Report of RC LACE stay at CHMI Prague
18.11.2019–29.11.2019
(plus local work at SHMI Bratislava afterwards)

INVESTIGATING SURFEX IN ALARO-1
(fixing snow albedo in SURFEX)

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1. Introduction

Stay objectives

During the previous stay [1], two kinds of inconsistencies between ISBA and SURFEX experiments were revealed (duplication of some atmospheric namelist variables in SURFEX; concerning implementation of TOUCANS stability functions in SURFEX). First kind is activation of moist gustiness correction and settings of wind shear. Second kind is modification of Richardson number in stable conditions and missing inverse turbulent Prandtl number in surface heat coefficient. There was also found useless use of antifibrillation with TOUCANS both in ISBA and SURFEX and incomplete antifibrillation in SURFEX generating wind oscillations on the lowes model level. After removing all of the above mentioned inconsistencies, difference in the lowest model level temperature between ISBA and SURFEX runs became acceptable at least in dry conditions and for short forecast lead times. Current stay focus on situations with significant soil moisture content and/or with snow cover.

Technical info

This work was done on NEC LX machine in Prague, using locally ported ARPEGE/IFS cycle 43t2_bf.09 with SURFEX version 8.0. All model integrations were performed on old ALADIN/CHMI operational domain ($\Delta x = 4.7\,\mathrm{km}$, 87 vertical levels, $\Delta t = 180\,\mathrm{s}$), using ALARO-1 physics with hydrostatic dynamical kernel.

2. Tests with constant emissivity and albedo

The main idea of this section is set up same emissivities and albedos for both experiments ISBA and SURFEX respectively. For both ISBA and SURFEX, constant emissivity and albedos in routine *APLPAR* were set as follows:

PALB(JLON)=0.2_JPRB
ZALBDIR(JLON)=0.2_JPRB
PEMIS(JLON)=1._JPRB

Case with base time 10-Sep-2018 from previous report [1] was inspected. On the figure 2.1 are plotted lowest model temperature difference between ISBA with emissivity and albedo from database and ISBA with constant emissivity albedo (left) and lowest model temperature difference between SURFEX with emissivity and albedo from database and SURFEX with constant emissivity albedo (right). The response differs in both cases. While ISBA is cooling over land, SURFEX is slightly warming. The response over sea is similar in both cases. It means that albedos of seas are similar in both ISBA and SURFEX databases. Incrising albedos from database value 0.06 to constant value 0.2 means that surface temperature over seas is not changed see fig. 2.2 but more sun radiation reflects and subsequently absorb in the atmosphere, fig 2.1. It seems that over land SURFEX albedo is close to 0.2, while in ISBA is significantly different. In case of land response on surface temperature is also visible.

Finally, lowest model temperature difference between SURFEX and ISBA with emissivities

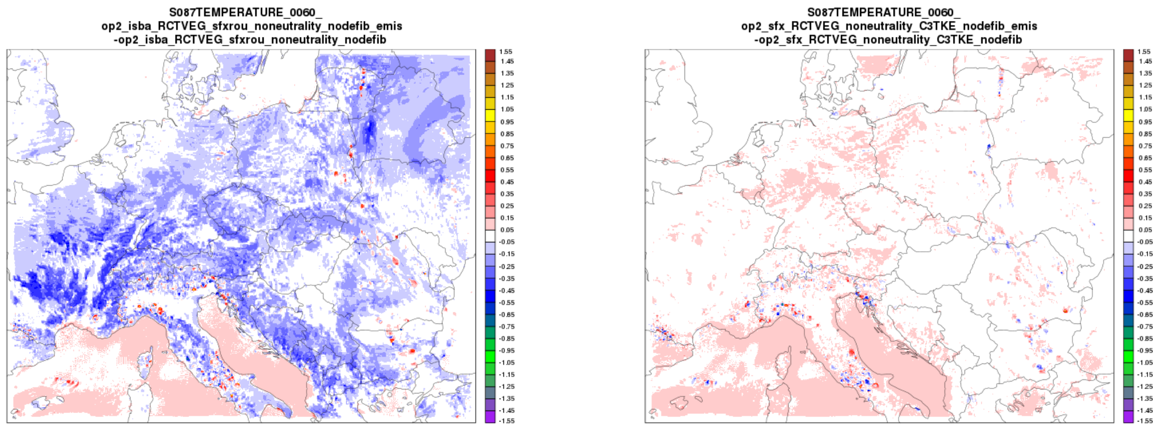

Figure 2.1: Constant emissivity and albedo minus emissivity and albedo from databases difference in the lowest model level temperature. **Left:** ISBA runs. **Right:** SURFEX runs. Forecast base time 10-Sep-2018 at 12 UTC. 3 h forecast.

