Hydrol. Earth Syst. Sci. Discuss.,
doi:10.5194/hess-2016-430-AC2, 2016

Hydrology and Earth System Sciences
Open Access
Discussions

Interactive comment on "Impacts of future deforestation and climate change on the hydrology of the Amazon basin: a multi-model analysis with a new set of land-cover change scenarios" *by* Matthieu Guimberteau et al.

Matthieu Guimberteau et al.

matthieu.guimberteau@lsce.ipsl.fr

Received and published: 28 November 2016

In addition to our answers to the reviewers, we re-wrote a new version of the manuscript which is available in Supplement. In this new version, the additional text is in blue and the deleted one in red.

REVIEWER

Scientific quality:

1) More details on the GCM bias correction and statistical downscaling methods should

be provided. Since the authors are evidently using others' results the methodology descriptions do not need to be exhaustive but the methods used in the referenced papers should be identified so readers do not have to look up the previous work.

AUTHORS

You are right. An additional sub-section (2.2 Climate change scenarios) in the section "Materials and methods" describes now in more details the GCM bias correction and statistical downscaling.

————————-

REVIEWER

2) The LSMs are not adequately or consistently described in the manuscript or supplemental material. It is not clear how the important hydrologic processes are represented, or how they are parameterized, in the three LSMs. Details regarding the spatial and temporal resolutions of the models should be presented in Table 2, along with much more detail regarding how particular hydrologic processes (evaporation, transpiration, unsaturated flow, groundwater flow, overland flow, river routing) are simulated in the models. The description of the models in the supplementary material is qualitative rather than quantitative and focuses most strongly on vegetative processes.

AUTHORS

For each model, we revised the section "Models" in the Supplementary Material and we focused more on the description of the hydrology modeling rather than the vegetation. Moreover, we added the informations of time and spatial resolutions for each model in Table 1 in the new manuscript.

————————-

REVIEWER

3) No evidence is given that the LSMs are able to adequately simulate historic ET and

river fluxes in the study region. The supplemental materials broadly states that two of the three models (LPJmL-DGVM and ORCHIDEE) have been widely tested, but a comparative summary of the three models predictions during the historic period should be presented. Historical rivers flows are included in Figure 14 but no attempt is made to attribute errors in predictions or discuss the relative magnitude of errors among LSMs. Section 3.3.3 discusses differences in LSM predictions in a qualitative way but without knowing specifics of how the processes are simulated in the different models it is difficult to generalize the results beyond this modeling exercise. Since the goal of this manuscript is to understand hydrologic change it is important to show that the hydrologic models make credible predictions of ET, soil moisture, groundwater levels, river flow during the historical time period, and to understand how specific differences in hydrologic representation among the models lead to differences in predictions.

AUTHORS

The three models used in our study are not hydrological models as mentioned in your last sentence. As discussed in point [3] of the response to the Reviewer 3, these LSMs were not calibrated for their hydrological and river routing parameters. In this paper, LSMs are used to evaluate the hydrological response of the vegetation to the climate change and land cover change which cannot be represented by most classical hydrological models. In the new Table S2 in Supplementary Material of the new manuscript, we give the results of comparison (Relative bias, Correlation and NRMSE) between ET and runoff simulated by the three models in present time and the observations. For ET comparison, we used the machine-learning FLUXNET product (Jung et al., 2010) itself uncertain for the Amazon basin because given the small number of flux tower measurements available. The evaluation of historical ET and runoff simulated by the different models over the Amazon basin can be also found in the literature:

- for ORCHIDEE: Guimberteau et al. (2012, 2014)

- for LPJmL-DGVM: Langerwisch et al. (2013)

- for INLAND-DGVM: Dias et al. (2015), Lyra et al. (2016)

We introduced Table S2 and cite these references in section 2.1. of the new manuscript.

