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Preliminary results at 500m and 200m with AROME over the Alps with physics adaptation

E. Bazile (ACCORD/AROME CSC - Météo-France/CNRM)
L. Rogel (DE_330), F. Voitus, R. Honnert, L. Auger, Y. Seity

EWGLAM/SRNWP, Reykjavik 25-28 September 2023

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Impact of "pseudo 3D effects", shallow convection and dynamics options for AROME-500m and below

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Outline

- “pseudo 3D effects” in the turbulence based on Goger et al. (2018) in AROME
- AROME @ 500m over Austria for a convective case 18 August 2022
- The COMBLE case with AROME 1.25km and 500m
- Preliminary test at 200m over Austria

Impact of Goger et al. (2018) in AROME

- Since cy48t2 horizontal gradients are available in the AROME physics (Honnert and El Khatib (2020))
- For complex terrain: Goger et al. (2018)

$$\left.\frac{\partial \overline{e}}{\partial t}\right|_{\text{shear}} = (C_s \Delta x)^2 \left[\left(\frac{\partial \overline{u}}{\partial x}\right)^2 + \left(\frac{\partial \overline{v}}{\partial y}\right)^2 + \frac{1}{2}\left(\frac{\partial \overline{u}}{\partial y} + \frac{\partial \overline{v}}{\partial x}\right)^2 \right]^{\frac{3}{2}}$$

where C_s is chosen to be the Smagorinsky constant.

- Preliminary results showed during the ACCORD ASM (March 2023) :
  - Very small impact of this additional term even at 500m over the Alps
  - The horizontal component of the TKE dynamical production is only 5-8% of the total

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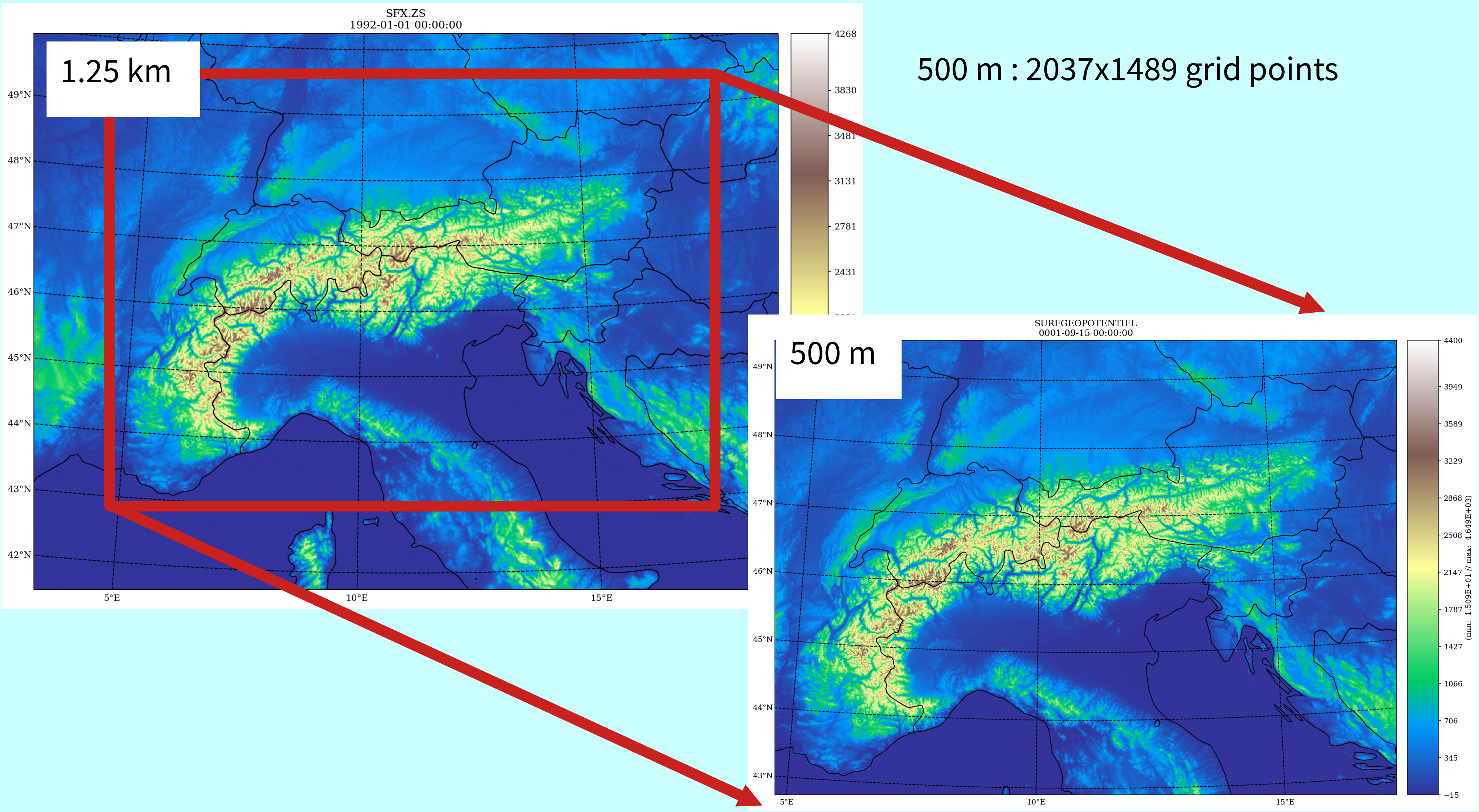
- Preliminary results showed during the ACCORD ASM (March 2023) :
  - Very small impact of this additional term even at 500m over the Alps
  - The horizontal component of the TKE dynamical production is only 5-8% of the total

- BUT … the horizontal derivative have been computed on the η coordinates and not z

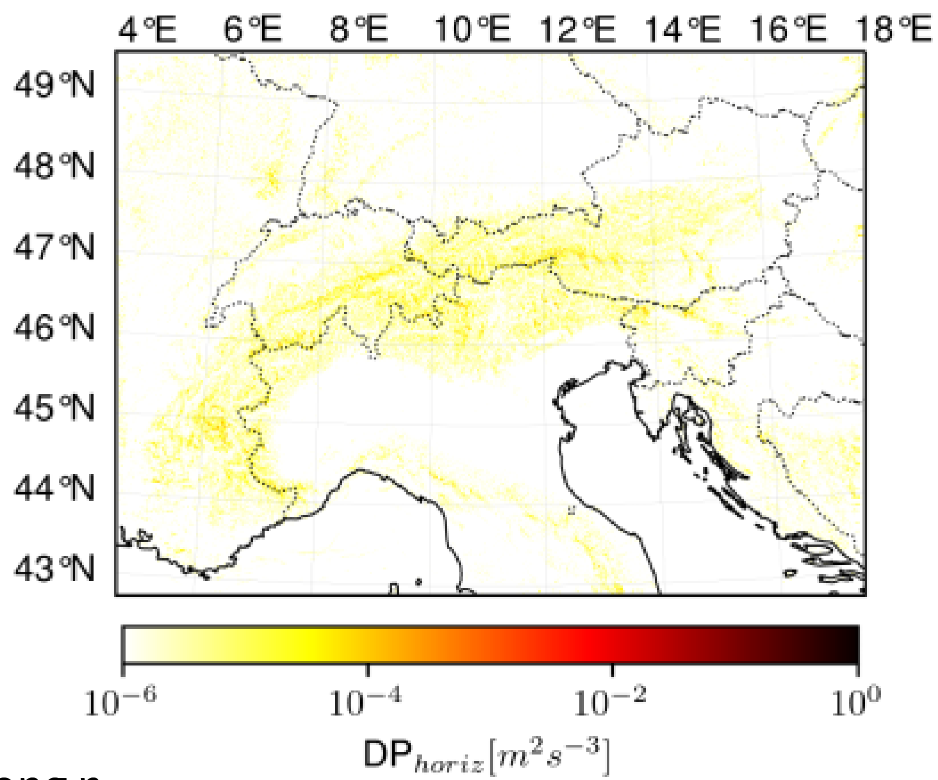
Domains for TEAMx

500 m : 2037x1489 grid points



Impact of Goger et al. (2018) in AROME

AROME @ 500m Level =120   ~ 2.5m



Along η

From L. Rogel, F. Voitus

Impact of Goger et al. (2018) in AROME

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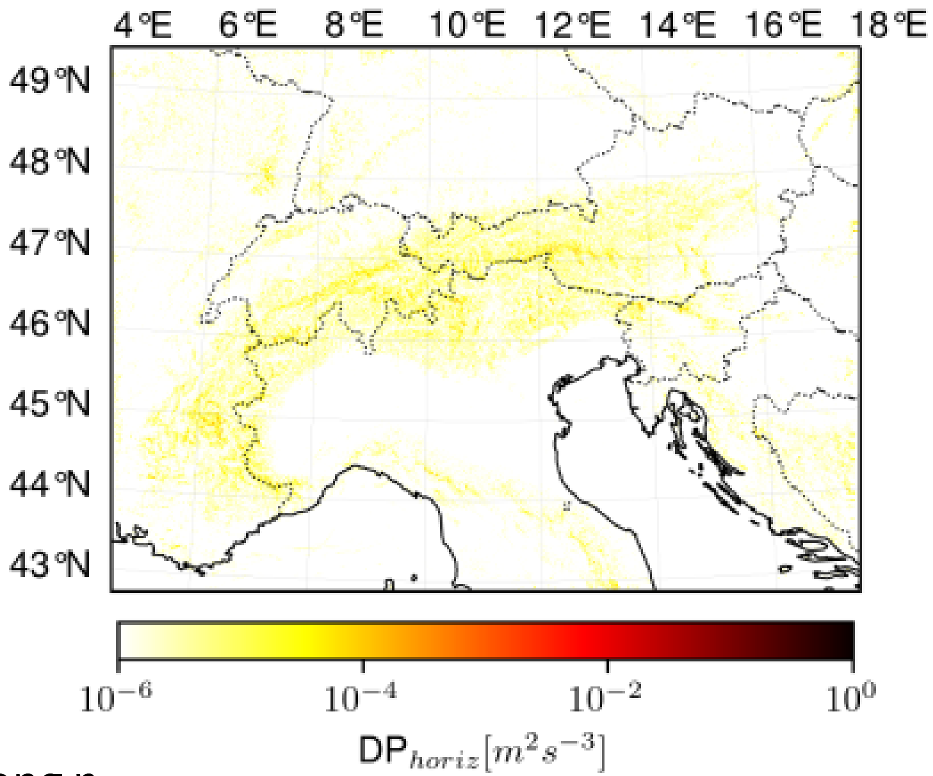


