Note: The original comments by Referee 1 (R) are in regular text. Replies by the authors

(A) are colored in green and changes in the text are in italics.

A: We thank the Referee for the very helpful advices and constructive critic. With their help we could improve the text readability and eliminate the unclear and partly mistakable parts, especially in the description of the study sites and the methodological part.

R: General comments: The paper presents an analysis of climate change impacts for some selected river basins of Africa, and is among a few that give a detailed comparative analysis of the impacts on a regional basis. The manuscript is well structured and technically sound, although there is a need for more clarity on many statements included, which sometimes prove to be false. The text, especially on the description of the study sites and the methods, could be significantly revised to avoid repetition and contraction of ideas.

Specific comments:

P13009, L10-14: This paragraph needs to be clarified with more evidences to prove the veracity of the statements included. "The basins of the Niger, Upper Blue Nile, Ubangi and Limpopo were chosen because they cover most of the water management infrastructure African climate zones". Which climate zones are you referring to and based on which classification? Could you please show these climate zones and how the basins chosen represent them all? This is very important as it determines the validity of the comparative analysis done in this study.

A: We agree with referees 1 and 2 that the justification for the selection of the basins was insufficient and the terminology of climate zones not exact as we refer to climate groups. We revised the whole paragraph, showing that the basins cover all major climate groups of Sub-Saharan Africa in the classification of Köppen (1900) after Strahler (2013). In addition, we explain in more detail the types and subtypes of the climate of each basin:

P13009, L10-11*"The selected basins of the Niger, Upper Blue Nile, Oubangui and Limpopo are distributed over all Sub-Saharan Africa, in the West, East Center and South (Fig.1). In addition they cover all climate groups of Sub-Saharan Africa according to the Köppen (1900) classification after Strahler (2013). Besides the tropical humid climates (A), dry climates (B), subtropical climates (C) and highland climates (H) they also cover most of the climatic types and subtypes of the continent. The Niger Basin cuts across all major climatic zones of West Africa, including the Guinean or Equatorial forest zone and the transitional tropical belt (Aw), the Sudan Savanna zone and the semi-arid or Sahel Savanna belt (BSh), and the desert region (Bwh) (Grijsen et al., 2013). The Upper Blue Nile basin represents the temperate highland climates (H) and the tropical dry and wet savanna climates of the low lands of East Africa (BSh and Aw) (Melesse et al., 2011). The transitional tropical climate of the Oubangui basin spreads over both tropical-humid climates of Central Africa (Aw,Af) (Wesselink et al., 1996). The Limpopo basin in the South-East of the continent is predominantly semi-arid (BSh, BSk) with the river valley being arid (BWh). The South African* *part of the basin is temperate with summer rainfall and cool to hot summers (Cwc, Cfa, Cwa,) and the Mozambiquian coastal plain is mainly warm-temperate with no dry season and hot summers (Af) (FAO, 2004)."*

Grijsen, J. G., Brown, C., Tarhule, A., B., Y., Taner, ., Talbi- Jordan, A., N., H., Guero, A., Y., R., Kone, S., Coulibaly, B. and Harshadeep, N.: Climate Risk Assessment for Water Resources Development in the Niger River Basin Part I: Context and Climate Projections, in Climate Variability - Regional and Thematic Patterns, edited by A. Tarhule, InTech, doi 10.5772/56707, 2013.

Köppen, W.: Versuch einer Klassifikation der Klimate, vorzugsweise nach ihren Beziehungen zur Pflanzenwelt, Geogr. Zeitschrift, 6, 593-611, 1900.

Melesse, A. M., Abtew, W., Setegn, S. G. and Dessalegne, T.: Hydrological Variability and Climate of the Upper Blue Nile River Basin, in Nile River Basin, edited by A. M. Melesse, pp. 3–37, Springer Netherlands, 3-37, 2011.

Strahler, A.: Introducing Physical Geography, Wiley, pp. 664, 2013.

R: P 12009, L11-12: "In addition, they are all highly dependent on the weather conditions, as their economy is mainly based on the primary sector". I do not understand this. You may want to rephrase the sentence to clearly explain the idea.

A: P 13009, L11-12: We agree that this sentence is confusing and not substantial for the study. Therefore we deleted it.

R: P13009, L15-18: This entire paragraph is very confusing and contradicting. Please note that heterogeneity is often related to media properties or physical features of the natural system such as topography, soil characteristics, geology and vegetation, and not to fluxes.

A: The sentence is indeed confusing and we changed it:

P 13009, L15-18: *"However, the diverse climates, topographical and geological conditions, soils, and vegetation types result in characteristic hydrological conditions in each of the basins. This can exemplarily be seen in the broad spectrum of runoff coefficients in the catchments, ranging from about 2% in the Limpopo catchment to 21% in the Oubangui (Fig. 1 and Table 1)."*

R: P13009, L19-L26: Again another contradiction with regard to the previous paragraph in which you talk about the uniqueness of the hydrological regime for each of the basins under study. Here I think there is need for you to revisit the classification of both climate zones and hydrological regimes for the basin under study. There is need for you to clearly prove that these basins are representative of most of the climate zone in Africa.

