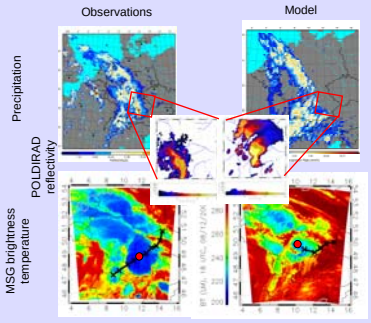
Priority Program SPP 1167 of the DFG

Quantitative Precipitation Forecast

QUEST – First Phase

Susanne Crewell[1], Felix Ament[1], Michael Baldauf[5], George Craig[2], Jürgen Fischer[3], Nicole van Lipzig[4], Martin Hagen[2], Monika Pfeifer[2], Marc Schröder[3], Wenchieh Yen[1]

[1)] Meteorological Institute, Munich University (MIM), [2)] Institute of Atmospheric Physics (DLR), [3)] Institute for Space Sciences, Free University of Berlin (FUB) , [4)] Katholieke Universiteit Leuven (KUL), [5)] German Meteorological Service, Offenbach (DWD)



Example: 12 August 2004, 18UTC. Modeled reflectivities in the POLDIRAD domain are derived from an improved LM simulation with reduced Foehn effects.

Objectives

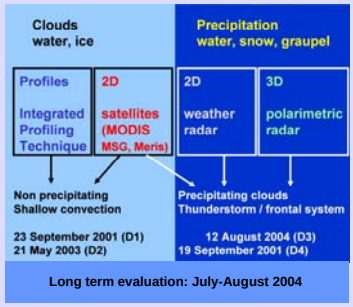
Precipitation is the final atmospheric process of the **hydrological cycle**. Consequently quantitative precipitation forecasts (QPF) can only be successful, if a model represents all processes of this cycle accurately (see left Figure). The project "Quantitative evaluation of regional precipitation 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 Lokal-Modell (LM) of DWD, but other models are considered as well.

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.

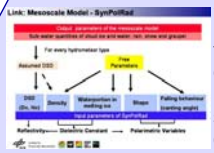


Sensors and quantities considered by QUEST.

Tool development

Polarimetric Radar forward operator SynPolRad

Polarimetric quantities measured by a polarimetric Radar like POLDIRAD of DLR gives information about hydrometeor types.



SynPolRad links measurements and model by transforming the model output into radar variables as if operating a synthetic polarimetric radar in the model domain.

Definition of cloud pattern descriptors

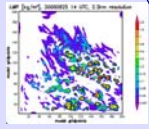
New measures to describe horizontal structure like e.g. the patchiness parameter (Schöder et al.) or the autocorrelation of liquid water path time series (van Lipzig et al.) have been defined and successfully applied for model verification.

Analysis of cloud optical depth

Cloud optical thickness is useful for evaluations since it is highly correlated with cloud water/ice content, important for the radiation budget and a relatively direct measurement from satellite. Tools to derive cloud optical depth from both MSG and models have been developed.

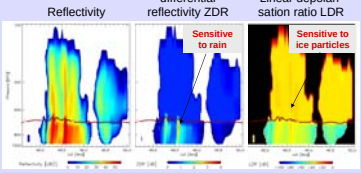
Tracking and Cell detection

By using a cell detection and tracking algorithm it is possible to verify the lifetime, size distribution and the movement of convective cells (see first Figure on this poster).



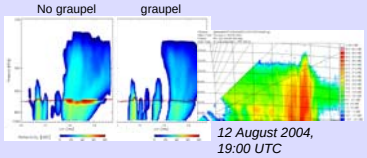
Hydrometeors

Detailed analysis of vertical hydrometeor structure using polarimetric radar quantities :



Vertical cross sections calculated from LM by SynPolRad at 12 August 2004, 17:00 UTC.

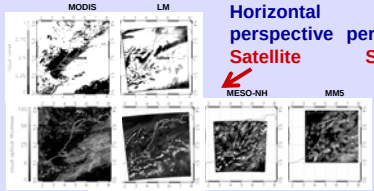
These comparisons can be used to verify and optimize microphysical schemes. For example, the implementation of a graupel scheme by DWD can be classified as a clear improvement, since spurious bright band structures are removed, however problems in density parameterization are evident (see Figure below).



12 August 2004, 19:00 UTC

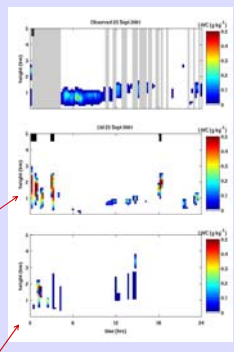
Cloud structure

Example: Case study 21 Sep. 2001

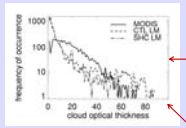


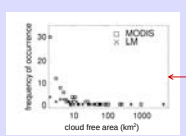
Horizontal perspective Satellite

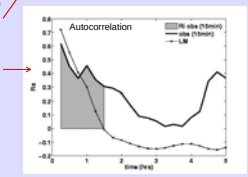
Vertical perspective Supersite Cabauw



- Modeled and observed cloud structure are different.
- LM underestimates clouds with moderate LWC / optical depth.
- Shallow convection scheme gives no significant benefit.
- LM underestimates the lifetime of clouds.
- LM has deficiencies to represent small-scale cloud structures.







Outlook: Testing of new dynamical schemes, 3-d turbulence scheme and more complex microphysics.

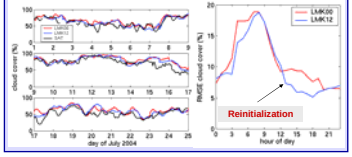
Long term evaluation

DWD performed long term (2 month) test runs with its new short range, fine-scale version of LM called LMK:

- lumped ensembles consisting of runs for 24h forecast time starting every 3h
- 2.8 km horizontal resolution
- domain of 1290x1180 km² centered over Germany
- enhanced model formulations.

It is ongoing work of QUEST to evaluate these runs with the tools developed for the case studies.

For example, LMK represents the overall evolution of cloud cover quite well with a moderate positive BIAS (see Figure below). Errors are most pronounced during the morning. The lumped ensemble offers the opportunity to analyze the effects of reinitialization.



Findings

- Using Graupel as prognostic variable is beneficial but further improvements to the scheme are needed.
  - LM underestimates the lifetime of clouds and has problems to simulate clouds with moderate LWC / optical depth.
    - With respect to the case studies, the shortcomings in cloud predictions are not solved by implementing a shallow convection scheme.

Status

- New evaluations tools are developed and have successfully been applied to case studies. Identification of first model deficiencies.
- Tools applied to a *first* long term evaluation.
- International collaboration established by coordinating a model intercomparision initiated at the Second WMO Cloud Modeling Workshop, Hamburg 2004.
- Close cooperation with DWD: Supporting development of the new Graupel scheme; Evaluation of LMK Testsuites; Joint Meetings

Publications (selected)

Van Lipzig et al.: "Model predicted low-level cloud parameters. Part I: Comparison with observations from the BALTEX Bridge Campaigns", Atmospheric Research, accepted

Schröder et al.: "Model predicted low-level cloud parameters. Part II: Comparison with satellite remote sensing observations during the BALTEX Bridge Campaigns", Atmospheric Research, accepted

Pfeifer, M., Craig, G., Hagen, M. and Keil, C.: "A polarimetric forward operator", Proceeding of ERAD 2004, 494-498

Van Lipzig, N., Wernli, H., Crewell, S., Gantner, L. and Behrendt, A.: "Synthesis of preliminary results of SPP verification projects", SPP Newsletter 1, 2005