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Hydrology and Earth System Sciences
Discussions

Interactive comment on "Land cover effects on hydrologic services under a precipitation gradient" *by* Ane Zabaleta et al.

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First of all the authors want to thank the Referee 2 for his comments which are contributing to the improvement of the manuscript. In the following we address the comments. All the changes included in the manscript itself, as well as in the tables and figures are included in the suplement file.

Anonymous Referee #2 This paper, discussing the influence of precipitation and land cover on hydrological indicators, is well-written and fits well within the scope of HESS. There are a few things to clarify though before publication, as listed below.

RC 1: The main things I would like to see more clarified are how the base and 5 other land cover combinations are created

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Discussion paper

AC 1: Land cover combination 0 was defined as a combination with a maximum area of exotic plantations, minimum area of native forests, and a low percentage of pasturelands (calculated as the remaining percentage to cover 100 % of the area). Combinations from 1 to 5 were calculated considering real data (e.g., maximum, minimum, or mean percentages of native forests, exotic plantations, and pasturelands (see Table 2)) and considering the sum of the three as 100 %.

Following the recommendation of both reviewers we better explained this part of the methodology, and the original text: "The different land cover combinations shown in Table 3 were explored under low and high precipitation conditions, and compared to a "base" land cover combination (combination 0) of 76 % exotic, 18 % pastureland, and 6 % native. Land cover combination 0 was defined as a combination with a maximum area of exotic plantations, minimum area of native forests, and a low percentage of pasturelands (calculated as the remaining percentage to cover 100 % of the area). Combinations from 1 to 5 were defined as realistic alternative patterns to combination 0. Differences between these patterns and combination 0 were calculated for each hydrological index under low and high precipitation conditions (Tables 4, 5 and 6). These combinations were defined considering real data (e.g., maximum, minimum, or mean percentages of native forests, exotic plantations, and pasturelands). Defined in this way, each combination was used to examine interactions between realistic data; results for scenarios that might be very different from the existing ones were not extrapolated."

was modified as follows: P7; L2: "The different land cover combinations shown in Table 3 were explored for the catchments, under low and high precipitation conditions, and compared to a "base" land cover combination (combination EXO) of 76 % exotic, 18 % pastureland, and 6 % native. Land cover combination EXO was defined as a combination with a maximum area of exotic plantations, minimum area of native forests, and a low percentage of pasturelands (calculated as the remaining percentage to cover 100 % of the area). Other 5 combinations were defined as realistic alternative patterns to combination EXO as they were calculated considering real data (e.g., maximum,

minimum, or mean percentages of native forests (NAT), exotic plantations (EXO), and pasturelands (PAST) (see Table 2)) and considering the sum of the three as 100 %. Following this approach combination EXO + PAST represents high percentages of exotic plantations and pastureland, combination EXO + NAT high percentage of forest, combination NAT high percentage of native forest, combination NAT + PAST is mostly native forests and pasturelands and combination EXO + NAT + PAST a mixture of average percentages of exotic plantations, native forests and pasturelands. Differences between these patterns and combination EXO were calculated for each hydrological index under low and high precipitation conditions (Table 4). Defined in this way, each combination was used to examine interactions between realistic data; results for combinations that might be very different from the existing ones were not extrapolated."

RC 2: and how dependent your conclusions are on changes in your assumptions (for instance a slight change in those combinations, or using only seasonal instead of 6 month precipitation, etc).

AC 2: Figures 2 and 3 show the effect of different land cover combinations in hydrological indices considering a precipitation gradient. In this sense, it could be considered that slight changes in those land cover combinations, inside the limits of maximum and minimum cover percentage considered for each of them, should give results inside the range of the obtained lines. However, changing land cover percentages out of the real limits could lead to erroneous extrapolation of results. In any case, this type of analysis should be more considered to obtain trends of changes than to obtain numerical absolute results.

Some new text explaining this was included in the new 4.5 subsection: P11; L24: "...the effect of different land cover combinations, apart from those analysed in this paper, and always inside the limits those included in the multiple regression models proposed, on different hydrological services may be applied. Results obtained, should be in the range of those shown in figures 2 and 3, and could be used to compare the benefits and disadvantages in each of the commented services."

Including precipitation of only one season in the analysis does not give significant statistical results. in order to clarify this, in the original text: "..., while for seasonal scale, precipitation of the season studied plus that of the previous season (6 months total) were considered."

The following was added: P6; L33: "..., while for seasonal scale, precipitation of the season studied plus that of the previous season (6 months total) were considered. The statistical analysis was also carried out considering precipitation of the studied season (3 months), however, no statistically significant results were found."

Introduction: RC 3: P2, line 8-10: what is the deforestation in hectares and /or the afforestation in %?

AC 3: Deforestation between 1990 and 2015 reported in the Global Forest Resources Assessment published by FAO in 2016 was about 129 millions of hectares (FAO, 2016).

