

SA72B-0544 1330h POSTER

PML boundary conditions implementation in 1D and 2D wave propagation code for an inhomogeneous, magnetized ionospheric plasma.

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We have developed 1D and 2D full-wave propagation codes with arbitrary direction of propagation to the magnetic field and the plasma density relevant to ionospheric interaction studies. A wave launched from the bottom of computational box should be allowed to propagate out of the simulation box (top boundary for the 1D case and top and side boundaries for the 2D case) without providing spurious reflection from these computational boundaries. We have implemented the use of a Perfectly-Matched-Layer (PML) technique using matrix-marching algorithms to accomplish these goals. Results for various 1D and 2D cases with the existence of mode conversion layers for specified density profiles will be presented. These codes can be used to accurately compute the detailed mode structure of radio wave in complex magnetized plasma environments.

SA11A MCC: 134 Monday 0830h

Nicolet Lecture (joint with SH, SM)

Presiding: D N Baker, University of Colorado, Boulder

SA11A-01 0830h INVITED

Aeronomy: From Exploration to Data Assimilation

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During the last century, there has been continual progress with regard to elucidating the important aeronomy processes that operate in the Earth's upper atmosphere. However, the progress was not uniform and there were certain periods of time when significant advances in knowledge were achieved due to an important discovery, a novel instrumental technique, or a new international program. Shortly after Marconi successfully transmitted radio signals across the Atlantic Ocean, the existence of the ionosphere was clearly established and its source, peak height, and layer characteristics were determined. In the mid-1940s, the rocket technology that became available was used by scientists to study the ionosphere and upper atmosphere. The great potential of this new technology, coupled with a major advance in ground-based instrumentation, led scientists to realize that a significant increase in knowledge of the terrestrial environment was possible. This resulted in the International Geophysical Year (1957-58) and the launch of the first satellite (Sputnik I). Another significant advance in aeronomy began in the mid-1980s, with the advent of supercomputers, the development of global numerical models, the existence of numerous ground-based instrument networks, and the proliferation of satellites. At the beginning of the new millennium, aeronomy is at the threshold of another rapid advance in knowledge due to the use of data assimilation techniques. Although data assimilation has been widely used by both meteorologists and oceanographers for several decades, only recently has there been a sufficient quantity of data for this approach to be useful in aeronomy. During the coming decade, tens of millions of measurements of the ionosphere-thermosphere system could become available on a daily basis from a myriad of in situ and remote sensing instruments. These data sets can be assimilated into a time-dependent, physics-based, numerical model of the ionosphere-thermosphere system via Kalman filters or other assimilation techniques. As a result, it will be possible to provide time-dependent 3-dimensional reconstructions of the ionospheric and thermospheric densities on an hourly basis day after day. These reconstructions will not only greatly advance aeronomy, but will also provide important societal benefits.

SA11B MCC: 134 Monday 1000h

Tracing the Sun-Earth Connection Into the Upper Atmosphere: Study of the April 2002 Events I (joint with SH, SM)

Presiding: L J Paxton, Applied Physics Laboratory; J U Kozyra, University of Michigan

SA11B-01 1000h INVITED

Tracing the Sun-Earth Connection: The April 14-24, 2002 Events

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The interaction of the Earth with the Sun and the local space environment is complex and presents many challenges if that interaction is to be fully understood. The April 14-24, 2002 events may well serve as the catalyst for a new way of approaching the science that we do. A flotilla of spacecraft that can study the Sun, the interplanetary medium, the magnetosphere, and the Earth's atmosphere are now providing data. For the first time we can trace, in some detail, the chain of causality from the Sun to the Earth. We also have available to us a range of first principle models that allow us to validate our understanding of the physics of these processes by completely specifying their inputs and comparing their outputs to actual observations. Data provide the ultimate reality check on the models. This reality check will allow us to evaluate how faithfully models handle the transition from one region of applicability to another as we trace this storm from the sun to the Earth. For convenience we can consider this system of systems to consist of four chains that span physics disciplines: solar particles, magnetospheric drivers, solar radiance, and energy balance. In the invited talks that follow each element in this chain will be summarized. In this event we are able to trace the production of a disturbance on the Sun as active regions, flares and coronal mass ejections, through the interplanetary medium until it impinges upon the magnetosphere and interacts with the Earth's upper atmosphere. The April storm is unique, not only for the behavior of the storm, but for the addition of the information provided by TIMED as the newest element in the constellation of satellites providing data. We hope that this interactive and cooperative study will be a paradigm for future activities

