China, Beijing, 20 September 2019

MAGNETETIC OBSERVATIONS PERSPECTIVES IN THE NORTHERN EURASIAN REGION

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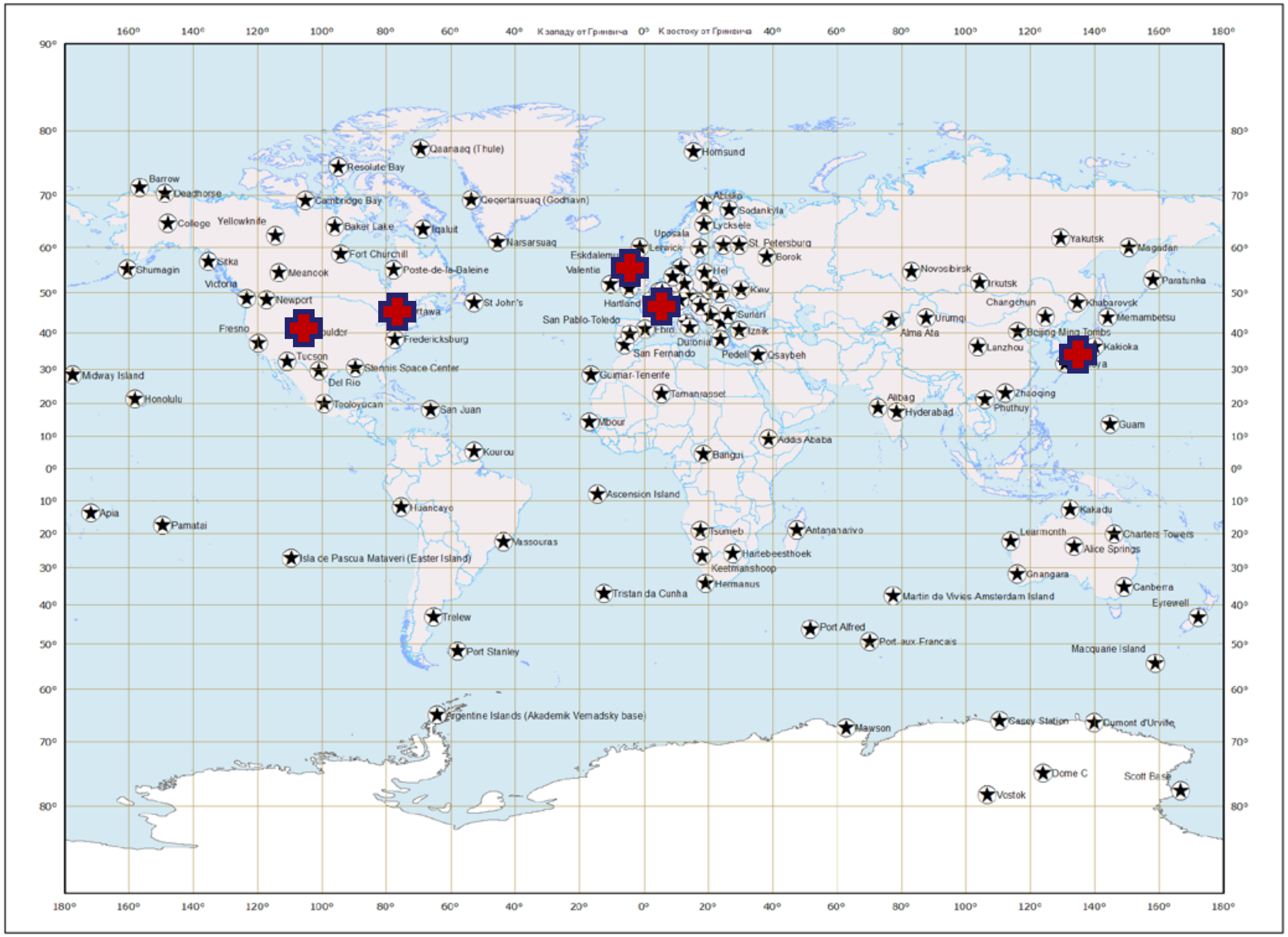
INTERMAGNET – International Real-time Magnetic Observatory Network



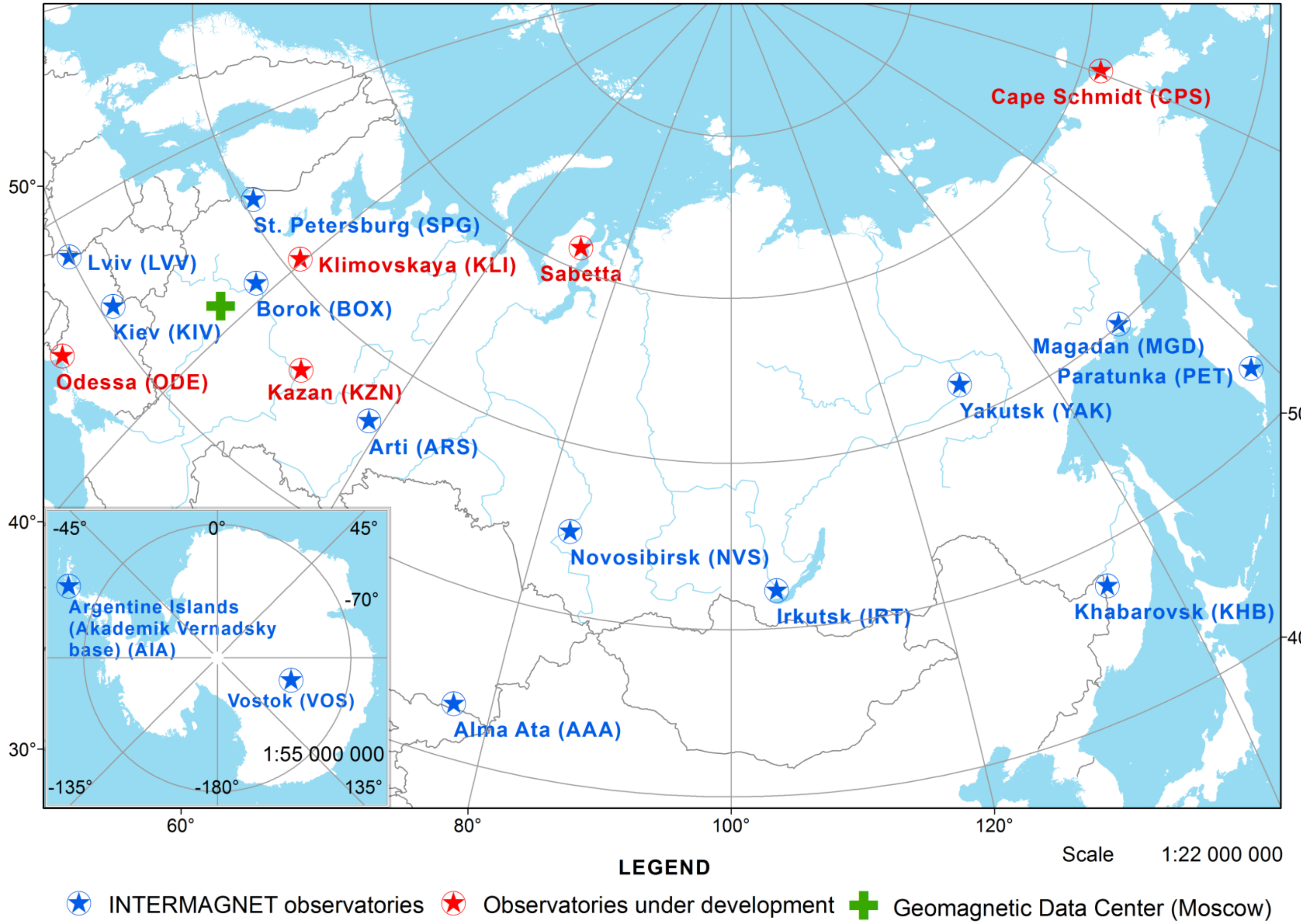
133 observatories (June 2017)

