High Resolution Verification of COSMO-I7 2m Temperature over Emilia-Romagna Region

Maria Stefania Tesini, Carlo Cacciamani

ARPA-SIM Regional Hydro-Meteorological Service of Emilia-Romagna, Bologna, Italy

1 Methodology and dataset

In this work we present a summary of the verification of the 2m temperature of COSMO-I7 over Emilia-Romagna region for the years 2005, 2006 and part of 2007. Comparison with other models is also shown. Configuration of COSMO-I7 operational implementation at ARPA-SIM, consisting of two 72-hour integrations every day (starting at 00 UTC and 12 UTC) with an horizontal resolution of 7 km, is summarized in Table 1.

Table 1: history of COSMO-I7 configuration

DATE	NAME (at ARPA-SIM)	MODEL VERSION	LEVELS	I.C. & B.C.	INTEGRATION DOMAIN
2005	LMSMR 2031	3.9 NUDGING	35	GME	234 × 272 pts. [domain1 in Fig. 2]
26/01/2006	LMSMR 3032	3.16 NUDGING PROG.PREC.	40	GME	234 × 272 pts. [domain1 in Fig. 2]
25/01/2007	LMSMR 4032	3.16 NUDGING PROG.PREC.	40	GME	297 × 313 pts. [domain 2 in Fig. 2]
25/01/2007	LMSMR 4032	3.16 NUDGING PROG.PREC.	40	IFS	297 × 313 pts. [domain 2 in Fig. 2]

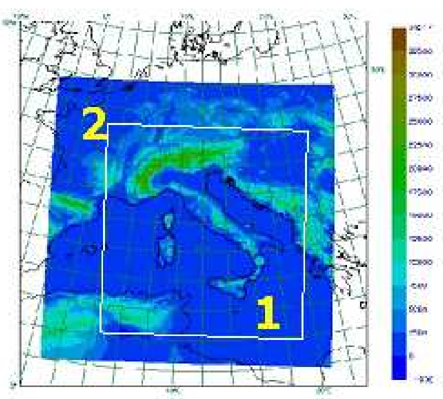

Figure 1: COSMO-I7 integration domain (before [1] and after [2] 25/01/2007)

The results have been generally computed seasonally or for shorter periods of time (e.g. two months) when model changes occurred. Verification was done with three-hourly observations

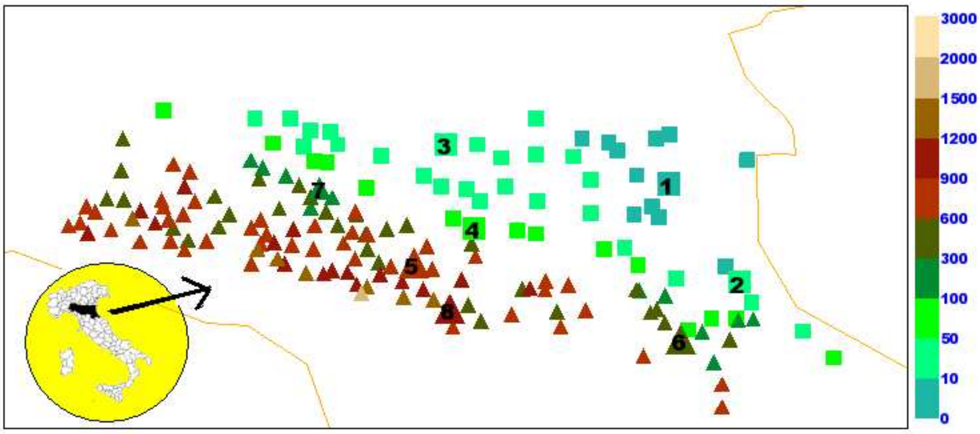

Figure 2: Emilia-Romagna ARPA-SIM observation network. Symbol colors indicate the height of the stations. Brown triangles represent mountain station (altitude >100 m) and green squares represent valley stations (altitude <100 m). Number edstation points are used in the following as a case study to show the different behavior of COSMO-I7 temperature forecast respect to the altitude of the stations.

from ARPA-SIM regional network and the nearest model grid-point. Results have been stratified depending on the altitude of the station: 56 stations below 100 m (indicated in the text as *valley stations)* and 114 above 100 m (indicated in the text as *mountain stations*). No correction for differences in height between station point and grid point has been computed and when this difference exceeds 50 m, the point was rejected. Land-sea mask has also been taken into account.

2 Results

Bias Error (or Mean Error) and Mean Absolute Error concerning seasonal verification of COSMO-I7 00UTC run for the year 2005, are presented in Fig. 3. A different behavior respect to the height of the stations can be observed: above 100m of altitude the model presents a negative bias during all the seasons, more pronounced in winter (up to - 4°C). In plain region model bias varies according to the seasons: nearly zero or negative (-1^{c}ircC) in winter and spring, positive in autumn and summer (up to 3^{c}ircC).

Concerning MAE it should be noted that in valley stations is about 2^{c}ircC on average, with a slightly increase during midday, except in summer when an additional positive error arises during the night (up to 3^{c}ircC). In mountain stations there is a clear worsening of the MAE during winter (more than 3^{c}ircC on average) and, less pronounced, in spring (2.5^{c}ircC on average).

It is interesting to note the quite large MAE (on average up to 2^{c}ircC) at the +3h forecast step and a very small trend with forecast time.

