EarthCARE-like payload on HALO

Lessons learned and plans for future validation

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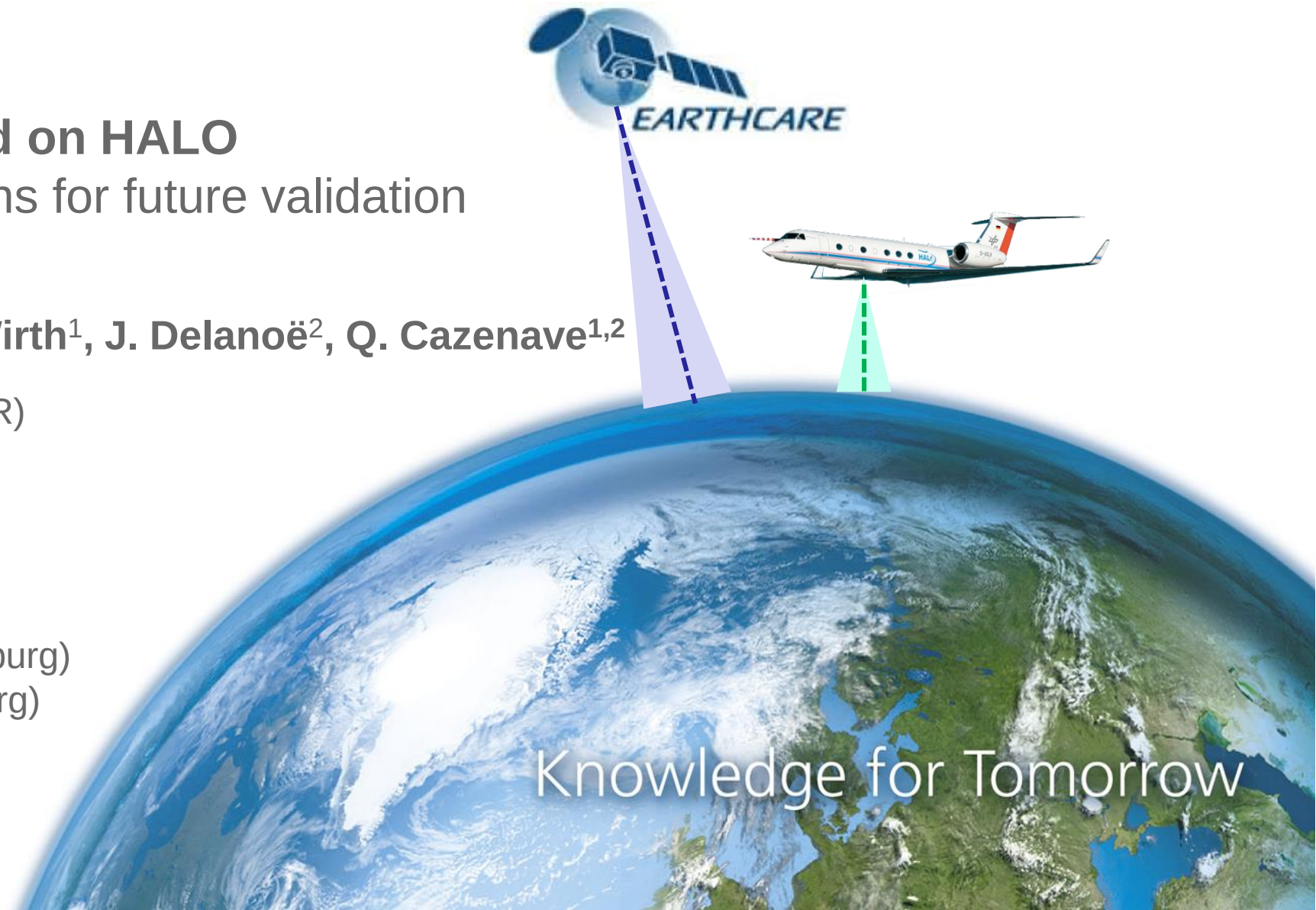
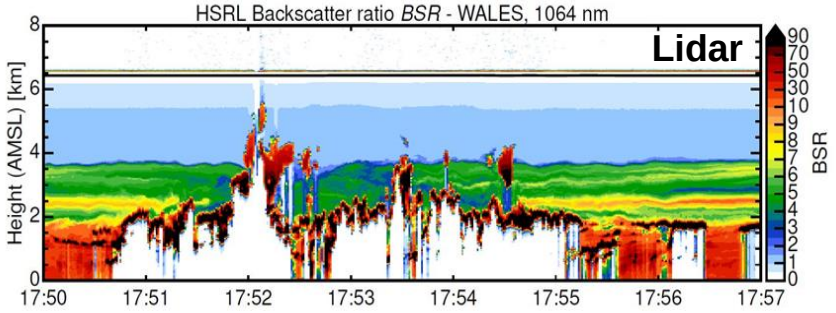
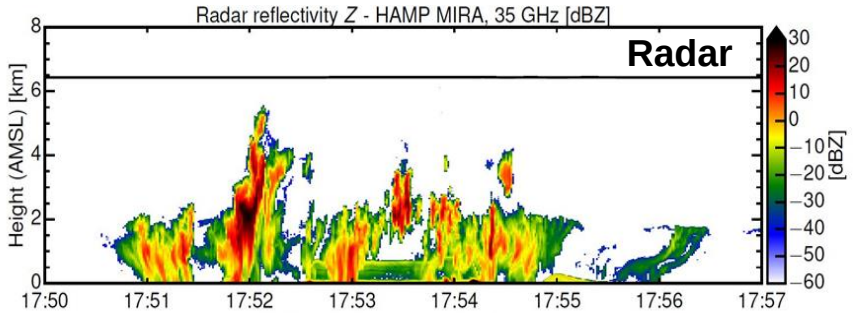
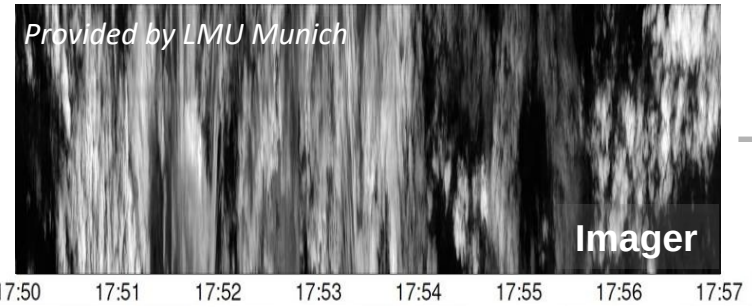