Масштаб 1: 120 000 000
Проекция: Миллера цилиндрическая

INTERMAGNET Geomagnetic Information Nodes (GINs):

- Ottawa (Canada)
- Golden (CO, USA)
- Edinburgh (UK)
- Paris (France)
- Kyoto (Japan)

Magnetic observatories in Russia and neighbouring countries



Saint-Petersburg (SPG)

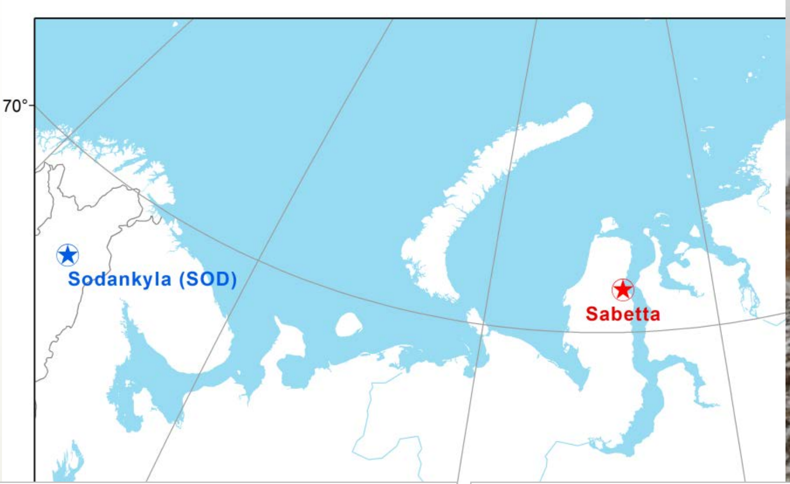
This is to
Certify
that
Saint Petersburg (SPG)
Has complied with the standards set by the
INTERMAGNET Executive Council
and is recognised as a
Full Participating Member
of
INTERMAGNET

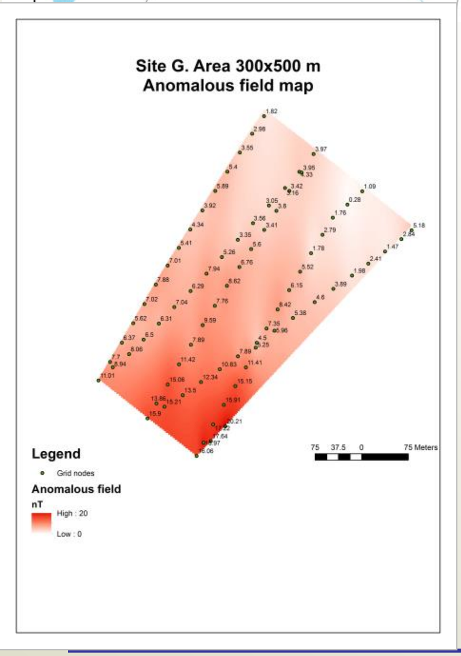
Signed
Chairman
INTERMAGNET Executive Council
Dated 9th June 2016

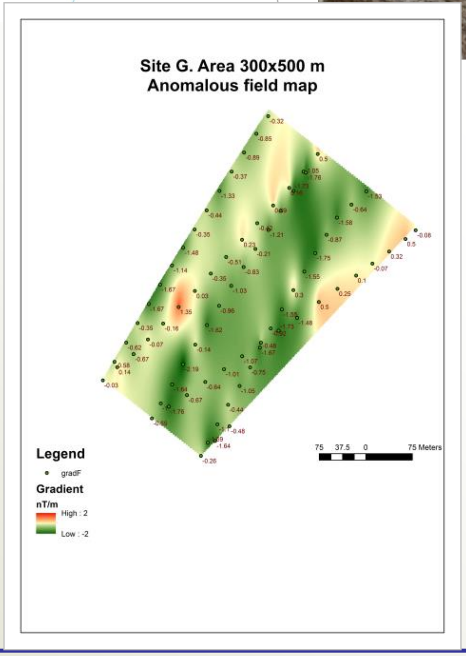
- Renovation and equipment upgrade, *2012–2013*
- Initiation of regular absolute measurements, *2013*
- INTERMAGNET approval, *2016*
- DOI assignment to data
- Production of definitive data

