Comparing Estimated and Observed Mg II Index at Solar Minimum:
1961 through 1981 vs 1978 to present

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Goal: Estimate Solar Irradiance Spectrum Over the Past Century

- Generate estimated UV irradiance with observed spectra and Ca II K images.
- Derive Mg II index for comparison with other proxies:
  - Sun spot number, F10.7 cm, etc.
- Observed spectra: HRTS, SKYLAB, SUSIM, TIMED-SEE and SORCE.
- Required input:
  - Ca II K images
    - BBSO 1990 to 1995
    - Mt Wilson: 1915 to 1985
    - Kodaikanal: 1913 to 1974
    - Arcetri: 1931 to 1974
Impact of Solar Variability on Earth’s Atmosphere

- Solar spectrum varies with wavelength.
- Altitude of absorption varies with wavelength.

Meier, et al., 1991
Estimated Solar Spectrum:
SUSIM, SORCE, TIMED-SEE, & Black Body

Where are the Ca II and Mg II lines

Ca II H & K lines
Mg II h & k lines
High and Low Resolution Mg II index

\[ P_{\text{MgII}} = \frac{4[I_{279.8} + I_{280.0} + I_{280.2}]}{3[I_{276.6} + I_{276.8} + I_{283.2} + I_{283.4}]} \]

Mg II Index observed from ~11/78 to present.

Snow et al. (2005)
Overview of Solar Spectral Irradiance Model

• Mathematical formulation

\[ F_{FD}(\lambda) = \Sigma_{i(QS)} B_{QS}(\lambda) \text{ CLV}(\lambda, r(i)) \Delta A \]
\[ + \Sigma_{j(AR)} B_{AR}(\lambda) \text{ CLV}(\lambda, r(j)) \Delta A \]
\[ + \Sigma_{k(SS)} B_{SS}(\lambda) \text{ CLV}(\lambda, r(k)) \Delta A \]

\[ F_{FD}(\lambda) = \text{Full disk solar irradiance} \]
\[ B_{QS}(\lambda) = \text{Quiet Sun brightness} \]
\[ B_{AR}(\lambda) = \text{Active Region brightness} \]
\[ B_{SS}(\lambda) = \text{Sun Spot brightness} \]
\[ \text{CLV}(\lambda, k) = \text{Quiet Sun limb CLV} \]
\[ \Delta A = \text{Size of the Ca II K pixels} \]

• Wavelength Range - 276 - 288nm (HRTS)

• Empirical Inputs
  - Quiet, Active, and Sun Spot Spectra
  - Ca II K images identify surface features
  - High Resolution CLV
Model Inputs: Ca II K Images and UV Spectra

BBSO Ca II K image (1/10/92)

Input Spectra From HRTS-9

- Active Sun
- Quiet Sun
- Sun Spot

Histogram of Ca II K Intensity
Model Results: Quiet Sun Spectrum
Model Results: Active Sun Spectrum
Model Results: Mg II Index

Using BBSO Ca II K images: 1991-1995
Number of Ca II K Images per Year from MWO

~ 39,260 Ca II K Images

Problems with MWO Ca II K Images:
- Generally don’t show sunspots - use tabular sunspot data
- No film step wedges before 1961 - develop correction method
Correction of MWO Images: H&D Curves

MWO image with “Step Wedge”
Model Results with MWO Images

Call K Image 1969-01-07.73

Call K Histogram

Full Resolution Estimated Spectrum

MgII k and h lines

Estimated and Observed Spectra

Difference (Observed - Estimated)
Mg II Index – Observation and Estimates
Minimum SS 19-20: 1/64-12/65
Minimum SS 20-21: 4/75-3/77
Minimum SS 22-23: 5/95-4/97
Mg II Index Histograms

![Mg II Index Histograms](image)
Examined the last five Solar Minima using estimated and observed Mg II Index.

Two of the last five Minima show a peaked distribution of Mg II Index.

Distribution for most recent Minimum has largest peak BUT peak occurs at a larger Mg II Index value: old cycle ends – new cycle begins.

Future Efforts: Complete MWO Ca II K processing and add other Ca II K data sets.