

## Status of ALARO with SURFEX

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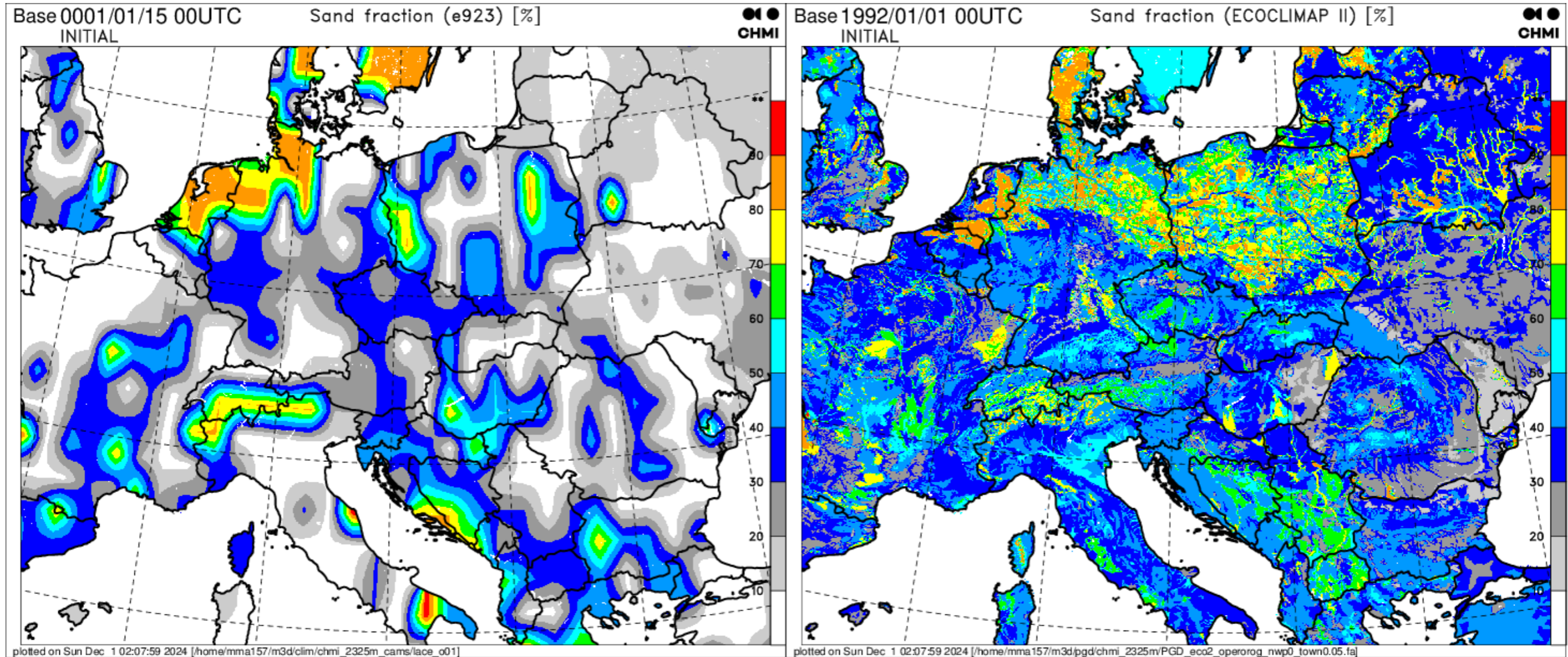
# Introduction

- ALARO developments, focusing on atmospheric physics, were build on old ISBA scheme.
- Underlying e923 physiography is outdated, surely not suitable for kilometric resolutions.
- Story of ALARO with SURFEX began already 10 years ago, in order to benefit from:
  - 1) modern, high resolution ECOCLIMAP physiography;
  - 2) advanced schemes available in SURFEX, relevant for NWP.
- Replacement of the surface scheme in mature NWP model is far from trivial. It comprises several challenges: interfacing, scientific consistency, numerical safety, tuning.
- On our way, we were helped many times by more experienced ACCORD colleagues, and by the SURFEX support team. Thanks to them, we now see the light at the end of tunnel! 😊  
Special credits go to Patrick Le Moigne, Adrien Napoly, and Patrick Samuelsson for all their explanations, advices, time, and patience.

# Why new physiography: Fraction of sand

e923

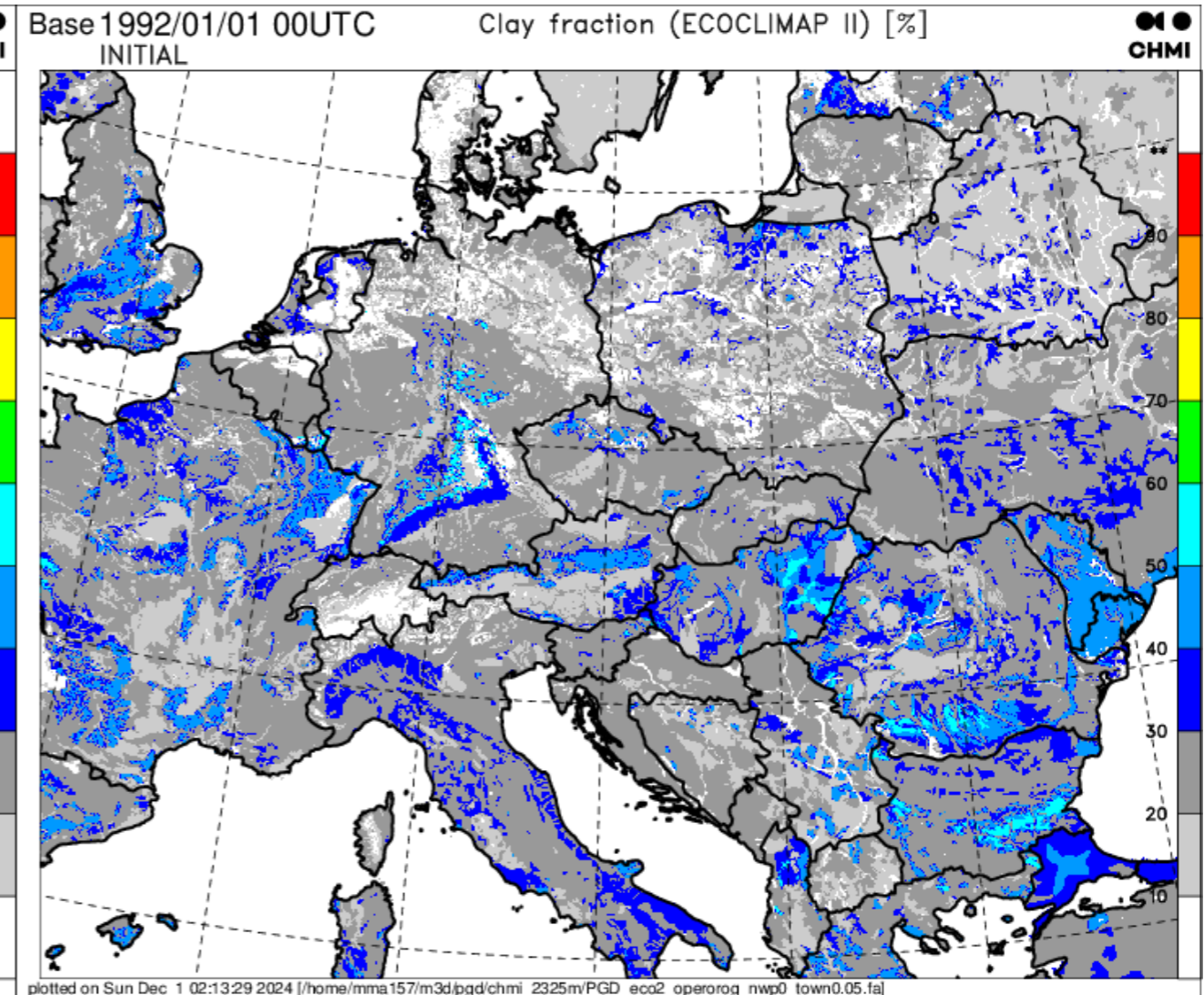
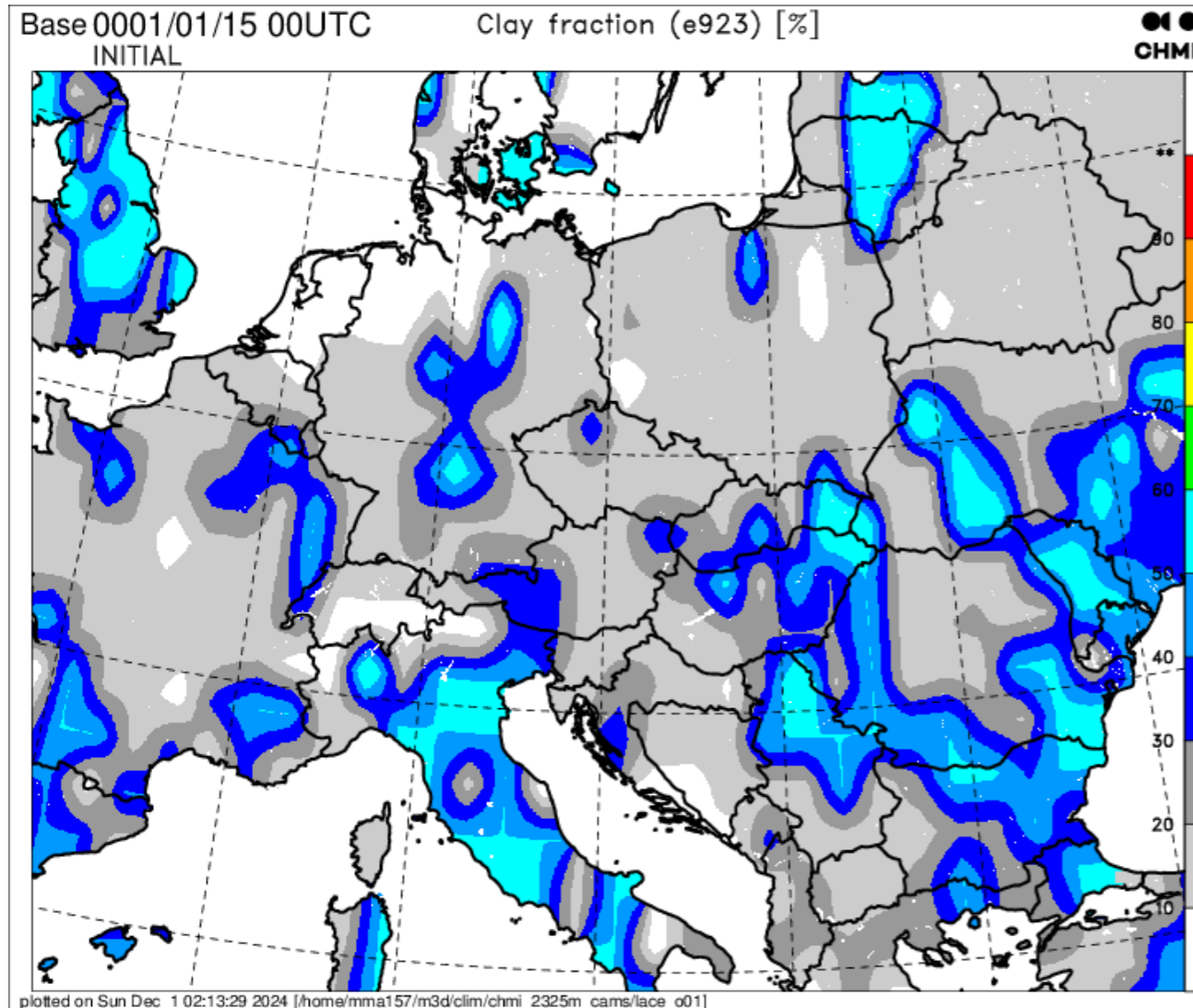
HWSD v2.01



