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Discussions**

Interactive
Comment

Interactive comment on "Natural variability and anthropogenic effects in a Central Mediterranean core" *by* S. Alessio et al.

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We thank this Referee for the detailed review of our paper and for his or her four specific comments. We reply to all four in the following.

1. "[...] **reasonable reproduction of the natural variability during the pre-industrial time.**"

   We fully agree that the extent to which our prediction models do simulate the variability during the pre-industrial era is a key test for how well they will perform in a predictive mode. Actually, the Referee seems to have missed the fact that this issue is addressed already in Fig. 1: the heavy black curve there IS the result of our SSA model, i.e. the data-adaptively smoothed version of the data, which we

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define as y_{obs} in Eq. (1) of the paper's original version (y_{LF} in the revised version). The accuracy of the prediction is further given by the narrowness of the pink rms error belt for the SSA-AR forecast in Fig. 5 and by the fact that the two curves obtained using independent methods — SSA-AR (red curve) and neural-network based (blue curve) — almost coincide. The width of this belt is a function of the lag and increases with the length of the validation interval into the future. This width has been determined using all the data of a long test section (308 points) by the statistical procedure described in the text and in Fig. 3.

For greater clarity, we insert here and in the revised version of the paper a new figure that shows, for both the SSA-AR and neural-network approaches, a direct comparison between the two predictions, on the one hand, and the smoothed data in a 64-point, 248-y-long test section, toward the end of the pre-industrial era (1592-1840 AD). This test section is almost twice as long as the modern forecast section.

The new figure (Fig. 4 in the revised manuscript, increasing thus the total number of figures in the paper from 6 to 7) is now discussed in the last two paragraphs of Section 3.

Clearly the agreement between the two forecasts and the observed LFV is excellent for a length of time equal to that of the modern, Industrial-Era predictions in Fig. 5 of the revised paper, i.e., out to roughly 1730 AD; it deteriorates only slightly beyond this range, i.e. for the latter part of the test section here.

2. "[. . .] **the question comes whether using all spectral components (i.e., the full series including higher-frequency variability) would significantly vary their results in terms of how the variability during the pre-industrial time is reproduced.**"

As pointed out by this Referee, all prediction methods perform better on noise-free and narrow frequency-band signals. For this reason, instead of forecasting

the whole series, we predict the individual, oscillatory components extracted by SSA (and shown in Fig. 2), as suggested by Penland et al. (1991). Ghil and Vautard (Nature, 1991) pointed out the contribution of decadal-scale signals to global and hemispheric-scale temperature variations well before Schlesinger and Ramankutty (Nature, 1994), and so did Plaut, Ghil and Vautard (Science, 1995). But we are only concerned here with the low-frequency part of the signal – namely the long-term trend and multi-decadal oscillations – and not with shorter-scale, interannual and decadal oscillations that were discussed by these authors.

SSA does separate different scales of variability, but these scales are not in one-to-one correspondence with different causes of variability, due to the climate system's well-known nonlinear, multi-scale interactions. For instance, (natural) solar forcing, has a decadal-scale, 11-year component, as well as multi-decadal and centennial ones (Sonett, C. P., Giampapa, M. S., Matthews, M. S., Eds., The Sun in Time, University of Arizona Press, 1991). All of these components act upon the climate system and can produce in turn other periodicities. In the present data set, though, the longer-term solar components are embedded in the oscillatory modes of Fig. 2, which were used in our forecasts, while the 11-year component, which is the only significant one we neglected in our two forecast models, cannot contribute to the long-term behavior over the last 150 years.

To clarify this matter further, we have labeled now the low-frequency signal defined in Eq. (1) as y_{LF}, instead of y_{obs}, as done in the paper's original version, and modified the text and the captions of the new Figs. 5 and 6 (i.e., the old Figs. 4 and 5) accordingly.

Furthermore, we have estimated separately the high-frequency variability plus red-noise background of the 18O record, i.e., the difference between the light-gray (total record) and the heavy-black (LFV part of the record) for the pre-industrial, 188 BC-1840 AD portion of the record and the Industrial Era (1841-1979 AD). The results are about 65 % and 32 %; the first one does not differ

significantly from the value of roughly 60 % obtained for the entire interval. More-over, the high-frequency variability plus red-noise background is lower during the Industrial Era than before. This notable fact is emphasized now in the last-but-one paragraph of Section 4.

3. **"The performance of the models can significantly change depending on the period selected for calibration"**, i.e. the learning section.

We fully agree that no prediction algorithm is perfect, and thus independent of various parameters, such as the length of the learning section. As with other parameters of the two independent methods we used, we varied this length: first we used a long learning section (700 years; Fig. 3.a1) and later an even longer one (1800 years; Fig. 3b). In both cases, we found substantially the same post-1840 prediction results. Moreover, it is true that the test section in the case of Fig. 3b becomes much shorter than in the case of Fig. 3.a1 (only 64 points), but it remains much longer than the forecast section (36 points), as pointed out in the reply to comment (i) above and in the caption of the new Fig. 4.

The numerous tests of robustness we carried out all indicate agreement between the two methods and ultimately yield substantial confidence in the Conclusions. The material in Section 3 is quite technical indeed, but the pertinent comments of this Referee only highlight further the need for the various tests we used.

4. **"**[. . .] **previous works** [. . .] **on Mediterranean temperature-related proxies** [. . .]**"**

Thank you for the additional references, all of which have now been included, along with a few more. As suggested, we placed our study in its regional context, by mentioning some recent studies on Mediterranean proxy records in the first paragraph of the Introduction.
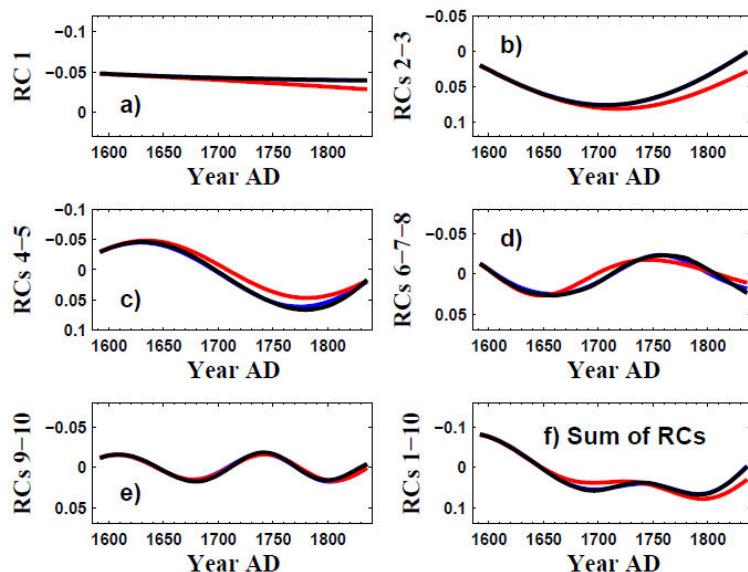
Fig. 4. Prediction results for the low-frequency variability (LFV) portion of the $\delta^{18}O$ time series over a test section 1592–1840 AD that immediately precedes the Industrial Era (IE). The predictions are shown separately for (a) the trend (RC1) and (b–e) for each of the four oscillatory pairs in Fig. 2, as well as for the sum of the components in panels (a–e), namely RCs 1–10: observed LFV in black, cf. Eq. (1); SSA-AR prediction in red; and neural-network prediction in blue. See text for details of the prediction methods.

Fig. 1. The new figure inserted in the revised manuscript, where it appears as Fig. 4