Regional Cooperation for
Limited Area Modeling in Central Europe

LACE
nwp central europe

Assembling Scientific Novelties in ALARO

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DHMZ SHMÚ OMSZ ZAMG ROMANIA ANM

ALARO Concept - recall

- ALARO: development concept for model physics enhancements – principles:
  - Clean governing equations for moist physics and flux-conservative interface to dynamics;
  - Mastering grey zone of moist deep convection as a flag ship;
  - Credo: consistency, unification, prognostic schemes, multi-scale.
- ALARO-0 baseline (December 2012)
  - Operational at many places for deterministic forecast, in EPS systems and it is also tested in climate mode, at various resolutions, across grey zone.
- Preparation of ALARO-1
  - Important developments completed;
  - Parallel suite of the first ALARO-1 started

ALARO Concept – novelties in 2014

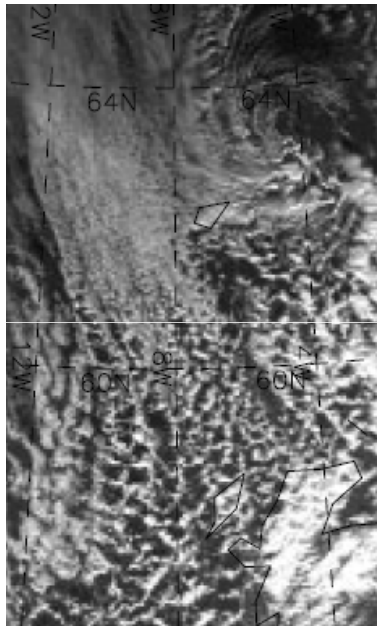
- Moist deep convection
  - Capitalizing on the 3MT (Multi-scale, Modular, Microphysics and Transport) scheme: WGNE grey zone experiment;
  - Assembling and validation of unsaturated downdraft and of Complementary Sub-grid Drafts aspects - ongoing;
- ACRANEB 2 – new radiation scheme
  - Core development is now completed, including the intermittency mechanism;
- Turbulence and shallow convection scheme TOUCANS
  - New concepts (Total Turbulent Energy) were introduced;
- Microphysics
  - Revised rain drop size distribution and more sophisticated vertical overlap of rain and precipitation enhanced the scheme.

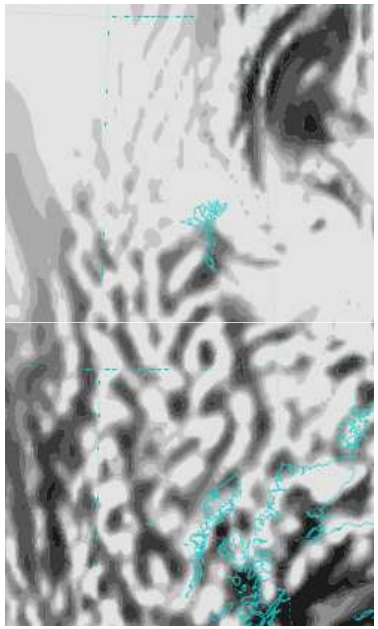
3MT scheme: a multi-scale performance

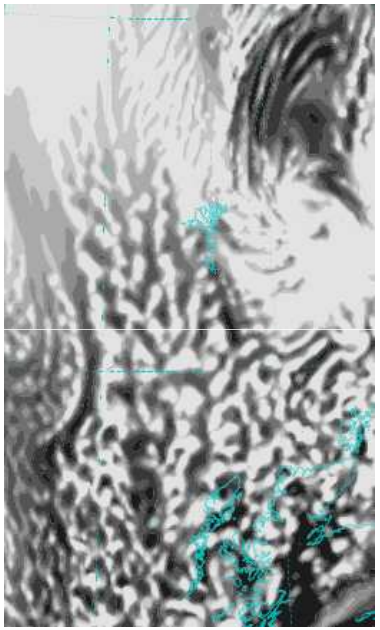
- The ALARO-0 baseline of 3MT was used for the WGNE Grey Zone Experiment - Cold Air Outbreak Case:
  - Run from 30 January 2010, 12 UTC, up to 36h;
  - Tests across horizontal resolutions 16km, 8km, 4km, 2km and 1km: a very tough test-bed for multi-scale convection parameterisations alike 3MT.

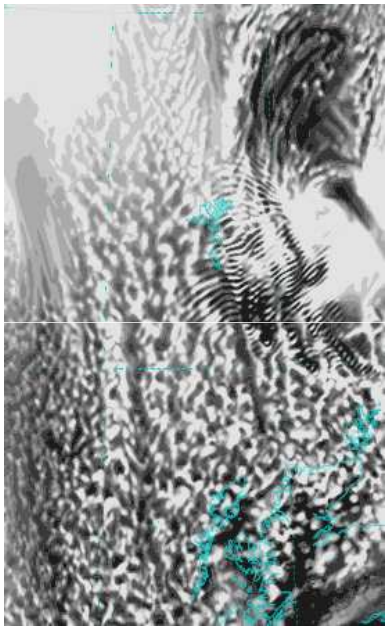
Cold air outbreak; WGNE grey-zone test; 24h total cloud-cover