EarthCARE-like payload on HALO

Combined active and passive remote sensing measurements







Aerosols and Ice clouds

Clouds and Precipitation

Profiles

Synergy

Cloud mask
Ice water content
Effective Radius
Radiative closure

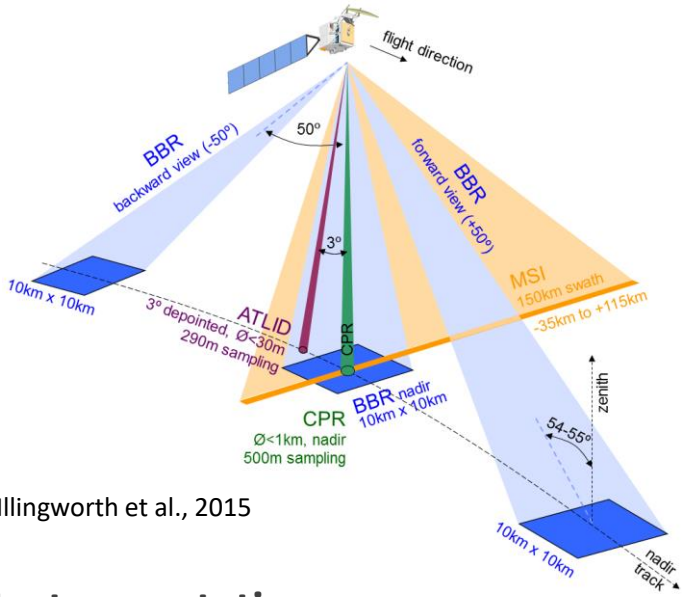
Aerosols and Clouds

Horizontal / Temporal

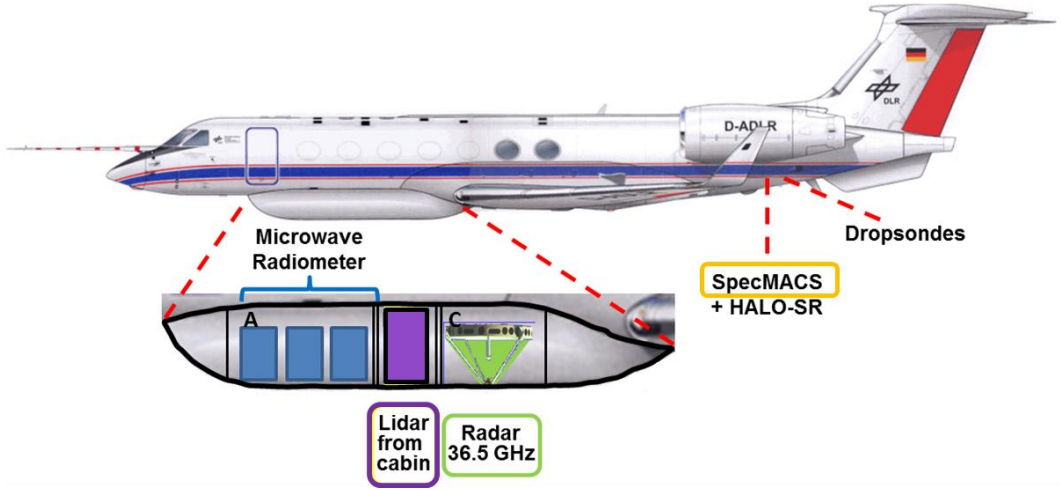
Radiative properties

EarthCARE-like payload on HALO

Combined active and passive remote sensing measurements



Illingworth et al., 2015



Instrumentation:

HSRL-Lidar (ATLID)
Cloud-Profiling Radar (CPR)
Multi-Spektral Imager (MSI)
Broadband Radiometer (BBR)

Instrumentation:

HSRL-Lidar (WALES)
Cloud-Profiling Radar (MIRA35)
Hyper-Spectral Imager (specMACS) / VELOX
Microwave Radiometer (HAMP)

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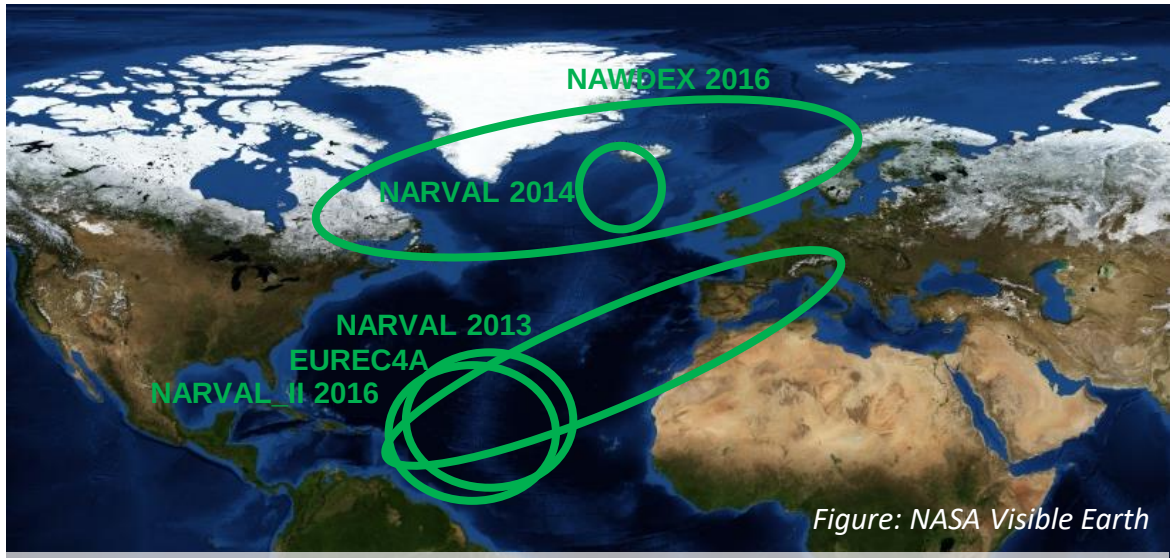
Campaign overview

Measurements during NARVAL, NAWDEX and EUREC4A



→ 5 campaigns with lidar + radar

Tropical North-Atlantic

- NARVAL-I: 10 – 20 Dec 2013 (dry season)
- NARVAL-II: 8 – 29 Aug 2016 (wet season)
- EUREC4A: 19 Jan – 19 Feb 2020 (dry season)

