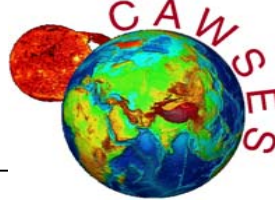




# CAWSES Space Weather Science & Applications Theme Report

Co-Chairs: Janet Kozyra (USA)  
Kazunari Shibata (Japan)

*IAGA Meeting, Toulouse, France  
July 23, 2005*



## **Theme 2: Space Weather Science & Applications**

*Co-Chairs: Janet Kozyra (USA) and Kazunari Shibata (Japan)*

### ***Overview Theme2 Panel: Sun-to-Earth System Science***

*Santimay Basu (USA), Walter Gonzalez (Brazil), Anatoly Petrukovich (Russia), Rainer Schwenn (Germany), Feng Si Wei (China) and R. Sridharan (India)*

### ***WG 2.1 Enhanced Resolution Worldwide GPS TEC Maps:***

*Working Group Leader: Anthea Coster (USA), M. Hernandez Pajares (Spain)*

*Membership: Santimay Basu (USA), Cesar Valladeres (USA), Catherine Mitchell (UK), Others In Process.*

### ***WG 2.2 CAWSES/IAGA/GEM Worldwide Magnetometer Observations:***

*Chair: Ian Mann (CANOPUS) Members: Ari Viljanen (IMAGE), Mark Engebretson (MACCS), Jeff Love (USGS), Mark Moldwin (MEASURE), Eftyhia Zesta (SAMBA), Kiyohumi Yumoto (210 MM) -- continuing to recruit additional magnetometer chains*

### ***WG 2.3 Solar Observations:***

*Chair: Nat Gopalswamy (USA), Bernie Jackson, S.T. Wu, Members: Need final list from Nat*

# Special Features of CAWSES Space Weather Theme, 2004-2008

Goal: Collaborative analysis of international sun-to-Earth data sets aimed at answering open questions in space weather understanding & prediction. Focus is on sun-Earth system behavior. Key to extending the range of useful space weather prediction.

Main Strategy: Sun-to-Earth campaigns (pre-planned, real-time based on delta sunspot or retrospective) driven by science questions

## New Feature:

- Progressive development of new global data analysis tools that require international collaboration
  - worldwide maps of geophysical quantities (ex: ULF wave power, hmF2, nmF2, high-resolution GPS TEC, etc.)
  - continuous time-series of solar observations (ex: continuous H alpha solar images)
- Use of new global data analysis tools in combination with other satellite & ground-based data in campaigns *to address science questions in ways that were not possible before.*

Capacity Building: Data sharing as a powerful capacity building exercise in developing nations. Puts local observations into the global view.

# Meetings & Workshops in 2004-5

- 11-12 Sept 2004 CAWSES & IAU symposium on “Coronal and Stellar Mass Ejections” in Beijing, China (Co-organized by Kazunari Shibata (Dr. Dasso from Argentina given partial support from CAWSES)
- 9-12 Nov 2004 Meeting in Japan between J. Kozyra, K. Shibata and Y. Kamide to discuss theme 2 working group structure & campaign plans
- 13-17 Dec 2004 Fall AGU Meeting, CAWSES-related session, “The Sun-Earth Connection: Superstorms and the Frontiers of Our Understanding”
- 31 Jan - 4 Feb 2005 Keynote talks at the Australian Institute of Physics meeting in Canberra,
  - Sunanda Basu, “The CAWSES Program”
  - J. Kozyra, K. Shibata, S. Basu, A. J. Coster, N. Gopalswamy, I. R. Mann and M. G. Mlynczak , Geospace system behavior from global observing campaigns, science at the core of the CAWSES space weather focus
  - Mlynczak, M. G., D. Marsh, R. Garcia, R. R11oble, F-J Lubken, J. Kozyra, and S. Basu, Expanding our knowledge and understanding of atmospheric ozone through CAWSES (Theme 3)

# Meetings & Workshops in 2004-5

- 23-27 May 2005 AGU Spring Joint Assembly, “Exploring the Global Response of the Sun-Heliosphere-Magnetosphere-Ionosphere-Atmosphere System, specifically addressing CAWSES and CAWSES-ICESTAR campaigns
- 27 Jun - 1 Jul 2005 “Coupled Geospace” workshop at CEDAR/GEM meeting in Santa Fe, NM focusing on the CAWSES campaign March/April 2004, the CAWSES/ICESTAR collaborative campaign on the Jan 2005 flare events, and others
- 5-9 July 2005 CAWSES-related session SP7, “Solar Flares and Coronal Mass Ejections” at the AOS (Asian Oceanus Society) meeting

# Update on CAWSES global maps & continuous solar time series - New International Research Tools

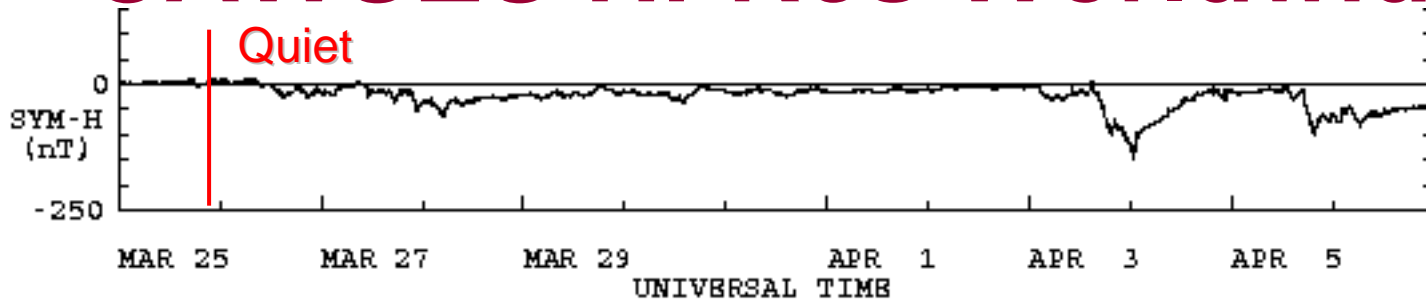
## First Results:

- CAWSES Hi-Res GPS TEC World Maps [Leads: Anthea Coster (USA) & M. Hernandez Pajares (Spain)]
- CAWSES/GAIM Assimilative Worldwide Maps of the Ionosphere [Lead: Jan Sojka, Utah State University]
- CAWSES/IAGA/GEM Worldwide ULF Wave Parameters [Leads: Ian Mann, Paul Loto'aniu, University of Alberta, CA]

## First Report:

- CAWSES Continuous H alpha Solar Observations Working Group, Hiroki Kurokawa (Chair), at theme 2 splinter meeting

# CAWSES Hi-Res Worldwide TEC



*Courtesy: Anthea Coster*

QuickTime™ and a  
Cinepak decompressor  
are needed to see this picture.

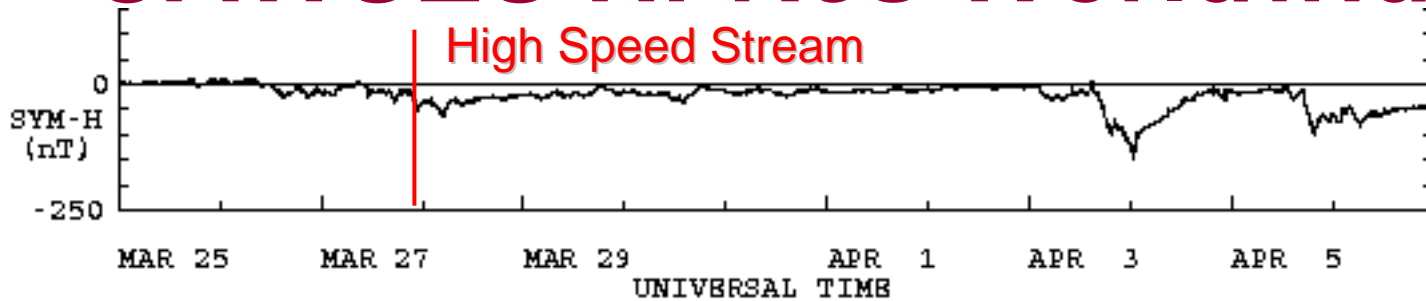
Big data  
gaps -  
oceans  
& SH

New  
GPS in  
Africa  
soon

Some Issues:

- Possible additional sources of real-time GPS (i.e., IGS, Suomi-Net, Canadian real-time differential network)
- Collaborations involving Australian data
- Critical need for observations over Africa - New progress in filling this gap
- Programs to provide GPS receivers & PC's in data gaps.

# CAWSES Hi-Res Worldwide TEC



*Courtesy: Anthea Coster*

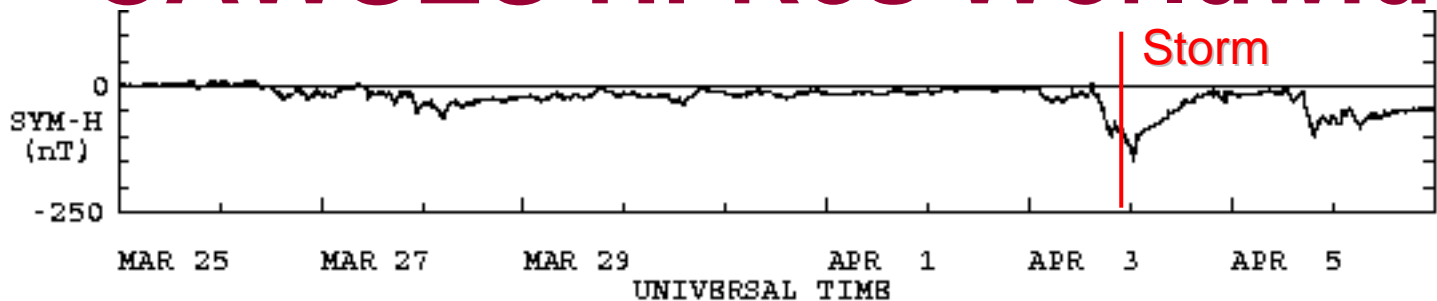
QuickTime™ and a  
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# CAWSES Hi-Res Worldwide TEC



Storm enhanced density (SED) *Courtesy: Anthea Coster*



QuickTime™ and a  
Cinepak decompressor  
are needed to see this picture.

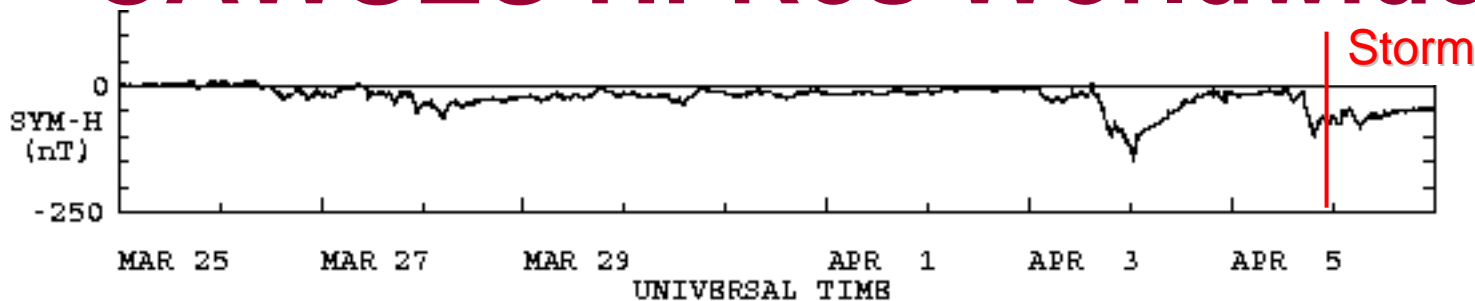
Enhanced  
dayside  
TEC



Some Issues:

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# CAWSES Hi-Res Worldwide TEC



## Some Issues:

- Possible additional sources of real-time GPS (i.e., IGS, Suomi-Net, Canadian real-time differential network)
- Collaborations involving Australian data
- Critical need for observations over Africa - New progress in filling this gap
- Programs to provide GPS receivers & PC's in data gaps.

