Regional Cooperation for
Limited Area Modeling in Central Europe

LACE
nwp central europe

ALARO physics developments

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EWGLAM and SRNWP meetings

DHMZ SHMU OMSZ ZAMG ROMANIA ANM

Talk outline

- ALARO-0 short recall

- ALARO-0 performance at varying horizontal resolutions
- ALARO-1 developments
  - Turbulence scheme
  - Radiation scheme
  - Convection

- Outlook

ALARO short recall

- One of the physical parameterization package inside ALADIN/HARMONIE system
- Characteristics:
  - multi-scale: parameterizations being as scale-independent as possible and giving physically consistent results over a wide range of model resolutions (in particular 10 km to 2 km)
  - consistency of all formulation, in particular within the 3MT framework for the macro physical parameterization of precipitations
  - a prognostic character of parameterizations, while they share the same information, approaches and level of complexity.
  - code stability, numerical efficiency and modularization
- Nowadays – ALARO applications running at grey zone scales

ALARO-0 short recall

- In the operational use in ALADIN countries
  - at, be, cz, hr, hu, pt, ro, sk, si, tr ; se
    model resolution between 8 km – 4 km, 2km
- In EPS systems
  - ALADIN-LAEF, GLAMEPS, EPS at HMS
- In climatological simulations
- Plans for a usage in
  - HarmonEPS convection-permitting ensemble system
  - multi model systems

ALARO-0 short recall

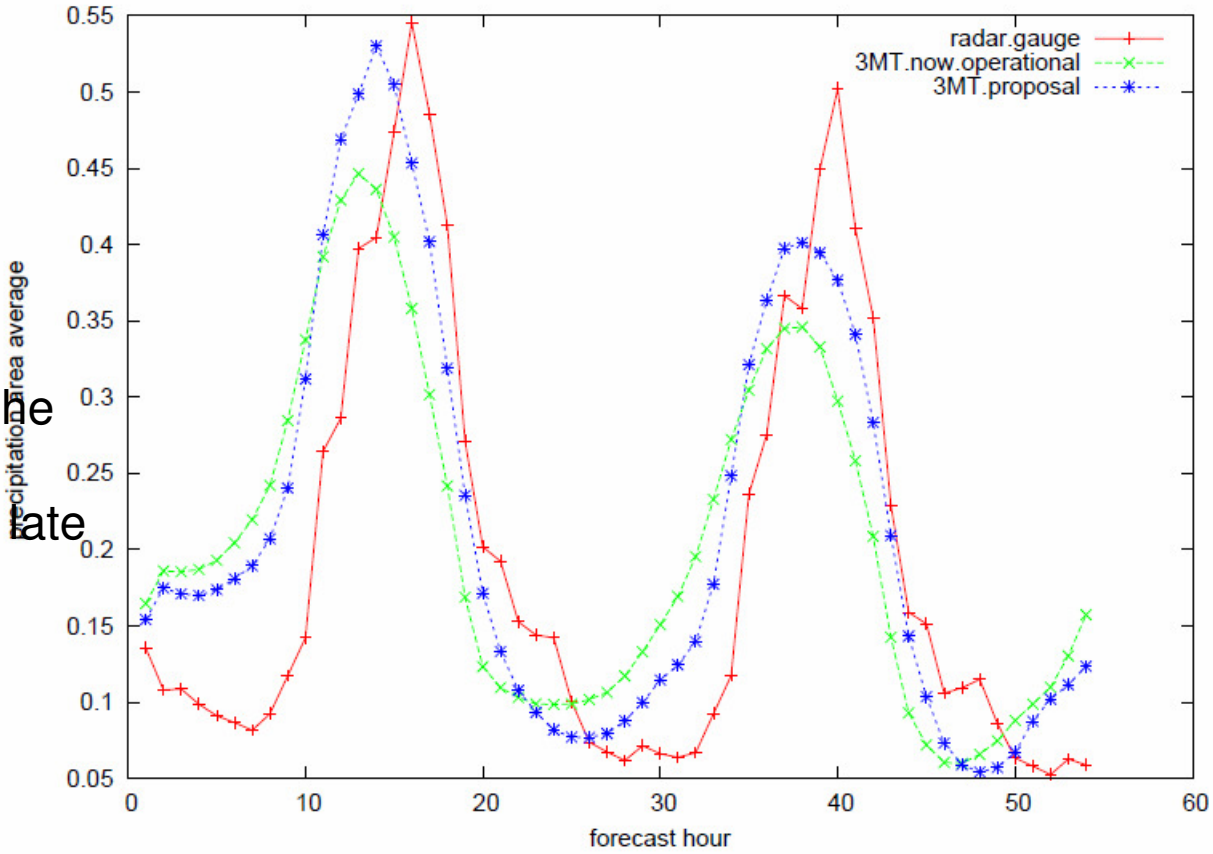
- introduction of a few improvements in the convection scheme 3MT
  - Sedimentation of cloud water and ice
  - Protection of convective condensation below diagnosed LCL
  - Corrections in downdraft and updraft computations
  - Retuning in cloudiness, convection and sedimentation computations
  - **Mixed type of closure instead of pure moisture convergence one in 3MT**
  - **Adaptive detrainment is made dependent on total evaporation (precipitation) at previous time-step**
  - **Entrainment rate is made dependent on rel. humidity of environment at previous time-step**
- Declaration of the **ALARO-0 baseline** December 2012

Impact on diurnal cycle

average of mean hourly precipitation over the Czech area
(11 realizations, Jun/Jul 2009)

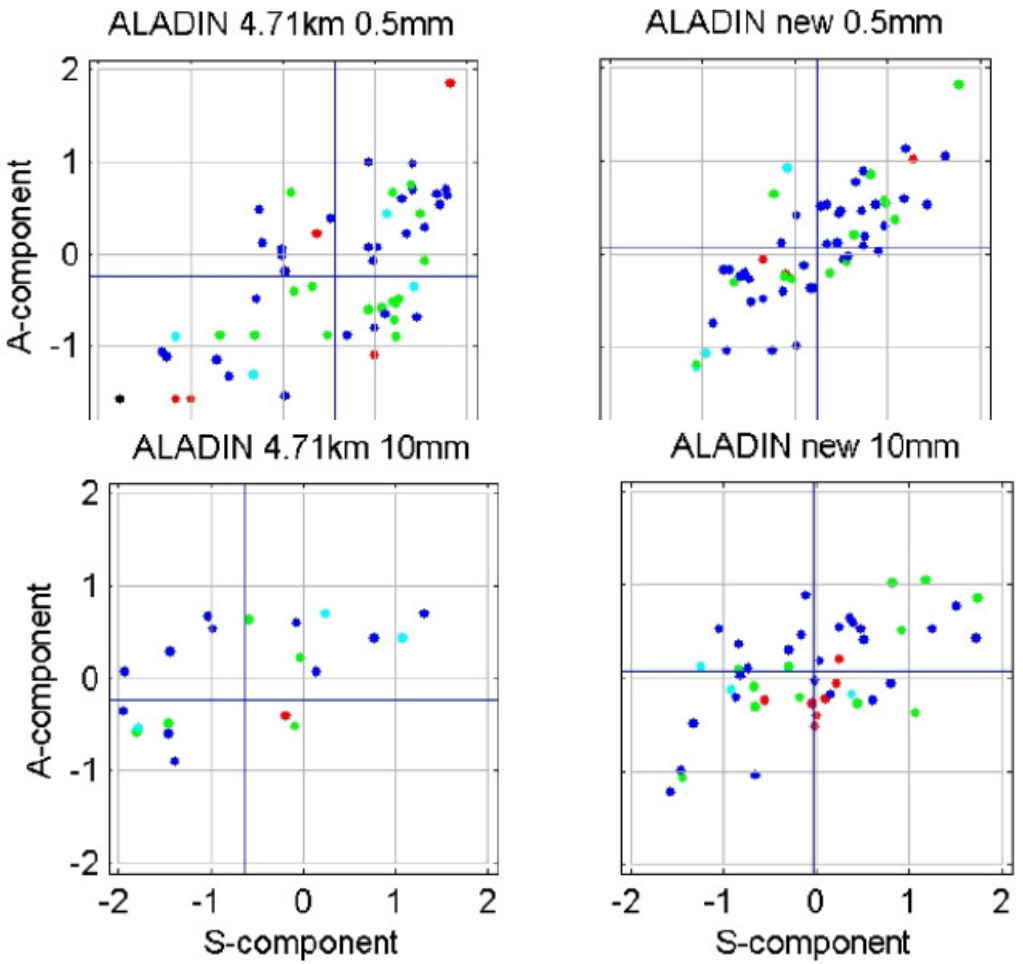
red - observations
green - ALARO-0 “old”
blue - ALARO-0 baseline

