

# Canadian Space Weather Forecast Centre

## Report to ISES

July 2014



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## INTRODUCTION

The Canadian Space Weather Forecast Centre (CSWFC) is operated by Natural Resources Canada. Developed originally in 1970s to help magnetic surveyors it now covers a wide range of phenomena from geomagnetic storms and effects on ground infrastructure to parameters of satellite environment at geostationary orbit. CSWFC services include a semi-automated short-term and long-term forecasts of geomagnetic activity at different locations over Canada updating every 15 minutes, and real-time services for multiple users, including Government Operation Centre of Public Safety and Security, infrastructure operators and general public.

Canada spans three quite distinctive zones (polar, auroral and subauroral) with different signatures of space weather impacts on the ground, the data and services provided by the CSWC/Geomagnetic Laboratory has its unique importance for the communication, navigation and ground infrastructures impacted by space weather as well as for the Government organisations, researches and general public.

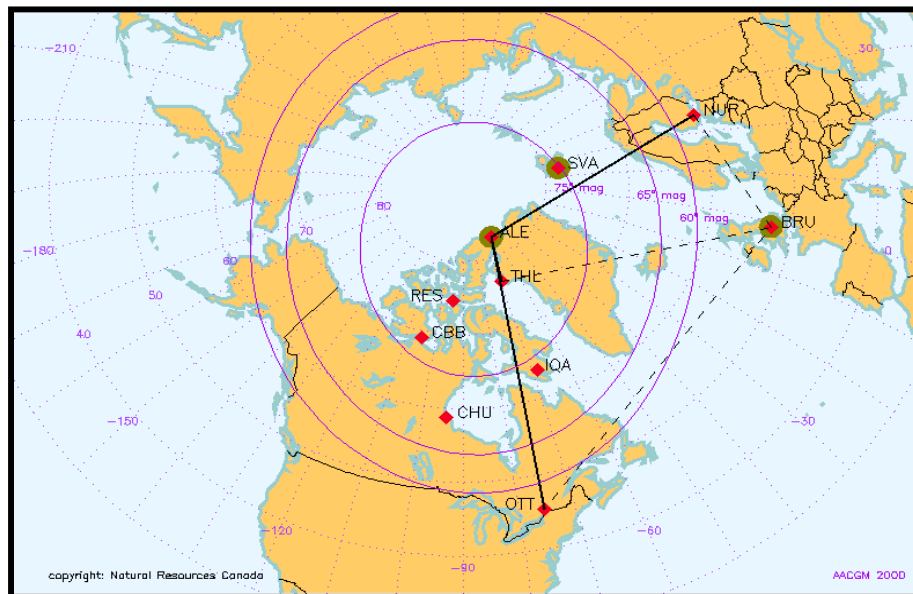
## RECENT ACCOMPLISHMENTS

### MONITORING OF THE IONOSPHERE:

Canadian Space Weather Forecast Centre/Geomagnetic Laboratory runs the network of riometers, which together with University of Calgary riometers provides data on the ionospheric conditions (D-region absorption) over the whole Canada, as shown in the map below (black dots-NRCan, red dots- U of Calgary). The new riometer has been installed in 2013 at Clyde River on Baffin Island (CLY) to enhance coverage of Polar Cap Absorption events.

