

MODELING SOLAR UV/EUV IRRADIANCE AND IONOSPHERE VARIATIONS WITH MT. WILSON MAGNETIC INDICIES

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LONG-TERM GOAL

The long term goal for this project is to develop new indices of solar outputs based on observations of solar magnetic fields made every clear day at the Mt. Wilson Observatory's 150-foot solar tower and to continue the acquisition of these observations. The data reduction is done within hours of at least one observation per day (weather permitting) and the results of the reduction are made available through the worldwide web. The analysis of the past database together with timely dissemination of new data is for the purpose of improving forecasts of the state of the earth's ionosphere in order to better predict the communications environment which relies on radio reflections from the various layers of the upper atmosphere.

SCIENTIFIC OBJECTIVES

The emissivity of the solar atmosphere depends on the strength of the magnetic field on the sun's surface. The solar surface is highly inhomogeneous and contains at least four types of region: quiet sun, chromospheric network, plages and sunspots. Each type of region contributes differently to the total flux of UV, EUV and X-ray output. The solar surface magnetic field is a recognized indicator of the nature and strength of each type of solar region. Our plan is to use the magnetograms obtained at the 150-foot tower on Mt. Wilson to quantitatively divide the solar surface into the different classifications and assign a strength of emission on the basis of the observed magnetic field strength. A second objective is to develop and test near term predictions of the solar output based on the observed magnetograms. Current reduced observations and the near-term predictions are made available on the worldwide web at address: http://www.astro.ucla.edu/~obs/150foot_data.htm.

A goal is to provide results of the observations on a near-real-time basis.

APPROACH

Every clear day the synoptic program at the Mt. Wilson Observatory's 150-foot tower uses the magnetograph system to carry out full solar disk scans which provide measurements of the surface magnetic field strength using the magnetically sensitive spectral line of neutral iron at a wavelength of 525.0 nm. This system has spatial resolution of 12 or 20 arcseconds squared. On portions of the solar surface having weak or no magnetic field, the rms variation of the measured field is 0.8 gauss and this represents an upper limit to the error of measurement of the system. On the basis of these measurements a region is considered to be quiet if its field is less than 3 gauss. Active network areas have fields between 3 and 8 gauss, plage regions have field between 8 and 80 gauss and areas with higher fields are considered to be sunspots. The precise breakpoints are still under study and may be modified. These numbers apply only to the magnetic fields obtained with the 525.0 nm line observed with the Mt. Wilson system and cannot be

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applied to any other magnetogram observations. Based on this classification, several indices are computed the best established of which is the Magnetic Plage Strength Index (MPSI) which was introduced by Ulrich (1991, Adv. Space Res., vol 11, no 4, p. 217). These full disk scans are carried out throughout the day and up to 20 per day full disk images are obtained. The first scan is reduced immediately so that its derived quantities can be posted to the above web address. The remainder of the scans are reduced overnight and averaged to provide the definitive daily result.

WORK COMPLETED

The derivation of the MPSI is now routine and the same-day results are posted most days before 1 PM Pacific Standard Time. Comparison of the MPSI to UV fluxes obtained with UARS satellite show that the MPSI has a 0.98 correlation coefficient with the observed Mg II h & k line core to wing ratio. Other correlation coefficients are given in Table 1 along with fitting coefficients which allow an estimate of the various ultraviolet fluxes based on the MPSI. These results will be extended through the use of additional indices which are still under development.

RESULTS

We have been able to model the sun's UV flux as indicated by the h & k spectral lines of ionized Magnesium. Although this spectral line itself is only indicative of overall UV emission, it is the most reliable parameter derived from the UARS mission due to the fact that it is based on a ratio of spectral fluxes measured in bands which are in close proximity. The 98% correlation we have obtained between our simple ground-based index (MPSI) and this core to wing ratio indicates that at least some of the important solar UV flux can be estimated with good precision. The daily results and plots like that in Figure 2 have been utilized at a growing rate with the number of web-site accesses growing from 2139 in October, 1996 to 7272 in October, 1997.

