



Status and plans of 48t1 and 49t1 e-suites at Météo-France

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CNRM, Météo-France and CNRS, Toulouse, France**

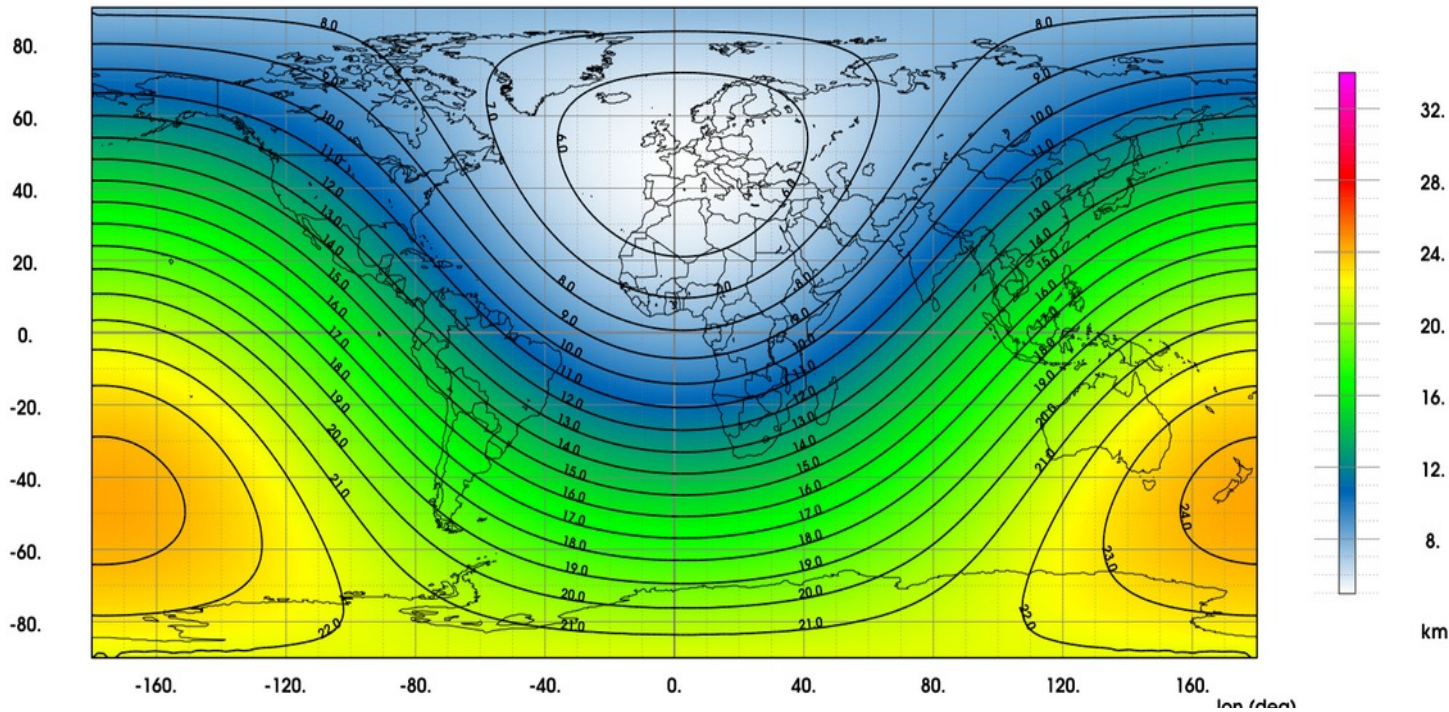
4th ACCORD All Staff Workshop, 15-19 April 2024, Norrköping

Plan

- Operational NWP systems (46t1)
- Content and evaluation of current e-suite (48t1)
- Major change in the Météo-France's production line
- Preparation of next e-suite (49t1)
- Conclusions and perspectives

Global operational NWP systems based on ARPEGE (CY46T1 since June 2022)

