CEDAR 2015

Walker-Ames Room, Kane Hall
University of Washington

Seattle, Washington

IT Poster Session
Wednesday June 24, 2015

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Data Assimilation

DATA-01 Global ionospheric specification and forecasting by inferring unobserved thermospheric and ionospheric state variables via an Ensemble Kalman Filter - by Chih-Ting Hsu

Status of First Author: Student IN poster competition, PhD

Authors: Chih-Ting Hsu, Tomoko Matsuo, Wenbin Wang, Jann-Yenq Liu

Abstract: This study demonstrates the significance of ion-neutral coupling to ionospheric data assimilation for ionospheric specification and forecast under different seasons and solar activities. Ensemble Kalman Filter (EnKF) is used to assimilate synthetic electron density profiles sampled according to the Formosa Satellite 3/Constellation Observing System for Meteorology, Ionosphere and Climate (FORMSAT-3/COSMIC) into the Thermosphere Ionosphere Electrodynamics General Circulation Model (TIEGCM). The combination of the EnKF and first-principles TIEGCM allows a self-consistent treatment of thermosphere and ionosphere coupling in the data assimilation and forecast. Because thermospheric variables affect ionospheric electron densities, different combinations of an observed ionospheric state variable (electron density) and unobserved ionospheric and thermospheric state variables (atomic oxygen ion density, neutral temperature, winds, and composition) are included as part of the EnKF state vector in experiments. Furthermore, these experiments are carried out under different solar activity (F10.7 are 190 and 69, respectively) and season (vernal equinox and summer solstice) to investigate the filter performance under different conditions. In the EnKF, the unobserved state variables are estimated and made dynamically and chemically consistent with the observed state variable, thus improving the performance of the data assimilation system. The impact on ensemble forecast is further examined by initializing the TIEGCM with the assimilation analysis.

DATA-02 Data Assimilation of Neutral Wind Measurements to Estimate the Ionosphere-Thermosphere State - by Daniel Sveta Miladinovich

Status of First Author: Student IN poster competition, PhD

Authors: Daniel S. Miladinovich, Seebany Datta-Barua, Gary S. Bust, Jonathan J. Makela

Abstract: Ionosphere-thermosphere coupling is a subject of intense research during the last decade. Several coupling mechanisms have been studied include gravity waves and/or neutral winds originating at the poles that then accelerate the ion drifts through collisional drag into what is called the disturbance dynamo effect. GPS scintillation studies have shown that plasma densities contain very fine structure and can rapidly change as an ionospheric storm evolves. Total electron content maps generated using Ionosphere Data Assimilation Four Dimensional (IDA4D) in a storm enhanced density (SED) plume that occurred over the south eastern United States during local night time on October 25th 2011. That is why this study aims to make use of readily available Fabry-Perot neutral wind measurements in a data assimilative method to better estimate ion drifts and neutral winds.
We are developing methods that assimilate electron density estimates, neutral wind measurements, and several different model results onto a discretized grid to optimally estimate neutral winds and ion drifts during storm time. The method is called Estimation of Model Parameters from Ionospheric Reverse Engineering (EMPIRE). It solves the ion continuity equation using a 3D variational based Kalman filtering technique. IDA4D estimates the assimilated electron densities and the Pisgah Astronomical Research Institute's (PARI) Fabry-Perot interferometer provides the assimilated neutral wind measurements. The results that will be presented in this poster will show Eulerian vector plots of the neutral wind and ion drifts over the entire region that is covered by the SED plume at different time steps throughout the storm.

Conclusions made on from results will be discussed alongside error analysis to better understand the relationship between neutral winds effect on the SED plume throughout this storm.

DATA-03 On the Importance of Data Assimilation for the Thermosphere Ionosphere System - by Mihail Codrescu

Status of First Author: Non-student, PhD

Authors: Mihail V. Codrescu, Stefan M. Codrescu

Abstract: Modern technological systems like GNSS positioning, HF communications, radar ranging, satellite communications, and power distribution are all affected by space weather and can become unreliable during disturbed conditions. For large space weather events the thermosphere and ionosphere, driven by strong external forcing and under the influence of feed-back loops, exhibit large deviations from climatology. Such extreme space weather conditions can have high impacts on systems and are notoriously difficult to reproduce by models. Successful specification and forecasting during such events requires physics based ionosphere thermosphere models and Data Assimilation (DA) schemes. DA in the thermosphere ionosphere system is required because of the impossibility to measure the forcing of the system with the necessary spatial and temporal resolution. New measurements from the COSMIC II and GOLD mission will be used to estimate the forcing. The Coupled Thermosphere Ionosphere Plasmasphere and Electrodynamics (CTIPe) model is currently evaluated to determine the possibility of its use as the background model for the development of a modular data assimilation system. In parallel, the uncertainty associated with the external forcing of the system, i.e. high-latitude convection and precipitation patterns, solar UV and EUV fluxes, and the waves propagating from below, and the uncertainties associated with them are being evaluated to establish requirements for the DA scheme.

Equatorial Thermosphere or Ionosphere

EQIT-01 Ionospheric Structure Observed by a Transequatorial HF Radio Experiment - by Ethan S. Miller

Status of First Author: Non-student, PhD

Authors: E. S. Miller, R. Nikoukar, L. J. Paxton, G. S. Bust

Abstract: A radio receiver instrument was installed at Tula, American Sa'moa 14 15' S, 170 34' W, -15.9 invariant), in February 2015. It monitors the HF time and frequency standard broadcast by station WWVH (21 59' N, 159 45' W, 21.7 invariant), located on the Hawaiian island of Kauai which is at nearly the same geomagnetic longitude of American Sa'moa. Initial Doppler-only results depict a richly dynamic and structured bottomside equatorial ionosphere even very early (14 LT) in the afternoon, with spectacular plumes at sunset and beyond. We will present a summary of observations to-date, azimuthal brightness images of interesting events, and proposed physical interpretations of the data.

EQIT-02 Observations of large and small scale ESF irregularities over Jicamarca from an all-sky imager and AMISR-14 - by Dustin A. Hickey

Status of First Author: Student IN poster competition, PhD

Authors: D. Hickey, C. Martinis, C. Sullivan, M. Milla, M. Nicolls, R. Varney, A. Strømme, and F. Rodrigues

Abstract: In 2014 an all-sky imager (ASI) and an AMISR system were installed at the Jicamarca Radio Observatory. The ASI measures airglow depletions associated with large scale equatorial spread F irregularities (10-200 km), while AMISR detects small scale irregularities (0.3 m). In this study we

compare data from AMISR with ASI images from August 21, 2014. AMISR had five beams perpendicular to B covering about 200 km, at 250 km altitude, in the E-W direction. This coverage allowed us to compare each beam with a different part of the ASI image and determine where in the optical image the echoes are coming from. Comparing the 250 km radar data with data from zenith on the ASI, we found that most of the echoes occur on the western wall of the depletion with a significant number of echoes also coming from the eastern wall. Results show that 44% percent of the 101 total number of cases had scatter coming from the western wall, 28% from the eastern wall, and 28% coming from regions where the beam covers parts of both walls. The main radar, which detects 3 m irregularities and has greater altitude coverage, was also running during this night in the JULIA imaging mode. Doing the same comparison we find that 58% of the cases have scatter occurring on the western wall and 23% on the eastern wall. At 2300 LT JULIA detects irregularities at 700 km and 250 km but not in-between; in contrast the ASI shows depletions extending continuously from Jicamarca zenith to latitudes that map to ~700 km at the magnetic equator.

EQIT-03 Validation of space based equatorial plasma bubbles measurements using ground based observations - by Dimitrios Iliou

Status of First Author: Student IN poster competition, Masters

Authors: Dimitrios Iliou, Jonathan J. Makela, Joseph Comberiate

Abstract: Observations of the nighttime 135.6-nm emission made by the Special Sensor Ultraviolet Spectrographic Imager (SSUSI) on board the Defense Meteorological Satellite Program (DMSP) F18 satellite can be used to detect and study postsunset ionosphere irregularities called equatorial plasma bubbles (EPBs). These structures tend to occur shortly after local sunset, have widths on the order of 100 km, and can extend in latitude into the tropical ionosphere. Small-scale irregularities associated with the EPBs can cause scintillations on trans-ionospheric radio waves. Observations from a space-borne platform, such as SSUSI allow for the generation of global statistics of the occurrence and morphology of EPBs. However, these observations need to be validated to understand the limitations caused by viewing geometry and resolution considerations and how they affect the ability of SSUSI to detect EPBs. An algorithm has been developed that compares the detection, location and width of the EPBs observed by SSUSI on DMSP and the ground-based Cornell Narrow Field Imager (CNFI) located on the Haleakala Volcano on Maui, Hawaii. The results of this comparison provides useful information of the ability of SSUSI to accurately detect EPBs as well as their spatial characteristics. It also demonstrates the importance of validating space based measurements using ground based observations.

EQIT-04 Signal Fading Characteristics of Low-latitude Scintillation Observed Across the GPS Frequency Bands - by Yu Jiao

Status of First Author: Student IN poster competition, PhD

Authors: Yu Jiao and Yu Morton

Abstract: During the past years, we have studied a large amount of ionospheric scintillation data collected using GNSS receivers and front ends established in Ascension Island, Brazil, Singapore, and Hong Kong during the 24th solar maximum. Using these data, signal fading level, duration, and separation on each GPS frequency as well as overlap between frequencies are analyzed to establish statistical relationships among these signal fading features across the three GPS bands. This poster will present scintillating signal intensity fading behaviors based on high rate data analysis from these low-latitude stations.

EQIT-05 Study of the longitudinal variability of equatorial electrojet current and its impact on ionospheric TEC in South America - by Sovit Khadka

Status of First Author: Student IN poster competition, Masters

Authors: Sovit Khadka, Cesar Valladares, Rezy Pradipta

Abstract: The daytime equatorial and low latitude ionospheric phenomena provide several observable quantities that can be used to forecast the dynamics and fluctuations of ionospheric plasma densities during the evening. Equatorial electrojet (EEJ) is one of the unique daytime ionospheric phenomena, defined as an intense eastward current flowing in the form of ribbon-shaped band of roughly 300 km wide in the E region ionosphere along the geomagnetic equator of the Earth. Although EEJ strengths has been studied extensively in general, relatively little is known about how EEJ strength affect the distribution of the ionospheric total electron content (TEC) over South America and whether there is significant longitudinal variation. We study the EEJ strengths using three pairs of magnetometers, one located at and another less than 9 degrees away from magnetic equator for each pair. We examine the data in different longitude sectors and investigate the EEJ's influence on the Global Positioning System (GPS)-TEC in South American continent. Our findings from this comparative study demonstrate that EEJ is weaker on the eastern side and gradually becomes stronger towards western side of South America. We also observed that EEJ strengths have some influence on the shape, size, amplitude and separation of equatorial Ionization anomaly (EIA) crests as seen through ionospheric TEC distribution measured using GPS.

EQIT-06 Equatorial F-region neutral winds and shears near sunset measured with chemical release techniques - by Andrew Kiene

Status of First Author: Student IN poster competition, Undergraduate

Authors: A. Kiene, M. F. Larsen, and E. Kudeki

Abstract: The period near sunset is a dynamic and critical time for the daily development of the equatorial nighttime ionosphere and the instabilities that occur there. The pre-conditions necessary for the development of Equatorial Spread F (ESF) plasma instabilities are a result of the rapid transition of the ionosphere during these hours. The neutral dynamics of the sunset ionosphere contribute greatly to the generation of currents and electric fields; however, the behavior of the neutrals is experimentally understood primarily through single-altitude measurements or measurements that provide weighted altitude means of the winds as a function of time. Vertically-resolved neutral wind measurements in the F region at sunset are very limited. We present two sets of sounding rocket chemical release measurements, one from a launch in the Marshall Islands on Kwajalein atoll and one from Alcantara, Brazil. Analysis of the chemical tracer motions has yielded vertically-resolved neutral wind profiles that show strong vertical gradients in the zonal wind that are unexpected by classical assumptions about the behavior of the neutral wind at these altitudes at sunset near the geomagnetic equator. In addition, these observations show that the direction of the neutral wind reverses over a period of approximately 20 minutes, indicating that the neutrals may be responding quickly to the rapidly changing solar conditions during sunset.

EQIT-07 Study of the equatorial valley region using Jicamarca ISR and VIPIR ionosonde - by Pablo M. Reyes

Status of First Author: Student IN poster competition, Masters

Authors: Pablo M. Reyes and Erhan Kudeki

Abstract: Incoherent scatter (IS) radar and high temporal resolution ionosonde data were taken concurrently at Jicamarca on January and April 2015 to bring more insight on the phenomena occurring in the ionospheric valley region. We will present new results from the two instruments. The work consists of analysis of these data establishing the time and spatial scale lengths, and propagation direction of gravity waves as possible drivers of 150-km irregularities. The Jicamarca IS was configured in a range aliased mode using an inter-pulse period (IPP) of 105 km that allows for Doppler shifts of up to 2 km/s. For the analysis of ionosonde data we are going to make full use of the multiple receiver data that we have from the Jicamarca ionosonde (VIPIR, Vertical Incidence Pulsed Ionospheric Radar). VIPIR interferometric data, by means of the angle of arrival is giving evidence that the ionospheric electron density contours are rippled.

Those ripples could be generated by gravity waves. Finally, by means of fitting both VIPIR ionograms and IS differential phase, we are going to obtain density profiles.

EQIT-08 On the occurrence of equatorial F-region irregularities and the magnitude of the pre-reversal enhancement of the evening plasma drifts - by Jessica Mae Smith

Status of First Author: Student IN poster competition, Masters

Authors: Jessica M. Smith, Fabiano S. Rodrigues, Marco A. Milla

Abstract: We have analyzed approximately 20 years of incoherent and coherent scatter measurements made by the Jicamarca radar near Lima, Peru. The measurements were made between 1994 and 2013. From the measurements, we have determined average vertical drifts curves as well as a metric for quantifying equatorial spread F (ESF). We have performed a climatological analysis of the (1) vertical drifts and (2) ESF for different seasons and solar flux conditions. In addition, we have also investigated (3) the role of evening vertical drifts in the occurrence of ESF on a case-by-case basis. We present a discussion of our findings of the climatological behavior of the vertical drifts and ESF in the Peruvian sector, as seen by the Jicamarca radar. We also describe our results on the extent at which the vertical drifts controls the development of ESF.

EQIT-09 The evolution of equatorial plasma depletions described by the CNOFS/CINDI mission - by Jonathon Smith

Status of First Author: Student IN poster competition, Undergraduate

Authors: Jonathon M. Smith and R. A. Heelis

Abstract: Since 2013 the C/NOFS satellite has orbited the Earth at altitudes between 350 km and 700 km in the equatorial region of the ionosphere. Using data from the Coupled Ion Neutral Dynamics Investigation (CINDI) we are able to detect discrete plasma depletions with spatial scales greater than 50 km along the satellite track. Each depletion is identified by profiles in in plasma density and velocity and each may be described by a characteristic width in apex longitude, relative density reduction and vertical flow velocity. Here we describe the distribution of plasma depletion parameters as a function of location, with a goal of discovering the relationships between these key parameters and the evolution of the depletions.

EQIT-10 Spectral observation of equatorial spread F irregularities using the MELISSA radar in the Brazilian sector - by Gebreab Zewdie

Status of First Author: Student IN poster competition, Masters

Authors: Gebreab K. Zewdie, Fabiano S. Rodrigues, Marco A. Milla

Abstract: Ionospheric spread irregularities are perturbations in the ionospheric electron density. Near the equatorial region, spread F is usually intense and known to affect the propagation of radio waves used for navigation and communication purposes. We currently seek a better understanding of spread F irregularities for fundamental and applied reasons. Coherent backscatter radar observations of meter-scale irregularities allow us to better understand the genesis, development and motion of the spread F. We used the MELISSA radar deployed at Sao Luis, Brazil (2.590 S, 44.210N) near the magnetic equator, to estimate Doppler power spectra of bottomtype, bottomside and topside spread F types. In this workshop we will present results of measurements the Doppler velocity of irregularities and spectral width to characterize , respectively, the line of sight velocity and turbulence of the spread F irregularities.

EQIT-11 Preliminary Comparative Observations between Jicamarca and Recently Installed VHF Radar in Huancayo, Peru - by Robert Sorbello

Status of First Author: Student NOT in poster competition, PhD

Authors: Robert Sorbello, Julio Urbina, Karim Kuyeng

Abstract: The Applied Signal Processing and Instrumentation Research Laboratory (ASPIRL) at Penn State recently installed a Very High Frequency (VHF) radar system in Huancayo, Perú. The new radar system is located approximately 170km to the east of the Jicamarca Radio Observatory (JRO) Incoherent Scatter Radar (ISR) and will eventually incorporate cognitive sensing techniques. The main goal of the radar at Huancayo is to continuously monitor the activity in the equatorial ionosphere to complement current investigations conducted at JRO, which are only probed and sampled intermittently from Jicamarca due to the operation costs and scheduling issues of the more powerful incoherent scatter system. Preliminary comparative results showed that the two radars located 170m apart are able to sense the same plasma irregularities developing in the ionosphere. Finer details of the plasma structure are noticeable with the radar at Huancayo because the range resolution was chosen to be 5 times greater than the JRO nighttime mode. However, the sensitivity of JRO far exceeds the system in Huancayo, leading to a more preferable dynamic range of the detected plasma irregularities. We report data of a two-day simultaneous observation in addition to a comparison of the chosen radar configurations at both facilities.

EQIT-12 Multi-Instrument Observations of MSTIDs - by Ross L. Dinsmore

Status of First Author: Student NOT in poster competition, Undergraduate

Authors: Ross L. Dinsmore and Dr. John Mathews

Abstract: Medium scale traveling ionospheric disturbances, referred to as MSTIDs subsequently, are ubiquitous in the ionosphere across the globe. Using multiple instruments, the direction and periodicity of MSTIDs were investigated. Using incoheirent scatter radar, MSTIDs were observed over a specified area. Then using world total electron content (TEC) data, the observations were corroborated over that area. Then the world TEC data was used to investigate MSTIDs all over the globe and across long ranges. The hourly perodicitiy of MSTIDs was confirmed. Additionally, the world TEC data showed more easily visible MSTID waves 45 degrees from the cardinal directions, suggesting the waves are coherient and at an angle.

