Verification of Lokal-Modell Operational Suites at ARPA-SIM: Impact of the Nudging-based Assimilation Scheme.

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Abstract

High resolution Quantitative Precipitation Forecast (QPF) obtained by non-hydrostatic model Lokal-Modell (LM) has been verified. In particular, standard version and nudging version (where temperature, wind, surface pressure and humidity are assimilated) of LM, both utilized at ARPA-SIM, have been compared. A comparison in terms of temperature and dew-point temperature has also been carried out.

1 Introduction

1.1 Lokal-Modell

The operational implementation of Lokal Modell (LM) at ARPA-SIM consists of two 72-hour integrations every day (starting at 00 UTC and 12 UTC) with an horizontal resolution of 7 km and a vertical discretization of 35 levels, over the domain reported in Fig. 1. In this work the 00 UTC suite is compared with a parallel experimental suite starting at the same time but where a mesoscale data assimilation based on a nudging scheme (horizontal wind, temperature, humidity and surface pressure are assimilated) is performed. At the time of writing (January 2004), both 00 and 12 UTC operational suites make use of the mesoscale data assimilation.

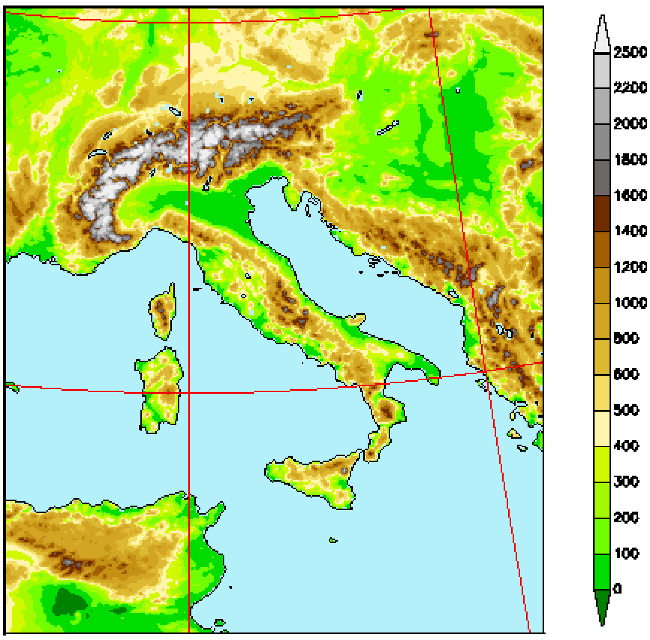

Figure 1: Operational domain of LM at ARPA-SIM.

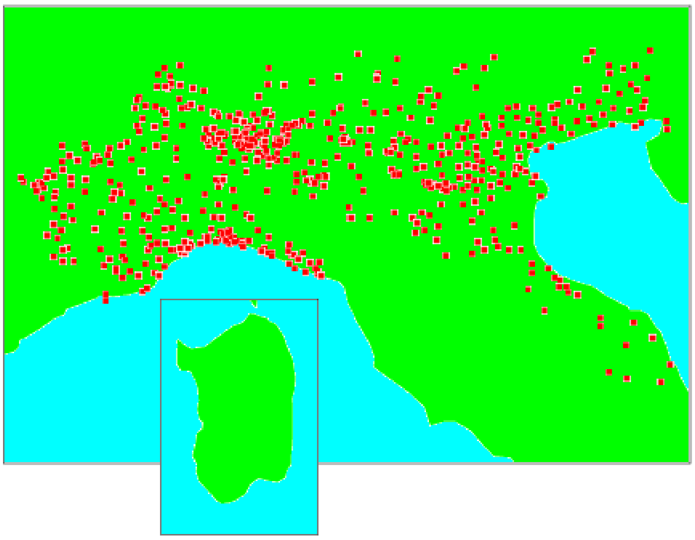

Figure 2: Operational domain of LM at ARPA-SIM.

1.2 Verification Methodology

An objective verification has been performed in order to assess the impact of the use of a mesoscale data assimilation on the operational model runs. In this report, the analysis is done in terms of three meteorological parameters: precipitation, temperature and dew-point temperature.