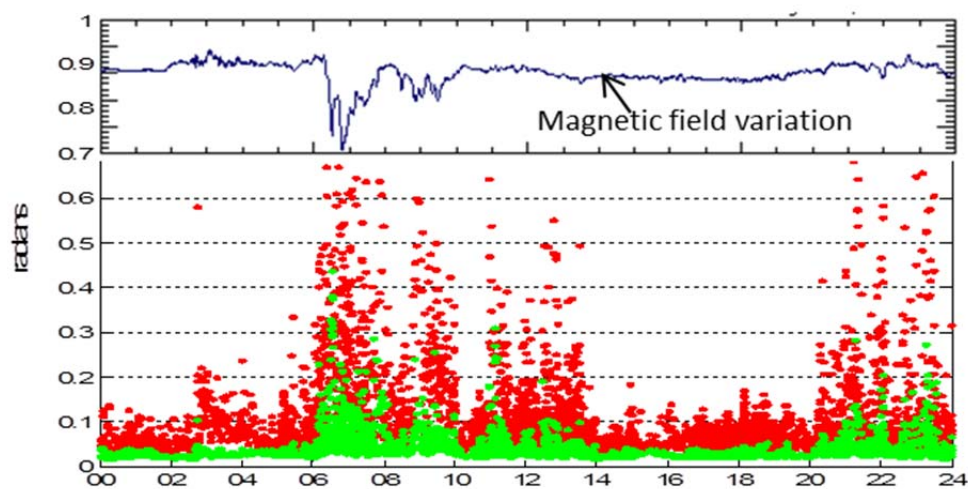


To enhance understanding of impacts of space weather on the radio propagation conditions in Northern Polar regions NRCan is participating in the project led by the University of Leicester. We are continuing to collect HF propagation data on signal strength, Doppler shift and direction of arrival at multiple sites across the Arctica as shown in the map below.



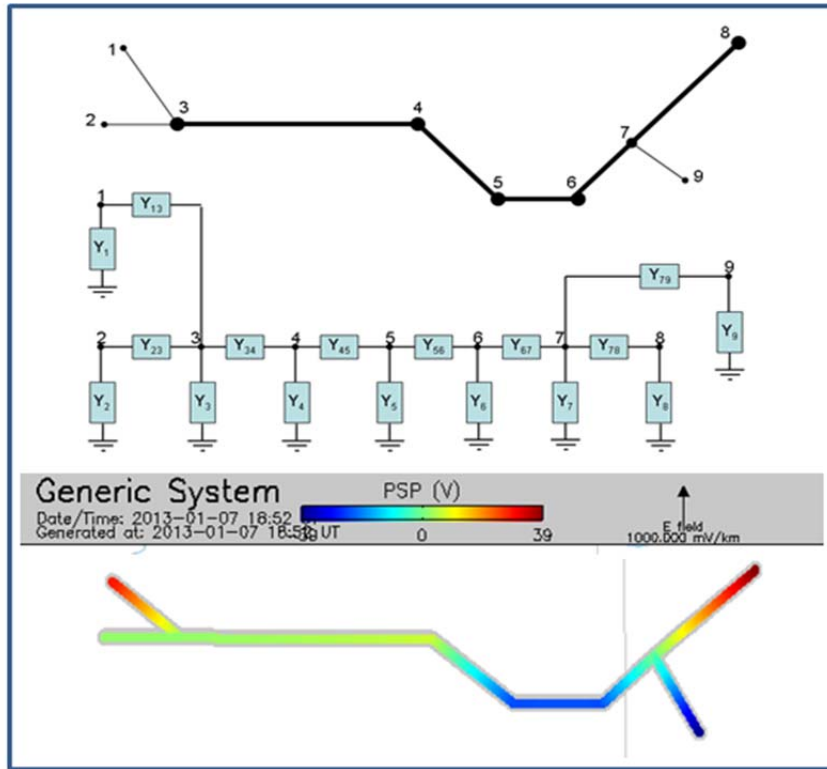
The space weather R&D team have joined forces with the Geodetic Survey to investigate the extent of the impacts of space weather on GPS signal in different regions of Canada, especially the auroral and polar regions where space weather disturbances are more intense.

### GPS Phase Scintillation at Yellowknife



## GROUND INFRASTRUCTURE:

Development work continues on software for modelling geomagnetically induced currents (GIC) in power systems and pipelines. For the pipeline operations, the new software can incorporate more realistic features of the pipeline networks, not only straight pipe, providing the opportunity for the operators to define custom configuration file (as shown below).

