Operational Verification of Vertical Profiles at Meteoswiss

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The operational upper-air verification at MeteoSwiss uses TEMP stations all over the integration domain to verify the vertical structure of the forecasts. For the operational setup of the Alpine Model (aLMo), refer to section 4 in this newsletter. However, note that the aLMo runs with the new two-category ice scheme since 11 May 2004 and with the prognostic precipitation scheme since 16 November 2004. Moreover, the model is integrated out to +72 hours since 16 September 2003 (recall that aLMo runs with ECMWF lateral boundary conditions rather than GME lateral boundary conditions since that date), which allows to compare verification results for +00 h, +24 h, +48 h, and +72 h, respectively.

In the following, we present the average vertical structure for 30 TEMP stations for the full climatic year 2004 (averaged over verification times 00 & 12 UTC; see Figs. 1 – 4; please note that the statistics for the uppermost level of 30 hPa is extremely limited, and hence the verification results at that level should be interpreted very carefully).

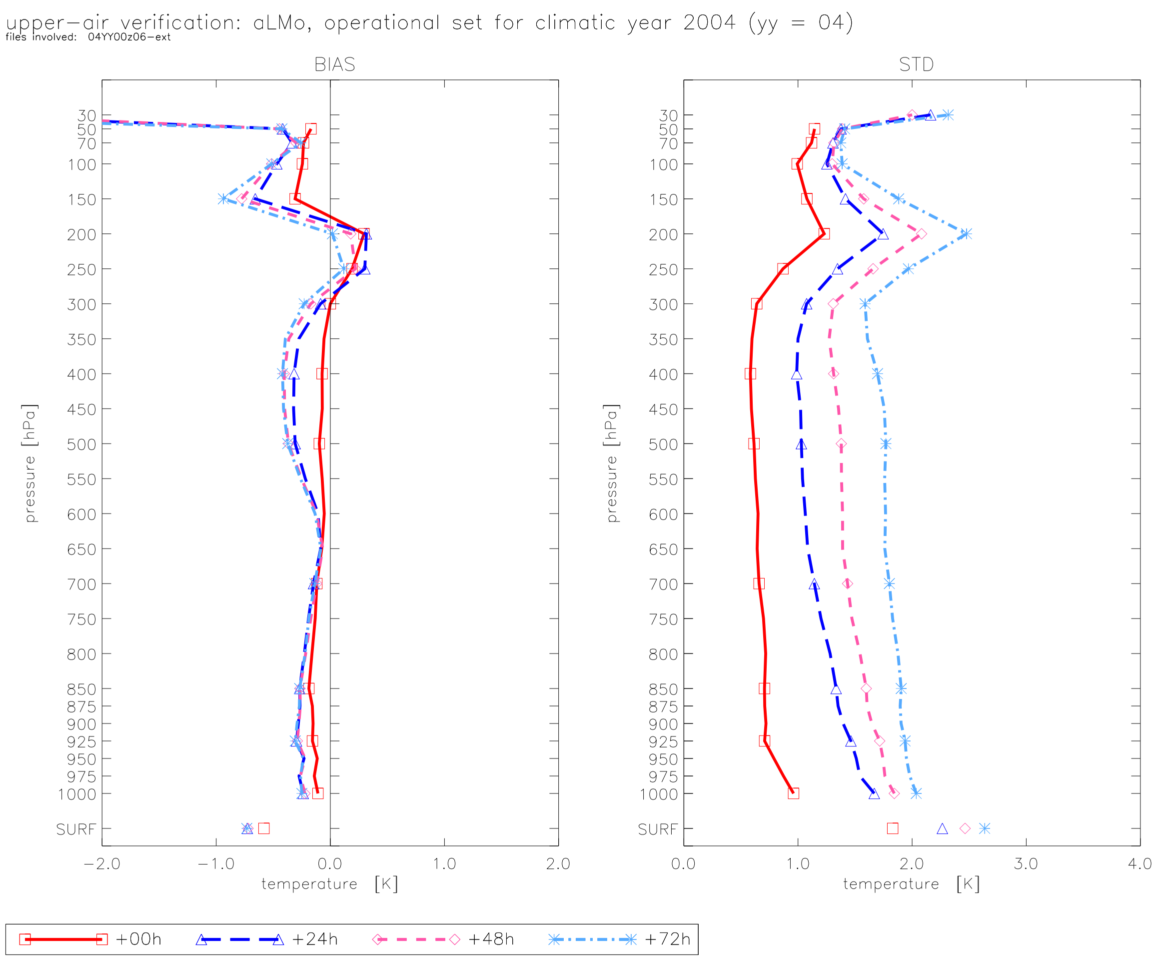

Figure 1: Mean error (BIAS) and standard deviation (STD) for temperature. Various forecast times (averaged over all stations and verification times 00 & 12 UTC) for the climatic year 2004 (1.12.2003 – 30.11.2004).

The verification plot for *temperature* (*cf.* Fig. 1) shows a cold bias throughout the troposphere, varying in magnitude between 0.1 K and 0.4 K. When looking at the different seasons (not shown), one finds that most seasons contribute similarly to this cold bias, except for the summer season, which shows a warm bias in between 800 hPa and 500 hPa, with a maximum at around 650 hPa, which is reflected in the minimum of the cold bias for the full climatic year at that level. At and above the tropopause level, a saw-like structure in the mean error of temperature can be observed, which is common to all seasons. The fact that most temperature biases increase with increasing forecast time hints at a systematic model deficiency. Concerning the standard deviation, largest spread is seen around the tropopause level.

