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Restart of regional climate modeling at CHMI

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with great thanks to many colleagues from inside/outside CHMI

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Introduction

- **R**egional **C**limate **M**odeling at CHMI was paused for nearly one decade.
- During that time, NWP version of model ALADIN/CHMI reached convection permitting resolution.
- In 2020, RCM activities were restarted within arising PERUN project, targeted on climate change impact for Czech Republic.
- To facilitate high resolution RCM, CHMI procured a new computer NEC SX Aurora TSUBASA (48 nodes x 8 VEs x 8 CPUs).
- It was decided to redevelop climate production line from scratch, catching up with convection permitting NWP model configuration.
- First climate run on the new computer was launched in 10/2021.

Strategy

- Exploit **well tuned NWP version** of so called ALARO canonical model configuration of the ALADIN system.
- Use the **same domain and resolution.**
- Make **minimal adaptations** necessary for meaningful climate simulations:
  - replace force-restore method for heat transfer in the soil by option with 4 soil levels;
  - at restart instants update prescribed physiography fields that have annual variation, and take SST from the driving system;
  - scale greenhouse gases consistently with driving scenario.
- Couple directly to global system, with **no intermediate model.**

Driving global systems

System	**ERA5**	**CNRM-ESM2-1**
Truncation	TL639	TL127
Horizontal mesh size	31 km	156 km
Atmospheric levels	137	91
Output frequency	3 h	6 h
Mode	reanalysis	free run without observations
Period	past	past & future
Reproduces weather of the day	yes	no

Simulation types

Driven by ERA5:

Reanalysis run – past weather (1989–present)

- 6 h cycle with CANARI surface analysis and upper air blending
- 30 h integrations launched at 00 UTC
- 2L ISBA scheme (force-restore as in operations)

Evaluation run – past weather (1989–present)

- no data assimilation/blending, 4L ISBA scheme
- chain of 10-day integrations with freely evolving surface

Driven by CNRM-ESM2-1:

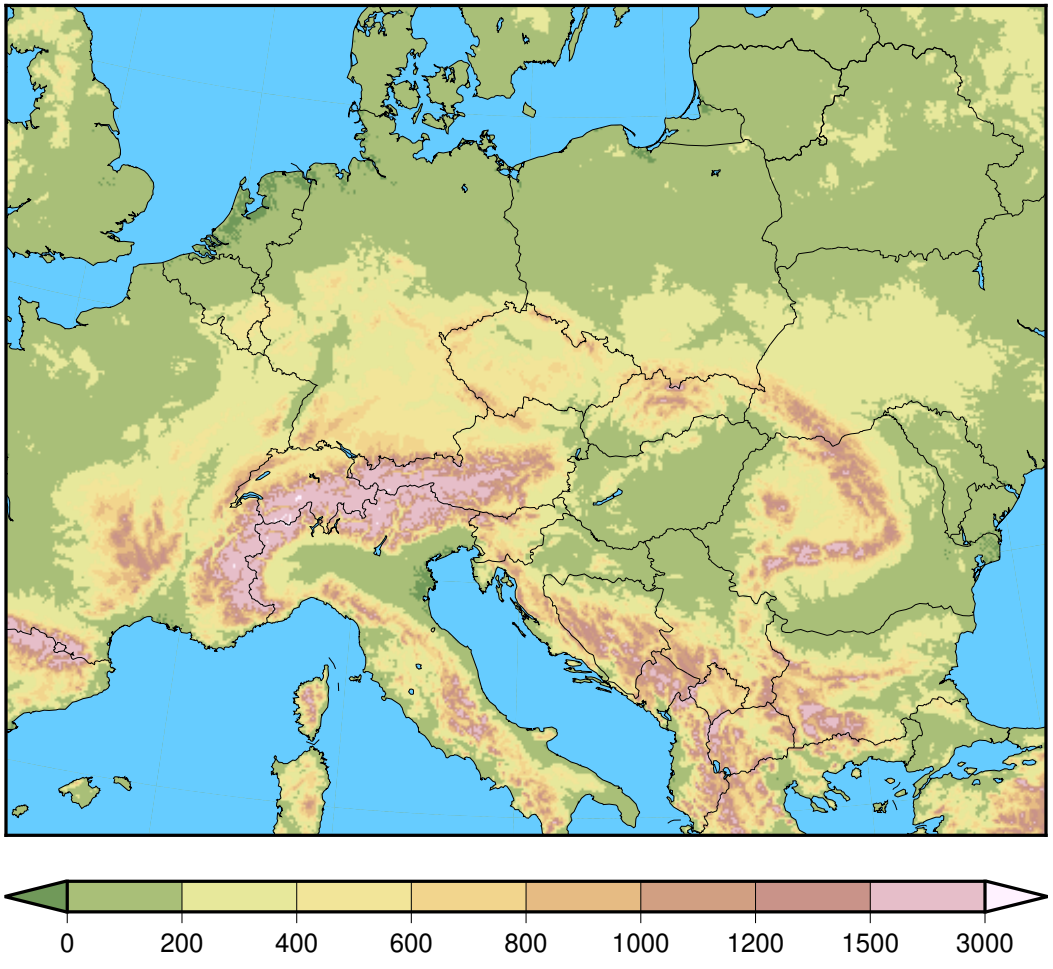
Historical run – past climate (1976–2014)

