Shigaraki UAV-Radar Experiments (ShUREX): Measuring Turbulence in the Lower Troposphere

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The Shigaraki UAV-Radar Experiment (ShUREX) is an international (US-Japan-France) observational field campaign, aimed at measuring and obtaining a better understanding of turbulent mixing and atmospheric structures in the lower troposphere. During the two campaigns in 2015 and 2016, the unmanned aerial vehicle (UAV) DataHawk (developed at the University of Colorado, Boulder, and equipped with high frequency response cold wire and pitot tube, as well as an IMET sonde) was flown near and over the VHF-band Middle and Upper Atmosphere (MU) radar to obtain measurements in the atmospheric column in the immediate vicinity of the radar. The radar was operated in range imaging mode to provide high vertical resolution of 20 m so that fine scale structures could be resolved. Simultaneous and continuous operation of the radar permitted the UAV to be commanded to sample interesting structures, guided in near real time by the radar images. ShUREX 2015 campaign was quite successful in achieving the goals set forth at the outset. It unambiguously demonstrated the utility of a small, inexpensive UAV, such as DataHawk, in probing the lower atmosphere and of the synergistic use of VHF radars and UAVs. We were able to sample interesting atmospheric structures such as sheets and layers (SL), MCT and convective boundary layer (CBL), guided in real time by the radar images. Salient results have been obtained and are described in greater detail in related publications. However, the less than optimal frequency response (100 Hz), combined with the high noise level of the coldwire and pitot turbulence sensors, prevented the use of the spectra above a certain frequency, leading to rather narrow inertial subranges in the turbulence spectra. In addition, the vibrations induced by the motor contaminated the turbulence spectra during ascent (and occasionally during descent when the throttle was high) and the discrete frequency spikes in the data had to be removed before deducing ε, C_T^2 and C_n^2. ShUREX 2016 campaign carried out in May-June 2016 used higher frequency response sensors (800 Hz) with much lower noise floor, which yielded broader inertial subranges without contamination by motor vibrations. This enabled more accurate and reliable derivation of the TKE dissipation rate ε and turbulence structure parameters such as C_T^2 and C_n^2. We will present some of these results in this talk. ShUREX 2015 and 2016 campaigns have demonstrated the presence of fine scale structures in the moist troposphere hitherto unknown or unappreciated by the atmospheric community. They also enabled simultaneous sampling of turbulent atmospheric structures such as MCT by in-situ turbulence sensors flown on a UAV and the radar. As productive as these campaigns have been, they do suffer from the deficiency that we were unable to map the complete evolution of structures such as MCT, SL and CBL. We were unable to catch a KHI event. We will attempt to sample these structures more comprehensively, concentrating on CBL and SL structures in ShUREX 2017 during June 2017.