WG5-Report from Switzerland: Verification of the COSMO Model in the Year 2006

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1 Operational Verification

1.1 Verification with European SYNOP [*Pirmin Kaufmann*]

The operational verification of the COSMO model has been extended to include the diurnal cycle in 6h-steps. For the verification of wind direction (DD_10M), the winds with observed speeds below 3 m/s are filtered out starting spring 2006. The effect of this filtering is largest on the standard deviation, which is strongly reduced. Unfortunately, some stations in valleys even as broad as the Po valley have too little data left after filtering, so that the number of stations is somewhat decreased.

Some highlights of the seasonal verification:

Autumn 2005 (September, October, November)

- The verification results are in the same range as for all previous autumns. The one exception however is worth mentioning: the standard deviation of the pressure error (both PMSL and PS) is lower than in any previous autumn.

Winter 2005/2006 (December, January, February)

- The standard deviation of the pressure error (both PMSL and PS) is considerably lower in the last two winters (2004/2005 and 2005/2006) than in all the winters before. This includes the first winter with IFS boundary conditions (winter 2004/2005), so that this likely cause does not seem to determine the drop.
- The strong dry bias of the previous winters in the dewpoint temperature (TD_2M) has disappeared this winter due to the introduction of the prognostic TKE scheme on 1 December 2005.

Spring 2006 (March, April, May)

- The standard deviation of the pressure error (both PMSL and PS) of 1 - 2 hPa is slightly lower than the results for spring last year and is considerably smaller than during the three springs (2001 - 2003) prior to the usage of IFS boundary conditions.
- The general cold bias in T_2M has disappeared.
- This spring, a wet bias instead of the usual dry bias is visible in TD_2M (due to the introduction of the prognostic TKE scheme on 1 December 2005).
- The precipitation bias (TOT_PREC) and the frequency bias for the 0.1 mm/12h threshold are both larger than in all previous spring seasons except spring 2001.

- Some stations are missing due to the frequent occurrence of wind below 3 m/s (observed), for which the corresponding wind direction is filtered out. Note that a comparison of the wind direction results with previous years, for which no such filtering was done, is meaningless !

Summer 2006 (June, July, August)

- A positive model pressure bias of 0.5 - 1.5 hPa prevails in the model domain, but in the reduced pressure (PMSL) only (see Figure 1). This bias seems to correspond to increasing altitude and is not seen in the station pressure (PS), which indicates that the error of the pressure reduction is considerably larger than the model error. Stations along the eastern boundary have negative biases. This pattern has now been repeated during 3 summers (2004, 2005, 2006).

