Convection-permitting ensemble simulations and Mediterranean HPEs

Benoît Vié[1]
Olivier Nuissier[1]
Véronique Ducrocq[1]

[1]Météo-France - CNRM

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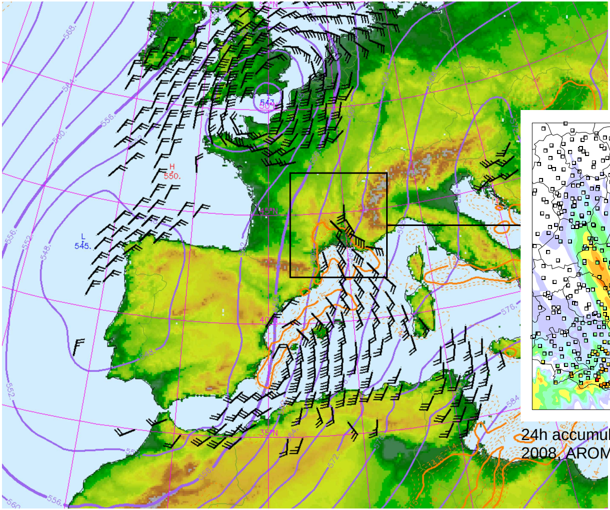
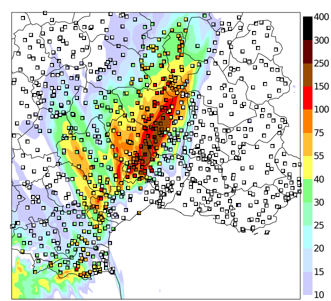
Why do we need a convection-permitting EPS?





24h accumulated precipitation, 12 UTC 2 Nov. 2008, AROME forecast and observations

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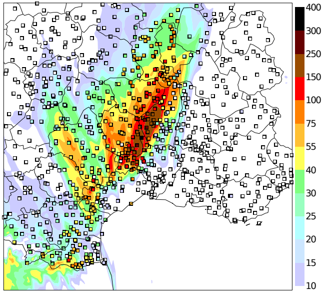
Why do we need a convection-permitting EPS?

- Convection-permitting, non-hydrostatic NWP models produce very *realistic* forecasts

- Realistic $\neq$ Real

- Runoff forecasts are very sensitive to the rainfall forecasts, especially for small and steep mountainous watersheds

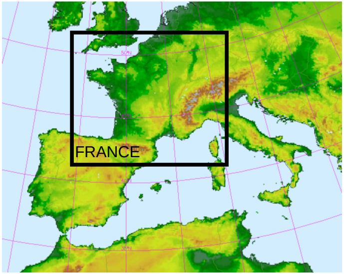
- EPSs are one method to evaluate the forecast uncertainty



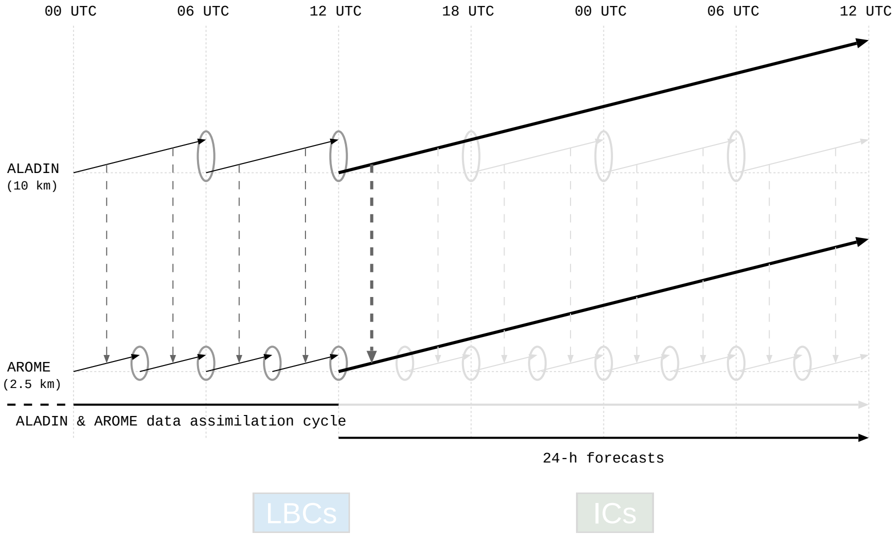
24h accumulated precipitation, 12 UTC 2 Nov. 2008, AROME forecast and observations

The AROME model (late 2008)

- Non-hydrostatic
- 2.5 km horizontal grid spacing
- 41 vertical levels
- 3D-VAR data assimilation scheme
- Bulk microphysics parameterization, 6 prognostic water variables: water vapour, cloud water, rainwater, primary ice, graupel and snow (Pinty and Jabouille, 1998, Caniaux, 1994)



