Assimilation of rainrates from BALTRAD network using latent heat nudging technique

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Introduction

BALTEX Radar Data Center, BRDC, located in Sweden collects different radar products generated during BALTEX special observing periods. We used radar data stored during BRIDGE experiment. Data are available from November 1999 to February 2002. Four different types of products were generated: radar reflectivity factor (DBZ), composite image generated from radar reflectivity factor, accumulated precipitation analysis products based on DBZ products and synoptic observations (Michelson, 2001), and wind profiles from Doppler radars. In composite products the Lambert Azimutal Equal Area projection with the spherical earth model is used. In this article we concentrated on 3-hour accumulated precipitation data. Spatial resolution of 815x1195 points of data is 2x2 km. Composite picture includes from 23 to 27 radar sites, depending on the availability. At the ICM we run operationally Unified Model tailored to the Central Europe area from May 1997, and from that period we collect all analyses and forecasts produced by our UMPL system (Herman-Izycki et al. 2002).

Observation processing system

Unified Model assimilates different types of observations (Lorenc et al., 1991) with basic assumption that raw observational data passed quality control during a previous stage of data processing. For these purposes the Observation Processing System (OPS) was designed. The OPS extracts conventional and satellite data from UKMO operational database, checks the quality of data using UM model background fields and finally creates the input files for an assimilation within the Unified Model. Radar data, generally available locally, are treated in different way, as these and cloud data are produced by the nowcasting system NIMROD. We decided to use OPS for a creation of input files with radar precipitation data. Writing new computer code BaltProg we were able, using selected procedures from OPS system and including new procedures for reading the BALTRAD data structure, to produce input files with radar precipitation data in format required by the UM system. We did not implement the quality control procedures, as precipitation data from BRIDGE experiment were quality controlled during the process of blending radar precipitation rates with precipitation totals from rain gauges measurements.

Latent heat nudging in Unified Model

Vertically integrated latent heating rate due to condensation within a cloud is approximately proportional to the net rain rate. The assimilation algorithm is independent on the origin of the rain rat data. The basic structure of the scheme is to calculate latent heating profiles from the model physics step, and to derive increments within the Assimilation Correction (AC) scheme to the potential temperature. This is based on scaling of the profiles by the amount equal to the value of rain estimated from radar data analysis to the model first guess value (Macpherson, 2001). Field of analysed precipitation is created as the sum of total precipitation (rain and snow from large scale and convective processes) and precipitation increments estimated by AC scheme from radar precipitation data. The input to the increment analysis consists of 3-hour precipitation totals prepared at the resolution of 4 km and then averaged onto the model grid. As a background, 3-hour mesoscale model precipitation forecast is used. The analysis is performed by 2-dimensional recursive filter technique (Hayden and Purser, 1988). Total latent heating increments are combined from latent heating increments to potential temperature due to convection and latent heating increments to potential temperature due to dynamics. The important part of the scheme is the search for a suitable nearby latent heating profiles for use in the LHN scheme. Depending on results of the search the scaling is performed to profile at the point itself, to the nearby profile at nearby point, by prescribed profile or observation is ignored.

Preliminary results

Described scheme was tested of one selected day: 23 July 2000.

