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Snow-monsoon teleconnections: testing competing mechanisms using idealized snow forcing conditions in a GCM

A. G. Turner (1) and J. M. Slingo (2,1)

(1) NCAS-Climate, University of Reading, United Kingdom (a.g.turner@rdg.ac.uk), (2) Met Office, Exeter, United Kingdom

Anomalous snow during the preceding winter or spring has long been regarded as a possible predictor for the Indian summer monsoon, with anomalously strong snow forcing being followed by weakened monsoon rainfall. However previous work in this area is inconclusive, in terms of the mechanism that communicates snow anomalies to the monsoon summer, and even the region from which snow has the most impact. The complex effects of ENSO on both the monsoon and snow distribution further complicate our understanding, particularly in observational studies reliant on a short data record for snow parameters. A 1050-year control integration of the HadCM3 coupled model is analysed and shows evidence for weakened monsoons being preceded by strong snow forcing over either the Himalaya/Tibetan Plateau, or north/west Eurasia. However, EOF analysis of springtime interannual variability in snow depth shows the leading mode to have opposite signs in these regions. Hence competing mechanisms are likely. The simulation of the ENSO-monsoon relationship in HadCM3 is poor however: it suffers from a poorly timed peak during the monsoon summer and incorrect sign the preceding winter. To test the competing mechanisms, ensemble integrations are carried out using the atmospheric component of HadCM3 and a variety of anomalous snow forcing initial conditions obtained from the control integration of the coupled model. Forcings are applied during spring over the Himalaya/Tibetan Plateau and north/west Eurasia regions, in conjunction with climatological SSTs in order to avoid the direct effects of ENSO. We demonstrate that forcing from the Himalaya region is dominant in this model and show its well-known negative correlation with Indian monsoon rainfall. Results from further experiments examine the relative importance of albedo and hydrological effects (including the underlying soil moisture and temperature fields with snow depth anomalies). We speculate that the inclusion of coupled air-sea interactions in the north Indian Ocean will further reinforce the snow-induced tropospheric cooling at Indian latitudes and strengthen the teleconnection.