ALARO Physics Developments

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LACE area leader for physics

Main developments

- **TOUCANS turbulence scheme**

  Ivan Baštak Duran, Jean-Francois Geleyn, Filip Vana

- **Radiation**

  Jan Mašek, Radmila Brožkova

- **Convection**

  Luc Gerard, Doina Banciu

- ***Celluar automata and 3MT***

  Lisa Bengtsston-Sedlar, Filip Vana

Radiation

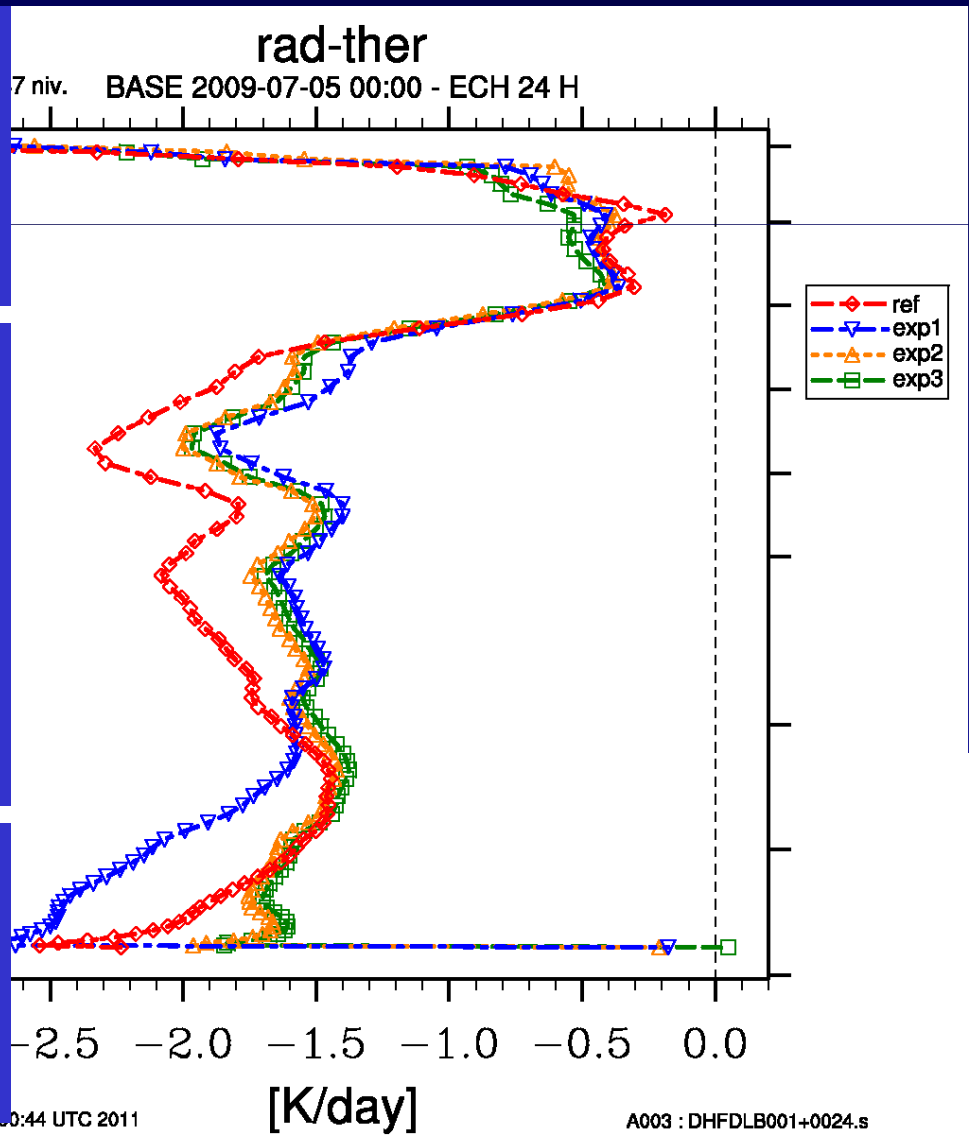
- 3D tests with modified radiation scheme (2009)
- Verification scores were not improved
- Concept has to be revisited

Radiation

in current ACRANEB (blue)
cooling is too much below 700hPa and too little from 700hPa up to tropopause

H2O thermal fit (orange)
cooling below 700hPa is removed, but too little cooling close to surface situation above 700hPa level improved only slightly

Small difference between orange and green indicates that problem is related to H2O



Radiation

- Functional form of broadband gaseous transmissions was revisited,
- Pade fits being replaced by rescaling of absorber amount.
- Accuracy of the new fits is very promising, waiting for implementation/validation in 3D model.
- New ACRANEB is expected to be competitive with RRTM, using single thermal band instead of 140.
- In order to compensate CPU increase due to more costly new fits, implementation of intermittent update of gaseous transmissions

