ABSTRACTS

2.95 The Imaging Capabilities of HESSI
E.J. Schmahl (UMd & NASA/GSFC), HESSI Team

The High Energy Solar Spectroscopic Imager (HESSI) will use rotational modulation synthesis for mapping hard X-ray and gamma-ray flares with spatial resolution of 2.3° and spectral resolution of ~ 1 keV. Like the Yohkoh/HXT hard X-ray telescope, HESSI relies on Fourier methods to produce images, but HESSI has many more sampled points in the Fourier plane, and is expected to produce higher resolution maps with greater dynamic range.

We summarize the methods to be used for HESSI imaging, touching on crucial details of modulation such as the Calibrated Event List, and describing the Back Projection method. Beyond these, we outline four basic tools for image reconstruction: CLEAN, MEM, PIXONS, and Forward Fitting. We present examples of simulated images for the existing reconstruction tools, with estimates of photometry and required computer resources.

Support for this work was provided by grant NAG-58849 from Goddard Spaceflight Center to the University of Maryland.

2.96 Solar Orbiter — A High Resolution Mission to the Sun and Inner Heliosphere
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The scientific rationale of the Solar Orbiter (SO) is to provide, at high spatial and temporal resolution, observations of the solar atmosphere and unexplored inner heliosphere. The most interesting and novel observations will be made in the almost heliosynchronous segments of the orbits at heliocentric distances near 45 R_E and out-of-ecliptic at heliographic latitudes of 6° to 38°. By going to 45 R_E, the SO will allow remote sensing of the solar atmosphere with unprecedented spatial resolution, and the almost heliosynchronous orbit segments will permit us to disentangle spatial and temporal variations in the solar wind in close linkage with the plasma and radiation conditions in the source regions of the Sun.

The strawman payload encompasses two instrument packages: Heliospheric Instruments — high-res visible light telescope and magnetograph (< 40 km), high-res X-ray/EUV imager (< 30 km), high-res UV spectrometer (< 100 km), EUV and visible-light coronographs, solar neutron and γ-ray detectors, radiometers. Heliospheric Instruments — solar wind analyzer, magnetometer, energetic particle detectors, IP dust detector, plasma wave analyzer, radio experiment, neutral particle detector.

Using solar electric propulsion (SEP) in conjunction with multiple planet swing-by manoeuvres, it will take SO two years to reach a perihelion of 45 R_E at an orbital period of 149 days, with an inclination ranging from 6.7° to 23.4° w.r.t. the ecliptic. During an extended mission phase of about 2 years the inclination will increase to 31.7°, leading to a maximum heliographic latitude of 38.3°.

The SO was one of the about 40 responses to the Call for Proposals for the next two “flexi-missions” (F2 and F3) within ESA’s Scientific Programme. At its meeting on 1 March 2000, ESA’s Space Science Advisory Committee recommended the Solar Orbiter among 5 other proposals for an assessment study. Launch is expected by the end of the decade.

2.97 New Diagnostics of Coronal Heating and Solar Wind Acceleration Processes Achievable With The Advanced Solar Coronal Explorer (ASCE)

The Advanced Solar Coronal Explorer (ASCE) is a proposed NASA Medium-class Explorer (MIDEX) mission that underwent a detailed Concept Study in 1999. The science payload includes large aperture EUV and visible light coronagraphs. ASCE’s unprecedented spectral range, spatial resolution, and sensitivity (30 to 100 times the EUV sensitivity of UVCS/SOHO) provide measurements needed to investigate the role of high-frequency and low-frequency waves in heating and accelerating the fast and slow speed solar wind. This presentation will outline the advanced capabilities of ASCE for obtaining detailed empirical descriptions of solar wind acceleration regions, specifying coronal temperatures, flow speeds, densities, and elemental abundances. Velocity distributions for electrons and more than 10 to 20 ion species with mass-to-charge ratios from 4 to 1 (including singly ionized helium) can be measured by ASCE in coronal holes and streamers. This information is sufficient to derive the wave-number power spectrum of magnetic fluctuations that affect the primary electron/proton plasma. The main goal is to identify the physical processes responsible for heating and acceleration of the primary particles and minor ions in the fast and slow speed solar wind.

