5. Merger of the empirical mixing length type with "E/N" parameterization

The former proposal is only one possibility of making the mixing length parameterization situation dependent. The Bougeault-Lacarrère mixing length is advantageous because of its non-local properties, while the classical K- theory evaluates mostly local conditions for turbulence. However, several semi-empirical parameterizations of turbulent fluxes use simple comparisons of local TKE and buoyancy values to estimate the mixing length (Cuxart et al., 2005). Similar parameterization was developed and tested also in the presented study.

The basic idea is the same as for the GCS06-BL89 merger. We use the empirical mixing length as a first guess (similarly to the previous case, it is the GCS06 mixing length). Additional information about turbulence comes from the tuned and limited function of TKE (e) and square of the Brunt-Väisälä frequency (N^2). The resulting formula yields:

$$l_{m/\theta} = l_{0_{m/\theta}} + k_{EN}\sqrt{\frac{e}{|N^2|}}$$

The tuning of the k_{EN} parameter is analogical to the parameterization of k in previous section.

$$k_{EN} = \beta_{EN} + \frac{2\left(\frac{z+z_{0/\theta}}{3H}\right)\lambda_{EN}}{1+\left(\frac{z+z_{0/\theta}}{3H}\right)^{c_{EN}}}$$

The values of k_{EN} in similar parameterization (NASA, WVU) are around 0.76 (refer again to Cuxart et al., 2005). However, the Stockholm University similarity energy model was using value of 3.04 which was later decreased to 0.22.

Because the e/N^2 ratio can have big spectrum of values (from 0 to infinity), it is necessary to bound it, above all for stratifications close to neutrality. The resulting mixing length yields:

$$l_{m/\theta} = l_{0_{m/\theta}} + \min\left(n_{m/\theta}, k_{EN}\sqrt{\frac{e}{|N^2|}}\right),$$

where the asymptotic parameter $n_{m/\theta}$ is vertically discretised:

$$n_{m/\theta} = \frac{2\left(\frac{z+z_{0/\theta}}{3H}\right)\lambda_{TKE}}{1+\left(\frac{z+z_{0/\theta}}{3H}\right)^{c_{EN}}}$$

Two setup of parameters (with analogous names as for the GCS06-LMBL parameterization) were tested :

Parameter	ALMKEN	BLMKEN	AFCEN	ALMZH	ALMTKE
Notion	λ_{EN}	β_{EN}	c_{EN}	H	λ_{TKE}
Setup1	0.5	0.1	3	1500	100
Setup2	5	1	3	1500	100

Table 3: Setup of parameters for defining the vertical profiles of the k_{EN} and n parameters used in the merged empirical – e/N scheme.

Actually, the second setup showed more sensitivity and more interesting results in both 1-D and 3-D simulations. The GCS06 parameterization was used again as first guess for the mixing length profile (with unchanged setup of parameters defined in table 1). The evolution of the mixing length seems, however, more realistic for the first setup (Figure 24a) than for high values of k_{EN} parameter which result in very noisy profile of mixing length (Figure 24b).

