Regional Cooperation for
Limited Area Modeling in Central Europe

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Physics Parametrization Developments in RC LACE

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Overview

- **ALARO CMC**
  - TOUCANS developments and mixing length formulation
  - Coupling with SURFEX
  - New topography and roughness length
- **AROME CMC**
  - **ICE3 and LIMA**
  - **Case studies**

Toucans and Mixing Length

- TOUCANS – Third Order moments (TOMs) Unified Condensation Accounting and N-dependent Solver (for turbulence and diffusion)
- Mario Hrastinski proceeded with his work on implementation of TKE-based mixing length in TOUCANS. In order to check the computation of BL89 integrals, the code was adapted to diagnose vertical parcel displacements (L_{up} and L_{down}) from the ARPEGE subroutine acbl89.F90. TOUCANS values were slightly smaller which is attributed to the impact of added shear term.
- Go to prognostic mixing length

SURFEX and ALARO1 (M. Dian, J. Mašek)

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▸ Fixing snow albedo - this is how it is computed in AL-ISBA

1) No melting case:

$$\alpha^{n+1} = \alpha^n - \mathrm{TOLIN}.\Delta t + \frac{F_{\mathrm{snow}}}{\mathrm{WNEW}} \cdot \Delta t., \qquad (3.3)$$

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

2) Melting case:

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

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

SURFEX (and ALARO1)

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Fixing snow albedo - in SURFEX

1) No melting case:

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

Replaced by 3.3

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:

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

Replaced by 3.4

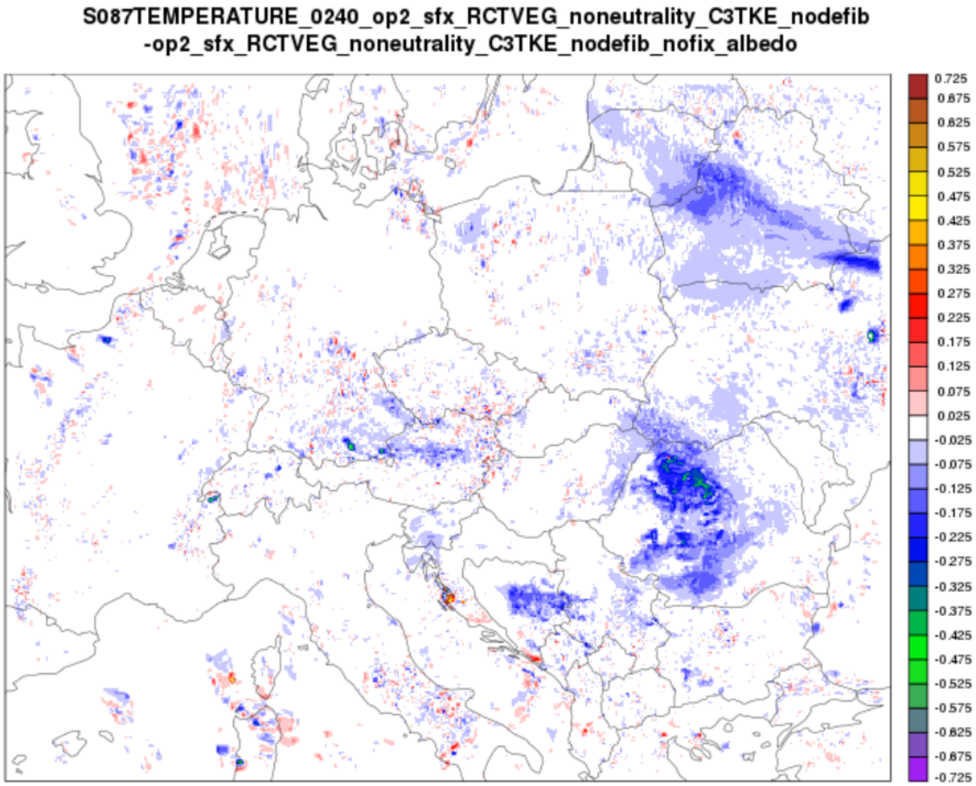
where XANS_TODRY = 0.24.
For small Δt[1]:

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

Replaced by 3.4

SURFEX (and ALARO1)

- Fixing snow albedo
  - - in SURFEX



SURFEX (and ALARO1)

