Van Allen Probes Coordination with the CEDAR Community

June 13, 2013

Introduction

Van Allen Probes is a stand-alone mission created to answer fundamental questions about the Earth's radiation belts. The CEDAR (Ionosphere-Thermosphere) community can provide Van Allen Probes both detailed multipoint measurements and global context. Conversely, Van Allen Probes provides in situ measurements of inner magnetospheric quantities that can help CEDAR scientists improve their understanding of how the magnetosphere affects the upper atmosphere. This white paper describes potential research topics that can be pursued jointly by the Van Allen Probes and CEDAR communities to their mutual benefit.

CEDAR supports Van Allen Probes: Global Context for In Situ Observations

The two-satellite Van Allen Probes constellation will provide in-situ measurements of critical RB quantities from two locations. The mission offers the first systematic multipoint measurements of radiation belt particles, fields, and waves. Although Van Allen Probes will provide information on radiation belt spatial variability not possible with a single spacecraft, the radiation belt problem remains spatially undersampled. Van Allen Probes will therefore benefit from the recent development within the CEDAR community of ground-based observational networks that sample a broad range of the magnetosphere through its magnetic footprints within the upper atmosphere. The CEDAR observations will help constrain conditions for particle energization and loss (particularly wave-particle interactions), and help answer science questions regarding how radiation belt conditions vary from storm to storm.

Specific measurements provided from the CEDAR community (and examples of the corresponding questions that they address) include:

- TEC ground-based observations of the plasmasphere boundary and plumes: Conditions near the plasmapause should favor the generation of EMIC waves. What is the correlation between the inner edge of the outer belt and the plasmapause, and what role do plumes play in generating EMIC waves?
- Energetic particle precipitation (EPP, observed with riometers, all-sky cameras, photometers, ionosondes, etc.): What fraction of electron flux decreases observed at Van Allen Probes are correlated with EPP signatures observed by ground networks, in conjunction with the BARREL mission?
- Large-scale, high-time resolution mapping of magnetospheric electric fields as projected into the mid and high-latitude ionosphere (SuperDARN, ISR, DMSP): What are the connections between storm-time electric field dynamics and plasma transport, especially in the inner magnetosphere, to ring current processes and radiation belt enhancement events, to be determined in conjunction with the TWIN mission?

- Geospace current systems (AMPERE, DMSP, SWARM, ground based magnetometer networks): How are hot plasma particle distributions measured by Van Allen Probes connected to the geospace currents measured by these complementary systems?
- ULF/ELF/VLF waves (e.g., EMIC, chorus, hiss, etc. ground based magnetometers, SuperDARN): What role does each wave play in radiation belt acceleration/loss mechanisms as deduced by Van Allen Probes? What are their relative contributions? What are the global characteristics of the ULF waves that accompany energization and decay of the radiation belts?
- Various tools available to CEDAR scientists are used to describe detailed storm-time behavior. These tools can be applied to help Van Allen Probes scientists distinguish variability between storms that may share similar Dst indices.
- Magnetometer networks (in conjunction with riometers?): How does substorm onset seed the outer zone electron population source?

Van Allen Probes supports CEDAR: Energetics and Electrodynamic Coupling

Research within the CEDAR community has established that magnetospheric particles and currents play major roles in significantly restructuring the upper atmosphere (thermosphere and ionosphere) during geomagnetic disturbances and substorms. Understanding the sources and variability of the ring current and the energetic particle populations that precipitate, causing the aurora, will significantly improve the CEDAR community's attempts to understand the complex interplay of interactions that unfold during geomagnetic storms and substorms. In particular, Van Allen Probes will provide the CEDAR community with:

- Ring current particle and electric/magnetic field measurements: How do shielding processes in the inner magnetosphere and current closure between magnetosphere and ionosphere impact the ionospheric electrodynamics (e.g., subauroral electric fields – SAPS) and the dynamics (e.g., storm enhanced densities – SEDs)?
- Plasmaspheric densities: What influences the field aligned coupling of the plasma between plasmasphere and ionosphere?
- EPP: What can Van Allen Probes tell us about precipitating electron populations, to understand how these affect the energy distribution, chemistry and transport of the upper/middle atmosphere?
- Impacts on the ionosphere and upper atmosphere: What are the effects of energetic precipitating particles on ionospheric structure, atmospheric heating, the formation of irregularities, and the generation of atmospheric gravity waves?
- Energy flow in the disturbed M-I-T system: what are the relations between storm-time processes in the magnetosphere and the coupling of energy into the I-T system?

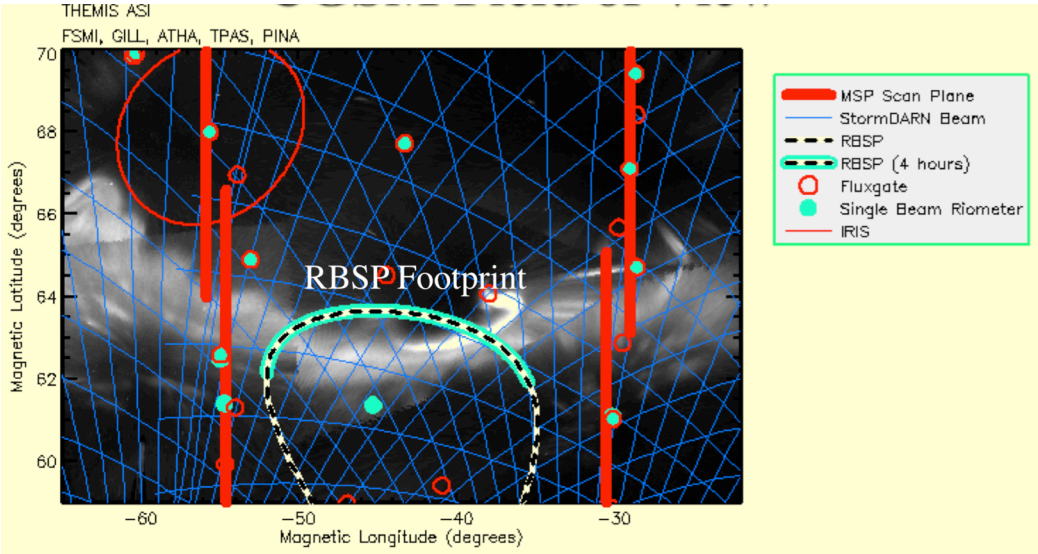

Figure 1 – Overlay of Van Allen Probes footprint with location of aurora and substorm activity from the ground based auroral observing facility. From E. Donovan.

Way Forward

There are numerous opportunities for Van Allen Probes to benefit from the contextual observations available from the CEDAR community. At the same time, Van Allen Probes measurements can improve physical understanding of M-I coupling of relevance to upper atmosphere dynamics. This white paper can serve as a guide for scientific and programmatic decision making that will increase science return to the Van Allen Probes and CEDAR communities. Collaborations are encouraged that can bring mutual benefit to CEDAR and Van Allen Probes science and can improve our big picture of the coupling between magnetosphere-ionosphere-atmosphere.