Upper-Air Verification at MeteoSwiss for 2002: Highlights

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1 Summary

In short:

- Verification results for 00 UTC and 12 UTC lead to very similar results.
- Substantial differences observed for the different seasons, most notably for temperature and wind speed. Largest error for winter.
- Large systematic errors in winter probably caused by bad forecasts in strong advective situations, which in turn are most vulnerable to systematic biases in the driving global model.
- Systematic improvement of temperature and relative humidity analysis due to nudging scheme.

2 Introduction

In addition to the operational upper-air verification report in section 8 of this newsletter *Operational Verification of Vertical Profiles at MeteoSwiss*, we will here focus on a few specific questions such as the dependence of the verification results on the verification time (*i.e.,* 00 UTC or 12 UTC) and the season and will also compare this year's results with the ones from last year (*c.f.* COSMO Newsletter 2, page 65).

The selection of presented results is thereby heavily biased towards "interesting" results — most often cases, where the model performs unsatisfactory — since we mainly look at verification plots to better understand what improvements to the model are most needed ...

3 Variations of verification results depending on verification time

In general, the verification results for 00 UTC and 12 UTC look fairly similar.

Some of the biggest differences can be observed for the relative humidity (see figure 1). Above 700 hPa, both the mean error and the standard deviation show a significant difference between the two verification times. In the boundary layer, the mean error shows a different behaviour between analysis time (*i.e.,* +00 h; not shown) and +48 h: for verification time 00 UTC, the mean error shrinks, whereas it gets slightly bigger for verification time 12 UTC.

4 Variations of verification results depending on season

Differences between different seasons are more spectacular.

As an example, figures 2 and 3 show the mean error and the standard deviation of temperature for +00 h and +48 h, respectively. For +48 h, winter (red) and summer (magenta)

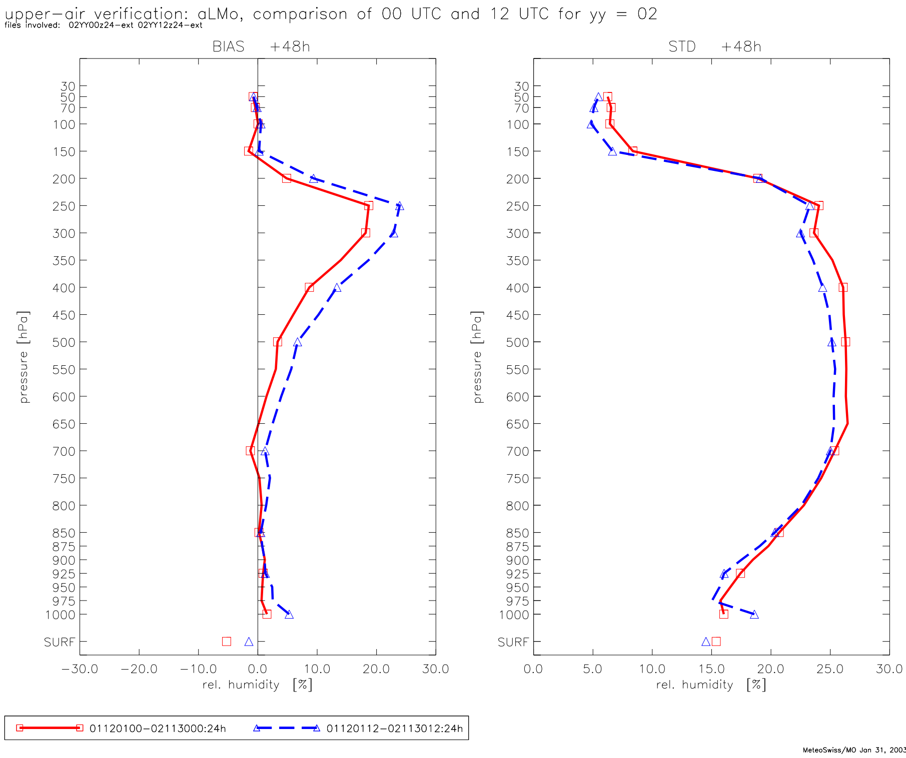

Figure 1: Mean error (BIAS) and standard deviation (STD) for relative humidity. Verification times 00 & 12 UTC (red and blue, respectively; averaged over all stations) for forecast time +48 h and the climatic year 2002 (1.12.2001–30.11.2002).

show mean errors significantly different from the other seasons. — We note that the winter season alone may explain a large fraction of the systematic temperature bias reported in the operational upper-air verification report in section 8 (*Operational Verification of Vertical Profiles at MeteoSwiss*).