2.98 A dream of a mission: the Stellar Imager and Seismic Probe
C.J. Schrijver (Stanford-Lockheed Institute for Space Research), K.G. Carpenter (Goddard Space Flight Center)

The Stellar Imager and Seismic Probe (SISP) is a mission to understand the various effects of magnetic fields on stars, the dynamos that generate them, and the internal structure and dynamics of the stars in which they exist.

The ultimate goal is to achieve the best-possible forecasting of solar activity on times scales ranging up to decades, and an understanding of the impact of stellar magnetic activity on astrophysics and life in the Universe. The road to that goal will revolutionize our understanding of stars and stellar systems, the building blocks of the Universe. SISP represents an advance in image detail of several hundred times over the Hubble Space Telescope. SISP will zoom in on what today - with few exceptions - we only know as point sources, revealing processes never before seen, thus providing a tool to astrophysics as fundamental as the microscope is to the study of life on Earth.

SISP is an ultraviolet aperture-synthesis imager with 8-10 telescopes with meter-class apertures, and a central hub with focal-plane instrumentation that allows spectrophotometry in passbands as narrow as a few Angstroms to hundreds of Angstroms. SISP will image stars and binaries with one hundred to one thousand resolution elements on their surface, and sound their interiors through asteroseismology to image internal structure, differential rotation, and large-scale circulations; this will provide accurate knowledge of stellar structure and evolution and complex transport processes, and will impact numerous branches of (astro)physics ranging from the Big Bang to the future of the Universe.

Fitting naturally within the NASA long-term time line, SISP complements defined missions, and with them will show us entire other solar systems, from the central star to their orbiting planets.

2.99 SUMI: The Solar Ultraviolet Magnetograph

A major focus of solar physics is the measurement of the temporal and spatial variability of solar magnetic fields from the photosphere into the lower corona, together with the study of how their behavior produces the dynamic phenomena in this region such as flares and CMEs. Considerable success has been achieved in the characterization of the full vector field in the photosphere, where \( \mathbf{B} \), the ratio of the gas pressure to the magnetic pressure, is \( \text{grad} \). At higher levels in the atmosphere where \( \mathbf{B} \) < 1, the magnetic field (through the Lorentz force) controls the structure and dynamics of the solar atmosphere, and rapid changes in structure with release of energy become possible. However, observations of the field at these higher levels have proven to be difficult, placing a serious limitation on our understanding of the physical processes occurring there. This poster will discuss the Solar Ultraviolet Magnetograph Investigation (SUMI), a hardware development study for an instrument capable of measuring the polarization in ultraviolet lines of C IV and Mg II formed in the transition region and upper chromosphere. We are currently developing optical technologies
necessary to build an instrument that will achieve a major advance in performance over that of earlier attempts (e.g., SMM/UVSP). Initially configured as a sounding rocket payload, such a UV magnetograph would allow us to make exploratory measurements extending the observation of solar magnetic fields into new and dynamic regimes.

This work is supported by NASA through the SEC Program in Solar Physics and the program for Technology Development for Explorer Missions and Sofia.

2.100
Investigation of Chromospheric and Coronal Structures with the Advanced Technology Solar Spectroscopic Imager
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We discuss a new rocket payload, the Advanced Technology Solar Spectroscopic Imager (ATSSI), that will obtain true spectroheliograms from \( \sim 300 \) Å to 1.5 Å. Using an array of quantum calorimeter detectors at the focus of a Wolter I telescope, it will obtain approximately 1000 spectra spanning the energy range from 150 eV to 3 keV with \( \sim 3 \) eV energy resolution and covering a 3.5 arc-minute by 3.5 arc-minute field of view with 6.25 arc-second pixels. Each spectrum will include spectral lines from ions ranging from C V to S XVI, generated over the temperature range from 600,000 K to \( > 10,000,000 \) K. The ATSSI will also obtain full disk images in lines of Fe XVII, Fe XII, Mg X, Fe IX, Ne VIII, O VI, C IV, and H I, all with resolution of \( \sim 1 \) arc-seconds, and high-resolution grating spectroheliograms in lines of Fe IX/X, O VII, and Mg II. These observations can be used to (a) model the flow of energy in the small structures associated with the chromospheric network, and investigate the nature of their interface with transition region and coronal plasmas; and (b) observe the thermal structure of coronal loops in sufficient detail to determine the spatial distribution of their non-thermal heating mechanism(s).

