

## ***Interactive comment on “Changing correlation structures of the Northern Hemisphere atmospheric circulation from 1000 to 2100 AD” by C. C. Raible et al.***

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### **General comments**

This manuscript studies the stability of spatial teleconnection patterns within the Northern Hemisphere, using a combination of reanalysis data and climate model simulations. The authors find that significant shifts take place in the centres of action of the North Atlantic Oscillation and the Pacific North American pattern, apparently as a result of natural internal climate variability. These findings challenge the assumption of stationarity that underlies the use of palaeoclimate proxies to reconstruct past changes in

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atmospheric modes.

The manuscript tackles a crucial question in palaeoclimatology – that of the stability of teleconnections. It is clearly within the scope of *Climate of the Past*, and makes a significant contribution towards our understanding of the stability of teleconnection patterns. The methods are appropriate and the presentation is generally clear. There is, however, some potential to polish the English language and grammar; I make some specific suggestions in this regard below.

I recommend that the manuscript be published in *Climate of the Past*, subject to the authors considering the following comments.

### **Specific comments**

1. P4989, L11: This sentence implies that different teleconnection patterns are found in the Northern Hemisphere only. Perhaps it could say something like “However, teleconnection patterns can also consist of two or more anti-correlated centres of action” instead.

2. P4993, L19-20: How is this achieved? This is explained in the caption of Figure 1, but it would be better to explain it here.

3. P4994: The authors should provide further information on the teleconnectivity maps developed by Wallace and Gutzler (1981). I had to read this paper before I could understand the figures in the current manuscript, particularly the derivation and meaning of the arrows. This should not be necessary, and the manuscript would benefit from a longer description of this technique at the start of Section 3.

4. P4994: I can see no explicit statement that the authors analyse data for the Northern Hemisphere. This is obvious from the figures, and perhaps from the title and introduction too, but it should be explicitly stated at the start of Section 3.

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5. P4994, L21: Figure 2 should be referenced at the end of this sentence.
6. P4995, L15: Is this agreement relative to the full period, or only to 1971-2000?
7. P4995, L21-22: True, but the teleconnections generally become much weaker. This should be stated.
8. Section 3.2: This is too long to be a single subsection: it currently consists of more than four pages of continuous text. I would suggest breaking it into at least two subsections, perhaps beginning a new subsection after line 8 on page 4998.
9. P4995, L27: The authors could clarify by stating "... change in the strength and spatial pattern of correlations structures ...".
10. P4996, L17: From Figure 3a, I'm not sure if I agree with this statement. To me, it is the period 1971-2000 that appears to be anomalous.
11. P4996, L28: Negative values are not shown in Figure 3, so the range of values spanned by CCSM3 cannot be determined by the reader.
12. P4997, L1: ...relative to the 1971-2000 baseline.
13. P4997, L17-19: This sentence is not clear to me. Could the authors please clarify?
14. P4997, L22: This is the first reference in the manuscript to the fact that this period is more reliable. Perhaps this should be stated earlier? Also, given this fact, perhaps it would be useful to show the teleconnectivity map for this period in Figure 2 – does it differ much from the map for the full period?
15. P4997, L28: ...relative to the 1971-2000 baseline.
16. P4997, L7-8: What range of values did the authors try? How about 100 years, or 138 years – which is the same duration as the TCR?
17. P4997, L11-15: This sentence is not clear to me. Could the authors please clarify?
18. P4999, L10-11: I don't see this shift from Figure 5d. If anything, there is a north-C2390

ward shift in CCSM3?

19. P4999, L24: Could the authors clarify exactly how the period 1915-1944 was chosen?
20. Section 4: I consider that the analysis in this section could be achieved using an alternative methodology, that would be both simpler and clearer. Currently the authors define two hypothetical new indices (WADP and AWAVE), based on the dominant teleconnection patterns during the period 1940-1969. They then derive correlation maps for these indices, and compare them with the correlation maps for different indices (NAO and PNA) and a different period (1971-2000). However, this does not reflect the manner in which proxies are used to reconstruct atmospheric modes. Proxies are used to reconstruct the evolution of a specific mode over time, not to reconstruct the dominant mode at all points in time. Hence, I suggest that the authors restrict themselves to using just the NAO and PNA, and then compare the correlation maps for these two indices for the periods 1940-1969 and 1971-2000. The differences between these two correlation maps would still demonstrate regions where the sign of the teleconnection has changed over time. However, these changes could now be directly related to the use of proxies to reconstruct known climate modes (the NAO and PNA). This would also avoid the need the authors to invent arbitrary new indices, which I consider to be strongly undesirable.
21. P5000, L23-25: How is the index derived from these two time series: addition? subtraction?
22. P5000, L26-27; P5001, L21-22 and L24-25: Format this text as equations, rather than inline.
23. P5001, L5-7: True, but this is not how proxies are used. It is the stability of the relationship with a specific mode that is important for the purposes of reconstruction.
24. P5001, L4-6: Do the authors know why this earlier study reached a contradictory

conclusion?

