Theoretical and experimental studies of the low-latitude thermosphere-ionosphere system, 2011 CEDAR Workshop, Tuesday June 28, 2011

Conveners: Odile de La Beajuardiere, Gang Lu, Jonathan Makela and Fabiano Rodrigues

Morning Session (June 28, Tuesday, 10:00AM-12:00PM, 7 Talks, 12-minute talks + 5 minutes for questions/answers)

1. (10:00-10:17) Low-Latitude Plasma Density Enhancements: Theory and Observation

JH Klenzing, DE Rowland, RF Pfaff, G Le, H Freudenreich, RA Haaser, AG Burrell, RA Stoneback, WR Coley, and RA Heelis

Plasma density structures are frequently encountered in the nighttime low-latitude ionosphere by probes on the Communication/Navigation Outage Forecasting System (C/NOFS) satellite. Of particular interest to us here are plasma density enhancements, which are typically observed ±15◦ away from the magnetic equator. The low inclination of the C/NOFS satellite offers an unprecedented opportunity to examine these structures and their associated electric fields and plasma velocities, including their field-aligned components, along an east-west trajectory. Among other observations, the data reveal a clear asymmetry in the velocity structure within and around these density enhancements. Previous data has shown that the peak perturbation in drift velocity associated with a density enhancement occurs simultaneously both perpendicular and parallel to the magnetic field, while the results presented here show that the peak perturbation in parallel flow typically occurs 25-100 km to the east of the peak perpendicular perturbation. We discuss this and other aspects of the observations in relation to previous observations and models, including new comparisons with the SAMI2 model.

2. (10:17-10:34) Vertical Winds in the Equatorial Region: Implications for F-region Stability

J. Meriwether

I will be presenting results for Peru and Brazil FPI measurements along with a historical review that suggests that downward vertical winds of 15 to 30 ms-1 may occur quite often in the equatorial region.

3. (10:34-10:51). Longitudinal variations in the F-region ionosphere and the topside ionosphere/plasmasphere: observations and model simulations

Nick Pedatella

Constellation Observing System for Meteorology Ionosphere and Climate (COSMIC) observations of the total electron content (TEC) above and below 800 km are used to study the local time and seasonal variation of longitude structures in both the F-region ionosphere as well as the topside ionosphere and plasmasphere. The COSMIC observations reveal the presence of distinct longitude variations in the topside ionosphere/plasmasphere TEC and these further exhibit a seasonal and local time dependence. The predominant feature observed at all local times in the topside ionosphere/plasmasphere TEC is a substantial maximum (minimum) during Northern Hemisphere winter (summer) around 300-360 deg geographic longitude. Around equinox, at a fixed local time, a wave-4 variation in longitude prevails in the daytime F-region TEC as well as the topside ionosphere/plasmasphere TEC. The wave-4 variation in longitude persists into the nighttime in the F-region; however, the nighttime topside ionosphere/plasmasphere TEC exhibits two maxima in longitude. The COSMIC observations clearly reveal the presence of substantial longitude variations in the F-region and topside ionosphere/plasmasphere and, to elucidate the source of the longitude variations, results are presented based on the coupling between the Global Ionosphere Plasmasphere model and the Thermosphere Ionosphere Electrodynamics General Circulation Model. The model simulations demonstrate that the orientation of the geomagnetic field plays a fundamental role in generating significant longitude variations in the topside ionosphere/plasmasphere but does not considerably influence longitude variations in the F-region ionosphere. The model results further confirm that nonmigrating tides are the primary mechanism for generating longitude variations in the F-region ionosphere. The coupled model additionally demonstrates that nonmigrating tides are also of considerable importance for the generation of longitude variations in the topside ionosphere/plasmasphere TEC.

4 (10:51-11:08am) Periodic structures in the equatorial ionosphere

Cheryl Huang

Description: We have analyzed detrended plasma density and in situ velocity measurements from the C/NOFS mission during the first 18 months after launch. Densities and velocities both show wavenumber 4 periodicity, suggestive of DE-3 tides. Climatology supports this hypothesis. In addition, broad plasma decreases (BPDs) which coincide with a minimum in the tidal structure at 330 degrees geographic longitude, are a persistent feature most evident on the nightside during June solstices. Simultaneous velocity measurements show a large downward (toward the Earth) meridional velocity in this location during these months. These results will be discussed.

