A Mg II Index Derived From Estimated Solar Spectra

J. S. Morrill (E. O. Hulburt Center for Space Research, Naval Research Laboratory, Washington DC)

Abstract

We have estimated values of the Mg II index using a model of solar spectral irradiance developed at the Naval Research Laboratory. This model uses Ca II K images and spatially resolved sun spot, quiet sun, and active sun spectra measured by the HRTS-9 rocket to generate the estimated spectra. These spectra are compared to observed spectra such as the UARS-SUSIM and UARS-SOLSTICE data sets. In order to further compare the observed and estimated spectra, a Mg II index is derived from these two sets of spectra. In this presentation we will review the details of the model, discuss the methods of deriving the Mg II index, and compare the Mg II variability resulting from the observed and estimated spectra. We have estimated values of the Mg II index using a model of solar spectral irradiance developed at the Naval Research Laboratory. This model uses Ca II K images and spatially resolved sun spot, quiet sun, and active sun spectra measured by the HRTS-9 rocket to generate the estimated spectra. These spectra are compared to observed spectra such as the UARS-SUSIM and UARS-SOLSTICE data sets. In order to further compare the observed and estimated spectra, a Mg II index is derived from these two sets of spectra. In this presentation we will review the details of the model, discuss the methods of deriving the Mg II index, and compare the Mg II variability resulting from the observed and estimated sectra.

Overview of NRL Irradiance Model

❑ Mathematical formulation

$$F_{FD}(\lambda) = \Sigma_{i(QS)} B_{QS}(\lambda)\, Ld(\lambda,i)\, \Delta A + \Sigma_{j(AR)} B_{AR}(\lambda)\, Ld(\lambda,j)\, \Delta A + \Sigma_{k(SS)} B_{SS}(\lambda)\, Ld(\lambda,k)\, \Delta A$$

$F_{FD}(\lambda)$ = Full disk solar irradiance.

$B_{QS}(\lambda)$ = Disk center Quiet Sun brightness.

$B_{AR}(\lambda)$ = Disk center Active Region brightness.

$B_{QS}(\lambda)$ = Disk center Sun Spot brightness.

$Ld(\lambda,k)$ = Quiet Sun limb darkening function.

ΔA = Angular size of the Ca II K pixels.

❑ Wavelength Coverage - 2760 to2880 Å (HRTS-9)
- 1940 to 3940 Å (SKYLAB)

❑ Empirical Inputs (calibrated) - Quiet Sun, Active Region, and Sun Spot Spectra
- Solar surface regions identified by full disk Ca II K images
- High Resolution Wavelength dependent limb darkening function

❑ Planned Comparison HiRes spectral indices. - Compare model spectra with observations & Mg II

Empirical Inputs: Ca II K Images

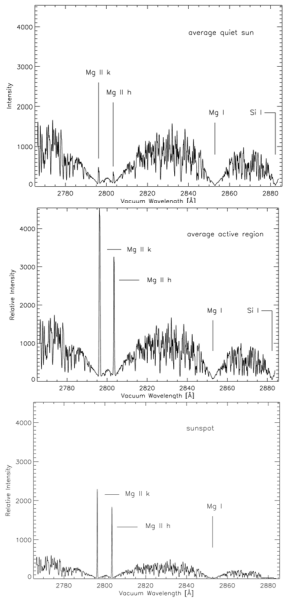
❑ Ca II K images from BBSO (limb darkening corrected) have been used to identify solar surface regions.

❑ The regions to be used in this model are, quiet sun, active regions, and sun spots.

❑ Spectra for these regions have been measured by HRTS-9 and will be derived from SKYLAB observations

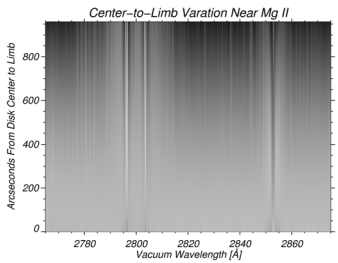
Empirical Inputs: Spectra

The Quiet Sun, Active Region and Sun Spot spectra used in this irradiance model are shown in the figures below. These spectra are effectively basis functions for the simple model outlined above.



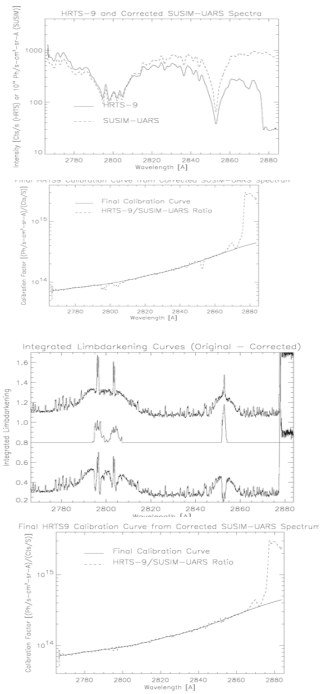
High Resolution Limb Darkening

The limb darkening function is derived from a Quiet Sun spectrogram measured by HRTS-9. The slit was aligned parallel to the solar equator with one end near disk center and the other end near the limb.



Role of Calibration in Limb Darkening

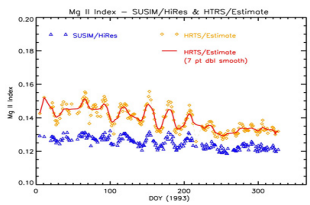
The following figures show the SKYLAB spectrum between 194 an 394 nm. These spectra are in units of film density and will require correction (film and absolute calibration) to absolute units (e.g mW/m² nm). Note that these spectra include the Ca II K line. Limb darkening curves will derived from spectra at different points on the disk.



Mg II Index Results

❑ A comparison between the MgII index derived from SUSIM HiRes Spectra and from the estimated spectra is shown below. The left figure shows the values from both sets of spectra. The index from the estimated spectra has been smoothed (11 pt double smooth - solid red line).

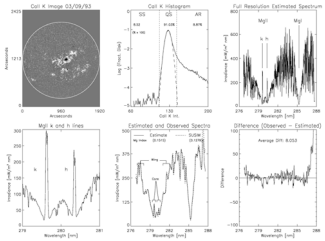
❑ In the figure on the right, the smoothed estimated index is shifted onto the SUSIM results and shows that the current model is able to recover the basic variability in the Mg II index even with the above differences.



Spectral Results

The two sets of figures below show two different extremes of solar activity. Each set includes (i) the source Ca II K image, (ii) the associated intensity histogram, (iii) the resulting estimated spectrum at full resolution, (iv) a close-up of the Mg II lines, (v) a comparison of the estimated and SUSIM spectra for this day, and (vi) the difference between the two spectra. The top set is from a day of relative high solar activity and the bottom set is from a very quiet day. The shape of the difference between spectra indicate the the limb darkening function requires further effort and this is currently underway. Figure (v) shows the regions used to calculate the Mg II index shown below.

Active Sun



Quiet Sun

Discussion

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