LWS/Geospace

Status & Directions

Outline:

- Status
- GMDT Recommended Objectives & Priorities
- GMDT Recommended Geospace Flight Elements
- Steps toward implementing the program
- Issues for the LWS/MOWG

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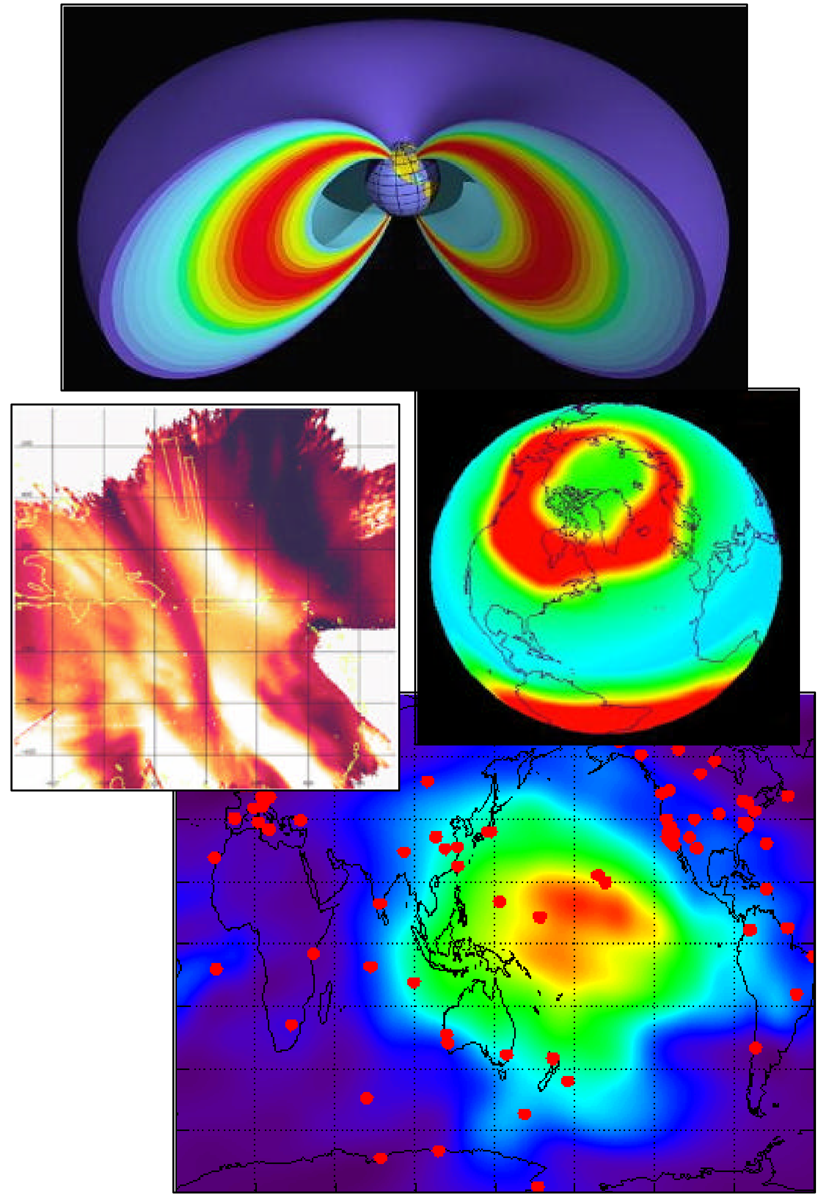
LWS/Geospace Missions Network

Goal: Understanding and characterizing those geospace phenomena that most affect life and society.

The Geospace Missions Definition Team has completed its work and defined a program with four components:

- The Geospace Missions Network
- Missions of Opportunity
- Leveraged Programs
- Instrument Development Program

Pre-mission concept development is underway at NASA/GSFC and JHU/APL.