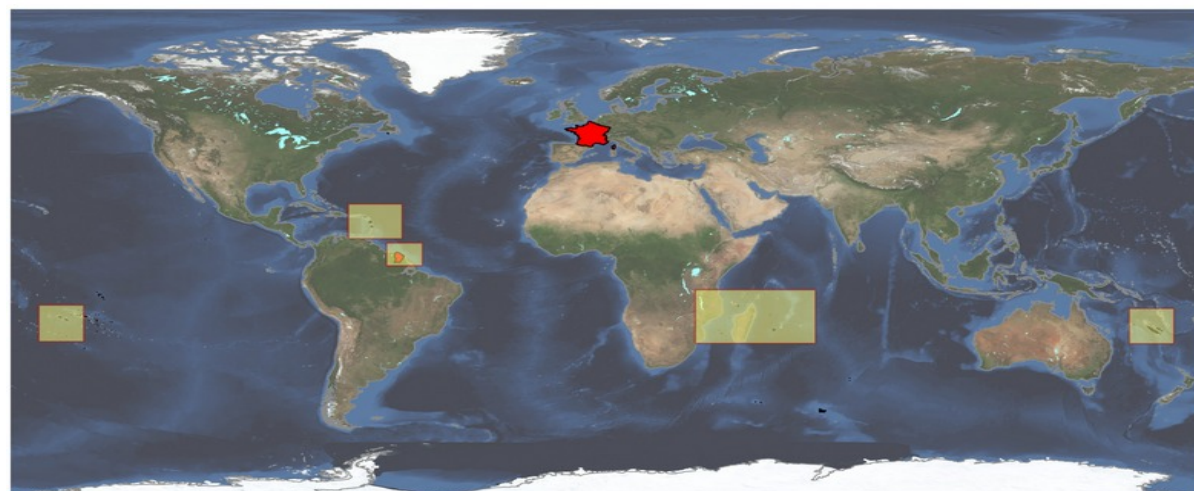
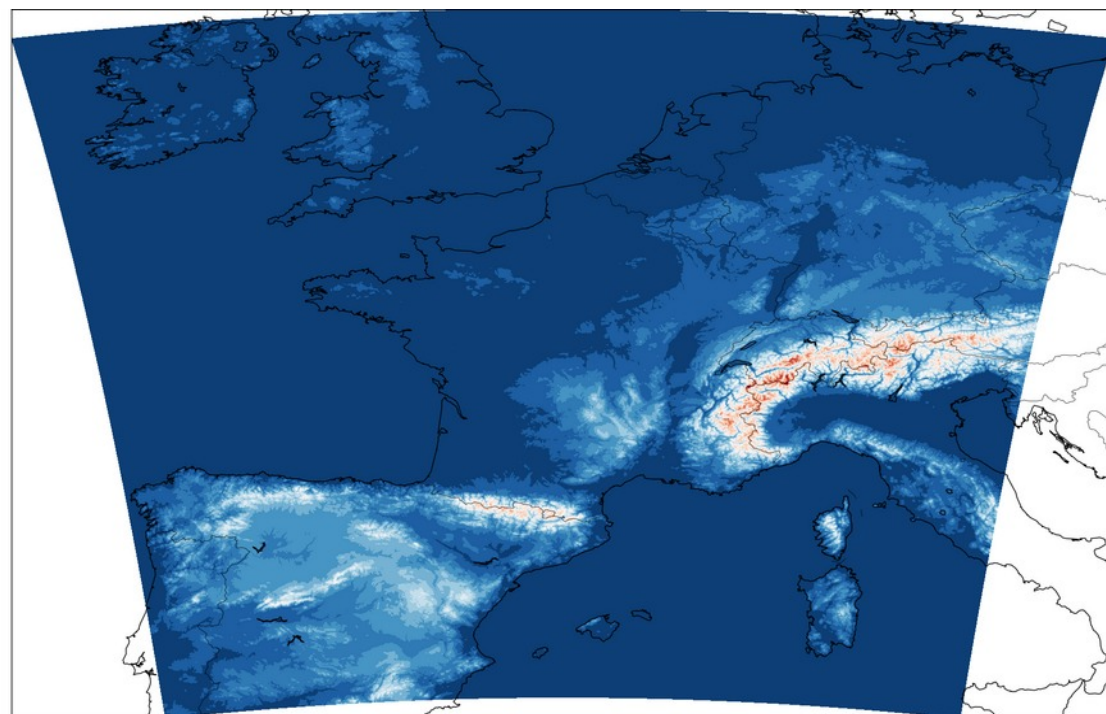
Systems	Characteristics
ARPEGE <i>Deterministic</i>	Tl1798c2.2 L105 (5km on W Europe) 4DVar (6h cycle): Tl224c1L105 & Tl499c1L105 5 forecasts per day up to 114h
ARPEGE-EDA (AEARP)	Tl499c1 L105 ; 50 members 4D-Var (6h cycle): Tl224c1 L105 Background covariances averaged on 12h and updated every 6h
ARPEGE-EPS (PEARP)	Tl1798c2.2 L90 (5km on W Europe) ; 34+1 members ; 4x102h 35 EDA members and singular vectors Perturbed parameters, 2 convection schemes



Horizontal resolution
ARPEGE/PEARP
 $5\text{km} < D_x < 24\text{km}$

Regional operational NWP systems based on AROME (CY46T1 since June 2022)

Systems	Characteristics
AROME-France <i>Deterministic</i>	1.3km L90 (from 5m to 10hPa) 3DVar (1h cycle) 8 forecasts per day up to 51h
AROME-France Nowcasting	1.3km L90 3DVar (no cycling – 10' cut-off) 24 forecasts per day up to 6h
AROME-IFS	1.3km L90– Dynamical adaptation of IFS (altitude) and Arome-Fr (surface) 4 forecasts per day up to 51h
AROME-EPS (PEARO)	1.3km L90 - 16+1 members Four times per day up to 51h Initial perturbations from AROME-EDA and boundary conditions from PEARP
AROME-EDA (AEARO)	3.25km L90 25 members 3DVar (3h cycle)
AROME Overseas (5 domains)	1.3km L90 – Dynamical adaptation of IFS (altitude) and Arpege (surface) 4 forecasts per day up to 51h
AROME-EPS Overseas (5 domains)	2.5km L90 – 15 members Same initial conditions AROME Overseas Lateral conditions from PEARP 2 forecasts per day up to 51h
AROME Assistances Commercial	2.5km L90 – several domains Dynamical adaptation Arpege



