

ALARO performance in the prototype convection-permitting RMI-EPS

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ALARO-1 Working Days

Bratislava, Slovakia, 11-13 March 2019

Outline

1. Current set-up
2. Thunderstorm cases: Belgium
3. Precipitation cases: Madeira (Portugal)
4. Verification scores: Belgium
5. Future plans

Current set-up

- ▶ AROME and ALARO models (both at 2.5km) are coupled to ECMWF ENS (vertical 65L).
- ▶ 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.

Current set-up

ALARO physics

- ▶ Deep convection parametrization with 3MT scheme
- ▶ Broadband radiation scheme ACRANEb with a single shortwave and single longwave interval
- ▶ Turbulence scheme based on K-theory using prognostic kinetic energy
- ▶ Shallow convection accounted for by making stability function dependent on local moisture

⇒ aim is to run at multiple resolutions across the grey zone, from 1km to 10km.

Current set-up

AROME physics

- ▶ No deep convection scheme
- ▶ A multi band radiation scheme, RRTMG_LW (longwave) and six-band SW6 (shortwave)
- ▶ Turbulence scheme (CBR) based on prognostic TKE equation, combined with diagnostic mixing length
- ▶ Mass flux scheme (PMMC09) for dry thermals and shallow cumuli

⇒ aim is to run at convection-permitting scales, roughly at 1km.

Current set-up

- ▶ Computation at ECMWF (ecgate/cca) and results automatically transferred to RMI.
- ▶ HarmonEPS system + RMI preprocessing and postprocessing scripts.
- ▶ One run takes about 100K SBU's, and roughly 4 hours computation time...
- ▶ Semi-operational runs, 2x per day, since September 2017.

RMI-EPS Prob PCP3h over 5mm (Legend)
Analysis: 2015/08/13 00UTC T+018 VT: 2015/08/13 18UTC

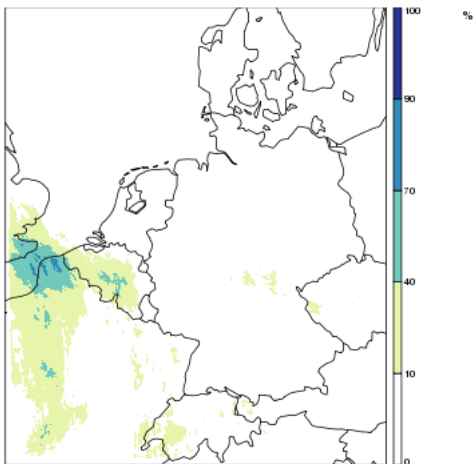


Figure: Probability plot RMI-EPS: 3h accumulated precipitation (> 5mm), forecast of 20150813 (00h UTC run) over full domain.

Current set-up

HarmonEPS_1 domain

- ▶ Standard domain of HarmonEPS system:
 $N = Nlon * Nlat = 450 * 540 = 291600$
($N = 870 * 660 = 574200$ for GLAMEPSv2).
- ▶ Changing domain also requires recomputing B-matrix for 3DVar (upper-air DA)...

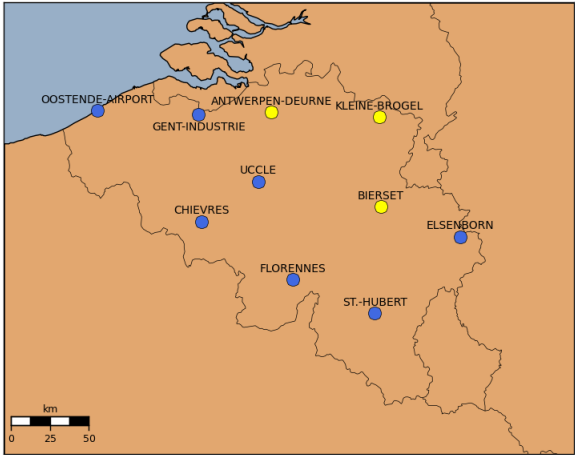


Figure: INDRA alert map for RMI-EPS: 6h accumulated precipitation forecast of 20150813 (00h UTC run).

RMI-EPS Precipitation forecast (3 hour accumulation)

Latest forecast: [2015-08-13 00 00 UTC](#)

Ensemble mean precipitation

RMI-EPS 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
Eisenborn	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 RMI-EPS: 3h accumulated precipitation forecast of 20150813 (00h UTC run).

Probability plot

Probability of exceeding thresholds.

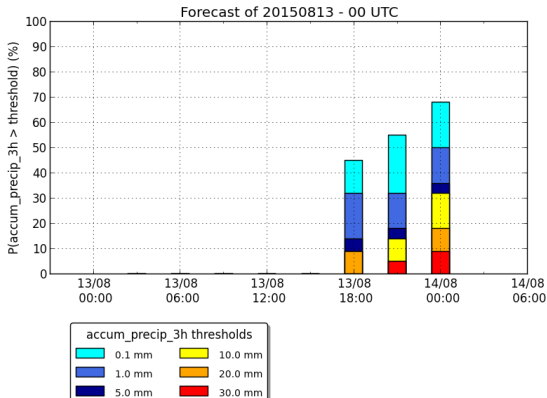


Figure: Probability plot RMI-EPS: 3h accumulated precipitation forecast of 20150813 (00h UTC run) for station Bierset (Belgium).

Thunderstorm cases: Belgium

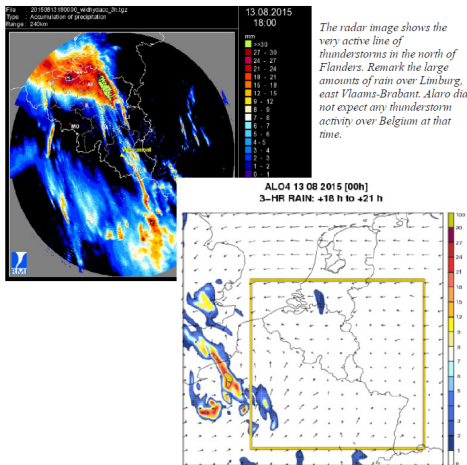


Figure: Thunderstorm on 13 August 2015: ALARO4 vs radar.
(Courtesy: S. Caluwaerts)

Thunderstorm cases: Belgium

13 August 2015

Waarschuwingen

Begin : 13/08/2015 17H - (lokale tijd)
Einde : 14/08/2015 05H - (lokale tijd)



Avertissements

Début : 13/08/2015 17H - (heure local)
Fin : 14/08/2015 05H - (heure local)

Onweer Wind Regen - Orage Vent Pluie

In de loop van donderdagnamiddag, donderdagavond en tijdens de nacht van donderdag op vrijdag verwachten we felle buien vanaf de Franse grens.

