of the ionosphere are associated with relativistic electron precipitation from the radiation belts and can be detected using GPS occultation measurements.

The Ionospheric Occultation Experiment (IOX) is a dual-frequency GPS receiver with a single Earth-limb viewing antenna. It is one of four experiments to be flown as part of the US Air Force Space Test Program PICOSat mission. The spacecraft is in a 67-degree inclination, 800-km altitude orbit, and has been making measurements at all local times since November 2001. We will present IOX observations from geomagnetically quiet and active periods. These measurements will be compared with in situ observations of relativistic electron precipitation (> 500 keV and > 1 MeV) from the SAMPEX satellite, in order to validate this new method for monitoring losses from the Earths radiation belts.

SM51A-0513 0830h POSTER

The GPS Energetic Particle Environment

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The Global Positioning System (GPS) satellites include two new charged particle instruments, the Low (LEP) and High (HXP) Energy Particle sensors, that permit to estimate the omnidirectional energetic particle fluxes in the energy range 0.14 to 6 MeV for electrons, and 6 to 100 MeV for protons. The first instruments were launched in February 2000, and up to eight additional instruments are expected on GPS orbit in the next few years. The inclined (55 degree) circular (20,000 km radius) orbits of the GPS satellites pass through the peak intensity region of the radiation belts four times per day. Hence, the LEP and HXP sensors sample the energetic particle environment in the range L = 4 to 10.

We describe in this paper the design and the responses of the LEP and HXP sensors. The responses are obtained by combining calibration data with Monte-Carlo (MCNP) and Analytical Probability (AP) calculations. The latter permit to include the contributions of the passive instrumental box and of the satellite to the electron responses. Examples of the main features of the GPS energetic particle environment observed during the first two years of operation will be presented, including energetic particle fluxes, high-latitude electron injections, electron energy spectra, and cosmic background.

SM51A-0514 0830h POSTER

Estimating Equatorial Electron Radiation Belt Fluxes in the Outer-Zone Using Navstar 10 BBDI Data

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When studying the outer electron radiation belt it is desirable to have both high time resolution and global coverage. In-situ satellites, such as those in geosynchronous orbit, constantly monitor the small region in which they exist, but do not give global coverage. However, medium and low Earth orbiting satellites, which slice through sections of the radiation belts at high latitudes, can be used to gain relatively global coverage with fairly reasonable time resolution. Unfortunately, in order to do this, assumptions must be made about the magnetic field and the equatorial particle distribution. To try to understand how accurately equatorial fluxes can be estimated from the data collected by these satellites, we compare data from the Navstar 10 (NS10) Global Positioning Satellite and the Combined Release and Radiation Effects Satellite (CRRES). We map data from the CRRES Medium Electrons A (MEA) sensor and High Energy Electron Fluxmeter (HEEF) to the latitude of NS10 and create average differential fluxes which can be compared to those estimated from the Burst Detector Dosimeter I (BBDI). In this poster we present the results of this study.

SM51A-0515 0830h POSTER

The trapped He flux dynamics observed on the TSUBASA satellite

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TSUBASA satellite was launched on February 2002. TSUBASA is placed in a geostationary transfer orbit having roughly a perigee of 500 km, an apogee of 37,000km, a 28.5 inclination, and a 645 minute period. The Standard Dose Monitor (SDOM) onboard TSUBASA has carried out measurements of energetic electrons, protons, and alpha particles.

He flux distribution greatly changed the substorm on April 19, 2001 event for the boundary. Possible source of the fluxes including remnants of solar particle population trapped during substroms, acceleration of hot plasma from the outer magnetosphere, and pitch-angle scattering from the top of the magnetic field line are discussed.