This data was included in the original text, where it said: "Worldwide, deforestation rates outstrip afforestation by several million hectares per year. Overall global forest cover declined by 3.25% between 1990 and 2015 (FAO, 2016)"

Now it says: P2; L8: "Worldwide, deforestation rates outstrip afforestation by several million hectares per year. Overall global forest cover declined by 3.25% (129 million ha) between 1990 and 2015 (FAO, 2016)"

FAO: Global Forest Resources Assessment 2015: How Are the World's Forests Changing? 2nd Ed., Food and Agriculture Organization of the United Nations, Rome, Italy, 2016.

Study area: RC 4: P3: is the study area a closed drainage network (I assume so) or is there inflow from other / higher regions?

The study area are 20 catchments located in the Gipuzkoa province with no inflow from other areas. In the manuscript, a first general description of the province is included in order to give some general geo-environmental characterization of the area and after,

specific land cover characteristics of the 20 catchments are resumed in Table 1 and Figure 1.

The text in the manuscript was slightly modified in order to clarify this point: Where it said: “The study area is in Gipuzkoa Province (1980 km2) in the Basque Country. . .” Now it says: P3; L14: “The studied catchments are located in Gipuzkoa Province (1980 km2), in the Basque Country. . .”

And where it said: P4; L10: “The study catchments exhibit a diverse mix of land cover types. . .” Now it says: “The catchments studied in this area exhibit a diverse mix of land cover types. . .”

Methodology: RC 5: P4, line 26-30: for clarity you could already indicate here that the land cover for 2002 and 2009 is very similar, to support the ‘merging’ of the two 5-year periods of hydrologic observations

AC 5: In fact, the authors created a unique database that includes both five-year periods, hydrological data are not merged considering one unique land cover distribution. However, land cover data corresponding to hydrological data from 2000-2001 to 2004-2005 is that from the 2002 inventory, and land cover data from the 2009 corresponds to hydrological data from 2007-2008 to 2011-2012.

Original text in the manuscript: “To maintain coherence with land cover data obtained from forest inventories carried out during 2002 and 2009, discharge data was considered for two five-hydrological-year periods. The first period, from 2000–2001 to 2004–2005, was compared with land cover data obtained during 2002 (IFN3, 2005). The second period, from 2007–2008 to 2011–2012, was compared with land cover data from 2009 (IFN4, 2011). In this way, two sets of discharge series, accounting for a total of 10 hydrological-years, were selected for each gauging station. To facilitate comparison among catchment responses, all discharge data, including those for hydrological indicators, are referred to as specific discharges (L s–1 km–2).”

Was slightly modified in order to clarify this point: P4; L28: “To maintain coherence with land cover data obtained from forest inventories carried out during 2002 and 2009, discharge data was considered for two five-hydrological-year periods. Data from the first period, from 2000–2001 to 2004–2005, was compared with land cover data obtained during 2002 (IFN3, 2005). Data from the second period, from 2007–2008 to 2011–2012, was compared with land cover data from 2009 (IFN4, 2011). In this way, hydrological data accounting for 10 hydrological-years were considered for each gauging station. To facilitate comparison among catchment responses, all discharge data, including those for hydrological indicators, are referred to as specific discharges (L s–1 km–2).”

RC 6: P4: line 31: in specific discharge unit L/s/km2 what is L? The letter would indicate a length but specific discharge = discharge / area so L would be a volume?

AC 6: In this case, L refers to a volume, litre, allowed in the SI (international system) and in the manuscript preparation guidelines of HESS. It could lead to confusion in a context in which dimensions are expressed, however, in this case, units are expressed for all dimensions (seconds for time or km2 for area) so that, we do not think it need any clarification in the text.

RC 7: P5, line 29-20: ‘Seasonal precipitation amounts : : : were also computed’, are they also based on estimates from the Environment and Hydraulic Works Department like annual precipitation or do you yourself compute them from the annual precipitation?

AC 7: Seasonal precipitation amounts were computed based on these annual precipitation amounts provided by the Environment and Hydraulic Works Department for each catchment and the seasonal distribution of precipitation in the hydro-meteorological stations listed in Table 1.

In order to clarify this in the manuscript, the original text: “Seasonal precipitation amounts for autumn (AP, mm), winter (WP, mm), spring (SpP, mm) and summer (SuP, mm) were also computed.”

Was modified as follows: P5; L31: “Seasonal precipitation amounts for autumn (AP, mm), winter (WP, mm), spring (SpP, mm) and summer (SuP, mm) were computed based on the annual precipitation amounts for each catchment and the seasonal distribution of precipitation in the hydro-meteorological station listed in Table 1 for each catchment”.

RC 8: P6, line 21-34: this section would be a bit more clear if you switch the paragraph starting in line 30 with that starting in line 25, since the “real values of explanatory variables” in line 23 are the land cover combinations explained starting from line 30 if I understand correctly?