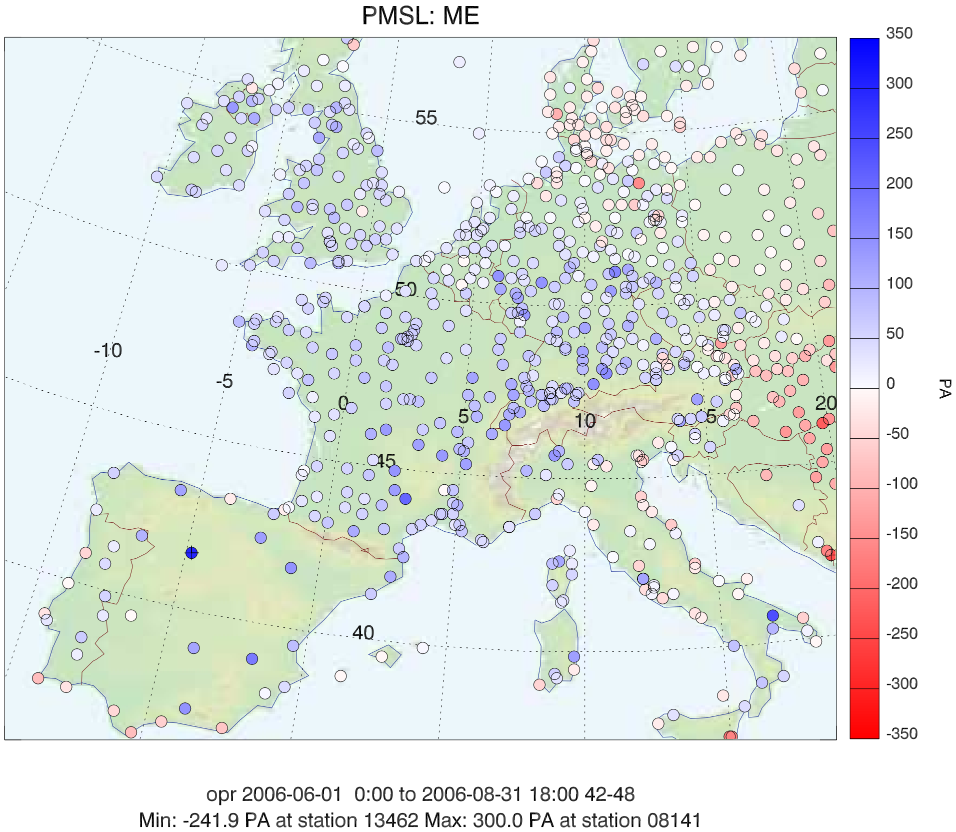

Figure 1: Bias of reduced pressure (PMSL) in Summer 2006 at the SYNOP locations for all 00 UTC and 12 UTC forecasts at +42h and +48h.

- The cold bias in T_2M of the previous summers has almost vanished. The average standard deviation has slightly increased from last summer and is between 2 and 2.5 K.
- A dry bias in TD_2M around -1 K occurs over the coastal areas and Italy. At the inland stations of all other countries, the bias is positive, indicating a wet bias, with values of 1 to 3 K. This is the strongest wet bias of all summers 2001 - 2006.
- There is a clear tendency for negative wind speed (FF_10M) biases along the coast,

up to 3 m/s. In contrast, at many inland stations the model has a positive bias with values up to +3 m/s, especially over north-eastern Austria.

- The precipitation bias generally ranges from 0 to 1 mm/12h at most stations, but increases considerably over the complex terrain of the Alps. It is somewhat higher than in the previous summer. The frequency bias for the thresholds 0.1 mm/12h and 1 mm/12h is larger than 1 at most stations and reaches very large numbers in the Alps (see Figure 2).

