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ORIGINAL ARTICLE

The Solar Cycle: a new prediction technique based on logarithmic values

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Abstract A new prediction technique based on logarithmic values is proposed to predict the maximum amplitude (R_m) of a solar cycle from the preceding minimum *aa* geomagnetic index (aa_{min}). The correlation between $\ln R_m$ and $\ln aa_{min}$ ($r = 0.92$) is slightly stronger than that between R_m and aa_{min} ($r = 0.90$). From this method, cycle 24 is predicted to have a peak size of $R_m(24) = 81.7(1 \pm 13.2\%)$. If the suggested error in *aa* (3 nT) before 1957 is corrected, the correlation coefficient between R_m and aa_{min} ($r = 0.94$) will be slightly higher, and the peak of cycle 24 is predicted much lower, $R_m(24) = 52.5 \pm 13.1$. Therefore, the prediction of R_m based on the relationship between R_m and aa_{min} depends greatly on the accurate measurement of *aa*.

Keywords Space weather · The Sun · The Solar Cycle

1 Introduction

Predicting the strength of an upcoming solar cycle (R_m) is important in both solar physics and space weather. A variety of methods have been used to do so, of which some are based on statistics and some others are related to physics (Kane 2007; Cameron and Schüssler 2007; Pesnell 2008; Hiremath 2008; Tlatov 2009; Messerotti et al. 2009; Petrovay 2010; Du and Wang 2010). A reliable prediction of R_m may test models for explaining the solar cycle (Pesnell 2008). Various solar dynamo models (e.g., Dikpati et al. 2006; Choudhuri et al. 2007) have been proposed to explain the solar cycle but the predictive skill of R_m needs to be checked in future (Cameron and Schüssler 2007; Pesnell 2008; Du 2011a). Based on the Solar Dynamo Amplitude (SODA) index, Schatten (2005) predicted that the peak sunspot number of the current cycle (24) will be low, at ∼80. Dikpati et al. (2006) predicted that the peak size of cycle 24 will be 30 %– 50% higher than that of cycle 23 based on a modified flux-transport dynamo model. In contrast, Choudhuri et al. (2007) predicted that the peak size of cycle 24 will be 30 %– 50% lower than that of cycle 23 based on a flux-transport dynamo model.

Since Ohl (1966) found a high correlation between the minimum *aa* geomagnetic activity (aa_{min}) in the declining phase of a solar cycle and the maximum sunspot number of the succeeding cycle (R_m), a great many papers related to this finding have been published over the past decades (Brown and Williams 1969; Kane 2010; Wilson 1990; Hathaway and Wilson 2006; Charvátová 2009; Wang and Sheeley 2009). The level of geomagnetic activity near the time of solar activity minimum has been shown to be a good indicator for the amplitude of the following solar activity maximum (Ohl 1976; Wilson 1990; Layden et al. 1991; Thompson 1993; Hathaway and Wilson 2006; Kane 2010). This method based on a solar dynamo concept that the geomagnetic activity during the declining phase of the preceding cycle or at the cycle minimum provides approximately a measure of the poloidal solar magnetic field that generates the toroidal field for the next cycle (Schatten et al. 1978).

When geomagnetic precursor methods are applied to the current cycle (24), some discrepancies are shown for different authors. Hathaway and Wilson (2006) predicted $R_m(24) = 160 \pm 25$ using the I component of *aa* by subtracting the linear *R* component with R_m from *aa* (Feynman 1982). Dabas et al. (2008) employed the number of geomag-

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