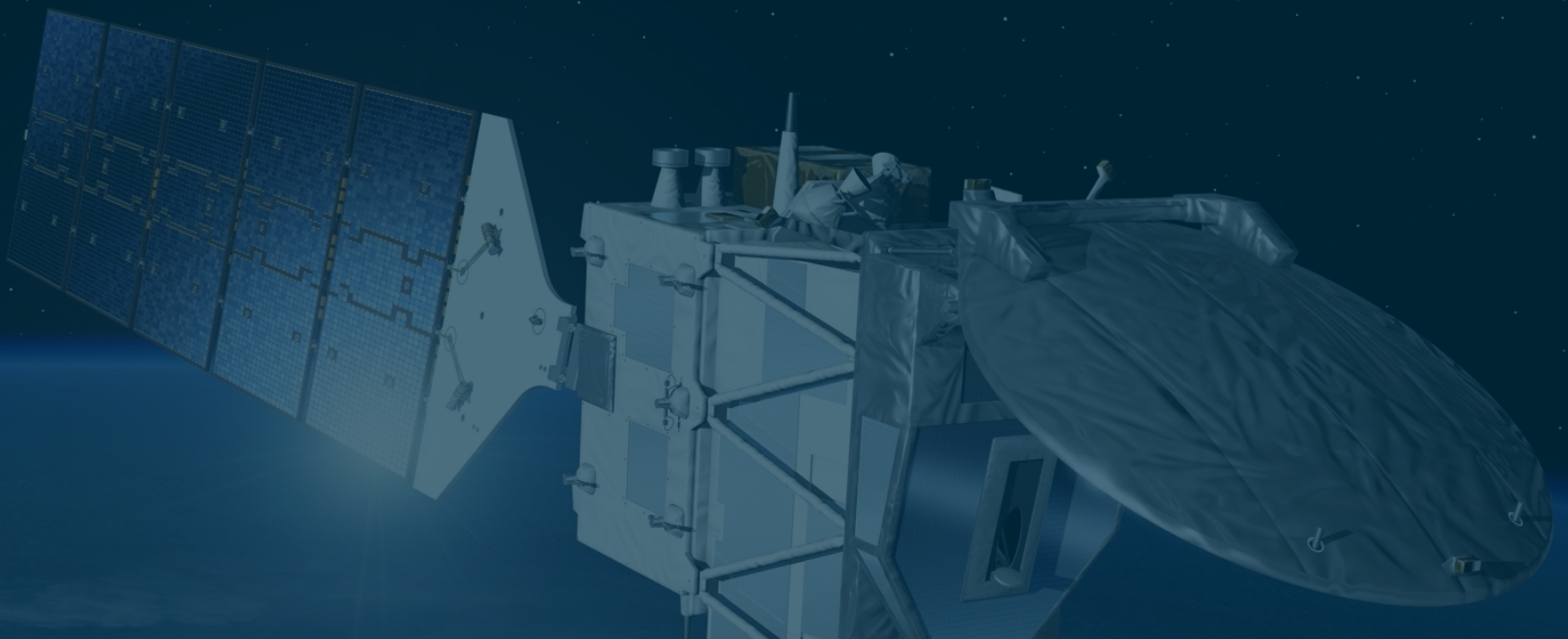


Introduction to ESA campaigns and Pre-launch lessons learned

2nd ESA EarthCARE Validation Workshop

25-28 May 2021 (online)

Why these campaigns?

- Improve our understanding of EarthCare measurements
- Develop and improve synergistic retrievals by bringing real measurements close enough to EarthCare but with even more information
- A very welcome rehearsal thanks to A-Train, flight strategies, way to compare measurements etc.
- …

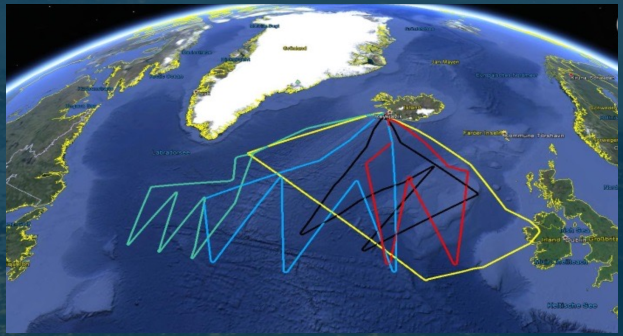
WHAT CAN WE LEARN VIA DIRECT COMPARISONS

EarthCARE – Pre-launch campaign activities

NARPEX (HALO with Radar-Lidar payload)

NARVAL-I south

- Base: Barbados
- Period: 10 – 20 Dec. 2013



NARVAL-I north

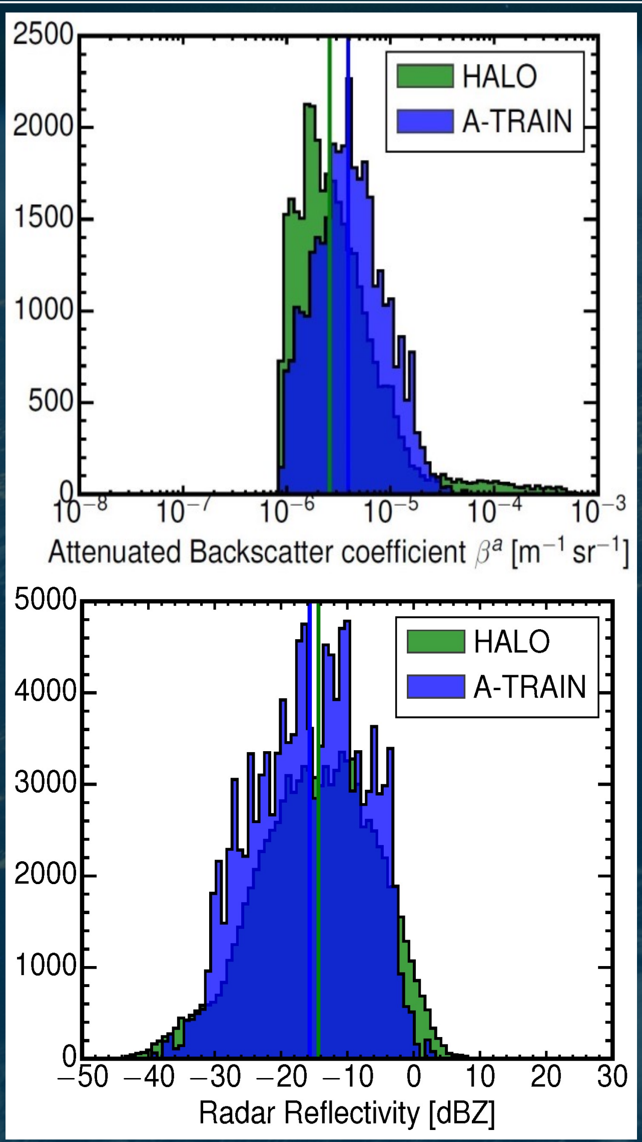
- Base: Iceland
- Period: 7 – 22 Jan. 2014

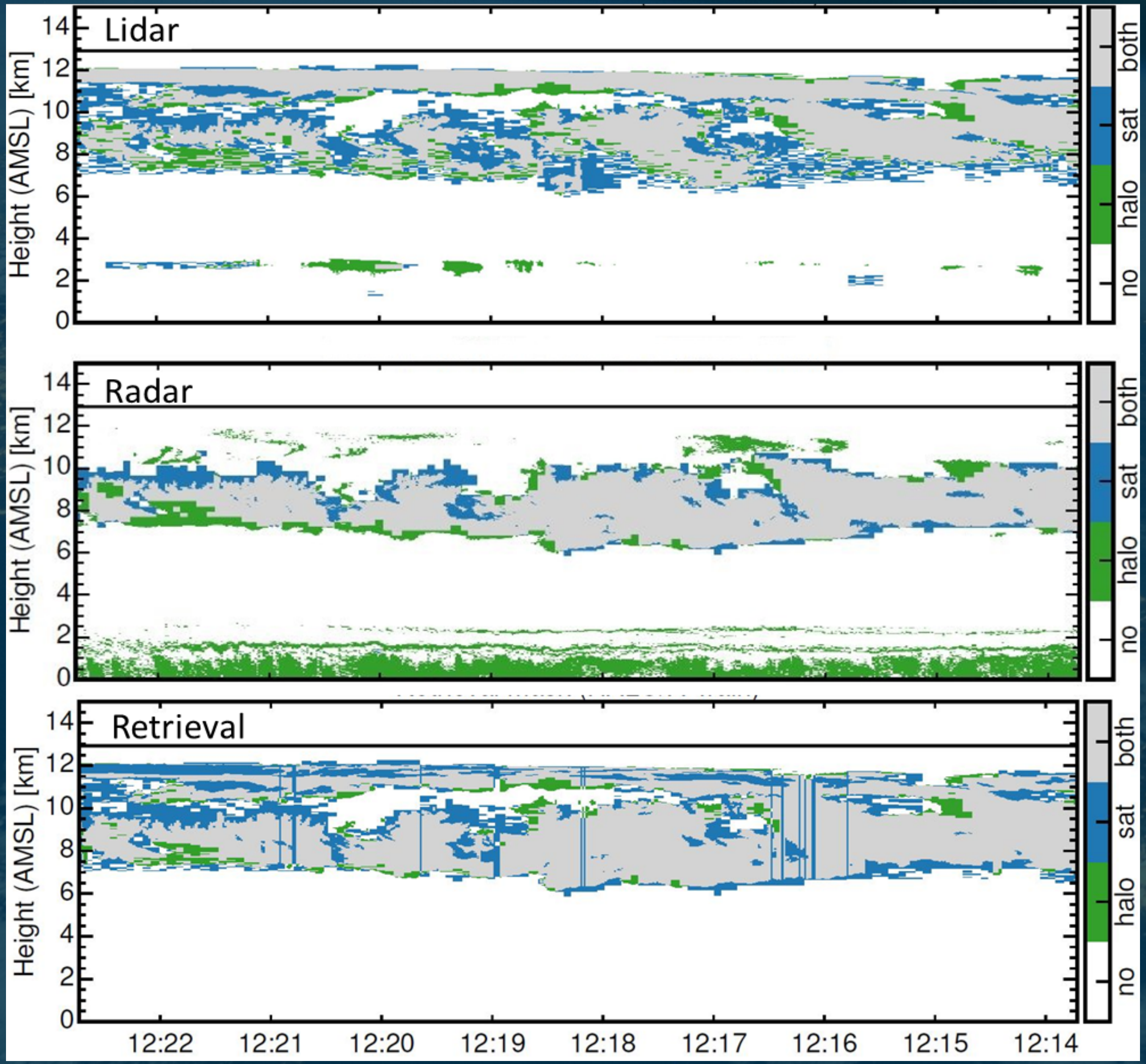
Summary: ~120 flight hours; 11 coordinated A-Train underpasses

