Nat. Hazards Earth Syst. Sci. Discuss., 2, C2043–C2056, 2014
www.nat-hazards-earth-syst-sci-discuss.net/2/C2043/2014/

Natural Hazards and Earth System Sciences
Discussions

Interactive comment on "Spatial and seasonal responses of precipitation in the Ganges and Brahmaputra river basins to ENSO and Indian Ocean dipole modes: implications for flooding and drought" *by* M. S. Pervez and G. M. Henebry

M. S. Pervez and G. M. Henebry

spervez@usgs.gov

Received and published: 11 September 2014

The manuscript assesses precipitation responses over two of India's major river basins in relation to ENSO and IOD. While the research is topical and has the potential to provide novel insights into Indian hydroclimate with societal implications, several major areas of concern need to be addressed before this paper may become acceptable for publication. In particular, the manuscript is overly descriptive, not very well written, with unspecific and vague language throughout. Further details for the data/methods

need to be provided, statistical robustness of the results addressed, and results need to bebetter embedded in existing literature. More detailed comments are given below.

The following represent major areas of concern: (1) The introduction is very short; as such, it ignores many relevant studies and does not provide the necessary background for the present study. A selection of additional literature is provided below. The new findings throughout the text also need to be better embedded and discussed in light of existing studies.

Response: We have collected the mentioned articles and reviewed them. We agree the articles will contribute significantly to improve not only the introduction section, but also the entire manuscript as a whole. We are in the process of rewriting the entire manuscript after re-doing the analysis with longer period time series data.

(2) The description throughout the manuscript is vague and unspecific. Please revise the text to be more specific and scientific.

Response: We are in the process of revising the entire manuscript as per suggestions and recommendations.

(3) The manuscript is overly descriptive and does not attempt to link the results in a dynamic/mechanistic way. Please consider including a discussion of the dynamics that might give rise to the precipitation responses you observe.

Response: We are addressing the mechanisms of the ENSO and IOD in terms of atmospheric circulations and associated observed changes in precipitation in the Ganges and Brahmaputra basins.

(4) Data and methods section needs to be considerably expanded to include the following:

Response: We are rewriting the entire method and data used section.

(a) ENSO/IOD classification: more detailed description of classification method used;

how does this compare to existing classifications (eg, Meyers et al 2007, Yamagata et al 2004)? What definition is used for an ENSO event?

Response: Agreed, we have revised the classification based on the method of Meyers et al., 2007 and are explaining the process in details in the method section.

(b) What SST data is used? What regions are chosen for the two DMI? (c) Include a better justification for the use of the very short daily precipitation station data, when considerably longer, high-quality data exists (IITM, Rajeevan et al 2006). It is strongly recommended to redo the analyses over a longer period. In particular as all analyses shown seem to be based on monthly means, it is unclear why the AISM data set has not been used.

Response: We understand your concern. We agreed, we needed to do the analysis for much longer time period. We have decided to re-run our analysis using much longer time-series precipitation and SST dataset. We have identified Global Precipitation Climatology Center (GPCC) version 6.0 data at 0.5°x0.5° resolution for precipitation, and Kaplan et al., 1998; Reynolds et al., 2002; Trenberth, 1997 for Pacific Ocean, and HadISS 1.1 for SST data over the Pacific and Indian Oceans. We have extended our analysis period from 1901 to 2010 (110 years). The GPCC is a well-studied and validated global observed precipitation data set. the GPCC as well as other SST data sets are publicly available in required format for the re-analysis. Your suggested (Rajeevan et al., 2006) precipitation data set is only for India and at 1°x1° resolution. Since the study basins include areas in China, Nepal, Bhutan, and Bangladesh in addition to India, we have decided to use GPCC to cover the entire study area.

(d) Where does the drought/flooding information come from? Please include an additional section in data/methods that describes this data set. How is flooding/drought defined? Please show the spatial extent and duration for these flooding/drought events. Specific comments

Response: We are citing for flooding and drought information that we are using in

our analysis. Here are some articles for example the provides flooding and drought information in this region: Webster et al., 2010; Hofer & Messerli, 2006; Mirza et al., 2001; Siddique et al., 1991. However, we understand that showing the spatial extents of all these flooding and drought events will be helpful, but including them in the article will yield too many maps therefore may not be feasible.

- p.1, L16: Which dipole modes are meant here?