MODIS ch 4 | **δx=8km** | **δx=4km** | **δx=2km** | **δx=1km**



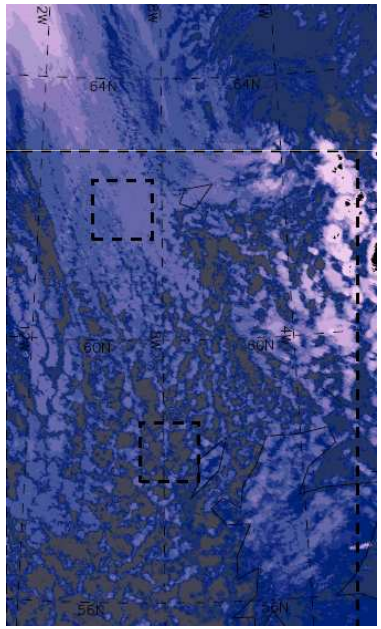


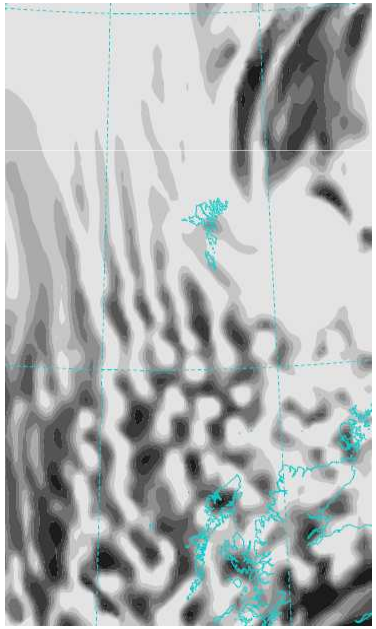


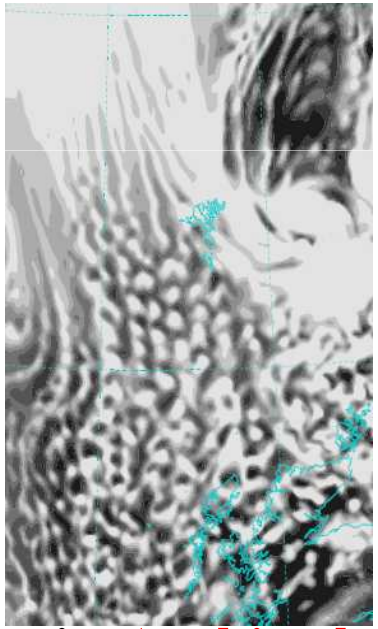


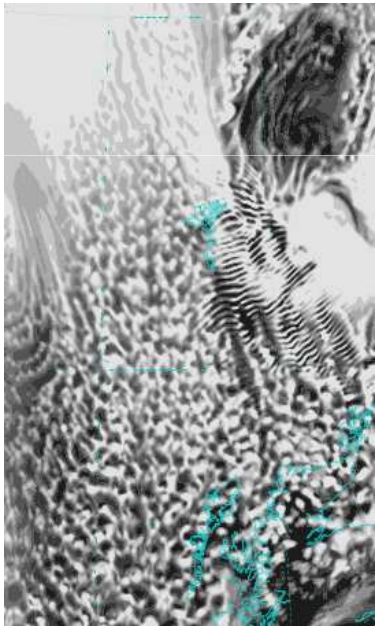
MODIS ch 31

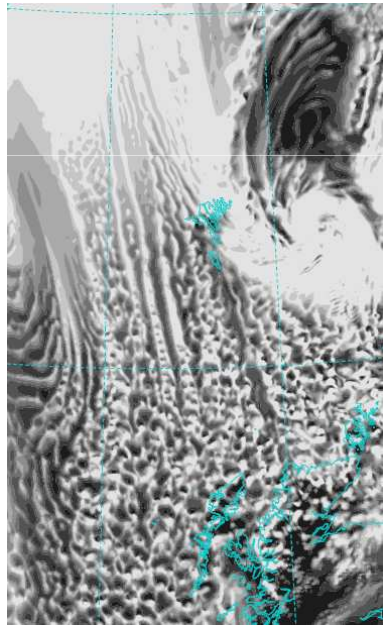
ALARO-0 physics (multiscale convective scheme ‘3MT’ activated)





