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Hydrology and Earth System Sciences Discussions

Interactive comment on "Predictability of soil moisture and river flows over France for the spring season" *by* S. Singla et al.

S. Singla et al.

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Reviewer 2 :

General comments :

The authors performed modeling experiments to estimate the contributions of the initial state (i.e. Soil moisture, snow and aquifer storage) as of January 31 and atmospheric forcings in the soil moisture (SWI) and river flow prediction skill during MAM, over France. Although the method used in this study is similar to a few previous studies, the findings of this work are very valuable. I especially liked that the authors considered the contributions of aquifer storage as well, besides soil moisture, snow cover and

atmospheric forcings. I would recommend the publication of this manuscript however there are some major issues and some minor comments which needs to be addressed by the authors before the publication.

- Response : We thank reviewer 2 for his valuable comments.

Major Issues:

(1) The authors used 9 randomly selected initial states and atmospheric forcings for RIS and RAF experiments, respectively. The objective of choosing 9 random members only is to keep those experiments consistent with Hydro-SF experiment that uses 9 members of the ENSEMBLES ARPEGE meteorological seasonal forecasts. However I think that conducting these experiments (RIS and RAF) with 9 ensembles members only, may not be appropriate. The RIS and RAF experiments (somewhat similar to Reverse-ESP and ESP experiments described in Wood and Lettenmaier (2008)) are conducted to partition the hydrologic (both SWI and river flow) prediction skill coming solely from the atmospheric forcings and the initial state respectively. In order to make sure that the experiments are doing what they are supposed to do it is essential that the distribution of the atmospheric forcings (in RAF experiment) and the initial state (in RIS experiment) is unconditional (random). I am not sure if 9 ensemble members can represent the climatological uncertainty (i.e. unconditional distribution) in the initial state and atmospheric forcings in the experiments. I would recommend authors to consider using about 20 ensembles or more for the experiments (* Li et al., (2009) used 19 members and Wood and Lettenmaier (2008) used 21 members) or demonstrate that the process the authors used to randomly select years for both experiments did not end up selecting years, which are biased towards wetter or drier than normal climatology. (For example, the authors can possibly use the same process to select 2-3 different sets of 9 random years and redo the analysis and compare the results among each set of the experiments). Furthermore it is not clear if the authors used the same randomly selected set of 9 years for both RIS and RAF experiments or different set of years for each experiments.

- Response : Because of the use of the ENSEMBLES dataset, the 9 atmospheric seasonal forecast provide 9 members. So we chose 9 members in order to avoid any biases in comparison of statistical scores. A test using all the 46 years would have been interesting from a theoretical point of view. Because of the constraint related to the ENSEMBLES dataset, it would be relevant to generate several 9 members for RAF and RIS experiments. However, it is not possible to do this in a limited amount of time because of the additional computer cost needed (several 9 members to be done for the 46-year period). So we propose to add a discussion on the absence of bias in the random process, described hereafter. To verify that our random selection did not biased the results toward drier or wetter years, we checked that dry or wet years were not over- or under-represented in the samples. Let's assume that a year is dry if it pertains to the driest 20% of the sample (below lower quintile). Theses years are present in the random selection 18% of the time. For the wetter years (above upper quintile), the percentage is 19,3%. These values are not statistically different (95% confident interval) from the 20%, convincing us that the random selection did not biased the sample. Moreover, we currently use the statistical downscaling method in Boé et al. (2006) and we are testing the influence of the ensemble size on downscaled seasonal meteorological forecasts (from 9 to 90 members). But in the present study, the objective was to give a first overview on what can we done with the hydrometeorological model and its potential.

(2) It is not clear how the percentage of groundwater contribution to spring discharge (Fig. 4) was calculated. Please provide the relevant equations. Also how was the contribution of groundwater separated from the contribution of soil moisture and snow?

- Response : A detailed description of MODCOU and relevant equations can be found in Habets et al. (2008). However we propose to add some details in the paper. The bottom runoff calculated by ISBA depends on soil moisture and is transferred to the aquifer (if is there is one on the same grid box). Surface runoff is routed in the surface model and finally transferred to the river. The snowmelt contribution is an input of ISBA,

that increases the soil moisture and is a contribution to both surface and bottom runoff. As a distributed aquifer model, MODCOU calculate the evolution of the ground water depending on the sources (bottom runoff of ISBA) and sinks (transfer to the rivers). The contribution of groundwater to river discharge is directly calculated by the MODCOU model for each time step and "river" grid meshes. If the groundwater table level is upper than the river level, then water is transferred to the river using a transfert coefficient : Q = TP (H – Ho) with H, the river level ; Ho , the groundwater table level ; TP, a transfer coefficient. The river flow Q exchanged is thus positive when the groundwater gives water to the river and negative for the opposite case The latter case is not implemented in the present version of SAFRAN-ISBA-MODCOU. The percentage of groundwater contribution to spring discharge is the percentage of the amount of water transferred form the aquifer to the river compared to the amount of water flowing at a given station. This part will be explained in more details.

Minor comments:

(1) P 7948: Line 16-18: The value was added in seasonal hydrologic forecasts (SWI and river flow) not seasonal meteorological forecasts. Please revise this sentence.

- Response : corrected.

