




# Canadian Space Environment Program and International Living With a Star

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W. Liu, CSA Program Scientist for Space Environment

**Canada** 



# Contents

- ILWS Through the Canadian Lense
- Canadian Capabilities & Contributions
- Potentials and Possibilities
- Keep ILWS Well-Grounded



# What Makes ILWS New

- ILWS emphasizes Systematic Study of the Sun-Earth System
- From
  - *Domain physics* – figure out how the parts work (pre-ILWS)
- To
  - *Inter-domain physics* – figure out how parts integrate and interact, and ultimately how the whole machine works (ILWS)





# Challenges

- Wide fleet dispersal vs narrow time window
- Decreasing real \$ vs increasing cost to tackle new problems
- Makes International LWS a natural solutions
- Major tasks facing ILWS WG
  - Participation
  - Coordination
  - Data Cooperation



# Parts to be Integrated

- Sun and Heliosphere
  - Solar interior, corona, solar wind...
- Magnetosphere/Radiation belts
  - SWM interaction, particle transport, acceleration, precipitation ...
- Upper Atmosphere/Ionosphere
  - Outflow, interaction with neutrals, climate impact ...
- Ground-based
  - Structures and dynamics on different scales, GICs and other s/w effects, truthing and context of s/c...



# CSA Program Strategy

- Nationally
  - Combine national resources to build national projects of critical mass
- Internationally
  - Use national projects as core contributions to ILWS
  - Seek leverage opportunity to reach new fronts
  - Use as "bank shot" to increase awareness and appreciation of space science in Canada

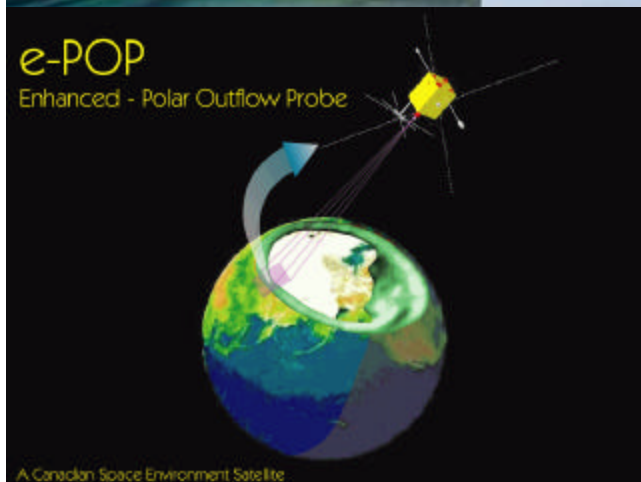


# Thrusts & Activities

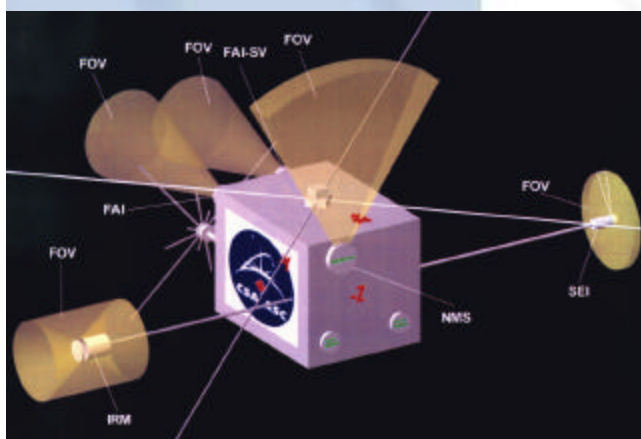
- Science:
  - Physics @ geospace/atmospheric interface
  - Integrated ground multi-instrument array with multiscale capability (1-1,000 km)
- Two national collaborative projects have emerged:
  - Enhanced Polar Outflow Probe (ePOP) for the study of wave-particle interactions associated with mass loss from the polar ionosphere
  - Geospace Monitoring, an integrated ground-based array, five times as large as CANOPUS



# ePOP



- Phase A to be completed by March 03 (launch ~05/06)
  - A one-year small satellite mission in an inclined ( $\sim 70^\circ$ ) elliptical ( $\sim 300 \times 2000$  km) polar orbit
  - Seven scientific payloads
  - Primary science objective: Acceleration of ion outflow and its effects on neutrals
  - Secondary science objective: Ionospheric tomography using space-ground radio propagation