AC 8: In this case, variables are precipitation and land cover types, and the next two paragraphs are explaining how those variables (precipitation first and land cover later) are considered. As in the first equation only precipitation is considered and in the second the equation is extended to land cover, the order selected was the one in the manuscript.

However, in order to clarify this, in the original text: “This allowed for a simple and direct interpretation of the influence of all variables.”

The following was added: P6; L26: “This allowed for a simple and direct interpretation of the influence of all variables (precipitation and land cover types)”.

RC 9: P6 line 25-29: How sensitive are your results to the choice to exclude outliers and to add precipitation of the previous study? i.e. are your conclusions different if you do not exclude outliers and / or only include precipitation of the 3-month season?

AC 9: The objective of the paper was to study the influence of land cover in a natural precipitation gradient. Including extreme values, would give us the response of catchments to extreme, very particular conditions, which, each of them, should be analyzed very carefully and deeply. Moreover, the inclusion of so particular values could bias the relationship between precipitation, land cover and hydrological services.

in order to clarify this, the original text: “To avoid considering outliers, the 1st and 3rd quartiles of the precipitation data series were calculated for the selected period (annual or seasonal) and defined as the low and high precipitation conditions.”

Was slightly modified as follows: P6; L30: “To avoid biased results affected by considering extreme values, the 1st and 3rd quartiles of the precipitation data series were calculated for the selected period (annual or seasonal) and defined as the low and high precipitation conditions.”

The authors do not know what the referee refers to when talking about precipitation of the previous study.

Including precipitation of only one season in the analysis does not give significant statistical results. in order to clarify this, in the original text: “. . ., while for seasonal scale, precipitation of the season studied plus that of the previous season (6 months total) were considered.”

The following was added: P6; L32: “. . ., while for seasonal scale, precipitation of the season studied plus that of the previous season (6 months total) were considered. The statistical analysis was also carried out considering precipitation of the studied season (3 months), however, no statistically significant results were found.”

RC 10: P6 line 30 – P7 line 5: are your 6 land cover combinations the most common ones in the region? If so how much of the area do they represent?

AC 10: The 6 land cover combinations created are based on real data, so that even if the combination itself may not exactly exist in any of the catchments as is, catchments with high percentage of exotic plantations (76 % in Aixola, Table 1); of native forests (66% in Añarbe, Table1); of paturelands (42 % in Urkulu, Table 1) exist. Table 1 shows the real combinations existing in the studied catchments and Table 2 shows the statistics for those land cover types. Additionally, in the study area section some general data for land cover in Gipuzkoa province are also included.

In this sense, the original text in the study area section: "... Forests are the main land use (73 % in 2011) (MAGRAMA, 2013). The original broad-leaved forests (oak–Quercus robur, and beech–Fagus sylvatica), presently reduced to 15 % of their original area, share space with tree plantations of rapid-growth exotic species such as Pinus radiata. These exotic species were introduced in the second half of the twentieth century as a result of government support for afforestation policies."

Was slightly modified as follows: P3; L30: "... Forests are the main land use (63 % in 2011) (MAGRAMA, 2013). The original broad-leaved forests (oak–Quercus robur, and beech–Fagus sylvatica), presently reduced to 15 % of their original area, account for 28 % of the province and share space with tree plantations of rapid-growth exotic species such as Pinus radiata. These exotic species were introduced in the second half of the twentieth century as a result of government support for afforestation policies."

*Note that a correction was also done in the forest type percentage due to incorrect data included in the previous version of the manuscript.

Results and discussion: RC 11: P8 line 20: Table 6 is mentioned before Table 5. Furthermore, you could mention in the table captions that you do not show insignificant results (now I wondered for instance why Table 6 did not include Sp90m – that results for Sp90m are insignificant is only mentioned in later sections).

AC 11: In the new version of the manuscript, and following recomentations of reviewer 1, tables 4, 5 and 6 were merged in one unique table.

About insignificant results not included, a footnote in tables 4, 5 and 6 was already included to mention not significant results are not included in those tables.

RC 12: P8 line 21: I think you refer to figure 2b (Sp50m) instead if 3b (Sp10m)

AC 12: We are very sorry for the mistake, the referee is wright, so that we changed the reference to the figure in the text

Where it said: "Regression results shown in Fig. 3b indicate that native forests,

pasturelands,. . .”

Now it says: P8; L33: “Regression results shown in Fig. 2b indicate that native forests, pasturelands,. . .”

RC 13: P9 line 14-16: what potentials are usually claimed?

AC 13: A potential of reducing high flows has for a long time been attributed to forests in the literature, and some governments have somehow applied this findings. In fact, as literally mentioned in the referenced paper (Robinson et al., 2003) “In February 1995, the Environment Ministers of France, Germany, Luxembourg and the Netherlands adopted the “Declaration of Arles” to take measures to reduce future flood risks, which include land management and forestry (WMO, 1995)”.

Please also note the supplement to this comment:
https://www.hydrol-earth-syst-sci-discuss.net/hess-2018-366/hess-2018-366-AC2-supplement.pdf

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