EQIT-13 Equatorial 130 km echoes at twilight - by Ronald R. Ilma

Status of First Author: Student NOT in poster competition, PhD

Authors: Ronald R. Ilma and David L. Hysell

Abstract: Large-scale plasma waves have been detected by the low-power JULIA radar at Jicamarca in the post-sunset topside E region (~130 km). These are a new class of equatorial irregularities and they have not been previously predicted. Although the source of these echoes have not been precisely determined, the current radar database, obtained under both single-line interferometric and aperture synthesis imaging modes, tentatively suggest that they are associated with a gradient drift instability capable of generating these large-scale primary waves. The statistical analysis of the single-baseline interferometry observations reveal that the probability to detect these echoes is relatively higher during equinox than solstice, in the altitudinal range from 120 to 140 km around twilight. Preliminary results from computer simulations code, which has been previously applied to Spread-F studies satisfactorily, show the emergence of waves in similar spatial and temporal conditions to radar echoes.

Irregularities of Ionosphere or Atmosphere

IRRI-01 Upper E region field-aligned echoes over Chung-Li radar - by Chien Ya Wang

Status of First Author: Non-student, PhD

Authors: Chien Ya Wang, Ting-An Lin, Yen-Hsyang Chu

Abstract: In this report the upper E region echoes occurred at height from 120~140 km will be presented. These kind echoes rarely detected by Chung-Li VHF radar. The characteristics of these echoes in range time intensity plots are most negative slope, appeared in range 150~200 km, sometimes associated with sporadic F region echoes (in range 300~450 km) and occurred before midnight with time duration from10~80 minutes. A typical event in 19 July 2009 is interesting, the first part echoes during 2000~2200 LT, interferometry analysis indicate multiple layers structure plasma irregularities moving eastward cross the radar echo region horizontally at height 120~130 km, persist about 20 minutes. The second part echoes occurred in 2200~2330. Quasi-periodic layer irregularities at height 130~140 km moving cross westward in periodic about 16~18 minutes, simultaneously, the normal sporadic E (Es) dissipated at about 100 and 110 km.The projection in horizontal plane indicate clearly periodic structure. The average horizontal trace velocity is 50 m/s, thus a horizontal wavelength can be estimated as about 60 km. Some implicit information about these echoes will be discussed.

IRRI-02 Spatial and Temporal Variation of the FORMOSAT-3/COSMIC S4 scintillation index using Tidal Analysis - by Pei-yun Chiu

Status of First Author: Student IN poster competition, Masters

Authors: Chiu Pei-yun and Loren C. Chang

Abstract: The tides from the lower atmosphere can propagate upward, causing the ionospheric perturbations. By using GPS radio occultation (RO) signals, FORMOSAT-3/COSMIC satellites can provide global morphology of the scintillation index, S4 index. We focus on the local time and spatial variation of the S4 index, and quantify the major variation modes through tidal analysis. The seasonal variations of the S4 index are presented in this method from 2007 to 2014 and the tidal signatures are examined.

IRRI-03 The effect of ionosphericirregularities on GNSS radio occultation signals - by Xinan Yue

Status of First Author: Non-student, PhD

Authors: Xinan Yue and William Chreiner

Abstract: GNSS based radio occultation technique has been a valuable method to remotely sense the Earth's atmosphere for the purpose of numerical weather prediction, climate and global change, and space weather. Since the GPS/MET mission, many LEO satellites have been launched equipped with GPS radio occultation payload, including CHAMP, GRACE, SAC-C, COSMIC, Metop-A/B, C/NOFS, and etc. Of these missions, COSMIC is the first constellation dedicated for radio occultation purpose. In this poster, we will show :(1) The ionospheric irregularities observed by COSMIC RO; (2) How the irregularities result in the loss of lock of RO signals (3) How the ionospheric irregularities influence the bending angle retrieval.

IRRI-04 Solar control of F region radar backscatter: Further insights from observations in the southern polar cap - by Leslie J. Lamarche

Status of First Author: Student IN poster competition, Undergraduate

Authors: Leslie J. Lamarche and Roman A. Makarevich

Abstract: The role of solar wind and illumination in production of small-scale F region plasma irregularities is investigated using a 4-year data set collected by the Super Dual Auroral Radar Network (SuperDARN) facility at the McMurdo station, Antarctica (MCM). Statistical analysis of ionospheric echoes detected by MCM shows that radar backscatter from the polar F region occurs in wide and persistent bands that exhibit systematic changes with local time, season, and solar cycle. It is demonstrated that all variations considered together form a distinct pattern. A comparison with F region model densities and raytracing simulations shows that this pattern is largely controlled by the F region solar-produced ionization during the day. During the night, however, MCM observations reveal a significant additional source of plasma density in the polar cap as compared with the model. An example of conjugate radar observations is presented that supports the idea of polar patches being this additional source of ionization on the nightside. Echo occurrence within the band exhibits a clear peak near the solar terminator, which suggests that small-scale irregularities form in turbulent cascade from large scales. Further, echo occurrence is enhanced for particular IMF orientations during the night. Observations indicate that solar illumination control of irregularity production is strong and not restricted to the nightside. Indirect solar wind control is also exerted by the IMF-dependent convection pattern, since the gradient-drift instability favors certain orientations between the plasma density gradients and convection velocity.

IRRI-05 Polar Ionosphere Structure and High Latitude Scintillation Impacts from the March 17, 2013 Geomagnetic Storm - by Diana C. Loucks

Status of First Author: Student IN poster competition, Masters

Authors: Diana Loucks, Scott Palo, Marcin Pilinski, Geoff Crowley, Jeff Thayer

Abstract: With the continuing reduction in seasonal Arctic sea ice extent, increase in ship traffic above the Arctic Circle is expected and will increase the overall communication and navigation footprint in the region. Ionospheric behavior in the polar regions can significantly impact Ultra High Frequency (UHF) transmissions including degradation of Global Positioning System (GPS) position solutions and communications interruptions. To address these operational concerns, a need arises to identify and understand the ionospheric structure that leads to disturbed conditions in Arctic latitudes.
This paper focuses on a case study with the goal of identifying correlative features between GPS scintillation and electron densities as seen by ground receivers in Alaska and the Poker Flat Incoherent Scatter Radar (PFISR). The month of March 2013 provides an opportunity to study ionospheric disturbances during both geomagnetically quiet and disturbed conditions, surrounding the geomagnetic storm of March 17, 2013. This particular storm was one of many quasi-annual St. Patrick's Day storms that occur at or near the vernal equinox and have been discussed in literature. The 2013 storm was classified by NASA as a G2 storm with the Disturbance Time Index (DST) bottoming out at -132 nT and the Kp Index reaching a peak value of 6.7. This storm was mild compared to the Hallowe'en Storms of 2003, which reached a DST of -383 nT, however a measureable response in the polar ionosphere was observed. Data from PFISR was analyzed during this period and is used as the basis for determining the ionospheric structure. Additionally, data available from a network of GPS receivers across Alaska provides phase scintillation information that can be used to infer the communications and navigation degradation. To further interpret these observations, SuperDARN derived convection patterns along with Ionospheric Data Assimilation Four Dimensional (IDA4D) and Assimilative Mapping of Ionospheric Electrodynamics (AMIE) assimilative models are utilized.

A baseline electron density during the magnetically quiet days preceding the storm, as indicated by Kp <3, was formed and compared to the overall data. In addition to storm time electron density enhancements and correlated GPS scintillation, the data also indicates nightly substorm and scintillation features prior to the storm and following storm recovery. Using satellite ephemeris data, a ray path for the GPS signal was calculated and used to determine where the rays pierced the PFISR beam. These results are used to correlate GPS scintillation with observed ionospheric structure.

IRRI-06 Characteristics, Variability and Impact of Atmospheric Gravity Waves in the Thermosphere-Ionosphere as Determined from Dynasonde Data - by Catalin Negrea

Status of First Author: Student IN poster competition, Masters

Authors: Catalin Negrea, Nikolay Zabotin, Terry Bullett, Mike Rietveld, Tim Fuller-Rowell, Mihail Codrescu

Abstract: Gravity waves are known to have a significant impact on the dynamics of the thermosphere-ionosphere. In some cases of large scale waves, localized changes of up to an order of magnitude have been reported in the ionospheric plasma. Smaller amplitude waves are believed to occur more frequently and are at least as important, as they transport significant amounts of energy and momentum over hundreds and thousands of km between atmospheric regions. Recent work has shown that accelerations due to gravity wave dissipation can be as high as 0.1 m*s-2 (100-1000 m/s/day). However, detailed results on the characteristics of wave activity at altitudes higher than 120 km have only been determined in a small number of instances. As a result, the variability of wave activity with time, geographical location and height are not well known. This paper presents advances made in recent years towards the study of gravity waves in the thermosphere-ionosphere using 2 minute cadence Dynasonde data from Wallops Island VA, San Juan, PR and Tromso, Norway in 2013 and 2014. Several instances of gravity wave activity are shown and wave parameters (frequency, horizontal and vertical wavevector components) are demonstrated to satisfy the theoretical dispersion relation. The tilt measurement, a product of the NeXtYZ inversion procedure, can be used to differentiate between waves propagating in the zonal and meridional directions. Analyzing the tilts spectra and its variability over a time period longer than 12 months at all three locations, we determined the first order geographical variability of wave activity as well as the seasonal variability at each location. The underlying neutral winds and neutral density can be inferred using a transfer function and background atmospheric parameters from a numerical model. Finally, the average gravity wave drag is estimated for several datasets at Wallops Island.

IRRI-07 Simultaneous investigation of F region irregularities made with Chung-Li VHF radar, Yonaguni all-sky imager and COSMIC satellite - by F. F. Lin

Status of First Author: Student NOT in poster competition, Masters

Authors: F.F. Lin, C.L. Su,C.Y. Wang, Y.H. Chu

Abstract: Three-meter field-aligned irregularities (3-m FAIs) occurred in post-sunset F region at low latitude on 5 February 2008 were observed by using the Chung-Li VHF radar. Interferometry measurements implemented at Chung-Li 52 MHz VHF radar show that the plasma structures of the3-m F FAIs are occurred in a height range of 250-350 km in a quasi-isotropic blob shape with a dimension of about 15–26 km. In order to investigate the characteristics of bottom-side F region plasma irregularities, simultaneously, the VHF backscatter radar, HF ionosonde, FORMOSA-3/COSMIC (COSMIC for short) scintillation probe, and Yonaguni all-sky imager are utilized. Multi-technique observations improve understanding the correlation of post-sunset F region plasma irregularities in different scale size. The altitude estimated from the COSMIC scintillation index is the same with from the radar echoes calculated by using interferometry measurement. The plums echoes of VHF radar on range-time-intensity (RTI) plot and spread F on ionograms take place at the same time. In addition, the eastward drift and tilted direction observed with Chung-Li radar are consistent with those detected by using Yonaguni airglow imagers. The results infer that the 3-m F FAIs might be influenced by the bulk motion of the large scale plasma irregularities. A comparison also suggests that the 3-m F FAIs observed in the northern crest of the equatorial ionization anomaly (EIA) are independent of those over midlatitude, but are closely related to those occurred at geomagnetic equator. In this paper, the plausible mechanism responsible for the generation results are analyzed and investigated.

IRRI-08 Kinetic simulations of Farley-Buneman instabilities - by Enrique Rojas

Status of First Author: Student NOT in poster competition, Undergraduate

Authors: Enrique Rojas

Abstract: More than 50 years have passed since the early works of Farley and Buneman, and although we have learned a lot there are still some unanswered questions. Given the complexity of this kind of systems, it is incredibly hard to obtain specific quantitative values to compare with data.

The usual approach to test theoretical models has been through computer simulations, to make the models evolve to obtain concrete data to be tested against measurements. So far, most of the numerical simulations for this phenomena have been implemented using PIC, but recently there has been a significant number of research projects involving high dimensional numerical solutions of the plasma kinetic equations.

In this work we are going to present the approach that we are going to follow for this simulations, namely a semi Lagrangian approach with three spatial and two velocity dimensions in phase space. We are also going to present data recently obtained with the Homer radar system in Alaska on the storm of last March.

IRRI-09 Development of a Parallel PIC/Fluid Simulation of E-region Farley-Buneman Turbulence - by Matthew Young

Status of First Author: Student NOT in poster competition, PhD

Authors: Matthew A. Young, Meers Oppenheim, Yakov Dimant

Abstract: The Farley-Buneman (FB) instability is a two-stream plasma instability that occurs at roughly 100 km in the E-region ionosphere. It develops when ion-neutral collisions dominate ion motion while electron motion is affected by both electron-neutral collisions and the background magnetic field. Kinetic and fluid theory, first developed in 1963, predict the dominant wavelengths observed in radar echoes, but fail to fully capture the behavior of saturated turbulence. Previous single-processor numerical simulations successfully modelled E-region FB turbulence but were limited to small domains and short time scales. In this work, we present a parallel simulation code able to model Farley-Buneman turbulence in the ionospheric E-region. This technique treats ions as macroparticles and electrons as an inertialess, quasi-neutral fluid subject to a static background magnetic field and an electrostatic potential. This approach requires solving an elliptic PDE that depends on plasma density, collision frequency, temperature, and ion flux. We use the Portable Extensible Toolkit for Scientific Computation (PETSc) to solve the resultant linear system on massively parallel supercomputers. This model has applications to instabilities in the E-region ionosphere, where collisionally demagnetized ions Pedersen drift in the direction of the background electric field while magnetized electrons Hall drift in the E x B direction. It also has potential applications to other collisional plasmas, such as those found throughout the ionospheric F-region and in the chromosphere of the Sun.

IRRI-10 Simultaneous detection of ionospheric perturbations using mid-latitude all-sky imagers and equatorial C/NOFS measurements - by Catherine Sullivan

Status of First Author: Student IN poster competition, Undergraduate

Authors: C. Sullivan, C. Martinis, R. Macinnis, W. Burke, R. Pfaff, M. Hairston

Abstract: In-situ data from the coupled ion neutral (CINDI) and vector electric field instrument (VEFI) onboard the Communication/Navigation Outage Forecasting System (C/NOFS) satellite are compared with 630.0 nm airglow data from all-sky imagers located outside the satellite's orbital path. The comparison is done by mapping the trajectory coordinates along magnetic field lines to the peak emission height of the 630.0 nm airglow. We present a study of medium scale travelling ionospheric disturbances (MSTIDs) and equatorial spread-F (ESF) in the American sector. Coincident variations in in-situ electric field, ion density,

and ground-based airglow measurements show similar behavior, an indication that perturbations are occurring along the entire field line, and that these type of comparisons can provide insight at mid-latitude locations along a field line where no measurements are available. A multi-night analysis of electric field perturbations shows a consistent picture for the presence of bright and dark bands associated with MSTIDs. ESF structures observed by magnetically conjugate all-sky imagers show differences that can be attributed to the presence of the South Atlantic Magnetic Anomaly. This study shows the importance of complementing remote sensing with in-situ observations of large scale structures at the equatorial ionosphere.

AMPERE-NEXT, draft prioritized back data purchase plans, and planned upgrades to AMPERE data and data products are also discussed.

Instrs or Techniques for Ionos or Thermos Obs

ITIT-01 Bistatic HF measurements of TIDs at White Sands, NM - by Eugene V. Dao

Status of First Author: Non-student, PhD

Authors: E. V. Dao

Abstract: The IARPA HFGeo program fielded several HF instruments at the White Sands Missile Range in New Mexico, for a week-long experiment in January, 2014. With a subset of the instruments (several spatially-spaced HF transmitters and a remote angle-of-arrival receiver system) and a novel bistatic technique, we were able to probe the bottom-side ionosphere with both spatial and temporal resolution. The bottom-side ionosphere was truly dynamic with the presence of Traveling Ionospheric Disturbances (TIDs) that we characterize in detail.

ITIT-02 Neutral Winds and Turbulence in the Lower Thermosphere as observed with Multi-Point, Chemical-Release Sounding Rocket Payloads - by Carl Andersen

Status of First Author: Student IN poster competition, Masters

Authors: Carl Anderson and Mark Conde

Abstract: Sounding rocket payloads capable of deploying multi-point chemical releases provide a unique tool for investigating the properties of the lower thermosphere. This type of payload consists of a collection of sub-payloads that are propelled laterally out of the rocket during flight. Each contains a canister of liquid tracer which, after separating from the main rocket, is dispersed by explosive detonation. The result is a luminous "puff" that can be tracked by triangulation using images taken from several ground stations, producing wind vector velocities with typical uncertainties of just 1-2 m/s. This technique can also be used to make observations regarding the turbulent and diffusive properties of this region of the atmosphere

ITIT-03 Exploiting Artificial Intelligence for Radio Data Selection on-board the Puerto Rico CubeSat - by Brett Isham

Status of First Author: Non-student, PhD

Authors: Brett Isham, Jan Bergman, Fredrik Bruhn, Peter Funk, Amilcar Rincon-Charris, Pedro Capo-Lugo, Lennart Ahlen, Arturs Stramkals

Abstract: The Puerto Rico CubeSat is a collaboration between Interamerican University of Puerto Rico, the University of Puerto Rico, the Ana G. Mendez University System (Puerto Rico), NASA Marshal Space

Flight Center (USA), the University of Alabama at Huntsville (USA), the Swedish Institute of Space Physics, and Malardalen University (Sweden).

Principle project goals include providing aerospace and systems engineering experiences to students at the participating institutions. Mission objectives include the acquisition of space weather data to aid in better understanding the Sun to Earth connection.

The Puerto Rico CubeSat is a 3U configuration, 10x10x30 cm. Active attitude control will be used to align the long (3U) axis along the orbital path, and the satellite will rotate along the 3U axis to assist in thermal management.

The Puerto Rico CubeSat will carry two scientific payloads, GimmeRF and CARLO. CARLO will measure low-frequency plasma turbulence, which affects radio propagation in the high-frequency radio band measured by GimmeRF. The orbit is anticipated to be about 400 km altitude, with undetermined inclination.

CubeSat missions are constrained by the limited resources provided by the platform. In particular, limited telemetry allocation remains a bottleneck. However, transmitting more data does not guarantee high value, since the value also depends on data quality. By exploiting fast on-board computing and efficient artificial intelligence (AI) algorithms for analysis and data selection, we plan to optimize the use of the telemetry link and increase the value of the Puerto Rico CubeSat mission. We hope that this project might point the way to the productive use of AI in space and other remote, low-data-bandwidth environments.

ITIT-04 HiT&MIS: Instrumentation for Auroral and Ionospheric Airglow Studies - by Saurav Aryal

Status of First Author: Student IN poster competition, PhD

Authors: Saurav Aryal(1) , Kuravi Hewawasam(1), Ryan Maguire(1), Supriya Chakrabarti(1), Timothy Cook(1), Jason Martel(1) and Jeffrey L Baumgardner(2), (1) University of Massachusetts Lowell, Lowell, MA, United States, (2)Boston University, Boston, MA, United States

Abstract: A High-Throughput Multi-slit Imaging Spectrograph (known as HiT&MIS) has been developed recently by our group.The spectrograph uses an echelle grating that operates at higher dispersion orders (about 28-43) such that extended sources for airglow and auroral emissions can be observed at high resolution (about 0.02 nm). By using four slits (instead of the conventional one slit setup), with the appropriate foreoptics it can image extended emission along a narrow field of view of about 0.1 X 50 degrees and has the capability to observe features located anywhere in the entire visible band. We have picked six prominent atmospheric emission lines (Hα: 656.3 nm, Hβ: 486.1 nm, O: 557.7 nm, O: 630.0 nm, O: 777.4 nm and N2+ : 427.8 nm) using order sorting interference filters at the entrance slits and a filter mosaic on an image plane. There is however the flexibility of observing other emission features by using different filter sets. Two spectrographs have been constructed and will be used for tomographic imaging of auroral phenomenon and observing airglow emission from different sites.