URL: <http://storms.jhuapl.edu>

SA11B-02 1020h INVITED

Solar Radiance Chain in the April 2002 Series of Flares

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The April 2002 series of solar storms included a number of GOES M- and X-class flares, in particular, a X1.5 flare on April 21 that was observed by many spacecraft - SoHO, TRACE, Wind, and the recently launched RHESSI (Ramaty High Energy Solar Spectroscopic Imager), which is designed to study flare hard X-ray/gamma-ray emissions. At the same time the effects of these emissions on the Earth were observed by a fleet of spacecraft, including TIMED, and by ground-based instrumentation. The effects of the increased energetic photon flux on the Earth's atmosphere during solar flares is usually small in comparison to geomagnetic disturbances, but large X-class flares (such as the one on April 21, 2002) that are several hours in duration can have significant consequences. When the 1 to 10 nm region of the solar spectrum is enhanced during a flare, the energy is deposited largely in the E-region of the ionosphere, 100 to 120 km altitude, where increases in ion density, photoelectron production, airglow emission, and odd-nitrogen production can result. Higher energy photons (such as observed by RHESSI) penetrate to lower altitudes, where they have less effect on the atmosphere but can still create additional ionization in the D-region of the ionosphere, 80 to 100 km altitude, that is disruptive of certain types of radio communication. Here we present the observations of solar photon emissions and their effects on the Earth's ionosphere and atmosphere.

URL: <http://storms.jhuapl.edu>

SA11B-03 1040h INVITED

Tracing the Sun-Earth Connection: The Solar Particle Chain in April 2002

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Soon after the RHESSI spacecraft observed an X-class solar flare early on 21 April 2002 a coronal mass ejection (CME) moving at ~2500 km/sec was observed by SOHO to emerge from near the west limb of the Sun. Almost simultaneously, Type-II and Type-III radio emission was observed by the Wind spacecraft, indicating the onset of particle acceleration near the Sun. The active region on the Sun responsible for this event was magnetically well-connected to the Earth, leading to a prompt enhancement at 1 A.U. of solar particles (>10 MeV) as seen by the ACE and SAMPEX spacecraft. Strong shock-related particle acceleration continued to occur as the CME propagated outward from the sun. The solar particle enhancement lasted from 21 April to 26 April (as seen by the NOAA/POES spacecraft) and included enhancement not only of solar protons and heavier nuclei extending to hundreds of MeV/nucleon but also solar electrons. The energetic particles produced near the sun, at this and preceding interplanetary shock waves, and deep within the Earth's radiation belts were all observed using TIMED and SNOE to produce substantial effects on the chemistry of the Earth's middle and upper atmosphere. We examine the impacts of this set of events on atmospheric heating and cooling rates and on ozone densities in the mesosphere. Using the remarkable constellation of available spacecraft, we are able to follow the particle chain from the Sun's surface all the way to the deep layers of Earth's atmosphere with unprecedented completeness.

SA11B-04 1100h INVITED

Overview of One Aspect of the Sun-Earth Connection during the April 2002 Events: the "Magnetospheric Driver" Chain

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We focus on tracing a series of space storm disturbances from their solar source regions, through modifications during heliospheric propagation, impacts on the magnetosphere and ultimate dissipation in the Earth's upper atmosphere. We are able to follow the linked chain from Sun to Earth because of an unprecedented collection of satellite and ground-based observations with the recently launched TIMED spacecraft completing our view into the upper atmosphere. The exciting new information is contained in the view of the global system response that is emerging from the collaborative analysis of these events by solar, heliospheric, magnetospheric and aeronomy communities. We will try here to provide a preliminary overview of one of the sun-to-Earth chains which led to significant Geospace impacts in this time interval, described as the "magnetospheric driver" chain. This overview will serve to place more detailed and focused talks given in this session into a global context. We describe a chain of events that started with a multiple set of eruptions at the Sun producing a complex highly perturbed plasma environment at Earth defined by three distinct time-periods of CME ejecta. The three storms that resulted were each characterized by quasi-periodic (every 2-3 hours) large-scale auroral activations in the high-latitude ionosphere. The effects of these spatial and temporal periodicities propagated throughout the magnetosphere, and into the ionosphere/upper atmosphere system producing important perturbations to the structure, dynamics and chemistry. The development of fine-scale structures in the auroral region was one interesting aspect of the periodicity.

SA11B-05 1120h INVITED

Energy Balance in the Sun-Earth System During the Solar Storm Events of April 2002

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The Solar Storm events of April 2002 offer a unique opportunity to observe and define the response of the Sun-Earth system to a large impulse of energy emanating from the Sun. An unprecedented series of observations allows us to trace the flow of energy from the Sun to the Earth and determine the balance of energy in the heliosphere, the magnetosphere, the thermosphere, and the Earth's lower atmosphere. Observations from the recently-launched Thermosphere-Ionosphere-Mesosphere Energetics and Dynamics (TIMED) satellite dramatically illustrate the response of the Earth's upper atmosphere to these events, while observations from satellites composing the Earth Observing System (EOS) may allow us to determine the effects of the solar activity on the lower atmosphere. This talk will focus on the balance of energy within the Sun-Earth system, on the conversion of energy from the Sun to heat and radiation within the Earth's atmosphere, and the subsequent impact on the atmospheric structure.

