AUTHORS' RESPONSES TO INTERATIVE COMMENT ON "ON THE SOURCES OF HYDROLOGICAL PREDICTION UNCERTAINTY IN THE AMAZON" BY Anonymous Referee #2

Hydrol. Earth Syst. Sci. Discuss., 9, 3739, 2012.

The authors are please to respond to the comments and suggestions by Reviewer in the following text, in which Reviewers' comments are shown in **bold** typeface, and the authors' replies in *italic*.

AUTHORS' RESPONSES TO COMMENTS BY ANONYMOUS REVIEWER #2.

Reviewer's general comment: This paper is interesting for hydrological forecasting improvements in the Amazonas basin taking into account many gauges into Amazonas drainage. However, three several gaps exist in the presentation of the paper: 1. In the paper describe that they use MGB-IPH model and give a citation by Paiva et al., 2011a. However, is not clear in the paper the skill of this model for hydrological simulations (e.g. Nash in the calibration and validation periods). In hydrological application we need know more details over hydrological simulations before use in hydrological forecasting. 2. Rainfall and discharge in the Amazonas basin exhibit contrasting opposition between its regions (see Espinoza et al., 2009 and Espinoza et al. 2010). Thus, is necessary describing better in the paper the different hydrological regimes into Amazonas basin (e.g. how much are different the parameters using MGB? They have relationship with the regimes?). Thus, discussions and conclusions should be related to these different regimes. Espinoza JC., et al. 2009b. Contrasting regional discharge evolutions in the Amazon Basin. Journal of Hydrology, 375, 297-311. Espinoza JC., et al. Spatio – Temporal rainfall variability in the Amazon Basin Countries (Brazil, Peru, Bolivia, Colombia and Ecuador). International Journal of Climatology, 29, 1574-1594. 3. For this study we use overall assimilation methods (TRMM, CRU, ENVISAT, etc.). Thus, what is the level of uncertainty into Amazonas basin because if are not describing Hydrological models are not more that mathematical tricks. Thus, my opinion is that this paper is acceptable for this journal only if these three points are highlighted in a new version of the paper.

Authors' response: *The authors are grateful for the Reviewer's opinion that the paper is interesting and for the comments that helped us to improve the manuscript. We have made our best efforts to address all corrections suggested.*
From what we understood, the reviewer suggests 3 improvements: i) describing MGB-IPH model skill in the Amazon; ii) Relating results to regional contrasts in hydrological regimes and iii) Discussing on predictability uncertainty due to model structure and parameter error, in addition to initial conditions and meteorological forcing errors that are already discussed in the paper. To meet these suggestions, the following modifications were done:

i) We agree with the Reviewer's opinion that information about model skill is important and we included it in the section "Hydrological Model", as described in the answer to the 8th reviewer's specific comment.

ii)We created a new section (2.1 Amazon River basin) where we provide a description of the Amazon River basin, including its different hydrological regimes following Espinoza et al. (2009a) and Espinoza et al. (2009b), as described in the answer for the second reviewer's specific comment. We also included comments in the discussion of results to relate our analyses to the contrasting hydrological regimes of the Amazon.

iii) As it is stated in the end of the introduction section of the manuscript, the objective of the paper is to " …evaluate the relative importance of hydrologic initial conditions (ICs) and model meteorological forcings (MFs) errors (precisely precipitation) as sources of stream flow forecast uncertainty in the Amazon River basin". We agree that errors in model structure and parameter play an important role in hydrological predictability, although its assessment is not included in the papers objectives. We choose to evaluate only ICs and MFs because we suppose that our hydrological model is already calibrated with sufficient skill and that the main source of errors in a forecast situation would be ICs and MFs. Still, to clarify it, we included the following sentence at the end of "Conclusions" section:

"Other kind of errors, such as in model structure and parameter, may also play an important role in hydrological predictability. However, we choose not to focus on it supposing that the hydrological model is already calibrated with sufficient skill and that the main source of errors in a forecast situation would be in ICs and MFs."

<u>Reviewer's specific comment</u>: p1/21: not reference in abstract

<u>Authors' response:</u> *We removed the reference from the abstract.*

<u>Reviewer's specific comment</u>: INTRODUCTION Rewrite this including differences hydrological regimes between Andes (for Sol Gauge), North (Neg), South-West (Pur and Mad), South (Tap) and global basin (Am). Is not clear in this section what region is explained.

