The future of the Nile

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Background

The Nile Basin is the main source of water in the North Eastern region of Africa and is perhaps one of the most critical river basins in Africa as the riparian countries constitute 40% of the population on the continent but only 10% of the area. This resource is under considerable stress with rising levels of water scarcity, high population growth, watershed degradation, and loss of environmental services and these water resources are critically sensitive to climate change. Many past studies have demonstrated that modelling current and future changes in river runoff presents a number of challenges; the large size of the basin, the relative scarcity of data, its geographical location and the corresponding dramatic variety of climatic conditions and diversity in hydrological characteristics. On top of these hydrological challenges, the current generation of global models does not provide a single consistent scenario for the future climate of the region.

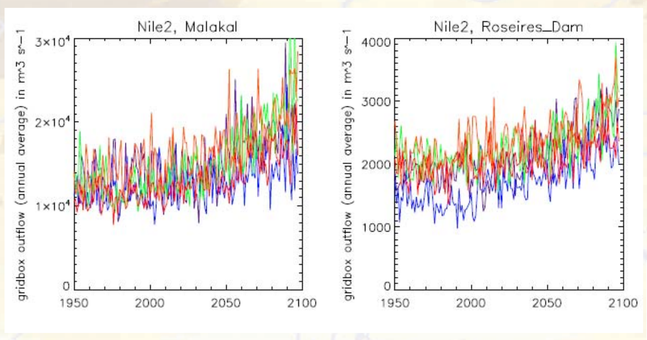
The Challenge

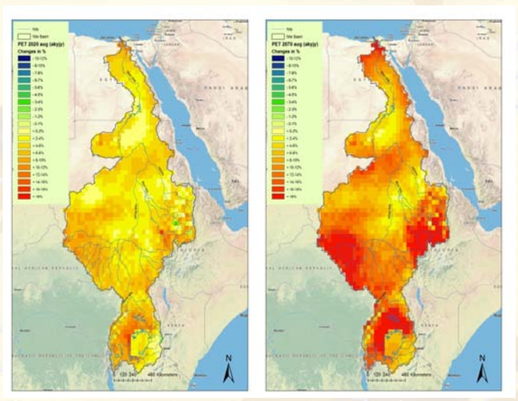
Decision-makers in region need to evaluate and implement climate adaptation measures. Such climate adaptation measures can be implemented at the local, sub-basin or national scale. However within trans-boundary basins like the Nile the implementation of such measures locally may have important impacts regionally, particularly downstream of those measures. Therefore tools and information are required to understand climate change and adaptation impacts at the regional scale. The large uncertainties in the climate projections, together with the natural variability in the Nile, suggest that there is a strong need to maximize adaptive capacity with the region.

Methods

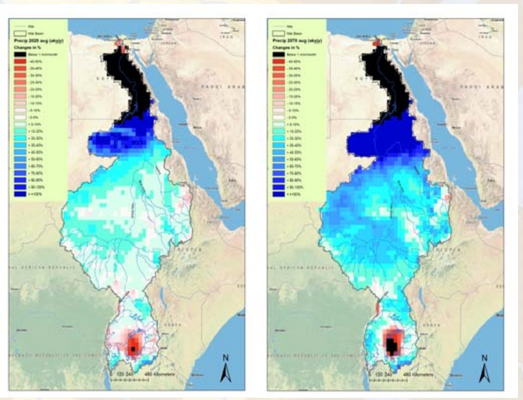
The project exploited a novel perturbed physics ensemble of climate models recently developed at Met Office Hadley Centre. A selection procedure was followed to identify a suitable sub-sample representative of the whole distribution based on the ability of the members to reproduce the key climatic processes in a number of regions of Africa. All simulations were done using A1B scenario. The selected ensemble members were then dynamically downscaled to 50 km using the PRECIS regional climate model. This is a limited area version of the global climate model developed by the Met Office Hadley Centre and it includes the description of a number of surface processes relevant for hydrology.

