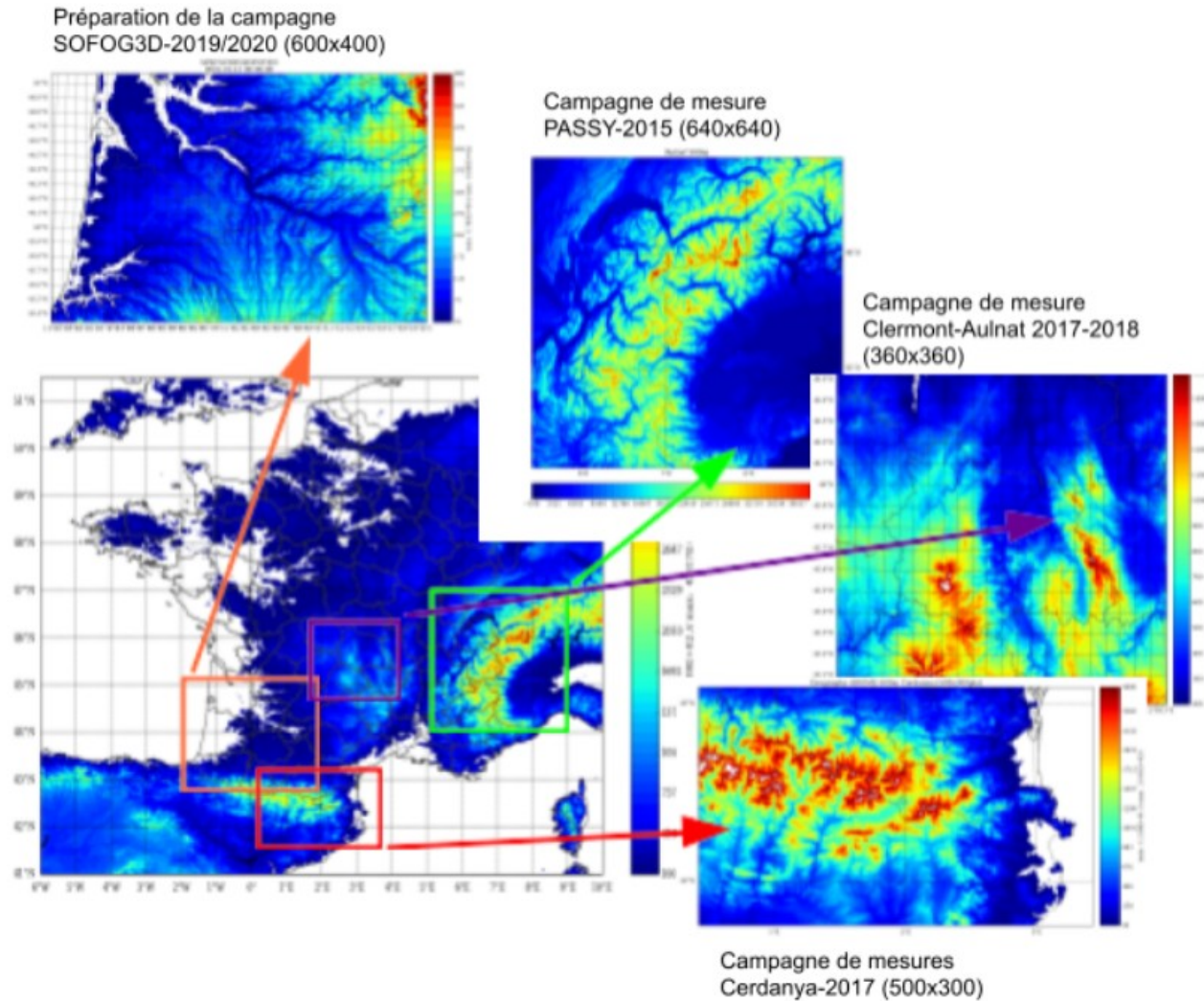# Towards AROME-500m operational configurations at Météo-France in 2024: strengths and weaknesses

*Yann Seity, Salomé Antoine, Rachel Honnert, Ludovic Auger, Eric Bazile*

- Some preliminary tests on fiels campains :



Préparation de la campagne SOFOG3D-2019/2020 (600x400)

Campagne de mesure PASSY-2015 (640x640)

Campagne de mesure Clermont-Aulnat 2017-2018 (360x360)

Campagne de mesures Cerdanya-2017 (500x300)

# Main characteristics

| | Paris<br>250km x 250km | MedAlp<br>480km x 576km |
|---|---|---|
| Forecast | 1xP36 (00TU)<br>Hourly outputs | 1xP24 (00 TU)<br>Hourly outputs |
| Nowcasting | 24xP6<br>15 min outputs | 12xP6<br>15 min outputs |

- 2 domains x 2 versions
- Without data assimilation
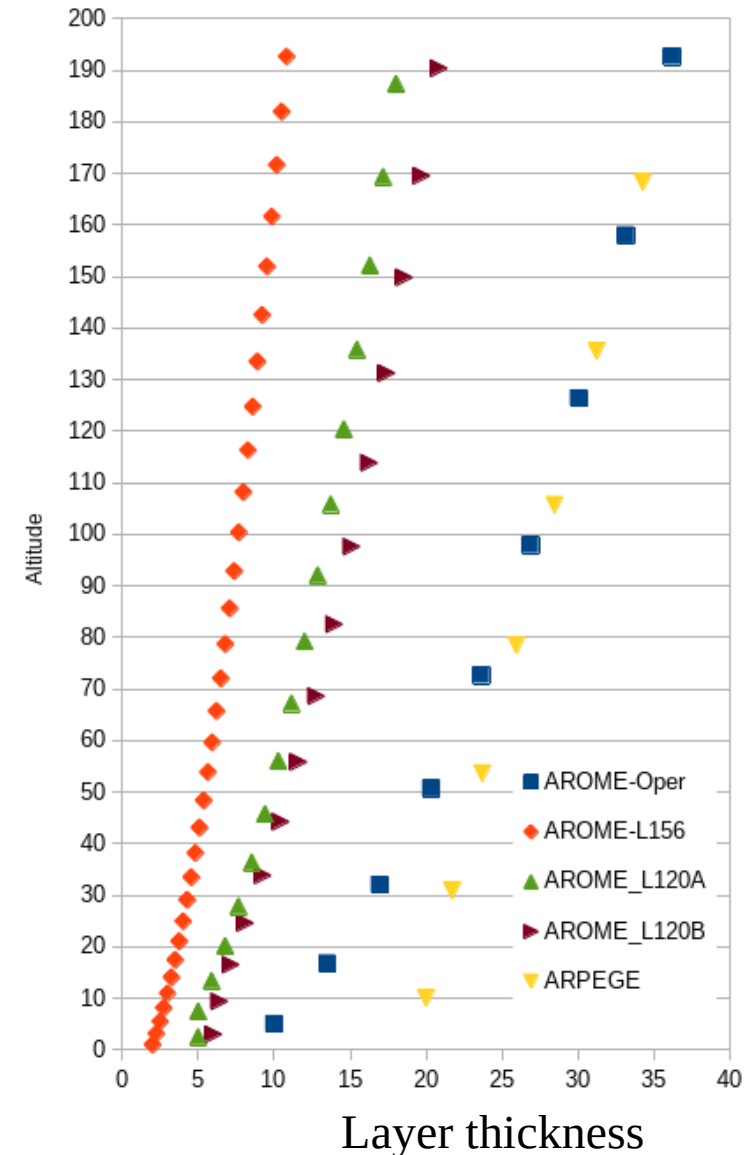- Single précision
- Deterministic runs
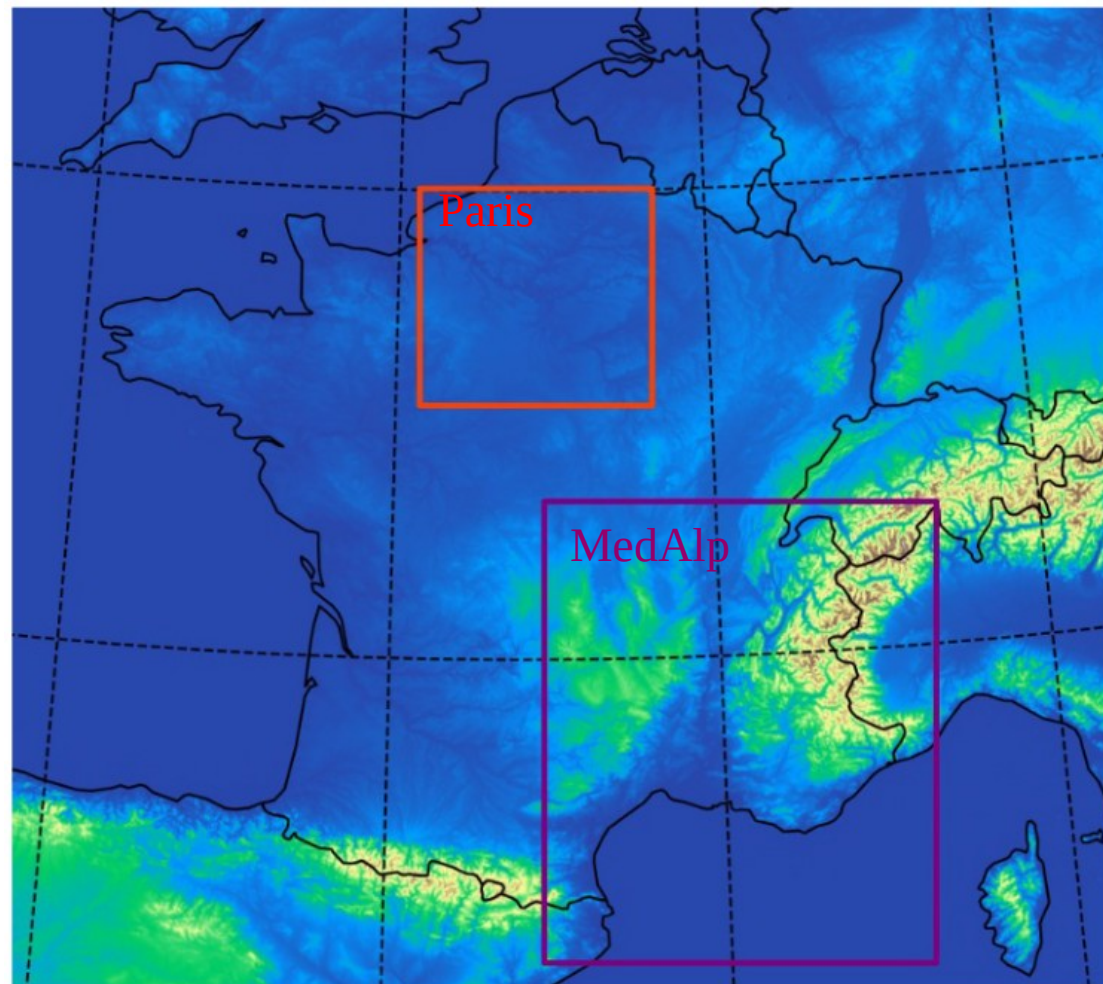
# About vertical resolution
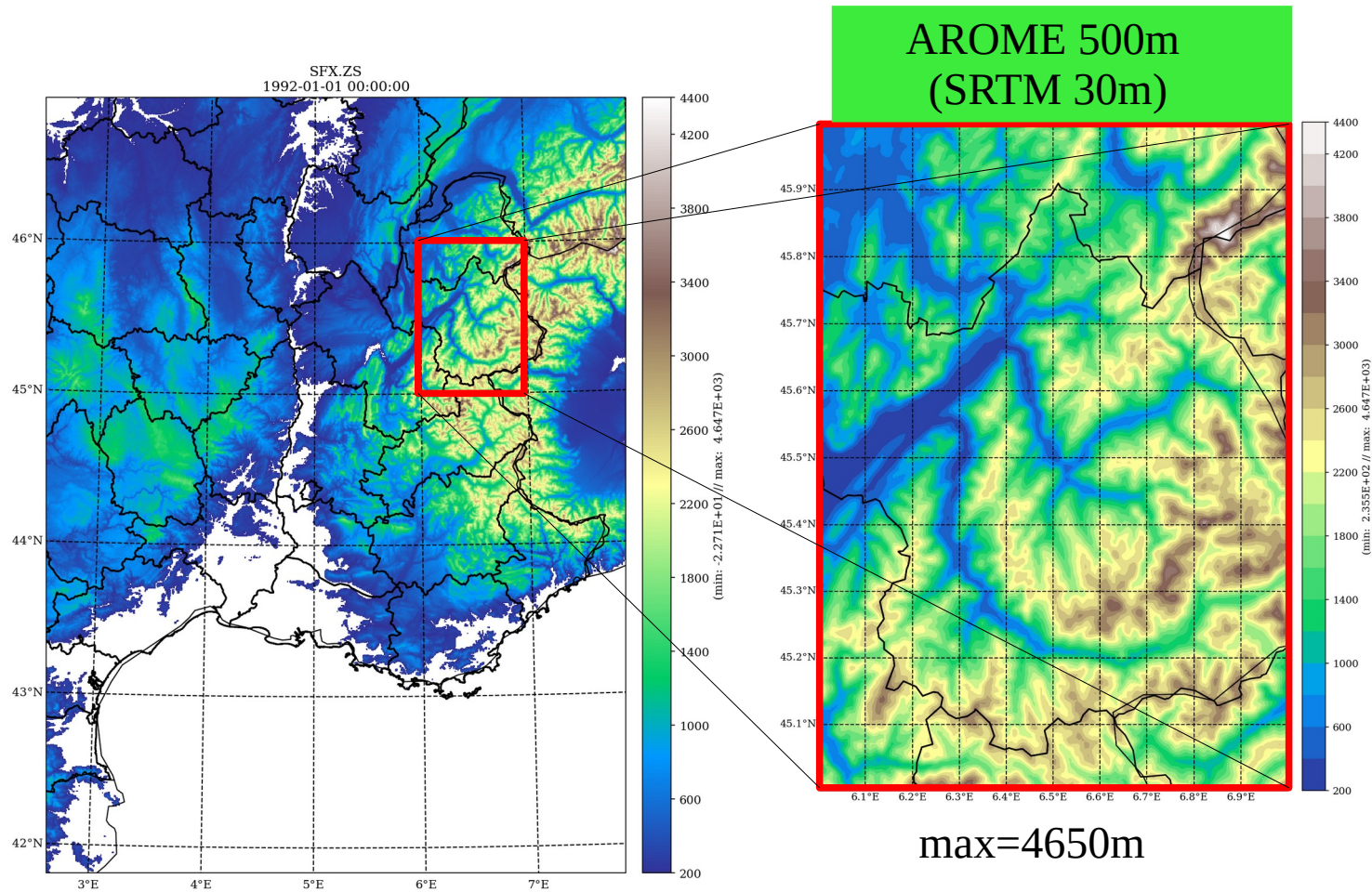
- L120A : lowest level at 2,5m