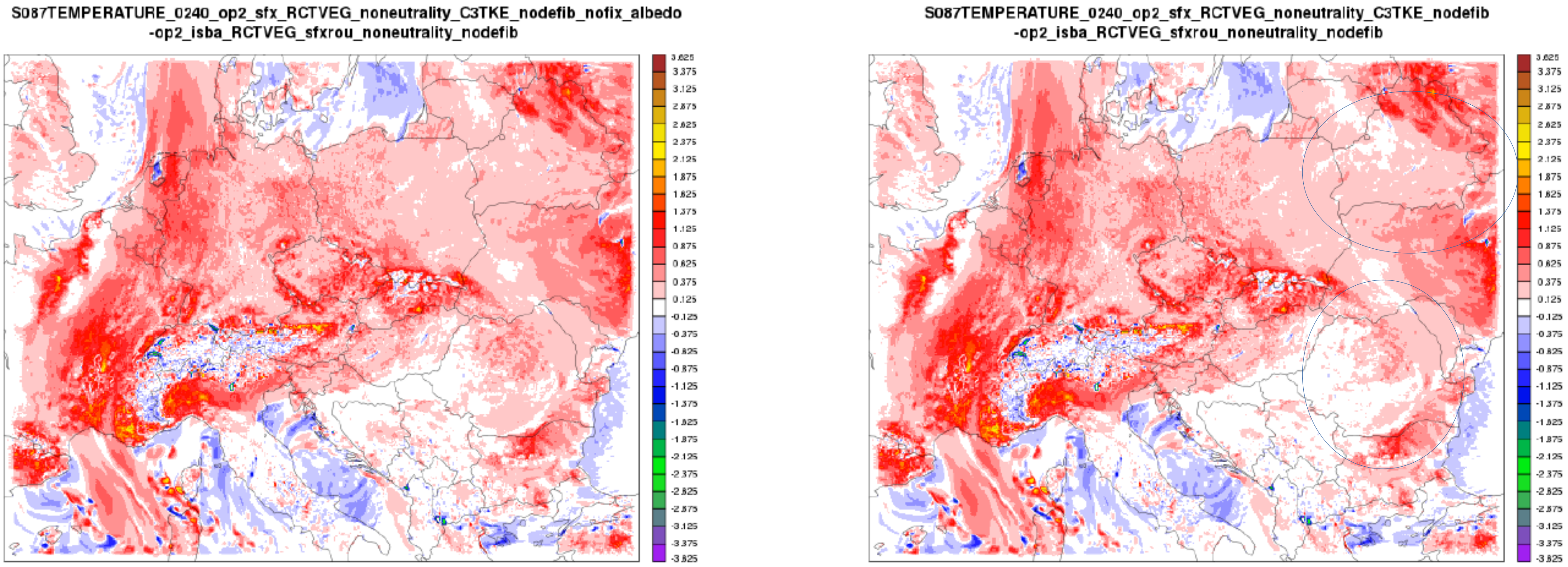
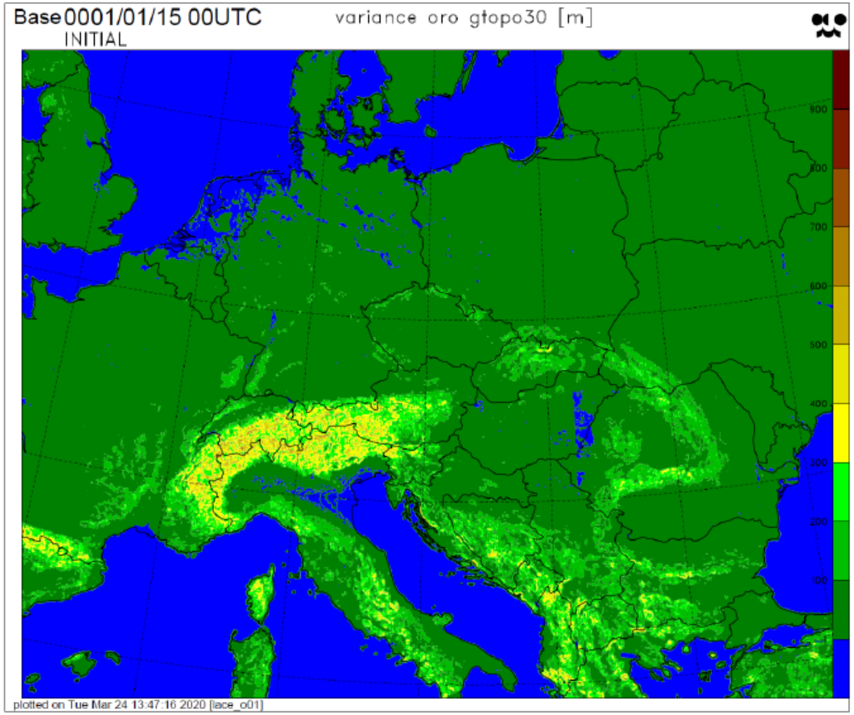


