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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 #1

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Review of Hemispherically asymmetric volcanic forcing of tropical hydroclimate and water isotopologue variability during the last millennium by C. M. Colose, A. N. Le Grande and M. Vuille

Recommendation: Accept with minor revisions

General comments: This paper investigates the influence of hemispheric asymmetries in volcanic forcing on the hydrological cycle in last millennium GCM runs, particularly focusing on shifts in the ITCZ and the energetics involved. It also examines the effect of volcanoes on d18O in precipitation, and on river flow. It concludes that these aerosol asymmetries are important, particularly through ITCZ shifts, and need to be taken into consideration in future studies. The paper is very well written, the analysis appears

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Discussion paper

sound and thorough, and the presentation of figures is good. ITCZ shifts in response to forcing is an emerging area of research. Focusing on the last millennium gives a much bigger sample of eruptions of differing aerosol distributions than the twentieth century allows, and the d18O results are novel and useful for paleo proxy studies. The response of rivers to eruptions is also a little studied area. The topic fits within the scope of ESD. Subject to the implementation of some minor corrections largely relating to clarity, the article is fit to publish in Earth System Dynamics.

Specific comments: Abstract- line 29: "The ITCZ shifts away from the hemisphere with greater forcing"- please specify that you mean greater NEGATIVE or VOLCANIC forcing.

Line 136- how many latitudinal bands does G08 use? Also line 144- could you add some more detail about the G08 dataset and how it was derived- e.g. ice core based? And more information about the aerosol transport model?

Line 140- "the impact of these smaller amplitude and slowly varying forcings is very small."- Did you test this, or is it speculation?

Line 154- is this at different levels in the stratosphere as well?

Line 157 "The stratospheric sulfate aerosol loadings given by G08 are a function of latitude, altitude and month"- What resolution is G08 both horizontally and vertically?

Line 175- How big is Pinatubo for comparison?

Line 184- is there any reason for using MJJAS and NDJFM for the warm and cold season rather than MJJASO and NDJFMA? I expect the results would be similar, but I'm just intrigued!

Lines 217-218 – "The G08 reconstructions used a simple transport model that does not allow for cross-equatorial aerosol transport" –I'm a bit confused as to what exactly this means and what the implications are- does it mean that if an eruption happens one side of the equator that none of the aerosols go to the other side?

Line 221- does this imply that Tambora has more aerosols in the NH than SH? Or that it is symmetrical. Can you be more specific?

Line 248 “In the ASYMMNH and SYMM results, the cooling peaks over the Eurasian and North American continents.” - But not in SYMM MJJAS

Line 250: Mid latitudes? or is it more high latitudes? Maybe mid to high latitudes?

Line 264: “suggesting AET away from the forced hemisphere” Do you mean towards?

Line 271: “after normalizing each event by a common global aerosol mass excursion, thereby accounting for differences in the average forcing among the different eruptions”. Maybe add a caveat that this doesn’t take into account things like coagulation of aerosols for bigger eruptions which tends to reduce climate effects for a given mass of aerosols (see Timmreck et al 2009), and assumes that the response pattern scales linearly. For ITCZ excursions, the end of the paper suggests that this is not the case for asymmetric forcing- the ITCZ moves more for a bigger forcing gradient between hemispheres.

Line 288- does this alignment error affect all/many eruptions in this dataset? Or is it just Laki?

Line 323- Maybe mention some more of the ENSO and volcano studies that have been done in the past- Whether or not volcanoes influence ENSO was certainly a bit of a controversial issue in the literature at one point. I am not totally up to date with the most recent studies though. Line 336- how big is a 0.5 °C El Nino anomaly compared to a typical El Nino event in the model? (e.g. a 1 standard deviation event?) Also, is it statistically significant?

Line 345- It might be helpful to remind the reader that Samalas is somewhere between NH and SYMM.

Line 364 “[rivers] are a useful variable in the context of monitoring since they integrate precipitation changes over time” – and space. I would have thought that rivers would

be more useful in integrating precipitation changes over space than over time?

Lines 371-393- I feel that these paragraphs disproportionately emphasise the regions where streamflow increases, when it actually decreases in a lot of areas. Can you make it more balanced? Line 383-384 In ASYMMSH, “the ITCZ moves northward, resulting in reduced river flux in the Amazon sector and increases in the Niger of central/western Africa” This is true for summer, but river flow decreases over the Niger in winter.

Line 407- is it worth mentioning that there are factors that affect d18O in the process of being incorporated into paleo archives from precipitation? Lines 426-417- could you outline briefly how the amount and temperature effects work and in which direction they affect d18O concentrations?

Line 455 “In regions where tropical South American precipitation does not exhibit very large changes, such in the NDJFM SYMM composites, temperature may explain much of the isotopic response, again consistent with findings in Colose et al. (2016).” Can you specify in which direction and how temperature affects the isotopic response?

Line 470-1:- are the arrows the right way round for the LW fluxes? They seem to be the opposite way round to the SW ones.

Line 509 “Moisture makes it more difficult for the tropical circulation to transport energy poleward”. How?

Figure comments

The size of some of the text on some figures is a bit small.

Figure 1: It would be nice to be able to see the absolute size of the volcanoes as well as the hemispheric contrast in aerosol loading- can you put in an extra time series? At the moment a perfectly symmetrical eruption will not show up at all. The overlap between the red and black lines also makes it difficult to see how big the black lines are in some cases. Also- what does FSNTC stand for?

Figure 2- I assume this is surface temperature? (Rather than temperature at a different level in the atmosphere?)

Figure 8 panel a- the legend is a bit small. Panels b and c- The colour of the thin lines is confusing because they are not that similar to their corresponding thick line- e.g. the thin orange lines look like they go with total AET rather than the dry component. Also- what depth of ocean is this for? All of it? And: "Grey envelope corresponds to the total AET anomaly vs. latitude in a control simulation using 50 realizations of a composite formed from the same dates as the ASYMMNH results"- I am not sure I entirely understand what you mean by this- are there 50 control runs? If there is only one control run, how are there 50 realisations if the same dates are used each time?

Figure 9: Could panels a and b be on the same scales to make them more obviously comparable?

Supplement figure S7- You don't mention what the box is showing.

Technical corrections: Line 226- you have missed Iles and Hegerl 2015 off the reference list at the end.

Line 454 – "such >AS< in the NDJFM SYMM composites"

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