URL: http://sees.tksc.nasda.go.jp

SM51A-0516 0830h POSTER

TSUBASA(MDS-1) observations of the radiation belt during magnetic storms

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Recently, in situ observation is required to investigate the fluctuation of the radiation belt. TSUBASA(MDS-1) measures magnetic field and high energy charged particle (electron, proton, alpha-particle) in equatorial plane from 500 to 36000km, so that, particle flux, pitch angle distribution, phase space density and itfs equatorial distribution can be measured. Information of these measurement results is very useful in order to clarify the cause of the radiation belt fluctuation, especially high-energy electron. TSUBASA was successfully launched by H-IIA launch vehicle from the Tanegashima Space Center on February 4, 2002. TSUBASA was injected into an elliptical orbit called a geostationary transfer orbit (GTO), with a spin rate of 5rpm, which makes the satellite attitude stable. We will report the observation result of TSUBASA during magnetic storms, and which is applicable in proposed theory about radiation belt fluctuation will be examined.

SM51A-0517 0830h POSTER

TSUBASA (MDS-1) Observations of Pc5 Pulsations in the Inner Magnetosphere

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Although it is known that variations of relativistic electron flux in the outer radiation belt correlate reasonably well with Pc5 pulsation power, we need more observational and theoretical supports in order to examine whether the Pc5 pulsations cause relativistic electron flux enhancements. In particular, we need to investigate spatial characteristics of Pc5 pulsations in space, since previous studies have focused on observations on the ground and at geostationary orbit. In order to approach this subject, we address Pc5 pulsations associated with enhanced relativistic electron flux by using data from the TSUBASA (MDS-1) satellite at geo-transfer orbit (500-36000km). The data includes high-energy charged particle flux (electron: 0.4-50MeV; proton: 0.9-250MeV) and high-resolution three vector components of magnetic field. We also compare these data with data from ground magnetometer networks and other satellites. The analyses showed that the relativistic electron flux depends on the L-shell parameter and time, and that drastic increases of the relativistic electron flux at L 5-7 correlate closely with occurrence of troidal-mode Pc5 pulsations with large amplitude. This is particularly noticeable when Pc5 pulsation activity is high because of interplanetary CME arrival at the Earth. The results imply that these Pc5 pulsations are a possible source accelerating energetic electrons in the regions.

SM51A-0518 0830h POSTER

TSUBASA (MDS-1) observations of energetic electrons and magnetic field variations in outer radiation belt

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We have investigated variations of energetic electrons (> 0.4 MeV) and magnetic field in the radiation belt obtained from the Standard DOse Monitor (SDOM) and the MAgnetoMeter (MAM) of the Space Environment Data Acquisition equipment (SEDA) onboard TSUBASA (the Mission Demonstration Test Satellite (MDS)-1) launched on February 4, 2002. Since TSUBASA is operated in the geostationary transfer orbit, it has provided rare opportunities of directly observing near-equatorial radiation belt plasma particles and magnetic field, having already included several large magnetic storms. The energetic electrons in the outer radiation belt are contributors to the total radiation dose deposited in lightly shielded spacecraft electronics for high altitude orbits and are known to have a drastic variability associated with geomagnetic storm and high speed solar wind streams. The abrupt energetic electron flux decreases in the outside of outer radiation belt show characteristic variations of in situ magnetic field. These observations have implications for the possible mechanisms of the depletion and the following recovery and/or buildup of energetic electrons in the outer radiation belt.

SM51B MCC: Hall D Friday 0830h

Spacecraft Charging and Related Instrumentation Posters

Presiding: **S T Lai,** Air Force Research Laboratory**; K R Lorentzen,** The Aerospace Corporation

SM51B-0519 0830h POSTER

Representation of the Geosynchronous Plasma Environment for Spacecraft Charging Calculations

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We are using the Los Alamos National Laboratory (LANL) Magnetospheric Plasma Analyzer (MPA) dataset to determine the best spectral representation of the charged particle environment for calculating spacecraft potential during magnetospheric substorms.

For 12 years LANL has been accumulating measurements of electron and proton spectra from MPA instruments aboard a series of geosynchronous satellites. These data provide both a plasma characterization and the potential of the instrument ground. Here we focus on data during eclipse periods in Sept. 2001, containing 970 measurements of charging to potentials ranging from 3 V to nearly 10 kV.

