Report on stay at ZAMG

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ALADIN-LAEF regional ensemble system comparing to the ALARO higher resolution deterministic model

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Even if in the last years, the weather models become more sophisticated and integrated at higher resolution, the prediction of the severe weather forecast is still a real challenge. On the one hand, the numerical forecasts are influenced by the uncertainties which appear in the initial conditions and on the other hand by the imperfection of the numerical model itself, including the lateral boundary conditions for the limited area models. In this way, many methods were developed and used in order to generate an ensemble system, its main purpose is to take into account these kind of errors.

The purpose of this study consists in the evaluation of the forecasts provided by the ALARO deterministic and ALADIN – LAEF ensemble system systems. Using the available forecasts of the ALARO deterministic model (4 runs per day), a time-lagged ensemble (ALARO-LAGGED) was produced, comprising 5 members. Therefore, 16 members of ALADIN – LAEF and 5 of ALARO-LAGGED are used in this evaluation. The systems performance was carried out for 2 months period (23 April to 23 June 2013, up to 48 hours) and the forecasts data are interpolated at 0.04º x 0.06º resolution for ALARO and at 0.1º x 0.14º for ALADIN-LAEF. The verification was performed over a domain which covers Europe and the verified parameters are: 2 m temperature (T2m), 10 m wind speed (W10m), 12 hour accumulated precipitation (PREC12h) and mean sea level pressure (MSLP).

The negative BIAS value of ALADIN-LAEF for 00 and 06h lead time can be noticed in Figure 1a. After these lead times, its BIAS is rather similar with the ALARO-LAGGED bias, but for 18 and 42 h, the BIAS is considerably smaller than ALARO-LAGGED. Figure 1b shows the bias for W10m. In this case, for both systems the BIAS is comparable and the values are negative, excepting 12 and 36h lead. For MSLP (Figure 1c), the BIAS for ALADIN-LAEF is positive for 00 and 06h lead times and ALARO-LAGGED is the one which outperforms ALADIN-LAEF. During night, for both systems, the BIAS has the lowest value, negative values. Regarding PREC12h (Figure 1d), for 18 and 42 h lead times, the BIAS of ALARO-LAGGED has better values for 18 and 42h and for ALADIN-LAEF they have negative values, positive ones for 30h.

For values of RMSE (Figure 1), for all surface parameters, are similar and the spread is larger for ALADIN-LAEF for all time steps. Both systems show a smaller spread compared to RMSE. Therefore, both of them are not enough statistical reliable (Buizza, 2005), but for ALADIN-LAEF this difference is smaller, concluding that it is more reliable one. It is expecting to have a smaller spread for ALARO-LAGGED due to the fact that its members are partially correlated because they are obtained using the same model with different ages.

In figure 2, it can be noticed the performance of both systems for percentage of outliers, showing that ALARO-LAGGED has more outliers than ALADIN-LAEF.

The results show that ALARO-LAGGED has a similar RMSE compared to the one of ALADIN-LAEF, its spread is smaller and has more outliers. Having less dispersion, it is not able to cover many possible atmospheric situations. So far, it can be noticed that the accuracy of both systems is similar, but ALADIN-LAEF is statistically more reliable.

Figure 3 shows the CRPSS of all the surface parameters used in this comparison, showing that both systems have positive values for all the lead times, excepting the MSLP at 00h. Both of them are more skillful than the reference one which is the most recent run of ALARO deterministic model.

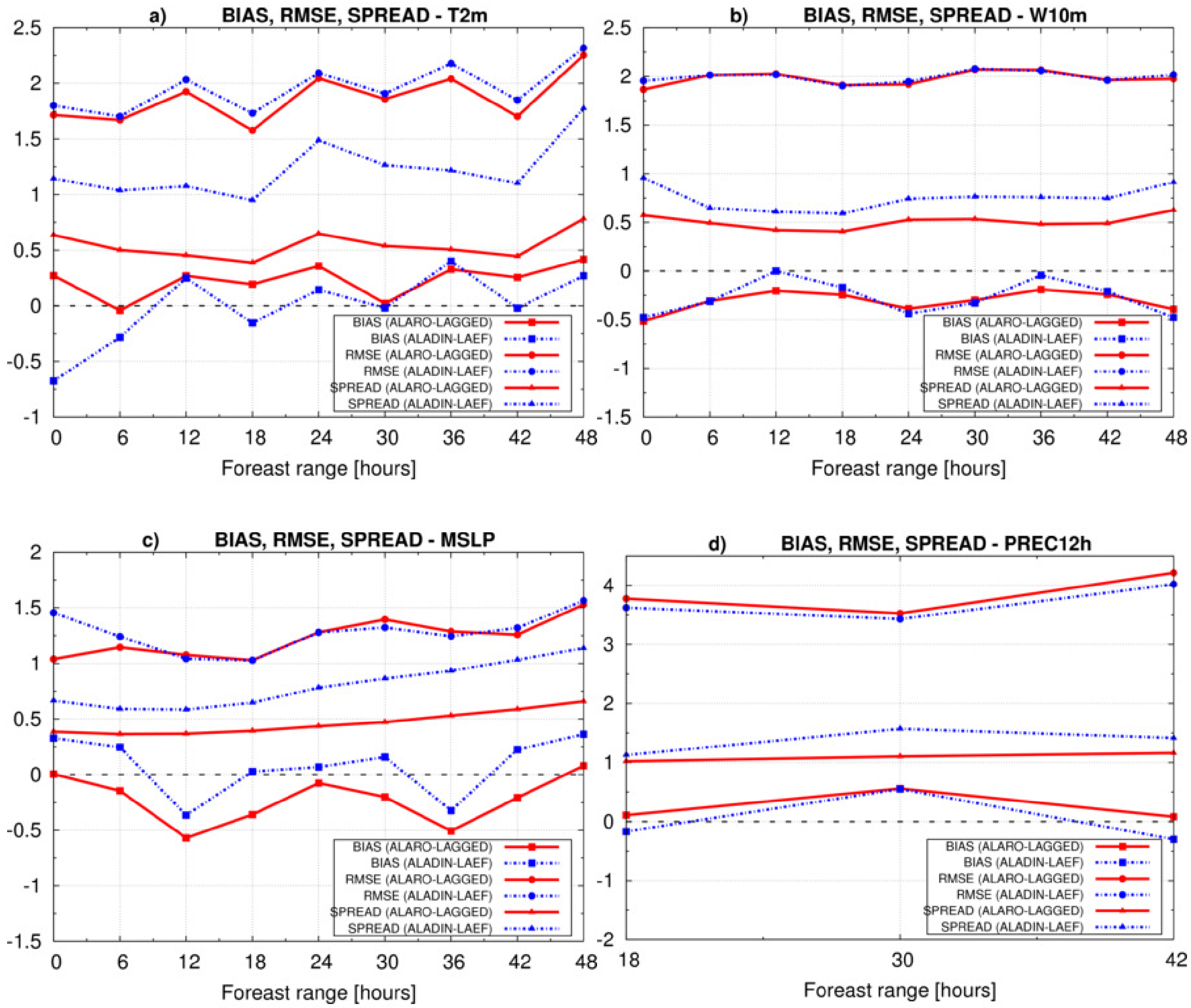

Figure 1. BIAS and RMSE of ensemble mean, ensemble spread of ALARO-LAGGED (red) and ALADIN-LAEF (blue): a) T2m; b) W10m; c) MSLP and d) PREC12h.

