Research and operation updates at Météo-France

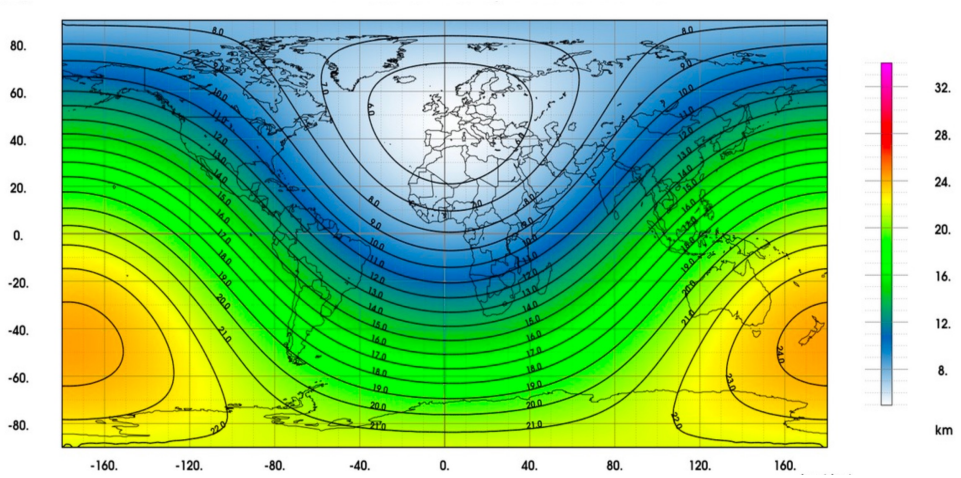
Romain Roehrig

with contributions from many CNRM colleagues

39th annual meeting of the WGNE, 4-8 November 2024, Toulouse, France

New e-suite (48t1) – Global systems

Systems	46t1 (June 2022)
ARPEGE (deterministic)	Tl1798c2.2 L105 (5km on W Europe) 4DVar (6h cycle): Tl224c1L105 & Tl499c1L105 4x per day up to 114h
ARPEGE-EDA	Tl499c1 L105 ; 50 members 4D-Var (6h cycle): Tl224c1 L105 Background covariances: 12-h avg / 6-h update
ARPEGE-EPS	Tl1798c2.2 L90 (5km on W Europe) ; 34+1 members ; 4x102h 35 EDA members and singular vectors Perturbed parameters, 2 convection schemes

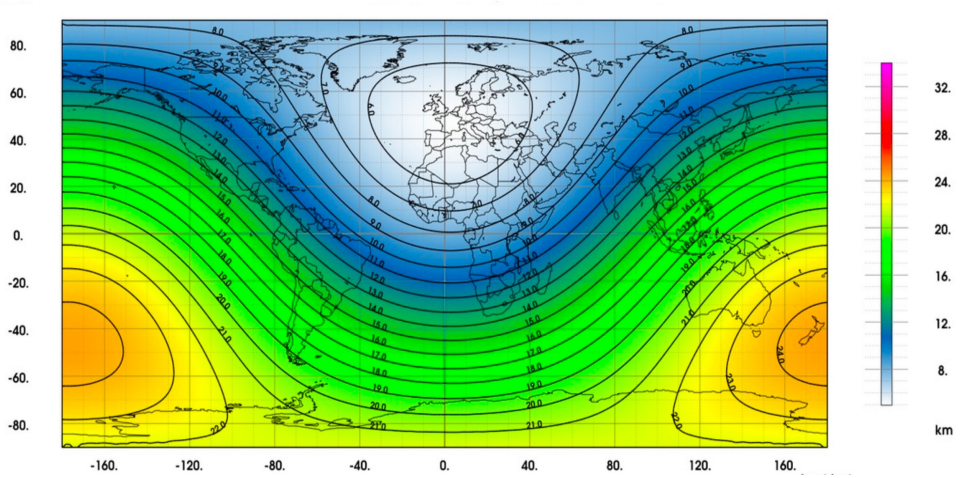


Tl1798c2.2: from 5 km over Western Europe to 24 km over the southern Pacific

Courtesy F. Bouyssel et al.

New e-suite (48t1) – Global systems

Systems	46t1 (June 2022)	48t1 main updates (14 October 2024)
ARPEGE (deterministic)	Tl1798c2.2 L105 (5km on W Europe) 4DVar (6h cycle): Tl224c1L105 & Tl499c1L105 4x per day up to 114h	Deep convection scheme updates (mixed closure, pr detrainment) **EcRad** with McICA solver New interpolations in the stratosphere SST product update (from Mercator)
ARPEGE-EDA	Tl499c1 L105 ; 50 members 4D-Var (6h cycle): Tl224c1 L105 Background covariances: 12-h avg / 6-h update	**Hybrid 4DVar** with 3D anisotropic covariances Direct assim. of **all-sky microwave radiances** Assim. of new **GNSS-RO** data Technical updates of assimilation schemes (OOPS)
ARPEGE-EPS	Tl1798c2.2 L90 (5km on W Europe) ; 34+1 members ; 4x102h 35 EDA members and singular vectors Perturbed parameters, 2 convection schemes	Removal of some singular vectors over NH/SH domains



