SA43A-08 1330h POSTER

Observations of Ionospheric Thermal Electrons as Measured by the Nightside Auroral Sounding Rocket SIERRA

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On January 14, 2002 the SIERRA sounding rocket was launched from Alaska into active substorm expansion aurora and reached 735 km altitude. For the first time, measurements of the cold ionospheric population in darkness were made by the UNH thermal electron detector (TED). At these middle altitudes, understanding this population is important because the thermal electrons can carry currents coupling the collisional atmosphere and the magnetospheric auroral source. The considerable instrumental difficulties with this measurement will be discussed including the effects of spacecraft potential, Debye length, applied skin bias, and surface charging. During flight, the TED instrument yielded thermal temperatures between 0.1 - 0.4 eV. We will examine the temperature variations compared by pitch angle and also in the overall context of auroral particle observations. Next we will show how well independent comparisons of density as derived by the TED and also an HF wave receiver plasma frequency measurement agree. This leads to an evaluation of two interesting topics: how the measured population agrees with a Maxwellian-shaped distribution and how accurate our estimate for the spacecraft potential is. These possibilities will be thoroughly discussed as we strive to understand the physics of the ambient cold population and its interaction with both auroral mechanisms and the local spacecraft environment.

SA43B CC: 519 A Thursday 1330h

New Frontiers in Equatorial Ionospheric Physics: Irregularities I

Presiding: **M Kelley,** Cornell University**; R Pfaff,** NASA Goddard Space Flight Center

SA43B-01 1330h INVITED

ROCSAT-1 Observations of the Low-latitude F-region Ionospheric Irregularities During Solar Maximum

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Over the passing solar maximum years the ROCSAT-1 IPEI payload has collected a large set of ionospheric irregularity data at the altitudes near 600 kilometers. Because of the long mission life and the 35-degree orbital inclination of ROCSAT-1 and because of the high sampling rate and the full duty-cycle operations of IPEI, the ROCSAT-1 IPEI data have several advantages over the existing data sets in studying the low-latitude ionospheric irregularities. These include (1) fast global coverage in local time and longitude so that the geomagnetic field configuration (longitude) effects can be separated from the local time effects, (2) continuous data sets enable us to examine the seasonal effects and dependencies on solar activity, (3) more observations under the great magnetic storm conditions, and (4) simultaneously high-resolution ion density and velocity data for investigating the spectral characteristics of the irregularities to the smallest scale of 15 meters along the satellite tracks. With these advantages, several new results are found. In this report, we present the statistical features of the morphology as well as occurrence probability of the irregularities observed by ROCSAT-1. Based upon these features, we discuss the role of relative importance among the neutral wind, electric field and density gradient in driving the irregularity structures under both quiet time and storm time conditions. Furthermore, we will report some results concerning the correlation between density and velocity spectra for those of fast rising bubbles from background plasma and for those of descending or fossil bubbles drifting with background plasma. The comparisons of the cross-spectral features between the two types of irregularity may help identifying the underlying processes (instabilities) that control the evolution of irregularity structures.

SA43B-02 1345h INVITED

Plasma Density Enhancements Associated With Equatorial Spread F

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Large-scale plasma density depletions are typically associated with equatorial spread F (ESF) plasma irregularities in the nightside F region, especially in the post-sunset sector. Data gathered on the ROCSAT-1 spacecraft reveal numerous cases of localized, discrete plasma density enhancements in the nightside low latitude region at 600 km altitude. In some cases, nearly simultaneous DMSP observations at 800 km reveal similar density enhancements in the same local time sector. These density enhancement structures occur in association with ESF plasma depletions, i.e., the density enhancements are observed in the same local time where ESF plasma depletions are also present simultaneously. Within these discrete structures, the plasma density may be enhanced by 2–3 times above the background density. The density enhancement regions have sharp, distinct edges with embedded irregularities that appear to have similar scale sizes and density fluctuation spectra as those typically found in plasma depletions. Examples studied here occur at local times about 3 hours after sunset near the equatorial anomaly region, 10° to 20° from the magnetic equator. The ion velocity data within the density enhancement regions show upward plasma drifts perpendicular to the magnetic field, similar to those within adjacent plasma depletion regions. The magnetic field-aligned plasma flows are generally poleward within the density enhancement regions. The observations suggest that density enhancement structures are caused by the polarization electric field which is generated within the equatorial plasma depletions and then maps to the higher latitudes along the magnetic field lines.