17 levels < 200m  / 9 in AROME-oper
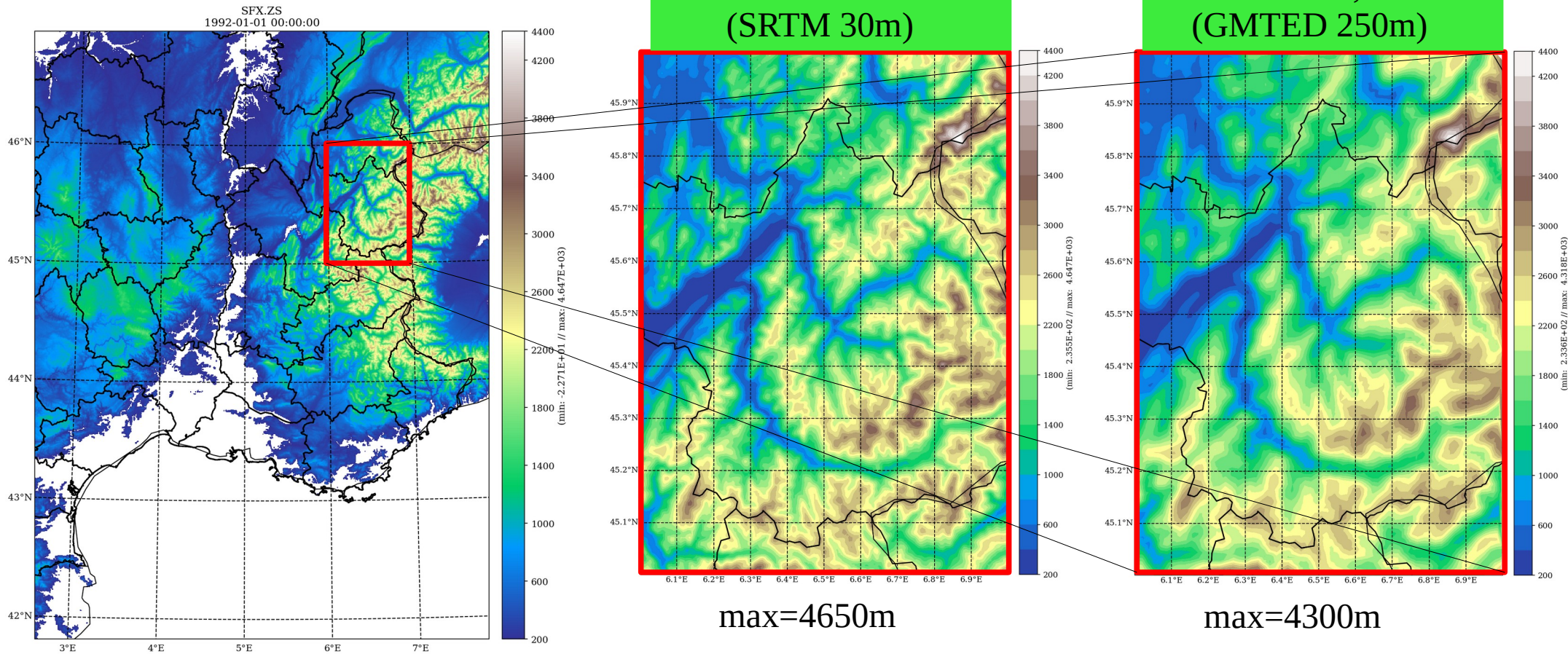L90 and 7 in ARPEGE L105

(Fog aspects :  Antoine et al., 2023)
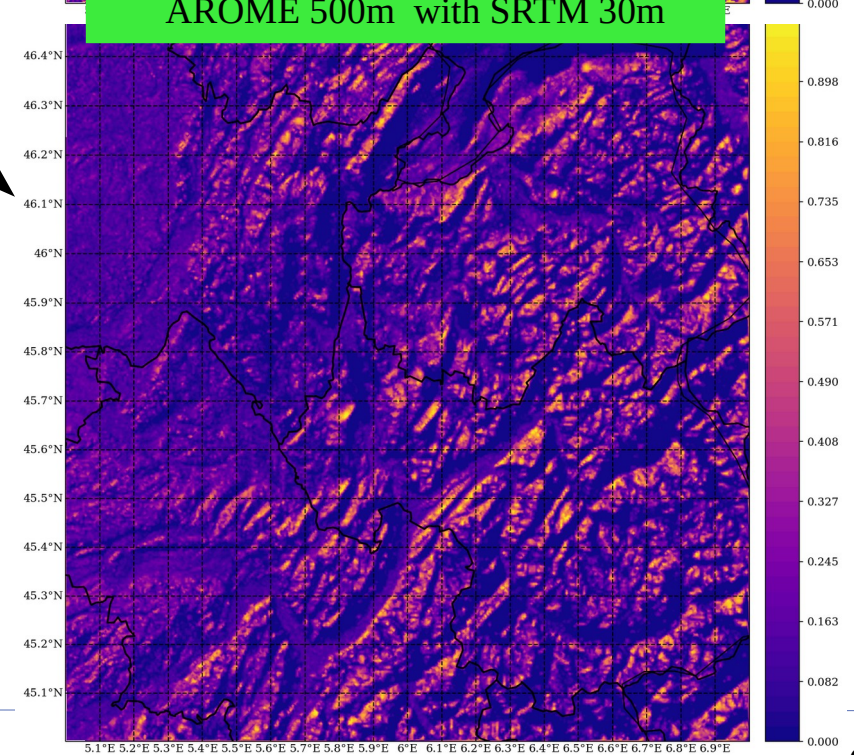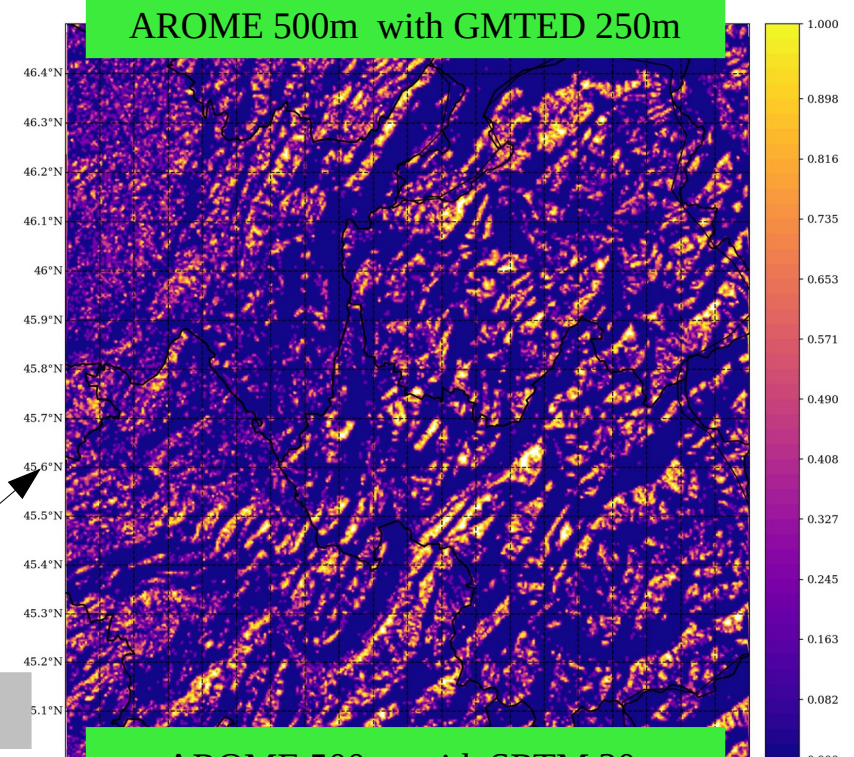