Weak SED?



Courtesy: Anthea Coster

QuickTime™ and a Cinepak decompressor are needed to see this picture.

Strongly enhanced dayside TEC



# CAWSES/GAIM Assimilative Ionosphere Model. Fills in sparse data coverage with physical model.

QuickTime™ and a TIFF (LZW) decompressor are needed to see this picture.

QuickTime™ and a TIFF (LZW) decompressor are needed to see this picture.

- **GAIM uses TEC data to reconstruct the ionosphere from 90 to >2000 km globally**
- **Striking changes in the ionosphere over Jicamarca not predicted in ionosphere forecast model (IFM).**

High speed stream activity

Quiet

Storm1

Storm2

# CAWSES/IAGA/GEM World Magnetometer Maps

Chair: Ian Mann, Canada (CANOPUS)

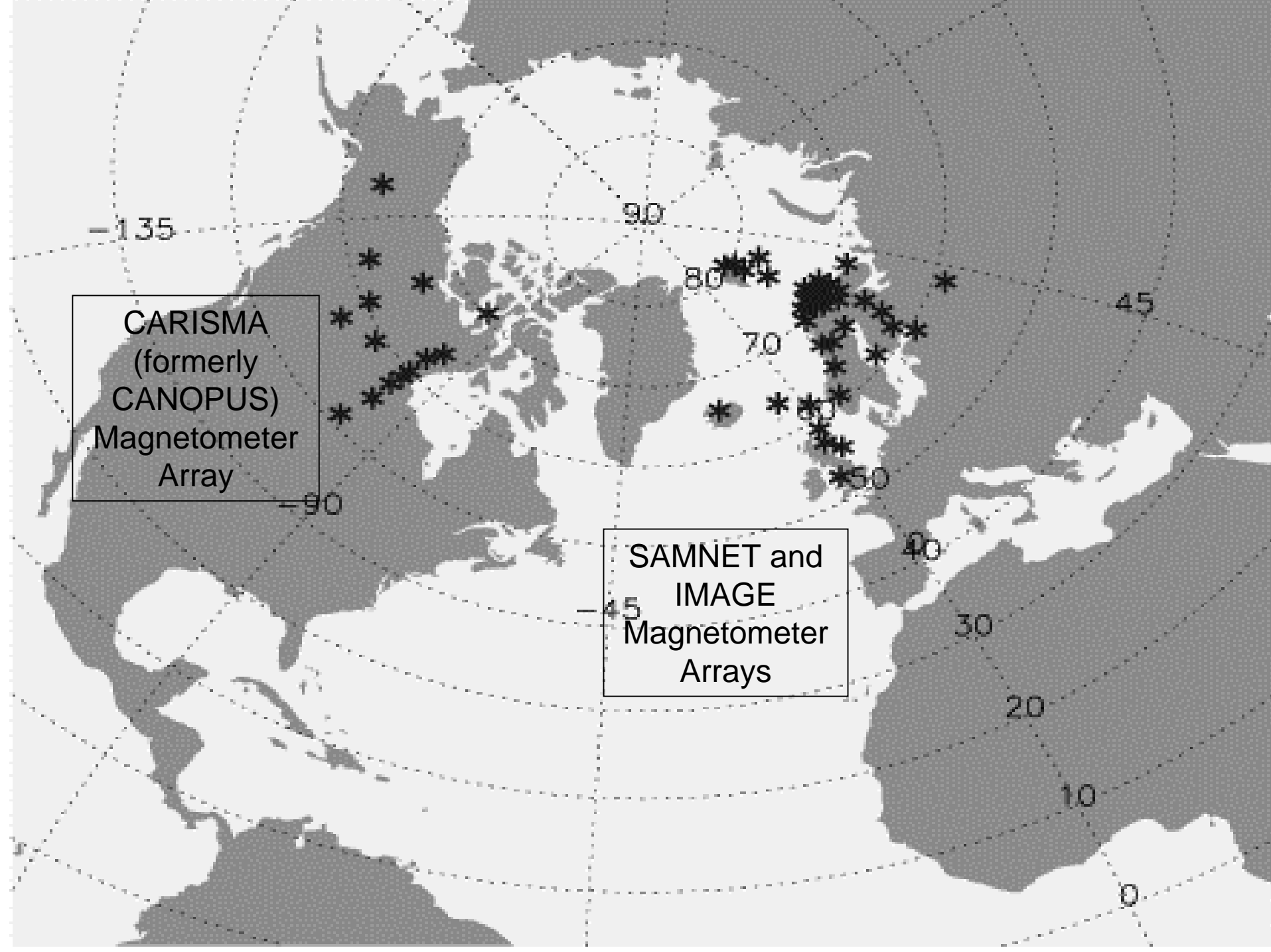
Members: Ari Viljanen (IMAGE), Mark Engebretson (MACCS), Jeff Love (USGS), Mark Moldwin (MEASURE), Eftyhia Zesta (SAMBA), Kiyohumi Yumoto (210 MM ).

