Regional Cooperation for Limited Area Modeling in Central Europe

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Surface related activities in RC LACE

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Overview

- Both ALADIN-ISBA and SURFEX used in operational applications in LACE
  - ALARO with old ALADIN-ISBA
  - AROME with various flavours of SURFEX
- ALARO with SURFEX
  - Do not disturb the surface (but one always does)
- Data assimilation
  - Tuning of soil moisture increments in CANARI
  - Observations for surface assimilation (SWI)
  - Assimilation of superficial soil moisture

Assimilation cycling strategy for RUC [DA1]

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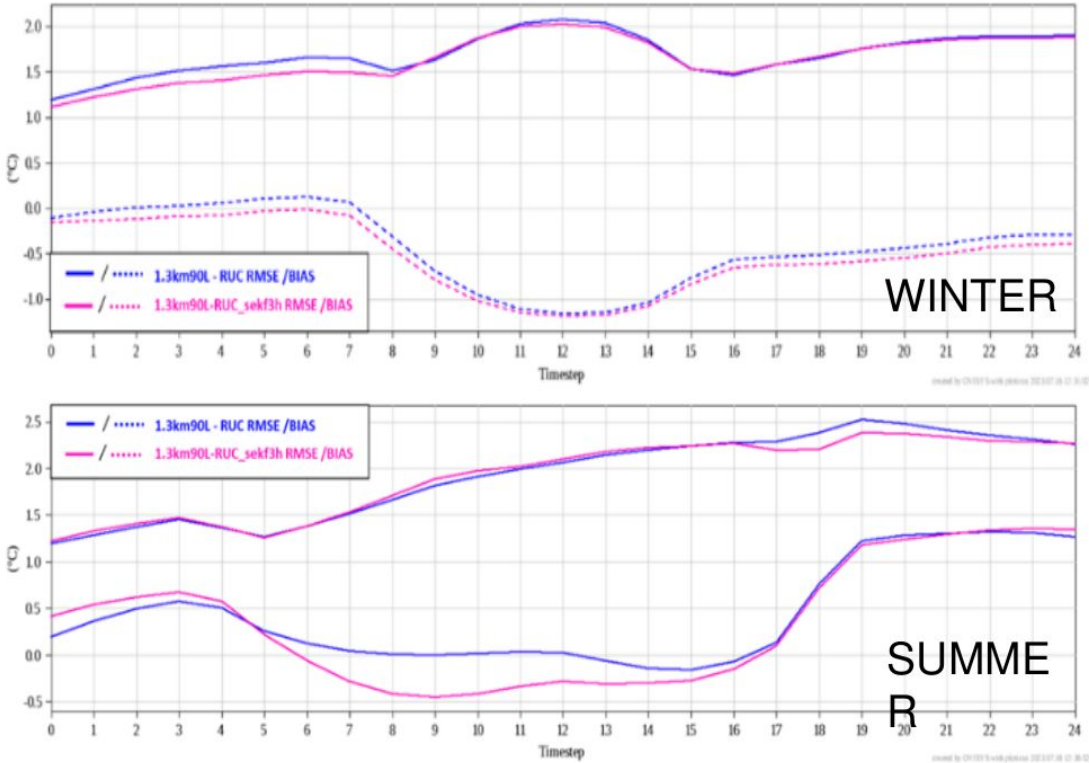
Tests with less-frequent surface DA in AROME-HU RUC (1.3 km):

- small improvement of RUC+SEKF3h for T2m in winter
- strong negative T2m bias degradation of RUC+SEKF3h in summer (but better RH2m)
- given mixed results and for simplicity of implementation, 1h cycle will be used for upper-air and surface



A. Varkonyi

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Tuning of soil moisture increments in CANARI

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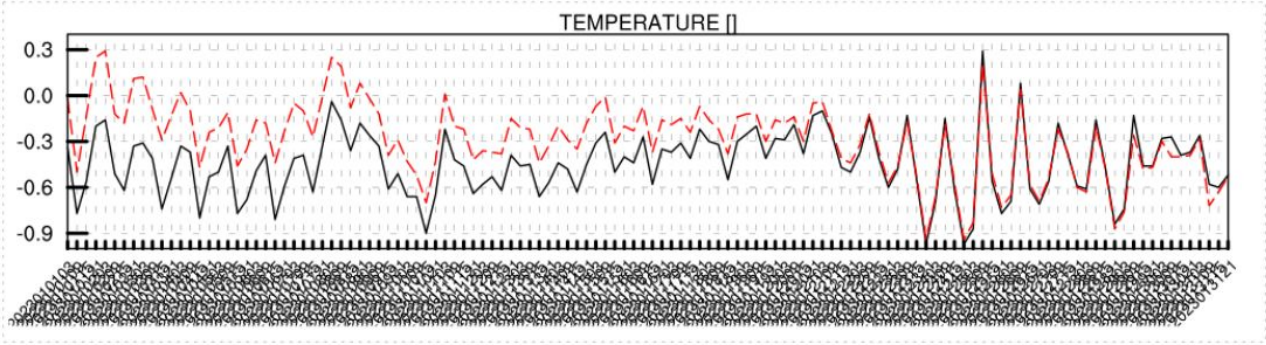
- ALARO-CZ: tuning to decrease the run-to-run jumpiness of the T2m forecast in 3h cycling: application of LISSEW option to average (in time) the increments of deep soil reservoir, extended to use up to 24 increments in case of 1h cycling.
- Switching-off relaxation towards climatology in CANARI has positive effect on T2m bias and snow amount
- Tuning of in BlendVar (ALARO SK) to decouple CANARI and atmospheric parameters (ANEBUL, SPRECIP and V10MX) improves screen-level scores but causes long term decrease in deep soil content.



