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Web-Based Information System for Modeling and Analysis of Parameters of Geomagnetic Field

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Abstract

Today the specialists in many scientific and applied spheres (such as biology, medicine, geophysics, geology, technics, sociology, psychology and many others) consider parameters of geomagnetic field and its variations as one of the key factors, which can influence on systems and objects of various origins. The estimation of the influence requires an effective approach to analyze the principles of distribution of geomagnetic field parameters on the Earth's surface, its subsoil and in circumterrestrial space. The approach causes a complicated problem to be solved, which is concerned with modeling and visualization of geomagnetic field and its variations parameters. The most effective and obvious solution to this problem is supposed to be an information system, because of the data-centric character of the problem itself. In spite of wide variety of approaches for mathematical modeling and graphical visualization of various data a problem of modeling, automated analyzing and 2D/3D-visualization of geomagnetic field and its variations is still not solved. In this paper the authors suggest the solution, which is based on modern geoinformation and web technologies and provides the mechanisms to calculate, analyze and visualize parameters of geomagnetic field and its variation.

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Keywords: geoinformation systems; geomagnetic field; geomagnetic variations; 2D/3D-visualization

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1. Introduction

More than 20 years ago Tim Berners-Lee invented World Wide Web (WWW). It started from Web 1.0 with static HTML pages, continued at Web 2.0 with "wisdom of crowd" ideology and stays at Web 3.0 with Semantic Web and intellectual agents. The most common thing for all these stages is their data centricity: with World Wide Web we have entered an epoch, where data is the most important and arguably largest natural resource.

"Data is next Intel Inside" is one of the key principles of modern information technologies. The things getting harder as new term "infoware" is going to replace traditional "software". And these data-centric applications require special technologies to store, retrieve, query, manipulate, send, receive, copy, and display any kinds of information. In this information space geographical data which is aimed to describe and characterize locations on the Earth plays a special role.

One of the best examples of this is a special class of information systems, which is widely known as GIS. GIS stands for geographical information system and is aimed to store, query, manipulate and display geospatial data which is referred to information explaining where something is and what is at a given location. In other words GIS can process any data which contains location (geodetic latitude and longitude, address, etc.). With GIS this data can be overlaid on top of one another on a single map.

GIS may be used for any number of different purposes and may combine countless sources of data that can be manipulated and updated at any time. There are a lot of examples of using GIS in Earth science, biology, ecology, physical sciences, hydrology and even social science. In these areas GIS increase efficiency, improve decision making, manage complex planning and also can be used as a universal language that is helping to create a common understanding and building consensus in decision-making process. Moreover GIS is an effective tool of science, which allows researchers to bring together, overlay, model, and visualize any phenomena and create a better understanding of it.

Although a wide range of using GIS in different scientific and applied areas there no any geoinformation technologies, which provide a calculation, geospatial connection, visualization and analysis of geomagnetic field, its variations and anomalies. However it is well-known that geomagnetic field is one of the key factors which can significantly influence on living organisms and technical objects. There are a lot of known cases, when geomagnetic variations and anomalies affect the performance of equipment, upset radio communications, blackout radars, disrupt radio navigation systems, and endanger living organisms.

Today all the data measured and collected about geomagnetic field is distributed in various sources and storages. It is obvious that necessity in integrated information space is very acute. Development of such integrated information space will provide a possibility to get any data about geomagnetic field at any point of the Earth's surface at any moment of time. And the initial step here is concerned with specialized applications which provide calculation of parameters of normal (undisturbed) geomagnetic field in real-time mode for any point on the Earth's surface.

The obvious way to solve the problem is to implement innovative information technologies there. In particular the most expectations are about using geoinformation systems to solve the problem. In this paper the authors suggest an approach to study, monitoring, analyze and visualize geomagnetic field, its variations and anomalies, which is based on modern Web and geoinformation technologies.

2. Geomagnetic Field and its Variations

According to the modern science, the Earth's outer core is liquid and mainly iron. Its chemical elements (such as iron and nickel) are among the main ones (at a depth of more than 670 km). These elements respectively make ~85.5 % and ~5.2 % of Earth's core mass fraction, i.e. totally more than 90 %. Permanent rotations of the Earth and its core cause the constant flows inside of the core and corresponding electric currents. According to the laws of magnetic hydrodynamics, these flows and currents provide the existence of geomagnetic field [1].