48t1 ARPEGE current e-suite

- Implement of assimilation schemes (ARPEGE, EDA) under **OOPS** (Object-oriented layer)
- **Hybrid 4DVAR** : 3D anisotropic covariances from ARPEGE-EDA
- ARPEGE-EDA : addition of a control unperturbed member
- **Direct assimilation of microwave radiances in « all-sky » conditions**
- Assimilation of **GNSS-RO data from SPIRE, GRACE-C, Sentinel-6**
- Variational debiasing of aircraft data
- Update of the « Tiedtke Bechtold » deep convection scheme
- WENO interpolations in the stratosphere (T and q)
- **Radiation : EcRad with McIca solver**
- Include the effect of solar eclipses on radiation
- SST from Mercator (PSY4 1/12° product, now moving to GLO12)
- ARPEGE-EPS : Removal of some singular vectors (over NH and SH domains)

48t1 AROME current e-suite

- Implementation of assimilation schemes (3DEnVar, AROME-EDA 3DVAR, AROME-NWC) under **OOPS**
- 3D Ensemble variational scheme « **3DEnVar** », replacing 3DVAR
- Use of Incremental Analysis Update (IAU)
- AROME-EDA (used for 3DEnVar): **50 members**, longer forecast term
- AROME-EPS: **24+1 members**
- Direct assimilation of microwave radiances in « all-sky » conditions
- Assimilation of GNSS-RO data from SPIRE, GRACE-C, Sentinel-6
- Assimilation of wind and temperature data derived from **Mode-S**
- Assimilation of wind scatterometer HY-2B and HY-2C
- AROME-NWC : assimilation of MeteoSat/RapidScan radiances
- SST from Mercator (PSY4 1/12° product, now moving to GLO12)
- Radiation/aerosols : **EcRad** with McIca solver and new aerosols climatology (IFS-COMPO)
- Include the effect of solar eclipses on radiation
- **Single precision (32b)** in production forecasts

48t1 e-suite evaluation: scorecards

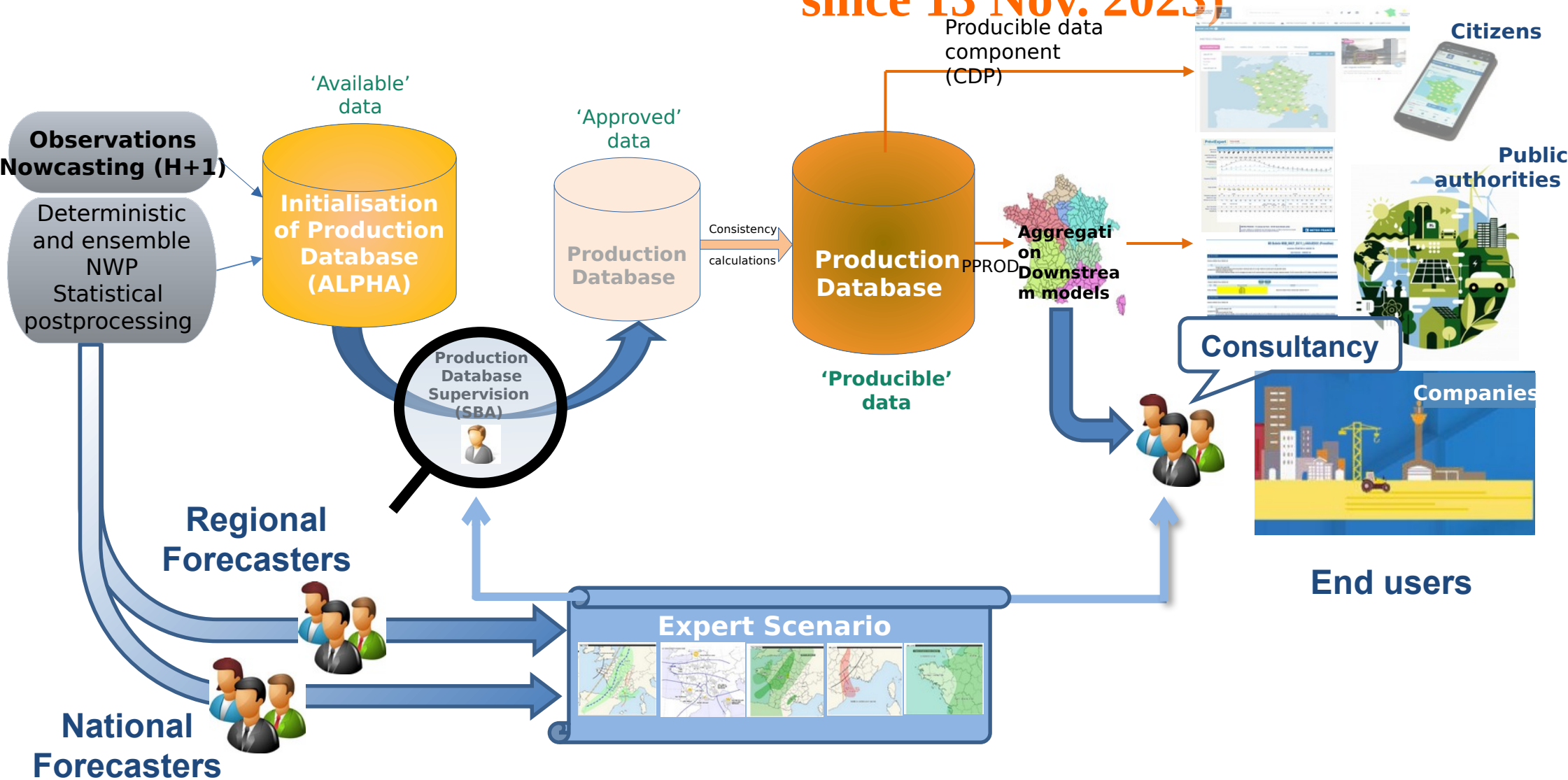
		EUROPE	NORD20	SUD20	TROPIQUES	GLOB	
REQM	T	250hPa					
		500hPa					
		850hPa					
	FF	250hPa					
		500hPa					
		850hPa					
	DD	250hPa					
		500hPa					
		850hPa					
	Z	250hPa					
		500hPa					
		850hPa					
	Q	400hPa					
		700hPa					
		850hPa					
	HU	400hPa					
		700hPa					
		850hPa					

