RMI-EPS: a prototype convection-permitting EPS for Belgium

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1 Introduction

In recent years, there have been several high-profile thunderstorms in Belgium, in particular the Pukkelpop thunderstorm of 2011, resulting in five casualties, and the Pentecost storms of 2014, leading to hundreds of million euros of damage. These cases highlighted again the importance of having a good forecast and warning system for severe weather. Probabilistic guidance from ensemble forecasts should be an important forecast tool for these events, since predicting their exact timing, location and intensity is generally very difficult, if not impossible.

With improved prediction of severe weather in mind, most European countries have started with the development of convection-permitting EPS in the last few years. At the Royal Meteorological Institute of Belgium (RMI), an experimental high-resolution (2.5km) ensemble with 11 ALARO members and 11 AROME members is currently being tested. This is meant to be a prototype for a future operational convection-permitting EPS over Belgium. In this article, we describe the current set-up of the system and discuss some forecast results for several thunderstorm episodes in August 2015. The performance of the ALARO and AROME members, and the usefulness of combining them in an ensemble is investigated. Additionally, a comparison is made with the global EPS of ECMWF and the pan-European mesoscale GLAMEPS. We conclude with our future plans toward an operational convection-permitting RMI-EPS.

2 Ensemble system configuration

The RMI-EPS system currently consists of 22 ensemble members, 11 with AROME physics and 11 with ALARO physics, all using cy38h1.1 with SURFEX, and running at 2.5km horizontal resolution with 65 vertical levels. Initial condition (IC) perturbations and lateral boundary conditions (LBC) are taken from the ensemble system of ECMWF (hereafter referred to as ECEPS). Each member has an independent surface assimilation cycle (CANARI). There are two control members, one AROME control (mbr000) and one ALARO control (mbr001), that both take their lateral boundary conditions from the ECEPS control member. They both have a 3DVAR (upper-air) data-assimilation cycle. Only conventional observations (SYNOP, AIRCRAFT, BUOY, TEMP en PILOT) are used, no satellite or radar data.

Initial conditions for the perturbed RMI-EPS members are created by adding initial perturbations of ECEPS members to the analysis (after 3DVAR) of the control members. This is done in pairs, in order to prevent that all perturbations of one type are added to only one type of physics. Namely the first perturbed member is an ALARO member (mbr002), taking IC perturbations and LBC from the first perturbed member of ECEPS, the next two members are then AROME members (mbr003 and mbr004) taking IC perturbations and LBC from the second and third perturbed member of ECEPS, and then again two ALARO members (mbr005 and mbr006), taking IC perturbations and LBC from the fourth and fifth perturbed member of ECEPS, and so on. This gives 10+1 AROME members and 10+1 ALARO members.

Currently, the forecast range is 36 hours, twice a day at 00 and 12 UTC, with a 6 hour data-assimilation cycle at 06 and 18 UTC. Computations are done at ECMWF's computing facilities (ecgate/cca) and only some standard products (probability maps, forecasts interpolated to locations,...) will be automatically transfered to RMI. A combination of the HarmonEPS system (cy38h1.1) with RMI preprocessing and postprocessing scripts is used. In order not to have to recompute the B-matrix for the data-assimilation, and to possibly allow comparisons with convection-permitting EPS from Météo-France and DWD, first tests were done with the default HarmonEPS_1 domain, shown in figure 1. In the future, a custom domain centered over Belgium will be defined and tested.

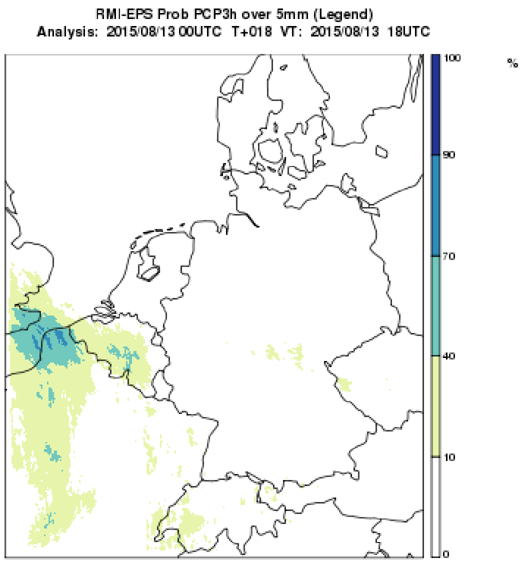

Figure 1: Probability plot RMI-EPS for 3h accumulated precipitation ($> 5mm$). Forecast of 13 August 2015 (00 UTC run) over full domain.