AROME forecasts and uncertainty



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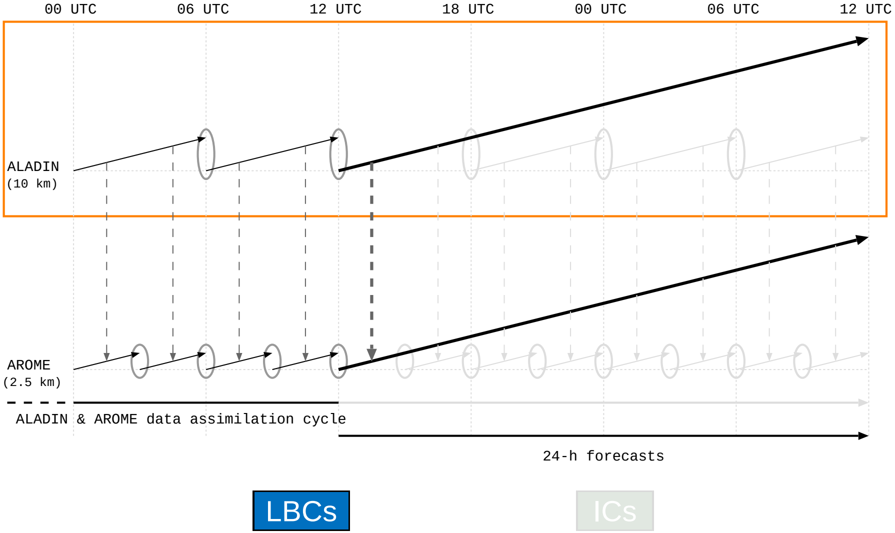

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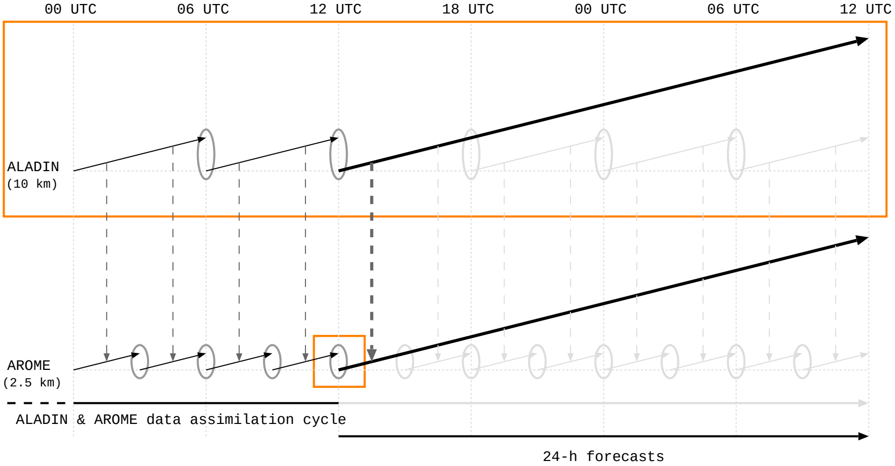

LBCs

ICs

The Ensemble experiments

AROME-PEARP

- Each AROME assimilation cycle uses LBCs from one PEARP (global, short range ensemble) member

AROME-PERTOBS

- Unique LBCs from the deterministic large scale forecast
- Each AROME assimilation cycle uses randomly perturbed observations

- The AROME-PEARP ensemble samples the uncertainty on synoptic-scale LBCs and initial conditions

The Ensemble experiments

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AROME-PERTOBS

- Unique LBCs from the deterministic large scale forecast
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- The ensemble data assimilation technique is known to sample the analysis error quite well (Berre et al., 2006)

The Ensemble experiments

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AROME-PERTOBS

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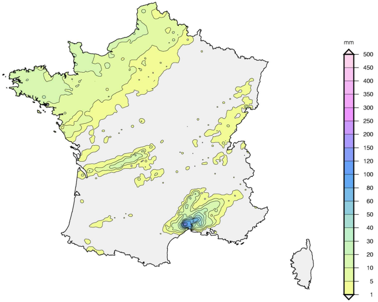
AROME-COMB

- LBCs from one PEARP member
- Assimilation of randomly perturbed observations

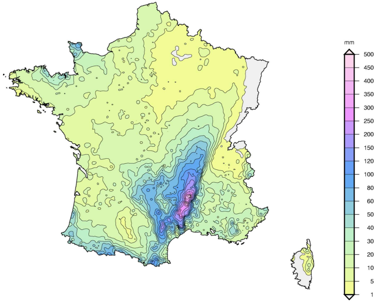
Evaluation period

31 (18) days

- 6 October 2008 -> 5 November 2008 (31 days)
- 15 October 2008 -> 1 November 2008 (18 days)



- 20 October 2008
  observed daily precipitation



- 1-2 November 2008
  observed daily precipitation

Results

Vié, B., O. Nuissier and V. Ducrocq, 2011: *Cloud-resolving ensemble simulations of Mediterranean Heavy Precipitating Events: Uncertainty on initial conditions and lateral boundary conditions*, MWR, 139:403-423

