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Scaling Analysis of Temperature and Liquid Water Content in the Marine Boundary Layer Clouds during POST

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We have analyzed the scaling behaviour of marine boundary layer (MBL) clouds using high-resolution (∼5.5 cm) temperature (T) and liquid water content (LWC) series from airborne measurements collected over Pacific Ocean during the Physics of Stratocumulus Top (POST) research campaign in summer of 2008. As an extension of the past studies for scale-invariant properties of MBL clouds, we studied variability of scaling exponents with height. We divided the horizontal flight segments (within MBL) and the inclined flight segments (across the cloud top region) into several layers and sublayers, and used power spectra and structure functions to estimate the scale-invariant regimes for each layer. The results show that both T and LWC within MBL have two distinct scaling regimes: the first one displays scale-invariance over a range from 1∼5 m to at least 7 km, and the second one goes from about 0.1∼1 m to 1∼5 m. For the large scales ($r > 1 \sim 5$ m), turbulence in MBL is multifractal, while scale break and scaling exponents (e.g., β, ζ_1, ζ_2, ζ_∞, H_1 and C_1) vary with height, most significantly in the cloud top region. The bifractal analysis shows that the standard scale-invariant stochastic models are not enough to represent the vertical structure of atmospheric turbulence in MBL, and suggests the existence of three turbulence regimes: near the surface, in the middle of boundary layer and in the cloud top region, which should be distinguished.