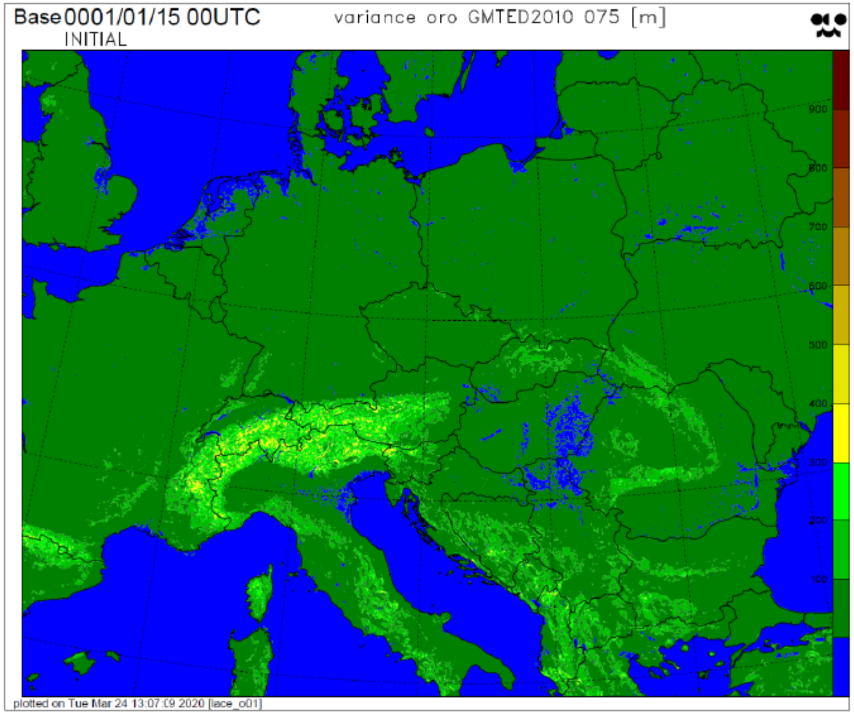
Figure 3.1: Difference in the lowest model level temperature. **Left:** SURFEX run without fixed snow fraction and albedo - ISBA. **Right:** SURFEX run with fixed snow fraction and albedo - ISBA Forecast base time 22-Jan-2019 at 00 UTC. 12 h forecast.

Roughness length (R. Brožkova, J. Mašek)

- When we switch from ALADIN-ISBA to SURFEX, we do not switch only the physical schemes
- The underlying topographical features, the fields that describe the soil and vegetation are also different
- Therefore, we can’t really understand if the differences are due to the physical schemes or the underlying data
- Focus on the roughness length

Roughness length (compute and test)





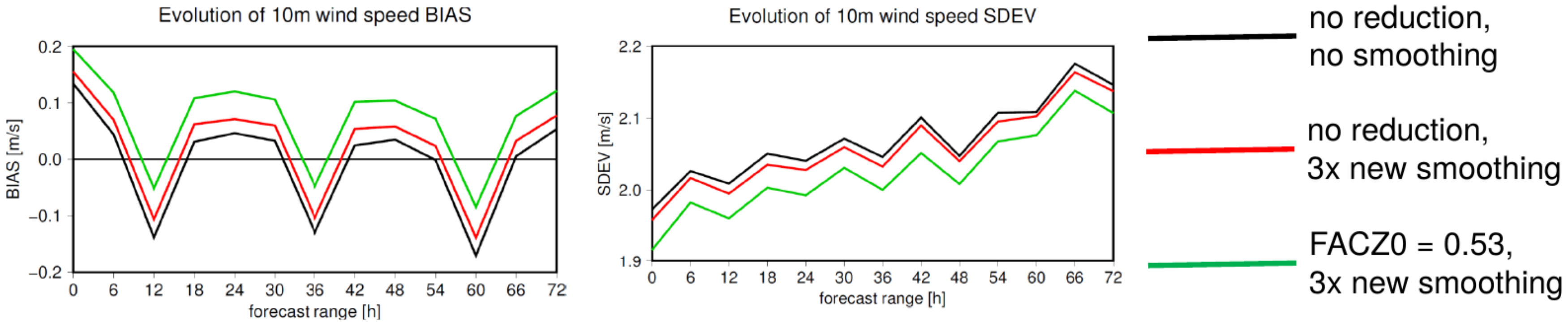
Left: orographic variance calculated from the old database GTOPO30. Right: orographic variance calculated from GMTED2010 with 7.5" resolution. Model grid: 2 325 m.

Roughness length (compute and test)

- FACZ0 is a reduction factor for orographic roughness length
  - 0.53 used with GTOPO30
  - 1 used in SURFEX

- NLISSZ is a smoothing operator
  - A value of 3 has been used with GTOPO30
  - (the smoothing operator in e923 should be replaced with Laplace type operator for very high resolutions)

Roughness length (compute and test)



- Wind speed at 10 m: bias (left) and standard deviation (right) for three experiments with different choice of the orographic roughness, see the legend. Verification domain: Central Europe, period November 2019.
- Smoothing and reduction of orographic roughness increases naturally the wind speed a bit, at the same time it reduces the random error. The old choice of FACZ0 = 0.53 seems somehow unbeatable.