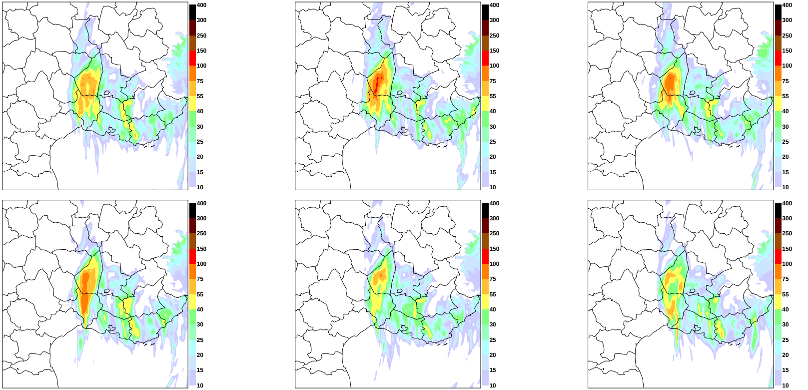
- The impact of uncertainty on LBCs rapidly overcomes the impact of uncertainty on ICs (after around 12 h in our configuration)
- The relative impact of ICs and LBCs depends on the meteorological situation
- The spread in the AROME-PEARP ensemble represents a temporal or spatial uncertainty better (it has a wider geographical extent)
- Promising precipitation scores, despite the underdispersion for low-level parameters

- The combination of both sources of uncertainty in the AROME-COMB ensemble improves the performance

Selective perturbation of observations

- Focus on important low-level parameters for the HPEs, as identified through case studies (O. Nuissier, V. Ducrocq) and idealized simulations (E. Bresson)

wind speed | humidity | temperature



00 UTC 31 Oct. 2010, 12-h accumulated precipitation, AROME forecasts

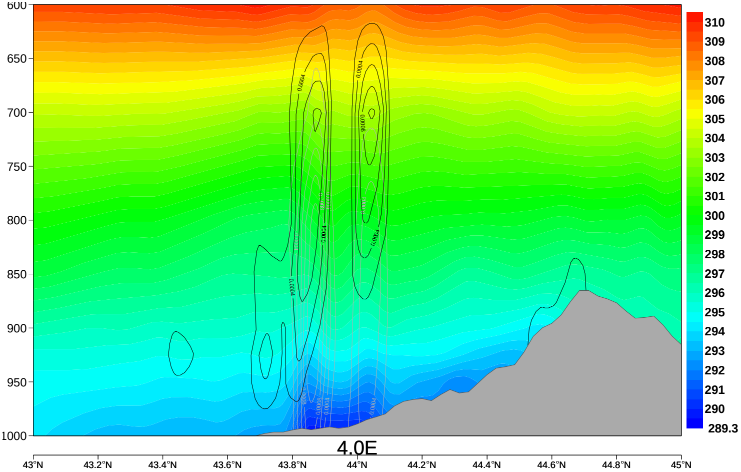
Taking model errors into consideration

With collaboration from É. Richard, S. Fresnay and A. Hally, Laboratoire d'Aérologie, Toulouse, France.

- Perturbation of 3 microphysical tendencies:
  - autoconversion
  - accretion
  - evaporation
- No effect on probabilistic scores
- For some special cases, changes both the intensity and position of the precipitating system

Taking model errors into consideration

20 Oct. 2008, 00 UTC + 12 h, θ_V (colours), CWC (black), RWC (gray)



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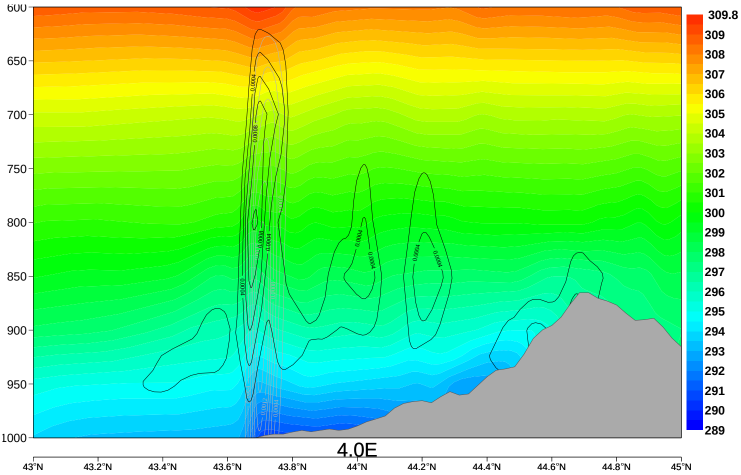
Taking model errors into consideration

