



INNOVATION  
EXPLORATION  
OBSERVATION  
INSPIRATION

# Overview of Space Weather Activities in Canada

Pierre Langlois  
February 2016



Agence spatiale  
canadienne

Canadian Space  
Agency



Natural Resources  
Canada

Ressources naturelles  
Canada



National Research  
Council Canada

Conseil national  
de recherches Canada

Canada



# Space Weather in Canada

- Natural Resources Canada
  - Forecasts, warnings, Interaction with the users
- National Research Council
  - F10.7 Solar Flux Measurements and expertise
- Canadian Space Agency
  - Scientific space missions
  - Data gathering and analysis to further space science in support of space weather

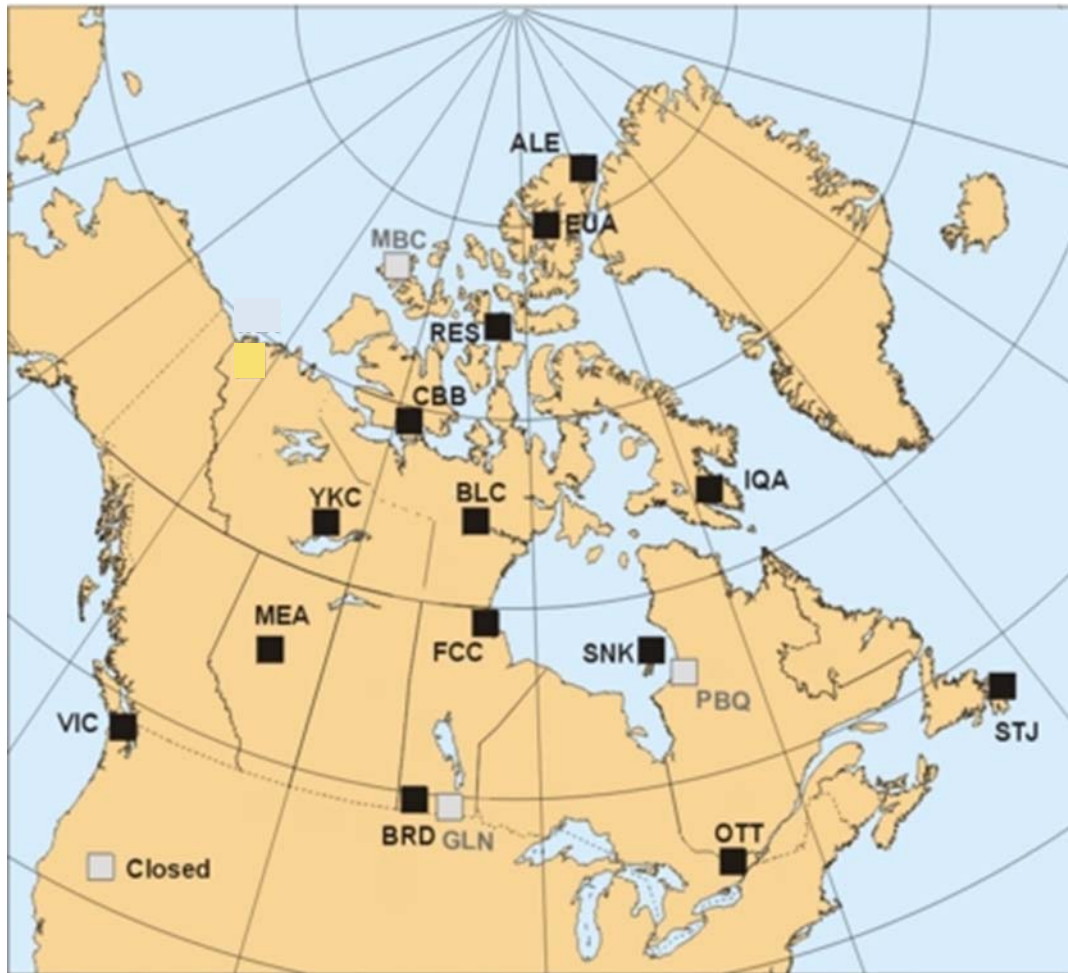


# Natural Resources Canada

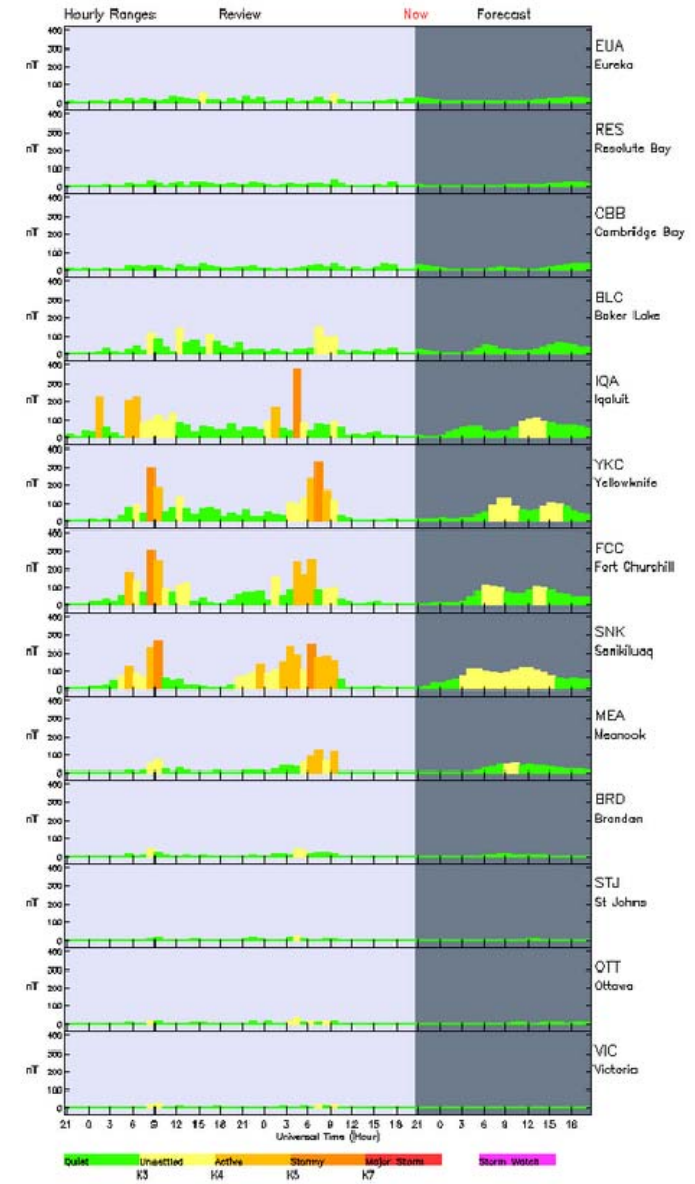
- Measurement Network
- Forecasting
- Outreach
- Protection of critical infrastructure



# Canadian Geomagnetic Observatory Network



Geomagnetic Activity at Canadian Magnetic Observatories 2016-02-01 at 20:45 UTC



Natural Resources Canada / Ressources naturelles Canada

# Space Weather Forecasting

Canadian Space Weather Forecast Centre  
