

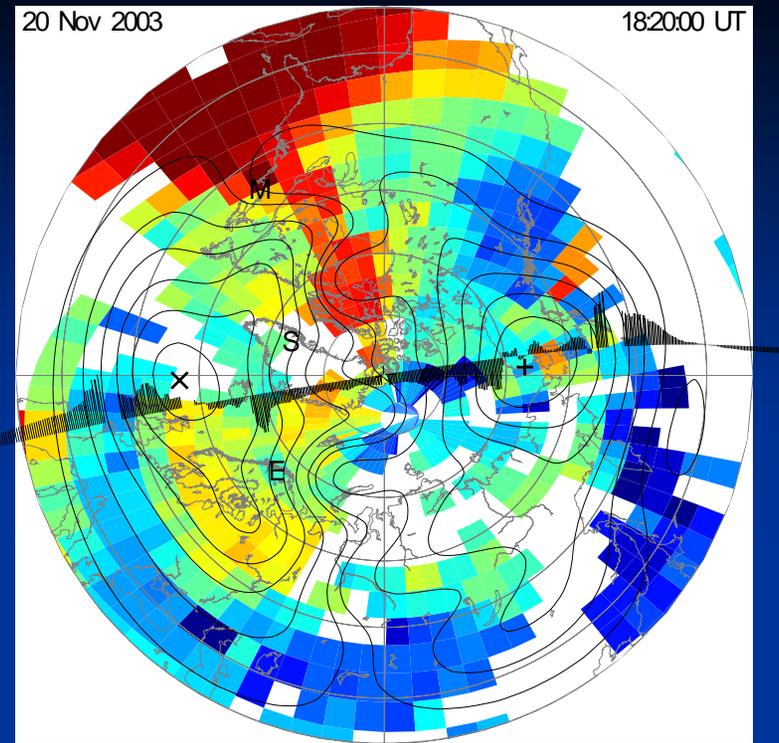
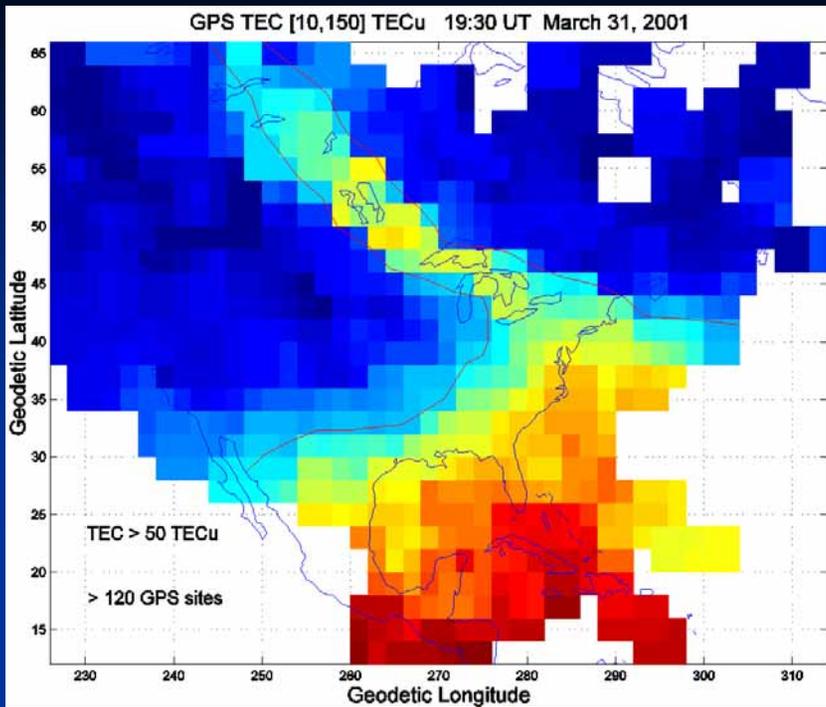


DASI

Distributed Arrays of Small Instruments

- GPS Receivers
- Optical Imagers
- Interferometers
- Ionosondes
- Scintillation and VLF Rx
- Tomography Receivers
- Solar Observations
- Magnetometers
- Passive & Active Radar
- Radio Receivers
- Riometers
- Neutron Monitors
- IPS Arrays
- Earth Current Monitors

Technology: ITR, Miniaturization
EPO Opportunities

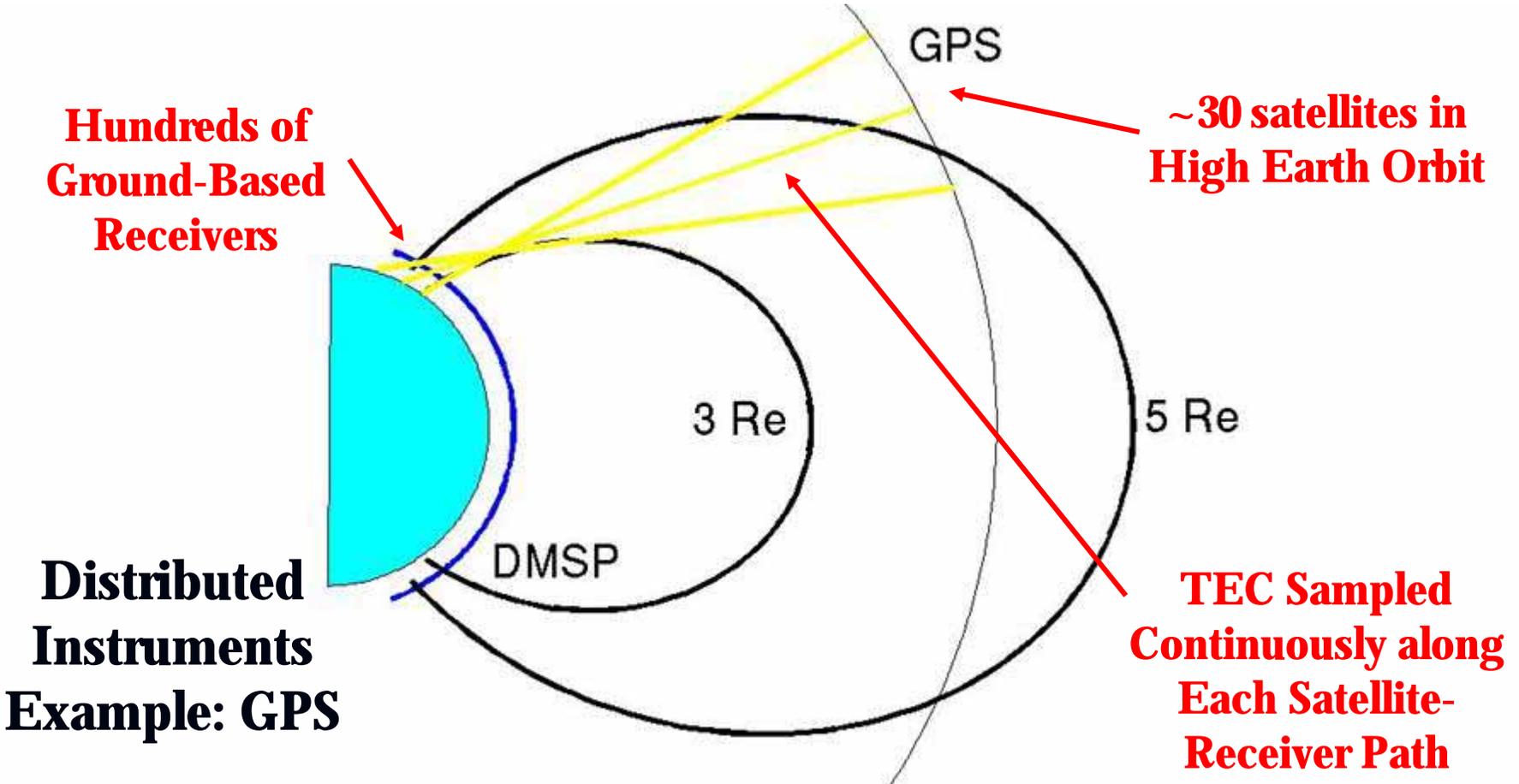


**CEDAR/GEM
Workshop
Geospace
System from
Ground and
Space**

DASI Overview

- The NAS Solar and Space Physics Decadal Survey has recommended that the **next major ground-based instrumentation initiative** be the deployment of arrays of space science research instrumentation
- DASI arrays will provide **continuous real-time observations** of Earthspace with the resolution needed to resolve mesoscale phenomena and their dynamic evolution
- Ground-based arrays will address the need for observations to support the next generation of **space weather data-assimilation** models
- The **time is right for DASI**: developing technology and IT systems support a new science capability

**GPS samples the ionosphere and plasmasphere to ~20,000 km.
Dual-frequency Faraday Rotation Observations give TEC
(Total Electron Content)**



