Earth Syst. Dynam. Discuss.,
doi:10.5194/esd-2016-19-RC2, 2016

Earth System Dynamics Discussions

Interactive comment on "Hemispherically asymmetric volcanic forcing of tropical hydroclimate and water isotopologue variability during the last millennium" *by* C. M. Colose et al.

Anonymous Referee #2

Received and published: 13 June 2016

Recommendation: Accept after minor revisions

Summary: The manuscript evaluates the tropical hydroclimate response to volcanic forcing, through analysis of the CESM and GISS-E2 last millennium simulations. Volcanic events are binned into one of three different categories, based on the spatial distribution of the aerosol loading. Changes in tropical precipitation are evaluated for each volcanic event type (i.e. NH, SH, or symmetric) and each model. Changes in δ18Oprecip are also evaluated for the isotope-enabled GISS-E2 runs. Changes in river discharge are reported. Various metrics of the ITCZ shift are evaluated and compared to changes in the atmospheric energy budget. The authors conclude that in response to greater forcing by volcanic aerosols in one hemisphere, the ITCZ shifts away from

the preferentially-forced hemisphere, resulting in large-scale depletion (enrichment) in the isotopic composition of tropical rainfall in the hemisphere the ITCZ moves towards (away from). The authors find that the zonal mean ITCZ shift is tightly coupled to the change in cross equatorial energy transport and the change in the energy flux equator, with the sensitivity of the ITCZ response to hemispherically asymmetric forcing highly dependent on the metric of ITCZ shift that is used. The authors conclude that the distribution of volcanic aerosols is critical for evaluating the hydroclimate response of volcanic forcing in paleoclimate data and models.

I recommend acceptance of this manuscript after minor revisions. The subject of the manuscript addresses relevant scientific questions that are within the scope of ESD. The concept of a tropical precipitation response to hemispherically asymmetric forcing has been well-documented, but in this manuscript is comprehensively applied to simulations of volcanic forcing in a manner that has not been previously reported. In addition, the analysis of the isotopic response of precipitation to volcanic forcing is novel. The authors give proper credit to prior relevant work while highlighting their own original contributions. The number and content of the figures is appropriate, the writing is clear, concise, and well-organized, and the conclusions are substantial and well supported by the results. The scientific methods are valid and clearly outlined. Some additional description and discussion of the relationship between the precipitation changes and the changes in the atmospheric energy budget is warranted. Specific revisions are suggested below.

Specific Comments:

Line 29-30: Revise "the isotopic composition of the ITCZ" to "the isotopic composition of precipitation in the ITCZ".

Line 33-35: Revise the final sentence of the abstract ("...for the testing of models against paleoclimate evidence.") to be more specific.

Line 75 (and elsewhere): Revise reference "Adam et al., 2016, in press" to "Adam et

al., 2016".

Line 87: Remove semi-colon before references.

Line 89: Add "in" between "asymmetries" and "the".

Line 189-190: Are the previous five seasons or five years used as a reference period? Both are mentioned.

Line 268: Remove "that these results are consistent with", as it is unnecessary and diminishes the clarity of the sentence.

Line 281: "... the ITCZ shift... may result in..." May result in or does result in? Has this been specifically evaluated in your analysis?

Line 282-283: Rephrase "...since the precipitation signal is strongest moving with the ITCZ". Unclear what is meant here.

Line 291: Rephrase "... and therefore we restrict the anomalous precipitation field to a single season" to "...and therefore we restrict the anomalous precipitation field to the same season".

Line 296-303: The reference to Fig. S8 is missing. I suggest revising or removing this paragraph, as it does not seem to add any new substantive information to the discussion.

Line 325: Replace "eruptions in Table 1, multiplied by 15 ensemble members" to "16 eruptions in Table 1, multiplied by 15 ensemble members".

Line 338: Suggest replacing "In addition" with "Consistent with the SST anomalies,"

Lines 341-344: Suggest replacing "we argue that the El Niño tendency in CESM is a forced response in ASYMMNH but otherwise depends on the state of internal variability concurrent with a given eruption. This explains why no such ENSO response is associated with..." with "we argue that the El Niño tendency in CESM is a forced response

in ASYMMNH but otherwise depends on the state of internal variability concurrent with a given eruption, as no such ENSO response is associated with..."

Lines 432: Rephrase or revise figure reference. Figure S5 shows that the NH-SH zonally precipitation asymmetry is correlated to the AOD gradient. It does not show a correlation between $\Delta(\delta 18Op)$ and ΔP.

Line 466-467 (Eqn 3): Derive this equation from first principles, or provide a description of how Eqn. 3 was derived (e.g. modify Eqn. 1 in Hwang and Frierson, GRL, 2010 to include the storage term).

Lines 523-527: Is this data shown? If not, state as such.

Lines 537-538: Unclear what is meant by "the anomalous precipitation response is still coherent". Rephrase to clarify.

Lines 552-553: Replace "regressing the different events in all three categories together" to "regressing the precipitation median against the AETeq for each eruption (after averaging over ensemble members)".

Lines 552-554: Cite which figure this data is taken from. Also add the equation of the regression lines and correlation coefficients in Fig. 9.

Lines 565-574: It is unclear how to interpret the representation of the ITCZ shift presented in Eqn. 7 (and the relationship between the ITCZ shift and AHTeq) without a theoretically-constrained N. It doesn't appear valid (or meaningful) to conclude that "energetically, it is quite easy to move the ITCZ", given that "the slope of the relationship between ITCZ location and AETeq may vary by a factor of 4-5 depending on the relationship used". Further explanation and discussion of this issue is needed here.

Lines 574-575: The final sentence in this paragraph seems abrupt and out of place. Consider adding a few sentences or a paragraph to summarize the findings of the energy budget analysis.

Line 687: Replace “to” with “in”.

Line 690: Replace “Results shown” with “Results are shown”.

Lines 693-694: Replace “N=the number of events used in each category, consistent with the number of listed events in Table 1 (multiplied by 15 for CESM and 3 for GISS-E2).” with “N=the number of events used in each category (consistent with the number of listed events in Table 1, multiplied by 15 ensemble members for CESM and 3 ensemble members for GISS-E2).”

Line 715: Replace “Ensemble/Eruption” with “Composite”

Lines 717-718: Replace “Lighter lines associated with the dry and latent components indicate the eruption spread, each averaged over 14 ensemble members.” with “Lighter lines represent individual eruptions, each averaged over 14 ensemble members.”

Figures

Fig. 2 and Fig. 4: Revise labels to be consistent with text. E.g. replace “North” and “South” with “ASYMMNH” and “ASYMMSH”.

Fig. 9: Plot ITCZ shift on same y-axis range for each subplot for visual clarity. Add 1:1 line to bottom left plot for visual clarity. Add equation of regression lines and correlation coefficients to upper subplots and bottom left subplot.

Interactive comment on Earth Syst. Dynam. Discuss., doi:10.5194/esd-2016-19, 2016.