The precipitation (TP) verification is based on the evaluation of contingency tables for different precipitation thresholds, from which is possible to deduce some verification indices: Bias Score (BS), Threat Score (TS), False Alarm Rate (FAR) and Heidke Skill Score (HSS) have been used in this work. This verification has been carried out in terms of 6-hour cumulated precipitation, comparing the observed value at a station point against the forecast value of the nearest grid point. Observations are derived from a raingauge network covering Northern Italy, showed in Fig. 2 and the considered period is from 1 March to 30 June 2003. Two thresholds have been considered: precipitation exceeding 1mm/6h and 10mm/6h. The considered period has been characterized by very little precipitation, so the number of observations exceeding the two thresholds is not so high (about 1000 and 400, respectively).

The temperature (T) and dew-point temperature (Td) verification has been carried out using the same network but the verification period goes from 1 March to 31 May 2003 (spring). The value observed at a station point has been compared against the forecast value of the nearest grid point, without any corrections for the differences in height between station point and grid point. When this difference exceeds 500m, the point has not been considered in the computation. The indices used are the mean absolute error (MAE) and the BIAS.

The definitions of the indices used in this work are the following:

Contingency Table		observed yes	observed no
forecasted	yes	a	b
forecasted	no	c	d

$$BS = \frac{a+b}{a+c}, \qquad TS = \frac{a}{a+b+c}, \qquad FAR = \frac{b}{a+b},$$

$$BIAS = \frac{1}{N}\sum_{i=1,N}^{N}(p_i - o_i), \qquad MAE = \frac{1}{N}\sum_{i=1,N}^{N}|p_i - o_i|.$$

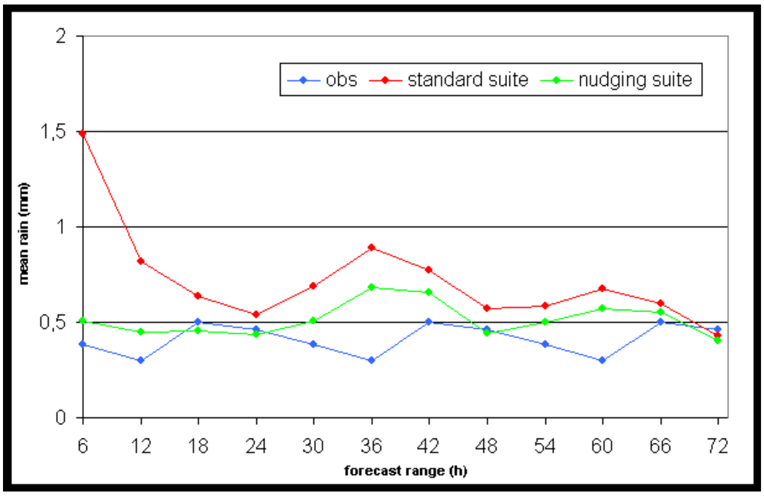

Figure 3: Trends, as a function of the forecast range, of the observed (blue line) and forecast (red line for the standard suite and green line for the nudging suite) precipitation, averaged over all station points and over the whole period.

2 Results

2.1 Precipitation

Precipitation trends averaged over the whole period and over all the station points with varying forecast range are shown in Fig. 3. Blue line is relative to the observed values, while the red and the green lines are relative to the forecast values interpolated on station points (LM standard version in red and the nudging one in green). It can be seen that the strong overestimate of the precipitation by the standard suite at the beginning of the integration ("spin-up" problem) is not present in the nudging suite. A 6-hour temporal phase shift between observed and forecast maxima is also evident.

- *Bias Score*
  The values of the Bias Score computed for the two LM suites at the different forecast range are shown in Fig. 4. A general improvement of the nudging suite with respect to the standard one is evident for both precipitation thresholds and for the whole integration period. The improvement is greater in the first 12 hours, especially for the highest threshold. Therefore the nudging scheme seems to be effective in order to eliminate the spin-up effect.

- *Threat Score*
  The values of the Threat Score computed for the two LM suites at the different forecast range are shown in Fig. 5. The performance of the nudging LM version is slightly better than the standard LM one. A convergence of the two lines at the end of the forecast period (third day of integration) is also evident.