2.101
Having Our Cake and Eating it, Too: Fast Imaging Spectroscopy With a Multi-Order Slitless Spectrograph
C. C. Kankelborg, D. W. Longcope, P. C. H. Martens (Department of Physics, Montana State University)

We describe a new type of EUV imaging spectrograph that combines high spectral, spatial and temporal resolution. The instrument consists of a slitless spectrograph with cameras placed at several diffraction orders. The unique information derived from simultaneous imaging at multiple orders allows the deconvolution of spectral and spatial information, thus overcoming the limitations of a traditional slitless spectrograph.

2.102
Solar Sail Mission Concepts
H. D. Winter (University of Memphis), D. Alexander (Lockheed Martin Solar and Astrophysics Lab.), C. R. McInnes (University of Glasgow, Scotland)

Solar sail technology is fast becoming a viable option for spacecraft propulsion and appears as an enabling technology in many plans for future space physics missions. We have developed a number of novel mission concepts which utilize the full potential of solar sail propulsion. These mission concepts include enhancements to existing ideas, some of which appear in the most recent SEC Roadmap, in addition to a number of new mission ideas.

Each mission considered incorporates a range of sail performance levels which allow an examination of the potential, both near-term and far-term, of attaining the specified mission goals. Two main issues arose from this work:

1) High energy orbits can be readily attained from a relatively small launch vehicle even for low performance sails, significantly reducing costs;
2) Improving technology can enhance a specific mission by either decreasing the travel times and increasing maneuverability, or by increasing the payload mass fraction.

This work was supported by an internal research and development contract from Lockheed Martin Advanced Technology Center.

2.103
Time-Dependent Tomography Of Heliospheric Features Using Global Thomson-Scattering Data From the Helios Spacecraft Photometers
B.V. Jackson, P.P. Hick (CASS/UCSD)

In the near future white-light, all-sky imagery of the heliosphere will become available from instruments such as the Air Force/NASA Solar Mass Ejection Imager (SMEI), and all-sky cameras as currently included in the instrument complement of the NASA Solar Probe and Solar Polar Sail mission and the ESA Solar Orbiter mission. To optimize the information available from these instruments, their 2-dimensional sky images need to be interpreted in three dimensions. We have developed a Computer Assisted Tomography (CAT) program that modifies a time-segmented three-dimensional kinematic heliospheric model to fit Thomson scattering observations and is designed specifically with observations from the above instrumentation in mind. Here we apply this technique to the Helios spacecraft photometer observations. The tomography program iteratively changes these models to least-squares fit observed global brightness data. The short time intervals of the kinematic modeling impose the restriction that the reconstructions primarily use outward solar wind motion to give perspective views of each point in space accessible to the observations. We plot these models as density Carrington maps and remote observer views for the Helios data sets. The results to date are commensurate with the observational coverage, temporal and spatial resolution, and signal to noise available from the original data. At solar maximum, the Helios photometer data show significant CME activity in the form of dense transient structures at all heliographic latitudes. We explore the location of these dense structures with respect to the heliospheric current sheet and regions of activity on the solar surface.

2.104
Periodogram Analysis of the Zurich and Schowe Series, Stability of the Quasi-Century and Quasi-Two Century Solar Cycles
B. Bonev (Ritter Astrophysical Research Center, Univ. of Toledo)

A cycle search technique, called T-R Periodogram Analysis, is applied to two basic time series for solar activity: the Zurich series (International Sunspot Number) and the Schowe series (after 296 AD). A criterion, based on Monte Carlo procedure, for the statistical reliability of the quasi-periodicities is developed. The stability of the identified cycles is examined by testing different fractions from the time interval covered by the series. All observed cycles, except those with 11-year, quasi-century, and quasi-two century periods, turn out to be highly questionable. The interpretation of the long-term solar variability is far from simple. A 100-year cycle which satisfies the Monte Carlo criterion is present only in the Zurich series data. The Schowe series highlights the generally accepted quasi-two century cycle that is well defined and determines the long-term solar activity behavior after about 1000 AD. On the other hand, between 296 AD and 1000 AD stable and statistically reliable cycles are not identified and the variations are irregular rather than cyclic. Weak periodicities are present but well below the noise level. This modulation in the features of the solar variability indicated in the Schowe series might be connected with the influence of a much longer periodicity than those discussed here, in particular the possible 2400-year cycle.
2.105

