ALARO Physics Developments

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ALARO

Main developments:

- Testing on the globe
  Radmila Brožkova, Francois Bouyssel
- Turbulence scheme TOUCANS
  Ivan Baštak Duran, Filip Vana, Jean-Francois Geleyn
- Radiation
  Jan Mašek, Radmila Brožkova
- Convection
  Luc Gerard, Doina Banciu

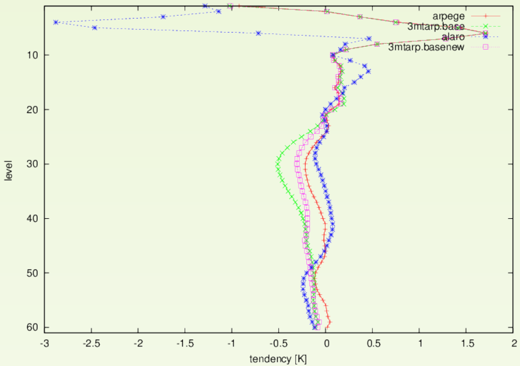
Testing on the globe

3MT in ARPEGE:

- 3MT associated with operational ARPEGE physics (code adaptions needed)
- Tests at coarser resolution on the globe (90km, no stretching, 60 levels)
- Tuning of some parameters
- A very good research tool
  - Possibility to test physics on the globe, including tropics
  - Understanding some aspects of the ALARO behaviour

Testing on the globe

Temperature tendences



red - ARPEGE

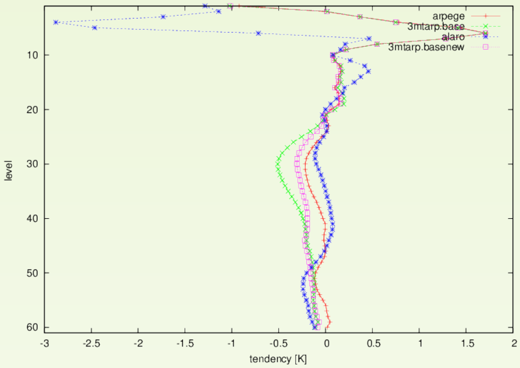
green - ARPEGE with 3MT (without retuning)

cyan - ARPEGE with 3MT

3MT in ARPEGE: retuning of some parameters is needed.

Testing on the globe

Temperature tendences



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cyan - ARPEGE with 3MT

blue - ALARO

ALARO is performing well also at coarser resolution.

3MT and shallow convection

- The spirit of 3MT should in principle allow to treat any kind of convection (precipitating [like up to now], non-precipitating, dry).
- But the link with the ‘resolved’ condensation requires that the convective part connects the ‘thermal’ with the environment
- Convective clouds have a ‘shell’ of subsident motions (Heus and Jonkers 2003)
- So shallow convection cannot enter the 3MT logic.

This lead to the decision to treat ‘shallow convection’ on the turbulent side.

TOUCANS

TOUCANS Third Order moments (TOMs) Unified Condensation Accounting and N-dependent Solver (for turbulence and diffusion)

Main features:

- prognostic TKE system: advection, diffusion, buoyancy/shear production and dissipation
- emulation of different TKE schemes: QNSE, CCH02, EFB (not coded), ..
- TKE and 'moist stability' dependent mixing lengths
- Shallow Convection Parametrisation (SCP) through modification of Richardson number (Ri)
- Third Order Moments parametrisation (following Canuto et al. (2007))

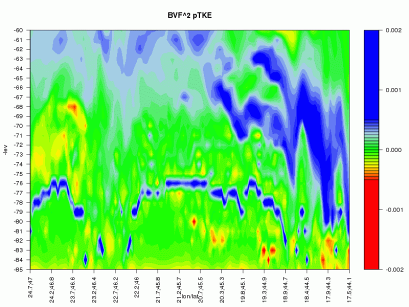
QNSE Sukoriansky et al. 2006 CCH02 Cheng et al. 2002 EFB EnergyFluxBudjet Zilitinkevick et al.

