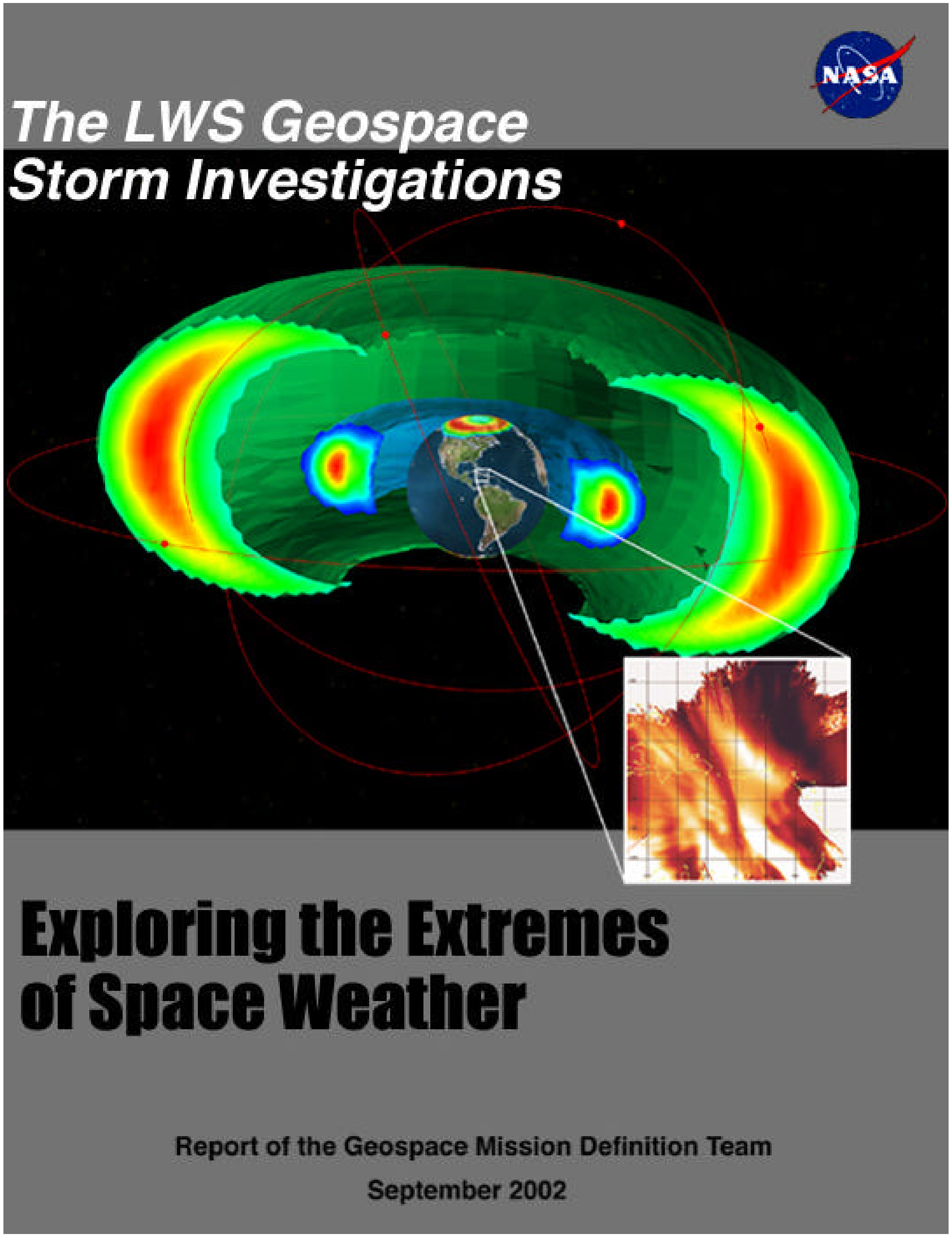


Report of the Geospace Mission Definition Team

Paul Kintner
Cornell University

On behalf of the GMDT committee and staff

GOALS

LWS

- Develop the scientific understanding necessary to enable the US to effectively address those aspects of the Connected Sun-Earth system that directly affect life and society.

GMDT

- The overarching objective of the Geospace program for Living With a Star is to develop a scientific understanding of the effects of solar variability on those geospace phenomena that most directly affect life and society.

Geospace Mission Definition Team

- Committee composed of 18 scientist and user representatives who:
  - Review and apply to geospace the science and user objectives from the LWS/Science Architecture Team.
  - Derive and prioritize measurement requirements from the science and user objectives.
  - Develop and prioritize set of flight elements.
- Prepare a geospace implementation plan with explicit priorities.