20 Oct. 2008, 00 UTC + 15 h, θ_v (colours), CWC (black), RWC (gray)



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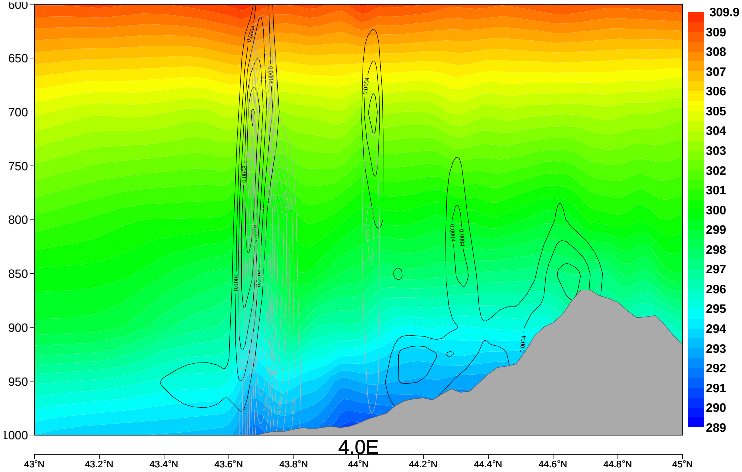
Taking model errors into consideration

20 Oct. 2008, 00 UTC + 18 h, θ_v (colours), CWC (black), RWC (gray)



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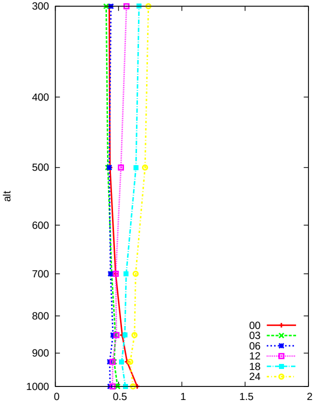
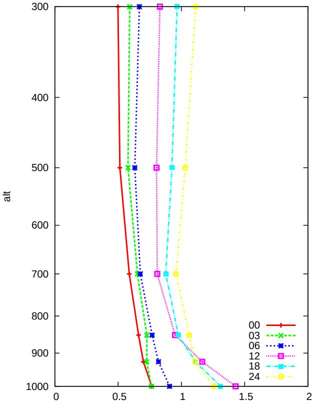
Ensemble spread

- Ensemble combining all the three sources of uncertainty
- Average over 18 days
- Vertical profiles of ensemble spread and RMSE for temperature



- Ensemble spread



- RMSE

Conclusions & prospects

Vié, B., O. Nuissier and V. Ducrocq, 2011: *Cloud-resolving ensemble simulations of Mediterranean Heavy Precipitating Events: Uncertainty on initial conditions and lateral boundary conditions*, MWR, 139:403-423

- Uncertainty on LBCs has the strongest impact on the CPM forecasts
- Focus on the predictability of HPEs or design a generic EPS?
- Better sampling of model errors (e.g. stochastic physics, F. Bouttier)
- Introducing perturbations of the low-level conditions (surface fields, orography...)
- Select a few representative members from a global ensemble (O. Nuissier)

- Perform a hydrometeorological evaluation of the ensemble forecasts within the framework of the MEDUP project, article to be submitted in NHESS (in collaboration with G. Molinié, LTHE, and B. Vincendon)
- Sept-Oct 2013: Special Observing Period of HyMeX

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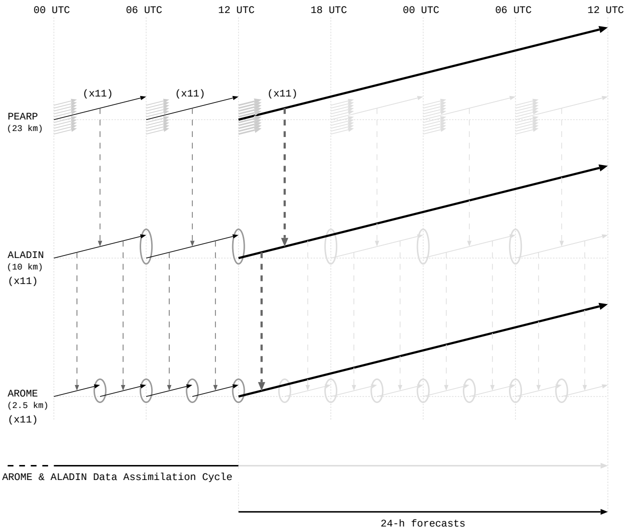
Questions ?