ARPEGE: Verification against IFS analysis (approx. 80 days)

AROME : Verification against French surface observations (approx. 120 days)

		REQM
Température	2m	
Humidité rel.	2m	
Force vent moyen	10m	
Direction vent moyen	10m	
Pmer	Mer	
Ntot	Sol	
Fx3	10m	
RR3	Sol	

The new Météo-France production line (Prediction-Production Programme, 3P; since 13 Nov. 2023)



→ Increased use of NWP and statistical postprocessing (ALPHA)

ALPHA – The initialisation of the production database

4 runs at D/D+1, 2 runs at D+2/D+14 - hourly time step from D to D+1, every 3 h from D+2 to D+14

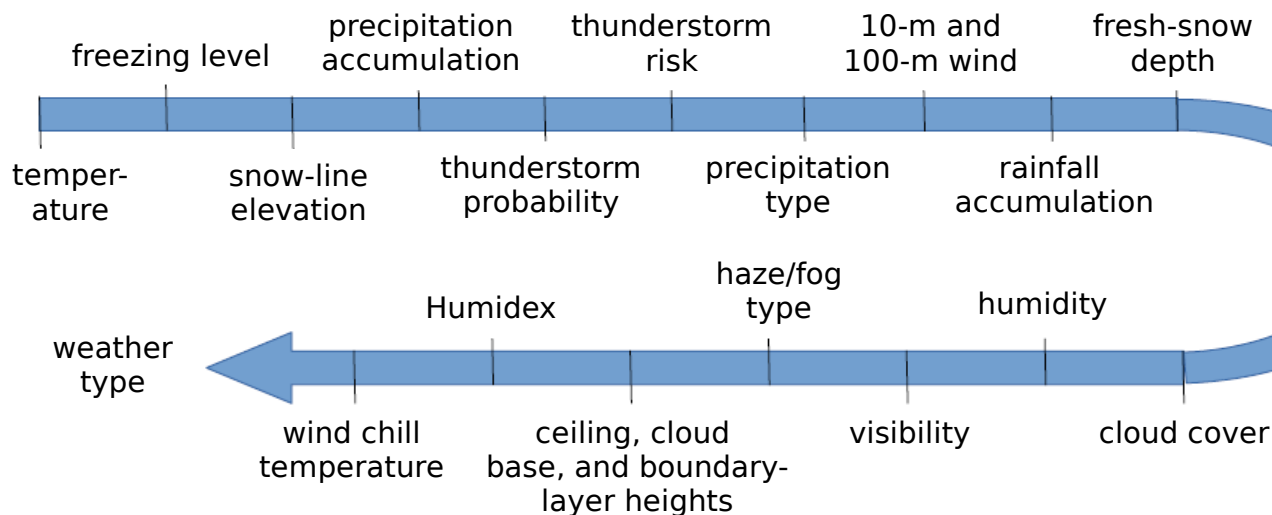
Input data for ALPHA algorithms:

- D/D+1: AROME-France (last 3 runs), AROME-IFS (last run), AROME-EPS (last 2 runs), [ARPEGE-EPS (last run), ARPEGE (last 3 runs) for the longer forecast terms of runs no. 1 and 4]
- D+2/D+3: ARPEGE (last 3 runs), ARPEGE (last 2 runs), **HRES (last 2 runs), ENS (last run)**
- D+4/D+14: **HRES (last run), ENS (last run)**

*The raw value of a model parameter is replaced by its statistically postprocessed value when available: temperature (AROME, ARPEGE, ARPEGE-EPS, **HRES, ENS**), humidity (AROME, AROME-EPS), precipitation (AROME-EPS).*

For each update and each forecast term from D to D+3 in the 'France' area, the weight of each of the models is adjusted according to the error of the models over the last 60 days.