Since model version has been updated at the end of January 2006, the verification results of this year, shown in Fig. 4, refers to COSMO 3.16 with 40 vertical levels. Verification results seem to suggest a general heating of COSMO-I7 2m temperature. In mountain regions this aspect produces a significant reduction in the model MAE respect to the previous year, particularly in winter, while in valley stations COSMO-I7 seems to produce worse results. In detail, an overestimation during nighttime is observed during all seasons in valley stations,

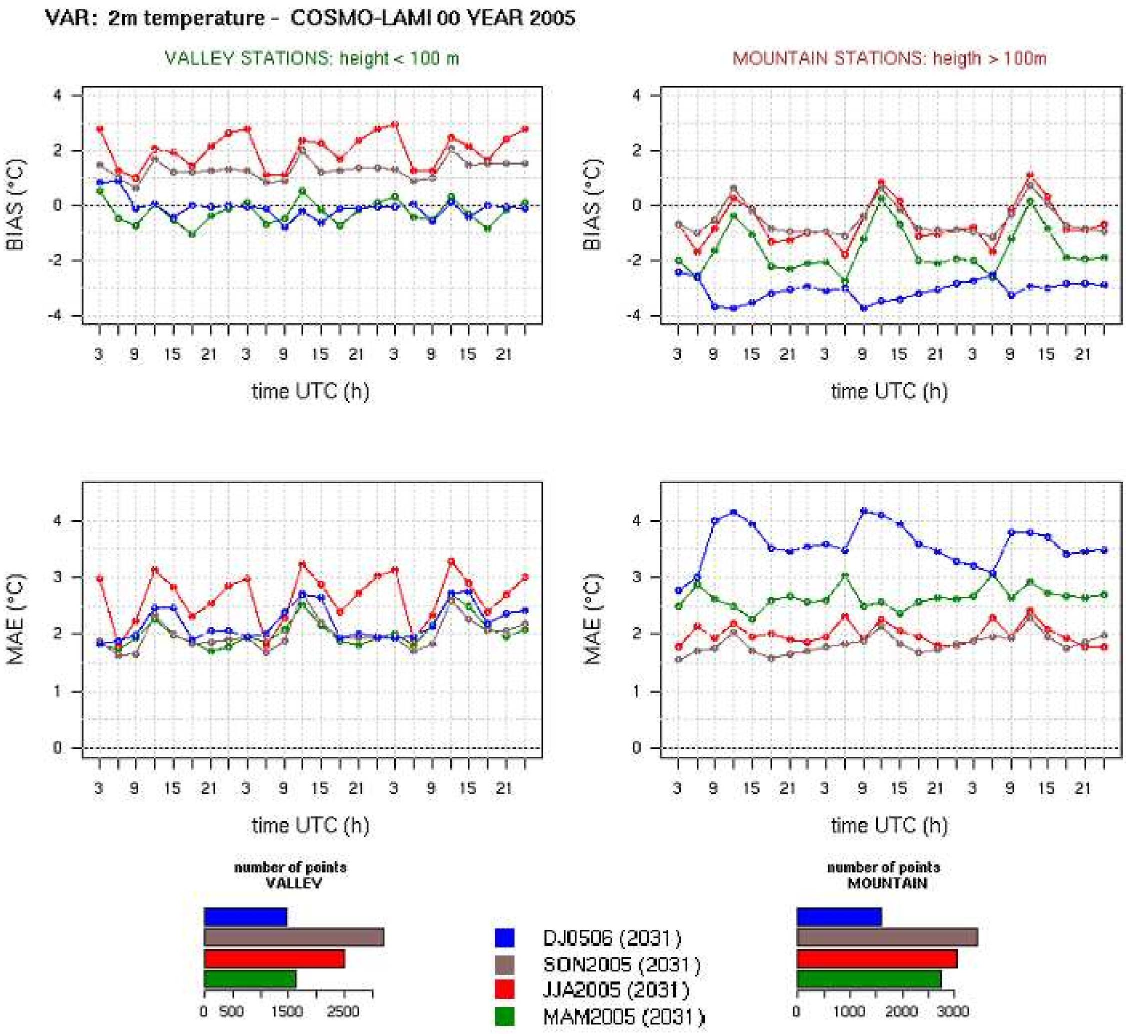

Figure 3: Bias Error (upper part) and Mean Absolute Error (lower part) for seasonal verification of COSMO-I7 (00UTC run) for year 2005. Left graphics refer to valley station (below 100m), right graphics refer to mountain stations (over 100m). The colors represent the seasons: green for spring (Mar2005–May2005), red for summer (Jun2005–Aug2005), brown for autumn (Sep2005–Nov2005),blue for winter (Dec2005–Jan2006). Barplots represent the number of points (stations × time period) used in the statistical computation.

while in 2005 this occurred only during summer. It should be pointed out that the error at the +3h forecast step (corresponding to 3UTC) is greater than $2^{c}irc$C (up to 4C in summer) and this error seems to reflect in the daily cycle. The MAE at the last forecast time is smaller than that observed at the +3h forecast step.

Comparison with other models (features summarized in Table 2) for summer and autumn 2006 is presented in Figs. 5 and 6. It is of note that the models of the "COSMO family" show a very similar behavior concerning the daily cycle. Runs starting at 12 UTC (COSMO-I7 and LMDET) exhibit a slightly smaller error during nighttime. It is interesting to point out a difference in the +3h forecast step error between models starting at 12UTC and 00UTC. No significant difference appear between COSMO-I7 12UTC runs with nudging assimilation and the Cosmo-LEPS deterministic run (LMDET) starting at 12UTC with no assimilation.

