Verification of aLMo with SYNOP and GPS data over Europe

Pirmin Kaufman

MeteoSwiss, Zurich, Switzerland

1 Introduction

The development of the surface verification of aLMo over the whole model domain continued in 2004. The last two of the six statistical measures that are now routinely plotted (Table 1) have been added in 2004.

Table 1: Routinely plotted verification parameter.

ME	Mean Error	Bias, average difference between model and observation
MAE	Mean Absolute Error	Average difference between model and observation, independent of sign
STDE	Standard Deviation of Error	Variability of error
RMSE	Root Mean Square Error	Error independent of sign, more weight to larger deviations
COR	Correlation	Correspondence of model fluctuations with observation
NOBS	Number of observations	Data availability

13 more statistical values (Table 2) are now also calculated but not routinely plotted because of their limited usability. The verification now also includes the parameters 10 m wind speed and direction, cloud cover, and 12-hourly precipitation sums.

Table 2: Routinely calculated but not plotted verification parameters.

NMOD	Number of model values
N	Number of valid (mod,obs) pairs, i.e. number of valid error values
MINE	Minimum of error
MAXE	Maximum of error
COV	Covariance
MMOD	Mean model
MOBS	Mean observation
STDMOD	Standard deviation of model
STDOBS	Standard deviation of observation
MINMOD	Minimum of model
MINOBS	Minimum of observation
MAXMOD	Maximum of model
MAXOBS	Maximum of observation

For the latter two, categorical statistics (Table 3) have been implemented but are not yet operationally plotted. The thresholds are set to 30% and 80% for cloud cover and to 0.1, 1, 2,

Table 3: Routinely calculated categorical scores (plots to be implemented).

OF	Observed frequency
ACC	Accuracy (or percent correct, by few authors called hit rate)
FBI	Frequency bias
POD	Probability of detection
FAR	False alarm ratio
THS	Threat score (or critical success index)
ETS	Equitable threat score
TSS	True skill statistics (or Pierce skill score, or Hanssen-Kuipers Discriminant)
HSS	Heidke skill score

10, 20, 30, and 50 mm for 12h-precipitation sums. A more sophisticated search algorithm for the assignment of the observation sites to model grid points has been implemented. Under the constraint that land points are always preferred over water points, the sum of the vertical plus the horizontal distance between observation site and model grid point is minimized, with a weighting factor for the vertical distance currently set to 500. This means that a grid point with 20 m height difference has the same summed distance than one at equal height but 10 km horizontal distance. The search area for model grid points is now circular instead of quadratic, with a radius over water of 2 grid points and over land of sqrt(2) grid points. Stations with height difference greater than 100 m are excluded as before. This algorithm allows optimizing the observation site to grid point relationship also below 100 m height difference. The algorithm agreed on within COSMO WG 5 (COSMO, 2000) would not allow this, even when the nearest grid points have nearly the same horizontal distance and only differ in height.

2 Results

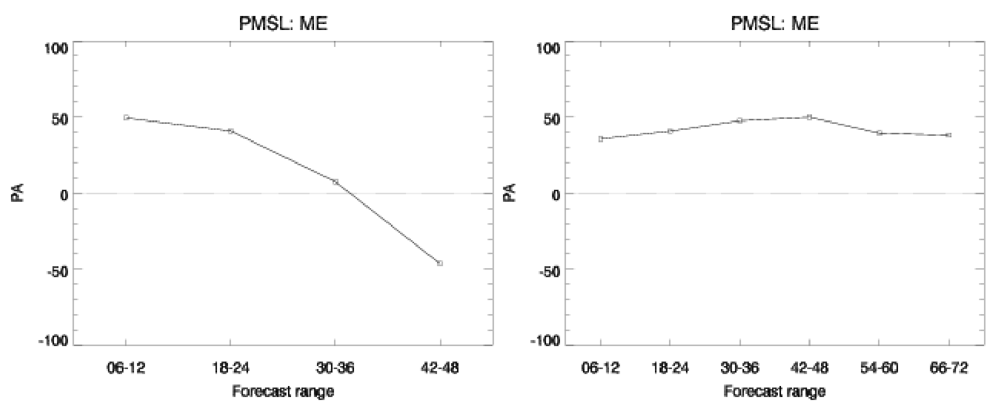

Figure 1: Evolution of pressure bias with forecast time for a) summer 2003 b) summer 2004.

