SWIMIC: Monitoring Geomagnetically Induced Currents in the UK Power Grid

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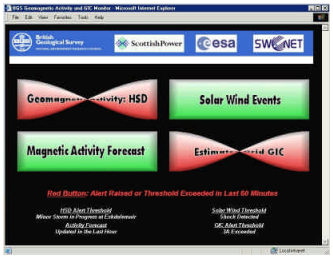
Aweb-based system for realtime monitoring andanalysis of geomagneticstorms andGICintheUK,knownasSWIMIC("Solar Wind monitoringandInductionModeling for Induced Currents"), is presented. SWIMIC wasdevelopedforScottish Power plcandwassupportedbyESAthroughtheESASpace WeatherPilotProject. Wediscuss the content of the webpages,thescience,themodelsandtheiraccuracies andwereviewhowwellSWIMICfulfills thedemandsofthewiderUKpower industry. We also consider thelikely futuredemands oftheindustryforGIC-relatedservices,suchasSWIMIC,inthe light of a recent reorganizationofthe UK power market.

Background

BGS has supplied geomagnetic monitoring and forecastdatatoScottish Power plc from1999.Data were used in the grid control to warn of GIC risk. We identified that moreadvanced warning,throughasolarwind shock monitor, and a whole-grid GIC calculatorwould add value to the service.ESA supported the development and all data were packaged as a web service(see right).



The SWIMICfrontpageduringa storm.Eachmainbuttonturnsred onthresholdcrossingandisalso animated to increase visibility.

User Requirements

Opinions on the ideas behind SWIMIC were sought by means of a power industry questionnaire. We wanted to know the levels of accuracy that werenecessary for a valid product, as well as update rates. The end-product meets most requirements, certainly in terms of the monitoring,forecast and GIC analysis tools.Thesolarwindmonitor does not meet expectations (e.g. 90%shockdetection requested) and thereforeneeds further development. Given the userresponses it wasdecidedearlyon to provide service accuracy statisticswiththerealtimedata,for reference,todescribewhatiscurrently scientifically possible.

User Responses

The response to SWIMIC waspositive,for example,ontheease of use, understanding ofdatadisplayed,updaterate, accuracies quoted. Feedback wasobtained fromsenior transformer engineersatScottishPowerandaseniorriskanalyst at National Grid Transco. Small changes, mostly cosmetic, were suggested.

Improvements to SWIMIC?

Some specific changes and additions were suggestedbythe UK powercompanyengineers:

1. A 'forensic analysis'function,i.e, the analysis of recent storms, with data rapidlystoredonlineforreference.
2. Moreeducational material.
3. Prediction ofgeomagnetic field variations, on time scalesof hoursahead,topredict GIC levels in thegrid. Gettingasmuch advanced and accurate warning is regardedasveryimportant, muchasforatmosphericweatherforecasting.

A Market for GIC Services?

The UKelectricity market changed inApril 2005.National Grid nowhasfullgridauthorityfortheUK.SWIMICwillbeused wherever possible todemonstrate capability for the UK market. SWIMIC will alsobemodifiedandadjustedasnecessaryduring this firstyear ofservice, taking into account SWENET developments. The future market, because oftheperceptionof costs, is probably at a European level, perhaps to a consortium of European powercompanies,eachderivingindividualbenefits fromajoint system. That waycostscanbespread.

Power grids are increasingly interconnected,acrossnational boundaries,potentiallyspreading GIC risk from country to country.Itisthereforebelievedthatpartnerships between nationalandinternationalinstitutes will be necessary to develop European GIC services. ESAinitiatives in developing space weatherserviceshavethereforebeenparticularlyusefulin fostering collaboration across the continentandinstartingan even wider international dialogue.