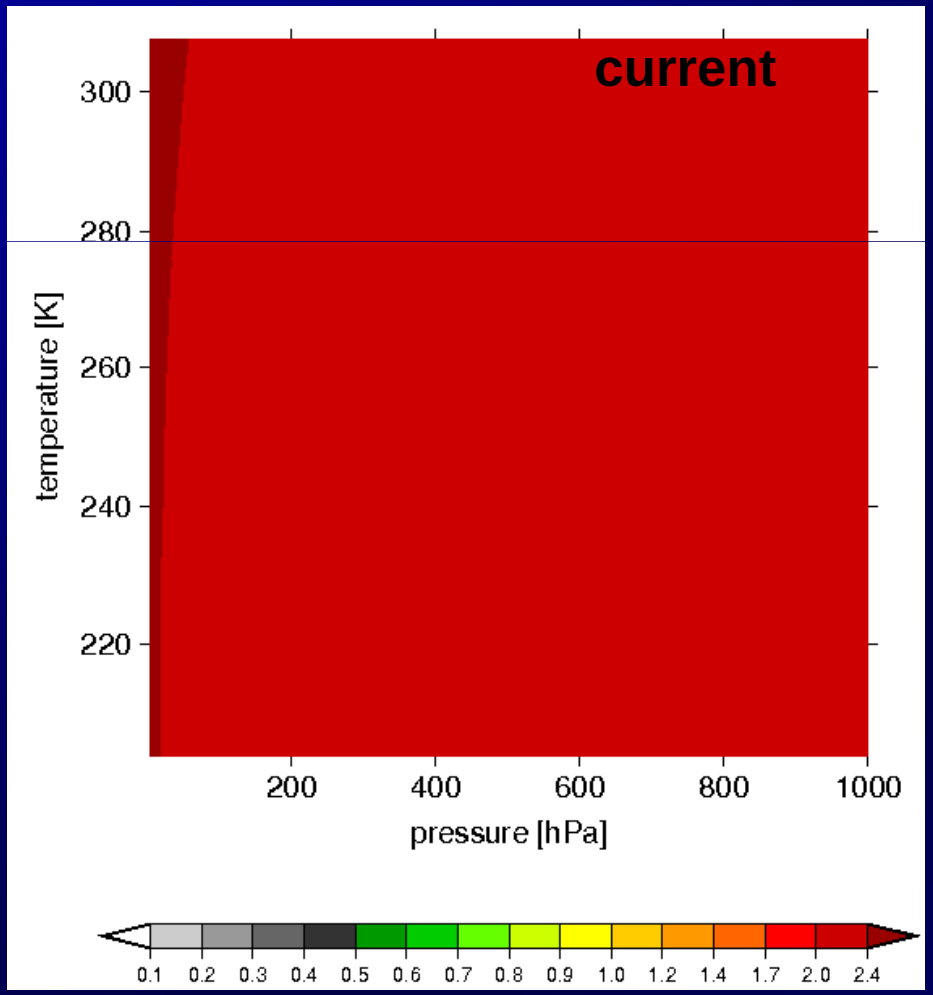
Radiation

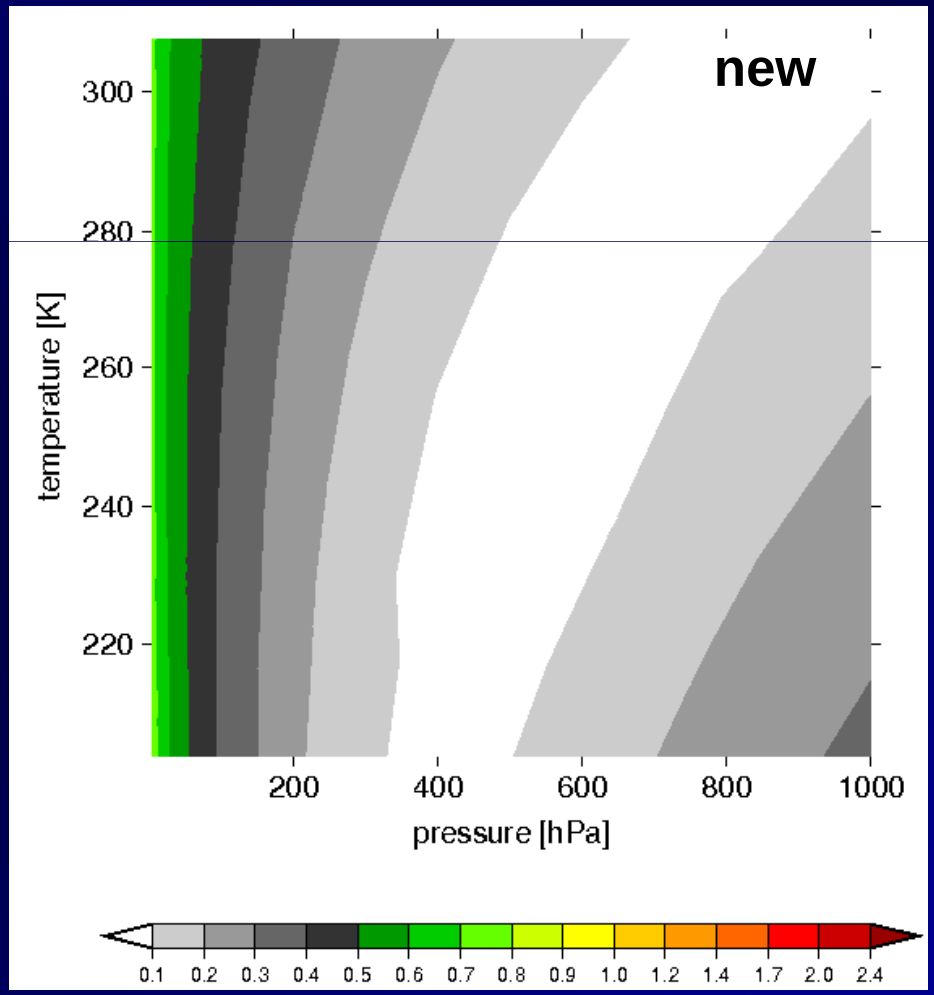
- *Proposing new functional form of broadband delta(u) fits (delta - optical depth; u – absorber amount)*
  - *broadband Malkmus formula corrected by Pade fit cannot reproduce reference log(delta) - log(u) slope in strong line limit*
  - *new function which fits broadband delta(u) dependency*
    - **still based on broadband Malkmus formula, but with absorber amount rescaled by 2-parametric function,**
    - **fully replacing 10-parametric Pade fit applied on resulting optical depth.**

Radiation – current results

- Error maps show overall quality of thermal fits with respect to pressure and temperature for homogeneous optical paths

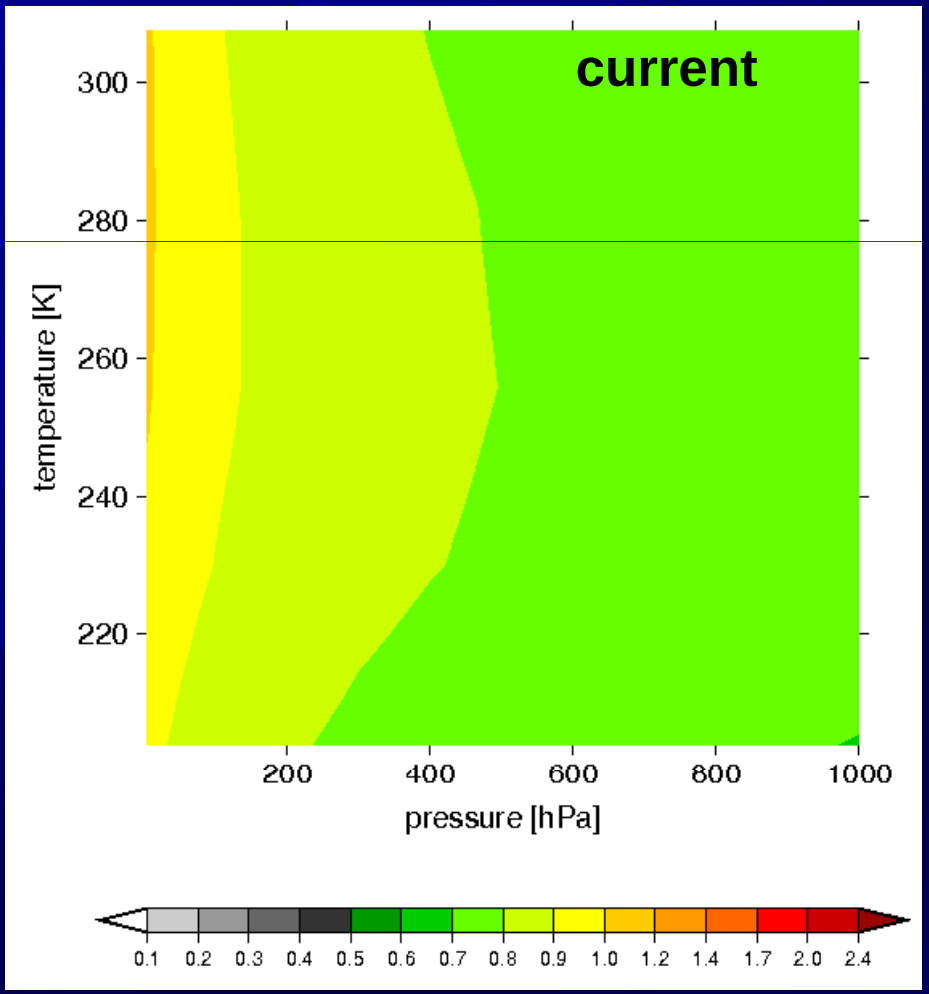
Error of fitted H2O fits optical depth in thermal band

