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Polluted cloud lines in satellite snapshots and satellite climatologies

Velle Toll, Heido Trofimov, Jorma Rahu, and Piia Post
University of Tartu, Institute of Physics, Tartu, Estonia (velle.toll@ut.ee)

It is challenging to separate the cause from effect in aerosol-cloud interactions. Anomalous cloud lines polluted by anthropogenic aerosols help distinguish the cause from effect as properties of polluted clouds can be directly compared to nearby unpolluted clouds' properties. Pollution tracks in clouds induced by localised aerosol emissions (Toll et al. 2019, Nature, https://doi.org/10.1038/s41586-019-1423-9) are visually detectable ship-track-like quasi-linear polluted cloud features in satellite snapshots. We detected similar anomalous polluted cloud lines in the long-term average satellite data, where cloud response to aerosol over a long time is recorded. Polluted cloud tracks are induced by various aerosol sources like oil refineries, smelters, coal-fired power plants, smaller industry towns, ships, and volcanoes. We detected polluted cloud tracks at spatial scales varying from tens of kilometres to thousands of kilometres (Trofimov et al. 2020; JGR Atmospheres, https://doi.org/10.1029/2020JD032575).

Polluted cloud tracks detected in satellite snapshots are excellent for the process-level understanding of aerosol-cloud interactions. Polluted cloud tracks recorded in satellite climatologies are great for estimating the average cloud response to aerosols. MODIS snapshots of polluted cloud tracks show relatively weak cloud water response to aerosols at various spatial scales. High-resolution analysis of South-East Atlantic shipping corridor shows partial off-set of the Twomey effect by decreased cloud water. Cloud fraction sometimes increases in the polluted cloud tracks and sometimes decreases compared to the nearby unpolluted clouds. The temporal evolution of cloud responses in pollution tracks estimated from geostationary SEVIRI data and meteorological conditions favourable for pollution track occurrence is presented. We expect that the utilisation of these real-world laboratories of aerosol impacts on clouds helps to improve global climate models' physical parameterisations.