TEC is a measure of integrated density in a 1 m² column

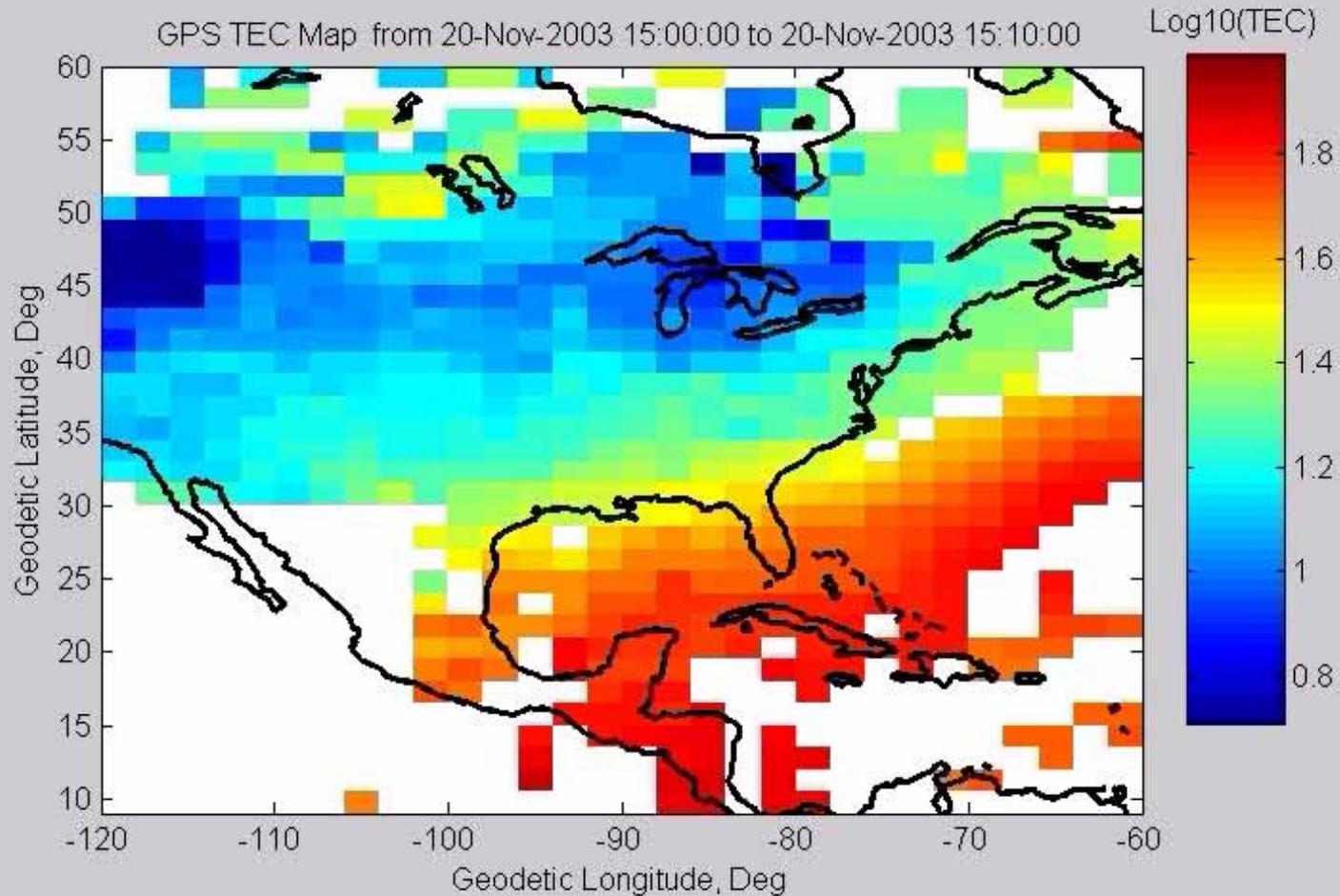
1 TEC unit = 10¹⁶ electrons m⁻²

Observations: GPS TEC

Day324  PM



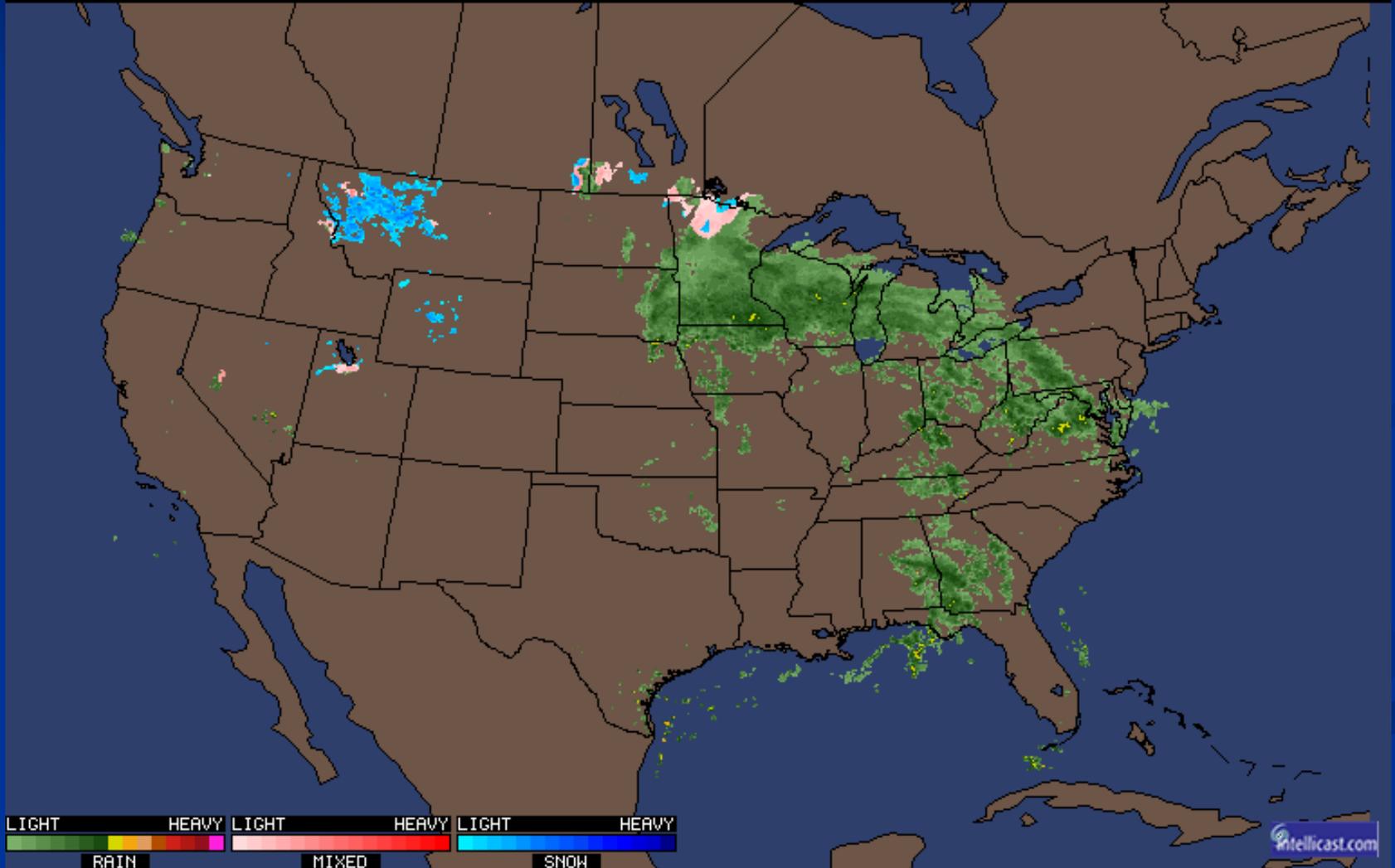
MIT Haystack Observatory



Today's Weather: NEXRAD

Observations of Meteorological Storm Front

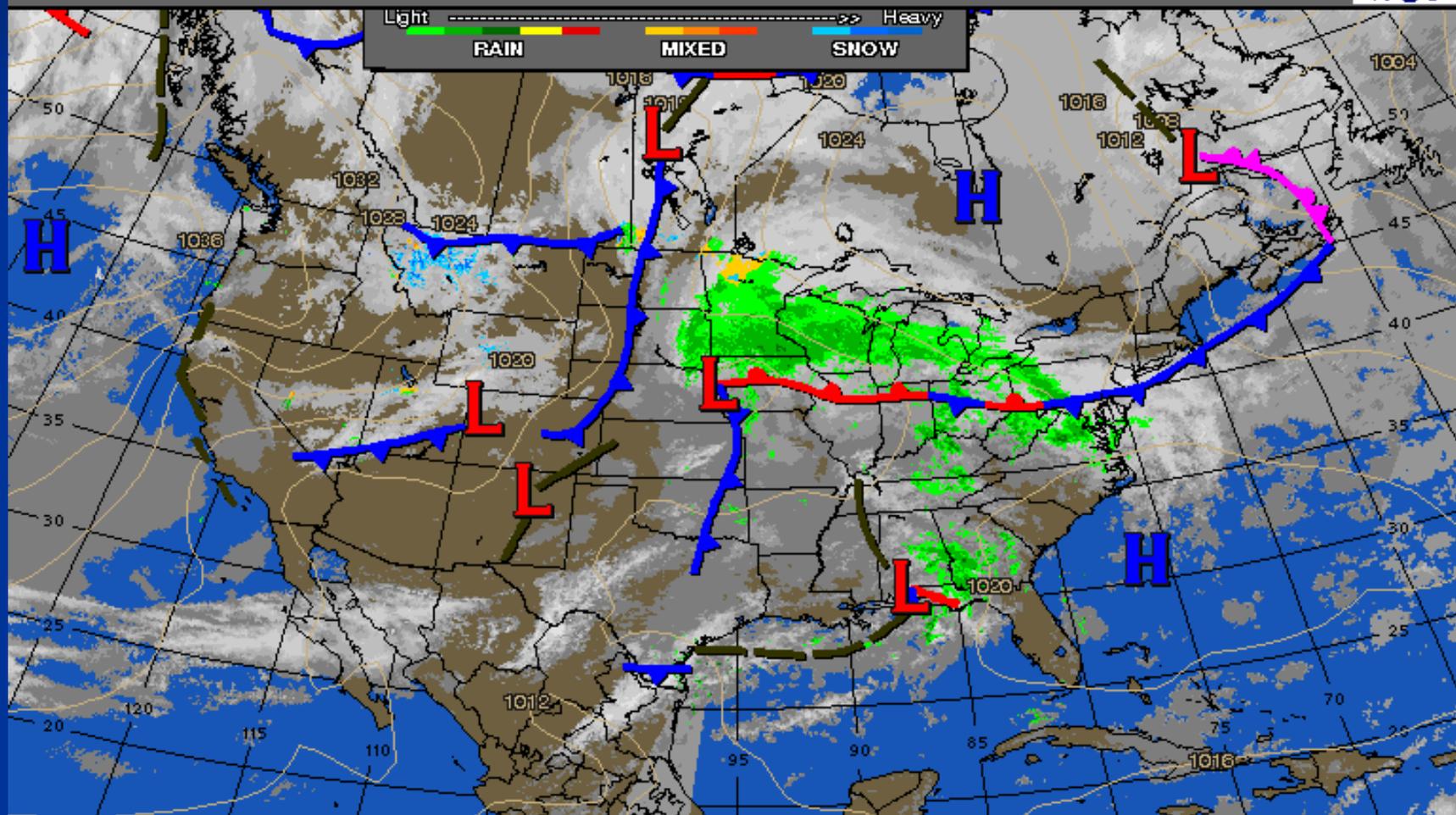
19:15 19-NOV-2004 GMT ©Copyright



Analysis & Understanding are Well Developed Distributed Observations & Assimilative Modeling

