Geosci. Model Dev. Discuss., 5, C1545–C1565, 2013
www.geosci-model-dev-discuss.net/5/C1545/2013/

Geoscientific Model Development Discussions

Interactive comment on "Stable water isotopes in the coupled atmosphere–land surface model ECHAM5-JSBACH" *by* B. Haese et al.

B. Haese et al.

Barbara.Haese@awi.de

Received and published: 15 March 2013

We would like to thank referee 1 for their comments which have helped to improve the submitted manuscript. Below we answer each comment in turn. Please find attached the manuscript in a revised form. Technical correction of the reviewer concerning grammatical errors and the typography of the manuscript are all included in the attached revised manuscript, but not explicitly mentioned again in the text following below.

1) General comments:

Reviewer: This paper describes the implementation of water isotopes in the JSBACH land surface model and evaluates the simulation of the isotopic composition of the precipitation when coupled to the ECHAM5 model. The isotopic version of ECHAM5 was

Full Screen / Esc

Printer-friendly Version

Interactive Discussion

Discussion Paper

already documented in Werner et al. (2011). This paper is a significant contribution because papers documenting water isotopes in land surface models are not so many. I felt however a bit frustrated because I couldn't understand everything, and in absence of further explanations, not everything makes sense. So I think that the paper could be improved in several ways as described in the specific comments.

Reply: We thank the reviewer for the overall positive rating of our presented work. In accordance with the reviewer's specific comments we have added more details to the model description, the difference between stand-alone ECHAM5 and ECHAM5-JSBACH, as well the model results. Furthermore, after receiving the two reviews on our manuscript, we have carefully checked all parts of the model code and unfortunately discovered a major coding error. As a consequence, we had to rerun all experiments with a new model version. Due to the new experiments the result part and the conclusion have been changed, too. We hope that this new manuscript is more complete and comprehensible.

2) Specific comments

Reviewer: 2.1) Better describe the JSBACH model:

To better understand the results and to better justify your hypotheses regarding isotopic implementation, it would be useful for the reader to know more about the JSBACH model.

1. What kind of model is it for the soil? How many layers? What kind of model is it for the snow?

Reply: For both soil moisture and snow cover the ECHAM5-JSBACH model uses a bucket model with one layer, each. The same is true for the skin layer. The approach is identical to the soil moisture model resp. the snow model which is used in ECHAM5. We have added a brief description in Sec. 2.1 (l. 112):

"In ECHAM5-JSBACH the same land hydrology model is used as in ECHAM5. The

GMDD

5, C1545–C1565, 2013

model comprises three surface water reservoirs: a snow layer (sn), water at the skin layer of the canopy or bare soil (wl), and a soil water layer (ws). These three types are each represented by a single layer bucket model, and each of them has a prescribed maximum field capacity. The snow reservoir is filled by snowfall and depleted by snow melt or sublimation. The skin layer and the soil layer are filled by rainfall and snow melt in the following order: first the skin layer is filled until its water holding capacity is exceeded and secondly the non intercepted water fills the soil reservoir. The modeled depletion of the skin layer can only occur by evaporation, the depletion of the soil water reservoir occurs by evapotranspiration. There is no exchange between these two reservoirs. If the soil water reservoir is saturated, surface runoff occurs. Drainage occurs independent of the new precipitation, and it is calculated if the amount of soil water reaches 5% or more of the maximal soil water capacity. ”

Reviewer: 2. In section 3.2.1 it is suggested that bare soil evaporation and transpiration are the only sources of total evapotranspiration. What about canopy-interception? Snow sublimation? How are they counted in fig 7?

Reply: This description was focused on the evapotranspiration processes from the soil water, only. In Fig. 7-a the annual mean amount of evapotranspiration is shown, this includes all reservoirs as a source (evaporation from bare soil and skin layer as well as snow sublimation. Now, we have changed this statement into (l. 368):

“When water evapotranspirates from the land surface, it can evaporate from bare soil or skin layer, sublimate from snow, or transpire through the vegetation.”

Reviewer: 3. Do you have any lakes or floodplains that provide additional sources of evapotranspiration? If not is it a problem for the isotopic simulation in some regions?

Reply: In ECHAM5-JSBACH, the same lake model is used as in the stand-alone ECHAM5 model. Lakes are prescribed by a lake mask and for large lakes (i.e., grid cells with a lake fraction greater than 50%), evaporation gets treated like over ocean water. This statement is added at Section 2.1. (l. 124):

GMDD
5, C1545–C1565, 2013

"Furthermore, lakes are prescribed by a lake mask, to calculate the evaporation over larger lakes (i.e., grid cells with a lake fraction greater than 50%) the same scheme as for the ocean is used."