and albedos - database values fig.2.3 (left) and lowest model temperature difference between SURFEX and ISBA with constant emissivity and albedo fig.2.3 (right) were plotted. After 3 hours cold areas are only slightly reduced. The case with base time 10-Sep-2018 was closed

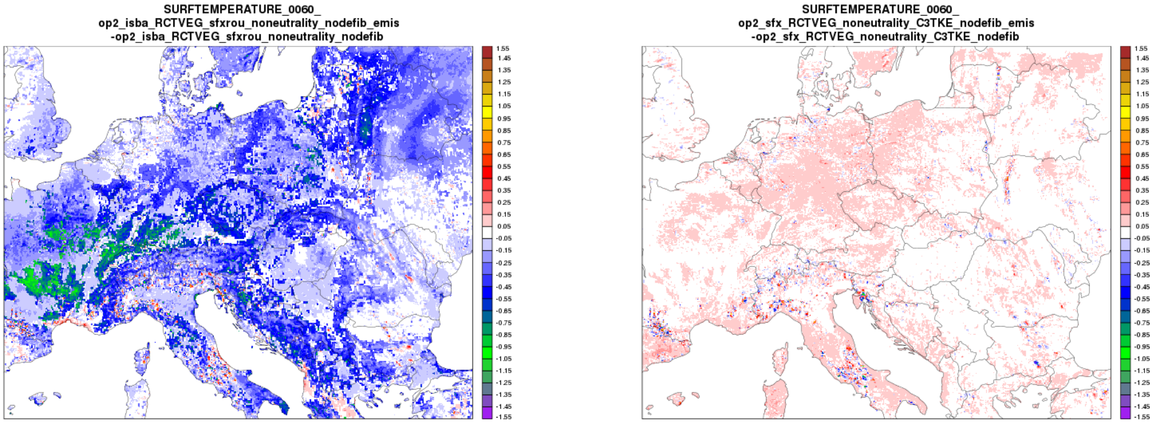

Figure 2.2: Constant emissivity and albedo minus emissivity and albedo from databases difference in the surface temperature. **Left:** ISBA runs. **Right:** SURFEX runs. Forecast base time 10-Sep-2018 at 12 UTC. 3 h forecast.

and the remaining difference is considered that SURFEX uses different databases for another fields.

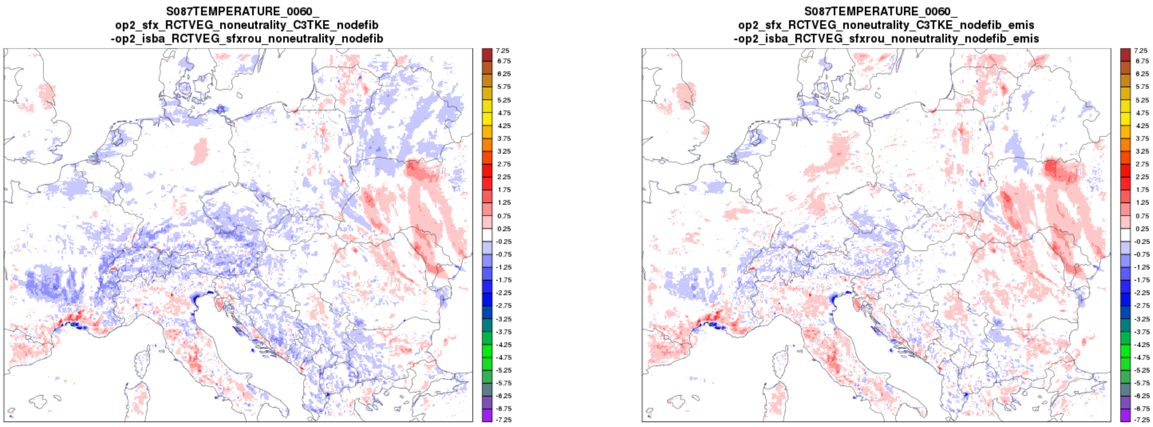

Figure 2.3: SURFEX minus ISBA difference in the lowest model level temperature. **Left:** Runs with albedo and emissivity from databases. **Right:** Runs with constant emissivity=1 and albedo=0.2. Forecast base time 10-Sep-2018 at 12 UTC. 3 h forecast.

3. Winter case

Next winter case was tested. Before running experiments, checking of snow fraction and snow albedo in SURFEX was performed.

