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Hydrology and Earth System Sciences Discussions

Interactive comment on "Characterization of the hydrological functioning of the Niger basin using the ISBA-TRIP model" *by* V. Pedinotti et al.

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General comments

The importance of representing floodplains and aquifers within the land surface and river modeling is explained in the discussion paper. The topic is very important for the hydrological modeling studies because incorporation of terrestrial water dynamics becomes possible recently by increasing availability of satellite datasets. The manuscript is scientifically well organized, and the analysis of the results suggests the possibility for improving the modeling system for continental hydrology.

I have one major concern in the proposed research. I personally believe that the deep

aquifer plays an important role in the hydrological cycle of the Niger basin, but the aquifer recharge scheme in the manuscript is only validated against just one in-situ measurement data of aquifer recharge rate. Since the aquifer recharge is a highly localized process, it cannot fully ensure the accuracy of the aquifer scheme in ISBA-TRIP model. I'm afraid that there still exist a possibility that the aquifer routine is just used as the tuning parameter for improving river discharge prediction. For ensuring the robustness of the model, I recommend to include the validation of aquifer scheme using other variables, such as flooded areas or water levels. If the predictability of other variables is improved by activating the aquifer scheme, the robustness of the aquifer scheme can be improved.

I think the manuscript is worth being published in HESS after some revisions. At first, the point described above should be included (or at least the uncertainty is discussed) in the revised manuscript. Other points to be improved are summarized below.

Specific comments

P.9174 L.6: Measurements on surface water and discharge are certainly lacking. However, I think observations of other terrestrial water processes such as groundwater recharge or evapotranspiration are also required for making a further discussion on the effect of aquifer discharge, which is one of the main topics of this manuscript.

P.9174 L.6: The flooding scheme does have an impact on evaporation loss, but it must also have an impact on the timing and amount of flood peak discharge by dumping flood waters in floodplain storages. Is it possible to make discussion on the contribution of the flooding scheme for separating those two effects?

P.9176 L.11: In addition to Dirmeyer et al. (2006) and Sheffield et al. (2008), Kim et al. (2009) recently performed validation of LSMs runoff using a RRM and atmospheric forcing with multi precipitation products. "Kim, H., P. J.-F. Yeh, T. Oki, and S. Kanae (2009), Role of rivers in the seasonal variations of terrestrial water storage over global basins, Geophys. Res. Lett., 36, L17402, doi:10.1029/2009GL039006."

P.9176 L.18: There is an advanced study of satellite altimetry by Enjolras and Rodrigues (2009), which intended to derive water surface elevation of narrow river channels by using likelihood-estimation problem. " Enjolras, V. M., and E. Rodriguez (2009), Using altimetry waveform data and ancillary information from SRTM, Landsat, and MODIS to retrieve river characteristics, IEEE Trans. Geosci. Rem. Sens., 47(6), 1869-1881."

P.9178 L.14 or around: Most recently, Yamazaki et al. (2011) and Paiva et al. (2011) developed new river routing models which explicitly describes floodplain topography and thus predict water surface elevations and discharge from diffusive and full-dynamic equations for 1-D river channels. Those works must be sited as recent developments on river routing models. "Yamazaki, D., S. Kanae, H. Kim, and T. Oki (2011), A physically-based description of floodplain inundation dynamics in a global river routing model. Water Resour. Res. 47, W04501, doi:10.1029/2010WR009726." " Paiva, R. C. D., W. Collischonn, and C. E. M. Tucci (2011), Large scale hydrologic and hydrodynamic modeling using limited data and a GIS based approach, J. Hydrol., 406, 170-181."

P.9180 L.20 Eq.(1): I think the vertical water flux term "(P-I-E)" should be multiplied by the ratio of flooded area to the grid area because "(P-I-E)" is only affective on floodplains.

P. 9183 Sections 3.1 and 3.2: The description on meteorological forcing is confusing. I understood that ALMIP forcing is used for the TRIP simulations without flooding scheme and ISBA-TRIP simulations with/without flooding scheme, while ECMWF-based forcing is used for the ISBA-TRIP simulations with/without aquifer scheme. Is this correct? It may be better to separately describe the experiment on flooding scheme in Section 3.1 and the experiment on deep aquifer scheme Sections 3.2 for avoiding miss-understanding.

P.9185 L.15: Could you please describe the spatial coverage of the MOD09GHK product?

P.9188 L.3: As I commented above, the floodplain also plays a role for attenuating flood wave by storing inundated waters during flooding. This impact is as important as the evaporation loss from floodplain water surface, thus it's worth being mentioned in this paragraph.

P.9188 L.23; or Figure 4: The numbers for model statistics are too small to see. Please enlarge the numbers in Figure 4, or add another table for summarize them.

P.9188 L.6: The purpose of using the 11 LSMs ensemble is not clear, because a similar discussion is also made in the following paragraph and Figure 5 using RFEH forcing. I imagine that you wanted to show that "the change due to flooding scheme is significant because the change due to the floodplain activation is larger than the uncertainty in input runoff given by the LSM ensembles". Is it correct?

