Validation of EarthCARE Cloud Microphysics Retrieval with the airborne HALO Microwave Package

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Validation and Calibration of Retrieval Algorithms

- in-situ observations
  - ground-based
  - airborne
- remote sensing
  - ground-based
    - vertical pointing
    - scanning
  - airborne
- operation
  - continuous
  - dedicated field campaigns
HALO – High Altitude and Long Range Aircraft

The new aircraft for the German atmospheric science community

- Gulfstream G550 modified as research platform for airborne atmospheric science and Earth observations
- Up to 9000 km range, max. 15.5 km altitude, max. 11 hours, max. 3 t scientific payload
Proposed Instrumentation for Validation Campaigns

- HAMP (HALO microwave package)
  - Cloud radar 36.5 GHz
  - Microwave radiometers in K-, V-, W-, F-, G-band
- WALES water vapour differential absorption lidar
  or Multi-λ High Spectral Resolution Lidar (HSRL)
- additional
  - Drop sondes
  - Microwave Temperature Profiler MTP
  - in-situ PMS probes
  - . . .
Installation of Instrumentation

- 183 GHz, A=80 mm
- 25 and 51 GHz
- 90 GHz, A=150 mm
- 118 GHz, A=120 mm
- CIWSIR sub-mm demonstrator 243, 325, 424, 664 GHz
- Lidar from cabin
- Radar 36.5 GHz
Cloud Radar

Standard METEK Ka-band cloud radar

- Less attenuation at 36 GHz compared to 94 GHz
- Polarization (LDR) for particle identification
- Doppler measurement of vertical velocity in clouds and precipitation (and clear-air echoes)

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<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
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<tr>
<td>Frequency</td>
<td>35.5 GHz</td>
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<tr>
<td>Peak Power</td>
<td>35 kW</td>
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<td>Diameter of Antenna</td>
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<td>Antenna Beam Width</td>
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<td>Sensitivity at 5 km</td>
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Estimation of Horizontal Wind Field

Currently under investigation:

- beam steerable into 3 (5) directions will give horizontal wind vector (algorithm like wind profilers or VAD technique)
- technical realization: flip mirror of Cassegrain antenna
### Passive Microwave Radiometer Specifications

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<th>Frequencies</th>
<th>K</th>
<th>H$_2$O</th>
<th>V</th>
<th>O$_2$</th>
<th>W atm. window</th>
<th>F</th>
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WALES Water Vapour Lidar

Differential absorption lidar
\( \lambda \ 935 \text{ nm} \)

Convection over the North Atlantic during IPY-Thorpex

H2O mixing ratio

attenuated backscatter ratio
Microwave Temperature Profiler

Example from NASA/JPL:
Temperature cross-section as a function of latitude for a DC8 flight from Alaska to Hawaii.

Using $O_2$ absorption bands 55-59 GHz
Example of MW Radiometer Retrieval using Simulated Brightness Temperatures

- CRM - Méso-NH
- 5 hydrometeor categories - cloud, cloud ice, snow, graupel, rain

- 1-D, plan-parallel RT model
- spherical particles with frequency-dependent density/size modification (Staelin, 2008)
- emissivity ([l] maps,[o] model)

M. Mech, Uni Köln
Continuous Ground-based Observations

- Environment research site Schneefernerhaus
- 2650 m MSL
- 300 m below Zugspitze summit
Instruments at Schneefernerhaus

- DPR radiometer (LWP, ice micro phys.)
- HATPRO radiometer (temp./hum.prof., ice mic.phys.)
- 36 GHz cloud radar
- PARSIVEL distrometer (particle size distr.)
- 2D video distrometer (particle size dist., shape)
Some Example Synergy Lidar (POLIS) – Cloud Radar

Lidar depolarization signal
 purple / blue: cloud droplets
 yellow / red: ice particles

Radar reflectivity factor

M. Wiegner, MIM, Uni München
Status

- HALO arrived at Oberpfaffenhofen in January 2009
- first mission (OMO) in July 2009

belly pod with radom segment
First Mission with HAMP and WALES

Demonstration mission with cloud radar and microwave radiometer scheduled for January/February 2011

- NARVAL (North Atlantic Rainfall VALidation)
  - Goose Bay
  - Barbados

- A-train underpass
Summary and Conclusion

- HAMP (HALO microwave package) provides sufficient and independent information to estimate cloud microphysical properties from airborne and ground-based platforms.
- Instruments will be ready by end of 2009.
- Complimentary measurements with lidar (water vapour DIAL or multi-λ HRSL) and in-situ sensors can be used to retrieve the state of the atmosphere for validation of satellite algorithms for A-Train, EarthCARE or GPM.
- Validation strategies will be:
  - Dedicated field campaigns using a number of instruments, either airborne or ground based.
  - Long term observations with ground based in-situ or remote sensing instruments.