Layer thickness

- Orography : MEDALP



AROME 500m
(SRTM 30m)

max=4650m

• Orography : MEDALP



AROME 500m
(SRTM 30m)

max=4650m

AROME 1,3km
(GMTED 250m)

max=4300m

# Subgrid orography

• More realistic subgrid parameters with strm 30m / gmted 250m


AROME 500m with GMTED 250m

Subgrid Fraction of N oriented slopes


AROME 500m with SRTM 30m


SFX.ZS
1992-01-01 00:00:00
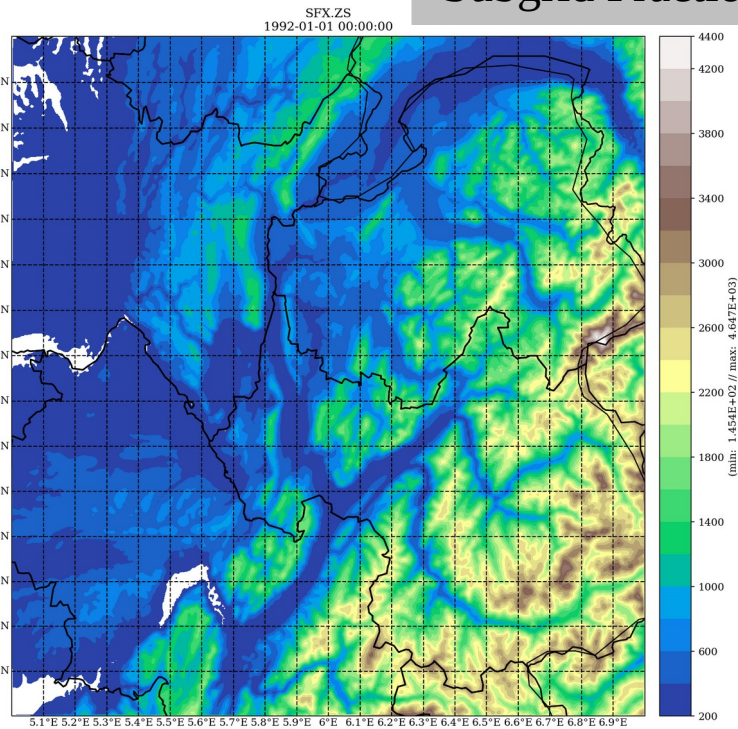
# Surface

- Orography : PARIS
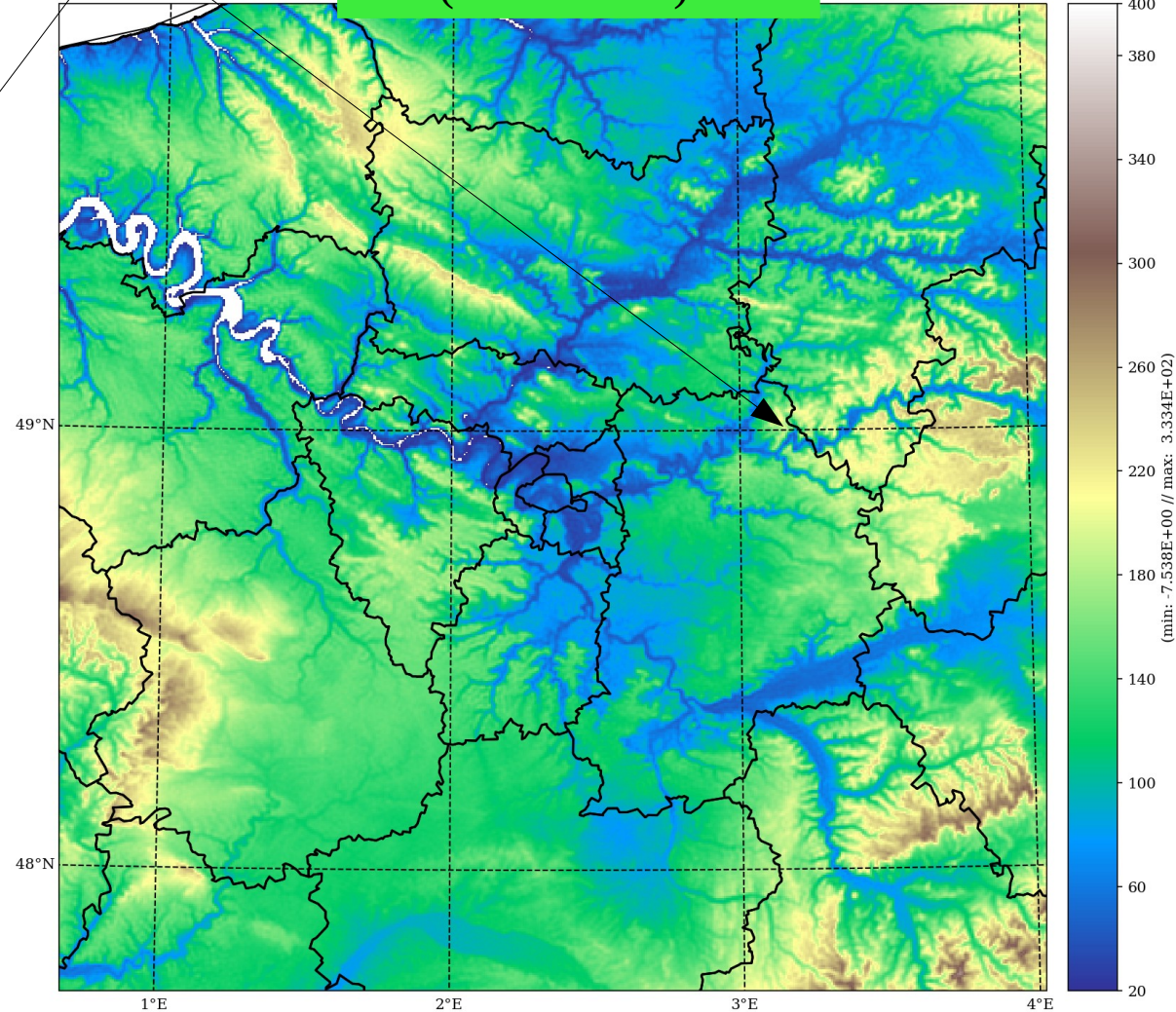
More realistic valleys
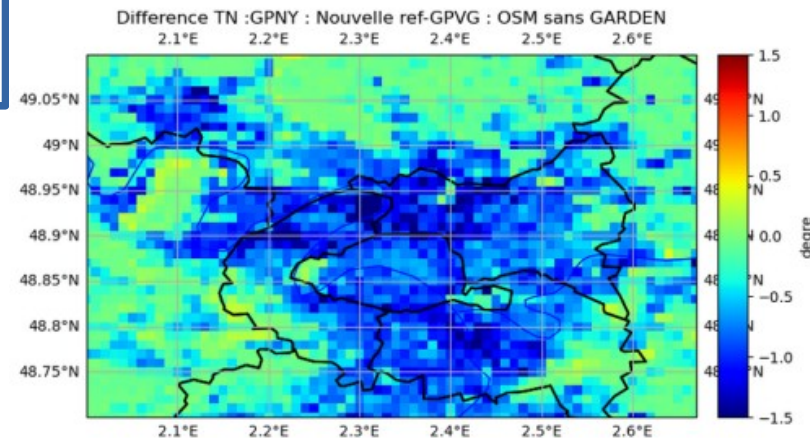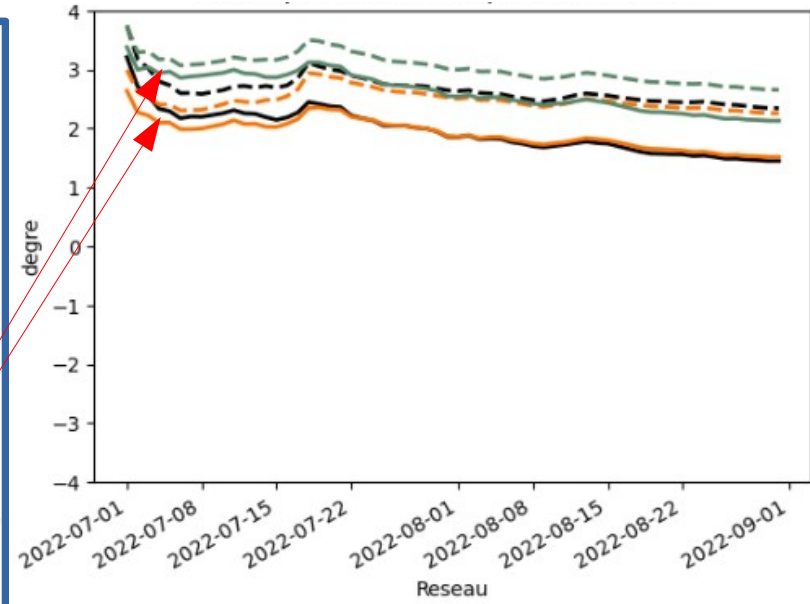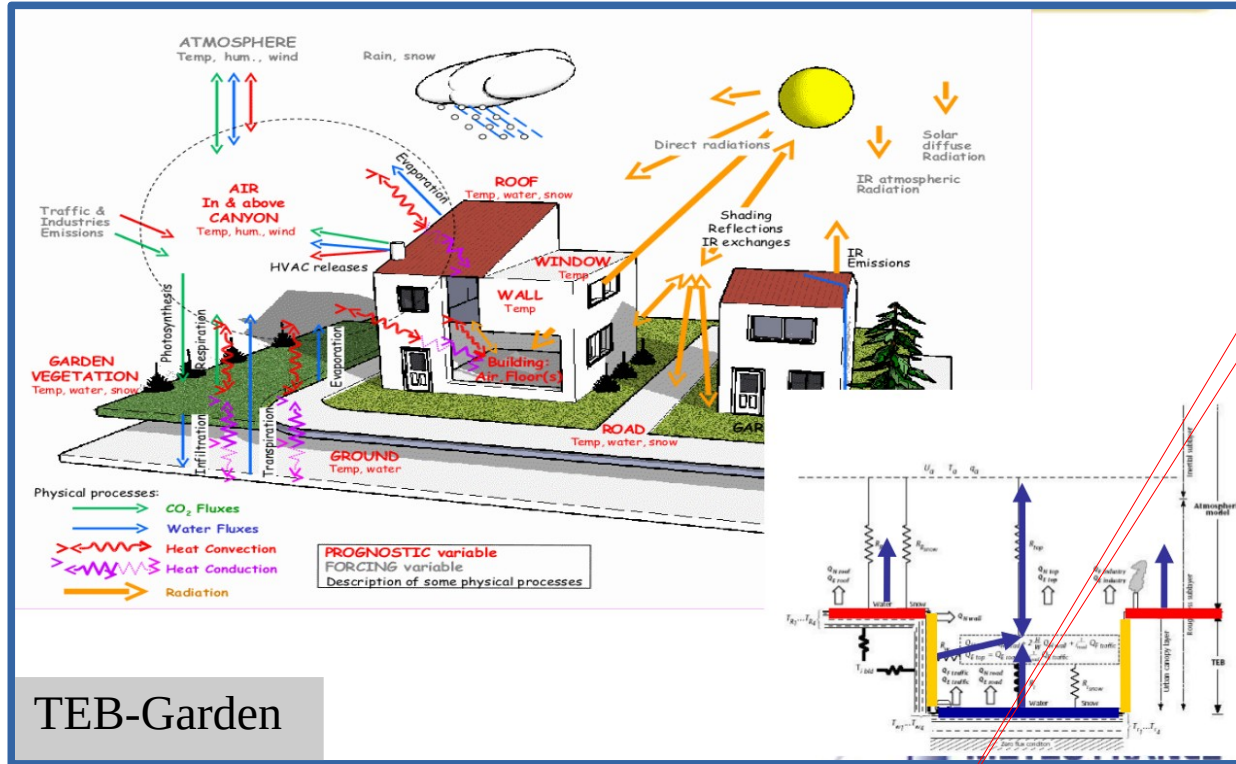
AROME 1,3km
(GMTED 250m)
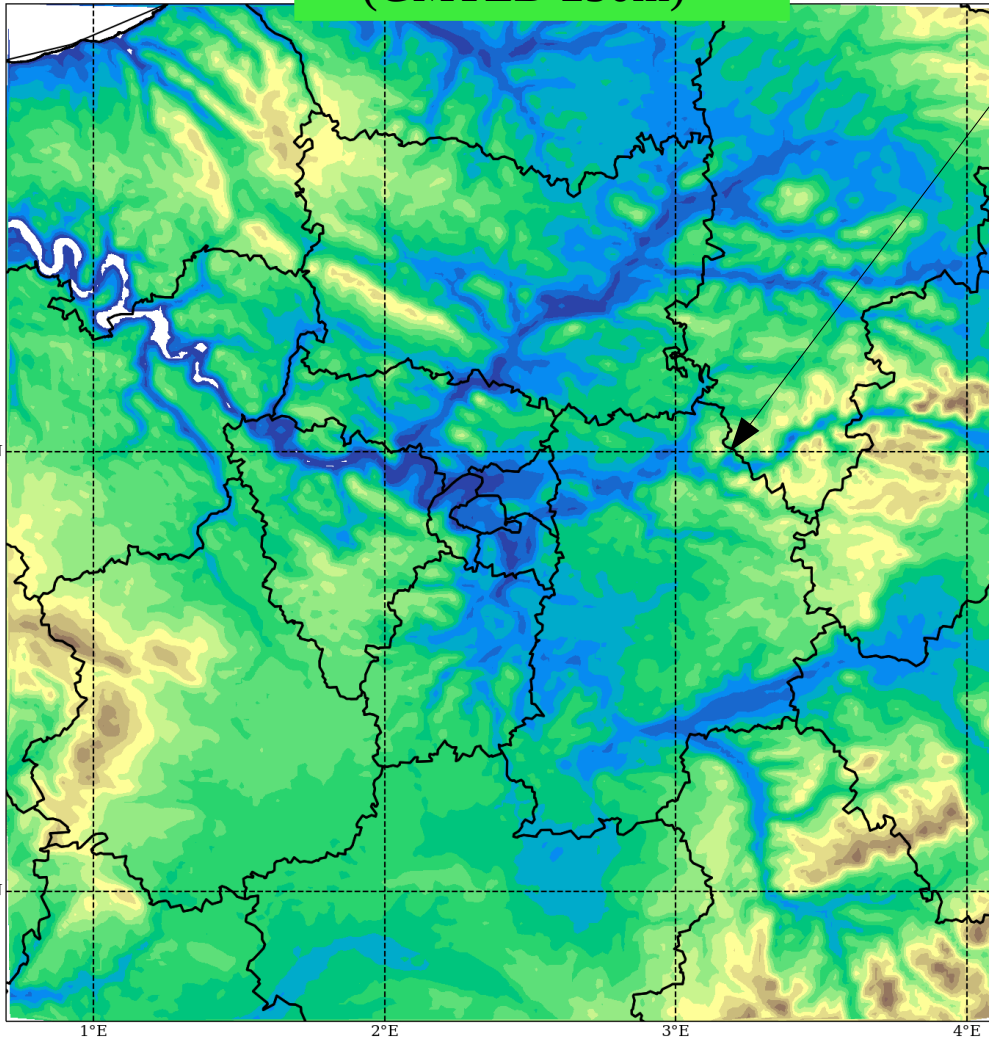
AROME 500m
(SRTM 30m)