A: We agree and revised the complete paragraph. Please see response to comment on P13009, L15-18.

R: P13010, L7: You may want to use Oubangui as it appears in many official documents.

A: We thank the referee for this advice and change the spelling of “Ubangi” to “Oubangi” in the text, tables and figures.

R: P13010, L7: This information is not true. Please note that the Congo Basin has four main tributaries, namely: Oubangui (north east), Sangha (north west), Lualaba (south east), and Kasai (south-west) which all pour flows into the main trunk of the Congo River, and Oubangui is far from being the second largest, both in terms of discharge and the drainage areas. Please see Tshimanga (2012), and Tshimanga and Hughes (2012) for more information.

A: We correct the information and change the sentence:

P13010, L7-8: *“The Oubangui River is a main tributary of the Congo River in the north-east part of the basin.”* The proposed citations with information about the Oubangui basin have been added at the end of the paragraph:

P13010, L13-15: *“The Oubangui basin is the least investigated of all four African basins and data is - even for African conditions - sparse (Tshimanga, 2012, Tshimanga and Hughes, 2012, Shanin, 2002; Wesselink et al., 1996).”*

Tshimanga, R.M., 2012. Hydrological uncertainty analysis and scenario based streamflow modelling for the Congo River Basin. PhD thesis, Rhodes University repository. South Africa.

Tshimanga, R.M. and Hughes, D.A., 2012. Climate change and impacts on the hydrology of the Congo Basin: the case of the northern sub-basins of the Oubangui and Sangha Rivers. Physics and Chemistry of the Earth 50–52 (2012) 72–83.

R: P13010, L10: Please be more explicit here. What do you refer to as regional rainy season?

A: As regional rainy season in the Oubangui basin we refer to the months between March and November. We change the sentence for a better understanding:

P13010, L10 *“Its hydrological regime follows the rainy season from March to November, with highest discharges from August to December and a total annual rainfall between 1300 mm/yr and 1700 mm/yr.”*

R: : P13011: Mm−3, what is this?

A: The correct unit is Mm^3 (million m^3).

R: Section 3: Methodology

P13012, L3: The desired spatial scales, I presume! P13013, L1: You previously stated “the desired scales” and here you mention/limit to “mesoscale”, sounds confusing!

A: We replaced the confusing sentence:

P13012, L3: *“The model was chosen because it is able to reproduce discharge on the mesoscale on a daily basis with high efficiency…”*

R: P13013, L3-4 “It allows the simulation of all interrelated processes within a single model framework” the sentence appears to be a tautology within the paragraph as there is already another statement: “SWIM is process-based and simulates the dominant eco-hydrological processes at the mesoscale such as evapotranspiration, vegetation growth, runoff generation and river discharge, and also considers feedback among these processes”, which seems to be more precise and informative.

A: The sentence was deleted as it indeed was a tautology. The former sentence was rephrased and a new citation added (see comment to Section 3.1):

13013, L1: *“SWIM is a process-based model and simulates the dominant eco-hydrological processes such as evapotranspiration, vegetation growth, runoff generation and river discharge, and also considers feedbacks among these processes (Krysanova et al., 2005).”*

Krysanova, V., Hattermann, F. and Wechsung, F.:Development of the ecohydrological model SWIM for regional impact studies and vulnerability assessment, Hydr. Process., 19, 763-783, doi: 10.1002/hyp.5619, 2005.

R: P13013, L15: Simulating percolation to the deep aquifer would imply a good understanding of the geological setting of the sub-basins, which I do not see in this study.

A: The SWIM model can incorporate a simple representation of a deep aquifer if information about quantitative losses is available. As in this study there is no such information, the deep aquifer is not mentioned in the text anymore (see complete text in response to comment on 13015, L1).

R: Section 3.1: I suggest you insert a graphical representation of the processes included in the model for a better illustration. The text could be rewritten to avoid repetition of ideas. It is important to show the parameters and the structure of the model and how it handles the various hydrological processes as mentioned in this section.

A: We agree with the reviewer that a graphical representation of the processes is needed for a better understanding of the model. Therefore we included a scheme of the model and added a new citation where the model SWIM is explained in more detail and more graphical illustration of the processes are included:

Krysanova, V., Hattermann, F. and Wechsung, F., 2005. Development of the ecohydrological model SWIM for regional impact studies and vulnerability assessment, Hydrological Processes, 19, pp.763-783.

In addition we revised many parts of the chapter in order to remove repetitions and improve the understandability also in the course of other comments of referee 1 and referee 2. Please see response to comment of referee 1 on P13015 L1, 13015 L6-7 and 13015 L7-9.

R: P13013, L26: Insert the appropriate reference for the SRTM dataset.

