Turbulence scales and energetics in clear air and clouds evaluated from MU radar and balloon measurements.

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Turbulence can play a key role in energy and matter exchange at small scales in the atmosphere. The mechanisms of turbulence generation are multiple and can interact between each other giving rise to miscellaneous characteristics of the turbulent regions from highly sporadic patches of any size to long lived layers with strongly varying depth and intensity. In the troposphere, turbulence can occur in clouds and in clear air. Most observation techniques using in situ or remote sensing sensors are either simply not adapted for turbulence detection or not efficient for detecting turbulence in both conditions. However, we recently developed balloon data processing methods for detecting temperature turbulence and retrieving some of its statistics (such as turbulent potential energy, a turbulence outer scale called Thorpe length, background stability, shear) in both dry and saturated conditions. These methods haven been applied to balloon data collected with Vaisala and Meisei radiosondes and the results were successfully compared with high temporal and range resolution observations performed by the VHF Middle and Upper atmosphere radar (MUR, Shigaraki Observatory). VHF-band radars are the sole remote sensing instruments capable of detecting turbulence in clear and cloudy airs throughout the entire troposphere and at any time of the day or night. Radar signals are processed so as to deliver statistical parameters related to the detected turbulence (echo power, power aspect ratio, and spectral width). The combination of radar and balloon observations thus makes it possible to estimate statistics of turbulence (in clouds and in clear air) such as turbulent kinetic and potential energies and buoyancy scale. Under the assumption of Kolmogorov-Obukov turbulence, temperature and refractive index structure constants, energy dissipation rates, Ozmidov scale, diffusivities and turbulent fluxes can also be retrieved. In the present work, results from MUR and balloon data collected during a one-week field campaign in November 2013 are presented. In particular, we will focus on the statistics obtained for turbulent events observed in clouds and in clear air, above and below upper-level frontal zones.