Modern information technologies for environmental monitoring and modeling

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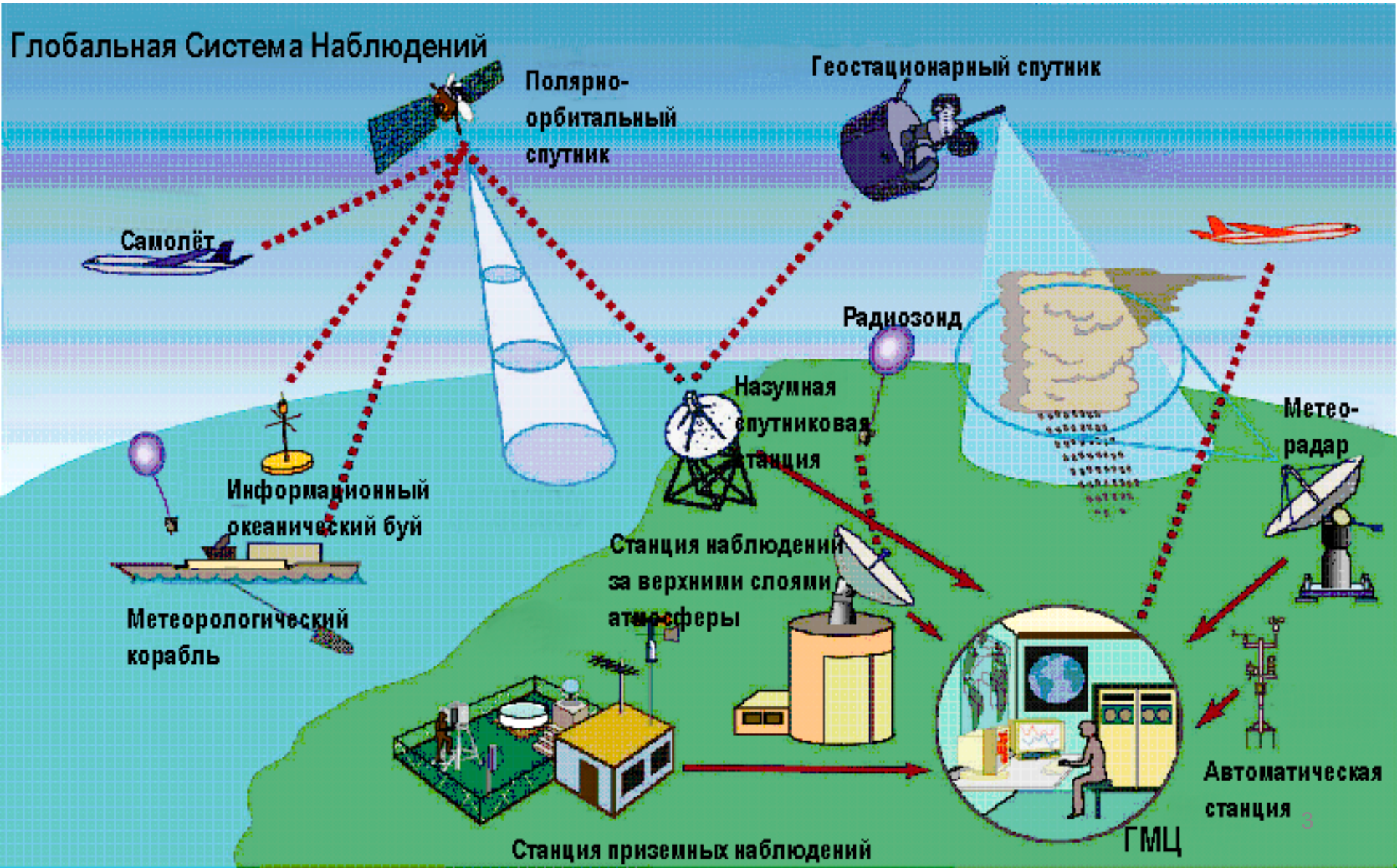
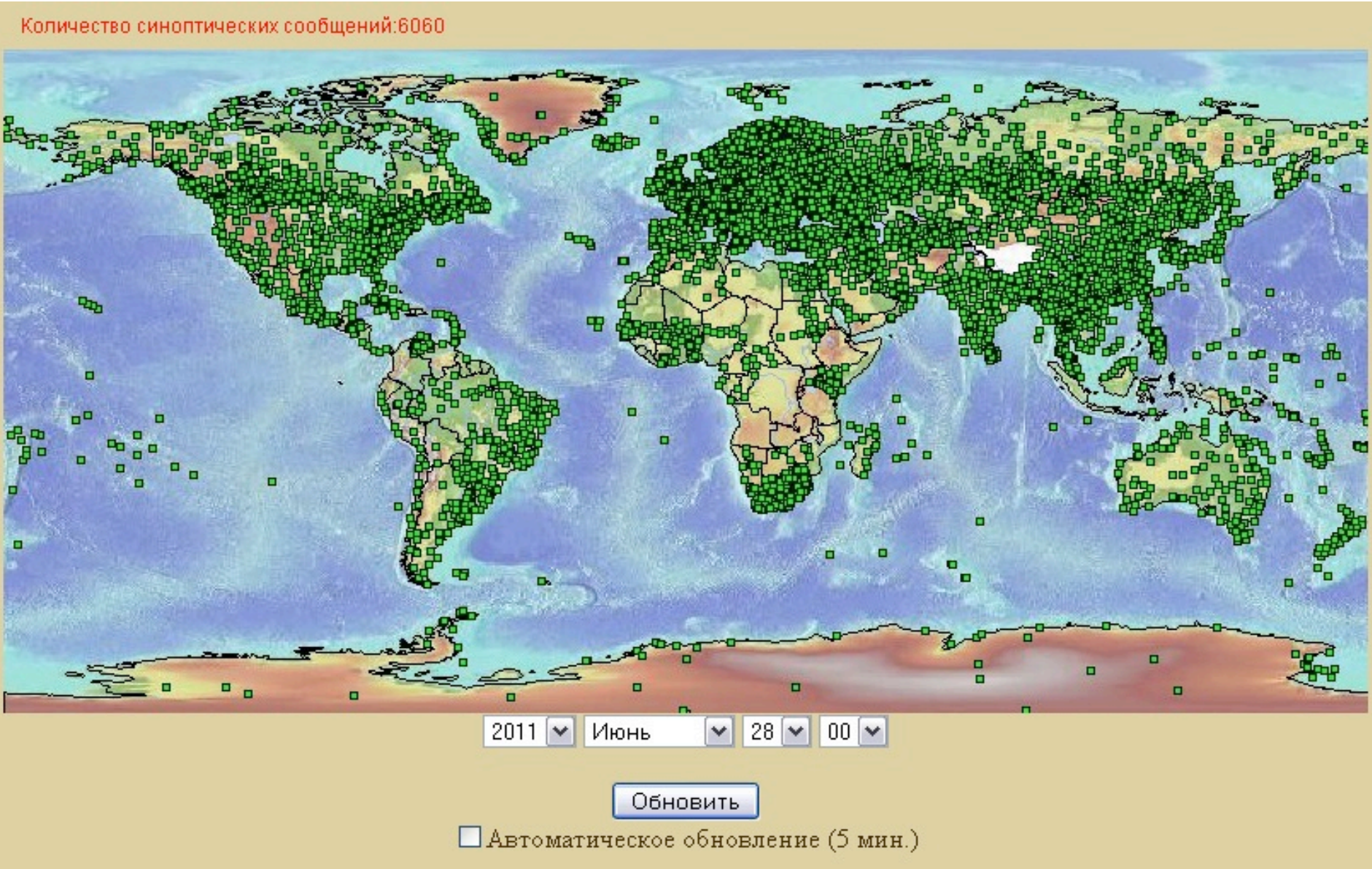