# Surface

- Soil type : Soilgrid (300 m) (Hengl et al.(2017) vs HWSD (1 km)
- Physiography : Ecoclimap-SG (300m) vs Ecoclimap 1 (1km)

  → 33 land cover types / 256 covers

  → more realistic LAI annual cycle. Comming from 2014-2016 CGLS LAI data (Munier et al.,2018)

  → more recent albedos 2008-2012 CGLS (Carrer et al.,2014)

# Garden option in TEB



TEB-Garden

Minimal diurnal T2m scores
OPER, 500m with Garden, 500m without Garden





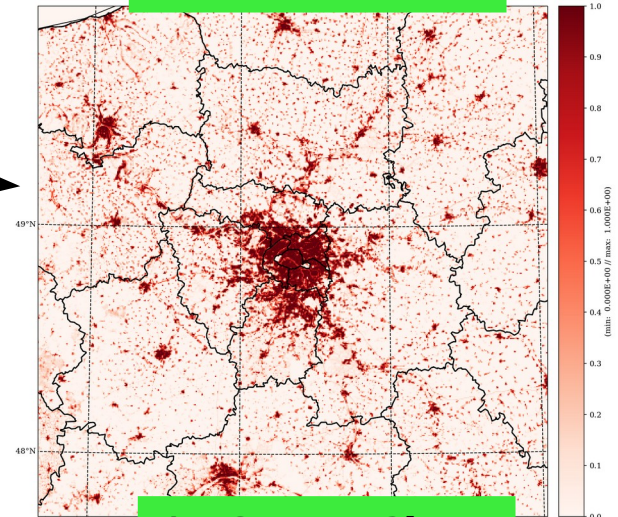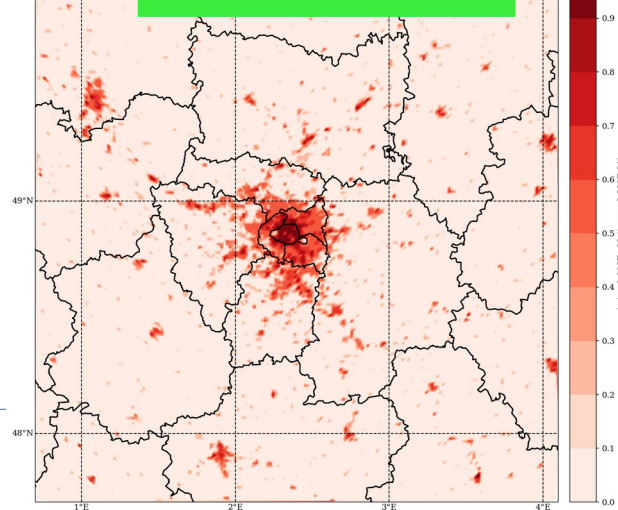- Better diurnal min temperatures with Garden option over Paris

# Surface

- Soil type : Soilgrid (300 m) (Hengl et al.(2017) vs HWSD (1 km)
- Physiography : Ecoclimap-SG (300m) vs Ecoclimap 1 (1km)
- Garden option in the town scheme
- Open Street Map (OSM) : Vector Open Source data
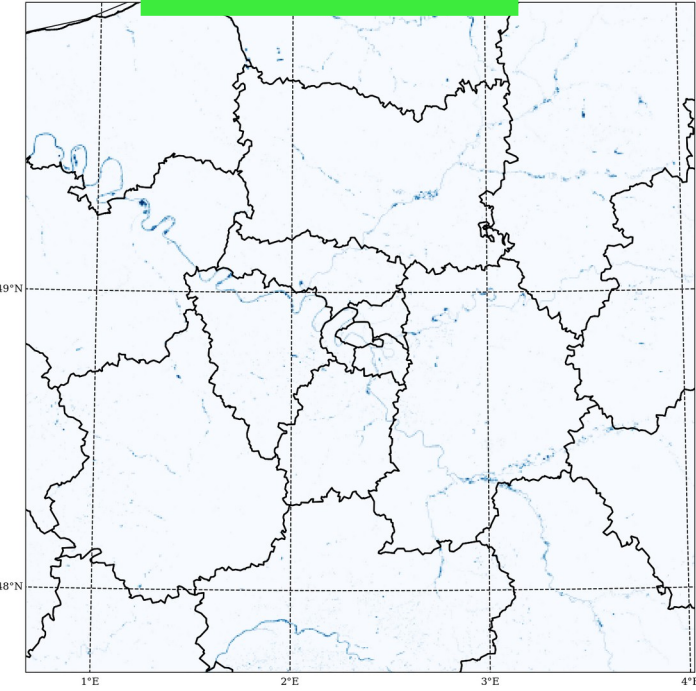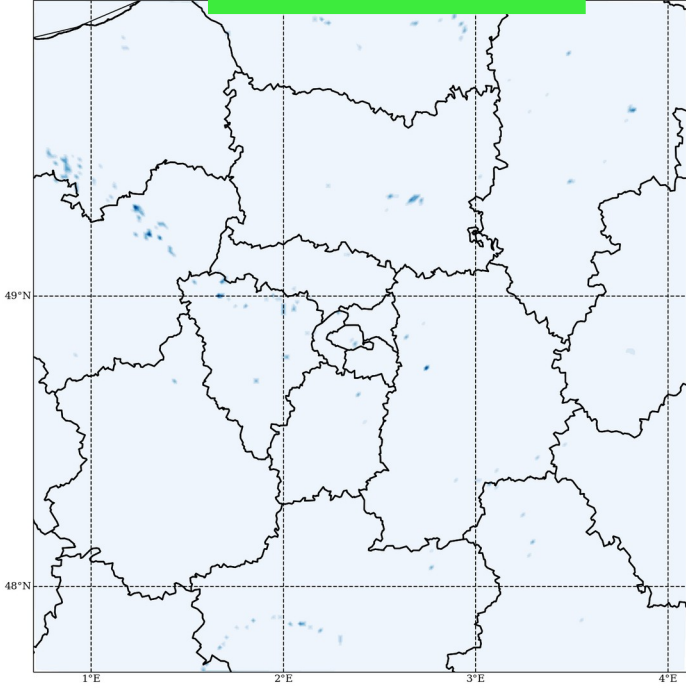  → more water and town, less nature

AROME-500m

AROME-500m

AROME-1,3km

AROME-500m

AROME-1,3km

100m PHY-EPS workshop

Tests/tunings performed over a 2 years period (2022-2023)