Model starts rain early;
Early decay as well;
Too much precipitation in the morning;
Lack of precipitation in the late afternoon and in the evening.



SAL verification

Czech area
22 Jun – 7 Jul 2009



0.5mm/3hours

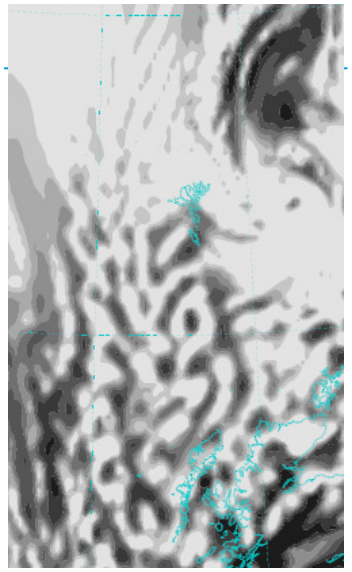
10mm/3hours

ALARO-0 baseline version

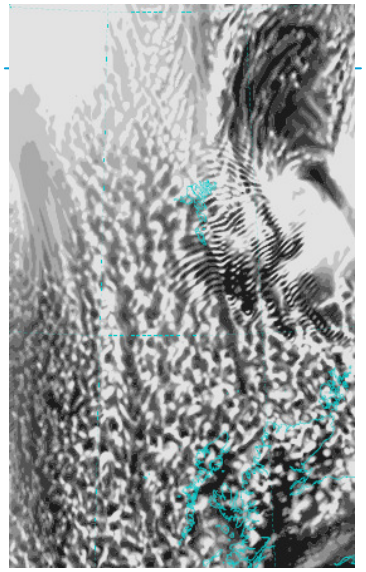
- grey-zone experiment defined by WGNE group (http://www.knmi.nl/samenw/greyzone/index.html)
  - cold-air outbreak case was simulated at various resolutions:

    16km, 8km, 4km, 2km and 1km
  - end of January 2010, north Atlantic
  - without and with parameterised moist deep convection

