Temporal and Periodic Variations of Sunspot Counts in Flaring and Non-flaring Active Regions

A. Kilcik, V. Yurchyshyn, B. Donmez, V.N. Obridko, A. Ozguc, J.P. Rozelot

Akdeniz University Faculty of Science, Department of Space Science and Technologies, 07058, Antalya, Turkey
Big Bear Solar Observatory, Big Bear City, CA 92314, USA
Korea Astronomy and Space Science Institute, 776 Daedeok-daero, Yuseong-gu, Daejeon, 305-348, South Korea
Pushkov Institute of Terrestrial Magnetism, Ionosphere and Radio Wave Propagation of the Russian Academy of Sciences (IZMIRAN), Troitsk, Moscow, 142190 Russia
Kandilli Observatory and Earthquake Research Institute, Bogazici University, 34684 Istanbul, Turkey
Universit´e de la Cˆote d'Azur (OCA-CNRS) and 77, Ch. des basses Moulieres, 06130 Grasse (F)

Outline

- Descriptions of the used data

- Methods

- Analysis and Results

- Conclusions

Data Description

In this study, we investigate temporal and periodic variations of sunspot counts depending on the flare production of ARs. The group classification and the flare data are only available since August 1996. Therefore, the analyzed time interval covers only solar cycle 23 (1996 through 2008) and the ascending and maximum phases of current cycle 24 (2009 through 2016). The raw data are taken from the Space Weather Prediction Center (SWPC). These data sets include all X-Ray flares and AR information. The daily total sunspot counts for flaring and non-flaring ARs were calculated and used for the period analysis. To compare the temporal variations of sunspot counts (SSCs) in flaring and non-flaring ARs for the investigated time period the monthly mean values were calculated. Then, to remove the short term fluctuations and reveal the long term trend a 12 steps running averaging was applied.

Used Methods

To reveal periodic variations in the SSC data two period analysis methods, Multitaper Method (MTM) and Morlet Wavelet Analysis, were applied with red noise approximations and 95% confidence level. Both method have previously been successfully used analysis of solar data.

