The interplay between observation and theory in characterising the magnetic field and dynamics of the core.

*Jackson, A

ETH Zurich, Institut fur Geophysik, Zurich, 8093, Switzerland

There is a large database of geomagnetic observations spanning the last centuries, and in the form of palaeomagnetic observations, the last millions of years. What is the best way to treat the data, in order to learn as much as possible about the magnetic field’s evolution and the dynamics of the core? I will argue that we are on the verge of a shift in interpretation technologies, and that we have much to learn from allied disciplines such as meteorology and atmospheric science. I will illustrate some ideas as to how we may be able to learn more about the dynamics of the interior of the core, by adding some relevant physics.

Parker’s Solar Wind: A History in the Making

*Zurbuchen, T H

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Approximately fifty years ago, Parker’s paper made history: It proposed a revolutionary concept of the supersonic solar wind, which, in part, defines the structure and size of the heliosphere and the space environment of each planet. This became one of the defining moments of space physics. We will provide a pictorial review of this exciting time, assess the status of this research area today, and provide an outlook toward ongoing and future topics of solar wind research.

Characterizing the Quiet Sun: Where is it?

*McIntosh, S

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Characterizing the Quiet Sun: Where is it?
**AB:** We will present and discuss results of the WHI Quiet Sun Characterization Campaign of April 10-16, 2008. Using high spatial and temporal resolution multi-wavelength observations from a broad suite of observatories we made a detailed study of the response of the quiet solar chromosphere, transition region and corona to the constantly evolving photospheric magnetic field. These joint observations show that there is no place in the solar atmosphere that is magnetically or dynamically "quiet".

DE: 7500 SOLAR PHYSICS, ASTROPHYSICS, AND ASTRONOMY
DE: 7507 Chromosphere
DE: 7509 Corona
DE: 7524 Magnetic fields
DE: 7529 Photosphere
SC: SPA-Solar and Heliospheric Physics [SH]
MN: 2008 Joint Assembly

**AB:** We present visualizations of combined heliospheric and geospace models to provide context for communicating the complex interactions of space weather. Scientific data and models are combined with modern animation tools to produce compelling visualizations to inform and educate. The Scientific Visualization Studio at NASA/Goddard Space Flight Center merges these techniques from the very different worlds of entertainment and science to enable scientists and the general public to ‘see the unseeable’ in new ways.


DE: 0530 Data presentation and visualization
DE: 7999 General or miscellaneous
SC: SPA-Solar and Heliospheric Physics [SH]
MN: 2008 Joint Assembly

**AB:** The concept of open magnetic flux can be ambiguous since, ultimately, all magnetic flux is closed. The concept is useful, however, for discussing distributions of types of magnetic flux in given domains and essential for discussing magnetic flux budgets. Conflicts over the concept arise between solar and heliospheric physicists owing to differing locations of the boundaries of their problems. What is open flux to a solar physicist may well be closed flux to a heliospheric physicist. The problem is not trivial because it bears upon the means by which the solar field reverses its polarity and the heliospheric field varies in
strength through the course of the solar cycle. Because both solar and heliospheric models of these processes successfully match a wide range of observations, it seems likely that a synthesis view can be reached. Steps in that direction will be outlined, taking into account the recently detected decline in heliospheric field strength at solar minimum.

DE: 2101 Coronal mass ejections (7513)
DE: 2134 Interplanetary magnetic fields
DE: 2162 Solar cycle variations (7536)
DE: 7524 Magnetic fields
DE: 7526 Magnetic reconnection (2723, 7835)
SC: SPA-Solar and Heliospheric Physics [SH]
MN: 2008 Joint Assembly

**HR:** 13:30h  
**AN:** SP33A-01 INVITED  
**Title:** Kinematic Dynamo Models Of The Solar Cycle  
**Author:** Nandy, D  
**EM:** nandi@mithra.physics.montana.edu  
**AF:** Montana State University, Department of Physics Montana State University, Bozeman, MT 59717, United States  
**AB:** In the kinematic approach to solar dynamo modeling, one solves for the mean magnetic field with given velocity fields such as differential rotation and meridional circulation; in addition, key physical processes such as turbulent diffusion, magnetic buoyancy and the dynamo $\alpha$-effect have to be parameterized appropriately. Kinematic dynamo models perhaps do not capture the full range of complexities of stellar convection zones and approximates complex processes through simple parameterizations. Nevertheless, the underlying physics of this class of models is relatively more transparent, they are computationally less demanding and they successfully explain many observed features of the solar cycle. In this lecture, I will trace the historical development of solar kinematic dynamo models, describe the basic physical ingredients and observational inputs necessary to build one, present our current state of understanding, and highlight outstanding problems.

DE: 2162 Solar cycle variations (7536)
DE: 7524 Magnetic fields
DE: 7536 Solar activity cycle (2162)
DE: 7537 Solar and stellar variability (1650)
DE: 7544 Stellar interiors and dynamo theory
SC: Solar Physics Division - AAS [SP]
MN: 2008 Joint Assembly

**HR:** 14:00h  
**AN:** SP33A-02 INVITED  
**Title:** Magnetic Fields in the Photosphere: Professor Parker's Contributions to our Understanding of Surface Activity on the Sun  
**Author:** Berger, T  
**EM:** merger@lmsal.com  
**AF:** Lockheed Martin Solar and Astrophysics Laboratory, O/ADBS B/252 3251 Hanover St., Palo Alto, CA 94304, United States  
**AB:** Magnetic fields in the photosphere of the Sun span sizes from large sunspot active regions on the order of 50 Mm down to the smallest observable magnetic elements 100 km or less in diameter. The generation of these fields in the convection zone and their subsequent interactions with photospheric flowfields are responsible for the majority of observed solar variability over a large range of time and wavelength scales. Professor Parker’s research has encompassed this range
and shed light on the origins of large scale active regions, the structure and dynamics of sunspots, and the implications of the highly dynamic interactions of magnetic elements with the convective flowfield. We review the contributions of Prof. Parker to these topics in the light of recent observations from both ground-based and space-based telescopes and point out issues of continuing controversy that require further theoretical and observational exploration.