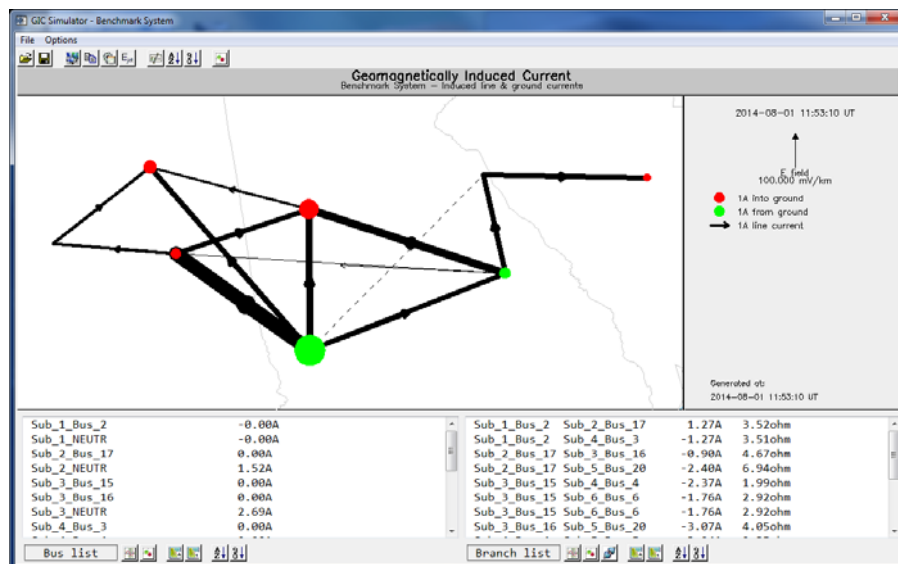


The new version of GIC simulator for power grids has been modified to handle multiple voltage levels of a power system and to provide information about GIC in individual transformer windings, not just the aggregated GIC value at each substation. The software allows a user to calculate GIC produced by a number of different inputs:

- i) a uniform electric field of any specified magnitude and direction
- ii) a varying east-west electrojet of specified frequency, amplitude, latitude and width
- iii) magnetic field data from one or two magnetic observatories.

In options (ii) and (iii) an earth conductivity model is used to calculate the electric fields. For option (iii) the user only needs to specify the date and time interval required and the GIC Simulator automatically retrieves the magnetic data from a web service running at the

Geomagnetic Laboratory in Ottawa. The illustration of the Simulator with benchmark network model is presented below.



#### ADVANCING THE SPACE WEATHER FORECAST

Numerical modeling represents an important part of activities at the CSWFC. In-house development of empirical, semi-empirical and physics-based simulation models and numerical techniques has potential to enhance SW forecast capabilities.

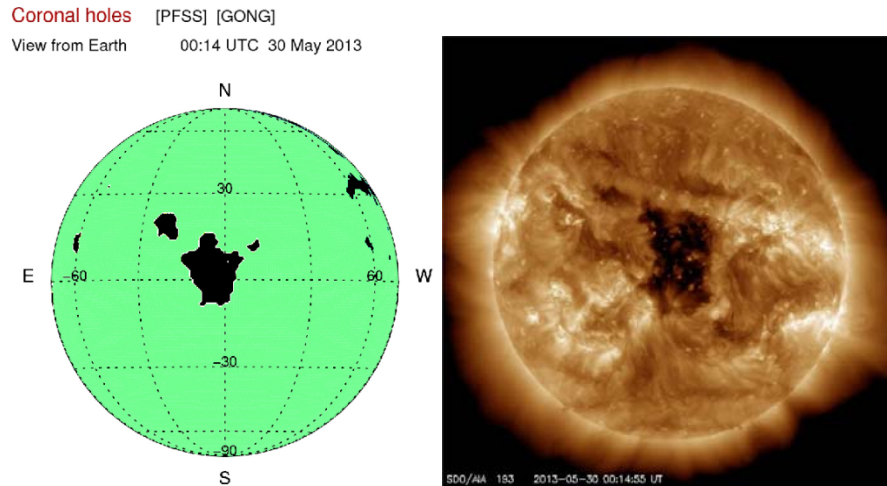
A SW numerical framework which consists of a number of Fortran and IDL routines has been developed. The modularity of its numerical components has opened opportunities to develop new SW forecast tools in a time efficient manner. In an operational-testing configuration of the modules based on the PFSS and Schatten models, the framework uses GONG magnetograms and provides SW forecasters with useful information about Sun–interplanetary conditions. This includes:

- Active regions.

