

*SPATIAL DATA INFRASTRUCTURE:  
CONCEPTION AND APPROACHES.  
Integration Russian Satellite datasets:  
system components and interaction*

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# *OUTLINE*

1. *Introduction.* Information Infrastructure solutions' approach
2. *e-Science: Concept of Virtual Observatory.*
3. *e-Infrastructure: Virtual Environment of spatial data*
4. *Spatial Data Infrastructure: SDI, NSDI, GSDI, INSPIRE*

- 
6. *Service Support Environment (SSE)*
  7. Integration of Russian Satellite Data  
*on the basis of SSE*
  8. Conclusion

A hand holding a globe is shown in the top left corner. The background features a blue gradient with a bar chart on the left and a map with arrows and numbers at the bottom.

Global change and Environmental research require to create spatial data infrastructure and provide effective access to geospatial data worldwide. Infrastructure solutions aims at:

- Develop the distributed environment for use the spatial data
- Provide the successful data access
- Improved management of global and local information. Use of spatial datasets is important in Government decision-making and development planning



# *Infrastructure Solutions*

- Integration of distributed information resources.

It aims at making the Information infrastructure on the basis Web services and XML. The access to the government services via Web by means of modern information and communication technologies.

- Another kind of tasks: e-Learning, e-Health, e-Environment, e-Science, e-Data, e-Catalogs
- Rise of Geoportals, interfacing with GIS systems

# ***Easy Access to Geo Spatial Information***

e-Government

**e-Science**

Digital World

Digital Earth

Digital Library

**Geoinformatics**

GeoSpatial Data

Earth Observation Data

# *Analysis of projects VO*

- Concept of *Virtual Observatory*: development of *IT* instruments for the access to heterogeneous distributed archives and catalogs of data and virtual collaborations.
- National *VO, USA, 2001* (<http://us-vo.org>) is creating the environment for astronomical research. Project NVO: more than 70 people at 20 organizations
- *Euro-VO, 2005* (<http://esavo.esac.esa.int>)  
*Euro-VO* consortium provides European astronomical community with the data access, research support, data interoperability standards and data centers coordination


- 
- *AstroGrid*, 2001, *UK* contribution to *VO*, (<http://www.astrogrid.org>). Project aims at producing a working datagrid for key *UK* databases. It s part of the world-wide drive toward the *VO*. *AstroGrid* covers astronomy, solar physics, and space plasma physics.
  - *International Virtual Observatory Alliance (IVOA)* 2002 (<http://www.ivoa.net>) develops common standards and infrastructures for data exchange and interoperability. *IVOA* Consortium Partners: *NVO*, *AstroGrid*, *Euro-VO*, *Australian VO*, *Canadian VO*, *VO of China*, *VO of India*, *Japanese VO*, *German Astrophysical VO*, *Spanish VO*, *Italian Data Grid for Astronomical Research*.



- The concept of Virtual Observatory provides researcher with the ability of using astronomic data from many different tools, with help of cutting-edge technologies and advancing international cooperation of scientific society.
- The tendency of avalanche-like data growth can be observed at fields such as Earth Sciences, Geophysics and Meteorology. Intensive studies of global warmth and climate change bring us to data collections growth at rates with order of several petabytes per day.


# *Virtual Scientific Centers*

- Along with “Virtual Observatory”, the programme “Virtual Scientific Center for Plasma Geophysics and Sun and Earth Physics” has been developing. International Consortium of Space Plasma Physics Research - Space Physics Archive Search and Extract (<http://www.igpp.ucla.edu/spase>) has been created by scientific society of Europe and USA.
- Technological achievements, uniting gigantic digital archives and databases, distributed all over the world, will fundamentally change type of researches of cosmic plasma, and will make it possible to solve problem of data access and exchange in Physics of Sun and Earth.



In the field of planets studies Planetary Data System:

- Science Data Archive (PDS) is being created by NASA.
- International Consortium has been established and an online archives system, composed of several geographically distributed centers, connected to Internet, has been formed for NASA' planetary science community. (*Proc. PV-2007 Conference. DLR, Munich, 2007*).


- 
- A natural step in Virtual Observatory concept progress is development Geoinformation infrastructure of distributed satellite data. Virtual Scientific Center project for Satellite Data is developed at Space Research Institute, Moscow, Russia (<http://iris.iki.rssi.ru>) as Distributed Environment of Integrated Information Resources in the field of Space Monitoring of Natural Environment. Virtual Scientific Center intending for collecting, storage and distribution of Satellite metadata catalogs provide for users data access, data searching, data request and recovery.

# *Spatial Data Infrastructure (SDI)*

- *SDI* infrastructure hosts geospatial data and metadata, provides a means of
  - discovering and evaluating the data,
  - provides methods to access the data.
- *SDI* components are realised: (i) geodata, (ii) technology (standards), and (iii) ability to find geo-related resources.

## *SDI:*

- Means of accessing data,
- Tools to enable use of data,
- Infrastructural services and ability to publish data.

A hand holding a globe is shown in the top left corner. The background features a blue and purple gradient with a bar chart on the left and technical drawings or maps on the right.

*SDI* abbreviation stands for a special kind of infrastructure based on computer networks with distributed databases and unique standards for:


- acquisition, measurements,
- processing, management
- maintenance, distribution of geo-spatial data
- single point of access the geodata.
- Infrastructure *SDI* supports better use of spatial data: digitalization of datasets, data processing and data storing have had a major impact on the world.

# *Spatial Data Infrastructure*

- *SDI is the e-Science Infrastructure*
- *SDI concept has been around for several years now.*
- *NSDI, USA, 1997: National Spatial Data Infrastructure (<http://www.fgdc.gov/nsdi>)*

*GSDI – Global Spatial Data Infrastructure Association, 2003 ([www.gsdi.org](http://www.gsdi.org))*

*Global SDI to support to collect, share, access and exploit Geo-information resources.*

- 
- *SDI* includes the interoperability between national databases, to use the tools provided from the international standardization work to set up architectures, standards and specifications.
  - Data sharing is a key purpose of *SDI*. Compatibility between *SDI* is necessary. Compatibility requires standards, and this is the basis for *Global SDI* relationship with *Open GeoSpatial Consortium*.

A vertical decorative bar on the left side of the slide. It features a hand holding a globe at the top, a bar chart with four bars of varying heights in the middle, and a map with various lines and arrows at the bottom. The background of the bar is a gradient of blue and purple.

# *Infrastructure for Spatial Information in Europe*

- European Union Infrastructure for Spatial Information – *INSPIRE*  
<<http://inspire.jrc.ec.europa.eu>>
- *INSPIRE* - Information infrastructure' solutions to support SDI - a Spatial Data Infrastructure within a united Europe  
(<http://www.ec-gis.org/inspire>).



# *INSPIRE*

- *INSPIRE* aims at making available relevant, harmonised and quality geospatial information, integrating other standards during the development process facilitates interoperability
- *INSPIRE* infrastructure will address technical standards, OpenGIS specifications, and protocols, including data access and the creation and maintenance of spatial information

# *EXCHANGE OF GEO-INFORMATION WEB-BASED, OPEN SOURCE*

## **INSPIRE: Establishing a Geo-Information Infrastructure SDI (Spatial Data Infrastructure)**

Access to international  
heterogeneous catalogues  
of geospatial metadata

Connect and Integrate Distributed  
GIS Resources for Virtual  
Collaborations

Data discovery;  
Search of multiple  
catalogues at the same  
time

Interoperability of  
independently developed  
applications (OGC)

Garmonization: Establish  
a structured set of  
standards for Geodata

Providing data services,  
Geo-information Web  
services

Use of Remote Sensing and  
Spatial Information Technologies  
in Earth Observation

A hand holding a globe, symbolizing global impact or environmental stewardship. The background features a bar chart and technical diagrams, suggesting data analysis and technology.

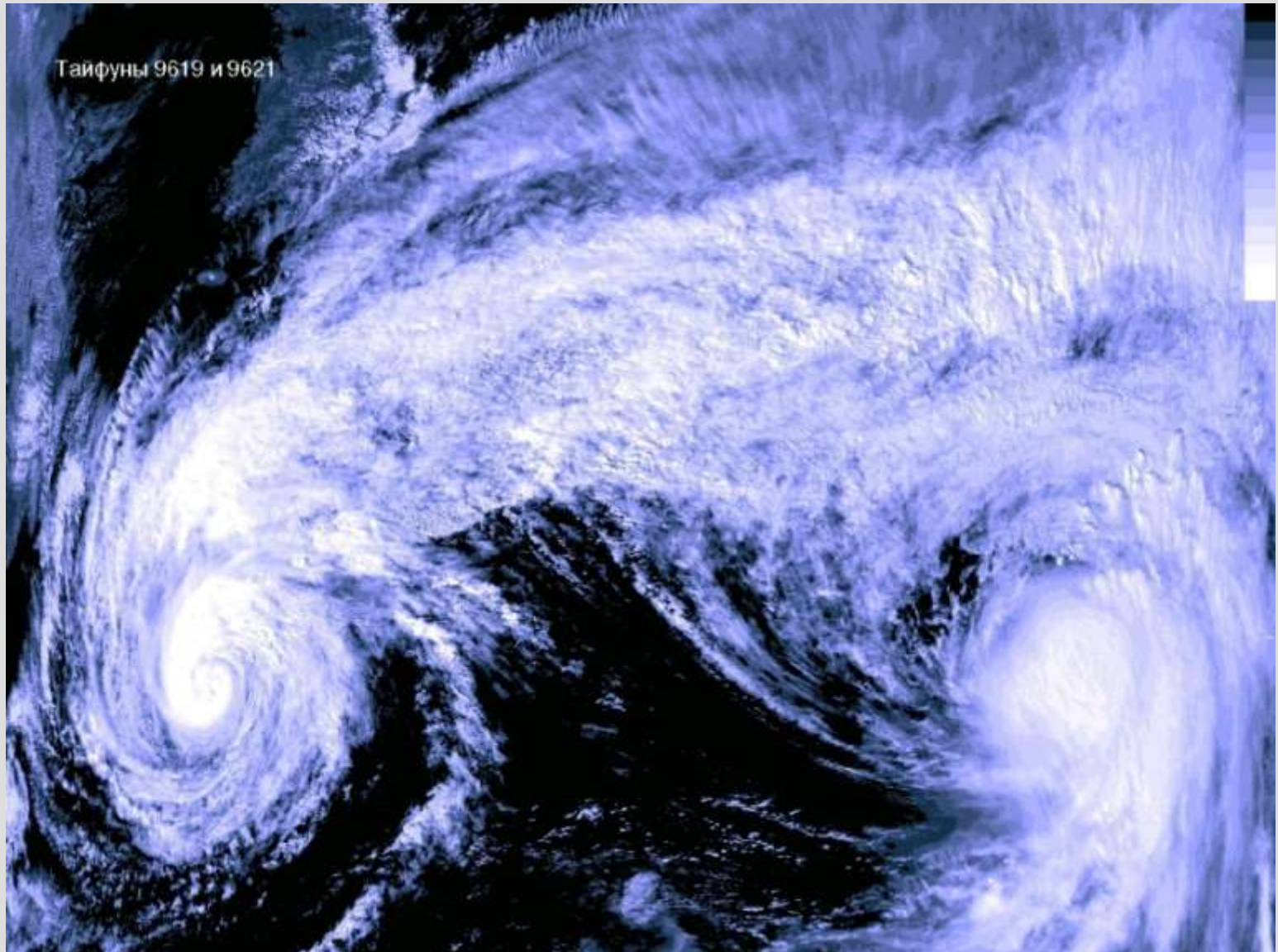
# *Applications for Natural Disasters Mitigations*

The size and complexity of information collections stored in large digital archives grow rapidly. Data centers are becoming a means for communities to share, or organize, and access their satellite archives.

