



AROME-EPS

Current status and future directions

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2nd ACCORD ASW, 8 April 2022

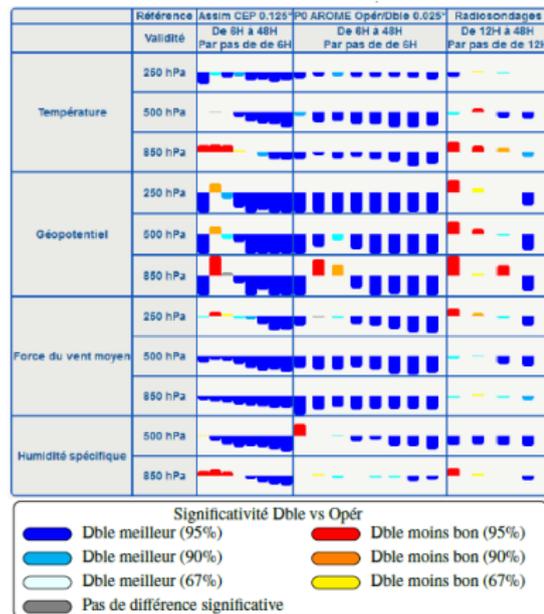


METEO FRANCE
Toujours un temps d'avance

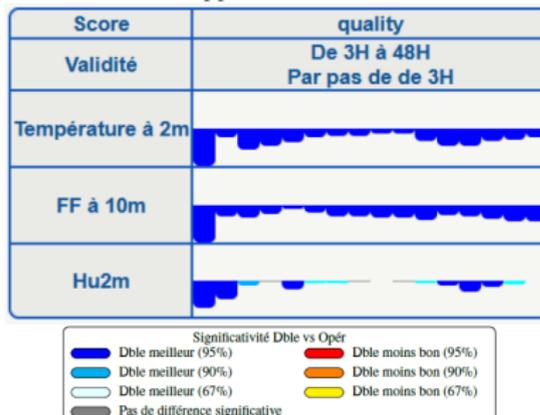
▷ Operational at Météo-France since 2016

- Based on AROME-France with a 2.5km resolution, 90 levels
- 16 perturbed members (no control run)
- 4 runs/day (03, 09, 15 et 21 UTC) up to 45/51h
- **LBCs** : subset of ARPEGE-EPS members selected with a clustering algorithm (Bouttier et Raynaud, 2018)
- **ICs** : from the AROME EDA (ens. of 3D-Vars, Raynaud *et al.*, 2016)
- **Model error** : SPPT (Bouttier *et al.*, 2012)
- **Surface conditions** : random perturbations of some variables (e.g., SST, Tground, HUGround ; Bouttier *et al.*, 2016)

- ▷ **High-resolution double suite, operational summer 2022**
 - Horizontal resolution upgrade to 1.3km, same as the deterministic forecast
 - 16 perturbed members + control run (deterministic)
 - 4 runs/day (03, 09, 15 et 21 UTC) up to 51h
 - New AROME physics (SLHD removed, ECUME v6)
 - LBCs from new ARPEGE-EPS (upgrade from 7.5km to 5km over France, new ARPEGE physics, multiphysics replaced by perturbed parameters)
 - Perturbations of ICs, model and surface conditions unchanged



(a) CRPS

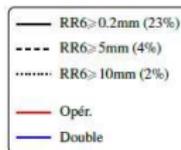
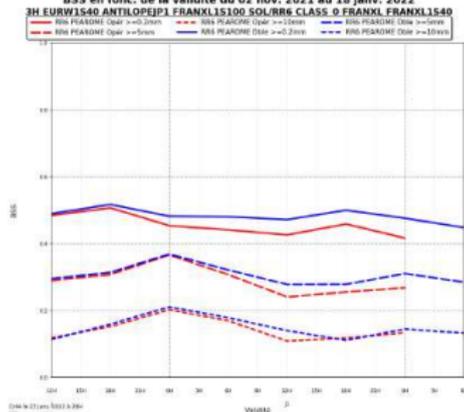


(b) RMSE

▷ Large and significant improvement for almost all variables and lead times.

