

Anatoly Soloviev

Degrees:

- D.Sc. in physics and mathematics (Schmidt Institute of Physics of the Earth of the Russian Academy of Sciences, 2014);
- Ph.D. in physics and mathematics (Schmidt Institute of Physics of the Earth of the Russian Academy of Sciences, 2005).

Education:

- In 2002-2005, Post-graduate study at the Schmidt Institute of Physics of the Earth of the Russian Academy of Sciences;
- In 1996-2002, Higher education in Applied Mathematics at the Moscow State Institute of Steel and Alloys.

Academic titles:

- Corresponding member of the Russian Academy of Sciences (2016);
- Professor of the Russian Academy of Sciences (2015).

Positions in Russia:

- Since 2014, Deputy Director for Science of the Geophysical Center of the Russian Academy of Sciences;
- Since 2010, Head of Laboratory of geoinformatics and geomagnetic studies of the Geophysical Center of the Russian Academy of Sciences;
- In 2005-2010, Leading researcher of the Geophysical Center of the Russian Academy of Sciences;
- In 1999-2005, Researcher of the Schmidt Institute of Physics of the Earth of the Russian Academy of Sciences.

Scientific interests include:

- Mathematical methods of data mining in geophysical applications:
 - clustering in multi-dimensional data sets,
 - morphological analysis and recognition of anomalies in time series;
- Geoinformation systems for geoscience data storage and analysis;
- Geomagnetic field studies using methods of geoinformatics;
- Systems of geomagnetic field observations.

Main scientific results:

The algorithm "Crystal", designed to detect areas of increased density in multidimensional data sets, was developed. It can be considered a post-clustering algorithm, as classical algorithms of cluster analysis are focused on the clustering - the simultaneous

combination of high density and separation. At the same time, "Crystal" solves the problems associated only with the first property. The formal foundation of "Crystal" is a fuzzy measure of proximity in the initial data array. In combination with the Euler deconvolution method the developed method allows the geometric characteristics and the modules of direction of magnetic moment vector of anomalies generating bodies with high resolution to be determined. It was confirmed by the successful application of the method to examine and clarify the geological structure of the Hoggar region (Algeria) according to the aeromagnetic survey. In particular, it was shown for the first time that tectonically similar areas, comprising the Hoggar massif, are characterized by the common direction of rock magnetization. A map, illustrating and predicting the depths of the crystalline basement roof was constructed, complementing the available geological data.

The Atlas of the Earth's Magnetic Field was developed and published, which reflects the evolution of the geomagnetic field from 1500 to 2010. The Atlas contains both the results of the latest achievements in modeling and mapping the magnetic field, and the results of direct geomagnetic observations and modeling in historical epochs. The Atlas is intended for a wide audience, including scientists, teachers, students and experts of applied Earth sciences. It is a unique cartographic product with the most comprehensive and scientifically sound characteristics of the charted phenomenon of geomagnetism.

For the first time an automated algorithmic system for the recognition of anthropogenic anomalous events in geomagnetic records using fuzzy logic and pattern recognition was developed. Due to its efficiency and accuracy, this system is comparable with the corresponding methods used by hand in the INTERMAGNET program. An algorithm learning system was optimized and a formalized method of evaluating the performance of algorithms for recognition of anomalous anthropogenic events on magnetograms during periods of quiet magnetic field and increased magnetic activity was developed. With the help of the developed algorithmic system the automated recognition of anthropogenic anomalies on the one-second magnetic data was carried out and the quality criteria applicable to second and half-second data were developed. The application of algorithmic system to recognition of anthropogenic anomalies in continuous mode allows the definitive (verified) data to be obtained in near real time. The latter gives an opportunity to address the challenges in the field of operational modeling and space physics.

The system of ground-based observations of the Earth's magnetic field on the territory of the Russian Federation was significantly developed. The fundamental achievements in this area include the expansion of observing networks in Russia by deploying new observatories of INTERMAGNET standard and establishing the Russian-Ukrainian center for the collection and processing of geomagnetic data on the basis of GC RAS (<http://geomag.gcras.ru/>). Due to a

number of parameters the center exceeds its foreign counterparts through the adoption of methods of automated analysis of incoming data and variational data correction to absolute values as they arrive.

A method for detecting and monitoring geomagnetic activity on the basis of the totality of ground-based observations of the Earth's magnetic field using discrete mathematical analysis (DMA) and GIS technologies was developed. While recognizing the activity the method allows monitoring the dynamics of magnetic storm expansion over the globe in real time. Evaluation of geomagnetic activity in different regions of the Earth is given in a single scale, while its local specificity is taken into account. The method does not require the identification of magnetically quiet days to determine Sq-variations. The developed measure of anomaly helps to analyze the subtle internal structure of magnetic storms, the dynamics of their development, both across the globe and within regions. The method was tested on the example of two strong geomagnetic storms observed during the 23rd solar cycle, based on the entire global network of INTERMAGNET magnetic observatories with 1-minute sampling rate.

On the basis of DMA the algorithmic detection of anomalous events in the time series of variations of the bottom water pressure, recorded by the worldwide network of bottom sensors of the hydrostatic pressure in the open ocean, was developed. The established system is capable to detect events in the accumulated data, not included into the available global catalogs of earthquakes and tsunamis because of their small magnitude. The method was used in solving the problem of recognition of the time segments corresponding to signals from underwater earthquakes (P-waves) and tsunami waves on the records of observations of DART-2 (Deep-ocean Assessment and Reporting of Tsunamis) system.

A multidisciplinary intellectual GIS "Data on Earth Sciences for the Territory of Russia and Neighboring Countries" was established (<http://gis.gcras.ru/>), continuously updated with new geospatial geological and geophysical data. Currently the analytical components of GIS based on mathematical methods of data mining are being developed.

Positions in national and international committees and organizations:

National positions:

Since 2013 Division vice-chair in the expert group on "Rational use of natural resources" of Scientific Coordination Council for Federal Special Purpose Program, since 2015 member of the Council for the creation of unified system of information management for scientific research of the Federal Agency of Scientific Organizations.

International positions:

Since 2017, Russian National Correspondent to International Association of Geomagnetism and Aeronomy of the International Union of Geodesy and Geophysics. Since

2015 Chair of Interdivisional Commission on History of the International Association of Geomagnetism and Aeronomy of the International Union of Geodesy and Geophysics, since 2014 Chair of the Task Group “Earth and Space Science Data Interoperability” of the Committee on Data for Science and Technology of the International Council for Science, since 2017 Vice chair of Commission on Data and Information of the International Union of Geodesy and Geophysics. In 2010-2016, visiting professor at Paris Institute of Physics of the Earth (IPGP, France). In 2008 and 2010, visiting researcher at NOAA National Geophysical Data Center (Boulder, Colorado, USA). In 2004, visiting researcher at the Laboratory of Volcanology of Clermont-Ferrand University (France).

Scientific editorship:

Since 2015 member of Data Science Journal editorial board, since 2017 member of Izvestiya, Atmospheric and Oceanic Physics journal editorial board, since 2017 editor-in-chief of the Geoinformatics Research Papers journal.

Publications:

List of scientific publications include more than 70 papers in Russian and foreign scientific journals, 2 monographs, more than 80 abstracts at Russian and international scientific conferences and over 10 certificates of intellectual property registration.