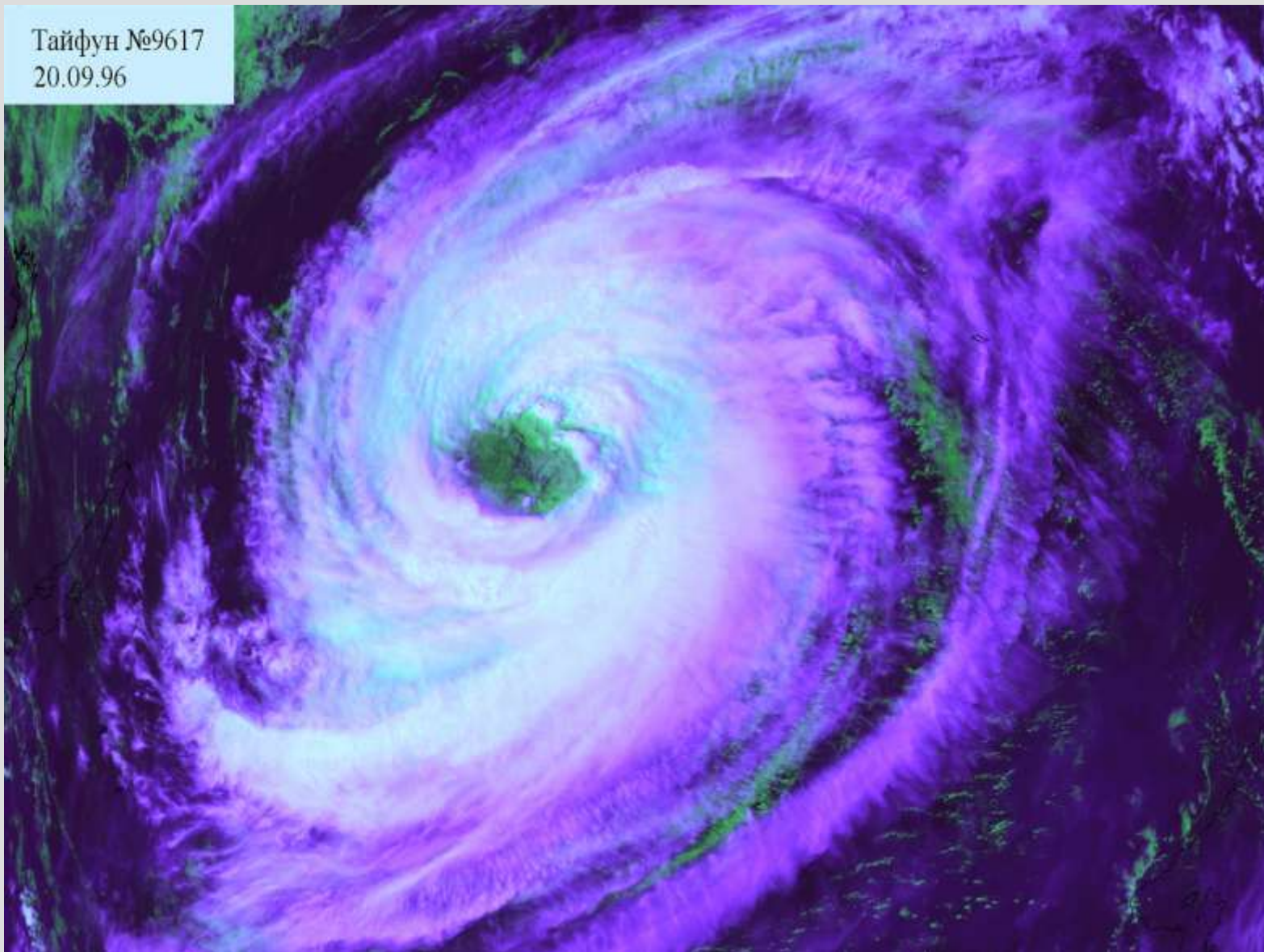
Some examples of image data cover topics such as - natural disasters, typhoons,

- oceanographic observations,
- monitoring sea ice in the Okhotsk sea,
- Satellite Environmental Monitoring,
- temperature maps of Moscow,
- forest fires.

