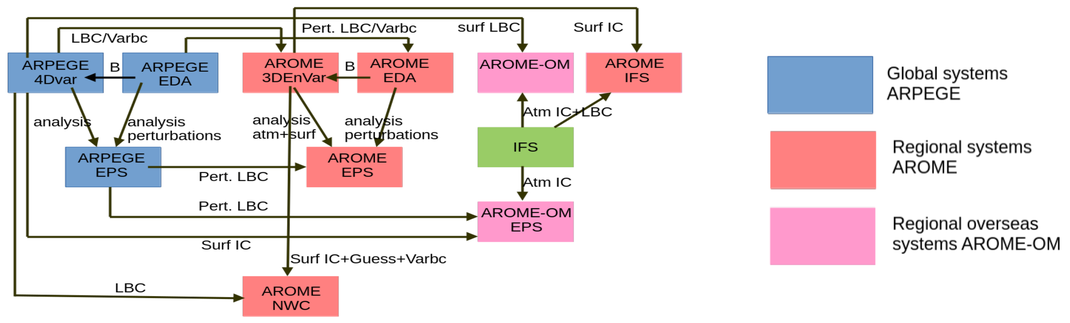
Overview of Météo-France NWP systems

Operational NWP systems



2 HPC, 2 implementations

In operations since February 2021

Migration to next HPC is planned in 2027

No upgrade during the 6 year contract

Each HPC: ATOS BULL Sequana XH2000

2292 computing nodes

2 AMD Epyc Rome processors with 64 cores at 2.25 Ghz

10.39 PFlops peak performance

Global operational NWP systems based on ARPEGE

operational suite: cy48t1_op1(since mid october 2024)

ARPEGE (determinist)

- Hybrid 4DVar (OOPS) with 6hr cycle : Tl224 c1 & Tl499 c1
- Hybrid flow-dependant B matrix from ARPEGE-EDA
- ***Observations***: "all sky" assimilation of microwave obs (MHS, MWHS2, GMI, AMSR2), ATMS from NOAA-21, ABI from GOES-17, update of R matrix for IASI, GNSS-RO (GRACE-C, Sentinel-6, Spire), WIGOS adaptations
- ***Physics*** : EcRad (McIca solver) radiation scheme,microphysics tunings, Surfex v8.1, use of SST from Mercator-Ocean GLO12, solar eclipse
- ***Dynamics*** : use of WENO interpolations for T and Q in stratosphere
- 4 forecasts per day

ARPEGE-EDA

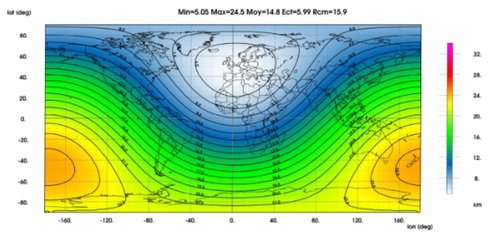
- Tl499 c1 / 600 s timestep
- 4DVar (OOPS) with 6hr cycle (Tl224 c1)
- 50 members
- recentering on the control member

ARPEGE-EPS

- 34 perturbed members + control
- 4 forecasts per day
- Initial perturbations from ARPEGE-EDA+SV
- random pertubed parameters + TKE, GWD, 2 convection schemes (Tiedtke+PCMT), microphysics, oceanic fluxes, solar radiation

Common features *(except otherwise noted)*

- Tl1798 c2.2 (5 to 24 km)
- 240s timestep
- 105 levels (10 m to 0.1 hPa)
- 102 hr forecast lead time

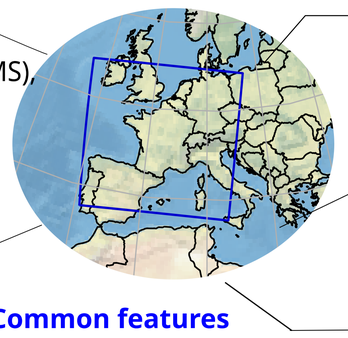


Regional operational NWP systems based on AROME

operational suite: cy48t1_op1(since mid october 2024)

AROME-France (determinist)

- 3DEnVar (OOPS) with 1h cycle +IAU
- EcRad+aerosol/ozone climatologies (CAMS), Surfex v8.1, SST Mercator-Ocean Glo12
- scatterometers HY-2B & HY-2C, Mode-S from EMADDC, GNSS-RO (GRACE-C, Sentinel-6, Spire), ATMS from NOAA-21, MWHS2 from FY3-E, WIGOS adaptations
- 8 forecasts per day



AROME-EPS

- 25 perturbed members + control
- 4 forecasts per day (+ 51hr)
- Initial perturbations from AROME-EDA
- SPPT
- LBCs from ARPEGE-EPS
- random surface perturbations

AROME-EDA

- 3.25 km, 100s timestep
- 3DVar (OOPS)with 3h cycle
- 50 members

AROME-IFS

- downscaling of IFS
- Arome surface
- 4 forecasts per day

AROME-NWC (Nowcasting)

