Regional Cooperation for
Limited Area Modeling in Central Europe

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Surface related activities in RC LACE

Martina Tudor presenting work of many

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Overview

Surface data assimilation

- an experiment with multilayer scheme on CLAEF1k domain
- SYNOP based snow analysis in CANARI
- tuning of soil water content initialization in OI/CANARI
- assimilation of satellite SWI within SEKF in AROME

Surface physics

- exploring advanced SURFEX options like ORORAD, TEB, snow etc (see below)
- a lot of testing of ALARO with SURFEX (presentation of Jan Mašek in half an hour)
- work with ECOCLIMAP I, II, SG
- and interrfacd of atmosphere with the (land) surfacd (see presentation of Mario in the Physics section)

The CLAEF1k system consists of 16 deterministic AROME ensemble members + 1 control member, all with a 1 km resolution over a domain of 1500 × 1350 grid points.

- Currently, the system runs on cycle 46 with SURFEX v8.0, using the legacy ISBA force restore option with 1 patch.
- The surface assimilation scheme consists of the CANARI analysis of the 2m temperature and humidity, which is then used by OI_MAIN to update the ISBA fields.
- Aim: perform a simple DA experiment of 2m quantities from CANARI with the SEKF method in SODA with the ISBA diffusion multilayer scheme,
- run in offline mode using the standalone version of SURFEX v8.1, since SURFEX v8.0 does not support multi-layer physics.

Problems

- initializing the multilayer ISBA-dif scheme from the ISBA force restore used in CLAEF1k.
- The surface assimilation scheme consists of the CANARI analysis of the 2m temperature and humidity, which is then used by OI_MAIN to update the ISBA fields.
- The initial PREP file was created through a somewhat convoluted process using EPyGram to transfer fields between files from different SURFEX versions.
- the initialization of the multilayer snow scheme from the D95 scheme not yet implemented in SURFEX.
- manually initialize the snowpack to layers of equal height and density according to the D95 fields - not suiteable for operations

Managed to produce an analysis for a single case.

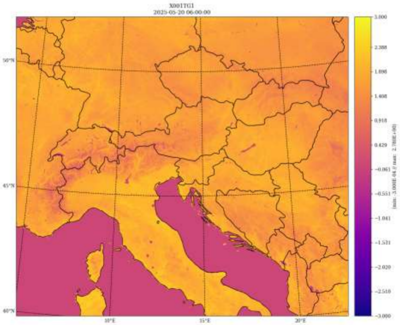

Figure: Increments of TG1 using SODA/SEKF and CANARI 2m analysis as observation for a single test case.

Implement snow analysis and find the optimal settings for the ALARO CSC, with following simplifications to asses the influence of snow depth analysis:

- feedbacks of snow cover to albedo to radiative balance to surface temperature eliminated
- no cycling, operational background
- only 06:00 UTC
- national Czech and Hungarian networks, GeoSphere Austria and Swiss WSL (separate for DA and validation)

Originally, ALARO underestimaed snow depth at all altitudes, increasing with altitude.

Quality control gives more wight to measurements at giher altitudes. studied for various tuning parameters (ORODIF, quality control parameter q, the vertical and horizontal correlation scaling parameters, and the observation and model background error estimates).
Multidimensional minimisation problem using wighted sum of RMSE in four altitude groups with two methods:

- The coordinate-descent solution results in a more active analysis and performs better at higher altitudes.
- The simplex solution is more conservative, leading to a balanced compromise between the different altitude groups, and has been chosen as the final setting.

Also see the CHMI poster!