Geospace Priorities Based on a Convolution of Importance and Potential for Progress

1 - Understand the acceleration, global distribution, and variability of energetic electrons and ions in the inner magnetosphere.

2A - Determine the effects of long and short term variability of the Sun on the global-scale behavior of the ionospheric electron density.

2B - Determine the solar and geospace causes of small scale ionospheric density irregularities in the 100 to 1000 km altitude range.

3A - Determine the effects of solar and geospace variability on the atmosphere enabling an improved specification of the neutral density in the thermosphere.

3B - Understand how solar variability and the geospace response determine the distribution of electric currents connecting the magnetosphere to the ionosphere.

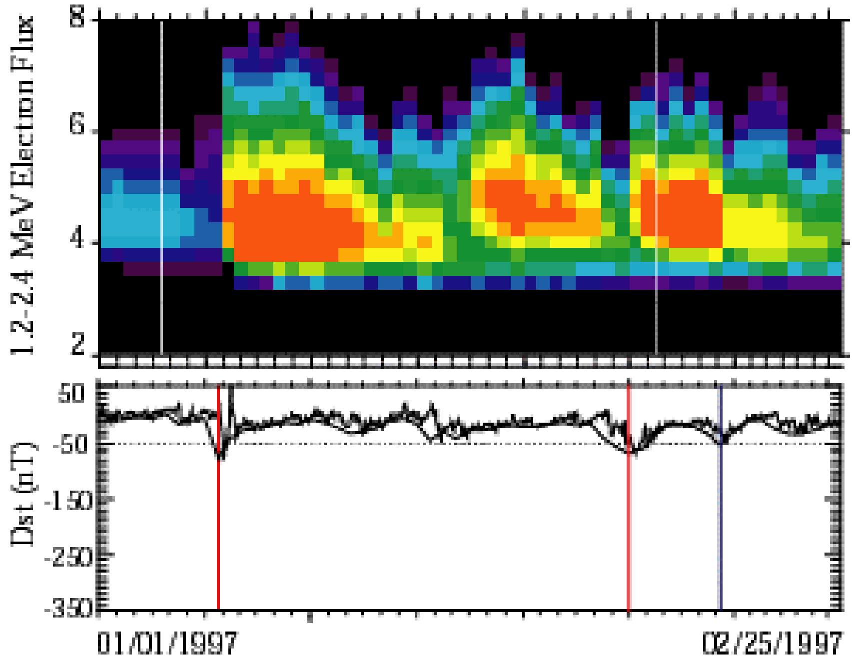
4- Determine the quantitative relationship between very energetic electron and ion fluxes in the interplanetary medium and their fluxes at low altitude, particularly the geomagnetic cut-offs.

5 - Quantify the geospace drivers that potentially affect ozone and climate.

Priority 1

- Understand the acceleration, global distribution, and variability of energetic electrons and ions in the inner magnetosphere.
  - Which physical processes produce radiation enhancement event?
  - What processes are responsible for radial transport and acceleration?
  - Do localized acceleration processes contribute significantly to radiation belt acceleration?
  - How do we distinguish among competing or simultaneous acceleration and transport events?
  - How do we predict and model the spatial, spectral, and temporal characteristics of radiation belt enhancements?