(2) P7950. L2-5: "For instance. . .. . . (Liang et al., 1994)". This sentence is not clear and not entirely accurate. Not sure if the authors are referring to the hydrologic forecasts systems or the studies conducted to analyze seasonal hydrologic forecasts, but operational hydrologic forecasts system in the United States also often use Noah or SAC models. Please revise this sentence.

- Response : we now specify the sentence. Indeed, we referred to the studies conducted to analyze seasonal hydrologic forecasts only and not operational hydrologic forecasts system.

(3) Page 7957: Line 17-18. Please cite those studies where the Brier score has been

used for the skill evaluation of hydrologic forecasts.

- Response : the Brier Score (BS) is more often used for seasonal atmospheric ensemble forecast than hydrological forecasts yet. However, we add now some references: Thirel, G., Regimbeau, F., Martin, E., Noilhan, J., and Habets, F. : Short- and medium-range hydrological ensemble forecasts over France, Atmos. Sci. Let., DOI: 10.1002/asl.254, 2010. Randrianasolo, A., Ramos, M.H., Thirel, G., Andréassian, V., and Martin, E. : Comparing the scores of hydrological ensemble forecasts issued by two different hydrological models, Atmos. Sci. Let., DOI: 10.1002/asl.259, 2010. Cloke, H.L., and Pappenberger, F. : Ensemble flood forecasting: a review. Journal of Hydrology, 375, 613–626, 2009.

(4) Page 7959: Line 3-5: "Most areas . . .. . .Southern Alps." I think the authors mean that most areas where SM prediction skill came from the initial SM state did not exhibit any skill for river flow. Since the study looks at the prediction skill of both SWI and river flow sometimes the use of the term "prediction skill" or "the skill" is confusing. Please consider clearly stating if the prediction skill refers to SWI or river flow prediction skill in this sentence and several other places in the manuscript.

- Response : we thank reviewer 2 for this valuable remark. So, we now specify in the manuscript what variable prediction skill refers to.

(5) Page 7959: Line 24: "The time correlation:. . . " Please include the figure number associated with this finding.

- Response : done.

(6) Please define acronyms such as SAFRAN, ISBA, MODCOU, ENSEMBLES and ARPEGE for those readers who may not be familiar with those acronyms.

- Response : the acronyms are now defined in the manuscript. - SAFRAN : Système d'Analyse Fournissant des Renseignements A la Neige (for analysis system contributing information for snow). - ISBA : Interface Sol-Biosphère-Atmosphère (for Interactions between Soil Biosphere and Atmosphere) - MODCOU : MODèle COUplé (for coupled model). - ENSEMBLES : there is nor acronym. - ARPEGE : Action de Recherche Petite Echelle Grande Echelle (for Research Project on Small and Large Scales).

(7) Page 7960: Line 5-6: "Conversely to the RAF. . ...." Not sure what authors mean by "worsening of scores". Please make it clear.

- Response : The RIS experiment is not the inverse experiment of RAF, but a complementary experiment. On figure 3, we observed the improvement of river and soil moisture prediction skill over some regions. On figure 5, what is important is the reduction of hydrological prediction skill on these same regions as well as on other regions. This better formulation is now added in the manuscript.

(8) Page 7960 and Table 2. Please explain the contents of Table 2 before discussing it. Also the conclusion based on this table "This means that, in some years, predictability appeared to come from the atmospheric forcing whereas, in other years, predictability came from land surface initial states" was hard for me to follow. Does this mean that the contributions of the initial state and atmospheric forcings in the prediction skill of river flow vary? Please specify how those years when atmospheric forcings showed higher contributions were different than the years when the initial state played a dominant role in the prediction of river flow. Also another comment related to the same paragraph, please consider using either the term "river flow" or "river discharge" in lines 20-21 on the same page for consistency.

- Response : we agree with reviewer 2 and thus explain now the contents of Table 2 as follow. Indeed, the contributions of the land surface initial state and atmospheric forcings vary and depend on years. Thus, when we observe river flow forecasts during one year when atmospheric forecasts contribute more than land surface initial state, the RAF experiment computes better river flows than the RIS experiment. Inversely, when the land surface initial state contributes more one year than another to river flow, the forecasts are better for RIS than RAF. This introduces a predicting skill for specific years. We consider now the term river flow in lines 20-21 for consistency.

(9) Page 7961: Line 4 and 25: Please consider rephrasing these sentences. For example line 4 could be rephrased as "Figure 6 (left) shows the temporal correlation between forecasted SWI using Hydro-SF experiment and its reference value obtained from SIM reanalysis."

- Response : We thank reviewer 2 for the proposed sentence on line 4 which is now corrected as well as on line 25.

(10) Page 7963: Line: 10-11: "Theoretical experiments .....the system". What does the authors mean by the term "internal predictive skill"?

- Response: "internal predictive skill" is indeed the prediction skill of the system compared with the climatology. We compare hydrological forecasts with the reanalysis model runs and not with observations (see first comments of the reviewer 1).

(11) I found it hard to read the labels on color scale of every figure except Fig 1 and 4. Also labels in Fig. 10 are hard to read. Please use bigger fonts.

- Response : bigger fonts are now used.

Interactive comment on Hydrol. Earth Syst. Sci. Discuss., 8, 7947, 2011.