Nonlinear solar cycles forecasting: theory and perspectives

by

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Abstract. In this paper we develop a modern approach in a solar cycle forecasting, based on mathematical theory of nonlinear dynamics. We start from design of the static curve fitting model for the experimental yearly sunspot number series on the time scale of 306 years since 1700 and establish Pearson's type III distribution as a least square optimal pulse shape of a solar cycle. The cycle-to-cycle evolution of the parameters of the cycle shape identifies different patterns like e.g. Gleissberg cycle and a strong anomaly in the cycle evolution during the Dalton minimum. On the next step we extract a chaotic mapping for the successive values of one of the key model parameters – the rate of the exponential rise-decline of the solar activity during *n*th cycle. We examine piece-wise linear and cubic spline surface technique for approximation of the found mapping and provide its probabilistic analysis: calculation of the invariant distribution and autocorrelation function. We find analytical relationships for the sunspots maximum and minima as well their occurrence times as functions of chaotic values of the parameter. On the base of Lyapunov spectrum analysis of the embedded mapping we establish a horizon of predictability of the method, which allows us to give most probable forecasting of the upcoming solar cycle 24 with an expected peak height of 80+/-21 occurring in 2011/2012. This "low amplitude" for the next cycle's activity prediction could be described as "mild" or "fair" space weather.