19:30 19-NOV-2004 GMT ©Copyright MSI Corporation <http://www.usi.com>

U.S. SURFACE ANALYSIS w/ Radar and IR Sat VALID AT 1800 UTC 19 NOV 04



UPDATED 19:54 UTC 19 NOV 04

UPDATED EVERY 3 HOURS

Report Outline (1)

- Executive summary (2 pages)
- 1. Introduction
 - Space Weather
 - Distributed Arrays of Small Instruments - The Next Logical Step
 2. DASI Background (Decadal Survey)
 - 1. Challenges
 - 2. DASI
 3. **DASI Workshop**
 - **Recurrent Themes**
 - **1. Insufficient Observations**
 - **2. Geospace as a System**
 - **3. Real-Time Observations**

Persistent Themes

■ 1 *Insufficient Observations*

Observational space physics is data-starved, producing large gaps in our ability to both characterize and understand important phenomena. This is particularly true for Space Weather events, which often are fast-developing and dynamic, and extend well beyond the normal spatial coverage of our current sensor arrays.

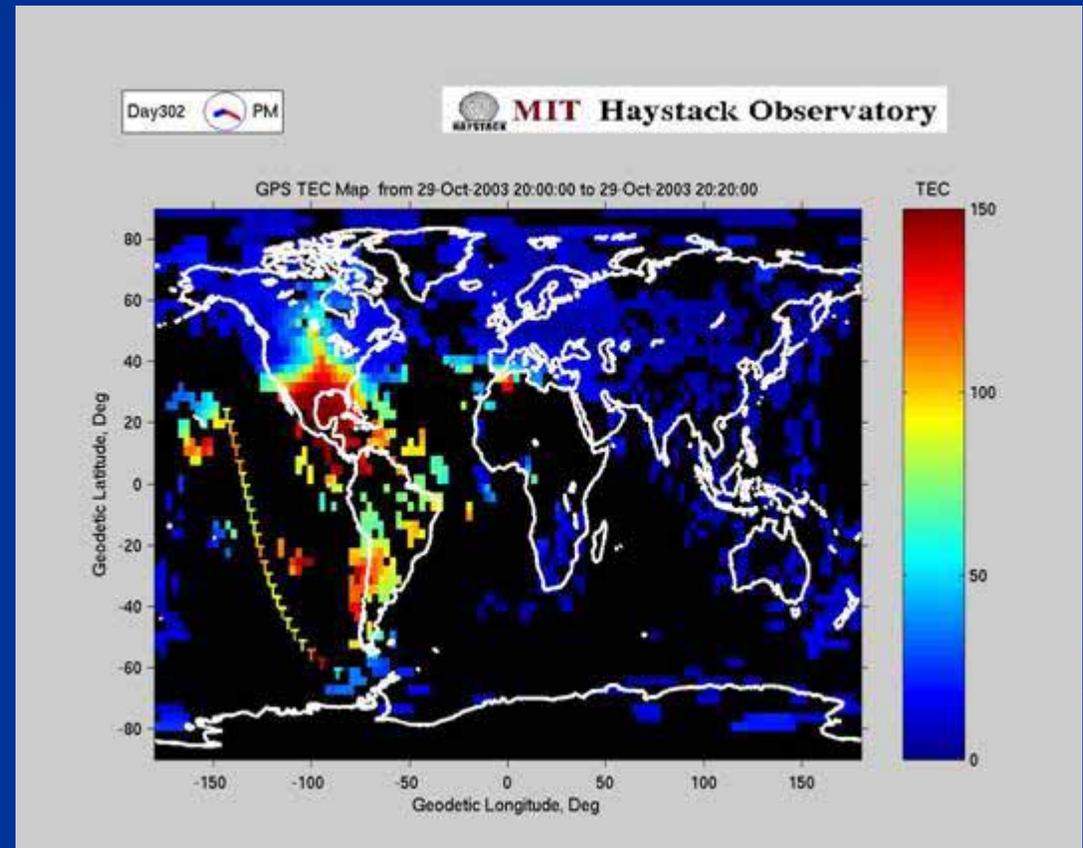
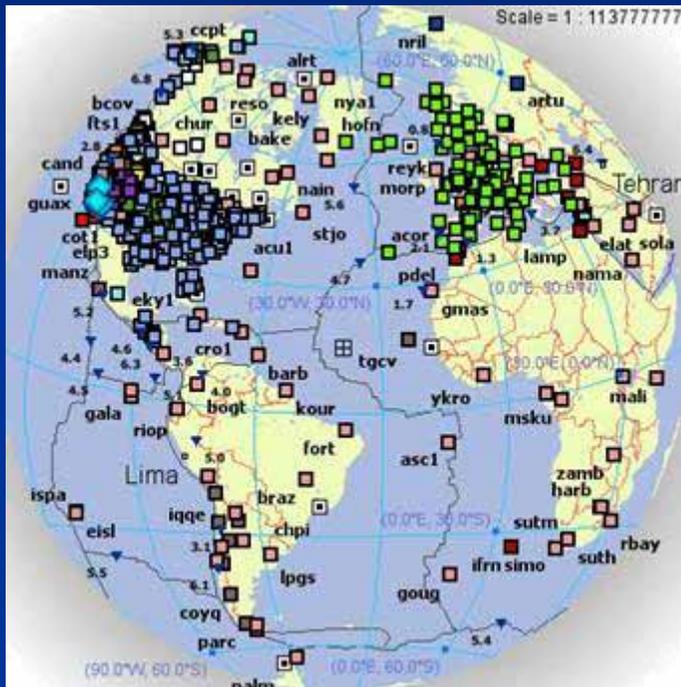
■ 2 *Geospace as a System*

Geospace processes involve **significant coupling across atmospheric layers** and ‘altitude boundaries’, as well as coupling across **multiple scale sizes** from global (1000s km), to local (10s km), to micro-scale (meter-scale and smaller).

