The authors thank the referee for constructive comments and recommendations which will help to improve the readability and quality of the paper.

Please find below the replies to reviewer #1

This paper presents its findings on the validation of SWAT simulated stream flow and sensitivity to climate change. However, it needs more details in the methodology and discussion. The paper does not present novel concepts or ideas, but does provide some basic information about the study area that could be useful for further comparative studies in that region.

Reply

We have revised the method section, added a subsection on the construction of the climate sensitivity scenarios and rewritten parts of the non-linear sensitivity analysis method. In addition, the introduction is rewritten to clearer state the motivation behind the study.

We agree that the concept is not novel, but the results are important in estimating the Eastern Nile sensitivity to future climate change. This study uses more in situ precipitation and temperature data than previous studies and we conduct both daily and monthly calibrations at several outlets. We provide streamflow estimates for the whole eastern Nile, and document the strong sensitivity of streamflow responses to precipitation which emphasis the particularly strong sensitivity of the relatively dry Tekeze catchment to precipitation changes.

Specific points:

1. The paper needs a lot of work to improve the grammar and construction of sentences to make it more readable. It is advisable to have a paper checked for grammatical errors before submission to a journal.

Reply

We have checked the grammar and sentence constructions for the entire text..

2. Distinguish between 'validation' and 'verification'. It seems these have been used interchangeably throughout the text.

Reply

We now use *validation* throughout the paper.

3. Detailed description of the river network in Section 2 can be made brief. Provide a larger diagram (Fig 5) of the basins and the main rivers of the study area.

Reply

Figure 5 has been remade in more detail. However the request for briefness in the description of the river network is only partly met. The reason is the request of reviewer 2 for a description of the details of each tributary. Thus the section is now revised to try to take into account the request of both reviewers.

4. There is no mention of the model setup; number of subbasins and the HRUs, area of the study area etc

Reply

We have included the model setup as a separate section (section 3.5) including number of sub basins, HRUs, areas etc.

5. There is no description of the climate change in the Methods (hypothetical or IPCC). These appear later in the results section 4.

Reply

This is now included as a separate subsection (section 3.8)

6. The author should comment on whether land use has changed over time in the study area. Only one land use map is used for the whole period. The author mentions land use as one of the main factors affecting soil erosion and evapotranspiration.

Reply

Land use of the study area has changed over time (Goldewijk,2001;Rembold et al.,2000;Legesse et al.,2003,Alemayehu et al.,2009; Rientjes et al.,2010) due to over increasing population density, urbanization, increased intensified agriculture, and water related infrastructure such as irrigation and hydropower production. This is now incorporated into the text (section 3.3.2) However, land use changes are not the focus of this study, thus, changes in landuse are not taken into account in the simulations. This is now clearly stated in section 3.3.2.

7. Since evapotranspiration accounts for more than half the water balance, it should be discussed more in the results and especially in relation to sensitivity to climate change (precipitation and temperature) and landuse.

Reply

We have incorporated more text on how streamflow is influenced by climatic changes via evapotranspiration for each subbasin in the revised manuscript, but in order to keep the text not too long we have not gone into details about this.

Below we have attached a table which shows the sensitivity of evapotranspiration to temperature and precipitation perturbations.

Table: Percentage change in simulated average annual evapotranspiration for different precipitation and temperature changes.

	Precipitation change (%)																			
Temp. change	**Blue Nile**							**Baro Akobo**							**Tekeze**						
	-20	**-10**	**-5**	**0**	**5**	**10**	**20**	**-20**	**-10**	**-5**	**0**	**5**	**10**	**20**	**-20**	**-10**	**-5**	**0**	**5**	**10**	**20**
0	-3.7	-1.7	-0.8	0.0	6.2	1.5	2.8	-6.1	-4.0	-3.1	0.0	-1.5	-0.8	0.4	-1.6	1.4	-0.7	0.0	1.0	5.9	7.8
2	0.4	2.6	3.6	4.4	4.9	6.0	7.4	2.3	5.0	6.1	9.5	8.0	8.8	10.3	-2.1	0.9	-1.6	-0.9	0.1	5.5	7.4
4	2.9	5.2	6.2	7.1	7.6	8.7	10.2	3.0	5.9	-1.5	10.7	7.6	10.0	11.6	1.0	4.4	1.0	2.7	7.6	9.7	11.8

8. Comment on whether the modeled evapotranspiration is reasonable or within the expected range for the land uses in the study area.

