Users documentation for turbulence scheme (pTKE, TOUCANS)

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1 Switches

1.1 Turbulence scheme

The schemes with prognostic TKE (pseudo-TKE and TOUCANS) are turned on with LPTKE=.TRUE., otherwise the Louis scheme is used. TOUCANS is turned on by LCOEFKTKE=.TRUE. .

It is possible to use TOUCANS only above the surface with setting LCOEFKSURF=.F., which is the default value. If LCOEFKSURF=.T. in TOUCANS the surface computations (ACTKEHMT) and 2m and 10m diagnostics (ACTKECLS) are made with stability dependencies matching those of the upper air part.

LPTKE	.TRUE.		.FALSE.
LCOEFKTKE	.TRUE.	.FALSE.	-
Scheme:	TOUCANS	pseudo-TKE	Louis scheme

1.2 Prognostic TTE

The prognostic treatment of Total Turbulent Energy(TTE) is turned on by LCOEFK_PTTE=.TRUE.

1.3 Flux based computation of source terms

The source terms in TKE equation can be computed from gradients only (LCOEFK_FLX=.FALSE.) or can be influenced by fluxes computed in previous time step (LCOEFK_FLX=.TRUE.). In case of prognostic treatment of TTE(LCOEFK_PTTE=.TRUE.) only flux computation is implemented(LCOEFK_FLX=.TRUE.).

1.4 TOUCANS emulation

We have 6 possibilities, which are controlled by the string CGTURS:

Emulation	CGTURS
model I	MD1
model II	MD2
RMC01	RMC
QNSE	QNSE
EFB	EFB
LOUIS	LOUIS

Please note that the choice CGTURS=LOUIS is not identical to using Louis stability functions as is the case in 'pure' Louis scheme (LPTKE=.F. and LCOEFKTKE=.F.) and pTKE scheme (LPTKE=.T. and LCOEFKTKE=.F.). This setup emulates Louis stability functions within the MD1/MD2 constraints. Also the z_0 dependence in the unstable case is omitted (assuming $z >> z0$) and the behavior in stable stratification is independent from height (assuming on all levels the same dependency as the one of the asymptotic behavoir at the surface).

The choice of turbulence scheme is connected with values of five free parameters: C_3, O_λ, ν, C_ϵ, and λ_0 (needed only if LCOEFK_PTTE=.TRUE.).

In case of emulating Louis scheme , RMC, QNSE and EFB the free parameters should correspond to original setting of the schemes:

Parameter	Parameter name	RMC	QNSE	EFB	Louis
C_3	C3TKEFREE	2.764	1.39	1.25	1.00
O_λ	ETKE_OLAM	2.0/3.0	0.324	0.113	2.0/3.0
$\nu \equiv (C_K C_\epsilon)^{\frac{1}{4}}$	NUPTKE	0.4647	0.504	0.532	0.52
C_ϵ	C_EPSILON	0.6784	0.798	0.889	0.8495
λ_0	ETKE_LAM0	2.0/3.0	0.324	0.105	2.0/3.0

In case of MD1 and MD2 the free parameters can be adjusted. We recommend these possible settings:

Parameter	Parameter name	MD1	MD2	MD2
C_3	C3TKEFREE	1.183	1.183	1.183
O_λ	ETKE_OLAM	2.0/3.0	2.0/3.0	0.29
$\nu \equiv (C_K C_\epsilon)^{\frac{1}{4}}$	NUPTKE	0.5265	0.5265	0.5265
C_ϵ	C_EPSILON	0.871	0.871	0.871
λ_0	ETKE_LAM0	2.0/3.0	2.0/3.0	0.29

1.4.1 Surface modification

To avoid too strong mixing near surface in unstable stratification the $f(Ri)$ function can be set to 1.0 in unstable stratification by using LCOEFK_F1=.T.

1.4.2 pseudo-TKE

pseudo-TKE is controlled by one degree of freedom ν (NUPTKE). The default value is 0.52.

1.5 Length scale

The length scale L can be calculated using the 'classical' z-dependent mixing length l_m (used in both CGMIXELEN='AY', and default CGMIXLEN='Z'; difference is in PBL height computation):

$$l_{m/h_{GC}} = \frac{\kappa z}{1 + \frac{\kappa z}{\lambda_{m/h}} \left[\frac{1+\exp\left(-a_{m/h}\sqrt{\frac{z}{H_{pbl}}}+b_{m/h}\right)}{\beta_{m/h}+\exp\left(-a_{m/h}\sqrt{\frac{z}{H_{pbl}}}+b_{m/h}\right)} \right]}. \quad (1)$$

(κ is Von Kármán constant, z is height, $a_{m/h}$, $b_{m/h}$ and $\lambda_{m/h}$ are tuning constants and H_{pbl} is PBL height) , which is then converted to length scale L via:

$$L_{GC} = \frac{\nu}{C_K} l_{mGC}. \quad (2)$$

Also the length scale L can be computed directly from TKE (e) L:

- modified Bougeault and Lacarrère (1989) approach:
  $L_{BL}(e) = \left(\frac{L_{up}^{-\frac{4}{5}} + L_{down}^{-\frac{4}{5}}}{2} \right)^{-\frac{5}{4}}$
  $L_{up}(e)$ ($L_{down}(e)$) - upward(downward) mixing distances
- $L_N = \sqrt{\frac{2.e}{N^2}}$ for stable regimes (N is Brunt-Väisälä Frequency)

For TOUCANS 6 combined mixing lengths are available in the code:

Parameter CGMIXELEN	$Ri > 0$	$Ri \leq 0$
EL0	L_{GC}	L_{GC}
EL1	L_{BL}	L_{BL}
EL2	L_{BL}	$\min\left(\sqrt{L_{BL}\,L_{GC}}, L_{BL}\right)$
EL3	$\min\left(L_N, L_{max}\right)$	L_{GC}
EL4	$\frac{L_{GC}\,L_N}{\sqrt{L_{GC}^2+L_N^2}}$	L_{GC}
EL5	$\min\left(L_{BL}, L_N\right)$	L_{BL}

L_{max} - upper limit for mixing length in stable stratification;

L_{GC} is (1) converted to TKE type mixing length.