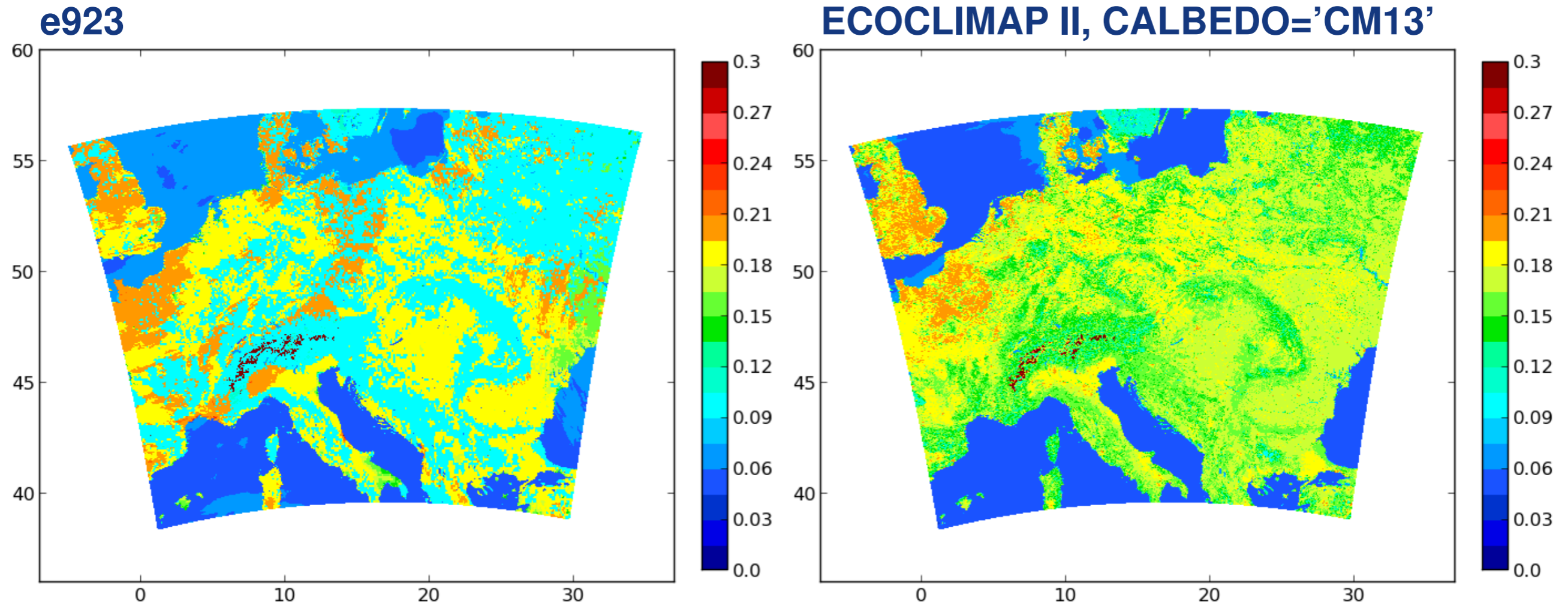
# Why new physiography: Fraction of clay

e923

HWSD v2.01



# Why new physiography: Surface albedo



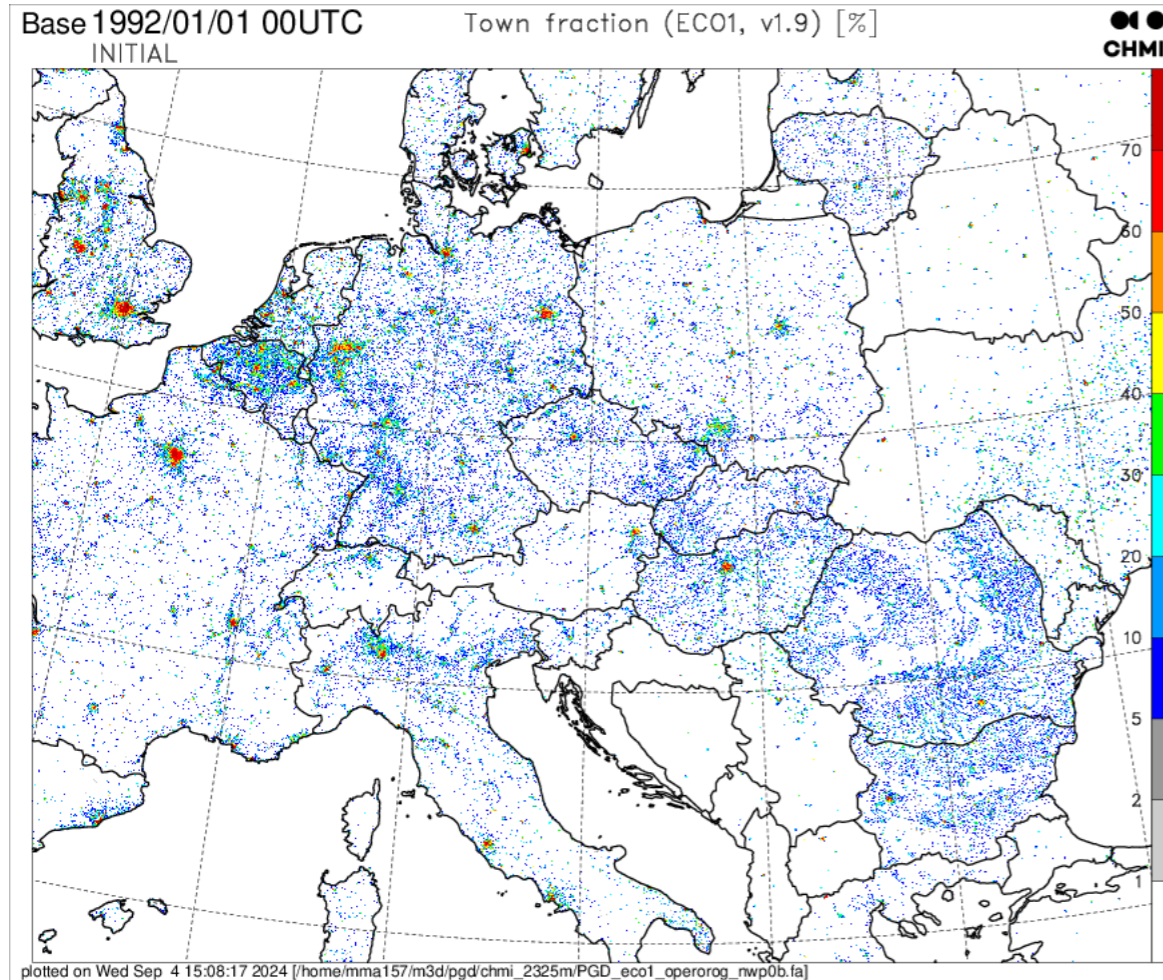
*Blue-sky albedo diagnosed as reflected to incoming cumulated SW flux. 15th June 2024.*

