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# Improvement of the subgrid vertical mixing parameterization in operational hydrostatic models at Météo-France

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A global variable mesh model (ARPEGE), an hydrostatic limited area model (ALADIN) with a 9.5km resolution over several regions of the world and a non-hydrostatic 2.5km resolution model (AROME) over France are used operationally at Météo-France for weather forecasting. Important modifications of the subgrid vertical mixing parameterization used in the hydrostatic models became operational in February 2009. The turbulence scheme (Louis, 1979) associated to a pseudo-shallow convection parameterization (Geleyn, 1987) has been replaced by a prognostic Turbulent Kinetic Energy scheme (TKE) associated to a mass flux shallow convection scheme. This development is characterised by a broad convergence between the parameterizations used in hydrostatic models with those of the operational non-hydrostatic model AROME.

The prognostic TKE scheme (Cuxart et al, 2000) is used with the tuning coefficients of AROME. The mixing length is computed using the formulation of Bougeault and Lacarrère (1989) (BL89) but with a modified combination between Lup and ldown. To improve the representation of stratocumulus, the scheme uses a top-Planetary Boundary Layer (PBL) entrainment parameterization following the ideas of Grenier and Bretherton (2001), with a modified integral formulation.

The shallow convection mass flux scheme is described in Bechtold et al. (2001). To solve a problem of too strong wind in the tropical PBL, it was found beneficial to amend both the mixing length and the TKE, following the approach of Lock and Mailhot (2006). The main idea of the connection between the shallow convection scheme and the turbulence scheme is to suppose that in a PBL, where occurs shallow convection, the turbulent mixing is enhanced by the presence of clouds. First, a thermal production term of TKE coming from the shallow convection scheme is computed. Secondly, a local modification of the BL89 mixing length is used. The BL89 mixing length is computed using the dry buoyancy and doesn't take into account the phase changes of water. In a cloud layer the result is an underestimation of the mixing length. The new approach consists of getting the thickness of the cloud from the shallow convection parameterization. When a shallow convection cloud is present upward (Lup) and downward (Ldown) computed mixing lengths are now taken at least equal to the distance between the current level and the top (respectively the bottom) of the cloud.

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