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Mixed-layer ocean responses to anthropogenic aerosol dimming from 1870 to 2000

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It is still debated, to what extent anthropogenic aerosol-induced changes in surface solar radiation (SSR) since industrialization affected surface temperatures (tsurf).

We use mixed-layer ocean (MLO) experiments with the general circulation model ECHAM6.1 and explicit aerosols (HAM2.2) to identify regions where this effect is discernible. For each decade from 1870 to 2000 we derive three equilibria: anthropogenic aerosol emissions and greenhouse gas concentrations at the respective decade's levels (ALL), either aerosols or greenhouse gases fixed at year 1850 levels (GHG and AERO). We duplicated parts of the experiments with different prescribed divergence of ocean heat transport (Q_ALL, Q_AERO, Q_GHG).

Comparing year 2000 with year 1870 equilibria, we find global average cooling of -1.4K for AERO, and warming of 1.4K for GHG. ALL and Q_ALL warm by 0.6K and 0.4K, respectively. The way divergence of ocean heat transport is prescribed thus matters. Pattern correlations of year 2000 tsurf responses in ALL with the sum of AERO and GHG are higher (0.88) than with Q_ALL (0.71) confirming additivity of global patterns, but not of global means. The imprint of anthropogenic aerosols on tsurf response patterns in ALL is distinct, thus potentially detectable.

Over the decades, ocean fractions affected by either changing aerosol optical depth or all-sky SSR vary in concert, supporting linkage between anthropogenic aerosols and all-sky SSR. SSR changes and tsurf responses are marginally collocated. Oceanic regions with strongest tsurf response to aerosol-induced SSR changes are the northern mid-latitudes and North Pacific with tsurf sensitivities up to -0.7K per Wm-2 SSR change.

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