# Roadmap

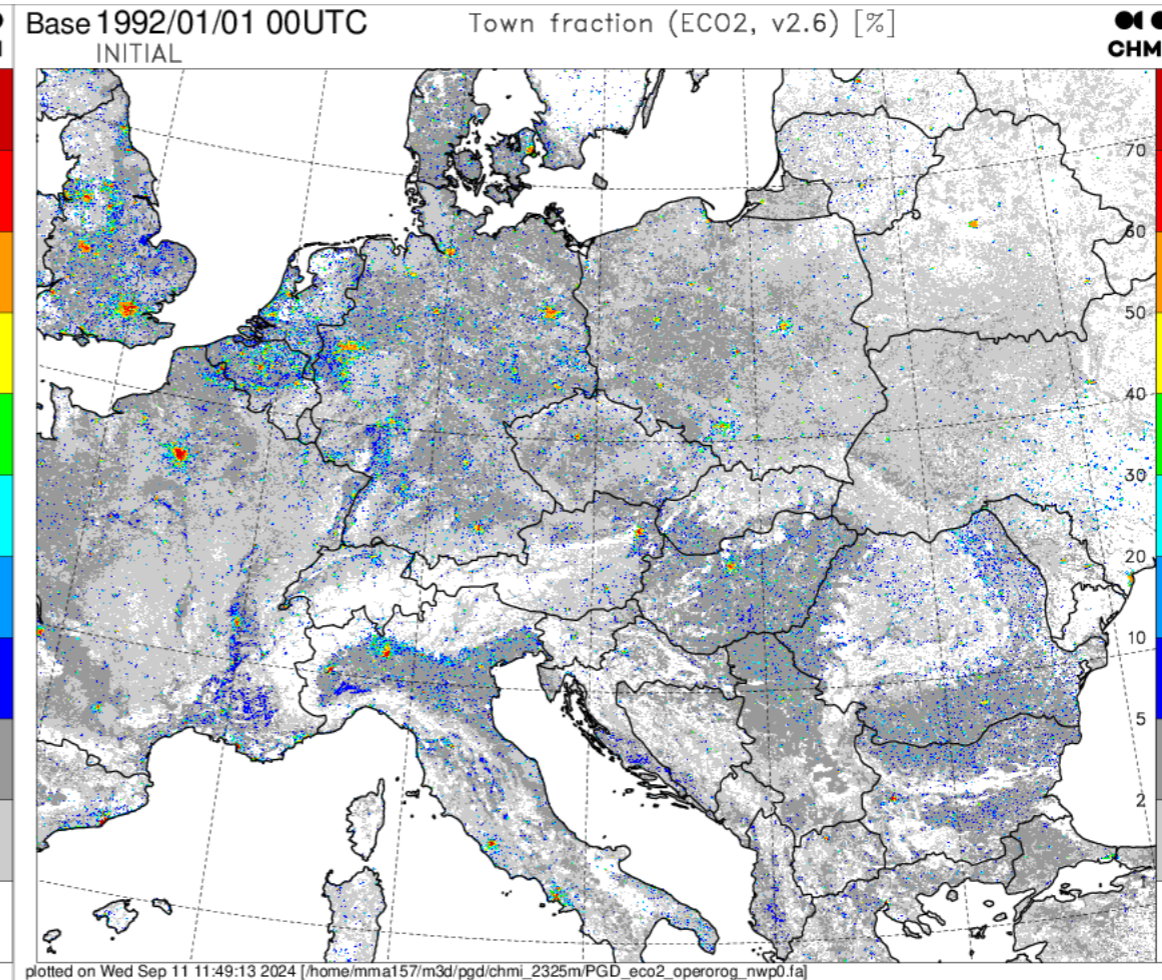
- **Step 1:** Smooth scientific transition of ALARO from old ISBA to SURFEX. **[DONE]**
  - We reached a point where the differences could not be further diminished due to different underlying physiographies.
  - Full import of SURFEX physiography to old ISBA was not worth the effort. It was done only for roughness lengths and subgrid-scale orography characteristics.
  - Transition exercise was useful, revealing most striking inconsistencies on code and setup levels. Moreover, during the SURFEX code inspection we became familiar with it a bit.
- **Step 2:** Activation of NWP attractive SURFEX options, not available in old ISBA. Making them technically working with ALARO. **[MOSTLY DONE]**
- **Step 3:** Tuning of ALARO with SURFEX, outperforming ALARO with old ISBA. **[STARTED]**
- **Step 4:** Creating data assimilation suite with SURFEX. **[TO BE DONE]**