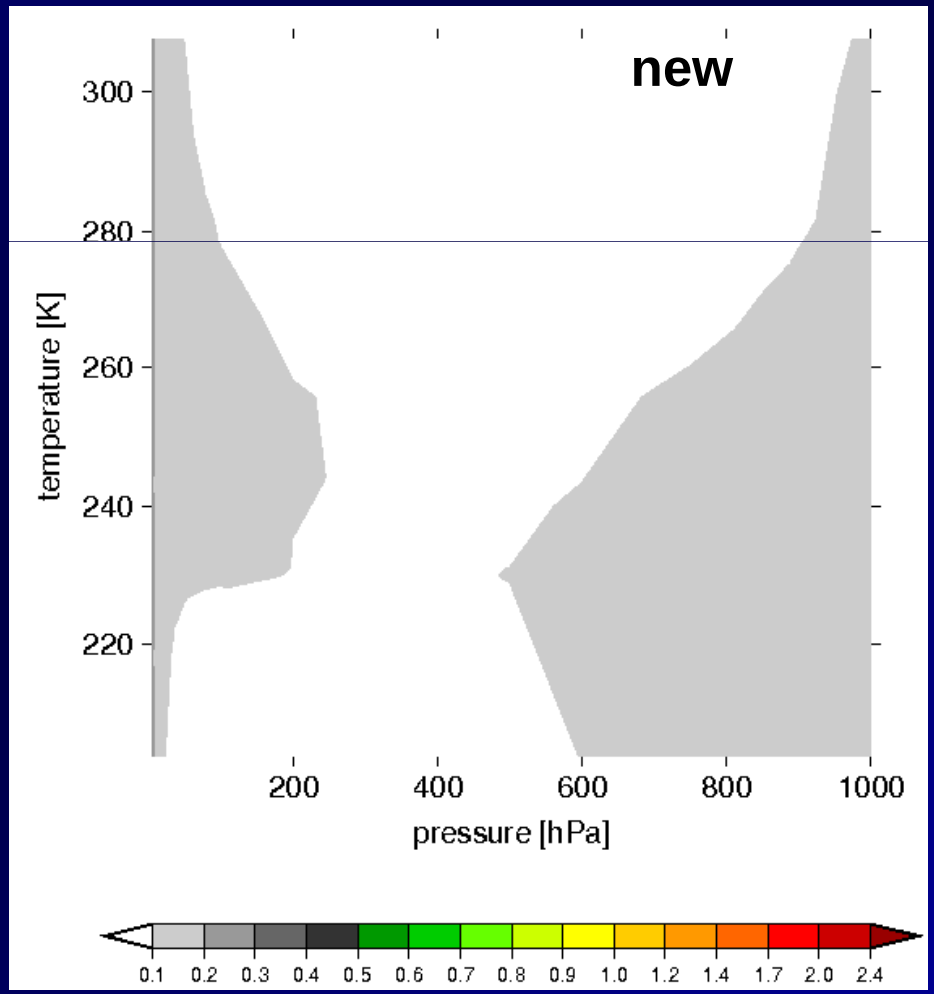




White and light grey color means almost perfect fit, green is acceptable, yellow to red is poor to catastrophic.

Error of fitted CO2+ optical depth in thermal band





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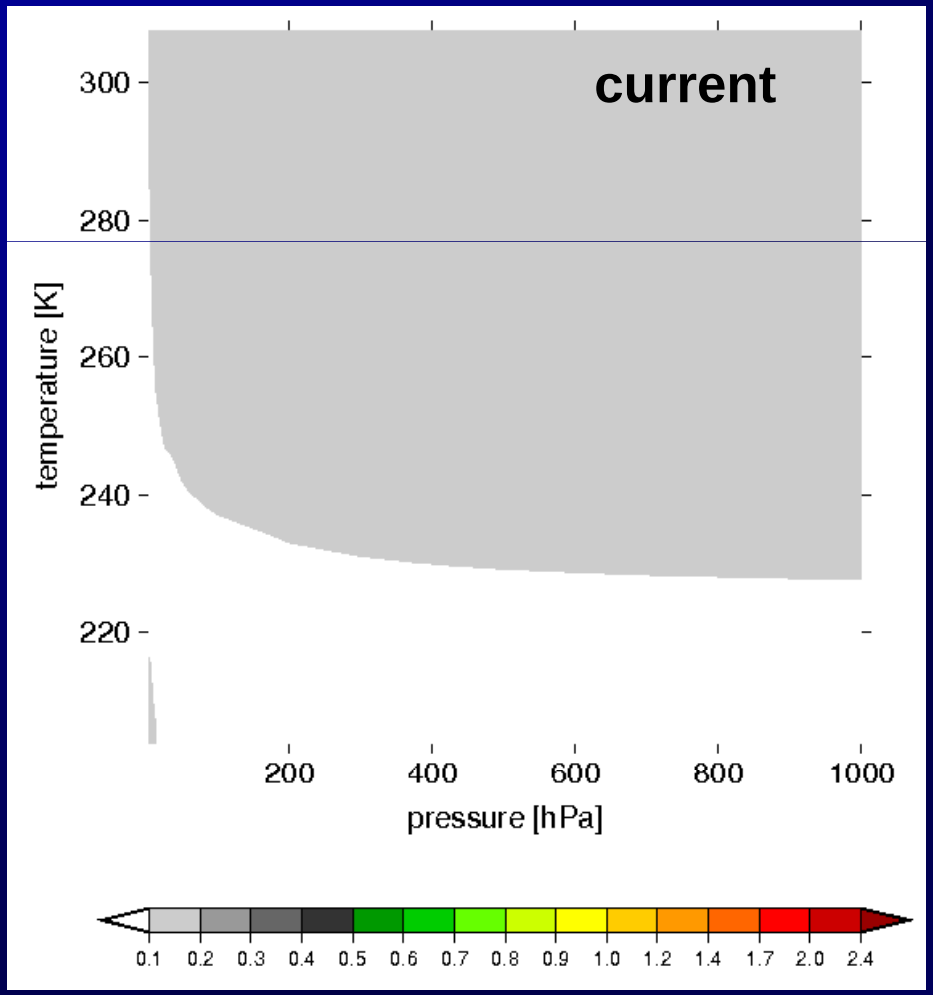
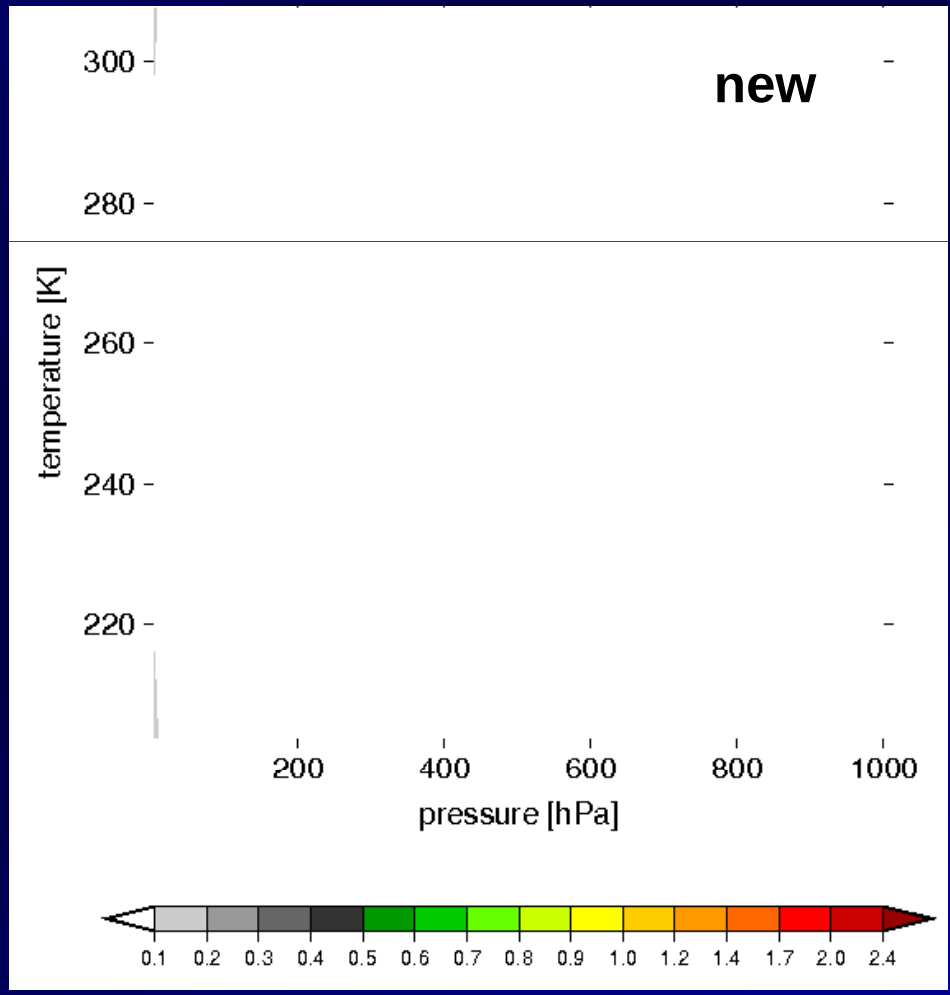
Error of fitted O3 optical depth in thermal band





