High Resolution Verification of Daily Cycle over Switzerland

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The following nomenclature for LM is used in the text below: aLMo means "Alpine Model", the LM version operational at MeteoSwiss and LMD means the operational LM version at DWD. Verification is done with hourly observations from the automated network of MeteoSwiss (ANETZ: 72 stations) and is stratified for 3 different height ranges (gridpoints < 800m, 800–1500m and > 1500m).

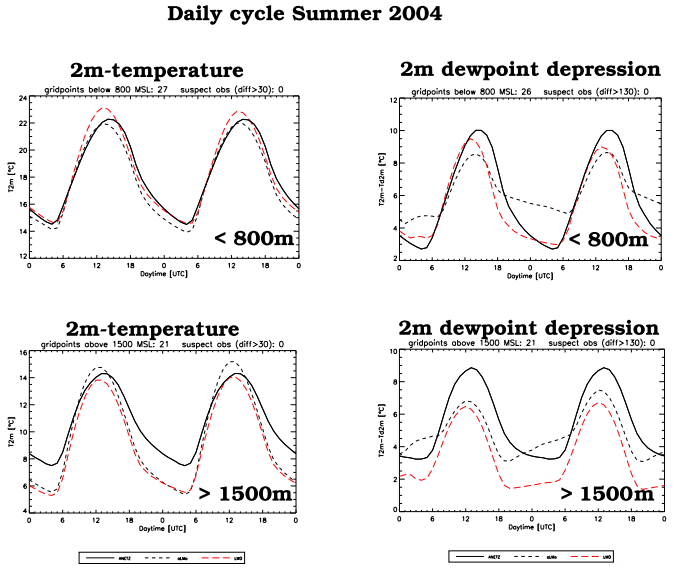

Figure 1: Verification of the daily cycle in Summer 2004 over Switzerland of 2m-temperature (left) and 2m-dewpoint depression (right) for gridpoints < 800m (upper part) and gridpoints > 1500m (lower part). Observations (ANETZ): full line black; aLMo: black dashed; LMD: red long dashes.

Results of aLMo and LMD have been computed monthly and seasonally for 2m-temperature, 2m-dewpoint and 2m-dewpoint depression, 10m-wind, precipitation (hourly sums for daily cycle and 6h sums for scores) and for cloud cover (3-hourly intervals). Three of the main differences between aLMo and LMD during the year 2004 are (1) the prognostic TKE-scheme, (2) the soil-moisture analysis (both operational at DWD, but not at MeteoSwiss) and (3) the different boundary conditions. Since 16 September 2003 aLMo runs with boundary conditions from ECMWF (IFS-frames) and this renders the interpretation of the differences with LMD (boundary conditions from GME) more difficult.

The following points are of main interest:

(1) The 2m-temperature cooling in the evening is too pronounced and there is a negative bias in Winter and Spring during night-time (in the late evening up to 1.5-2.0 K in aLMo and 1 K in LMD). The diurnal amplitude is too large. It is less pronounced in Summer for gridpoints < 800m and is a little bit larger in LMD than in aLMo. The daily maxima is reached ∼ 1.5 hour too early. In LMD with the prognostic TKE

