Impact of climate change and human development on future freshwater availability in Africa

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With a constantly growing global population, ensuring a sustainable food production is one of the biggest challenges that humanity is expected to face in the near future. Moreover climate change is adding pressure on our planet; indeed according to the Intergovernmental Panel on Climate Change (IPCC), CO2 emissions will be responsible for changes in temperature and precipitation distribution with unforeseen consequences on freshwater availability for agriculture. Based on the modelling work of the Coupled Model Intercomparison Project (CMIP5), we conduct a systematic analysis of long-term climate forecasts in order to identify and quantify signals of human development on freshwater consumption in the main African river basins. An ensemble of climatic and land variables from CMIP5's outputs - mainly temperature, precipitation, runoff and land cover - for the period 2006-2100 was used to calculate actual evapotranspiration and the evaporative ratio (ratio of actual evapotranspiration to precipitation) through water balance. These parameters were evaluated within the Budyko framework - a hydroclimatic analysis tool that links water availability and energy demand - as obtained from a selection of climate simulations with different emission scenarios to determine potential hydroclimatic change. Some of the those simulations include land cover forecasts, allowing to map out the land use change pathways and discern the relative impact of land and climatic drivers on forthcoming freshwater availability.
By analyzing rose plots for change in Budyko space we found that freshwater availability is changing in a heterogeneous way across the continent in terms of both intensity and directions. Some common patterns emerges across all the models within African basins. In particular, the most serious CMIP5 emission scenario, shows consistent increasing trends of the ratio of potential evapotranspiration to precipitation while less congruous results appear for the evaporative ratio in the model simulations. The first can be explained by the strong dependence of potential evapotranspiration on temperature, which experience an increasing trend due to global CO2 emissions. On the other hand, the evaporative ratio is linked to many complex ocean-land-atmosphere dynamics, which are very sensitive to model components and settings. Directions and magnitudes of such a change in hydroclimatic signals vary from model to model and can be interpreted as evidence of climate change and land use change effects, according to models design characteristics. Considerations about combined climate and land change effect on evapotranspiration is thus deduced by discerning from model land cover components, and the effect on future freshwater use trends is calculated with this methodology.
The applied methodology and results of this study can be a useful tool to bridge the state of the art in climate modelling to climate change mitigation strategies, supporting policy makers to develop sustainable water management and land use change practices.

Keywords: Future freshwater consumption, Budyko framework, Africa