We thank referee 1 for the hints to the correct references and inserted them:

A: P13013, L26: "*For all four regions, a digital elevation model derived from the Shuttle Radar Topography Missions with 90 m resolution (Jarvis et al., 2008) was used.*"

Jarvis, A., H.I. Reuter, A. Nelson, E. Guevara, 2008. Hole-filled SRTM for the globe Version 4, available at: http://srtm.csi.cgiar. org/ [Accessed March 2, 2013].

R: P13014, L2: Insert the appropriate reference for the Global Land Cover dataset.

A: The correct citation was inserted:

P13014, L2: *"Land use data were reclassified from the Global Land Cover (Bartholomé and Belward, 2005)."*

Bartholomé, E. and Belward, A.S., 2005. GLC2000: a new approach to global land cover mapping from Earth observation data, International Journal of Remote Sensing, 29(9), pp. 1959-1977.

R: 13014 L12: The recommended reference for GRDC data is Fekete et al. (1999).

A: The correct citation was inserted:

13014 L12: *"Observed river discharge data from the Global Runoff Data Centre was used to calibrate and validate the model (Fekete et al., 1999)."*

Fekete, B.M., Vorosmarty, C.J., Grabs, W., 1999. Global, composite runoff fields based on observed river discharge and simulated water balances, GRDC Report 22, Global Runoff Data Center, Koblenz, Germany.

R: 13014 L13-17: In addition to bias correction, there is an important step to consider for choosing a GCM to be used in climate change analysis; that is the skill test (see IPCCTGICA, 2007, Tshimanga and Hughes, 2012). I do understand that for the purpose of comparison you have to maintain the same GCMs for all the study sites but bear in mind that the uncertainty due to a relative performance of GCMs in reproducing historical patterns of variability in climate for a given site will be ignored in this case.

A: We agree with the referee and added an explanation why we did no skill test for the ESM Ensemble and revised the whole paragraph:

13014 L13-20: *"For analyzing climate trends we used the output of an ensemble of 19 CMIP5 ESMs. Of this ensemble, five ESMs (HadGEM2-ES, IPSL-5 CM5A-LR, MIROC-ESM-CHEM, GFDL-ESM2M, NorESM1-M) outputs were used for driving the hydrological model (Table 2). The accurate way of choosing the ESMS for the regions would have been a skill test (see IPCC-TGICA, 2007, Tshimanga and Hughes, 2012). But as we compare different regions and have to maintain the same ESMs for the intercomparison we used all five models which are available in a bias corrected version from the Inter-Sectoral Impact Model Intercomparison Project (ISI-MIP) (Hempel et al., 2013), taking into account that the relative performance of the ESMs in reproducing historical patterns will be ignored. Instead we added an analysis where we compare the chosen ESMs with the whole ensemble in order to see their characteristics in terms of precipitation and temperature (Figs. 5 and 6)."*

R: 13015 L1: I would have expected to see a description of the procedures used to delineate the sub-basins included. How did you delineate these sub-basins, it is not known.

A: We extend the model description in section 3.1, explaining in more detail the delineation process and the meaning of hydrotopes, subbasins and subcatchments in the context of SWIM:

P13013, L6-21*"SWIM disaggregates a river basin to subbasins and hydrotopes. The subbasins were delineated on the basis of flow accumulation in a Digital Elevation Model (DEM). The size of the subbasins usually ranges between 150-1500km², depending on topography and the focused precision. In large basins as modeled in this study, the size of the subbasins derived in the delineation process is a trade between the exactness of the model and its manageability, also in terms of computing power. The resulting subbasins are then subdivided into hydrotopes, each with same type of soil and land use class. The daily weather input is interpolated to subbasin centroids, and includes mean, minimum and maximum temperature, as well as precipitation, relative humidity and global radiation. On each hydrotope within a subbasin the daily weather is added. Subsequently in each of these hydrotopes, the model is calculating water fluxes and the water balance for the soil column subdivided into several layers. Its hydrological system includes the soil surface, the root zone of the soil and the shallow aquifer. The water balance for the shallow aquifer includes ground water recharge, capillary rise to the soil profile and lateral flow. The percolation from the soil profile is assumed to recharge the shallow aquifer. The water balance of the soil includes precipitation, evapotranspiration, percolation, surface runoff, and subsurface runoff. The output of each hydrotope is then aggregated at subbasins level, taking retention into account, and then the routing of lateral fluxes starts. The basin can be subdivided into subcatchments which can be separately parameterized if discharge data is available for the outlet of each subcatchment. The model is described in detail in Krysanova et al. (2000) and Krysanova et al. (2005). Recent model developments and extensions that are used in the different basin model projects for this study are described in the model set-up."*

R: In this table (Table 3) the period for validation is given but not calibration!

A: We included the calibration periods and results for all basins and also added the calibration results for the second gauging station in the Limpopo basin in table 3. For the calibration results of the 17 other gauging stations of the Niger basin we added an additional table in the supplementary material. In addition we added the results for the validation of the daily time series as requested in the comment on P 13017, L5 (see Fig. 3).

