SA44A-05 1630h

Equatorial and mid-latitude spread-F associated with large-scale traveling ionospheric disturbances

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Near dawn on October 2, 2002, intense pre-dawn plasma irregularities were detected over Arecibo, PR and at equatorial stations in Brazil and Jicamarca. The F-peak in the mid-latitude ionosphere was well over 400 km at this time, having been driven to this height by a large-scale traveling ionospheric disturbance. The mapping of electric fields from the equatorial region to mid-latitudes cannot explain the mid-latitude irregularities, nor can standard linear instability theory. We suggest instead that eastward, gravitationally driven currents may have dominated and caused perturbations in the bottomside region to polarize and grow. Evidence is presented for an initial corrugation, perhaps associated with higher frequency gravity waves. In the equatorial region, a large uplift of the F layer was also observed, however such a layer motion cannot be explained by neutral wind effects due to the small dip angle. In addition, uplifts appear to occur fairly regularly in the post-midnight sector in the equatorial region, at least near equinox. If such a motion were due to electric fields, one would expect the field to switch direction, from westward to eastward, however this has not typically been observed. Instead, we show evidence that the southern crest of the anomaly moved equatorward, implying that advection of a higher density, higher altitude plasma into the equatorial region may be able to cause an uplift. Such an effect implies a new source for equatorial spread-F.

SA44A-06 1645h

Evidence of Localized and Anisotropic Irregularity Growth Associated With Equatorial Spread-F Plasma Depletions Observed by the San Marco Satellite Electric Field Instrument

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Irregularities in equatorial spread-F develop from a variety of plasma instabilities, for which the Rayleigh-Taylor mechanism is the most dominant at scales of tens of kilometers and longer. Shorter scale waves also contribute to the spectra, and develop from drift wave instabilities, turbulent cascades, and other processes. In situ observations permit in-depth understanding of both the evolving irregularity spectra and the instability processes at work. Important observable parameters include the vector spectral distributions, the local DC electric field, and the local plasma density and associated gradients. In situ electric field measurements provide detailed knowledge of both the irregularities and their wavevector directions since the wave electric field is parallel to the k-vector in an electrostatic wave. Although the San Marco data set is very limited in bandwidth, its measurements nonetheless contribute to our knowledge of spread-F irregularities. We present filter bank data that provide evidence for non-uniform short scale (10's of meter and shorter) wave growth associated with the walls of plasma depletions. In addition, by filtering the DC electric field components, we also show evidence of km-scale irregularities that are highly anisotropic and relate them to the driving DC electric fields within the depletion region. The results are used to help elucidate our current understanding of spread-F instabilities.

SA51A CC: 220 C-E Friday 0830h

New Frontiers in Equatorial Ionospheric Effects Posters

Presiding: **B Basu,** Air Force Research Laboratory**; P R Straus,** Aerospace Corporation

SA51A-01 0830h POSTER

The COSMIC-TIP (Tiny Ionospheric Photometer) InfoBase Data Products

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The Tiny Ionospheric Photometer (TIP) is a scientific experiment on the ROCSAT-3/COSMIC constellation. These six micro satellites to be launched in the fall of 2005 will fly in 700-800 km circular orbits with 72-degree inclinations. Each satellite also contains two other science instruments, the GPS Occultation Receiver (GOX) and the Tri-Band Beacon (TBB). The constellation will collect atmospheric remote sensing data for weather prediction, ionosphere, climate, and gravity research. The TIP is a small, simple instrument for observing the Earth's far-ultraviolet airglow narrow-band at the 135.6 nm wavelength to characterize the ionosphere. This emission is produced by recombination of O^+ ions and electrons, which is the natural decay process for the ionosphere. At night, the strength of the emission is proportional to the square of the electron density. This measurement will be used to produce a number of ionospheric data products. This measurement will also be combined with vertical gradient measurements, provided by GPS occultation, to reconstruct highly accurate electron density profiles in the nighttime ionosphere. The TIP InfoBase is a relational database management system that provides the TIP data products to the scientific community. The InfoBase breaks from the traditional approach, in which a database is simply a catalog to a set of flat-files. Instead, the InfoBase stores all the TIP data products internally within the relational database. Thus all data products may be searched by user-defined queries over the entire mission period and returned to the user without the hindrance of file boundaries. Custom code provides for direct delivery of data products to science users' IDL sessions for reduction, modeling and analysis.

