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0n March 27, 2003, a multiple rocket and radar investigation was carried out from Poker Flat, Alaska to investigate the complex electrodynamics and neutral-plasma coupling inherent to the high latitude, lower ionosphere (100-200 km) and in particular to quantify the Joule heating in this region. Measurements within these altitudes gathered along vertical trajectories permit the Joule heating to be calculated where the Pedersen conductivity maximizes and where the ratio of the ion-neutral collision frequency to the ion gyro frequency varies considerably. Two instrumented rockets were launched into a post-midnight aurora within 3 minutes of each other, achieving apogees near 200 km while a third rocket was launched a minute later that released TMA trails to measure the neutral wind velocity. In this presentation, we focus on the in situ measurements of DC, quasi-DC, and AC electric fields gathered using the double probe technique, although we also use the measurements of plasma density, energetic electrons, and suprathermal ions to calculate conductivities and other important parameters related to Joule heating. In addition, data from the imaging coherent scatter radar provide information concerning the ambient plasma drifts and enable the in situ data to be placed in context. During the upleg of each rocket, the in situ measurements revealed 50mV/m DC electric fields directed towards the equator that, for each rocket, became considerably structured near apogee and during the downleg portions of their trajectories. Each payload encountered intermediate (10 km - 100 km) and small scale (10m - 10 km) electric fields with the largest amplitudes along their paths typically within the range of 5-25 mV/m. Such waves can contribute significantly to Joule heating, although they are frequently not included in models due to their small spatial scales. The rocket payloads also encountered intense (20-30 mV/m) Farley-Buneman two-stream waves with very short wavelengths (1-10m) in the auroral electrojet region (90-118 km). We use the neutral wind measurements to establish the relative frame of the ion and neutral gases and calculate the Joule heating associated with the electric fields at all scales as a function of altitude.

SA21C-06 1135h

Imaging Radar Observations of the Auroral Electrojet During the JOULE Campaign.

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We have used aperture synthesis imaging techniques to observe the radar aurora with a 30 MHz radar from Anchorage, Alaska during the JOULE campaign. Radar imaging allows us to sort the echoes into bearing as well as in range and Doppler bins. Because of the high radar PRF and low radar frequency, the echoes we observed, both type 1 and type 2, were underspread, and the data therefore suffer no range, Doppler, or bearing ambiguities. The radar range and azimuth resolution was 2.5 km and about 0.4°, respectively, during our observations. We observed type 1 and type 2 echoes with Doppler shifts that varied rapidly and sometimes discontinuously with range and azimuth (and time), suggesting fine structure in the electric field on the scale of the radar resolution. Using regularization methods, it should be possible to infer the convection pattern in the volume illuminated by the radar and to calculate the contribution to the overall Joule heating rate from the fine structure. It will also be possible to make direct comparisons between the electric fields and winds measured in situ and the Doppler spectra measured by the radar for the first time.

URL: http://landau.geo.cornell.edu

SA21C-07 1150h

Relationship between magnetospheric energy sources and ionospheric variability during the substorm cycle

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Magnetospheric substorms produce intense localized perturbations in the ionosphere as a result of the dissipation of electromagnetic and kinetic energy. The true spatial-temporal variability of the ionospheric response is not captured by space-borne auroral imagers, nor by ground-based magnetometers, nor by coherent backscatter radars. Efforts to assimilate these diagnostics into a coherent picture of electrodynamic coupling are inherently unreliable during active periods. The undersampled variability cannot be treated as an averaging effect since the underlying physics is itself scale-dependent (e.g., Alfvenic versus inverted-V versus diffuse aurora). This paper considers the relationship between the magnetospheric energy source and small-scale ionospheric variability during the substorm cycle. A combination of space-borne measurements from FAST and IMAGE, and IS radar and optical measurements from the Sondrestrom facility is used to identify changes in the ionospheric plasma state (Te, Ti, Ne, Vi, and ion production rate) with respect to specific features in the magnetospheric source, thereby resolving the scale dependent physics. Implications for various approaches to modelling high-latitude MI coupling are discussed.

