Answer to comments from Referee 1 (anonymous)

N.B.: We responded to each series of comments in separate documents, and provided as supplement the revised manuscript. Since the changes in the manuscript were numerous, we uploaded two versions of it: one with all modifications visible in the revision mode, and the revised version with all proposed modifications accepted, to provide a more readable overlook of the manuscript. Page and line numbers in our responses refer to the document in revision mode.

General comments:

Referee comment

The paper is focus on the assessment of the balance between demand and availability at river basin scale. I consider the paper of potential interest to HESS readership.

Authors' response:

Thank you for your interest in this paper.

Specific comments:

Referee comment

In the proposed basin scale analysis there is not any reference about groundwater resources and the influence that their management (groundwater stress) could have on stream flows (stream depletion due to pumpings).

Authors' response:

The lack of discussion on groundwater was also pointed out by other reviewers. This is indeed a clear deficiency and we included more details and discussion on our account of interconnections between groundwater and surface water in the revised version (see changes in the methods and discussion sections, stated lower).

Referee comment

I think that the hypothesis assumed by the authors to approach groundwater and stream-aquifer interaction within their simulation should be clearly pointed in the paper (in the method and in the limitations described in the discussion). A paragraph about the different stream-aquifer interaction approaches existing in the literature should also be included within the introduction.

Authors' response:

Elements on groundwater and stream-aquifer interactions were added in the Methods and Discussion sections. We also mentioned it in the introduction; however we believe that adding a whole paragraph might unbalance the introduction.

An explanation of our account of return flows was added: it assumes a strong link between surface and groundwater since part of the losses from supply networks and inefficient irrigation techniques were considered to return to surface flow at the outlet of each sub-basin. The part to return to surface flow

was determined, as explained in section 3.3.2: “Return flow rates were tested from 0 to 1 with a step of 0.1 and were calibrated by optimizing goodness of fit criteria including NSE on low flows (…)”.

Authors’ changes in manuscript:

- We added a paragraph in the introduction to emphasize the need to properly account for water withdrawals and water use, and interaction between groundwater and surface water:

p.4, lines 11 to 15:

“Finally, a complex issue is the representation of the interactions between groundwater and surface water, i.e. the use of groundwater resources and the influence that their management could have on streamflow, and the partition of return flows from network losses and inefficient irrigation techniques between evaporation, groundwater recharge and return to surface flow.”

-In the Methods section we added:

-a short description of the GR4j model (section 3.2.2, p.11 lines 34-35): “It simulates streamflow via a production function (which determines effective precipitation, filling a production reservoir) and a routing function.”

-an explanation of our account of return flows (section 3.3.2, p.14 lines 12 to 14): “For each type of water demand, a part of the water withdrawn was considered to return to the environment and*, in fine*, to the streamflow at the outlet of the sub-basin in which the water was pumped.”

-Finally, we added a paragraph in the discussion section (p.25, line 35):

“Another point to consider is the assumption made on groundwater simulation and the groundwater-surface flow links. The hydrological model used in this study does not fully account for groundwater and groundwater-surface flow links. It simulates streamflow coming from both surface and groundwater sources. Other models that properly account for surface water-interactions exist (e.g. Pulido-Velazquez et al., 2007; 2012). However, the application of such models at the scale of the Herault or the Ebro basin is complex, considering the heterogeneity of hydrogeological contexts (e.g. the Herault basin varies from schist to karstic and alluvial zones), and the availability of piezometric data, too sparse in space and in time to allow acceptable calibration and validation of a more complex hydrological model over the 40-year period. Considering the small contribution of groundwater to water supply in the Ebro basin (4%, see CHE (2011)), this modeling issue probably has a limited impact of the simulation of streamflow. In the Herault, the sub-basins of the Vis at Saint-Laurent, Herault at Gignac and Lergue at Lodeve have developed karstic systems, and low flows are comprised almost exclusively of streamflow from karstic springs. Our simulations somewhat underestimate low flows of the Vis at Saint Laurent and the Herault at Gignac, which could be explained by the inability of the GR4j model to represent to complex karstic system. However the main water withdrawal in these areas is by far the Gignac irrigation canal, which takes water directly from the Herault river upstream from Gignac. In the downstream sub-basin of the Herault (the Agde area), most of the water supply comes from the alluvial aquifer a few meters from the river bed. In our simulations, we assumed these withdrawals impacted surface flow directly, since surface and groundwater flows have been showed to be tightly linked in this area (Weng and Dörfliger, 2002).”

References:

Pulido-Velazquez, D., Sahuquillo, A., Andreu, J., Pulido-Velazquez, M, 2007. An efficient conceptual model to simulate water body-aquifer interaction in Conjunctive Use Management Model. Water Resources Research 43: W07407, doi: 0.1029/2006WR005064

Pulido-Velazquez, D., Sahuquillo, A., Andreu, J., 2012. A conceptual-numerical model to simulate hydraulic head in aquifers that are hydraulically connected to surface water bodies. Hydrological Processes 26, 1435-1448.

Weng P., Dörfliger, 2002. N. Projet PACTES — module: contribution des eaux souterraines aux crues et inondations; site de l'Hérault. BRGM/RP-51718-FR.

Referee comment

In some cases too simple stream-aquifer approaches (that not consider spatial distribution of the stresses (pumping far or near to the stream-aquifer hydraulic connection), geometry or aquifer heterogeneity) produce important errors. Could it explain the difference observed in some sub-basin?

Authors' response:

Considering the small part of groundwater in water withdrawals in the Ebro basin (4%, see CHE (2011)), we do not believe this could explain the differences between simulated and observed streamflow in sub-basins of the Ebro. In the Herault, the sub-basins of the Vis at Saint-Laurent, Herault at Gignac and Lergue at Lodeve have developed karstic systems, and low flows are comprised almost exclusively of streamflow from karstic springs. Our simulations somewhat underestimate low flows of the Vis at Saint Laurent and the Herault at Gignac, which could be explained by the incapacity of the GR4j model to represent to complex karstic system. However the main water withdrawal in these areas is by far the Gignac irrigation canal, which takes water directly from the Herault river upstream from Gignac. In the downstream sub-basin of the Herault (the Agde area), most of the pumping is done in the alluvial aquifer a few meters from the river bed. In our simulations, we assumed these withdrawals impacted surface flow directly.

Authors' change to manuscript:

See paragraph added in the discussion, stated previously.

Referee comment:

The paper is well written and organized, although some cite in the text are missing in the "References" section (the author needs to carefully check them again), and there are some minor typos (eg. Pulido-Velasquez instead of Pulido-Velazquez should be corrected within the text and reference list).

Authors' response:

References were checked and typos were corrected.