Snow analysis for ALARO CSC using ISBA (c) Jáchym Ševčik and Alena Trojakova

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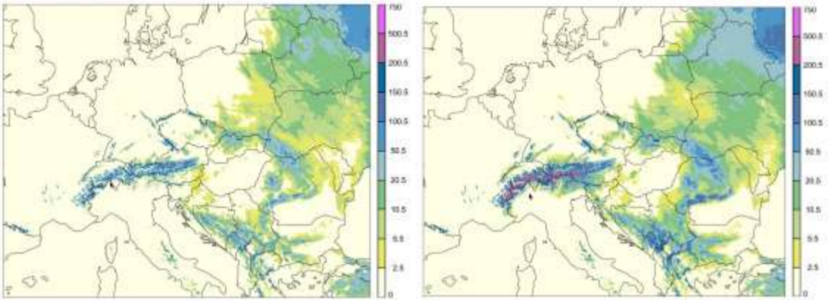

Figure: The snow reservoir of first guess (on left) and analysis (on right) on 25th January 2022. The analysis is using the simplex settings.

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82% of the Hungarian raw data were accepted by the data controllers, so it was decided to allow all raw observations to enter the OPLACE database.

- LAESNM = .T. (active snow assimilation)
- REF_S_SN = 5 kg/m2 (background error standard deviation)
- REF_A_SN = 50.000 m (horizontal correlation length)
- REF_AP_SN = 0.05 m (vertical correlation length)
- ECTERO(1,1,92,1) = 4 kg/m2 (observation error standard deviation)
- LAOROFLEXREJSN = .T. (altitude-dependent quality check)
- OROFLEXREJS = 20.
- LOBSNEG = .T.
- ORODIF = 10.000 m (maximum altitude difference between the observation and the model grid point)
- OROLIM = 10.000 m (maximum altitude for surface observation)
- LAECHK = .F. (spatial quality check)

Snow depth analysis in AROME-HU (c) Helga Kolláthné Tóth

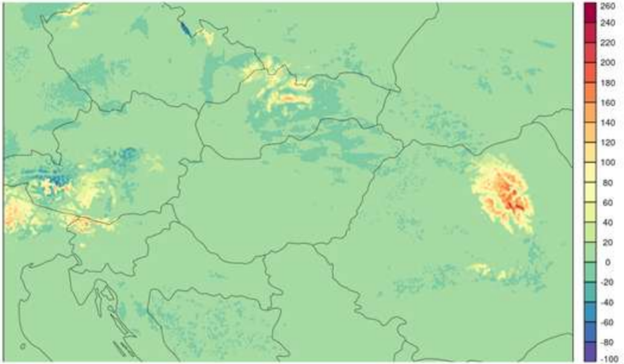


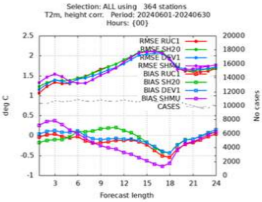
Figure: The difference of the snow-water equivalent [kg/m2] between experiment with the modifications and the reference run at 6 UTC on 2 February 2025.

See HungaroMet poster for additional snow data assimilation impact.

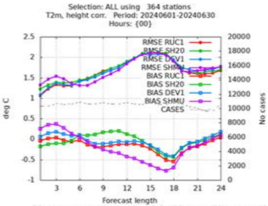
- The default vertical corretlation function is not very satisfying for snoe in high peaks, so the modification with MESCAN approach was applied in CANARI-OIMAIN.
- It works well in mountains in winter but increments spread too low in Alpine valleys in the summer.
- They also tested the relaxation towards climatology in AROME-RUC system to avoid accumulation of snow on highest Alpine peaks which are not covered by observation (same problem as ALARO CZ)
- ALARO CZ operational system stopped relaxation towards climatology in spring 2024, but in the absence of snow data assimilation, it accumulated a lot of snow in some spots.
- one needs to modify the code ov oi_control.F90 to let climatology values enter CANARI-OIMAIN properly (cy43t2,cy46t1)

Tuning of soil water content initialization in OI/CANARI (c) André Simon

Smoothing of deep soil wetness had a neutral or slightly negative impact on the scores of surface parameters (T2m, Q2m). 1h cycling frequency improved the results.



