Toward convection-permitting EPS

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Outline

1. Current set-up
2. Thunderstorm cases
3. Future plans

Current set-up

- AROME and ALARO models (both at 2.5km) are coupled to ECMWF ENS.
- 22 limited area ensemble members:
  10+1 from ALARO and 10+1 from AROME
  (cy38h1.1, both with SURFEX).
- Forecast range: 36 hours (at 00 and 12 UTC).
- Surface assimilation cycle (CANARI) + 3DVar upper-air data assimilation for control members.

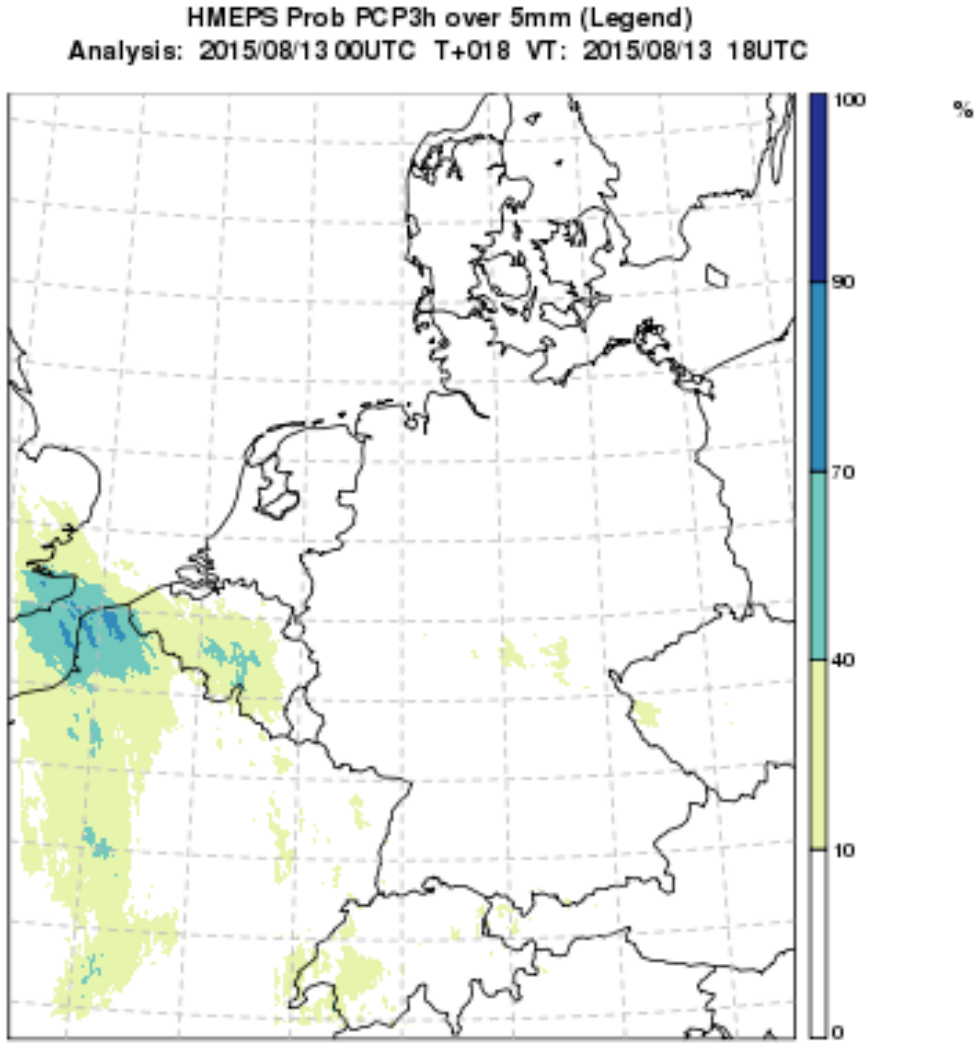

Figure: Probability plot HMEPS: 3h accumulated precipitation ($> 5mm$), forecast of 20150813 (00h UTC run) over full domain.