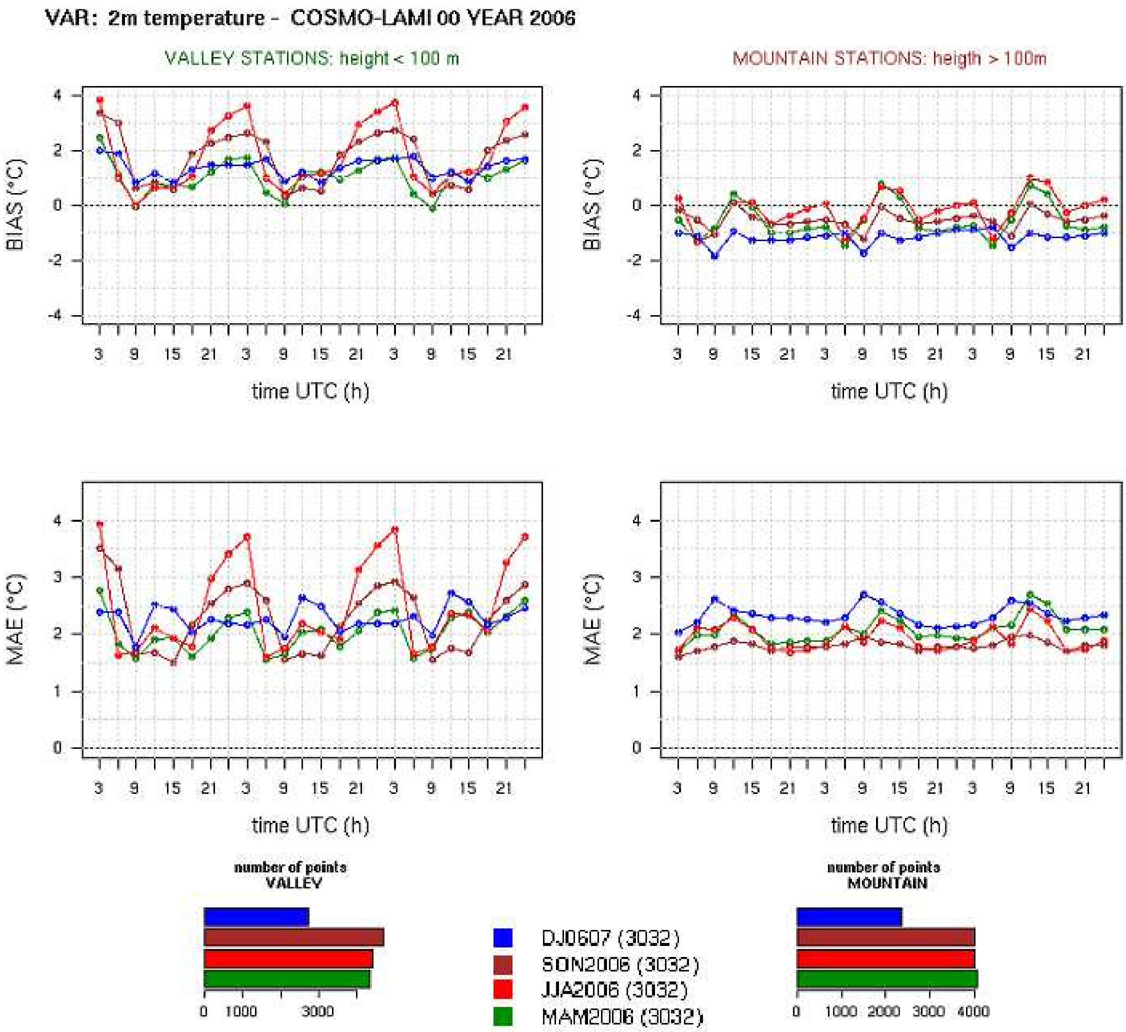

Figure 4: Bias Error (upper part) and Mean Absolute Error (lower part) for seasonal verification of COSMO-I7 (00UTC run) for year 2006. Left graphics refer to valley station (below 100m), right graphics refer to mountain stations (over 100m). The colors represent the seasons: green for spring (Mar2006–May2006), red for summer (Jun2006–Aug2006), brown for autumn (Sep2006–Nov2006),blue for winter (Dec2006–Jan2007). Barplots represent the number of points (stations × time period) used in the statistical computation.

COSMO-I7 integration domain changed at the end of January 2007 moving to a larger one (see fig.2) and since 3 April 2007 COSMO-I7 runs with boundary condition from ECMWF. For these reasons we present in Figs. 7 and 8 the verifications of two periods, February-March and April-May instead of the usual seasonal verification. The changes in domain configuration do not seem to modify the errors features pointed out in the previous year verification.

3 February-March 2007: a qualitative study

For the period February-March a qualitative analysis has been done graphically by drawing a scatterplot of COSMO-I7 00UTC forecast against observed temperature in valley stations

Table 2: Main features of models used for comparison

NAME (at ARPA-SIM)	MODEL FEATURES
E-SUITE (RK) LMSMR 3033	as COSMO-I7 (LMSMR 3032) with Runge-Kutta scheme run starting time: 00UTC
LMDET (reference version of COSMO-LEPS)	$\sim$ 10 km horizontal resolution 40 vertical levels I.C. & B.C.: IFS (ECMWF) NO NUDGING COSMO-LEPS integration domain run starting time: 12UTC
ECMWF	global model $\sim$ 50 km horizontal resolution run starting time: 00 UTC & 12UTC

(Fig. 9) and in mountain stations (Fig. 10). If the forecasting system were perfect, all points would lie on a straight line that starts at the origin and has a slope of unity. While the behavior of the model concerning the observations in mountain points seems to be nearly linear, even if there is a fair amount of scatter around the ideal line, COSMO-I7 in valley points exhibits a systematic overestimation errors. It should be noted that no temperature below zero were forecasted in the period February-March 2007 despite some observed frosts.