T2m bias in FG of 3h cycling (January 2023)

relaxation to climatology (0.045)
No relaxation

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Tuning of soil moisture increments in CANARI

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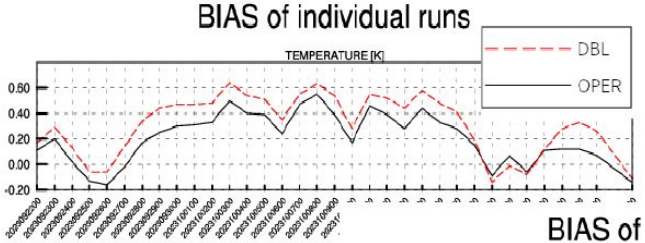
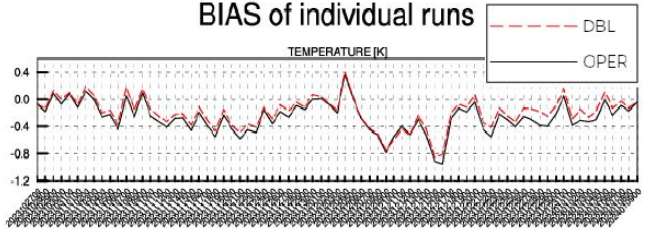
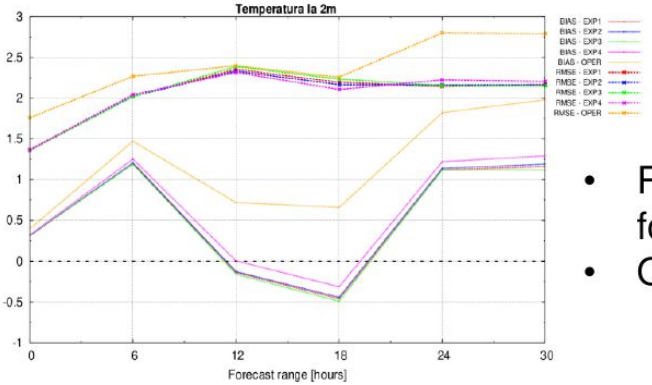
- CANARI at CHMI had to be retuned in 3-h cycling due to bias in T2m
- Operational tuning contains relaxation to climatology but with half the coefficients of the 6-h cycle
- No relaxation to snow climatology
- Launched in operations in February 2024



Before tuning



After tuning



- Romania, selecting the best polynomes ISBA for CANARI
- OI improves screen level parameters

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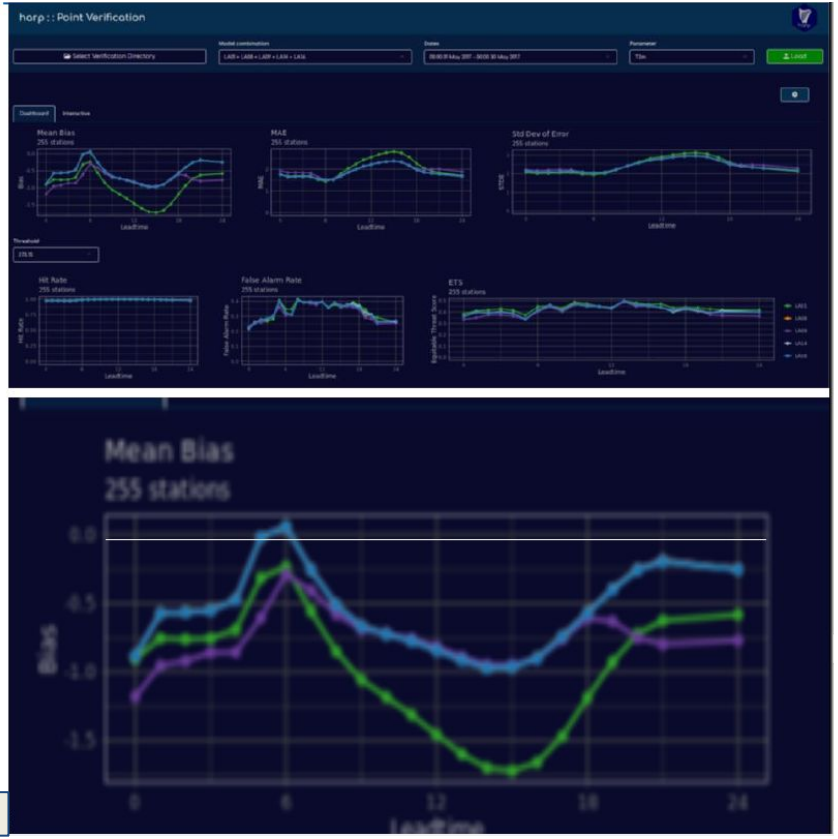
Observations for surface assimilation (SWI)

- Tests of (prognostic) LAI assimilation (cy43t1, SURFEX 8.0, SEKF) at GeoSphere Austria
- Tested various choices of patches, land cover data
- Sentinel-2 based data interpolated to model grid assimilated either for the average LAI or separated for broadleaf forests (P4), needle leaf forests (P5) and grassland (P10)
- Local modifications (assim_nature_isba_ekf.F90)
- Impact for screen-level parameters (T2m) is strong and positive, precipitation is only slightly affected



Reference (1 patch, no DA)
Prognostic LAI
Prognostic LAI + assim

Assimilation of superficial soil moisture [SU2]

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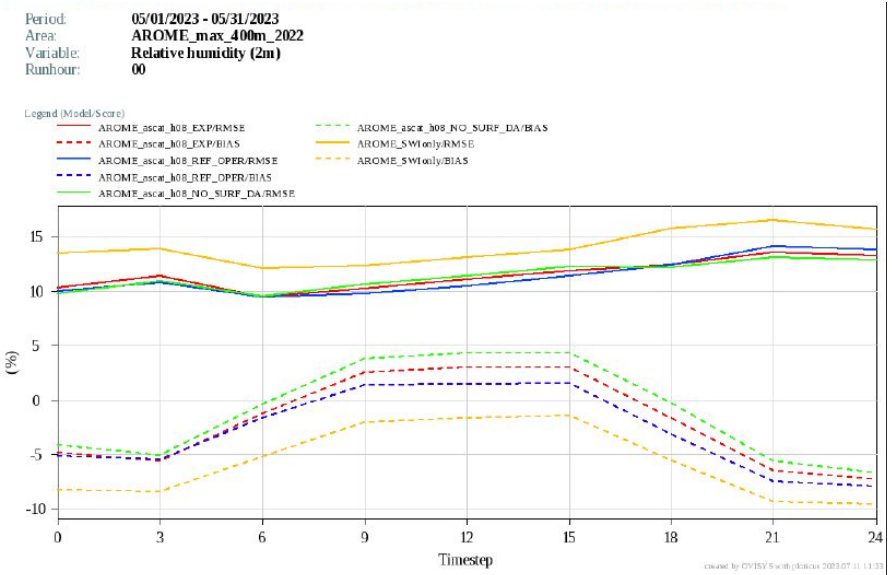
- Inline DA of satellite based superficial soil moisture (SSM) observations with SURFEX through SEKF.
- Observations: H08–SM-OBS-2 (H08) by EUMETSAT, based on ASCAT.
- Scaling and processing of raw data (25 km) to 1 km at GeoSphere
- Experiments:
  - Operational AROME-HU with 3h SEKF (T2m, RH2m)
  - No surface assimilation
  - AROME-HU with 3h SEKF (SSM assimilation at 09, 21UTC), two setups
- Near-real time product, feasible for operations
- Neutral or deteriorated results (with low obs. error) not yet satisfactory
- Investigation continued in second part of the year with 4 different setup of assimilation



