Responses to R. Eichinger

For clarity we repeat the reviewer comments in blue italic font and the replies are in black.

In the masuscript "Interannual variability of isotopic composition in water vapor over West Africa and its relation to ENSO", the authors, Okazaki, A. et al., use a global, isotope-enabled climate model, in order to examine the relationship between West African rainfall patterns and ENSO activity. The evaluation of the model with respect to the given region nicely shows that the model is suitable to face the given science question. The analysis method and the sensitivity experiment are well chosen. The relationship with ENSO shows the value of this method for climate reconstructions. The conclusion section as well as some parts of the other sections, however, are somewhat disorganised and require restructuring. Moreover, several minor aspects should be taken into account before publishing. A list of specific comments and some technical corrections is given below.

We thank the reviewer very much for the overall positive and valuable comments.

Specific comments:

1. *P24444 L11f: "As the observations cover relatively short periods" seems to be a rather one-sided reason for choosing to use a model.*
   We added several reasons to use a model in the manuscript. Needless to say, models are indispensable to investigate the physical mechanism in detail, and are useful to compensate facts found in observation data.

2. *P24444 L15: A (half) sentence about the compared time scales of the variability could be added here.*
   Thank you. We modified the sentence as "We compare the simulated and observed variability of $\delta^{18}O$ at daily to interannual timescale".

3. *P24444 L16: The sensitivity experiments should be mentioned here.*
   We mentioned the sensitivity experiments in the text as follows: "Section 4 investigates the factors controlling $\delta^{18}O_v$ at the interannual time scale by analyzing the simulation results and confirms the role of the identified factors by sensitivity experiments".

4. *I would appreciate some brief information about the technical realization of the method*

described in Sect. 2.3.

Thank you for your comment. We used the simulated 6 hourly data for each variable, and the averaged value of each term is shown in Fig. 8. These information is included in the revised manuscript.

5. *P24448 L15-16: "Multiplying Eq. (1) by Rw, subtracting from Eq. (2) yields". The sentence and the procedure is unclear to me.*

   Thank you for your comments. Actually, we have ordered text check service before the first submission of this manuscript, and the English in this document has been checked by at least two professional editors, both native speakers of English (For a certificate, please see: http://www.textcheck.com/certificate/EpmIEi). If this sentence is unclear, we would modify it as "Multiplying Eq. (1) by R_w, and subtracting that from Eq. (2) we obtain". We hope this makes the sentence clearer.

6. *P24449 L14: In order to strengthen your evaluation you could refer to Werner et al. 2011 here, since they write: "According to C. Frankenberg (personal communication, 2010), potential errors in the satellite retrieval algorithms might lead to a general bias of absolute SCIAMACHY Dv values up to 20‰'" However, I am not sure if that also applies for the corrected satellite retrieval you are using.*

   Thank you for pointing this out. According to Scheepmaker et al. (2014), the corrected version of SCIAMACHY is negatively biased on the whole when compared with FTS, which have higher precision and accuracy. In that sense, the model is more negatively biased and the discrepancy from the FTS, which we think is the closest to the truth, is even larger than 20‰. Accordingly we decided to leave this part as it was. Comparison with FTS would be the next of the model-data comparison research.

7. *Sect. 2.2 is missing a couple of information about the model and the simulation: Since convection is very important in the study, the applied convection scheme should be mentioned. Also mention the time stepping and the output time step of the simulation are worth mentioning. Is there a reference for the NCEP SSTs? What initial conditions were used? Please (despite the reference to Yoshimura et al. 2008) add a little bit of information about the way of the implementation of the water isotopologues into the model. This is important regarding e.g. the assumptions that have been made (see e.g. P13 L12-13).*