Order of parameters for calculating the deterministic value



Deterministic value: For each point and forecast term, only the forecast members for the type of weather most likely to occur are used to calculate the deterministic value (for wind, only the members of the prevailing wind direction).

ALPHA – The initialisation of the production database

4 runs at D/D+1, 2 runs at D+2/D+14 - hourly time step from D to D+1, every 3 h from D+2 to D+14

Input data for ALPHA algorithms:

- D/D+1: AROME-France (last 3 runs), AROME-IFS (last run), AROME-EPS (last 2 runs), [ARPEGE-EPS (last run), ARPEGE (last 3 runs) for the longer forecast terms of runs no. 1 and 4]
- D+2/D+3: ARPEGE (last 3 runs), ARPEGE (last 2 runs), **HRES (last 2 runs), ENS (last run)**
- D+4/D+14: **HRES (last run), ENS (last run)**

*The raw value of a model parameter is replaced by its statistically postprocessed value when available: temperature (AROME, ARPEGE, ARPEGE-EPS, **HRES, ENS**), humidity (AROME, AROME-EPS), precipitation (AROME-EPS).*

For each update and each forecast term from D to D+3 in the 'France' area, the weight of each of the models is adjusted according to the error of the models over the last 60 days.

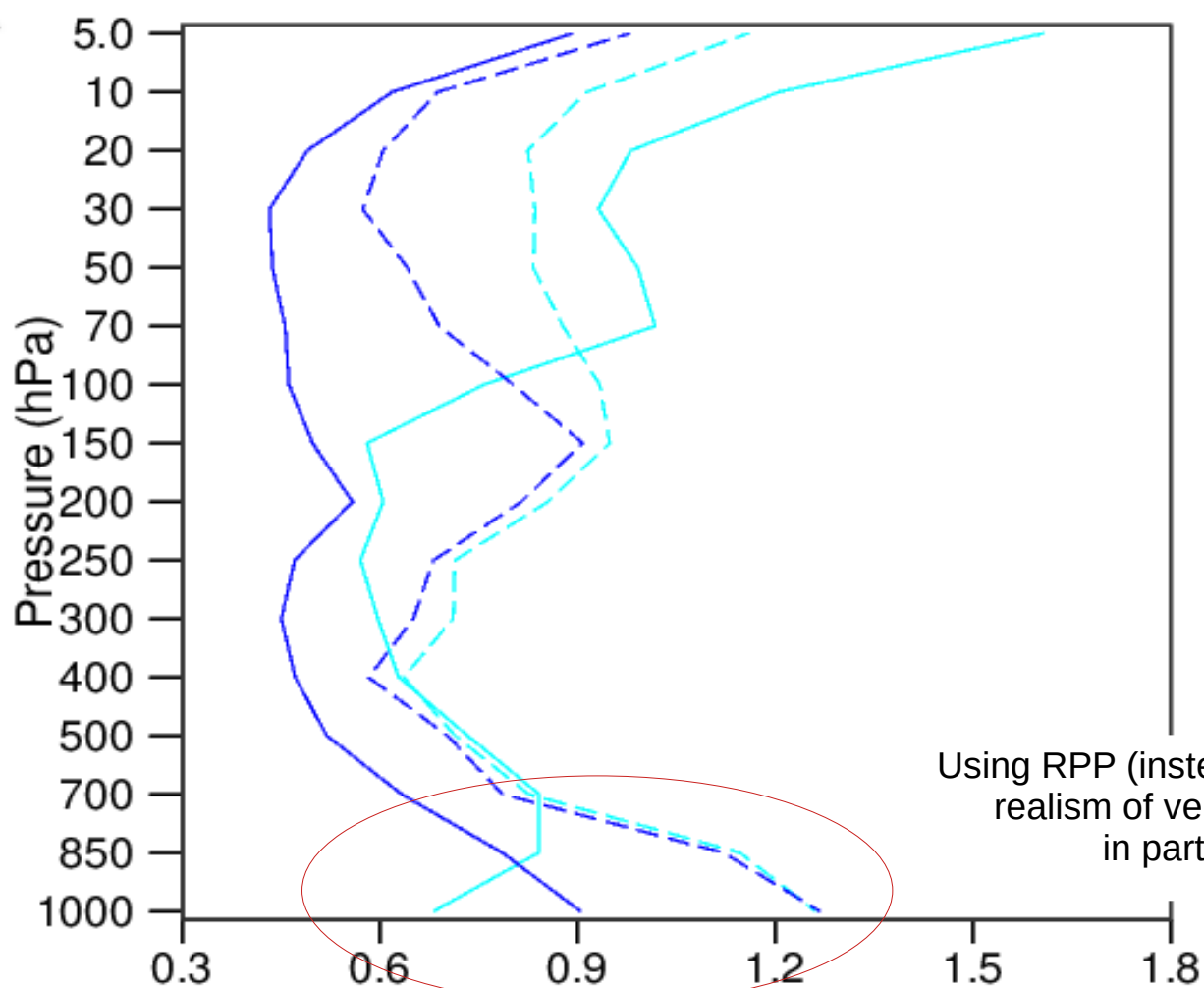
The new Météo-France production line requires some evolutions in the validation process of the e-suite. Therefore the operational implementation of 48t1 e-suite has been delayed and is planned in September 2024 or later (date to be confirmed)