- same as evaluation run, different driving system

Scenario run – future climate (2015–2100)

- same as historical run, chosen CMIP6 climate scenario
- so far calculated for SSP1-2.6, SSP2-4.5 and SSP5-8.5

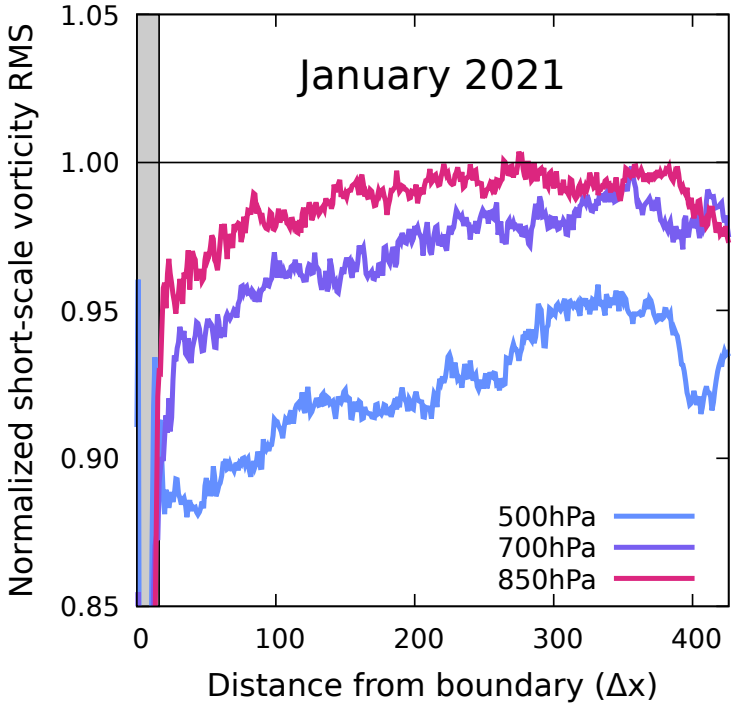
Integration domain

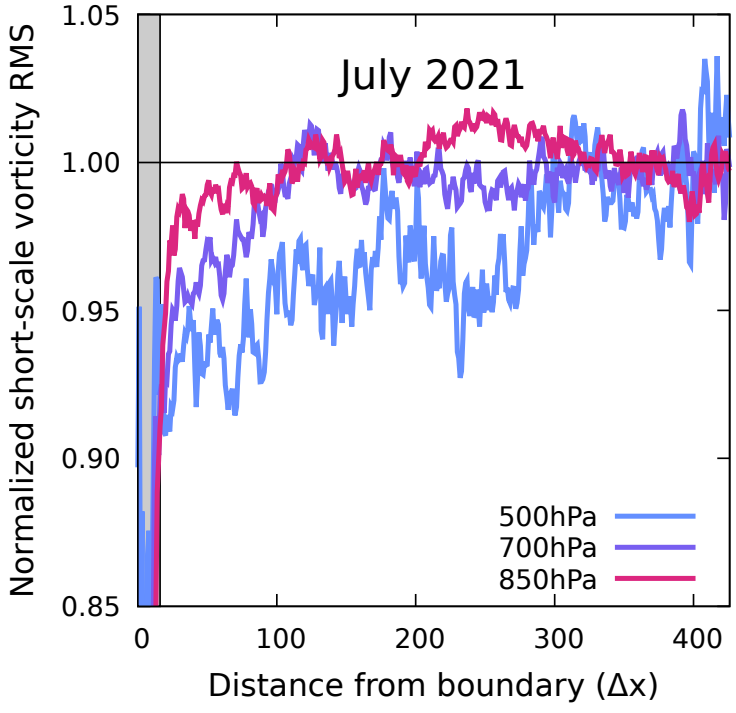


Neither too big, nor too small:
1080 $\times$ 864 grid-points
linear truncation (E539 $\times$ 431)
quadratic orography (E359 $\times$ 287)
11 point wide extension zone
16 point wide coupling zone
