Physics activities in RC-LACE

Mario Hrastinski (with contributions from many colleagues)

GeoSphere Austria · DHMZ · Czech Hydrometeorological Institute · IMGW · HungaroMet Hungarian Meteorological Service · METEO ROMANIA · SHMU · ARSO METEO Slovenia

Outline

- ► TOUCANS turbulence scheme developments

- ► Clouds-precipitation microphysics developments and testing

- ► Cloud-Aerosol-Radiation (CAR) activities

- ► ALARO in single precision

- ► ALARO refactoring

- ► (Sub-)kilometre sensitivity studies

- Vertical Turbulence Length Scale (TLS) development:

  - reference & new formulation (talk of Mario Hrastinski)

  - subtopic: estimation of the PBL height (H_{PBL})

- Revision of the Third-Order-Moments (TOMs) parameterization (the work of Peter Smerkol)

- Getting towards the 3D turbulence parameterization (talk of Petra Smoliková):

  - quasi-3D turbulence and horizontal TLS

  - 1D+2D turbulence based on SLHD

▶ There is no method that estimates the H_{PBL} accurately enough for different stability conditions:

The weak-capping-inversion method:

$$\theta_v(z_i) \geq \frac{1}{z_i} \int_0^{z_i} \theta_v(z)dz + 0.25K \qquad (1)$$

convective and near-neutral PBL

Ayotte et al. (1996)
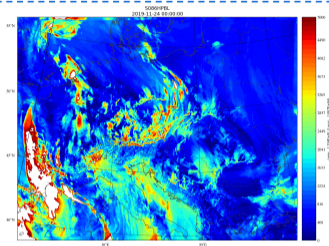
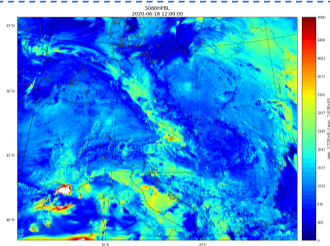TKE-based method:

$$H_{PBL} = \frac{z_{05}}{0.95} \qquad (2)$$
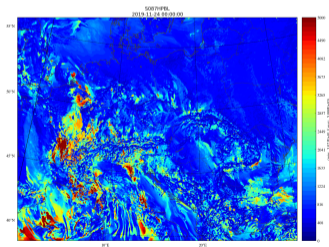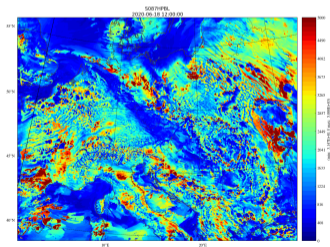
more general

Kosović and Curry (2000)

▶ A new and more robust method following Baštak Ďuran et al. (2022) is also coded:

$$H_{PBL} = c_{pblh} \cdot \sqrt{\int_{z=0}^{z_{top}} L_{up} \cdot dz}, \qquad c_{pblh} = 1.75 \qquad (3)$$

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TOUCANS turbulence scheme developments

WCIM method

TKE-based method

summer   winter

Clouds-precipitation microphysics developments and testing

Tuning and testing new options in ALARO three-ice microphysics

▶ Three-ice scheme, with Lopez evaporation, was tuned to become suitable for use in operations at CHMI (final tuning is in parallel suite)

▶ The aim: to reduce the cold BIAS of temperature and worsened STD of wind speed/direction and keep reduced BIAS of precipitation and SW radiation in autumn

TUNING:

1. Reduction of evaporation:
   REVASX[RSG] - rain only

2. Autoconversion coeff. (rain)

3. HUCREDRA ↑

Precipitation bias (20221108-20221129, 22 days)
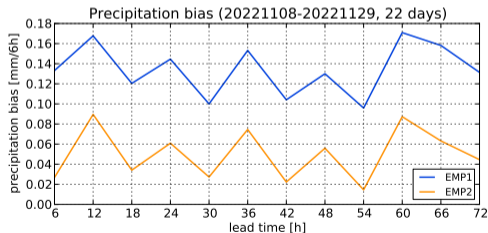
The work of Radmila Brožková and David Němec