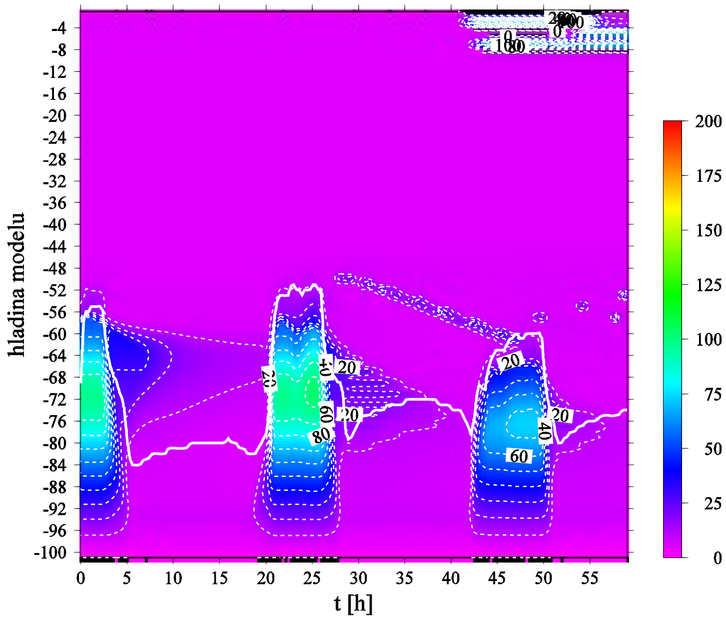

Fig. 24a: Evolution of the mixing length in the GABLS2 experiment with the 1st setup of the tested e/N parameterization (ALMKEN=0.5, BLMKEN=0.1)

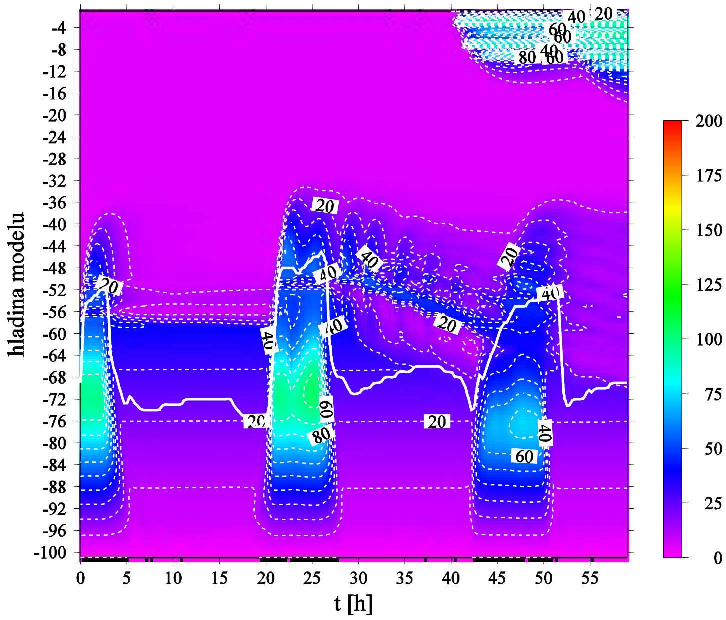

Fig. 24b: The same as in a) except for setup 2 (ALMKEN=5, BLMKEN=1)

The TKE evolution does not show many different or particular features with respect to GCS06 or LMBL experiments. It is surprising that the PBL height simulation for the first setup of the e/N parameterization is very similar to the GCS06-BL89 (LMBL) parameterization (Fig. 25). The PBL height for the second setup is exaggerated, but still showing daily variation and comparable results with the original GC05 parameterization setup (ALMAV = 400).

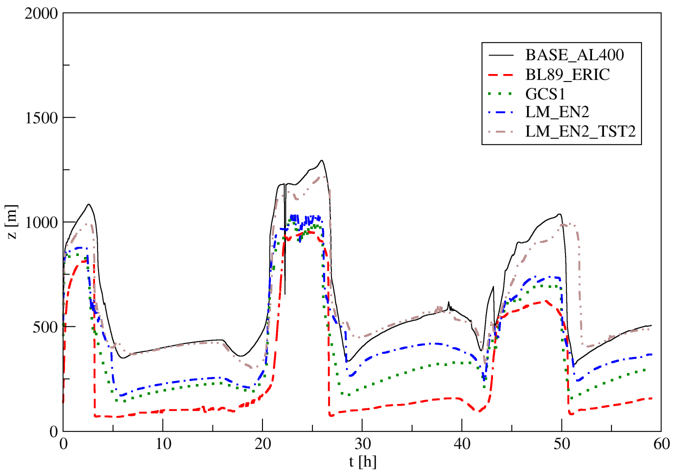

Fig. 25: GABLS2 diagnostics of the PBL height for the reference BL89 parameterization (dashed line), GC05 scheme, ALMAV=400 (solid line), GCS06 (dotted), e/N scheme with λ_{EN} =0.5 and β_{EN} = 0.1 (dash-dotted) and e/N scheme with λ_{EN} =5 and β_{EN} = 1 (dash-double dotted line).