Solar Spectral Variability as Measured by the SORCE SIM Instrument

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Presentation Outline

♦ The SIM Instrument (Briefly)
♦ The Solar Spectrum and Solar Variability as Measured by SIM
  • Discussion on SIM Spectral Irradiance Time Series at Different Levels of Solar Activity
  • Target the April 21 through October 1 time period
Executive Summary on SIM – The First 642 Days

♦ All instrument subsystems functional

♦ Produces high precision data for characterization of spectral solar variability. (See contents of this presentation & Fontenla et al., in preparation for Solar Physics)

♦ Important information about the infrared behavior of plage inferred from analysis of the SIM IR channel. (Fontenla et al., Ap. J. Lett., 2003)
Instrument Attributes Overview

UV
Vis2
Vis1
ESR

Fery
Prism

Sun
35 mm

Focal Plane
400 mm

IR

To ESR

From Entrance Slit

Suprasil 300

R=435.3 mm
Concave

R=445.4 mm
Aluminized Convex

Bolometer Detail
- Illuminated Face
- NiP Black Surface
- 50 kΩ Thermistors
- Integral thin film resistor on diamond

Aluminized Sphere
Kapton Suspension System
Exit Slit Plane
Light From Spectrometer
Reference Bolometer
Active Bolometer
ESR full scan requires 15 orbits to complete
♦ Moderate resolution instruments respond to the *density* of lines, not necessarily to the lines themselves.
Standard Indicators of Solar Activity

- **F10.7 Radio Flux**
  - Flux maxima occur on nearly 27-day centers in phase with Mg II.

- **Mg II Core-Wing Ration (NOAA16)**
  - Structure shows more contrast than F10.7 and is more ‘triangular’ in nature.

- **Total Solar Irradiance (TIM)**
  - The presence of sunspot groups on the solar disk cause a decrease in irradiance but are not in phase with the plage indicators.
Days of Maximum Mg II Activity

- Maxima do not correspond to a single active region but to a distribution of active regions and active network over a hemisphere.
- Some active regions seen in Ca II are not associated with sunspots but occur at times and places where sunspots were located.
Days of Minimum Mg II Activity

♦ Mostly quiet, but some periods had randomly distributed small sunspot groups.
♦ Images show band of active network close to the equator
♦ Ca II plage with no sunspots was common
Solar Variability in the Ultraviolet

250 nm: UV Pseudo-Continuum
- Formed from continuum flux from the top of the photosphere and densely spaced spectral lines in the lower chromosphere.
- Continuum contribution decreases with sunspot blocking, lines increase intensity due to presence of plage.
- Chromospheric component tends to dominate.

280 nm: Mg II
- Resolution 1.1 nm, so contains pseudo-continuum & the cores of the Mg II lines.
- 280 nm peaks when the plage areas are the largest.
- Flux is affected by the presence of active network structures.

304 nm: Near-UV Pseudo-Continuum
- Continuum formed in deeper layers of the photosphere with less densely spaced lines than at 250 nm.
- Time series resembles TSI and is more photospheric in nature than chromospheric.
- A factor of ~2x contrast enhancement compared to TSI
Solar Variability in the Visible – Short Wavelengths

430 nm: G Band
- Formed from densely spaced spectral lines; CH molecular, Fe I resonance and H Balmer γ (434.25 nm)
- Molecular lines formed at the top of the photosphere and bottom of chromosphere.
- Time series resembles TSI but about 2x more contrast

480 nm: Irradiance Peak
- Predominately Continuum with low density atomic lines
- Photosphere in character
- Time series resembles G Band

589 nm: Na I D
- Na I D lines formed in the lower chromosphere but with large departures from LTE and do not display emission at the core.
- Very similar in character to TSI, but broader in extent.
Solar Variability in the Visible – Long Wavelengths

- **656 nm: Hα**
  - Instrument function ~15 nm FWHM
  - At this point so time series contains continuum contribution
  - Almost indential in character to TSI

- **857 nm: Ca II Triplet**
  - Instrument function ~25 nm FWHM
  - Contrast is now less that for TSI

- **1000 nm: Ca I Resonance**
  - Facular brightening on the limb just barely compensates for sunspot areas still on the disk at this wavelength

Date:
- 4/29/2004
- 5/27/2004
- 6/24/2004
- 7/22/2004
- 8/19/2004
- 9/16/2004
Solar Variability in the Infrared

- In all cases, less sunspot contrast than TSI.
- For 1400 & 1590 nm traces, no appearance of brightness enhancements due to presence of plage on the solar limbs.
- On 5/21 and 8/19 differences from TSI are attributable to the appearance of plage structures on the limb from other wavelengths.
- Feature A shows an enhancement of IR brightness above that of TSI that is not present at the visible wavelengths. Same observation as discussed in Fontenla et al.
- Notice that the enhancement does not appear time period B.
- What is the nature of Feature A? Possibly an extended deep photospheric feature with very low contrast.
CONCLUSIONS

♦ SIM is ultraviolet, visible and infrared channels yield excellent information on solar spectral variability.

♦ Plage, network, and sunspot solar surface features contribute to the variability signal observed by the SIM.

♦ Solar images, TSI, and solar modeling in conjunction with SIM measurements provide an effective suite research tools to investigate solar variability.

♦ The characterization of solar features in the infrared remain one of the more important research questions that SIM can address.