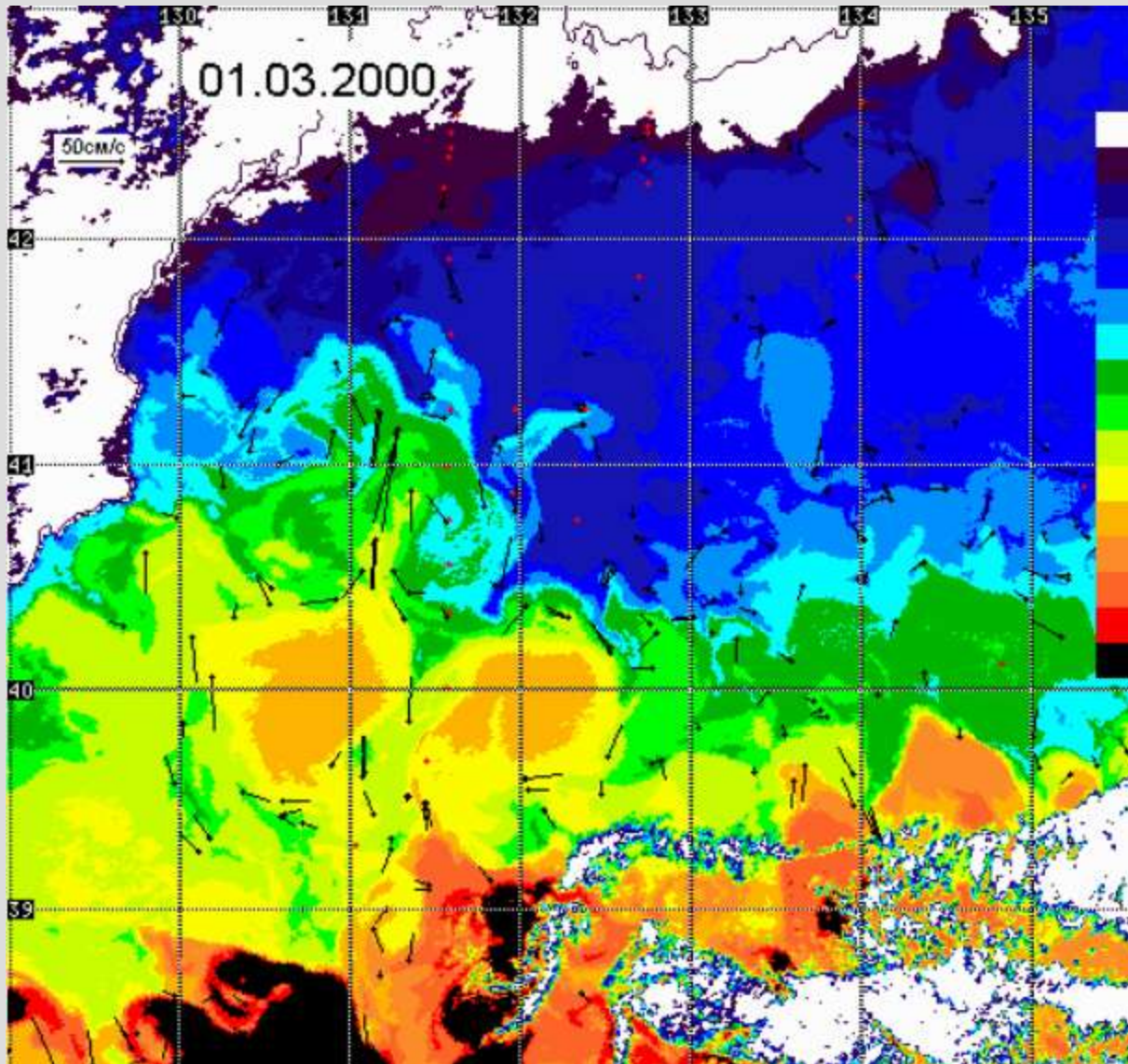
# TYPHOON



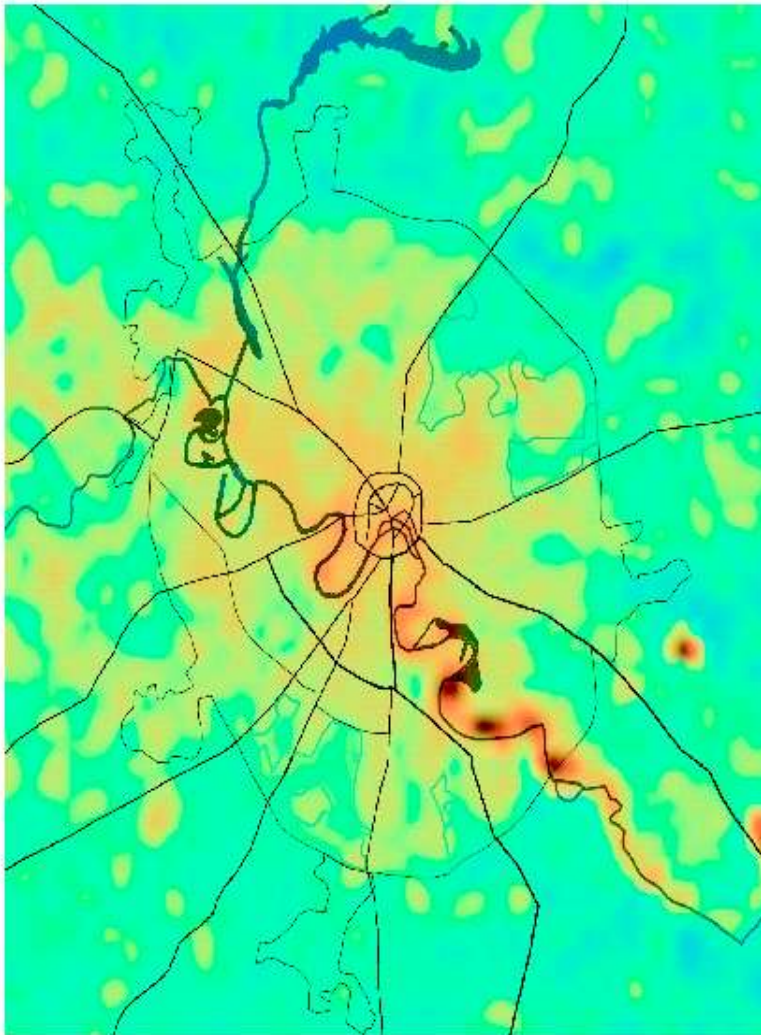
Тайфун №9617  
20.09.96



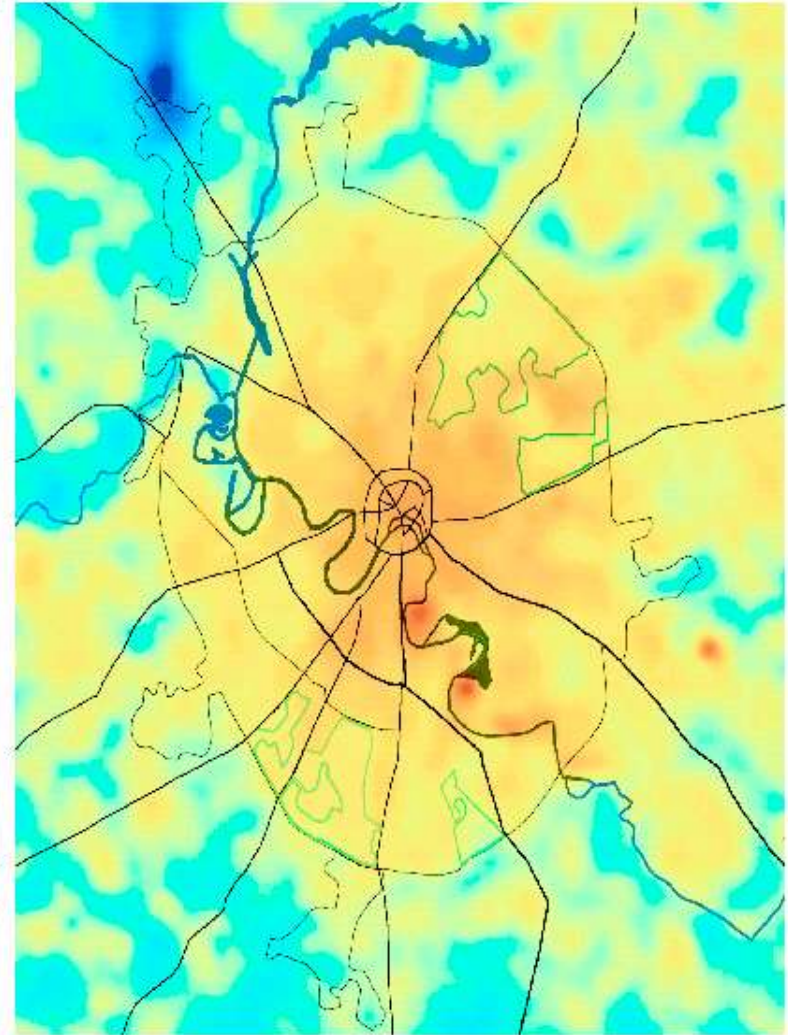
# OCEAN SURFACE CURRENT MEASUREMENTS



# TEMPERATURE MAPS OF MOSCOW



09.03.1999

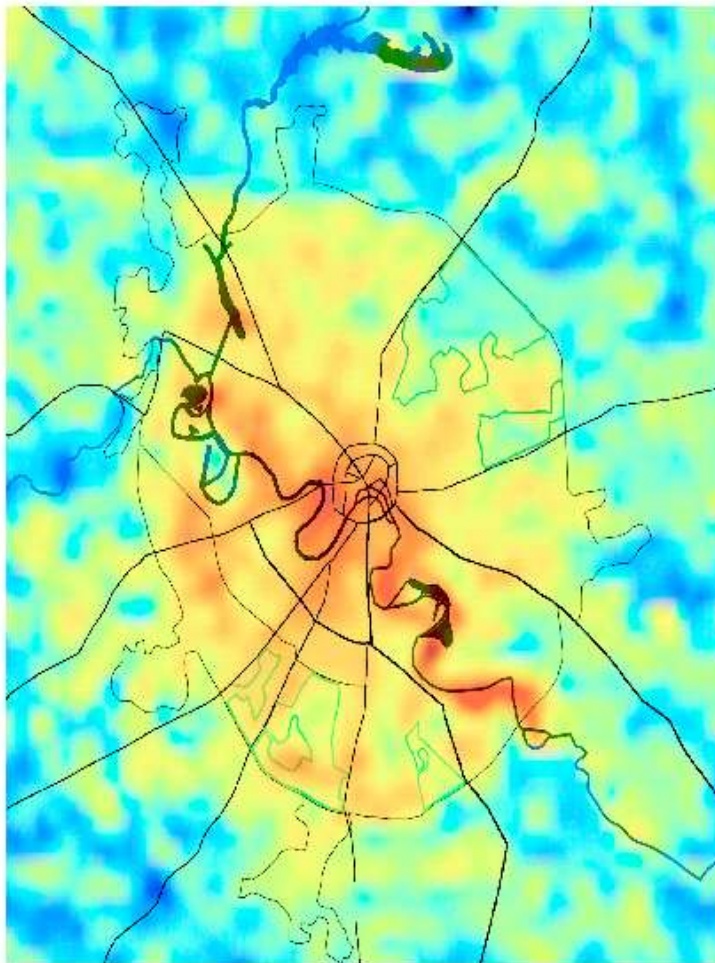


21.03.1999

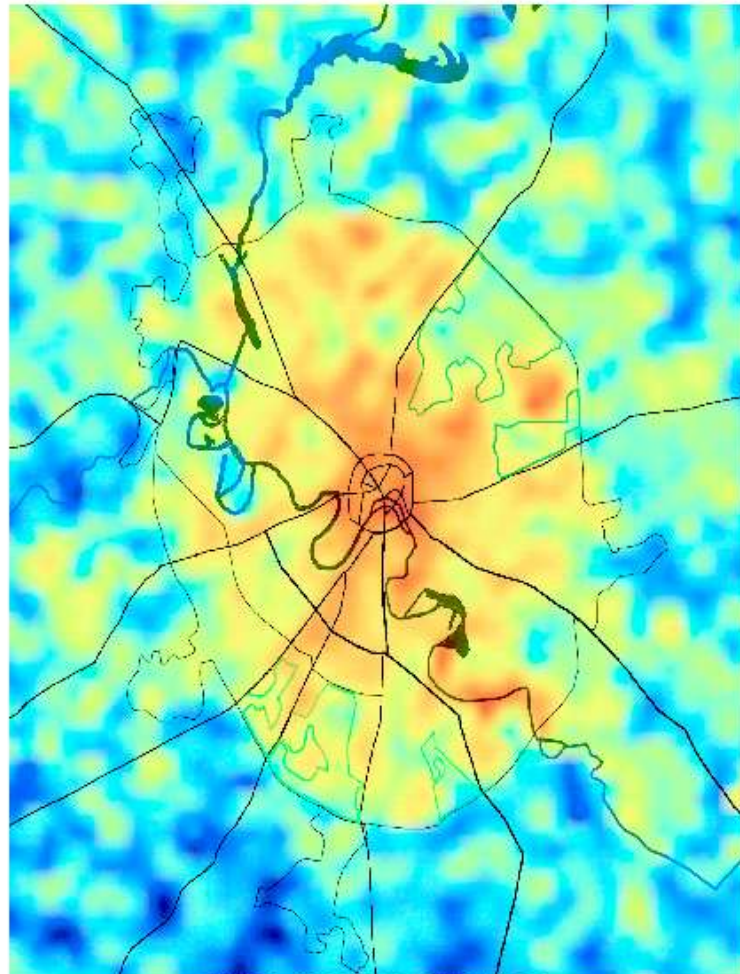
Примеры температурных карт г. Москва.