5. (11:08-11:25) Modulation of equatorial electrojet plasma waves by overshielding electric field during geomagnetic storms

E. B. Shume, E. R. de Paula, and M. A. Abdu

Abstract: This report presents day-time 30 MHz radar observations of equatorial electrojet plasma irregularities in Sao Luis (Brazil) during the January 10, 2002, September 4, 2002, and November 6, 2001 geomagnetic storms. Modulation of equatorial electrojet plasma waves by the overshielding electric field are detected by the radar during the January and September storm events. The depressions of radar echo intensity observed by the Sao Luis radar during the January 10, 2002 and September 4, 2002 storms are caused by inhibition of large, medium, and short scale electrojet plasma waves by the overshielding electric field. Corresponding to the depressions of the radar echoes, counter equatorial electrojet were observed by ground-based magnetometer in Sao Luis. The influences of disturbance dynamo, undershielding, and overshielding electric fields on the equatorial electrojet irregularities and current have been evident on the November 6, 2001 radar and magnetic field data. This study demonstrates the control of the equatorial electrojet plasma waves (growth and suppression) by the IMF, and also the coupling between the high-latitude and equatorial ionospheres.

6. (11:25 – 11:42) Generation and evolution of broad plasma depletions in the equatorial ionosphere near dawn: C/NOFS measurements and simulations

Chaosong Huang, O. de La Beaujardiere, J. M. Retterer, P. A. Roddy, D. E. Hunton, J. O. Ballenthin,
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An unexpected feature revealed by the C/NOFS measurements is the presence of deep plasma depletions near dawn. The observations show that the plasma bubbles observed in the midnight-dawn sector originate in the evening sector. The plasma bubbles continue growing for ~4 hours, and the plasma flow inside the bubbles remain upward for ~8 hours. The longitudinal width of a single, fully developed plasma bubble can reach 700 km. The broad plasma depletions cover a longitudinal range of 2000-4000 km and result from merging of multiple plasma bubbles. Numerical simulations of the PBMOD verify the feasibility of the merging process of bubbles.

7. (11:42-12:00) Update on DC Electric Fields, Magnetic Fields, and Plasma Irregularities Observed on the C/NOFS Satellite

R. Pfaff

We present new results from the Vector Electric Field Investigation (VEFI) on the C/NOFS satellite. In particular, during recent nighttime perigee passes, we show new observations of km-scale waves, large-scale undulations associated with regions at or below the F-peak, and evidence of structured magnetic fields associated with diamagnetic currents and other current processes. The data are discussed in the context of current ideas regarding low latitude instabilities and plasma structures.

Afternoon Session (June 28, 01:30PM-03:30PM, 7 Talks, 12-minute talks + 5 minutes for questions/answers)

1. (1:30-1:47) Numerical simulations of equatorial ionospheric irregularities

D. Hysell, H. Aveiro and R. Ilma

We describe 3D numerical simulations of plasma instabilities in the equatorial F, valley, and E regions, paying special attention to the effects of non-equipotential magnetic field lines.

2. (1:47-2:04) Seasonal Meridional Drifts and the Occurrence of Irregularities observed by C/NOFS

Russell Stoneback

The Coupled Ion Neutral Dynamics Investigation (CINDI) onboard the Communications/Navigation Outage Forecast System (C/NOFS) satellite provides a unique opportunity to study in-situ ion drifts and the occurrence of irregularities as the Sun transitions out of an extended solar minimum. Seasonal averages of meridional drifts for 2009 show variations from previous observations with downward drifts in the afternoon and upward drifts across midnight. When this occurred an enhancement in the occurrence of post-midnight irregularities was also observed. The relationship between seasonally averaged meridional drifts and the occurrence of medium-scale irregularities will be presented through 2011.

3. (2:04 – 2:21) SAMI3/ESF Modeling of Observed Phenomena Associated with Equatorial Spread-F

J. Krall, J. D. Huba and G. Joyce

Results of the NRL SAMI3/ESF three-dimensional simulation code have been shown to compare well to observations of equatorial spread-F (ESF). The SAMI3/ESF ``wedge'' simulation geometry conforms to a dipole field geometry that extends up to 3200 km at the equator and down to and altitude of 85 km, but extends over only 4-8 degrees in longitude. The full SAMI3 ionosphere equations are solved, providing ion dynamics both along and across the field. The potential is solved in two dimensions in the equatorial plane under a field-line equipotential approximation. We present three examples of SAMI3/ESF results and corresponding observations: plasma ``blobs,'' ESF airglow enhancements (equatorial plasma bubbles [EPBs] that suddenly brighten) and the co-incidence of ``electrified'' meso-scale traveling ionospheric disturbances and EPBs. In all cases, SAMI3/ESF reproduces key features of the observations and shows interesting measurable phenomena that have not yet been measured.