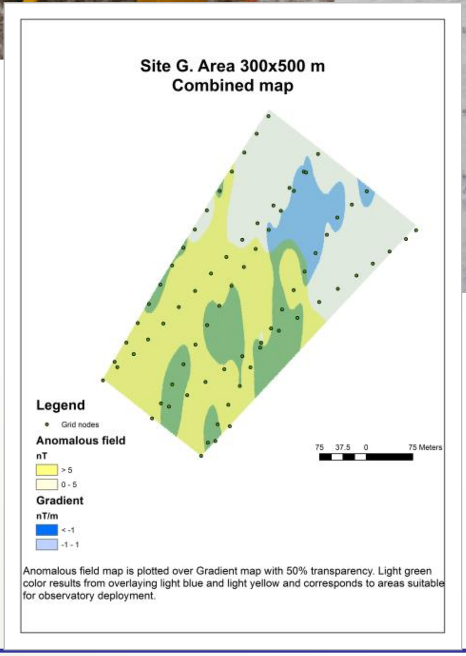
Sidorov et al. (2017) *Saint Petersburg magnetic observatory: from Voeikovo subdivision to INTERMAGNET certification. Geosci. Instrum. Method. Data Syst. Discuss. (in review).* ***doi: 10.5194/gi-2017-35***

Deployment of magnetic observatory in Sabetta

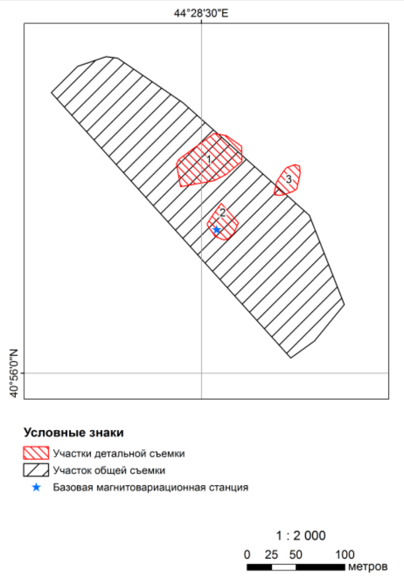


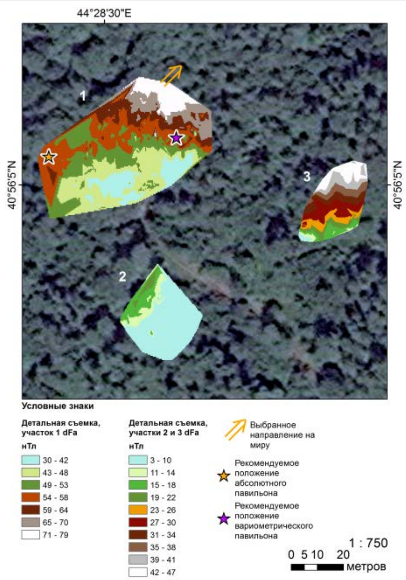


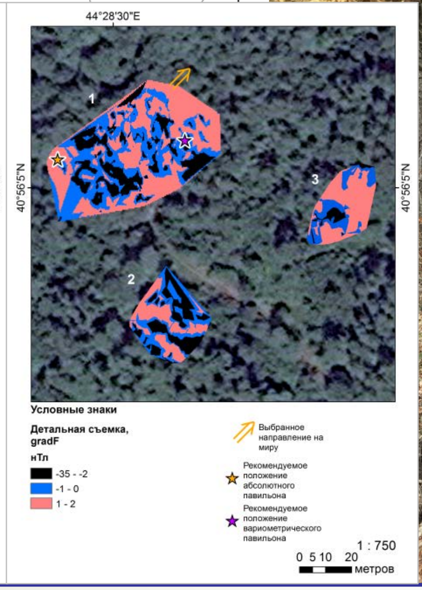




Deployment of magnetic observatory in Armenia







Satellite magnetic observations

- 3 identical satellites
- Low polar orbit ~ 500 km
- Estimated period of operation ~ 4 years
- 50 Hz and 1 Hz sampling

Launched on 22 November 2013 from the ***Plesetsk*** *spaceport with the* ***Rokot*** *carrier rocket*

Aims:

Internal field:

- Geodynamo, outer core and mantle coupling
- Magnetic pole drift
- Crustal magnetism
- Electric 3D mantle conductivity
- Oceanic streams

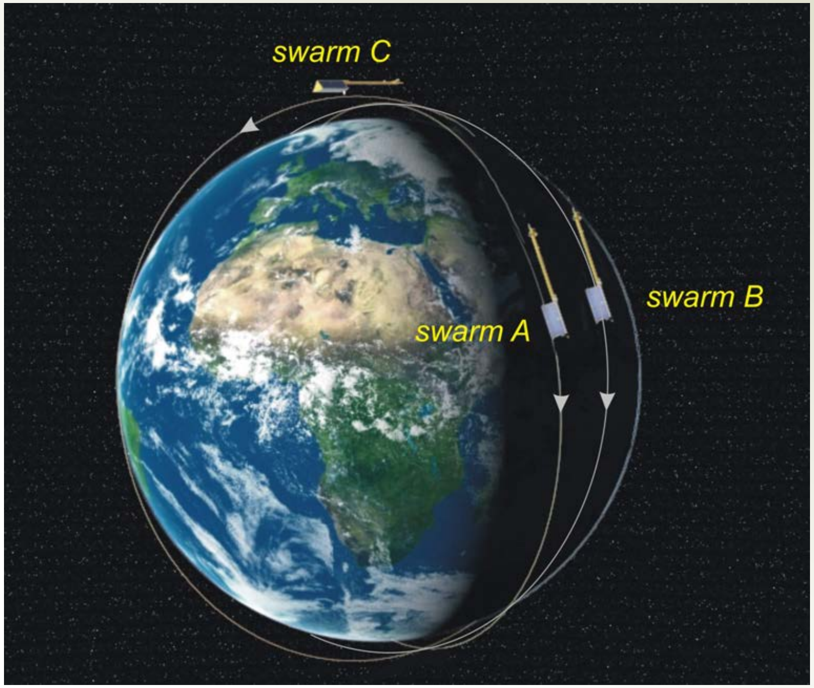
External field:

- Magnetospheric and ionospheric electric currents
- Upper atmosphere dynamics
- ….