URL: http://isr.sri.com

SA21C-08 1205h

High-Resolution Limb Observations of Proton Aurora

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The interaction of precipitating protons in the upper atmosphere involves charge exchange, ionization, elastic and inelastic collisions, and the deposition of energy from the bottom of the F-region to the D-region of the ionosphere. These processes and the transport of incident protons through this range of altitudes has been described through a variety of modeling techniques but there has been a dearth of altitude-resolved observations of proton precipitation with which to validate such models. We present new limb observations of Doppler-shifted Lyman-α proton aurora emissions obtained by the High-resolution Ionospheric and Thermospheric Spectrograph (HITS) aboard the Advanced Research and Global Observation Satellite (ARGOS) that fill this niche. HITS performs limb scans that include tangent altitudes between 90 km and 400 km with approximately 5 km vertical resolution. The Doppler shifts of the proton aurora Lyman-α emissions are measured with 1.5 Angstrom resolution and are used to infer mean energies of the incident protons as a function of altitude. Observed energy-range (dE/dz) relations are compared to those predicted by a Monte Carlo simulation of proton transport in the upper atmosphere.

SA22A MCC: Level 1 Tuesday 1330h

Small-Scale Processes in the High-Latitude E Region III Posters

(joint with SM, AE)

Presiding: **M Conde,** University of Alaska**; M Larsen,** Clemson University

SA22A-0094 1330h POSTER

SMALL SCALE STRUCTURE IN THE HORIZONTAL NEUTRAL WIND FIELD AT SONDRESTROM (KANGERLUSSUAQ), GREENLAND

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The thermospheric neutral wind field at Sondrestrom (Kangerlussuaq), Greenland is monitored with two independent instruments: direct measurements of the neutral wind are obtained optically by a Fabry-Perot interferometer, while an incoherent scatter radar indirectly determines the wind from plasma drift measurements. The location of the aeronomical observatory places it under the auroral oval during dusk and dawn and within the polar cap during the midnight sector. During all of these periods, electron and ion precipitation enhance the ionization of the E and F regions of the ionosphere in localized regions. This paper will describe the neutral wind field during these auroral events. The morphology of the auroral emissions is characterized by all sky imagery, which provides a context to the more narrow fields observed by the wind monitors.

SA22A-0095 1330h POSTER

Determination of the Altitude of Cosmic Noise Absorption at Cusp Latitudes Using the Vertical Parallax Technique

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The overlapping beam patterns of two closely spaced imaging riometers have been used to make direct observations of the altitude of maximum ionospheric absorption of cosmic radio noise. The method employs the simple vertical parallax technique. One drawback of the riometry technique of observing density enhancements in the ionosphere has been its inability to retrieve direct height information regarding precipitation regions from absorption measurements. To obtain absorption height information requires either the application of a multifrequency technique, or coordination of riometer data and data from independent instruments such as iono-digisondes or incoherent scatter radar. The unique proximal location of the Southern Hemisphere Imaging Riometer Experiment *SHIRE*, located at Davis, Antarctica and the NIPR/STELab imaging riometer at Zhongshan, Antarctica, just 109km away, presents an opportunity to use parallax methods as a means of determining the altitude of Cosmic Noise Absorption in the cusp region, on an event basis. The relative fields of view of the two instruments have near optimal overlap for the application of parallax methods of this kind, with overlapping beams at any altitude above 40km. Using this new technique, we confirm the altitude of maximum radiowave absorption at between 90 and 100km *ionosphericDregion* for auroral zone precipitation on the nightside, indicating precipitation

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of magnetospheric electrons >10keV in energy. We also report on the observation of riometer absorption events occurring in the ionospheric E and F regions. Studies of auroral absorption events with multiple enhancements show that the altitude at which individual enhancements occur may vary significantly. This is reflected in the variation of the peak absorption level for each enhancement.

SA22A-0096 1330h POSTER

Comparing height profiles of the ionospheric electron density derived from remote sensing of UV- and X-ray emissions and from EISCAT radar data

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Height profiles of the electron density in the E-layer and upper D-region can be derived on a global scale using remote sensing of UV- and X-ray emissions by the UVI and PIXIE cameras onboard the Polar-satellite. The first step in the procedure is to use the UVI and PIXIE measurements to estimate the precipitating electron energy spectra from less than 1 keV to 100 keV. From the electron spectra, we then infer the height profiles of the electron density. In this study, we investigate the reliability of the derived electron density values by comparing with simultaneously measured height profiles of the electron density by the EISCAT radar located at Tromso, Norway.