R: 13015 L6-7: Please specify the terms sub-basins and sub-catchments to avoid confusion from your readers. Please state how you merged the 1923 sub-basins to form 18 sub-catchments.

A: Please see answer to comment for 13015 L1.

R: 13015 L7-9: Adding the process of flood plains into model is, to my understanding, a crucial part of the paper and the procedures used should be adequately described. How does this component work and how was it formulated, should be clarified. Please note that there is now a growing interest in understanding hydrological processes of floodplains/wetlands of Africa (Hughes et al., 2013) and modelling approaches that enable this understanding should be promoted.

A: Incorporating these processes into the model was indeed a prerequisite to adequately simulate discharge of the Niger River downstream the Inner Niger Delta. However, this manuscript does not focus on model development. Therefore, we added following brief description of the module to the text:

P13015, L9-13: *"In addition to this heterogeneity the flood plains of the Inner Niger Delta (IND) in Mali have a significant impact on the flow regime of the Niger River. About 40% percent of the inflowing water evaporates from the huge floodplain and discharge patterns at the outlet differ significantly. It is therefore indispensable to incorporate processes such as flooding and release into the hydrological model in order to account for increased infiltration and evaporation from the additional water surface. Based on the Digital Elevation Model, inundation zones are delineated for each subbasin in the floodplain. Moreover, ponds were identified where water gets trapped and is not allowed to flow back to the channel system. It is assumed that if discharge exceeds the water holding capacity of the river at a subbasin inlet, the surplus flows into the inundation zone(s). This threshold is computed by multiplying cross-sectional area by flow velocity. At each time step, water is released from the storages into the downstream subbasin according to the routing scheme. The volume of water to be released from storage is a linear function of the current storage volume. Areas (hydrotopes) in the flood plain switch dynamically from water to land phase implementing different functions for land cover, infiltration, percolation and evapotranspiration. The SWIM inundation module which is described in detail in Liersch et al. (2012) significantly improved discharge simulations at the IND outlet."*

R: P13015, L27-28 until P 13016, L1-4: I disagree with the authors on this aspect. The Oubangui drainage system, with an area of about 500 000 km2, is characterised by large variation in soil and land cover types as well as a transitional tropical climate. The dominant soils include a variety of Ferralsols, Arenosols, Regosols, Nitosols, Gleysols and Lithosols, with areas of shallow and deep soils across the sub-basins (up to 400cm of soil depth for Orthic ferralsols, see Webb et al., 1991). Similarly, there is a large variation in the distribution of the vegetation types in the Oubangui, which consists of mosaic vegetation and broadleaved deciduous or evergreen forest/ woodland. So sating that Oubangui is more homogenous appears to be very subjective and does not reflect the reality. In addition, the source of streamflow data used by the authors (GRDC) contains a good coverage of gauging stations for the Oubangui and limiting your analysis to only one station on the basis of the homogeneity in the basin is not really convincing.

A: We thank referee 1 for providing this information and agree with the comment. We revised the description of the Oubangui basin. The former statement of the most homogeneous basin is only correct in terms of topography but not as a statement for the catchment hydrology. Therefore we changed the sentence:

P13015, L27-28 until P 13016, L1-4: *"The Oubangui Basin consists mainly of a peneplain and contains a broad range of different soil and vegetation types. The model for the catchment was calibrated for the gauging station Bangui."*

We are aware of the additional gauging stations in the Oubangui catchment. However, as we focus on the discharge at the outlet (Bangui) and the validation did show adequate results for this gauging station, there was no need to subdivide the basin into subcatchments. Still we are aware, that a spatial inconsistency of model performance in a very large basin like the Oubangui might lead to substantial deviations in the modelled discharge at the outlet under climatic change conditions. Therefore we used discharge data of the additional stations Kembe (Kotto River), Bangassou (Mbomou River) and Rafai (Chinko River) and checked the model efficiency in these more upstream parts of the basin visually during the calibration phase. As the coverage with weather stations is very sparse in the Oubangui basin, we only used gauging stations with catchments larger than 50,000km². The results were satisfactory and in the right order of magnitude for all three stations. Hence the homogeneous calibration and parameterization by means of the data of the Bangui gauging station for the whole basin proves to be adequate in this case.

R: Section 4.1: It is a bit surprising that you only present the results for validation and not calibration. How do you justify this? You may want to clarify what you mean by validation as the term is generally used in conjunction with calibration, and in practice applied to check if the model is able to reproduce the right simulation with the same parameters used for calibration but in a different period.

A: We used the terms calibration and validation in the same context as described by referee 1. We agree that the information about calibration is useful and added the results for the calibration in table 3. In addition to the stations validated we include the stations in the Niger and the Limpopo basin which were only used for calibration of subcatchments (see table 3 and supplementary material table 1). The subcatchments were not separately validated as we compare the discharge at the outlet of the basins. In section 4.1 we only refer to the validation as we understand the calibration in this study as part of the model set-up and the validation results were also a part of the results and also part of the discussion.

