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The effect of boundary layer and surface characteristics on non-Gaussian turbulent fluctuations of temperature

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We use simultaneously measured near-ground micrometeorological and boundary layer data to examine the relation between the probability density function (PDF) of a turbulent scalar such as temperature and its vertical profile. Turbulent temperature time series of 10 to 20 s^{-1} resolution are taken from eddy covariance stations measuring at 1.45 to 120 m above ground level, and vertical profiles of potential temperature were composed of tower and aircraft measurements.

The relation between skewness and kurtosis of the turbulent near-ground data was evaluated using the Pearson system of distributions, and indicates that a part of their non-Gaussianity is due to the existence of a well-defined lower limit to fluctuations. To a lesser extend, an upper limit is also indicated.

During unstable situations, the lower limit could be related to the minimum of potential temperature available in the boundary layer. During stable situations, it was related to the effective surface temperature at the measurement site estimated from outgoing longwave radiation. The upper limit could be related with considerably less rigidity and a systematic underestimation, which we attribute to well mixing by small-scale turbulence, to the surface temperature during unstable situations.

Two types of theoretical PDFs are compared to the turbulent histograms. The first type, the beta distribution was empirically chosen from classical statistics based on matching the first four sample moments and has already been used to empirically model scalar concentrations in plumes. The second type was theoretically derived from simplified assumptions on atmospheric dispersion. Both support the assumption that turbulent scalar PDFs in horizontally homogeneous conditions have finite tails.