3 Thunderstorm case studies

We studied a series of thunderstorm events over Belgium occurring in August 2015, with generally positive results for the RMI-EPS system. As an illustration, we take the thunderstorms of 13 August 2015 shown in figure 2. This case was interesting as our operational deterministic LAM model gave very little precipitation over Belgium (figure 2), while our forecasters nevertheless gave a ‘code orange’ warning for the west of the country. In reality, the largest amount of precipitation was actually observed in the east of the country, and this was in fact nicely predicted by the RMI-EPS, as shown by the regional probabilities in figure 3.

4 Verification

A preliminary statistical verification over 15 forecasts around several thunderstorm episodes in August 2015 also gave encouraging results. Figure 5 and 6 show the RMSE and ensemble spread for 6h accumulated precipitation and 2-meter temperature, with scores being averages over 10 standard WMO weather stations evenly spread over the whole of Belgium (as shown in figure 4).

For precipitation, the RMSE of RMI-EPS is comparable with those of GLAMEPS and ECEPS, while the ensemble spread is clearly larger and closer to the RMSE. For 2-meter temperature, the RMSE is somewhat smaller than GLAMEPS and ECEPS in the first 24h, and somewhat larger thereafter. The ensemble spread on the other hand is clearly worse than GLAMEPS, but still much better than ECEPS.

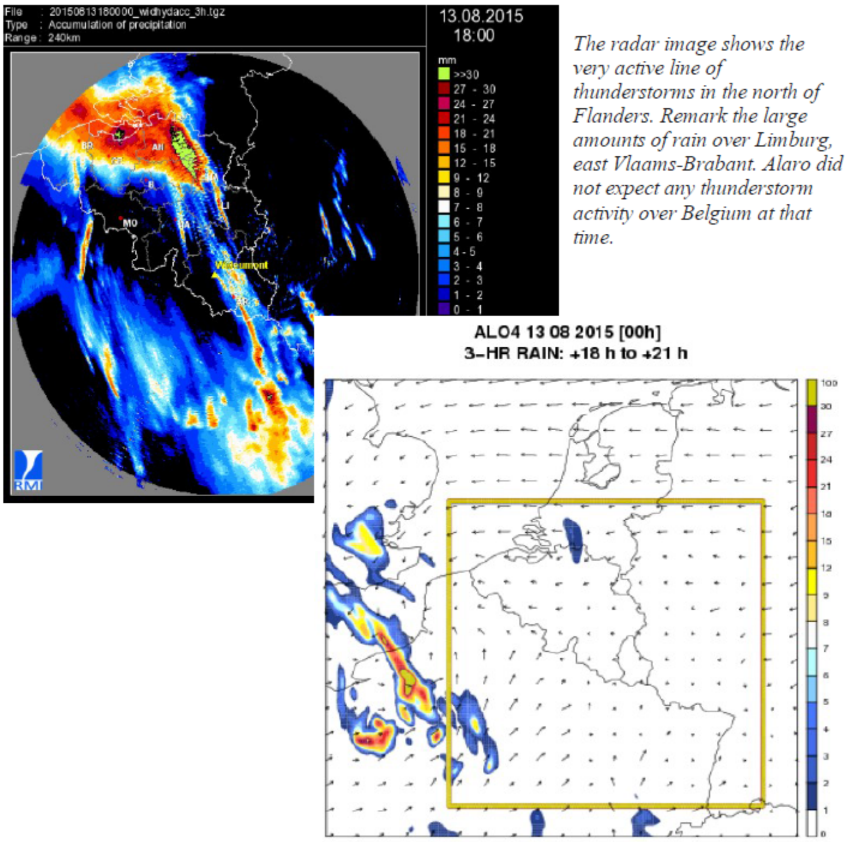

Figure 2: Thunderstorm over Belgium on 13 August 2015: radar (left) and operational deterministic model ALARO4 (right). (Courtesy: S. Caluwaerts)