- Time step = 20s  (versus 50s in AROME1,3km) cf next slides
- Numerical diffusion of Temperature as other dynamic variables (versus no diffusion in AROME 1.3km).  Very sensitive for model stability
- « $Ri_{max}$ tuning » (0,2 => 0.05)
- Water deposition on vegetation (impact on cloud water contents in fogs (Antoine et al. 2023)
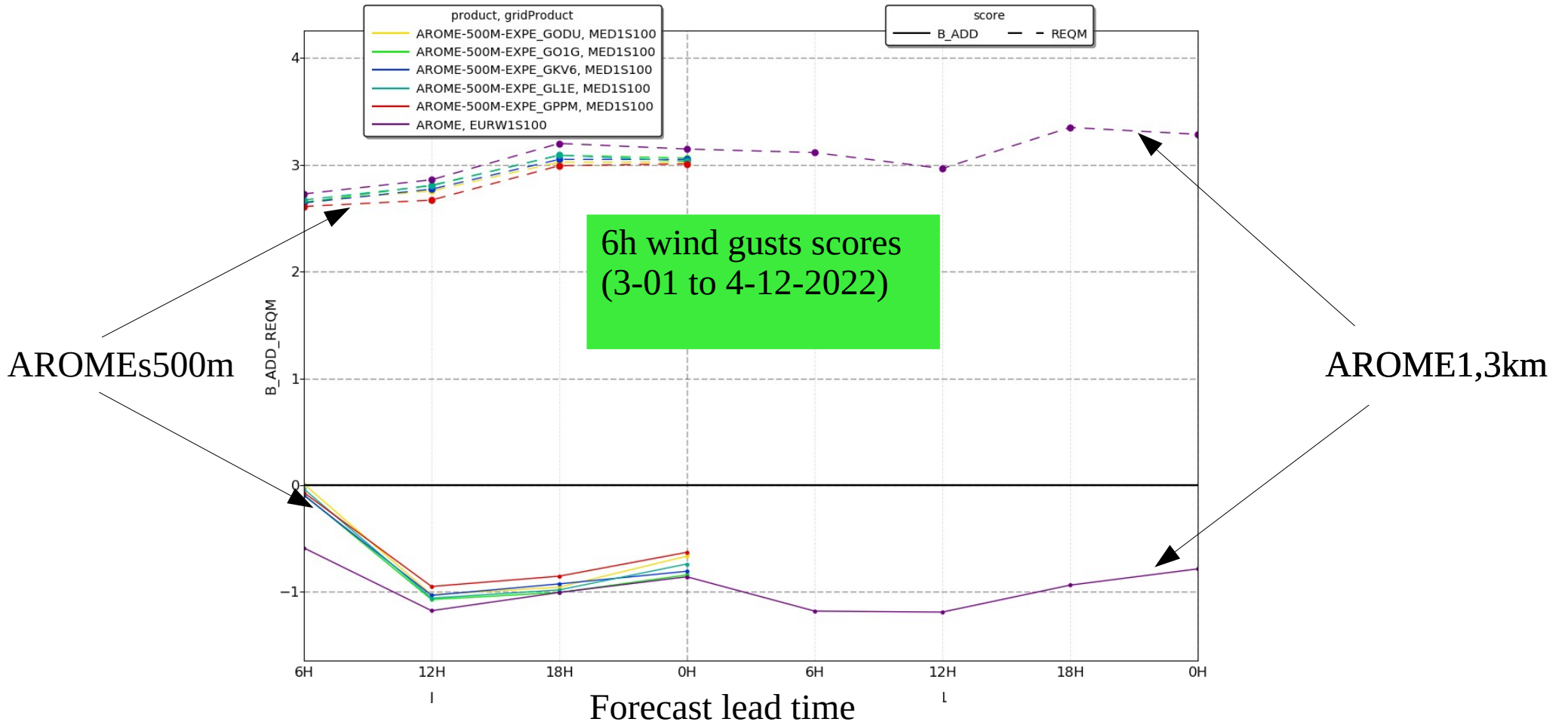- Tuning on vegetation thermal capacities (cf next slides)

# Real time forecasts

- Since summer 2023, the 4 AROME 500m configurations are run in real-time in research mode

- with plots and scores calculations

- But not so much forecasters feedbacks (lack of time, not available in their operational visualisation tool)

# Some scores : wind gusts on MEDALP



Legend — product, gridProduct:
- AROME-500M-EXPE_GODU, MED1S100
- AROME-500M-EXPE_GO1G, MED1S100
- AROME-500M-EXPE_GKV6, MED1S100
- AROME-500M-EXPE_GL1E, MED1S100
- AROME-500M-EXPE_GPPM, MED1S100
- AROME, EURW1S100

Legend — score: B_ADD, REQM

6h wind gusts scores
(3-01 to 4-12-2022)

AROMEs500m

AROME1,3km

B_ADD_REQM (y-axis)

Forecast lead time (x-axis): 6H, 12H, 18H, 0H, 6H, 12H, 18H, 0H

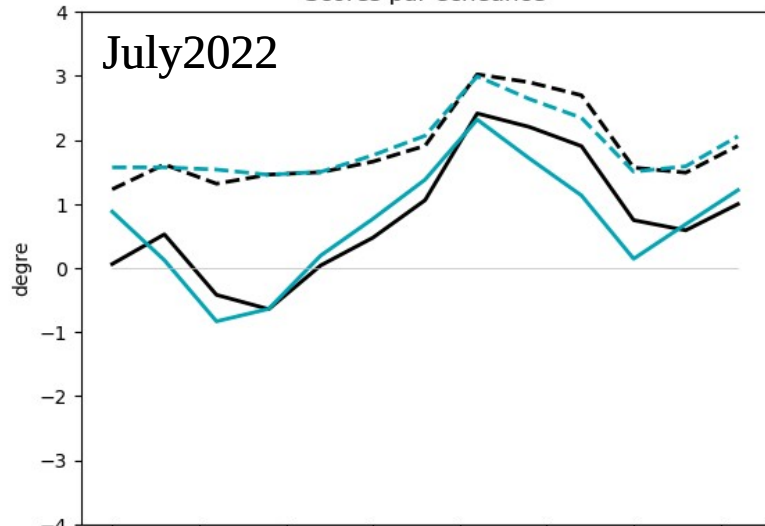- Bias and Rmse improved at all forecast lead times

# T2m scores



PARIS

MEDALP
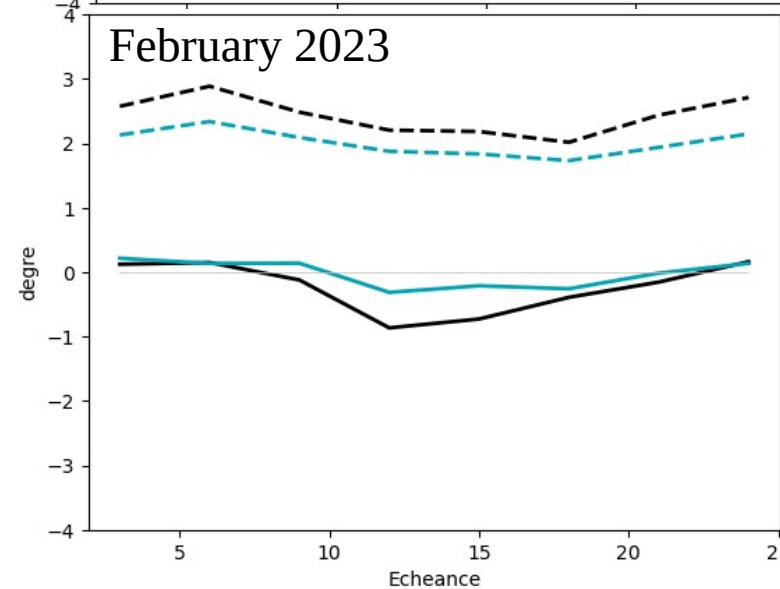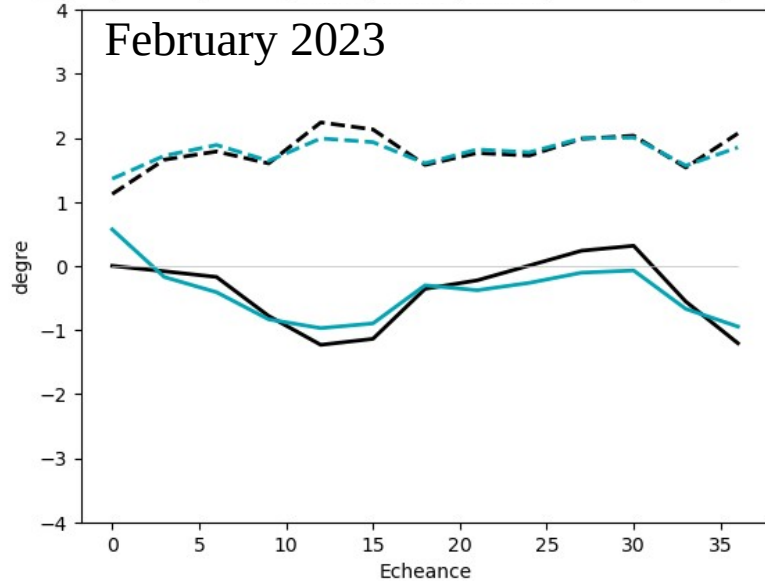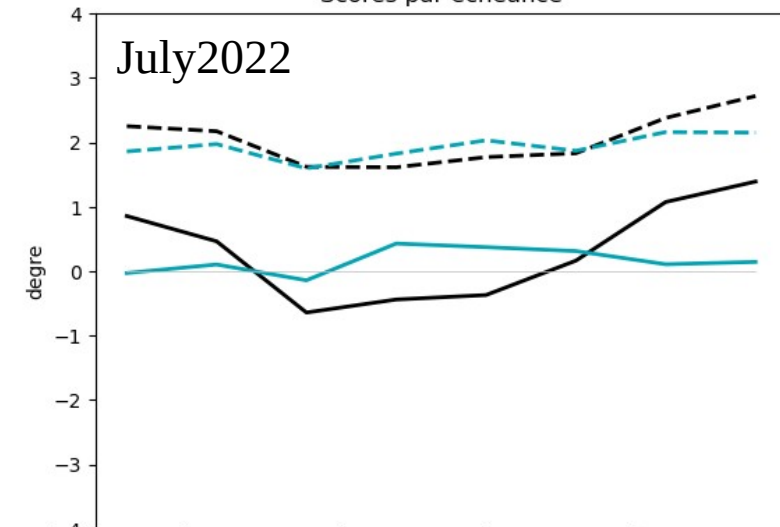
- Larger improvments on MEDALP domain, especially in winter
- More neutral on PARIS
- Some tuning required for PARIS in order to fix a nocturnal warm bias ( → modified vegetation thermal inertias in both domains)