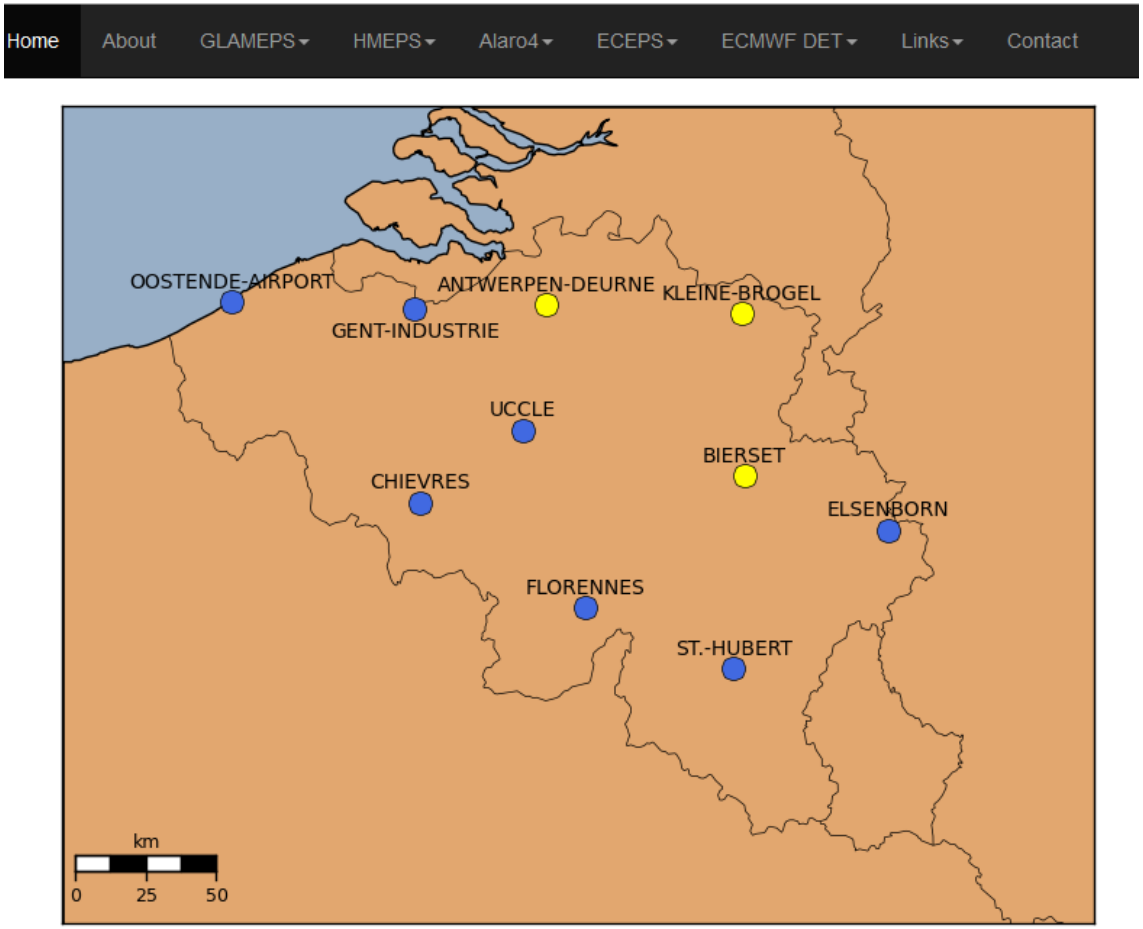

Figure: INDRA alert map for HMEPS: 6h accumulated precipitation forecast of 20150813 (00h UTC run).

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HMEPS Precipitation forecast (3 hour accumulation)

Latest forecast: 2015-08-13 00:00 UTC

Ensemble mean precipitation

HMEPS forecast of 13/08 00:00:

Stations / Forecast	13/08 03:00	13/08 06:00	13/08 09:00	13/08 12:00	13/08 15:00	13/08 18:00	13/08 21:00	14/08 00:00
Oostende-Airport	0.0	0.0	0.0	0.1	0.1	2.0	5.7	1.4
Gent-Industrie	0.0	0.0	0.0	0.0	0.0	1.0	3.7	1.3
Chievres	0.0	0.0	0.0	0.1	0.0	3.3	2.6	0.9
Uccle	0.0	0.0	0.0	0.0	0.0	4.9	2.9	1.1
Antwerpen-Deurne	0.0	0.0	0.0	0.0	0.0	1.4	6.4	4.0
Florennes	0.0	0.0	0.0	0.0	0.3	4.9	2.0	0.2
St.-Hubert	0.0	0.0	0.0	0.0	0.4	4.5	2.5	1.2
Bierset	0.0	0.0	0.0	0.0	0.0	3.5	3.2	8.5
Kleine-Brogel	0.0	0.0	0.0	0.0	0.0	0.3	3.8	7.6
Elsenborn	0.0	0.0	0.0	0.0	0.0	0.0	1.1	7.1

Click station names for detailed forecasts.

Figure: INDRA station table for HMEPS: 3h accumulated precipitation forecast of 20150813 (00h UTC run).

