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Hydrology and Earth System Sciences
Discussions

Interactive comment on "Using StorAge Selection functions to quantify ecohydrological controls on the time-variant age of evapotranspiration, soil water, and recharge" *by* Aaron A. Smith et al.

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The authors thank Reviewer 2 for their additional comments. The authors are unsure of what Reviewer 2 means when describing the Craig-Gordon model as a 'black-box'. While not without its assumptions, the Craig-Gordon model was derived from physically-based processes and is the most widely used isotopic model. Additional isotopic models are generally developed from its framework (eg. see He & Smith, 1999). However, there are numerous methods to estimate the atmospheric parameters of the Craig-Gordon model (e.g. α, εk) which may have an influence on the evaporation fractionation. From these methods (Figure 1 below shows an example of the difference

of two methods used to estimate α in the Craig-Gordon model) it is anticipated that the largest influence on the isotopic fractionation is the selection of the diffusion ratio (Di/D) as well as the turbulence parameter (n). The diffusion ratio has relatively high ranges (0.9757 – 0.9955; Horita et al., 2008), which results in a range in εk of 4.5 to 24.9‰ (εk=(1-h)·n·((D/Di)ˆn-1)) assuming n = 1. This corresponds to a maximum range of ~6‰ in δ^* (directly influences the fractionation in each time-step; see Gibson, 2002) with a relative humidity of 80% (the long-term average at the site) and the conditions shown in Figure 1 (see below). In hindsight to the previous response, the authors should have clearly stated that the parameters of the Craig-Gordon model will also be tested in the proposed sensitivity analysis. As the turbulence parameter (n) was estimated as temporally variable, the sensitivity will be tested with time-invariant parameters (eg. n =0.5 or n=1).

For clarity, the rational for not testing additional distribution shapes is due to the multitude of shapes that have already been tested. From initial testing of the model with other distributions (e.g. uniform, exponential, gamma), it was determined that the use (and selection) of a single distribution was restrictive to the model results. However, additional testing of distributions revealed that the beta distribution, with appropriate parameterisation, could replicate the shapes of other commonly used distributions (see Figure 2 below). As such, the parameterisation of the beta distribution included in the model calibration were; high preference of near surface water (β » α; equivalent to a exponential distribution), uniform selection/random mixing (β = α = 1; equivalent to a uniform distribution), higher preference of mid-depth waters (α > 1, β » α; equivalent to a gamma distribution), and high preference of water from near the bottom of the domain (α » β). Calibration of these parameter ranges ensured that testing of multiple different distribution shapes was conducted. Figure 2 shows the PDF and CDF of an exponential, gamma, and uniform distribution with in addition to the PDF and CDF of beta distributions tested within the model. For each different distribution (i.e. exponential, gamma, and uniform), the beta distribution is shown to imitate the shape quite well. The additional benefit of the beta distribution is the other shapes it may produce (see orange lines, Figure 2). As previously suggested, the authors will conduct a sensitivity analysis of the beta distribution parameters (which changes the shape of evaporation and root-uptake selection). Finally, the parameterization of the beta distribution used for both evaporation and root-uptake fluxes tested of both time-variant and time-invariant conditions (λ in Equations 13&14 was permitted to equal 0, time-invariant conditions), therefore this model structure does not make the assumption that uptake is time-variant or time-invariant.

References

Gibson, J. (2002), Short-term evaporation and water budget comparisons in shallow Arctic lakes using non-steady isotope mass balance, Journal of Hydrology, 264(1-4), 242-261, DOI: 10.1016/S0022-1694(02)00091-4

He, H., and Smith, R. B. (1999), An advective-diffusive isotopic evaporationâĂŘcondensation model, Journal of Geophysical Research, 104(D15), 18619–18630, DOI:10.1029/1999JD900335.

Horita, J., Rozanski, K., and Cohen, K. (2008), Isotope effects in the evaporation of water: a status report of the Craig–Gordon model, Isotopes in Environmental and Health Studies, 44(1), 23-49, DOI: 10.1080/10256010801887174

Horita, J., Wesolowski, D.J. (1994), Liquid-vapor fractionation of oxygen and hydrogen isotopes of water from the freezing to the critical-temperature. Geochimica et Cosmochimica Acta, 58, 3425–3437, DOI: 10.1016/0016-7037(94)90096-5

Majoube, M. (1971), Fractionnement en oxygene 18 et en deuterium entre l'eau et sa vapeur. Journal de Chimie Physique, 68, 1423–1436. DOI: 10.1051/jcp/1971681423

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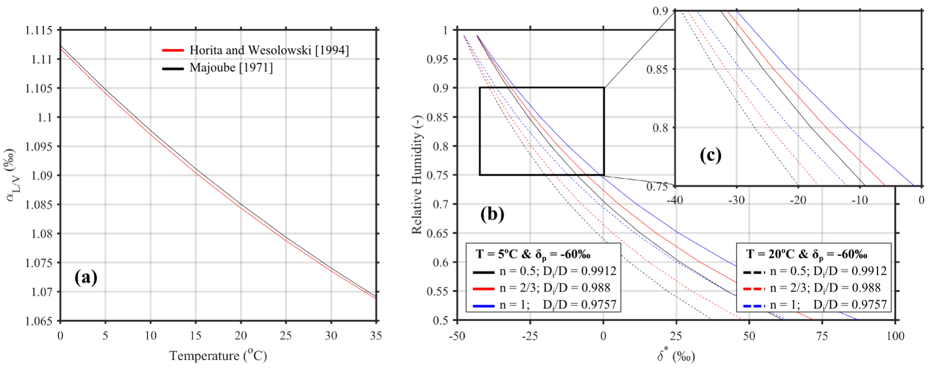

Fig. 1. a) Estimation of αL/V (fractionation parameter) against temperature, b) The estimation of δ*, c) subplot of plot b

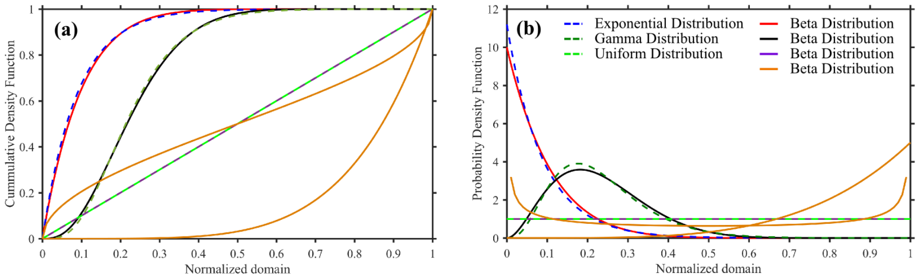

Fig. 2. a) The CDF of an exponential, gamma, and uniform distribution with a corresponding beta distribution parameterisation. b) The corresponding PDF of the CDFs in Fig2.a