NOAA 15

# TEMPERATURE MAPS OF MOSCOW



16.11.1999



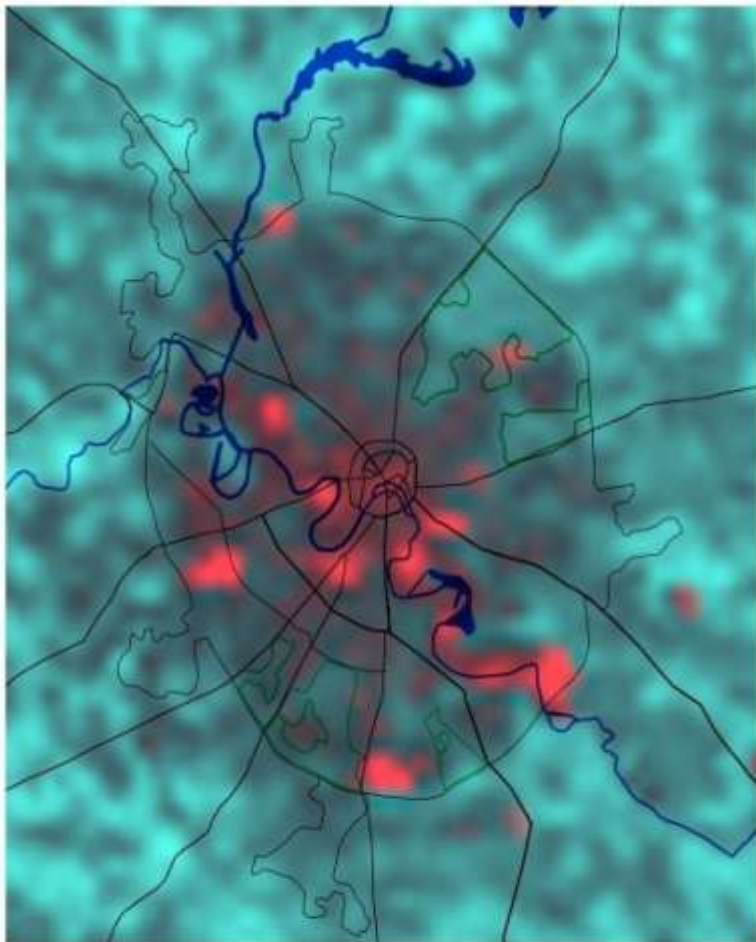
01.12.1999

Примеры температурных карт г. Москва  
NOAA 15

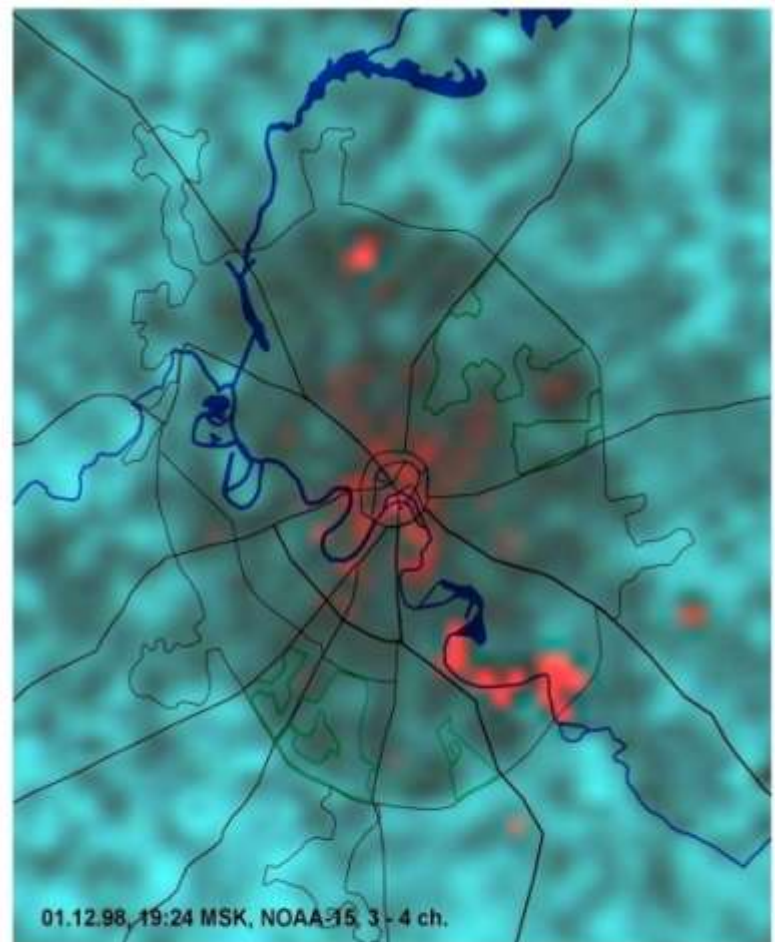


# *SATELLITE ENVIRONMENTAL MONITORING*

Let us consider the thermal Infra Red anomalies, relating to Power Plants



16.11.1998

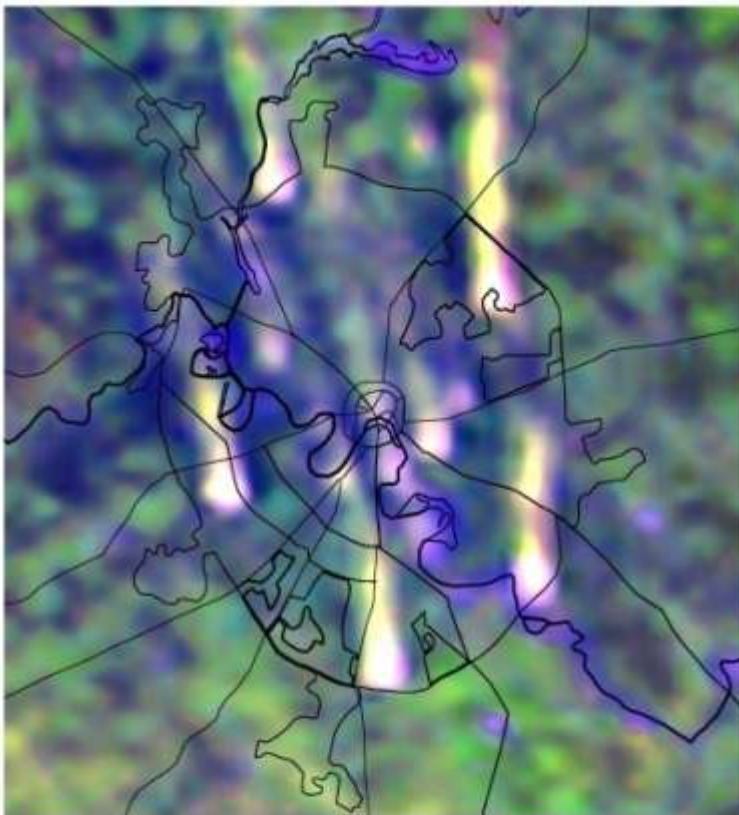


01.12.1998

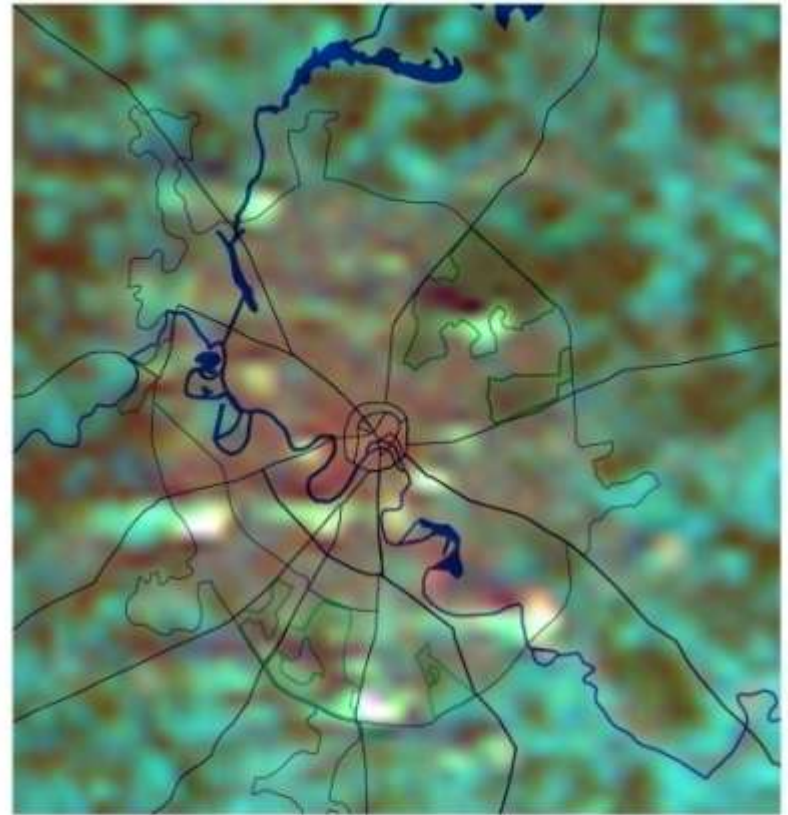
**Example of revealing of temperature anomalous points  
(Moscow, 3-4 channels of the satellite NOAA-15)**