LWS/Geospace Project Formulation

LWS Geospace Study Scientist: Robert Hoffman
Mission Definition Team, chaired by Paul Kintner
GMDT Report published, September, 2002

Not pictured: Rod Heelis, Bob Schunk, and Michael Golightly

Geospace Status

- Current mission concept consists of two mission elements, the **Ionospheric-Thermospheric Storm Probes** (including an Earth Imager) and the **Radiation Belt Storm Probes;**
  - 2 SMEX size spacecraft per mission element
  - Projected launch readiness dates: FY08 for ITSP, FY10 for RBSP
  - If possible, all assets up by start of Solar Max
- Geospace missions formally assigned to JHU/APL
- AO for FUV imager mission-of-opportunity in 2003/2004;
- AO for instrumentation on I-T Storm Probes in 2003/2004;
- AO for instrumentation on RB Storm Probes to follow thereafter;
- Actively negotiating ILWS partnerships for mission implementation.
- **GMDT core missions and science measurements fit within cost cap of $400M (RY$)**

Radiation Belt Priority Observables

Priority Objective: Characterize and understand the acceleration, global distribution, and variability of the radiation belt electrons and ions that produce harsh environments for spacecraft and humans.

Which physical processes produce radiation belt enhancements?

- Direct convection
- Explosive inductive electric fields
- ULF waves and classical diffusion
- Magnetospheric waves generated by interplanetary shocks.
- Local, invariant-violating acceleration processes

Measurements:

- Simultaneous particle intensities at various radial distant separations
- Simultaneous multi-point phase space densities (full pitch angles and **B**)
- Global convection/transient **E,** and **E** and **B** waves
- Simultaneous multipoint **B** for characterizing dynamic configuration
- Ring current ion composition and intensity

Radiation Belt Priority Observables

What are the dominant mechanisms for relativistic electron loss?

- Drift out of magnetosphere
- Current sheet scattering
- Plasma wave scattering
- Coulomb scattering

Measurements:

- Global convection/transient **E**
- Electron pitch angle distributions sufficient to calculate loss rates
- Low-altitude electron precipitation
- Power spectral intensity of relevant plasma waves

What role does the ring current play in radiation belt creation and loss?

- Time history, locus, composition, and energy of ring current ions
- Role of ring current in storm-time waves affecting radiation particles
- Role of the ring current on global electric and magnetic fields that cause radiation belt transport

Measurements:

- In-situ ring current ion composition, pressure gradients
- Global distribution and evolution of ring current ion composition, energy density and pressure gradients

Ionosphere-Thermosphere Priority Observables

Priority Objective: Characterize and understand mid-latitude ionospheric variability and irregularities that affect communications, navigation and radar systems.

How does the I-T system vary in response to changing solar EUV?

- Solar EUV spectral irradiance
- In-situ I-T neutral composition, temperature, and winds
- In-situ plasma density and plasma density height profiles
- Global distributions of O/N_2 and Ne

How does the mid- and low-latitude I-T system respond to positive-phase storms?

- In-situ electric-fields/ion-drifts, neutral wind and composition, plasma density, and density-height profiles sampled simultaneously at adjacent longitudes.
- Role and evolution of penetrating polarization fields
- Role of magnetospheric inputs and fields on identified, in-situ parameters.
- Density gradient proxies for conductivity gradients and scintillation sources.
- Role of neutral winds on plasma transport and polarization fields.

Ionosphere-Thermosphere Priority Observables

Negative-phase ionospheric storm development, evolution, & recovery

- Spatial structure and temporal evolution of Joule heating.
- Thermospheric winds over range of <u>longitude separations</u>.
- Temperature/composition response to neutral upwelling and downwelling.
- Extent and evolution of dayside O depletions
- Composition transport by winds
- Relationship between neutral composition structures and ion depletions.
- Neutral wind – electric field relationship.
- Importance of dynamo processes in plasma transport
- Role of <u>latitude-longitude</u> thermal structure in global circulation

Sources and characteristics of mid-latitude ionospheric irregularities

- Extend, morphology, amplitudes of mid-latitude irregularities
- Discover free-energy sources
- Spectral properties that produce scintillations
- Determine detailed electric field/density wave characteristics of irregularities

Overview of Radiation Belt Storm Probes

Description: Main spacecraft and trailing smaller spacecraft in near equatorial, elliptical orbits (~500 km x 4.5 R_E altitude)

Mission Life: 2 years with optional 3-yr extension

Launch Date: 2010

Space Access: One launch on Medium Class ELV

Measurements, main spacecraft:

- 20 keV - 20 MeV electrons
- **B** and ULF waves
- DC E-field
- B and E VLF waves
- ring current ions (20-600keV), composition
- **plus, if feasible,**
  - energetic protons (1-200 MeV)
  - 0.01 – 20 keV ions and electrons

Measurements, smaller spacecraft:

- 20 keV - 1 MeV electrons
- **B** and ULF waves
- ring current ions (20-600keV), composition

Overview of Ionosphere-Thermosphere Storm Probes

Description: Twin ionospheric spacecraft at 60? inclination, 450 km altitude circular orbits, separated by 10? - 20? longitude

Mission Life: 3 years with optional 2-yr extension

Launch Date: 2009

Space Access: One launch on Medium Class ELV

Measurements, both spacecraft:

- plasma density, drift, and density fluctuations
- thermospheric wind, density and composition
- ionospheric (Ne) altitude profiles
- in-orbit scintillations

including,

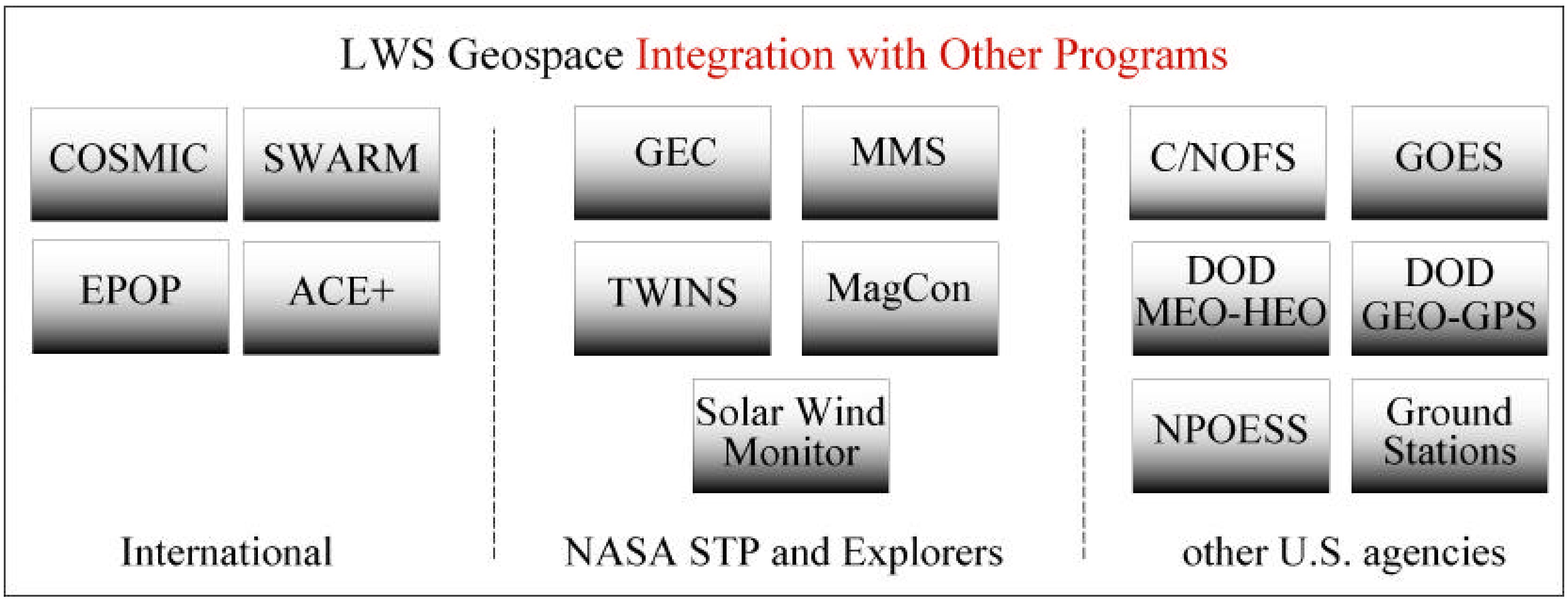
- EUV spectral flux on LWS Solar Dynamics Observatory spacecraft**,**
- I-T mid-latitude imager package at GEO: FUV for O/N_2 and Ne

plus, if feasible,

- Auroral electron precipitation
- Currents (**B**)
- AC electric fields

Integration with Other Programs to form a Single Observing Resource

Data from non-LWS spacecraft before, during and following the LWS flight phase, if coordinated and combined with LWS to **form a single observing resource**, will maximize our understanding and characterization of the Geospace systems.



