what would be seen coming from an expanded and continuous, auroral oval source region. The ENA emissions coming from the winter hemisphere vary diurnally in intensity suggesting that under these conditions the dayside auroral oval/cusp region is the dominate source of the emissions. As activity increases, the altitude range of the auroral zone ENA emission region increases. This presentation will address the following three questions raised by this data. 1) Where do these neutral emissions come from? 2) What processes produce them? 3) What does this data tell us about ionosphere/magnetosphere coupling processes?

SA31B-05 0945h

Storm-Time Enhancements of Balmer-alpha Brightness at Arecibo: Transport of Atomic H or Low Latitude Aurora ?

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Two-fold enhancements of the atomic hydrogen Balmer-alpha airglow brightness are witnessed in the first 48 hours following the DST excursion demarking magnetic storm onset. The cause of these secular airglow brightness variations are alternately ascribed to enhancements of the atomic hydrogen column abundance due to global exospheric transport, or to collisional excitation of the Balmer-alpha emission by energetic neutral atoms generated in the ring current by proton recombination. These alternatives are evaluated by inspection of Balmer-alpha Doppler line profiles measured by the Arecibo Fabry-Perot interferometer during these post-storm brightness enhancements. The line profile analyses show no strong evidence for collisional excitation of those fine structure spectral components not present in the quiescent Balmer-alpha airglow feature pumped only by resonant-fluorescence of solar Lyman-beta photons. As such, the Arecibo data are consistent with global transport of neutral H to mid-latitudes following magnetic storms.

SA32A CC: 519 A Wednesday 1030h

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

Presiding: **J Semeter,** SRI International; **R Schunk,** Utah State University

SA32A-01 1030h INVITED

3-D Dynamic Behavior of the Generalized Polar Wind With Low-Altitude Auroral Ion Energization

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The effects of low-altitude energization (LAE) of ions in the auroral region are investigated using a 3-D dynamic model. In this study, we simulate the behavior of a large number (∼100 to 1000) of plasma-filled geomagnetic tubes. The model is composed of two components. The high-altitude component is based on a macroscopic particle-in-cell (mac-PIC) approach that extends from an altitude of 1200 km to several Earth radii. The lower boundary conditions of the mac-PIC model are provided by a 3-D fluid-like model (low-altitude component) that extends down to 100 km in altitude. The total number of simulation particles in the mac-PIC component is more than 10^8. The generalized polar wind is followed for about 12 hours with a time step of 2.5 seconds. The computing-intensive nature of the model requires utilization of super computers with ∼100 to 1000 processors. A 3-D picture is assembled from the temporal evolution of the individual flux tubes by keeping track of their locations. The resulting 3-D dynamic picture is investigated with special emphasis on the role that the LAE plays. The main conclusions are: (1) In the absence of LAE, the dominant source of escaping O^+ occurs within the polar cap due to the influence of magnetospheric electrons; (2) Both upward and downward O^+ fluxes occur at low altitudes, while only upward O^+ fluxes occur at high altitudes; and (3) Downward O^+ fluxes occur essentially during the storm recovery phase, at the equatorward edge of the polar cap, within the dawn-noon sector.

SA32A-02 1050h

Observations of Ionospheric Outflows at low and Middle Altitudes

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Ionospheric outflows as observed at middle altitudes, such as those sampled by the FAST spacecraft, appear to be controlled by two energy inputs to the ionosphere: Poynting flux and soft electron precipitation. The former produces outflows because of ion heating in the ionosphere through collisional ion-neutral friction, the latter through electron heating. FAST observations alone can only partially address the relative importance of the two processes, since both Poynting flux and electron precipitation are often correlated. Observations of the lower altitude ionosphere, below 800 km, by radars such as the EISCAT Svalbard Radar (ESR), can resolve this ambiguity. The ESR provides observations of ion and electron temperatures as well as field-aligned ion flow velocities. Preliminary analysis indicates that electron temperatures are usually enhanced in regions of ionospheric outflows as observed by FAST. In addition there are indications that the ions are also heated. Furthermore, the ion heating is at times observed to extend to lower altitudes than the electron heating, with a corresponding structure in the upward flow velocities.

