EGU General Assembly 2024

EGU24-4329, updated on 21 May 2024
https://doi.org/10.5194/egusphere-egu24-4329
EGU General Assembly 2024

Comparing ML retrieved and invisible ship tracks to probe the meteorological dependence of cloud susceptibility to aerosol

Peter Manshausen[1], Duncan Watson-Parris[2], and Philip Stier[1]
[1]University of Oxford, Atmospheric, Oceanic and Planetary Physics, Department of Physics, Oxford, UK
[2]Scripps Institution of Oceanography and Halicioglu Data Science Institute, University of California San Diego, La Jolla, CA, USA

Aerosol-cloud interactions continue to resist reliable quantification, partly owing to their strong dependence on cloud and weather regimes. For a long time, opportunistic experiments such as ship tracks have been used to overcome issues of confounding. Recent advances leverage (i) Machine Learning (ML) to drastically enlarge ship track data bases, and (ii) 'invisible ship tracks', found by advecting ship emissions, to overcome selection biases in ship track studies. Here, we combine both approaches, to advance our understanding of how meteorology controls cloud responses to aerosol emissions. Firstly, we show that even though the ML dataset is much larger than previous hand-logged data sets, it still contains only a fraction of less than 1% of the cloud regions polluted by shipping. This means less than 1% of ship tracks are visible. Secondly, we find that this fraction varies strongly with location and season, with the Southern Hemisphere winter leading to most visible tracks in the Stratocumulus regions of the SE Pacific and SE Atlantic. Thirdly, we identify meteorological regimes favourable to the visibility of tracks, using ML methods such as Random Forests and Explainable AI, alongside traditional methodsThe regime favourable to visible tracks is defined by a stable lower troposphere and little vertical movement, low sea surface temperatures, high cloud cover, and low boundary layer heights. Lastly, we quantify the link between ship track visibility and albedo change in polluted clouds, establishing to what extent days with visible tracks are those when cloud albedo is most susceptible to aerosol. Building on this relationship, a predictive model like our Random Forest has applications in deliberate Marine Cloud Brightening by predicting the days that are most susceptible to aerosol perturbations.