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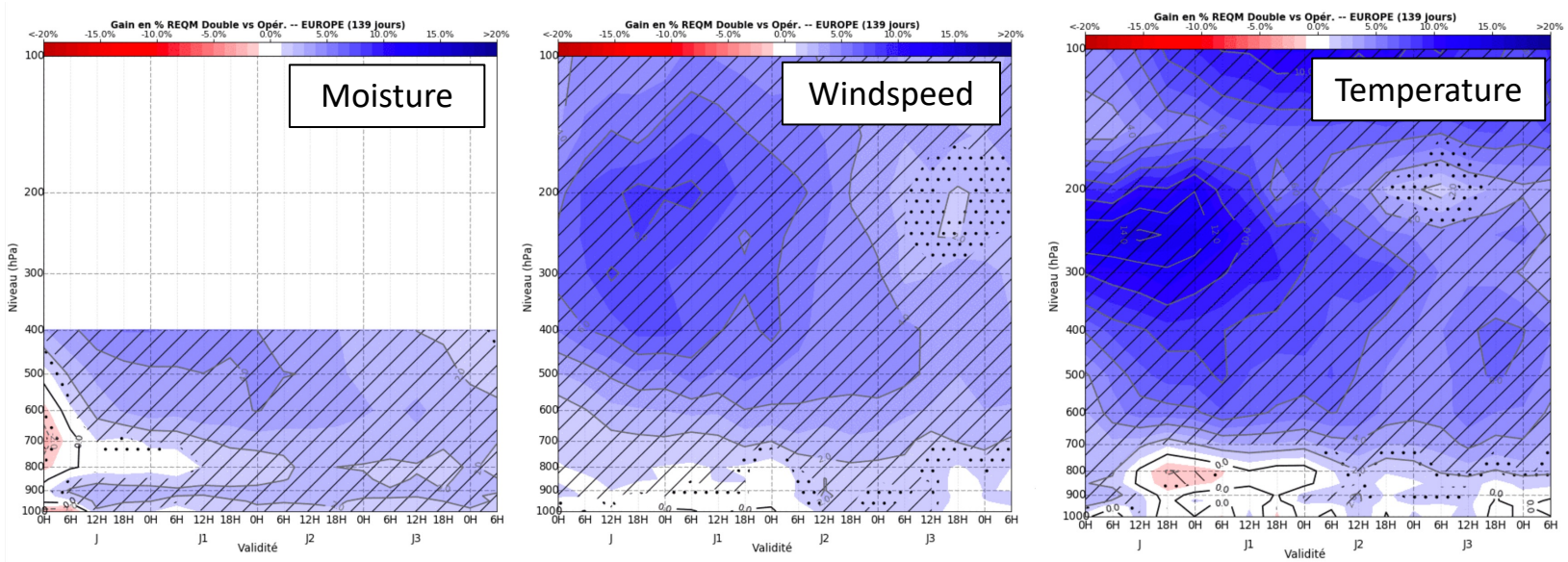
New e-suite (48t1) – Global systems

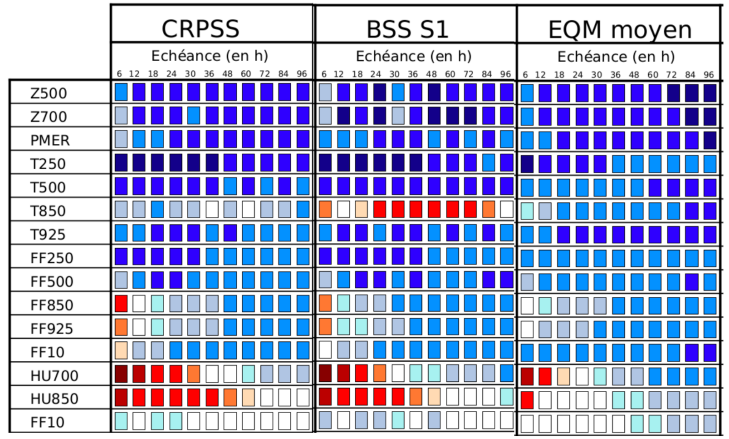
Score card 48t1 vs 46t1
4 months / Europe

	Réf.	Radiosondages	Analyses CEP
	Grille	GLOB025	GLOB025
	Ech.	0H à 96H pas de 12H	0H à 102H pas de 6H
Géopotentiel	100hPa		
	500hPa		
	850hPa		
	1000hPa		
Pression	Mer		
Température	100hPa		
	500hPa		
	850hPa		
	1000hPa		
Température corrigée	2m		
Vent	250hPa		
	500hPa		
	850hPa		
FF	10m		
Humidité	400hPa		
	700hPa		
	850hPa		
	2m		

RMSE gain (in %) 48t1 vs 46t1
4 months / Europe – Ref: IFS analyses



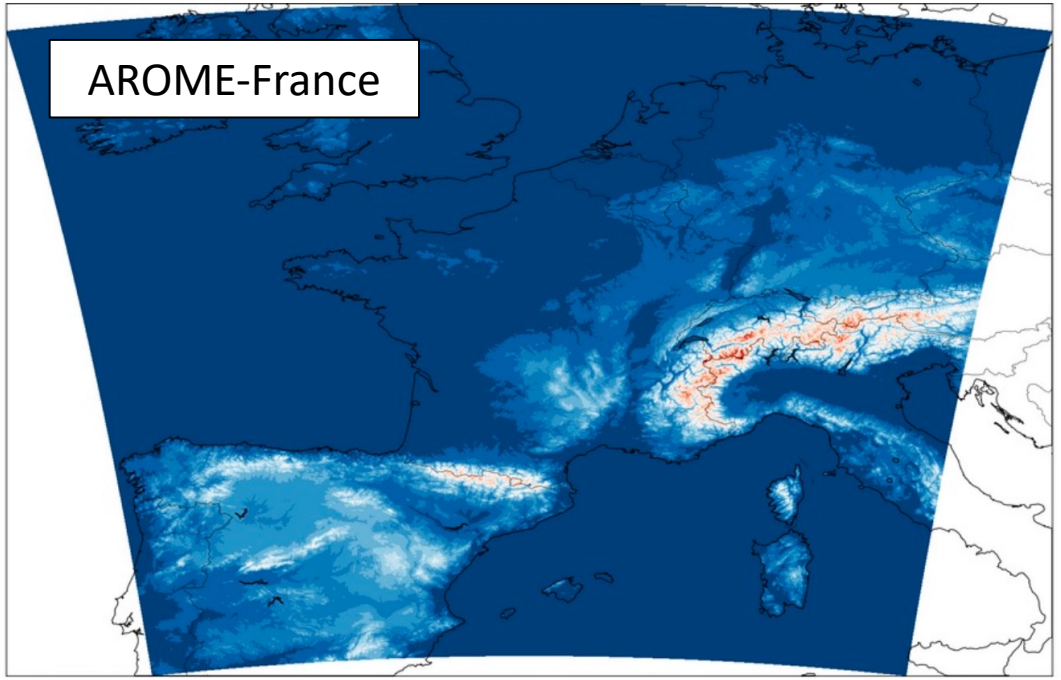
ARPEGE-EPS skill scores 48t1 vs 46t1
6 months / Europe
Ref.: ARPEGE analysis + stations

