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Most empirical studies undertaken in the past focused on the connection of the solar cycle with climatic variables at specific geographic locations. We have investigated the influence of the 11-year solar cycle on extensive climate variables, the semi-permanent centers of action. Based on analysis of more than one hundred years of sea level pressure data we conclude that extremes in solar variability as measured by the annual sunspot numbers correlate highly with the locations of the semi-permanent pressure systems in the North Pacific. The Aleutian Low moves westward during solar maximum conditions and the Hawaiian High moves northward. Also, the area-weighted surface pressure of the Aleutian Low is significantly higher near the solar maximum. As a result large anomalies in regional climatic conditions in North America and East Asia are generated in the extreme phases of the solar cycle. Concomitant displacements of planetary waves in the troposphere and the stratosphere suggest pathways that couple solar variations to surface climate.

SH11E-04 1120h INVITED

Ultraviolet Radiation and Stratospheric Ozone

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Ultraviolet radiation from the sun produces ozone in the stratosphere and it participates in the destruction of ozone. Absorption of solar ultraviolet radiation by ozone is the primary heating mechanism leading to the maximum in temperature at the stratopause. Variations of solar ultraviolet radiation on both the 27-day solar rotation period and the 11-year solar cycle affect ozone by several mechanisms. The temperature and ozone in the upper stratosphere respond to solar uv variations as a coupled system. An increase in uv leads to an increase in the production of ozone through the photolysis of molecular oxygen. An increase in uv leads to an increase in temperature through the heating by ozone photolysis. The increase in temperature leads to a partially-offsetting decrease in ozone through temperature-dependent reaction rate coefficients. The ozone variation modulates the heating by ozone photolysis. The increase in ozone at solar maximum enhances the uv heating. The processes are understood and supported by long-term data sets. Variation in the upper stratospheric temperatures will lead to a change in the behavior of waves propagating upward from the troposphere. Changes in the pattern of wave dissipation will lead to acceleration or deceleration of the mean flow and changes in the residual or transport circulation. This mechanism could lead to the propagation of the solar cycle effect of solar uv variation from the upper stratosphere downward to the lower stratosphere. This process is not well-understood and has been the subject of an increasing number of model studies. I will review the data analyses for solar cycle and their comparison to model results.

SH11E-05 1140h INVITED

Effects of Solar Ultraviolet Variability on the Stratosphere: A Sun-Climate Connection

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Solar ultraviolet radiation at wavelengths near 200 nm is responsible for photodissociation of molecular oxygen and ozone production in the stratosphere. On the time scale of the 27-day solar rotation period, previous work has documented the response of the upper stratosphere and lower mesosphere to solar UV variations. This response is largely a result of direct photochemical and radiative forcing. Recent work, however, indicates an additional response to 27-day UV forcing in the lower stratosphere, including the tropical tropopause region. The thermal response maximizes near the 100 hPa level and amounts to 0.24 +/- 0.07 Kelvin for a 4% change in the solar UV flux near 200 nm (typical of UV variations occurring on this time scale under solar maximum conditions). The phase lag is 2 +/- 2 days. Parallel analyses using other solar-correlated variables (total solar irradiance, Galactic cosmic ray flux, etc.) verify that the solar UV flux is the most probable forcing mechanism. It is suggested that the observed thermal response near the tropical tropopause is caused by changes in upwelling rates induced by the direct effects of solar UV forcing in the upper stratosphere. On the time scale of the 11-year solar cycle, stratospheric total column ozone and lower stratospheric temperature are also observed to vary approximately in phase with the solar UV flux during the period since 1979 when continuous global satellite measurements began. Most of the column ozone variation occurs in the lower stratosphere (85% below 16 hPa), a result that contrasts with most prior model predictions. At low latitudes, there is evidence that the observed ozone and temperature variation is caused by changes in upwelling rates that are, in turn, probably due to observed decadal changes in extratropical wave forcing. The latter may be modulated by the direct effects of solar UV variations in the upper stratosphere. These observed lower stratospheric dynamical effects of solar UV variations and their secondary tropospheric consequences must be understood to allow more accurate model simulations of solar-induced climate change.