Furthermore, we do not simulate floodplains. We do not detected any problems due to this restriction, yet.

Reviewer: 4. Can you summarize briefly the main differences between JSBACH and the default soil model of ECHAM5? We learn progressively some differences along the results section, but it would be good to have a synthetic summary in the model description. For example, this could be a synthetic table.

Reply: There is no difference between the soil model used in ECHAM5 and the one used in ECHAM5-JSBACH. Major differences between stand-alone ECHAM5 and the ECHAM5 -JSBACH model are related to processes occurring on vegetated land surface areas (e.g. plant phenology, distribution of different vegetation types). As a result, the calculation of albedo differs between both models, which leads, among others, to different simulations of the land surface temperature. This statement is added at Section 2.1. (l. 112):

"In ECHAM5-JSBACH the same land hydrology model is used as in ECHAM5."

Reviewer: 5. We discover on section 3.1 that the maximal soil depth varies spatially and is different between stand-alone ECHAM5 and JSBACH. Can you explain very briefly how the maximal soil depth is calculated in each model? This could go in the synthetic table suggested above.

Reply: By the term "soil layer depth" we referred to the maximal soil water capacity of each grid cell, which is expressed as a maximum water column height in the model. We have corrected this term in the revised manuscript version for clarity reasons. The maximal soil water capacity is prescribed for each grid cell (Hagemann et al., 1999). The differences in the maximal soil water capacity between ECHAM5 and ECHAM5-

GMDD

5, C1545–C1565, 2013

Interactive Comment

JSBACH is the result of a model tuning for the horizontal resolution T31, which was introduced to enable a better simulation of tropical vegetation coverage. This explaining is added at l. 299 at the new version:

"This difference between ECHAM5 and ECHAM5-JSBACH was introduced to enable a more realistic simulation of vegetation coverage over the tropical regions (Hagemann et al., 1999)."

Reviewer: 6. How are surface runoff and drainage treated? What are their relative contribution to total runoff? This point is crucial for isotopic fractionation, see below. The model description section could be cut into a basic description and then an isotopic description.

Reply: We are added this brief description at the model description (l. 120):

"If the soil water reservoir is saturated, surface runoff occurs. Drainage occurs independent of the new precipitation, and it is calculated if the amount of soil water reaches 5% or more of the maximal soil water capacity. The runoff resp. drainage scheme is based on examination of variations of the field capacity for soil water over the land surface (Dümenil and Tondini, 1992)."

In the revised text, the first three paragraphs of Section 2.1 give now a brief basic description of the hydrology in ECHAM5-JSBACH (l. 112). It follows a description of those parts of the isotope model in ECHAM5-JSBACH, which are implemented in an identical manner as in ECHAM5-wiso (l. 127). The last part of the model description is about the general implementation of the evapotranspiration processes over land surfaces and the related isotopic composition of the evapotranspiration (l. 140). We have always added the isotopic counterpart directly after the description of the general hydrologic process to highlight the tight linkage between both implementations.

Reviewer: 2.2) Better describe the isotopic implementation and justify the underlying hypotheses

GMDD

5, C1545–C1565, 2013

1. Why don't you take into account fractionation during evaporation of plant-intercepted water? Does the model simulate any throughfall? If all the water evaporates from the plants within a few time steps but at the same time some of this enriched water drips to the ground, then fractionation needs to be taken into account. For example, this source of fractionated water was suggested as a possible contribution to the d-excess increase in the Amazon (Gat and Matsui (1991)).

Reply: The ECHAM5-JSBACH model does not simulate any through-fall of plant-intercepted water. The maximal amount of water in the skin reservoir wl is defined by a maximal water holding capacity, after this capacity is reached the residual amount of new precipitation water gets directly into the soil reservoir. Based on this implementation of the skin reservoir, there is no exchange modeled between skin reservoir and soil reservoir. Because the water holding capacity of wl is so small that the entire reservoir evaporates within few time-steps, we assume that no fractionation occurs during evaporation from the skin layer. The following description in respect to the through-fall added at l. 116:

"The skin layer and the soil layer are filled by rainfall and snow melt in the following order: first the skin layer is filled until its water holding capacity is exceeded and secondly the non intercepted water fills the soil reservoir. The modeled depletion of the skin layer can only occur by evaporation, the depletion of the soil water reservoir occurs by evapotranspiration. There is no exchange between these two reservoirs."

