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Comment on acp-2022-12

Anonymous Referee #2

Referee comment on "Disentangling the impact of air–sea interaction and boundary layer cloud formation on stable water isotope signals in the warm sector of a Southern Ocean cyclone" by Iris Thurnherr and Franziska Aemisegger, Atmos. Chem. Phys. Discuss., https://doi.org/10.5194/acp-2022-12-RC2, 2022

Thurnherr and Aemisegger provide a detailed, well-written manuscript that seeks to investigate the process-level causes of low vapor d-excess observed during the 2016/17 Antarctic Circumnavigation Expedition. They apply three single-process models representing impacts on isotope ratios from (a) ocean evaporation, (b) dew formation and deposition, and (c) upwind distillation, and demonstrate that these three processes follow diagnostic pathways in $d^{18}O$/d-excess space. They then also compare the results from their process models to a regional NWP model simulation including isotopes to validate these models. Taken together, they suggest a larger than previously appreciated role for dew formation over the ocean for altering the d-excess of near-surface water vapor, particularly in the warm sector of extratropical cyclones.

Their analysis is rather detailed, and the process modeling provides interesting insights into the evolution of d-excess in near-surface water vapor. This paper represents a nice contribution, and only have a handful of suggestions for revision below.

Line-by-line notes

- L. 36 – there appears to be an extra '2' in the denominator for R here.
- L. 44-46: might be good to cite a few of the observational studies that dew formation is a non-equilibrium process (e.g., Deshpande et al., 2013; Wen et al., 2012), since condensation processes are still (often) thought of as equilibrium to first order.
- L. 61-62: d can also change purely due to equilibrium effects when the Rayleigh f is very low (e.g., Bony et al., 2008; Dütsch et al., 2017)
- L. 104: which laser spectrometer was used and how was it calibrated?
- L. 115: could the authors clarify what explicit treatment of deep convection means (i.e., is this model non-hydrostatic)?
- L. 136-137: These seem to be fairly unusual choices for the isotope ratio of the ocean,

could the authors clarify how these values were chosen? This is of particular note for this manuscript as it could be in part responsible for producing evaporation fluxes with a lower d-excess than might be expected. For example, using values for SMOW ($\delta^{18}O$ = 0‰, $\delta^{2}H$ = 0‰), the water undergoing evaporation has a d-excess of 0‰, but an ocean initial condition of ($\delta^{18}O$ = 1‰, $\delta^{2}H$ = 1‰) has a d-excess of -7‰, which would seem to bring down the d-excess of the evaporative flux by ~7‰ as well.

- L. 169: there is often a lot of confusion regarding α_k, often stemming from whether it is defined based on D_i/D (and hence, $\alpha_k < 1$) or D/D_i (hence $\alpha_k > 1$) (e.g., Benetti et al., 2014), where D_i is the diffusivity of the isotopologue with a substituted atom (^{2}H or ^{18}O). Obviously, both can be correct depending on how the equations are cast, but it may be worth specifying that you are referring to an α_k value based on D_i/D in your work, since the alternative definition is also widely used.
- L. 235: I think the supplemental figures are not numbered in text in the order they appear.
- L. 251-252: I think this sentence could be a bit more clear – clearly rainout could play a role in altering SWIs, but it's not clear why you might expect to see these at the ocean-water interface if there has been substantial adiabatic lifting (presumably along isentropes, cf. (Bailey et al., 2019)?). Presumably this would be through mixing and/or subsidence, but it's not made clear here.
- L. 304 – is THE a misrendered θ_e? (Also, there appears to be some inconsistency in case: a capital Θ is used in Fig. 5 and L. 340 instead of the lower-case θ used elsewhere)
- L. 437-441 – this is an interesting point! In addition to the mixing process here, I wonder if the more turbulent coupling between the surface and the near-surface atmosphere could have the effect of altering the 'effective' kinetic fractionation factor here as well and alter d independent of mixing, for example by changing the value of the exponent used on the ratio of diffusivities (eq. 5 in (Pfahl & Wernli, 2009), also (e.g., Gat, 1996; Mathieu & Bariac, 1996; Merlivat & Jouzel, 1979; Riley et al., 2002)

References

Bailey, A., Singh, H. K. A., & Nusbaumer, J. (2019). Evaluating a Moist Isentropic Framework for Poleward Moisture Transport: Implications for Water Isotopes Over Antarctica. *Geophysical Research Letters*, *46*(13), 7819–7827. https://doi.org/10.1029/2019GL082965

Benetti, M., Reverdin, G., Pierre, C., Merlivat, L., Risi, C., Steen-Larsen, H. C., & Vimeux, F. (2014). Deuterium excess in marine water vapor: Dependency on relative humidity and surface wind speed during evaporation. *Journal of Geophysical Research: Atmospheres*, *119*(2), 584–593. https://doi.org/10.1002/2013JD020535

Bony, S., Risi, C., & Vimeux, F. (2008). Influence of convective processes on the isotopic composition ($\delta^{18}O$ and δD) of precipitation and water vapor in the tropics: 1. Radiative-convective equilibrium and Tropical Ocean–Global Atmosphere–Coupled Ocean-Atmosphere Response Experiment (TOGA-COARE) simulations. *Journal of Geophysical Research*, *113*(D19). https://doi.org/10.1029/2008JD009942

Deshpande, R., Maurya, A., Kumar, B., Sarkar, A., & Gupta, S. (2013). Kinetic fractionation of water isotopes during liquid condensation under super-saturated condition. *Geochimica et Cosmochimica Acta*, *100*, 60–72.

Dütsch, M., Pfahl, S., & Sodemann, H. (2017). The Impact of Nonequilibrium and Equilibrium Fractionation on Two Different Deuterium Excess Definitions. *Journal of Geophysical Research: Atmospheres*. https://doi.org/10.1002/2017JD027085

Gat, J. R. (1996). Oxygen and hydrogen isotopes in the hydrologic cycle. *Annual Review of Earth and Planetary Sciences*, *24*, 225–62.

Mathieu, R., & Bariac, T. (1996). A numerical model for the simulation of stable isotope profiles in drying soils. *Journal of Geophysical Research: Atmospheres*, *101*(D7), 12685–12696. https://doi.org/10.1029/96JD00223

Merlivat, L., & Jouzel, J. (1979). Global climatic interpretation of the deuterium-oxygen 18 relationship for precipitation. *Journal of Geophysical Research*, *84*(C8), 5029. https://doi.org/10.1029/JC084iC08p05029

Pfahl, S., & Wernli, H. (2009). Lagrangian simulations of stable isotopes in water vapor: An evaluation of nonequilibrium fractionation in the Craig-Gordon model. *Journal of Geophysical Research*, *114*(D20). https://doi.org/10.1029/2009JD012054

Riley, W. J., Still, C. J., Torn, M. S., & Berry, J. A. (2002). A mechanistic model of $H_2{}^{18}O$ and $C^{18}OO$ fluxes between ecosystems and the atmosphere: Model description and sensitivity analyses. *Global Biogeochemical Cycles*, *16*(4), 42-1-42–14. https://doi.org/10.1029/2002GB001878

Wen, X.-F., Lee, X., Sun, X.-M., Wang, J.-L., Hu, Z.-M., Li, S.-G., & Yu, G.-R. (2012). Dew water isotopic ratios and their relationships to ecosystem water pools and fluxes in a cropland and a grassland in China. *Oecologia*,*168*(2), 549–561.