   We added the information about the model and the simulations as described below. The convection scheme is the Relaxed Arakawa-Schubert Scheme (Moorthi and Suarez, 1992). The main time integration scheme is leapfrog scheme, and temporal resolution of the output is 6h. SST data is the same as the one used in NCEP-DOE Reanalysis 2 (http://www.esrl.noaa.gov/psd/data/gridded/data.ncep.reanalysis2.surface.html) and we

referred Kanamitsu et al. (2002) in the revised manuscript. After a spin-up period of about 10 years with the constant 1979 forcing, the simulation was run from 1979 to 2012 as in Yoshimura et al. (2008). For the sensitivity experiments, we use the same initial condition as the standard simulation. Isotopes processes were incorporated following Joussaume et al. (1984): Isotopic fractionation takes place whenever phase transition occurs. Most fractionation can be assumed to occur at thermodynamic equilibrium, except for three particular cases; surface evaporation from open water; condensation from vapor to ice in supersaturation conditions under -20 deg-C; and evaporation and isotopic exchange from liquid raindrop into unsaturated air. IsoGSM assumes no fractionation when water evapotranspires over land.

8. *In the description of the sensitivity experiment in Sect 2.2: It should be made more clear that the specific fractionation effects are switched off only in certain regions of the model.*

   Thank you for your comments. In the sensitivity experiments, the effect of condensation, evaporation from raindrop, isotopic exchange between droplet and surrounding vapor are all banned.

9. *P24449 L26 – P10 L1: "The correlation between the two figures" Do you mean the δ value at 10°N here? Please make that more precise. Please also state once, what kind of correlation you are calculating (Pearsons?) and what P stands for.*

   We calculated the temporal correlation between the observed and simulated zonally averaged dD (5W-5E), that is, Fig. 2a and 2b. The correlation used is Pearson product moment correlation coefficient, and P stands for significance level.

10. *P24450 L17-19: It would be useful to include the most important values from the table in the text here, too.*

    We included the values in the text as follows: "In the sensitivity experiment E10, the average (-14.9‰ for monsoon season) and standard deviation (1.8‰ for monsoon season) were comparable with the observation (average and standard deviation for monsoon season are -15.2‰ and 1.8‰ respectively), and the correlation was slightly improved."

11. *P24451 L12-22: The last paragraph of Sect. 3.2 is summarizing and concluding Sect. 3.1 and Sect 3.2. Therefore, it should be a separate Section (3.3).*

    We have split Sect. 3.2 into two sections and entitled the latter section as "overview of IsoGSM evaluation".

12. *P24451 L26-P12 L2: Please refer to a figure here.*

    Figure 4 and Figure 5 are referred in the text.

13. *P24452 L26 – P13 L3: The readability of this part could be improved by separating the two points: Analysis period and analyzed quantity. The reasons for the respective choices would be clearer then. Also, Fig. 5 does not show this point! Maybe you mean Fig. 4.*

    Thank you for your comment. We have changed the part to describe analysis period and analyzed quality separately. As for the figure referred here, Fig. 5 is correct. The point we meant to show was that the timing of isotopic depletion starts in June as in Fig. 5. Taking all into account, we modified this part as follows; "As the analysis specifies the contribution of each factor to the change in isotopic composition of precipitable water, the analysis period should start before initiation of isotopic depletion and end at the most depleted point. Under this consideration, the analysis period was June-August to capture the decrease in isotopic composition of precipitable water (Fig. 5). Though our target is the variation in isotopic composition of surface vapor, here we analyze precipitable water because the seasonal variation in the isotopic composition of precipitable water is almost the same as the surface $\delta^{18}O_v$".

14. *P24453 L4-5: "our simulation does not resolve at what height condensation and re-evaporation take place". This point as a reason for the choice of the quantity is not obvious to me. I would appreciate a more detailed explanation.*

    What we want to know here is that what controls the isotopic composition of surface vapor and we should apply the isoflux analysis to lower layer. To do so, condensation and re-evaporation amount in the layer is required. However our simulation does not resolve at what height condensation and re-evaporation take place, preventing us from analyzing the lower layer. We will refine the sentence to make this point clearer in the revised version of manuscript.