The dependence of mixing length L on TKE can be tuned by the parameter TKEMULT (by default TKEMULT=1): $L(e) \rightarrow L(\text{TKEMULT}.e)$

1.5.1 Prognostic mixing length

The prognostic treatment of mixing length is turned on by LCOEFK_PL=.TRUE.

The vertical diffusion and relaxation towards equilibrium value can be modified by coefficients ETKE_KLM and ETKE_TAULM, respectively. Default values are ETKE_KLM=1.0 and ETKE_TAULM=1.0.

1.6 Influence of moisture

1.6.1 Shallow convection parametrisation

Shallow convection can be parametrised with parametrisation after Geleyn 1987 (Ri^*) or with new shallow convection parametrisation based on Pascal Marquet's moist entropy potential temperature θ_{s1}: 1, Ri^{**} - similar to Ri^* approach (q_{sat} dependence):

LCOEFK_THS1	.TRUE.	.FALSE.
Ri:	Ri^{**}	Ri^*

The 'sharpness' of on and off switching of shallow convection parametrisation by Ri^{**} is controlled by ETKE_RIFC_MAF. The default value is ETKE_RIFC_MAF=0.5. Higher value makes the transition from $Ri < 0$ to $Ri > 0$ less steep.

Note that currently Ri^* or Ri^{**} are used as inputs for computation of Shallow Convection Cloudiness(SCC) - LCOEFK_RIS=.TRUE. Currently there is no other alternative, i.e LCOEFK_RIS=.FALSE. is not usable.

Moist AntiFibrillation (AF) scheme can be turned on by setting XDAMP=1 (recommended in all cases).

1.6.2 Conservation(entropy) and conversion(energy) aspects

In hybrid mode - LCOEFK_RIH=.TRUE. a pair of stability parameters is used: Rif_{s1} (or Ri_{s1}) and Rif_m (or Ri_m) to separate the conservation and conversion aspect in the turbulent exchange coefficients. Currently this approach is not usable.

1.6.3 Influence of skewness

If LCOEFK_SCQ=.TRUE. the Q (specifically horizontal part of the deviation form Gaussianity for the influence of the partial cloudiness on the buoyancy flux) is influenced by skewness equivalent parameter - C_n. Otherwise (If LCOEFK_SCQ=.FALSE.) Q=SCC.

1.6.4 Mixing length influenced by moisture

If LCOEFK_ML=.TRUE. then TKE based mixing lengths (L_{BL} and L_N, not L_{GC}) are computed from moist BVF. Currently this approach is not usable.

1.7 Third Order Moments (TOMs)

TOMs parametrisation is turned on by LCOEFK_TOMS=.TRUE. .

It is possible to tune individual TOMs terms by multiplying factors
(default values are 1.0):

TOM term	Multiplying parameter
$\overline{w'^3}$	ETKE_CG01
$\overline{w'\theta'^2}$	ETKE_CG02
$\overline{w'^2\theta'}$	ETKE_CG03

1.8 Turbulent diffusion of condensates

Turbulent diffusion of condensates is turned on by setting NDIFFNEB=1. Default value NDIFFNEB=0 turns the diffusion of condensates off.

1.9 Security

The limitation for τ against too small values is set by ETKE_BETA_EPS :
$\tau = \tau + \text{ETKE\_BETA\_EPS}\,\Delta t$. The default value is 0.02.

The limitation for τ against too large values is set by ETKE_GAMMA_EPS :
$\tau = \frac{\tau}{1+\text{ETKE\_GAMMA\_EPS}\,\frac{\tau}{\Delta t}}$. The default value is 0.03.

2 Reasonable setup

&NAMPHY
LPTKE=.T.,
LCOEFKTKE=.T.,
LCOEFKSURF=.T.,
LCVPP=.T.,
LCOEFK_THS1=.F.,
LCOEFK_RIH=.F.,
LCOEFK_TOMS=.T.,
LCOEFK_PTTE=.T.,
LCOEFK_FLX=.T.,
LCOEFK_SCQ=.T.,
LCOEFK_PL=.F.,
LCOEFK_ML=.F.,
CGMIXLEN='EL0',
CGTURS='MD2',
LDIFCONS=.T.,
NDIFFNEB=1,
LCOEFK_F1=.T.,

&NAMPHY0
C3TKEFREE=1.183,
ETKE_OLAM=0.29,
ETKE_LAM0=0.29,
NUPTKE=0.5265,
C_EPSILON=0.871,
ETKE_CG01=1.0,
ETKE_CG02=1.0,
ETKE_CG03=1.0,
ETKE_TAULM=1.0,
ETKE_KLM=1.0,
ETKE_RIFC_MAF=0.5,
ETKE_BETA_EPS=0.05,
ETKE_GAMMA_EPS =0.03,
TKEMULT=1.0,
XDAMP=1.0,