Objectives:

- Use of different radar / lidar wavelengths (measurements and calculations)
- Comparing airborne and space borne radar / lidar measurements (resolution / measurement range)
- Studying small scale structures with airborne and space borne lidar

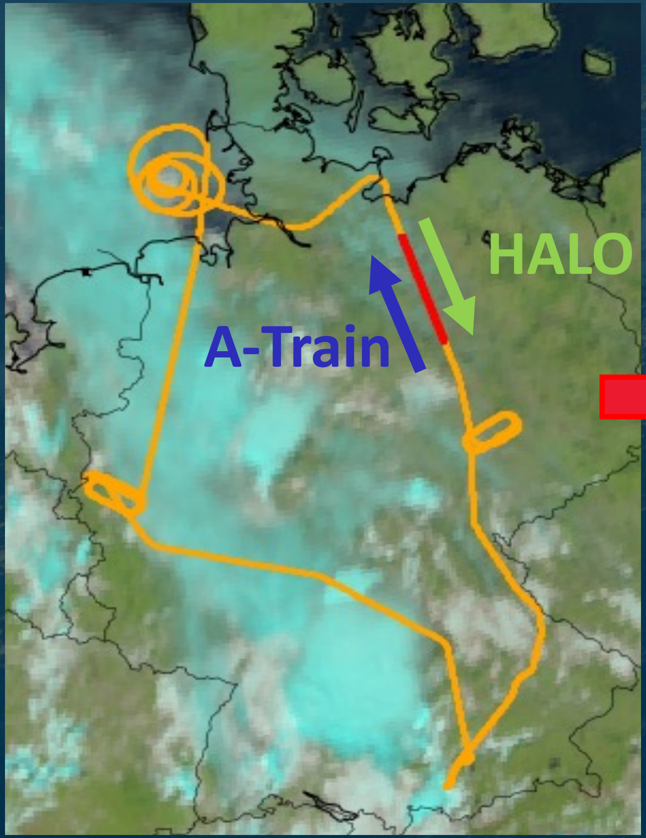
Comparing airborne and space-borne measurements