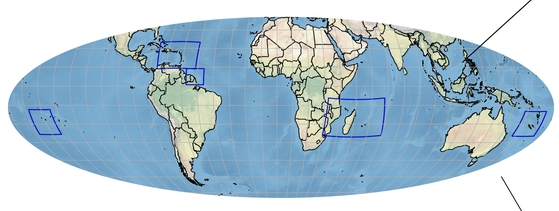
- 3DVar, guess from 3dvarfr, 10' cut-off
- 24 forecasts per day (+6hr)

Common features *(except otherwise noted)*

- 1.3 km, 50s timestep
- 90 levels (5m to 10 hPa)
- 51 forecast lead time
- uncycled forecasts in single precision

AROME-Overseas (AROME-OM)

- 5 domains, use of mixed precision
- 4 forecasts per day (+78hr on demand)
- Downscaling of IFS with prior "warmup"
- Use of Arpege surface (continent)
- 1D ocean model



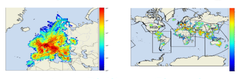
EPS AROME-Overseas (AROME-OM-EPS)

- 5 domains, 2 runs per day (+78hr on demand)
- 15 members (LBC=ARPEGE-EPS) +1 control (LBC=ARPEGE) at 2.5 km, mixed precision, hydrostatic
- Use of IFS as unperturbed initial conditions
- Boundary conditions + initial perturbations : ARPEGE-EPS
- Model errors via SPPT + Perturbation of surface + ocean layers

Next e-suite for Global NWP systems in cy49t1_op1

e-suite in may 2025, switch in operation in autumn 2026

- **Observations**
  - surface winds from Scatterometers on board HY-2D and Oceansat3
  - review of AMV assimilation with new adjustments and new observations (winds from MetOp low-orbiting moving satellites)
  - EMADDC Mode-S data



courtesy Philippe Chambon

→ wind data impacting surface to upper air analyses

- CrIs FSR, GOES-18/ABI, FY-3E/MWTS-3 (monitoring) → new T and Hu profiles
- satellite snow cover IMS data → first satellite data for surface analyse
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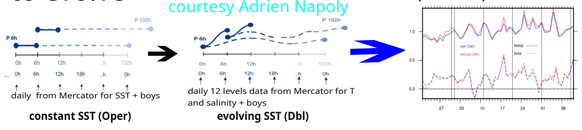
→ evaluation in progress
launch 2025-07 and 2025-08

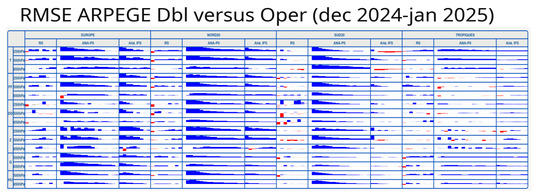

- **Physics**: Ocean Mixing Layer (1D model) to enable SST to evolve

courtesy Adrien Napoly



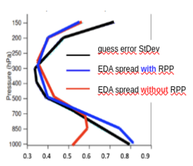
Time series of rmse and bias for T1000hPa on Europe-Atlantic (51 cases)

RMSE ARPEGE Dbl versus Oper (dec 2024-jan 2025)

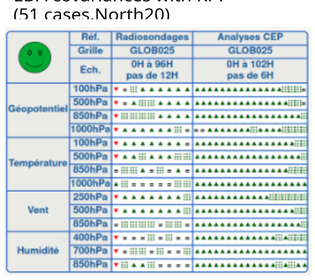


- **ARPEGE-EDA :** RPP on 30 model parameters → Improved EDA perturbations & covariances

More realistic spread in PBL

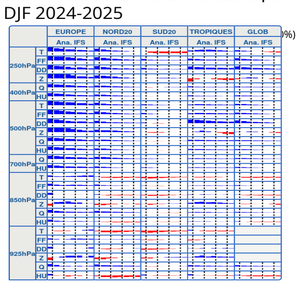


RMSE 4DVar ARPEGE using EDA covariances with RPP (51 cases,North20)



- **ARPEGE-EPS:** singular vectors removed & perturbations of initial surface states via EDA (T2m, Hu2m & whole ocean water column)

CRPS ARPEGE-EPS Dbl versus Oper DJF 2024-2025



courtesy Nicole Girardo & Loik Berre

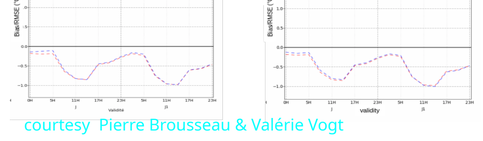
courtesy Laurent Descamps, Carole Labadie & Pierric Cébron

Next e-suite for Regional NWP systems in cy49t1_op1

e-suite in autumn 2025, switch in operation in autums 2026

- **Assimilation**
  - 4DEnVar+SDL (**AROME**)

