

Interactive comment on “Potential effects of climate change on inundation patterns in the Amazon Basin” by F. Langerwisch et al.

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Reply to

Comments on “Potential effects of climate change on inundation patterns in the Amazon basin” (Manuscript # HESSD-9-261-2012) by F. Langerwisch, S. Rost, D. Gerten, B. Poulter, A. Rammig, and W. Cramer

Dear Editors,

Thank you for sending us the reviews of our manuscript. We appreciated the constructive comments which will help us to improve the manuscript. According to your instructions we have now written a reply to the referees comments. We will wait for

C1220

your response before we change the manuscript accordingly.

Below, we have addressed each of the referee’s comments separately. According to the referee’s suggestions, we will state the aims in the revised manuscript more clearly; we will restructure the introduction and parts of the methods and we will remove irrelevant parts from the discussion.

Please contact me if you need any further information.

Yours sincerely, Fanny Langerwisch

Response to Comments of Referee #2

General Comments: ‘The manuscript “Potential effects of climate change on inundation patterns in the Amazon Basin” discusses how these potential changes could impact “plant and animal species”. This is indeed an interesting scientific question within the scope of HESS. However, this discussion is very general, the evaluation of the results over the current period is very inconclusive, and therefore these results remain largely hypothetical forward-looking. The link between flooding and biodiversity is widely discussed but is not really the object of the present study. This study is generally disappointing against objectives and targets.’ Reply: In order to improve our manuscript, we will state the objectives and targets of our study more clearly in the abstract and in the introduction (see also comment #1 of referee 1). We will put more emphasis on the evaluation and discussion of our methods and remove paragraphs on biological consequences of the inundation changes.

Specific Comments: 1 Comment: ‘Some sentences are characteristic of the approximations that dot this study; For example: The first sentence of the abstract “A key factor for the functioning and diversity of Amazonian rain forests is annual flooding”. The rain forest functioning and diversity depends on many factors, and only the Igapo and Varzea forests (this last one rapidly disappearing) are affected by flooding, as the terra firme forest, largely preponderant in area, occupies land never flooded (as its

C1221

name clearly states) and therefore does not depend on flooding.’ Reply: For clarification we will change this sentence to “Floodplain forests, namely the Igapó and Várzea, cover about 12% of the central Amazon basin. A key factor for their functioning and diversity is annual flooding.”

2 Comment: ‘Also: “Much of Central Amazonia is influenced by annual flooding caused by snow melt in the Andes and precipitation across the basin”; The part of snow and ice melting in the Amazon flood is anecdotal. Andean glaciers cover only 2000 km². The annual flow of glaciers is estimated at 25 m³ / s, with only 17 m³ / s draining towards the Amazon. This discharge represents little more than a drop of water (actually 0.0081% of the flow of the Amazon) J.-L. Guyot, pers. communication.’ Reply: According to the reviewer’s suggestion, we will change the sentence.

3 Comment: ‘The entire study is based on a false premise: the flooding patterns that are influencing the biodiversity within floodplains are strongly related to the connectivity between the river and the floodplain (Bonnet et al., 2010, 2011). The connectivity is largely dependant on numerous narrow and spatially complex channels, overflowing representing a part very variable with time, seasonally and inter-annually. These characteristics turn impossible to assess these flooding patterns and therefore to investigate their future changes, describing them by a 0.5°lat×0.5°lon gridded model.’ Reply: We agree with the reviewer that the connectivity between floodplain and river depends on small-scale characteristics, such as small channels. We approximate this connectivity on a large-scale of 0.5° by building our analysis on a high resolution digital elevation model (DEM) and thus capture small-scale characteristics. We are aware that this simplification cannot fully represent the actual characteristics of the floodplain. In order to address the limitations and scope of our approach at this scale, which is to estimate changes in basin wide pattern of inundation duration and area, we will add a further paragraph in the discussion section. See also comment #5.

4 Comment: ‘Nothing is new (or very close to nothing) in the methods and the data used. The LPJmL model has been applied in previous studies with a “globally homo-

C1222

geneous flow velocity of 1ms⁻¹ (Rost et al., 2008), which had difficulties to reproduce the Amazonian hydrograph”. A later study has “improved the reproduction of the hydrograph by applying a homogeneously reduced flow velocity of 0.25ms⁻¹ to the Amazon Basin”.’ Reply: Our methods description was obviously misleading. LPJmL originally uses a homogeneous flow velocity of 1.0 m s⁻¹, which leads in the Amazon basin to hydrographs which are about four to six months out of phase with observation. The novelty of our methods is to use adapted flow velocities for each grid cell in the basin calculated from a digital elevation model with particular focus on the Amazon floodplain. We will make this clearer to the reader by changing P265 L24ff and P266 L5ff accordingly.

