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CaII K Imaging to Understand UV Irradiance Variability

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Abstract. To identify and understand the underlying physical mechanisms of total solar and UV irradiance variability and to estimate the contribution of various chromospheric features to UV irradiance, detailed analysis of spatially resolved data is required. The various chromospheric features have been segregated and different parameters have been derived from CaII K Spectroheliograms of NSO/Sac Peak and Kodaikanal Observatory and compared with UV irradiance flux measured in MgII h and k lines by NOAA 9 satellite. The important results of this detailed analysis of CaII K Images of 1992 together with UV irradiance data will be discussed in this paper.

Key words. Chromosphere: CaII K Emission—UV Irradiance.

1. Introduction

The CaII H and K resonance lines have been recognized as useful indicators for identifying regions of chromospheric activity on the solar surface. A two-dimensional image of the Sun (spectroheliogram) obtained in these lines shows that the three agencies responsible for CaII emission are: the plages, the network, and the intranetwork elements. The changes in the network and intranetwork elements related to solar activity are less understood, especially because of the lack of systematic and quantitative measurements of these chromospheric features.

In our earlier paper (Kariyappa & Pap 1996, hereafter Paper I), we have discussed the observational details, a new method of analysis, and the preliminary results of the CaII K spectroheliograms of the National Solar Observatory at Sacramento Peak (NSO/Sac Peak). The main purpose of the present paper is to separate and to derive the relative intensity and area of various chromospheric features from 424 images for the years 1980 and 1992. The results of the relative intensity and the area of the chromospheric features compared to UV irradiance will also be discussed.

2. Results and discussion

To analyze the CaII K spectroheliograms and to separate various chromospheric magnetic features, we have calculated histograms over the complete full-disc image (Paper I). We have applied the corrections for the background emulsion noise, the limb darkening, and for the disk center intensity to all the images before extracting the intensity and area of the chromospheric features. In general, the pixel intensity values for intranetwork elements will fall in the ‘toe’ portion, for network elements in the ‘peak’ portion and for plages in the ‘tail’ portion of the histogram plot (Paper I, figure 2). Using the relative intensity levels in the histogram plots, the K-images containing individual features have been displayed to examine the morphological structures to make sure the fixed intensity range for the features is correct. The main criteria used here to distinguish between various features are: very bright, large and compact structures correspond to plages, the cellular structures with bright boundaries correspond to network elements and the remaining features are associated to background and intranetwork regions. We first assumed the intensity levels that might bound the plage pixels in a histogram, and then examined images in which the pixels with greater or lesser intensities than those bounds were masked. The bounding intensities were then adjusted until the masked images accurately mapped the plage regions. Similar processes were used for the network and intranetwork features. The relative intensity and the number of pixels for different features have been derived. The uncertainties in the determination of the intensity as well as the area are ± 5 in intensity units and ±600 pixels respectively.

In Fig. 1, we show the time series of the variation in averaged relative intensity of plage, network, and intranetwork elements and MgII c/w ratio of NOAA9/SBUV2 for the year 1992. The intensity of plages and the network decrease from maximum activity conditions to solar minimum (e.g. Foukal & Lean 1988), in a fashion similar to that of the full-disk Ca K intensity values, FWHM, and MgII c/w ratios (Paper I). It is interesting to note that the intranetwork elements also show a behavior during 1992 similar to that of the plages and the network, and all the parameters of these chromospheric features are well correlated with the MgII c/w ratio.

The time series of the variation in the area (total number of pixels) of plages, network, and intranetwork elements and MgII c/w ratio for 1992 is plotted in Fig. 2. It can be seen, the plage area shows a variation over similar 1992 to that of the plage intensity, indicating that during high solar activity conditions the plages cover a larger area. However, our results indicate an anticorrelation between the relative intensity and area of network elements for the time interval of 1980 and 1992. We find that the general behavior in relative intensity and area of the various chromospheric features of 1980 is similar to that of the variation seen in 1992.

The anticorrelation .found between the intensity and area of the network indicates that during solar minimum the network is fainter but it covers a larger area, and therefore it may give a significant contribution to irradiance changes. We note that from an independent analysis of Kodaikanal CaII K-spectroheliograms for a longer period between 1957 and 1983, it has been shown that the area of the network elements at the center of the solar disc in a quiet region of the Sun’s surface is anticorrelated with the solar cycle (Kariyappa & Sivaraman 1994). Muller & Roudier (1994) have shown that the number variation in photospheric network bright points (NBPs) is in antiphase with the sunspot number. In addition, recently Berrilli *et al.* (1999) have found from an analysis of PSPT CaII K images that the network cell size is anticorrelated with the solar activity.