# *SMOKE LOOPS*



14.11.1998

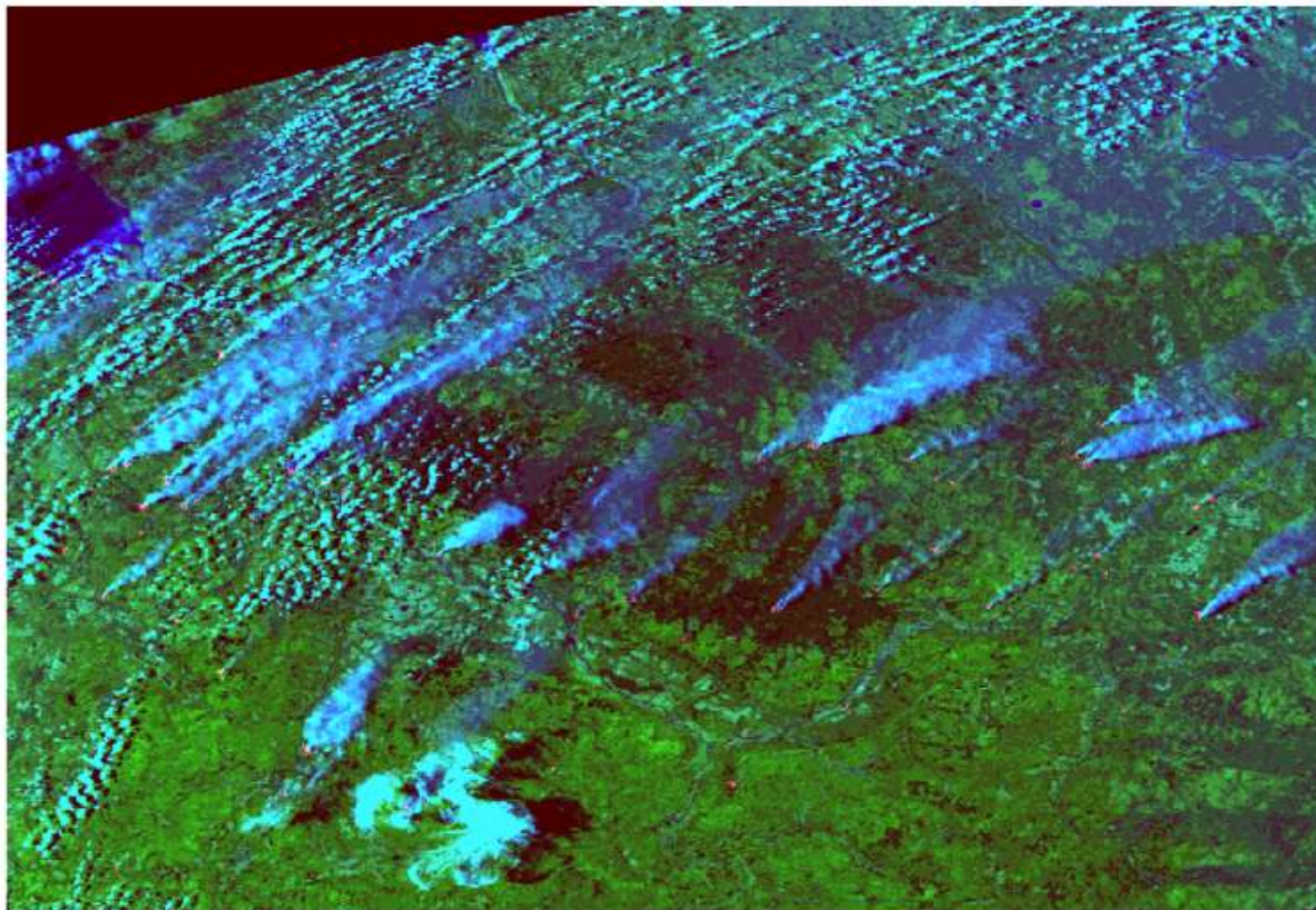


16.11.98

**Example of revealing of Smoke loops  
from Thermo electric power Station  
(1-3 channels of satellite NOAA-15)**

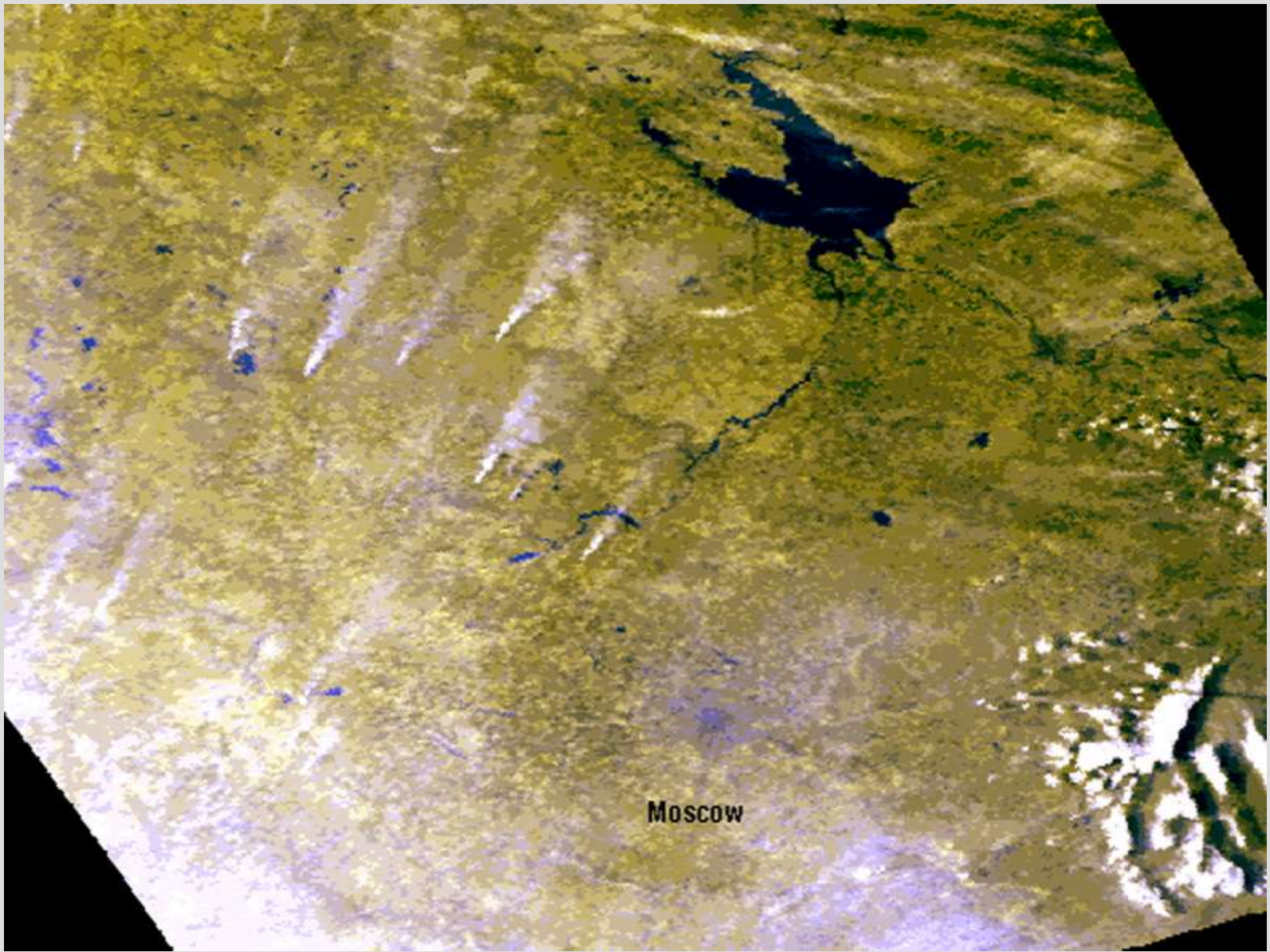


# *SATELLITE MONITORING OF FOREST FIRES*

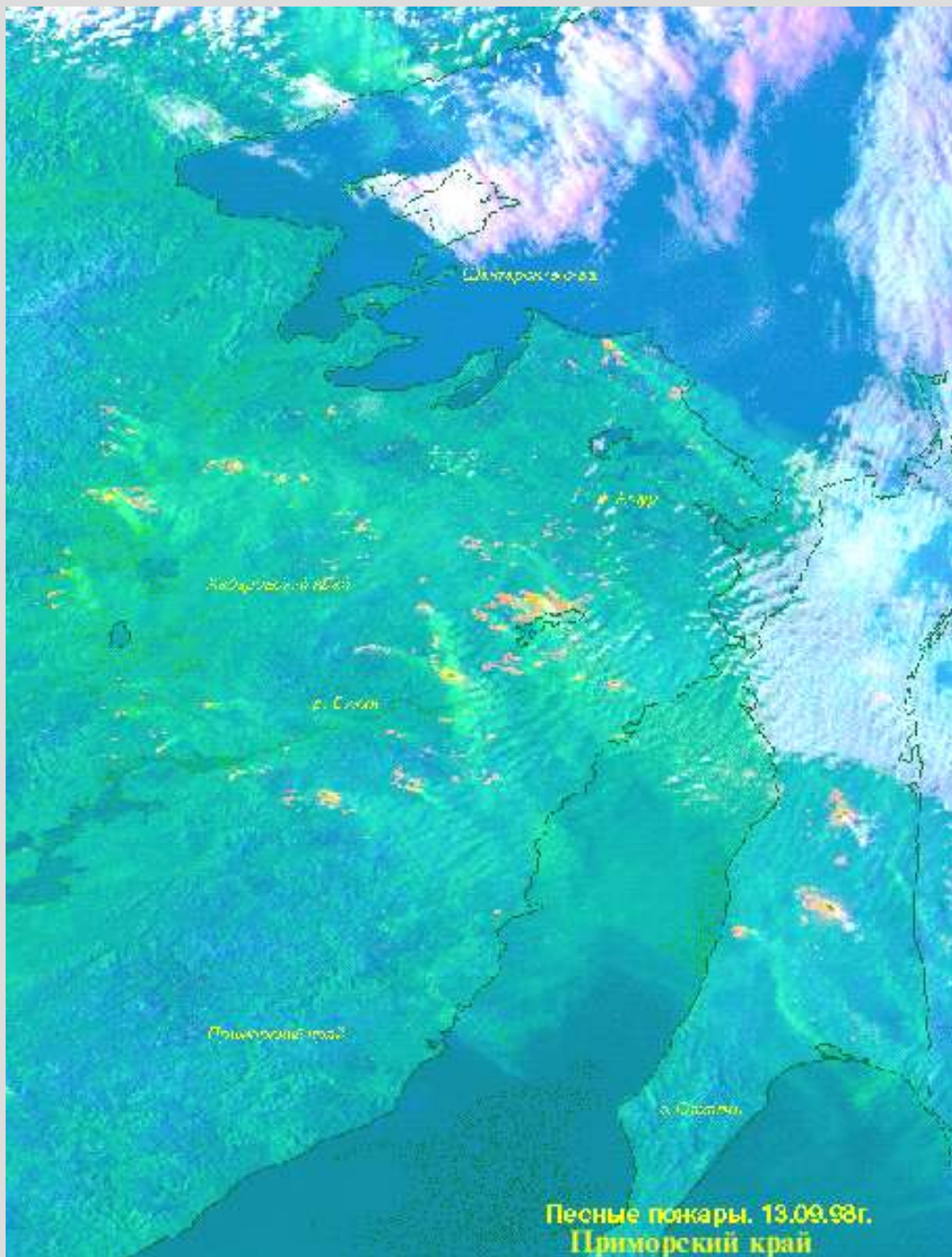


Выделение очагов пожаров цифровой обработкой данных AVHRR. 10 августа 1997 года.  
Проведено трансформирование в проекцию карты.

