GIVE
German Initiative for the Validation of EarthCARE

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and the GIVE Team

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GIVE overview

- GIVE is a **coordinated initiative** to bundle the expertise of the German atmospheric research community (lead: TROPOS, support: EarthCARE Project Office).
- GIVE aims at the **validation of the entire chain** of EarthCARE L1 and L2 products and the evaluation of related algorithms and instrument calibrations.
- GIVE includes
  - **EarthCARE-to-ground validation**
  - **EarthCARE-to-aircraft validation**
  - **EarthCARE-to-satellite validation**
  - **Model-supported validation studies**
- GIVE validation activities will include **dedicated campaigns** as well as **long-term support** over the mission lifetime.

GIVE team

Short Name	Institution - Group	Team Members [Co-I(s) in bold]
DLR-Airborne	German Aerospace Centre – Lidar and Radar Group for Aerosol and Cloud Research and the Cloud Physics Department, Institute of Atmospheric Physics	**Silke Groß, Christiane Voigt**, Florian Ewald, Martin Wirth, Bernhard Mayer
DLR-Sat	German Aerospace Centre – Atmospheric Remote Sensing Department, Institute of Atmospheric Physics	**Luca Bugliaro**, Margarita Vázquez-Navarro, André Butz
DWD-RAO	German Meteorological Service – Richard-Aßmann Observatory Lindenberg	**Volker Lehmann, Jens Reichardt**, Ulrich Görsdorf, Ronny Leinweber, Christine Knist, Ruud Dirksen
FZJ	Forschungszentrum Jülich	**Anne Caroline Lange**, Hendrick Elbern, Philipp Franke, Luise Fröhlich
FUB	Free University of Berlin	**Jürgen Fischer**, Nicole Docter, Florian Tornow, Rene Preusker, Thomas Ruhtz
KIT	Karlsruhe Institute of Technology	**Corinna Hoose, Quentin Coopman**, Olimpia Bruno
LIM-AR	University of Leipzig – Atmospheric Radiation Group	**Manfred Wendisch**, Andre Ehrlich, Evelyn Jäkel
LIM-CGC	University of Leipzig – Clouds and Global Climate Group	**Odran Sourdeval, Christine Nam**, Johannes Quaas, Anja Hünerbein
LMU-MIM	Ludwig Maximilian University Munich – Meteorological Institute Munich	**Bernhard Mayer**, Tobias Zinner, Volker Freudenthaler, Silke Groß
MPI-M	Max Planck Institute for Meteorology	**Marcus Klingebiel**, Lutz Hirsch, Stefan Kinne, Ilya Serikov, Bjorn Stevens
TROPOS-Ground	Leibniz Institute for Tropospheric Research – Ground-based Remote Sensing Group	**Holger Baars**, **Ulla Wandinger (GIVE proposal PI),** Albert Ansmann, Dietrich Althausen, Ronny Engelmann, Birgit Heese, **Patric Seifert**, Johannes Bühl, Heike Kalesse
TROPOS-Sat	Leibniz Institute for Tropospheric Research – Satellite Remote Sensing Group	**Hartwig Deneke, Anja Hünerbein**, Andreas Macke, Rainer Hollman (DWD), Martin Stengel (DWD)
U-Cologne	University of Cologne	**Pavlos Kollias**, Susanne Crewell, Ulrich Löhnert, Lukas Pfitzenmaier, Stefan Kneifel, Alessandro Battaglia (U. Leicester), Alexis Berne (EPFL), Nicole Van Lipzig (KU Leuven)
U-Hamburg	University of Hamburg	**Stefan Bühler**, Ákos Horváth, Verena Grützun, Manfred Brath

GIVE objectives

GIVE contributes to the EarthCARE mission objectives and the objectives of the EarthCARE Cal/Val activity by:

1. Validation of the EarthCARE ESA ATLID, MSI and BBR Level 1 products
2. Validation of the EarthCARE ESA ATLID, CPR, MSI and BBR Level 2a and 2b aerosol, cloud, precipitation and radiation products
3. Validation of the EarthCARE ESA radiation closure concept

GIVE contributes to the AO objectives by:

- Independent measurements from other satellite, airborne and ground-based instruments to estimate uncertainties of the EarthCARE products
- Comparisons with model results to investigate the spatial and temporal representativeness of EarthCARE observations
- Long-term observations to assess accuracy, resolution and stability of the EarthCARE instruments
- Experiments to assess and validate the EarthCARE retrieval algorithms and processing chain

GIVE contributions

GIVE contributions in response to the EarthCARE Cal/Val AO call include:

- Assessment of methods/algorithms for ***instrument calibration***
- Assessment of proposed methods/algorithms for ***external calibration***
- Independent estimates of achievable ***localisation*** and ***co-alignment errors***
- Independent determination of ***instrument stability***
- Comparison of ***geophysical products*** (cloud, aerosol, precipitation and radiation properties) with independent ground-based, airborne and satellite measurements and model results, including consideration of representativity errors
- Impact of ***auxiliary information*** used in the processing
- Characterisation of major ***error sources*** and their dependencies on secondary parameters
- ***Error budget*** compilations

EarthCARE-to-ground validation

DWD-RAO, LIM-AR, LMU-MIM, MPI-M, TROPOS-Ground, TROPOS-Sat, U-Cologne

→ see poster no. 49: GIVE – EarthCARE-to-ground validation

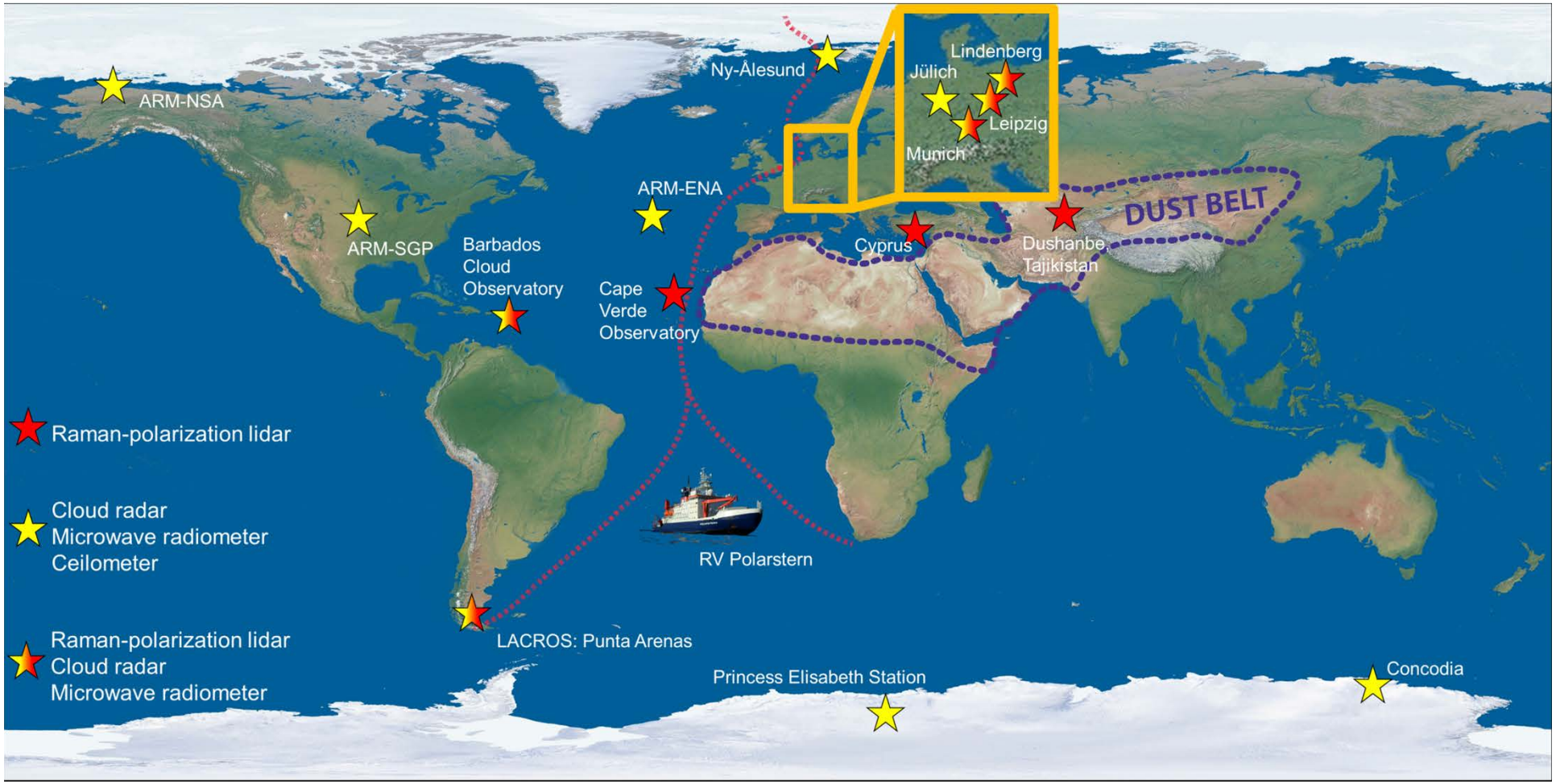
EarthCARE-to-ground validation activities