Former experiment with 3h cycling and run-time LBC (LISSEW4) - DEV1



New experiment with 1h cycling and lagged LBC (LISSEW7) - DEV1

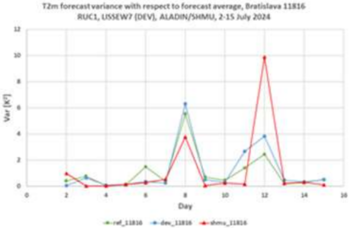


Figure: Left and cdntre: Scores from the "dev" experiments with smoothing the deep soil wetness in 1km resolution rapid update cycle for the 1 month period of June 2024. Right: Comparison of the forecast variance of T2m forecasts from 00,06,12,18 UTC with respect to their average, in case of the reference RUC (ruc), experiment with smoothing the deep soil wetness (dev) and operational ALARO/SHMU (shmu) for station Bratislava (11816).

The assimilation of ASCAT H08 Level-2 soil moisture product with AROME cy43t2, 2.5 km horizontal resolution from May to October 2023 with a 1-week spin-up using 3-hourly assimilation cycle. The following settings were used in SEKF for observation and model errors:

- xerrobs: ASCAT wg1 = 0.1 (wfc-wwilt) m3/m3; T2M = 1 K; Rh2M= 7
- xsigma: $wg_1 = 0.1m^3/m^3$ (wfc-wwilt) ; $wg_2 = 0.1m^3/m^3$; $tg_1 = 2K$; $tg_2 = 2K$,

where wfc and wwilt are the water content at field capacity and at wilting point, respectively.

The enhanced model and the observation errors resulted in high spatial variability of soil moisture, with adjacent very wet and very dry areas leading to unrealistic small-scale spatial fluctuations. However, using reduced model and observation errors the analysis increments became very small, indicating that the corrections from the observations are limited.

Assimilation of satellite moisture information (SWI) within SEKF in AROME (c) Helga Kolláthné Tóth

- the root zone soil moisture became more realistic and less underestimated
- The RMSE values of 2-meter temperature and relative humidity improved at night, however, the daytime systematic errors increased

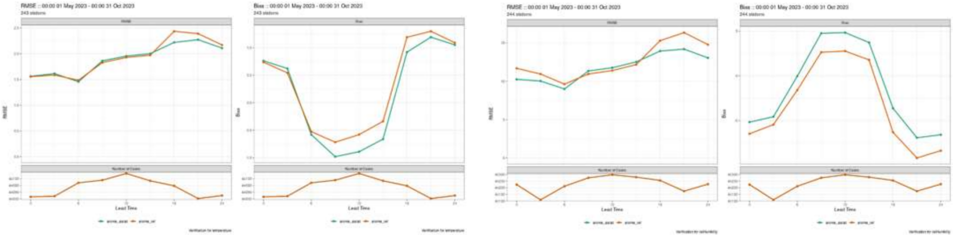


Figure: RMSE (left) and bias (right) for 2-meter temperature (K; left) and 2-meter relative humidity; (% bottom) in function of lead time [h] over Hungary for March–October 2023 based on 0 UTC runs of AROME assimilating (brown) and without (green) ASCAT data.

Initialization issues with ALARO+SURFEX (c) Alena Trojaková and Jan Mašek (spoiler alert!)

3-5 February 2024 ALARO+SURFEX, initialized from ALARO+ISBA, exhibits a warm bias due to too dry soil. When initialized from ARPEGE+SURFEX DA:

- (i) T2m bias and random error are reduced,
- (ii) negative bias of RH is corrected, but its diurnal amplitude increases, and
- (iii) random error of RH is smaller than the ISBA reference.

Surface DA becomes an urgent task, since meaningful tuning cannot be achieved without the reliable surface initialization.

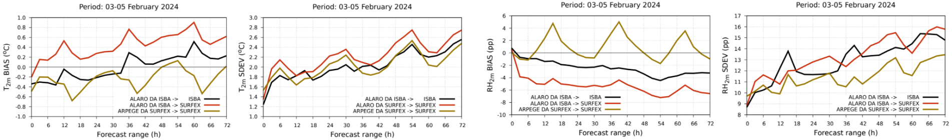


Figure: Comparison of ALARO+SURFEX simulations initialized from ALARO+ISBA or ARPEGE+SURFEX DA against the ALARO+ISBA reference: 2-m temperature (far left) and 2-m RH biases (centre right) and respective standard deviations (centre left and far right).