AROME-HU SEKF T2m, RH2m
AROME-HU – no surf. DA
AROME-HU – SEKF SSM (σ_{obs}= 0.4)
AROME-HU – SEKF-SSM (σ_{obs}= 0.1)

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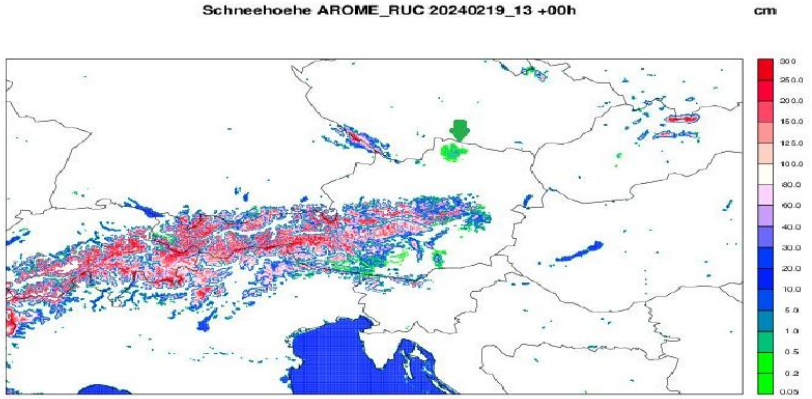
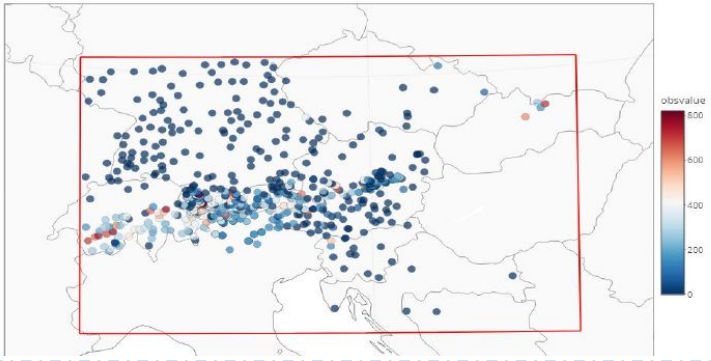
Assimilation of Synop snow observations

- Synop snow height in CANARI is independent of station height and therefore mountain peak station data often get rejected due to higher total snow amounts
- rejection limit made dependent on height

- Synop snow observation studied in Hungary,
- all snow measurements have to be checked by human
- Significant delays in availability
- New uncontrolled data will be available soor
- First test with assimilation on cy43 indicates problems plan to test on cy46



AROME_RUC: Observations Map
db=ecma_sfc, DTG=2024-02-19 06 UTC, obname=synop, varname=snow



SURFEX - validation and development of existing components for NWP

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Testing soil and snow schemes in SURFEX with ALARO (G. Stachura and J. Mašek)

- The main goal was to test the functionality of a multi-layer snow scheme and the diffusive soil scheme with ALARO
- Schemes tested: i) snow (single-layer EBA vs. 3-layer ES) and ii) soil (3-layer force restore vs. 14-layer diffusion scheme)
- Snow scheme is tested on a high-pressure system over the domain (10 January 2017 - 12 UTC run; T_{min} impact); initialization - horizontally homogeneous distribution of snow

exp	CSNOW	CISBA	NSNOW_LAYERS	XWSNOW [kg/m^2]	XRSNOW [kg/m^3]	XASNOW [1]	XTSNOW [K]	XTG_* [K]	XWCRN [kg/m^2]
1	EBA	3-L	-	10	100	0.85	273.15	273.15	4
2	3-L	3-L	3	10	100	0.85	273.15	273.15	4
3	3-L	DIF (n=14)	3	10	100	0.85	273.15	273.15	4
4	EBA	3-L	-	100	100	0.85	273.15	273.15	10
5	3-L	3-L	3	100	100	0.85	273.15	273.15	10

SURFEX - validation and development of existing components for NWP

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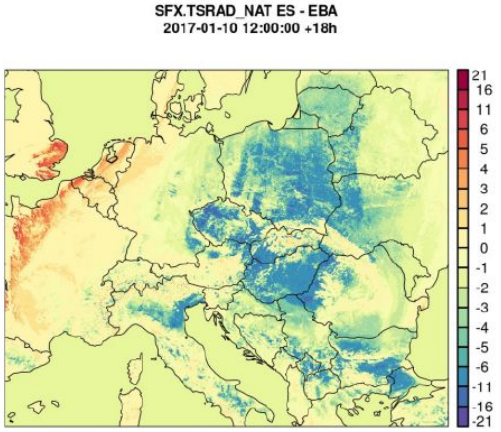
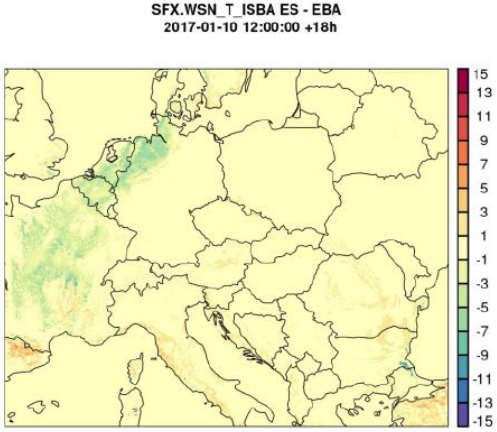
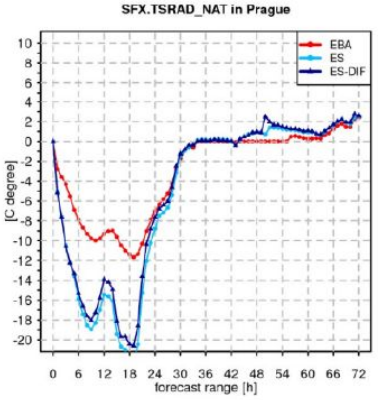
Testing soil and snow schemes in SURFEX with ALARO (G. Stachura and J. Mašek)