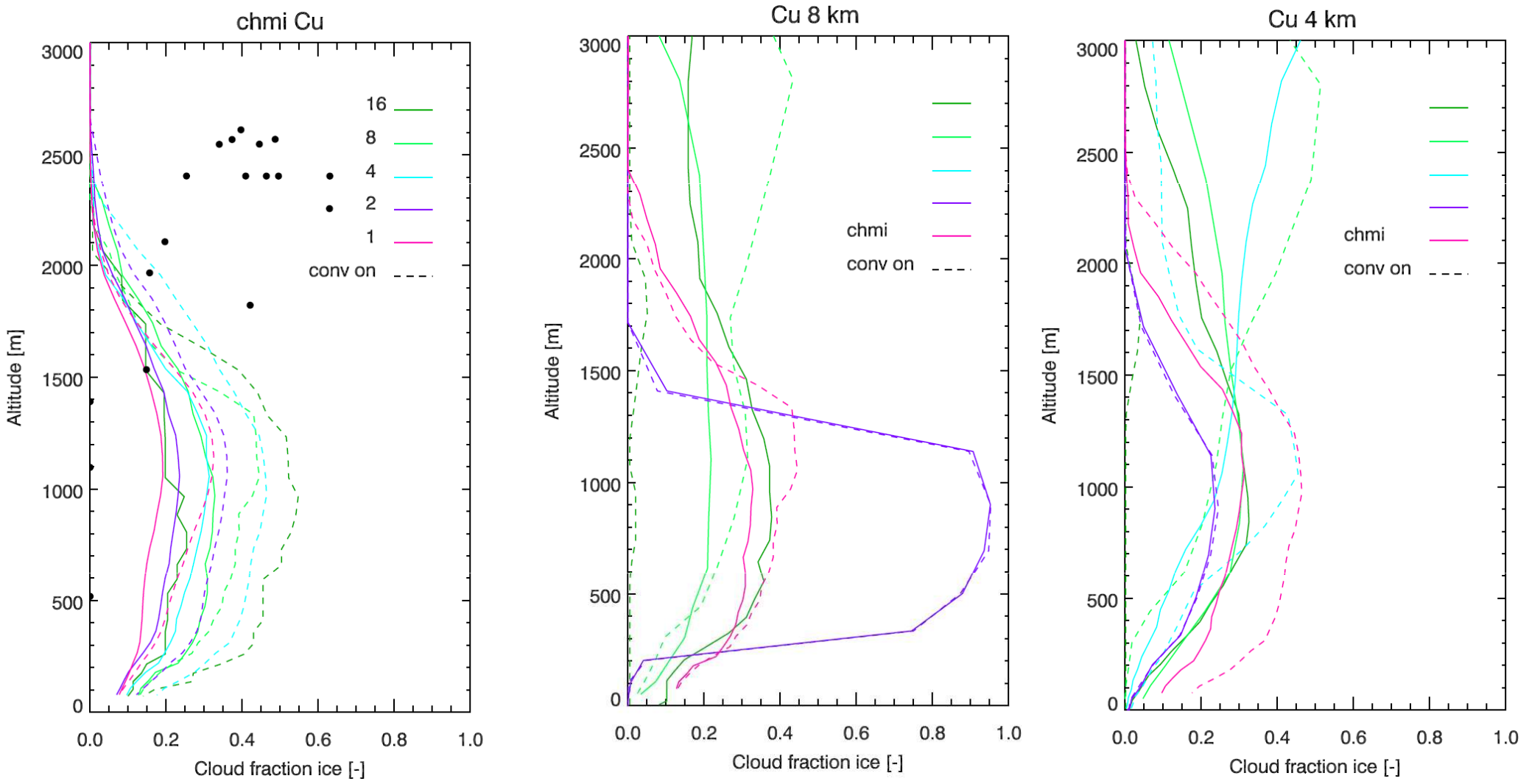






ALARO-0 physics (multiscale convective scheme ‘3MT’ disabled)