NRCan Canadian Hazards Information Service

Government of Canada / Gouvernement du Canada

Space Weather Canada  
www.spaceweather.gc.ca

Home > Services

**Services**

- What is Space Weather?
- Space Weather Forecast
- Data and Services

**Information**

- Effects on Technology
- Principles of forecasting
- More Information
- F.A.Q.
- About Us

**External Links**

- Geomagnetism
- NRCan
- CSA
- Proactive disclosure
- RSS Feeds

**Geomagnetic Activity**

	Current Conditions	24 Hour Forecast	24 to 48 Hour Forecast
<b>Polar</b>	■	■	■
<b>Auroral</b>	■	■	■
<b>Sub-auroral</b>	■	■	■

**Current Conditions**

- Polar: unsettled
- Auroral: quiet
- Sub-Auroral: quiet

**24 Hour Forecast**

- Polar: quiet+ unsettled intervals
- Auroral: quiet
- Sub-Auroral: quiet

**Review and Forecast**

24 Hour Review

**Near-Earth environment**

	Current Conditions	Day 1 Forecast	Day 7 Forecast
<b>GEOS</b>	■	■	■

**Current Conditions**

- electron fluence at geostationary orbit: moderate

**Day 1 Forecast**

- electron fluence at geostationary orbit: normal

**Energetic Electron Fluence**

Fluence (electrons/cm<sup>2</sup>-sr-day)