Another parameter for which seasonal upper-air verification results look fairly different is wind speed (*c.f.* figures 4 and 5). At the tropopause level, the winter season (red) shows largest mean errors, and together with the summer season (magenta) contributes most to the systematic slow-down of the atmosphere with increasing forecast time throughout most of the troposphere as reported in *Operational Verification of Vertical Profiles at MeteoSwiss* in section 8.

A closer look to the winter season

Since the winter season seems to explain most of the systematic model biases seen for the entire climatic year 2002, we try to find out what type of synoptic situation is mostly responsible for this behaviour. To this end, we use a weather-type dependent verification (see the contribution *Weather Situation-Dependent Stratification of Precipitation and Upper-air Verification of the Alpine Model (aLMo)* in section 8 for more details on the weather-type dependent verification done at MeteoSwiss) to stratify the upper-air verification plots for winter into different weather-types.

Figures 6 and 7 show the verification results for temperature (forecast times +00 h and +48 h, respectively) for weather-types "convective", "advective", "mixed" and "jet" (40, 29, 1 and 20 days for winter 2002, respectively). For the upper part of the troposphere, "jet" situations add most to the observed bias at +48 h, whereas in the lower part of the troposphere, no clear separation between the different weather types is visible.

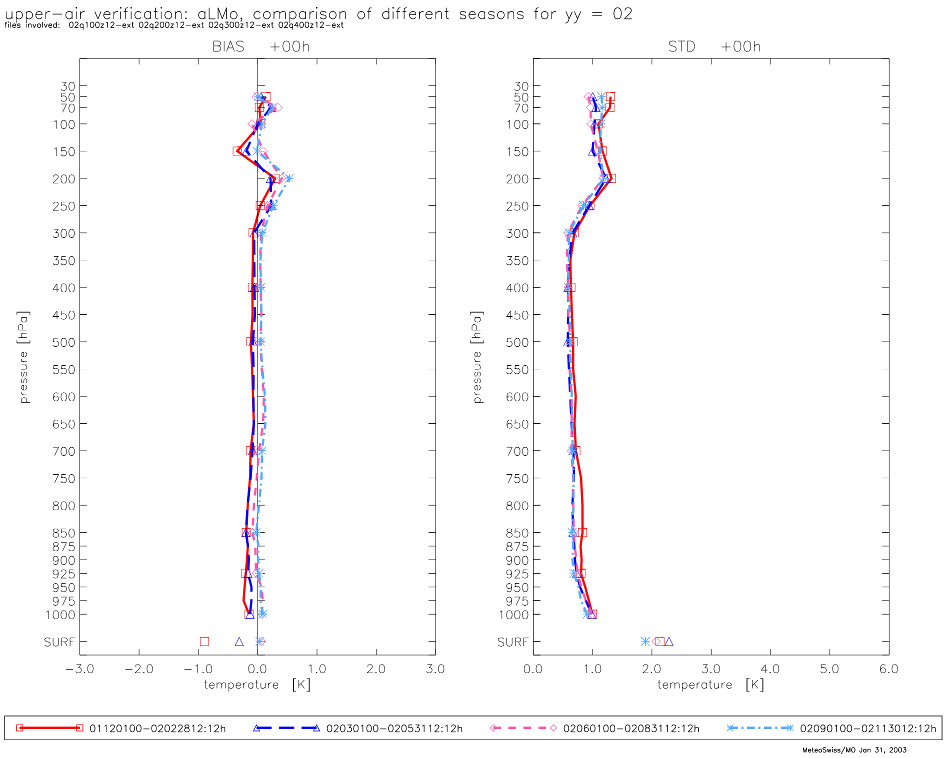

Figure 2: Mean error (BIAS) and standard deviation (STD) for temperature. Different seasons (averaged over all stations) for forecast time +00 h and the climatic year 2002 (1.12.2001–30.11.2002).

