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Interactive comment on "An interaction network perspective on the relation between patterns of sea surface temperature variability and global mean surface temperature" *by* A. Tantet and H. A. Dijkstra

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Point by point reply to reviewer #2

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We thank the reviewer for his/her careful reading, the positive assessment and for the

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Interactive Discussion

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useful comments on the manuscript.

1. *Major point: 1. The two weakness of the paper are: a) all of the analyses are conducted for zero lag (line 20, page 747)*

   b) the analysis is restricted to 50S to 80N

   There is a statement on the top of page 748 that reads: Even though the links in the network are based on SST correlations at zero lag, a connection is not only representative of instantaneous relationship, since the time series are 13 months low-pass filtered. I am nonetheless quite concerned that, despite this off-hand statement, the paper may be lacking physical meaning due to the assumption, throughout, of zero lag. Most analyses that related ENSO to either global land surface temperature, global ocean surface temperature, or global mean surface temperature assume some type of lag. See Table 1 of Foster and Rahmstorf, Global temperature evolution, 1979–2010, Envir. Res. Lett., 6, 044022, doi:10.1088/1748-9326/6/4/044022, 2011 for instance. Use of a 13 month low pass filter is unlikely to properly represent what known time lapses in the global extent of ENSO. Physically, it takes months for the ENSO (or AMOC) to exert an influence on other parts of the world. Also, the AMOC is expected. Also, the Hadley SST record extends further south than 50S. The restriction to 50S to 80N is therefore hard to understand. As stated in Srokosz et al., Past, present, and future changes in the Atlantic meridional overturning circulation, BAMS, 93, 1663– 1676, 10.1175/BAMSD-11-00151.1, 2012: A weakened AMOC is typically accompanied by a slight warming of the Southern Hemisphere, though details differ between models. It is incumbent that the authors address the physical limitations of their otherwise exhaustive analysis due to the choices to show results only for zero lag and to restrict SST to 50S to 80N.

   From Liu and Alexander (2007) and Trenberth (1998) we would expect the time scale of ENSO teleconnections to be of 2-6 weeks (Atmospheric Rossby wave propagation) to 1-2 months (due to changes surface sensible latent heat fluxes mixing and entrainment). However, Foster and Rahmstorf (2011) find that indices of global temperature lag of 0-1, 2-5 and 5-7 months the main "exogenous factors". Even if these lags are lower than 13 months (the cut-off period of the low-pass filter), the time series' periods close to 13 months could contribute to lower the correlations at zero lag. To test if this may have affected the results of the H-SST network (13months low-pass filter), the degree, communities and correlations of the communities to the indices of global temperatures are calculated for 1 month lags (Fig. 1 and Table 1), 3 months lags (Fig. 2 and Table 2) and 6 months lags (Fig. 3 and Table 3).

The in-degree is the sum of the links pointing to a given node. The out-degree, the sum of the links pointing outward a given node. The symmetric degree the sum of both the in-degree and the out-degree divided by 2 (i.e. the degree of the symmetrized adjacency matrix). We can see that the degree centrality and the main communities for any lags (Fig. 1, 2 and 3) are similar to the zero lag case. The comparison of the in and out-degree centralities confirms that the tropical pacific variability leads the extra-tropical, Indian and Atlantic variability.

Regarding the limitation to 50 degree South, we decided not to go further South simply because of the lack of in-situ observations in the HadISST (coming from the HadSST2 dataset which is based on ICOADS), in particular before 1950, as you can see Fig. 4 a) and b) below. In our point of view, this argument is sufficient and this limitation should be accepted. This limitation can be seen Fig. 3 in Deser (2010, "Sea Surface Temperature Variability: Patterns and Mechanisms"). Thus, this article will be cited in revision to support our choice to limit our analysis to North of 50 degree South.

