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Lagrangian evaluation of marine aerosols sources in an Earth System Model.

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Increasing the current understanding of how the Earth will respond to a warming climate requires a more accurate representation of aerosols by Earth system models (ESMs). Reducing current uncertainties associated with model estimates of climate change sensitivity to greenhouse gas emissions is hampered by our understanding of the impact aerosol particles have on the radiative budget via their interactions with clouds. The complexity of such interactions leads to their imperfect representation in models.

Emissions of marine organic aerosols play a relevant role on cloud formation in regions where there is a high concentration of phytoplankton, for example in the Southern Ocean (SO). Comparisons between GCMs and satellite observations over the SO show that the models simulate too little reflection of shortwave radiation and this is strongly linked with modelled cloud properties. A potential cause of this issue is a source of missing aerosols in the ESM.

In this study we evaluate the ability of a state-of-the-art ESM, UKESM1, in reproducing aerosol particles originating from organic marine sources that reach a measurement station in pristine air through long-range transport. UKESM1 is developed by the Met. Office and our simulation is nudged by reanalysis datasets for a fair comparison with observations. This ESM is unique in using its ocean biogeochemistry module to interactively simulate the emission of marine organic aerosols. To this end, a novel Lagrangian trajectory framework for evaluating GCMs has been developed. This method makes use of satellite measurements of chlorophyll concentration (a proxy of phytoplankton abundance in the sea surface) at the sea surface, together with the cloud condensation nuclei (CCN) concentration at 0.5% of supersaturation measured at Cape Grim (Southern Ocean, Tasmania) station. Chlorophyll and wind speed data are collocated along air mass trajectories, which are calculated through the HYSPLIT model. A source-receptor analysis is then performed to look for potential spatial correlation between the collocated chlorophyll concentration experienced by air parcel paths coming from a defined clean air sector of the boundary layer (to avoid anthropogenic influences) and CCN measurements. Additionally, a temporal correlation analysis is performed in this framework. This method is applied to both UKESM1 output data and observations to evaluate aerosol processes in climate models.

Preliminary results show a positive correlation in model data between marine organic activity and CCN production that is found also in the observations. Despite the model well representing the

seasonal variability of CCN at the station, the model struggles to reproduce the positive relationship obtained from the observations between wind speed and CCN concentration during the winter season. This can be attributed to a potential missing source in the model.