Development of Range Imaging Wind Profiler for Observations of Atmospheric Boundary Layer

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It is important to observe atmospheric turbulence in order to clarify developing processes of the atmospheric boundary layer. However, it is not so easy to observe atmospheric turbulence. In FY2003, the MU (middle and upper atmosphere) radar was equipped with an ultra-multi-channel system, which enabled us to observe three dimensional structures of the atmospheric turbulence by means of radar imaging techniques. Limitation of the MU radar is that it cannot observe the lower part of the atmosphere below 2 km, because it takes about 10 μs to switch from transmitting to receiving. Therefore we have developed a range imaging wind profiler for observing the atmospheric boundary layer by upgrading the 1.3-GHz wind profiler system (LQ7) installed at the Shigaraki MU Observatory (Figure 1).

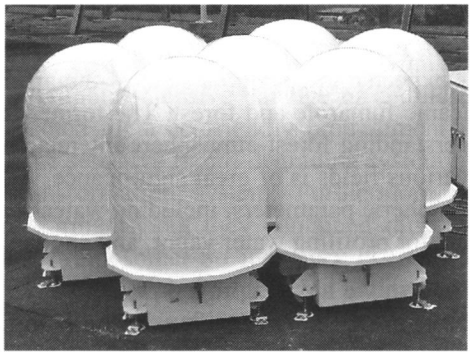

Figure 1. LQ-7 wind profiler installed at the Shigaraki MU Observatory.

Frequency Domain Interferometry (FDI) is a technique to obtain high range resolution using the phase difference among receiving signals for various transmitting frequencies. We applied the FDI technique to LQ7 which was upgraded to use five frequencies of -500 kHz, -250 kHz, 0, +250 kHz, +500 kHz relative to 1357.5 MHz. As shown in Figure 2, FDI observation results using Capon method could provide us the detailed turbulence structure. Owing to severe ground clutter, the original data from the radar were not useful for the FDI analysis. We developed a technique to suppress the ground clutter, and succeeded in the FDI analysis. We have evaluated range imaging performance of LQ7 comparing with the observation results with other frequency radars. Vertical velocity and horizontal wind with LQ7 are consistent with those by other radars. Maximum observation height, which is defined by signal to noise ratio > -10 dB, is about 3.5 km in summer and about 2.5 km in winter. Developing process of the atmospheric boundary layer is observed with LQ7, which is impossible by the MU radar. Simultaneous observations with LQ7 and 35-GHz radar on September 24 and 25, 2009 show that the atmospheric boundary layer corresponds to cloud variations. Horizontal wind is consistent to the pressure distribution and topography. With their results, we concluded that the radar imaging technique applied to the 1.3-GHz wind profiler is very useful to study the lower atmosphere dynamics.

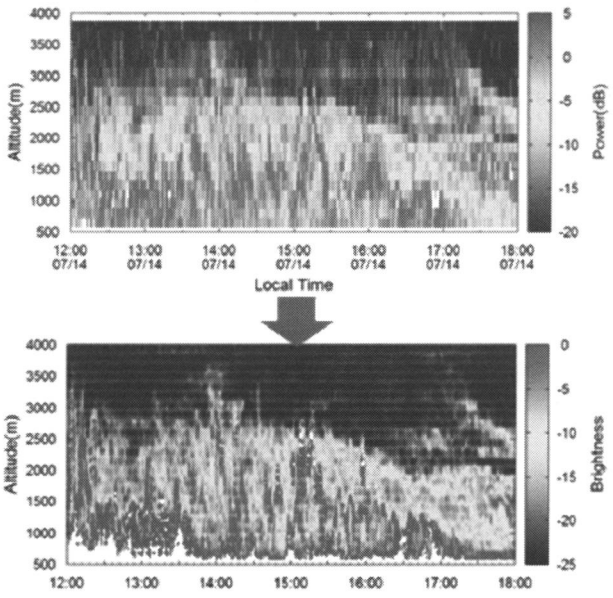

Figure 2. Example of time-height sections of echo intensities observed with standard mode (upper) and FDI mode (lower) of LQ-7.