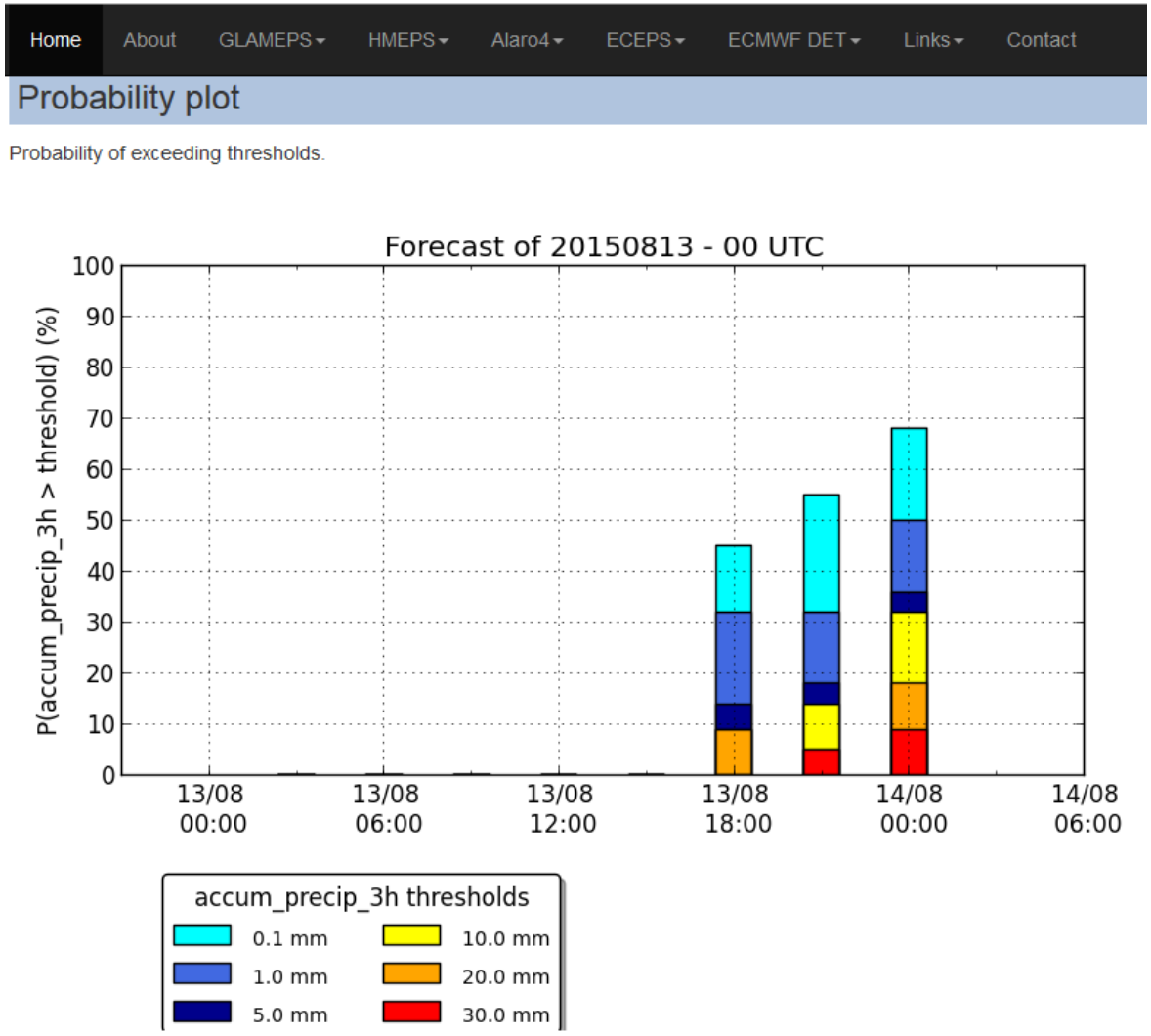

Figure: Probability plot HMEPS: 3h accumulated precipitation forecast of 20150813 (00h UTC run) for station Bierset (Belgium).

Thunderstorm cases

- Severe thunderstorms can cause a significant loss of life and property. Notable examples:
  - Pukkelpop thunderstorm of 2011 (5 deaths).
