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Retrieving thin warm clouds properties by radiative transfer modelling and ground based spectral measurements and analysis in the longwave IR

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Small, thin clouds usually fall below the detector or model resolution and therefore their effects are not considered. Most of the remote sensing techniques are dedicated to retrieve the properties of large, developed clouds, while most of the clouds models lack the required spatial resolution in order to account for small clouds. Nevertheless, previous studies suggested small clouds should be numerous and their cumulative effect on the reflectance and radiative forcing might be substantial. A novel method to retrieve the optical and microphysical properties of thin warm clouds has been developed. The method relies on ground-based spectral measurements and analysis of the zenith sky in the longwave IR, and it is efficient for retrieving the properties of warm clouds with liquid water path (LWP) that spans from as high as ∼50g/m2 and down to ∼0.05g/m2 with a minimum of about 0.01 visible optical depth. The retrieval methodology exploits fine spectral differences between droplets with different radii and it relies on three elements: A detailed radiative transfer calculations in the longwave IR regime, signal enhancement by subtraction of a clear sky reference, and spectral matching method that identifies the measured signal originates from water droplets. We will present the theoretical basis for the retrieval technique, along with a discussion regarding its limitations, robustness, and efficacy. In addition, a controlled experiment was conducted in order to validate the main principle of the methodology. Artificial clouds were sprayed and their effective radii were retrieved and measured in situ simultaneously. Several case studies of thin clouds, which were measured during a field campaign, will be presented as well. These clouds are characterized by short lifetime, LWP smaller than 10g/m2, and small effective radii.

The proposed method can be of use in several aspects. The frequency and optical properties of very thin water clouds can be studied in order to evaluate their total radiative forcing. In addition, the unique properties of the clouds' inter region (also known as the "clouds' twilight zone") can be explored. Moreover, it can be also used to study the optical and microphysical spatial properties of clouds' edges, and shed light on mixing mechanisms.