Regional Cooperation for Limited Area Modeling in Central Europe

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RC LACE Upper Air Physics

Bogdan Bochenek & co (presented by Martina Tudor)

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Overview

- ALARO Refactoring and preparation for (GPU) accelerators
- Cloud Aerosol Radiation interactions
- TOUCANS Turbulence scheme
- Fixing issues in operational AROME HU
- ALARO Microphysics
- New products

ALARO refactoring

- **ALARO Refactoring and preparation for (GPU) accelerators**
- **Alaro Refactoring Working Week, Prague, 7-11 November 2022**
- *Participants*
- Daan Degrauwe, Radmila Brozkova, Jan Masek, David Nemec, Mario Hrastinski, Bogdan Bochenek (remote), Martina Tudor
  - **explanation of necessary changes for accelerators:**
    - **introduction of smart structures (FIELD_API)**
    - **introduction of directives !=PARALLEL**
    - **removal of GFL loops**
    - **identify blocks with well-defined input and output**
    - **functionality of fxtran-based scripts to move OpenMP loop from CPG_DRV level down to APL_ALARO level**

Study the cloud/aerosol/radiation (CAR) interactions (PH6)

- In the new pack (developments suggested by Jan Masek, Daniel Martin, Laura Rontu and Ana Sljivic on top of CY46T1_bf7), developments give possibility to use three different sources of atmospheric aerosols in the ALARO and AROME model:
  - Tegen climate files,
  - monthly CAMS aerosol MMRs and
  - near-real time CAMS forecast/analysis.
- Currently, in operational forecast, information about aerosol concentration comes from outdated data source - climatological files containing six Tegen aerosol types (sea salt; soil dust (1-10μm); soil dust (<1μm); sulfate (H2SO4); carbonaceous aerosol; black carbon).
- In addition to these, some hardcoded background values are assumed when preparing aerosol optical properties for the default radiation scheme.

Study the cloud/aerosol/radiation (CAR) interactions (PH6)

- **updated climatological files** (eleven CAMS aerosol MMRs) as well as
- **daily analyses and forecasts of atmospheric aerosol** (CAMS global NRT).
- The AROME model validation and testing includes analysis of data transfer of aerosol MMRs in the model but also their impact on the forecast by using two different radiation schemes.
- Reference configuration of ALARO model (ACRANEB2 radiation scheme) and AROME model (radiation scheme ACRANEB2 or Foucault-Morcrette) were prepared by Jan Masek on CHMI operational domain.
  - AROME model with the IFS radiation is working properly with the new monthly climate fields.
  - the differences between new experiment and reference for predicted T2m, RH2m and WSP10m are small (see the figures in the next slide).
- When AROME was run using ACRANEB2 radiation scheme, a problem occurred when using the new vertical profiles of aerosol runtime optical properties calculated by routine aeropt.F90 (variable YLAERO_MIX). At the zero-time step, several fields had NaN values, e.g.: X001TG1, X001TG2, SFX.RN_ISBA, SFX.T2M_ISBA.
- Work to be continued in CHMI