Die buien kunnen gepaard gaan met onweer, plaatselijk hagel en rukwinden.

In westen (West- Vlaanderen en het westen van Oost- Vlaanderen en Henegouwen) kan er veel neerslag op korte tijd vallen. Plaatselijk kan er tussen 20 en 30 l/m² vallen.

Provincies	13/8	14/8	15/8
Vlaanderen			
Kant			
West-Vlaanderen			
Oost-Vlaanderen			
Antwerpen			
Limburg			
Vlaams-Brabant			
Brussel			
Brussel			

groen - Er worden geen significante problemen verwacht ten gevolge van onweer.

geel - Er is plaatselijk kans op onweer. Een lokaal onweer is niet zonder gevaar. Er is kans op intense regenval, hagelbuien, blikseminslagen en/of felle rukwinden die lokaal voor overlast kunnen zorgen.

oranje - Er is verspreid kans op hevige onweer met mogelijk overlast op meerdere plaatsen. Intense regenval, hagelbuien, blikseminslagen en/of hevige rukwinden kunnen in grote schaal veroorzaken. Overvloedige regen is mogelijk en kan voor wateroverlast zorgen. Er is ook kans op vallende bomen/takken. Wees dus op uw hoofd en blijf in de mate van het mogelijke binnen.

rood - Er is een grote kans op hevige onweer met waarschijnlijk overlast op meerdere plaatsen. Intense regenval, hagelbuien, blikseminslagen en/of hevige rukwinden kunnen grote schade veroorzaken. Overvloedige regen is mogelijk en kan voor wateroverlast zorgen. Er is ook kans op vallende bomen/takken. Wees dus op uw hoofd en blijf in de mate van het mogelijke binnen.

Jeu di dans l'après-midi, jeudi soir et encore la nuit de jeudi à vendredi, nous prévoyons des averses intenses à partir de la frontière française.

Ces averses pourront être accompagnées d'orage, localement de grêle et de rafales de vent.

Dans l'ouest (la Flandre Occidentale et l'ouest de la Flandre Orientale et du Hainaut) on prévoit de fortes précipitations en peu de temps. Localement des quantités comprises entre 20 et 30 l/m² seront possibles.

Provincies	13/8	14/8	15/8
Wallonie			
Lige			
Hainaut			
Namur			
Luxembourg			
Brabant wallon			
Bruxelles			
Bruxelles			

vert - On ne prévoit pas de problèmes significatifs suite aux orages.

jaune - Il y a un risque d'orage local. Un orage local n'est pas sans danger. Des pluies intenses, des averses de grêle, des impacts de boue et/ou de fortes rafales de vent peuvent provoquer des problèmes localement.

orange - Il y a un risque répandu d'orages violents et des problèmes sont possibles en plusieurs endroits. Des pluies intenses, des averses de grêle, des impacts de boue et/ou de fortes rafales de vent peuvent causer des dégâts assez importants. Des pluies abondantes sont possibles et peuvent conduire à des inondations. Il y a également un risque de chute (de branches) d'arbres. Soyez donc sur vos gardes et évitez autant que possible de prendre la route.

rouge - Il y a un risque élevé d'orages violents avec probablement des problèmes en plusieurs endroits. Des pluies intenses, des averses de grêle, des impacts de boue et/ou de fortes rafales de vent peuvent causer des dégâts importants. Des pluies abondantes sont possibles et peuvent conduire à des inondations. Il y a également un risque de chute (de branches) d'arbres. Soyez donc sur vos gardes et évitez autant que possible de sortir.

Thunderstorm cases: Belgium

13 August 2015

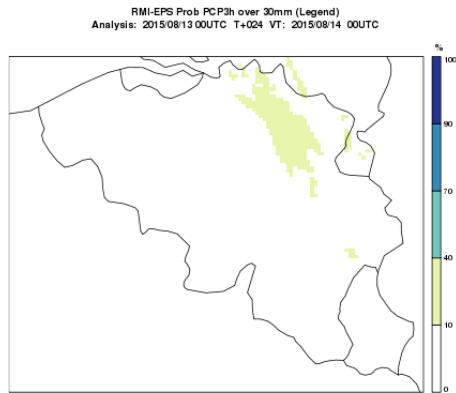


Figure: Probability plot RMI-EPS: 3h accumulated precipitation (> 30mm), forecast of 20150813 (00UTC) +24h over Belgium.

Thunderstorm cases: Belgium

13 August 2015

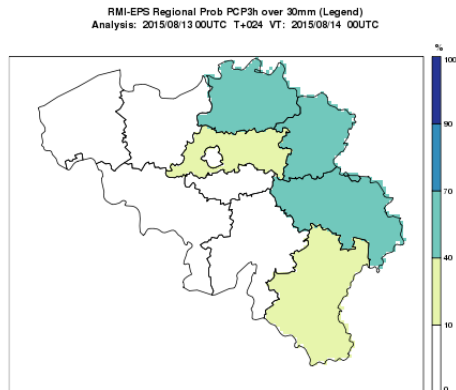


Figure: Regional probability plot RMI-EPS: 3h accumulated precipitation ($> 30mm$), forecast of 20150813 (00UTC) +24h.

