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Preliminary Prediction of the Strength of the 24th 11-Year Solar Cycle

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Abstract. A suggested method is proposed to forecast the general features of the 11- year solar activity principle cycle. It is based upon the count of lengths and durations of spotless events, prevailing in the preceding minimum of the coming new cycle. The method has been successfully applied to predict the strengths and time of rises for the 22^{nd} and 23^{rd} 11-year cycles. The proposed precursor technique is further developed to make preliminary prediction of the maximum relative sunspot number and the time of rise of the 24^{th} 11-year cycle. The predicted values of these parameters are found to be 90.7 ± 9.2 and 4.6 ± 1.2 year respectively. In addition, neural, Fuzzy neural and genetic algorithms have been also applied for the confirmation of the predicted results. A comparison with the early predictions used by other methods is given.

Keywords. Prediction, Sunspot, Solar Cycle, Nural Networke

1. Introduction

The prediction of the fundamental features of the 11-year solar cycle is vital and of prime importance for many astrophysical and geophysical fields of researches. A wide variety of methods have been proposed to predict the amplitude and the onset of the next cycle for a few years ahead-Numerous numerical techniques have been developed, among these methods, the odd /even behavior, the spectral techniques, the polar magnetic field, mixed methods and geomagnetic precursor . . . .etc. A new suggested method depending on the measurements of the spotless events prevailing in the preceding minimum of the new coming 11- year cycle was proposed as a prediction precursor of the various characteristics of the examined cycle.

2. Data Used

The records of daily sunspot numbers were collected according to the Boulder preliminary report of National Geophysical Data Center (NGDC) , (NOAA) in addition to the documented Mckinnon (1987) data which an update of Waldmeier's(1961) compilation. The interval of our presentation includes good cycles (cycle 7-9) (Eddy, 1977), and the modern era sunspot cycles (cycles 10-23).

3. Analysis

1-The relation between the minimum sunspot number R_m and the number of spotless event S_{om}.

$R_m = (15.4173 \pm 1.1812) - (0.02625 \pm 0.00302)S_{om}$, for Cycles from $7 - 22$.
$R_m = (15.1582 \pm 1.2203) - (0.02527 \pm 0.00322)S_{om}$, for Cycles from $8 - 22$.
$R_m = (14.6864 \pm 1.3465) - (0.02436 \pm 0.00343)S_{om}$, for Cycles from $10 - 22$.
The above relation gives an average value of $R_m = 8.6 \pm 0.43$.

2– The least square empirical equations for the ratio R_M/R_m against S_{om}/S_{omn} are as follows,

$\ln R_M/R_m = (1.6996 \pm 0.5635) + (1.4559 \pm 0.4655) S_{om}/S_{omn}$, for Cycles $7 - 22$.
$\ln R_M/R_m = (2.1205 \pm 0.2894) + (0.9234 \pm 0.2469) S_{om}/S_{omn}$, for Cycles $8 - 22$.
$\ln R_M/R_m = (2.1529 \pm 0.2932) + (0.9064 \pm 0.2384) S_{om}/S_{omn}$, for Cycles $10 - 22$.

According to the defined relations R_{M24} and T_{r24} for the cycle 24^{th} can be represented in the following forms:

$R_{M24} = (187.1697 \pm 21.7179) - (0.1855 \pm 0.0566) S_{omn} = 84.6 \pm 9.6$, for cycles $7 - 22$.
$T_{r24} = (2.5343 \pm 0.5363) + (0.0044 \pm 0.00144) S_{omn} = 5.0 \pm 1.3$ Year, for cycles $7 - 22$.

$R_{M24} = (184.0987 \pm 22.9376) - (0.1740 \pm 0.0617) S_{omn} = 98 \pm 7.6$, for cycles $8 - 22$.
$T_{r24} = (2.8504 \pm 0.4394) + (0.0032 \pm 0.0012) S_{omn} = 4.4 \pm 1$ Year, for cycles $8 - 22$.

$R_{M24} = (183.0482 \pm 25.6187) - (0.1733 \pm 0.0670) S_{omn} = 89.6 \pm 10.5$, for cycles $10 - 22$.
$T_{r24} = (2.7260 \pm 0.4346) + (0.0034 \pm 0.0011) S_{omn} = 4.5 \pm 1.2$ Year, for cycles $10 - 22$.