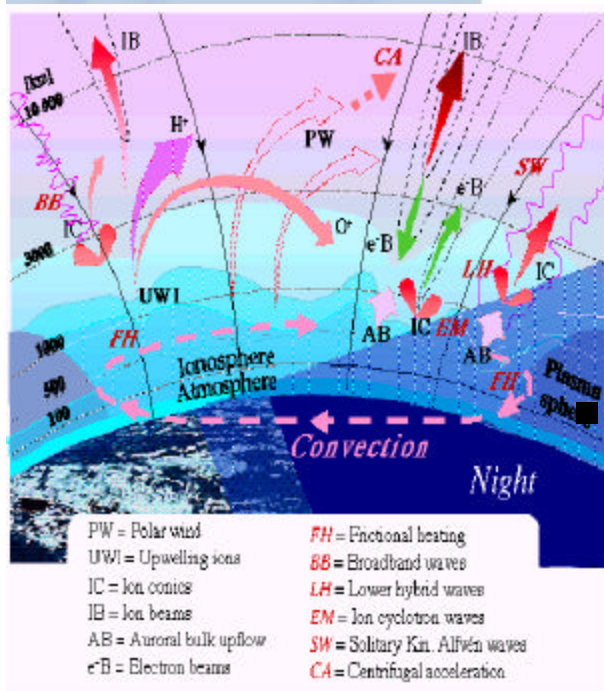




# ePOP Particle Physics

## ■ Micro-physics @ ~10 m scale, by measuring

- Ion distribution between 1 and 100 eV and 1-40 amu @ 10 ms resolution
- Electron distribution between 2 and 200 eV @ 10 ms resolution
- Neutral species distribution
- Fast auroral imager

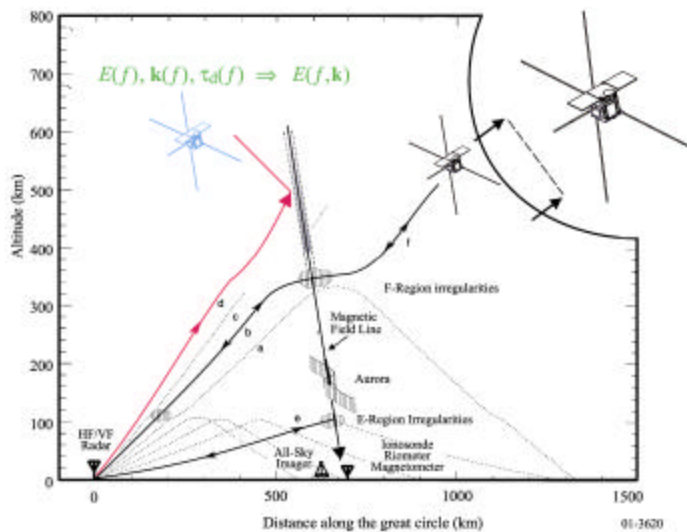


## Science Questions

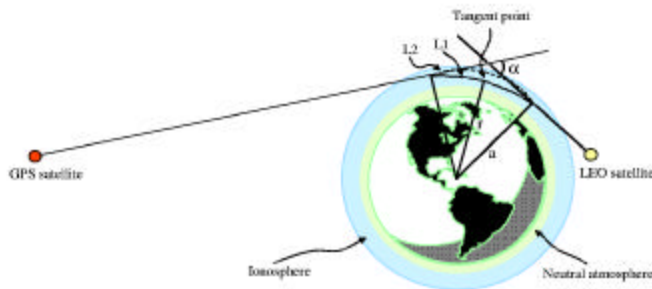
- How are charged particles accelerated by ionospheric waves?
- How strongly do accelerated ions drag neutrals upward?
- The ionosphere as a source of magnetospheric particles
- New 'collisionless physics', if outflowing ions were found to interact strongly with neutrals



# ePOP Radio Physics



- 100-30 kHz: local VLF waves
  - Help identify the acceleration mechanism
- MHz: wave propagation to s/c from ground radars and ionosondes
- GHz: GPS occultation and beacon
  - Tomography of ionosphere





