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Large-amplitude Kelvin-Helmholtz billows observed with the MU radar in the troposphere and lower stratosphere

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The high-resolution capabilities of the MU radar (50 MHz) of Kyoto University have been utilized for an extensive study of Kelvin-Helmholtz (KH) instabilities in the troposphere and lower stratosphere. In particular, the MU radar has been operated in range imaging mode using five carrier frequencies for one month in October-November 2008. Profiles of radar reflectivity in three directions near the zenith are obtained at a range resolution of a few ten meters or less and a time resolution of about 24.4 s. Other atmospheric parameters such as horizontal and vertical winds, wind shears and turbulence parameters are also estimated. The potential ability of KH instabilities to mix and to produce layer splitting is particularly addressed. The reflectivity patterns resulting from KH instabilities reveal a rich variety of structures, which are described through three cases. The first case is representative of almost all the observed KHI events, i.e., a train of KH billows or braids without any evidence of breaking, mixing, neutralization, and layer splitting. On the contrary, the second case shows all the stages of evolution of the KH instability in the lower troposphere from its excitation to the formation of a double layer at its decaying stage. This case is unique in the present data set. The third case has never been reported until now. It shows possible turbulent plumes or wisps at the base of a nearly neutralized layer above the thermal tropopause. They might be the result of almost complete but still active turbulent mixing generated by the KH instabilities.

Keywords: MU radar, Kelvin-Helmholtz (KH) instabilities, KH billows, double layer, turbulent plumes, radar range imaging