Verification of aLMo Runs with European SYNOP and GPS Data

Pirmin Kaufmann

MeteoSwiss, Krähbühlstrasse 58, 8044 Zürich, Switzerland

Abstract

A seasonal verification of all aLMo forecasts back to the beginning of the LM pre-operational phase in summer 2000 has now been completed with consistent settings and scaling, and the results are available at http://www.cosmo-model.org in the member area. A new verification of integrated water vapour (IWV) with remote sensing data derived from the Global Positioning System (GPS) zenith total delay (ZTD) measurements has been completed last year and will be made available on the web page. It currently relies on data provided by KNMI in the framework of COST-716 and the TOUGH project.

1 Introduction

In 2002, the verification of the Alpine Model (aLMo) surface fields has been extended to cover the whole model domain, using all available European SYNOP stations (Kaufmann 2003). During 2003, the verification package has been improved and the shortcomings that were described in the last COSMO Newsletter have been eliminated. The following configuration changes and improvements were made:

- The height difference between station and model elevation is now limited to 100 m instead of 500 m.
- The model elevation of the nearest four grid points is now compared to the altitude of each station to minimize vertical discrepancy.
- Station pressure and 2 m-temperature are now interpolated vertically to compensate for remaining altitude difference.
- The error magnitude is limited to exclude observational errors.
- A requirement for the availability has been introduced, it is set to 80 % of the verified time range and to 33 % of the stations.
- The lower limit for the data quality coded in BUFR as confidence level can be chosen freely.

With this configuration, all seasons since summer 2000 have been verified. MeteoSwiss started running the LM in pre-operational mode on a regular basis at the beginning of July 2000. During the first two month (July and August), only the 00 UTC integrations were carried out. In November 2000, the original unfiltered orography was replaced by a filtered orography. These changes in the model setup have to be considered when comparing the first two seasons (summer and autumn 2000) of the aLMo verification to the seasons thereafter. Due to this limited comparability, the results of these two seasons are not available on the COSMO web page.

The mean error (ME), mean absolute error (MAE), standard deviation of the error (STDE), and root mean square error (RMSE) are computed for the following parameters: Pressure

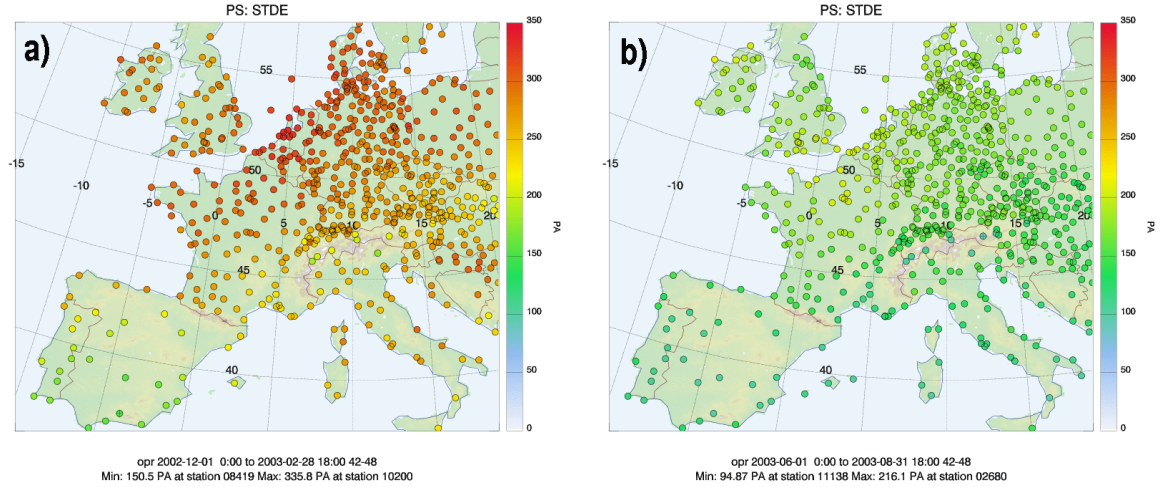

Figure 1: Standard deviation of errors for surface pressure for the forecast range +42 and +48 h of the 00 UTC and 12 UTC aLMo integrations; (a) winter 2002/3, (b) summer 2003.

reduced to mean sea level (PMSL), pressure at station height (PS), temperature at 2 m (T_2M), and dewpoint temperature at 2 m (TD_2M). The verification of integrated water vapour (IWV) has been added in 2003. Three types of verification are made: A temporal verification, a spatial verification and a verification totalling the spatial and temporal scores.

