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Smoke interacting with clouds in the south-east Atlantic: representing CLARIFY case studies with the Unified Model

Hamish Gordon, Daniel Grosvenor, Kenneth Carslaw, and Paul Field
University of Leeds, Leeds, United Kingdom (hamish.gordon@cern.ch)

Smoke from African fires mixes into clouds near Ascension Island in the south-east Atlantic, substantially influencing their radiative properties over a vast swathe of ocean[1]. The area of mixing coincides with the transition from stratocumulus to cumulus clouds, so any effects of aerosols on cloud cover are likely to be particularly important[2].

The clouds are strongly influenced by droplet concentration and liquid water path, both of which are difficult to represent in models. The droplet concentration requires accurate horizontal and vertical positioning of realistic aerosol plumes. In regional or global models, the liquid water path depends on correct representation of the boundary layer and on the sub-grid cloud fraction. Evaluation of the droplet concentration can be challenging as satellite retrievals may be compromised by above-cloud aerosol, which itself affects the properties of the clouds[3]. However, the recent CLARIFY campaign provides key in-situ data and fresh insights on how to deal with these issues.

This presentation will show how the aerosol-cloud interactions in this region can be represented in a convection-permitting regional Unified Model simulation driven by the HadGEM-UKCA global aerosol-climate model. The 4km-resolution regional simulation has two-moment aerosol driving two-moment cloud microphysics (the CASIM scheme[4]). In our model, the presence of smoke aerosol leads to a substantial increase in cloud droplet number, and also to significant effects on the cloud microphysics and boundary layer dynamics. We will highlight key challenges in simulating the stratocumulus-to-cumulus transition in the tropical Atlantic with large-scale models, for example the representation of aerosol mixing into the boundary layer. We will also show comparisons of our model to measurement data from the CLARIFY campaign.

1. Zuidema et al, BAMS 1131 (2016)
2. Yamaguchi et al, GRL 42 10478-10485 (2015)
3. Wilcox, ACP 12 139-149 (2012)
4. Shipway & Hill, QJRMS 138, 2196–2211 (2012)