Regional Cooperation for Limited Area Modeling in Central Europe

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Physics activities in RC-LACE

Mario Hrastinski and RC-LACE Physics Team

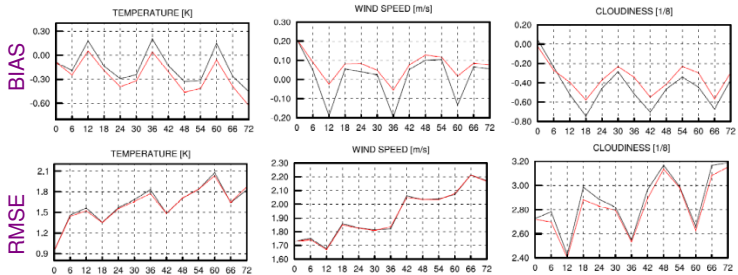
GeoSphere Austria
DHMZ
Czech Hydrometeorological Institute
IMGW
HungaroMet Hungarian Meteorological Service
METEO ROMANIA
SHMU
ARSO METEO Slovenia

Outline

- Testing the ALARO-CMC with the new TLS
- The development of a two-moment microphysics scheme (talk by D. Němec)
- Testing ecRad scheme within the ALARO-CMC
- Cloud-Aerosol-Radiation (CAR) activities
- ALARO physics in single precision
- (Sub-)kilometre ALARO-CMC experiments
- Summary

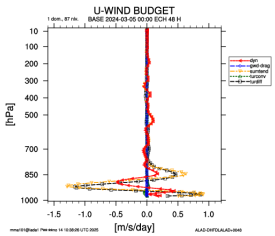
Testing the ALARO-CMC with the new TLS

- The initial tests were performed in a nearly dry case (7 September 2023) - ”internal” TLS tuning
- The tuning continued in cloudy and fully moist periods: 3-10 March 2024 (Sc regime), 15-30 June 2024 (convection), 9-18 September 2024 (floods) and 26-30 December 2024 (stable period with fog)
- Besides tuning the settings of TLS formulation, the response of the following schemes was studied: therm.-dyn. adjustment, radiation cloud scheme, vegetation therm. coeff. and resistance to evaporation



— REF — EXP

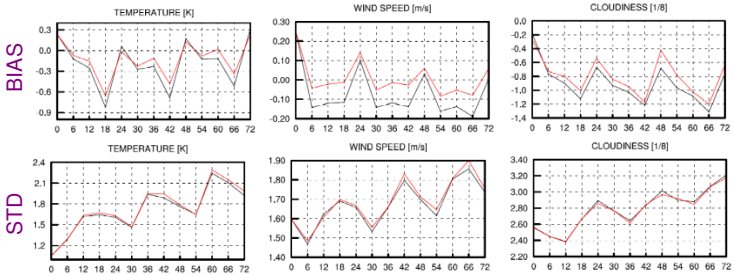
3-10 March 2024

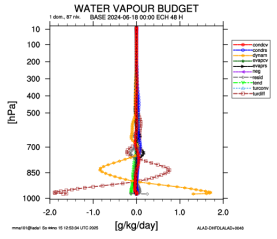


The work of Radmila Brožková

Testing the ALARO-CMC with the new TLS

- The BIAS-es behave similarly as in the spring period, while STD for some surface parameters is deteriorated (T2m, RH2m and WS10m)
- The upper-air scores are nearly neutral (except T850); improve the interaction with deep convection scheme
- The options still to address are (i) the method to determine the PBL height (noisy) and (ii) the moist gustiness correction (reacts differently for REF and EXP)





— REF — EXP

15-26 June 2024

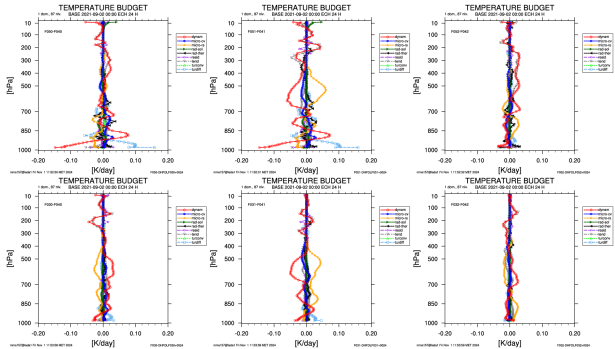
more details in ALARO-1 WD talks of Radmila Brožková