Extra-tropical North-Atlantic

- NARVAL-I: 7 – 22 Jan 2014
- NAWDEX: 15 Sep – 18 Oct 2016

→ ~400 flight hours with radar-lidar instrumentation

- **17 coordinated A-Train underpass**
- 6 coordinated HALO – FF20 legs

→ different resolution/sensitivity

→ different wavelength combination

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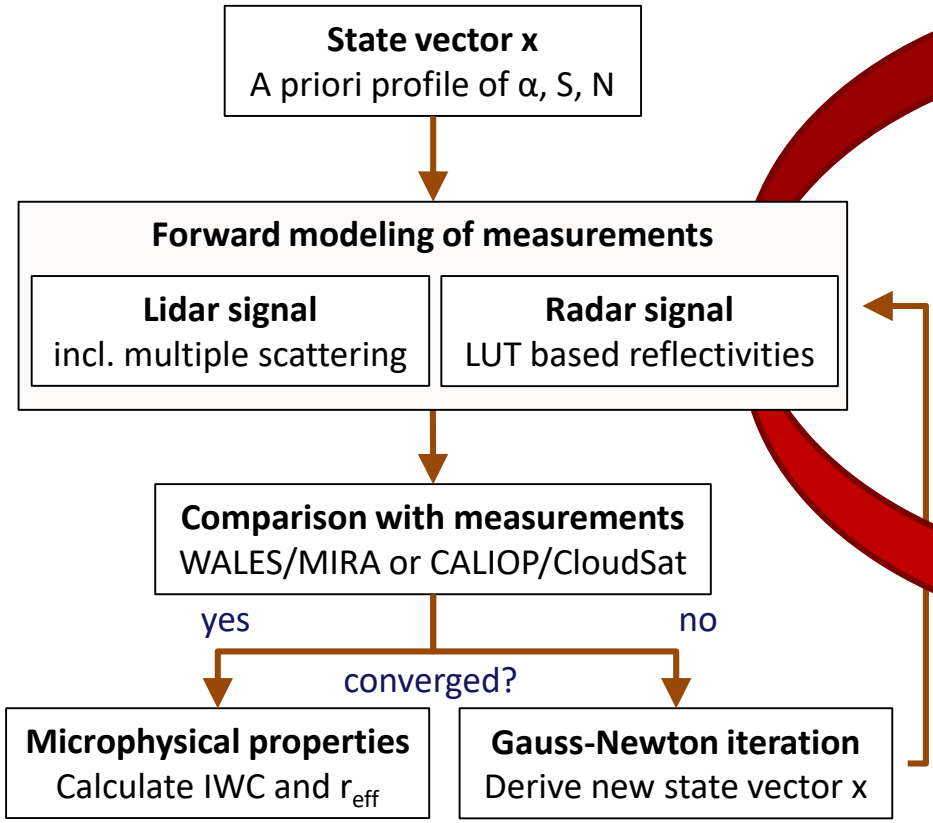
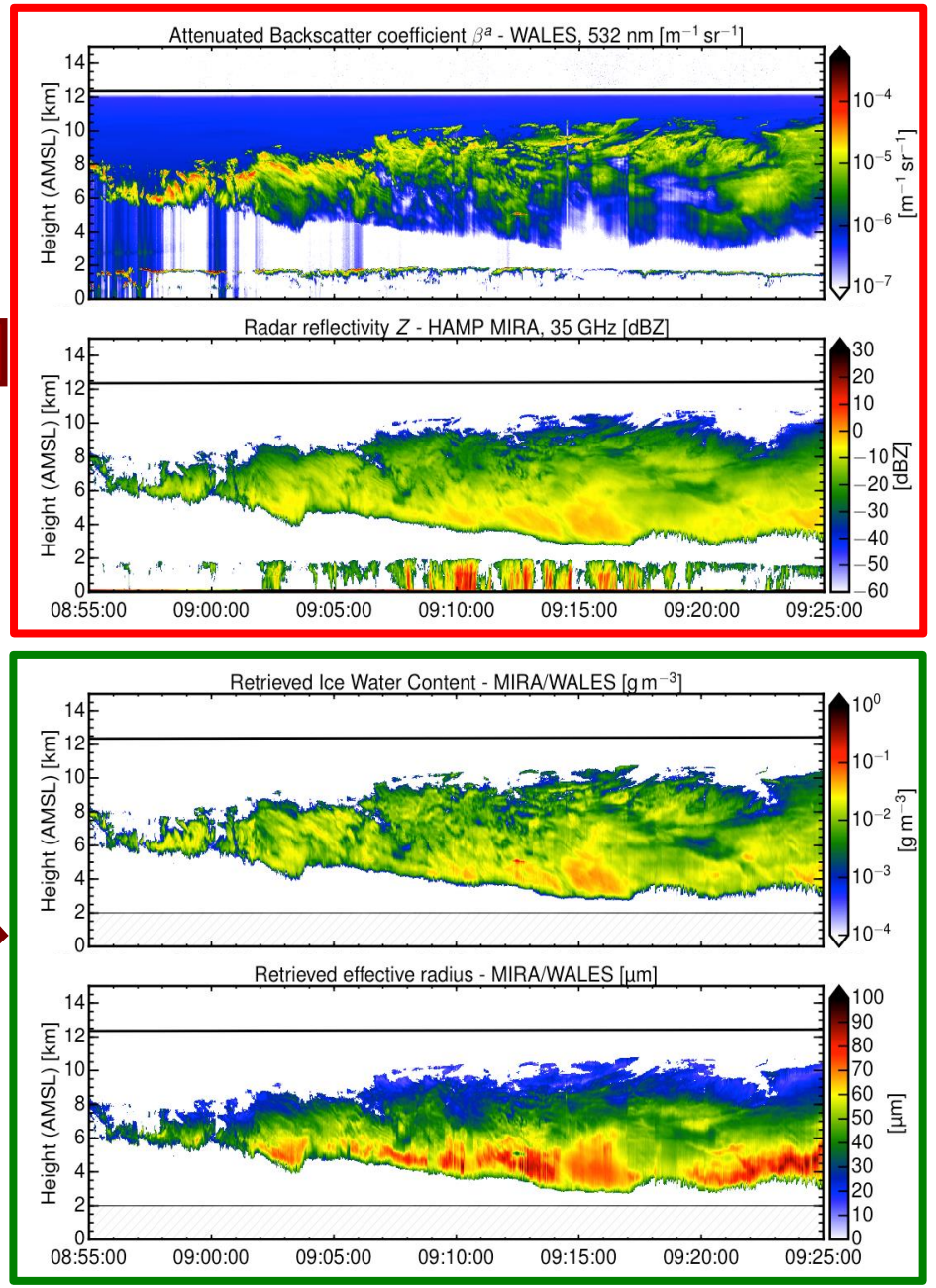
Synergistic retrieval