SA22A-0097 1330h POSTER

Mesoscale and semiglobal scale view of the ionospheric electrodynamics of auroral torches

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Within a substorm recovery phase, a train of omega bands formed in the early morning sector of the auroral oval on June 26, 1998, from 02-04 UT. Some of the omega bands extended far polewards as auroral torches. These phenomena were observed on a semiglobal scale using the UVI and PIXIE instruments on the POLAR satellite, allowing to estimate electron spectra and ionospheric conductance distributions. In addition, semiglobal scale estimates of horizontal currents, field-aligned currents, and Joule heating were calculated using the AMIE procedure. Simultaneously, the omega bands/ torches were observed in Northern Scandinavia by the MIRACLE network, consisting of the IMAGE magnetometer network, the STARE coherent scatter radar, and all-sky cameras. The ground magnetic data were supplemented by the temporary BEAR network, the most extensive and dense magnetometer network set up in Scandinavia as yet. The ground-based data allow to calculate two-dimensional distributions of ionospheric horizontal currents, conductances, and field-aligned currents on a scale of 50 km (mesoscale), using the 2D method of characteristics. In this presentation we concentrate on the analysis of the mesoscale ionospheric electrodynamics of the auroral torches for a few selected, representative timesteps. These results will be embedded in and compared with the semiglobal observations and analysis results. Particularly, we developed a new technique of combining UVI and PIXIE data that allows us to compute the conductances on areas smaller than the original 700 km resolution of PIXIE. We compare the results of this technique with the ones of the 2D method of characteristics.

SA22A-0098 1330h POSTER

Morphology of aurorae in λ557.7-nm optical temperatures

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An all-sky scanning Fabry-Perot spectrometer (FPS) was used to observe variations in the temperature of auroral λ557.7-nm [O I] emissions over Poker Flat, Alaska (65.11°N, 147.12°W). The data sets were acquired using the Poker Flat Scanning Doppler Imager (SDI) during the 2002-2003 winter observing season. Temperatures derived from Doppler-broadened spectra were used to approximate the emission altitude, which in turn can be used to infer the characteristic energy of precipitating electron population. Several cases with differing magnetic local time (MLT) and auroral activity were analyzed, and the results are as follows: (1) A dramatic temperature drop (200K) over the entire sky occurred immediately after a major auroral brightening; the temperature remained lower than the pre-brightening value for many minutes after the auroral intensity had resumed its quiescent levels. (2) A local increase of temperature, coinciding with a weak auroral arc, was observed approximately 25 minutes before a substorm onset event propagated westward across the instrument's field of view. This was followed by a sudden increase in auroral luminosity and a sharp decrease in the temperature in the vicinity of the arcs. (3) A westward-traveling surge was observed to contain a region of elevated temperature relative to that of the band itself. For the cases considered, the "heating" rates required to produce such temperature changes at a single height could only result from physically unreasonable currents for the modest geophysical activity observed here. The sudden temporal and spatial changes in Doppler temperatures observed are likely to be owing to the λ557.7-nm emission height changing as a response to variations in the characteristic energy of the precipitating electron population. The Scanning Doppler Imager at Poker Flat Research Range is currently the only instrument capable of measuring temperatures of auroral emissions in a true all-sky imaging sense, and thus is a valuable tool for estimating geometric and energetic auroral parameters.

SA22A-0099 1330h POSTER

Observations Of Small-scale Thermospheric Neutral Winds Associated With Auroral Activity

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Many researchers reported that strong thermospheric vertical winds (10-150 m/s) would occur associated with auroral activity. However, the generation processes of vertical winds and its relationship to atmospheric gravity waves (AGWs) are not understood well. To clarify the characteristics of neutral winds associated with auroral emission, we have examined vertical and horizontal winds estimated from OI 557.7 nm and OI 630 nm data obtained by a Fabry-Perot Doppler at Syowa station, Antarctica (66.4 deg. MLAT). In this paper, we present case studies of vertical winds obtained on 20 nights during the period from July to October in 1996, and in addition, the quasi-periodic oscillation of neutral winds observed on September 12, 1996. The characteristics of vertical winds are summarized as follows. 1) In 5 cases out of 8 breakup events, strong (∼20 m/s) and temporal upward winds existed in the E region poleward of breakup aurora. 2) Downward winds (∼ - 40 m/s) were generally seen in the E region within bright auroras. 3) Oscillations of vertical winds with a period of a few hours were observed in the F region on 4 cases when the aurora oval appeared in the poleward region of Syowa. On the case on September 12, 1996, it is found from 557.7 nm data that quasi-periodic wind oscillations occurred poleward of Syowa, while a stable discrete aurora appeared in the ∼350 km equatorward of Syowa. The amplitudes of neutral wind variations were considerably large (∼600 m/s), and the typical period was ∼8 minutes which is almost equal to the local Brunt-Visala period estimated from the MSISE-90 model. It is concluded that we could not attribute these periodic winds to AGWs since the apparent phase velocity was ∼930 m/s which is much greater than the local sound speed (∼410 m/s), and, therefore, it is difficult to apply a simple dispersion relation of AGWs to the observed wind variations.