Preparation of next e-suite based on 49t1 Some ARPEGE modifications (TBC)

On-going validations of 49t1 for ARPEGE configurations

- **Revision of model error representation in ARPEGE EDA** : use of Randomly Perturbed Parameters (RPP) in the model and in RTTOV instead of multiplicative inflation
- Improvement in the selection algorithm for the observation thinning
- Extend direct assimilation of microwave radiances in « all-sky » conditions (AMSU-A)
- **Assimilation of Mode-S, GOES ABI 18 and GNSS-RO Planet-IQ and Sentinel (>30km) data**
- Revision of observation errors for GNSS-RO and AMV data
- Assimilation of snow coverage satellite products
- Tuning of the « Tiedtke Bechtold » deep convection scheme
- New aerosols climatology (IFS-COMPO)
- Ocean Mixing Layer parameterization scheme
- **Simple precision (32b)** in production forecasts
- ARPEGE-EPS : Adaptation to EDA (RPP) and revision of singular vectors contribution

Revision of model error representation in ARPEGE EDA : use of RPP instead of multiplicative inflation

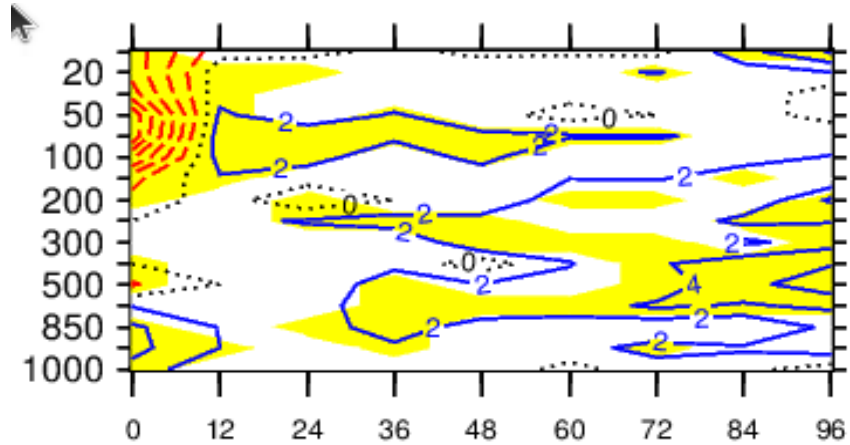


Using RPP (instead of inflation) improves the realism of vertical variations of spread, in particular at low levels.

Specified sigmab's for T (full lines) & diagnosed sigmab's (dashed lines) for **EDA_RPP** vs **EDA_inflation** (North. Extratropics)

(N. Girardot, L. Berre, E. Arbogast)

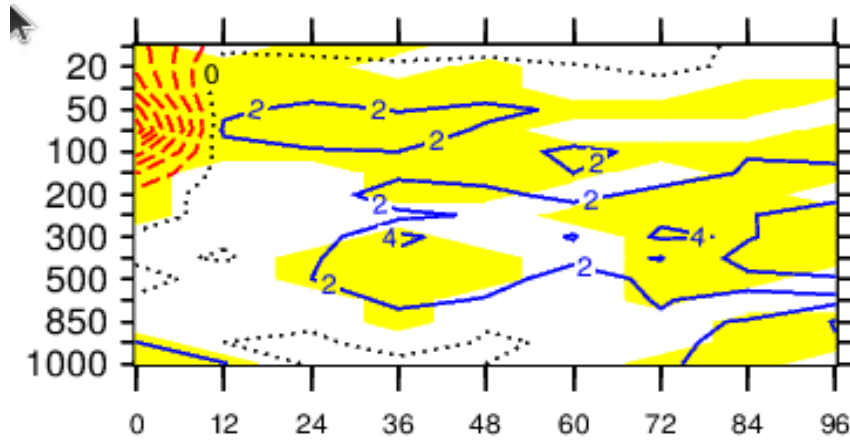
Impact of covariances (B) from new ARPEGE EDA : model parameter perturbations (RPP) and RT perturbations in allsky microwave obs (pertH)



