# Verification of LAMI at Synop Stations

Patrizio Emiliani, Alessandro Galliani

*(CNMCA), Roma, Italy*

## 1 Introduction

A synthesis of LAMI (the Italian version of LM) verification results for the year 2004 is presented. The surface parameters analysed are 2m Temperature (2m T), 2m Dew Point Temperature (2m TD), 10m Wind Speed (10m WS), Mean sea Level Pressure (MSLP), and rainfall for which verification has been considered only for the period Nov. 2003 - May 2004. The LAMI version here verified is lm_f90 3.5 with initial state given by Nudging data assimilation scheme (see Table 1). These five parameters are not explicit model variables but they are computed through some internal post-processing which may introduce extra errors. Nevertheless, since the internal post-processing is generally based on some diagnostic balance among the model variables, which is derived from physical constraints, it is still possible to have some important information about problems in the formulation and in the configuration of the model itself.

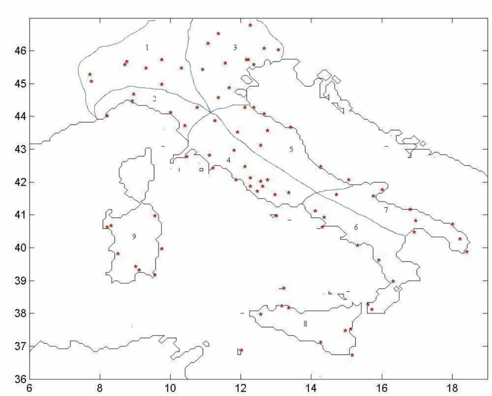

Figure 1: Synoptic Italian network and a classification of Italy in 9 climatological areas.

The observations forming the control data set were collected on 3-hourly basis from synoptic Italian network, including 89 manned stations and distributed over the Italian area. Figure 1 shows the distribution of the stations used to compute verification. Stations were divided in three classes according to geographical location; mountain stations ( $>$ 700m), valley stations or inner lowland stations and coastal stations. Station classification has designed in order to check systematic errors related with different geographical and surface conditions. This approach can give two type of results: information about the model ability in reproducing correct surface processes through a correct climatology in different geographical areas and indication of possible source of error through a comparison in different areas. In the following some results will be shown obtained from the verification of daily cycle for 2m Temperature, 2m Dew Point Temperature, 10m Wind Speed, MSLP and for the categorical rainfall verification.

Table 1: *UGM, ARPA–SIM, ARPA Piemonte LM configuration running at CINECA in Bologna.*

| | |
|---|---|
| Domain size | 234 × 272 gridpoints |
| Horizontal grid spacing | $0.0625^o$ ($\cong$ 7) km |
| Number of layers | 35, base–state presure based hybrid |
| Time step and integration scheme | 40 s, 3 time–level split–explicit |
| Forecast range | 72 h |
| Initial time of model runs | 00 UTC |
| Lateral boundary conditions | Interpolated from GME at 1h interval |
| Initial state | Nudging data assimilation scheme, no initialisation |
| External analysis | None |
| Special features | Use of filetered topography, new TKE scheme, new surface–layer scheme |
| Model version | lm_f90 3.5 |
| Hardware | IBM SP pwr4 (using 32 of 512 processors) |

## 2 Daily Cycle

In order to verify the diurnal behaviour of the model, the couples forecast-observation, for which the mean error (ME, forecast minus observation) and the mean absolute error (MAE) have been computed, were stratified according to the hour of the day (3-hourly frequency), the month of the year and the forecast range (day 1 and day 2). Synchronous and co-located couples forecast-observation, independently from the station position, form each sample. In such way systematic errors due to inconsistency in the surface representation of the model (inconsistency in the terrain elevation and in the percentage of the surface covered by water are the main error sources over Italy) are somewhat dumped and the signal of daily and seasonal oscillation is retained.

## 3 2m-Temperature

Figures 2a, 3a, 4a and 5a show the behaviour of 2m-Temperature forecast error respectively for all Italian stations, for coastal stations, for valley and mountain stations.

A clear diurnal cycle is present in all the figures and for all months in the mean error pattern. All figures, except coastal stations (see Fig. 3a), show a common feature characterized by a cold bias during the cold months (January, February, November and December), more accentuated for mountain sites with values of about -1.5$^o$C.

Coastal ME patterns (Fig. 3a), present, both for day 1 and day 2, positive peaks around sunrise (06 UTC in the cold months and 03 UTC in the warm months) and negative peaks during the afternoon, near sunset, with a cycle amplitude of about 2.5$^o$C in the warm season and about 1$^o$C in the other period of the year. A different behaviour is shown by valley and mountain stations figures where positive peaks occur around midday, with a delay of 3-6 hours respect to coastal station, while negative peaks still occur near sunset.