We have made progress in modelling the important Lyman α line flux. This radiation heats the lower thermosphere below 200 km and was not well modelled by the MPSI. By dividing the magnetic field into additional groupings of 0.5 to 3.0 gauss and 3.0 to 8.0 gauss we have been able raise the correlation between the Lyman α flux and a new index from 94% to 97%.

We have implemented a simple recursive model predictor which is applied to the daily plots and included as a 30-day projection. In monitoring the performance of this predictor, it is evident that its performance is variable. It is not able to anticipate changes in the level of solar activity due to the sudden appearance or disappearance of active regions. The more gradual evolution of active regions coupled with solar rotation does produce a highly predictable pattern.

IMPACT/APPLICATION

Our goal is to assist in the understanding of the role of solar variability in modifying the state of the earth's ionosphere. Our approach to this goal is to make our data freely available and to indicate how the ground-based solar indices relate to solar UV output. Our recent publication entitled "Modeling Solar UV Variations Using Mount Wilson Observatory Indices" (Parker, Ulrich and Pap, 1997, Solar Physics, in press) makes clear the utility of the ground-based indices for this application. Although the worldwide web system is set up to facilitate the distribution of the data, it is difficult to evaluate the utilization of this system as a predictive tool. At present there is no identifiable systematic access of this resource from any web-site with a .mil suffix. In contrast the Space Environment Laboratory in Boulder Colorado regularly obtains data from our

system and uses it in its space environment forecasts. Table 1 shows that our indices are better suited to evaluation of the ionospheric state than is the traditionally used 10.7 mHz radio flux.

TRANSITIONS

In order to estimate the utilization of the Mt. Wilson near-real-time data, we regularly execute a web statistics summary program. The number of accesses to individual web pages has increased steadily since they were initiated in May 1996. Most of these appear to be for the purpose of generally estimating the state of solar activity since a typical session consists of an examination of a selection of the solar images available on our web-site. In order to increase utilization for the purpose of solar UV flux estimation, we will add to our pages a chart and table like Figure 1 and Table 1 along with appropriate text. This will allow our site be found by search engines.

RELATED PROJECTS

The ground-based indices are being used by Pap, et al., (1997) to study the long-term variations in the total solar and UV irradiances. The historical data from this project extends back to 1967 and this database can be used to address questions concerning the solar output at successive solar minima and maxima. The above paper finds that the variations were similar at minimum and maximum for solar cycles 21 and 22. The ground-based indices are among the few tools available for comparison to direct flux measurements which cover more than one solar cycle. The minimum levels of both the MPSI and the Mg II h & k c/w ratio were about the same for cycles 21 and 22.

REFERENCES

Parker, D. G., Ulrich, R. K. and Pap, J. M., 1997. "Modeling Solar UV Variations Using Mount Wilson Observatory Indices," *Solar Physics*, (in press).