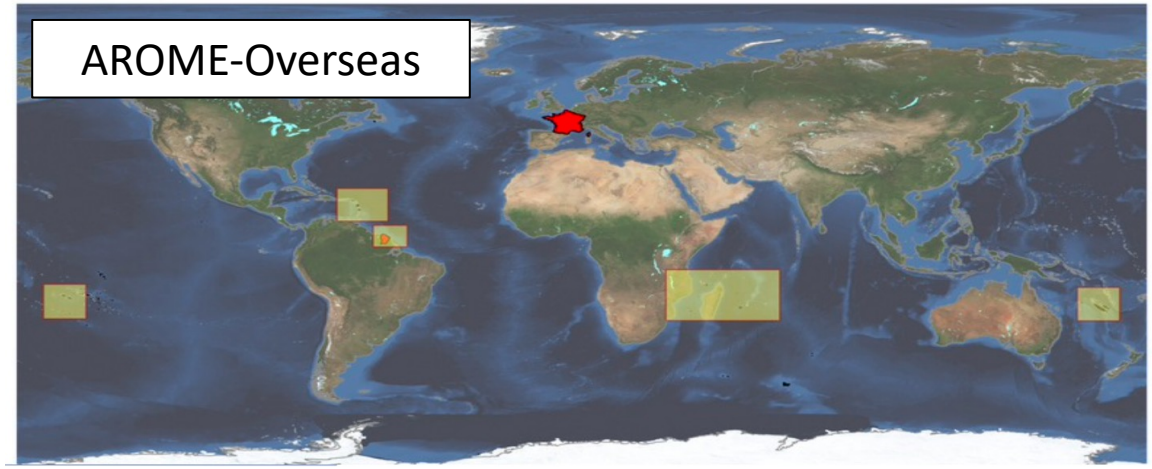


Courtesy F. Bouyssel, M. Plu et al.

New e-suite (48t1) – AROME-based regional systems

Systems	46t1 (June 2022)
AROME-France (deterministic)	1.3km L90 / 3DVar (1h cycle) 8x per day, up to 51h
AROME-France Nowcasting	1.3km L90 / 3DVar (no cycling – 10' cut-off) 24x per day, up to 6h
AROME-IFS	1.3km L90 Init/LBC: IFS + AROME-Fr (sfc) 4x per day, up to 51h
AROME-EDA	3.25km L90 / 25 members 3DVar (3h cycle)
AROME-EPS	1.3km L90 / 16+1 members Initial perturbations: AROME-EDA LBC: ARPEGE-EPS 4x per day up to 51h
AROME-Overseas (5 domains)	1.3km L90 Init/LBC: IFS + ARPEGE (sfc) 4x per day, up to 51h
AROME-EPS Overseas (5 domains)	2.5km L90 / 15 members Init. as AROME-Overseas LBC from ARPEGE-EPS 2x per day, up to 51h
Various 'on-demand' AROME configuration	2.5km L90 / Several domains ARPEGE dyn. adaptation





Courtesy F. Bouyssel et al.

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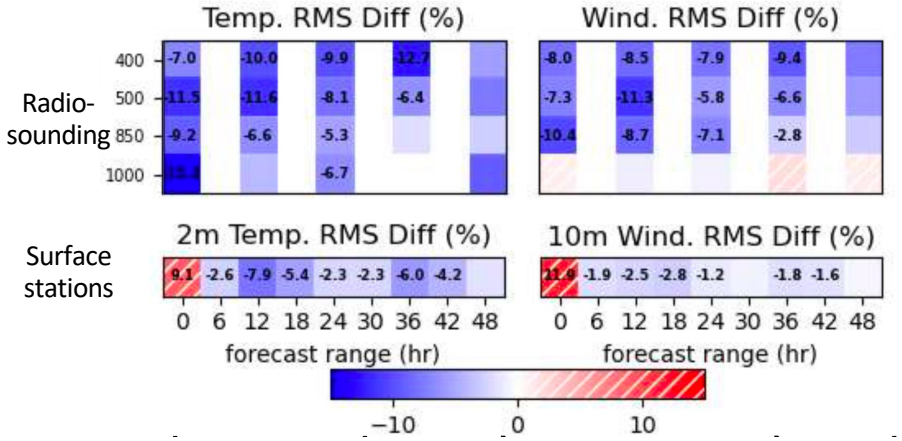
48t1 main updates (14 October 2024)

