

# Model error simulation using the RPP scheme in AROME-EDA

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1) AROME-EDA at Météo-France and RPP setup

2) Impact of RPP on AROME-EDA and AROME-France (through covariances)

3) Conclusions and future work

## AROME-EDA at Météo-France in cy49 (parallel suite)

- Settings :
  - 50 members
  - 3.2 km horizontal resolution, hydrostatic
  - 3-hour cycle, 3DEnVar
  - Same observations assimilated as in AROME-France
- Purpose :
  - Providing **background error covariances** to AROME's EnVar scheme (operational 3DEnVar, and 4DEnVar in cy49)
  - Providing **initial perturbations** to AROME-EPS
- Perturbations :
  - **Observations** : adding random noise to observations corresponding to observation errors
  - **SST** : adding a random noise field controlled by a correlation distance and standard deviation
  - **Lateral boundary conditions** : provided by ARPEGE-EDA (global model)
  - **Model** : perturbing the tendency of physical processes (SPPT) to represent model uncertainties

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- ✓ SPPT : simple and effective method but no perturbation near surface (below 2000m) and near the model top (above 200 hPa) + same perturbation applied to all physical processes
- ✓ Need to increase ensemble spread by simulating unrepresented model error components

## Test of random parameter perturbations (RPP) – Wimmer et al.

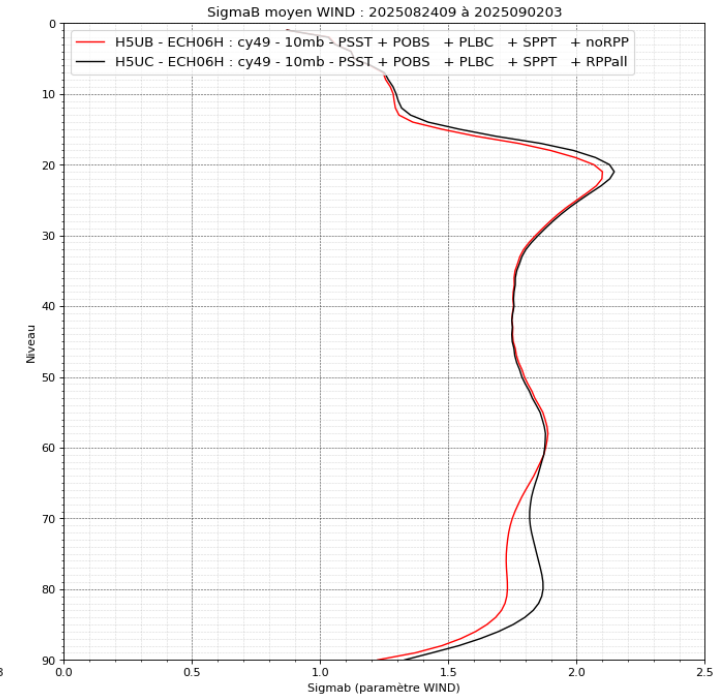
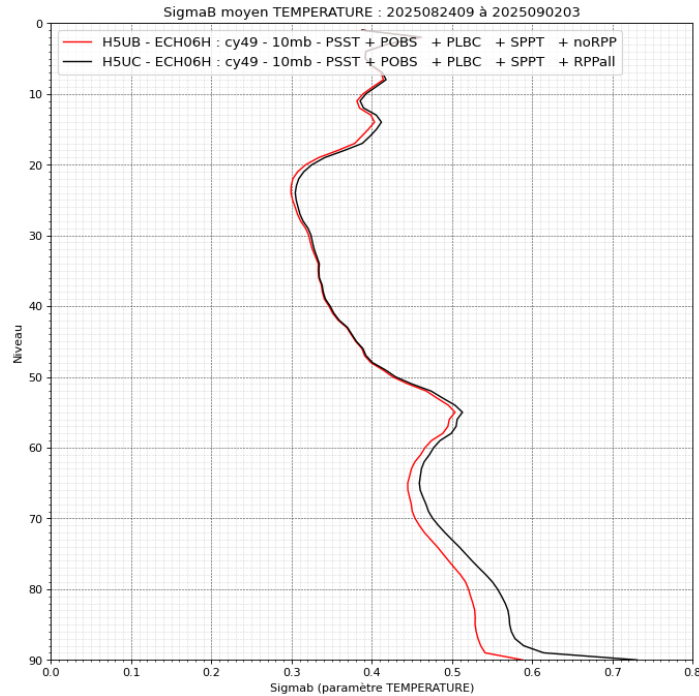
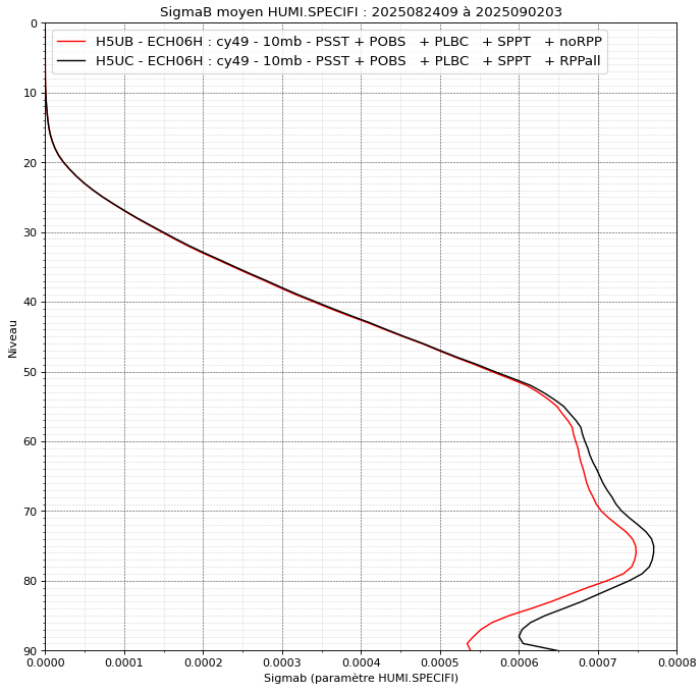
- RPP approach :
  - Random perturbations are added to model parameter values,
  - Random drawing is performed once at the beginning of the forecast for each member, and does not depend on space or time step.
- First test in AROME-EDA :
  - 10-member experiments, from 24/08/2025 to 01/09/2025
  - RPPall = reference + RPP activated.
  - The list of perturbed parameters, along with their ranges and sampling distributions, are the same as those used in AROME-EPS in MF's parallel suite in cy49, and based on physical experts.