Significant Events

- SEC Theme Director has decided to continue with planning for the Geospace Core Missions (2-IT, 2-RB and an FUV on a Mission of Opportunity).
  - To remain within the $400M allocated budget, the Program office and Headquarters will seek partners (both national and international) to offset cost.
  - In the event that we are unable to secure partners, we will plan to the existing schedule and cost guidelines.
- Announcement of Opportunities (AO) are in the process of being developed that reflect the above strategy.

LWS MOWG, Geospace Status: backup slides

Significant Events

Project office has been working since September to:

- fully define mission implications of GMDT objectives and recommendations
- develop requirements for strawman instrument suites
- understand resulting liens on the spacecraft and mission scenarios
- develop mission concepts for meeting requirements and liens
- estimate costs for delivering those mission concepts
- evaluate how other assets can contribute

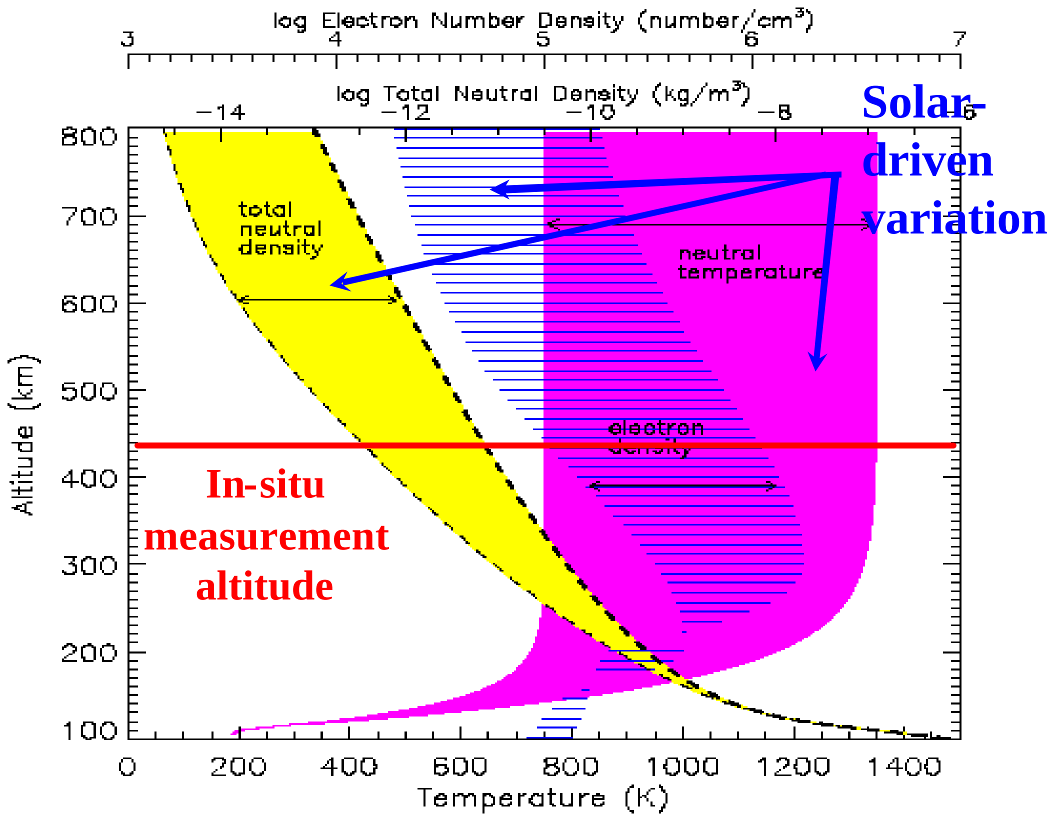
ITSP Science Issue #1: How does the I-T system vary in response to changing fluxes of solar EUV radiation?

- Is Solar EUV forcing consistent with the IT ground state?
- How does the IT system respond to changing solar EUV?

• SDO provides Solar EUV input.

