Reach of the Danube River Delta (2003 - 2004), Technical Design and Development of Real-time Decision Support System for Flood Forecasting and Management in Transcarpathian Region of Ukraine - AIVS TISZA-2 (2001 - 2003). The group is participating in Fifth and Sixth Framework Program, INTAS, INCO-COPERNICUS Programs, TACIS and in a set of bilateral projects concerning pollutant transport in rivers, lakes and coastal seas, flood risk assessment and management. Recent projects are NATO Project "Flood Preparedness and Response in the Carpathian Region – Assessments and Recommendations" (2001-2002), "Water and environmental management issues of the Ukrainian Part of the Tisza River Basin" - Subcontract to the EC Contract № EVK1-CT-2001-00099 (2002-2003) and "Development of decision support system to simulate PCB propagation in the Kalamazoo River, MI" (Contract with ALTARUM Institute, USA , 2003).
Dr.Sergey L.Kivva, team leader of UCEWP group, senior research associate, is an expert in the applied mathematics, finite-difference methods and computational modelling of groundwater and surface water.
Dr. Mark Zheleznyak is an expert in environmental risk assessment and contamination of inland waters.

These scientists and organisations together with GMES RUSSIA current partners allowed us to elaborate and propose the Specific Targeted Research Project (STREP project) within INCO FP6 Call.
The project title is: Irkutsk Regional Information System for Environmental Protection (IRIS).

The proposed project will assess the current status and dynamics of the Irkutsk Region's (South-westen Siberia, Lake Baikal) forestry environment, influenced by man-made changes and anthropogenic impact arising from pollution sources located in the region and in adjacent areas. It will investigate the responsiveness and vulnerability of forestry environment within the Region under different scenarios of industrial development and nature-preserving measures.
The output of the project is the development of the efficient simulation and management tool (IRIS) for practical use by regional governance and nature-protection services for the management of risks associated with man-made changes and anthropogenic stress affecting the forestry environments of the target region through the atmosphere and land runoff.

Scientific and technological objectives of the project are:

1. To create dedicated environmental databases integrated in a Geographical Information System (GIS) for the Irkutsk Region.

2. To develop a set of scenarios for possible regional sustainable industrial development (including forestry) and availability/implementation of nature-preserving measures.

3. To assess man-made changes and anthropogenic impact on forestry environments from industrial pollution sources using troposphere and run-off transport models for the current

situation and for the future according to elaborated scenarios together with local government.

4. To assess the impact of the increasing tourism and the increasing construction activities (dachas and guest-housing) along the shore of Baikal Lake on the vulnerable environmental conditions.

5. To assess the potential risks arising from anthropogenic stress according to the elaborated scenarios and to develop recommendations on remediation measures.

6. To integrate developed databases, transport models, industrial development scenarios and results of prognostic simulations into the Irkutsk Regional Information System (IRIS).

7. Handover and implementation of the information system to the Irkutsk Region Governmental Agency.

The choice of this particular geographic territory of Russian Federation(**see Fig. 6.12**) was caused by the following considerations.

The Irkutsk Region is rich: rich of natural resources and rich of historical human impact. The Irkutsk region is environmentally important due to its central, indicatory location in the Eurasian boreal zone. The Irkutsk region is politically important since its development represents the economic and sustainable growth in the vast rural territories of Siberia.

The Irkutsk region needs *__the environmental protection system__* since:

- it encompasses 0,5 Mio square kilometres of high value timber,
- it forms the western border of the Earth's largest freshwater reserve – Lake Baikal,
- it is reach of mineral resources (gold, diamonds, graphite, gems) and the gas,
- it has a very diverse, touristically attractive landscapes similar to alpine environments, and, last but not least
- its ecosystem vulnerability is very high and recovery rate very slow due to the extreme continental climate.