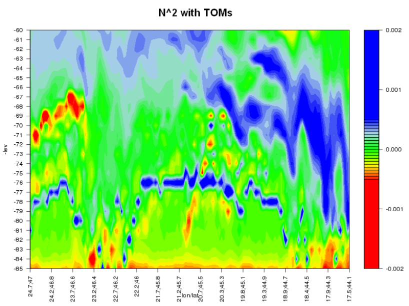
TOUCANS

Vertical cross section for Brunt Vaisalla frequency

PseudoTKE (current)

TOUCANS with Third Order Moments



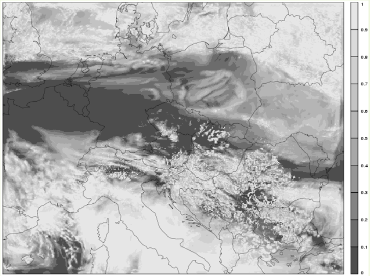


30h of integration, start at 3.3.2011 6:00 am, operational CHMI horizontal and vertical resolution

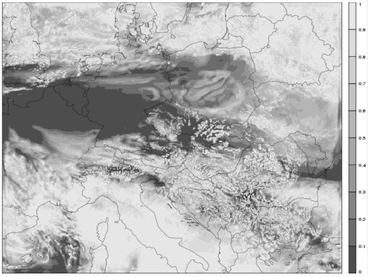
TOUCANS

Cloudiness

PseudoTKE (current)



TOUCANS with Third Order Moments



More shallow convection (inversion) clouds, but disappearing during the daytime.

TOUCANS

Shallow Convection Parametrisation

- *Ri* for SCP is computed from Shallow Convection Cloudiness (*SCC*) using moist entropy potential temperature [after Marquet P. , Geleyn, J.-F. (2012)]
- *SCC* must be computed independently (not completely solved)
- hybrid mode of *Ri* for SCP is also possible:
  Ri_m used for TKE computation,
  Ri_{s1} used for stab. functions computation

TOUCANS

Under development

- prognostic mixing length
  - following EFB, but prognostic mixing length instead of prognostic time-scale, due to easier implementation
  - technically usage of (stable) TKE solver
- prognostic *SCC* after Tompkins
  - prognostic distribution width and skewness, with equilibrium target values restricted to turbulence considerations

Radiation

Radiative transfer scheme (ACRANEB)

- comparable to RRTM in quality, but using just single thermal band instead of 140 spectral intervals
- keeping cost linear in number of levels thanks to use of NER formalism with bracketting
- with possibility of intermittent (e.g. hourly) update of gaseous transmissions, while keeping full feedback with cloudiness (i.e. cloud optical properties updated every time step)
- work on new gaseous transmissions focusing on thermal band (clear sky computations in solar band do not bring extra problems)

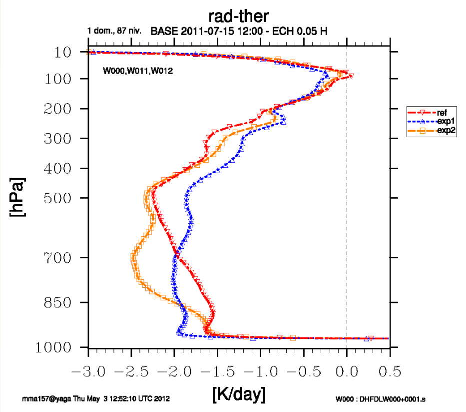
Radiation

New gaseous transmissions

- improved homogeneous fits, import of H_2O e-type continuum, parametrisation of non-random gaseous overlaps
- 3D experiments indicated problem with H_2O thermal transmissions: too much cooling in lower atmosphere

Radiation

Heating rates in thermal band, clearsky non-isothermal case



red - RTM

blue - ACRANEB (current operational settings)

yellow - ACRANEB2 (version from spring 2012)

Too much cooling between 600-900hPa levels.

Improvement of gaseous transmissions alone deteriorates the results.

Efficient error compensation in current ACRANEB.