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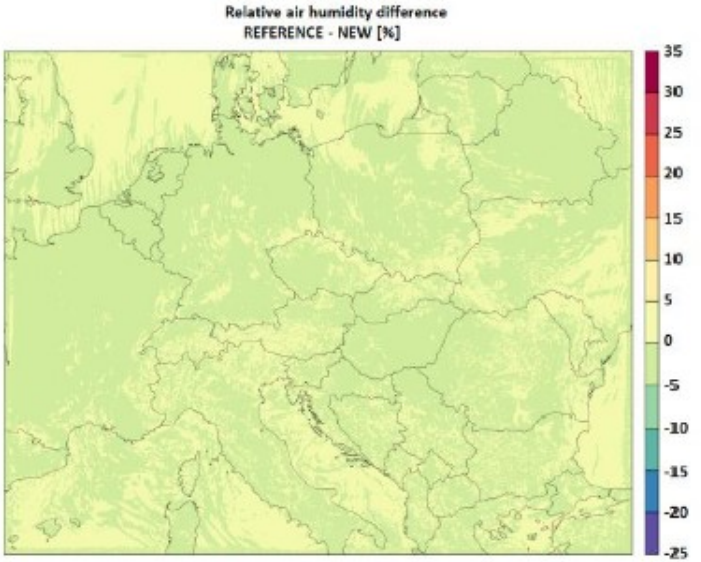
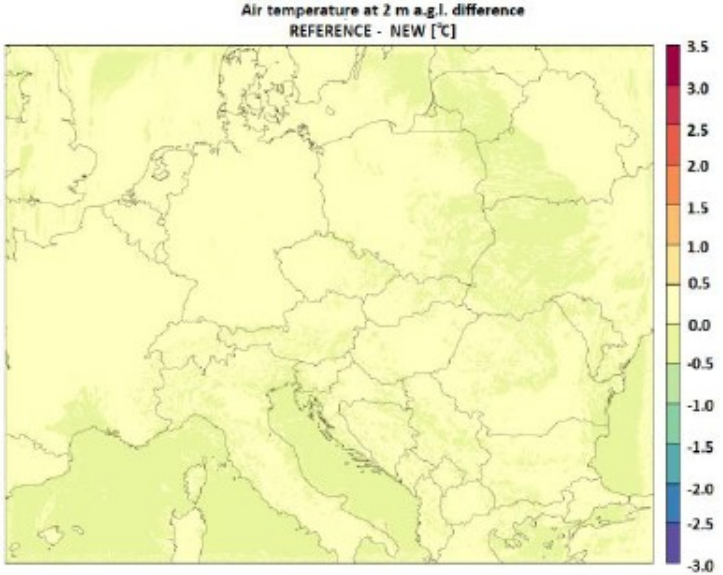
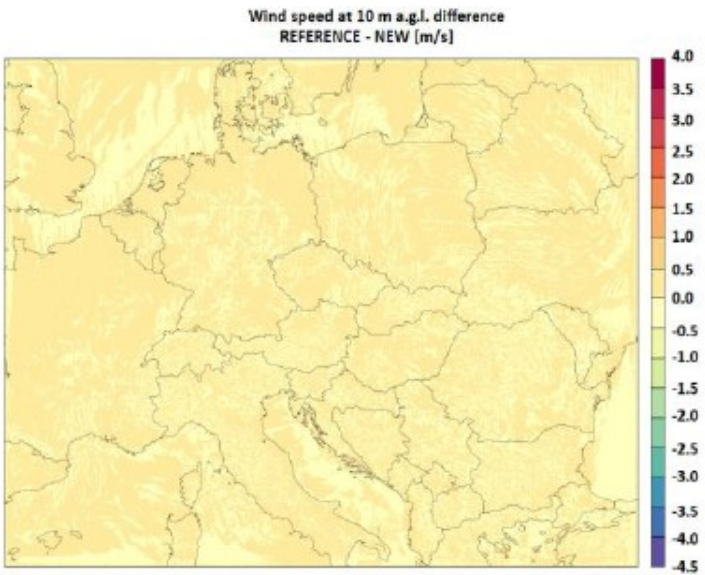
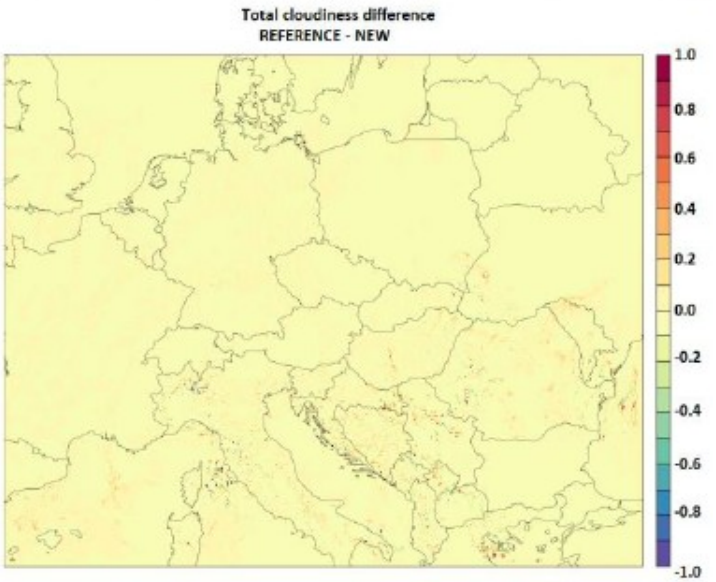
Changes in relative humidity (top left), 2m temperature (top right), 10m wind (bottom left) and cloudiness (bottom right).