We will combine HiT&MIS data with data from other instruments such as LITES (Limb-imaging Ionospheric and Thermospheric Extreme-ultraviolet Spectrograph: on ISS), HiTIES (A High Throughput Imaging Echelle Spectrograph), HIRISE (HIgh Resolution Imaging Spectrograph using Echelle grating) and CHIMES (Continuous High-resolution Instrument for Multiwavelength Echelle Spectroscopy) as well as other ground based resources such as the GIRO (Global Ionospheric Radio Observatory) network, along with the 11 all-sky imagers operated by Boston University for a comprehensive understanding of upper atmospheric and ionospheric phenomena.

ITIT-05 Cubesat and ground-based instrumentation for TEC measurements at low latitudes - by Edgardo Pacheco

Status of First Author: Non-student, PhD

Authors: E.E. Pacheco, J.S. Chavez, F. Villanueva, C.E. Valladares, C. De La Jara, J. Ortiz, M. Milla

Abstract: CubeSat projects have a very high potential to contribute to the development of space science with the participation of a growing number of research centers, universities and scientific organizations. The objective of this project is the development of the first Peruvian satellite-borne instrumentation and a ground-based receiver for ionospheric studies. This space instrumentation will be utilized for the investigation of ionospheric variability and for the detection of plasma irregularities responsible for radio scintillations by measuring the total electron content (TEC). This parameter can be obtained by measuring the phase difference between radio frequency signals that propagate through the ionosphere. A dual frequency radio beacon system that will transmit the signals from space to the ground is being developed for low Earth orbit CubeSats as well as a ground-based receiver station that will be placed at a low latitude to detect signals from the satellite beacon. The receiver, based on a software-defined radio (SDR) system, will be used for the acquisition of the radio waves and digital signal processing will be applied to the measurements in order to obtain the TEC. We present a description of the systems design and the concept of a future scientific mission that will help to understand the generation and evolution of plasma irregularities at low latitudes. The resultant TEC measurements can provide useful information for modeling and specification of the ionosphere.

ITIT-06 Tackling Inverse Problems with Markov Chain Radiative Transfer - by George Geddes

Status of First Author: Student IN poster competition, PhD

Authors: George Geddes, Supriya Chakrabarti, Tim Cook

Abstract: Emission profiles of the resonantly scattered O-II 83.4 nm triplet can in principle be used to estimate electron density profiles in the F2 region of the ionosphere. Given the emission source profile, solution of this inverse problem is possible, but requires significant computation. The traditional feautrier solution to the radiative transfer problem requires many iterations to solve and is time-consuming to compute. A markov chain approach to the problem produces similar results simply by constructing a matrix. The approach presented here yields faster results and therefore can be used to perform the inversion with higher resolution of ionospheric parameters than would otherwise be possible.

ITIT-07 Initial results from HF radio wave propagation studies with ePOP - by Gareth William Perry

Status of First Author: Non-student, PhD

Authors: G.W. Perry, H. G. James, R. G. Gillies, G.C. Hussey, K. A. McWilliams, and A. W. Yau

Abstract: The enhanced Polar Outflow Probe (e-POP) is a suite of instruments onboard the CAScade, Smallsat and IOnospheric Polar Explorer (CASSIOPE) satellite launched into a 1500 km by 325 km elliptical polar orbit on September 29, 2013. One component of e-POP is the Radio Receiver Instrument (RRI) designed to study both artificially and naturally generated radio emissions in the 10 Hz to 18 MHz regime. One experimental objective of e-POP is to coordinate RRI with radars from the Super Dual Auroral Radar Network (SuperDARN) to study HF radio propagation and investigate the source of coherent backscatter in the ionosphere. We present initial results from these coordinated studies including evidence that SuperDARN radar beams can undergo significant lateral refraction in the auroral and high-latitude ionosphere. Furthermore, we demonstrate the feasibility of using the back lobe radiation from SuperDARN radars as a tool for ionospheric studies.

ITIT-08 Contemporary Auroral Tomography Techniques - by Michael Hirsch

Status of First Author: Student IN poster competition, Masters

Authors: Michael Hirsch and Joshua Semeter

Abstract: We discuss our approach to high spatial and temporal resolution auroral tomography, along with an exploration of the observation tradespace in time and space of ground-based observations. We discuss the modeling and processing effort relevant to answering science questions on small and large time scales via 100+ frame/second optical auroral observations. Tightly time synchronized observations from two or more sensitive cameras enables tomographic reconstruction using a first principles physical model yielding new insight into the fine dynamics of primary electron precipitation into the ionosphere down to the ten millisecond scale. The High Speed Tomography (HiST) rapidly redeployable instrument contributes to the global synoptic perspective by providing multi-year persistent observations with little user intervention needed due to our OpenCV-based algorithms. Transformative helioscience system observations over solar cycle scales requires systems that take a different approach to systems engineering than legacy systems that assumed frequent human interaction or maintenance. The techniques we use to study the fine scale spatio-temporal dynamics of the magnetospheric drivers of the aurora can be adapted to other instruments and meta-instruments studying magnetosphere-ionosphere coupling.

ITIT-09 Radiative Transfer Modeling of the OI 135.6-nm Emissions in the Nighttime Ionosphere - by Jianqi Qin

Status of First Author: Non-student, PhD

Authors: Jianqi Qin, Jonathan J. Makela, Farzad Kamalabadi, and Rebort R. Meier

Abstract: Remote sensing of the nighttime OI 135.6-nm emissions has been widely used as one of the primary means for quantifying F-region ionospheric plasma parameters. However, an inversion algorithm that properly accounts for the multiple production mechanisms as well as radiative transfer effects on the 135.6-nm emissions is yet to be developed. In this work, we first develop a forward model to numerically simulate the transport of the OI 135.6-nm emissions produced by radiative recombination and mutual neutralization in the nighttime ionosphere. The forward modeling results indicate that under certain conditions mutual neutralization can contribute up to a factor of 0.6 as much as those from radiative recombination to the nighttime OI 135.6-nm emissions. Moreover, resonant scattering by atomic oxygen and pure absorption by oxygen molecules can reduce the brightness observed by satellite-borne spectrometers in the limb direction while enhancing the brightness in the nadir direction by ~25%. Further analysis shows that without properly addressing these effects in the inversion process for the cases studied, the peak electron density in the F-region ionosphere can be overestimated by up to ~24%. For accurate retrieval of the ionospheric electron density, we develop an inverse model that accounts for the effects of mutual neutralization, resonant scattering, and pure absorption. This inversion method requires the densities of O and O2 to be known from the MSIS00 and IRI12 models in order to solve the radiative transfer equations. Modeling results demonstrate that the proposed inverse model can accurately retrieve the electron density if the true O and O2 densities are known. However, only ~1% error is introduced in the retrieved hmf2 and Nmf2 if we use O and O2 densities that are overestimated by 100% when compared to the true values.

ITIT-10 High Frequency Propagation Modeling results from Metal Oxide Space Cloud (MOSC) experiment - by Dev Joshi

Status of First Author: Student IN poster competition, Masters

Authors: Dev Joshi, Keith Groves, William McNeil, Ronald Caton, R. Todd Parris, Todd Pederson, Paul Cannon, Matthew Angling, Natasha Jackson-Booth

Abstract: The Air Force Research Laboratory (AFRL) launched two sounding rockets in the Kwajalein Atoll, Marshall Islands, in May 2013 known as the Metal Oxide Space Cloud (MOSC) experiment to study the interactions of artificial ionization and the background plasma. The rockets released samarium metal vapor in the lower F-region of the ionosphere that ionized forming a plasma cloud. A host of diagnostic instruments were used to probe and characterize the cloud including the ALTAIR incoherent scatter radar, multiple GPS and optical instruments, satellite radio beacons, and a dedicated network of high frequency (HF) radio links. Data from ALTAIR incoherent scatter radar and HF radio links have been analyzed to understand the impacts of the artificial ionization on radio wave propagation. During the first release the ionosphere was disturbed, rising rapidly and spread F formed within minutes after the release, while during the second release the ionosphere was canonically quiescent. Because the ambient environment was significantly less dynamic during the second release we were able to model the propagation results in a relatively straightforward manner. To address the disturbed conditions present during the first release we have developed a new method of assimilating oblique ionosonde data to generate the background ionosphere that can have numerous applications for HF systems. Observations and modeling confirm that the small amounts of ionized material injected in the lower-F region resulted in significant changes to the natural propagation environment.

ITIT-11 Ionospheric scattering observations using extended SuperDARN pulse sequences with multi-frequency Bayesian inference methods - by Jeff Spaleta

Status of First Author: Non-student, PhD

Authors: J. Spaleta, W. Bristow, J. Klein

Abstract: A new dual frequency Bayesian technique for generating real-time refractive index corrected Doppler velocities at the McMurdo radar was presented last year. The technique provides estimates of both true line of sight velocity, as well as an estimate of the plasma frequency in the scattering region. Subsequent investigation has found that the the previously reported estimated plasma frequency precision was limited by the available spectral information of the traditional 8-pulse SuperDARN pulse sequence. In order to better resolve plasma frequency estimates, a novel 16 pulse sequence was developed and employed at the McMurdo SuperDARN radar. The use of extended pulse sequence leads to much improved resolution of plasma frequency compared to the standard 8-pulse sequence, under the conditions that plasma velocities are large enough for the plasma index of refraction to have a noticeable change on measured Doppler velocity as a function of radar frequency. At velocities near zero, plasma frequency is effectively unresolved using this technique.

ITIT-12 Web-based radar controller system with 16 programmable output channels - by Jorge Ortiz

Status of First Author: Student IN poster competition, PhD

Authors: Jorge Ortiz, Joaquín Verástegui, Marco Milla

Abstract: Radars require specialized electronic systems to drive the output of their transmitter signals with high timing resolution. In addition, multiple signals for transmission, coding, and phase switching are needed to synchronize the radar with clocking systems and data acquisition devices. Often, each radar will use a fixed custom controller only for use in its specialized operation.

We present the Jicamarca Radar Controller v2.0 system, which combines an ethernet-based hardware platform with a web-based user interface. It has 16-programmable output channels, each of which can be configured as Tx drivers, codification, modulation and synchronization signals. It also implements a self-sensing module for visual display of the signal forms being driven on its outputs. The core logic resides in an FPGA, allowing changes and improvements to be reprogrammed in the field.

The results from its operation show an improvement in user-interface and immediate visual feedback on the shapes of the waves being configured for a radar experiment. The 16Mb DRAM memory for holding pulse train changes allows for high-resolution timing of pulses with long Inter-Pulse Periods (IPPs) for experiments on the troposphere, stratosphere, mesosphere, and ionosphere. It is currently in prototype phase at the Jicamarca Radio Observatory for multiple atmospheric experiments. The controller software runs on an internet browser and connects with a server through Gigabit Ethernet to automatically configure the device remotely. A display screen at the front of the device can show the current state of the programmed lines from its self-sensing module, and this information is replicated in the web interface for remote monitoring of experiments.

The Jicamarca Radar Controller v2.0 fills many of the needs of radar systems by using a modular approach and non-specialized hardware and software interfaces, while providing a robust software for experiment configuration.

ITIT-13 The Prototype Incoherent Scatter Radar System of Nanchang University, China - by Ming Yao

Status of First Author: Non-student, PhD

Authors: Ming Yao, Xiaohua Deng, Erhan Kudeki

Abstract: Incoherent scatter radar (ISR) is the only ground based instrument, which can detect space plasma parameters from tens to thousands of kilometers height above the earth. The Prototype Incoherent Scatter Radar System of Nanchang University, a versatile space detection radar, will be built by Nanchang University to detect the ionosphere over Sanya, Hainan Island, China. Software-defined radio (SDR)-based and active phased antenna array are the two most significant features of this radar system. It can probe real time plasma parameters in the altitude range of the low altitude ionosphere according to simulation. The novel ISR introduced in this paper has the advantages of low power and modularization. When properly configurated, this system can also carry out coherent scatter detection and wind profile detection. This paper will introduce the design of this software defined ISR prototype system.

ITIT-14 Improving geolocation of SuperDARN measurements using HAARP-induced backscatter - by Timothy Joseph Palinski

Status of First Author: Student IN poster competition, PhD

Authors: Timothy J. Palinski(1), Simon G. Shepherd(1), and William A. Bristow(2)
(1) Thayer School of Engineering, Dartmouth College
(2) Geophysical Institute, University of Alaska - Fairbanks

Abstract: The HAARP ionospheric heater located in Gakoka, Alaska provides an excellent opportunity to calibrate various geolocation techniques of SuperDARN backscatter for those radars with HAARP in their field of view. Using observations of HAARP-induced backscatter from radars in Kodiak, Alaska (kod) and Christmas Valley, Oregon (cvw), we compare geolocation techniques for the following propagation paths: 1/2-hop E and F-region (kod), and 1-1/2-hop and 2-1/2-hop F-region (cvw). A series of HAARP experiments conducted in April of 2014 form the basis of the present study. From these data, we demonstrate that model-based geolocation techniques are inadequate for multi-hop backscatter, resulting in errors as high as 500 km in the case of our standard virtual height model. However, by utilizing elevation angle of arrival measurements, we show significant improvement in the geolocation of multi-hop backscatter, reducing errors to within a typical range gate of 45 km for both 1-1/2-hop and 2-1/2-hop paths.

ITIT-15 Computing acceleration of ambiguity function estimation algorithms with GPU - by Weiwei Sun

Status of First Author: Student IN poster competition, PhD

Authors: Weiwei Sun, John D. Sahr

Abstract: We investigate several ways to evaluate the cross ambiguity function. In the past, we have used an algorithm which computes all Doppler shifts for a specific range. In this work we compare that algorithm to the dual algorithm, which computes all ranges for a specific Doppler shift. In both cases efforts to speed the computation with a coherent integration step are developed. This investigation will be applied to scenarios involving the detection of Auroral irregularties and aircraft, using both narrow bandwidth commercial FM and wide bandwidth digital TV broadcasts. Finally we will implement these algorithms on an nVidea Kepler K10 GPU, which is capable of 4500 GFlop in single precision.

With the "range first" algorithm our estimates show that the Auroral/FM cross ambiguity can be estimated with about 0.5 GFlop, and the Auroral/DTV can be estimated with about 1700 GFlop. On the other hand, the "doppler first" algorithm can estimate the Auroral/DTV cross ambiguity with approximately 20 GFlop --- an improvement by a factor of 100. We will show time and performance results for the several algorithms and scenarios to guide future development of detection and interferometry in passive radar systems.

ITIT-16 Seeking Lagrangian Coherent Structures in Ionospheric-Thermospheric Flows - by Ningchao Wang

Status of First Author: Student IN poster competition, PhD

Authors: Ningchao Wang, Seebany Datta-Barua, Dino Okic

Abstract: The ionosphere-thermosphere (IT) system interacts through energy exchange and transport by collisions, diffusion and advection. There are numerous techniques for analysis of the IT diffusion-advection interactions, based on modeling, measurements, and data assimilation.Recently, numerical techniques in fluid dynamical analysis has led to the understanding that Lagrangian Coherent Structures (LCS), invisible but material boundaries in time-varying flow field, can yield insight into transport processes.

In this work, we propose to apply the LCS analysis methods to IT models for the first time. Our objective is to explore whether there is a governing structure (i.e. LCS) to the flow in ionosphere and thermosphere, and what it may look like. In the longer term, this can lead to a better understanding of the dynamics and interaction of plasma and neutral constituents in the upper atmosphere. We first introduce the concept of the LCS and the mathematics underlying the computation of its location in a time-varying flow field. The finite time Lyapunov exponent (FTLE) is a scalar field over the flow domain whose regions of maxima define the LCS.

We use publicly available software, flowVC[1], to calculate the governing structure for test case flow fields: double-gyre[2], regular pendulum, and forced pendulum[3]. First, Matlab is used to generate velocity fields for each time stamp on a regular grid. These are provided as inputs to flowVC in binary format. Then flowVC is used to calculate the FTLE for the flow field, generating the output files in binary format. We applythe code bin2vtk[1] to convert the binary format into one usable by the open source data visualization software ParaView. We find and illustrate the LCS in the three sample flow fields for the forward time integration.

We show initial results applying this method to a 2-dimensional model of the thermosphere to study the flow field of the neutral wind. With the use of the Horizontal Wind Model 2014 (HWM14), the velocity datafor a single altitude is obtained. As with the example flow fields, flowVC is applied to the HWM14

wind fields to obtain the Lagrangian Coherent Structures. We will illustrate these in a first look at thermospheric LCS.

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ITIT-17 Is the long-term variation of the estimated GPS differential code biases associated with ionospheric variability? - by Jiahao Zhong

Status of First Author: Student IN poster competition, PhD

Authors: Jiahao Zhong, Jiuhou Lei, Xinan Yue, Xiankang Dou, Wenbin Wang, Bill Schreiner

Abstract: The Global Positioning System (GPS) differential code biases (DCB) provided by the International GNSS Service (IGS) show solar cycle like variation during 2002-2013. This study is to examine whether this variation of the GPS DCBs is associated with ionospheric variability. The GPS observations from low earth orbit (LEO) satellites including CHAMP, GRACE and Jason-1 are used to address this issue. The GPS DCBs estimated from the LEO-based observations at different orbit altitudes show a similar tendency as the IGS DCBs. However, this solar cycle like dependency is eliminated when the DCBs of 13 continuously operating GPS satellites are constrained to zero-mean. Our results thus revealed that ionospheric variation is not responsible for the long-term variation of the GPS DCBs. Instead, it is attributed to the GPS satellite replacement with different satellite types and the zero-mean condition imposed on all satellite DCBs. In addition, the receiver DCB will suffer the opposite long-term variation of the GPS DCB. After the long-term variation caused by the GPS satellite replacement is removed, the CHAMP DCB is found to be strongly dependent on the receiver temperature. This result suggests that the accuracy of LEO-based TEC can be significantly improved if the receiver temperature effect on the DCB estimation is considered.