## Test of random parameter perturbations (RPP) – Wimmer et al.

Scheme	Parameter	Physical meaning	Default	Range
Radiation	RCADDECOR	Coeff 1 in the eq of decorrelation	0.75	0.375 - 1.125
	RCBDECOR	Coeff 2 in the eq of decorrelation	2.149	1.0745 - 3.2235
	CLOUD_INHOM_DECORR_SCALING	short wave inhomogeneity factor	0.5	0 - 1
Microphysics	RCRIAUTI	Snow autoconversion threshold	0.2e-3	0.2e-4 - 0.25e-3
	RCRIAUTC	Rain autoconversion threshold	1e-3	0.4e-3 - 1e-3
	VSIGQSAT	Constant for subgrid condensation	0.02	0 - 0.1
Turbulence	XLINI	Minimum mixing length	0	0 - 0.2
	XCTD	Constant for dissipation of temp. and vapour pressure fluctuations	1.2	0.98 - 1.2
	XCTP	Constant for temperature and vapour pressure correlations	4.65	1.035 - 22.22
	XCEP	Constant for wind-pressure correlations	2.11	0.225 - 4.0
	XCED	Constant for dissipation of TKE	0.85	0.4 - 2
	XPHI_LIM	Threshold value for $Sc^{-1}$ and $Pr^{-1}$	3	1 - 4.5
	XCET	Constant for transport of TKE	0.4	0.072 - 1.512
Surface	XRIMAX	Critical Richardson number	0.2	0 - 0.3
	XFRACZO	Coefficient of orographic drag	5	2 - 10
Shallow convection	XCMF	Closure coefficient at bottom level	0.065	0 - 0.1
	XABUO	Coefficient of the buoyancy	1	0.7 - 1.5
	XBDETR	Coefficient of the detrainment	1e-6	0 - 1
	XENTR_DRY	Coefficient for dry entrainment	0.55	0.1 - 0.699

- 5 parameterizations perturbed
- The default value is used in the deterministic AROME model.
- The distribution of perturbation range is flat, not gaussian. (For some parameters, the default value is not in the middle of the range.)