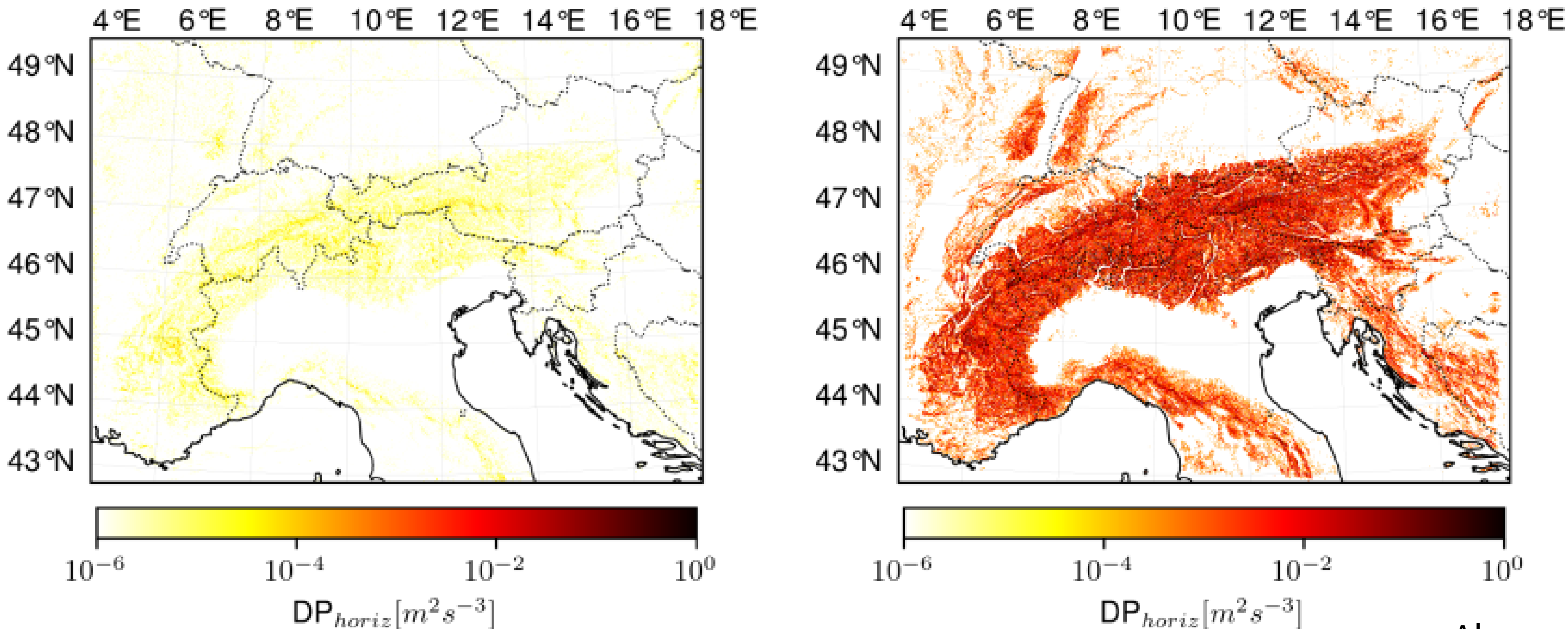
Along η

$$\left.\frac{\partial u}{\partial x}\right|_z = \left.\frac{\partial u}{\partial x}\right|_\eta \underbrace{- \left.\frac{\partial \Phi}{\partial x}\right|_\eta \frac{\partial u}{\partial \Phi}}_{\text{Metric term}}$$

From L. Rogel, F. Voitus

Impact of Goger et al. (2018) in AROME

AROME @ 500m Level =120   ~ 2.5m



Along η

Along z

$$\left.\frac{\partial u}{\partial x}\right|_z = \left.\frac{\partial u}{\partial x}\right|_\eta - \underbrace{\left.\frac{\partial \Phi}{\partial x}\right|_\eta \frac{\partial u}{\partial \Phi}}_{\text{Metric term}}$$

From L. Rogel, F. Voitus

Horizontal mixing length

$$\left.\frac{\partial \overline{e}}{\partial t}\right|_{\text{shear}} = (C_s \Delta x)^2 \left[\left(\frac{\partial \overline{u}}{\partial x}\right)^2 + \left(\frac{\partial \overline{v}}{\partial y}\right)^2 + \frac{1}{2}\left(\frac{\partial \overline{u}}{\partial y} + \frac{\partial \overline{v}}{\partial x}\right)^2 \right]^{\frac{3}{2}}$$

where C_s is chosen to be the Smagorinsky constant.

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where C_s is chosen to be the Smagorinsky constant.

$$L_{\text{smag}}^{(1)} = c_{\text{smag}} \sqrt{\Delta x \cos \alpha_x \, \Delta y \cos \alpha_y}$$

$$\alpha_x = \arctan \frac{\partial z_S}{\partial x} \qquad \alpha_y = \arctan \frac{\partial z_S}{\partial y}$$

Modified Smagorinsky (1963) with the slope

From Leo Rogel, F. Voitus

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Modified Smagorinsky (1963) with the slope

Wang et al. (2021)

$$L_{\text{W}} = \left(\frac{\Delta_0}{\sqrt{\Delta x \Delta y}}\right)^{\alpha} \frac{\sqrt{U^2 + V^2}}{\left[(\partial_x V)^2 + (\partial_y U)^2\right]^{1/4} \left[(\partial_x U)^2 + (\partial_y V)^2\right]^{1/4}}$$

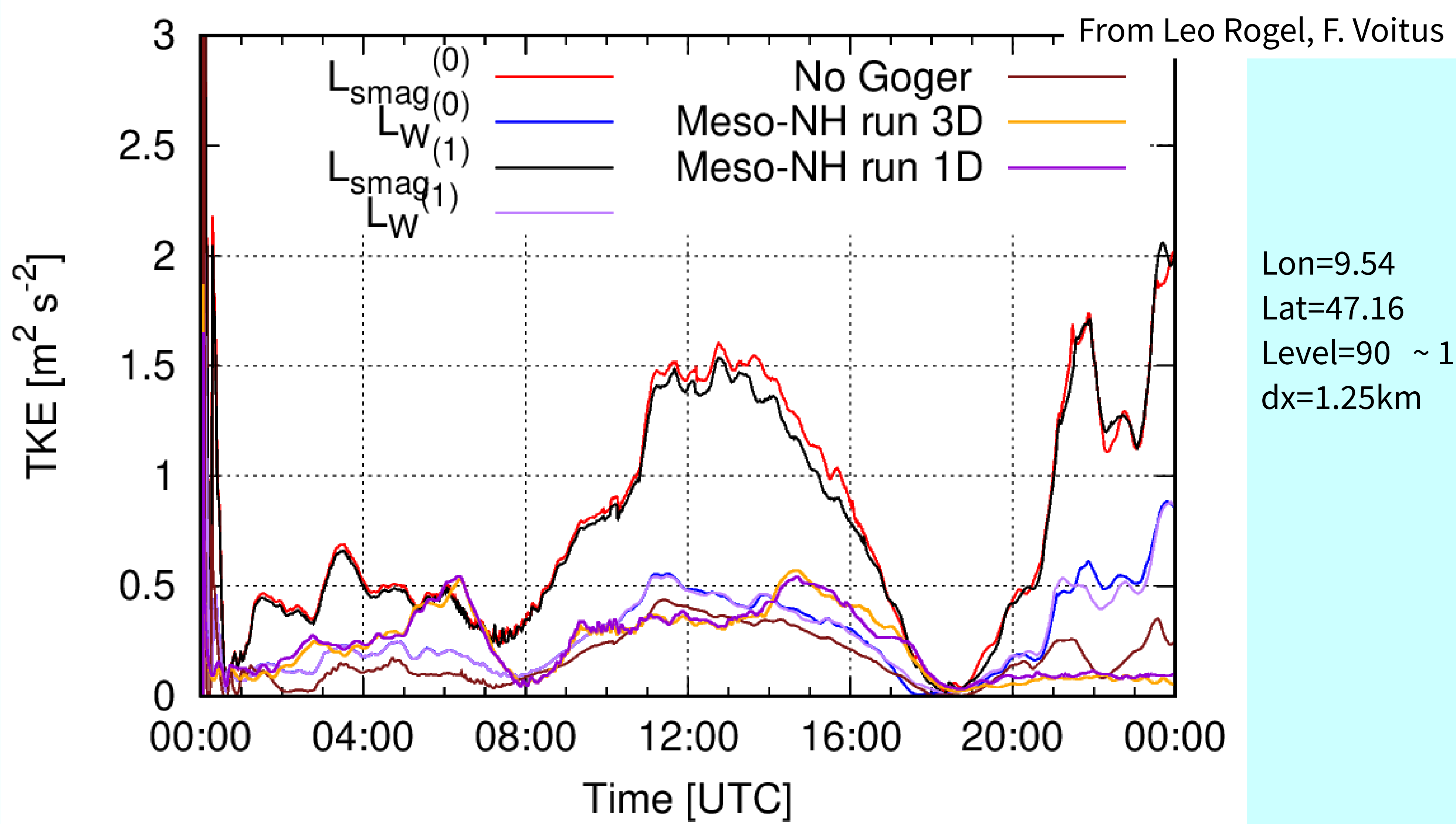
$$L_{\text{W}}^{(0)} = \min\left[L_{\text{W}}, L_{\text{smag}}^{(0)}\right]$$