SA11B-06 1140h INVITED

TIME(D) for SYNERGY

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The launch of NASA's Thermosphere Ionosphere Mesosphere Energetics and Dynamics (TIMED) spacecraft on December 7, 2001 coupled with collaborative efforts supported by the NSF CEDAR program, has inaugurated a new era in the study of the Sun-Earth Connection (SEC). The goal of SEC science is to trace the flow of energy from the Sun into the Earth's atmosphere. We have studied most of the individual elements in this chain, but the TIMED launch put in place the final link. It is already clear that TIMED and CEDAR/TIMED data will enable us to greatly expand our understanding of the energetics and dynamics of the upper atmosphere. The TIMED launch has, however, also catalyzed studies in many areas outside of its prime region of interest. With TIMED in place we have, in combination with an already substantial fleet of other spacecraft and an extensive collaborating ground-based community, for the first time, instrumentation in position to study energy flow all the way from the center of the Sun to the surface of the Earth. The fact that the effects of solar activity can now be traced down into the atmosphere is leading to a new paradigm in SEC studies in which researchers focus on understanding the processes that connect different regions rather than detailing the properties of one or another specific area. This is being ably demonstrated by the ongoing study of the April 14 to 24, 2002, period, which is rich in both the variety of geophysical phenomena that are observed and the availability of the data with which to explore and characterize these phenomena. Several examples of the sorts of new perspective that TIMED has fostered will be presented.

SA12A MCC: 134 Monday 1330h

Tracing the Sun-Earth Connection Into the Upper Atmosphere: Study of the April 2002 Events II (joint with SH, SM)

Presiding: N J Fox, Applied Physics Laboratory; E R Talaat, Applied Physics Laboratory

SA12A-01 1330h

RHESSI Observations of Flares During the Storms Period from 14 to 24 April 2002

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The Reuven Ramaty High Energy Solar Spectroscopic Imager (RHESSI) observes X-rays and gamma rays from solar flares in the energy range from 3 keV to 17 MeV with a duty cycle of about 50%. The RHESSI observations of the flares during the Storms Workshop period from 14 to 24 April, 2002, will be reviewed. Many GOES C- and M-class flares were observed including the M2.6 flare on 17 April that was followed by a CME. The X1.5 flare on 21 April was particularly well observed with RHESSI in X-rays from its start at 00:40 UT until 01:33 UT on the first orbit, just before the soft X-ray peak. Footpoint emission was detected to energies as high as 200 keV, and a spatially-separated coronal source was identified at energies below about 30 keV. The coronal X-ray source was followed for over 12 more hours on subsequent orbits as it gradually rose to over 130,000 km above the limb. The X-ray images and spectra of this flare will be presented in relation to the TRACE images in the 195-angstrom band and the LASCO images of the associated CME.

URL: <http://hesperia.gsfc.nasa.gov/~ptg/hessi/20020421/>

SA12A-02 1345h

Solar, Interplanetary, and Geospace Disturbances Associated with the April 2002 Coronal Mass Ejections

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The Solar and Heliospheric Observatory (SOHO) detected a large number of coronal mass ejections (CMEs) during the April 14-24, 2002 period. We describe the properties of these CMEs and contrast them with those of the general population of CMEs. We explore the connection of these CMEs to the interplanetary shocks and the solar energetic particles events using Wind and GOES data, respectively. We assess the extent of preconditioning of the corona by repeated flaring and mass ejections from the active regions involved. Based on the arrival times of the interplanetary CMEs and shocks, we discuss the evolution of these disturbances as they propagated between the Sun and Earth. We compare the extended nature of the main phase of the complex geomagnetic storm to other similar extended storm periods

URL: http://cdaw.gsfc.nasa.gov/CME_list/sec/

SA12A-03 1400h

Composition and Spectra of Solar Energetic Particles from ~0.1 to >100 MeV/nucleon during the April, 2002 Storms Period

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We report measurements of the composition, energy spectra, and time variations of solar energetic particles (SEPs) during the April 14-24, 2002 Storms period. This period included three fast coronal mass ejections (CMEs) and several interplanetary shocks that affected the low-energy particle intensity at 1 AU, including the 4/21/02 SEP event that was among the largest of solar cycle 23. We use data from ACE and SAMPEX to measure the energy spectra of accelerated ions from H to Fe ($1 \leq Z \leq 26$) over the energy range from ~0.1 to >100 MeV/nucleon during the course of this event. By comparing the onset time of >30 MeV protons with CME images from SOHO we determine that the highest energy particles were first accelerated within 3 solar radii of the Sun. The high-energy (>5 MeV/nucleon) spectra of all species have a 'knee' at 10-20 MeV/nucleon - at lower energies (<1 MeV/nucleon) there is a separate spectral component that most likely reflects the contributions of particles accelerated by interplanetary shocks as they approach 1 AU. By combining data from several instruments over a wide energy range it is possible to characterize the separate acceleration processes at work during this time period and to provide a comprehensive measure of solar and interplanetary particle input to the Earth's upper atmosphere.