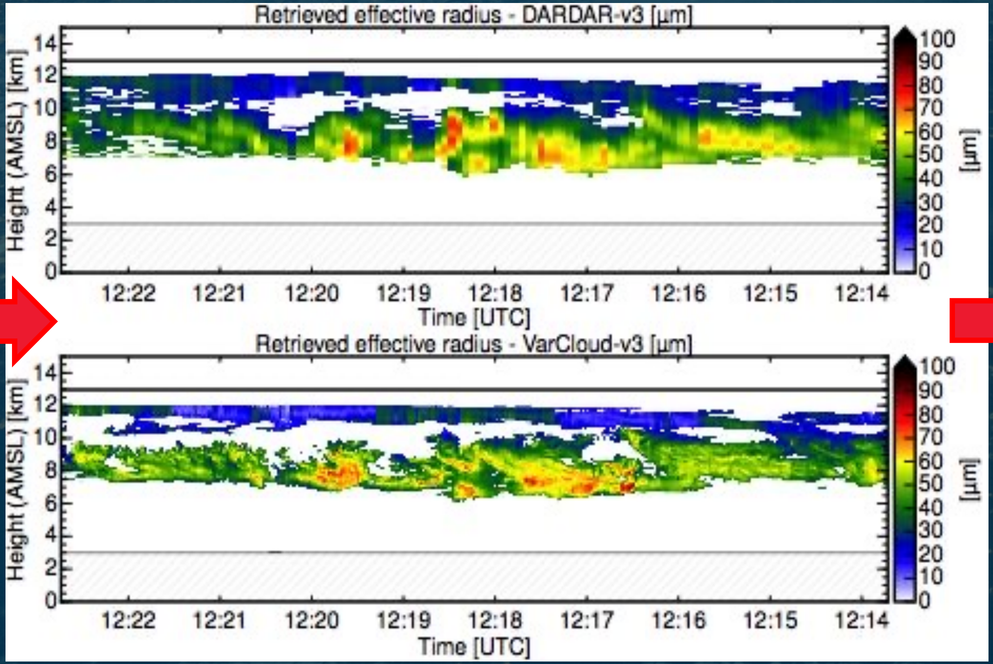


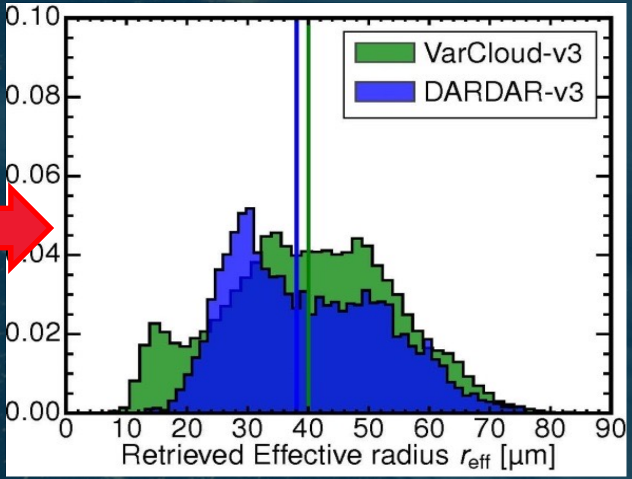


Comparing airborne and space-borne measurements

24 July 2013





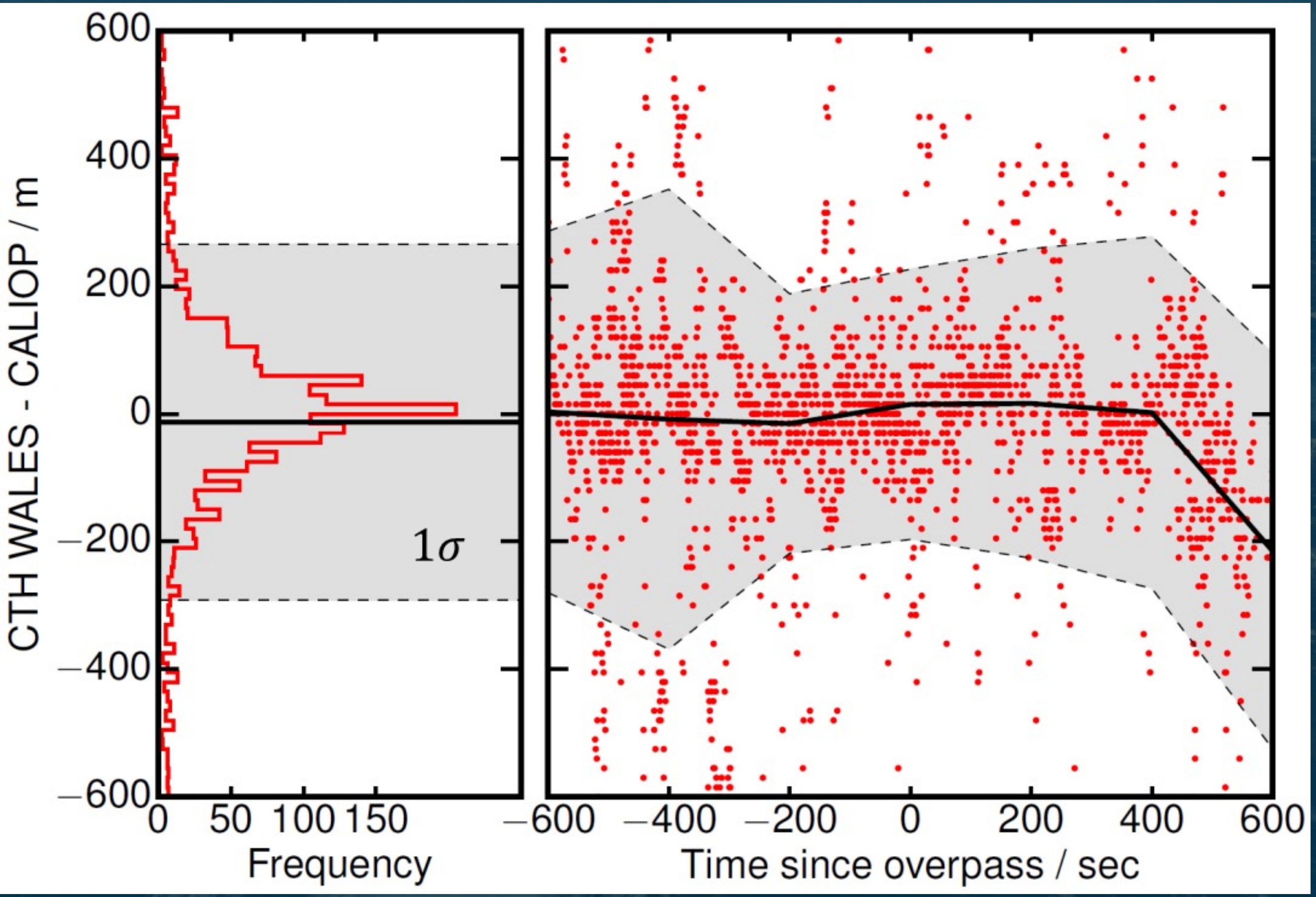


Comparing small scale structures

DLR esa

CALIPSO underpasses

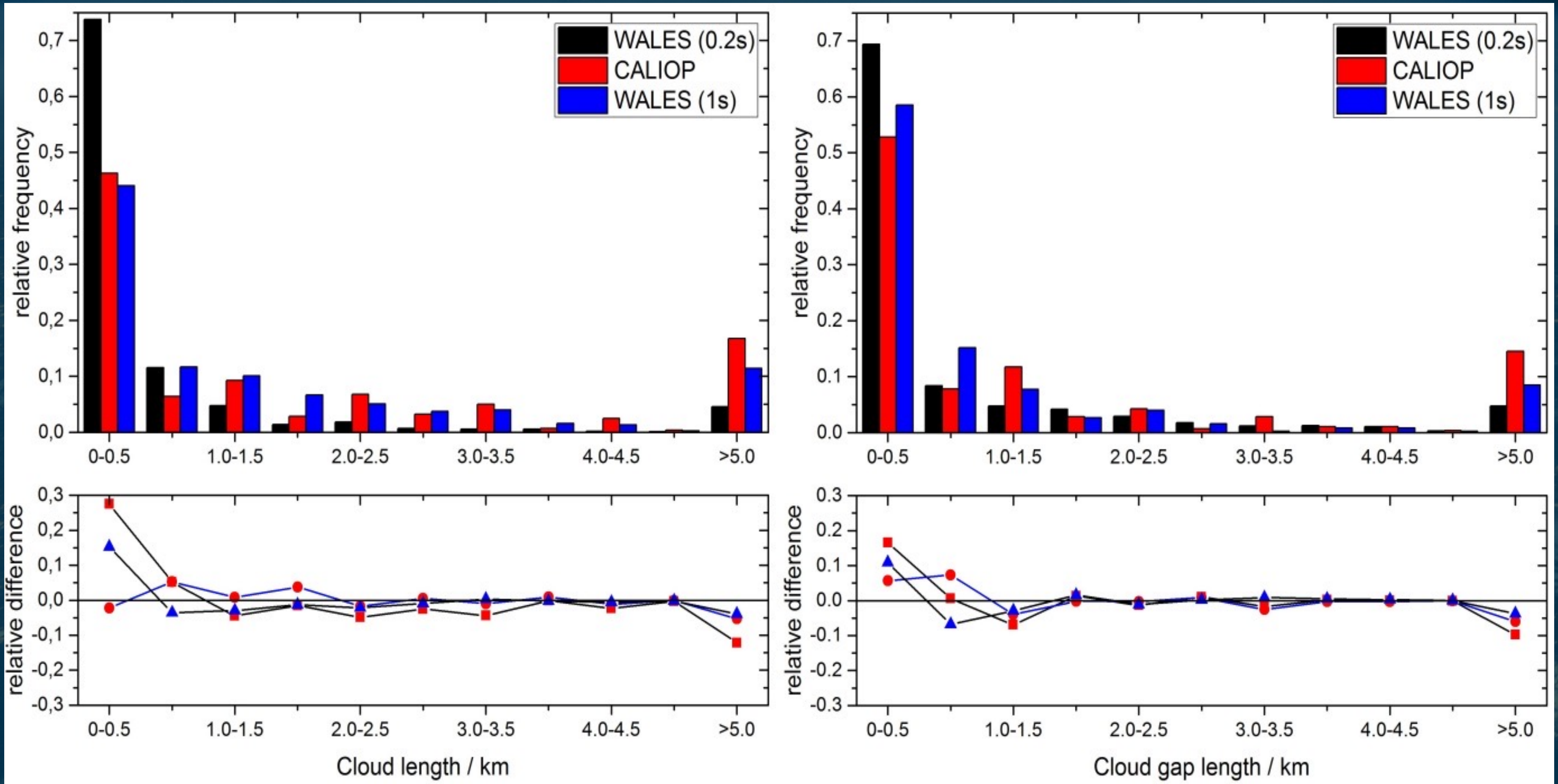
Direct comparison of **cloud top height** derived from airborne and space-borne lidar



→Good agreement within +/- 200 m height for up to 400 sec time difference

Comparing small scale structures

All flights/measurements during NARVAL



→Underestimation of small scale structures with coarser resolution

TEAM UP TO IMPROVE OUR UNDERSTANDING – TEST RETRIEVALS AND CLOSURE

Airborne tandem-platforms

Remote sensing measurements on HALO and SAFIRE

HALO

Aircraft:

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

Payload:

- **High spectral resolution lidar** (532 nm) and water vapor DIAL
- **Doppler Cloud Radar** (35 GHz)
- Hyper-spectral **radiometer (specMACS)**
- **Microwave** radiometer

SAFIRE

Aircraft:

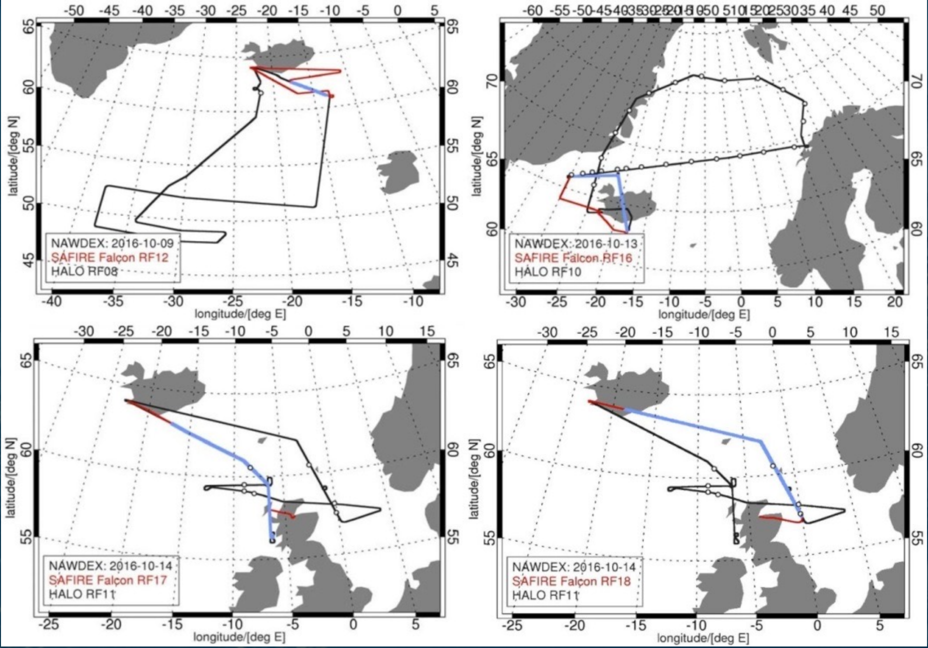
- Dassault Falcon 20-E5
- Endurance: **3.5 flight hours**
- Maximum cruising altitude: **13 km**

Payload:

- **High spectral resolution lidar** (355 nm)
- **Doppler Cloud Radar** (94 GHz)
- IR radiometer

EarthCARE – Pre-launch campaign activities

EPATAN (FF20 – HALO; both with Radar-Lidar payload)



<u>28th of September to 17th of October 2016</u>

- Number of scientific flights (FF20): 15
- Number of scientific flight hours (FF20): 46.5
- Number of released dropsondes (FF20): 59
- Number of CloudSat-CALIPSO underpasses: 3
- Number of co-located flight legs: 5

Common flights of French F20 (red) and HALO (black) during NAWDEX. Common flight tracks are marked blue.

Objectives:

- Use of different radar / lidar wavelengths / different sensitivity (joint flights)
- Contribute to a better understanding of EarthCARE measurements
- First rehearsal of cal/val strategy (ensuring readiness of the systems)

Synergistic Radar/Lidar retrieval

Testing and further development

Optimal estimation approach (Delanoë and Hogan., 2008)

State vector x
A priori profile of α, S, N

Forward modeling of measurements

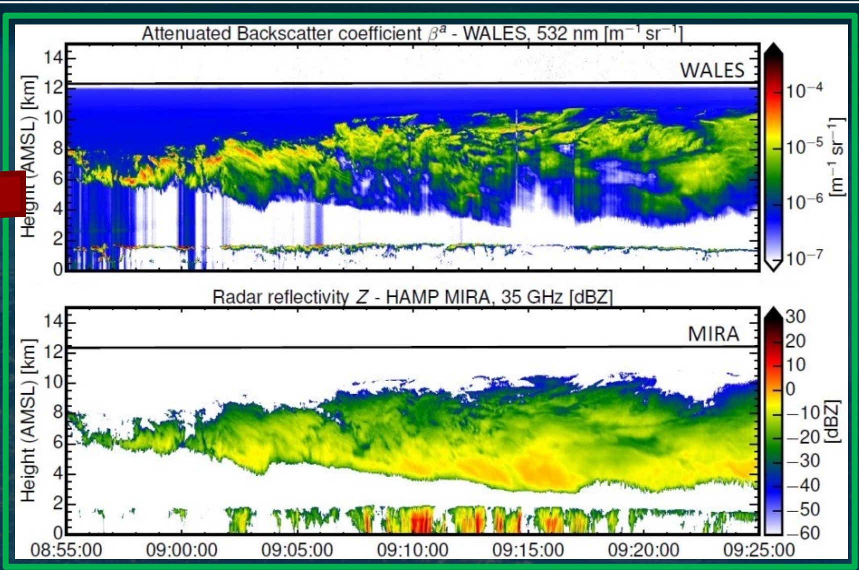
Lidar signal	**Radar signal**
incl. multiple scattering	LUT based reflectivities