Thunderstorm cases: Belgium

13 August 2015

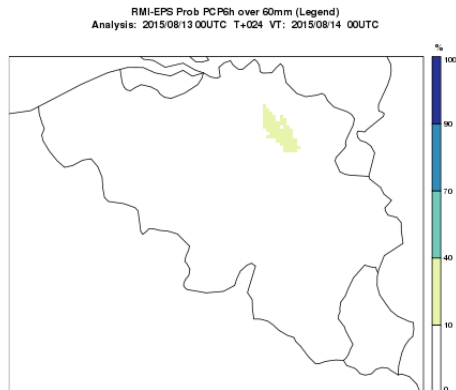


Figure: Probability plot RMI-EPS: 6h accumulated precipitation (> 60mm), forecast of 20150813 (00UTC) +24h over Belgium.

Thunderstorm cases: Belgium

13 August 2015

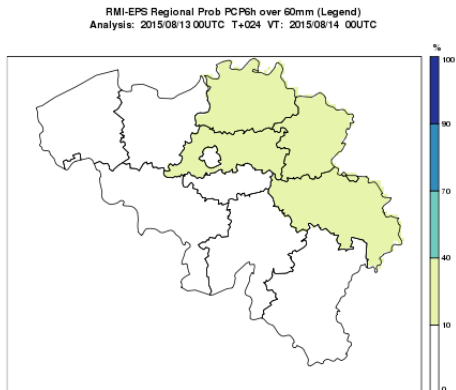
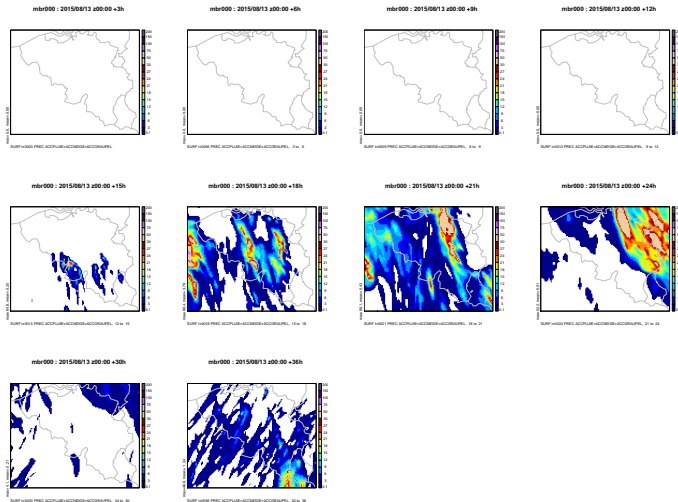


Figure: Regional probability plot RMI-EPS: 6h accumulated precipitation ($> 60mm$), forecast of 20150813 (00UTC) +24h.

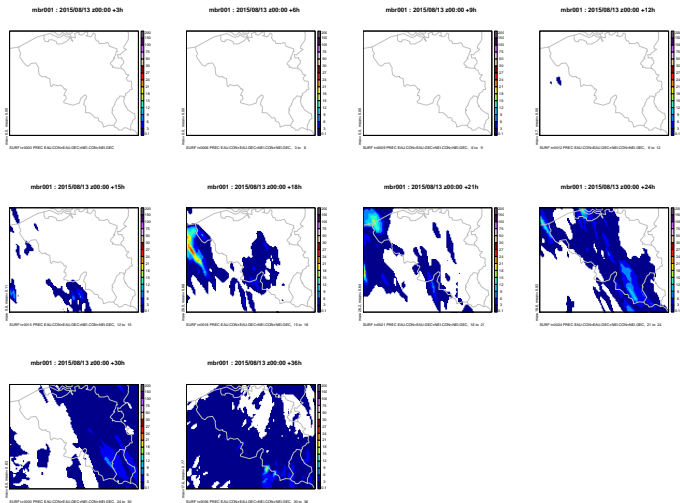
Thunderstorm cases: Belgium

13 August 2015: AROME control member of RMI-EPS



Thunderstorm cases: Belgium

13 August 2015: ALARO control member of RMI-EPS



Thunderstorm cases: Belgium

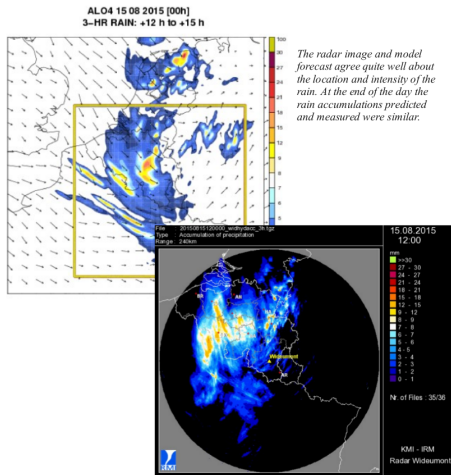


Figure: Thunderstorm on 15 August 2015: ALARO4 vs radar.
(Courtesy: S. Caluwaerts)

Thunderstorm cases: Belgium

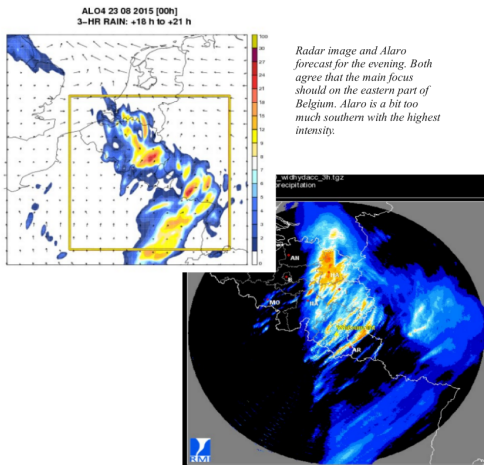


Figure: Thunderstorm on 23 August 2015: ALARO4 vs radar.
(Courtesy: S. Caluwaerts)

Thunderstorm cases: Belgium

23 August 2015

Waarschuwingen

Begin : 23/08/2015 13H - (lokale tijd)
Einde : 23/08/2015 23H - (lokale tijd)



Alertissements

Début : 23/08/2015 13H - (heure local)
Fin : 23/08/2015 23H - (heure local)

Onweer Regen - Orage Pluie

In de loop van de namiddag bereiken buien met onweer ons land vanaf de Franse grens. Plaatselijk kan er hierbij veel neerslag vallen in korte tijd, vooral in het centrum en oosten, maar het is elders niet uitgesloten. Er is ook kans op hagel en rukwinden tot 70 km/h. Komende nacht verlaten de laatste onweersbuien ons land via het noordoosten.

