Cloud statistics and NWP-model validation based on long term measurements of a 35 GHz radar

Deutscher Wetterdienst
Wetter und Klima aus einer Hand

Outline
- Cloud cover and fraction statistics have been derived from Ka-Band Radar measurements at Lindenberg for nearly 7 years.
- Radar measurements have been compared to human expert observations (synop) and NWP model simulations.
- Ice cloud parametrization has been improved based on radar data.

Time series of cloud cover
- Excellent agreement between radar and local observer (synop)
- Differences between radar and model smaller than 3%
- Good agreement between observations and models. COSMO-DE shows underestimation
- Significant annual cycle, minimum in summer, maximum in winter

Example of a detailed analysis:
Mean and frequency distribution of cloud fraction
- Large discontinuity in cloud fraction distribution above 5 km
- Parameterisation scheme of stratiform clouds:
  \[ C = \max \left\{ 1, \min \left( \frac{\log(q_i)}{10} - \log(0.1) \right) \right\} \]
  
  \( q_i \): ice water content (iwc)
  \( a, b \): empirical parameters (a=0.2, b=5 x 10^{-5})
  Verification based on radar derived cloud fraction and ice water content. (Cloudnet)

Impact study for January 2011
- Elimination of discontinuity in cloud fraction distribution above 5 km
- Better agreement between radar and model

Data
Radar (MIRA36):
- Cloud base (in combination with ceilometer) and cloud top
- Cloud cover
- Cloud fraction (corresp. to model layers)
- Ice water content (Illingworth et al., 2007 Cloudnet, Bull.Amer. Meteor. Soc, 86)

Synop (local observer):
- Cloud cover at Lindenberg as hourly estimates

Models (DWD):
- Cloud cover and cloud fraction as hourly outputs for
  - GME (\( \Delta x = 40 \) km, output interval \( \Delta t = 1 \) h, 40 layers)
  - COSMO-EU (\( \Delta x = 7 \) km, \( \Delta t = 1 \) hour, 40 layers)
  - COSMO-DE (\( \Delta x = 2.8 \) km, \( \Delta t = 0.25 \) h, 50 layers), see Monthly Weather Review 2011 ; e-View, doi: 10.1175/MWR-D-10-05013.1

Summary
- Good agreement between radar derived and local observer estimated cloud cover for total and low clouds.
- Significant differences between radar and model regarding vertical distribution of cloud fraction.
- Deficiencies in parameterization of ice clouds are a possible reason for radar-model differences.
- A modification of parameterization on the base of radar measurements yield an obvious improvement of model simulated cloud fraction.