$$L_{\text{W}}^{(1)} = \min\left[L_{\text{W}}, L_{\text{smag}}^{(1)}\right]$$

$\alpha = 1.5$ et $\Delta_0 = 500\text{m}$

From Leo Rogel, F. Voitus

Impact of horizontal mixing length



Lon=9.54
Lat=47.16
Level=90 ~ 10m
dx=1.25km

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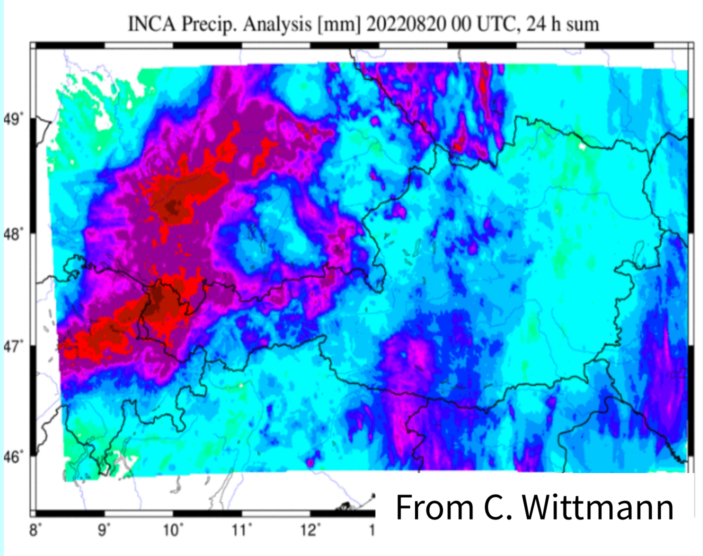
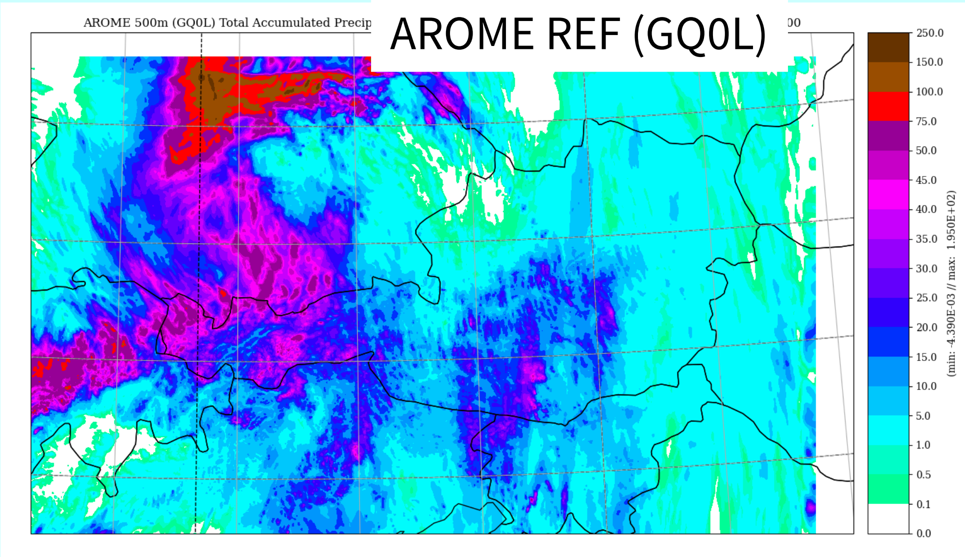
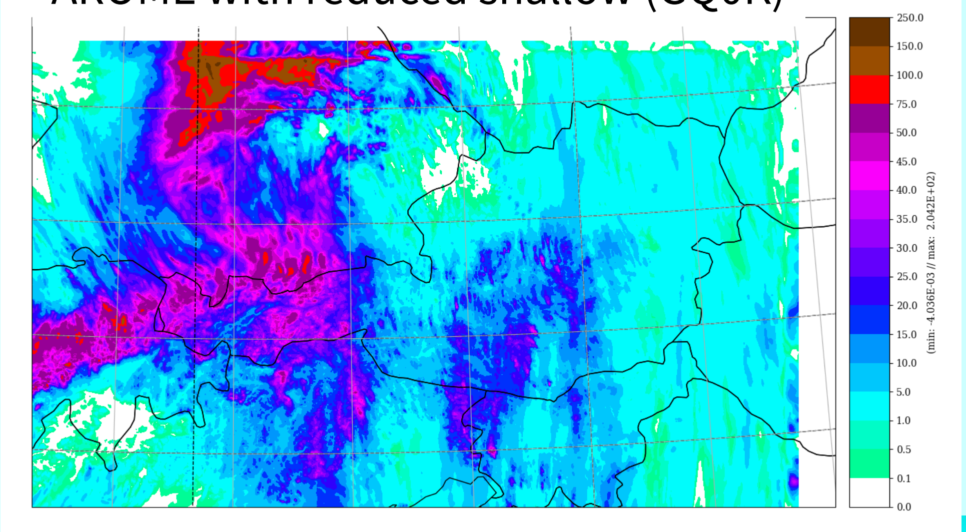
AROME-500m : 18 August 2022 00h: Rain +48h-24h



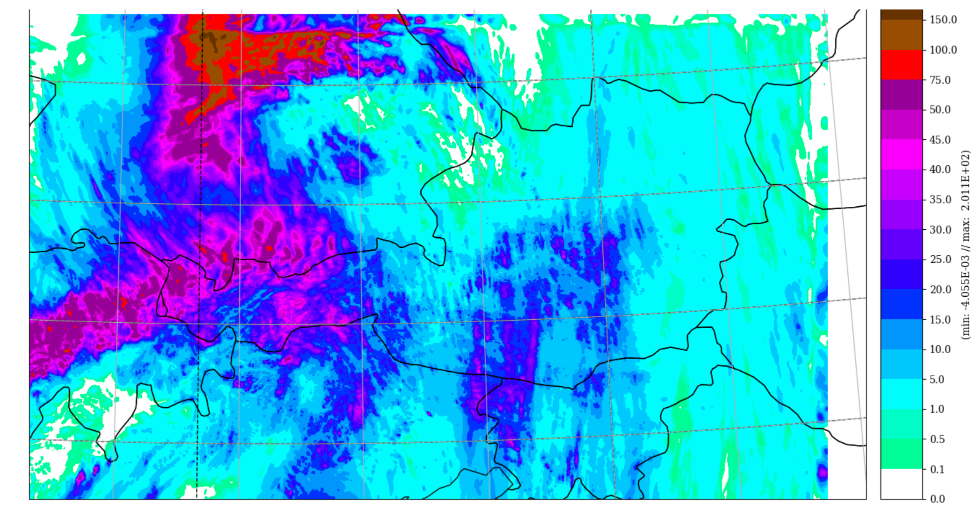
AROME REF (GQ0L)



AROME with reduced shallow (GQ0K)



AROME with reduced shallow and Goger (GPX4)