Data management problems:

- Flat binary format
- Daily files
- No access interface

Swarm constellation



Challenges in geomagnetic data handling

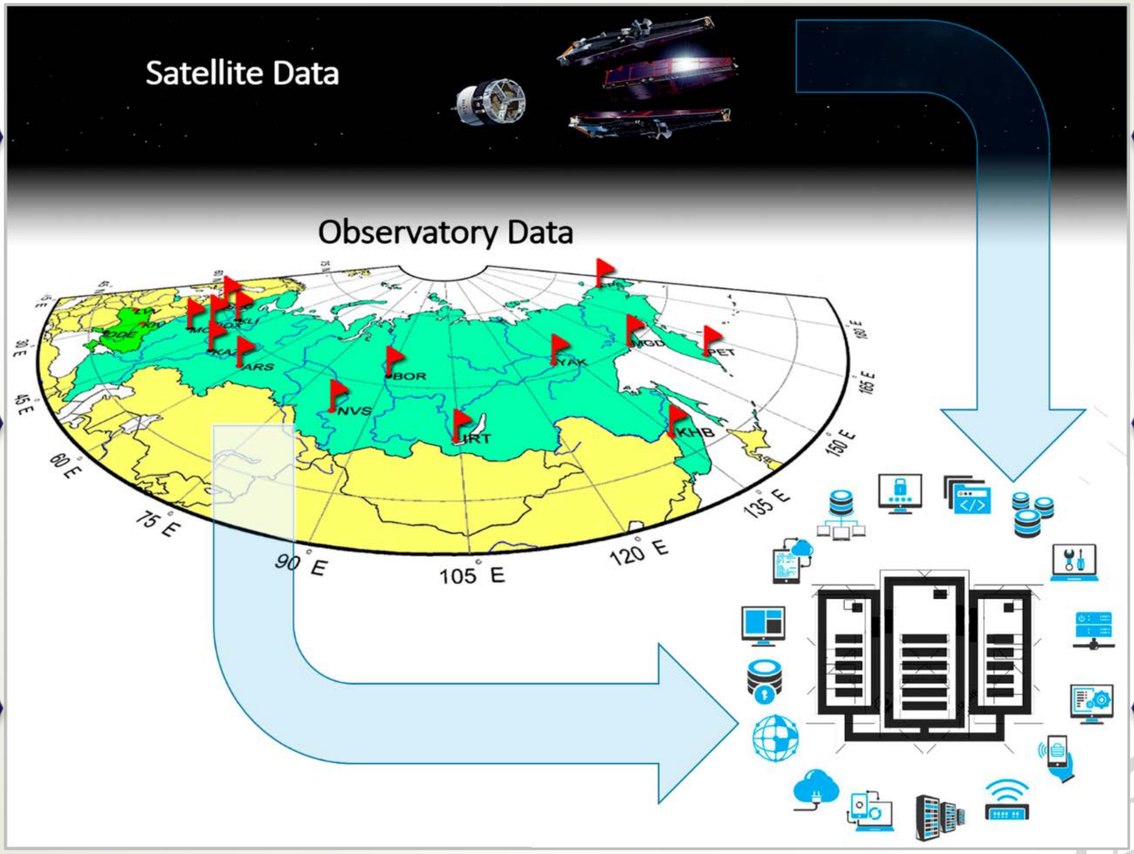
- Integration of diverse data into a unified analytical system
- Development of adequate data mining methods for big data analysis

Data integration and analysis. MAGNUS

Unified storage of observatory and satellite data

On-the-fly analysis of data streams

Recognition of magnetic anomalies in real-time



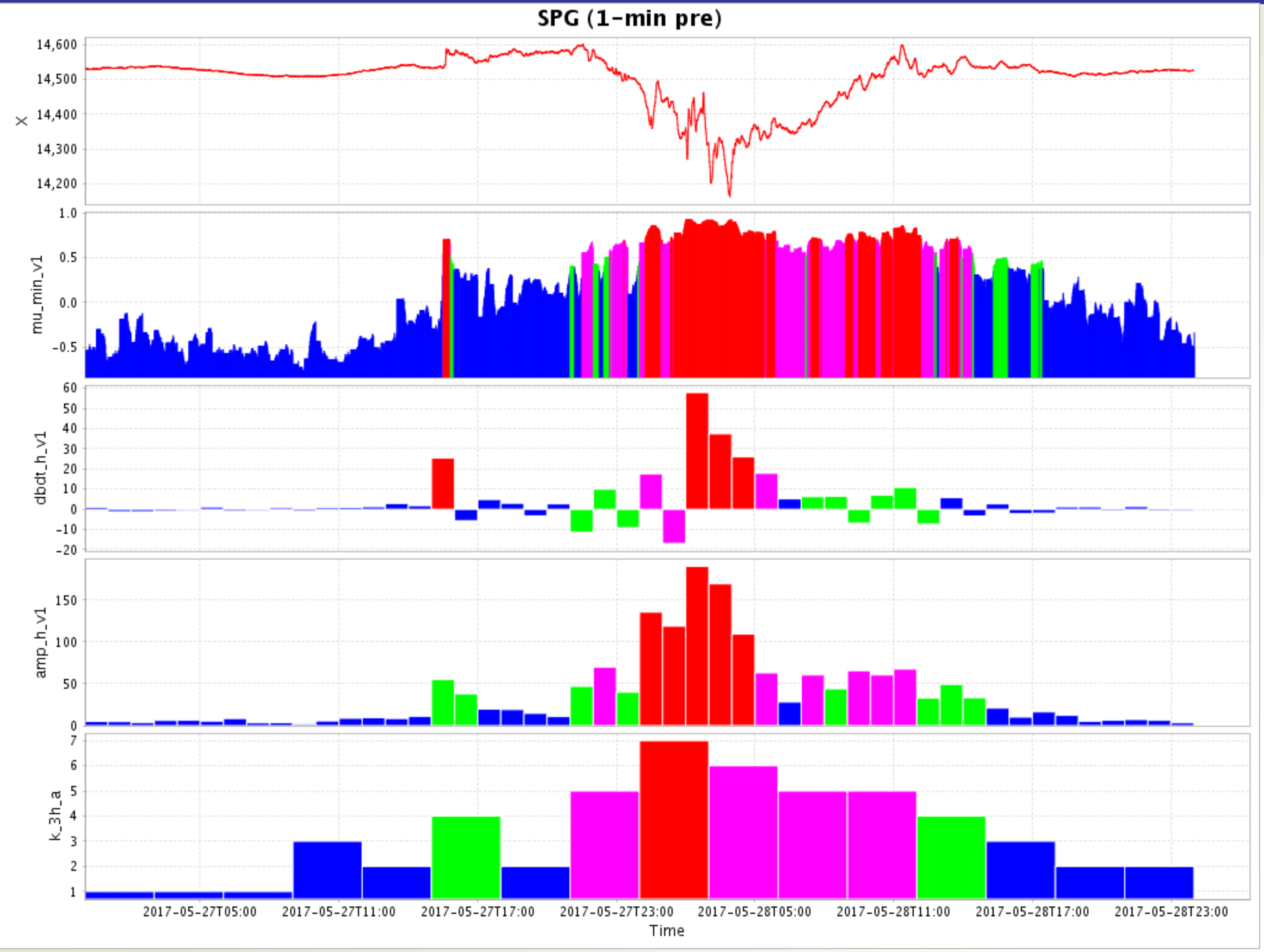
Analytical Data Center

Online model calculations

Online interactive data access

Data Visualization

MAGNUS. Assessment of geomagnetic activity (SPG)