ITIT-18 Plasma density wakes around CubeSats in the Earth's Ionosphere - by Robert Albarran

Status of First Author: Student NOT in poster competition, Masters

Authors: Robert M Albarran II and Aroh Barjatya

Abstract: Spinning or tumbling CubeSats with Langmuir probes deployed on booms will render spin-modulated plasma densities as the probes move in and out of the spacecraft wake. It is traditionally assumed that the lower density measurements from the spin-cycle are made in the spacecraft wake and the higher density measurements are outside the wake. Although this assumption is valid for larger spacecraft in the Earth's ionosphere, this paper scrutinizes its relevance for CubeSats in similar conditions. Spacecraft-plasma interactions- surface charging, plasma sheaths and wakes- are less understood for CubeSats and the small CubeSat dimensions must be considered with respect to characteristic length scales of the space plasma environment, namely, the Debye length. We use a spacecraft charging tool: SPIS, to investigate CubeSat interactions with the meso-thermal plasma environment. For ionospheric densities, the CubeSat dimensions of 10 cm is comparable to the sheath thickness. Our simulations show that under such circumstances, a negatively charged CubeSat in meso-thermal ionospheric conditions creates an ion focus region in the far-wake. An independently written, first principles code in MATLAB verifies that this feature is a direct result of the CubeSat behaving like a Langmuir probe in the thick-sheath model. The work performed in this paper cautions the community towards assuming CubeSats to have density

depletions in their wakes, and stresses the necessity of having an accurate attitude solution to derive ambient plasma densities from spin-modulated Langmuir probe measurements on CubeSats.

ITIT-19 Comparison of Gradient-Based GPS TEC Estimation with Arecibo and Jicamarca Incoherent Scatter Radar - by Harrison W Bourne

Status of First Author: Student NOT in poster competition, Undergraduate

Authors: Harrison W Bourne and Dr. Yu Morton

Abstract: This poster presents a comparison between TEC estimated using a spatial gradient based approach for dual frequency receivers and using two Incoherent Scatter Radars (ISRs), one at the National Astronomy and Ionosphere Center (NIAC) near Arecibo, Puerto Rico and another at the Jicamarca Radar Observatory (JRO) near Lima Peru. The purpose of this comparison is to verify the accuracy of the spatial gradient TEC estimation method in measuring the overall electron content and small fluctuations caused by ionospheric structures such as sporadic-E in the receiver viewing area. The paper compares the TEC estimated by our dual frequency GPS spatial gradient based method with TEC derived from ISR electron density profiles. The GPS and ISR data were collected simultaneously between March 25 and 27 2011 as well as January 23 and 26 2014 at NIAC using an array of four GPS receivers and from March 6 to March 11 2013 at JRO using a single GPS receiver.

ITIT-20 Field-Widened Spatial Heterodyne Spectroscopy: Calibration Techniques for Ha Airglow Observations - by Derek Gardner

Status of First Author: Student NOT in poster competition, Undergraduate

Authors: D. D. Gardner, E. J. Mierkiewicz, F. L. Roesler, J. M. Harlander, K. P. Jaehnig, S. M. Nossal, L. M. Haffner, J. W. Percival

Abstract: During 2013, a new, high resolution field-widened spatial heterodyne spectrometer (FW-SHS) uniquely designed to observe geocoronal Balmer-alpha emission ([Ha], 6563A) was installed at Pine Bluff Observatory (PBO) near Madison Wisconsin. FW-SHS observations were conducted to compare with an already well-characterized dual-etalon Fabry Perot Interferometer (FPI) optimized for [Ha], also at PBO. The FW-SHS is a robust new Fourier-transform instrument that combines a large throughput advantage with high spectral resolution and a relatively long spectral baseline (~ 10x that of the FPI) in a compact, versatile instrument with no moving parts. Coincident [Ha] observations by FW-SHS and FPI were obtained over similar integration times, resolving power (~80,000 at [Ha]) and field-of-view (1.8 and 1.4 degrees, respectively).

This poster describes the FW-SHS data analysis and reduction techniques, and resulting [Ha] observation results collected from observing nights across 2013 and 2014. Initial FW-SHS observations of Balmer-alpha intensity and temperature (doppler width) vs. viewing geometry (shadow altitude) show close agreement with the geocoronal theory and observations previously obtained at PBO by FPI. The FW-SHS is capable of determining geocoronal Balmer-alpha doppler shifts on the order of 100 m/s across a 640km/s [Ha] spectral bandpass, within a dynamic time scale on the order of minutes.

ITIT-21 Design and Gate Driver Verification for a CubeSat Time-of-Flight Reflectron Mass Spectrometer for Upper Atmosphere Composition Measurements - by Michelle Pyle

Status of First Author: Student NOT in poster competition, Masters

Authors: Michelle Pyle and Dr. Ryan Davidson

Abstract: Variations of gas density and composition in Earth's thermosphere and ionosphere are key indicators of interactions between different layers of Earth's atmosphere. The nature of interactions between neutral and ion species in the upper atmosphere is an active area of study in Heliophysics and there is much to learn about the dynamic relationship between the ionosphere and neutral thermosphere. Mass Spectrometers are among an array of instruments used to explore Earth's upper atmosphere and other space environments. Normally, these instruments are substantial in size and deployed on larger satellites. Data from these larger instruments generally provides information from a specific point in time at a single location. Studies of atmospheric density and composition with multiple locations for each time point could be performed by CubeSat swarms if proper instrumentation were available to fit CubeSat payload restrictions. The proposed miniaturized time-of-flight (TOF) mass spectrometer (MS) will have a mass resolution and range sufficient for measuring the composition of Earth's thermosphere and ionosphere while operating within the power and space constraints of a CubeSat. The capabilities of this instrument would potentially dramatically reduce the cost of future missions while simultaneously enhancing the science return. The design employs miniaturization of TOF-MS technology, including resolution refinement techniques used for larger instruments and standard concepts for TOF-MS components such as acceleration grids, a Bradbury-Nielsen wire gate, a gridless ion mirror, and microchannel plate detector. The open time of the instrument gate device has been shown to significantly degrade resolving power of the instrument. An electronic driver for a miniature Bradbury-Nielsen gate has been developed to operate at high voltages and reduce the gate open time.

ITIT-22 A Correlative Study of Ground-Based EMCCD Narrow-band Imaging and In-Situ Rocket Data - by Guy Alan Grubbs

Status of First Author: Student IN poster competition, Undergraduate

Authors: Guy Grubbs II, Marilia Samara, Robert Michell, Don Hampton

Abstract: The purpose of this research is to conduct a correlative study on the active aurora using ground-based measurements and in-situ sounding rocket data. The Ground-to-Rocket Electrodynamics-Electrons Correlative Experiment (GREECE) mission successfully launched from Poker Flat, Alaska on 03 March 2014 at 11:09:50 UT and reached an apogee of approximately 335 km during a luminous auroral event. Multiple ground-based electron-multiplying charge-coupled device (EMCCD) imagers were positioned at Venetie, Alaska and aimed along magnetic zenith in order to observe the brightness of different auroral emission lines (427.8, 557.7, and 844.6 nm with a 47 degree field of view) at the magnetic footpoint of the payload, near apogee. Emission line brightness data are correlated with electron characteristics measured by the GREECE on-board electron spectrometer. Ratios of different auroral emission lines are compared to previously published methods and models which predict electron energy distribution using ground-based multi-spectral imaging. This research aims to describe the auroral emissions produced from a known precipitating electron distribution, such that we can more accurately use ground-based imaging and photometry to infer the characteristics of the precipitating electrons. These techniques can then be applied over larger scales and longer times, when only multi-spectral imaging data are available with no corresponding in situ data.

ITIT-23 A Generalized Data Analysis Software Suite - by John Swoboda

Status of First Author: Student IN poster competition, PhD

Authors: John Swoboda, Anna Stuhlmacher, Andrew Lee, Joshua Semeter

Abstract: Many researchers in aeronomy work with date sets from my different types of sensors: radars, all sky cameras etc. Often though, researchers develop different sets of software for each of their sensors to analyze the data. These codebases often have a lot of functionality overlap which yields a large amount of seemingly unnecessary recoding. Another complication is also added data from different sensors need to be combined which requires time and spatial registration of the data.

We have developed a software codebase with the goal to answer the difficulty associated with analyzing data from multiple sensors. We have created a standard format which sensor data can be read into, at which the user has access to a library of different plotting, interpolation and analysis functions. This code base is composed of MATLAB and Python repositories that have the same functionality. There are also generalized outputs for data so it can be moved from language to language if multiple users are work together and use the different languages.

We will detail our software structure along with examples with data from multiple sources. The workflow will be detailed to show the intended use of the software and how new users can plug in their data. We will also give the address to the repositories so people can begin using the code.

It is our hope that this will help increase productivity of the various research communities that may use this. We also hope to find more collaborators to help develop this software suite further in order to add more functionality.

ITIT-24 Topside Ionospheric Plasma Temperatures Retrieved From FORMOSAT-3/COSMIC Observations - by Jack Chieh Wang

Status of First Author: Student NOT in poster competition, Masters

Authors: Jack C. Wang, Loren C. Chang, Jann-yenq Liu

Abstract: Bottom-side ionospheric electron profiles now can be well-determined thanks to mature development of ground-based instruments, such as ionosonde, or incoherent radar. However, the topside ionosphere, located above the F2 layer peak to the exobase (from 200~400 km to 600~1000km, depending on solar activity) is still not well understood. Previously, the electron density distribution and plasma temperatures in the topside ionosphere could only be measured by incoherent scatter radar, in-situ sounding rocket, or certain satellite instruments, making it hard to draw a global map of electron density and plasma temperatures in the topside ionosphere. FORMOSAT-3/ Constellation Observing System for Meteorology, Ionosphere, and Climate (F3/C) using the GPS radio occultation method (GPS-RO) now can give us great opportunities to determine the global electron density profiles above the F2 layer peak. We also present results showing how the plasma temperatures may be estimated from such GPS-RO observations. This study first examines the structure and variability of electron densities in topside ionosphere. Seasonal F3/C observations will first be assimilated into a gridded model in latitude, longitude, altitude, and local time. The resulting vertical profiles at each gridpoint will then be used to infer the vertical scale height of the topside ionosphere. Next, we retrieved the seasonal and local-time variabilities of topside plasma temperature from the scale height of topside ionospheric electron densities. This is one of the first times that topside plasma temperatures can be globally determined using remote sensing techniques.

ITIT-25 AMPERE-II Status and Plans - by Brian Jay Anderson

Status of First Author: Non-student, PhD

Authors: B.J. Anderson, H. Korth, R.J. Barnes, C.L. Waters

Abstract: Collection of magnetometer data from the 66 Iridium satellites resumed under NSF sponsorship through the Active Magnetosphere and Polar Electrodynamics Response Experiment-II (AMPERE-II) project. Data acquisition was halted at the end of May 2013 but resumed on 23 February 2015 and is planned to continue through September of 2019. Data were archived by Iridium for the June 2013 – February 2015 time frame and will be purchased during the course of AMPERE-II. The first back-data purchased are being prioritized by activity and community interest. Meanwhile, data have been acquired for the March 17-18, 2015 storm and for the activity in mid-May 2015 associated with a high-speed stream. AMPERE-II spans the transition of Iridium from the first generation of satellites to Iridium NEXT, with the first launches of new satellites scheduled for 2015. The Iridium NEXT satellites offer more than 2.5x higher continuous magnetic field sampling and more than 10x higher attitude knowledge. This should lead

to much improved baselines and better latitude resolution for global specification of global-scale polar electrodynamics. Examples of the continuation data, comparisons with performance expected for

Long Term Variations of the Ionosphere-Thermosphere

LTVI-01 Simulations of greenhouse gas influences on thermospheric atomic hydrogen - by Susan M. Nossal

Status of First Author: Non-student, PhD

Authors: Susan Nossal, Liying Qian, Stan C. Solomon, Alan G. Burns, Wenbin Wang

Abstract: Rises in both atmospheric carbon dioxide and methane are predicted to lead to increases in atomic hydrogen in the upper thermosphere. Geocoronal hydrogen is a byproduct of chemical and physical processes lower in the atmosphere that involved important radiative species such as methane and water vapor, and is more globally uniform than are hydrogen-containing species at lower altitudes. We will present results from simulations using the NCAR Global Mean Model to investigate mechanistically the effects of separately doubling carbon dioxide and methane to study the influence of temperature and source species changes on the hydrogen distribution. We also study the role of the solar cycle in the response of hydrogen. The solar cycle has a larger effect on both the modeled upper atmospheric temperature and hydrogen distribution than do sensitivity studies involving a doubling of greenhouse gases.

LTVI-02 A climatological analysis of Fabry-Perot derived thermospheric winds and temperatures from solar minimum to maximum - by Daniel James Fisher

Status of First Author: Student IN poster competition, Masters

Authors: Daniel J. Fisher, Jonathan J. Makela, John W. Meriwether, Ricardo A. Buriti, Zouhair Benkhaldoun, Mohamed Kaab, Amine Lagheryeb

Abstract: Several Fabry-Perot interferometers have been operating nearly continuously in Brazil since August 2009, the eastern United States since June 2011, and in Morocco since November 2013. They measure the Doppler shift and broadening of the 630.0-nm airglow emission from ~250-km altitude to deduce thermospheric winds and temperatures. We present a climatological analysis of these quiet-time parameters including estimated vertical winds. We also discuss the variation both in day-to-day measurements and over the solar cycle. These results show surprisingly little neutral wind dependence on solar cycle, while the temperature dependence on solar cycle is prominent. These results are of great import for validating thermospheric models, and also for dissecting wave and tidal features in the FPI data.

LTVI-03 Topside Ionospheric Response to Solar EUV Variability - by Jessica Marie Hawkins

Status of First Author: Student IN poster competition, Masters

Authors: Jessica Marie Hawkins and Phillip Charles Anderson

Abstract: We present an analysis of 23 years of thermal plasma measurements in the topside ionosphere from the DMSP spacecraft. The H+/O+ ratio and density vary dramatically with the solar cycle; cross-correlation coefficients between E10.7 and the daily averaged densities are greater than 0.85. The ionospheric parameters also vary dramatically with season, particularly at latitudes away from the equator where the solar zenith angle varies greatly with season. There are also 27-day solar rotation periodicities in the density, associated with periodicities in the directly-measured solar EUV flux. Empirical Orthogonal

Function (EOF) analysis captures over 95% of the variation in the density in the first two principal components. The first principal component (PC1) is clearly associated with the solar EUV while the second principal component (PC2) is clearly associated with the SZA variation. The magnitude of the variation of the response of the topside ionosphere to solar EUV variability is shown to be closely related to the ionospheric composition. This is interpreted as the result of the effect of composition on the scale height in the topside ionosphere and the "pivot effect" in which the variation in density near the F2 peak is amplified by a factor of e at an altitude a scale height above the F2 peak. When the topside ionosphere is H+ dominated during solar minimum, DMSP may be much less than a scale height above the F2 peak while during solar maximum , when it is O+ dominated, DMSP may be several scale heights above the F2 peak.

LTVI-04 Plasma Temperatures in the Topside Ionosphere - by Chih-Te Hsu

Status of First Author: Student IN poster competition, PhD

Authors: C. T. Hsu and R. A. Heelis

Abstract: In the topside ionosphere during the daytime, the thermal electrons are directly heated by photoelectron fluxes from the local and conjugate hemispheres. The heat is lost primarily through collisions with the ions, with the loss rate being dependent on the ion mass. Likewise the ions are heated by collisions with the electrons and lost primarily through conduction to lower altitudes. In this work we examine the ion and electron temperatures in the topside ionosphere during daytime observed by the DMSP F15 satellite. The variations of electron and ion temperature with plasma density and composition indicate how the heat is exchanged between the different constituent ions and role played by solar zenith angle.

LTVI-05 Solar, Magnetic and Ionospheriic Variability in Solar Cycles 19-21 - by Lucia Villanueva

Status of First Author: Student NOT in poster competition, PhD

Authors: Lucia Villanueva and Agustin Udias

Abstract: Long term predictions of HF radio communications frequencies has always been of key interest even now, when telecommunications has long evolved mainly towards satellite communications, allowing more frequent people inter connection in real time around the world. Those predictions, useful for planning purposes is critical nowadays, not only because the very well-known large variations of MUF and LUF, (Maximum and Lowest Usable Frequencies), closely related to Solar activity variations, but because the frequency of scintillation events, affecting satellite signals, are also dependent on solar cycle activity. Increasing interest lately is related to the lowest maximum of the last solar cycles, poorly predicted by most the official panel of experts for SC 24, when R12 arrived only to around 75. A very short maximum was predicted by a new method presented by authors in ESWW9, Brussels 2012.

The purpose of this work was to find the index that better predict foF2, the critical Frequency of F2 layer for Tortosa ionospheric Station, in Spain. This parameter directly related to MUF(0 km) in the prediction programs, could be improved if we found a new index instead R2. Which was commonly used in most of the ionospheric prediction programs as "Blue Deck", IONCAP, ICPAC, or CIELO (prediction program developed at Universidad Politecnica de Madrid).

In this poster we show results for solar cycles 19-21. The seasonal variation is clearly seen in the ionospheric indices T and MF2, not clear in the solar indices which only show yearly variability. The magnetic index Ap has not maximum in similar dates although it shows a very clear seasonal variation too. The amplitude of annual and seasonal variations are clearly dependent on the size of the solar activity, so they can be predicted, as we were able to show an Analog model for the ionospheric index MF2 only based on the R12 maximum (EGU 2013). We also present a block diagram of the process considered in the program named SUN, which has considered basic definitions as Julian day and leap years. The variability

is clearly seen using only the difference of the monthly means and the smooth monthly means in the plots, considering separated solar cycles.

The most important result of this work is to see the clear seasonal variation of foF2 quite similar to that observed in the MF2 index, so, this is the best index to model foF2 for Tortosa. The monthly mean and the smooth monthly variation were calculated using the daily values of magnetic index Ap and daily data of two solar indices, F10.7 and Ri, taking into account the same formula to calculate R12 in the SGD Bulletins (Coffey, 1996). The program for data processing was developed in C++ language. We acknowledge the WDCs and Tortosa Ebro Observatory for data availability, mainly Dr. L. F. Alberca and G. Sole.