P.9189 L.13: Is it possible to include the observation-based validation of evaporation amount? Since aquifer infiltration is only validated by the in-situ observation at one site, comparison between modeled and observed evaporation will improve the robustness of the aquifer scheme.

P.9190 L.9: I cannot find the sensitivity tests for time decay factor and the function "alpha" in the Section 5.

P.9190 L.17: I think aquifer filling ratio has a large locality. It is difficult to make a comparison between local observation and basin-wide modeled value. At least, could you please show the spatial distribution (and inter annual variation if possible) of aquifer filling ratio simulated by ISBA-TRIP model?

P.9191 L.26: The bias of the altimeter can be smaller than 20 cm, but can ISBA-TRIP predict absolute water surface elevations (i.e. height above sea surface)? It seems from Figure 9 that only relative water level change is compared in this study.

P.9192 L.9: When kinematic wave equation is used for discharge calculation, the predictability of water surface elevation becomes bad in flat river basins with floodplains (Yamazaki et al., 2011). In addition to the uncertainty in river bed slope, limitation of the kinematic wave approach should be noted. "Yamazaki, D., S. Kanae, H. Kim, and T. Oki (2011), A physically-based description of floodplain inundation dynamics in a global river routing model. Water Resour. Res. 47, W04501, doi:10.1029/2010WR009726."

P.9193 L.6: Discussion on the role of river water storage can be found in the paper by Kim et al. (2009). "Kim, H., P. J.-F. Yeh, T. Oki, and S. Kanae (2009), Role of rivers in the seasonal variations of terrestrial water storage over global basins, Geophys. Res. Lett., 36, L17402, doi:10.1029/2009GL039006."

P.9193 L.7: Is it possible to make a sensitivity test on the time delay factor in the Section 4.5? I can firstly find the discussion on them in Section 6, even though they are listed in Table 2.

P.9194 L.9: I think sensitivity of water height to the width parameter depends on the condition that whether the site has flooding event or not. When the site has flooding event, the water height change becomes smaller with narrower width because narrower with tend to cause more flooding. While in the site without flooding, narrower width may enhance the water level variation. Could you please check this point?

P.9196 L.5: It is probably better to note that infiltration from river bed to soil is not represented in the model (it only occurs from floodplains to soil, right?), so that simulated river discharge can still be overestimated.

P.9196 L.21: The seasonal cycle of simulated aquifer storage is regulated by the time delay factor for aquifer. Actually, the simulated aquifer storage is theoretically possible to be fitted to the GRACE observation by choosing a certain value for the time decay factor. Since there is no observed value for validating the time delay factor of aquifer, we cannot avoid the possibility that simulated aquifer storage is just calibrated against GRACE.

P.9198 L.13: It's better to include the sensitivity test for time declay factors in Section 4.6. They are firstly discussed in the "Discussion" section even though they are listed in the Table 2 in Section 4.6.

P.9200 L.8: "the spatio-temporal variability of the flooded areas". Is it possible to compare the spatial distributions of flooded area between the model and the observations? It seems only temporal variation is discussed in the manuscript.

P.9202 L.14: How is "the downstream river height loss" calculated? The topographic relief within a 0.5 degree grid-box is too large for describing the river height loss, so that simply using grid-averaged elevation will cause large uncertainty. For more realistic representation of the river height loss, we should include realistic sub-grid-scale topography as done by Yamazaki et al. (2009, 2011). "Yamazaki, D., T. Oki., and S. Kanae (2009), Deriving a global river network map and its sub-grid topographic characteristics from a fine-resolution flow direction map, Hydrol. Earth Syst. Sci., 13, 2241–2251." "Yamazaki, D., S. Kanae, H. Kim, and T. Oki (2011), A physically-based description of floodplain inundation dynamics in a global river routing model. Water Resour. Res. 47, W04501, doi:10.1029/2010WR009726."

P.9203 L.18: I cannot find the description on floodplain width in "Appendix A".

P.9204 L.1: Readers may be interested in how to calculate the depth of floodplains, because it is important variable to calculate river-floodplain water exchange.

Technical Corrections

P.9178 L.7: HYDRA developed by Coe (2000) was run at 5 "arc-minutes" resolution, not at 5 "arc-degree" resolution.

P.9178 L.14: Why don't you start a new paragraph from the sentence " More recently, Decharme et al. (2008, 2011) used this approach". The topic seems to shift to the limitations of Decharme's model for representing the hydrological processes of the Niger basin.

P.9180 L.10: "the Mannungs equation" -> "the Manning's equation"

P.9189 L.16: Where is "Section 5.2b"?

P.9190 L.14: "23 mm 5 mm". Probably the code "plus or minus" is missing,

P.9193 L.14: "Table 1" -> "Table 2"

P.9196 L.18: "see Sect. 5" -> "see Sect. 4.5". I found there are some more confusions between "Section" and "Sub-sections".

Figures 4, 5, 11 and 12: Please enlarge the numbers for statistics, or create another table to summarize them.

Interactive comment on Hydrol. Earth Syst. Sci. Discuss., 8, 9173, 2011.