  - Pentecost storms of 2014 (several 100 million euro in damage).
- Short-range ensemble systems are being developed at convection-permitting scales (1 to 2.5 km horizontal resolution) to improve high-impact weather forecasting.

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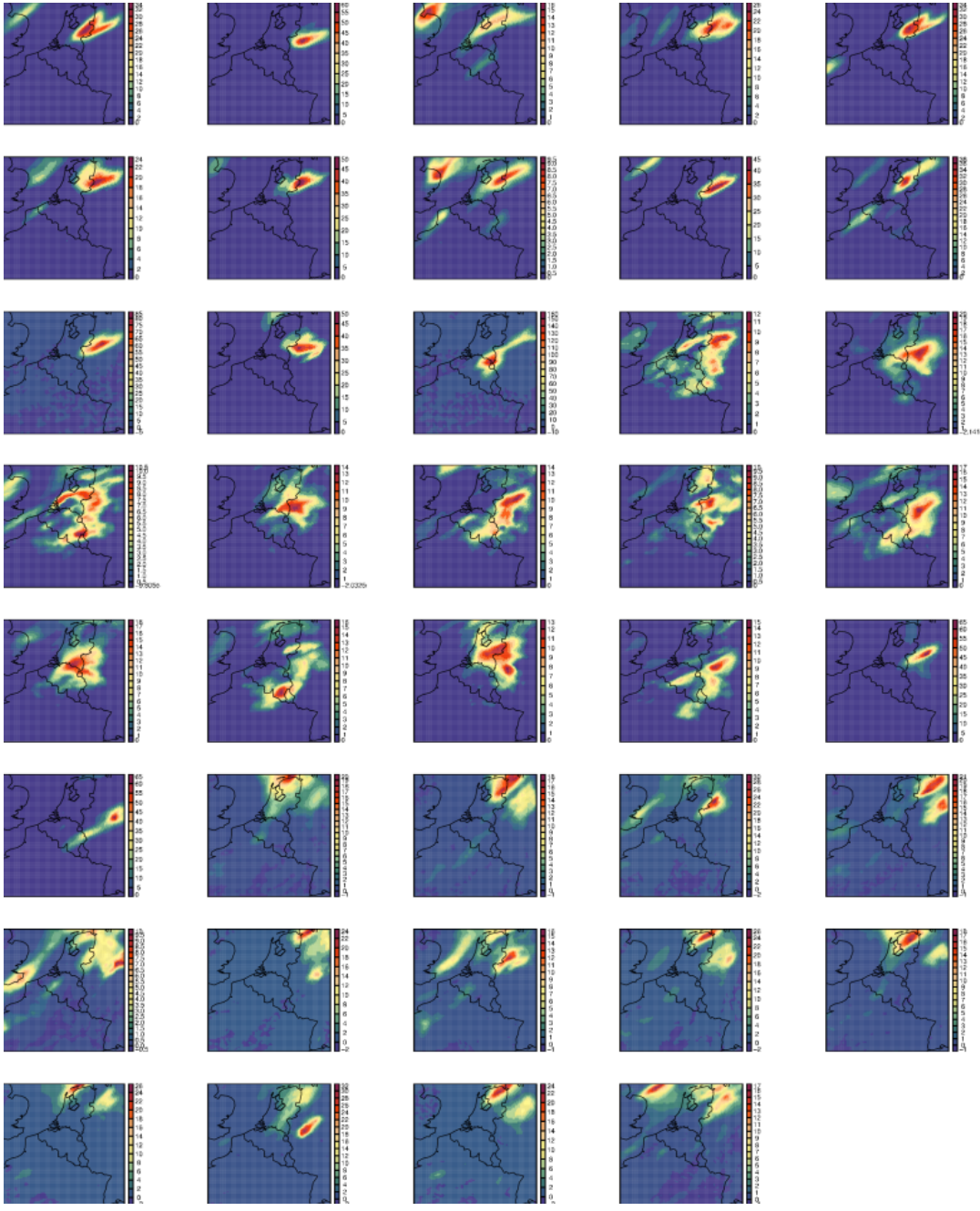
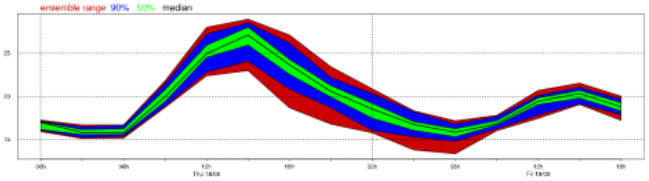