SH11E-06 1200h INVITED

Energy Balance, Climate, and Life – Work of M. Budyko

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This talk will review the work of Mikhail I. Budyko, author of "Climate and Life" and many other works, who died recently at the age of 81 in St. Petersburg, Russia. He directed the Division for Climate Change Research at the State Hydrological Institute. We will explore Budyko's work in clarifying the role of energy balance in determining planetary climate, and the role of climate in regulating Earth's biosphere.

SH12A MCC: Level 2 Monday 1330h

The Sun's Spectrum and Life on Earth II Posters *(joint with A, SA, GC)*

Presiding: **G Rottman,** Laboratory for Atmospheric and Space Physics, University of Colorado**; E Hilsenrath,** NASA Goddard Space Flight Center

SH12A-1151 1330h POSTER

Observations of Solar Spectral Irradiance Change During Cycle 22 from NOAA-9 SBUV/2

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The NOAA-9 Solar Backscatter Ultraviolet, model 2 (SBUV/2) instrument is one of a series of instruments providing daily solar spectral irradiance measurements in the middle and near ultraviolet since 1978. This instrument did not have onboard monitoring of all time-dependent response changes that affect the solar data. Thus a combination of internal and external techniques was used to derive the instrument's long-term instrument characterization. The corrected NOAA-9 solar spectral irradiance data between 170 and 400 nm extend from March 1985 to May 1997, spanning two solar cycle minima with a single instrument. The NOAA-9 data show an amplitude of 9.3(±2.3)% (81-day averaged) at 200-205 nm for solar cycle 22. This is consistent with the result of $\Delta F_{200-205} = 8.3(\pm 2.6)\%$ for cycle 21 from Nimbus-7 SBUV and $\Delta F_{200-205} = 10(\pm 2)\%$ (daily values) for cycle 23 from UARS SUSIM. NOAA-9 data at 245-250 nm show a solar cycle amplitude of $\Delta F_{245-250} = 5.7(\pm 1.8)\%$. These data were used to investigate whether there was a trend in absolute solar spectral irradiance between the solar cycle 21 and 22 minima. We find an irradiance difference of ±1% or less between the two minima. The observed differences are less than the uncertainty in the long-term instrument calibration and should not be considered statistically significant. NOAA-9 SBUV/2 data can be combined with other instruments to create a 25-year record of solar UV irradiance.

SH12A-1152 1330h POSTER

Spectral Solar Irradiance Variability from VIRGO on SOHO: 1996 to present

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Since February 1996 VIRGO filterradiometers on SOHO monitor spectral solar irradiance at 402, 500 and 862nm with a bandwidth of 5nm. SOHO's vantage point at L1 allows uninterrupted observations of the Sun, 24 h a day and 365 days an year. Besides the 3-month gap during the SOHO vacation in summer 1998 and a few other minor gaps the record covers more than 99% of the period up to now of almost 8 years of observations. The long-term behaviour of the operational channels is dominated by instrumental degradation masking the solar variability signature. However, comparisons with the back-up channels allows to take off some of the instrumental long-term variation, and the resulting time series can now provide reliable information about variability with periods up to about 4–500 days. Time series with the long-term variation removed and the corresponding periodogram show many similarities between the three channels and total solar irradiance. Details about the spectral redistribution during changes of TSI are investigated by multivariate spectral analysis. Furthermore, comparison of the spectral analysis of the cleaned 1-minute sampled time series during solar minimum (1996/7) and maximum (2001/2) allows to asses the variation of power with the activity cycle in a range from about 30 nHz (about 1 year period) up to 8 mHz (5-minute oscillations). The variability with activity of the three colours is compared with the one of TSI.

