

Interactive comment on “Teleconnections and relationship between ENSO and SAM in reconstructions and models over the past millennium” by Christoph Dätwyler et al.

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Overview – the authors are examining relationships between austral summer ENSO and SAM indices from reconstructions and model simulations over the last millennia. As these relationships are important for understanding climate variations across the mid and high latitudes of the Southern Hemisphere, and no research to my knowledge has been done on these relationships this far back in time, the work is very important. The paper is extremely well written, concise, and easy to follow. I enjoyed it very much, and suggest it be published after the authors address my three main concerns, and

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two very minor suggestions.

Major concerns: 1. Figure 1 – is there a way that uncertainty in the reconstructions (both the Fogt and the proxy-based) can be accounted for when calculating the correlation, and this can be shown as some sort of confidence interval around the correlations? While you can do this as a statistical test that the correlation is zero (95% confidence interval on the correlation magnitude itself), I think it would be more telling to represent the confidence intervals as a function of the error / uncertainty in the various reconstructions, perhaps through some Monte Carlo sampling? This would help to determine if shifts to positive correlations in Fogt reconstruction in 1955 or the proxy-based reconstructions in years 1100-1300 are different than zero when accounting for the uncertainty in the reconstructions. I understand this a goal of Figure 2, but you can also do this in the real-world sense in Figure 1.

Response 1: Yes. We calculated the significance in two different ways and shaded values exceeding the 95% confidence threshold with grey and cyan colour respectively. The cyan shading corresponds to significant individual 31-year window correlations ($p < 0.05$), taking auto-correlation of lag 1 into account. The grey shading represents values that exceed the 95% confidence range obtained from the uncertainty in the reconstructions. The 95% confidence range was calculated from the running correlations of 1000 ensemble members of the SAM and ENSO reconstructions. For the SAM reconstruction the data can be downloaded from <https://www.ncdc.noaa.gov/paleo-search/study/23130> and for ENSO, an ensemble of 1000 reconstructions was generated by adding noise to the reconstruction with the same AR1 coefficient as the reconstruction and variance equal to the square of two times the augmented standard deviation of the residuals between the reconstruction and target ENSO index over the reference period 1930-1990 (SDres.aug, formula as in Dätwyler et al. 2019).

2. I have trouble interpreting Figure 4, since it is based on the sign of the correlation, rather than the phases of either ENSO or SAM. This would mean the negative composite, for example, contains years of ENSO+ and SAM- (El Nino with SAM-) as

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well as ENSO- and SAM+ (La Nina with SAM+). One would expect this would lead to cancellation of many of the circulation features since the phase of the two modes are opposite, and indeed in Fig. 4 you do not see any SAM signatures in SLP over Antarctica, or really any ENSO signatures in temperature or SLP in the tropical Pacific. I suggest redoing these to have a more meaningful result, since previous work suggests high southern latitude ENSO teleconnections are stronger when there is a negative ENSO-SAM correlation. To do this, you can continue to use the correlation as a tool to select years, but then make sure to adjust the anomalies based on the phases of ENSO / SAM before compositing to be consistent and avoid cancellation. For example, you could multiply the years of SAM- and El Nino by negative 1 before adding these two the years with SAM+ and La Nina, to represent the circulation specifically during negative correlation events. I think this would be much more meaningful. The IPO signature may emerge more than the ENSO one since it is a persistent mode of variability, whereas ENSO and SAM change phase much more frequently.

Response 2: Thank you for the suggestion. Note that a negative correlation can not only arise during ENSO+ with SAM- and ENSO- with SAM+, but may also occur during ENSO+ with SAM+ and ENSO- with SAM- when both vary opposed to each other. But we agree that our approach may lead to the cancellation of circulation features and will recalculate the patterns in Fig. 4 taking the phases of ENSO and SAM into account and test the suggested multiplication of temperature/SLP patterns by negative 1 of either years with SAM+ and La Niña or SAM- and El Niño.