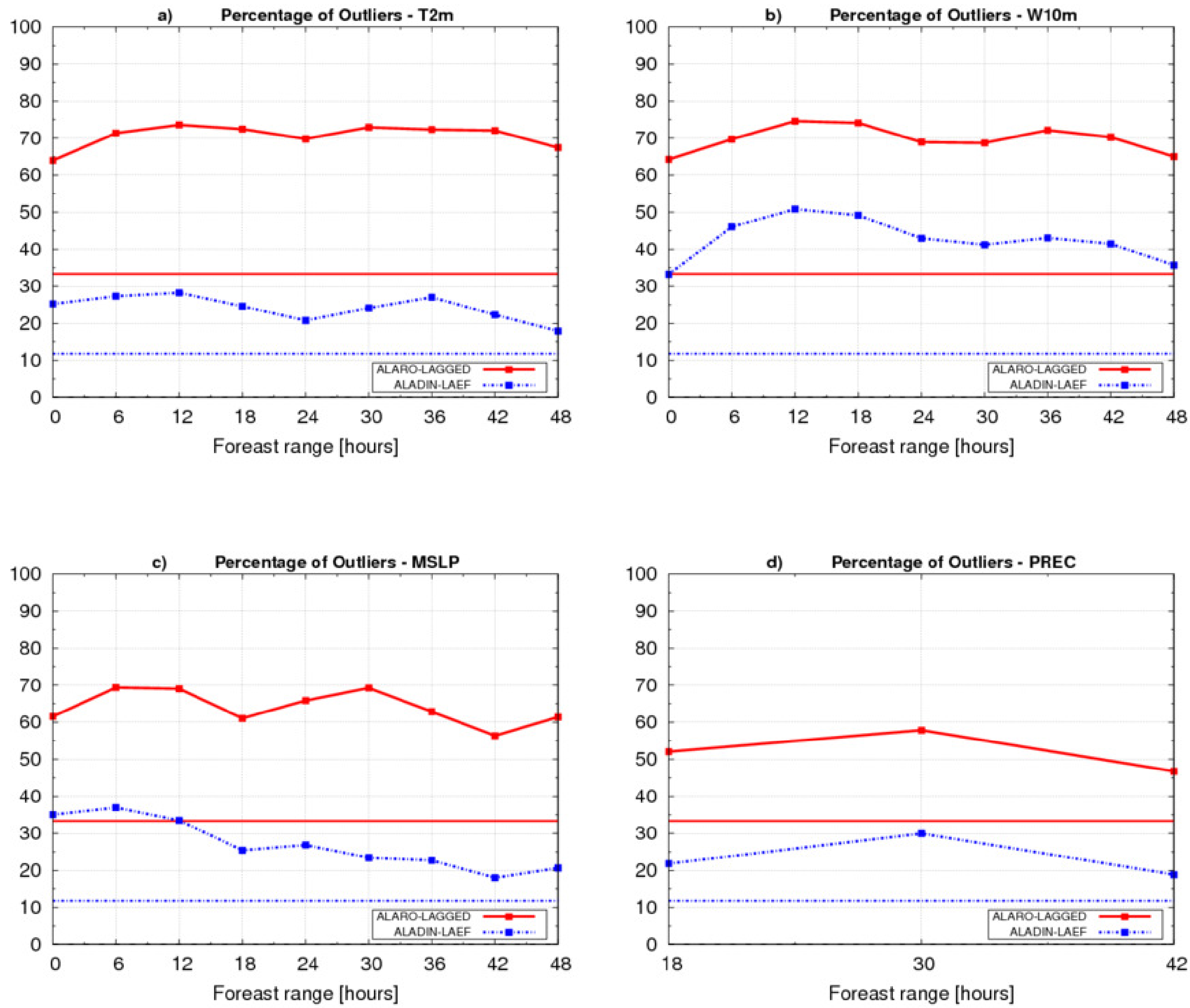

Figure 2. Percentage of outliers of ALARO-LAGGED (red) and ALADIN-LAEF (blue) a) T2m; b) W10m; c) MSLP and d) PREC12h

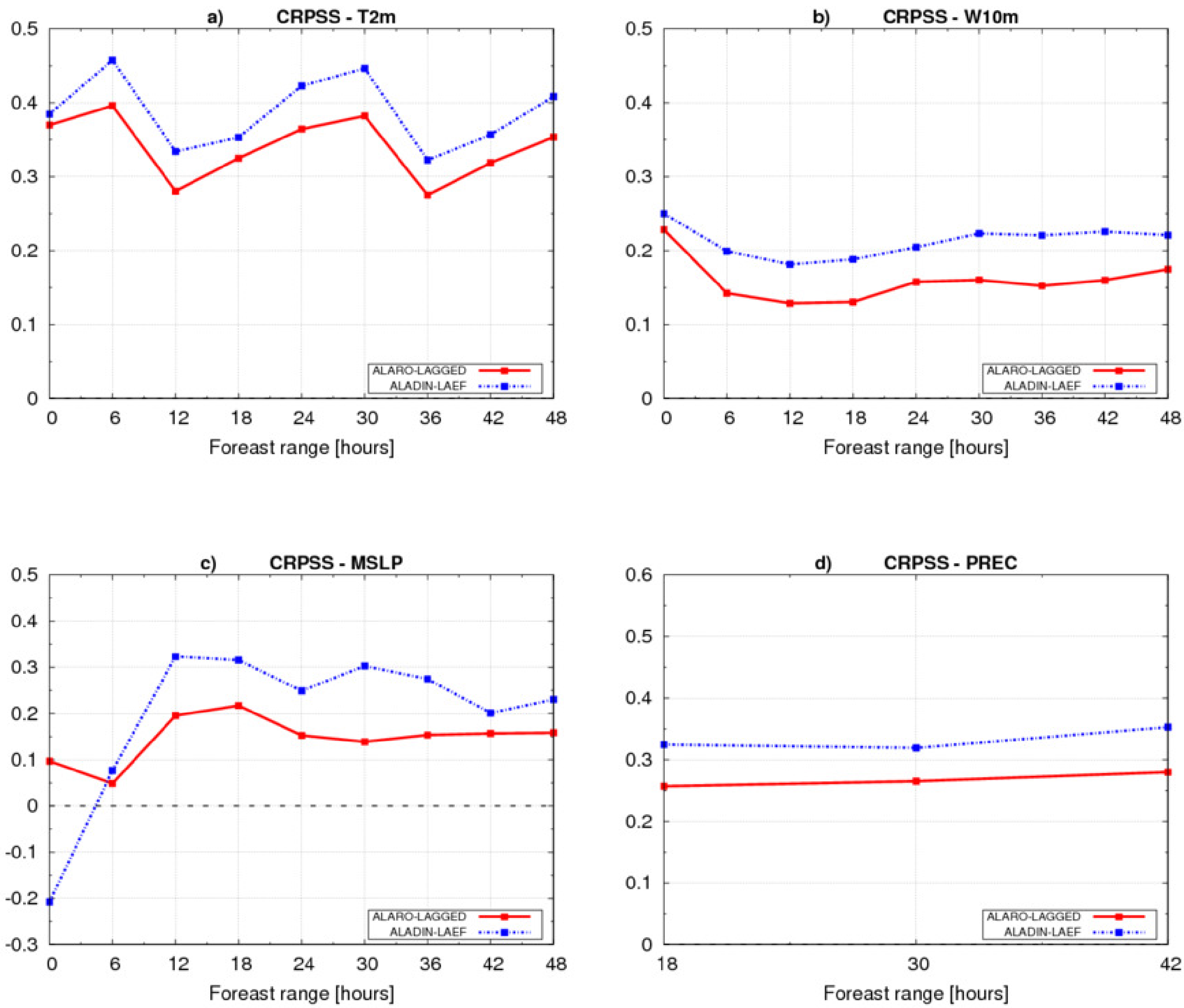

Figure 3. CRPSS of ALARO-LAGGED (red) and ALADIN-LAEF (blue) a) T2m; b) W10m; c) MSLP and d) PREC12h

Another method, in order to do the evaluation between these two systems, the mean and the median of the ALADIN-LAEF are computed, allowing the comparison in a deterministic way.

The BIAS of T2m (a), W10m (b) and MSLP (c) of the most recent run of the ALARO deterministic model and the mean and the median of ALADIN-LAEF have the same tendency of the curves (Figure 4). For ALADIN-LAEF, the BIAS of T2m and MSLP indicates better results than ALARO starting from 12h forecast range. For W10m, BIAS has negative values over the forecast ranges for both systems. The MAE and RMSE scores (Figure 5) of T2m are slightly superior for ALADIN-LAEF and similar for W10m. Regarding MSLP, at beginning and the end of the forecast lenght, the ALARO has better values than ALADIN-LAEF.

