of hydromagnetic waves of SC impulses with the ionosphere and these electric field drive the ionospheric currents to which ground magnetometers respond during sudden impulses and sudden commencements. Power spectra and polarization characteristics of these pulsation events are presented and discussed in the light of the physical processes due to the Equatorial Ionization Anomaly - EIA and possible enhancement of electric fields in the SAMA region. In order to investigate the relationship of the pulsation events on the interplanetary shock parameters, plasma and IMF data from the satellite ACE are used.

SM31A-14 0830h POSTER

A Survey of Dayside Pc 3-4 Magnetic Pulsations Observed by the Polar Satellite and Antarctic Ground Stations

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Pc 3-4 pulsations (with frequencies from ~15 to 50 mHz) are commonly observed in magnetic field data from satellites throughout much of the dayside magnetosphere, and in ground-based data at latitudes from the equator to the cusp. The precession of Polar's apogee from its initial location over the northern polar cap in 1996-1997 to equatorial latitudes in 2002-2003 allows it to survey the outer magnetosphere over a wide range of latitudes and L shells. In this study we compare simultaneous magnetic field data from the Polar satellite with data from a set of ground-based search coil magnetometers in Antarctica (at latitudes from 66° to 74° MLAT) in order to characterize the regions of Pc 3-4 pulsation activity in the noon sector in terms of L shell and magnetic latitude, and to characterize those waves which do or do not appear simultaneously in space and on the ground at high latitudes. We find that Pc 3-4 activity with observed compressional components consistently appeared over a range of L shells and latitudes between +20 and -30 degrees, typically crossing the equator; a small number of purely compressional wave events appeared to be localized very near the magnetic equator. Purely transverse pulsations occurred over a much broader latitudinal range than those with compressional components. The overall power of the compressional component of Pc 3-4 activity seems to increase with distance from the Earth.

SM31B CC: 518 C Wednesday 0830h

Relativistic Electrons in the Earth's Inner Magnetosphere: Observations, Models, and Space Weather Implications I

Presiding: **S R Elkington,** University of Colorado**; R H Friedel,** Los Alamos National Laboratory

SM31B-01 0830h INVITED

The Rate of Electron Acceleration and Loss due to Wave-Particle Interactions

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Intense plasma wave emissions are generated in the radiation belts during the convective injection of plasmasheet particles into the outer radiation zone. Natural gradients in the velocity space distribution of the injected low-energy population provide the source of free energy for the excitation of these waves. Excited waves can also resonant with the high-energy relativistic electrons, causing either precipitation loss or local acceleration by energy diffusion. In the basically collisionless magnetospheric environment, plasma waves provide an efficient mechanism for the transfer of energy from thermal plasmasheet particles to the high-energy radiation belt population. Model calculations of the effective rate of local electron acceleration and loss will be presented and applied to explain observations of the global distribution of energetic radiation belt electrons during geomagnetically disturbed conditions.

SM31B-02 0845h INVITED

Relativistic Electron Phase Space Density Gradients: Past, Present, and Future

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A critical parameter for understanding radiation belt electron dynamics is the gradient in phase space density as a function of radius. Typically one wants to calculate phase space densities as a function of the adiabatic invariants of particle motion. Phase space densities gradients at fixed values of the invariants help reveal diffusive transport processes, stochastic acceleration processes, adiabatic motion of particles in response to the storm time ring current, loss due to atmospheric precipitation, and other critical processes for radiation belt dynamics. The primary challenge in these studies is that instruments do not measure phase space density or the adiabatic invariants. They measure fluxes in fixed energy channels as a function of spatial location and time. This drives us to use magnetic field models to calculate the adiabatic invariants (particularly the bounce and drift invariants) leading to a strong relationship between the accuracy of the field models and the accuracy of the gradients. Furthermore satellite orbit periods are typically similar to the relevant time scales for physical processes. Typically multi-satellite measurements are needed to compare phase space densities at different locations. This talk will review recent work on determining phase space density gradients as a function of fixed invariants. We will discuss the conclusions of those studies and the limits on their generality. We will consider current work using the present configuration of satellites measuring the inner magnetosphere and explore what types of studies can be most fruitful for closure of current scientific questions. We will also look at the limitations of current models and measurements and look ahead to what will be possible given future missions such as LWS.