DE: 7524 Magnetic fields  
DE: 7529 Photosphere  
SC: Solar Physics Division - AAS [SP]  
MN: 2008 Joint Assembly

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HR: 14:30h  
AN: SP33A-03 INVITED  
Coronal Heating and Structure  
*Antiochos, S K  
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AB: The existence of the Sun's million-degree corona is one of the oldest and most challenging problems in all space physics. It is generally accepted that the solar magnetic field is responsible for both the heating and the structure of coronal plasma, but the physical mechanisms are still not clearly understood. Gene Parker has made many seminal contributions to solving the coronal heating problem, in particular, his widely-used nano-flare model. Parker argued that in closed field regions the complex motions of the photosphere must lead to the formation of fine-scale electric currents in the corona and, consequently, to continual bursts of magnetic reconnection. We discuss the implications of these ideas for understanding the observed features of the corona. We show that the type of reconnection proposed by Parker may well account for all the well-known observations of both the closed and open field corona, and we discuss the implications of our results for upcoming NASA missions. This work was supported by the NASA HTP and TR&T programs.

DE: 7509 Corona  
DE: 7511 Coronal holes  
DE: 7524 Magnetic fields  
DE: 7526 Magnetic reconnection (2723, 7835)  
SC: Solar Physics Division - AAS [SP]  
MN: 2008 Joint Assembly

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HR: 08:50h  
AN: SH31C-02 INVITED  
Quantitative modeling of magnetic reconnection creating a twisted flux rope  
*Longcope, D  
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AB: Coronal mass ejections (CMEs) are one of the key elements coupling solar activity throughout the heliosphere. A two-dimensional model, called CSHKP has been used to explain the observed sequence of events in a typical CME. They are launched from the solar corona above reversals in photospheric magnetic polarity. Chromospheric emission during the accompanying two-ribbon flare provides evidence of magnetic reconnection. Magnetic clouds, structures observed in situ, are believed to be twisted magnetic flux ropes launched into space by the CME. Here I demonstrate a three-dimensional generalization of the CSHKP model. This model provides a quantitative picture of how reconnection in a two-ribbon flare can produce a twisted flux rope from an arcade of slightly sheared coronal field
lines. It quantifies relationships between the initial shear, the amount of flux reconnected and the total axial flux in the twisted rope. The model predicts reconnection occurring in a sequence which progresses upward even if the reconnection sites themselves do not move. This work was supported by NSF through grant ATM-0416340.

DE: 7513 Coronal mass ejections (2101)
DE: 7526 Magnetic reconnection (2723, 7835)
SC: SPA-Solar and Heliospheric Physics [SH]
MN: 2008 Joint Assembly

How Solar Flares Work

Hudson, H S

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Geophysics, radio astronomy, Japan, the ionosphere, X and gamma rays: all have contributed to my view of how solar flares and their partner coronal mass ejections (CMEs) work. A solar flare (and a CME, it turns out) has an "impulsive phase" in which catastrophic and dominant energy release from magnetic storage takes place, resulting in particle acceleration. The impulsive restructuring of the coronal currents and fields leads directly (if still mysteriously) to the many observable phenomena, which can reach the surface of the Earth. In particular we now recognize that the term "impulsive phase" correctly captures the basic morphology of the process: it is highly intermittent in both space and time, even though it underlies large-scale phenomena such as CME eruptions. We still cannot resolve the scales of the flare intermittency, but we can use in-situ observations of possibly analogous processes in the solar wind and magnetosphere for guidance.

DE: 7513 Coronal mass ejections (2101)
DE: 7514 Energetic particles (2114)
DE: 7519 Flares
DE: 7524 Magnetic fields
DE: 7554 X-rays, gamma rays, and neutrinos
SC: Union [U]
MN: 2008 Joint Assembly

Global Geomagnetic Field Changes Over the Past 10 kyrs

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Knowledge of past geomagnetic field changes, particularly the dominating dipole contribution, is of interest for a broad range of studies where the shielding effect of the field for the near-Earth environment plays a role, like e.g. for cosmogenic isotope production rates or cosmic ray induced ionization. Direct links between magnetic field variations and climate changes are a topic of current controversial debate. Several reconstructions of geomagnetic field changes over the past millennia have been devised recently. They represent either the dipole moment only by the calculation of virtual axial dipole moments (VADM) from archeointensity data, or also include long-wavelength parts of the more complex field structure by global spherical harmonic modeling. I present new spherical
harmonic models for the past 3 and 10 kyrs and compare particularly the dipole evolution given by these models to earlier reconstructions. I discuss potential reasons for systematic bias in any of the dipole moment reconstructions and argue that VADMs and spherical harmonic dipole moments should probably be taken as upper and lower bounds, respectively, for the true Holocene dipole magnitude.

DE: 1503 Archeomagnetism
DE: 1521 Paleointensity
DE: 1560 Time variations: secular and longer
SC: Geomagnetism and Paleomagnetism [GP]
MN: 2008 Joint Assembly

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HR: 17:30h
AN: SH44A-06 INVITED

Turbulence and Fossil Structure in the Solar Wind
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AB: The solar wind at 1 AU is full of discontinuities. These can be seen by sudden large changes in the magnetic-field direction, by sudden changes in the magnetic-field strength, by sudden changes in the plasma properties (density, ion temperature, ionic composition), by sudden large changes in the flow velocity. These discontinuities are interpreted to be the walls of independently moving magnetic flux tubes (plasma tubes) with a spread of orientations about the Parker-spiral direction. This flux-tube texture of the plasma has strong implications for the flow properties of the solar wind: (a) much of the fluctuating flow of the solar wind is owed to relative motions of neighboring flux tubes and (b) often large-scale solar-wind flows break up along these flux tubes. The flux-tube texture also affects the properties of the MHD turbulence in the solar wind: (a) the turbulence is confined to the insides of the flux tubes and (b) any field-line wandering driven by the turbulence is also confined to a flux tube. Using measurements from ACE, the statistical properties of the flux tubes at 1 AU are examined, including their sizes, shapes, and orientations. Mapping the flux tubes back to the rotating sun, they are statistically compared with granule and supergranule structures on the solar surface.