<u>Authors' response:</u> *We created a new section (2.1 Amazon River basin) where we describe the Amazon River basin, including its different hydrological regimes and other characteristics.*

"The Amazon River basin is the largest hydrological system of the world. It has approximately 6 million km^2, is responsible for ~15% of fresh water dumped into the oceans and covers several South American countries, including Brazil, Bolivia, Peru, Colombia, Ecuador, Venezuela and Guiana (Fig. 1a). The Amazon presents three main morphological units, namely the Andes, Amazon plain and the Guyanese and Brazilian shields (Fig. 1). Extensive seasonally flooded areas are found at the Amazon plains (Hess et al., 2003; Papa et al., 2010; Prigent et al., 2007) (see Fig. 1b), which store and release large amounts of water from the rivers and consequently attenuate and delay flood waves into several days or months (Paiva et al., 2011b).

Due to its size, the Amazon basin presents important spatial rainfall variability, as briefly described below following Espinoza et al. (2009a). Extremely rainy regions (more than 3000 mm/year) are found in the northeast, in the Amazon delta exposed by the intertropical convergence zone (ITCZ) and at southeast close to the South Atlantic Convergence Zone (SACZ). Rainfall decreases towards southeast (~1500 – 2000 *mm/year) and also in the Andes as function of altitude (rainfall is generally less than 1000 mm/year in areas over 3000 m). Concerning the seasonal cycle, contrasting rainfall regimes are found in northern and southern areas, with rainy season in June, July and August – JJA (in December, January and February - DJF) in the North (South). Seasonal variability, with defined wet and dry seasons, is present at southern and eastern areas, including Xingu, Tapajós, Madeira, Purus and Juruá river basins, but also at northern areas from Branco river basins (see Fig. 1a). Areas located at Northwest (Maranon, Japurá and Negro river basins) exhibit weaker seasonal regime with large amounts of rainfall rates during the role year (see Fig. 1a).*

Regions with different discharge regimes are also observed in the Amazon, as described by Espinoza et al. (2009b) and as can be seen in Table 1. Rivers draining southern areas such as the Xingu, Tapajós, Madeira, Purus and Juruá (Fig. 1a) exhibit a sounthern tropical regime, with a maximum from March to May (MAM) and a minimum from August to October (Table 1). A northern tropical regime is found at Branco River, where maximum flow occurs during June to August and minimum during December to March. Other rivers have weaker seasonal regimes (see sVC values from Table 1), in some cases due to rainfall characteristics (e.g. Negro and Japura Rivers) and in the Solimões/Amazon main stem, due to the contribution of lagged hydrographs from northern and southern areas. In the latter, high water occurs generally from May to July and low water from September to November and 1-3 months earlier in upper Solimões due to the flood wave travel time."

<u>Reviewer's specific comment</u>: p2/17-24: What region of the Amazonas is describe here

<u>Authors' response:</u> *Uvo and Grahan (1998) and Uvo et al. (2000) developed forecasts for 6 rivers from Brazilian Amazon, including water level at Negro River in Manaus, and discharge at Balbina, Belo Monte, Samuel, Curua-Una and Porteira sites. We modified this sentence and now it reads as follows:*

"Uvo and Grahan (1998) and Uvo et al. (2000) developed seasonal water level and discharge forecasts (March-May period) for 6 river stream gauges in the Brazilian Amazon, including Negro River at Manaus and Belo Monte, Samuel and Balbina reservoirs sites, based on rain gauge data, streamflow data and Pacific and Atlantic Ocean sea surface temperatures (SSTs) using a canonical correlation analysis in the first and an artificial neural network approach in the latter."

<u>Reviewer's specific comment</u>: p2/25: central Amazonia is referenced with what gauge Am???

<u>Authors' response:</u> *Schongart and Junk (2007) developed statistical based forecasts of maximum water levels at central amazon, more precisely at Negro River in Manaus. We modified this part of the manuscript and now it reads as follows:*

"Schongart and Junk (2007) presented retrospective forecasts of the maximum water level in Central Amazonia (Manaus) using El Niño - Southern Oscillation (ENSO) indices."

