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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.

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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

Major Comments:

[1] Use of the new LCC scenarios is novel in your study. Therefore, it is important to

provide some literature review indicating how different your results are compared to the previous studies. You discuss Siqueira Júnior et al. (2015) in Page 11 Line 32. I suggest you provide this type of examples more often so that the manuscript is well set within the context of the existing literature.

AUTHORS

We agree with the reviewer. In the introduction, we included a more comprehensive explanation about the difference from the previous studies concerning land use scenario modeling. We also explain the need of updated scenarios given the changes in the deforestation dynamics during the last decade.

Concerning the response of the hydrology to Amazon deforestation, there have been several studies addressing the Amazon deforestation effects with models since the late 1980s. Most of these papers describe climate impacts, notably on rainfall (Lejeune et al., 2016; Spracklen and Garcia-Carreras, 2015) based on GCM (coupled) simulations and did not really focus on surface hydrology. In offline mode (thus with an inconsistent treatment of atmospheric feedbacks between LSM water fluxes and CCM water fluxes), the studies published in the literature focused on deforestation effect only for the historical periods.

We found one very recent study (Lamparter et al., 2016) analyzing the impact of Amazon deforestation on the hydrology in offline models using four different scenarios (trend, sustainable, legal and illegal) provided by the LANDSHIFT model during the Carbiocial project. The trend scenario showed an increase of low flows in an upper catchment of the Tapajos, in agreement with our findings. We added this reference in the discussion, in section 4.2.

References cited:

- Lamparter, G.; Nobrega, R. L. B.; Kovacs, K.; Amorim, R. S. & Gerold, G. Modelling hydrological impacts of agricultural expansion in two macro-catchments in Southern

Amazonia, Brazil, Reg. Environ. Change, 2016

- Lejeune, Q.; Davin, E. L.; Guillod, B. P. & Seneviratne, S. I. Influence of Amazonian deforestation on the future evolution of regional surface fluxes, circulation, surface temperature and precipitation, Clim. Dyn., 2014, 44, 2769-2786

- Spracklen, D. and Garcia-Carreras, L. The impact of Amazonian deforestation on Amazon basin rainfall, Geophys. Res. Lett., 2015, 42, 9546-9552

REVIEWER

[2] Include a discussion on why you selected the three models. I have seen that you have provided details about individual models in the supplementary materials, however, a discussion is warranted on why these three particular models were selected. How are the models different from each other and why does that difference matter? Discuss why you think that multi-model approach is better than selecting the single best model (based on historical simulation performance).

AUTHORS

The three models used in our study represent the state of the art in global land surface modeling. ORCHIDEE and LPJmL-DGVM are used e.g. for ISIMIP project (The Inter-Sectoral Impact Model Intercomparison Project, https://www.isimip.org/) that aimed at contributing to a quantitative and cross-sectoral synthesis of the differential impacts of climate change, including the associated uncertainties. INLAND-DGVM has been widely tested over South American biomes to represent the biosphere-atmosphere interactions. Thus, the three LSMs are representative of the diversity of approaches to describe the functioning of the coupled system vegetation-hydrology. Moreover, two out of three models integrate different river routing schemes and are thus able to simulate the change of river discharge with climate change and in interaction with the land cover change. We added this information in section 2.1 of the new version of the manuscript.

We would like to mention also that the best model in present time does not give necessary trustable results in a climatic change perspective, as reported by e.g. Habets et al. (2013). In addition, dominant hydrological processes (and sources of uncertainty from each process) can change between present and future. With the CLSM model, Magand et al. (2015) found that the parameters controlling soil moisture had more influence in the future than in present time, for instance. Under climatic change conditions, they found that the dominant process was no longer related to snow but rather to evapotranspiration model equations. Thus, that is why we did not trust any specific model, and we preferred to adopt a multi-model approach in our paper, recommended by Knutti (2010).

References cited:

- Habets F., Boé J., Déqué M., Ducharne A., Gascoin S., Hachour A., Martin E., Pagé C., Sauquet E., Terray L., Thiéry D., Oudin L. and Viennot P. (2013) Impact of climate change on the hydrogeology of two basins in northern France, Clim. Change, 121, 771-785

- Knutti, R. (2010) The end of model democracy?, Climatic Change, 102:395. doi:10.1007/s10584-010-9800-2

- Magand C., Ducharne A., Le Moine N. and Brigode P. (2015) Parameter transferability under changing climate: case study with a land surface model in the Durance watershed, France, Hydrolog. Sci. J., 60, 1408-1423

REVIEWER

[3] Are the LSMs calibrated? It is really difficult to trust a model if it is not calibrated and evaluated. As you know, model outcomes are subject to vary (often significantly) if the parameter values are changed, given that the model structure is fixed. So, model calibration/evaluation is crucial for any model simulation-based studies.

AUTHORS

The LSMs were not calibrated by adjusting hydrological or water routing parameters. Calibration of LSMs with a routing scheme and rather complex soil-plant water transfer models is a difficult task because of the much higher number of parameters than in hydrological (catchment hydrology) models. Moreover, calibration is site and time specific and does not ensure a good behavior of a LSM in very large catchments, the domain of application of the LSMs. We added the non-calibration information in section 2.1 of the new version of the manuscript.