10<sup>0</sup> 10<sup>1</sup> 10<sup>2</sup> 10<sup>3</sup> 10<sup>4</sup> 10<sup>5</sup> 10<sup>6</sup> 10<sup>7</sup> 10<sup>8</sup> 10<sup>9</sup> 10<sup>10</sup>

2012-08-19 10:19 UT 2012-08-19 11:00 UT 2012-08-19 12:00 UT 2012-08-19 13:00 UT 2012-08-19 14:00 UT 2012-08-19 15:00 UT

Observed Forecast Current conditions: 15:00 UT

Current conditions based on data from: Canada

Government Operations Centre



Critical Infrastructure Operators



# Space Weather Canada Twitter Feed

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Canada

TWEETS 1,649 FOLLOWING 10 FOLLOWERS 2,123 Follow

**Space Weather Canada** @SpaceWeatherCA  
#Geomagnetic activity in #Canada.  
Terms of use: [ow.ly/sjOBH](#) Français: @MeteoSpatialeCA  
Canada  
[spaceweather.gc.ca/index-eng.php](#)  
Joined July 2012

**Tweets Tweets & replies**

 **Space Weather Canada** @SpaceWeatherCA · 4h  
12 Feb 12:15 UT STORMY geomagnetic activity currently observed: auroral zone [goo.gl/UijKmW](#)

 **Space Weather Canada** @SpaceWeatherCA · 14h  
12 Feb 02:15 UT STORMY geomagnetic activity currently observed: auroral zone [goo.gl/UijKmW](#)

 **Space Weather Canada** @SpaceWeatherCA · Feb 9  
9 Feb 11:30 UT STORMY geomagnetic activity currently observed: auroral zone [goo.gl/UijKmW](#)

**New to Twitter?**  
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**You may also like · Refresh**

-  **Space Weather** @spaceweather
-  **AuroraMAX** @AuroraMAX
-  **Dr. Tamitha Skov** @TamithaSkov
-  **SpaceWeatherLive** @\_SpaceWeather\_
-  **Aurora\_Alerts** @Aurora\_Alerts



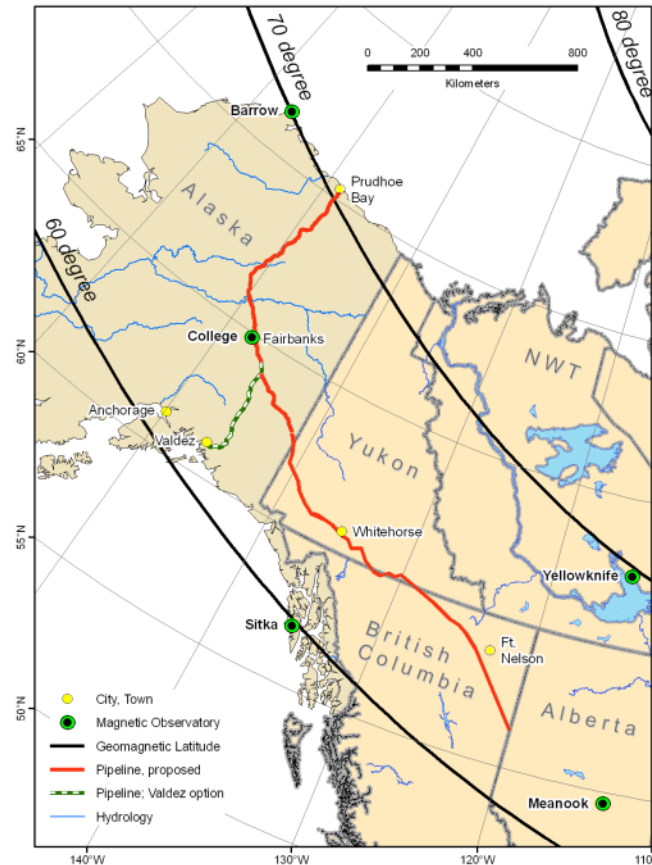
# Hazard Assessment for Critical Infrastructure

**Risk:** Pipeline Corrosion, corruption of surveys



**Mitigation:**  
Incorporating geomagnetic hazard assessment into pipeline design

*DRAFT 24 June AKPipe4*



## Online service for pipeline operators

**Space Weather Canada - Pipeline Service**  
Sample Pipelines

Pre-defined options are straight East-West pipeline, straight North-South pipeline, pipeline with one bend or pipeline with 5 sections. Total length of each sample pipeline is described below, electrical properties and dimensions are default values.

