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Investigation of the Directional Structure of Horizontal Cloud Inhomogeneities Derived from Ground-Based and Airborne Spectral Imaging and Cloud Resolving Models

Michael Schäfer (1), Eike Bierwirth (1,2), André Ehrlich (1), Evelyn Jäkel (1), Katharina Loewe (3), Frank Werner (4), Corinna Hoose (3), and Manfred Wendisch (1)

(1) University of Leipzig, Leipzig Institute for Meteorology, Leipzig, Germany (michael.schaefer@uni-leipzig.de), (2) now at: PIER-ELECTRONIC GmbH, Nassaustr. 33–35, 65719 Hofheim-Wallau, Germany, (3) Karlsruhe Institute of Technology, Institute of Meteorology and Climate Research, Karlsruhe, Germany, (4) Joint Center for Earth Systems Technology, University of Maryland, 5523 Research Park Drive 320, Baltimore, MD 21228

Clouds exhibit considerable horizontal inhomogeneities of their optical and microphysical properties. This complicates their realistic representation in weather and climate models. In order to investigate cloud inhomogeneities with respect to their horizontal structure, two-dimensional (2D) fields of optical thickness of subtropical cirrus and Arctic stratus are investigated. The applied 2D cloud optical thickness fields with a spatial resolution of less than 10 m are derived from (a) ground-based measured downward (transmitted) solar spectral radiance fields of four subtropical cirrus clouds, and (b) upward (reflected) radiances measured airborne above ten Arctic stratus clouds. The measurements were performed during the two field campaigns: (a) Clouds, Aerosol, Radiation, and tuRbulence in the trade wInd regime over BArbados (CARRIBA), and (b) VERtical Distribution of Ice in Arctic clouds (VERDI). One-dimensional (1D) inhomogeneity parameters and 2D autocorrelation functions are derived from the retrieved fields of cloud optical thickness. For each measurement case, the typical spatial scale of horizontal cloud inhomogeneities is quantified. The results reveal that considerable cloud inhomogeneities with prevailing directional structures are found in most of the investigated cloud cases; the cloud inhomogeneities favour a specific horizontal direction while across this direction the cloud is of homogeneous character. The investigations show that it is not sufficient to quantify horizontal cloud inhomogeneities by 1D inhomogeneity parameters; 2D parameters are strongly required. Additionally, the applied methods are used in conjunction with simulated fields of Arctic stratus obtained from cloud resolving models in order to (I) validate model results against measurements and (II) to increase the number of available cloud fields, which improves the statistics of investigated cloud cases.