On the minimum - maximum method for the solar cycle prediction

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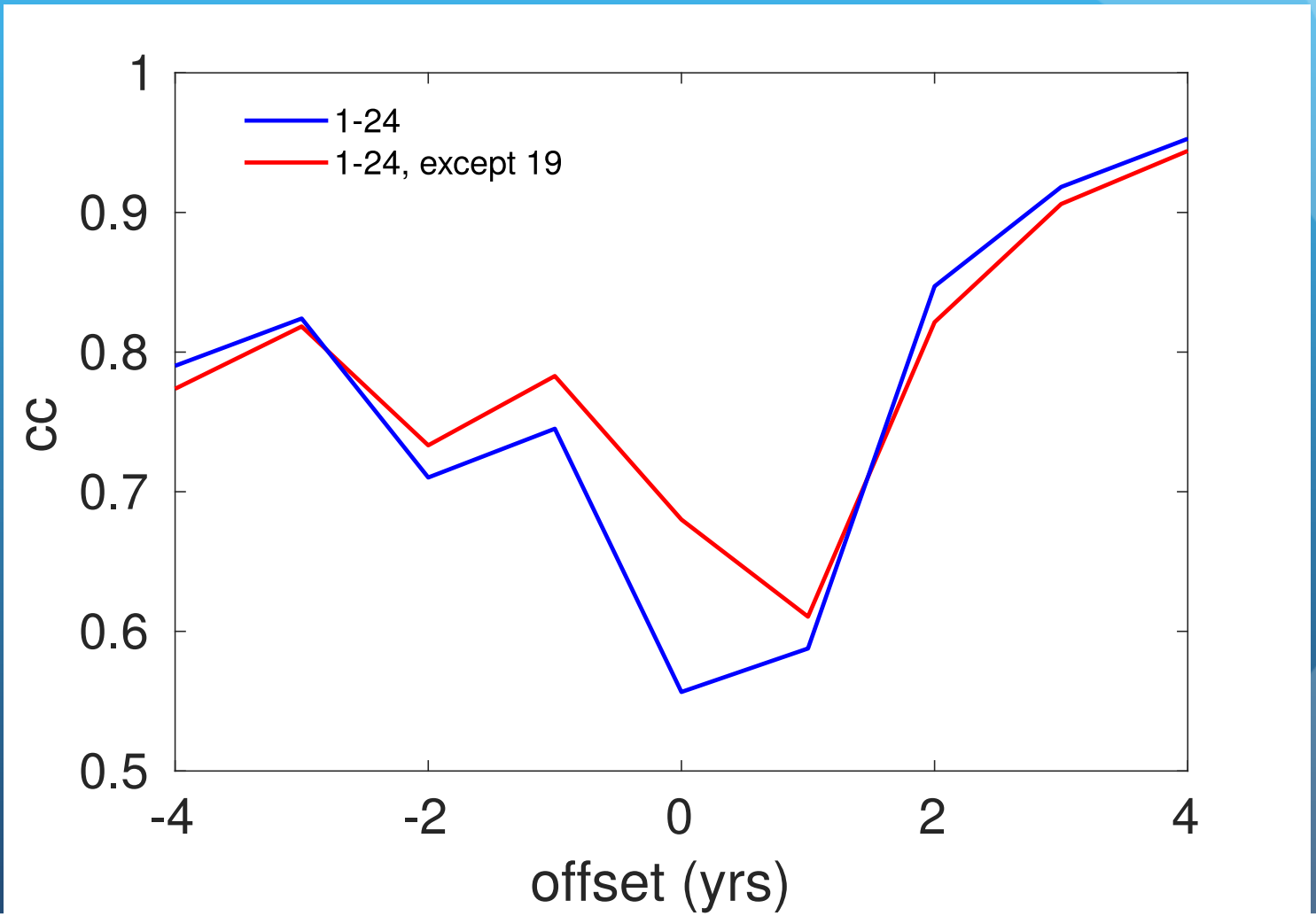
Introduction