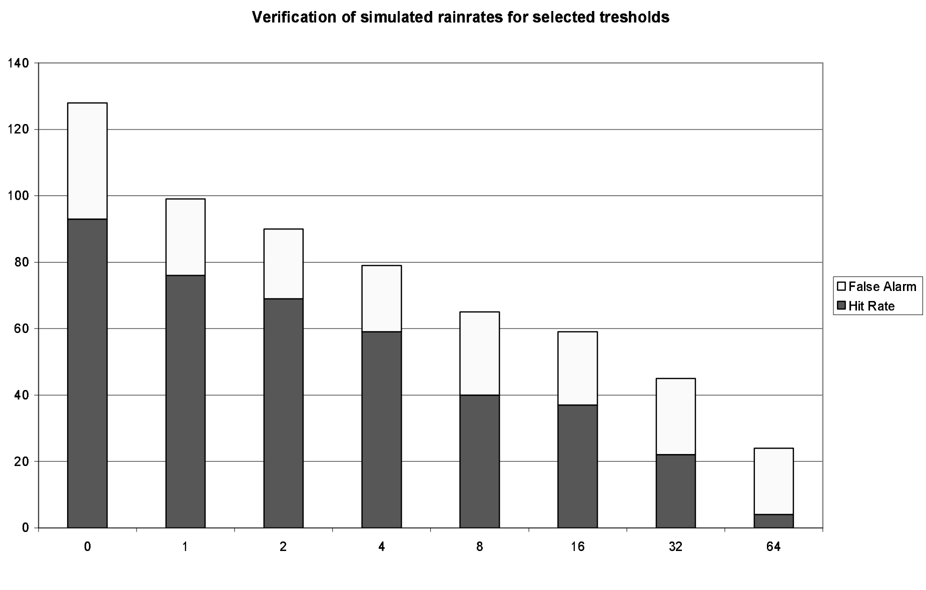
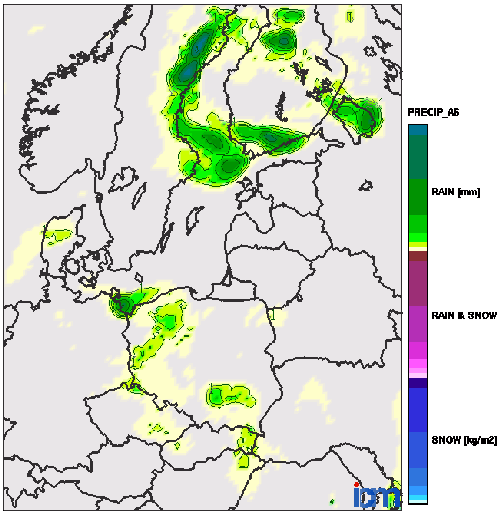
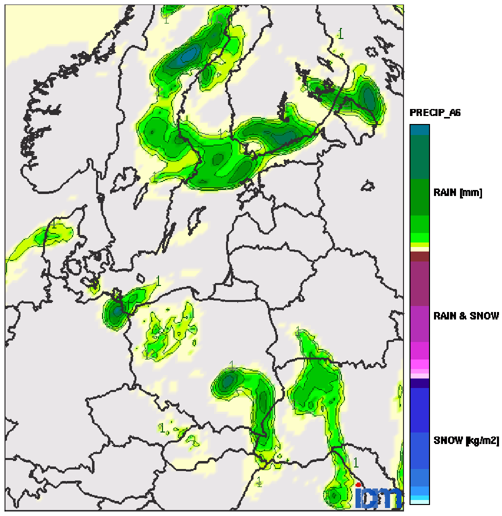


Fig. 1 Verification statistics for daily precipitation totals (control run)

