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Aerosol-cloud interactions from combined observations with geostationary and polar-orbiting sensors

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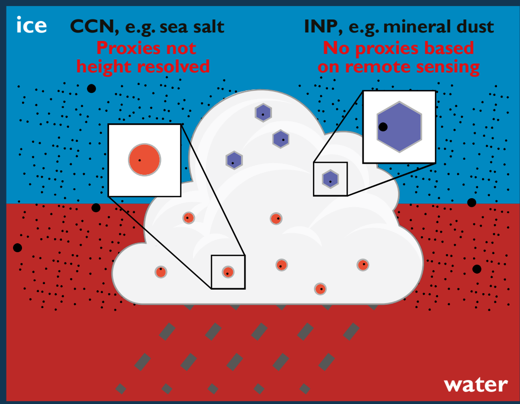
Abstract

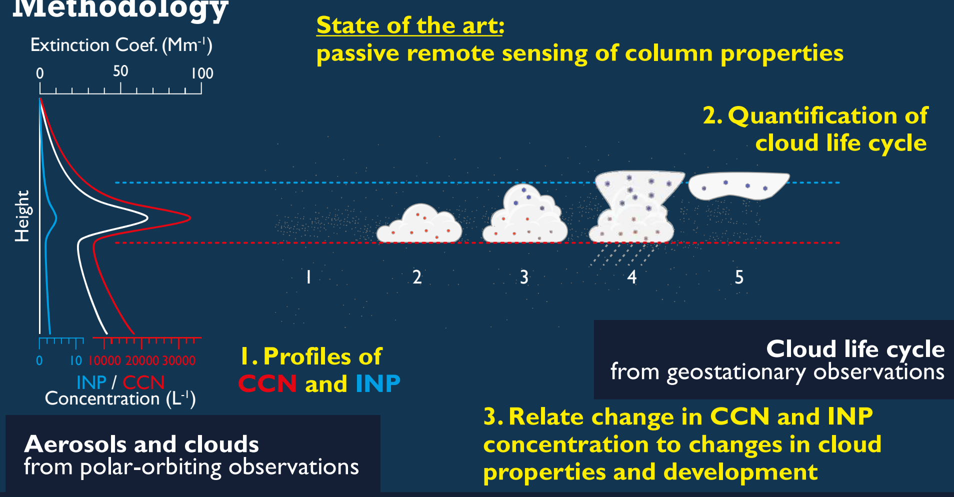
Atmospheric aerosol particles act as cloud condensation nuclei (CCN) in liquid-water clouds and as ice nucleating particles (INP) in ice-containing clouds. Changes in aerosol concentration affect the albedo, development, phase, lifetime and rain rate of clouds. These aerosol-cloud interactions (ACI) and the resulting climate effects have been in the focus of atmospheric research for several decades. Nevertheless, the IPCC still concludes that ACI cause the largest uncertainty in assessing climate change as they are understood only with medium confidence.

We will improve our understanding of ACI by enhancing the representation of the aerosols relevant for cloud processes and by quantifying temporal changes in cloud properties throughout the cloud life cycle. We will gain unprecedented insight in CCN and INP concentrations from spaceborne lidar data. In addition, the development of clouds before and after the snap-shot view of polar-orbiting sensors will be characterised by tracking those clouds in time-resolved geostationary observations. This information will be used to study the effects of CCN and INP on the albedo, liquid and ice water content, droplet and crystal size, development, phase and rain rate of clouds within different regimes carefully accounting for the meteorological background.

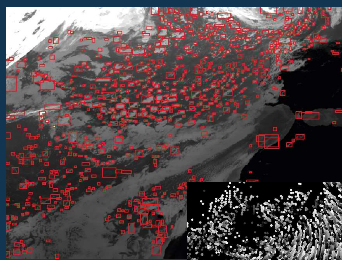
How do aerosols affect clouds?



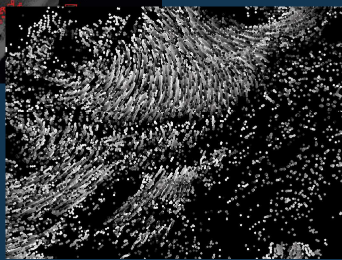
Methodology



Cloud tracking



We use particle imaging velocimetry and the optical flow technique to track isolated clouds in SEVIRI imagery.



Cloud location and size is matched with cloud properties from, e.g. the CLAAS data set.

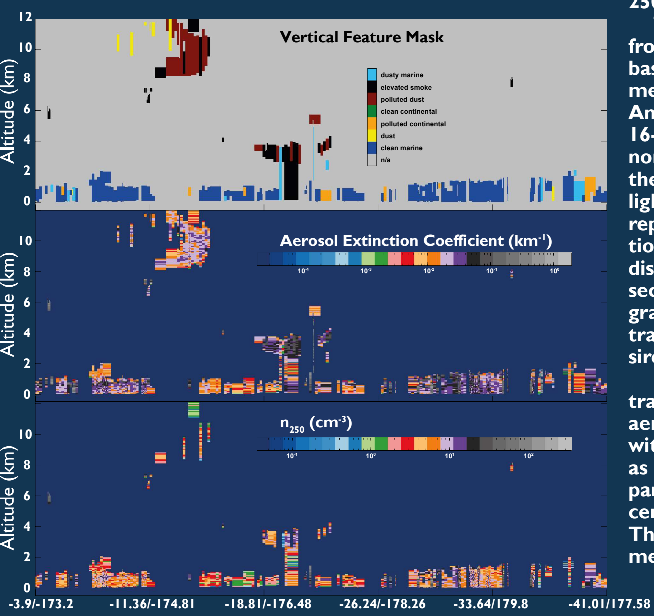
We start with well-defined and easily recognizable cloud scenes such as isolated cumulus and alto-cumulus to assess the usefulness of different masking and tracking methodologies. From there we will move on to increasingly complex cloud types and regimes.

The resulting cloud tracks and their associated cloud properties (information on cloud development and lifetime) are matched with active and passive observations from polar orbiting satellites for validation and to study aerosol-cloud interactions.

Initially, we will focus on scenes with strong aerosol signals to study the feasibility of relating the thus inferred aerosol and cloud information.

Retrieval of CCN and INP concentrations

We use aerosol extinction profiles from spaceborne CALIPSO lidar measurements to get an estimate of the concentration of particles with dry radii larger than 50 nm, (n_{50}) 100 nm (n_{100}), and 250 nm (n_{250}).



These values are obtained from using (i) conversion factors based on AERONET measurements following Mamouri and Ansmann (2016, doi:10.5194/acp-16-5905-2016) and (ii) scaling the normalized size distributions of the CALIPSO aerosol model in light-scattering calculations to reproduce the measured extinction coefficients. Number size distributions obtained from the second approach are then integrated to get number concentrations of particles of the desired size range.

Finally, these number concentrations for particles of different aerosol types are used together with meteorological information as input to aerosol-type specific parameterizations that give concentrations of CCN and INP. This is a considerable advancement over current spaceborne proxies such as AOT and the aerosol index.

PACIFIC team

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