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

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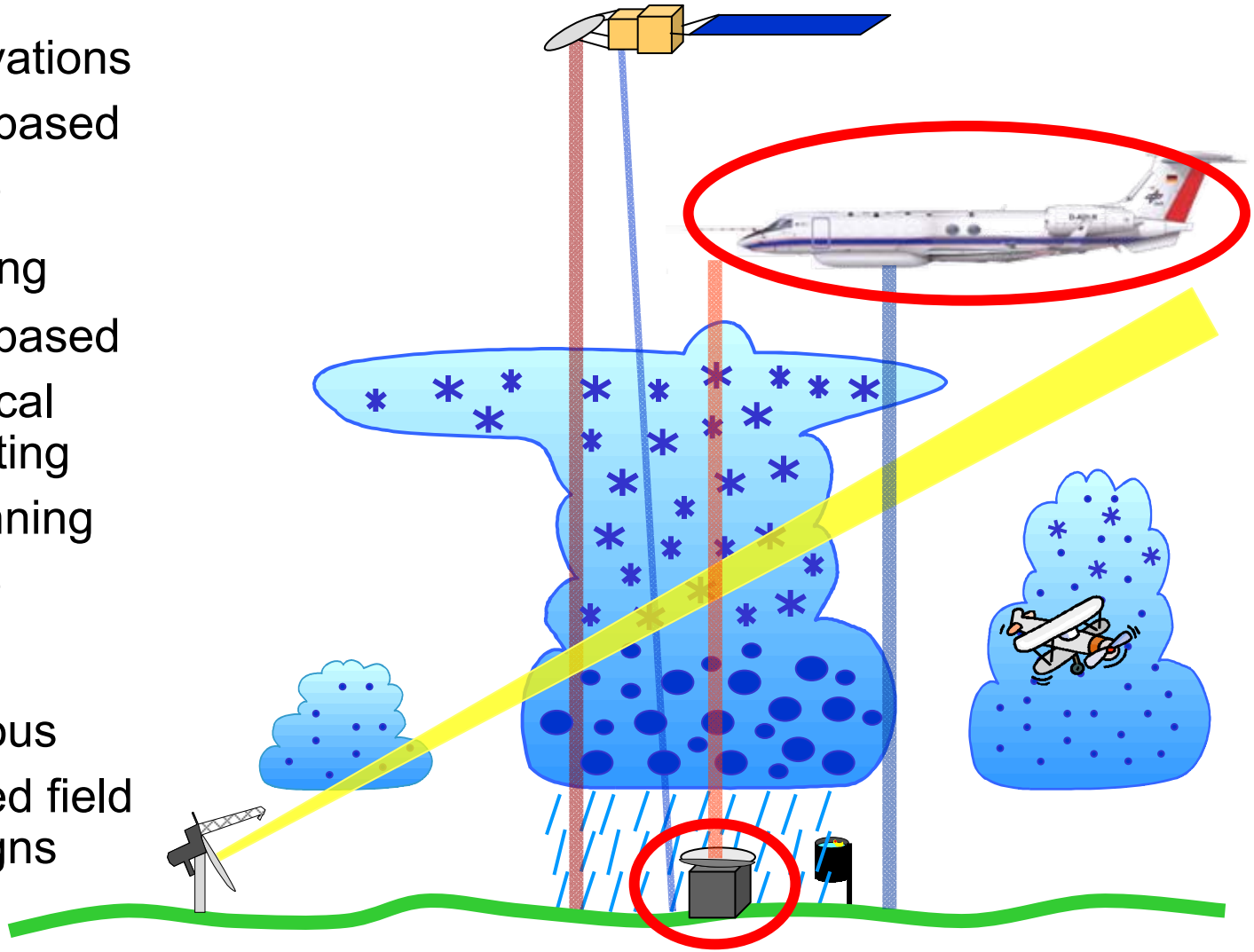
Validation and Calibration of Retrieval Algorithms

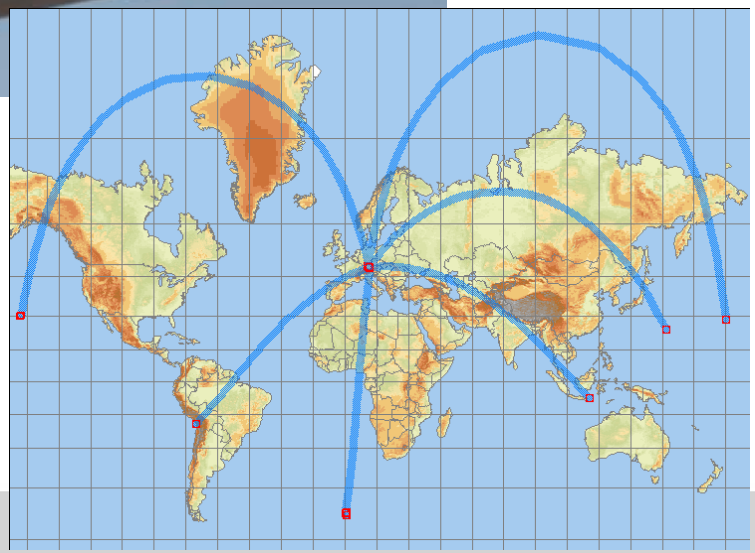
- in-situ observations
  - ground-based
  - airborne
- remote sensing
  - ground-based
    - vertical pointing
    - scanning
  - airborne
- operation
  - continuous
  - dedicated field campaigns