## Siberia region

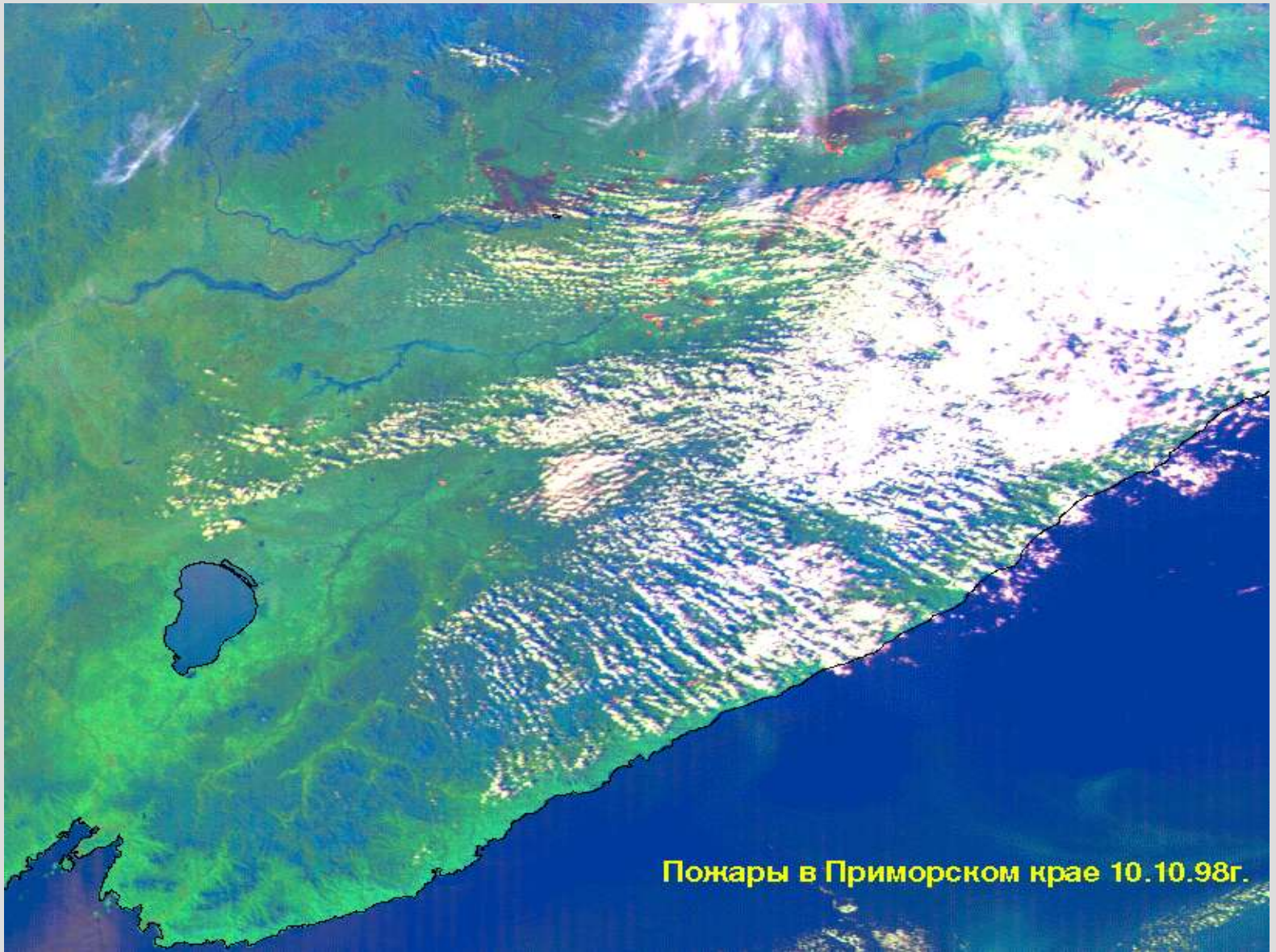


Moscow region



# Pacific Region

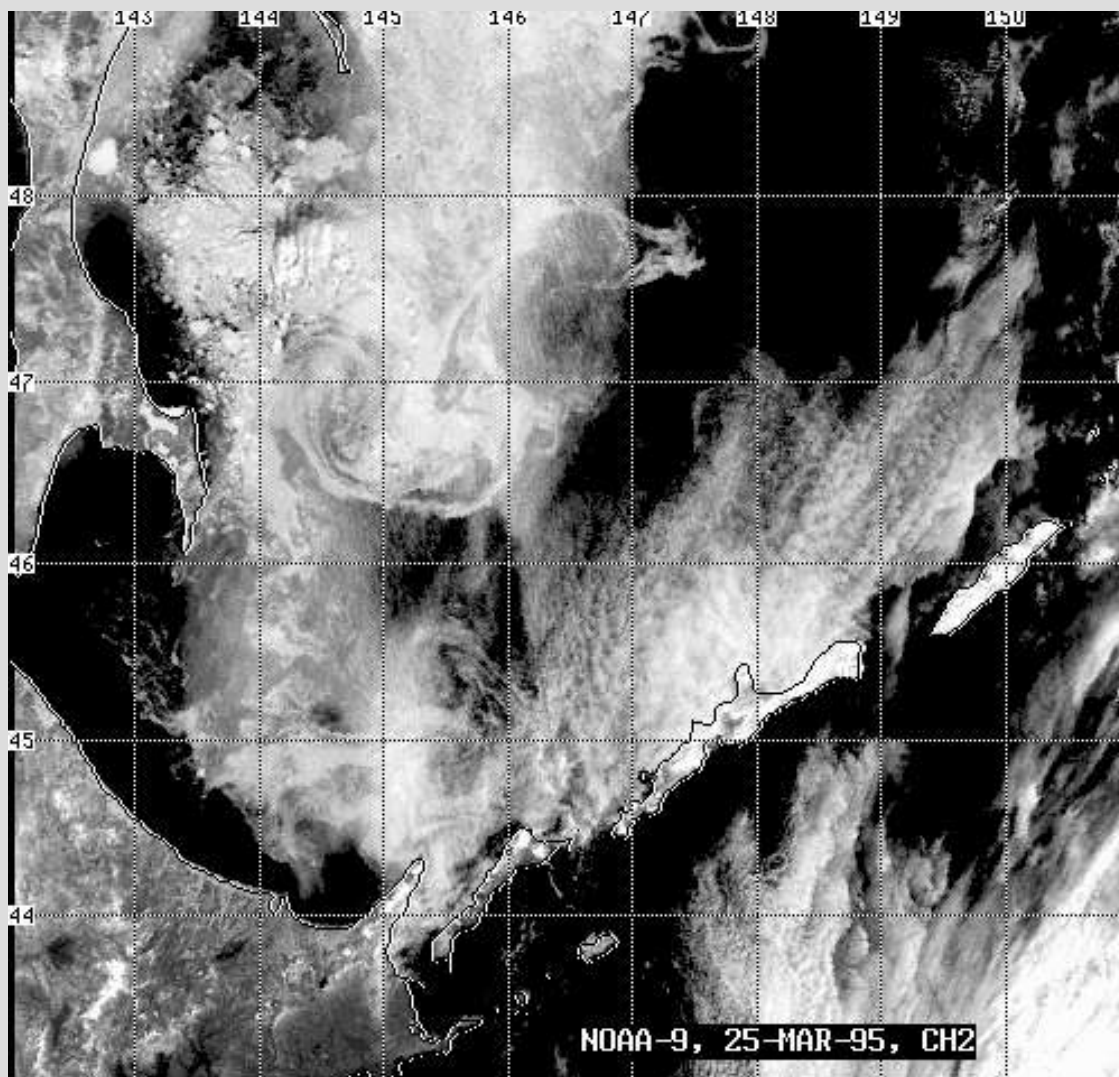
Песные пожары. 13.09.98г.  
Приморский край



Пожары в Приморском крае 10.10.98г.

***Pacific Region***

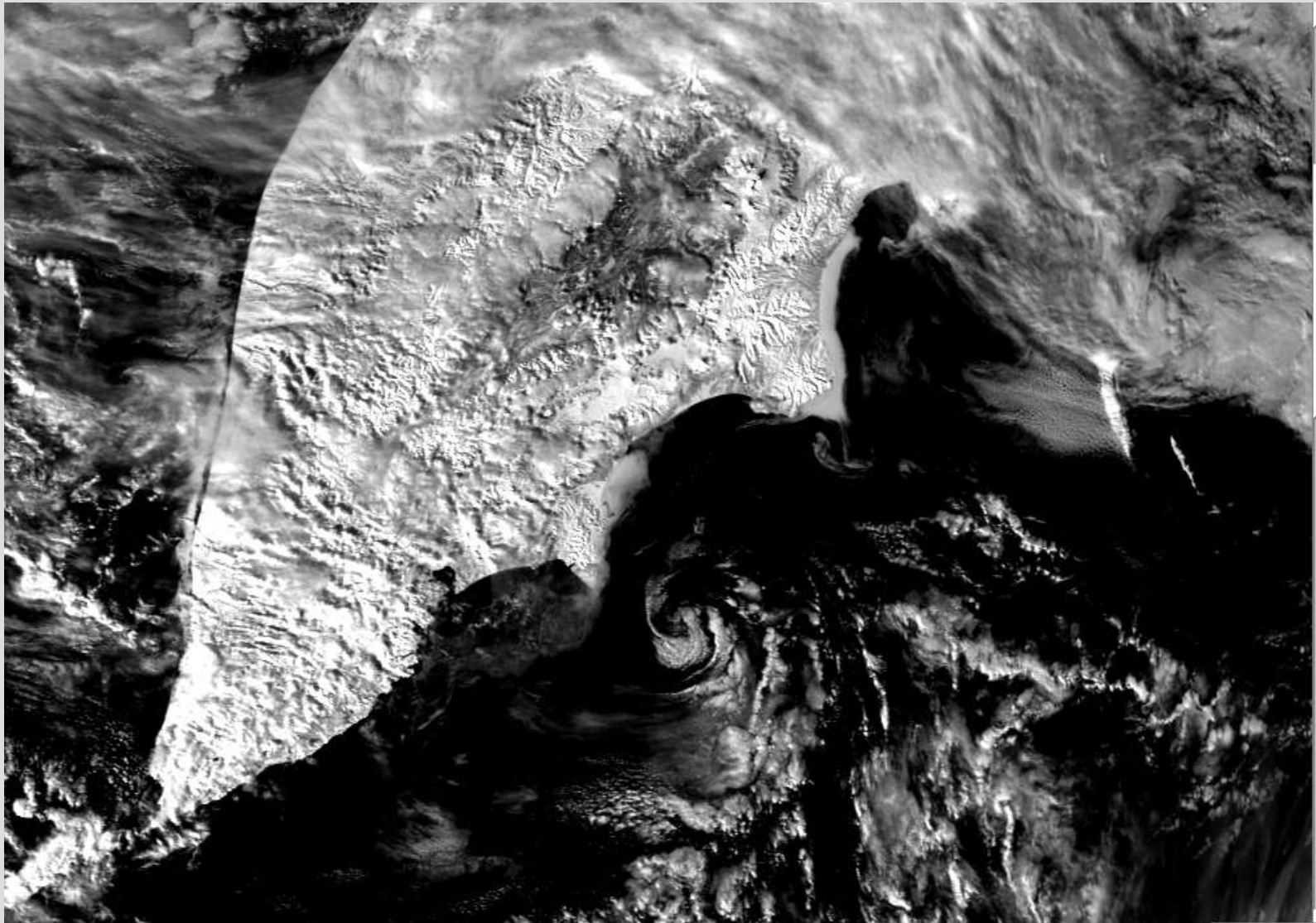
# SEA ICE MONITORING IN THE OKHOTSK SEA



Ледовые вихри в Охотском море



# *SNOW SURFACE*

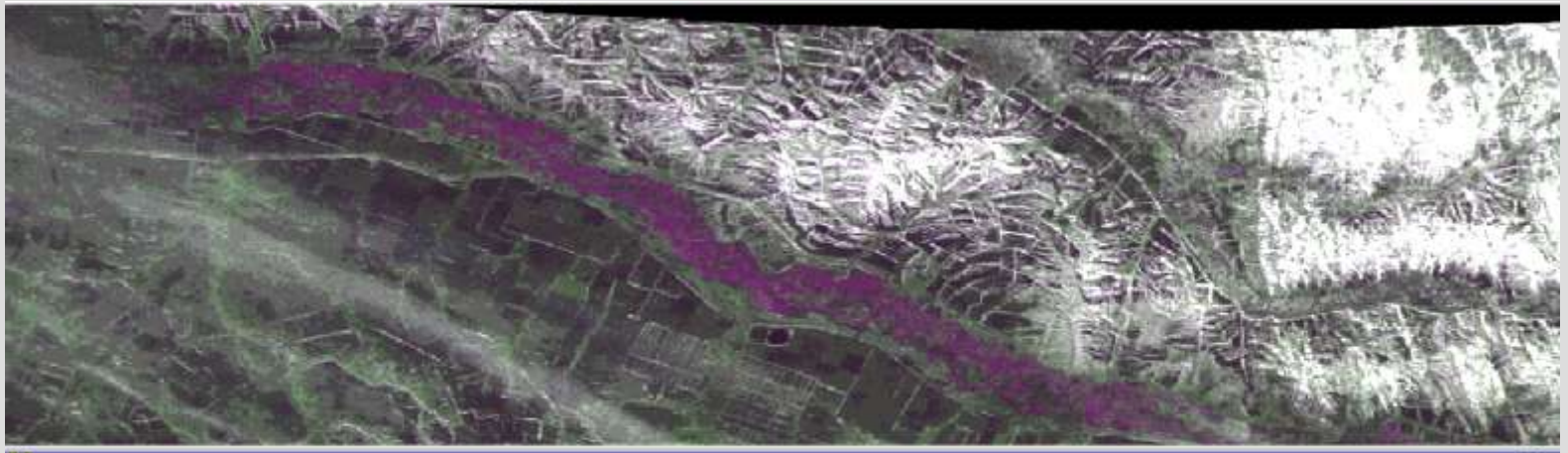


Снеговой покров (10.03.99)

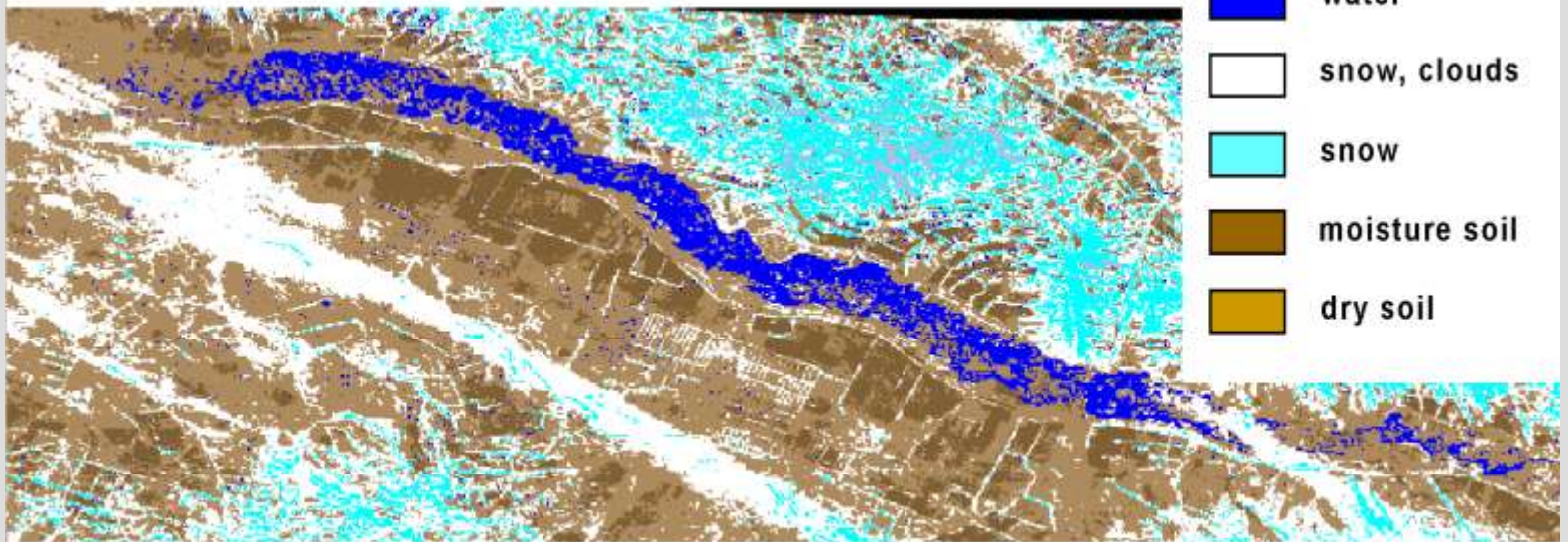
## Large city' pollutions on the snow



# *FLOOD EVENTS*



Original.