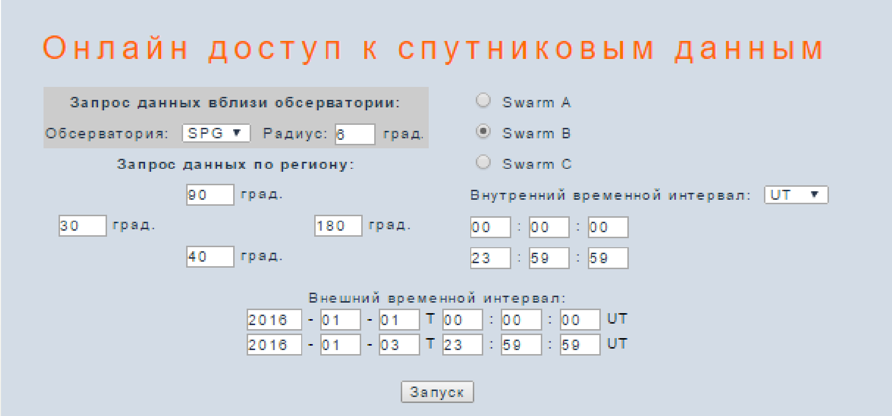


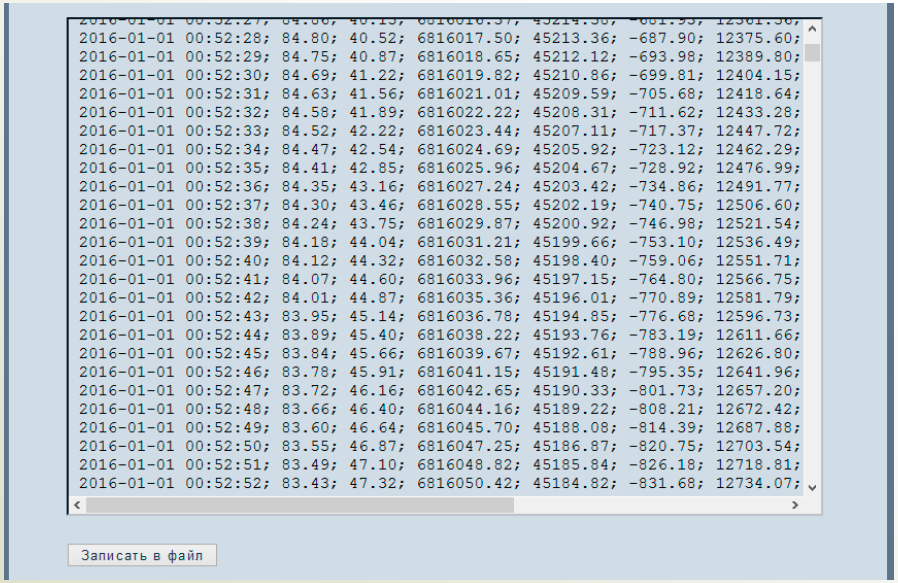
Agayan et al. (2016) The Study of Time Series Using the DMA Methods and Geophysical Applications. Data Science Journal. 15(16). **doi: 10.5334/dsj-2016-016**

red – strong anomaly, **purple** – anomaly, **green** – weak anomaly, **blue** – background

MAGNUS. Online access to satellite data (digital and plots)