Testing ecRad scheme within the ALARO-CMC

- Testing in ALARO-CMC on CY48T3 during Sophia Schaefer's stay at CHMI (with support from Ján Mašek)
- Testing in 1D and 3D models (intermittency): (i) ecRad shortwave fluxes are more accurate, (ii) ACRANEB2 intermittency is more time consistent and (iii) ecRad 5-35% higher cost (15-min and no-intermittency)

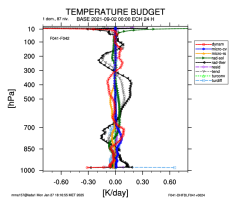
1-h

15-min



old IFS scheme | ecRad | ACRANEB2

1. scheme settings as close as possible (cloud optics)
2. narrowband model also compared to ecRad



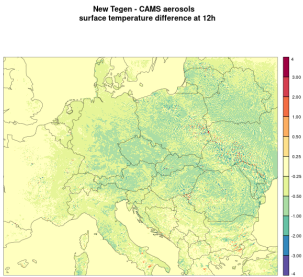
ecRad - ACRANEB2

Cloud-Aerosol-Radiation (CAR) activities

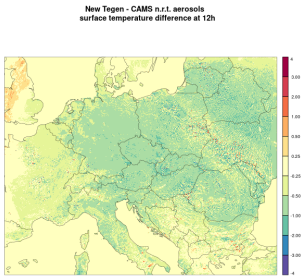
- The dataflow for CAMS aerosols was finalized during Piotr Sekuła's stay at CHMI, enabling also a combination of 2D climatology and 3D n.r.t options; currently works for configurations using the ACRANEB2 scheme
- Additionally, the e923 procedure was extended with step 12; enables interpolating global CAMS 2D aerosols climatology to any LAM domain
- A pull request was submitted to CY50 and includes (developments of J. Mašek, L. Rontu, P. Sekuła and Ana Šljivić):
  - Importing different types of CAMS aerosols
  - Externalization of ACRANEB2 aerosols
  - The conversion of CAMS MMRs to aerosol optical properties
  - The vertical distribution of 2D CAMS climatological aerosols
  - Externalization of the effective radius from ACRANEB2 scheme
- The technical document on the use of CAMS aerosols can be found at: https://redmine.umr-cnrm.fr/attachments/6098

Cloud-Aerosol-Radiation (CAR) activities

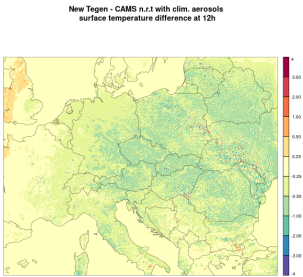
- The validation was performed in 7 September 2023 clear sky case; the differences between the new and old code using Tegen aerosols were minor and estimated as acceptable
- The differences between experiments using different sources of aerosols were substantial
- The first steps towards the operational implementation of 2D CAMS were undertaken at CHMI: (i) big impact, (ii) avoid tropospheric background values (tune stratospheric) and (iii) tuning of other schemes



TEGEN - 2D CAMS



TEGEN - n.r.t. CAMS



TEGEN - "hybrid" 2D+n.r.t. CAMS

ALARO physics in single precision

- The starting point was CY46T1-bf07 + local developments at CHMI (29 subroutines modified for SP) - shown last time
- The focus shifted towards CY49T2 which enables testing with the refactored code
- SP coding strategy:
  - Numerical security is set strictly by using EPSILON and TINY:

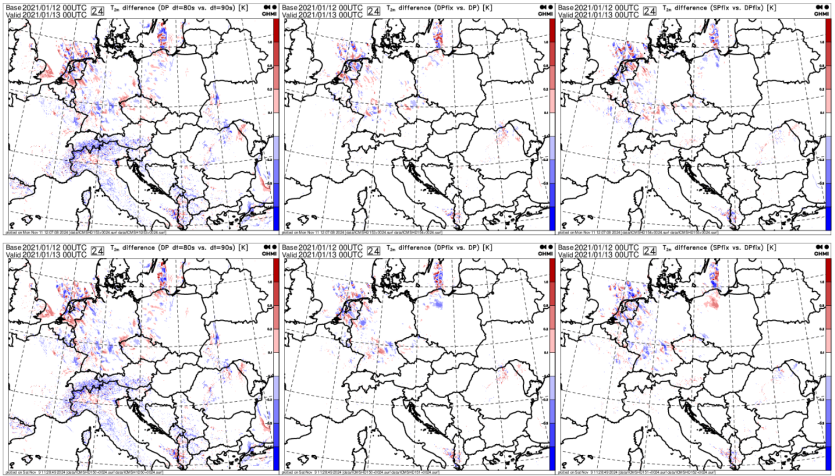
    ZEPS1=1.E-80␣JPRB $\longrightarrow$ ZEPS1=10.␣JPRB*TINY(1.␣JPRB)
  - Separating numerical and physical security constants:

    ```
    ! numerical security
    ZTRLI =10.␣JPRB*TINY(1.␣JPRB) ! minimum transmission
    ZARGLI =LOG(ZTRLI)
    ZEPSNEB=10.␣JPRB*EPSILON(1.␣JPRB) ! protection of cloud fraction

    ! physical security
    ZEPSAL =1.E-04 ! minimum co-albedo
    ZSECUR=4.␣JPRB*RSIGMA*RG*TSPHY
    ```

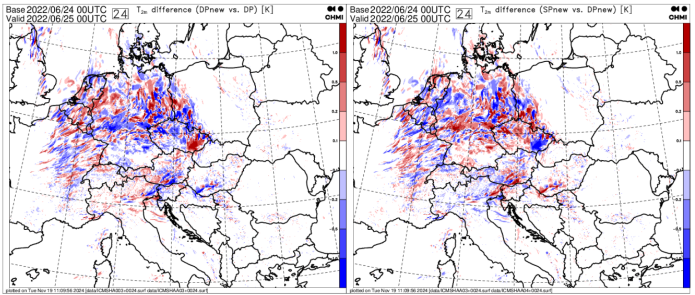
The work of:
Oldřich Španiel and Ján Mašek

ALARO physics in single precision

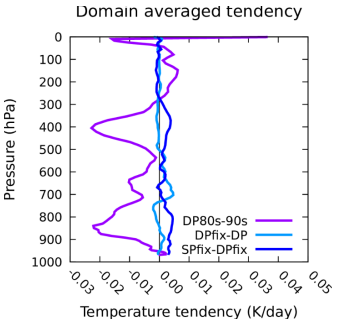


ALARO physics in single precision

- The patterns of DP_{fix} vs. DP and SP_{fix} vs. DP_{fix} differences roughly match (appear where ”something happens”)
- The impact of SP is slightly stronger than DP fixes and weaker than the Δt modification



DP_{fix} vs. DP SP_{fix} vs. DP_{fix}



ALARO physics in single precision

- The savings on elapsed time: (i) DEODE domain on Atos (1500 x 1500 GP) - 50% and (ii) CRO domain on Belenos (1620 x 1500 GP) - 56%
- A pull request is submitted to CY50
- Currently, the VFE option does not work combined with hydrostatic dynamics and some configurations of vertical levels, e.g., for A-LAEF (investigation is ongoing)
- The main future objective is ALARO-1 SP implementation into CY48T3 and CY49T2 with SURFEX

(Sub-)kilometre ALARO-CMC experiments

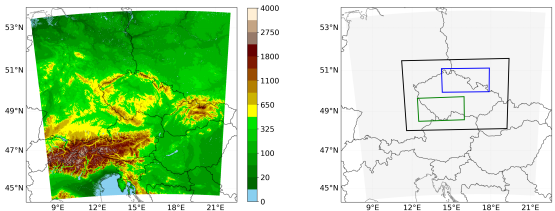
- The ultimate goal is to have a $\Delta x \sim< 1$km configuration providing an added value to the existing operational configurations; addressing dynamics and physics settings
- The horizontal diffusion performs more-less fine but it is hard to tune it as Δx decreases
- Introducing 3D turbulence effects (1D + 2D and Goger et al. 2018, 2019):

$$K_{M,ver} = L_K C_K \sqrt{e_k}\, \chi_3(Ri)$$

$$K_{M,hor} = L_K^H C_K^H \sqrt{e_k}\, \chi_{3,hor}(Ri)$$

$$K_{H,ver} = L_K C_K C_3 \sqrt{e_k}\, \phi_3(Ri)$$

$$K_{H,hor} = L_K^H C_K^H C_3 \sqrt{e_k}\, \phi_{3,hor}(Ri)$$



NHYD dyn., ICI scheme (1 iter.), horiz. diff. and ALARO-1 phy. of ALADIN-CZ oper.; INIT: ALADIN-CZ, LBC: ARPEGE (3-h)

