3. Adjustment proposals for the current mixing length parameterization

According to tests with ALMAV asymptotes it seems that the dimension of the mixing length should somehow follow the evolution of the PBL parameterised or diagnosed during the model run. The dependency of the maximum mixing length and diagnosed PBL height in the reference (EBREF) experiment is not trivial (the mixing length computation is here not dependent on PBL height parameterization). The use of 1-D model for setting of the ALMAV – PBL dependency formulation is acceptable only as a first guess, since other methods as LES type of experiments should be more valid for this task. Nevertheless, Figure 15 shows a spectrum of the mixing length maxima within the diagnosed PBL as a function of PBL height (h_{PBL}). In some parts, a linear approximation can be used, giving reasonable correlation coefficient ($R^2 = 0.93$).

Thus:

$$ALMAV = p\,h_{PBL} + q = 0.5916\,h_{PBL} - 45.644$$

The way of making ALMAV a dependent variable should respect some more constraints:

a) the PBL height might be limited by a threshold (as by XMINLM in the TM kind of parameterization) to avoid very low heights of the PBL.
The ALMAV should be bigger than a minimum threshold for mixing length asymptote (ALMIN), smaller than the current height of the PBL and smaller than some maximum threshold (ALMAX) applied for the mixing length. Hence: $ALMIN < ALMAV \le ALMAX$ and $XMINLM = f(ALMIN)$, or, more precisely, $XMINLM = (ALMIN - q)\,/\,p$

b) The asymptotic mixing length at the top of the model atmosphere should remain independent from the height of the PBL, hence, its value will be defined by parameter ALMBED, while the asymptotic parameter β (ZBEDIFV, former tunable BEDIFV) will be computed as:

$$ZBEDIFV = ALMBED\,/\,ALMAV$$

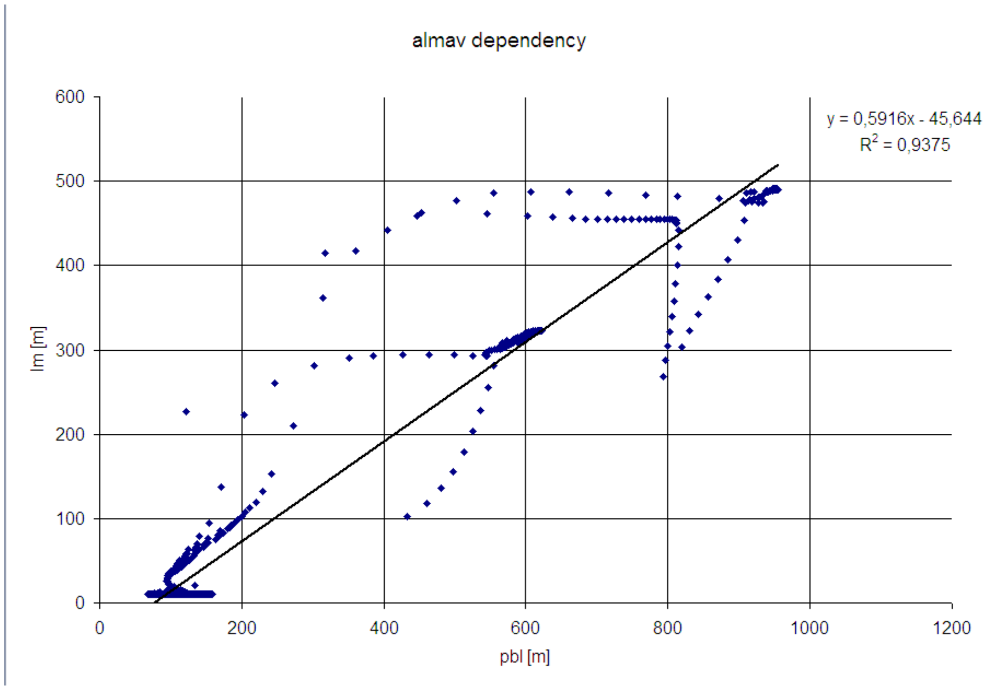

Figure 15: Maximum mixing length and diagnostic PBL dependency assumed from the EBREF reference experiment using the BL89 parameterization of mixing length.