Satellite data in digital form





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2016-01-01	00:52:29;	84.75;	40.87;	6816018.65;	45212.12;	-693.98;	12389.80;
2016-01-01	00:52:30;	84.69;	41.22;	6816019.82;	45210.86;	-699.81;	12404.15;
2016-01-01	00:52:31;	84.63;	41.56;	6816021.01;	45209.59;	-705.68;	12418.64;
2016-01-01	00:52:32;	84.58;	41.89;	6816022.22;	45208.31;	-711.62;	12433.28;
2016-01-01	00:52:33;	84.52;	42.22;	6816023.44;	45207.11;	-717.37;	12447.72;
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2016-01-01	00:52:37;	84.30;	43.46;	6816028.55;	45202.19;	-740.75;	12506.60;
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2016-01-01	00:52:44;	83.89;	45.40;	6816038.22;	45193.76;	-783.19;	12611.66;
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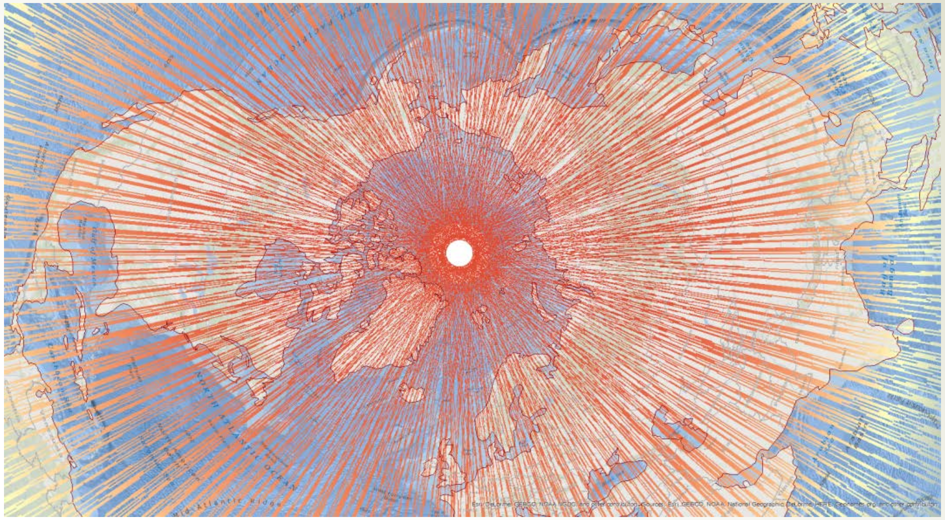
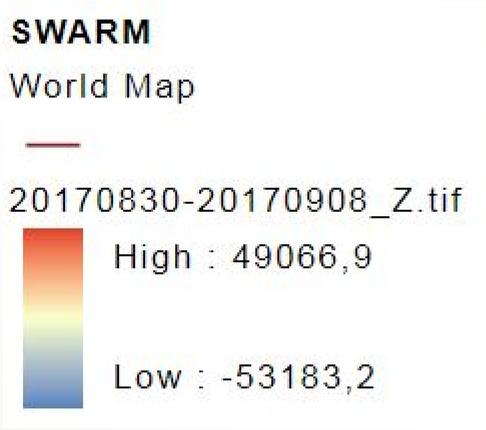
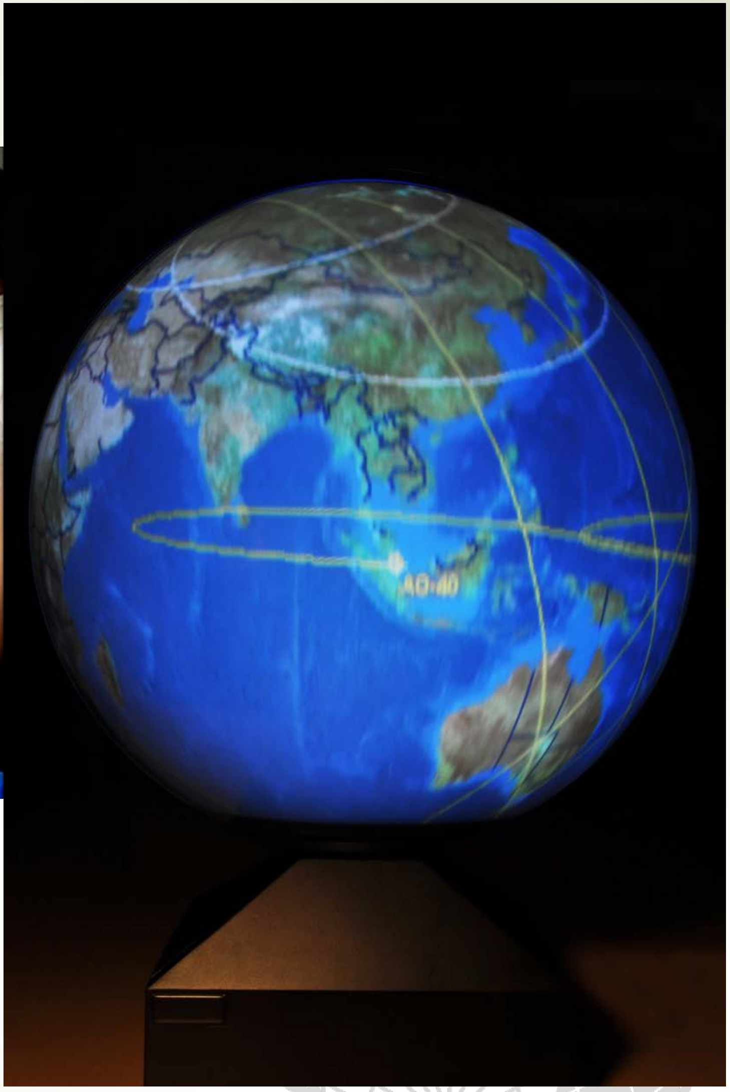
Записать в файл

Satellite data in GIS environment





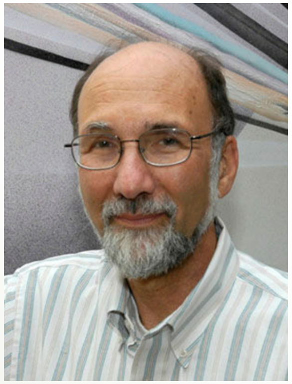
MAGNUS. Data visualization on a spherical display



MAGNUS and Big Data concept

MAGNUS is in agreement with the **Four V’s** concept associated with **Big Data**:

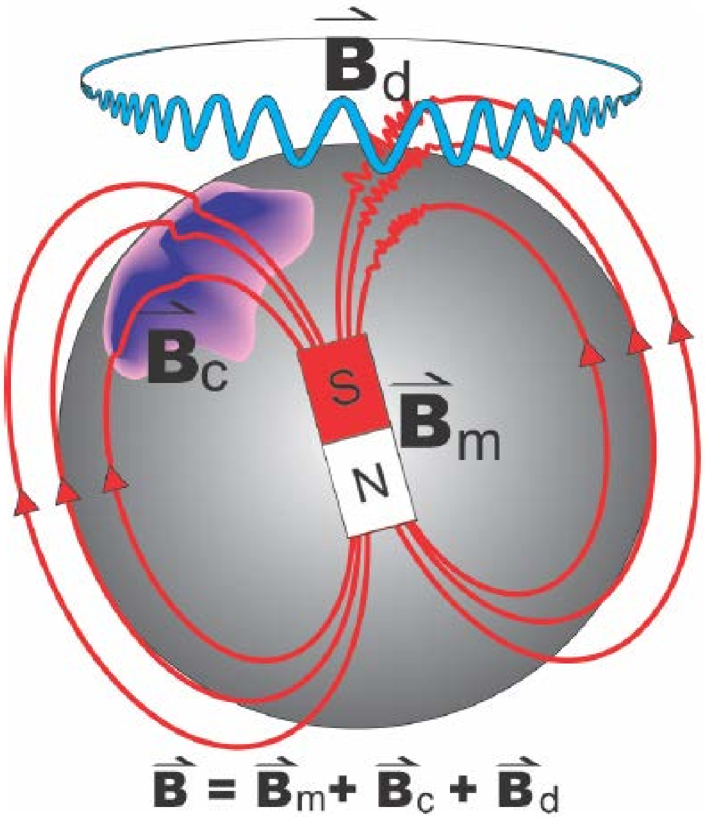
- **Volume** — integration of extensive geomagnetic data arrays
- **Variety** — coordinated processing of multi-observatory and satellite data
- **Velocity** — minimization of access delay to initial, verified and processed data
- **Veracity** — automated verification of initial magnetograms using advanced data mining methods



Prof. Fred S. Roberts

CCICADA, USA

The Earth's magnetic field



The Earth's magnetic field (MF) can be defined as a vector quantity B, expressed as a sum of the contributions from three main sources

$$B = B_m + B_c + B_d$$

Internal part of MF (almost constant)