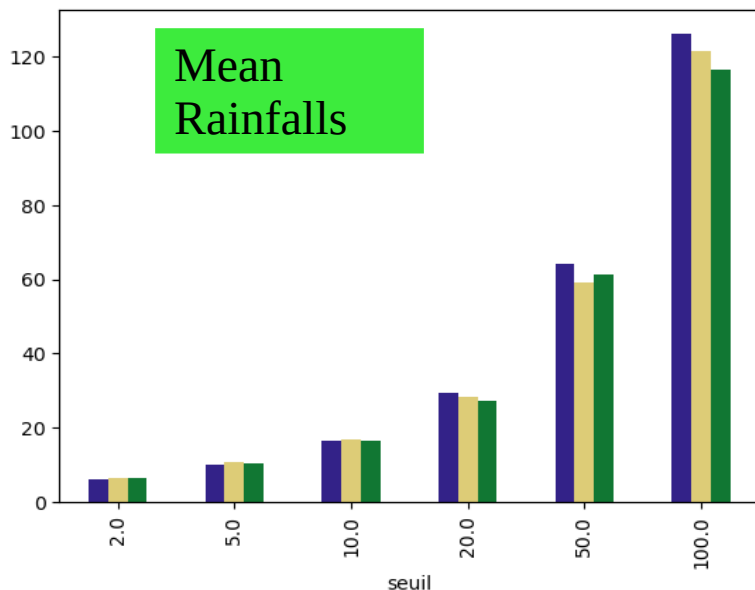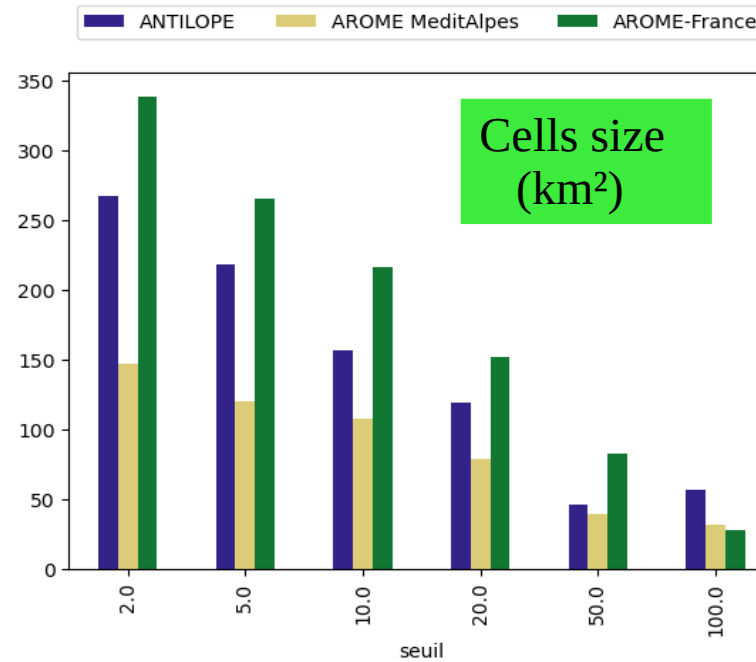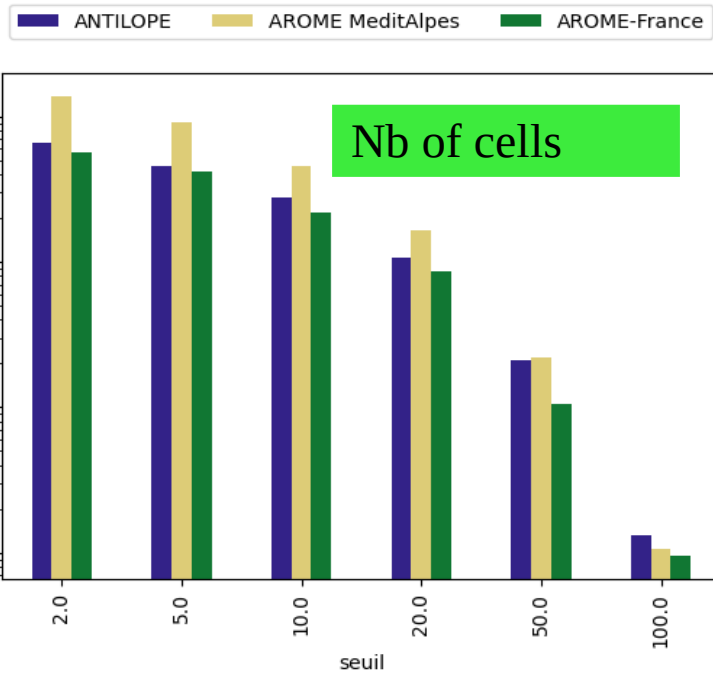# Convective cells statistics (on 3H rainfalls)
## 12 convective days between July-Nov 2022 MEDALP
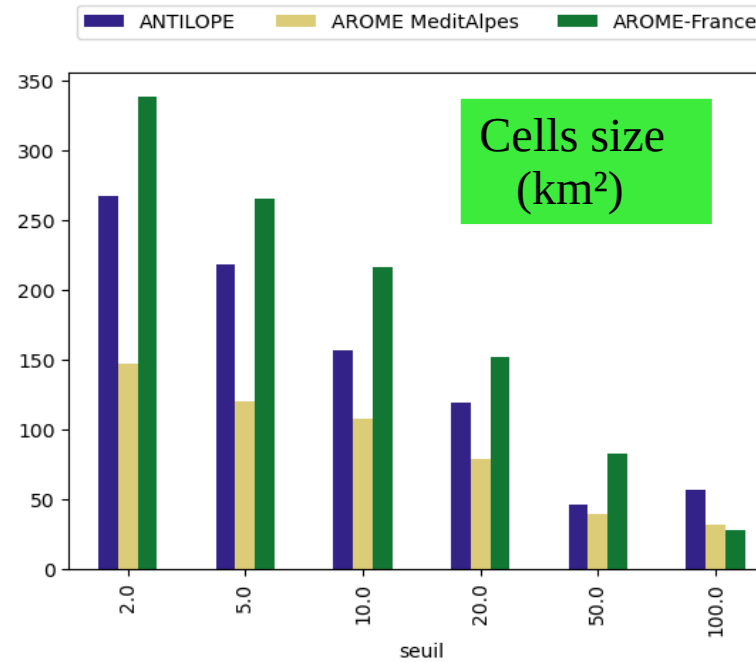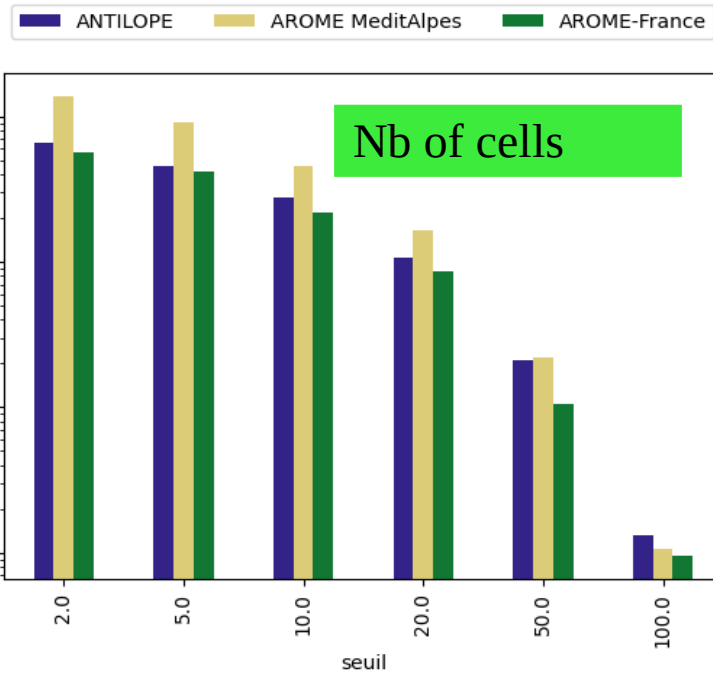


→ Too small and numerous cells in AROME-500m

→ In the past, when moving AROME from 2,5 km to 1,3 km we were closer to observations (Brousseau et al., 2016), by chance ?

# Convective cells statistics (on 3H rainfalls)
## 12 convective days between July-Nov 2022 MEDALP



→ Too small and numerous cells in AROME-500m

→ In the past, when moving AROME from 2,5 km to 1,3 km we were closer to observations (Brousseau et al., 2016), by chance ?

→ But, at 500m, we have correct 3h rainfalls

**AROME-500m Forecast :**

- FF10m : PARIS : Reduce AROME-1,3km overestimation

     MEDALP : Idem but with light overestimation during night

- Hu2m : Reduced night dry bias.

- T2m : Better on MEDALP, more neutral on PARIS

- Rainfalls : Too small and numerous convective cells, but with correct rainfalls.

**AROME-500m Nowcasting :**

- Good scores on MEDALP (T2m, Hu2m, Gusts10m, neutral for Rainfalls), more neutral/slightly worse over PARIS
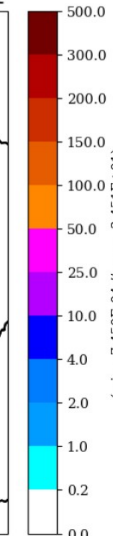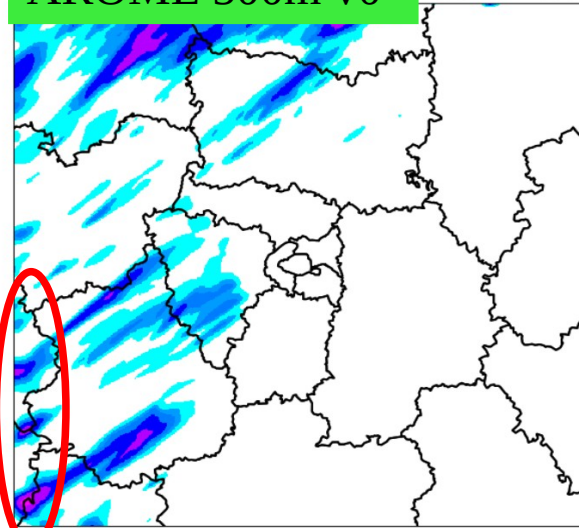
# Unrealistic cumulative rain structures in shower cases : Need of a more frequent udpated lateral boundary conditions
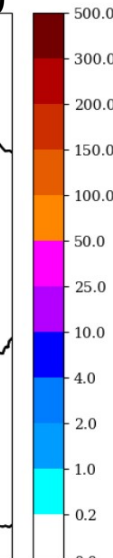


3h cumulated rainfall  20230901 (12-15TU)
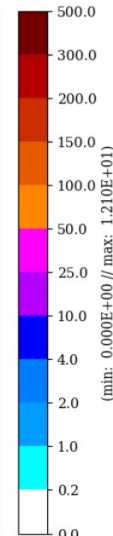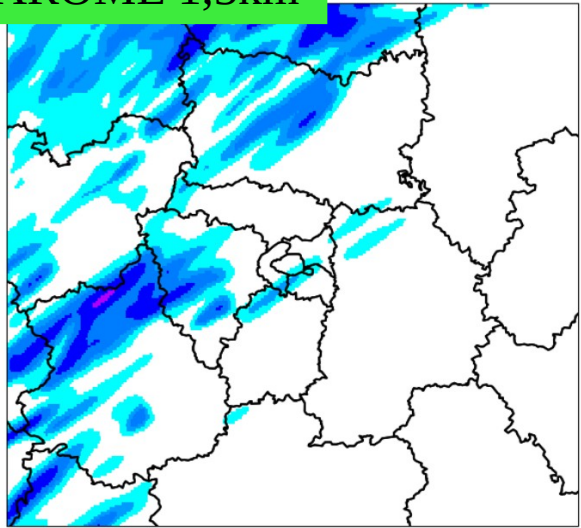
AROME 1,3km    max=12