URL: http://tipweb.nrl.navy.mil

SA51A-02 0830h POSTER

Traveling Ionospheric Disturbance Characteristics Over Texas Using the TIDDBIT HF Doppler Radar

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Atmospheric gravity waves (AGW) are generated by numerous lower atmospheric processes, such as storms, and by auroral processes in the ionosphere. At ionospheric heights, the motion of the neutral gas in the AGW sets the ionosphere into motion. The waves displace the isoionic contours, resulting in a travelling ionospheric disturbance (TID). TIDs can be thought of as traveling corrugations in the ionosphere, and they can seriously affect HF radio communications and surveillance systems. Consequently, one of the most sensitive methods for detecting transient changes in the ionosphere is the HF Doppler technique operating in the 3-10 MHz band. A simple Doppler system consists of a CW (continuous wave) radio transmitter and receiver, which are highly frequency-stable. When a HF radio wave is reflected from the ionosphere, movement of the reflection point during passage of a TID produces a change in phase path and a Doppler shift proportional to the time rate of change of the phase path. The Doppler system is sensitive to motions of the ionospheric reflection point, and it therefore provides an accurate measure of both the TID and AGW periods. Similarly, because the TID velocity is determined simply from triangulation using the time-delays between perturbations at different reflection points, the TID velocities are also an accurate estimate of the underlying gravity wave horizontal and vertical trace velocities. HF Doppler systems have advantages over all other techniques for the measurement of TID characteristics. They are more amenable to analysis than data from ionosonde chains , and their time resolution (30 sec) is much higher than that of ionosondes . Unlike total electron content (TEC) methods, which respond to height-integrated TID effects, the HF Doppler radar responds to TIDs at the altitude of the radio reflection point. Finally, HF Doppler systems have low power consumption, so that both spatial and temporal resolution can be maintained for many days without the costs that would be associated with an incoherent-scatter radar. SwRI recently designed, built and deployed an HF Doppler sounding system for three months, in Texas, to investigate TIDs. The TIDDBIT radar consisted of three transmitters (Austin, Uvalde and St. Hedwig) and a receiver in San Antonio, Texas. Using cross-spectral analysis and triangulation of the TIDDBIT signals, TID speeds and azimuths were obtained for each wave frequency. We provide a synoptic survey of the TID characteristics observed over Texas during January-March 2002. Such a system would be of great utility for the study of gravity wave seeding of low latitude ionospheric irregularities.

SA51A-03 0830h POSTER

First 630 nm daytime and nighttime observations of thermospheric winds and temperatures with the Second Generation Optimized Fabry Perot Doppler Imager (SOFDI)

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The Second Generation Optimized Fabry Perot Doppler Imager (SOFDI), a state-of-the-art triple-etalon Fabry Perot interferometer with 4 independent field-of-views, has been successfully constructed and is now making initial observations of 630 nm OI emission in upstate New York during both day and night. In this paper we report on results from four different experiments. First, we present the results of a uninterrupted 48-hour calibration run which demonstrates the pressure and temperature stability of the system. Second, we show that SOFDI can make measurements of thermospheric winds with an accuracy of 15 ms^{-1} within 20 minutes for the daytime and 5 ms^{-1} within 5 minutes for the nighttime. Third, we report on nighttime observations of thermospheric vertical winds. Finally, we report the first recent observations of continuous 24-hour observations of thermospheric winds and temperatures, demonstrating SOFDI's daytime and nighttime observational capabilities. In conclusion, we highlight both 1) immediate scientific goals of the SOFDI instrument in combination with the Cornell all-sky imager and the MIT-Haystack optical observatory, and 2) long range plans which involve placement of the SOFDI observatory at the magnetic equator for measurements of equatorial winds and temperatures.

