SM21A-14 0830h POSTER

Estimating Atmospheric Neutral Density Using Joule Heating Proxies

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Currently, neutral density models that are used to estimate the atmospheric drag on low-earth orbiting satellites use F10.7 as a proxy for solar EUV input, and the ap index as a proxy for the geomagnetic input. Recent work has shown that the neutral density at a 450-km altitude as estimated by the CHAMP satellite is much better correlated to the polar cap index than the ap index. In this study, we use a portion of the CHAMP data set to develop parameters for estimating the atmospheric neutral density at 450 km, and then use those parameters to estimate the neutral density during a different portion of the CHAMP data set. We develop a skill score to determine how well we are able to predict neutral density.

SM21B CC: 518 A Tuesday 0830h

Ground-Based Arrays for the 21st Century II *(joint with SA)*

Presiding: **M Connors,** Athabasca University**; R E Denton,** Dartmouth College

SM21B-01 0830h INVITED

The Super Dual Auroral Radar Network (SuperDARN): A ground-based array of HF radars for global-scale studies of ionospheric and magnetospheric processes

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Radars have been utilized since early in the 20th century for remote investigations of Earth's upper atmosphere. Many of the terms used to describe the ionosphere in particular were derived from the characteristics of radar soundings. It is now appreciated that the ionosphere also provides a portal for viewing processes in the magnetosphere, including the impact of variability in the solar wind. Beginning in the 1970s, efforts were made to construct small systems of ionospheric radars for research at high latitudes (e.g., STARE, SABRE). These efforts culminated in the last decade with the realization of the SuperDARN concept. An international consortium of researchers and funding agencies assembled networks of HF radars that provide large-scale coverage of the high-latitude ionosphere in both hemispheres. The northern component comprises 9 instruments with sites that extend westward from Scandinavia to Alaska while the southern component consists of 6 instruments with fields of view that converge over Antarctica. The radars observe coherent backscatter from ionization irregularities in the E and F regions and measure their motions. Synthesis of the velocity data sets results in global-scale images of the convection of ionospheric plasma that are analogous to images of auroral luminosity obtained with spaced-based instruments. The radars operate continuously with a cadence of 1 or 2 minutes. Summary information is downloaded from the northern radars via real-time internet links to JHU/APL where they are combined into a nowcast of the ionospheric space weather. Further expansion of SuperDARN is planned for both hemispheres and may include sites that will extend the coverage higher into the polar cap and to mid-latitudes. The range of studies pursued with SuperDARN includes convection dynamics, M-I coupling, atmospheric gravity waves, substorm processes, ionospheric modeling, and ULF pulsations. New areas for development include estimation of the global Poynting flux with the Iridium satellite network, coordinated studies of the polar cap ionosphere with AMISR, and the exploitation of meteor scatter to study the global distribution of mesospheric winds. In this talk we will review the status of SuperDARN, describe some of the scientific and technical accomplishments to date, and discuss the application of the data to the solution of current research problems.

