Fractality in the perimeter of tropical clouds observed by Himawari-8 or simulated by a high-resolution model

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Cloud clusters show a wide variety of shape and size, and their spatial pattern is often taken up as a typical example of fractal. However, the methods of studying fractal are in an early stage of development. In this study, we conducted fractal analysis on the perimeter of tropical clouds using satellite observation and cloud-resolving simulation of sub-kilometer resolution. We evaluated fractal dimension as a function of spatial scale (transient fractal dimension) and quantified the characteristic spatial scale of the pattern from the scale where self-similarity breaks down. From the observational data from HIMAWARI-8, It is shown that the self-similarity of the cloud perimeter persists only in the spatial scale range from 2 km up to 30 km. The limit of the self-similarity is suggested to be the characteristic scale of the pattern formation of tropical clouds. The cloud-resolving simulation data with NICAM also shows finite-size self-similarity. However, the profile of the transient fractal dimension changed with integration time far more rapidly than HIMAWARI-8 observation, and it lost its self-similarity at the end of the 48-hour simulation. This process is suggested to reflect the increase of stratiform cloud in the upper-troposphere as an adjustment to the transition of spatial resolution.

Keywords: fractal, HIMAWARI-8, cloud-resolving model