DE: 2109 Discontinuities (7811)
DE: 2149 MHD waves and turbulence (2752, 6050, 7836)
DE: 2169 Solar wind sources
DE: 7524 Magnetic fields
SC: SPA-Solar and Heliospheric Physics [SH]
MN: 2008 Joint Assembly

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HR: 16:20h
AN: SH44A-02 INVITED

~30 Years of Solar-Wind Data: The Floor and More
*E W Cliver
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AB:ng-term reconstructions of solar wind parameters have implications for topics ranging from the operation of the solar dynamo to solar variability and climate change. Such reconstructions of the solar wind interplanetary magnetic field (IMF) strength, beginning with the seminal work of Lockwood et al. (1999), have been varied and contentious but appear to be converging along the following lines: an
IMF floor of ~4.5 nT in the ecliptic plane on which solar cycle variations (closed flux from coronal mass ejections) ride. A recent reconstruction based on cosmic ray data by McCracken is at variance with this picture, however, and the differences remain to be resolved. The average IMF strength near Earth during 2007 was 4.5 nT (rotation averages from January 2007- present ranged from 4.1-5.2 nT). Annual averages approaching this value were last inferred (via the IDV index) for 1901 and 1902 (both ~4.7 nT). During the last century, it appears that there has been an increase, of unknown cause, in the solar wind speed of ~15%.

DE: 2134 Interplanetary magnetic fields
DE: 2164 Solar wind plasma
DE: 7537 Solar and stellar variability (1650)
SC: SPA-Solar and Heliospheric Physics [SH]
MN: 2008 Joint Assembly

Coronal Loops as the Sources for Solar Wind

* Schwadron, N

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The source of the solar wind has been an important puzzle in solar and heliospheric physics. While it is clear that the fast solar wind originates from coronal holes, the source of slow solar wind remains highly controversial. The strong differences between the composition of fast and slow wind, and the rapid variability of this composition in the slow solar wind pose a major obstacle for models with steady solar wind sources. On the other hand the observed composition is explained naturally by the conjecture that the solar wind arises from the material stored in loops, which are then opened through interchange reconnection with open field lines. The interchange reconnection process inherently supplies the mass and energy to generate the solar wind. Models for the sources of solar wind are then naturally divided between flux tube expansion models in which the final properties of the wind are dictated by the steady large-scale magnetic field structure, and loop source models in which the solar wind arises from material stored in loops that are opened through interchange reconnection. Traditionally, these models have been viewed as radically different. However, recent work is softening the strong distinction. Careful analysis of solar wind composition data and remote observations show a continuous transition between the fast and slow solar wind. This linkage between fast and slow wind suggests that the conjectures of flux tube expansion and loop sources are not exclusive; they may operate simultaneously and there may be a feedback process between the two physical drivers.

DE: 2164 Solar wind plasma
DE: 2169 Solar wind sources
DE: 7509 Corona
DE: 7526 Magnetic reconnection (2723, 7835)
SC: SPA-Solar and Heliospheric Physics [SH]
MN: 2008 Joint Assembly

Magnetic Reconnection and Flare Loop Formation in Solar Eruptions

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Solar eruptions are sudden ejections of coronal plasma and magnetic field into the interplanetary medium, accompanied by large flares in the solar atmosphere. These events are the most dynamic phenomena in the solar corona and are important drivers of space weather through particle acceleration, flare-induced coronal heating, and the interaction of the ejecta with the Earth's magnetosphere. Magnetic reconnection is believed to be the key driver of these eruptions and their associated flares, and recently the combination of high resolution solar observations and high performance computing has allowed us to make breakthroughs in understanding how this reconnection proceeds. I will present simulations of the coronal reconnection and flaring which occur behind these eruptions, focusing on localized, three dimensional reconnection in a post-eruption current sheet. I will show how the resulting reconnected fields can form evacuated coronal downflows, hot arcades of post-eruption loops, and photospheric ribbons of H-alpha flare emission, as observed by solar missions such as SOHO, TRACE, STEREO and Hinode. I will then discuss the implications of this work for the creation of plasmoids via reconnection in the Earth's magnetotail current sheet.

DE: 7519 Flares
DE: 7526 Magnetic reconnection (2723, 7835)
SC: Solar Physics Division - AAS [SP]
MN: 2008 Joint Assembly

Lunar Magnetism.

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Models of lunar magnetism need to explain (1) strong Natural Remanent Magnetization (NRM), as indicated by IRMs normalization in some of the returned Apollo samples with ages from about 3.9Ae to 3.65Ae, (2) magnetic anomalies antipodal to the young basins of a similar age, (3) the absence of major magnetic anomalies over these same basins, (4) the presence of central anomalies over some Nectarian and PreNectarian basins, and finally (5) strong fields with scale lengths of homogeneity of the order of kms, or less, found over the Cayley Formations and similar material. Observations (1), (2) and (4) have frequently been taken to require the presence of a lunar dynamo. However, if there had been a lunar dynamo at this time, why are there so few samples that carry an unequivocal strong NRM appropriate for TRM in the proposed dynamo fields. It is also an uncomfortable coincidence that the dynamo appears to cease to give strong fields close to the end of the time of heavy bombardment. Given these difficulties with the lunar dynamo model, it is worth reexamining other possible explanations of lunar magnetism. The obvious candidate is impact related shock magnetization, which already appears to provide an explanation for the magnetization of 62235, a key sample with strong magnetization. Hood's model accounts for the antipodal anomalies, while the observations at Vredefort may account for the anomalies over central peaks and uplifted ring structures in major basins. The question that remains is whether all of the observed lunar magnetization can be explained by impact related magnetization, or whether a dynamo is still required.

