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Interactive comment on "Predicting the maximum *aa/Ap* index through its relationship with the preceding minimum" *by* Zhanle Du

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Reply to Referee # 2 Overall modifications The manuscript has been thoroughly revised based on two referees. We discuss mainly the result using the 3-hourly aa index since 1868 in Sect 2. For each 3 days' interval, we find out the highest/lowest aa index (aaH/aaL) from 24 values of the 3-hourly aa indices. In order to reduce accidental events in the data, both aaH and aaL are smoothed by 363 days (121 points) to mimic the 13-month smoothing, as suggested by Referee 1. The maximum of aaH (aaHmax) is found to be well correlated to the preceding minimum of either aaH (aaHmin, r=0.85) or aaL (aaLmin, r=0.89) for the 11-year solar cycle. Based on these correlations, the strength of geomagnetic activity for cycle 25 is estimated to be aaHmax (25)= 85.5±6.9 (nT), similar to the average over the past cycles, but about 32% higher than that of

cycle 24. The rise time (THr) from aaHmin to aaHmax is found to be only weakly anti-correlated to the following aaHmax, r=-0.42. Such a weak correlation is no longer used to estimate THr as suggested by Referee 2. Similar result can also be obtained if using the 363-day-smoothing highest/lowest 3-hourly Ap index in 3-day-interval (ApH/ApL), shown in Sect. 3. The maximum of ApH (ApHmax) is well correlated to the preceding minimum of ApH (ApHmin, r=0.96) or ApL (ApLmin, r=0.79) for the 11-year solar cycle. The rise time (THa) from ApHmin to ApHmax is reversely correlated to the preceding minimum of ApL (ApLmin, r=-0.72). For the 13-month smoothed monthly mean aa (Ap) index, the result is moved down to Sect. 4, retained as a comparison, as suggested by Referee 2, but using only the aa index since 1868. The maximum aa(Ap) index, aamax (Apmax), of the solar cycle is also well correlated to the preceding minimum, aamin (Apmin), with a correlation coefficient of r= 0.95(0.86). 'Predict' is changed to 'estimate' as suggested by Referee 2. ————————

The author identified maximum and minimums of smoothed aa and Ap indices through several solar cycles and calculate correlations between minimum and maximum values and between min/max values with respect to the preceding-following cycle. The relations that are found through the means of linear regression are then use to predict estimated aa/Ap minimum/maximum values for solar cycle 25.

Main comments 1. My main concern is with the selection of the dataset. It is not clear to me why the author choose to work with the 13-month smoothed aa index instead of the highest resolution available. Smoothing everything will naturally result in predictions that converge to the mean values and therefore fail to capture the spiky behavior of storm indices. This is particularly relevant in the case of Ap index. As shown in Table 1, the Ap smoothed monthly means corresponds to period of at most minor geomagnetic activity. Therefore all storm activity is lost. I suggest the author repeat the calculations using the highest available temporal resolution of the indices and compare them with the current results of the manuscript. R: Yes. We did. This suggestion is similar to that by Referee # 1: "To do so I could suggest to construct two

data sets of the observed aa index minimum and maximum values for each 3 days or more. These two sets could be smoothed for 13 months." In the revised manuscript, we used the 3-hourly aa index of ISGI since 1868 (highest resolution). For each 3-day-interval, we find out the highest aa index (aaH) and the lowest aa index (aaL) from 24 values of the 3-hourly aa indices. Then, both aaH and aaL are smoothed by 363 days (121 points) to mimic the 13-month smoothing, as suggested by Referee # 1. The results are similar to those using 13-month smoothed monthly mean values, apart from that the maximum is estimated to be around 85 for the highest value. The results using 13-month smoothed monthly mean values are now retained and changed to Section 4.

2 Page 2 L19-21 These results are hardly relevant. Simpler methods will estimate the duration of solar cycle phases with significantly better accuracy (For example, NOAA predicts a rising duration with an error of $\sim$8 months). Estimating the duration of half a cycle with an uncertainty of almost half the solar cycle results in a disconnection between the mathematical results and the known repetitiveness of the studies phenomena. There's a reason it is called the 11-year cycle. I suggest the author to revise the calculations and to interpret them in the context of what could be a reasonable assumption of the duration of the phases of SC25. R: As the anti-correlation coefficient between the rise time and the following maximum is very weak, we do no longer use it to estimate the rise time. The rise time of aa index is defined as the time duration from the minimum to the following maximum of aa/Ap index. The weak correlation between the rise time and the following maximum is related to the fact that the geomagnetic activity minimum (maximum) is not aligned to the solar (sunspot) activity minimum (maximum) in time, as shown in Fig.10 for the time difference of aamax to Rmax, ΔTmax(a), and that of aamin to Rmin, ΔTmin (b). In most cases, aamax (aamin) lags behind Rmax (Rmin). But in some other cases, aamax (aamin) precedes Rmax (Rmin). If the rise time is computed from the minimum of sunspot activity to aaHmax, the correlation is even weaker, r=-0.14.

3. The main results of the paper (shown in Figures 1-4) are heavily influenced by

the decision of using smoothed indices. While they may be correct in that particular context, the author should consider if the methodology utilized is the appropriate for this particular problem. Going back to point 1, if a different dataset is utilized, all figures need to be remade. On a note regarding presentation of the figures, adding colors to the different lines and making the figures of the appropriate size will significantly improve the readability. R: Yes. The dataset is replaced by the 3-hourly aa index of ISGI since 1868 as stated in 1. The rise time is defined as in 2. The lines of figures are shown in colors.

Specific comments 1) Title: I suggest replacing "minimum" with "solar minimum" to explicitly refer to solar cycle. Note that currently the title is misleading, as the prediction is regarding the smoothed data. Please adjust accordingly. R: Yes. We did. To clearly describe the data used, the title is changed to 'Estimating the maximum of 363-day-smoothing highest 3-hourly aa index in 3-day-interval by the preceding minimum of highest/lowest aa value for the 11-year solar cycle'. 2) Page 2 L10 - What is the meaning of a double plus-minus. Is it referring to different error sources? In that case please specify. L18 – Do you mean anti-correlated? L26 What do you mean by deviations? Please provide relevant references. R: The double plus-minus refers to different error sources, 'where $\pm$3.9 and $\pm$2.1 are derived from the uncertainty of aaHmax (25) and the standard deviation of the fitting of Ap to aa, respectively.' Yes. Thank you. It means anti-correlated. It changed to 'deviations of orbital motions of Satellites' (Yoshida and Yamagishi, 2010; Petrovay, 2020).

3) Page 4 L2-3 Predicted or estimated? A prediction is a statement about the future. A correlation between two variables at most indicates the ability to estimate one when the other is available, which appear to be the case. R: Yes. We changed 'estimated' to 'estimated'.

4) Page 7 L2-4 This extremely high correlation is clearly affected by the process of smoothing the data. Similar with other figures and equations, please correct based on major comments. R: Yes. We do. This figure is replaced by Fig.7(a) for the scat-

ter plot of the 363-day-smoothing 3-hourly Ap against aa indices since 1932 (dots). The correlation coefficient between them is r=0.93 (or 0.75 if using the non-smoothed series).

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