- Physics
  - **EcRad** with McICA solver, new aerosol climatology
  - SST product update (from Mercator)
- Assimilation
  - Direct assim. of **all-sky microwave radiances**
  - Assim. of new **GNSS-RO** data
  - **AROME-EDA: 3DEnVar / 50 members**
  - **AROME-EPS: 24+1 members**
  - Technical updates of assimilation schemes (OOPS)
- Technical:
  - **Mixed precision** in all forecasts

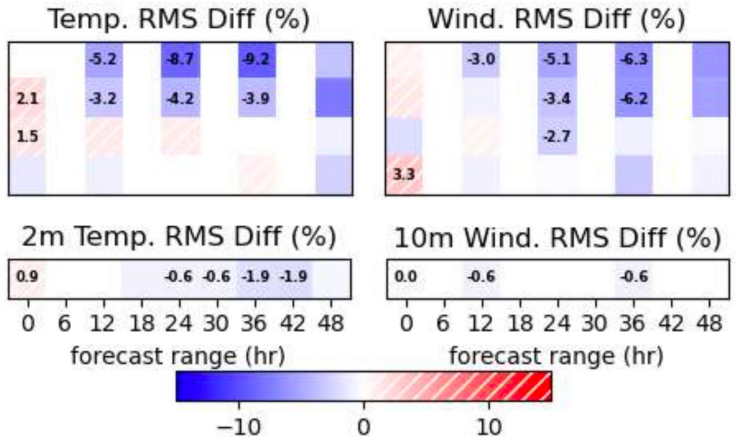
Courtesy F. Bouyssel et al.

New e-suite (48t1) – AROME-France

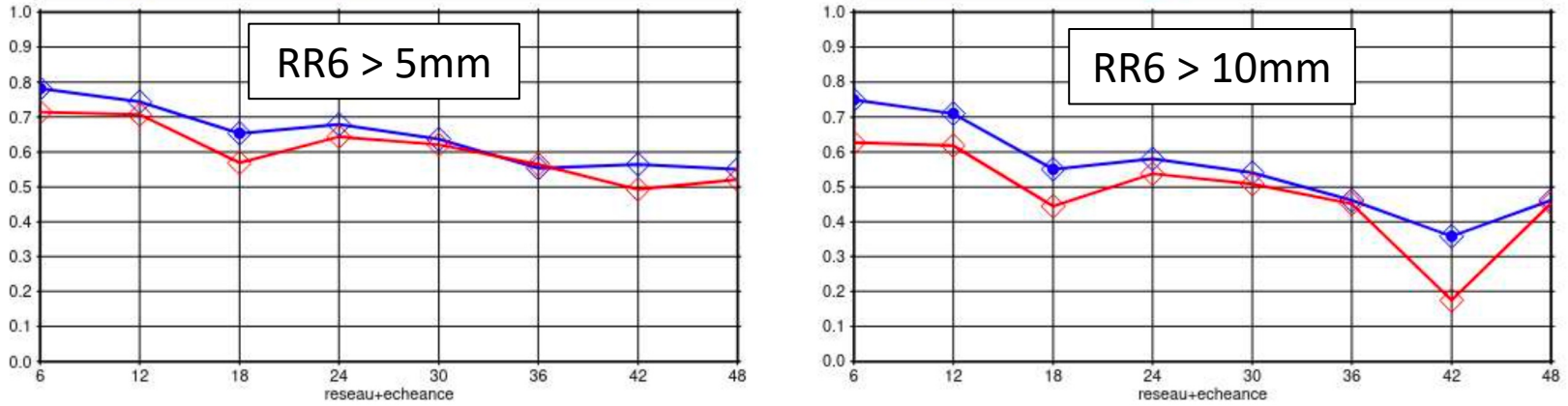
RMSE improvement 48t1 vs 46t1
3 months / France



RMSE improvement due to
new ARPEGE 48t1 LBC



Brier skill score for 6-hourly precipitation (3 months / France)



