Photometric Observations of Solar Irradiance Variability from SFO

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Data Description

CFDT=Cartesian Full-Disk Telescope
Daily observations (digital images) continue using CFDT1 (since 1986) and CFDT2 (since 1992). Observations obtained on about 60% of days. Photometric indices available on request.
Data Description, Cont'd.

- Basic Observing Technique

- Linear photodiode array is oriented N-S
- Image is scanned using Earth's rotation
- Sky transparency is recorded every line
- Original idea from Gordon Hurford passed on by Hugh Hudson at WARTS workshop (NASA SP-310)
Image Size & Scale

CFDT1
Size: 512 x 512 pixels
Scale: 5.12 arc-sec/px

CFDT2
Size: 1024 x 1024 pixels
Scale: 2.5 arc-sec/px
<table>
<thead>
<tr>
<th></th>
<th>Wavelengths (BP)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CFDT1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>673.2 (10) nm</td>
</tr>
<tr>
<td></td>
<td>473.2 (10) nm</td>
</tr>
<tr>
<td></td>
<td>393.4 (1.0) nm</td>
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<tr>
<td>CFDT2</td>
<td></td>
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<tr>
<td></td>
<td>673.2 (10) nm</td>
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<tr>
<td></td>
<td>473.2 (10) nm</td>
</tr>
<tr>
<td></td>
<td>393.4 (1.0) nm</td>
</tr>
<tr>
<td></td>
<td>393.4 (0.3) nm</td>
</tr>
<tr>
<td></td>
<td>778. (10) nm</td>
</tr>
<tr>
<td></td>
<td>998. (10) nm</td>
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</tbody>
</table>
Venus Transit,
5 June 2012 (max contrast = -.88)
Scientific Justification

Need to understand and remove solar changes from other forms of climate forcing.

Spacecraft measurements of TSI and SSI not imaged.

Our program measures relative changes due to solar activity.

Our photometric indices correlate with TSI with $R^2$ better than 0.9.
Photometric Indices

Red Images

Photometric Sum

\[ \Sigma_r = \sum_i (\Delta I/I) \Phi_r(\mu) \quad [\text{no feature identification}] \]

Photometric Sunspot Index (model)

\[ PSI = C_S \sum A_S (3\mu + 2) \quad [\leq -8.5\%, \text{only}] \]

K-line Images

\[ \Sigma_k = \sum_i (\Delta I/I) \Phi_k(\mu) \quad [\text{no feature identification}] \]

PFI = \( C_p \sum A_f (3\mu + 2)(1/\mu - a) \quad [\geq 4.8\%, \text{only}] \)
REGRESSION RESULTS

- $S = S_0 + A \times \Sigma_r + B \times \Sigma_K$
- $S_0 = 1360.81 \pm 0.004$
- $A = 1.025 \pm 0.008$
- $B = 0.1257 \pm 0.001$
- $R^2 = 0.9495$
- $N = 1253$
Scientific Just. (cont'd)

- Our data can be used to correct S/C upsets.
- Our data can be used to connect different S/C TSI (having different scale factors).
- Imaged data necessary to understand the sources of TSI and SSI variations.
NIMBUS-7 vs CFDT1 w/NOAA9 DATA
747 Data Points - 1988-93

RESIDUALS, (Nimbus-SnN), W/m²

Day of Year, May 88 - Dec 93
Bolometric Contrast

The Bolometric Contrast, $\alpha$, is the bolometric irradiance deficit of a sunspot as seen from the surface of the Sun, not from the Earth.

A similar term for faculae/ network is not so easy; the facular contrast is a sensitive function of disk position.
Bolometric Contrast, con't.

The bolometric contrast, $\alpha_{\text{eff}}$, of a sunspot is the irradiance deficit as seen at the surface of the sun; not from the earth. It is given by

$$\text{DEF}/(2 \times \text{PSI})$$

The bolometric contrast, when integrated over the solar sky of a sunspot, gives its luminosity deficit.
composite deficit, no time correction
composite using sfo(blue and red)cfdt2
673 nm
cfdt1, limb error vs. rms contrast
$y = 2.32 \times 10^{-6} x + 0.254$
Annual Means

R_G and R_z vs. A_s (CFDT1)
Facular Excess, SFO & SDO

Excess_1600

Date

1600
0 500 1000 1500 2000 2500 3000 3500 4000 4500

Column B
Column J
Facular Area, SFO & SDO

\[ f(x) = 1.6777786445x - 2862.9205395099 \]

\[ R^2 = 0.9690538433 \]
Acknowledgements

- Support has come from the University and grants from NASA and the NSF.
- Over the years, many student observers have contributed to data collection and data analysis.
- The work using SDO data was carried out by Kemal Yassin and Debi P. Choudhary.