- ES scheme has a lower radiative temperature than EBA (over snow covered areas) and melts snow faster (cf. Western Europe)
- The impact of the diffusive soil scheme in ES experiments is relatively small







Unlike EBA, ES allows $T_{surf} > 0$

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SURFEX - validation and development of existing components for NWP

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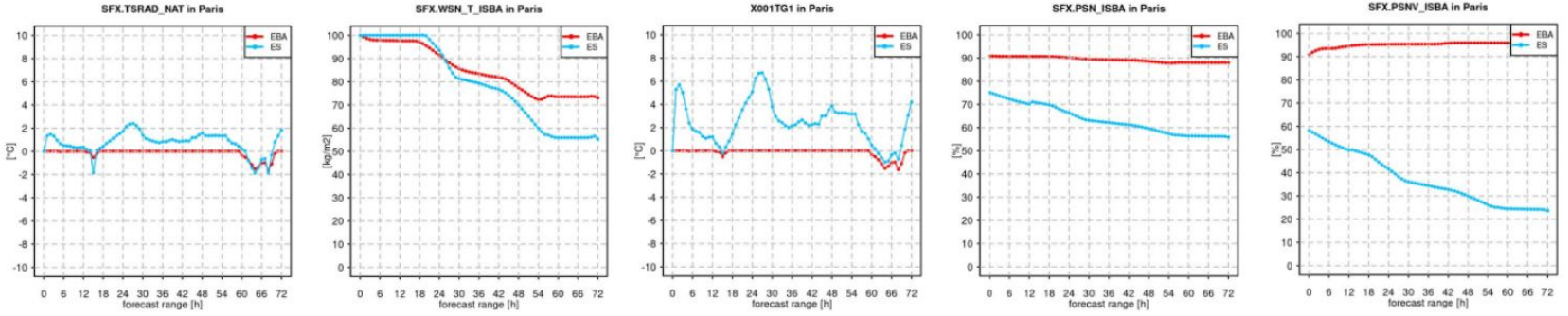
Testing soil and snow schemes in SURFEX with ALARO (G. Stachura and J. Mašek)

- To further inspect the diff., the amount of snow is set to 100 cm and SWE_{crit}=10 kgm^{-2}
- ES melts snow faster (particularly during the daytime); T_{rad} and T_{gl1} stay positive for most of the time - may be partly explained by lower SF_{tot} (more snow free area)
- For EBA SF_{veg} increases in time (potential bug; right most sub-plot); SEB analysis: i) daytime (ES warmer-all comp.) and ii) nighttime (ES cooler; less cloudy - LW flux)



T_{rad} SWE T_{gl1} SF_{tot} SF_{veg}

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Improve quality of surface characterization

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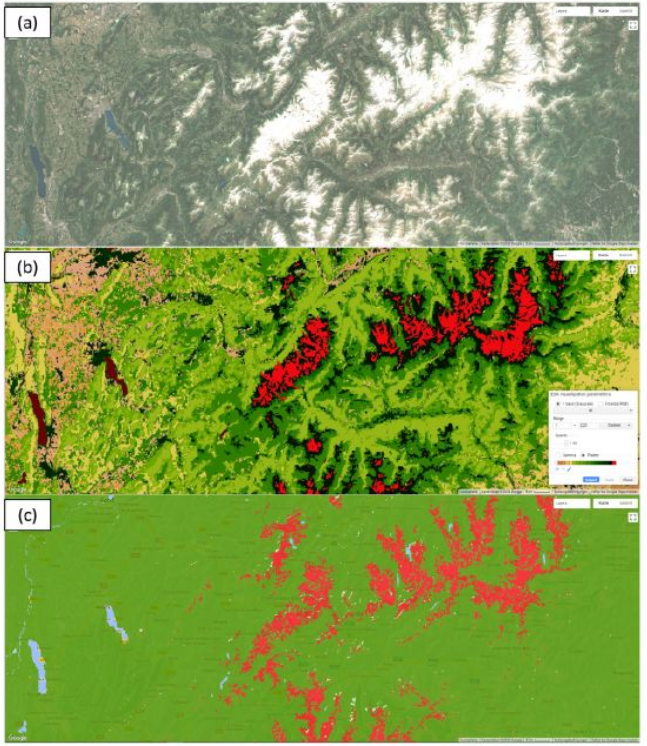
- EUMETNET/C-SRNWP project ‘Evaluation and updates of ESA-CCIglobal land cover map for NWP needs’
- GEE and GitLab chosen to handle Sentinel 2 data and gather issues in land cover data
- The algorithm to isolate snow and ice from Sentinel 2:
  - from SentinelHub; based NDSI, NDVI and brightness of Band 3
  - exclude cloudiness: Scene Classification Map (SCL) of Sentinel 2
  - exclude water/moist areas with already corrected ESA-CCI LCM
- Generally good matching of (b) and (c), although the mask has more pixels; might be due to dirt on glaciers
- Further inspection is needed; maybe on different period



S. Oswald

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ALARO with SURFEX

- Since the spring, extensive debugging of ALARO with SURFEX on cy46t1 was ongoing involving both LACE (Radmila Brožková, Neva Pristov, Matjaž Licar, Ján Mašek) and non-LACE people (Daan Degrauwe).
- **Several blocking issues were fixed**. Most important developments include:
  - finalization of subroutine ACTKEZOTLS (SURFEX counterpart of ACTKEHMT);
  - identification of uninitialized array passed to ACDIFV3, causing occasional crashes of ALARO with SURFEX when TOMs are active;
  - fixed update of latent heats and moist cp under key LCPL_ARP=T, reproducing ALARO thermodynamic choices (old update was not consistent and it could create negative latent heats in the long term runs with SURFEX);
  - consistent application of moist gustiness correction;
  - avoided call of proxy subroutine ARO_GROUND_DIAG_Z0 in prognostic zero timestep;
  - several fixes in the TEB scheme.