Cumulus area profiles of ice cloud fraction

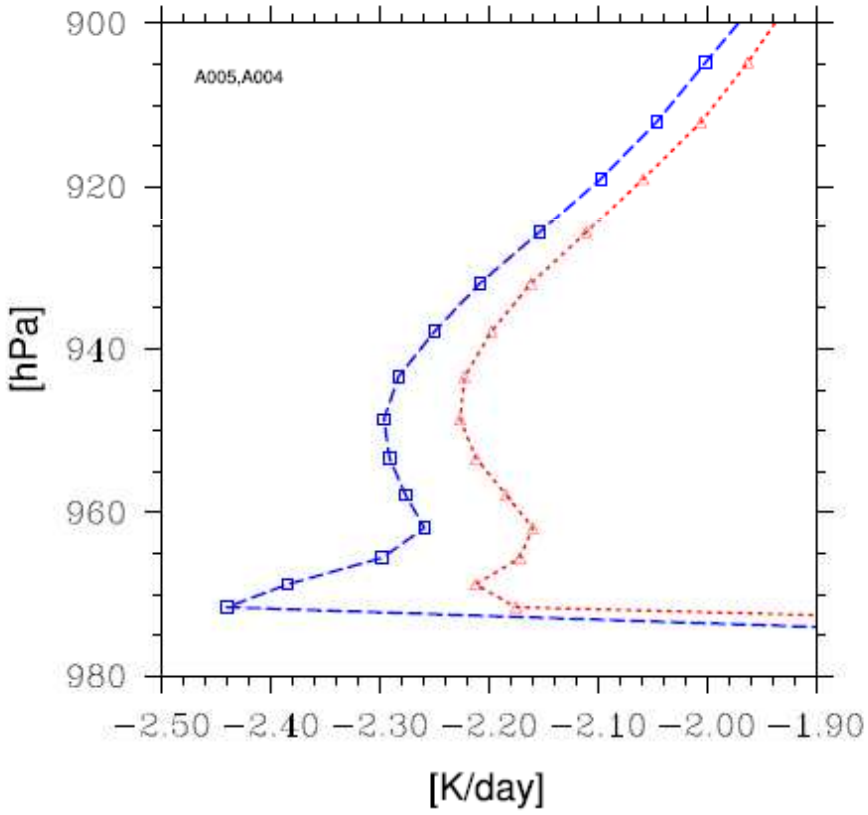


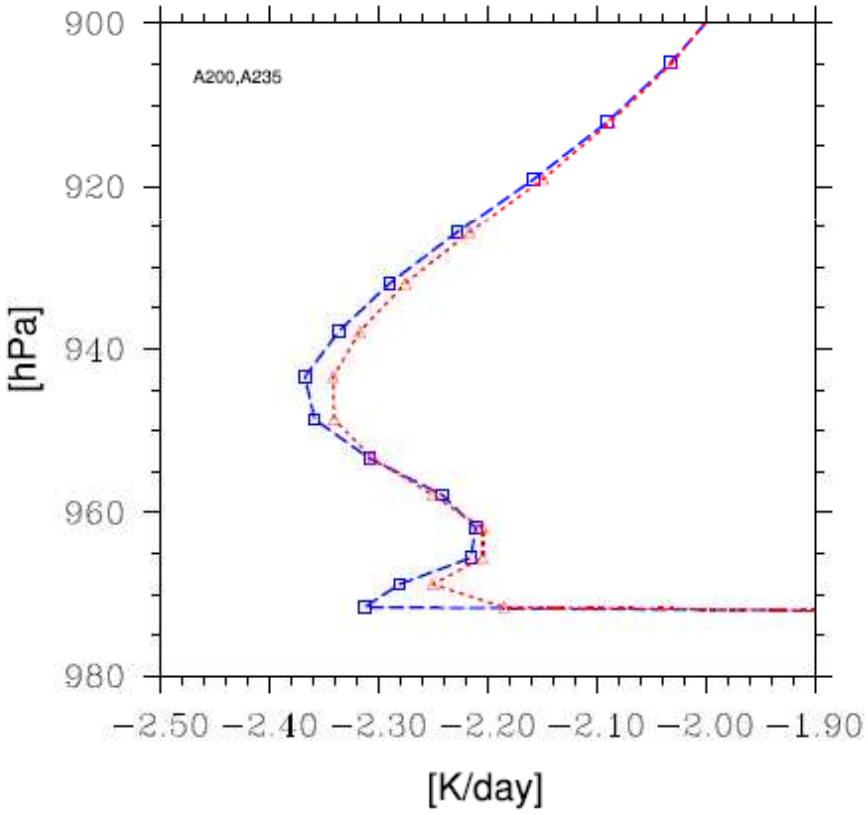
ALARO 3MT does not change so abruptly the solution with the change of resolutio

ACRANEB2: new radiation scheme

- The scheme is based on Net Exchange Rate (NER) method – another way of getting precision for the gaseous transmissions without going to fine granularity of spectral discretization;
- Computation savings are met by accepting different level of accuracy for NER terms:
  - The most important terms are computed exactly (cooling to space, exchange with surface) or nearly exactly (exchange between adjacent levels);
  - Exchanges between non-adjacent levels are diagnosed, using an intermittency strategy (computing exact relations only once every 3 hours).
- NER allows for a separated computation of cloudy optical effects:
  - second intermittency level for gaseous transmissions computation (once every hour) while ***keeping radiation-cloud interaction at every model time-step***, a feature important at high resolutions.
- The resulting scheme called ACRANEB2, with double-level of intermittency, yields a nice accuracy/computing-price ratio when compared with state-of-the-art solutions.

Radiation schemes – test of intermittency



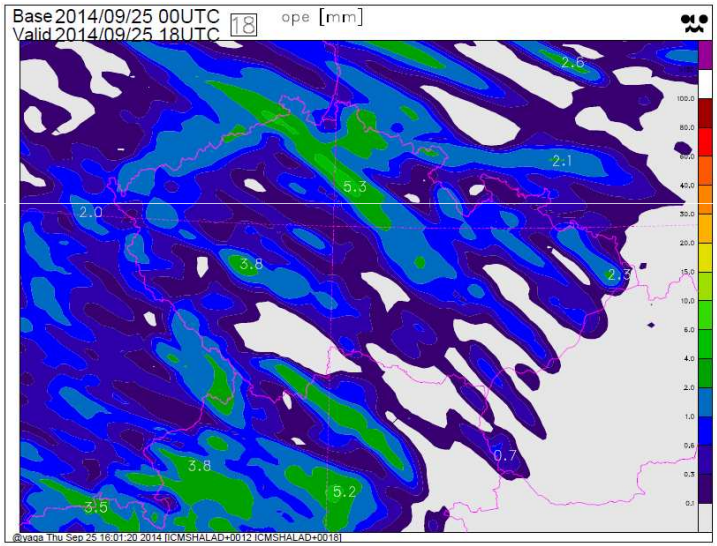


Impact of1h intermittency in RRTM/FMR scheme (left) and 1h/3h two-level intermittency in ACRANEB2 (right) shown on 12h domain average long-wave heating rates: red – refe computation without any intermittency, blue – intermittent computation.
RRTM/FMR intermittency applies also to clouds, while ACRANEB2 intermittency does n One clearly sees the advantage of the second strategy.