Concerning the Mean Absolute Error a diurnal cycle is still present in the curve, even if it is not so clear like in ME curves. Minimum in MAE, corresponding to better absolute accuracy, occur in the early morning both for valley and mountain area and in the evening for coastal stations; lower absolute accuracy, that is MAE maximum, occurs for all the sites around midday, 12UTC. Another difference is evident in MAE curves for mountain stations where low values occur in the warm season while the opposite happen for valley and coastal stations, where maximum MAE values occurs during summer.

## 4 10m wind speed

In Figures 2b, 3b, 4b and 5b the curves relative to mean error and mean absolute error of 10m wind speed are shown, for a technical reason were not available wind data for May and June. Even if the amplitude is small (less then 1 m/s) a diurnal cycle is present in ME curves. An overestimation of wind speed, positive bias, occurs for valley and coastal stations, more pronounced when dynamical circulation is dominant, that is during the cold months. It is interesting to point out the attention to low MEA values during summer for coastal stations, meaning a good model interpretation of local breeze circulation, but with a general low underestimation of the wind in the warm hours, with negative ME values during late morning and afternoon.

## 5 2m Dew Point Temperature

In Figures 2c, 3c, 4c and 5c 2m Dew Point Temperature ME is shown. First of all a clear general positive bias is present (Fig. 2c. More in detail, a positive bias occurs for coastal stations (about 0.4$^o$C in the warm season and more than 0.7$^o$C in the other periods of the year, see Fig. 3c), and mountain stations (with a bias of 1°C but with a cycle amplitude between 2°C and 3°C, see Fig. 5c). During October an anomaly appear for mountain stations with too low MAE and ME values. Valley stations, on the contrary, didn t present positive bias, during the cold season a negative bias, -0.5°C, is observed. Both, valley and mountain stations (Fig. 4-5c) present a well evident ME diurnal cycle with positive peaks occurring around midday, in phase with maximum MAE values, and minimum values occurring close to sunrise hours.

## 6 Mean Sea Level Pressure

Figures 2d, 3d and 4d show MSLP mean error and mean absolute error for the year 2004. Mean error curves don t show any diurnal cycle; a positive bias affect the d+1 ME line with exception in December. ME d+2 curve (pink line) shows a different situation, in fact starting with a positive bias at 03 UTC (corresponding at forecast range +27hrs) ME decrease systematically to negative values, meaning a systematic loss of mass in function of time. MAE curves show how the mean sea level pressure is less affected by local circulations or by model physics and is dominated by the atmosphere dynamics; in fact, MAE increases quasilinearly in function of forecast range (for each month, d+1 curve starts with +03 hrs and stops with +24 hrs while d+2 curve starts with +27 hrs to +48hrs forecast range) with a high degradation in MAE values during the months characterized by strong atmospheric motions.