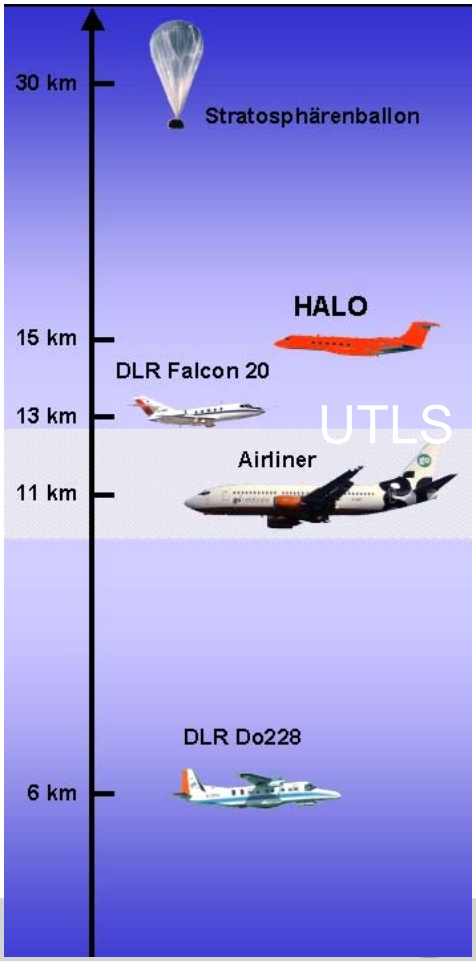


HALO – High Altitude and Long Range Aircraft

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

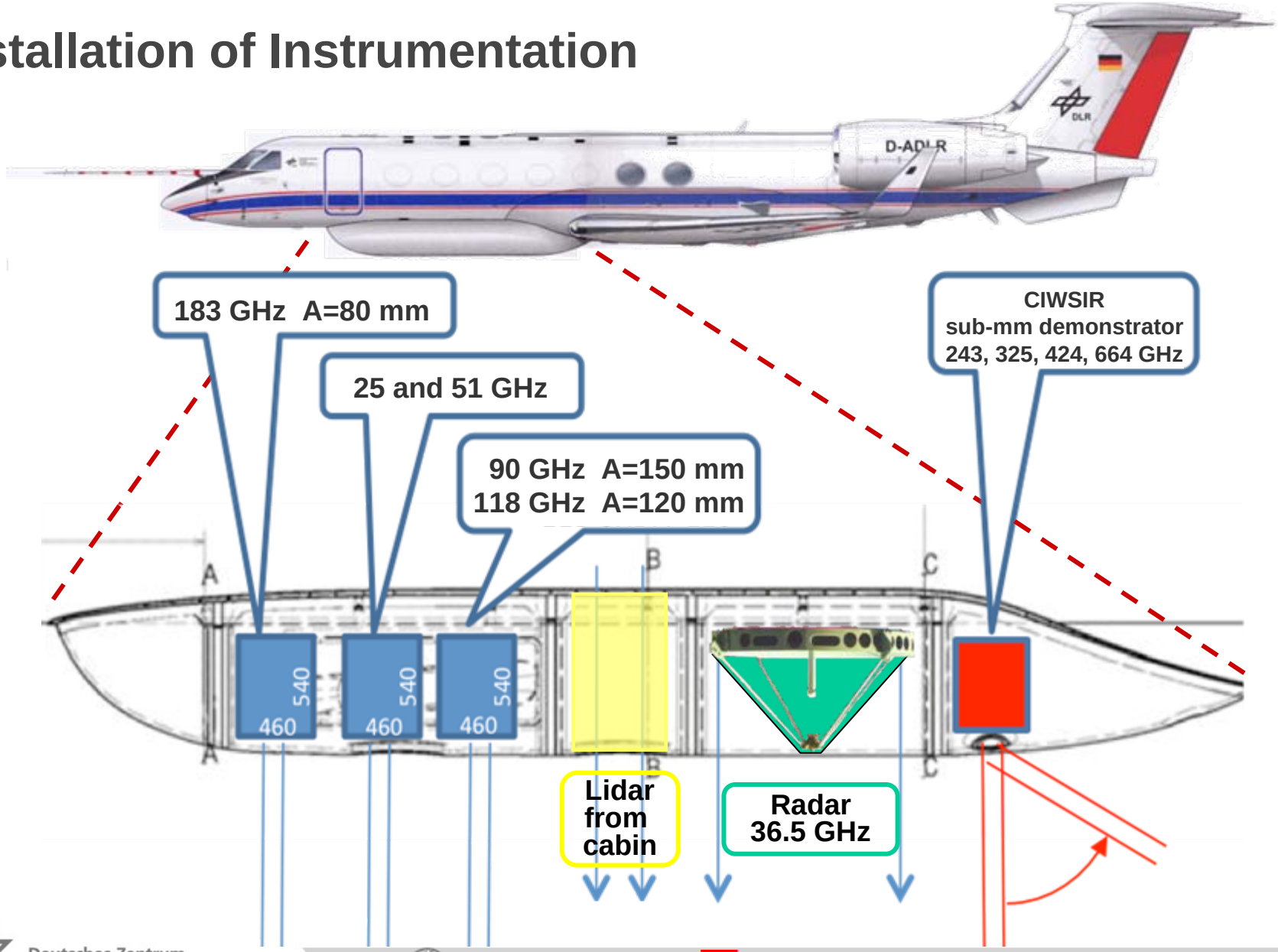




Proposed Instrumentation for Validation Campaigns

- 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

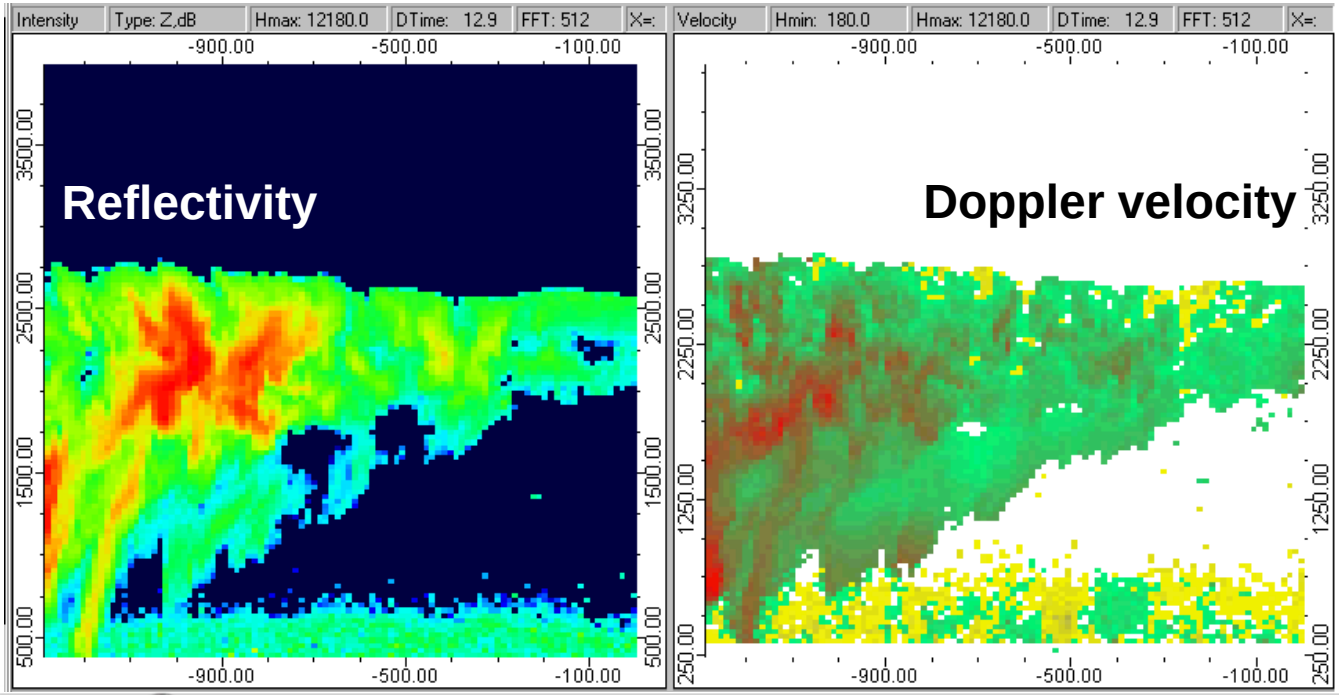