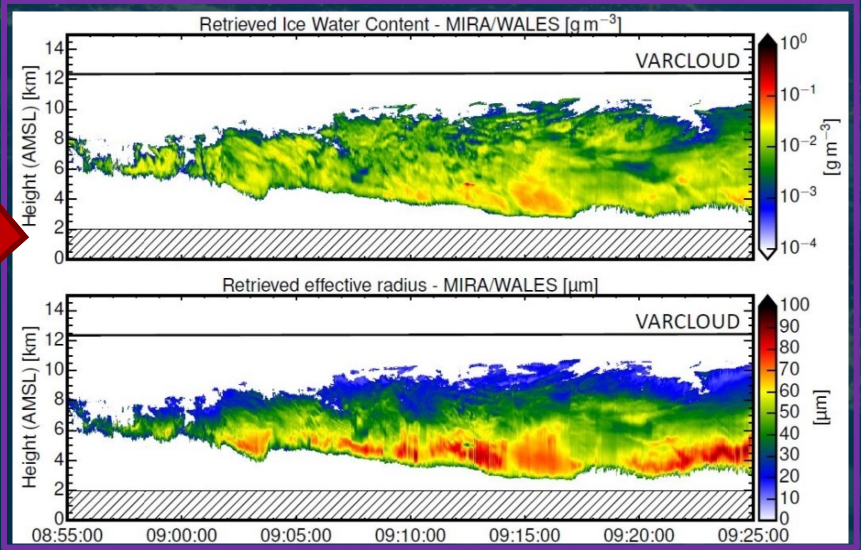
Comparison with measurements
WALES/MIRA or CALIOP/CloudSat

converged?

yes → **Microphysical properties**
Calculate IWC and r_{eff}

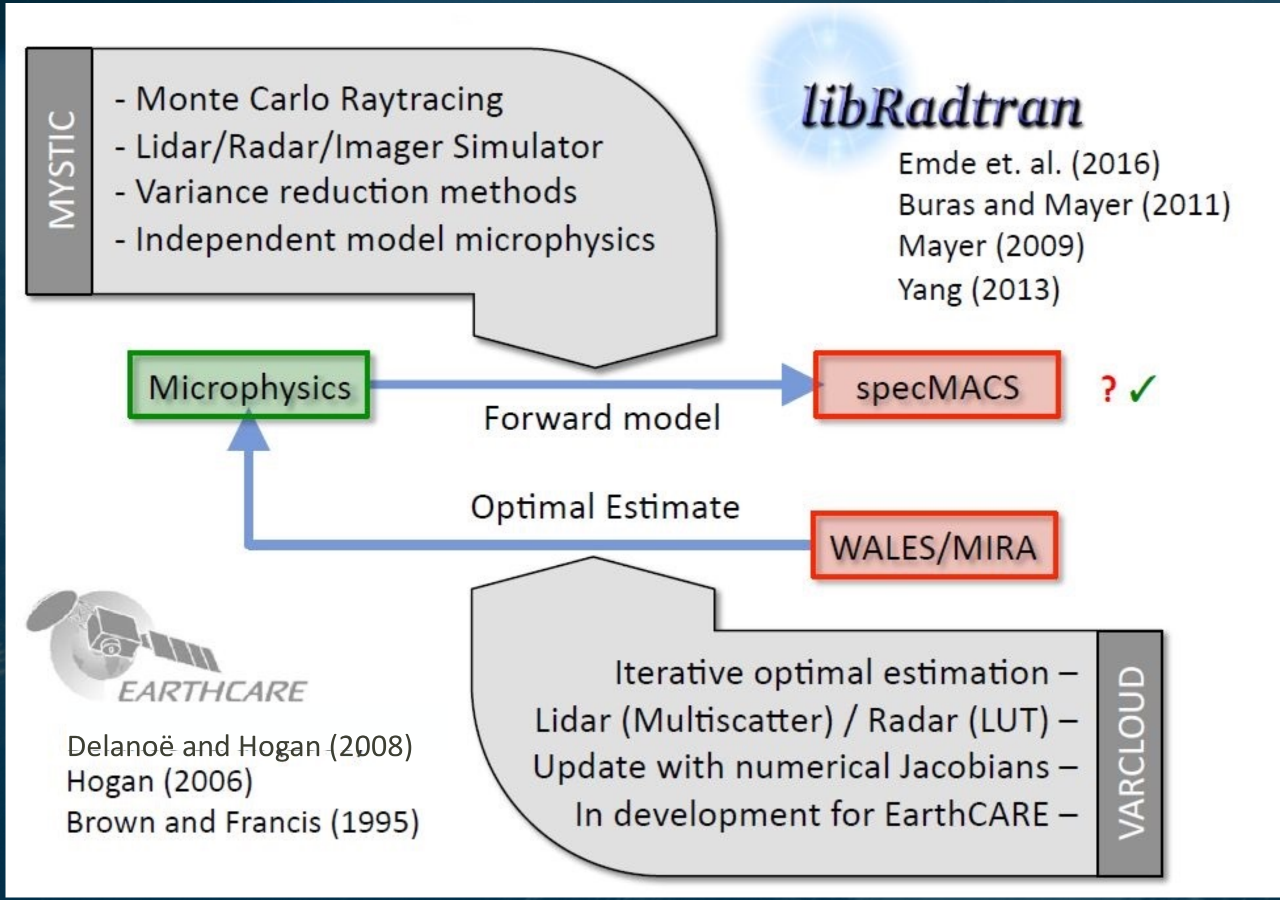
no → **Gauss-Newton iteration**
Derive new state vector x





Cazenave et al., 2019

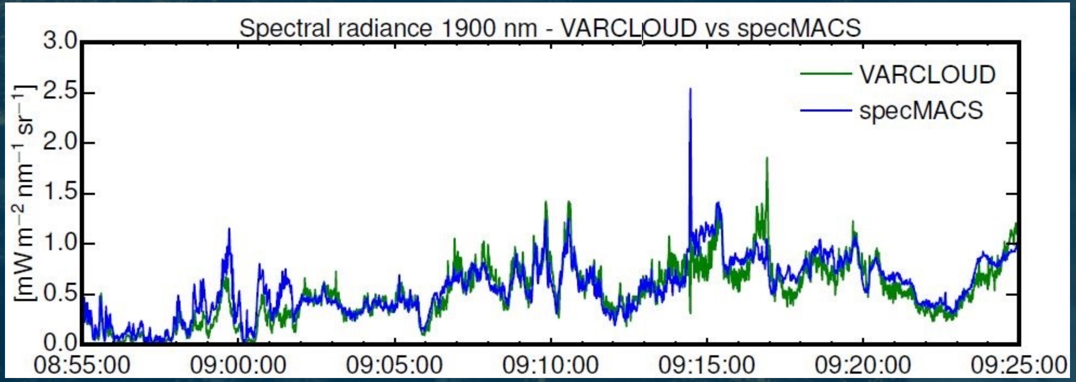
Closure study – Radar-Lidar vs. specMACS



Ewald et al., 2021

→ Forward modeling of spectral radiances using microphysical properties derived from synergistic radar/lidar measurements