Standardized Coordinate Systems for Solar Image Data

W.T. Thompson (SM&A Corp., NASA Goddard SFC)

The current state of describing the coordinates of solar image data is chaotic, and does not take into account the most recent developments in the coordinate systems for astronomy in general, especially as related to FITS files. A set of formal systems for describing the coordinates of solar image data is proposed. These systems build on current practice in applying coordinates to solar image data. Both heliographic and heliocentric coordinates are discussed. A distinction is also drawn between heliographic and helioprojective coordinates, where the latter takes the observer’s exact geometry into account. The extension of these coordinate systems to observations made from non-terrestrial viewpoints, such as STEREO and Solar Probe, is discussed. A formal system for incorporation of these coordinates into FITS files, based on the FITS World Coordinate System, is described, together with examples.

This work was supported by NASA grant NAS5-32350.

2.106

A National Solar Digital Observatory

F. Hill (NSO)

The continuing development of the Internet as a research tool, combined with an improving funding climate, has sparked new interest in the development of Internet-linked astronomical data bases and analysis tools. Here I outline a concept for a National Solar Digital Observatory (NSDO), a set of data archives and analysis tools distributed in physical location at sites which already host such systems. A central web site would be implemented from which a user could search all of the component archives, select and download data, and perform analyses. Example components include NSO’s Digital Library containing its synoptic and GONG data, and the forthcoming SOLIS archive. Several other archives, in various stages of development, also exist. Potential analysis tools include content-based searches, visualized programming tools, and graphics routines. The existence of an NSDO would greatly facilitate solar physics research, as a user would no longer need to have detailed knowledge of all solar archive sites. It would also improve public outreach efforts.

The National Solar Observatory is operated by AURA, Inc. under a cooperative agreement with the National Science Foundation.

2.107

A New Method of Determining Line-of-Sight Velocity Using MLSO/CHIP He I 1083 nm Observations

T. E. Holzer, H. R. Gilbert, D. F. Elmore (NCAR/HAO), R. M. MacQueen (Rhodes College)

A new method for determining line-of-sight velocity has been developed for the MLSO/CHIP He I 1083 nm instrument. The method involves tuning the Lyot-type spectral filter to seven different positions during each observing sequence (lasting about 3 minutes). The algorithm for line-of-sight velocity determination using these seven filter positions yields an accuracy of better than 10 km/s over a line-of-sight velocity range from 100 km/s to +100 km/s. The method is applicable to the observation of filaments, surges, sprays, and other features exhibiting sufficiently strong absorption or emission in the 1083 nm line. It therefore will be particularly useful in the study of eruptive events seen against the solar disk, such as filament eruptions associated with earthward-directed coronal mass ejections.

The High Altitude Observatory (HAO) is part of the National Center for Atmospheric Research (NCAR), which is sponsored by the National Science Foundation under the management of the University Corporation for Atmospheric Research.

2.108

First Observations with the Global High-Resolution H-alpha Network


We are in the final stages of establishing a three-site global network for continuous full disk H-alpha observations based on our experience with making high-resolution full disk H-alpha observations at Big Bear Solar Observatory. Utilizing existing telescopes at Big Bear Solar Observatory (USA), Kanzelhoehe Solar Observatory (Austria), and Yunnan Astronomical Observatory (China), the three stations are each equipped with 2K X 2K CCD detectors and will monitor the Sun at a 1 minute cadence.

We expect to monitor the emergence of each new flux region to obtain an unbiased data set in order to understand why some regions grow to super-activity while most decay quickly, as well as a more complete and uniform set of flare observations. We also expect to implement automatic detection of filament eruptions. Having high cadence data from three observing stations will also increase the accuracy of solar rotation rates as determined by feature tracking techniques.

We will show the first data sets from the new network.