SA32A-03 1105h

Origin of type-2 thermal-ion upflows in the auroral ionosphere

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The origin of thermal ion outflows exceeding 1 km/s in the high latitude F region has been a subject of considerable debate. For cases with strong convection electric fields, the evaporation' of the ions due to frictional heating below 400-500 km has been shown to provide some satisfactory answers. By contrast, in the more frequent subclass of outflow events observed over auroral arcs, called type-2, there is no observational evidence for ion frictional heating. Instead, an electron temperature increase of up to 6000 K is observed over the outflow region. In this case, field-aligned electric fields have long been suspected to be involved, but this explanation did not seem to agree with expectations from the ion momentum balance. In the present work we introduce for the first time the electron energy balance in the analysis. We couple this equation with the ion momentum balance to study the salient features of the observations and conclude that type-2 ion outflows and the accompanying electron heating events are indeed consistent with the existence of a field-aligned electric field. However, for our explanation to work, we have to require that allowance be made for electron scattering by high frequency turbulence. This turbulence could be generated at first by the very fast response of the electrons themselves to a newly imposed field-aligned field. Their high frequencies would make it impossible for the ions to be affected by the waves. We have found the electron collision frequency associated with scattering from the waves to be rather modest, i.e., comparable to the ambient electron-ion collision frequency. The field-aligned electric field inferred from the observations is likewise of the same order of magnitude as the normal ambipolar field, at least for the case that we have studied in detail. We propose that the field-aligned electric field is maintained by the north-south motion of an east-west arc. The magnetic perturbation associated with the arc itself converts a small fraction of the perpendicular electric field into a field parallel to the total magnetic field, while the north-south motion ensures that the conversion never stops.

SA32A-04 1120h

Inductive Magnetosphere-Ionosphere Coupling

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A method for coupling a global magnetospheric MHD model to either an empirical ionospheric model or a dynamic ionospheric-thermospheric model is described for conditions in which inductive electric fields are important at low altitude. Existing coupling schemes based on quasistatic dynamics are valid for processes occurring on time scales of order 100 s or longer. The formulation developed here provides an efficient algorithm for extending the validity of the coupling model to faster magnetospheric processes, down to time scales of order 10 s, while retaining the physics of quasistatic coupling as the long time-scale limit. Both lumped and distributed formulations for the coupling-region fields are developed. The inclusion of magnetic induction gives rise to magnetic energy storage at low altitude. With additional extensions of the coupling model, this magnetic energy reservoir may provide a causal conduit for parameterizing ion heating processes leading to outflow.

URL: http://thayer.dartmouth.edu/spacescience/wl/pub/Lotko04.pdf

SA32A-05 1135h

Modeling the Continuous Ionosphere - Thermosphere - Magnetosphere System with the Integrated Space Weather Prediction Model (ISM)

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Historically, global models of the magnetosphere and ionosphere/thermosphere have operated in isolation, with each type of model treating the other region as a boundary condition. In recent years, existing stand-alone models have been linked together to create models that cover the entire ionosphere-thermosphere-magnetosphere (I-T-M) system. Unlike these models, the Integrated Space Weather Prediction Model (ISM) is a global first-principles two-material MHD model of the entire I-T-M system with no boundaries between the different regions. The two-material MHD equations, complete with the full Ohm's law including the Hall terms, provide self-consistent electromagnetic and material coupling throughout the ISM computational domain which extends from 40 earth radii (R_e) sunward of the earth to 300 R_e tailward, and down to a lower ionospheric boundary at approximately 100 km altitude. We describe the model and use currents, electric fields, and ion and neutral velocities to illustrate the I-T-M coupling that is inherent in ISM.

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SA32A-06 1150h

What Governs Ion Outflow Composition?

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The variety of outflows in the polar ionosphere fall into two categories: bulk ion flows with energies up to a few eV, such as the polar wind and auroral bulk upflow, and energetic ion outflows such as upward ion beams and conics, in which a portion of the ion population is accelerated to much higher energies, and upwelling ions in the cleft, which have typical energies up to a few tens of eV and characteristic temperatures of a few eV. In general, the composition of each outflow population in

each category exhibits specific solar activity, seasonal, and magnetic activity dependences. In this paper, we examine the contributing factors that govern or play a key role in the composition of ionospheric ion outflow, using statistical results from ion composition observations on Akebono, Polar, and Dynamics Explorer-1.