World hydrometeorological observation network



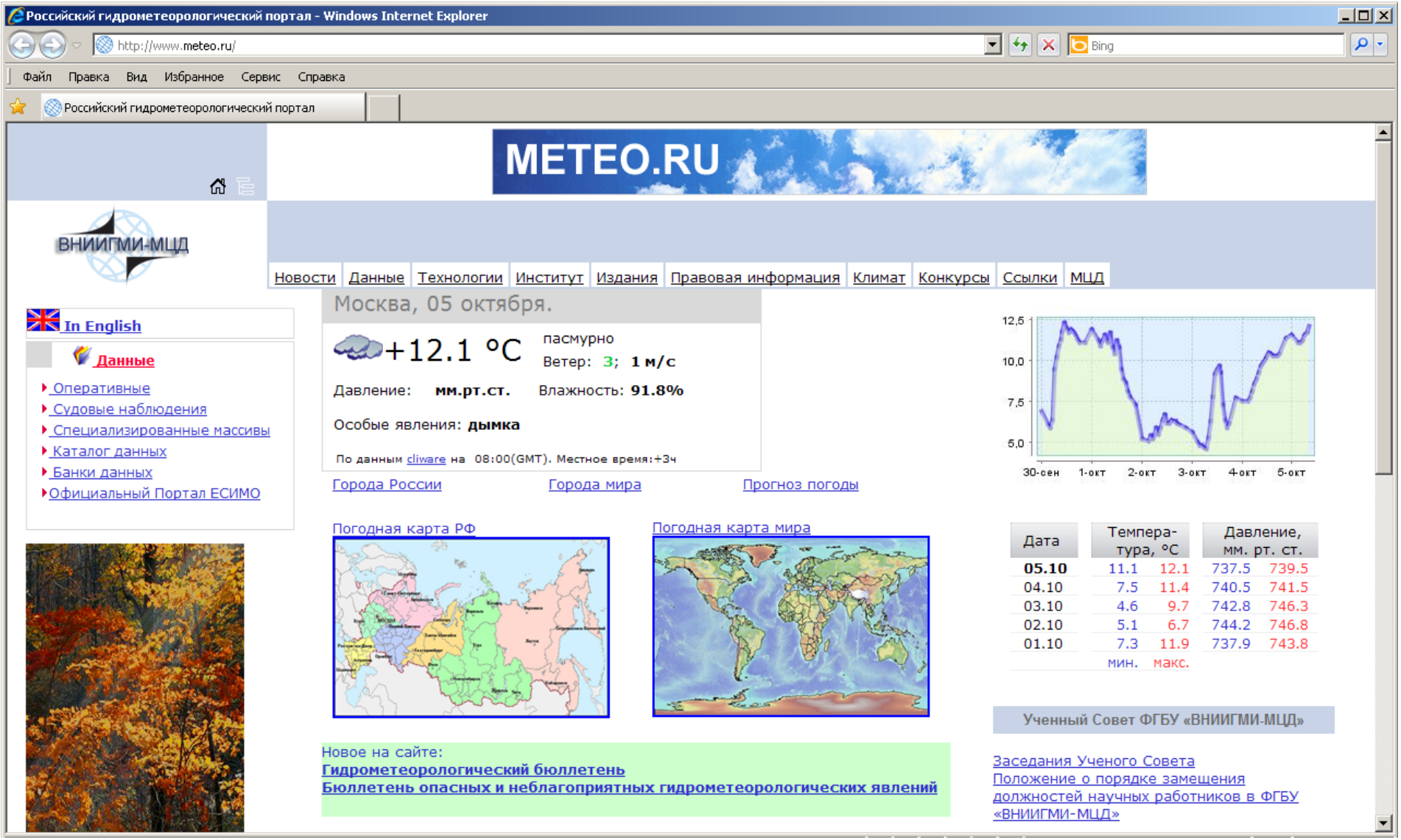
Introduction

Peculiarities of environmental sciences:

- Wide range of spatiotemporal scales of the processes and phenomena studied;
- Intense acquisition of time series of georeferenced geophysical data;
- Strict requirements to spatiotemporal distribution and accuracy of observational data;
- Permanent increase of number of measured values and parameters;
- Application of mathematical methods for data processing and modeling;
- Necessity to develop distributed information systems in order to access to environmental information.

Information-computational technologies

Russian hydrometeorological portal



Information-computational technologies

NCEP Climate Forecast System Reanalysis

Information-computational technologies

RIMS Rapid Integrated Mapping System
Hydrology, meteorology: data, models, analysis

http://rims.unh.edu/

http://earthatlas.sr.unh.edu/maps
http://neespi.sr.unh.edu/maps
http://nh-rims.sr.unh.edu/maps
http://www.riverthreat.net/maps
http://riceghg.sr.unh.edu/maps

Information-computational technologies

SIRS – Information-computational structure for Siberian Integrated Regional Studies

Web portals for complex analysis of datasets of georeferenced geophysical data aimed at monitoring and forecasting climatic and ecosystem changes (meteorological observations, models, reanalyses, remote sensing data) that provide an interactive access to the data, models and tools :

- **ATMOS** (http://atmos.iao.ru/ and http://atmos.scert.ru/)
- **RISKS** (http://climate.risks.scert.ru/)
- **ENVIROMIS CLIMATE** (http://enviromis.scert.ru/en/)

Information-measuring technologies – application fields:

- Available networks for specialized monitoring (hydrometeorological, aerosol-radiation, greenhouse gases, etc.) are necessary but not enough for complex monitoring of environmental processes.