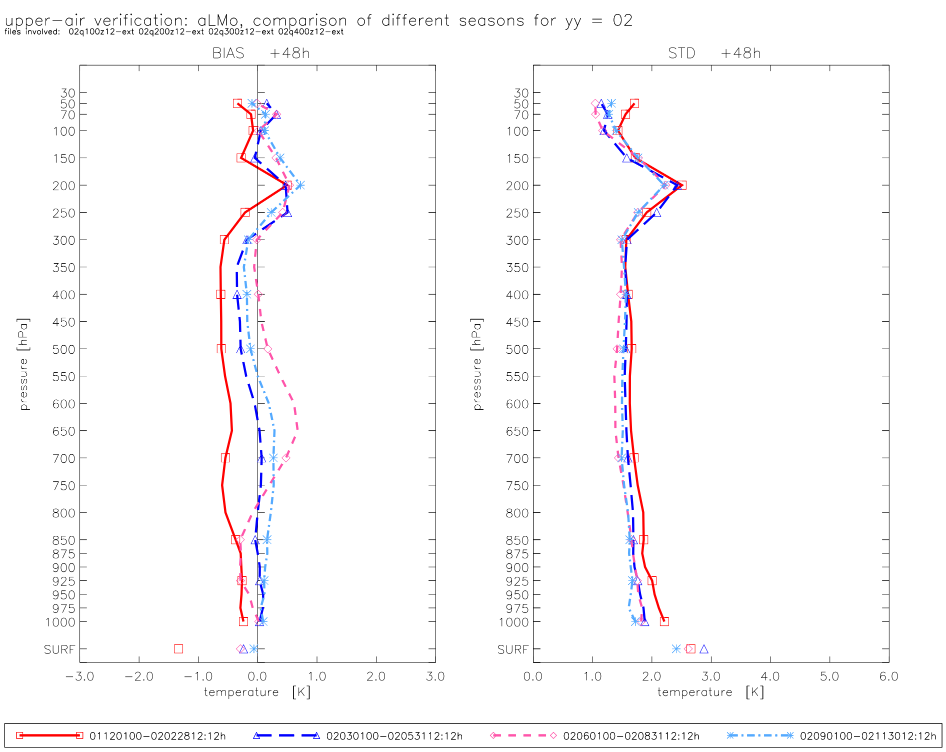

Figure 3: Mean error (BIAS) and standard deviation (STD) for temperature. Different seasons (averaged over all stations) for forecast time +48 h and the climatic year 2002 (1.12.2001–30.11.2002).

