High Resolution Regional Reanalysis for Europe and Germany

Jan D. Keller[1,2], Christian Ohlwein[1,3], Petra Friederichs[3], Andreas Hense[3], Susanne Crewell[4], Christoph Wosnitza[1,3], Ieda Pscheidt[1,3], Stefan Kneifel[1,4], Stefanie Redl[1,4], Sandra Steinke[1,4]

[1]*Hans-Ertel-Center for Weather Research, Climate Monitoring Branch* – [2]*Deutscher Wetterdienst, Offenbach, Germany*
[3]*Meteorological Institute, University of Bonn, Germany* – [4]*Institute for Geophysics and Meteorology, University of Cologne, Germany*

Reanalysis Scope

A high-resolution regional reanalysis for Germany and Europe will be conducted e.g. to provide information for climate monitoring or verification purposes. The reanalysis will be based on the operational weather prediction system of the Deutscher Wetterdienst (DWD, German Meteorological Service).

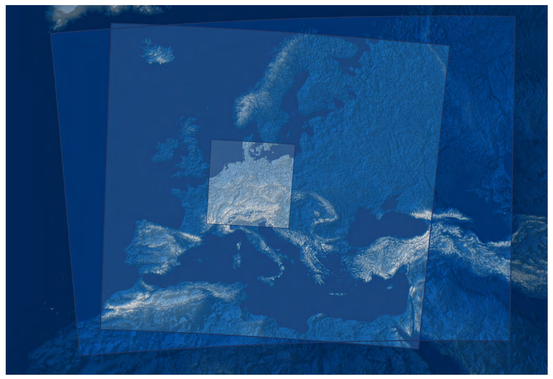

Figure: Map showing the domains of the reanalysis. From outer to inner: CORDEX Europe, COSMO-EU, COSMO-DE

Using ERA-Interim/ERA-40 data as boundary conditions a two step nesting is performed with a European reanalysis at an approximate resolution of 7 or 10 km and a German domain at 3 km.

Figure: Timeline of the planned reanalyses – with spin-up period and a possible continuation (light blue)

At first, two main reanalysis periods are targeted:

- 2007-2011 – exploiting a maximum of observations
- 1982-2011 – reduced but homogeneous observation data set

The output timestep will be 60 minutes for 3D and 15 minutes for 2D variables.

Data Assimilation Scheme

The reanalysis cycle is composed of the mesoscale NWP model COSMO and its data assimilation system which is based on the nudging method. With this method it is possible to continuously assimilate all standard upper atmosphere (radiosondes, aircraft) and surface pressure observations into the model state.
In addition the European reanalysis includes a soil moisture (SMA) and SST analysis once a day as well as a snow analysis every 6 hours.
The German reanalysis will make use of a latent heat nudging (LHN) algorithm to enhance the analyzed precipitation fields.

Evaluation of Test Analyses

Several tests have been performed for the month of June 2007 to check the proper configuration of the reanalysis system and to verify that the output is reasonable.

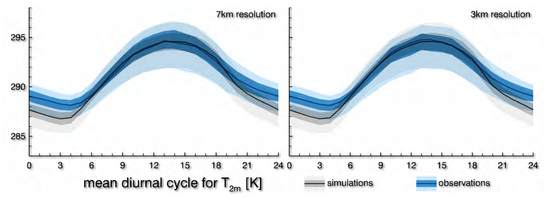

Figure: Mean diurnal cycle for 2 meter temperature from observations (grey) and simulated station data (blue) for June 2007 over Germany for 7 km (left) and 3 km (right) resolutions (time in UTC).

The results show a good representation of the diurnal cycle with a warm bias during the night which is know to be generated by the 2 meter temperature diagnostics of COSMO.
Precipitation analyses for the test period show a high accuracy when verified against rain gauges from all over Germany. An additional significant positive impact on the quality of precipitation fields can be found when latent heat nudging is turned on.

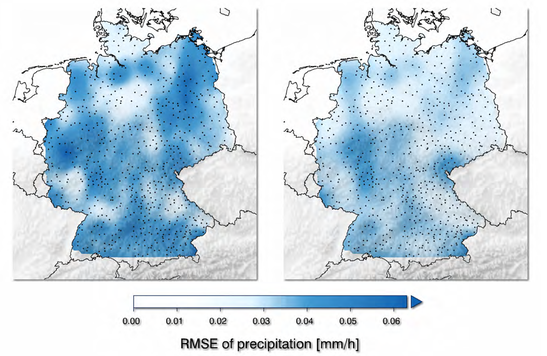

Figure: RMSE of hourly precipitation for June 2007 over Germany with LHN turned off (left) and on (right).

