Priority Program SPP 1167 of the DFG

Quantitative Precipitation Forecast

QUEST – Second Phase

Susanne Crewell[1], Felix Ament[1,2], Michael Baldauf[3], George Craig[4], Jürgen Fischer[5], Anja Hünerbein[5], Nicole van Lipzig[6], Martin Hagen[4], Monika Pfeifer[4], Thorsten Reinhardt[1], Marc Schröder[3,5], Axel Seifert[3], Stefan Stapelberg[5]

[1)] Institute for Geophysics and Meteorology, University of Cologne (IGMK), [2)] MeteoSwiss,
[3)] German Meteorological Service, Offenbach (DWD), [4)]Institute of Atmospheric Physics (DLR),
[5)] Institute for Space Sciences, Free University of Berlin (FUB) , [6)] Katholieke Universiteit Leuven (KUL).

Objectives

Precipitation is the final atmospheric process of the **hydrological cycle**. Consequently quantitative precipitation forecasts (QPF) can only be successful, if a model represents all processes of this cycle accurately. The project "Quantitative evaluation of regional precipitation forecasts using multi-dimensional **remote sensing observations**" (QUEST) aims at a complete analysis of the modeled hydrological cycle in order to **identify the reasons of QPF deficiencies** and to give **distinct advices for model improvement**.

Strategy

I. Development of new, non-standard **evaluation tools** (model-to-observation techniques, non-standard quantities, new verification measures).

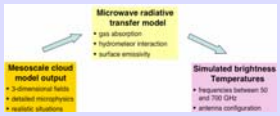
II. Applications of these tools to **case studies**; Identification of model deficiencies; Focus on COSMO-Models of DWD,

III. **Long term evaluation** using QUEST evaluation tools: Verifying case study results; Synergetic use of all tools to assess cross correlation of model errors; Case study selection.

Tool development

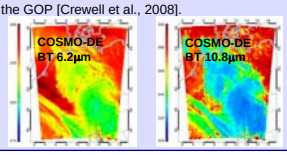
Microwave Radiation Simulator (SynSatMic)

A microwave radiation simulator (**SynSatMic**) originally developed for the French Méso-NH model [Mech et al., 2007] was adapted to the COSMO-DE model taking into account the assumptions in the COSMO-DE microphysics like drop size distributions, density etc. It was already applied within case studies for comparisons with AMSU observations (see below).



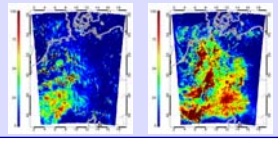
Synthetic Satellite Simulator (Synsat)

A problem with the angular geometry in the synthetic satellite simulator (**SynSat**) implemenation at DWD could be identified and fixed. This was validated by comparisons with FUB's advanced RT code. Synthetic brightness temperatures at 9 frequencies are now used routinely for COSMO evaluation within case studies and for long-term evaluation as part of the GOP [Crewell et al., 2008].



Analysis of Cloud Optical Depth

An algorithm to derive optical thickness from MSG observations has been developed, validated and implemented. The derived fields and time series data at anchor stations are routinely produced as part of the GOP for comparison with model-derived cloud optical depth.

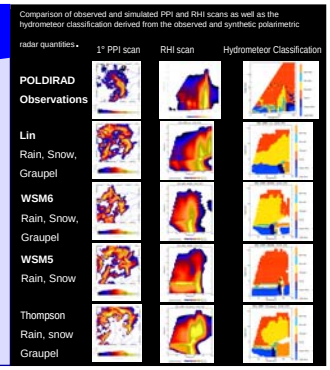


Polarimetric Radar Forward Operator SynPolRad

The work on the polarimetric radar simulator (**SynPolRad**) concerned

- the ability to simulate cloud and micro rain radar
- technical improvements especially computation time
- integration of several different microphysical schemes
- comparison of COSMO forecasts with those of the French Méso-NH model also including prognostic hail

The right figure clearly shows the strong effect of the different parameterizations on the thunderstorm representation.

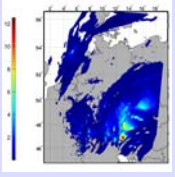


Case Studies

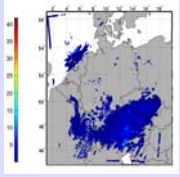
In order to demonstrate the QUEST tools - in particular the forward operators - two case studies (a stratiform case 3 August 2006 and a convective case 28 August 2006 were performed [Pfeifer et al., 2008].

