

SH42A CC: 518 A Thursday 1030h**Violent Sun-Earth Connection Events of October-November 2003: Geospace Impact II (joint with SA, SM)****Presiding:** C Farrugia, University of New Hampshire; X Li, University of Colorado**SH42A-01 1030h INVITED****Violent Sun-Earth Connection Events of October-November 2003 and the Earth's Radiation Belts****J Bernard Blake** (310-336-7078; jbernard.blake@aero.org)

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The response of the Earth's radiation belts to the events of October-November 2003 were complex and differed in interesting ways from other remarkable events in the past several years. In contrast to the two events in November 2001, no new, long-lasting ion belts were formed, and those persisting from the November 2001 event were unaffected. However energetic electrons were injected deeply into the slot region, and included energies up to several MeV, but not above 10 MeV. ESP electrons with energies above 10 MeV were seen for several hours, and penetrated to $L = 3.5$, but apparently not injected into the radiation belts. Data from SAMPEX, Polar, HEO1, HEO3 and MEO1 will be used to illustrate these and other happenings during this period of intense solar and geomagnetic activity.

SH42A-02 1050h INVITED**Impact of Fast CMEs on Ring Current During October-November 2003 Super Storms****Yusuke Ebihara**¹ (301-286-6674;

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We survey the major impacts, on the terrestrial ring current, of a series of fast coronal mass ejections that occurred in October and November 2003. Our study focuses on the energetics of the ring current ions (with energy range of tens of keV) trapped by the geomagnetic field. Fortunately, the good coverage of satellite orbits in various regions enables us to monitor how the ring current responds to the unusual variation of the solar wind and the interplanetary magnetic field (IMF) during these super storms. The DMSP F13 satellite provides measurements of the polar cap potential drop which is the total strength of convection, and saturation of the polar cap potential drop is evident. An excellent constellation of LANL satellites provides temporal and spatial variation of the source population of

the ring current (plasma sheet density and temperature) at the geosynchronous altitude. The low-altitude NOAA 17 satellite continuously monitored the temporal evolution of the trapped and precipitating particles with energy greater than 30 keV. An extremely deep penetration of the ring current ions was detected on November 20, with 30-80 keV ions reaching $L=1.5$ or less. The IMAGE satellite captured the global distribution of the ring current protons by measurement of the energetic neutral atoms (ENAs), even though the IMAGE/HENA instrument suffered from extremely ENA high count rates when IMAGE was at low altitude during the super storms. On October 29th, IMAGE/HENA monitored an abrupt injection and exhaustion of the ring current protons due to a spike of negative IMF Bz that reached -40 nT and lasted only for about 7 minutes, according to Geotail/MGF just upstream of the bow shock. This short-lived and highly-intensive spike depressed SYM (as a proxy of Dst) to about -300 nT within 1 hour. Simulations are performed with the Comprehensive Ring Current Model to investigate the physical processes governing the ring current during the super storms. An initial result of the simulation is that the rapid recovery of the ring current as indicated by Dst cannot be solely attributed to charge exchange with neutral atoms during the storms. Unusual pitch angle scattering (leading to precipitation into the atmosphere) or other processes (decrease in the plasma sheet density and temperature) may be required.

SH42A-03 1110h**Global Modeling of Magnetospheric Effects of the October-November 2003 Geomagnetic Storms****Joachim Raeder** (603-862-3414; J.Raeder@unh.edu)

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The large magnetic storms of October-November 2003 provide us with a unique opportunity to study the response of the magnetosphere to extreme solar wind and interplanetary magnetic field conditions. While these storms did not stand out in terms of Dst size, they are associated with unprecedented values of the solar wind speed. Although the solar wind measurements were contaminated by solar energetic protons, the efforts of the ACE team have yielded a reliable data set that allows us to model this event with high-quality input data to our model. In this talk we present results from global simulations of these events. Specifically, we discuss the response of the magnetopause, the evolution of the cross polar-cap potential, and the evolution of the open flux in the geomagnetic tail.