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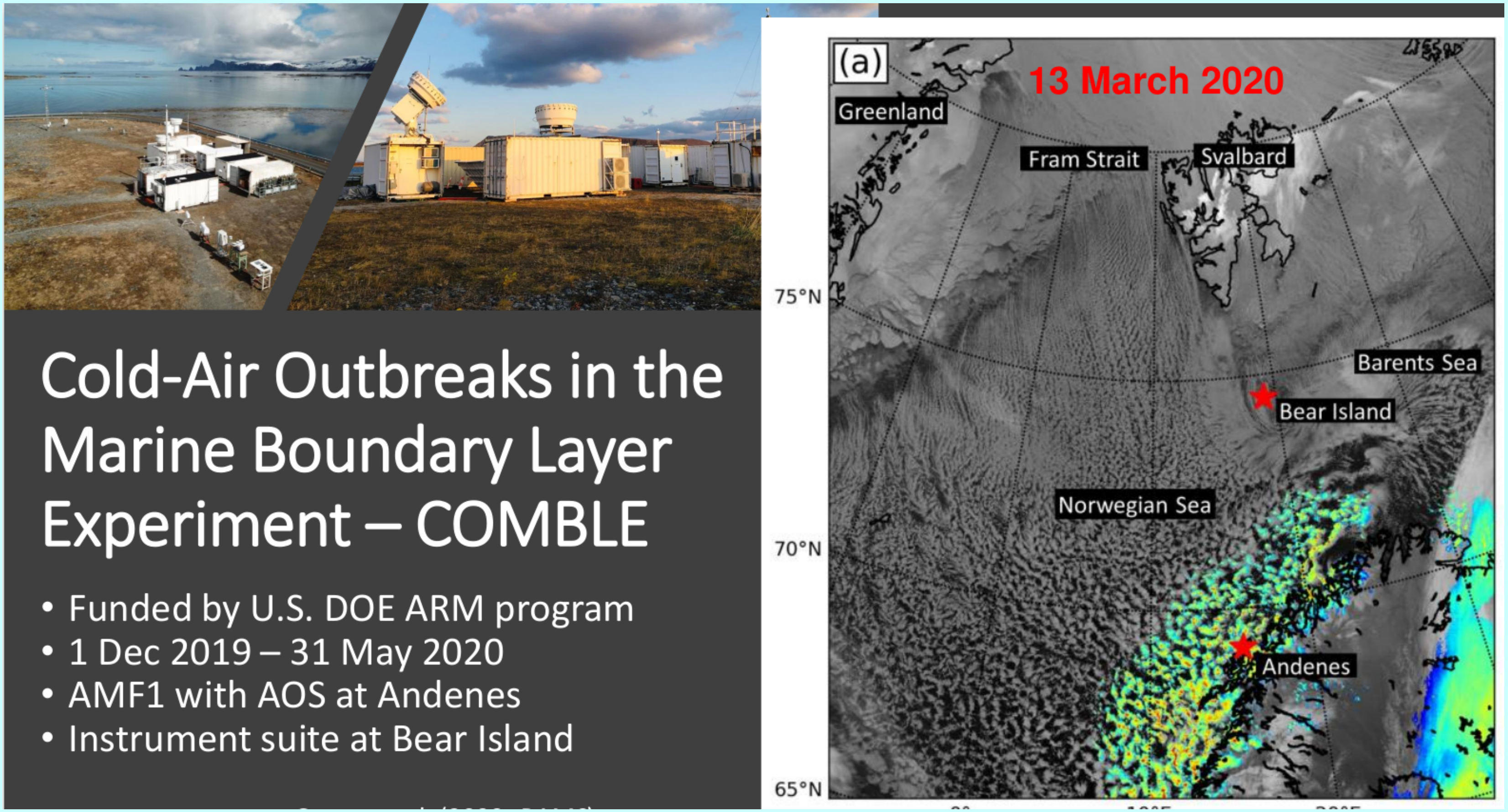
From Geerts et al. (2022, BAMS)



Courtesy T. Juliano (NCAR)

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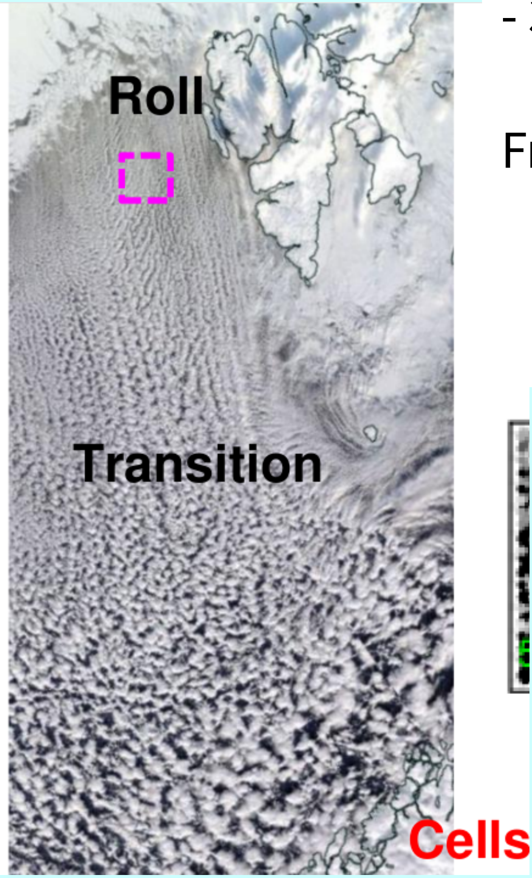
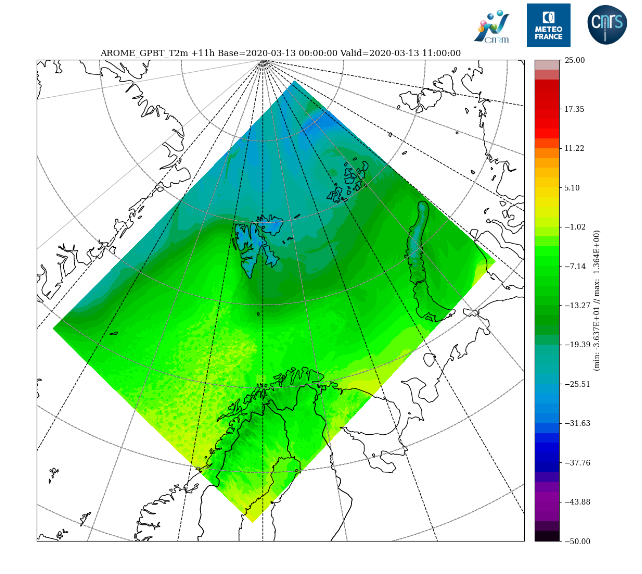
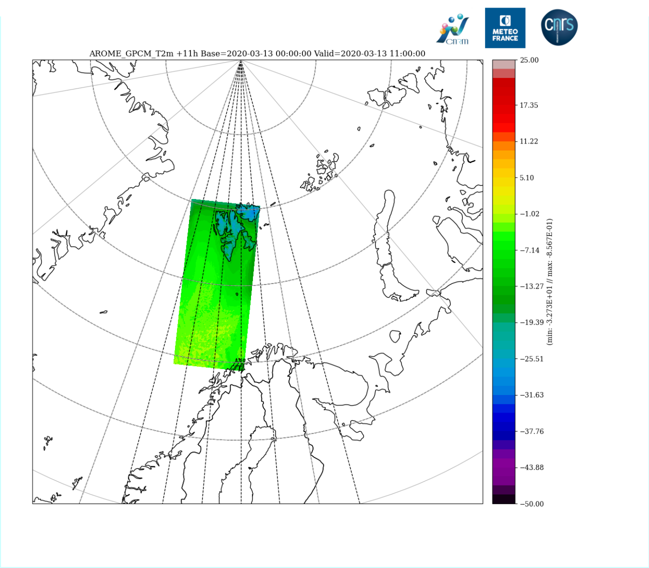
COMBLE



- 3 configurations of the NH model AROME over Svalbard
  - 1.25 Km 90 vertical levels (similar to AROME version used over France for the dynamics and physics). (1500x1920 grid points)
  - 500m and 90 vertical levels (1st level at 5m) (1024x2430 grid points)
  - 500m and 120 vertical levels (1st level at 2.5m) (1024x2430 grid points)