Long-term mission support and dedicated campaigns together with aircraft observations

- **Highly instrumented stations** with NRT data provision (ACTRIS-Cloudnet /ARM standards)
  - Stations operated by German partners: Barbados, Lindenberg, Jülich, Munich
  - Stations used in collaboration with international partners: Ny Ålesund, Princess Elisabeth, Concordia, ARM-SGP, ARM-NSA, ARM-ENA
- **Mobile facilities** for deployment in specific location and close to EarthCARE track (ACTRIS-Cloudnet/EARLINET and BSRN standards)
  - Land-based facility LACROS
  - Radiation station
  - Pyranometer network (90 instruments)

  } can be deployed together
  - Ship-borne facility OCEANET (usually deployed on research vessel Polarstern)
- **Network of automated Raman polarization lidars** (PollyNET, ACTRIS-EARLINET standard)
  - Stations: Leipzig/Germany, Dushanbe/Tajikistan, Tel Aviv/Israel, Limassol/Cyprus, Mindelo/Cape Verde + mobile instruments (focus on global dust belt)
- **Radiation networks** used for the studies:
  - DWD (26 stations in Germany)
  - BSRN (59 stations worldwide)
  - NOAA SURFRAD (9 stations in US)

Global ground-based activities



→ see poster no. 49: GIVE – EarthCARE-to-ground validation

Barbados Cloud Observatory

Photo: F. Jansen

Clouds

2 x 35 GHz cloud radar

Ceilometer

Micro rain radar

Optical disdrometer

1.5 µm Doppler lidar

Aerosols

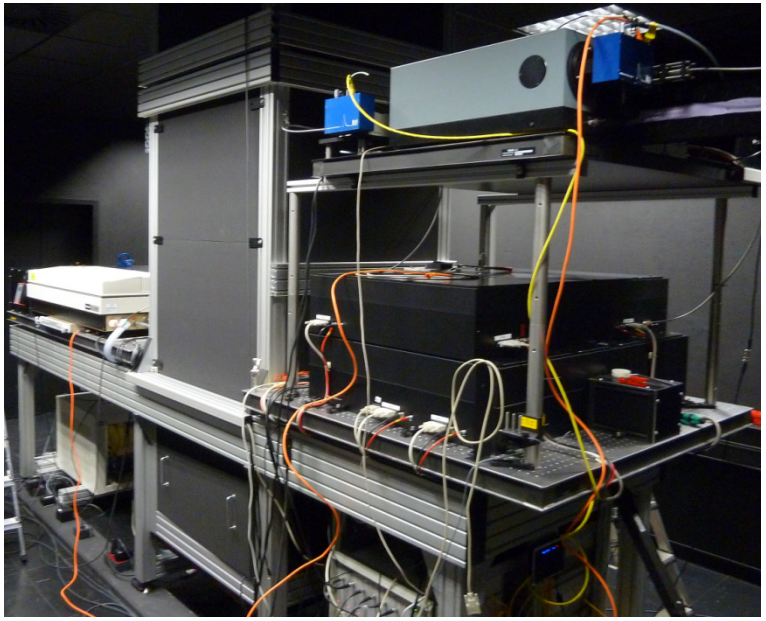
MWL Raman-polarization lidar

Radiation

Surface radiation station

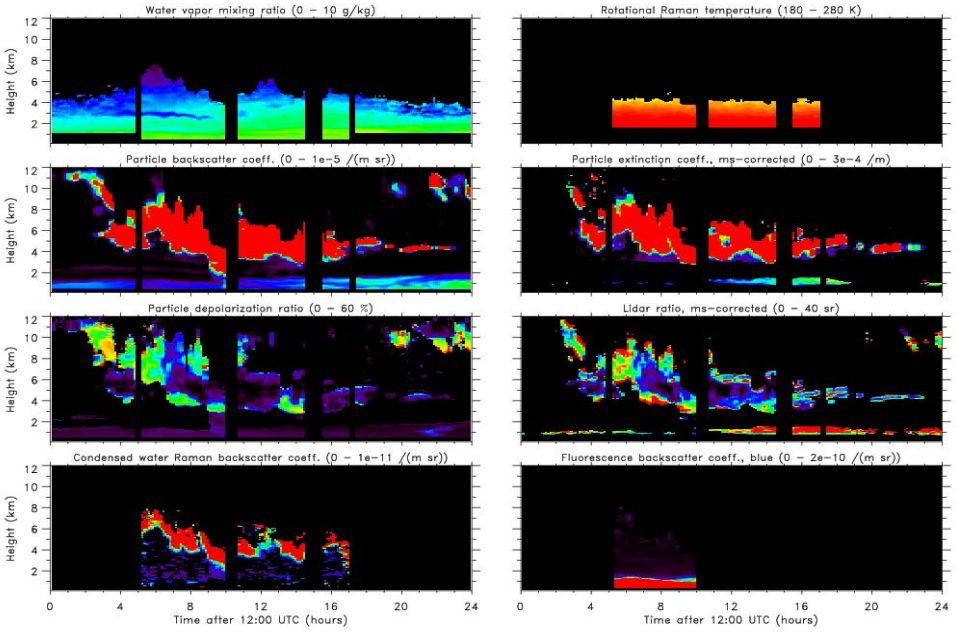
All-sky imager

RAMSES @ Meteorological Observatory Lindenberg

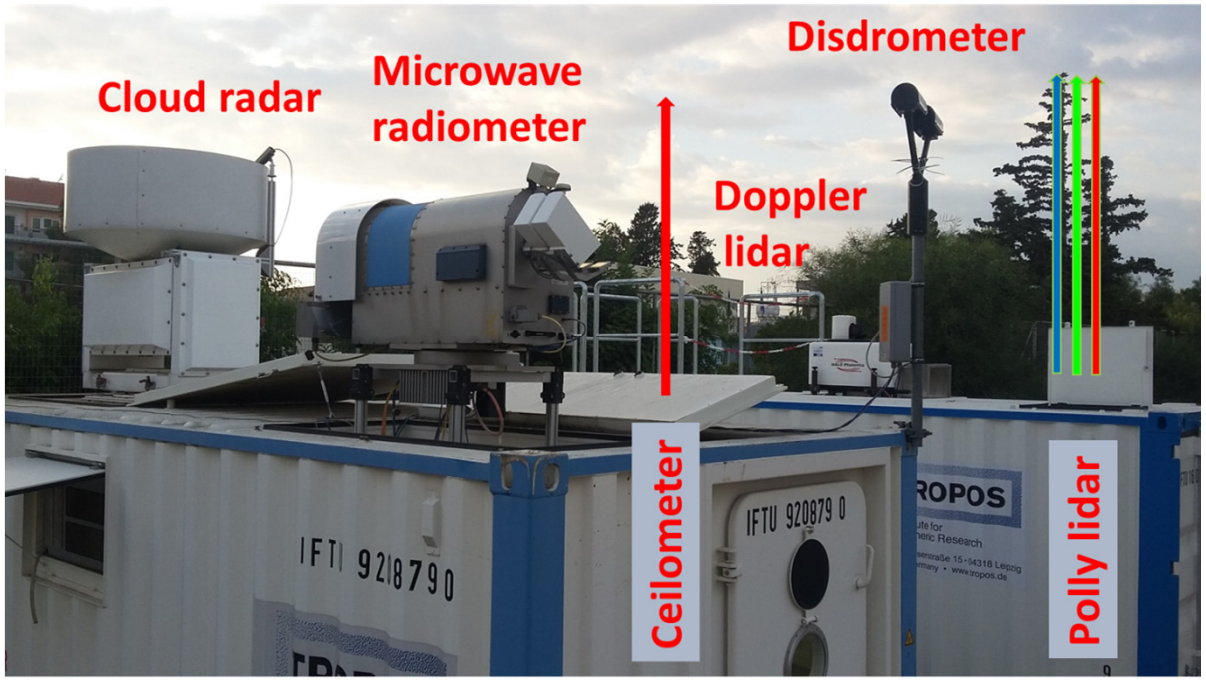


RAMSES – autonomous spectroscopic Raman lidar @355 nm

- Water-vapor mixing ratio
- Temperature
- **Particle backscatter coefficient (355 nm)**