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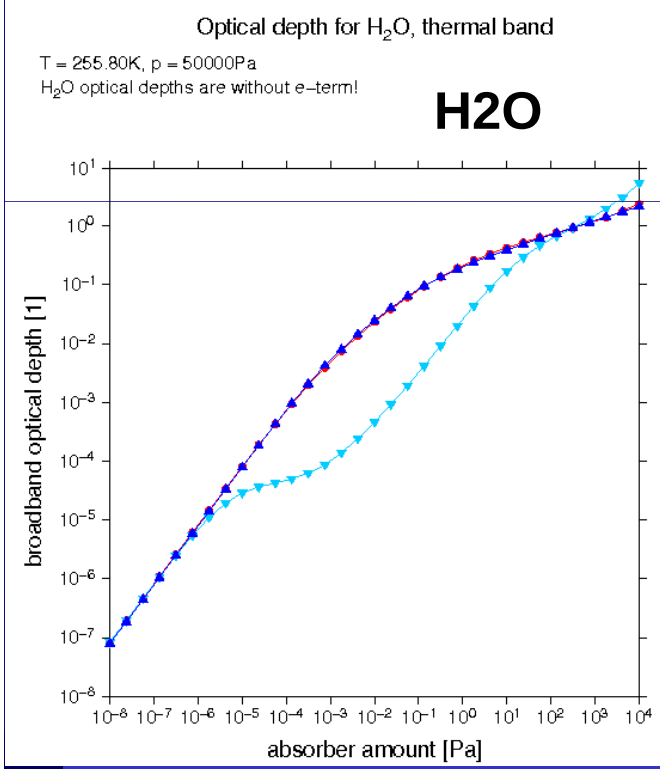
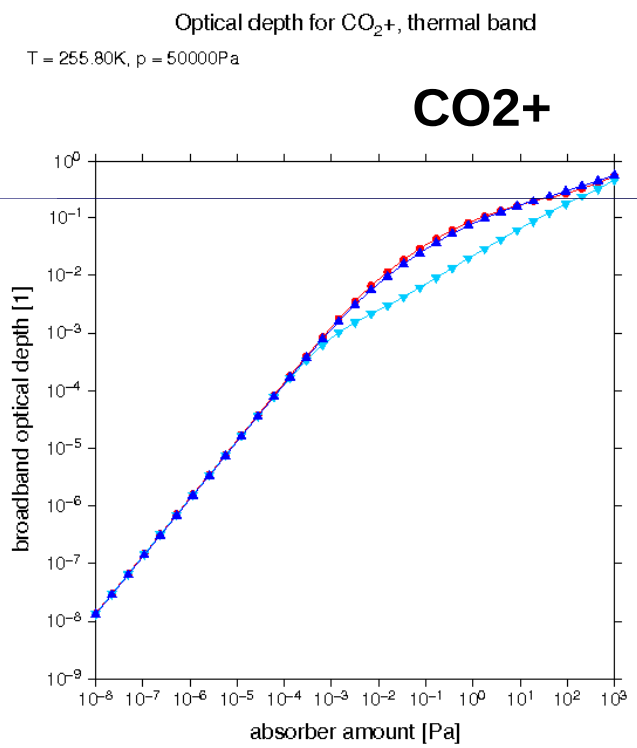
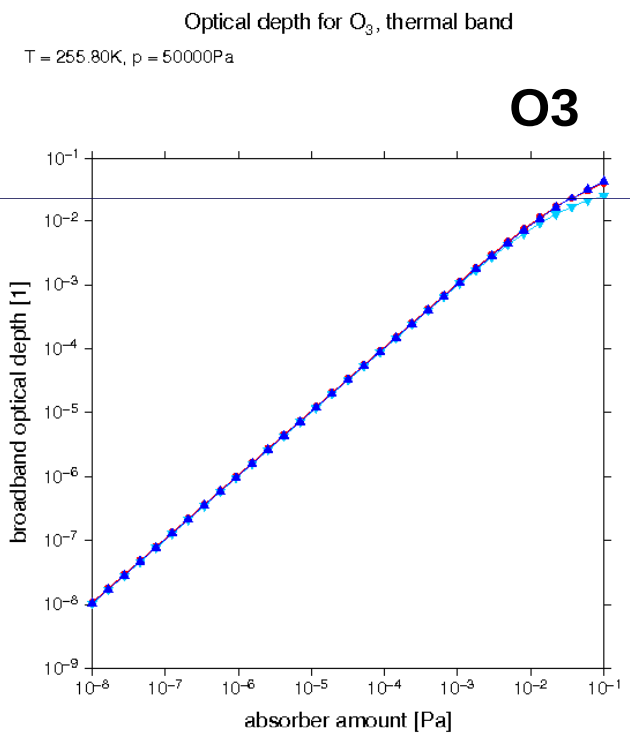
Optical depth for H2O, CO2+ and O3 thermal band







Significant improvement for H2O.

Red - SPLIDACO reference; Light blue - current fits in ACRANEB
Dark blue - the new fits

Convection

Aim: ensure convergence with explicit treatment of convection at very high resolution

Main features of the new package are:

- More realistic downdraft scheme
- Specific features of updraft improving the high resolution behaviour:
  perturbation approach, time evolution, triggering, closure issues.

