Rieger-type periodicity in total irradiance of the Sun as a star

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Introduction

Rieger type periodicity is a mid range periodicity of 150-200 days in solar activity (Rieger et al. 1984). The periodicity can be find in many solar activity indices. Total solar irradiance permits to use the Sun as a star to study stellar light curves from recent space missions. We study periodic variations of total solar irradiance (TSI) based on SATIRE-S and SOHO/VIRGO data during solar cycles 23-24 on time scales of Rieger-type periodicity. Then we compare the power spectrum of oscillations in total solar irradiance to those of sunspot and faculae data in order to determine their contributions.

Data and Methods

SOHO/VIRGO combining two radiometers (Diarad and PMO6-V) and two sunphotometers, which measure the spectral irradiance at 402, 500, and 862 nm with 5 nm passbands.

SATIRE-S reconstruction model, which includes the data of TSI and Spectral Solar Irradiance (SSI) starting from 1947 (Yeo et al., 2014).

GRO USAF/NOAA sunspot area data, that has continuous data for cycles 23-24.

Wavelet analisys We look for variations on time scales of Rieger type periodicity using Morlet wavelet transform.

Conclusion

Rieger-type periodicities were studied in the total irradiance of the Sun during the solar cycles 23-24. The study is important to use the Sun as a star approach to analyse stellar light curves form Kepler, CoRoT and TESS missions.

1. Wavelet analyses of the TSI data (VIRGO and SATIRE) revealed the pronounced peaks at the periods of 180 days and 115 days in the cycle 23, while the similar analysis display the strong peaks at 170 days and 145 days in the cycle 24.

2. Using the Sun as a star analog, the short term periods can be revealed from stellar light curves of recent space missions.

References

[1] Rieger, E., Share, G. H., Forrest, D. J., Kanbach, G., Reppin, C., et al. 1984, Nature, 312, 623 [2] Yeo, K. L., Krivova, N. A., Solanki, S. K. 2017, JGRA, 122, 3888

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Total solar irradiance of the Sun during the cycles 23-24

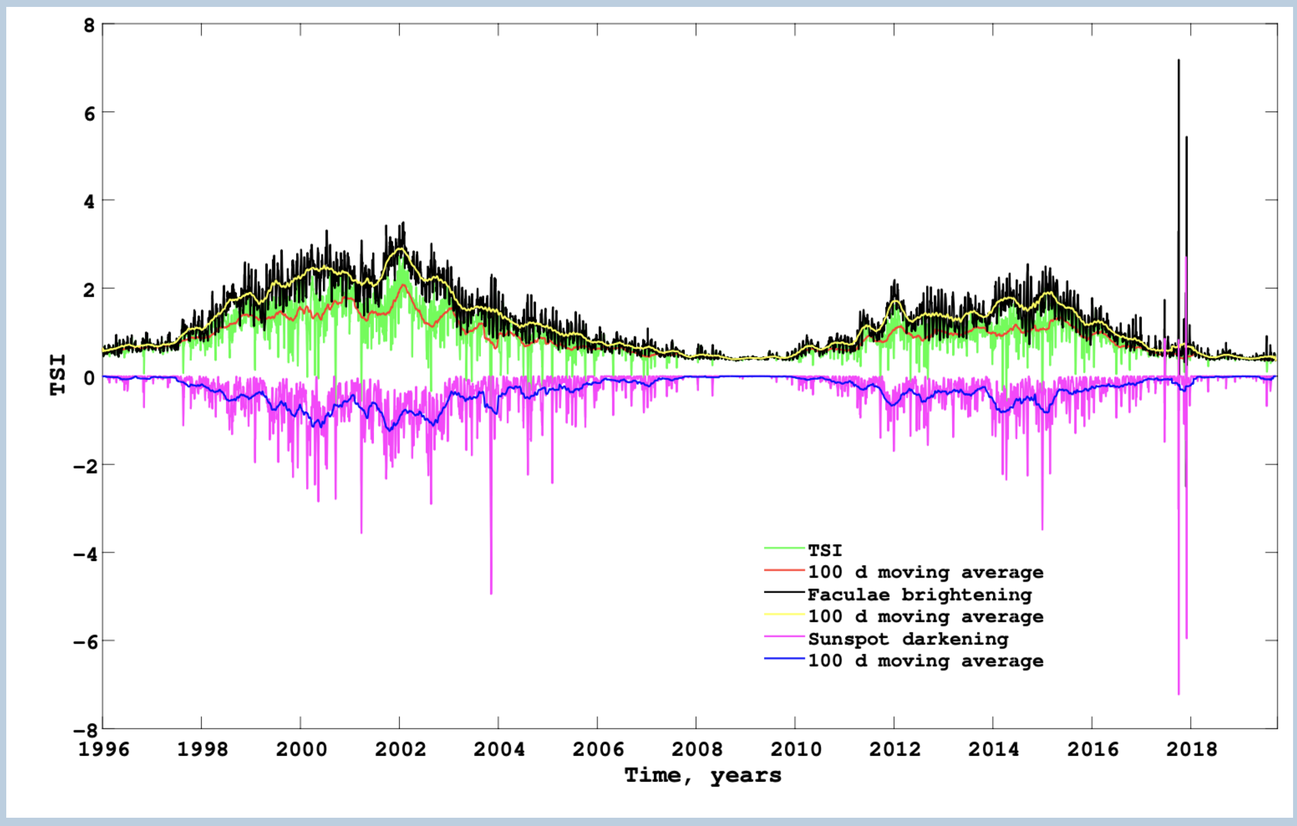

Figure 1: Total solar irradiance (green line) during solar cycles 23-24 from SATIRE-S data in the units of W m^{-2}. Red curve shows 100 day moving average of TSI. Black line corresponds to the faculae brightening (with yellow curve as the 100 day average), while the purple line shows the contribution of the sunspot darkening (blue curve as 100 day average).