# General problems: Fraction of town (1)

## ECOCLIMAP I



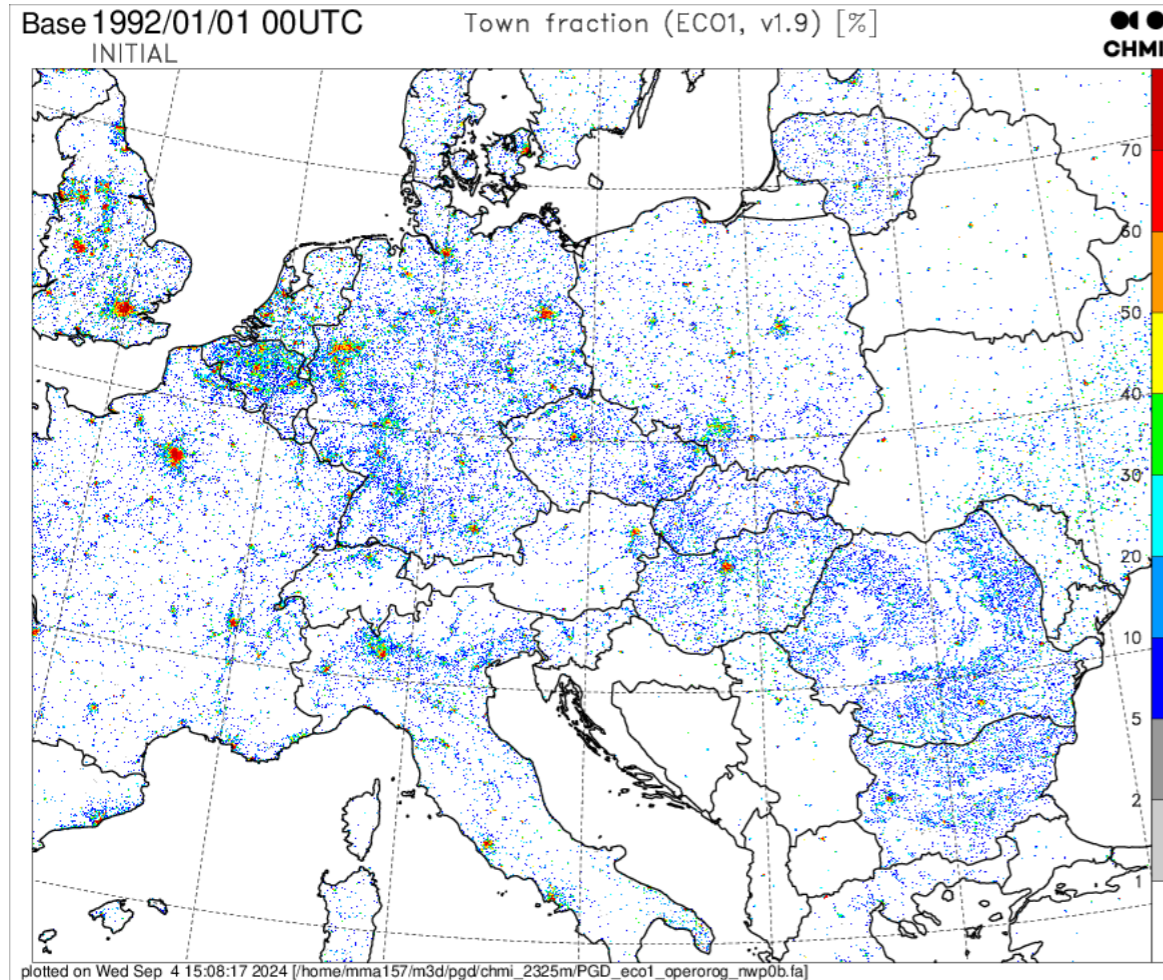
## ECOCLIMAP II



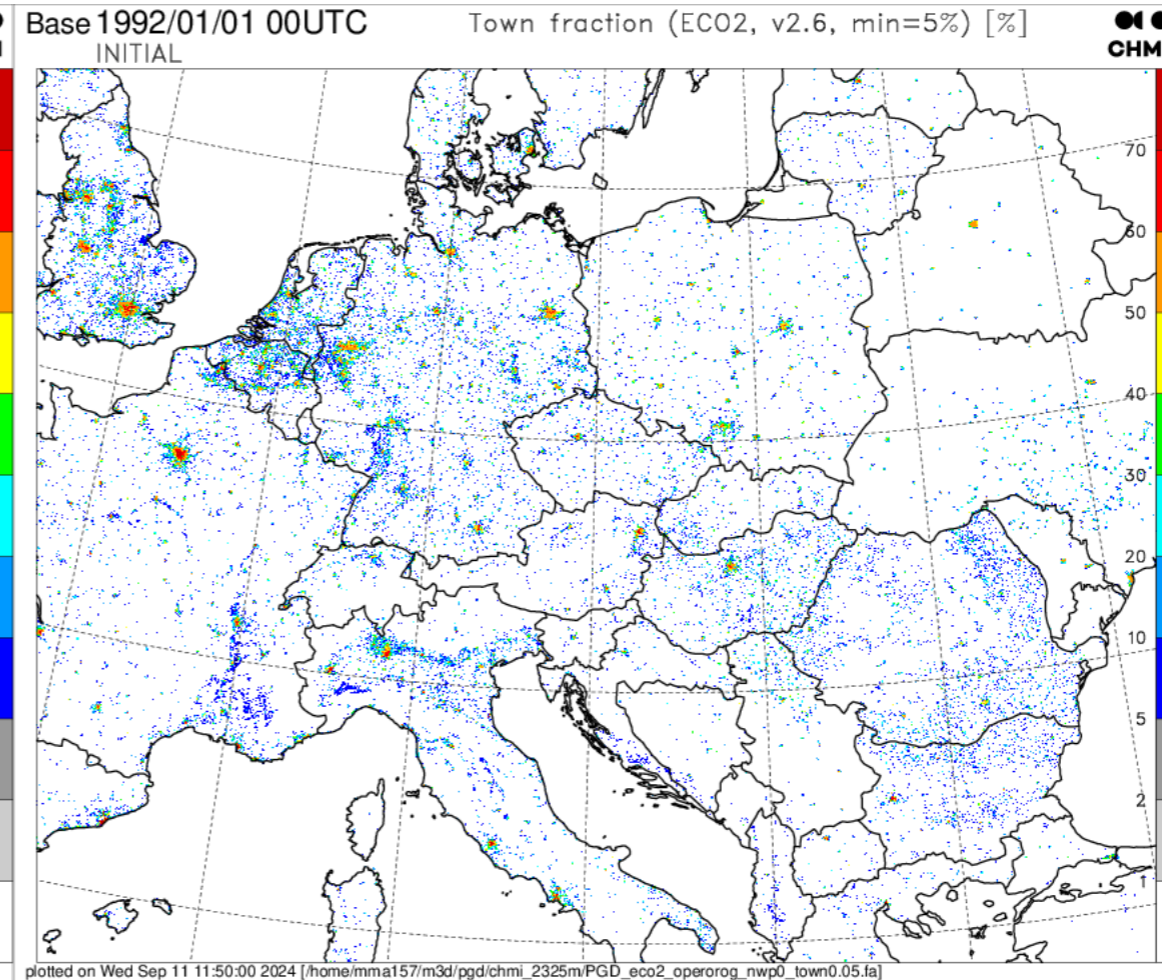
*ECOCLIMAP II values are suspicious, most of domain has town fractions 1–5%.*

# General problems: Fraction of town (2)

## ECOCLIMAP I



## ECOCLIMAP II, filtered values < 5%

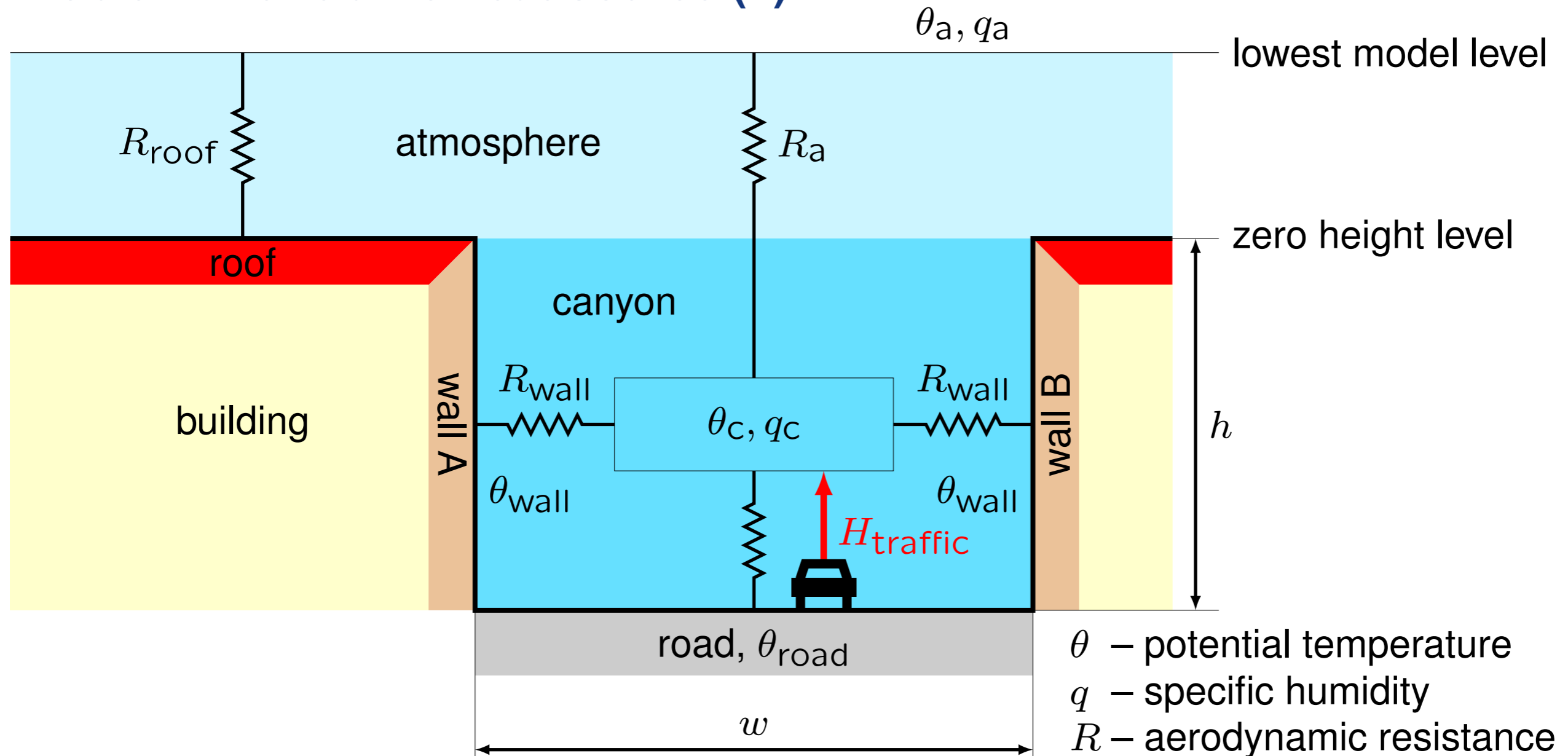


*Adopted solution is to convert ECOCLIMAP II town fractions smaller than 5% to nature.*

# ALARO specific problems

- SURFEX in ALARO is interfaced to TOUCANS turbulence and ACRANE2 radiation.
- This was source of specific problems related to:
  - use of single short-wave spectral band in ACRANE2;
  - inclusion of orographic roughness length on the patch level;
  - different shape of TOUCANS stability functions;
  - much finer TOUCANS protection of aerodynamic conductances against too small values;
  - long ALARO time-step length combined with time-explicit SURFEX schemes.
- Some problems are consequence of SURFEX discretization issues. Due to different choices, they can be masked or escaped in (HARMONIE-)AROME and ARPEGE.
- Most of the problems in ALARO+SURFEX were fixed or bypassed, few are still pending.