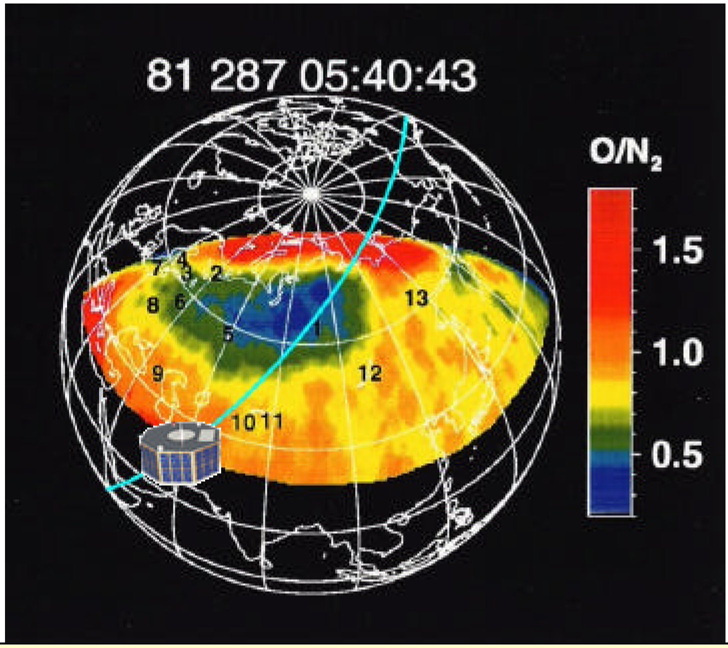
• ITSP S/C provides atmospheric / ionospheric mid-latitude response near critical F-region density maximum (in situ + remote GPS)

• Global (day / night) FUV imager distinguishes geostorm (mesoscale) from EUV (largescale) effects.

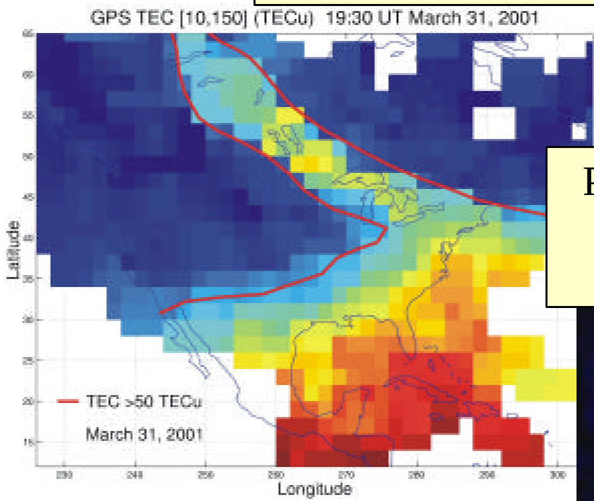


ITSP Science Issue #2 & 3: How does mid-latitude I-T system respond to gemomagnetic storms (positive and negative)?

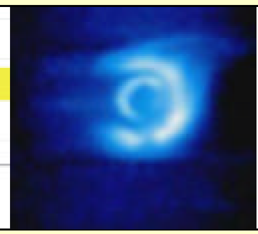
- Distributions and characteristics of ionospheric storms, and role of the magnetosphere
- What causes transport (winds, electric fields)?
- Composition response to winds and Joule heating (role of chemistry, etc.)
- Neutral dynamics effects on ionospheric depletions



RB/I-T electric field connection influences I-T dynamics



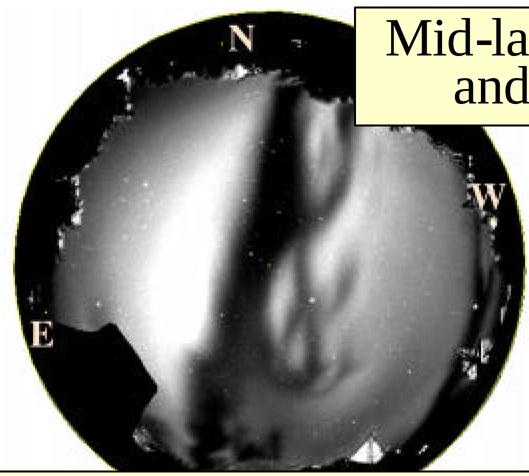
Plasmasphere as seen by IMAGE



- Imaging (day/night) yields distributions & some characteristics of storm dynamics
- ITSP S/C quantifies associated local densities, compositions, winds, electric fields.
- Imaging + local parameters yield estimates of gradients and transport processes.
- Imaging + local parameters yield role of atmosphere on ionospheric density.
- RBSP S/C determine inner magnetic state and geoelectric connection fields.