To localize the periodicities obtained from the MTM analysis we applied the Morlet Wavelet analysis method to the daily SSC data separately for flaring and Non-flaring ARs.
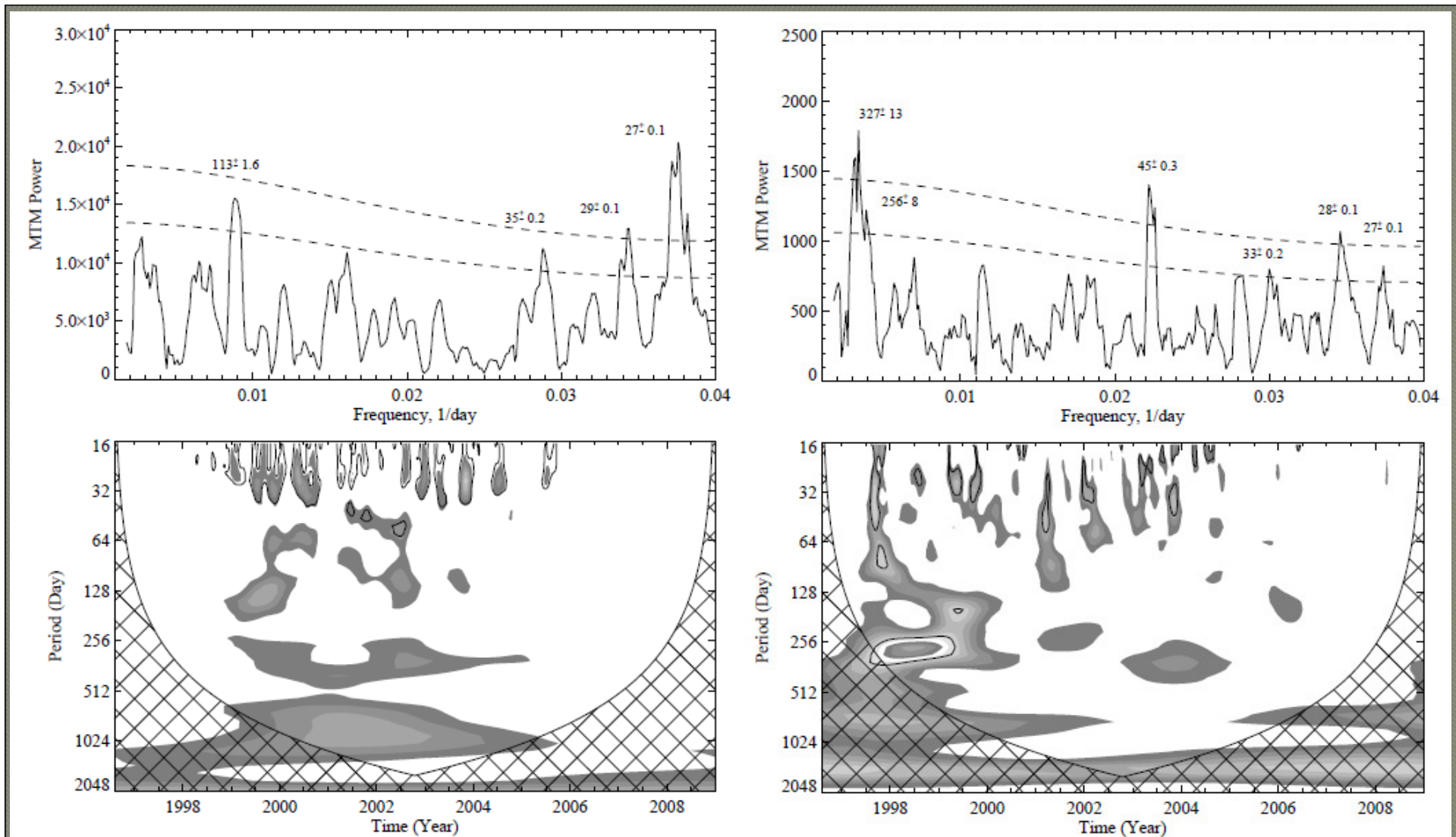
Analysis and Results
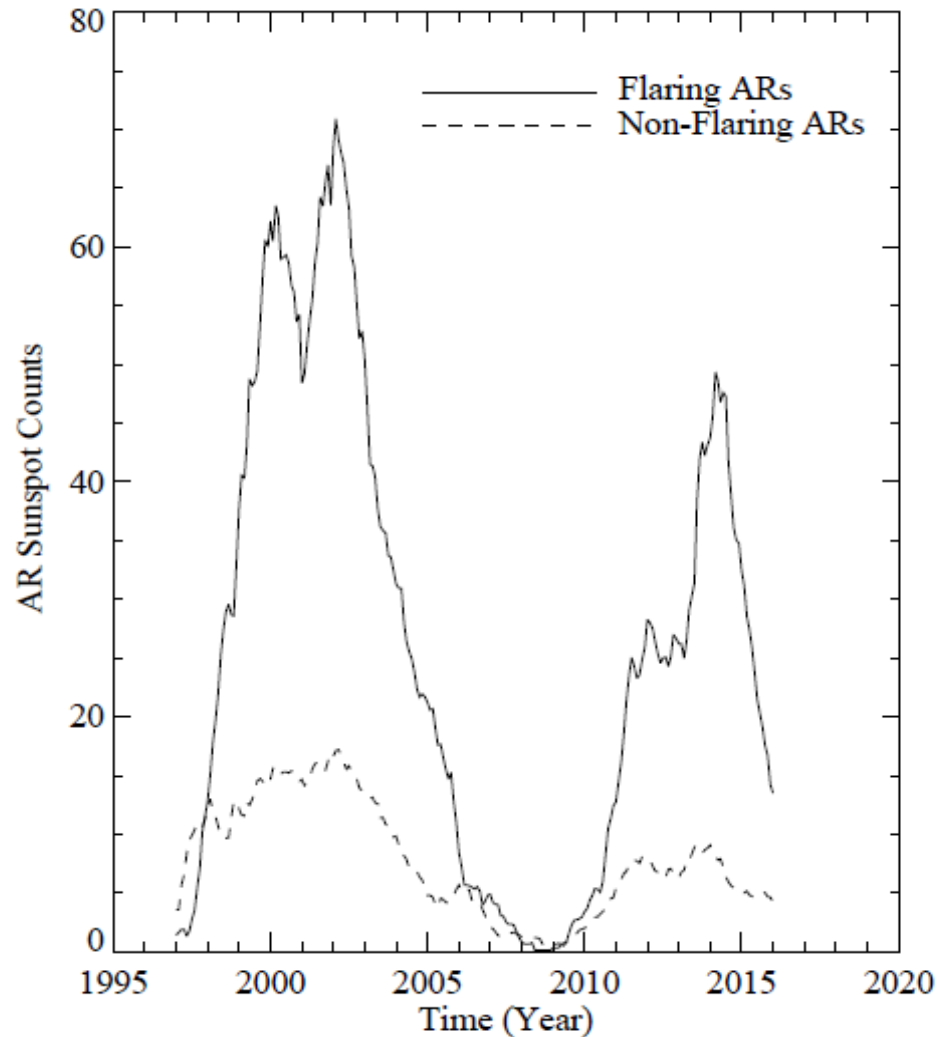
Figure 1. *Temporal variations of SSCs in flaring (solid line) and non-flaring (dashed line) ARs for 1996–2016 time period.*