First data product: ULF wave power distribution maps

Plans:

- Extend to include other arrays and stations
- Extend to create other magnetometer data products based on the time-series data.
  - new ULF wave indices
  - ULF magnetospheric density maps

Data Host: Space Sciences Data Portal (SSDP), University of Alberta (PI:Robert Rankin)

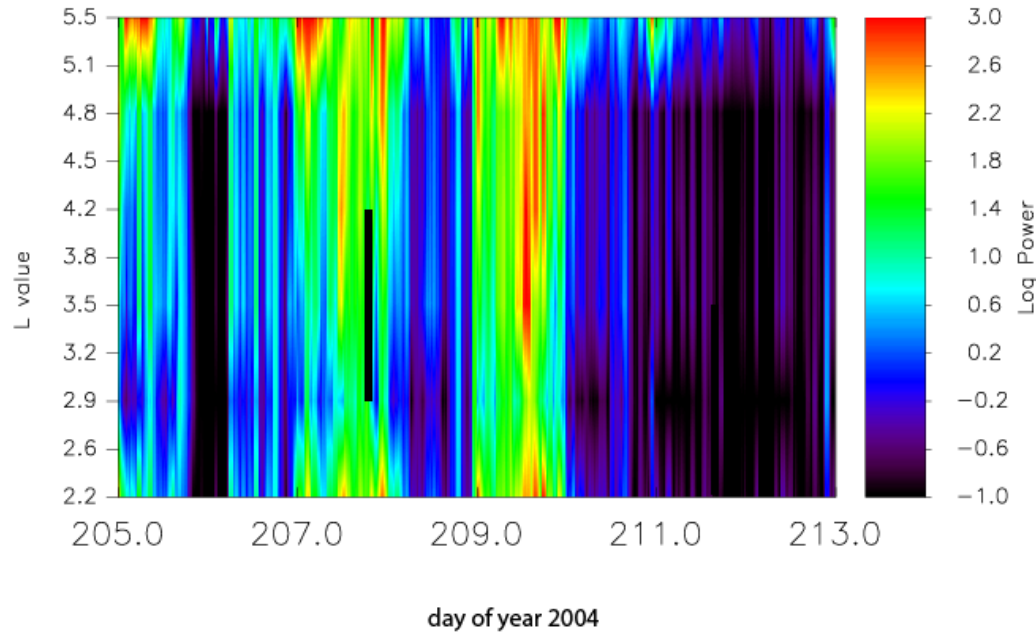


CARISMA  
(formerly  
CANOPUS)  
Magnetometer  
Array

SAMNET and  
IMAGE  
Magnetometer  
Arrays

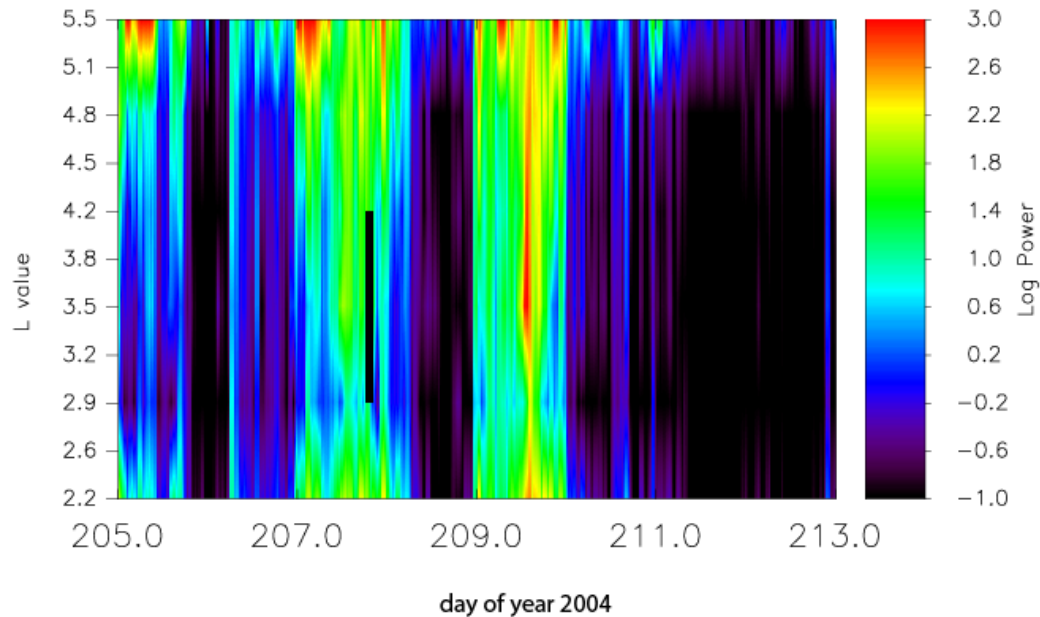
# July 2004 – ULF Power Confined to Higher L