# Geospace Monitoring

- Is an integration of all Canadian ground-based experiments, including CANOPUS
  - Solar radio monitoring
  - Enhanced (4×) CANOPUS magnetometers
  - NORSTAR auroral imaging array
  - Canadian SuperDARN and CADI
  - Center for Data Assimilation and Modeling
  - Canadian Space Weather Forecast Service
- CSA is aiming for real-time data delivery from >70 instruments in the array – space/w utility





# Solar Radio Monitoring

- Daily monitor of solar energy output by proxy (F10.7)
  - Superseded by recent Sun-observing techniques, but is more widely used and inexpensive to operate
  - Has over 50 years of data for climatological analysis, unmatched by s/c data
  - Canada is the sole producer of the data

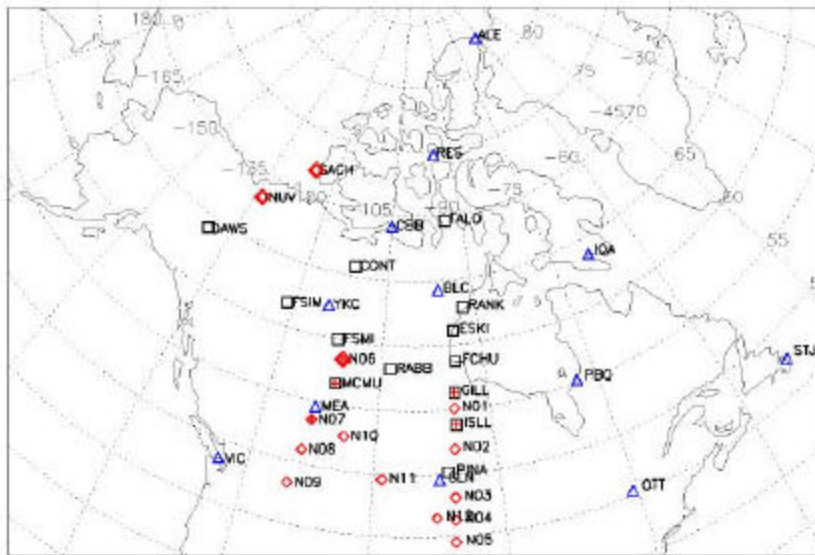


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# Enhanced Magnetometer Array

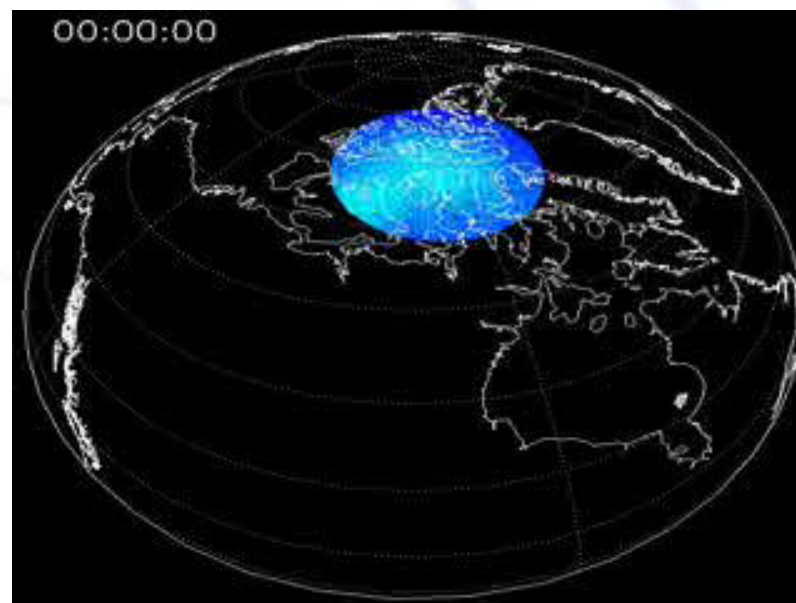
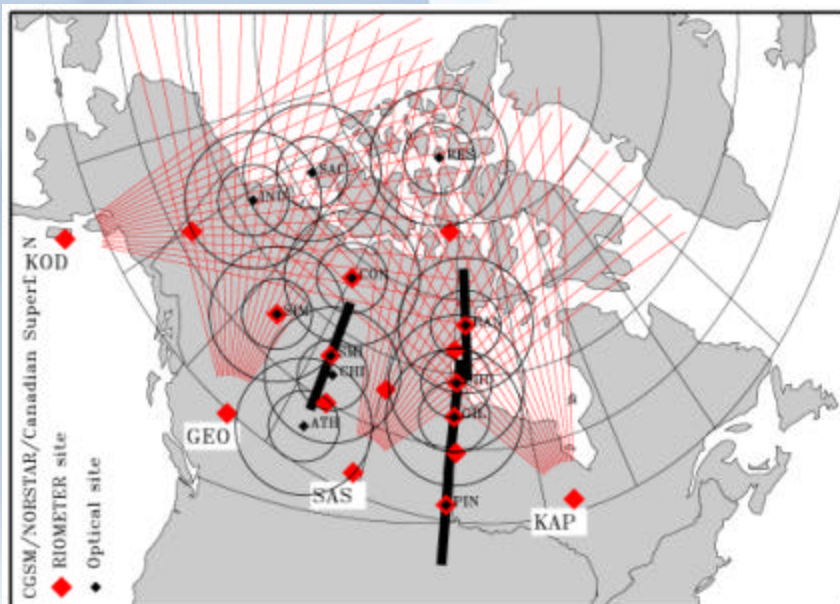