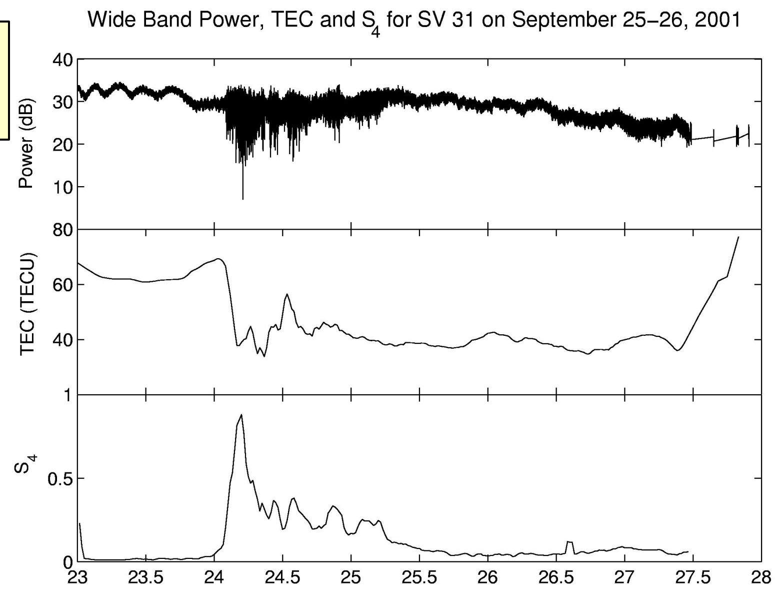
ITSP Science Issue #4: What are the sources and characteristics of ionospheric irregularities at mid-latitudes?

- Morpology, extent, amplitudes of irregularities.
- Sources of free energy and drivers.
- Details characteristics of irregularities (spectra, wave characteristics)



