Operational Verification of Vertical Profiles at MeteoSwiss

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The operational upper-air verification at MeteoSwiss uses a set of 28 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 4.5 in this Newsletter.

In this paper, we present the analogous results to last year's report, that is, the average vertical structure for all 28 stations for the full climatic year 2002 (averaged over verification times 00 & 12 UTC; see figures 1–5). Additionally, a few highlights of the 2002 dataset are discussed in another contribution in this Section (*Upper-Air Verification at MeteoSwiss for 2002: Highlights*), together with a comparison of the verification results for 2002 and 2001.

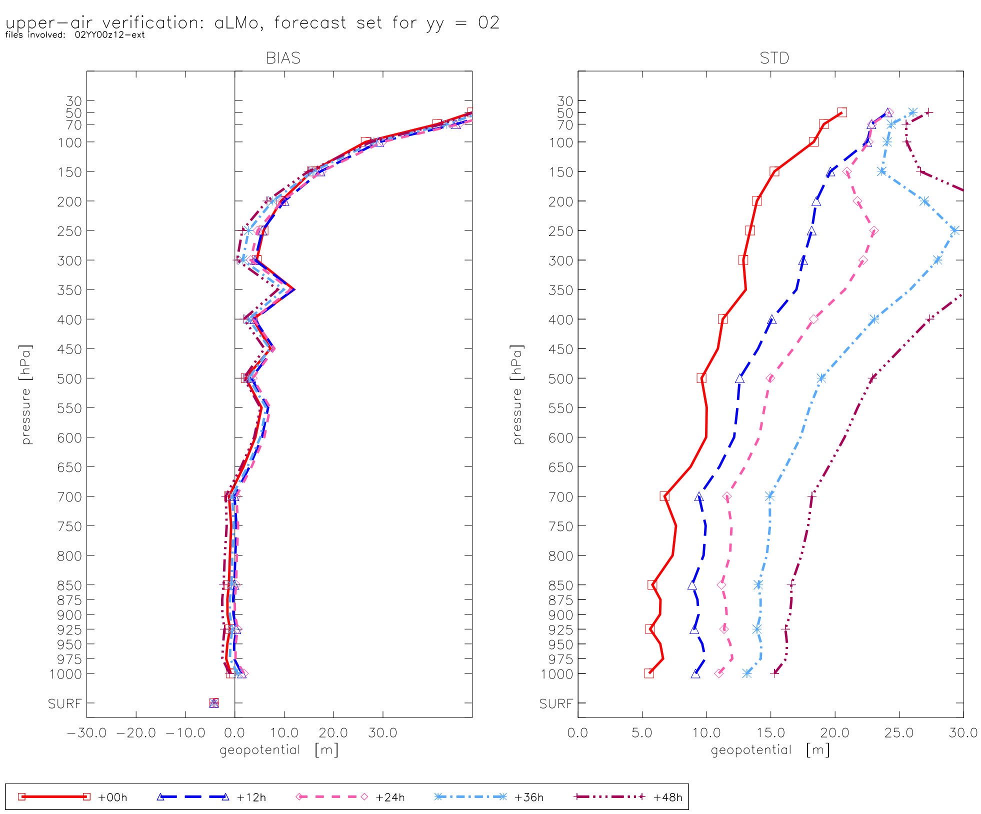

Figure 1: Mean error (BIAS) and standard deviation (STD) for the geopotential. Various forecast times (averaged over all stations and verification times 00 & 12 UTC) for the climatic year 2002 (1.12.2001–30.11.2002).