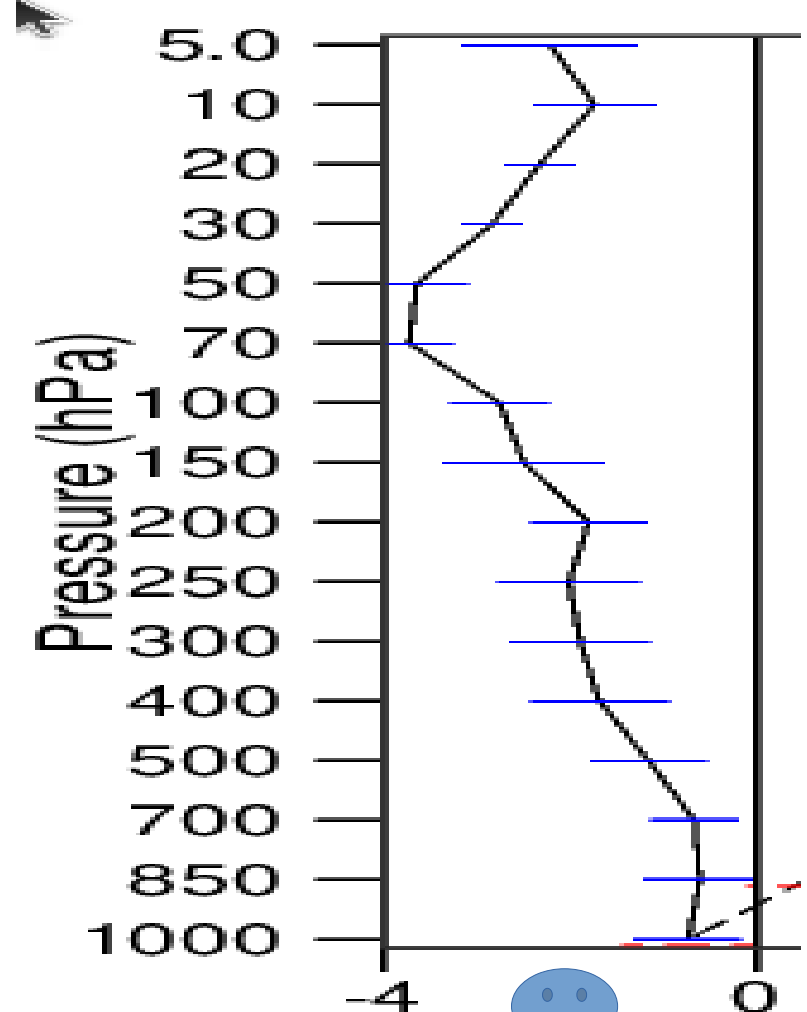
Temperature



Wind



%RMSE diff (RS) of forecasts
with **RPP+perth** vs **Ref**
over 2 months (Europe)



%RMS diff (wind, RS) of obs-guess
with **RPP+perth** vs **Ref**
over 2 months (North. Extratropics)

(N. Girardot, M. Borderies, L. Berre, E. Arbogast)

Preparation of next e-suite based on 49t1 Some AROME modifications (TBC)