- CANOPUS magnetometer
- △ NRCAN magnetometer
- ◇ Proposed new fluxgate magnetometer site
- ⊕ Proposed new pulsation magnetometer
- Piggy back site

- Global magnetospheric waves and derivative information
  - New array has nearly 50 magnetometers, as opposed to CANOPUS's 13
  - Two complete chains for comprehensive MLT comparison and plasmasphere to psbl coverage
  - Much improved co-coverage with other instruments



# Ground-based Imaging



- NORSTAR will cover most of Canada with 10 all-sky imagers. On the right is a foretaste from 3. The goal is to use the precipitation pattern to remote-sense magnetospheric structures and dynamics

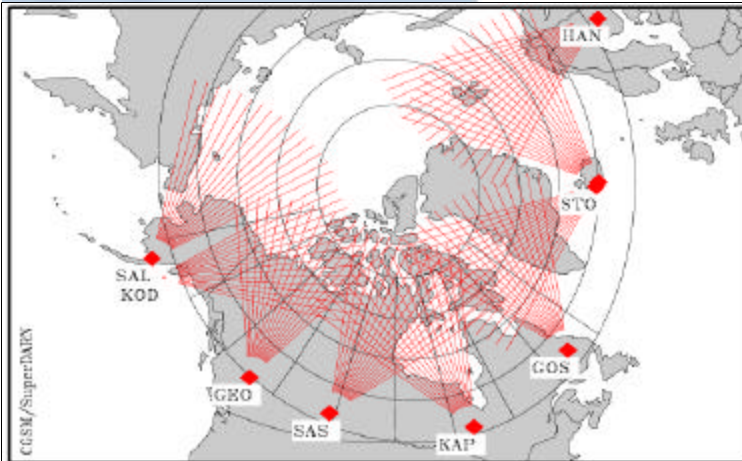
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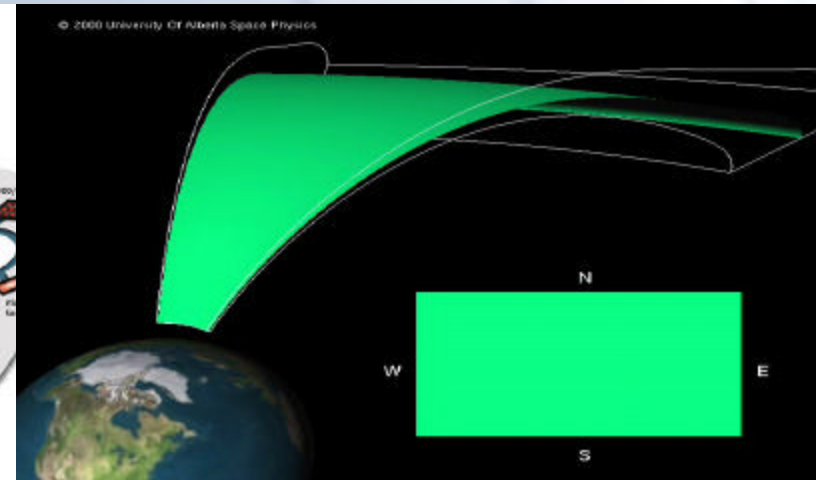
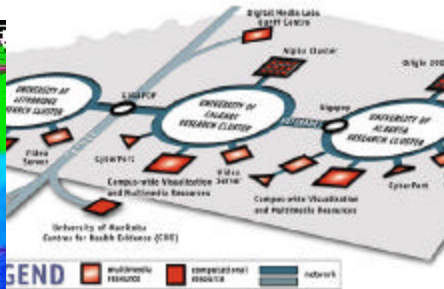
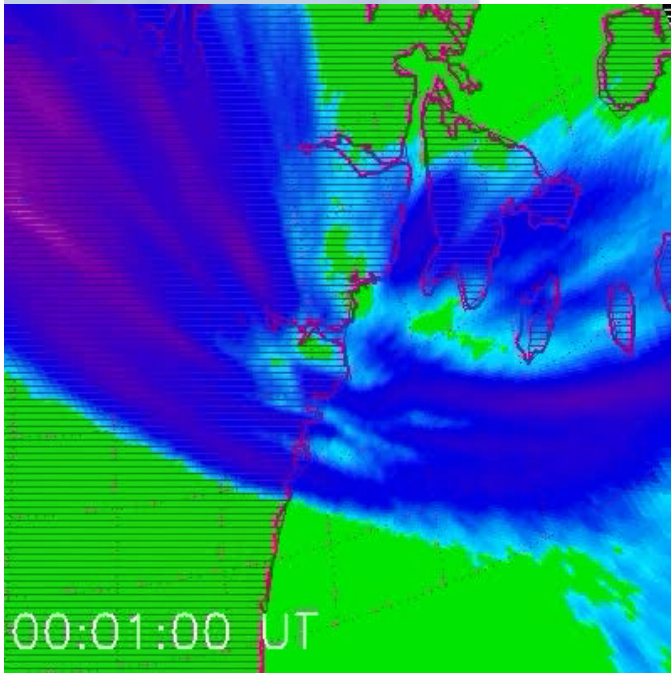
# Canadian SuperDARN/CADI