$\Delta x = 2.3$ km, 87 vertical levels

Creation of small scales by spatial spin-up

- Direct coupling to system CNRM-ESM2-1 is a challenge, because our **RCM resolution is higher by factor 67!**
- **Domain must be large enough** to create correct short scales in the region of interest ⇒ verified using little sisters experiment:





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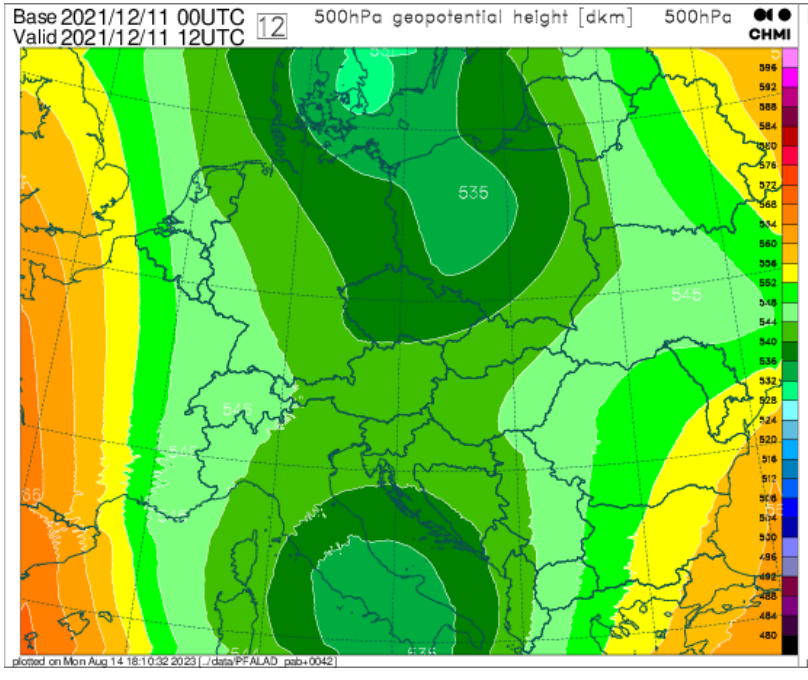
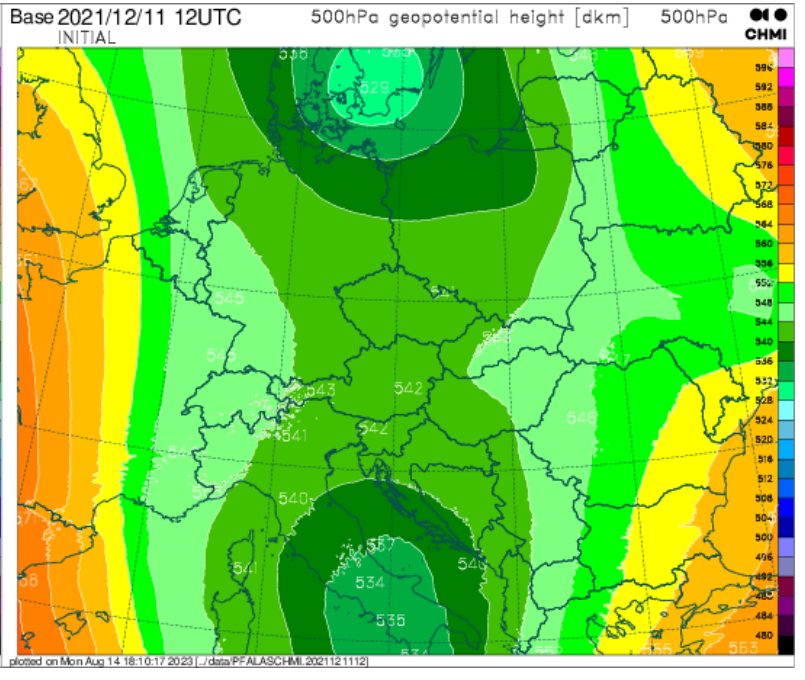
Control of large scales via lateral coupling