Unsaturated downdraft

- depending of its velocity, the downdraft air cannot reach saturation
- the downdraft starts at level of minimum theta_e (650 hPa), its departure from a saturated descent depends on its velocity (Betts and Silva Dias)
- diagnostic closure: downdraft area is around 1/3 of precipitation area

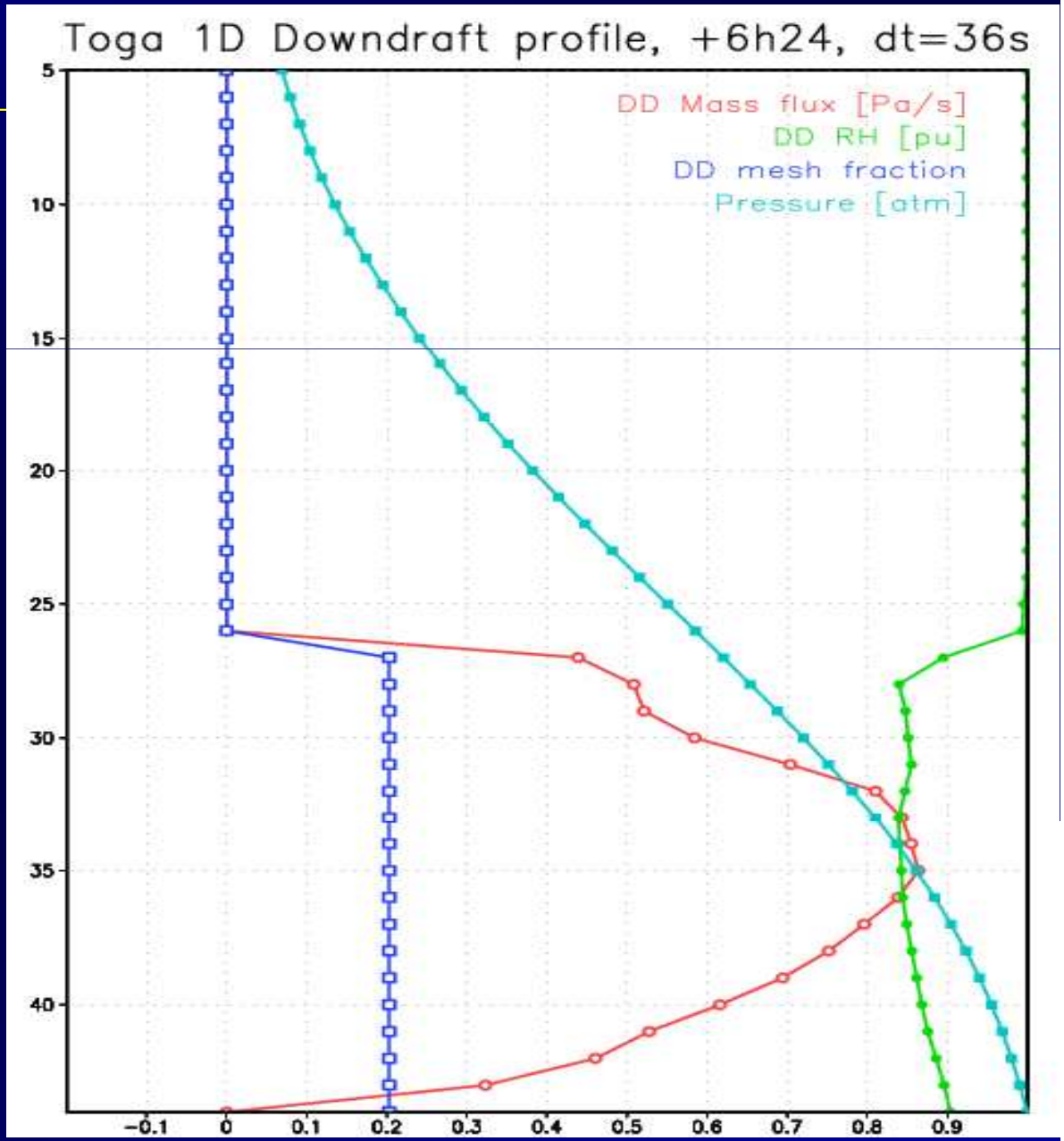
Downdraft profile

1D simulation:

The downdraft mass flux starts around the level 600hPa (red)

the mesh fraction is constant (dark blue)

the relative humidity (green)
- first decreases strongly,
- increasing towards the surface following the slowing down of the downdraft velocity.



A new set of concepts in deep convective updraft scheme

- the evolution over several time steps:
  - the use of prognostic variables for updraft velocity and mesh fraction
  - the gradual elevation of the cloud top
- a perturbation approach,
  - the updrafts are considered to be partly resolved,
  - the subgrid scheme has to provide a complementary contribution; the evolution of the updraft properties together with its vertical velocity is formulated
- triggering criteria
  - using partly the Updraft Source Layer approach of the KFC schemes, together with additional refinements
- the closure is based on CAPE

Convection

Development of an academic validation environment setup based on Weisman and Klemp (1982)

- to be used at different resolutions (between 8 and 1 km)
- the initial state allows the modifications of values which determine the convection development
  - the temperature perturbation size, intensity and location,
  - the vertical wind shear and
  - near surface specific humidity