WGNE grey-zone test, ALARO-0, cloud cover at 24h range

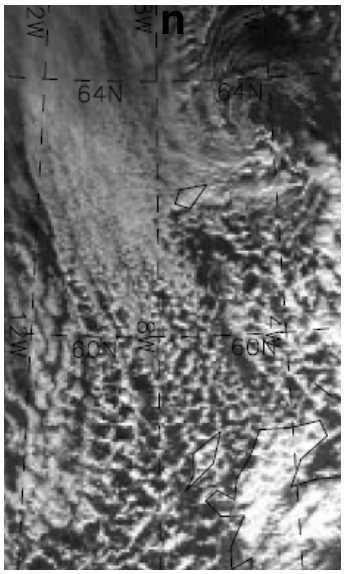


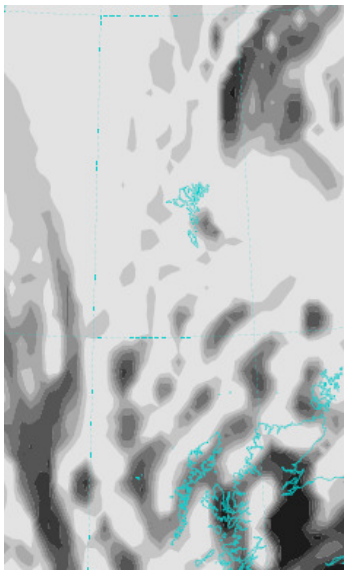
8km



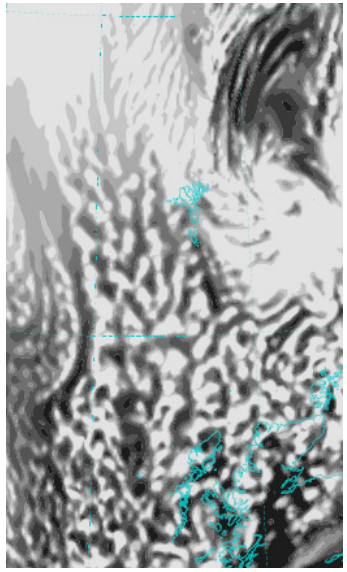
2km

MODIS radiance observatio

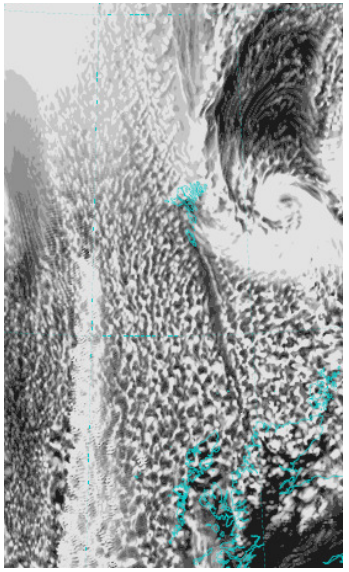




16km

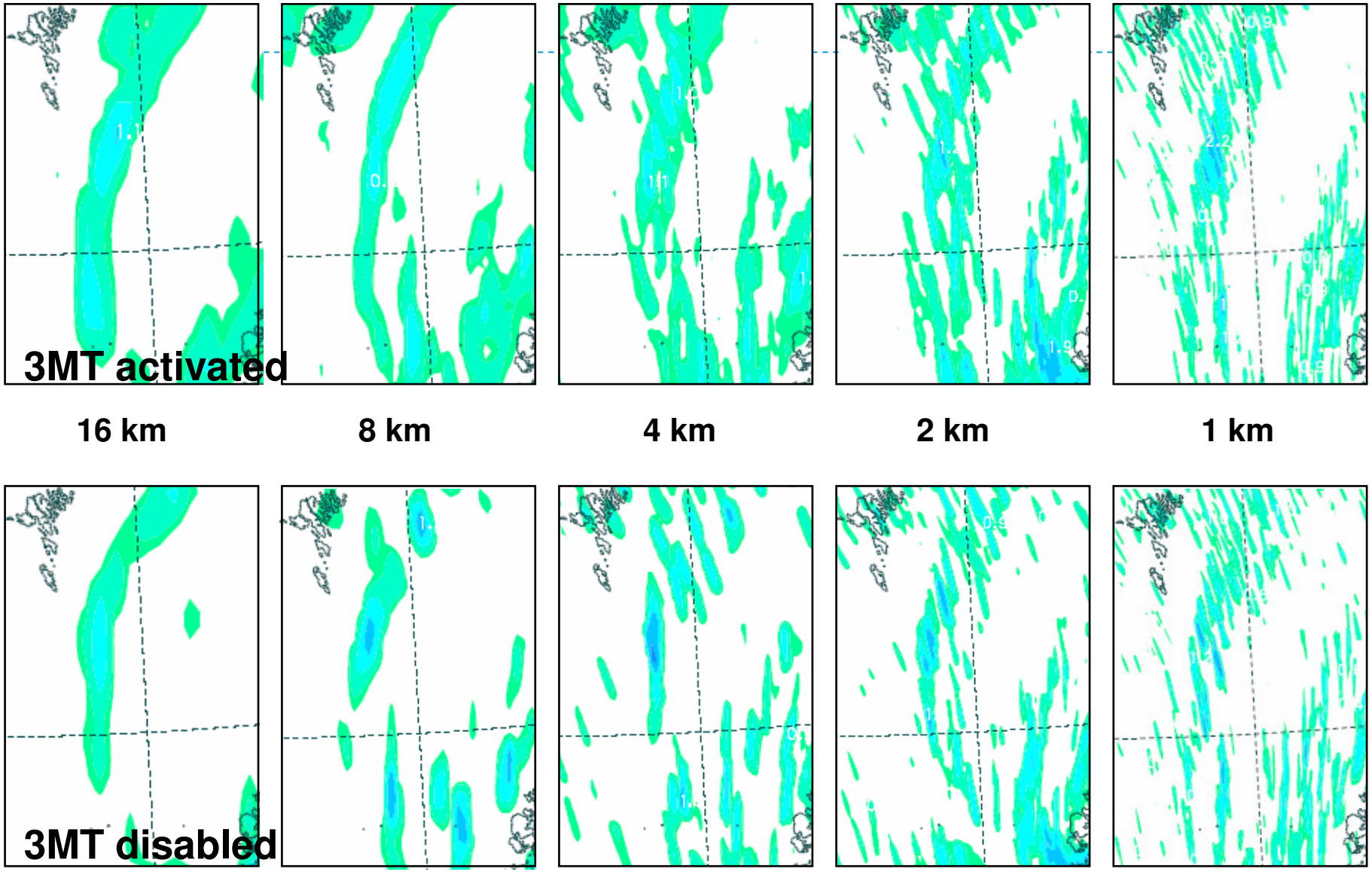


4km



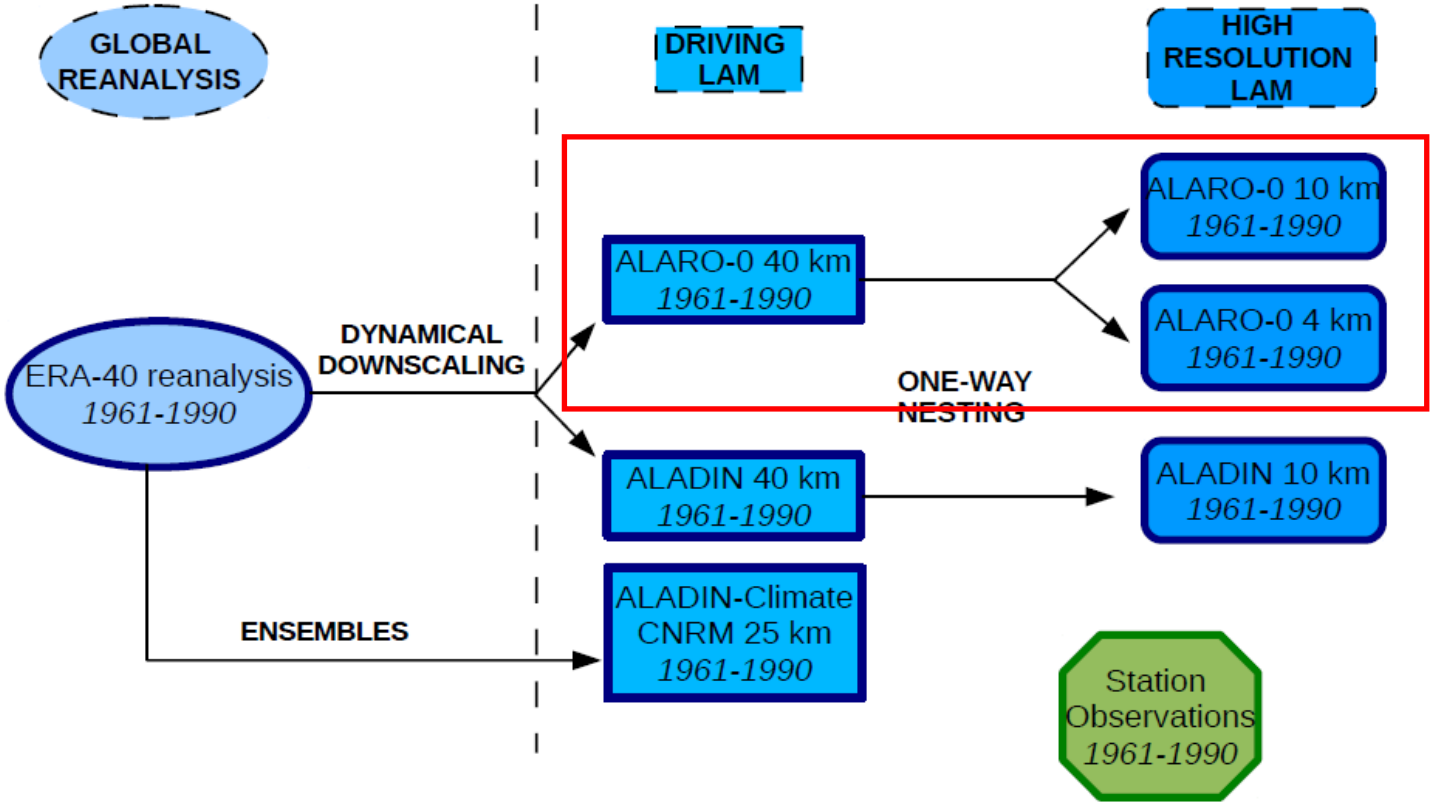
1km

WGNE grey-zone test, ALARO-0, 1h precipitation (30.1.2010 12+31h)