1. The monthly means of the daily total SSCs in the flaring ARs are about four times larger than the non-flaring ones.

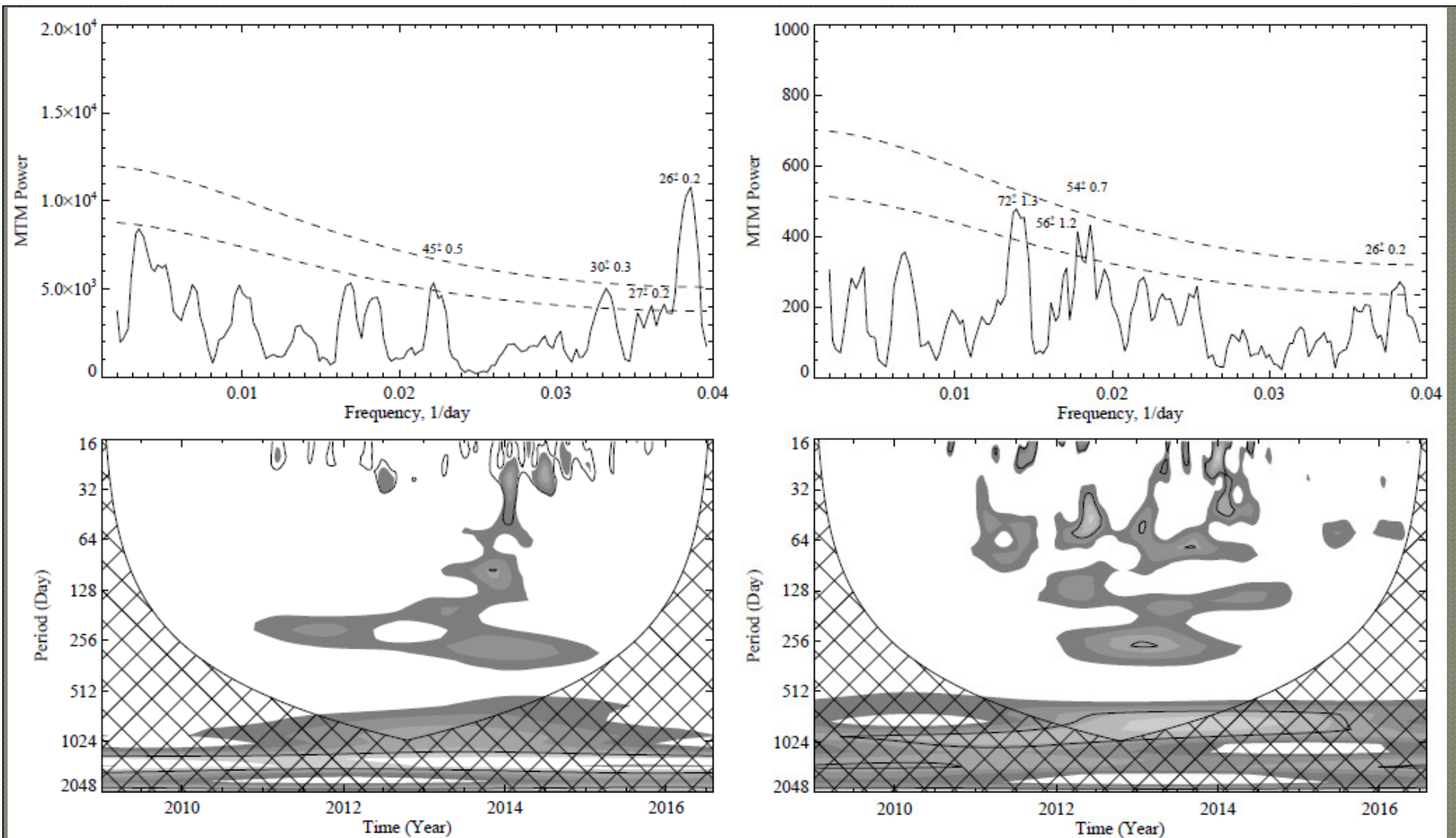2. SSCs in both data sets follows sunspot cycle with some differences

