On ALADIN Precipitation Forecasts over the European Alps

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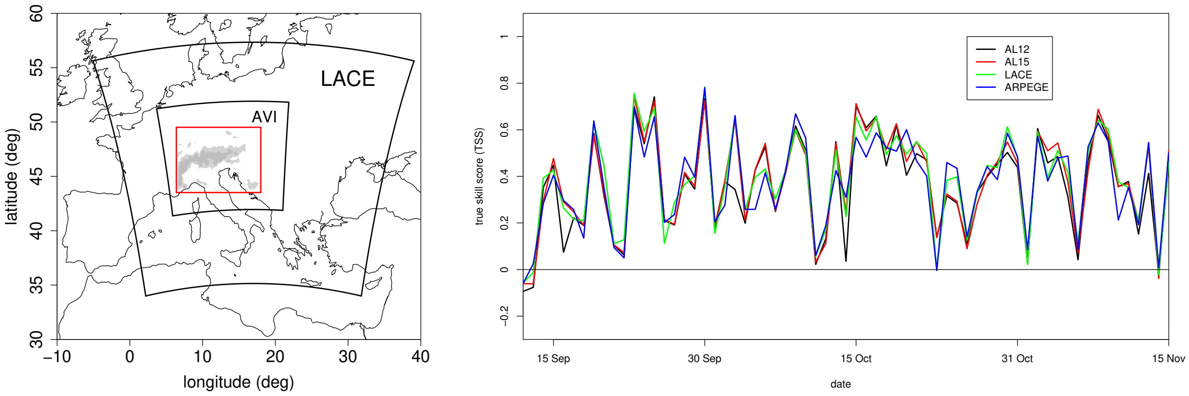
1 Introduction

Forecasting precipitation over complex terrain is a challenging task, in particular, for high-resolution limited-area models. In this report we compare ALADIN precipitation forecasts (9.6 km gridspacing) from different model versions to the high-resolution rain-gauge analysis (Frei and Haeller, 2001) available for the Mesoscale Alpine Programme Special Observation Period (MAP SOP, Sept. 7 to Nov. 15, 1999). This precipitation analysis has a time resolution of 24 h and a spatial resolution of 25 km, thus the forecasted precipitation fields are aggregated to 25 km. To assess the impact of the validation grid, additional comparisons have been carried out for gridspacings of 50 and 100 km, respectively.

The target area covers most of the European Alps and substantial part of the domain of ALADIN/VIENNA, the operational configuration at the Austrian weather service (ZAMG). Investigations have been performed for the period Sept. 12 to Nov. 15, 1999. Within this period several events of heavy precipitation have been observed with 24 h accumulated rainfall of more than 100 mm in particular regions.

2 ALADIN simulations



(a) (b)

Figure 1: (a) Domain bounds for model configurations and (b) time-series of true-skill-score (TSS) for different configurations.

We have performed simulations with the hydrostatic ALADIN/VIENNA (AVI) system for model cycles 12 and 15. With both model configurations sequences of 65 forecasts (Sept. 12 to Nov. 15, 1999) have been carried out, each over 30 hours discarding the leading 6 hours of the forecast to avoid a possible spin-up within the model. The forecasts are nested (6 hour coupling) into ALADIN/LACE data for 1999. From these forecasts daily precipitation amounts are obtained, as the difference between forecasts valid at t+30 and t+6, respectively. In addition, precipitation forecasts from ALADIN/LACE as well as from ARPEGE are used for comparison. For every configuration the precipitation fields are interpolated onto the validation grid using an inverse-distance-weighting method on the basis of the 16 nearest gridpoints. Assuming that the effective resolution is 4Δx and above (see e.g. Grasso, 2000) this choice seems reasonable. The agreement between the forecasted precipitation fields and the rain gauge analysis is investigated through bias and RMS fields as well as quantitatively in terms of skill scores. Fig. 1a illustrates the model configuration domains (i.e., LACE and AVI) as well as the validation region shown as red box. In the following, results are presented for the comparison of predicted precipitation rates derived from the model forecasts with the MAP SOP rain-gauge analysis. The statistics are computed on the basis of the 65 consecutive days from Sept. 12 to Nov. 15, 1999.

Table 1 summarizes the performance for the four model configurations in terms of bias, root-mean-square error (rms) and skill scores for gridspacings of 25, 50, and 100 km, respectively. The bias is computed as analysed precipitation minus model prediction. The individual entries in Table 1 are bias [mm/day], rms [mm/day], rank-correlation (cor), variance ratio (r.var, computed as ratio model/analysis), hit rate (HR), probability of detection (POD), and true-skill-score (TSS). For the definition of accuracy and skill scores, refer to Wilks (1995). Focusing on the comparison between model versions 12 and 15 (i.e. the first two rows in Table 1) reveals that there is a clear difference between the two model versions in terms of predicted rainfall. The TSS as well as the rank-order correlation suggest that AL15 produces slightly more accurate precipitation fields. The most significant differences between the two configurations are observed for the model bias and the variance ratio. Comparing the statistics of the different ALADIN configurations to ARPEGE reveals that the performance of ARPEGE is similar or even slightly better in terms of skill-scores, although the model bias is larger. Increasing the gridspacing of the underlying validation grid results in smaller rms differences as well as higher correlations as expected due to the inherent smoothing of the fields.

