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 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.

SA12A-04 1415h

The Release and Propagation of Near-Relativistic Electrons During the April 2002 Sun-Earth Connection Events

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Relativistic solar electrons can play a role in the magnetospheric-ionosphere system response. Because their transit time to Earth is little more than 10 minutes, detailed knowledge of their acceleration, injection, and propagation mechanisms is critical to establishing a causality chain to the Earth's upper atmosphere. The time period 14-24 April 2002 contains two periods of high intensities ($\sim 10^6$/cm^{2}s.sr.MeV) of near-relativistic electrons (38-315 keV) measured by the EPAM experiment on the ACE spacecraft that we can use to probe the causality of this response. First, on April 17 near-relativistic electrons were injected in association with flare and coronal mass ejection (CME) activity (2N/M1.2 flare S14W34 at 07:46 UT). By coincidence, an interplanetary shock passed over ACE less than 3 hours later at 10:21 UT, somewhat enhancing the impulsively injected particles. The electron intensities then decayed over the next day to $\sim$ 3% of their post-shock value. Second, the large west limb activity on 21 April 2002 (2N/M2.6 flare S14W84 at 00:43 UT) was associated with at least three erupting (CMEs), as imaged by LASCO on the SOHO spacecraft. The earliest projected CME launch (extrapolated to 1 $R_\odot$) was at 01:15 UT for the dominant CME in the ecliptic plane, which had a projected speed of 2247 km/sec off the west limb. Electrons were injected promptly into the interplanetary medium when the radial distance of this CME was $\sim$3.5 $R_\odot$), based on the arrival of 175-315 keV electrons at the ACE spacecraft and assuming a path length of 1.2 AU. Unlike the 17 April event, the electron intensities continued to rise by $\sim$300% over the next day, and then decayed only by $\sim$10% when the CME-related shock arrived at ACE at 04:15 UT on 23 April. Consequently, even though the peak intensities of the first and second electron events were comparable, the fluence in the second was much greater (contributing to its increased geo-effectiveness).

SA12A-05 1430h

Global "Sawtooth " Activity in the April 2002 Geomagnetic Storm

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One of the most interesting aspects of the April 2002 geomagnetic storm was the quasi-periodic geomagnetic activity that we refer to as "sawtooth" events. Sawtooth events were first identified as an intriguing signature in the LANL geosynchronous energetic particle fluxes showing sharp increases in particle fluxes followed by gradual decreases which repeat roughly every 2-3 hours. The variations are similar to the standard dropout and injection of energetic particles see in isolated substorms. However, unlike isolated substorms, after each injection a new dropout begins immediately, over a broad range of energies, producing the characteristic sawtooth profile. Furthermore the sawtooth signatures are seen at all local times, not just the near-midnight sector. Space magnetometer data show that the dropouts and injections are produced by exceptionally strong stretching and dipolarization of the magnetic field and confirm that the stretching begins immediately after the preceding injection without an intervening recovery phase. However, ENA observations show that these events are true injections of fresh particles and not an adiabatic re-arrangement in response to the field changes. Auroral observations likewise show clear auroral onsets with each sawtooth injection, but those onsets can be embedded in ongoing auroral activity rather than distinct episodes separated by quiet intervals. It is not surprising that sawtooth activity is a subset of geomagnetic storm activity (intervals of large negative Dst). The quasi-periodicity and clear separation of each onset are not, however, characteristic of most geomagnetic storms. Additionally, each individual sawtooth is associated with an increase in the SYM-H component. Sawtooth intervals such as those in the April 2002 storm provide a unique opportunity to deconvolve the effects of quasi-steady and impulsive responses of the magnetosphere. In addition to discussing the magnetospheric response and solar wind driving that produces these interesting sawtooth signatures we discuss the implications for the interpretation of the broad range of geomagnetic responses to the April 2002 storm interval.