ALARO with SURFEX in DA and RUC

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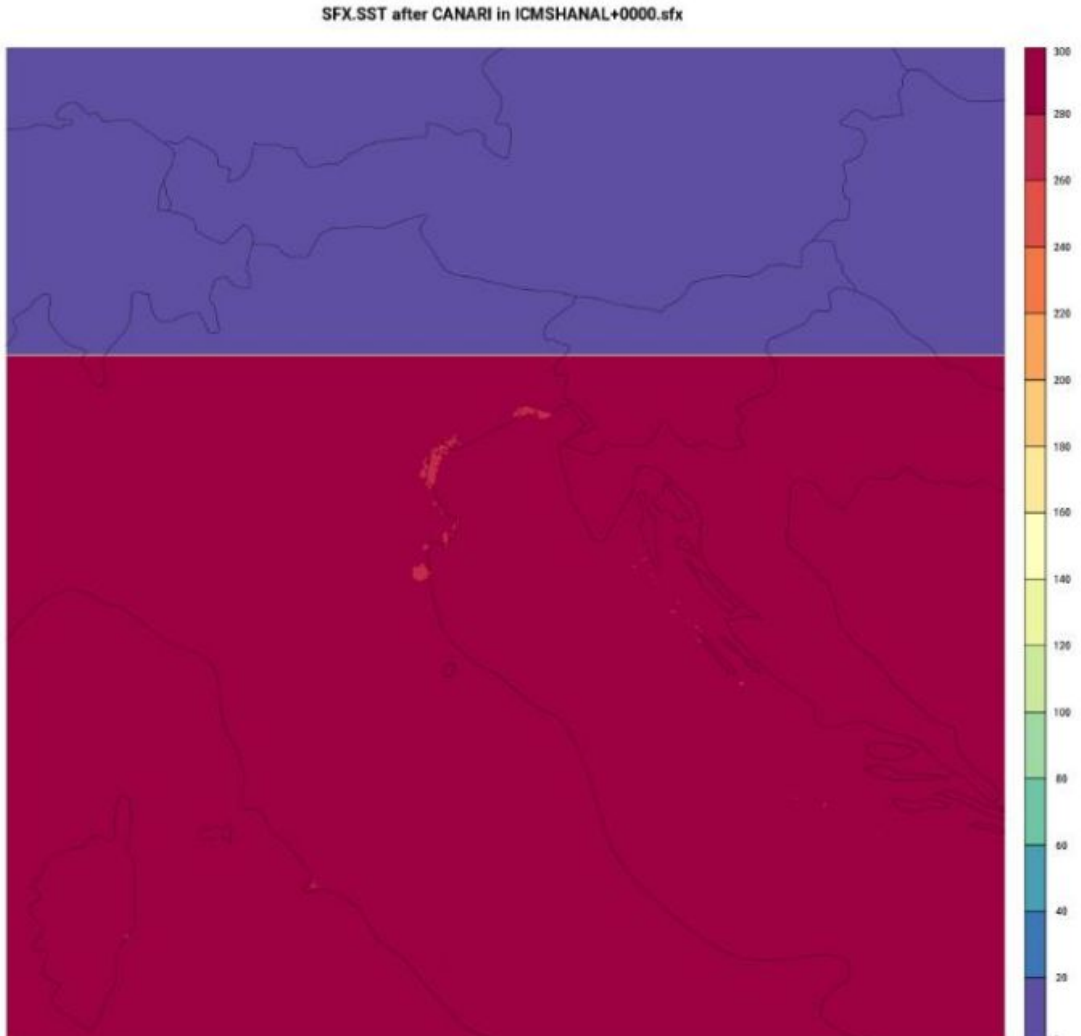
- Initial goal is to perform a short test run of the 1.3km ALARO RUC model run operationally at **ARSO**, with SURFEX enabled as the surface scheme.
- The 1 hour assimilation cycle includes 3Dvar minimisation for the upper air assimilation, as well as the use of OI-MAIN to update soil variables based on the CANARI T2m and RH2m analyses. **Analysis of SST is not performed**, so this field is taken from the ECMWF based LBC files. The version of the code used is cy43t2bf9 with some local modifications by CHMI. This test run should replicate the results of the operational suite, or at least inform of any remaining issues of ALARO with SURFEX. Once these issues are addressed, SURFEX will be implemented operationally.

ALARO with SURFEX

The figure shows SFX.SST following CANARI/OI-MAIN for an example when no SST is assimilated.
If the case of no assimmilation of the SST, one should copy the field from the LBC files using a combination of blendsur and addsu utilities.



ALARO with SURFEX (c) Jan Mašek

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- Developments done on ALARO with SURFEX (on both sides) was submitted for CY49T1 The contribution is inspected and the recommendations from Patrick S. are implemented
  - Uninitialized array entering TOMS computations in SURFEX
  - Numerical safety and compatibility with the old ISBA scheme
    - Definition of the effective roughness length
    - Discrimination between WCRIN and WNEW (SURFEX only 1st)
    - Evolution of latent heats and moist Cp at surface (LCPL_ARP=T)
  - **The above fixes do not ensure bit reproducibility for AROME and ARPEGE**

ALARO with SURFEX (c) Jan Mašek

- In order to have a smooth transition from ISBA used in ALADIN to the one in SURFEX, the latter was modified
  - Use effective roughness length to apply the effect of subgrid topography on turbulence
  - Implement FACz0 scaling on orographic roughness length
  - Enable RCTVEG like setting of surface thermic coefficient
- Latent heat dependence on temperature is linear in ALARO and constant in SURFEX
  - Debugged in the nature tile, not implemeted elsewhere
- ISBA to SURFEX comparisons have to be compatible!

ALARO with SURFEX (c) Jan Mašek

- New stuff (in SURFEX!)
  - Roughess length averaging now includes the orographic roughness
  - Snow impact on roughness length via snow height
  - TOUCANS screen level interpolation
  - Scaling of the tree height via namelist (10m wind diag)
-

ALARO with SURFEX (c) Jan Mašek

- **Roughness length averaging over patches/tiles** goes via neutral drag and heat coefficients with respect to the forcing height Z :

$$C_{DN} = \left[\frac{\kappa}{\ln(1 + Z/z_0)}\right]^2 \qquad C_{HN} = \frac{\kappa^2}{\ln(1 + Z/z_0)\ln(1 + Z/z_{0H})}$$

$$C_{DN}(\overline{z_0}) \equiv \sum_i w_i C_{DN}(z_{0i}) \qquad C_{HN}(\overline{z_0}, \overline{z_{0H}}) \equiv \sum_i w_i C_{HN}(z_{0i}, z_{0Hi})$$

- SURFEX approximations:
  - $\ln(1 + Z/z0) \approx \ln(Z/z0)$, assumes $z0 \ll Z$;
  - thermal roughness length z0H averaged by the same formula as mechanical roughness length z0 , i.e. without the cross term.
- Assumption $z0 \ll Z$ does not hold when the lowest model level is too low, especially when orographic component is included in z0 .
- Option LZ0 AVG EXACT=T implements unapproximated formulas. Orographic roughness can then be included by option LZ0 EFF=T.