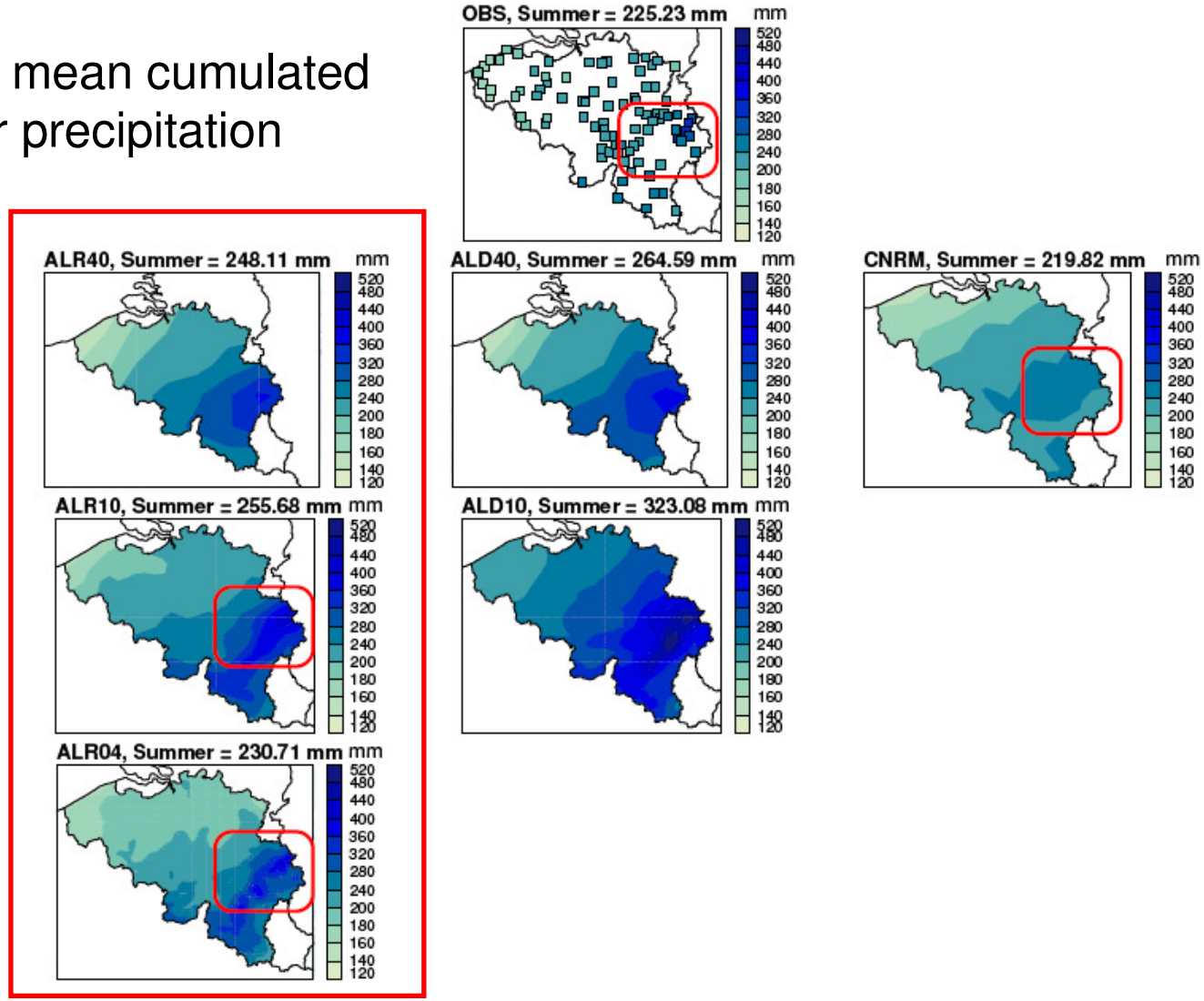
Regional climate

- One of the questions:
  - How performs ALARO-0 at varying horizontal resolutions?



Improvement of ALARO-0

30-year mean cumulated summer precipitation



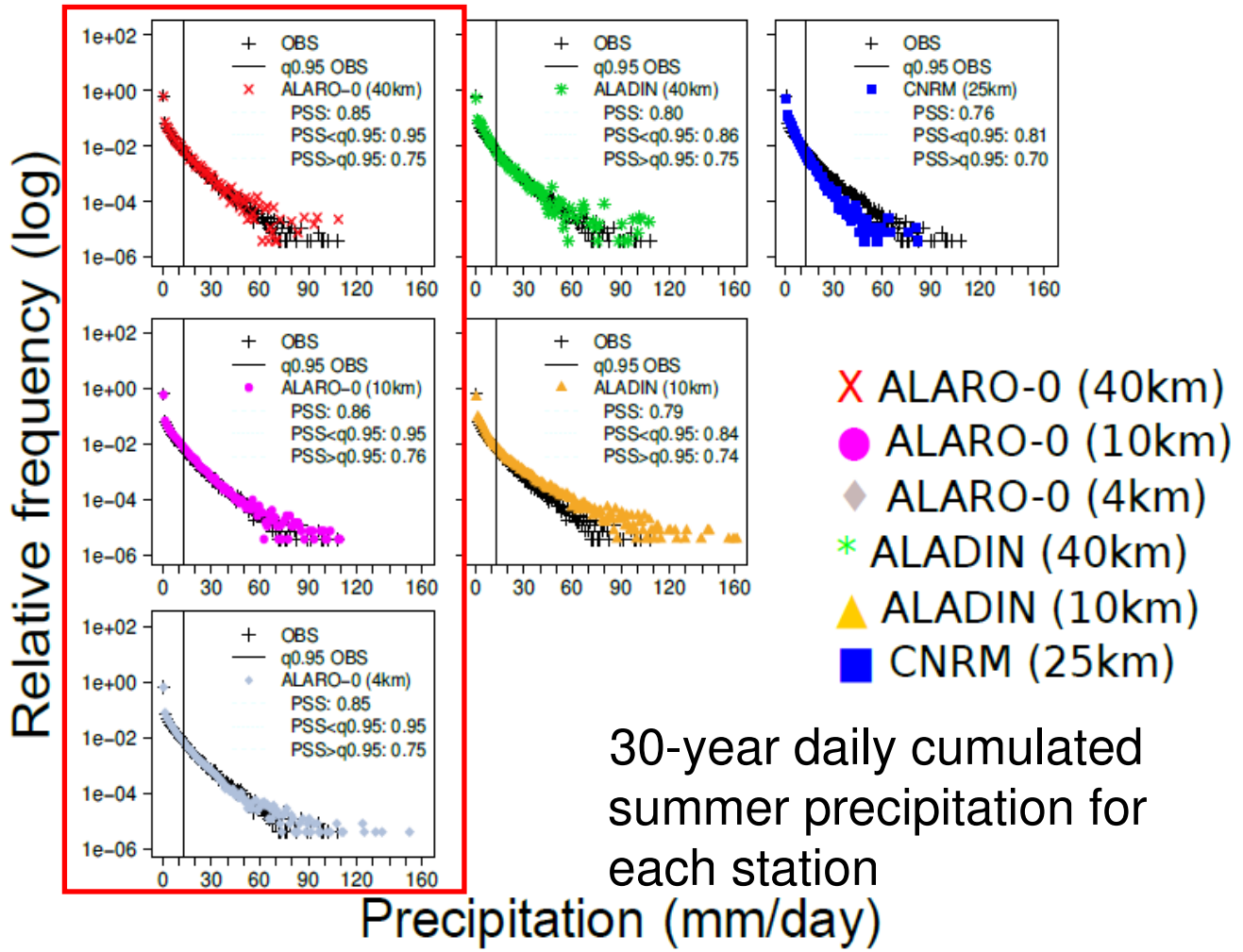
Improvement of ALARO-0

- modeling of extreme precipitation events

40 km

10 km

4 km



30-year daily cumulated summer precipitation for each station

Reference:

- De Troch, R., Hamdi, R., Van de Vyver, H., Geleyn, J.-F. and Termonia, P. (2013).
  Multiscale Performance of the ALARO-0 Model for Simulating Extreme Summer Precipitation Climatology in Belgium.
  Journal of Climate In Press.