Assess/improve quality of surface characterization (c) Daniel Deaçu

Investigated the impact of ECOCLIMAP-I, ECOCLIMAP-II and ECOCLIMAP-SG vegetation distribution in Alpine valleys

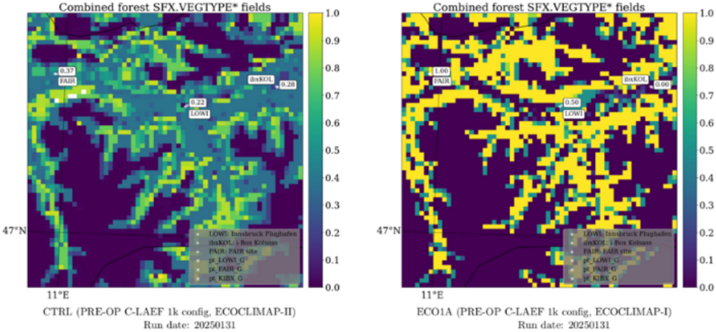


Figure: Forest fraction (ECOCLIMAP-II vs. ECOCLIMAP-I).

Issues with forest and grass in E-II prevented the implementation of a set of SURFEX changes targeting soil freezing, which had improved simulations with PGD and CLIM files derived from E-I

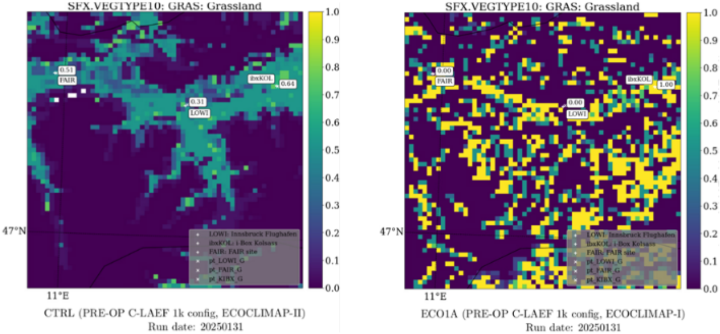
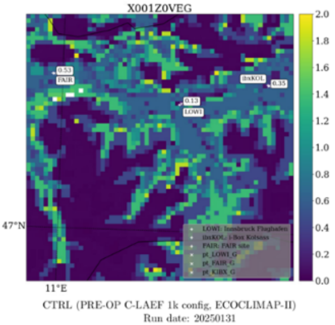


Figure: Grass fraction (ECOCLIMAP-II vs. ECOCLIMAP-I).

Unrealistic forest fraction leads to unrealistic values of surface parameters, (the aerodynamic and thermal roughness lengths, and albedo).



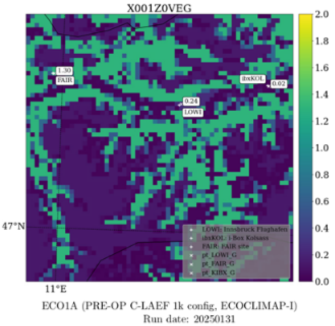


Figure: z0m fraction (ECOCLIMAP-II vs. ECOCLIMAP-I).

Assess/improve quality of surface characterization (c) Daniel Deaçu

Investigating the impact of ECOCLIMAP-I,-II and SG vegetation distribution in Alpine valleys (work of Daniel Deacu) Substantial changes in the C-LAEF AlpeAdria system behaviour near the surface were found when attempting to switch from ECOCLIMAP-I to ECOCLIMAP-II physiography Large differences between the two data sets over Alps: (i) an overestimation of forest fraction by ECOCLIMAP-II at the Inn Valley floor and (ii) an underestimation along its slopes (both generally applicable)

