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During the period 29 October - 6 November four shocks were observed at Earth by ACE/SWEPAM/MAG and ACE/SWICS on 29 October, 30 October, 4 November, and 6 November. Two distinct and very intense geomagnetic storms, associated with the X17.2 and X10/2B flares, rank as the largest storms of Solar Cycle 23. For example, the X17.2 flare (28 October, S16E08 in AR0486), via its associated halo CME and shock wave, was responsible for the Dst = -347 nT index on 30 October 2003. We will present the use of an adaptive grid 2D MHD model to study these four shocks in detail. Accordingly, four separate pressure pulses, at the appropriate times and with different strengths and duration are introduced at the Sun to mimic the four flares. The results show that the simulated solar wind velocity time series successfully match the observations at L1.

SH51A-15 0830h INVITED POSTER

IMF and Ejecta Coherence Lengths During the Events of October-November 2003

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A three-spacecraft study is presented on coherence/correlation lengths of the IMF and interplanetary ejecta during the violent events of October-November 2003. The data come from ACE, orbiting around the L1 point, Geotail, following a trajectory in the dayside magnetosheath/ solar wind, and WIND, nominally located near midtail at ∼150 Earth radii downstream. The rapid flapping of the geomagnetic tail yielded long time intervals when Wind was in the downtail magnetosheath. Our primary aim is to compare the levels of correlation in the ACE-Geotail measurements and the ACE-WIND measurements, and examine them as a function of interplanetary structure and interspacecraft distance. To bring the results into proper perspective, another very active interval is examined. In this case, a repetitive sequence of solar transients gave rise to a periodic and high correlation length. The results are then intercompared.

SH51A-16 0830h POSTER

Giant X-Ray Bursts on Oct.28 and Nov.4, 2003 observed by Cluster

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Active region (Sunspot) 10486, which was about 15 times the size of Earth blasted off some mega-flares. The largest two of them were on 28 October and 4 November 2003. In fact, the Nov. 4, 2003 one saturated many X-ray detectors on the NOAA's GOES satellites and HESSI; the jury was therefore out for a while on the definitive classification of the flare (best estimate was made by NOAA X28, with a peak around 19:50 UT). It is a new #1 X-ray flare for the record books. The second-strongest flare in this historic two-week series was an X17 event on Oct. 28, 2003. However, those two giant X-ray bursts have been observed continuously by RAPID-IES onboard Cluster. Cluster was located on the duskside around 19 MLT near the magnetopause and not affected by any magnetospheric electron background at the time of the Oct. 28th and Nov 4th event. The obvious energy dispersion signatures, first from low energy to high followed by high energy to low versus time have been observed for both giant X-ray bursts. During Nov. 4, 2003 event, the RAPID instrument on s/c2 was in a mode that permitted the full 3D distribution (144 pixels) to be obtained over the unit sphere. All of the counts shown in the plot for s/c2 were registered by the two pixels that see the disk of the sun during the 4 sec rotation of the s/c. We will analyze and report on the energy dependent signature of the response of the IES sensors to these intense X-ray fluxes in terms of sensor implications and physical insights for the flare itself.

SH51B CC: 518 A Friday 0830h

Analysis of the 1859 Carrington Event and Other Major Superstorms II *(joint with SA, SM)*

Presiding: **A J Ridley,** University of Michigan**; G Siscoe,** Center for Space Physics, Boston University

SH51B-01 0830h INVITED

R.C. Carrington and the 1859 Space Weather Event

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R.C. Carrington (1826-1875) is remembered in this session as the co-discoverer of the first solar flare ever reported - on 1 September 1859. The ensuing space weather event remains a "worst case scenario" for solar-terrestrial interaction. Carrington was one of the most accomplished solar astronomers of the 19th century and is credited with the discovery of differential rotation and the variation of sunspot latitude over the solar cycle. I will review Carrington's life, which ended soon and sadly after a brief but brilliant career, and the scientific times in which he worked. I will assess the contemporary impact of Carrington's flare observation and will briefly recount how the meaning of the tantalizing clue presented by this event gradually came to light.