2.109

First Results from the Big Bear Solar Observatory’s Digital Vectormagnetograph

T. J. Spirock, C. Denker, H. Chen, J. Qui, P. R. Goode, H. Wang (Big Bear Solar Observatory)

During the past three years, the Big Bear Solar Observatory has begun an aggressive program to upgrade the observatory’s instrumentation. In the forefront of this effort is the development of a highly sensitive, high cadence, filter-based, digital vector magnetograph for the observatory’s 10" vacuum refractor to replace the old video magnetograph to improve our measurements of the FeI line at 6301A. The hardware is being replaced by a 512 x 512, 12-bit, 30 frames per second CCD camera and high quality polarization optics. In addition, software tools are being written to aid instrument development by quickly evaluating images (bias, cross talk, etc.) and to generate near real-time vector magnetograms, which will aid space weather forecasting and the support of space weather missions. Data acquisition, data calibration and flat fielding methods will be discussed and quiet sun and active region magnetograms will be presented.

2.110

On the Absolute Alignment of GONG Images

C.G. Toner (NSO/GONG)

In order to combine data from the six instruments in the GONG network, the alignment of all of the images must be known to a fairly high precision (~ 0.1 for GONG classical and ~ 0.01 for GONG+). The relative orientation is obtained using the angular cross-correlation method described by Toner and Harvey (1998). To obtain the absolute orientation the Project periodically records a day of drift scans, where the image of the Sun is allowed to drift across the CCD repeatedly throughout the day. These data are then analyzed to deduce the direction of Terrestrial East-West.

The transit of Mercury on Nov. 15, 1999, which was observed by three of the GONG instruments, provided an independent check on the current alignment procedures. Here we present a comparison of the alignment of GONG images as deduced from both drift scans and the Mercury transit.

The Global Oscillation Network Group (GONG) is managed by the National Solar Observatory, which is operated by AURA, Inc. under a cooperative agreement with the National Science Foundation.
The Status of SOLIS
J. Harvey (NSO), SOLIS Team

SOLIS (Synoptic Optical Long-term Investigations of the Sun) is a project to replace several of NSO's existing synoptic instruments with a modern, state-of-the-art observing system. It will provide the community with full disk vector and high sensitivity longitudinal magnetograms, narrow spectral band images at several popular wavelengths, and sun-as-a-star spectra, all with good cadence and calibration. The project started in early 1995 and should be in operation in 2001. The system is designed to be movable and will be initially installed on top of the Kitt Peak Vacuum Telescope tower. A new equatorial mounting has been built and is temporarily located at the GONG observing site in Tucson. The Integrated Sunlight Spectrometer (ISS) is a fiber-fed double-pass spectrograph equipped with a thinned, back-side illuminated CCD camera. The ISS has produced good spectra from the K line to the 1083 nm He I line. The current effort is on development and implementation of spectrophotometric calibrations. A 50-cm aperture Vector SpectroMagnetograph (VSM) is designed to produce full disk (and also smaller areas) vector and high sensitivity magnetograms and 1083 nm maps. The VSM is currently being fabricated and assembled. A key part of the VSM is a custom CCD camera that produces 300 frames per second of spectropolarimetric data. The required CCDs have been produced with good yield, but the full camera system is behind schedule. A filter-based imager, the Full Disk Patrol (FDP) will produce digital images in a number of well known lines. It is designed to acquire simple Dopplergrams as well as intensity images, but does not make magnetograms. The FDP uses two filters, one for 1083 nm and a tunable one for 380-680 nm. The first filter is essentially complete while the second one is under construction. A vital element of SOLIS is the data handling system which acquires, reduces and distributes data. First generation acquisition software has been implemented with the ISS. A storage area network system will buffer the real time data at the observing site. This has been procured and tested. A 45 Mb/s data line is being installed between Kitt Peak and Tucson to allow rapid transfer of large volumes of data. Data reduction algorithms are being tested. Assistance with design issues has generously been provided by HAO, Lockheed-Martin, the University of Hawaii, and the US Air Force group at Sac Peak. NASA and the ONR have provided funds to augment the development of SOLIS. The major funding comes from the NSF Office of Multidisciplinary Activity and the NSO base budget.

Seismic Imaging of the Far Side and Interior of the Sun
D.C. Braun (NWRA-CoRA & SPRC), C. Lindsey (SPRC)

Images of active regions on the far side of the Sun were derived by applying seismic holography to observations from the SOI-MDI instrument on the SOHO spacecraft. Synoptic seismic imaging of far-side solar activity will allow anticipation of the appearance of large active regions more than a week ahead of their arrival on the east limb. The technical requirements for a synoptic monitor appear to be quite modest, given real time access to observations from the Global Oscillations Network Group, for example. Currently, seismic images of the solar far side are easily computed in less than a day using a single-processor Pentium-based PC running Linux.