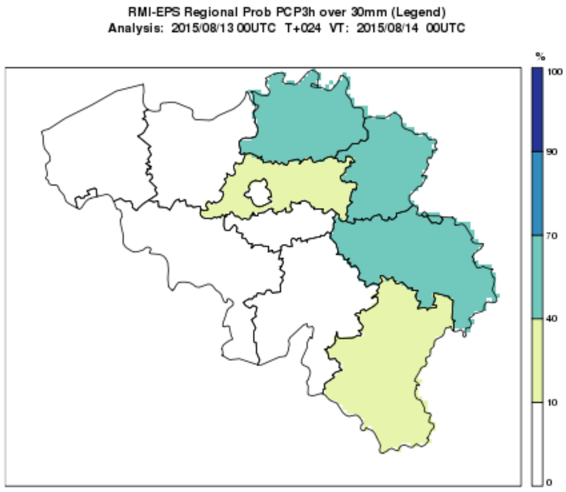

Figure 3: Regional probability plot RMI-EPS for 3h accumulated precipitation (> $30mm$). Forecast of 13 August 2015 (00 UTC) for lead time +24h.

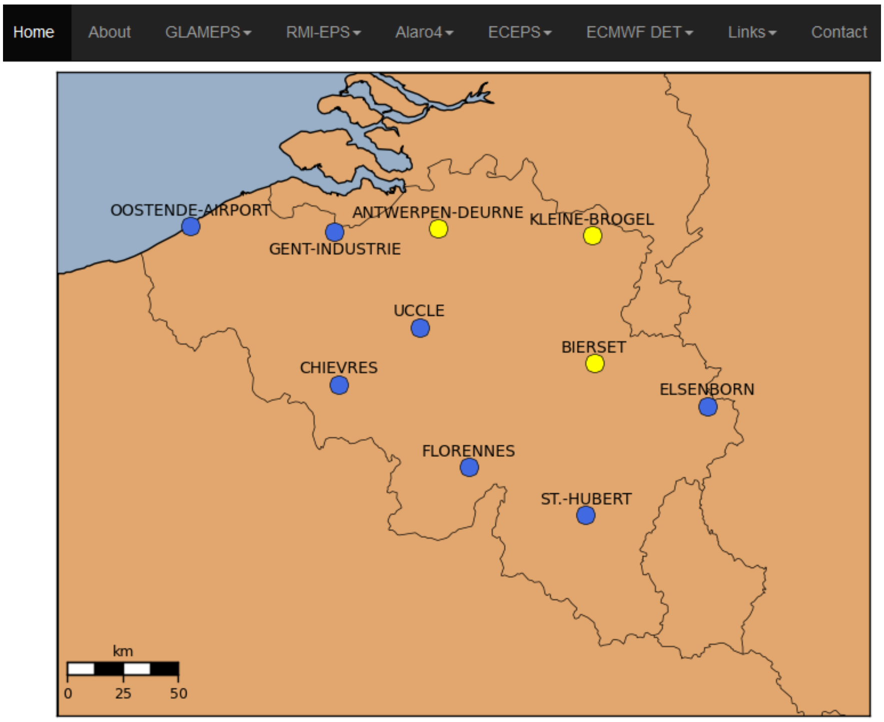

Figure 4: Location of the 10 standard synop stations used in the verification.