GLAMEPS-o-GRAM

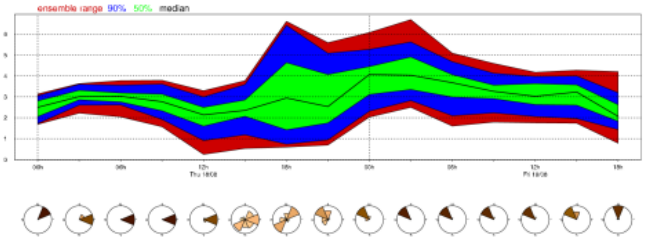
Hasselt

Forecast date: Thursday 18 August 2011, 00h UTC

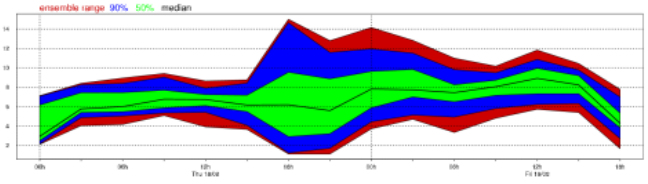
2m Temperature



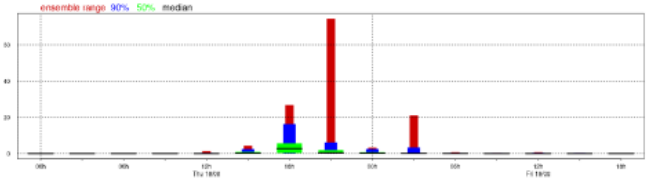
10m Wind



10m Wind Gusts



3h Precipitation



Thunderstorm cases

Pentecost

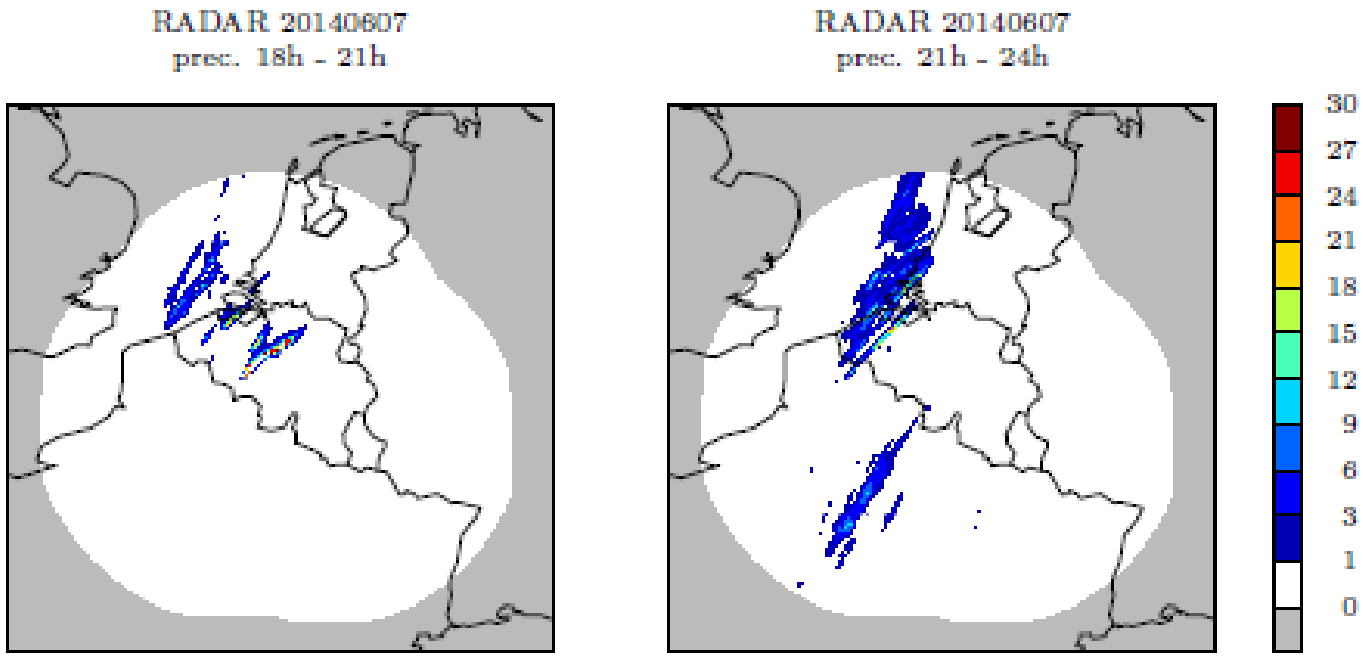


Figure: Radar images of 7 June 2014 between 18h and 24h UTC. On the left, a heavy hail event over Brussels.

Thunderstorm cases

Pentecost

- Hail event of Saturday 7 June 2014 was relatively small scale (see radar images).
- High profile event, as it occurred live on TV, during a football match of our national team in Brussels (Belgium against Tunisia).
- Most of our operational models did not predict this event.

Thunderstorm cases

Pentecost

- In the 00h UTC run of 7 June, neither GLAMEPS, the ECMWF models (deterministic and EPS), or our operational LAM model (4km ALARO coupled to ARPEGE) showed any convective activity (see next figure).

Thunderstorm cases

Pentecost

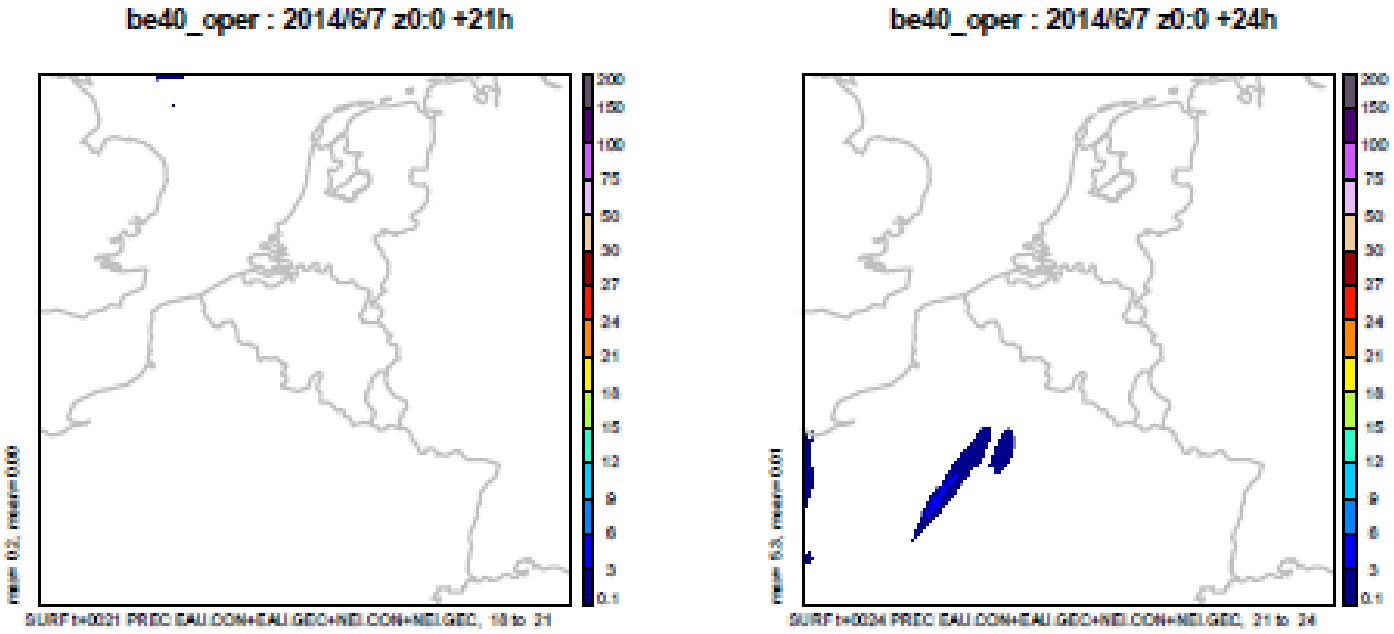


Figure: Operational Belgian LAM (4km ALARO coupled to ARPEGE). Forecast of 7 June 2014, 00h UTC. Accumulated 3-hourly precipitation for lead times +21h (left) and +24h (right).

Thunderstorm cases

Pentecost

- The 12h UTC run, did predict some convective precipitation (see next figure), but timing, position and shape differ from what was observed (respectively later, more eastwards, and more large scale).
  - Moreover, this run was only available around 17h UTC, so only 1 to 2 hours before the event happened.