MidLatitude Thermosphere or Ionosphere

MDIT-01 Midnight ionosphere collapse at Townsville and its relationship to the meridional neutral wind over a complete solar cycle - by Patrick Dandenault

Status of First Author: Student IN poster competition, PhD

Author: Patrick Dandenault

Abstract: Ionospheric F2 layer heights (hmF2) are sensitive to the motion of neutral winds along magnetic field lines. Techniques have been developed to derive the magnetic meridional component of neutral winds in the thermosphere using values of hmF2 derived from ionosonde measurements. This research describes an analysis of the "midnight collapse" phenomenon, a large drop in the F-layer peak height (hmF2), observed at Townsville over a full solar cycle. Townsville has the same geographic and geomagnetic characteristics as Arecibo, where multiple midnight collapse studies have previously been undertaken. 'Equivalent' neutral wind speeds are obtained from F2 layer heights that comprise both neutral wind and electric field contributions to changes in hmF2. The behavior of hmF2 and meridional neutral wind velocities are analyzed during the equinox periods for each year, where the effect of F region electric fields on the dynamics of the ionospheric plasma is expected to be insignificant. Equivalent neutral winds are being generated using a vast global ionosonde database of mid-latitude ionosonde measurements that spans the years 1961-1990 with the goal of developing a new empirical neutral wind model. In the database, there are nearly 100 ionosonde sites in the mid-latitudes and the wind values being generated at each site have a one-hour time resolution. This paper presents a comparison of the F2 layer heights and properties of derived equivalent neutral winds with other data and models.

MDIT-02 Sources and Characteristics of Medium Scale Traveling Ionospheric Disturbances Observed by a Longitudinally Distributed Chain of SuperDARN Radars Across the United States - by Nathaniel Anthony Frissell

Status of First Author: Student IN poster competition, PhD

Authors: Nathaniel A Frissell, Joseph B Baker, J. Michael Ruohoniemi, Andrew J Gerrard, Ethan S Miller, Mary Lou West

Abstract: Medium Scale Traveling Ionospheric Disturbances (MSTIDs) are wave-like perturbations of the F-region ionosphere with horizontal wavelengths on the order of 100-250 km and periods between ~15 - 60 min. In SuperDARN data, MSTID signatures are manifested as quasi-periodic enhancements of ground scatter power moving through the radar FOV. High latitude SuperDARN MSTIDs have been studied for many years and are generally attributed to atmospheric gravity waves (AGWs) launched by auroral sources.

Recent extension of the SuperDARN network to midlatitudes has revealed that MSTIDs are routinely observed at midlatitudes as well. Our previous research using the single radar in Blackstone (BKS),

Virginia found a primary MSTID propagation direction which suggests that high latitude activity is also the primary source of midlatitude MSTIDs. Although the primary source appears to be well north of the radar, it was still unclear whether auroral/space weather sources are in fact the primary driver. This study extends this research by surveying multiple midlatitude radars in Oregon (CVW and CVE), Kansas (FHW and FHW), and Virginia (BKS and WAL) during the SuperDARN MSTID seasons (November – April) of 2010 to the present. As in the previous BKS study, MSTIDs observed by all radars had typical wavelengths between 250 to 500 km and horizontal velocities between 100 and 250 m/s. In all radars, the dominant population of MSTIDs propagated in a southward direction, ranging from 135˚to 250˚geographic azimuth. The dominant southward direction suggests high latitude sources. However, no apparent correlation with solar wind, interplanetary magnetic field, auroral, or geomagnetic activity has been identified. Spectral analysis has shown that MSTID activity is strongest in November and December, and weakens from January through February. Additionally, periods of both strong and weak MSTID activity lasting on the order of 7 to 10 days spreading across the entire United States have been identified. These large-scale, multi-day events suggest MSTID activity may be driven by long lasting, quasi-global events rather than transient space weather phenomena.

MDIT-03 Observations of storm-time mid-latitude ion-neutral coupling using SuperDARN radars and NATION Fabry-Perot interferometers - by Pratik P. Joshi

Status of First Author: Student IN poster competition, Masters

Authors: P. P. Joshi*(1), J. B. H. Baker(1), J. M. Ruohoniemi (1), J. J. Makela (2), D. J. Fisher (2), B. J. Harding (2), N. A. Frissell (1) and E. G. Thomas (1)

Abstract: Ion-neutral interaction is known to be an important influence for driving ionospheric convection at high latitudes, particularly during the recovery phase of geomagnetic storms. However, at middle latitudes, the precise interplay between ions and neutrals is less understood, largely because of the paucity of measurements that have traditionally been available. In this work, we investigate mid-latitude ion-neutral coupling during the geomagnetic storm of October 2-3, 2013, using co-located measurements from SuperDARN radars and NATION Fabry-Perot Interferometers (FPIs). The timescales on which the coupling operates is analyzed using momentum exchange theory and time-lagged correlation analysis. During the main phase, we find the neutrals respond to the ion convection on a timescale of ~84 minutes, which is comparable to what might be observed at high latitudes, but significantly faster than what is expected from local ion-drag momentum forcing alone. This suggests other storm time-time influences are important for driving the neutrals during the main phase, such as Joule heating. During the late recovery phase, however, the neutrals were observed to drive the ions without any significant time delay, consistent with the so-called “neutral fly wheel effect” or disturbance dynamo.

MDIT-04 An Analysis of Topside Ionospheric Profiles from Alouette-1 Satellite During Solar Minimum - by Eunsol Kim

Status of First Author: Student IN poster competition, Masters

Authors: Eunsol Kim, Junseok Hong, Yong Ha Kim

Abstract: Alouette-1 satellite measured ionospheric profiles near 290° longitude from 1962 to 1972. We derived scale heights at 1000km from the profiles of low (20°S ~ 20°N) and middle (20° ~ 40°) geomagnetic latitudes. The data were concentrated on early 1960’s when solar activity was low so that we analyzed the data when low solar activity (F10.7<120) and low geomagnetic activity (Ap<12) condition. The scale heights are generally lower in the daytime than nighttime, as expected from the theory that solar EUV radiation produces ions in the F-region to cause steep topside profiles during the day, whereas ions are recombined with electrons resulting in slow gradient at night. We also find that the scale heights of mid-latitude profiles stay particularly small during daytime in June solstice. However, the scale heights show large day-to-day variations, implying that the ionospheric profiles at 1000 km are constantly changing

by vertical transport, rather than in diffusive equilibrium. We also derived transition heights between O+ and He+/H+, which show a clear minimum at dawn for low latitude profiles due to reducing O+ density at night. However, the transition heights of mid-latitude are lower during daytime in December solstice, contrary to a simple theory. The local time variation of electron densities at 1000 km resembles closely that of He, implying He+ dominance. To verify IRI-2012 model that has assimilated Alouette-1 profiles, we will present comparisons of scale heights, transition heights, and electron densities between Alouette-1 and IRI-2012 profiles.

MDIT-05 Evidence for a radiative recombination source of O 844.6 nm emission at mid-latitudes - by Lara Waldrop

Status of First Author: Student NOT in poster competition, PhD

Authors: Lara Waldrop, Elizabeth Geyerman, Robert Kerr, Nestor Aponte, and Michael Sulzer

Abstract: Photoelectron (PE) impact on ground-state O(3P) atoms is well known as a major source of twilight 844.6 nm emission in the mid-latitude thermosphere. Knowledge of the PE flux can be used to infer thermospheric oxygen density, [O], from photometric measurements of 844.6 nm airglow, provided that PE impact is the dominant process generating the observed emission. In this work, we present evidence that an alternative process, radiative recombination (RR) of O+ ions, can be a non-negligible source of 844.6 nm emission relative to PE impact at mid-latitudes, such that it must be taken into account in order to use this airglow emission for remote sensing of thermospheric [O]. During several spring observational campaigns at Arecibo Observatory using a tilting-filter photometer, significant 844.6 nm emission exceeding ~10 R is observed throughout the night. This emission is highly unlikely to arise from PE impact excitation, since PE generation requires solar illumination of either the local or geomagnetically conjugate thermosphere. Supporting evidence that RR is the responsible mechanism for the generation of the night-time emission is derived from coincident measurement of electron and O+ ion density and temperature by the Arecibo incoherent scatter radar.

MDIT-06 Experiment Design to Assess Ionospheric Perturbations During a Solar Eclipse - by Magdalina Moses

Status of First Author: Student NOT in poster competition, Undergraduate

Authors: Magdalina Moses, Gregory Earle, and Nathaniel Frissell

Abstract: On August 21, 2017 there will be a total solar eclipse over the United States traveling from Oregon to South Carolina. The objectives of this study are to determine what ionospheric changes we expect to observe during the eclipse, and to devise an experiment to make appropriate observations. Solar eclipses offer a way to make observations on the dependence of the ionospheric density on the sun's radiation. There are significant differences between the conditions during a solar eclipse and the conditions normally experienced at sunset and sunrise, including the east-west motion of the eclipse terminator, the speed of the transition, and the continued visibility of the corona throughout the eclipse interval. Taken together these factors imply that unique ionospheric responses to the eclipse may be expected. We expect to find that the eclipse will produce unique changes in the ionosphere's electric fields and Total Electron Content (TEC). Flux tube integrated effects may also be significant in an eclipse. Balloon experiments or remote sensing may offer promising ionospheric observation techniques for the 2017 eclipse.

Magnetosphere-Ionosphere-Thermosphere Coupling

MITC-01 Thermospheric wind impacts on ionospheric upflow and outflow - by Meghan Burleigh

Status of First Author: Student IN poster competition, Masters

Authors: Meghan Burleigh and Matthew Zettergren

Abstract: Significant amounts of ionospheric plasma can be transported to high altitudes in response to neutral winds, electron precipitation and frictional heating. At these high altitudes, transverse ion acceleration is thought to potentially give upflowing ions sufficient energy to outflow to the magnetosphere. This study examines the thermospheric wind regulation of ionospheric upflow and outflow with a focus on how the lower ionosphere dynamics feed source populations for transverse energization and determine the types, and amounts, of outflowing ions. Used here in this study is a multi-fluid ionospheric model, based on a modified 16-moment mathematical description, which consists of a set of equations describing the evolution of the mass, momentum, parallel and perpendicular energy of all species relevant to the E, F, and topside ionospheric regions. This model encapsulates the basic ionospheric upflow processes and transverse heating effects leading to ion outflow and is closed through an electrostatic treatment of the auroral currents while including an ad hoc resonant heating term to describe transverse energization. Using this model, the species response characteristics of lower ionosphere dynamics and transverse energization are examined focusing on the influence of thermospheric winds on ionospheric upflow and outflow to the magnetosphere.

MITC-02 Kinetic modeling of ionospheric frictional heating and O+ outflows - by Anthony Pritchard

Status of First Author: Student IN poster competition, Masters

Authors: Anthony Pritchard, Matthew Zettergren, Jean-Pierre St-Maurice

Abstract: At auroral latitudes of the ionosphere, convective DC electric fields in the E and F-region often cause strong frictional drift heating of ions, resulting in large field-aligned upflows that have significant temperature anisotropies and highly non-Maxwellian velocity distributions. Once elevated to the transition and collisionless regions, the heavy ions of these upflows have gyrofrequencies within the frequency range of electric wave field turbulence that is present in the topside ionosphere, which can result in strong transverse ion-cyclotron resonance heating and large field-aligned outflows to the magnetosphere. This process also leads to highly non-Maxwellian plasma conditions. The exact details of the plasma anisotropies associated with both the low altitude frictional heating and the high altitude wave heating are still not well known.

In order to accurately reproduce the expected auroral ion velocity distribution functions under conditions of strong electric fields, this study uses two independent Monte Carlo simulations. One model computes F-region upflow velocity distributions for O+, NO+, or N2+ due to DC field-induced frictional heating by using a detailed description of collisions with neutrals. The model is currently being made height-dependent by including the effects of vertical transport, changing collision rates, and ion-ion collisions at higher altitudes. A second model is used to examine wave heating at topside altitudes and above. This model uses a macroparticle guiding center tracing approach to produce ion velocity distributions of O+ outflows accelerated by BBELF wave fields. The model also includes the effects of field-aligned ambipolar electric fields self-consistently. These models are used to simulate upflowing and outflowing ion distribution functions in both the collisional and collisionless regimes and further illustrate the drift velocities, temperature anisotropies, heat fluxes, and stresses to be expected from strong electric field driving of the ionosphere.

MITC-03 Spatial and Energy Scale of Electron Microbursts observed by the FIREBIRD-II CubeSats - by Alexander Crew

Status of First Author: Non-student, PhD

Authors: Alexander Crew, Harlan Spence, Dave Klumpar, Bern Blake, and the FIREBIRD team

Abstract: Focused Investigations of Relativistic Electron Burst Intensity, Range, and Dynamics II (FIREBIRD-II) is an NSF CubeSat mission specifically designed to address key science questions about microbursts. Launched on January 31, 2015 it consists of a pair of identical 1.5U CubeSats, which measure electron microburst precipitation in low-Earth Orbit. Microbursts, which are short (~100ms) intense bursts of electron precipitation to the Earth's atmosphere, are one particular form of electron loss from the Earth's radiation belts and have often been associated with intense chorus wave activity. Each spacecraft carries a pair of solid state detectors to measure the precipitating electrons in 6 energy channels from 200 keV to 1 MeV in energy at 18.75 ms time resolution. We will present observations of microbursts observed simultaneously on both spacecraft as they separated to address the spatial scale of individual microburst events. Furthermore, we present measurements of the energy spectra of individual events over the entire observable energy range.

MITC-04 The Dynamics of the Ionospheric Convection Pattern - by Yun-Ju Chen

Status of First Author: Student IN poster competition, PhD

Authors: Y. J. Chen, R. A. Heelis and J. A. Cumnock

Abstract: Systematic observations of the high latitude ionospheric plasma motion reveal that when a two-cell convection pattern can be identified the interplanetray magnetic field (IMF) has a significant influence on the location of the convection reversal boundary. We present results from a study of data from the DMSP F13 and F15 satellites over the period from 2000 to 2007, that describe the location of the reversal boundary and how it is reconfigured by changes in By and Bz. The data suggest that changes in By and Bz are equally effective in producing reversal boundary motions and the boundary moves more prominently on the dawnside or duskside dependent on By. A further important insight of this study is that in general the boundary is not well described by a circle that is usually considered in an expanding/contracting polar cap paradigm.

MITC-05 The storm-time red line and fast oxygen: comparison of ground-based optical and space-based energetic neutral atom observations - by Brian J. Harding

Status of First Author: Student IN poster competition, Masters

Authors: Brian J. Harding, Jonathan J. Makela, Phil W. Valek, John W. Meriwether

Abstract: Recent observations by a network of ground-based interferometers suggest that the 630.0-nm red line airglow emission is sensitive to particle precipitation at midlatitudes. Our hypothesis is that precipitating oxygen ions undergo charge-exchange collisions with neutral atoms, creating fast oxygen. Red-line photons emitted from these fast oxygen atoms contaminate the nominal red-line spectrum and complicate the extraction of thermospheric wind and temperature during geomagnetic storms; however, they may also constitute a phenomenon that can be used to monitor inner magnetospheric conditions from the ground. To test our hypothesis, we compare ground-based observations from the North American Thermosphere Ionosphere Observation Network (NATION) of Fabry-Perot interferometers with space-based observations from Two Wide-angle Imaging Neutral-atom Spectrometers (TWINS).

MITC-06 Characterizing high-latitude Joule heating in terms of the variance in PFISR electric fields - by Lucas Hurd

Status of First Author: Student IN poster competition, Masters

Authors: Hurd, L. D. and M. F. Larsen

Abstract: Previous radar experiments have shown that fluctuations in the electric field can contribute significantly to the net Joule heating in the high-latitude regions, however, these studies have been limited to studying these fluctuations on scales of several hundred kilometers and the extent of the effects on the heating with regards to activity level has yet to be determined. We present several cases from the PFISR Ion Neutral Observations in the Thermosphere (PINOT) campaign characterizing the heating effects due to variance in the electric field on a variety of spatial and temporal scales in moderate and active geomagnetic conditions both inside and outside the auroral oval over the Alaskan sector. The Poker Flat Incoherent Scatter Radar (PFISR) was used to sample the E-region electric field every 3 minutes for several hours with spatially resolved measurements every 0.25 degrees of latitude in the radar field-of-view. The power spectral density was calculated applying the Hanning window function over 1 hour interval subsets within the measurements – i.e., 20 discrete data points. As expected, the heating is strongest during active conditions, however, we show that including the variance derived from the power spectra in the Joule heating calculation during moderate activity (Kp < 4) can result in as much as a factor of two increase in the height-integrated heating compared against only considering the mean or instantaneous electric field, which agrees with previous theoretical studies. Moreover, we further define small-scale variance to be frequencies corresponding to structure in the time domain on scales of less than 20 minutes that contribute to the total signal power and show that these small-scale variations are a non-negligible consideration in the heating calculations, implying more resolved measurements may result in higher heating values overall. Specifically, the small-scale variance seems most important during negative bays in the H-component of the magnetic field during active conditions (Kp > 6).

MITC-07 Precipitation Effects Joule Heating and Neutral Densities of the Polar Ionosphere- by Joseph B. Jensen

Status of First Author: Student IN poster competition, PhD

Authors: Joseph B. Jensen and Jimmy Raeder

Abstract: Using the coupled OpenGGCM-CTIM model an analysis is made of the precipitation effects on joule heating and neutral densities in the polar ionosphere-thermosphere system. The advantages of using a magnetosphere model to constrain the upper ionosphere with the potential and precipitation flux are discussed. To gain a greater understanding of the effects of precipitation on the polar ionosphere, we ran two simulations with the effects of precipitation turned on and off. Comparisons are made of the altitude dependence of the current systems, joule heating, and neutral densities of the polar ionosphere-thermosphere system.

MITC-08 Self-Consistent Ring Current-Ionosphere/Thermosphere Coupling: Initial Results - by Nick Perlongo

Status of First Author: Student IN poster competition, PhD

Authors: Nick Perlongo, Aaron Ridley, Michael Liemohn, Roxanne Katus

Abstract: The ring current heavily influences the morphology of the ionosphere, especially during storm time. Potentially resulting features such as sub-auroral polarization streams (SAPS) and storm-enhanced densities (SEDs) can create radio scintillation and enhance satellite drag. In this study, two new couplings were created. The first between the hot electron ion drift integrator (HEIDI) and the global thermosphere-ionosphere model (GITM), and in the second a self-consistent auroral model was developed in HEIDI. HEIDI was then used to drive GITM for two different storms. Initial results of total electron content (TEC), ion velocities/temperatures, and electric fields are shown. The results are compared with GPS and incoherent scatter radar data. GITM simulations driven by HEIDI with an old auroral model as well Weimer potentials/hemispheric power are also compared and contrasted.