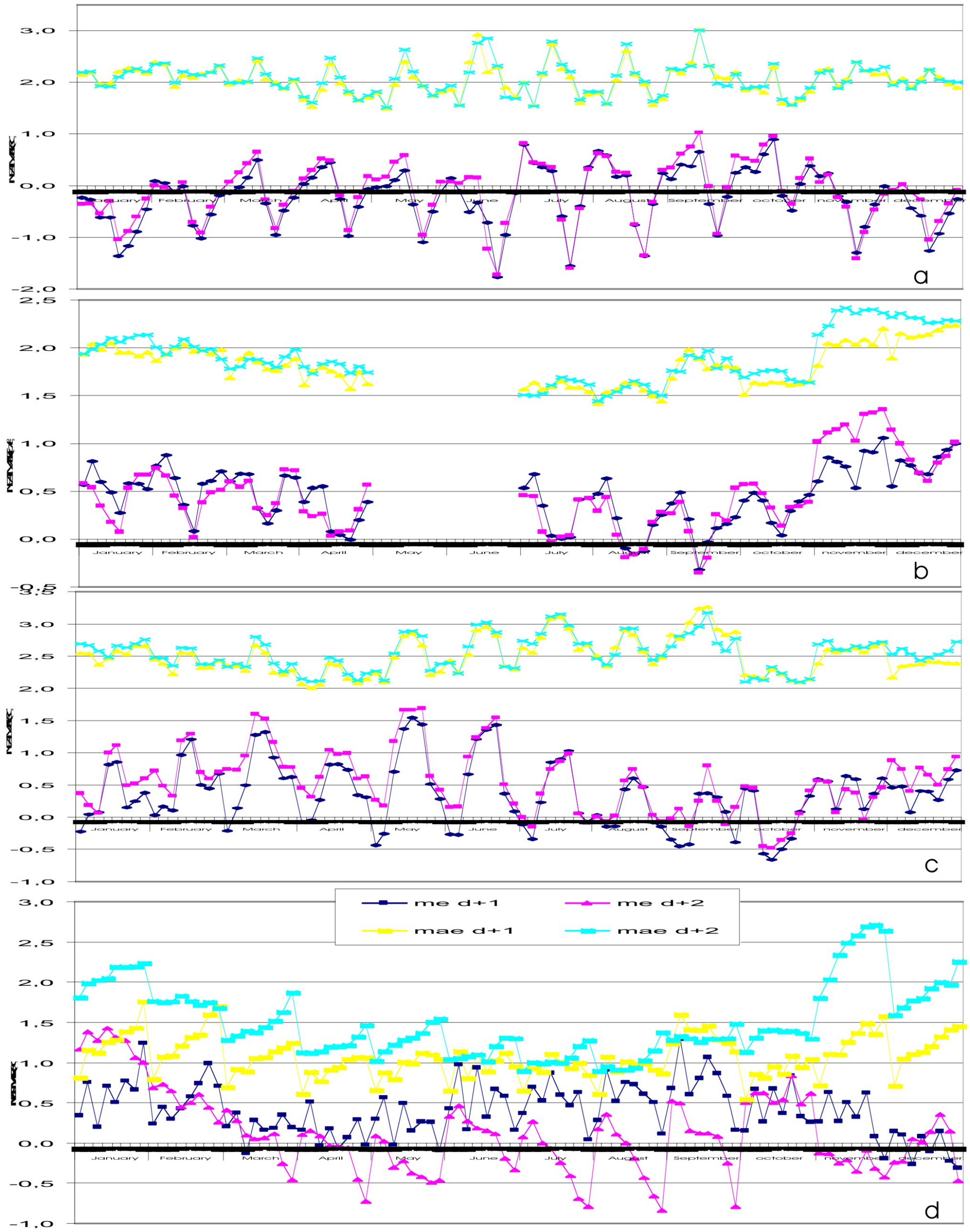


Figure 2: LAMI monthly mean error and mean absolute error of 2m Temperature (a), 10m wind speed (b), 2m dew point temperature (c) and mean sea level pressure (d) for Italian stations, 2004.

