

February 15 to March 15, 2003 are used to determine the EB vertical drift of plasma for a one-month period. The data-determined driver is used to drive the LLIONS model and obtain a specification of the ionosphere in the Peruvian sector. The GPS-TEC observation chain of South America and TOPEX TEC data are used to examine the veracity of the LLIONS results. A second model study will make adjustments to the LLIONS drivers, both EB and meridional neutral wind, to move LLIONS results into optimal agreement with TEC data. The comparisons of the two runs are used to give insights into the remaining problems of ionospheric models and unknowns in the drivers.

SA42A-03 1100h

Theoretically Modeling the Ionospheric Response at Low Latitudes to the Great Storms in October, 2003

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In the low latitude, ionospheric F region, the primary transport mechanism that determines the electron and ion density distributions is the magnitude of the daytime, upward ExB drift velocity. During the geomagnetic storms on Oct. 29 and 30, 2003, we have inferred these upward ExB drift velocities from ground-based magnetometer observations at Jicamarca and Piura, Peru as a function of local time (0700 - 1700LT). On both days these ExB drifts exceeded 80 m/sec which is about four times greater than the normal, quiet time value of 20 m/sec. We study the ionospheric response in the Peruvian longitude sector to these large upward drifts by theoretically-calculating electron and ion densities as a function of altitude, latitude and local time using the time-dependent Low-Latitude Ionospheric Sector model (LLIONS). This is a single sector ionosphere model capable of incorporating data-determined drivers. Initial results indicate that the large, upward ExB drift velocities on Oct. 29 produce equatorial anomaly crests in ionization at +/- 22° dip latitude rather than the usual +/- 16° dip latitude. We compare the theoretically-calculated results with a variety of ground-based and satellite observations for Oct. 28, 29, 30 and 31 and discuss the implications of these comparisons as they relate to the capabilities of current theoretical models and our ability to infer ionospheric drivers such as ExB drifts.

SA42A-04 1115h INVITED

Assimilative Modeling of Low-Latitude Ionosphere

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Ionospheric zonal electric field and thermospheric winds drive and affect the sharp latitudinal structures and occurrence of irregularities in the low latitude ionosphere. The prediction of the daily variability of these ionospheric features against their climatological patterns requires the prediction of the dynamical driving forces. We will present a fully 3-dimensional (3-D) global assimilative ionospheric model (GAIM) and its application to low-latitude modeling, particularly to the estimation of the dynamical driving forces. GAIM numerically solves the ionospheric plasma fluid-dynamic equations to obtain ion and electron densities on a 3-D grid, and optimizes the solutions by assimilating various kinds of ionospheric measurements such as line-of-sight total electron content (TEC) derived from dual-frequency Global Positioning System (GPS) measurements. The GAIM optimization techniques include

the Kalman filter and 4-dimensional variational approach (4DVAR). The Kalman filter corrects the modeled ionospheric state by estimating its error covariance. The 4DVAR technique estimates the model driving forces that satisfy a requirement of minimization of the difference between the modeled state and observations in an entire region. The assimilative modeling of low-latitude ionosphere can be conducted by combining both optimization techniques and particularly through the estimation of plasma drift (driven by zonal electric field) and thermospheric winds. Examples of such modeling with assimilation of GPS data available from global and regional GPS networks will be presented. A short-term forecast scheme for prediction of ionospheric weather conditions will also be presented that utilizes the GAIM with the optimized solutions of both dynamical forces and state.