Scores for T2m (march 2024) for AROME

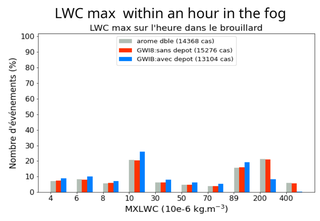


courtesy Pierre Brousseau & Valérie Vogt

  - 3DEr

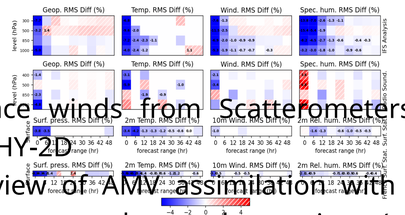
- **Physics** : account taken of the deposit to reduce overestimation of cloud water content in fog

LWC max within an hour in the fog



courtesy Salomé Antoine

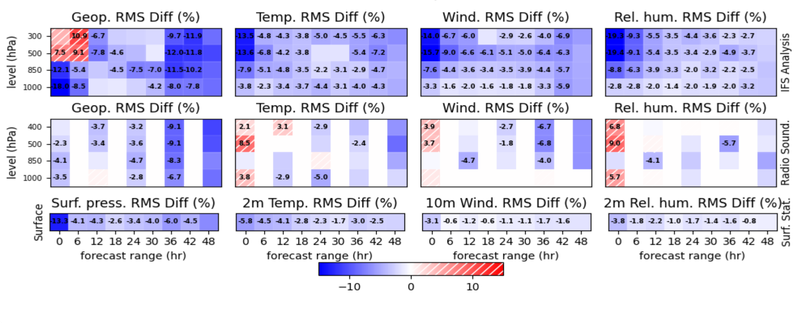
- **Observations**
  - Mode-S from EMADDC with new white list and adaptating weighting
  - direct assimilation of ground-based radar reflectivities



  - surface winds from Scatterometers on board HY-2D
  - review of AMV assimilation with new adjustments and new observations (winds from MetOp low-orbiting moving satellites)

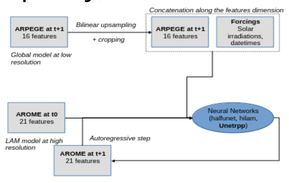
courtesy Nicolas Fourrié & Olivier Audouin

AROME France Dbl versus Oper 20241015-20241225



Towards an AROME-AI model

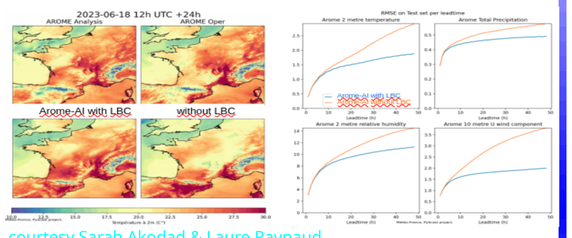
- Météo-France has developed the py4cast framework for the training of deep learning models
- research demonstrator of AROME-AI (2.5km,1hr timestep): trained in py4cast using 2 years of oper AROME analyses as training data and ARPEGE analyses/forecasts as forcing data (in LBC exp only)



Model	Levels	Parameters
ARPEGE	4 Isobaric levels [250, 500, 700, 850]	T, U, V, Z
AROME	10m	U, V
AROME	2m	T, HU
AROME	4 Isobaric levels [250, 500, 700, 850]	T, U, V, Z
AROME	Ground	PRECIP

Table: Parameters used in the coupling experiment.

first results

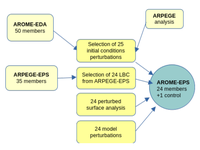


courtesy Sarah Akodad & Laure Raynaud

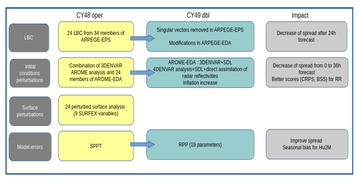
Ongoing activities

- Development of a streched-grid model in Anemoi (~Bris model of Met Norway)
- Several training datasets to be considered
  - Operational AROME archive (~ 4 years)
  - ARRA : an AROME analysis (1970-2020 available end-2025)
- And also : probabilistic emulator, statistical downscaling, multi-modal training, explainability tools

- **AROME-EPS**

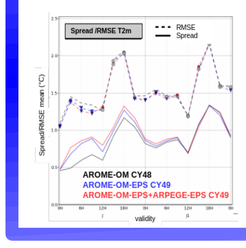


courtesy Grégory Roux



AROME-EPS Dbl versus Oper 10 apr-16 jun 2025

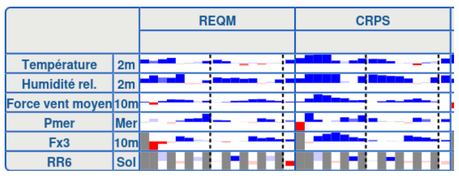
- **AROME-OM-EPS**: use IAU to add properly initial perturbations from ARPEGE-EPS



22 oct- 20 nov 2024 over Guyana

courtesy Olivier Nuissier

AROME-OM-EPS Dbl versus Oper 22 oct- 20 nov 2024 over Guyana



Collaborative work of DESR/CNRM/GMAP

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22-25 September 2025

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