Answers to the interactive comments from Dr. L.A. Melsen (lieke.melsen@wur.nl).

Firstly, the authors would like to thank Dr. L.A. Melsen for the thoughtful review. Please allow us to answer below the topics and points which you figured out in the interactive comments. Please note that the **RC** stands for the referee comments, **AR** is the abbreviation of author's response and **AC** indicates the author's changes in manuscript. There are 05 major points:

1. The priority to improve the spatial resolution of the routing scheme
   RC: The manuscript clearly demonstrates the uncertainty introduced by forcing data. Furthermore, uncertainty introduced by human impact, and model structural uncertainty in ORCHIDEE have been discussed. Also uncertainty in the concept of the routing scheme are discussed (does not account for stream flow velocity changes, bank overflow, etc.). As a reader, it is still unclear to me why the priority was set to improving the spatial resolution of the routing, rather than to any of these other sources of uncertainty (which are substantial). The results clearly demonstrate that the improvements from the higher resolution routing model are difficult to validate given all the other sources of uncertainty. Continuing on this point, p.3 lines 3-5 refer to the discussion of global hyper-resolution models. This fits well in line with what has been done in this paper, but overlooks the discussion that is going on within hydrological sciences on whether focusing only on increasing the spatial resolution is the best way forward (see e.g. the comment that Beven and Cloke wrote).
   AR: The improvement of the spatial resolution of the routing is the first and necessary step before any further developments of the model. In fact, it provides the basis for further modification of the routing scheme with a focus on the representation of human activities. In addition, only the descriptions of the river basins is improved, the structure of the model is kept the same as in the earlier version. This allows to investigate the importance of catchment delineation in the routing scheme. Modifications to the stream flow velocity, bank overflow, or human impacts can only made after the routing scheme operates at the new high resolution so that value of each improvement can be evaluated. For example, in the earlier version of the routing scheme in the ORCHIDEE model, the parameterization of irrigation and floodplain has already been integrated (De Rosnay et al., 2003; Guimberteau et al., 2012b; d'Orgeval et al., 2008; Guimberteau et al., 2012a). But these representations of human processes or flood plains were based on a hypothesis that HTU were rather large i.e. at scale of $1/2^o$. This is not valid any more and thus these parameterizations need to be revised in order to work with high resolution descriptions of the river basins. For more information at this points, please also consider the answers for minor comment #2 and #4. For more realistic modeling of irrigation operation in the ORCHIDEE model, the new digital global map of irrigation areas should be implemented such as the newest version from Siebert et al. (2013) with the horizontal resolution of 10 km. About the argument of hyper-resolution models, the authors thank the reviewer for the reference from Beven and Cloke (2012), the authors will add more arguments on the part which discuss about the global hyper-resolution models. Nevertheless, since the effect of all uncertainty sources (e.g. epistemic uncertainty) is difficult to separately evaluated, the spatial resolution might be a proper starting point to investigate. The more careful evaluation of the impact of these uncertainty sources on the operation of the river routing scheme is worthy another study.
   AC: In the manuscript, the authors added the information about the irrigation and floodplain representations in the earlier version of routing scheme. After the p.2 lines 30, the authors added: "Especially, the modeling infrastructure of irrigation is integrated in this routing scheme which is validated over the Indian Peninsula (De Rosnay et al., 2003) as well as applied to study the impact of irrigation on the onset of the Indian summer monsoon (Guimberteau et al., 2012b). The representation of floodplains and swamps is also included in this routing scheme in order to study the surface infiltration processes over the West African (d'Orgeval et al., 2008) or evaluate the ability of the ORCHIDEE model to simulate streamflow over the Amazon River basin (Guimberteau et al., 2012a)." About the argument of the hyper-resolution model, after the p.3 lines 8, the authors added:"Certainly, refining grid scale can not resolve the problems of epistemic uncertainties in hydrological predictions thus requires a strong collaboration among the community in order to comprehensively approach this research direction (Beven and Cloke, 2012)."

2. The calibration of the three reservoir parameters

RC: In Section 3.4, three reservoir parameters have been calibrated based on the Rhone data, and subsequently these parameters have simply been applied to all basins. That does make me wonder how sensitive the routing model is to these parameters, and how different the parameters are when calibrated on another basin. I think this is too important to simply step over like is done now.