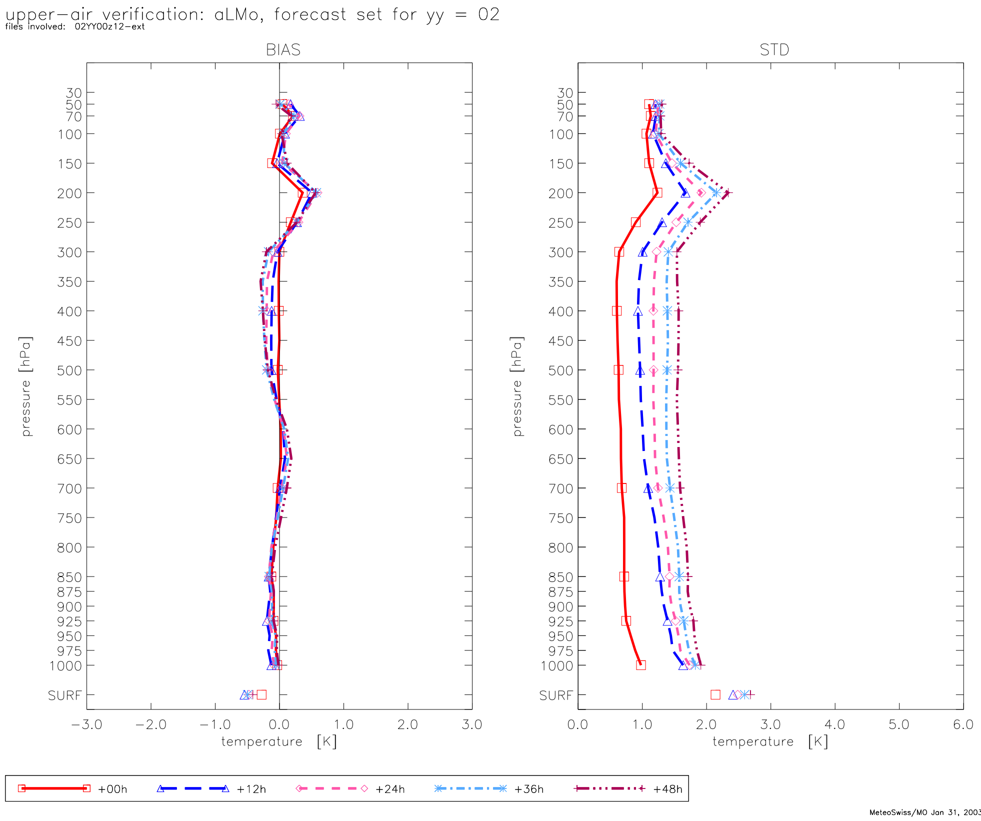

Figure 2: Mean error (BIAS) and standard deviation (STD) for temperature. Various forecast times (averaged over all stations and verification times 00 & 12 UTC for the climatic year 2002 (1.12.2001–30.11.2002).