And in respect to the fractionation of evaporation from skin reservoir (l. 166):

"The skin layer wl is modeled as a thin layer of water, which in general evaporates completely within a few model time steps. If this entire water reservoir evaporates, the total flux has an identical isotopic composition as the water source and no fractionation occurred. As this study focuses on annual mean changes, we assume for simplification that no fractionation occurs during evaporation from skin layer at any time step, which is expressed as:"

GMDD
5, C1545–C1565, 2013

Interactive Comment

Reviewer: 2. Can you give the formulation of the kinetic fractionation coefficients that you use in the different simulations? Which one leads to the strongest fractionation in terms of delta^18O? Which one leads to the strongest fractionation in terms of d-excess? Can you remind the hypotheses and limitations underlying these 2 formulations?

Reply: In the new version we added the formulation of the kinetic fractionation coefficients and a briefly description on which factors the equations are based at l. 188:

"First, we assume that the same kinetic fractionation factor as for evaporation over the ocean can be used over land as well:

alpha_k=1-lambda*k,

with k=0.006 if |V_s|<=7[m/s], and k=0.000285x|V_s|+0.00082 if |V_s|>7[m/s],

lambda=1 for 18O, and lambda=0.88 for D.

Here V_s is the horizontal wind speed on the surface and lambda describe the ratio of the isotope molecular diffusivity in air. In this approach alpha_k is depending on the molecular and turbulent resistance of water vapor and has been described in detail by Merlivat and Jouzel, 1979. The second approach is presented by the study Mathieu and Bariac, 1996. Where alpha_k is calculated as the nth power of the molecular diffusivity ratio in air:

alpha_k=1/((d_v/d^x_v)^n),

with d_v (d^x_v) as the vapor diffusivity in air (vapor diffusivity of the isotopic species x). The exponent n includes the influence of the turbulent and molecular resistance and we use, as suggested by (Riley et al., 2002), n=0.67."

The approach given by Mathieu and Bariac (1996) shows the strongest effect of fractionation in terms of delta^18O as well as in terms of the Deuterium excess. Which is written at Sect. 3.2.3 l. 540:

GMDD

5, C1545–C1565, 2013

"The simulations have shown that the setup FEK_diffres leads to the strongest fractionation in terms of deltaˆ18O_P as well as in terms of d-excess (not shown)."

Reviewer: 3. If the soil model is multi-layer, what kind of scheme do you use for water transport and diffusion into the soil?

Reply: The soil water model has one layer, so we do not have water transport or diffusion into the soil. (please see item 1, at 2.1)

Reviewer: 4. p 3390 l 3-9: Sachse et al. (2012) is cited suggesting the existence of some fractionation during transpiration. I think this paper has been misinterpreted. Fractionation from leaf water to evapotranspiration is well known, but it doesn't imply that there is fractionation from soil water to evapotranspiration. What's important for your implementation is the fractionation from soil water to transpiration. At time scales larger than daily, a steady state is reached in which all the soil water taken up by the roots is transpired. So what's important is the fractionation during soil water uptake by the roots. And numerous studies have shown there is no fractionation during root uptake, or at most very small fractionation for specific species (Washburn and Smith (1934); Wershaw et al. (1966); Zimmermann et al. (1967); Ziegler et al. (1976); White et al. (1985); Barnes and Allison (1988); Dawson and Ehleringer (1991); Walker and Richardson (1991); Dawson and Ehleringer (1993); PJ et al. (1993); Ellsworth and Williams (2007)). Even Sachse et al. (2012) argues there is no fractionation during root uptake. Some papers document the effect of fractionation at leaf level on the transpiration flux composition, but this plays at sub-daily time scales (Lai et al. (2006); Lee et al. (2007b)). This is not what you are looking at. The paragraph suggests that previous studies neglecting fractionation during transpiration were wrong, but actually all citations I know suggest they were right.

Reply: We absolutely agree with the reviewer on this topic and also rate fractionation from soil water to transpiration as negligible, in general. However, in JSBACH, the hydrology inside of the plants leading to transpiration is not explicitly described. E.g., the

GMDD

5, C1545–C1565, 2013

Interactive Comment

Full Screen / Esc

Printer-friendly Version

Interactive Discussion

Discussion Paper

model does not contain any leaf water reservoir. The transpiration through plants is simply calculated as a potential evaporation flux of soil water multiplied by a transpiration efficiency factor (please see Eq. 5 in the revised manuscript). The experiment FET is a pure sensitivity study performed to analyze what happens if the entire evapotranspiration flux from soil reservoir would fractionate. We are aware that this assumption does not mimic the natural process . We added a more detailed description regarding this FET simulation at Sect. 2.1 l. 206 of the revised text. Furthermore, in the revised version we have now omitted the reference to the isotopic leaf water composition by Sachse et al. to avoid any confusion on this topic.