Geomagnetic field is a complex structured natural matter with ambiguous field characteristics, which is distributed in the Earth (and near-Earth) space and interacts with both astronomical objects and terrestrial objects / processes on the Earth's surface, subsoil and in near-Earth space [2,3].

Because of the permanent interaction with the magnetic fields, which are generated by the Sun, the planets of the Solar system and other celestial bodies and systems, the Earth's magnetic field can be significantly deformed.

Herewith geomagnetic field becomes some kind of protective shield, which prevents a penetration of the Solar wind to the geospace (the Solar wind is a flow of ionized particles (they are mostly helium-hydrogen plasma), which radially flows from the Solar corona to the outer space). The Solar wind interacts with this barrier, flows around the Earth and creates a special region with the geomagnetic field inside, which is known as the Earth's magnetosphere. Typical teardrop shape of the magnetosphere is explained by the balance of the Solar wind dynamic pressure and coronal plasma flows heats on the one side, and the Earth's magnetic field pressure on the other side.

Geomagnetic variations are declinations of observed amplitude parameters of the Earth's magnetosphere from the calculated values, which are defined as a normal (or undisturbed) state of geomagnetosphere. The events and processes, which cause geomagnetic variations, have various and independent origin. Besides, all local and global deformations of geomagnetosphere significantly differ by both their amplitude-frequency and probabilistic estimations and characteristics. As a result the actual picture of geomagnetic field is a complicated superposition of probabilistic set of geomagnetic variations, which are caused by the number of uncoordinated events. That's why their estimation by traditional physical quantities (magnetic field intensity, frequency, magnetic induction, etc.) is useful.

Today the specialists in many scientific and applied spheres (such as biology, medicine, geophysics, geology, technics, sociology, psychology and many others) consider parameters of geomagnetic field and its variations as one of the key factors, which can influence on systems and objects of various origins. They pay great attention to correlations between external geomagnetic variations and existence and evolution of various objects and systems.

This interest is based on idea, that some components of geomagnetic variations or their combinations can influence on biological, technical, geological and other objects and systems in common and on human in particular. As a result, distorted normal conditions of existence force these objects and systems to either adapt to changes of magnetic state (via deformation, mutation, etc.) or keep existing there in stressed (or unstable) mode [4,5].

The full vector of the Earth's magnetic field intensity in any geographical point with spatiotemporal coordinates is defined as follows:

$$\boldsymbol{B}_{ge} = \boldsymbol{B}_1 + \boldsymbol{B}_2 + \boldsymbol{B}_3,$$

where $\boldsymbol{B}_1$ is an intensity vector of GMF of intraterrestrial sources; $\boldsymbol{B}_2$ is a regular component of intensity vector of geomagnetic field of magnetosphere currents, which is calculated in solar-magnetosphere coordinate system; $\boldsymbol{B}_3$ is a geomagnetic field intensity vector component with technogenic origin.

The normal (or undisturbed) geomagnetic field is supposed as a value of $\boldsymbol{B}_1$ vector with excluding a component, which is caused by magnetic properties of rocks (including magnetic anomalies). So, this component can be excluded as a geomagnetic variation:

$$\boldsymbol{B}_0 = \boldsymbol{B}_1 - \Delta \boldsymbol{B}'_1,$$

where $\boldsymbol{B}_0$ is an undisturbed GMF intensity in the point with the spatiotemporal coordinates; $\Delta\boldsymbol{B}'_1$ is a component of GMF of intraterrestrial sources, which represents magnetic properties of the rocks.

Solving the problem of analytical estimation of $\boldsymbol{B}_0$ parameters, it is helpful to represent the model of main field by spherical harmonic series, which depend on geographical coordinates.