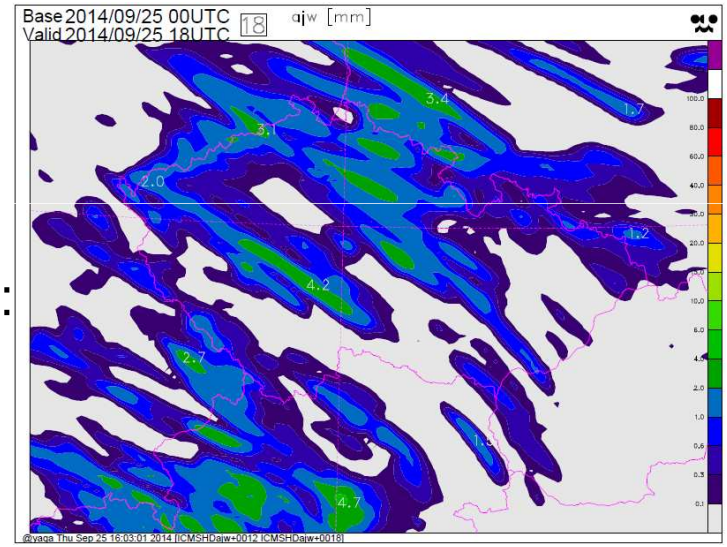
Microphysics: geometry and drop size distributions

- Geometry of clouds and precipitation – necessary at resolutions with sub-grid scale variance:
  - Starting from two basic hypotheses on “maximum-random” and fully “random” overlaps in the vertical, an intermediate solution allows for a small degree of randomness also in case of adjacent levels;
  - New solution parameterizes more realistic cloud (Shonk et al., 2010) and falling precipitation (J. Van den Bergh, personal communication) scenes.
- Rain drop size distributions:
  - Parameterization of rain drop size distribution was adjusted after Abel and Boutle (2012) proposal. At this occasion the whole of sedimentation, collection and phase changes formulations for ice phases were also improved (M. Van Ginderachter, personal communication);
  - Ensuing larger proportion of smaller drops in case of light rain leads to a higher evaporation rate – it diminishes the problem of the drizzle/light rain overestimation especially in winter.

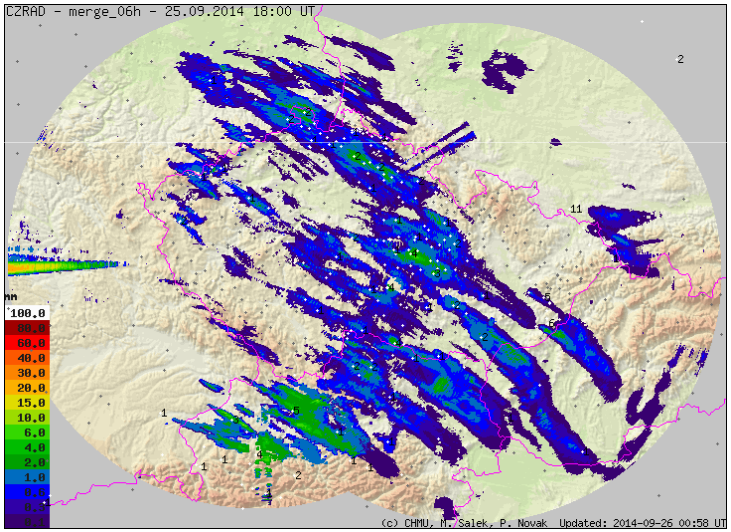
Microphysics – less drizzle



Forecast starting at
25/09/2014 00UTC
up to +18h.
Afternoon light showers:
6h precipitation sum
From 12h to 18h UTC



Operational forecast



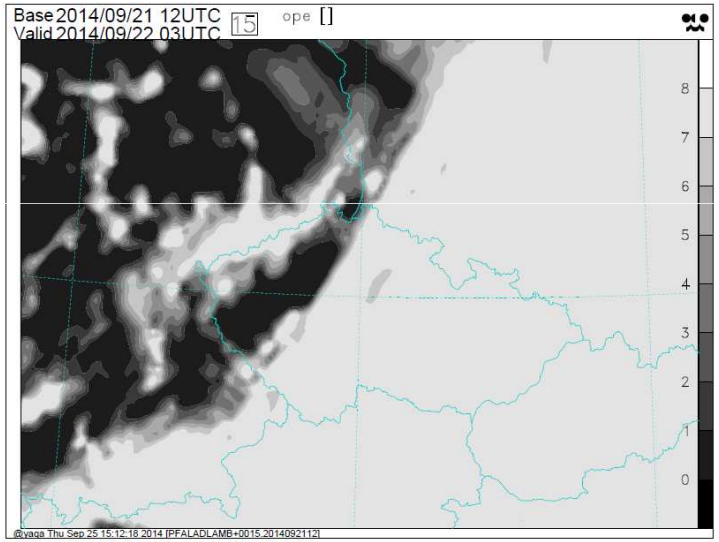
Parallel suite forecast:
less areas of weak rain.