On-going validations of 49t1 for AROME configurations

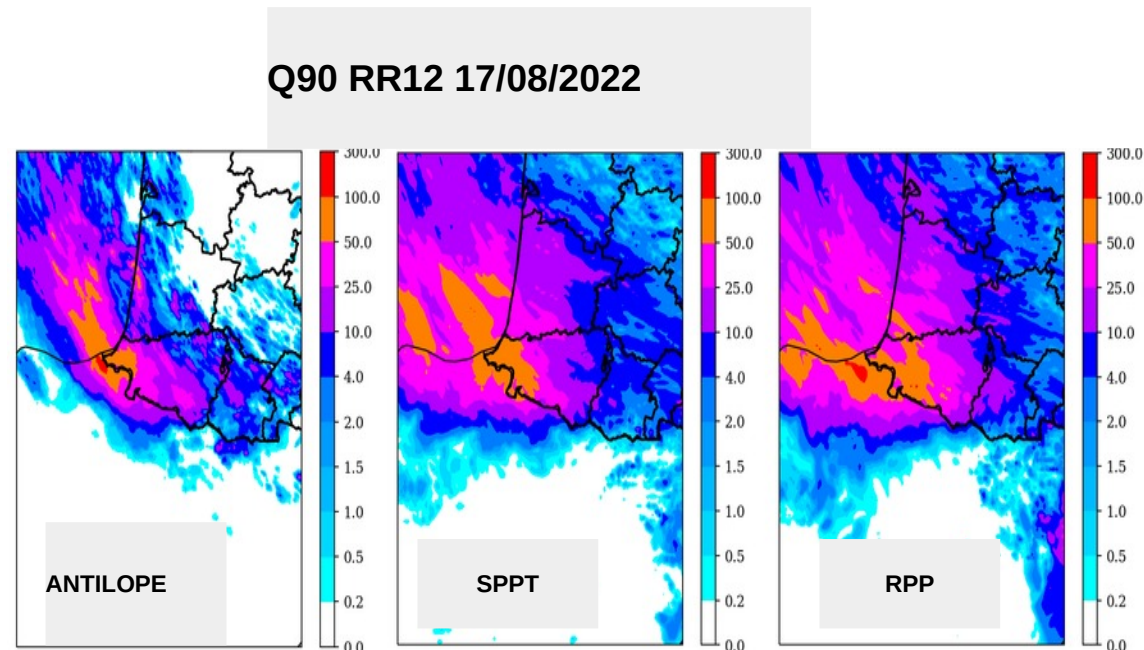
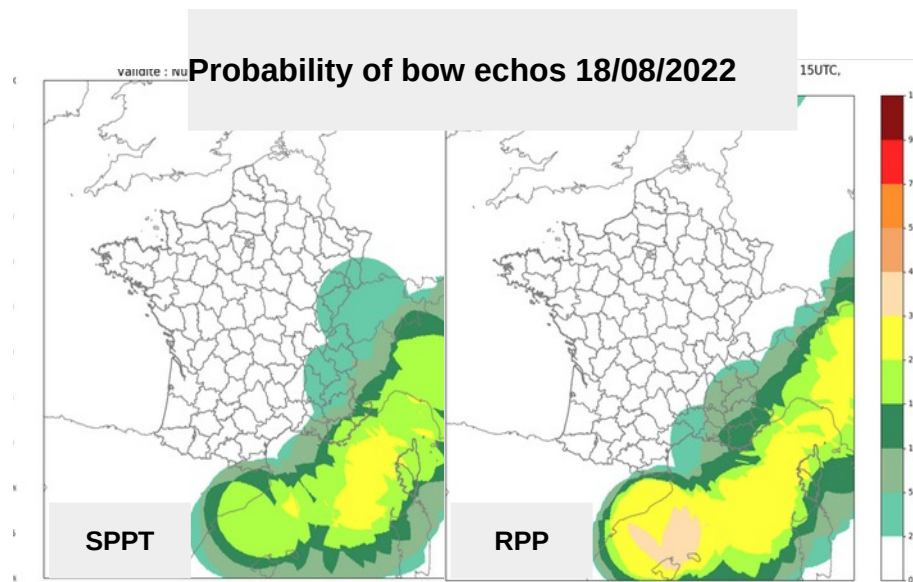
- AROME: 4D Ensemble variational scheme « **4DEnVar** » (**P. Brousseau's presentation**) + **SDL**
- AROME-EDA: « **3DEnVar** » + **IAU** + **SDL** + **Mode-S**
- **Direct assimilation of radar reflectivities**
- Same modifications as ARPEGE for satellite observations (IR, MW, SCAT, AMV, GNSS-RO)
- Monitoring of LI/MTG-I observations
- Initialization with real time dust aerosols (radiative effects)
- Revision of the PDF function in the statistical cloud scheme
- **AROME-EPS: Revision of model error representation** : use of Randomly Perturbed Parameters (RPP) in the model (in addition or without SPPT) ; adaptations of Arome evolution in Arome assimilation (4DEnVar and 3DEnVar in EDA).
- New diagnostics (Potential temperature Theta-S, etc.)

Model error in Arome-EPS

- Test of Random Perturbed Parameters (**RPP**) on **18** parameters (in radiation, microphysics, turbulence, surface and convection parametrisations)
- Sensitivity experiments to range values, distributions and standard deviations

Wimmer, M., et al. (2022). *Sensitivity analysis of the convective-scale AROME model to physical and dynamical parameters*. Quarterly Journal of the Royal Meteorological Society, 148(743), 920–942

- RPP with best configuration show slightly better scores (CRPS, spread, BSS) than operational SPPT on average for most surface variables, neutral for wind gusts
- Show some skill on several convective cases



(Courtesy of G. Roux)

Conclusions and perspectives

- **48t1 e-suite fully deployed with encouraging evaluation, especially for Arome due to 3DEnVar**
 - E-suite ARPEGE LBC files available on « ftp-pro-int.meteo.fr »: hourly outputs, maximum lead time +102h at 00Z, and +54h at 06,12,18Z
 - Operational switch foreseen in Sept 2024 or later (date TBC): e-suite LBC files will replace the present ones on « ftp-pro.meteo.fr », Max lead time +102h at all initial times
- **Next e-suite based on 49t1 in preparation including 4DEnVar in Arome and direct assimilation of radar reflectivities and revision of model error representation in Arome-EPS**
 - Planning of 49t1 e-suite: installation starting beginning 2025 and operational implementation foreseen mid-2026
- **Next HPC procurement: benchmark (10/2024) ; installation of the first new HPC (S1/2027)** (R. El Khatib's presentation)
- R&D activities for preparation of technical and scientific evolutions for future e-suites: IRS/MTG-S, Metop-SG, configurations on next HPC, Arome ML-data driven first prototype, etc.

Thank you for your attention