The AROME-PEARP experiment



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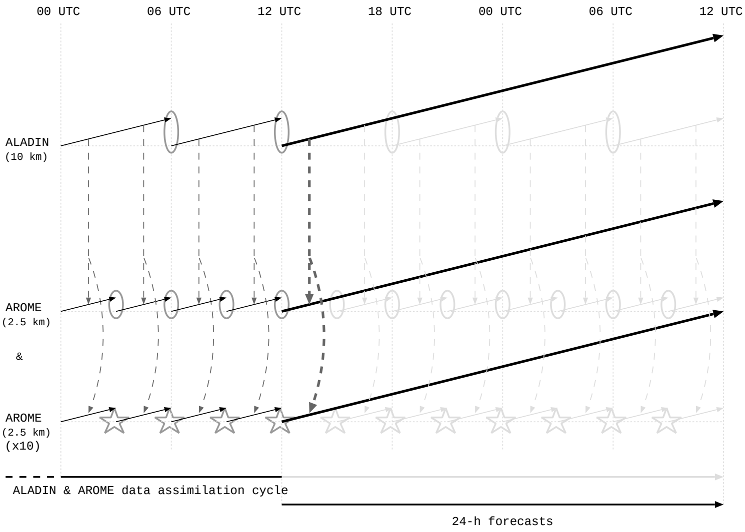
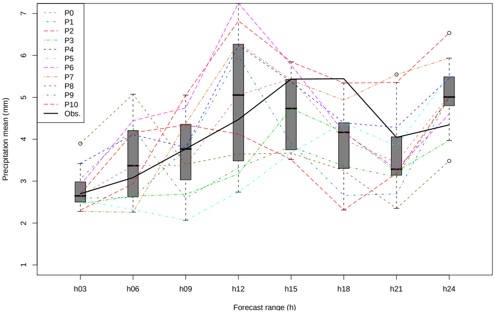
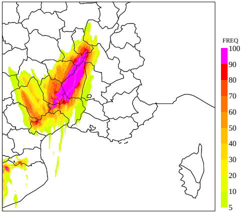
The AROME-PERTOBS experiment



Example on a case study: 1-2 Nov. 2008

AROME-PEARP | AROME-PERTOBS | AROME-COMB





RR24 $\geq$ 50 mm probability

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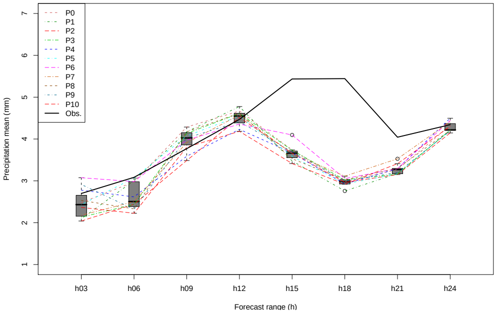

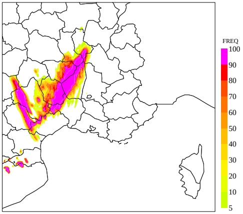

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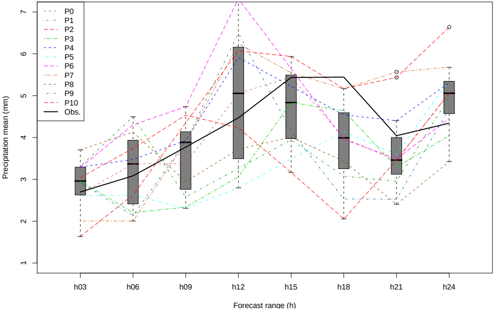