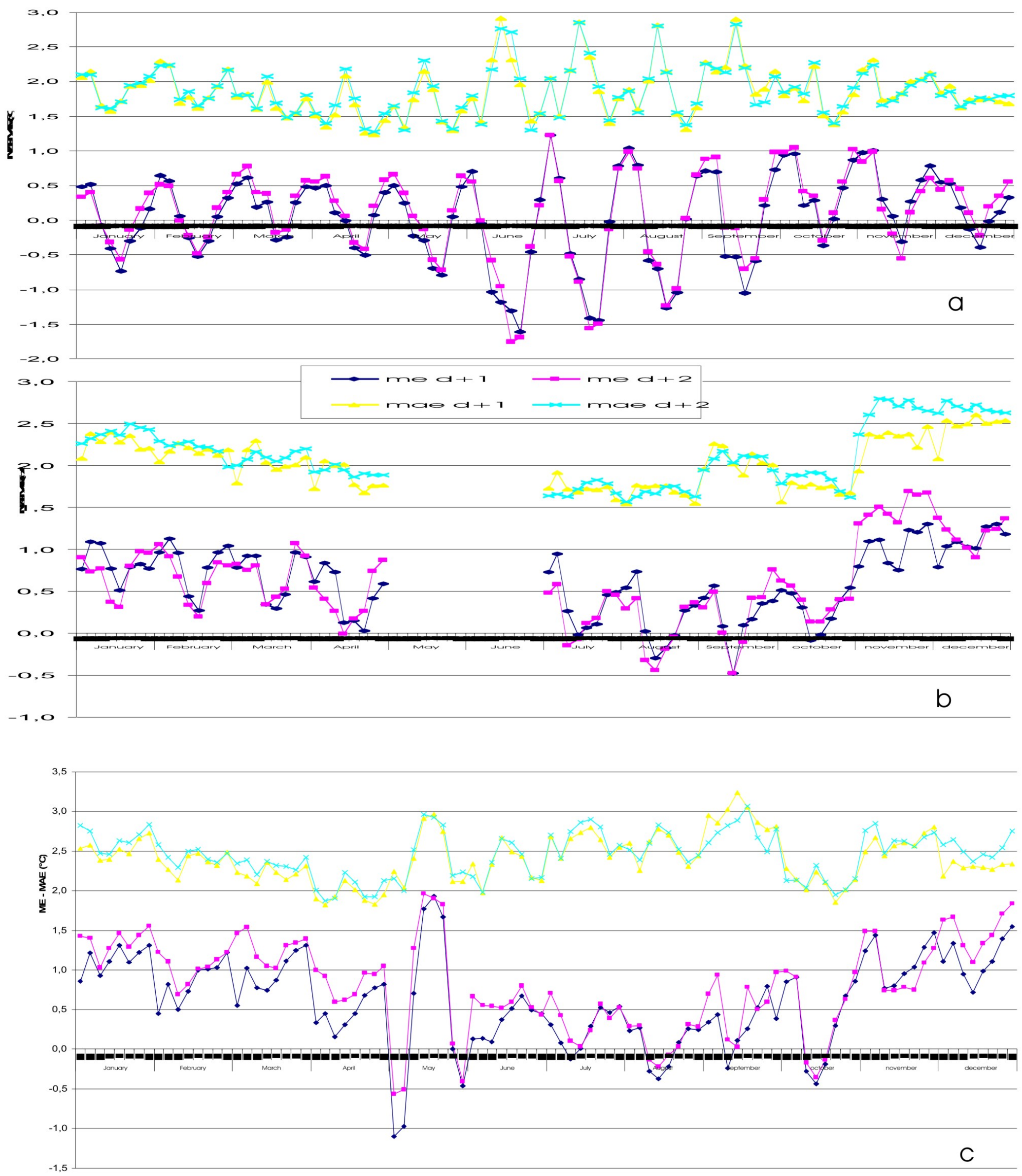


Figure 3: LAMI monthly mean error and mean absolute error of 2m Temperature (a), 10m wind speed (b), 2m dew point temperature (c) for coastal stations, 2004.