15. *P24453 L7. "may be" is very weak here! It should be assured that it is, otherwise, this part of the evaluation would be untenable.*

    Thank you for pointing this out. The correlation between daily column $\delta^{18}O_v$ and surface $\delta^{18}O_v$ is 0.43 at Niamey and the relation is statistically significant at less than 0.1% level all over West Africa in the simulation. Therefore we rephrased the sentence as "should be".

16. *P24453 L16-18: Fig. 8 implies that the overall impact of advection is very low, in comparison to the others. Please state the scientific reason for still carrying out the analysis. Without, it seems pointless to do it.*

    The advection sometimes lowers δ_W and sometimes enriches δ_W, and the effect shown in Fig. 8a is the temporally averaged value. Hence the fact that the averaged value is very low does not readily imply that the impact itself is small. The effect should be subdivided to precisely evaluate the impact. Accordingly we decomposed the effect into that of wind

directions. We will try to make this point clearer in the revised version of manuscript.

17. *P24453 L23: "the southerly flow decreases δw and the easterly flow increases δw". Can you add brief explanations for this behaviour?*

    Yes, we added brief explanation for this in the revised version of the manuscript. Since The impact of southerly flow is negative and that of easterly flow is positive, which means, the southerly flow decreases δw and the easterly flow increases δw.

18. *P24454 L4: It seems like the correlation values R was forgotten here.*

    We meant that "The only term significantly different at 5% significance level other than $(d\delta_v/dt)W$ is the impact of southerly flow". Hence we think R is not necessary to be noted here, but we changed the sentence as written above.

19. *P24454 L16: Something is incorrect here (number, sign or text). A correlation of R<-0.4 is a fairly strong anticorrelation, not a relatively weak correlation.*

    According to textbook of statistics, such as Evans (1996), a correlation value of $0.2<R<0.4$ is suggested to be "weak".

20. *P24456 L7: "ENSO is not the only mode affecting...". Please mention very briefly what others there are.*

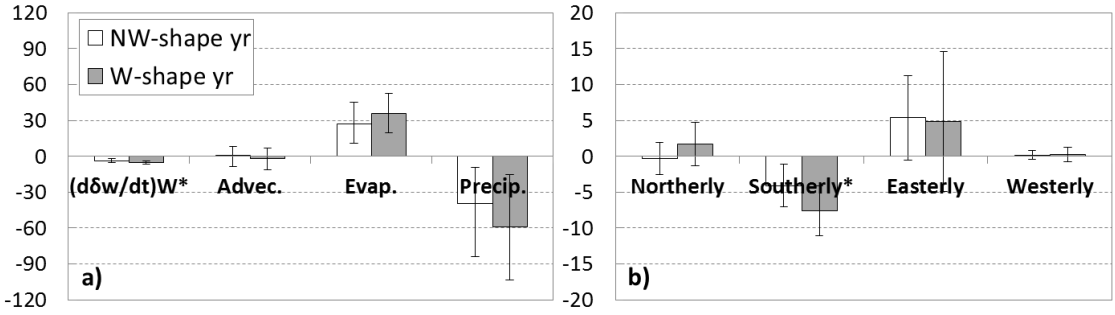
    We added brief information on what affects West African rainfall as follows: "ENSO is not the only mode affecting West African rainfall; Global Warming, inter-decadal Pacific Oscillation (IPO), and Atlantic Multidecadal Oscillation (AMO) are found to have significant impact on West Africa (Mohino et al., 2011a)".

21. *Captions Fig. 1 and Fig. 2: "the average of the average". Which average of which average? Anyway it sounds halting, maybe you can once use "mean" instead. Moreover, I am not sure what you mean by "which consists of measurements taken at least 10 times within 6 h". Maybe: which consists of at least 10 measurements within every 6 h?*

    We changed the sentence following your suggestion as "the mean value of the average, which consists of at least 10 measurements within every 6h". Thank you.