Cloud Radar

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)

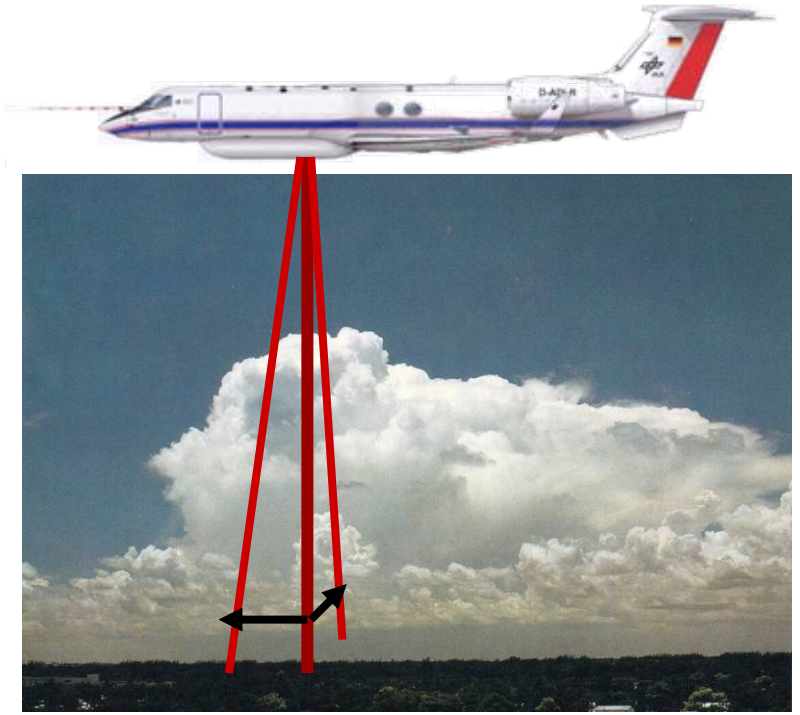
Frequency	35.5 GHz
Peak Power	35 kW
Diameter of Antenna	1.1 m
Antenna Beam Width	0.5 deg.
Sensitivity at 5 km	-44.5 dBZ



Estimation of Horizontal Wind Field

Currently under investigation:

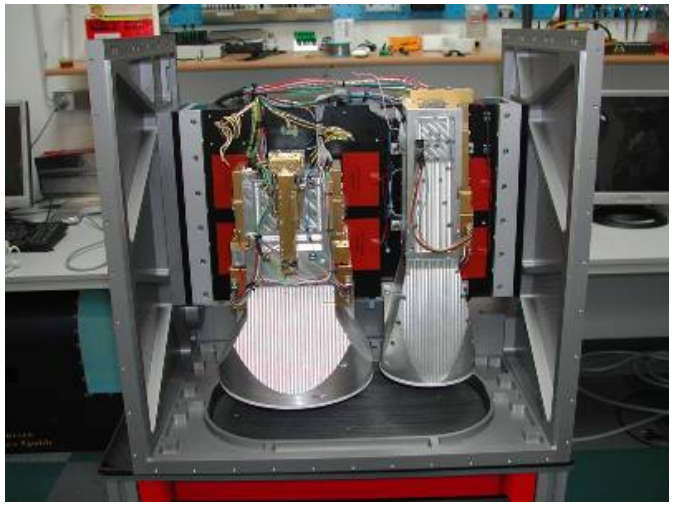
- beam steerable into 3 (5) directions will give horizontal wind vector (algorithm like wind profilers or VAD technique)
- technical realization: flip mirror of Cassegrain antenna

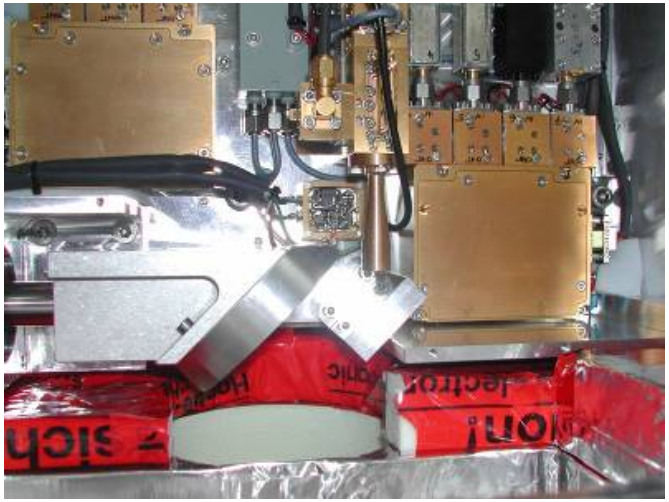


Passive Microwave Radiometer Specifications

	K H_2O	V O_2	W atmos. window	F O_2	G H_2O
Frequencies	22.24	50.30	90.0	118.75±8.5	183.31±12.5
	23.04	51.76		118.75±4.2	183.31±7.5
	23.84	52.80		118.75±2.3	183.31±4.5
	25.44	53.75		118.75±1.4	183.31±3.5
	26.24				183.31±2.5
	27.84				183.31±1.5
	31.40				183.31±0.6
FWHM	4.0°	3.5°	2.5°	2.5°	2.5°