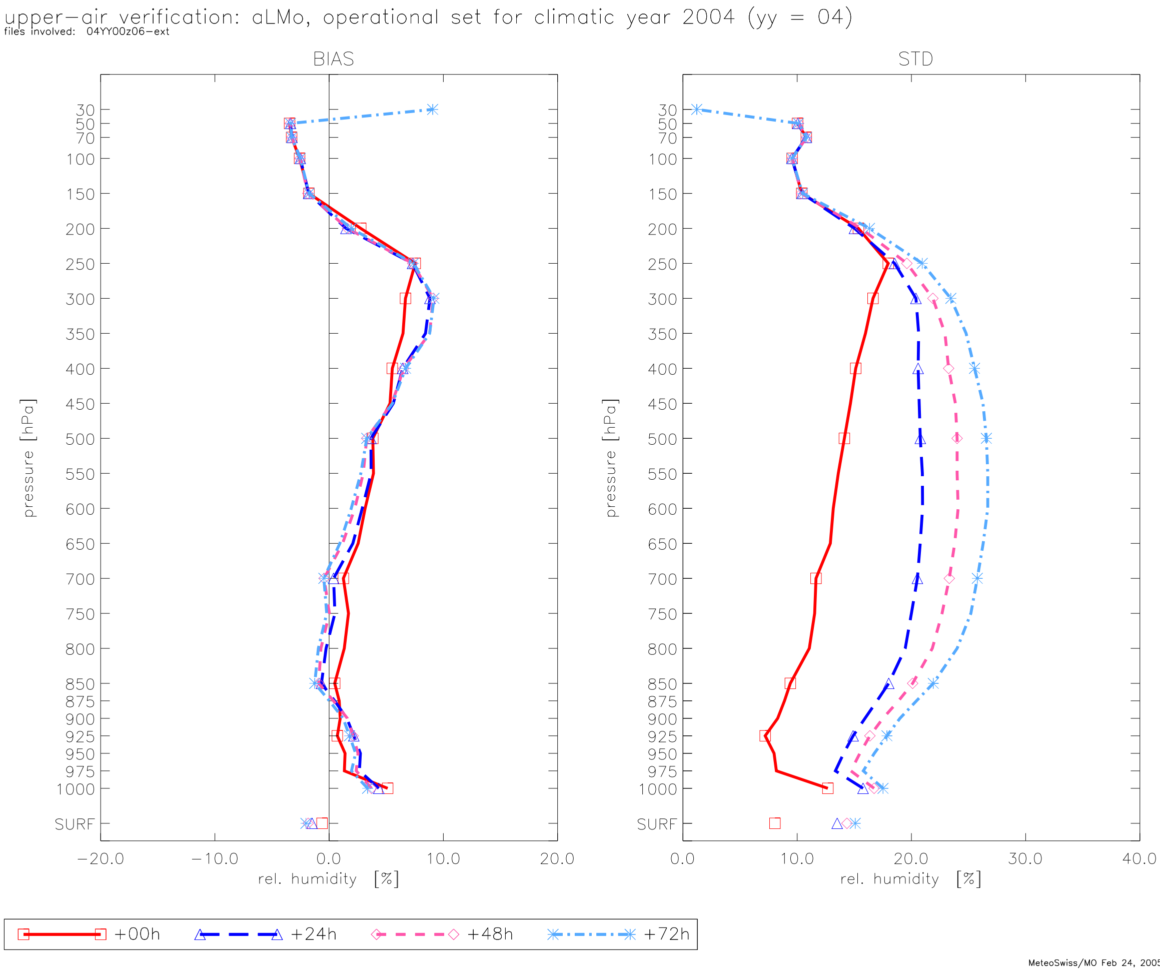

Figure 2: Mean error (BIAS) and standard deviation (STD) for relative humidity with respect to water. Various forecast times (averaged over all stations and verification times 00 & 12 UTC) for the climatic year 2004 (1.12.2003 – 30.11.2004).

Looking at the verification results for the *relative humidity* (*cf.* Fig. 2) the mean error is moderate up to 700 hPa, with a clear and increasing moist bias towards the surface. Above 700 hPa, relative humidity with respect to water is systematically biased towards positive values, since for the old grid-scale precipitation scheme (one-category ice scheme, *i.e.*, no cloud ice; in operation until mid 2004) specific humidity values need to be artificially increased at analysis time to compensate for the difference in saturation vapour pressure over water and ice at temperatures below freezing (for the two seasons after the switch to the new cloud ice scheme, the bias in relative humidity is at most 6% throughout the atmosphere; not shown). The standard deviation is reasonably uniform throughout the troposphere, with a slight increase towards the surface.

