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Simultaneous multi-layer retrievals of ice and water cloud properties using passive measurements

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Due to their important temporal and spatial coverage, cirrus are cloud types that are recognized as having a strong impact on the Earth-Atmosphere radiation balance. This impact is however still poorly understood, because of the difficulties to properly describe their microphysical and optical properties in global climate models.
Therefore, many studies have been conducted during the last decades, to characterize cirrus properties more accurately. Since 2002, the satellite constellation A-Train assists to this purpose, thanks to a multitude of active and passive instruments dedicated to a precise study of the Earth and its atmosphere. Instruments measuring in the thermal infrared such as IIR (Infrared Imaging Radiometer) and MODIS (MODerate resolution Imaging Spectroradiometer) have proven to be particularly helpful in the study of cirrus.
With this recent possibility of synergism between spatial instruments, across a wide range of wavelengths, the use of optimal estimation in retrieval schemes has become commonplace. This method appears to be highly efficient for dealing with a large number of measurements in order to retrieve very different kinds of parameters. It also has the advantage of clearly accounting for the measurement accuracy and the non-retrieved parameter errors. In this study, we use such a scheme to retrieve the optical and microphysical properties of cirrus, but also of the liquid water clouds that may lie underneath. It can indeed be observed that the presence of liquid water clouds might strongly impact the retrievals of cirrus properties, but yet very few methods propose simultaneous retrieval in the case of multi-layer scenes. The state vector, that defines the parameters to be retrieved, is composed of the cirrus ice water content, the optical thickness of liquid water clouds, and the effective radius of their liquid droplets. The measurement vector is composed of radiances in the infrared and visible spectral ranges. In order to describe the cirrus microphysics, we utilize a parameterization developed by A. J. Baran, that describes the optical properties as function of the cloud IWC and the cloud temperature. The water clouds are described using Mie-Lorenz theory. The positions of the cloudy layers are given by the lidar CALIOP, which limits the retrievals to its track.
The preliminary results show accurate retrievals of all parameters in multi-layer cases. The radiances simulated using the retrieved parameters, along with their associated errors, are in strong correlation with the measurements. Also, comparisons of our IWP retrievals with diverse A-Train operational products active and passive measurements (CALIOP, IIR, MODIS, DARDAR products) show strong similarities. The first conclusions of this study thus prove that it can be possible to retrieve simultaneously liquid and ice cloud properties. These results are encouraging, since future incorporation of spectral bands sensitive to the cloud altitude and vertical extent could allow straying from the lidar track, in order to retrieve accurate cirrus properties across much larger areas.