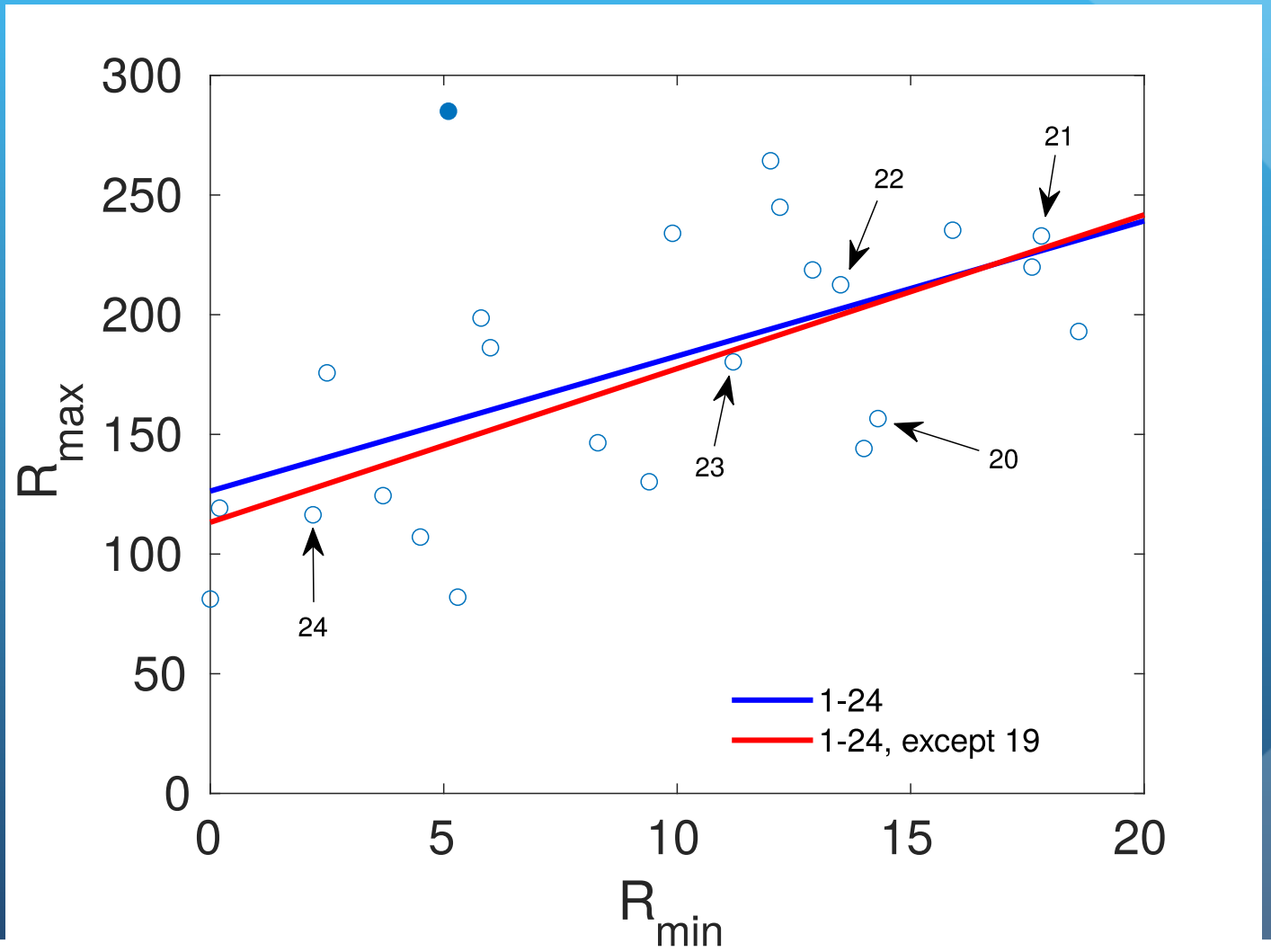
- the minimum-maximum method: precursor class of forecasting methods
- linear relationship between R_min and the next R_max
- a modified min-max method: time shift around solar min
- data se used: the revised 13-month smoothed monthly total sunspot number from SILSO/SIDC
- cycle nos. 1-24 ➔ prediction for no. 25
- with and without solar cycle no. 19

The correlation coefficient CC of the minimum – maximum relationship for different values of the time offset in years.