Response: Both the positive and negative modes of the IOD

- p.1, L19: The occurrence is La Nina and positive IOD is very rare (see Meyers et al. 2007); in light of this, the results might not be representative.

Response: We agree, although we are using a longer study period (1901-2010), still the frequency of La Niña and positive dipole events are very rare (only 2 years out of 110). Therefore we are not deriving precipitation anomaly statistics (spatial and temporal) for this combination of the event as it will not be representative.

- p.1, L26: “Major flooding and drought” seems a contradiction, unless a “respectively” in L27 is missing?

Response: Yes, sentence will be revised.

- p. 2, intro: Please add more recent references to ENSO’s impact on Asian climate.

Response: Agree, we are rewriting the entire manuscript.

- p.2, L11: Insert “sea” before “surface temperature”.

Response: Thanks, we will correct that.

- p.2, L15: Specify that the 12% refer to interannual SST and/or what seasonal dependence this has.

Response: Summer: we are rewriting the entire manuscript.

- p.2, L17: One cannot ‘tune’ an IOD mode to the Ganges/Brahmaputra basin. Please

reword to clarify that you are trying to define an index that is strongly associated with regional precipitation.

Response: Agreed, in the current analysis, we are using conventional IOD index computed as the difference between averaged zonal western and eastern tropical Indian Ocean. We are using 50° E-70° E, 10° S-10° N as western zone and 90° E-110° E, 10° S-Equator as eastern zone defined by Saji et al., 1999 for the IOD index. Unlike the previous analysis, the same IOD index will be used in this re-analysis for both basins.

- p.2, L19: Please be specific what regional extent is used for these indices.

Response: We are using 50° E-70° E, 10° S-10° N as western zone and 90° E-110° E, 10° S-Equator as eastern zone defined by Saji et al., 1999 for the IOD index.

- p.2, L23: Rather than referring to the index, ie. DMI, you should refer to the mode here (as you are doing for ENSO).

Response: We will make changes accordingly.

- p.2, L24: Please refer to the specific IPCC chapter here that details these findings. Also refer to Cai et al. 2013.

Response: Agree, we will do so

- p.3, L2: Please refer to the specific IPCC chapter here.

Response: Agree, will be added while review.

- p.3, L2: The introduction is very short and does not do justice to existing literature on the topic, nor does it provide the necessary background for the study. Please expand the discussion on the following topics: projected changes in the monsoon, ENSO, IOD. While not exhaustive, some additional references are listed below.

Response: We are rewriting the entire manuscript.

- p.3, L3: Reword to ": : : each river basin: : :".

Response: Agree, we will correct that.

- p.3, L13: Should be "India".

Response: Yes, will be corrected.

- p.3, L18: Should be "resource: : : population who rely on: : :".

Response: Yes, will be corrected.

- p.3, L21: Please include "respectively" at the end of the sentence.

Response: We will revise the sentence.

- p.3, L24: Actually, it is not possible to see this in Figure 1. Suggest revising the metric shown in Figure 1 to conclusively demonstrate this.

Response: We will revise the map in figure 1.

- p.3, L29: Should be "under a changing".

Response: Yes, we will add "a" before "changing"

- p.4, L3-5: Why choose this set of precipitation records for this study? The short period 1982-2010 severely limits the confidence in the results presented here. It is strongly recommended to redo the analysis with longer records available (eg IITM data or Rajeevan et al 2006).

Response: Agreed, we are redoing the analysis using GPCC precipitation data over 110 years (1901-2010) period. We are using GPCC because, unlike Rajeevan et al., 2006 data set, it is available for China, Nepal, Bhutan, and Bangladesh, and has better spatial resolution (0.5°x0.5°).

- p.4. methods/data: considerably expand the description of this section, as detailed in main comments above.

Response: We are rewriting the entire manuscript.

- p.4, L25-26: Why distinguish between two different types of IOD when lumping results together afterward? Please show results separately for the different types.

Response: In our re-analysis, we are using the same conventional IOD events for both basins.

- p.5, L4-7: This sentence does not make sense and is contradictory.

Response: We will revise the sentence.

- p.5, L7: Should this not be “intensive”, rather than extensive?

Response: Agree, we will change it to “intensive”

- p.5, L15-17: Wrong cause-and-effect: changes in OLR do not cause variations in convection; reword; similar applies to Walker circulation changes.