The main field generated in the Earth's core B_m

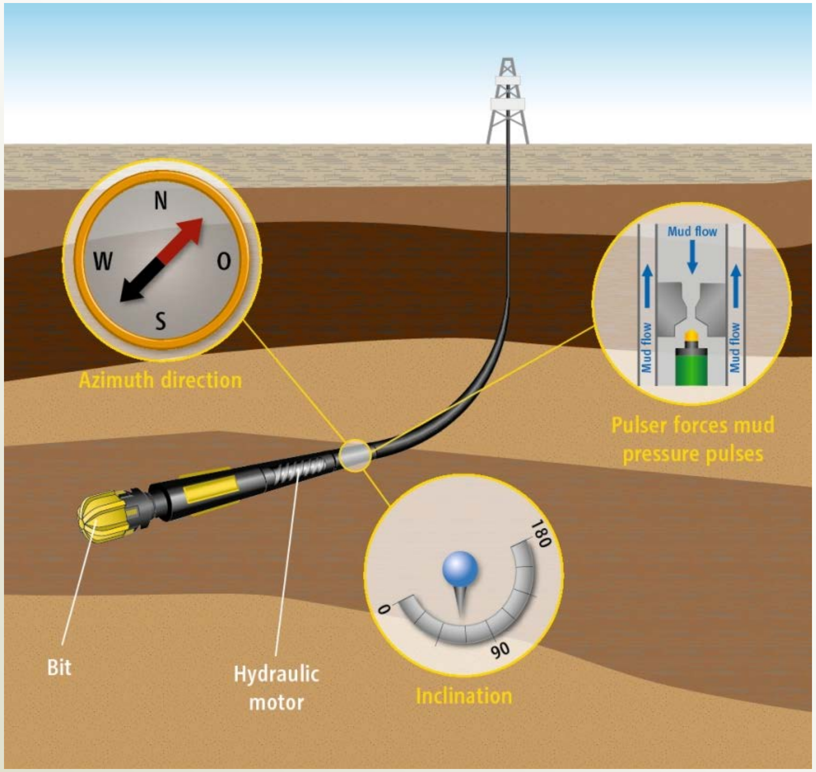
- **The crustal field from local rocks B_c**

External of MF (very variable)

- **The disturbance field from electrical currents flowing in the ionosphere and magnetosphere B_d**

Directional drilling

Oil and gas wells are commonly between 1500 m and 3000 m in vertical extent and can be as much as 10000 m in total length.



To make sure the well path is drilled according to the pre-defined plan, a navigation method called **directional surveying** is applied. It relies on the fundamental geophysical quantities of the **Earth's magnetic field** and the **Earth's gravity field** to define the orientation of the downhole surveying device.

Downhole survey instrumentation includes Magnetometer and Accelerometer

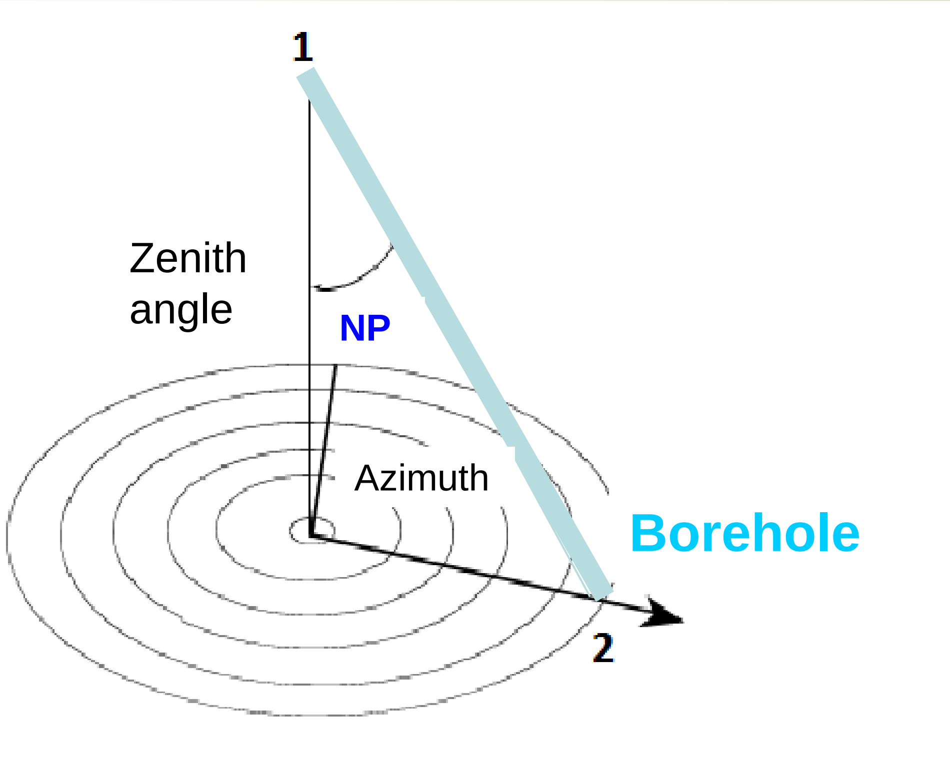
Orientation in magnetic wellbore directional surveying

The drilling angles are calculated from the following directional survey sensor outputs:

- Measured depth
- Zenith angle
- Azimuth

The magnetic declination
is used to correct the azimuth from magnetic North to true North.

