SEE Bulletin

Developing Tomorrow's Space Technologies Today

NASA's Space Environments and Effects Program

Winter 1998 Issue

The Start of the New Solar Cycle 23

The space environment characteristics and associated spacecraft effects with which the Space Environments and Effects (SEE) Program are concerned are all, to one degree or another, affected by aspects of the sun's activity, which is cyclic. Thus, our ability to identify the magnitude, time of start, maximum, and approximate profile of a new solar cycle and to produce viable and consistent estimates for the expected behavior of the new solar cycle, is of considerable importance to the SEE Program activities.

Early identification of the magnitude and time of the start of a new solar cycle and of the maximum tends to occupy many people's time as we approach either event. The importance of this identification is due to the use of future solar cycle estimates in radiation and ionosphere models, spacecraft orbital lifetime predictions, etc. plus scientific interests associated with estimating changes in solar activity, frequency of flares, etc. However, there are several ways the identification of a solar cycle minimum can be accomplished, depending upon one's intended use of the information and how the measurements are analyzed.

The classic technique for defining the time of minimum of a new solar cycle, as published in the historical records, has been to use the Zurich 13-month smoothed sunspot number (SSN) computed on a running monthly basis with the date attributed to the mid-month. Once a minimum SSN value has been firmly established, the month and year of occurrence is designated as the start of a new solar cycle. However, some groups now use a 12-month smoothed SSN computed on a running monthly basis. These two techniques may also be applied to the solar 10.7 cm flux (F10.7) to produce alternative means for identifying the minimum of a new solar cycle. Yet another technique is to identify the start of a new solar cycle as being when new sunspot groups occur on the sun at the higher latitudes, the old cycle sunspots having migrated toward the sun's equator and declining in number. Needless to say, each of these techniques (and others) for identifying the start date of a new solar cycle can produce different dates, sometimes by a year or more.

Each month the Electromagnetics and Aerospace Environments Branch of NASA's Marshall Space Flight Center, using the Marshall Solar Activity Future Estimate (MSAFE) Model, provides updated statistical estimates of future Zurich 13-month smoothed solar flux. Details of the MSAFE Model are contained in NASA Technical Memorandum 4759, Statistical Technique for Intermediate and Long-Range Estimation of 13-Month Smoothed Solar Flux and Geomagnetic Index. The primary use of the MSAFE Model products is as an input to orbital altitude atmospheric density models used to predict spacecraft drag. The Branch uses a well defined objective process to provide an early identification for the occurrence of a provisional solar cycle minimum, using the observed Zurich 13-month smoothed solar flux. The provisional smoothed solar flux minimum for solar cycle 23 was identified as May 1996 at 71.4 units in the January 1997 issue of the NASA Marshall Space Flight Center solar activity memorandum, which, each month, provides updated products from the MSAFE Model. The MSAFE Model was re-initialized accordingly. In this case the observed Zurich 13-month smoothed SSN also produced a provisional minimum of 8.1 units for May 1996.

The May 1996 provisional minimum identified for solar cycle 23 recently (with the April 1997 smoothed solar flux value of 76.8) met the criteria for declaration as the minimum of record and thus the classical start for solar cycle 23. Based on the historical records of observed

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smoothed solar flux measurements made since 1947, this decision can be made once the observed Zurich 13-month solar flux data, computed on a running monthly basis, equals or exceeds 76 units. This confirmation of the minimum date was announced in the December 1997 issue of the NASA Marshall Space Flight Center solar activity memorandum.

The magnitude of the smoothed solar flux minimum for May 1996 was 71.4 units. The observed smoothed solar flux value, based on data through November 1997, is 78.4 units. Using the November data, the MSAFE Model produced a smoothed solar flux estimate of solar cycle maximum for June 2000 with a magnitude of 230.0 units at the 95% confidence level, 153.9 at the 50% (nominal) level, and 104.5 units at the 5% confidence level. However, if the observed Zurich 13-month smoothed solar flux value had decreased below the provisional minimum of 71.4 units, it follows that another provisional minimum and date would have been identified. The MSAFE Model would then have been re-initialized and the future estimate for solar cycle 23 adjusted accordingly.