SH12A-1153 1330h POSTER

The Solar Soft X-ray Irradiance and its None-flare Variability

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The interval from 1965 to 1970 represents a unique period of time during which full-disk solar soft X-ray spectral observations and broadband soft X-ray flux measurements were made concurrently. Bragg crystal spectrometers flown on sounding rockets and orbiting spacecrafts provided data on spectral distributions between 0.8 and 2.5 nm during non-flaring periods, but with rather uncertain flux calibrations, while simultaneous observations by the NRL Solrad series of ionization chambers provided broadband and instrumentally stable flux coverage. We have combined these two types of observations to obtain in-flight calibration of the crystal spectrometer data taken over a wide range of solar activity. The Chianti spectral program was used to derive solar spectra matching the emission line distributions observed by the spectrometers and these theoretical spectra (with derived continua) were applied to the Solrad ion chamber measurements to recalculate their sensitivities for actual spectral distributions rather than for the "gray body" radiation used originally. The resulting absolute integrated flux values were then applied to the spectrometer observations to obtain absolute fluxes in specific emission lines. Changes in individual line fluxes between 0.8 and 2.5 nm as a function of the 2800 Mhz (F10) radio flux have also been determined and will be presented.

SH12A-1154 1330h POSTER

Time Series Analysis of SOLSTICE Measurements

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Solar radiation is the major energy source for the Earth's biosphere and atmospheric and ocean circulations. Variations of solar irradiance have been a major concern of scientists both in solar physics and atmospheric sciences. A number of missions have been carried out to monitor changes in total solar irradiance (TSI) [see Fröhlich and Lean, 1998 for review] and spectral solar irradiance (SSI) [e.g., SOLSTICE on UARS and VIRGO on SOHO]. Observations over a long time period reveal the connection between variations in solar irradiance and surface magnetic fields of the Sun [Lean1997]. This connection provides a guide to scientists in modeling solar irradiances [e.g., Fontenla et al., 1999; Krivova et al., 2003].
Solar spectral observations have now been made over a relatively long time period, allowing statistical analysis. This paper focuses on predictability of solar spectral irradiance using observed SSI from SOLSTICE .

Analysis of predictability is based on nonlinear dynamics using an artificial neural network in a reconstructed phase space [Abarbanel et al., 1993]. In the analysis, we first examine the average mutual information of the observed time series and a delayed time series. The time delay that gives local minimum of mutual information is chosen as the time-delay for phase space reconstruction [Fraser and Swinney, 1986]. The embedding dimension of the reconstructed phase space is determined using the false neighbors and false strands method [Kennel and Abarbanel, 2002]. Subsequently, we use a multi-layer feed-forward network with back propagation scheme [e.g., Haykin, 1994] to model the time series. The predictability of solar irradiance as a function of wavelength is considered.

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SH12A-1155 1330h POSTER

Solar Ultraviolet Spectral Irradiance: Early Results From the SOLar STellar Irradiance Comparison Experiment II Aboard the Solar Radiation and Climate Experiment Spacecraft

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The SOLar STellar Irradiance Comparison Experiment II (SOLSTICE II) is a component of the Solar Radiation and Climate Experiment (SORCE) satellite that was launched in January 2003. SOLSTICE II uses a pair of diffraction grating spectrometers to measure solar irradiance from 115 nm to 320 nm with a spectral resolution of 0.1 nm at a cadence of 6 hours. Our goal is to provide a five-year ultraviolet solar irradiance record that has a 5 percent absolute accuracy and a 0.5 percent per year relative accuracy, which overlaps with measurements being made by SOLSTICE I, launched aboard the Upper Atmosphere Research Satellite (UARS) in September 1991. The SOLSTICE technique compares measurements of solar irradiance with those from an ensemble of bright, stable, main sequence B-A stars. This allows us to accurately monitor changes in solar irradiance on the time scale of decades. It also provides a relative (rather than absolute) data set for future generations of researchers to use in solar irradiance variability studies. We will present early results from SOLSTICE II and discuss its anticipated performance over the course of the SORCE mission.

SH12A-1156 1330h POSTER

Solar Magnesium II Observations From the SORCE SOLSTICE

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The Magnesium II h & k doublet at 280 nm is an important diagnostic of solar activity. The Solar-Stellar Irradiance Comparison Experiment (SOLSTICE) onboard the Solar Radiation and Climate Experiment (SORCE) measures the solar spectral irradiance in the neighborhood of Mg II nearly every orbit. The SOLSTICE instrument on SORCE has a resolving power of 3000 in the MUV,which is sufficient to resolve the emission cores in the Mg II lines. These observations allow analysis of Mg II variation on timescales from hours to years as the SORCE data record grows. We will discuss comparisons of the Mg II index derived from SORCE SOLSTICE with lower-resolution instruments.