- Coronal magnetic field and sector boundaries.

- Derived coronal holes (Figure below) and open field lines from the sub-Earth positions to the source of the solar wind.



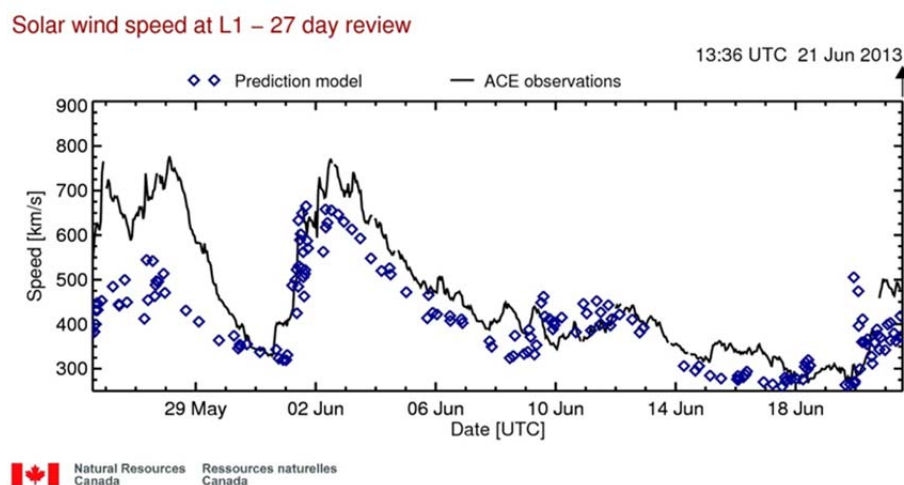


Comparison between numerically derived coronal holes and SDO observations.

Furthermore, using a semi-empirical relation between coronal magnetic field and background solar wind speed (modified WSA), the framework provides:

- o Solar wind speed map at 5 solar radii.
- o 7 day forecast of the solar wind speed.
- o 27 day forecast of the solar wind speed

The framework runs eight times a day and the outputs are displayed as line plots, 2D planar maps and as projections onto a spherical surface as viewed from the Earth and STEREO A and B satellites. 27 day forecast of the solar wind speed predictions and ACE satellite observations is presented in Figure below.



## FORECAST: OPERATIONAL PRODUCTS

Space weather bulletin (English and French) has become operational and is provided daily. The users are multiple Government Departments with the main one is the Government Operation Centre of Public Safety and Security Department. Example of the text is shown below (English).

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*Space Weather Bulletin - 2014-08-06 issued at 21:33 UT (16:33 EST)*

### *Summary*

- *There is currently no major storm watch in effect.*
- *See our website for current information: <http://www.spaceweather.gc.ca> (updated every 15 minutes)*

### *Current Conditions (21:15 UT)*

#### *Geomagnetic Activity:*

- *polar cap zone: unsettled*
- *auroral zone: quiet*
- *sub-auroral zone: quiet*

#### *Environment at Geostationary orbit:*

- *energetic electron fluence at geostationary orbit: normal*

#### *Possible Impacts on Technology:*

- *Impacts are not expected.*

### *24 Hour Forecast*

#### *Geomagnetic Activity:*

- *polar cap zone: quiet with active intervals*
- *auroral zone: quiet with unsettled intervals*
- *sub-auroral zone: quiet*

