Retrospective Analysis of Regional Climate: The German Reanalysis Project - Potential of remote sensing observations.

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A precise, comprehensive, and self consistent analysis of the past climate system state is a requirement for detection and attribution of regional climate change and subsequent measures of mitigation and adaptation strategies. Due to the complexity of the climate system and vast differences in quality and availability between monitoring systems, the problem of providing a detailed picture of past climate variability, especially on comparably small regional scales, is far away from being solved. A homogeneous and highly resolved gridded data set is a prerequisite for a vast field of applications and research projects and hence a particular challenge facing the community at large. Retrospective analyses of the atmospheric state provide a valuable resource in climate research and applications. Over the past decade, a number of such retrospective analysis, i.e. reanalysis, have been created on a global basis e.g. NCEP-NCAR reanalysis dataset NNR (1948-present), the European Centre for Medium Range Weather Forecasting (ECMWF) Reanalysis Archive ERA 40 (1957-2002) and the ECMWF Reanalysis Archive Interim ERA Interim (1989-present). In contrast to global products, regional reanalysis products are comparably rare.

This contribution will present an overview and first results of the recently started German Reanalysis Project. The German Reanalysis Project is the first phase (2011-2014) of the joint project Retrospective Analysis of Regional Climate for Use in Climate Change Analysis funded by the Hans Ertel Centre for Weather Research programme (HErZ). Overall vision of the project is to develop a self-consistent assessment and analysis of regional climate in Germany and Central Europe over the past decades at an appropriate spatial and temporal resolution. It encompasses the synergetic use and assimilation of heterogeneous monitoring networks, including historical station data and satellite data, to construct state-of-the-art regional reanalysis data sets for Germany and Central Europe and their evaluation.

The reanalysis will be based on the current forecast system at the German Meteorological Service (DWD). A data basis of free-atmosphere, near-surface, and soil-vegetation observations is extended with respect to the operational use and assimilated in a limited area model. The regional reanalysis will be based on the COSMO-DE model with a horizontal grid spacing of 2.8 km resolution, as it is in operational use at DWD. Two different versions of the reanalysis will focus on the comparably short time frame of 5 years with the maximum amount of observation data and nested into ERA-interim, and the past decades with a reduced data basis, in order to aim at more homogeneous time series than typically available in long-term reanalyses. The results of the short term regional reanalysis are verified and quality controlled via various observational datasets including in-situ and remote sensing observations. For this, an active/passive microwave (MW) forward operator has been developed in order to provide pseudo-observations from model output fields for verification in the space of observations and to prepare for future data assimilation.

The German Reanalysis Project will provide a quality-controlled and homogenised data set as a basis for the detection and assessment of regional climate change in past and future, for the statistical postprocessing of operational forecasts, for the analysis of systematic model errors of the respective regional model, and for verification and calibration of impact models like e.g. hydrological models. With respect to this the main objectives of this project are:

- Provide a quality controlled retrospective analysis of regional climate and its uncertainty in an area covering Germany;
- Provide detailed diagnostics of the energy, water, and momentum cycles of the reanalysed
  atmospheric climate state;
- Optimise climate monitoring by synergetic use of different monitoring networks
- Incorporate satellite data for validation and their subsequent use in assimilation

Synergetic evaluation of the reanalysis data will make use of a multitude of data (rain gauges, radar, micro rain radar, ceilometer network, high-resolution radio soundings, GPS network for integrated water vapor) available by the General Observation Period (GOP) during 2007/08 (Crewell et al., 2008). In addition to those ground-based networks a major focus will lie on microwave radiances provided by passive satellite sensors. The assimilation of microwave radiances as observed by polar orbiting satellites builds currently the back bone of operational data assimilation of global models. However, the information is generally limited to humidity and temperature in clear sky situations. Because microwave observations are also strongly affected by clouds and precipitation, the use of this information is highly desirable, but is complicated by the fact that scattering at particles of different size and shape needs to be accounted for.