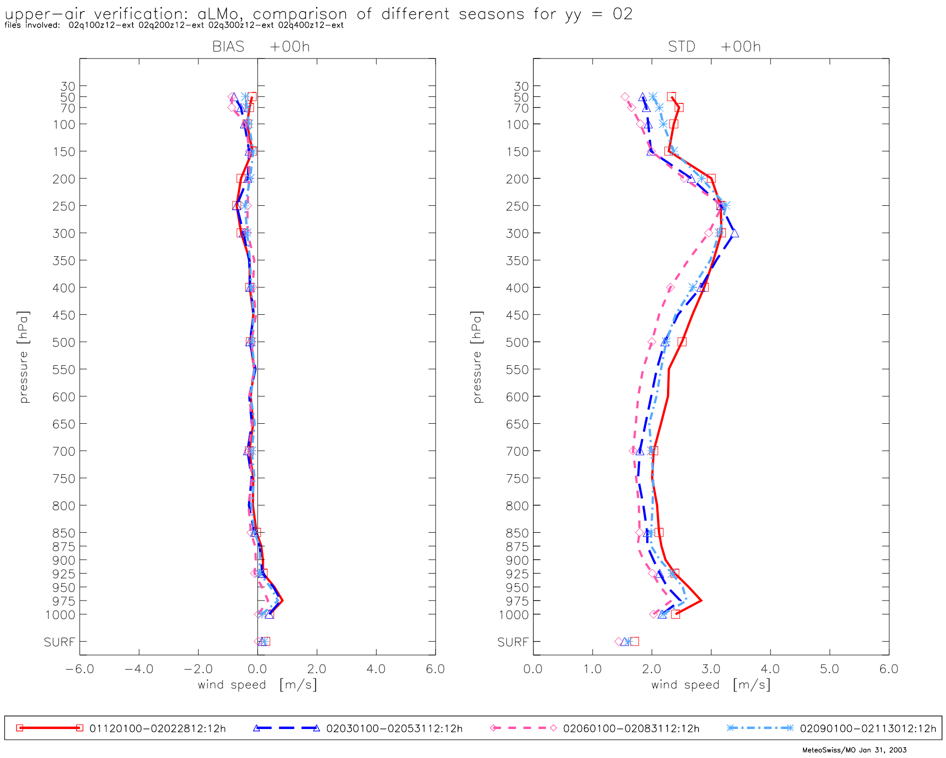

Figure 4: Mean error (BIAS) and standard deviation (STD) for wind speed. Different seasons (averaged over all stations) for forecast time +00 h and the climatic year 2002 (1.12.2001–30.11.2002).

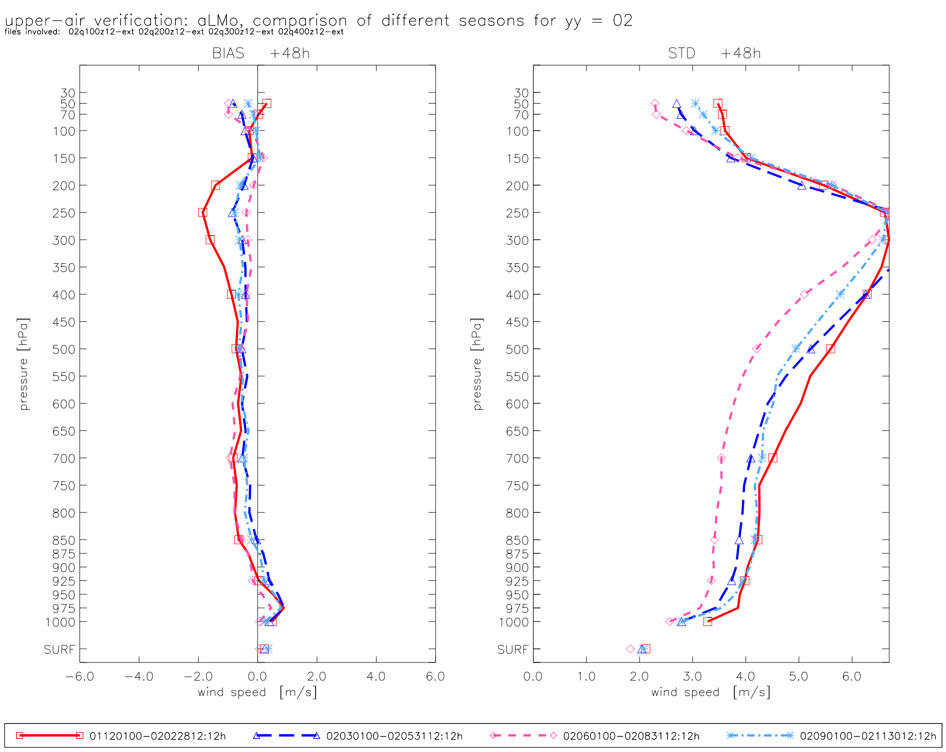

Figure 5: Mean error (BIAS) and standard deviation (STD) for wind speed. Different seasons (averaged over all stations) for forecast time +48 h and the climatic year 2002 (1.12.2001–30.11.2002).

