In-Situ Observations of Ubiquitous “Sheet and Layer” Structures in the Free Troposphere with Multiple Coordinated Small Unmanned Aircraft Systems

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The vertical structure of the free atmosphere under stable conditions is characterized by thin, strongly stable, often non-turbulent “sheets” separated by thicker, weakly stratified, often turbulent “layers”. The Sheet-and-Layer (S&L) structures have been known to play an important role in transport and mixing of heat, momentum and possibly have implications on larger-scale dynamics like strong, localized Kelvin Helmholtz Instabilities and associated turbulence. Lack of understanding of the dynamics of S&L structures is largely attributed to the observational challenges in sampling the relevant atmospheric structures with sufficient spatial and temporal resolution. The DataHawk Unmanned Aircraft System (UAS) developed at the University of Colorado, Boulder was deployed to conduct in-situ observations of the lower atmosphere under nocturnal stable conditions in conjunction with NCAR’s Integrated Sounding System (ISS) radar for ground-based observations at Dugway Proving Grounds, Utah. A total of 72 flights launched in sorties of 3 aircraft at a time for durations over 100 minutes and continuously operating between altitudes of 15 m and 3,000 m AGL were coordinated with 93 radiosondes launches. The DataHawk measurements of wind components, potential temperature, Brunt–Väisälä frequency, and Gradient Richardson Number are compared with the radiosonde measurements. The dynamics of the observed S&L structures are studied through estimates of turbulent kinetic energy dissipation rates and temperature structure function parameters from the high-resolution measurements of velocity and temperature fluctuations by the DataHawk UAS. The observation strategies, associated challenges, analysis results, the preliminary efforts at modeling the S&L structures and their implications to the large-scale atmospheric dynamics are discussed.

Keywords: Unmanned Aircraft Systems, insitu observations, stable sheets, turbulent layers