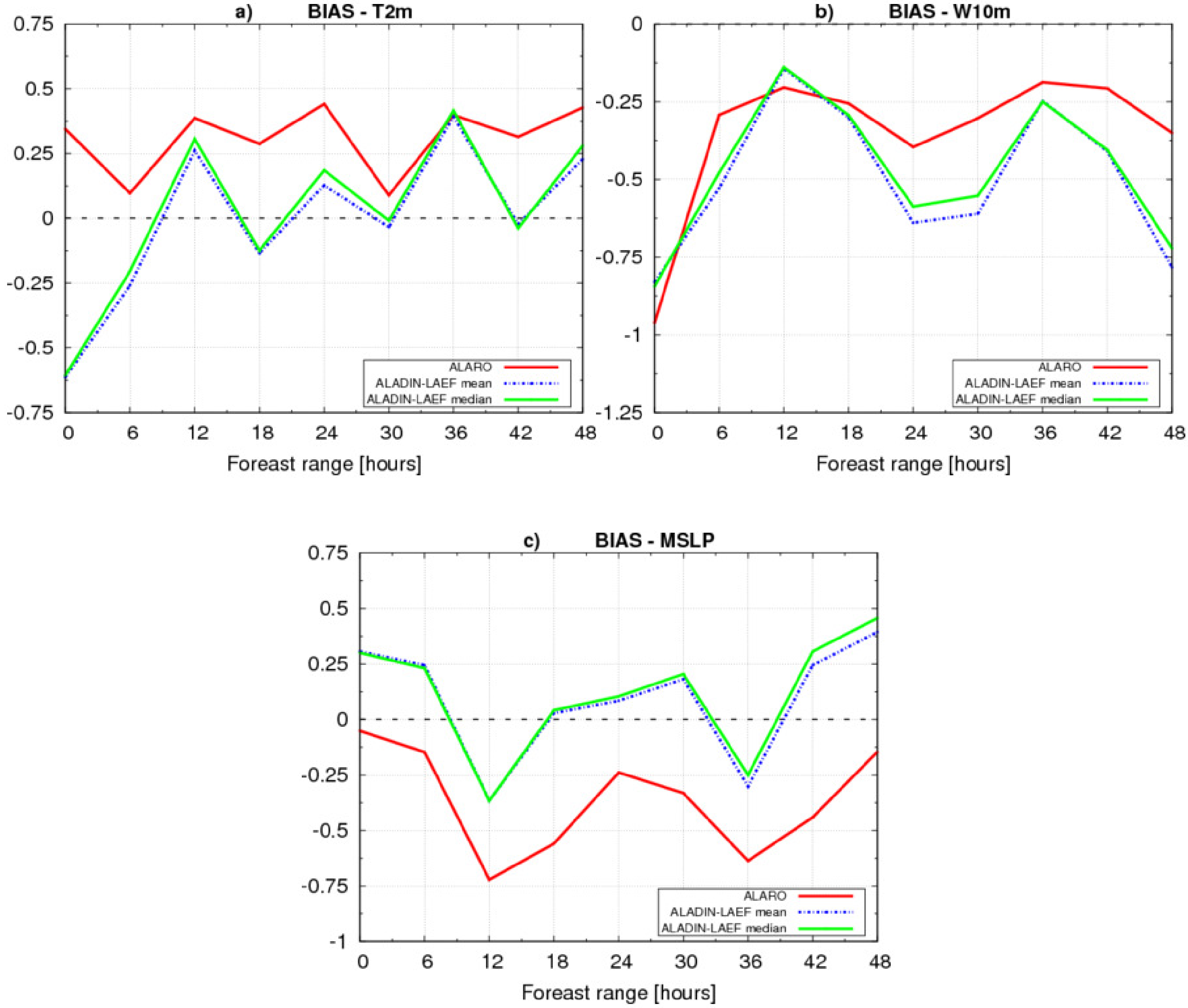

Figure 4. BIAS of ALARO (red) and ALADIN-LAEF mean (blue) ALADIN-LAEF median (green): a) T2m; b) W10m; c) MSLP

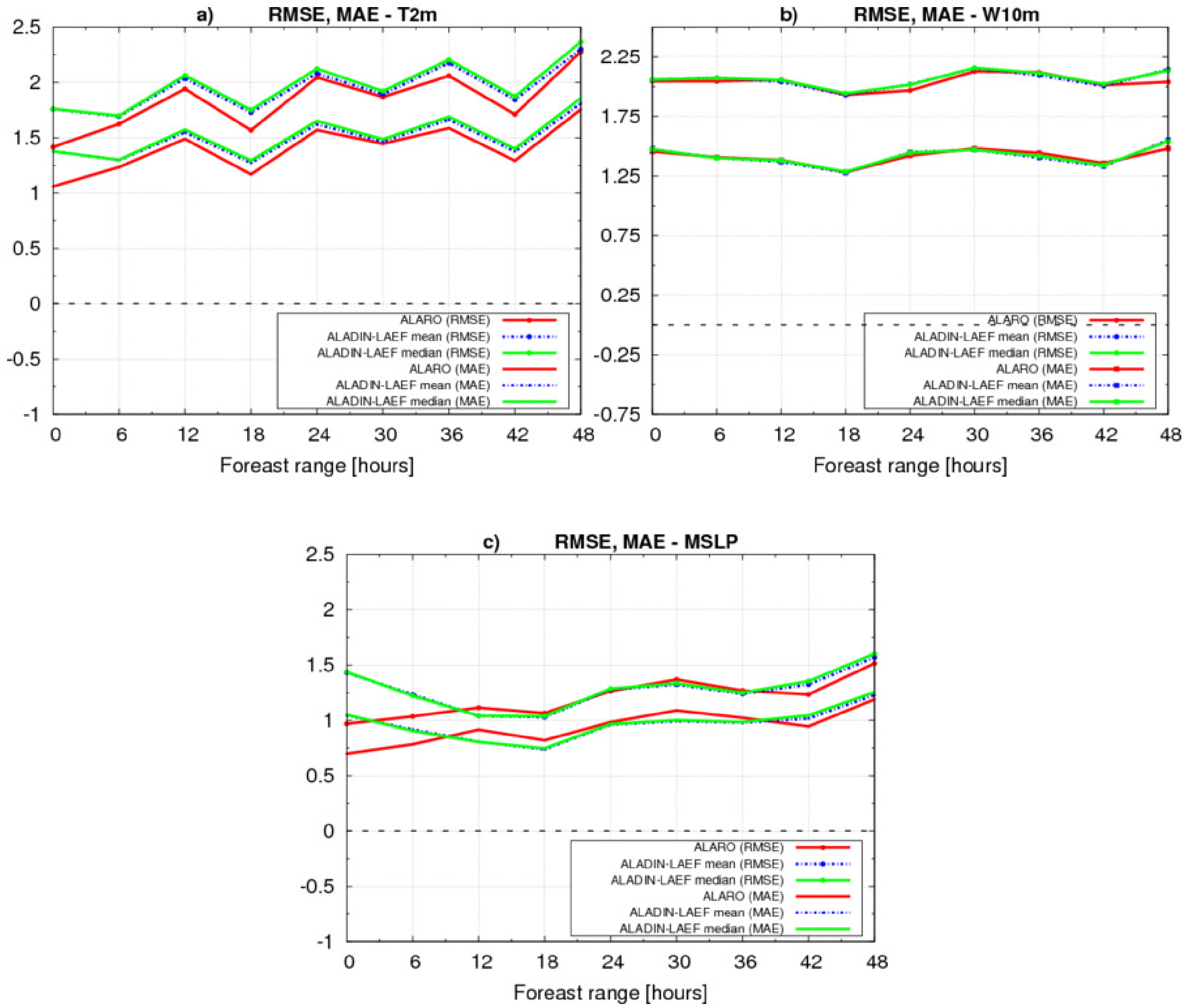

Figure 5. BIAS of ALARO (red) and ALADIN-LAEF mean (blue) ALADIN-LAEF median (green): a) T2m; b) W10m; c) MSLP

The SAL verification has been performed for the entire period for different thresholds (greater than 0.1 mm, 1 mm, 2 mm and 5 mm). For the lower thresholds (up to 2 mm), the curves of the structure component (S) are much closer to 0 for the higher resolution model ALARO (not shown). Otherwise for 5 mm threshold, in Figure 6 (a) it can be noticed the median value of the ALADIN-LAEF has a better structure for forecast ranges greater than 18 hours. The amplitude component (A) shows that all the systems tend to underestimate the area mean precipitation, the curves being, in general, further from the zero-line with negative values. We must keep in mind that the ALADIN-LAEF system has a lower resolution than ALARO, but it is able to capture the structure of the observed precipitation for 5 mm threshold.