SA51A-04 0830h POSTER

Ionospheric profiles from dayside UV limb scans

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With the launch of the first Special Sensor for Ultraviolet Limb Imaging (SSULI) on the Defense Meteorological Satellite Program (DMSP), ionospheric electron density retrievals from ultraviolet limb scans are receiving much attention as part of the calibration and validation effort. This study evaluates the performance of dayside electron density retrieval algorithms, which use the 91.1-nm emissions observed on the Low Resolution Airglow and Auroral Spectrograph (LORAAS), a similar ultraviolet limb imager. Specifically, the dayside electron density profiles produced by two research algorithms are integrated to produce vertical total electron content (TEC) and compared with radar altimetry observations of TEC from coincident TOPEX satellite passes. These comparisons show the accuracy of the algorithms for reproducing TEC, the location of the Appelton anomaly peaks and their latitudinal extent. Inaccuracies in the comparisons help illuminate deficiencies, which lead to improvements in the algorithms. Additionally, the UV limb data and radar altimetry data are combined in order to reconstruct a high-resolution ionospheric specification. The limb scans provide vertical resolution in the ionosphere and the altimetry data provides horizontal resolution. When combined a 2D reconstruction of the ionosphere is obtained over a large geographic region with high spatial resolution. Comparisons of the electron density generated from this method with the UV-only algorithms also help to demonstrate to utility of the 91.1-nm algorithms for specifying the equatorial ionosphere.

SA51A-05 0830h POSTER

Observations and Modeling of the Low Latitude Enhanced 6300 Å Airglow Emission Structures Known as the Pre-Midnight Brightness Wave (PMBW) and Midnight Brightness Wave (MBW)

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All-sky imaging observations of 6300 Å airglow emissions conducted at Arequipa, Peru (16.2°S, 71.35°W) revealed the persistent occurrence of two distinct enhanced airglow features known as the pre-midnight brightness wave (PMBW) and midnight brightness wave (MBW) (Colerico et al., 1996). The MBW is the 6300 Å airglow signature of the thermospheric midnight temperature maximum (MTM), having an apparent north-south propagation through the field of view of the imaging system near local midnight. The PMBW occurs earlier in the evening near 20 LT propagating from south to north through the field of view. It was not clear whether the PMBW shared the same generation mechanism as the MBW. The MTM is a large scale neutral temperature anomaly which develops near the geographic equator and propagates poleward. Although, the MTM's generation mechanisms are not well understood, it is thought to be the result of the interaction between upward propagating tides in the lower atmosphere with those produced in-situ in the thermosphere (Fesen, 1986). However, the combination of necessary tidal modes is still unknown. In this paper we investigate the origins of the PMBW and MBW using the self-consistent, physics based Thermosphere-Ionosphere-Electrodynamical General Circulation Model (TIEGCM) and the Naval Research Lab (NRL) SAMI-2 semi-empirical ionospheric model. We show that the PMBW is the result of the relaxation of the low-latitude intertropical arcs. We present the first successful MBW simulations through the incorporation of the Anderson et al. [1987] Semi-empirical Low-latitude Ionospheric Model (SLIM) analytical meridional winds equations into the SAMI-2 model which provided a terdiurnal tidal mode not present in either the TIEGCM winds or Horizontal Wind Model 93 (HWM 93) meridional winds normally employed in the SAMI-2 model. We suggest that the terdiurnal tidal mode plays an important role in MTM development. The model results will be compared to averaged MBW observations over the combined latitudinal range of three southern hemisphere imagers located in the American sector: Arequipa (16.2°S, 71.35°W), Tucuman (26.5°S, 65.15°W), and El Leoncito (31.8°S, 69.0°W). Harmonic decompositions of the SLIM, TIEGCM, and HWM93 meridional winds into the amplitude and phase of their diurnal, semi-diurnal, and terdiurnal components will be presented and compared. We show that while the amplitudes are similar for all three models for each of the tidal components, the phases of components of the SLIM winds differ significantly from TIEGCM and HWM93, suggesting that the phases of the tidal components play a significant role in the development of the MTM and its 6300 Å signature, the MBW.

SA51A-06 0830h POSTER

Observational and Modeling Analysis of the Coupling Between Neutral Winds and the Low-Latitude Ionosphere

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The Appleton anomaly is caused by the upward E x B drift of the equatorial ionospheric plasma and subsequent diffusion along magnetic field lines to lower altitudes at higher absolute latitudes. The strength and location of the Appleton anomaly has been thought to be controlled mainly by the interaction of the neutral winds with the electric and magnetic fields. Variability can arise from different geophysical processes affecting the neutral dynamics and the electric field. In addition, asymmetries in the densities between the two peaks of the anomaly can induce hemispheric differences in the zonal wind circulation through ion drag. This paper examines the climatological relationship between observed neutral winds and temperatures, and observed low-latitude ionospheric structure. Recent global observations of the low latitude ionospheric structure revealed by TIMED/GUVI, TOPEX and DMSP, as well as neutral wind and temperature obtained from the UARS/WINDII instrument, allow us to investigate the interplay between the neutral atmosphere and ionosphere. We will interpret these results using seasonal runs of a global general circulation model of the thermosphere and ionosphere, TIME-GCM.