SA33A CC: 519 A Wednesday 1330h

Ionosphere Anomalies

Presiding: **A G Burns,** National Center for Atmospheric Research; **B P Williams,** Colorado State University

SA33A-01 1330h

Model of Anomalous Electron Heating in the E Region

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The objective of this paper is to present a numerical model of anomalous electron heating due to the Farley-Buneman instability. The model includes some basic elements. The turbulent electric field is assessed by a heuristic model, based on physical reasoning and on a comparison with few in-situ observations available. Since the electron distribution under a strong electric field is non-Maxwellian, the computer code is employed which solves local kinetic equation that describes the evolution of the electron distribution function in the presence of turbulent electric field. Then the frequency of electron-neutral collisions along with the rate of electron inelastic losses is computed using the modified electron distribution function. The electron and ion temperature are found from the equations describing the energy balance which includes the inelastic losses. The effect of the electron and ion heating on the sound speed, and thus on the threshold of the F-B instability is also taken into account. Finally the output of the model is checked against some available radar observations of the elevated electron temperature obtained during magnetic storms.

SA33A-02 1345h

Coincident extremely large sporadic sodium and sporadic E layers observed in the lower thermosphere over Colorado and Utah

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On the night of June 2, 2002, the CSU sodium lidar measured an extremely strong sporadic sodium layer lasting from 3.5 to 5 UT with several weaker layers later in the night at 6 and 9 UT. There is a double layer stucture with peaks at 101 and 104 km. The peak sodium density was 21,000 atoms/cm^3 with a column abundance up to twice the normal sodium layer. The peak density was 500 times greater than the typical density at that altitude. The abundance and strength factor were higher than any reported in the literature. The two lidar beams, separated by 80km at this altitude, both measured 1 hour periodicities in the abundance, but directly out-of-phase. There is also evidence for strong wave activity in the lidar temperatures and winds. The NOAA Boulder ionosonde measured an foEs of 14.3 MHz at 3 UT on this night, the highest value during 2002. The Bear Lake, Utah dynasonde also measured intense Es between 2-5 UT and again from 6-8 UT about 700 km west of the lidar, with most of the ionograms during these intervals measuring Es up to 12 MHz, the limit of the ionosonde sweep. Other ionosondes around North America on the NGDC database measured normal foEs values that night, so it was a localized event. Using the sodium density, wind and temperature from the lidar and the ionospheric data from the ionosondes, we will investigate the formation mechanism for this extreme event.

SA33A-03 1400h

Propagation of the Lightning Electromagnetic Pulse Through the E- and F-region Ionosphere and the Generation of Parallel Electric Fields

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Sounding rockets launched by Mike Kelley and his group at Cornell demonstrated the existence of transient (1 ms) electric fields associated with lightning strikes at high altitudes above active thunderstorms. These electric fields had a component parallel to the Earth's magnetic field, and were unipolar and large in amplitude. They were thought to be strong enough to energize electrons and generate strong turbulence as the beams thermalized. The parallel electric fields were observed on multiple flights, but high time resolution measurements were not made within 100 km horizontal distance of lightning strokes, where the electric fields are largest. In 2000 the "Lightning Bolt" sounding rocket (NASA 27.143) was launched directly over an active thunderstorm to an apogee near 300 km. The sounding rocket was equipped with sensitive electric and magnetic field instruments as well as a photometer and electrostatic analyser for measuring accelerated electrons. The electric and magnetic fields were sampled at 10 million samples per second, letting us fully resolve the structure of the parallel electric field pulse up to and beyond the plasma frequency. We will present results from the Lightning Bolt mission, concentrating on the parallel electric field pulses that arrive before the lower-frequency whistler wave modes. We observe pulses with peak electric fields of a few mV/m lasting for a substantial fraction of a millisecond. Superimposed on this is high-frequency turbulence, comparable in amplitude to the pulse itself. This is the first direct observation of this structure in the parallel electric field, within 100 km horizontal distance of the lightning stroke. We will present evidence for the method of generation of these parallel fields, and discuss their probable effect on ionospheric electrons.