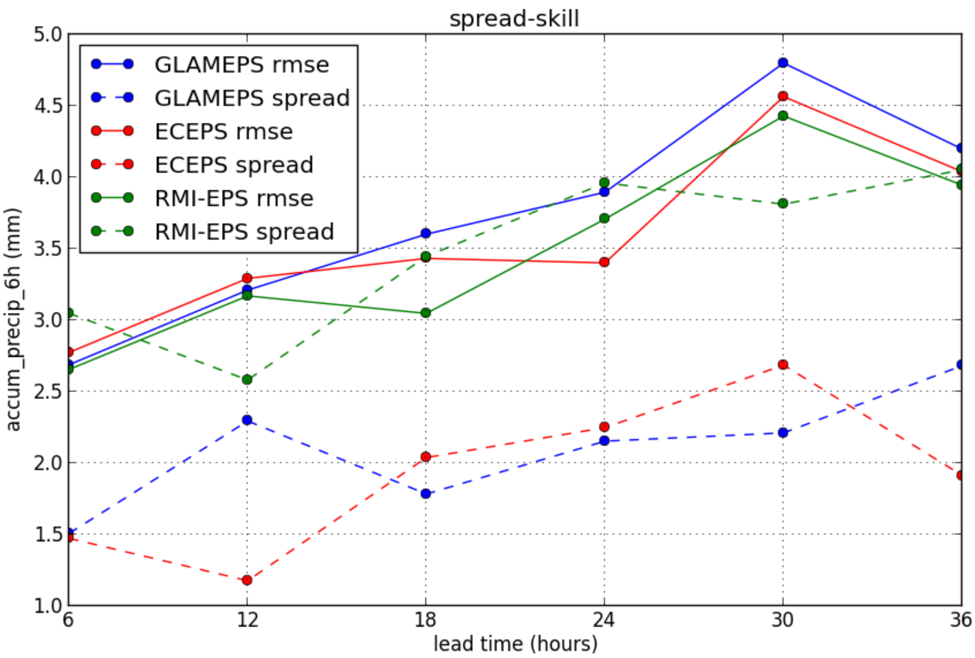

Figure 5: RMSE and spread for 6h accumulated precipitation: thunderstorm cases of August 2015. Comparison of RMI-EPS with GLAMEPS and ECEPS.

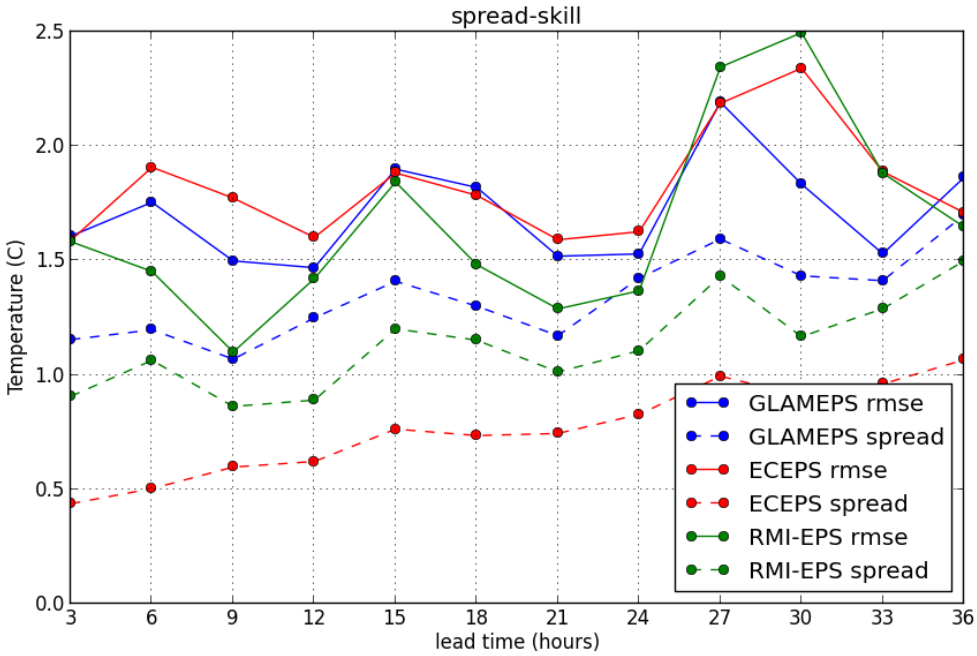

Figure 6: RMSE and spread for 2-meter temperature: thunderstorm cases of August 2015. Comparison of RMI-EPS with GLAMEPS and ECEPS.