Figure 2. *The multi-taper method (MTM, upper panel) and the Morlet wavelet (lower panel) analysis results for SSCs in flaring (left panel) and non-flaring (right panel) ARs during the solar Cycle 23 (1996–2008). The main peaks are labeled with the period in days in the MTM power spectrum. The horizontal dashed lines indicate the 95% and 99% confidence levels. The black contours in the wavelet scalogram indicate the 95% confidence level and the hatched area below the thin black line is the cone of influence (COI).*

Figure 2 shows observed periods of SSCs in flaring and non-flaring ARs and their localizations during the solar cycle 23. Detected periods are quite different in both MTM spectrum and wavelet scalograms:

i)the largest detected period in the flaring ARs is 113 days, while there are much higher periodicities (327, 312, and 256 days) in non-flaring ARs,

ii)ii) there is a very prominent 45 day peak in non-flaring ARs, which does not appear in flaring ARs. The only similarity between the periodicities of the two data sets is the existence of solar rotation periods (27-35 days).

iii)All periods detected with the MTM appear in the wavelet scalograms, but significance level of some periodicities is below the 95% confidence level.

Figure 3. *The multi-taper method (MTM, upper panel) and the Morlet wavelet (lower panel) analysis results for SSCs in flaring and non-flaring ARs during the solar Cycle 24 (2009–2016). The main peaks are labeled with the period in days in the MTM power spectrum. The horizontal dashed lines indicate the 95% and 99% confidence levels. The black contours in the wavelet scalogram indicate the 95% confidence level and the hatched area below the thin black line is the cone of influence (COI).*

Figure 3 shows the SSCs periodic variations for the ascending and the maximum phases of solar cycle 24 which also show remarkable differences between the flaring and non-flaring ARs:

1. There are no meaningful periodicities in MTM spectrum of flaring ARs exceeding 45 days, while we detect 72 day periodicity in non-flaring ARs.

2. Some larger periodicities (about 250 and 600 days) appear in the wavelet scalograms of non-flaring ARs. Again solar rotation periodicities exist in both cases.

Table 1. Periods obtained from the MTM analysis. The first column corresponds to the obtained periods and the rest of the columns show the presence of these periods in all cases by means of their significance levels.

Period	Flaring ARs		Non-flaring ARs	
	Cycle 23	Cycle 24	Cycle 23	Cycle 24
315–327	–	–	+ >95	–
293	–	–	+ >95	–
256	–	–	+ >95	–
113	+ >95	–	–	–
72	–	–	–	+ >95
54–56	–	–	–	+ >95
45	+ >99	+ >95	–	–
26–63	+ >95	+ >95	+ >95	+ >95

Conclusions

i) The temporal variation of monthly means of daily total SSCs in flaring and non-flaring ARs are different and these differences are also varying from cycle to cycle; temporal profile of non-flaring ARs are wider than the flaring ones during the solar cycle 23, while they are almost the same during the current cycle 24. The second peak of flaring ARs are strongly dominate during current cycle 24, while this difference is not such a remarkable during solar cycle 23. SSCs in the non-flaring ARs have comparable magnitude of the first and second peaks in the current solar cycle, while the first peak is almost not existent in case of the flaring ARs.

ii) Periodic variations observed in SSCs of flaring and non-flaring ARs are quite different in both MTM spectrum and wavelet scalograms and these variations are also different from cycle to cycle; the largest detected period in the flaring ARs is 113 days, while there are much higher periodicities (327, 312, and 256 days) in non-flaring ARs. There are no meaningful periodicities in MTM spectrum of flaring ARs exceeding 45 days during current cycle 24, while a 113 days periodicity detected from flaring ARs of solar cycle 23. For the non-flaring ARs the largest period is 72 days during current cycle 24, while the largest period is 327 days during solar cycle 23.

Thank you for your attention