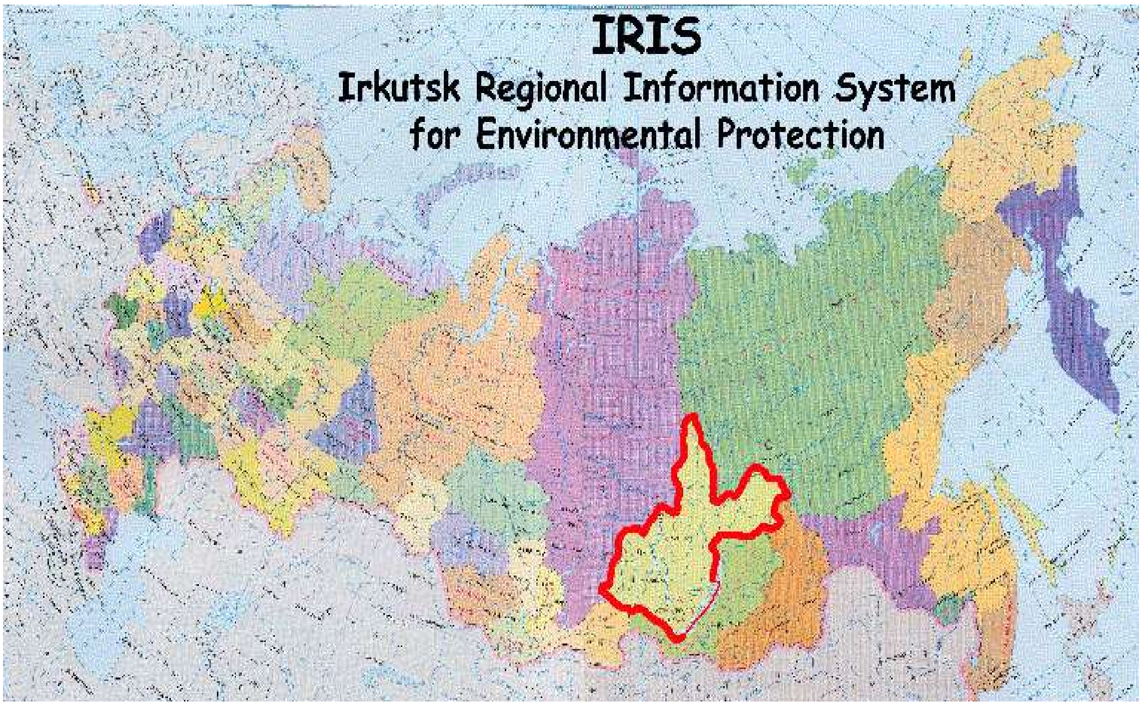
Located in the heart of Siberia, Irkutsk has a long history of exploration which started three centuries ago with fir merchandising. Strategically the region is located on the route to the Russian Far East as well as to Mongolia and China. Two major railroads were constructed in the region in the last century that cross it: the Transsiberian in the South and the Baikal-Amur Magistral (BAM) in the North. The many years of human impact culminated in heavy industrial development during Sovjet times – causing electricity demands which are supplied by one of the largest hydro-power plants of the country: the Angara Dam near the city of Bratsk. Recently, i.e. the last five years , national and international tourism is strongly increasing due to Irkutsk's airport convenient geographical location about 50 km from Lake Baikal, the Pearl of Russia and Sacred Sea of the locals. Atmospheric pollutions by large industrial zones, contamination by untreated waste water effluents and higher run-off loads of nutrients caused by intensified land use and timber logging are pointed out as today's most apparent risks for this **UNESCO World Heritage Site.** Very recently , in 2003, plans were published to build a gas pipeline the Irkutsk region and along the shore of Baikal to explore resources in the Russian Far East and for selling gas to China and other Asian countries.

The innovation-related activities planned in the framework of the current proposal include matching of the two prognostic models - (i) the troposphere model and (ii) the model of energy and mass transfer in forest environment – to each other and to GIS data serving as boundary and initial conditions for calculations. Special codes will be developed as a superstructure of Region Information system based on GIS and model codes.

Impact on European and global levels

The international dimension of project implementation is strongly connected with problems of climate change essential worldwide and, in particular, for EU Member States. Climate change is believed to be a function of concentrations of greenhouse gases (GHGs), particularly carbon dioxide, in the atmosphere. The Intergovernmental Panel on Climate Change, which assesses the science of this phenomenon, has concluded that human activities in forests can have significant effects on the atmospheric concentration of carbon dioxide. The United Nations Framework Convention on Climate Change of 1992 has the objective to stabilise the greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system. The Kyoto Protocol to the UNFCCC is a key policy tool to be used to achieve this.