3rd August 2006

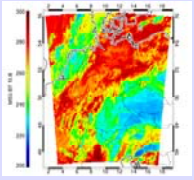
COSMO-DE: frozen hydrometeors



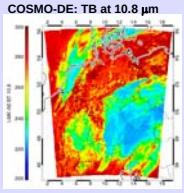
COSMO-DE: surface rain rate



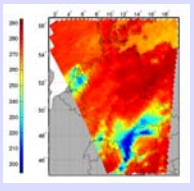
MSG: TB at 10.8 µm



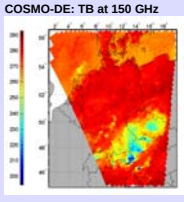
COSMO-DE: TB at 10.8 µm



AMSU: TB at 150 GHz



COSMO-DE: TB at 150 GHz



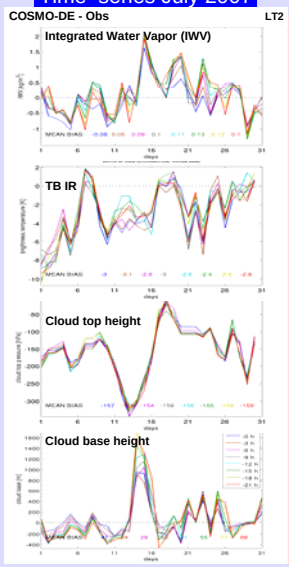
Complementary information from different remote sensing systems:

- MSG Infrared observations indicate widespread system with high clouds over Germany
- AMSU Microwave observations indicate cores of precipitating system
- further information is available from water vapor channels in IR (temporal inform.) and microwave

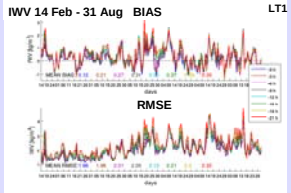
Long-term evaluation

Evaluation of **GOP is the central activity** of QUEST. Emphasis is on DWD's short-range forecast model COSMO-DE (2.8 km mesh size, 421*461 gridpoints covering Germany and surroundings, explicit simulation of deep convection; lagged ensemble: 21-h forecasts started every three hours.)

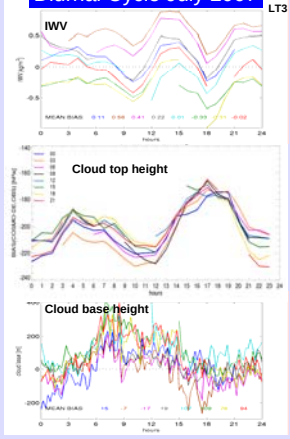
Time series July 2007



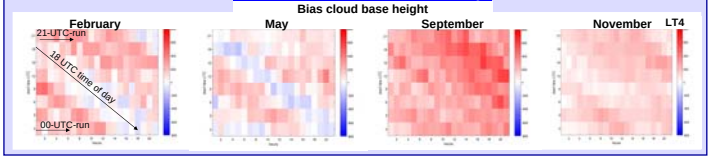
Long-term timeseries



Diurnal Cycle July 2007



Month-to-month Variability



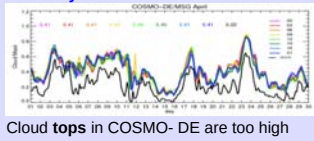
Findings

Water Vapour

- **COSMO-DE** integrated water vapour (IWV) is **higher** (Fig. LT1, LT2, LT3) and COSMO-EU is drier than GPS observations (not shown)
- From longer time series **cases** with especially high/poor model performance as well as those with strong variations with lead time can be identified **objectively** (Fig. LT1)
- Modelled IWV depends strongly on **start time** of the forecast with those started at 12, 15 and 18 UTC being the driest ones (Fig. LT3) ➔ most likely cause are the assimilated 12 UTC radiosonde observations showing a daytime humidity dry bias
- COSMO models are **moister** relative to GPS in **south** than in north Germany (not shown).
- Radiosoundings reveal largest problems in the mid troposphere and the **top of the boundary layer** (not shown)
- COSMO-DE and COSMO-EU show similar vertical structure in bias (humidity and temperature) during **winter** but not in **summer.** In summer COSMO-DE seems to be better.

Clouds

- **too many clouds** in COSMO-DE



- Cloud **tops** in COSMO- DE are too high and consequently are slightly **too cold** compared to MSG (Fig. LT2)
- Bias in cloud **base** is **highly variable** from month to month with some obvious diurnal features (Fig. LT4)

Precipitation

- Spatial patterns in monthly precipitation well captured in winter, while **total amount overestimated**; more complicated picture in summer (not shown)

Publications (selected)

Crewell, S., et al., 2008: General Observation Period 2007: Concept and first results, *Meteorol. Z.*, submitted.

Mech, M., S. Crewell, I. Meirold-Mautner, C. Prigent, and J.-P. Chaboureau, 2007: Information content of millimeter observations for hydrometeor properties in mid-latitudes. IEEE Transactions on Geoscience and Remote Sensing, 45(7), 2287-2298.

Pfeifer, M., W. Yen, M. Hagen, G. Craig, T. Reinhardt, M. Mech, S. Crewell, A. Hünerbein, J. Fischer, M. Schröder, and M. Baldauf, 2008: Validating precipitation forecasts using sensor synergy: The case study approach, to be submitted.

Pfeifer, M.; G. Craig, M. Hagen, and C. Keil, 2007: A polarimetric radar forward operator for model evaluation. *Journal of Applied Meteorology and Climatology*, submitted.

Status

- WP "Tool Development" completed, tools being ready and have successfully been applied to case studies and long-term-evaluation. Identification of first model deficiencies.
- Evaluation of GOP 2007 started. Regionalization and weather-regime classification prepared.
- Close cooperation with DWD; Evaluation of COSMO-model operational output and testsuites; joint meetings.