- Our intention is to **avoid spectral nudging,** not to affect internal solution created by high-resolution model dynamics and physics.
- Then, **domain should be small enough** to prevent large-scale drift from driving solution ⇒ verified using little sisters experiment:

run driven by filtered analyses



verifying unfiltered analysis



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Model configuration (first version)

NH dynamical kernel:

- fully compressible Euler equations, spectral/VFD discretization
- 2TL iterated centered-implicit scheme, 1 iteration, time-step 90 s
- semi-Lagrangian advection, non-linear horizontal diffusion

ALARO-1 physics:

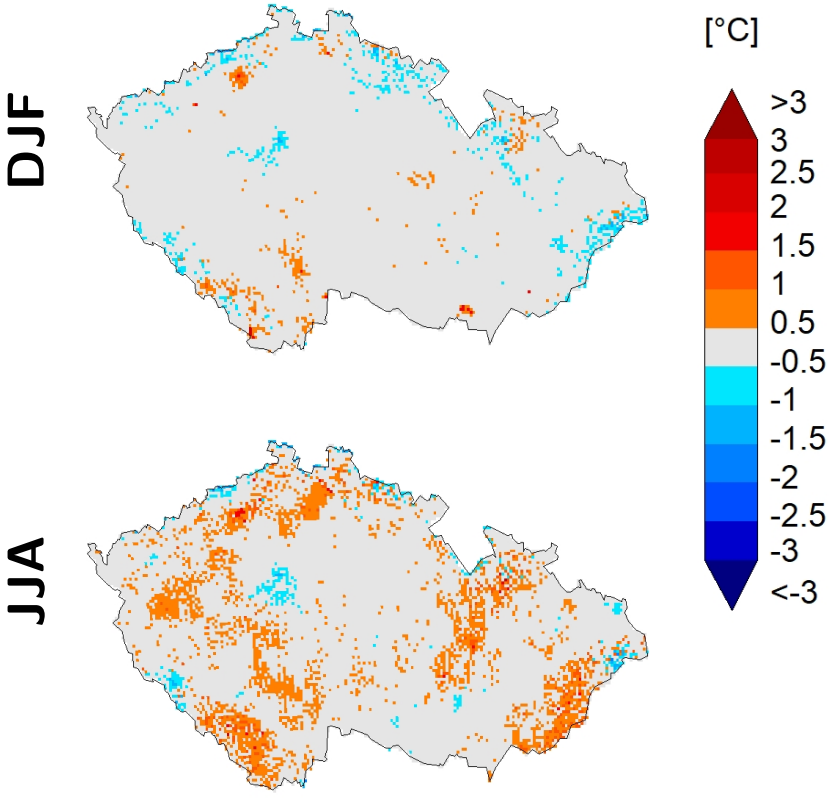
- 2L/4L ISBA surface scheme
- TOUCANS turbulence with two prognostic energies, TKE & TTE
- ACRANEB2 broadband radiation with selective intermittency
- 3MT moist deep convection parameterization still on
- prognostic graupel not yet activated
- family of GWD parameterizations off

Physiography:

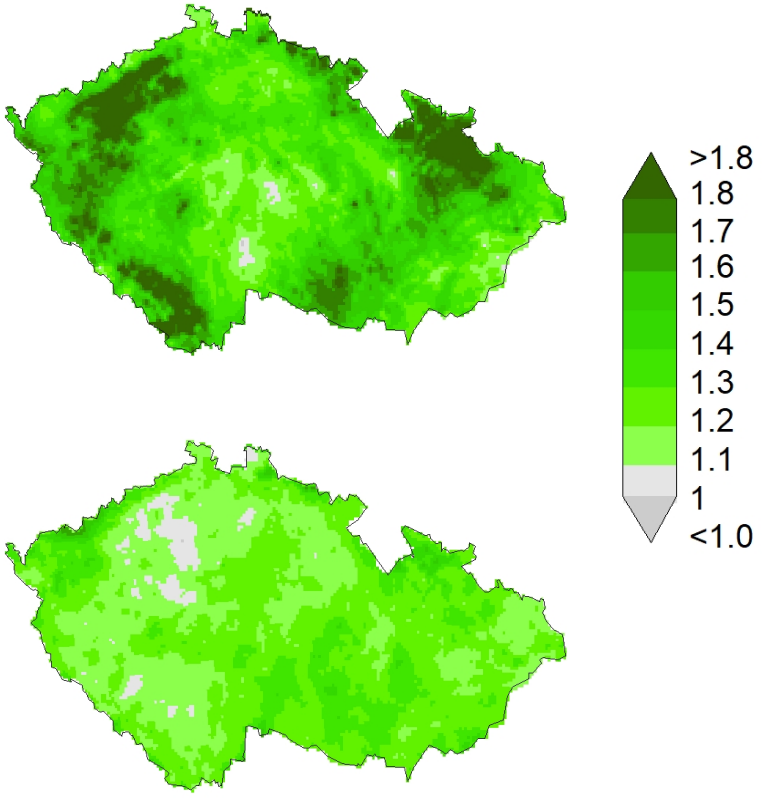
- topography & orographic roughness length from GMTED2010 7.5”
- vegetation roughness length from ECOCLIMAP II
- other physiography fields still taken from older datasets
- present day aerosols (Tegen et al. 1997) and ozone

Results: Bias of **reanalysis run** against CZ stations, 1995–2014

Daily 2m temperature bias (268 stations)



Precipitation relative bias (787 stations)



Figures by Romana Beranová

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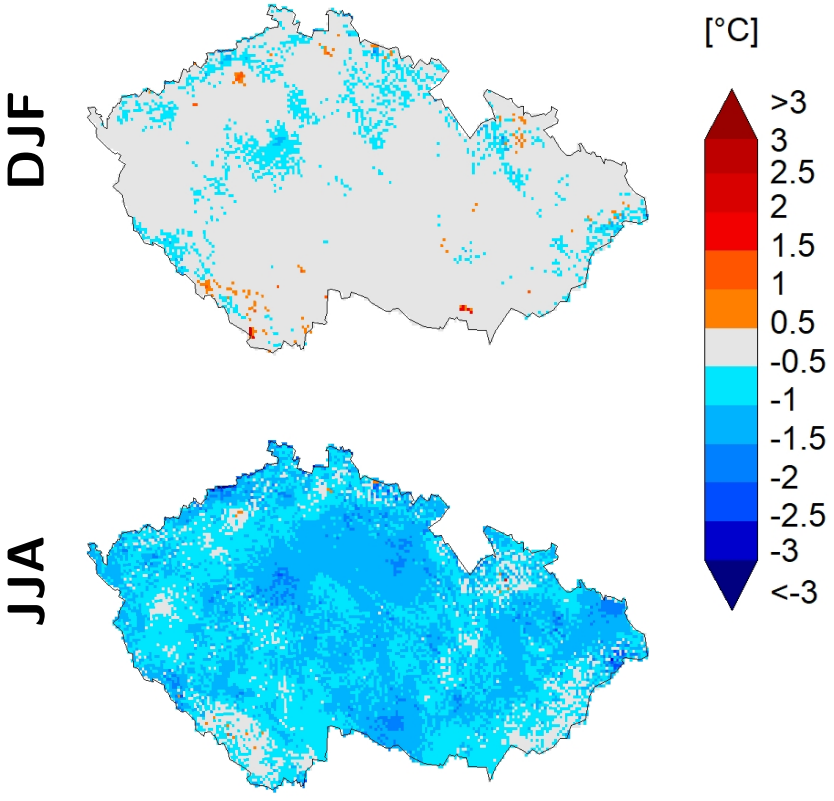
Results: Bias of **evaluation run** against CZ stations, 1995–2014

Daily 2m temperature bias (268 stations)