Provincies	23/8										24/8										25/8									
	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29
Vlaanderen																														
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rood - Er is een grote kans op hevige onweer met waarschijnlijk overlast op meerdere plaatsen. Intense regenval, hagelbuien en/of blikseminslagen kunnen grote schade veroorzaken. Overloevende regen is mogelijk en kan voor wateroverlast zorgen. Wees dus op uw hoede en blijf in de mate van het mogelijk binnen.

Dans le courant de l'après-midi, des averses et orages atteindront notre pays depuis la frontière française. Localement, de fortes précipitations en peu de temps sont possibles, surtout dans le centre et l'est, mais elles ne sont pas exclues ailleurs. Il y aura également un risque de grêle et de rafales de 70 km/h. Cette nuit, les dernières averses orageuses nous quitteront par le nord-est.

Provincies	23/8										24/8										25/8									
	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29
Wallonie																														
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Hainaut																														
Namur																														
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Thunderstorm cases: Belgium

23 August 2015

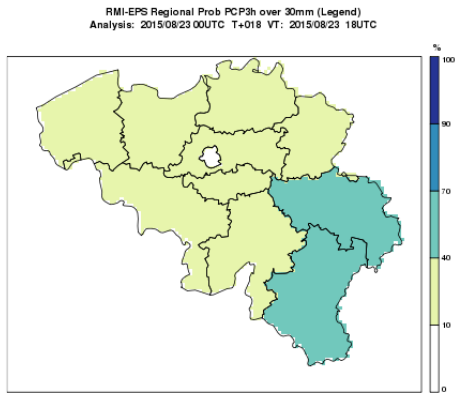


Figure: Regional probability plot RMI-EPS: 3h accumulated precipitation ($> 30mm$), forecast of 20150823 (00UTC) +18h.

Thunderstorm cases: Belgium

23 August 2015

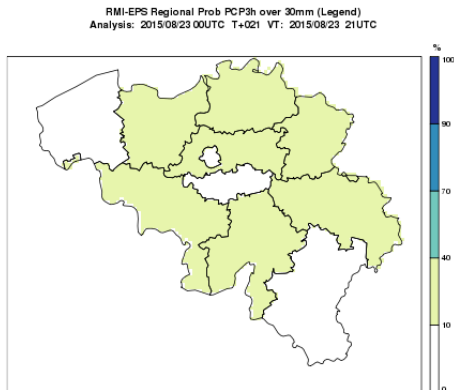


Figure: Regional probability plot RMI-EPS: 3h accumulated precipitation ($> 30mm$), forecast of 20150823 (00UTC) +21h.

Thunderstorm cases: Belgium

23 August 2015

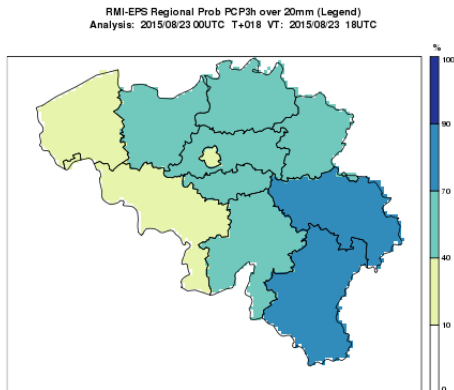


Figure: Regional probability plot RMI-EPS: 3h accumulated precipitation ($> 20mm$), forecast of 20150823 (00UTC) +18h.

Thunderstorm cases: Belgium

23 August 2015

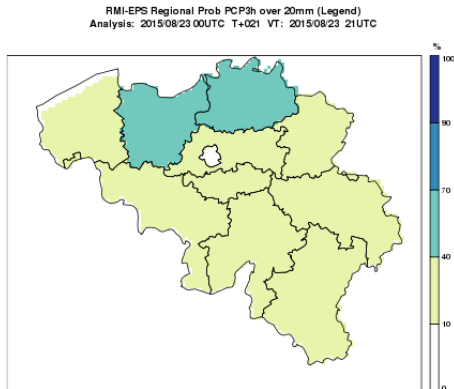
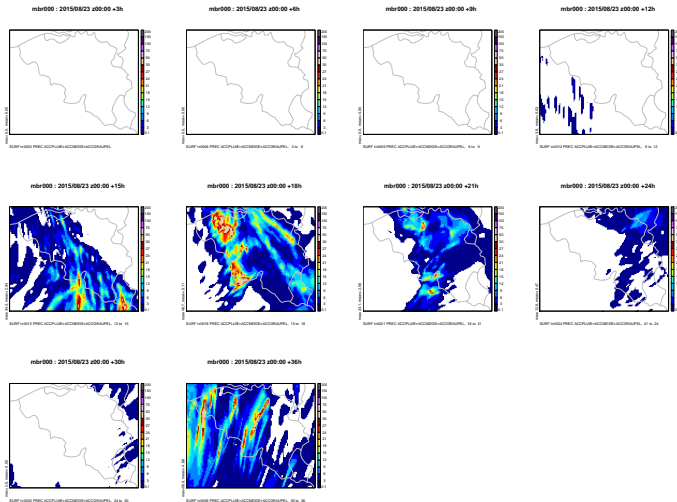


Figure: Regional probability plot RMI-EPS: 3h accumulated precipitation ($> 20mm$), forecast of 20150823 (00UTC) +21h.