SA42A-05 1130h

GPS Occultation Sensor Contributions to Studies of the Equatorial Ionosphere

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The GPS occultation remote sensing technique provides highly precise profiles of limb-viewing total electron content (TEC). These TEC profiles can be converted into electron density profiles given assumption of spherical symmetry. In cases where ancillary data characterizing horizontal gradients is available, the spherical symmetry assumption can be relaxed and more accurate vertical density profiles can be inferred. While such profiles are more similar to traditional (e.g., ISR, ionosonde) ionospheric measurements, the occultation TEC observations can also be directly compared with a modeled ionosphere. We present such comparisons using the NCAR-TIMEGCM model together with both simulated occultation data and observations made by the Ionospheric Occultation Experiment (IOX). Our focus is to evaluate the extent to which occultation data can be used to identify the state of the equatorial anomaly (e.g. crest separation, altitude, and asymmetry). The anomaly region state is related to the strength of the pre-reversal enhancement (PRE) of the vertical ion drift and the meridional neutral wind. The TIMEGCM model provides a self-consistent picture of the equatorial ionosphere, including variability in the PRE driven by nighttime conductivity gradients in the E-region. The ability of occultation sensors to measure this low altitude portion of the ionosphere will also be discussed. Finally, GPS occultation measurements of ionospheric scintillation are also possible, but the sensitivity to ionospheric irregularities varies dependent on the occultation geometry relative to the Earth's magnetic field.

SA42A-06 1145h

Relative Importance of Direct Penetration and Disturbance Dynamo Electric Fields on the Storm-Time Equatorial Ionosphere and Thermosphere

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During geomagnetically active conditions, there are two major mechanisms responsible for ionospheric electric-field disturbances at low latitudes. The first is the direct penetration to lower latitudes of the electric field due to magnetosphere-ionosphere interactions at high latitudes. The penetration electric field reaches

the magnetic equator almost instantaneously, but tends to decay with a time scale less than one hour. The time scale depends on under/overshielding conditions determined by magnetospheric properties and ionospheric conductivity. The second mechanism is the effect of the disturbed wind on ionospheric dynamo processes. The disturbance winds develop over a period of hours and can persist for several hours due to the neutral-air inertia. It has been difficult to actually identify the relative importance of these two mechanisms for the disturbance in the equatorial electric field and for the associated changes in the ionosphere and thermosphere in individual cases. This study utilizes the Coupled Thermosphere-Ionosphere-Plasmasphere-Electrodynamics (CTIPE) model where the mid-/low-latitude electrodynamics is solved self-consistently with the global ionosphere and thermosphere system. In order to investigate the effect of the direct penetration electric field together with the disturbance dynamo process on the equatorial ionosphere and thermosphere, Rice Convection Model (RCM) electric fields are imposed on CTIPE. Our preliminary results indicate that the direct penetration electric field can modify the ionospheric dynamo by changing the conductivity and neutral wind. We discuss our results in relation to observations of low-latitude ionospheric disturbances.

SA43A CC: 220 C-E Thursday 1330h

The Extended Ionosphere: A Unifying Approach to Magnetosphere-Ionosphere Coupling III Posters (joint with SM)

Presiding: J Semeter, SRI

International; J Horwitz, University of Alabama in Huntsville

SA43A-01 1330h POSTER

Auroral energy deposition in the ionospheric F-region studied through ground-based optical tomography

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Studies of ionospheric perturbations produced by the aurora generally focus on the E-region where the majority of the kinetic energy flux is deposited. However, it is the state of the topside ionosphere that is most critical for mass coupling with the magnetosphere. In this paper, ground-based optical tomography is used to characterize auroral energy deposition in the E- and F-regions simultaneously. The tomographic data are derived using two imaging spectrometers in a 290km baseline near Sondrestrom, Greenland. Vertical profiles of volume emission rate were reconstructed for four prominent auroral emissions: 470.9 nm (N2+ 1NG), 557.7 nm (OI 1S), 630.0 nm (OI 1D), and 844.6 nm (O 3P). The ionospheric response was monitored using the Sondrestrom Incoherent Scatter Radar (ISR). An analysis of a stable auroral arc near the polarward edge of the auroral oval revealed a latitudinally broad region of 844.6 emission at 250km above a narrower region of 470.9 and 557.7 emission. The 844.6 emission is produced by impact of 11 eV electrons on atomic oxygen, suggesting that the primary electron spectrum had both a high and low energy component. The ISR measurements showed intense F-region ion heating on this flux tube, and a factor-2 increase over the ambient plasma density at 300km, demonstrating that the low energy end of the precipitating particle spectrum can have a significant affect on the topside ionosphere, even in relatively hard auroral arcs.