As example in Fig. 11 is shown COSMO-I7 2m temperature forecast for the 5^{th} of February 2007 03UTC (+3h forecast): all the Po valley has a forecasted temperate of about 3 ^{c}ircC while observations present negative value (up to -4^{c}ircC in many stations). The overestimations of 2m temperature in valley stations during nighttime can be ascribe to a wrong cloud cover forecast, but in the case shown the model correctly reproduce clear sky conditions .

Another possible source of this type of error is the relationship between 2m temperature and the first level temperature. As example, time series of forecast 2m T and lowermost T (HLD4041) of COSMO-I7 00 UTC and observed temperature in 10 stations at different altitude for the 4^{th} and 5^{th} of February 2007 are presented in Fig. 12 (see dataset map in Fig. 1 for the geographical position).

Further investigations are needed to understand these type of errors, in relations also with surface wind, soil moisture, heat exchange etc.

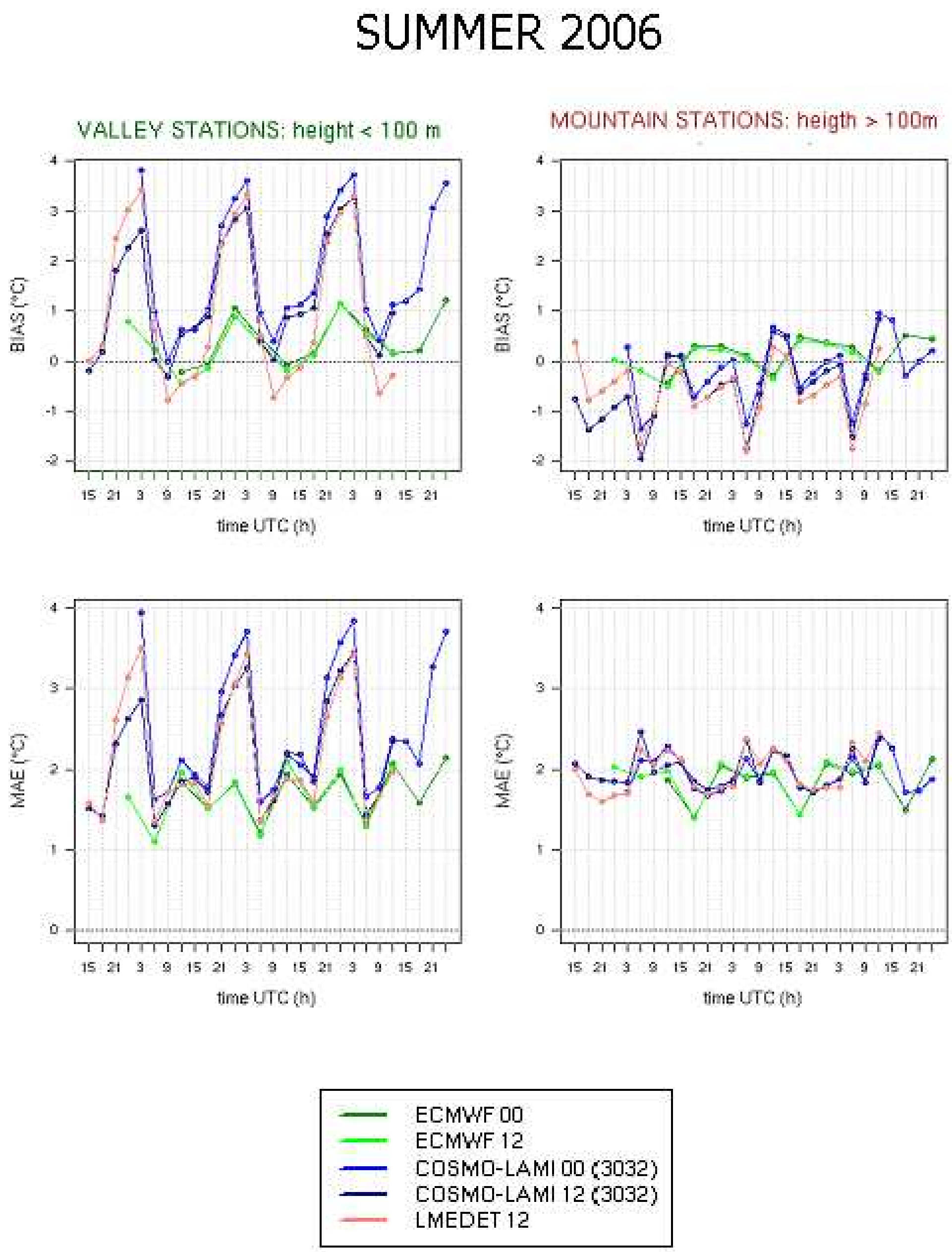

Figure 5: Comparison of summer 2006 verification of COMSO-I7 (runs 00UTC and 12 UTC), ECMWF (runs 00UTC and 12 UTC) and LMDET models. ECMWF verification has been computed using a 6h forecast step.

