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, $O^+ + O \rightarrow O + O^+$, 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.

The whistler waves become unstable when the number density of the relativistic electron beam is high enough to overcome the damping by the population of colder electrons. The threshold conditions are studied for different ranges of the relevant atmospheric parameters. Once the whistler waves maintain large amplitudes due to the instability, the conditions for self-focusing and channel formation, and consequently the beam propagation are studied.

SA34A CC: 517 A Wednesday 1530h

Parker Lecture *(joint with SH, SM)*

Presiding: **D N Baker,** Laboratory for Atmospheric and Space Physics

SA34A-01 1540h INVITED

The Sun and Heliosphere as Revealed by Suprathermal Electrons

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Solar wind electron distributions near 1 AU are generally well described as a superposition of two distinct components: a cool core or thermal component and a relatively hot suprathermal component. The breakpoint between these two populations commonly occurs at about 60 eV at 1 AU. The suprathermal component carries the solar wind electron heat flux, is almost always nearly collisionless, behaves largely as a test particle population streaming freely through the solar wind along the heliospheric magnetic field, and is commonly highly anisotropic in the solar wind rest frame. In this lecture I demonstrate some of the remarkable spatial and temporal intensity and pitch angle variability of the suprathermal electron component at energies below about 1.4 keV, relate that variability to different solar and heliospheric processes, and illustrate aspects of the large-scale magnetic topology of the heliosphere revealed by suprathermal electron observations.

SA41A CC: 220 C-E Thursday 0830h

General Circulation Models, Global Dynamics, Energetics, and Composition in Solar System Atmospheres I Posters *(joint with P, SM)*

Presiding: **I Mueller-Wodarg,** Imperial College London; **G Crowley,** Southwest Research Institute

SA41A-01 0830h POSTER

Simulations of High-Latitude Vortices in the Atmosphere of Jupiter

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Jupiter's atmosphere as a function of latitude consists of persistent, alternating anticyclonic and cyclonic domains. Interestingly, all the anticyclonic domains contain conspicuous, long-lived anticyclones that drift zonally at speeds that are intermediate between the domain's alternating currents. The largest and oldest is the Great Red Spot (GRS) at 22°S, which has a minor axis greater than 12,000 km and an age measured in centuries, and the next largest and oldest are the White Oval Spots (WOS) at 33°S, which numbered three for over six decades but have recently merged into a single vortex that covers about 50% the area of the GRS. The amplitude and structure of the wind fields associated with the GRS and WOS have been well sampled with Earth-based and spacecraft observations. We are interested in both how the vortices are constructed and to what extent their dynamics tells us about the environment they reside in, especially the vertical structure of the atmosphere. Theories of the nonlinear stability of vortices indicate that different balances may hold for large versus small anticyclones, but unfortunately, this is difficult to test directly because we do not yet have good observations of the structure inside Jupiter's many smaller vortices. However, we can begin to reduce the possibilities of their interior structure and their environment with forward modeling. Here, we use the EPIC atmospheric model to study Jupiter's anticyclonic domain centered at 60°N, which contains two relatively large anticyclones with minor axes of ∼5,000 km that have persisted for over ten years. The bulk dynamics of these two vortices is well constrained by observations, for example they are known to often merge with smaller vortices that have minor axes ∼3,000 km. We find that for plausible temperature and wind profiles, their interactions mainly depend on the amplitude of their interior wind field, such that we can use the observations to constrain their structure. We present these results and discuss the relationship we have found between the strength of the vortices and their size and latitudinal position. This research is funded by NASA's Planetary Atmospheres and EPSCoR Programs.

URL: http://www.louisville.edu/research/cpl

SA41A-02 0830h POSTER

The thermospheres of Earth, Titan and Saturn compared

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While measurements for the past 4 decades have given us an in-depth understanding of our terrestrial thermosphere and its coupling to the lower atmosphere, the ionosphere and magnetospthere, little is yet known about the upper atmospheres on other planets of our solar system. In the coming months, the arrival of the Cassini/Huygens spacecraft at Saturn and Titan will give us a wealth of new observational constraints on their upper atmospheres which, in spite of their equal distances from the Sun, host very different environments. Using recently developed General Circulation Models for Saturn and Titan, we may however already in anticipation of these observations obtain an understanding of principal processes controlling the dynamics, energetics and global composition in their thermospheres. This talk will highlight some key results from such simulations and elaborate an understanding of similarities and differences between Earth, Saturn and Titan.