# Contribution of RPP to AROME-EDA's spread Profiles of sigmaB - Parameters : Q, T and WIND - Forecast range +6h



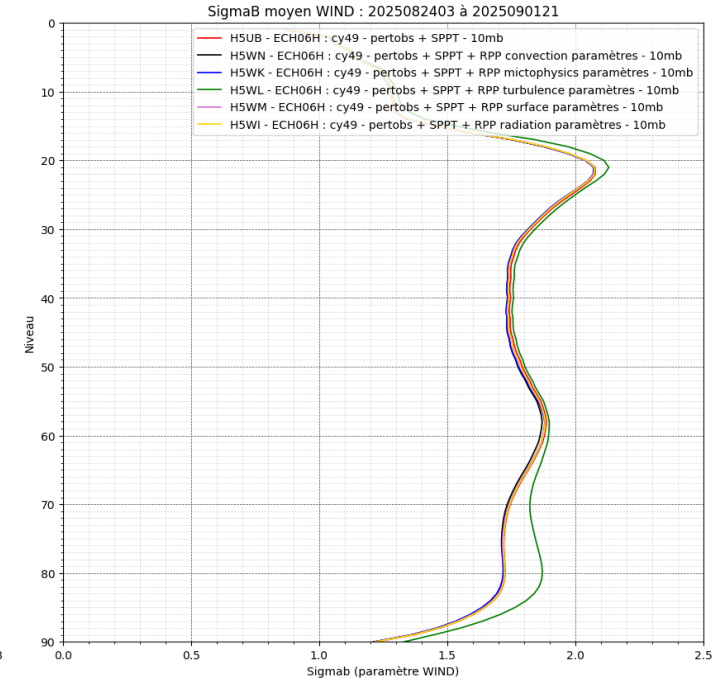
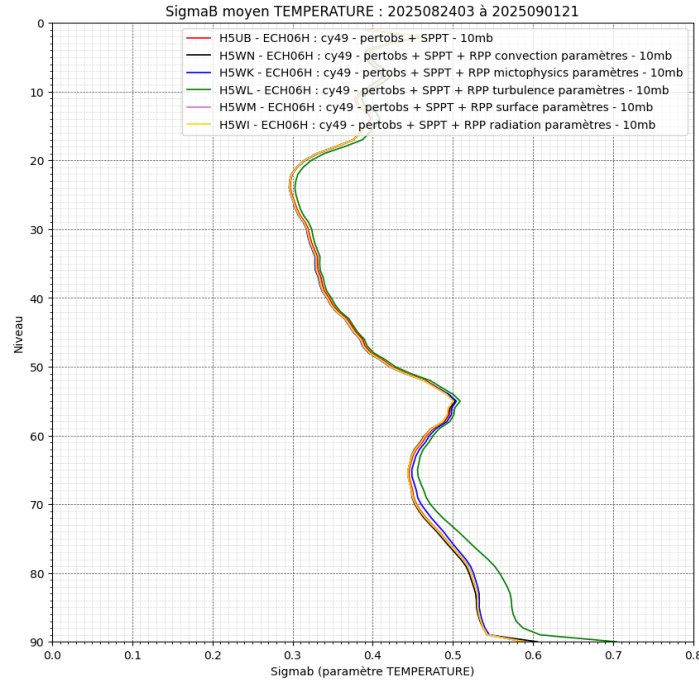
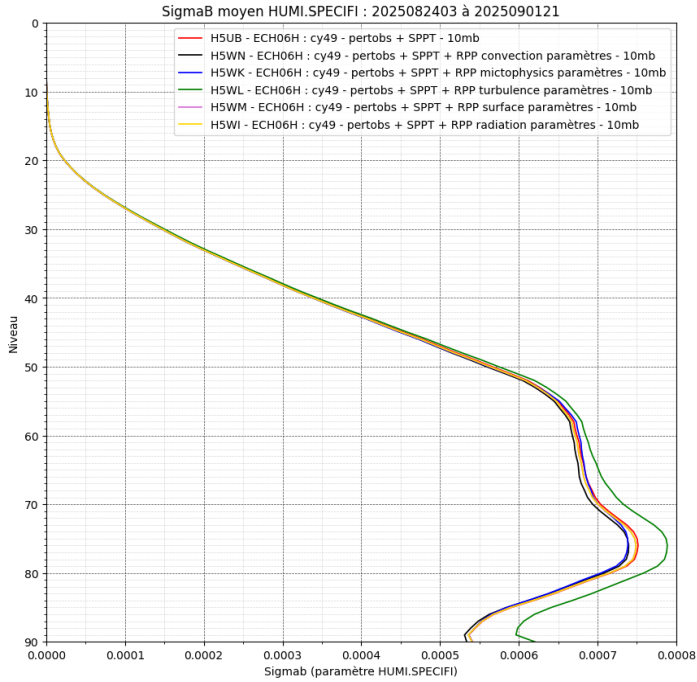
## Reference in red