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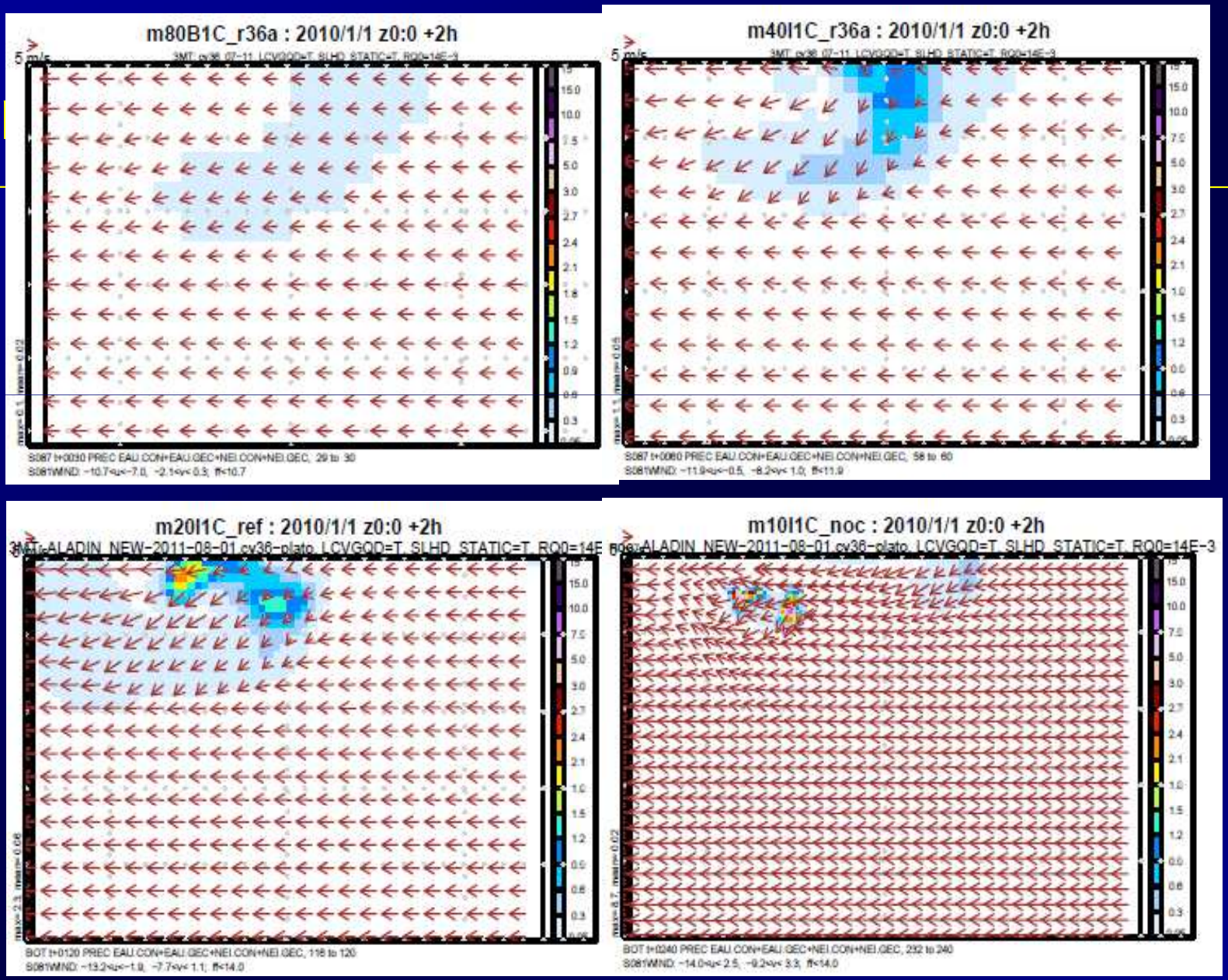
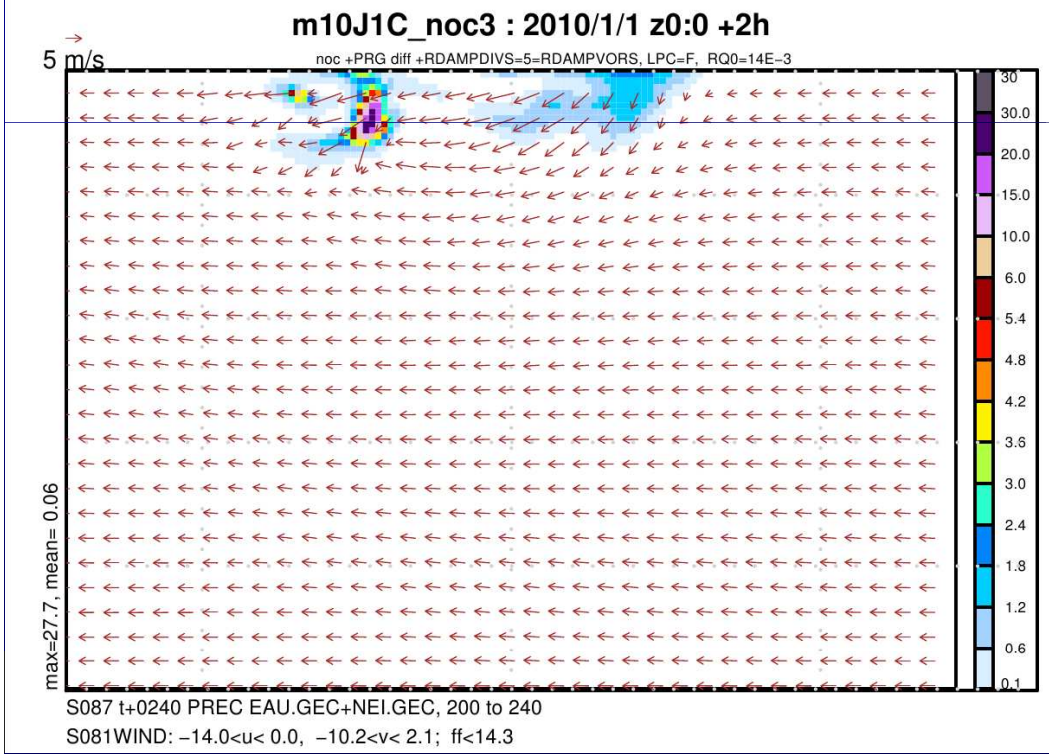


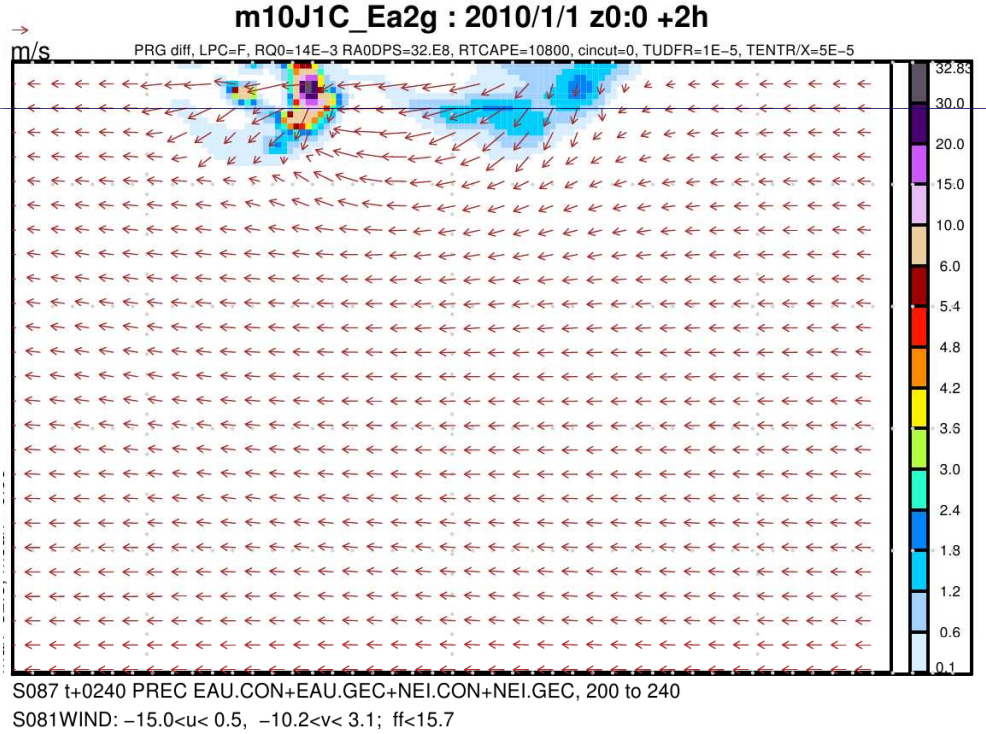
3MT simulations at different resolutions: 8 km (up left), 4 km (up right), 2km (down left) and simulation without convection (down right)