Talk by David Němec

Clouds-precipitation microphysics developments and testing

Development of two-moment ALARO microphysics scheme with aerosols

▶ Use of CAMS climatological aerosols is intended in the first stage (activation scheme for cloud droplets - look-up table created at time step "0")

▶ activation formula changed from Sundquist to Khairoutdinov and Kogan (2000); Eq. for rain collecting CI and CW also follows KK00

KK00 activation scheme off
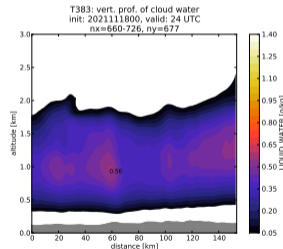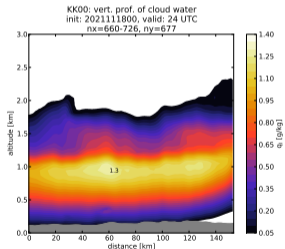
KK00 activation scheme on

The work of David Němec and Radmila Brožková

Clouds-precipitation microphysics developments and testing

Testing the subgrid statistical cloud scheme at HungaroMet Nonprofit Zrt.

► Following previous studies, a more prognostic cloud scheme (LOSIGMAS=.T.; VSIGQSAT=0.02) was run in parallel to operational AROME-HU during the summer

► Objective and subjective verification approaches used to validate the performance (forecasters included) - variable performance of the new scheme

► New scheme: i) the most positive feature: cloudiness dissipation (improved radiation and T_{2m-max}) and ii) stronger conv. cells and wind gusts (sometimes false alarms)
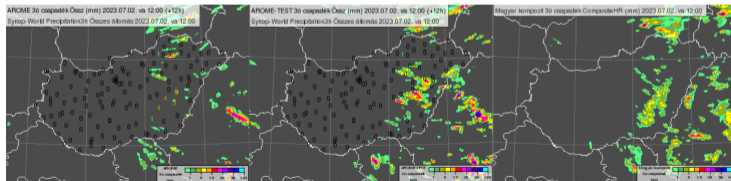

Operational since 6th Nov 2023

The work of: Boglárka Tóth and Balázs Szintai

Cloud-Aerosol-Radiation (CAR) activities

## Externalization of the effective radius from radiation

- ► The cloud liquid/ice effective radii (ER) radii was externalized from ACRANEB2 to enable the use in microphysics

- ► The results are not reproducible with the old way, but differences are minor

- ► There is a power relation between the ER computed in radiation and microphysics (problem for small values)

- ► Cloud fraction (CF) used for both is not the same (also in AROME)

- ► Further studying of CF treatment is needed
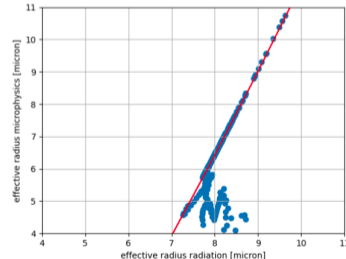
  The work of: Ana Šljivić and Ján Mašek

**Vertical distribution of climatological aerosols**

► The dataflow for 2D climatological and 3D n.r.t aerosols is finalized and tested (the report of Piotr Sekuła)

► Content of climatological aerosols and their distribution:

  ► Tegen: aerosol optical depth at 550nm (AOD550) for 6 fields (exponential decay)

  ► 2D CAMS: vertically integrated mass/area for 11 aerosol species (gamma distribution)
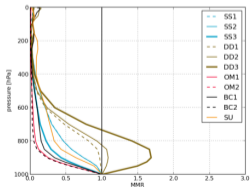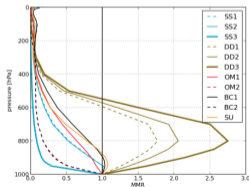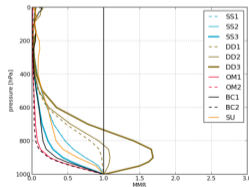

(a) January   (b) June   (c) all months

The work of: Piotr Sekuła,
Ana Šljivić and Ján Mašek

Talk by Ján Mašek

► 10

Cloud-Aerosol-Radiation (CAR) activities

The preparation of 2D CAMS aerosols

► Starting from vertically integrated mass for 11 aerosol species (0.75 x 0.75°): monthly files in period 2003-2022 (EAC4)