- **Particle extinction coefficient (355 nm)**
- **Particle linear depolarization ratio (355 nm)**
- Backscatter coefficient of condensed water (396 – 406 nm)
- Backscatter coefficient of UV-A fluorescence (392 – 395 nm)
- Backscatter coefficient of bluish fluorescence (445 – 537 nm)
- Backscatter coefficient of greenish fluorescence (537 – 625 nm)
- Backscatter coefficient of red fluorescence (625 – 712 nm)



LACROS Mobile Facility



Limassol, Cyprus (2016 – 2018)

Punta Arenas, Chile (2018 – 2019)

- **Below-track positioning for EarthCARE**
- **Combination with aircraft campaigns**

Clouds

35 GHz cloud radar

Ceilometer

Micro rain radar

Optical disdrometer

1.5 µm Doppler lidar

Aerosols

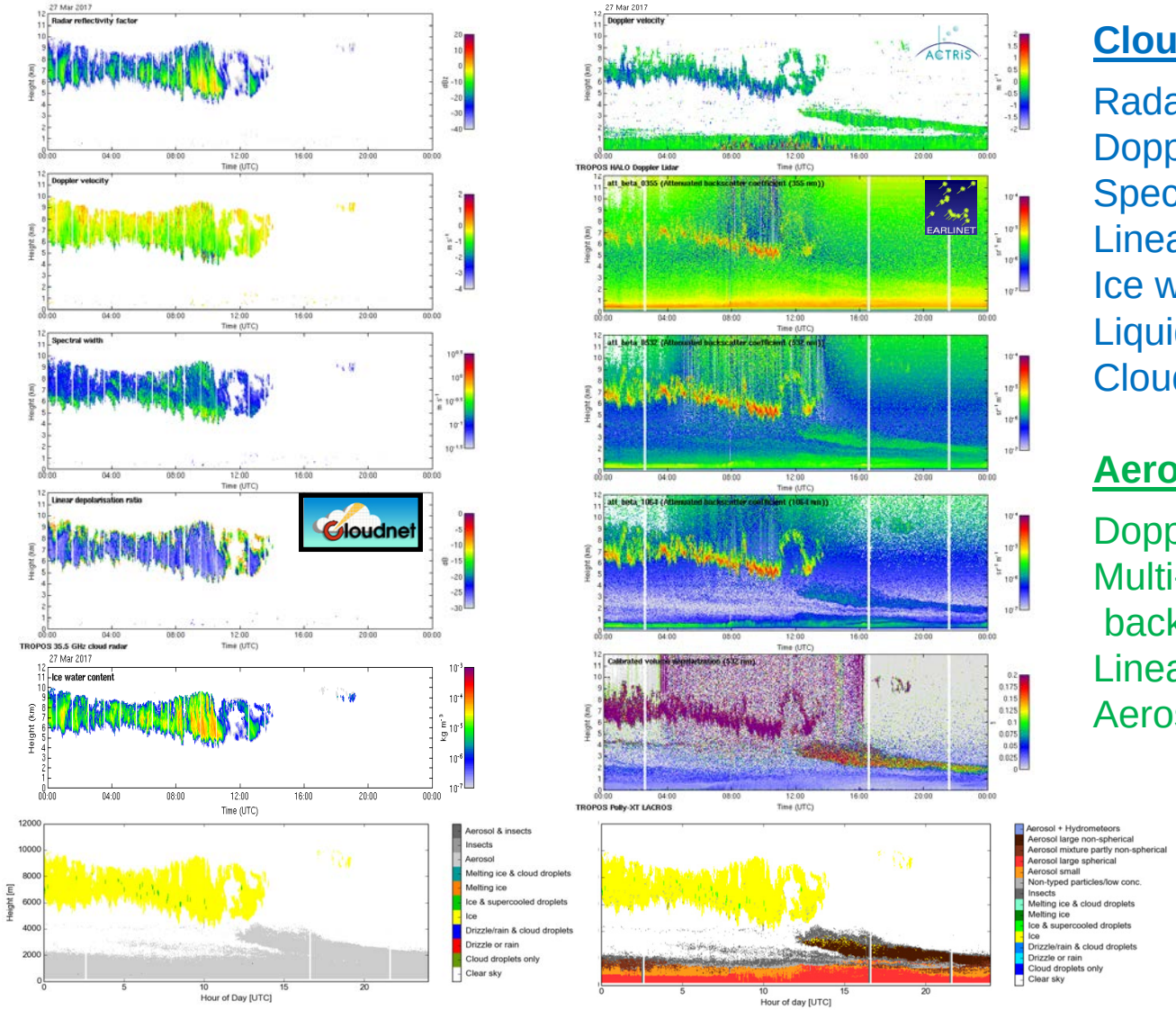
MWL Raman-polarization lidar PollyXT

Radiation

Surface radiation station

All-sky imager

Automated NRT data generation



Clouds

Radar reflectivity factor
Doppler velocity (radar)
Spectral width
Linear depolarization ratio (radar)
Ice water content
Liquid water content
Cloud classification

Aerosols/Ice clouds

Doppler velocity (lidar)
Multi-wavelength attenuated backscatter coefficient
Linear depolarization ratio (lidar)
Aerosol classification

EarthCARE-to-aircraft validation

DLR-Airborne, LIM-AR, U-Hamburg, U-Cologne

→ see poster no. 50: GIVE – EarthCARE-to-aircraft validation

Airborne platforms used for EarthCARE cal/val activities

Falcon

http://www.dlr.de

- Dassault Falcon 20-E5
- Endurance: 4 flight hours
- Maximum cruising altitude: 13 km
- limited payload

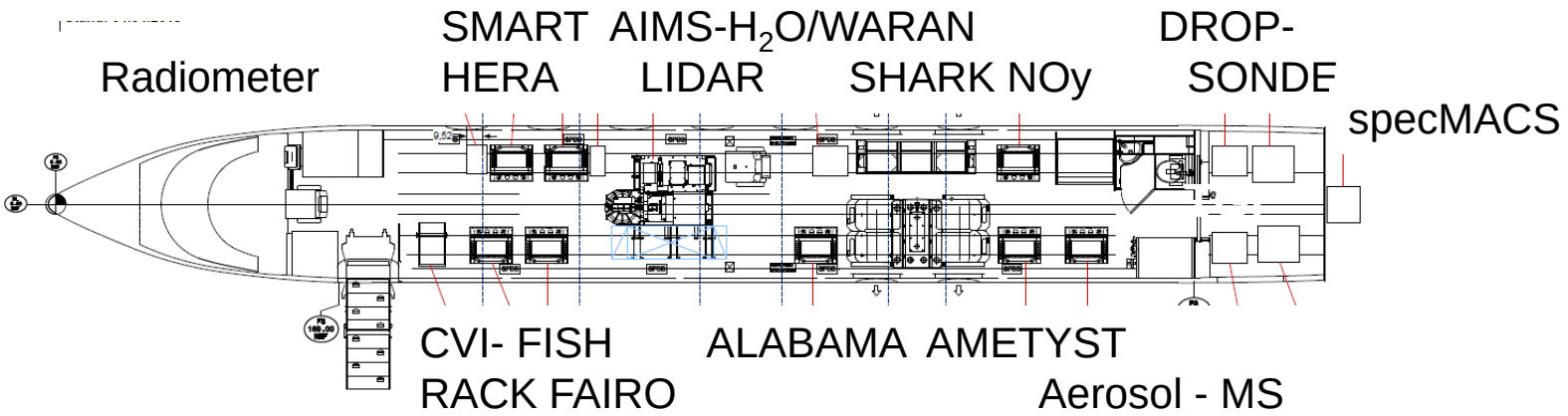
HALO

http://www.halo.dlr.de

- Modified Gulfstream G550 business jet
- Endurance: > 10 flight hours
- Maximum cruising altitude: > 15 km
- Extended payload

Additional contributions from other platforms (e.g. POLAR-5) are possible.