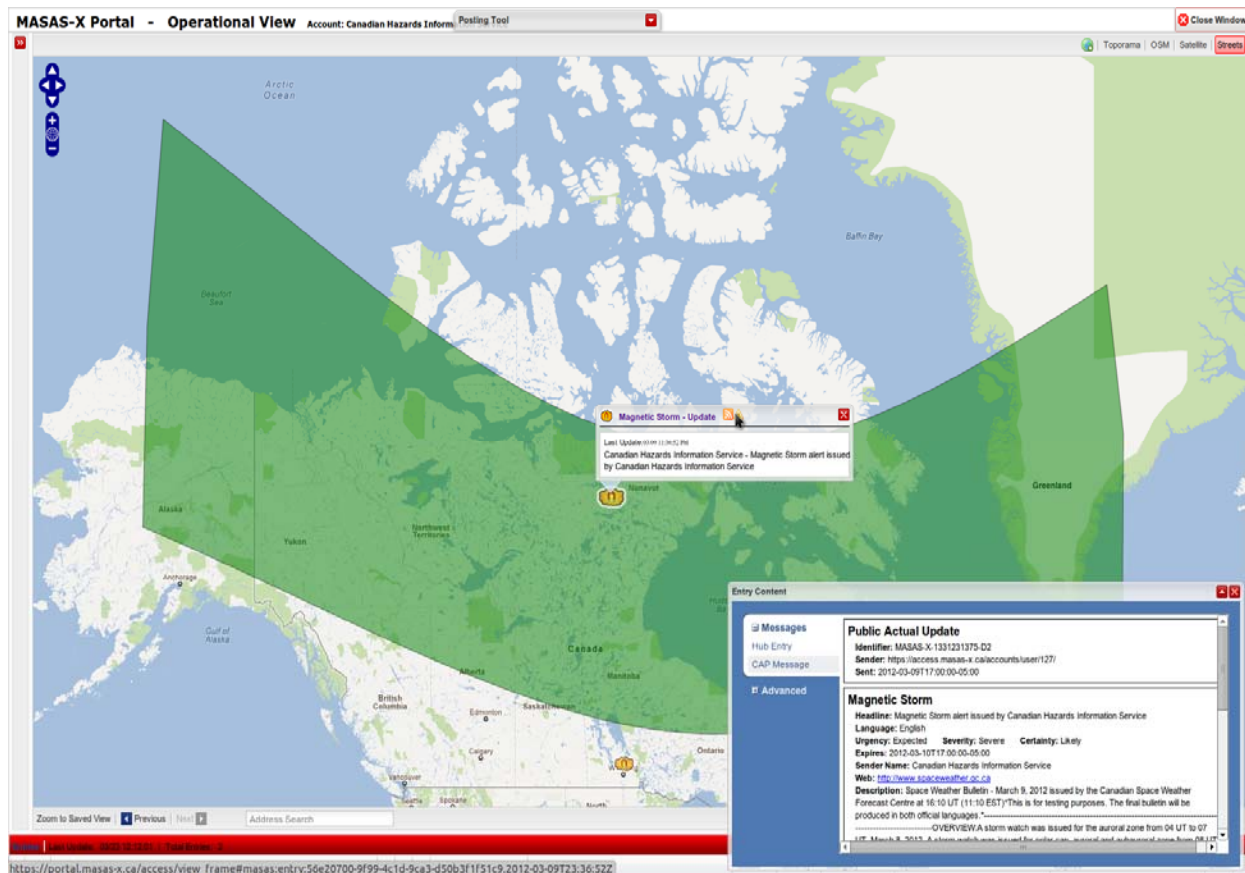
#### *Environment at Geostationary orbit:*

- *energetic electron fluence at geostationary orbit: moderate*

#### *Possible Impacts on Technology:*

- *Impacts are not expected.*
-

Geomagnetic forecast has become a part of the all-hazards service, the prototype of the display is shown below. This is on-going work led by the Canadian Hazard Information Service seismology group.



## FORECAST VERIFICATION RESULTS

Forecast validation plots are running automatically and are available internally for the space weather researchers' analysis and forecast improvements. In the last year the forecast of the hourly range indices for the polar cap showing very good quality, forecast of the auroral activity is also quite good, but the forecast of the subauroral activity showing significant deflection from the observational results. These evaluation plots for July are shown in the figures below. The reasons for these large deviations are under investigations.



