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Estimation of the contribution of small, thin, warm clouds to the radiative forcing of a cloud field, using ground based measurements

E. Hirsch (1), E. Agassi (2), and I. Koren (1)

(1) Weizmann Institute, Israel (eitan.hirsch@weizmann.ac.il), (2) Israel Institute for Biological Research, Israel

Clouds modulate the Earth's atmosphere by reflecting solar radiation and absorbing and reemitting longwave radiation. The vast majority of the remote sensing techniques to study clouds are utilized by space borne sensors. Therefore, most of our knowledge and statistics are biased towards large, thick, and developed clouds. As a result, small clouds are usually ignored and their contribution to the total reflectance and radiative forcing is less explored. Nevertheless, past studies have shown a clear power-law distribution of the frequency and size of warm convective clouds, suggesting that significant portion of the reflectance of such cloud fields originates from small undetectable clouds. In addition, it was also shown that the inter-region between clouds (also known as the "cloud's twilight zone") is characterized by optically unique properties, which are partly a result of small, undetectable clouds. In this study, we make use of a ground based measurement assembly and a newly developed retrieval method, to shed some light on these important but poorly monitored small and thin clouds. A field campaign was carried out during the summertime of 2011 and its data provides information on the optical and microphysical properties of such clouds as well as on their distribution, with very fine spatial resolution at the order of few tens of square meters, and temporal resolution as high as 2 seconds. Along with the frequency of occurrence of these clouds, we can calculate their contribution to the cumulative reflectance and radiative forcing. We present several detailed case studies, where the contribution of clouds containing liquid water path (LWP) smaller than 10g/m2, to the total daily reflectance field and radiative forcing exceeded 50%. These evidence suggest that more care is needed when modeling cloud fields, developing space-borne remote sensing retrievals, and calculating the reflectance and radiative forcing of a cloud field, especially when small, thin clouds are involved.