Review of Khosrawi et al

September 9, 2021

This paper documents the improvements in the simulation of meteorological fields in the tropics through the assimilation of synthetic isotopic observations. The added value compared to Toride et al 2020, a previous paper by the same group, is not clear (major comment 1.1). The paper is long, giving the impression of new information compared to Toride et al, but this is because the paper includes many paragraphs that are not clearly connected with the subject (major comment 1.2).

Another major problem is that the added value of the assimilation of isotopic observations compared to simpler humidity observations is not clear, and not even discussed. I fear that readers of this paper could be mislead about the advantages of assimilating water isotopic observations (major comments 1.3).

There is also a problem with the definition of the regions of interest, which seems to stem from misunderstanding of the global precipitation distribution and seasonal migration of the ITCZ (major comment 1.4).

1 Major comments

1.1 The added value of this paper compared to Toride et al 2020 is not clear

Toride et al already documents the added value of assimilating water isotopic observations to improve the simulation of atmospheric variables. l 59-63, the authors justify the added value of this study compared to Toride using two arguments:

- Toride et al was global whereas this paper focuses on the tropics. Yet, in Toride et al, there were already maps and cross sections allowing us to see what happens in the Tropics.
- This paper focuses on latent heating profiles. However, Toride et al already included discussion of the effects on latent heating profiles. The vertical circulation and the precipitation , which are documented in this study, were already documented in Toride et al as well.

In addition, the discussion of latent heating and vertical circulation in this study is mainly restricted to a description of the spatial fields, which have already been known for a long time and do not tell anything about the added value of isotopic assimilation (see major comment 1.3).

Therefore, the added value of this paper compared to Toride et al is not clear.

A possible added value, which could be interesting, is to try and understand the mechanisms by which the assimilation of δD improves the latent heating profiles. The improvements described in the paper could be physically explained.

1.2 The paper includes many paragraphs that are not clearly connected with the subject

- p 3-4: 18 lines are devoted to the description of the IASI observations, yet, these are not used in this study. Rather, synthetic data mimicking IASI observations are used. This sub-section should be reoriented to describe the generation of the synthetic IASI data. A brief description of the IASI observations can be useful with this aim, but not per se, and only the information useful to generate the synthetic data is necessary.
- l 235-265: this describes the vertical circulation and diabatic profiles in 3 regions. These are well-known features of the large-scale atmospheric circulation. This could be recalled in just a few lines, with adequate citations. In addition, the differences between the regions simply reflect the summer location of the ITCZ,

not intrinsic properties of convection over different continents as suggested by the paper (see comment 1.4).

- l 357-366: the connection between this discussion and the effect of assimilation is not clear.
- Fig 15: this is very basic climatology and could go to SI. Again, this simply reflects the ITCZ location relative to the defined boxes (see comment 1.4).
- l 407-419: the connection with the subject of the paper is not clear.

The paper could be much shorter if it was more focused on its initial science question.

1.3 The added value of the assimilation of isotopic observations compared to simpler humidity observations is not clear

The water isotopic composition is often strongly correlated with the specific humidity in both observations and models, e.g. [Noone, 2012, Galewsky et al., 2016]. Measuring specific humidity is much easier, cheaper and widespread than measuring the isotopic composition. Therefore, the information gained from isotopic observations is always assessed relative to the information gained from specific humidity.

Here, the study quantified the improvement associated with the assimilation of isotopic observations, but what is the part of this improvement that we could already have just by assimilating humidity observations? Toride et al showed that actually, the improvement would be even better if assimilating humidity observations than if assimilating isotopic observations, and that the improvement is tiny if assimilating both δD and humidity compared to assimilating only humidity.

Therefore, I fear that readers of this paper could be mislead about the advantages of assimilating water isotopic observations. I think that the added value of assimilating isotopic observations should be quantified relative to assimilating both conventional variables and concomitant humidity observations, and not just relative to conventional measurements.

1.4 Problem with the definition of regions of interest

Why selecting the 10S-10N region, for a month of August? It is well-known that the ITCZ during this month is located further North. Fig 5 illustrates that the defined regions are on the edge of the ITCZ. These boxes are thus heterogeneous, with one part in the ITCZ and one outside. The analysis would be more meaningful if the boxes represented more homogeneous meteorological conditions.

What is the rationale for choosing these regions? If the goal is to look at the ITCZ, then boxes further North should be chosen. If the goal is to look at the descending branches of the Hadley cell, then boxes should be chosen further South.

I suspect that the definition of the regions actually stems from mis-understanding of the global precipitation distribution and of the seasonal migration of the ITCZ. This is reflected by the wrong statement in l 400: "the monsoon over Africa is located at this time of the year directly over the equator". It has long been observed that the ITCZ over Africa in summer is located around 10N, as shown by your Fig 5 and documented by many previous studies, e.g. [Thorncroft et al., 2011]. The authors cite Geen et al 2020 for this statement, yet that also show seasonal monsoons in Africa with the ITCZ located around 10N in summer (see their fig 1).

If boxes were adequately chosen, the additional separation into upward and downward branches (l 376-394) would become useless, and this would additionally simplify the paper (see comment 1.2).

2 Minor comments

- l 217: "the absence of convection ... leads to strong subsidence": or rather vis versa?
- l 325: "lacks the synoptic-scale temporal variations": these are not visible on Fig 9. Fig 9 should rather be plotted in absolute values, not differences. Otherwise, we cannot see what is the magnitude of the synoptic-scale temporal variations. l 305: "with respect to temporal variability of this parameter": this is an additional reason why Fig 9 should show the temporal variability, not just differences between simulations.
- l 349: "correct in isoGSM": correct to what observations? No observations are shown here.

- Fig 11: why is the noDA simulation so difference from the Nature run? What is the difference between the noDA and the Nature run, except for different initial conditions? I can understand different synoptic variations, but why such different mean δD-$\delta^{18}O$ relationships?
- l 365: this sentence is not grammatically correct.
- When δD is assimilated, what happens with $\delta^{18}O$? Is it left free? Or is it assimilated assuming some δD-$\delta^{18}O$ relationship? What is the impact of the way $\delta^{18}O$ is assimilated (or not) on the results regarding δD-$\delta^{18}O$ relationships and d-excess?
- l 408: wrong, moistening by rain evaporation is known to increase d-excess in the vapor, e.g. [Tremoy et al., 2014]
- l 445: upward or downward? heating or cooling? If both, this sentence should just say "all regions"

References

[Galewsky et al., 2016] Galewsky, J., Steen-Larsen, H. C., Field, R. D., Worden, J., Risi, C., and Schneider, M. (2016). Stable isotopes in atmospheric water vapor and applications to the hydrologic cycle. *Reviews of Geophysics*, 54(4):809–865.

[Noone, 2012] Noone, D. (2012). Pairing measurements of the water vapor isotope ratio with humidity to deduce atmospheric moistening and dehydration in the tropical mid-troposphere. *Journal of Climate*, 25(13):4476–4494.

[Thorncroft et al., 2011] Thorncroft, C. D., Nguyen, H., Zhang, C., and Peyrillé, P. (2011). Annual cycle of the west african monsoon: regional circulations and associated water vapour transport. *Quarterly Journal of the Royal Meteorological Society*, 137(654):129–147.

[Tremoy et al., 2014] Tremoy, G., Vimeux, F., Soumana, S., Souley, I., Risi, C., Cattani, O., Favreau, G., and Oi, M. (2014). Clustering mesoscale convective systems with laser-based water vapor delta18O monitoring in Niamey (Niger). *J. Geophys. Res.*, 119(9):5079–5103, DOI: 10.1002/2013JD020968.