- *False Alarm Rate*
  The values of the False Alarm Rate computed for the two LM suites at the different forecast range are shown in Fig. 6. The amount of false alarms is greatly reduced with the use of the mesoscale assimilation, for both precipitation thresholds. This is especially true in the first half of the integration period, while the two lines tend to converge after 60 hours.

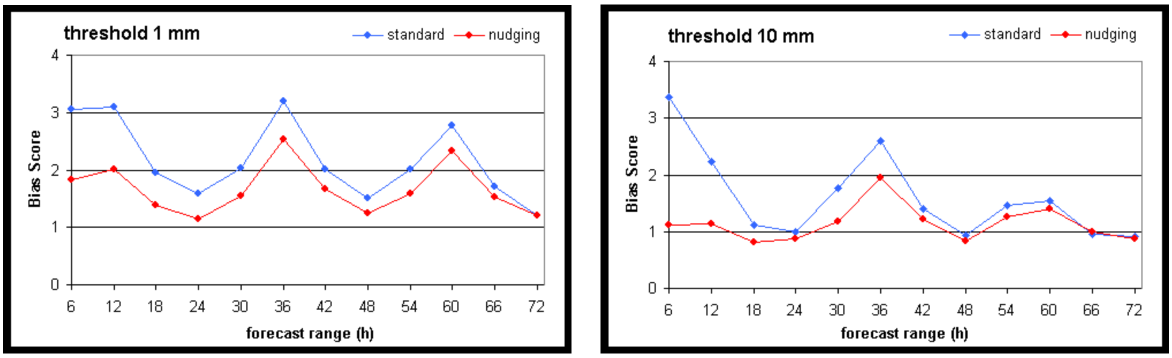

Figure 4: Bias Score as a function of the forecast range, for two precipitation thresholds (1mm/6h in the top panel and 10mm/6h in the bottom panel). Blue line is relative to the standard suite, while red line is relative to the nudging suite.

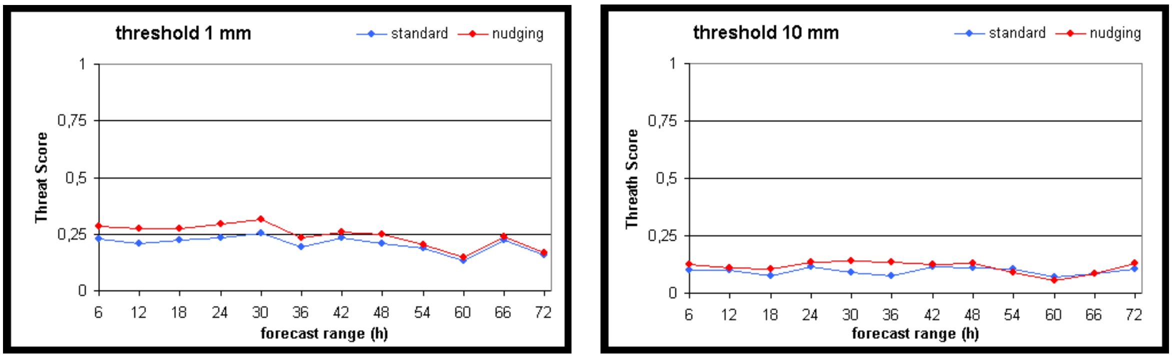

Figure 5: Threat Score as a function of the forecast range, for two precipitation thresholds (1mm/6h in the top panel and 10mm/6h in the bottom panel). Blue line is relative to the standard suite, while red line is relative to the nudging suite.