Convection W&K experiment

No parameterization



With new scheme

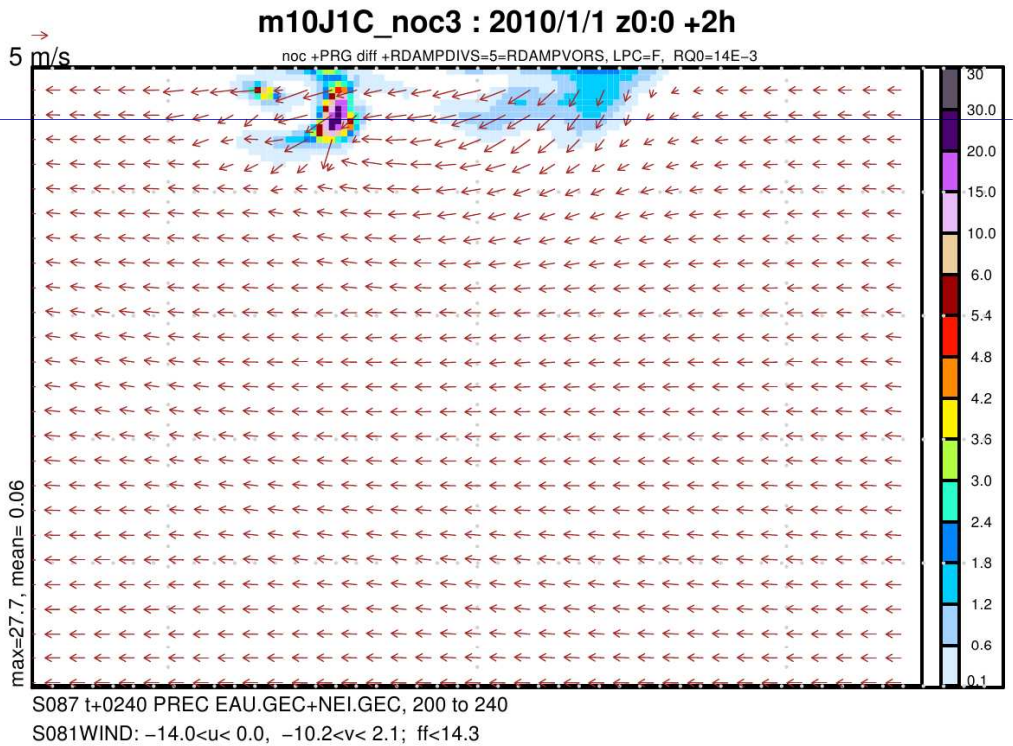


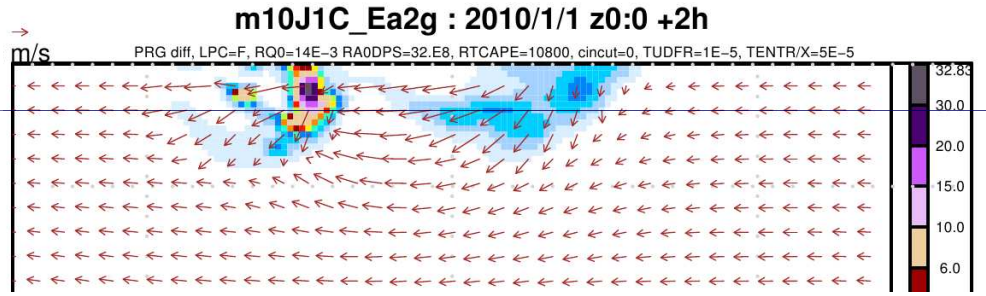
1km resolution (87 levels), 2 hours integration (time step 30s)
last 20 minutes surface precipitation and the wind at 190m above the surface

