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Surface solar radiation in 20th century Europe: dimming and brightening as seen by ECHAM5-HAM

D. Folini and M. Wild
ETH Zurich, Institute for Atmospheric and Climate Science, Switzerland

The 20th century has seen a tremendous population growth and industrialization on a global scale. One particular 'hot spot' of these developments is Europe. 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.

Analyzing these simulation data for Europe, we find a clear decrease of surface solar radiation (SSR) from about 1950 to 1980, followed by a renewed increase. This dimming / brightening is well known from observational data. The modeled and observed magnitude of the phenomenon are in good agreement, although dimming in the model ceases too early. One possible explanation for the latter could lie with the prescribed aerosol emissions, in particular too weak SO_2 emissions or
a too early reduction of black carbon emissions. Modeled SSR changes show substantial regional differences in magnitude and timing, again in line with observations. The model data further suggests a substantial random / natural variability / cloud component with regard to SSR changes under all sky conditions. While some ensemble members show a much more pronounced dimming than the ensemble average, others show hardly any dimming. Interestingly, the brightening signal after 1990 is found to be more robust in this respect. Surface temperatures bear some imprint of the SSR changes, especially in Eastern Europe,
but the dominant effect comes from the prescribed SST - which themselves may bear the imprint of changing aerosol emissions.

For details see Folini and Wild, JGR 116, 2011.