Anyone interested in receiving the monthly updated products from the MSAFE Model may do so by communicating with the Electromagnetics and Aerospace Environments Branch via e-mail to <jerry.owens @msfc.nasa.gov>, Fax to 205-544-8807, or by regular mail to Jerry K. Owens, Mail Stop EL23, NASA Marshall Space Flight Center, Huntsville, Alabama 35812

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MEEP Retrieved After 18 Month Exposure on Mir - *Some Surprising and Not So Surprising First Observations*

by William H. Kinard

The Mir Environmental Exposure Package, MEEP for short, was actually four separate packages each containing a different experiment to measure the environments and/or effects of the environments surrounding Mir as a part of the International Space Station (ISS) Phase I Risks Mitigation Program. Two of the four MEEP packages contained experiments to investigate the meteoroid and man-made orbiting debris environments. The other two packages contained experiments to investigate the Shuttle and Mir induced contamination environments and the combined effects of the induced contamination and the natural space environments on materials that may be used on ISS. The test specimens for each of the four MEEP experiments were mounted in separate Passive Experiment Containers (PECs) for the trips to and from Mir via the Shuttle and for the 18 month external exposure on Mir.

Open PEC clamped to handrail on Mir/Orbiter Docking Adapter exposing experiment specimens to the space environments.

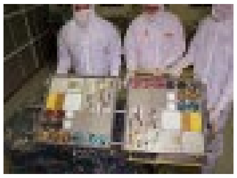
The PECs that were used for the MEEP, which were developed at the NASA Langley Research Center, are reusable suitcase-like containers which were attached to the side wall of the Shuttle cargo bay for transportation to and from Mir. While the Shuttle was on-orbit and docked to the Mir, the PECs were removed from the cargo bay, transferred to the desired exposure locations on the Mir/Shuttle Docking Module and clamped to handrails by astronauts during an EVA operation. The PECs employ a novel clamp that allows them to be attached to any protruding structure on Mir or ISS (such as a handrail), rotated to the desired facing directions and locked in place. After the astronauts clamp the PECs in place, they open them by rotating one-half of the PEC 360^0 to expose the internally mounted experiment specimens. The retrieval of the PECs after the desired exposure involves essentially the same operations performed in a reverse sequence.

PECs with Mir and soon with ISS offer opportunities for space experiments today that are similar to those offered by the LDEF a decade ago. An investigator can build, integrate in a PEC, and perform final testing of his experiment in his laboratory as illustrated below. The PEC is essentially the equivalent of an LDEF tray and the Mir or ISS is essentially the equivalent of the LDEF structure.

The four passive MEEP experiments are shown below in their respective PECs before they were shipped to KSC. These experiments are passive and thus the primary data returned from them is derived from comparisons of pre and post flight observations and measurements of the exposed specimens.

1. Polished Plate Meteoroid and Debris (PPMD) Experiment developed by NASA LaRC.

2. Orbiting Debris Collection (ODC) Experiment developed by NASA JSC.



3. Passive Optical Sample Assembly (POSA-I) Experiment developed by NASA MSFC.

4. Passive Optical Sample Assembly (POSA-II) Experiment developed by Boeing Information, Space and Defense Systems.

The PPMD Experiment exposed aluminum, gold, and zinc targets to cratering by impacting particles and thus capture of impactor residue. Pin hole cameras and optical and electron microscope specimens were also mounted on each exposed surface of the PPMD Experiment for orientation and cleanliness measurements. The ODC Experiment exposed monolithic "tiles" of very low density pure SiO_2 aerogel to capture

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Space Portable SpectroReflectometer

by Stuart Clifton, Marshall Space Flight Center

The Space Portable SpectroReflectometer (SPSR) was developed to provide a means to make in situ inspections of spacecraft surfaces in order to determine the effects of the natural and induced space environment on optical, thermal, and space power.

The stability of materials used in space continues to be a limiting technology for long-term space missions, since spacecraft exterior surfaces often degrade during exposure to the space environment. The resulting degradation can seriously affect the performance of critical spacecraft systems including thermal control systems, solar arrays, and optical instruments. In particular, the damaging effects of the space environment may severely impact spacecraft thermal control surfaces which are critically important to mission performance and whose optical/thermal properties must be maintained within design limits. To make an accurate assessment of the condition of external thermal control surfaces, the optical properties of the surfaces must be measured directly on actual space hardware. This continuing need to inspect these optical properties is particularly important for International Space Station (ISS) where maintenance and repair are major issues for operational life.