SH51B-02 0850h INVITED

Historically Large Geomagnetic Storms and Potential Electric Power Grid Impacts

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While recent work has been done to examine the possible Dst Intensity of historically large geomagnetic storms, the impacts caused to modern day electric power grids from these storms occurs due to rapid rate-of-change of regional geomagnetic fields which in most cases are driven by large ionospheric electrojet current intensifications. These temporally and spatially dynamic disturbance morphologies are not well-characterized by Dst or other broad geomagnetic storm indices. For estimates of storm intensity that correctly scale the threat potential to electric power grids, it is necessary to describe the rate-of-change of geomagnetic field. The rate-of-change of the geomagnetic field (dB/dt usually measured in nT/min) creates at ground level a geoelectric field that causes the flow of geomagnetically-induced currents (GIC) through ground connection points in electric power grids. Therefore in general, the larger the dB/dt, the larger the resulting geo-electric field and GIC in exposed power grid infrastructures and the greater the operational impact these induced currents will have on the power grid. Both extensive modeling analysis and recent operational experience suggests that power grids are becoming more vulnerable to geomagnetic storms as they grow in size and complexity. Also, large power grid blackouts have occurred at relatively low geomagnetic storm intensities. For example, the regional disturbance intensity that triggered the Hydro Quebec collapse during the March 13, 1989 Superstorm only reached an intensity of 479 nT/min. Large numbers of power system impacts in the United States were also observed for intensities that ranged from 300 to 600 nT/min during this storm. Yet both recent and historical data indicate that storms with disturbance levels that range from 2000 nT/min to as much 5000 nT/min may be possible over extensive regions at latitudes of concern for large continental power grids across North America and Europe. Large GIC have also been observed in power grids at low latitude locations due to other geomagnetic storm processes that in combination have the potential to suggest global-scale power grid disruptions might be plausible for historically large storms. An overview of these findings will be provided.

SH51B-03 0910h

Historic Superstorms and their Effects on Ground Electrical Systems

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The 1859 superstorm produced widespread disturbances to the telegraph system. Such was the power of the induced electric fields that telegraph operators in the eastern US disconnected their batteries and used the "celestial power" to send messages. Since then there have been many evolutions in technology with messages now being transmitted under the oceans via optical fibre cables and power being transmitted over long distances on high voltage networks. However it seems that each technological development is followed by a magnetic superstorm to remind us of our vulnerablility to the solar-terrestrial environment. This presentation details the system disturbances observed in the superstorms of September 1859, March 1940, February 1958, August 1972, and March 1989, examines the features of the magnetic disturbances that caused the problems. Consideration is also given to the characteristics of the solar-terrestrial disturbances that would have produced these effects.

SH51B-04 0925h

Solar Proton Events for 450 Years: The Carrington Event in Perspective

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Using the impulsive nitrate measurements in polar ice as identifiers of solar proton events in the past, we have identified 19 events over the period 1561-1950 that equal or exceed the >30 MeV fluence measured during the August 1972 and October 1989 events. The largest nitrate deposition (and largest solar proton fluence above 30 MeV) occurred in late 1859 in time association with the Carrington flare of September 1859. The Carrington flare occurred near the central meridian of the sun; the interplanetary disturbance associated with the solar activity rapidly traveled toward the earth resulting in an extremely large geomagnetic storm commencing within 17.1 hours of the visual observation of the solar flare. While this event was remarkable by itself, historical records indicate that the Carrington event was part of a sequence of solar activity as an active region traversed the solar disk. We compare the derived solar proton fluence for the Carrington event of 18.8 x 10**9 above 30 MeV with the solar proton fluence from more recent episodes of solar activity.

SH51B-05 0940h INVITED

The Possible Magnetospheric, Ionospheric, and Thermospheric Response to the 1859 Carrington CME.