The pressure bias increases with forecast time in winter, but decreases in summer. This general pattern of the pressure bias evolution however has changed for the summer season between 2003 and 2004. While still valid in summer 2003 (Fig 1a), in summer 2004 the pressure bias remained close to zero (0.2 hPa) over the whole forecast range of 72 hours (Fig. 1b). The comparison of the IFS-driven parallel test chain with the operational GME-driven aLMo in summer 2003 indicates that this is probably due to the IFS boundary conditions, which became operationally used in autumn 2003. The standard deviation of the pressure error over the northern half of the model domain is usually considerably higher in winter (~ 3 hPa, 48 h forecast range) than in summer (~ 1.5 hPa). In winter 2004/05, the elevated standard deviation only appears over the northernmost part of the domain and is smaller than in previous winters.

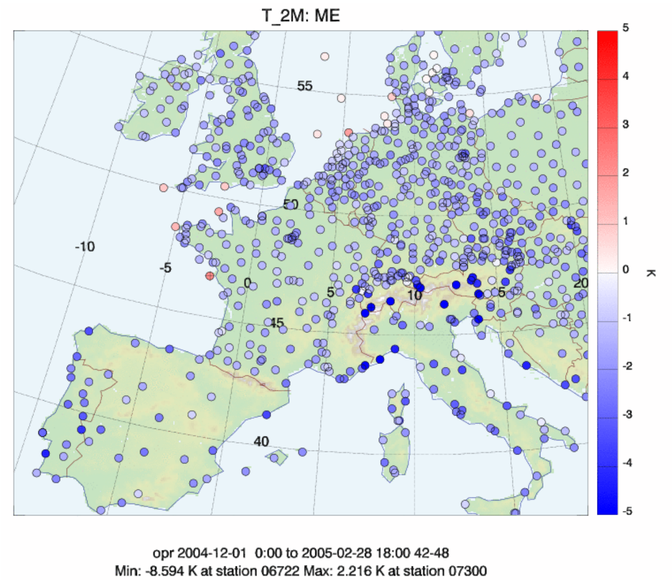

Figure 2: Temperature (2 m) bias for winter 2004/05 and forecast range 42-48 h. Blue indicates model is too cold, red model is too warm.

The well-known cold bias of the 2 m temperature in winter continues to exist and is more negative in 2004/05 (Fig. 2; whole model domain: -1.7 deg C at +48 h) than in previous winters (e.g. -1.4 deg C in 2003/04). Coastal stations (near seas or lakes) in winter produce large positive biases (up to 6 deg C) when used to verify with model grid points that have water as surface type. The verification results with land points instead of water points gives considerably better results. Some small islands and oil platforms however do verify well with water grid points in the model (light red and white dots in Fig. 2) and should not be eliminated from the verification, thus water points are still allowed if no land points are available within the search radius. The standard deviation of the 2 m-temperature error increases with the complexity of the terrain (not shown).

The wind speed has a slight negative bias when measured over the whole model domain. There is however an important difference between coastal and inland stations (Fig. 3). While the bias is strongly negative at coastal stations (down to -6 m/s), it is strongly positive at many inland stations (up to 3.7 m/s), especially during winter. Interestingly, island and oil-platform stations that are compared with model grid points over water also show a positive bias, indicating that the wind speed over water is also overestimated. The standard deviation of the error (2 m/s) is larger near the coast than at the inland stations. This is probably due to the varying sign of the error depending on the wind blowing off the sea or off the land.

The wind direction bias over Europe (Fig. 4) amounts to 10 - 20 degrees and is much more evenly distributed than the speed bias. The positive bias indicates that the model wind direction has a clockwise offset. As opposed to the wind speed, the standard deviation of the wind direction error increases with distance form the coast from 30 degree to 100 degree in the complex terrain of the Alps. This large standard deviation is due to the variable winds at low wind speeds which are not excluded in this verification and are more frequent in complex terrain due to topographic shielding, channeling, and local thermal wind systems.