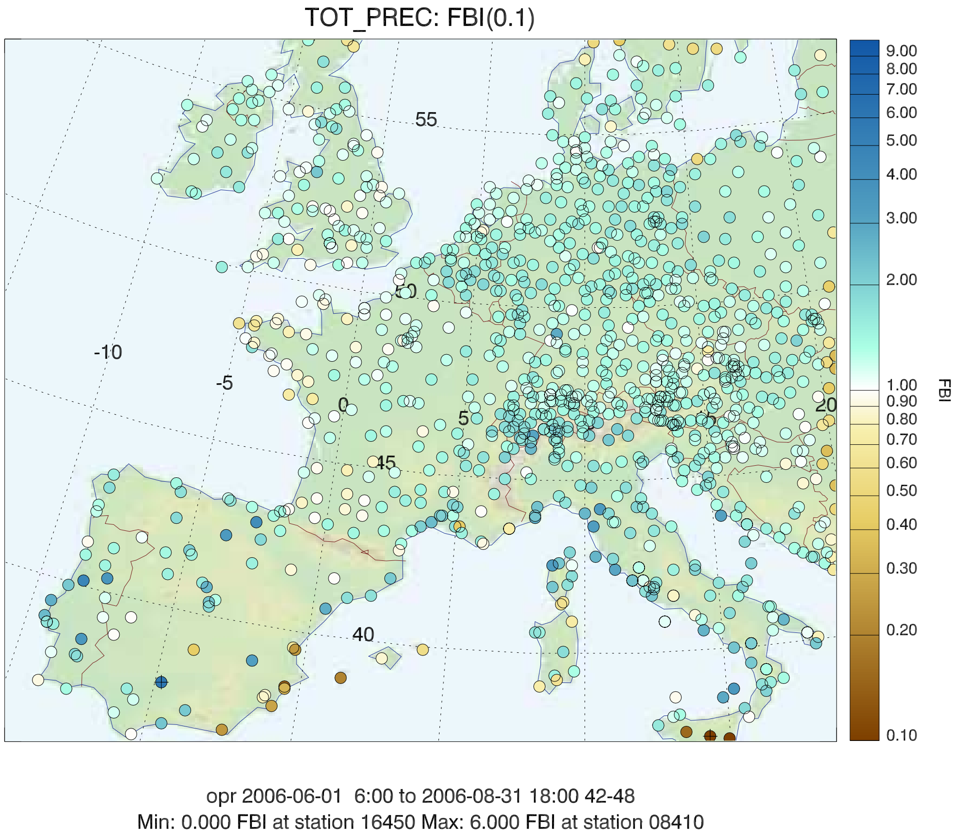

Figure 2: Frequency bias total precipitation for the threshold 0.1 mm/12h in Summer 2006 at the SYNOP locations for all 00 UTC and 12 UTC forecasts at +42h.

Autumn 2006 (September, October, November)

- The cold/dry bias in temperature (T_2M) and dewpoint temperature (TD_2M) is much smaller than for all preceding autumns due to the prognostic TKE scheme introduced in late 2005.

- The precipitation (TOT_PREC) bias and the frequency bias for the 1 mm/12h threshold are both larger than in all previous autumns except autumn 2001.

1.2 Verification of daily cycle over Switzerland [*Francis Schubiger*]

We give here some highlights of the seasonal verification in a hourly resolution with the automatic network of MeteoSwiss.

Precipitation

- During Winter 05/06 precipitation are overestimated, especially for gridpoints > 800 m (due to a strong overestimation of amounts < 2 mm/6h). The low amounts [0.1 mm/6h] show an overestimation at all height ranges: 65% for gridpoints < 800 m and up to 90% for gridpoints > 1500 m. The high amounts [10 mm/6h] are underestimated by 20% for gridpoints < 800 m and overestimated by 30-35% for gridpoints > 1500 m.
- In Spring, Summer and Autumn 06 precipitation amounts have almost no bias for gridpoints < 800 m but are overestimated at gridpoints > 800 m by 30-40% (and up to more than 50% in Autumn). The low amounts [0.1 mm/6h] show an overestimation at all height ranges: for gridpoints < 800 m 15-20% (Spring and Autumn) - 30% (in Summer) and for gridpoins > 1500 m up to 60% (even 90% in Autumn). The high amounts [10 mm/6h, about 2-3% of all cases] are underestimated for gridpoints < 800 m by 20-30% and overestimated for gridpoints > 800 m by 30-40% (even 50-60% in Autumn).
- In Summer 06 the diurnal cycle is too pronounced over mountains (especially in the height range 800-1500 m) and the maximum is reached 4h too early (15 UTC instead of 19 UTC).

2m-temperature

- In Winter 05/06 there is a negative bias during night-time of the order of 2K for gridpoints < 800 m and up to 5 K for gridpoints > 1500 m. The daily amplitude is exaggerated by 2 K for gridpoints < 800 m.
- Spring 06 shows (as compared to Spring 05) a stronger daily cycle and higher values for gridpoints < 800 m (i.e. already in Spring [and not only Summer] too high maxima). The daily cycle is exaggerated for gridpoints < 800 m by 2K: 1K too cold during the night and maxima of 1K too high. For gridpoints > 800 m, there is a negative bias of 2K in the height range of 800-1500 m and even 4K for gridpoints > 1500 m.
- In Summer 06 the daily amplitude for gridpoints < 800 m is only slightly exaggerated with a bias which is mostly slightly positive (up to 1K). For the gridpoints in the height range > 1500 m the bias is always negative (1-2K). As compared to Summer 05 we have higher observed values (about 1K), a greater positive bias < 800 m and a greater negative bias > 1500 m.
- In Autumn 06 the daily amplitude is slightly exaggerated for gridpoints < 800 m: positive during the day (bias up to +1K) and slightly negative during the night. For the gridpoints in the height range > 1500 m the bias is always negative (2K).
- In all seasons the maxima for 2m-temperature is reached 1.5 hours too early and 70% of all forecasts corrected with Kalman filter are within ± 2K at each forecast hour.

