WATER RESOURCES

Future Nile river flows

Climate change is projected to increase annual Nile river flow; importantly, year-to-year variability is also expected to increase markedly. More variable flows could present a challenge for consistent water resource provision in this region.

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Nile river flows have shown notable variability throughout recorded history. Now analysis of climate models suggests that in the future interannual variability is likely to increase, with important consequences for the reliability of associated water resources[1]. This comes at a critical time, when the major Grand Ethiopian Renaissance Dam is nearing completion and Ethiopia is recovering from a serious drought associated with the 2015 El Niño event. Rivers draining the Ethiopian Highlands (the Eastern Nile Basin), particularly the Blue Nile, are the dominant source of downstream main Nile flows, complemented by Lake Victoria outflows and some runoff from the White Nile system. The rapidly growing populations of arid and semi-arid downstream countries Egypt and Sudan are highly reliant on the Nile for their freshwater.

Rainfall and river flows in the Eastern Nile Basin are strongly seasonal, peaking around late boreal summer, and exhibit a marked association with the El Niño Southern Oscillation (ENSO), with drier conditions tending to occur during El Niño events[2]. The El Niño event of 2015 was the strongest on record and was associated with a consistent tele-connection pattern of drought in large parts of the Eastern Nile Basin (Fig. 1). Siam and Eltahir[1] demonstrate, using historical observations, close correspondence between the number of years with moderate-to-strong ENSO activity and the variability of Nile flows, with ENSO accounting for about 27% of Nile variability. They use two approaches to estimate the future flows simulated by global climate models (GCMs) and project an almost 15% increase in flow and 50% increase in standard deviation (variability) for the twenty-first century compared to the twentieth century. These changes are consistent with other work showing increases in the frequency of El Niño and La Niña events projected by GCMs[3] and also reflect a general wetting trend across all years.

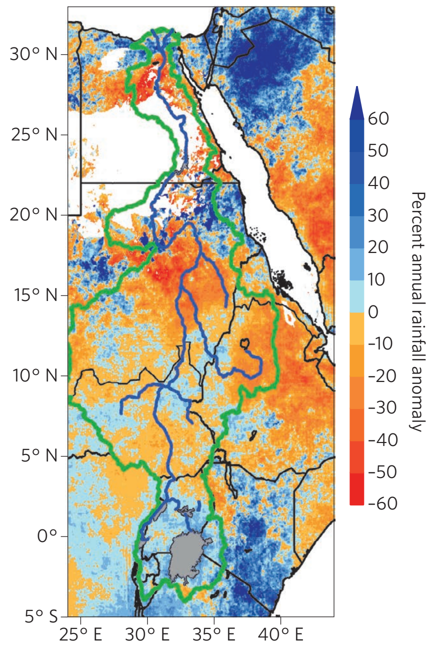

Figure 1 | Percent annual rainfall anomaly for 2015 with respect to the period 1981–2016 (data from ref. 10). The Nile Basin boundary is denoted by a bold green line. Oceans and seas appear in white and on land; grid cells with average rainfall less than 144 mm per year are also shown in white. Figure prepared by N. Mittal and C. Siderius, both at the Grantham Research Institute for Climate Change and the Environment, London School of Economics and Political Science.

Greater Nile flows would on balance be a good thing as they would partially alleviate the increasingly narrow gap between water availability and use in the basin. An increase in variability, however, creates a problem for managing reliability of flows and hydropower generation. Concern about the multi-year variability of the Nile goes back a long way. It was the original stimulation for the famous hydrologist Hurst's pioneering work on persistence and the long-term storage of reservoirs, and guided design of Egypt's High Aswan Dam[4]. Until now, storage was primarily a problem for Egypt. With the construction of the Grand Ethiopian Renaissance Dam it has become an international issue, one which according to Siam and Eltahir's findings could become an even bigger challenge due to climate change. They use Hurst's original equation to show that enhanced interannual variability in the twenty-first century reduces reliability of maintaining flows at a specific level and would require roughly 55% additional storage capacity to achieve existing levels of reliability. Whilst most studies highlight a mix of benefits and costs for the Grand Ethiopian Renaissance Dam[5], there is particular interest in the dam-filling strategies. These have a direct effect on downstream flows, and are sensitive to differences in hydrological variability (which affect trade-offs between downstream flow disruption and hydropower generation[6]).

All studies of future climate impacts based on GCMs are highly contingent upon their ability to simulate realistically the current processes influencing regional climate and their evolution in response to greenhouse gas forcing. Siam and Eltahir[1] provide a range of ±35% on their results which reflects one very important source of uncertainty; differences between GCM projections. Whilst their main results are presented for an ensemble of GCMs that have been found to produce acceptable simulation of ENSO behaviour, the conclusions are robust across different GCM combinations. Testing our confidence in GCM simulation of African climate is an important area of research, particularly in cases where GCM projections may begin to inform real world decisions, for example, as promoted through the Future Climate For Africa programme (http://go.nature.com/2oI3qMv). Contrasts between observed prolonged drying trends in parts of the Greater Horn of Africa and GCM projections for wetting emphasize, among other things, the need to provide more comprehensive process-based understandings of projections and improved understanding of drivers of variability[7]. Moreover, it is not necessarily the case that selecting ensembles of GCMs based on their ability to simulate specific aspects of African climate will reduce the uncertainty range in rainfall projections[8]. For many parts of Africa, GCM projections remain highly divergent, underscoring the need to stress-test planning and infrastructure design against a range of future conditions[9] that are likely to alter over time as new GCM results become available.

Ethiopia has enjoyed political stability and relatively benign rainfall patterns in the Eastern Nile Basin after conflict and successive dry years during the 1980s. Together with sustained economic growth and a strong national focus on improving food security — for example, a major Productive Safety Net Programme — the effects of the 2015 drought have been reduced compared to previous emergencies. In contrast, the unfolding tragedy in neighbouring South Sudan demonstrates the devastating effects of conflict and fragile governance when entangled with drought.

Completion of the Grand Ethiopian Renaissance Dam will mean that the threat of enhanced interannual variability in Nile river flows highlighted by Siam and Eltahir[1] has international consequences. Their work may be too late and provide insufficient evidence to alter the dam's design, but there are important implications for filling and future management strategies, reinforcing the need for consensus and regional cooperation over Nile waters. ❐

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Published online: 24 April 2017