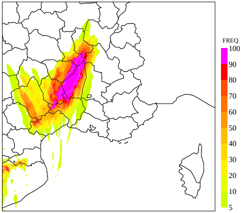

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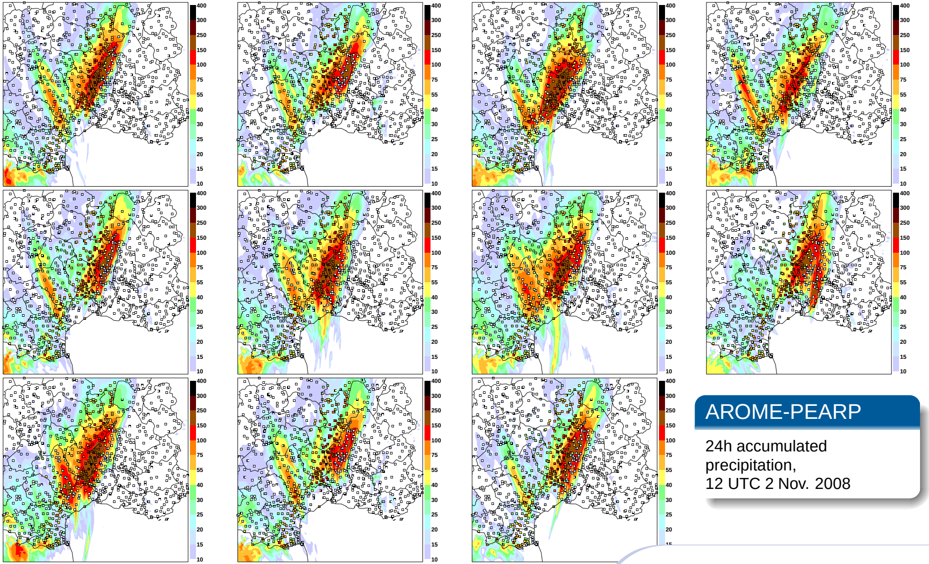
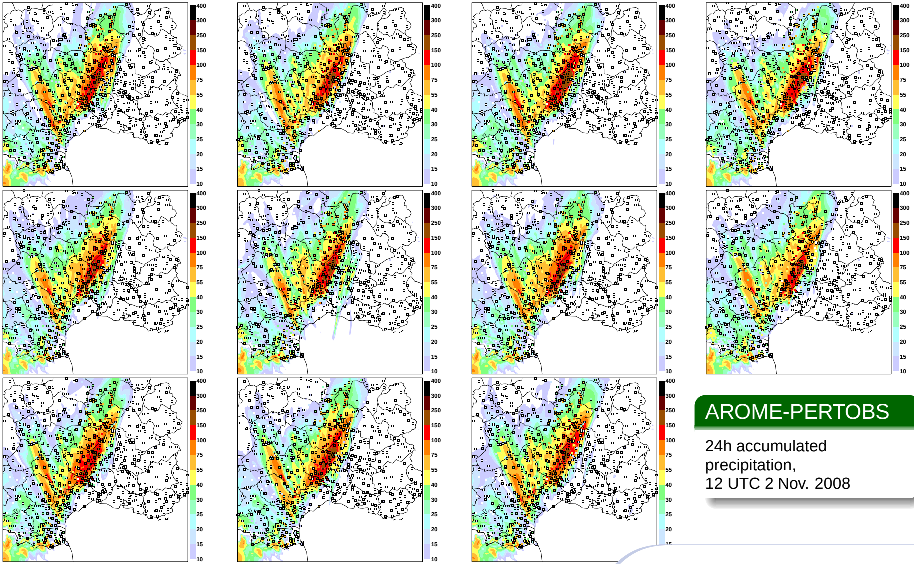


AROME-PEARP

24h accumulated precipitation,
12 UTC 2 Nov. 2008

Example on a case study: 1-2 Nov. 2008



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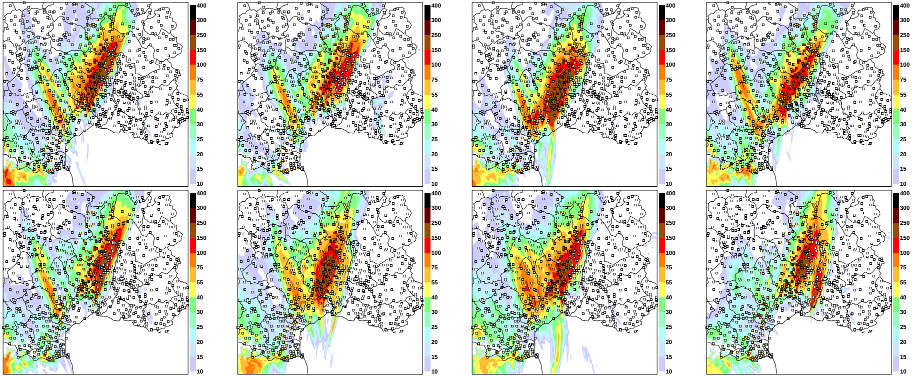

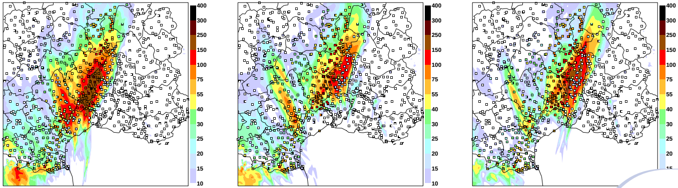

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Case study: 20 Oct. 2008

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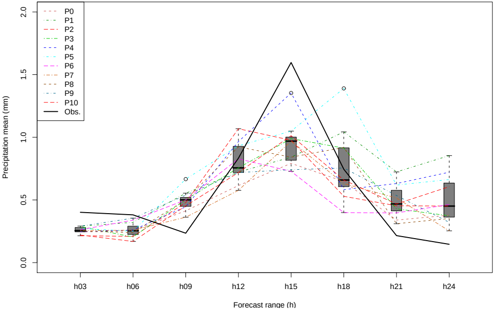

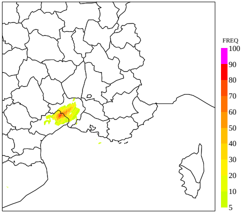

RR24 $\geq$ 50 mm probability

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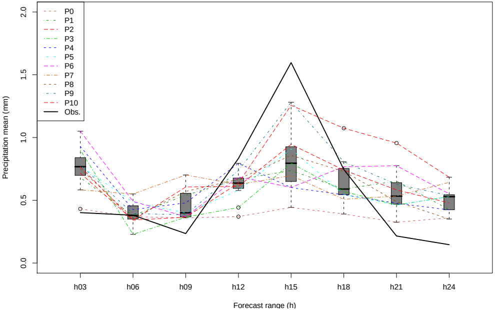