Turbulence & shallow convection (PH1)

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- With goals set at the TOUCANS brainstorming week last year, review of literature was performed (mainly of references in existing TOUCANS documentation, but also some papers that references are referring to), with the aim of **theory revision**.
- Revision is needed mostly for derivation of problematic TOMs terms, where the validity of current TOMs scheme is not totally clear.
- Theory revision is in progress, so far **the basic Reynolds decomposition scheme for equations for up to and including the fourth order terms was revised** (needed for TOMs derivation).

Turbulence & shallow convection (PH1)

- Closure schemes needed in TOUCANS are currently under revision:
  - Canuto 2nd order closure based on Reynolds decomposition (a Mellor-Yamada type closure),
  - Redelsperger 2nd order closure based on exchange coefficients with prognostic TKE,
  - Zilitinkevich EFB closure with two prognostic energies (TKE + TTE),
  - Canuto closure for TOMs,
- Revision of TOUCANS scheme and inclusion of moisture still needs to be done.
- In parallel with revision, new documentation for TOUCANS is being written.
- After theory revision, code cleaning and testing of TOMs schemes in increasing complexity (from dry, neutral, without temporal term to full TOMs scheme) will begin.

Testing new scheme for subgrid variance of the saturation departure in AROME/HU

- In AROME there are two options available to compute the subgrid variance of the saturation departure.
  - The older version (LOSIGMAS=.F.) computes this variance diagnostically,
  - while the new version (LOSIGMAS=.T.) computes this prognostically using the Turbulent Kinetic Energy scheme.
- The two schemes produce a significantly different cloud cover: the diagnostic formulation simulates smooth cloud fields while the prognostic formulation tends to produce a cloud cover value with two categories (“zero or one”), with lower average values.
- The operational 2.5 km AROME version of OMSZ applies the diagnostic formulation

Testing new scheme for subgrid variance of the saturation departure in AROME/HU

- Forecasters gave feedback that in some cases during winter 2022/2023 AROME/HU significantly overestimated the cloud cover and consequently underestimated 2 meter temperature.
- Modification of LOSIGMAS from .F. to .T. for these cases improved forecasts of cloud cover and temperature.
- After these successful case studies two longer periods were tested, one in summer (2022-08-01–2022-08-31) and one in winter (2022-12-17–2023-01-17).
- For all the experiments the tuning parameter VSIGQSAT (regulating the width of the PDF) was set to the default value of 0.02.
- For the summer period, additionally, SAL verification was performed for precipitation using radar data.
- The impact of the modification varies for different variables.
- For cloud cover and surface incoming radiation, a significant reduction of the positive bias can be observed, however, RMSE scores deteriorate, which could be attributed to the more discrete cloud cover field.