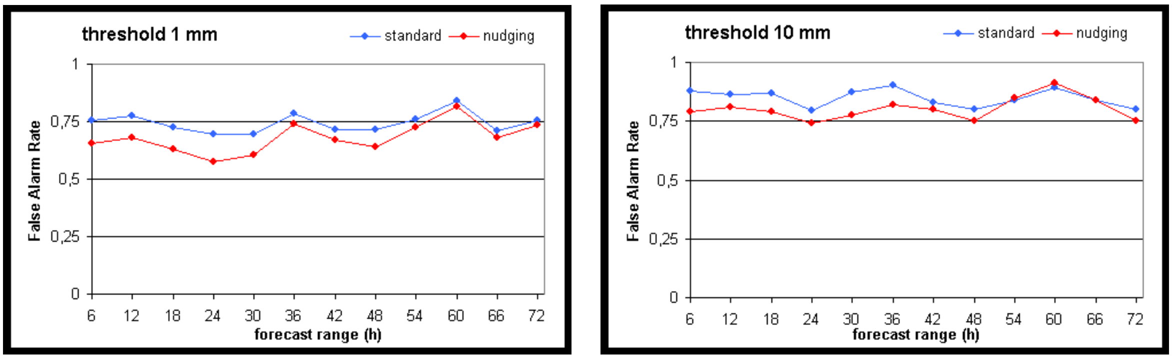

Figure 6: False Alarm Rate as a function of the forecast range, for two precipitation thresholds (1mm/6h in the top panel and 10mm/6h in the bottom panel). Blue line is relative to the standard suite, while red line is relative to the nudging suite.

2.2 Temperature

The values of the mean absolute error (MAE) and of the bias (as defined at the end of Section 1.2) computed for the two LM suites at the different forecast ranges are shown in Fig. 7. The performance of the two suites are almost identical, a negative bias being evident along the whole integration period. The bias exhibits a diurnal cycle, with a minimum in

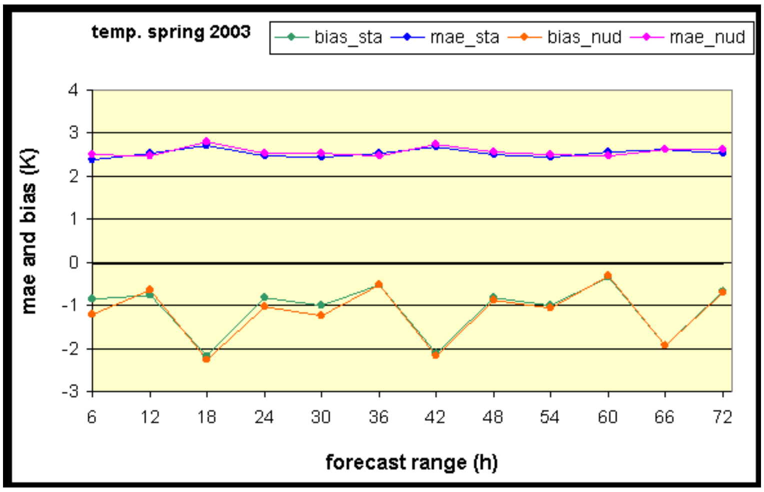

Figure 7: Mean Absolute Error and Bias of 2m-temperature as a function of the forecast range. The blue line is the MAE relative to the standard suite, while the pink line is the MAE of the nudging suite. The red line is the bias of the nudging suite while the green line is the bias of the standard suite.

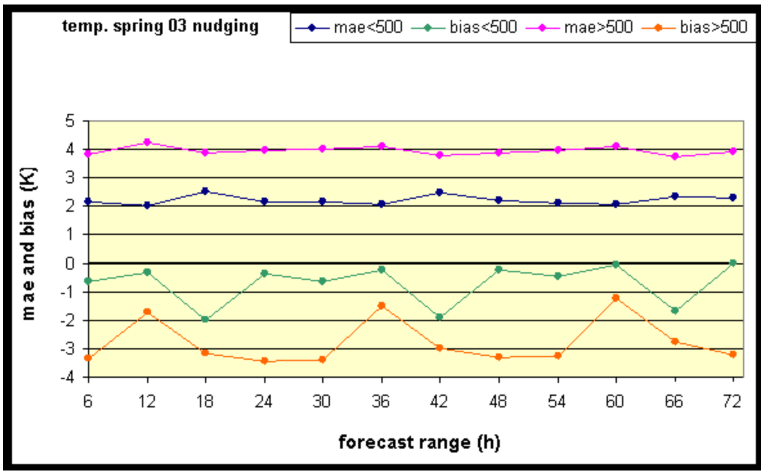

Figure 8: Mean Absolute Error and Bias of 2m-temperature as a function of the forecast range. The blue line is the MAE for the stations below 500 m, while the pink line is the MAE for the stations above 500m. The green line is the bias for the stations below 500 m, while the red line is the bias for the stations above 500 m.

the afternoon. The mean absolute error is about 2.5 degrees.