MITC-09 Microburt Spatio-Temporal Morphology and the Electron Energy Distribution Measurments using the FIREBIRD II Spacecraft - by Mykhaylo Shumko

Status of First Author: Student IN poster competition, PhD

Authors: M.S. Shumko, D. M. Klumpar, H. E. Spence, A. B. Crew, B. A. Larsen, and J. B. Blake

Abstract: The FIREBIRD-II (Focused Intensity Focused Investigations of Relativistic Electron Burst Intensity, Range, and Dynamics) mission is presently exploring the consequences of complex interactions deep in the Earth's radiation belts that result in significant loss of stably trapped energetic electrons. The primary signatures that FIREBIRD observes from ~500 km altitude in low earth orbit are sporadic and sudden bursts of Van Allen Belt electrons precipitating into the upper atmosphere. While such electron microbursts have directly been observed by previous satellites, and the Bremsstrahlung X-rays they produce have been observed by high altitude balloons, their spatio-temporal morphology and the electron energy distributions within individual events has not been characterized. By measuring these characteristics, some of the causative mechanisms that have been proposed will be eliminated and further theoretical refinements on others will be enabled. The FIREBIRD investigation uses a pair of identically instrumented 1.5 U CubeSats, flying in a high inclination leader-follower configuration to make first-ever dual satellite measurements of the spatial and temporal dimensions of microbursts. Microbursts have been observed from the two satellites, launched on January 31, 2015, at inter-satellite separations as close as 10 km. The particle detector system on each satellite consists of two sensor elements with complementary geometric factors to extend the dynamic range. Each of the detector elements measures electrons in six energy channels between 200 keV and 1 MeV. This presentation will describe the FIREBIRD investigation and present an analysis of early results on the spatial scale of microbursts and their energy dependence. The FIREBIRD mission has been supported by the National Science Foundation and builds upon a strong heritage of small satellite development and mission operations at Montana State University and energetic particle instrument development at The University of New Hampshire, with collaborators at The Aerospace Corporation and the Los Alamos National Laboratory.

MITC-10 Conjugate space-based and ground-based observations of energetic electrons during substorms - by Nithin Sivadas

Status of First Author: Student IN poster competition, Masters

Authors: Nithin Sivadas and Joshua Semeter

Abstract: The visible aurora is an indicator of ionization caused by precipitating charged particles from the magnetosphere. Sudden brightening of the nightside auroral arc is observed during the expansion phase of substorms. The electrons responsible for the aurora are mostly thought to originate from within the plasmasheet. Recent observations made using Poker Flat Incoherent Scatter Radar (PFISR) during the poleward expansion of an auroral substorm indicate precipitation of energetic electrons greater than 300 keV. Magnetically conjugate THEMIS measurements confirm changes in the plasmasheet thickness during this period. Our observations suggest that there is more to be understood about the link between magnetotail dynamics and energetic electron precipitation during substorms. Understanding this link may open up a novel and potentially invaluable way of diagnosing the magnetosphere from the ground.

MITC-11 Event Detection Methods for Lightning-Induced Electron Precipitation using FIREBIRD-II - by Austin Sousa

Status of First Author: Student IN poster competition, PhD

Authors: Austin Sousa, Alexander Crew, Robert Marshall, Sigrid Close

Abstract: Lightning-induced Electron Precipitation (LEP) is thought to be a major loss function in the Earth's electron belts. VLF (~3-30kHz) whistler-mode waves can coherently interact with radiation belt electrons ~100 keV - 1 MeV, altering their pitch angles, and thereby scattering electrons to and modifying their mirror altitudes; when scattered to a low enough altitude, electrons can be removed from the magnetosphere by collisions with ionospheric constituents. Lightning provides a natural, constantly-occurring source of VLF whistler-mode waves.

The FIREBIRD-II mission consists of a pair of cubesats, each with two electron spectrometers, spanning energies from 250 kev to 1 Mev. Originally designed to study spatial variation of outer-belt microbursts, FIREBIRD-II provides a suitable platform to study LEP. FIREBIRD-II provides high time resolution (18.75 ms) and energy resolution (6 logarithmically spaced channels) at the expense of reduced data availability necessitating a robust scheme for identifying periods of interest.

In this work we use an end-to-end numerical simulation of LEP to map lightning strokes to a most-likely precipitation location. We incorporate lightning intensity and location data from the GLD360 sensor network to optimize event selection in order to download data over FIREBIRD's low-bandwidth downlink. Ultimately, FIREBIRD data will provide one-to-one correlative measurements of a lightning stroke and subsequent precipitation. We will use FIREBIRD measurements of LEP to determine the direct relationship between lightning intensity, measured by GLD360, and precipitated electron flux, in order to better quantify the global effect of lightning on the radiation belts.

MITC-12 The solar wind-polar cap open field interaction - by Kevin Urban

Status of First Author: Student IN poster competition, PhD

Authors: Kevin Urban, Andrew Gerrard, Louis Lanzerotti

Abstract: Over the past decade it has been shown the ULF waves in the solar wind can drive related oscillations in the magnetosphere, where such wave activity can be detected within geosynchronous orbit and even on the ground. However, due to a lack of data from the deep polar cap, similar studies relating solar wind ULF and ground-based observed ULF waves is lacking. Given recent observations of very large Joule Heating estimates from DMSP, along with large heating observed by the CHAMP satellite, it is natural to question the degree that such solar wind ULFs can directly cause such heating. In this paper we address this correspondence through use of high-latitude fluxgate magnetometers (up to 86 degrees magnetic latitude, as part of the Automatic Geophysical Observatory program) and solar wind plasma and magnetic field data provided by ACE. We illustrate how the solar wind directly drives both the mean polar cap open field and ULF activity along open field lines during a ~50-day geomagnetically quiet period followed by ~15 days of very intense geomagnetic activity.

MITC-13 Locating the source of short-duration pulsating aurora - by Jason Ahrns

Status of First Author: Student NOT in poster competition, Undergraduate

Authors: Jason Ahrns and Donald L. Hampton

Abstract: Motivated by observations of very short duration (~30ms) pulsating aurora, a time-of-flight calculation and energy transport model is developed to locate the source of the auroral modulation using population dispersion.

MITC-14 Investigating the Non-Maxwellian Ion Velocity Distribution via RISR - by Hassanali Akbari**Status of First Author: Student NOT in poster competition, PhD**

Authors: Hassanali Akbari and Joshua Semeter

Abstract: Incoherent scatter radars (ISRs) measure the frequency spectrum of the scattered signal from random thermal fluctuations in the ionospheric plasma. Once fitted to a theoretical model, the shape of the spectrum provides estimates to a number of plasma parameters. The theoretical models of the frequency spectrum of the scattered signal have been often developed based on a set of assumptions on the state of the plasma. One of the most common assumptions is that the plasma is in thermal equilibrium consisting of electron and ion populations that can be described by Maxwellian distributions. Such assumptions, however, are commonly violated at high latitudes where interactions between the ionosphere and the magnetosphere result in a very dynamic plasma environment.
One example of such violations occurs on the edge of auroral arcs when the presence of strong electric fields (<= 100 mV/m) drives the ions through the neural particles and the collisions between the two species cause the ion velocity distribution to deviate from Maxwellian. In such cases the assumption of thermal equilibrium in the standard ISR fitting procedure results in significant errors in derivation of the plasma parameters. In this study using measurements from the Resolute Bay incoherent scatter radar (RISR) we investigate the ISR spectral anomalies due to the non-Maxwellian ion distribution and investigate the level of error in estimating the plasma parameters that arises due to the wrong imposed assumption.

MITC-15 Search for Drivers of Cusp Alfven Waves and Ion Outflow - by Spencer Hatch

Status of First Author: Student NOT in poster competition, Undergraduate

Authors: Spencer Hatch and Jim LaBelle

Abstract: It is well known that the cusp region of the terrestrial magnetic field is regularly the site of intense outflow of ions, and it is likely that several mechanisms, separately and in concert, drive these outflows. Among these mechanisms, dispersive Alfvèn waves have been confirmed by observation and simulation to be directly connected with intense ion outflow, energy deposition, and broadband electron precipitation. A recent global-scale MHD simulation has predicted two distinct and spatially separate signatures of electron precipitation in the cusp region when the interplanetary magnetic field is strongly duskward or dawnward. One signature is primarily characterized by direct-entry electron precipitation, and the other by broadband precipitation. The difference appears to be the result of an asymmetric response in Alfvènic Poynting flux and electron precipitation to predominantly dawnward or duskward IMF. We have tested this prediction using a large database of over 237,000 Alfvènic field-aligned currents (FACs) derived from FAST satellite observations. Our current analysis suggests that Alfvènic activity is enhanced in a direction opposite that of the prevailing By component of the IMF. The Alfvénic FAC database also shows promise for examining the Alfvénic response to storm conditions. We present some preliminary results here.

Planetary Studies

PLAN-01 Monostatic and Bistatic Delay Doppler Imaging of the Moon – by Saiveena Kesaraju

Status of First Author: Student IN poster competition, PhD

Authors: Saivenna Kesaraju, J. D. Mathews, Juha Vierinen

Abstract: Imaging results from monostatic and bistatic radar observations of the Moon made at a wavelength of 68 cm (440.2 MHz) with the Millstone MISA radar transceiving and the Arecibo Gregorian system receiving are presented. These images were generated so as to calibrate both the HPLA (High-

Power Large Aperture) systems while simultaneous tracking the respective sub-radar points on the Moon. The Delay-Doppler mapping technique along with appropriate Ephemeris data from JPL Horizons (http://ssd.jpl.nasa.gov/?horizons) system was used to confirm target tracking, time alignment of the bistatic observations, target motion compensation, relative and absolute delays, and to generate the high-resolution, focused radar images of the Moon. Both the Millstone monostatic and the Millstone-Arecibo bistatic images have the same resolution of 150m along the range/delay direction and of 0.083 Hz resolution along the Doppler direction. Generation of the two images demonstrates a wide range of physical phenomena associated with the observations along with some advanced signal processing techniques.

Polar Aeronomy

POLA-01 The C-REX Sounding Rocket Mission - by Mark Conde

Status of First Author: Non-student, PhD

Authors: Mark Conde, Miguel Larsen, Don Hampton, Manbharat Dhadly, Jason Ahrns, Anasuya Aruliah, Yoshihiro Kakinami, Barret Barker, Andrew Kiene, Fred Sigernes, Dag Lorentze

Abstract: For reasons that are not well understood, there are permanent enhancements in the neutral mass density in Earth's thermosphere in the vicinity of the northern and southern geomagnetic cusps, and at altitudes of around 400 km. Such enhancements are expected to cause small but important and currently unpredictable perturbations to the orbits of spacecraft flying through them. Here we report on a NASA sounding rocket mission to study mechanisms responsible for establishing and maintaining these enhancements. On November 24, 2014, a Black-Brant 12 sounding rocket was launched from Andoya Space Center out over the Greenland Sea, and into the enhancement region associated with the ionospheric footprint of the northern geomagnetic cusp. It released ten rocket-propelled "grenades" that dispersed barium strontium tracer clouds into the thermosphere throughout a 3D volume extending over many tens of km around the main trajectory, and spanning heights from 190 to 400 km. Subsequent motions of the ionized barium and neutral barium/strontium components of the clouds were determined by photographic triangulation, using cameras based at Longyearbyen, Ny-Alesund, and aboard a NASA aircraft flying just south of Svalbard. Initial results of this analysis will be presented, and the implications for the mechanism(s) responsible for the density anomaly will be discussed.

POLA-02 Dependence of High Latitude Upper Atmospheric Horizontal Winds, Vertical Winds, and Temperatures on Geospace Conditions and Orientation of Interplanetary Magnetic Field - by Manbharat Singh Dhadly

Status of First Author: Student IN poster competition, PhD

Authors: Manbharat Singh Dhadly, Mark Conde, Donald Hampton

Abstract: We analyzed the climatological behavior of horizontal winds, vertical winds, and temperatures above Alaska using line-of-sight Doppler shifts of 630nm optical emission, which originates from atomic oxygen in Earth’s thermosphere at around 240 km altitude. Spectra of this emission were recorded over a wide geographic region above Poker Flat, Alaska (65.12N, 147.47W) using a ground based all-sky wavelength scanning Doppler Fabry-Perot interferometer (SDI). This wide field was divided (in software) into multiple zones (115 used here), allowing independent spectra to be sampled from many directions simultaneously. As a result, it is capable of recording the wind field’s time history over a wide geographic region with high spatial resolution. Although such climatological studies have been performed previously using satellites, models, and narrow field Fabry-Perot interferometers, there are no published climatological studies of thermospheric winds and temperatures using either SDI data or any other technique with comparable geographic coverage and resolution. Wind summary dial plots were produced to depict the climatology of the horizontal winds and temperatures for different geomagnetic conditions and orientation

of interplanetary magnetic field (IMF). Results show that horizontal winds and temperatures had a strong dependence on geospace activity; and a small but detectable dependence on orientation of IMF. The latitudinal shears in horizontal winds were stronger when geospace conditions were active compared to the latitudinal shears for quiet geospace conditions. Also, shears appeared earlier over Poker Flat when geospace conditions were active. The vertical winds were observed to be strongly dependent on the geospace and dawn-dusk component of IMF. The vertical winds showed very small dependence on the north-south component of IMF.

POLA-03 Spatial-temporal structure and plasma feature of polar cap patches - RISR observations - by Jun Liang

Status of First Author: Non-student, PhD

Authors: Jun Liang, Qinghe Zhang, Eric Donovan, Emma Spanswick, and Darren Chaddock

Abstract: Polar cap patches are islands of high-density ionospheric plasma surrounded by relatively low-density ambient plasma. They usually originate near the dayside cusp and convect across the pole from day to night. In this study, we report the observations of an interval of repetitively occurring, intense polar cap patches during a major storm interval on February 27, 2014. By using Resolute Bay Incoherent Scatter Radar (RISR) measurements, we are able to investigate the spatial-temporal structures of those polar cap patches as well as the plasma parameters (the EXB flow, ion/electron temperatures, etc.) associated with the patches in an unprecedented detail. We find that: (a) the polar cap patches exist dominantly in the upper F-region, and their altitude profile can roughly maintain throughout the passage of the patches over the field-of-view of RISR. (b) Each patch occurs in conjunction with a moderate poleward flow burst, and the motion of the patch is consistent with the local convective plasma flow. (c) There is an anti-correlation between the high-density patch and the decrease of the electron temperature, i.e., the electron temperature within the patch is distinctly lower than that of the ambient ionosphere. More interestingly, the electron temperature is much higher than the ion temperature in the absence of the patch, yet inside the patch they become fairly comparable. This is further corroborated by a comparison between two DMSP passages in the presence and in the absence of the patch, respectively. Based upon the above salient features, we further explore the potential generation mechanism and plasma dynamics associated with the polar cap patch.

POLA-04 Dual radar investigation of E region plasma waves in the southern polar cap - by Victoriya Forsythe

Status of First Author: Student IN poster competition, PhD

Authors: V.V. Forsythe, R.A. Makarevich

Abstract: Origins and characteristics of small-scale plasma irregularities in the polar ionosphere are investigated using a dual radar setup in which E region is probed from two opposite directions. The two Super Dual Auroral Radar Network (SuperDARN) facilities at the McMurdo and Dome Concordia Antarctic stations operating concurrently since January 2013 enable a greater opportunity to differentiate between causes of variations in irregularity characteristics as compared with a single-radar setup. Detailed comparisons between irregularity velocities reveal presence of two important cases. In certain intervals, strong agreement is observed when velocities are compared at the same physical locations, i.e. at radar ranges that are conjugate to each other (a case of a conjugate-range agreement). Such an agreement is widely expected if velocity at a given location is controlled largely by the convection electric field. In other cases, however, agreement is observed when measurements are considered at the same range for both radars (a case of an actual-range agreement). This implies that it is not the electric field at a given location that is the dominant factor in this case. The conjugate (actual) agreement is seen when echo band is wide (narrow) in range and located further away from (closer to) each radar. Actual-range agreement may be explained for certain E-region density conditions when an inclined irregularity layer is produced in which irregularity altitude increases with radar range. Presented analysis of dual radar observations in the polar

cap provide further insight into relative importance of variations in altitude and convection in controlling E region irregularity characteristics.

POLA-05 Phase Scintillation and TEC from a Latitude Chain of GPS Receivers in Alaska- by Irfan Azeem

Status of First Author: Non-student, PhD

Authors: Irfan Azeem, Geoff Crowley, Adam Reynolds, and Patrick McBride

Abstract: In this paper, we present recent results from a latitudinally extended array of GPS receivers measuring ionospheric scintillation in Alaska. The receivers were deployed at sites in Kaktovik (70.1° N, 143.6° W), Toolik (68.6° N, 149.6° W), Fort Yukon (66.6° N, 145.2° W), Poker Flat (65.1° N, 147.4° W), Eagle (64.8° N, 141.2° W), and Gakona (62.4° N, 145.2° W). The phase scintillation database analyzed covers November 9, 2012 to Jan 31, 2015. We present comparisons of phase scintillation measurements from the GPS array and auroral emissions from an All-Sky Imager (ASI) and a Meridian Spectrograph at Poker Flat to characterize the correspondence between scintillation and auroral features. Results from November 13, 2012 and November 20, 2012 show a strong correlation with 630.0 nm auroral emissions indicating F-region irregularities may be a source of scintillations. Utilizing the ASI data, we also demonstrate the localized nature of the night-time phase scintillation. In this paper we demonstrate our ability to map scintillation in real-time, and to provide space weather services to GPS users. We present results from a statistical analysis of multi-year phase scintillation data from the chain and show that the severity of phase scintillation decreases with decreasing latitude, and the largest phase scintillations occur near magnetic midnight. We also present the scintillation frequency distribution statistics from the GPS chain in Alaska to highlight the differences in temporal variations of low, moderate, and severe scintillation events. The results show that weak scintillation events show a diurnal variation with a well-defined minimum near 0000 MLT while moderate and strong scintillations both have Gaussian distributions with peaks near the midnight sector.

POLA-06 Swarm in situ observations of F-region polar cap patches created by cusp precipitation - by Lindsay Victoria Goodwin

Status of First Author: Student IN poster competition, Masters

Authors: L. Goodwin, B. Iserhienrhien, D. M. Miles, S. Patra, C. van der Meeren, S. C. Buchert, J. Burchill, L. B. N. Clausen, D. J. Knudsen, K. A. McWilliams, and J. Moen.

Abstract: High-resolution in situ measurements from the three Swarm spacecraft, in a string-of-pearls configuration, provide new insights about the combined role of flow channel events and particle impact ionization in creating F-region electron density structures in the northern Scandinavian dayside cusp. We present a case of polar cap patch formation where a reconnection-driven low-density relative westward flow channel is eroding the dayside solar-ionized plasma but where particle impact ionization in the cusp dominates the initial plasma structuring. In the cusp, density features are observed which are twice as dense as the solar-ionized background. These features then follow the polar cap convection and become less structured and lower in amplitude. These are the first in situ observations tracking polar cap patch evolution from creation by plasma transport and enhancement by cusp precipitation, through entrainment in the polar cap flow and relaxation into smooth patches as they approach the nightside auroral oval.