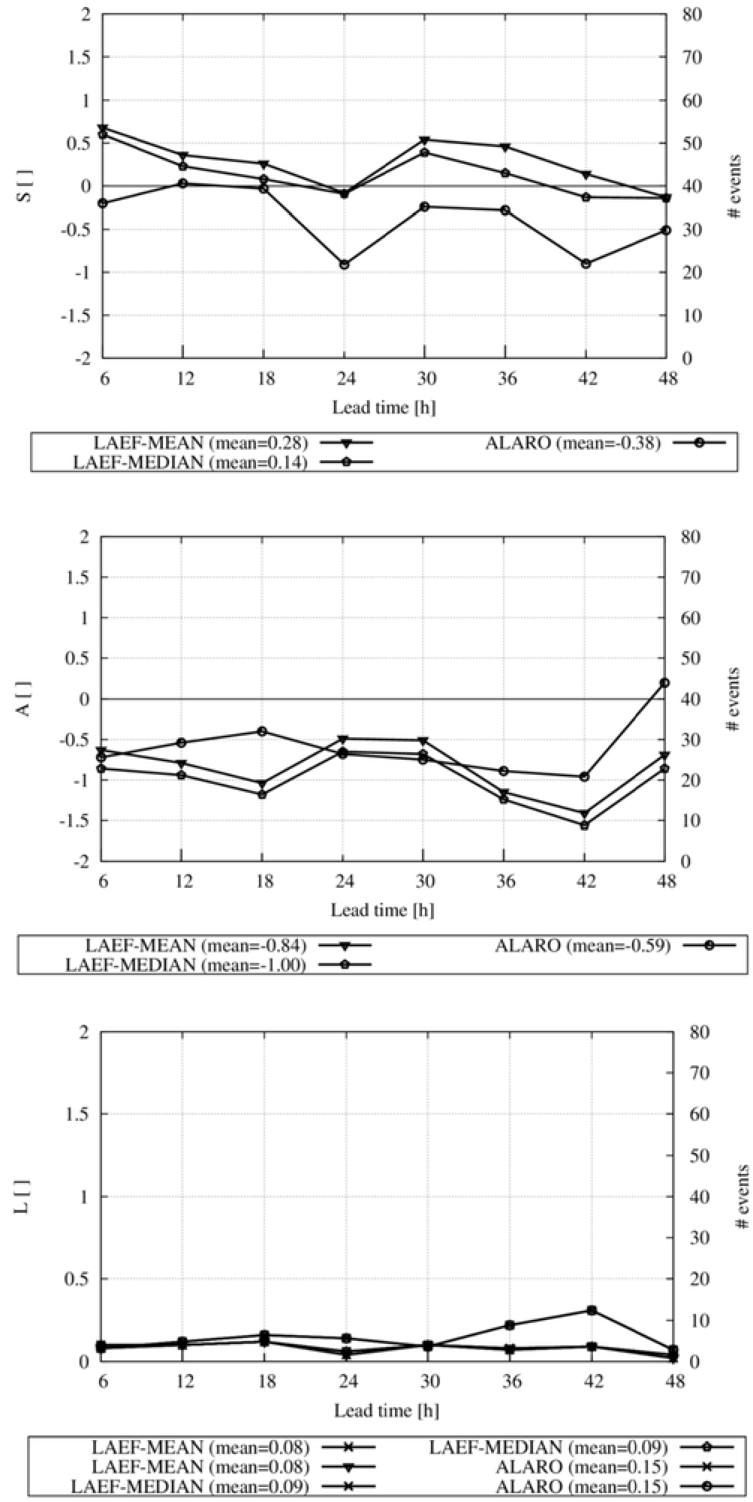

Figure 9. SAL component of ALARO-LAGGED (black-solid) and ALADIN-LAEF mean (black-dashed) ALADIN-LAEF median (gray-dashed): a) **S**tructure; b) **A**mplitude; c) **L**ocation, averaged over Austria domain

Also, FSS was computed for the same thresholds and it has, in general, the same trend as SAL score. Taking into account the results obtained above (Figure 6), Figure 7 shows the FSS score for threshold greater than 5 mm, for different spatial scales (from 1 to 80 km) and only two forecast ranges from the beginning of the interval and two from the end are chosen for the evaluation. FSS varies from 0 to one (perfect score). For all these forecast ranges, it can be noticed the performance of the median of ALADIN-LAEF. Even if for the first two forecast ranges, ALARO model is better than the mean of the ALADIN-LAEF, for the last two it becomes less performant.

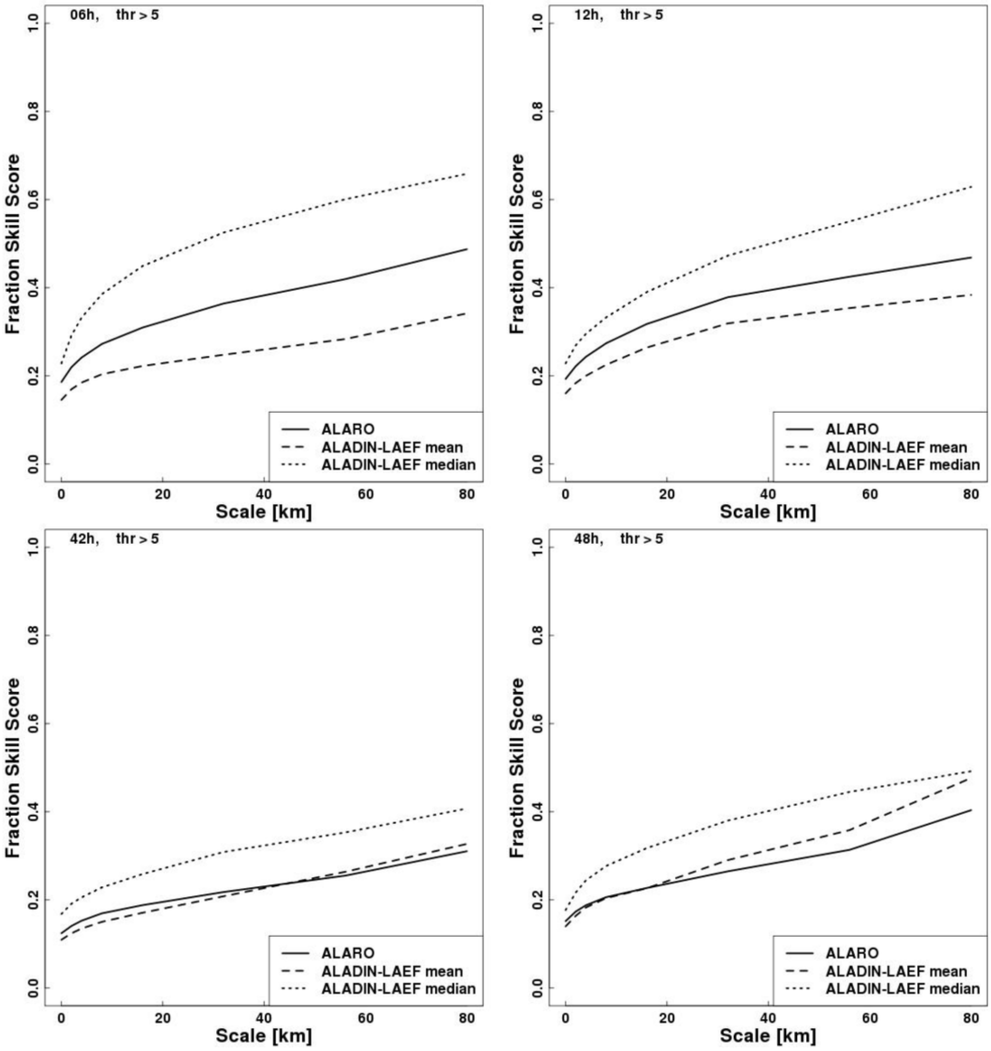

Figure 7. Fraction Skill Score of ALARO-LAGGED (black-solid) and ALADIN-LAEF mean (black-dashed) ALADIN-LAEF median (gray-dashed) for different thresholds,

Case Study

A severe heavy precipitation and flooding event occurred in the period of 31 May – 3 June 2013, affecting the central Europe. The ALARO and ALADIN-LAEF forecasts are used. In Austria, between 31.05.2013, 00 UTC – 03.06.2013, 00 UTC, the highest amount of precipitation was reached up to 300 l/m2 in 72 hours (Figure 8). Our focus is, mainly, on 01.06.2013, 18 UTC – 02.06.2013, 06 UTC interval, which is the event onset when the highest precipitation amounts were registered. Figure 9 contains INCA 6 hour cumulated precipitation over two intervals: 01.06.2013, 18 UTC – 02.06.2013, 00 UTC (a) and 02.06.2013, 00 UTC – 02.06.2013, 06 UTC (b).

Figure 10 contains the area mean of the 06 hours cumulated precipitation for INCA, ALADIN-LAEF and ALARO-LAGGED ensembles averaged over the domain (11.00 to 14.00 E longitude, 47.10 to 48.40 N latitude) which covers the most important area with heavy precipitation (RR Zentrum in figure 8). In Figure 10a, it can be observed that up to 24 lead time, the members of ALADIN-LAEF are not so dispersed than INCA and much closer to it than the ALARO-LAGGED members. After 24 lead time, when the amount of precipitation is starting to increase (up to 15 l/m2), the ALADIN-LAEF members are more dispersed, many of them underestimate the amount of precipitation. The large spread in the predicted precipitation is the result of the uncertainties, indicating a certain probability of a severe event. Thereby, through the larger spread of ALADIN-LAEF, there is a signal, which should be taken into account, that the forecast will be less predictable. The larger spread of ALADIN-LAEF was, also, confirmed by the results obtained for 2 month verification period. The 30 h lead time from Figure 10b corresponds to the 06 h lead time of the next day. It can be noticed, that in this case, both systems have a smaller spread at the beginning of the integrations resulting that the event is more predictable. This is due to the fact that in the initial conditions are not present too many uncertainties.