Snow fraction:

In SURFEX snow fraction is calculated as follows:

$$f_{\text{snow}} = \frac{W_{\text{snow}}}{W_{\text{snow}} + W_{\text{snow}}^{\text{crit}}}, \tag{3.1}$$

where W_{snow} is snow reservoir and $W_{\text{snow}}^{\text{crit}} = 10$ kg m^{-2} is a critical value for which $f_{\text{snow}} = \frac{1}{2}$. Snow fraction in ISBA is calculated as:

$$f_{\text{snow}} = \frac{W_{\text{snow}}}{W_{\text{snow}} + W_{\text{snow}}^{\text{crit}} \cdot \left(1 + \frac{z_{0\text{D}}^{\text{nosnow}}}{a_2}\right)}, \tag{3.2}$$

where $z_{0\text{D}}^{\text{nosnow}}$ is material value of dynamical roughness without snow and $a_2 = 10$ is tuning parameter.[2]. In this case, the critical value of $W_{\text{snow}}^{\text{crit}}$ is modulated by factor $1 - 1.2$. Calculation of snow fraction in routine *MODE_SURF_SNOW_FRAC* was unified. It also means, that argument of roughness $z_{0\text{D}}$ is necessary in calling function snow_frac_ground in routine *ISBA_SNOW_FRAC*. In case of D95 snow scheme routine *ISBA_FLUXES* calls function snow_frac_ground. This scheme is not used in our tests. Therefore, in this case the second argument of function snow_frac_ground will be filled with zero.

Snow albedo:

Calculating of snow albedo for both ISBA and SURFEX was investigated. Snow albedo in ISBA case is calculating by two formulas.

1) No melting case:

$$\alpha^{n+1} = \alpha^n - \text{TOLIN}.\Delta t + \frac{F_{\text{snow}}}{\text{WNEW}} \cdot \Delta t., \tag{3.3}$$

where TOLIN $= 0.008/86400$ s^{-1} is constant of aging of snow, F_{snow} is intensity of snowing and WNEW $= 10$ kg.m^{-2} .

2) Melting case:

$$\alpha^{n+1} = \alpha^n - \text{TOEXP}(\alpha^n - \alpha_{\min}).\Delta t + \frac{F_{\text{snow}}}{\text{WNEW}} \cdot \Delta t., \tag{3.4}$$

where TOEXP $= 0.24/86400$ s^{-1} is constant of aging of snow in melting case and $\alpha_{\min} = 0.5$ is threshold for albedo of snow.

Snow albedo in SURFEX is calculated as follows:

1) No melting case:

$$\alpha^{n+1} = \alpha^n - \text{XANS\_TODRY}.\frac{\Delta t}{\text{XDAY}} + \frac{F_{\text{snow}}}{\text{XWCRN}} \cdot \Delta t \cdot (\alpha_{\max} - \alpha_{\min}), \quad (3.5)$$

where XANS_TODRY = 0.008 is aging of snow, XDAY = 86400s , F_{snow} is intensity of snowing, XWCRN = 10 kg.m^{-2} and $(\alpha_{\max} - \alpha_{\min}) = 0.35$.

2) Melting case:

$$\alpha^{n+1} = \alpha_{\min} + \exp\left[-\text{XANS\_T}\frac{\Delta t}{\text{XDAY}}\right](\alpha^n - \alpha_{\min}) + \frac{F_{\text{snow}}}{\text{XWCRN}} \cdot \Delta t \cdot (\alpha_{\max} - \alpha_{\min}), \quad (3.6)$$

where XANS_TODRY = 0.24.
For small Δt[1]:

$$\alpha^{n+1} = \alpha^n - \text{XANS\_T}\frac{\Delta t}{\text{XDAY}}(\alpha^n - \alpha_{\min}) + \frac{F_{\text{snow}}}{\text{XWCRN}} \cdot \Delta t \cdot (\alpha_{\max} - \alpha_{\min}), \quad (3.7)$$

Terms in ISBA and SURFEX for aging of snow are same both for no melting and melting case. Incrising albedo in SURFEX during snowing is damped by factor $\alpha_{\max} - \alpha_{\min} = 0.35$ while in ISBA is not provided. Futhermore, in SURFEX parameter XWCRN (critical value of snow reservoir for which fraction of snow $f_{\text{snow}} = \frac{1}{2}$) instead of parameter WNEW is used. It is obvious bug when WNEW $\neq$ XWCRN. Thus was formulas (3.5) and (3.6) replaced by (3.3) and (3.4) in *HYDRO_SNOW*.

Winter case with forecast base time 22-Jan-2019 at 00 UTC was choosen. On the figure 3.1 are plotted differences of lowest model level temperature. Comparison beetwen SURFEX run without fixed snow fraction and snow albedo - ISBA (left) and SURFEX run with fixed snow fraction and snow albedo - ISBA (right) differs slightly (more "white" areas in Belarus , Ukraine and in Romania mountains), while differences about 2 degrees remain. So SURFEX run with fixed snow fraction and snow albedo - SURFEX run without fixed snow fraction and snow albedo was also plotted, see fig. 3.1. Impact of fixed snow fraction and snow albedo is less than half degree.