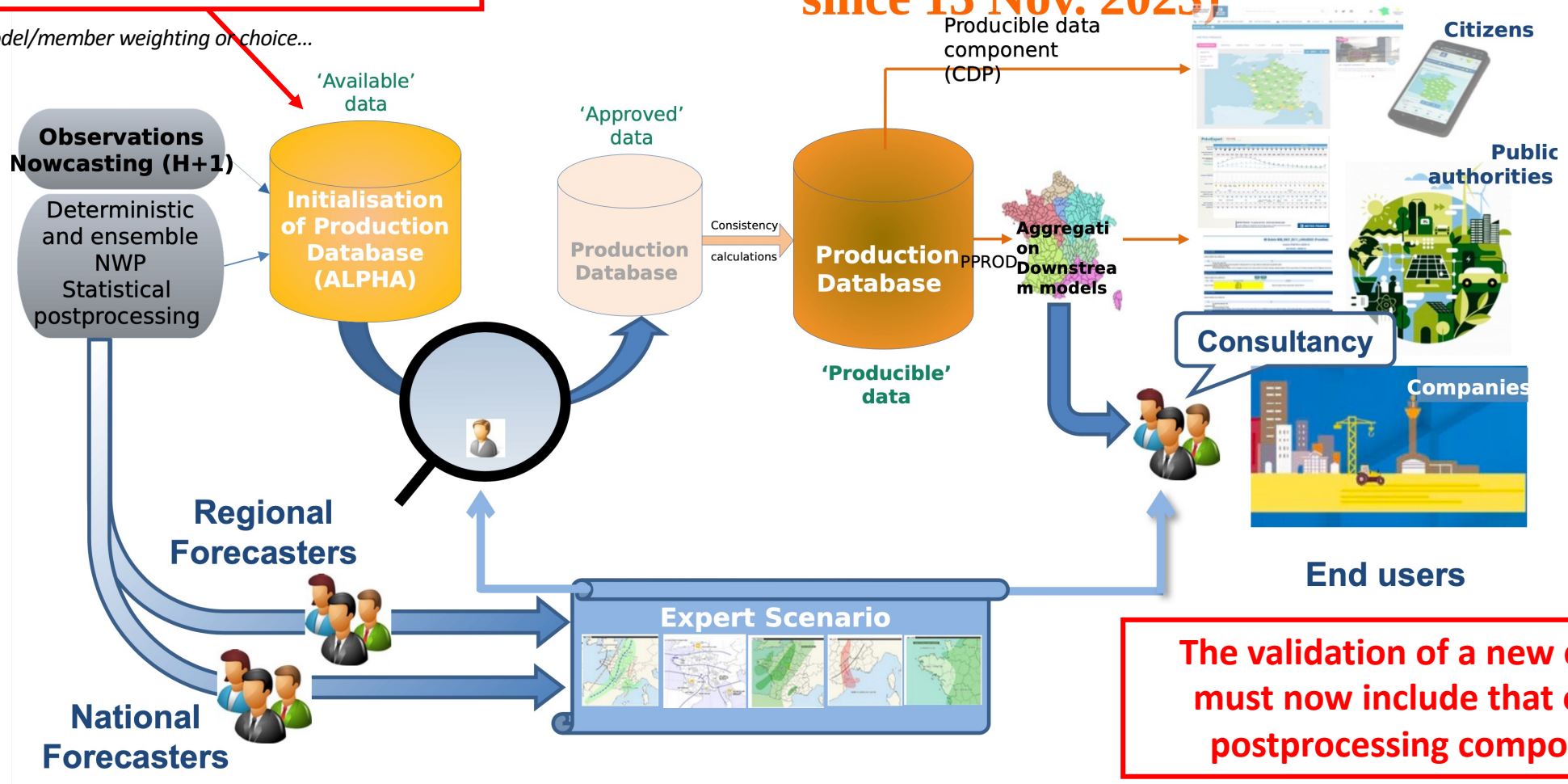
46t1
48t1

Courtesy Y. Seity, P. Brousseau et al.

Recent complexification of the production line

Statistical postprocessing dependent on models' versions + time-dependent adjustments

Bias-correction, model/member weighting or choice…

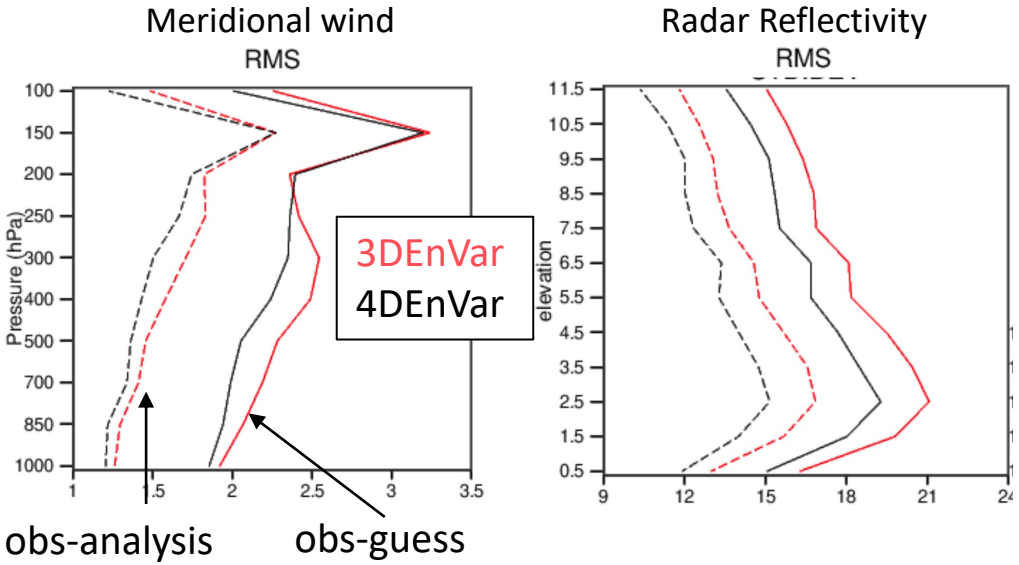


→ Increased use of NWP and statistical postprocessing (ALPHA)

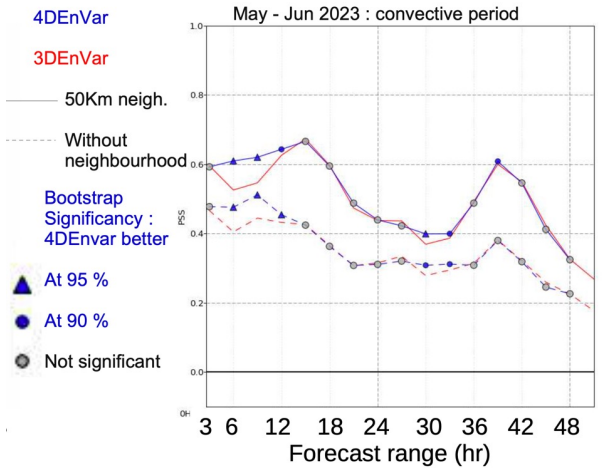
Courtesy F. Bouyssel et al.