SA51A-07 0830h POSTER

The CERTO and CITRIS Instruments for Radio Scintillation and Electron Density Tomography from the C/NOFS, COSMIC, NPSAT1 and STPSAT1 Satellites

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A new constellation of radio beacon and radio beacon receivers will be providing global measurements of radio scintillations and total electron content (TEC) for near real time measurements of the ionosphere. This constellation is comprised of the NRL Coherent Electromagnetic Radio Tomography (CERTO) beacons on the Communications/Navigation Forecast Outage System (C/NOFS) satellite, the six Constellation Observing System for Meteorology, Ionosphere and Climate (COSMIC) satellites, and the Naval Postgraduate (NPSAT1) Satellite. These satellites will be launched in the time period of 2004 through 2006. The CERTO beacons operating at 150.012, 400.032, and 1066.752 MHz will be transmitting to ground receivers located in chains to acquire TEC data for computerized ionospheric tomography (CIT). In addition, in early 2006 a five frequency receiver will be placed in low earth orbit with the United States Air Force Space Test Program (STPSAT1) satellite. This CITRIS receiver will use radio beacon transmissions from the French DORIS network of ground beacons at 401.25 and 2036.25 MHz and space-based beacons at 150, 400 and 1067 MHz to measure the earth's ionosphere. On board tracking software will lock onto Doppler shifted frequencies to determine total electron content (TEC) and scintillation parameters. The STPSAT1 will be launched along with a companion satellite (NPSAT1) which carries the CERTO radio beacon and a Langmuir probe. All of the CERTO beacons as well as the ionospheric sensors on STPSAT1 and NPSAT1 are being constructed at the Naval Research Laboratory. The data obtained using the CITRIS instrument will provide a global description of the ionosphere from orbits with inclinations ranging from 15 degrees to 70 degrees and altitudes from 375 to 800 km. The tandem operations of the CITRIS and CERTO instruments will provide the fully low-earth-orbit based occultation measurements of the ionosphere. All of the data will be available for rapid assimilation ionospheric, space-weather models.

SA51A-08 0830h POSTER

Dependence of Daytime Equatorial Electron Densities on the Solar Soft X-Ray Flux

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Comparisons of short term variations in the soft X-ray data from the SNOE satellite and equatorial electron density data show excellent agreement. After removal of trends with periods longer than 27 days during undisturbed times (Ap $<$ 20), correlations of 0.7 are seen between the soft X-ray fluxes and the electron data. This is significantly better than the correlation, 0.6, found between F10.7 and the electron data. Both direct, changes in the ion production rate, and indirect, changes in the neutral density, effects contribute to the correlation between the solar fluxes and the electron data. Soft X-ray measurements from the SNOE satellite in wavelength bands of 2-7 nm, 6-19 nm and 17-20 nm have been compared with electron density data (TEC measurements from Ancon, Peru) for a period of almost three years. The excellent correlations observed indicate that even broad band measurements of the actual solar soft X-ray fluxes provide a significant increase in the accuracy of ionospheric predictions.

SA51A-09 0830h POSTER

Modeling the Effects of Gravity and Plasma Pressure on the Magnetic Perturbations at Low-Latitudes with the TIEGCM

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We use the National Center for Atmospheric Research Thermosphere-Ionosphere-Electrodynamics General-Circulation Model (TIEGCM) to calculate the electric currents and their associated geomagnetic perturbations generated by the ionospheric wind dynamo, including the effects of currents driven by gravity and plasma pressure gradients. The magnetic perturbations at the ground and at satellite height are determined by spherical-harmonic analysis of the three-dimensional current system. In regions of enhanced plasma density like the equatorial anomaly the influence of currents driven by gravity and plasma pressure gradients on the magnetic perturbations is most pronounced. The CHAMP satellite with measurements of the magnetic field as well as the plasma density could quantify for the first time the size of the diamagnetic effect associated with plasma pressure on the magnetic perturbations, which can be up to 5 nanoteslas. We will

show examples from TIEGCM model runs to illustrate the importance of plasma pressure and the gravity-driven currents to the calculation of the magnetic perturbations. We will examine the spatial distribution of the change in magnetic field strength due these effects and compare with the observations from the CHAMP satellite.