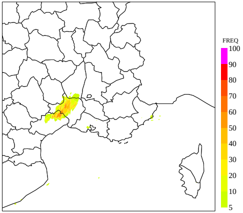

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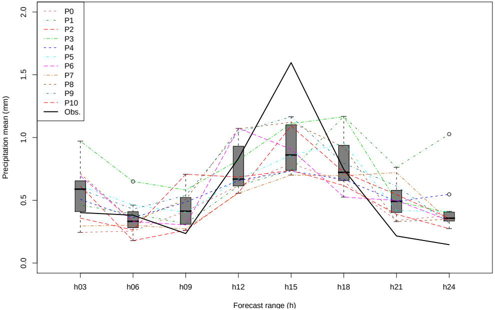
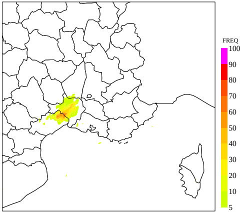
Case study: 20 Oct. 2008

AROME-PEARP AROME-PERTOBS **AROME-COMB**





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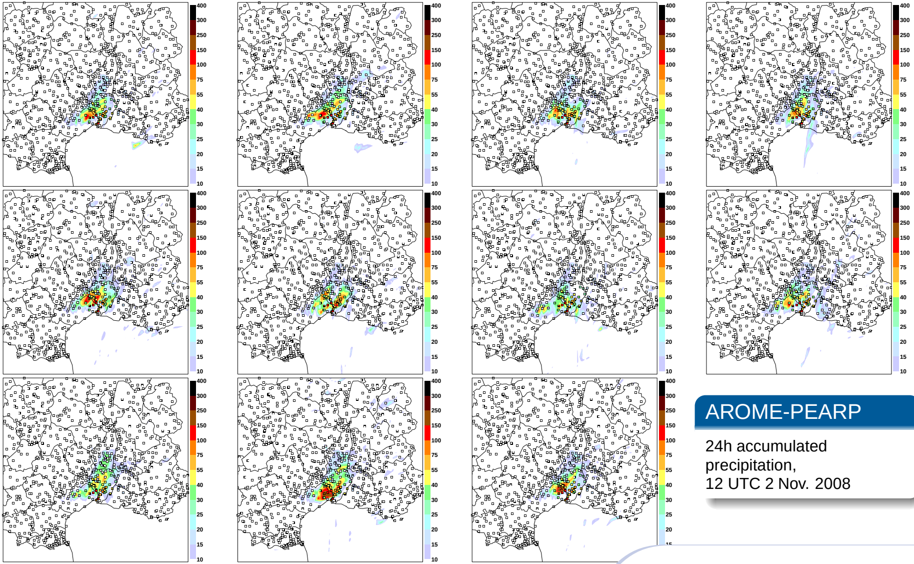

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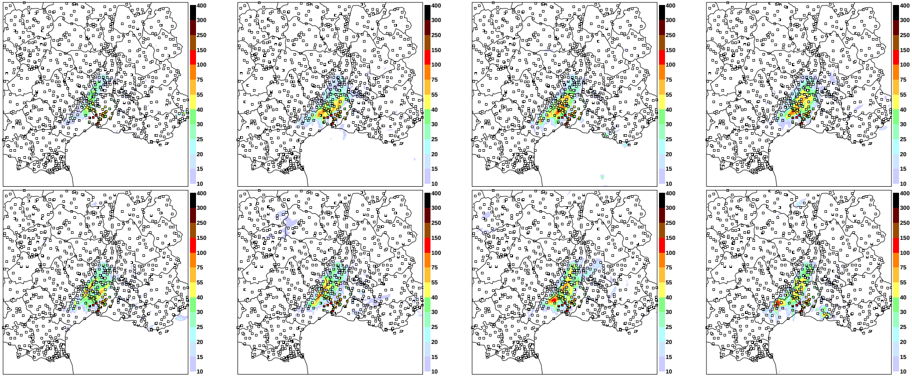