Preparing the next AROME e-suite (49t1)

From 3DEnVar to 4DEnVar in AROME-France



Pierce Skill Score for 3-hourly precipitation
Convective period [May-June 2023]



Other foreseen updates (TBC, and among others)

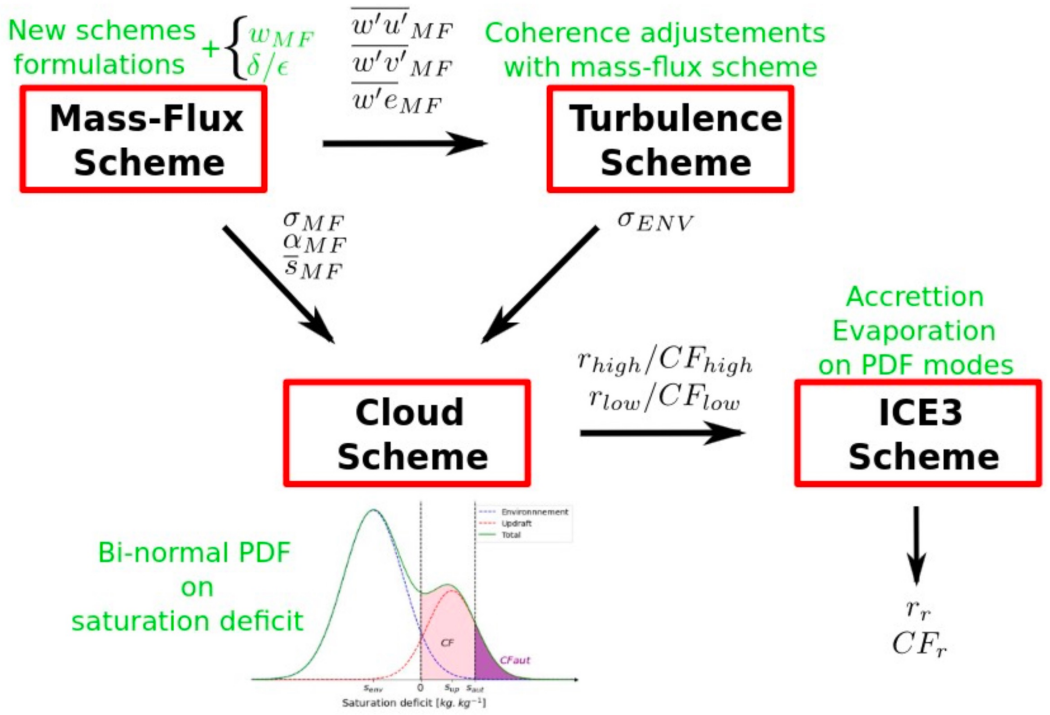
- Physics
  - Revised statistical cloud scheme
  - Initialisation with real-time dust aerosols
- Assimilation
  - Scale-dependent localization (SDL)
  - Direct assimilation of radar reflectivities
- AROME-EPS: from SPPT to RPP(+SPPT?)

Operational implementation ~mid-2026

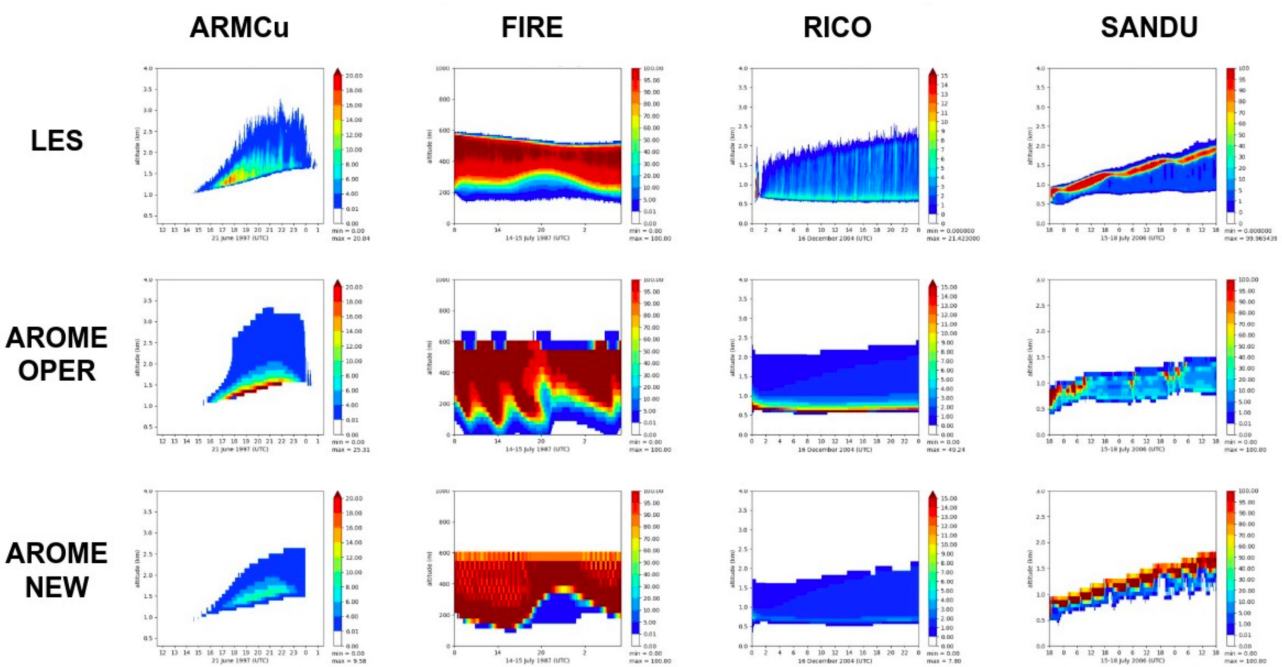
Courtesy P. Brousseau, F. Bouyssel et al.

