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The two-energies turbulence scheme coupled to the assumed PDF method

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An update of the two-energy turbulence scheme is presented. The two-energy scheme is an extension of a Turbulence Kinetic Energy (TKE) scheme following the ideas of Zilitinkevich et al. (2013), but valid for the whole stability range and including the influence of moisture. The additional turbulence prognostic energy is used for the calculation of the stability parameter. The stability parameter is thus not anymore strictly local and has a prognostic character. These characteristics enable the two-energy scheme to model both turbulence and clouds in the atmospheric boundary layer. The original implementation of the two-energy scheme is able to successfully model shallow convection without the need of an additional parameterization for non-local fluxes. However, the performance of the two-energy scheme is worse in stratocumulus cases, where it tends to overestimate the erosion of the stable layers due to over-mixing. We have identified the causes of the over-mixing in the stable layers. First, the non-local stability parameter does not consider local stratification, which leads to its underestimation and subsequent over-mixing. Second, the scheme lacks an internal parameter that could distinguish between a shallow convection regime and a stratocumulus regime, thus the scheme can not be calibrated in this respect. And third, the turbulence length scale formulation is not flexible enough to adjust to all possible regimes in the ABL. To alleviate this problem, we propose several modifications: an update of the stability parameter, a modified computation of the turbulence length scale, and introduction of the influence of entropy potential temperature into the scheme. In addition, the two-energy scheme is coupled to a simplified assumed PDF method in order to achieve a more universal representation of the cloudy regimes. The updated turbulence scheme is evaluated for selected idealized and real cases in the ICON modeling framework.