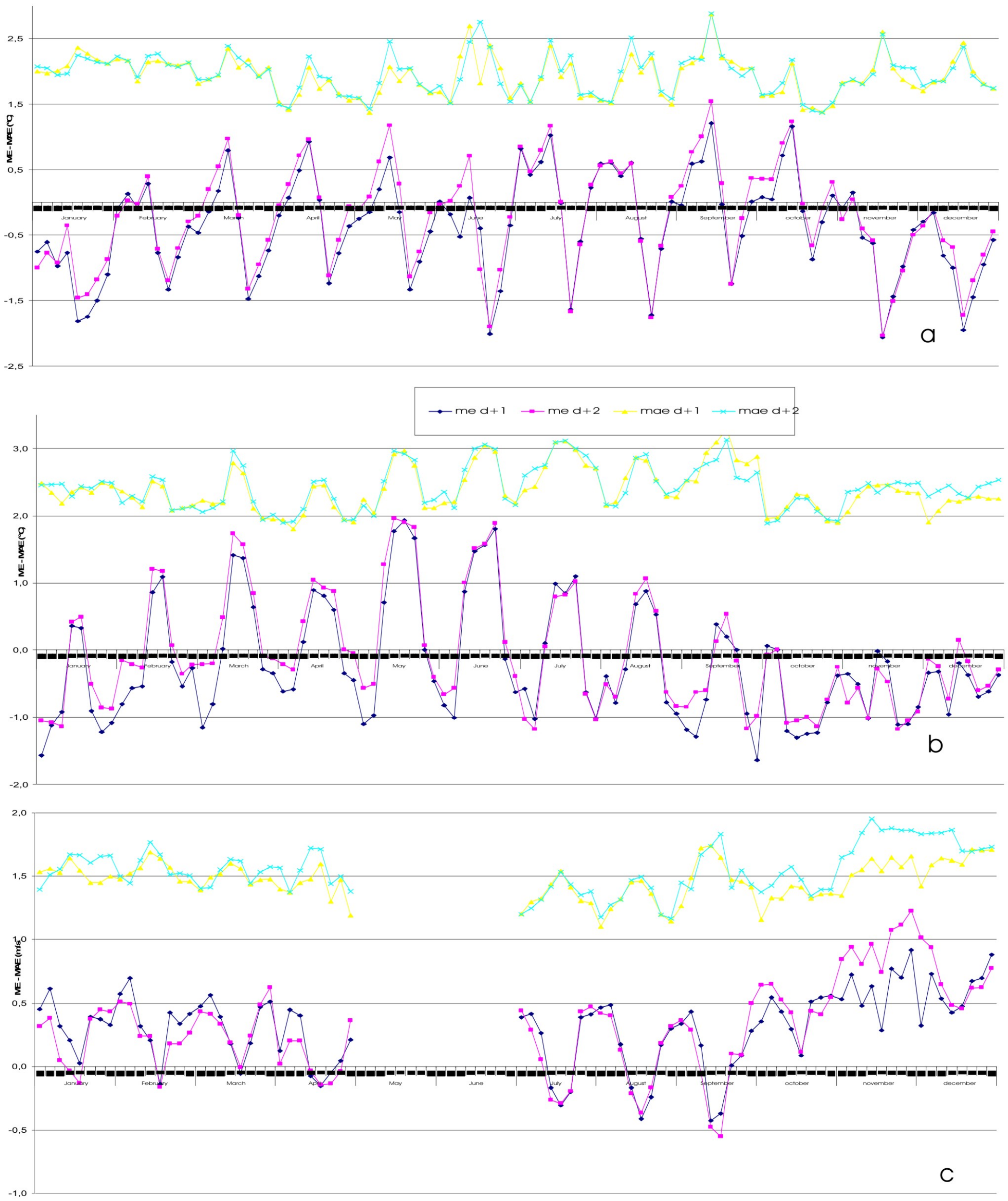


Figure 4: LAMI monthly mean error and mean absolute error of 2m Temperature (a), 10m wind speed (b), 2m dew point temperature (c) for valley stations, 2004.

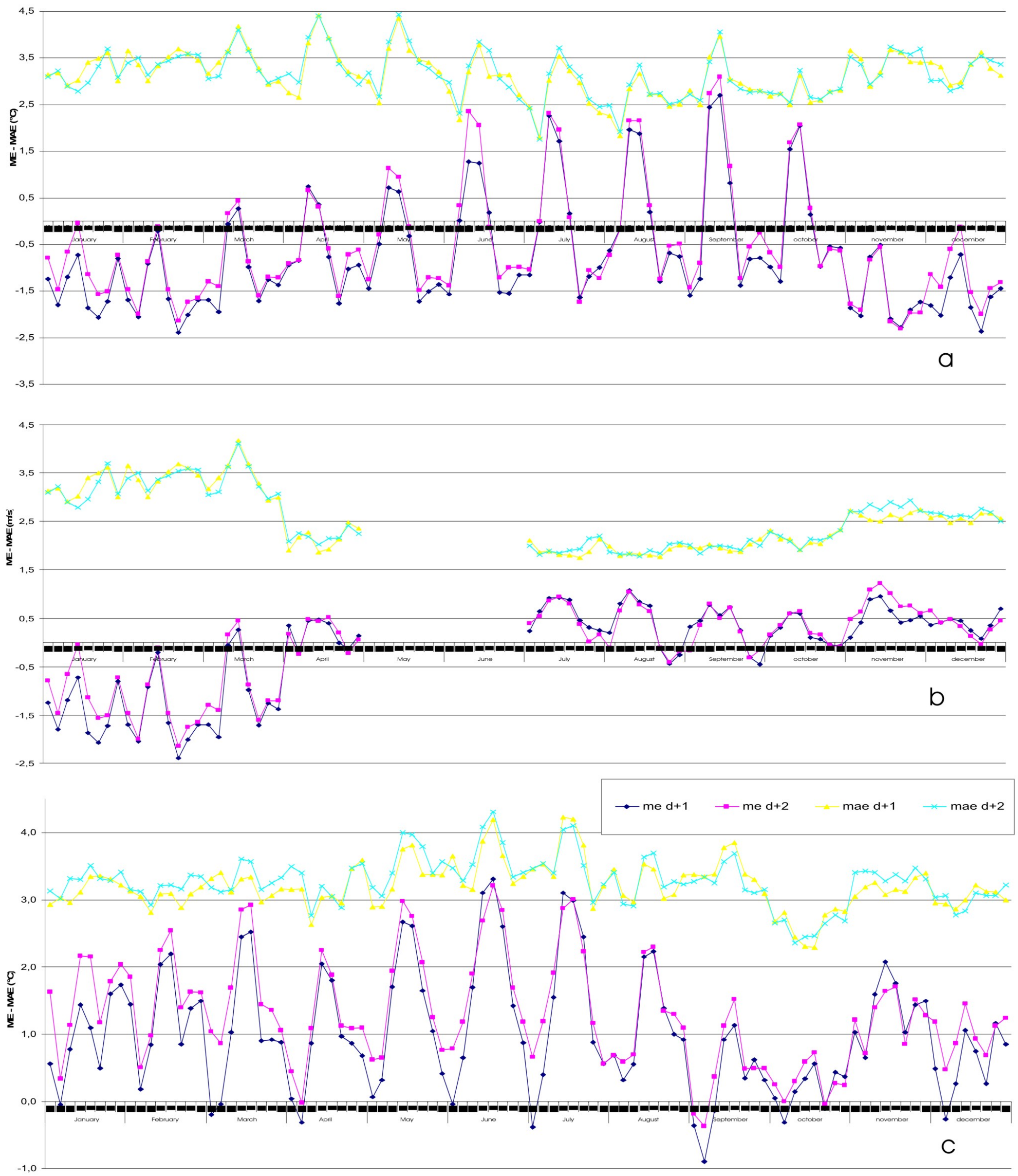


Figure 5: LAMI monthly mean error and mean absolute error of 2m Temperature (a), 10m wind speed (b), 2m dew point temperature (c) for mountain stations, 2004.