“Since the hydrology inside the plants is not described by ECHAM5-JSBACH, the transpired water is modeled as a potential transpiration flux:

T = *C_V*|v_h|*S^-1(q_vap-q_sat)

The factor S^-1 is the transpiration efficiency, which includes among others the stomatal resistance of canopy. A detailed description can be found in DKRZ (1992). Gat (1996) has shown that there is no fractionation between isotopes as roots take up water. This leads to the model assumption that the isotopic composition (R^x_veg) inside the plants is identical to the isotopic composition of the soil water (R^x_ws=R^x_veg). If we assume no fractionation occurring during transpiration, the transpiration isotope flux is calculated as follows:

T^x=R^x_ws**C_V*|v_h|*S^-1(q_vap-q_sat)

To estimate the potential maximum fractionation effect for the combined evapotranspiration flux over land surface, we perform an additional sensitivity study. Here we assume that the equilibrium fractionation occurs during both evaporation and transpiration. As JSBACH model does not resolve the hydrology inside the plants and does not simulate the amount of leaf water, we assume that the whole amount of transpired water can fractionate. This leads to the altered Eq. 10:

GMDD

5, C1545–C1565, 2013

$T\hat{}x=*C\_V*|v\_h|*S\hat{}-1(q\hat{}x\_vap-(R\hat{}x\_ws*q\_sat)/\alpha\hat{}x(T))$.

We are aware that this sensitivity study does not mimic the natural process of isotope changes during transpiration (e. g. described by Sachse et al., 2012). Nevertheless we rate it as a useful for estimating upper limit of isotope changes related to the simulated evapotranspiration in ECHAM5-JSBACH."

Reviewer: 5. The fractionation during transpiration is difficult to justify physically. This experiment is rather an idealized experiment exploring an extreme case. This should be stated explicitly. Later on, the paper compares the model-data agreement of the noF, FE and FET simulations. It is very interesting to compare these 3 simulations, but please clarify that nothing can be concluded about the realism of these simulations. If the FE simulation is not the best, it probably reflects error compensations.

Reply: See comment above. We have now also added a statement on the idealized FET sensitivity experiment in the manuscript part comparing the noF, FE and FET simulations (Sect. 2.2 l. 240).

"The fractionation process over land will be varied between no fractionation (simulation named noF), fractionation occurring during evaporation only (FE), and the idealized setup where fractionation occurring during both evaporation and transpiration (FET)."

Reviewer: 6. How do you treat surface runoff and drainage? If the rain runoffs at the surface, then this runoff has the composition of the rain. In this case, due to water balance, the composition of total evapotranspiration has the composition of the total water inputs into the soil. In contrast, if the soil drains, this drainage has the composition of the soil water which is enriched. In this case, due to the water balance constrain, the total evapotranspiration is more depleted than the total water input into the soil.

Reply: We added the brief description at Sect. 2.1 l. 140 of the revised text:

"The water isotope tracer are almost passive in the land surface scheme JSBACH. So for example, during surface runoff and drainage the stable water isotopes are com-

GMDD

5, C1545–C1565, 2013

pletely passive tracer and are following the normal water. The runoff is calculated as a composition of precipitation and snow melt. The same is valid for the calculation of its isotope ratio. The drainage has the isotopic composition of the soil water."

Reviewer: 7. What do you do for snow melt?

Reply: We assume no fractionation during snow melt. Thus, the melt water has the same isotopic composition as the snow. The melt water is added to the skin reservoir and the soil reservoir, respectively. After these reservoir are filled the residual melt water is added to the runoff. The revised manuscript now includes a description of theses processes (Sect. 2.1 l. 143):

"We also assume no fractionation during snow melt. Thus, the melt water has the same isotopic composition as the snow. The melt water is added to the skin reservoir and the soil reservoir, respectively. After these reservoir are filled the residual melt water is added to the runoff."

Reviewer: 8. How does you implementation of water isotopes compare with other models (e.g. (e.g. Melayah et al. (1996); Riley et al. (2002); Braud et al. (2005); Yoshimura et al. (2006))? What is the degree of complexity compared to these models? For example, do you neglect exchanges with the vapor phase in the soil? The processes that you neglect should be stated more clearly.

Reply: Compared to the sophisticated complex surface models listed by the reviewer, the hydrological model in JSBACH is very simplified. All water reservoirs are described as one-layer bucket models with a prescribed water holding capacity. So, processes like the transport of water inside the plants, exchanges with the vapor phase inside the soil, exchange between, or water at the skin layer (wl) and soil water are neglected in these model. Due to this simplified land-surface model we implement the stable water isotopes almost as a passive tracer in JSBACH. The only exception is the evapotranspiration flux, where we include the fractionation processes. In the new version of the manuscript, the description of the model is more detailed and we tried to add the

GMDD

5, C1545–C1565, 2013

Interactive Comment

simplifications in the description. (please see the revised sect. 2.1)

Reviewer: 2.3) Better explain the results

Reply: Major parts of result part of the manuscript have been re-written. We hope that this new text version is more comprehensible.