ALARO with SURFEX (c) Jan Mašek

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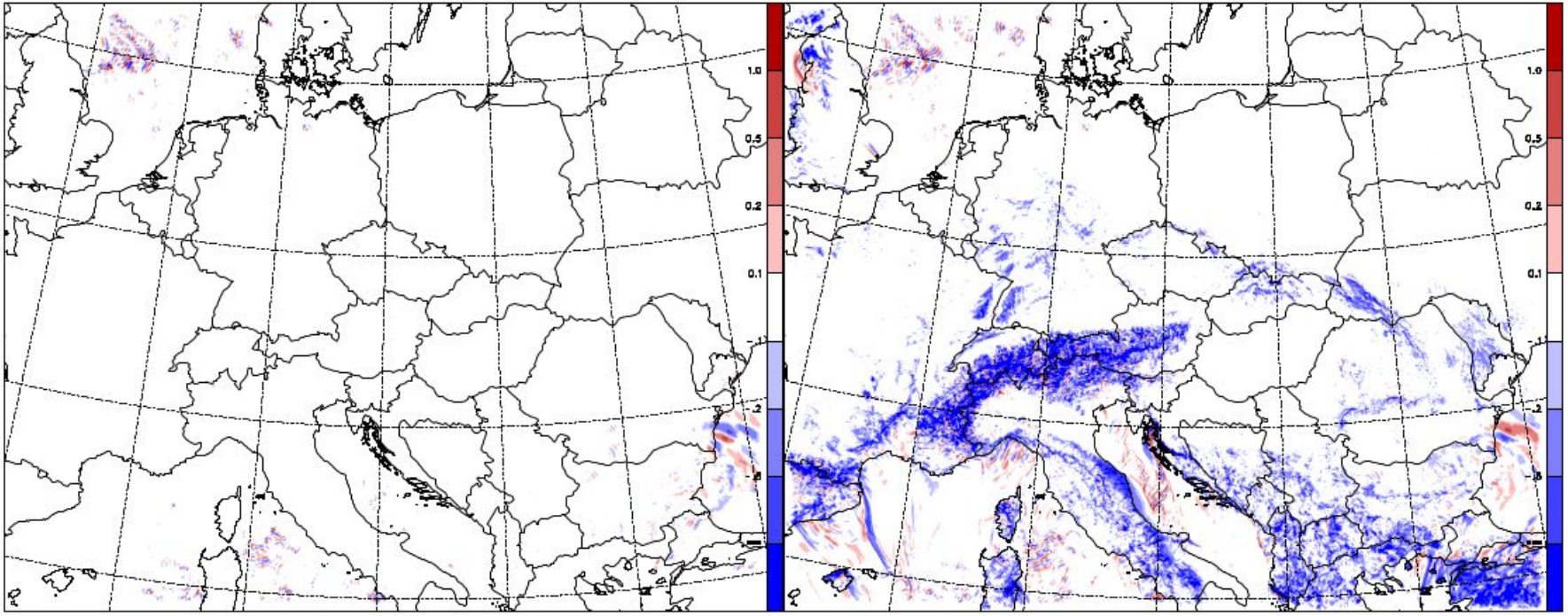
option LZO_AVG_EXACT=T

option LZO_EFF=T



- Impact of roughness length treatment on 10 m wind speed (ALARO with SURFEX; 6-hour forecast) contour levels ±(0.1, 0.2, 0.5, 1) m/s
- impact of exact roughness length averaging on 6h forecast of 10m wind speed (left)
- impact of added orographic roughness length on 6h forecast of 10m wind speed (right)

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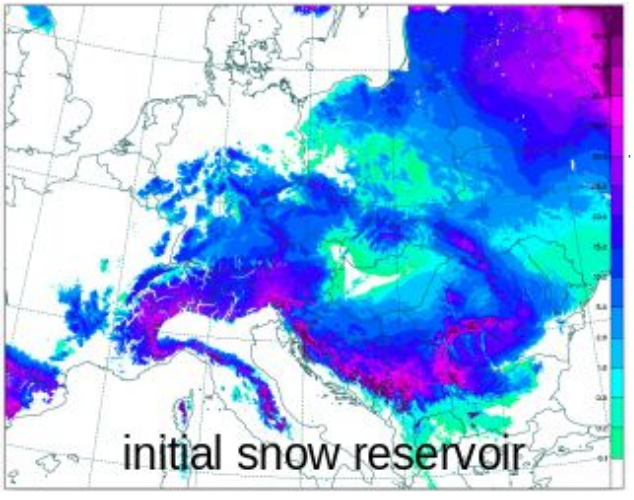
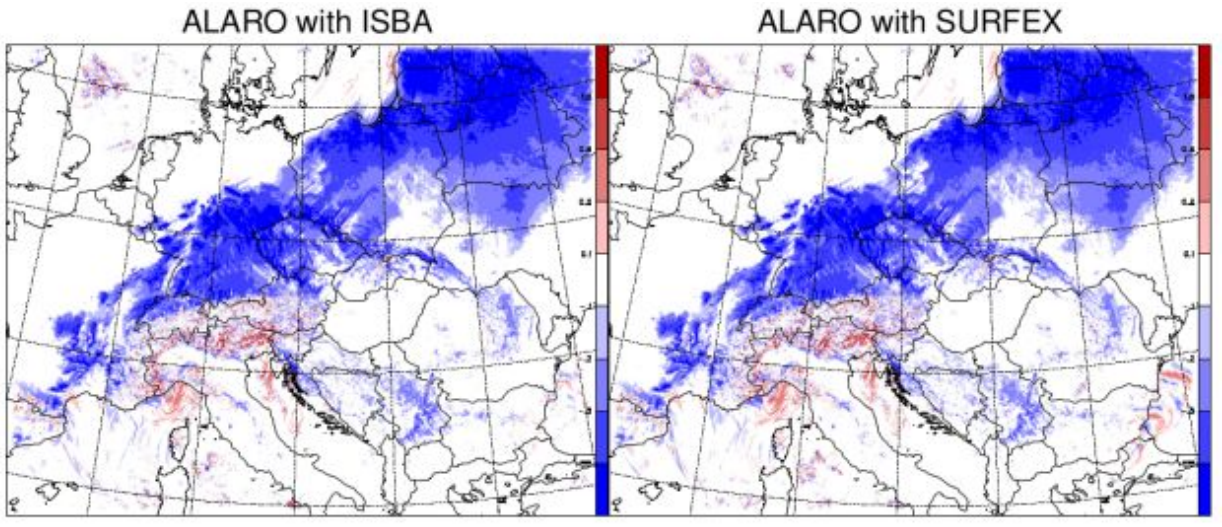




