

*Regional Cooperation for
Limited Area Modeling in Central Europe*



Wrap up of TOUCANS brainstorming

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1. Latest developments
2. Further topics of interest
3. Validation a tools
4. Documentation and code cleanup
5. Meetings and cooperation

Turbulence Length scale - L

- ▶ $K_M = \frac{\nu^4}{C_\epsilon} \chi_3(Ri_f^*) \sqrt{e_k} L$, $K_H = C_3 \frac{\nu^4}{C_\epsilon} \phi_3(Ri_f^*) \sqrt{e_k} L$
- ▶ Algebraic formulation dependent on the PBL height (L_{GC}) is currently used.
- ▶ TKE and buoyancy-shear-based formulation, following Rodier et al. (2017) (L_{BS}), is being developed.
- ▶ Scaling and asymptotic behavior of L_{BS} is being improved.
- ▶ L_{BS} should improve (decrease) turbulence mixing in stable stratification.

Turbulence Length scale

- ▶ Implementation of L_{BS} based length scale + publication (2+1 months)
- ▶ PBL height diagnostics (1 month)
- ▶ scale-awareness? (2 months, secondary priority)

Third Order Moments (TOMs) parameterization

- ▶ $\overline{w'\theta'} = -K_H \frac{\partial \theta}{\partial z} + A_1^\theta \frac{\partial \overline{w'^3}}{\partial z} + A_2^\theta \frac{\partial \overline{w'\theta'^2}}{\partial z} + A_3^\theta \frac{\partial \overline{w'^2\theta'}}{\partial z}$
- ▶ TOMs should enable **counter-gradient** and **non-gradient** turbulent transport of scalars.
- ▶ Several numerical issues were corrected, but some are still blocking further progress.
- ▶ Some theoretical assumptions could be revised.

TOMs

- ▶ gradual increase in complexity approach: starting from dry, neutral, „without temporal term” formulation to full TOMs formulation (4 months)
- ▶ revision of theory (2 months)

1D+2D (3D) turbulence parametrization

- ▶ introduces horizontal aspect to turbulence:
 - ▶ horizontal shear term in TKE and TTE (L_H should be variable):

$$\frac{\partial}{\partial t} (e_{k,t})_{HS} = \underbrace{(c_s \Delta x)^2}_{L_H} \cdot \left[\left(\frac{\partial u}{\partial x} \right)^2 + \left(\frac{\partial v}{\partial y} \right)^2 + \frac{1}{2} \left(\frac{\partial u}{\partial y} + \frac{\partial v}{\partial x} \right)^2 \right]^{\frac{3}{2}}$$

- ▶ horizontal mixing based on SLHD approach ($\Psi = u, v, s_{sL}, q_t \dots$):

$$\frac{\partial \Psi}{\partial t} + \dots = -K_{M/H,hor} \frac{\partial \Psi^2}{\partial x^2} - K_{M/H,hor} \frac{\partial \Psi^2}{\partial y^2} + \frac{\partial}{\partial z} (\overline{w' \Psi'}) + \dots$$

1D+2D turbulence

- ▶ Horizontal (scale-aware) length scale L_H formulation is first required.
- ▶ L_H link to L_V via anisotropy provided by TOUCANS (3 months)
- ▶ contribution from horizontal shear term to TKE/TTE equations (1 month)
- ▶ SLHD approach for horizontal transport (2 months)

2TE scheme oscillations

- ▶ original implementation of 2TE scheme was prone to $\sim 2\Delta t$ oscillations in stable stratification
- ▶ more implicit temporal discretization removes the problem for the timestep lengths of interest
- ▶ implementation bug was found recently
- ▶ fix further enhances low inversion clouds
- ▶ fix increases cold T2m bias, mitigation ways are sought

2TE+APDF update

- ▶ Update improves representation of Stratocumulus.
- ▶ The buoyancy term is computed via the APDF method.
- ▶ The stability parameter is computed from local gradients (Ri_f^{GR}) and turbulence energies (Ri_f^{TE}):

$$Ri_f^* = C_{Ri_f} Ri_f^{GR} + (1 - C_{Ri_f}) Ri_f^{TE}$$

- ▶ Extension for the turbulence exchange coefficients for TOMs: $K_{e_k} = K_{e_s} = \left(C_{e_k} \overline{w'^2} + C_{\theta_s} \frac{g}{\theta_0} \overline{w'\theta'_s} \tau_k \right) \tau_k$

2TE+APDF update

- ▶ implement and test APDF extension? (3 months)
- ▶ stability parameter reformulation: blending of local and non-local Ri_f (1 month)
- ▶ K_{e_k} formulation extension - connection to TOMs (2 months)

Further topics of interest

- ▶ grey zone of turbulence, scale-awareness of turbulence parameterization
- ▶ coupling to surface (TKE, TTE, TOMs)
- ▶ cold bias in T2m caused by reduced mixing in stable stratification
- ▶ turbulence related diagnostics: gust, PBL height, ...
- ▶ compatibility with GPU refactoring
- ▶ perturbed physics tunings for A-LAEF (see code cleaning)

Validation a tools

- ▶ standard scores
- ▶ DDH, epygram
- ▶ MUSC in combination with LES - idealized cases
- ▶ Tower, surface flux, and other measurements.
- ▶ Length scale diagnostic from LES

Documentation and code cleanup

- ▶ Unused branches of code could be removed to simplify the code (particularly Model I, and EFB, RMC01, QNSE emulations)
- ▶ Further reorganization of the code in TOUCANS would increase readability
- ▶ Documentation should be continuously maintained: update according to code, remove out-dated sections and include experimental options.

Future meetings

- ▶ participants?
- ▶ scope?
- ▶ size/duration?
- ▶ frequency?

Other forms of cooperation

- ▶ potential to cooperate with other turbulence groups?
(inside/outside ACCORD, NWP groups/university, ...)

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Thank you for your attention.



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