- Delayed response (phase shifts) of regional systems on global impact factors points to necessity of development of general terms for regional and global monitoring.

- Taking into account mesoscale inhomogeneity of observed climatic changes in Siberia, complex monitoring network should be geographically distributed and consider scales of characteristic Siberian ecosystems (forests, bogs, steep, mountain, Arctic zone, etc.).

Information-measuring systems for atmosphere monitoring.

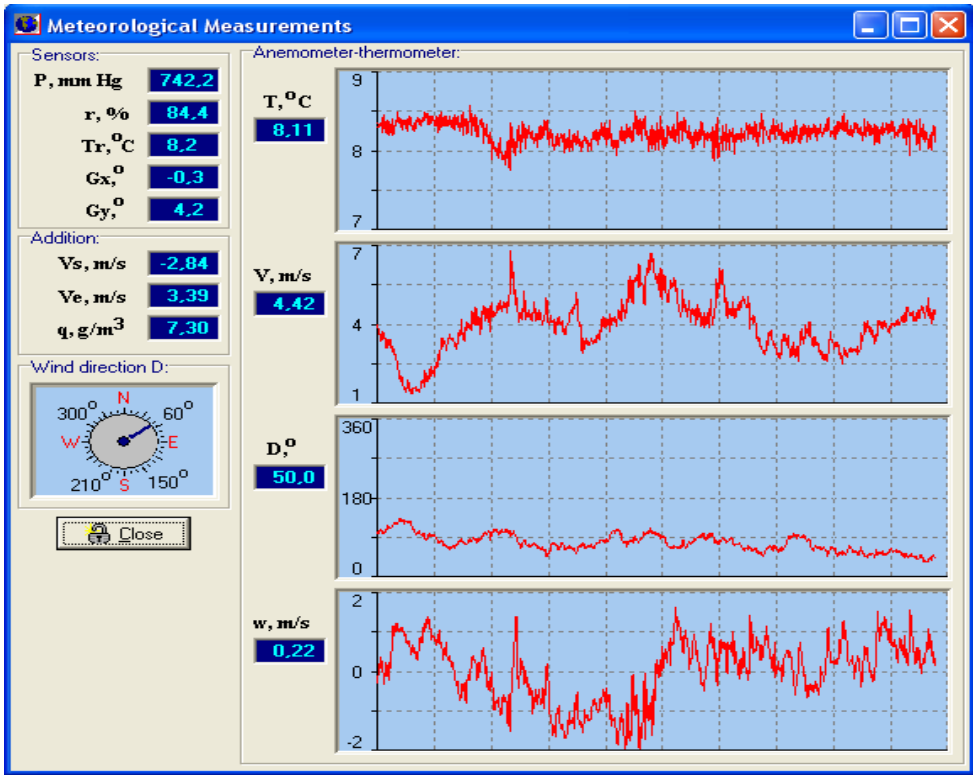
Devices designed at IMCES SB RAS

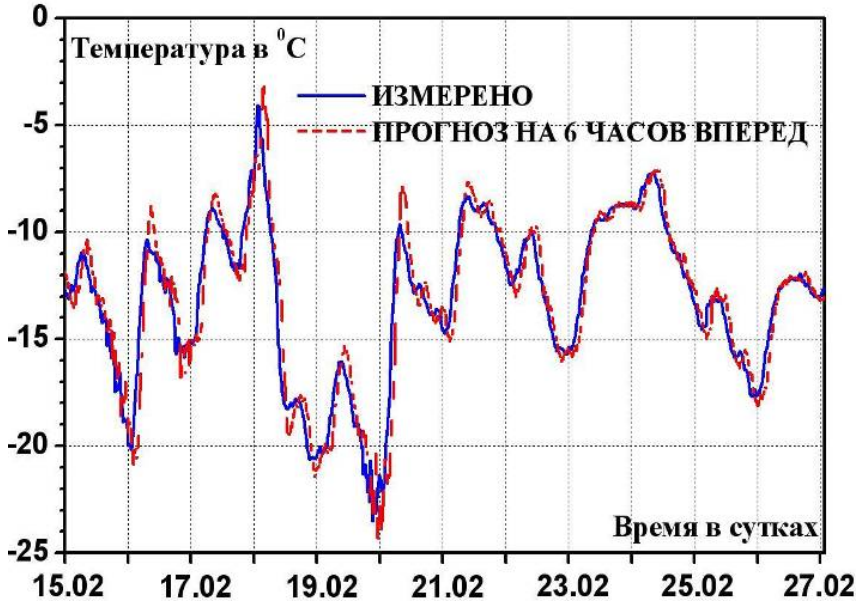
AMK-03 Automated meteorological complex

1B65 Mobile automated meteorological set

Measurable parameter	Measurement range	Accuracy
Horizontal wind velocity	0.1 ÷ 30 m/s	< 0.37 m/s
Vertical wind velocity	-15 to +15 m/s	< 0.37m/s
Horizontal wind direction	0 ÷ 360°	± 2°
Air temperature	-50 to +55 °C	< 0.37 °C
Relative air humidity	15 ÷ 100 %	± 2.5% at $T > 0$ °C; ± 5% at $T \leq 0$ °C
Atmospheric pressure	520 ÷ 800 mm Hg	1 mm Hg