Images after classification.

## Detection and estimates of floods



# *Global Monitoring for Environment and Security (GMES)*

There is a need for a global infrastructure of data due to *GIGAS* activities such as

- . *GMES* (Global Monitoring for Environment and Security),
- . *GEOSS* (Global Earth Observing System of Systems) and
- . *INSPIRE*.

*GMES* is a joint *ESA-EU* initiative and *GMES* services will all be designed to meet common data and information requirements and will have global dimension.




*GMES* provide Europe with an independent global information system in support of its Environment and Security policies.

*GMES* is developing into a major European activity. *GMES* aims to link major satellite and surface based systems for Global Environmental Observations of the atmosphere, oceans, land and biota.



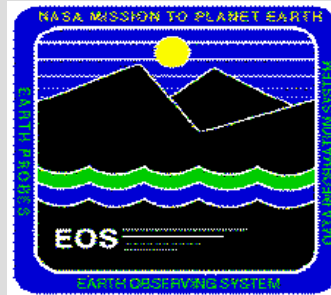
## *Russian satellite datasets*

- For many years Russia has been carrying out an extensive programme of Earth Observation using a range of satellite remote sensing instruments.
- Russian satellites have collected large volumes of data over the years, and exploitation of this data world-wide could have a wide variety of uses, notably Environmental Monitoring and Natural Disaster mitigation.



For Russian data to be considered as part of this, it needs to be accessible, linked to, and interoperable with, other National (*EOSDIS*) and International (*INFEO*) Information Systems. However, despite the large volumes of data generated by these systems they are not exploited as much as they could be, especially outside Russia. It is important that such potentially useful datasets are utilised to the maximum extent possible in order to achieve maximum cost effectiveness from the previous space investments and to justify future expenditure on new and continuing programmes.

# *EOSDIS*



## *EOSDIS*

(Earth Observing System Data  
and Information System)



# *EOSDIS*

One of the world's largest scientific data systems *EOSDIS* has stored over three petabytes of earth science data in a geographically distributed mass storage system. Many changes have occurred in the ten years while the system was operational. In its first operational year (2000), the *EOSDIS* system had increased NASA's collection of earth science data holdings eight-fold. Today, *EOSDIS* collects over 7,000 gigabytes of data per week, almost 60 times more than the hubble space telescope.



# *EOSDIS*

The *Earth Observing System (EOS) Data and Information System (EOSDIS)* enables the collection of *Earth* science data from the *EOS* spacecraft. As *NASA's Earth* science data system, *EOSDIS* provides command and control, scheduling, data processing, and data archiving and distribution services for *EOS* missions. *Earth Observing System (EOS)* is a



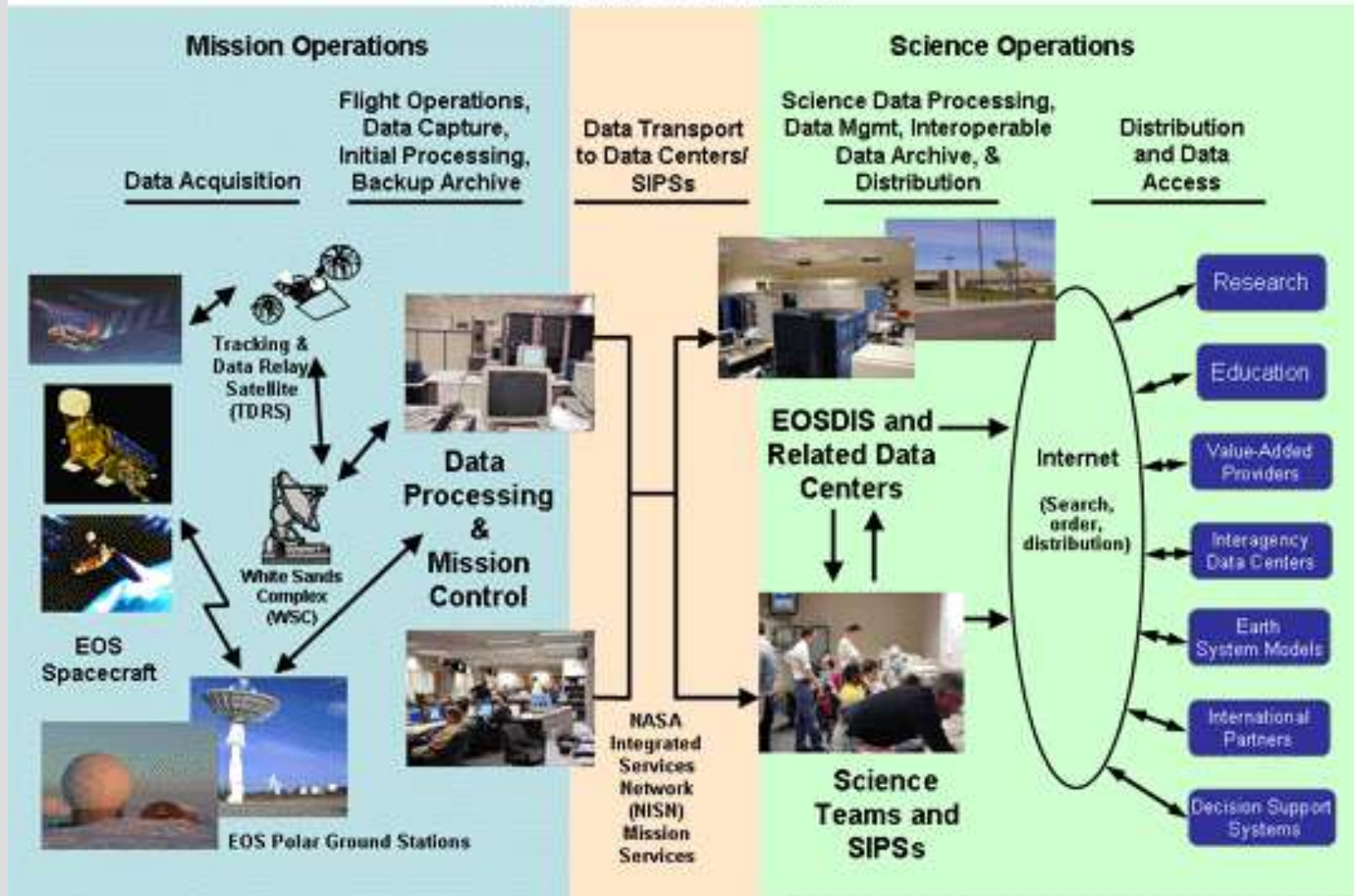
## *EOS data*

coordinated series of polar-orbiting and low inclination satellites for long-term global observations of the land surface, biosphere, solid Earth, atmosphere, and oceans.

*EOS* is a major component of the Earth Science Division of NASA's Science Mission Directorate.


*EOS* enables an improved understanding of the Earth as an integrated system.

# EOSDIS Context



# *EOSDIS*

- Main goals of *EOSDIS* are improvement of mechanisms for data access by arranging Data Centers *DAAC* for information exchange and creating metadata bases; creation of spatial databases; creation of theme data, crucial for government organization and holding of national discussion forums; preparation of educational programmes for personnel training; development of comprehensive partnership and coordination of data collection and usage.

- 
- The Distributed Active Archive Centers (*DAAC's*) process, archive, document, and distribute data from NASA's past and current Earth-observing satellites and field measurement programs. Each center serves a specific Earth system science discipline and provides users with data products, services, and data-handling tools unique to the center's specialty. User services include:(i) Assistance in selecting and obtaining data, (ii) Access to data-handling and visualization tools, (iii) Notification of data-related news, (iv) Technical support and referrals

# *Earth Observation Programme of the European Commission*



- *INFEO* (Infrastructure for Spatial Information in Europe)



- *eoPortal* – Data access Portal *ESA Group on Earth Observations (GEO)*



- *GMES* (*Global Monitoring for Environment and Security*)
- *GEOSS* (*Global Earth Observation System of Systems*)

# *INFEO*

*INFEO* offers access to *Earth Observation data*, services and data catalogues around the world.

Informational system *INFEO* (Infrastructure for Spatial Information in Europe) is an initiative of European Space Agency, which is entrusted to solve the problem of access to distributed *Earth Observation data*.