Radiation

The problem was studied with 1D comparison against reference spectrally averaged narrow band computations

1: Precision of fitted gaseous transmissions
   Fits which looked satisfactory in space of transmissions proved to be very poor when used in model to compute thermal heating rates.

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2: **Accuracy of overlap treatment**
   Broadband approach cannot work without overlap treatment. Proper tuning needed to provide acceptable heating rates.

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Broadband approach cannot work without overlap treatment. Proper tuning needed to provide acceptable heating rates.

3: SPLIDACO reference is itself not very accurate
New fitting reference needed.

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2: Accuracy of overlap treatment
Broadband approach cannot work without overlap treatment. Proper tuning needed to provide acceptable heating rates.

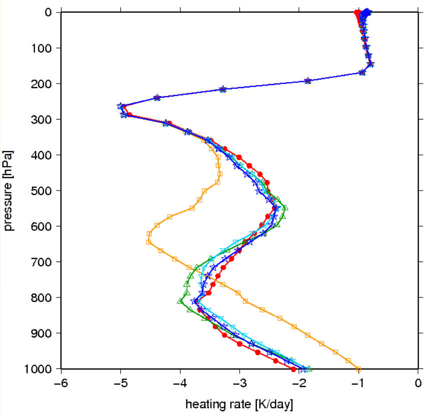
3: SPLIDACO reference is itself not very accurate
New fitting reference needed.

4: Ignored double temperature dependency of broadband thermal transmissions
Considerable error in non-isothermal case.
Code redesign needed.

Radiation

2. Accuracy of overlap treatment

Heating rates in thermal band, isothermal case



red - SPLIDACO reference

green - ACRANEB2 with first version of overlap fits

light blue - ACRANEB2 with improved accuracy of overlap treatment

blue - ACRANEB2 with overlaps tuned to minimize heating rate error for this case

yellow - ACRANEB2 with ignoring non-random overlaps

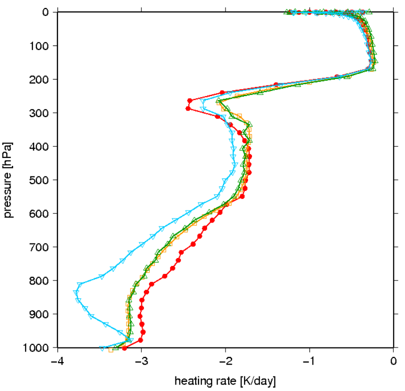
Broadband approach cannot work without overlap treatment.

Proper tuning needed to provide acceptable heating rates.

Radiation

3. SPLIDACO reference is itself not very accurate

Heating rates in thermal band, non-isothermal case



red - AER (line by line RTM)

blue - SPLIDACO

green - GLA

yellow - GFDL

Rough estimate of how uncertain H_2O data are.

SPLIDACO is too much separated from the rest.

Convection

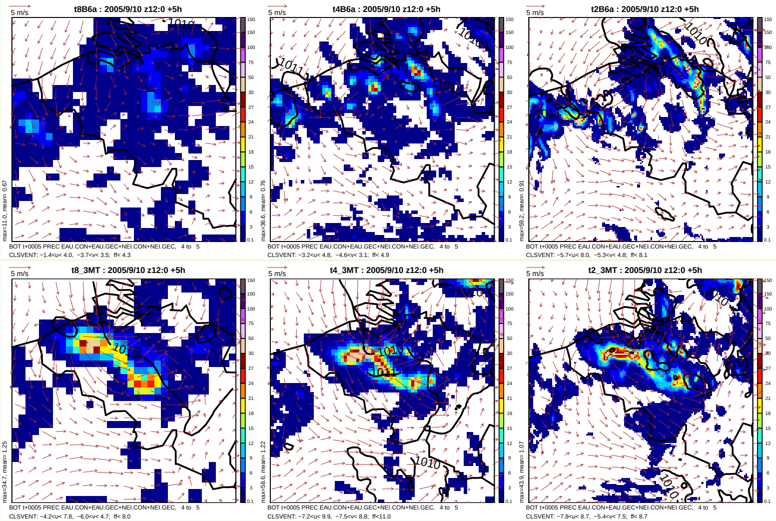
CSU (complementary subgrid updraft)