ALARO-1 developments (<10 km, down to 1 km)

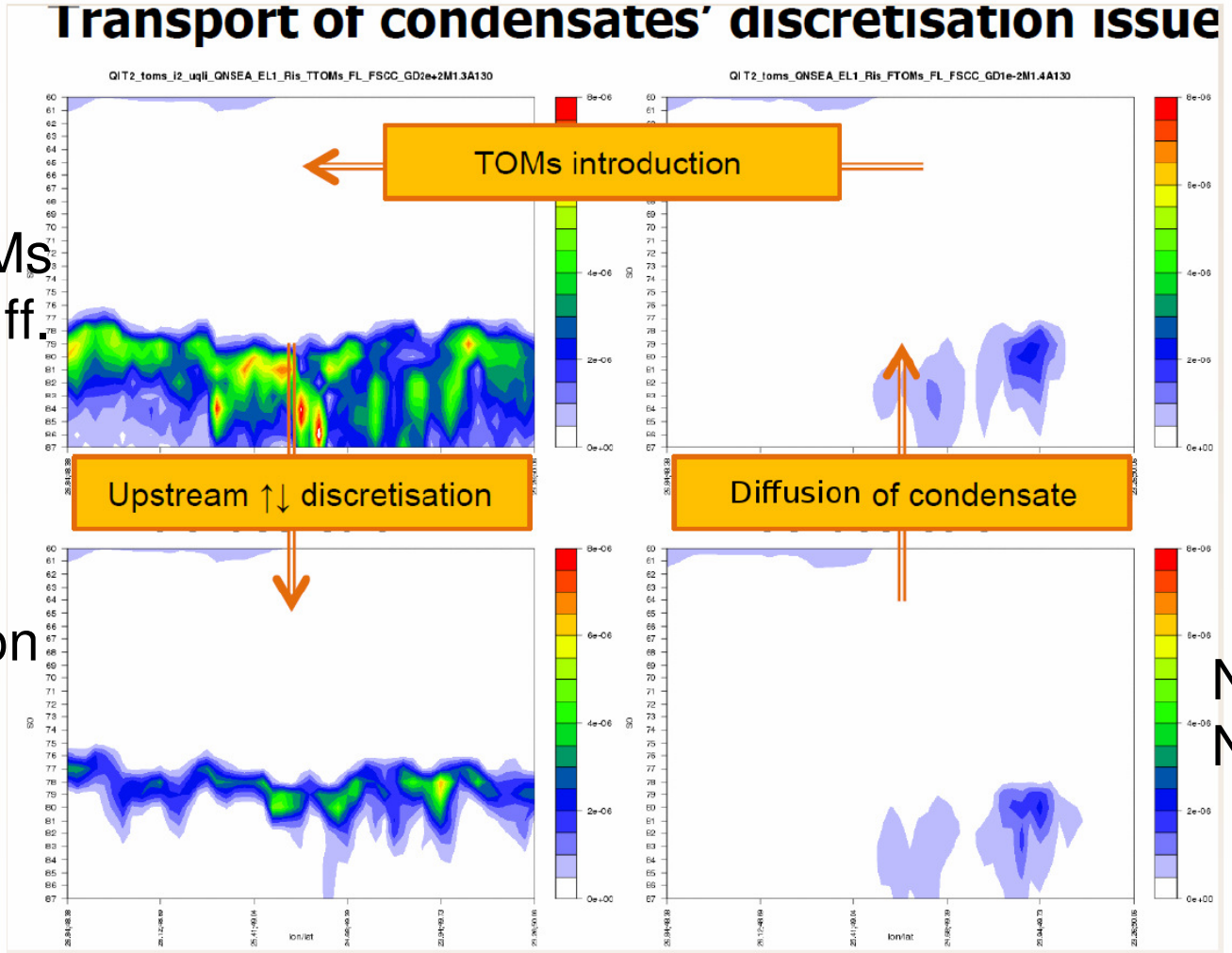
- Turbulence scheme TOUCANS
- Radiation
- Convection
  - Unsaturated downdraft scheme,
  - CSD (Convective Subgrid Drafts): ascent, closure, triggering, evolution,
- *Cloud scheme*
- *Microphysics, prognostic graupel*

TOUCANS

- prognostic TKE system: advection, diffusion, buoyancy/shear production and dissipation
- emulation of different TKE schemes: QNSE, CCH02, EFB,… (via various stability functions)
- TKE and ’moist stability’ dependent mixing lengths
- Shallow Convection Parametrisation (SCP) through modification of Richardson number (Ri)
- influence of moisture and phase changes on intensity of turbulence
- liquid water and ice (ql/i) vertical turb. diffusion
- Third Order Moments parameterization (following Canuto et al.(2007)) for heat and moisture

TOUCANS

ice condensates vertical cross-section



With TOMs
With qi diff.

No TOMs
With qi diff.

Introduction of stable numerical treatment

No TOMs,
No qi diff.

TOUCANS

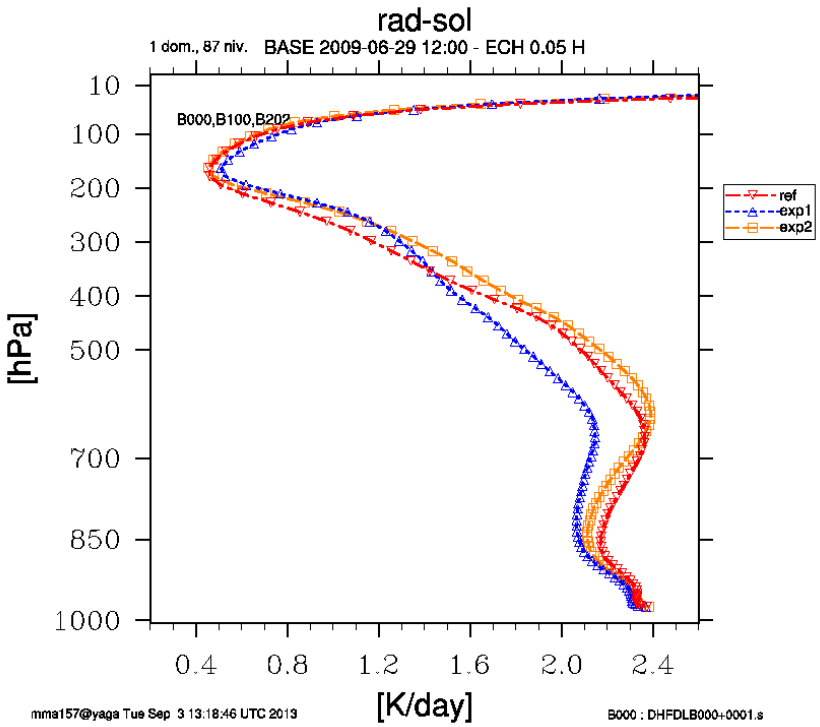
- Testing and tuning of various options
- Searching for an optimal set-up for operational use
- Preparations for treatment of
  - prognostic turbulent total energy (TTE)
  - prognostic handling of mixing length
  - prognostic shallow convection cloudiness (SCC)

