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The cloud lifetime: modeling and remote sensing framework

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Depending on the cloud's height in the atmosphere, it consists of variously shaped ice crystals (cold cloud) or spherical liquid water droplets (warm cloud). Droplets grow by condensation becoming heavy enough to be pulled down by the gravity in the form of drizzle or rain, precipitating towards the ground. Stratocumulus cloud is a type of a warm cloud that demonstrates this process frequently, stretching thousands of kilometers far and wide in the horizontal direction, much like a sheet. Due to its property to reflect a great part of the incoming solar radiation and its vast horizontal spatial coverage, the droplet and cloud evolution play a role in the large scale radiative balance. The connection between the micro-scaled cloud droplet evolution and thousands of kilometers of cloud variable radiative properties can be related through the definition of the term the cloud lifetime.
To observe the stage of the cloud evolution, remote sensing instruments are used to profile its structure. Ground based active instruments radar and lidar in synergy compose the ratio of observables that discriminates between the gradually evolving categories of drizzling clouds. In this project we used a large eddy simulation to construct limited domain cloud scenes that reproduce a well behaving Stratocumulus cloud evolution. We apply a separate synthetic remote sensing observations retrieval model of the EarthCARE (Earth Cloud, Aerosol and Radiation Explorer) to the cloud scene and relate it to the top of the cloud reflectance, made by using the satellite mode of the simulator. The advantage of this mode is the compatibility in the sensitivity and configuration of the existing satellite imagers. They provide an overview of the horizontal structure and variability change of the cloud sheets that the ground sensors lack hence, a combination of both the ground and space-borne instruments perspective is used.

Uncertainties in this project framework can arise from two sides: the fact that atmospheric model output is used as a frozen in time cloud scene creates possibilities for shortcomings due to preset interaction of the cloud droplets evolution and interaction with the environment in the model, based on mean statistics; and from the assumption that the synthetic observations are true, because they are in principle an array of models: scene creation model, forward model and the custom configuration for hardware details of the instrument. Placing this framework in the context to categorize the cloud lifetime based on the size of its droplets and their evolution, even when both uncertainties are combined we still get a correlation between the variables we observe using synthetic observations. This matches the case as it would appear using real instrument setup and observations. Is it the case due to artificially perfected model parameterizations? A possible indicator would be a cross-combined platform where either a modeled cloud is used to which real instrument retrievals are applied or a reverse layout where synthetic observations are applied to a real cloud. However, the proposed test would have a questionable amount of uncertainty of its own due to the artificial combination of the real and synthetic data.