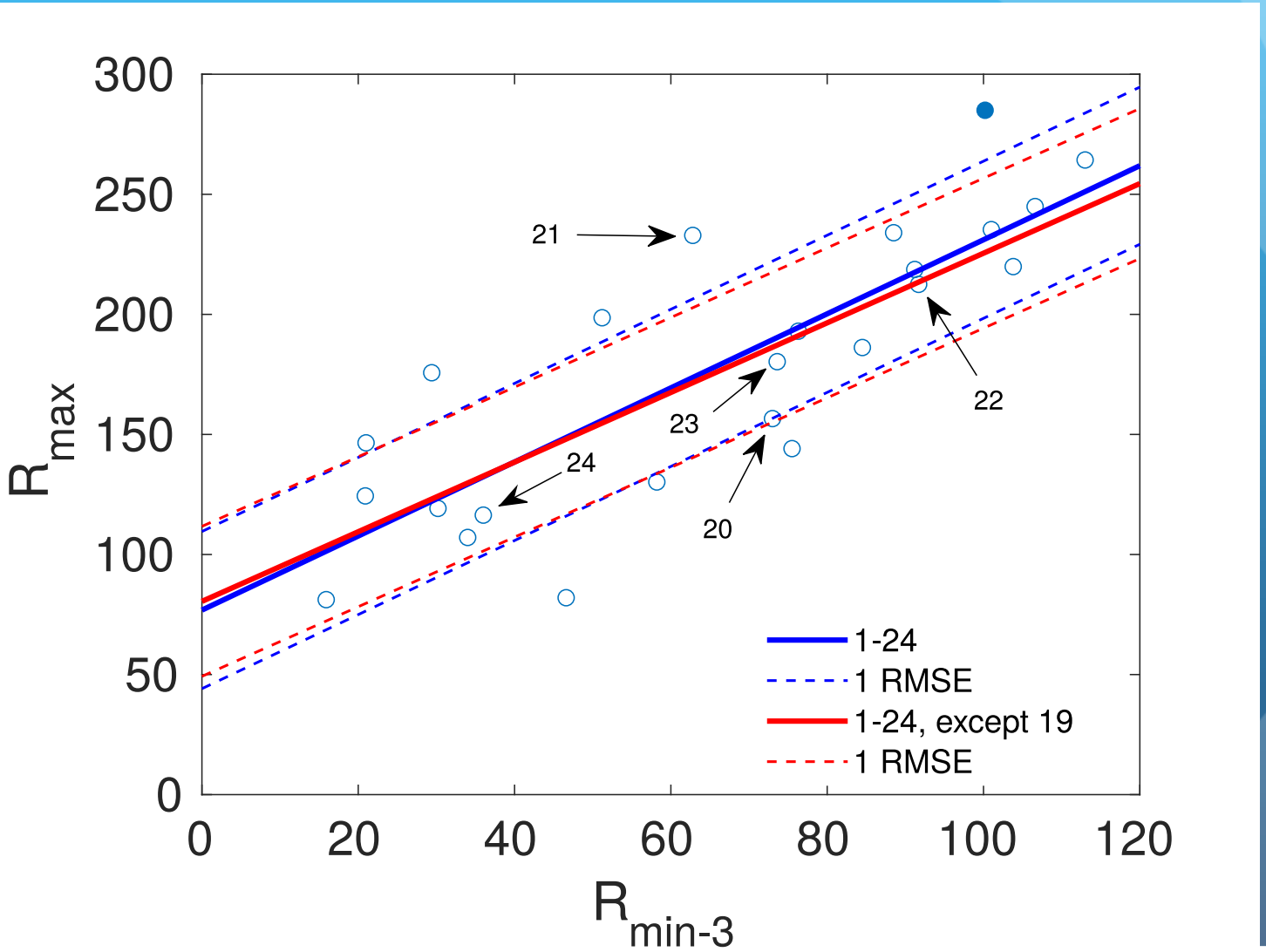
The peak smoothed monthly sunspot number in solar cycle maxima as a function of the same quantity in the preceding solar minimum, for solar cycles nos. 1-24.