2. *Please re-write the abstract to reflect the findings of the paper in the language that most earth system modelers, who know nothing about network theory and page ranks, can understand. For example, the thoughts on lines 16 to 19, page 759, should be reflected in the abstract.*

   The abstract will be modified in revision to:
   ”On interannual-to-multidecadal time scales variability in sea surface temperature appears to be organized in large-scale spatiotemporal patterns. In this paper, we investigate these patterns by studying the community structure of interaction networks constructed from sea surface temperature observations. Much of the community structure can be interpreted using known dominant patterns of variability, such as the El Niño/Southern Oscillation and the Atlantic Multidecadal Oscillation. The community detection method allows to bypass some shortcomings of Empirical Orthogonal Function analysis or composite analysis and can provide additional information with respect to these classical analysis tools. Secondly, the study of the relationship between the communities and indices of global surface temperature shows that, while El Niño/Southern Oscillation is most influent on interannual time scales, the Indian-West Pacific and North Atlantic may also play a key role on decadal time scales. Finally, we show that the comparison of the community structure from simulations and observations can help detect model biases.”

3. *Two recent important papers on the AMO and the AMOC should be cited. Srokosz et al., Past, present, and future changes in the Atlantic meridional overturning circulation, BAMS, 93, 1663–1676, 10.1175/BAMSD-11-00151.1, 2012 provide a nice overview of how North Atlantic temperatures may serve as a proxy for variations in the strength of the AMOC. The submitted paper lacks any physical discussion of the AMOC: this should be added upon revision, with*

a reference to Srokosz et al. (2012) or perhaps to Srokosz et al. (2012) and references therein. Canty et al., An empirical model of global climate – Part 1: A critical evaluation of volcanic cooling, ACP, 13, 3997–4031, doi:10.5194/acp-13-3997-2013, 2013 was published (18 April 2013) before Muller et al. (2013) was even submitted (22 April 2013). Canty et al. (2013) (their Figure 9 and related discussion) showed "that the variability of global land surface temperatures (GLST) is strongly connected to the AMO". This paper must be cited on lines 10 to 12 of page 745, and perhaps elsewhere. Indeed, even though the manner of presentation of the submitted paper is starkly different than the presentation in Canty et al., it seems these two papers reach rather similar conclusions for the analyses that overlap.

The suggested papers will be cited and shortly discussed in the revised version. Also the Srokosz et al. paper will be used to introduce the possible connection between the AMO and AMOC variability.

4. *The phrase "qualitatively identical" on page 747 is an oxymoron. Please consider different wording.*

   Will be modified in revision by:
   "Qualitatively similar"

5. *Figure 4 is first mentioned on line 13, page 753. At this stage, however, Figure 3 has not yet been referenced. I assume ESDD expects figure numbers to reflect the order of reference in the paper.*

   Figures will be reordered in revision.

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6. *For the record, I doubt the statement on page 758 "Also, the phase synchronization of the time series of both communities has contributed, to a large extend, to the increase in GMST since the 1970s" would survive serious scientific scrutiny because the analysis appears to be conducted entirely using linear detrending of the various time series. Yikes! The radiative forcing of climate due to rising GHGs and anthropogenic aerosols has not been linear except for very short time periods. Ideally, this entire analysis should be repeated using a proxy for anthropogenic RF of climate to detrend the various data sets, rather than a linear term, as has been done in several studies including the above mentioned Canty et al. paper. I am not however actually suggesting the detrending be handled differently at this stage, as this would be a timely prohibitive suggestion. I am however stating, for the ESDD record, skepticism about this sentence.*