Testing new scheme for subgrid variance of the saturation departure in AROME/HU

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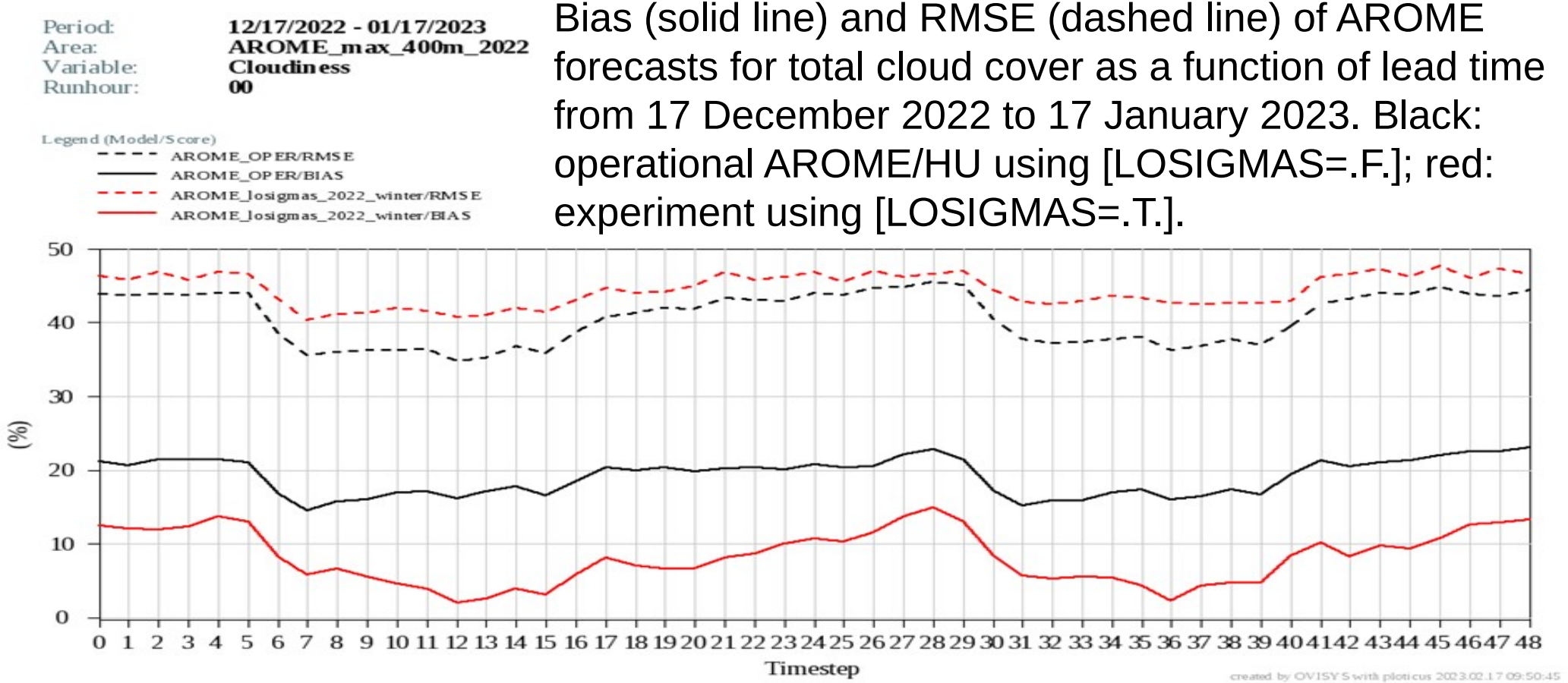
Bias (solid line) and RMSE (dashed line) of AROME forecasts for total cloud cover as a function of lead time from 17 December 2022 to 17 January 2023. Black: operational AROME/HU using [LOSIGMAS=.F.]; red: experiment using [LOSIGMAS=.T.].



