Final Report Summary - ACCLAIM (Aerosols effects on convective clouds and climate)

Clouds play a key role in the climate system. Small anthropogenic perturbations of the cloud system potentially have large climate effects, in terms of the radiation balance, hence global temperature, as well as the hydrological cycle, with effects on precipitation. Aerosols perturb the global radiation budget directly, by scattering and absorption, as well as indirectly, by the modification of cloud properties and occurrence. The physics of aerosol effects on large scale “stratiform” clouds is reasonably well understood. However, while large aerosol effects on convective clouds and precipitation have been postulated, robust evidence for and quantitative estimates of those effects had remained elusive.

The primary objective of ACCLAIM has been to understand the effects of aerosols on convective clouds as basis for improved global estimates of anthropogenic climate effects. ACCLAIM set out to i) unravel the governing principles of aerosol effects on convective clouds; ii) provide quantitative constraints on satellite-retrieved relationships between convective clouds and aerosols; and ultimately iii) to enable global
climate models to represent the full range of anthropogenic climate perturbations and quantify the climate response to aerosol effects on convective clouds.

ACCLAIM has achieved its objective through interdisciplinary research in a single team, combining novel global aerosol-convection climate modelling studies with satellite remote sensing and high-resolution process modelling. Our research has advanced our physical understanding of aerosol convection interactions, led to the development of new data analysis and modelling techniques and highlighted uncertainties across a large part of prior research.

For example, while prior satellite based research claimed vast effects of aerosols on precipitation we could show that carefully controlling for many confounding factors significantly reduces the magnitude of these effects. While the vast majority of existing climate models has simplistic representations of convective clouds that cannot represent aerosol effects on convection, we have developed and applied the Convective Cloud Field Model in the aerosol climate model ECHAM-HAM, with explicit coupling between aerosol and convective microphysics. We could also show that uncertainties in the representation of cloud process affect conclusions from a significant amount of prior work on aerosol-convection interactions in cloud resolving models.

Overall, our results demonstrate that aerosol effects on convection defy simplistic idealised models. Effects are highly regime dependent and their magnitude on larger scales may be smaller than previously assumed. It will still require strong international efforts to deliver robust quantitative estimates of uncertainties of aerosol effects across scales, but this project has provided major inputs to all key research strands in this area of research.

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