Observations – radar
estimate combined with
rain gauges.

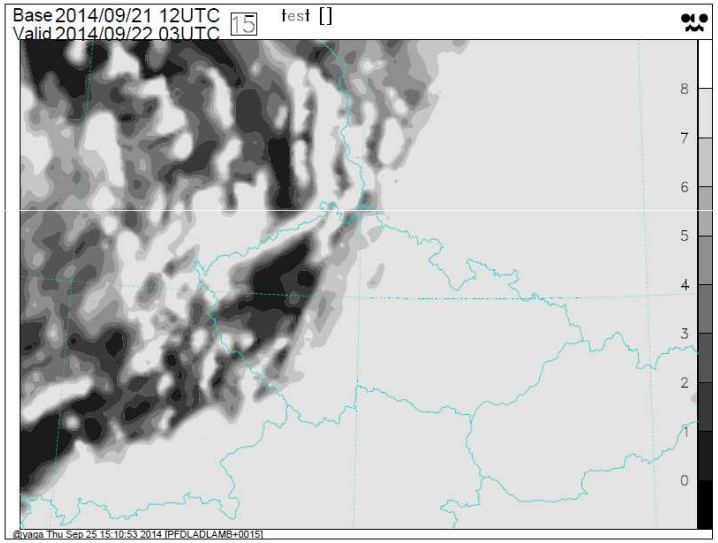
TOUCANS: turbulence and shallow convection

- Key ingredients of the scheme ***(original combination in NWP)***:
  - Prognostic equations for both Turbulent Kinetic Energy (TKE) and Turbulent Total Energy (TTE*, sum of kinetic- and moist potential energy);
  - Prognostic handling of length-scale *L*;
  - Accounting moist Third Order Moment (TOM) terms;
  - Turbulent diffusion of cloud condensates.
- Closure – stability dependent adjustment of model's TKE and TTE energies:
  - Leads to a modular system: one can equally well emulate and (if needed) tune, 'Mellor-Yamada with no critical Richardson number', QNSE, EFB, etc. , see Bašták-Ďurán et. al., 2014.
  - All resulting solutions (valid from $R_i=-\infty$ to $R_i=+\infty$) have the correct asymptotic behaviors for the extreme cases.
- For shallow convection closure, ongoing work on an improved version of the proposal of Lewellen and Lewellen, 2004 (LL04).

Boundary layer after cold front

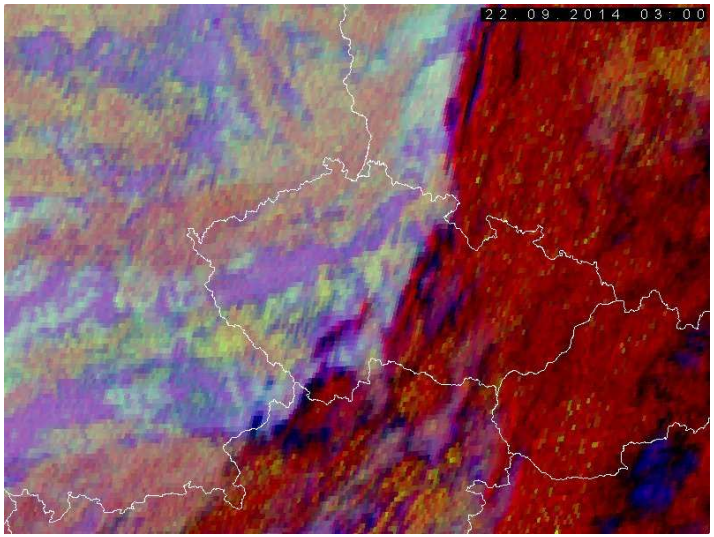


Forecast starting at 21/09/2014 12UTC up to +15h.
Severe cold front case, cloud scene at 3h UTC on 22/09/2014



Operational forecast

Observations – MSG "night microphysics":
red – thick clouds;
ocher – medium/low clouds;
light green – lowest clouds/fog
rose - terrain