Fundamental principle of this system is providing interoperability



# *INFEO*

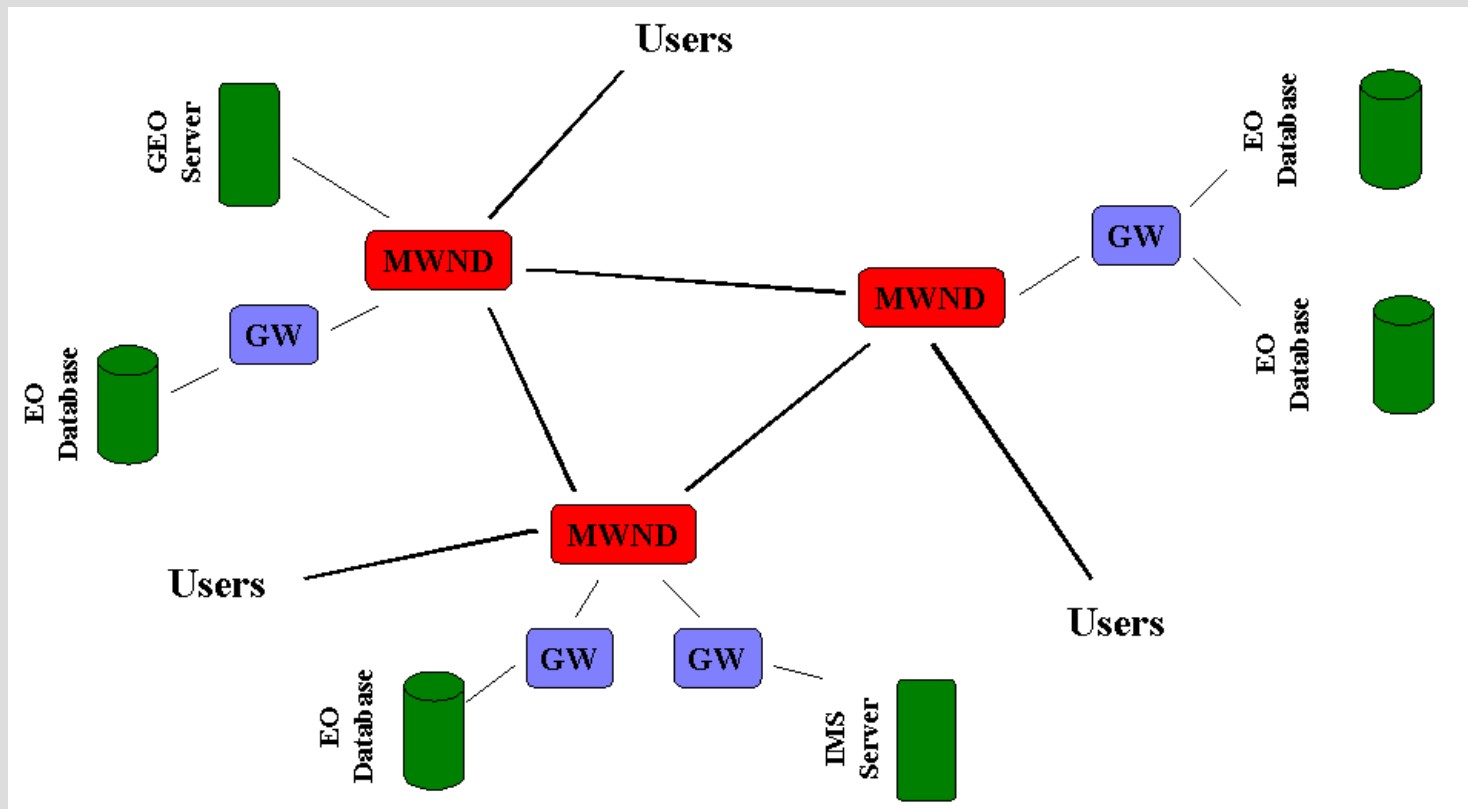
- Interoperability is the ability of interaction for heterogeneous services and data catalogues within the bounds of unified informational system. The main functions of *INFEO* system are creation of uniform information environment, providing single access point for information



## *INFEO*

search of data and retrieval in all archives and catalogues, registered in the system, independently of their geographical location and internal data format.

- Nodes network, so-called *Middleware Nodes (MWNDs)*, underlies in first-generation distributed informational system. Every node contains collections metadata, which describe data, accessible through gateways.



## *CIP/ODBC Gateway*

Users can receive the access to *eoPortal* data over *MWNDs*. *MWND* (middleware node) is a top-level component of *INFEO/eoPortal*.



# INFEO

- For information retrieval, user inquires system via *WWW*-server on one of the *MWND* nodes, where distributed request is formed and then sent to relevant gateways. Request results are united and shown to user. Gateway is intermediate between *MWND* node and data provider's catalogue or archive. Gateway exchanges information with *MWND* node via *CIP* (Catalogue Interoperability Protocol), receiving search queries from it and returning search results in respond.



# *INFEO*

- For the user the goal of *CIP* was one single interface to access to distributed international *EO* catalogues, locate diverse *EO* data sets, use data from different disciplines, access data in themes, use browse, inventory, directory, order. For the provider, the goal of *CIP* was one single toolkit to re-use software, access to all my catalogues, save costs, increase services, increase user community.
- *CIP*, regulating rules of interaction for users and *EO* data catalogues, underlies in distributed informational system.




## *INFEO*

- Special three-level principle for access distribution is used to support simultaneous user access to great number of catalogues. User specifies inquiry via web-interface and sends it to *MWND* node, which correspondingly redirects the query to a set of data catalogues servers. Servers, which possess data, which meet search criteria, return responses to *MWND* node, via which user gets unified search result.

# SSE


- The logical extension of *INFEO* system was development and adoption of second-generation technologies. The reason for it was aspiration to extend Earth Observation participation in global ecological monitoring, to improve interaction with worldwide information EO systems for the tasks of Natural Environment protection and necessity to support demands of *INSPIRE* EU Directions regarding compatibility with other informational systems.

- 
- Second-generation integration technologies development is aimed at migration from approach, based on Z39.50/Gateways technology, to usage of web-services (*XML* over *SOAP/HTTP*) for connecting external catalogues with *INFEO* catalogues. Second-generation integration technologies, which had been named *EOLI-XML*, is external interface for message exchange between server and client, based on *SOAP* protocol.




# *SSE*

- *EOLI-XML* technology underlies in *SSE* (Service Support Environment) system, which is developed for solving stated problems by creating open, service-oriented, distributed environment.
- *SSE* system is infrastructure, unified environment for consumers and providers of data and services.



*SSE* unifies its users on basis of *XML* standard with usage of *SOAP* messages exchange protocols and description language of web-services *WSDL* (Web Service Definition Language).

Any service that is being integrated into *SSE* environment should provide *SOAP*-interface, according to *SSE ICD* (Interface Control Document). Main objectives of *SSE* infrastructure creation are provide environment,



maximally simplifying interaction of “service-provider – user” and “service-provider – service-provider” types; simplify integration of already existing services, providing versatile *XML*-based interface, permitting evasion of changing structure; provide users with unified entry point – Internet portal of the system. *SSE* system consists of two major constituents: *SSE Portal Server* and *AOI Server*, together forming Internet-portal, with which the end user interacts.

A vertical decorative sidebar on the left side of the slide. It features a blue and purple color scheme. At the top, there is a circular graphic of a hand holding a globe. Below that is a bar chart with four vertical bars of varying heights. At the bottom, there is a partial view of a computer keyboard.

# *SSE*

The *SSE* platform is based on different technologies that have been integrated into a unique and powerful environment.

To orchestrate the supply chain of *EO* and Geospatial Information, *SSE* provides the best available technologies and standards:

- *SSE* supports the Service Oriented Architecture (SOA) paradigm and simplifies the integration of *Web* services through the *Toolbox* environment.



# *SSE*

- Toolbox environment accessible as a free download from the *SSE* portal which converts any legacy service in a *SOA* based one, dramatically reducing the coding problems.

The service chaining is supported by an orchestration engine that provides a Standard workflow definition language. dramatically reducing the coding problems.



# *SSE*

- The service chaining is supported by an orchestration engine that provides a Standard workflow definition language.
- The service provider can decide, without restraint, to capitalize on a workflow editor or to use its default workflows.
- The Service output can be published in different ways exploiting a wide set of geospatial information tools and services either on the provider or on the *SSE* side,



## SSE

- including an interface to the *ESA DDS* (Interface Control Document) for data delivery via satellite.


This approach allows the service provider to offer the functionalities either as individual

Web services or aggregated at a single interface and:

- foster the development of reusable services
- avoid the duplication of frequently used processing software

# *SSE*

- facilitate the combination of any services to business processes (“Orchestration”).
- The definition and prototyping of services is made easy within the Service Support Environment (*SSE*), a neutrally managed, open and distributed platform.
- *SSE* offers an exclusive opportunity to integrate a wide range of heterogeneous Earth Observation data and
- Geospatial information services, including product catalogues.

- 
- Experiment excellence joining the community of developers and value adders which exploits *SSE*, its unique test bed, and the best available technologies and standards.

The *SSE* environment supports service prototyping and demonstration processes, allowing to design automatically executed workflows. This avoids the manual replication of the same task, with a valuable decrease of the overall development effort.

# SSE


In this way *SSE streamlines* both the time to get the Earth Observation data and that to deliver the service to the end-user.

*SSE* works to:

- Orchestrate synchronous and asynchronous Web Services for online and offline processes
- Provide an overarching infrastructure, neutrally managed by *ESA*
- Integrate the access to Earth Observation data within service prototyping and delivery

# SSE

- Empower service providers through a business process management platform
- Minimize service providers' upfront investments
- Allow the use of Open standards to facilitate adoption and evolution
- Facilitate the integration of satellite data and geospatial information within the processing and exploitation chains

- 
- Technologies and principles of building distributed systems, have great potential for further development and even today they provide extensive means for arranging distributed heterogeneous data and services in single global system. Extension vector of each next generation of distributed informational systems consists of three main summands: going away from shortcomings of existing system, improving technical and informational characteristics, solving new problems, which did not even exist at a point of development previous-generation system.



## *SSE Russian segment*

Russian scientists took active participation in projects of building distributed systems all generation both in development and adoption phases. Thus, on basis of *INFEO IRIS* and *INSPIRE* (*EOLI-XML* and *SSE* technologies) projects, Russian segment of distributed informational system on the basis *SSE* have been built. Russian segment of distributed informational system for satellite archives have been implemented with collaboration of Space Research Institute (IKI) and Institute of Automation and Control Process (IAPU), Vladyvostok.



## *SSE Russian segment*

Laboratory of Satellite Monitoring of *Institute Automatic and Controls Process*, Vladyvostok (<http://satellite.dvo.ru>) acts as the Remote

Sensing data provider for Pacific and Far-East Regions. Software and hardware for functioning of the segment is located in *Space Research Institute*, Moscow

(<http://iris.iki.rssi.ru>). Scientific community of Remote Sensing has gained opportunity to access data of one of Russian EO satellite data providers via global distributed system.



## *SSE Russian segment*

- The main aim of this project is to improve the accessibility of Russian Satellite Remote Sensing data,
  - generating Russian satellite information resources, linking the information resources with Russia and with the European eo/Porttal (metadata/catalogue) system in order to provide interoperable catalogue access and ensuring that end users are involved, provide a single point of access to data.

# *Russian segment SSE*

Russian segment *SSE* provides:

- i) Environment to bring together data users and providers,
- ii) Homogeneous Access to international heterogeneous catalogues of geospatial metadata and documentation,
- iii) Search of multiple catalogues at the same time,
- iv) One Search Interface and garmonised presentation of results.



## SEARCH TYPES:

- i) detailed descriptions about data sets, data sources, instruments, projects
- ii) single point of entry for facilitating the use of Satellite imagery and GIS .

## RESULT of SEARCH:

online access to existing data.

# CONCLUSION

Remote Sensing EO data is one of important sources for geospatial data and information.

Considerable progress has been made in:

i) Remote Sensing data access, ii) Interoperability, iii) Management of very large volumes of *EO* data. Thank to data harmonization efforts, using *ISO* and *OGC* standards access to satellite datasets archived at through eo/Portal Data Gateway. Russian segment of *SSE* provide an huge amount of Remote Sensing data to a broad user community in Russia.