8 Results and Methods of Model Verification

This section summarizes some of the operational verification results for the LM forecasts at various COSMO meteorological centres, both for near-surface and upper-air parameters. More detailed detailed verification results are presented on a quarterly basis at the COSMO web-site. We also include research oriented contributions related to the development and test of new methods of model verification, including the use of high-resolution non-GTS data, and remote sensing data from radar and satellites. Another topic is the verification of parallel test suites to evaluate the performance of new physical or dynamical model components.

Most of the papers included in this section are write-ups from the COSMO annual meeting 2002 in Warsaw. Many thanks to all of you who provided contributions for the present issue of the Newsletter. The numbering of equations and figures in this section refers to each paper.

Before continuing with the contributions, we summarize shortly some aspects of the general model behaviour in the operational applications. Also, some conclusions on model deficiencies from the recent verification results as well as from diagnostic evaluations and from case studies are summarized.

(a) General Assessment of Model Performance

During the course of the operational and pre-operational applications of the LM at COSMO meteorological centres, the model has proven to run stable, robust and efficient. Only one blow-up (due to a CFL instability) for the Lothar Christmas Storm (24 December 1999) has been recorded up to now.

Also, no significant problems related to the lateral relaxation boundary conditions or to the use of nonhydrostatic dynamics have been encountered. In general the relaxation boundary conditions with an updating frequency of 1 hour work well despite of the quite large GME/LM grid spacing aspect ratio of about 1:9. Unlike for inflow boundaries, where the flow systems in general are adapted consistently from the driving model (even for fast moving storm systems) problems may sometimes arise along the outflow boundaries whenever the inner solution evolves much different from the imposed solution of the driving model (e.g a faster movement of fronts or a different evolution of convective systems). As the two solution do not fit, the relaxation results in artificial divergence or convergence generating vertical accelerations. In such cases, this can produce narrow bands of clouds and precipitation along the lateral boundaries. However, any significant detrimental impacts on the inner solutions have not been observed so far.

Grid-point storm like effects have not been noticed up to now. This is a clear advantage compared to hydrostatic models, which at high resolution often tend to generate grid-point storms (which even may result in blow-ups) in case of convectively unstable stratification. In such situations, the nonhydrostatic model dynamics seems to be much more robust. Also, no worrying numerical problems have been encountered from using a large-scale convection scheme at 7 km grid-spacing in a nonhydrostatic dynamic framework.

The prediction of cyclones and of frontal clouds and precipitation is in general well simulated by the LM. Exceptions occur for large errors in position and timing of storm systems from the driving model along the lateral boundaries. The simulation of convective systems such as squall-lines or air-mass thunderstorms reveals a number of deficiencies: Position and timing errors occur quite often, but a better localization of air-mass convection is achieved when topographical forcings are relevant; especially, the the diurnal cycle of convection is not well represented.

Model Deficiencies

From the verification results for the last year, we can summarize some basic problems:

- During evening and nighttime, the 2m-temperature has a quite large cold bias, especially during winter. This effect is less pronounced when the new TKE turbulence and surface layer scheme is used, together with the soil moisture analysis.
- The mean diurnal cycle of 2m-temperature is represented with a too large amplitude (for both the old and new turbulence schemes), especially during summer. Also, the maximum is achieved too early (at noon) and the temperature starts to decrease too early in the afternoon.
- The diurnal cycle of the 2m-dewpoint-temperature is not well captured. With the new TKE turbulence and surface layer scheme the diurnal cycle is somewhat better represented by the model.
- 10-m winds appear to be underestimated both in winter and summer.
- In summer, the mean daily cycle of both total cloudiness and precipitation is not well represented. Especially, the precipitation peaks too early (at noon) by about 6-12 h.
- Low precipitation amounts appear to be overestimated by the model. This may result from convective drizzle or from a too slow evaporation of rain below stratiform clouds.
- Over regions with complex and steep topography (especially over the Alps), the simulated precipitation patterns are still not very satisfactory. However, some progress has been made by introducing the filtered topography and the new scheme for horizontal diffusion.
- A long-standing problem is the windward shift of maximum precipitation over mountain ranges, and much too less precipitation over the leeside. This effect is much more pronounced in winter than in summer.
- Precipitation scores are better for the 12 UTC runs than for the OO UTC runs. The reason for this behaviour is unclear.
- When starting from interpolated GME analyses, there is a quite strong spin-down of precipitation during the first 12-h of integration, indicating a too intense dynamical adaption of the initial fields.

At the recent COSMO meeting, several new work packages have been defined to investigate these problems and to find short-term remedies.