SH12A-1157 1330h POSTER

Physical Synthesis of the Solar Radiance, a Tool for Understanding Spectral Irradiance

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In this paper we summarize the current status of our physical modeling of the solar radiation and briefly describe the key improvements in the methods we use to compute synthetic solar spectrum. We use 7 solar atmosphere models for summarizing the features observed on the solar disk, and we compute the emitted spectrum at 10 positions on the disk. These models and disk positions are intended to cover the significant features of quiet and active Sun that are linked with solar irradiance variations. The calculation is extremely detailed and each of the many thousands of spectral lines is fully resolved so that the spectra can be convolved with any instrument function and compared with observations at high or low spectral resolution. Our version 1 code and models provide very good agreement with observations of spectral irradiance between ∼450 and ∼1000 nm, but is not accurate outside that range. We describe the basic procedures used in Version 1 and the differences with the procedures that will be used in Version 2 for improving the synthesis accuracy over a more extended wavelength range. We expect that version 2 will be a major step in understanding the solar spectral irradiance and its variations beyond what is currently available from any solar irradiance models.

SH12A-1158 1330h POSTER

Solar Spectral Irradiance Variability in the Visible and Infrared During the SORCE Mission

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The Spectral Irradiance Monitor (SIM) is a dual prism spectrometer onboard the SORCE (Solar Irradiance and Climate Experiment) satellite that was launched in January 2003. SIM covers the wavelength region 200- 2700 nm with a spectral resolution varying from 0.25 to 34 nm over this range. The primary detector for this instrument is an electrical substitution radiometer (ESR), and three additional photodiode detectors complement the ESR measurement and span the spectral range from 308 to 1600 nm; these photodiodes provide the bulk of the data used to study solar variability. The ESR calibrates the radiant sensitivities of the photodiodes in flight, and pre-flight measurements of the prism transmission and the spectral response function give the absolute calibration of the instrument. The SIM solar spectrum is in good agreement with other standard solar spectra such as the SOLSPEC spectrum (Thuillier et al. Metrologia, 35, 689, 1998) and the Davos World Radiation Center Reference Spectrum (Wehrli, C., World Radiation Center (WRC) Publication No. 615, Davos-Dorf, Switzerland, July 1985). SIM is able to detect short-term spectral irradiance variability of about 0.1% in the of 27-day solar rotation period induced by the appearance and varying intensity of solar structural features (such as sun spots and plage) relative to the quiet sun. A comparative study of the SIM solar spectrum relative to other standard spectra and an analysis of short-term solar variability as measured by SIM will be presented.

URL: http://lasp/programs_missions/present/off_site/sorce.html

SH12A-1159 1330h POSTER

Modeling Solar Irradiance With the PSPT Solar Disk Observations and RISE Solar Spectrum Synthesis

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The PSPT (Precision Solar Photometric Telescope) at the Mauna Loa Solar Observatory produces full disk solar images in the Ca II-K spectral line (393 nm ± 0.15 nm), blue (409.3 nm ± 0.15 nm) continuum, and red (607.2 nm ± 0.15 nm) continuum, with ∼0.1% photometric precision and 1 arc sec pixels. The RISE (Radiative Inputs of the Sun to Earth) spectral synthesis calculation is based on 7 solar atmosphere models corresponding to quiet and active solar features, and currently calculates the emitted intensity as a function of wavelength from 0.5 to 10 micron for 10 positions in the solar disk. We use the RISE-derived center-to-limb variation functions for each surface feature in the instrument spectral band to extract the feature distribution on the solar surface corresponding to each PSPT image. The average disk intensity as a function of wavelength is then constructed using the RISE calculated spectra for each feature and position on the disk. We present the results of a preliminary study of solar irradiance calculations and comparisons with measurements from the Solar Radiation and Climate Experiment (SORCE) satellite. These comparisons are made with the Spectral Irradiance Monitor (SIM), which measures spectral irradiance (200 nm - 2700 nm). In addition to the preliminary results, we present future plans for comparisons with SIM data.