SA33A-04 1415h

Electron Impact Dissociative Excitation of Ionospheric Ions: Rate Coefficients and Implications for Ionospheric Studies.

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A survey of the literature indicates that dissociative recombination is seemingly the only interaction between molecular ions and electrons that is considered in ionospheric studies. Dissociative recombination begins with a collision between an electron and a molecular ion in which the ion captures the electron, resulting in the formation of an unstable neutral molecule that subsequently stabilizes by dissociating. In the dissociative recombination of an arbitrary molecular ion AB^+; AB^+ + e yields A^* + B. Being effectively the only electron loss mechanism in planetary ionospheres, dissociative recombination is a very significant process. Owing to the typically high reaction rates, dissociative recombination in general is the most important interaction between molecular ions and electrons in planetary ionospheres. We discuss at length the dissociative recombination of ionospheric ions in a topical review paper (2003ja010132) that will appear in the near future in JGR: Space Physics. Dissociative recombination is, however, not the only possible interaction. In recent years, molecular physicists have made considerable progress in the study of a variety of molecular ion-electron processes both theoretically and experimentally. One of these processes in particular, electron impact dissociative excitation, is potentially of considerable significance for ionospheric studies. In the dissociative excitation of an arbitrary molecular ion AB^+; AB^+ + e yields A^* + B^+ + e. Experiments have consistently shown that as collision energy increases, dissociative excitation cross sections begin to dominate over dissociative recombination cross sections. Like dissociative recombination, dissociative excitation is a source of excited atoms and so both processes will contribute to emissions. Unlike dissociative recombination, dissociative excitation is a source of atomic ions and after a dissociative excitation interaction there is still a free electron. These differences have potential implications for a variety of studies, including those which involve ionospheric composition, and those which involve electron cooling rates. Using published experimental electron impact dissociative excitation cross sections for NO^+, $O_2{}^+$, and $N_2{}^+$ we have calculated both temperature dependent and energy dependent reaction rates for the dissociative excitation of these species of ions. These calculations, in conjunction with our previous work on the dissociative recombination of ionospheric ions, have allowed us to estimate dissociative excitation to dissociative recombination branching ratios for these species of ions for both ground state and vibrationally excited ions. We have found that as collision energies increase, dissociative excitation rates can dominate dissociative recombination rates by up to two orders of magnitude. We will present the results of our reaction rate and branching ratio calculations as well as a discussion of possible implications.

SA33A-05 1430h

Ion Cyclotron Heating of Ionospheric O^+ Ions in the Presence of Finite Collisions

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A quasi-linear mechanism for ionospheric O^+ ion acceleration by left hand polarized ion cyclotron waves propagating along the magnetic field lines is proposed. Ion-ion collisions, which enhance the classical quasilinear heating process and the charge exchange reactions, $O^+ + O \to O + O^+$, that quench the heating, are included in the physical model. The derived equation governing the evolution of the distribution function and describing the heating process in the presence of collisions is solved numerically. The impact of collisions on the heating process is assessed for different ionospheric heights. The results of this theoretical investigation are compared with observational data primarily related to ion acceleration in the topside ionosphere (at altitudes greater than 300 Km). The fundamental difference between the proposed model and previous published models is the addition and therefore the impact of collisions on the heating process.

SA33A-06 1445h

Gamma Ray Flashes due to Plasma Effects in the Stratosphere: Role of Whister Waves Gamma Ray Flashes due to Plasma Effects in the Stratosphere: Role of Whister Waves

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The gamma ray flashes observed by satellites are correlated with thunderstorms and can be due to the large electric fields associated with the latter. This mechanism has many essential steps. It starts with the creation of a beam of runaway electrons by the static electric field in the upper part of a thunder cloud. As the beam propagates upward it interacts with whistler waves generated during cloud-to-ground lightning discharges. This leads to self-focusing of the whistler wave, producing ducts which guide the relativistic electron beam to higher altitudes. Such beams could reach altitudes in excess of 30 km so that the gamma rays generated by bremsstrahlung emission can escape the atmosphere. In this model for gamma ray generation the whistler waves play an essentila role and their properties under the lower atmospheric heights are studied.