3. Also, it is odd to have a focus on the Aleutian Low in Fig. 4 – why would this be influenced by ENSO and SAM? A more robust measure would be in the SH (where SAM has a direct influence), such as the Amundsen Sea Low, which is known to change in its magnitude based on ENSO / SAM relationships. Compositing Fig. 4 in the fashion described above should make for a clear connection with the ASL.

Response 3: Referee #2 notes that the Aleutian low pattern we see in Fig. 4 is possibly only a teleconnection related to ENSO. We agree with this. At the current state of

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knowledge, we cannot provide a sound dynamical explanation how the Aleutian low stands in relation to ENSO-SAM correlations. Therefore, we decided to restrict our analysis of spatial patterns to the SH only, where a direct link to both ENSO and SAM is more obvious. The text in the manuscript at all relevant places will be changed accordingly.

Minor suggestions:

1. Figure 1 – suggest clarifying that ENSO is based on the Nino 3.4 index, as some other studies have used the SOI and therefore had a positive correlation

Response 4: Ok, done.

2. The authors may wish to cite / incorporate a recent study which looked at stationarity in pressure relationships between the mid / high latitudes of the SH over the last century in models and reconstruction, also using perfect pseudoproxy model reconstructions (Clark and Fogt 2019): Clark, L., and R. Fogt, 2019: Southern Hemisphere Pressure Relationships during the 20th Century – Implications for Climate Reconstructions and Model Evaluation. *Geosciences*, 9, 413, <https://doi.org/10.3390/geosciences9100413>.

Response 5: Ok.

Interactive comment on *Clim. Past Discuss.*, <https://doi.org/10.5194/cp-2019-110>, 2019.

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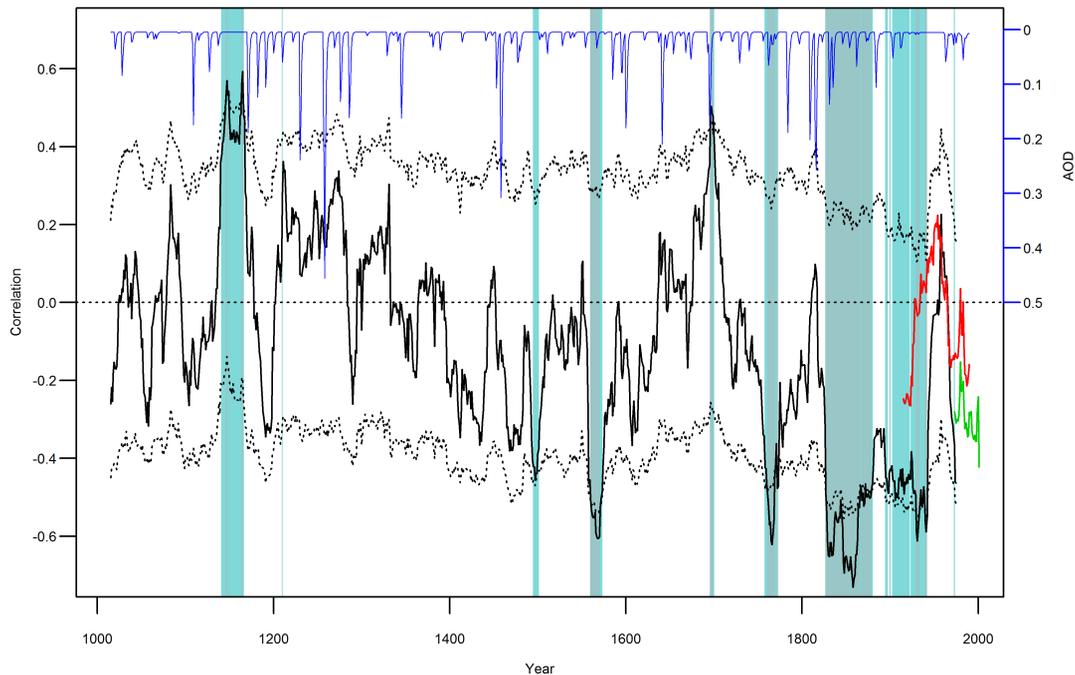


Fig. 1. Updated Fig. 1. Added shading of significant correlations.

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