SH42A-04 1125h INVITED**Simulation of the Halloween Magnetic Storm****C C Goodrich** (ccg@bu.edu)M J Wiltberger² (wiltbjem@ucar.edu)W Wang² (wbwang@ucar.edu)J G Lyon¹ (lyon@tinman.dartmouth.edu)L Kepko¹ (lkepk@bu.edu)¹Center for Space Physics, Boston University 725 Commonwealth Ave, Boston, MA 02215, United States²High Altitude Observatory, National Center for Atmospheric Research, Boston, CO 80301, United States

A central goal of the Center for Integrated Space Weather Modeling is to understand the intense solar and resulting terrestrial activity that occurred from October 22 to November 04 2003. In this paper we focus on the geospace impact toward the end of this period, October 29 to November 1. Using upstream solar wind data, we simulate the response of the earth's magnetosphere and ionosphere/thermosphere in two ways. First we use the Lyon-Fedder-Mobarry (LFM) global MHD code to simulate both the magnetosphere and ionosphere. In addition, we simulate this period with the version of LFM that we have coupled to the NCAR Thermosphere Ionosphere Nested Grid (TING) code, in which TING replaces the height integrated ionosphere model integral to LFM. We have attempted to use as accurate solar wind observations as possible for our simulations. To this end, we have attempted to ameliorate the effect of flare particles on the ACE plasma measurements by using SOHO and WIND data. We will compare our results with the available magnetospheric and ionospheric observations, in particular AMIE results and observations from geosynchronous satellites. [This work is supported by NSF grant ATM-0120950].

SH42A-05 1145h**Energized Ions in the Dayside Magnetosphere During the SEC Events of Late October 2003****M F Thomsen**¹ (505-667-1210; mthomsen@lanl.gov)C A Cattell² (cattell@fields.space.umn.edu)B Lavraud¹J E Borovsky¹J Dombek²¹Los Alamos National Laboratory, MS D466, Los Alamos, NM 87545, United States²University of Minnesota, 116 Church St. SE, Minneapolis, MN 55455, United States

The strong solar wind disturbances of late October 2003 produced dramatic consequences in the magnetospheric environment at geosynchronous orbit, including numerous magnetopause crossings, encounters with polar cap field lines, extensive intervals of extremely dense plasma sheet, and strong flows of field-aligned ions, reaching energies above 10 keV. In apparent association with sudden dynamic pressure variations, temporal bursts of field-aligned ions were observed by several Los Alamos geosynchronous satellites over a wide range of dayside local times. These bursts exhibited clear time-of-flight dispersion characteristics, enabling the estimation of the burst time, ion species, and source location. In the same time frame, the FAST satellite made numerous passes through the pre-noon sector at low altitudes. For at least 7 consecutive orbits (14 hours) on 31 October and for several orbits on both 29 and 30 October, FAST observed multiple bands in the ion energy spectrum in the region from $L 4$ to $L 12$ on the day side. The energy of the bands ranged from 50 eV to 10 keV, and the energy of each band remained fairly constant across the full latitude range of a given pass. Multiple bands were observed in both H^+ and O^+ , and the band energies for the two species were essentially the same. Comparison of the low-altitude banded ions and the simultaneously-observed geosynchronous field-aligned ions provides important constraints on the source mechanism(s) for this significant contribution to the dayside ion population.

SH43A CC: 220 C-E Thursday 1330h**Analysis of the 1859 Carrington Event and Other Major Superstorms I Posters (joint with SA, SM)****Presiding:** D F Smart, Air Force

Research Laboratory; M A Shea, Air Force Research Laboratory

SH43A-01 1330h POSTER**The Carrington Event: Possible Solar Proton Intensity-Time Profile****D. F. Smart**¹ (+1-603-888-6839; sssrc@msn.com)M. A. Shea¹ (+1-603-888-6839; sssrc@msn.com)K. G. McCracken² (+1-301-405-4854; jellore@hinet.com.au)¹Air Force Research Laboratory (VSBX)(Emeritus), 29 Randolph Road, Hanscom AFB, Bedford, MA 01731-3010, United States²IPST, University of Maryland, College Park, MD 29742, United States

We evaluate the >30 MeV proton fluence associated with the Carrington event as 1.9×10^{10} protons per sqcm based on the analysis of solar proton generated NO(y) radicals that are deposited in polar ice. (See McCracken et al., JGR, 106, 21,585, 2001.) We construct a possible intensity-time profile of the solar particle flux for this event by assuming that it is part of the class of interplanetary shock dominated events where the maximum particle flux is observed as the shock passes the earth. We show that most of the very large solar proton fluence events (those with >30 MeV omnidirectional fluence exceeding 1×10^{10} protons per cmsq) observed at the earth during the last 50 years belong to this class of event.