Parallel suite forecast: more active boundary layer marked by lower level clouds

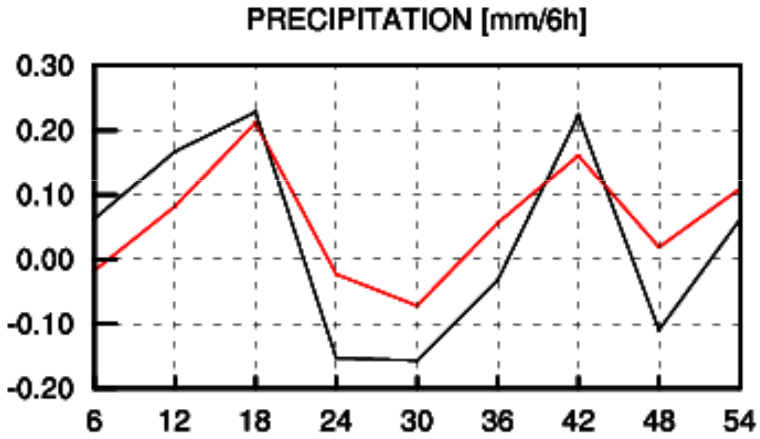
Novelties in the ALARO-1 parallel suite

- ACRANEB 2 radiation scheme;
  - Double intermittency in thermal band with 1h (gaseous transmissions) and 3h (full vertical exchange matrix) intervals;
  - Cloud-gas overlap in solar band;
  - New fit of cloud optical properties.
- TOUCANS - turbulence and shallow convection
  - Prognostic TKE and TTE;
  - Moist Third Order Moments;
  - Prognostic length scale;
  - Turbulent diffusion of cloud condensates.
- Microphysics
  - Geometry of clouds and precipitation – more realism;
  - Improved rain drop size distribution.

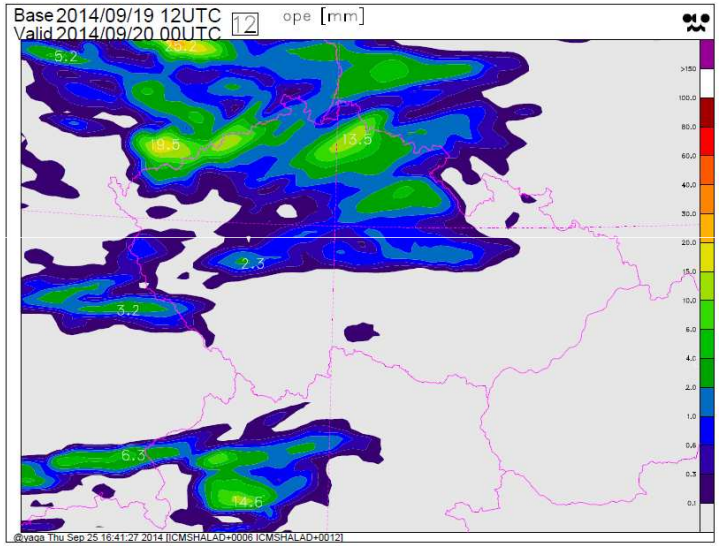
Some results of the parallel suite (1)

- Further improved diurnal cycle of moist deep convection:
  - Precipitation peak shifted to evening hours;
  - Convection decays later than before.
  - This is demonstrated on the 6h precipitation sum bias:

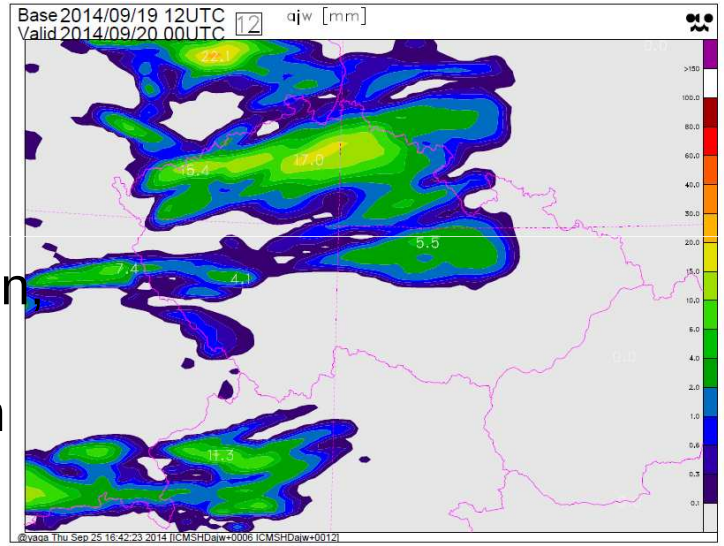
Scores over LACE domain
Precipitation bias [mm/6h]
Network: 0h UTC
Period: 20140918 – 20140923
operational version
test



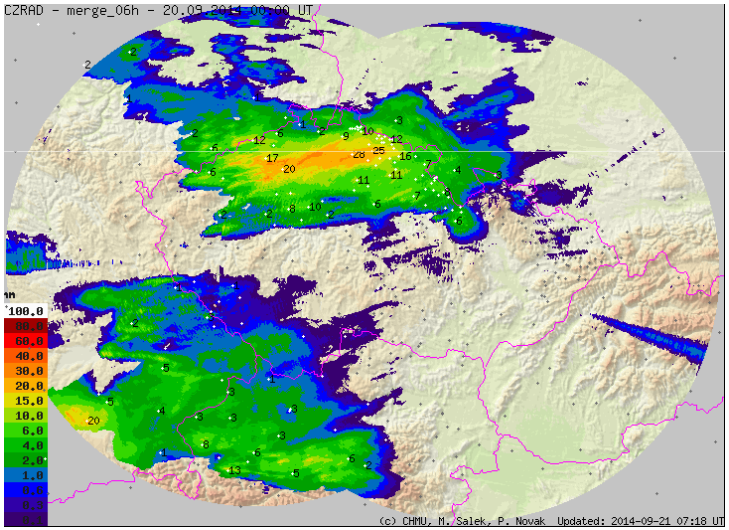
Some results of the parallel suite (2)