- Old inclusion of snow via snow fraction f^{snow} (underestimates roughness length of forest with $f^{\text{snow}} \approx 1$):

$$z_0^{\text{eff}} = \sqrt{(1 - f^{\text{snow}})(z_0^{\text{veg}})^2 + f^{\text{snow}}(z_0^{\text{snow}})^2 + (z_0^{\text{orog}})^2}$$

$$z_0^{\text{snow}} = 1\,\text{mm}$$

- New inclusion of snow via snow height (`LZOSNOWH[_ARP]=T`):

$$z_0^{\text{eff}} = \sqrt{\max(z_0^{\text{veg}} - a \cdot h^{\text{snow}}, z_0^{\text{snow}})^2 + (z_0^{\text{orog}})^2}$$

$$a = \texttt{[X]RZO\_TO\_HEIGHT} = 0.1$$

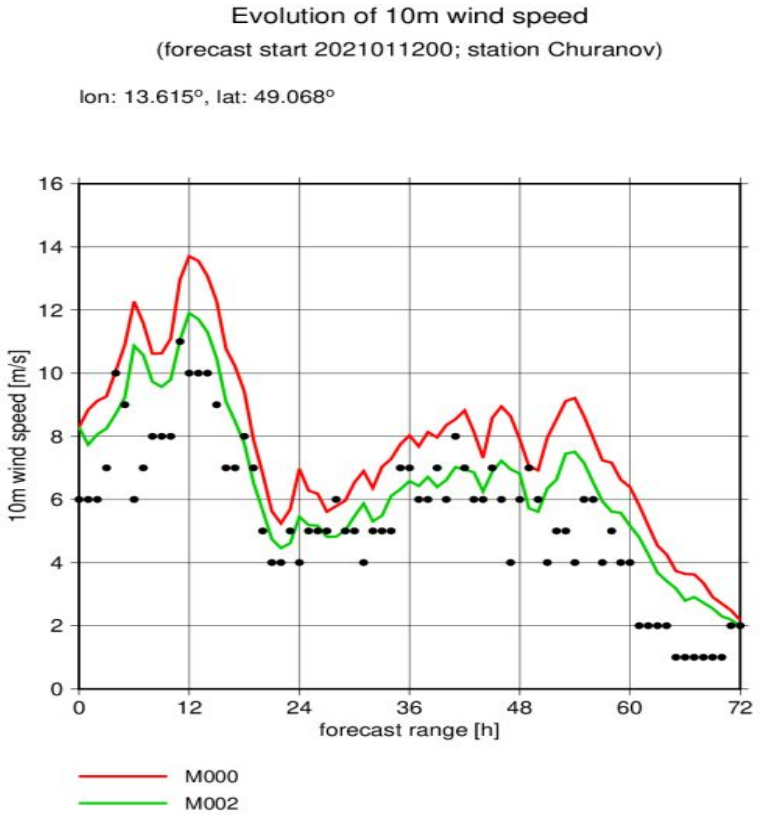
$h^{\text{tree}} = 20\,\text{m}$, $z_0^{\text{veg}} = 2\,\text{m}$, $z_0^{\text{orog}} = 0$, $h^{\text{snow}} = 1\,\text{m}$, $f^{\text{snow}} = 0.95$ $\Rightarrow$

with snow, old: $z_0^{\text{eff}} = 0.45\,\text{m}$
with snow, new: $z_0^{\text{eff}} = 1.90\,\text{m}$
without snow: $z_0^{\text{eff}} = 2.00\,\text{m}$

- **Snow impact on roughness**
- impact of new snow treatment on 6-hour forecast of 10m wind speed (with ISBA scheme and with SURFEX)
- contour levels ±(0.1, 0.2, 0.5, 1) m/s
- Differences largest where there is snow AND strong wind

ALARO with SURFEX (c) Jan Mašek

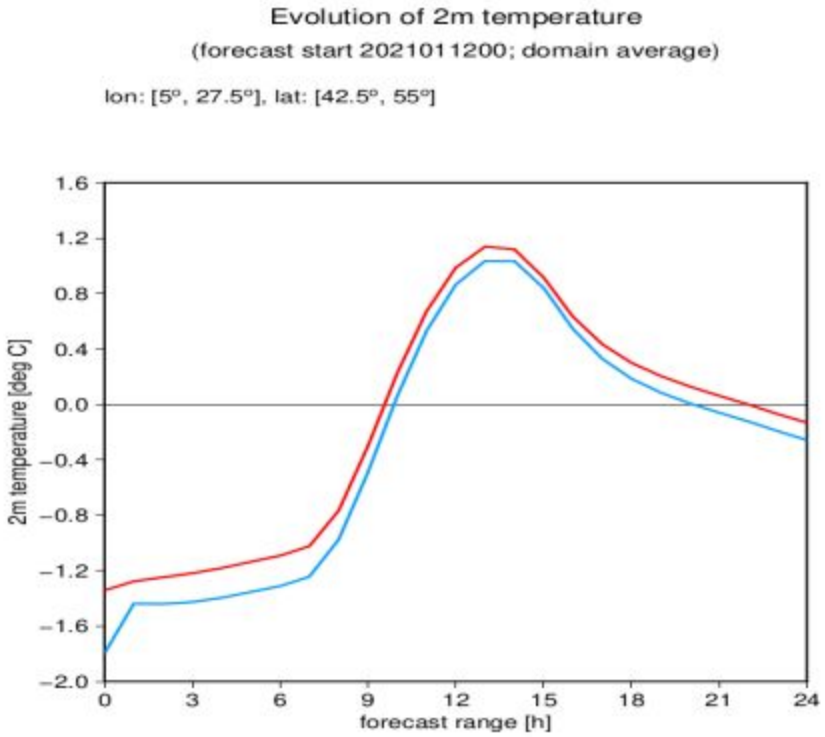
- Impact of roughness treatment of vegetation with snow at the mountain station Churáňov. Red line is the reference, green line is the experiment with new roughness treatment, black dots are measurements.