SH43A-02 1330h POSTER

The Carrington Storm of 1859 IMF, IEF, TPP, and Dst

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From the shock transit time of the 1859 Carrington event, we use statistical relations to infer a shock speed, ICME speed, and maximum ICME field strength. Using average upstream solar wind and IMF conditions, we also infer the profiles of the ram pressure and IMF strength through the ICME-sheath. The Bombay magnetogram for the event gives the magnitude of the SSC and the duration of the transit time passed the earth of the ICME sheath. Since this event occurred during Solar Cycle 10, there is a statistical likelihood that the IMF in the ICME went from north to south as it passed the earth. We use these pieces of information, statistical relations and inferences to construct a probable scenario for the time sequence of solar wind and IMF parameters for the event. We feed this sequence of parameters into analytical models that convert upstream solar wind and IMF data into estimates of the position of the stagnation point, the value of the transpolar potential, and the profile of Dst. Some results: This was probably a two-phase Dst storm with the ICME-sheath driving the first phase and the trailing half of the ICME the second phase. The transpolar potential saturated at a value that probably exceeded 400 kV, and Dst probably reached -600 nT during both storm phases. The stagnation point probably moved to within 3 Re of the center of earth.

SH43A-03 1330h POSTER

How big was the Carrington 1859 Flare?

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The 1859 space weather event was distinguished by its great geomagnetic storm, widespread low-latitude aurora, and intense solar energetic particle event (inferred from the NO₃ concentration in polar ice cores). Arguably each of these three effects was the largest ever observed. What can we say about the size of the associated solar flare? We have two observations with which to make such an assessment: (1) Carrington's and Hodgson's report of the white-light flare and (2) the solar flare effect or magnetic crochet observed in the Kew and Greenwich magnetograms. Estimates of the area, duration, spectrum, and intensity of the white-light emission indicate a large (~2 x 10³⁰ erg) but not unequal event (the white-light emission of the 24 April 1984 >X13 flare contained ~6 x 10³⁰ erg). The magnetic crochet of 130 nT in the horizontal force, however, exceeds that for all >X10 soft X-ray flares observed from 1984-2002 (we are presently compiling magnetic data for the recent October-November 2003 activity for comparison with the 1859 event). Thus at this point, we can conservatively say that Carrington's flare likely had a soft X-ray classification >X10 and was at least comparable to the largest flares recorded during the spacecraft era.

SH43A-04 1330h POSTER

Magnetosphere-Ionosphere Coupling During Major Storms

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We have investigated the response of the magnetosphere-ionosphere coupled system under extreme forcing during a number of superstorms when Dst was less than -250 nT. We find that (1) large penetration electric fields are generated which extend to the equatorial region causing ionospheric irregularities; (2) the cross-polar cap potential saturates at levels well below that predicted from the interplanetary electric field imposed on the Earth; (3) intense

ionospheric field-aligned currents are observed intermittently during the main phases of the storms which have incommensurate ground magnetic signatures; (4) the magnetic field which maps to the ring current is inflated well beyond pre-storm distances. We will discuss these phenomena and their consequences for the global M-I system.

SH43A-05 1330h POSTER

Comparisons of magnetospheric simulations of the 1859 Carrington event with and without inner magnetospheric coupling

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The University of Michigan has recently completed a prototype space weather modeling framework (SWMF), including a global magnetospheric MHD model (BATSRUS), the Rice Convection Model (RCM), and a global ionosphere thermosphere model (GITM). The RCM provides high-energy particle physics within the inner magnetospheric region, which MHD is unable to model. These high-energy particles make up the ring current. This distribution of particles can dramatically alter the pressure distribution, and thus the global configuration, of the magnetosphere. It is therefore of interest to examine the results of simulations with and without the RCM to quantify the effects of the ring current on the global state of the magnetosphere. This is done for the 1859 Carrington event, in which the simulations of the magnetosphere without the ring current showed the magnetopause to be completely within geosynchronous orbit at all local times. We will show how the ring current changes the structure and location of the magnetopause, cusps, and ionospheric current system during this extremely disturbed period.