The scatter plot diagrams (not shown here) between the relative intensity and area of the various features and the MgII c/w ratio show that the variation of the relative intensity and the area of the listed features contributes significantly to the changes in UV irradiance. This result demonstrates that both the intensity and area of the various spatial structures have to be taken into account in the irradiance models. Although the

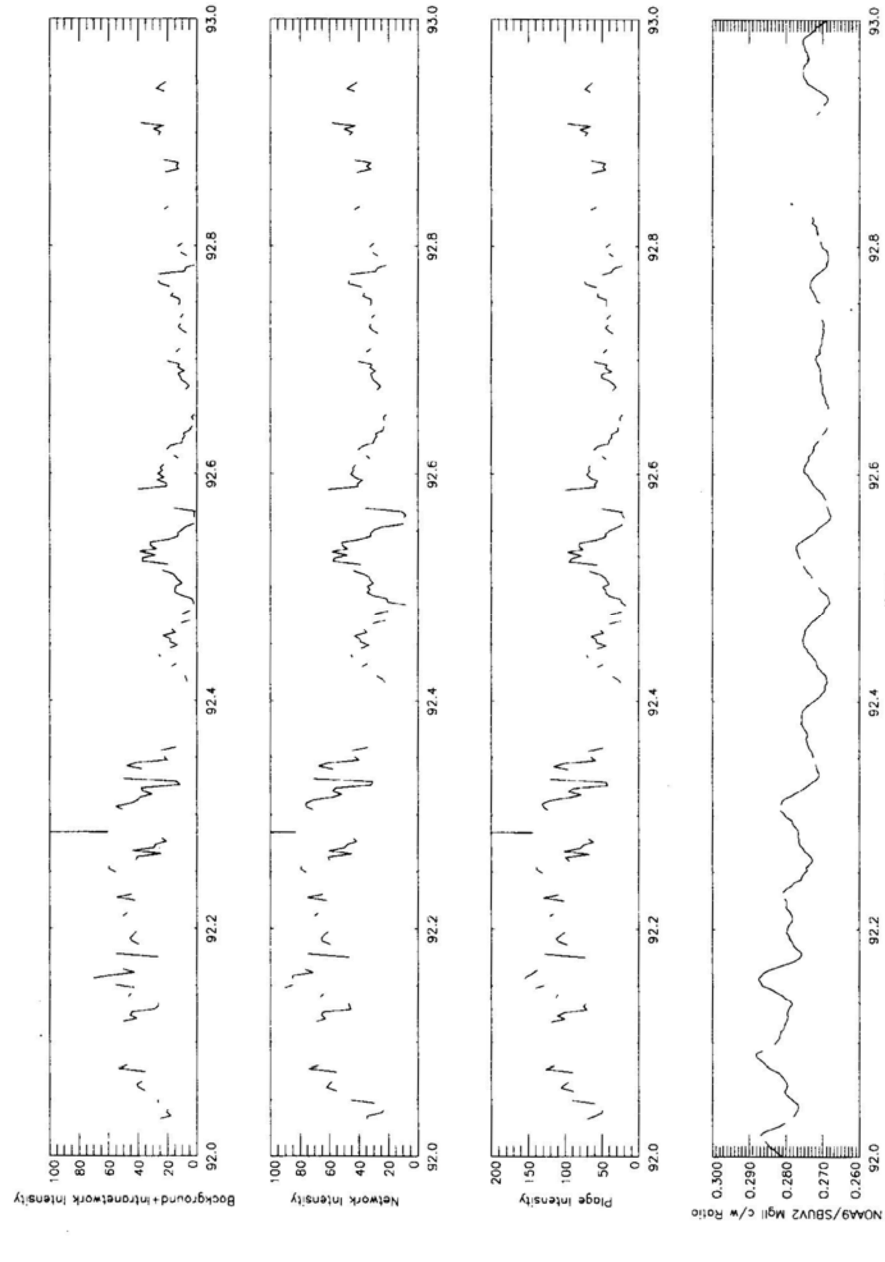

Figure 1. Time series (*from bottom to top*) of NOAA9/SBUV2 MgII c/w ratio, averaged relative intensity of plages, network and intranetwork elements for the time interval of 1992.