Comparing the contribution of the AROME and ALARO members to the RMI-EPS ensemble, we see that the AROME members tend to overestimate the amount of precipitation, while the ALARO members tend to underestimate the amount of precipitation, but curiously the bias of the two models conspire to cancel out almost perfectly, see figure 7. The ALARO members are clearly underspread (partly due to missing a thunderstorm event completely), but have a better RMSE than the AROME members (although they might suffer unduly from the double penalty problem), see figure 8. Nevertheless, combining them improves both the spread and RMSE, as the scores of RMI-EPS in figure 8 show. It also leads to a better CRPS, as can be seen in figure 9.

5 Conclusion and future plans

Even though there are still many improvements possible to the current RMI-EPS set-up, its performance is already surprisingly good, or to use ALADIN parlance 'better than expected'. The RMI-EPS system was able to predict some severe thunderstorms that were completely missed by our operational deterministic model, and preliminary verification scores suggest it compares well with already existing state of the art ensemble prediction systems like ECEPS and GLAMEPS. The AROME and ALARO physics seem to be good complements to each other. They can give rise to quite different results in extreme cases, and combining members from both models improves bias, RMSE, spread to RMSE ratio and CRPS.

At the moment, all the perturbed members have the same physics (and dynamics) settings as their corresponding control member. In the future, multiphysics options (e.g. different tunings, parameterizations,...) for the perturbed members will be tested. An upgrade to ALARO-1 physics is also planned, but for this some issues with SURFEX will first have to be resolved. To improve the spread for 2-meter temperature, additional surface perturbations (on top of the current independent surface assimilation cycle) will be investigated.

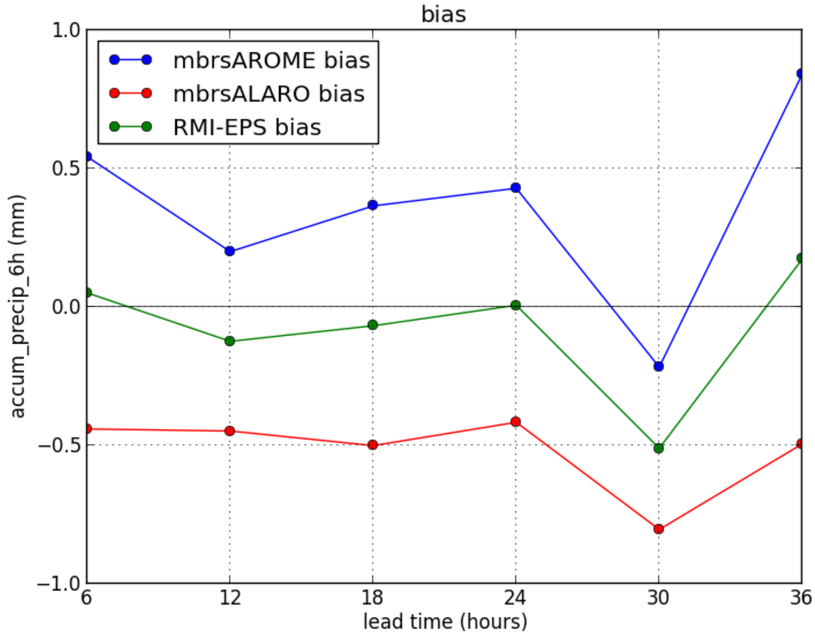

Figure 7: Bias for 6h accumulated precipitation: thunderstorm cases of August 2015. Comparison of the ALARO and AROME members within RMI-EPS.

