EFB in ARPEGE/AROME: some practical aspects

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EFB working days
18-22 March 2012 Toulouse, France

Conclusions from the workshop on the SBL (Dec 2012)

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WG_turb: Trials

- **Tests (cloudfree atmosphere)**
  - Use GABLS-1 and GABLS-3
    - Examine diagnostic variances of potential temperature and moisture in current ALARO/AROME TKE-scheme, compare with available LES output
    - Include de-coupled prognostic E_p and compare to diagnostic one
    - Run EFB model and analyse

Physics package in MUSC

	ARPEGE/ALADIN	AROME	ALARO0
Surface	ISBA (Noilhan, Planton (89), Giard Bazile (2000)) or SURFEX	SURFEX with ISBA, ECUME, TEB	ISBA (Noilhan, Planton (89),Giard Bazile (2000)) or SURFEX
Coeff K diffusion	TKE – CBR2000 (HL) modified for Km	TKE –CBR2000 (FL) modified for Km	TOUCANS (I. Bastak, JF. Geleyn)
L Mixing length	BL89 with possible modifications from the shallow and deep convection	BL 89	Int. HCLA Ayotte Several options
Shallow convection	KFB Bechtold et al 2000 or EDKF from AROME	EDKF (Pergaud et al 2009)	Geleyn 87 modified Ri
Clouds	Smith(90) or f0, f1, f2 Bougeault (82)	f0, f1, f2 Bougeault (82)	Xu & Randall
Micro-Physics	Ql,Qi,Qr,Qs Lopez(2002) Bouteloup et al (2005)	Ql,Qi,Qr,Qs,Qg Pinty and Jabouille 1998	Ql,Qi,Qr,Qs
Convection	Bougeault 85 with modifications	No	3MT-deep
Radiation	RRTM for LW (Mlawer et al. 1997) and Morcrette et al. 2001 for SW (6b)		New-Geleyn

Variances of potential temperature GABLS1:

For the TKE scheme (Cuxart et al. 2000) used in AROME/ARPEGE:

$$\theta'^2 = \frac{2}{3}\frac{L_m^{\ 2}}{C_s \cdot C_\theta}\left(\frac{\partial\theta}{\partial z}\right)^2 \phi_3$$

$$\phi_3 = \frac{1}{1 + C \cdot \beta \dfrac{L_m^2}{\overline{e_T}} \dfrac{\partial \overline{\theta_{vl}}}{\partial z}}$$

$$C_s = 4$$

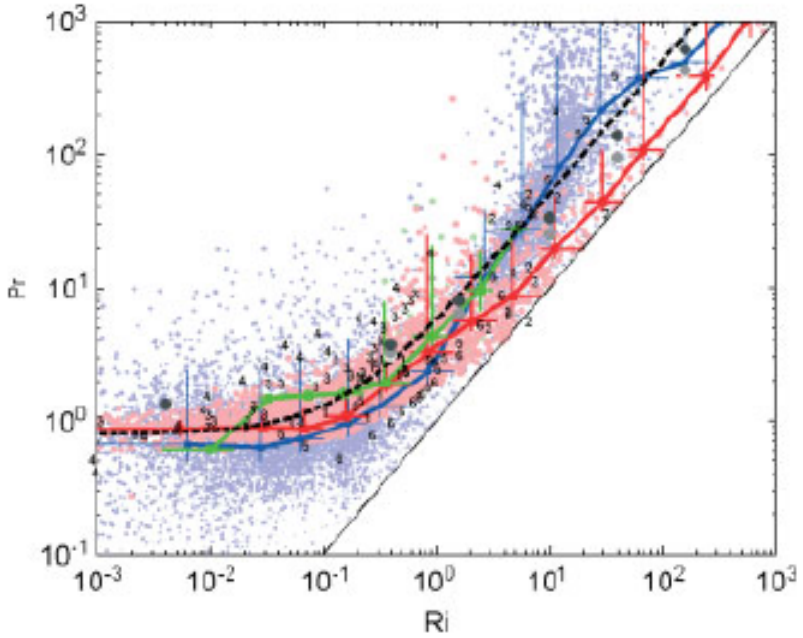
$$C_\theta = 1.2$$

or for Phi3 assuming a stationary equilibrium (eq21 from Cuxart et al 2000):