POLA-07 Altitude-power simulations of enhanced 427.8 nm wavelength airglow observed during ionosphere HF-modification experiments at HAARP and EISCAT - by Christopher Fallen

Status of First Author: Non-student, PhD

Authors: C. T. Fallen and B. J. Watkins

Abstract: Thermosphere airglow with 427.8 nm wavelength is observed during aurora and may be used as a ground-based diagnostic for estimating precipitating electron energy flux. High-power high-frequency (HF) radio transmissions from the High-frequency Active Auroral Research Program (HAARP) facility in Alaska and the European Incoherent Scatter Scientific Association (EISCAT) facility in Norway have also induced thermospheric 427.8 nm airglow. The 427.8 nm airglow emission occurs during the allowed (fast) transition from excited N2+(B) ion to ground electronic states. Impact ionization of N2 molecules by energetic electrons is a significant source of N2+(B) ions during aurora and is generally assumed to be the sole mechanism responsible for artificial HF-enhanced 427.8 nm airglow.

However, other competing mechanisms cannot necessarily be summarily rejected because measured artificial 427.8 nm airglow intensities are small -- less than 20 R -- and no direct simultaneous measurements of HF-accelerated electron energy distributions exist. Another source of 427.8 nm airglow relevant to both aurora and ionosphere HF modification is resonant scatter of sunlight by N2+ ions. Ionosphere electron heating by high-power HF electromagnetic waves can increase plasma densities, including N2+ ion densities, in the topside ionosphere and thereby increase 427.8 nm airglow.

We present a survey of HF modification experiments at HAARP and EISCAT that report measurements of enhanced 427.8 nm airglow along with results from selected corresponding Self-Consistent Ionosphere Model (SCIM) simulations. The altitude and power volume density of the simulated HF-plasma energy source was varied for each experiment to illustrate the relative importance of electron impact and resonant scatter mechanisms potentially responsible for artificial 427.8 nm airglow. Electron acceleration to energies exceeding 20 eV in the lower F region will result in 427.8 nm airglow enhancements and short-lived plasma density enhancements. Resonant scatter may also be an important mechanism when electrons near the F2-region peak density layer are heated due to efficient transport of electron heat along the geomagnetic field, enhancing N2+ ion densities far above the HF-plasma interaction region; electron acceleration in this region results in long-lived plasma density enhancements that are, in principle, observable with incoherent scatter radar (ISR) even after the acceleration source is removed. No such prolonged plasma density enhancements have yet been observed with ISR.

POLA-08 Dependence of height-integrated Pedersen conductivity in high-latitudes
by Yang Lu

Status of First Author: Student IN poster competition, PhD

Authors: Yang Lu, Yue Deng, Cheng Sheng, Xinan Yue

Abstract: Altitudinal distribution of Joule heating is very important to the thermosphere and ionosphere, which is roughly proportional to the Pedersen conductance at high latitudes. Based on the Constellation Observing System for Meteorology, Ionosphere, and Climate (COSMIC) satellites observations from 2008-2013, the height-integrated Pedersen conductivities in both E (100–150 km) and F (150–600 km) regions and their ratio have been calculated. The seasonal variation of ratio for both hemisphere and the interhemisphrical asymmetry been examined, and also the variation trend for different solar activity conditions.

POLA-09 Vertical Incidence Pulsed Ionospheric Radar (VIPIR) installed at Jang Bogo Station, Antarctica - by Geonhwa Jee

Status of First Author: Non-student, PhD

Authors: Geonhwa Jee, Terence Bullett, Jeong-Han Kim, Changsup Lee, Hyuckjin Kwon, Justin Mabie

Abstract: Vertical Incidence Pulsed Ionospheric Radar (VIPIR) was installed at Jang Bogo Station (JBS), Antarctica in March 2015 in order to monitor the ionosphere in the polar region. The VIPIR system

consists of an inverted log periodic antenna (LPA) designed by CIRES, University of Colorado, HF radar developed by Scion Associates, and Dynasonde analysis software. With this powerful and sophisticated ionosonde system, we will continually monitor the ionosphere not only for the traditional ionospheric parameters including the electron density profile and ion drifts, but the three-dimensional electron density profile can also be constructed by inverting the measured data. The observed data from VIPIR will be utilized to study the ionosphere and thermosphere and their couplings in the auroral and/or polar cap regions over JBS, Antarctica, in combination with the observations for the thermosphere by Fabry-Perot Interferometer (FPI) simultaneously operated at JBS. In this study, we will report the current status of the radar system and its preliminary observations for the ionosphere.

POLA-10 Correlation between Poynting flux and soft electron precipitation in the dayside polar cap boundary regions - by Cheng Sheng

Status of First Author: Student IN poster competition, PhD

Authors: Cheng Sheng, Yue Deng, Yi-Jiun Su, Delores Knipp, Cheryl Y. Huang, Daniel Ober, and Rob Redmon

Abstract: DMSP spacecraft have observed signatures of enhanced electromagnetic (Poynting flux) and kinetic (soft electron precipitation) energy deposition in the polar cap boundary regions, including the cusp. With strict criteria of region identification, the correlation between these energy inputs has been investigated in detail. The two different energy sources are coincident in some cases, but a clear displacement can also be identified in others, depending on the location and conditions. The consequence of the energy displacement has been simulated in the Global Ionosphere-Thermosphere Model (GITM) through by comparing two cases. In one case, the two different energy sources are coincident, and in the other case, they are not. The difference in the ionosphere and thermosphere between the two runs has been examined, which represents the significance of the energy correlation to the upper atmosphere response. These results will help to specify the horizontal distribution of energy inputs in the ionosphere-thermosphere modeling.

POLA-11 Observation for the neutral winds in the polar upper atmosphere by Fabry-Perot interferometer at Jang Bogo Station, Antarctica - by Changsup Lee

Status of First Author: Non-student, PhD

Authors: Changsup Lee, Geonhwa Jee, Qian Wu, Hyuckjin Kwon, Jeong-Han Kim, Yong Ha Kim

Abstract: Fabry-Perot interferometer (FPI) has been continuously operating at Jang Bogo Station (JBS), Antarctica since its installation in March 2014 to observe the neutral winds in the polar upper atmosphere. JBS is located at Terra Nova Bay in Antarctica and the local weather around JBS is most suitable for the optical observations such as FPI due to nearly 80% of clear night during dark period. The horizontal wind data in the upper mesosphere and thermosphere obtained from March to October, 2014 are analyzed to investigate the physical characteristics of neutral winds in the polar region during both geomagnetically quiet and disturbed periods. Neutral winds at three different altitudes (87km, 97km, 250km) will be examined at various geophysical conditions and also compared with the winds in the subauroral region. Finally, the neutral winds and the 630.0 nm airglow emission intensity at 250km altitude will be discussed for their correlation with the solar wind.

POLA-12 Triggering and evolution of dayside polar cap airglow patches by satellite-imager coordinated observations - by Boyi Wang

Status of First Author: Student IN poster competition, PhD

Authors: Boyi Wang; Yukitoshi Nishimura; Larry R. Lyons; Ying Zou; Harald U. Frey; Stephen B. Mende

Abstract: Recent imager and radar observations in the nightside polar cap have shown evidence of localized flow channels propagating anti-sunward, and polar cap patches have been shown to be associated with such flow channels. To understand how flow channels propagate into the polar cap, we use an all-sky imager in Antarctica and DMSP to determine properties of density and flows associated with dayside polar cap patches. We identified 49 conjunction events during the southern winter seasons of 2007-2011. In a majority (44) of events, longitudinally narrow flow enhancements directed anti-sunward are found to be collocated with the patches and are substantially larger than the large-scale background flows, and widths of the flow enhancements are comparable to the patch widths (~400 km). Fast flows of >~2000 m/s are predominantly seen during large IMF |By| and small |Bz|, and the flow speed decreases with increasing –Bz. The presence of fast, anti-sunward flow channels associated with the polar cap patches suggests that the flow channels form in the dayside polar region, and can serve as the source of flow channels deep in the polar cap. Furthermore, we checked the IMF condition and sheath condition based on the conjunctions between THEMIS B/C and PMAFs observed by AGO ASI images during 2008 and 2009, trying to find the drivers of PMAF. The possible candidates are foreshock reflected ions and southward turning of IMF Bz component. 3 cases will show the correlation between foreshock reflected ions and PMAFs.

POLA-13 Thermospheric Wind Observations Inside the Northern Polar Cap – by Qian Wu

Status of First Author: Non-student, PhD

Authors: Qian Wu and William Ward

Abstract: Polar cap is the region when the magnetosphere interacts more directly with the ionosphere and thermosphere through ion neutral collision and cross polar cap potential. The energy from the magnetosphere is converted into kinetic and thermal energy (via Joule heat) in the thermosphere. In order to understand the ionosphere and thermosphere response to the magnetosphere forcing, one has to know how the energy deposits into the thermosphere. Thermospheric winds are a key parameter for estimating the Joule heating. Joule heating changes the dynamics of the thermosphere, which leads to upwelling. Upwelling then changes the chemical environment of the ionosphere and decreases the ionosphere density. Enhanced by the Joule heating, the thermospheric winds push the ion-depleted ionosphere into the mid-latitude region. In every step of the process, the thermospheric winds play a critical role. Hence, monitoring the thermospheric wind in the high latitude region is essential. In November 2014, two ground-based Fabry-Perot interferometers were deployed in Eureka and Resolute Canada to measure the thermospheric winds by Doppler remote sensing the O 630 nm airglow emission. For the first time, two Fabry Perot interferometers are operational inside the polar cap to provide more robust observational capability and opportunity to explore the thermosphere structure inside the polar cap. The observational results from these two instruments will be analyzed in comparison with model simulations.

POLA-14 Connection of polar cap arc and associated meso-scale flow to nightside auroral oval disturbances - by Ying Zou

Status of First Author: Student IN poster competition, PhD

Authors: Ying Zou; Yukitoshi Nishimura; Larry R. Lyons; Eric F. Donovan; Kazuo Shiokawa, J. Michael Ruohoniemi; Kathryn A. McWilliams; Nozomu Nishitani

Abstract: Recent studies have suggested that polar cap flows are highly structured and that localized flow enhancements can lead to nightside auroral disturbances. However, limited by radar measurements, where these flows come from and when and where they impinge on the auroral poleward boundary in relation to oval disturbances remain ambiguous. Utilizing the coordinated observations of an array of 630.0 nm all-sky imager (ASIs) and SuperDARN radars, we study the influence of these flows on auroral oval activity over wide area and in 2-D using polar cap arcs. Comparing with radar measurements, we found that polar cap arcs well trace the propagation of localized flows with an uncertainty of a few minutes. As these arcs extend equatorward to and visually contact the auroral poleward boundary, an intensification in the oval appeared within a few minutes lag and ~10° longitudinal separation. This intensification is spatially

connected to the polar cap arc, indicating that polar cap flows traversing the open-closed field line boundary and directly connecting to disturbances in the plasma sheet. These disturbances can be intensifications located along the auroral poleward boundary, i.e. poleward boundary intensification, or brightening of the only arc within the oval with or without substantial poleward expansion (threshold of 3°), depending on whether the oval is sufficiently thick for detecting multiple arc structures. We surveyed data during 6 winter seasons and focus on steady polar cap arcs lasting >1 h. We have found 34 arcs and most of them (~85%) show an association with oval intensifications. These intensifications statistically occur within 10 min and ±1 h MLT from the contact time and location. The fact that all intensifications occur at or after the contact indicates that they are likely to be triggered by localized polar cap flows. These oval disturbances are usually <1 h MLT wide. An examination of IMF suggests that our events preferentially occur under +Bz, +By, and -Bx.

POLA-15 Intense Poynting flux at very high latitude during magnetic storms: GITM simulation results - by Cheng Sheng

Status of First Author: Student IN poster competition, PhD

Authors: Cheng Sheng, Yue Deng, Manqi Shi, Yanshi Huang, Cheryl Y. Huang

Abstract: Previous DMSP observations [Huang et al., 2015] have shown large Poynting flux in the polar cap region during magnetic storms, which could be comparable to and sometimes larger than that in the auroral region. Real-event simulations for magnetic storms have been conducted using the Global Ionosphere-Thermosphere Model (GITM). The spatial distribution and temporal variation of the altitudinal integrated Joule heating at high latitudes have been investigated. The integrated Joule heating has also been compared with the DMSP derived Poynting flux along satellite trajectories. This study will help us get a more comprehensive idea about how the geomagnetic energy is distributed at high latitudes during storm periods. The challenges in modeling the ionosphere/thermosphere response to magnetic storms have been discussed as well.

POLA-16 Indirect Momentum-Energy Coupling in the F-region Ionosphere-Thermosphere System - by Vicki Hsu

Status of First Author: Student IN poster competition, PhD

Authors: Vivki Hsu, Jeffrey P. Thayer, Wenbin Wang, Alan Burns

Abstract: Thermospheric neutral properties, such as wind, temperature, and neutral mass density, are influenced by momentum and energy sources. Much work has focused on the response of the thermosphere when driven by energy sources from the magnetosphere that result in direct heating of the neutral gas. This leads to a dynamical response of the thermosphere described as a direct circulation. However, sources that change the momentum transfer to the neutral gas can lead to thermal changes through a dynamical response that would be characterized as an indirect circulation. The ionosphere-thermosphere (I/T) system is tightly coupled by momentum and energy, thus the path for a direct energy source is to change the energy and then the momentum, while the route for an indirect source is to change the momentum and then the energy. For the indirect energy source, changes in the ion drag force modify the neutral wind field, which causes adiabatic heating or cooling, leading to variations in the thermal energy of the system. All of the important forces and processes exist for describing both the direct and indirect energy sources, but it is the time evolution of the processes that will define how the thermosphere responds. In this work, we present an indirect energy mechanism that can alter the thermospheric neutral mass density and temperature. We use the NCAR TIEGCM to demonstrate the processes in the mechanism and its contribution to the formation of polar region neutral structures. This study illustrates how changes in the ion drag force can indirectly affect the energy of the F-region I/T system, and generate neutral mass density and temperature anomalies.

POLA-17 Simultaneous velocity and temperature measurements of the thermospheric neutral atmosphere and ionospheric plasma above 200 km over Poker Flat, Alaska - by Samuel Sanders

Status of First Author: Student IN poster competition, Undergraduate

Authors: S. Sanders, J. Meriwether, D. Hampton, L. Navarro, M. Nicolls

Abstract: Measurements of the Doppler shift and the Doppler broadening of the 732-nm O+(2P) spectral profile with a high resolution Fabry-Perot interferometer (FPI) are used to determine the height-integrated ion temperature and ion velocity for the lower auroral F-region between 225 and 325 km. The production of this emission is soft electron impact with thermospheric atomic oxygen in aurora. Quenching of the emission at altitudes above 225 km is negligible, and the lifetime of the O+(2P) metastable state is ~5 s. The nominal peak in the volume emission rate for the O+(2P) 732-nm emission is 225-250 km overlapping rather closely with that of the O(1D) state. Auroral 732-nm measurements obtained at the Poker Flat Research Range located near Fairbanks, Alaska (65.1° N, 147.5° W) using the narrow field FPI show that there often exists molecular nitrogen contamination from the 1PG band emission but the 732-nm spectra can still be used for Doppler shift determination. As such, near-simultaneous common volume measurements of the 630-nm and 732-nm emissions of the O(1D) and O+(2P) states were obtained during the geomagnetic storm of 17 March 2015 as part of a campaign of collaborative observations with the PFISR radar in which both instruments looked in a series of directions along the same line-of-sight into the airglow or aurora. These results represent an opportunity to compare optical and radar auroral measurements of ion temperatures and ion drifts. The Joule heating rate of the neutral atmosphere can be expressed as frictional heating, $(\partial E_n)/\partial t=\sum(n_i m_i \nu_{in}) [(V_i-V_n)]^2$, as described by Carlson et al. 2012. An equivalent heating rate is derived by replacing the frictional heating term with that of a heat exchange term, $(\partial E_n)/\partial t=(3k_B)/m_n \sum(n_i m_i \nu_{in}) (T_i-T_n)$. Thus, the temperature difference of Ti and Tn should represent an excellent proxy measurement of the ion frictional dissipation caused by a velocity difference in Vi and Vn. Preliminary data analysis show the neutral temperature to be typically 1500 K for the first two nights of this storm period. FPI results of vertical winds and neutral temperatures for the narrow-field FPI observatories located at Eagle, AK (64.8° N, 141.2° W), and Ft. Yukon, AK (66.6° N, 145.3° W) will also be presented for this period of very substantive geomagnetic activity.

Solar Terr Interactions in the Upper Atmosphere

SOLA-01 Ionosphere Plasmasphere Electrodynamics (IPE) Model Development for connection between terrestrial and space weather - by Naomi Maruyama

Status of First Author: Non-student, PhD

Authors: N. Maruyama, Y.-Y. Sun, P. G. Richards, J. Middlecoff, T.-W. Fang, T. Fuller-Rowell, A. Richmond, A. Maute, R. Akmaev, J.-Y. Liu, C. Valladares

Abstract: IPE model has been developed at NOAA SWPC, in order to improve our specification of ionosphere and plasmasphere in response to external forcing from both above and below, and to be coupled to whole atmosphere models for understanding an impact of the terrestrial weather to space weather. The model describes the time dependent, three-dimensional, global density of nine ion species, electron density, temperatures of electron and ions in the ionosphere and plasmasphere. The parallel plasma transport is based on Field Line Interhemispheric Plasma (FLIP) Model [Richards et al., 1990]. A realistic model of Earth's magnetic field is implemented by using the APEX coordinate system [Richmond, 1995]. Global, seamless plasma transport perpendicular to the magnetic field has been included all the way from the equator to the poles. The electrodynamics solver is based on the TIEGCM [Richmond and Maute 2013]. It self-consistently calculates the electric field as one of the main driver for the Ionosphere-Plasmasphere module. The code has been parallelized using MPI/Scalable Modeling System (SMS) [Govett et al., 2003], in order to speed up the code to meet so that its run speed will be comparable to that of the whole

atmosphere model. The code scales reasonably well, and runs up to 640 processors, by decomposing both latitude and longitude direction in a flexible manner determined at run time. The recent developments will be updated in this presentation.

SOLA-02 Ionosphere-Thermosphere-Plasmasphere coupling from the new Ionosphere Plasmasphere Electrodynamics (IPE) Model - by Naomi Maruyama

Status of First Author: Non-student, PhD

Authors: N. Maruyama, P.G. Richards, Y.-Y. Sun, T.-W. Fang,T. Fuller-Rowell

Abstract: Storm time response of the ionosphere goes through different phases of positive and negative storms throughout a storm, while plasmaspheric plasmas get eroded during the main phase of the storm and gradually refilled for several days. Storm Enhanced Densities (SEDs) seem to be connected between ionosphere and plasmasphere, however, in general, storm time responses between ionosphere and plasmasphere needs to be consistently understood in detail for various phases of a storm and for individual events. The main goal of this study is to improve our scientific understanding of the Ionosphere-Plasmasphere coupling, in particular, the storm time coupling associated with SEDs. How is the plasma redistributed in both parallel and perpendicular directions? A new Ionosphere-Plasmasphere-Electrodynamics (IPE) model is used to address the dynamic ionosphere-plasmasphere-thermosphere coupling. The model describes the time dependent, three-dimensional, global density of nine ion species, electron density, temperatures of electron and ions in the ionosphere and plasmasphere. The parallel plasma transport is based on the Field Line Interhemispheric Plasma (FLIP) Model [Richards et al., 1990]. A realistic model of Earth's magnetic field is implemented by using the APEX coordinate system [Richmond, 1995].