SH12A-1160 1330h POSTER

Pre-Launch and On-Orbit Calibration of the Spectral Irrandiance Monitor (SIM) on SORCE

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The Spectral Irradiance Monitor (SIM) aboard the Solar Radiation and Climate Experiment (SORCE) satellite measures the solar spectral irradiance from 200 - 2700 nm. SIM is a Féry prism spectrometer that uses an electrical substitution radiometer (ESR) to monitor the absolute irradiance calibration throughout operation. The two SIM instruments on SORCE are mirror images of each other, mounted side-by-side in the same package. Since the prism transmission coefficient is a term that appears directly in the instrument's measurement equation, laboratory measurements are required for data analysis. Ratiometric laboratory measurements of the prism transmission as a function of wavelength and polarization will be presented, along with experiment descriptions. Furthermore, on-orbit experiments monitor changes in prism transmission to maintain the pre-launch calibration. Each SIM can calibrate the other. During an on-orbit transmission measurement, one SIM directs monochromatic light into the second via a periscope mechanism. The second SIM then uses internal optics to measure its prism transmission ratiometrically. Preliminary results from the ongoing prism degredation analysis will also be presented.

SH12A-1161 1330h POSTER

A Model of Solar Spectral Irradiance Near Mg II

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SH

A model of solar spectral irradiance has been developed that predicts the solar spectrum near Mg II at 280nm. This model uses sun spot, active region, and quiet sun spectra and high resolution limb darkening curves observed by the Naval Research Laboratory's HRTS rocket as the basis for modeling solar spectral variability. Ground-based Ca II K images are used to determine the contribution of each of these solar surface features to the total solar spectrum. The resulting spectra are at a resolution of about 0.01nm. These model spectra are currently being compared to observed spectra in order to identifty the solar sources of spectral variability. A predicted Mg II index is compared with the observed values of the index.

SH12A-1162 1330h POSTER

Solar UV and EUV Irradiance and Solar Indices

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Studies of the solar UV (120–290 nm) spectral irradiance have shown that its variation correlates well with that of the core-to-wing ratio of the Mg II compound absorption feature near 280 nm. The two chromospheric emission lines in the feature's core cause nearly all of the Mg II index variation. The Mg II index has also been shown to correlate with solar He II emerging from the transition region. Although earlier studies appeared to show that an accurate representation of the solar Ly-α irradiance required the separation of the long- and short-term components of the Mg II index, recently recalibrated measurements show that Ly-α also has a linear relationship with Mg II. We analyze the solar spectral irradiance derived from SOHO EIT images roughly corresponding to coronal line emissions of Fe IX/X, Fe XII, and Fe XV and find that the Mg II index represents their variation more effectively than the more commonly used F10.7 cm flux. The long-term behavior of F10.7, Mg II, and sunspot number are compared showing a strong divergence of the latter during the latter stages of the solar cycle 23 maximum.

SH12A-1163 1330h POSTER

The SORCE Science Data Products available at the NASA GES DAAC

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The Solar Radiation and Climate Experiment (SORCE) was launched into Earth orbit in January 2003. About a month after launch, the four instruments aboard SORCE began making scientific measurements. The instruments are the Total Irradiance Monitor (TIM), the Solar Stellar Irradiance Comparison Experiment (SOLSTICE), the Spectral Irradiance Monitor (SIM), and the XUV Photometer System (XPS). TIM measures the total solar irradiance, while the other three instruments measure the solar spectral irradiance from x-rays, ultraviolet, visible and the near infrared spectral regions. This presentation describes the SORCE standard science data products and data support provided by the NASA Goddard Earth Sciences Distributed Active Archive Center (GES DAAC). There are four level 3 standard products: daily averaged solar spectral irradiance (SOR3SSID), 6-hourly averaged solar spectral irradiance (SOR3SSI6), daily averaged total solar irradiance (SOR3TSID) and 6-hourly averaged total solar irradiance (SOR3TSI6). All of the SORCE derived product files are generated using the Hierarchical Data Format version 5 (HDF5), and are available to the public free of charge.