SA43B-03 1400h INVITED

Longitudinal Distribution of Equatorial Plasma Bubbles

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Defense Meteorological Satellite Program (DMSP) satellites regularly encounter severe plasma depletions at low magnetic latitudes in the evening local time sector. Data from these operational spacecraft provide unique perspectives on the global and secular variability of these phenomena. We concentrate on two aspects of their distribution in longitude. The first concerns systematic seasonal/longitudinal effects described by Tsunoda [1985] who argued that equatorial plasma bubbles (EPBs) are most apt to form when/where the dusk terminator and equatorial magnetic field are most closely aligned. We tested this hypothesis by considering the monthly and longitudinal distributions of approximately 10,000 EPBs encountered during more than 100,000 DMSP orbits between 1989 and 2002. While the data generally support Tsunoda's hypothesis, they reveal several unpredicted features. The second aspect concerns longitudinal effects whereby the local minimum in EPB rates occurs near the west coast of South America. We argue that precipitation of inner belt particles near the South Atlantic Anomaly (SAA) increases ionospheric conductance to reduce EPB growth rates. Weakened conductance gradients near the dusk terminator also diminish polarization electric fields needed to maintain current continuity. We suggest several ways to incorporate SAA effects into global models for EPB growth. Reference: Tsunoda, R. T., JGR, 90, 447, 1985.

SA43B-04 1415h INVITED

A Three Dimensional Model for Equatorial Ionospheric Bubbles

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Previous models of equatorial plasma bubbles have been two-dimensional, describing the structure of the bubbles/plumes strictly perpendicular to the geomagnetic field in the equatorial plane or describing field-line integrated quantities. Our goal is to introduce the third dimension, and describe the variations along the direction of the geomagnetic field. Plasma transport within the three-dimensional structure is described using the perpendicular transport code of our previous two-dimensional bubble model along with a parallel transport code. The resulting plasma densities are then used to evaluate the field-line integrals of conductivity and current density in the current-continuity equation to provide self-consistent electric fields. In runs of the model, we find that the three-dimensional plasma exhibits the same upwelling instability found in two dimensions, with a similar tendency for the plumes to bifurcate in the plane perpendicular to the geomagnetic field. In new results, we find that the uplifting flux tubes of low plasma density tend to remain depleted from end to end, at least until they rise to the equatorial heights that map to the equatorial ionization anomalies. The anomalies tend to be structured on the inside (low latitude), smooth on the outside. These three-dimensional structures will be illustrated with computer animations. Images of equatorial bubbles as depletions of airglow emission are a useful diagnostic of bubble structure. We compare the predictions of the bubble model with some of the common views of airglow images of equatorial features. In-situ measurements of plasma density in the vicinity of the bubbles give us a set of constraints on the bubble extent. Another important diagnostic of bubble structure is the extent of radio scintillation measured by ground-based receivers. As an application of the model, this parameter is pursued with the goal of making forecasts of the scintillation.

SA43B-05 1430h

Spatial Variations of Scintillation and TEC During Equatorial Spread F

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Numerous studies of geophysical observables associated with large-scale instabilities in the post-sunset equatorial ionosphere have been conducted for several decades; these observables include electric fields, electron density profiles, total electron content (TEC), plasma and neutral drift, scintillations and coherent radar backscatter. Despite a general understanding of the local correlations between these parameters during the on-set and evolution of equatorial bubbles, detailed knowledge of the variations of these parameters as a