SA43A-02 1330h POSTER

Coupling between horizontal and vertical ion transport along the nightside polar cap boundary

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Conjugate observations by the incoherent scatter radar at Sondrestrom, Greenland, and the Wideband Imaging Camera (WIC) on the IMAGE satellite have been used to establish a causal relationship between drifting F-region plasma structure in the polar ionosphere and upward ion number flux near the poleward edge of the auroral oval. A longitudinally extended patch of enhanced F-region density was observed as it advected equatorward across the open-closed field line boundary and into a region of discrete auroral rays and strong ion upflow ($V_i > 800$ m/s at 900 km altitude). Upward velocities within the upflow region remained constant during the patch transit, such that the upflowing number flux was directly controlled by F-region density (both increased by a factor of 2 within the patch). Because polar cap patches and ion upflows are both longitudinally extended, quasi-stable features of the nightside polar cap boundary, the observed interaction can produce a global-scale increase in plasma density at higher altitudes where suprathermal outflows are initiated.

URL: <http://isr.sri.com>

SA43A-03 1330h POSTER

Satellite observations of the polar cap O⁺ trough at 5000 km altitudeWen Zeng¹ (256-824-5138; zengw@cspar.uah.edu)James L Horwitz¹ (256-824-6662; horwitzj@cspar.uah.edu)Paul D Craven² (256-961-7639; paul.d.craven@nsstc.uah.edu)Fred J. Rich³ (Frederick.Rich@hanscom.af.mil)Thomas E Moore⁴ (thomas.e.moore@nasa.gov)¹Center for Space Plasma and Aeronomic Research, University of Alabama in Huntsville, Huntsville, AL 35899²Space Sciences Department, Code SD50, NASA/MSFC/NSSTC, Huntsville, AL 35805³Air Force Research Laboratory, AFRL, Hanscom AFB, MA 01731-3010, United States⁴Laboratory for Extraterrestrial Physics, Code 692, NASA/Goddard Space Flight Center, Greenbelt, MD 20771

The Thermal Ion Dynamics Experiment (TIDE) onboard the Polar satellite has observed O⁺ ion density trough regions, in which the O⁺ densities were at least one order of magnitude lower than the surrounding O⁺ densities. These were observed in the polar cap during POLAR perigee passes at approximately 5000 km altitude. The estimated O⁺ densities were generally lower than 0.01 per cc within these trough regions. From December 1, 1997 to November 30, 1998, polar cap O⁺ troughs in Polar/TIDE observations occurred at a frequency of about 48%. The O⁺ density troughs were always located on the nightside portion of the polar cap magnetosphere/ionosphere, and the invariant latitude spans of such troughs were as large as 23° in extent. The trough occurrence displayed strong seasonal dependence; in the winter season (e.g. for July in the southern hemisphere) the O⁺ ion density trough occurrence frequency ranged up to 92%, while during the summer season (e.g. for January in the southern hemisphere) it decreased to as infrequent as 15%. The O⁺ ion density trough occurrence appeared relatively independent of the geomagnetic Kp index, and IMF Bz. By conditions, although it generally anti-correlated with the solar wind dynamic pressures in the solar wind dynamic pressure range 0.8 - 2.6 nanopascal. However, as suggested by the seasonal dependence, the O⁺ ion density trough occurrence was strongly related to the solar zenith angle (SZA). In the SZA range 50° to 125°, the trough occurrence increased monotonically with SZA. Case-by-case examinations of near-simultaneous O⁺ densities and vertical velocities observed by the DMSP satellite group orbiting at 840 km altitude indicate that the O⁺ density troughs observed at 5000 km altitude at times exhibited apparent relationships with features of the topside ionosphere. Finally, preliminary transport simulations indicate that some of the troughs could be produced by the effects of recombination when the F-region feet of these flux tubes circulate through dark regions for several hours.