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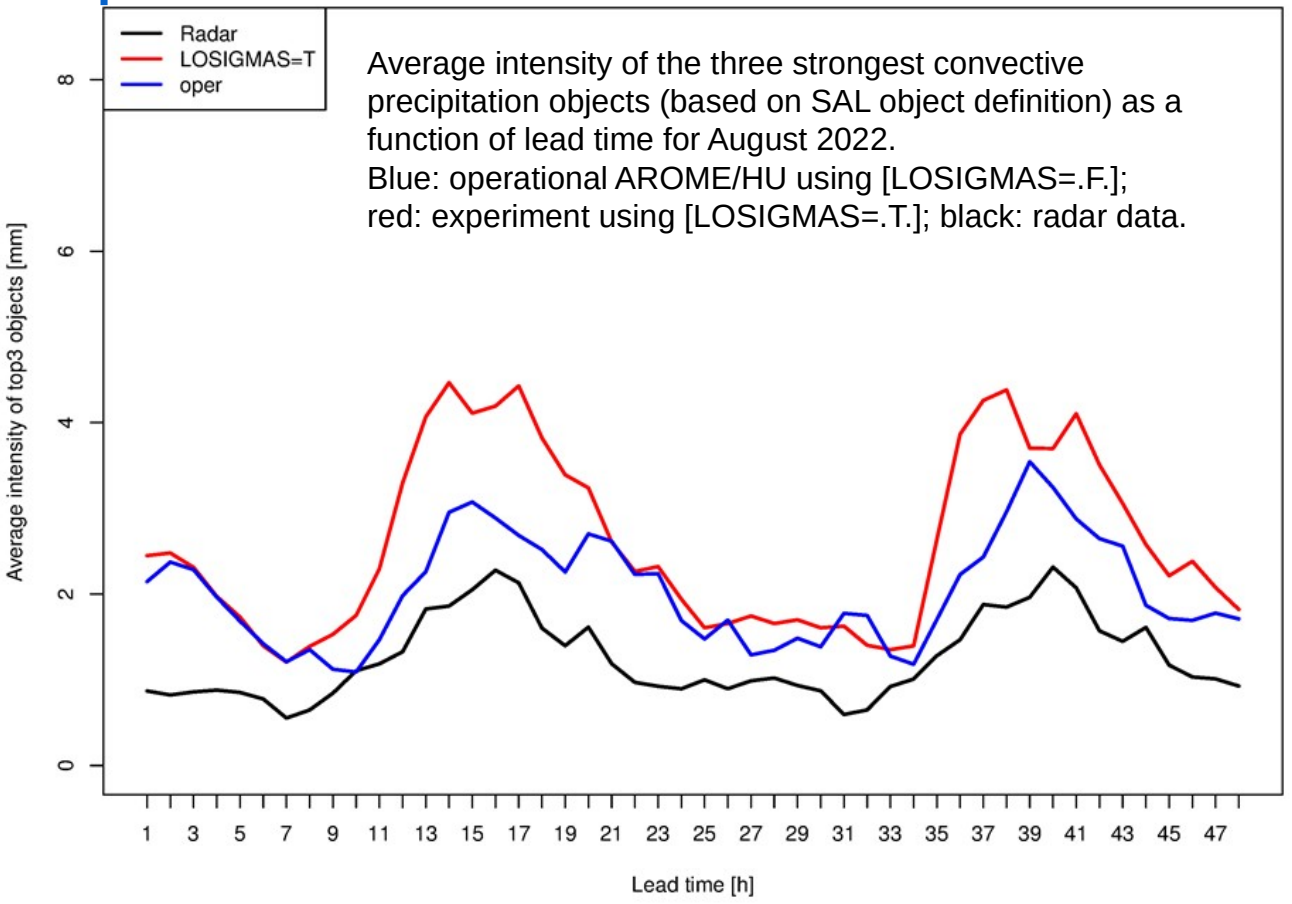
Testing new scheme for subgrid variance of the saturation departure in AROME/HU

For convective precipitation, a deterioration can be observed as the **new version simulates too strong convective cells**.

For other variables the modification results in mostly neutral impact.



Average intensity of the three strongest convective precipitation objects (based on SAL object definition) as a function of lead time for August 2022.
Blue: operational AROME/HU using [LOSIGMAS=.F.];
red: experiment using [LOSIGMAS=.T.]; black: radar data.

