Cloud-resolving ensemble simulations and Mediterranean HPEs

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Why do we need a cloud-resolving EPS?

24h accumulated precipitation, 12 UTC 2 Nov. 2008, AROME forecast and observations
Why do we need a cloud-resolving EPS?

- Cloud-resolving, non-hydrostatic NWP models produce very realistic forecasts
- Realistic ≠ 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

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

- 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

ALADIN
(10 km)

AROME
(2.5 km)

ALADIN & AROME data assimilation cycle

LBCs

ICs

24-h forecasts
AROME forecasts and uncertainty

ALADIN (10 km) vs AROME (2.5 km)

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24-h forecasts

LBCs

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AROME forecasts and uncertainty

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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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- 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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Evaluation periods

31 (18) days

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

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

AROME-COMB
24h accumulated precipitation, 12 UTC 2 Nov. 2008

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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

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Precipitation: Ensemble spread

![Graph showing precipitation ensemble spread](image)
Ensemble spread for 925hPa wind speed

Rank histograms: a U-shaped histogram shows ensemble underdispersion

RMSE vs. Ensemble spread
Conclusions

Impact of uncertainty on LBCs and ICs

- **ICs**: short forecast ranges
- **LBCs**: grows with lead time, rapidly overcomes the uncertainty on ICs
- **ICs** and **LBCs**: depends on the atmospheric state

Ensemble evaluation

- Promising precipitation scores
- Underdispersive ensembles, especially for low-level parameters to which the HPEs are very sensitive.
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Prospects

LBCs
- How to select a few relevant forecasts from a global EPS?

ICs: perturbed observations method
- What happens where few observations are available?

What else?
- Model errors have to be investigated.
- Other ensemble generation techniques (ETKF...)
- Huge computing time and data volumes!
  a testbed for our cloud resolving EPS
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- The END -
The AROME-PEARP experiment

AROME & ALADIN Data Assimilation Cycle

24-h forecasts
The AROME-PERTOBS experiment
Example on a case study: 1-2 Nov. 2008

AROME-PEARP  AROME-PERTOBS  AROME-COMB

Forecast range (h)

RR24 ≥ 50 mm probability
Example on a case study: 1-2 Nov. 2008

AROME-PEARP  AROME-PERTOBS  AROME-COMB

Forecast range (h) vs Precipitation mean (mm)

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AROME-PEARP | AROME-PERTOBS | AROME-COMB

Forecast range (h)

Precipitation mean (mm)

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Obs.

P0
P1
P2
P3
P4
P5
P6
P7
P8
P9
P10
Case study: 20 Oct. 2008

AROME-PEARP  AROME-PERTOBS  AROME-COMB

![Graph showing precipitation mean (mm) over forecast range (h)]

**Forecast range (h)**

**Precipitation mean (mm)**

- P0
- P1
- P2
- P3
- P4
- P5
- P6
- P7
- P8
- P9
- P10
- Obs.

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FREQ

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Precipitation mean (mm)
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