SA51A-10 0830h POSTER

Specification and Prediction of the Equatorial Ionosphere

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High Dimensional Model Representation (HDMR) techniques are used to build Fully Equivalent Operational Models (FEOMs) from equatorial ionospheric datasets. These FEOMs provide the basis for organizing the data, gaining statistical information from it, and performing geophysical model predictions. In addition to their use in building both interpolative and predictive models based on data, these techniques can be used to identify the order of importance of the input variables, providing helpful insight into the physics of the system.

SA51A-11 0830h POSTER

Characteristics of Electromagnetic Modes in Nighttime Equatorial Plasma

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Unequal electron and ion flow velocities, which can result from the presence of gravity and/or electric field in collisional plasma, give rise to a net current density that provides excitation energy for plasma instabilities. In the presence of density gradient, the instability is of collisional interchange type. The generalized Rayleigh-Taylor instability (GRTI) is an example of such instability and is believed to be responsible for the generation of the so-called bubbles (regions of depleted density) in the nighttime equatorial ionosphere. Scintillation caused by the bubbles can degrade and disrupt the communication and navigation systems that depend on trans-ionospheric radio links. The GRTI has so far been studied only in the electrostatic limit, making the ad hoc assumption that the magnetic field fluctuations are negligible. However, magnetic field data from CHAMP satellite seem to indicate the presence of measurable magnetic fluctuations associated with the bubbles. The magnetometer on C/NOFS satellite will also be sensitive enough to detect any magnetic fluctuation. This prompted us to extend our linear stability analysis of GRTI to include the magnetic fluctuations. The eigenvalue equation for electromagnetic modes driven by the combined effects of the gravity and an eastward electric field has been derived. Analysis of the equation using realistic ionospheric plasma parameters will be presented. In particular, the growth rates and the spectral characteristics of the modes, together with the estimate of the strength of the magnetic field fluctuation relative to that of the electric field fluctuation, will be discussed.

SA51A-12 0830h POSTER

Studies of Equatorial Spread F Using a Network of GPS Receivers in South America

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In this paper we compile recent contributions to the morphology of equatorial ionospheric irregularities and physical insights in the theory of equatorial spread F from data collected with a latitudinally spaced network of GPS receivers. We have determined that for 90 percent of the days examined between 2001 and 2002, scintillations are confined within the boundaries of the 50 percent decay limit of the anomaly crests. We have also observed that when GPS scintillations/TEC depletions developed at altitudes below 500 km, or when they persisted after the typical nighttime descent of the F region, the ratio of the crest-to-equator TEC was above 2 and the crests were displaced 10 or more from the magnetic equator. This later finding reinforces the view that the Rayleigh-Taylor instability (RTI) mechanism needs to consider an entire flux-tube that becomes unstable. And, calculations of the growth rate need to consider quantities integrated along a flux tube from one extreme of the field line in the northern E region down to the other end of the field lines in the southern E region. We also found that quite often during the December solstice there exists a sharp scintillation boundary at the 74 W longitude meridian. This boundary defines a region of absence or the existence of very few TEC depletions toward the west of the 74 meridian and more numerous scintillation events at the eastern longitudes, over the Amazon rain forest. We also discuss the results of a recent correlation analysis between bottomside traces detected with the JULIA radar and the TEC values measured by the network of GPS receivers.