Different runs of ALADIN-LAEF and ALARO-LAGGED were used in this evaluation. Figure 11 and 13 show the forecasts of ALADIN-LAEF which starts at 31.12.2013, 12 UTC and 01.06.2013, 12 UTC and valid at the same moment 02.06.2013, 00 UTC (36h and 12h lead time). Figure 12 and 14 contain the same forecasts, but for ALARO-LAGGED.

In figure 9a, it can be noticed that in the western part of Austria the amount of precipitation is up to 70-80 l/m2 in 6 hours. Thereby, for the first interval, the run from 31.05.2013, 12 UTC of both systems are able to give signals of a severe event with 36 hours before (Figures 12 and 14). The ALARO-LAGGED members are more or less the same, but forecasts of the ALADIN-LAEF members show different future scenarios, having a larger spread. The mean and median values of ALARO-LAGGED show better precipitation pattern. For the maximum value, the systems show different peaks of the precipitation amount which are present in observation. The precipitation structure is larger for ALARO-LAGGED than the observed one but for ALADIN-LAEF is smaller. Afterwards, the run from 01.06.2013, 12 UTC, with 12 hours before, is the one which can lead to a better weather situation understanding for ALADIN-LAEF. Even the mean, median and minimum of the ALARO-LAGGED show a better precipitation pattern, it is obvious for the maximum value that ALADIN-LAEF is able to give more information. Using the precipitation maximum values of an ensemble it is useful because more information are obtained. An ensemble gives many weather possible scenarios and a maximum value gives the peaks over the members.

In the next 6 hours, the system has almost the same structure, but more extended within Austria. Figures 15 and 18 show ensemble systems forecasts for 42h lead time. The peaks of precipitation amount are better forecast by the finer ALARO-LAGGED ensemble. Both systems missed to forecast or to give an appropriate signal for the precipitation amount or structure from the northern part of Austria. The information from the deterministic lagged members is very valuable. But if, only, the most recent run of ALARO-LAGGED ensemble (member 1), which is integrated at the same time as ALADIN-LAEF ensemble, it can be noticed that it is not capable to capture the whole precipitation structure and ALADIN-LAEF ensemble gives more information. Thereby, the added value of ALADIN-LAEF is worth to be taken into account. Going further, to the run from 01.06.2013, 12 UTC, the results of ALADIN-LAEF lead to a better forecast. An overall information is retrieved from maximum value.

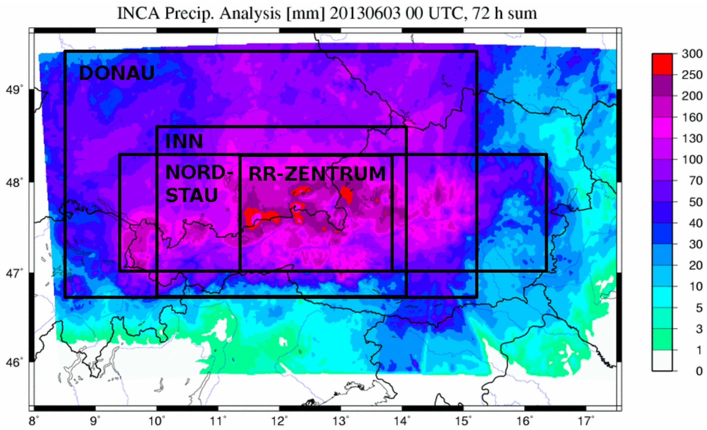

Figure 8: INCA 72 hours cumulated precipitation: 31.05.2013, 00 UTC – 03.06.2013, 00 UTC

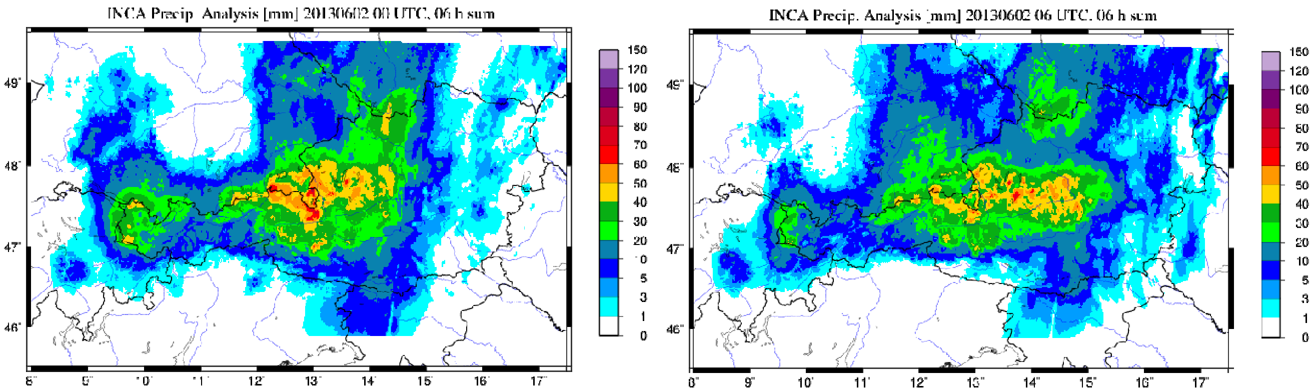

Fig 9: INCA 6 hours cumulated precipitation: 01.06.2013, 18 UTC – 02.06.2013, 00 UTC (a), 02.06.2013, 00 UTC – 02.06.2013, 06 UTC (b)

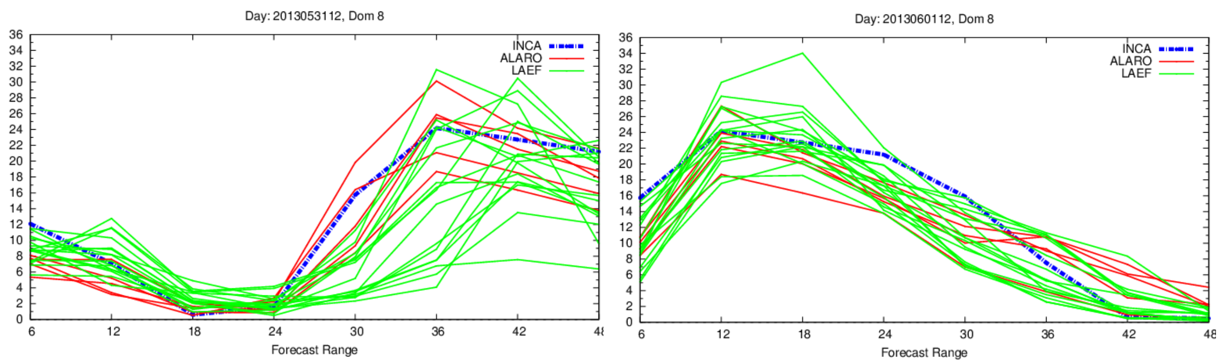

Fig 10: 6 hours cumulated precipitation starting from 31.05.2013, 12 UTC (a) and 01.06.2013, 12 UTC (b): INCA (blue), ALADIN-LAEF members (green), ALARO-LAGGED members (red).