Forests act as carbon reservoirs by storing large amounts of carbon in trees, understory vegetation, the forest floor, and soil. In addition, changes in forests, such as the growth of trees, can remove carbon dioxide from the atmosphere. Forests thus can act as a sink for absorbing emissions from human or other natural sources. Conversely, when human activities degrade a forest, both the reservoir and the sink potential are damaged, and the forest can become a substantial source of carbon dioxide emissions. There is no doubt today that the role of the boreal forests is essential. In this context the Siberian taiga, which is the largest forest region in the world, and Irkutsk region as a part of taiga is of vital importance



XI. Summary and Conclusions

The GMES RUSSIA project is completed and in this last paragraph we would like to summarise our main findings and lessons learned with regard to:

- technical-scientific assessment of the environmental monitoring infrastructure in Russia
- socio-economic and institutional issues of the GMES in Russia
- and at last, but not least the coordinator's managerial activities on establishing close links between EC and Russian relevant scientific groups, individuals and organisations and preparation of the new research initiatives for future.

Technical-scientific assessment issues.

Our work allowed to realise the administrative structure of the environmental monitoring in Russia and define the main ministries involved in this field of activities. The latter are:

- Russian Aviation and Space Agency (**ROSAVIAKOSMOS**)
- Russian Ministry of Natural Resources (**MPR)**
- Russian Federal Service for Hydrometeorology and Environmental Monitoring (**ROSHYDROMET**)
- Russian Emergency Committee (**EMERCOM**)
- Russian Federal State Committee on Land Resources (**GOSKOMZEM**)
- Russian Academy of Sciences (**RAS**).

While the all above ministries and subordinated offices and organisations provide monitoring of the basic environmental components such as Water, Air, Forests, Land resources, Ecological situations, **ROSAVIAKOSMOS plays the dominant role** in the development and operational exploitation of the current and future space sensors and instruments. The space instruments for monitoring of environment that are under operation now and those expected in the nearest future are developed in accordance to the official *document* ***"The Concept of Development of the Space Systems for monitoring of Environment".*** Here the main goals and objectives are grouped and categorized. As a result of thorough analysis of the monitoring tasks and objectives **ROSAVIAKOSMOS** specialists have developed the launch program of remote sensing satellites for the monitoring of environment. This program is presented in Fig.4.3 of the annual report [1].
In accordance to our chosen thematic priorities we presented the detailed analysis of *atmospheric monitoring, environmental stress monitoring, forest monitoring.* In the conclusions to corresponding chapters of the annual report [1] and to chapter I of the current report the recommendations are given what should be done for improvement of the quality of the monitoring and which organisational and legislative measures should be undertaken in this direction. The trend and necessity of utilisation of the data from European satellites ENVISAT, Bird, RADARSAT etc. are strongly pronounced by our Russian partners. The latter creates the valid pre-condition for future successful Russian –Europe co-operation.

Socio-economic and institutional issues of GMES in Russia.

In this report the detailed description and careful analysis of the four case studies with regard to socio-economic assessments is presented. These case studies comprise not only the most painful and dangerous for environment and human health events and phenomena such as oil spill accidents and air pollutions from industrial enterprises, but sea ice monitoring in the Northern Sea Route – the task of extreme importance for Russia- as well. These case studies encompass different geographic territories: Caspian Sea region in the Russian South, Khanty-Mansijsk Autonomous Region in western Siberia, Russian Arctic.

In all case studies the panorama of the ecological damage from oil spills and air pollutions is given with significant portion of details and quantitative estimates. The interrelationships between ecological impact and living conditions of different regional biota inhabitants are presented. The necessity of the utilisation of global satellite monitoring systems is underlined and its cost efficiency is emphasised. The recommendations are given on a choice of particular sensors and instruments that give the advantages and bring economic profit.

We present in this report the description of data policy issues regulated in Russia by special legislative acts and agreements. This policy basically concerns the prices on remote sensing images and categories of organisations having possibility and access to this type of information.

Organisational and managerial activities of Co-ordinator of the project.

The important part of the project tasks was connected with performing the organisational and managerial activities with regard to participation of the Russian partners in conferences and meetings in Europe, establishing new contacts with relevant research groups and individuals and preparation of the new research initiatives.