SA51A-13 0830h POSTER

Equatorial Plasma Bubble Observations by DMSP and ROCSAT

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We have extended our equatorial plasma bubble (EPB) studies by comparing evening sector plasma densities from four polar-orbiting satellites of the Defense Meteorological Satellite Program (DMSP) with measurements from the Republic of China Satellite (ROCSAT) in a 35° inclination orbit. Observations of individual EPBs detected by both ROCSAT and DMSP during March and April of 2000 were well correlated when satellite orbital paths crossed the same longitude within ±15 minutes. After determining basic criteria for detecting plasma density depletions in the 1-second ROCSAT data, we compiled a statistical database of EPB occurrence rates for March and April of 2000 and 2002 for comparison with the DMSP EPB database for 1989-2002. Despite the fact that the ROCSAT orbital period and inclination limit the time the satellite is in an appropriate location to observe EPBs, three significant results were noted. (1) The rate of ROCSAT EPB encounters at topside altitudes rose rapidly after 19:00 MLT and peaked between 20:00 and 22:00 MLT close to the orbital planes of DMSP F12, F14, and F15. (2) EPB occurrence rates have Gaussian distributions centered at the magnetic equator with a half-width of approximately 8°. (3) The longitude distributions of EPB detections by ROCSAT and DMSP were qualitatively similar. These results indicate substantial agreement between ROCSAT and DMSP observations and provide new insights on EPB phenomenology.

SA51A-14 0830h POSTER

A Comparison of Equatorial Plasma Bubble Observations by DMSP, ROCSAT, and CHAMP

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We compare evening sector plasma density measurements from polar-orbiting satellites of the Defense Meteorological Satellite Program (DMSP) and the Challenging Minisatellite Payload (CHAMP) Program with observations from the Republic of China Satellite (ROCSAT) in a low-inclination orbit. Our study focused on several days during March of 2002 when multiple satellite conjunctions enabled comparison of equatorial plasma bubble (EPB) observations in the evening sector at ∼400 (CHAMP), ∼600 (ROCSAT), and 840 (DMSP) km altitudes. Radar measurements taken during an Atmosphere Explorer E overflight of Kwajalein show that EPBs have elongated, wedge-like cross sections that extend from their bottomside sources into the topside ionosphere [Tsunoda et al., 1982]. Objectives of this study are to validate the Tsunoda model of EPB development and to establish criteria for distinguishing between EPB encounters and times when the peak of the F layer rose above 400 km. Multipoint observations at various altitudes also provide critical insights on EPB formation, magnitude, and duration that will be useful for mission planning and the analysis of data acquired by the Communication/Navigation Outage Forecasting System (C/NOFS) satellite. Reference: Tsunoda, R. T., et al., JGR, 87, 9171,1982.

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Statistical Analysis of Equatorial Spread F Activity Seen From TIMED/GUVI

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GUVI (Global Ultraviolet Imager) brightness measurements at 1356 Å have been used to detect the occurrence of depletions in the airglow that are indicative of Equatorial Spread F (ESF). Analysis of two years of GUVI data has provided statistical information about the seasonal variation of ESF occurrence in different longitude sectors of the world as well as the corresponding characteristics of the Equatorial Ionization Anomaly (EIA). Inversion of these brightness measurements yields electron density images that are used to characterize the peak electron density values in the EIA as well as the height of the electron density peak in the F region. Past observations have detected enhanced ESF at Atlantic longitudes during northern winter, at Pacific longitudes during northern summer, and at Indian longitudes during equinoctial periods. ESF appearance has been associated with symmetric distributions of background electron density with respect to the magnetic equator. ESF is also associated with steep plasma density gradients in the bottomside ionosphere and F region peaks above 350 km. The results of the statistical analysis of GUVI data are presented along with comparisons to previously observed ESF behavior.

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Equatorial Plasma Bubbles triggered by Storm time penetration electric fields

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A number of recent studies point to the role of the penetration electric field in the triggering of equatorial plasma bubbles (EPB) [Huang et al., JGR, 106, 2001; Basu et al., JGR, 106, 2001; Su et al., JGR, 107, 2002]. In three magnetic storms from the recent solar maximum period (Jan 13-14, 1999; October 21-22, 1999; September 17-18, 2000) equatorial plasma bubbles were observed during the storm main phase and early recovery. Data from several DMSP satellites points to the penetration of the magnetospheric electric field to the equator in the dusk sector as occurring just before these bubbles were observed. Evidence of this is seen in the rapid increase in the electron density (at 830 km altitude) at the dip equator and the increase in the relative abundance of O^+ just north or south of the dip equator. In this presentation we will discuss the time development of the interplanetary electric field, the polar cap potential, and the penetration electric field in relationship to the appearance and characteristics of EPB seen in these storms.