## 7 Precipitation

The verification results for the period from Oct/2003 to May/2004 are summarized in Fig. 6, where FBIAS, TS, POD and FAR scores are presented for all Italian stations, without any stratifications (for stratified precipitation scores see the COSMO web site). Fig. 6a shows a FBIAS comparison between LAMI, 00-UTC run, and ECM global model, 12-UTC run. For low threshold values, until 4mm/day, LAMI shows an overestimation of 20-30% (60% for ECM model). LAMI FBIAS increases with threshold valuesday curve has a small FBIAS increment, showing for high threshold values an overestimation of about 50%, while the second day line increase up to FBIAS value of 2.5, even if for intense precipitation the results coming out from this verification method should be carefully taken in account. Threat Score for 24 hours cumulated rainfall are reported in Fig. 6b. Both models show comparable TS values for d+1 forecast, decreasing in function of thresholds; while d+2 LAMI line shows a more pronounced forecast degradation respect to ECM model.

POD and FAR analysis plots (Fig. 6c) show, for low threshold, higher ECM values respect to LAMI. The obtained results are in agreement with the ECM rainfall overforecast (see Fig. 6a). A different situation appears starting from threshold values of about 10mm/day, where LAMI is characterized by high POD and FAR values. These differences in single POD and FAR analysis disappear considering d+1 POD/FAR ratio (Fig. 6d), that gives comparable values for both models, instead of d+2 forecast for which ECM works better than LAMI.

In the next session, rainfall verifications for the analysed period are presented, considering events due to south-west wind field regime and associated to frontal systems. At the beginning, stations were stratified in five regions: North, Centre, South, Adriatic and Tyrrhenian. Verification results obtained using this kind of stratification are summarized in Fig. 7. As expected, the model shows better performances in respect to the analysis effected without any kind of weather regime filter (precipitation associated to south west flux are well extended and well defined and so are easier to detected by the Model), and the scores for the different areas (North, Cent., South, Adriat. And Tyrrh.) are closer to one each other, even if Central region has better scores.

Considering the same weather pattern (South-West flux), rainfall verification was computed adopting another stations stratification. Italy was divided in 9 areas (see Fig. ugm-fig:1) more or less characterized by the same weather events.

This time a marked difference in the model performances (Fig. 8) associated to the considered areas occurs. Verification scores for day+1 forecast indicate good model performances associated to NW areas (1 and 2 curves) and bad results for the two islands (Sardinia and Sicily, 8 and 9 curves). It is interesting to note how LAMI over Liguria region shows high scores values also for high precipitation thresholds, meaning good spatial and time phase forecast in the development of Genoa Gulf cyclogenesis and the associated weather phenomena.