Reviewer: This is my major comment. Almost everywhere, it is written that when there is more fractionation at evapotranspiration, #18Op becomes more enriched: examples: p 3390 l 17, p 3391 l 6, p 3396, l 13. I would expect the contrary. The explanation given in p 3390 l26-29 is not convincing. If there is more fractionation at evapotranspiration, then the evapotranspiration should become more depleted. As a consequence, the resulting vapor and precipitation should be more depleted. At the continental scale for example, to first order the water vapor advected from the ocean equals the precipitation over the continent plus the total runoff going back to the ocean. If there is some fractionation during evapotranspiration, then the soil becomes more enriched and so the runoff going back to the ocean becomes more enriched. If the composition of the water vapor advected from the ocean doesn't change, then it means that the continental precipitation needs to become more depleted. This is just mass conservation. If you get the contrary, it suggests a mass conservation problem. The fact that the soil water gets more enriched when there is fractionation cannot ex-plain that the subsequent evapotranspiration becomes more enriched. The subsequent evapotranspiration will always be more depleted. Even in the extreme case of no drainage, whatever how strong the fractionation is, the total evapotranspiration composition will equal the total precipitation composition. If the authors are sure there is no conservation problem in their model, then they need to explain better their results. Some mass balance considerations are necessary. It would be good to plot somewhere the composition of the runoff, or at least to give the global average and compare it to evapotranspiration and precipitation.

Reply: As stated above, we have discovered a serious coding error in our isotope

GMDD

5, C1545–C1565, 2013

Interactive Comment

Full Screen / Esc

Printer-friendly Version

Interactive Discussion

Discussion Paper

code which required a complete rerun of all simulations. The results of the new model version are in much better agreement with the reviewer's arguments on isotopic enrichment (depletion) in soil water (precipitation) for the effect of fractionation during evaporation. We did not find any conservation problem in the model.

2.4) Miscellaneous

Reviewer: 1. l 3377 l23: among other land surface models with isotopes, you can cite Riley et al. (2002); Cuntz et al. (2003); Braud et al. (2005). Among land surface-atmosphere models with isotopes, you can cite Risi et al. (2010)

Reply: We cited Riley et al. (2002), Cuntz et al. (2003), and Braud et al. (2005). Risi et al. (2010) is mainly using the model LMDZ-wiso which is introduced in Risi et al (2010b). As far as we know, a description of the surface model ORCHIDEE-iso, which is referred to in the Risi et el (2010) article, has not been published, yet.

Sect. 1 l. 35: "After the pioneering work by Joussaume et al. (1984), several atmospheric general circulation models (AGCMs) were enhanced with modules for modeling stable water isotopes in the hydrological cycle (e.g., Jouzel et al., 1987; Hoffmann et al., 1998; Noone and Simmonds, 2002; Lee et al., 2007; Risi et al., 2010b; Werner et al., 2011). Further oceanic GCMs (Schmidt, 1998; Xu et al., 2012), coupled atmosphere-ocean models (Schmidt et al., 2007; Tindall et al., 2009), land surface schemes (Riley et al., 2002; Cuntz et al., 2003; Braud et al., 2005; Yoshimura et al., 2006; Fischer, 2006), as well as coupled land surface-atmosphere models (Aleinov and Schmidt, 2006) have also been enhanced with modules of stable water isotopes."

Reviewer: 2. p 3383 l5: what are your motivations for comparing the 2 resolutions? I understand comparing resolutions for an atmospheric model is important and this was done nicely in Werner et al. (2011). But why doing it again here? What are the added value of re-doing itT when coupling with a land surface model? For example, maybe with higher resolution you can better resolve spatial patterns in vegetation distribution?

GMDD
5, C1545–C1565, 2013

Reply: We agree with the reviewer's comment that resolution-dependency is more important for an atmospheric model. However, due to the strong coupling of land surface and atmospheric processes in ECHAM5-JSBACH, we wanted to analyze the performance of this new model for two different model resolutions, too. A higher resolution of ECHAM5-JSBACH allows an improved spatial better in vegetation distribution but also includes a different prescription of the maximum water capacity for soil water (see Sect. 3.1.1 l. 299 of the revised manuscript). By comparing ECHAM5-JSBACH-wiso simulations in T31 and T63 mode with the related stand-alone ECHAM5-wiso simulations, we are able getting a first impression on the resolution-dependency of the isotope results from this new model.