The scalar potential of induction of intraterrestrial sources geomagnetic field U [nT·km] in the point with spherical coordinates r, θ, λ is defined by the expression (1).

$$U = R_{\mathrm{E}} \sum_{n=1}^{N} \sum_{m=0}^{n} \left(g_n^m \cos(m\lambda) + h_n^m \sin(m\lambda) \right) \left(\frac{R_{\mathrm{E}}}{r} \right)^{n+1} P_n^m \cos\theta, \tag{1}$$

where r is a distance from the Earth's center to the observation point (geocentric distance), [km]; λ is a longitude from Greenwich meridian, [degrees]; θ is a polar angle (collatitude, θ = (π/2)-φ', [degrees], where φ' is a latitude in spherical coordinates, [degrees]); R_E is an average radius of the Earth, R_E = 6371.03, [km]; $g^n{}_m(t)$, $h^n{}_m(t)$ are spherical harmonic coefficients, [nT], which depend on time; $P^n{}_m$ are Schmidt normalized associated Legendre functions of degree n and order m.

In geophysical literature the expression (1) is widely known as a Gaussian and generally recognized as an international standard for undisturbed state of geomagnetic field.

The amount of performed spherical harmonic analysis is significant. However a problem of spherical harmonic optimal length is still acute. Thus, the analyses with great amount of elements prove Gauss hypothesis about convergence of spherical harmonic, which represents a geomagnetic potential. As usual in spherical harmonic analyses the harmonics are limited by 8–10 elements. But for sufficiently homogeneous and highly accurate data the harmonics series can be extended up to 12 and 13 harmonics. Coefficients of harmonics with higher orders by their values are compared with or less than error of coefficients definition.

Due to temporal variations of the main field the coefficients of harmonic series (spherical harmonic coefficients) are periodically (once in 5 years) recalculated with the new experimental data. The changes of the main field for one year (or secular variation) are also represented by spherical harmonics series, which are available at http://www.ngdc.noaa.gov/ IAGA/vmod/igrf11coeffs.txt.

Schmidt normalized associated Legendre functions $P^n{}_m$ from expression (1) in general can be defined as an orthogonal polynomial, which is represented as follows (2).

$$P_n^m(\cos\theta) = 1\cdot3\cdot5\ldots(2n-1)\cdot\sqrt{\frac{\varepsilon_m}{(n+m)!(n-m)!}}\times \\ \times\sin^m\theta\Big[\cos^{n-m}\theta - \frac{(n-m)(n-m-1)}{2(2n-1)}\cos^{n-m-2}\theta + \\ +\frac{(n-m)(n-m-1)(n-m-2)(n-m-3)}{2\cdot4(2n-1)(2n-3)}\cos^{n-m-4}\theta - \ldots\Big], \tag{2}$$

where ε_m is a normalization factor (ε_m = 2 for $m \geq 1$ and ε_m = 1 for m = 0); n is a degree of spherical harmonics; m is an order of spherical harmonics.

3. Geomagnetic Calculators

Geomagnetic (or magnetic) calculator is a special type of a web application, which provides an estimation of magnetic field at a given point on Earth.

Modern geomagnetic calculators provide the simplest functionality. When a user enters a location to be calculated, application estimates parameters of geomagnetic field in the point.

Here is a list of the most popular services:

- NGDC NOAA (http://www.ngdc.noaa.gov/geomag-web/)
- INTERMAGNET (http://www.intermagnet.org/data-donnee/data-eng.php)
- British Geological Survey (http://www.intermagnet.org/data-donnee/data-eng.php)
- U.S. Geological Survey (http://geomag.usgs.gov/)
- etc.

There are two main problems with these applications. First problem is concerned with defining a location to be studied. All applications provide simple input fields for geodetic coordinates of the point. A user has to know exact parameters of the place that is impossible sometimes. So, it is a limitation of the application, and some users are aware of using it due to this reason.

Another problem is connected with data accuracy. Mathematical model of geomagnetic field is based on full geodetic coordinates of a given point, e.g. latitude, longitude and altitude. All applications suppose altitude as 0 km, so results of calculation are correct just for this elevation. A user can enter the altitude value into input field, but these data is also specific. Nobody knows the eleveation of his position (except the professionals). So, this value is always referred to as 0. The question is how reliable these results in this case?

In addition some calculators do not use date parameter for estimation of geomagnetic field, e.g. do not take into account secular variations.