Vegetation roughness length

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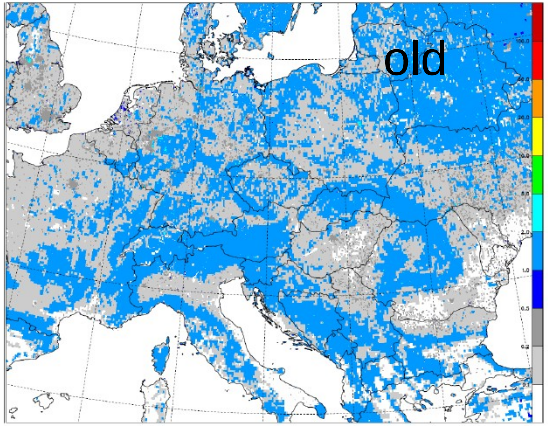
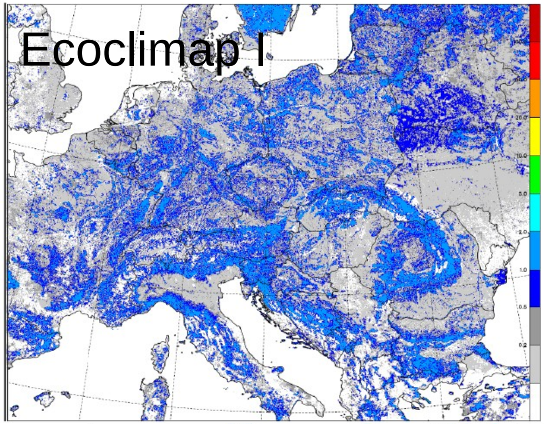
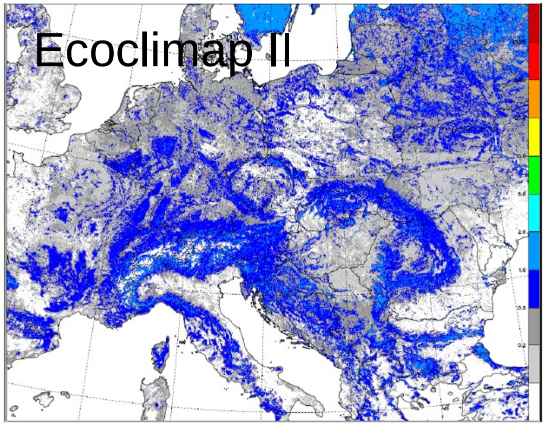
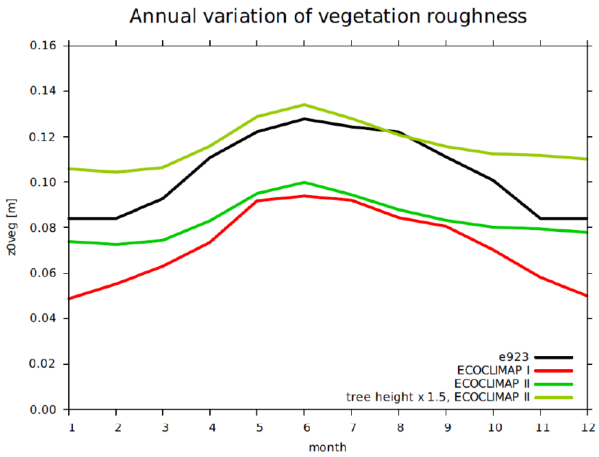