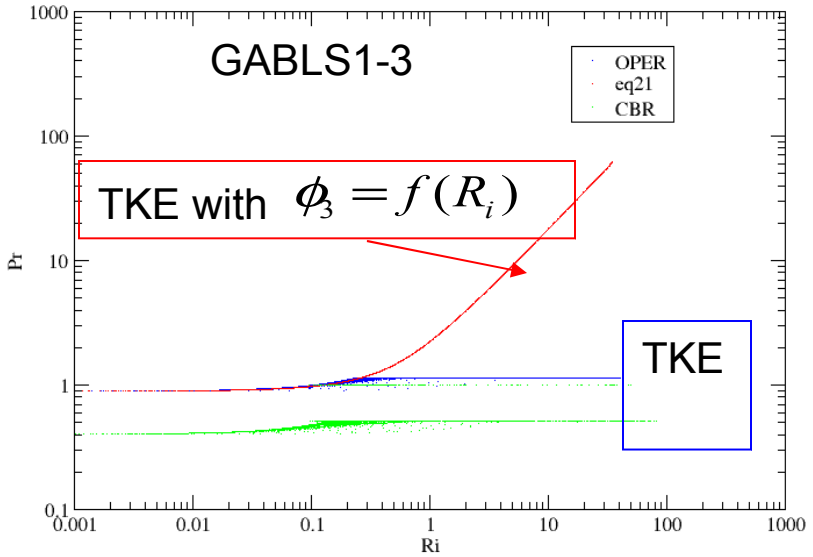
$$\phi_3 = \frac{1}{1 + C_4 \cdot \dfrac{R_i}{f(R_i)}}$$

Some weaknesses …

1. We still have warm bias → interaction with the surface and the snow scheme
2. Following Galperin et al 2007 and Zilitinkevich et al 2008 turbulence survives for Ri>>1. It is not the case with TKE …



From Zilitinkevich et al 2008



$$\Pr = \frac{K_m}{K_h} = \frac{1}{\alpha_\theta \phi_3}$$

with $\alpha_\theta = 1.13$

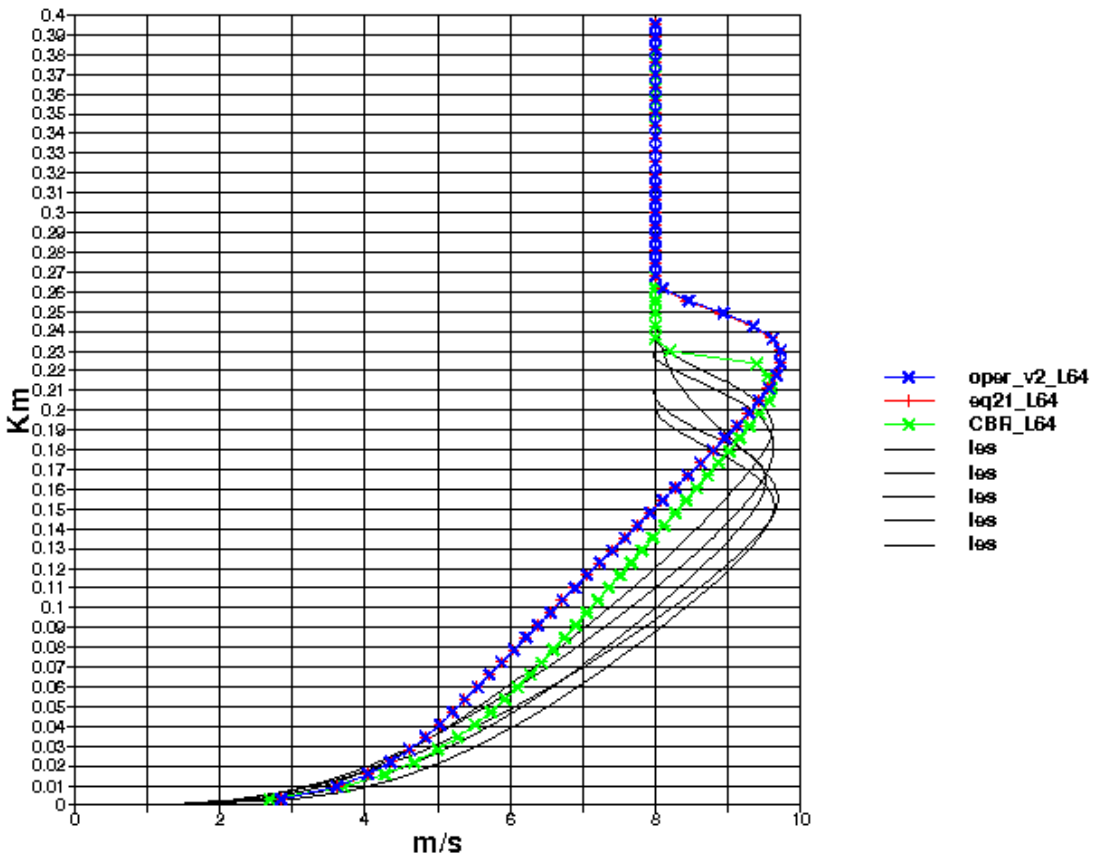
$0.78 \le \phi_3 \le 2.2$

Impact of Phi3=f(Ri)