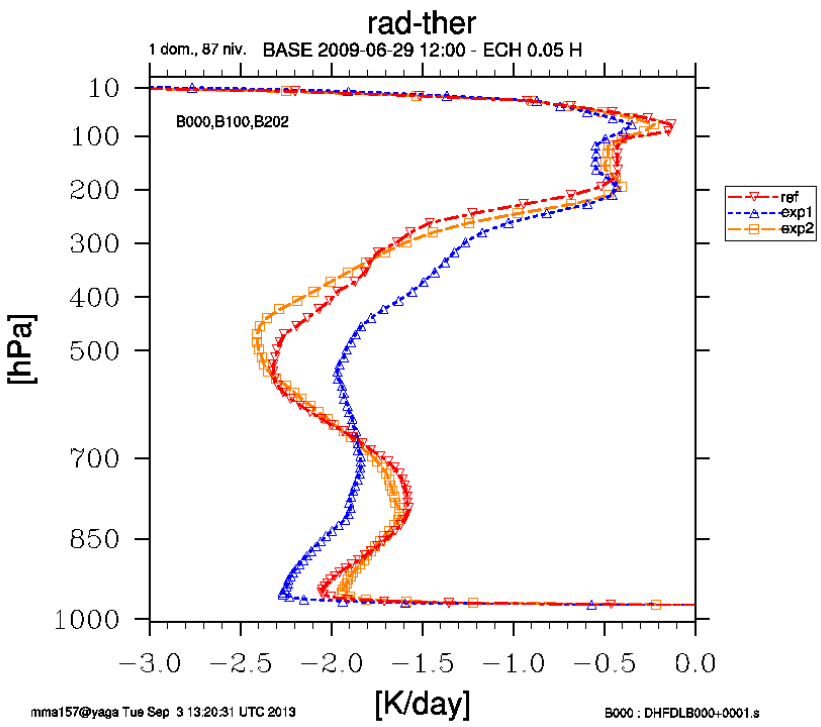
Radiation scheme

- improvement of all gaseous transmissions
  - fits of individual gaseous are more accurate
  - parameterization of non-random gaseous overlaps
  - H_2O e-type continuum is included into H_2O transmission
  - fitted against upgraded SPLIDACO reference
- CO2+ composition is updated to 2010 concentrations
- broadband Voigt treatment (dominant above 70 km)
- NER scheme is revisited
- statistical model is completely reformulated
- intermittent computation of thermal gaseous transmission (every hour), interactions with cloudiness are computed at every time-step
- cloud simulation model is updated and improved
- validation in 3D model, comparison with RRTM is ongoing

Radiation scheme

Clear sky DDH heating rates, single time-step experiment at noon





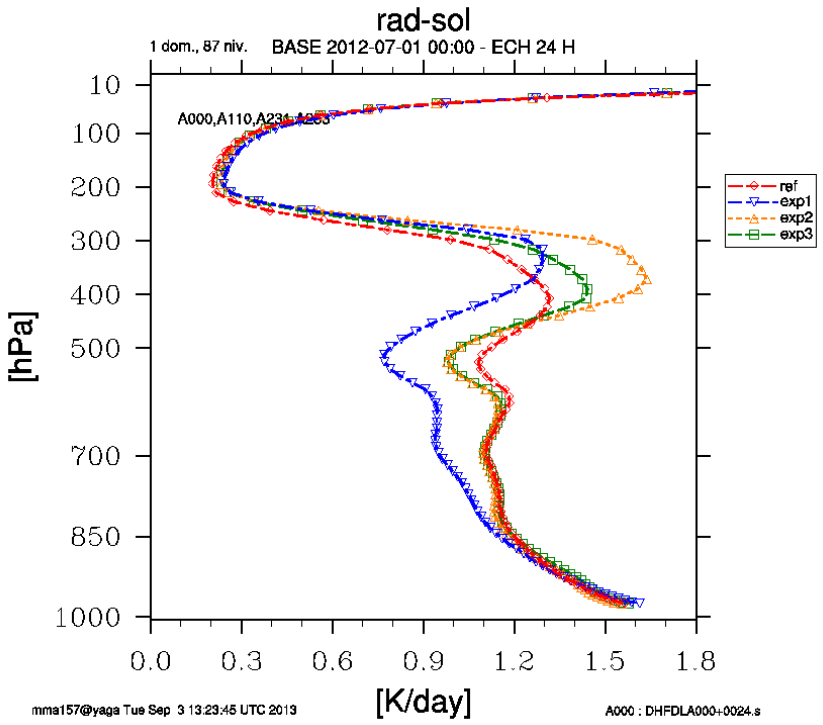
solar

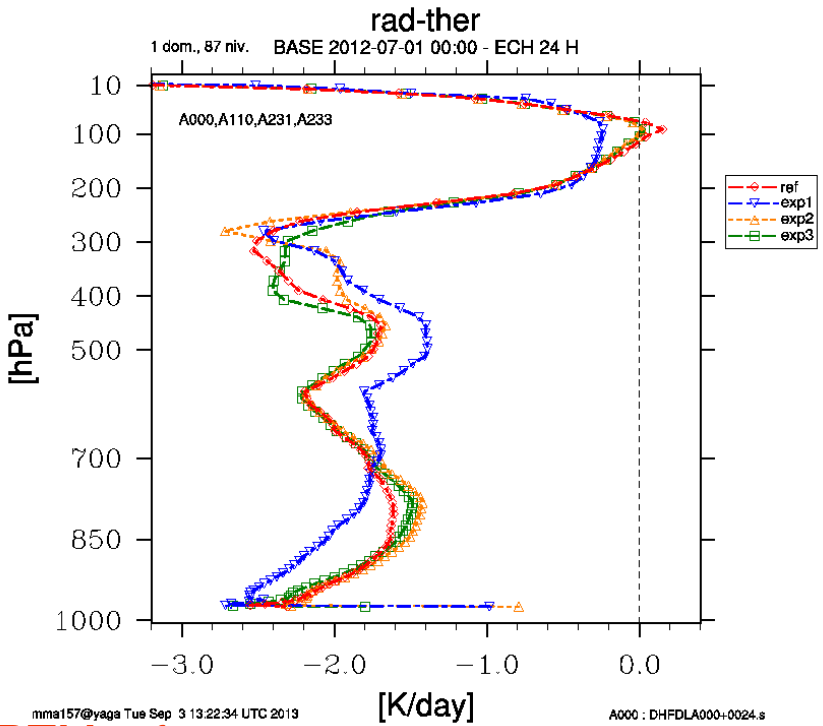
red - FMR/RRTM reference
blue - oper ACRANEB
yellow - ACRANEB2

thermal

Radiation scheme

24 hour DDH heating rates for full integrations including aerosols and clouds





solar

red - FMR/RRTM reference
blue - oper ACRANEB
yellow - ACRANEB2
green - ACRANEB2, new ice clouds

