Quantitative evaluation of high-resolution precipitation forecasts using multi-dimensional remote sensing observations (QUEST)

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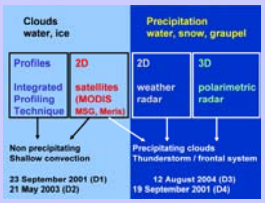
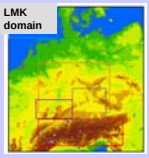
Objectives and Methodology

- The new generation of numerical weather prediction (NWP) models provides precipitation forecasts with **horizontal grid spacing in the order of a few kilometers**.
- Because the amount of precipitation at the ground results from a complex process chain a thorough evaluation of model performance and consistency should to consider **multiple atmospheric parameters**.
- We use high-resolution, multi-dimensional remote sensing observations from satellite (e.g. from Meteosat Second Generation (MSG), MODIS) and ground (radar and profiling stations) for the evaluation of the non-hydrostatic **Lokal-Modell Kürzestfrist (LMK)** of the German Meteorological Service (DWD) with 2.8 km resolution.
- Both, detailed **case study analyses** and **long-term statistical model evaluations** are performed to investigate model performance.

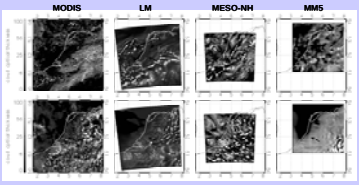




Strategy

Observations

- multi-frequency radiances
- polarimetric radar quantities
- ground based and space borne observations



Retrieval

- water vapour
- cloud properties
- precipitation

Forward Operator

- SynPolRad (polarimetric radar)
- SynSat (MSG, MODIS)
- SynSatMic (AMSU, SSM/I)

Weather Forecasts

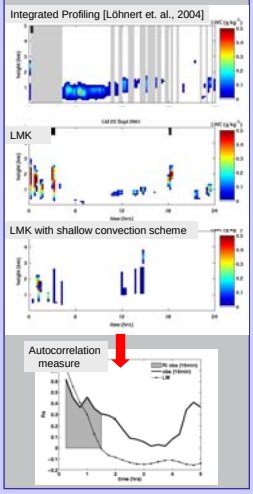
three-dimensional description of the forecasted atmospheric state

(Optical thickness: Matching model and observations involves retrieval and model operator)

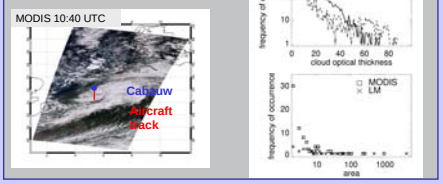
Case Study Approach

WMO Cloud Modelling Workshop 2004
Stratocumulus deck over the Netherlands on 23 September 2001

Ground-based observations of liquid water content at Cabauw



Satellite observations of optical depth



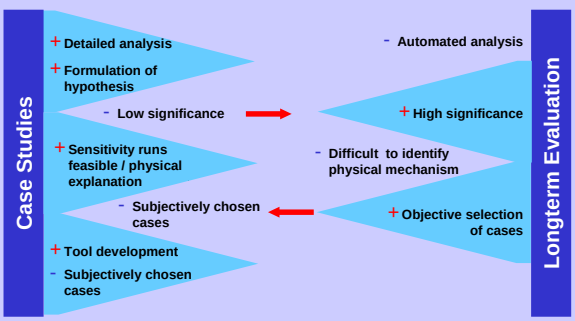
- Modeled and observed cloud structure are different.
- LM underestimates clouds with moderate LWC / optical depth.
- Shallow convection scheme gives no significant benefit.
- LM underestimates the life-time of clouds.
- LM has deficiencies to represent small-scale cloud structures.
- representativity of aircraft observation makes them difficult to use in model evaluation

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

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

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

Synthesis



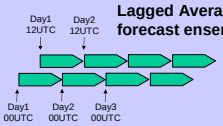
Outlook: In 2007 a long-term evaluation of the whole LMK area will be performed as part of the German QPF priority program : the **General Observation Period (GOP).** In summer the Convective and Orographically-induced Precipitation Study (COPS) will be performed in South Germany providing detailed data for case studies.

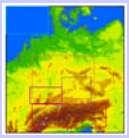
Longterm Evaluation

LMK Testsuite 2.2b July 2004

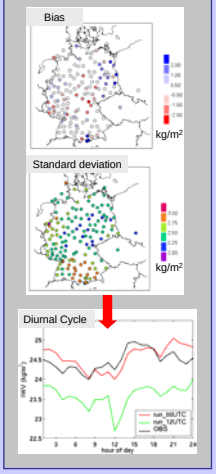
- 2.8 km horizontal resolution, 50 vertical layers, prognostic treatment of cloud water, cloud ice, rain and snow
- LMK expected to be operational at DWD in spring 2007 (see talk by Michael Baldauf)

Lagged Average forecast ensemble

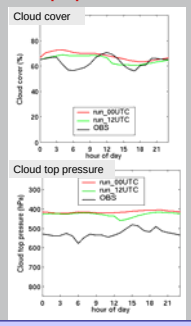




GPS network observ. of water vapor column

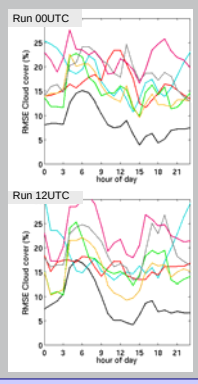


Meteosat 2nd Generation cloud properties

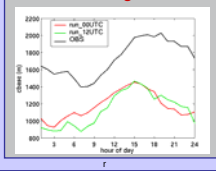


Regionalization

Cloud cover (%) LMK00/ LMK12	BIAS (%)	STD (%)	Correlation
LMK domain	8 / 5	9 / 9	0.80 / 0.80
North Sea	**9 / 8**	17 / 17	0.72 / 0.70
alps	6 / 2	14 / 15	0.78 / 0.81
flat area	**9 / 7**	17 / 17	0.68 / 0.70
low mountains	7 / 5	15 / 16	0.68 / 0.67
Poldirad areat	5 / 2	17 / 17	0.72 / 0.75
COPS area	4 / 0	**22 / 20**	**0.49 / 0.61**

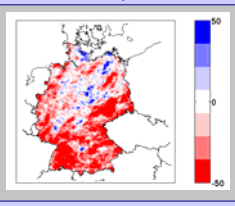


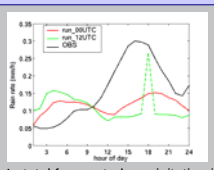
Ceilometer network obs. cloud base height



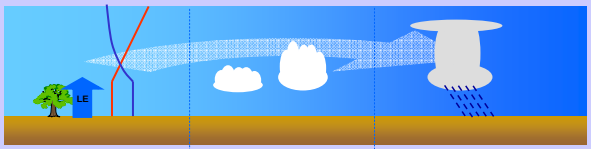
Surface precipitation

Relative bias in accumulated precipitation over the month compared to combined radar/rain gauge product





In total forecasted precipitation is ~ 20 % too low.



- Boundary layer tends to be too thin and too wet
- IWV predicted very well
- IWV bias of -0.85 kg/m² for run started at 12 UTC

- Clouds too thick
- Total cloud cover agrees well with MSG
- see Poster by Schröder et al. for more on observations

- Precipitation underestimated by 20%
- Observed timing maximum not reproduced
- see Poster by Pfeifer for precipitation microphysics