(Sub-)kilometre ALARO-CMC experiments

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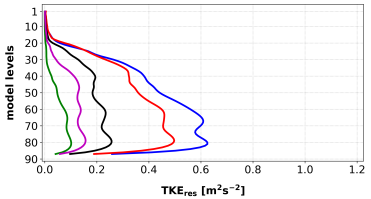
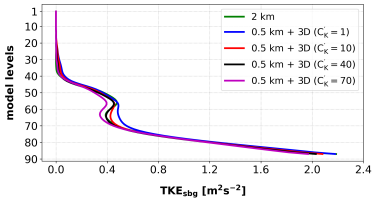
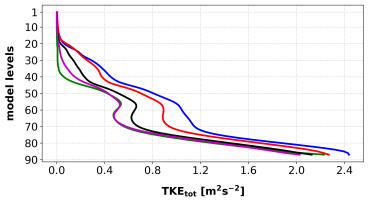
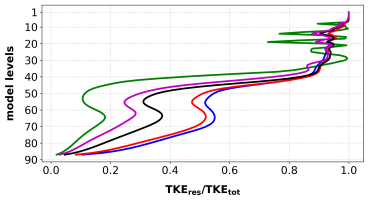
- Testing the sensitivity to 1D+2D scheme's intensity:









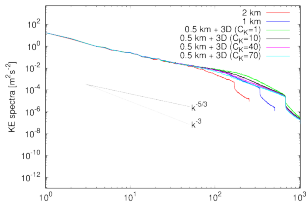
$$C_K^H = C'_K \cdot C_K$$

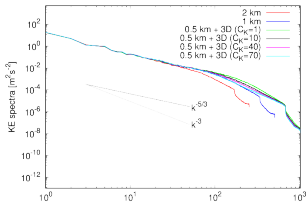
1. Strong sensitivity to the L_K^H formulation Wang et al. (2021)
2. sensitivity to L_K^H protection: $c \cdot \Delta x$

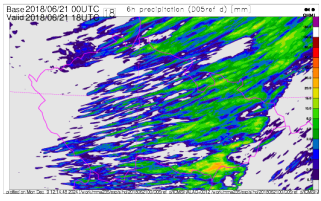
The work of:
Mario Hrastinski
Petra Smoliková

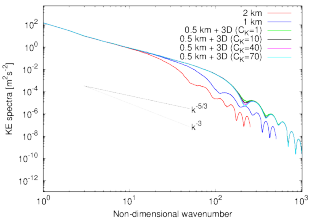
(Sub-)kilometre ALARO-CMC experiments

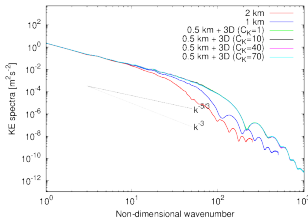
- The impact off the 3D turbulence at $\Delta x = 0.5$ km:

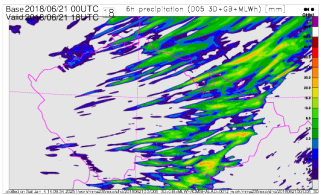












(Sub-)kilometre ALARO-CMC experiments

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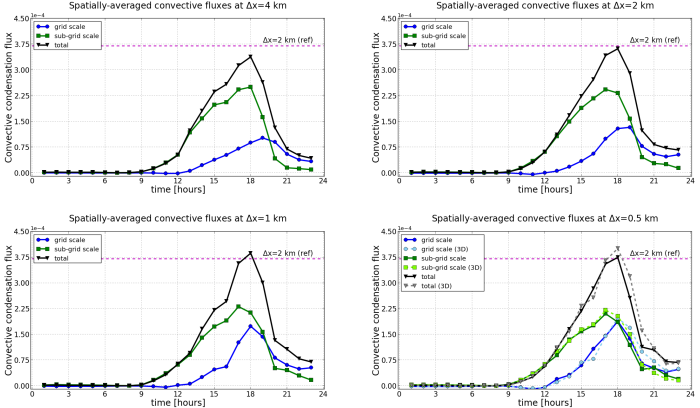
- How 3MT scheme adapts as horizontal resolution increases?