Combining Radar and Lidar measurements

Optimal estimate approach (Delanoë et al., 2008)

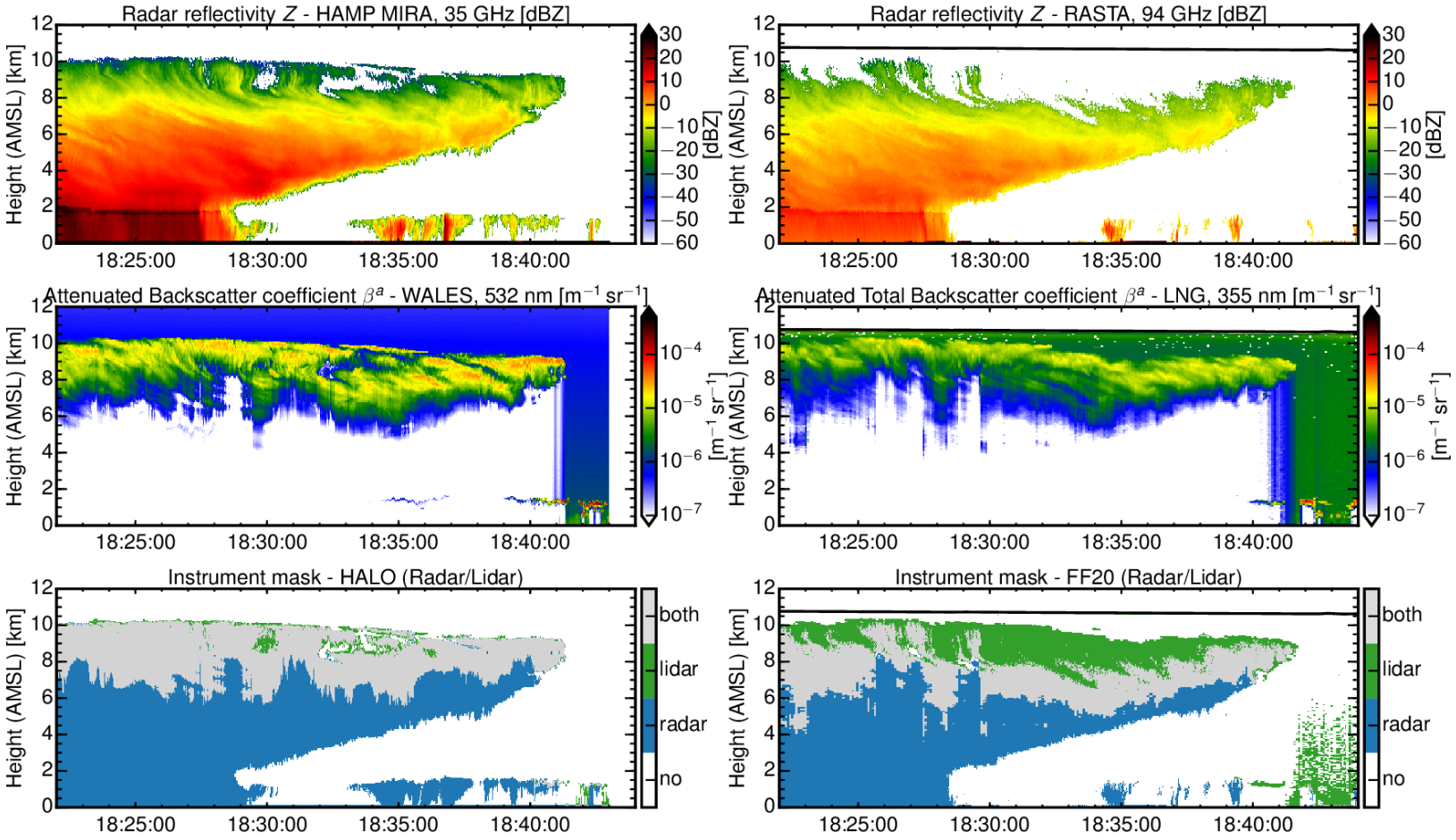


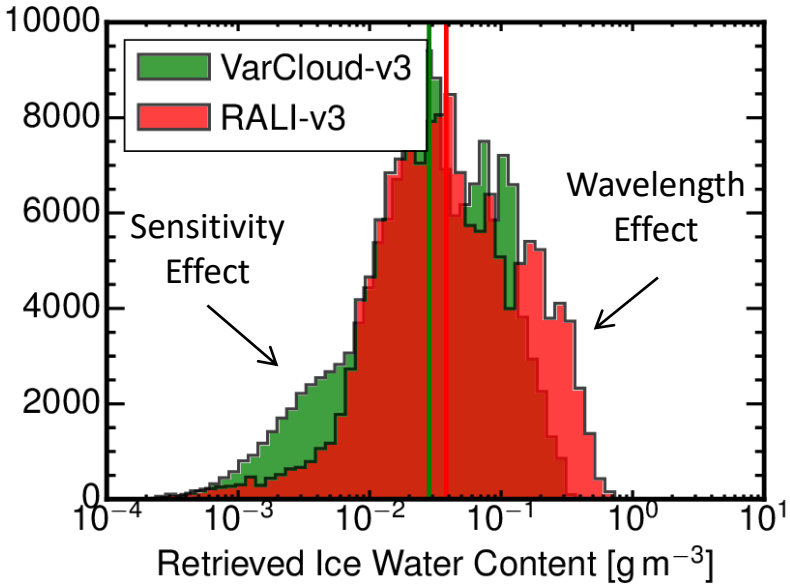