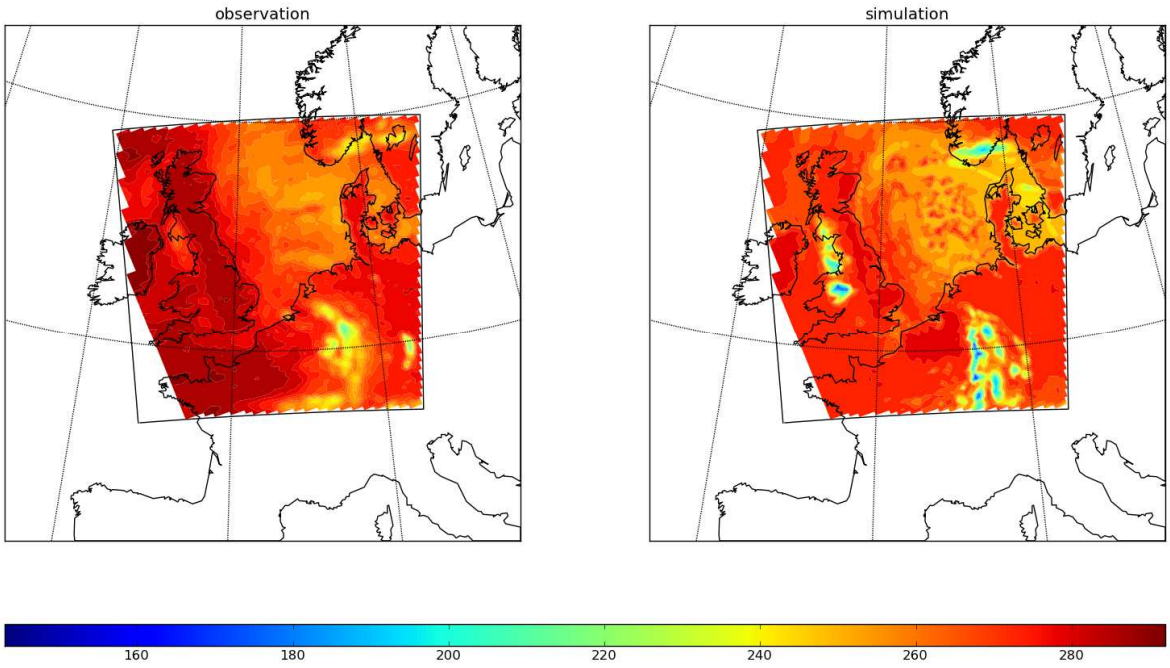

Fig. 1: Test case of a frontal system for the newly developed MW forward operator PAMTRA. The resulting brightness temperatures (TB in K) at 150 GHz are shown for AMSU (left) and the PAMTRA simulations (right).

State of the art attempts (Bauer et al., 2010) to include precipitation information therefore rely on a relatively simple treatment of scattering effects like those implemented in the *V* fast radiative transfer model RTTOV. Here we will make use of our newly developed detailed active/passive microwave simulator PAMTRA. Comparisons of numerical weather prediction models coupled to such an explicit radiative transfer model with AMSU observations have shown encouraging results (Meirold-Mautner et al., 2007) and the superiority compared to

RTTOV (Sreerekha et al., 2008). We will show first results of the application of the recently developed PAMTRA simulator to the first reanalysis test-runs with AMSU, SSMI/S observations. Radiative simulations especially at high frequencies rely on realistic representations of ice/snow habits for scattering calculations as they are included in PAMTRA. Long-term comparisons of active/passive microwave observations with PAMTRA simulations will be used to validate the precipitation variability over Germany, Central Europe and other locations.

The application of the MW forward operator to the reanalysis period and its synergy with the GOP data are especially suited to investigate the quality of the radar latent heat nudging scheme, which redistributes the different hydrometeor types in the vertical and therefore has a strong influence on microwave radiances. This allows the analysis of spin up effects, boundary effects and the influence of different weather type regimes. In order to investigate the vertical structure we also make use of Cloudsat data which can analogously simulated by PAMTRA. Standard verification statistics have been applied to the synthetic remote sensing data sets derived from the Short term/Full term reanalysis on one hand and the time series of the respective satellites (Meteosat, AMSU, SSMI/S). Especially the systematic errors will be of importance as they are a major obstacle for a direct assimilation of satellite data at a later stage of the project.

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