DE: 1595 Planetary magnetism: all frequencies and wavelengths
SC: Union [U]
MN: 2008 Joint Assembly
AB: The vision of the Global Earth Observation System of Systems (GEOSS) is to enable a healthy public, economy, and planet through an integrated, comprehensive, and sustained Earth observation system of systems. GEOSS is a global effort to meet the need for timely, quality, long-term information as a basis for sound decision making and enhanced delivery of benefits to society. Benefits are foreseen in a broad range of important societal-economic issues, including understanding health and the environment, water management, ecosystems and biodiversity, weather forecasting, disaster preparation and recovery, ocean monitoring and prediction, climate change and sustainable growth, and agriculture sustainability. GEOSS is coordinated by an international Group on Earth Observations (GEO) established in 2005 and involving 72 countries, the European Commission, and 46 participating organizations. As a Ministerial-level organization, GEO represents a two-way dialog with policy makers on the importance of Earth observations to science and societal benefits. This talk will provide an update of recent GEOSS activities and progress.

DE: 1694 Instruments and techniques
DE: 1794 Instruments and techniques
DE: 3394 Instruments and techniques
SC: Union [U]
MN: 2008 Joint Assembly

AB: Magnetic reconnection underlies the energy release observed in eruptive events in the solar corona (such as solar flares and coronal mass ejections) and in the Earth’s magnetosphere. The theory of magnetic reconnection was originally developed to understand observations by Ron Giovanelli, who discovered that solar flares occur where the coronal magnetic field changes directions. Pioneers in space plasma theory such as James Dungey, Peter Sweet, Eugene Parker, and Harry Petschek first elucidated the underlying physical effects that lead to this massive energy release. Since then, much effort has been made to understand what process or processes cause magnetic reconnection to be fast enough to be consistent with observations, such as anomalous resistivity, secondary instabilities, and the Hall effect. However, a thorough understanding of this important process remains a topic of intense study. In celebration of the 50th anniversary of Parker’s paper predicting the high-speed solar wind, this talk will review the history of the theory of magnetic reconnection. The present status of the field will be discussed, and remaining unanswered questions will be summarized.

DE: 1739 Solar/planetary relationships
DE: 2723 Magnetic reconnection (7526, 7835)
DE: 7509 Corona
DE: 7526 Magnetic reconnection (2723, 7835)
Reconstruction of solar activity in the past using cosmogenic radiocarbon

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The production rate of radiocarbon in the atmosphere is dominated by the state of the magnetic activity of the Sun, since radiocarbon is mainly produced by the incoming galactic cosmic rays modulated by solar wind and the interplanetary magnetic field in the heliosphere. By analyzing the radiocarbon contents in sequentially stratified layers of natural materials such as tree-rings, we are able to reconstruct the variations of solar magnetic activity in the past. By combining the radiocarbon records obtained using several old trees, the aspect of long-term variability of solar activity back to more than ~10,000 years has been investigated so far. Although the variability of carbon cycle due to possible climate change, which could also affect the radiocarbon content in tree-rings, is not fully understood, the records of radiocarbon provide the information of solar variations including the multi-decadal, multi-centennial and multi-millennial solar cycles as well as the 11-year solar cycle and their variance in the pre-historical periods. The knowledge of the variations of solar activity obtainable with radiocarbon is useful not only for understanding solar dynamo mechanism but also for determining the extent of the influence of the Sun on climate change. In this paper, I review the results, problems and future prospects of the investigations using radiocarbon.

Long-term changes of the heliospheric magnetic field and plasma flows as inferred from historical records of geomagnetic activity

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The revival of interest in deriving past variations in solar wind properties from geomagnetic activity has led to the correction and validation of old geomagnetic indices and the synthesis of new indices. We present the latest results of combining all available corrected indices to infer past variations in the solar wind. The limitations of the derivations are discussed. The theoretical challenges in reconciling the inferred solar wind properties with the past variations in photospheric activity and the large scale modulation of galactic cosmic rays are described.

DE: 1555 Time variations: diurnal to decadal
DE: 1560 Time variations: secular and longer
DE: 2134 Interplanetary magnetic fields
DE: 2162 Solar cycle variations (7536)
SC: Geomagnetism and Paleomagnetism [GP]
MN: 2008 Joint Assembly

HR: 16:00h
AN: SH34A-01 INVITED

A Guided Tour of Heliospheric Waves, Shocks and Energetic Particles

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A Bis Parker Lecture is a personal guided tour through the heliosphere featuring hydromagnetic waves, shocks, and energetic particle populations, their observed behavior from the Sun to the solar wind termination shock, and the theoretical concepts that have been developed to describe them. As a first-year graduate student, I first met Gene Parker in January 1967 when he was my instructor in Electrodynamics at the University of Chicago. His contributions to our understanding of heliospheric waves, shocks, and energetic particles over the last 50 years have molded our view of these diverse but connected heliospheric phenomena. I shall mention those contributions that have been particularly influential in my own work. The tour will include, for example, stops at Earth's bow shock, the shocks bounding corotating interaction regions in the solar wind, the solar wind termination shock, the space environment around comets, the mass and momentum loading of the solar wind through its interaction with the interstellar gas, the theory of diffusive shock acceleration, and the process of stochastic acceleration. The lecture will end with a list of outstanding puzzles concerning
energetic particle transport and shock structure for which we seek solutions as we complete Voyagers' exploration of the outer heliosphere and start to explore the inner neighborhood of the Sun.

DE: 2114 Energetic particles (7514)
DE: 2124 Heliopause and solar wind termination
DE: 2139 Interplanetary shocks
DE: 2149 MHD waves and turbulence (2752, 6050, 7836)
SC: SPA-Solar and Heliospheric Physics [SH]
MN: 2008 Joint Assembly

HR: 14:48h
AN: SH53A-07 INVITED

Whole Heliosphere Interval: Overview of Heliospheric Observations

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Heliosphere Team, W

The Whole Heliosphere Interval (http://ihy2007.org/WHI/) is an international observing and coordinated modeling effort to characterize the interconnections of the 3-dimensional sun-heliosphere-planetary system originating from Carrington Rotation 2068. WHI takes place one solar cycle after the "Whole Sun Month" campaign of 1996. Both WSM and WHI covered the sun and heliosphere near solar minimum conditions, providing a basis for comparison from one solar cycle to the next. The primary goals for WHI include the characterization and modeling in 3D of the solar minimum heliosphere, and to trace the affects of solar structure and activity via the solar wind to Earth, other planetary systems, and the outer heliosphere. Team participants address solar, heliospheric, geospace, planetary systems, space weather, and sun-climate observations and models. In this talk, we provide a "first results" summary of the heliospheric observations portion of WHI. At this writing, the heliospheric observations are expected to include modeling as well as measurements from L1 (ACE, SOHO, Wind), other solar longitudes near 1 AU (STEREO A, STEREO B), remote sensing from Earth or near-Earth (Ooty Radio Observatory, SMEI, EISCAT), out-of-the ecliptic (Ulysses), and from the outer heliosphere (Voyager, IBEX). For Voyager and IBEX, the observing interval extends until the affects originating from CR 2068 reach the outer heliosphere, several months later.