2 Temporal and Spatial Verification

The temporal verification calculates a verification score for series of verification times. Currently, a three month span of 6-hourly SYNOP observations are used. The resulting time series of scores can be used to determine the times at which the aLMo performed well, and those at which the forecast errors where considerable. The latter are prime candidates for case studies aiming towards model improvement. An example for this verification was presented in the last newsletter (Kaufmann 2003).

The spatial verification yields a score at each available SYNOP station. Two examples for winter 2002/3 and summer 2003 are shown in Fig. 1. The STDE of the surface pressure is much larger in winter than in summer. Especially the stations in the northern half of the model domain have a relatively large error of approximately 3 hPa. The seasonal dependence of this error is the same for all years, as will be seen below.

3 Total Scores

A spatial and temporal aggregation of the model errors is calculated and results in one total verification score for all stations and the whole season. This value is calculated for each forecast range separately. In Fig. 2, the mean error of the surface pressure for the same seasons as in Fig. 1 is shown. With increasing forecast range, the mean error slightly increases in winter (Fig. 2 a) and strongly decreases in summer (Fig. 2 b). The strong decrease in summer has already been shown for the summer 2002 in the last Newsletter (Kaufmann 2003) and is a consistent feature of aLMo during the warm season.

The evolution of the scores since the beginning of the pre-operational phase in summer 2000 until autumn 2003 is shown in Fig. 3. The results are valid for the forecast range +42 h to +48 h. In all parameters, a clear seasonal cycle is present, and a large inter-annual

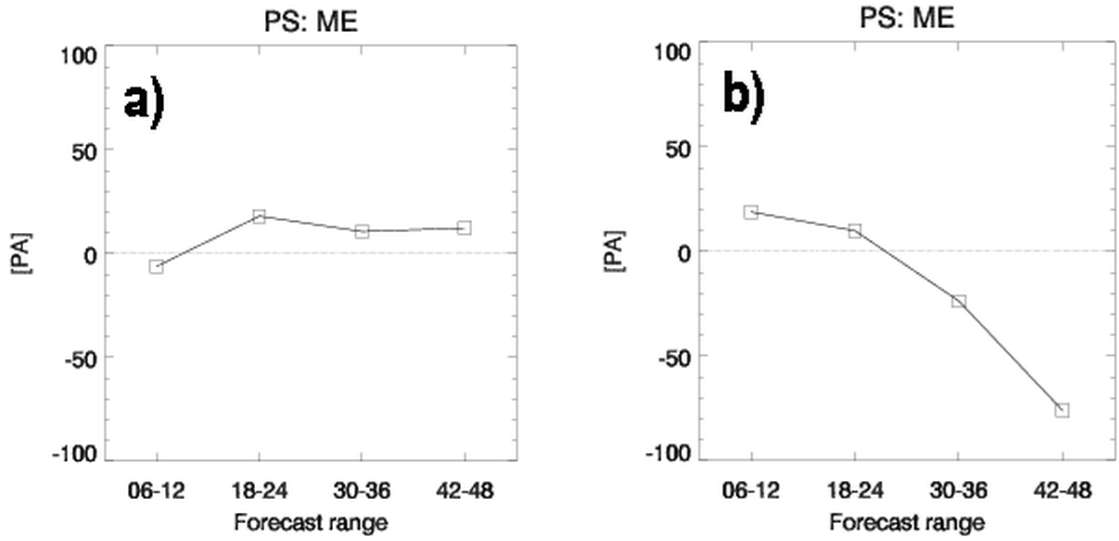

Figure 2: Dependence of the model bias (mean error) on forecast range; (a) winter 2002/3, (b) summer 2003.