Positive contribution of **RPP** to the ensemble spread primarily in the boundary layer and around the tropopause (level 20)

$$\sigma_{wind}^b = \sqrt{(\sigma_u^b)^2 + (\sigma_v^b)^2}$$

# Individual contribution of RPP-Perturbed Physical Parameterizations to AROME-EDA's spread

## Profiles of sigmaB - Parameters : Q, T and WIND - Forecast range +6h



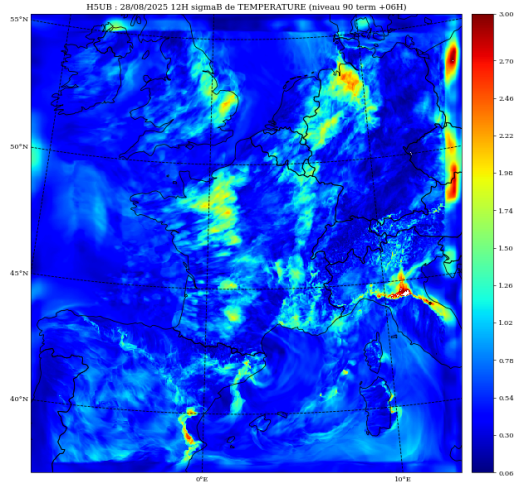
**NoRPP**, **RPP\_rad**, **RPP\_microphys**, **RPP\_turb**, **RPP\_surf**, **RPP\_shallowconv**

The perturbation of the **turbulence** scheme has the greatest impact on AROME-EDA's spread.  
The perturbation of other schemes has no impact (or even a negative impact) during this period.  
Note: A few numerical crashes occurred (in the convection and microphysics schemes).

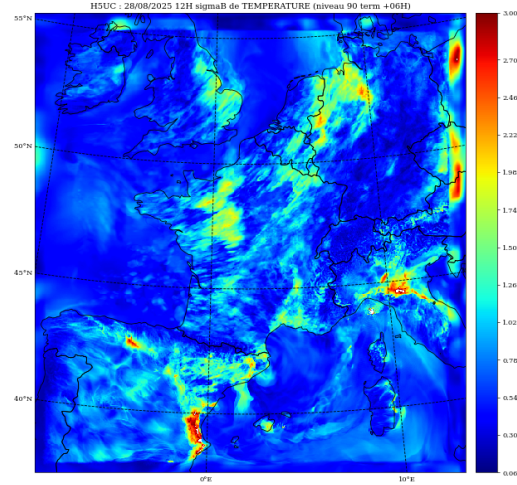
$$\sigma_{wind}^b = \sqrt{(\sigma_u^b)^2 + (\sigma_v^b)^2}$$

