Simultaneous observations of atmospheric structure with UAV and the MU radar

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Turbulence mixing is an important process that contributes to the vertical transport of heat and substance. The MU (Middle and Upper atmosphere) radar is the atmospheric radar located at Shigaraki, Koka, Shiga Prefecture, has the center frequency of 46.5 MHz, the antenna diameter of 103 m, and the peak output power of 1 MW, and has been operated since 1984. In 2004 it is upgraded to enable radar imaging observation which provides us the improved range resolution data. The MU radar can be accurately image the turbulence structure and is one of the most powerful tools to study the relationship to meso-synoptic scale phenomena.

In recent years, small unmanned aerial vehicle (UAV) has been attracting attention as an observation tool of the lower atmosphere. As Japan-USA-France international collaborative research, ShUREX (Shigaraki, UAV-Radar Experiment) campaign using simultaneously small UAVs developed by the University of Colorado and the MU radar has been carried out in June of 2015 and 2016. The UAV is small, lightweight, low cost, reusable, and autonomous flight possible using GPS, and it is possible to obtain a high-resolution data of the turbulence parameters by the temperature sensor of 100-Hz sampling, in addition to temperature, humidity, and barometric pressure data of 1-Hz sampling. Take-off and landing of the UAV was carried out at a pasture in 1-km southwest from the MU Observatory. The flight method previously programmed in advance takeoff before, it is also possible to change the flight method after takeoff according to the situation.

We have compared between the time-altitude cross-section of the echo intensity obtained with the range imaging mode of the MU radar and temporal variations of UAV altitude and temperature measured by the UAV in June 9, 2015. At 15:50-16:10, the UAV was flying horizontally, but large temperature variations were observed. Temperature variations correlated with the vertical fluctuation of the strong echo layer existing around the flight altitude, and a good correlation was found with the vertical flow observed by the MU radar. From the vertical profile of the temperature measured by UAV in the following time period, it is confirmed that a deep temperature inversion layer existed and a strong echo layer accompanied it. By modeling the measured temperature profile and assuming that the temperature profile varies up and down according to the echo layer, temperature variation was reproduced. It was almost consistent with the observation result. We plan a third campaign using UAVs and the MU radar in 2017.