Thunderstorm cases

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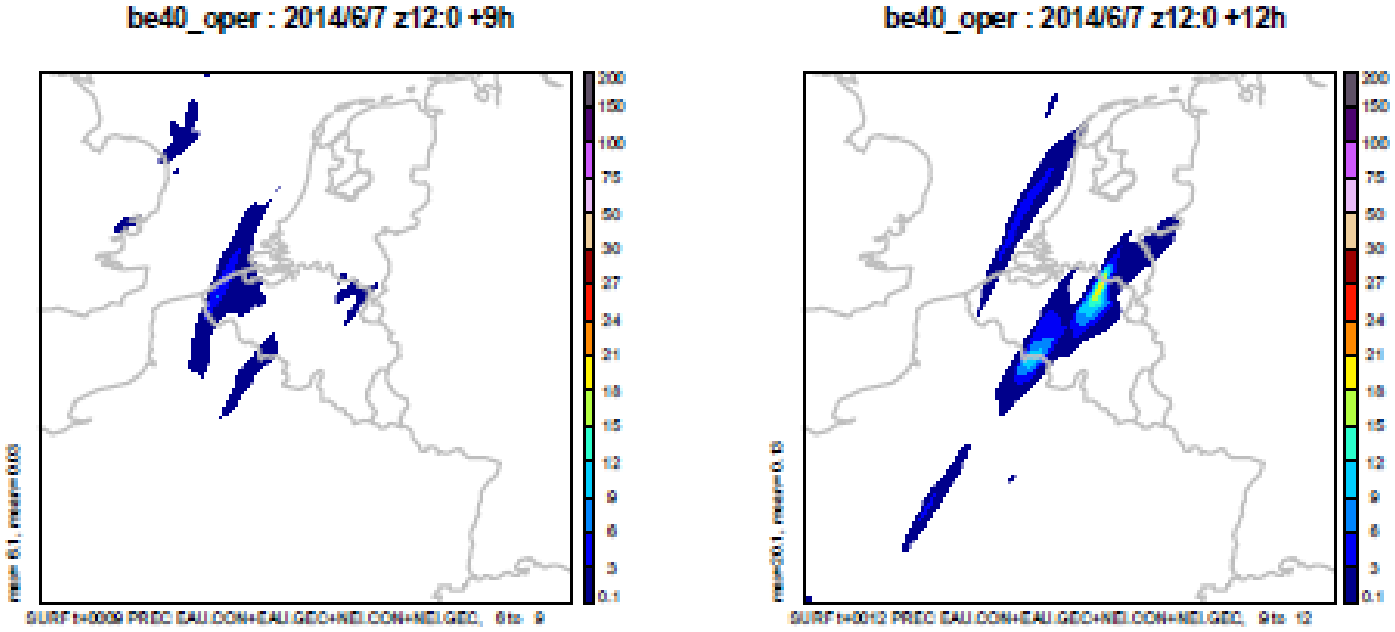

Figure: Operational Belgian LAM (4km ALARO coupled to ARPEGE). Forecast of 7 June 2014, 12h UTC. Accumulated 3-hourly precipitation for lead times +9h (left) and +12h (right).

Thunderstorm cases

Pentecost

- Experiments at convection-permitting scale, consisted of coupling one AROME member and one ALARO member (both with horizontal resolution of 2.5km) to the deterministic ECMWF model.
  - Coupling with ECMWF instead of ARPEGE does not help in this case.
  - AROME member does also not predict the event.
  - It seems 3DVAR has little influence on the forecasts of the thunderstorms, particularly precipitation.
  - Somewhat better location in general when running over a bigger domain.

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Thunderstorm cases

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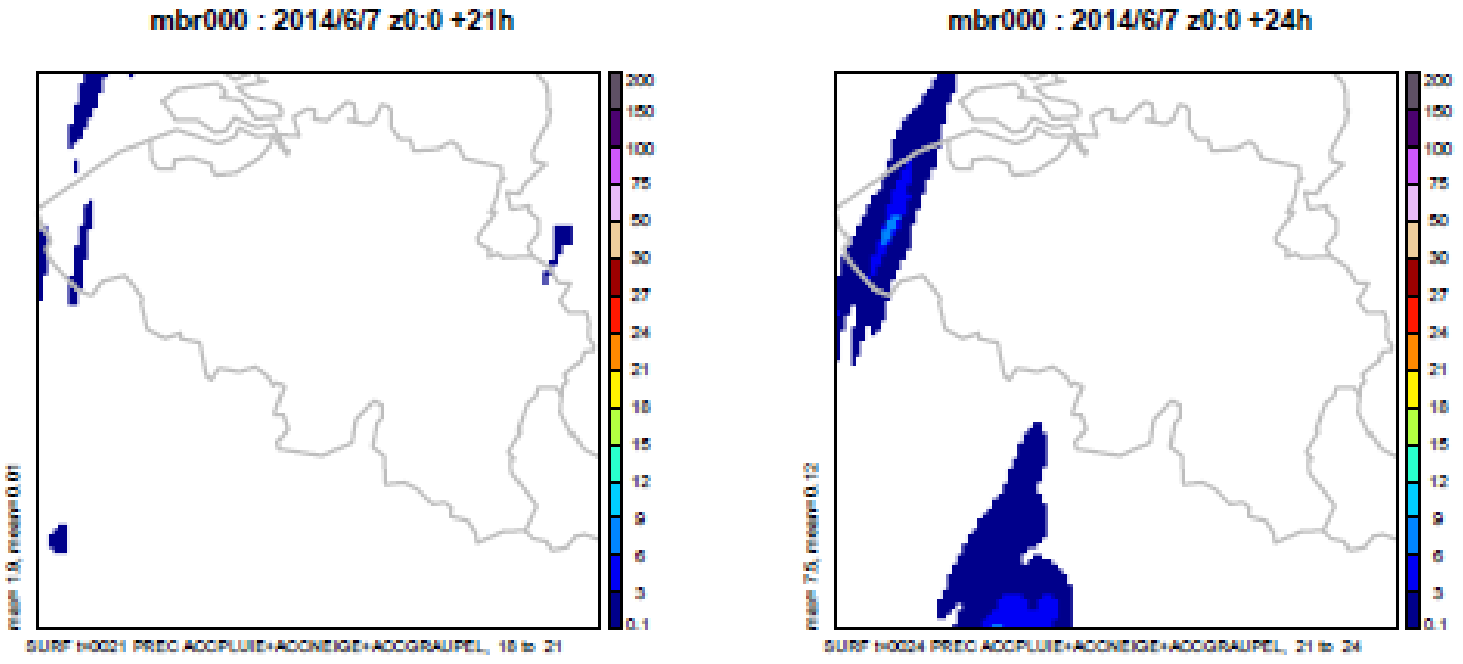