Response: We will revise the section.

- p.5, L16: How these results are linked to the Hadley circulation here are unclear.

Response: We are revising the discussion according to re-analysis results.

- p.5, L18-19: Again, why distinguish two different types of IOD when lumping results together? Show separately.

Response: We are using the same IOD events for both basins, we are not distinguishing IOD separately for these two basins in the re-analysis.

- p.5, L22-23: “: : : increased precipitation was relatively less: : :” – reword to clarify meaning.

Response: We will revise the sentence.

- p.5, L28: Again, OLR does not cause changes in clouds – it is a metric to measure presence of clouds.

Response: We will revise the sentence.

- p.6, L8-10: The results seem to indicate average conditions. Please indicate significance.

Response: In the re-analysis, we are using Monte Carlo simulations and two-tailed t test to define significance. We are revising the statement accordingly. To see the preliminary re-analysis results, please refer to the new figures we have added in the author response section.

- p.7, first para: This section is very hard to follow, as it is unclear when Figure 3 and Figure 4 are discussed. Please restructure to be more coherent. Consider also to only discuss significant results. The majority of ENSO/IOD combinations do not indicate significant deviations in precipitation from average conditions for the two ocean basins.

Response: We are rewriting the entire manuscript.

- p.7, L7-8: What is a “cycle of dry conditions” and “below the expected mean of dry conditions”?

Response: We will revise the statement according to the results of re-analysis

- p.7, L17: Reword to “for neutral ENSO conditions”.

Response: We will correct that.

- p.7, L29: Figure 4 does show significant precipitation changes. Please correct text.
Response: We will correct the statement.

- p.8, Section 4.3: This whole section needs to be more quantitative; in its present state it is very anecdotal and arbitrary. Please conduct a detailed statistical analysis that demonstrates that there are indeed significant changes in drought and flood incidence.

Response: We agreed: we are using Monte Carlo simulations and two-tailed t test to identify the spatial and temporal anomalies with statistical significance. Please refer to the attached figures to view an example.

- p.9, L10: Provide specific chapter.

Response: We will revise the sentence and citation.

Table/Figures - Table 3: Where does the drought/flooding information come from? Please include an additional section in data/methods that describes this data set. How is flooding/drought defined? Please show the spatial extent and duration for these flooding/drought events.

Response: We have extended the table for 110 years and citing the sources of information for this table.

- Figure 1: The metric mm/day is not helpful, given the large seasonality. Only show monsoon precipitation or standard deviation of precipitation to indicate key regions. 1982-2010 is an odd period to choose for climatology.

Response: We made change in the unit of Figure 1 to mm per month. Now we are using 1951-2000 as the climatology for GPCC precipitation.

- Figure 2: Which DMI is shown, E-W or N-S? Why introduce separate types, if the results are not shown separately?

Response: Agree, in the re-analysis we are using the same conventional IOD index for both basins.

- Figure 2: Indicate where precipitation anomalies are significant. Without significance levels, anomalies are not useful.

Response: Agreed, we are using a Monte Carlo simulation and a two-tailed t test to show the significance of the anomalies both spatially and temporally. Please refer to the attached figures for an example.

- Figure 2: What months do the precipitation anomalies refer to?

Response: July to October

- Figures 2-4: Please indicate for each subplot how many years each entails.

Response: Agreed, we have added them on the upper right corner of the each plot. Please refer to the attached figures for example.

Additional references to be included

Response: We have already collected and reviewed these articles. We than the reviewer for the suggestions and comments, we believe addressing these comments will significantly improve the re-analysis and the manuscript.

- Cai et al. 2013: Projected response of the Indian Ocean Dipole to greenhouse warming. Nature Geoscience, 6, 999-1007. - Du et al. 2013: A New Type of the Indian Ocean Dipole since the Mid-1970s. J. Climate, 26, 959-972. - Meyers et al. 2007: The Years of El Niño, La Niña, and Interactions with the Tropical Indian Ocean. J. Climate, 20, 2872–2880. - Rajeevan et al 2006: High resolution daily gridded rainfall data for the Indian region: Analysis of break and active monsoon spells. Current Science, 91 - Saji & Yamagata 2003: Possible impacts of Indian Ocean Dipole mode events on global climate. Climate Res, 25, 151-169. - Schott et al. 2009: Indian Ocean variability and climate variability. Rev. Geophys., 47, RG1002, doi:10.1029/2007RG000245. - Ummenhofer et al. 2011: Multi-decadal modulation of the El Niño-Indian monsoon relationship by Indian Ocean variability. Environmental Research Letters, 6, 034006 - Weller & Cai 2014: Meridional variability of atmospheric convection associated with the Indian Ocean Dipole Mode. Scientific Reports, 4, DOI:10.1038/srep03590 - Yamagata et al 2004: Coupled ocean–atmosphere variability in the tropical Indian Ocean. Ocean–Atmosphere Interaction and Climate Variability. Geophys. Monogr., Vol. 147, Amer. Geophys. Union, 189–212. Interactive comment on Nat. Hazards Earth Syst. Sci. Discuss., 2, 1671, 2014.