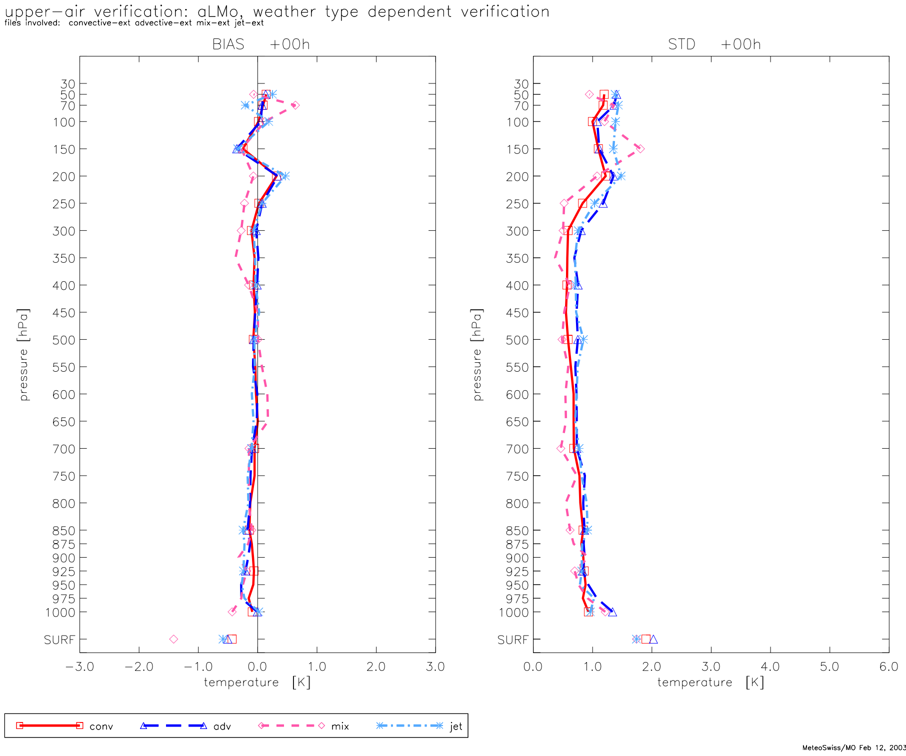

Figure 6: Mean error (BIAS) and standard deviation (STD) for temperature. Different weather-types (averaged over all stations; 12 UTC verification time) for forecast time +00 h and the winter season 2002 (1.12.2001–28.2.2002).

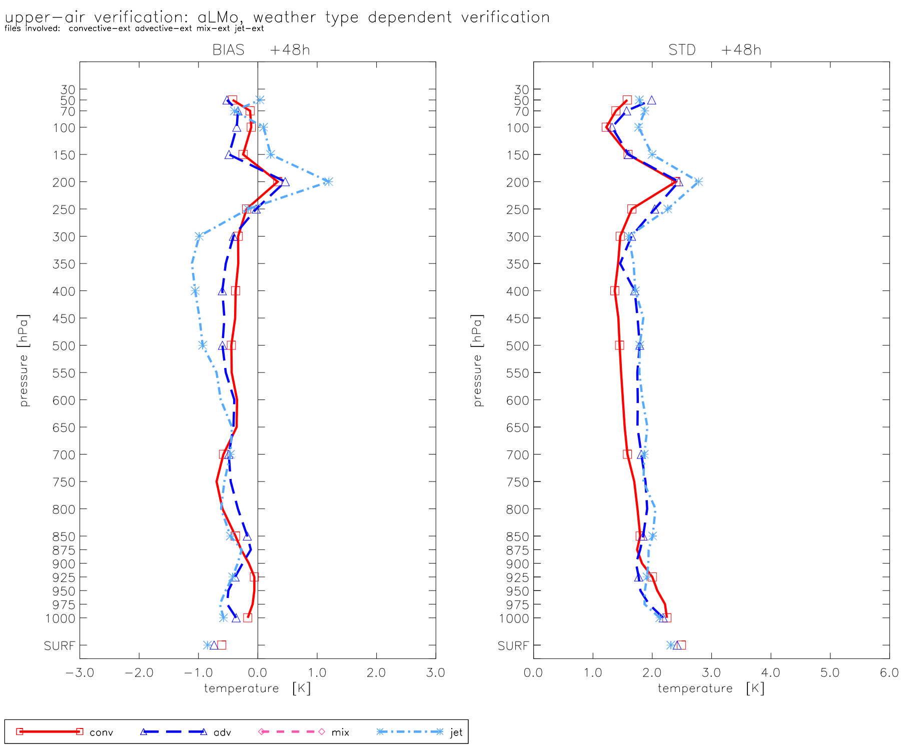

Figure 7: Mean error (BIAS) and standard deviation (STD) for temperature. Different weather-types (averaged over all stations; 12 UTC verification time) for forecast time +48 h and the winter season 2002 (1.12.2001–28.2.2002).