Our ability to predict and "postdict" charging has suffered from both a lack of reliable secondary emission and backscattered electron yields and poor characterization of the plasma environment. One difficulty lies in the common practice of fitting the plasma data to a Maxwellian or Double Maxwellian distribution function, which may not represent the data well for charging purposes.

The net current to the spacecraft is the sum of the incident electron and ion fluxes, secondary and backscattered electron fluxes, and photoelectron flux. The integral of the incident spectrum against the yield functions gives the secondary and backscattered fluxes. At equilibrium, the net current is zero.

We calculate the spacecraft potential using the measured fluxes, either directly or through a fit, with appropriate correction for the difference between the measured and postulated potential. The ratio of the calculated to the measured potential tests the accuracy of

the net flux calculation. The potential computed using the measured fluxes and the best available material properties of graphite carbon, with a secondary electron escape fraction of 81%, is within a factor of three of the measured potential for nearly all the data. Using a Kappa function fit to the electron distribution and a Maxwellian function fit to the ion distribution gives similar agreement.

We present the accuracy of chassis potential calculations using a variety of fits to the measured spectra. These functions will be available for implementation in spacecraft charging codes such as the SEE Spacecraft Charging Handbook and NASCAP-2K.

SM51B-0520 0830h POSTER

Spacecraft Charging at Geosynchronous Altitude: Application Development

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We report on progress made toward the development of a geosynchronous spacecraft surface charging application that combines environmental results from the Magnetospheric Specification Model (MSM) with a minimal spacecraft approximation. Surface charging is identified as a net electron current to the kapton spacecraft determined by integrating electron, proton, and oxygen fluxes along with secondary and backscatter yields specified as a function of energy. A validation study of the MSM, covering 20-50 keV electrons from the Charge Control System (CCS) on a DSCS III B-7 spacecraft, indicated that the MSM consistently tracked the diurnal and seasonal variations of this energetic portion of the surface charging particle population [Hilmer and Ginet, J. Atmos. and Solar-Terr. Phys., 62, 1275, 2000]. Initial comparisons of on-orbit spacecraft frame charging measurements from CCS with results obtained using MSM output indicated that the MSM produced ion and electron fluxes, as well as evolving electron spectral features, well enough to reproduce geosynchronous spacecraft charging current densities in the two largest of three events studied in the geosynchronous environment. [Hilmer et al., Proc. of 7th SCTC, 23-27 April 2001, ESA SP-476, 235, 2001]. We will provide an overview of the updated MSM/charging algorithm simulations performed using a variety of input parameter combinations in order to quantify the potential benefits of integrating MSM environment specification with advanced charging codes such as NASCAP-2K to produce system-specific charging applications.

SM51B-0521 0830h POSTER

Spacecraft Charging in Sunlight: Theory and Observations

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Photoemission flux from surfaces as measured in the laboratory is about an order of magnitude larger than the average ambient electron flux at the geosynchronous environment. Yet, spacecraft charging to negative voltages often occurs. Previously, Besse and Rubin [1980] suggested a monopole-dipole model to explain the blocking of photoemission on the sunlit side. No systematic validation of the model has been reported because of the scarcity of coordinated data of spacecraft charging and space environment. By using the Besse-Rubin model, we calculate the ratio of charging voltages in sunlight and in eclipse. We examine the spacecraft potentials of the Los Alamos National Laboratory geosynchronous satellite (LANL-1989-046, LANL-1990-095, LANL-1991-084, LANL-97A) in sunlight and in eclipse at various ambient electron temperatures. We provide physical interpretation to the observed critical temperature for the onset of spacecraft charging in sunlight and in eclipse.

Besse, A.L. and A.G. Rubin, A simple analysis of spacecraft charging involving blocked photoelectron currents, J. Geophys. Res., 85, A5, 2324-2328, 1980.