Combined in-situ and remote sensing payload on HALO



- 16 Rack-Instruments
- Information on backscatter and depolarization, extinction, IWC, ice residuals, ice nucleating particles, aerosol composition & size, radiation (LW & SW), RHI, T, trace gases (e.g. NOx, O3)

Planned campaign: **CIRRUS_HL**

Date: Oct – Dec 2020 (before EarthCARE launch)

Location: Kiruna (Sweden) or Iceland

Duration: 6 weeks

Partners: DLR, KIT, U- Leipzig, Mainz, München, Heidelberg, MPI-C, TROPOS, FZJ, PSI, ETH

in-situ payload on DLR Falcon

Planned campaign: **ECO2FLY**

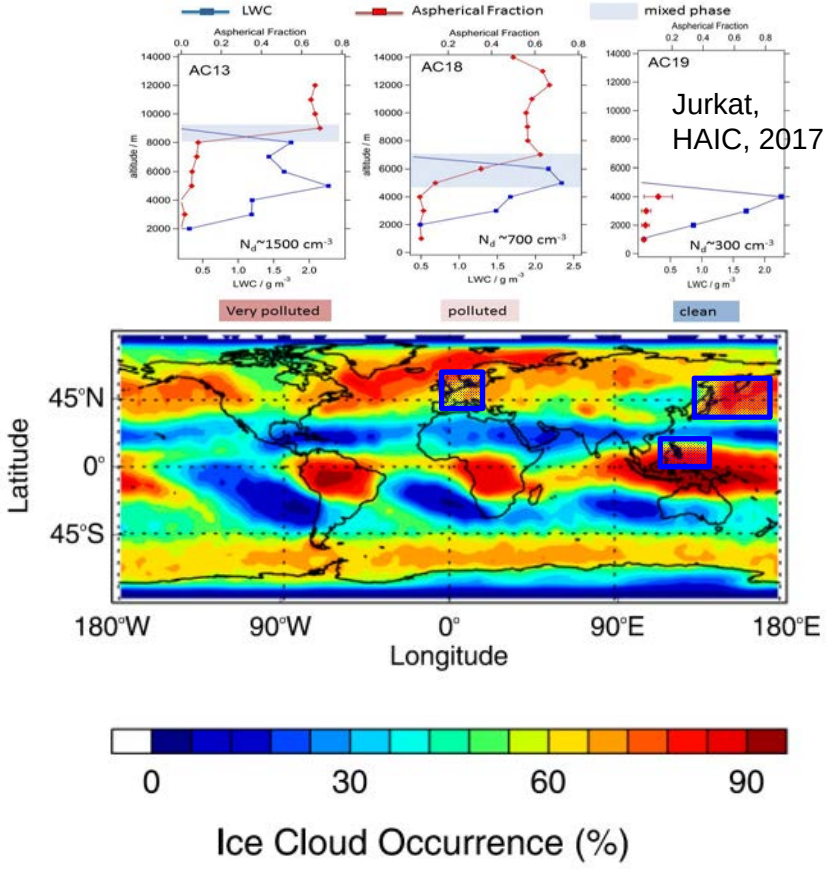
Date: Feb-Apr 2021

Location:
Germany /Japan

Duration: 6 weeks
Flight hours: 70h

Partners: DLR, NASA, Uni-M

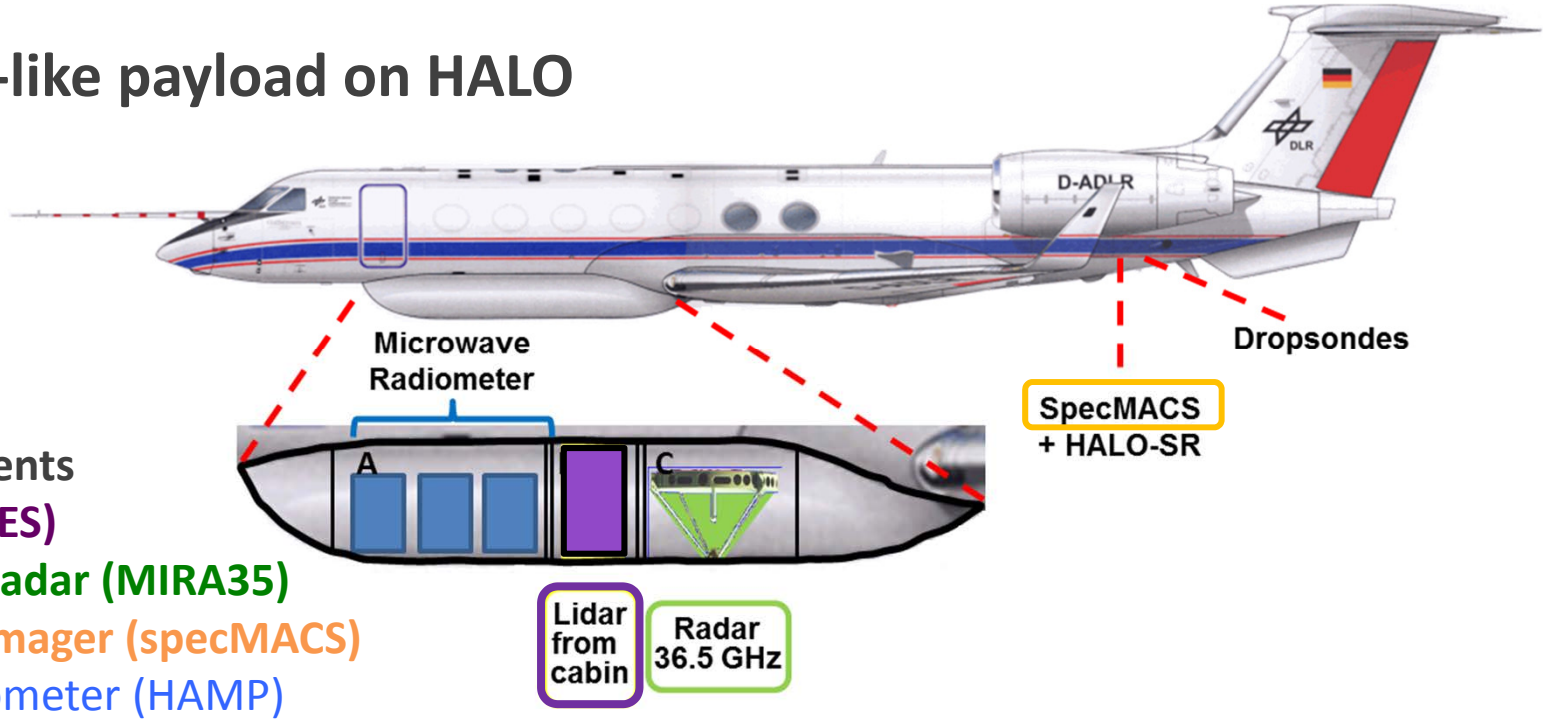
More campaigns with in-situ payload after 2021 possible but so far not confirmed and funded



Hong & Liu, J Clim, 2015

DLR

EarthCARE-like payload on HALO



Scientific Instruments

- **HSRL-Lidar (WALES)**
- **Cloud-Profiling Radar (MIRA35)**
- **Hyper-Spektral Imager (specMACS)**
- Microwave Radiometer (HAMP)

Planned campaigns:

EUREC4A

Date: Jan/Feb 2020

Location: Barbados

AC3

Date: Mar-May 2021

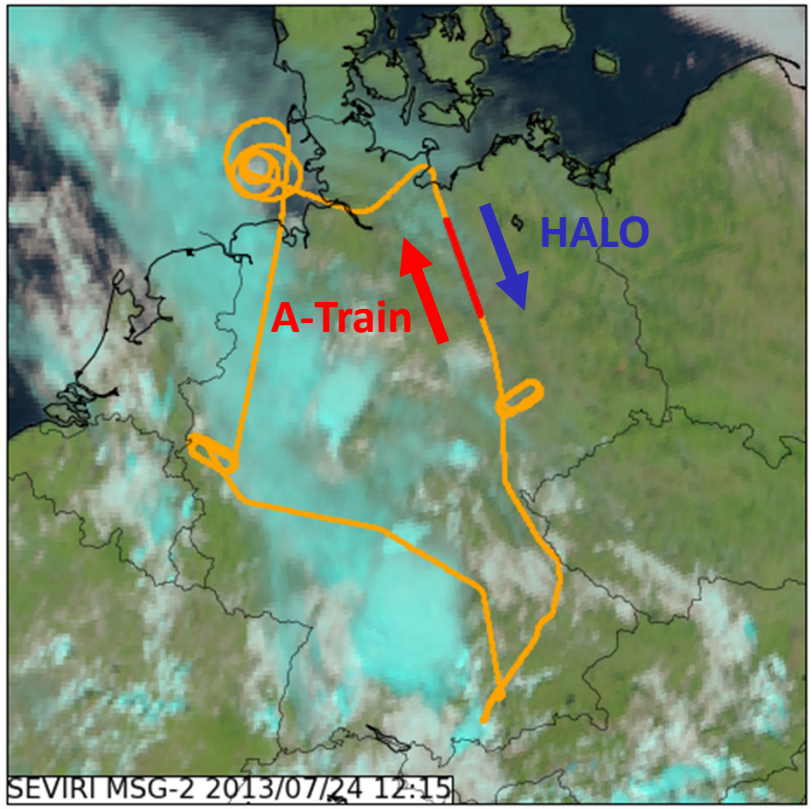
Location: Kiruna (Sweden)

Additional flights with HALO are contemplated in the time period 2022-2025. It is also considered to apply for an HALO campaign specifically designated to EarthCARE Cal/Val.

