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Modelling hydro-climatic suitability of malaria transmission in Africa: new patterns emerge

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The availability of water at the ground surface for vector mosquito larval habitats is a critical environmental control of malaria transmission. While ambient air temperature controls the rate of several components of the malaria transmission cycle, extensive laboratory and field studies mean that suitable temperature ranges are well established. In contrast, estimation of surface water availability from current global datasets remains challenging. Instead, monthly rainfall is typically used as a proxy for habitat availability; a threshold of 80 mm per month has gained traction as a proxy for breeding habitat in continental-scale models of malaria climate suitability in Africa and has been applied across the globe. However, since complex and spatially variable hydrological processes (e.g. infiltration, evaporation, soil moisture storage, transfer through and storage in river networks) are omitted, a wide variety of rainfall thresholds are found in the literature that leads to large differences in environmental suitability estimates. Moreover, irrigated areas have been observed to provide suitable year-round habitat for Anopheles mosquitos but are not included in such models.

Here we show that across continental Africa, the estimated geographic range of climatic suitability for malaria transmission is more sensitive to precipitation thresholds than the thermal response curves applied. To address this problem and provide a more physical-basis for larval habitat estimation, we use daily climate predictions from seven downscaled general circulation models to run a continental-scale hydrological model (Lisflood) for a process-based representation of mosquito breeding habitat availability. A more complex pattern of malaria climatic suitability emerges as water is routed through drainage networks and river corridors serve as year-round transmission foci. The area estimated to be hydro-climatically suitable for stable malaria transmission is smaller than previous models suggest; however, more people are found in longer-transmission season areas due to higher-density populations along rivers and in irrigated areas. Hydro-climatic predictions of malaria suitable areas show only a very small increase in state-of-the-

art future climate scenarios; however, bigger geographical shifts are observed than with most rainfall threshold models and the pattern of that shift is very different when a hydrological model is used to estimate surface water availability for vector breeding.