DE: 7500 SOLAR PHYSICS, ASTROPHYSICS, AND ASTRONOMY
DE: 7800 SPACE PLASMA PHYSICS
SC: SPA-Solar and Heliospheric Physics [SH]
MN: 2008 Joint Assembly

HR: 08:50h
AN: SH51C-02 INVITED

The Build-up of Current Sheets in Complex Topologies by Photospheric Driving.

Pariat, E
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The most violent solar coronal phenomena all involve magnetic reconnection which allows the release of stored magnetic energy into other forms of energy. The triggering of solar reconnection in a low resistivity environment requires the build-up of intense electric current sheets, which are also the cornerstone of particle acceleration mechanisms. Magnetic configurations with a complex topology, i.e., with separatrices, are the most obvious configurations where current sheets can form, and therefore where reconnection can efficiently occur. As I will show through several examples, motions of the field lines at the photospheric level, even if regular, slow and spatially smooth, can lead to the formation of current sheets along the separatrices. However, with such topology the formation of the current sheet is extremely fast, so there is little time for energy to build up before reconnection sets in. How can large amounts of magnetic energy be stored before reconnection is triggered? “Quasi-Separatrix Layers” (QSLs), which are regions where there is a drastic yet continuous change in field-line linkage, generalizing the definition of separatrices, offer a natural solution to this storage problem. Based on observational and numerical examples, I will compare the energy build-up problem in separatrices and QSLs topologies and discuss the implications on the observable properties of reconnection.

DE: 7500 SOLAR PHYSICS, ASTROPHYSICS, AND ASTRONOMY
DE: 7519 Flares
DE: 7524 Magnetic fields
DE: 7526 Magnetic reconnection (2723, 7835)
SC: SPA-Solar and Heliospheric Physics [SH]
MN: 2008 Joint Assembly
Transport effects in the form of non-collisional energy loss were introduced to the thin-thick target model to account for the discrepancy. We show that those energy losses can be interpreted by an electric field and associated return current. This is direct evidence for return currents in solar flare loops.

### End of Document
on the U.S. Pacific Northwest (PNW). Through research and interaction with regional stakeholders, the CIG works to increase the resilience of the Pacific Northwest to fluctuations and long-term changes in climate. The CIG’s research focuses on four key sectors of the PNW environment: water resources, aquatic ecosystems, forests, and coasts. This talk focuses specifically on the water resources sector of CIG, and its work addressing potential climate change impacts on the region's hydrology, and the potential for adaptation of water management, primarily through changes in reservoir operating policies, in response to projected effects of climate change. In the Pacific Northwest, as in most of the western U.S., warming temperatures are expected to result in lower winter snowpack, thus shifting seasonal runoff peaks earlier in the year, and increasing the duration of the summer and fall low flow period. The CIG is currently conducting a statewide assessment of the impacts of climate change for the State of Washington based on IPCC 2007 climate scenarios. Hydrologic scenarios have been generated by downscaling GCM scenarios to 1/16 degree latitude-longitude spatial resolution, and using these downscaled scenarios to force the macroscale Variable Infiltration Capacity (VIC) model. We describe the range of hydrologic projections recently performed for 16 downscaled GCMs and 2 global emissions scenarios for the next 100 years, with particular attention on the Puget Sound basin and the Yakima River basin. We also evaluate implications of the changing climate for the Columbia River reservoir system, both in terms of the tradeoff between reservoir releases made for salmonid protection and restoration and hydropower generation, and for flood control.

DE: 1807 Climate impacts
SC: Global Climate Change [GC]
MN: 2008 Joint Assembly

HR: 13:30h
AN: GP53A-01 INVITED
TI: * Fuller, M
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AB: The possibility that precession might play a role in driving the geodynamo was proposed by Malkus (1968). However, papers by Rochester et al. (1975) and Loper (1975) argued strongly against any such role for precession. Since that time Vanyo (1991) has been among the most persistent advocates for precession as a power source for the dynamo and has shown that precession can generate more complicated patterns of motion than previously recognized (Vanyo and Dunn, 2002). To test this idea, we need to see if there is expression of the obliquity period in the paleomagnetic record. However, even that observation remains controversial to date. The power at 41,000 years is only weak. In an attempt to test the role of precession, further investigations of the expression of obliquity in the paleomagnetic record were carried out. It does appear that (1) excursions and major intensity lows are associated with minima in the obliquity signal during the last 800 kyrs (2) the distribution of the length of events less than 100,000 years peaks at 30 – 40,000 years. i.e. a little shorter than the obliquity cycle (3) reversals preferentially occur when the amplitude of the obliquity signal is low in the past 5 Myrs. (4) reversals occur preferentially within the obliquity cycle close to the point of inflection in the decrease from the maximum value. Some confirmation has emerged for observations 1 and 4. These observations have now been reexamined with special emphasis upon the most recent and best dated reversals and excursions. The results are consistent with the earlier suggestion that there is expression of the 41,000yr obliquity cycle in the paleomagnetic record. Thus precession may play a role in driving the dynamo. However, as has been suggested, relative motion between core and mantle that could give rise to similar
core motions may also be caused by changes in surface mass distribution due to climatic changes and in particular ice melting.