R: P 13017, L3: I believe you should have determined an initial threshold for the model evaluation using PBIAS criteria, and if so how do you justify the model performance given large variation of the PBIAS (from 2.1% in the Niger and 39% in the Upper Blue Nile)?

A: We did not determine a fixed initial threshold for the PBIAS because we focused mainly on the relative changes of discharge under climate change and wanted to include all four basins. However, we are aware of the large differences in model performance and the deficiencies of the Upper Blue Nile (UBN) model and the Oubangui model in terms of PBIAS though the NSE is adequate. The comparison of simulated and observed discharge shows that the overestimation of discharge in the UBN originates mainly from the low flows during the dry season and the discharge peaks are well represented. These discrepancies might derive from not included water management in the UBN about we have no quantitative information. For the Oubangui, the low flows are well represented but the discharge peaks during the rainy season are overestimated. This might be a result of the calibration with uncertain precipitation data due to the low density of rainfall stations in the basin. Therefore we stated already in the text:

P 1307, L16-18:*"In terms of PBIAS, results are very good for the Niger basin and the Limpopo basin, whereas for the Oubangui basin and the Upper Blue Nile basin they show distinct deviations."*

However, we agree with the referee that this source of uncertainty should be communicated more pronounced in the discussion. Therefore we revised the respective paragraph in section 5.2.:

P 13027, L23-27: *"This tendency of increasing high flows in the observations matches our findings in all basins studied except the Oubangui basin (Fig. 9, 4). However, the Oubangui basin modelling has shown a substandard efficiency in terms of high flows in the PBIAS criteria and the projections of decreasing or stable high flows should be interpreted carefully. Still the performance of the model in the other basins in terms of high flows during the validation, especially in the Niger basin and the Upper Blue Nile basin, was good and the increase of high flows holds especially for the Upper Blue Nile basin, where simulations driven by all climate models resulted in a distinct increase in high flows for both RCPs and both scenario periods."*

P 13028, L13-14: *"However, the mean changes in Q90 are positive for the Niger basin, Upper Blue Nile basin and Limpopo basin (Table 4). In regard of the deficiencies in terms of PBIAS during the low flows in the Upper Blue Nile basin, these results should be interpreted with caution also when looking on relative changes."*

R: P 13017, L5: Although not clearly stated, it seems that your model has been conditioned at daily time step, but the simulation results (Figure 2) are presented at monthly time step. How do you justify this?

A: We agree with referee 1. Though the monthly model outputs are sufficient for representing average flows and seasonal dynamics, a daily validation would increase the information about uncertainty, especially for the high (Q10) and low (Q90) flows which are calculated on the basis of the daily outputs. Therefore we added a validation of the daily time series for all for basins in Figure 3.

In addition, we changed section 4.1:

P13017, L6-18*: "The SWIM model was basically able to reproduce the hydrological characteristics of each basin reasonably well, with NSE of the monthly runoff rate ranging between 0.63 and 0.9 and the daily runoff rate ranging from 0.55 to 0.89. However, the validation showed heterogeneous results in terms of the NSE, ranging from adequate in the Oubangui basin and Limpopo basin to very good in the Niger basin. The model was able to reproduce high and low flows for the Niger basin well, and in terms of seasonality the results are very good for both daily and aggregated monthly model output. The Upper Blue Nile basin shows good results for the modelling of seasonality for daily and monthly output data with adequate representation of high flows but an overestimation of low flows. For the Limpopo basin the difference between daily and monthly runoff rate is high. When aggregated to monthly time series, the validation shows a slight underestimation of high flow and overestimation of low flow, but the total efficiency is good. For the daily time series, some peaks were well modeled but others are missing almost completely. The model for the Oubangui basin has distinct deficiencies in reproducing high and low flows, but regarding discharge seasonality the model gives adequate results during the validation period for monthly and daily data."*

R: Section 4.2: I do not understand to which conclusion you would like to reach with the comparisons made in Figures 4 and 5, using the mean climate variables (temperature and precipitation) in the far projection period (2070–2099) relative to the base period (1970–1999) for RCP 8.5 for five bias-corrected model projections (colored lines), the uncorrected ESMs (colored dashed lines) and 14 ENSEMBLE ESMs (grey dashed lines). My understanding is that you started by choosing the bias-corrected climate models to be used for your analysis, thus eliminating part of uncertainty due to climate input. However, it appears that you are here using those uncorrected climate models and the 14 ensembles in the analysis. Please be more explicit here as these comparisons seem to bring confusion.