SM51B-0522 0830h POSTER

Charging of Mirrors in Space : A Proposed Cause of Satellite Solar Panel Anomalies

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Photoemission from surfaces decreases with the reflectivity. We propose that optical mirrors at geosynchronous altitudes will charge in sunlight as if in eclipse. The Boeing 702-model geosynchronous satellite features two long solar panels at each side. Each panel is equipped with two mirrors flanking both sides for sunlight enhancement on the solar cells. The entire 702-model satellite fleet has suffered a similar fate, namely, gradual, permanent, and sometimes stepwise degradation. We propose that sudden development of differential charging between the solar panels and the mirrors at their sides could be the culprit. Differential charging of mirrored solar panels may develop when the satellite is coming out of eclipse. We present a case study of an event : the sudden 25 percent degradation of PanAmSat PAS-7, a Boeing 702-model satellite [Ref] . Indeed, it did occur shortly after eclipse exit in the morning of Sept 6, 2001. Finally, we suggest a simple method for mitigating the problem.

Ref. http://sat-nd.com/failures/702arrays.html

SM51B-0523 0830h POSTER

Using PEACE Data to Study Charging of the Cluster Spacecraft

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In most of the magnetosphere when the Cluster spacecraft are in sunlight and when the ASPOC (Active Spacecraft POtential Control) instrument is off, the spacecraft potential is positive and is determined by a current balance between emitted photoelectrons and incoming plasma electrons. The plasma ion current is almost always negligible in these circumstances. The PEACE (Plasma Electron And Current Experiment) measures the properties of both photoelectrons and plasma electrons. Therefore it should be possible to understand the usual charging of the spacecraft by analyzing the PEACE electron data to obtain the photoelectron and plasma electron properties. It is important to understand the charging of the spacecraft in order to obtain accurate estimates of the charged particle densities, especially at low energies.

We have examined a number of intervals when the ASPOC instrument was turned on or off and have compared PEACE electron data before and after ASPOC switching. We report on these results and give a preliminary evaluation of the status of the charging of the Cluster spacecraft.

We acknowledge use of the EFW (Electric Field and Wave) instrument to obtain values of the spacecraft potential and thank M. Andre, G. Gustaffson, F. Mozer and A. Pedersen for their help.

SM51B-0524 0830h POSTER

Electron density vs Spacecraft Potential on CLUSTER near perigee: a statistical study

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The perigee passes of CLUSTER allow us to perform valuable multipoint observations of the plasmasphere.In many studies related to these observations, one needs high resolution measurements of the electron density. The problem is that above 80 e-/cc, which is usually the case near perigee, only the spacecraft potential is available. Therefore, we have put a particular attention to better understanding the relationship between the spacecraft potential (ScP), measured by the EFW experiment, and the electron density (N_e).

Below L=6, the CLUSTER electron particle instrument (PEACE) is turned off to avoid any possible damage while crossing the radiation belts. Therefore, near perigee ($L \sim 4$), the only instrument available to estimate the total plasma density, within the range 0.2-80 cm^{-3}, is the WHISPER relaxation sounder. In its sounding mode, the density is often measured every 28 s and in the passive mode every 2.2s. For comparison, ScP is continuously recorded every 0.2s.

By combining the measurements of EFW and WHISPER, we modelise the local behavior of N_e vs ScP. When the density reaches values above 80 cm^{-3}, our model is used to estimate the electron density from the ScP measurements only. A detailed explanation of this new method and its application to a single CLUSTER dataset near perigee, is given in Moullard et al. (GRL, in press, 2002).

We present here the results of a statistical study of the application of this new method based on 2 years of CLUSTER perigee passes. Different modelisations are tested and the range of their related parameters based on these two years of data will be presented. Comparisons between the 4 CLUSTER satellites as well as the POLAR mission will be addressed.