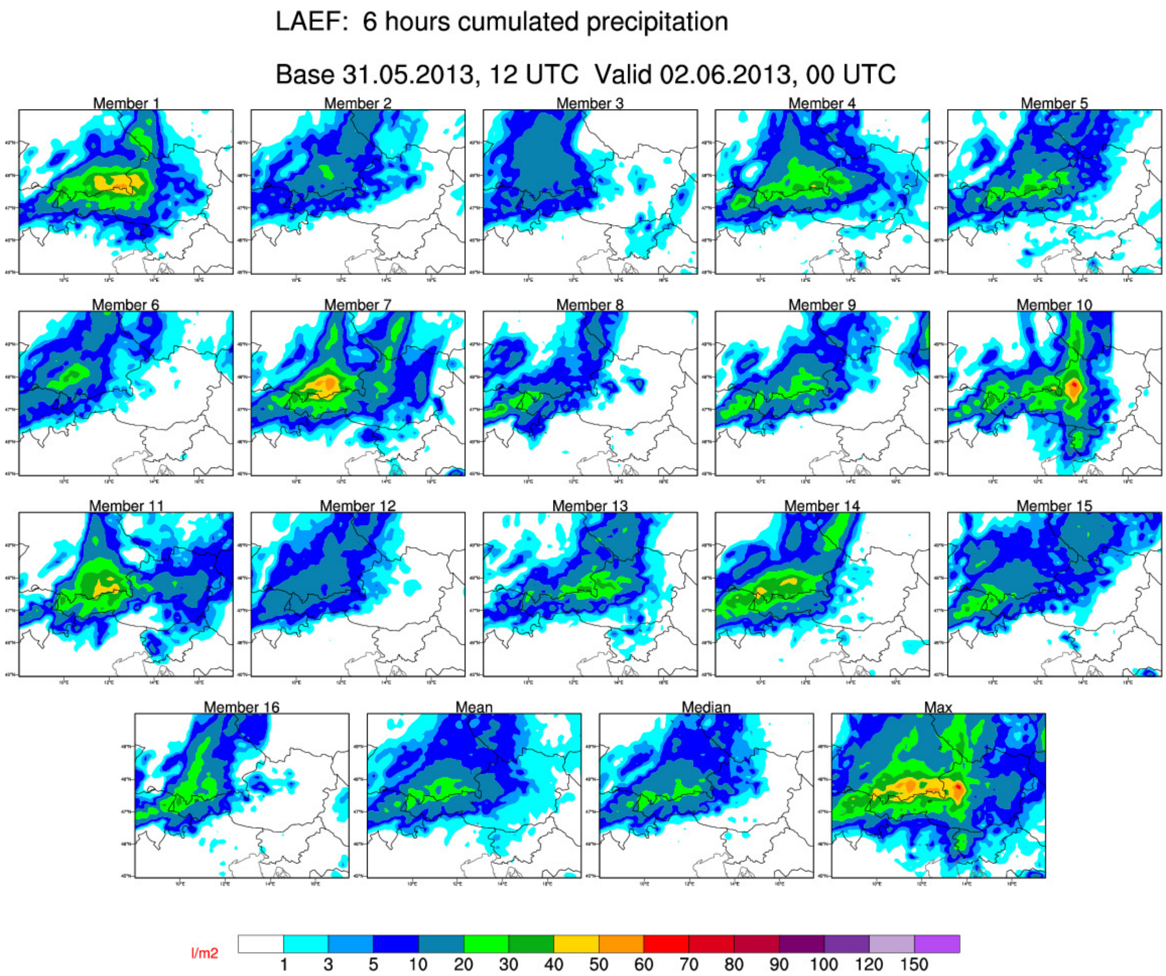

Figure 11： 6 hours cumulated precipitation for ALADIN-LAEF, 31.05.2013, 12 UTC + 36 h

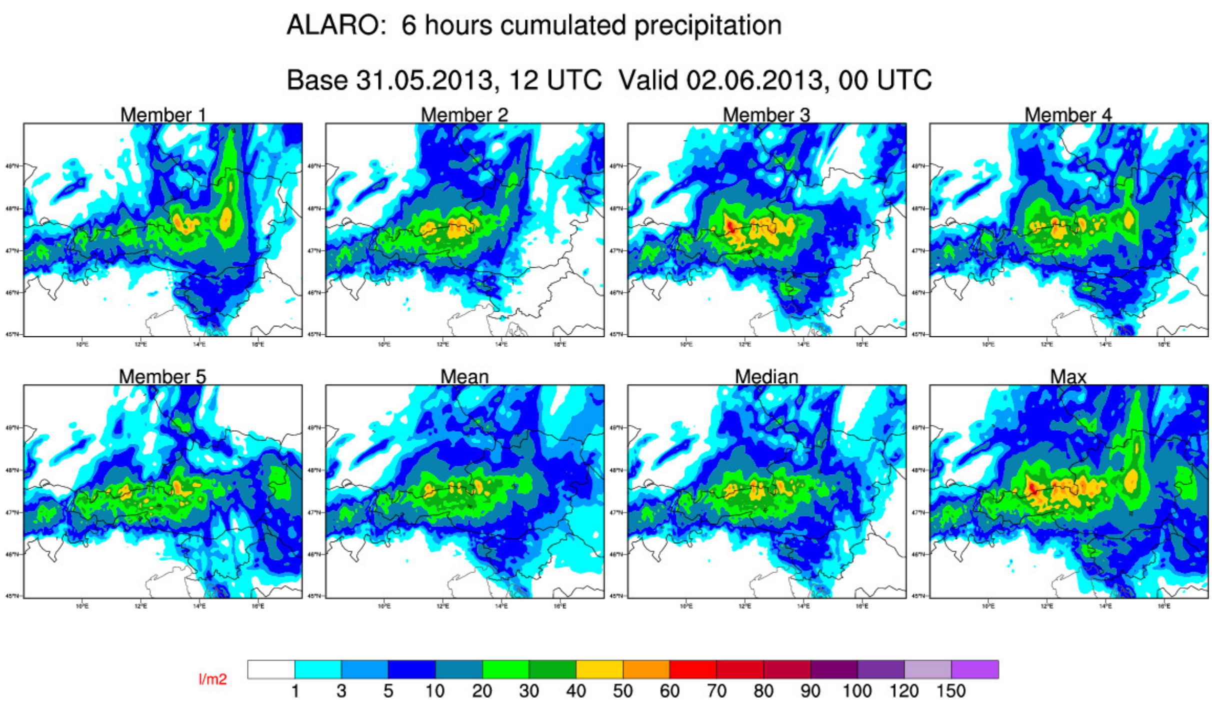

Figure 12: 6 hours cumulated precipitation for ALARO-LAGGED, 31.05.2013, 12 UTC + 36 h

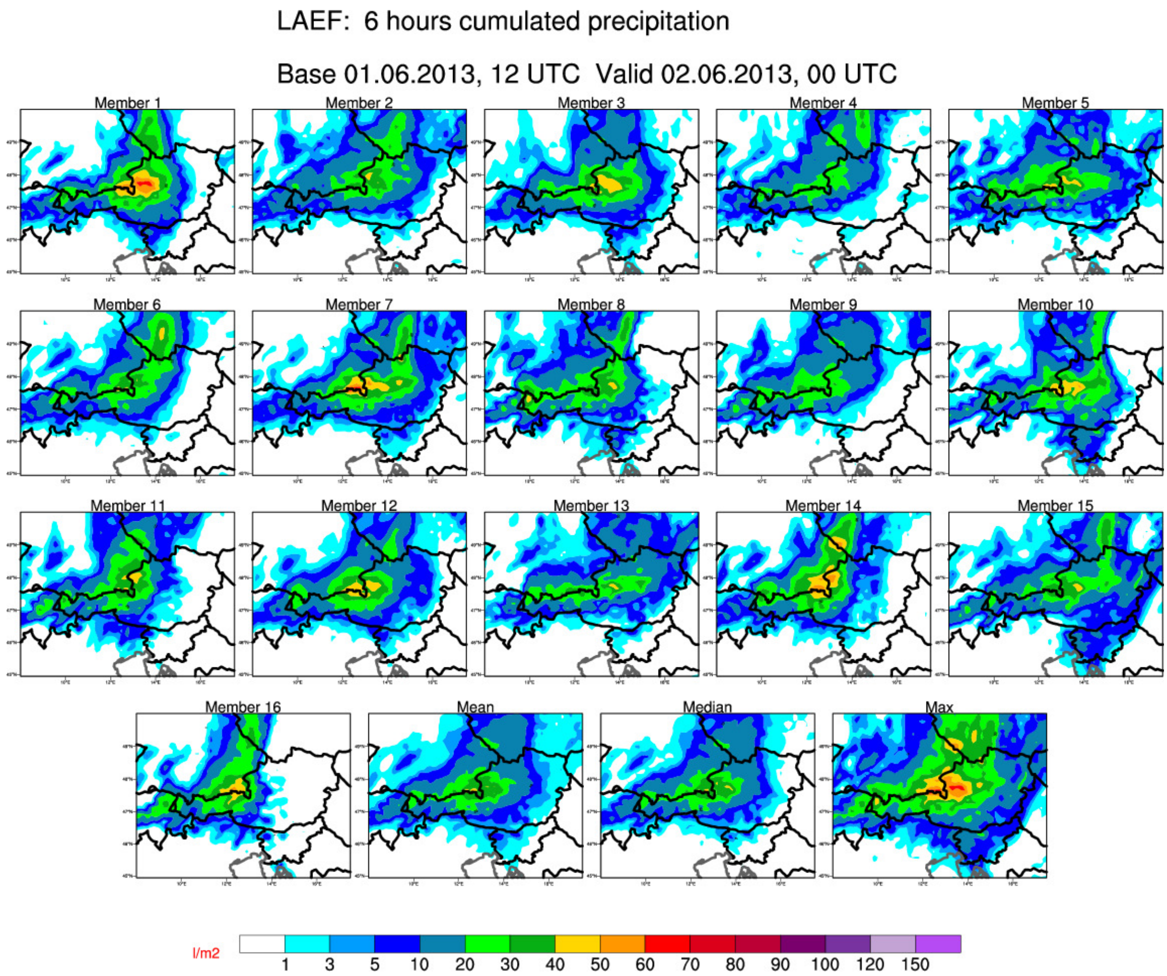

Figure 13: 6 hours cumulated precipitation for ALADIN-LAEF, 01.06.2013, 12 UTC + 12 h

