

Interactive comment on “Coherence among the Northern Hemisphere land, cryosphere, and ocean responses to natural variability and anthropogenic forcing during the satellite era” by A. Gonsamo et al.

Anonymous Referee #2

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In this paper, the authors selected a lot of indicators of land, cryosphere and ocean from different observational datasets to assess their changes over time, in particular focusing on interannual variability. They also analyzed the relationships with each other to show how different components of earth's climate system are responding to forcings and attributed these observed changes to natural variability and anthropogenic forcings.

Major comments: The authors attempted to provide a comprehensive assessment of current changes in climate system, which is kind of a mini version IPCC report. Overall

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this is really a big topic because almost each part can be an individual research field. In this case, it is understandable that the analysis for each part cannot go very deep. I just have a feeling that the authors put much stuff in the paper but I am so sure what is actually “new” out of the results. Because for all changes detected, there are numerous related papers from those specialized fields that not only detected such change but also studied the mechanisms. So the authors really have to make it clear and emphasize what is new in this paper compared with other similar research, which is something I didn't get so far after reading it.

I don't quite understand the rationale for these particular indicators chosen in this study. Why it has to be these indicators instead of others to represent land, cryosphere and ocean, as well as the forcings? Any strong reasons for these indicators? And how well are they in representing land, cryosphere and ocean? The authors need to explain their considerations when choosing these indicators. To me some variables are not very relevant. For example, it seems cosmic ray doesn't really matter to climate change, and I didn't see any benefits of including Stratospheric Aerosol Optical Thickness in the analysis. For land, I think there are many more important indicators like extreme events, precipitation, vegetation productivity, and hydrology variables that need to be evaluated but are missing here. For phenology, the authors only use few variables to reflect the spring phenology, while summer and autumn phenology are not included. These questions again are related to the authors' motivation and purpose.

There are many terms or categories used in the paper relating to the selected variables but have never been defined explicitly. Since there are 15+ variables in the paper, so without clearly defined, it may cause some confusions especially when the authors refer to something like “forcing and response variables” “natural variability and anthropogenic forcing variables” and “teleconnection variables”. In many cases, I don't know what exactly these terms indicate to.

The overall presentation needs to be improved before publication. One problem is that figures and tables are not well integrated into the text. The table and figures are very

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informative but it seems a lot of information has not been conveyed effectively into text. For example, there isn't much discussion about Figure 3 in the text. Tables and figures are complex with lots of numbers and curves, so the meanings are not easy to interpret directly. And because of this, in many cases, I got lost when the authors refer a sentence to a figure. When I look back at the figure/table, I don't know from where the authors' statement gets its support. One solution is to explicitly describe the key features or patterns in table/figure and directly referring them in the text.

Minor comments:

P2 L2-4: Hasn't the IPCC report provided enough quantitative evidence to attribute observed change to human and natural forcings? For future climate projection, the differences among models are substantial, but models do pretty well in simulating historical changes. I have seen a lot of attribution studies so from my perspective they are not rare. Maybe the authors should be more specific on this point.

L16 and L17: What aspects of human and natural systems have these studies looked at in regard to the climate change impacts? It is better to provide direct information or a summary from these papers, because listing only the author names has very little practical meanings to readers.

L30-33: Please explain how the variations in solar radiation and cosmic rays can influence global climate trends.

P3 L12-17: What are the considerations for choosing these particular indicators rather than many alternative indicators? For example, for land indicators, any particular reasons for not including vegetation greenness or productivity? And for phenology, why only spring is included?

Since the title is about coherence, does that mean any indicators that exhibit inconsistent response among land, cryosphere, and ocean responses are naturally excluded in the analysis? What about these inconsistencies?

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For section 2, it is better to have a summary table including all these variables, their categories, with additional information (e.g., gridded or station data, sources, time span, etc.). When introducing each variable in the text, group them into proper category that is consistent in the following content, such as land, ice, ocean, response, forcing, natural or anthropogenic factors.

L20: Please point out the location of Point Barrow since not everyone is familiar with this place. Also for Kiel station. Giving their latitude and longitude would be enough.

L27: Please define satellite era.

L31: Missing reference for SSM/I data? Every dataset needs to come with a source.

P4 L10: Why only use the flower bloom day of Canada? Phenology has quite large regional difference. I am not sure if the flower bloom day of Canada is a suitable indicator for the entire northern hemisphere. How many stations are there and what is their spatial coverage?

L29: Undefined acronym TOPEX, VIRGO, SOHO, ACRIM.

L23-29: What is the spatial coverage of RAD?

P6 L15: Why anomalies are calculated only for winter and why trends are removed here?

Table 1: I felt Table 1 is difficult to understand. Perhaps Table 1 can be reorganized in a way that variables are grouped into response and forcing variables, or other meaningful categories. I don't understand what different shades actually mean here. Adding a new row and a column to specify the name of each category is helpful. Also, I don't understand how the number in italic bold font represents both long-term and interannual co-variability. Some of correlations make very little physical sense. For example, it shows 63% interannual variability of temperature can be explained by spring thaw, while 29% interannual variability of spring thaw can be explained by temperature. Even 63% is higher, but it has little physical meaning because we know it is temperature vari-

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ability that drives spring thaw but not the opposite.

For analysis section in P7: How did the datasets with different temporal periods treated in the correlation analysis of interannual variability and trends, by using the overlapping period?

P7 L5: Have the response and forcing variables here clearly defined earlier in the manuscript?

L15-17: How many PCAs are selected? Maybe Table 2 should be referred here.

L24-25 I don't understand the meaning of "temperature mediation"? This has been frequently mentioned in the paper but I didn't see any explanations prior its appearance.

P8 L3: Such four categories should be defined or mentioned earlier in dataset sections.

L12: It obvious that both RF of WMGHG (steady rise) and temperature (with fluctuation) increased through time (1980-2010), I don't understand where the "highly correlated" come from.

L21-25: Which exact number in Table 1 is referred to support "significantly correlated" in this sentence "ST and SOS are also significantly correlated with temperature after data detrending (Table 1) indicating both long-term and interannual covariability ($p < 0.01$)". Because there are two sets of numbers: A explained by B and B explained by A, I don't know which one of them is the case here. According to Table 1, there is no significant correlation between FEB and T, but in figure 2(b) they show some kind of co-variability. Why do these two places show inconsistency with each other?

Table 2: Please add full name of each variable. It is very hard to remember these acronyms since too many of them are contained in the paper.

L30-31: I don't know how this statement comes out of Table 2. And again, what is the temperature mediation? Without explaining this term in the beginning, I cannot quite follow the rest of this paragraph.

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Figure 4. It seems the growing season annually integrated normalized difference vegetation index (NDVI) appears here but is not chosen as an indicator. Why is that? Table 2: Please clearly define land, cryosphere and ocean "indicators", and natural variability and anthropogenic forcing "variables" throughout the paper. It is unclear from the table that which variable belongs to what category, especially when they are referred in the text. P11 L13: I suggest listing the "several explanations" one by one (first, second. . .) for clarity. L26: By what criteria these variables grouped into three sets are considered to be coherent for their interannual pattern?

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