SH52A MCC: 2008 Friday 1340h

Space Science Research With Societal Consequences IV *(joint with SA, SM, AE)*

Presiding: **D Baker,** Laboratory for Atmospheric and Space Physics, University of Colorado**; T Lui,** Applied Physics Laboratory, Johns Hopkins University

SH52A-01 1340h INVITED

Transitioning From Space Physics Research to Space Weather Application at The Johns Hopkins University Applied Physics Laboratory (JHU/APL)

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The ability to monitor and predict our near-Earth space environment ("space weather") lags its sister discipline of terrestrial weather studies by years, in both observational and forecast capabilities. However, with current rapid progress in space physics research, and with current and near-future space environment sensors on research and operational satellites, the space weather operational community can reach new levels of maturity. A rapid transition of scientific research results into prototype operational products is especially important. This paper addresses the concept of rapid transition and presents examples carried out recently by scientists at JHU/APL, such as: OVATION (Oval Variation, Assessment, Tracking, Intensity and Online Nowcasting), and real-time geomagnetic activity nowcasting using observations from limited ground magnetometer stations. Several potential future application projects will be discussed as well; these space-environment products are designed to coincide with operationally significant events, such as communication outages or space object tracking.

SH52A-02 1400h

A Radiation Belt Forecasting Model

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While there are existing models that specify and forecast the radiation belt environment, hardly any of them covers the entire radiation belt region and energy range. We have developed a forecasting model to predict the global radiation belt environment. The model is a data-driven physics-based model, which solves the bounce averaged convection-diffusion equation of plasma distribution functions in the ranges of 2-10 earth radii and 10 keV to 5 MeV energy. The effects of fluctuating magnetic and electric fields in particle transport, energy and pitch-angle diffusions due to wave-particle interactions are included in the model. A plasmasphere model is also embedded in the forecasting model to specify the cold plasma distribution for wave diffusion coefficient calculations. Simulation results of several magnetic storms suggest that the inductive electric field associated with time-varying magnetic field and energy diffusion as plasmas interacting with the whistler chorus are potential mechanisms to explain the electron enhancements often seen during storm recovery phases.

SH52A-03 1415h

Categorized Observed and Modeled Stormtime Reponses at Geosynchronous Orbit

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Solar wind and geosynchronous orbit data for over 400 storms (minimum Dst < -30 nT) from 1989 through 2002 have been categorized according to various storm parameters (minimum Dst, peak solar wind pressure, minimum interplanetary Bz, main phase length, and peak plasma sheet density, and solar cycle phase, for example). The superposed epoch averages of the data in some of these categories are presented and discussed. Morphological differences in the geosynchronous response as a function of storm category are detailed. The implications of these results for the stormtime ring current are also explored. The averaged upstream conditions are used as input to the Comprehensive Space Environment Model (CSEM) to simulate each of these storm classifications. Initial results of these numerical experiments are presented and discussed. Finally, comparisons of observations and model results at geosynchronous orbit are given (1) to assess the quality of the CSEM results and (2) to quantitatively examine the ring current dynamics.

SH52A-04 1430h

Forecast and Specification of Radiation Belt Electrons Based on Solar Wind Measurements

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Relativistic electrons in the Earth's magnetosphere are of considerable practical importance because of their effect on spacecraft and because of their radiation hazard to astronauts who perform extravehicular activity. The good correlation between solar wind velocity and MeV electron fluxes at geosynchronous orbit has long been established. We have developed a radial diffusion model, using solar wind parameters as the only input, to reproduce the variation of the MeV electrons at geosynchronous orbit. Based on this model, we have constructed a real-time model that forecasts one to two days in advance the daily averaged >2 MeV electron flux at geosynchronous orbit using real-time solar wind data from ACE. The forecasts from this model are available on the web in real time. A natural extension of our current model is to create a system for making quantitative forecasts and specifications of radiation belt electrons at different radial distances and different local times based on the solar wind conditions. The successes and obstacles associated with this extension will be discussed in this presentation.

URL: http://lasp.colorado.edu/∼lix/

SH52A-05 1445h

HEO Observations of the Radiation Belt Electron Fluxes: Comparison with Model Predictions and a Source for Model Updates