→ Comparison with measured spectral radiances with specMACS

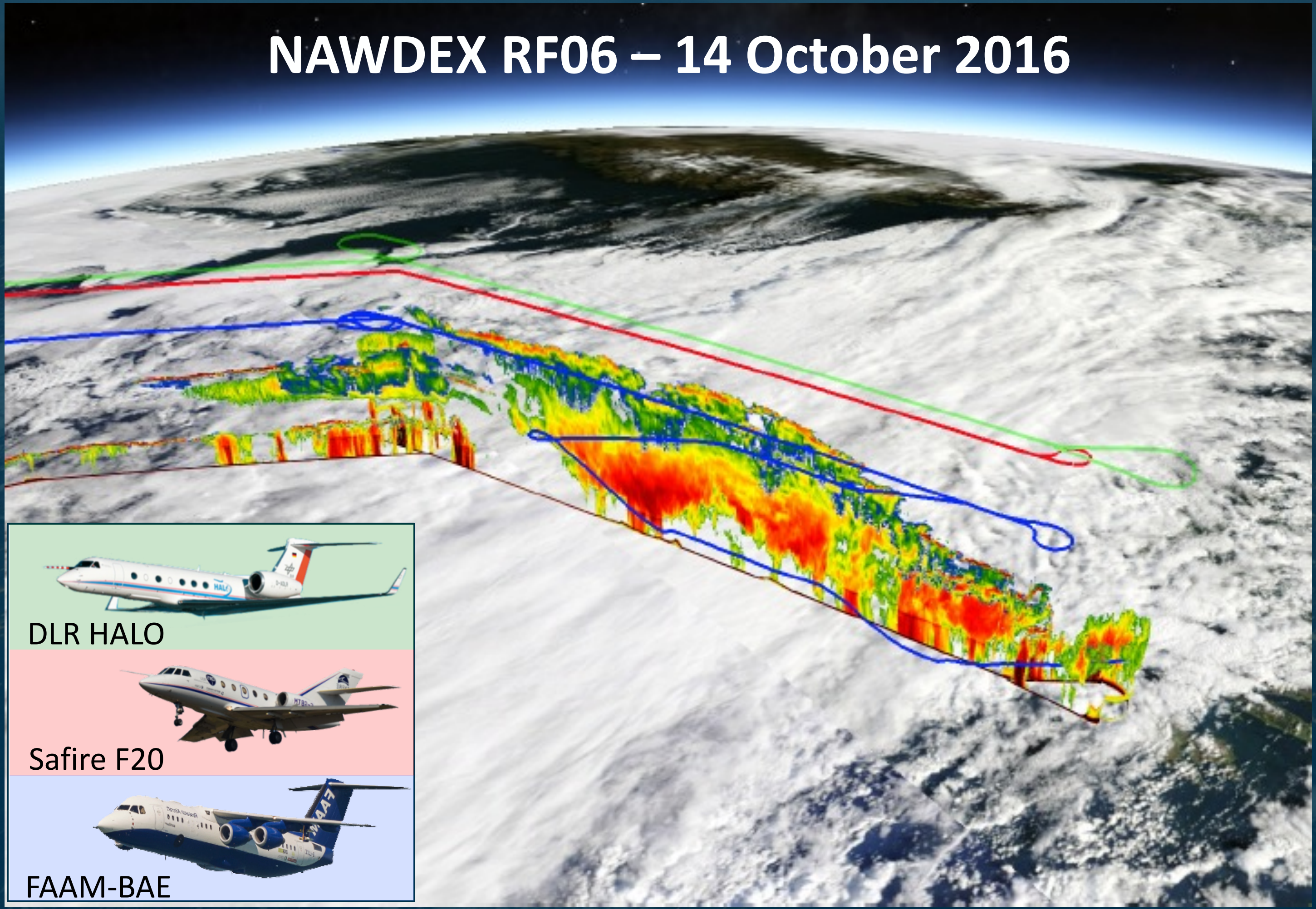


→ Good agreement of simulated and measured spectral radiance at 1900 nm

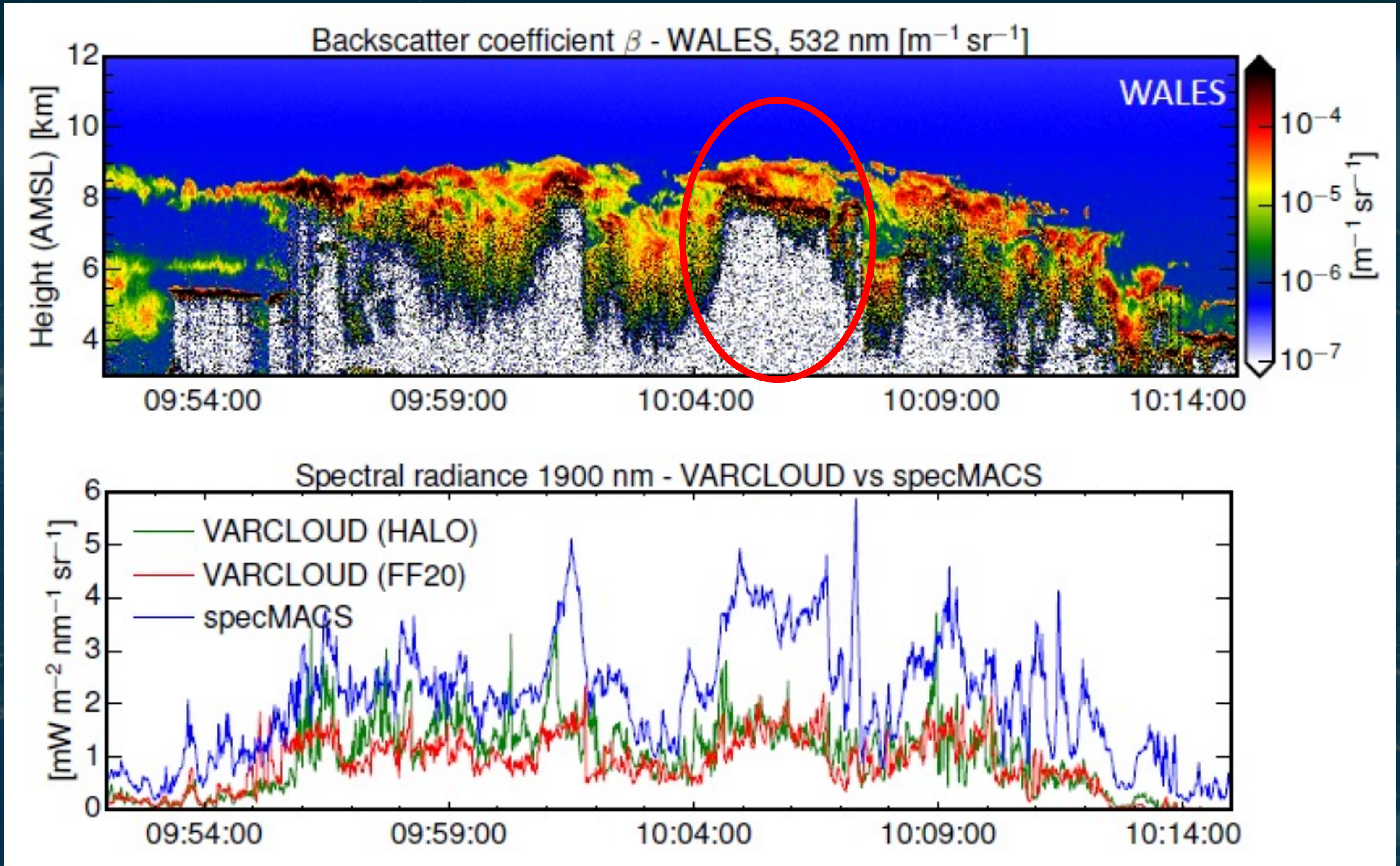
WHAT CAN WE LEARN WITH CLOSURE AND IN-SITU