The authors suggest the following points to improve geomagnetic calculators:

- using maps, e.g. geographical information technologies. Geomagnetic field is estimated by geodetical coordinates of a given point on Earth. This class of data is referred to as geospatial and is traditionally processed by geoinformation systems and technologies. With a map in application a user can simply pick up the point by mouse clicking.
- altitude calculation. To increase the accuracy of calculation it is necessary to provide an actual value of the altitude of a given point. The best solution is to get the value automatically on the basis of geodetic latitude and longitude of a point. However this feature does not exclude a possibility of correcting data just to see how magnetic field changes with elevation;
- multiple ways of a point definition. To increase a flexibility and performance of geomagnetic calculator it is necessary to provide various ways of defining a point for calculation (for example, map, input fields, geolocation, geopositioning, etc.). With this feature a user can use application in the most suitable form (even without any knowledge about his geoposition).
- date selection. Estimation of geomagnetic field depends on the moment of time (or epoch) of calculation. Mathematical model is based on a set of matrices of spherical harmonic coefficients, which are corrected every 5 years. With date selection option a user can can compare parameters of geomagnetic field in a given point at different time periods.
- report generation. It is simple and obvious feature, but it is still not performed by existing geomagnetic calculators. A user can save results of calculation into PDF-file (or in any other format) and print it for further use. Report containf both results of calculation of parameters of geomagnetic field and geospatial data of a given point on Earth (latitude, longitude, altitude, Earth parameters).
- platform-independency. To increase the range of users a geomagnetic calculator is to be available at any platforms. Whether a user requires an application with mobile device (tablet or smartphone, for example), he gets the same functionality as with personal computer.
- visualization. The most popular approach to visualize parameters of geomagnetic field is a set of contours. Each contour is a curve along which the parameter of geomagnetic field has a constant value. A user chooses a parameter to be visualized and the system renders on the map a set of contours, which represent a distribution of magnetic field on the Earth's surface.
- three-dimensional representation. It is obvious, that in this case geoinformation system provides much more information than any other system or technology. And it is even more important due to the dynamic properties and multilevel scale ability.

To provide the defined requirements the authors suggested and developed specialized Web-based information system for calculation of parameters of geomagnetic field – S-Service.

4. S-Service to Calculate Parameters of Geomagnetic Field

The main scientific area of GIMS Research Laboratory (Russian Federation) is development of geoinformation systems for monitoring, modeling, control, complex analysis and forecasting of parameters of geomagnetic field, its variations and anomalies for scientists, researches and specialists. Its main project is geographical web-portal "Geomagnet" (http://www.geomagnet.ru/index-en.html) with four services providing observation, analysis, three-dimensional visualization and calculation of parameters of geomagnetic field. In this paper the authors represent the application (service) for calculation of parameters of normal geomagnetic field – S-Service (http://www.geomagnet.ru/S/index-en.html) [6].

S-Service is a Web-based application providing calculation parameters of geomagnetic field and secular variations according to the set of coordinates and dates (Fig. 1). A user of any level can calculate and analyze parameters of geomagnetic field at his current location or at any other point on the Earth.

S-Service is a responsive application which does not depend on device type and parameters and looks and works similarly at any devices – from phones to tablets to desktops. This platform- and device-independency is realized on the basis of special framework "Bootstrap" (http://getbootstrap.com/) that is a set of programming libraries for HTML, CSS and JavaScript (JQuery). Flexibility and performance of the application are also increased by supporting HTML5 and CSS3 standards.

Interface of the application consists of two functional parts. First (and the biggest) panel was developed for map rendering. All manipulations with geospatial data are visualized in this area (markers, zoom, geolocation, contours, etc.). Another panel is used to display information about both initial (spatiotemporal coordinates) and calculated (characteristics of geomagnetic field) parameters. Information panel also provides a possibility to see coordinates of the mouse pointer during its moving on map.

Functions providing map rendering and functionality are based on two APIs: ESRI ArcGIS for JavaScript and Google Maps API. Depending on the demand and available functionality scripts in the application operate with either one or both of them.

The basic rendering of map and processing of mouse pointer position are provided by ESRI ArcGIS API for JavaScript. It is a lightweight object-oriented technology for embedding maps into web applications. The technology is based on Dojo framework featuring Ajax and DHTML elements.