- Global energy circulation
  - 4 of the 9 northern radars are based in Canada
  - U. Saskatchewan is the data copy center and operation schedule manager
  - Nine ionosondes @ polar cap boundary to complement radars





# Data Assimilation and Modeling



- CSA has full access to a major CFI funded HPC and data grid facility for global-multiscale modeling and TB-level online data storage and manipulation.
- Integration of this element into Geospace Monitoring provides a fast track for Data (left)-Theory (right) Convergence





# Canadian S/W Forecast Service

Canada

Natural Resources Canada / Ressources naturelles Canada

Canada

Francais | Contact us | Help | Search | Canada Site

Space Weather | Earth's Magnetic Field | Geomagnetic Laboratory | Canadian Space Agency

Geological Survey of Canada

**Space Weather Canada**  
ISSES Regional Warning Centre for Canada

Geomagnetic Field - CURRENT STATUS 2002 08 26 18:45 UT

Polar	Active	
Auroral	Unsettled	
Sub-auroral	Quiet	Latest Forecast

The Canadian Space Weather Forecast Centre in Ottawa is operated by [Natural Resources Canada](#), with support from the [Canadian Space Agency](#). It is a Regional Warning Centre (RWC) of the International Space Environment Service (ISES, formerly IUWDS). The ISES global network monitors a variety of parameters that help to characterize the conditions on the Sun, in space between the Sun and Earth, and on the Earth. The data are used by Regional Warning Centres and others to develop Space Weather warnings and alerts.