Deep convection parametrisation with a set of high resolution-specific features:

- ascent - perturbation approach to compute subgrid contibution to updraft
- CAPE closure
- cloud evolution over several time-steps
- triggering - adapted Updraft Source Layer (Kain-Fritsch) technique

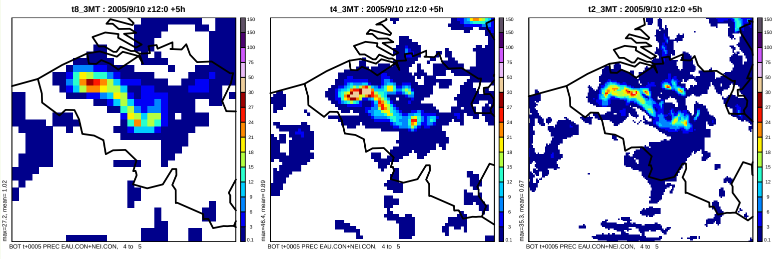
3D experiments Thunderstorms over Belgium on 10 Sep 2005.

1-hour accumulated surface precipitation.
Alaro with CSU-scheme (top) and Alaro-0 3MT (bottom)
forecast at 8km, 4km, 2km.



3D experiments

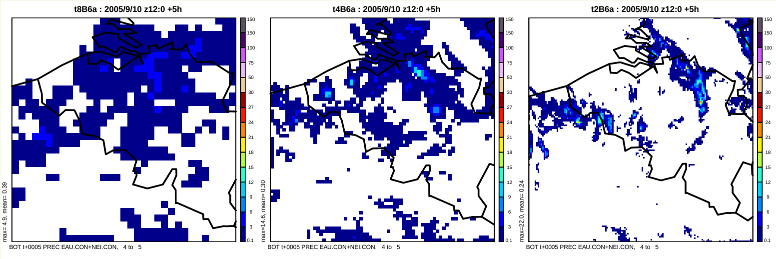
1-hour accumulated surface precipitation - subgrid part of precipitation.
Alaro-0 3MT forecast at 8km, 4km, 2km.



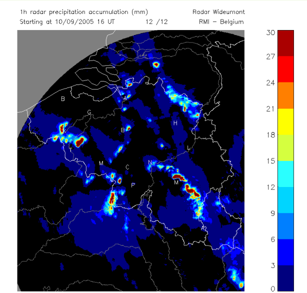
3MT produces an excessive response of the subgrid scheme in this situation, especially at coarse resolution, and this has a strong impact on the structure of the precipitation.

3D experiments

1-hour accumulated surface precipitation - subgrid part of precipitation.
Alaro with CSU-scheme forecast at 8km, 4km, 2km.



The convergence towards 100% resolved precipitation is not yet evident at 2km. (in reality convective cells in this situation were quite smaller).



Convection

CSU (complementary subgrid updraft)

The academic model tests using a perturbation of 3 km radius showed:

- the subgrid contribution became very small at 1 km resolution
- least 6 grid boxes are needed to resolve completely a structure or phenomenon
- so with 1 km grid mesh distance
  convective cells greater than 6 km can be resolved
  for smaller ones parametrisation can still produce an improvement

Outlook and plans

- ALARO-0 ($>$ 4 km resolution)

  Prepare a base-line version with all recent improvements and tuned diagnostics of screen level fields

- ALARO-1 ($<$ 10 km, down to 1 km)
  assembling strategy in 2 steps:

step 1 radiation, TOUCANS, unsaturated downdraft

step 2 CSU, TOUCANS evolution, prognostic graupel, thermodynamic adjustment,
unified cloud treatment in radiation, shallow convection, thermodynamic adjustment and 3MT

Outlook and plans

- validation
  - investment in testbeds and facilities
  - validation of developments (2 steps)
  - tests at higher resolution (scales around 2 km mesh-size)
- development
  - cloud scheme, 3D extension of turbulence, microphysics
  - stochastic physics (CA) and Rash Kristjansen condensation scheme with 3MT and TOUCANS

Thank you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