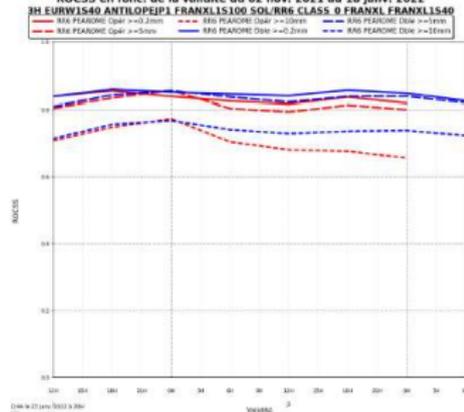
BSS RR6 vs ANTILOPEJP1 Qualité des probabilités prévues

BSS en fonc. de la validité du 02 nov. 2021 au 18 janv. 2022



ROCSS RR6 vs ANTILOPEJP1 Pouvoir discriminant (oui/non)

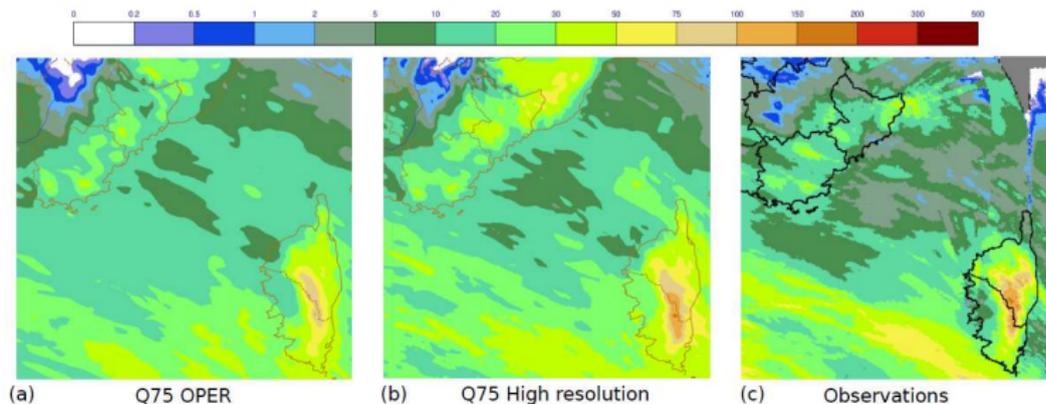
ROCSS en fonc. de la validité du 02 nov. 2021 au 18 janv. 2022



▷ Large performance increase, especially at longer lead times, mainly due to improvements in the LBCs.

A case study - Heavy rainfall

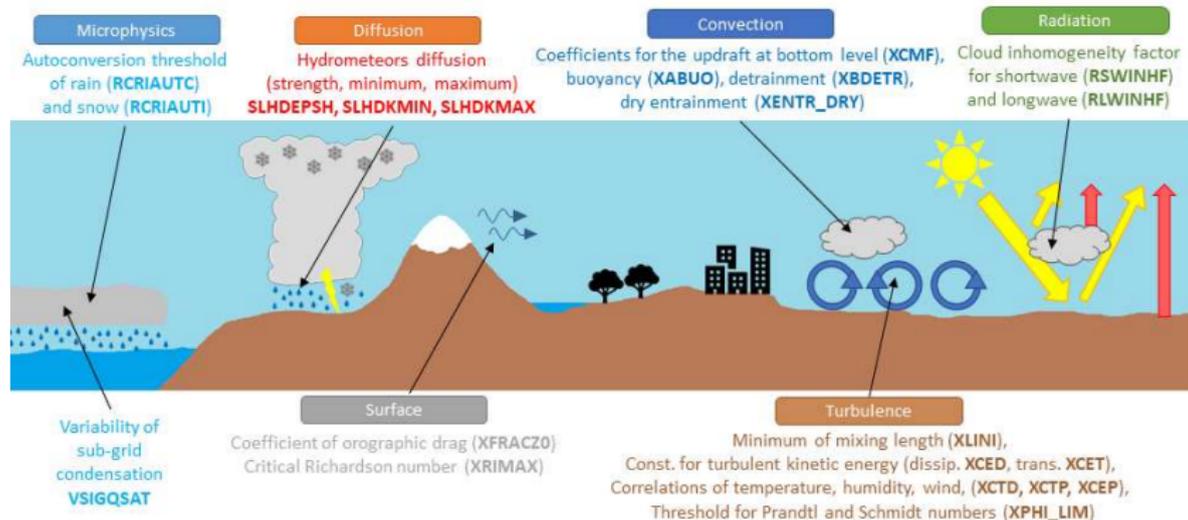
▷ 24h-accumulated precipitation on 11/11/2021



▷ Increase of rainfall with the high-resolution Arome-EPS, in better agreement with observations.