The last paragraph of section 4.1 will be modified modified, also to address suggestions of Referee #1, to:
"Fig. 7 represents the linear regressions against the GMST and GLST indices of the time series of the IWP community (#2), the NA community (#3) and of the bivariate time series of the IWP and NA communities (multiple-regression) in a least-square sense. The bivariate fits to the GMST and GLST result in coefficients of multiple-determination (a measure of how much the fitted time series determine the original time series, von Storch and Zwiers, 1999b) of 0.87 and 0.66, respectively. This shows that the patterns of both communities can, together, statistically explain most of the decadal variability of the GMST and the largest part of the decadal variability of the GLST. Using 365 the ENSO time series does not significantly improve the fits. However, this analysis is only statistical and no causality between the time series of the communities and the indices can be stated. Also, the increase in GMST since the 1970s may

be explained by the phase synchronization of the time series of the IWP and NA communities, although, once again, the increase of both this index and the time series of the communities could also arise from other factors such as an increased radiative forcing (Fig. 7)."

7. *Line 3 of page 759 ends "to the GLST". Is this correct ?!? I think perhaps GOST is what was meant.*

   Will no longer appear in revision.

8. *The phrase "are orphan" appears on page 759. I do not know that this phrase means in a scientific context: please consider different wording.*

   "orphan" will be modified by "unassigned", also in figures.

9. *Lines 6 to 10 of page 762 state "First, the maximum cross-correlation..." Would be helpful if a figure supporting this sentence could be added, either to main or a brief supplement.*

   Fig. 5 below supports this results and will be referred to in the revision.

10. *Line 3, page 767, "Muller, R. a." should be "Muller, R. A."*

   Will be corrected in revision.

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11. *The tables would be easier to understand if the names of the first few communities could be given in the words that appear above each table.*

Will be corrected in revision.

12. *Unless "orphans" is common terminology in the networking literature, I suggest using another word such as "unassigned" for the caption of Figure 2.*

"orphan" will be modified by "unassigned", also in figures.

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Table 1: month lagged correlations between the mean time series of the communities of the H-SST network (leading) and the indices of mean, land and ocean surface temperatures (all time series 1y low-pass filtered).

#	GMST	GLST	GOST
1 - ENSO	0.67161678	0.45589982	0.70926222
2 - NA	0.57248614	0.4233938	0.57519615
3 - IWP	0.45940515	0.41284102	0.40564595
4	0.41068169	0.21874071	0.45466412
5	0.41009885	0.2940669	0.41575881
6	0.24066926	0.09759924	0.29333672
7	0.26109901	0.10244507	0.32830994
8	0.22085852	0.17480195	0.21005715
9	0.12315437	0.06085132	0.14000618
10	0.28264313	0.07256433	0.36307722

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Table 2: 3 months lagged correlations between the mean time series of the communities of the H-SST network (leading) and the indices of mean, land and ocean surface temperatures (all time series 1y low-pass filtered).

#	GMST	GLST	GOST
1 - ENSO	0.66249889	0.48015901	0.67741634
2 - NA	0.53068653	0.40353910	0.5250237
3 - IWP	0.38365722	0.36012528	0.32531346
4	0.41361743	0.22213375	0.45593627
5	0.36530452	0.27236820	0.36326893
6	0.22427549	0.07929348	0.28126405
7	0.26732102	0.10066790	0.33860070
8	0.22836062	0.18774839	0.21299816
9	0.09113784	0.04500302	0.10052892
10	0.29752819	0.07440657	0.38412518

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Table 3: 6 months lagged correlations between the mean time series of the communities of the H-SST network (leading) and the indices of mean, land and ocean surface temperatures (all time series 1y low-pass filtered).

#	GMST	GLST	GOST
1 - ENSO	0.58499060	0.47340240	0.56141456]
2 - NA	0.45401349	0.35178805	0.44361628
3 - IWP	0.30310963	0.28703733	0.25190319
4	0.41424104	0.22254897	0.45538058
5	0.26013804	0.21043949	0.24532924
6	0.20877611	0.07365488	0.26104321
7	0.28324762	0.12736901	0.34409639
8	0.22254048	0.18827413	0.20365027
9	0.05572406	0.02357534	0.05846505
10	0.31325264	0.09646040	0.39132391

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