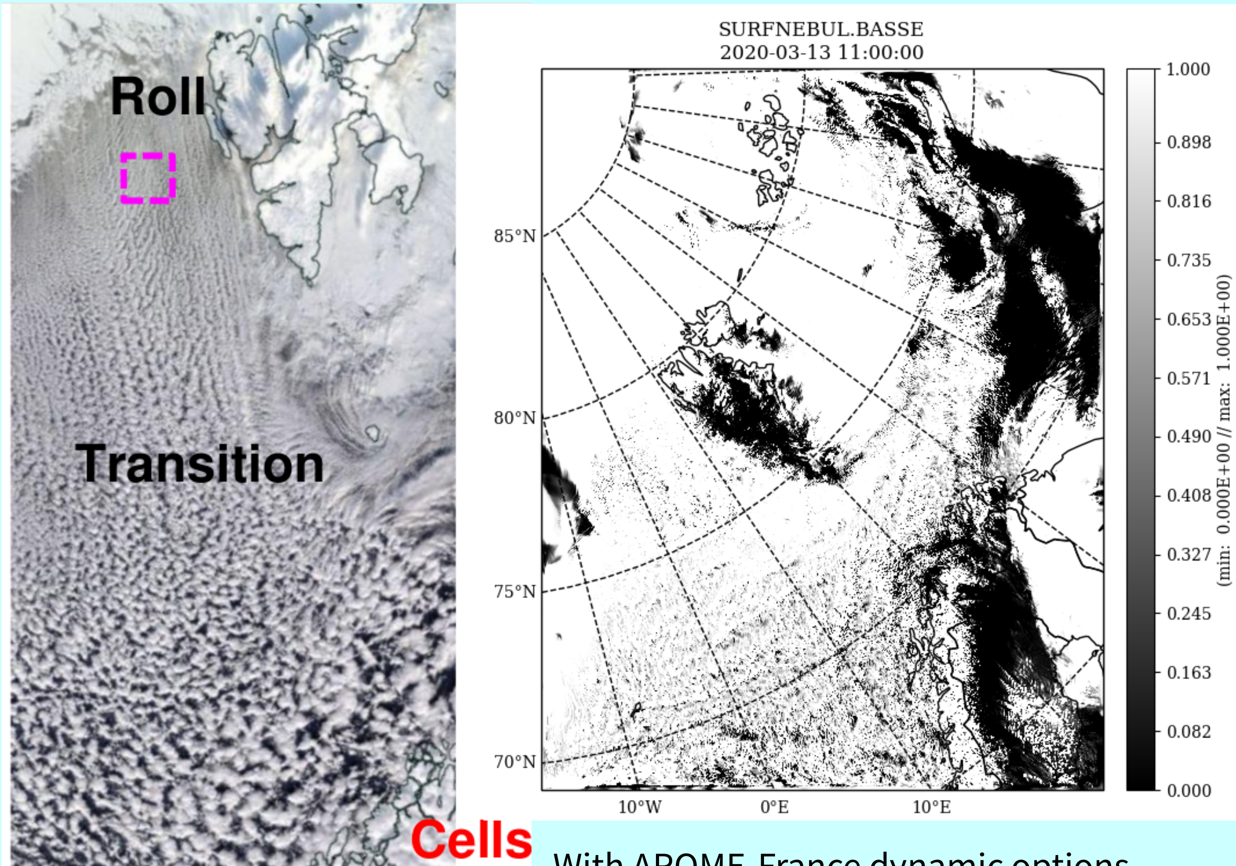


T2m AOME 1.25km
13th March 2020 11TU



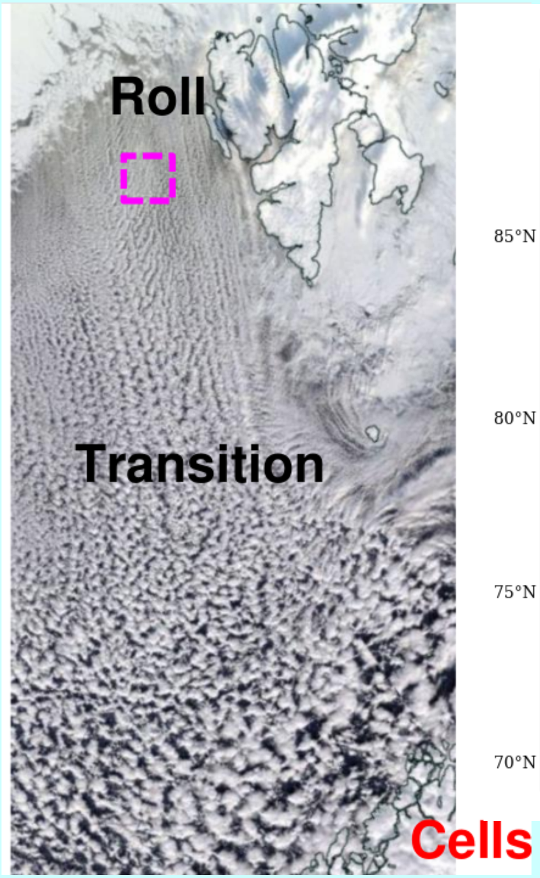
T2m AOME 500m
13th March 2020 11TU

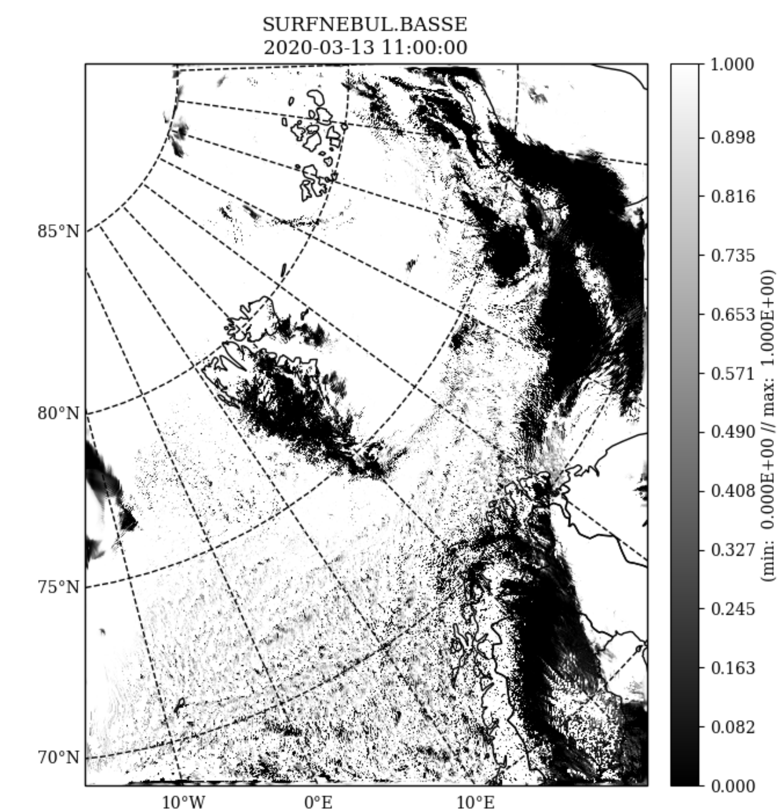
COMBLE with AROME 1.25km



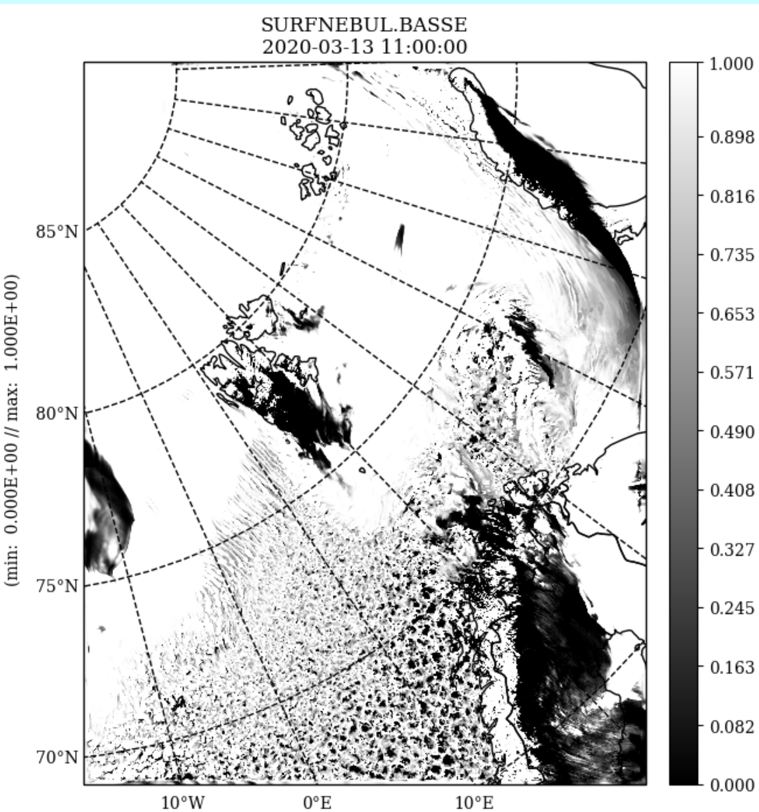
With AROME-France dynamic options

COMBLE with AROME 1.25km



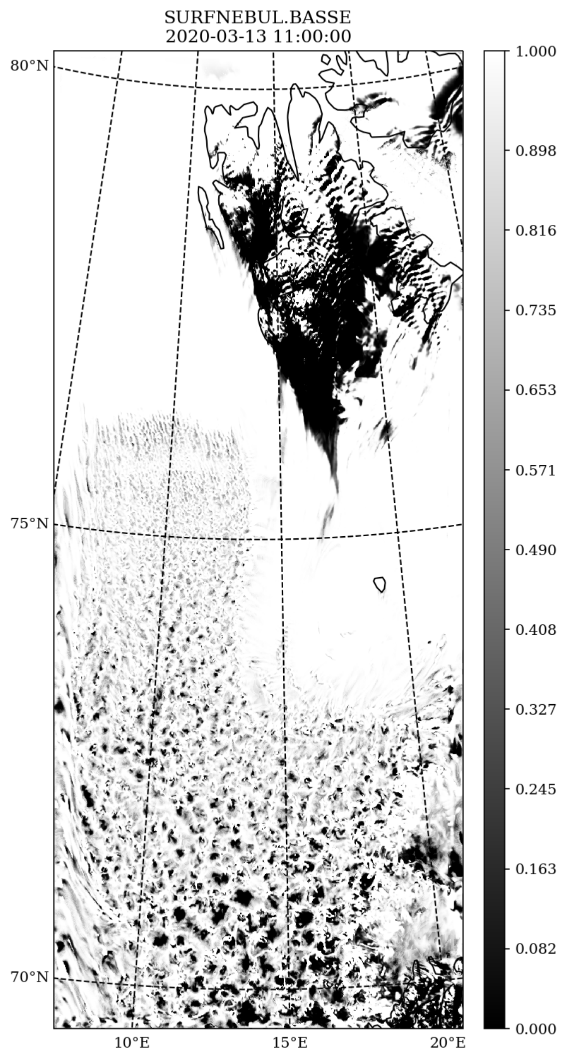