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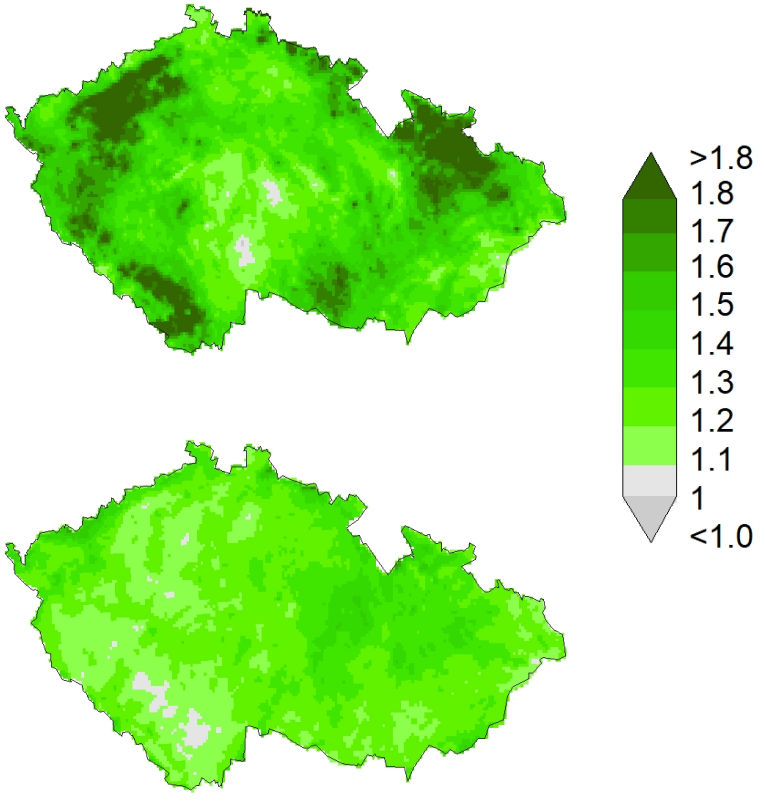

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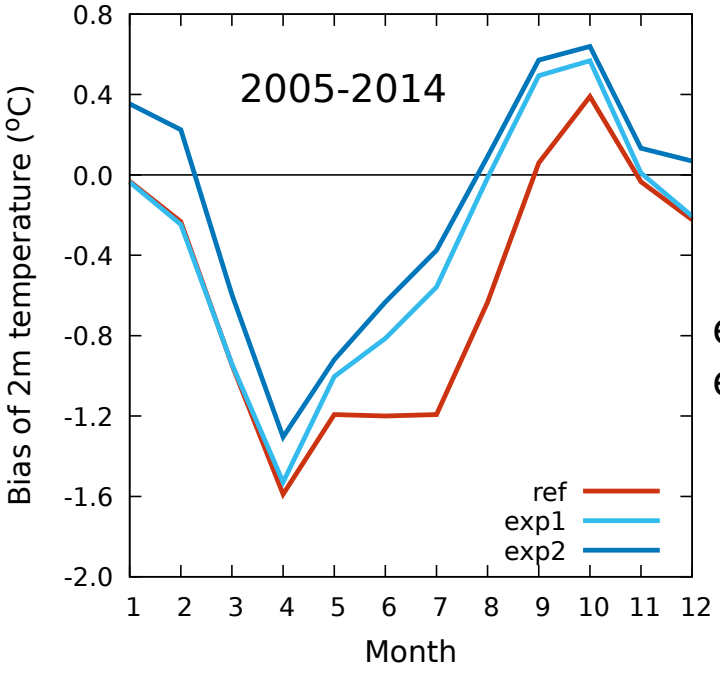
Challenges of NWP → RCM approach

- **Consistency with global driving system,** limited by reduced complexity of NWP-like RCM.
- **Control of biases** in simulations with freely evolving surface:



ref: evaluation run
exp1: ref + soil depth reduced by 30%
exp2: exp1 + improved ALARO-1 physics

Plans

- Second version of RCM configuration is in preparation, it will contain **improved ALARO-1 physics:**
  - prognostic graupel;
  - Lopez evaporation;
  - revised impact of snow on vegetation roughness length, etc.
- In historical and scenario runs, present day **aerosols and ozone** will be replaced by those **from driving system CNRM-ESM2-1.**
- Key issue will be **switch of ALARO-1 to SURFEX** scheme with:
  - ECOCLIMAP II physiography;
  - 2 or 3 nature patches;
  - 14L diffuse ISBA scheme;
  - 12L or 6L explicit snow scheme;
  - TEB scheme for urban areas;
  - ECUME parameterization of sea fluxes;
  - FLAKE scheme for lakes.

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