Cazenave et al., 2019



Analysis of multi-wavelength measurements

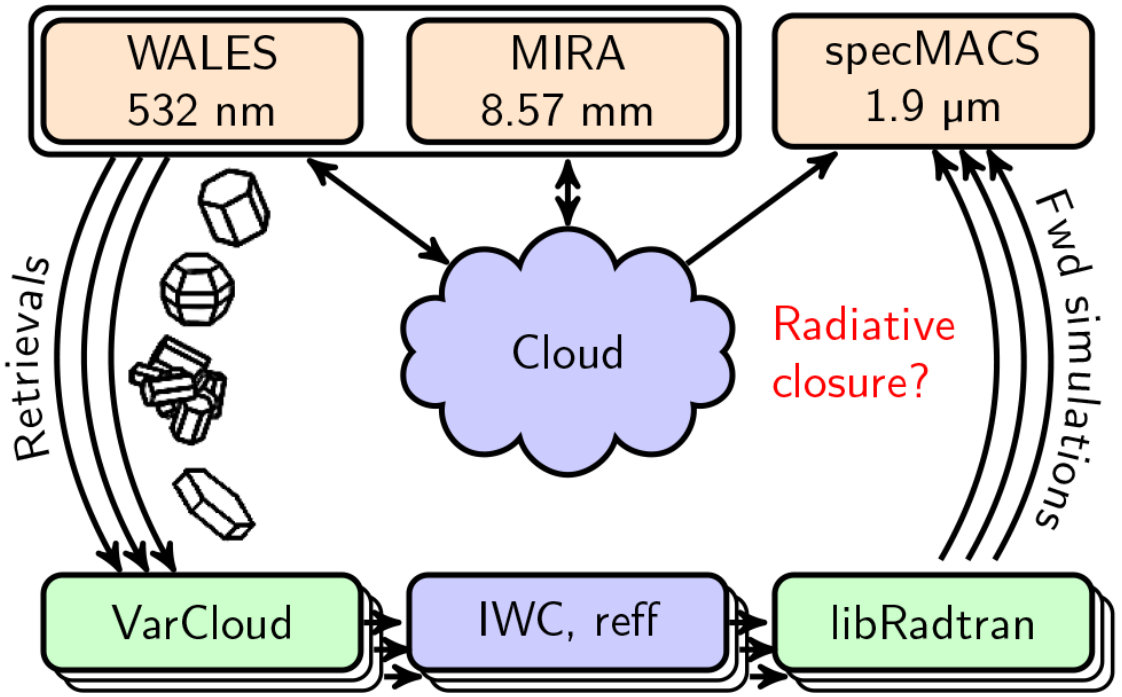
Comparison of Level 1 and Level 2 data between HALO and FF20