Results

Cycle 23 Wavelet spectrum of TSI (left and middle panels) gives two pronounced peaks at the periods of 180 days and 115 days in the cycle 23. The 180d is in the range of typical Rieger period, while 115d is quite short one. A 115d period is also well seen in sunspot data, however the strong power at 180d is absent and there is a strong peak at 165d. Another weak peak in the power spectrum of TSI is around 145 days, which is also seen in full disk sunspot spectrum. There are two peaks in sunspot data of the cycle 23 at 165 days and 135 days, which are totally absent in TSI spectrum. The TSI includes the contributions from Faculae brightening (FB) and sunspot darkening (SD), which may cancel each other in the TSI and so the oscillations have almost no contributions (it is also possible that the oscillations are out of phase in SD and FB, which leads to their disappearance in TSI, but the reason is unclear).

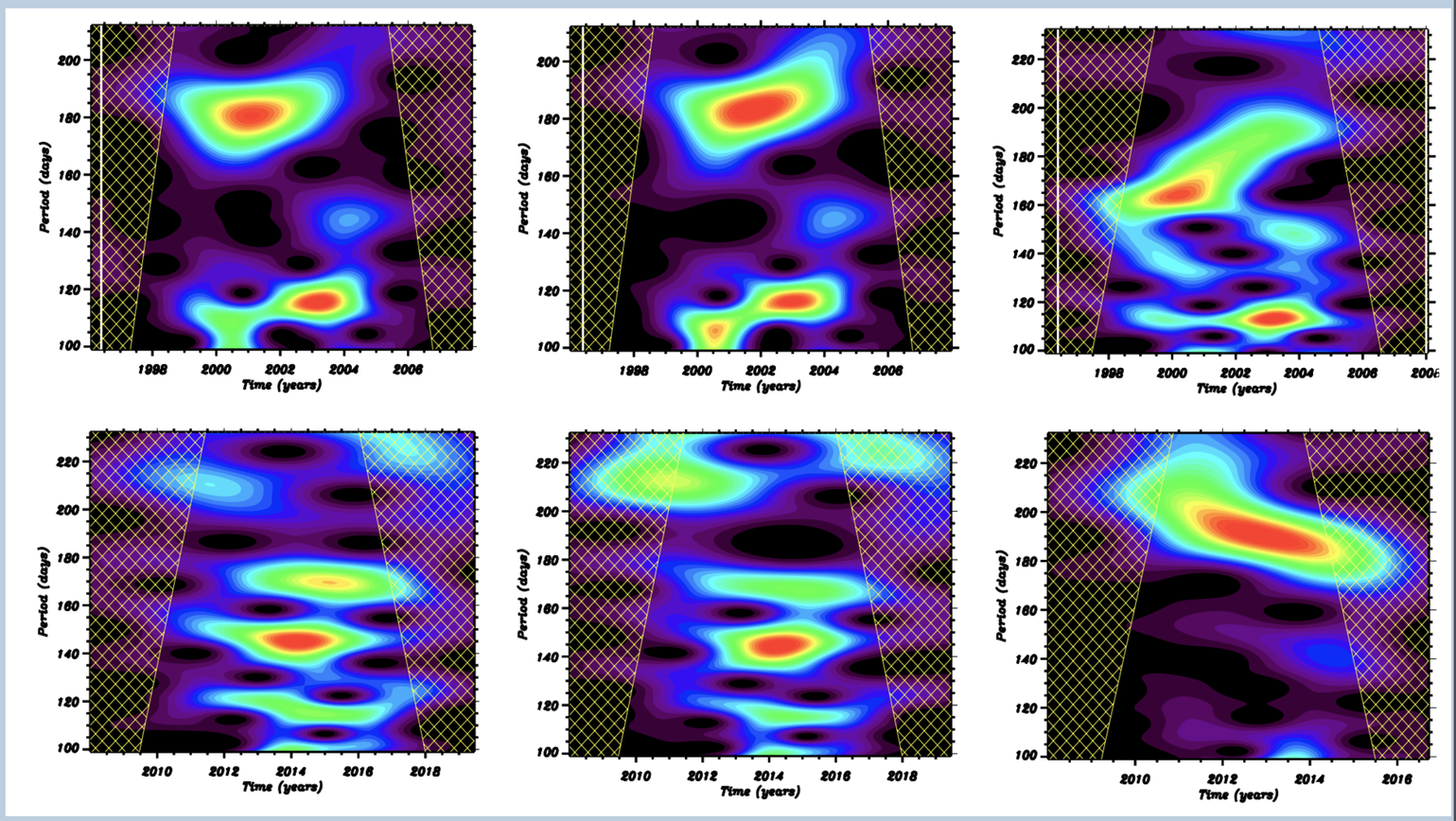

Figure 2: Morlet wavelet analysis in the period range of 100-220 days. Upper and lower panels correspond to the cycle 23 and 24 correspondingly. Left panels show the wavelet spectrum based on VIRGO data. Middle panels correspond to the SATIRE data. Right panels display the GRO full disk sunspot area data.

Cycle 24 The cycle 24 shows basically similar properties as the cycle 23, however with slightly different periods. TSI displays the strong periodicity at 170 days and 145 days, while weaker periods are seen around 210 days and 110-115 days. All these periods are probably connected to SD rather than FB. The period of 190 days seen in the sunspot data is probably cancelled in TSI spectrum due to the same periodicity in the faculae brightening.