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Response of the North-African summer monsoon to precession and obliquity forcing in EC-Earth

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We have used a high-resolution coupled climate model, EC-Earth, to investigate the response of the North-African summer monsoon to separate precession and obliquity forcing. Four experiments were performed: minimum and maximum precession, both with fixed minimum obliquity, and maximum and minimum obliquity, both with a circular orbit in order to exclude precession. We compare our results to previous model results (Tuenter et al. 2003, The response of the African summer monsoon to remote and local forcing due to precession and obliquity, Global and Planetary Change 36: 219-235), in which the same experimental set-up was used for an intermediate complexity model.

In our EC-Earth experiments, strongly increased summer insolation during a precession minimum compared to a precession maximum results in more intense and more northward heat lows over the Sahara, drawing in stronger south-westerly winds. A stronger South Atlantic high pressure area further enhances the meridional pressure gradient across the equator. Precipitation over the tropical Atlantic is decreased and more moisture is transported landwards from both the northern and southern tropical Atlantic. The African Easterly Jet and Inter Tropical Convergence Zone are located further north, in agreement with the strengthening and northward extension of monsoonal precipitation.

Obliquity-induced summer insolation changes over the tropics are very small, but nonetheless they result in notable changes in precipitation and monsoonal circulation over North-Africa. During high obliquity monsoonal precipitation is slightly increased and extends further north, in relation to stronger and more northward heat lows over the Sahara. The precipitation increase originates mostly from the tropical Atlantic.

Our results provide an explanation for the precession and obliquity signals preserved in the sedimentary record of North-Africa, but the mechanisms are very different than suggested in a previous model study (Tuenter et al. 2003). Using a quasi-geostrophic model of intermediate complexity they show a smaller response to separate precession and obliquity forcing, suggesting that northerly moisture transport from higher latitudes plays an important role. In contrast, we argue that moisture transport from both the northern and southern tropical Atlantic is responsible for the precession as well as the obliquity signal in the North-African monsoon.