Possibilities for validation activities – EarthCARE-like payload

Direct comparisons of EarthCARE products

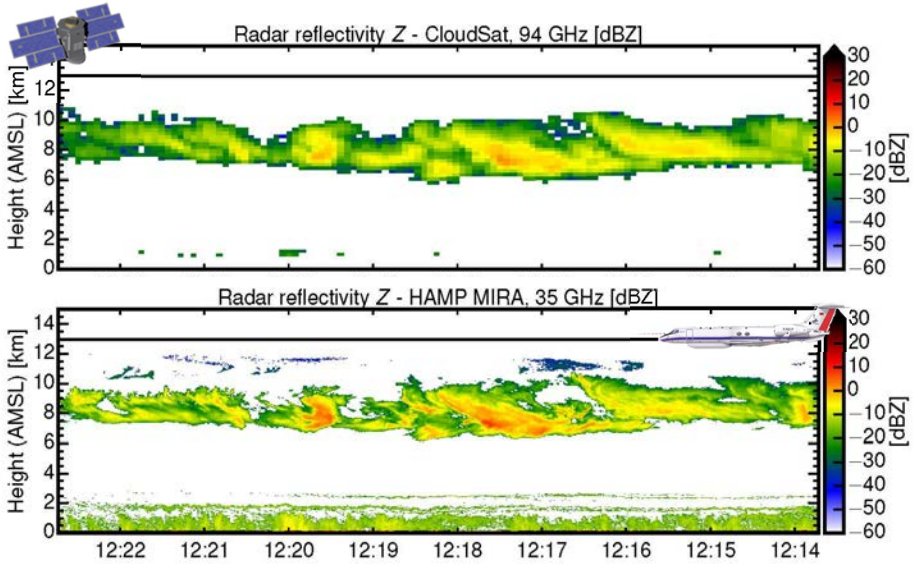
24 July 2013



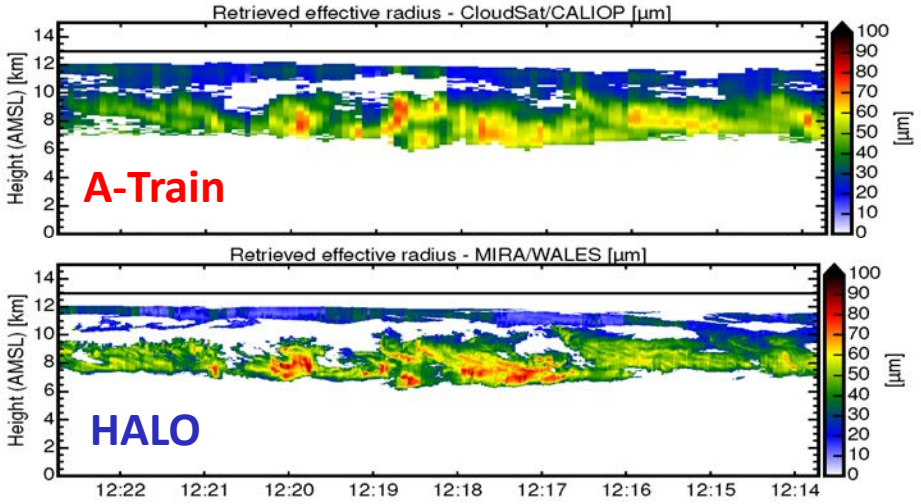
→ Coordinated satellite underpass

→ Direct comparisons

Level 1b +2a



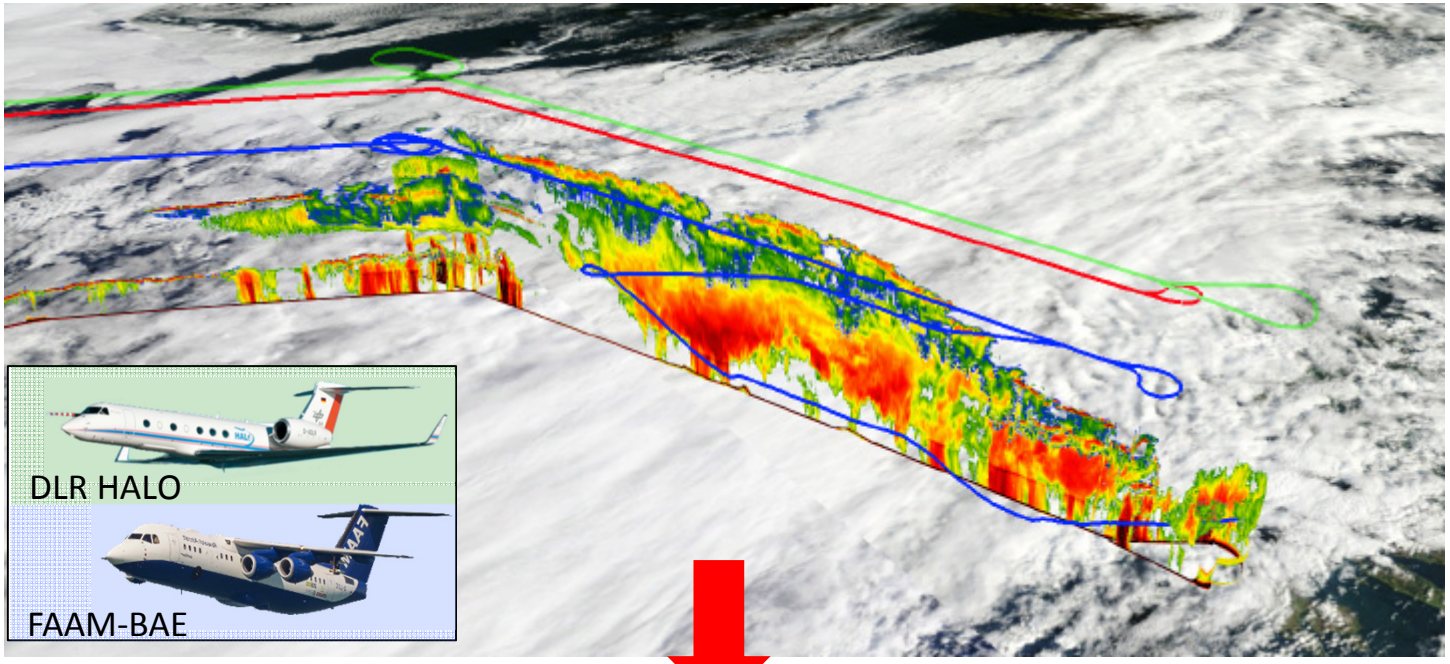
Level 2b



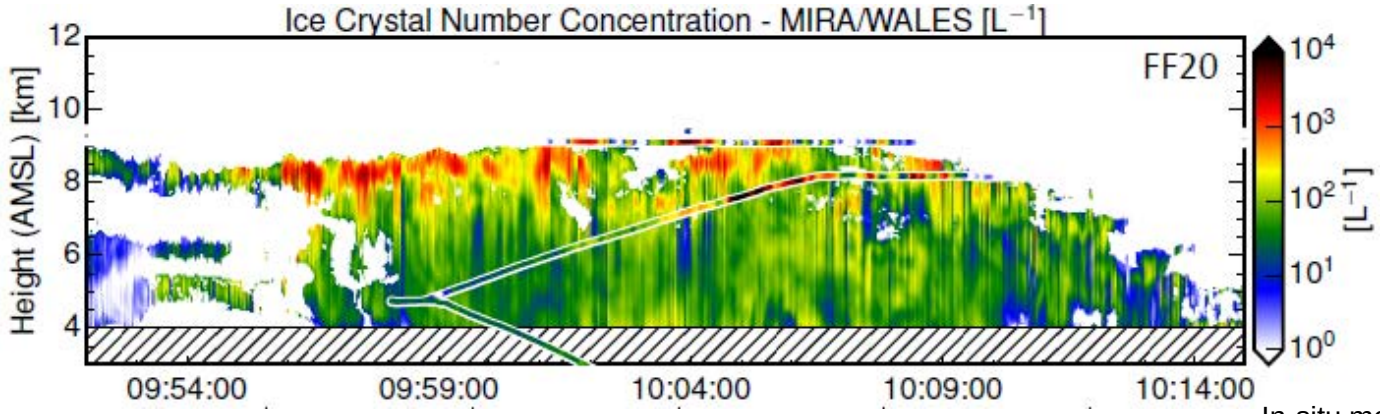
Possibilities for validation activities – in-situ (+ remote sensing)

Direct comparisons of EarthCARE Level 2 products

NAWDEX RF06 – 14 October 2016



Level 2b



In-situ measurements: S. Fox

EarthCARE-to-satellite validation

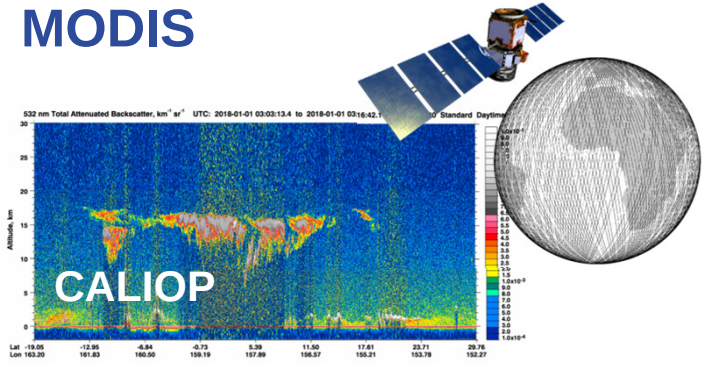
DLR-Sat, FUB, KIT, TROPOS-Sat, U-Hamburg

→ see poster no. 51: GIVE – EarthCARE-to-satellite validation

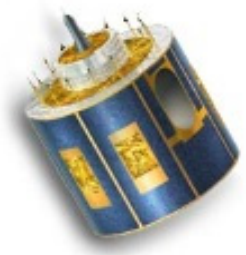
EarthCARE-to-satellite validation activities

Long-term mission monitoring and evaluation with satellite observations

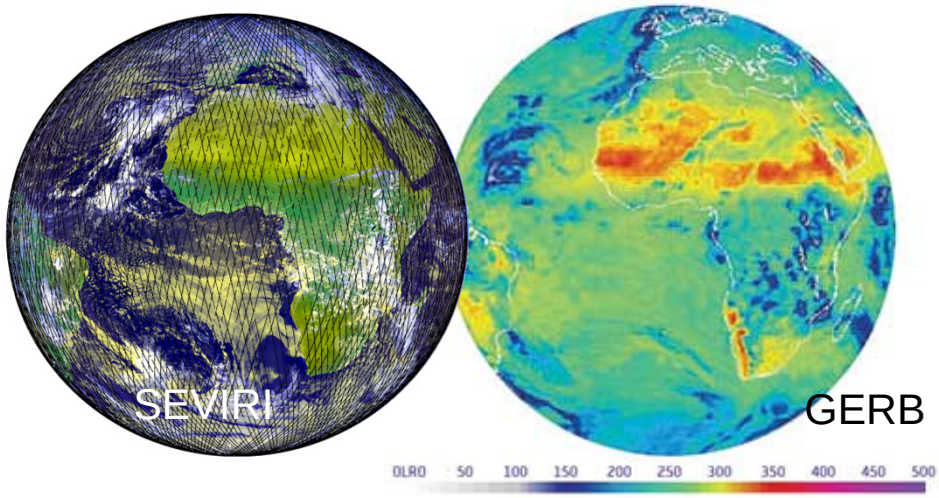
Polar orbiting satellite from A-train CALIOP, POLDER, MODIS



Geostationary satellite MSG with SEVIRI and GERB



Repeat cycle 15 min full disk
Repeat cycle 5 min N-Africa - EU



as well as OLCI, SLSTR, SCaRaB and MHS (MW)

TROPOS

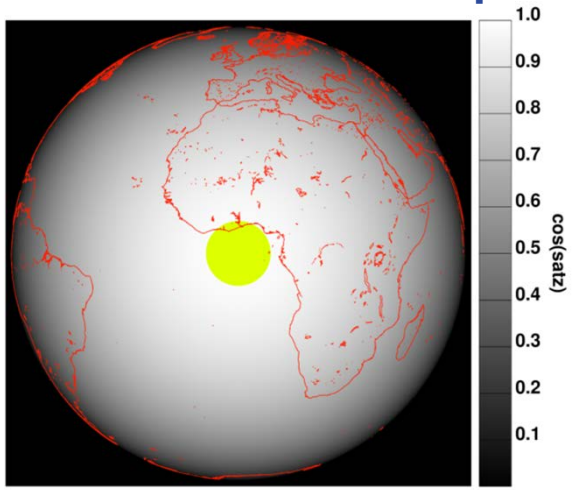
EarthCARE-to-satellite validation activities

Long-term mission monitoring and evaluation with satellite observations

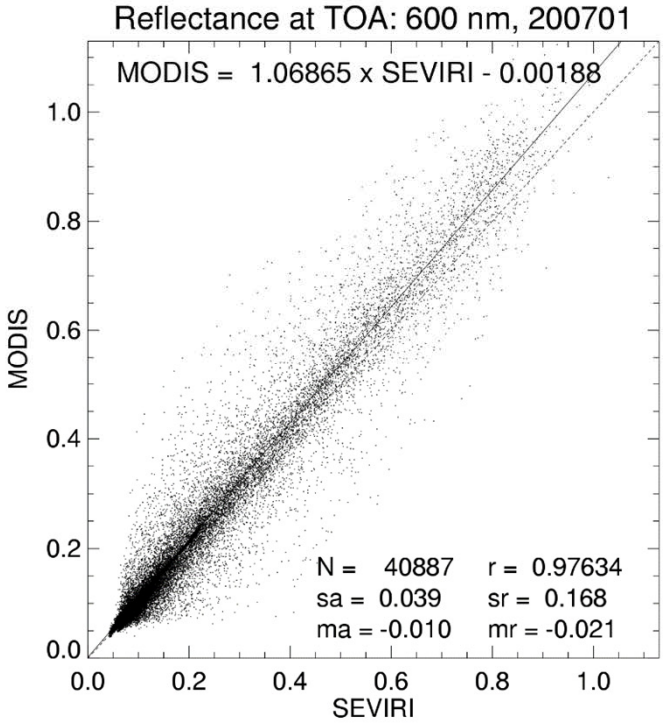
Focus on:

Level 1 MSI and BBR

e.g. L1 products: Radiance/Reflectivity
comparison MSG/SEVIRI – EarthCARE/MSI



libRadtran



Use allsky observations close to SSP of SEVIRI against MSI with similar viewing zenith angles to compare radiances and reflectivities.