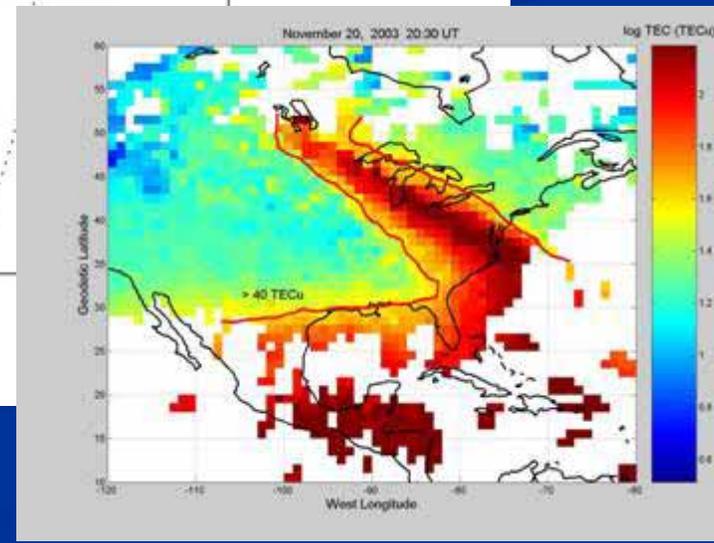
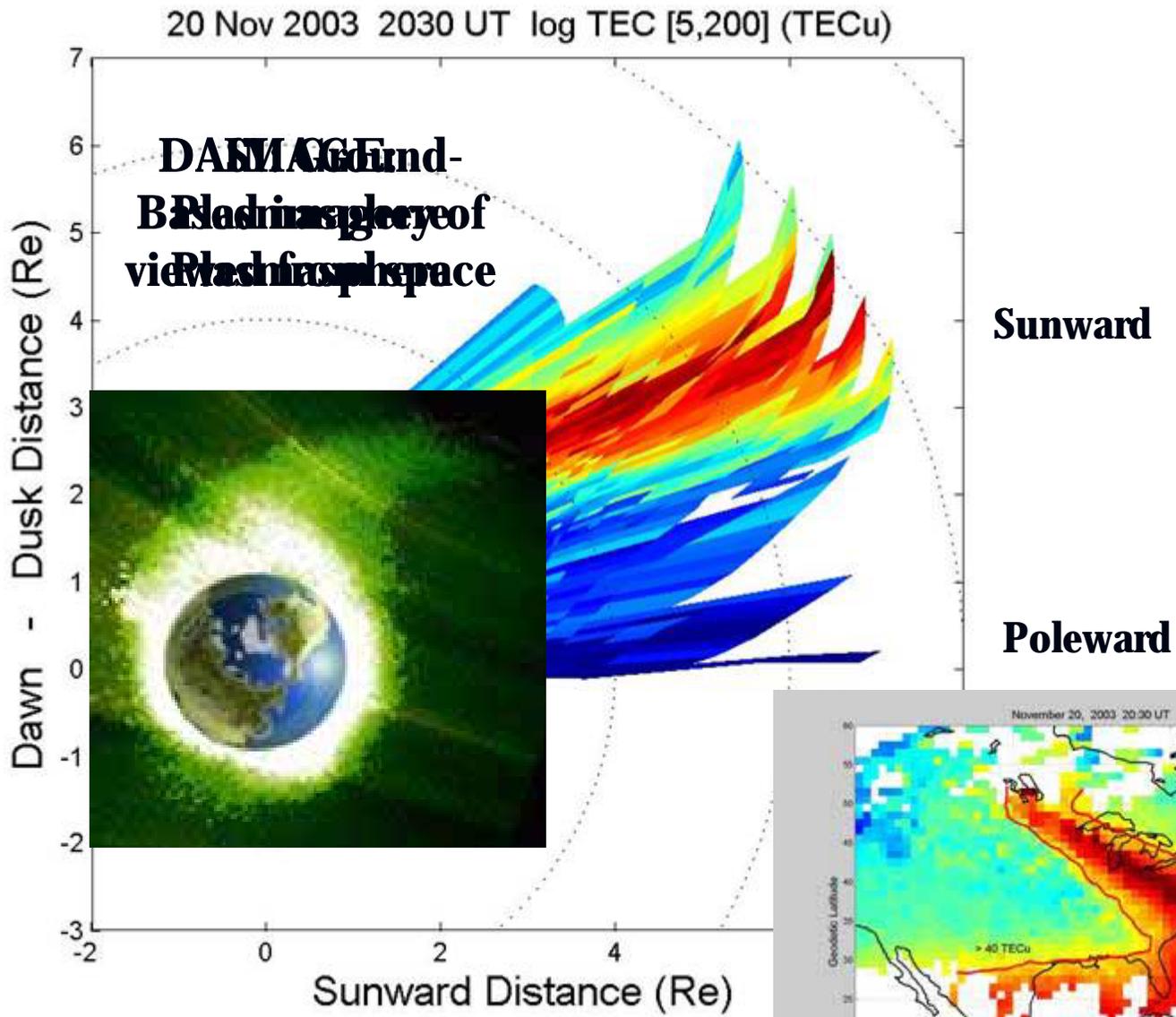
■ 3 *Real-Time Observations*

Elucidation of the fundamental coupling processes requires **continuous real-time measurements** from a distributed array of diverse instruments as well as physics-based data assimilation models.

Current Arrays: Limits on Global Coverage & Real-Time Access (e.g. GPS Receivers)



**Issues:
Logistics & International
Participation**

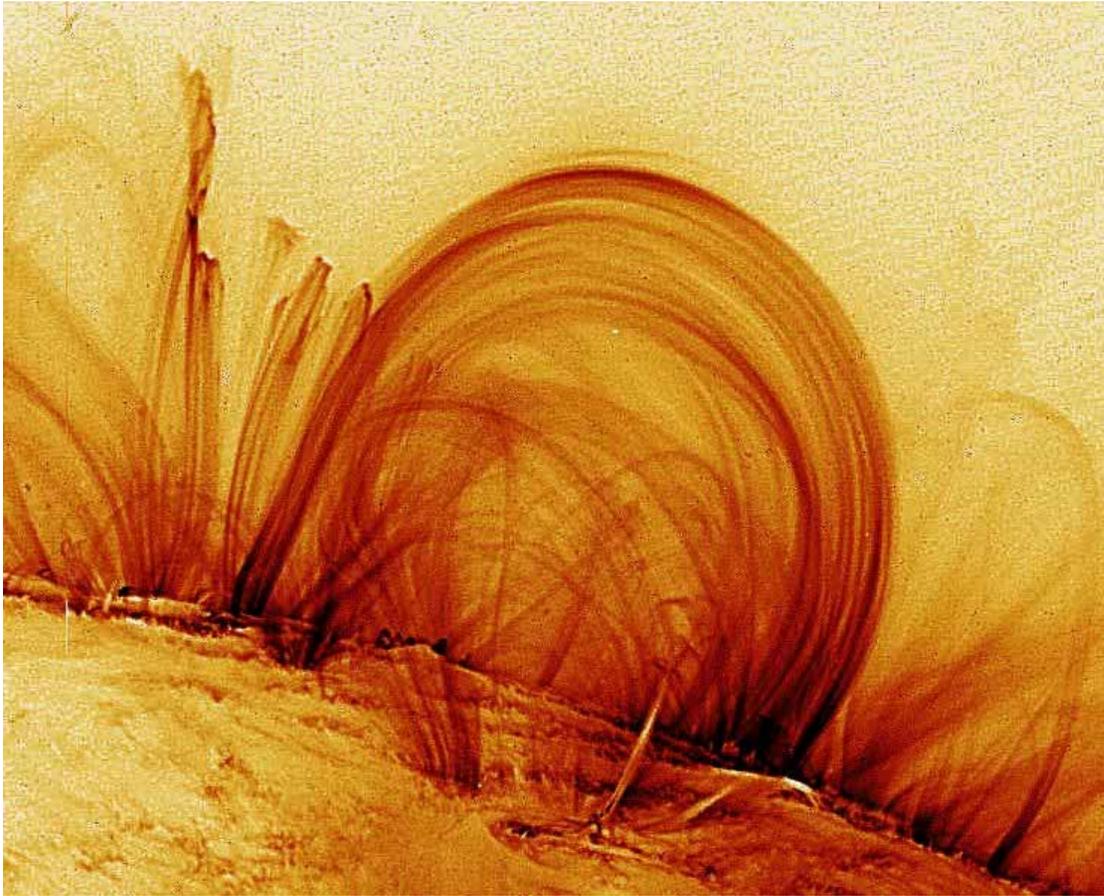


Geospace as a System

Report Outline (2)

- **4. Compelling Science**
 - **1. Solar - Interplanetary**
 - 1. Magnetic Fields
 - 2. Solar Activity
 - 3. Solar Variability
 - 4. Interplanetary Scintillations
 - **2. Magnetosphere-Ionosphere**
 - **1. Plasma Redistribution**
 - 2. Particle Energization
 - 3. Effects of Preconditioning
 - **3. Thermosphere-Ionosphere**
 - 1. Ion-Neutral Coupling
 - 2. Waves and TI Variability

Solar Magnetic Fields & Variability



The Sun as the Driver of the Geospace Environment

■ Structure and Dynamics of the Sun's Interior

- local helioseismology

■ Solar Activity

- 1) understand CME formation

- 2) provide information about the magnetic structure of earth-directed CMEs and solar wind

- 3) predict the onset of large solar flares

- 4) learn how and where solar energetic particles are accelerated

■ Heliospheric Structure

- 1) identify the magnetic processes that accelerate the solar wind

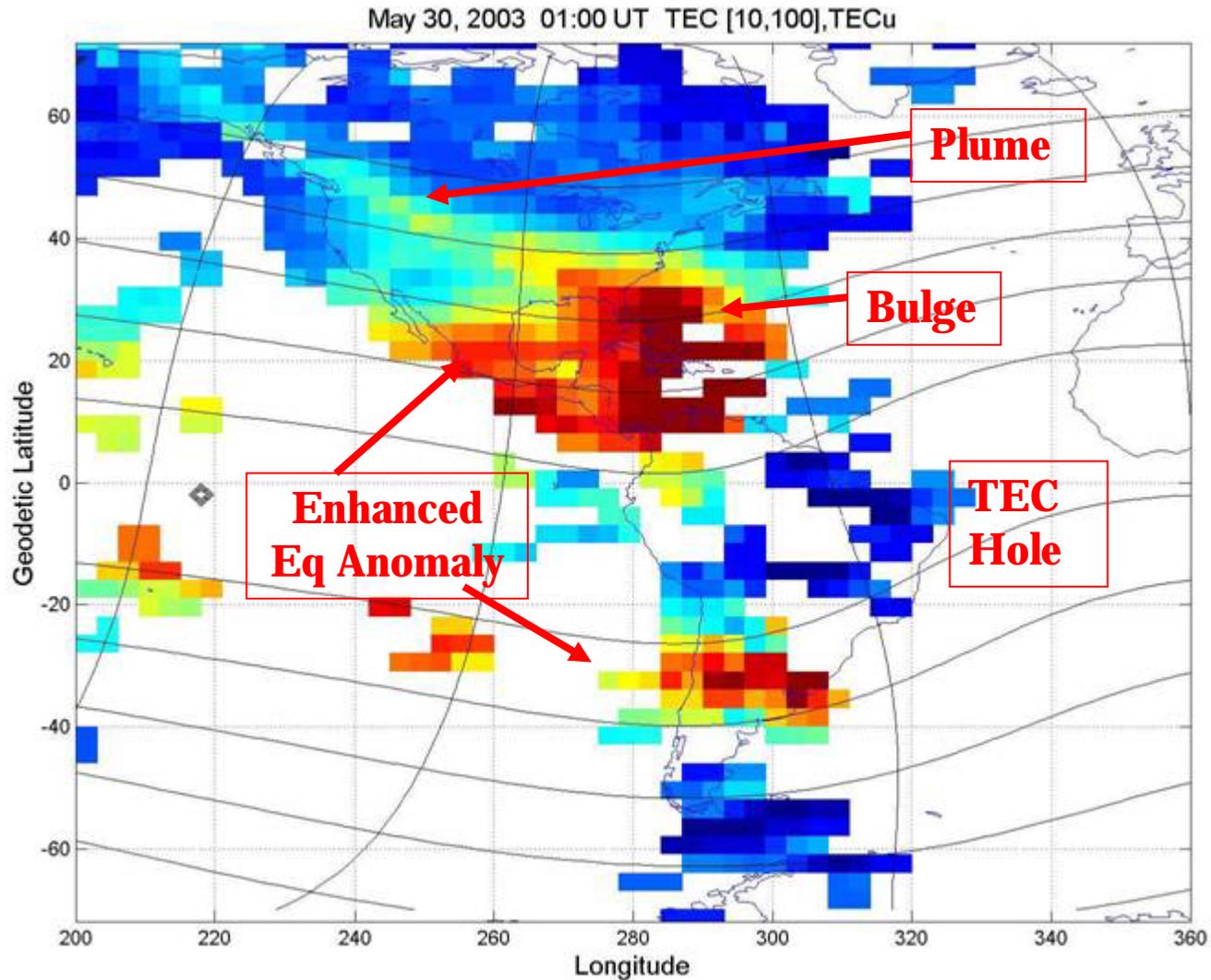
- 2) understand the interactions of CMEs and solar wind streams

