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Reconstruction of Total Solar Irradiance on Multiple Time Scales

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Abstract. We have developed regression models of total solar irradiance on different time scales by parameterizing the combined influence of sunspots and faculae. These models are useful in identifying the key parameters responsible for temporal variations.

Keywords : Sun: activity – Sun: variability – irradiance

The total solar irradiance (TSI) varies over time scales of minutes to years and decades. The main physical components that contribute to the radiation changes are related to solar activity during the passage of active regions on the solar disk. It is well known that sunspots, which are relatively dark, lead to a reduction in irradiance, whereas the opposite happens due to faculae. Therefore a competition of their relative strengths determines the solar irradiance variability. The facular emission exceeds the corresponding sunspot deficit, causing a net increase in total irradiance near the maximum phase of solar activity. Various measurements of these features are used to model and explain solar irradiance variability. (Frohlich and Lean, 1998; Solanki and Fligge, 1999; Lean, 2001 and references therein).

In this study, we construct regression models including the independent and combined influences of various solar activities to study variability of solar irradiance on multiple time scales. We use version *d*25_05 of composite time series of TSI which is available from 1978-2002. To investigate the role of key parameter for temporal variations in TSI, we considered different measures of solar activity. The sunspot contribution is quantified by the measured areas of sunspots while facular brightness is alternatively calculated with facular area, Mg II core-to-wing ratio, 10.7 cm radio flux or Ca II K emission index.

The reconstructed and observed TSI on short and long time scales are displayed in Figure 1. The irradiance variations for a period less than one solar rotation can only be explained by the combined influence of active regions (sunspots and faculae) while a single activity index reliably

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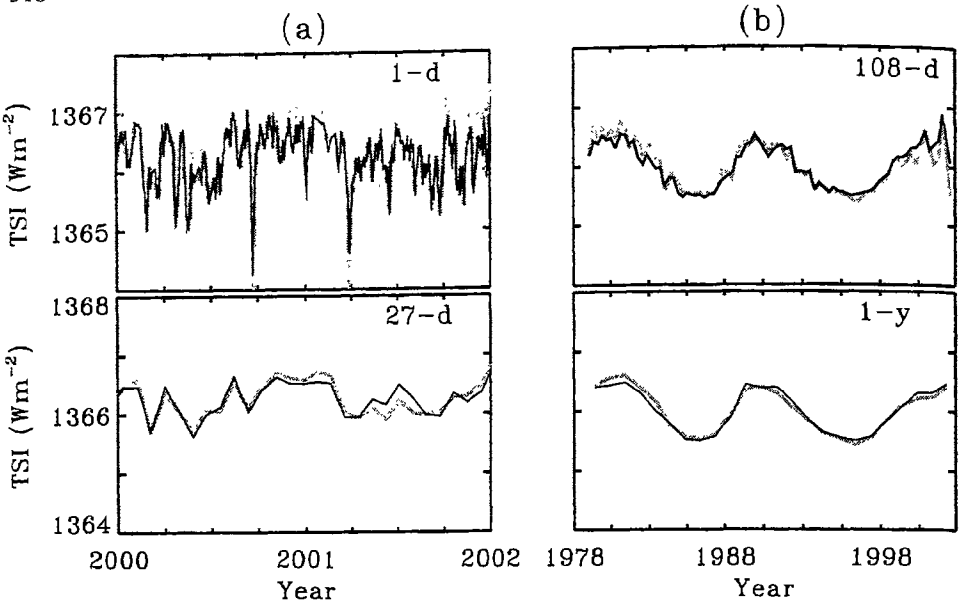

Figure 1. The reconstructed total solar irradiance using sunspot area for sunspot darkening and Mg II ratio for facular brightening (grey line). The observed values are shown by dark lines. Figures (a) and (b) correspond to the variations on short and long time scales, respectively.

explains the variations on longer time scales. The day to day variation in solar irradiance is explained by these models with an accuracy greater than 80% and there is significant improvement in correlation ($\geq$ 99%) for yearly variations.

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