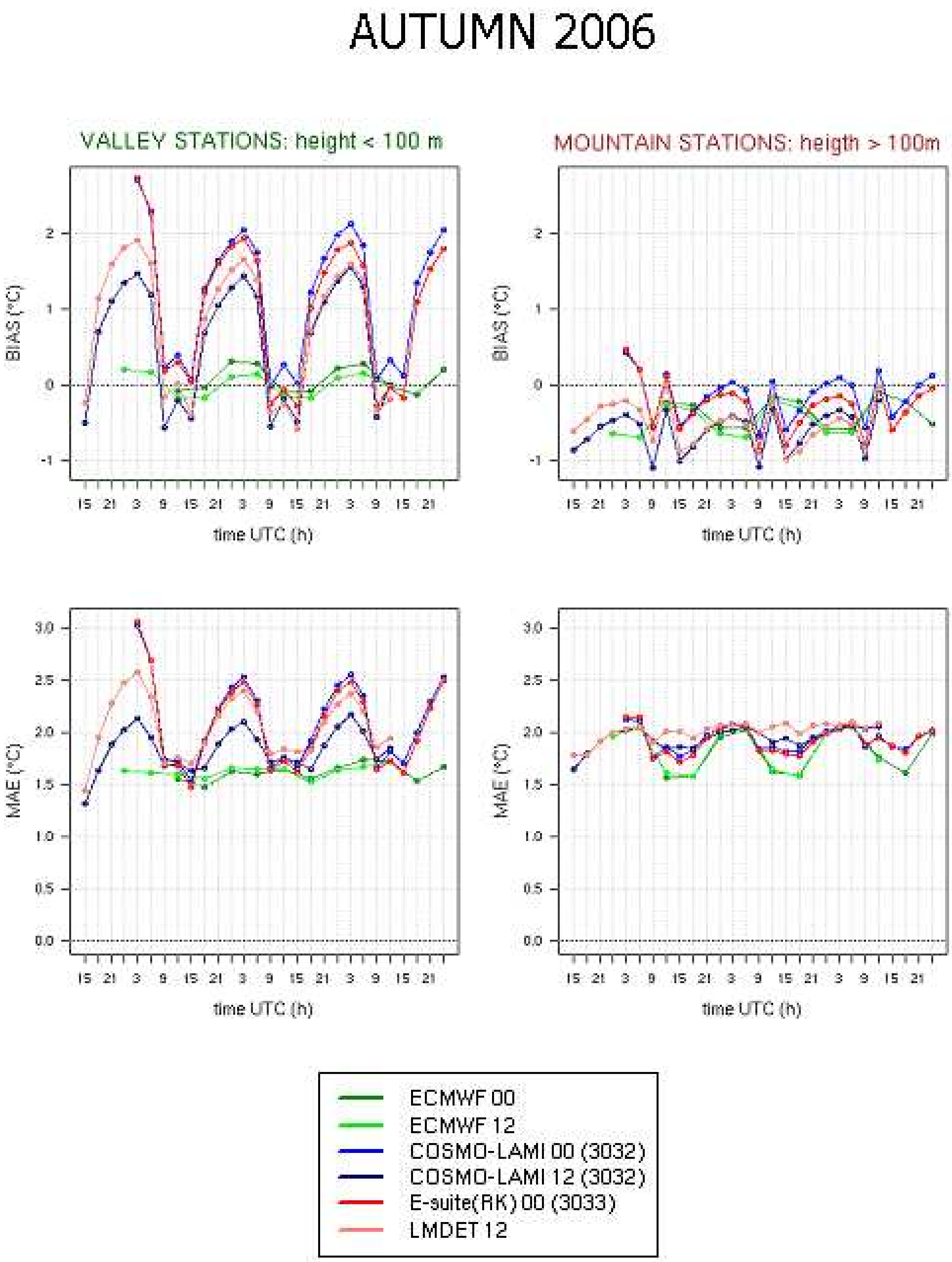

Figure 6: Comparison of autumn 2006 verification of COMSO-I7 (runs 00UTC and 12 UTC and Experimental Suite), ECMWF (runs 00UTC and 12 UTC) and LMDET models. ECMWF verification has been computed using a 6h forecast step.