Information-measuring technologies for *in-situ* atmosphere monitoring



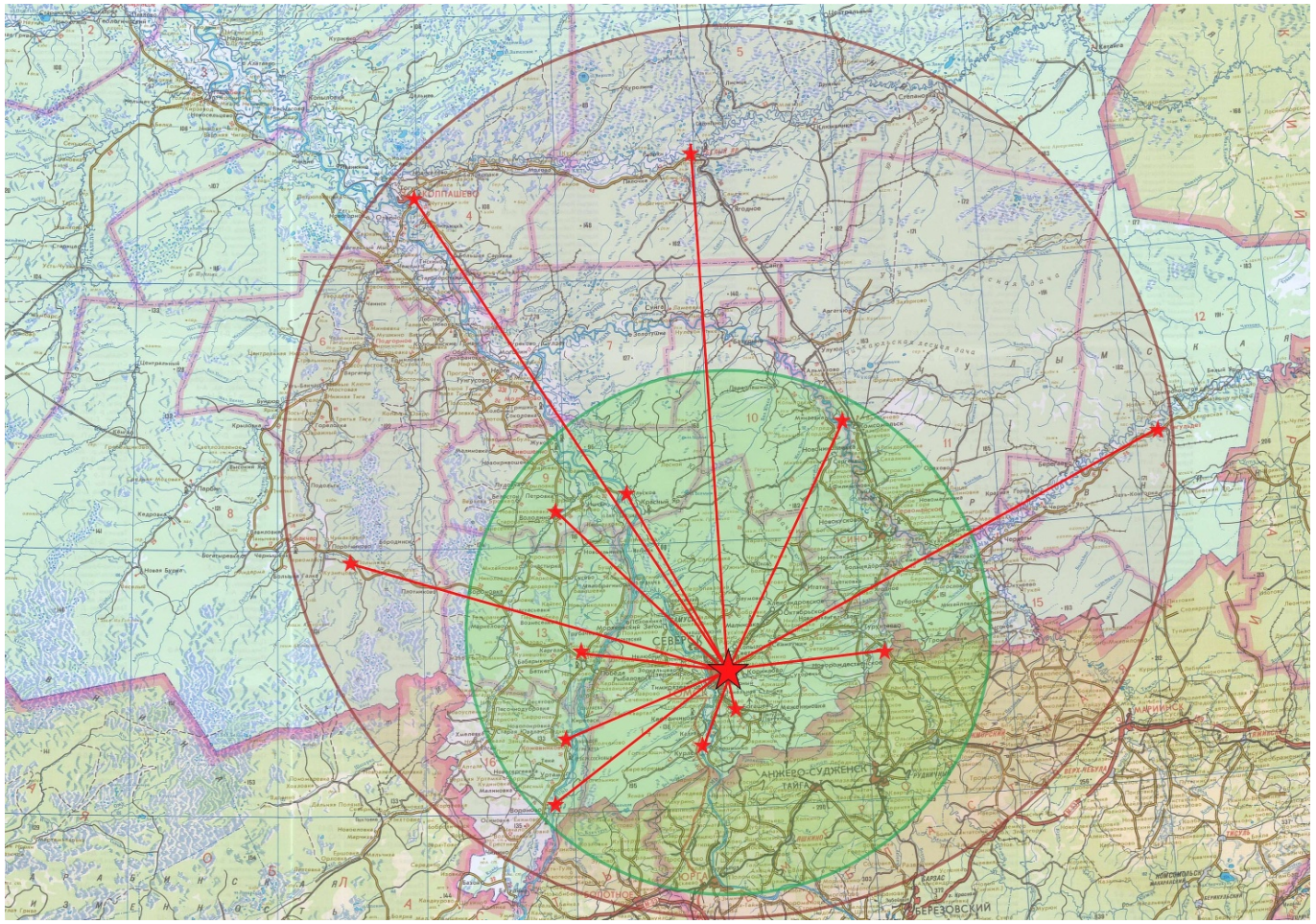


AMK-03:

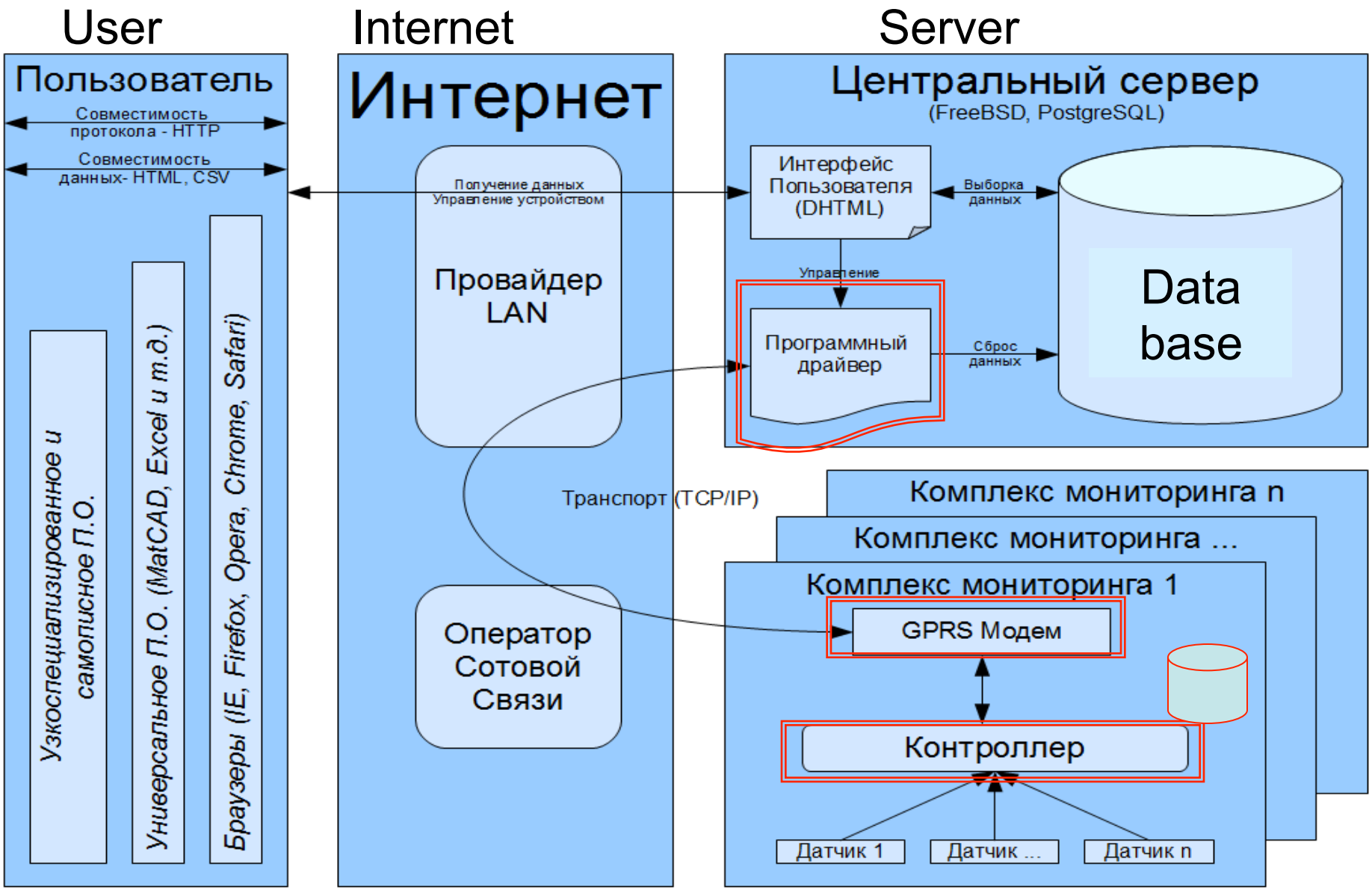
- measurement of 6 instant values of meteorological quantities;
- computation and storage of more than 60 characteristics of atmosphere state.