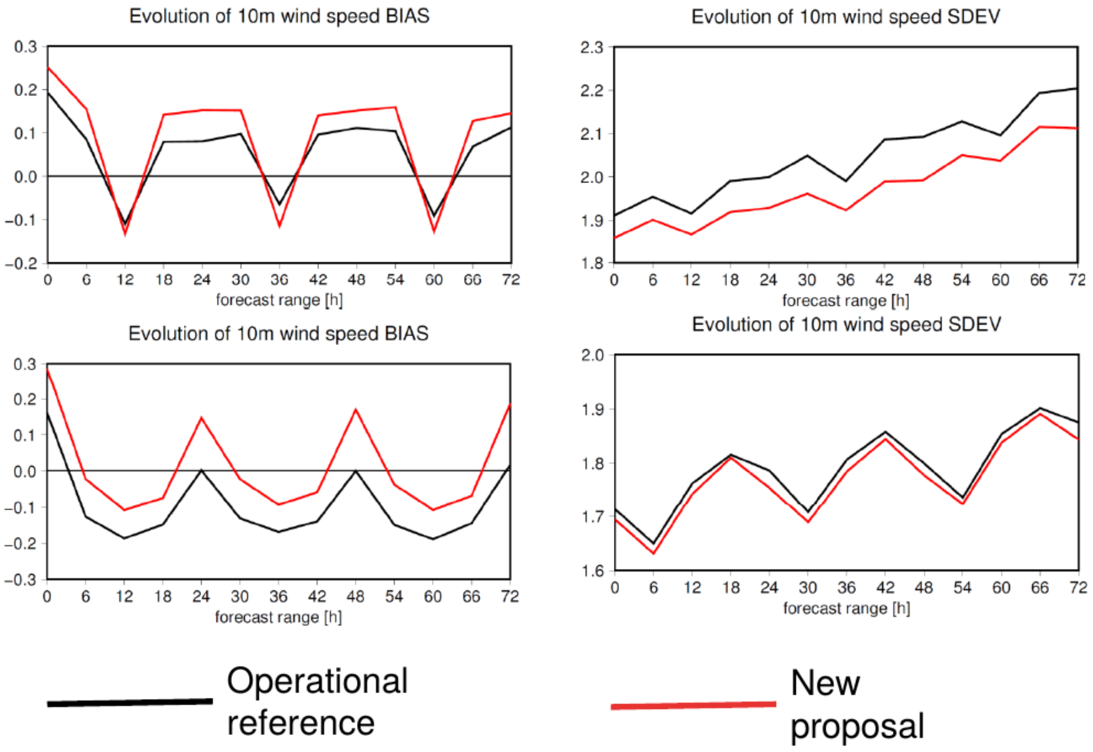


- Multiplying the tree height by 1.5 gives us a plausible solution for getting a right model response.
-



Vegetation and orographic roughness length

- FACZ0=0.53
- 1.5
- Laplace x 3
- Switch off GWD
- 21 Nov-10 Dec 2019
- 14 – 31 May 2019



AROME microphysics (V. Hommonai)

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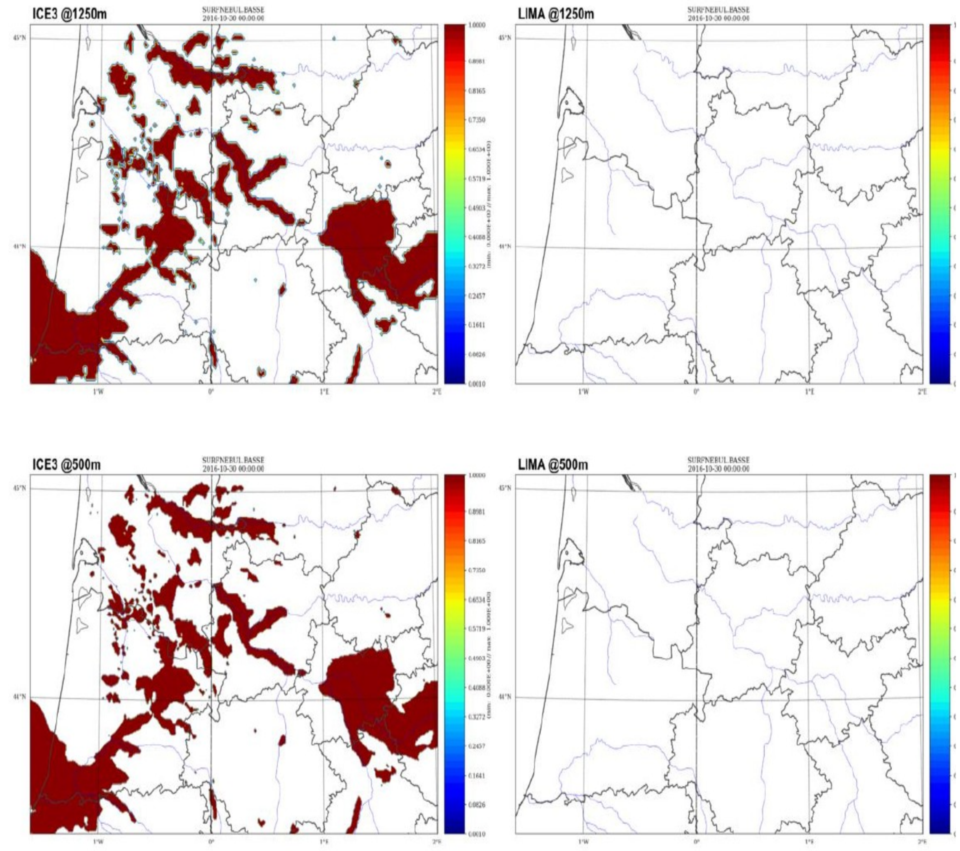


Figure 1:Low cloud cover fields on 30/10/2016 00UTC (initial state) in four cases: ICE3 (left) and LIMA (ri
at 1250m (top) and 500m (bottom) resolution.