SA22A-0100 1330h POSTER

Determination of Total Atmospheric Density in the 80-150 km Altitude Range Using X-ray Occultation Sounding

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The U.S. Naval Research Laboratory launched the Unconventional Stellar Aspect (USA) experiment aboard the Advanced Research and Global Observation Satellite (ARGOS) in 1999. USA is an X-ray timing experiment with a large collecting area and microsecond time resolution. USA consists of a collimated proportional counter X-ray telescope and two detectors with 1000 cm2 effective area each and sensitive to 1-15 keV photons. The Proportional Counter Array (PCA) experiment on NASA's Rossi X-ray Timing Explorer (RXTE) has been operating since December 30, 1995. The PCA features unprecedented time resolution in combination with moderate spectral resolution. Time scales from microseconds to months are covered in an instantaneous spectral range from 2 to 250 keV. We demonstrate that X-ray Occultation Sounding (XOS) is a viable method to determine the structure of the upper atmosphere in terms of the total number density of atmospheric constituents by using atmospheric occultation of celestial x-ray sources. We now have an ensemble of approximately 30 occultations of two different X-ray sources using both the USA and PCA experiments. In general, our measurements demonstrate general agreement with the nominal NRLMSISE-00 model (Picone et al 2000), but with some differences of up to 30% at some altitudes for some occultations. Also, we demonstrate that XOS is very sensitive to satellite position determination and the time resolution of the occultation data. In addition, some of these results are compared to results obtained from the High Resolution Airglow/Aurora Spectroscopy Experiment (HIRAAS) experiment. This research is the first to study the neutral atmosphere in this energy range, and complements UV airglow remote sensing techniques used aboard ARGOS that are less sensitive to nighttime neutral density.

SA22A-0101 1330h POSTER

Horizontal Sounding Rocket Plasma Density Measurements of Growth Phase Aurora

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The Horizontal E-Region Experiment (HEX) sounding rocket was launched on March 25, 2003 at 09:50:01 UT from Poker Flat, Alaska into a near horizontal trajectory through a stable, growth phase auroral arc. The near horizontal flight path of the probe first transited a broad, diffuse aurora, then through the stable auroral

arc that was the primary subject of the HEX experiment and finally through a dim, fading arc before reentering the atmosphere. The HEX payload included a trimethyl aluminum (TMA) chemical tracer, photometer and plasma instrument to investigate vertical winds that may exist in the E-region of the ionosphere poleward of a stable auroral arc. The plasma probe measured the ambient relative plasma density to determine if plasma depletions might be associated with vertical winds observed by the TMA tracers. The plasma probe successfully returned in-situ measurements from the vicinity of the auroral arcs, but did not detect plasma depletion signatures linked to vertical winds. Analysis of the response of the plasma instrument in the context of the experiment will be presented. Primary emphasis will be placed on interpreting the response of the plasma instrument's segmented fixed DC collector to resolve ambient positive ion density and secondary auroral electron energy and density estimates as the probe passed through these three auroral regions.

SA22A-0102 1330h POSTER

Hemispheric asymmetries in the location and intensity of the auroral ovals and their association with ionospheric convection and IMF

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As the orbit of the Polar spacecraft has precessed over time, the VIS Earth camera has been able to capture simultaneous images of the aurora in both the northern and southern hemispheres. The angular resolution of these images is sufficient to be able to determine the accurate location and intensity of the two ovals. Preliminary studies have revealed that while the auroras seem to be mirror images of one another on a broad scale, there are a number of fine scale features which are not conjugate in both hemispheres. The mapping of the auroras has revealed that there are longitudinal differences in the onset locations. In this paper, we use the radars of the northern and southern SuperDARN network to investigate whether the convection patterns match the longitudinal differences in the onset locations of the auroral features in the two hemispheres. Differences in the auroral intensity detected in the two hemispheres were found and we determined their association with the electric field strength and convection speeds. The IMF data were studied to determine if these hemispheric asymmetries were due to variations in the IMF direction.