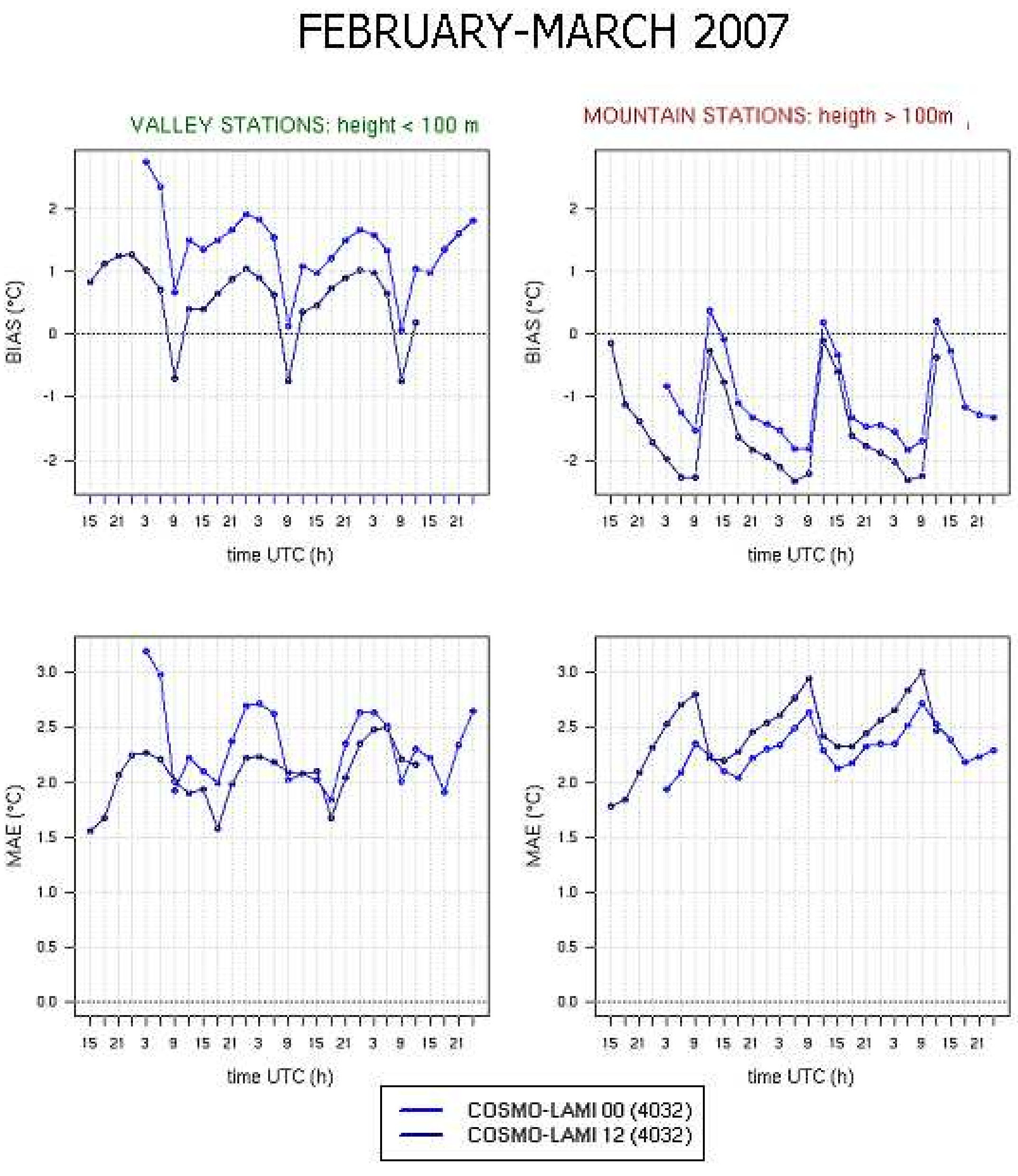

Figure 7: February-March 2007 verification results for COSMO-I7 00UTC and 12UTC runs for valley stations(left part) and mountain stations(right part)

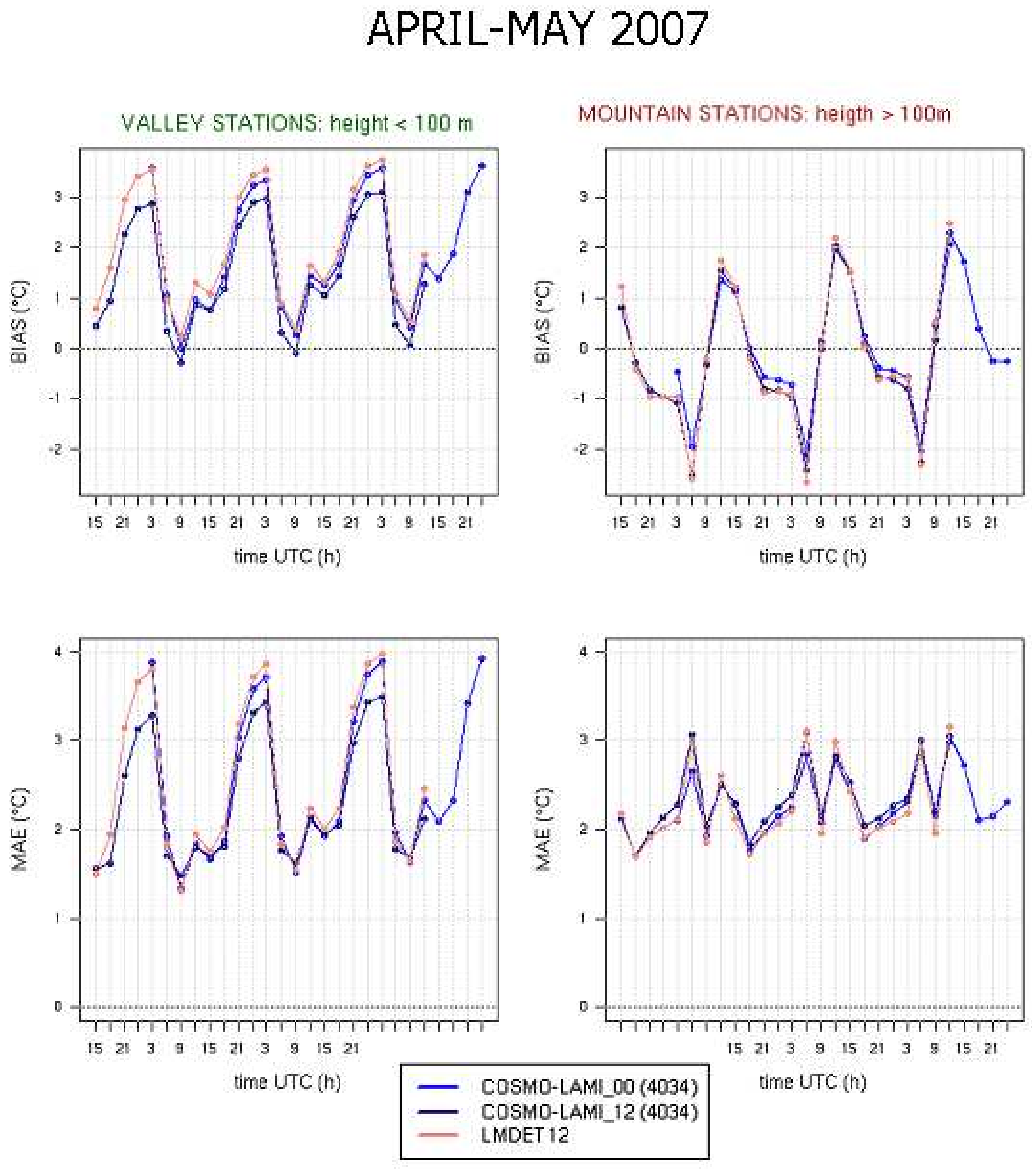

Figure 8: April-May 2007 verification results for COSMO-I7 00UTC and 12UTC runs for valley stations(left part) and mountain stations(right part)