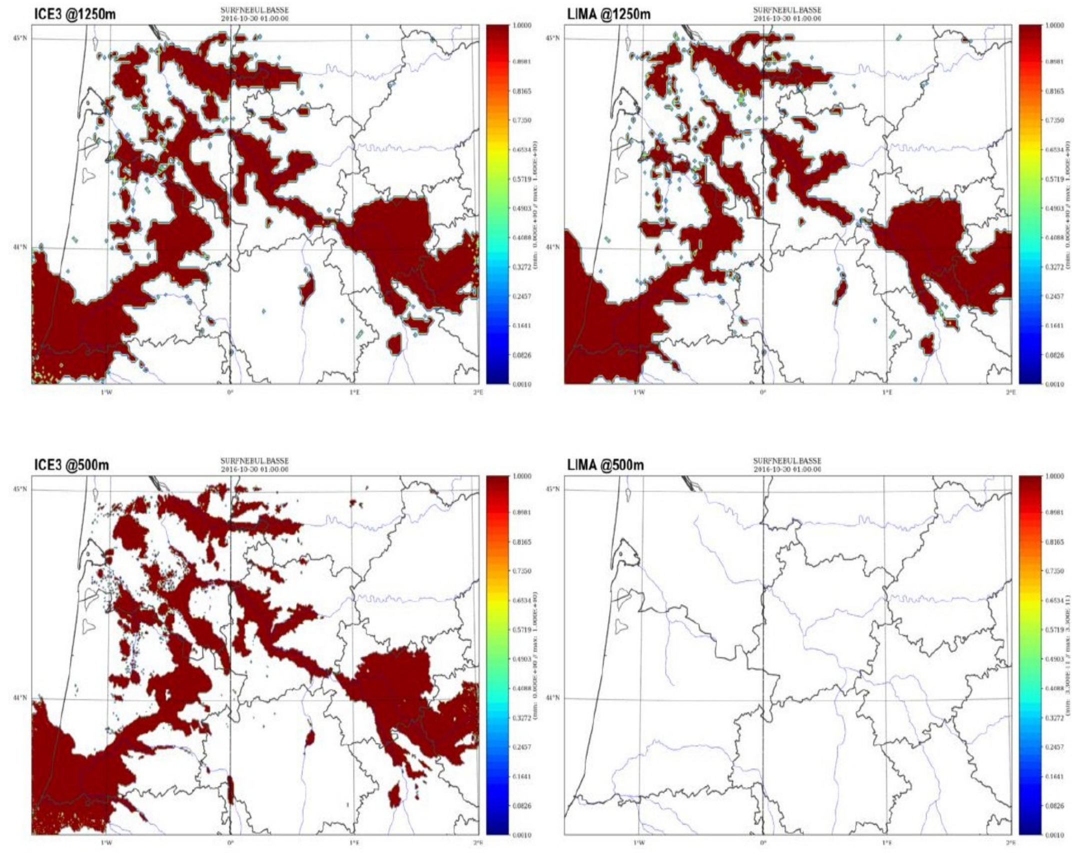


Figure 2: Low cloud cover fields on 30/10/2016 01UTC (+1h forecast) in four cases: ICE3 (left) and LIMA (right) at 1250m (top) and 500m (bottom) resolution.