SOLA-03 Improving storm-time NO Cooling in CTIPe model using TIMED/SABER Observations - by Mariangel Fedrizzi

Status of First Author: Non-student, PhD

Authors: M. Fedrizzi, T. Fuller-Rowell, M. Codrescu, M. G. Mlynczak, D. R. Marsh

Abstract: The temperature of the Earth's thermosphere can be substantially increased during geomagnetic storms mainly due to high-latitude Joule heating induced by magnetospheric convection and auroral particle precipitation. Thermospheric heating increases atmospheric density and the drag on low-Earth orbiting satellites. The main cooling mechanism controlling the recovery of neutral temperature and density following geomagnetic activity is infrared emission from nitric oxide (NO) at 5.3 micrometers. NO is produced by both solar and auroral activity, the first due to solar EUV and X-rays the second due to dissociation of N2 by particle precipitation, and has a typical lifetime of 12 to 24 hours in the mid and lower thermosphere. NO cooling in the thermosphere peaks between 150 and 200 km altitude. In this study, about 10 years of NASA TIMED/SABER satellite measurements of radiative power at 5.3 micrometers are being used to evaluate CTIPe model estimates of global NO cooling during storm-time conditions.

Currently, CTIPe uses time-dependent estimates of NO obtained from Marsh et al. [2004] empirical model based on Student Nitric Oxide Explorer (SNOE) satellite data rather than solving for minor species photochemistry self-consistently. This empirical model is based solely on SNOE observations, when Kp rarely exceeded 5. The goal is to improve CTIPe model timescale for neutral density response and recovery during geomagnetic storms.

SOLA-04 The relationship between high-speed solar wind streams and ozone loss in the upper stratosphere and mesosphere - by Ji-hee Lee

Status of First Author: Non-student, Masters

Authors: Ji-Hee Lee, Geonhwa Jee, Young-Sil Kwak

Abstract: The solar wind is a stream of plasma released from the upper atmosphere of the Sun. The solar wind is divided into two components: slow and fast solar winds. The fast solar wind is thought to originate from coronal holes, which are funnel-like regions of open field lines in the Sun's magnetic field. The physical characteristics of fast solar wind are closely related to variations in space environments including the Earth's magnetosphere and the upper and lower atmospheres. Although its effects are not as strong as solar energetic particle events such as flare and CME, the high-speed solar wind stream more prevalently occurs and may affect the atmospheric chemistry. In this study, we analyzed the atmospheric density data for HO2 and O3 obtained by MLS onboard the AURA satellite according to solar wind speed measured by ACE satellite from 2005 to 2011 in order to study on the atmospheric effects of the high-speed solar wind streams. We report a preliminary result of this analysis.

SOLA-05 Predictability and Ensemble Modeling of the Space-Atmosphere Interaction Region (SAIR) - by Tomoko Matsuo

Status of First Author: Non-student, PhD

Authors: Tomoko Matsuo, Tim Fuller-Rowell,Tzu-Wei Fang, Valery Yudin, Kayo Ide, Daryl Kleist, Adam Kubaryk, Xinan Yue, Chih-Ting Hsu, Rashid Akmaev, Houjun Wang, Jeff Whitaker, Rodney Viereck, Mihail Codrescu, Arthur Richmond, Tom Woods, Thomas Immel, Brian Anderson, Larry Paxton and Jann-Yeng Liu

Abstract: The Space-Atmosphere Interaction Region (SAIR), encompassing the mesosphere, thermosphere and ionosphere, is an intersection between geospace and the Earth’s atmosphere, and is exposed to vacillating conditions of both space and terrestrial weather. Recent observational and modeling studies have revealed clear reaches of terrestrial weather far beyond the mesosphere lower thermosphere region into the topside ionosphere. At the same time, the region lends itself to forcing originating from the Sun and solar-wind magnetosphere interactions. The predictability of the SAIR is a fundamental question in Heliophysics, and calls for a paradigm shift from a deterministic to a probabilistic modeling framework. To meet with this contemporary modeling and simulation challenge, we will systematically compare and combine ensemble simulations of a comprehensive whole atmosphere model, coupled with an ionosphere and plasmasphere model called the Integrated Dynamics in Earth’s Atmosphere (IDEA) with global Earth and geospace observations. Building on the National Weather Service's operational ensemble forecasting and data assimilation systems as well as our earlier efforts, we will construct an ensemble forecasting and data assimilation system that will ultimately be capable of assimilating observations from the ground to SAIR. We will present the project overview along with some initial results from our new interdisciplinary initiatives.

SOLA-06 Approximating Midlatitude Fall-off Velocity Profiles in the Dawn and Dusk Sectors of the High Latitude Convection Pattern - by Janelle Valarie Jenniges

Status of First Author: Student IN poster competition, PhD

Authors: Janelle V. Jenniges, Jan J. Sojka, Roderick A. Heelis

Abstract: It is well known that the polar cap convection pattern is highly dependent on the orientation of the interplanetary magnetic field (IMF) and its radius depends significantly on geomagnetic activity. In contrast, the midlatitude fall-off of the high latitude electric field is relatively less understood. This region connects the high latitude polar cap convection to the region where the ring currents modify the low latitude penetration electric field equatorward of the polar cap boundary. The electric field in this midlatitude region is typically modeled as a simple fall-off, but magnetosphere-ionosphere dynamics may create structure in this region that has previously been neglected by ionospheric models. We investigate the latitude dependence of the plasma drift in this region as a function of the Kp index. Data from the Defense Meteorological Satellite Program (DMSP) in both the dusk and dawn sectors for each northern hemisphere

polar pass are analyzed and fit to three functions describing the fall-off with decreasing latitude: an exponential, a sine, and a Gaussian. The fits are obtained by linearizing the data and using a linear least square fit algorithm to minimize the errors in two free parameters. Kp trends were computed by analyzing various parameters against Kp for each function. The results indicate that the polar cap radius, auroral region boundaries, and midlatitude fall-off have a statistically significant variation with the geomagnetic index. A comparison of these Kp trends to output from several empirical models provided confidence in many of the results. It was found that the polar cap radius goes as 12.2 + 1.1*Kp while the fall-off can be modeled using a sine function with Vy = A/sin(x)^B, where x is the colatitude, A = 3.47 + 0.75*Kp, and B=4.86 + 0.52*Kp. The Utah State University (USU) Time Dependent Ionosphere Model (TDIM) was run using these results and a comparison of the model output using the original and new polar cap radius and fall-off functions will be shown.

SOLA-07 Towards Forecasting Ionospheric Storms with Physics-based Modeling - by Xing Meng

Status of First Author: Non-student, PhD

Authors: X. Meng, A. J. Mannucci, and O. P. Verkhoglyadova

Abstract: We explore the feasibility of ionospheric forecasts with the current generation of physics-based models. Specifically, we focus on total electron content (TEC) predictions using the Global Ionosphere-Thermosphere Model (GITM), for ionospheric storms driven by corotating interaction region/high-speed-stream events. GITM simulations are performed in a forecast mode for four typical high-speed-stream events during 2007-2012. The simulated TEC disturbances are quantified through a metric, which is then illustrated through global maps color-coded by the TEC disturbance level. To evaluate the forecasts, we compare the simulated TEC disturbances with Global Positioning System satellite observations. Examples of model-data agreement and disagreement are discussed, aiming to understand the model behavior and improve future forecasts.

SOLA-08 Quantitative assessment of the neutral wind contribution to Joule heating during geomagnetic storms - by Emine Ceren Kalafatoglu Eyiguler

Status of First Author: Student IN poster competition, PhD

Authors: Emine Ceren Kalafatoglu Eyiguler, Zerefsan Kaymaz

Abstract: Thermospheric neutral wind plays a major role on ionospheric electrodynamics. During substorms and geomagnetic storms the effects of the neutral wind increase owing to the enhanced magnetosphere-ionosphere coupling and increased energy input to the system. Neutral wind can act as both a reduction and enhancement mechanism for the Joule heating. In this study, we quantify the neutral wind effects on Joule heating during a severe geomagnetic storm using different neutral wind patterns estimated from two physics-based models (GITM and TIEGCM) and HWM93 empirical model. By using the same electric field, magnetic field and Pedersen conductivities and just changing the neutral wind data set, we quantify the effects of using different neutral wind data on the spatial variation and magnitude of the resultant Joule heating.

SOLA-09 Global Total Electron Content Response to the 17 March 2015 Geomagnetic Storm - by Yang-Yi Sun

Status of First Author: Non-student, PhD

Authors: Yang-Yi Sun and Jann-Yenq Liu

Abstract: A severe geomagnetic storm, which is the largest during the weak solar cycle 24, occurred on 17 March 2015 at 0445 UT. The minimum Dst value is less than −200 nT and Kp reaches a value of 8.

Global features of the long-duration positive and negative ionospheric storms are studied using the Taiwan Real-time Global Ionospheric Map (TWR GIM) that is developed at the National Central University. The TWR GIM is constructed from global vertical total electron content (TEC) observations, which are measured by about 120 ground-based GPS stations and FORMOSAT-3/COSMIC, using a spherical harmonics expansion. The results show that the positive storm is pronounced at mid- and low-latitudes in the first day after the storm onset. The negative storm remains present in the equatorial ionization anomaly crest regions more than one week. The relationship between the long-duration TEC changes and variations in electric field and O/N2 ratio are also examined.

SOLA-10 A quantitative analysis of solar flux effects on the ionosphere by using FISM spetra - by Jeongheon Kim

Status of First Author: Student IN poster competition, PhD

Authors: Jeongheon Kim, YongHa Kim, GeonHwa Jee

Abstract: It has been known that the intense solar flux of EUV and X-ray causes the ionosphere to change abruptly to the level of interfering radio communication. Now that more accurate observations of solar EUV and X-ray fluxes are available, we study the effect of solar flux variation on the ionosphere by comparing a physic-based model results with ionosonde and TEC (total electron content) data. For the quantitative analysis we have revised the SAMI2 model by including both photoionization of X-ray spectral range (below 50 A) and photoelectron impact ionization. As the input of the real-time solar EUV and X-ray flux (1~105.0 nm) to the model, we adopted FISM (Flare Irradiance Spectral Model) spectra for various solar conditions in the F10.7 range of 70~280. For every 20 increase in F10.7 from 70 we selected corresponding days in the last solar cycle when FISM spectra are available and calculated peak densities of E and F2 layers, and TEC. For these selected days we obtained from GIRO(Global Ionospheric Radio Observatory) network at least 10 sets of ionosonde data that contain critical frequencies of E and F2 layers (foE, foF2) with appropriate confidence levels. The information on TEC was obtained from IRI-2012 model for the selected days. We will present quantitative comparison of E and F2 peak densities and TEC between the revised SAMI2 model results and measurements.

SOLA-11 On the electric field mapping of the F-region to the E-region at Arecibo - by Yong Gong

Status of First Author: Non-student, PhD

Authors: Yong Gong, Qihou Zhou, Shaodong Zhang

Abstract: We present the first analysis of the electric field mapping of the ionospheric F-region to the E-region at low latitude. The electric field is generally assumed to be height invariant and can be mapped from the F-region to the E-region along the magnetic field line due to the high conductivity. Using the Arecibo incoherent scatter radar and applying the ion momentum equation, we develop a method to verify the electric field mapping in terms of examining whether the F-region eastward ExB ion drift is equal to the E-region eastward ion drift at locations that the E-region vertical ion drift is zero. Our method avoids using the ion-neutral collision frequency, which is considered to be the most uncertain parameter in computing the E-region electric field using radar measurements. The results show that time variation of the F-region eastward ExB ion drift and the E-region eastward ion drift at the locations where vertical ion drift equals to zero are not consistent. This may imply that the E-region electric field cannot be mapped from the F-region at the low latitude. A generally applied method that using the F-region ExB ion drifts to computer the E-region electric field and then deducing the E-region zonal wind is questionable.

SOLA-12 Model simulation of ion and electron density profiles in lower part of ionosphere - by Yen-Chieh Lin

Status of First Author: Student IN poster competition, PhD

Authors: Yen-Chieh Lin and Yen-Hsyang Chu

Abstract: Solar extreme ultraviolet radiation (EUV) and X-rays play critical roles in producing the daytime ions and electrons in lower part of ionosphere through photoionization process. The EUVAC and HFG solar proxy models have long been widely used in ionospheric community to model solar irrdiance flux as a function of F10.7. Recently, solar EUV and X-ray intensities with much finer spectral resolution and higher accuracy and precision are provided by the Extreme Ultraviolet Variability Eperiment (EVE) of the Solar Dynamic Observatory (SDO) mission. In this study, on the basis of these three solar irradiance sources, we establish a time dependent theoretical numerical model to simulate the corresponding density profiles of the ions and free electron in E and lower F1 regions. We take account of the photoionization production rates of the ions (i.e., O+(2P), O+(2D), N2+, O+(4S), N+, O2+, and NO+) , the chemical reactions between the ionizations and the neutral compositions (O, O2, N2, N, NO), and the photoelectron ionization production effect in the model. A comparison between the model simulations and the AE-C satellite in-situ measurements indicates that the SDO-EVE can result in much more accurate simulation results than EUVAC and HFG solar irradiance models.

SOLA-13 New Results on the Midnight Temperature Maximum for Middle Latitudes - by Rafael Mesquita

Status of First Author: Student IN poster competition, Undergraduate

Authors: R. Mesquita, J. Meriwether, J. Makela, S. Sanders, D. Fisher.

Abstract: In this work, we present a statistical study of the Fabry-Perot interferometer (FPI) thermospheric temperature measurements obtained with the North American Thermosphere Ionosphere Observation Network (NATION, 5 FPI sites located in the latitudinal range of 35.2ºN to 42.40ºN in the eastern continental USA) regarding the amplitude and occurrence frequency of the midnight temperature maximum (MTM) structure at mid-latitudes. Previously, the approach adopted determined the MTM amplitude from analysis of the differences of the FPI temperatures relative to MSIS model temperatures. The new approach presented in this paper uses a fitting model similar to that developed by Boston University for radar data analysis in which the observed temperatures are fitted to a multi-parameter model that allows for the nominal nighttime cooling trend of the background temperatures. This makes the extraction of the MTM structure relative to the background temperature variation easier to achieve so that the amplitude and peak occurrence time can be determined automatically with this algorithm with good accuracy. This new technique was applied to the NATION database for observations obtained between 2011 and 2014 so that the statistics of amplitude and appearance frequency can be determined. Preliminary results obtained thus far for the NATION database suggest the highest/lowest frequency of MTM occurrence for the summer/winter season, respectively. An interesting feature of the NATION results shows evidence for latitudinal variations of the MTM amplitude by 20 to 50% that are difficult to understand as viscous damping of the tidal structure forcing the MTM structure is not expected to show much variation with a change in latitude.

SOLA-14 Variation of the nighttime enhancement in Thermospheric density - by Haibing Ruan

Status of First Author: Student IN poster competition, PhD

Authors: Haibing Ruan, Jian Du, Matt Cook, Wenbin Wang, Jia Yue, Quan Gan, Xiankang Dou, Jiuhou Lei

Abstract: The midnight temperature maximum, known as MTM, occurs over the equatorial region and is generally believed to be due to the upward propagation of atmospheric tides according to the recent studies. Associated with the MTM is the thermospheric density enhancement near midnight, or midnight density maximum (MDM). In this work, we investigate the latitudinal variations of the MDM using thermospheric density observations by the CHAMP satellite and simulations from the Thermosphere Ionosphere

Electrodynamics-General Circulation Model (TIE-GCM). The sampling of the CHAMP satellite allows for the observation of a statistical average of the midnight density maximum (MDM). Using the TIE-GCM runs with/without terdiurnal tides at the model lower boundary, we explore the impact of the terdiurnal tides on the upper atmosphere and MTM/MDM. From the CHAMP observations, it was found that the MDM of the thermosphere, a manifestation of the MTM, occurs in all seasons at both low and medium solar activity levels, but its structures vary significantly with season and solar activity. The results from the TIE-GCM indicate that the terdiurnal tides from the low altitudes contribute significantly to the nighttime temperature and density enhancements.

SOLA-15 Influence of auroral streamers on rapid evolution of SAPS flows -
by Bea Gallardo-Lacourt

Status of First Author: Student NOT in poster competition, Masters

Authors: Bea Gallardo-Lacourt, T. Nishimura, L. R. Lyons, V. Angelopoulos, E. F. Donovan, J. M. Ruohoniemi, K. A. McWilliams, and N. Nishitani

Abstract: An important manifestation of plasma transport in the ionosphere is Subauroral Polarization Streams or SAPS, which are strong westward flow lying just equatorward of the electron auroral oval and thus of enhanced ionospheric conductivities of the auroral oval. While SAPS are known to intensify due to substorm injections, recent studies showed that large variability of SAPS flow can occur well after substorm onset and even during non-substorm times. These SAPS enhancements have been suggested to occur in association with auroral streamers that propagate equatorward and then turn azimuthally, a suggestion that would indicate that plasma sheet fast flows propagate into the inner magnetosphere and increase subauroral flows. We present auroral images from the THEMIS ground-based all-sky-imager array and 2-d line-of-sight flow observations from the SuperDARN radars that share fields of view with the imagers to investigate systematically the association between SAPS and auroral streamers. We surveyed events from December 2007 to April 2013 for which high or mid-latitude SuperDARN radars were available to measure the SAPS flows, and identified 74 events. For streamers observed near the equatorward boundary of the auroral oval either while turning, or after having turned, westward, we find westward flow enhancements of ~200 m/s slightly equatorward of the streamers. We also found a correlation between auroral streamers, proton aurora intensifications and localized westward flow enhancements. A preliminary survey suggests that >90% of the streamers that turn westward lead to westward flow enhancements. We also characterize the SAPS flow channel width and timing relative to streamers reaching radar echo meridians. The strong influence of auroral streamers on rapid evolution of SAPS flows suggests that transient fast earthward plasma sheet flows can lead to westward SAPS flow enhancements in the subauroral region, and that such enhancements are far more common than just during substorms because of the frequent occurrences of streamers under various geomagnetic conditions.