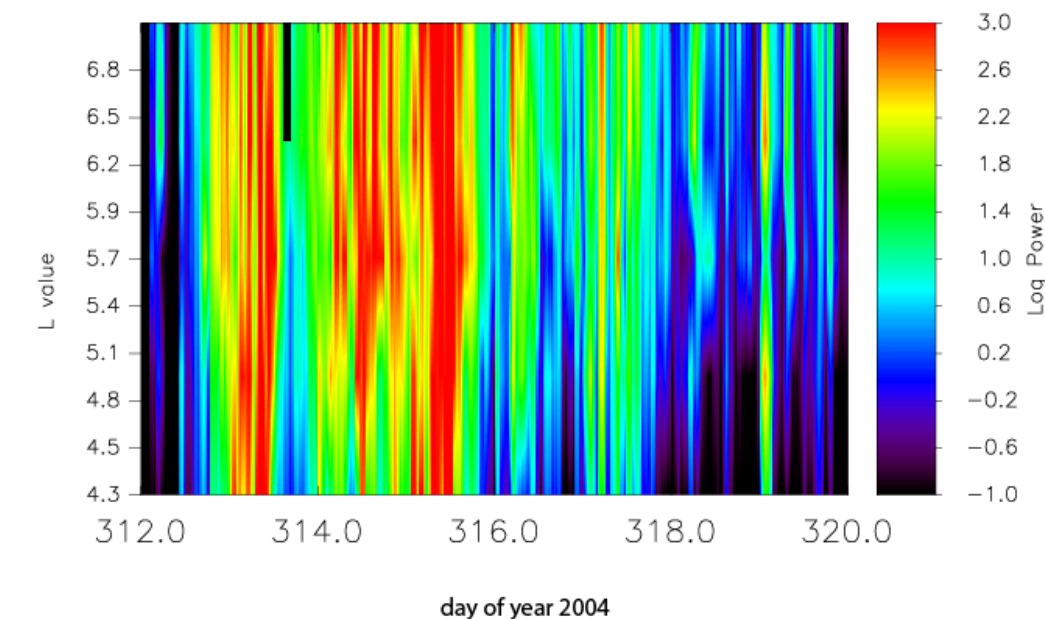
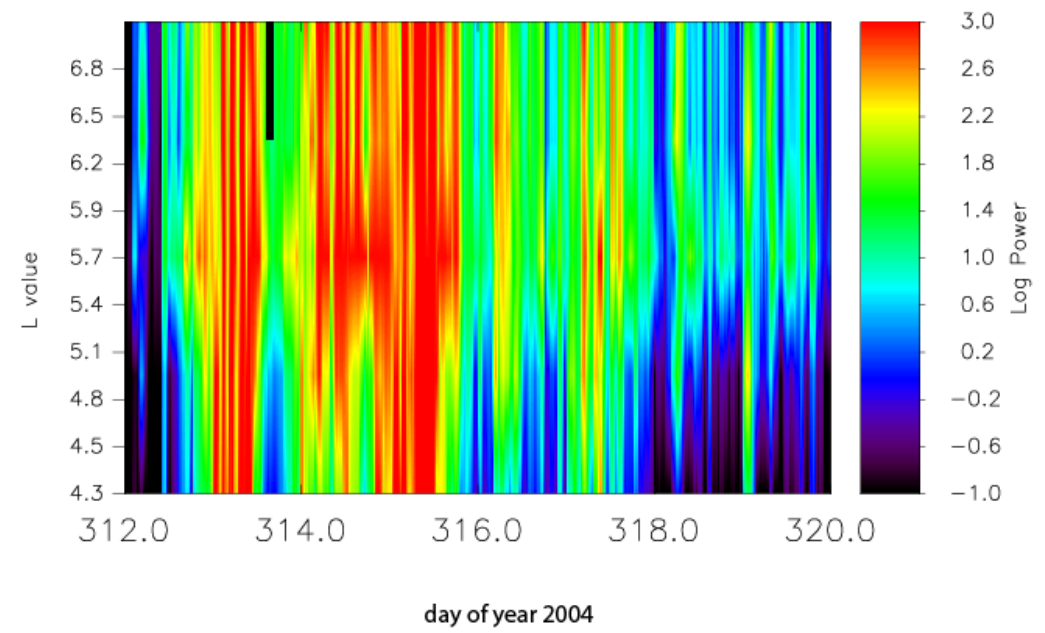
Total ULF Wave Power 63.77 L :2.24000–5.45000 Step:500 Slnt:1sec H 30/7/2004



Total ULF Wave Power 63.77 L :2.24000–5.45000 Step:500 Slnt:1sec

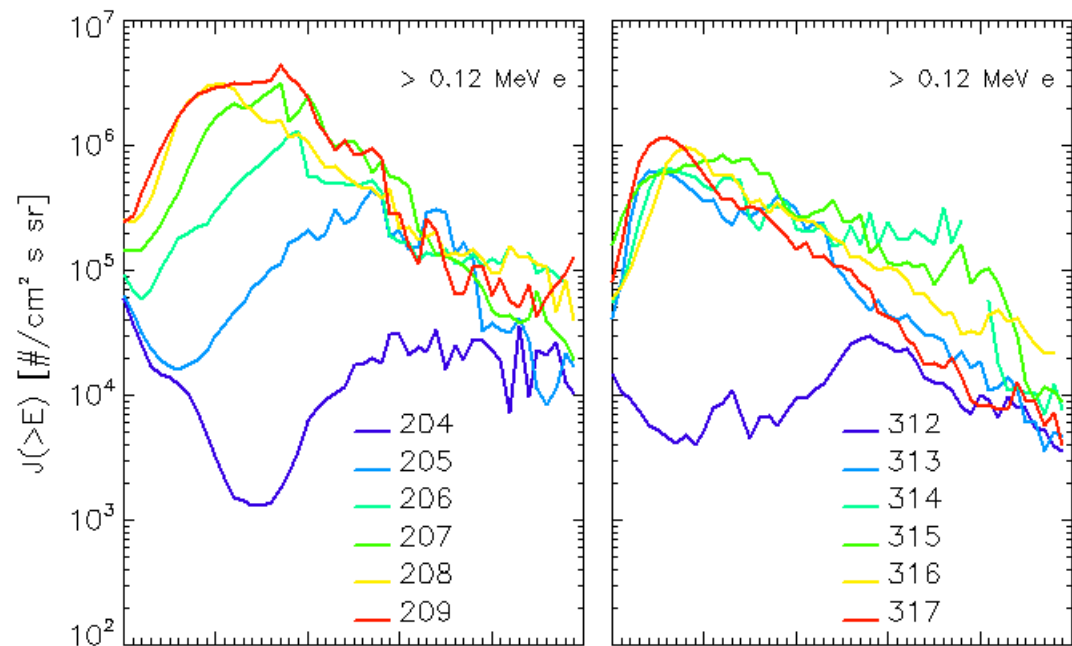
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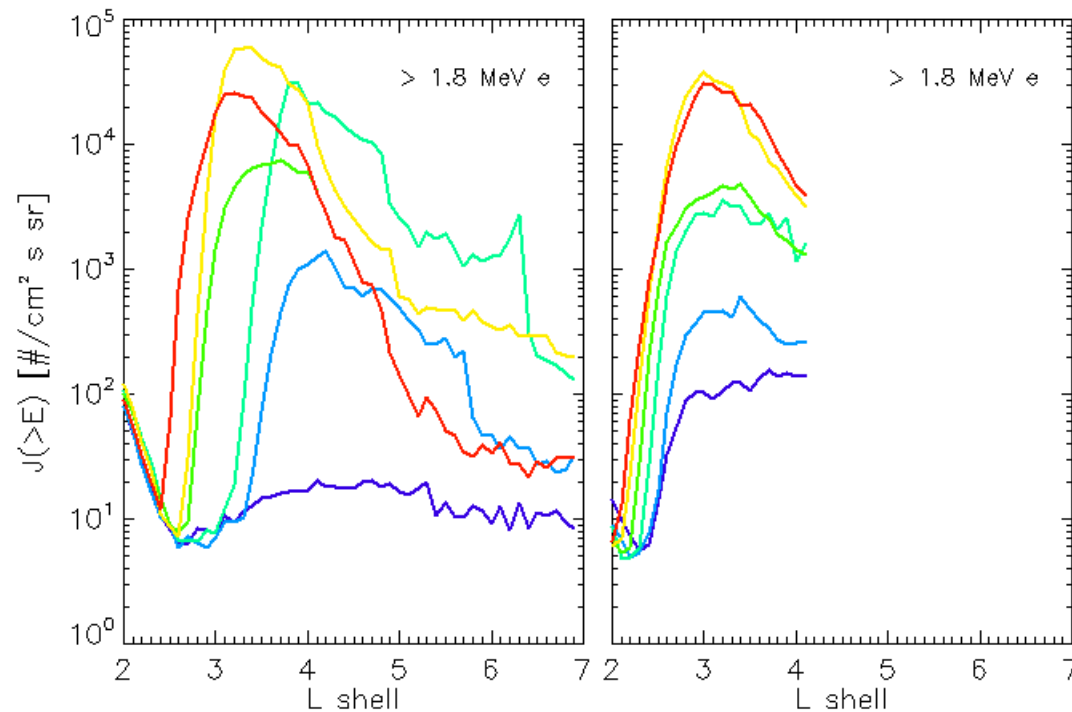