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Testing new scheme for subgrid variance of the saturation departure in AROME/HU

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- Further studies have been conducted to test the impact of the different settings of the subgrid variance of the saturation departure. Sensitivity of the forecasts towards the VSIGQSAT parameter has been investigated, and the two time periods used in previous studies have been re-run with **VSIGQSAT=0.06** setting. This resulted in slightly improved scores for most parameters, however, incoming solar radiation significantly degraded, especially in winter. Consequently, the decision was taken that further tests will be conducted with the VSIGQSAT=0.02 setting.
- As the previous summer period (August 2022) was very dry, another period (July 2021) was chosen to investigate **the impact on summer convection**. Daytime T2m RMSE improved slightly. Convective precipitation degraded slightly. Other parameters neutral.
- After careful analysis of the results the decision was taken that the LOSIGMAS=T, VSIGQSAT=0.02 is worth to be tested on **a longer summer period as a parallel suite with involvement of forecasters in the model evaluation** on a daily basis. The parallel suite was started at the end of June and will be run until mid September.

ALARO microphysics developments

- Freezing drizzle case
- An interesting case of freezing drizzle occured as a result of super-cooled warm rain process (SWRP).
- It turned out that there is no way to incorporate it into the precipitation type diagnostics, because the conditions are not unique for this phenomenon.
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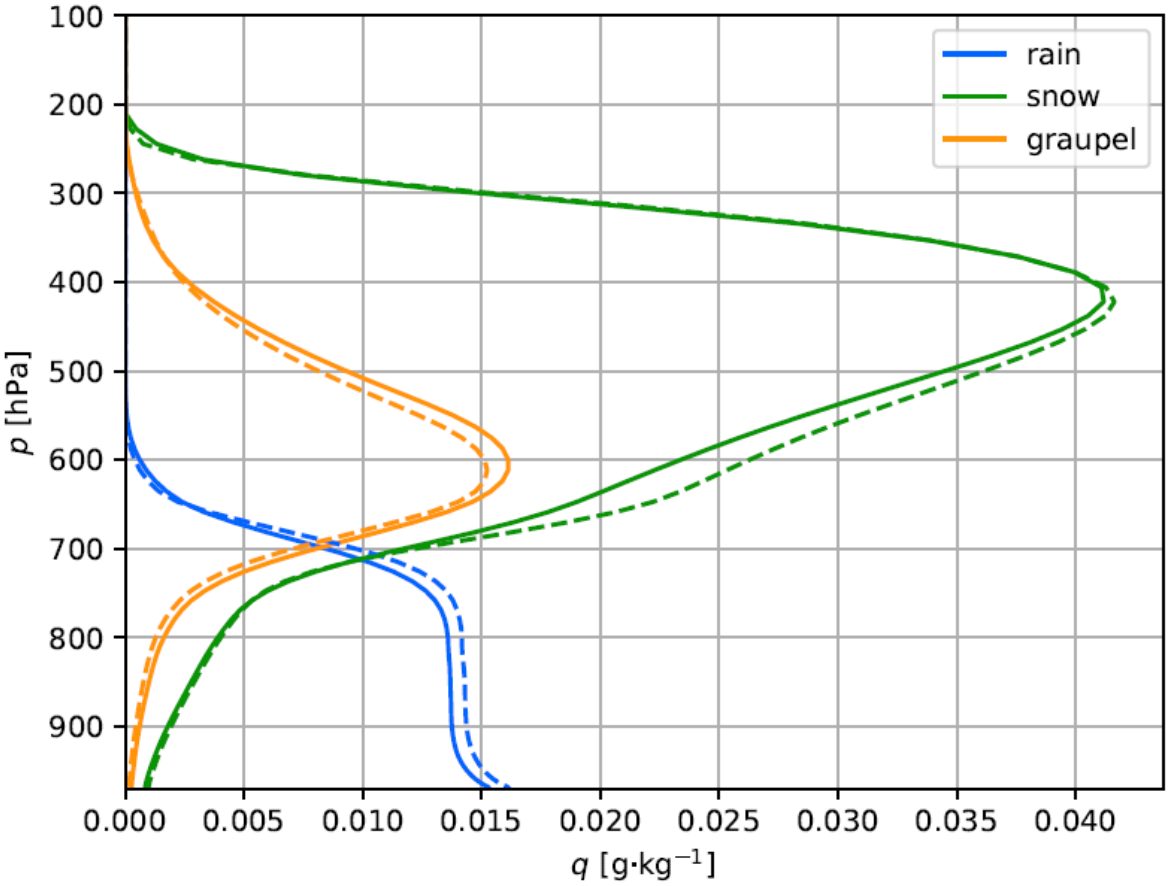
ALARO microphysics developments