Reviewer: 3. p 3387 l 25: "decrease in the amount of precipitation or an increase in soil moisture": I understand that according to the amount effect, a decrease in precipitation leads to an increase in #18Op. But how does soil moisture affect #18Op? The rationale needs to be better explained in terms of processes. Same p 3388 l 5.

Reply: "p 3387 l 25" is rewritten in the new version: "These anomaly can be related to decrease of in the amount of precipitation in ECHAM5-JSBACH-wiso related to ECHAM5-wiso." (please see Sect. 3.1.2 l. 329)

Reviewer: 4. p 3396 l 1-2: why? with a one layer model with vertically uniform isotopic composition, the surface soil water will be too depleted and the deeper soil water will be too enriched. So the transpiration will be too enriched but the bare soil evaporation will be too depleted.

Reply: We agree with the reviewer and changed the text in the new manuscript version: "Enrichment does mainly occur in the upper soil layers, while water in deeper soil layers, which can be used for plant transpiration, is more depleted. Thus, a one-layer bucked model will most likely result in too depleted isotope values of evaporated and too enriched isotope values of transpired water." (please see Sect. 3.2.2 l. 501)

Reviewer: 5. Can you give more information about the GNIP stations: how many years

GMDD

5, C1545–C1565, 2013

Interactive Comment

Full Screen / Esc

Printer-friendly Version

Interactive Discussion

Discussion Paper

are recorded on each stations? What is their longitude and latitude, or is it possible to show their location on a map?

Reply: For this study we choose 248 GNIP stations where isotope data has been recorded for at least three consecutive years within the time period 1961 to 2008, and where at least 10 months of data per year are available. As a further restriction, we only use stations, which provide a full monthly mean data set, including values of 2 m air temperature, precipitation amount, and the isotopic composition of precipitation. A more detailed description can be found in Sect. 2.3 l. 252. Furthermore, the location of the individual stations is shown in Fig. 3.

Reviewer: 6. section 3.2.2: is it possible to give an idea of the basic performance of the model regarding soil water, evapotranspiration and #18Ows? If not, can you highlight the difficulty of evaluating these variables? In perspective, can you mention some national or international efforts to establish a network of #18Ows measurements? e.g. MIBA (http://www-naweb.iaea.org/napc/ih/IHS_resources_miba.html), BASIN (http://basin.yolasite.com/).

Reply: We do not compare the simulated delta 18Ows with observational data because of two reasons: Firstly, the networks for isotopes in biosphere, like MIBA and BASIN are still under construction. Further the available data is only preliminary and does not represent long term annual mean values. However long term annual mean values would be needed for the comparison. Secondly, since we use the one layer bucket model in ECHAM5-JSBACH, it is impossible to simulate a vertical isotope profile within the soil. Hence a comparison with observed isotope soil water profiles is not feasible. This is added in sect. 4 l. 564:

“At present, it is not possible to evaluate these simulated soil water changes by direct observations. Networks for isotopes in the biosphere, like MIBA (Moisture Isotopes in the Biosphere and Atmosphere) or BASIN (Biogeosphere-Atmosphere Stable Isotope Network), which might also monitor the isotopic compositions of soil water, are still un-

GMDD

5, C1545–C1565, 2013

der construction. Available data is only preliminary and does not represent long-term annual mean values. A potential model-data comparison is further hampered by the simple soil water scheme of ECHAM5-JSBACH. It is well known that the isotopic composition of soil moisture can strongly vary with depth. But since in ECHAM5-JSBACH a one layer bucket model is used, it is not possible to simulate a vertical isotope profile within the soil. It remains open how the simulated isotopic composition in the soil would change for a more complex multi-layer soil scheme and if a better agreement with any observations might be achieved."

Reviewer: 7. You say the noF simulation agrees best with observations. However, from a physical point of view, we know that the most realistic should be the FE simulation. This suggests that they are error compensations. Probably the noF simulation agrees best for the wrong reason. Can you elaborate on that a bit more? This comment is related to my previous comment: to identify the compensation of errors, it would be great to evaluate #18Ows.

Reply: Due this part of the conclusion have been changed completely. Please find the new conclusion in the new version of the paper.

References:

Aleinov, I. and Schmidt, G. A.: Water isotopes in the GISS ModelE land surface scheme, Global and Planetary Change, 51, 108–120, 2006.

BASIN: The Biogeosphere-Atmosphere Stable Isotope Network, http://basin.yolasite.com, last access: 03/07/2013.

Braud, I., Bariac, T., Gaudet, J. P. and Vauclin, M.: SiSPAT-Isotope, a coupled heat, water and stable isotope (HDO and H218O) transport model for bare soil. Part I. Model description and first verifications, Journal of Hydrology, 309, 301-320, 2005.