SM51B-0525 0830h POSTER

Automated analysis of Current-Voltage Characteristics for the ISL experiment of DEMETER

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Langmuir probes are used on rockets and satellites to measure electron and ion densities and electron temperatures in the ionosphere. Typical output of this instrument is a current-voltage characteristic which further analysis alows to determine basic plasma parameters, namely the plasma density of electrons and protons, electron temerature and the plasma potential with respect to the spacecraft. A segmented Langmuir probe will be onboard the CNES spacecraft DEMETER alowing measurements of Current-Voltage characteristics with rate 1sec. In this paper we present a description of the method alowing automated numerical processing of the current-voltage characteristics and we compare several methods used for the analysis of the I-V curves to determine the basic parameters of the plasma environment. We discuss their applicability and precission to given cases of real measurements performed by the instrument in the plasma chamber.

SM51B-0526 0830h POSTER

Temporal Variation of Sounding Rocket Langmuir Probe Contamination*

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A novel technique for removing surface contaminants from a sounding rocket spherical Langmuir probe has been developed in the NRL Space Chamber Laboratory. Contamination layers present on probe surfaces can skew the collected data, resulting in the incorrect determination of plasma parameters. Despite careful cleaning procedures prior to launch, probe surfaces can become coated with layers of adsorbed neutral gas in less than a second when exposed to atmosphere. Our laboratory tests show that by heating the probe from

the interior using a small halogen lamp, adsorbed neutral particles can be removed from the probe surface, allowing accurate plasma parameter measurements to be made. We present data indicating the effective times required for decontamination and any subsequent recontamination in the absence of heating under a variety of plasma and neutral gas conditions.

*Work supported by ONR.

SM51B-0527 0830h POSTER

In-situ observation of aurora fine structure and simulation of satellite-plasma interaction

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INDEX satellite is scheduled to be launched in 2004 by ISAS/JAPAN in order to investigate the aurora fine structure. This satellite is designed to fly polar orbit with hight of 680km. Main instruments are the electron/ion analyzer, the aurora camera and the impedance probe. All insturments are designed to measure small scale plasma parameters down to 100m scale. In order to distinguish background plasma phenomena from the disturbances due to the satellite itself, we have developed a new simulation code which simulates electromagnetic environment in the vicinity of a spacecraft. This code solves plasma particle behavior as well as background electric and magnetic field. The simulation code adopts unstructured-grid as the spatial coordinate system. This enables us to model 3-dimensional shape of the spacecraft. We will be able to show the results from the spacecraft charging simulations and possible applications to the observation of plasma fine structure in the earth's auroral region.

URL: http://www.isc.nipr.ac.jp/~mokada

SM51C MCC: 133 Friday 0830h

Magnetic Reconnection: Theory and Observation *(joint with NG, SH)*

Presiding: **M Shay,** University of Maryland**; A Otto,** University of Alaska, Fairbanks

SM51C-01 0830h

The Cessation of Magnetic Reconnection

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Collisionless magnetic reconnection has been a subject of continuing research for many years. Over the last ten years, considerable progress has been made in our understanding of the physics of the dissipation region. More recently, a number of research activities have focused on the onset of magnetic reconnection. The question of how and why magnetic reconnection terminates, however, remains largely unaddressed by past and present research. In order to shed some light on this problem, we present results from particle-in-cell simulations of magnetic reconnection, which take into account the presence of different plasmas in the reconnection inflow region. We will show that sufficiently massive plasma populations, such as potentially provided by oxygen beams of ionospheric origin, can substantially slow down or terminate the reconnection dynamics. Further emphasis will be on the acceleration of such plasmas in the reconnection process.

SM51C-02 0845h INVITED

Observations of Electron Holes and Their Relationship to Magnetic Reconnection

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Recent observations from the Polar satellite and new 3d particle simulation results have provided evidence suggesting that electron holes may play an important role in the dynamics of reconnection. Solitary waves (the electric field signature of electron holes) are commonly observed in and near the magnetopause current layer during subsolar, equatorial crossings of the magnetopause. The solitary waves had amplitudes up to 40 mV/m, velocities from 150 km/s to >2000 km/s, and scale sizes the order of a kilometer (comparable to the Debye length). Almost all the observed solitary waves were positive potential structures with potentials of 0.1 to 5 Volts. Positive potential solitary waves moving with velocities of 1000s of km/s are consistent with electron phase-space holes. Drake et al. [2002] have shown that electron holes develop in 3d particle simulations of reconnection, which include a guide magnetic field. The electron holes strongly scatter the electrons, and produce anomalous resistivity. The experimental and theoretical results provide strong support for the idea that electron holes play a critical role in the reconnection process at the Earths magnetopause and may, therefore, be important in other regions where reconnection occurs. We will discuss Polar and Cluster observations of electron holes at the magnetopause to adress this idea.