2m-dewpoint

- Due to the introduction of the prognostic TKE scheme on 1 December 2005, the diurnal amplitude is less exaggerated (but for gridpoints < 800 m it is still about 3K instead of 1-1.5 K). The strong negative bias on the mountain gridpoints (> 800 m) disappeared.

10m-wind

- For gridpoints < 800 m the bias of the 10m-wind speed is always positive by 0.6 - 0.9 m s^{-1} (maximal at 06 UTC, minimal at 18 UTC). The diurnal amplitude is almost correct. For gridpoints > 1500 m the speed has a great negative bias, due to the same PBL-parametrization over mountains than over flat terrain.

Cloudiness

- The diurnal cycle of total cloudiness is not well reproduced. For gridpoints > 800 m there is a positive bias of up to 1.5 octa during nighttime. The 12 UTC forecasts (but not the 00 UTC forecasts !) start with a negative bias.
- By comparing the results for gridpoints < 800 m and > 1500 m for Winter 05/06 it is clear that the model is not able to forecast correctly the low level clouds (wintertime stratus, see Figure 3). But at analysis time at 00 UTC there is almost no bias for gridpoints < 800 m, i.e. the assimilation of low level clouds (stratus) in the nudging scheme during nighttime seems satisfactory.

Convection and Cloudiness

- A feature that should be investigated (by WG3) concerns the cloud cover in case of convection (already mentioned in the last report [Arpagaus, et.al., 2006]): results for summer over the Alps suggest that the cloud amount in convective situations is too low (see Figure 4). While the observed cloud coverage shows a clear diurnal cycle (lower panel) in accordance with the observed precipitation (upper panel), the diurnal variation is almost absent in the model cloud coverage. Figure 4 shows also results of the test chain with the new Kain-Fritsch-Bechtold convection scheme (for details see in this Newsletter the report in WG3 "Evaluation of the Kain-Fritsch/Bechtold convection scheme").

1.3 Verification of the vertical profiles at TEMP stations [*André Walser*]

Winter 2005/2006 (December, January, February)

The bias for temperature shows a clear cold bias up to 1.1 K (compared to 0.6 K in winter 2004/2005) between 1000 hPa and 300 hPa, with the maximum at 1000 hPa. The increase with forecast time is largest between analysis and +24h. While the bias is quite small at the tropopause height, we note another cold bias up to 1.2 K (at 50 hPa), also increasing with forecast time. This cold bias is clearly smaller than in winter 2004/2005 (2.0 K). Concerning the standard deviation, temperature shows largest spread close to the surface, around the tropopause level as well as in the stratosphere where it is clearly smaller than in winter 2004/2005. The scores for humidity and wind speed/direction do not show significant changes compared to winter 2004/2005.

Spring 2006 (March, April, May)

Good news: the cold bias in temperature between 600 and 300 hPa after analysis time noted for spring in the last years almost vanished and the cold bias above the tropopause is reduced as well (see Figure 5). On the other hand, the standard deviation is very similar compared to spring 2005. Also for this season, the scores for humidity and wind speed/direction do not show significant changes compared to spring 2005.