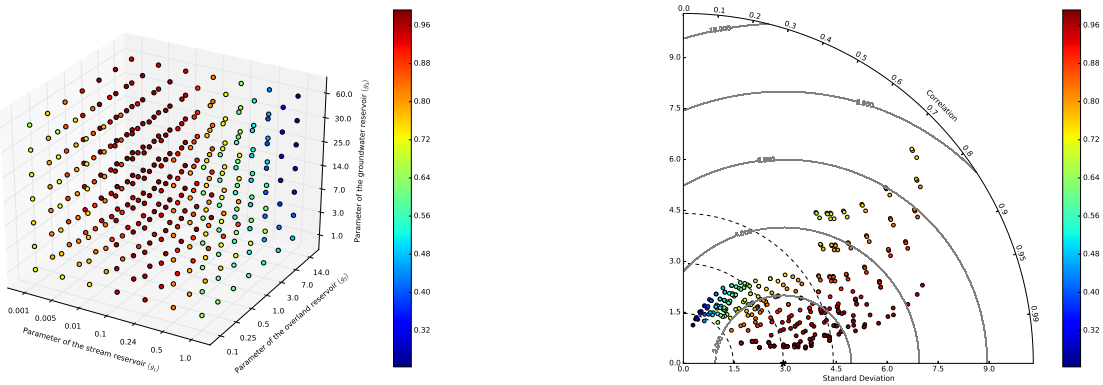
AR: The calibration of three reservoir parameters is definitely an important issue when the routing scheme is particularly applied for a specific catchment. The user of the routing scheme can adjust these parameters to reproduce reasonably the historical observed hydrograph of river discharge at that catchment. However, in this study, we focus on the application of new topography information from the HydroSHEDS data in order to better represent the topographical control on the stream flow speed at a a larger scale and independently of specific issue of individual catchments. The major idea is finding an acceptable parameter set for generic application worldwide. Therefore, the three parameters are calibrated at the station Beaucaire (the Rhone river) with the target of simulating river discharge comparably to the earlier version of the routing scheme. The earlier version of the routing scheme has shown its ability to simulate reasonably well a large number of basins as can be verified in the following references : (Ngo-Duc et al., 2005b, a; De Rosnay et al., 2003; Guimberteau et al., 2012b, a).

AC: *In section 3.4, along with other modification related to another reviewer, the calibration of three parameters based on a theoretical sensitivity test is presented. Figure 1 is added in order to show the sensitivity of the routing model to these parameters. Figure 1 presents the sensitivity of the new routing scheme to the reservoir parameters in a theoretical test at the station Beaucaire (the Rhône river). In this test, the runoff and drainage are not gathered from the soil moisture module of the ORCHIDEE model. During the first 03 days, one $kg.m^{-2}.day^{-1}$ divided up in the runoff and drainage for all grid cells and the analyses are for daily time series of one year. The old routing scheme is used to generate reference case at the Rhône river due to its efficient applications in previous studies (Ngo-Duc et al., 2005b, a; De Rosnay et al., 2003; Guimberteau et al., 2012b, a). The core idea is to determine new reservoir parameter set that can reproduce the same simulated results as the old routing scheme. Both two routing schemes are simulated at the horizontal resolution of 1/2°. In the old routing scheme, the Rhône river basin covers 65 grid cells of the ORCHIDEE model while it is only 48 grid cells in the new routing scheme. The new routing scheme is configured with parameter of stream reservoir (g_1) varied from 0.001 to 1.0 day/km, the overland reservoir parameter (g_2) is from 0.1 to 14.0 day/km and the groundwater reservoir parameter (g_3) is from 1.0 to 60.0 day/km. The higher value of correlation coefficient shown in the Figure 1 (red color) highlights the parameter sets at which the new routing scheme reproduces results closed to the old routing scheme. Determining a specific parameter set also requires the evaluation based on other evaluated metrics such as the root mean square error and standard deviation as shown in the Taylor diagram of Figure 1b. The sensitivity of the simulated discharge to these reservoir parameters requires a comprehensive study which considers more case studies. The theoretical test presented above is a suggestion to the method of determining the reservoir parameters if it is necessary in further study. It also highlights the difficulty to compare the sensitivity between three parameters.*

3. The added value of the DEM and flow direction from the HydroSHEDS

RC: Many results are presented at the monthly time scale. First thing I wondered is the added value of the high resolution routing for the monthly timescale, because in principle all that routing does is delaying the water over time, but given the size of the basins, this effect is expected to be limited on the monthly time scale. So, then the added value of the improved routing is basically only in better delineation of the basins compared to the coarse resolution scheme, for which a complex DEM and flow direction scheme is not necessary. Could you respond to that?