Cuntz, Ciais, Hoffmann, and Knorr: A comprahensive global three-dimensional model of D18O in atmospheric CO2: 1. Validation of surface processes, Journal of Geophys-

GMDD

5, C1545–C1565, 2013

Interactive Comment

ical Research, 108, 4527, doi:10.1029/2002JD003153, 2003.

Dawson, T. and Ehleringer, J.: Streamside trees that do not use stream water. Nature, 350:335–337, 1991.

Dawson, T. and Ehleringer, J.: Isotopic enrichment of water in the “woody” tissues:

Implications for plant water source, water uptake, and other studies which use the stableisotopic composition of cellulose. Geochim Cosmochim Acta, 57: 3487–3492, 1993.

DKRZ: The ECHAM3 atmospheric general circulation model, Tech. Rep. 6, Deutsches Klimarechenzentrum, Ham-burg, Germany, 1992.

Dümenil, L. and Tondini, E.: A rainfall-runoff scheme for use in the Hamburg climate model. In: Advances in Theoretical Hydrology, A Tribute to James Dooge (Ed. J. P. O’Kane), Elsevier Science, 129–157, 1992.

Ellsworth, P. Z. and Williams, D. G.: Hydrogen isotope fractionation during water uptake by woody xerophytes. Plant and Soil, 291 (1-2), 93–107, 2007.

Fischer, M. J.: iCHASM, a flexible land-surface model that incorporates stable water isotopes, Global and Planatary Change, 51, 121–130, 2006.

Gat, J. R.: Oxygen and Hydrogen Isotopes in the Hydrologic cycle, Earth and Planetary Sciences, 24, 225–262, doi:10.1146/annurev.earth.24.1.225, 1996.

Hagemann, Botzet, Dümenil, and Machenhauer: Derivation of global GCM boundary conditions from 1 km land use satellite data, MPI. Rep. No. 289, Max Planck Institute for Meteorology, Hamburg, Germany, 1999.

Hoffmann, G., Werner, M., and Heimann, M.: Water isotope module of the ECHAM atmospheric general circulation model: A study on timescales from days to several years, Journal of Geophysical Research, 103, 871–896, 1998.

GMDD

5, C1545–C1565, 2013

Interactive Comment

IAEA: Moisture Isotopes in the Biosphere and Atmosphere (MIBA), http://www-naweb.iaea.org/napc/ih/IHS_resources_miba.html, last access: 03/07/2013.

Joussaume, S., Sadourny, R., and Jouzel, J.: A General Circulation Model of Water Isotope Cycles in the Atmosphere, Nature, 311(5981), 24–29, doi:10.1038/311024a0, 1984.

Jouzel, J., Russell, G. L., Suozzo, R. J., Koster, R. D., White, J. W. C., and Broecker, W. S.: Simulations of the HDO and H2 18O Atmospheric Cycles Using the NASA GISS General Circulation Model: The Seasonal Cycle for Present-Day Conditions, Journal of Geophysical Research, 92, 739–760, doi:10.1029/JD092iD12p14739, 1987.

Lai, C.-T., Ehleringer, J., Bond, B., and U, K. P.: Contributions of evaporation, isotopic non-steady state transpiration, and atmospheric mixing on the deltaO18 of water vapor in Pacific Northwest coniferous forests. Plant, Cell and Environment, 29(1), 77–94, 2006.

Lee, J.-E., Fung, I., DePaolo, D. J., and Henning, C. C.: Analysis of the global distribution of water isotopes using the NCAR atmospheric general circulation model, Journal of Geophysical Research, 112, D16 306, doi:10.1029/2006JD007657, 2007.

Lee, X., Kim, K., and Smith, R.: Temporal variations of the 18O/16O signal of the whole-canopy transpiration in a temperate forest. Global Biogeochem. Cycles, 21, GB3013, doi:10.1029/2006GB002871, 2007b.

Mathieu, R. and Bariac, T.: A numerical model for the simulation of stable isotope profiles in drying soils, Journal of Geophysical Research, 101, 685–696, 1996.

Melayah, A., Bruckler, L., and Bariac, T.: Modeling the transport of water stable isotopes in unsaturated soils under natural conditions 1. theory. water resources res., 32, 2047–2054, 1996.

Merlivat, L. and Jouzel, J.: Global Climatic Interpretation of the Deuterium-Oxygen 18 Relationship for Precipitation, Journal of Geophysical Research, 84, 5029–5033, 1979.

Noone, D. and Simmonds, I.: Associations between d18O of Water and Climate Parameters in a Simulation of Atmospheric Circulation for 1979-95, Journal of Climate, 15(22), 3150–3169, 2002.

PJ, T., GR, W., and J-P, B.: Extraction of water from eucalyptus trees for analysis of deuterium and oxygen-18. Plant Cell Environ, 16, 269–277, 1993.

