Project Title

Radiative Effects of Marine Boundary Layer Clouds

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Allocation period:
01.01.2023 – 31.12.2023

On average over 70% of the Earth's surface is covered by clouds at any given time [1]. Their occurrence, or their absence, impacts our daily life in terms of everyday "weather", and they play a crucial role in the Earth's climate.

Clouds facilitate the transfer of heat from Earth's surface to the atmosphere through evaporation at the surface and condensation above. Clouds also reflect and absorb incoming sunlight in the shortwave (SW) and the longwave (LW) spectrum of light. Thereby their optical thickness in the visible or the near-infrared spectrum plays a crucial role in regulating the amount of incident radiation that reaches the surface.

Specifically low-level stratiform clouds, i.e. clouds that form in the lowest 1 – 3 km of the atmosphere and extend vertically only a few hundred meters, remain a considerable source of uncertainty in the climate system. These clouds cover around 23% of Earth's ocean surface [2] and are particularly important for the net radiative balance of incoming and outgoing radiation at the surface.

Due to their brightness, or albedo, which ranges between 0.2 – 0.4, they are very reflective in the SW spectrum of light. At the same time these clouds exert only a small radiative-effect in the LW spectrum due to their proximity to the surface. In the global mean low-level stratiform clouds cool the Earth by ~ -40 Wm^{-2} [3], with the greatest cooling occurring in the sub tropics. However, near the poles, in regions of low solar insolation, the LW cloud-radiative effect dominates and induces a surface warming term of ~ 20 Wm^{-2} throughout most of the year [4].

Any given field of low-level clouds may span hundreds of kilometres and may organise in different ways. The established organisation, or cloud morphology, within these cloud fields governs cloud characteristics such as cloud water content, precipitation statistics, cloud fraction, and cloud albedo. Furthermore, low-level clouds occur in two distinct thermodynamic regimes. Either the non-vapour phase of the cloud consists of water only, the *pure-liquid* regime, or a mixture of liquid and ice, the *mixed-phase* regime.

Our research projects focuses on cloud physical processes and aerosol-cloud interactions in marine boundary layer clouds from the subtropics to the poles. We are particularly interested in constraining how microphysical processes in their interaction with cloud dynamics, thermodynamics, radiation and environmental conditions alter the climate-relevant cloud-radiative effect. In addition to unintentional cloud-seeding processes by particulate anthropogenic emissions, we also investigate the efficacy, limitations, and potential risks from a physical science perspective of deliberate marine cloud seeding approaches.

To answer these questions we use the numerical weather prediction (NWP) and climate model ICON. Most simulations will be run in NWP mode from cloud-resolving to mesoscale resolutions. Multiple sensitivity experiments are performed in conjunction with ground-based and satellite-based remote sensing retrievals, or in-situ observations to constrain the relative importance of different cloud processes.

References:

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