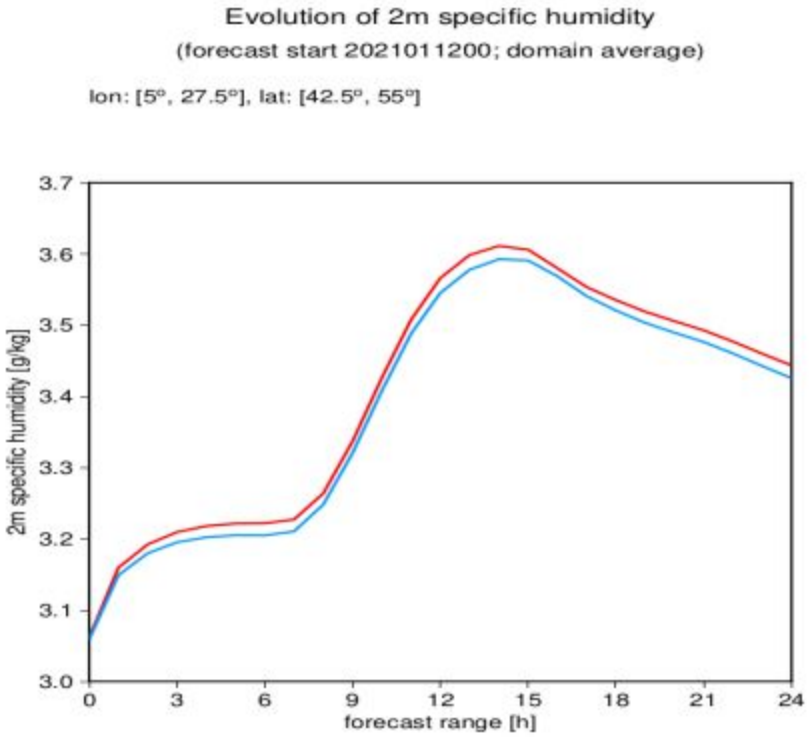


ALARO with SURFEX (c) Jan Mašek

- In SURFEX, Geleyn and Dian screen level interpolation is available (N2M=2,3)
- However, SURFEX implementation differs from its NWP counterpart in ACNTCLS/ACTKECLS:
  - interpolation is applied directly on temperature, while it should be applied on conservative variable (potential temperature or static stability);
  - one term in Geleyn interpolation weight is approximated.
- In ALARO-1 with SURFEX, TOUCANS screen level interpolation can replace the SURFEX one (option LCLS TOUCANS=T).
- Implementation of N2M=2,3 was not touched, since these options are used operational ARPEGE and AROME models.
- Future harmonization with N2M is possible, consensus is needed.

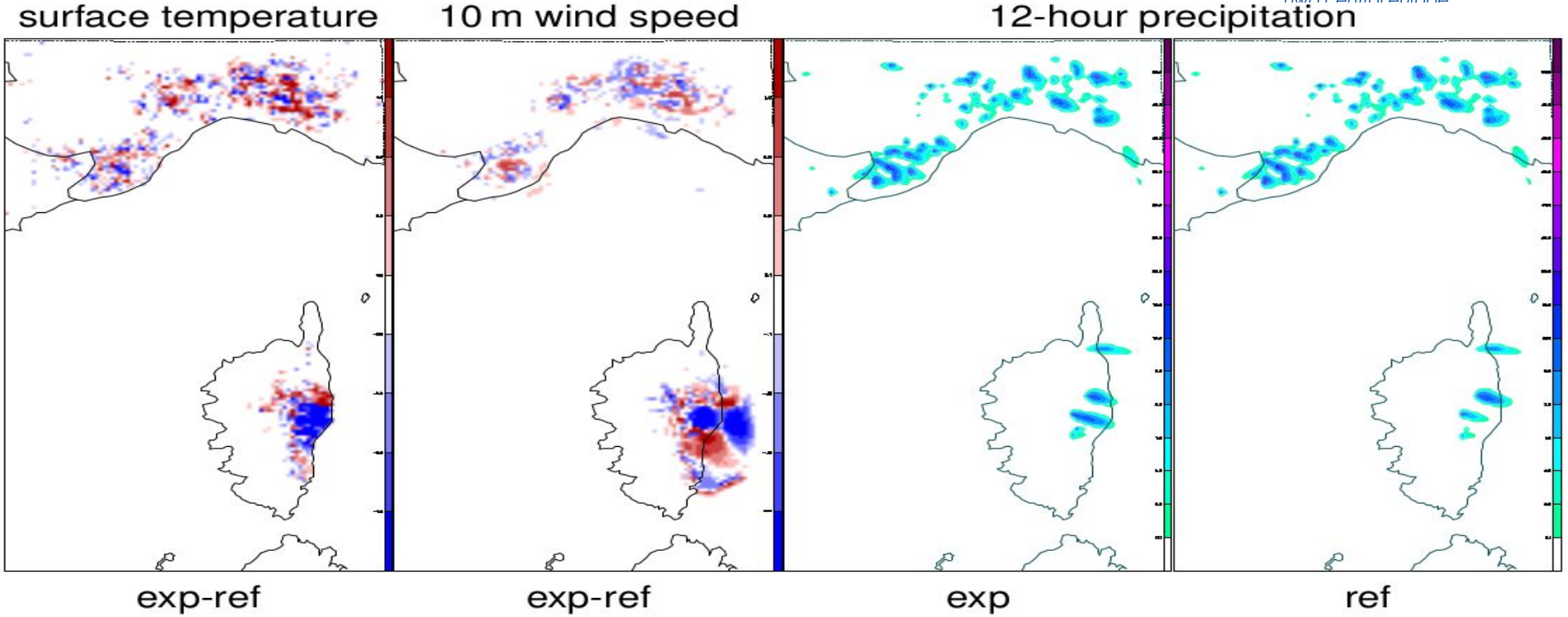
ALARO with SURFEX (c) Jan Mašek





- Geleyn screen level interpolation LSCL_TOUCANS=T vs N2M=2, ALARO with SURFEX,
- impact of ALARO screen level interpolation on q2m and t2m (24-hour evolution of domain average; red - ALARO interpolation, blue - SURFEX interpolation N2M=2)

Impact on AROME forecast (c) Jan Mašek



- Impact of the SURFEX modset on 12-hour AROME forecast: surface temperature (left) and 10m wind (centre left), 12h cumulated precipitation with new SURFEX code (centre right) and reference (right).

More information on

- National posters of
  - Czech republic (ALARO with SURFEX)
  - Slovakia (ALARO with SURFEX)
  - Poland (pre-operational surface DA)
  - Romania (pre-operational surface DA)
  - Hungary (SURFEX DA)
  - Austria (SURFEX)
  -

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Thank you for your attention.

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