SM31B-03 0900h

Pre and Post Storm Energetic Electron Observations in the Inner Magnetosphere

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We examine the energetic electron observations from SCATHA and other satellites to study the inner magnetosphere electron distributions both pre and post storm. In particular, we examine the SCATHA electron radial profiles to set the pre storm conditions and monitor the changes following the storm. The SCATHA satellite provides electron observations covering the energy range from keV to > 1 MeV over a radial distance of 5.2 to 7.2 Re geocentric near the magnetic equator in the 1980's. These data will be compared with simultaneous LANL geosynchronous (GEO) and GPS near equatorial data at 6.6 and 4.2 Re respectively where available. Similarly, we will compare HEO and GPS data for recent storms. The HEO satellites sample L values ranging from 2 to more than 10, spanning the GPS and GEO coverage in L but not at the equator. As an example, the SCATHA data for the 12 April 1981 storm shows that during the initial post main-phase electron flux rise the phase space density (PSD) radial profile at M=100 MeV/G is flat in the L=5.5–6.5 range and falling for L=6.5–8.3, indicating a possible peak in PSD below GEO altitudes. At the time of the peak flux at GEO and SCATHA on 17–18 April the PSD radial profile is essentially flat over the L=5.5–8.4 range indicating that any earthward fall-off in PSD is well below L=5.5. The observations provide a view of the energetic particles from the source region, beyond geosynchronous, down to SCATHA perigee at 5.5 and, at times, down to L=4.2, near the peak of the outer electron radiation belt. The results will provide constraints on the PSD profiles that can be assumed in transport models and will be discussed in that context.

SM31B-04 0915h

Statistical Results of POLAR Relativistic Electron Phase Space Density Gradients

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A major outstanding question in inner magnetospheric research is the origin and acceleration mechanisms responsible for the variability of the relativistic electrons in the Earth's radiation belts. A critical parameter for such dynamics is the gradient in phase space density (PSD) as a function of radius, with PSD calculated as a function of the adiabatic invariants of particle motion. In a recent study, POLAR data has been examined over a range of L and a peak in PSD at 4-6 Earth radii has indicated the possibility of a localized source region of radiation belt relativistic electron enhancements. This result has been repeated in a study by the current authors, which also suggested a sufficient population at CLUSTER radial distances to supply the inner magnetosphere by radial transport, agreeing well with particle tracing models. In this study we extend previous work by examining a measurements by the POLAR satellite over its mission lifetime, 1997 to the present day. Due to the precession of the orbit, POLAR equatorial crossings range from L=4 to L=9 depending on the year of measurement, such that in a statistical sense POLAR fills in the region of primary interest with an unprecedented density of equatorial PSD measurements. Our statistical analysis of equatorial crossings provides the first opportunity to investigate the phase space density profiles over a full range of all three invariants (mu, J, and L*) and over a variety of geomagnetic conditions.

SM31B-05 0930h INVITED

Vision for a Virtual Radiation Belt Observatory

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Satellite engineers, operators, and scientists now share a common desire to understand the structure and variability of the earth's radiation belts. Continuing upsets to space operations demonstrate a need for improved scientific understanding of the radiation belts, more accurate models, and better transfer of scientific understanding to space technology and operations. Currently, the resources necessary for such advancements are beyond the scope of an individual researcher. Thus, we discuss plans to advance our understanding of the radiation belts and mitigate the hazards they pose

to society by creating a Virtual Radiation Belt Observatory (ViRBO). The observatory will be an open access near real time and long term archive of observed and simulated radiation belt model data. It will enable scientists to test theoretical mechanisms proposed to explain how particles are accelerated and removed from the radiation belts and it will provide improved tools for engineers designing satellites and operators assessing satellite malfunctions. The observatory will capitalize on radiation belt modeling efforts currently underway at institutions throughout the country and support the goals of the electronic Geophysical Year (eGY) endorsed by the world wide community.

SM32A CC: 518 C Wednesday 1030h

Relativistic Electrons in the Earth's Inner Magnetosphere: Observations, Models, and Space Weather Implications II

Presiding: **G D Reeves,** Los Alamos National Laboratory**; J F Fennell,** Aerospace Corporation

SM32A-01 1030h

Characteristics of the March 31, 2001 0630 substorm injection front

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The global field reconfiguration associated with a geomagnetic substorm can have a significant impact on the dynamics of energetic particles (> keV) in the near-Earth tail and inner magnetosphere. For example, the Earthward-propagating wavefront associated with substorm onset can energize and inject plasma sheet particles into the stable trapping region of the inner magnetosphere and potentially provide a seed population of radiation belt particles. The physical characteristics of the injection front, including the amplitude of the perturbation fields, the propagation velocity, and the spatial extent of the wave front, determine the degree to which different magnetospheric populations are affected by the substorm onset. In this work, we examine the substorm occurring at 0630 UT during the March 31, 2001 geomagnetic storm. Using 3d MHD simulations of the event, we analyze the characteristics of the global geomagnetic field prior to onset, and discuss the properties and evolution of the subsequent substorm injection front. Test particle simulations are used to track the motion of ions and electrons moving under the influence of the dynamic substorm fields, in an effort to determine the properties and origin of those particles most effectively injected and trapped in the inner magnetosphere.