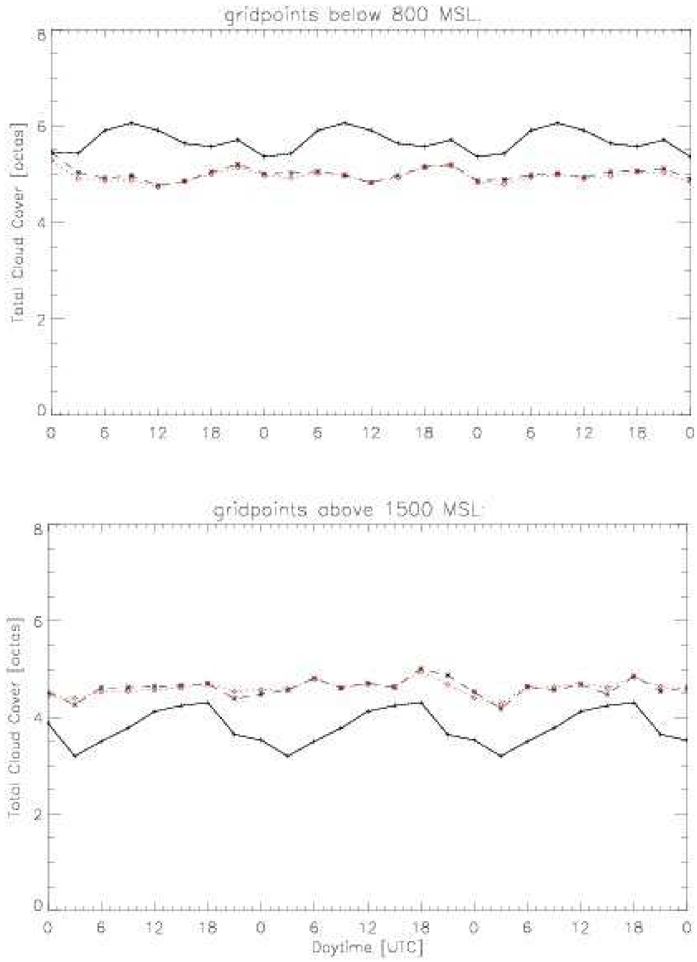

Figure 3: Verification of the diurnal cycle of total cloudiness of Winter 05/06 for gridpoints over Switzerland $<$ 800 m (upper part) and $>$ 1500 m (lower part). Observations (ANETZ): full line black; COSMO: dashed (in black verified with 1 gridpoint and in red verified with all gridpoints within 30 km around the observation location).

Summer 2006 (June, July, September)

We note no significant changes in the scores compared to summer 2005, except that for analysis time (i.e. +00h) the bias for temperature in the troposphere has almost vanished. However, it is the consequence of a new warm bias at 12 UTC compensating the known cold bias at 00 UTC.

Autumn 2006 (October, November, December)

As for spring, the known cold bias in temperature between 600 hPa and 300 hPa is substantially reduced and it is now in the order of only -0.2 K (2005 up to -0.6K). However, we note again a cold bias below 700 hPa (up to -0.6 K), that was almost vanished in autumn 2005. The bias of relative humidity is fairly small for analysis time (slightly positive) below 300 hPa. For forecast times, we note a moist bias up to 10% (2005: 8%) between 650 and 100 hPa. The known dry bias between 950 hPa and 700 hPa is almost vanished this autumn which is, however, related to the larger cold bias mentioned above. The mean error for wind direction is very small, especially in the free atmosphere. However, we note a new positive