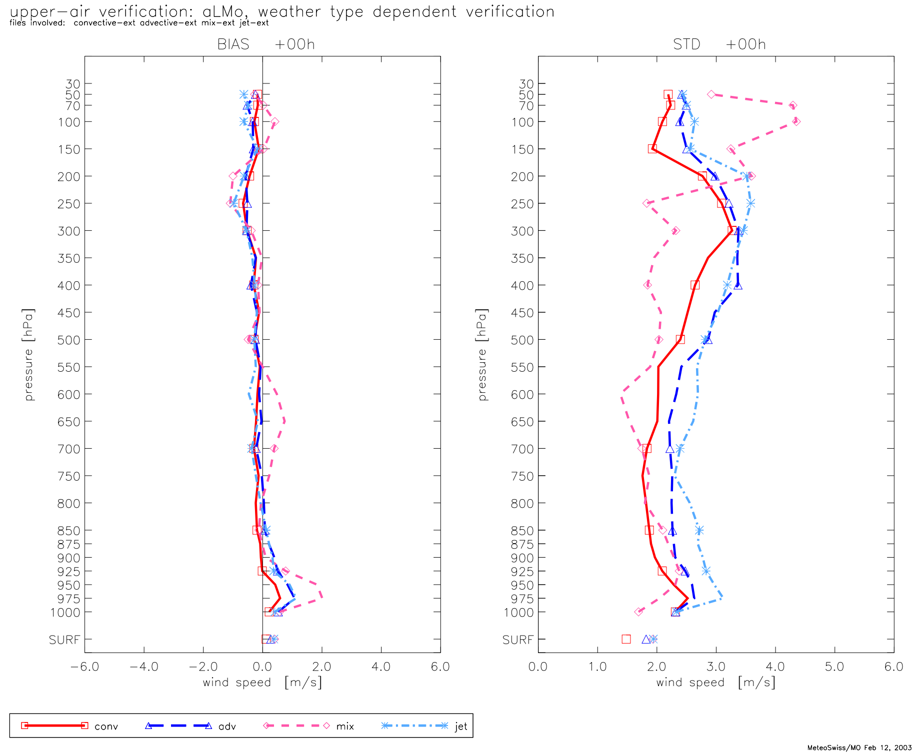

Figure 8: Mean error (BIAS) and standard deviation (STD) for wind speed. Different weather-types (averaged over all stations; 12 UTC verification time) for forecast time +00 h and the winter season 2002 (1.12.2001–28.2.2002).