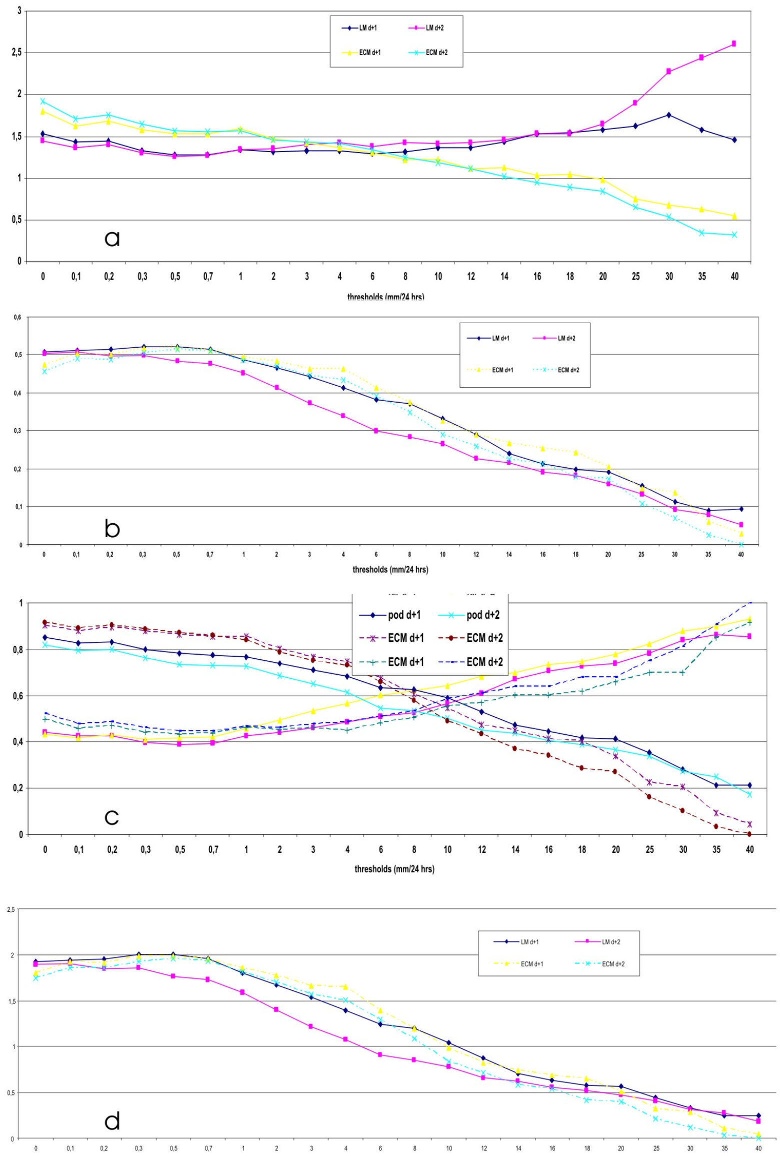


Figure 6: LAMI (00 UTC run) and ECM (12 UTC run) for all Italian stations without any stratification: FBIAS (a), TS (b), FAR-POD (c), POD/FAR (d).

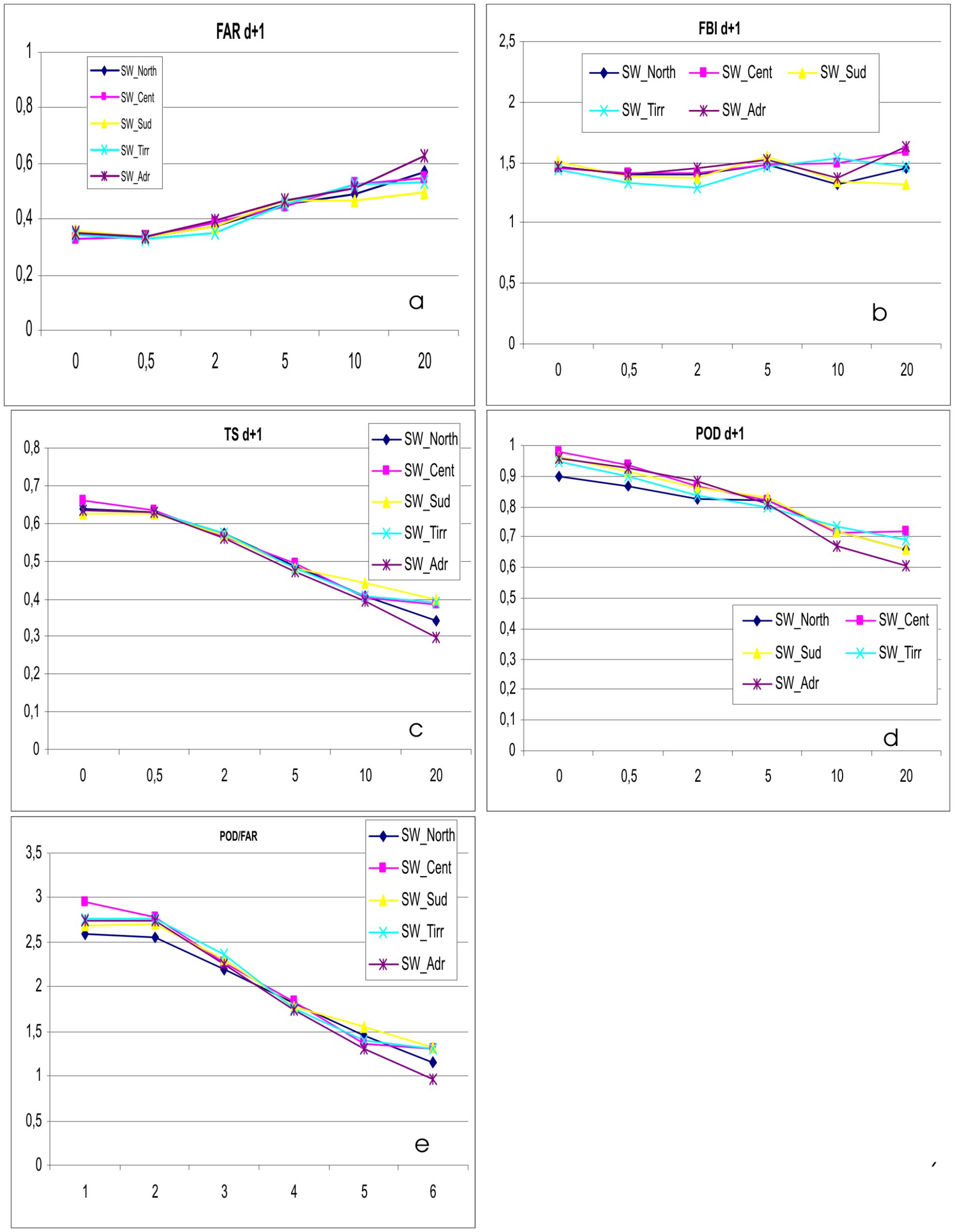


Figure 7: LAMI scores, d+1 cumulated rainfall, for precipitation due to South West fluxes stratifying Italy in five areas: North, Centre, South, Adriatic and Tyrrhenian. FAR (a), FBI (b), TS (c), POD (d), POD/FAR (e).