SM21B-02 0845h

Transionospheric HF Propagation Experiments at Auroral Latitudes

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High-frequency (HF) propagation experiments are planned as part of the Enhanced Polar Outflow Probe (ePOP) satellite mission to be launched for the Canadian Space Agency in 2007. Ground transmitters such as the CADI ionosondes and the SuperDARN radars will be operated collaboratively to emit waves for detection by the Radio Receiver Instrument of ePOP during passes in the vicinity. The scientific goals include improved understanding of F-region morphology and dynamics, wave scattering and microphysical plasma processes. Partly as preparation for ePOP, transionospheric HF propagation data recorded by the receivers of the ISIS-I and ISIS-II spacecraft are being analyzed. The measurements were made in spring-summer 1978. A ground transmitter was built in Ottawa especially for the project. Some of the ISIS data were obtained in digital form from http://nssdc.gsfc.nasa.gov/space/isis/isis-status.html. These digital data are being surveyed in an attempt to establish repeatable propagation characteristics. From these characteristics, the goal is to understand the processes experienced by waves passing through the ionosphere. Several tens of ISIS-II passes recorded at a fixed frequency of 9.303 MHz have been examined. Swept-frequency ionograms interleaved with these fixed-frequency measurements allow two-dimensional electron density distributions to be modeled in altitude and latitude. Computer code has been developed for three-dimensional ray tracing. The computed latitudinal extent of the zone irradiated at the ISIS-II altitude is approximately as observed. Within this "iris" of accessibility, the peak intensity of waves recorded at the spacecraft is within about 10 dB of what is computed with a link calculation. This calculation is based on a model for the 1-kW transmitter, a radiant-transfer calculation that follows the focusing/defocusing of rays using a three-ray pencil between ground and the satellite, and the orientation of the sounder receiving dipole. Poleward rays result in dispersed pulses, indicating quasi-perpendicular propagation that is forward scattered. Equatorward pulses are comparatively sharp and occasionally exhibit periodic fades with beat frequencies between 1 and 4 Hz.

SM21B-03 0900h

Mid-continent Magnetoseismic Chain (McMAC): A Ground-based Magnetometer Chain for Magnetospheric Sounding

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The Mid-continent Magnetoseismic Chain (McMaC) is a National Science Foundation (NSF) project that conducts research in magnetospheric sounding using ground magnetic field observations. We refer to the methodology used in this research as "magnetoseismology," reflecting its similarity to terrestrial seismology and helioseismology. The magnetoseismic research consists of two parts: the normal mode analysis that deduces the plasma density along a field line from its resonant frequencies, and the travel-time analysis that infers the density distribution in an extended region by timing the arrival of impulsive signals at multiple locations. To provide necessary data for employing magnetoseismic methods, 9 new magnetic stations will be installed in the United States and Mexico roughly along the 330° magnetic longitude meridian. These new stations will be equipped with highly sensitive fluxgate magnetometers synchronized by GPS signals. The McMAC stations and the "Fort Churchill Line" of the CANOPUS will be on the same meridian, and together they form a long north-south chain of magnetometers whose L-values range from 1.3 to 11.7. A database of the mass density of magnetospheric plasma derived from magnetoseismic methods will be established to investigate magnetospheric dynamics under different solar wind and ionospheric conditions.

SM21B-04 0915h

Plasmaspheric mass density response to geomagnetic storms determined from ULF resonance data

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The equatorial mass density the plasmasphere shows a systematic depletion in response to geomagnetic storms. A superposed epoch study of plasmaspheric mass density determined using ULF resonance data from the MEASURE magnetometer array shows a clear and systematic decrease in mass density in the day following the main phase onset of a storm. The average mass loss for $L < 3$ is roughly 35 percent of the prestorm mass density based on 81 events. The mass density typically returns to pre-storm levels within days of the storm onset. Specific storms are studied in detail to examine the variability of the plasmaspheric response to changing geomagnetic conditions.

SM21B-05 0930h

Plasmaspheric Depletion, Refilling and Plasmapause Dynamics: Coordinated Ground-Based and IMAGE Satellite Studies.

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Ground-based magnetometer and IMAGE satellite RPI and EUV instrument data have been employed in order to monitor the magnetospheric plasma density and thus plasmapause dynamics which occurred throughout a prolonged moderately active interval between the 5th and 17th May 2001. The ground-based results derived using the cross-phase technique were compared to in-situ satellite measurements, as well as model and observed plasmapause location, during both depletion and refilling intervals. The results of the ground-based and satellite techniques show excellent agreement, thus validating the ground-based technique and verifying its usefulness for monitoring global plasmaspheric dynamics. Comparison of cross-phase determined plasma density and RPI determined electron number density also enabled heavy ion dynamics to be examined, the results suggesting the presence of an enhanced heavy ion population in the inner plasmatrough region during the refilling interval. An observationally elusive reverse cross-phase signature was also identified in the vicinity of a very steep plasmapause. Using the excellent combined RPI and cross-phase coverage we compare our reverse cross-phase observations to those expected theoretically.

