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African rainfall variability: Sensitivity of rainfall, as simulated by a high resolution GCM, to varying orography

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Globally, Africa is probably the most vulnerable region to food insecurity. Agriculture is of primary importance in the continent's food production, however this is a rain-fed activity and is totally dependent on water availability; a commodity which is both highly varied and often very sparse across Africa. In order to make better short- and long-term forecasts of rainfall variability, and therefore water availability, we need to improve our understanding of both current and future climate variability and change. Therefore, this study aims to investigate the performance of a general circulation model (GCM) in the simulation of present-day African rainfall and climate, and whether increasing the spatial resolution of the model's land surface scheme, and in particular its representation of orography, improves the simulated rainfall.

A variety of model runs from the UK Met Office Hadley Centre's latest generation GCM (the HadGEM1 family) are analyzed. Model evaluation is done via comparison with observational, satellite and reanalysis datasets. Then, to better understand the relationship between orography and rainfall variability, two model runs were analyzed from the NUGEM model, another version of the Hadley Centre model. The two model runs are identical (in terms of atmospheric resolution, parameterizations, model physics, etc.), with the only difference being the spatial resolution of the land surface and in particular its orography.

The results suggest that more rainfall is observed over the Ethiopian Highlands and Kenyan Highlands as the spatial resolution increases. The difference between the model runs and satellite data shows a decrease in the dry bias over the Ethiopian Highlands, again as the spatial resolution increases. This implies more accurate rainfall is simulated over the Ethiopian Highlands by the higher resolution model run. This may be due to the effect of orography, also suggested by the difference in wind patterns over the region.

By comparing the two NUGAM model runs, rainfall is more localized and stronger over the mountain peaks for the higher resolution run. The higher resolution orography gives stronger uplift along the hillsides at lower pressure levels, and at the mountainous regions at upper pressure levels. This could bring stronger and more localized rainfall over the mountainous regions. It is suggested that in the higher resolution model, the vertical winds are stronger when reaching the mountains, associated with stronger uplift aloft. The surface winds near the Ethiopian Highlands are slightly stronger for the higher resolution model, which may be due to a smaller value of roughness in the region.