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We have developed a database of energetic electron fluxes from observations taken by the HEO (94-026 and 97-068) satellites in the inner magnetosphere. The HEO satellites are in highly elliptical orbits, with orbital periods near 12 hours, that cover the L range 2 to 10 for HEO 97-068 and above 3.5 for HEO 94-026. HEO 97-068 covers the same L values at both high (above 2 Re geocentric) and low (below 1.2 Re geocentric) altitudes. Each satellite carries sensors that measure electron and proton fluxes over a wide range of energies. These data have been organized in B, L and MLT using the IGRF and Olsen-Pfizer field models. The database includes the total dose and dose rates observed behind several different shield thickness. The radiation dose measurements are compared to predictions from the current standard models (AE8 and AP8). One and four year average dose measurements indicate that the models over estimate the expected dose by significant factors, especially at shielding levels between 10 and 150 mils Al. The database has been used to study the dynamic response of the radiation belts to magnetic storms and for comparison with observations by other spacecraft. For example, we have compared the electron responses at the same L both at high and low altitudes as a check on the assertion that the radiation belt responses are coherent, i.e. the same at low altitudes as nearer the equator. In particular, we intercompare the HEO 97-068 high and low altitude fluxes and the SAMPEX low altitude fluxes. We find that the high and low altitude fluxes do indeed track each other quite well with the low altitude 1.5 MeV electron fluxes being about 10 percent of the high altitude fluxes for L = 3 to 6, except during magnetic storm main phase. We have measured the flux decays that relate to the long-term losses following storm-time enhancements. As an example, at L = 3 the high-altitude 1.5 MeV electron fluxes were found to have three distinct 1/e decay times near 5, 10.5 and 17.5 days. These and other results obtained from the database will be presented, summarized and related to ongoing efforts to update the standard models.

SH52A-06 1500h

Relativistic Electron Variability in Earth's Magnetosphere

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The trapped electron flux in Earth's magnetosphere is highly dynamic, varying over many orders of magnitude on time scales ranging from minutes to days to years. In this research, we have concentrated on determining the solar wind and magnetospheric conditions that lead to abrupt energetic electron dropouts and enhancements, and on the local-time dependence, radial dependence, and energy dependence of the response of the energetic particles to these conditions. This research has not been limited to time intervals of strong geomagnetic storms, since considerable variability in the radiation belt populations is observed during weak storms or even during non-storm times. We have found that abrupt flux dropouts occur through a combination of solar wind driving and a preconditioning of the magnetosphere. The dropouts occur coincident with the onset of moderate geomagnetic activity following a period of prolonged quiet conditions. Furthermore, we have found that there is a strong preference for the dropouts initially to occur in the dusk sector of the magnetosphere due to an asymmetric distortion of the magnetic field. Although the dropouts initially result from adiabatic motion of the electrons and not due to actual loss, it is often the case that actual loss from the magnetosphere does eventually occur prior to the recovery of the magnetic field. The relative importance of the enhanced ring current, tail-like magnetic field stretching, and magnetopause compression for causing the abrupt particle dropouts is discussed.

SH52A-07 1515h

Stormtime Ionospheric Irregularities in SAPS-Related Troughs: Causes of GPS Scintillations at Mid Latitudes

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Radio-wave scintillations are space weather effects caused by ionospheric plasma density irregularities. The subauroral ionosphere, at magnetic latitudes corresponding to the northeastern US, is generally free of such irregularities and consequently scintillations. Recently, Basu et al. [JGR, 106, 30389, 2001] and Ledvina et al. [GRL, 29, 10.1029/2002GL014770] reported observations of strong GPS phase and amplitude scintillations at 1.5 GHz at Hanscom AFB, MA and Ithaca, NY during the magnetic storms of 23 September, 1999 and 25 - 26 September, 2001, respectively. We report results of a survey of small-scale plasma density and electromagnetic oscillations detected by DMSP F13, 14, and 15 satellites while flying over the affected regions at altitude of 840 km. Langmuir probe data, sampled at a rate of 24 Hz, show that during the scintillation intervals the amplitudes of density oscillations in the frequency range of 3-10 Hz increased by a factor of 100. The enhanced fluctuations appeared at the poleward edges of large-scale density troughs, embedded within subauroral polarization streams. When Doppler-shifted from spacecraft frames of reference the oscillations correspond to irregularities with spatial scales of 2-0.7 km. Most likely these irregularities are responsible for radio-signal scintillations at frequencies near 1 GHz.

SH52B MCC: 2008 Friday 1600h

Space Science Research With Societal Consequences V *(joint with SA, SM, AE)*

Presiding: **R Pfaff,** NASA Goddard Space Flight Center**; R Robinson,** National Science Foundation

SH52B-01 1600h INVITED

Response of the Low Latitude Thermosphere and Ionosphere to Geomagnetic Storms

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Electrodynamics dominates the structure of the low latitude ionosphere. During a storm, equatorial electric fields are severely disrupted by a combination of magnetospheric penetration and neutral wind dynamo electric fields. The result is a dramatic change in the plasma structure and the local-time occurrence of plasma irregularities. Numerical simulations using a coupled thermosphere, ionosphere, plasmasphere, electrodynamic model have been used to unravel the complex storm-time response of the upper atmosphere, and aid in the understanding and interpretation of the phenomena. Contrary to previous expectations, the dynamo action of the neutral winds can be large and rapid, and follow closely behind the penetration fields. The rapid dynamo fields are forced by the meridional wind surges that drive zonal Pedersen currents, causing charges to build up at the terminators that immediately leak to the equator. The global wind system is highly dynamic during these disturbances as winds “slosh” from one hemisphere to the other. The electrodynamics responds quickly to the dynamics and exhibits rapid and large changes in the electric fields and in the equatorial plasma distribution. If the dynamo and penetration electrodynamic processes act constructively, plasma at the magnetic equator can be completely decimated and the anomaly peaks can move well into mid-latitudes.