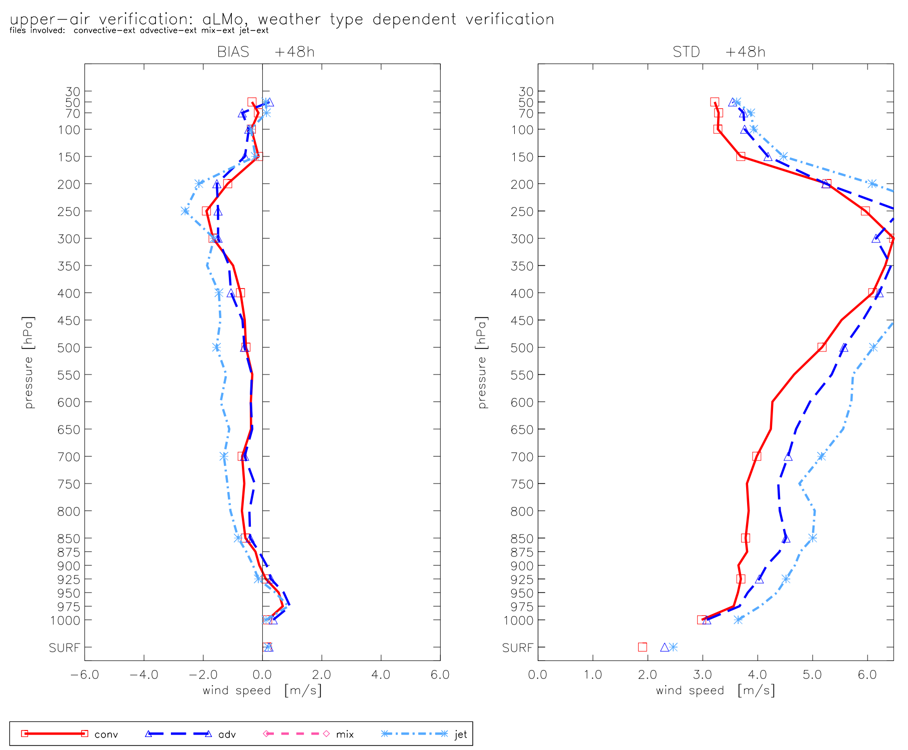

Figure 9: Mean error (BIAS) and standard deviation (STD) for wind speed. Different weather-types (averaged over all stations, 12 UTC verification time) for forecast time +48 h and the winter season 2002 (1.12.2001–28.2.2002).

Concerning wind speed (see figures 8 and 9), "jet" situations have a larger bias than the other three synoptic weather-types throughout the (free) troposphere.

Both results (which are also obtained when looking at the weather-type dependent verification results for the full climatic year 2002 rather than just winter; not shown) indicate that strong advective situations cause most of the systematic error for temperature and wind speed, which opens room for speculations that the systematic biases are, in fact, not the result of some systematic model deficiency but rather the influence of (imperfect) boundary conditions. And indeed, first preliminary results at DWD show, that the GME has a systematic bias for the wind speed analogous to the one observed for the aLMo (no results for temperature yet).

5 Comparison with verification results of 2001

Finally, we compare the upper-air verification results of 2002 with the ones from 2001. Note that the nudging scheme was introduced operationally on the 31st of October, 2001, and hence the two data sets, besides being from different climatic years, also separate fairly well between aLMo runs from interpolated GME fields and from its own nudging assimilation, respectively.

Figure 10 shows the mean error and standard deviation of the temperature profiles for climatic years 2001 and 2002 at analysis time. As expected, the nudged temperature profiles (*i.e.,* 2002) verify much better then the ones obtained from interpolating the coarser-grid GME initial data. At +48 h forecast time, the improvement ist still visible for the mean error in the upper half of the troposphere, but has totally vanished for the standard deviation (not shown).