# November Low L-Shell Penetration of ULF Power

a) July – gradual  $> 1.8$  MeV flux rise towards lower L



b) November –  $> 1.8$  MeV flux rises at all L simultaneously





# CAWSES Space Weather Campaign

- **Analysis Plan:**

- ✓ **Phase 1 (completed):** Collect data during the campaign interval
- ✓ **Phase 2 (completed):** Construct global maps of important quantities:
  - CAWSES Worldwide Hi-Resolution GPS TEC Maps
  - CAWSES GAIM Worldwide Assimilative Ionospheric Maps
  - CAWSES/IAGA/GEM Worldwide ULF Wave Parameters
  - CAWSES Continuous H alpha solar observations
- **Phase 3:** Kick-off post-event analysis with virtual workshops to enable worldwide participation. Combine world maps with local observations to give them global context. Support international collaborations
- **Phase 4:** Archive sun-to-Earth data sets, global model runs, assimilative model runs

QuickTime™ and a  
TIFF (LZW) decompressor  
are needed to see this picture.

# CAWSES Space Weather Science and Applications

Worldwide Internet  
Workshops

Dates  
TBD

## Workshop Goals

- Assess the data collected by participants
- Identify key science issues
- Provide access to CAWSES worldwide space weather maps and continuous solar observations to address outstanding science questions in new ways
- Support worldwide collaborations

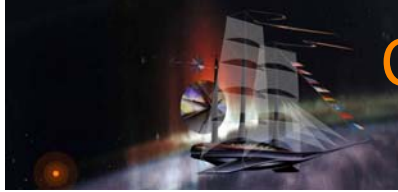
CAWSES March-  
April 2004 Campaign

CAWSES-ICESTAR  
15-24 Jan 2005 Long  
-Duration Flare  
Events

Collaboration with Johns Hopkins Applied Physics Lab, NASA LWS  
program, Community Coordinated Modeling Ctr

Website is under  
development at  
JHU/APL

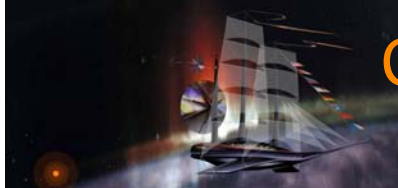
Examples follow of how  
the website was set-up  
for a previous workshop  
which had a virtual  
poster session as one  
component



# CAWSES Space Weather

Worldwide Internet Workshop

- Apply the virtual poster software developed by Rob Barnes to run at least two internet-only workshops open to all international participants.
  - Workshop 1: Data Exchange
  - Workshop 2: Major Science Issues
- Each workshop would be comprised of both invited and contributed posters arranged within a series of sessions that span 5 days - Members of theme panel and/or working groups would chair sessions, recruit participants.
- Rob Barnes' software allows for communication with authors through message boards and email exchanges.
- Authors would agree to respond rapidly to questions and comments during the day of their poster and as possible throughout the week of the workshop.



# CAWSES Space Weather

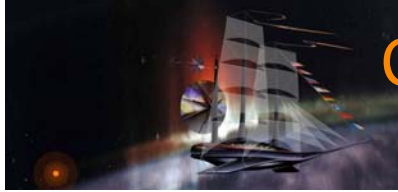
Worldwide Internet Workshop

- **Virtual Observatory Software collaborations:**

- Serve the comprehensive campaign data sets using virtual observatory software developed by Michelle Weiss (JHU/APL). Collaborate with eGY 2007 efforts for this aspect.
- Serve magnetometer data using the Virtual Global Magnetic Observatory (VGMO), developed at University of Michigan, in collaboration with the ICESTAR program (contacts: A. Ridley, V. Papitshvilli, V. Petrov)
- Need to inquire about possible collaboration with the Storms CDAW ??