SM51C-03 0905h INVITED

Development of Electron Holes and Anomalous Resistivity in 3-D Magnetic Reconnection

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Magnetic reconnection with a guide field is explored with full particle simulations and theory to understand the development of turbulence and anomalous resistivity and its impact on the rate of reconnection and particle heating. Electrons around the magnetic x-line and separatrices are accelerated to high velocity by the reconnection electric field. The resulting magnetic-field-aligned electron beams are unstable to Buneman as well as current driven lower-hybrid waves. The Buneman instability evolves into distinct nonlinear structures consisting of localized regions of bipolar parallel electric field with net positive charge, "electron holes". The electron holes are localized both parallel and transverse to the magnetic field with scale lengths of 10's of Debye lengths. The holes couple strongly to a current driven lower-hybrid wave. The complex nonlinear interaction bewteen the electron holes and lower hybrid wave controls both the lifetime and the spatial distribution of electron holes parallel to the magnetic field. The interaction of the electron beam with the turbulence produces extended tails on the electron velocity distributions. The turbulence induced anomalous resistivity is spatially patchy and highly time dependent. Comparisons are made with recent observations of electron holes at the Earth's magnetopause [Cattell, et al., 2002]. Implications for magnetic reconnection and particle energization in space and astrophysical plasmas are discussed.

SM51C-04 0925h

Small Scale Magnetopause - Cluster Interferometric Measurements

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Recent observations by Cluster spacecraft have shown the existence of very narrow boundaries within the magnetopause having large electric fields associated to them. These narrow layers can be associated with large Poynting flux and several hundred volt potential drops. We study in detail the structure of these narrow regions using interferometry measurements between different probes (100m) on the same spacecraft as well as between different spacecrafts (100km). Thus we can estimate the phase speed of the narrow structures with respect to the magnetopause as well as their temporal and spatial character. We study several events with different large scale properties of the magnetopause to see the possible relation between the narrow structures and the large scale phenomena at the magnetopause (e.g., reconnection).

SM51C-05 0940h INVITED

Study of Fast Reconnection in Laboratory Plasmas

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With abundant data from space satellites and the recently developed laboratory experiments, there exist many opportunities for collaborative study between space and laboratory experimental research. In this talk, we highlight the recent laboratory experimental data from the MRX device [1] in comparison with the space observations [2] as well as with the recent numerical simulations[3] addressing a major question why the observed reconnection rates are much faster than predictions by the classical theories, such as the Sweet-Parker model. There exist two leading theories for the underlying physics: one based on laminar 2D structures due to the Hall terms in the generalized Ohms law and another based on resistivity enhancement (or the so-called anomalous resistivity) due to the inherently 3D micro-instabilities. Experimental efforts are under way to study both mechanisms in MRX, where the fast reconnection rates have been regularly observed in the low collisionality regime. A fine structure probe with spatial resolution of 1 mm (2-3 electron skin depth) is being installed. Also a special focus will be put on the electrostatic and magnetic turbulence which have recently been identified in the neutral sheet. The details of the characteristics of the turbulence measured by Hodogram probe and internal pick-up probes will be presented along with theoretical interpretations and discussions on its relation with the observed fast reconnection in space. Work supported by DOE, NASA And NSF. 1. M. Yamada et al., Phys. Plasmas 4, 1936, (1997) 2. F. Mozer et al, Phys. Rev. Letts. 15002, 1, (2002) 3. M.A. Shay et al J. Geophys. Res. 103, 9165 (1998)

URL: http://w3.pppl.gov/~mrx/