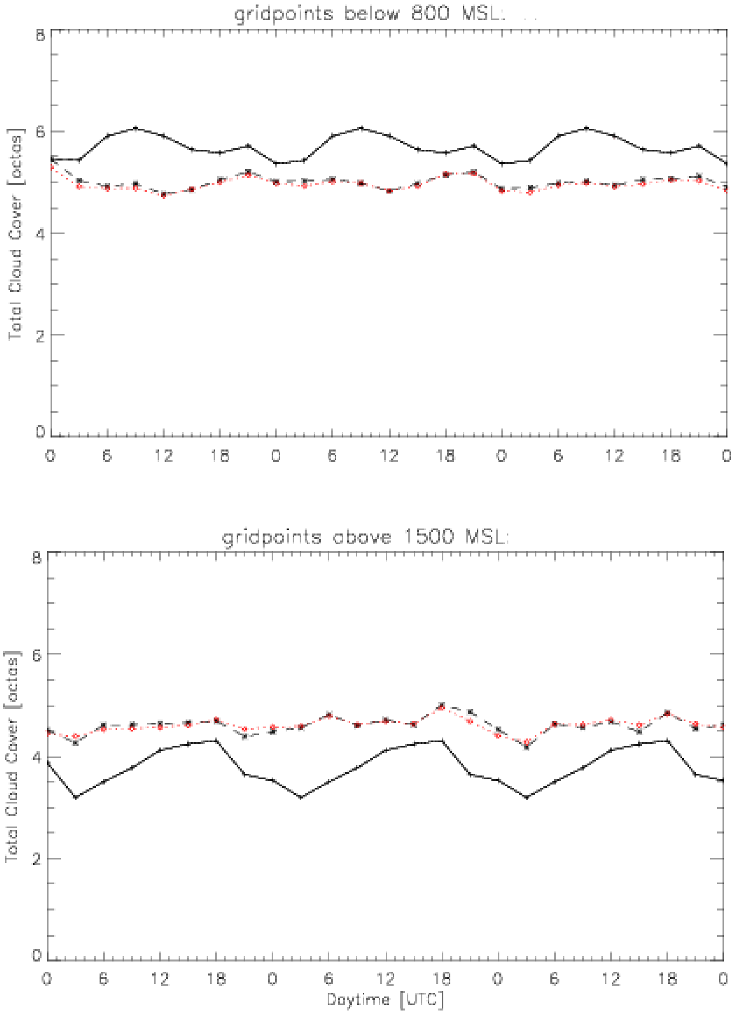

Figure 4: Verification of the diurnal cycle of precipitation (upper part) and cloud cover (lower part) from 20 May to 31 July 2006 for gripoints > 1500 m over Switzerland. Observations (ANETZ): full line black; operational COSMO: black dashed; COSMO with the Kain/Fritsch-Bechtold convection scheme: red long dashed

bias up to 5 degrees between 950 hPa and 750 hPa for all lead-times. On the other hand, the standard deviation is reduced by about 5 degrees for all three forecast times compared to autumn 2005. The scores for wind speed do not show significant changes.

2 Verification studies

2.1 Weather situation-dependent verification of upper-air data [*André Walser*]

A weather situation-dependent verification of the vertical structure of the COSMO Model based on the Schüepp classification (Schüepp 1979) is performed over the full data-set for the climatic year 2005 (1.12.2004 - 30.11.2005). The most interesting results are:

- Significant differences between classes high, flat, and low for temperature. The forecasts error (standard deviation) for the class low is almost twice as large as for the class high in the upper troposphere (but smaller in the boundary layer!), which is noted also for