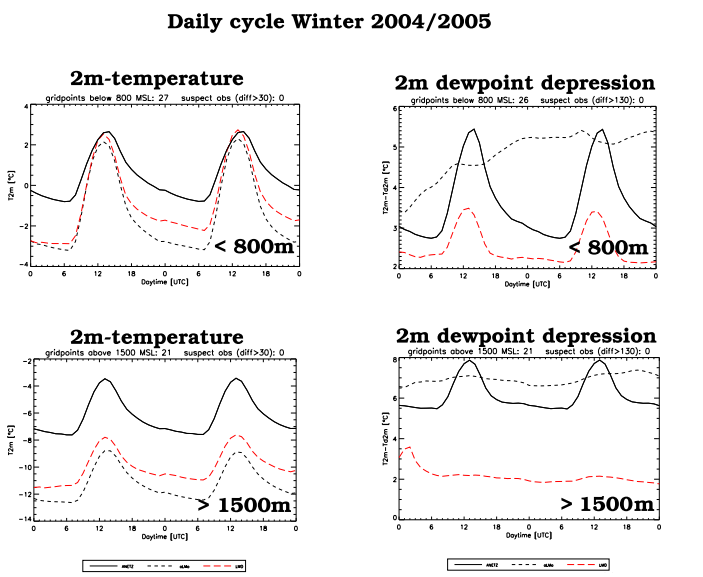

Figure 2: Verification of the daily cycle in Winter 2004/2005 over Switzerland of 2m-temperature (left) and 2m-dewpoint depression (right) for gridpoints < 800m (upper part) and gridpoints > 1500m (lower part). Observations (ANETZ): full line black; aLMo: black dashed; LMD: red long dashes.

scheme and soil moisture analysis the daily maxima for gridpoints < 800 m is 1K higher than in aLMo. This gives a greater positive bias in LMD with exception of the Winter. See Fig. 1 and 2 (left side) for results of Summer 2004 and Winter 2004/2005 for gridpoints < 800 m (upper part) and 1500 m (lower part).

(2) The daily cycle of 2m-dewpoint depression is not well reproduced (aLMo too moist during daytime and too dry during night-time). The TKE scheme, operational in LMD, corrects partly (in Summer and Autumn mostly) this cycle but the values are too low in Winter and Spring (constant negative bias, i.e. too moist). aLMo shows in Winter for gridpoints < 800m an increasing drying (positive bias) with increasing forecast time. See Fig. 1 and 2 (right side) for results of Summer 2004 and Winter 2004/2005 for gridpoints < 800 m (upper part) and 1500 m (lower part).

(3) The results for precipitation are summarized in Table 1 with the scores for the frequency bias of the five seasons (from Winter 03/04 to Winter 04/05) for the thresholds 0.1, 2, 10 and 30 mm/6h for aLMo and LMD. It shows an overestimation for low amounts (0.1 mm/6h) of 35-65% (except in Summer only 20%): this overestimation is most pronounced in the Prealps (altitude range 800-1500m). The high amounts (10 mm/6h) are in aLMo slightly underestimated by $\sim$ 10% and in LMD overestimated in Winter and Spring (40-50%) and underestimated in Summer and Autumn (by 10-25%). In Summer there is a too strong diurnal cycle on the mountain gridpoints (due to a too pronounced convection at daytime) and the daily maxima are forecasted about 4h too early (see Fig. 3 upper part). Differences between aLMo and LMD are more pronouced in Winter (surprisingly when the soil-moisture analysis operational in LMD but not in aLMo should not be important): LMD shows a stronger overall overerstimation (see Fig. 3 lower part). Since Autumn 2003 the differences between aLMo and LMD are partly due to the different lateral boundary conditions (aLMo runs with IFS-frames, LMD with GME) and the comparison between aLMo and LMD is not obvious (See

threshold	winter 03/04	spring 04	summer 04	autumn 04	winter 04/05
0.1 mm/6h					
aLMo	151	162	120	135	162
LMD	151	164	121	145	183
2.0 mm/6h					
aLMo	122	124	101	109	162
LMD	139	147	97	112	219
10 mm/6h	1.69	1.37	2.61	1.92	0.88
aLMo	89	91	84	106	91
LMD	137	130	76	94	231
30 mm/6h	0.033	0.090	0.222	0.091	0.0501
aLMo	139	75	114	268	0
LMD	475	93	82	166	7

Table 1: Frequency bias (%) of predicted precipitation over Switzerland. For all 6h-sums from +6h until +48h of all 00 UTC and 12 UTC-forecasts, compared to 69 ANETZ stations. The LM precipitation is the mean over 5 gridpoints. For the high amounts (10 and 30 mm/6h) the percentage of occurrences (%)is given. The columns give the values for the four seasons and (on the right part) for the period where aLMo run both with GME- and IFS-boundary conditions.