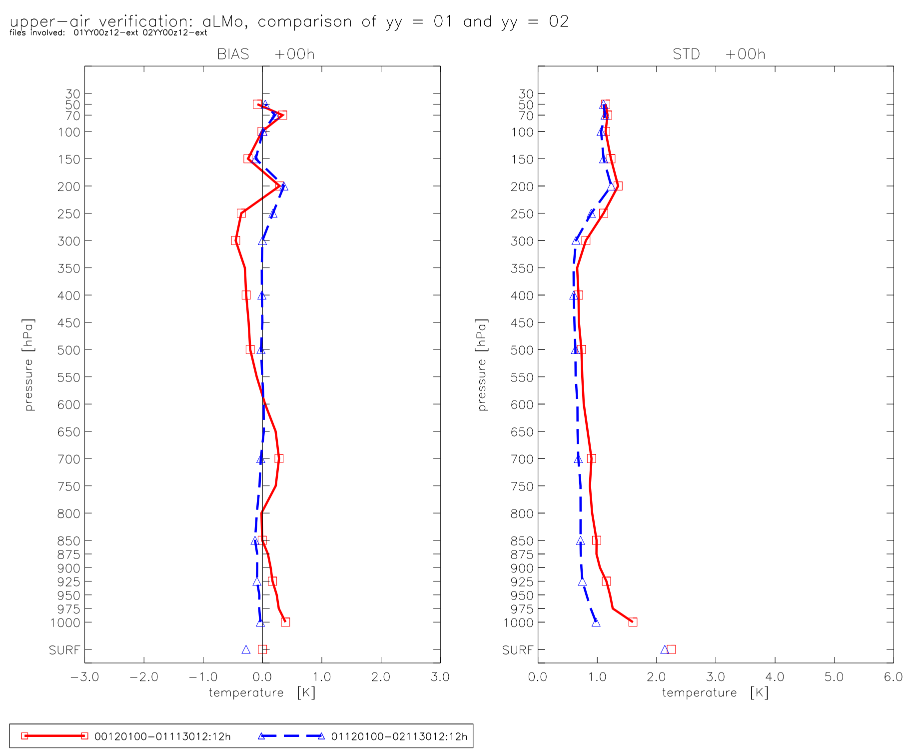

Figure 10: Mean error (BIAS) and standard deviation (STD) for temperature. Verification results for 2001 (red) and 2002 (blue) for forecast time +00 h (averaged over all stations and verification times 00 & 12 UTC).

The relative humidity, depicted in figure 11, also shows a clear improvement for 2002, both for the mean error (only consider the results below 700 hPa, due to the systematic bias towards positive values caused by the fact that 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) and the standard deviation. At forecast time +48 h, differences between the two data sets are marginal, with a small advantage in the mean error below 850 hPa for the aLMo runs based on the nudging assimilation over the 2001 data set (not shown).

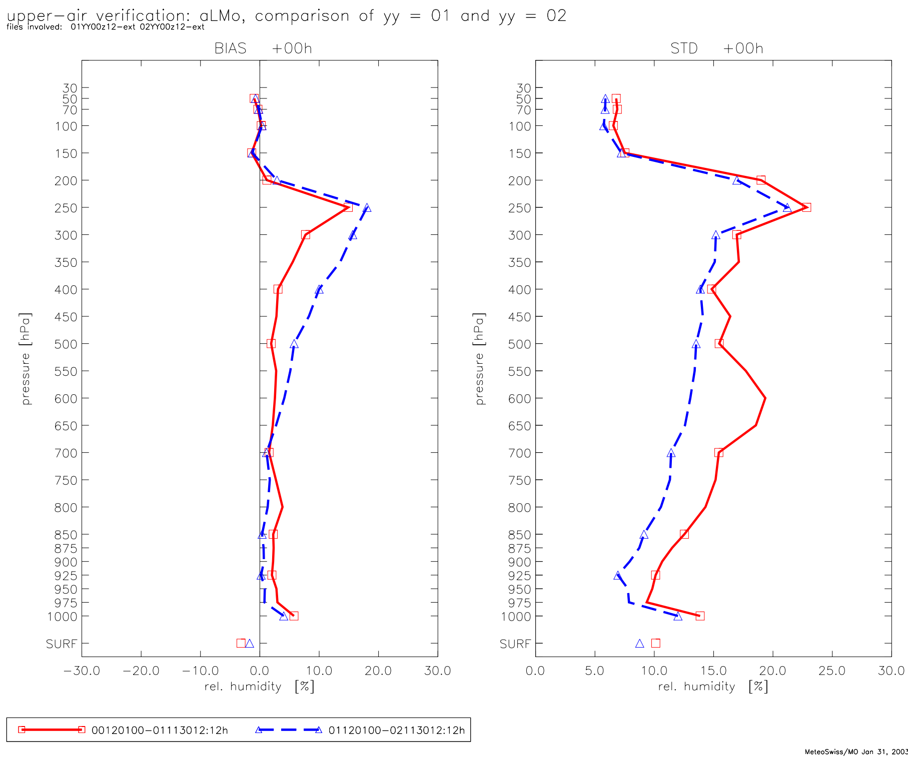

Figure 11: Mean error (BIAS) and standard deviation (STD) for relative humidity. Verification results for 2001 (red) and 2002 (blue) for forecast time +00 h (averaged over all stations and verification times 00 & 12 UTC).