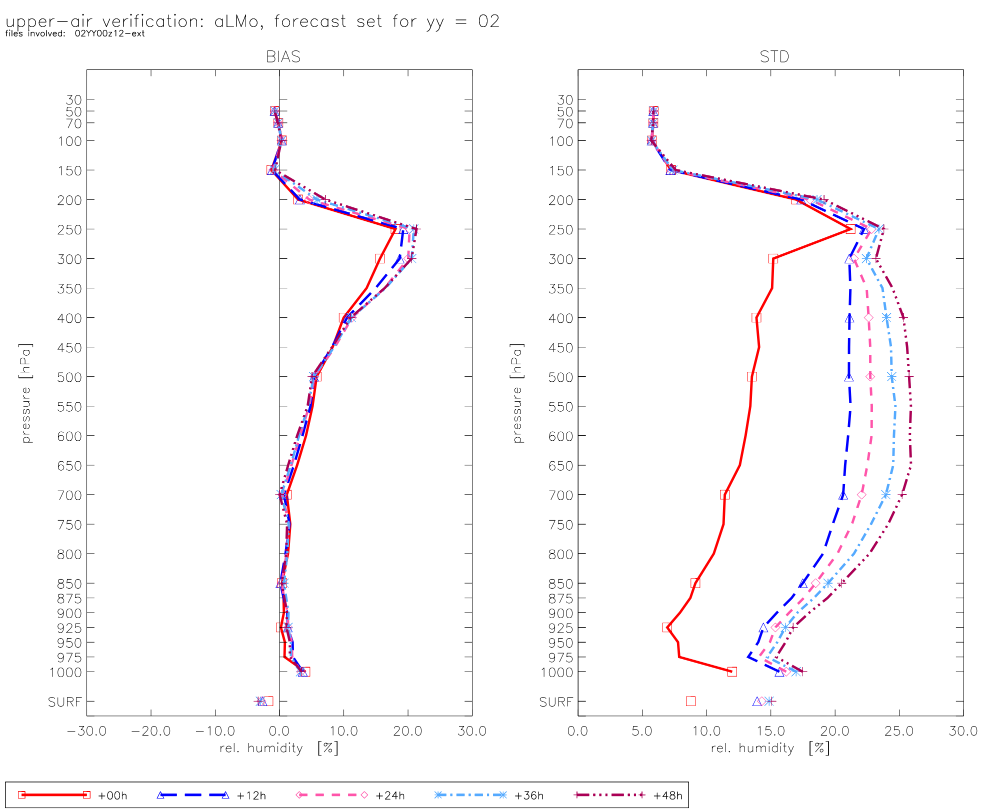

Figure 3: Mean error (BIAS) and standard deviation (STD) for relative humidity with respect to water. Various forecast times (averaged over all stations and verification times 00 & 12 UTC) for the climatic year 2002 (1.12.2001–30.11.2002).

The verification plots for *geopotential* (*c.f.* figure 1) and *temperature* (*c.f.* figure 2) show a very different behaviour for different regions of the atmosphere. The drastic increase of the geopotential mean error in the stratosphere, the most obvious deficiency seen in the upper-air verification plots considered, is probably related to an error in the interpolation scheme (GME2LM) for pressure. The saw-like structure in the mean error of temperature at and above the tropopause level is possibly linked to the behaviour of the geopotential mean error mentioned above, but may also be due to the limited vertical resolution of the model at the tropopause height. From the middle atmosphere up to the tropopause, a negative bias in the temperature profile increasing with increasing forecast time hints at a systematic model deficiency, which is not yet understood. In the lower troposphere finally, temperature and geopotential validate well. Concerning the standard deviation, both geopotential and temperature show largest spread around the tropopause level.

Up to 700 hPa, the mean error for the forecasted *relative humidity* (*c.f.* figure 3) is fairly small, with a tendency to positive values towards the surface. Above 700 hPa, relative humidity with respect to water is systematically biased towards positive values, since for the current grid-scale precipitation scheme (no cloud ice) 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.

The mean error of the *wind direction* (*c.f.* figure 4) is very small, especially above the boundary layer. As expected, there is a clear increase for both mean error and standard deviation towards the surface. A deterioration of the standard deviation is also observed in the stratosphere.