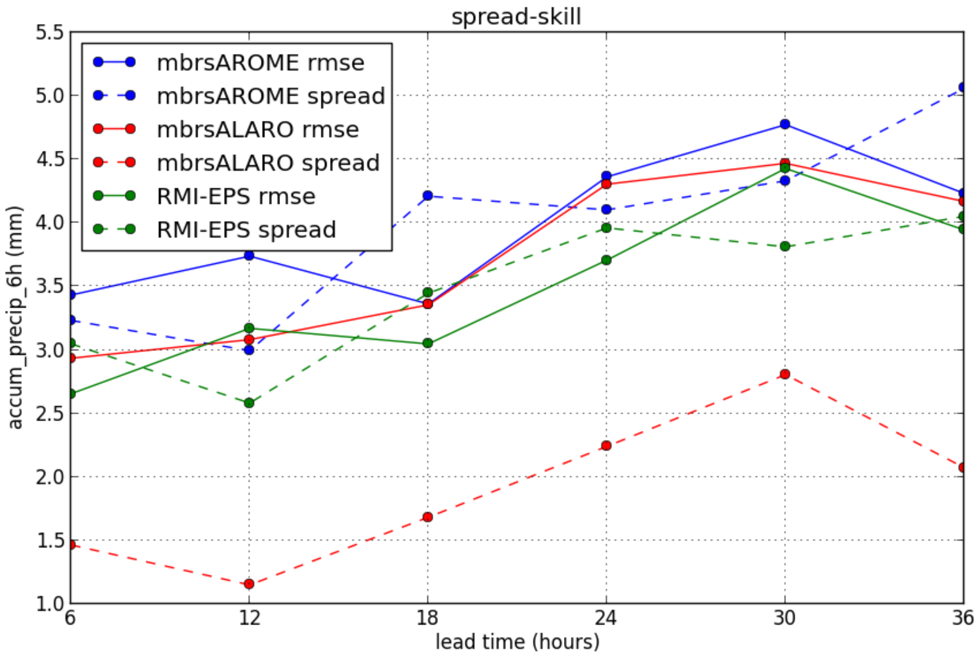

Figure 8: RMSE and spread for 6h accumulated precipitation: thunderstorm cases of August 2015. Comparison of the ALARO and AROME members within RMI-EPS.

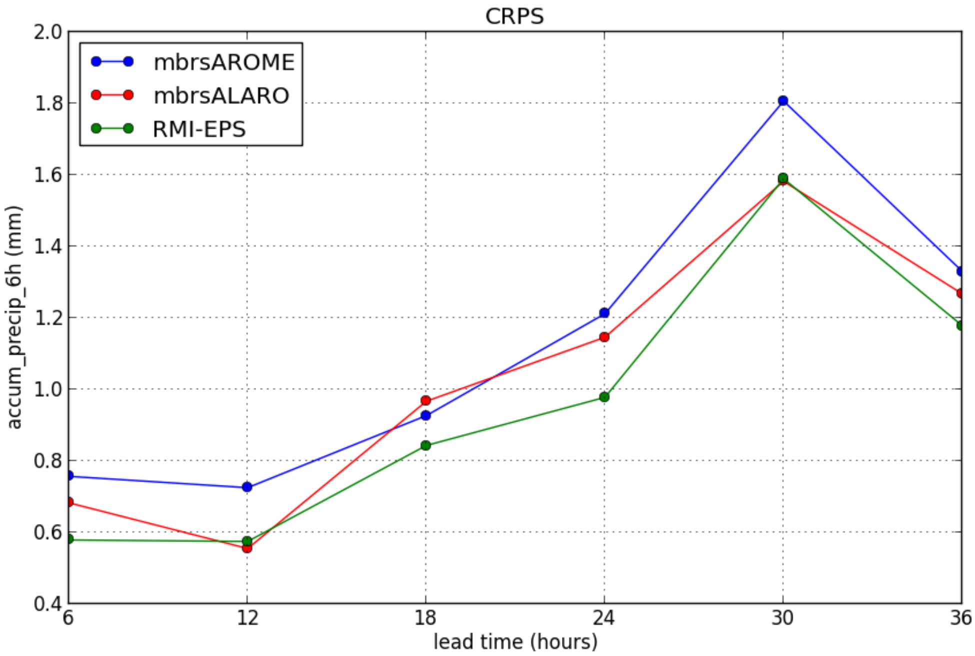

Figure 9: CRPS for 6h accumulated precipitation: thunderstorm cases of August 2015. Comparison of the ALARO and AROME members within RMI-EPS.

In the course of 2017, daily semi-operational runs are going to be implemented, and a new domain centred around Belgium will probably be used. Lagged boundaries or a longer forecast range might also be considered, if they turn out beneficial in an operational context.

6 Acknowledgements

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