# Sigmatb of 6-hour forecasts for temperature and specific humidity 20250828T12 level 90

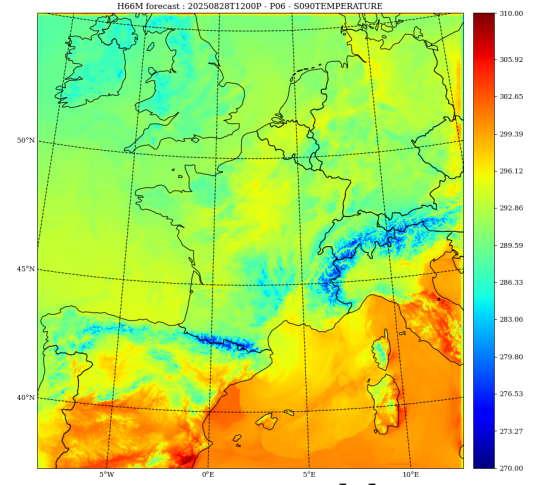
Temperature



NoRPP sigmaB



RPPall sigmaB

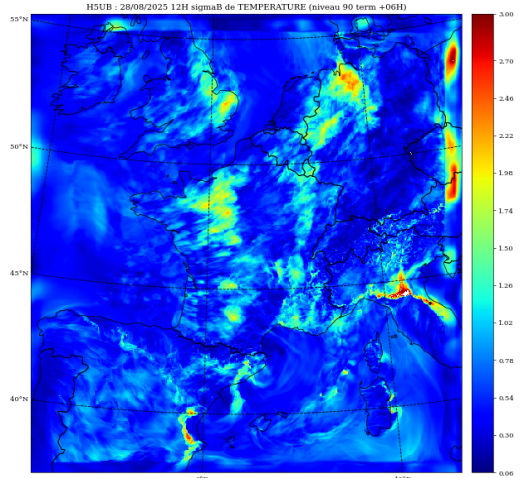


Deterministic model state

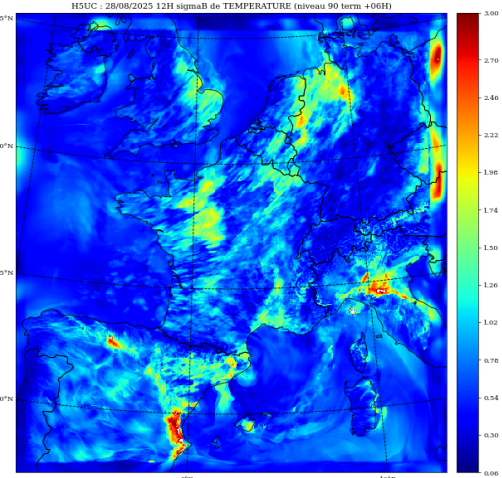
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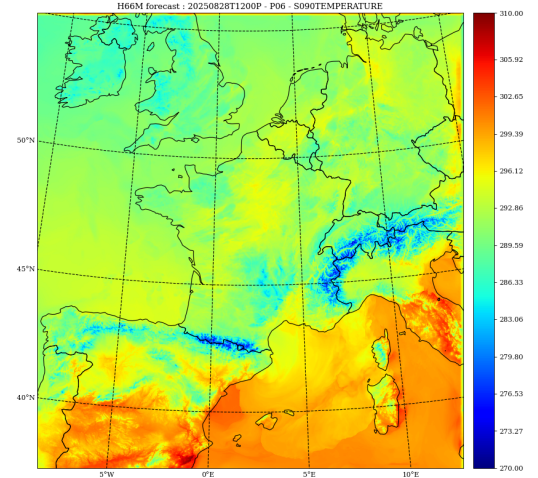
Temperature



NoRPP sigmaB

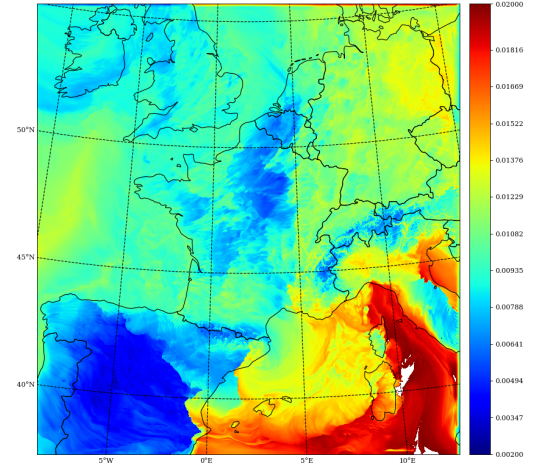
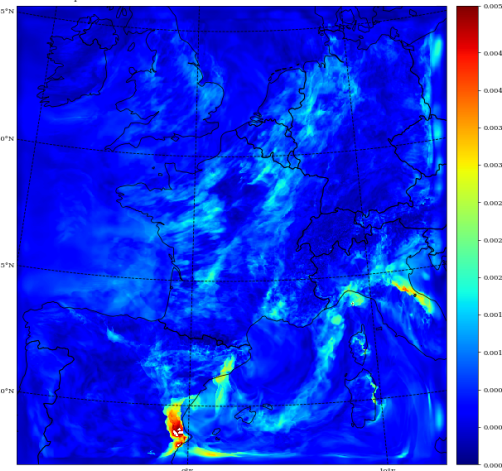
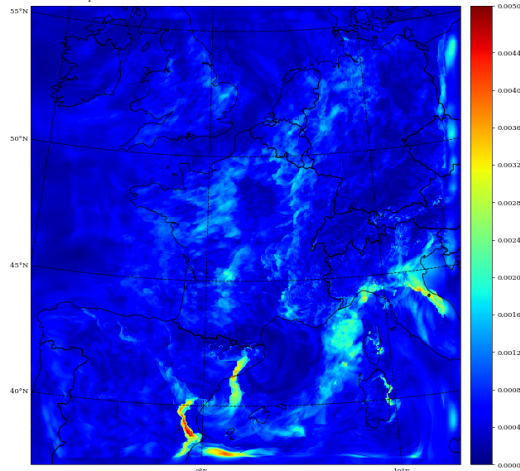