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The 1859 Carrington event is interesting because of the possible strength of the magnetic field and incredibly strong solar wind ram pressure. This is because the coronal mass ejection only took 18 hours to propagate from the Sun to the Earth, implying a speed of over 1700 km/s, with associated magnetic fields of over

200 nT. Using the space weather modeling framework (SWMF) we have simulated the possible response of the near-Earth space environment to a coronal mass ejection (CME) which took 18 hours to travel from the Sun to the Earth. We find that the magnetosphere was compressed to within 4 Earth Radii on the dayside and within geosynchronous orbit at all local times. We further find that the timings of the magnetospheric compressions align quite well with the magnetic field measurements of the 1859 storm. We will present results of the ionospheric cross polar cap potential, thermospheric densities and temperatures, ring current strength, and other magnetospheric, ionospheric, and thermospheric quantities through out the CME.

SH52A CC: 519 A Friday 1030h

Solar Wind II

Presiding: **K W Ogilvie,** NASA Goddard Space Flight Center**; I G Richardson,** NASA Goddard Space Flight Center

SH52A-01 1030h

MHD Simulation of the Breakout Model for CME Initiation

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The “breakout” model has been proposed to explain coronal mass ejection (CME) initiation (Antiochos 1998; Antiochos et al. 1999). MHD simulations performed to date of the breakout model have used rather idealized models of the corona. In this work we will describe MHD simulations of the axisymmetric breakout model in which we include the important effect of the solar wind. In particular, our study will focus on the speed of the CMEs produced to see if the breakout model can explain observations of fast CMEs. Research supported by NSF (CISM) and NASA.

SH52A-02 1045h

MHD Modeling of 3D Coronal Eruptions

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We will investigate the evolution and stability of localized coronal magnetic fields as a model for the initiation of coronal mass ejections. Our emphasis will be on relating the topology of the magnetic field to its tendency to erupt. We will study three-dimensional coronal configurations that model the magnetic field of an active region embedded in a global dipolar coronal magnetic field, including the effect of the solar wind. Research supported by NSF (CISM) and NASA.

SH52A-03 1100h

Correlation Among Flare Emissions, CME Acceleration and Enhanced Magnetic Reconnection

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Recent solar observations have shown that the flare emission and the flux rope motion and the magnetic reconnection rate are closely related. Filament eruptions in the lower corona and CMEs in the higher corona are considered as the motion of flux ropes. From the flare-CME-filament observations it was observed that the most intense peak in the flare nonthermal emissions (hard X-ray, microwaves) and the maximum rate of increase in the total soft X-ray emission during the flare rise phase occur at the time of maximum acceleration of the flux rope's rising motion. Moreover, the magnetic reconnection rate obtained from the magnetogram data and horizontally expanding two-ribbon emissions is found to temporally correlate with the flux rope acceleration. We have performed resistive MHD simulations of the temporal evolution of flux rope motion and magnetic reconnection rate by employing a nonuniform anomalous resistivity. The simulation results show that the flux rope's accelerated rising motion is associated with an enhanced magnetic reconnection rate and thus an enhanced reconnection electric field in the current sheet during the flare rise phase. The results are in good quantitative agreement with observations of the acceleration of flux ropes (CMEs) for several CME-flare events. For the X-class flare events the peak reconnection electric field is $\sim O(10^3\ \mathrm{V/m})$ or larger, enough to accelerate electrons to over 100 keV in a field-aligned distance of 0.1 km and produce an impulsive hard X-ray emission observed during the flare rise phase, consistent with the estimated reconnection rate based on observations. Comparisons of the flux rope height, velocity and acceleration between our simulation results and observed CME-flare events will be presented.