Coordinated HALO – FF20 - FAAM flight

Comparison with specMACS and in-situ measurements



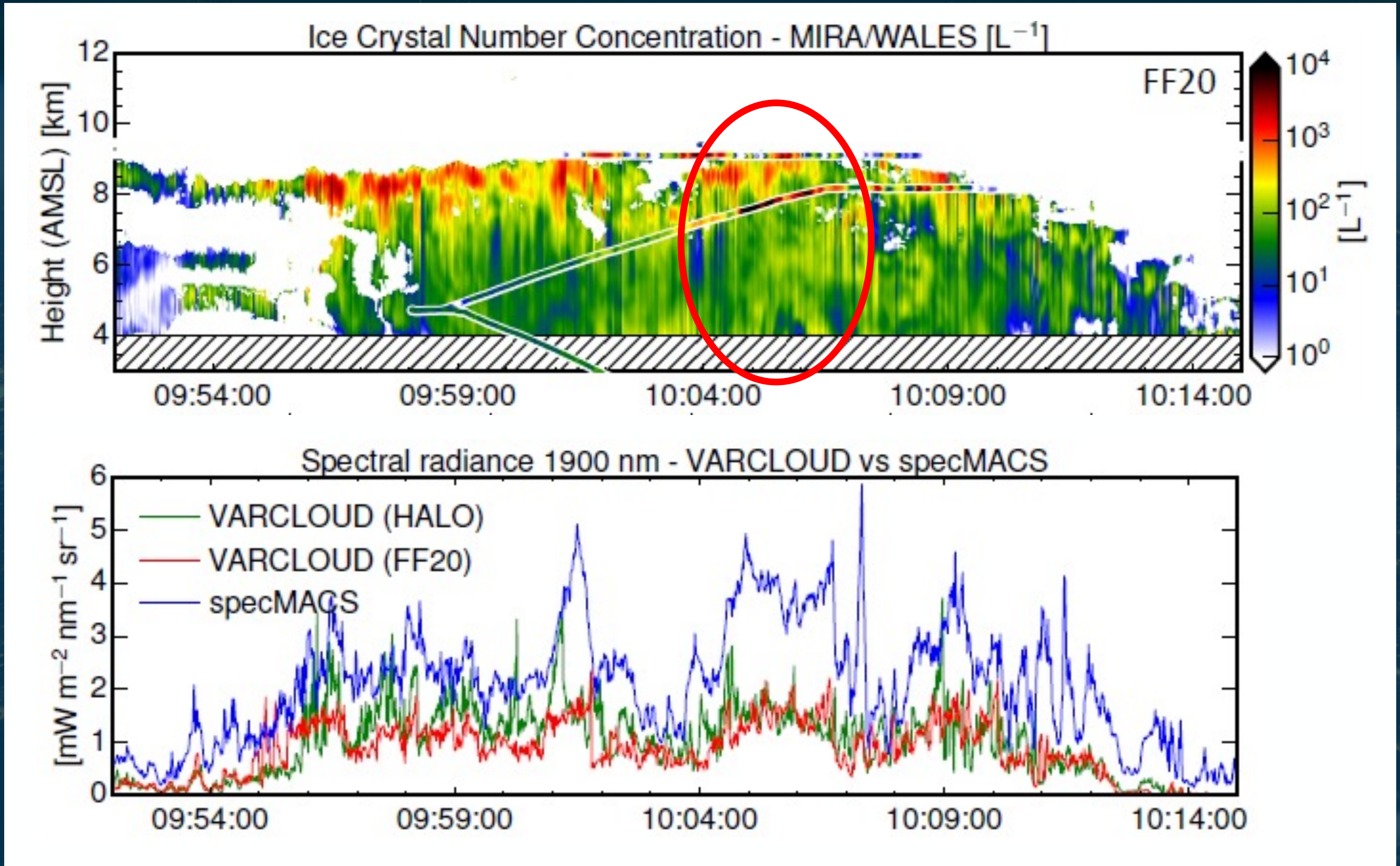
Comparison with specMACS



Ewald et al., 2021

NO agreement of simulated and measured spectral radiance at 1900 nm

Comparison with specMACS

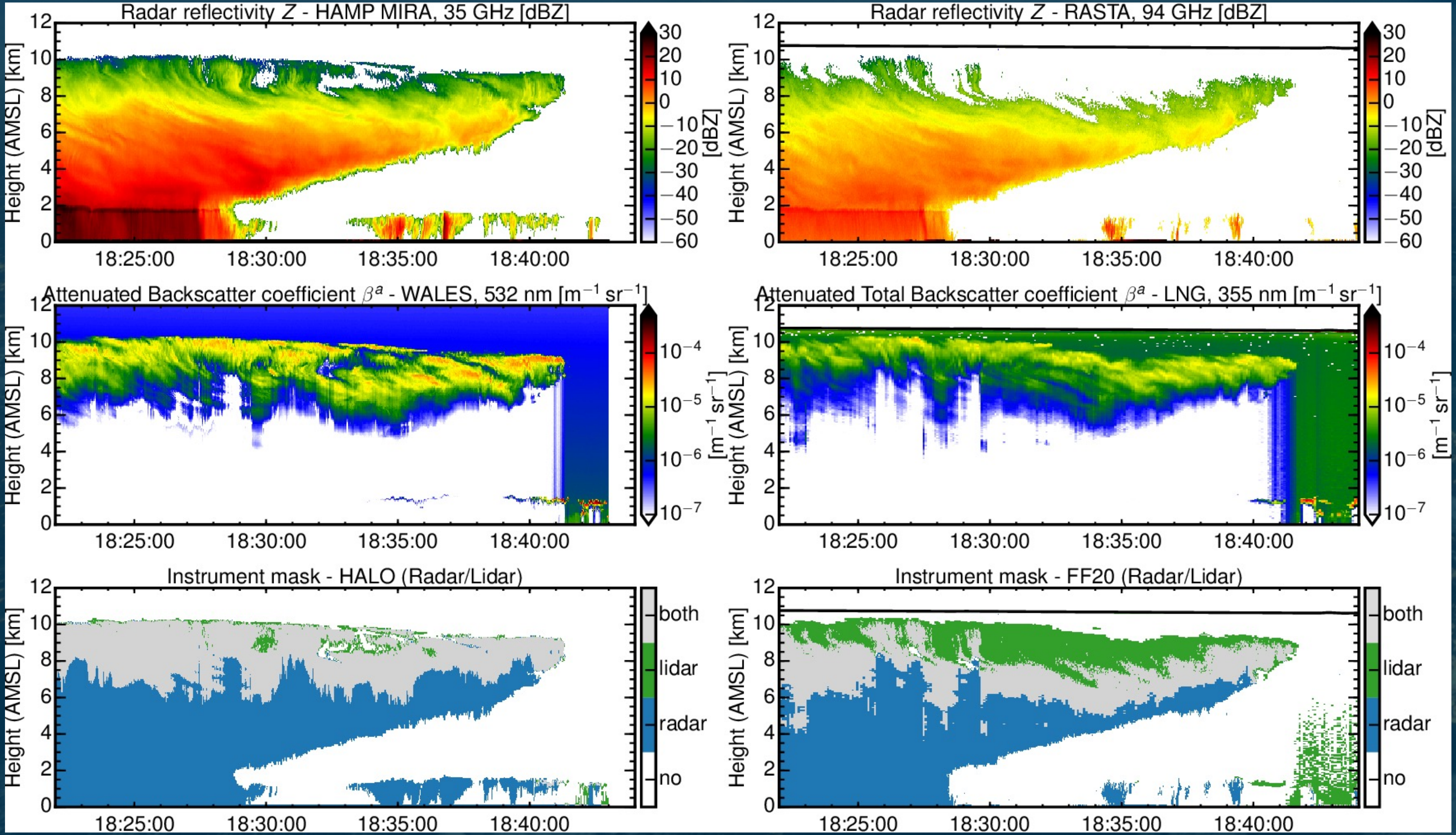


Ewald et al., 2021

NO agreement of simulated and measured spectral radiance at 1900 nm

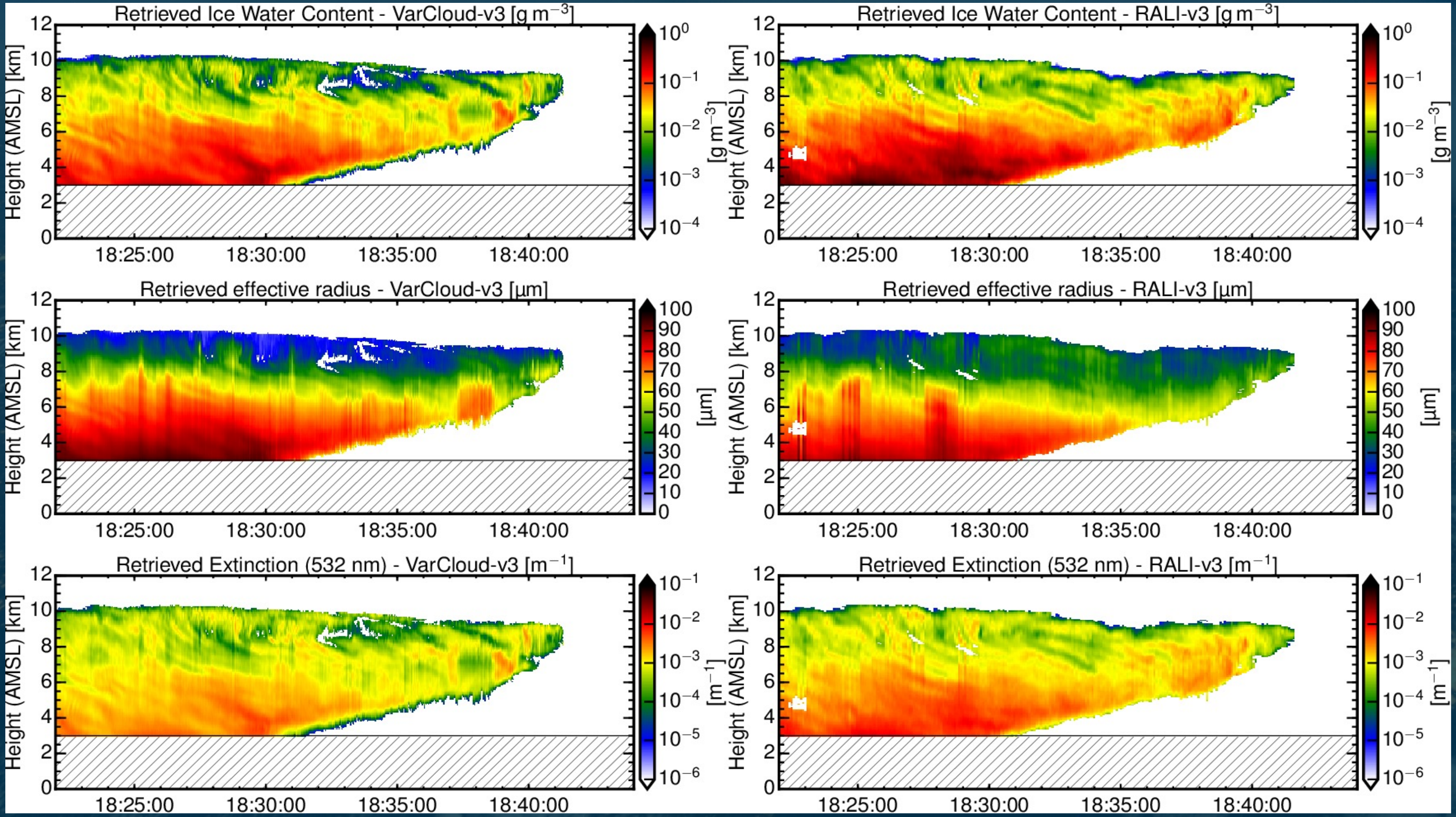
Analysis of multi-wavelength measurements

Comparison of Level1 measurements between HALO and FF20



Analysis of multi-wavelength measurements

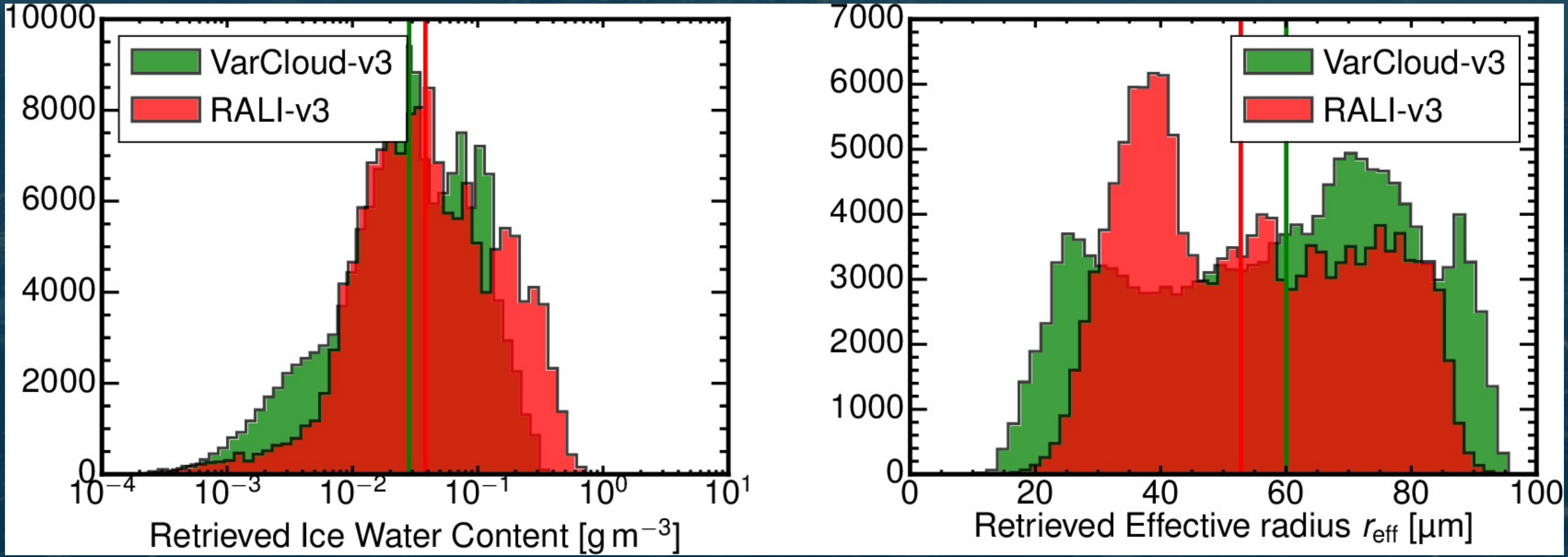
Comparison of Level2 data between HALO and FF20