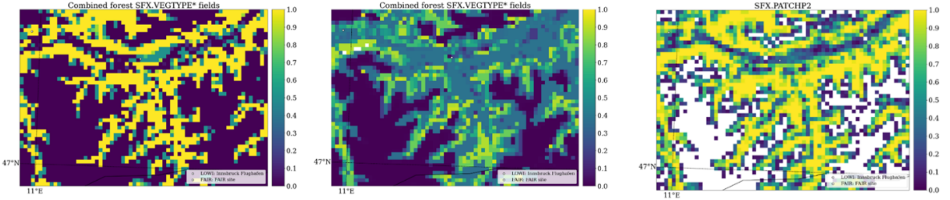


Figure: Forest fraction (ECOCLIMAP-I vs. ECOCLIMAP-II vs. ECOCLIMAP-SG)

Implementation of ECOCLIMAP-SG physiography in the ALARO CSC (c) Mario Hrastinski (first results!)

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- solve eventual technical problems
- preliminary assesment off ECOCLIMAP SG vx ECOCLIMAP II fields
- launch the ALARO forecast using ECOCLIMAP SG data

- SURFEX8.1+,
- CY49t1, blenos
- 2.3 km, NH, CZ domain
- 12 Jan 2021 and
- 3 Jun 2025
- oper CZ analysis,
- 72 hr fcst
- LBCs ARPEGE, 3hr

```
&NAM_FRAC
  LECOCLIMAP=.T.,
  LECOSG=.T.,
/
&NAMCOVER
  YCOVER='COVERECOSG_2010_V0.0',
  YCOVERFILETYPE='DIREC',
/
```

Employing versions newer than V0.0 and V0.1 resulted in a crash of the PGD step. Subsequent steps, including integration, were successful except when LGARDEN=.TRUE. (third urban patch) was activated, which led to a PGD crash due to insufficient memory. More urban areas in SG but no need for filtering as in II. Also, new features in inland water in SG.

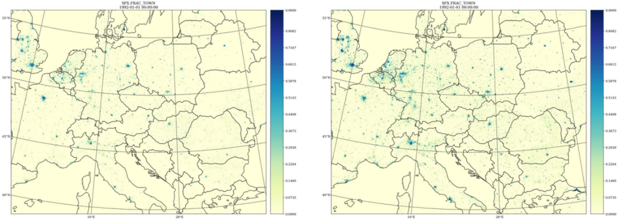

Figure: The town fraction for CHMI's operational domain obtained from: (a) ECOCLIMAP-II physiography with filtering of values of urban areas lower than 5% and (b) ECOCLIMAP-SG physiography (without filtering).

Implementation of ECOCLIMAP-SG physiography in the ALARO CSC (c) Mario Hrastinski (first results!)

ECOCLIMAP II roughness length data

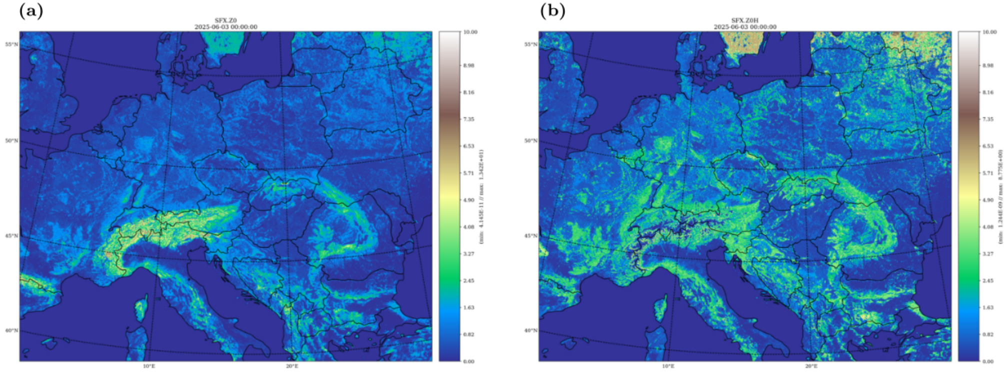

Figure: (a)-(b) The mechanical (z0m) and thermal (z0h) roughness length multiplied with 30 obtained from the ECOCLIMAP-II data.