Science (1): Global Aspects of Localized SPW Effects

(Plasmasphere Boundary Layer Science)

- **Meso-scale SPW features which cross wide spans of latitude** and couple low-mid-auroral-polar latitudes. Disturbance features with significant applications effects.
- Great **spatial/temporal variability in occurrence**. Rapid coupling across regimes of system. Spatial localization (e.g. SSA).
- Involve thermal plasma and its effects, electric fields, relationship to particle precipitation and wave growth and interactions.
- **Questions:** Reason for longitude effects; sources and characteristics of electric fields; cause of SPW features (e.g. gradients produced by 2ndary wave growth along boundaries); relationship to scintillation and intense wave growth (ERB). Thermal plasma effects on the development of M/S storm?

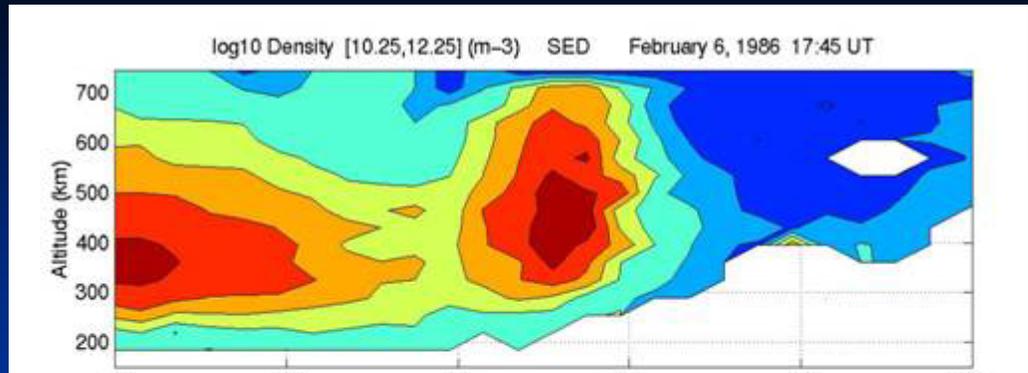
M-I Coupling Leads to Processes and Structures which Span and Interconnect the M-I-T System



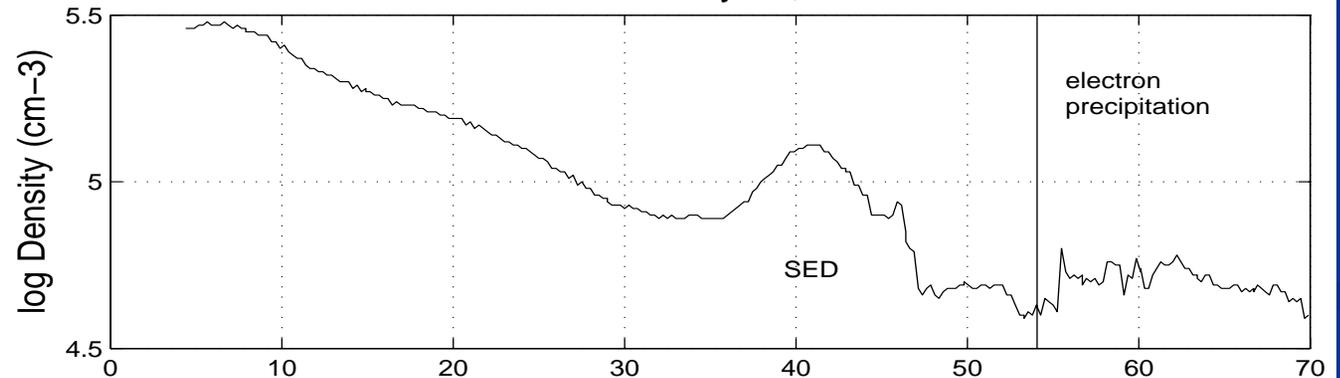
Regionally-Localized but Recurrent Space Weather Events

