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Surface solar radiation and hydrological cycle in 20th century China: sensitivity studies with ECHAM5-HAM

D. Folini and M. Wild

ETH Zurich, Institute for Atmospheric and Climate Science, Switzerland (doris.folini@env.ethz.ch)

The world, and China in particular, has seen a tremendous population growth and industrialization in the 20th century. These changes were 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.

Here we analyze these simulation data with particular focus on surface solar radiation, temperature, and the hydrological cycle in China. Physical mechanisms able to explain the results will be discussed. We generally find the strongest effects in the east of the country, where urbanization and industrialization is strongest and emissions increased most. The decrease of surface solar radiation (SSR) under clear sky conditions reaches up to around -8 W / m2 per decade from 1950 to 1990. Comparable values are found for all sky conditions. Dimming ceases in the second half of the 1990s, when we even see a renewed increase in SSR in some regions. Overall, these findings are in line with observation based estimates. Modeled surface temperatures reflect the decrease in SSR but carry also a substantial SST signature. After remaining roughly constant from 1870 to 1900, we find modeled surface temperatures to increase by about 1 degree Celsius till 1950, then decrease again by -0.2 to -1.2 degree Celsius till 1990, before a renewed increase sets in. Precipitation decreases in our model results from 1950 to 2000 by up to 10% or 150 mm per year, mostly due to suppression of convective precipitation. Regional differences and decadal scale variations are, however, substantial. And while convective precipitation is primarily affected by changing aerosol emissions, large scale precipitation bears in addition the imprint of prescribed SSTs - which themselves may already include an aerosol signature.