Advances on model error - Perturbed Parameters

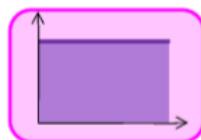
- ▷ Implementation of **Perturbed Parameters** approaches to replace or complement current SPPT
- ▷ 21 parameters involved in all parametrizations, provided by physics experts, along with variation ranges



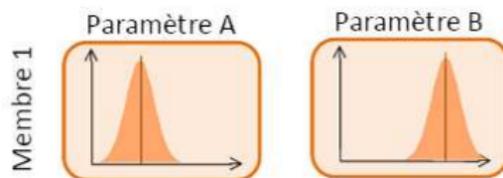
Advances on model error - Perturbed Parameters

▷ Different configurations :

- Optimized fixed perturbed parameters : best configuration among 1000 trials (B-PP)
- Random perturbed parameters from a uniform distribution (RPP)



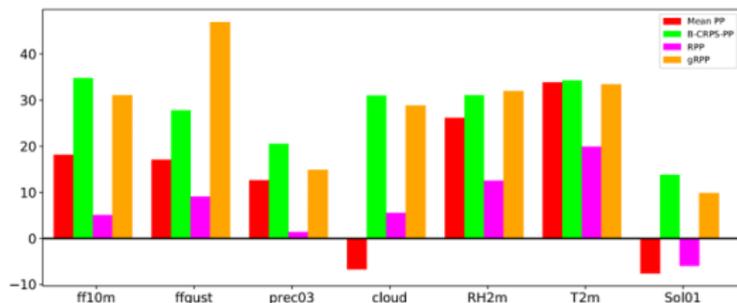
- Random perturbed parameters from a gaussian distribution centred around the optimized values (gRPP)



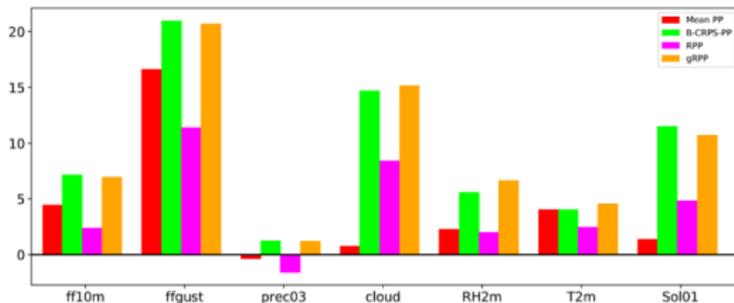
▷ No spatio-temporal perturbations.

Advances on model error - Evaluation of PP/RPP

- ▷ % improvement/degradation wrt SPPT (Arome-EPS 2.5km)
- ▷ All PP/RPPs improve the EPS performance, especially when it is optimized

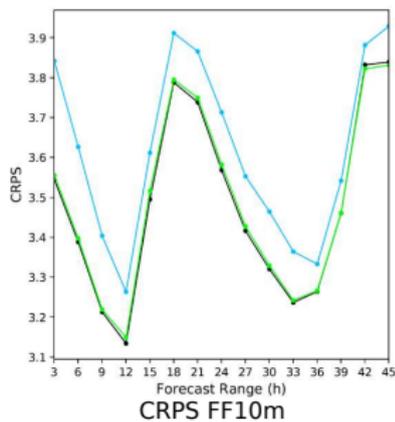
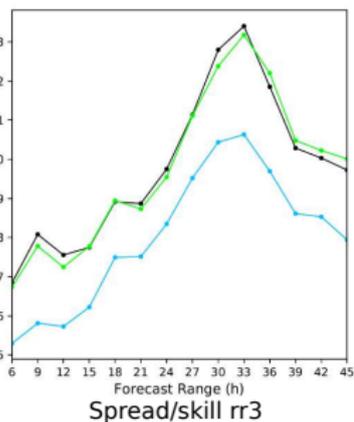
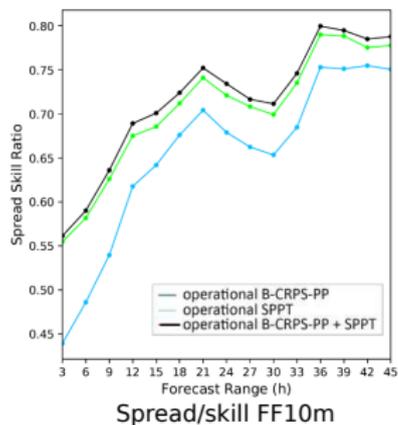