Mid-latitude depletions and scintillations

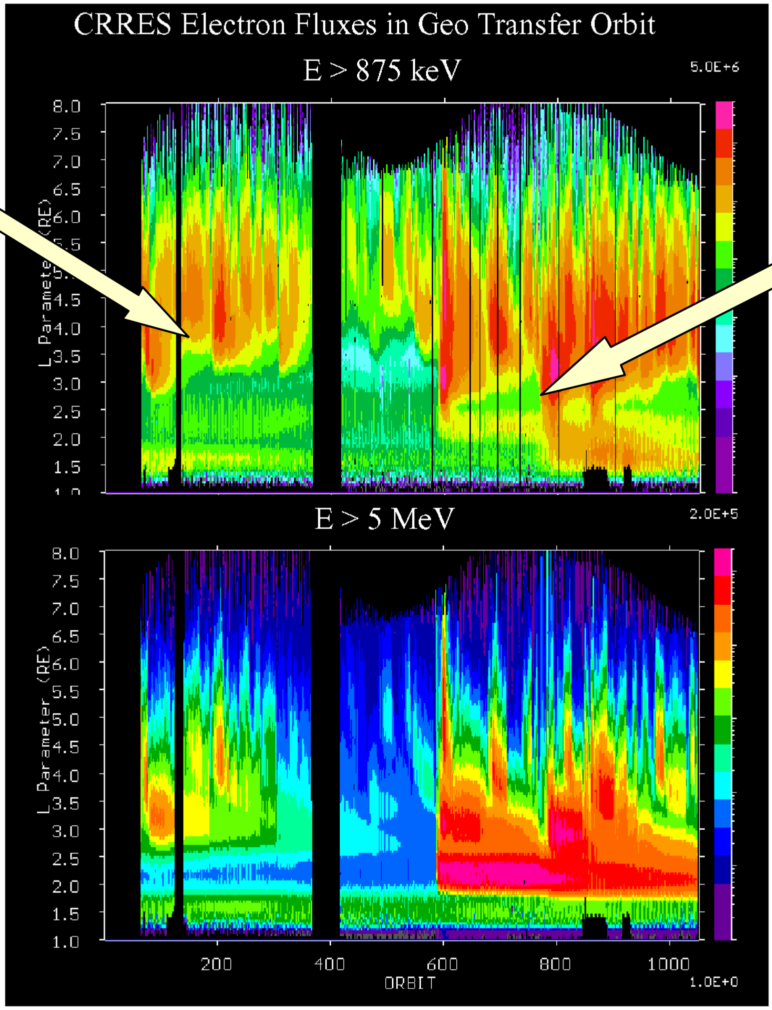
630 nm airglow emissions Arecibo



- ITSP S/C characterizes irregularity extent, amplitudes, morphology
- ITSP S/C GPS characterizes scintillation effects.
- ITSP S/C quantifies associated local densities, compositions, winds, electric fields.
- Imaging + local parameters yield estimates of gradient drivers of irregularities.
- Imaging + local parameters yield morphology of wind and plasma drift drivers.
- RBSP S/C assess connection to magnetospheric (electric field) drivers.

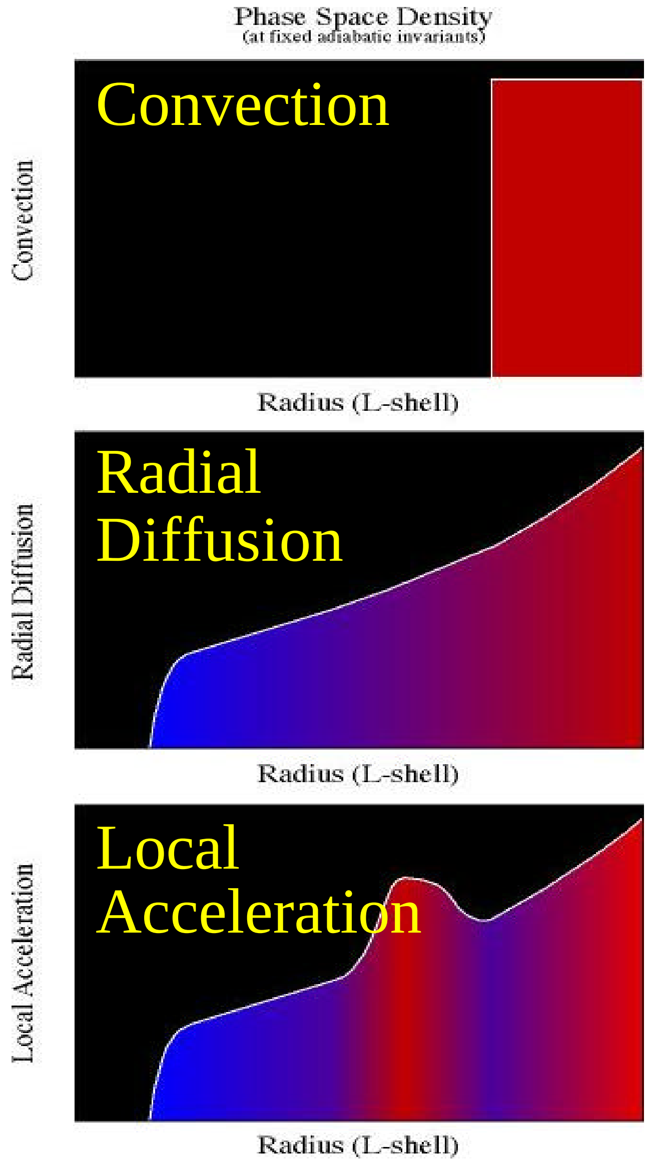
2 RBSP S/C distinguish storm-driven diffusive and shock acceleration and transport processes affecting spacecraft health and safety

2 RB spacecraft assess whether diffusive transport is accompanied by local acceleration processes



2 RB spacecraft track the propagation of shocks that generate new radiation belts

Two RBSP track phase space density evolution to assess the role of local acceleration processes



Phase Space Density is a transport invariant. Simultaneous measurements of phase space density distributions at multiple L-shells, and, at other times, along 2 local times will determine radial diffusion rates and impulsive transport characteristics and distinguish between adiabatic and non-adiabatic energization.