Reply

We made a check on the estimated actual evapotranspiration of the study area with recently published papers (Mohamed et al., 2003 and Tekleab et al., 2011). Mohamed et al., (2003) estimated (sat-

ellite based estimates) ET to 1287mm/yr for Sobat. Tekleab et al., (2011) estimated ET to be 488-1204mm/yr for a number of small watersheds within Abbay subbasin (using a top-down approach). As shown in the table below the estimated ET in this study was within the expected range of previous investigations. Our Baro Akobo numbers range from 800-1200 mm (though not covering exactly the same region this can be compared to the Sobat values of Mohamed et al.) and our Abbay numbers range from 500-1100 mm which are in the range of the Tekleab et al., (2011) values. It should be noted that we could not find any observational studies from the region thus comparison of the estimated ET for the different landuse types in the study area has not been possible.

Table: Actual evapotranspiration estimations using the SWAT model for landuse types for Abbay/Baro Akobo/Tekeze subbasins,respectively

Landuse Type	**ETa Abbay/Baro/Tekeze**
Grass	536-1018/815-1024/334-695
Forest	638-1125/872-1205/338-840
Openwater	1820
Wetland	797
Agriculture	526-1054/869-1149/323-779
Shrub land	549-1023/821-1071/319-737

9. Was the observed stream flow separated into surface runoff and base flow prior to Calibration? This would ensure that the simulated runoff and baseflow closely match the observed (separated) flow. Since the paper is about 'Validation', it requires a thorough model calibration that ensures all components of the simulated water balance are reasonable.

Reply

Yes. The calibration and validation was conducted for both baseflow and surface runoff. We have noted how the calibration and validation simulations were conducted in the methodology section. However, since the focus was mainly on streamflow component we have not mentioned the baseflow part in the result section.

The table below shows the quality of the calibrated and simulated baseflow

Table: Summary of daily base flow statistics for calibration and validation for the three Eastern Nile Subbasins

Location	Calibration				Validation			
	ENS	RSR	PBias	R^2	ENS	RSR	PBias	R^2
Abbay at Kessie	0.75	0.43	-1.89	0.75	0.78	0.26	-16.12	0.80
Baro at Gambella	0.74	0.34	0.49	0.77	0.78	0.33	-1.87	0.79
Tekeze at Emdabare	0.74	0.64	1.77	0.74	0.76	0.10	-10.20	0.77

10. The paper could also benefit from an uncertainty analysis of the SWAT model (Parameters and outputs).

Reply

An uncertainty analysis was conducted, but not included in the text. After the selected parameters were calibrated using both manual and automatic calibration techniques, we conducted uncertainty analysis from the embedded parasol, SUFI-2 and GLUE methods in ArcSWAT-x model and SWAT-CUP4, but we didn't mention the outputs in the result section.

However, we show the final tuned calibrated parameters and the model efficiency statistics from the automatic calibration. Below we give a short account of the uncertainty analysis we did. To keep the article not too lengthy we have not added this to the revised paper.

Uncertainty analysis to SWAT simulated outputs and parameter uncertainties were made using SUFI-2, GLUE and parasol methods. These are the methods embedded in ArcSWAT-x model. We also conducted similar analysis using SWAT-CUP4 for comparison among the outputs. Accordingly, the 95% prediction uncertainties(95PPU) using SUFI-2/GLUE/parasol methods for the Abbay; Baro Akobo; Tekeze subbasins were 77%/76%/45%; 64%/55%/38%; 60%/48%/27% for p-factor and 0.71/0.7/0.52; 0.55/0.48/0,36; 0.51/0.43/0.33 for r-factor, respectively during the calibration period. Small deviations were observed while we used SWAT-CUP4 method. Note that the advantage of using SWAT-CUP model is that the effect of different objective functions without having to run SWAT-CUP again could be seen. For example, an improved in p-factor values and r-factor values were obtained when we changed the objective functions from summation form of the square error (sum) and multiplicative form (mult) of the square error to Nash-Sutcliffe (1970) (NS) and coefficient of determination (R^2).