(a) Spread/skill



(b) CRPS

Advances on model error - Evaluation of PP/RPP

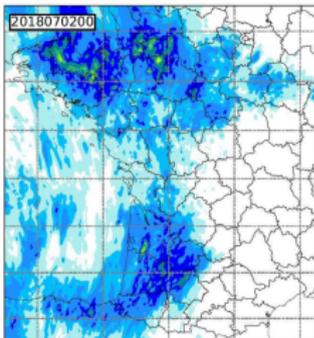


- ▷ Adding SPPT on top of PP only marginally improves the results for surface variables
- ▷ We should more deeply investigate the way the two methods create dispersion.

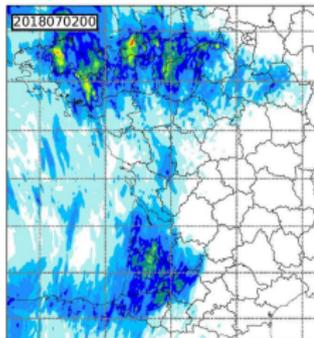
Advances on model error - A case study

- ▷ Convection over France
- ▷ Improved prediction (intensity) with PP/RPP

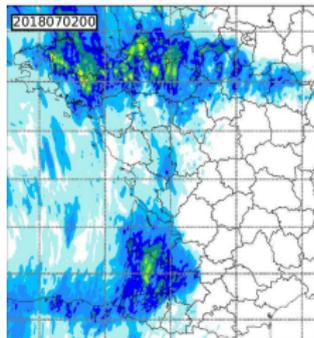
SPPT



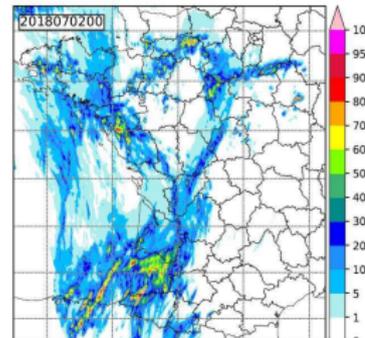
B-CRPS-PP



gRPP



Observations

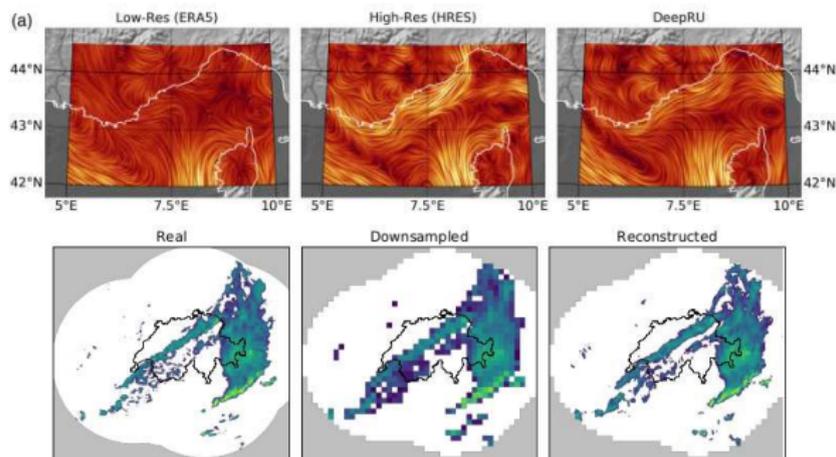


- *Future work*

- ▷ Ongoing work to test PP/RPP in the high-resolution Arome-EPS
- ▷ More diagnostics to understand differences between PP and SPPT
- ▷ Extension to SPP