GABLS1

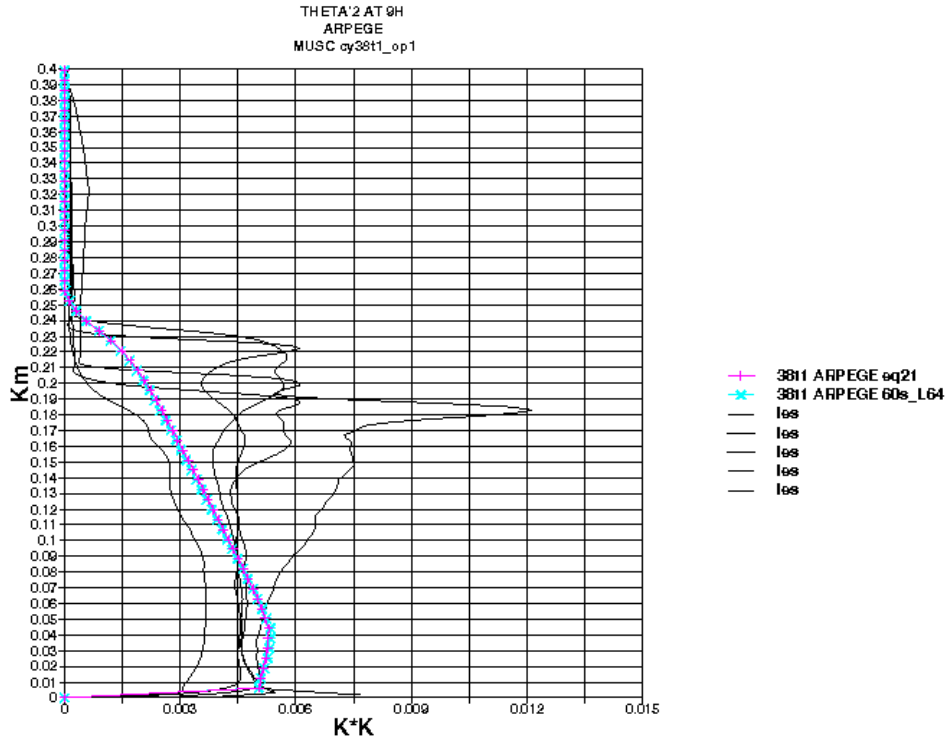
$$(\overline{w'q_t'}) = -\alpha_\theta \alpha_u l \sqrt{\overline{e_T}} \cdot \frac{\partial \overline{q_t}}{\partial z} \cdot \phi_3 \qquad (\overline{w'\theta_l'}) = -\alpha_\theta \alpha_u l \sqrt{\overline{e_T}} \cdot \frac{\partial \overline{\theta_l}}{\partial z} \cdot \phi_3$$

$$P_\theta = \beta \cdot (\overline{w'\theta_{vl}'}) = \beta \cdot E_q (\overline{w'q_t'}) + \beta \cdot E_\theta (\overline{w'\theta_l'})$$



Variances of potential temperature GABLS1:

```
### SUBROUTINE ACTURB ########
DO JLEV=1,KLEV-1
DO JLON=KIDIA,KFDIA
     ZTHETA_p2(JLON,JLEV)=2._JPRB/3._JPRB*PLMECT(JLON,JLEV)**2 &
    & *PPHI3(JLON,JLEV)/(ARSCH*ARSCQ)* &
    & ((ZTHETA(JLON,JLEV)-ZTHETA(JLON,JLEV+1))/ZDPHI)**2
  ENDDO ! JLON
ENDDO ! JLEV
IF(LMUSCLFA) CALL WRSCMR(IMUSCLFA,'ZTHETA_p2',ZTHETA_p2,KLON,KLEV+1)
```



Code modifications based on cy38t1_op1:

- 3 GFL (YEFB1, YEFB2, YEFB2) added by Y. Bouteloup for 3 new prognostic variables (Ep or theta variance, humidity variance and covariance of theta and q)
- For the turbulence code used in ARPEGE, it seems feasible to implement the 4.2 proposal (Zilitinkevich et al 2012):
  - add Ep equation (eq88) (ACTURB and ACEVOLET)
  - Diagnose vertical component Ez with eq 92 (ACTURB)
  - Computes Km and Kh with eq 95 (ACTURB)
  - As a 1st step use the current mixing length (BL89)
- Minimum code modifications, still use the same algorithm for the tri-diag resolution and the flux computations.
- Probably less complex than the Valery's proposal for the AROME turbulence code
- Interesting to compare the two approaches on GABLS1 and GABLS3 but also with the modified TOUCAN (ALARO scheme)