SM21B-06 0945h

Field-line resonances in arbitrary magnetic field topology

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We present first results of a cold plasma field-line resonance model which can be utilized in arbitrary magnetic field topology. It turns out that for realistic magnetospheric magnetic fields there is no orthogonal coordinate system which is aligned everywhere with the background magnetic field. Therefore, a more general description based on covariant-contravariant formalism is required. We discuss the mathematical methods for computing the metric tensor coefficients required in this case and present the set of equations for covariant components of the perturbation electric and magnetic fields. An eigenvalue problem for these equations is solved numerically to compute the fundamental resonance frequency of a twisted magnetic field line and the results for several background field configurations are shown.

SM22A CC: 518 A Tuesday 1030h

Ground-Based Arrays for the 21st Century III *(joint with SA)*

Presiding: **R E Denton,** Dartmouth College**; B J Fraser,** Cooperative Research Centre for Satellite Systems

SM22A-01 1030h INVITED

Maximizing utility of THEMIS All-Sky Imager Array Data for Science, Space Weather, and Public Outreach

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THEMIS (Time History of Events and Macroscale Interactions during Substorms) is scheduled for launch in 2006. THEMIS will consist of five satellites on equatorial orbits with apogees at 10, 20, and 30 Re, relatively phased on those orbits so every four sidereal days the five satellites are in conjunction over central Canada. The primary scientific objective of the THEMIS mission is to elucidate the physical sequence of events leading up to and immediately following substorm expansive phase onset. THEMIS has a significant ground-based observational component which includes a continent wide array of 20 white light auroral All-Sky Imagers (ASIs). The ASIs will operate at a cadence of one image every five seconds, and will be used to identify the location and timing of auroral substorm onset. Data from the ASIs will be available in real time and retrospectively from a web page and ftp tree. The first of these imagers was deployed in Athabasca in the summer of 2003. The entire array will be operational by fall 2006. This new array will provide a staggering amount of data. Scientific exploitation of this data set demands work in advance on the development of summary files, merging images to create mosaics, automatic techniques for cloud detection and auroral classification, and the placing of the auroral features within a magnetospheric context. Archival, rapid retrieval, and data mining requires the establishment of effective metadata and storage capacity. Rapid identification of events, space weather, and sustaining public awareness of and interest in our activities requires and effective real-time web-based display capability.

SM22A-02 1045h

All Sky Imager Array for the determination of the onset times and locations of substorms

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As the ground based component of the THEMIS NASA MIDEX program an array of optical observatories will be deployed across the entire North American arctic region. There will be 16 stations located in Canada and 4 in Alaska. The purpose of the stations is to provide spatially contiguous high time resolution coverage of the entire North American arctic region to document the aurora magnetically conjugate to the 5 THEMIS satellites. The requirement is to measure the location of the onset to an accuracy of about 1 degree of latitude and the time of onset to better than 10 second accuracy. To minimize the cost and complexity of the program the instruments operate with panchromatic wavelength response and they image on bare CCD-s. The image repetition rate (cadence) will be one image every 5 seconds and the exposure time is 1 sec in duration. The cameras have a demonstrated sensitivity of better than 1 kR. The images consisting of the full data set will be stored at the field site on hard disks for annual collection. Summary data, integrated to a grid of resolution better than one degree latitude will be retrieved via the wired or satellite internet. The cameras will operate in climate controlled enclosures to facilitate unattended operation. A magnetometer will be collocated with the cameras at each field station. It is the intention of the project to have local teachers perform routine on site supervision of the instruments and to take advantage of the educational outreach potential of their participation in the program.