RPPall sigmaB



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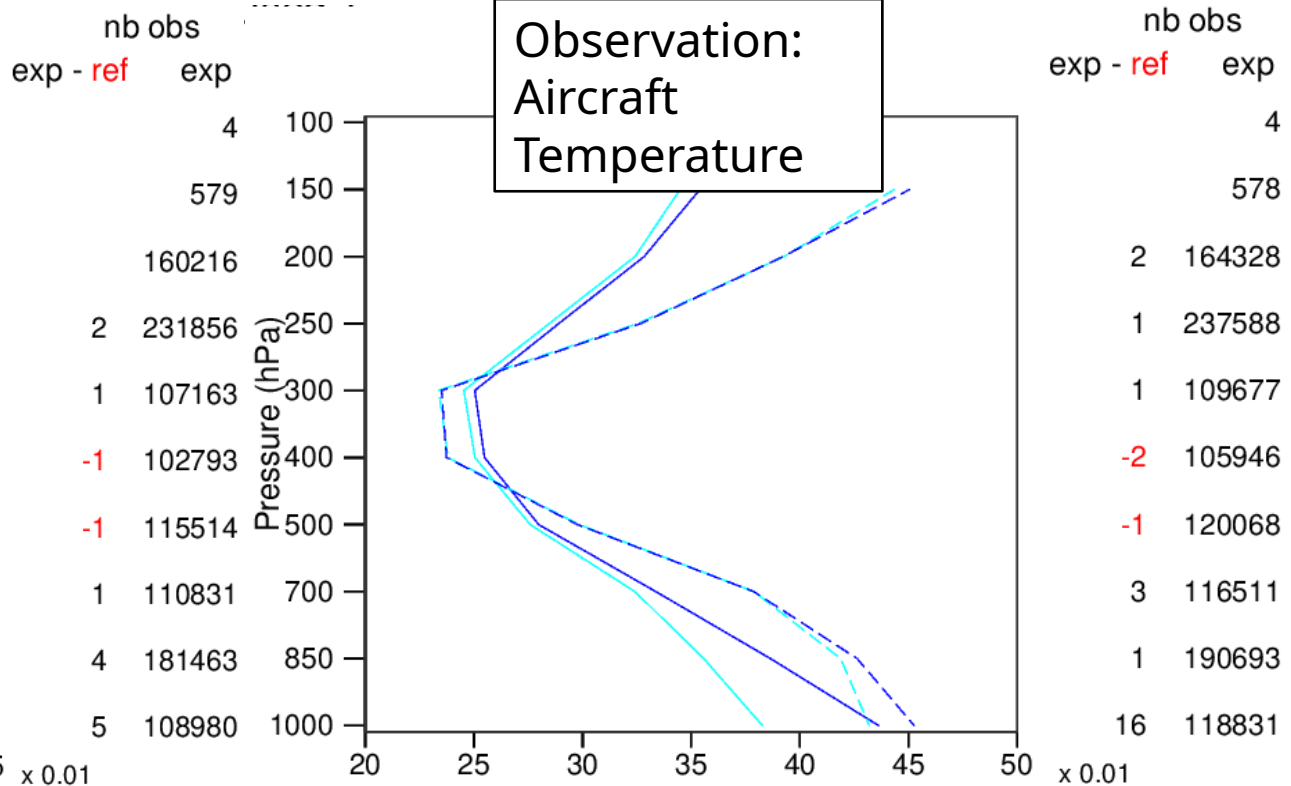
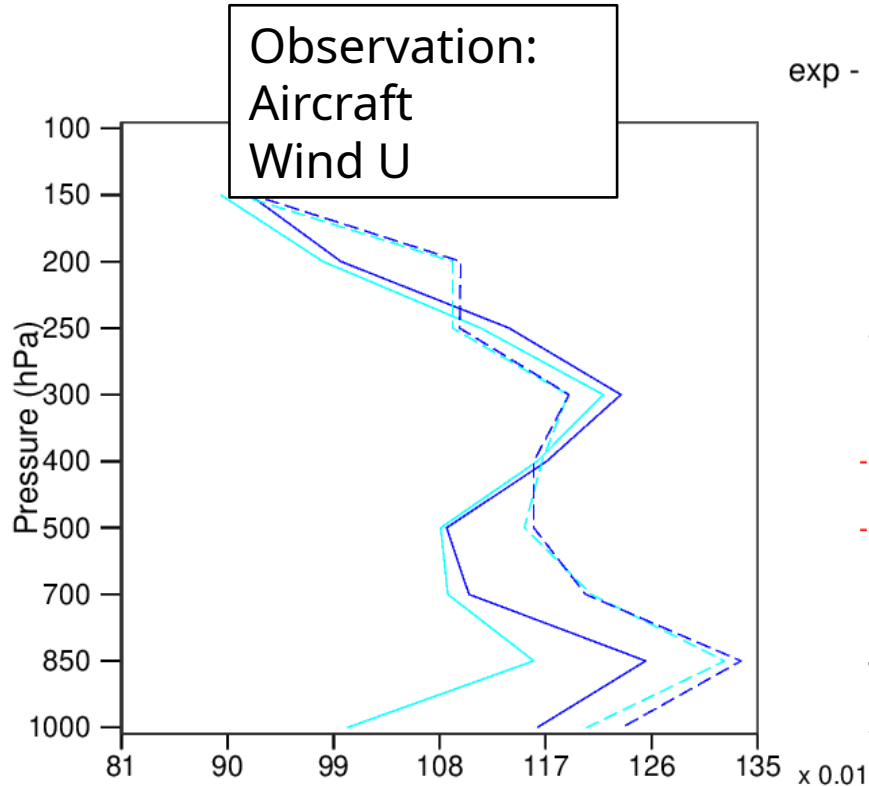
Specific humidity