AR: *The major function of the routing scheme is to transfer the water from continent to its outlet at ocean or lake with proper time delay. In the routing scheme presented in this study, the time delay is controlled by the slope index which is calculated based on the complex DEM. The construction of river network for varying spatial resolution of the ORCHIDEE model (e.g. from 1° to 1/8°) is assisted by the flow direction. Therefore, the DEM and flow direction from the HydroSHEDS is necessary for this routing scheme. The time scale of interest for validating the simulated river discharge simulated by a land surface model is usually monthly scale. So the analysis of results is firstly presented at the monthly time scale. Certainly, the construction of river network based on a 1 km hydrography data allows to simulate the streamflow at higher time scale such as weekly or daily. This due to the fact that the capability of representation a*



(a) (b)

Figure 1. Sensitivity of simulated discharge to the varying reservoir parameters based on a theoretical test at the station Beaucaire (the Rhone river). The color shows the Pearson correlation coefficent of simulated discharge between old and new routing scheme. The black star in the Taylor diagram (right) denotes the result from the old routing scheme. The gray arcs are the axis for root mean square error.

river network with a lot of HTUs in the routing scheme as well as the time delay in transferring through these HTUs can reproduce the streamflow variation at frequency of daily or weekly.

AC: Considering all comments from both two reviewer, the section of Discussion is re-written. In which, the role of the complex DEM and flow direction from the HydroSHEDS is emphasized in the river basin construction which allows to flexibly delay the water with various basin size.

4. The analysis on the daily time scale

RC: The analysis on the daily time scale (e.g. Sect 5.3) to discuss model performance seems therefore more relevant, but only shows results in terms of a flow duration curve, and from a flow duration curve it is hard to retrieve timing-information. Is it not possible to include hydrograph-information to demonstrate the simulations versus observations directly?

AR: The timing-information for the analysis on the daily time scale can be retrieved from the evaluation metrics in the Table 3 which includes Pearson correlation coefficient, Nash–Sutcliffe efficiency, Cross-correlation lag time. The statistical metrics to measure differences between time-series is a more clever way for a long simulation period (1979-2013) than plotting daily series. Moreover, there are still a lot of required improvement for the routing scheme (e.g. representation of flood plain, irrigation, dams) if we want to simulate accurately the magnitude and variation of daily streamflow. The daily time series of river discharge are more affected by water management.

AC: No modification in the article.

5. The reconstruction of the conclusion

RC: The current conclusion (sect 7) consists of one paragraph with the results, while the second paragraph is basically only recommendations. I think it would improve the strength of the paper to not end with mentioning everything that is missing still, but describe what has been added with this rrs. Furthermore, the results of section 4 and 5 could be touched upon in the conclusion.

AR: Thank you for the comments from the reviewer. The first idea of the authors is to recall the improvement of the new routing scheme in the Discussion section then to give perspective of further development in the Conclusion section. The authors will be reorganize the arguments between section 4, 5 and 7.

AC: The conclusion is modified as the suggestion from the reviewer.

The corrected 06 minor points are:

1. The duplicate of figure caption
   RC: General; there is a tendency throughout the manuscript to describe the figure legend in the main text (see e.g. p.8 l.15). This is not necessary and makes the manuscript less nice to read. Describe the legend in the figure caption and the conclusions from the figure in the main text.
   AR: Thank you for your comments. The authors will remove the redundant description of the figure legend in the main text.
   AC: The description of the figure legend are removed from the main text (e.g. see p.10 l.23...).

2. The confusion of neglected anthropogenic processes in the ORCHIDEE model
   RC: As not being very familiar with the models discussed in the Introduction, I don't see the logic between the section starting on p.2 l.7 and the section on p.2 l.20. The first section says: ".. redistribution in turn can feed other processes in the LSM (floodplain evaporation, irrigation). Then it continues to describe how post-processing routing schemes neglects feedback interactions between river discharge and soil hydrology. In the second section, the ORCHIDEE routing is described, but as far as I could find in the manuscript, this routing also does not account for floodplain evaporation, irrigation, or river discharge / soil hydrology interaction. Therefore this is confusing to the reader.
   AR: Thank you for the comment from the reviewer. As mentioned above in the answer for the major comment #1, the representations of floodplain and irrigation exist in the earlier version of the ORCHIDEE model. These parameterizations are switched off because their hypothesis are incompatible with the high resolution. They will be revised and added again once the high resolution routing is operational. The authors will provides this information in the Introduction part of the article.
   AC: The authors added the information of the floodplain and irrigation representation in the earlier version of the ORCHIDEE model after p.2 l.30.

3. The color of the Figure 1.
   RC: Figure 1: the red colour appears in the legend, but is also used to indicate the regions of this study. It is unclear if the red colour then still refers to the legend colour too.
   AR: The authors will use another color palette without red color for displaying the area of river catchments. The red color is still used to emphasize the 12 researched rivers.
   AC: The color of the Figure 1 in the manuscript is modified as the Figure 2 below.