Acknowledgments

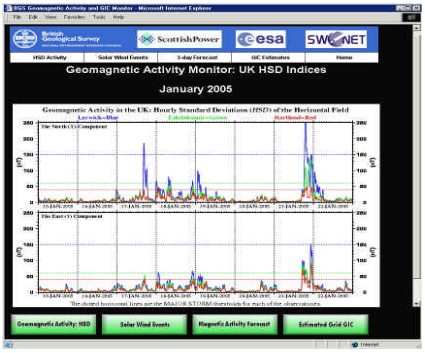
ScottishPowerplcarethankedfortheirdataandsupport.We wouldalsoliketoacknowledgetheSpaceEnvironmentCenter (NOAA/SEC)foraccesstoACEsatellitedata.Thanksaredue toESA/ESTECforencouragingthisServiceDevelopmentActivity throughtheSpaceWeatherPilotProject.

SWIMIC Web Data Pages: Examples

ThereareFourmainpagestoSWIMIC.Foreachof these we show some web screen shots. Many oftheexamplesrefertodataproducedduringrecent storms such as the29th-30th October 2003 severe magnetic storm. Usingdropdownmenususers can also access background information on the data displayed, including the accuracy of results. The science and implementation detailsofSWIMICareexplainedinanAGU Space Weather paper(Thomson *etal*,2005,toappear).

Monitoring Data

The progressofgeomagneticactivityis monitoredbychangesinUKobservatory hourlystandard deviations (*HSD*),updated every 15 minutes. Userscanclickon individual days for a closer look.



***HSD* Facts andFigures:**

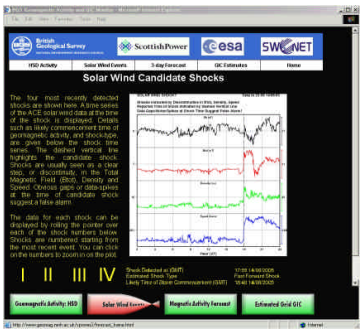
1. Data reliability is currently >98% (data available touser).
2. *HSD* of >300 nT isbelievedtobea 'reasonable'GIC threat level,e.g. For GICoftensofAmps. *HSD*>30 nT is used as warningindicator.

Forecast Data

Daily 3-dayaheadactivityforecastsareissued bynooneachnormalworkingday, both by email and through SWIMIC. Forecasts cover noon-noon intervals, as activity oftenstraddles local midnight in the UK.Forecastcoveris alsoprovidedonotherdaysduringperiodsof higher GIC risk.

Forecast Facts and Figures:

1. Stormforecastdetection rate varies from50% to10%at1-3days.
2. Falsealarmratesare42%-57% at 1-3 days.



Solar Wind Shock Monitor

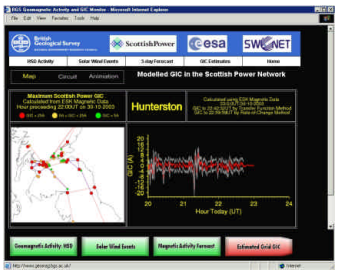
Shocks are detected inACEsolarwinddataby two thresholding techniques. One method uses both MAG and SWEPAM data. The other is less accurate but remains operational during severe storms but uses only MAGtotalfield

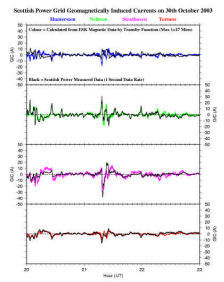
Shock Detector Facts and Figures:

1. Between 2000-2004SWIMICdetected181 shocks, 62%ofwhichwerealsoreportedina SOHO quality-checked catalogue.
2. ThehigherqualitySWIMICdetectoralonehad an 85%agreementwithSOHO.Lowerquality SWIMIC 'detections' canoccurbecauseof data noise.

Geomagnetic Induced Current 'Nowcast'

Time series of GIC are estimatedat4sitesinthe grid by a transfer function method. GIC everywhere are estimatedbyaDCgrid modelandelectricfield model, determinedby nearreal time UK magnetic fielddata.GridGICanimation is used.





GICModel Facts&Figures:

1. Transfer function model accuracy is shown right.
2. Grid modelaccuracy is shown farright.
3. Upperrightshowsactual GIC (black) and transfer functionestimated GIC(colour)during October2003storm.