New insights into small-scale tropospheric turbulence from original radar and balloon data analyses

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Small-scale turbulence in the troposphere may have a significant impact, for example, on vertical transport of constituents, cloud life cycle and aircraft comfort. The detection of turbulent events is still challenging however. In the present work, we describe original outcomes by comparing VHF-radar and balloon observation results. Wilson et al. (2010, 2011) presented a robust processing method which allows the identification of overturning regions produced by turbulence from in situ profiles. The method, based on Thorpe analysis can be applied to profiles collected from radiosondes. It also makes it possible to quantify turbulence intensity within the turbulent regions. These results are compared with results of observations from the 46.5 MHz MU (Middle and Upper Atmosphere) radar (Shigaraki MU observatory, 34.85N, 136.15E; Japan) continuously operated for three weeks in range imaging mode (time resolution: 24 s, range resolution: typically 30 m) when intensive balloon launches (every ˜3 hours) were carried out. Raw data collected from 36 RS92G Vaisala radiosondes during night periods were processed at a vertical resolution of 3-5 m. It is found that more than 90 % of the overturns produced by atmospheric turbulence and instabilities are associated with nearly isotropic, i.e. non vertically-enhanced, radar echoes, consistent with the detection of isotropic turbulence. Reciprocally, vertically enhanced radar echoes were generally not associated with selected turbulent layers. This result strongly suggests the non-turbulent nature of these radar echoes. Estimates of the refractive index structure constant Cn2 from balloon data (using various methods consistent between each others) compare well with radar echo power (corrected from range attenuation effects) in these layers. Correlation coefficients between the balloon and radar estimates of about 0.8 were found. Orthogonal linear regressions indicate proportionality between Cn2 and radar echo power. From these results, we thus propose an empirical radar calibration for absolute Cn2 estimates from MU radar measurements in high resolution mode and a criterion for monitoring the deepest (>40 m) turbulent layers in the troposphere.

References:

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