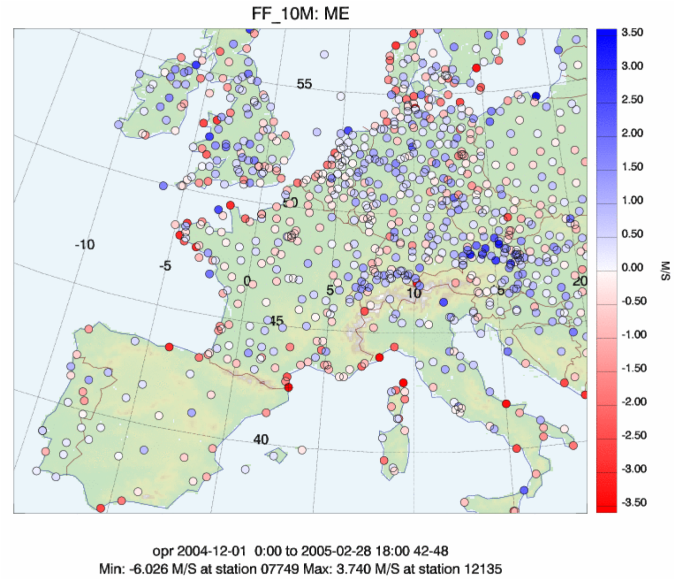

Figure 3: Wind speed (10 m) bias for winter 2004/05 and forecast range 42-48 h. Red indicates model wind is too slow, blue too strong.

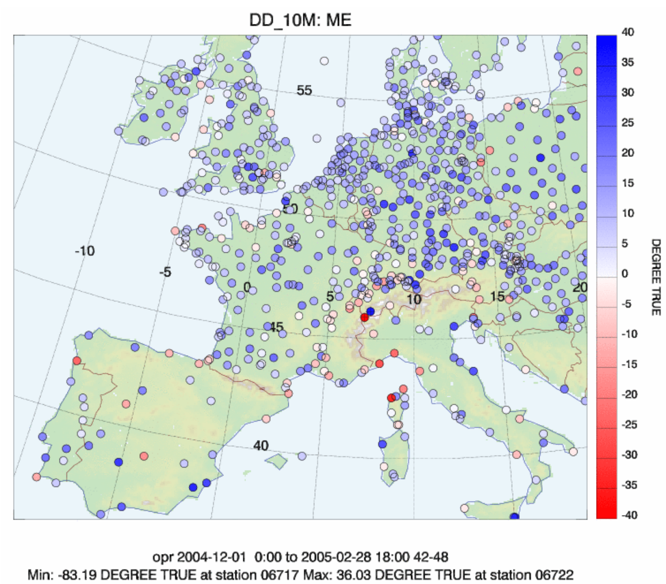

Figure 4: Wind direction (10 m) bias for winter 2004/05 and forecast range 42-48 h. Positive bias indicates clockwise offset.

The cloud cover bias is mostly slightly negative (-7%, independent of the season). A positive bias is often present over Belgium and sometimes also over the Netherlands, northern Germany, Denmark, and Poland. The standard deviation of the error is around 35% (+48 h) for the whole model domain.

The model bias against GPS-derived integrated water vapor (IWV) is more negative in summer (-1.4 mm at +48 h, all European sites processed by Swisstopo) and in complex terrain (up to 6 mm) than in winter (-0.5 mm) or flat terrain. The most probable explanation for the more negative bias in summer is the increased specific humidity content that leads to larger absolute errors even when the relative errors stay the same. In complex terrain, the increased height differences between GPS antennae, SYNOP station and model grid point in complex terrain probably lead to larger errors in the calculation of the IWV. The standard deviation of the error (summer ~ 5 mm, winter ~ 2.5 mm at +48 h) is not affected by complex terrain, supporting the assumption that the bias is due to these height differences.

3 Conclusions

The change of the driving model from GME to IFS in autumn 2003 had a positive effect in the summertime pressure bias. The verification results for newly added parameters wind, cloud cover, and precipitation are not yet available for the seasons before the change. For temperature and dew point temperature, the variation from year to year is larger than an eventual change due to the driving model.

The fact that many U.K. stations that report reduced pressure dont report the pressure at station height, and that many stations in Spain, Italy and the Balkans do not report any measurements at nighttime, remains a nuisance for an all-European verification.

References

COSMO, 2000: Verification Workshop report, 14-15 February 2000, Bologna, Italy, available from www.comso-model.org (private pages).