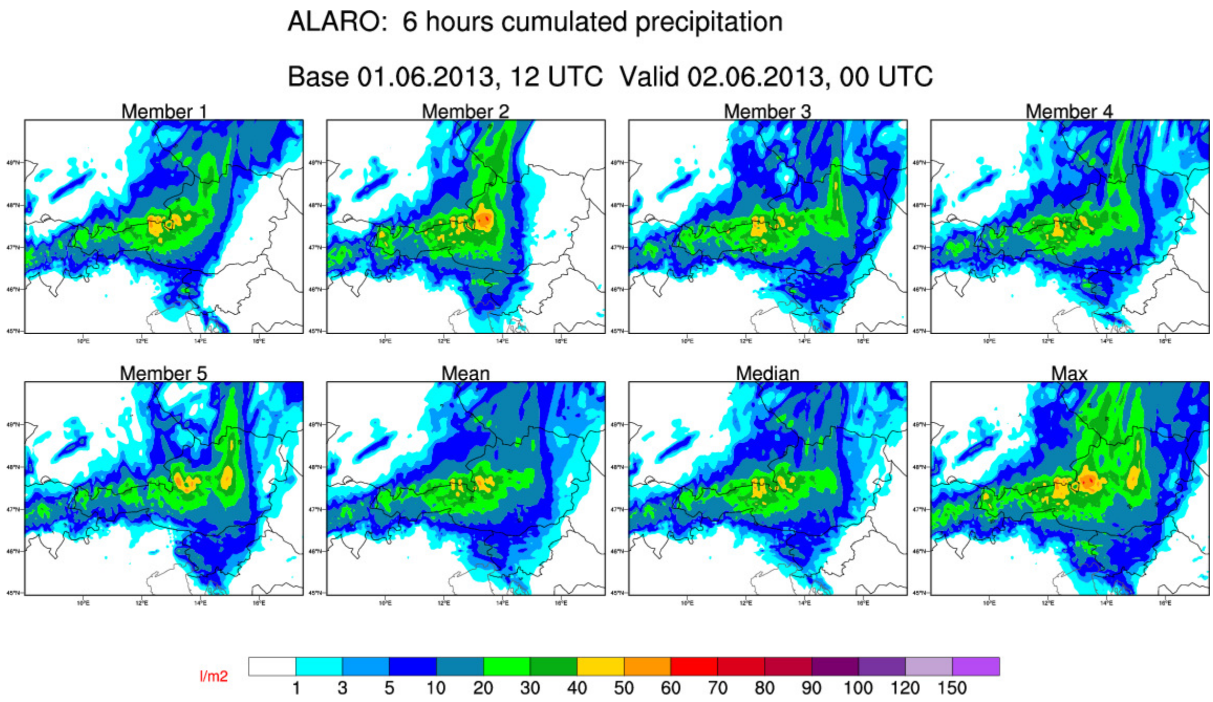

Figure 14: 6 hours cumulated precipitation for ALARO-LAGGED, 01.06.2013, 12 UTC + 12 h

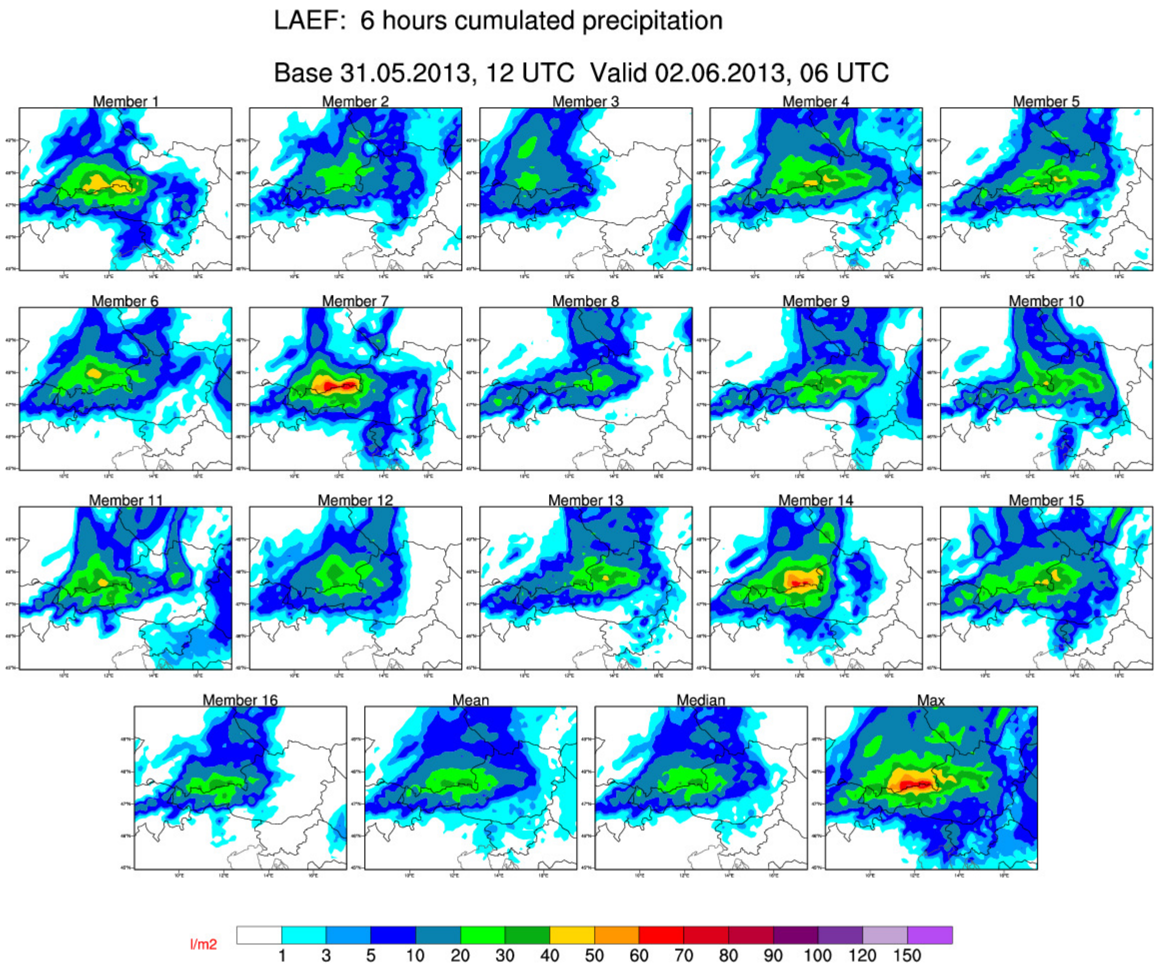

Figure 15: 6 hours cumulated precipitation for ALADIN-LAEF, 31.06.2013, 12 UTC + 42 h