Different spectral channel characteristics are accounted for by radiative transfer calculations based on libRadtran.

EarthCARE-to-satellite validation activities

Long-term mission monitoring and evaluation with satellite observations

Focus on:

Level 2 ATLID, CPR, MSI and BBR products

EarthCARE aerosol products to be validated:

MSI L2a , ATLID L2a

- Level 2 MSI aerosol product validation, performance monitoring and evaluation with observations of OLCI, SLSTR, CALIOP/ATLID and MODIS

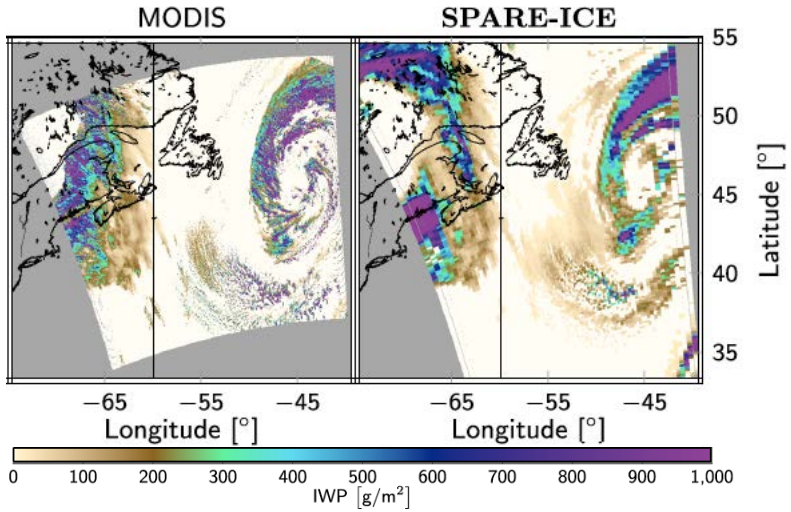
EarthCARE cloud products to be validated:

MSI L2a

- Comparison/Evaluation of the MSI level 2 cloud products with adapted MSI algorithm and standard passive imager cloud products

ATLID L2a, CPR L2a, ATLID-MSI L2b, ATLID-CPR-MSI L2b

- Cloud phase, cloud ice water path and cloud liquid water path, both single-instrument and synergy products (e.g. SPARE-ICE: Synergistic Passive Atmospheric Retrieval Experiment-ICE)

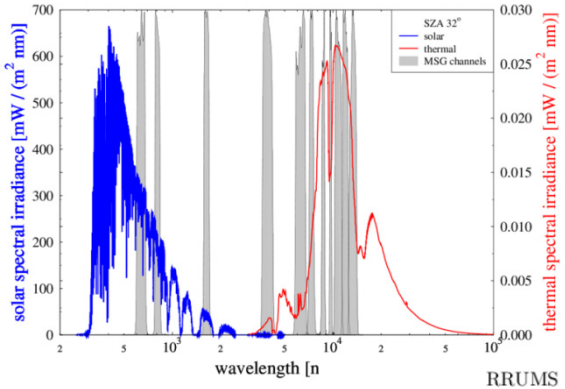


TROPOS

EarthCARE-to-satellite validation activities

EarthCARE radiation products to be validated -> radiative closure assessment :
MSI-BBR L2b
ATLID-BBR-MSI L2b

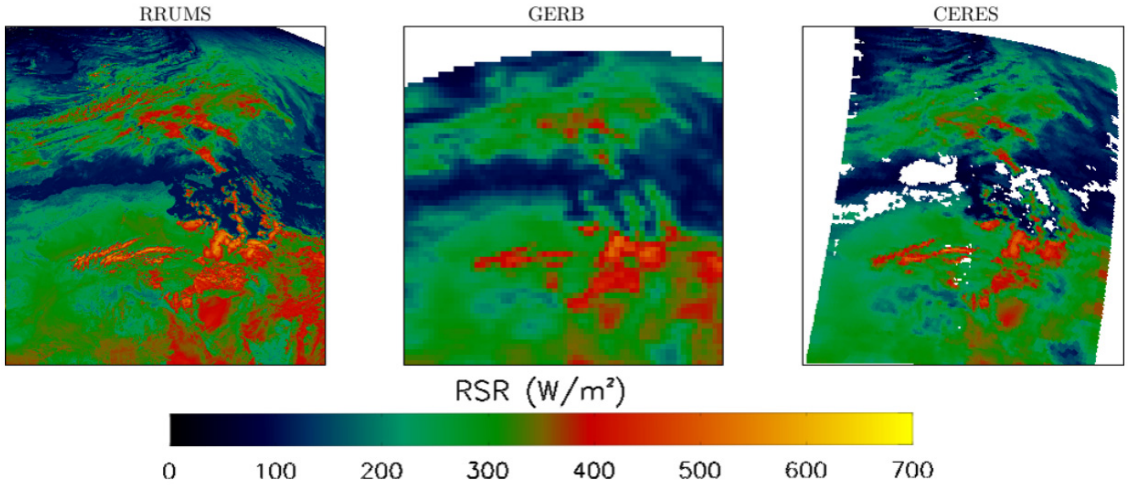
e.g. L2 products: TOA flux
comparison MSG/SEVIRI – EarthCARE/BBR



RRUMS (Rapid Retrieval of Upwelling Irradiances from MSG/SEVIRI): reconstructs solar and thermal TOA fluxes from spectral information of MSG/SEVIRI in full spatial and temporal SEVIRI resolution.

Vàzquez-Navarro et al. 2013

Compare EarthCARE/BBR fluxes to RRUMS results.



TROPOS

EarthCARE-to-satellite validation activities

Long-term mission monitoring and evaluation with satellite observations

Goals:

- Step-by-step assesment of the product chain for BBR and MSI
- Comparison of instantaneous, monthly- and seasonal-average of EarthCARE products with several passive instruments
- Error estimation with respect to the performance, retrieval uncertainties and limitations for different geographical/meteorological cloud scenes
- Long term validation and statistical outcome of stability, consistency
- Assessment of the BBR product chain will provide confidence for the radiative closure assessment

→ **see poster no. 51: GIVE – EarthCARE-to-satellite validation**

Model-supported validation studies

FZJ, KIT, LIM-CGC

→ see poster no. 52: GIVE – Model-supported validation studies

Model-supported validation studies

- **EarthCARE aerosol products** from ATLID and MSI over Europe will be validated by **data-assimilation-based analyses** (4D-var) produced by the ***EURopean Air pollution Dispersion – Inverse Model (EURAD-IM)***.
  - Independent ground-based measurements from the lidar network are considered for assimilation (in collaboration with the ground-based validation activities).
  - Assimilation data from ground-based networks and satellites will be interpolated in space and time and compared with EarthCARE data along the track and across the swath to obtain information on spatial and temporal representativeness of data.

- **EarthCARE cloud retrievals** will be investigated by using **large-scale high-resolution simulations of cloud structures** with the ***ICON atmospheric model in a Large-Eddy Model configuration (ICON-LEM)***.
  - COSP satellite simulator will be used to generate synthetic Level 1 measurements of MSI, ATLID and CPR.
  - Operational EarthCARE cloud retrievals will be applied to the synthetic measurements and tested against the model truth.
  - High-resolution simulations will be run for episodes observed by EarthCARE with a focus on the validation of mixed-phase cloud retrievals and in support of campaigns.