Improving the shallow cloud parameterizations in AROME

Updated formulations
And improved consistency among schemes



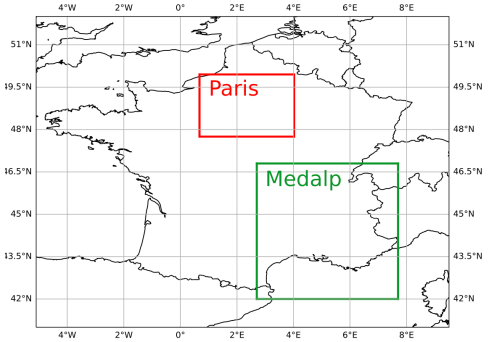
1D-LES comparisons



Courtesy S. Riette, A. Marcel et al.

Towards AROME-500m

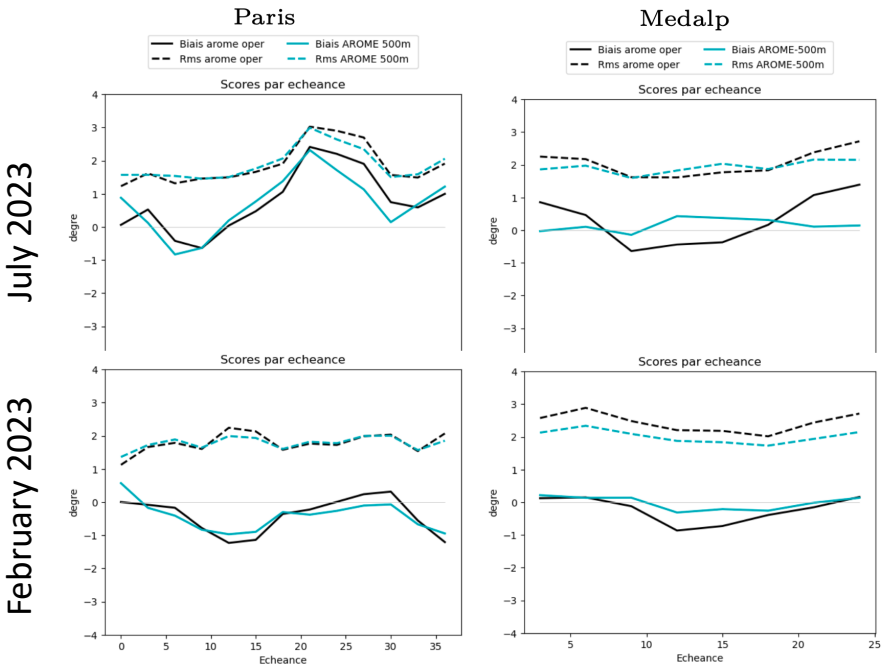
- Deterministic forecast, no data assimilation
- 500m, 120 vertical levels (1st at 2.5m), dt=20s
- 2 domains Paris/Medalp
- 1 forecast per day up to +36/24h
- + nowcasting 24x per day, up to +6h



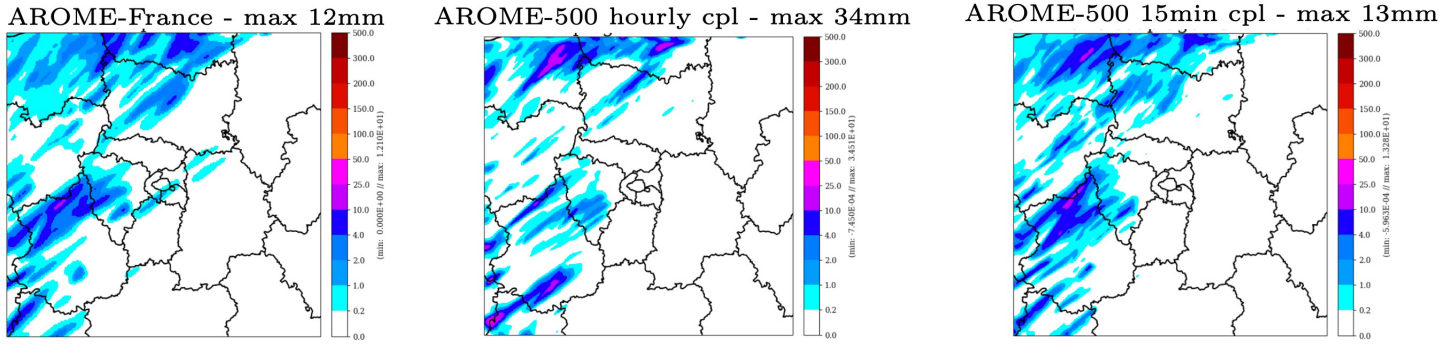
- Much work on surface properties (topography, vegetation, urban areas)
- Adding temperature numerical diffusion
- A few adjustment in turbulence and land surface schemes
- Adding droplet deposition for improved fog representation

- 2 years, 'in operations' since August 2023, only for research/testing so far.

Bias/RMSE for 2-m Temperature



Need to increase (lateral) coupling frequency
to keep consistency with the parent model



+ Too many and too small convective cells

Courtesy S. Antoine et al.