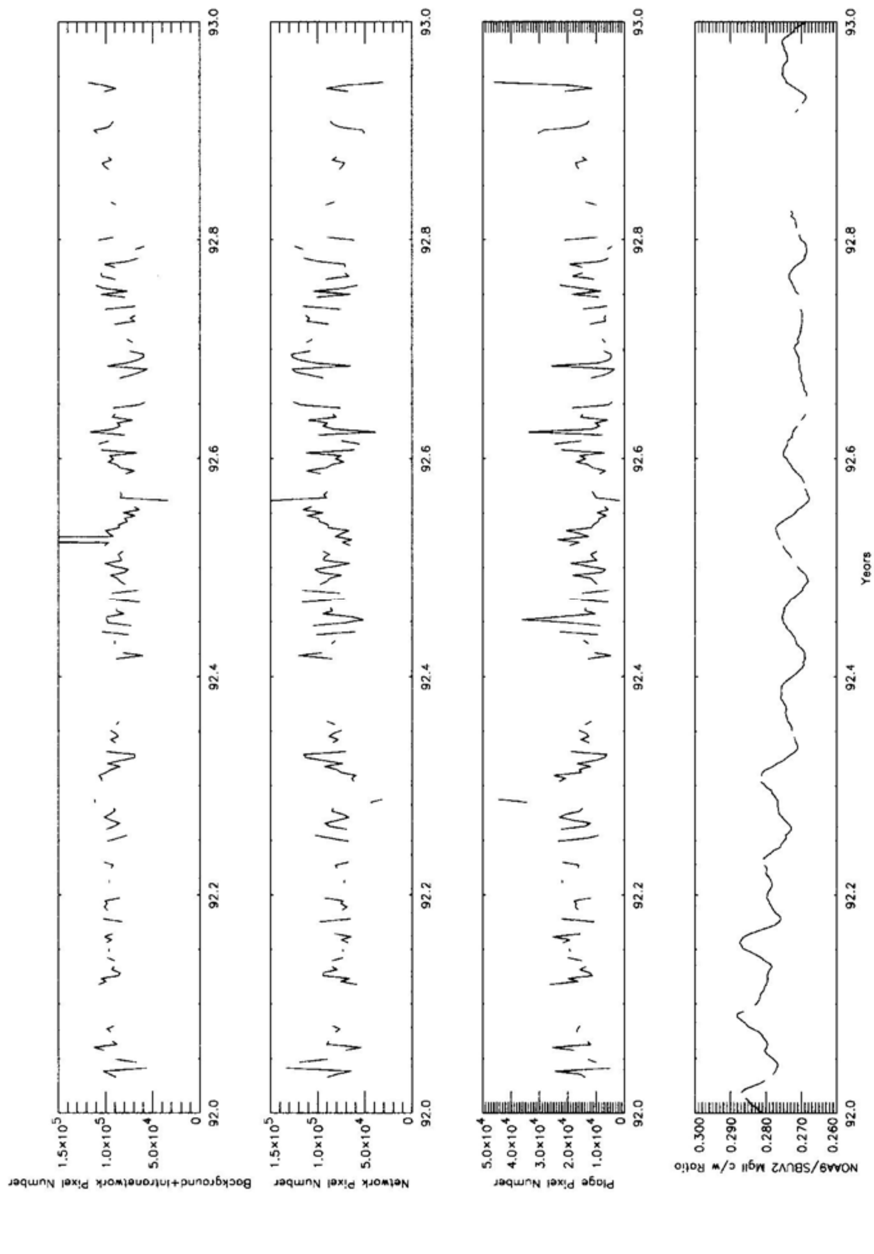

Figure 2. Time series (*from bottom to top*) of NOAA9/SBUV2 MgII c/w ratio, area of plages, network, and intranetwork elements for the time interval of 1992. Note that there is a peak-to-peak anticorrelation in the area of network with that of the variation of plages and intranetwork elements.

network and intranetwork elements are much fainter than the plages, they cover a large fraction of the solar disk. Therefore, they may contribute significantly to the changes in UV (and total) irradiance. These results may explain the discrepancy between the UV models (Foukal & Lean 1988; Pap 1992) and measurements at the time of solar minimum.

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