A: We showed the uncorrected runs and the other 14 ESM runs in order to display the influence of the bias-correction and in order to see, where the respective models, used later on as input for the hydrological modelling, lie in a larger ensemble. In the figures you can see whether they are covering the whole range of projections or if a model is especially dry or wet, warm or cold. As we missed to explain this in the text before, we added this sentence:

"In Figure 5 and 6, temperature and precipitation of these climate runs were compared to the uncorrected runs and 14 other CMIP5 models in order to display the influence of the bias correction and where the respective models lie in a larger ensemble, i.e. if the model is especially dry or wet, warm or cold or in the middle of the whole ensemble. "

R: P13019L5-6, I presume mm month-1

A: We changed mm mon-1 in mm month-1 in the whole text.

R: P13021, L15-21: This is very contradictory as you previously mentioned that due to unrealistically high precipitation values produced by WFD for the Ubangi, this dataset has been replaced by the GPCC data (see P13016, L3-6). So, which dataset did use to force your model in the Oubangui? WFD or GPCC?

A: Alike in the other basins the calibration and validation as well as the control run shown in Fig. 8 and also used for the climate sensitivity analysis and Fig. 7 was done with the WFD. However, the precipitation correction of the WFD which is based on GPCC, lead to unrealistically high precipitation values. Therefore we calculated them back to the original GPCC values for the Oubangui (see P13016, L1-6). Still all other parameters are from the original WFD data why we refer to it in the text and figures as WFD. In order to be clear here, we changed the sentence about the changes in the Oubangui WFD dataset to:

P13016, L4-6: *"Therefore, WFD precipitation was replaced by original uncorrected GPCC data for the calibration in this basin while all other parameters are still from the original WFD (Schneider et al., 2013)."*

R: Section 4.4: Impact of climate change on discharge and seasonality: In this section, the impacts of climate change on river flows are, understandably, analysed with regard to the trend in rainfall (section 4.2). What about the role of evapotranspiration which could be very important due to increase in air temperature, and thus influence greatly on the availability of water resources? In this respect, Tshimanga and Hughes (2012) found that there was a decrease in runoff for the near-future projections in the Oubangui due to very little change in rainfall from the historical conditions but with major increase in evapotranspiration. Therefore, the change in evapotranspiration was a key element of climate change impacts on water resources availability.

How do you correlate the climate trends as shown in section 4.2 and the trends in discharge due to the impacts of climate change as shown in section 4.4? I think, this could illustrate which component of the climate has more influence on streamflow variation.

A: We agree with referee 1 that changes in evapotranspiration are crucial for the development of streamflow. For this reason we showed projections of temperature in Figure 5 as temperature is the main parameter indicating changes in evapotranspiration and mentioned in the text P13017, L20. However, in order to detect whether changes in rainfall or the increase in temperature have more influence on streamflow, a more complex analysis would be necessary, also taking account of spatial patterns in climate changes, the role of vegetation in more detail and also radiation. However, this would be beyond the scope of the study and therefore we do not discuss all potential reasons of streamflow changes. In order to be more explicit with that, we added these sentences:

P13027, L 10: *"The projections of increasing streamflow in the basins are especially remarkable as in all catchments a substantial increase of temperature (Fig. 5) and hence potential evapotranspiration is projected, which would lead under constant rainfall to a reduction of streamflow. In the Oubangui basin it can be seen exemplarily that the increase of rainfall in the climate models does not automatically lead to an increase of discharge but the increase in evapotranspiration often leads to a decrease of streamflow despite increasing rainfall. This is in line with other studies in this basin (Tshimanga and Hughes, 2012)."*

R: P13022, Fig 7: The figure could be transformed into a table for a better readability.

A: Indeed, the figure is not very easy to read. But if we would transform all the information of 4 basins, in 3 time slices, for RCP 2.6 and 8.5 for all five models and 12 months into one table, it would have at least 1200 fields, which would be also hardly readable. And a reduction of information as for example mean annual values or a mean for the five models would lead to a substantial loss of information used in the discussion. Therefore we would prefer to include the figure.

R: P13022, L8-9: There is a need to be clear on the time step used for modelling. Is it daily or monthly? This is really confusing. You processed the forcing data WFD at the daily time step and if they were aggregated to fit the model at the monthly time step, this should be mentioned.

A: SWIM has a daily time step and the discharge of the control runs with WFD and of the projections with the corrected ESMs is on a daily basis. The monthly time step is used for presenting some of the results for our large river basins. In order to make that clear in the context of the analysis of mean monthly values, we added a sentence at the beginning of section 4.4:

P13022, L8-9 *"Figure 8 shows mean monthly discharge values and their changes, derived from the daily model output for all 4 basins and 5 models in the different time periods and for both RCPs."*

R: Section 5.3 Changes in hydrological extremes: If your model has been conditioned at the monthly time step, then it will be difficult to convincingly quantify hydrological extremes.

A: The evaluation of Q10 and Q90 was done with the original daily outputs of the model. This should be clarified with the additional sentence added in section 4.3.

R: P13029, L6: "These two parameters" Which parameters are you referring to?

A: We agree with the referee and changed the sentence:

"Hence, the uncertainty in terms of streamflow, which is largely influenced by both, temperature and precipitation, derives mainly from uncertainties in precipitation."