With ArcGIS API the map is initialized as follows:

```
require([  "esri/map", "esri/graphic") {
            map = new Map("map", {
             basemap: "streets",
            center: [54.7249, 55.9425],
            zoom: 5,
            minZoom: 3,
            sliderPosition: "top-right"  });
```

The code fragment creates a map instance which is centered at default coordinates (54.7249, 55.9425) and located in "div" HTML-element with id equal to "map". Due to demands of interface conception the "sliderPosition" option is also set. This option sets a position of zoom slider on the map and it is necessary to declare it in map initialization code, because CSS settings of map elements can be just partially changed from ESRI CSS (http://js.arcgis.com/3.12/dijit/themes/claro/claro.css).

To calculate parameters of geomagnetic field a user has to define spatiotemporal coordinates of the point on the Earth's surface. In S-Service geodetic latitude and longitude can be defined by various ways.

The simplest way to define the current geographical position of the user is a geolocation function [7]. This function takes IP address of device, which a user operates to access the Internet. This possibility allows the user to get the point without its searching on the map or filling the appropriate input fields.

Geolocation function is based on the functionality of ArcGIS API in LocateButton widget:

```
var geoLocate  = new esri.dijit.LocateButton({map: map}, "LocateButton");
geoLocate.on("locate",geolocation);
geoLocate.startup();
```

The fragment above links locate button to the map and defines a function (geolocation) to process it. It is necessary to mention that since this can compromise user privacy, the position is not available unless the user approves it.

The widget uses functional possibilities of HTML5 Geolocation API with getCurrentPosition() method to get the user's position. If user's location is available the script puts a marker at the appropriate point (function "createMarker") and calculated parameters of geomagnetic field there (function "calcGMF"). Otherwise the service gives a user an appropriate message:

```
navigator.geolocation.getCurrentPosition(function(pos) {
var point = new esri.geometry.Point(pos.coords.longitude.toFixed(4), pos.coords.latitude.toFixed(4));
createMarker(esri.geometry.geographicToWebMercator(point));
calcGMF(pos.coords.latitude.toFixed(4), pos.coords.longitude.toFixed(4), 0);
}, function errorCallback(error) {
                    alert("Your browser do not support geolocation");
});
```

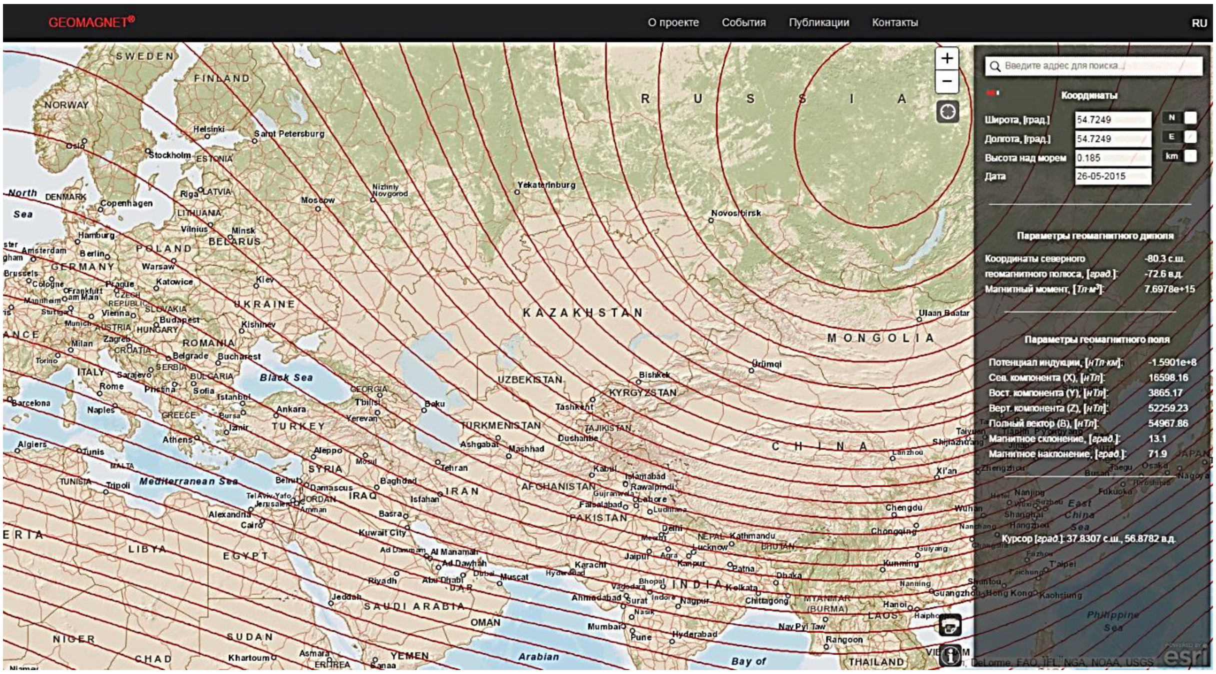

Fig. 1. S-Service (http://www.geomagnet.ru/S/index-en.html)