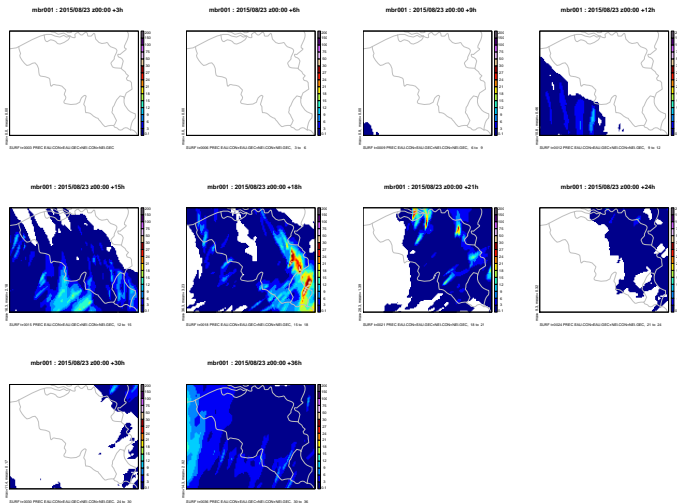
Thunderstorm cases: Belgium

23 August 2015: AROME control member of RMI-EPS



Thunderstorm cases: Belgium

23 August 2015: ALARO control member of RMI-EPS



Precipitation cases: Madeira (Portugal)

Convection permitting EPS on Madeira cases

- ▶ João Rio (IPMA) and Geert Smet (RMI)
- ▶ report on FR stay at RMI
- ▶ available at <https://orfeo.kbr.be/>
new institutional Open Access repository for
Federal Science Policy funded research

Precipitation cases: Madeira (Portugal)

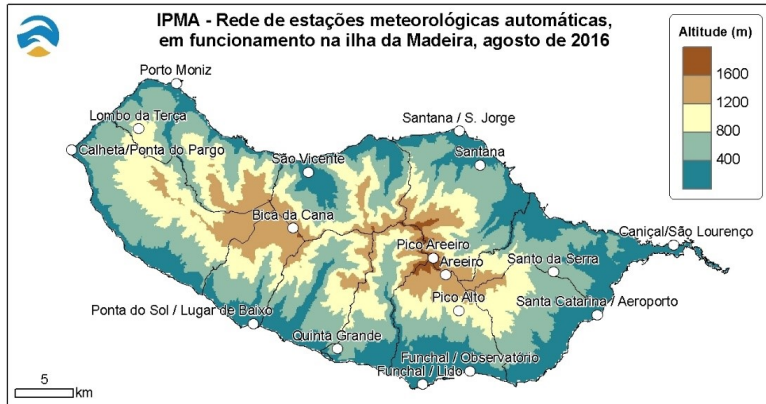


Figure: Orography and weather stations in Madeira

Precipitation cases: Madeira (Portugal)

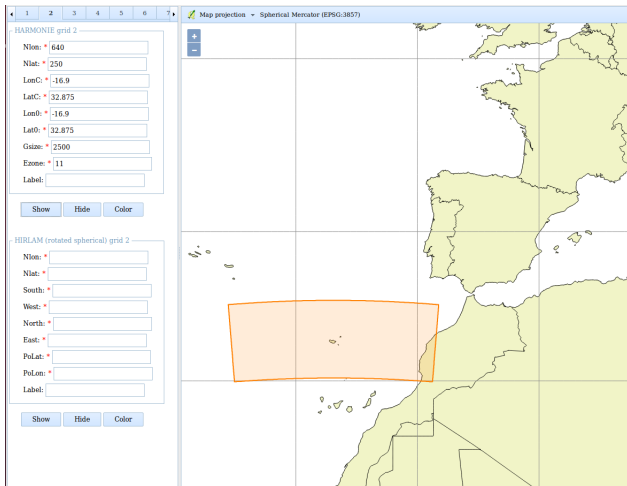


Figure: Madeira domain used in RMI-EPS

Heavy convective precipitation

16 October 2015

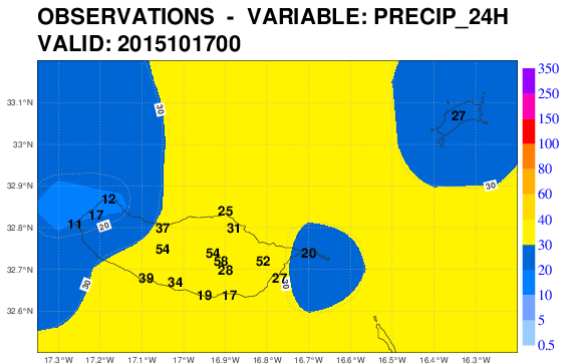


Figure: obs 24h precipitation (mm) in Madeira, on 16 Oct 2015

Heavy convective precipitation

16 October 2015

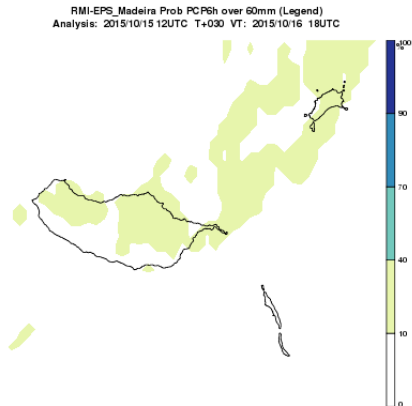


Figure: Probability of precipitation above 60mm/6h, from the RMI-EPS run from 12 UTC of October 15th, valid at +30h.

Heavy convective precipitation

16 October 2015

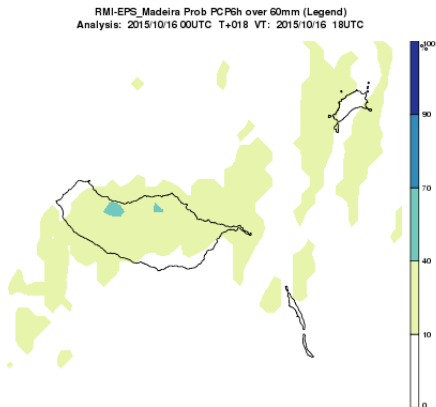


Figure: Probability of precipitation above 60mm/6h, from the RMI-EPS run from 00 UTC of October 16th, valid at 18 UTC.

