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Sun-as-a-Star, Chromospheric Lines, 1974-2009

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Abstract. We update the McMath-Pierce spectral line scan archives for Ca II K, He I 10830 Å, Ca II 8542 Å, and H I 6562 Å, both for full-disk and center-disk measurements . The Ca K3 intensity feature displays a peak-to-peak activity cycle modulation of $\sim$ 37% and He 10830 Å about 100%. SOLIS observations of the Ca K index suggest a cycle 23-24 minimum in late 2008 followed by a 0.7% rise by late 2009. Other McMath-Pierce indices display no evidence yet of cycle 24. Center-disk Ca K index measurements (optically averaged over the central 2-arcmin), show no particular response to cycle activity, i.e. the quiet disk is constant. A similar null response is found for the center-disk Wilson-Bappu effect.

Key words. Sun: activity – Sun: chromosphere

1. Introduction

Observations of the profiles of solar chromospheric lines during the past 35 years provide quantitative indicators of solar chromospheric activity. The disk-integrated solar spectral observations can be compared with similar observations of other stars and with different measures of solar activity to infer the nature of stellar activity cycles and the causes of solar spectral variability.

2. Archive extracts

Figure 1 shows the intensity of the Ca K3 (absorption feature in the core of the line) from October 1974 to October 2009. There is some evidence of a zero-level shift accompanying a change to a larger grating in 1992. The lower spectral resolution Ca K index, a 1 Å average over the K232 features at the line core, (reproduced on other figures to represent the activity cycle) is essentially the same.

The SOLIS Integrated Sunlight Spectrometer (ISS) Ca K index observations, which began in 2006 (Keller, Harvey, & Giampapa 2003) and are obtained daily, weather permitting, have recently indicated a rising signal of cycle 24; here deduced to be about 0.7% in weighted average amplitude. The weights are the inverse of the errors of the daily measurements. In Fig. 2 this ISS data is compared with the 10.7 cm radio flux (from www.spaceweather.gc.ca), and the comparatively sparse McMath-Pierce record. The latter two compare well, although this may not be significant.

Only slightly less often, be ginning in 1974, we observed by means of a small lens

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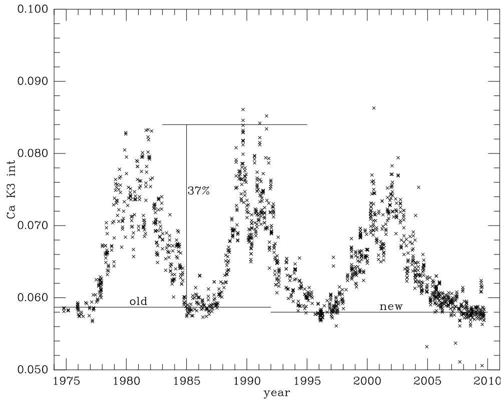

Fig. 1. Measurements of the sun-as-star intensity of the Ca K3 spectral feature relative to a specific continuum level in the K1 wings (White & Livingston 1981). The horizontal lines labeled old and new indicate the minima of the solar activity cycle observed with two different gratings.

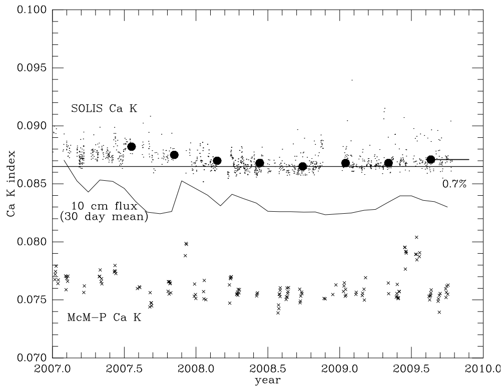

Fig. 2. Recent measurements of the Ca K index. Shown are daily observations using the SOLIS Integrated Sunlight Spectrometer (ISS) and monthly observations using the McMath-Pierce telescope with 0.01 subtracted. The thin line is a 30-day mean of 10.7 cm radio flux measurements. The large dots are four-solar-rotation weighted averages of the ISS observations. Both the radio and ISS observations suggest a minimum of activity late in 2008.

placed near the ceiling of the observing room, the center of the imaged solar disk (CD). The CD Ca K index results are shown in Fig. 3. Initially the lens was positioned at geometric disk center, but beginning in 1984 we offset the position slightly if any plage was detected

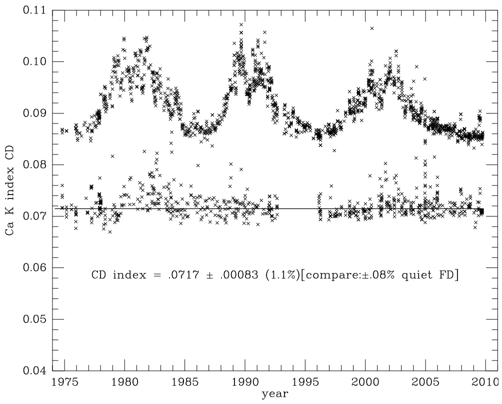

Fig. 3. Measurements of the center-disk Ca K index (crosses with horizontal line fit). The upper plot is the full-disk Ca K index plotted for comparison.

