

Precursors of Solar Cycles 24 and 25 at Middle and High Latitudes**A.A. Golovko***Institute of Solar-Terrestrial Physics,
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Abstract. Magnetic activity in the middle latitude zone from 40 to 60 degrees was investigated using a multifractal segmentation method. Statistics of magnetic knots with a size of 3–4'' revealed the peak of maximum 20 times higher than the background level of the knots population number during 2007–2008, which preceded by two years the beginning of the solar cycle 24. A similar peak commenced in 2016 gives the prediction of the beginning of cycle 25 during 2018.

1 Introduction

Forecast of 11-year solar cycle is necessary for planning the human activity, because many phenomena on the Earth, for example climate changes (Maruyama et al., 2017), show correlation with solar activity level. An adequate information and identification of precursors of the next activity cycle set the task of forecast into the category of early diagnostics of the cycle beginning. This makes information about the cycle precursors valuable and timely for users.

The concept of precursors and early manifestations of a new cycle at high heliolatitudes was formulated by Sheeley (1964), Chistyakov (1986), Makarov and Makarova (1996), La Bonte and Howard (1982) Tlatov (2009). A new cycle originates in the polar zone, where the polar faculae and bright dots observed in K CaII line arise. This occurs at the descending phase of previous activity cycle.

In the current work, the method of multifractal segmentation (Golovko and Salakhutdinova, 2012; 2015) is applied to the study of magnetic activity at latitudes higher than 40 degrees.

2 Data and methods

The daily magnetograms of the full solar disk have been obtained with the SOLIS vector spectromagnetograph (Henney et al., 2006). We used the longitudinal field magnetograms in FITS format for the time interval since August 23, 2003, till October 22, 2017, published at the site <https://solis.nso.edu/>. A pixel size is 1.14''. The magnetograms were treated using the version of multifractal analysis described by Levi-Vehel and Vojak (1998), Makarenko and Knyazeva (2009).

3 Results

Each segmented image was combined with the Stonyhurst grid, and in the middle latitude zones from 40 to 60 degrees, the magnetic knots, which were recognized by the program as new magnetic fluxes, were registered as events. Their coordinates, as well as magnetic polarity, were recorded. Figure 1c shows the latitude zones.

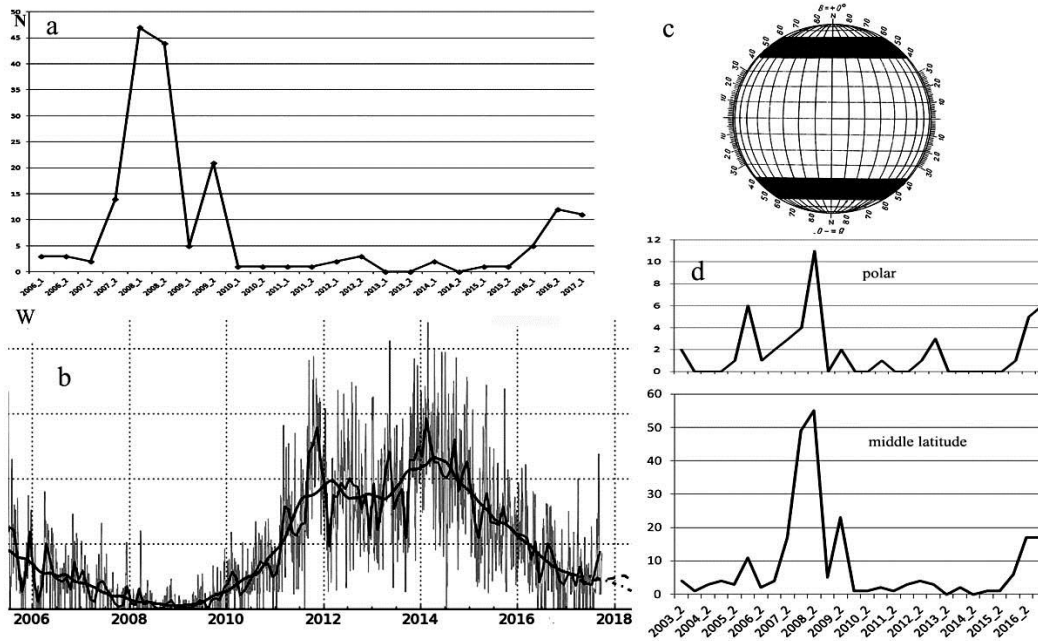


Figure 1: a – Temporal variation of the new magnetic knots at the middle latitudes, b – Wolf number, c – view of middle latitude belt on the Stonyhurst grid, d – variation of magnetic knots at latitude higher 60 degrees.

Number N of such knots over each half-year was calculated. In Figure 1a the temporal variation of N is presented together with the curve of Wolf numbers W (Figure 1b). There is an abrupt peak of N in 2007–2008, two years before the beginning of the cycle 24. Hence, this peak is the immediate precursor of the cycle, and its large amplitude demonstrates its reality. A very low level of the events’ number was observed in 2010–2015, when activity was concentrated in the equatorial zone.

The same statistics was done for the polar zones higher than 60 degrees, and the result is shown in the Figure 1d in comparison to the first curve. Evidently, the main peaks coincide.

In 2016 an analogous increase in N commenced, resembling the situation of 2008, which can be considered as the early diagnostic of the beginning of cycle 25.

The interpretation of the described phenomenon has the spatial and temporal aspects. In the spatial aspect, the magnetic knots have a size of 3-4", three times larger than the spatial resolution (1.14"), because the computation uses two rows of pixels in the vicinity of a current point of the image. In the temporal aspect, the duration of the condition of “new magnetic flux” is short, 1–2 hours (Golovko and Salakhutdinova, 2015). It is in accordance with the results of the statistical study of magnetic patches observed with the HMI SDO facility (Javaherian et al., 2017). They showed that 95 per cent of magnetic patches, or knots, with areas from 2 to 8 square arcsec have lifetimes shorter than 100 min.

The magnetic polarity of the knots should be taken into consideration: we compared their polarity with the polarity of background large-scale magnetic field at the middle latitude according to the chart published by Mordvinov and Golubeva (2017). We obtained a coincidence percentage of 77. Besides that, we should emphasize a considerable intermittency of the background field patches in 2007, which coincides with the fifty-fifty ratio of magnetic knots with positive and negative polarity. It implies a fast reconstruction of the magnetic field distribution in 2007.

Our study has led to the following conclusions:

1. The method of multifractal segmentation for the latitude higher than 40 degrees revealed a population of magnetic knots, whose number varies in phase with the cycle of solar activity.
2. In 2007–2009, two years before the beginning of the solar cycle 24, an increase in the number of magnetic knots at middle latitudes (40–60 degrees) occurred and reached a peak value 20 times larger than the background level of 2010–2015. A smaller effect, synchronous with the latter one, is observed for the polar zone of latitudes higher than 60 degrees. These facts can be considered as early diagnostic of the beginning of a cycle.
3. The increase in the number of magnetic knots since 2016, analogous to the effect of 2007, can be considered as the precursor of the beginning of cycle 25, anticipated during 2018.

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Предвестники 24 и 25 солнечных циклов на средних и высоких широтах

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Резюме. Исследована магнитная активность в средней зоне широт от 40 до 60 градусов с использованием метода мультифрактальной сегментации. Статистика магнитных узлов размером 3–4'' выявила пик максимума, в 20 раз превышающий фоновый уровень, для численности популяции узлов в течение 2007–2008 годов, предшествовавший на 2 года начало солнечного цикла 24. Подобный пик, начавший проявляться в 2016 г., позволяет предсказать начало 25 цикла в 2018 г.