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Estimating turbulent kinetic energy dissipation rate and external intermittency from DNS of atmospheric stratified flows

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Atmospheric turbulence is one of the key physical mechanism that is behind the occurrence of many atmospheric phenomena such as cloud formation and processes, atmospheric convection etc. The estimation of the actual turbulent kinetic energy (TKE) dissipation rate from fine resolution simulation or in-situ airborne measurement of atmospheric flows is needed to formulate sub-grid models for large eddy simulation or Lagrangian trajectory analysis of passive scalars.

Indirect methods like power spectral density and structure function have been proposed to calculate ϵ from 1D velocity time series using the local isotropy assumption. Alternatively, the zero-crossing approach, which requires counting the number of times the velocity signal zero-crossing events happens, have been introduced by Sreenivasan et al (1983) to calculate ϵ. Wacławczyk et al. (2017) proposed two possible modifications to the zero-crossing method to estimate ϵ from measurement data with spectral cut-off. One of them is based on the inertial-range arguments and the second one on the reconstruction of the unknown, missing part of the energy spectrum. We tested the performance of this new methods and the model assumptions based on Direct Numerical Simulation (DNS) data of stratocumulus cloud-top and free convection with atmospheric stratification (Mellado, 2017). We compared the estimation of the turbulent kinetic energy (TKE) dissipation rate using power spectral density, structure function and the new approaches with the actual TKE dissipation rate calculated from Direct Numerical Simulation (DNS). We obtained a good agreement of the reconstructed part of the spectrum with DNS data.

References

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