SED

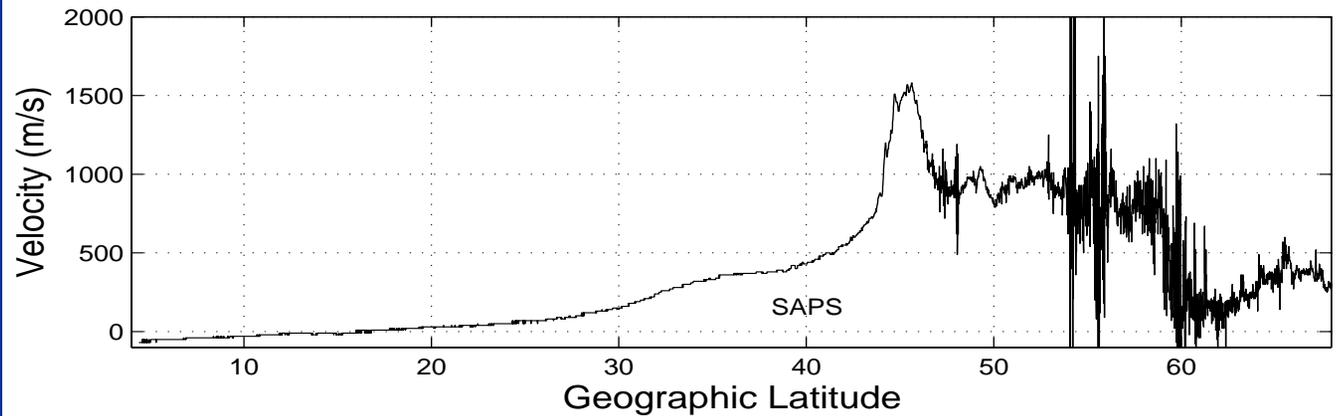
SAPS



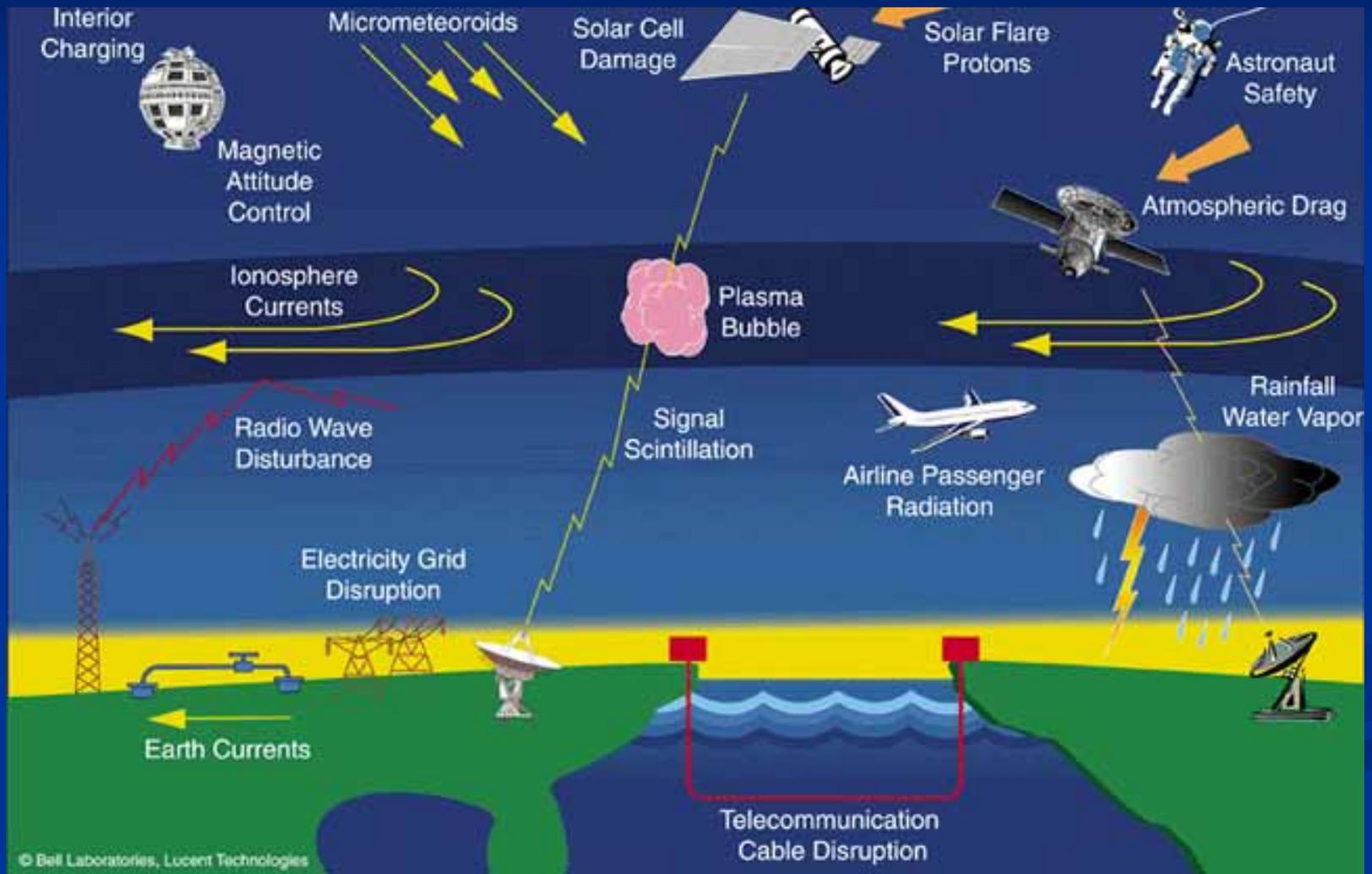
DMSP F-13 RPA May 30, 2003 01:35 UT



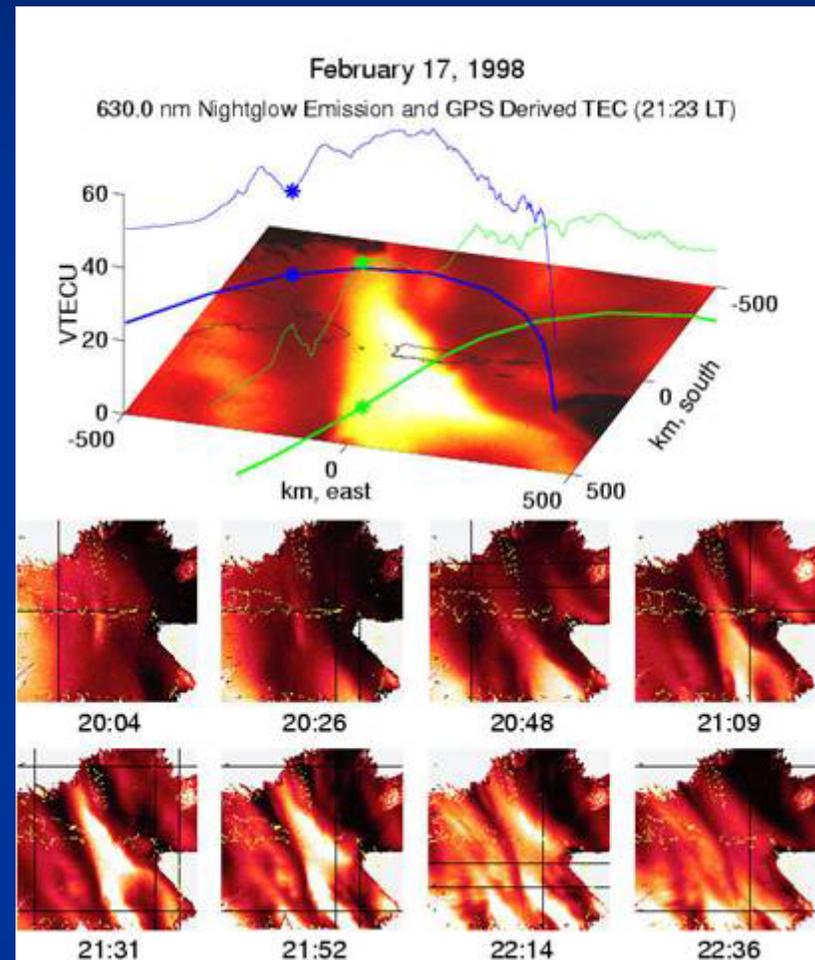
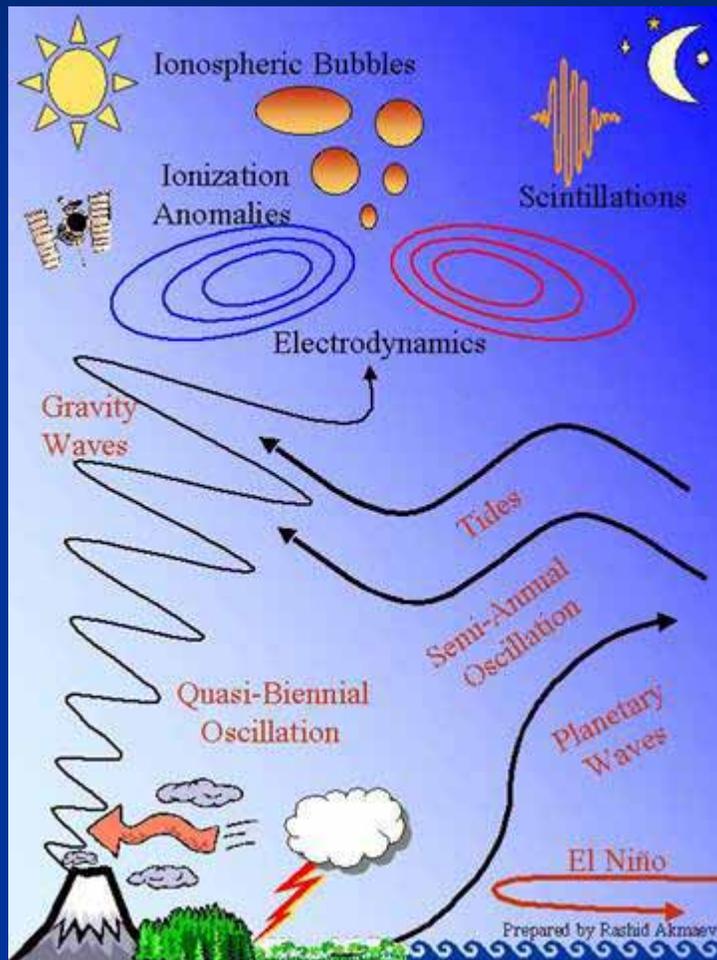
DMSP IDM



Space Weather



Waves, Processes, and Disturbance Response in the Thermosphere-Ionosphere System



Science (2): Quiescent State of the Ionosphere-Thermosphere (I-T) System

- **Geospace must be addressed as a system.** The coupling among the principal region of geospace is not understood. **Disturbances (e.g. SPW event) involve both the characteristics of the external drivers (e.g. IMF/SW) as well as the pre-existing state and structure of the T-I-M regions. The system response throughout SPW events depends in poorly-understood ways on the initial conditions of the geospace system.** Multi-technique continuous observations are needed with a spatial resolution appropriate to characterize these systems. global coverage with near RT data. **The coupling among the principal T-I-M regions (in both quiet and disturbed conditions) must be addressed and the feedback and/or control of one region on processes in the others is to be addressed.**
- **Questions:** How does the global TI system respond to geomagnetic storms?
How does the global response vary with altitude and time?
What are the local/global responses to Solar Proton Events?
How deep into the atmosphere do the local and global effects penetrate?
How does the thermosphere affect the ionosphere?...the magnetosphere?

Report Outline (3)

- **5. Instruments**
 - 1. Radiowave Instruments
 - 2. Magnetometers
 - 3. Optical Instruments
 - 4. Computer Models
- **6. Existing Arrays**
- **7. Infrastructure Issues**
 - 1. Information Technology
 - 2. Instrument Deployment and Logistics
- **8. Education Opportunities**
- **9. Summary and Conclusions**
 - Next Steps
- **10. References**



Distributed Instruments (HF Radar: SuperDARN)