## Comparison with Desroziers diagnostics

"Validation" of ensemble spread from 50-member EDA experiments :  
 in RPP-EDA (dark blue), ensemble spread (full line) is more consistent with the diagnosed background error (dashed line) than in NoRPP-EDA (cyan).

- bkg\_error (NoRPP50)
- - - Est bkg std err (NoRPP50)
- bkg\_error (RPPall50)
- - - Est bkg std err (RPPall50)



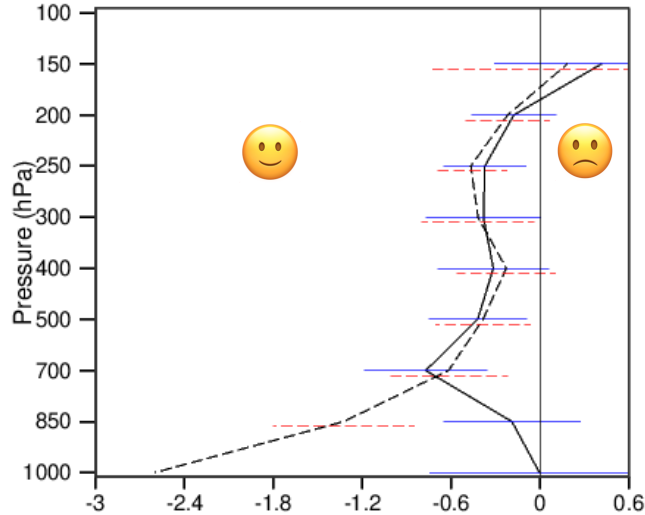
# Impact of RPP-EDA covariances on AROME deterministic run (DA and forecasts)

- Simulation period: 24/08/2025 – 26/09/2025
- All experiments (AROME-EDA and AROME-France) are based on cy49
- AROME-EDA :
  - 50 members
  - NoRPP = reference
  - RPPall = reference+RPP, perturbing all schemes
- AROME-France :
  - NoRPPcov = 4DEnVar deterministic experiment that uses B from NoRPP EDA
  - RPPcov = 4DEnVar deterministic experiment that uses B from RPPall EDA

# RPPcov : impact on the assimilation cycle

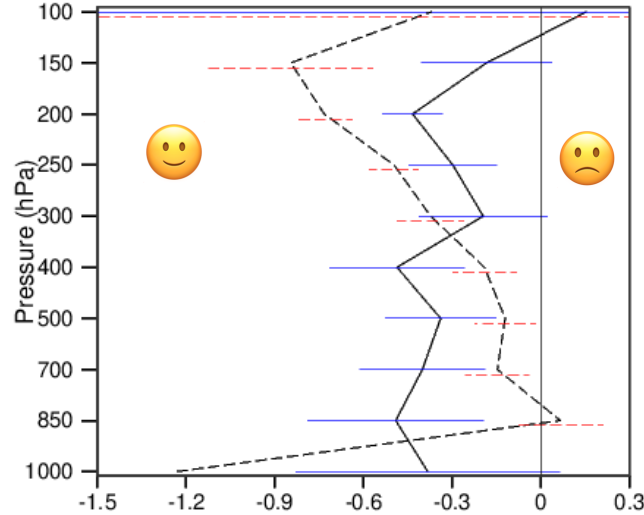
AIREP-T N.Hemis  
Used T

RMS (diff %)



MODES-Uwind N.Hemis  
Used U

RMS (diff %)

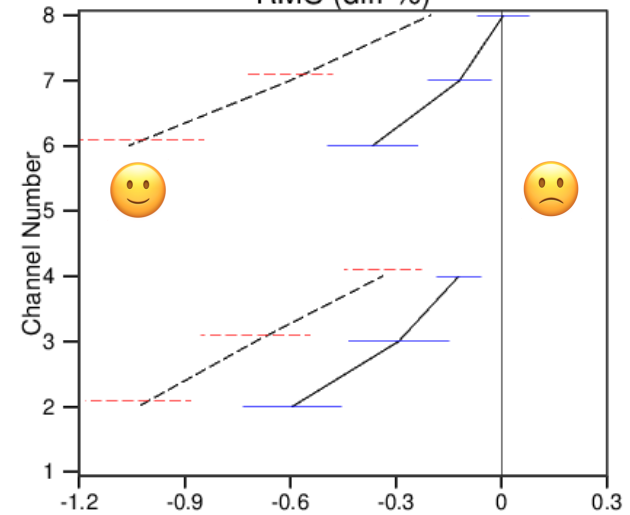


Tb SEVIRI HR Met10

Used Tb

instr 5529,instr 5629,instr 5729,instr 5829...