4. The representation of irrigation and floodplains in the ORCHIDEE model
   RC: p.6 l.7: it is unclear how this scheme allows for irrigation withdrawal and flood plains. Perhaps elaborate on that. Furthermore, it is correct that irrigation is not accounted for in this study, right? If the routing allows for that, why was it excluded in a application in a region where irrigation is expect to play an important role?
   AR: The information of representation of irrigation and floodplain in the ORCHIDEE model is provided in the Introduction as the minor comment number #2. Yes, the irrigation is not accounted for in this study. The routing allows for that but only for the earlier version which is limited by river map at the $1/2^o$ resolution. For the new routing scheme, it is required a lot of modification in the routing scheme in order to integrate the irrigated area map to simulate the irrigation operation. Indeed, this study not only emphasizes the importance of the irrigation representation in the routing scheme but also provides the foundation for further integration of irrigation in the routing scheme.
   AC: Due to the modification in the Introduction, there is no modification in the p.6 l.7.

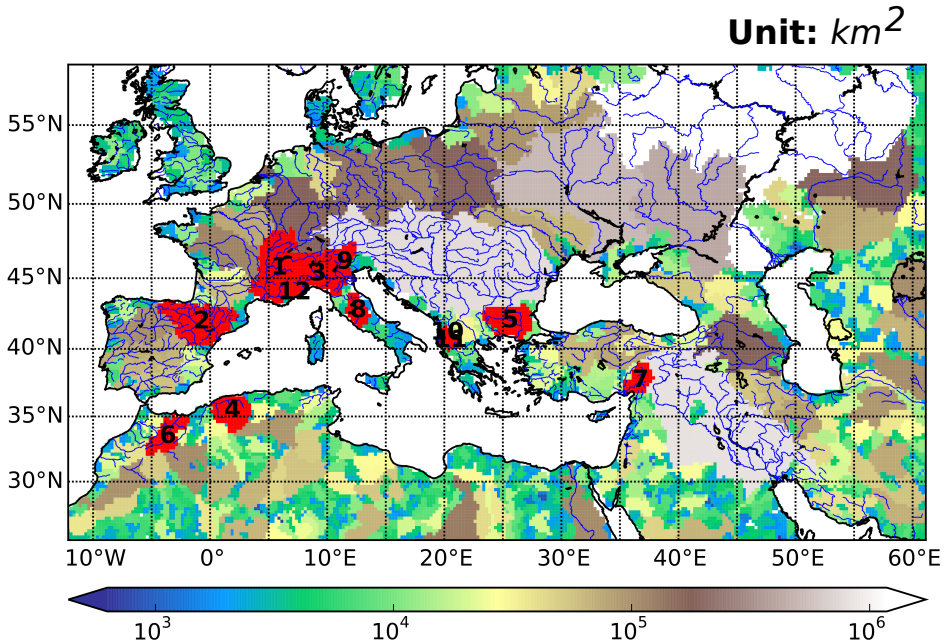


Figure 2. Extended simulation domain. The main watersheds are colorized as a function of maximum upstream area (km^2). They were extracted for an ORCHIDEE resolution of 1/4°, with a threshold HTU number of 50. The twelve studied river basins are colored in red. They are numbered from 1 to 12, and the corresponding names are given in Table **??**. The river network is plotted in blue based on the dataset from the Generic Mapping Tools (http://gmt.soest.hawaii.edu). River names are Rhône, Ebro, Po, Chelif, Maritsa, Moulouya, Ceyhan, Tiber, Adige, Shkumbinit, Devollit, Var corresponded to number from 1 to 12, respectively.

5. The spectrum analysis
   RC: p.14 l. 28 I am not familiar with the power spectrums discussed here. Perhaps some more information on this methodology can be provided, and what the implications of the results are.
   AR: The authors will provide more arguments with references in order to give more information on the spectrum analysis.
   AC: More arguments about power spectrum analysis are provide in the paragraph starts at p.14 l.28.

6. A strong statement in the Discussion
   RC: p.17 l. 15 I don't see how the results support this (strong) statement.
   AR: The argument which the reviewer mentioned is: "The fact that the new RRS explicitly accounts for the higher quality topographical information from HydroSHEDS probably compensates the disadvantage of using simple reservoir parameters for all rivers, which is a legacy from the old RRS." Higher resolution topographical information was brought to the model without changing the simple reservoir based flow model, in order to be able to evaluate its impact on the quality of the model independently of the hypothesis in the flow model. In a second stage the flow model can be improved and floodplains or irrigation added. They will then take full advantage of the improved topographic information.
   AC: The statement is refined as: "The new RRS which explicitly accounts for the higher quality topographical information from HydroSHEDS improves the simulated discharge although we use a simple reservoir model for the flow and the same parameters for all rives, which is a legacy from the old RRS."

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