AROME microphysics

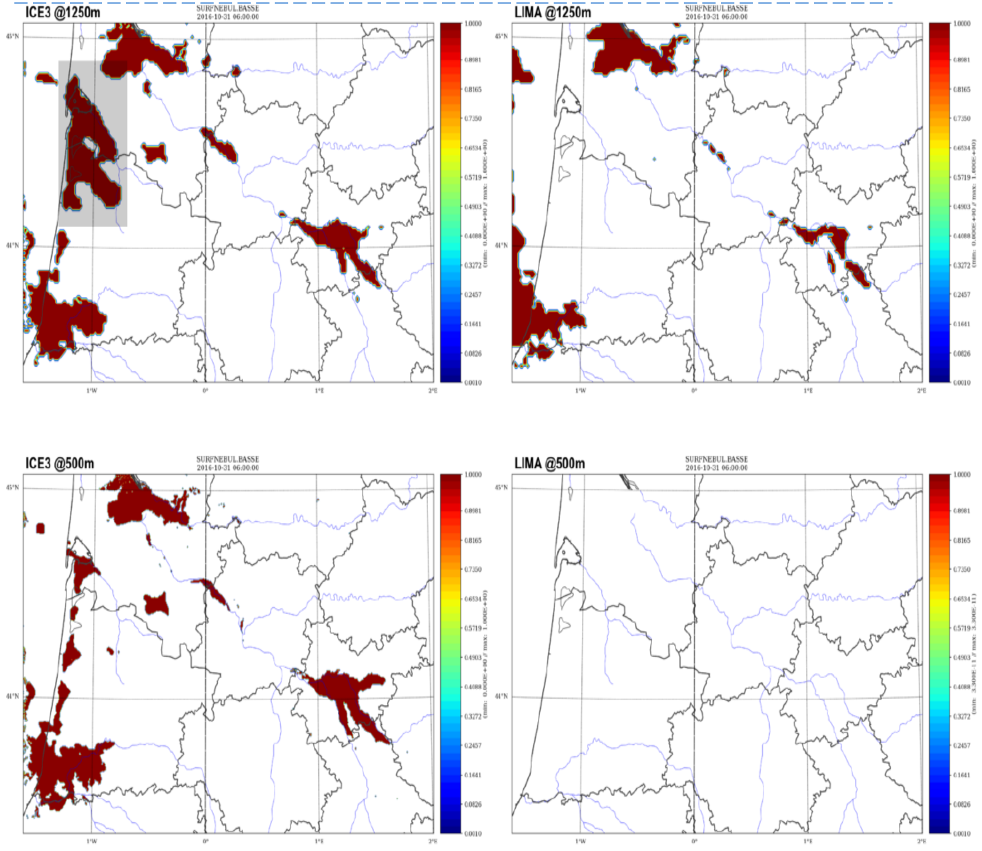
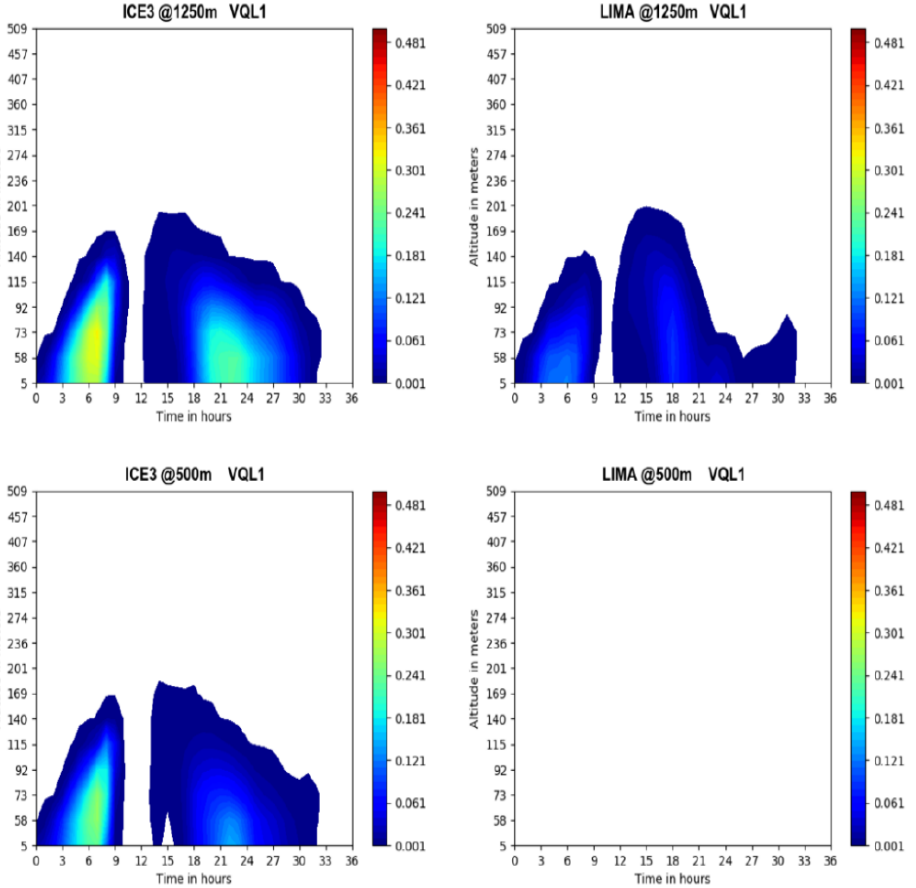


Figure 3: Low cloud cover fields on 31/10/2016 06UTC (+30h forecast) in four cases: ICE3 (left) and LIMA (right) at 1250m (top) and 500m (bottom) resolution. Grey rectangle shows the DDH domain.



Time-height cross section of LWC in four cases: ICE3 (left) and LIMA (right) at 1250m (top) and 500m (bottom) resolution.