URL: http://daac.gsfc.nasa.gov/upperatm/sorce/

SH12B MCC: 2008 Monday 1340h

The Termination Shock, Heliosheath, and Heliopause II

Presiding: **M E Hill,** University of Maryland**; J R Jokipii,** University of Arizona

SH12B-01 1340h INVITED

A Brief Overview of the Heliosphere and Heliosheath

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Recent intriguing observations from the Voyager I suggest that the spacecraft has observed phenomena associated with the near proximity of the termination shock, or possibly even the crossing of the termination shock itself. This overview will summarize briefly the nature of the shock and phenomena which might be expected to be observed in its vicinity, in order to place the recent observations and some recent ideas into context.

SH12B-02 1355h INVITED

Unusual Energetic Particle Signatures as Voyager 1 Approaches the Heliospheric Termination Shock

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The heliospheric termination shock is the expected site for the acceleration of anomalous cosmic rays and the further re-acceleration of low energy particles from the inner solar system and of galactic cosmic rays. Increases in the intensity of these diverse energetic particle populations are one of the expected harbingers of Voyagers approach to the termination shock. In mid-2002 as Voyager 1 moved beyond 85 AU there began an increase of 2-3 MeV ions that remained at an unusually high level near 0.1 protons/cm^2 - s - sr - MeV ions for some 6 months. This event differs from any previously observed in that there is a simultaneous increase in galactic cosmic ray ions and electrons, anomalous cosmic rays and low energy ions. However the low intensity level and the spectral form of the anomalous cosmic ray component indicates that we have not reached the termination shock and the observed increase is a precursor event of the type expected as Voyager approaches the shock. Beginning in 2003.09 the unusual increases are abruptly terminated by the passage of a large interplanetary transient.

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Evidence That Voyager 1 Exited the Solar Wind at ~85 AU and Re-entered at ~87 AU in August 2002 and February 2003.

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The LECP instrument on V1, V2 consists of a collection of solid-state detectors designed to perform measurements of ions (~30keV to 10s of MeV) and electrons (~28 keV to ~10 MeV), including elemental composition over a range of energies ($\gtrsim$0.3 MeV/nuc) and species (H, He, C, N, O, Ne, etc). Salient features of the observations during 2002-2003 are as follows: (a) A gradual increase in ~1 MeV proton intensity in late 2000 culminated in an 100-fold step increase in mid-2002 lasting for >6 months and ending within a few hours in early 2003. (b) The step increase was seen in energies ranging from ~40 keV to >70 MeV for protons and >0.35 MeV for electrons. (c) Large intensity fluctuations lasting from <1 to several days were present coherently in all energies and species throughout the period. (d) The composition of H, He, O and C are consistent with an ACR or PUI source. (e) Outward streaming anisotropies show that the particle source lies inside the V1 location. (f) Generalized (non-linear) Compton-Getting fits to the angular distributions show the convection velocity changed from 300 km/s to <50km/s and back to ~230km/s before, during, and after the increase, respectively. Post-reentry observations show frequent inward and some outward proton flows, suggesting a significant radial component of the IMF. The observations will be discussed in the context of current theoretical models of the interaction between the heliosphere and the local interstellar medium.

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Search for the Heliosheath with Voyager 1 Magnetic Field Measurements

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The magnetic field measured by Voyager 1 (V1) near 85 AU from 2002.0 to 2003.17 has the expected properties for the heliospheric magnetic field at that distance and epoch of the solar cycle. The average field magnitude is $< B >= 0.04$ nT, significantly lower than the value predicted for the heliosheath. The fluctuations in B observed during 2002 are similar to those observed during 2001. The distribution of daily averages of B is lognormal, and the normalized standard deviation $SD(B)/< B >= 0.55$ for hourly averages of B, similar to previous heliospheric observations. Changes in the intensity of > 70 MeV/n cosmic rays are correlated with changes in B, as has been observed in the heliosphere beyond 11 AU. The V1 magnetic field observations from 2002.0 2003.17 do not provide evidence for exit from the heliosphere, entry into the heliosheath, or transit of the termination shock near 85 AU.

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The Return of the Heliospheric 2-3 kHz Radio Emission During Solar Cycle 23

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