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Is there hope for reducing the uncertainty associated with aerosols in climate projections?

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Together with imminent climate action, building a sustainable future for the humanity requires striving for healthier environments. Atmospheric aerosol particles (also referred to as particulate matter, PM) play a key role in defining the air that the future generations will breathe but also the climates they live in, PM being an important short-lived climate forcer but also a key component of air quality and global environmental health hazard. The contribution of aerosol particles has been a key uncertainty in estimates of the Earth's radiative forcing since the establishment of the Intergovernmental Panel for Climate Change (IPCC) and still remains as the single largest quoted source of uncertainty in the anthropogenic climate forcing during the industrial period. In the latest assessment by the IPCC, the radiative forcing by aerosol particles has been estimated to be -0.45 W m-2 (between -0.95 and 0.05 W m-2) for aerosol-radiation interactions (RFari) and -0.45 W m-2 (between -1.25 and 0 W m-2) for aerosol-cloud interactions (RFaci). Recent reviews indicate no significant reduction in the uncertainty. The large range of possible aerosol forcing values has serious consequences for climate projections and therefore developing strategies for reaching Paris agreement targets. It is currently not possible to say if a reduction in aerosol emissions due to air pollution mitigation and a phase-out of aerosol emissions will result in a noticeable increase in global mean temperature or in a negligible climate effect. We will discuss the components and reasons of this uncertainty, focusing on those that are important for aerosol-cloud interactions. We will identify critical bottlenecks in 1) scientific understanding of fundamental aerosol and cloud microphysical processes; 2) method development for improving the understanding of aerosol, cloud, and aerosol-cloud processes as well as their representation in Earth System Models (ESMs); and 3) knowledge transfer within and between the relevant research communities. We will argue for key actions to overcome these bottlenecks, giving examples of good practices for breaking new ground in this long-standing problem that continues to intrigue the atmospheric and climate science communities. Besides enhancing the scientific understanding of the Earth system within the realm of natural science based on multiple lines of evidence, and developing novel (e.g. machine learning –based) methodologies for analyzing existing observational data and model output, we call for additional perspectives from social science and humanities on the communication and knowledge transfer practices within atmospheric and climate research.

Making the relevant knowledge transfer pathways and processes transparent is urgently needed to enable systematic determination of the actions required to maximally utilize the existing knowledge, and to ensure effective implementation of new results that may help to narrow down the uncertainty associated with aerosols in climate projections. Improved understanding of the role of aerosols in the climate system will result in enhanced credibility of ESMs and hence also tighter constraints for policies aiming for simultaneous climate neutrality and zero pollution targets.

The FORCeS consortium: Partners of the H2020 project FORCeS (https://forces-project.eu/)