COSMO Newsletter 4, 63–66: the overestimation of precipitation in aLMo is partly removed with the IFS-frames).

(4) Verification of 10m-wind (for representative stations corresponding to a gridpoint $<$ 800m) gave an overestimation of the wind speed of $\sim$ 0.5-0.8 m/s both in aLMo and LMD (except in Spring and Summer daytime with an overestimation of $<$ 0.5 m/s). The diurnal cycle is qualitatively better in LMD (due to TKE-scheme) but the daytime values are even higher, i.e. positive bias greater (see also COSMO Newsletter 2, page 201). For the gridpoints $>$ 1500m the wind speed is strongly underestimated, due to the same PBL-parametrization over mountains than over flat terrain. See Fig. 4 for results of Summer 2003 and Winter 2004/2005 for gridpoints $<$ 800 m.
The mean error in 10m-wind direction (verified for observed wind speed $>$ 3 m/s) is very little, but it changed in sign during this year for LMD from a range of +5 to +10 degrees (i.e. a little bit biased in clockwise direction) to 0 to -5 degrees. LMD gives a bias that is in overall about 5 degrees more in anti-clockwise direction.

(5) The diurnal cycle of total cloudiness is not well reproduced (especially in Spring and Summer): there is a mostly a negative bias (up to $\sim$ 0.5 octa), except during the night (postive bias up to 0.5-1.0 octa in Spring). Except the first 6-9 h of forecast, LMD has higher values than aLMo by $\sim$ 0.2 octa. See Fig. 5 for results of Summer 2004 and Winter 2004/2005 for gridpoints $<$ 800 m and $>$ 1500m. In Winter 2004/2005 with frequent high pressure situations in December and January (stratus with top below 1000 m asl) the low cloud amount (stratus) was not well reproduced even at analysis time (with the nudging assimilation scheme): aLMo and LMD gave about the same cloud amount for gridpoints $<$ 800m and $>$ 1500m, but the observations gave a cloud amount of 1.5-2 octa higher for gridpoints $<$ 800m as compared to those $>$ 1500m.
As in Summer 2003, it is interesting to compare the following two behaviours on the

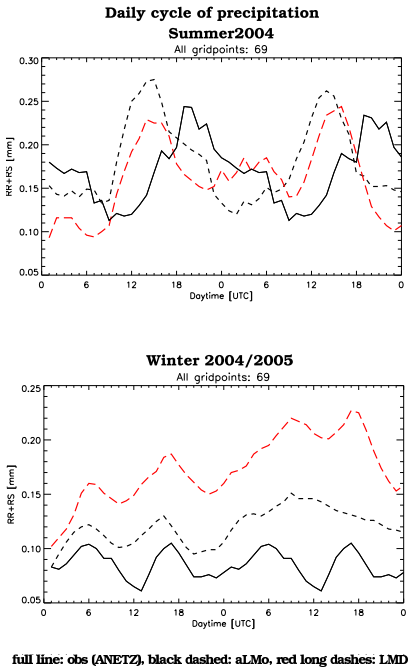

Figure 3: Verification of the daily cycle of precipitation for all 69 gridpoints corresponding to an ANETZ-station in Summer 2004 and Winter 2004/2005.