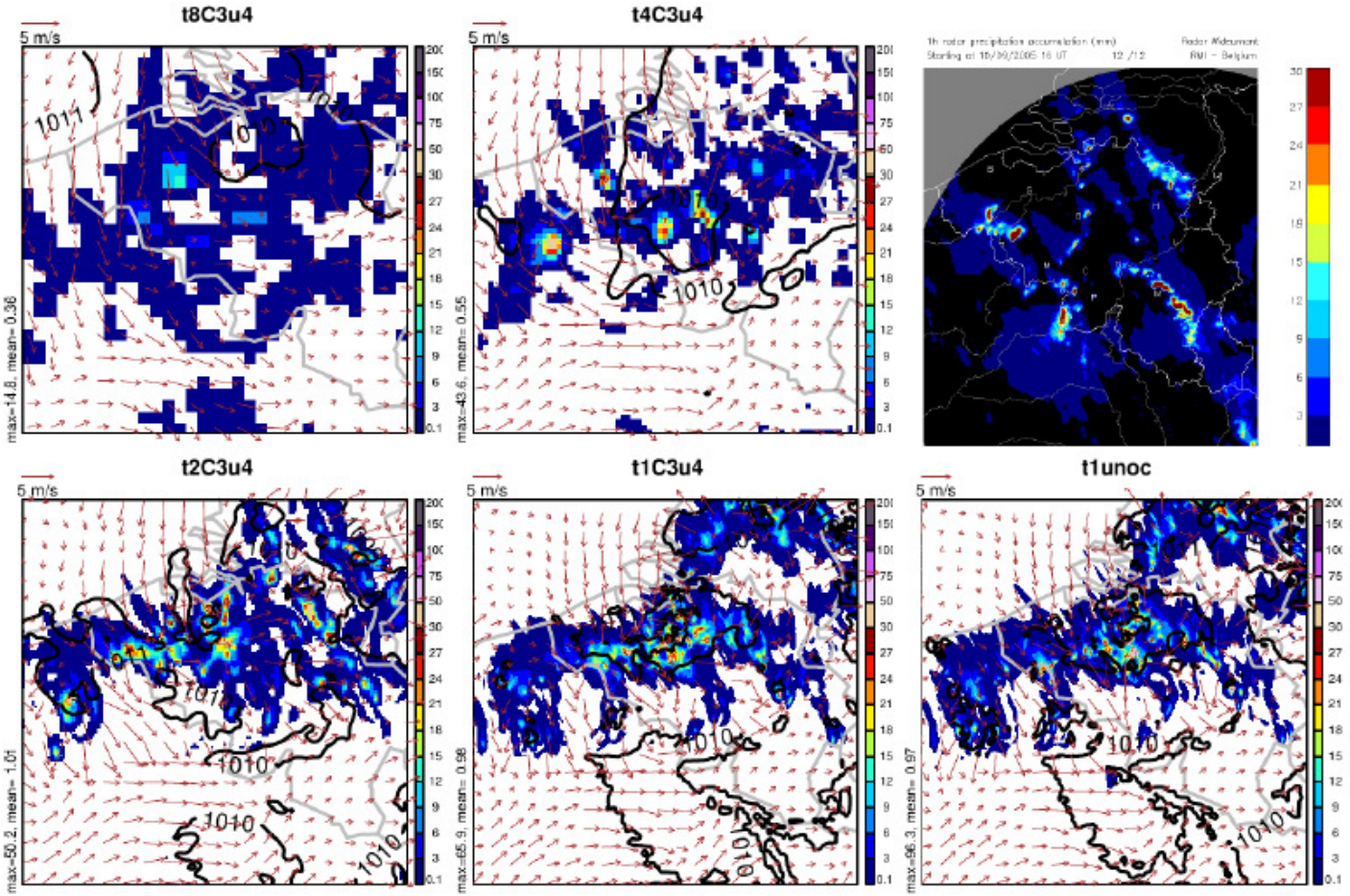
thermal

Convection

- CSD (Complementary Subgrid Draft)
  Deep convection parameterization with a set of high resolution-specific features:
  all the 3MT features plus (mainly):
  - Perturbation approach to compute subgrid contribution to updraft
  - Specific closure (CAPE or mixed) allowing extinction when the 'real updraft' mesh fraction would reach 1
  - Specific triggering (for complementary behaviour across resolutions)
  - Gradually rising cloud top (cloud evolution over several time-steps)
  - Perturbation approach also applied in unsaturated downdraft parameterization.