Figure: AROME member of HarmonEPS (coupled to deterministic ECMWF). Forecast of 7 June 2014, run of 00h UTC. Accumulated 3-hourly precipitation for lead time +21h (left) and +24h (right).

Thunderstorm cases

Pentecost

- Experiments at convection-permitting scale (2.5km), with ALARO-1.
  - Coupling with ARPEGE, over same domain and with same vertical levels (65L).
  - Additionally, an ensemble was created with the SLAF (Scaled Lagged Average Forecast) method.
  - In cooperation with IMGW-Poland (Bogdan Bochenek and Malgorzata Szczech-Gajewska).

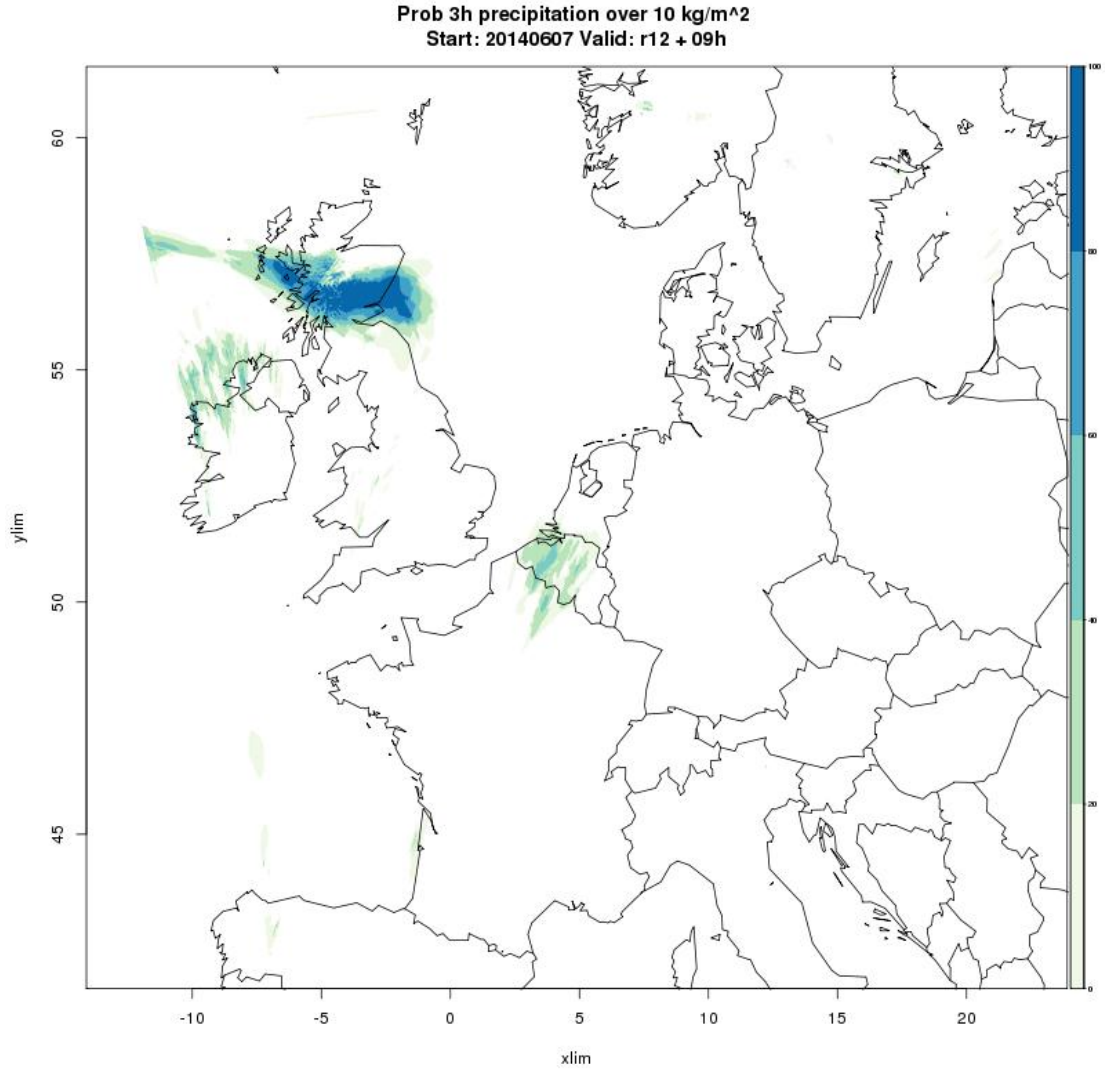

Figure: ALARO-1 coupled to ARPEGE (with SLAF). Probability of 3-hourly accumulated precipitation over 10mm. Forecast of 7 June 2014, 12h UTC run, lead time +9h.

