EGU2020-4920
https://doi.org/10.5194/egusphere-egu2020-4920
EGU General Assembly 2020

A CMIP6 multi-model study of fast responses on pre-industrial climate due to present-day aerosols

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We present an analysis of the fast responses on pre-industrial climate due to present-day aerosols in a multi-model study based on Coupled Model Intercomparison Project Phase 6 (CMIP6) simulations from 10 Earth System Models (ESMs) and General Circulation Models (GCMs). The aforementioned simulations were implemented within the framework of the Aerosol Chemistry Model Intercomparison Project (AerChemMIP). All models carried out two sets of simulations; a control experiment with all forcings set to the year 1850 and a perturbation experiment with all forcings identical to the control, except for aerosols with precursor emissions set to the year 2014. The perturbation by the present-day aerosols indicates negative top of the atmosphere (TOA) effective radiative forcing (ERF) values around the globe, especially over continental regions of the Northern Hemisphere in summer, with the largest negative values appearing over East Asia. Simulations in 3 models (CNRM-ESM2-1, MRI-ESM2-0 and NorESM2-LM) with individual perturbation experiments using present day SO_2, BC and OC emissions show the dominating role of sulfates in all-aerosols ERF. In response to the pattern of all aerosols ERF, the fast temperature responses are characterised by cooling over the continental areas, especially in the Northern Hemisphere, with the largest cooling over East Asia and India and sulfate being the dominant aerosol surface temperature driver for present-day emissions. The largest fast precipitation responses are seen in the tropical belt regions, generally characterized by a reduction over continental regions and a southward shift of the tropical rain belt. This is a characteristic and robust feature among most models in this study, associated with a southward shift of the Intertropical convergence zone (ITCZ) and a weakening of the monsoon systems around the globe

(Asia, Africa and America) in response to hemispherically asymmetric cooling from a Northern Hemisphere aerosol perturbation. An interesting feature in aerosol induced circulation changes is a characteristic dipole pattern with intensification of the Icelandic Low and an anticyclonic anomaly over Southeastern Europe, inducing warm air advection towards the northern polar latitudes in winter.

This research was funded by the project "PANhellenic infrastructure for Atmospheric Composition and climatE change" (MIS 5021516) which is implemented under the Action "Reinforcement of the Research and Innovation Infrastructure", funded by the Operational Programme "Competitiveness, Entrepreneurship and Innovation" (NSRF 2014-2020) and co-financed by Greece and the European Union (European Regional Development Fund).