K,V

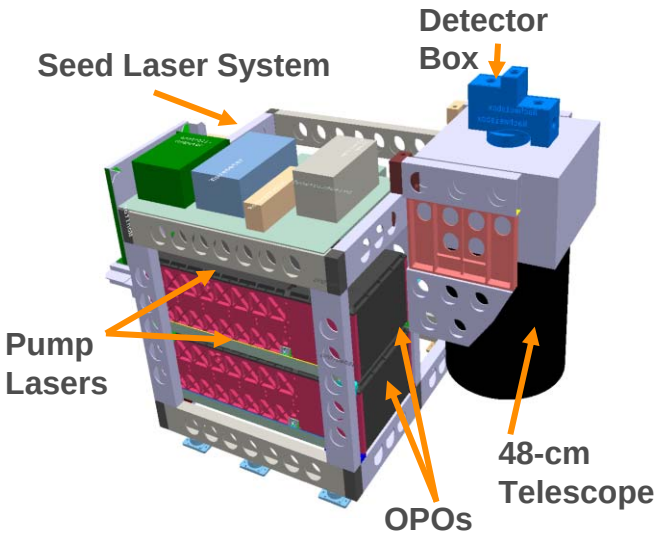




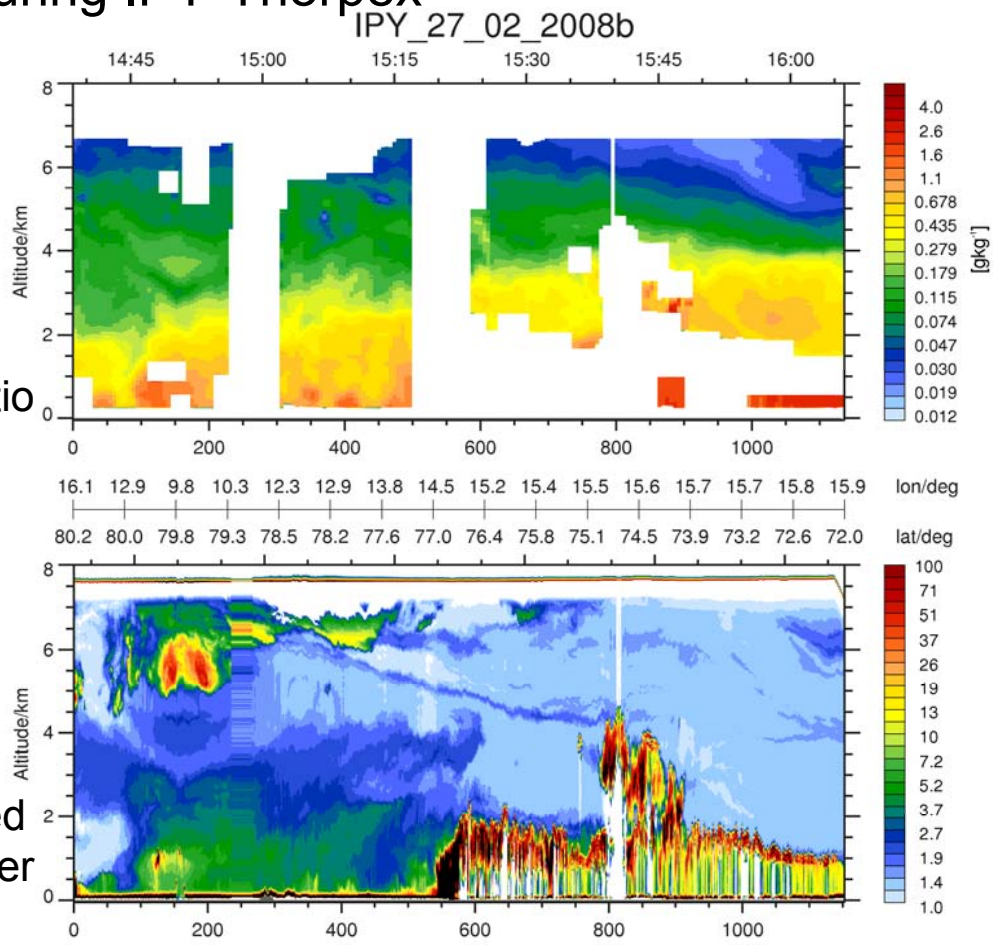
G

WALES Water Vapour Lidar

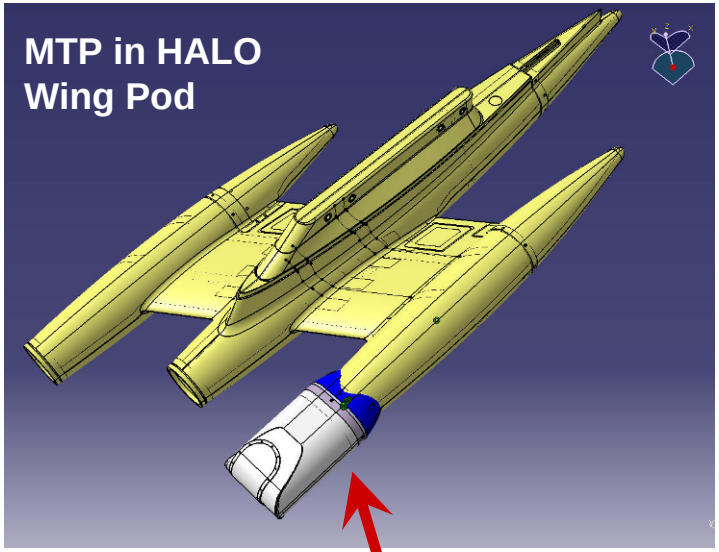
Differential absorption lidar
λ 935 nm

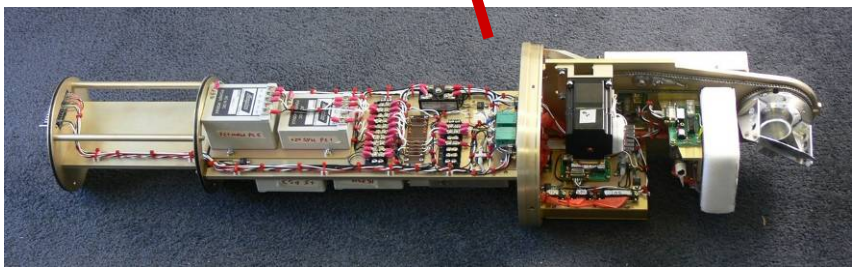


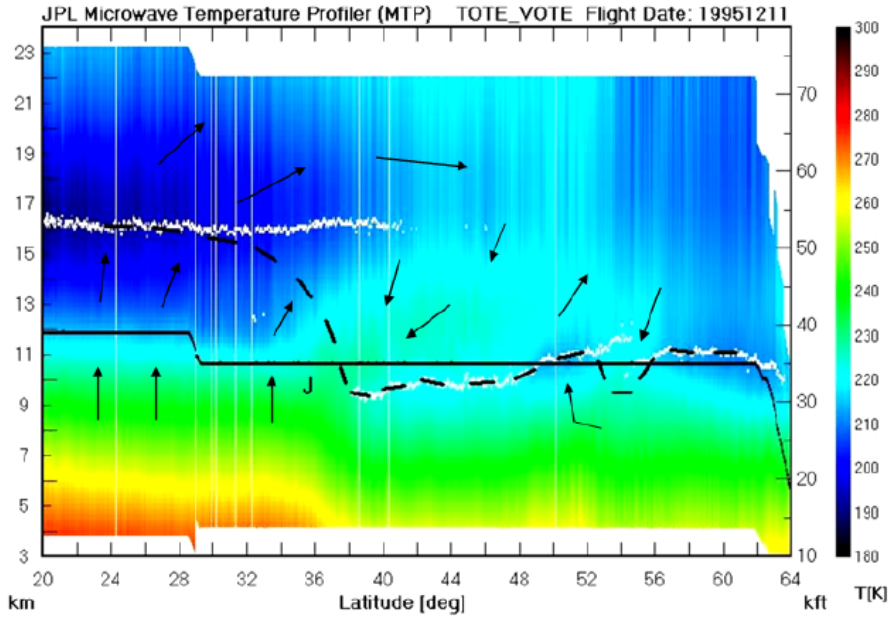
Convection over the North Atlantic during IPY-Thorpex