These high-resolution simulations were bias-corrected and used together with a regional hydrological model to assess the impacts of climate change on the river runoff. For the first project, which was looking at the inflow in the Great Aswan dam, the Nile forecast system, which is routinely used at the Ministry of Water Resources and Irrigation in Cairo, was used. For the second project the regional hydrological MIKE HYDRO model was used instead.





Simulated changes in the potential evapotranspiration for August.
Left: future period 2021 to 2050. Right: future period 2071 to 2100.

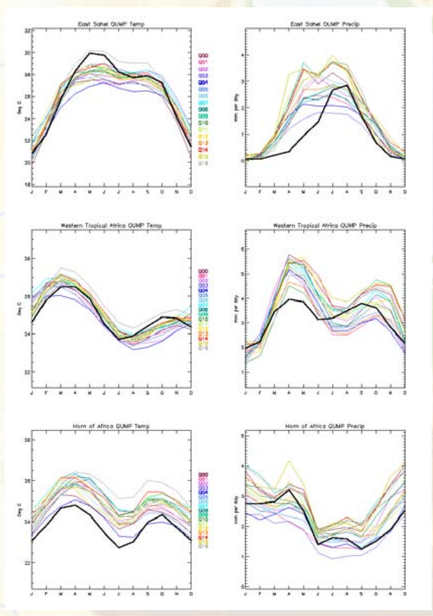


Simulated changes in the rainfall for August.
Left: future period 2021 to 2050. Right: future period 2071 to 2100.

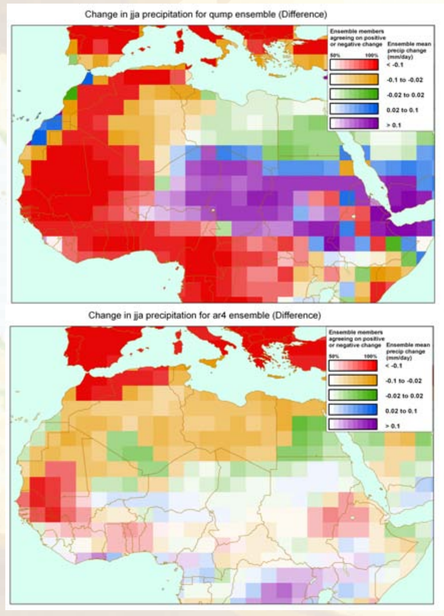
Key regions

For the next phase of the project we decided to focus on some key regions within the Nile basin. In particular two regions were considered to be crucially important: the western Ethiopian plateau, where the Blue Nile has its sources, and the Lake Victoria region because it represents the source of the White Nile. While the Blue Nile provides most of the water in floods season for the main Nile south of Khartoum the White Nile has a nearly constant flow throughout the year and provide most of the water in the main Nile during the low-flow season.

Are the simulations realistic?



How do our simulations compare with others CMIP3 simulations?



Conclusions and future work

Our simulations suggest climate change will generally increase the flow in the river Nile. While some sort of consensus exists in the literature on a possible increase in river flow up until mid-21st century, much more disagreement exists in the projections for the end of the century. In that respect, it is worth stressing here that our results are solely based on a specific family of model (i.e. HadCM3) which appears to be generally wetter than the CMIP3 ensemble mean for part of the region.

The increase in river flow appears to be a robust feature across the ensemble. Despite having changed the domain size, the domain position, the land surface scheme and the set of ensemble members downscaled between the two projects the final conclusions in terms of river flow appear to be broadly consistent.

However, it should be noted that two critical areas of the Nile are currently poorly represented in most models: Lake Victoria and the Sudd. When comparing to present-day observations, we found a significant overestimation of rainfall over Lake Victoria. It is now well established that convection over the lake depends on nighttime convergence which in turn is controlled by the regional orography and by the lake temperature. Coupling the RCM to a lake model is likely to improve precipitation estimates over the lake. The Sudd is also a difficult region to model and may benefit from a explicit representation of marshland in the model.

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