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Water resources: future Nile river flows

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Future Nile river flows

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Throughout recorded history variability has been a perennial feature of Nile river flows. New analysis of climate model results suggests that in the future inter-annual variability is likely to increase with important consequences for reliability of 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 2015's El Niño. 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 associated with a consistent tele-connection pattern of drought in large parts of the Eastern Nile Basin (Figure 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 obtain an almost 15% increase in flow and 50% increase in standard deviation (variability) for the 21st century compared to the 20th 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 in all years.

Greater Nile flows would on balance be a good thing by partially alleviating 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 multi-year variability on 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 construction of the Grand Ethiopian Renaissance Dam it becomes 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 inter-annual variability in the 21st 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 affects 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 to their results of +/- 35% which reflects one very important source of uncertainty; differences between GCM projections. Whilst their main results are presented for an ensemble of GCMs which 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 (7). Contrasts between observed prolonged drying trends in parts of the Greater Horn of Africa and GCM projections for wetting emphasise, among other things, the need to provide more comprehensive process-based understandings of projections and improved understanding of drivers of variability (8). 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 (9). 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 (10) 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 through for example a major Productive Safety Net Programme the effects of 2015's drought have been reduced in comparison to earlier 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 inter-annual variability in Nile river flows highlighted by Siam and Eltahir (1) has international consequences. It may be too late and not enough evidence in itself, 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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