Implementation of ECOCLIMAP-SG physiography in the ALARO CSC (c) Mario Hrastinski (first results!)

ECOCLIMAP SG mechanical roughness length data. No scaling was applied to the tree height during runtime! Scaling applied in these plots to facilitate comparson!

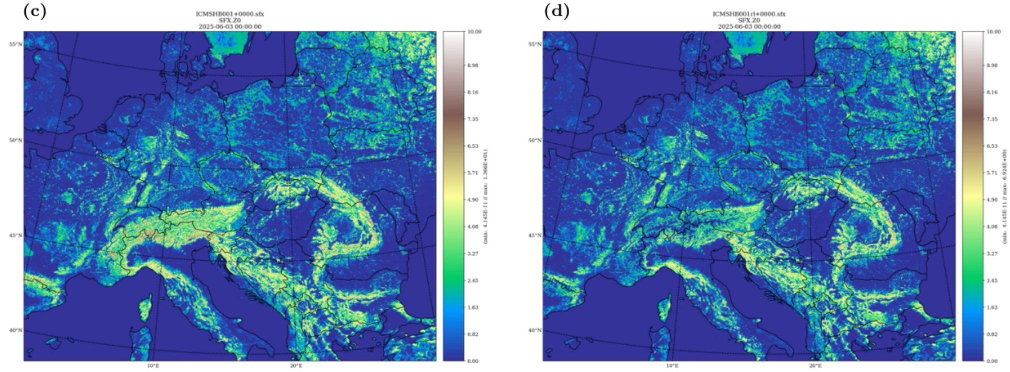

Figure: (c)-(d) z0m obtained from the ECOCLIMAP-SG data with and without using the effective roughness length concept, respectively.

Implementation of ECOCLIMAP-SG physiography in the ALARO CSC (c) Mario Hrastinski (first results!)

ECOCLIMAP SG mechanical roughness length differences if computed with or without the effective roughness length concept and the thermal roughness length.

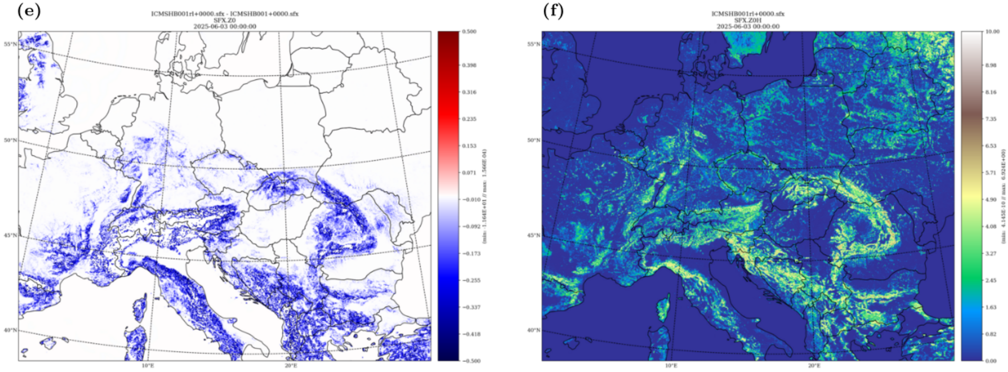

Figure: (e) the difference between (d) and (c). (f) z0h obtained from the ECOCLIMAP-SG data and multiplied with 10

Implementation of ECOCLIMAP-SG physiography in the ALARO CSC (c) Mario Hrastinski (first results!

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Summer(Fig), SG simulations are slightly warmer than those using II during daytime and cooler at nighttime. The impact of TEB is also more pronounced with SG.

Figure: Domain-averaged: (a) 2-m temperature for various experiments (see legend) and (b) corresponding differences relative to the reference based on the ISBA scheme, for the summer case 3 June 2025.

