Geophysical Research Abstracts, Vol. 9, 05282, 2007
SRef-ID: 1607-7962/gra/EGU2007-A-05282

Mid-Holocene monsoons: a multi-model analysis of the inter-hemispheric differences in the responses to orbital forcing and ocean feedbacks

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The response of monsoon circulation to 6 ka orbital forcing in the northern and southern hemisphere has been examined in 17 atmospheric general circulation models and 11 coupled ocean-atmosphere general circulation models. The atmospheric response to increased insolation in the northern subtropics strengthens the northern-hemisphere summer monsoons and leads to increased monsoonal precipitation in western North America, northern Africa and China; ocean feedbacks amplify this response and lead to further increase in monsoon precipitation in these three regions. The atmospheric response to reduced insolation in the southern subtropics weakens the southern-hemisphere summer monsoons and leads to decreased monsoonal precipitation in northern South America, southern Africa and northern Australia; ocean feedbacks weaken this response so that the decrease in rainfall is smaller than might otherwise be expected. The role of the ocean in monsoonal circulation in equatorial regions is more complex. There is no discernable impact of orbital forcing in central North America in the atmosphere-only simulations but a strong increase in precipitation in the ocean-atmosphere simulations. In contrast, there is a strong atmospheric response to orbital forcing over northern India but ocean feedback reduces the strength of the change in the monsoon although it still remains stronger than today. Although there are differences in magnitude and exact location of regional precipitation changes from model to model, the same basic mechanisms are involved in the oceanic modulation of the response to orbital forcing and this gives rise to a robust ensemble response for each of the monsoon systems.