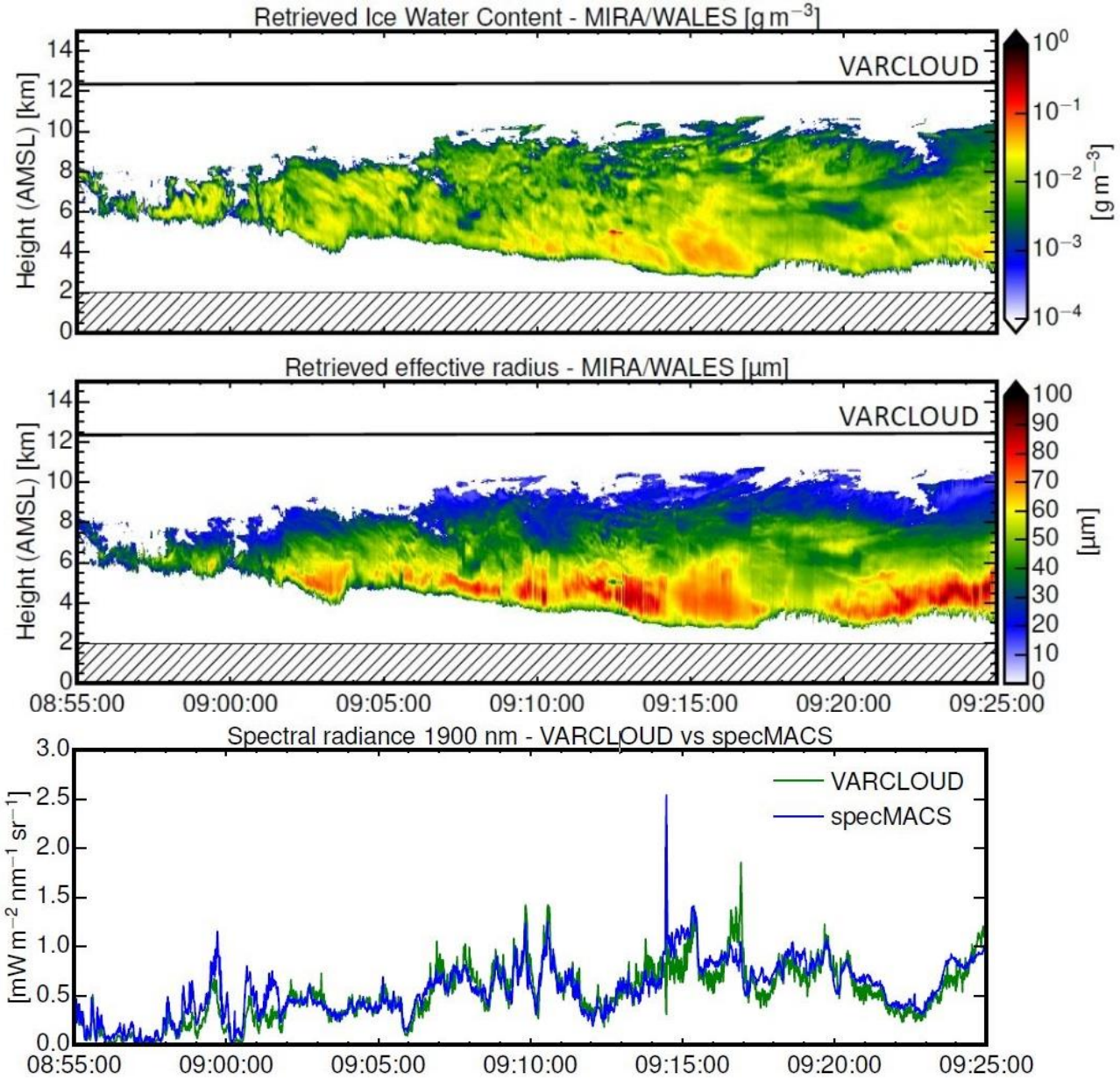


Closure study

Radar-Lidar vs. specMACS – 1 October 2016