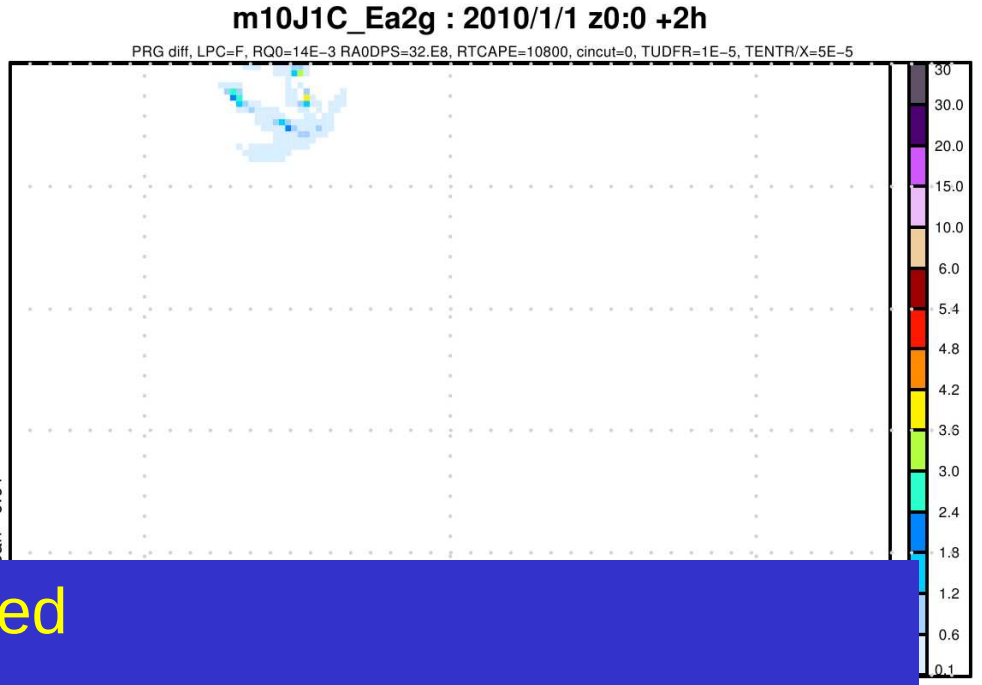
Convection W&K experiment

No parameterization

With new scheme





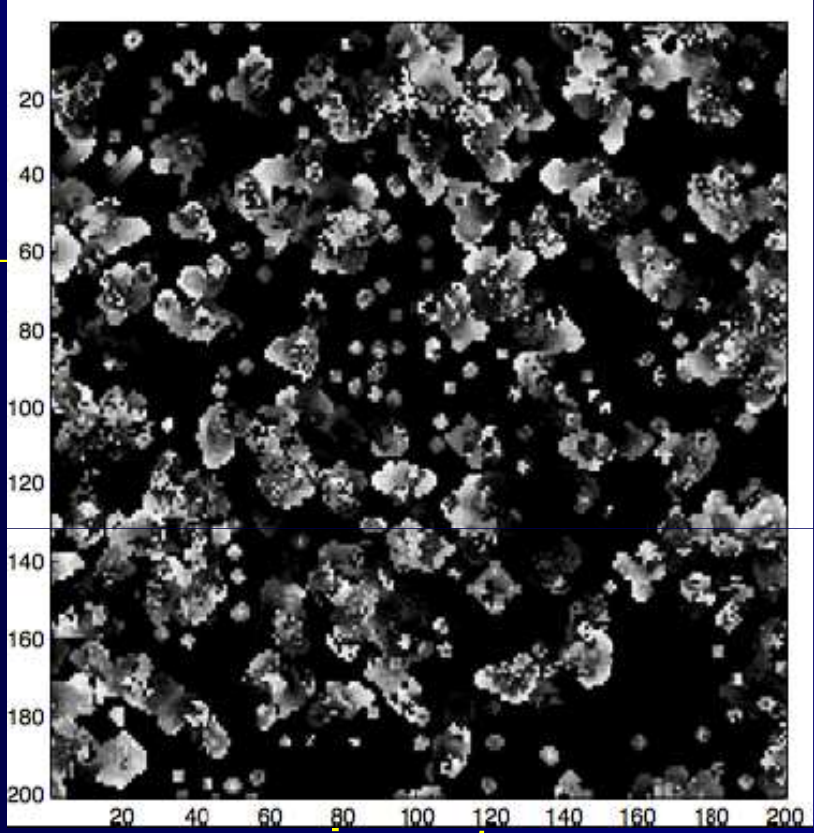


1km resolution (87 levels), 2 hours in

Subgrid contribution is strongly reduced

surface

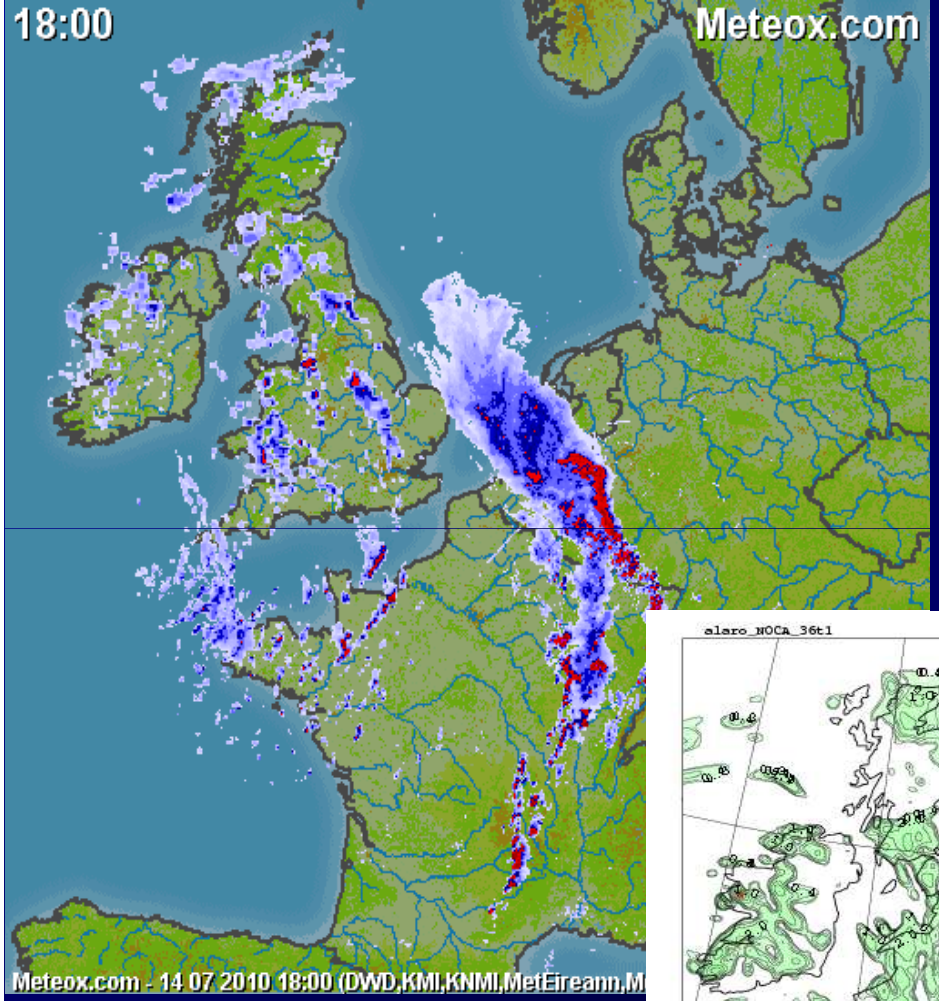
Celluar Automata



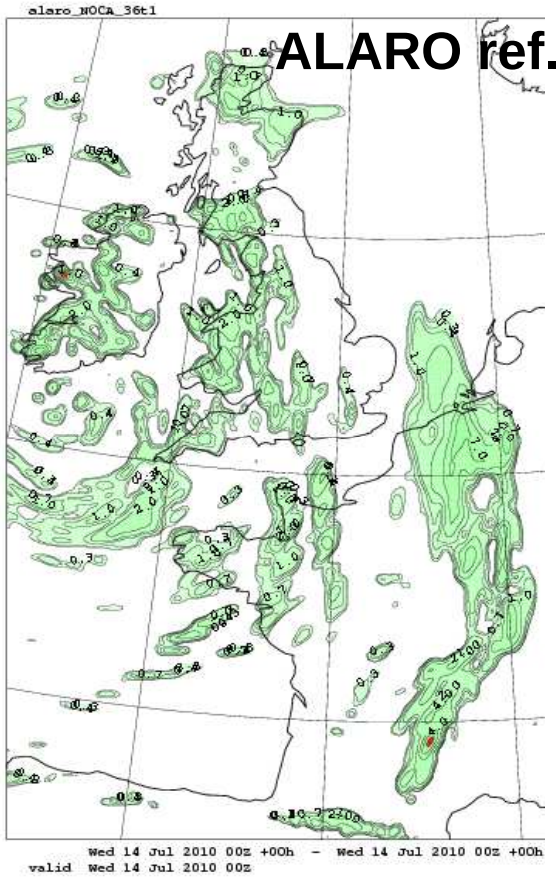
- Self-organization by cellular automata (CA) is introduced to the deep convection parameterization
  - uses CAPE and moisture convergence as input,
  - functions as an input to the updraft mesh fraction in the closure of the parameterization.
- acting on a higher resolution and can communicate across model grid boxes

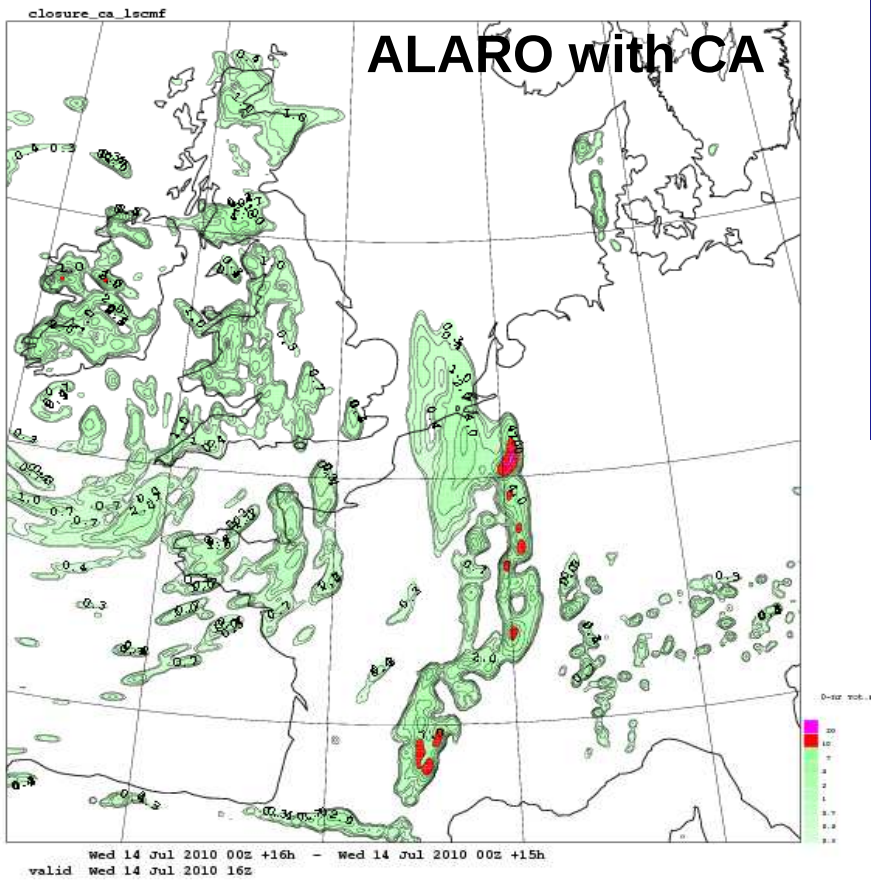
Example of a squall-line

the CA is active in the leading edge of the line, yielding more intense organized convective cells



1h precip from radar





Outlook and plans

- further physics development:
  - radiation, TOUCANS, convection, cloud scheme, 3D-1D extension of turbulence, microphysics
  - stochastic physics, Rash Kristjansen condensation scheme with 3MT and TOUCANS
- validation
  - radiation (new ACRANEB) and TOUCANS as new base
  - adding novelties in convection and CA
- to improve operational ALARO configuration
- tests at higher resolution (scales around 2 km mesh-size)