# Problem with traffic heat source (1)



## Problem with traffic heat source (2)

- By default, TEB assumes constant heat source from traffic between 6:00 and 18:00 local time:

$$\frac{\theta_c - \theta_a}{R_{\text{top}}} = \frac{\theta_{\text{road}} - \theta_c}{R_{\text{road}}} + \frac{2h}{w} \cdot \frac{\theta_{\text{wall}} - \theta_c}{R_{\text{wall}}} + \frac{H_{\text{traffic}}}{c_p \rho a}$$
$$\theta_c = \left[ \frac{\theta_a}{R_{\text{top}}} + \frac{\theta_{\text{road}}}{R_{\text{road}}} + \frac{2h}{w} \cdot \frac{\theta_{\text{wall}}}{R_{\text{wall}}} + \frac{H_{\text{traffic}}}{c_p \rho a} \right] / \left[ \frac{1}{R_{\text{top}}} + \frac{1}{R_{\text{road}}} + \frac{2h}{w} \cdot \frac{1}{R_{\text{wall}}} \right]$$

- Canyon potential temperature  $\theta_c$  is a **weighted average** of  $\theta_a$ ,  $\theta_{\text{road}}$  and  $\theta_{\text{wall}}$  (safe), plus an **additional term**  $(\Delta\theta_c)_{\text{traffic}}$  (problematic).
- In strongly stable stratification,  $(\Delta\theta_c)_{\text{traffic}}$  can reach 100 K or more, resulting in canyon temperature  $T_c \sim 400$  K. For such unmeteorological  $T_c$ , model saturation function returns negative value  $\Rightarrow$  removal of supersaturation yields canyon specific humidity  $q_c < 0$ !
- For  $H_{\text{traffic}} > 0$ , road aerodynamic resistance should be limited so that term  $(\Delta\theta_c)_{\text{traffic}}$  remains realistic. Currently we bypass the problem by setting traffic sources to zero.

# Code status

- **SURFEX v8.0+:**
  - all ALARO+SURFEX modifications available in local Prague **cy46t1mp\_op3sfx**;
  - all but 2 latest fixes are available in operational Prague **cy46t1as\_op1**.
- **SURFEX v8.1+:**
  - first set of fixes (roughness length averaging, TOUCANS stability functions, moist gustiness correction, LCLS\_TOUCANS, LZ0SNOWH\_ARP) available in official IAL **cy49t1**;
  - second set of fixes (LCLS\_TOUCANS in time-step zero, LZ0SNOWH\_ARP for multi-layer snow schemes, TEB with TOUCANS) submitted to IAL **cy49t2\_bf**, re-submission is asked;
  - ALARO+SURFEX modifications backphased on top of **cy48t3\_bf.03** not debugged yet.
- **SURFEX v9:** Phasing of ALARO+SURFEX modifications not agreed yet.

# Candidate NWP configuration in short

- To be on a safe side, we based our starting NWP SURFEX configuration on MF AROME.
- We adjusted it to our wishes/constraints, taking into account advice from SURFEX experts:
  - ECOCLIMAP II physiography, HWSD soil maps, satellite based albedo map;
  - ISBA 3L force-restore scheme with 3 patches, D95 snow scheme;
  - TEB with building energy model (BEM) and garden option;
  - ECUME sea fluxes (instead of ECUME6) and FLAKE model (with care).
- Tuning of orographic and vegetation roughness lengths is domain specific  $\Rightarrow$  do it yourself. 😊
- Some desired options/combinations are not yet working in ALARO:
  - i) **LORORAD=T**; ii) **LGARDEN=T** combined with **CALBEDO='CM13'**.

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Color key: **PGD**, **PREP**, **SURFEX** integration

# Candidate NWP configuration in detail

- Proposal for cy46t1mp\_op3sfx with SURFEX v8.0+:
  - **physiography:** ECOCLIMAP II v2.6 with filtered fraction of town, CALBEDO='CM13';
  - **sea tile:** CSEA='SEAFLX', CSEA\_FLUX='ECUME';
  - **inland water tile:** CWATER='FLAKE', LRM\_RIVER=T;
  - **nature tile:** CISBA='3-L', NPATCH=3, CSNOW='D95', XTAU\_SMELT=0, LZ0SNOWH\_ARP=T, CSCOND='NP89';
  - **urban tile:** CTOWN='TEB', LTOWN\_TO\_ROCK=F, LGARDEN=T, XUNIF\_H\_TRAFFIC=0, XUNIF\_LE\_TRAFFIC=0, CCH\_BEM='DOE-2';
  - **common:** CCOUPLING='I', LZ0\_AVG\_EXACT=T, LZ0\_EFF=T, LDRAG\_COEF\_ARP=T, LALDTHRES=T, LCLS\_TOUCANS=T, N2M=0.

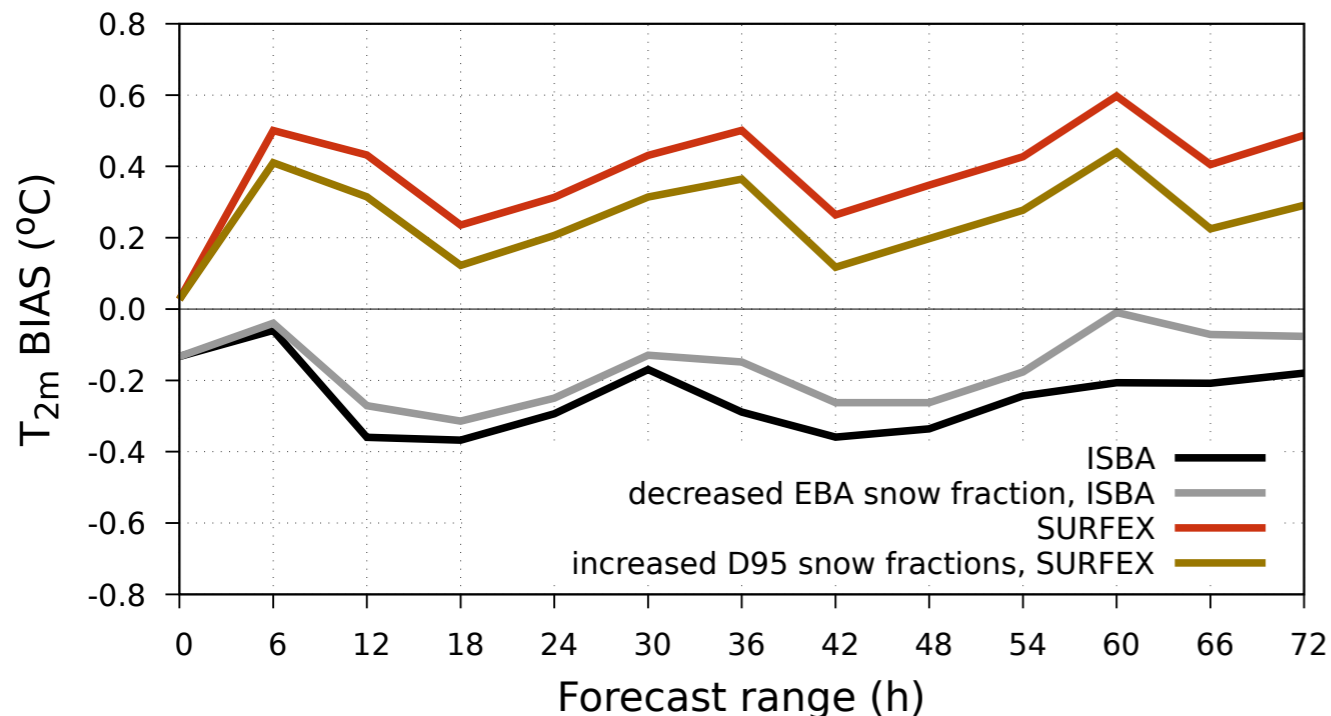
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Color key: PGD, PREP, SURFEX integration