Comparison of measured air temperature values with a 6-hour forecast, which is based on application of Kalman filtering algorithm to mathematical model calculating meteorological quantities' evolution with time.

STORM RING – a regional information-measuring system for monitoring of dangerous meteorological events – joint project of IMCES SB RAS and SibrHRI (Novosibirsk)



Information-measuring system structure

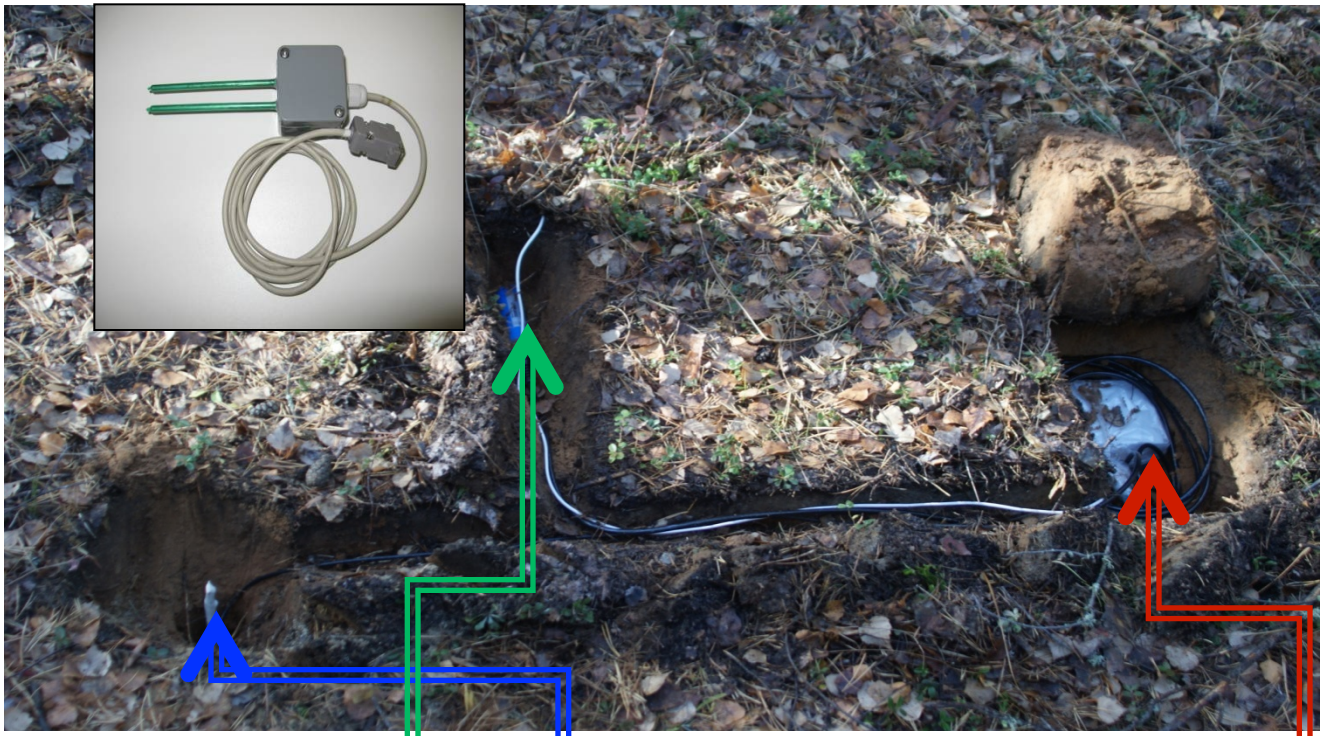


New information-measuring technologies – software-controlled self-maintained monitoring stations:

Requirements to equipment:

- Low power consumption, providing autonomous operation during long time period (more than one year);
- Interfaces for sensors' connection;
- Provision of sufficient measurement accuracy and service life in various exploitation conditions;
- Mobile or satellite interface for immediate data transfer, control, change of operation protocol, alarm;
- Low cost and simple maintenance.

IMCES SB RAS developed a basic system of networked software-controlled meters of environmental parameters, as well as technology for monitoring database formation realizing remote Web-access.



Installation of soil temperature probe, IMCO TRIME-PICO32 soil moisture detector and AIPT2 controller.