- **Community Coordinated Modeling Center Collaboration:**

- Run sun-to-Earth community models for the campaign intervals
- Designing meta data files that describe the model inputs and version so that model runs can be replicated if needed
- Design and test new model output displays that are directly comparable to a selected set of observations (i.e., at the location of ground-based radars or along satellite trajectories in the same display format as the data)
- Provide mapping along magnetic fields lines from MHD models
- Provide standard outputs like magnetopause location, etc.
- Contact: Masha Kuznetsova (CCMC, NASA Goddard SFC)



# CAWSES Space Weather

Worldwide Internet Workshop

- **Participants:**

- International science community and more than 40 space and ground-based observing programs that participated in the CAWSES campaign

- **Some Key Observations in the March/April 2004 Campaign:**

- Unusual undulating auroral forms appeared during both of these moderate storm intervals along with triggering of equatorial bubbles [Larry Paxton]
- Development of prompt penetration electric fields [Dave Anderson]
- Storm enhanced density plume, and enhanced subauroral electric fields at Millstone Hill Radar [Chaosong Huang, John Foster]
- Highest levels of odd nitrogen ever observed by the UARS satellite (launched 1994) with corresponding depletions in ozone [Cora Randall, University of Colorado; James Russell III, Hampton University]
- CAWSES worldwide space weather maps of ULF wave parameters enables evaluation of their role in radiation belt energization

# Storms 2

Sun Earth Connections Workshop for the April 11-24, 2002 Storms

[INFORMATION AGENDA](#)

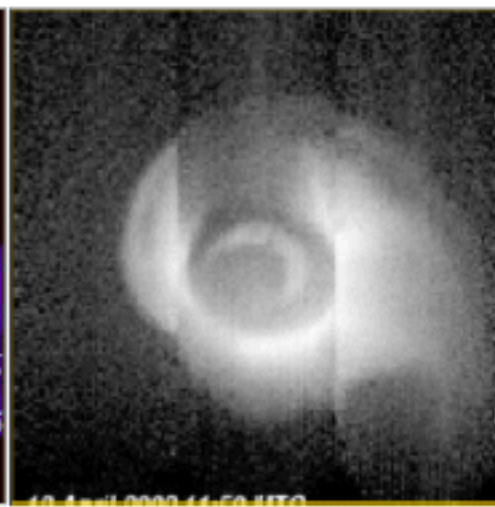
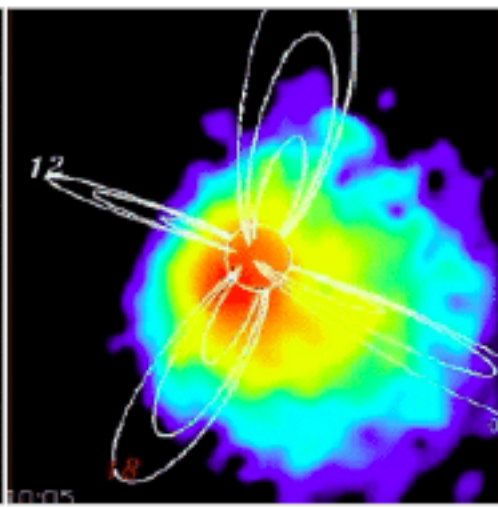
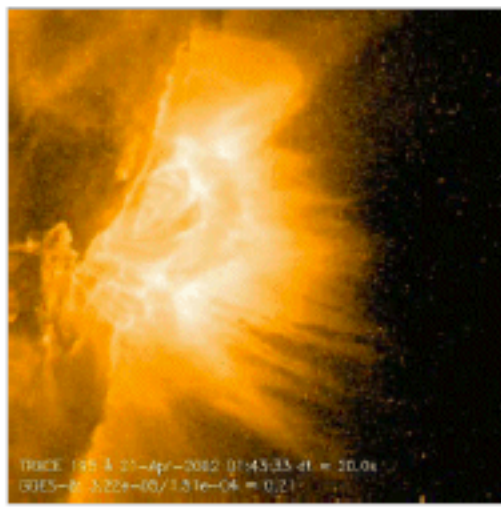
[ABSTRACT & POSTER SUBMISSION](#)

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# Storms Meeting Abstract and Poster Submission

**Please Note:** You must [register](#) for the meeting before you can submit an abstract.

Please fill in your email address below to begin the abstract and poster submission process.

E-Mail Address:

# Storms 2

Sun Earth Connections Workshop for the April 14-24, 2002 Storms

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SUBMISSION](#)

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## Virtual Poster Session

*Please note we have created message boards for each virtual poster. If you wish to contribute to the discussion please do so [here](#).*

### A Global Inventory of Energetic Particle Input to the Atmosphere during the Period April 14-26, 2002

**Authors:** D.S.Evans

**E-mail:** [David.S.Evans@noaa.gov](mailto:David.S.Evans@noaa.gov)

#### **Abstract:**

The NOAA POES Space Environment Monitor includes solid-state detectors that monitor the fluxes of radiation belt particles (electrons 30 keV to >1000 keV in three energy channels and ions 30 keV to 2500 keV in 4 energy channels) precipitating into Earth's atmosphere. A separate set of detectors monitor the fluxes of solar energetic particles over the energy range from 2500 keV to 140 meV in 6 energy channels. Observations made during the April 14-26 period by the NOAA-15 and NOAA-16 satellites were extracted and processed to create a global inventory of the energetic particle input to the atmosphere as a function of particle energy over the full energy range available. The inventory was made on a 3-hour time cadence and separately for the geographic northern and southern hemisphere. A power point display (the poster from the Fall, 2002 AGU meeting) explains the procedure used and shows a synopsis of the results of that procedure both for the magnetic storm interval of April 16-18 and the energetic solar particle event of April 21- 23. The complete inventory of energetic particle input to the atmosphere is currently in the form of matrices covering the latitude range above 30 degrees geographic latitude in one- degree intervals and full geographic longitude range in two-degree intervals. Each element in a matrix is the reconstructed particle (electron or ion) directional intensity within specific energy bands in units of particles cm<sup>-2</sup> sec<sup>-1</sup> ster<sup>-1</sup> for that geographic location. These results are available from SEC for every three-hour interval for the full 13-day period. A full day's set of data, for both the storm-day of April 17 and the solar particle event of April 21, are available at this workshop together with two FORTRAN programs designed to read and unpack those data files.