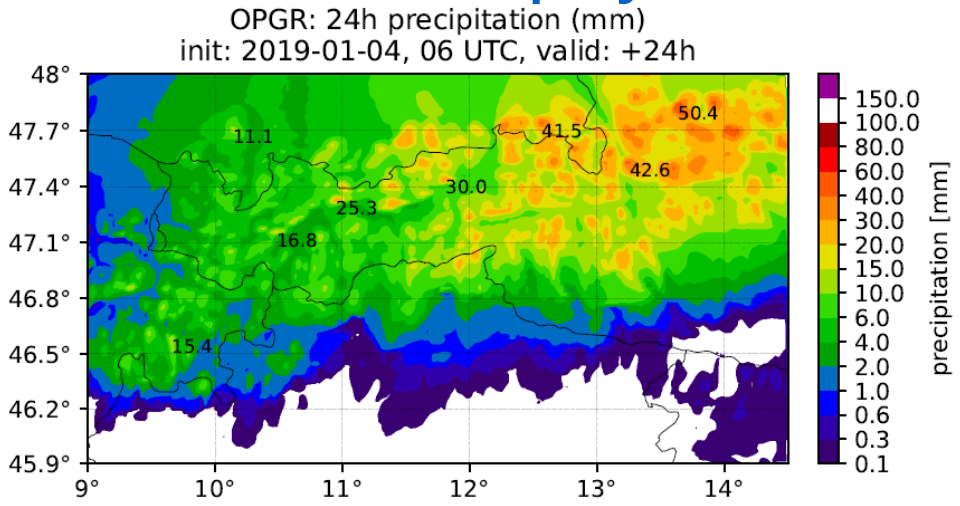
- **Evaporation:**
- In ALARO microphysics, there is the option to run the Lopez version of processes, activating the switch LARPMPS. However, this activates all of them.
  - The research has shown that the evaporation would be the only interesting candidate to take. Current ALARO evaporation scheme is a Kessler type. The formulation by Lopez is a more common one. The main impact of using the Lopez scheme is the higher evaporation rate.
  - A new option in ALARO microphysics to use the Lopez formulation of evaporation of precipitating species was added and extended to graupel.
  - Also its version with the Abel-Boutle distribution (existing LAB12 switch) for rain (instead of Marshall-Palmer) was developed.