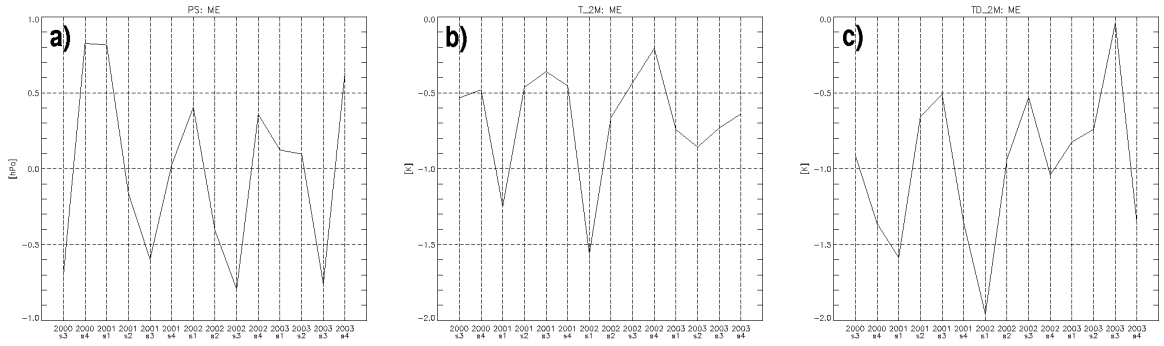

Figure 3: Evolution of seasonal model bias for the forecast range +42 to +48 h since summer 2000 (2000s3); (a) surface pressure, (b) 2 m temperature, (c) 2 m dewpoint.

variability is evident. The surface pressure (Fig. 3a) and the pressure reduced to mean sea level (not shown) both have a positive bias of about 0.5 hPa in winter and a negative bias of about 0.7 hPa in summer. The 2 m-temperature (Fig. 3b) is about 1 K too low in winter and 0.5 K too low in summer, and the dewpoint temperature (Fig. 3c) is about 1.5 K too low in winter and 0.5 K too low in summer. A too low dewpoint temperature is equivalent with an underestimated water vapour content.

A systematic bias of the model can be removed in post-processing or in the interpretation process by an informed forecaster. A more important figure of the model quality is the STDE, giving a reliability measure of the model after compensating for the systematic bias. In Fig. 4, the STDE of PS shows like the bias a seasonal cycle and no clear trend. The last season however, autumn 2003(2003s4), is exceptionally low compared to all three previous autumns, possibly indicating an improving quality of the model forecast due to the use of ECMWF-IFS boundary values. An evaluation of the ECMWF-IFS instead of the GME boundary conditions during summer 2003 has shown a decreased STDE for all parameters. It remains to be seen if the lower STDE values in autumn 2003 is a positive quality signal that persists into the future.

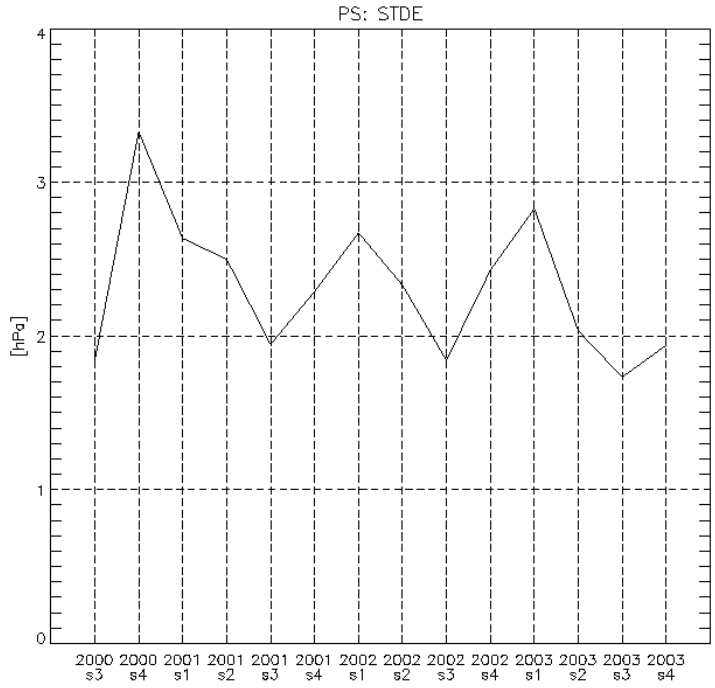

Figure 4: Evolution of standard deviation of errors for the forecast range +42 to +48 h since summer 2000 (2000s3) for surface pressure.