Microwave Temperature Profiler







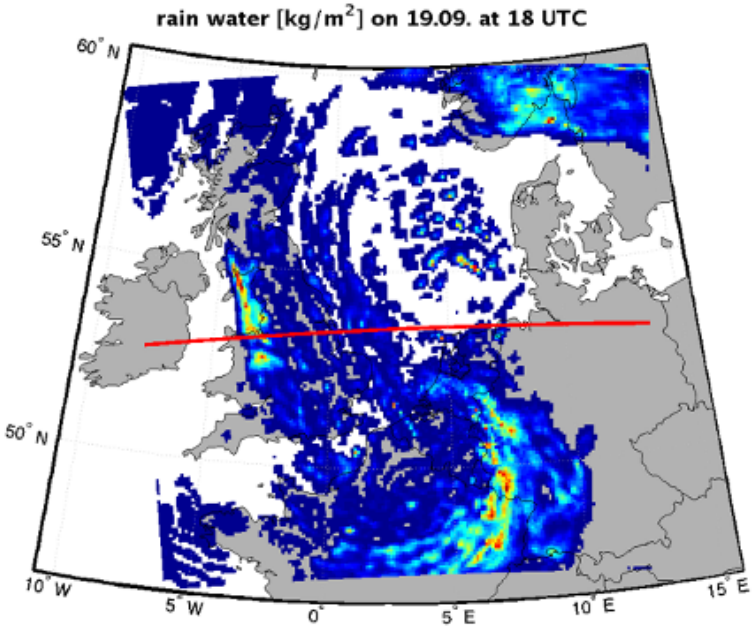
Example from NASA/JPL: Temperature cross-section as a function of latitude for a DC8 flight from Alaska to Hawaii.

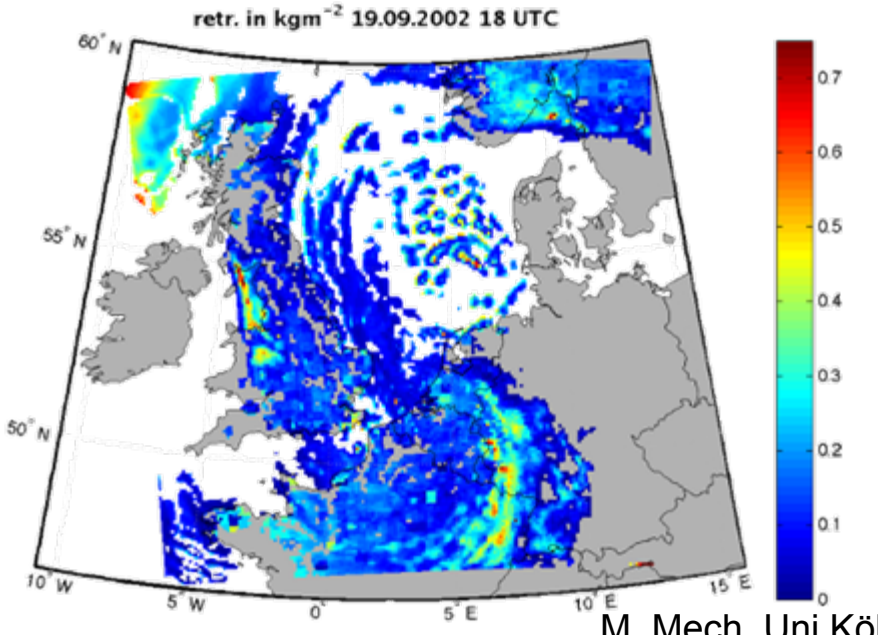
Using O_2 absorption bands 55-59 GHz

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)





