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Dimming over the oceans: mixed layer ocean experiments from 1870 to 2000

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Sea surface temperature (SSTs) changes are known to affect precipitation patterns. However, it is still subject to debate, whether anthropogenic aerosols are capable of affecting SSTs, which could feed back on precipitation patterns.

To influence SSTs, anthropogenic aerosols need to reduce incoming surface solar radiation (SSR) through direct or indirect effects for a sufficiently long time span over a sufficiently large area. To quantify the maximum potential SST response to anthropogenic aerosol dimming over the past decades, we performed equilibrium experiments with the general circulation model, ECHAM and explicit aerosol representation (ECHAM6-HAM2.2) and a mixed-layer ocean (MLO). Every ten years, we let the system equilibrate to the conditions (aerosol and greenhouse gas burdens, GHG) of that specific year. Each experiment is conducted over 50 years, of which the first 10 years are discarded. We generated three sets of decadal equilibria covering the entire 20th century and part of the 19th century (from 1870) : One, where both GHG and anthropogenic aerosols are set to the respective decade, one where GHG levels are held constant at 1850s levels, and one where anthropogenic aerosols are held constant at 1850s levels. Deep ocean heat fluxes are prescribed based on the surface energy flux climatology derived from an atmosphere-only integration with pre-industrial (year 1850) conditions for aerosols and GHG and climatological SSTs (average of Hadley Center SSTs, observation based, over the years 1871-1900).

Results of these findings will be discussed, especially the SST and precipitation responses seen in the different equilibria. Moreover, results will be put in context with transient experiments with prescribed SSTs.

The presented results are part of a project aiming at quantifying the effect of anthropogenic aerosols on SSTs. The results will serve as a basis for future experiments using a dynamic ocean model to quantify the transient response of the ocean to anthropogenic aerosol forcing.