SA22A-0103 1330h POSTER

Electric Field Estimates of the Auroral Electrojet from Imaging Radar Observations

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A 30 Mhz imaging radar located in Anchorage, Alaska provided ground support for the JOULE campaign in March 2003. During the campaign, we observed type 1 and type 2 echoes with Doppler shifts that showed rapid variations in space and time. We will present velocity field variations using spectral decomposition of the radar echo types and provide electric field estimates as a function of range and azimuth. Instrumented rocket flights took place in the region illuminated by the radar which would allow us to compare the electric field estimates from the radar with the in-situ rocket measurements.

SA22A-0104 1330h POSTER

Simple Diffusion Theory Models for Joule Heating in the Thermosphere

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The precipitation of accelerated charged particles and strong increases in ionospheric currents during geomagnetic disturbances take place mainly in the auroral oval. This energy is transmitted to the thermosphere, raising exospheric temperatures there. The thermal energy is transmitted equatorward by gravity waves and neutral winds which can be described by a diffusion equation with some suitable diffusion coefficient. The observed dependence of the enhancement of the exospheric temperature on geomagnetic latitude and the Kp index is determined. Simple diffusion theory models for the latitudinal variation of Tinf are obtained by solving the heat equation in a two-dimensional plane and transforming the solution on to the curved spherical surface of the thermosphere. Analytical solutions for three simple models are obtained: (1) An instantaneous line source at the geomagnetic pole; (2) An instantaneous cylindrical source covering the auroral oval and the polar cap; and (3) An instantaneous annular cylindrical source coinciding with the auroral oval. Models 1 and 2 yield good agreements with the observed latitudinal variation of Tinf with suitable choices of the standard deviations. Model 3 gives only fair agreement with observation.

SA22A-0105 1330h POSTER

Transonic Heating Effects in the Auroral Thermosphere

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We review substantial recent developments to the CTIP coupled thermosphere-ionosphere-plasmasphere model, using observations from the Aberystwyth ionospheric tomographic imaging chain and the IMAGE satellite to benchmark and validate the model results. Thermospheric heating in auroral regions has classically been viewed as a combination of Joule Heating (macroscopic frictional heating from the ionosphere), Lorentz forcing (microscopic momentum transfer from ions) and particle precipitation. Of these, it has been shown that above about 110 km, Joule Heating is the dominant energy transfer mechanism. However, ion velocities during disturbed times often approach or exceed the neutral sound speed. We investigate shock front heating through modelling using the improved CTIP model and compare these with in-situ satellite observation. We conclude that shock heating may be a significant contribution to the auroral thermosphere-ionosphere energy balance.

SA22B MCC: 2006 Tuesday 1340h

Ionosphere Measurements and Models II

Presiding: **A G Burns,** National Center for Atmospheric Research**; J M Ruohoniemi,** Applied Physics Laboratory, Johns Hopkins University

SA22B-01 1340h

Direct Comparison of DMSP and SuperDARN Measurements of Ion Flows in the Polar Ionosphere

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The horizontal convective ion flow in the polar ionosphere plays a key role in characterizing the conditions connecting the Earth's ionosphere with the magnetosphere and the solar wind. Currently there are two methods of directly measuring the horizontal ion flow in the F-layer: the ion flow detectors onboard the polar-orbiting DMSP satellites and using the radar signals detected by the SuperDARN radar arrays. Each method has its own strengths and limitations, but in the regions where they overlap the question arises over whether their measurements match or not. To date some informal studies have shown a fair amount of agreement, but no systematic comparison has ever been done before this. We have identified a set of over 50 events during 2001 when there were good data from SuperDARN corresponding to periods when the DMSP satellites passed through their fields of view. These events occur under all IMF conditions and during various Kp levels. We present the results of the first look at four of these events that contain six or more DMSP passes. We compare the measured horizontal ion flows observed by both sets of instruments to determine how closely they match. In addition we compare the polar cap potential drop measured by the DMSP-F13 satellite with the potential calculated by SuperDARN using a combination of radar observations and model predictions

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Comparison of 30 Day Continuous EISCAT Svalbard ISR Data with an Ionospheric Model Driven by SuperDARN Convection Patterns

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During October and November 2002 the EISCAT incoherent scatter radar at Svalbard, Norway, operated continuously over a 30 day period. Altitude profiles of electron density are available at high time resolution throughout the study period. The observations collected during this campaign present an unprecedented opportunity for model/data comparisons, of both a space weather and a climatological nature. The Utah State University Time Dependent Ionospheric Model (TDIM) has been used to simulate the ionosphere above Svalbard throughout the month-long study period. In the first stage of this study, in which statistical-empirical representations of the convection electric field and auroral precipitation patterns were used, the model/data comparison brought us insight

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