DE: 1510 Dynamo: theories and simulations
DE: 1513 Geomagnetic excursions
DE: 1521 Paleointensity
DE: 1535 Reversals: process, timescale, magnetostratigraphy
SC: Geomagnetism and Paleomagnetism [GP]
MN: 2008 Joint Assembly

Overview of First Results on the State of the Geospace-Atmosphere System during the IHY Whole Heliosphere Interval (WHI)

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AB: The 20 March - 16 April 2008 Whole Heliosphere Interval (WHI), part of the IHY program and cosponsored by the CAWSES program, offers a valuable opportunity to take an interdisciplinary look at the ground-state of the sun-Earth system during a time when solar and magnetic activity are at a 22-year low and the heliosphere is dominated by structures associated with open solar magnetic flux. The present solar minimum is unusually deep with monthly sunspot numbers dipping to values below those of the last 4 solar cycles and monthly magnetic activity at levels comparable to the quietest intervals over this same time period. During this time, the signatures of geomagnetic activity that usually dominate the geospace-upper atmosphere basic state are at a minimum allowing a clearer view of the coupling with the lower atmosphere. Magnetic activity that does occur is largely in response to high speed streams associated with open magnetic flux. Questions naturally arise as to the relationship between geospace-atmosphere coupling processes during solar minimum and those that may be operating throughout longer intervals during historical Grand Minima in solar activity. This talk provides an overview of first results on the state of geospace and coupled atmospheric regions during this interval with help and collaboration from campaign participants. Contact information for the observers, and details of additional presentations about the observation reported in this talk, will be provided to support preparations for an upcoming interdisciplinary analysis effort planned to span the entire Sun-Earth system.

DE: 2162 Solar cycle variations (7536)
DE: 2427 Ionosphere/atmosphere interactions (0335)
DE: 2431 Ionosphere/magnetosphere interactions (2736)
DE: 2784 Solar wind/magnetosphere interactions
DE: 3369 Thermospheric dynamics (0358)
SC: SPA-Solar and Heliospheric Physics [SH]
MN: 2008 Joint Assembly

Assessing the Economic Impacts of Weather

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AB: Understanding the socio-economic impacts of weather provides a basis for prioritizing actions to mitigate and respond to weather events and understanding
the value of improvements in weather forecasts. In this talk we discuss two
studies of the economic impacts of weather: (1) an empirical study of the
sensitivity of state-sector level economic activity to weather variability and (2) an
assessment of the quality of data on storm damages in the US as primarily
collected through the National Weather Service's Storm Data Program. In the first
study, 24 years of state level sector economic data and historical weather
observations are used to form a panel combining weather information with
economic data. A translog function is estimated of sectoral sensitivity and
vulnerability to weather variability. Eleven sectors are ranked based on their
degree of sensitivity to weather, states more sensitive to weather impacts are
identified, and the aggregate dollar amount of variation in U.S. economic activity
attributable to weather variability is calculated. Estimates indicate that US
economic output varies by about 3.4% due to weather variability. While
considerably smaller than prior estimates, our estimate represents about 469
billion a year in 2007 dollars. In our work to update and revise damage data in the
Extreme Weather Sourcebook (www.sip.ucar.edu/sourcebook), we have
confronted issues concerning the depth, accuracy and consistency of storm
damage data collection. This type of data has been used in many studies
exploring changes in weather impacts over time but there has been little
recognition of the quality of the data. In the second study reported here, we
examine issues with weather induced damage data quality to prompt a dialogue
about reliability of scattered and inconsistent data from multiple sources. We hope
this will lead to efforts to reduce the error in reported damages and to better
reporting and organization of storm damage data in the future. We advocate a
longer term effort to standardize collection, reporting, and archiving of data on
weather related damage to provide reliable information for future decision making.
Doing so is critical to providing a stronger basis for integrating efforts to improve
forecasts of high impact weather events.

UR: http://www.sip.ucar.edu/sourcebook
DE: 6620 Science policy (0485)
SC: Union [U]
MN: 2008 Joint Assembly

HR: 08:30h
AN: SH51C-01 INVITED
Observations of Accelerated Particles in the Solar Atmosphere and Interplanetary Space

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ABe Sun is the most energetic particle accelerator in the solar system. Observations of hard X-ray/gamma-ray continuum and gamma-ray line emission show that electrons are accelerated to \( >\sim 100\) s of MeV and ions up to GeV energies, respectively, in large solar flares. Direct in situ observations of solar energetic particles (SEPs) near 1 AU suggest that shock waves driven by fast (>1000 km/s) coronal mass ejections (CMEs) accelerate ions and electrons to similar energies, at altitudes of \( \sim 2 \) to 40 solar radii. Both CMEs and large flares involve the transient release of up to \( 10^{32-33}\) ergs. The flare-accelerated tens of keV electrons and \( >\)MeV ions often containing 10-50% or more of the total energy released, indicating the particle acceleration is intimately related to the energy release mechanism. RHESSI (Ramaty High Energy Solar Spectroscopic Imager) observations show strong evidence for both the ion and electron acceleration and the energy release in flares to be associated with the process of magnetic reconnection. Electron acceleration to \( >\sim 10\) keV is observed in small
flares and even in microflares that occur as often as every several minutes near solar maximum. Radio type III bursts indicate that electron acceleration can occur high in the corona, often without flare signatures at lower altitude. At 1 AU, hundreds of small impulsive SEP events dominated by <1 to 100 keV electrons and often accompanied by tens of keV to MeV/nuc ions, strongly enriched in 3He and heavies, are detected per year near solar maximum. Here I review the recent RHESSI and related in situ observations as they bear on the fundamental acceleration processes that are occurring, and discuss the prospects for key measurements from future space missions.