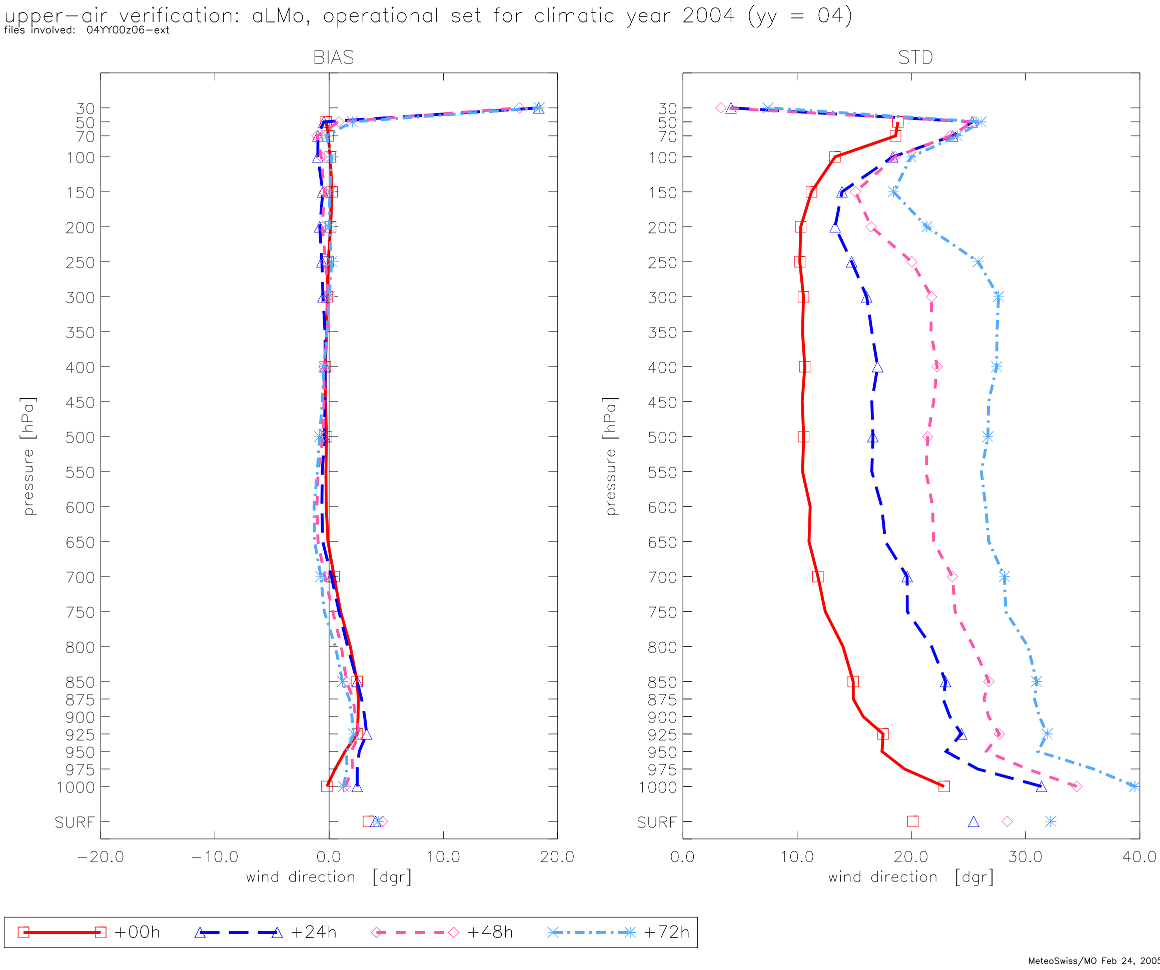

Figure 3: Mean error (BIAS) and standard deviation (STD) for wind direction. Various forecast times (averaged over all stations and verification times 00 & 12 UTC) for the climatic year 2004 (1.12.2003 – 30.11.2004).

Wind direction (*cf.* Fig. 3) exhibits a very small mean error, especially above the boundary layer. As expected, there is a marked increase for both mean error and standard deviation towards the surface. A deterioration of the standard deviation is also observed in the stratosphere.

The mean error of the *wind speed* (*cf.* Fig. 4) is small. The largest bias is observed for the boundary layer and around the tropopause height. Although seasonal differences in the (small) mean error are fairly small, the main contributions to the prevailing negative bias stem from the spring and summer seasons, whereas the positive bias in the boundary layer is largest in winter (not shown). The standard deviation is largest at the tropopause, consistent with the highest winds at this level.

Concerning the interplay between the assimilation scheme and the daily spread of the forecasts, we note that the standard deviation increases almost linearly from forecast time +06 h to +72 h with a substantially larger difference between analysis time (*i.e.*, +00 h) and +06 h for all parameters except the (un-nudged) geopotential (not shown).

Let us finally compare these verification results with other years (see older COSMO Newsletters for comparison), always bearing in mind that inter-annual differences in the weather situations may lead to larger differences in the verification results then possible model improvements. The systematic errors in temperature and especially wind speed observed in