Information-measuring monitoring system on Great Vasyugan Bog

Self-maintained monitoring stations

Great Vasyugan Bog, Tomsk oblast

TUNKA station, Buryatiya

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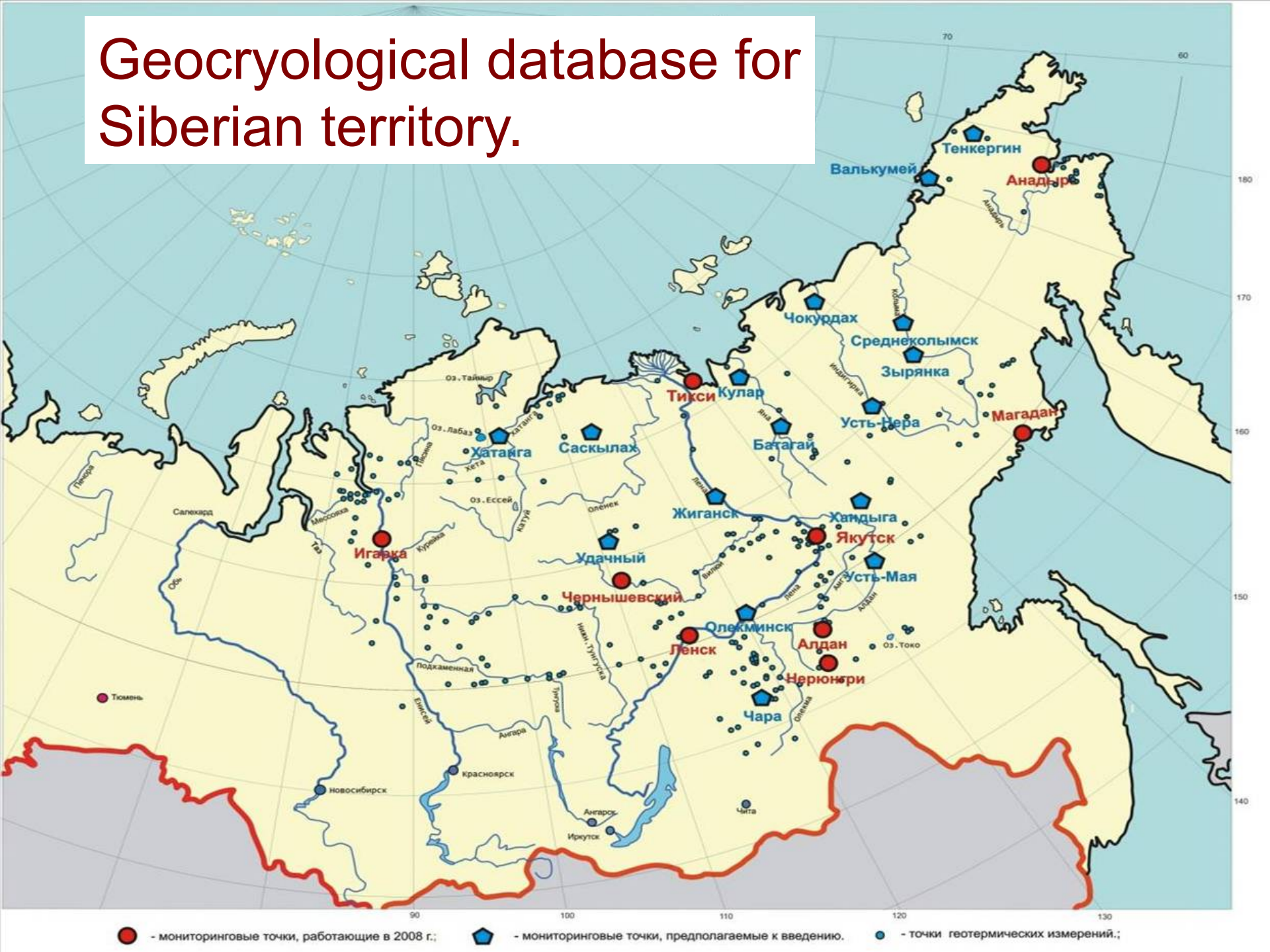
Self-maintained monitoring station

Parameter	Measurement range, accuracy
Atmospheric pressure	500 … 810 mm Hg, ±1.5 %
Air temperature and humidity	-55 … +50°C, ±0.1 °C; 0 … 100%, ±3.5 %.
Horizontal wind velocity and direction	0.9 … 78 m/s, ±5 %; 0 … 360°, ±7 %
Soil temperature profile	-55 … +50°C, ±0.1 °C
Soil moisture	0 … 100%, 0 ... 40%: ±1 %; 40 ... 70%: ±2 %; Temperature range: -15…+50°C
Water table	0 … 10.5 m, ±1%
Liquid precipitation amount	± 0.2 mm
Water conductivity	10^{-8} … 0.2 Cm/m, ±5 %
Snow depth (m)	0 … 1.2 m, ±0.05 m
Solar radiation	range 0.2 … 10 μm, ±5 %, 10 – 2000 W/m^2

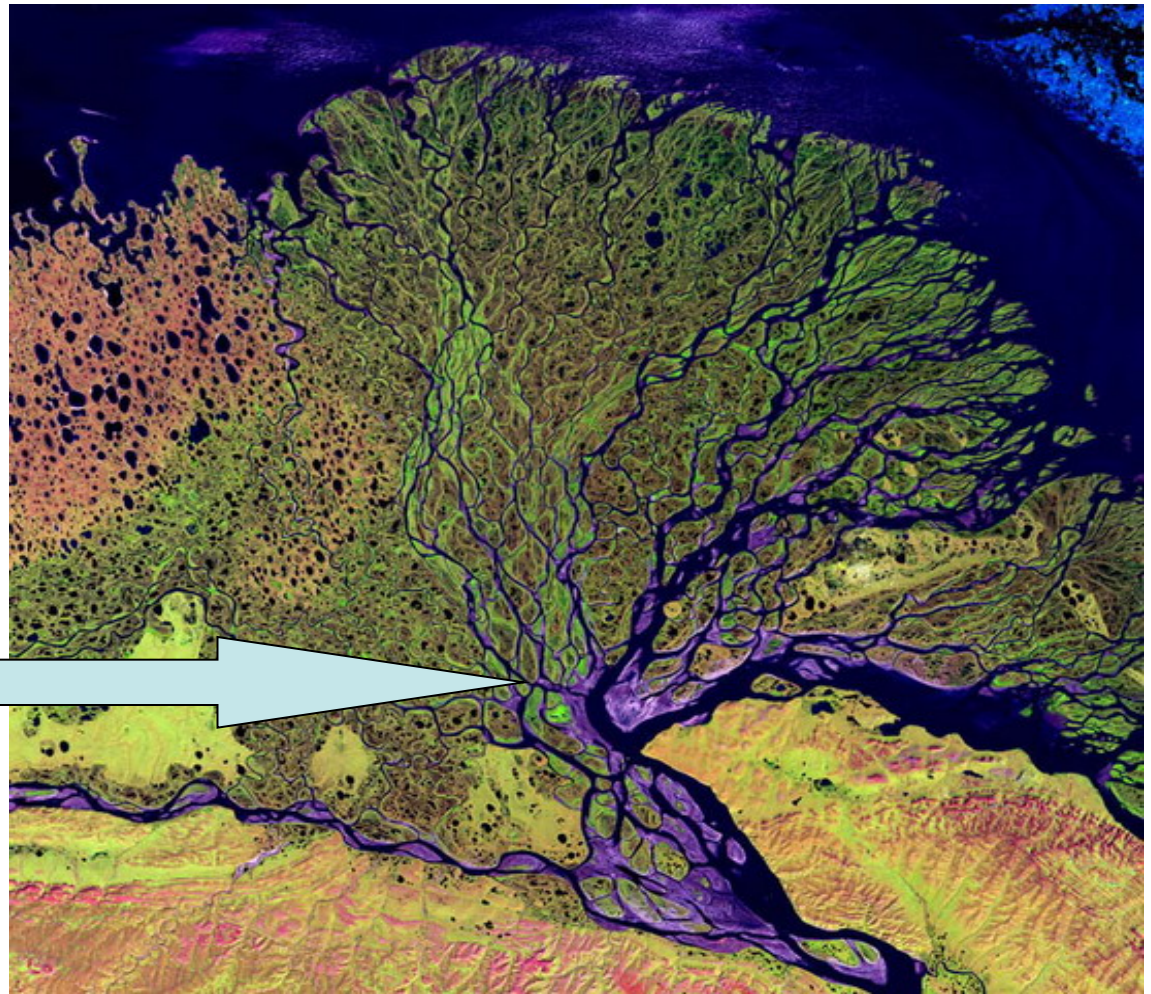
Main application fields for self-maintained measuring systems in Arctic :

- Creation of a distributed monitoring network with sufficient covering to form climatic and geocryological database for Siberia
- Validation of numerical mesoscale climatic models
- Investigation of sea temperature fields
- Investigation of underwater permafrost in Arctic

Geocryological database for Siberian territory.