# Verification: Winter period with much snow

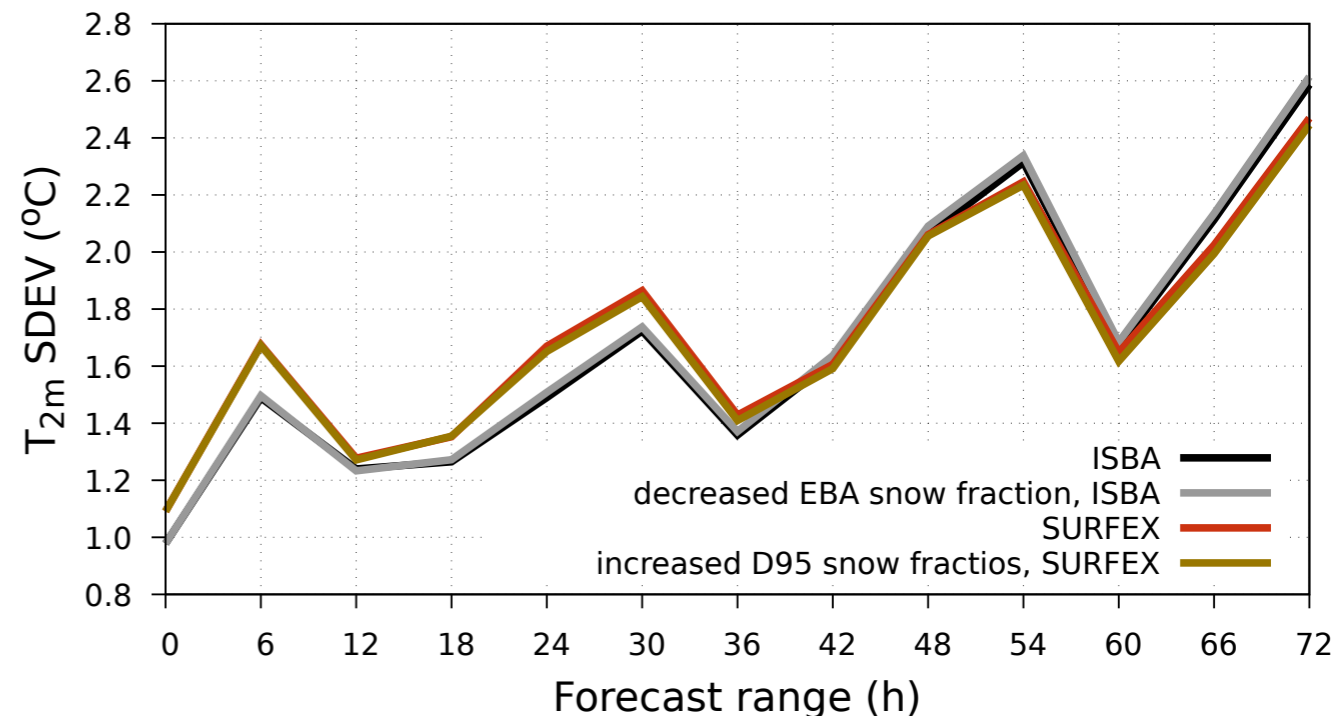
## BIAS of 2m temperature

Period: 12-14 January 2021



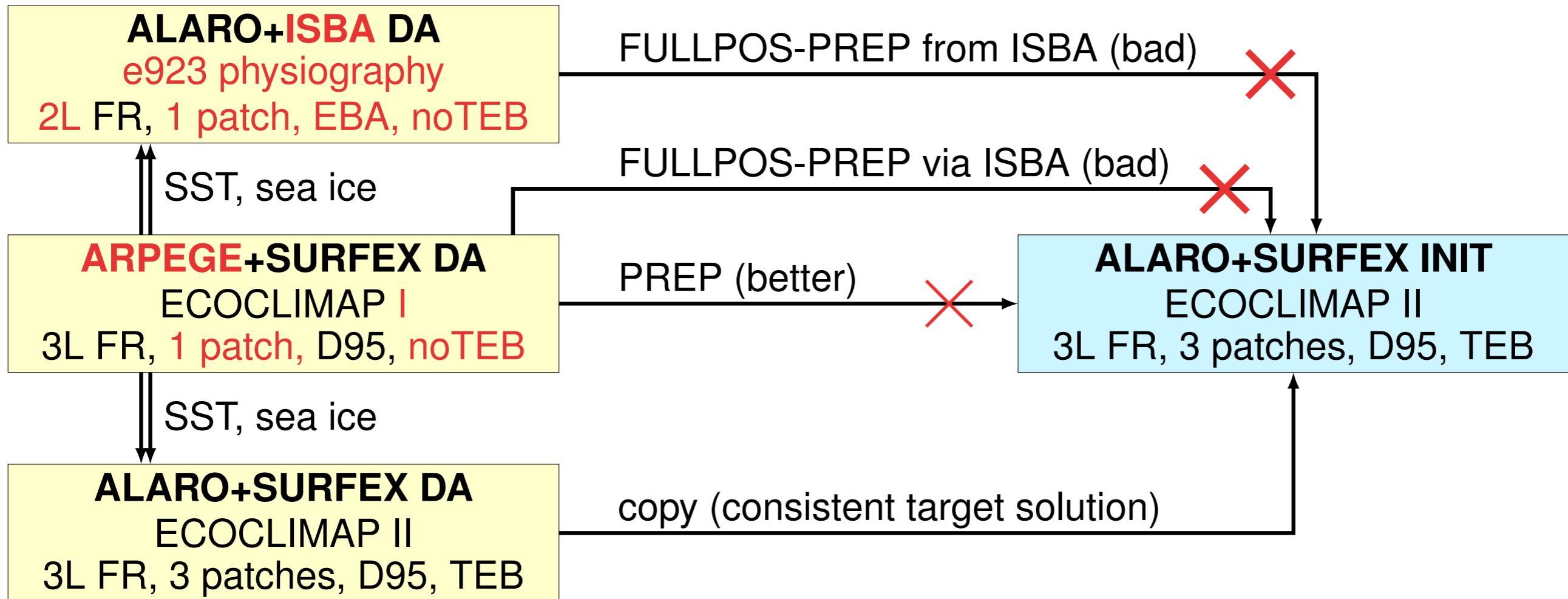
## SDEV of 2m temperature

Period: 12-14 January 2021



*SURFEX run is much warmer than ISBA reference (left panel: red versus black). To bring the biases closer, snow fractions in ISBA/SURFEX run were modified by doubling/halving the critical amount of snow (left panel: gray/brown). D95 snow melt limitation is off.*