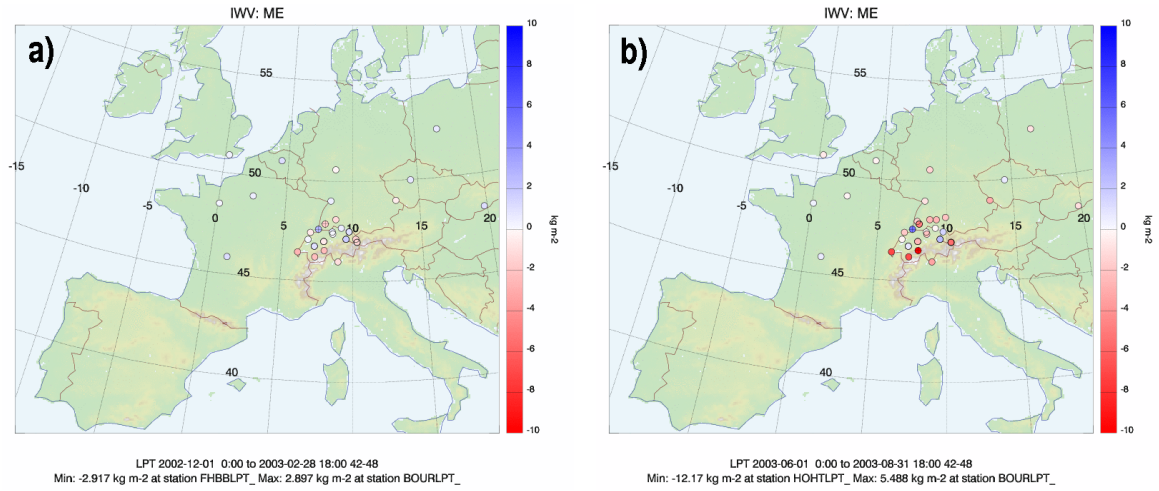

Figure 5: Model bias (mean error) of integrated water vapour for the forecast range +42 and +48 h of the 00 UTC and 12 UTC aLMo integrations; (a) winter 2002/3, (b) summer 2003.

4 GPS Verification

Last year, the verification was extended to include the vertically integrated water vapour content (IWV) derived from the Global Positioning System (GPS). Several processing centres throughout Europe provide zenith total delay (ZTD) measurements, each primarily focussing on its home country but still providing some overlap with other European countries. The ZTD values of three centres are deemed reliable from the experience during COST-716 and are used here. The calculation of the IWV from ZTD requires the knowledge of the air density above the GPS antenna. This is calculated with the temperature and pressure measurements from a nearby SYNOP station. The processed IWV data is provided by KNMI in the framework of the COST-716 and the TOUGH project. The aLMo derives the IWV

value directly from the specific water vapour content. A future aLMo version will calculate ZTD values that can be directly compared to the ZTD values measured by any of the present (GPS) and future (Galileo, GLONASS) global navigation satellite system (GNSS).

An example of the verification of the aLMo IWV is shown in Fig. 5. The stations shown are those processed by Swisstopo. The IWV bias shows a seasonal cycle, with smaller bias in winter than in summer. This bias is largest in the mountains, so that it could be related to the height difference between the GPS antenna, the SYNOP station, and the model surface. This dependence on height differences remains to be explored in the future work.

References

Kaufmann, Pirmin, 2003: Verification of aLMo runs at SYNOP-Stations. COSMO Newsletter no 3, G. Doms and U. Schttler (Eds.), DWD, Germany (available at www.como-model.org), p. 76 - 79.