There are several sources of uncertainty for hydrological models simulations of hydrological change under climate change, in particular due to the calibration. Brigode et al. (2013) found that the hydrological model robustness was the major source of variability in streamflow projections (for 89 catchments in northern and central France) in future climate conditions, leading to difficulties to calibrate hydrological models for climate change studies (i.e. when the climatic space between calibration and validation periods is different). This result corroborates with the findings of Vaze et al. (2010), Merz et al. (2011) and Coron et al. (2012) in other catchments.

Moreover, as we said in the previous point, a "realistic model" in present time does not give necessary realistic results in a climatic change perspective.

References cited:

- Brigode P., Oudin L. and Perrin C. (2013) Hydrological model parameter instability: A source of additional uncertainty in estimating the hydrological impacts of climate change?, J. Hydrol., 476, 410-425.

- Coron, L., Andréassian, V., Perrin, C., Lerat, J., Vaze, J., Bourqui, M., Hendrickx, F., 2012. Crash testing hydrological models in contrasted climate conditions: an experiment on 216 Australian catchments. Water Resour. Res.. http://dx.doi.org/10.1029/2011WR011721.

- Merz, R., Parajka, J., Blöschl, G., 2011. Time stability of catchment model parameters: implications for climate impact analyses. Water Resour. Res. 47, W02531. http://dx.doi.org/10.1029/2010WR009505.

- Vaze, J., Post, D.A., Chiew, F.H.S., Perraud, J.M., Viney, N.R., Teng, J., 2010. Climate non-stationarity – validity of calibrated rainfall-runoff models for use in climate change studies. J. Hydrol. 394 (3–4), 447–457, doi : 16/j.jhydrol.2010.09.018.

REVIEWER

Having said that, I understand that calibrating three LSMs might be difficult. However, you should at least show how consistent the model simulations are. For this study, it would be essential to compare the historical simulations of discharge and ET from all three models against the observed data.

AUTHORS

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.

- 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, Nature Publishing Group, 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

You show historical discharge in Fig. 14, however, one of the three models is missing.

AUTHORS

INLAND-DGVM does not include a river routing scheme and thus cannot simulate river discharge. Only ORCHIDEE and LPJmL-DGVM are able to simulate discharge. To clarify this point, we added the information:

- in the text at line 24, page 12, in section 3.3.5 of the new manuscript.

- in the “Model setup” column of Table 1 of the new manuscript

- in the captions of Figures 12 and 13 of the new manuscript

REVIEWER

Minor Comments:

[1] Page 2 Line 24: Please add citations.

AUTHORS

Added in the text.

REVIEWER

[2] Page 2 Line 27: Please add citations.

AUTHORS

Added in the text.

REVIEWER

[3] Page 3 Line 16: Please state what you have done more clearly. Whether you have used a 3D matrix or not is probably not that important in the introduction section. I suggest you avoid this type of technical detailing in the introduction section and focus on them more in the 'Materials and Methods' section.

AUTHORS

We modified the last sentence of the introduction section to state more clearly what we have done.

REVIEWER

[4] Page 6 Line 2: Any specific reason for selecting these two periods?

AUTHORS

We chose these two periods to have a focus on the middle and the end of the century which present two levels of deforestation very different in our scenarios.

REVIEWER

[5] Page 8 Line 18: I see a huge difference in between-LSM ET simulations. I wonder how much of this variability is attributed to improper model calibration. Any comments?

AUTHORS

LSMs are not calibrated and cannot be at such a large scale, especially for ET because of the high uncertainties in the ET products.

REVIEWER

[6] Page 31 Fig 12: How is the 'range' defined here?

AUTHORS

For a given LSM and each month, the range is defined as the minimum and the maximum values of simulated ET between the three climate change scenarios.

REVIEWER

[7] Page 33 Fig 14: Why are there only two models?

AUTHORS

INLAND-DGVM does not include a river routing scheme and thus cannot simulate river discharge. Only ORCHIDEE and LPJmL-DGVM are able to simulate discharge. To clarify this point, we added the information:

- in the text at line 24, page 12, in section 3.3.5 of the new manuscript.

- in the "Model setup" column of Table 1 of the new manuscript

- in the captions of Figures 12 and 13 of the new manuscript

REVIEWER

Figure Related Comments:

[1] Fig 1a: The axis labels and ticks are not very clear.

AUTHORS

The axis labels and ticks are made clearer.

REVIEWER

[2] Fig 8: The plot legends are too small. Maybe use one set of legends instead of four with a larger font?

AUTHORS

Yes, you are right. We use now one set of legends.

REVIEWER

[3] Fig 13: Maybe change the color for transpiration?

AUTHORS

Done in this figure. Moreover, the lines of ET, Runoff and Transpiration are thicker for better clarity.

Please also note the supplement to this comment:
http://www.hydrol-earth-syst-sci-discuss.net/hess-2016-430/hess-2016-430-AC3-supplement.pdf

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