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2012 WORKSHOP REPORT: Radiation Belt and Waves Focus Group

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The GEM Radiation Belt and Waves Focus Group began the week with a discussion of the ongoing RBW Particle Challenge, whereby GEM radiation belt modelers undertake simulations of the radiation belt dynamics for a specified period from the CRRES era. We had two presentations summarizing results from the UCLA and LANL modeling efforts. In both cases, modelers noted substantial heating associated with the introduction of chorus waves in the simulations, far exceeding observed heating rates. The UCLA model noted that the introduction of appropriate cross terms in the diffusion tensor reduced the rate of heating to be more in line with observations, while the LANL group assumed a lower level of chorus wave activity than statistical models suggest, pending inclusion of cross terms in their model. We also discussed relevant physical processes that may be included in future models participating in the challenge. Magnetopause shadowing was noted as an important process governing loss at high altitudes, with ring current activity playing a role in concert with magnetopause position. Seed populations of energetic electrons injected from the tail were modeled in the context of a low energy and high-L boundary conditions for dynamic models of the belts.

The group devoted a session to general radiation belt modeling efforts, with a focus on preparing radiation belt models for RBSP data. Data assimilation methods were used in efforts to determine the source location for radiation belt heating, with separate efforts focused on the outer zone electron and the inner zone proton belts. **A study of radial diffusion coefficients used in radiation belt modeling underscored similarities and differences in transport rates inferred from** a variety of sources including previous empirical estimates, those obtained from recent global MHD simulations, in situ, as well as **ground observations of magnetospheric ULF wave activity**. Work was presented regarding the probability distribution of radiation belt fluxes as associated with solar wind speed, where it was shown that normalizing the observations by solar wind speed occurrence frequency made flux dependence on solar wind activity much more apparent. There was discussion of the appropriate basis functions used to describe radiation belt pitch angle diffusion. Radiation belt loss mechanisms were discussed in the context of observed radiation belt decay times, and additional discussion focused on the effects of magnetopause shadowing on radiation belt losses.

Wave-particle interactions are a key part of the dynamics of the outer zone electron belt. EMIC wave growth and propagation was the focus of modeling efforts examining an event observed by Cluster, and a separate study examined 'microburst' precipitation of electrons observed at LEO. A study of the evolution of the outer zone phase space density profile in response to a high speed stream showed the dynamics of the radiation belts in the context of typical solar wind conditions for such events, and investigations of the injection of electrons into the slot region likewise looked for associations between solar wind conditions and slot populations. We discussed non-linear wave particle interactions, both in the context of structured chorus waves, **and with global ULF waves.** In the latter case, global models of the magnetosphere suggest that radial diffusion may not be an adequate descriptor of the transport process in the outer zone.

The group devoted two sessions to discussions of wave excitation, propagation, and distribution, focusing on both ULF and ELF/VLF waves. Initial results from the coupled LFM/RCM global were analyzed for Pc-5 ULF wave activity, showing the significant effect of the plasmasphere

on supported resonant wave modes within the magnetosphere. Statistical studies of Pc-5 ULF waves observed by THEMIS suggested the existence of global cavity/waveguide modes, most easily observed during periods of relatively calm solar wind, with most events being observed in the noon sector. There was extensive discussion on the characteristics and physics of magnetospheric EMIC waves, with event studies contrasting the polarization state, heavy ion heating, and source regions associated with different levels of warm ion anisotropy and solar wind conditions; persistent, localized EMIC waves were reported in association with pressure increases in another event observed by ground magnetometers during a high speed solar wind event. There were also reports of active modeling efforts devoted to understanding the physical origins and characteristics of EMIC waves. Separate numerical studies of the effect of O+ concentrations indicated that oxygen ion concentrations can have a significant effect on wave generation regions, oxygen heating, and wave polarization and propagation. Simulations of Pc-1 waves in the ionospheric Alfven resonator suggested the effect of ionospheric conductivity on ground-based signatures of these waves.

Numerical models of wave excitation and propagation at VLF frequencies looked at whistler propagation and amplification as a function of wave frequency and local density variations, including ducting effects along gradients in the plasma density and confinement of waves within the plasmasphere. Nonlinear processes including mode-mode wave coupling were considered in the context of wave excitation and particle heating. Statistical analyses of the source locations of magnetospheric chorus were seen to be consistent with numerical simulations of electron temperature anisotropies induced in the off-equatorial magnetic minima near the dayside cusps, while studies of THEMIS observations of magnetosonic and discrete hiss-like chorus worked to improve our understanding of the occurrence and characteristics of these wave populations.

The Radiation Belt and Waves Focus Group is undertaking a challenge in the numerical modeling of the magnetospheric waves relevant to radiation belt transport, loss, and acceleration, with a goal of identifying the relevant physics and numerics important for reproducing real observations. The framework of this challenge will be worked out over the coming weeks and announced at the Fall AGU GEM Mini-workshop, and will include efforts to model wave activity under both observed and idealized magnetospheric conditions, covering important wave populations at VLF/ELF and ULF frequencies. We welcome thoughts from the wider GEM community on issues such as boundary and initial conditions for the simulations and relevant observations and metrics for validation, and encourage participation of all those with an interest in modeling aspects of the magnetospheric wave environment.