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How might river flows in West Africa change in the future?

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West Africa has a history of extreme climate variability especially in its semi-arid Sahelian region. With rising air temperatures, there are growing indications that the long-term climate across West Africa is changing [3], affecting ecosystems and environments and potentially impacting on hydrological extremes such as severe floods and droughts. There is still considerable uncertainty as to how climate change will affect rainfall patterns but the direction of change and current impacts are largely known. However, the impact on river flows is less well understood. In the work presented here, we aim to address this gap in our understanding. Regional scale grid-based hydrological simulations for West Africa are used to support an analysis of change in peak river flows under a range of projected future climate scenarios (CMIP5) up to the end of the century. A physically-based hydrological model has been configured and assessed to simulate flows continuously across the whole of West Africa on a 10km grid. The model (Hydrological Modelling Framework - HMF) includes estimates of water use, current and future population growth, and wetland inundation to achieve spatially-consistent simulations of river flows at across the whole region. Model simulated river flows for an ensemble of future climate simulations are analysed in order to quantify projected changes in the frequency, severity, timing and scale of extreme events across West Africa. The results are highly spatially variable across the region, highlight vulnerable regions and countries, and provide valuable information for planners of development and infrastructure.

Introduction

In recent decades, West Africa has experienced some of the most extreme rainfall variability anywhere in the world and has a history of prolonged and severe droughts, most notably in its semi-arid Sahelian region. There is an increasing indication that the long-term climate across West Africa is changing, which can lead to extreme hydrological situations (floods as well as droughts). AMMA-2050 investigated how the West African monsoon will change in future decades, and examined the causes of High Impact Weather (HIW) and how they might change in the future. We used this information to increase the understanding of FUTURE changes in peak river flows. We carried out simulations of regional scale hydrological modelling under a range of climate scenarios using present-day and future climate data and a gridded hydrological model – the Hydrological Modelling Framework (HMF).

Hydrological Modelling

The HMF model is a grid-based, spatially distributed hydrological model similar to the G2G [1]. It uses surface and sub-surface runoff-production and kinematic-wave routing of flows along river channels. It has been set up for rivers across West Africa with the aim of estimating projected future impacts of climate change through scenario development. The model includes estimates of water use, current and future population growth, endorheic regions and wetland inundation to achieve a spatially-consistent models of river flows at across the whole region (Figure 1).

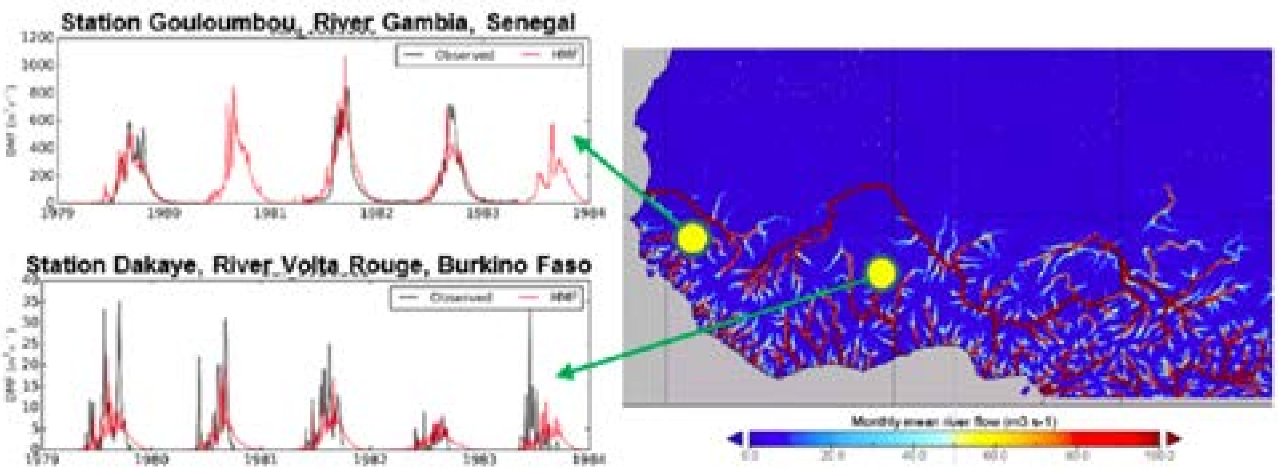

Figure 1. Modelling historical river flows across West Africa with HMF

Using CMIP5 climate model projections up to the end of the century [2] we conducted regional-scale climate-impact simulation to quantify projected changes in the peak flow events across West Africa and highlight vulnerable countries (Figure 2).

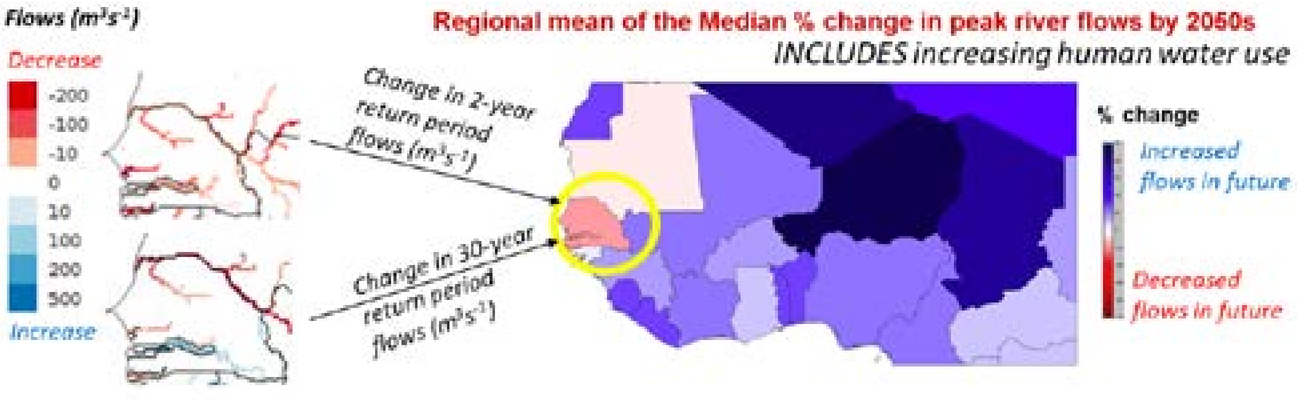

Figure 2. Change in peak river flows by 2050s. This is the median change in flows between present (1976 – 2005) and future (2030 – 2059) across 29 RCP8.5 CMIP5 models.

Conclusions

Across West Africa most hydrological simulations using CMIP5 projected climate data agree that peak river flows will increase in future except in Senegal and neighbouring rivers, where a majority of models agree on future decrease in peak flows.

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Evaluation and projected changes in daily rainfall characteristics over Central Africa based on a multi-model ensemble mean of CMIP5 simulations

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This study uses daily rainfall data from CMIP5 project and eight rainfall indices defined by the ETCCDI, to investigate the changes in extreme weather conditions over Central Africa (CA) under the RCP8.5. The performance of the multi-model ensemble (MME) mean which in fact refers to the best performing models selected through the Taylor diagram analysis was evaluated by observed datasets during the historical period (1998–2005). Results show that although some uncertainties may exist between observation datasets (TRMM and GPCP), MME consistently outperform individual models and reasonably reproduced the observed pattern rainfall indices over the region. The assessment of the climate change signal in those indices was done for the late twenty-first century, relative to the baseline historical time period (1976–2005). We found a significant increase in PRCPTOT over southern (northern) CA from December to February (from September to November). This is mainly due to the increase of high intense rainfall events rather than their frequency. The results also reveal that the increase in PRCPTOT was coupled with