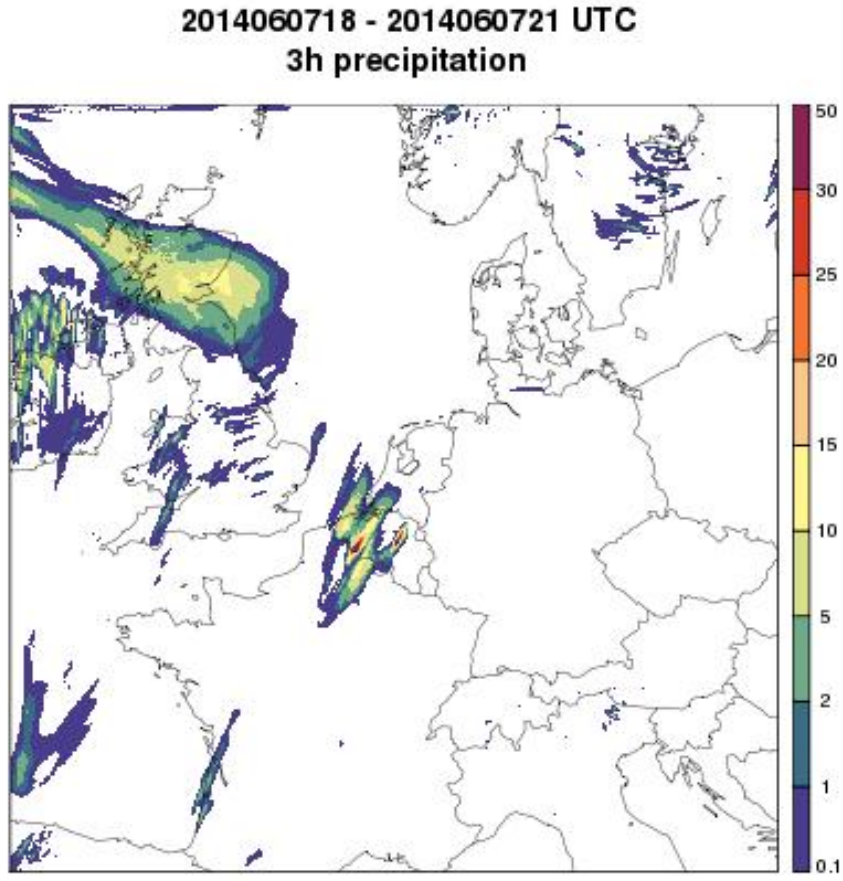

Figure: SLAF member of ALARO-1 coupled to ARPEGE. Accumulated 3-hourly precipitation. Forecast of 7 June 2014, 12h UTC, lead time +9h.

Thunderstorm cases

Pentecost

- Consistent with Belgian results, the 00h UTC runs showed very little precipitation, but some activity was seen in the 12h UTC runs.
- Interestingly, a few SLAF members predicted more than 30mm of precipitation, closer to what was observed, but with too broad structure.
- Next, we plan to test coupling to ECMWF (deterministic + SLAF) and to ECMWF-EPS.

Future plans

- A good ensemble should give a realistic estimate of the uncertainties in the forecast(s).
- How to best account for model uncertainty at convection-permitting scales?
- Perturbation techniques are used that have been applied in lower resolution ensembles (> 10 km), but do not work as well at high resolutions.
- PROPOSAL: implement and test more physically based perturbations.

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Future plans

- The stochastic SPPT method is used in ECMWF's forecasting system (30km resolution!).
  - Representing uncertainty coming from all the physical parameterizations in an aggregate way.
- Tested in several convection-permitting ensemble systems (Bouttier et al., 2012; Callado, 2013; Romine et al., 2014; Szúcs, 2013).
- Spread of the ensemble is generally improved, but bias problems, reduced deterministic model skill.
- Large horizontal autocorrelation scale (hundreds of km), i.e. synoptic instead of convective scale.

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Future plans

More physical perturbations by perturbing the physical parameters, and/or by introducing stochasticity at the process level:

- turbulence parameterization
- deep convection (e.g. triggering mechanism)
- vertical cloud geometry
- microphysics, e.g. sampling pdf's used in the statistical sedimentation scheme of ALARO.

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Future plans

- Comparison with SPPT.
  - statistical verification against observations over a long (summer) period
  - thunderstorm case studies
- Comparison of SLAF method with coupling to ECMWF-EPS.
- Influence of the initial and boundary conditions, and the interaction with the physical perturbations.

Future plans

- Higher horizontal resolution ? (e.g. from 2.5 km to 1.3 km)
- Bigger domain ?
- Lagged boundaries ? (due to operational constraints)

THANK YOU

References

- Bouttier F, Vié B, Nuissier O, Raynaud L. 2012. Impact of stochastic physics in a convection-permitting ensemble. Mon. Weather. Rev. 140: 3706-3721.
- Callado A. 2013. Towards stochastic parametrisations in convection-permitting HARMONIE EPS. SRNWP PHY-EPS Workshop, Madrid 18-20 June 2013.
- Romine G, Schwartz C, Berner J, Fossell K, Snyder C, Anderson J, Weisman M. 2014. Representing forecast error in convection-permitting ensemble system. Mon. Weather Rev. 142: 4519-4541.

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References

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