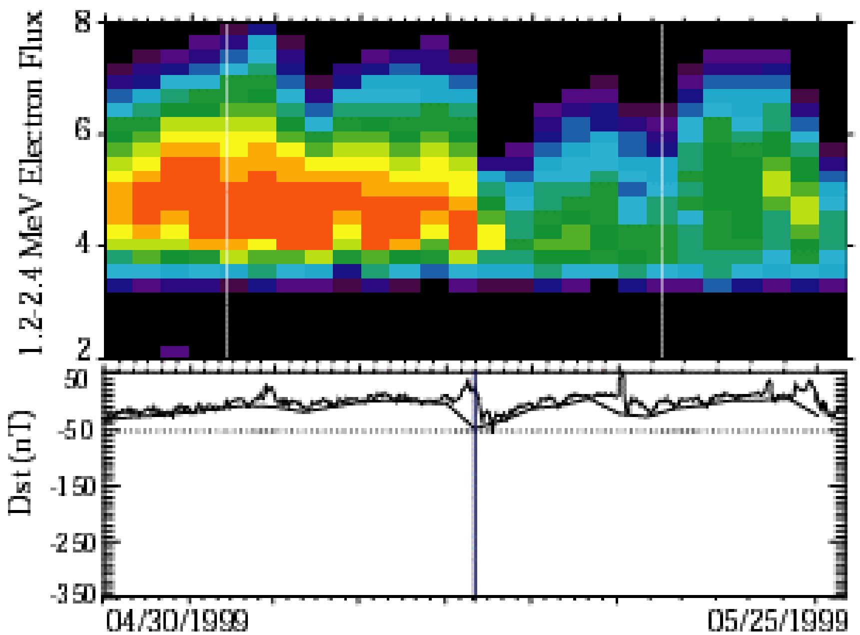
Not All Storms Produce Radiation Belts

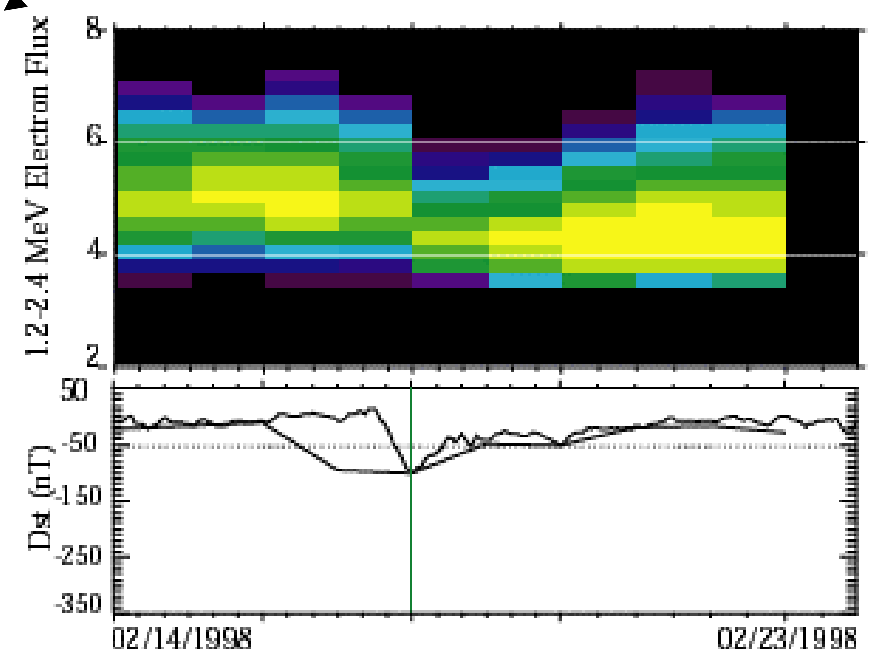


MORE

SAME

LESS





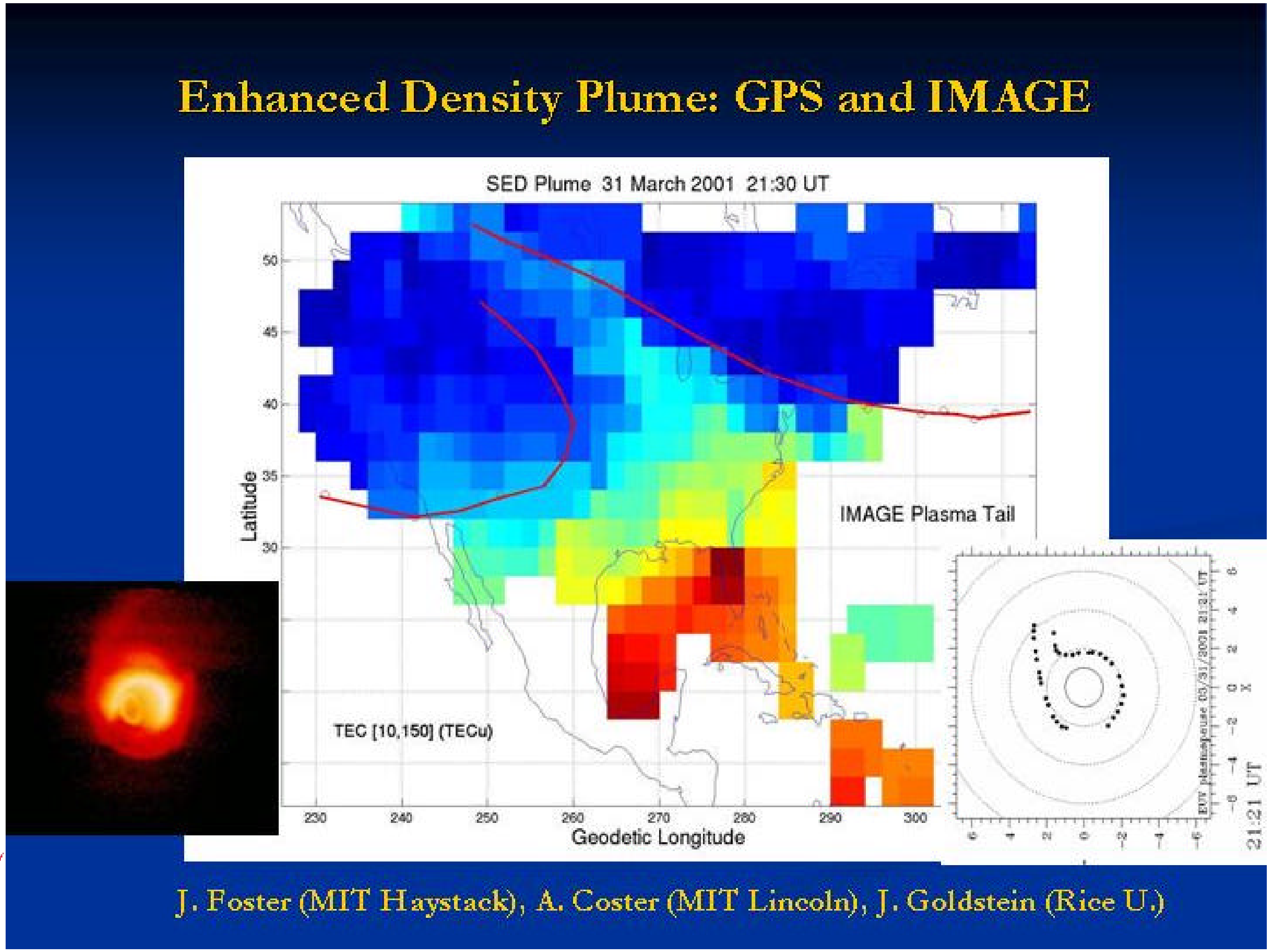
Priority 2A

- Determine the effects of long and short term variability of the Sun on the global-scale behavior of the ionospheric electron density.
  - How does the I-T system vary in response to changing flux of solar EUV radiation?
  - How does the mid and low-latitude I-T system respond to geomagnetic storms?
  - How do negative-phase ionospheric storms develop, evolve, and recover?
- Note overlap with priority 3A
  - Determine the effects of solar and geospace variability on the atmosphere enabling an improved specification of the neutral density in the thermosphere.

Priority 2B

- Determine the solar and geospace causes of small scale ionospheric density irregularities in the 100 to 1000 km altitude range.
  - What are the sources and characteristics of ionospheric irregularities at mid-latitudes?
  - What are the space weather effects of ionospheric variability at mid-latitudes?

Storm Enhanced Densities



Components of the Geospace Program

- EUV solar flux monitor
- Radiation Belt Storm Probes
  - Big bother and trailing little brother in near equatorial GTO
  - Energetic particles, ring current, fields
- Ionospheric-Thermospheric Storm Probes
  - Two twin ionospheric spacecraft at 60° inc, 400 km altitude, and separated by about 5° in longitude (ionospheric density and irregularities)
- FUV imager in geosynchronous orbit
- Polar, 9 Re circular imaging spacecraft
  - ENA, FUV (O/N_2 and Ne^2), auroral imaging

Closure Through Theory, Modeling, and Simulation

- Climatological and Empirical Models
  - Characterization
- Nowcast Models
  - Operational awareness
- First-principles models
  - Improve understanding
- Data assimilation models
  - Combine all of the above and yield forecasts for realistic boundary conditions