In the case of validation, the p-factor brackets 69%, 69% and 41% of the observations and r-factor values of 0.73, 0.69 and 0.65 for Abbay, Baro Akobo and Tekeze subbasins respectively based on SUFI-2 method.

The above variations in p-factor and r-factor values were clearly coupled with the performance statistics. The lower p-factor and r-factors indicated a weaker performance.. In other words, the SWAT model couldn't capture the measured flow for lower p-factors and r-factors.

11. Why was 2080-2100 chosen for the climate change analysis? It has been shown in many previous studies that the uncertainty in future climate change is much greater than that due to parameterization of hydrological models. Comment on how meaningful the results presented here are?

Reply

The fact that the uncertainty in future climate change is larger than the uncertainty in parameterization of hydrological models we feel is important information. In our judgment this does not hamper the meaningfulness of the results, it only underscores a few important conclusion: Based on the state of the art climate models little can be said about future changes in Eastern Nile streamflow. Estimates strongly dependent on the choice of climate model, which emphasis the need for doing ensemble runs using different climate models in this type of assessment.

The choice of 2080-2100 as the analysis period is a common choice which has the advantage of a large climatic forcing and therefore a large signal to noise ratio. Thus any climate change signal is clearly distinguished from the models internal variability and we can be certain that the change we calculate from the individual models is mainly due to the different models response to the forcings and less due

to models internal variability.

12. Generally, results should not be repeated in the 'Summary and Conclusion' section unless they emphasize a main point in the conclusion.

Reply

We have redrafted this section and put more focus on the main points.

13. In my opinion, appendix A is not necessary. A reference to the SWAT manual should suffice. Appendix B should just be 'Acknowledgment'.

Reply

We have removed both appendixes A and B in the revised manuscript.

14. Improve on figures. Some are too small to be seen well.

Reply

Figures are made larger and improved.

References

Dagnachew Legesse, Christine Vallet-Coulomb, Francoise Gasse.: Hydrological response of a catchment to climate and land use changes in Tropical Africa: case study South Central Ethiopia, J.Hydrology, doi: 10.1016/S0022-1694(03)00019-2, 2003.

Fikir Alemayehu, Nurhussen Taha, Jan Nyssen, Atkilt Girma, Amanuel Zenebe, Mintesinot Behailu, Seppe Deckers, Jean Poesen.: The impacts of watershed management on land use and land cover dynamics in Eastern Tigray (Ethiopia), Resources, Conservation and Recycling, Vol. 53, No. 4. (February 2009), pp. 192-198. doi:10.1016/j.resconrec.2008.11.007 Key: citeulike: 4611863, 2009.

Kees Klein Goldewijk.:Estimating global land use change over the past 300 years: The HYDE Database, Global Biogeochemical cycles, vol.15, No.2,Pages 417-433, June 2001,2001.

Rientjes, T. H. M., Haile, A. T., Kebede, E., Mannaerts, C. M. M., Habib, E., and Steenhuis, T. S.: Changes in land cover, rainfall and stream flow in Upper Gilgel Abbay catchment, Blue Nile basin – Ethiopia, Hydrol. Earth Syst. Sci., 15, 1979-1989, doi: 10.5194/hess-15-1979-2011, 2011.

Tekleab, S., Uhlenbrook, S., Mohamed, Y., Savenije, H. H. G., Ayalew, S., Temesgen, M., and Wenninger, J.: Water balance modeling of Upper Blue Nile catchments using a top-down approach, Hydrol. Earth Syst. Sci. Discuss., 7, 6851-6886, doi: 10.5194/hessd-7-6851-2010.

Y.A. Mohameda, W.G.M. Bastiaanssenb, H.H.G. Savenije: Spatial variability of evaporation and moisture storage in the swamps of the upper Nile studied by remote sensing techniques, Journal of Hydrology 289 (2004) 145–164, doi:10.1016/j.jhydrol.2003.11.038