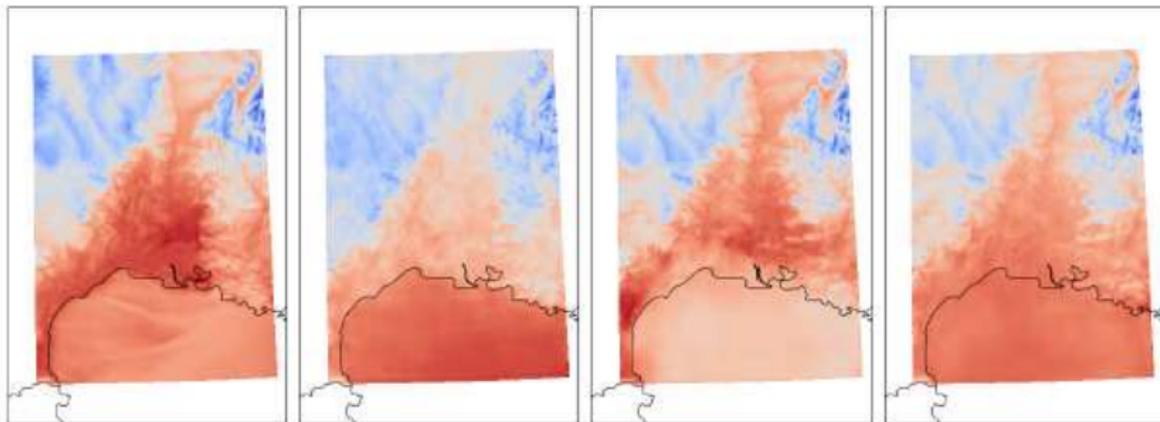
Toward very high resolutions with AI-based statistical downscaling

- ▷ Learn a relationship between coarse-scale simulations and fine-scale simulations.
- ▷ Target : Arome 500m
- ▷ Encouraging POC studies for downscaling weather/climate forecasts (e.g., Leinonen et al., 2020 ; Höhlelein et al., 2020)



Toward big ensembles with AI-based forecast generation

- ▷ Increase the NWP sampling from $O(10)$ to $O(1000)$ thanks to complementary AI-generated forecasts
- ▷ Leverage the power of **deep generative models** such as **Generative Adversarial Networks (GANs)** to create realistic forecasts.

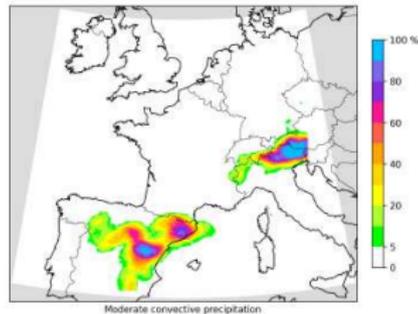
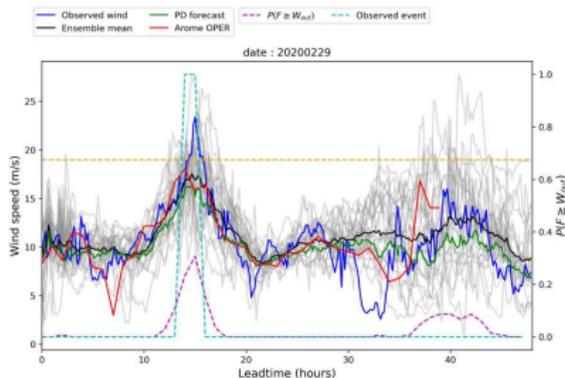


True or fake ?

Promoting EPS towards end-users

Several research projects are ongoing to use Arome-EPS in applications

- ▷ Agriculture : probabilistic forecasts of diseases and pests development
- ▷ Solar and wind energy
- ▷ Convective risk for Air Traffic Management
- ▷ Atmospheric dispersion of pollutants



Conclusions and future works

- The future high-resolution Arome-EPS leads to enhanced forecasts for almost all variables and lead times
- Perturbing parameters is a promising approach for improving Arome-EPS, but optimization is needed
- Comparison and combination with SPPT will be pursued
- Combining standard EPS design with state-of-the-art AI methods may be worth investigating to reach very high resolutions and sizes
- The added value of ensemble forecasts is currently investigated in several application domains