SA12A-06 1445h

Global Ionospheric Response to the April 2002 Storm: Tracing the Energy Flow

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The first coordinated TIMED/CEDAR storm campaign of April 14-24, 2002, provides an excellent opportunity for the space physics community to tackle some outstanding questions regarding the Sun-Earth connection, such as the energy coupling between the Sun and the Earth. A set of comprehensive data has been collected both from space and from ground to study this event, including the global auroral images from the IMAGE FUV instrument, auroral precipitation from polar orbiting satellites, ion drifts from the SuperDARN radars, and magnetic perturbations from a global network of ground magnetometers. The Assimilative Mapping of Ionospheric Electrodynamics (AMIE) procedure is used to derive "snapshot" maps of the large-scale ionospheric electrodynamic fields. The preliminary analysis of the data has indicated dynamic changes in the ionospheric electrodynamic system during the storm, with AE going up to 2400 nT and Dst going down to -150 nT. Energy deposition in terms of auroral precipitation and Joule heating will be estimated, and the variability of the energy inputs associated with geomagnetic activity as well as solar wind conditions will be examined. We also investigate energy partitioning in the upper atmosphere.

SA12A-07 1530h

The Relative Atmospheric Impacts and Energy Inputs of Precipitating Solar and Magnetospheric Ion and Electron Populations during the 17-24 April 2002 Events

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A rich variety of solar and magnetospheric particles precipitated into the upper atmosphere during a series of 3 magnetic storms and a solar particle event that occurred in rapid succession linked to active region 9906. These populations include: large-scale periodic (every 2-3 hours) activations of the auroral oval precipitation, a significant auroral high energy tail, ring current precipitation, a series of solar protons and solar relativistic electron populations entering the expanded storm-time polar cap, and one of the larger solar energetic particle events of this solar cycle including enhanced >10 MeV/nucleon particles, near-relativistic electrons and high energy protons. The relatively soft energy spectrum of the solar proton event has interesting implications for the depth of penetration and ultimate impacts on the upper atmosphere. The combination of these solar and magnetospheric particles produced dramatic and long-lasting changes to the structure, chemistry and composition of the upper atmosphere. We focus on the relative energy input from each of these populations versus time and estimate their contributions to heating, ionization and the production of chemically-active minor species in the upper atmosphere. We use this information to identify solar drivers that produced particularly geoeffective particle inputs to the upper atmosphere both in terms of energy input and the altitude where they produce their maximum impacts.

SA12A-08 1545h

Multi-Instrument Observations of Ionospheric Outflow in Response to the Storm Events of 14-24 April 2002

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The major storm events of 14-24 April 2002, initiated by several solar disturbances, produced significant

enhancements in many regions within the terrestrial magnetosphere. In particular, we investigate the ionospheric response to such disturbances as observed by close orbiting spacecraft. Data will be presented from the LENA imager on the IMAGE spacecraft, the TIDE instrument on Polar and the ion spectrometer on the four Cluster spacecraft. All the instruments observe outflow on the 18th April 2002, although the orbits of the spacecraft are such that the timings of the outflow are not simultaneous. Nevertheless, the magnetosphere is highly disturbed at this time due to the arrival of interplanetary shocks and the storm activity as a result. In this study we present the observations from the three spacecraft and make an attempt to place these observations into context with the large-scale Sun-Earth interaction which has taken place. The outflow events are most likely a result of the enhanced magnetospheric activity, though we try to relate the event to particular features observed in both the solar wind and the inner magnetosphere.

SA12A-09 1600h

Penetration Electric Fields and Magnetospheric Convection During the April 2002 Storm

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We present measurements of the cross-polar-cap potential drop and the extent and magnitude of the electric field penetration during the April 2002 storm, provided by ion drift measurements on three DMSP spacecraft. The cross-polar-cap potential drop exceeded 150 kV on four occasions near Dst minima on April 17, 18, 19, and 20. In the absence of significant shielding near the inner edge of the ring current, measurable electric field penetration to low L-values was observed, maximizing near the Dst minima. The auroral oval reached a minimum magnetic latitude near 50 degrees while substantial electric fields penetrated to below 40 degrees magnetic latitude. The potential drop equatorward/earthward of the auroral oval/electron plasma sheet was a sizable fraction of the total potential drop across the polar cap/magnetosphere during the main and early recovery phases of the storms, at times exceeding 60 kV. We discuss these results and their implications of the formation and decay of the storm time ring current.