function of latitude on a given magnetic meridian is lacking. During the Oct-Nov 2002 Conjugate Points Equatorial Experiment (COPEX) campaign was conducted at three sites in western Brazil; one site was situated at the magnetic equator while the other two were selected at magnetic conjugate locations approximately ± 10° MLat. The campaign was organized and coordinated by the Aeronomy Group at the Brazilian National Institute for Space Research (Instituto Nacional de Pesquisas Espaciais- INPE). A number of diagnostic instruments, including digisondes, GPS scintillation and TEC diagnostics, VHF scintillations and plasma drifts, and all-sky imagers were operated routinely throughout the campaign period. The work presented here focuses on the meridional variations of GPS and VHF scintillations from the northern to the southern anomaly regions (± 15° MLat) and their correlation with total electron content over the same spatial extent. The key issue for consideration is whether the scintillation intensity is directly proportional to electron density (i.e., TEC) across a flux tube implying constant $\Delta N/N$ within the instability region, or whether some other relative scaling between the density and scintillation exists. The results provide insight into the distribution of irregularities and, indirectly, the energetics of instabilities within a flux tube. The outcome of this investigation directly impacts techniques to extrapolate local measurements to other latitudes based on knowledge of the meridional density structure from, for example, an ionospheric model of the ambient density.

SA43B-06 1445h INVITED

Equatorial Spread F Variability Investigations in Brazil: Preliminary Results from Conjugate Point Equatorial Experiments Campaign - COPEX

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Equatorial spread F variability can result from diverse conditions of the coupling processes that control the dynamic state of the ambient ionosphere-atmosphere system of the evening hours. While the sunset associated prereversal electric field enhancement (PRE) is known to be the most basic prerequisite for initiating ESF development, the intensity of an event seems to be controlled also by other factors, such as the symmetry/asymmetry of the ionization anomaly, flux tube integrated conductivities, and a possible (but largely unknown) perturbation source. An evaluation of the possible contributions from some of these factors to the observed ESF variability can be possible from measurements carried out over equatorial and conjugate points locations. A conjugate point equatorial observational campaign (COPEX) was conducted in Brazil during October to December 2002. The COPEX used digital ionosondes, all-sky imagers, GPS receivers, and other 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. Other digisondes at eastern longitudes in Brazil complemented these measurements . Our results are based on the analysis of selected data sets, and we address the questions concerning: Trans-equatorial thermospheric winds and their effect on the ESF development; ESF variability under magnetospheric forcing through disturbance electric fields and winds; and the possible role of sporadic E layers on the ESF variability

SA44A CC: 519 A Thursday 1530h

New Frontiers in Equatorial Ionospheric Physics: Irregularities II

Presiding: **M Kelley,** Cornell University**; R Pfaff,** NASA Goddard Space Flight Center

SA44A-01 1530h

Space-Time Variabilty of Ionospheric Scintillaion in the Equatorial Region

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The marked day-to-day variability of equatorial ionospheric irregularities (scale lengths of tens of m to hundreds of m) has been investigated by performing multi-frequency scintillation observations at specific locations by many investigators worldwide. In addition to such temporal variability, multi-satellite observations from one station reveal extreme spatial variability when a region with intense irregularities may remain separated from a benign region by only 500 km over an entire night. In this paper, we show that the GUVI sensor on the TIMED satellite can image the equatorial anomaly on a global scale and such images can be used to specify in space and time the scintillating and non-scintillating regions. We present a case study of GUVI images on two successive nights during an equinoctial period. On one night the equatorial anomaly was well-developed at all longitudes when the crests of the equatorial anomaly were widely separated in latitude. This indicated the presence of a strong zonal electric field at the magnetic equator, which is also a pre-requisite for the formation of ionospheric irregularities. It is shown that on this night scintillations were indeed observed at widely separated locations around the globe. The adjacent day showed the collapse of the equatorial anomaly over a wide longitude swath implying that irregularities are not likely to be formed in these regions. The scintillation observations at Calcutta, India and at Singapore located in this region indicate the absence of scintillation. The study reveals that the GUVI images of the equatorial anomaly can be used to specify scintillating and non-scintillating regions on a global scale.

