Impact of Potential Large-scale and Medium-scale Irrigation on the West African Monsoon and its Dependence on Location of Irrigated Area

Elfath A. B. Eltahir1, and Eun-Soon Im2

1Ralph M. Parsons Laboratory, Massachusetts Institute of Technology, Cambridge, Massachusetts
2Singapore-MIT Alliance for Research and Technology, Center for Environmental Sensing and Modeling

Abstract

This study investigates the impact of potential large-scale (about 400,000 km2) and medium-scale (about 60,000 km2) irrigation on the climate of West Africa using the MIT Regional Climate Model. A new irrigation module is implemented to assess the impact of location and scheduling of irrigation on rainfall distribution over West Africa. A control simulation (without irrigation) and various sensitivity experiments (with irrigation) are performed and compared to discern the effects of irrigation location, size and scheduling. In general, the irrigation-induced surface cooling due to anomalously wet soil tends to suppress moist convection and rainfall, which in turn induces local subsidence and low level anti-cyclical circulation. These local effects are dominated by a consistent reduction of local rainfall over the irrigated land, irrespective of its location. However, the remote response of rainfall distribution to irrigation exhibits a significant sensitivity to the latitudinal position of irrigation. The low-level northeasterly flow associated with anti-cyclical circulation centered over the irrigation area can enhance the extent of low level convergence through interaction with the prevailing monsoon flow, leading to significant increase in rainfall. Despite much reduced forcing of irrigation water, the medium-scale irrigation seems to draw the same response as large-scale irrigation, which supports the robustness of the response to irrigation in our modeling system. Both large-scale and medium-scale irrigation experiments show that an optimal irrigation location and scheduling exists that would lead to a more efficient use of irrigation water. The approach of using a regional climate model to investigate the impact of location and size of irrigation schemes may be the first step in incorporating land-atmosphere interactions in the design of location and size of irrigation projects. However, this theoretical study is still in early stages of development and further research is needed before any practical application in water resources planning.

Experimental Design

The Effect of Large-Scale Irrigation on Rainfall Change

Spatial distribution of rainfall difference between irrigation sensitivity and control (CONT) experiments averaged over May to September

The Effect of Medium-Scale Irrigation on Rainfall Change

The Effect of Potential Large-scale and Medium-scale Irrigation on the West African Monsoon and its Dependence on Location of Irrigated Area

Mechanism of Local Response

The relationship between rainfall and runoff with irrigation and control (CONT) is shown in the figure.

References


Acknowledgements

This research was supported by the National Research Foundation Singapore through the Singapore-MIT Alliance for Research and Technology’s (SMART) Center for Environmental Sensing and Modeling (CENSAM) interdisciplinary research program.