Our results are compared with early methods of prediction in Table (1) (Kane, 1999, Badalyn2000 and Duhau 2003). We must mention that our suggested methods have been successfully applied to predict the strengths and the time of rises for the 22^{nd} and 23^{rd} 11-year cycles (R.H. Hamid. and A.A. Galal, 1994, and R.H.hamid. 2000). These comparisons are illustrated in Table (2) and Table (3). Recently a promising method depending on the time series analysis such as neural network; fuzzy neural and genetic algorithms have been applied. Fuzzy logic neural network was established for prediction of the coming 24^{th} solar activity cycle.

Table (1)
Selected maximum amplitude predictions
For solar cycle 24

$Reference$	$Value Of R_M$
Kane,1999	105 ± 9
Badalyn,2000	50 at 2010 - 2011
Duhau,2001	87.5 ± 23.5
Hamid and Galal,2004	90.7 ± 9.2
	at 2010 - 2011
	Tr =4.6 ± 1.2 Y
Fuzzy Logic Neural Network	110
Observed value	?

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Table (2)
Selected maximum amplitude predictions
For solar cycle 22

Max.sunspotno.	*Reference*
Kane,1982	35 ± 165
Thompson,1993	148.3
Fuzzy neural model	150
Spotless precursor	153+18
Observed value	157.6

Table (3)
Selected maximum amplitude predictions
For solar cycle 23

Max.sunspotno.	*Reference*
Kopecky,1991	208
Wilson,1992	198.8± 26.5
Letfus,1993	195.8± 17
Schatten et al,1996	183± 30
Thompson,1996	164.9
Bounar et al,1997	158
	160± 30
Joselyn *et al.*,1997	156
Li,1997	149.3± 19.9
Rajmal,1997	158± 18
Wilson *et al.*,1998a	160± 30
Wilson *et al.*,1998b	152± 29
Hanslmeier,1999	154± 21
Hathaway *et al.*,1999	140± 25
Kane,1999	140± 9
Lantos,2000	133,122,110
Fuzzy neural model	132
Spotless precursor	134± 10.3
Observed value	124

4. Conclusion

We may conclude that there is an indication that a long - term oscillation 80 - 100 years may be operative and in a few coming cycles the sunspot maximum may be smaller and rebound thereafter.

References

Badalyan, O.G., Obridko, V.N., & Sykora, J. 2000, *Solar Phys.* 199, 421
Bounar, K. H., Cliver, E., W., & Boriakoff, V. 1997a, *Solar Phys.* 176, 221.
Bounar, K. H., Cliver, E., W., & Boriakoff, V. 1997a, *Solar Phys.* 176, 211.
Duhau, S. 2003, *Solar Phys.* 213, 203.

https://doi.org/10.1017/S1743921306002390 Published online by Cambridge University Press

Eddy, J.A. 1977, *Historical evidence for the output and its variation* Associated university press, Boulder, Colorado. p. 51.

Hamid, R.H. & Galal, A.A 1994, *Bulletin of NRIAG (X).*

Hamid, R.H. 2000, *Bulletin of NRIAG, Astron. (A).*

Hanslmeier, A., Denkmayr, K., & Wass, P. 1999, *Solar Phys.* 184, 213.

Hathaway, D. H., Wilson, R. M., & Reichmann, E. J. 1999, *J. Geophys Res.* 104, 22375.

Joselyn, J. A., Anderson, J. B., Coffey, H., Harvey, K., Hathaway, D., Heckman, G., G., & Kane, R.P. 1999, *Solar Phys.* 189,217.

Kane, R.P. 2001, *Solar Phys.* 202,395.

Kopecky, M. 1991, *Bull Asdtron Inst. Czech* 42, 157.

Lantos, P. 2000, *La Recherche, 332, 16.*

Letfus, V. 1993, *Solar Phys.* 149, 405.

Li, Y. 1997, *Solar Phys.* 170, 437.

Mckinnon, J. 1987, *Report UAG-85*, NOAA, Boulder CO p.5.

Rajmal, J. 1997, *Solar Phys.* 176,431.

Schatten, K., Meyers, D. J., & Sofia, S. 1996, *J. Geophys Res. Lett.* 23, 605.

Thompson, R. J. 1996, *Solar Terrestrial Predictions* V. Proc. of a workshop at Hitachi, Japan.

Waldmeier, M. 1961, *the sunspot activity in the years 1610-1960* Swiss Fedral Observatory Zurich.

Wilson, R. M. 1992, *Solar Phys.* 140, 181.

Wilson, R. M., Hathaway, D. H., & Reichmann, E. J. 1998a, *J. Geophys Res.* 103, 6595.

Wilson, R. M., Hathaway, D. H., & Reichmann, E. J. 1998b, *J. Geophys Res.* 103, 17411.