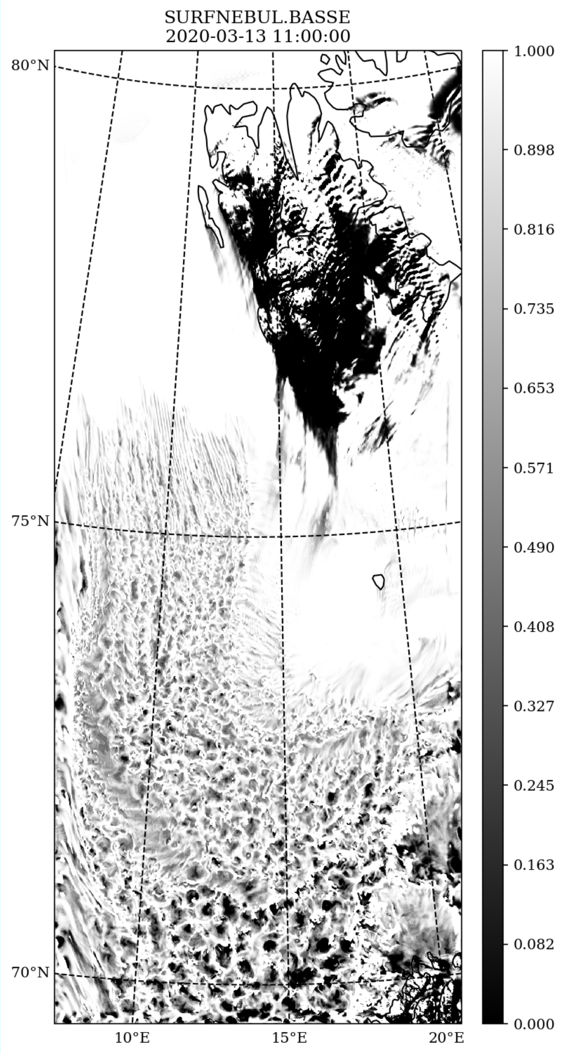
With AROME-France dynamic options

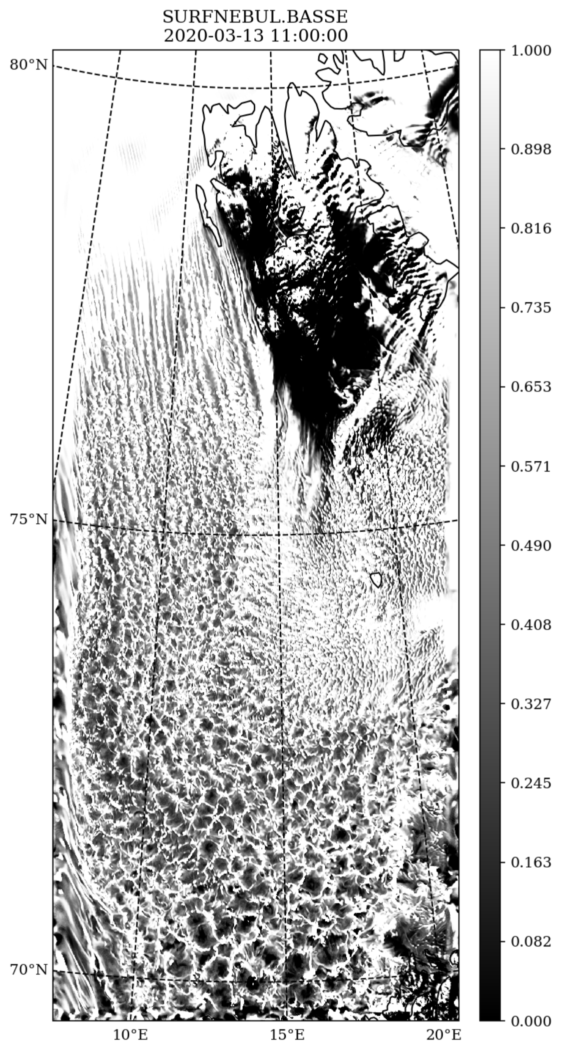


AROME used for YOPP and RALI-THINICE
2 iter. in the PC scheme and CHEAP=F

COMBLE with AROME 500m L90



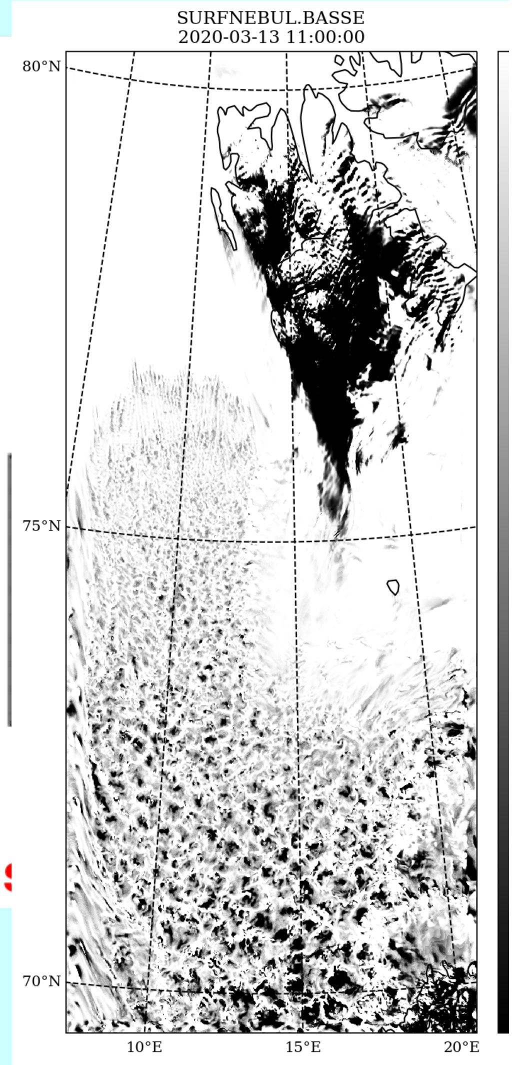




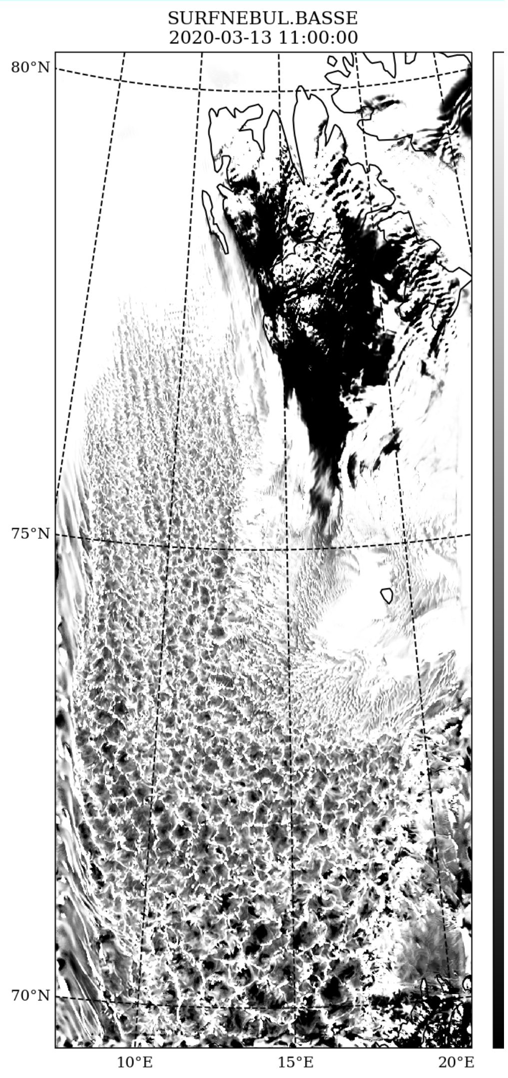
XCMF=0.065 XCMF=0.03 XCMF=0.01

coefficient for the mass flux at the first level of the updraft (closure)