22. *Fig. 8: The display makes it hard to see the absolute quantities, maybe (dotted) horizontal lines could help*

    We have added the dotted-horizontal lines on Fig. 8.



23. *Caption Fig. 8: I am not sure about the unit. Should it not only be "‰d"? Why mm? Plus, SI unit for day is d.*

    The quantity shown in the Fig. 8 is each term either in Eq. (4) or in Eq. (5), and the term consists of ‰ and mm/d (c.f. $(\delta_P-\delta_W)P$). The description of the unit is corrected to "‰mm/d". Thank you very much.

24. *The conclusion Section appears disorganized. E.g. P17 L7-13 and L18-24 are rather a discussion (and kind of outlook) and could be put into the respective Sections (Or a separate discussion section). The last paragraph also is an outlook and has not been discussed before. The chronology of the paper is not represented. A conclusive statement at the end of the paragraph (and therewith the paper) including the meaning of the study with respect to the actual science question is entirely lacking and missing.*

    Thank you for your comments. In the revised version of the manuscript, the last section is greatly improved. We changed the structure of the section; the anterior part summarized the paper in accordance with the chronology of the paper, and discussion and perspective are described in the latter part with a conclusive statement at the end of the section. We have an opinion that it is scientifically worthwhile and necessary to confirm the relation between West African rainfall and isotopic variability at the interannual timescale, which enables us to reconstruct detailed West African rainfall. This should help disentangle the non-stationarity of the various SST basins.

Technical corrections:

1. *P24443 L29: Please provide the equation for how to calculate δ values and the standard for δ18O you are using.*

    The definition of δ has been included in the revised version of manuscript. As for the standard, our model predicts $R/R_{standard}$, and the notion of the standard does not included.

2. *P24447 L22: "…there are no differences in underlying mechanisms to produce changes".*

Please revise the english.

Corrected.

3. *P24447 L27: changes in "the" isotopic composition*

   Corrected.

4. *P24449 L16: "5W-5S" should be: "5W-5E", plus, a half sentence about what region that covers would improve the readability.*

   Thank you very much. Corrected.

5. *P24450 L 4-6: Maybe better: The bias in the mean field and "the" underestimated seasonality are "also" common "in" other GCMs*

   Thank you. Corrected.

6. *P24450 L20: equilibrium fraction"ation"*

   Corrected.

7. *From Sect. 3.2 on: Please always state that you are analyzing isotope "ratios". E.g. P24450 L27ff: Although our target is the isotope ratio of near-surface water vapor, we use the isotope ratio of precipitation to validate model reproducibility of the near-surface water vapor isotope ratio at the interannual timescale.*

   Thank you very much. We checked this part throughout the manuscript and corrected if there are sentences which lack "ratio (s)".

8. *P24451 L2-3: The other "one" is*

   Corrected.

9. *P24452 L3: We term the year"s"*

   Corrected.

10. *P24452 L27: : : :, the analysis period should start before "the" initiation*

    Corrected.

11. *P24454 L3: the impact of "the" southerly flow*

    Corrected.

12. *P24455 L16-17: ...averaged "the" NINO3 index calculated from "the" NCEP SST...*

    Corrected.

13. *P24456 L5: : : : variability of "the" isotopic composition...*

    Corrected.

14. *P24456 L15: ...the relation between "the"isotope ratio...*

    Corrected.

15. *P24456 L25: GCM"s"*

    Corrected.

16. *P24457 L16: equilibrium fraction"ation"*

    Corrected.

17. *Caption Fig. 7: "isotopic composition". Please state that it is δ18O (not another isotope)*

    Thank you. Corrected.

18. *Caption Fig. 8: ...derivative of "the" isotopic...*

    Corrected.

19. *Caption Fig. 10: ...between "the" annual averaged..., "the" simulated… vapor isotope "ratio". 2 times more, please add "ratio"*

    Thank you. Corrected.