An important thing is that HTML5 Geolocation API represents result coordinates in geographical coordinate system, while ArcGIS map uses a Mercator projection. Function “geographicToWebMercator” covers it and transforms geographic projection into Web Mercator projection.

Another way to define a point is to pick it up on the map. A user can move through the map (using keyboard or mouse) and click at the point. All necessary spatiotemporal parameters of the point are calculated automatically and immediately displayed on screen:

```
map.on("click", pickPoint);
```

Both mentioned ways of point definition do not require exact coordinates of location. All necessary geospatial data can be obtained automatically. More complicated way is concerned with entering coordinates into input fields. It is a good way to calculate parameters of geomagnetic field and see the point on map with high accuracy (up to a few meters). After that the application displays the point on the map and the parameters of normal geomagnetic field there.

Also S-Service provides a geocoding functionality to define a point to be calculated. Geocoding is a transformation from address full form “postal code, country, city, street, building number” or short form (just one item or their combination) into the coordinates set “north latitude, east longitude”. To find the point a user enters

address of the place he is interested in. The address can be represented at any level (city name, address with city and street names, full address including building number, etc.). In S-Service address is a value of input field with id equal to “search” and geocoding functionality is programmed as follows:
(https://developers.google.com/maps/documentation/javascript/geocoding?hl=en)

```
var address = document.getElementById('search').value;
var geocoder = new google.maps.Geocoder();
geocoder.geocode( { 'address': address}, function(results, status) {
  if (status == google.maps.GeocoderStatus.OK) {
      calcGMF(results[0].geometry.location.lat(),results[0].geometry.location.lng(),0);
      var point = new esri.geometry.Point(results[0].geometry.location.lng(),results[0].geometry.location.lat());
      point = esri.geometry.geographicToWebMercator(point);
      createMarker(point);
 } else {
      alert('Unknown object');
}
});
```

Parameters of geomagnetic field in the geographical point depend on its elevation. With defined geographic coordinates S-Service gets elevation value automatically. However ArcGIS API does not provide any obvious methods to get this value. That is why there is another cartographical technology in S-Service code – Google Maps API. In the API the application uses a special service "ElevationService" which provides elevation data for all locations on the Earth surface (even locations on the ocean floor). It is an object with an asynchronous interaction: after sending a request to the server a user (or a web page) does not wait for its response and keeps performing all existing operations (or start new ones) in background mode.

S-Service provides representation of geodetical coordinates in one of the two formats: “decimal degrees” (DD) and “degrees – minutes – seconds” (DMS). A user can choose any of coordinates representation form before or after defining the point. Depending on the chosen format a user gets the appropriate input mask.

An input mask is realized with jQuery plugin “jQuery Masked Input” (https://plugins.jquery.com/maskedinput/). The plugin forces fixed width inputs to follow a certain pattern (“99.9999” for DD and “99°99'99.99"” for DMS). Input mask is set with JavaScript code as follows:

```
jQuery(function($){$("#shir").mask("99°99'99.99"");});
```

In calculating elevation value of the point the application also takes into account the metric system and represents the results in the appropriate form. Two types of representation of the altitude value are provided (kilometers / feet). A user can choose any of them before or after defining the point.

