Atmospheric Chemistry and Physics
An Interactive Open Access Journal of the European Geosciences Union

Atmos. Chem. Phys., 6, 2887-2894, 2006
www.atmos-chem-phys.net/6/2887/2006/

The time-space exchangeability of satellite retrieved relations between cloud top temperature and particle effective radius

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Abstract. A 3-minute 3-km rapid scan of the METEOSAT Second Generation geostationary satellite over southern Africa was applied to tracking the evolution of cloud top temperature (T) and particle effective radius (r_e) of convective elements. The evolution of T-r_e relations showed little dependence on time, leaving r_e to depend almost exclusively on T. Furthermore, cloud elements that fully grew to large cumulonimbus stature had the same T-r_e relations as other clouds in the same area with limited development that decayed without ever becoming a cumulonimbus. Therefore, a snap shot of T-r_e relations over a cloud field provides the same relations as composed from tracking the time evolution of T and r_e of individual clouds, and then compositing them. This is the essence of exchangeability of time and space scales, i.e., ergodicity, of the T-r_e relations for convective clouds. This property has allowed inference of the microphysical evolution of convective clouds with a snap shot from a polar orbiter. The fundamental causes for the ergodicity are suggested to be the observed stability of r_e for a given height above cloud base in a convective cloud, and the constant renewal of growing cloud tops with cloud bubbles that replace the cloud tops with fresh cloud matter from below.

Final Revised Paper (PDF, 2061 KB) Discussion Paper (ACPD)

Citation: Lensky, I. M. and Rosenfeld, D.: The time-space exchangeability of satellite retrieved relations between cloud top temperature and particle effective radius, Atmos. Chem. Phys., 6, 2887-2894, 2006. Bibtex EndNote Reference Manager