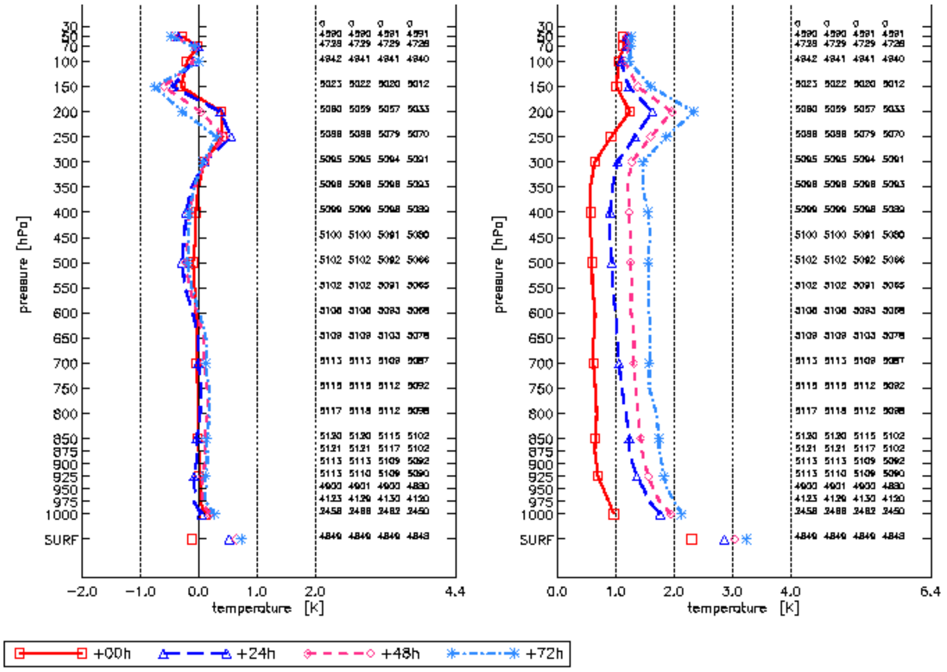

Figure 5: Vertical profile of temperature bias (left) and standard deviation (right) for Spring 06

the individual regions. The bias is also worse for this class.

- The forecasts error for wind speed is clearly larger in class low compared to class high, in particular between 700 hPa and tropopause. This is valid for every region, with the largest differences for stations "south of Alps" and the smallest for stations "north of Alps".

- Differences between the classes for the 4 flow directions are smaller than expected. Overall, class east seems to reveal the largest forecast errors and biases, in particular for wind direction (but not for humidity).

2.2 Verification of COSMO precipitation forecast using radar composite network

[*Emanuele Zala*]

A weather situation-dependent verification of COSMO precipitation based on Swiss radar composite data was performed over the climatic year 2005. Two weather classification were used: the Schüepp classification (Schüepp 1979), which is used daily by MeteoSwiss forecast office, and a simple experimental classification based mainly on 500 hPa winds and surface pressure distribution over the alpine region.

Main results:

- better results in 2005 as compared to 2004, especially for the advective cases due to the introduction of the prognostic precipitation scheme. The pattern dry/wet/dry/wet in the cross-section from North to South is less pronounced

- significant differences of COSMO QPF for different weather classes

- confirmation of the COSMO QPF overestimation over the relief

- significant underestimation of precipitations over Swiss plateau, specifically in SW regimes
- generally good performance in situations with weak advection.

2.3 Verification of different test suites [*Francis Schubiger*]

In 2006 the following COSMO test suites have been verified with SYNOPs, hourly data from ANETZ and TEMPs (the verification results are documented on MeteoSwiss intranet webpages that can be made available on request):

- COSMO version 3.16 for the period 16-31.08.05
- prognostic TKE scheme and COSMO 3.16 for the period 1-15.09.05
- different versions of the multilayer soil model (namely a version with a merge strategy, instead of "free soil-model") for the period 18-30.06.05 starting from its own assimilation
- IFS boundary conditions from the IFS T799 (the new high-resolution global forecasting system of ECMWF) for the period 23.02-06.03.06
- COSMO version 3.19 for the period 15.05-01.06.06
- Kain-Fritsch-Bechtold convection scheme for the period 20.05-31.10.06: see Figure 4.
- Snow analysis and multilayer soil model with a merge strategy for the months of December 05, March 06 and July 06
- Higher frequency of the radiation call (15 minutes instead of 1 hour) for the period 14-30.06.06

References

Arpagaus, M., P. Kaufmann, G. de Morsier, D. Ruffieux, F. Schubiger, A. Walser, E. Zala 2006: WG5-report from Switzerland: Verification of aLMo in the year 2005. *COSMO Newsletter*, No. 6, pp. 165-171.