► The averaging is done with a python script producing ASCII output, which is converted to monthly binary files used in **eincli12.F90** (adaptation for lon-lat convention of e923)

► The scripts are available on **belenos** and 2D CAMS aerosols can be prepared by running the step 12 of e923 procedure (the documentation is being prepared)
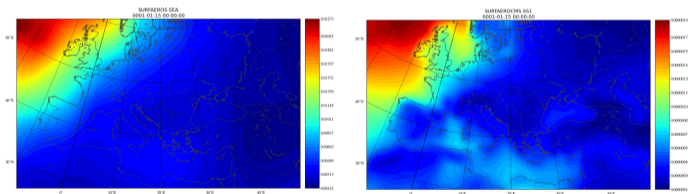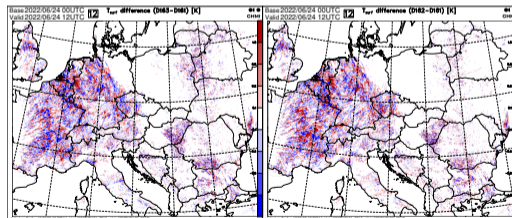

The work of:
Ana Šljivić and Ján Mašek

Code based on the work of:
Piotr Sekuła and Laura Rontu

ALARO in single precision

▶ The starting point was CY46T1-bf07 (with the addition of local developments of CHMI)

▶ The idea of interfacing the previous single precision (SP) version of ACRANEB2 with double precision (DP) ALARO is abandoned - undesirable in the long term

▶ ALARO-0 SP is working (more detailed validation is needed), while for ALARO-1 fixes in TOUCANS and 3MT schemes were necessary
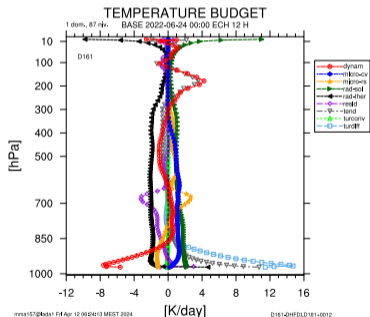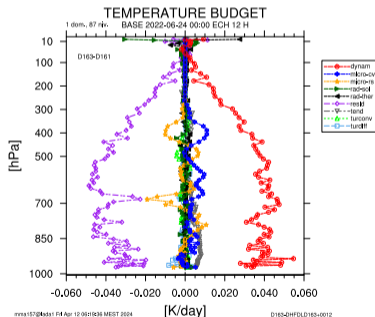

DP vs. SP   DP vs. SP   DP1 vs. DP2

ALARO in single precision
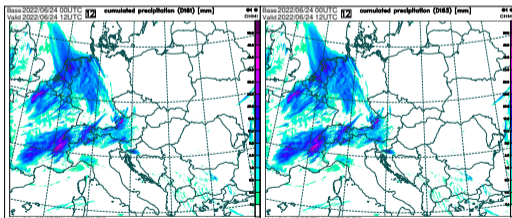
► Small difference in total temp. tendency after +12 hours

► Saving on elapsed time is between 36% (SHMI's local HPC) and 45% (belenos)

► On a CY46T1 there is a problem with SP hydrostatic VFE with 87 levels

DP

DP-SP

The work of:
Oldřich Španiel
Ján Mašek

With support from:
Radmila Brožková

▶ At the ALARO refactoring WW, a team of RC-LACE scientists and Daan Degrauwe (RMI) created a baseline version of APL_ALARO on CY48T3 and identified blocks of related computations that can be organized together:

  ▶ i) initializations and ii) negative humidity correction (**Daan Degrauwe**)

  ▶ iii) surface and turbulence preparation (**Bogdan Bochenek**)

  ▶ iv) mixing length and v) turbulence with surface (**Mario Hrastinski**)

  ▶ vi) radiation (**Ján Mašek**)

  ▶ vii) deep convection and viii) microphysics (**Radmila Brožková**)

  ▶ ix) diagnostics with dust (**Martina Tudor**)

