Geophysical Research Abstracts
Vol. 14, EGU2012-5187, 2012
EGU General Assembly 2012

Recent changes in surface solar radiation and precipitation in India: sensitivity studies with ECHAM5-HAM

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Population growth and industrialization is progressing at an unprecedented rate on a global scale. One region undergoing a particularly fast transition is India. These changes are accompanied, among others, by a substantial increase in aerosol emission. To learn more about associated consequences for the climate system we have carried out a comparatively large set of transient sensitivity studies with the global atmosphere only climate model ECHAM5-HAM, using aerosol emission data from NIES (National Institute of Environmental Studies, Japan) and prescribed, observation based sea surface temperatures (SSTs) from the Hadley Center. The sensitivity studies cover the period from 1870 to 2005 and comprise ensembles of simulations (up to 13 members per ensemble), which allow to address the role of different aerosol species, greenhouse gases, and prescribed sea surface temperatures.

We present and analysis of these simulation data with particular focus on surface solar radiation (SSR) and precipitation in India, and discuss potential physical mechanisms involved. Modeled annual mean SSR is found to decrease over the Indian subcontinent (land between 67E / 90E / 10N / 25N) at a rate of about -3 to -4 W/m2 per decade. This dimming is roughly in line with observation based estimates. The decrease is comparable under all sky conditions. Regional and seasonal differences are substantial, with the Ganges plane showing the strongest dimming. Aerosols are transported far out over the Indian ocean, leading to a substantial decrease in SSR also there. Modeled precipitation captures well the annual monsoon cycle. The observed, recent decrease in precipitation is, however, overestimated by the model. More precisely, the model captures the observed precipitation reduction in northern India in July / August, but not the observed increase in precipitation in May / June. Our sensitivity studies suggest that the atmosphere only response to increasing aerosol emissions is a reduction of precipitation in the Ganges plane and an increase of precipitation in southern India. The most important factor for the modeled precipitation changes are, however, the observation based prescribed SSTs - which themselves may already encapsulate a substantial aerosol effect.