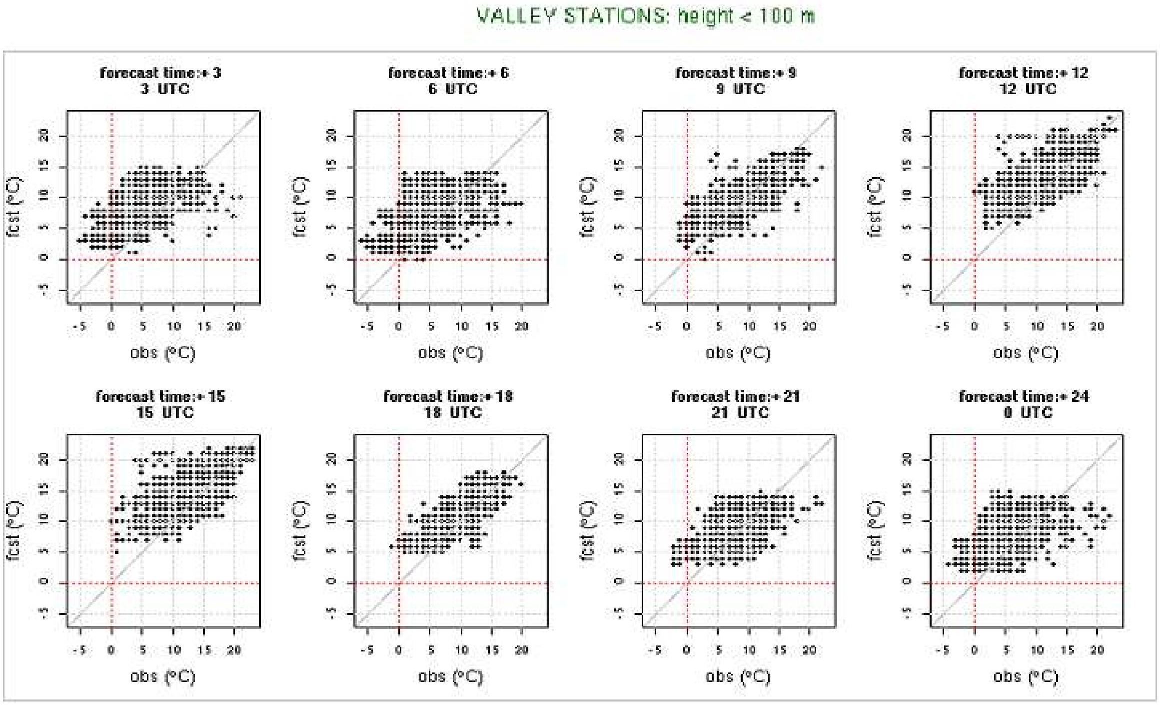

Figure 9: Scatterplot of COSMO-I7 2m temperature for valley station in the period February-March 2007 against observations. Each frame represents a forecast step (from +3h corresponding to 3 UTC to +24h corresponding to 00 UTC)

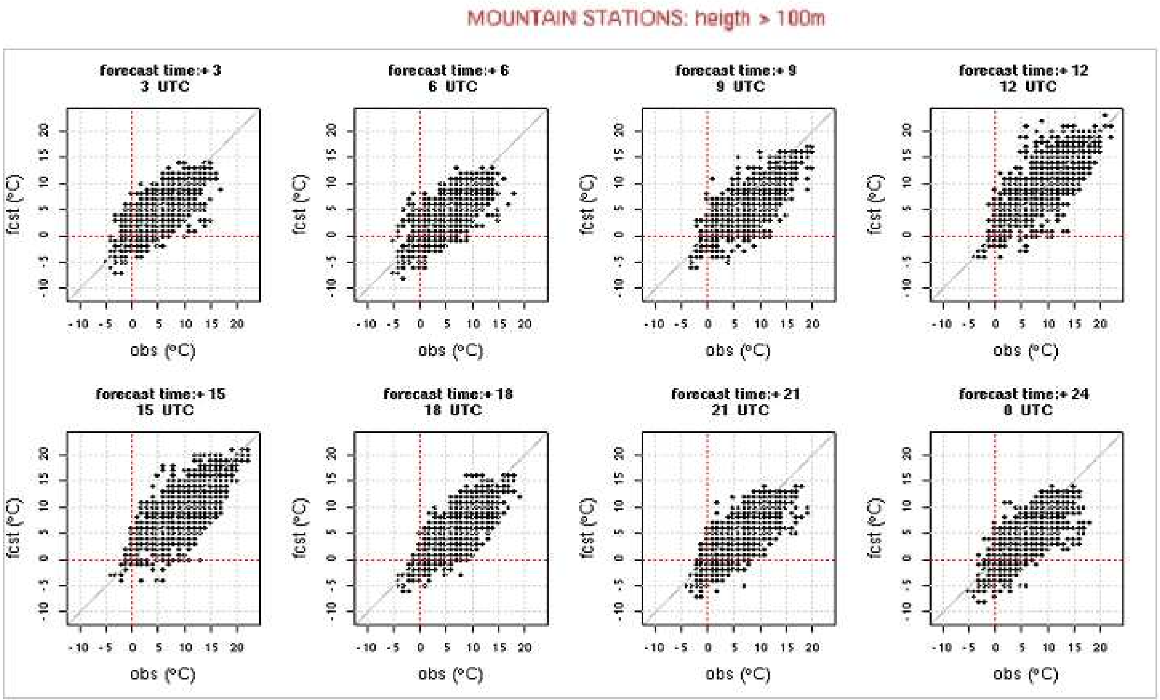

Figure 10: Scatterplot of COSMO-I7 2m temperature for mountain station in the period February-March 2007 against observations. Each frame represents a forecast step (from +3h corresponding to 3 UTC to +24h corresponding to 00 UTC)