25. P5003, L28: I don't think any of the analysis in the paper investigates whether or not proxies are able to determine the dominant mode, so I suggest removing these words.

26. P5004, L1-2: From Figures 7 and 8, this appears to be predominantly a consequence of the distribution of the proxies, rather than a consequence of a difference in the stability of the teleconnection patterns. I suggest wording this sentence more carefully.

27. Figure 1: The radiative forcings in panel a are shown as anomalies. What baseline was used?

28. Figure 2: In panel a, should the arrow over Siberia be cyan, rather than red?

29. Figure 3: I suggest plotting negative values as well.

### Technical corrections and suggested edits

- P4988, L2: Replace "to understand" with "in understanding".
- P4988, L5-6: Replace "allows scrutinizing these concepts and assumptions" with "allows these concepts and assumptions to be scrutinised".
- P4988, L11: Replace "center" with "centres" (note that Climate of the Past uses British English, and so "center" should also be "centre" throughout).
- P4988, L14 and hereafter: Replace "in the period" with "during the period".
- P4989, L1: Replace "in" with "using".
- P4989, L4: Replace "are" with "have been".

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- P4989, L16 and hereafter: Add "the" before "Azores".
- P4989, L24: Perhaps insert "interests of the" before "climate".
- P4989, L25: Replace "the last" with "recent".
- P4989, L26: Replace "in" with "of".
- P4990, L11: Replace "reliable" with "reliably".
- P4990, L18: Remove "climate".
- P4990, L24: Insert "have" after "studies".
- P4990, L29: Insert "the" before "Central".
- P4991, L3: Insert "a" before "continuum".
- P4991, L11: Reverse the words "measure" and "teleconnectivity".
- P4991, L21: Replace "conclusive" with "concluding".
- P4992, L3: Replace "bases" with "is based on".
- P4992, L5 and hereafter: Remove "the" before "NCAR".
- P4992, L13: Perhaps insert ", a horizontal resolution of" before "T85".
- P4992, L25 and hereafter: Remove "the" before "CCSM3".
- P4992, L16: Replace "condition" with "conditions".
- P4993, L10: Remove "over".
- P4993, L27: Remove the comma after "simulations".

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- P4995, L27: Replace “hints” with “hint”.
- P4996, L1: Replace “in” with “using”.
- P4996, L9: Replace “shows” with “show”.
- P4996, L10: Replace “deteriorate the correlation pattern” with “cause the correlation pattern to deteriorate”.
- P4996, L23: Replace “a disagreeing” with “an anomalous”.
- P4996, L26: Replace “problems to correctly simulate” with “deficiencies in their simulation of”.
- P4996, L29: “indicates” would be better than “means”.
- P4997, L24: Remove first instance of “the”.
- P4997, L26; Perhaps “support” would be better than “confirm”.
- P4997, L7-8: Perhaps say “Moreover, the results are not sensitive to the window size.”.
- P4997, L11: Insert “an” before “index”.
- P4998, L20: Insert “is” before “the”, and remove “is” after “analysis”.
- P4999, L9: Insert “the” before “North”.
- P4999, L10: Replace “resembles” with “resemble”.
- P4999, L20: Replace “of” with “in”.
- P4999, L24: Replace “disagreeing” with “anomalous”.

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- P5000, L5: Replace “favoring” with “favouring”; insert “the conclusion” before “that”.
- P5000, L6: Replace “appear to be” with “are”.
- P5002, L12: Replace “of” with “for”.
- P5002, L21: Replace “of under-representing” with “from under-representation of”.
- P5002, L23: Do the authors mean “demonstrates” rather than “resembles”?
- P5003, L1: Insert “temporal” before “variability”.
- P5003, L2; Perhaps insert “significantly” before “different”.
- P5003, L15: Insert “the” before “Atlantic”.
- P5003, L17: Replace “like” with “such as”.
- P5003, L19-20: Replace “future research foci” with “to be the focus of future research”.
- P5003, L28: Insert “us” after “allow”.
- P5003, L29: Replace “how” with “what”.
- Table 1: In the caption, “SRE” should be “SRES”; in the top row of the table, capitalise “forcing” and “model”.
- Figure 1, caption: Insert “the” before “visible”.
- Figure 4, caption: Replace “1880-1909” with “1940-1969”; “(g,h)” should be in bold; the second instance of “(e,f)” should be “(i,j)”.

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- Figure 6, caption: The reference period for panel b is also different from Figure 5.

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Interactive comment on *Clim. Past Discuss.*, 9, 4987, 2013.

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