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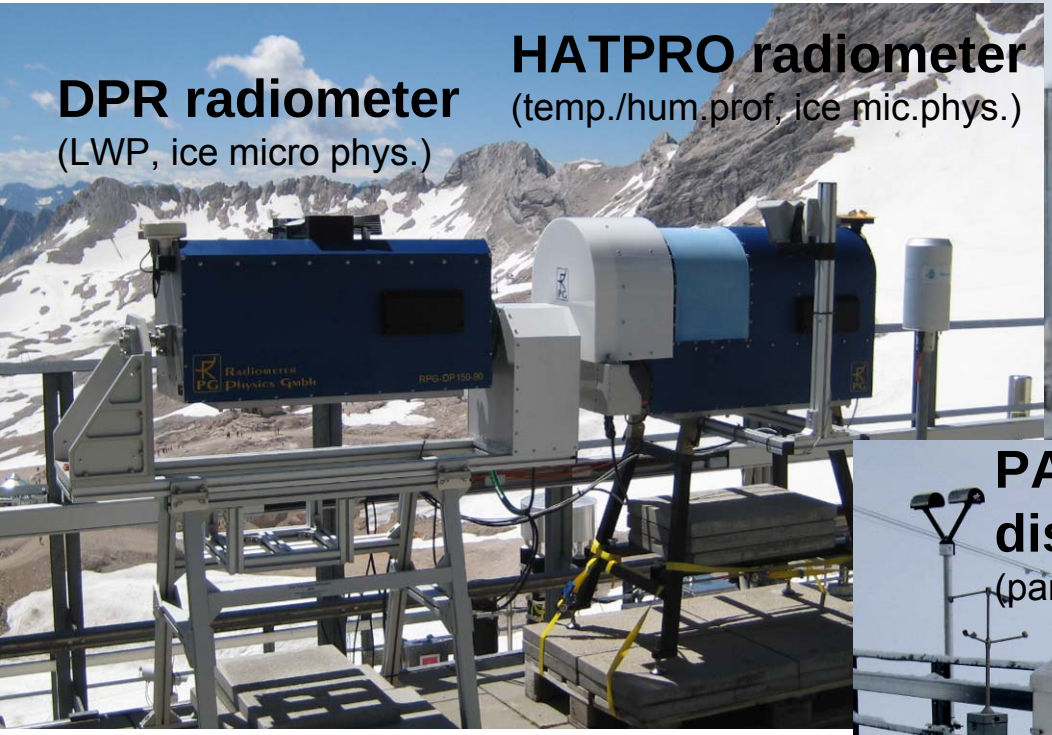
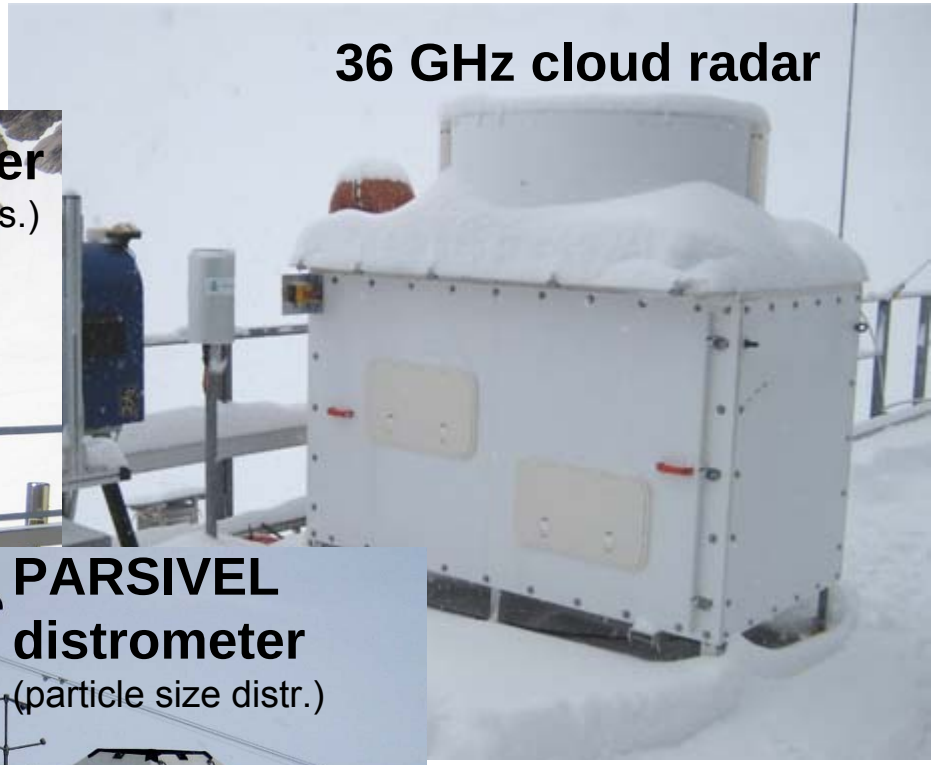
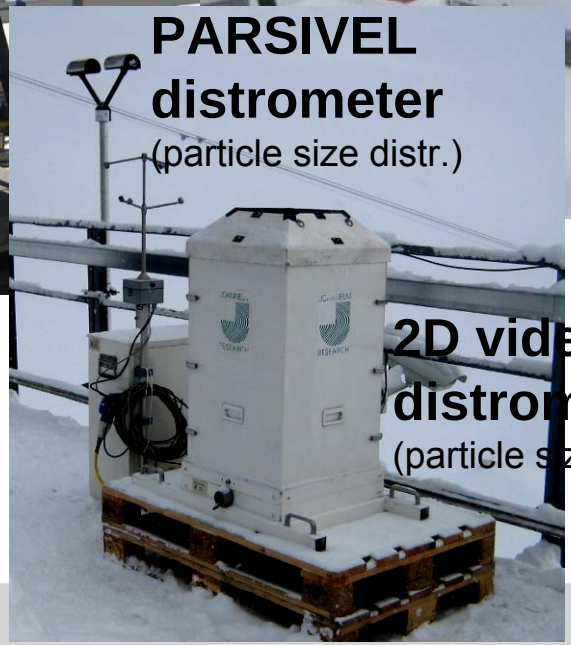
Continuous Ground-based Observations