AROME 500m v0    max=34

Radar observation    max=20

10

# Unrealistic cumulative rain structures in shower cases : Need of a more frequent udpated lateral boundary conditions
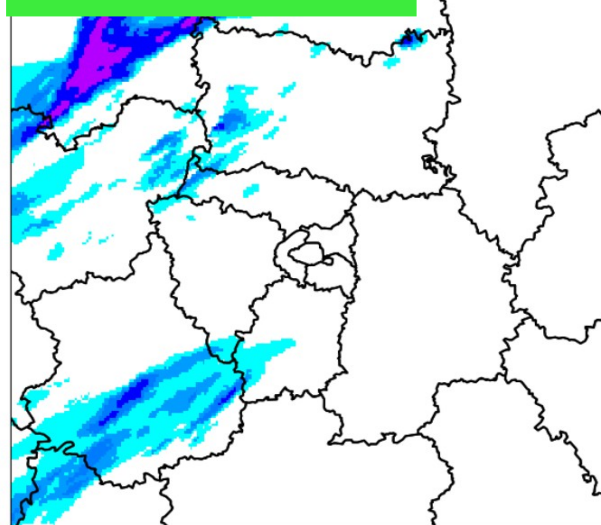


3h cumulated rainfall  20230901 (12-15TU)

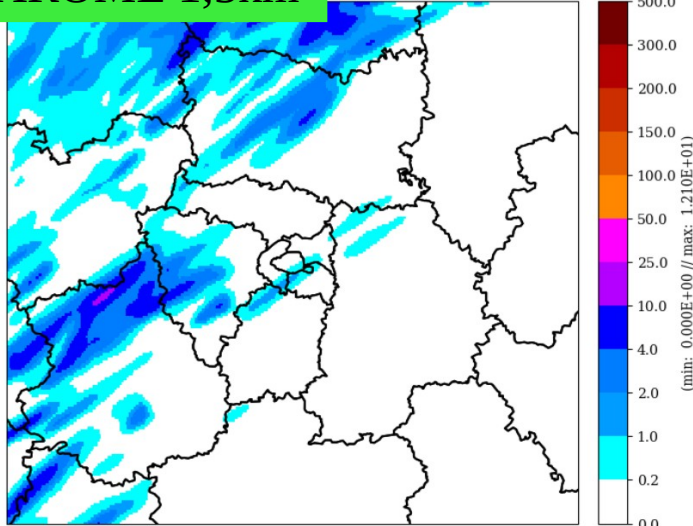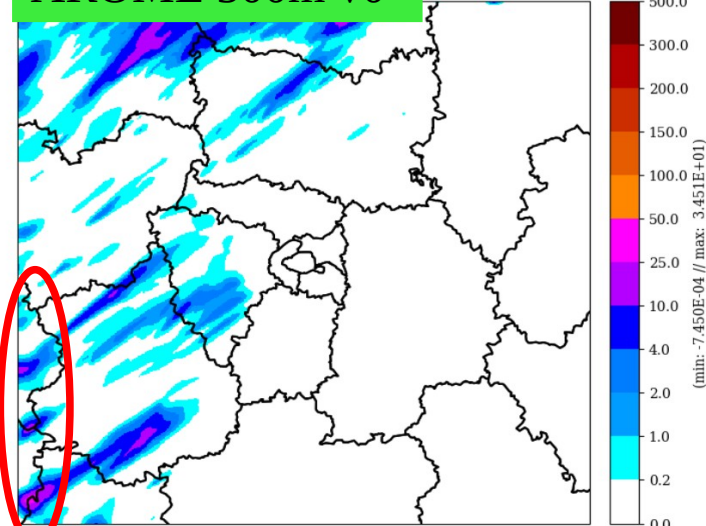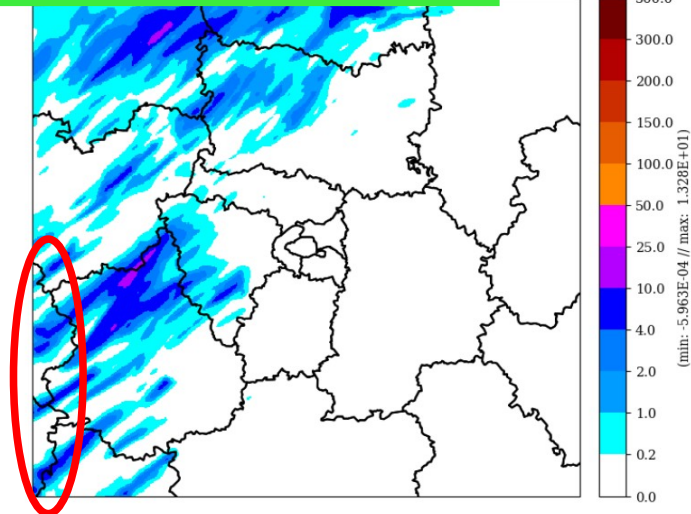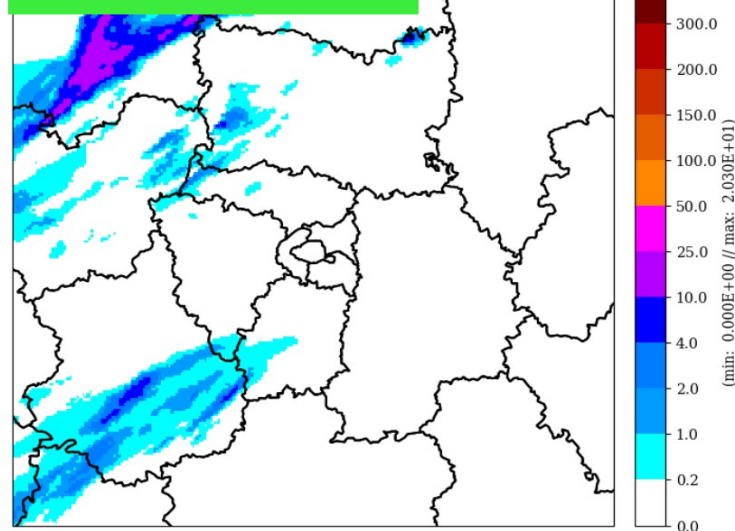AROME 1,3km   max=12

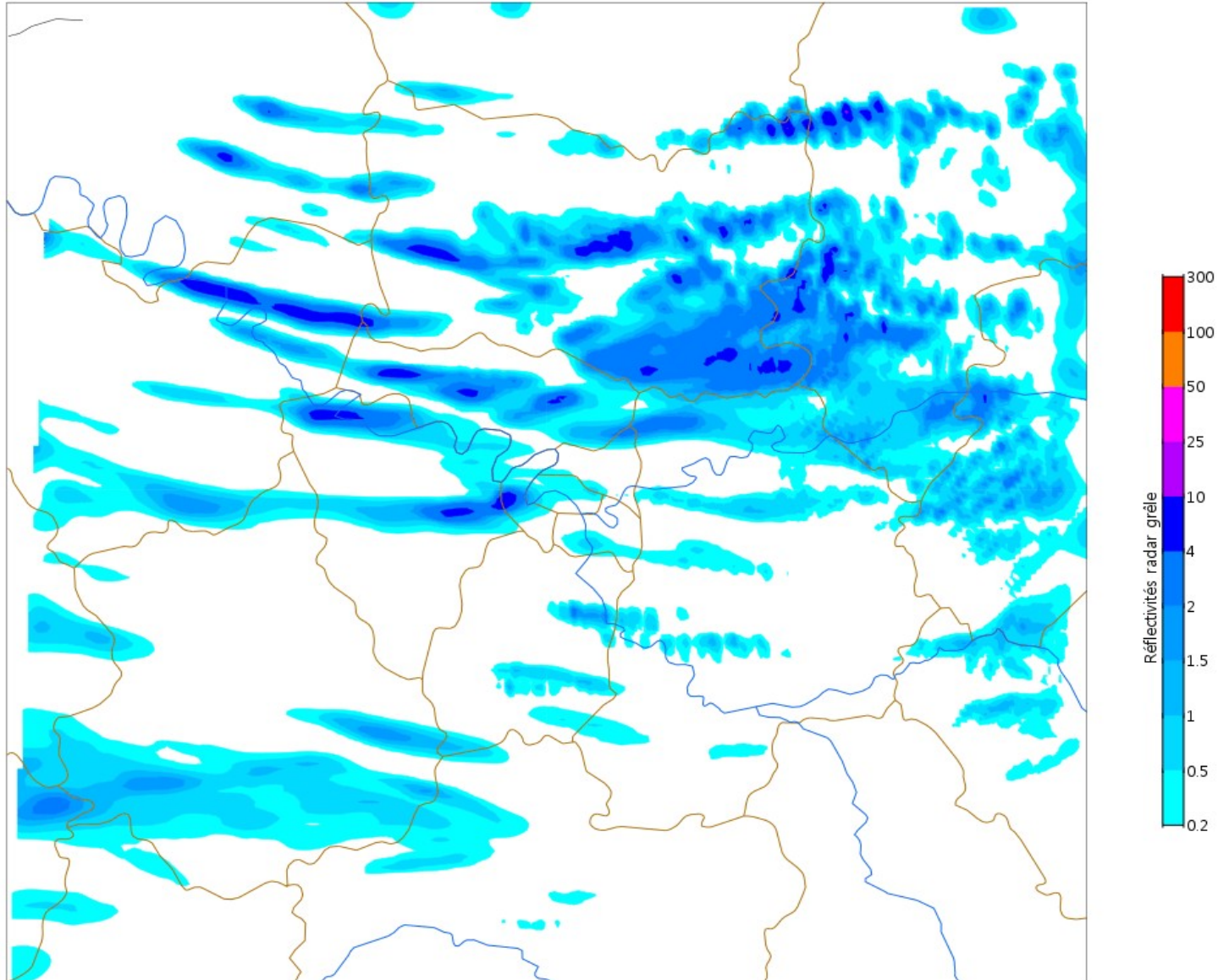AROME 500m v0   max=34

AROME 500m 15 min coupling   max=13

Radar observation   max=20

# Other problems on rainfalls...

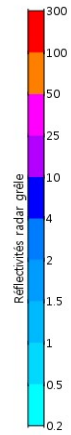Simulated radar reflectivity  20231120 15TU
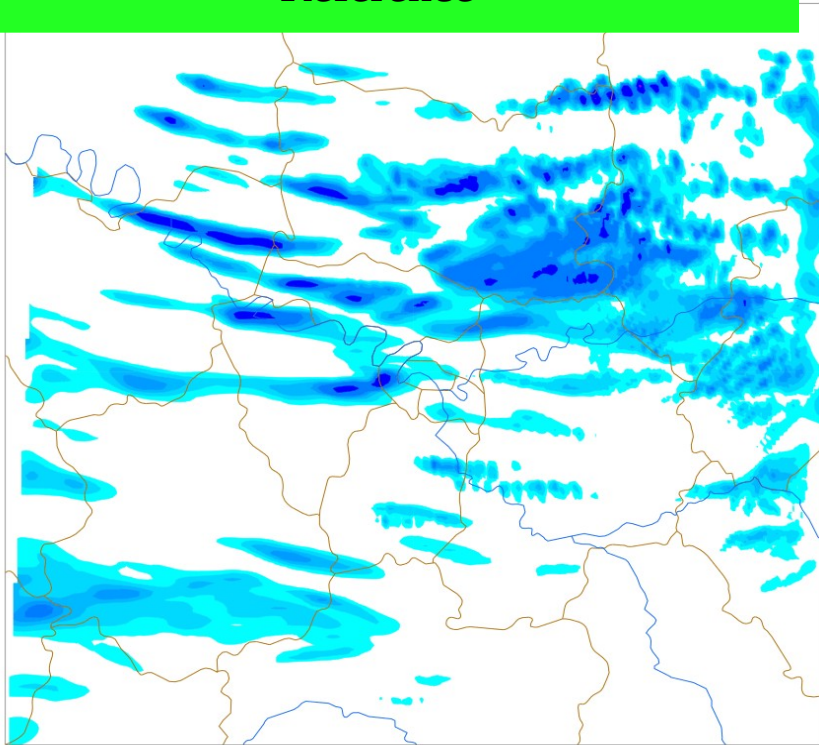
# Also in temperature and wind