# Surface initialization

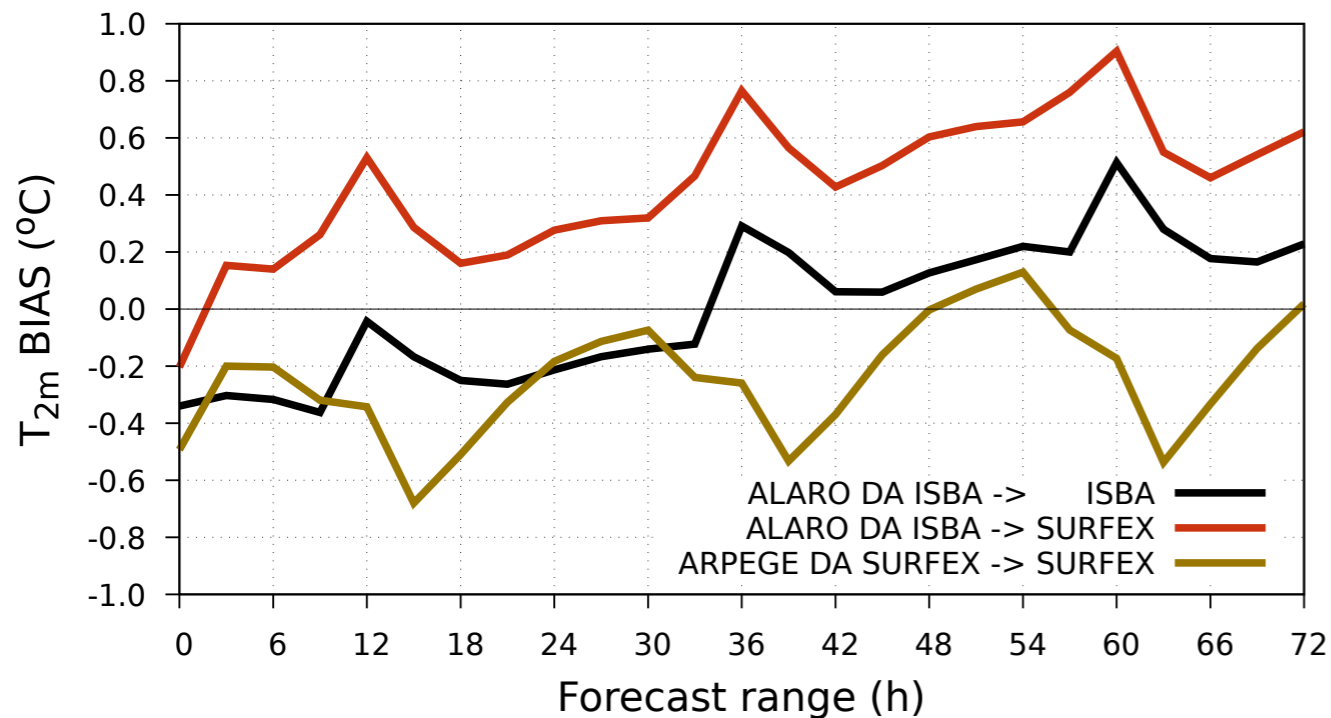


*Discrepancies between DA and forecast configurations are in red color.*

# Verification: Winter period with little snow (1)

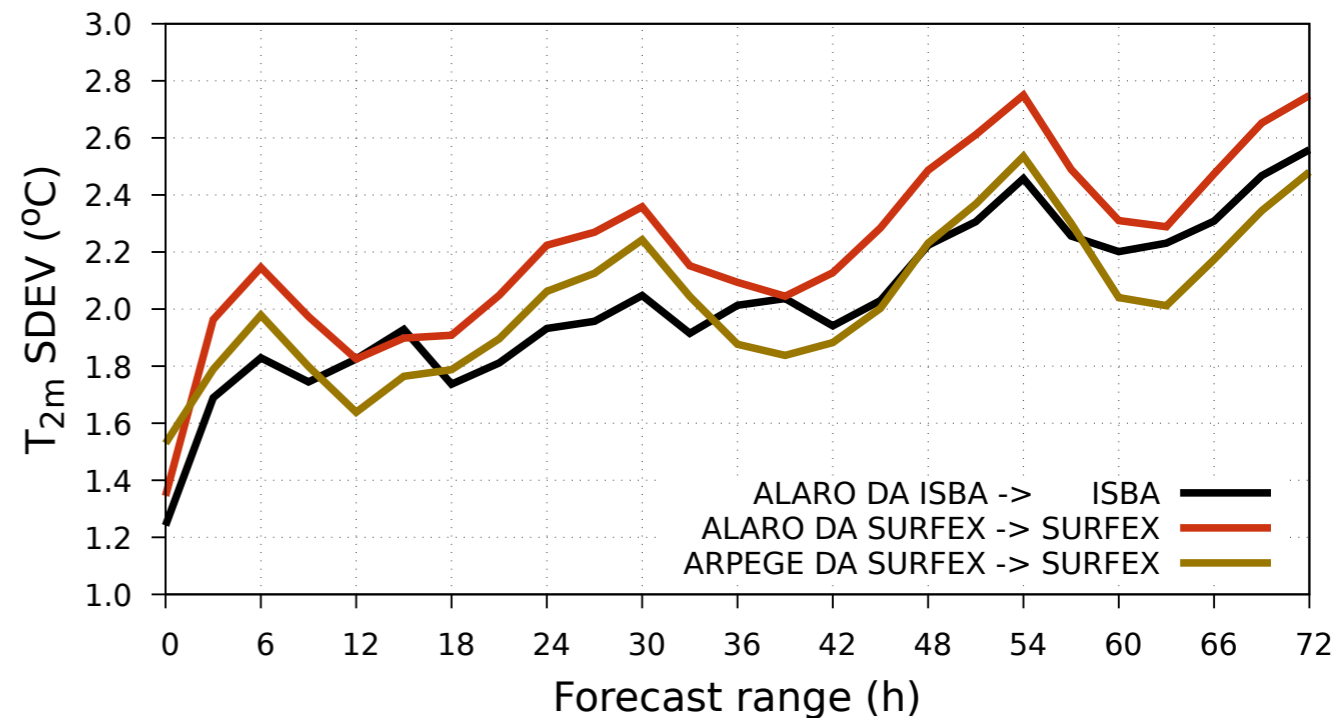
## BIAS of 2m temperature

Period: 03-05 February 2024



## SDEV of 2m temperature

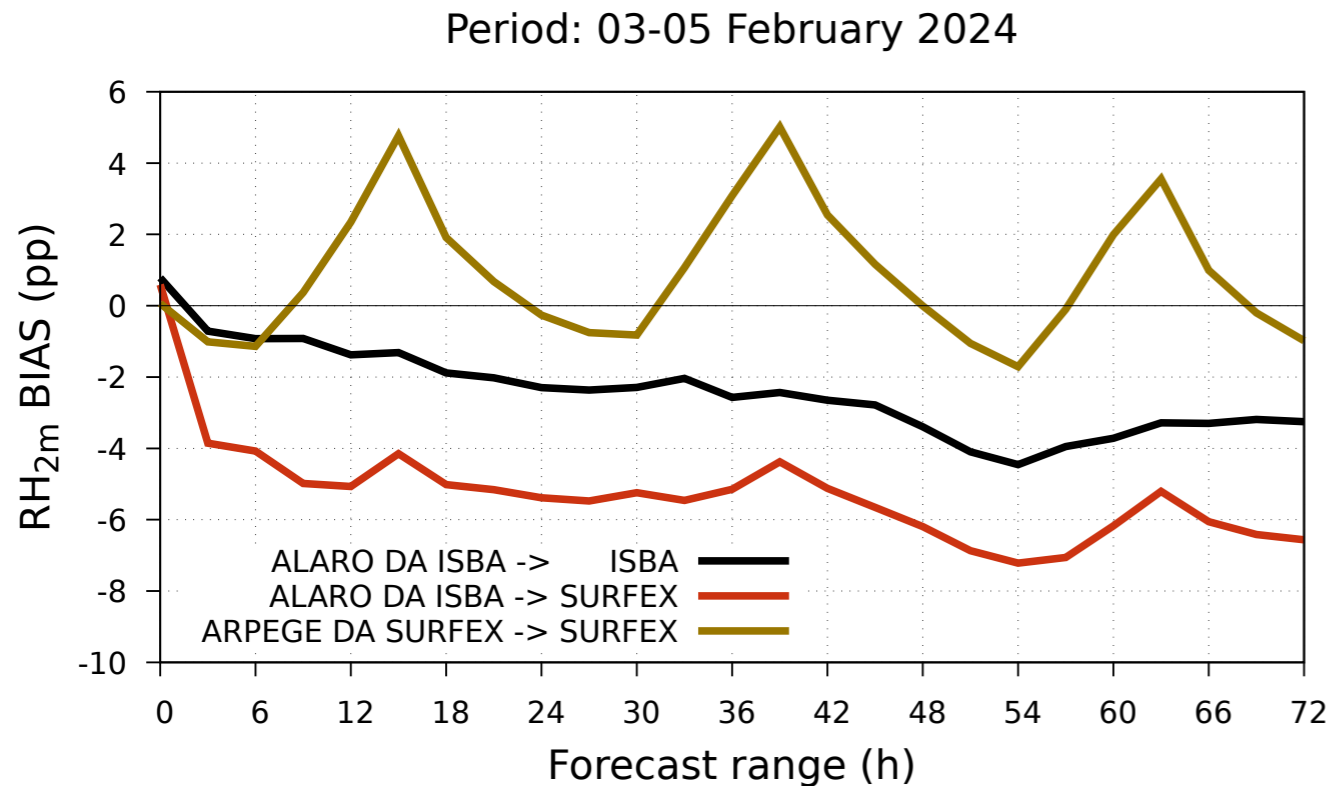
Period: 03-05 February 2024



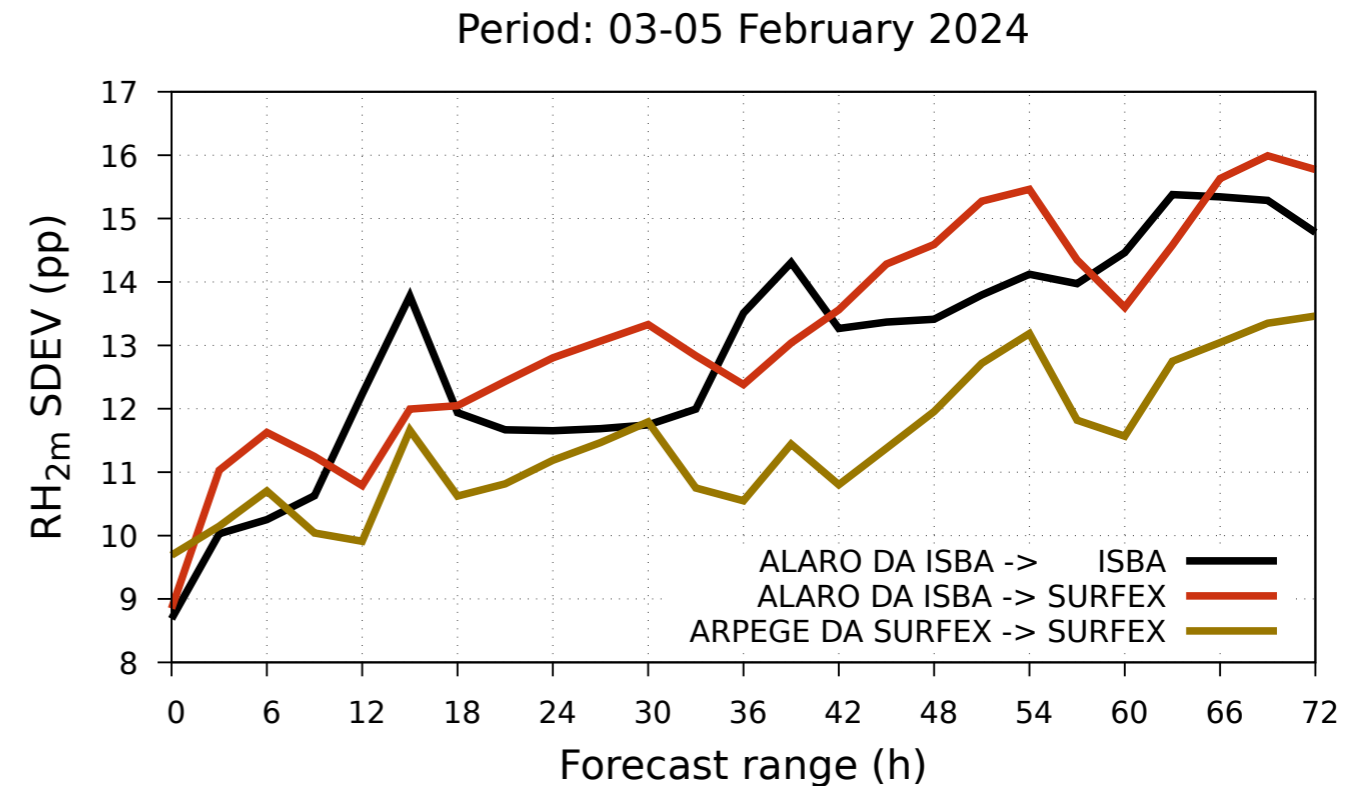
*SURFEX run initialized from ALARO+ISBA DA suffers from significant warm bias due to too dry soil (left panel: red versus black). Initialization from ARPEGE+SURFEX DA helps, reducing also random error (right panel: brown versus red). Garden option is off.*