25km	bias [mm/day]	rms [mm/day]	cor [1]	r.var [1]	HR [1]	POD [1]	TSS [1]
AL12	0.21	7.07	0.44	1.40	0.75	0.66	0.36
AL15	-0.41	6.99	0.49	1.72	0.78	0.71	0.39
LACE	-0.53	7.00	0.49	1.91	0.78	0.73	0.40
ARPEGE	-0.50	6.88	0.49	1.98	0.78	0.74	0.39

50km	bias [mm/day]	rms [mm/day]	cor [1]	r.var [1]	HR [1]	POD [1]	TSS [1]
AL12	0.26	6.32	0.48	1.40	0.77	0.71	0.40
AL15	-0.38	6.18	0.52	1.69	0.80	0.75	0.42
LACE	-0.51	6.18	0.53	1.83	0.80	0.78	0.43
ARPEGE	-0.52	6.20	0.53	1.94	0.79	0.77	0.42

100km	bias [mm/day]	rms [mm/day]	cor [1]	r.var [1]	HR [1]	POD [1]	TSS [1]
AL12	0.30	5.59	0.55	0.76	0.79	0.76	0.40
AL15	-0.43	5.32	0.58	1.19	0.81	0.80	0.39
LACE	-0.53	5.30	0.59	1.28	0.81	0.82	0.39
ARPEGE	-0.57	5.45	0.59	1.27	0.81	0.82	0.41

Table 1: Statistics of precipitation fields for different model configurations computed with respect to MAP SOP rain gauge analysis for gridspacing of 25, 50, and 100 km

Fig. 1b shows TSS for the 65 individual dates computed for a gridspacing of 25 km. It is clear that even for the large validation domain considered here more than 10 dates are associated with very poor forecasts. The best skill-scores within this period are close to 0.8 for all configurations. The mean values of the individual curves can be seen from the last column in Table 1 (25 km).

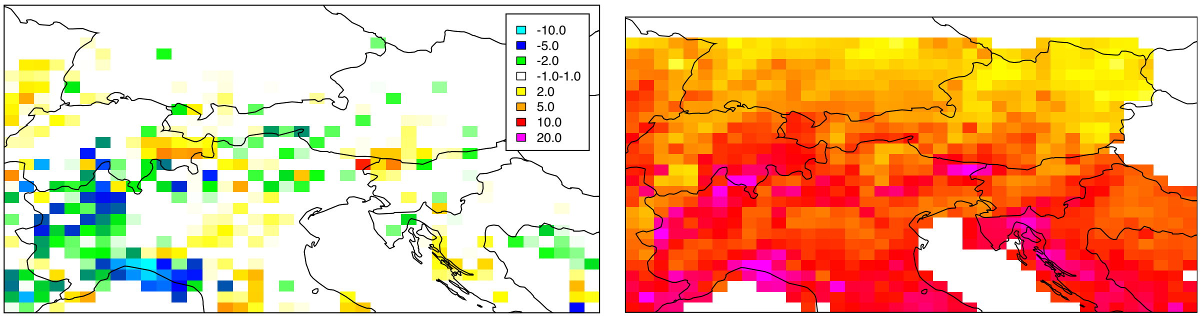


Figure 2: Bias (left) and rms (right) [mm/day] for AL12 computed from the 65 consecutive dates and gridspacing of 25km. Bias is computed as rain-gauge analysis minus model forecast.

Let us now look at the difference between model versions 12 and 15 in terms of spatial fields. Figs. 2 and 3 show bias (a) and rms (b) fields for 25 km gridspacing. Not surprisingly, the strongest bias is found on the windward side of the Alps with extrema of -10 mm/day. The differences between Figs. 2 and 3 are small though the statistics (see Table 1) suggest that version 15 produces more accurate precipitation forecasts with respect to the rain-gauge analysis considered here.

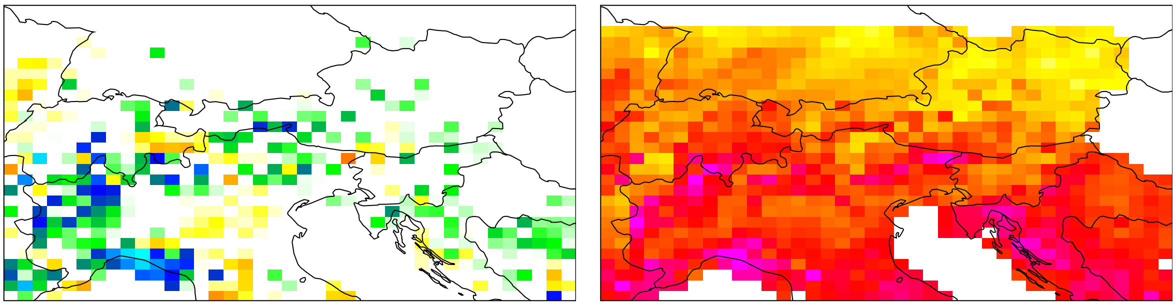


Figure 3: as Fig. 2, but for model version 15 (AL15).

3 Conclusions

Precipitation forecasts over the Alps have been compared to the MAP SOP rain-gauge analysis for different validation grids. The smallest gridspacing considered for the validation grid is 25 km. The results suggests that there is an improvement in terms of predicted rainfall between ALADIN versions 12 and 15 even on the (fairly) large scales considered within this study. The average TSS is between 0.4 and 0.5 depending on the validation grid considered. The comparison of the ALADIN configurations to ARPEGE suggests that on scales of 25 km or above, as considered here, there is hardly any improvement in terms of precipitation forecasts. We stress that the results presented here are by no means complete and are presumably dependent on the reference analysis as well as the validation method chosen. Nevertheless, we think that the MAP SOP and the approaches considered here might serve as a basis for future evaluations of the performance of ALADIN not only with respect to precipitation but also for other variables.

Consequently, the next step is to investigate approaches for validation on scales of 10 km suitable for ALADIN precipitation forecasts. These approaches include the use of precipitation fields derived from radar data as well as the indirect validation of precipitation against observed runoff measurements (Ahrens et al., 2003).

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