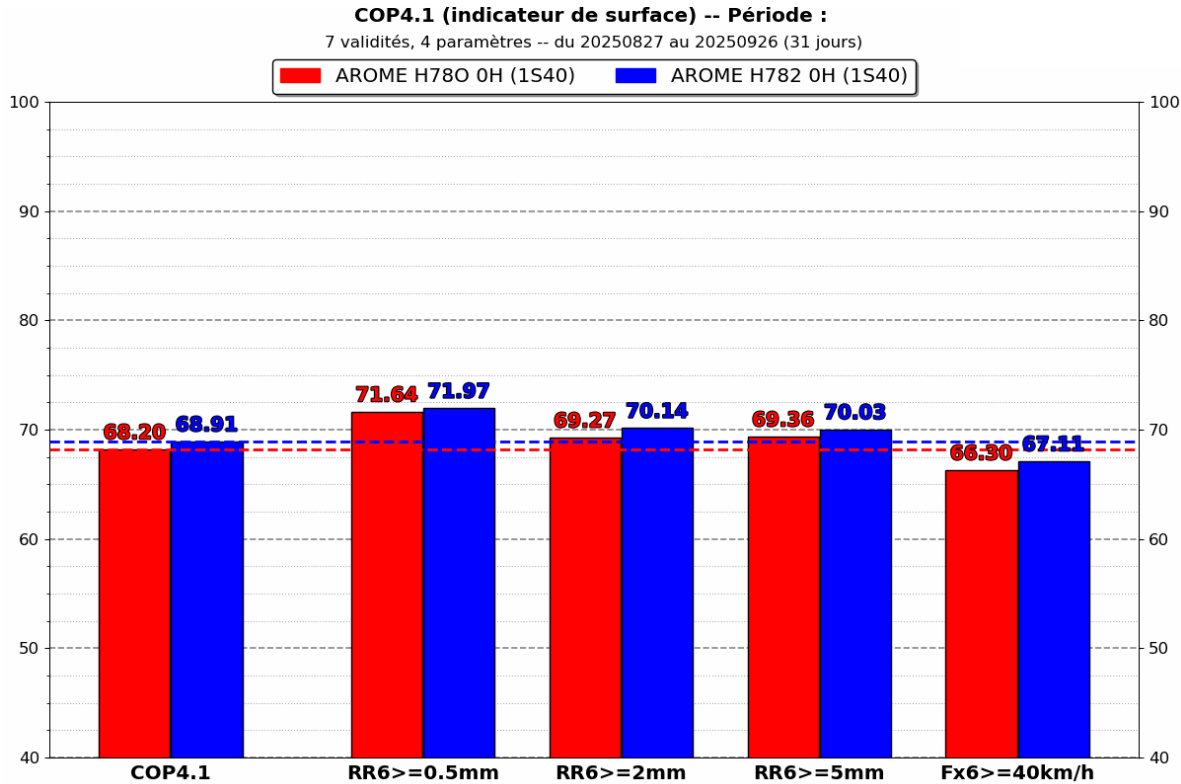
RMS (diff %)



Relative difference (%) of RMS of background departures for aircraft temperature, mode-S winds and SEVIRI channels for RPPcov experiment (ref = NoRPPcov)

- Slight positive impact on obs-guess for all obstypes,
- Increased analysis fit to observations.

# RPPcov : impact on precipitations



- Slight positive impact on 6-hour accumulations and wind gusts.

## Conclusion

- Conclusions :
  - The RPP scheme increases ensemble spread, primarily in the boundary layer and in areas of strong gradients,
  - This increase is mainly due to the perturbation of the turbulence scheme, while the contribution of other physical parameterizations is very modest,
  - The ensemble spread with RPP shows better consistency with the Desroziers diagnostic compared to the reference ensemble,
  - Impact on the DA cycle of the deterministic is slightly positive,
  - Impact on forecast scores rather neutral,
  - Numerical instabilities are primarily due to the XCMF parameter.
- Future Work :
  - Modify the list and ranges of perturbed parameters,
  - Investigate other time periods, and case studies.

**Thank you for your attention !**

## References

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