Observation of vertical air motion in midlevel shallow-layer clouds by the Equatorial Atmosphere Radar and lidar

KISHI Toyohisa
Laboratory of Radar Atmospheric Science, RISH, Kyoto University

Shallow-layer clouds are confined to shallow layers of air in which the rate of cooling resulting in cloud formation is rather slight. These clouds are generally about 1 km or less in vertical extent, and include low-level ones (fog, stratus, and stratocumulus), midlevel ones (altostratus and altocumulus), and high-level ones (cirrus, cirrostratus, and cirrocumulus). Though shallow-layer clouds can occur quite locally, they can also be very widespread, covering mesoscale or even synoptic-scale regions. This prosperity of shallow-layer clouds to cover great areas has a major impact on the climate of the earth through the absorptive and scattering effects of these cloud layers in the earth's radiation balance. Though mean vertical air motion in shallow-layer clouds is smaller compared with ones in convective clouds, previous numerical computations have shown that vertical air velocity (hereafter *W*) plays a crucial role in the formation and maintenance of shallow-layer clouds. However, observations of *W* in and around shallow-layer clouds are scarce because means to measure *W* are limited.

VHF Doppler radars observe height profiles of vertical and horizontal winds by receiving echoes from fluctuations of refractive index and hence have the capability to directly observe them both in clear and cloudy regions. Lidars which lase for transmission are useful for observing vertical profiles of small-sized cloud particles with a diameter of less than several hundred micrometers, due to their short wavelength transmitted. In this study, VHF (47-MHz) Doppler radars named as the Equatorial Atmosphere Radar (hereafter EAR) and 532-nm lidar operated by Tokyo Metropolitan University were used to observe *W* in and around midlevel shallow-layer clouds with high time and vertical resolutions (167 sec and 150 m, respectively). Frequency power spectrum data obtained with vertically-pointed radar beam were used to obtain *W* and and spectral width. Spectral width is a measure of turbulent intensity of *W* within sampling time and volume.

Figure shows a time-altitude plot of spectral width observed by the vertically-pointed radar beam of the EAR. Within the clouds, turbulent motion (spectral width of greater than 0.4 m s^{-1}) was observed in the upper part of shallow layer clouds. In the upper part of clouds (around 8.215 km), downward *W* was dominant. In the middle part (around 7.615 km), highly turbulent *W* was observed. In the bottom part (around 6.415 km), turbulence of *W* was small (figures not shown). Such features found in *W* were observed for the first time.

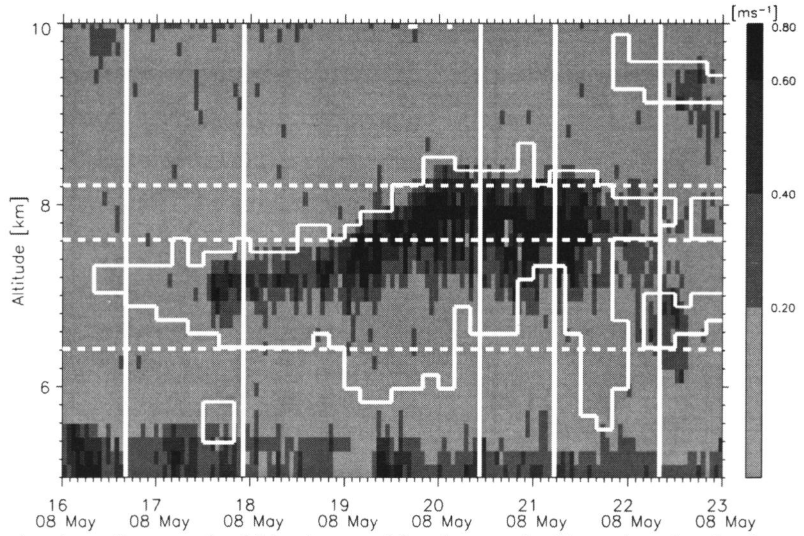

Figure: Time-altitude plot of spectral width observed by the vertically-pointed radar beam of the EAR from 1600 to 2300 LST 8 May 2004. Spectral width is defined as half-power full-width. Thick white curve indicates cloudy area where lidar observed significant enhancements of received signal. Three white broken lines show altitude near cloud top (8.215 km), middle of clouds (7.615 km), and cloud bottom (6.415 km).