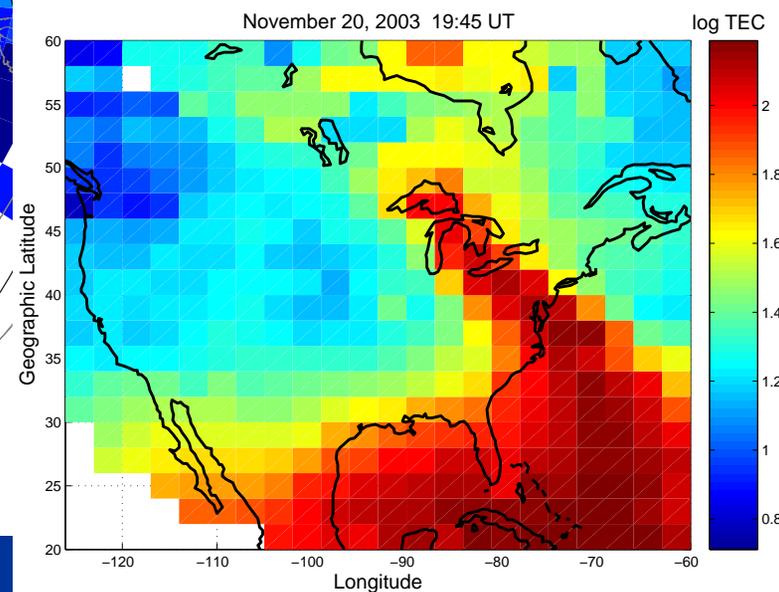
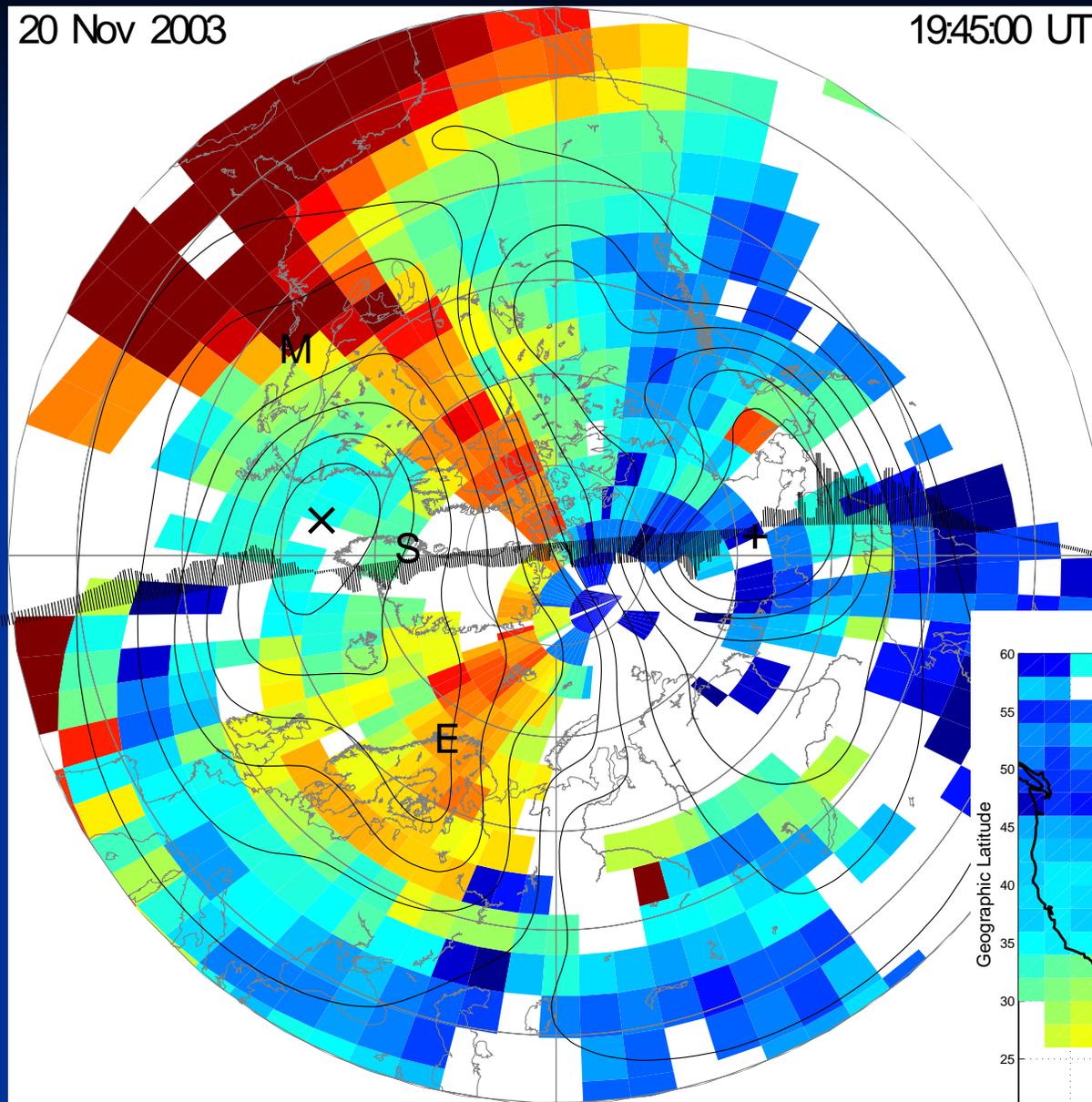
20 Nov 2003