Interactive comment on Nat. Hazards Earth Syst. Sci. Discuss., 2, 1671, 2014.

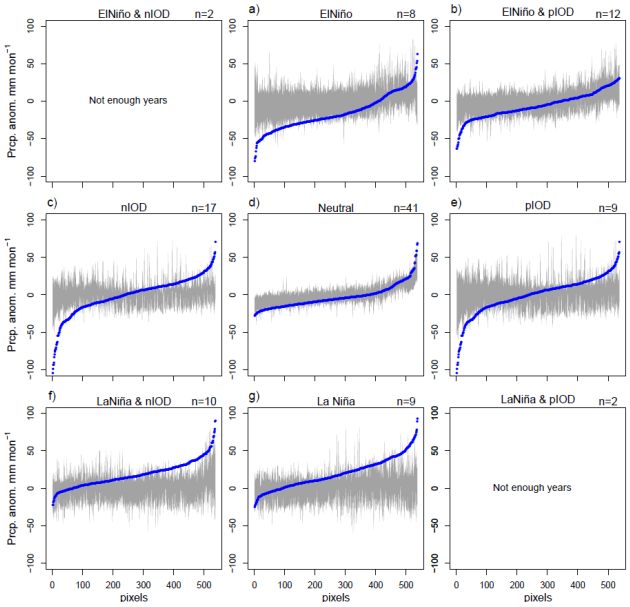

Figure 2: Composite of the mean precipitation anomaly for June through October for each pixel in the basins when El Niño, La Niña, and positive or negative IOD occurred, co-occurred, or did not develop. The number of observed years for each ENSO-IOD combination is indicated with *n*. Combination specific precipitation anomalies (mm mon-1) are shown with blue dots; long-term mean anomalies are shown with a black line and its 10% and 80% lower and upper bounds as determined by Monte Carlo testing, and a two-tailed t test at 80% confidence level is shown with gray shading. Where the blue dots lie outside the gray shaded area, the values are significantly different from the long-term variance.

Fig. 1.

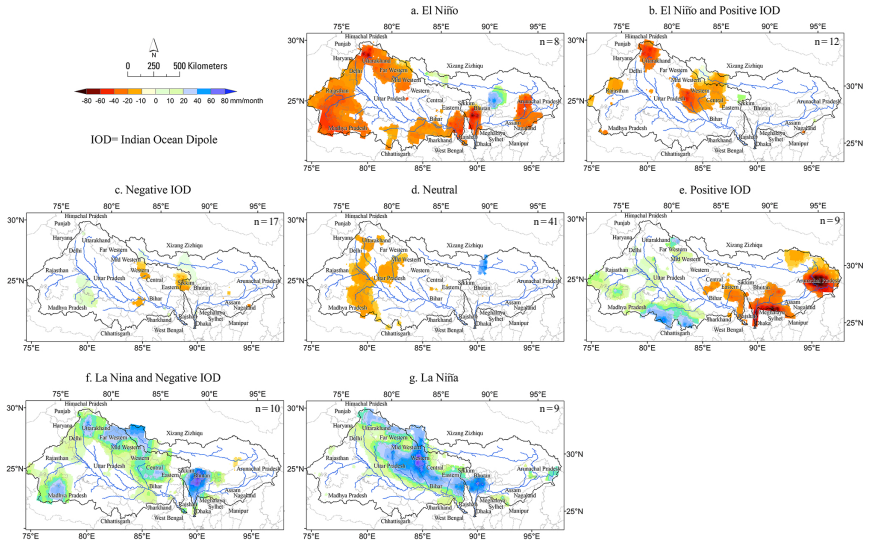

Figure 3. Composite of the spatially distributed June through October total precipitation anomalies (mm) in occurrence, co-occurrence, or absence of El Niño, La Niña, and positive or negative IOD categories with the number of observed years (n) in each category indicated. Only anomalies are shown that are significantly different from the long-term variance as determined by Monte Carlo testing and two-tailed t test at 80% confidence level.