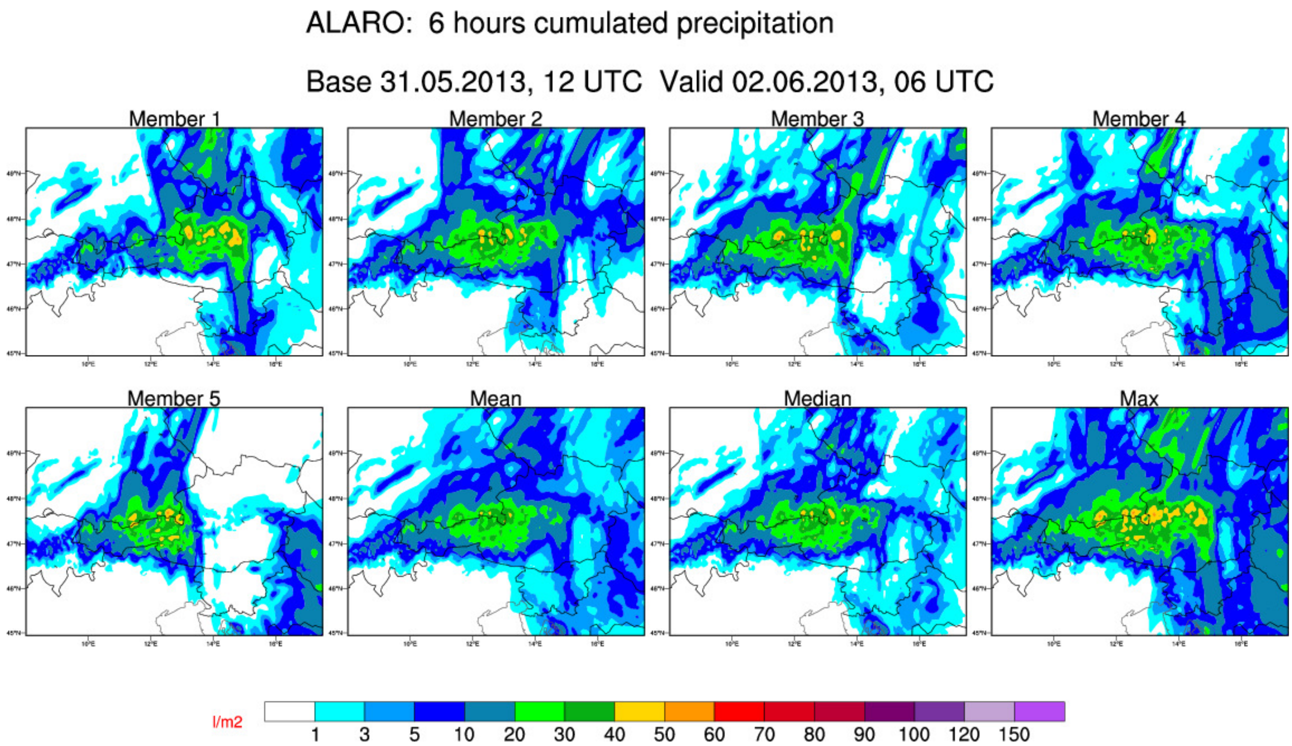

Figure 16: 6 hours cumulated precipitation for ALARO-LAGGED, 31.05.2013, 12 UTC + 42 h

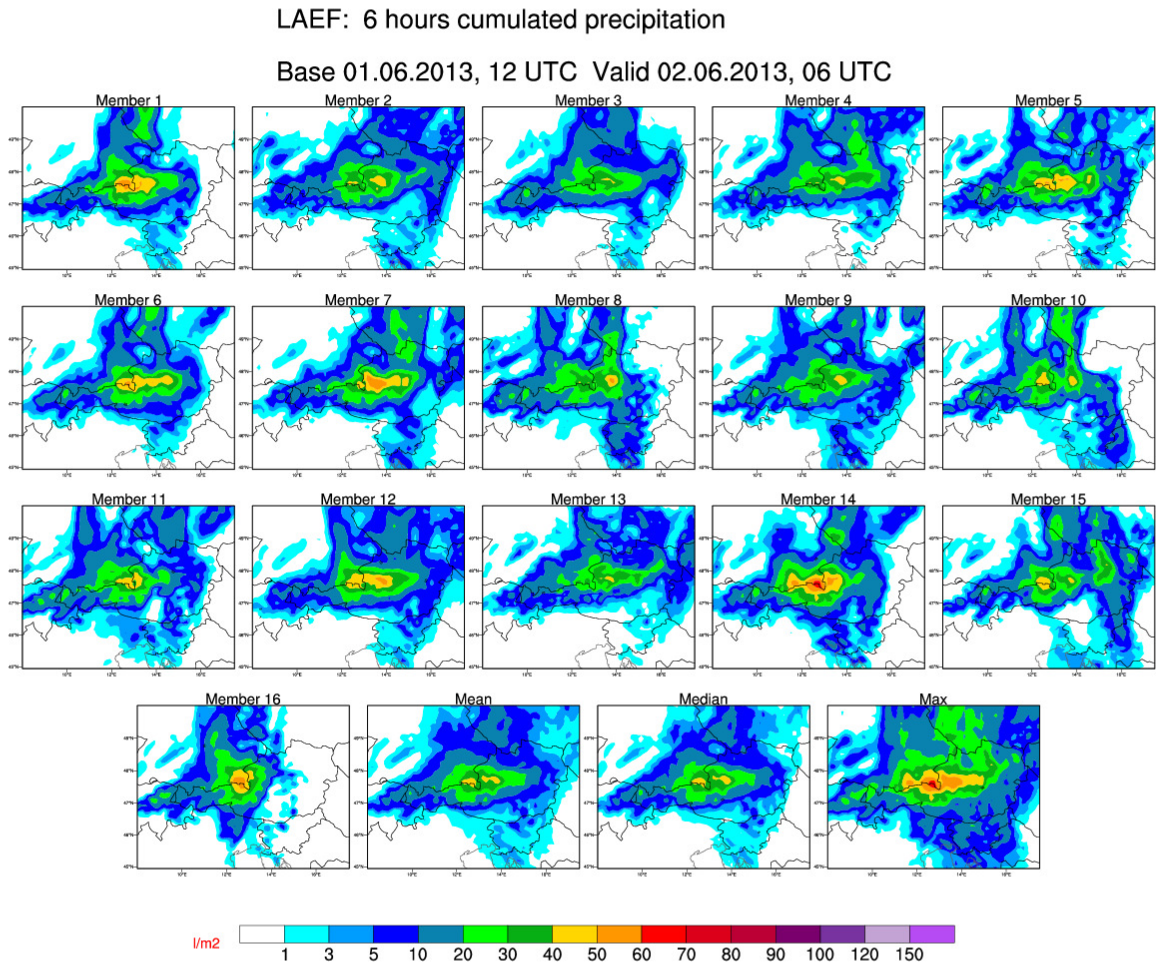

Figure 17: 6 hours cumulated precipitation for ALARO-LAGGED, 31.05.2013, 12 UTC + 42 h

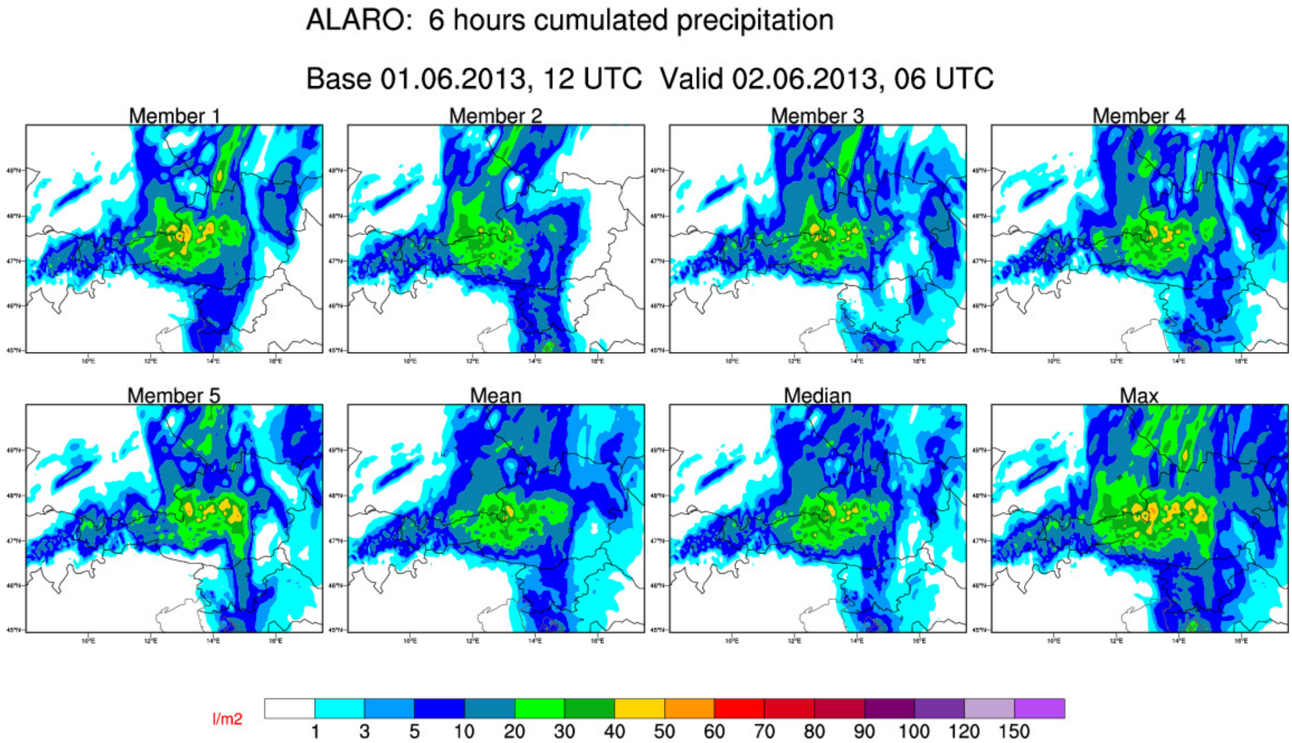

Figure 18: 6 hours cumulated precipitation for ALARO-LAGGED, 01.06.2013, 12 UTC + 18 h