As the LHN method influences vertical motion a comparison of MSG satellite observations to synthetic satellite images generated with RTTOV show that the LHN artificially triggers convective cells which change the vertical structure and hydrometeor distribution in the model. Because of the positive impact on the precipitation analysis, LHN will be used but the effect on cloud structure will be investigated in detail.
The test results confirm that the system is able to produce high-quality reanalyses on the European as well as the German domain. Work is underway to set up a portable version of the reanalysis system to allow for carrying out multiple reanaylsis streams at different computing centers for an earlier availability of the data.

Passive Forward Operators

Reanalysis verification methods will be extended by using satellite measurements. Therefore, model output will be transferred to observation space by applying satellite forward operators. RTTOV will be operationally turned on in the reanalyses to generate simulated IR satellite images.

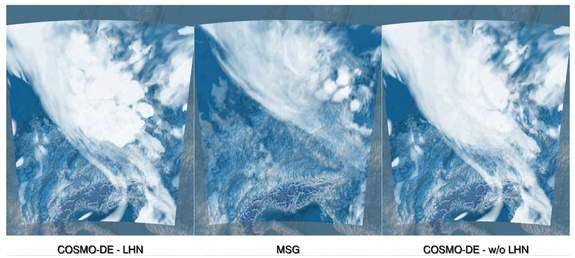

Figure: Synthetic satellite images with LHN turned off (left) and turned on (right) compared to the corresponding MSG image (center) at 16 June 2007 04 UTC.

For microwave (MW) radiation observations a forward operator called PAMTRA (Passive and Active Microwave TRAnsfer) has been developed in order to produce pseudo-observations based on the COSMO reanalysis output.

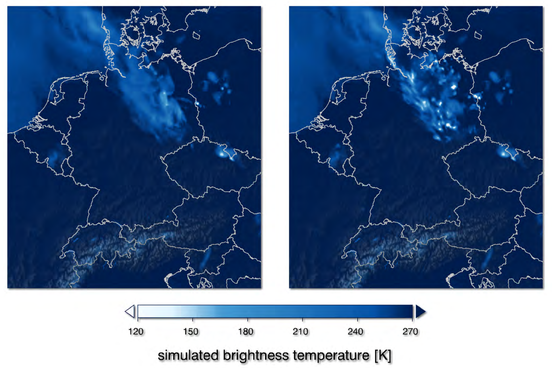

Figure: Simulated passive MW brightness temperature from PAMTRA at 150 GHz for a space-borne sensor based on COSMO-DE reanalysis output fields for 16 June 2007 at 04 UTC with LHN turned off (left) and on (right).

Results from the test period show that in convective situations, the LHN triggers convective cells containing very large amounts of frozen hydrometeors and the overall cloud field becomes more fractioned. The passive MW observations are thus an important complement to the MSG observations in the infrared to investigate cloud characteristics since they are able to provide information about the "thickness" i.e. the total hydrometeor content of the cloud.

Active Forward Operators

In order to explore the vertical structure of the reanalysis especially in cloud systems, first experiments were conducted to use PAMTRA for simulating an active cloud radar.

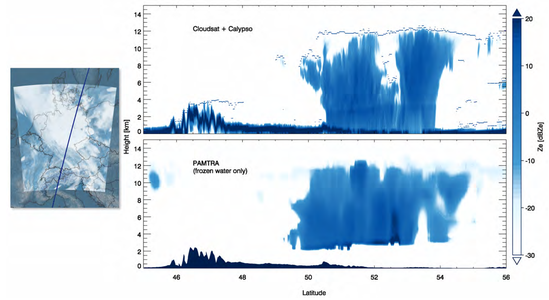

Figure: Vertical radar reflectivity at 94 GHz for 16 June 2007 (00 UTC) for a cross-section of the COSMO-DE domain. Top: CloudSat and cloud top information from Callipso (blue dots); Bottom: PAMTRA simulation using LHN (only frozen hydrometeors above the melting layer have been considered in the simulations)

Using more Observations

As radar data is only available for a short period, it would not be usable in the long term reanalysis. However, the LHN scheme proves to be beneficial in terms of the quality of analyzed precipitation fields. Therefore a disaggregation of precipitation observations will be implemented using rain gauge measurements and satellite data to generate spatial precipitation fields which can then be used as input for the LHN instead of radar data. Another part of the project focuses on the exploitation of observational data which is currently not assimilated into the model state. Therefore, it is investigated to which degree statistical transfer functions can be applied to derive information on model parameters which can be assimilated from currently unused data e.g. 2 meter temperature.

Further Information

Project website

Download poster

Feel free to contact us: **jan.keller@dwd.de**

Register at our project website to be informed when our reanalysis data becomes available.