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

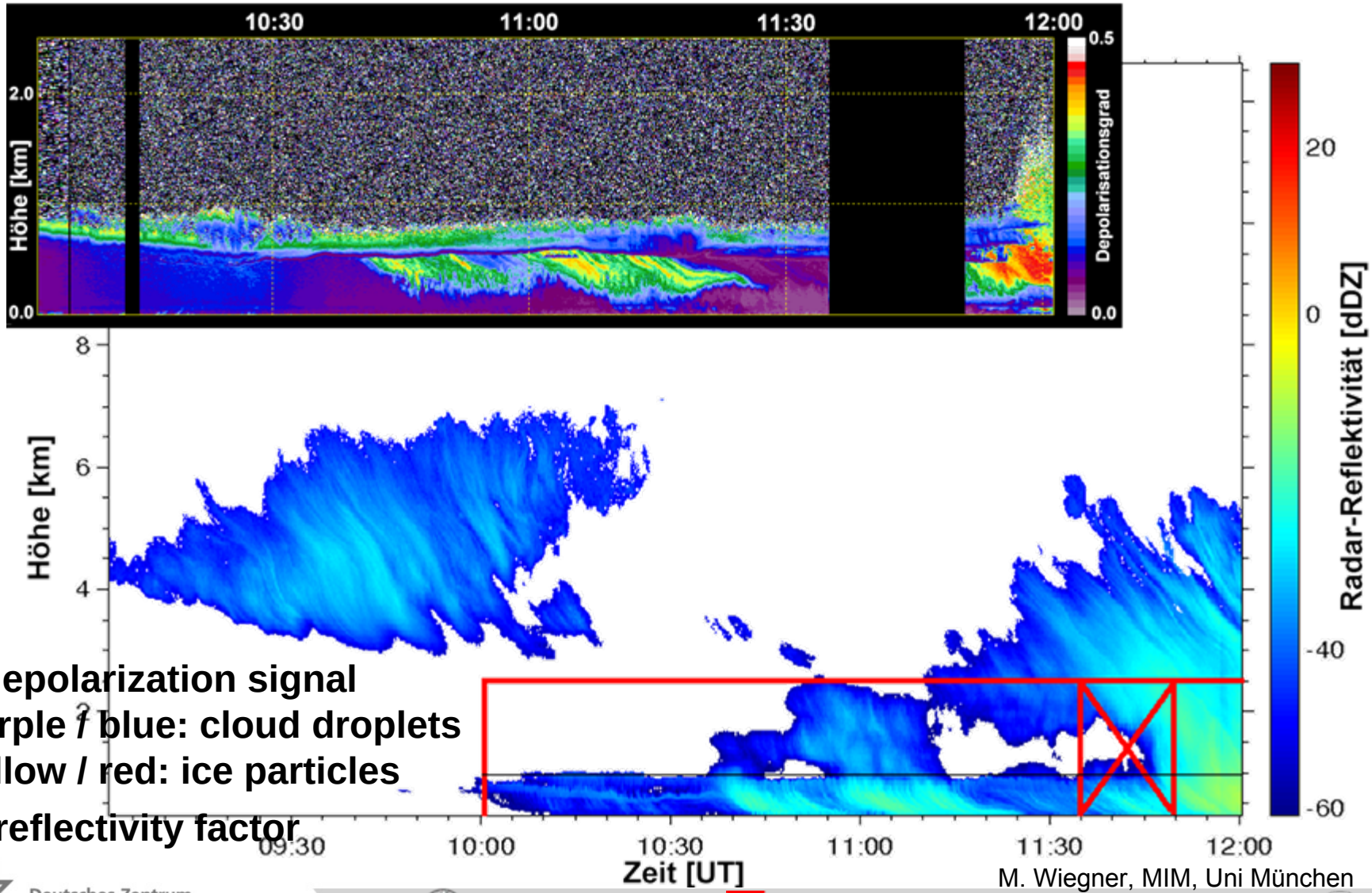
Instruments at Schneefernerhaus







Some Example Synergy Lidar (POLIS) – Cloud Radar



Lidar depolarization signal

purple / blue: cloud droplets

yellow / red: ice particles

Radar reflectivity factor

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Status

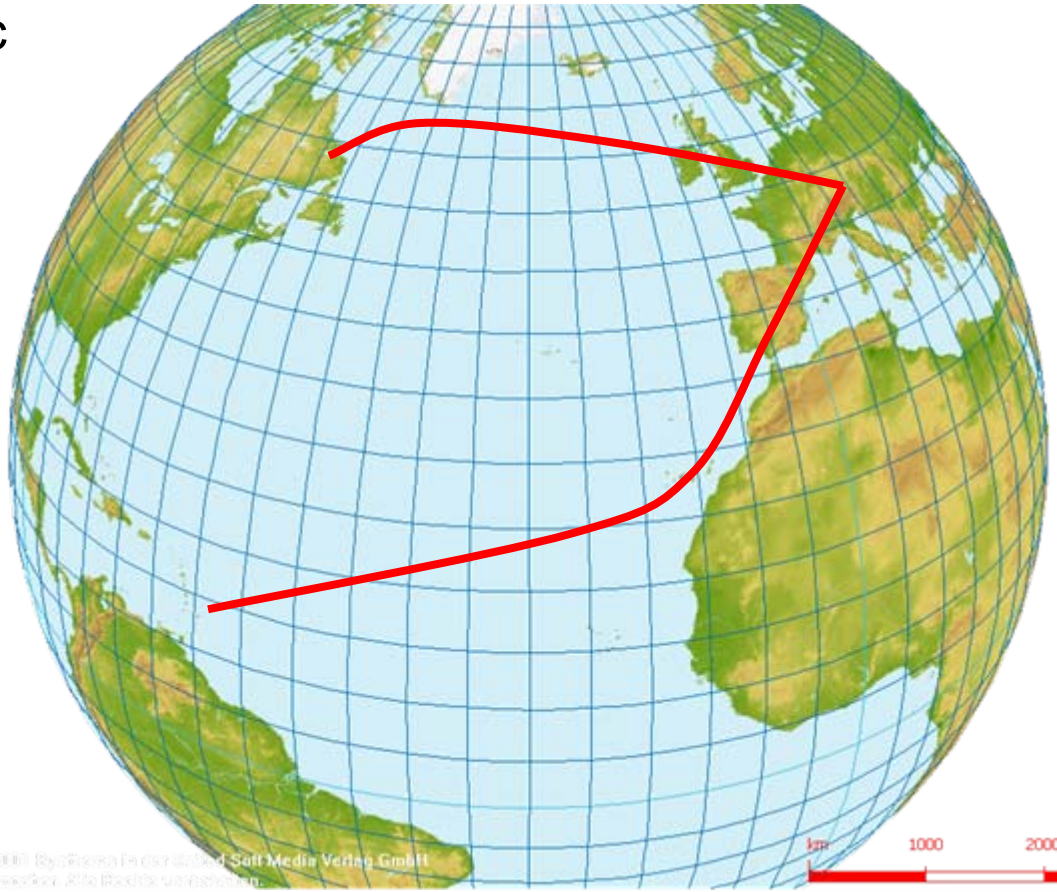
- HALO arrived at Oberpfaffenhofen in January 2009
- first mission (OMO) in July 2009

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