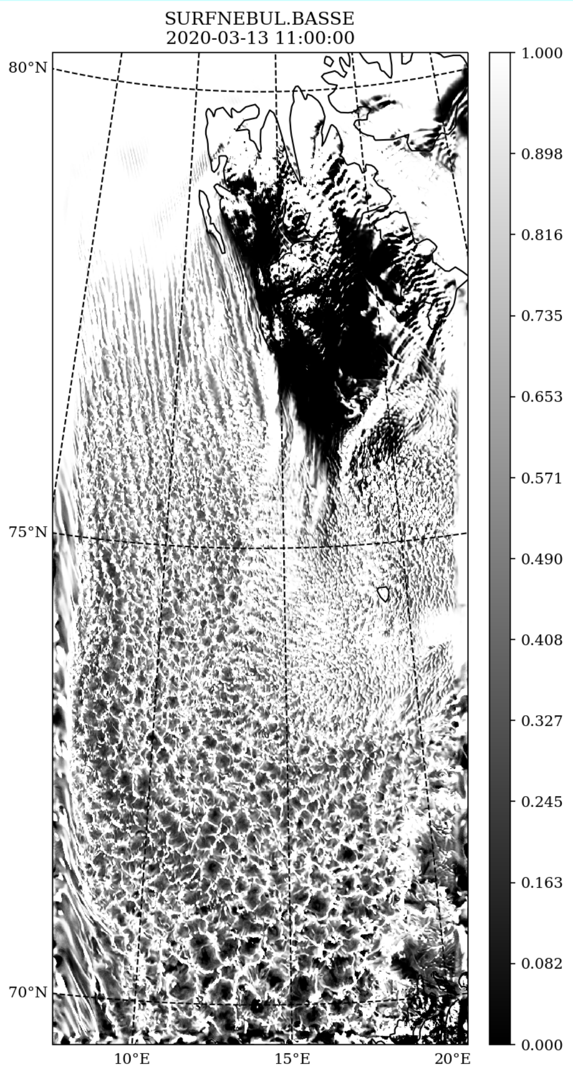
COMBLE with AROME 500m L90



Ref

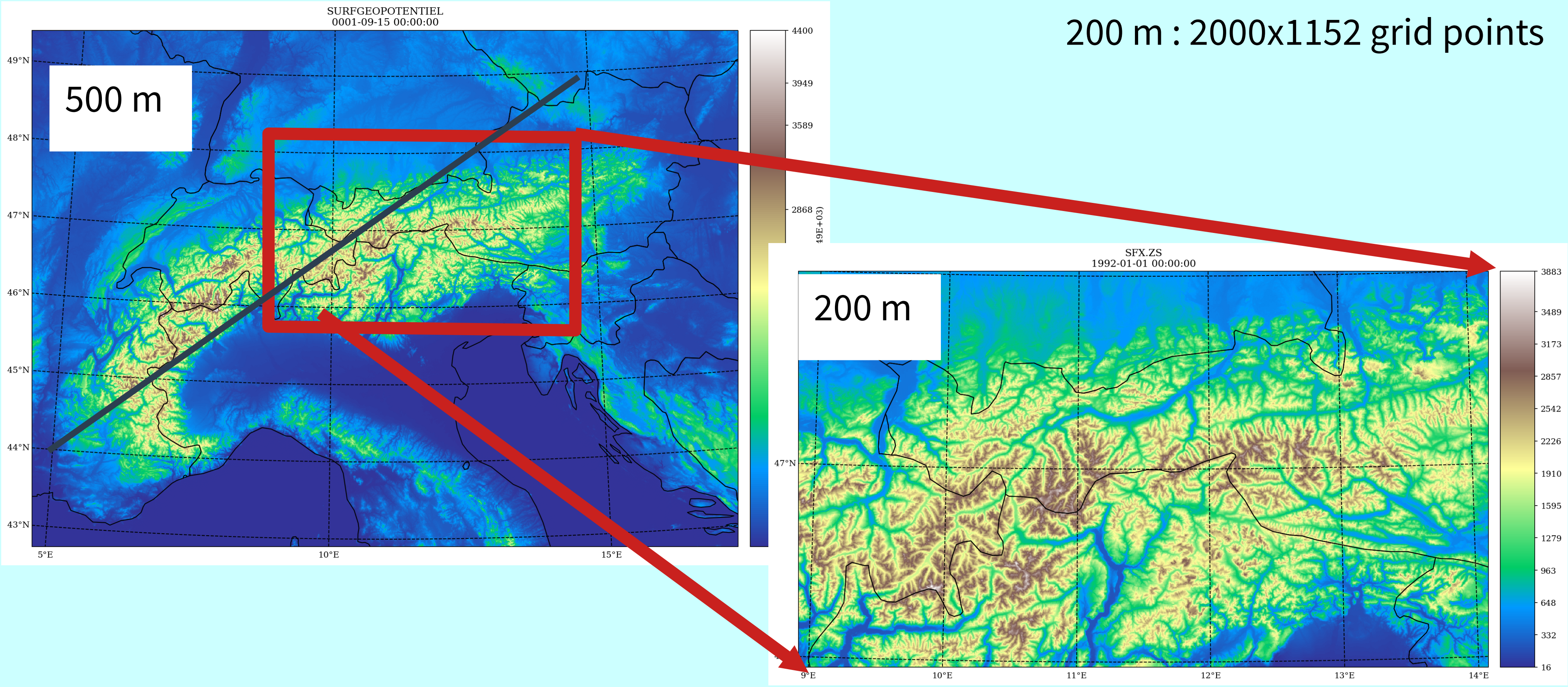


With shallow scale aware
(Lancz et al. (2018))