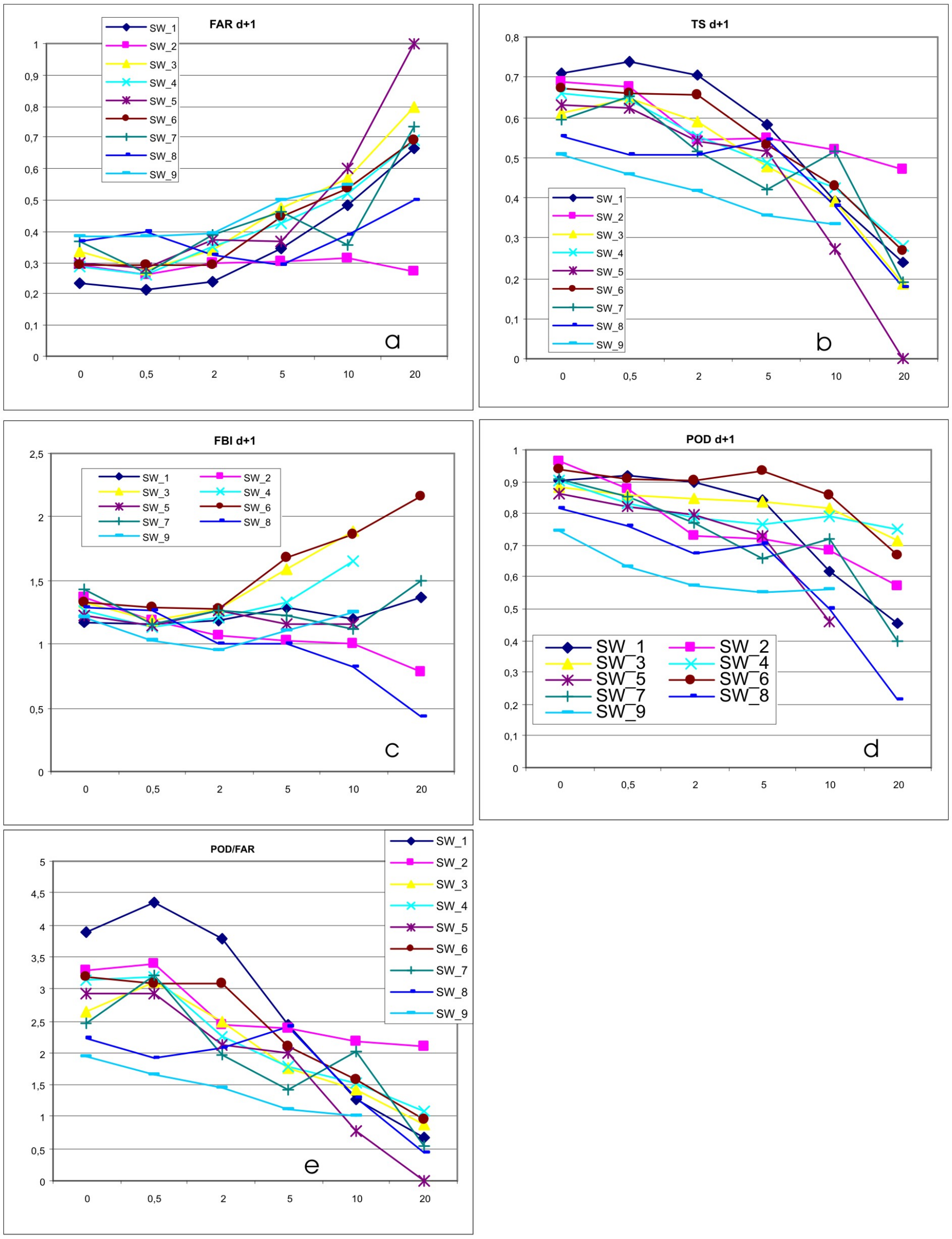


Figure 8: LAMI scores, d+1 cumulated rainfall, for precipitation due to South West fluxes stratifying Italy in nine areas: see 1. FAR (a), FBI (b), TS (c), POD (d), POD/FAR (e).