Forecast starting at
19/09/2014 12UTC
up to +12h.
Shallow trough convection
in warm air mass.
6h precipitation sum from
18 to 24h UTC



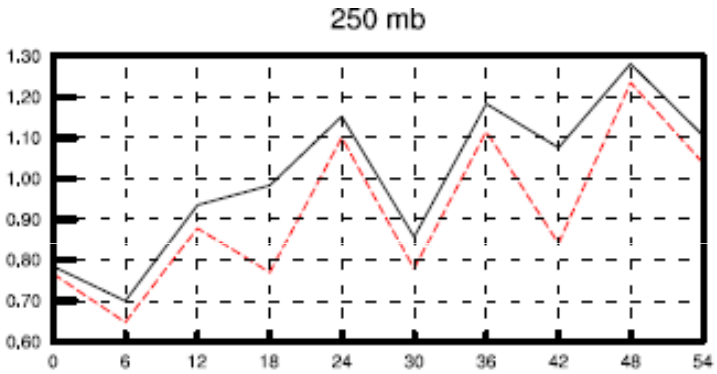
Operational forecast

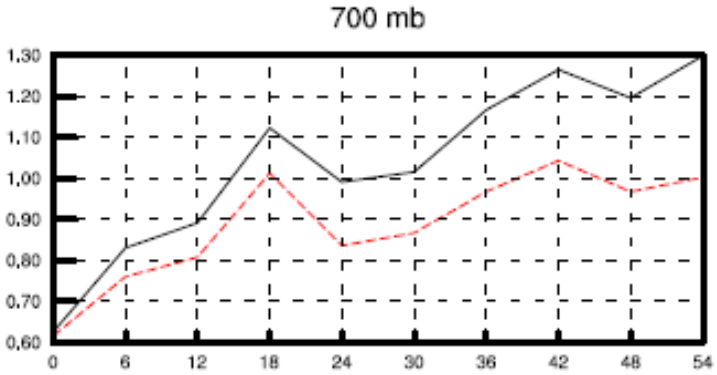


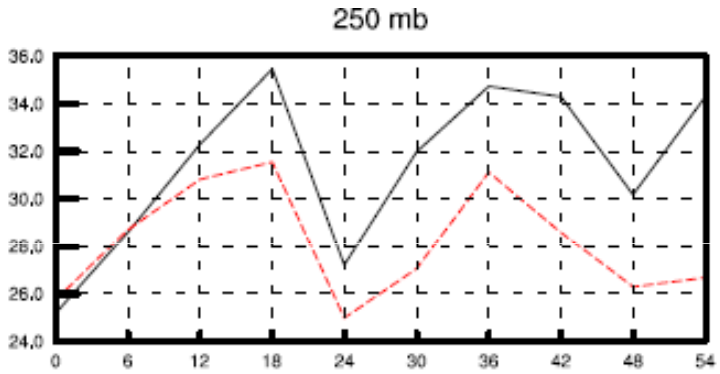
Parallel suite forecast:
convection is more active
in the night.

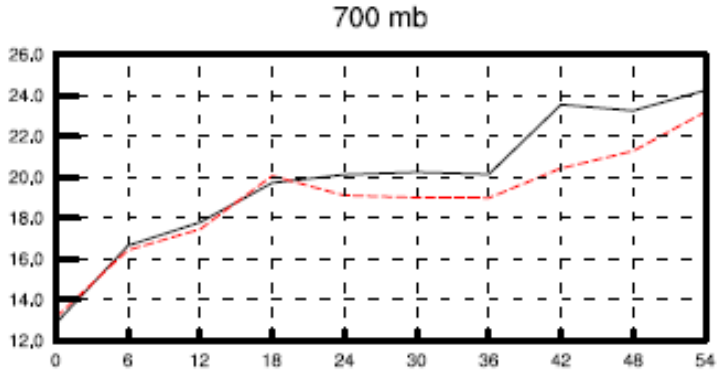
Observations – radar
estimate combined with
rain gauges.

Some results of the parallel suite (3)









Temperature RMSE Scores over LACE domain Relative Humidity RMSE

Network: 0h UTC

Period: 20090624 – 20090704

today operational ——————

test - - - -

Outlook

- Enhancement of the 3MT downdraft parameterization towards unsaturated downdraft option;
- Adding aspects of Complementary Sub-grid Drafts to new radiation, turbulence and microphysics;
- Further enhancements of the shallow convection and length scale parameterization in TOUCANS;
- Introduction of the intermittency in solar band;
- Steps towards the unification of cloud cover representations;
- Linking with the SURFEX scheme.

Thank you for your attention