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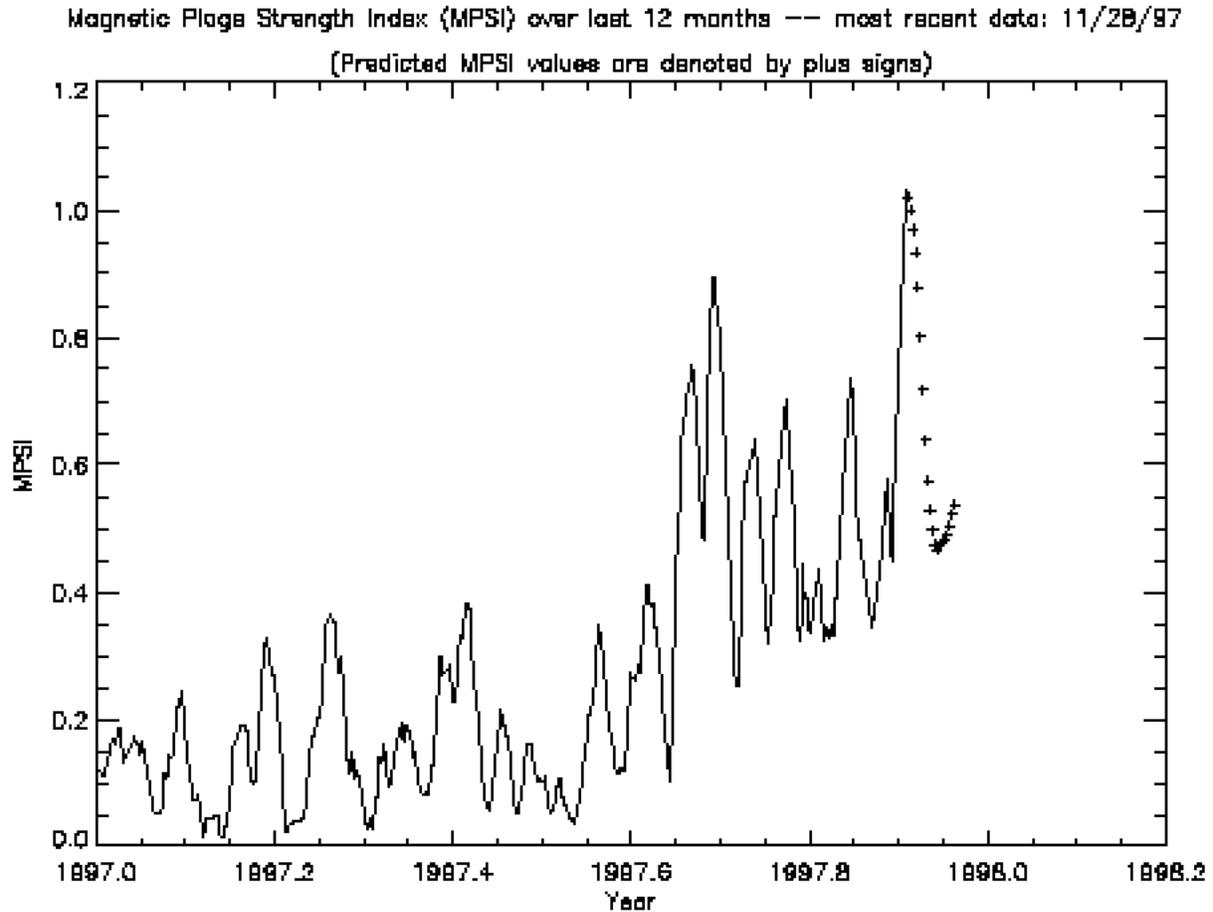


Figure 1. Graph Available on the Web Page at http://www.astro.uda.edu/~obs/150_dat.htm

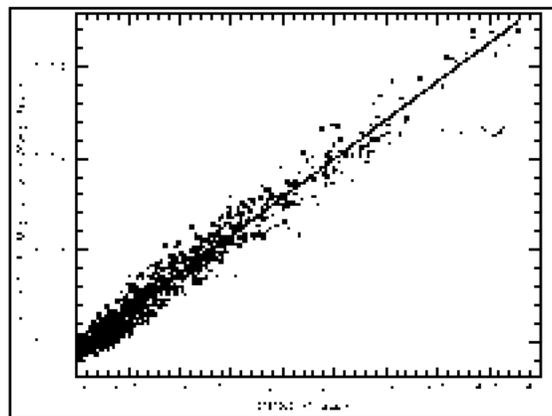


Figure 2. The Correlation Between Observed Solar Ultra-Violet Radiation and An Index Derived From Magnetograms at the Mt. Wilson Observatory.

Table 1 - Comparison of MPSI and F10.7 Correlations		
<i>UV Index</i>	<i>MPSI</i>	<i>F10.7</i>
SOLSTICE Mg c/w	0.980	0.92
SUSIM Mg c/w	0.970	0.91
SOLSTICE Ly- α	0.947	0.90
SUSIM Ly- α	0.935	0.89
SOLSTICE 200-205 nm Flux	0.938	0.85

Table 1. Comparison of MPSI and F10.7 Correlations