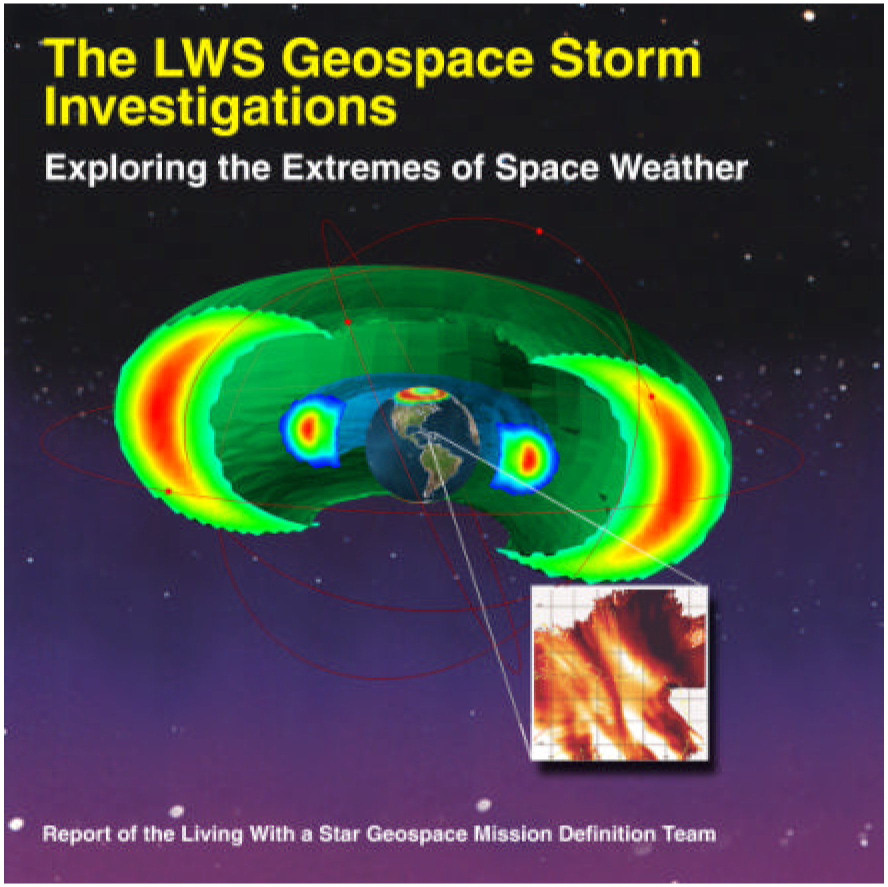
Reality of the Geospace Program

- We cannot afford all elements, so…
- Success requires integration with other programs that provide:
  - Solar wind parameters
  - High latitude magnetospheric energy input to I-T
  - Magnetospheric seed populations for the radiation belts
  - Global distribution of ULF waves
  - Measurements of low-latitude I-T system and irregularities

… and Collaboration with Complementary Programs

- Other space weather programs
  – International LWS, CCMC, DOD-MURI, NSF Center for Integrated Space Weather Modeling, NSWP, CEDAR, GEM, SHINE, DOD-National Security Space Weather Architecture
- DOD spacecraft yielding energetic particles