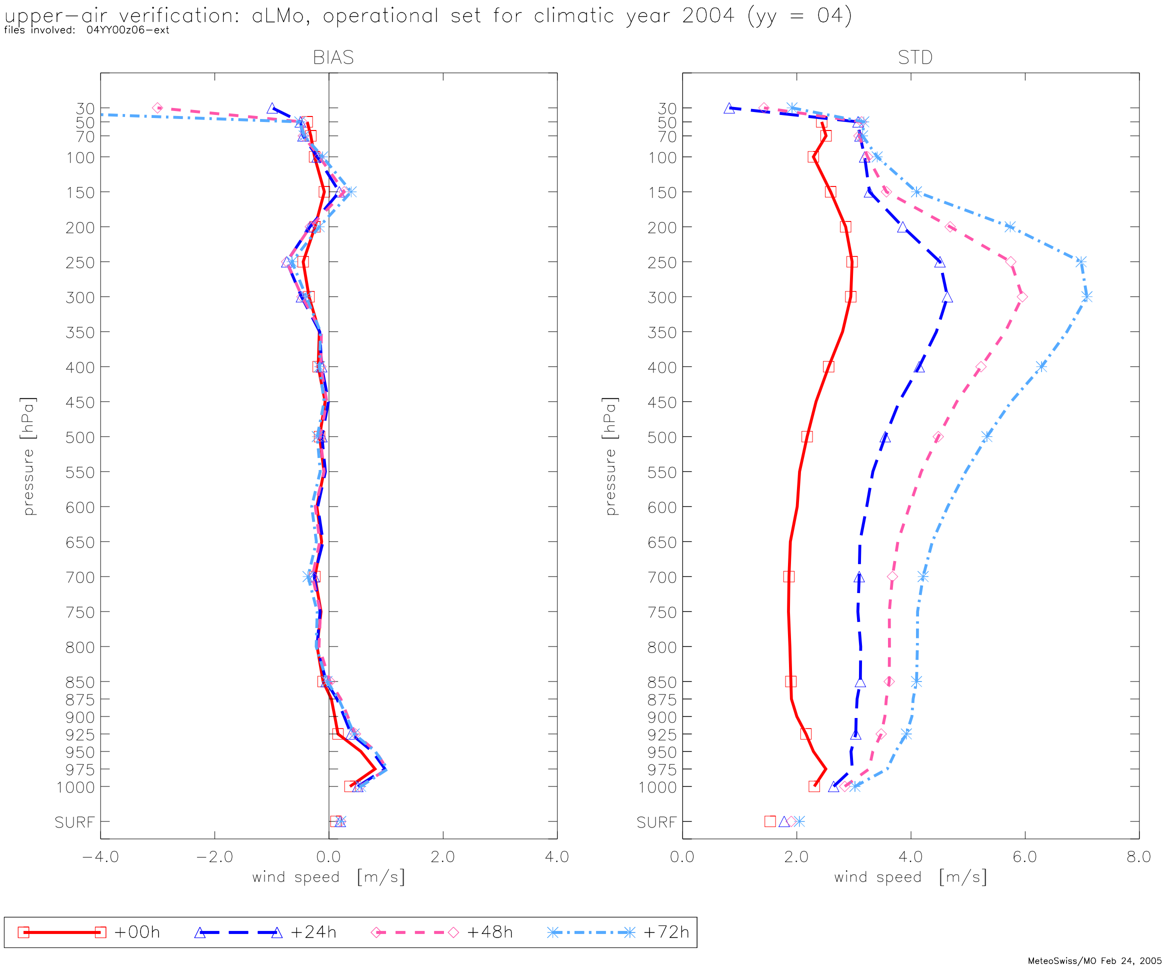

Figure 4: Mean error (BIAS) and standard deviation (STD) for wind speed. Various forecast times (averaged over all stations and verification times 00 & 12 UTC) for the climatic year 2004 (1.12.2003 – 30.11.2004).

earlier years, some of which may have been due to the driving global model, have disappeared. However, by using the ECMWF global forecasts (IFS) as lateral boundary conditions without any mechanism to damp reflections at the upper boundary (*i.e.*, no Rayleigh damping, since aLMo runs with IFS frames rather than full 3d fields), we may have introduced new problems, especially concerning the forecast of temperature in the stratosphere. Nevertheless, a clear improvement of the standard deviation as compared to the climatic year 2003 can be observed for all parameters verified (not shown).