Fig. 2.

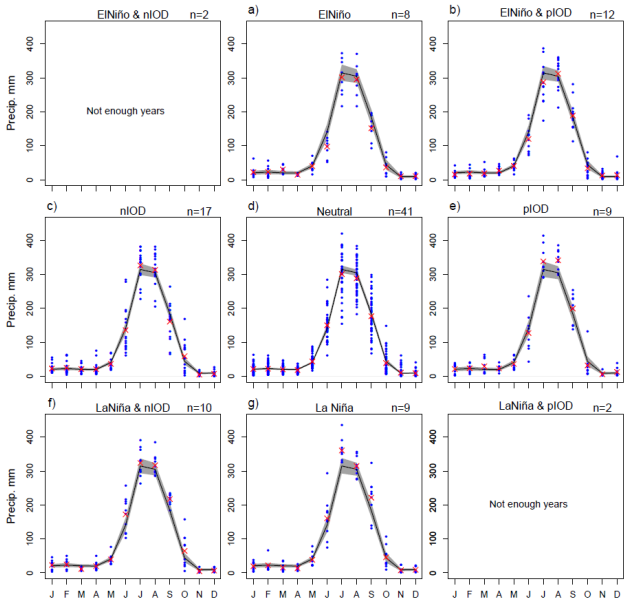

Figure 4. Composite of the Ganges basin precipitation (mm) by month when El Niño, La Niña, and positive or negative IOD occurred, co-occurred, or did not develop. The number of observed years for each ENSO-IOD combination is indicated with *n*. The seasonal cycle from January to December is shown for the period 1901–2010. The black line is the mean of all years (1901–2010). Within each combination, observed years (n) are shown with blue dots; the red x is the mean of the observed years, and its confidence levels are shown with gray shading as determined by Monte Carlo testing and a two-tailed t test at 80% confidence interval. Where the read x lies outside the gray shaded area, the values are significantly different from the long-term variance of that month.

Fig. 3.

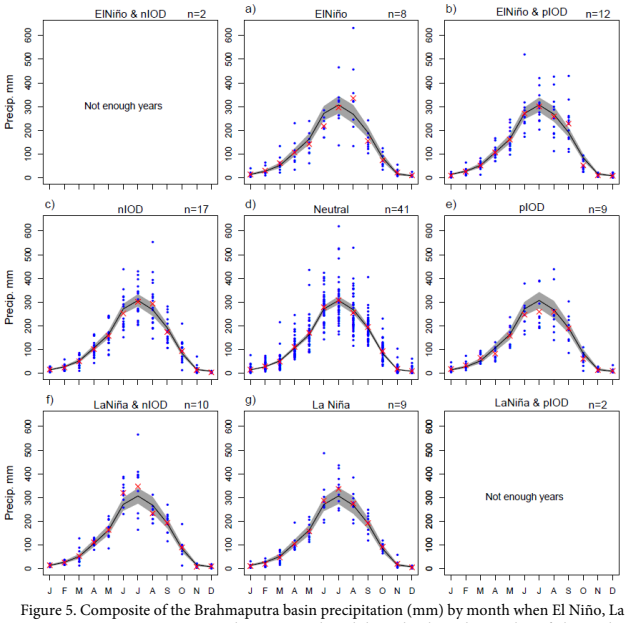

Figure 5. Composite of the Brahmaputra basin precipitation (mm) by month when El Niño, La Niña, and positive or negative IOD occurred, co-occurred, or did not develop. The number of observed years for each ENSO-IOD combination is indicated with . The seasonal cycle from January to December is shown for the period 1901–2010. The black line is the mean of all years (1901–2010). Within each combination, observed years (n) are shown with blue dots; the red x is the mean of the observed years, and its confidence levels are shown with gray shading as determined by Monte Carlo testing and a two-tailed t test at 80% confidence interval. Where the read x lies outside the gray shaded area, the values are significantly different from the long-term variance of that month.

Fig. 4.