References cited:

- Dias L. C. P., Macedo M., Marcia N., Costa M. H., Coe M. T. and Neill C. (2015) Effects of land cover change on evapotranspiration and streamflow of small catchments in the Upper Xingu River Basin, Central Brazil, J. Hydrol.: Reg. Stud., 4, 108-122

- Guimberteau M., Drapeau G., Ronchail J., Sultan B., Polcher J., Martinez J. M., Prigent C., Guyot J. L., Cochonneau G., Espinoza J. C., Filizola N., Fraizy P., Lavado W., De Oliveira E., Pombosa R., Noriega L. and Vauchel, P. (2012) Discharge simulation in the sub-basins of the Amazon using ORCHIDEE forced by new datasets, Hydrol. Earth Syst. Sc., 16, 911-935

- Guimberteau M., Ducharne A., Ciais P., Boisier J.-P., Peng S., De Weirdt M. and Verbeeck H. (2014) Testing conceptual and physically based soil hydrology schemes against observations for the Amazon Basin, Geosci. Model Dev., 7, 1115-1136

- Jung, M.; Reichstein, M.; Ciais, P.; Seneviratne, S.; Sheffield, J.; Goulden, M.; Bonan, G.; Cescatti, A.; Chen, J.; De Jeu, R.; Johannes Dolman, A.; Eugster, W.; Gerten, D.; Gianelle, D.; Gobron, N.; Heinke, J.; Kimball, J.; Law, B. E.; Montagnani, L.; Mu, Q.; Mueller, B.; Oleson, K.; Papale, D.; Richardson, A. D.; Roupsard, O.; Running, S.; Tomelleri, E.; Viovy, N.; Weber, U.; Williams, C.; Wood, E.; Zaehle, S. & Zhang, K. Recent decline in the global land evapotranspiration trend due to limited moisture supply, Nature, 2010, 467, 951-954

- Langerwisch F., Rost S., Gerten D., Poulter B., Rammig A. and Cramer W. (2013) Potential effects of climate change on inundation patterns in the Amazon Basin, Hydrol. Earth Syst. Sc., 17, 2247-2262

- Lyra A. d. A., Chou S. C. and Sampaio G. d. O. (2016) Sensitivity of the Amazon biome to high resolution climate change projections, Acta Amazon., 46, 175-188

———————-

REVIEWER

4) The description of the development of the deforestation scenarios is somewhat confusing. I am not a land use change modeler but it is not clear to me how the results from the participatory process in certain parts of the study region were extrapolated and incorporated into the LuccME and CLUE models, or why two different land use change models were required. The manuscript states (e.g. line 21 p 5 and line 34 p 5) that maps were used to "calibrate and validate the deforestation model", and scenarios were "translated into model parameters" but no details are given on the methods, parameter values or prediction accuracies. I am left wondering how good the land use change models are, and how much the precise spatial distribution of deforestation shown in figure 7 matters, versus a more generic uniform decrease in forest area across the domain. If the actual locations of increased deforestation make a difference to predictions of future hydrologic change this would be interesting.

AUTHORS

We agree with the reviewer. We rewrote section 2.3. to clarify the following points:

- About the participatory process, there was no extrapolation. Two stakeholder workshops were held for discussing the whole Brazilian Amazon future, along four axes: natural resources, social development, economic activities and institutional context. The results are multi-dimensional and rich qualitative storylines. To feed the spatial model of land use, only some selected elements of the storylines were used - mainly concerning to the natural resources theme: (a) deforestation rates; (b) secondary vegetation dynamics; (c) roads and protected areas network; (d) law enforcement. The quantification process for the Brazilian Amazon is described in Aguiar et al. (2016). For the Bolivian Amazon, expert-driven premises about these same selected elements

were adopted - respecting however the Bolivian socioeconomic and political specificities, as explained in Tejada et al. (2015). There were no resources in the project to repeat the participatory process, and it was actually not mandatory to parametrize the model.

- About LuccME and CLUE, we apologize for not explaining it correctly in the earlier version of the manuscript. LuccME is an open source modeling framework that implements a version of the CLUE model. We made it more clear in the manuscript.