condensation fluxes in convective updraught

1. 3MT scheme adapts only slightly with Δx
2. Total condensation flux increases with the grid-scale part
3. Tuning the 3MT scheme is needed (small to moderate impact so far)

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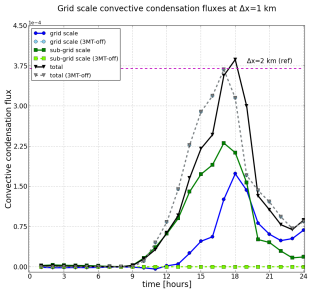
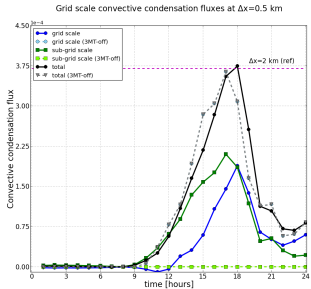
(Sub-)kilometre ALARO-CMC experiments

- The impact off 3MT scheme at $\Delta x = 1.0$ km and $\Delta x = 0.5$ km:





condensation fluxes in convective updraught

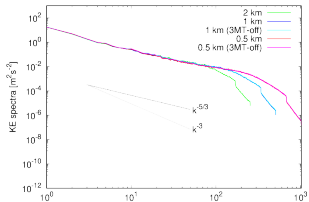
1. The maximum is shifted to one hour earlier
2. The total magnitude is comparable

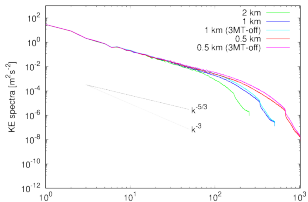
Can we simply switch off the 3MT scheme?

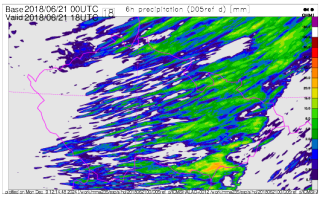
The work of:
Mario Hrastinski
Radmila Brožková
Petra Smoliková

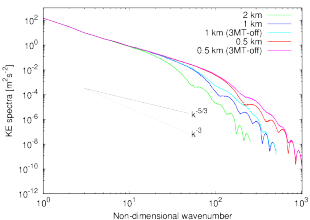
(Sub-)kilometre ALARO-CMC experiments

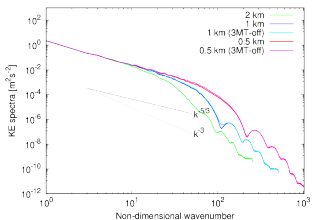
- The impact off 3MT scheme at $\Delta x = 1.0$ km and $\Delta x = 0.5$ km:

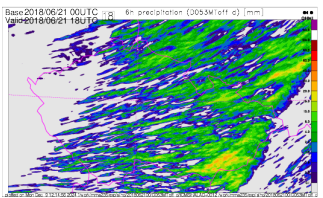












Summary

- Currently, there is an ongoing development of a two-moment microphysics scheme and ALARO-CMC in single-precision
- In addition, the wet snow and ice accretion scheme is interfaced with prognostic graupel and validation/tuning is ongoing (the work of Andre Simon)
- Several developments are in a mature stage and ready for pre-operational testing (or already being tested): (i) the new TLS formulation and (ii) CAMS-based aerosols
- Attempts are made to optimize te ALARO-CMC performance at $\Delta x \sim<$ 1km. Optimizing the horizontal diffusion and interaction between turbulence and convection is essential. More details in talk of Mario Hrastinski at ALARO-1 WD.
- Recent physics developments are introduced into the new version of the A-LAEF, including: Lopez scheme, clouds adjustments, new z_0 (with snow impact) and diagnostic fields and new TLS formulation. More details in talk of Martin Belluš at ALARO-1 WD.

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Thank you for your attention!

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