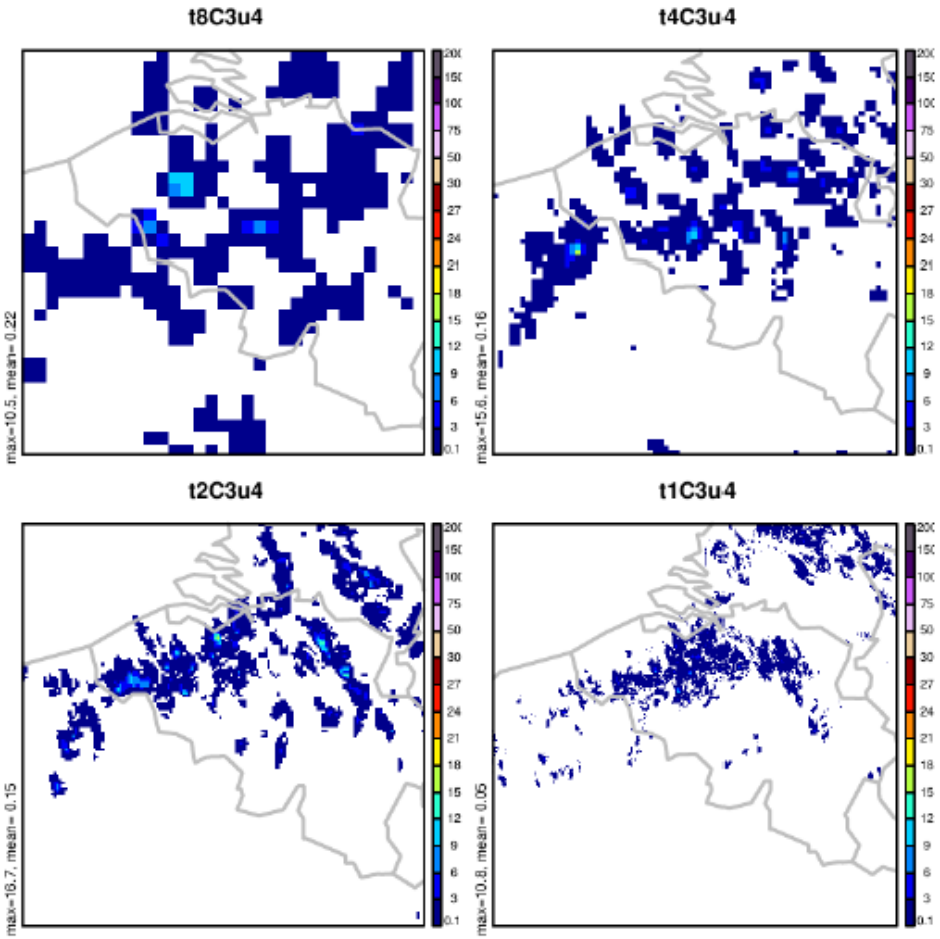
Convection

BB case, total precipitation at 8 km, 4 km, 2 km, 1km



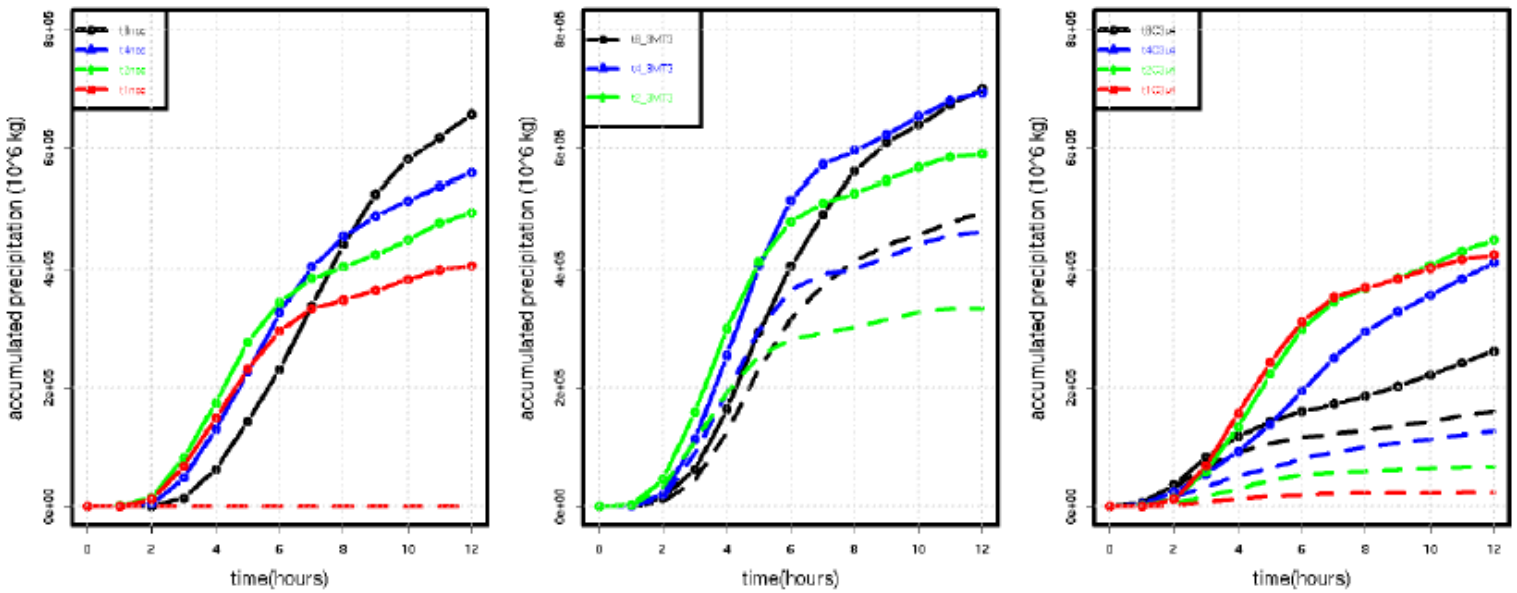
Convection

BB case, sub-grid precipitation at 8, 4, 2, 1km



Convection

Total precipitation accumulation in time



NoCP 3MT CSD

8km, 4km, 2km,1km, total (solid) vs subgrid (dash)

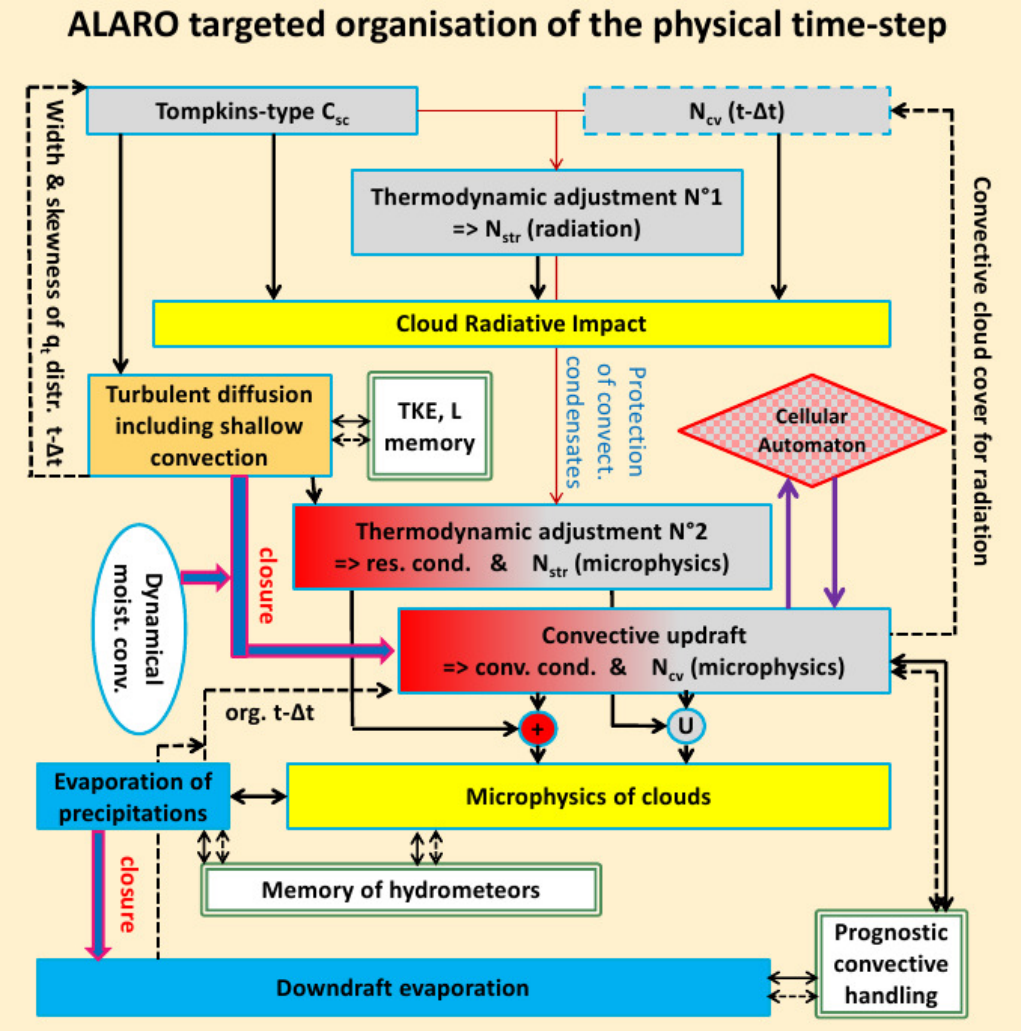
The extinction of the subgrid part is well apparent for the CSD

Plans

- Assembling strategy in 2 steps
  - Step 1: TOUCANS, Unsaturated downdraft and radiation (ACRANEB2)
  - Step 2:
    - complementary sub-grid drafts (CSD),
    - TOUCANS evolution,
    - prognostic graupel,
    - thermodynamic adjustment,
    - unified cloud treatment in radiation, shallow convection, thermodynamic adjustment and 3MT,
    - Cellular Automaton some adoptions needed

- Validation
  - investment in testbeds and facilities
  - validation of developments
  - tests at higher resolution (scales around 2 km mesh-size)

Thank you.


ALARO targeted organisation of the physical time-step
Tompkins-type C_{sc}
N_{cv} (t-Δt)
Width & skewness of q_t distr. t-Δt
Thermodynamic adjustment N°1
=> N_{str} (radiation)
Cloud Radiative Impact
Turbulent diffusion including shallow convection
TKE, L memory
Protection of convect. condensates
Cellular Automaton
Convective cloud cover for radiation
Thermodynamic adjustment N°2
=> res. cond. & N_{str} (microphysics)
Dynamical moist. conv.
closure
Convective updraft
=> conv. cond. & N_{cv} (microphysics)
org. t-Δt
+
U
Evaporation of precipitations
Microphysics of clouds
closure
Memory of hydrometeors
Prognostic convective handling
Downdraft evaporation