5 Changes to the Model System

In this section, important changes to the LM-system which have been introduced during the last year are briefly described, and the possible impact on the forecast products are summarized. Of course, changes in the host model GME can also have a significant impact on the LM forecasts. Important changes to GME and its data assimilation are summarized below.

- GME now uses a prognostic treatment of sea-ice. The climatological ice temperatures, which were used before, have been replaced by a forecast for the thickness and the surface temperature of the ice. The part of a grid box, that is covered by ice, is determined in the 00 UTC analysis and only those grid elements, that are fully covered, are considered. During a GME forecast, the ice can melt, but new ice points can only be treated by the analysis scheme. The new scheme gives a more realistic horizontal distribution of the ice surface temperature in polar regions (March 2004).

- A new version of GME has been introduced which uses a horizontal resolution of about 40 km (60 km before) and 40 vertical layers (31 before). The lowest model level is now 10 meters above ground. The mean area covered by a grid box is 1384 km^2 (3100 km^2 before). This version of GME uses the new multi-layer soil model, that is also tested in the LM. Objective verification shows that the forecast of near-surface weather parameters (temperature and dew-point temperature) is improved significantly (September 2004).

- In the assimilation system the use of humidity from the Pseudo-Temps of ECMWF levels below 700hPa level has been excluded. The ECMWF model has a different humidity structure over sea, compared to GME, which led to a too moist atmosphere in the GME (December 2004).

- Atmospheric Motion Vector Winds (AMVs) are now used in BUFR format in the global assimilation system. Compared to the use of the SATOB format, the information is now obtained at a higher temporal and spatial resolution. It can be distinguished, whether the wind is derived from cloudy or clear-sky parts of the water vapor picture. In the BUFR format an information is included about the quality of the derived wind. Besides, the MSG satellites will not deliver the SATOB code any more. Monitoring of the AMV's in SATOB and in BUFR format shows a good, in large parts even higher quality of the BUFR format (February 2005).

For more detailed information on changes to GME and its data assimilation, please refer to the *Quarterly Report of the Operational NWP-Models of the Deutscher Wetterdienst* (available at `www.dwd.de`).

5.1 Major Changes to LM

During 2004/05 a number of updates of LM, cycle 3, have been introduced. The changes from version 3.8 up to version 3.15 are described below. The main features are – besides code optimization and bug corrections – the preparation of 1DVar satellite retrievals for data assimilation, the introduction of the graupel scheme and a second option for the Rayleigh damping.

Notes on lm_f90 Version 3.8

This version was created on 23 March 2004. Inconsistencies in the treatment of the linked lists for the namelist group `/GRIBOUT/` between the output of the model levels and the output of the synthetic satellite images have been removed. Besides a bug correction in the prognostic precipitation scheme, some optimizations and technical changes for the Runge-Kutta scheme have been implemented.

Notes on lm_f90 Version 3.9

This version was created on 22 April 2004. Bugs in the computation of the backward trajectories for the semi-Lagrange advection of precipitation have been corrected.

Notes on lm_f90 Version 3.10

This version was created on 23 June 2004. The treatment of the error-values from the RTTOV-library has been changed. If only soft-limits are violated, the synthetic satellite images are computed anyhow. If a violation of the hard-limits occurs, only the computation of the images for this special step are skipped. Only if a general error occurs, the computation of the synthetic satellite pictures is switched off, but LM integration is going on.

Notes on lm_f90 Version 3.11

This version was created on 28 July 2004. As only change it contains the introduction of Floating Point Exception trapping for IBM machines. At the beginning of the main program `lmorg.F90`, a special routine is called that initializes a special IBM trap handler.

With this change, the first `ifdef` has been implemented in the LM. The reason is the call of this specific IBM routine that allows an efficient trapping of floating point exceptions without using compiler options that would slow down program execution. To activate this trap handler, the main program has to be compiled with the option `-DFPEABORT`. The main program now has the extension `.F90`.

Notes on lm_f90 Version 3.12

This version was created on 15 September 2004. It prepares the assimilation of 1DVar satellite retrievals, introduces an option for a revised quality control for humidity and a new multi-level check, and re-organizes the observation processing.

- Preparation of 1DVar satellite retrievals from MSG or ATOVS radiances:
  A new module `src_obs_1dvar_org.f90` has been introduced, which contains the framework of organizing the observation processing (i.e. production) of satellite retrievals. The retrieved profiles are included in the process of computing the observation increments (without further quality control), spreading and nudging. This means, once the retrievals are available, they can be nudged immediately. New variables have beed defined in the module `data_nudge_all.f90`, which may become namelist variables in a later version, when the production of the retrievals by means of a 1DVar minimization is included.

- Revised quality control of vertical profiles (option):
  If this option is turned on (if `qcvf(4)` $>$ `0`), new (smaller) stability-dependent thresholds for the quality control of (radiosonde) humidity profiles and a new formulation of the multi-level check are used. This option is based on the formulation in the global analysis scheme.

- Re-organization of the observation processing:
  Several subroutines from the module `src_obs_processing.f90` have been outsourced to new modules. All `include`-files are now really included in the source code of the modules.

- Initialization of prognostic precipitation:
  When running with prognostic precipitation, there is the need to initialize the three-dimensional rain- and snow-field in the beginning of the forecast. Up to now these fields have been set to zero, with the results that there is a lack of total precipitation of about 30 % at the surface in the first hours. Two options have been implemented:

  - Diagnostic initialization: The microphysics scheme is used with minor modifications to diagnose the grid scale rain and snow. This option can be chosen by the new namelist parameter `ldiniprec=.TRUE.`.
  - Prognostic initialization: Initial values have to be provided for grid scale rain and snow from the nudging run. This option can be chosen by the new namelist parameter `lana_qr_qs=.TRUE.`

  If there is no assimilation suite to provide rain and snow (if e.g. starting from interpolated GME-analyses), only the option `ldiniprec=.TRUE.` can be used.