However, ALMAV dependency is only first task, which has to be done for better properties of the mixing length within and above the PBL and for possible merger with the BL89 parameterization (use of different parameterization for K-coefficients computation and for the TKE part is physically not correct). Comparing to BL89 mixing length behaviour, the transition of the mixing length from PBL to upper atmospheric values should be steeper. This task requires modification of the GC05 mixing length parameterization to allow the shaping of the profile more general and more tunable. The new proposal (GCS06) yields:

$$l_{m/\theta} = \frac{\kappa\left(z+z_{0/\theta}\right)}{1+\frac{\kappa\left(z+z_{0/\theta}\right)}{\lambda_{m/\theta}}\left(\frac{1+\varepsilon_{1m/\theta}}{\beta_{m/\theta}+\varepsilon_{2m/\theta}}\right)},$$

Where:

$$\varepsilon_{1m/\theta} = e^{-\alpha_{1m/\theta}\left(\frac{\left(z+z_{0/\theta}\right)}{h_{PBL}}\right)^{c}+\beta_{1m/\theta}} \quad \text{and} \quad \varepsilon_{2m/\theta} = e^{-\alpha_{2m/\theta}\left(\frac{\left(z+z_{0/\theta}\right)}{h_{PBL}}\right)^{c}+\beta_{2m/\theta}}$$

Thus, by increasing the multiplicator c in both functions ε_1 and ε_2 and using different parameters α and β it is possible to increase the asymmetry of the mixing length function (Fig. 16). An example of reasonable setup for this kind of parameterization (routine ACMIXLENZ) is given by table 1a) – c). All modifications are activated by combination of logical switches LPRGML=.T. and LGCS=.T.

Parameter	ALMIN	ALMAX	ALMBED	APP	AQQ
Denotation	$\lambda_{\min}$	$\lambda_{\max}$	$\lambda_m \cdot \beta_m$	p	q
Value	15	500	5	0.5916	-45.644

Table 1a: Setup of parameters for activation of the ALMAV dependency on the height of the PBL

Parameter	A0ML_AU	A0ML_AU2	A0ML_BU	A0ML_BU2	AFC
Denotation	α_{1m}	α_{2m}	β_{1m}	β_{2m}	c
Value	10.	4.	1.	0.	2

Table 1b: Parameters for tuning the shape of the mixing length for momentum

Parameter	A0ML_AT	A0ML_AT2	A0ML_BT	A0ML_BT2
Denotation	$\alpha_{1\theta}$	$\alpha_{2\theta}$	$\beta_{1\theta}$	$\beta_{2\theta}$
Value	10.	6.	2.5	0.

Table 1c: As in b), except for enthalpy

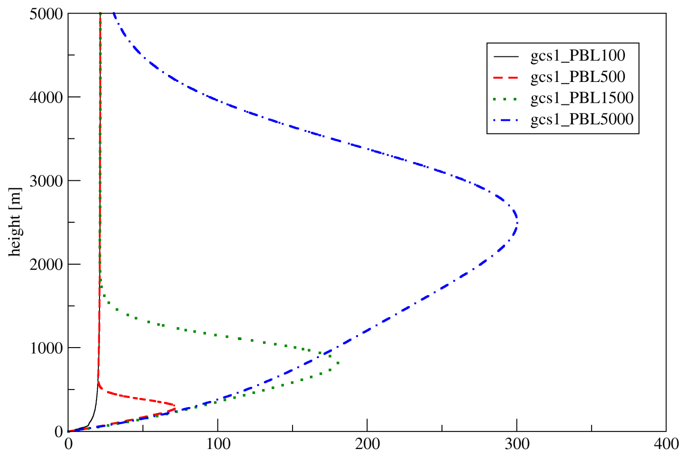

Figure 16: Setup of GCS06 mixing length curves for various heights of the PBL (10, 100, 500, 1500, 5000 m). The setup of parameters as in 1 a) – c)

Experiments on the GABLS2 case show course of the mixing length which is qualitatively closer to the BL89 mixing length parameterization (Fig. 17). On the other hand, the maximum values reached by the GCS06 representation of mixing length might better fit the K-type of parameterization (1-st order closure).