SH43A-06 1330h INVITED POSTER

Modeling the Carrington Event: sun-to-earth propagation of a very fast CME

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We present a three-dimensional (3D) numerical ideal magnetohydrodynamics (MHD) model describing the time-dependent propagation of a CME from the solar corona to Earth in just 18 hours. The simulations are performed using the BATS-R-US (Block Adaptive Tree Solarwind Roe Upwind Scheme) code. We begin by developing a global steady-state model of the corona that possesses high-latitude coronal holes and a helmet streamer structure with a current sheet at the equator. The Archimedean spiral topology of the interplanetary magnetic field is reproduced along with fast and slow speed solar wind. Within this model system, we drive a CME to erupt by the introduction of a Gibson-Low magnetic flux rope that is embedded in the helmet streamer in an initial state of force imbalance. The flux rope rapidly expands driving a very fast CME with an initial speed of in excess of 4000 km/s and slowing to a speed of nearly 2000 km/s at Earth. We find our model predicts a thin sheath around the flux rope, passing the earth in only two hours. Shocked solar wind temperatures at 1 AU are in excess of 10 million degrees. Physics based AMR allows us to capture the structure of the CME focused on a particular Sun-Earth line with high spatial resolution given to the bow shock ahead of the flux rope.

SH43B CC: 518 A Thursday 1330h

Violent Sun-Earth Connection Events of October-November 2003:

Ionosphere/Atmosphere I (joint with SA, SM)

Presiding: S Basu, Air Force Research Laboratory; A D Richmond, NCAR High Altitude Observatory

SH43B-01 1330h INVITED

Impacts to Electric Power Grid Infrastructures From the Violent Sun-Earth Connection Events of October-November 2003

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The solar flare activity of October-November 2003 reached historic intensity levels and produced several large Earth-directed CME's that had the potential to cause historically large geomagnetic storms as well. These CME's did cause various geomagnetic storm indices, particularly the regional K and Planetary Kp index, to reach maximum levels for many hours. However, the resulting geomagnetic storms, while causing isolated and important disruptions to power grids, were not of historically large size when considering the rate-of-change of regional geomagnetic fields in many locations. Impacts to power grids are caused by large dB/dt variations in regional geomagnetic fields, in most cases the peak geomagnetic disturbance intensities (in nT/min) were only a fraction of what has occurred during historically large geomagnetic storm events. A review will be provided of the CME passages and features of the passage that drove resulting geomagnetic storm events and impacts to electric power grid infrastructures on October 29-30, 2003. A brief overview of the geomagnetic storm disturbance morphologies and intensities relative to other noteworthy storms will also be provided.

SH43B-02 1350h INVITED

IMAGE-FUV observations of the October-November 2003 flare and magnetic storm effects on Earth

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The series of solar flares and coronal mass ejections that occurred between October 26 and November 4, 2003 had extraordinary effects on Earth's upper atmospheric and space environments. In several areas these effects can be quantified by space-based global imagers such as the Far Ultraviolet Imager on the NASA-IMAGE satellite. The immediate effects of the X-Ray and EUV components of the solar flares on terrestrial photoelectron fluxes are evident in the rapid, global variations in FUV brightness. IMAGE was favorably positioned in its 14-hour orbit to monitor the time variation of the photoelectron flux enhancement during four of the X-class flares, including the two greatest flares of the period, providing an indirect measure of the solar EUV irradiance enhancements. Also measured indirectly by the FUV geocoronal imager is the enhancement in the solar FUV HI Lyman alpha irradiance during each of the four flares. The October 28, 2003 flare produced an estimated 20% enhancement in the solar Lyman alpha irradiance at Earth, the largest increase ever observed. The global FUV imager also is able to determine the effects of the CME induced magnetic storms on thermospheric composition, with accurate global measurements of the FUV emissions of OI at 135.6 nm. A global survey of the O/N₂ ratios through the entire period of activity is therefore possible. Comparisons with TIMED-GUVI flare observations and NCAR TIMEGCM O/N₂ will be made for cross-validation purposes.