4. (2:21 – 2:38) Equatorial Spread F occurrence variations over Jicamarca and longitude variations of the prereversal enhancement near solar minimum

E. E. Pacheco 1, B. G. Fejer 1, J. L. Chau 2, R. A. Heelis 3and R. A. Stoneback 3
1Center for Atmospheric and Space Sciences, Utah State University
2Jicamarca Radio Observatorio, Instituto Geofisico del Peru
3Hanson Center for Space Sciences, University of Texas at Dallas

We use the 3-m irregularities from the JULIA system to study the quiet-time ($Kp \leq 3$) climatology of equatorial spread F in the Peruvian sector during the 2007-2009 low solar flux period. Our results show seasonal variations in the spread-F occurrence that are strong function of local time and altitude. Additionally, we also use the ion drift measurements from C/NOFS to study the longitude dependence of the prereversal enhancement and its possible influence on the spread F occurrence during low solar flux conditions.

5. (2:38-2:55) Equatorial Plasma Bubbles Generated by the Fields of WAM, the Whole Atmosphere Model

J. Retterer

One of the key issues concerning the formation of equatorial plasma bubbles and the radio scintillation that they cause is the mechanism and structure of the phenomena that trigger them. Usually, simulations of the generation of plasma bubbles rely on some arbitrary initial perturbation that develops into the bubble as a consequence of the Rayleigh-Taylor and other plasma instabilities. For this study (done with the 3-d plasma bubble model of Retterer), we instead begin with no initial plasma perturbation, but rely on the structured winds and dynamo electric fields of the Whole Atmosphere Model (WAM) to naturally generate the plasma perturbations that develop into bubbles when the plasma becomes unstable. WAM is a 150-layer general circulation model based on the US National Weather Service's operational Global Forecast System (GFS) model extended upward to cover the atmosphere from the ground to about 600 km. It was developed as part of the Integrated Dynamics through Earth's Atmosphere (IDEA) project to study the generation, vertical propagation, possible nonlinear interactions, and effects of planetary waves and tides originating in the lower atmosphere, as part of an effort to understand the variability of the upper atmosphere and ionosphere.)

6. (2:55-3:12) Scintillation Prediction From DMSP/SSUSI UV Observations

Joseph Comberiate

As assimilative models begin to incorporate a higher volume of global measurements and full-physics models include irregularity-generating processes, it should be possible to improve models and forecasts of UHF and L1-band scintillation in the near future. In this context, we seek to evaluate the link between space-based UV observations of the equatorial ionization anomaly and equatorial plasma bubbles and ground-based observations of GPS and UHF scintillation. We have developed a technique that routinely detects equatorial plasma bubbles and characterizes the equatorial ionosphere in TIMED/GUVI and DMSP/SSUSI data from 2002-2007. These observations are coordinated with databases of UHF and L1-band scintillation observations from Peru and Hawaii. We present an evaluation of the link between equatorial plasma bubbles occurrence and scintillation as the bubbles drift through the nightside ionosphere and develop metrics for scoring the ability to nowcast and predict future scintillation occurrence from SSUSI observations.

7. (3:12-3:30) Kinetic Simulations of Small-Scale Spread-F

Yann Tambouret

In the past few decades researchers have made very good progress in understanding large-scale Spread-F irregularities and ultimately relating them to the collisional Rayleigh-Taylor instability. Small-scale (< 10 m) irregularities, however, cannot be explained by any obvious linear theory. We present 2D, non-periodic Particle-in-Cell (PIC) simulations that explore the small to medium-scale through gradient driven, collisionless dynamics. These simulations include kinetic effects essential to understanding the dynamics at this length scale. We envision the large-scale waves produce the gradient driver for the small-scale dynamics, and we investigate how varying the background conditions, e.g. the gradient length-scale, affect the growth of small-scale waves.