SM22A-03 1100h

THEMIS Ground-based magnetometer arrays and their education and public outreach potential

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The THEMIS ground-based magnetometer array is unique in that 12 of the 20 magnetometers will be located at high schools and tribal colleges in the Northern United States as part of the THEMIS Education and Public Outreach plan. These magnetometers will help to teach students and teachers around the country about ground-based arrays, auroral physics, and space physics in general. This large ground-based array, together with an extensive THEMIS all-sky camera array in Canada and Alaska, will be used to determine the onset of substorms when the five THEMIS satellites are conjugate to these stations in the magnetotail. Because the twelve magnetometers that will be housed in schools are research-grade magnetometers, teachers and students will be able to learn about substorms using the same data which scientists will use. With the partnership of the Space Grant Consortium network, the Lawrence Hall of Science's Great Explorations in Math and Science (GEMS) teacher network, and the OSS Broker Facilitators, we are currently selecting schools and teachers that meet a very particular set of criteria both from the science and the education point-of-view. A competition in each of the states is being held to find the school best suited to teach about and house the magnetometer. We will give the results of the schools selected to participate in the THEMIS ground-based magnetometer array and education and public outreach program. We will also discuss education materials being developed to facilitate how the data will be used in the schools. In addition, through the Student Observation Network (S.O.N.) of the Sun Earth Education Forum, we will become part of a national network of classrooms who are willing to learn more and predict space weather. We will also present a brief overview of our THEMIS education and public outreach programs' Informal Education and Teacher Professional Development.

URL: http://cse.ssl.berkeley.edu/themis/

SM22A-04 1115h

Global Network of Fabry-Perot Interferometers to Observe Mesospheric and Thermospheric Dynamics

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Measurements of mesospheric and thermospheric dynamics have been obtained by numerous groups over the past several decades through the application of automatically-operating Fabry-Perot interferometers (FPI). These instruments are designed to observe the Doppler shifts and Doppler broadening of airglow emissions such as the atomic oxygen lines at 557.7 nm and 630.0 nm or a rotational line of OH molecular emissions. A variety of different FPI instrumental designs has been developed over the years in the acquisition of these results, but recent developments in detector technology have made possible the construction and deployment of FPI observatories on a scale not considered feasible until now. Moreover, operations of FPI observatories with data analyzed in real time for deposition by Internet into a central archival center for data assimilation purposes are now quite feasible. What would be the benefits and likely expenses for operating a network of such modernized FPI observatories? This paper will present a historical survey of past FPI research in terms of science results achieved, summarize the possible benefits to be gained, and close with a plan for the future expansion of the existing network of FPI observatories.

SM22A-05 1130h

Imaging Ionospheric Disturbances with a Global Array of the Ground-Based GPS TEC Receivers

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A prime example of distributed arrays of small instruments for space science research is found in the use of the existing global array of GPS receivers to provide high spatial/temporal resolution mapping of the total electron electron content (TEC) at equatorial, mid, auroral, and polar latitudes. Particularly dramatic effects are observed during major disturbances when magnetospheric electric fields perturb and redistribute the thermal plasmas of inner magnetosphere (plasmasphere/ionosphere). Enhancement and poleward displacement of the equatorial anomalies (EA), the formation of plasmaspheric drainage plumes which erode the outer plasmasphere and produce significant storm enhanced density and space weather effects at mid latitudes, and tongues of ionization which span the polar caps are all a part of the systematic redistribution of the low-latitude thermal plasma during strong events. The present distribution of GPS receivers permits mapping such features primarily over the land masses of North America and Europe, where 1x1 deg spatial and 30-sec temporal observations of vertical TEC can be achieved. Few receivers currently exist in developing countries and large gaps in coverage exist over the oceans. However, the large and meso-scale characteristics and evolution of these thermal plasma storm effects can be identified in the global maps. We address the cross-calibration of ground-based and space-based techniques to image and sample such features by comparing simultaneous observations of the major features observed during the strong storm on May 30,

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