

Real-Time Forecast Service for Geomagnetically Induced Currents

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Business plan

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1 Executive Summary

The real-time forecast service for geomagnetically induced currents is a service development activity (SDA) of an ESA Space Weather Pilot Project. It has been developed by the Swedish Institute of Space Physics (IRF) in collaboration with the Finnish Meteorological Institute (FMI) and Elforsk AB.

The objective of this SDA is to provide real-time forecast of geomagnetically induced currents (GICs) at Oskarshamn/Simpevarp, in the southern part of the Swedish power grid. The purpose is also to provide general information about the ground effects of space weather to the general public and to educate the public and decision makers about GIC and how forecasts can help to mitigate the effects.

Geomagnetically induced currents are driven by the geoelectric field associated with a magnetic disturbance in, e.g., electric power transmission grids. When flowing through transformers, GIC may cause saturation leading to several problems: an increase of harmonics, unnecessary relay trippings, an increase in reactive power demands, voltage drops, a black-out of the whole system, and permanent damage to transformers.

A prototype of the service can be found on internet
<http://www.lund.irf.se/gicpilot/gicforecast/>.

2 Company Summary

The Swedish Institute of Space Physics (Institutet för rymdfysik, IRF) is a governmental research institute with 110 employees. Its primary task is to carry out basic research, education and associated observatory activities in space physics, space technology and atmospheric physics. IRF has employees in Kiruna, Umeå, Uppsala and Lund. The main office is located in Kiruna

The main research subject of the Finnish Meteorological Institute is the Earth's atmosphere and meteorology. Other research topics include the study of the Earth's near space and planetary atmospheres.

Elforsk was established on 17 December 1992. Its operations are organised in five programme areas Hydropower, Electricity and Heat Production, Transmission and Distribution, Utilisation, and Strategies and Systems. Elforsk has its office in Stockholm. The company conducts RD projects on a contract basis, primarily on behalf of its owners and their member companies.

3 Products and Services

The purpose of this ESA Service Development Activity (SDA) is to provide real-time forecasts of geomagnetically induced currents (GICs) in the southern part of the Swedish power grid. It will

also provide general information about the ground effects of space weather to the general public and educate the public and decision makers about GIC and yield information how forecasts can help mitigate the harmful effects of GIC.

Forecasts of the rate-of-change of the local geomagnetic field, the geoelectrical field on the ground, and GIC are calculated based on information from magnetometer stations. The models produce forecasts every 10 minutes. The real-time system includes a database that is updated in real-time and several prediction modules. It can also be used to determine the future risks for hazardous conditions to occur.

The SQL database can be used as an educational tool to learn more about space weather especially the hazardous environment conditions that can be harmful to power systems and that can cause problems on other ground-based and space systems.

The software needed to run the forecast modules is based on MATLAB a commonly used commercial product.

The forecast service uses methods developed in collaboration between IRF-Lund, FMI and Elforsk AB.

4 Market Analysis

GIC forecasts can be used to help, e.g., the power industry and the general society to mitigate the effects of space weather. The forecasting software is a versatile tool in post-analysis too.

A cost-benefit analysis made in cooperation with the Swedish power industry shows that this type of service is important. The cost-benefit analysis is presented in a separate document. A warning system and a monitoring system was recommended (Skarp, 2003) to mitigate the effects and herewith reduce the cost of GIC disturbances.

A warning system was estimated (Skarp, 2003) to cost only 2 MSEK plus an annual cost of 0.6 MSEK for operation and maintenance. Using a warning system was estimated (Skarp, 2003) to reduce the cost by 78.66%, 74.98%, 78.33% and 79.96% for the four cases A-D.

5 Strategy and Implementation

Knowledge about Sun-Earth relations has been implemented in the system, e.g., by introducing models using information about the solar wind for the determination of geomagnetically induced currents. The models are based on neural network techniques.

The tools, e.g., the programming methods, have been used to make the web interface software as platform-independent as possible.

The GIC forecast tool can be related or connected to other systems that are used to study effects by space weather conditions and processes. The systems will thereby become more complete as tools for prediction and analysis. Other examples of effects caused by the space weather conditions are anomalies on spacecraft and corrosion problems in pipelines.

The GIC forecast system will be maintained by IRF for at least the next three-year period. Software will be corrected when failures are reported or suggestions for minor improvements are made.

A magnetometer was installed and it will enhance the possibilities of monitoring geomagnetic activity in the region of interest.

6 Web Plan

A GIC forecast web page can be found at <http://www.lund.irf.se/gicpilot/gicforecast/>

7 Management

The GIC forecast will be accessible at the Space Weather Center of the Swedish Institute of Space Physics Lund facilities. It will be used by scientists and PhD-students at the Swedish Institute of Space Physics. We will also encourage others to test and use the system.

The database is regularly updated with new real-time data, and new historical data will be added if they become available.

8 Financial Plan

The Swedish Institute of Space Physics will investigate possibilities for financing an extension of the service. One interesting extension would be to increase the advance time that warnings can be given.

We are also open to proposals about future collaboration.