**Source Documents/Supporting Files:** [posters/Evans](#)

### The duskside Plasmapause "Undulation" of 17 April 2002

**Authors:** J. Golstein, J. Kozyra, A Mannucci

**E-mail:** [Jerry.Goldstein.Adv00@Alum.Dartmouth.ORG](mailto:Jerry.Goldstein.Adv00@Alum.Dartmouth.ORG)



[INFORMATION AGENDA](#)

[ABSTRACT & POSTER  
SUBMISSION](#)

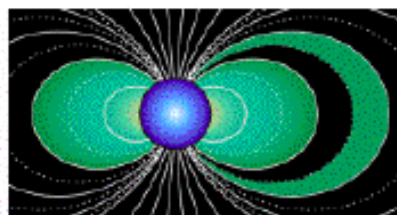
[ABSTRACT  
LIST](#)

[ONLINE PRESENTATIONS &  
POSTERS](#)

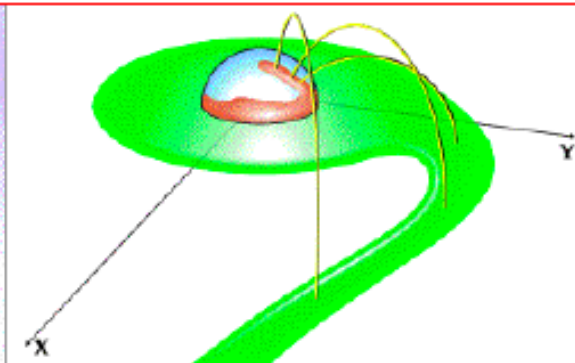
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BOARDS](#)

[PREVIOUS  
MEETINGS](#)

[Message Boards Home Previous 1 2 3 4 5 6 7 8 9 10 11 Next](#)



## The Duskside Plasmopause “Undulation” of 17 April 2002



J. Goldstein<sup>1</sup>, J. Kozyra<sup>2</sup>, A. Mannucci<sup>3</sup>.

<sup>1</sup>Southwest Research Institute

<sup>2</sup>University of Michigan

<sup>3</sup>Jet Propulsion Laboratory

# Collaboration with Theme 3

- Project: Understanding Atmospheric Coupling Processes Through Numerical Modeling
- Coordinators: Gang Lu, Maura Hagan, Art Richmond

## **Planned Activities:**

Numerical modeling using the TIME-GCM will be carried out for selected CAWSES campaigns. Data collection for the first CAWSES campaign of March 25-April 6, 2004, is currently under the way. Observations of ion drifts from HF and IS radars and satellites, magnetic perturbations from ground and satellite-borne magnetometers, auroral emissions from space and ground (such as meridian scan photometers) are all useful data inputs to AMIE to derive global maps of ionospheric electrodynamic fields during the campaign. The time-varying AMIE outputs will then be used as inputs to drive the TIME-GCM at the model's upper boundary. Diurnal and semi-diurnal tides from the GSWM will be used to specify the lower boundary of the model. In addition, the TIME-GCM runs will also be made using the NCEP as inputs. The model outputs will be made available to the CAWSES community to aid data interpretation and model validation.

Similar comparative model and data analysis effort will be carried out for other selected CAWSES campaigns.

# Value of CAWSES to IHY, eGY, IPY

- Progressively develop a set of new international data analysis tools
  - Valuable asset for space research
  - Combined with satellite data they give new ways of investigating important science questions
  - Lasting legacy after IGY celebrations
- Collect & preserve comprehensive sets of international sun-to-Earth observations
  - Valuable for developing assimilative space weather models
  - Important for testing understanding and predictive capabilities of sun-to-Earth models
  - Worldwide resource for sun-Earth system science during and after IGY
- Build up an international community familiar with campaign tools & collaborative analysis ready to participate in the IGY
- Help refine science questions and needs for worldwide campaigns over the next 2 years in preparation for the IGY celebration.

# Critical Joint Needs with IHY, eGY, IPY: Data Environment

Baseline Need: Seamless access sun-to-earth data sets worldwide (including developing nations) -- through Virtual Observatories?

## Wish List:

- High level, analyzed and interpreted data by instrument teams
- On-the-fly generation of integrated data products (world-maps, continuous time series) constructed by networks of worldwide observatories
- Summary data on a common time or spatial axis at vantage points throughout the geospace system
- Mapping between regions
- Tracking of science questions that develop
- Smart data searches (looking for similar features, similar events, statistics in Virtual Observatories)
- Model simulations as data sets
  - viewed along satellite trajectories
  - mapped to ground-based sites
  - Plotted with observations in common format
  - post-processed quantities (i.e., Poynting flux, B field energy, etc.)
- Support for assimilative models
- Secure proprietary data sharing for space weather user community

# Summary: Suggestions for CAWSES and I\*Y 2007 Collaborations

- Joint development of data environment & worldwide campaign analysis tools
- Collaborative effort to collect and archive comprehensive sun-to-Earth data sets during IHY.
  - NSF contribution: Request to run all ISR radars opportunistically during magnetic activity throughout 2007
  - International Space Agency contributions: Request to make available relevant satellite data during as many magnetically active periods as possible in 2007
  - CAWSES, ICESTAR, CEDAR and other programs: Recruit & coordinate worldwide ground-based contributions
  - CAWSES: Make available the set of new global ground-based analysis tools during magnetically active periods
  - IHY/CAWSES: Recruit large-scale model outputs & assimilative models as part of the archived data sets

# Summary: Suggestions for CAWSES and I\*Y 2007 Collaborations

- Comprehensive sun-to-Earth data sets would be an important worldwide resource and lasting legacy, freely available during and after the I\*Y for research efforts aimed at:
  - Focused science question within the global context
  - Sun-to-earth system science research issues
  - Design of new space missions
  - Identifying important gaps in ground-based arrays
  - Testing of design concepts for ground-based instrument arrays
  - Assimilative space weather modeling efforts
  - Verification of sun-to-Earth and large-scale space weather models
  - Testing of predictive capabilities of space weather models