AROME microphysics

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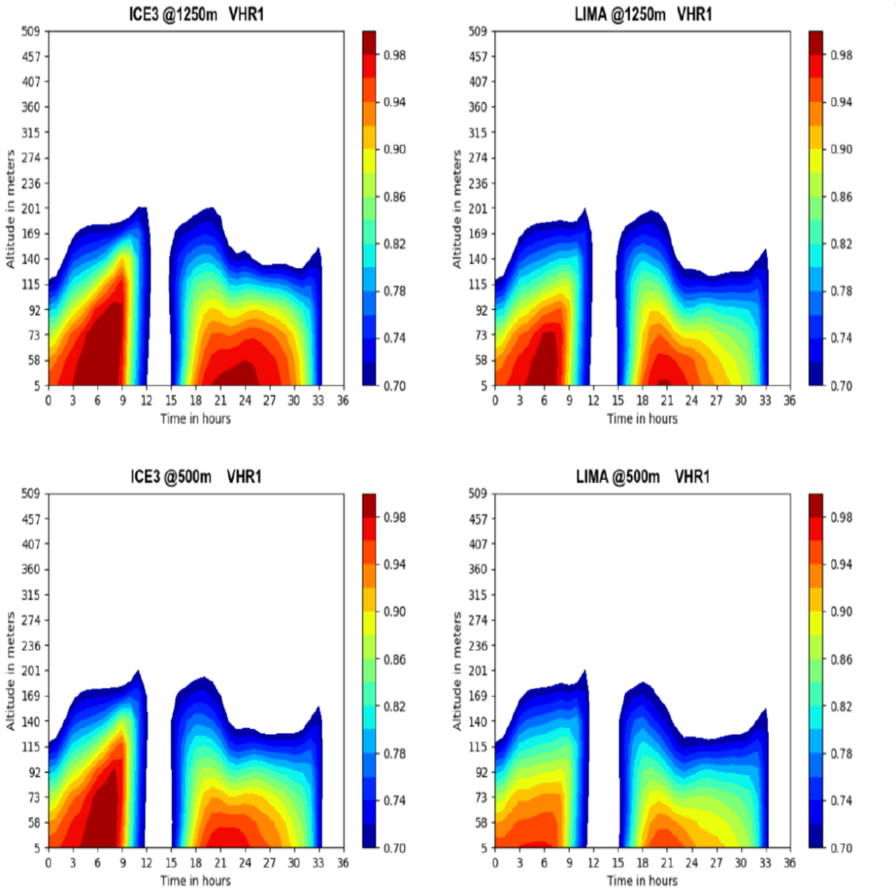

Figure 6: Time-height cross section of relative humidity in four cases: ICE3 (left) and LIMA (right) at (top) and 500m (bottom) resolution.

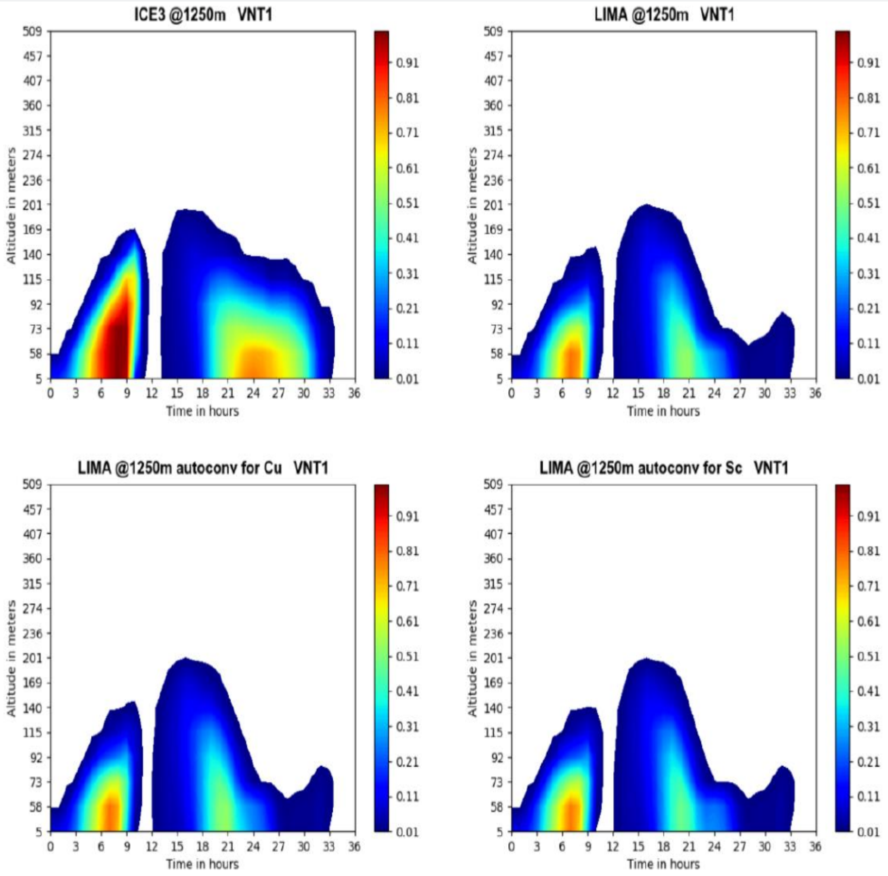

Figure 9: Time-height cross section of cloud fraction in the case of ICE3 (top left) and three cases of LIMA: original autoconversion function (top right), autoconversion for cumulus clouds (bottom left) and autoconversion for stratocumulus clouds (bottom right). Each simulation was run at 1250 m resolution.

To do

- Prognostic mixing length
- Prognostic graupel tuning and validation
- New diagnostic parameters coding, tuning and validation
- Aerosols
- Radiation
- SURFEX with ALARO1
- New surface fields
- AROME and ALARO case studies
- ...

Thank you for your attention.