DE: 7513 Coronal mass ejections (2101)
DE: 7514 Energetic particles (2114)
DE: 7519 Flares
DE: 7554 X-rays, gamma rays, and neutrinos
DE: 7845 Particle acceleration
SC: SPA-Solar and Heliospheric Physics [SH]
MN: 2008 Joint Assembly

Quantitative Correlation Analysis of Gravity, Magnetic, and Thermal Potential Fields

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ABe correlations between the effects of different potential fields can greatly limit ambiguities of interpretation and improve the signal-to-noise ratio in anomaly mapping. In addition, correlative anomalies are well suited from estimating the physical properties of sources because the phase differences in the anomalies completely determine the correlations. The basis for quantitatively correlating geological variations in potential fields is the inverse distance function that describes the geometry between source and observation points. Poisson's theorem relates correlative density and magnetization contrasts, whereas the correlations of these contrasts with thermal conductivity contrasts may be quantified by the heat production equivalence of thermal sources. We present several examples in both data and spectral domains to illustrate the advantages and limitations of quantifying correlations between potential fields. These examples include analyzing free-air gravity anomaly observations for isostatically disturbed crustal components, modeling regional magnetic anomaly observations for the Curie isotherm within the crust, and quantifying correlative crustal density and magnetization contrasts from gravity and magnetic anomaly observations.

DE: 0925 Magnetic and electrical methods (5109)
DE: 1214 Geopotential theory and determination (0903)
Gene Parker's insights from 50 years ago provided the key causal link between energy deposition in the solar corona and the acceleration of solar wind streams. However, the community is still far from agreement concerning the actual physical processes that give rise to this energy. It is still unknown whether the solar wind is fed by flux tubes that remain open (and are energized by footpoint-driven wavelike fluctuations) or if mass and energy is input more intermittently from closed loops into the open-field regions. No matter the relative importance of reconnections and loop-openings, though, we do know that waves and turbulent motions are present everywhere from the photosphere to the heliosphere, and it is important to determine how they affect the mean state of the plasma. In this presentation, I will give a summary of wave/turbulence models that seem to succeed in explaining the time-steady properties of the corona (and the fast and slow solar wind). The coronal heating and solar wind acceleration in these models comes from anisotropic turbulent cascade, which is driven by the partial reflection of low-frequency Alfvén waves propagating along the open magnetic flux tubes. Specifically, a 2D model of coronal holes and streamers at solar minimum reproduces the latitudinal bifurcation of slow and fast streams seen by Ulysses. The radial gradient of the Alfvén speed affects where the waves are reflected and damped, and thus whether energy is deposited below or above Parker's critical point. As predicted by earlier studies, a larger coronal expansion factor gives rise to a slower and denser wind, higher temperature at the coronal base, less intense Alfvén waves at 1 AU, and correlative trends for commonly measured ratios of ion charge states and FIP-sensitive abundances that are in general agreement with observations. Finally, I will outline the types of future observations that would be most able to test and refine these ideas.

Long-term geomagnetic activity: Recent problems, developments and consequences for space climate

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Geomagnetic activity forms one of the most reliable and versatile ways to study the long-term change in the Sun and heliosphere, i.e., space climate. Continuous measurements of geomagnetic activity exist since the mid-19th century, covering...
more than 160 years. In addition to the long-term trend, geomagnetic activity
depicts persistent patterns and periodicities, the most dominant of which are the
solar cycle variation and the semiannual variation. Other significant fluctuations
include the annual variation, 1.3-1.8-year variation and the 22-year variation. All
these variations reflect some fundamental properties of the Sun and the
Sun-Earth connection. Interestingly, although some of these patterns are known
for a long time (e.g., the semiannual variation for nearly 150 years), they are
properly understood only since recently. The overall level of geomagnetic activity
has increased during the last 100 years although the exact amount of increase is
still under debate. Also, the estimates based on geomagnetic activity about the
long-term change of various solar and heliospheric parameters, like the intensity
of the heliospheric magnetic field, the solar wind speed and the total solar
irradiance, vary considerably. These differences are caused by problems in the
quality of archival data, by inhomogeneities and errors in geomagnetic indices and
by the unsatisfactory level of understanding the relations between solar,
heliospheric and geomagnetic parameters. E.g., it has been noted recently that
errors in archival data may lead to seriously flawed estimates of the centennial
trend. Also, it is known that the longest and most used long-term geomagnetic
index, the aa index, is inhomogeneous and depicts an excessively large
centennial increase. Accordingly, all estimates based on the aa index yield
excessively large centennial changes and need to be corrected. Taking into
account the crucial role of the Sun for, e.g., the global climate, the long-term
change in solar activity has considerable social interest and should be evaluated
as reliably as possible. Recently, new indices of long- term geomagnetic activity
have been developed based on digitally available hourly values of the
geomagnetic field. These indices allow for a detailed examination of their
properties, being therefore more straightforward and more reliable than earlier
indices. One group of these new indices follows the traditional definition of the 3-
hourly K index method, another measures hourly variability in the night sector
only. Here I will review the principles and status of the traditional and new indices
of geomagnetic activity, discuss the present understanding of the various
systematic patterns depicted by geomagnetic activity, including the centennial
change of geomagnetic activity and its implications about the long-term change of
the Sun.

DE: 1530 Rapid time variations
DE: 2162 Solar cycle variations (7536)
DE: 2784 Solar wind/magnetosphere interactions
DE: 7537 Solar and stellar variability (1650)
SC: Geomagnetism and Paleomagnetism [GP]
MN: 2008 Joint Assembly