SH52B-02 1620h

The Advantages of Cheap, Connected, and Plentiful GNSS Observations

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During the next solar maximum GNSS (Global Navigation Satellite System) technology will enable TEC and scintillation measurements with inexpensive receivers that are conveniently sited on roof tops, simply connected via the web, and easily operated at universities, science centers, and schools. This development presents a singular opportunity beyond current strategies for investigating the ionosphere. Ionospheric disturbances, irregularities, and societal impact have been investigated for decades at equatorial latitudes and high latitudes. Mid-latitude disturbances have largely been neglected until recently because of the relative infrequency of events. At equatorial latitudes investigations have primarily been from single sites prior to the advent of GPS. Even at high latitudes ionospheric measurements relating to density and irregularities have primarily been from single sites. With GNSS technology enabling ionospheric instrumentation equivalent to weather buoys, the extreme events with societal impact at mid-latitudes can be characterized and the dynamic global ionospheric behavior and response to forcing can be investigated. We show several examples to support this conclusion.

SH52B-03 1635h

GPS Occultation Sensor Observations of the Ionospheric E-Region

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GPS occultation sensor measurements of the GPS L1 (1575 MHz) and L2 (1227 MHz) signal phase can be used to derive line-of-sight total electron content (TEC). The GPS TEC values are highly precise in a relative sense, with noise levels on the order of 0.01 TECu. Limb-viewing occultation profiles of vertical TEC may be converted into electron density profiles by means of the Abel transform. The high relative TEC accuracy potentially leads to very precise profiles, resulting in an ability to remotely sense density features below the 10E4/cc level. Thus one would expect GPS occultations to provide a new means for observing E-region features. This is particular true because the E-region often has significant vertical refractivity gradients, to which the occultation technique is particularly sensitive. However, the absolute accuracy of these retrievals can be compromised by the presence of F-region gradients, which violate the Abel assumption of spherical symmetry. We present an initial analysis of the gradient effects on E-region retrievals and discuss methods to mitigate the effects of asymmetry. Examples from simulations and actual observations from the Ionospheric Occultation Experiment (IOX) will be presented to illustrate our results. The utility of low-density E-region measurements will be discussed in the context of validation of models predicting the evolution of the structure of the post-sunset equatorial anomaly region.

SH52B-04 1650h

Towards a Predictive Model of Low Latitude Ionospheric Space Weather

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Space weather in the earth's equatorial ionosphere, in the form of rising bubble structures, can have significant effects on space-based satellite communications and navigation system and, as a result, have important societal consequences. For example, the Global Positioning System (GPS) can suffer severe scintillation and fading due to the ionospheric density structures associated with equatorial ionospheric bubbles. The development of a predictive model of equatorial ionospheric bubbles will help to mitigate against the deleterious effects of low latitude ionospheric structure and variability. A fully three-dimensional model of the evolution of equatorial ionospheric bubbles is needed to develop a predictive capability. Using numerical simulation techniques we have studied the 3D linear and nonlinear evolution of equatorial ionospheric bubbles. The background ionosphere used to initialize the 3D mesoscale bubble model is computed from a first-principles macroscale equatorial fountain model. Near the prereversal enhancement the 3D mesoscale bubble model is initialized using the background parameters over the entire geomagnetic flux tube. We find that bubble-like structures with extremely sharp gradients can be generated off the equator at anomaly latitudes. We study the effects of various parameters, e.g., prereversal drifts, neutral wind effects, background Pedersen conductivity, and parallel conductivity on the evolution and triggering of equatorial bubbles. Initial studies using data assimilation will be presented as well as comparision with experimental data.

SH52B-05 1705h

Conjugate Point Equatorial Experiments in Brazil: Preliminary results on Space Weather Related Variabilities in Spread F and Ionization Anomaly.

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We will present some preliminary results from a conjugate point equatorial observational campaign (COPEX) conducted in Brazil during October to December 2002. The COPEX utilized digital ionosondes, digisondes, all-sky imagers and other different complementary instruments at the magnetic equatorial and conjugate point stations in the western longitude sector of Brazil. The campaign objective was to investigate the equatorial spread F/plasma bubble irregularity (ESF) generation conditions in terms of the ambient ionosphere-thermosphere properties along the magnetic flux tubes in which they occur. The COPEX digisonde observations permitted field line mapping of the conjugate E layers to dip equatorial F layer peak/bottomside, and are complemented by other digisondes at eastward longitudes in Brazil. Conjugate point symmetry/ asymmetry conditions of the equatorial ionization anomaly and associated ionosphere-thermosphere dynamics, disturbance electric fields and winds, arising from magnetosphere / ionosphere coupling and conductivity distributions are among the most suspected causes of the widely observed variability in the ESF intensity. These questions are addressed using the analysis of selected days during quiet and disturbed intervals of the capaign period.

URL: http://www.dae.inpe.br

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