Deep convection in ARPEGE

Introducing convective organisation in the IFS Tiedtke-Bechtold scheme

- Proxy for convective organization M_o :

$$\frac{dM_o}{dt} = c_1\, Evap + c_2\, \overline{w} - \frac{M_o}{\tau}$$

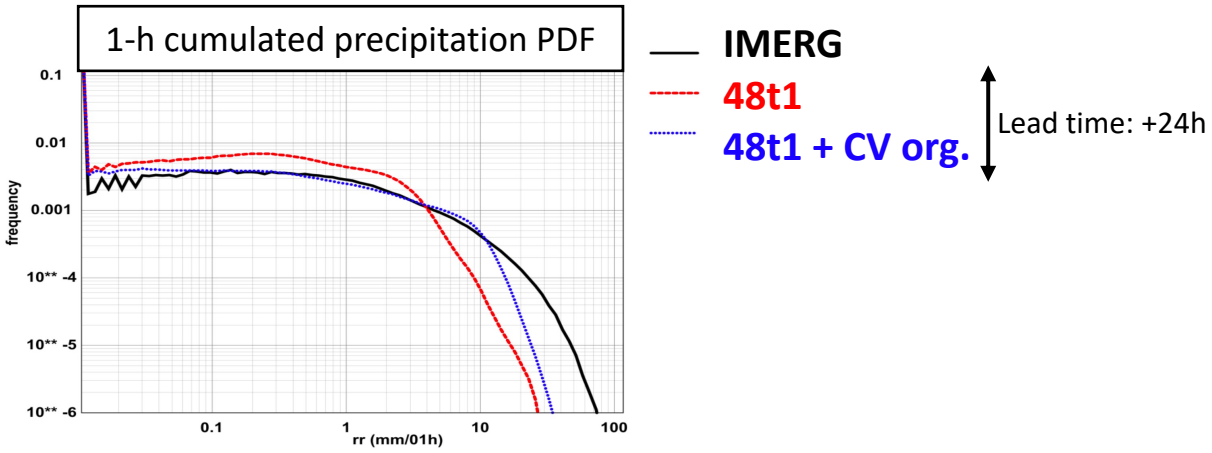
- *Evap* is the evaporation of convective precipitation :

$$Evap = -\frac{\partial RR}{\partial p}$$

- M_o is 3D and advected by the semi-lagrangian advection scheme.
- Entrainment

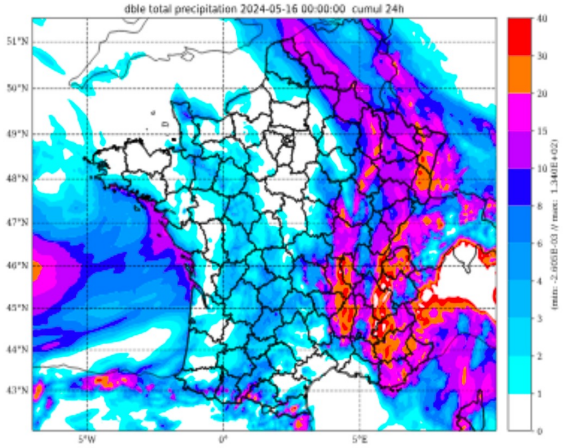
$$E_{up} = \epsilon_{up}\, f_\epsilon\, \frac{M_{up}}{\overline{\rho}}\, (1.3 - RH)\, f_{scale}\, g(M_o)$$

- CAPE consumption time : $\tau = \frac{H}{\overline{w}_{up}}$ is replaced by $\tau = h(M_o)$.

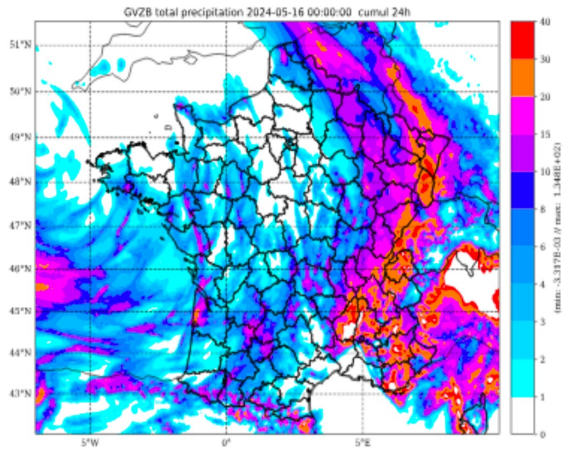


Init: 14 May 2024 / Lead time: +48h
24-h cumulated precipitation

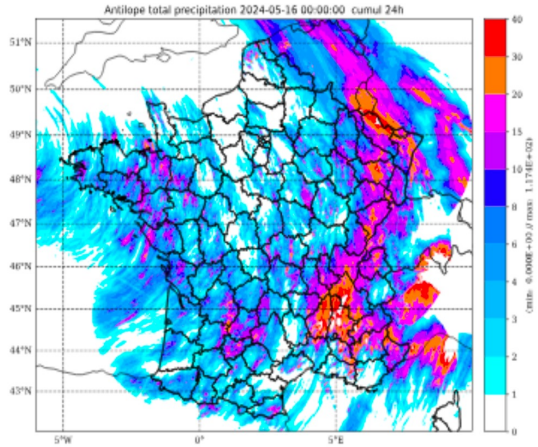
48t1



48t1 + CV org.



ANTILOPE (Radar)



Courtesy J.-M. Piriou et al.

Summary

- Selective emphasis on recent research activities at Météo-France

- The latest version of the MF NWP systems in operations since 14 October 2024
- Preparing the next update, foreseen in operation near mid-2026
- Latest e-suite on our current HPC. New HPC to be implemented in 2027, still uncertain architecture.

- Other MF activities include
  - Work on the microphysical parameterization (mixed phase, secondary ice production, from 1 to 2 moments)
  - Developing a regional system with more Earth system components (AROBASE, cf. Cindy's talk)
  - Preparing the model for GPU (and other accelerators): refactoring the code for source-to-source translation
  - Increasing activities on IA for NWP (cf. Sara's talk)

  - Preparing the CNRM contribution to CMIP7
    - AR7 Fast Track: same system as CMIP6, with a slight update for emission-driven capability
    - CMIP7-Science: more ambitions:
      - Revised/updated physics/chemistry in most CNRM-ESM components, within an enhanced seamless strategy, at least for the atmosphere.
      - Improved conservation features
      - Improved tuning strategy, using semi-automatic tools
      - Optimisation (mixed precision, I/O)