19:45:00 UT

Multi-Instrument Clusters to Address Physical Processes

Polar TOI

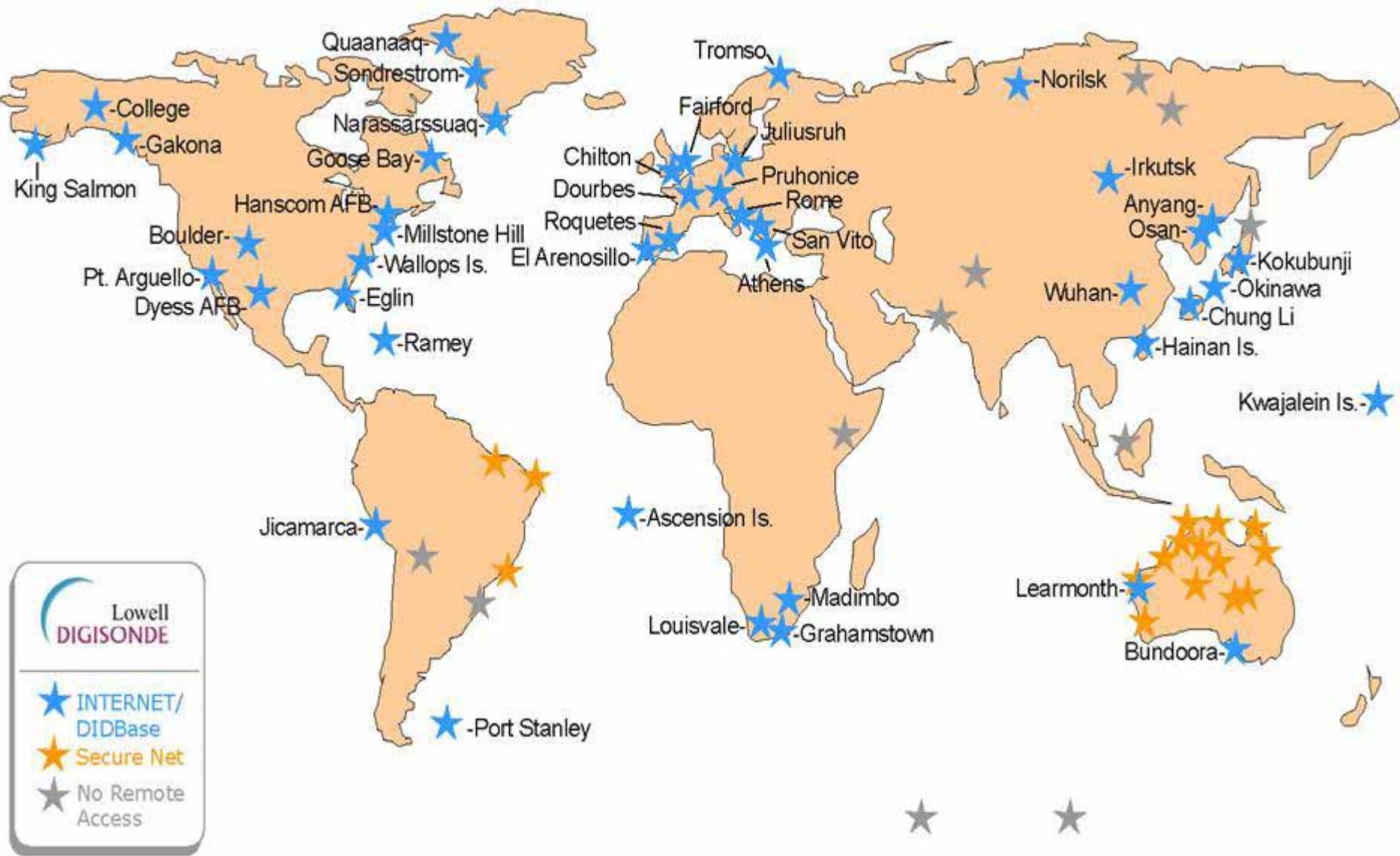
GPS TEC Map



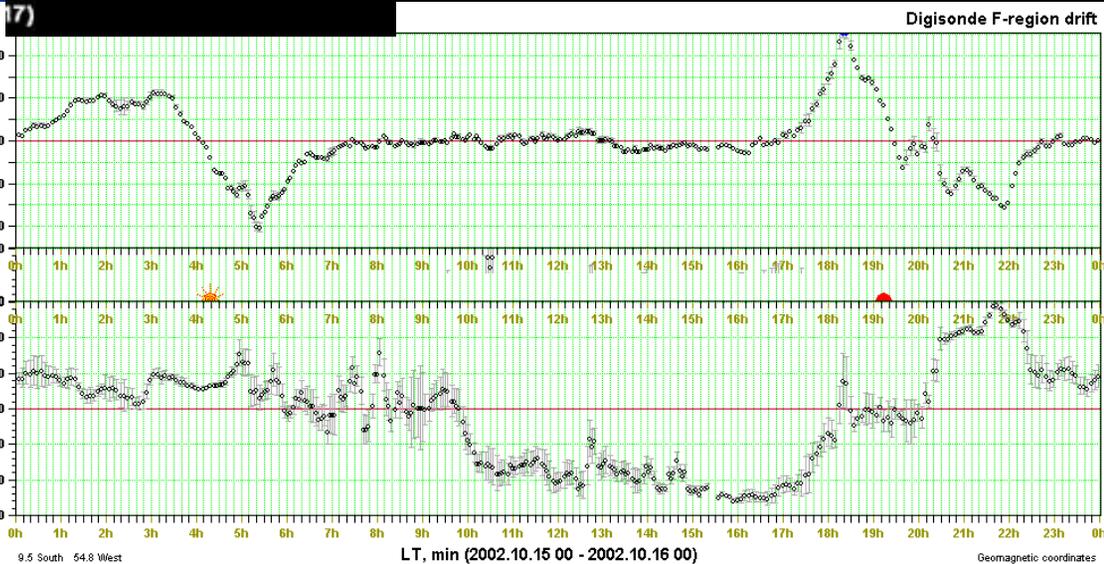
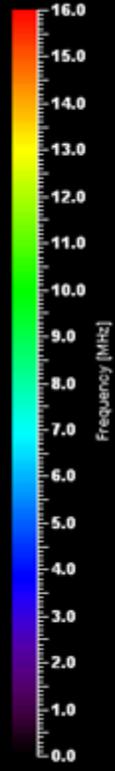
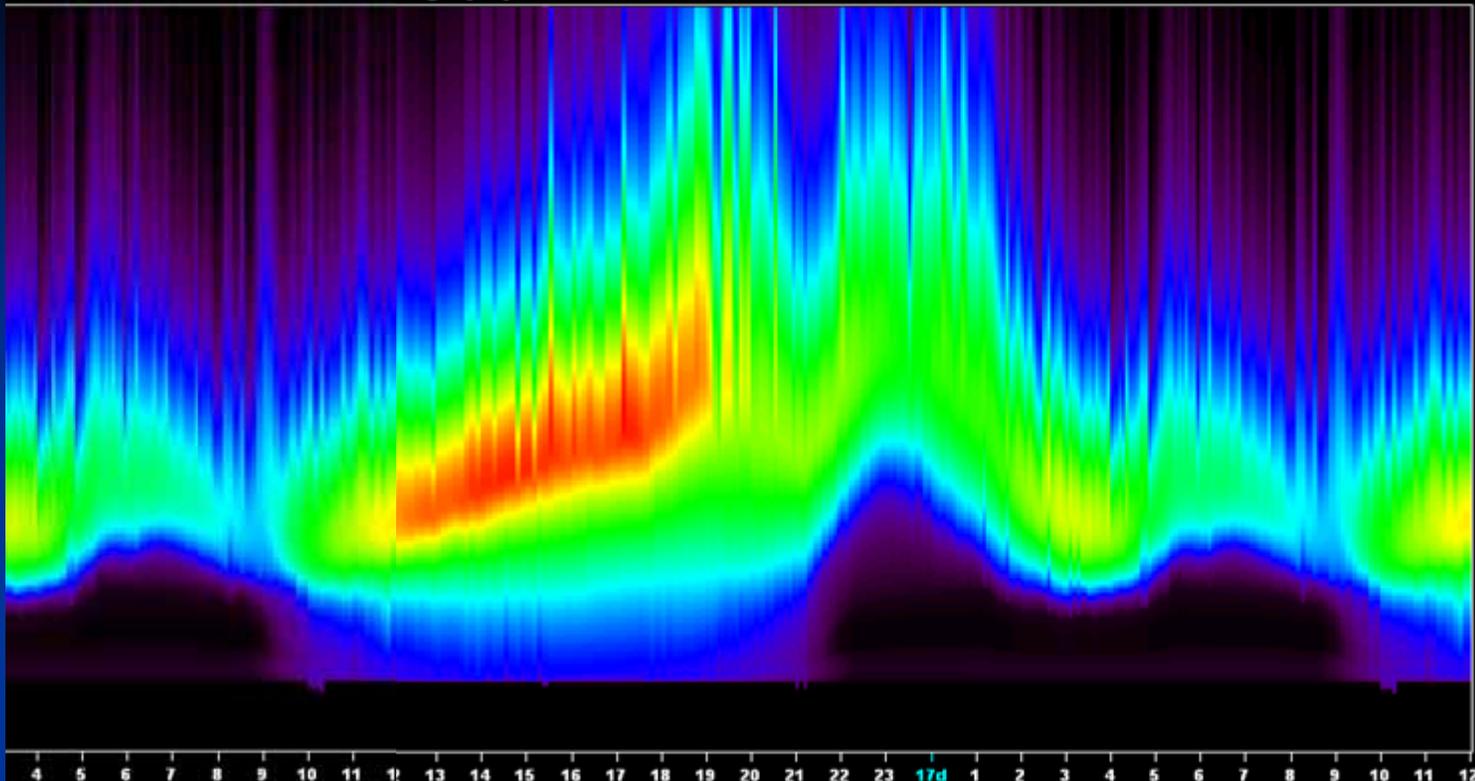
Merged SuperDARN/DMSRP Convection

[Foster et al., JGR 2005]

Digisonde Network

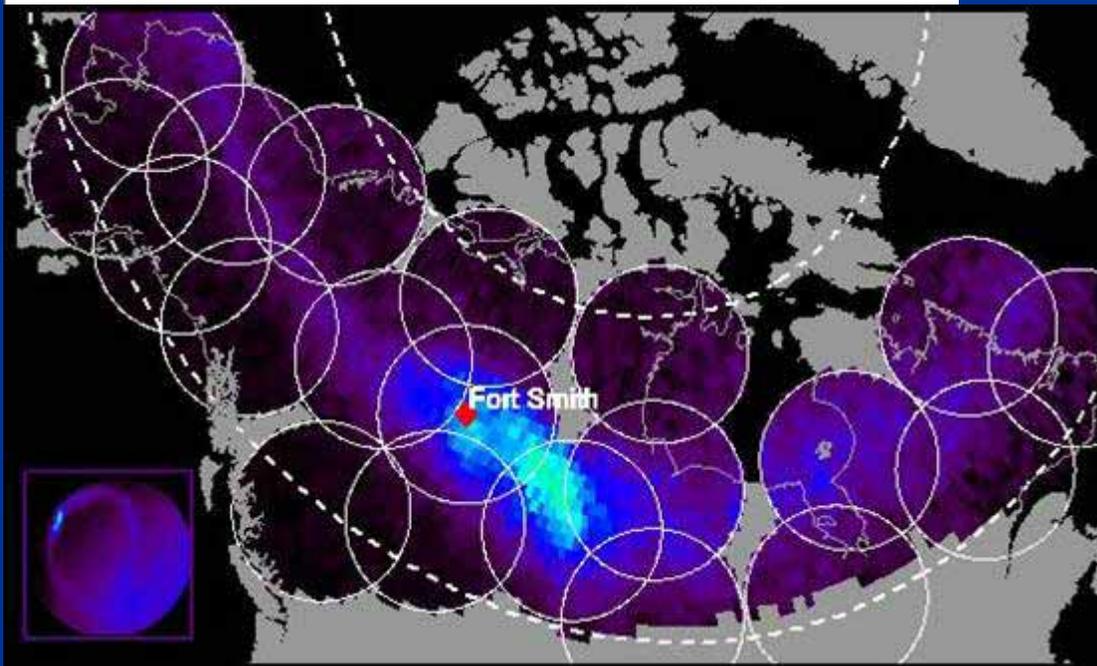


Height [km]



Lowell Digisonde
October 15-16, 2002
Cachimbo

Auroral Processes: Distributed Imagers (Themis)





Large Instruments (Radar/Lidar: AMISR)

New Instruments: ISIS (Intercepted Signals for Ionospheric Science)



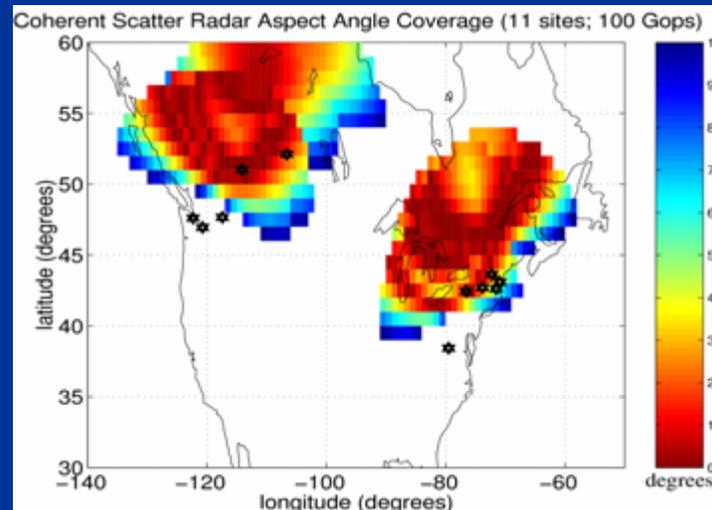
Multirole Coherent Software Radio Network

Multistatic Active and Passive Radar,
Radio Scintillation Studies, RF monitoring

Cluster Computer Operational!

ISIS Array Node Assembly Has Started!

First Node Deployment to Greenbank Radio Observatory
Summer 2005; Deployment Supported by MIT Lincoln Lab
Multistatic Active Radar with MIT Millstone Hill Radar
140 Foot Telescope at Greenbank



MIT Haystack Observatory

Issues for Instrumentation and Arrays

- Instrument types and their Deployment should be **driven by the needs of the science**
- Different processes have ‘correlation lengths’ which involve different scale sizes. Therefore, DASI sub-arrays will have **differing spatial extent**.
- **State of the art IT systems** will be needed to realize the DASI architecture

DASI Report: Other Themes

- **Education:** Distributed instruments and R-T publicly-accessible data provide **extensive opportunities**.
- **State of the art IT systems** will be needed to realize the DASI architecture
- SYNERGY: RT access to **different types of data** will enable new science arising from their **combination**.
- Instrument types and their Deployment should be **driven by the needs of the science**
- Different processes have 'correlation lengths' which involve different scale sizes. Therefore, DASI sub-arrays will have **differing spatial extent**.

Where is DASI Headed?

- **The time is right for DASI:** developing technology and IT systems support a new science capability
- **Community involvement and planning workshops** are needed to evolve a DASI implementation plan.
- **State of the art IT systems** will be needed to realize the DASI architecture – DASI must participate and keep abreast of IT development
- **A phased, scaled approach to DASI should be adopted**