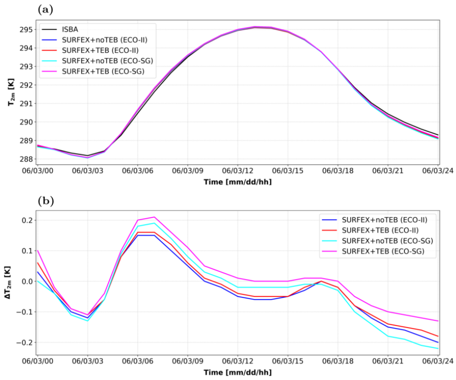

Figure: ...

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Implementation of ECOCLIMAP-SG physiography in the ALARO CSC (c) Mario Hrastinski (first results!

Need for re-tuning of the model when changing the phisiography? More detailed validation is required, focusing on LGARDEN=.TRUE.

Figure: Domain-averaged: (a) 10-m wind speed for various experiments (see legend) and (b) corresponding differences relative to the reference based on the ISBA scheme, for the summer case 3 June 2025.

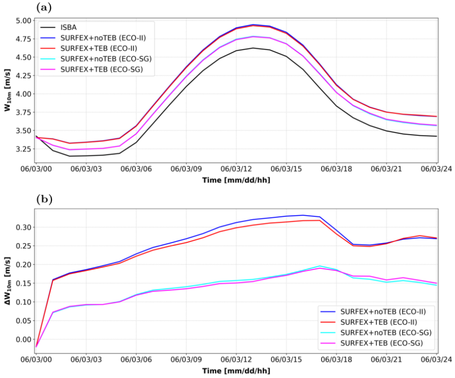

Figure: ...

Modifying the code to distinguish vertical levels 'seen' by dynamics and turbulence (c) Mario Hrastinski and Petra Smoliková - see physics session!

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Illustration of the proposed approach for safely lowering the first model level (KLEV) by (i) decoupling it from the forcing level in the turbulence scheme (KLEVTUR) and (ii) introducing an in - terpolation layer to ensure a non-zero near-surface tendency due to vertical turbulent diffusion. The red arrows indicate the variable nature of KLEVTUR, while the circles and "X" markers represent fluxes computed by the TOUCANS scheme and interpolated values, respectively. Tilded overbars de- note model half-levels.

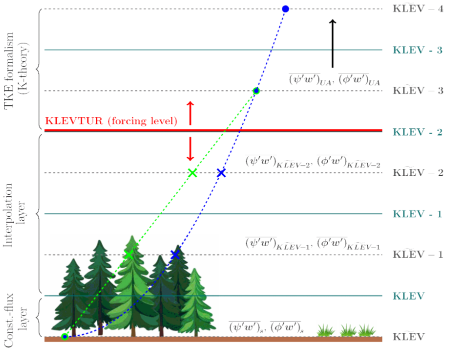

Figure: ...

Modifying the code to distinguish vertical levels 'seen' by dynamics and turbulence (c) Mario Hrastinski and Petra Smoliková - physics session!

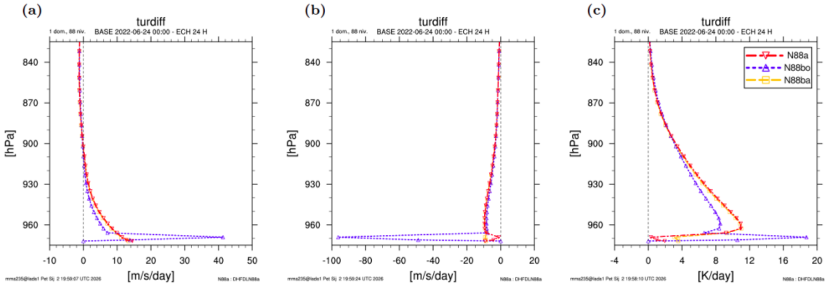

Figure: Domain-averaged vertical profiles of turbulent diffusion tendency after 24-h of integration in the summer convection case on 24 June 2022 for: (a) zonal wind, (b) meridional wind and (c) temperature. N88a, N88bo and N88ba correspond to KLEV = KLEVTUR=88 experiment (red), as well as original N88b (blue) and adjusted N88b experiments (orange) with KLEV ¡ KLEVTUR, respectively.

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Thank you for your attention.

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