SA44A-02 1545h INVITED

Bottom-type scattering layers and equatorial spread *F*

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Jicamarca radar observations of bottom-type coherent scattering layers in the postsunset bottomside *F* region ionosphere are presented and analyzed. The morphology of the primary waves seen in radar images of the layers indicates that wind-driven gradient drift instabilities are operating. In one layer event when topside spread *F* did not occur, irregularities were distributed uniformly in space throughout the layers. In another event when topside spread *F* did occur, the irregularities within the bottom-type layers were horizontally clustered, the clusters separated by about 30 km. The same horizontal periodicity was evident in the radar plumes and large-scale irregularities that emerged later in the event. We surmise that horizontal periodicity in bottom-type layer irregularity distribution is indicative of large-scale horizontal waves in the bottomside *F* region that may serve as seed waves for large-scale Rayleigh Taylor instabilities.

SA44A-03 1600h

Fully kinetic simulations and linear theory of thermally modified E-region instabilities

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We present new results of our continuing efforts to simulate and model turbulent E-region plasma driven by a strong ambient DC electric field. Such processes, including the Farley-Buneman (FB) and gradient drift instabilities, have been studied experimentally and theoretically for four decades. In the last decade, two new thermally driven instabilities have been described along with some supporting observational evidence. In this talk, we will show the significant role played by ion thermal effects in fully kinetic, 2-D, simulations. These simulations demonstrate that thermal effects become especially pronounced when the E-region instability is driven by a large DC electric field, well above the threshold of the FB instability, as typically found in the high-latitude electrojet. For more moderate driving electric fields, the 2-D turbulent waves show some modifications due to thermal effects. We will also discuss the linear theory of thermal waves based on simplified fluid models. These models predict that ion thermal effects play an important role at the top of the E-region (∼105-130 km), while electron thermal effects should prove important in the lower E and upper D regions (∼75-105 km). They also show that both the ion and electron thermal driving mechanisms strongly modify the linear behavior of the FB instability in a homogeneous plasma. We conclude by arguing that thermal effects will have consequences for the saturated behavior of the electrojet waves and, hence, for radar and rocket observations and electrojet conductivities.

URL: http://bu-ast.bu.edu/∼meerso

SA44A-04 1615h

Characteristics of low latitude E-region plasma irregularities observed by the Gadanki radar.

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The Indian MST radar at Gadanki (13.5 deg N, 79.2 deg E, 6.4 deg N magnetic dip) is a high power coherent pulsed Doppler radar operating at a frequency of 53 MHz. By steering its antenna beam at 13 deg N off zenith, it can be used to observe field aligned irregularities in the E-region. Experiments to study such irregularities have been conducted regularly at Gadanki since 1994. At its 'tropical' rather than 'equatorial' position, the latitude of the Gadanki radar is such that it should be both a bit too high to observe field-aligned irregularities generated by the equatorial electrojet and a bit too low to observe mid-latitude field-aligned irregularities associated with blanketing Es layers (the latter are usually confined to higher latitudes). In spite of these differences, the radar has observed many types of echoes that are reminiscent of both the middle and the equatorial latitudes. For instance, the Gadanki echoes are not limited to the nighttime, as would be the case for mid-latitude situations. Instead, echoes are seen both during the day and at night, and are observed in multiple layers, in similarity to equatorial situations. On the other hand, contrary to the equatorial situation, the Gadanki echoes are typically devoid of "type I" spectra. Their predominantly "type II" signatures makes them rather similar to midlatitude echoes instead. In addition, the Gadanki radar has sometimes observed QP echoes, which is a mid-latitude phenomenon that is not observed at the equator. Finally, the Gadanki radar has also detected the so-called '150 km echoes', which up until now has always been thought to be strictly an equatorial phenomenon. Taken as a whole, the various observations suggest that while the tropical latitudes are indeed a region of transition in echo morphology, they are at times an extension of the midlatitude phenomena, while at other times being an extension of the equatorial latitudes. This discovery could become useful when trying to assess the strength of the excitation mechanisms from neighboring altitudes, since their appearance at tropical latitudes should presumably be a matter of driving the phenomena particularly hard.

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