Interactive On/Off flipswitches (to choose a metric system for an altitude and input type for coordinates) are performed with user interface prototyping service “Proto.IO” (https://proto.io/). It provides a set of online tools to generate pure CSS3 On/Off flipswitches with animated transitions. The code generated by online services is embedded into the application CSS and HTML markup as follows:

```
<div class="onoffswitch_form">
  <input type="checkbox" name="onoffswitch_form" class="onoffswitch-checkbox_form"
   id="input_type" checked>
      <label class="onoffswitch-label_form" for="input_type">
        <span class="onoffswitch-inner_form"></span>
        <span class="onoffswitch-switch_form"></span>
      </label>
</div>
```

Parameters of geomagnetic field also depend on the date of calculation. Secular variation of magnetic field are the field changes in time, so value of parameters calculated can significantly vary at different moments. S-Service uses a current date as default, but a user can change it with provided datepicker. The datepicker is also programmed with JQuery.UI JavaScript Library that is a set of plugins of user interface interactions, effects, widgets, and themes built on top of the jQuery JavaScript Library (https://jqueryui.com/). After web page loaded datepicker is initialized and linked to “div” HTML-element:

```
$(function() {
        $( "#data" ).datepicker({
                dateFormat: 'dd-mm-yy'
        });
        $("#data").datepicker("setDate", new Date());
});
```

Parameters of geomagnetic field are calculated according to mathematical model that is represented in previous chapters. Its program realization in PHP is a set of functions to calculate such parameters as:

- north component of geomagnetic field induction vector;
- vertical component of geomagnetic field induction vector;
- magnetic declination and dip;
- scalar potential of geomagnetic field induction vector.

PHP script of calculation of parameters of geomagnetic field generates result set in XML format. In S-Service XML is preferred format due to large amount of parameters and the necessity of their processing and decomposition on client side. There are also some other known approaches to get a set of different values, but this way seem to be the most effective for the authors.

It is important to mention that this realization is based on the authors-suggested algorithm of calculation of parameters of geomagnetic field. The algorithm supposes special scheme to minimize the possible error because of the rounding. The error of the calculation is less than 2 %.

Server-side scripts send results of calculation to client in asynchronous mode with Ajax function:

```
var url = "script.php?lat=" + shir + "&lng=" + dolg + "&data=" + data + "&alt=" + alt;
$.ajax({ url: url,
                context: document.body,
                success: function(xml){
                showCalcResults(xml);
}});
```

Initially result data is represented in XML format, but on client side it is processed as textual data. To process obtained results they are loaded into DOM object and then decompose on separate items as follows:

```
var xmlDoc = jQuery.parseXML(request);
if (xmlDoc) {
        var lamda = xmlDoc.getElementsByTagName("lamda")[0].firstChild.nodeValue;
}
```

To visualize the results of calculation the application provides a set of contours, where each contour is a curve along which the parameter of geomagnetic field has a constant value. A user chooses a parameter to be visualized and the system renders on the map a set of contours, which represent a distribution of magnetic field on the Earth’s surface (Fig. 1).

Contours are rendered from KML file (XML-based file format used to represent geographic features) that can be dynamically generated or is located on server. ArgGIS API provides special class "KMLLayer" that is used to create a layer based on a KML file (.kml, .kmz):

```
var kmlUrl = "http://www.geomagnet.ru/KML/WMM2015_contour.kmz";
  var kml = new KMLLayer(kmlUrl);
  map.addLayer(kml);
  kml.on("load", function() {
    domStyle.set("loader", "display", "none");
    $('#loader').html('')
  });
```

Code fragment above creates a new layer from .kmz file and displays loading bar while the layer rendering.

Also to extend the functionality of the developed Web GIS "GIMS-calculator" there were programmed an option of generating electronic report about the research results with file or printer form and a possibility of three-dimensional modeling.

5. Conclusion

Geomagnetic field is a complex structured natural matter with ambiguous field characteristics, which is distributed in the Earth (and near-Earth) space and interacts with both astronomical objects and objects / processes on the Earth's surface, subsoil and in near-Earth space. Geomagnetic field and its variation can influence on systems and objects of various origins. The estimation of the influence requires an effective approach to analyze the principles of distribution of geomagnetic field parameters on the Earth's surface, its subsoil and in circumterrestrial space. The approach causes a complicated problem to be solved, which is concerned with modeling and visualization of geomagnetic field and its variations parameters. The most effective and obvious solution to this problem is supposed to be a geoinformation system.

Web-based geoinformation system "S-Service" (by GIMS Research Laboratory, Russian Federation) provides the complex calculation, analysis and 2D/3D-visualization of geomagnetic field and its variations parameters. Geomagnetic field and its variations models, which are represented and described by "S-Service", meet the requirements of specialists in various areas. They effectively provide formatting and structuring the data about the Earth magnetosphere parameters and their further analysis.

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