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Atmospheric Chemistry and Physics
Discussions

Interactive comment on "Meridional and vertical variations of the water vapour isotopic composition in the marine boundary layer over the Atlantic and Southern Ocean" *by* Iris Thurnherr et al.

Anonymous Referee #2

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Review of Âń Meridional and vertical variations of the water vapour isotopic composition in the marine boundary layer over the Atlantic and Southern OceanÂż by Iris Thurnherr et al,

The manuscript presents a time series of vapour isotopic composition from the marine boundary layer from an expedition that realised a circumpolar around Antarctica. The dataset presented in this manuscript is the first of its kind: providing an unique spatial coverage of the vapour isotopic composition of the Southern Ocean, at two different heights in the marine boundary layer. The quality of the produced data is rigorously

assessed by a large number of calibrations, tests of the impact of the ship itself on the measurements and the presence of multiple instruments. The manuscript focuses on two aspects of the results: first, the meridional variations of the isotopic composition in the marine boundary layer, and second, the vertical variations. The authors have developed a physical qualitative framework to explain the results. While the analysis of the result is done thoroughly and with adequate justification, no attempt to use previous theory of the formation of the isotopic composition of the vapour in the marine boundary layer is presented here. A large amount of the theories were set in a period where analytical capabilities did not provide such extensive dataset, and it is an important duty that to confront these theories to field measurements. I believe these changes will be relatively easy for the authors, and that they will strengthen an already important manuscript for the link between isotopic composition and marine boundary layer dynamics.

Main comments: 1. Uncertainty evaluation: The second message of the manuscript (section 4.2) details the vertical differences between two infrared spectrometers that were installed at 8 and 13 meters, respectively. On average, significant differences are observed between these two instruments. A significant amount of work is dedicated in this manuscript into characterising the instruments performances. Yet, the results in section 4.2 do not include an error bar for which the differences are significant between the two instruments. In particular, in Fig. 10, a significant number of datapoints presented have very small difference (< 0.2 ‰ in δ18O for instance). Considering the precisions of the instruments (in particular the 2120), it is difficult to assess the relevance of these datapoints. This is a key aspect to be able to justify the wind speed dependency, and it seems that most of the results necessary to evaluate the statistical significance of the results are already presented here. I would suggest make use of the standard deviation of the differences (for instance in Fig. 5) and use pertinent statistical tests (for instance Kruskall Wallis tests) to evaluate in which cases are the differences statistically significant.

2. In the manuscript, the authors do not provide any quantitative evaluation of the vertical differences of the isotopic composition in the marine boundary layer. Yet, formulations have been predicted, based on very limited number of observations compared to this study. While I generally agree with the qualitative proposition of the authors, I believe that they should have tested previous formulations. From articles already mentioned in the manuscript, I would suggest to compare their results to models of isotopes in the boundary layers, namely Craig (1965), Merlivat (1978), or again Benetti et al. (2018). I would suggest to use formulations developed in Cappa et al. (2003), and the parametrisations of Merlivat (1978) for the dependency of the diffusion with turbulence. I suggest that these parametrisations, which already include an increasing impact of turbulence with wind speed, should be tested. Due to the considerable amount of data of the authors, I would suggest evaluating this on typical cases (for instance, the regimes [I], [II] and [III] identified by the authors. Also, as here δ18O is expected to decrease monotonously with height, I would suggest that the authors identify the different contributions to d-exc and δ18O (or δD and δ18O) in an isotope-isotope space (for instance δD vs δ18O) and illustrate which process is characterised with slopes higher or lower than the meteoric water line.

Minor comments:

Page 2, Line 10: "The atmospheric water cycle is an essential component of the Earth's climate system" The water cycle is not just atmospheric by definition. Page 2, line 24: "SWIs are tracers of moist atmospheric processes because they record phase changes in the atmosphere." What is a moist atmospheric process ? Sentence unclear Page 3, line 28 to 35: I would suggest include articles such as (Craig, 1965;Cappa et al., 2003). Page 4, line 5 to 19: The link with the isotopes and their limits in this context is missing.

Benetti, M., Lacour, J. L., Sveinbjörnsdóttir, A., Aloisi, G., Reverdin, G., Risi, C., Peters, A., and SteenâĂŘLarsen, H.: A framework to study mixing processes in the marine boundary layer using water vapor isotope measurements, Geophysical Research

Letters, 45, 2524-2532, 2018. Cappa, C. D., Hendricks, M. B., DePaolo, D. J., and Cohen, R. C.: Isotopic fractionation of water during evaporation, J. Geophys. Res.-Atmos., 108, 10, 10.1029/2003jd003597, 2003. Craig, H., Gordon, A. : Deuterium and oxygen 18 variations in the ocean and the marine atmosphere, Stable Isotopes in Oceanic Studies and Paleotemperatures, 130, 1965. Merlivat, L.: The dependence of bulk evaporation coefficients on air-water interfacial conditions as determined by the isotopic method, Journal of Geophysical Research: Oceans, 83, 2977-2980, 10.1029/JC083iC06p02977, 1978.

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