RC LACE Stay Report

Topic: Debugging and testing Toucans module for Alaro-1

Peter Smerkol, Prague, 6th March – 19th March 2016

Introduction

TOUCANS (Third Order moments Unified Condensation Accounting and N-dependent Solver for turbulence and diffusion) is a compact turbulence parameterization, used in the ALARO-1 physical package. TOUCANS integrates several ideas in turbulence parameterization: no existence of critical Richardson number, anisotropy of turbulence, prognostic treatment of mixing length, third order moments parameterization, parameterization of moisture influence and possibility of 3D turbulence parameterization (see reference: *Ivan Bašták Ďurán, 2015: TOUCANS documentation*).

My work focused on the code that calculates the Third order moments corrections to heat and moisture fluxes, found in the ACDIFV3 routine of the TOUCANS module.

Third order moments (TOMs) parameterization

This parameterization is used for modelling non-local effects of turbulence on heat and moisture by large eddies. The baseline of parameterization is the method from *Canuto V.M., Y. Cheng, A.M. Howard, 2007: Non-local ocean mixing model and a new plume model for deep convection. Ocean Modelling 16, 28-46* (CCH07). Here, TOMs terms are approximated in the heat flux equation via the Second order moments:

$$\overline{w'\theta'} = -K_H \frac{\partial \theta'}{\partial z} + A_1^{\theta} \frac{\partial \overline{w'^3}}{\partial z} + A_2^{\theta} \frac{\partial \overline{w'\theta'^2}}{\partial z} + A_3^{\theta} \frac{\partial \overline{w'^2\theta'}}{\partial z}$$

$$\overline{w'^3} = -0.06 \frac{g}{\theta} \tau_k^2 \overline{w'^2} \frac{\partial \overline{w'\theta'^2}}{\partial z}$$

$$\overline{w'\theta'^2} = -\tau_k \overline{w'\theta'} \frac{\partial \overline{w'\theta'}}{\partial z}$$

$$\overline{w'^2\theta} = -0.3\tau_k \overline{w'^2} \frac{\partial \overline{w'\theta'}}{\partial z}$$

This approach is adapted for the moist case, where the static energy s_{sL} and total specific content of water q_t are diffused instead of the temperature. The general shape of equations for s_{sL} and q_t can be written as:

$$\overline{w's_{sL}'} + A_t \frac{\partial \overline{w's_{sL}'}}{\partial t} = -K_H'' \frac{\partial s_{sL}}{\partial z} + A_1^{s_{sL}} \frac{\partial \overline{w'^3}}{\partial z} + A_2^{s_{sL}} \frac{\partial \overline{w's_{sL}'^2}}{\partial z} + A_3^{s_{sL}} \frac{\partial \overline{w'^2 s_{sL}'}}{\partial z}$$

$$\overline{w'q_t'} + A_t \frac{\partial \overline{w'q_t'}}{\partial t} = -K_H'' \frac{\partial q_t}{\partial z} + A_1^{q_t} \frac{\partial \overline{w'^3}}{\partial z} + A_2^{q_t} \frac{\partial \overline{w'q_t'^2}}{\partial z} + A_3^{q_t} \frac{\partial \overline{w'^2 q_t'}}{\partial z}$$

where the coefficients in the equations can be expressed using the full prognostic equations for heat and moisture fluxes and for static energy, moisture and vertical velocity variances and approximations from CCH07.

The above equations can be discretized for solving, where an iterative scheme with two iterations is used. The result of the solved equations is the TOMs correction to heat and moisture fluxes (see *Ivan Bašták Ďurán, 2015: TOUCANS documentation*).

WORK

The calculation of the TOMS corrections is implemented in the routine ACDIFV3 of the TOUCANS module (controlled by the LCOEFK_TOMS flag). The routine includes the preparations of all variables that enter the solver and the solver algorithm itself, and also the calculation of corrections of the condensates fluxes (controlled by the LDIFCONS flag). It is known that in the current version of the code, a few bugs exist (see *Ivan Bašták Ďurán, 2015: TOUCANS documentation*).

The work that was done is:

- Code comments were updated and improved,
- Code was reorganized to have a more logical structure,
- Code optimisation regarding unnecessary loops, divisions and some unused pieces of code was performed,
- Code was rechecked for bugs from the beginning, and the known bugs were identified, and also some new ones were found.

TO BE DONE

The work was not completed, and will continue from home. What needs to be done is explained below:

When bugs are corrected, it causes the solver algorithm to become unstable, therefore the algorithm needs to be studied in order to perform corrections to it that ensure its stability. After this, the results need to be re-verified to ensure they are correct.

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