The generation of additional source terms in the TKE equation of NWP models at DWD with special relevance for the stable boundary layer - non locality by scale separation and inclusion of SGS surface structures

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During stable thermal stratification and vanishing vertical wind shear, the parameterized prognostic TKE equation in its traditional form contains only sink terms, leading to a complete break down of turbulence and thus to vanishing vertical mixing. Since this is almost never the case in reality, something seems to be missing in the traditional TKE equation.

In deed, traditional schemes usually are not consistent, because they do not consider the interaction of turbulence with non turbulent sub grid scale (SGS) processes related to scales, whose spectral densities can not be expressed with the help of only one master length scale. Thus they are incomplete and can not describe turbulence adequately in the above situation.

However, the missing interaction can be described by strict scale separation using an appropriate filter operator, which is suitable to express the influence by SGS topographic structures of the lower model boundary as well. In the end this leads most notably to two additional terms in the TKE equation of our turbulence scheme, both related to SGS inhomogeneities at the lower model boundary:

- the thermal circulation scale "buoyancy production term", expressing the production of SGS kinetic energy (SKE) by non turbulent direct thermal circulation

- the mechanical circulation scale "wake production term", expressing the production of SKE by form drag.

Although both source terms belong to non turbulent, coherent SGS flow patterns, they enter the TKE equation by a scale interaction term describing turbulent shear production by circulation scale flow patterns. However, related SGS flux densities (non local fluxes) have to be added to the turbulent ones in the first order equations. While a wake production term is already known in the TKE equation, the circulation scale buoyancy term seems to be a new development, producing TKE even for vanishing mean wind and stable stratification.