**Regional Geomagnetic Conditions**  
Real-Time Reports and Forecasts

- Eastern North America
- Southern prairies
- Southwestern Canada
- Northern prairies
- Eastern auroral region
- Central auroral region
- Western auroral region
- Latest Data From Canadian Magnetic Observatories

**Short Term Magnetic Forecasts**

- Tabular - Three Zone
- Map - Three Zone
- Graph - Three Zone
- Graph - Multi-Station

**Long Term Magnetic Forecasts**

- Forecasts
- Review of past activity

**Latest Forecast**

HOME  
Geomag HOME

More SpaceWeather Information

- LASCO Images
- Maps of Coronal Holes
- ACE plots

Solar 10.7 cm Radio Flux, Penticton, Canada

- Latest Solar Radio Flux Report

Forecast of Energetic Electron Fluence

CANOPUS Real-Time Auroral Oval

CANOPUS Project

SuperDARN

- Operational web-based srvc ([www.spaceweather.ca](http://www.spaceweather.ca))
  - Supported by NRCan and CSA
  - 90,000 service requests/hits per year
  - Client services for power, pipeline, and commsat operators



# What Future Holds

- ILWS has Agency support
- However, must identify and justify new missions/initiatives
- Missions restricted to small satellite class and LEO
- What are the best opportunities for Canada? (Int'l input needed)



# In Space

- Contribute to the Ionospheric Mapper?
- Develop a separate small (micro) sat constellation with smaller ILWS agencies?
- A hybrid mission focusing on how space plasma processes impact the neutral atmosphere?
- ...



# In Between...

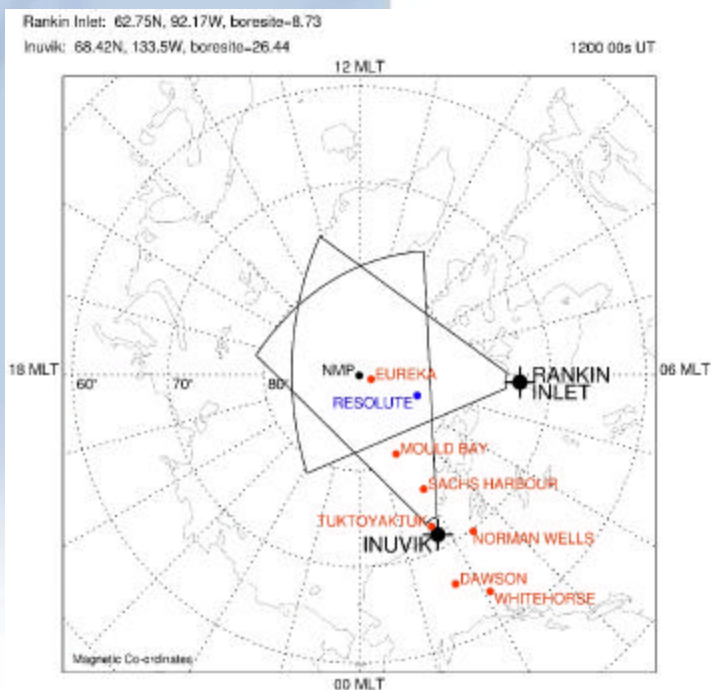


- THEMIS
  - 5 microsat constellation to sequence the "substorm genome"
  - Orbital conjunction with Canadian ground arrays
- Other possibilities include space/ground radio science



# On the Ground

- Polar cap is a coverage gap
- PolarDARN as part of an int'l Arctic initiative (in connection with, e.g., RAO/AMSIR)
- Existing ground networks in Canada, Scandinavia, Greenland, Antarctica, etc, should be better coordinated.





# Keep ILWS Well-Grounded

- ILWS must "leave no science behind"
- Ground-based science (include such grounded activities as theory and modeling) has a tremendous amount to add (whether space agency-funded or not)
- CSA willing to be the "special interest" voice for ground-based science within ILWS
- However, initiative and leadership must come from the community



# Things to Consider

- Implementation of a harmonized international ground-based data resource
- Coordinated operation of same-type instruments (e.g., magnetometers, solar observatories)
- Joint-operation of different instruments (i.e., develop a 1 Re Geosynchronous Satellite)



# Things to Consider

- Think of something new, drastic, and globally captivating to excite the community and Agency people alike
- Develop "ground-up" space mission proposals (i.e., space mission support ground observations, rather than the traditional paradigm)





# Concluding Remarks

1. ILWS's focus on systematic study is our best bet for major breakthroughs understanding the Sun-Earth System
2. Canada has important contributions to make, and is committed to making them
3. Ground-based science is an integral part of ILWS, and the community needs to develop new and creative ideas to give ILWS a solid ground to stand on.