In addition to providing new applications for space weather prediction, the development of solar acoustic holography is opening new diagnostic avenues in the study of the solar interior. Phase-sensitive seismic holography is producing high-resolution maps of sound travel-time anomalies caused by magnetic forces in the immediate subsurfacephere, apparent thermal enhancements in acoustic moats around sunspots, and Doppler signatures of subsurface flows. Seismic holography applied to global modes, such as those used to image the far side, has directly demonstrated the influence of active regions on these modes. This reinforces a growing consensus that reduced sound travel times in magnetic regions explain the entirety of the frequency shifts of global modes with the solar cycle. Phase-sensitive holography will also be used to probe thermal and Doppler perturbations deep in the solar convection zone and the tachocline.

This work is supported by grants NAG5-7236 from NASA and AST-9528249 from NSF, and by a contract, PY-0184, from Stanford University.

Prediction of X-Ray Flare Evolution using Temporal Lognormal Fits
P.L. Bornmann (NOAA/SEC)

The lognormal function, a gaussian with log time, can be used to fit the temporal evolution of the observed x-ray flux from solar flares observed with the disk-integrating GOES X-Ray Sensor. Current fits are reproducing the decay of the x-ray flare based on four fitting parameters derived from the rise phase observations. This the first time we have had a method for predicting the decay of the event from the evolution during the rise phase. This approach also provides the potential to predict the time-integrated (and spatially integrated) flux used for prediction of a subsequent particle event before the flare actually begins to decay. It also provides an opportunity to predict when a flare will fall below levels that have significance to human systems such as short-wave radio and over-the-horizon radar. Scientifically, the success of the lognormal function can be viewed as evidence that the release of x-ray emission is based on a series of physical processes for which the output is statistically proportional to the input (for example, collisional excitation and perhaps energy release as an avalanche of multiple reconnection sites). The success of many of the fits raises the question of why some fits are less successful and whether they represent a unique class of event or merely a limitation of the current fitting process.

EUV irradiance variations measured with the SOHO Coronal Diagnostic Spectrometer

The Coronal Diagnostic Spectrometer aboard the Solar and Heliospheric Observatory observes the solar EUV spectrum in two bands between 308-379 Å and 513-633 Å. The full Sun irradiance can be measured by rastering the instrument over the solar disk. Measurements of the solar irradiance have been made starting 25 March 1997 and continuing to the present, ranging from very quiet to very active Sun. These measurements are the only current EUV spectral irradiance measurements taken on a regular basis. As well as irradiance values, the most recent observations also provide moderate resolution solar images to help quantify the important sources of the irradiance variability. The dependence of individual spectral lines on the solar cycle is presented, spanning the temperature range from 3 × 10⁶ K to 2.7 × 10⁸ K. The important spectral lines of He II and Si XI at 304 Å are observed in second order and separated. The high spectral resolution of these measurements, combined with the coverage of a significant portion of the solar cycle, provide a unique dataset for understanding solar variability in the EUV. In addition, these data are important input for interpreting data from broadband and lower resolution irradiance monitors, such as the SOHO SEM and TIMED.

Global Solar Variability: Cycle 23 Indicates a Change from Recent Cycles
G. de Toma (LASP/UC), O. R. White (HAO/NCAR), G. A. Chapman, S. R. Walton (SFO,CSUN), K. L. Harvey (SPRC)

This paper focuses on the rising phase of solar cycle 23 from the time of solar minimum in 1996 to the present high activity level. A number of observations indicate that cycle 23 maximum is now close, and maybe already in the maximum phase. They include the distribution of coronal streamers, the presence of long-lived solar coronal holes at low latitudes, the latitudinal distribution of sunspot regions, and the unipolar magnetic fields in the polar region.

Most of the activity indices, i.e. sunspot number, sunspot area, photospheric magnetic flux, 10.7 cm radio flux, and UV irradiances, indicate this cycle as a relatively weak cycle as compared to cycles 21 and 22. In particular, observations at San Fernando Observatory of sunspot and facular area are a factor of two or more lower than in solar cycle 22. This is