Review

Title: What controls deuterium excess in global precipitation?

Authors: S. Pfahl, H. Sodemann

Journal: Climate of the Past

Reviewer: M. Werner

Preluding Remark: Several months ago, an earlier version of this manuscript was submitted by the authors to "Geophysical Research Letters" (GRL) and I was one of the chosen (anonymous) reviewers for this previous submission. At the end of the review process the GRL editor rejected the manuscript and suggested the submission to another journal. By chance, the handling CP editor has now asked me for a review of this article, too. After discussing the history of the manuscript with the editor and editorial support of Copernicus Publications, I accepted reviewing this (re-submitted) article.

In their manuscript Pfahl and Sodemann examine the global spatial pattern and seasonal variations of a second-order stable water isotope parameter, the deuterium excess *d*. Analyzing available measurements of *d* in water vapor above the ocean surface they find a linear relationship between *d* and relative humidity RH. By combining this relationship with global fields of specific humidity, temperature and latent heat flux from the ECWMF ERA-Interim reanalysis dataset the authors are able to model *d* in evaporation on a global scale. Their results show convincing agreement with available *d* measurements in precipitation available from the GNIP database.

As already stated in my previous review for GRL, I rate this study as well designed, and its findings definitely merit to be published in a journal like CP. Although the relevance of RH changes for the *d* signal has already been proposed by Merlivat, Jouzel and others many years ago, more recent studies have focused on the influence of SST changes on the deuterium excess signal, solely. This new study reminds us that source temperature changes are not the only important factor influencing the *d* signal. This finding is of high relevance for paleoclimate reconstructions based on stable water isotope measurements and will most certainly initiate a new discussion about the interpretation of observed *d* changes.

The authors have carefully addressed some major concerns I've had with the old manuscript version regarding the implications of this study for the interpretation of *d* changes measured in deep ice cores from Greenland and Antarctica. Furthermore, the potential influence of SST on the deuterium excess is now discussed in much more detail, which further improves the manuscript. Although I still do not share the authors' view that there exists no influence of SST on *d* on longer time scales (p. 4758, l. 18-20) I agree with them that the potential influence of RH on *d* should be considered more carefully in future studies.

Detailed points are as follows.

p. 4751, l. 21-22: How well does RH calculated from ERA-Interim data agree with the observed RH values shown in Fig. 1a? Please add a short comparison of modeled vs. observed RH.

p. 4751, l. 24-26: I do not understand this point about the exclusion of spin-up effects for latent heat flux. Please clarify these statements. Furthermore, why is the latent heat flux, but not the evaporation flux chosen for the necessary weighting calculations? Evaporation

is also available within the ERA-Interim dataset and should correspond more closely to the precipitation-weighting of the GNIP data. Please explain this selection in more detail in a revised text.

p. 4752, l. 22-23: Can one really exclude moisture exchange between the two hemispheres on a seasonal time scale? E.g., in some regions the position of the ITCZ shifts between 20°N and 20°S during the year. Please discuss this assumption and the implications for your calculations in some more detail.

p. 4753, 1st paragraph: Please give some numbers on the global annual mean budgets. How well do means of *d* in precipitation and evaporation agree?

p. 4753, l. 10-11: Could recycling of continental water also have an effect on the seasonal *d* signal in precipitation?

p. 4753, l. 13-16: The explanation of the negative bias in the SH due to sparse spatial coverage of GNIP stations is not very convincing. Apart from Europe, the spatial coverage of GNIP stations in the NH and SH seems to be rather similar (cf. Fig.2). One could further test this hypothesis by excluding some parts of the Southern Ocean for the calculation of the SH *d* values.

p. 4754, l. 6-7: I can't see a clear east-west gradient of *d* in precipitation over Eurasia. Please clarify this statement.

p. 4754, l. 11-13: How large is the modeled interannual variability of *d* in evaporation? Can this really explain the differences at the Pacific Island stations?

p. 4746, l. 15-20: I cannot follow the authors' argument why a possible change in *d* due to a shift in precipitation seasonality can be rather related to RH than SST changes. Please explain this argument in detail or omit it.

p. 4758, l. 1-17: Again, I cannot follow the authors' argument. Recent isotope climate model studies may show substantial differences in simulated *d* values. But how can these model deviations allow us to drawing conclusions about the importance of SST and RH changes for the *d* signal in precipitation? Please explain.

p. 4758, l. 18-20: I rate this statement as too single-sided and suggest using the same wording as in the abstract: "All together, there is no convincing evidence that RH might be less important for long-term palaeoclimatic *d* changes compared to moisture source temperature variations."