SA43A-04 1330h POSTER

Simulations of polar cap field-aligned electron density profiles measured with IMAGE Radio Plasma Imager

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The Radio Plasma Imager (RPI) aboard the IMAGE spacecraft can be used to measure density profiles along magnetic field lines in the polar magnetosphere. The recently-developed Dynamic Fluid semi-Kinetic (DyFK) model is used to simulate the ion field-aligned flows within flux tubes drifting along a model specified convection line across the polar ionosphere. In this DyFK model, the collision-dominated portion of the flux tube is treated with a moment-based fluid model for altitudes from 120 to 1100 km, while the generalized semi-kinetic model is used for 800 km to 3 R_E region where collisions are not necessarily dominant and the distribution functions can not be assumed Maxwellian. The effects of auroral soft electron precipitation, centrifugal acceleration, wave-driven transverse ion heating and parallel potentials are incorporated into the simulation of the ion field-aligned transport. The modeled field-aligned electron density profiles in the polar cap are compared with several field-aligned density profiles measured by IMAGE/RPI on March 4, 2003, in a weak magnetic storm (minimum Det value of -58 nT). The electron densities were substantially elevated during the magnetic storm, with electron density reaching 10 cm⁻³ at 2.8 R_E altitude. It is found that reasonable parameters for the indicated auroral processes raise the modeled electron densities to the level of the densities measured by the IMAGE/RPI. The simulation results indicate that O⁺ becomes the dominant ion species in the altitude range considered.

SA43A-05 1330h POSTER

Conductance Effects on Inner Magnetospheric Plasma Morphology: Model Comparisons With IMAGE EUV, MENA, and HENA Data

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Modeling results of the inner magnetosphere showing the influence of ionospheric conductance on the inner magnetospheric electric fields during the April 17, 2002 magnetic storm are presented. Kinetic plasma transport code results are analyzed in combination with observations of the inner magnetospheric plasma populations, in particular those from the IMAGE satellite. Qualitative and quantitative comparisons are made with the observations from EUV, MENA, and HENA, covering the entire energy range simulated by the model (0 to 300 keV). The electric field description, and in particular the ionospheric conductance, is the only variable between the simulations. Results from the data-model comparisons are discussed, detailing the strengths and weaknesses of each conductance choice for each energy channel.

SA43A-06 1330h POSTER

The responses of the thermospheric neutral wind circulation and temperature to intense Joule heating during geomagnetic storms

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The Center for Integrated Space weather Modeling (CISM) suite of models was run recently to perform an end-to-end simulation of the solar-terrestrial environment. The Coupled Magnetosphere-Ionosphere Model (CMIT) is one of the models used in this run. The CMIT has two components: the LFM global magnetosphere model and the Thermosphere-Ionosphere Nested Grid (TING) model. The CMIT was driven by the simulated solar wind data from solar coronal and solar wind models. In this paper, we present the thermosphere-ionosphere response to variations in the energy and momentum inputs from the magnetosphere under various solar wind conditions. It is found that: 1) During the IMF Bz southward period, the neutrals and ions were tightly coupled. The neutral winds followed the ion two-cell-convection pattern. Their speeds were greatly enhanced due to the enhanced ion drifts during the geomagnetic storm. Neutral temperature also increased; 2) During the Bz northward, but by negative period, the ions and neutrals were less coupled. Significant Joule heating occurred, which enhanced the F-region neutral temperature to a maximum of more than 2000 K. In this period F-region neutral winds were driven mostly by the pressure gradient force instead of the ion convection pattern; 3) During the long period when IMF Bz was northward and By was close to zero, the F region neutral winds weakened significantly and neutral temperatures were greatly reduced. Features of semidiurnal tides were evident in both the neutral winds and temperatures.

SA43A-07 1330h POSTER

Composition Changes in a CISM End-to-end Run.

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Recently the CISM suite of models was run together to produce an end-to-end run from the Sun's corona to the Earth's ionosphere and thermosphere. The resulting Interplanetary Magnetic Field (IMF) pattern displayed a number of interesting features. Of interest to this study is the rapid transition from Bz zero conditions to Bz southward conditions and then to Bz northward conditions. In conjunction with the end-to-end run a simulation was made for comparison purposes using the default statistical inputs to the TING model, the thermosphere/ionosphere component of the CISM end-to-end model. Significant changes between the two TING model runs were noticed: 1) it was shown in a previous presentation that precipitation in the statistical model reacts much more quickly to changes in IMF than the coupled magnetosphere/ionosphere/thermosphere model does, which has important implications for the response time of thermospheric composition to sudden changes in IMF; 2) the continuation of Joule heating in Bz northward conditions caused unusual changes in thermospheric composition.

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.

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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