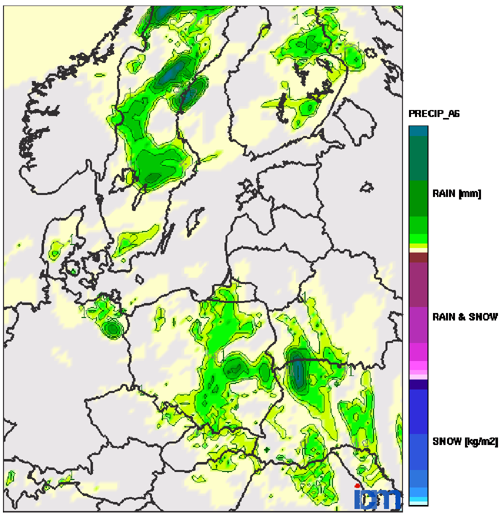
23 July 2000, 00:00 UTC



23 July 2000, 06:00 UTC



23 July 2000, 12:00 UTC



23 July 2000, 18:00 UTC

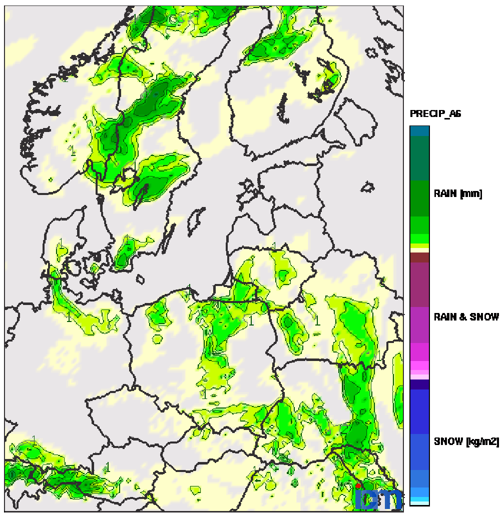
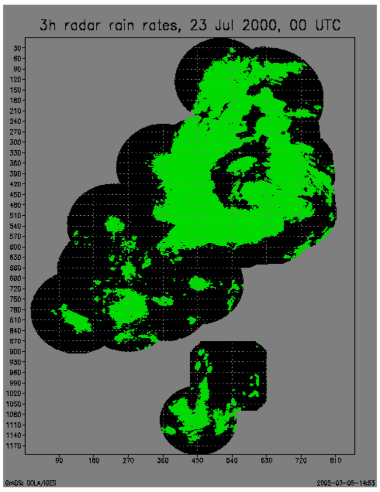
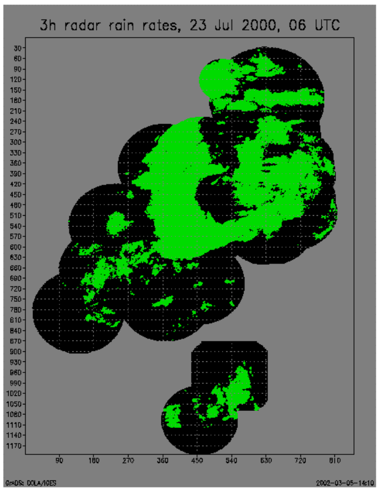


Fig. 2 Precipitation patterns from control model run (without assimilation of radar data)

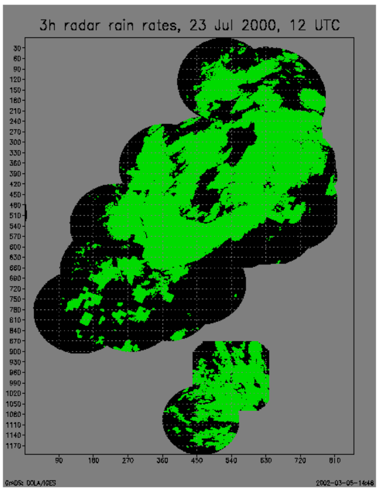
23 July 2000, 00 UTC



23 July 2000, 06 UTC



23 July 2000, 12 UTC



23 July 2000, 18 UTC

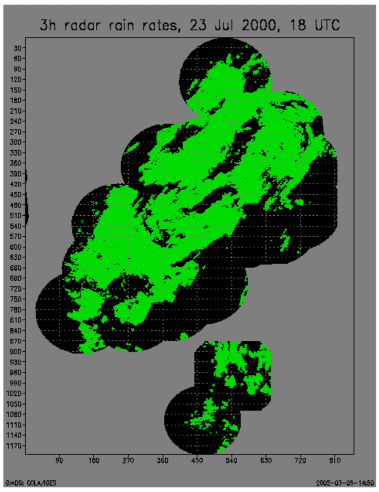


Fig. 3 3h precipitation totals from radar reflectivities

For verification purposes we implemented hit rate (HR) and false alarm rate (FAR) statistics computed from contigency table, which counts observed dry (less than a given treshold) and wet (great or equal than selected treshold) cases against forecasted dry and wet cases. Picture 1 presents both verification scores for number of selected tresholds. The model overestimates small precipitation rates and underestimates high precipitation rates. The hit rate is better than false alarm rate till the treshold of 16 mm/day. Picture 2 shows 6-hourly accumulated precipitation amount simulated by UMPL model. These images can be compared with 3-hourly accumulated precipitation amount estimated from radar reflectivity data presented on picture 3. After assimilation of rainfall rates by LHN technique similar verification scores were computed. Generally, behaviour of the model in assimilation run (scores not included) was similar to that in control run. Some moderate improvements were noticed. Hit alarm rate for small precipitation was 2% better, and for the treshold of 16 mm/day 6% better in the case of assimilated rainfall compared with control run.

Conclusions

To get these preliminary results quite heavy programming effort was involved. Practically to both systems used (OPS, UMPL) new procedures and many of changes to the code were introduced. Now we have tool to more detailed analysis of the impact of rainfall data assimilation on the quality of the model forecasts, and we planned to explore it more deeply. We acknowledge the UKMO for the possibility to use Unified Model and OPS source codes and the BALTEX Radar Data Center for the archive of the radar data.

References

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