**SITE: OTT**  
**PIPELINE CHARACTERISTICS**

**Electrical properties are:**

Steel Resistivity (Ohm-m)	12x10 <sup>-6</sup>
Coating Conductance (S/m <sup>2</sup> )	1x10 <sup>-6</sup>

**Termination time-dates are:**

Starting End	Low, 0.1 Ohm
Ending end	Low, 0.1 Ohm

**Pipeline Dimensions are:**

External Diameter (m)	0.324
Wall Thickness (m)	0.007
Coating Thickness (m)	0.0007

**Directions:**

450 km from East to West, then 450 km from South to North	900 km from East to West	450 km from South to North, then 460 km from East to West
900 km from South to North	a more realistic pipeline	



**NRC-CNRC**

From *Discovery*  
to *Innovation...*

# NRC F10.7 solar flux measurements

- F10.7 solar flux is an excellent proxy to the sunspot number and solar activity
- The National Research Council performs world standard measurements since 1947



National Research  
Council Canada

Conseil national  
de recherches Canada





# Canadian Space Agency

- Ground-based Measurements
- Space Missions
- Government and Industry Support
- Academic Development





# Geospace Observatory (GO) Canada

- Ground measurement arrays – open data
- 10 projects
- 5 Universities
- Magnetometers
- SuperDARN
- Ionosondes
- Ionospheric scintillation
- Auroral Observations
- Riometers
- VLF receivers
- Neutral wind measurements





# THEMIS ground instrument operation

- NASA / Time History of Events and Macroscale Interactions during Substorms
  - Launched in 2007
  - 3 satellites
- NASA performs satellite measurements
- CSA performs ground-based measurements
  - University of Alberta – Ian Mann
    - Magnetometers
  - University of Calgary - Eric Donovan
    - Ground Based Observatories



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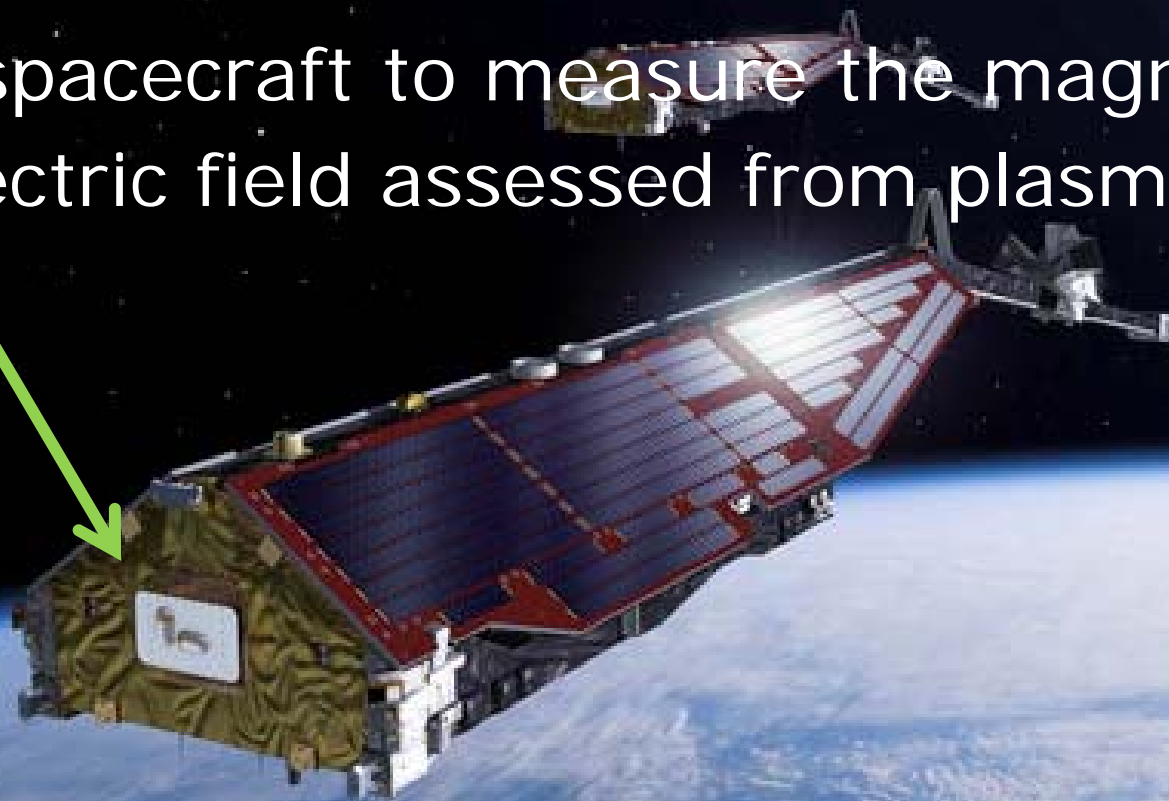
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# SWARM Electric Field Instrument