Model-supported validation using EURAD-IM

EarthCARE aerosol products to be validated:

- MSI Level 2a
- ATLID Level 1 and Level 2a
- Synergy ATLID-MSI(-CPR) Level 2b
- X-Met Level 1d
- X-JSG Level 1d

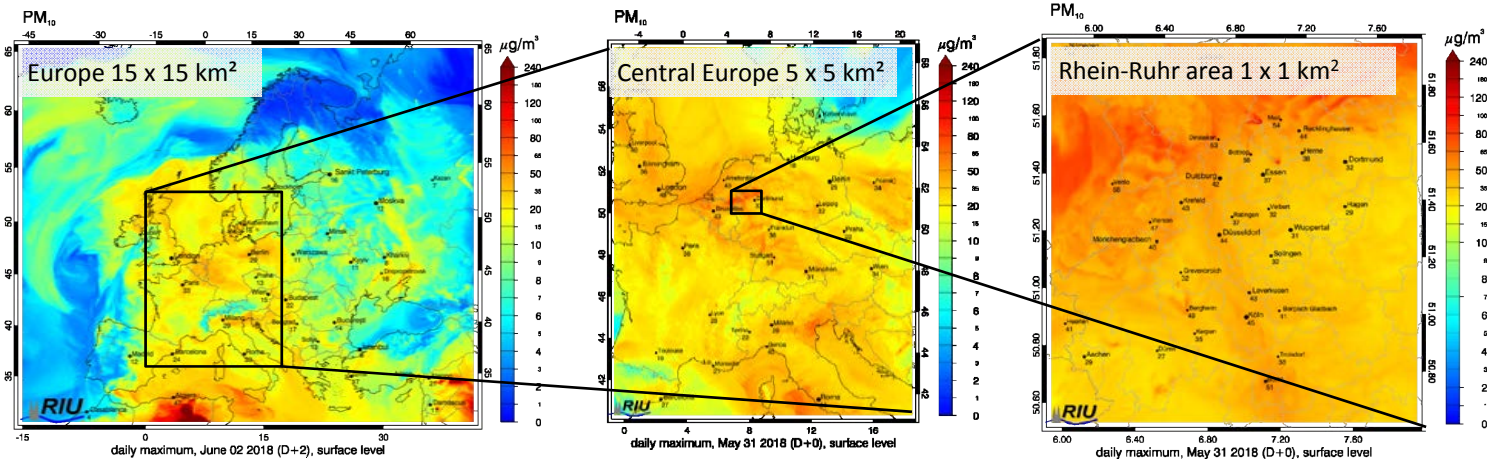
EURAD-IM analysed parameters for intercomparison:

- Profiles of aerosol mass concentrations of various species (e. g. **mineral dust, sea salt, sulfate, organic aerosol, black/elemental carbon,** PM10, etc.)
- AOD
- Aerosol extinction coefficients
- Pressure, temperature, relative humidity

EURAD IM System

Horizontal resolution:
75 km – 500 m (nesting)

Vertical resolution:
terrain following sigma-coordinates (23 -50 tropospheric layers)



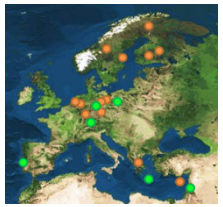
Model-supported validation using EURAD-IM

Validation methodology:

4D-var assimilation of independent ground-based and satellite data

Interpolation of information in space and time

Direct comparison of analysis with EarthCARE data along the observation swath

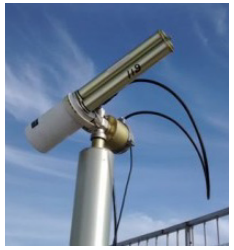


http://polly.tropos.de

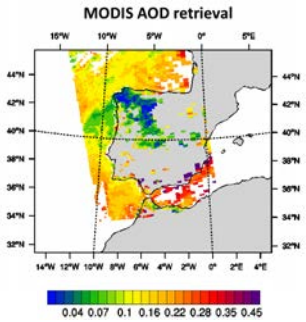
e.g. vertically resolved lidar network data

Leipzig.de

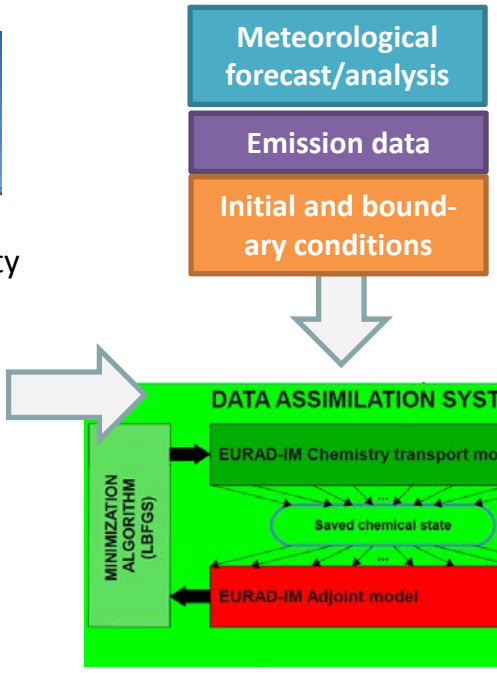
e.g. in situ air quality or campaign data

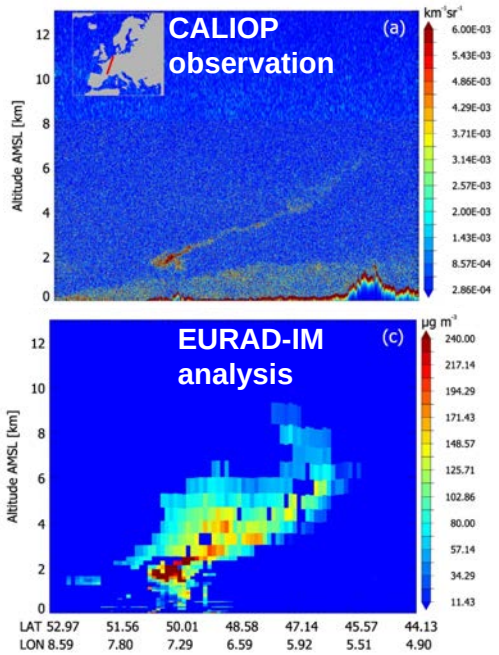


cyprusremotesensing.com



e.g. vertically integrated observations as AOD from networks or satellites





Preparatory activities: Development of observation operators to compare model quantities with observational data, identical twin experiments, OSSEs

Summary

GIVE validation methods of EarthCARE products

Instrument/Synergy	Product	Ground	Airborne	Satellite	Model
ATLID	Level 1	✓	✓		✓
ATLID	Level 2a (FM, AER, ICE, TC, EBD, CTH, ALD)	✓	✓	✓	✓
ATLID	Level 2a JAXA (CLA)	✓		✓	✓
MSI	Level 1		✓	✓	
MSI	Level 1c (RGR)		✓	✓	
MSI	Level 2a (CM, COP, AOT)	✓	✓	✓	✓
MSI	Level 2a JAXA (CLP)	✓		✓	✓
CPR	Level 1	✓	✓		
CPR	Level 2a (FMR, CD, TC, CLD)	✓	✓	✓	✓
CPR	Level 2a JAXA (ECO, CLP)	✓			
BBR	BBR Level 1			✓	
Auxiliary Data	X-MET Level 1d	✓		✓	✓
Joint Standard Grid	X-JSG Level 1d	✓		✓	✓
ATLID - CPR	Level 2b (TC)	✓	✓		
ATLID - CPR	Level 2b JAXA (CLP)	✓			✓
ATLID - MSI	Level 2b (MO, CTH, ACD)	✓		✓	✓
MSI - BBR	Level 2b (RAD)		✓	✓	✓
ATLID - BBR - MSI	Level 2b (FLX)		✓	✓	✓
ATLID - CPR - MSI	Level 2b (CAP, COM, 3D, RT)	✓	✓	✓	✓
ATLID - CPR - MSI	Level 2b JAXA (CLP)	✓			
ATLID - CPR - MSI - BBR	*Level 2b (DF)*	*Closure @ BOA*		*Closure @ TOA*	
ATLID - CPR - MSI - BBR	*Level 2b JAXA (RAD)*				✓

Summary

- GIVE involves **more than 60 scientists** from 14 research groups in 11 institutes and external collaborators.
- GIVE aims at the **validation of the entire chain of EarthCARE L1 and L2 products** and contributes to radiation closure studies at TOA and BOA.
- GIVE makes use of a large number of **highly instrumented research infrastructe facilities** located inside and outside of Germany, including airborne, shipborne and ground-based installations.
- GIVE combines **experimental and modeling approaches**.

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