- The reason for having regionalized the spatial model (Brazil, Bolivia and the other countries) is now explained in the text. The Amazon drainage basin covers an area of about 7,500,000 km2 (2,900,000 sq mi), or roughly 40 percent of the South American continent. It is located in the countries of Bolivia, Brazil, Colombia, Ecuador, Peru and Venezuela. Each country in the basin has its own socioeconomic and institutional context, and therefore specific aspects to be taken into consideration when building scenarios. To avoid oversimplifications, our choice was generating updated scenarios only in Brazil and Bolivia, the most important deforestation hotspots in the basin. The Brazilian portion of the basin covers approximately 50% of the area, being also where most of the deforestation hotspots have been located in the previous decades. Bolivia has also been facing an intensive deforestation process for agricultural expansion around the Santa Cruz area. For the other countries, existing spatial projections were used.

- We added some additional methodological information in the manuscript. Aguiar et al., (2016) and Tejada et al. (2015) provide further detail about the quantification process, including calibration and validation steps, considering observed spatial patterns. One important thing is that scenarios are not predictions (Raskin et al., 2005), "They are about envisioning future pathways and accounting for critical uncertainties". Therefore, our hydrological analysis results are valid and sound considering the selected land use scenarios and their underlying premises.

—————————-

REVIEWER

The authors present a wide range of results showing how future projections differ based on GCM, LSM and LCC scenario. However it is unclear at the end of my reading of the manuscript what are the dominant drivers of these differences, or what new insights or actionable information has been generated from this study. It would be useful if the authors could synthesize their results to quantitatively apportion uncertainty for various hydrologic predictions among the three sources (GCM, LSM, LCC).

AUTHORS

Thank you for this helpful remark. With the ANOVA framework, we decomposed in the revised manuscript the overall uncertainty in future runoff/ET projections into the fraction of uncertainty that is related/explained by GCMs (climate change uncertainty in our framework), LSMs, LCC scenarios, and by the interactions between these factors. The new Figure 14 gives the different contributions of these factors to total uncertainty in ET and runoff changes for the Amazon basin and eight catchments. We rewrote the section 4.3. and added information in the conclusion to highlight the dominant uncertainty in ET and runoff projections among the three sources.

—————————-

REVIEWER

It might also be interesting to weight the ensemble of future projections based on historical reliability of the GCMs and LSMs and possibly the convergence of their future predictions (see e.g. reliability ensemble averaging (e.g. Giorgi and Mearns, Geophysical Research Letters, 2003; Asefa and Adams, Regional Climate Change 2013).

AUTHORS

Thank you for this remark but the choice to weight the ensemble of future projections

is very controversial (Knutti et al., 2010). In most studies the weighted averages and model spread are similar to those of the unweighted ensemble due to the absence of correlation between the observations used to weight the models and the models' future projections (Knutti et al., 2010). Moreover, in our study, we have only three elements for each source of uncertainties which is not sufficient to weight the ensemble. Thus, we decided not to weight the ensemble of future projections for our study.

References cited:

- Knutti, R. The end of model democracy?, Clim. Change, 2010, 102, 395-404

- Knutti, R.; Furrer, R.; Tebaldi, C.; Cermak, J. & Meehl, G. A. Challenges in Combining Projections from Multiple Climate Models, J. Climate, 2010, 23, 2739-2758

—————————-

REVIEWER

Presentation quality:

[. . .] many of the labels and legends are difficult to read (e.g. Fig 1a, Fig 4 , Fig 8, Fig 13). In addition the figures are quite numerous. It would be helpful if the figures could be reduced and their content synthesized to more succinctly present the study's major findings and conclusions.

AUTHORS

- We improved the labels and legends in the figures in the new manuscript:

* Fig 1a: the axis labels and ticks are made clearer.

* Figs 4 and 7: as suggested by the reviewer 3, we use now one set of legends instead of four with a larger font

* Fig 11: the lines of ET, Runoff and Transpiration are thicker. We changed the color of Transpiration line by a darker green.

- We put the Figures 7 and 12 of the first version of the manuscript in Supplementary Material (now Figs S2 and S3).

Please also note the supplement to this comment:
http://www.hydrol-earth-syst-sci-discuss.net/hess-2016-430/hess-2016-430-AC2-supplement.pdf

---

Interactive comment on Hydrol. Earth Syst. Sci. Discuss., doi:10.5194/hess-2016-430, 2016.