5 Comment: ‘The present study tries to discriminate flow velocity based on orography. It is well known that discharge and therefore flow velocity in the Amazon basin is not linearly related to slope in a large part of the basin. The method to derive slope from DEM is detailed unnecessarily. The well known Manning-Strickler equation is overly simplified in order to calculate the flow velocity. A complicate method is used to evaluate flow direction in order to assess the inundation areas, while flow direction grids are available in the same dataset that employed to calculate the flow velocity (HydroSHEDS - WWF HydroSHEDS, 2007).’ Reply: Our methods description was probably misleading here. Of course we do not linearly correlate flow velocity with slope, instead we apply the Manning-Strickler equation. We agree with the referee, that in large parts of the basin the inclination is indeed very small which results in small flow velocities. However, in a former version of LPJmL we did not include heterogeneous, but reduced flow velocities of 0.25 m s⁻¹ and have been able to reproduce hydrograph only for some sites. Thus, we were able to improve the reproduction of the observed hydrograph with our new approach. We estimated this velocity based on a high resolution DEM and can thus reproduce some of the variability within our 0.5 × 0.5 degree grid cell. By applying such a high resolution DEM we are able to estimate orographic effects on large basins as the Amazon basin (about 6 106 km² in size), where small-scale measurements are only available for small parts of the area. According to your and referee 1 suggestions,

C1223

we will move the detailed description to the appendix (see also comment #4 of referee 1). We are aware of the flow direction maps also provided by the HydroSHEDS database, but since we had to calculate slope and slope configuration from the DEM, we decided also to use the same DEM to calculate the other parameters we needed to have a consistent database. The main focus of our study was to assess the possible changes in inundation patterns due to climate change. For this purpose we applied the well-known approach of slope-depending velocities calculated using Manning-Strickler to a large-scale basin. We are able to show that a simplified version of the Manning-Strickler equation (with fix k and R) leads to a reproduction of observed hydrographs, which correct time of high and low water peak and correct amount of water. This shows us that the Manning-Strickler equation can be applied on such a large-scale. We will add a further paragraph on a more detailed analysis of an inclusion of other k and R values (in P267 L16ff).

6 Comment: 'The derived inundated patterns are only assessed against global areal values. Studies based on multiple satellite data are ignored while they have long demonstrated the potential of flooding assessment (Decharme et al., 2008 and many studies by Prigent et al., Papa et al., Frappart et al., since this time).' Reply: Our methods description was obviously misleading. We indeed compared simulated inundation patterns against observed data for the Amazon basin from remote sensing products from several sources and regions (Hamilton et al., 2002; Melack et al., 2004; Richey et al., 2002). According to the reviewer's suggestion we will include the above mentioned studies in our assessment.

7 Comment: 'Only monthly data of temperature and cloud cover, linearly daily interpolated, are used, turning the daily time step of the model of little use, especially since the results are evaluated against monthly values of discharge.' Reply: Indeed, the model requires a daily simulation time step to compute core processes such as photosynthesis, water fluxes, and vegetation growth. Since daily climate data directly from GCMs (which are not necessarily better than those produced with a weather generator) and

C1224

also reliable daily discharge observations are often not available and/or since it is computationally too costly to run the model with daily inputs, we had to go the way that is chosen in most large-scale, multiple-scenario studies, i.e. using monthly inputs and recalculate them to quasi-daily values. Whether the treatment of climate data with the present implementation of the weather generator in our model significantly affects simulation results relative to the climate change signal is being investigated in an on-going study (Wallace et al., in preparation). We will add a further paragraph on this in the discussion section.

References Hamilton, S. K., Sippel, S. J. and Melack, J. M.: Comparison of inundation patterns among major South American floodplains, *Journal of Geophysical Research-Atmospheres*, 107(D20), 5/1–5/14, doi:10.1029/2000JD000306, 2002. Melack, J. M., Hess, L. L., Gastil, M., Forsberg, B. R., Hamilton, S. K., Lima, I. B. T. and Novo, E. M. L. .: Regionalization of methane emissions in the Amazon Basin with microwave remote sensing, *Global Change Biology*, 10(5), 530–544, doi:10.1111/j.1529-8817.2003.00763.x, 2004. Richey, J. E., Melack, J. M., Aufdenkampe, A. K., Ballester, V. M. and Hess, L. L.: Outgassing from Amazonian rivers and wetlands as a large tropical source of atmospheric CO₂, *Nature*, 416(6881), 617–620, doi:10.1038/416617a, 2002.

Interactive comment on Hydrol. Earth Syst. Sci. Discuss., 9, 261, 2012.

C1225