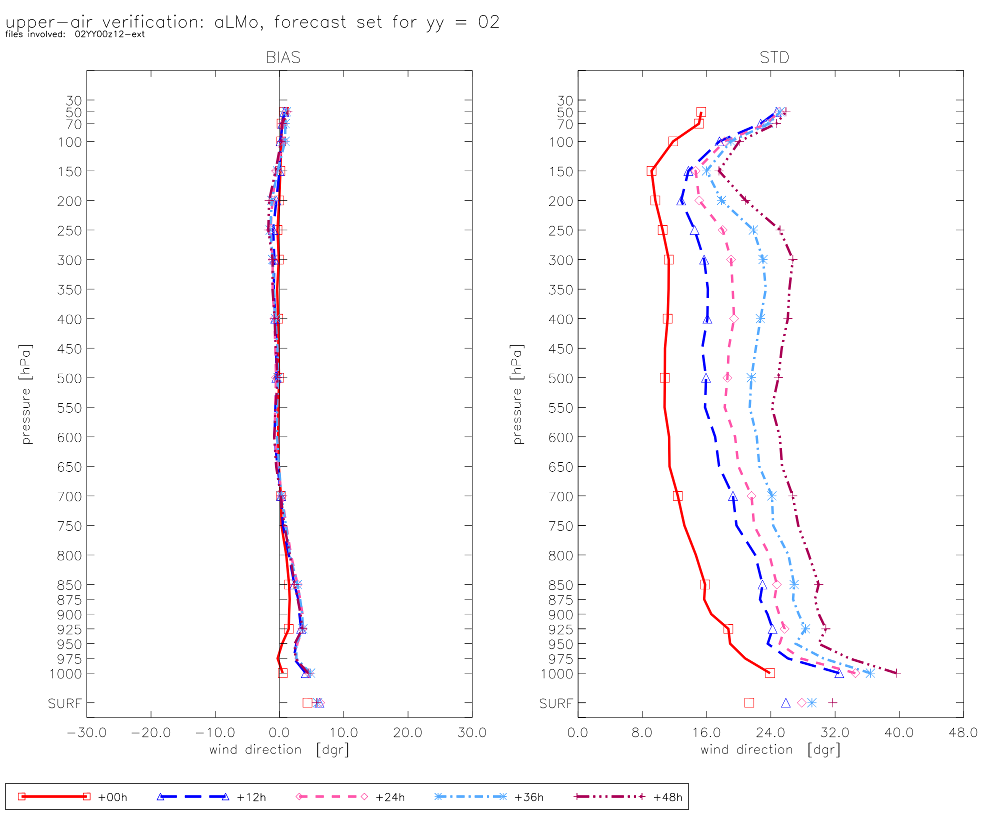

Figure 4: Mean error (BIAS) and standard deviation (STD) for wind direction. Various forecast times (averaged over all stations and verification times 00 & 12 UTC) for the climatic year 2002 (1.12.2001–30.11.2002).

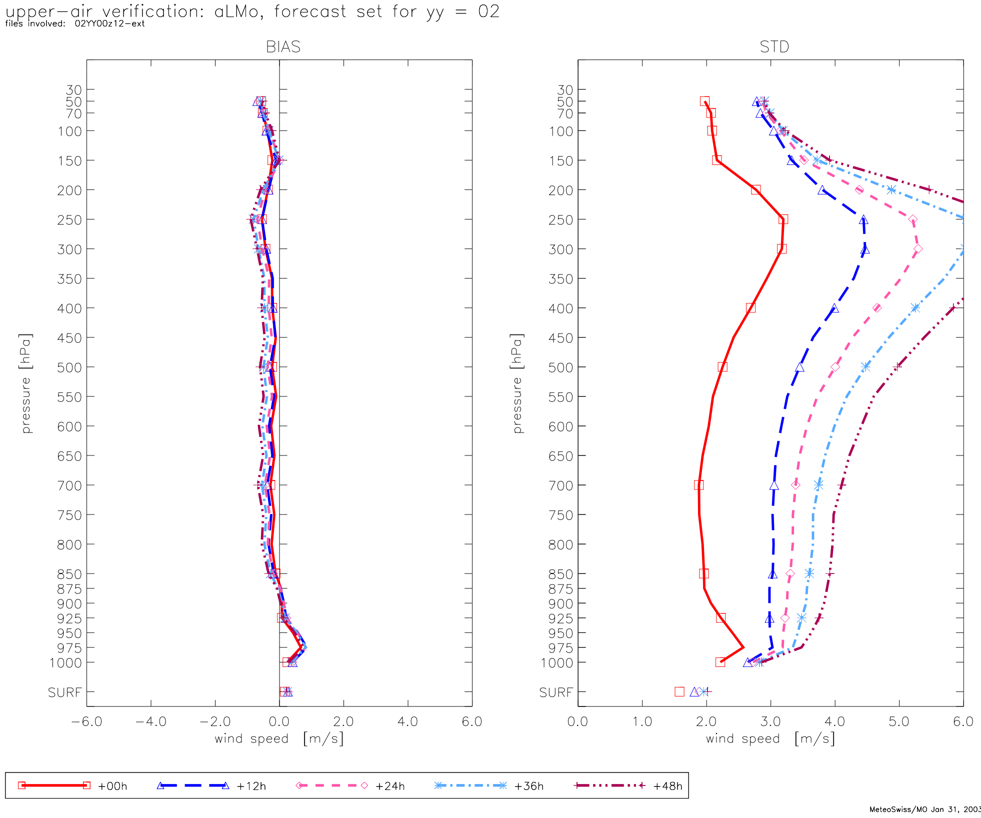

Figure 5: Mean error (BIAS) and standard deviation (STD) for wind speed. Various forecast times (averaged over all stations and verification times 00 & 12 UTC) for the climatic year 2002 (1.12.2001–30.11.2002).

The mean error of the *wind speed* (*c.f.* figure 5) is fairly small. The largest bias is observed for the boundary layer and at the tropopause height. Worth remarking is the non-negligible slow-down of the atmosphere with increasing forecast time throughout most of the troposphere, hinting at another systematic model error or a systematic bias of the driving global model (*i.e.*, the boundary conditions, in our case the GME). The standard deviation is largest at the tropopause, consistent with the highest winds at this level.

Finally, we note that the standard deviation increases almost linearly from forecast time +12 h to +48 h with a substantially larger difference between analysis time (*i.e.*, +00 h) and +12 h for all parameters except the (un-nudged) geopotential.