In Fig. 8, verification has been carried out by subdividing the sample according to the station height (below and above 500 m) but only for the nudging suite. The negative bias in much stronger for the mountain stations and also the mean absolute error reaches 4 degrees for these stations.

2.3 Dew-point Temperature

The values of the mean absolute error (MAE) and of the bias computed for the two LM suites at the different forecast ranges are shown in the Fig. 9. The nudging version of LM is able to reduce both the bias and the mean absolute error, especially in the first day of integration. Both measures exhibit a diurnal strong cycle, with the maximum value of the error at 12 UTC.

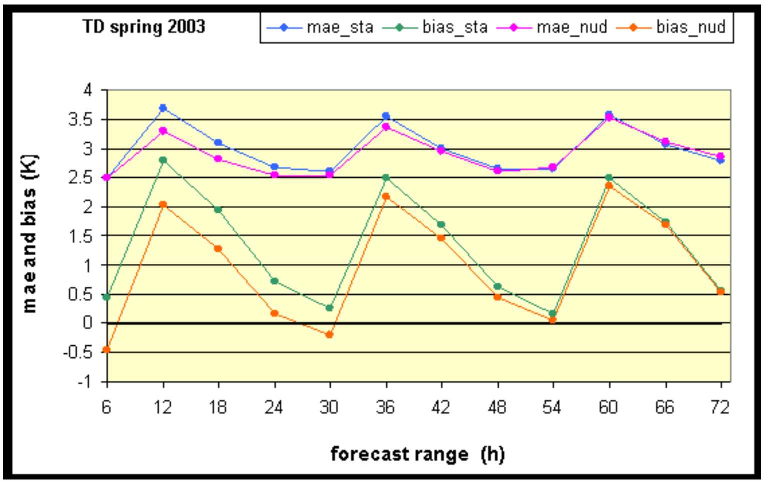

Figure 9: Mean Absolute Error and Bias of 2m-dewpoint temperature as a function of the forecast range. The blue line is the MAE for the stations below 500 m, while the pink line is the MAE for the stations above 500m. The green line is the bias for the stations below 500 m, while the red line is the bias for the stations above 500 m.

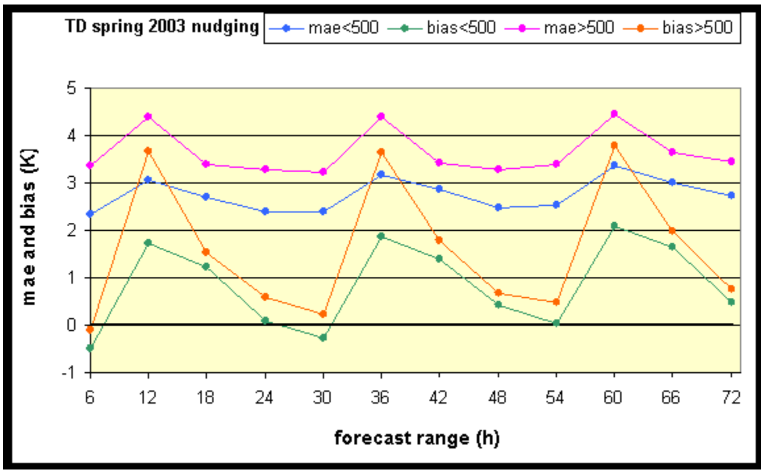

Figure 10: Mean Absolute Error and Bias of 2m-dewpoint temperture as a function of the forecast range. The blue line is the MAE for the stations below 500 m, while the pink line is the MAE for the stations above 500m. The green line is the bias for the stations below 500 m, while the red line is the bias for the stations above 500 m.

Also for this variable verification has been carried out by subdividing the sample according to the station high (below and above 500m), but only for the nudging suite. Both the bias and the MAE have higher values for the stations above 500 m.