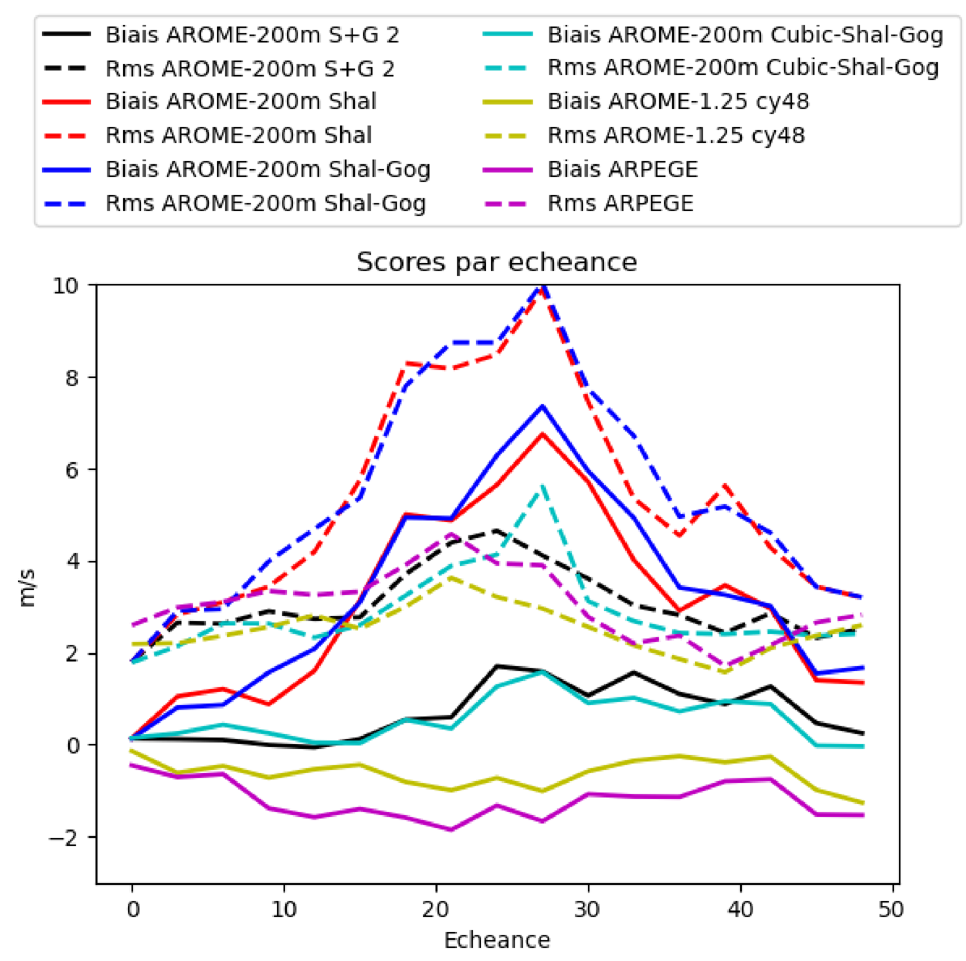
XCMF=0.01

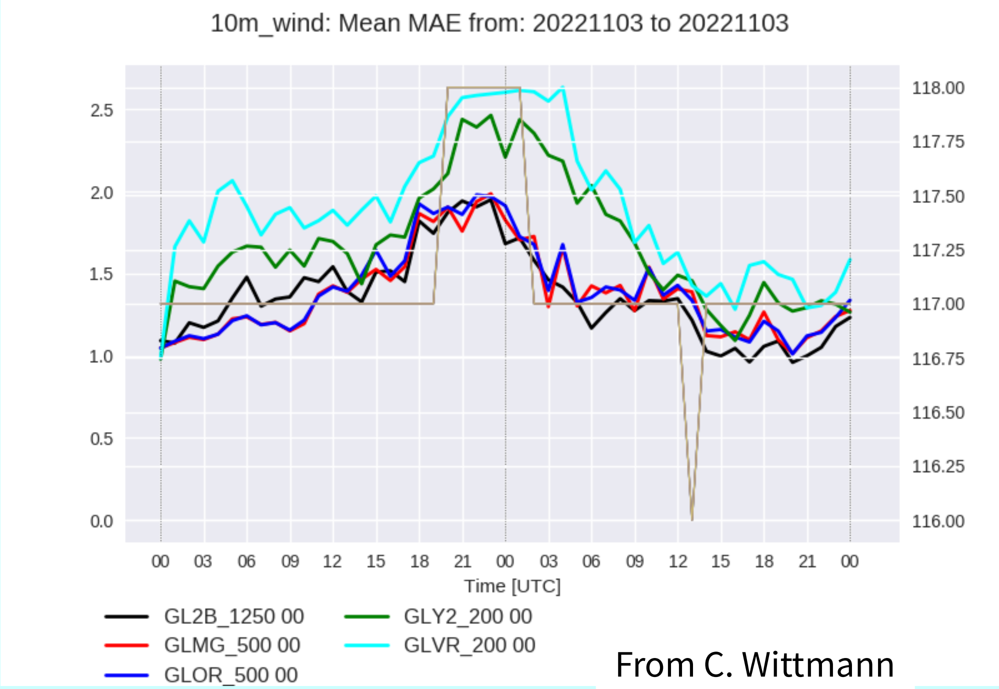
AROME 200m : 2000x 1152 L90



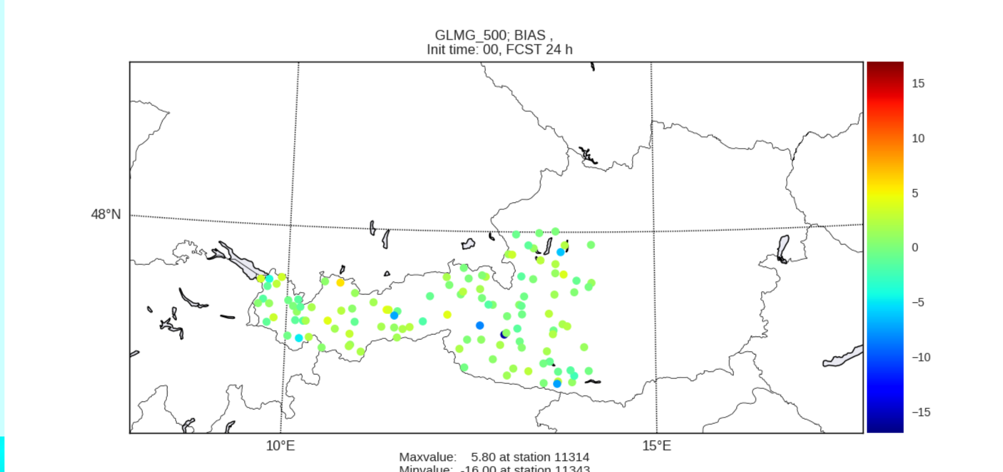
200 m : 2000x1152 grid points

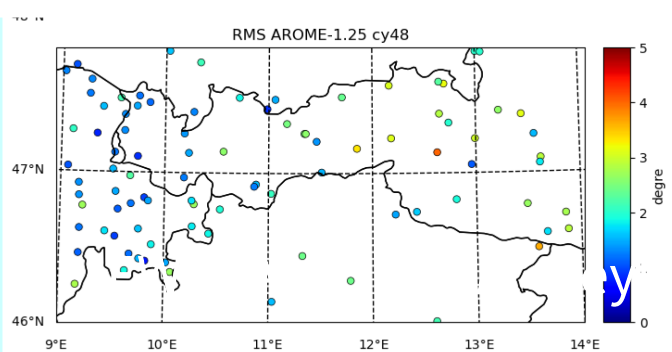
3 November 2022 : 10m Wind Speed





From C. Wittmann





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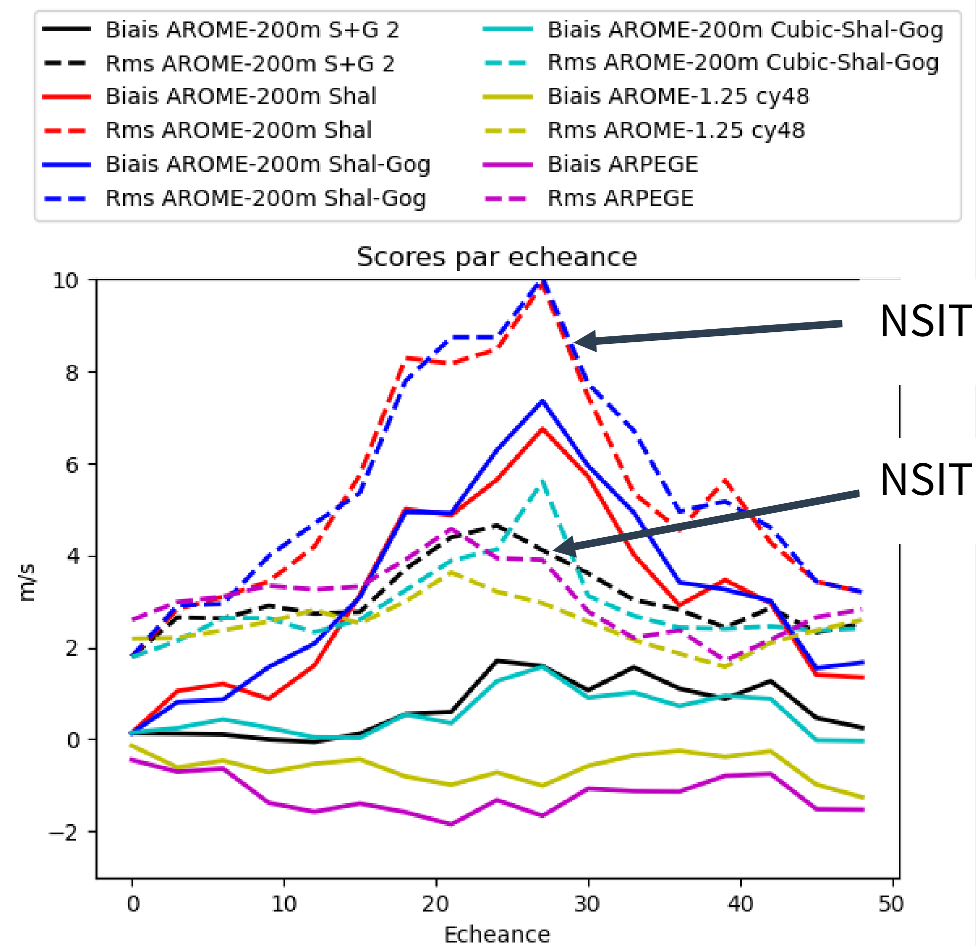
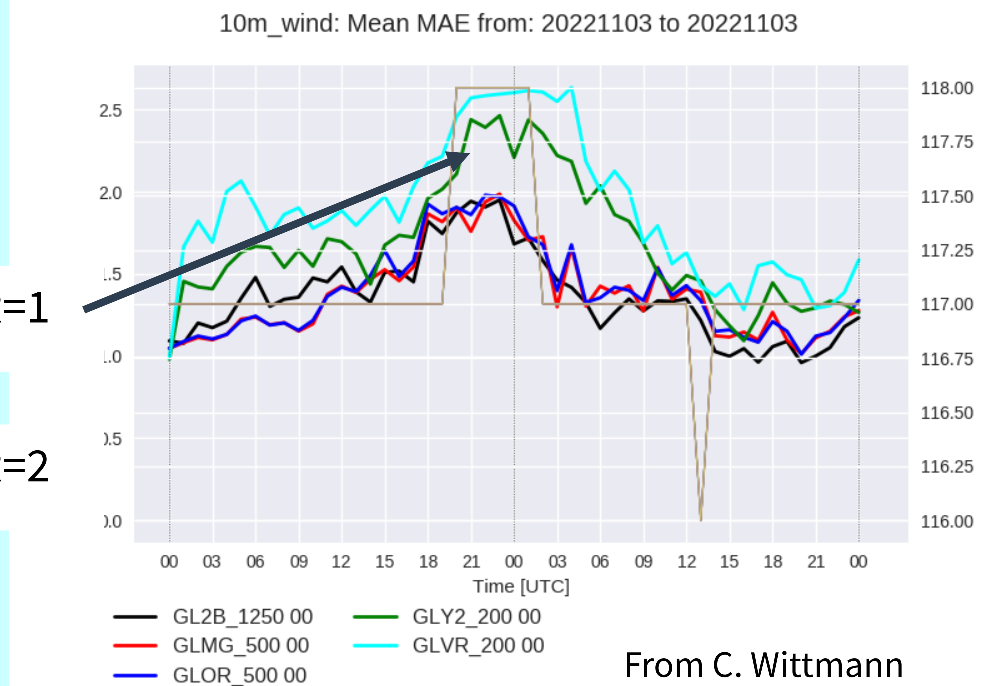


NSITER=1

NSITER=2



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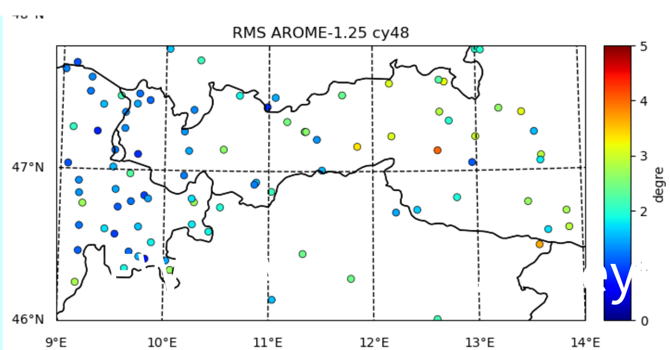

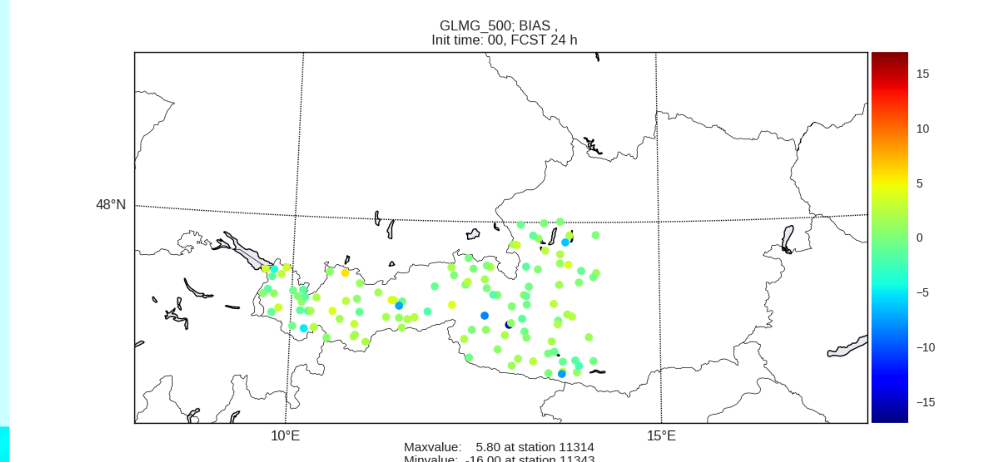

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Some preliminary conclusions :

- The horizontal gradients are now computed on z and not η
  - The horizontal dynamical production of TKE is significantly increased → creates instability with the default L_horiz
  - The Wang et al (2021) formulation for L_horiz is promising ...
  - More evaluation is needed at 500m ...with probably some adaptation/tuning/scale aware shallow convection

- Still small impact of the "Goger term" however we can expect more impact in stable boundary condition in winter in the Alpine Valley

- Very preliminary @ 200m over the Alps
  - Need to be careful for the dynamics options with at least NSITER=2 and dt=6s before testing physics impact ...