In the Arctic the magnetic declination is unstable



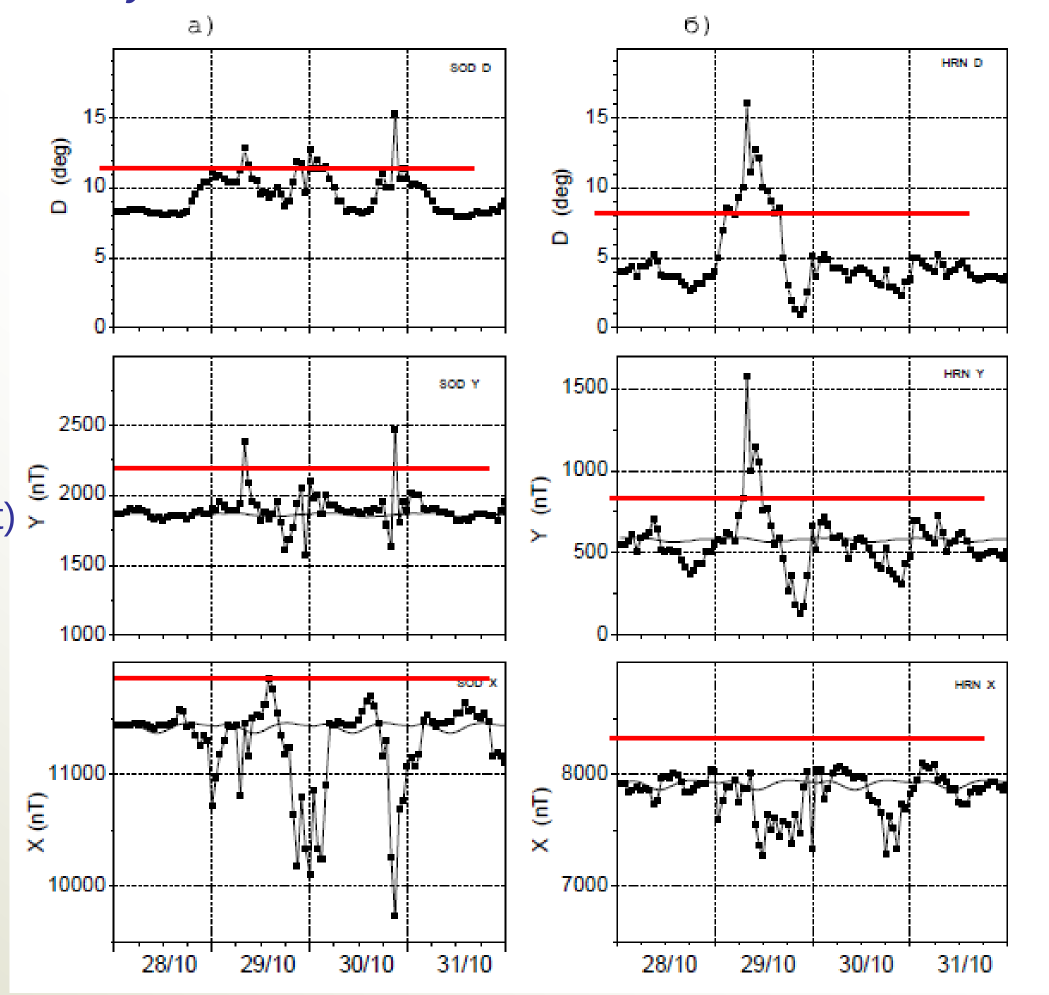
Variations in Declination and horizontal geomagnetic component during the magnetic storm on October 28-30, 2003 (as measured by magnetic observatories located in the European Arctic)

Sodankyla 67°N, 26°E　　*Horsund 77°N, 15°E*

Declination

Y-component (directed to the west)

X-component (directed to the north

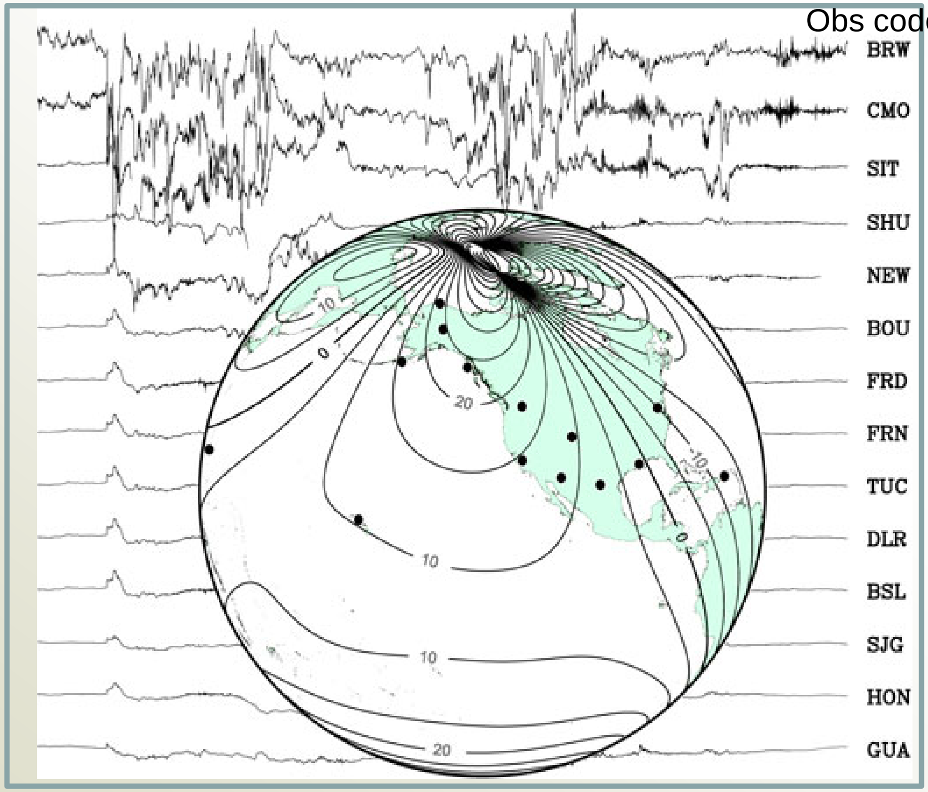


Red line – quiet level

Amplitude of the storm-time disturbances in Declination exceeds several degrees

Wellbore positioning challenges at high latitudes because of strong effect of magnetic storms

Map showing the storm-time magnetic records at different latitudes and contour lines giving horizontal magnetic intensity



The largest amplitude of sporadic disturbances in magnetic declination are observed in the Arctic

Uncertainty in the direction to the true North – Geological target might be missed

Detection of the sporadic magnetic disturbances using a stationary magnetic observatory is needed for the real-time correction of the downhole survey magnetometer data

Conclusions for magnetic support of directional drilling

- **Magnetic directional surveying in the Arctic, especially at distant offshore locations, introduces new challenges that need to be solved to be able to drill deviated wells in a safe and efficient manner. For that active development of the magnetic observations network is in Polar region is badly needed.**

- **An increased azimuth uncertainty caused by a smaller horizontal magnetic field component and larger fluctuations in the geomagnetic parameters are significant and could limit the development of oil and gas fields.**

- **How to manage the drilling operations while a magnetic storm is ongoing may be more critical issue than the increase in the wellbore positional uncertainty itself.**