SA41A-03 0830h POSTER

Implementation of Clouds and Precipitation for Gas-Giant GCM simulations in the EPIC Model

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To date, most gas-giant atmospheric models have either been general circulation models (GCM) without active hydrological cycles, which capture many aspects of the observed vorticity dynamics but lack the important energy transfers and feedbacks of moist convection, or 1D or 2D simulations that include latent-heat release but are missing the full range of global dynamics. We present a progress report on the implementation and evaluation of a fully active hydrological cycle in the EPIC general circulation model with application to gas giants. For each species activated by the user (water, ammonia, etc.) we invoke five continuity equations covering the following phases: vapor, cloud liquid, cloud ice, rain and snow. For the interactions between phases we have adapted recent Earth-cloud schemes and developed simplified parameterizations for jovian conditions where necessary, which we describe. We are currently testing the behavior of the model in 1D and 2D cases, which facilitates comparison to previous work. For 3D simulations, our goals are to simulate the highly energetic convective water clouds observed northwest of Jupiter's Great Red Spot, and the characteristic filamentary morphology of ammonia clouds in Jupiter's cyclonic regions. This research is funded by NASA's Planetary Atmospheres and EPSCoR Programs.

SA41A-04 0830h POSTER

Application of the Isentropic/Terrain-Following Hybrid EPIC GCM to Venus with Topography

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A major problem in planetary atmospheric dynamics that remains elusive to our understanding is equatorial superrotation. Our neighboring planet Venus exhibits this trait: the solid planet has a very slow retrograde rotation of 243 days while the cloud top travels at speeds of 100 ms^{-1} at the equator, a feature known as the "four-day" wind. In order to maintain equatorial superrotation on Venus, three-dimensional (non-axisymmetric) eddies must transport angular momentum to low latitudes (Hide 1969). Several models support the Gierasch mechanism in which Hadley cells pump angular momentum upward at the equator and wave instabilities transport it towards the equator. However, there is also support for solar thermal tides and for topographically excited gravity waves as alternative eddy sources. One of the challenges is to distinguish the contribution of these effects on a given altitude region. Yamamoto and Takahashi (2003) are the first to report a fully developed superrotation for Venus. They use a low-resolution model that employs simplified physics and a configuration for Newtonian cooling, which, as they point out, uses a vertical heating profile that has an altitude of maximum heating rate that is 10 km lower than that of the cloud-top heating maximum. As our first terrestrial-planet application of the EPIC model with its new hybrid isentropic/terrain-following vertical coordinate, we are experimenting with the Yamamoto and Takahashi configuration and are performing additional sensitivity tests regarding the horizontal resolution and the Newtonian cooling profile. By using a hybrid as opposed to a traditional sigma terrain-following vertical coordinate, the EPIC GCM is able to conveniently calculate the Eliassen-Palm flux divergence in isentropic coordinates to diagnose wave transience and nonconservative effects and avoids having the signature of the topography carried all the way to the top of the model. None of the published Venus GCM work to date includes topography, although several authors have noted its likely importance. In fact, Venus has tall mountains: Ishtar Terra covers an area similar to that of Australia and contains the highest mountain, Maxwell Montes (10 km), and Aphrodite Terra covers an area similar to that of South America. We are testing the effects of orographic waves by scaling the topography (obtained from high-resolution Magellan data) from zero to full height in a series of simulations.

URL: http://www.louisville.edu/research/cpl/

SA41A-05 0830h POSTER

Meteorological Results From the Surface to the Thermosphere Using the Global Mars Multiscale Model

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We present the latest results from the G3M (Global Mars multiscale Model). The model is based on a semi-Lagrangian semi-implicit dynamical framework employed in the Canadian Meteorological Service of Canada's weather forecast model, GEM (Global Environmental Multiscale) model. The physics incorporated into the model includes a PBL, radiative heating by solar and IR of CO_2 and (currently a climatological distribution) aerosols, surface thermal conduction. The radiative scheme accounts for the absorption and scattering by dust in the solar and Infra-Red wavelengths, the CO_2 15 μm absorption band in the Infra-Red region and non-LTE effects of CO_2 cooling in the thermosphere, and the absorption of solar EUV and UV in the thermosphere and thermal conduction. The MOLA and TES measurements from MGS are used for the surface topography and the surface albedo and thermal conductivity respectively. The upper boundary has been extended to about 200km in order to have a more comprehensive dynamical interaction between the lower and