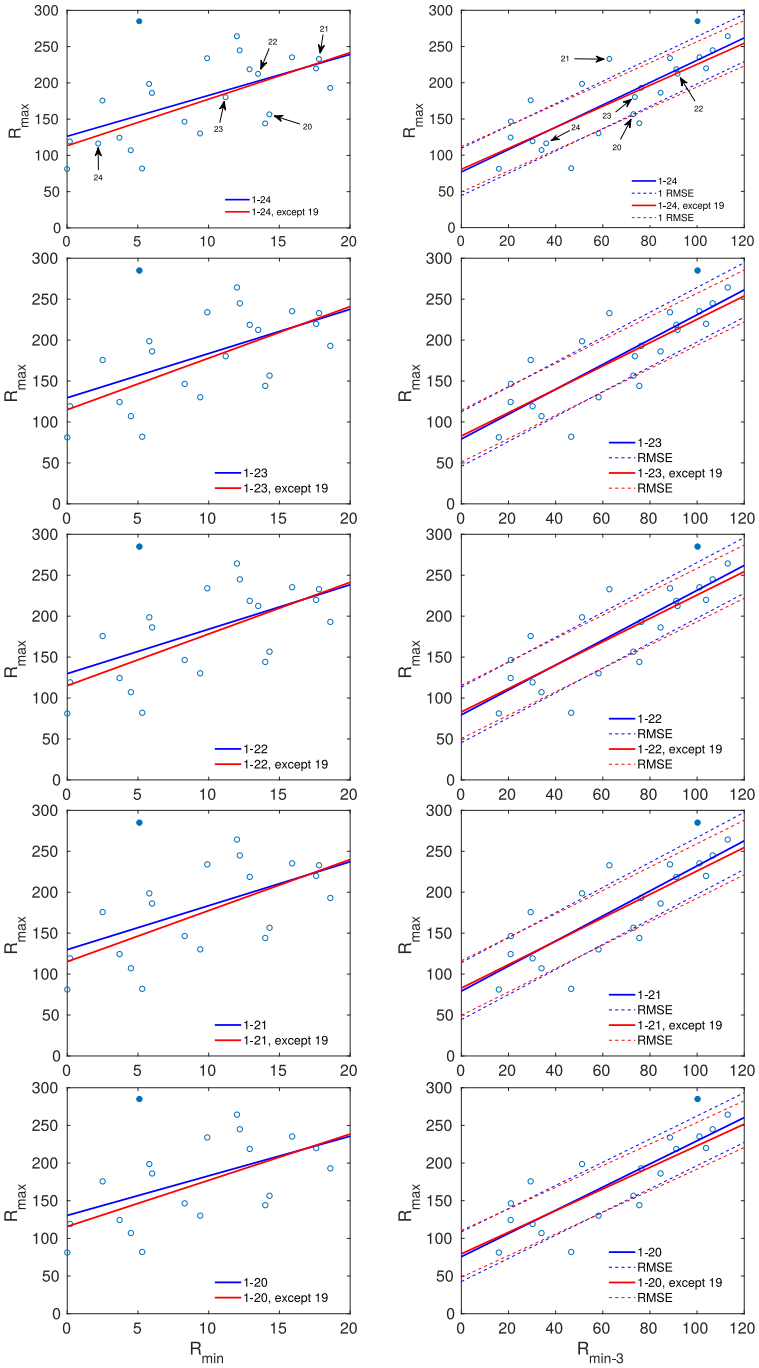
$Rmax = a \times Rmin + b$



Similar to previous Figure, but for the values 3 years before the activity minima. Dashed lines represent uncertainty of the fits.

$Rmax = a \times Rmin{-}3 + b$




R_max
R_min
R_min-3
1-24
1-24, except 19
1 RMSE
1-23
1-23, except 19
RMSE
1-22
1-22, except 19
1-21
1-21, except 19
1-20
1-20, except 19
20
21
22
23
24

Summary of results I

$R_{max} = a \times R_{min}(t) + b$

solar cycles 1-24:

$R_{max} = (5.6 \pm 1.8) \times R_{min} + (126 \pm 20)$; CC = 0.56

$R_{max} = (1.5 \pm 0.2) \times R_{min-3} + (77 \pm 17)$; CC = 0.82

solar cycles 1-24, without cycle no.19:

$R_{max} = (6.4 \pm 1.5) \times R_{min} + (113 \pm 17)$; CC = 0.68

$R_{max} = (1.4 \pm 0.2) \times R_{min-3} + (80 \pm 16)$; CC = 0.82

Summary of results II

- Our prediction for the maximal amplitude of the solar cycle no. 25:

$R_{max} = 137 \pm 48$ (R_{min}, R_{max}, nos: 1 – 24)

$R_{max} = 121 \pm 33$ (R_{min-3}, R_{max}, nos: 1 – 24)

$R_{max} = 125 \pm 40$ (R_{min}, R_{max}, excl. no. 19)

$R_{max} = 122 \pm 31$ (R_{min-3}, R_{max}, excl. no. 19)

Conclusions

- The next solar maximum (cycle no. 25) will be of the similar amplitude as the previous one, or even lower:

$$R_{max} = 121 \pm 33 \quad \text{(3 years before min predictor)}$$

- The reliability of the "3 years before the minimum" predictor is experimentally justified by the largest correlation coefficient and verified with the Student t-test; it is independent of including/excluding cycle no. 19
- the method is satisfactorily explained with the two empirical well-known findings: the extended solar cycle and the Waldmeier effect

Acknowledgements

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