SPSR is a portable instrument used to determine the solar absorptance (alpha) of materials surfaces. Alpha is one of the key thermal control properties for materials used on spacecraft external surfaces, and its measurement yields an indication of the effects of the space environment on these surfaces. SPSR, developed by NASA, will be first utilized in a joint USA/Russian experiment designed to directly measure the alpha of external Mir thermal control surfaces. It has been developed as an ISS Risk Mitigation Experiment designed to better the understanding of the potential environment around ISS and its effects on ISS materials and systems.

The SPSR determines the total hemispherical reflectance of external Mir surfaces. Measurements cover the spectral range 250-2500 nm with a spectral resolution of at least 5% with an accuracy of + 3% and repeatability of +1%. The small battery-powered unit measures 53 cm x 34 cm x 36 cm and weighs 16.7 kg. The unit provides an absolute type measurement and is self-calibrating with automatic data integration to calculate solar absorptance. The specific objectives of SPSR are to determine effects and damage mechanisms of the Mir space environment on materials, to provide data to validate ground test facilities and prediction models, and to develop and test a reusable flight instrument for the in situ measurement of operational spacecraft surfaces.

Operationally, the SPSR was transported to the Mir during the STS-86 mission. It is scheduled to be utilized during two Extravehicular Activity (EVA) operations currently scheduled in early to mid January in which the hand-carried device will be placed onto surfaces to be measured and clamped in place using handrails. Three measurements each are planned at four different Z-93 radiator surface locations situated on the core and Kavant II modules. Reflectance data gathered by the SPSR is displayed and recorded by the crew as the measurements are made. The data is then stored in the unit's internal memory and transferred to a Mir Interface to Payloads Systems (MIPS) computer for storage on optical disk and downlinking by means of the Mir telemetry system. The SPSR will remain on the Mir until it is returned to earth at the conclusion of the STS-89 mission scheduled for late January, 1998.

SPSR was developed by AZ Technology and managed by NASA'S Marshall Space Flight Center. Principal Investigator of the experiment is Ralph Carruth (MSFC) with co-investigators of James Zwiener (MSFC), Donald Wilkes (AZ Technology), and Dr. Stanislov Naumov (Russian Space Company - Energia). John Owens (MSFC) is the SPSR Project manager.

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impacting particles intact. The POSA I Experiment exposed approximately 388 samples of over 100 different types of materials as well as atomic oxygen pin hole cameras and two solar ultraviolet fluence monitors. The POSA II Experiment also exposed a large number of samples of many different materials and concentrators to increase the flux of atomic oxygen and the solar intensity on some of the samples. The detailed post flight analyses of the specimens are still in a very preliminary state, however, the early observations have revealed some interesting contamination results.

Two of the experiments (PPMD and POSA II) exhibit unexpected stains and residue from liquid splatters on some surfaces.

Residue of splatters on zinc plates exposed on the ram side of the PPMD Experiment.

Unsplattered zinc plates exposed on the wake side of the PPMD Experiment

Chemical analysis of the splatter residues, which covered 10% of the area of some surfaces, indicate the liquid included material from a biological source and it probably resulted from either the Shuttle or Mir waste water dumps. Deposits of silicon or silicones were also found on many of the exposed surfaces. These deposits are similar to those found on surfaces of the retrieved LDEF specimens.

Numerous craters resulting from hypervelocity debris impacts and the expected effects of atomic oxygen and ultraviolet radiation are also observed on many of the exposed experiment test specimens.

Additional information regarding the MEEP Experiments and results from the on-going post-flight analyses can soon be obtained from the SEE website and currently from the following contacts:

1. PPMD Experiment

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2. ODC Experiment

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3. POSA I Experiment

Jim Zweiner, Tel. 205-544-2528, e-mail: jim.zweiner@msfc.nasa.gov

4. POSA II Experiment

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- ***NASA/Air Force Partnership Council***
- ***OPM Preliminary Results***
- ***1997 NRA Selections***

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http://see.msfc.nasa.gov/

Recent Website Additions:

- Development of a Physics-Based Solar EUV Irradiance Variability Model for Upper Atmosphere Density Forecasting: *http://bdc.nrl.navy.mil/SSD/NRLEUV/*
- National Superconducting Cyclotron Laboratory: *http://www.nscl.msu.edu*
- NASA CR 4776, The On-Orbit Radio Frequency Environment: *http://see.msfc.nasa.gov/see/ee/eepub.html*

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