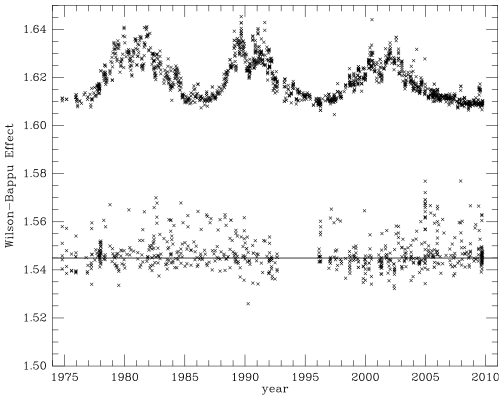

Fig. 4. Measurements of the center-disk Wilson-Bappu effect (crosses with horizontal line fit). The upper plot is the full-disk Ca K index plotted at an arbitrary ordinate position and scale for comparison.

there. So the record thereafter is strictly the quiet sun. Although this CD record is somewhat noisy (±1.1%) compared to the quiet FD sun (±0.1%), we conclude that the quiet solar atmosphere is unaffected by solar activity at the levels of our noise.

A topic discussed by Ayres at this meeting (Ayres 2009) is the Wilson-Bappu (W–B) effect. Complementing the Ca K index, the W-B effect is the log of the full width of the K2 emission feature in km s^{-1} units (White & Livingston 1981). Figure 4 compares the center-disk W-B effect with the full-disk Ca K

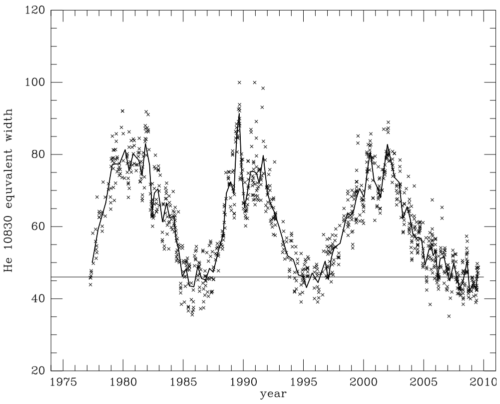

Fig. 5. Measurements of the full-disk equivalent width of the He 10830 Å feature (in mÅ). A 10-point running mean curve is overlaid on the measurements.

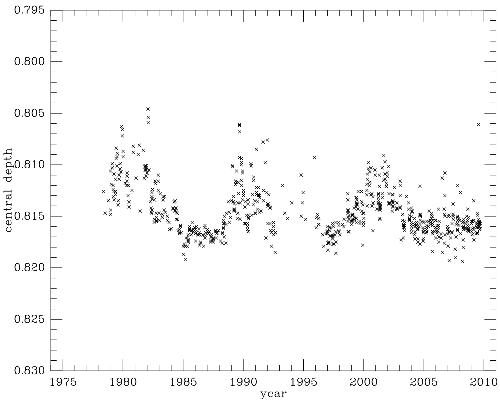

Fig. 6. Measurements of the full-disk center depth of the 8542 Å line (crosses; note inverted scale).

index. In common with the CD K index, no indication of the activity cycle is seen in center-disk observations.

We mention that similar results , i.e., a lack of cycle activity at a level of ±0.4%, are found for the photosphere archives based on weak lines such as C 5380 Å and Fe 5379 Å (Livingston et al. 2007). A difficulty with photospheric observations has been sensitivity to the center-to-limb intensity variation, which was altered by the 1992 change to a larger grating. This change meant we were now integrating the full solar disk whereas previously part of the disk was cut off.

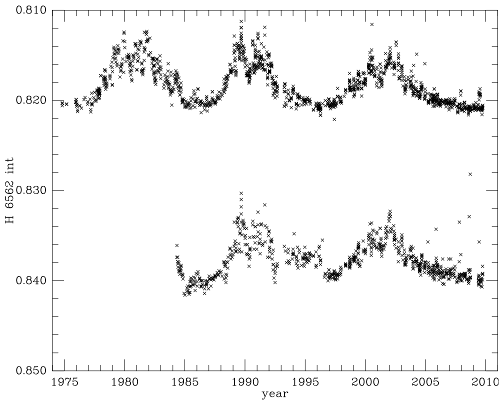

Fig. 7. Measurements of the full-disk center depth of the H 6562 Å line (crosses; note inverted scale). The upper plot is the full-disk Ca K index plotted at an arbitrary ordinate position and scale for comparison.

Figures 5, 6, and 7 show respectively, the results of the FD measurements of the He 10830 Å equivalent width (corrected for water blends), and the Ca 8542 Å and H 6562 Å central line depths. Perhaps the notable features here are the activity cycle modulation and the absence, so far, of cycle 24 activity. We note, however, that recent SOLIS images of the solar disk taken with 10830 Å show an increasing number of small, cycle 24 absorption features.

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