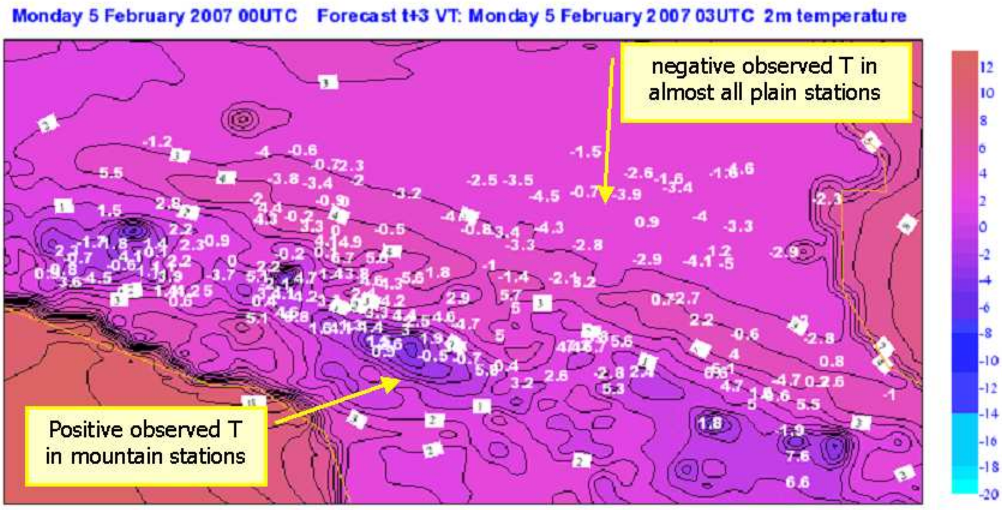

Figure 11: 5th February 2007 03 UTC: contour map of COSMO-I7 2m temperure (+3h) and observed value (in white).

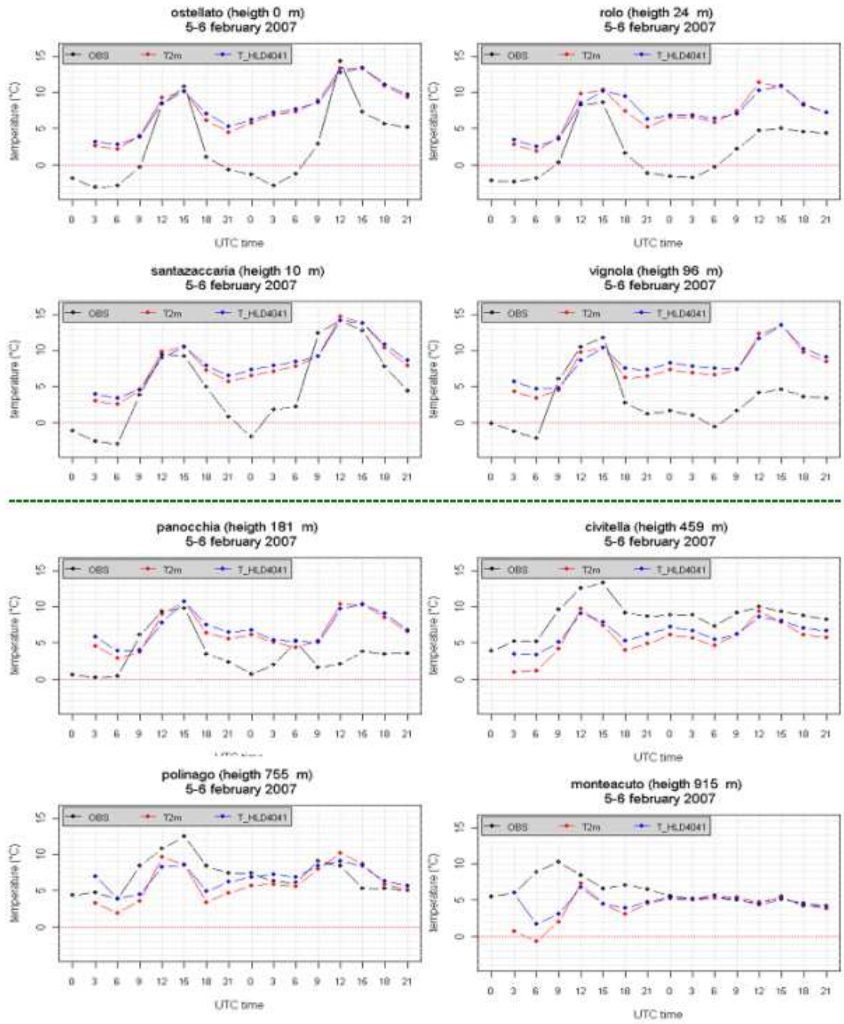

Figure 12: Forecast 2m T and lowermost T (HLD4041) of COSMO-I7 00 UTC (+3h to +45h) and observed temperature in 8 stations at different altitude (<100 m: 4 upper frames,>100 m: 4 lower frames). Observations: black line, COSMO-I7 2m temperature: red line, COSMO-I7 T HLD4041: blue line.