  – LANL-GEO, GPS, MEO, HEO, STP
- Ionosphere-Thermosphere observations
  – NPOESS, ground-based GPS chains, COSMIC, EQUARS, C/NOFS
- NASA programs
  – TWINS, MAGCON

Report Completed in September



http://lws.gsfc.nasa.gov/lws_presentations.htm

Acknowledgements

Committee: S. Basu, J. Fennell, T. Fuller-Rowell, G. Germany, G. Ginet, M. Golightly, R. Heelis, M. Hudson, R. Meier, D. Michell, R. Pfaff, Jr., G. Reeves, R. Robinson, R. Schunk, H. Singer, J. Sojka, R. Thorne, R. Wolf, J. Wygant

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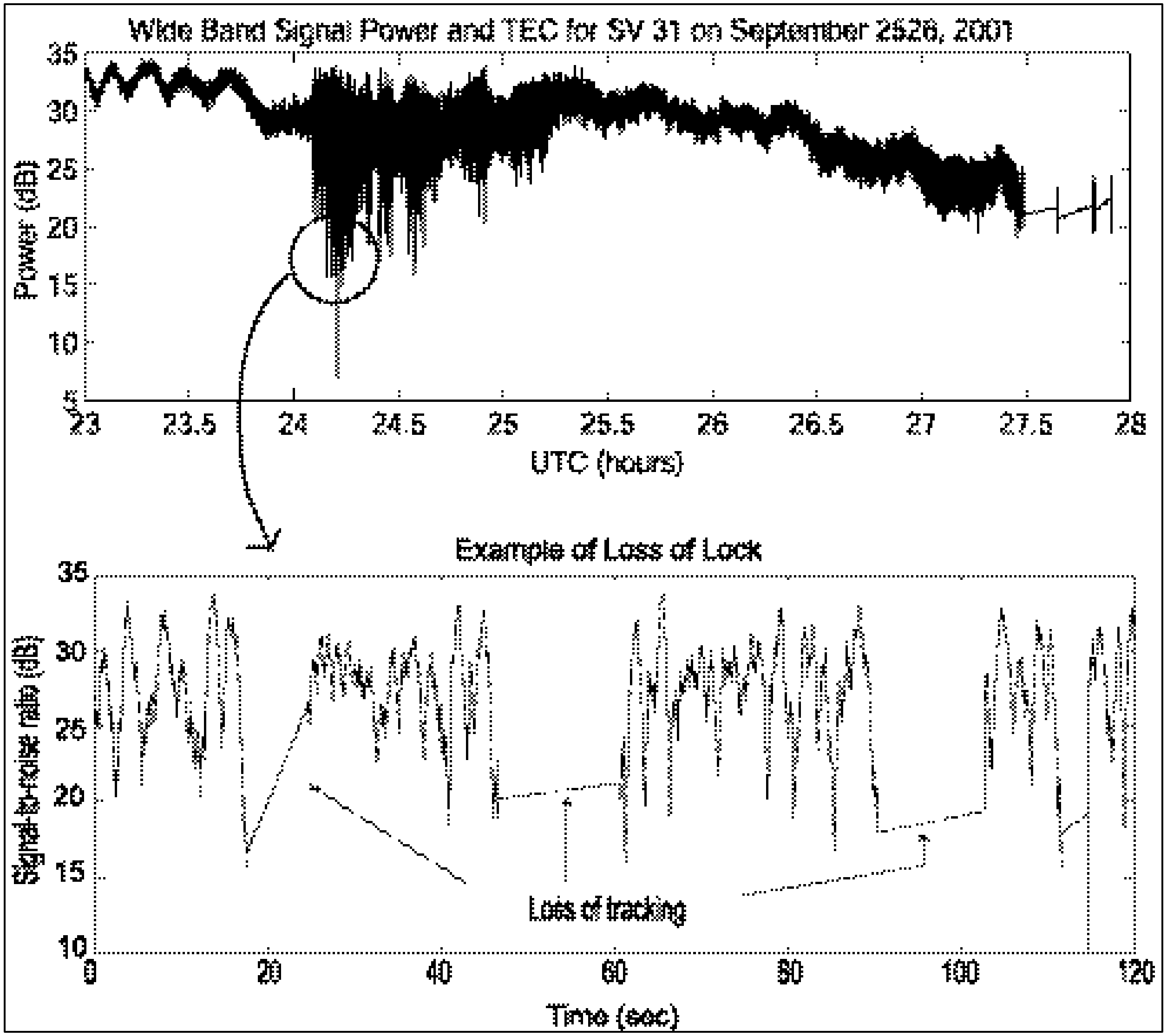
Presenters: John Foster, Robert McCoy, Fred Herrero, Francois LeFeuvre, Peter Engleman, William Denig