SA12A-10 1615h

The Global Ionosphere During the April 17 to 20, 2002 Magnetic Storm

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The structure of the global ionosphere during the April 17 to 20, 2002 magnetic storm is investigated using a number of simulation techniques. The observations show that the daytime densities were reduced by a factor of 3 for three consecutive days within the continental US. Although they are in the same longitude sector, the East and West coasts of the US show differing patterns. The Northern and Southern hemisphere also behave differently, in spite of the fact that the storm is close to equinox. During most of the storm period, the Equatorial Appleton anomaly is reduced, both in strength and in width. The ionospheric assimilative model called PRISM was used to estimate the profiles of ionospheric density throughout the globe during the April 2002 magnetic storm. The inputs to PRISM are vertical Total Electron Content (TEC), F-region Maximum density and height, as well as DMSP data such as high-latitude particles and auroral boundaries. TIEGCM simulations of the ionosphere for these days were performed. We compare the output from the assimilative model with that from the TIEGCM simulation in order to explain the reasons for the agreements and disagreements between the theoretical simulation model, and the ionospheric assimilation model. To explain the behavior of the Equatorial anomaly, we examine the electrodynamics in the low-latitude region for the event.

SA12A-11 1630h

GUVI/TIMED Observations During the April 14-24, 2002 Storm

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The Global Ultraviolet Imager (GUVI) on the NASA Thermosphere Ionosphere Mesosphere Energetics and Dynamics (TIMED) spacecraft is a hyperspectral imager that operates in the far ultraviolet (110 to 180 nm). During the April storm GUVI observed changes in the observed radiance that can be interpreted in terms of changes in composition in the ionosphere and thermosphere (IT) and the coupled response of the IT system to forcing from outside the atmosphere.

In this paper we review the results of the ASPEN TIMEGCM runs and compare them to the GUVI observations. We will report on our analysis of the neutral composition measurements and the observed change that occured in response to external inputs. We will also report on our analysis of the GUVI observations of the nightside ionosphere. In those observations we see the clear signature of the interaction of the IT system as it responds to high latitude forcing.

URL: http://guvi.jhuapl.edu

SA12A-12 1645h

HALOE Observations of Perturbations in High Northern Latitude NO and Ozone During the April 2002 Solar Storm Episode

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The April 2002 solar storm event provides a unique opportunity to study the resulting effects on upper atmospheric constituents such as NO and ozone. Two sources may perturb these constituents. For a magnetic-storm-source, energetic particles collide with and dissociate nitrogen molecules in the lower thermosphere to produce excited nitrogen atoms which then combine with O to produce NO. The NO subsequently gets transported down to lower altitudes where it reacts with and thus destroys mesospheric and possibly stratospheric ozone. For a solar-particle-event-source, high-energy particles penetrate directly into the mesosphere, break apart nitrogen molecules and water vapor, creating NOx and HOx to destroy ozone in the middle atmosphere. We present perturbations in high northern latitude NO and ozone as measured by the Halogen Occultation Experiment (HALOE) aboard the Upper Atmosphere Research Satellite between April 20-27. HALOE observations show an order of magnitude increase in mesospheric NO and a factor of 2 decrease in mesospheric O3. We will also compare these observations with NASA GSFC 2D model computations.

SA21A MCC: Hall D Tuesday 0830h

Extracting Power From Multiple Rivers of Data I Posters *(joint with SH, SM)*

Presiding: **E Hildner,** NOAA Space Environment Center**; T Fuller-Rowell,** CIRES University of Colorado and NOAA Space Environment Center

SA21A-0419 0830h POSTER

Exospheric temperature formulation for use in atmospheric density models based on new data and proxies

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The exospheric temperature for the Earth's upper atmosphere is often specified by an empirical formulation for Jacchia-type neutral thermosphere density models. The Jacchia 1970 model, for example, uses an equation that was derived from a relationship between the 10.7 cm solar radio flux (F10.7) and observed satellite drag nearly 40 years ago. F10.7 is representative of solar coronal emissions. In the last few years, advances in two separate areas have converged to provide an enormous step forward in exospheric temperature/thermospheric density specification. First, information on the long term orbit evolution of a few key satellites over several solar cycles became available. Second, the E10.7 solar proxy, representative of both chromospheric and coronal solar emissions, was developed and compared with the F10.7 proxy for use in