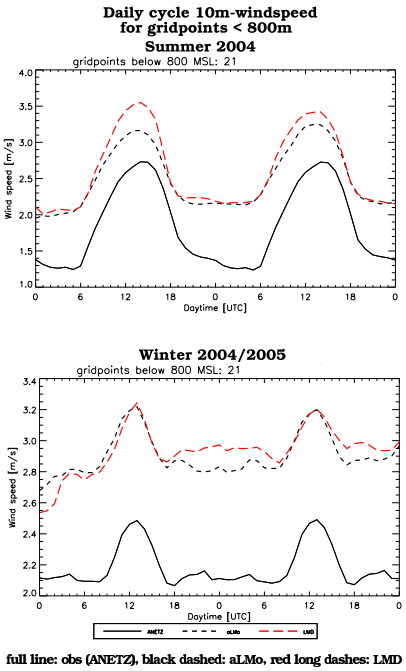

Figure 4: Verification of the daily cycle of 10m-wind speed for gridpoints $<$ 800m over Switzerland in Summer 2004 (upper part) and Winter 2004/2005 (lower part). Observations (ANETZ): full line black; aLMo: black dashed; LMD: red long dashes. Observations (ANETZ): full line black; aLMo: black dashed; LMD: red long dashes.

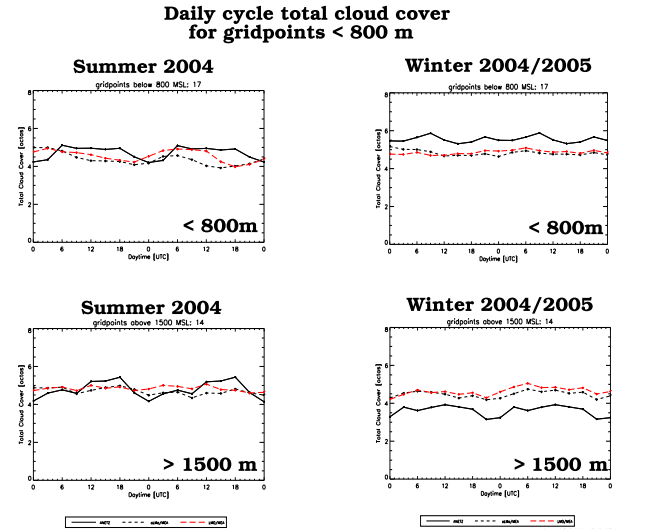

Figure 5: Verification of the daily cycle of total cloud cover over Switzerland in Winter 2002/2003 (left) and Summer 2003 (right) for gridpoints < 800m (upper part, 17 locations) and for gridpoints > 1500m (lower part, 16 locations). Observations (ANETZ): full line black; aLMo: black dashed; LMD: red long dashes. The LM total cloud cover is the mean of 41 gridpoints around the observation station and for three hours, to take in account that an observer sees in the mean a sky radius of ~ 30 km.

diurnal cycle for mountain gridpoints in Summer: missing of the cycle for cloud cover and too exaggerated cycle for precipitation (see Fig. 6). It suggests that cloud amount in convective situations is too low.

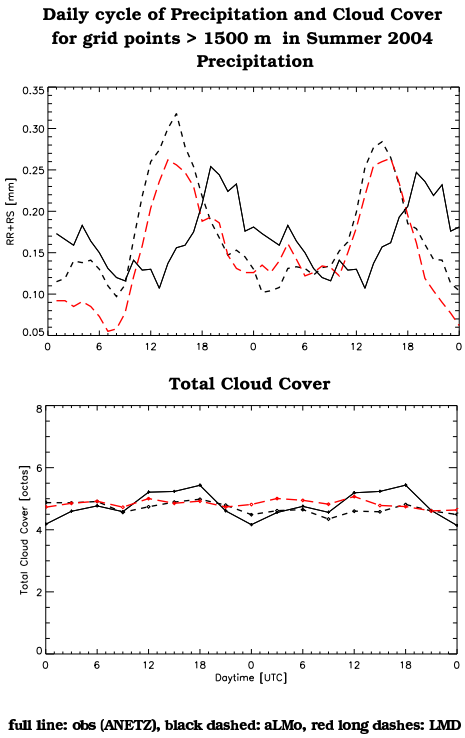

Figure 6: Verification of the daily cycle of precipitation (upper part) and total cloud cover (lower part) for gridpoints > 1500m over Switzerland in Summer 2004. Observations (ANETZ): full line black; aLMo: black dashed; LMD: red long dashes.