Enhanced precipitation over mountains

30 March 2016

OBSERVATIONS - VARIABLE: PRECIP_24H
VALID: 2016033100

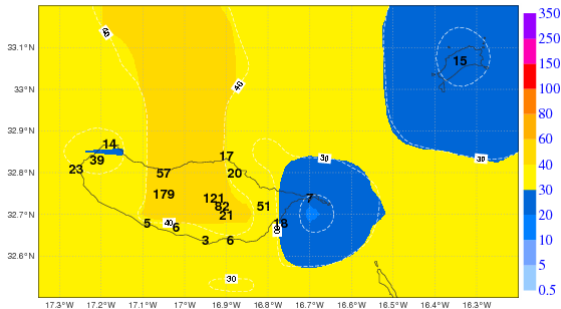


Figure: obs 24h precipitation (mm) in Madeira, on 30 March 2016

Enhanced precipitation over mountains

30 March 2016

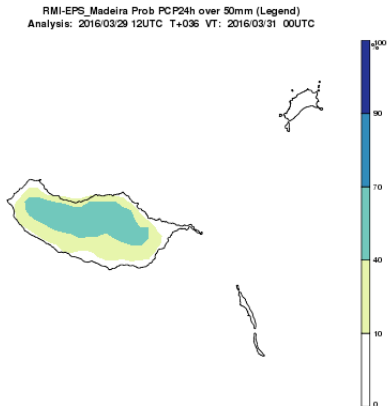


Figure: Probability of precipitation above 50mm/24h, from the RMI-EPS run from 12 UTC of March 29th, valid at +36h.

Enhanced precipitation over mountains

30 March 2016

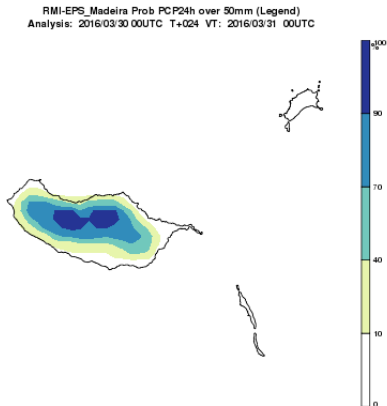


Figure: Probability of precipitation above 50mm/24h, from the RMI-EPS run from 00 UTC of March 30th, valid at +24h.

Enhanced precipitation over mountains

30 March 2016

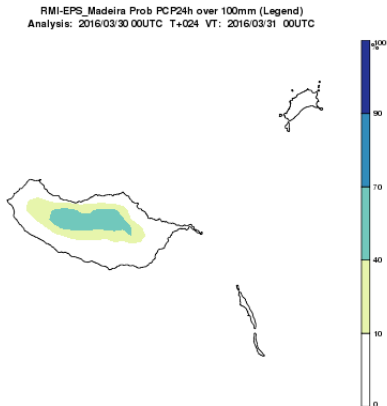


Figure: Probability of precipitation above 100mm/24h, from the RMI-EPS run from 00 UTC of March 30th, valid at +24h.

Over-active convection

28 October 2016

AROME precipitação total (mm) acumulada em 3 horas
Run: 2016-10-28 00UTC Validade: 2016-10-28 21UTC

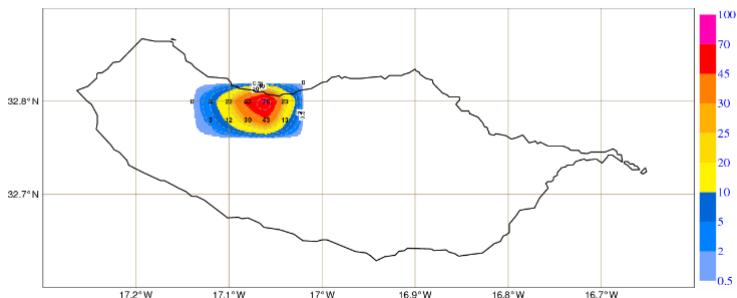


Figure: AROME-MAD 3h precipitation, valid at 21UTC of 28 October 2016, from the 00 UTC run of October 28th.

Over-active convection

28 October 2016

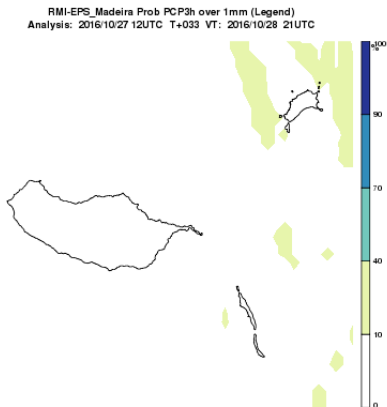


Figure: Probability of precipitation above 1mm/3h, from the RMI-EPS run from 12 UTC of October 27th, valid at +33h.

Over-active convection

28 October 2016

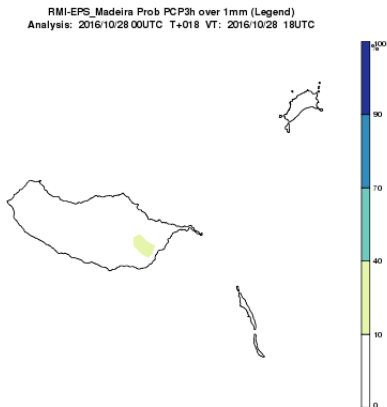


Figure: Probability of precipitation above 1mm/3h, from the RMI-EPS run from 00 UTC of October 28th, valid at +18h.

Over-active convection

28 October 2016

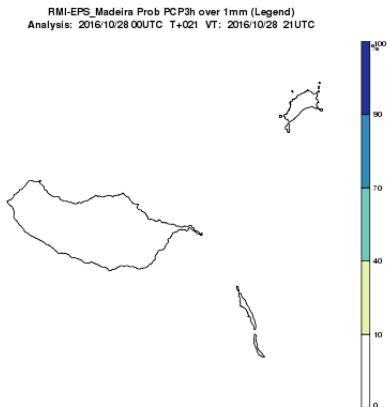


Figure: Probability of precipitation above 1mm/3h, from the RMI-EPS run from 00 UTC of October 28th, valid at +21h.