<u>Reviewer's specific comment</u>: P2/29: hydrological forecast systems not necessary replace by HFS

<u>Authors' response:</u> *Corrected.*

<u>Reviewer's specific comment</u>: METHODS Here exists another gap: in order of explain better the results and understand better the manuscript we need include in this section a description of the data used (6 gauges), mean discharge, mean elevation, drainage area, etc. Include a Table

<u>Authors' response:</u> *We included the following table describing the 6 gauge stations where results are discussed in detail:*

Table 1 –Gauging stations from Fig. 1a with summary of discharge regime, MGB-IPH model skill and results.

ID	*Station*	*River*	*Area ($10^3 km^2$)*	*Qmean ($10^3 m^3/s$)*	*Qmin ($10^3 m^3/s$)*	*Qmax ($10^3 m^3/s$)*	*sVC ($10^3 m^3/s$)*	*ENS*	*T (days)*
Sol 10075000	*Tamshiyacu*	*Upper Solimões*	724	29.5	14.5 (sep)	43.0 (may)	0.35	*0.74*	*37*
Neg 14840000	*Moura*	*Negro*	648	31.4	10.7 (jan)	55.6 (aug)	0.59	*0.65*	*56*
Mad 15860000	*Faz. Vista Alegre*	*Madeira*	1320	26.9	6.5 (sep)	53.0 (apr)	0.65	*0.92*	*53*
Tap 17730000	*Itaituba*	*Tapajós*	461	11.2	3.5 (sep)	22.8 (mar)	0.64	*0.87*	*41*
Pur 13880000	*Canutama*	*Purus*	238	6.4	1.3 (oct)	12.8 (apr)	0.71	*0.91*	*34*
Am 17050001	*Obidos*	*Amazon*	4714	182.8	98.6 (nov)	250.1 (jun)	0.31	*0.77*	*72*

Qmean – mean discharge, Qmin and Qmax – minimum and maximum monthly discharge derived from climatology with respective time of occurrence, sVC – seasonal coefficient of variability computed as the ratio between the standard deviation of monthly discharges and Qmean, ENS – Nash and Suttcliffe index from simulated and observed discharges, T values as described in 2.2 and 3.1.

<u>Reviewer's specific comment</u>: Section 2.1 ESP versus rev-ESP approach need be complete with reference to figure 1 a), b), c) and d); for instance: P4/10: Replace ESP by ESP (Fig. 1a). Same in p4/17, p4/25, p4/27

<u>Authors' response:</u> *We now included references for Fig. 1a, 1b, 1c and 1d as suggested.*

<u>Reviewer's specific comment</u>: Suggestion: Improve the Hydrological model section including MGB parameters and skills for each one gauge

<u>Authors' response:</u> *We agree with the Reviewer's opinion that information about model skill is important. We included the Nash and Suttcliffe index in Table 1 for each* *gauging station where results are discussed in detail. We decided not to include model parameters since this is already discussed in Paiva et al. (2012), where the model calibration and validation is presented and because it would strongly increase the size of the manuscript. We also included the following sentence to provide overall information on model skill:*

"Comparisons between simulations and observations showed relatively high Nash and Suttcliffe index (ENS) values and a good model performance. ENS values were larger than 0.6 in ~70% of discharge gauges (111 sites) and Table 1 shows ENS ranging from 0.65 to 0.91 at the 6 discharge gauging stations analyzed in Section 3.1 (Fig. 1a). Also, ENS values where larger than 0.6 in ~60% of the 212 water level stations derived from satellite altimetry. Similarly, total Amazon flood extent and terrestrial water storage agreed with observations with ENS values of 0.71 and 0.93, respectively."

Reviewer's specific comment: Results need be rewrite taking into account the differences of regimens into Amazonas basin

Authors' response: *We included comments in the discussion of results to relate our analyses to the contrasting hydrological regimes of the Amazon.*

Reviewer's specific comment: Conclusions: Not use the word "speculate" when describe conclusions because if not there are perspectives, please change of word or remove these paragraphs

Authors' response: *We corrected this part of the manuscript to remove this expression.*