



EMS Annual Meeting Abstracts

Vol. 18, EMS2021-270, 2021

<https://doi.org/10.5194/ems2021-270>

EMS Annual Meeting 2021

© Author(s) 2022. This work is distributed under the Creative Commons Attribution 4.0 License.



A Budget-Based Turbulence Length Scale Diagnostic

Stephanie Reilly¹, Ivan Bašták Ďurán^{1,2}, and Juerg Schmidli^{1,2}

¹Goethe University Frankfurt, Institute for Atmospheric and Environmental Sciences, Department of Geosciences, Germany (reilly@iau.uni-frankfurt.de)

²Hans Ertel Centre for Weather Research, Offenbach, Germany

The most frequently used boundary-layer turbulence parameterization in numerical weather prediction (NWP) and general circulation (GC) models are turbulence kinetic energy (TKE) based schemes. However, these parameterizations suffer from a potential weakness, namely the strong dependence on an ad-hoc quantity, the so-called turbulence length scale. The turbulence length scale is used to parameterize the molecular dissipation of TKE and is required to calculate the turbulence exchange coefficients. Traditional turbulence length scale formulations are designed for scales that are located above the energy production range of the turbulence spectra, hence the transfer of TKE across scales is not considered. However, as computational power increase, there is an increase in the potential for simulating turbulence at resolutions that are within the energy production range of turbulence. This is a gray zone problem. In order to represent turbulence processes accurately at these resolutions, the transfer of TKE across scales needs to be accounted for. For this purpose, a new turbulence length scale diagnostic, that can be used in the development of new turbulence length scale formulations, has been developed. The new diagnostic uses the budget of TKE and the budgets of scalar variances to estimate the effective dissipation rate, which encapsulate the sum of the molecular dissipation and the cross-scale TKE transfer. The effective dissipation rate is then associated with the new scale-dependent turbulence length scale. Several idealized LES cases, simulated with the MicroHH model, are used to diagnose the turbulence length scale. It has been found that in the gray zone of turbulence the new turbulence length scale strongly depends on the horizontal grid spacing, and that this scale-dependence is also height-dependent. The new diagnostic is used for the evaluation of existing turbulence length scale formulations.