Notes on lm_f90 Version 3.13

This version was created on 3 December 2004. Three new features have been introduced and a modified version of the multi-layer soil model has been implemented. At the moment, all schemes are for testing only.

- Graupel scheme: This scheme can be chosen by setting `itype_gscp=4`. Then the hydrometeor graupel is added for the microphysics calculation.

- 3D turbulence scheme: This scheme is possible only in combination with the new Runge-Kutta dynamical core. It can be switched on with the namelist-variable (from /PHYCTL/) `itype_turb=5/7`. Together with this scheme a prognostic treatment of TKE can be chosen (namelist variable `lprog_tke=.TRUE.`.

- Latent Heat Nudging: The basic version of the latent heat nudging has been implemented. This scheme is still under testing and development.

- The multi-layer soil model, already implemented in LM, has been adapted to the GME version.

Notes on lm_f90 Version 3.14

This version was created on 25 January 2005. A new option for the Rayleigh-damping in the upper layers has been introduced and updates of the Runge-Kutta-scheme and the latent

heat nudging have been implemented. Bugs in the computation of the land-sea-mask and in the lower boundary for the latent and sensible heat flux have been corrected.

- There was an inconsistency in the treatment of grid boxes having a fraction of land of exactly 50 %. They are considered as land points, but because of a bug in the computation of the land-sea-mask, used in the LM, no soil model has been computed for these points. This has been corrected.

- The diagnostic computation of the latent and sensible heat flux in the dynamics now uses the same lower boundary formulation than the other prognostic calculations.

- Rayleigh damping: The new option allows a Rayleigh-damping in the upper layers, even when only frames for the boundary fields (e.g. from the IFS model) are provided. This procedure does not use the boundary fields, but LM forecast fields, which have been filtered to remove small-scale phenomenons. This kind of damping can be chosen with the new namelist variable `itype_spubc=2` (=1: already implemented kind of damping using boundary fields).

- Runge-Kutta scheme: The possibility for using an upwind 1st order and centered differences 2nd order advection operator has been implemented.

- Latent Heat Nudging: A scaling factor for diagnostic reference precipitation has been implemented as new namelist variable `rlhn_scale_dp`.

Notes on lm_f90 Version 3.15

This version was created on 3 March 2005. It contains two bug fixes and some technical adaptations for running with a big model domain (LME development at DWD):

- There was a bug in the computation of vertical aerosol profiles. This lead to a wrong vertical distribution of the different aerosol components and therefore to wrong optical thicknesses of the aerosols in the atmospheric layers. The optical thickness of some aerosol types was over- and the one of other types underestimated. This resulted in a partial compensation of the error for the radiation computation and masked the error in the overall results. Influences of this correction are expected for solar radiation fluxes for clear-sky conditions, but are rather small.

- After reading the first boundary file, the surface pressure has to be calculated again, if the initial data come from an analysis and the boundary data from a forecast of a different model. This is necessary, because the initial data set and the first boundary data set are mixed in this case, which changes the atmospheric pressure.

- For the calculation of the maximal wind gusts, the two lowest model levels are interpolated to a height of approximately 30 meters, then the gusts are derived from these values. This is an intermediate solution until a more sophisticated algorithm (e.g. regarding to Brasseur) has been implemented.

- A new namelist variable `nunit_of_time` has been implemented, to specify this Grib value. The following values are possible:

Value	Meaning
0	1 minute
1	1 hour
2	1 day
10	3 hours
11	6 hours
12	12 hours
13	15 minutes
14	30 minutes

Note that the values 13 and 14 are not Grib standard, but are necessary if Grib outputs in a frequency less than 1 hour are done.

5.2 Major Changes to GME2LM

There were two changes of the GME2LM in the last year. Only the first one was a real update, the second update only introduced the IBM trap handler for floating point exceptions similar to LM 3.11.

Notes on GME2LM Version 1.19

This version of GME2LM was created on 18 March 2004. The changes are:

- Adaptations for working with bitmaps and the 40 km / 40 level version of GME
- Interpolation of the new soil variable `FRESHSNW` from GME- to LM-fields for the multi-layer soil model.
- Additional treatment of the orography for the Z-coordinate version of the LM. A new namelist-variable `l_topo_z` has been introduced. The default of this variable is `.FALSE.`.
- Some Grib-names and tables have been changed to be consistent with the LM.

All changes only concerned non-operational parts of GME2LM, the operational results therefore are not changed.

Notes on GME2LM Version 1.20

This version of GME2LM was created on 21 July 2004. The IBM trap handler for detecting floating point exceptions has been introduced (see also LM Version 3.11).

5.3 The new Interpolation Program INT2LM

The new interpolation program is an extension of the GME2LM. It can interpolate data from the global model of ECMWF, the IFS, and from the LM itself. INT2LM is a joint COSMO development, where the tasks have been distributed to the centers as follows:

- DWD: parallel framework of the program; GME2LM

- ARPA-SIM: IFS2LM
- MeteoSwiss, DWD: LM2LM

After the implementation of several development- and testing-versions, the first official version of the new library `int2lm` is available since 12 April 2005 (Version 1.1). INT2LM will replace GME2LM and the former test versions IFS2LM and LM2LM in the near future.