Precipitation cases: Madeira (Portugal)

- ▶ On average AROME forecasts give higher amounts of precipitation (than ALARO), especially in convective events.
- ▶ The EPS offers improved guidance for a given event, but does not necessarily imply that that a given event can be forecast sooner.
- ▶ The LAMEPS always depends on (good) initial and lateral boundary conditions from a global model.

Precipitation cases: Madeira (Portugal)

- ▶ As the EPS provides an ensemble of possible outcomes of the weather conditions, it increases the confidence the weather centre has when issuing a given forecast or warning.
- ▶ Running RMI-EPS with ECMWF as the parent model was beneficial in removing an artificial structure (over-active convection) that was present in the operational AROME-MAD forecast, which is coupled with ARPEGE.

Verification scores: Belgium

- ▶ Three periods:
 - 1) August 2015: several thunderstorms (15 forecasts).
 - 2) 15 May 2018 - 14 June 2018: 1 month of daily forecasts (2 runs per day).
 - 3) 18 Sep 2017 - 31 Dec 2017: 3.5 months of daily forecasts (2 runs per day).
- ▶ Point-based (not spatial): 10 standard synop stations spread evenly over Belgium.
- ▶ INDRA verification tools.
(Courtesy: J. Van den Bergh)

Verification scores

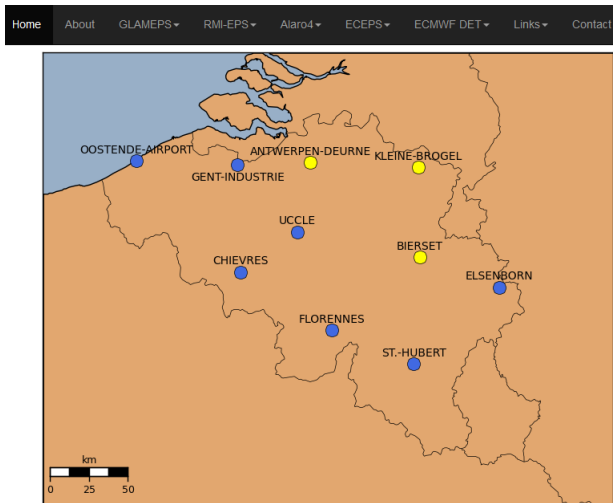


Figure: INDRA synop stations.

Verification scores

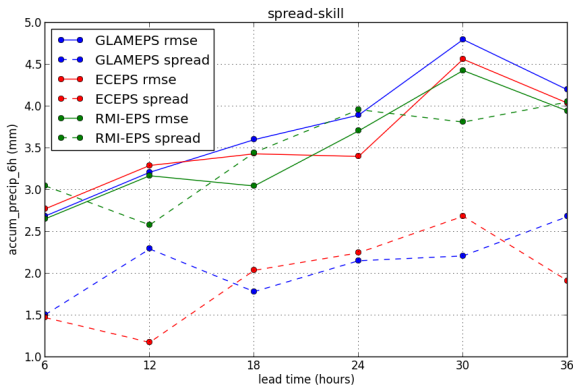


Figure: RMSE and spread for 6h accumulated precipitation: thunderstorm cases of August 2015 (averages over 10 standard stations in Belgium).

Verification scores

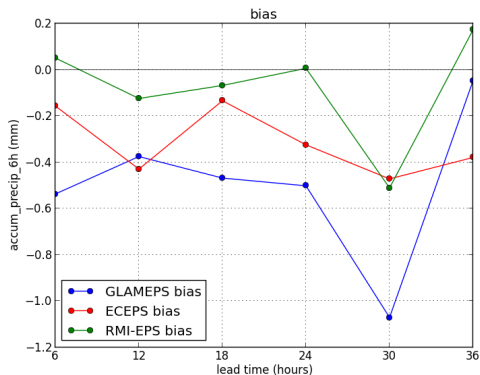


Figure: Bias for 6h accumulated precipitation: thunderstorm cases of August 2015 (averages over 10 standard stations in Belgium).

Verification scores

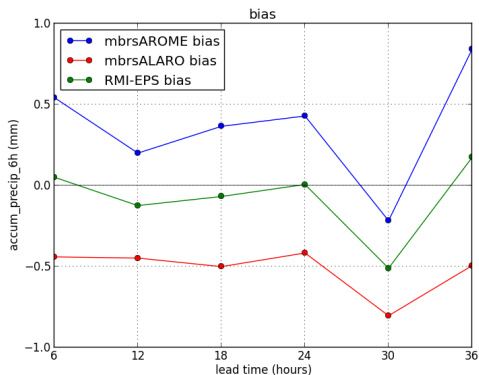


Figure: Bias for 6h accumulated precipitation: thunderstorm cases of August 2015 (averages over 10 standard stations in Belgium).

Verification scores

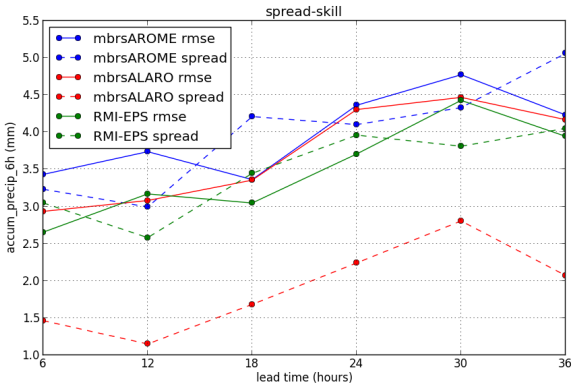


Figure: RMSE and spread for 6h accumulated precipitation: thunderstorm cases of August 2015 (averages over 10 standard stations in Belgium).

Verification scores

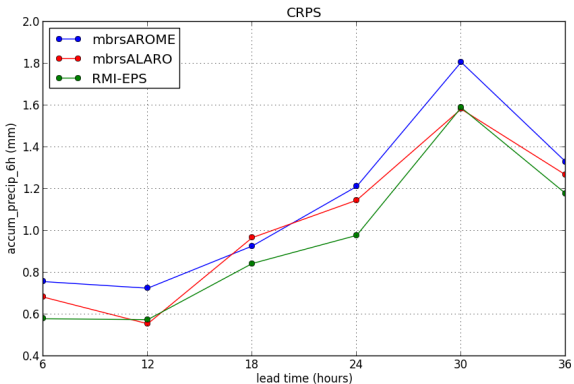


Figure: CRPS for 6h accumulated precipitation: thunderstorm cases of August 2015 (averages over 10 standard stations in Belgium).

