

Short reply to specific comment of reviewer 1 on equation 3

Zurich, the 13th of December 2013

We would like to thank reviewer 1 for his/her constructive comments on the manuscript that will help us to improve our paper. We will respond to the full review at the end of the discussion phase but would like to address reviewer 1's specific comment on section 7 and particularly on equation 3.

We fully agree that the approach we present in section 7 of this paper is only a first attempt to estimate the transpiration fraction of continental evaporation using the d - h_s relation. This should be seen as a feasibility study. The main aim of this paper is to better understand the mechanisms behind variations of the continental water vapour deuterium excess signal at the daily timescale. We will make this point clearer in our revision of the paper and add some explanations on the limits of our approach to estimate the transpiration fraction using the d - h_s relation.

The discrepancy between reviewer 1's derivation and the one in our ACPD manuscript is not due to a calculation error but is due to a different treatment of the closure assumption. In his/her derivation reviewer 1 assumes that both R_v and h_s are the same for all evaporation sites (ocean or continent). We also assume that h_s is the same at all evaporation sites, but we apply the closure assumption for ocean evaporation, soil evaporation and transpiration separately, whereas reviewer 1 applies the closure assumption globally over all the evaporation sites. It is this specific treatment of the closure assumption and not a calculation error that leads to our equation 3 for the isotope ratio of the boundary layer water vapour.

We will change the symbol use as it is generally done with $\alpha > 1$ and $k = 1 - \frac{1}{\alpha_K}$ in the manuscript revision. Using our symbols, as in the paper (i.e. $\alpha < 1$ and $k = \frac{1}{\alpha_K}$) the heavy isotope ratio of the water vapour mix containing moisture originating from ocean evaporation R_{vo} , transpiration R_{vT} and soil evaporation R_{vE} is:

$$R_v = f_o R_{vo} + (1 - f_o) \cdot [f_T \cdot R_{vT} + (1 - f_T) \cdot R_{vE}]. \quad (1)$$

We apply the closure assumption for each individual evaporation type:

$$\begin{aligned} R_{vo} &= \frac{k_o \cdot (R_o \cdot \alpha - h_s \cdot R_{vo})}{1 - h_s} \\ \rightarrow R_{vo} \cdot (1 + \frac{k_o \cdot h_s}{1 - h_s}) &= k_o \cdot R_o \cdot \alpha \\ \rightarrow R_{vo} &= \frac{k_o \cdot R_o \cdot \alpha}{1 - h_s \cdot (1 - k_o)} \end{aligned} \quad (2)$$

$$R_{vT} = R_c \quad (3)$$

$$R_{vE} = \frac{k_c \cdot R_c \cdot \alpha}{1 - h_s \cdot (1 - k_c)} \quad (4)$$

where f_o is the fraction of ocean evaporation, f_T the transpiration fraction, k_o the non-equilibrium fractionation factor for ocean evaporation, k_c the non-equilibrium fractionation factor for continental evaporation, R_o the isotope ratio of ocean water, R_c the isotope ratio of continental surface water, h_s the relative humidity with respect to surface temperature, α the equilibrium fractionation coefficient.

The two approaches involve two different strong assumptions with different physical meaning. The physical meaning of the reviewer's approach is that the atmosphere is well mixed and that R_v is the same over the ocean and the continents. In our approach the isotope signature of continental moisture does not influence oceanic sources. This is reasonable, since in our case air masses are typically first advected over the ocean and then over the continent. However, the isotope signature of oceanic moisture may affect continental moisture and R_{vT} may influence R_{vE} at one specific location. It is not clear a priori which of the two approaches is better. We will thus conduct a sensitivity test, which will allow us to evaluate the impact of reviewer 1's approach on our transpiration fraction estimates. A more sophisticated treatment of the individual sources will be studied in future research. In this paper we reveal the potential of the d - h_s relation to estimate the transpiration fraction of continental evaporation.