R: P13029,L8-9: It is not demonstrated in your paper, hence you cannot bring it into discussion

here.

We agree with the referee and deleted the statement.

R: P13029, L16-19: The methods used are supposed to have been defined earlier in the methods' section and not here in the discussion. You cannot start to bring the methods in the discussion.

A: We agree with the referee and put the respective sentences into the methodology chapter:

P13014, L29: *"The trend-preservation in the bias correction can lead to extreme precipitation corrections in exceptional cases. An example of this can be seen in the case of the IPSL model in the Upper Blue Nile basin, where the almost rainless October was corrected by a high factor during the base period. In the future scenarios, this factor resulted in a very strong increase in precipitation during October, which exceeds the usual peak of the rainy season in August (see supplementary material, Fig. 2)."*

Table 3 Characteristics of basin models and validation results

	Niger	Upper Blue Nile	Oubangui	Limpopo
Number of subbasins	1,923	558	377	2,020
Number of hydrotopes	13,883	1,700	1,734	13,085
Number of included reservoirs	5	0	0	8
Number of included irrigation schemes	0	0	0	31
Number of gauging stations used for calibration	18	1	1	2
Gauging station(s) used for calibration/ validation	Lokoja[a]	El Diem	Bangui	Sicacate, Oxenham Ranch
Calibration period	1972-1982[a]	1961-1970	1981-1990	1971-1978
NSE[b] (daily)	0.92	0.81	0.66	0.72, 0.73
PBIAS[c]	8.6	20.9	19.1	11.5, -6.7
Validation period	1983-1992[a]	1971-1980	1971-1980	1980-1987 [d]
NSE[b] (daily)	0.89	0.63	0.6	0.55
NSE[b] (monthly)	0.9	0.73	0.63	0.8
PBIAS[c]	2.1	39	15.7	3.4

a) In the Niger basin 18 gauging stations have been used for the calibration. For the additional 17 calibration periods and results see supplementary material table 1.

b) Nash-Sutcliffe Efficiency.

c) Percent bias of monthly average.

d) The gauging station Oxenham Ranch was only used for calibration and not validated.

Table 1 supplementary material: Calibration results for additional stations in the Niger basin model

Gauging station	Kouroussa	Selingué	Koulikoro	Douna (Bani River)	Kirango Aval	Akka	Diré	Koryoume	Tossaye
Calibration period	1965-1974	1965-1974	1964-1974	1964-1974	1975-1981	1987-1990	1964-1974	1979-1986	1968-1979
NSE/ PBIAS[a,b]	0.85/ 3.3	0.78/ 6.1	0.92/ 5.8	0.87/ 9.9	0.79/ 29.3	0.48/ -42.6	0.81/ -2.2	0.75/ -4.8	0.82/ 0.2

Gauging station	Ansongo	Kandadji	Niamey	Malanville	Yidere Bode	Shiroro (Kaduna River)[c]	Riao (Benue River)[c]	Ibi (Benue River)
Calibration period	1968-1979	1976-1986	1976-1986	1976-1986	1985-1995	1982-1990	1971-1980	1970-1981
NSE/ PBIAS[a,b]	0.81/ 7.5	0.84/ 9.6	0.76/ 16.2	0.4/ 32.3	0.61/ 27.3	0.52/ 35.4	0.7/ 59.4	0.9/ 14.8

[a] Nash-Sutcliffe Efficiency of daily model output.

[b] Percent bias of monthly average.

[c] At the stations Riao and Shiroro only monthly data has been available and used for calibration and calculation of NSE and PBIAS.

