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Climate of the Past
Discussions

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

Anonymous Referee #2

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Dätwyler et al. study the correlation between ENSO and SAM using the CESM last millennium ensemble and two proxy-based reconstructions. They argue for a variable relationship, with a long-term mean anti-correlation of around -0.3. This is in agreement with previous work.

The paper is overall well-written, well-referenced and easy to follow. To me the strongest point is the pseudo-proxy validation effort of the ENSO and SAM records. Since these reconstructions were made by Dätwyler himself, this effort would perhaps have been more appropriately discussed in the original papers that presented these records. While the analyses appear to be technically valid, I am not sure whether

the work contributes meaningfully to our understanding of atmospheric dynamics (see comments below). The focus is purely on correlation analysis of various indices, which is a strong limitation of the study. A discussion of the potential and limitations of such an approach is needed. Also, including an understanding of the underlying climate dynamics would make for a more mean interesting paper.

Comments:

Since there are many different indices of ENSO and its teleconnections, as well as different indices of the SAM, it is not clear to me whether the presented correlation represents fundamental atmospheric dynamics or just an artifact of how the indices are defined. A different choice of indices may give a different result. For example, the ENSO teleconnection to the South Pacific is often associated with the PSA1 pattern. The SAM and PSA1 patterns are commonly defined as the first and second EOF pattern of SH extra-tropical geopotential height anomalies – in which definition they are orthogonal by construction and therefore have a correlation of r=0. Positive ENSO/PSA1 is associated with a weakened Amundsen Sea low via a Rossby wave train; all else being equal this will show up as a negative SAM phase in the definition of the authors (positive SLP anomaly at 65S), even without any SAM-specific dynamics being involved. I think the authors should check whether the correlation they observe is an artifact of the choice of indices, or something more fundamental. At least this important caveat should be discussed.

The long-term average correlation is weak (r around -0.3, or less than 10% of variance explained). Two timeseries that are weakly correlated will always have periods of stronger and weaker correlation. Since the extremes in this running-window correlation are not very obviously linked to any climate patterns (Fig. 4), could this pattern simply arise from the autocorrelation of both time series? Also, with only 31 years in the running window, I imagine anything below $|r| = 0.35$ or so may not exceed 95% confidence. Are these variations statistically significant?

The authors implicate the Aleutian low in periods where the SAM-ENSO relationship is anomalous. Is there a good dynamical explanation for this? I think of the Aleutian Low as the NH analog of the Amundsen Sea low. Given that ENSO teleconnection patterns have hemispheric symmetry [Seager et al., 2003], could this simply be a NH ENSO teleconnection? I find it hard to believe the Aleutian low is actually driving these SH high-latitude phenomena; more likely it is just a downstream indicator of certain anomalies in tropical Pacific convection.

There is little discussion of, or insight into, the atmospheric dynamics that may drive these observations. What does this correlation represent, and why is it important in the first place? Does it reflect an influence of ENSO on SAM (most likely, right?) or vice versa?

How is it possible that the correlation in 1800-2000 CE is stronger in noisy pseudo proxies (Fig. 3b) than in noise-free pseudo proxies? This is very counter-intuitive. Is the noise applied to the ENSO and SAM proxies correlated? In the supplement it is mentioned that several proxies are used in both reconstructions – could this produce such an unexpected result?

The authors only show the 31-yr running window correlations. However, both ENSO activity and the SAM have long-term (multi-centennial) variations also, that are not captured in such an analysis. What correlation do you get for different window lengths? What is the correlation of the full time series without any filtering?

The authors conclude (surprisingly) that the no-noise pseudo-proxies may be a better representation of the real world than the noisy pseudo proxies (Section 3.3). It seems this is based on the red and black lines overlapping in Figs. 3c and 3d. However, the reconstructions use multiple types of proxies – could it be that different proxies have different SNR levels? Also, the SAM red curve seems to overlap with the blue line better in the early part of the reconstruction – wouldn't that imply that SNR=0.5 is a good choice for the SAM reconstruction after all?

Minor comments:

L21 and elsewhere: What are "negative teleconnections"? I suppose you mean negative SAM-ENSO correlations. This is not the same. Please replace here and throughout the paper.

L33: "little is known about the interplay between them"... Elsewhere you cite a handful of papers on this topic, I think you should cite them here also.

L41: Negative correlation: Please describe in words what this means climatically. I assume it is a positive ENSO phase (El Nino) coinciding with a negative SAM phase (weak vortex, SH westerlies displaced northward).

L154-156: Why is the interval chosen asymmetrically at +3 to -2 stdev?

L169: correlation strength is in the eye of the beholder, but I would not call a correlation in the 0.2 to 0.3 range strong. That is only 5-10% of variance explained.

L170, L180 and throughout: "breakdown" seems an inappropriate word. In weakly correlated time series like these there will always be periods of stronger and weaker correlation. Nothing may have changed.

L189: observational data is confusing here. Do you mean proxy or instrumental data? Both are observational. Please clarify.

L204: I interpret the trend in Fig 3a is an artifact of the proxy reconstruction, given that the model relationship is steady (Fig. 2). Is that correct? Please state this more explicitly.

L207: why do the noisy proxies have stronger correlations than the no-noisy proxies?

L226: The binary choice between SNR=0.5 and perfect proxies is of course artificial. Can you estimate the optimal SNR value? Surely there must be some noise in the proxies (realistically a different SNR for each proxy type/archive).

L255: Can you please remind the reader how these are defined? What years are averaged?

L291: "teleconnections break apart or are particularly strong" should be: correlations are weak or particularly strong. You're not studying the teleconnection patterns directly, this is all extrapolation.

Figure 1: Can you show the correlation for longer time windows also? Which of these values are statistically significant? With only 31 years in the window, I imagine anything below r = 0.35 or so does not exceed 95% confidence. Last, note that DJF is when ENSO is strongest, but SAM feedbacks and lifetime are strongest in spring (SON).

Figure 4: You note that the model strongly underestimates the variability in the ENSO-SAM correlation, suggesting it may lack the relevant dynamics that drives this in the real world – maybe state this caveat when interpreting this figure. On the left y-axes labels, replace "teleconnection" with "correlation". How is statistical significance determined? Do you compare the anomalous years to the statistics of the full model run? It is surprising that the strongest SAT and SLP anomalies are not statistically significant.

Reference: Seager, R., N. Harnik, Y. Kushnir, W. Robinson, and J. Miller (2003), Mechanisms of Hemispherically Symmetric Climate Variability, J. Clim., 16(18), 2960-2978, doi: 10.1175/1520-0442(2003)016<2960:MOHSCV>2.0.CO;2.

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