SM32A-02 1045h

Observations of Outer Zone Relativistic Electrons during the October-November 2003 Geomagnetic Storms

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We report on the measurements of outer zone relativistic electrons during the months of October and November 2003. This period showed high fluxes of relativistic electrons which resulted from the magnetosphere being driven by strong coronal mass ejections with solar wind speeds exceeding 1000 Km/sec. Our previous studies of electron energization events have shown that they exhibit spatial and pitch angle coherence. Such coherent behavior is indicative of energization of preferred pitch-angle electrons followed by rapid scattering and/or pitch-angle independent energization of relativistic electrons. It is of interest to examine these properties during "extreme" events such as the October-November period when the magnetosphere was subject to extremely intense solar drivers. We will investigate the pitch-angle and spatial coherence of relativistic electrons during the October-November event and compare them with the more "usual" events. We will use data collected by sensors onboard SAMPEX and POLAR which provide full coverage of the outer zone over energies ranging from about 0.5 MeV to about 15 MeV.

SM32A-03 1100h

Extreme MeV Electron Fluxes at Geosynchronous Orbit

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Following the work of Koons [2001], we examine the statistical properties of extremely high MeV electron fluxes at geosynchronous orbit. We extend the analysis to include a variety of timescales and energies using observations from Los Alamos and NOAA/GOES spacecraft. We use the statistical formalism of the generalized extreme value distribution, which represents the probability distribution of the maximum value taken out of a sample of fixed size. By taking the maximum flux observed in many non-overlapping intervals of several days, we can determine whether the maximum flux at Geosynchronous is likely to have a finite upper limit or an exponential or power-law tail. Our analysis indicates that MeV electron fluxes over a broad range of energies and timescales have a finite upper limit, a true worst case. However, the statistical estimate of this upper limit is inherently uncertain. We explore the sensitivity of the flux upper limit to changes in the sample interval. In particular, we find that samples from the declining phase (i.e. 1995) dominate the maximum value distribution.

SM32A-04 1115h INVITED

Predicting Radiation Belt Electron Fluxes and Space Weather Implications

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The intimate connection between the variations of radiation belt electrons and the solar wind velocity was identified soon after the solar wind was measured. This connection was demonstrated by the existence of a 27-day periodicity in the intensities of trapped electrons in the outer radiation belt. This correlation provides the base for scientists to develop various models to predict the variations of MeV electrons in the Earth's magnetosphere. In this presentation, the long-term and short-term variations of outer belt electron fluxes will be reviewed, so will the attempts and results of predicting their variations based on solar wind measurements.

SM32A-05 1130h

Electron Flux Prediction in the Radiation Belt Using Autoregressive Models With Optimally-Estimated Coefficients.

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Linear autoregressive (AR) processes have modeled many natural systems successfully. In this study, fourth and sixth order Kalman filters were used to identify the coefficients in time series of relativistic electron flux measurements in the region 1<L<10, available from SAMPEX. The estimation was done recursively, so that the optimal estimated coefficients up to the time of the most recent input measurement were computed. In addition to coefficient identification, AR model electron flux predictions using the optimal coefficients were compared to actual electron flux measured at the predicted time by SAMPEX, and the prediction accuracy was assessed. Results of this estimation and prediction, across all L-shells, demonstrated that the leading term in the autoregressive model was dominant. Further results indicate a nearly linear dependence in the leading coefficient with L-shell in the range from L=3 to L=10. Through these results, dynamical processes present in the outer radiation belt can be inferred. Autoregressive filters of higher order did not demonstrate marked improvement in their electron flux measurement prediction when compared with actual SAMPEX measurements. These results indicate the need for external inputs as can be provided by ARX models that will include solar wind measurements for improved modeled electron flux predictions.

SM32A-06 1145h

Modeling the Radiation Belt Electrons With Radial Diffusion Driven by the Solar Wind

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A radial diffusion model for predicting the relativistic electron flux in the outer radiation belt will be described. The model was developed by expanding the Li et al. [2001] geosynchronous prediction model, which simulates the relativistic electrons with the radial diffusion equation and a loss term. The diffusion equation is solved by making the diffusion coefficient a function of solar wind parameters. The Li et al. model is extended for prediction inside geosynchronous orbit by making some of the model parameters functions of L to represent the changing environment of radiation belt electrons at different L-shells. Using the extended model, prediction efficiencies of 0.54 and 0.56 were achieved for $L = 4$ and $L = 6$, respectively, for the year 1998 when compared with POLAR measurements at $L = 4$ and LANL geosynchronous measurements. These results, and those for individual storms, will be presented.

SM33A CC: 220 C-E Wednesday 1330h

Magnetosphere-Ionosphere Coupling in the Solar System III Posters *(joint with P, SA)*

Presiding: **B H Mauk,** The Johns Hopkins University, Applied Physics Laboratory**; C J Frank,** Southwest Research Institute

SM33A-01 1330h POSTER

Coupled Model of Storm Time Effects on the Low- to Mid-Latitude Ionosphere

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The details of how magnetospherically driven penetration electric fields couple to the mid- and low-latitude ionosphere and generate large scale variations and structure in the plasma density is of paramount importance to the NASA Living with a Star Program. We are developing a computational tool for self-consistent modeling of the coupled inner magnetosphere-ionosphere system. The approach is to combine two existing, but compatible, computer models which treat different parts of the physical system: the Rice Convection Model (RCM), which models the electrodynamics of the inner magnetosphere;

S M