Shigaraki, UAV-Radar Experiment (ShUREX)

*Hiroyuki Hashiguchi[1], Takashi Mori[1], Lakshmi Kantha[2], Dale Lawrence[2], Tyler Mixa[2], Hubert Luce[3], Richard Wilson[4], Toshitaka Tsuda[1], Masanori Yabuki[1]

1.Research Institute for Sustainable Humanosphere, Kyoto University, 2.University of Colorado Boulder, USA, 3.Toulon University, MIO, France, 4.LATMOS, France

Turbulence mixing is an important process that contributes to the vertical transport of heat and substance, but it is difficult to be observed because its scale is very small. The atmospheric radar transmits the radiowave and receives backscattered echoes from turbulence to measure wind velocity profiles with high time resolution, so it has advantage in the observation of atmospheric turbulence. 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 most accurately image the turbulence structure and is the most powerful tool to study the relationship to meso-synoptic scale phenomena. For example, although atmospheric turbulence due to the Kelvin-Helmholtz instability is known to occur in strong wind shear region, continuous turbulence structure under the cloud base has been imaged by the MU radar.
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 last June. The UAV is a small (wing width 1 m), lightweight (700 g), low cost (about $1,000), reusable, 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. Since the UAV cannot take off with their own runway, a method of take-off by pulling a rubber (Bungee method) or a method of the release at the appropriate altitude from a meteorological balloon filled with helium (Balloon method) is used. The flight method previously programmed in advance takeoff before, it is also possible to change the flight method after takeoff according to the situation. It is possible to continuously fly about one hour.
The time-altitude cross-section of the echo intensity obtained with the range imaging mode of the MU radar is shown in figure. Triangular shape of the echoes underlying during 8:10-8:40 is due to UAV. Strong echoes (turbulence) in the vicinity of the cloud base at 4-5 km are observed.
Currently, we are analyzing the observation data of the MU radar and UAV in details. Atmospheric turbulence is present everywhere, impact on human life is not small, and the observation and prediction also for the safe operation of the aircraft is an important issue. We plan a second campaign using UAVs and the MU radar in the following fiscal year.

Keywords: MU radar, UAV, Atmospheric turbulence