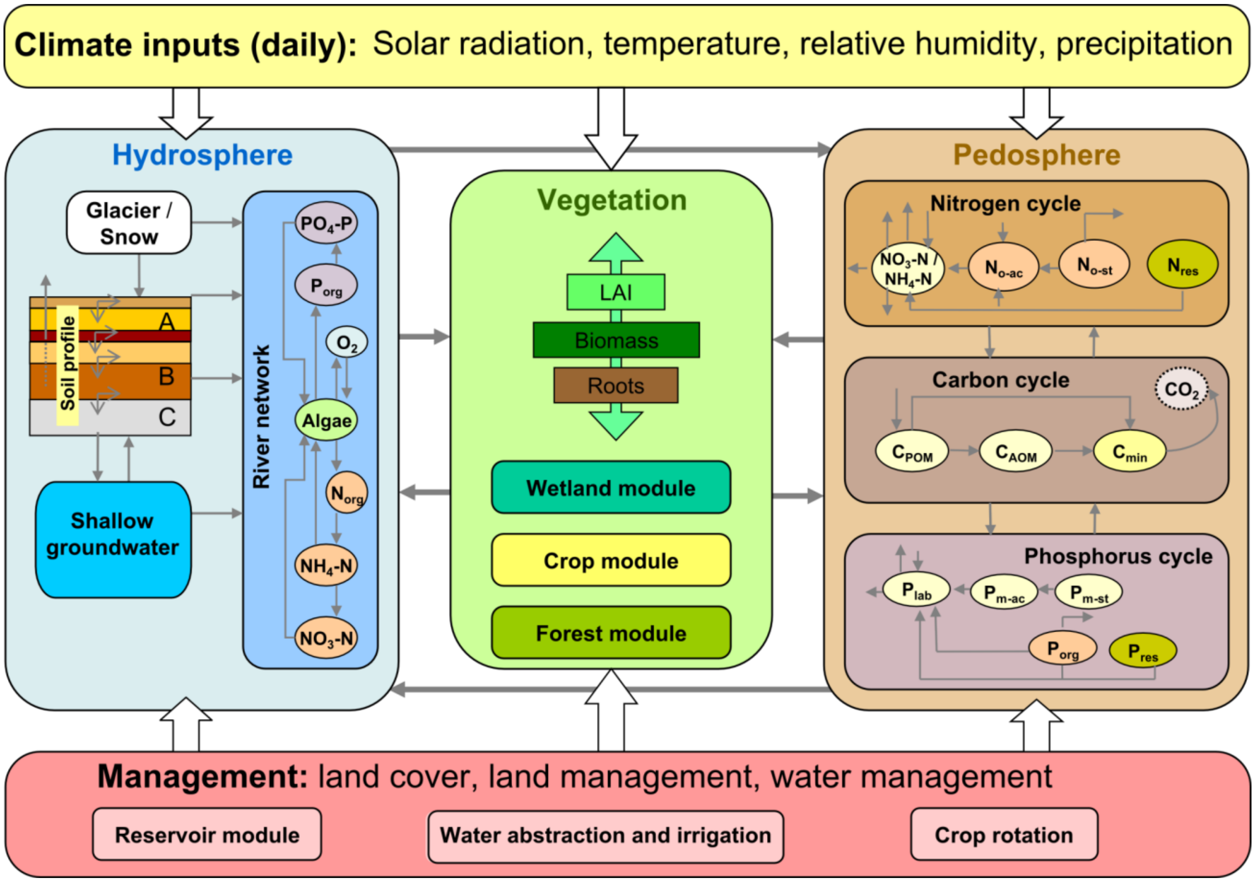

Figure 2 Structure of the eco-hydrological model SWIM.

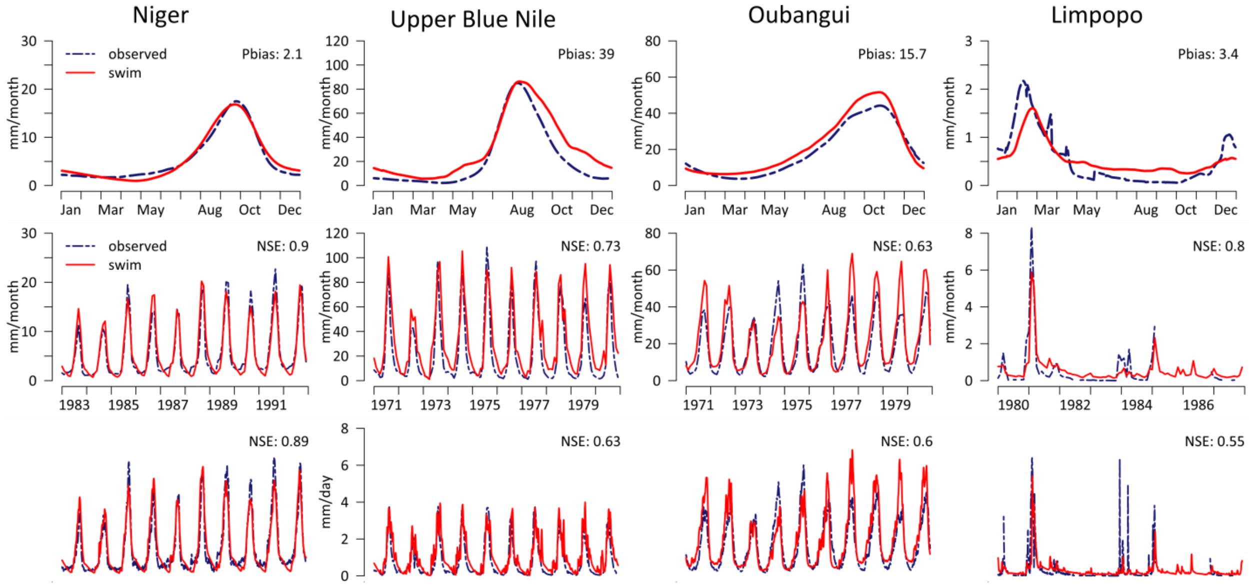

Figure 3 Validation of SWIM at the outlets of the four basins. In the top row the seasonality of monthly runoff rate in validation period and PBIAS, in the middle row the monthly runoff rate and in the bottom row the daily runoff rate in the validation period, the latter two with Nash-Sutcliffe Efficiency.