Program on Comprehensive investigations of the state and evolution of Siberian Arctic environment is under formation based on International Research Station “Samoilovsky Island”



Samoilovsky island

Lena river mouth

International Research Station «Samoilovsky Island»

August 2010

April, 2012

Physical grounds and technologies of very low-frequency (VLF) monitoring

Very **L**ow **F**requency range:
f = 3 ÷ 30 kHz, λ = 10 ÷ 100 km

Sources of pulsed VLF fields:

- Solar-terrestrial interactions;
- Atmospheric processes;
- Lithosphere processes;
- Strains in materials and constructions, surfaces, solid dielectrics

Nairal **P**ulsed **E**lecto**M**agnetic **F**ield of the **E**arth (NPEMFE)

Physical grounds and technologies of very low-frequency (VLF) monitoring

Very **L**ow **F**requency range:
f = 3 ÷ 30 kHz, λ = 10 ÷ 100 km

Peculiarities in VLF NPEMFE propagation :

- can penetrate deeply into the Earth crust and sea water;
- due to diffraction propagate for a long distances in the atmosphere;
- strong attenuation of electromagnetic field components when penetrating in the earth crust.

Physical grounds and technologies of very low-frequency (VLF) monitoring

Very **L**ow **F**requency range:
f = 3 ÷ 30 kHz, λ = 10 ÷ 100 km

Electromagnetic field structure *(E and H components)* is studied for spatial objects of various scales *L* (relative to wavelength *λ* of the fields recorded):

- ***L / λ << 1*** **: microscale** (concrete constructions, bridges, tunnels, roads, etc.);

- ***L / λ ~ 1*** **: mesoscale** (local lithosphere structures and inhomogeneities, landslides, mines, open-pits, etc.);

- ***L / λ >> 1*** **: macroscale** (seismic monitoring, investigation of internal Earth structure).

Monitoring of lithosphere structure and anomalous processes - mesoscale

$L / \lambda \sim 1$: mesoscale

Information from:

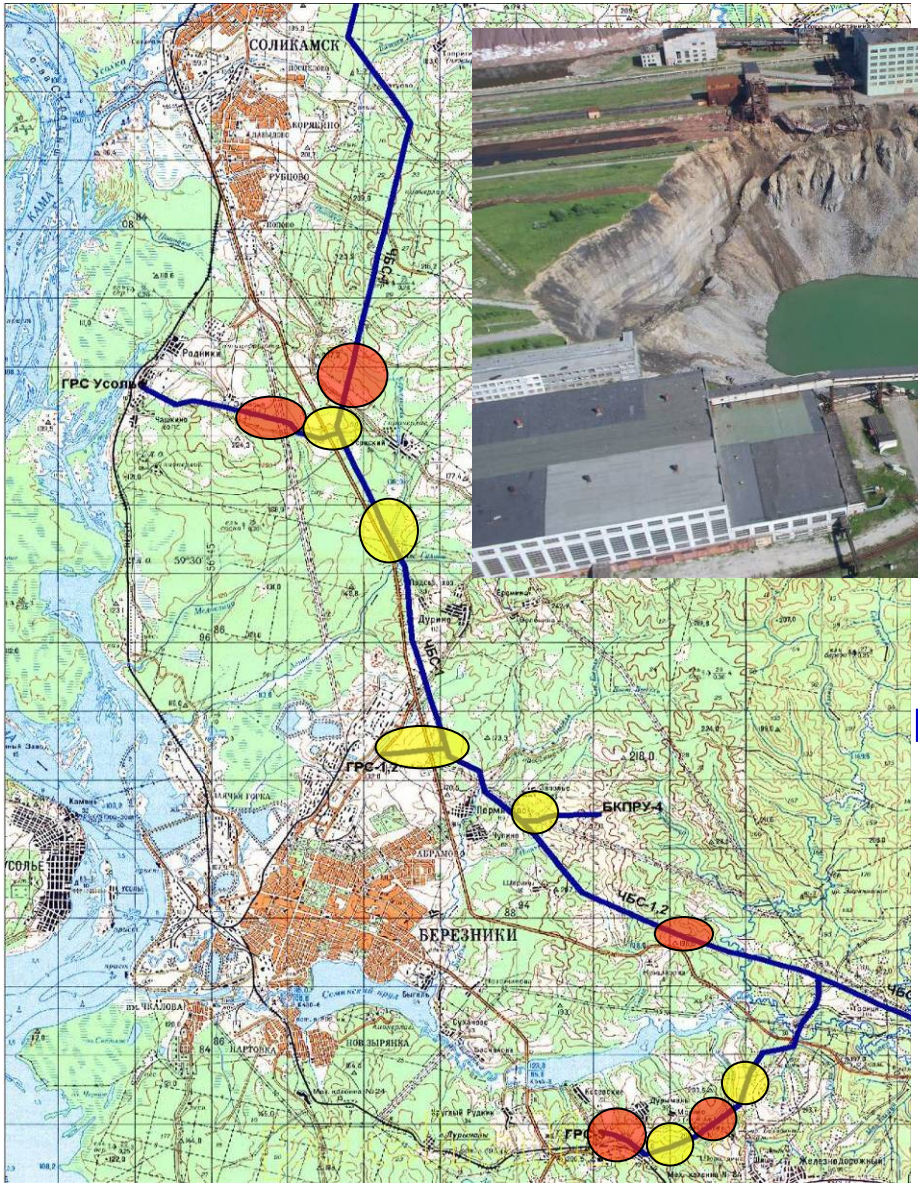
- emission of pulsed VLF radiation from lithosphere structures and inhomogeneities present in detection zone;
- alteration of a signal coming from remote sources by lithosphere structures and inhomogeneities.