Riley, W. J., Still, C. J., Torn, M. S., and Berry, J. A.: A mechanistic model of H218O and C18OO fluxes between ecosystems and the atmosphere: Model description and sensitivity analyses, Global Biogeochemical Cycles, 16, 1095, 14 PP., 2002.

Risi, C., Bony, S., Vimeux, F., Frankenberg, C., and Noone, D.: Understanding the Sahelian water budget through the isotopic composition of water vapor and precipitation. J. Geophys. Res, 115, D24110:doi:10.1029/2010JD014690, 2010.

Risi, C., Bony, S., Vimeux, F., and Jouzel, J.: Water-stable isotopes in the LMDZ4 general circulation model: Model evaluation for present-day and past climates and applications to climatic interpretations of tropical isotopic records, Journal of Geophysical Research, 115, D12 118, 27 PP., doi:10.1029/2009JD013255, 2010b.

Sachse, D., Billault, I., Bowen, G. J., Chikaraishi, Y., Dawson, T. E., Feakins, S. J., Freeman, K. H., Magill, C. R., McInerney, F. A., van der Meer, M. T. J., Polissar, P., Robins, R. J., Sachs, J. P., Schmidt, H.-L., Sessions, A. L., White, J. W., West, J. B., and Kahmen, A.: Molecular Paleohydrology: Interpreting the Hydrogen-Isotopic Composition of Lipid Biomarkers from Photosynthesizing Organisms, Ann. rev. of Earth and Planetary Science, 40, 221–249, doi:10.1146/annurev-earth-042711-105535, 2012.

Schmidt, G. A.: Oxygen-18 variations in a global ocean model, Geophys. Res. Lett., 25, 1201–1204, doi:10.1029/98GL50866, 1998.

Schmidt, G. A., LeGrande, A. N., and Hoffmann, G.: Water isotope expressions of intrinsic and forced variability in a coupled ocean-atmosphere model, Journal of Geophysical Research, 112, D10 103, 18 PP., doi:10.1029/2006JDoo7781, 2007.

GMDD

5, C1545–C1565, 2013

Interactive Comment

Tindall, J. C., Valdes, P. J., and Sime, L. C.: Stable water isotopes in HadCM3: Isotopic signature of El Nino-Southern Oscillation and the tropical amount effect, Journal of Geophysical Research, 114, D04 111, doi:10.1029/2008JD010825, 2009.

Walker, C. and Richardson, S.: The use of stable isotopes of water in characterizing the source of water in vegetation. Chem Geol (Iso Geosci), 94, 145–158, 1991. Washburn, E. and Smith, E.: The isotopic fractionation of water by physiological processes. Science, 79, 188–189, 1934.

Werner, M., Langebroek, P., Carlsen, T., Herold, M., and Lohmann, G.: Stable water isotopes in the ECHAM5 general circulation model: Towards high-resolution isotope modeling on a global scale, Journal of Geophysical Research, 116, D15 109, doi:10.1029/2011JD015681, 2011.

Wershaw, R., Friedman, I., Heller, S., and Frank, P.: Hydrogen isotopic fractionation of water passing through trees. Hobson GD, Speers GC, Inderson DE (eds) Advances in organic geochemistry. International series of monographs on earth sciences, 32, 55–67, Pergamon Press, New York, 1966.

White, J., Cook, E., Lawrence, J., and WS, B.: The d/h ratios of sap in tree: Implications for water sources and tree ring d/h ratios. Geochim Cosmochim Acta, 49, 237–246, 1985.

Xu, X., Werner, M., Butzin, M., and Lohmann, G.: Water isotope variations in the global ocean model MPI-OM, Geosientific Model Development, 5, 809–818, doi:10.5194/gmd-5-809-2012, 2012.

Yoshimura, K., Miyazaki, S., Kanae, S., and Oki, T.: Iso-MATSIRO, a land surface model that incorporates stable water isotopes, Global and Planetary Change, 51, 90–107, 2006.

Zimmermann, U., Ehhalt, E., and Munnich, K.: Soil-water movement and evapotranspiration: changes in the isotopic composition of the water. Proceedings of the

GMDD

5, C1545–C1565, 2013

Interactive Comment

symposium on isotopes in hydrology, 14–18 November, IAEA, Vienna, 567–585, 1967.

Please also note the supplement to this comment:
http://www.geosci-model-dev-discuss.net/5/C1545/2013/gmdd-5-C1545-2013-supplement.pdf

---

Interactive comment on Geosci. Model Dev. Discuss., 5, 3375, 2012.

GMDD

5, C1545–C1565, 2013

Interactive Comment