Our project partners participated in the 2-d, 3-d and 4-th GMES FORUMS in Noordwjik (Netherlands), Athens (Greece) and Baveno (Italy) in 2003. The latter played the crucial role in their understanding of GMES ideas and how to cope with project's tasks. Several meetings were arranged for Russian partners by the coordinator in German Space Agency (DLR) - Oberpffafenhofen, Germany. The last achievements in radar remote sensing and European activities with regard to new space instruments have been discussed during these meetings what allowed our Russian partners to receive the understanding of their functional capabilities in the task of environmental monitoring.

Part of our work was devoted to the development of the new communication tools between Russia and Europe. Here the significant step forward has been done. Chapter X of the annual report [1] describes the design of the effective communication tools. The proposed concept of interactive database with sophisticated but user's friendly search mechanism allows to bridge the gap existing in the communication and information exchange between Russia and Europe. Along with this interactive WEB site, located in Novosibirsk server the coordinator of the project – Friedrich-Schiller University Jena – arranged the WEB site in the University server under the URL address**:** **www.gmes-russia.uni-jena.de/**

Here one has free access to all reports and documents of the GMES RUSSIA project to all information about GMES-RUSSIA project.

The search and establishing contacts with new relevant GMES scientific groups, individuals and organisations in Russia and Ukraine has been done. As a result we found:

- Irkutsk Science Centre (ISC), Irkutsk, Russia

Department's leader – Dr.Dumova is simultaneously a member of regional administration and has a position of vice governor of Irkutsk Region.

- Centre for Aerospace Research (CASRE), Kiev, Ukraine

Professor Vadim I. Lyalko - Director, Centre for Aerospace Research of the Earth, Institute of the Geological Science, National Academy of Science of Ukraine.

Dr. Alexei I. Sakhatsky - senior research associate, Department of Energy Mass Exchange in Geosystems,

- Ukrainian Centre of Environmental and Water Resources (UCEWP), Kiev, Ukraine

Dr.Sergey L.Kivva, team leader of UCEWP group, senior research associate, is an expert in the applied mathematics, finite-difference methods and computational modelling of groundwater and surface water.

Dr. Mark Zheleznyak is an expert in environmental risk assessment and contamination of inland waters.

These scientists and organisations together with GMES RUSSIA current partners allowed us to elaborate and propose the Specific Targeted Research Project (STREP project) within INCO FP6 Call.

The project title is: Irkutsk Regional Information System for Environmental Protection (IRIS).

Another project which we formulated and prepare at the moment has **the title: "Forest Monitoring".** The part of GMES Russia project partners along with

- Mr. Leonid N. Vashchuk, Forest Service of Irkutsk General Survey of Natural Resources (FS of GSNR) of Russian Ministry of Natural Resources - Russian Federation;
- Prof. Sten Nilsson and Prof. Anatoly Shvidenko, International Institute for Applied System Analysis (IIASA), Austria

participate in intensive preparatory work. GSE Forest Monitoring is a European Space Agency (ESA) funded project, which forms part of the Global Monitoring for Environment and Security Services Element (GMES). The GSE Forest Monitoring portfolio provides information to potential users and beneficiaries of the forestry sector. The project services are aimed to serve managers, policy or decision makers with interests in the forestry sector. The service option Forest Monitoring in Russia coordinated and managed by the **FSU Jena** focuses on the development of reliable, effective and cost-efficient
methodologies for forest observation and mapping at regional level. The provided service will combine both high and low resolution EO-data as well as in-situ and forest inventory data.

References

1. GMES RUSSIA Annual Report, Friedrich-Schiller University Jena, October 2003.
2. BICEPS: Building an Information Capacity for Environmental Protection and Security, Second Interim Report, May 2003

3. DPAG: Data Policy Assessment, Interim Report, University College London, May 2003
4. GMES SOCIO-ECONOMIC STUDY (GSES).SOCIO-ECONOMIC IMPACTS REPORT GSeS D4, 2003, ESYS Consulting, UK
5. GMES SOCIO-ECONOMIC STUDY (GSES). SOCIO-ECONOMIC IMPACTS REPORT. Executive Summary, 2003, ESYS Consulting, UK
6. Malysheva N., Shvidenko A., An Overview of Remote Sensing in Russian Forestry, Interm Report IR-00-034, Approved by Gordon J. MacDonald Director IIASA 27 June 2000.
7. Global Monitoring for Environment and Security, Final report for initial period, ESA, November 2003