SH52A-04 1115h

Basic Properties of Anisotropic Stellar Wind Expansion in the Fluid Approach

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In the solar wind, which is the prototype of stellar wind, two kinds of particle temperature anisotropy are observed. The proton temperature perpendicular to the interplanetary magnetic field (IMF) is larger than the parallel temperature in coronal holes at the origin of the fast solar wind. This anisotropy can be very large for atomic oxygen ions. This phenomenon is associated to wave-particle interactions. However, it is known that without any particle interaction, the opposite type of temperature anisotropy should develop in the expansion. This is probably the case in the slow solar wind source regions. In both cases, the electron seem to be rather isotropic in the corona but for less collisional medium the anisotropy should increase. This presentation is devoted to an analysis of dynamical properties of stellar atmosphere in the presence of the two kinds of temperature/pressure anisotropy. We choose to consider the one fluid approach in order to focus on the basic properties. The hydrostatic equilibrium conditions, the transcritical solution properties, the expansion velocity and the mass loss rate are analyzed for anisotropic isothermal and non-isothermal atmospheres. The extension of such analysis to two fluid models and multimoment models established for weakly collisional stellar winds are discussed.

SH52A-05 1130h

Evidence for Coexisting Hot and Cool Polar Coronal Jets - Coordinated Observations of SOHO and TRACE

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The polar coronal jets were first observed by SOHO instruments (EIT, LASCO, UVCS) during the last solar minimum. They were small, fast ejections originating from flaring UV bright points within large polar coronal holes. The polar holes disappeared at solar maximum and the jets were not visible anymore. Currently, however, as the Sun's activity declines, the polar holes again became permanent structures and new polar coronal jets were observed by specially designed SOHO Joint Observing Program (JOP 155). Their frequency of several events per day appear comparable to the frequency from last solar minimum. Also, the speed of $\sim$ 400 km s^{-1} at 1.6 $R_\odot$ is consistent with typical velocities of polar jets in 1996-1998. The ejections are believed to be triggered by the field line reconnection between the emerging magnetic dipole and pre-existing unipolar field. Existing models predict that the hot jet is ejected together with another jet made of cool material. The coordinated SOHO and TRACE observations within JOP 155 provide unique opportunity to test this prediction. We will present observations and discuss evidence supporting the model.

SH52A-06 1145h

The Cassini Solar Conjunction Faraday Rotation Experiment

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The Cassini Solar Faraday Rotation Experiment was conducted during the spacecraft's solar conjunctions in 2002 and 2003. A total of 160 hours of open-loop radio science data was collected at frequencies of 8 and 32 GHz (X- and Ka-bands), i.e., frequencies much higher than the plasma frequencies, but sufficiently low to undergo measurable Faraday rotation in the solar corona. During the 2002 experiment, four Coronal Mass Ejections crossed the signal ray path between Cassini and the Earth, each one imparting a different signature in the radio sounding data. The first occurred during the day of conjunction when the spacecraft's signal ray path passed to within approximately 2 solar radii of the Sun's center. The second occurred 1 day later at a solar offset distance of 3 solar radii. As shown by the EIT imager on SOHO, this event was oriented almost perpendicular to the first CME. It had a significant impact on the signal, causing the Ka-band translator on Cassini to lose lock on the uplink signal from Earth. The 3rd and 4th CMEs occurred 2 days later as a paired event when the Cassini solar offset was roughly 5 solar radii. The data received during the minimum solar elongation attained during the 2003 conjunction (proximate ray path point: 1.25 solar radii) were highly variable and represent the closest radio occultation measurement to the surface of the Sun. We discuss the Cassini Faraday Rotation data and develop models of the coronal electron density and magnetic field to simulate the measurements.

SH53A CC: 220 C-E Friday 1330h

Violent Sun-Earth Connection Events of October-November 2003 II Posters

(joint with SA, SM)

Presiding: **T H Zurbuchen,** University of Michigan**; Q Zong,** Boston University

SH53A-01 1330h POSTER

Spectral and dynamical properties of October-November 2003 storm injected electrons as observed by TSX5/CEASE

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