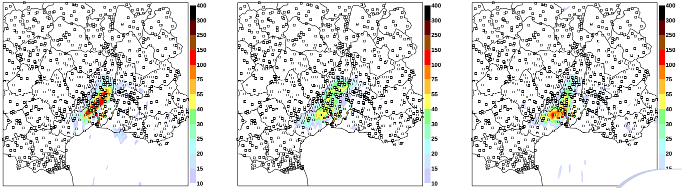

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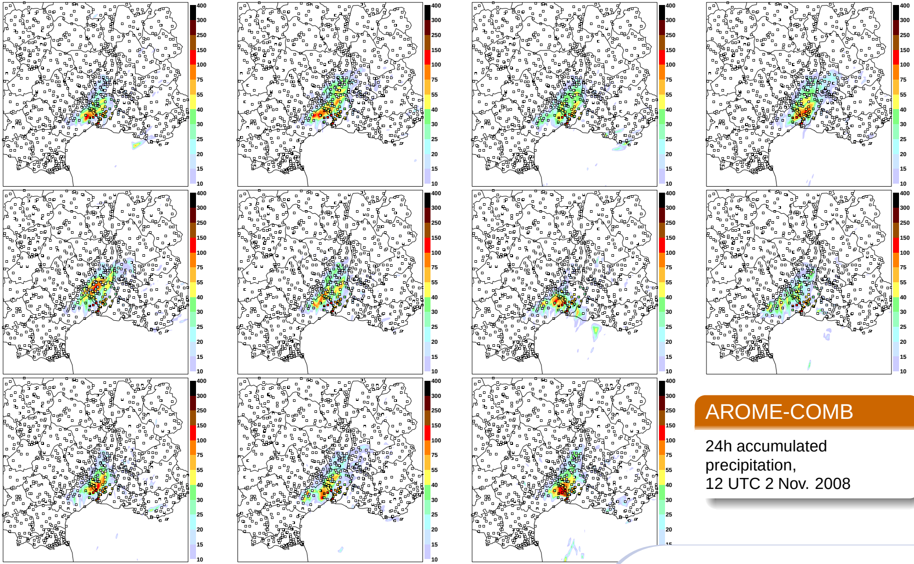

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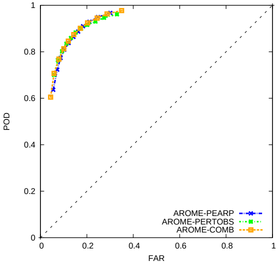
Precipitation: ROC and reliability diagram

Relative Operating Characteristics

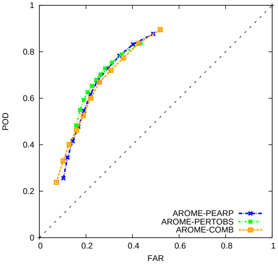
- Probability Of Detection against False Alarm Rate
- The upper the curve is, the better the resolution of the ensemble is

Reliability diagram

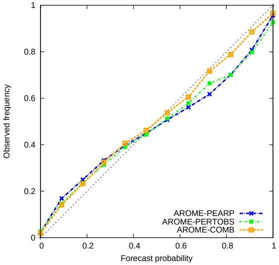
- Observed frequency against forecast probability



RR24 $\geq$ 0.5 mm



RR24 $\geq$ 10 mm



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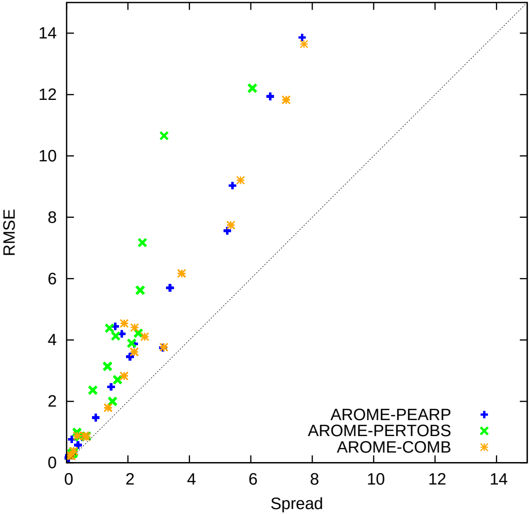
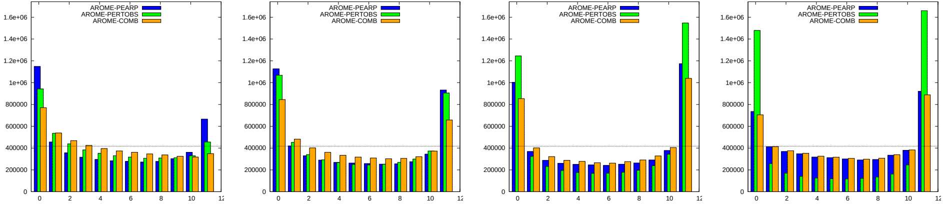
Precipitation: Ensemble spread

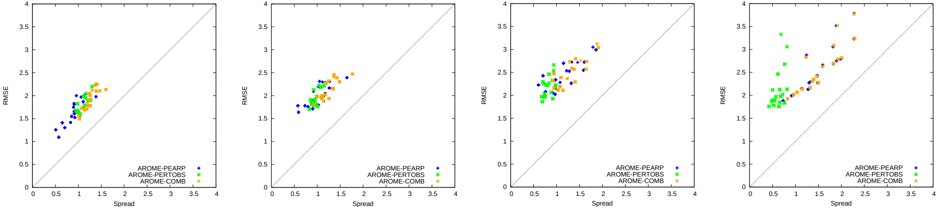


Ensemble spread for 925hPa wind speed

Rank histograms: a U-shaped histogram shows ensemble underdispersion



3h 6h 12h 24h



RMSE vs. Ensemble spread