Analysis of multi-wavelength measurements

Comparison of Level2 data between HALO and FF20

Investigating the effects of different wavelengths on retrieved properties



Mie scattering / attenuation at 94 GHz leads to:

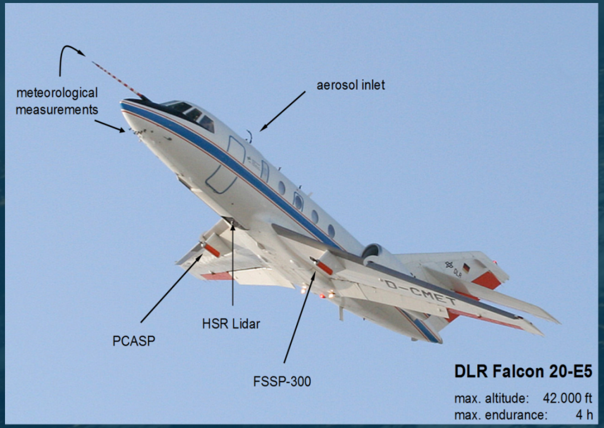
- larger values of IWC
- lower values of Reff

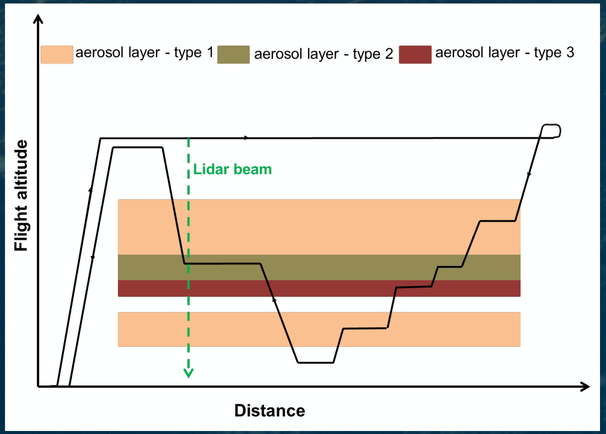
AEROSOL CLASSIFICATION

Aerosol type classification scheme

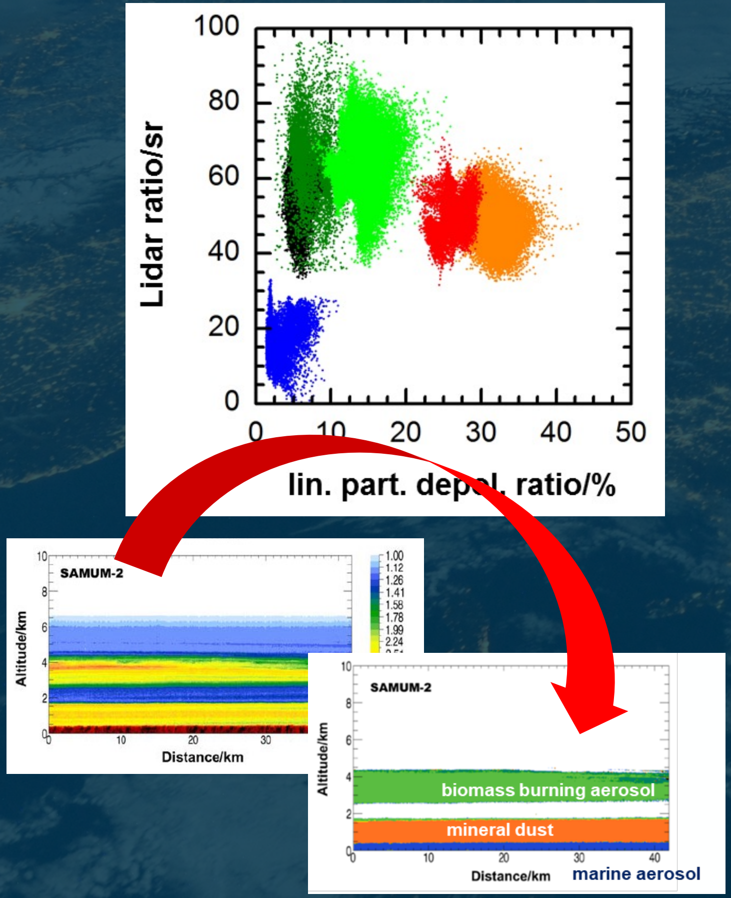
ICAROHS - Project

Measurement strategy

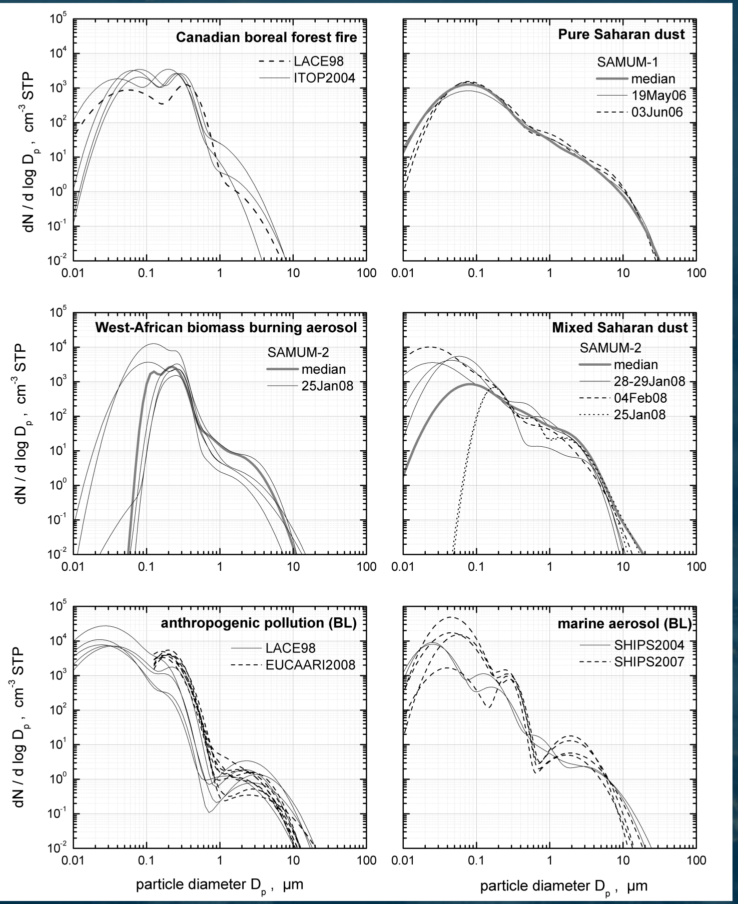




Aerosol classification

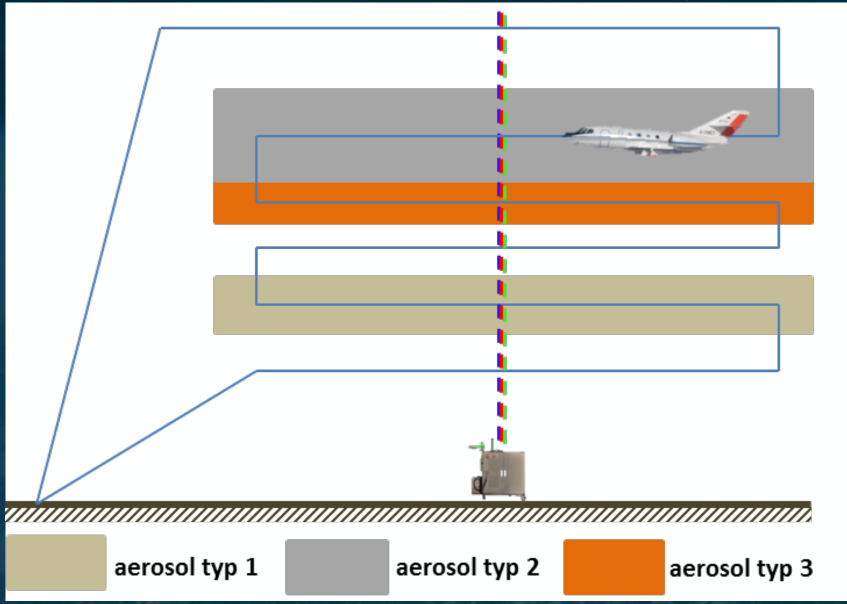


Linking optical and microphysical properties



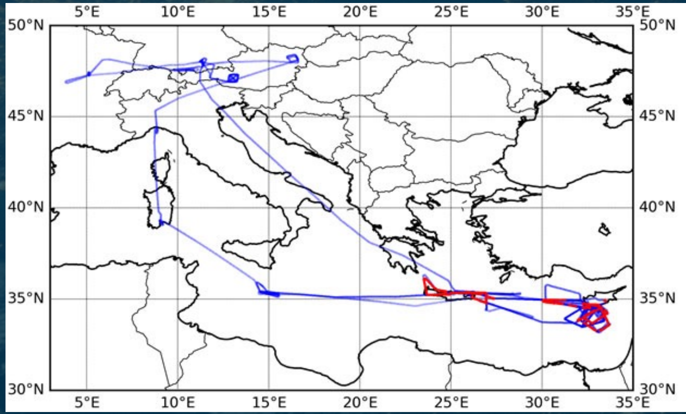
Groß et al., 2013

A-CARE (DLR-Falcon (in-situ) + ground-based lidar)



April 2017

- Measurement side: Cyprus
- Overflights over ground station in Cyprus and Crete: 2
- Variable aerosol situation
- Coordinated (ground-based) remote sensing and airborne in-situ measurements



Objectives:

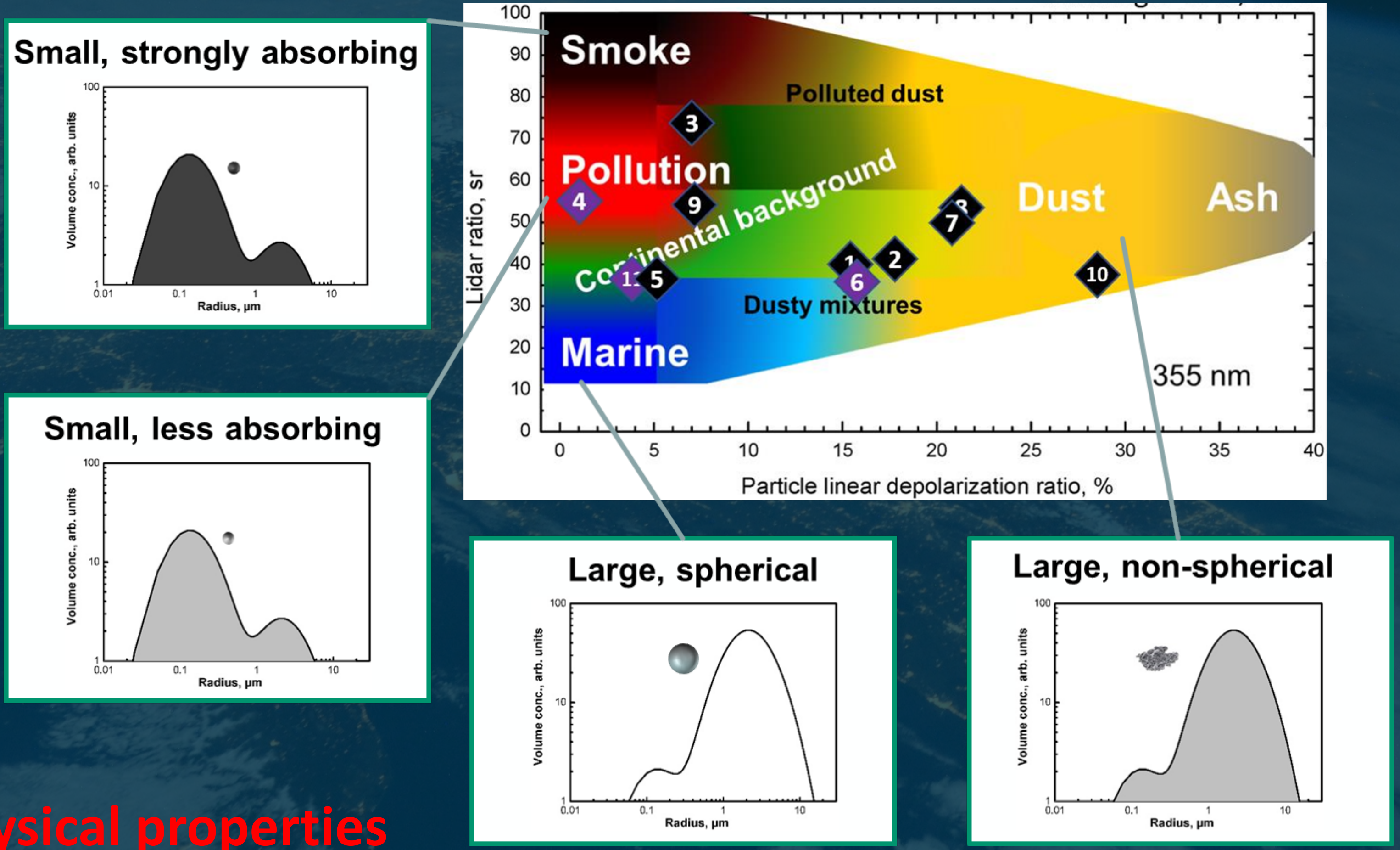
- Analysis of airborne in-situ measurements
- Analysis and quality control of ground-based remote sensing measurements and assessment for Level-2 processing
- Relate microphysical properties measured in situ to the remote sensing data and refine the HETEAC model accordingly

Aerosol type classification scheme

HETEC – Hybrid End-to-End Aerosol Classification

To connect **microphysical, optical** and **radiative** properties of pre-defined aerosol components

- **Aerosol classification model** developed for EarthCARE and implemented in ECSIM
- 4 basic aerosol components with **prescribed microphysical properties to calculate mixtures**
- **Radiation closure for aerosol** from ATLID & MSI with BBR



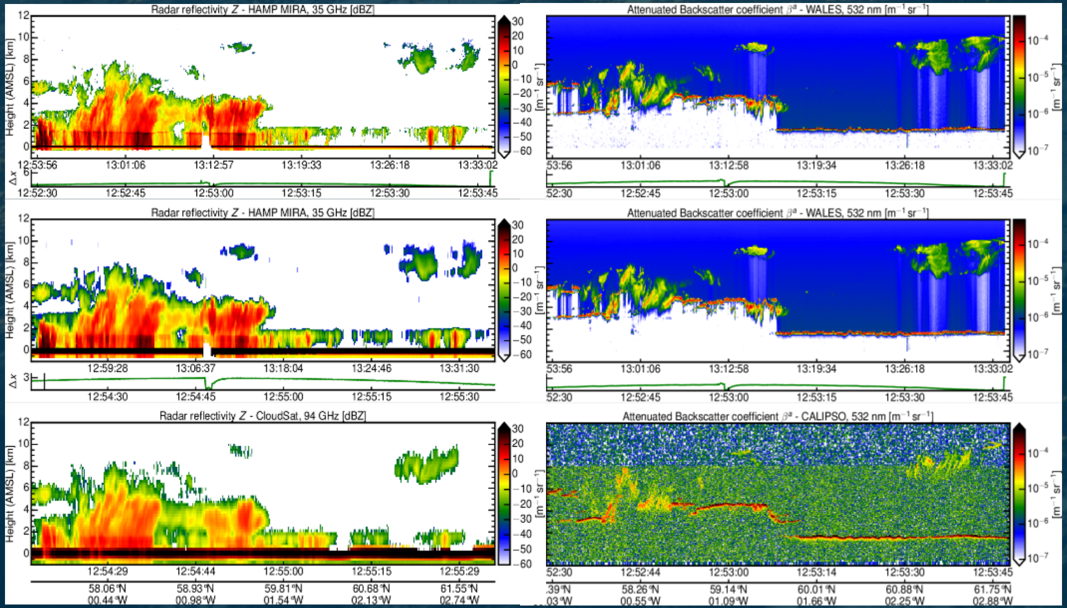
Comparison of retrieved microphysical properties with airborne in-situ measurements shows good agreement

Wandinger et al., 2016

Campaign gaps

Bringing together airborne measurements and the EC Level-2 algorithms

- Use of the retrieved properties from airborne radar-lidar+… to **simulate the measurements from space**. We can address multiple scattering for both radar and lidar (for example) and the impact of the beam filling/geometry.
- Formatting our airborne data in order to be **used by EC-processors**

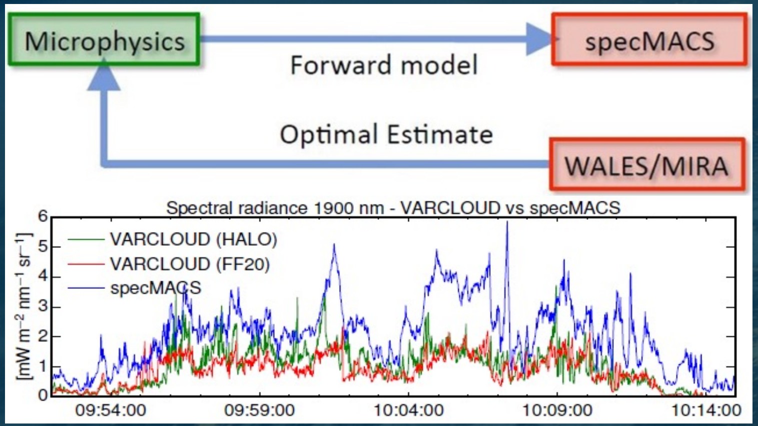


Airborne radar lidar measurements have been rescaled to EarthCARE resolution but without considering sensitivity for future space borne measurements

→ Use of existing and new data to perform sensitivity studies

Campaign gaps

- **Radiative closure** (active/passive – passive)

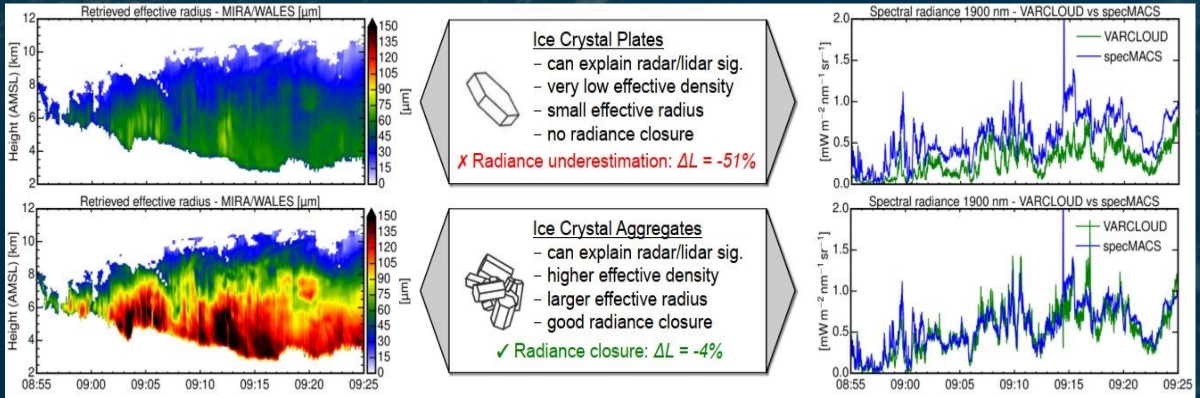


First closure studies show that under certain conditions microphysical retrievals fail

→ Perform more closure studies

→ Test the use of additional information in microphysical retrievals (passive remote sensing measurements, Doppler measurements)

- **Ice microphysical properties** used in retrieval



→ Investigate the impact of used ice microphysical properties