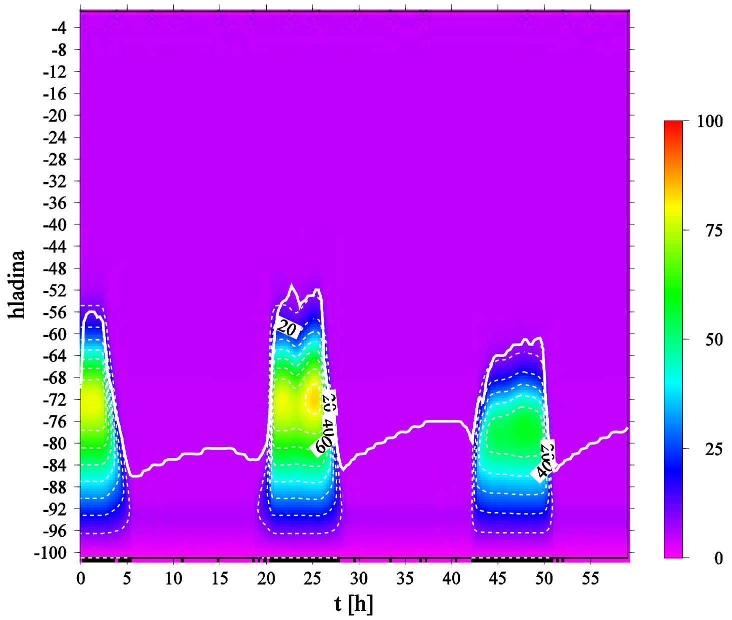

Figure 17: Time evolution of the mixing length in the GABLS2 experiment for the GCS06 parameterization

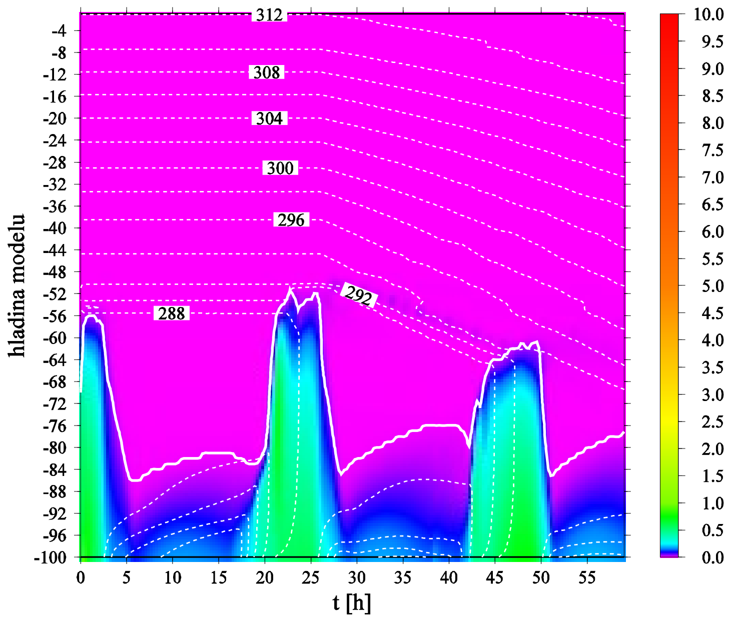

Figure 18: Time evolution of the TKE and potential temperature (as in Fig. 9) for the GCS1 kind of parameterization

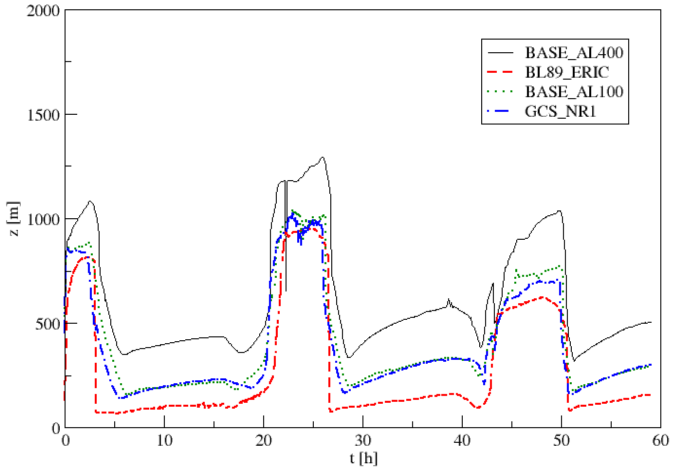

Figure 19: GABLS2 diagnostics of the PBL height and comparison of the reference BL89 parameterization (ERIC, dashed line), GC05 scheme with ALMAV=400 (solid line), GC05 with ALMAV=100 (dotted) and GCS06 mixing length parameterization (GCS_NR1, dash-dotted line). The setup of the GCS06 parameters is the same as in tables 1a) – c).

The TKE evolution shows slight improvements against the reference GC05 run using constant ALMAV=400 (compare figures 10 and 18). For the diagnostic PBL height the improvement is significant (Figure 19) and approaches the GC05 results with ALMAV = 100 (with noisy character of the second daily maximum as well, however).