# Verification: Winter period with little snow (2)

## BIAS of 2m relative humidity



## SDEV of 2m relative humidity



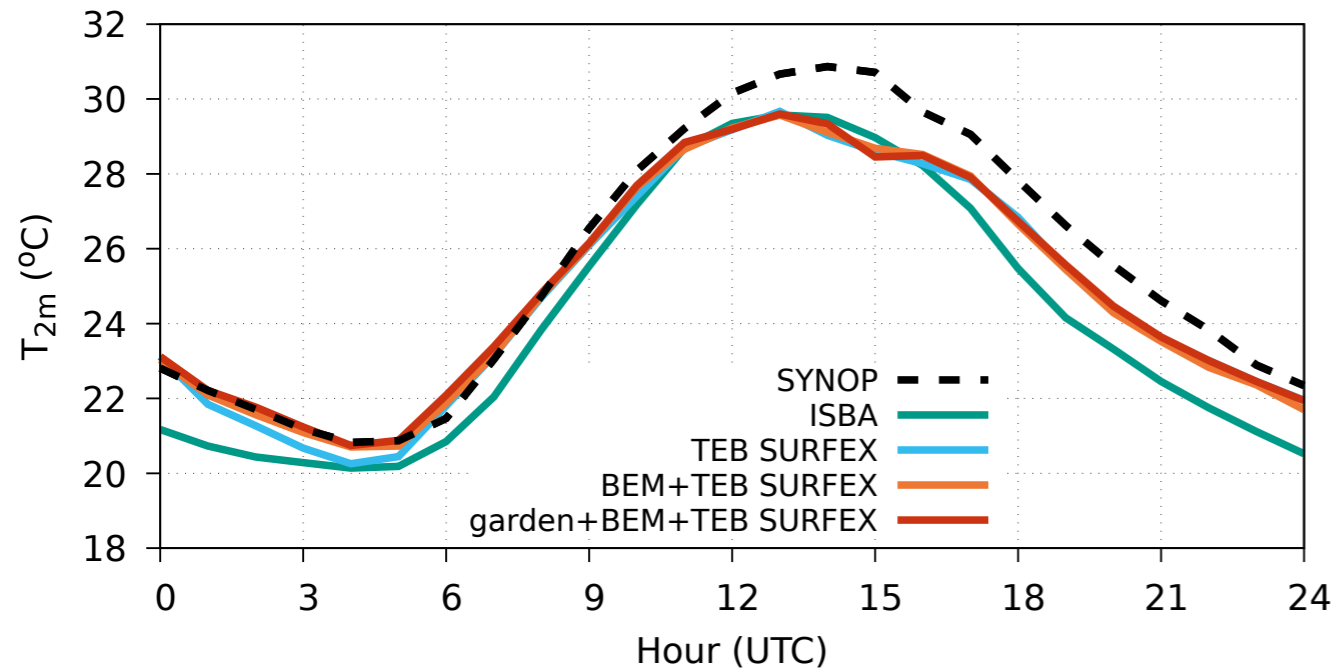
*SURFEX initialization from ARPEGE-SURFEX DA removes negative relative humidity bias, but the error gains considerable diurnal amplitude (left panel: brown versus red).*

*Random error is smaller than for ISBA reference (right panel: brown versus black).*

# Verification: TEB scheme

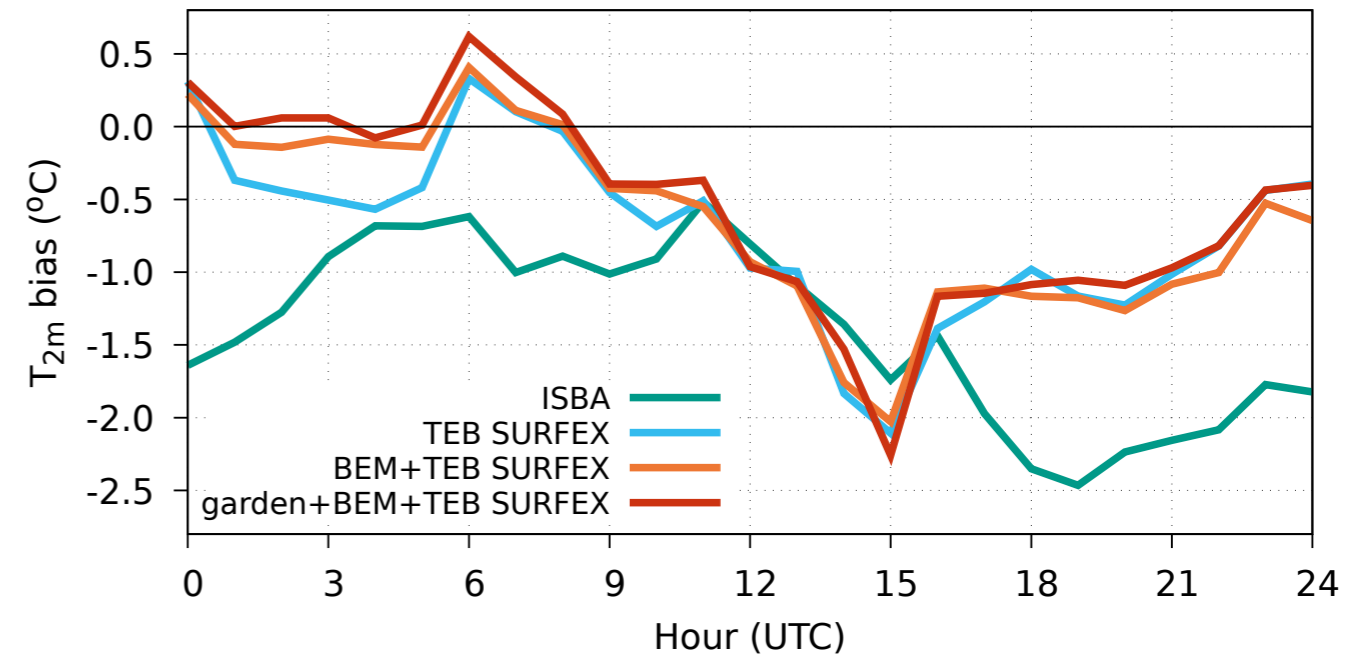
## 2m temperature

2m temperature: Praha-Klementinum  
(29.6.-1.7.2024, 3.-6.9.2024)



## BIAS of 2m temperature

Bias of 2m temperature: Praha-Klementinum  
(29.6.-1.7.2024, 3.-6.9.2024)



*TEB considerably reduces cold bias in Prague centre during the night (blue, orange and red versus green). The best configuration involves building energy model and garden option (red).*

# Conclusions

- Interfacing of ALARO with SURFEX revealed various problems that had to be fixed.
- ALARO+SURFEX modset based on cy46t1\_export is now well consolidated, working with most of options desired for NWP.
- A full modset was reimplemented also in cy49t2\_bf, but it is not yet part of IAL repository. The work will have to be redone once more when SURFEX v9 becomes available.
- A candidate NWP configuration for ALARO with SURFEX v8.0+ was proposed, and the tuning exercise has started recently.
- Meaningful tuning cannot be obtained without reliable surface initialization ⇒ **surface data assimilation for ALARO+SURFEX becomes an urgent issue.**
- Move to SURFEX v8.1+ opens a way to ECOCLIMAP Second Generation, and to multi-energy balance (ISBA-MEB). For the time being we keep ECOCLIMAP II and force-restore scheme.

**Thank you for your attention**

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