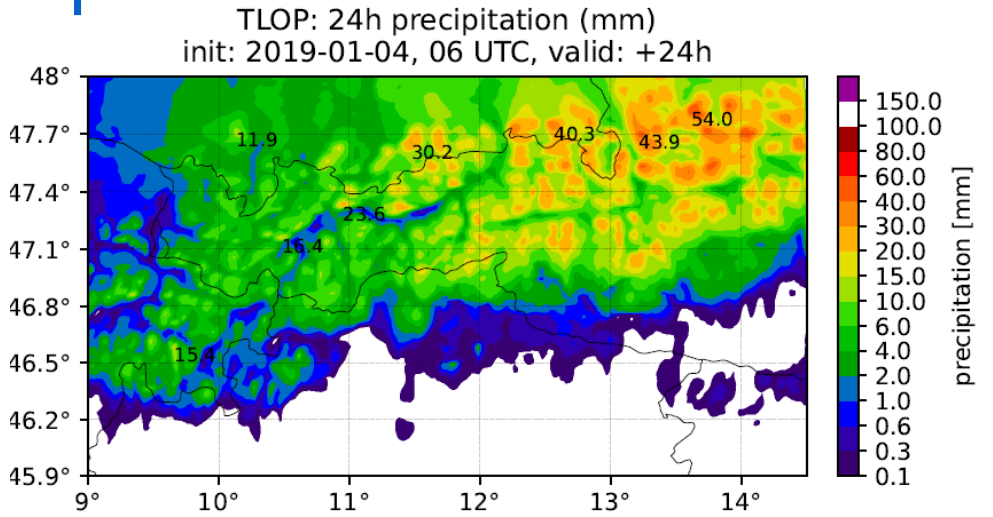
ALARO microphysics developments

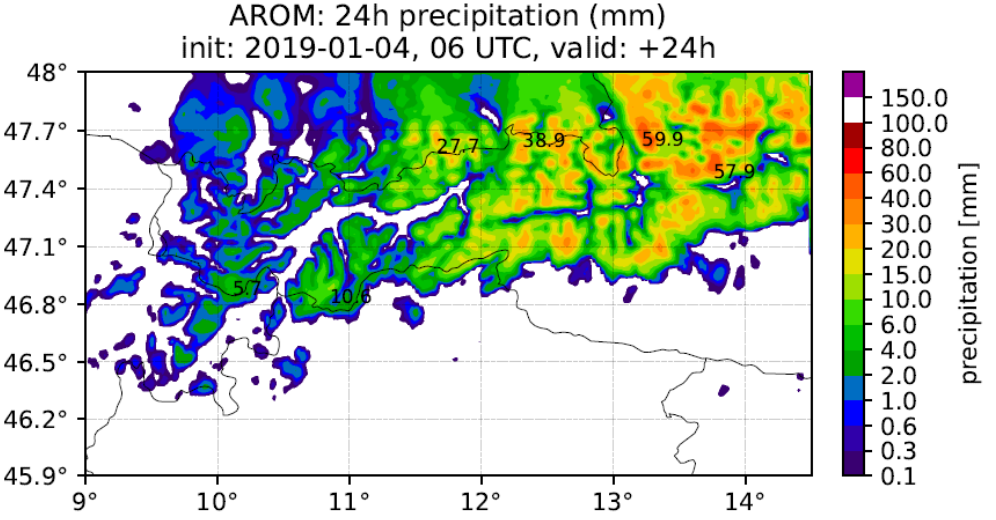
Vertical profiles of specific contents of hydrometeors for the convection case on 24-06-2022 at 18 UTC. Solid lines - Lopez formulation of evaporation, dashed lines – reference. Feedbacks are complex. With Lopez evaporation, there is less snow but more graupel.



ALARO microphysics developments







Impact of the Lopez evaporation on the case of 04-01-2019, the luv/lee case.

Top – reference,

top right – activated evaporation by Lopez,

right – Arome.

ALARO microphysics developments

- **Autoconversion**
- The autoconversion proces was studied, where several options were examined, for example the one of Khairoutdinov and Kogan (2000). However this one lead to an exaggerated content of cloud water and was not considered further.
- On the other hand the other threshold of ice autoconversion, following Chaboureau and Pinty (2006), was implemented and it is included in the package of microphysics enhancements of ALARO at CHMI.
- In addition, critical liquid water content for autoconversion of cloud water has been retuned.

ALARO microphysics developments

- Proposal of the package of microphysics enhancements and tests
  - During summer the package of modifications in microphysics, containing above mentioned autoconversion thresholds and evaporation formulation following Lopez was extensively tested.
  - More intensive evaporation lead to retuning of other parameters in the microphysics and also in cloudiness for radiation.
  - In addition, a partial reduction of evaporation seems needed (this is also done in ARPEGE but much more).
  - The final proposal including tunings is expected to be ready in autumn.

New products

- CHMI implemented to the local cycle CY46T1 in Prague a couple of products useful for convection weather conditions, some were backphased from CY48. These are:
  - **Storm relative helicity;**
  - **Updraft helicity;**
  - **Updraft and downdraft track;**
  - **Calculation of both MUCAPE and MLCAPE;**

Summary

- ALARO Refactoring done (GPU to be optimized)
- Cloud Aerosol Radiation interactions can use different aerosol as input
- New ideas and developments for the TOUCANS Turbulence scheme
- Issues in operational AROME HU fixed using subgrid condensation scheme
- ALARO Microphysics development under way
- New products available for postprocessing

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