[1] 3 minutes in 4.7km horizontal resulotion model is this condition fulfilled

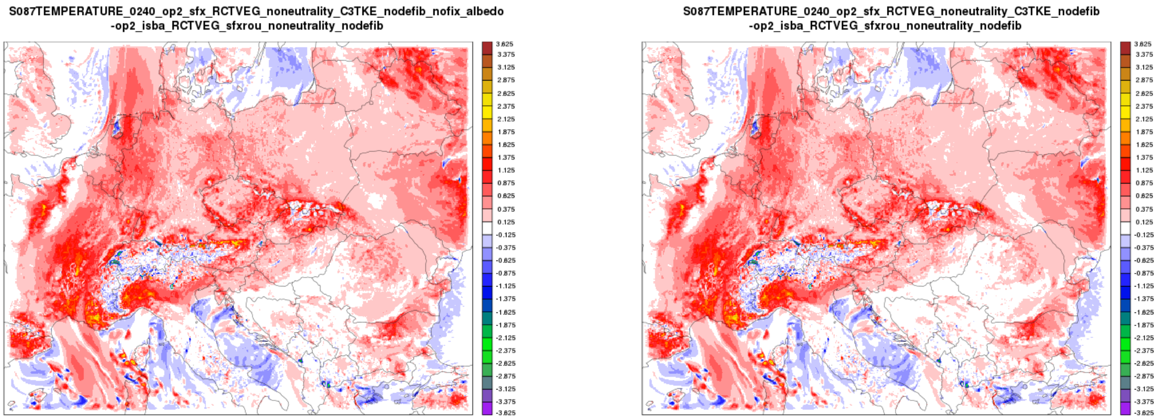

Figure 3.1: Difference in the lowest model level temperature. **Left:** SURFEX run without fixed snow fraction and albedo - ISBA. **Right:** SURFEX run with fixed snow fraction and albedo - ISBA Forecast base time 22-Jan-2019 at 00 UTC. 12 h forecast.

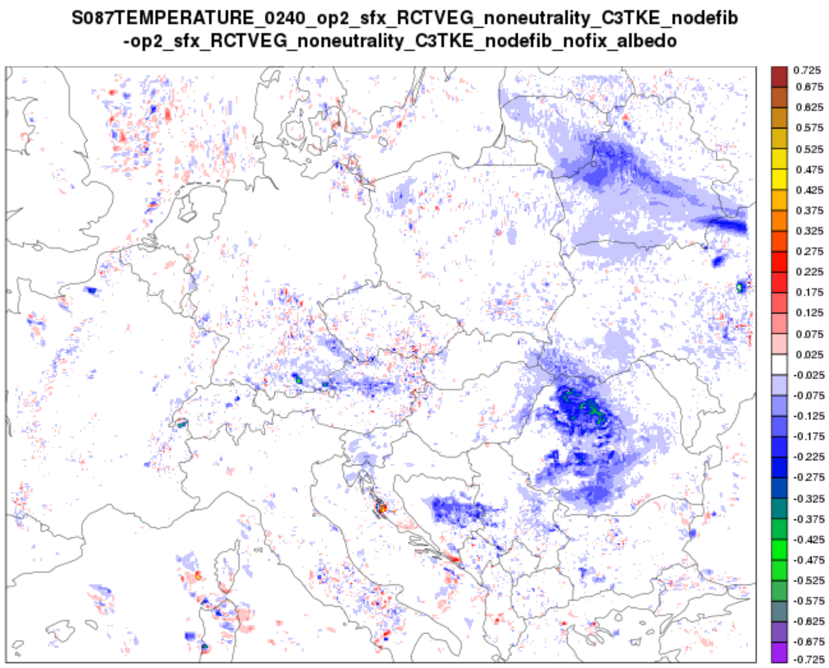

Figure 3.2: SURFEX run with fixed snow fraction and albedo - SURFEX run with fixed snow fraction and albedo. Difference in the lowest model level temperature. Forecast base time 22-Jan-2019 at 00 UTC. 12 h forecast.

Differences between ISBA and SURFEX are still not acceptable. Finally, evaporation on both sides ISBA and SURFEX was tried to zero. In SURFEX, difuse solver for evaporation is written in *ARP_GROUND_PARAM*, while in ISBA is written in *ACDIFV2*, so this test was not performed yet.

Bibliography

[1] Dian, M., and Mašek, J., 2019: Investigating SURFEX in ALARO-1 (harmonization of dry aspects with ISBA). *RC LACE stay report.*

[2] Mašek, J., 2018: Improved treatment of surface roughness in the ISBA scheme. *RC LACE report.*