Since 1995, self-consistent models of the geodynamo became available. There
are certain problems, but some of these models have shown behaviors quite
similar to those observed by paleomagnetism, including polarity reversals (Kono
and Roberts, 2002). There is thus a hope that the combination of paleomagnetism
and dynamo theory may provide us a very comprehensive understanding of the
geomagnetic field. In this paper, I will try to highlight the possibilities and
limitations in such studies. From satellite observations, it was shown that the
power of the magnetic field contained in each degree is nearly the same if measured at the core-mantle boundary (CMB). The core field can be seen only to degree 13 or 14 where the field power is about \((10 \text{ nT})^2\). Beyond that, the crustal magnetization dominates and the core signal is lost. The value of 10 nT is far larger than the accuracy of the present-day instruments, but much smaller than the resolution obtainable by paleomagnetic observations. We may safely assume that the error in paleomagnetic measurements (in direction) is of the order of 10 degrees. This error corresponds to the resolution of about 1/5. The relative powers of the low degree terms in the magnetic field at the surface are 1.0, 0.033, 0.019, 0.0055 (Langel and Estes, 1982). This means that only the degrees 1 to 3 terms may be distinguished by paleomagnetic data. From the combination of dipole, quadrupole, and octupole, what we can deduce about the fundamental properties of the geomagnetic field? Here are some of the possibilities, which may give important clues when we compare with dynamo simulation results. (1) The current dipole power is several times larger than the value expected from the trend line produced by degrees 2--13. Is this a persistent feature or transient? (2) In PSV analysis, the angular standard deviation increases with latitude. Kono and Tanaka (1995) showed that it is possible only if the \((2,1)\) (degree, order) or \((3,2)\) term is very large. But the present field does not show such features. What is the solution of this difference? (3) If the dynamo is very simple, the dynamo modes may be divided into two distinct groups (dipole family and quadrupole family) due to the selection rules (Roberts and Stix, 1972). McFadden et al. (1988) derived a paleosecular variation model based on this separation. Is it a real feature?

DE: 1507 Core processes (1213, 8115)
DE: 1510 Dynamo: theories and simulations
DE: 1522 Paleomagnetic secular variation
DE: 1535 Reversals: process, timescale, magnetostratigraphy
SC: Geomagnetism and Paleomagnetism [GP]
MN: 2008 Joint Assembly

HR: 16:40h
AN: SH44A-03 INVITED

**DETERMINATION OF THE VALUE AND VARIABILITY OF THE SUN'S OPEN MAGNETIC FLUX USING A GLOBAL MHD MODEL**

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AB: The underlying value and variation of the Sun's open, unsigned magnetic flux is of fundamental scientific importance, yet its properties remain poorly known. For example, do long term (on the time-scale of ~ 100 years) changes in the strength of the solar magnetic field exist and do they persist through the heliosphere? If present, they may have a direct impact on space climate, including implications for the transport of cosmic rays (CRs), and as such, may affect technology, space, and even terrestrial climate. Global MHD models are capable of reproducing the structure of the large-scale solar and interplanetary magnetic field (at least in the absence of transient phenomena such as Coronal Mass Ejections), and should, in principle, be able to address this topic. However, they rely - and depend crucially - on boundary conditions derived from observations of the photospheric magnetic field. In spite of ~ 40 years of measurements, accurate estimates of the radial component of the photospheric magnetic field remain difficult to make. In this study, we attempt to find a "ground truth" estimate of the photospheric magnetic field by carefully comparing both disk magnetograms and diachronic (previously known as synoptic) maps from 6 different observatories (KPVT, SOLIS, GONG, MDI, WSO, and MWO). We find that although there is a general consensus between several of them, there are also some significant discrepancies. Using data from these observatories, we compute global heliospheric solutions for a selection of epochs during the last 3 solar cycles and compare the results with in situ observations. We apply these results to several topics related to the Sun's open flux.

DE: 2134 Interplanetary magnetic fields
DE: 2164 Solar wind plasma
DE: 7509 Corona
DE: 7524 Magnetic fields
DE: 7536 Solar activity cycle (2162)
SC: SPA-Solar and Heliospheric Physics [SH]
MN: 2008 Joint Assembly

HR: 16:45h
AN: GC54A-04 INVITED

Water Planning and Climate Change: Actionable Intelligence Yet?

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AB: In a rational planning framework, water planners design major water projects by evaluating tradeoffs of costs, benefits, and risks to life and property. The evaluation is based on anticipated future runoff and streamflow. Generally, planners have invoked the stationarity approximation: they have assumed that hydrologic conditions during the planned lifetime of a project will be similar to those observed in the past. Contemporary anthropogenic climate change arguably makes stationarity untenable. In principle, stationarity-based planning under nonstationarity potentially leads to incorrect assessment of tradeoffs, suboptimal decisions, and excessive financial and environmental costs (e.g., a reservoir that is too big to ever be filled) and/or insufficient benefits (e.g., levees that are too small to hold back the flood waters). As the reigning default assumption for planning, stationarity is an easy target for criticism; provision of a practical alternative is not so easy. The leading alternative, use of quantitative climate-change projections from global climate models in conjunction with water planners’ river-basin models, has serious shortcomings of its own. Climate models...
(1) neglect some terrestrial processes known to influence runoff and streamflow; (2) do not represent precipitation well at the finer resolved time and space scales; (3) do not resolve any processes at the even finer spatial scale of relevance to much of water planning; and (4) disagree among themselves about some changes. Even setting aside the issue of scale mismatch, for which various "downscaling" methods have been proposed, outputs from climate models generally are not directly transferable to river-basin models, and river-basin models commonly use empiricisms whose historical validity might not extrapolate well under climate change. So climate science is informing water management that stationarity is a flawed assumption, but it has not presented a universally and reliably superior alternative. What is to be done? Is climate-change information of sufficient strength to justify making decisions that differ from those that would be optimal under stationarity? I.e., does climate science provide "actionable intelligence" to water planners? A conservative approach to planning in the presence of climate change would begin with stationarity as a base and then superpose, with quantitative estimates of uncertainties, those model-projected changes that appear to be qualitatively robust. The current state of science suggests that the following changes could be considered robust: (1) reduction in the fraction of precipitation falling as snow and earlier seasonal melting of snow, with consequent seasonal redistribution of runoff and streamflow; (2) gradual sea-level rise with heightened risk of encroachment of saline water into coastal surface- and ground-water-supply sources; and (3) global redistribution of precipitation and resultant runoff, with regional focal points ("hot spots") of desiccation and moistening. Even considering the attendant uncertainties, the available information about these changes can significantly affect the cost-benefit-risk tradeoffs of existing and prospective water projects and, therefore, can rationally inform decisions about future courses of action or inaction.

DE: 1600 GLOBAL CHANGE
DE: 1655 Water cycles (1836)
DE: 1803 Anthropogenic effects (4802, 4902)
DE: 1880 Water management (6334)
SC: Global Climate Change [GC]
MN: 2008 Joint Assembly

New Search