Sources of noise:

- components of natural pulsed electromagnetic field of the Earth from other sources.

Alignment of a system of VLF recorders in field

Technologies for VLF monitoring of lithosphere structures and anomalous processes

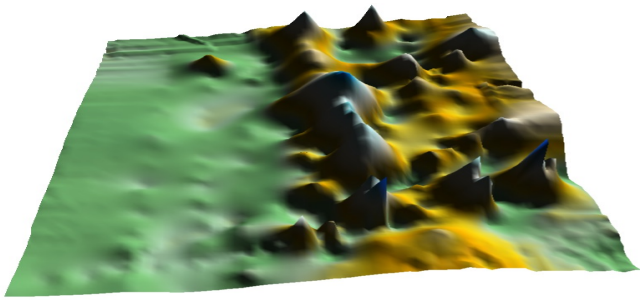


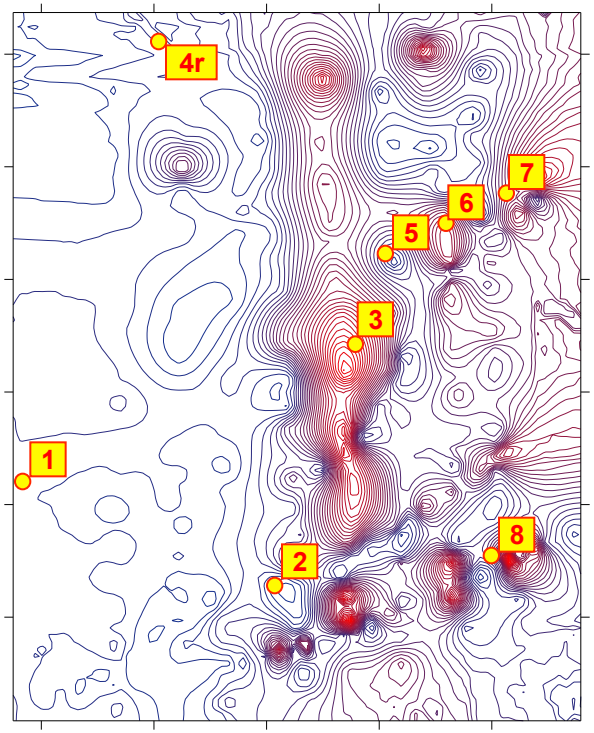
MGR-01 Programmable multichannel geophysical recorder

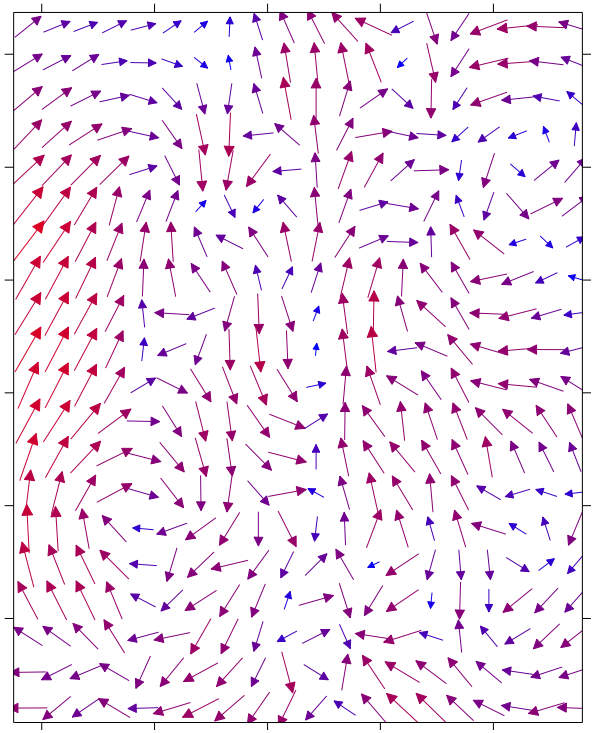
Geodynamic mapping at ChBS-1, 2 pipeline

Information-measuring technologies for environmental monitoring

Electromagnetic method is applied to outline geophysical structures and to monitor geodynamic processes from radio noise in VLF range. It makes a basis for information-measuring technology for landslide risks assessment.

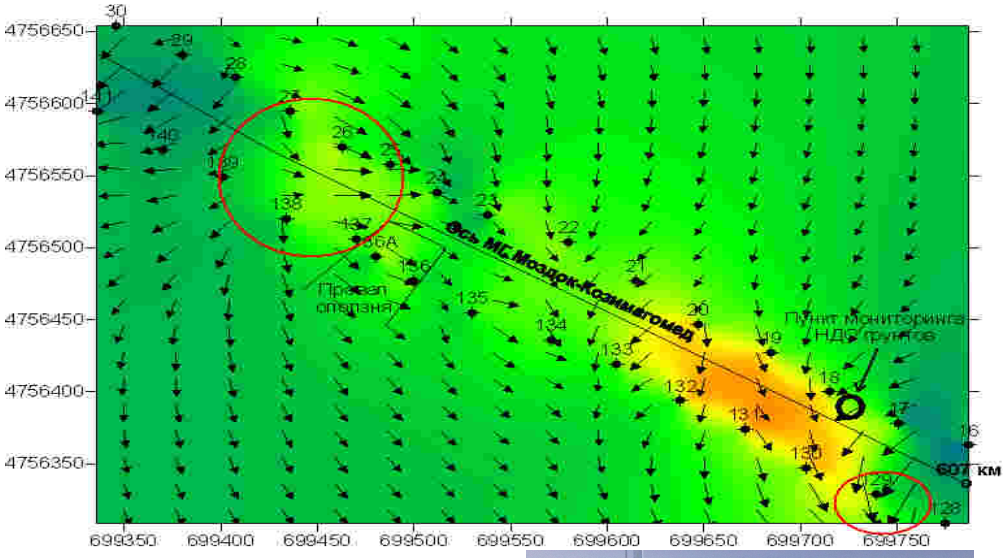






Assessment of landslide activity at Kama river near Siberia- West Europe pipeline (yellow dots are MGR-01 instruments)

Technologies for VLF monitoring of lithosphere structures and anomalous processes



A system is created for monitoring and forecast of geodynamic processes at pipelines:

- Urengoi-Pomary-Uzhgorod
- Mozdok-Kazimagomed
- Dzuarikau -Tskhinval

Since 2010 the system transfers data onto IMCES SB RAS server

Conclusion

Measuring, Information and computational technologies are both instruments and infrastructure for researches


Thanks for your attention!