- ESA Swarm mission – Launched 2013
- 3 spacecraft to measure the magnetic field
- Electric field assessed from plasma drift



• University of Calgary – David Knudsen



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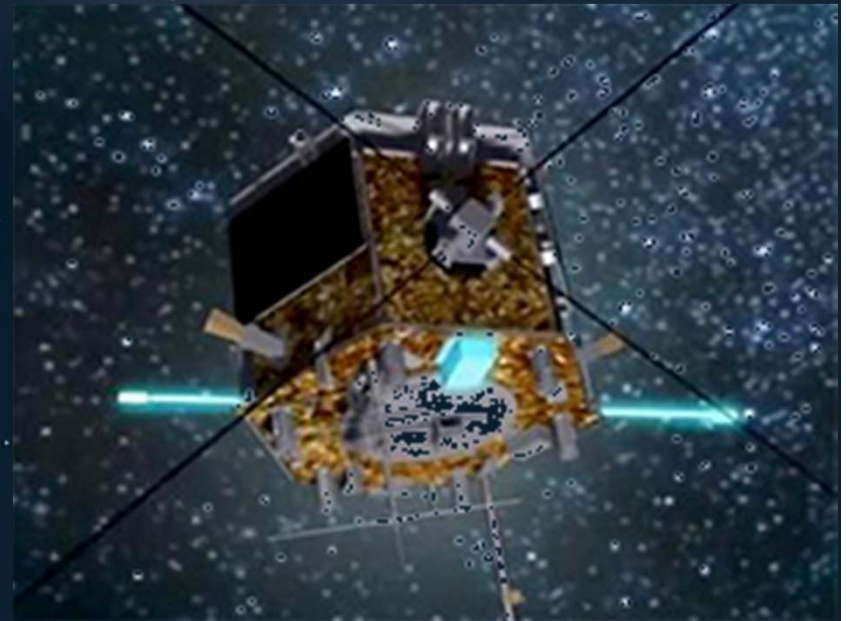
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# Enhanced Polar Outflow Probe

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- CASSIOPE Satellite
  - Owned by MDA
  - Launched in 2013
  - Operated by the University of Calgary – Andrew Yau
- Studies space weather
  - Magnetic field
  - Particles
  - Radio waves
  - GPS
  - Aurora Imaging





# Supported Research Projects

- Science and application grants
- Academic Development
  - CaNoRock Canada Norway student sounding Rocket exchange program
  - Energetic Particle Explorer (EPEX)
  - MAGnetometer Integrating Controlled Attitude with Low-noise Science (MAGICALS)
  - Multipoint In-situ Magnetometers on the ICI Rocket (MIMIR)
  - Balloon Observations of X-rays for Research and Education (BOXER)
  - Airborne Balloon Observations of VLF waves and Electrons over the Array for Broadband Observations of VLF-ELF Emissions (ABOVE2)



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# Geomagnetically Induced Currents work supported by CSA

- Magnetometer Arrays

- CARISMA
- AUTUMN
- THEMIS

- GIC studies

- University of Alberta:

- Substorm triggering and advances in large GIC specification and forecasting using GO Canada data

- University of Calgary

- Canadian geomagnetic variability - past present, and prediction



# Questions?



Canada