Technical Writing Consultant: W. S. Lewis

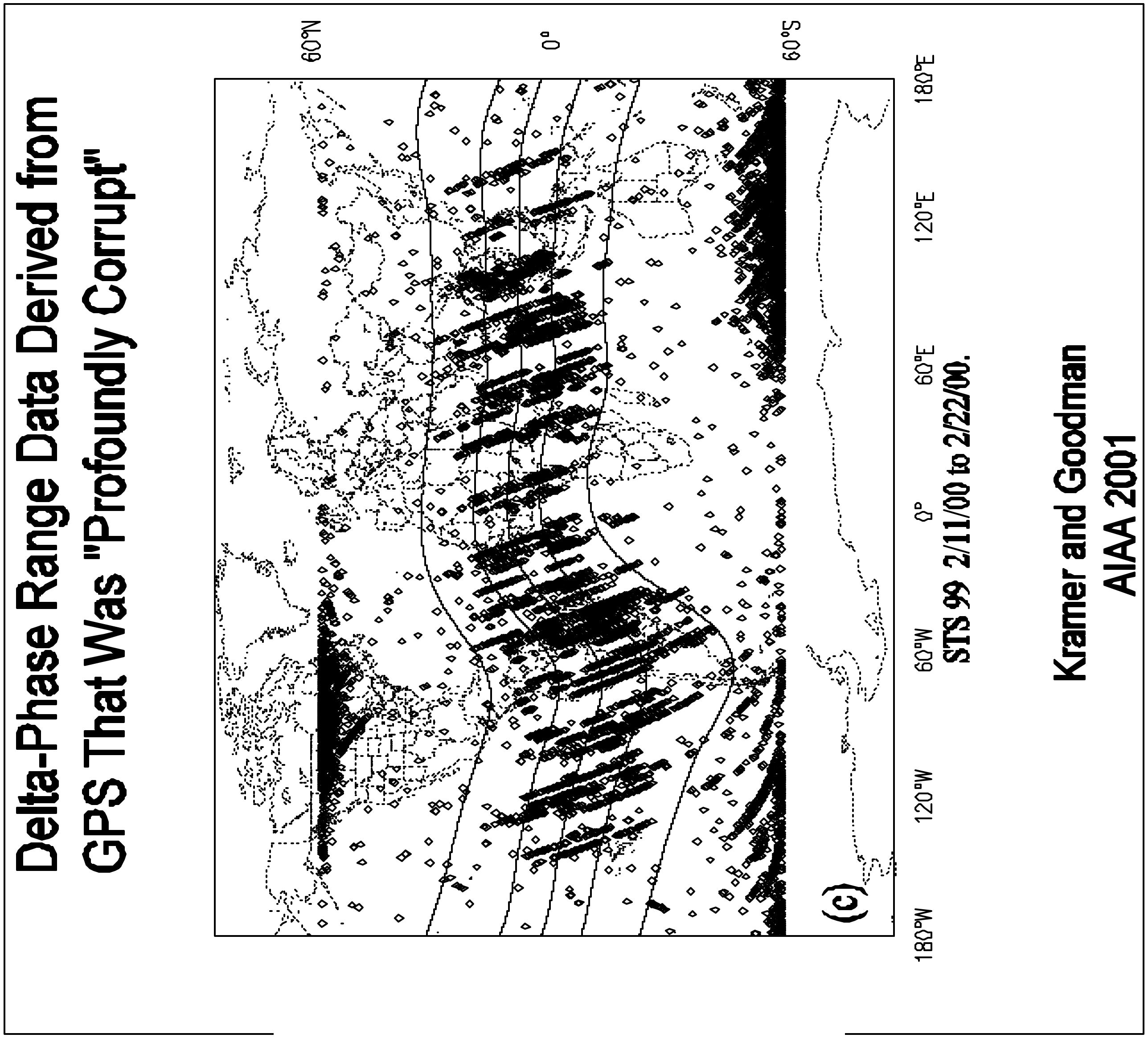
Examples of GMDT Science

- Mid-latitude ionospheric storms
- Suddenly created radiation belts

GPS Tracking Failure in Ithaca, NY



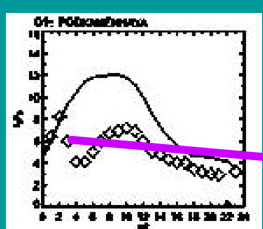
Scintillations Affect Shuttle

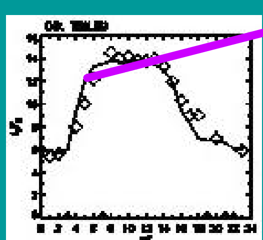


Negative Ionospheric Storm Tracks Region of Low O/N_2

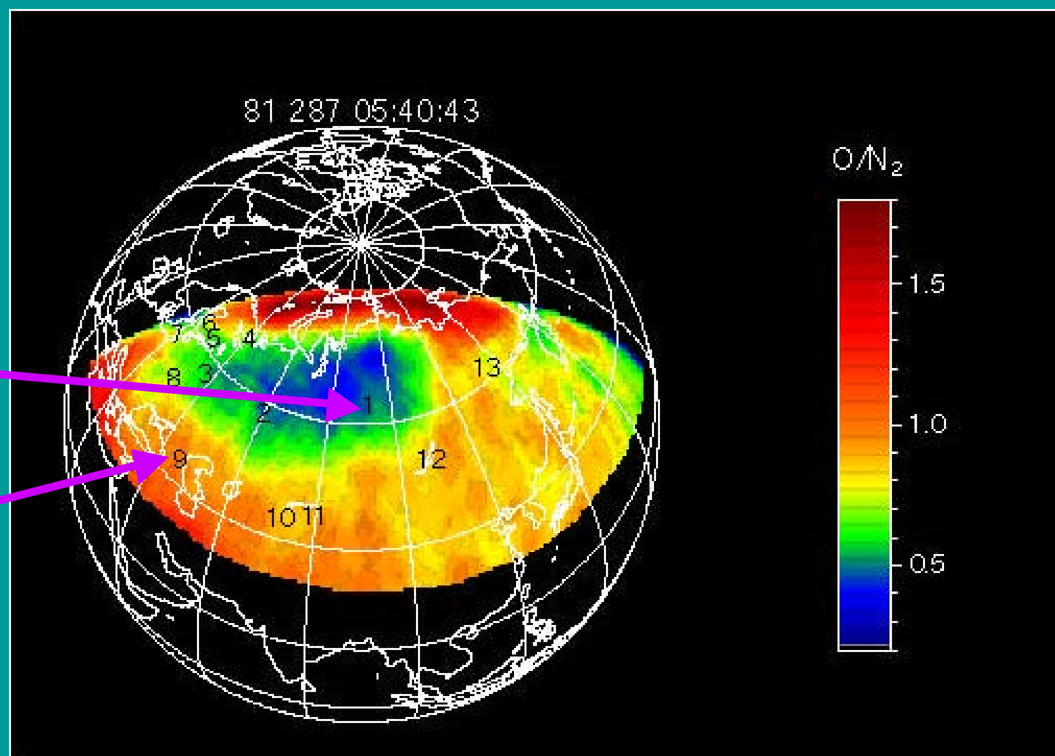
Ionosonde
24 hr data
14 Oct. 1981

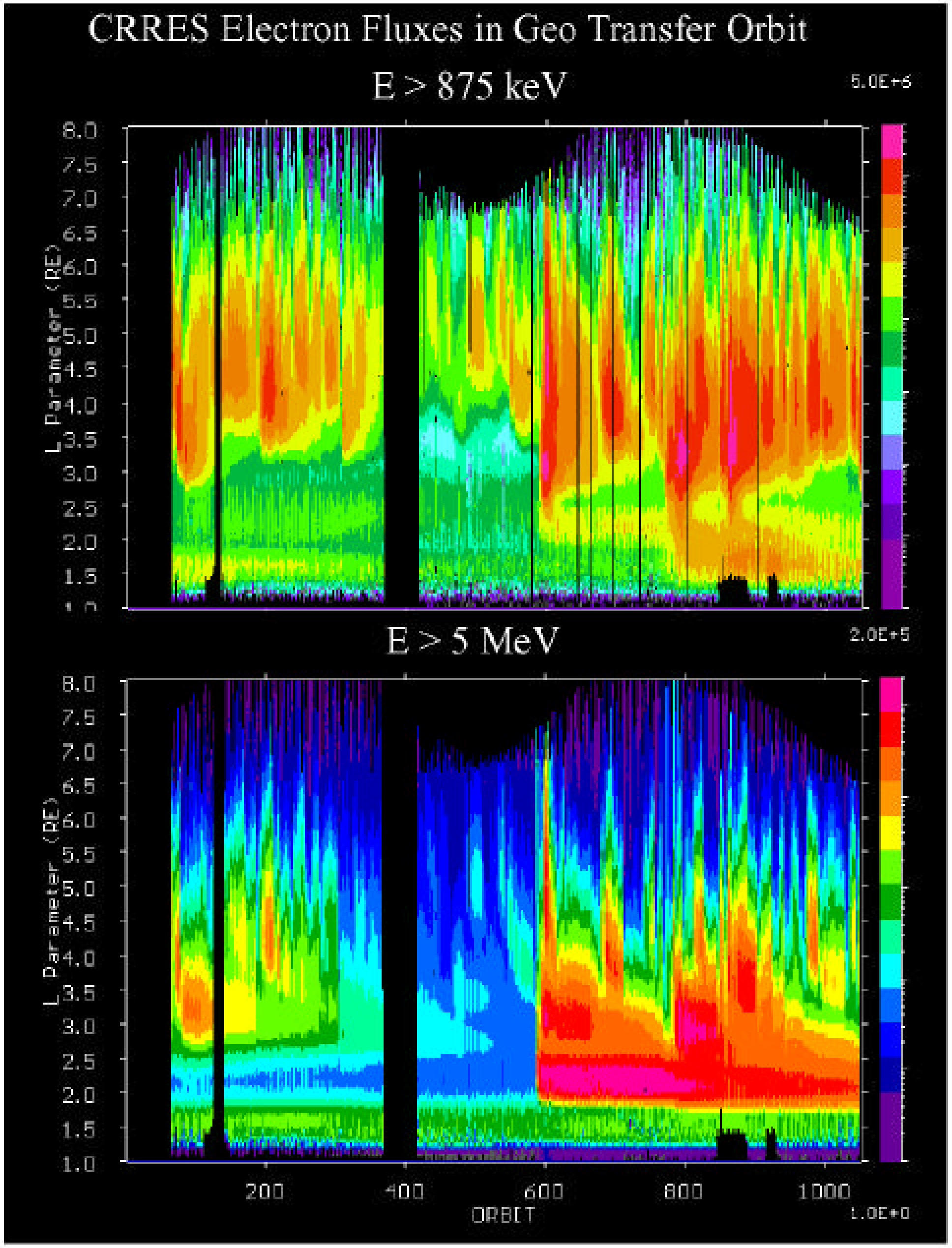
Monthly Mean
Daily Data





f_oF_2 follows O/N_2 inferred from DE-1 FUV image





Sudden creation of radiation belts- acceleration is not diffusive!

Ionospheric Measurements on Twin Spacecraft

- Plasma density, drift, and density fluctuations
- Thermospheric wind, density and composition
- Ionospheric (Ne) altitude profiles
- In-orbit scintillations
- Plus
  - Auroral electron precipitation
  - Currents (B)
  - AC electric fields

Radiation Belt Measurements

- Big brother
  - 20keV-20MeV electrons
  - B and ULF waves
  - DC E-field
  - B and E VLF waves
  - Ring current ions (20-600keV) and composition
  - Plus
    - Energetic Protons(1-200 MeV)
- Little brother
  - 20keV-1MeV electrons
  - B and ULF waves
  - Ring current ions (20-600keV) and composition
- Plus in LEO
  - precipitating energetic electrons
  - proton monitor

Living With a Star
Geospace Mission Definition Team Report

Exploring the Extremes of Space Weather

Paul Kintner

Cornell University

On behalf of the GMDT committee and staff