Verification scores

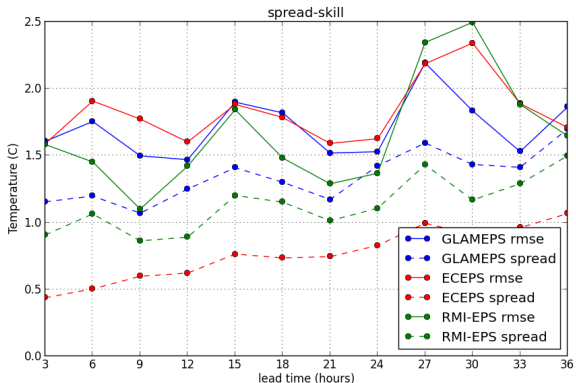


Figure: RMSE and spread for T2M: thunderstorm cases of August 2015 (averages over 10 standard stations in Belgium).

Verification scores

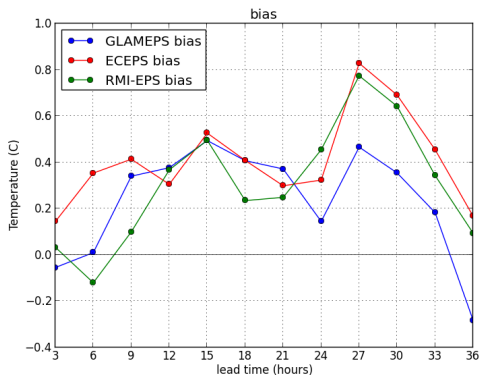


Figure: Bias for T2M: thunderstorm cases of August 2015 (averages over 10 standard stations in Belgium).

Verification scores

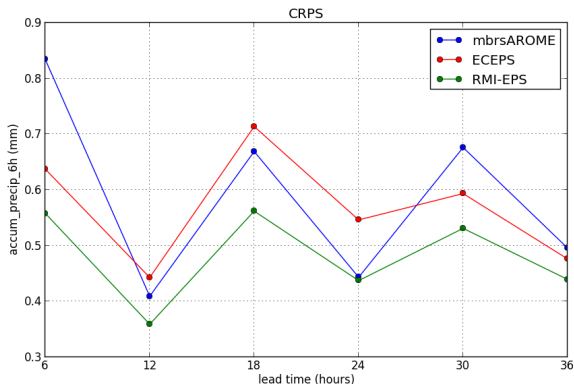


Figure: CRPS for 6h accumulated precipitation: 15 May 2018 - 14 June 2018 (averages over 10 standard stations in Belgium).

Verification scores

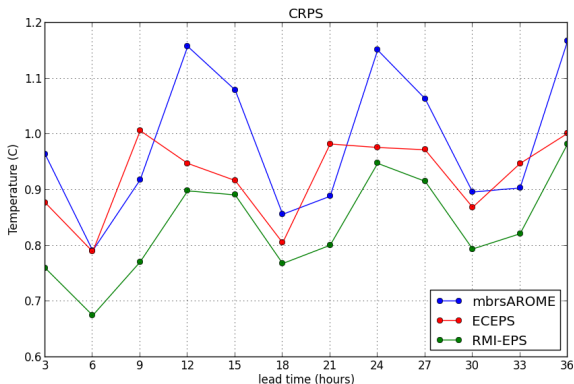


Figure: CRPS for 2-meter temperature: 15 May 2018 - 14 June 2018 (averages over 10 standard stations in Belgium).

Verification scores

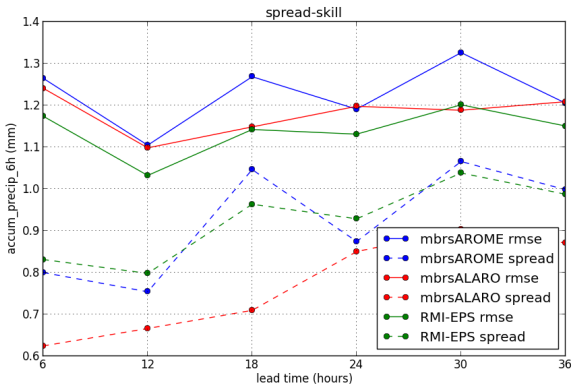


Figure: RMSE and spread for 6h accumulated precipitation: 18 Sep 2017 - 31 Dec 2017 (averages over 10 standard stations in Belgium).

Verification scores

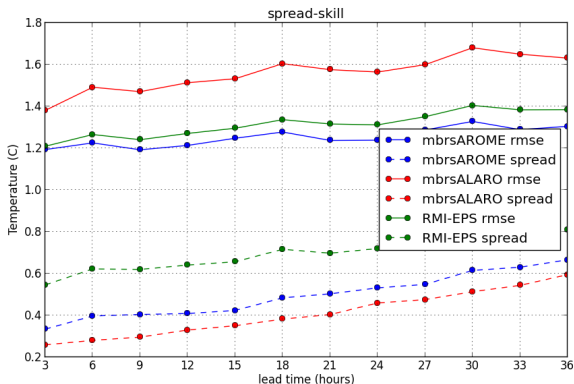


Figure: RMSE and spread for 2m temperature: 18 Sep 2017 - 31 Dec 2017 (averages over 10 standard stations in Belgium).

Future plans

Short term

- ▶ Additional surface perturbations.
 - Should improve T2m spread.
 - Influence on thunderstorm forecasts?
- ▶ An automatic monthly and seasonal verification (of INDRA).
- ▶ New domain centred around Belgium?

Future plans

Long term

Upper-air physics

- ▶ Multiphysics (e.g. different tunings).
- ▶ Tests with ALARO-1 (instead of ALARO-0).
- ▶ Perturbation of physical processes (parameter perturbation).