Spectrum T@3000m


U-wind@3000m


T@3000m

Section of {'FA': 'S*TEMPERATURE'} between
<- (2.5, 49.5) and (4.0, 49.50000000000003) ->
2023-11-20 15:00:00



- Unrealistic energy accumulation between 2-4km
- Tests in the model dynamics…

# Solution...

METEO FRANCE
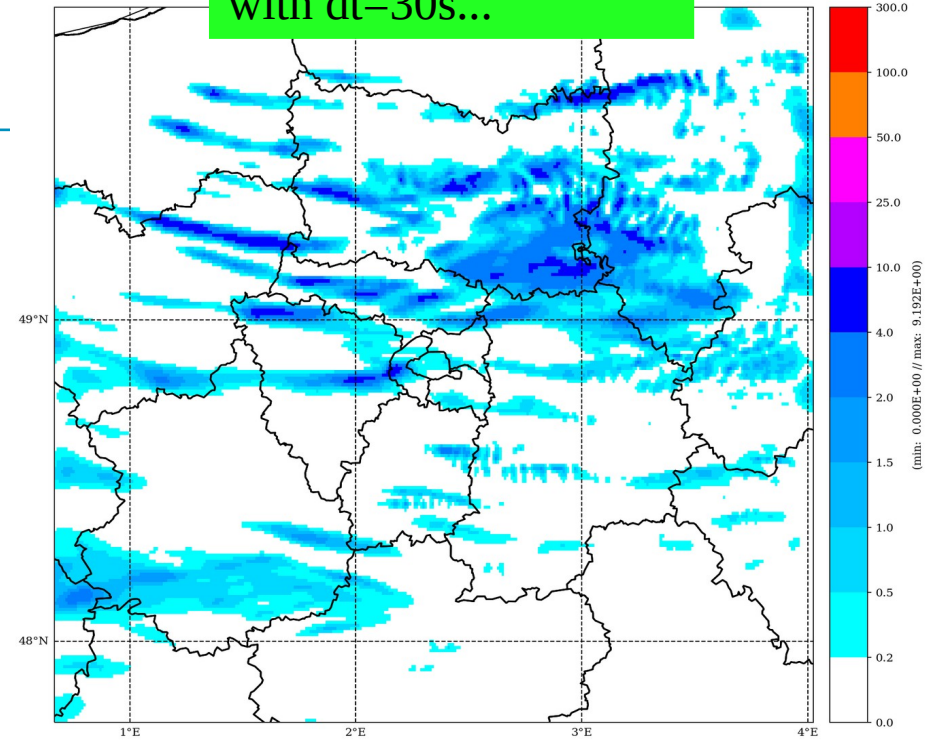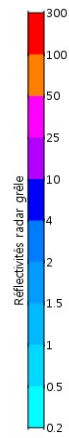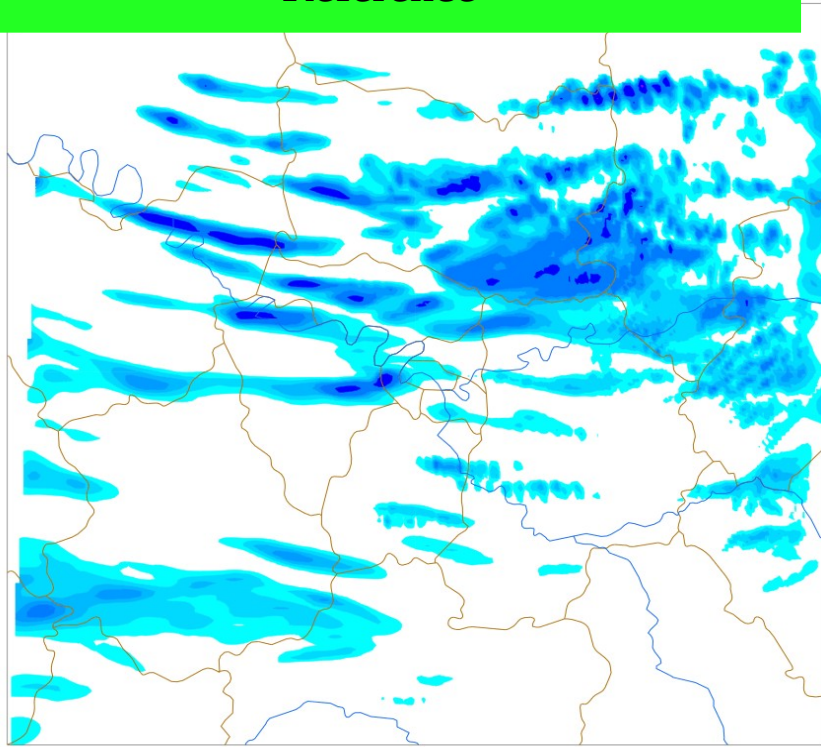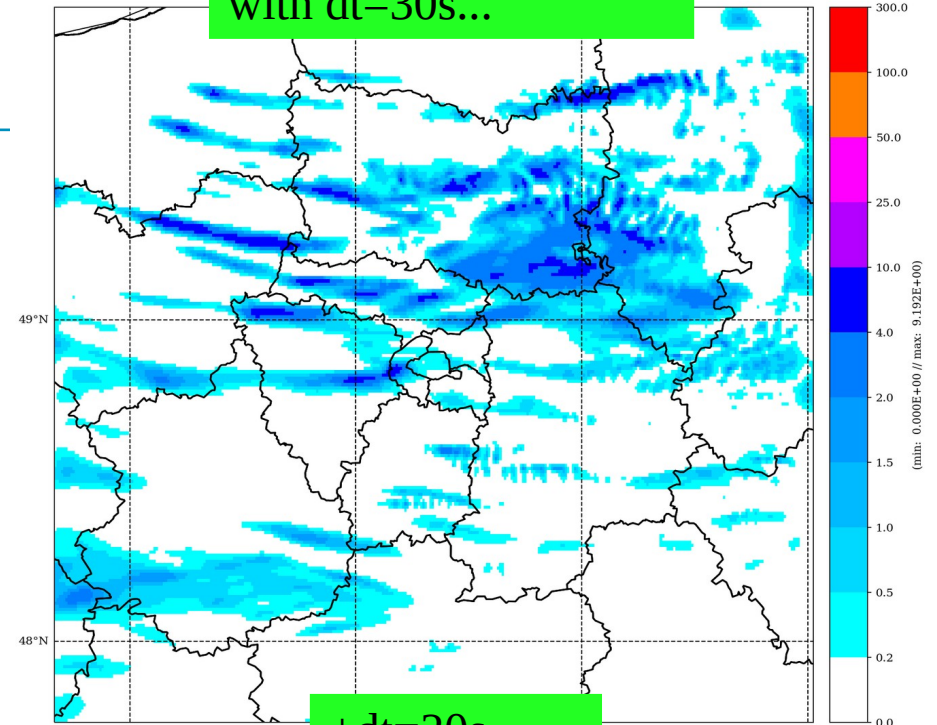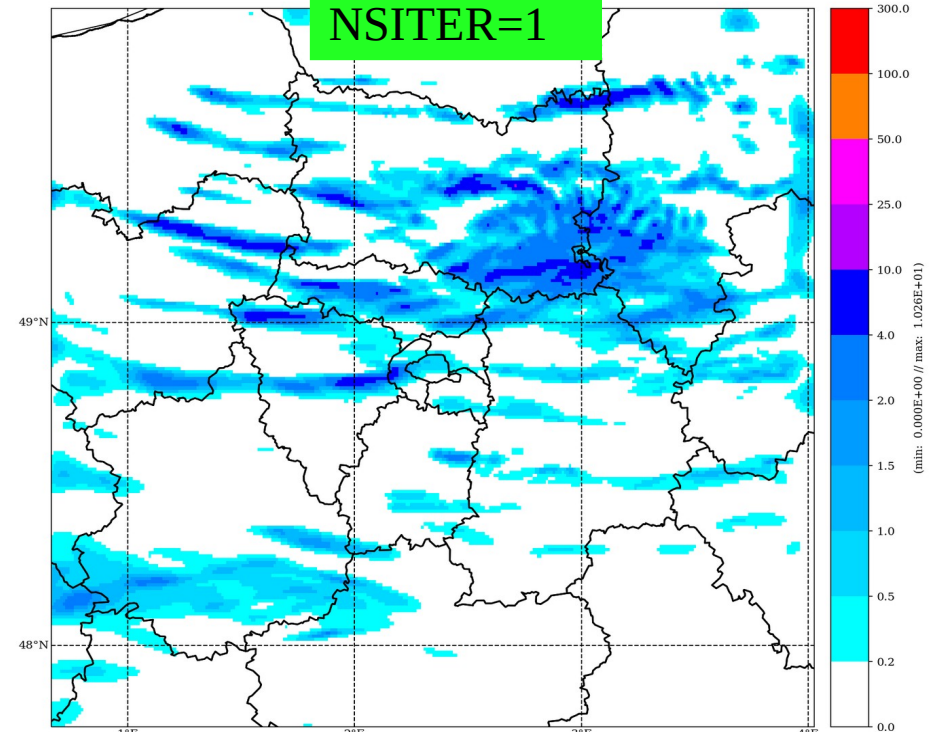
# Solution...

- No fix found with dt=30s

- With dt=20s, we have found a solution (+10 % CPU time only → ok).
- OK on PARIS and MEDALP 2022 and 2023.
- Used since 1-01-2024

# Validation / limits

- More impact/improvements on MEDALP / PARIS (orography, domain size)

- Not so easy to show systematic benefits of 500m/1,3km (domain size, need of specific data assimilation ?)

- Not obvious that we have good forecasts for the good reasons

- Need of high resolution observations for validation (field campains)

- Detailed case studies (high impact weather situation)

- Need of 3D physics (radiation, turbulence ?)

- Shallow convection grey zone adaptation from Lancz et al. tested but not included  (unrealistic rolls...)

# Next steps

- **Summer 2024** : for various reasons, not oper for PARIS Olympics, but will participate to model intercomparison exercise (PARIS-RDP)

- **Autumn 2024** : oper MEDALP forecast

- **Winter 2024-Winter2025** : Model support for the TEAMx field campain over the Alps ($\rightarrow$ new intercomparison cases with detailed observations)

- **2025** : on a new supercomputer, AROME-Fr 4D EnVar @750m (with cubic grid) ?
  ($\rightarrow$ small AROMEs-500m stopped ?)