▶ The merging of contributions and phasing to CY49T1 was done in late summer (the contribution is accepted into the common IAL code)

▶ Further refactoring of diagnostics (DDH and EZDIAG) and turbulence is planned

(Sub-)kilometre sensitivity studies (with AROME in Alps)

- ▶ The cooperation between Geosphere Austria and University of Innsbruck: AROME related research in Alps (Benedikt Wibmer and Daniel Deacu)

- ▶ Studying: i) the impact of resolution on thermally driven flows in the valley and ii) stable PBL and Alpine cold pools (model intercomparison)

- ▶ overall structure well captured
- ▶ onset and magn. improve with dx
- ▶ problem: morning down-valley wind

TeamX, i-Box and MUSC

Talk of Benedikt Wibmer

# (Sub-)kilometre sensitivity studies (with ALARO at SHMI)

AWS
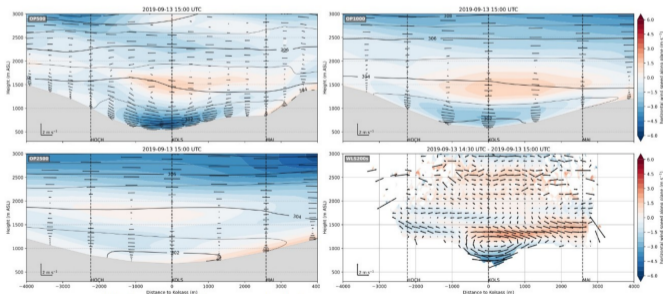
- ▶ Study of 28 August 2023 windstorm in SW Slovakia (event not predicted by regular HIRES models, although the system producing gusts was)

- ▶ RUC1 (CY48T3 & 87 levels); positive impact of prognostic graupel, while explicit conv. is rather ambiguous, 3D-Var way better than dyn. adapt.
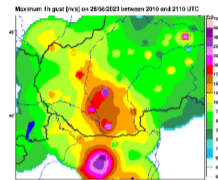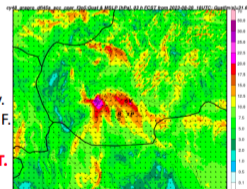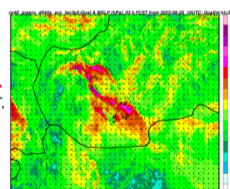

DFI+SCC
param. conv.
LSTRAPRO=.F.

LGRAPRO=.F.
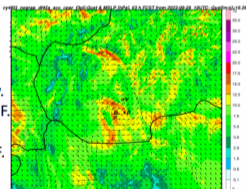
DFI+SCC
param. conv.
LSTRAPRO=.F.

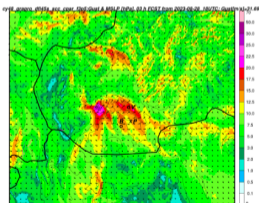LGRAPRO=.T.

DFI+SCC
explicit conv.
LSTRAPRO=.T.
LGRAPRO=.T.

The work of: André Simon

(Sub-)kilometre sensitivity studies (with ALARO at SHMI)

▶ The impact of the method to compute wind gusts; old method produces too strong gusty (inconsistent with upper-air wind)

▶ The hectometric runs were also tested; similar results to their "mother" models (more detailed fields but not more informative)
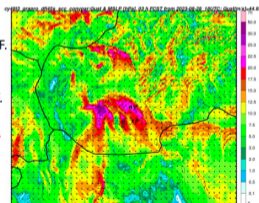

Gust scheme as in AROME (TKE-based)

LSTRAPRO=.F.
DFI+SCC
Param conv.
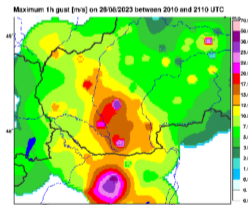LGRAPRO=.F.

LRAFTKE=.T.
FACRAF=3.5

Gust scheme as in ALADIN/SHMU (dynamic velocity)

LSTRAPRO=.F.
DFI+SCC
Param conv.
LGRAPRO=.F.

LRAFTUR=.T.
FACRAF=12

AWS

The work of: André Simon

Thank you for your attention.