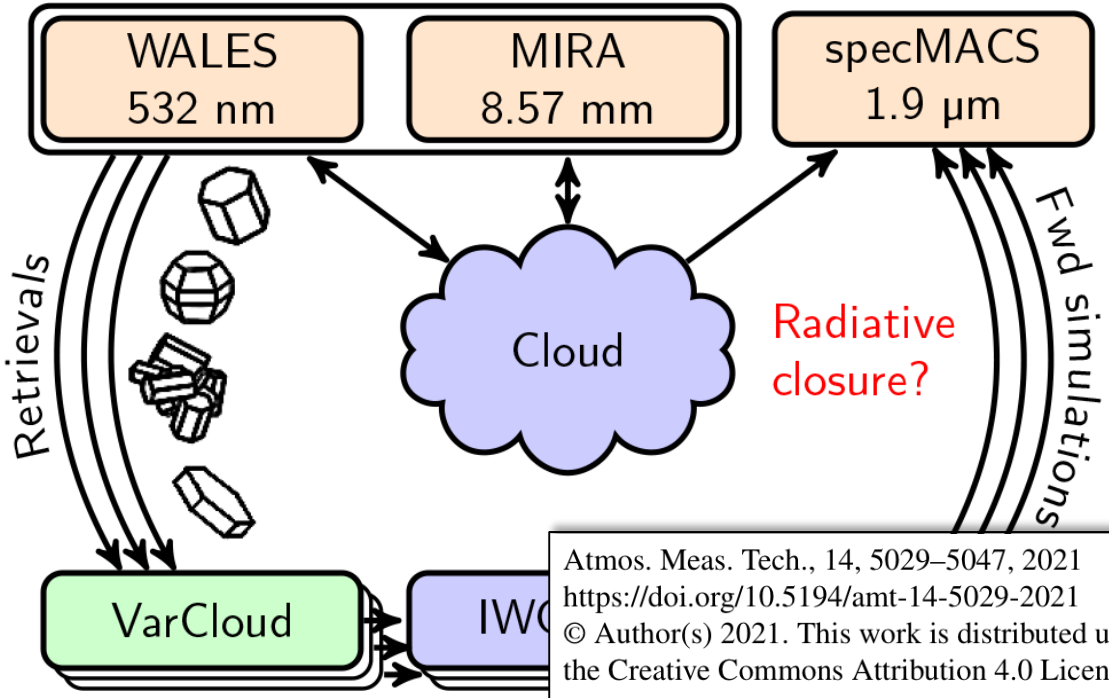
Good agreement of simulated and measured spectral radiance at 1900 nm



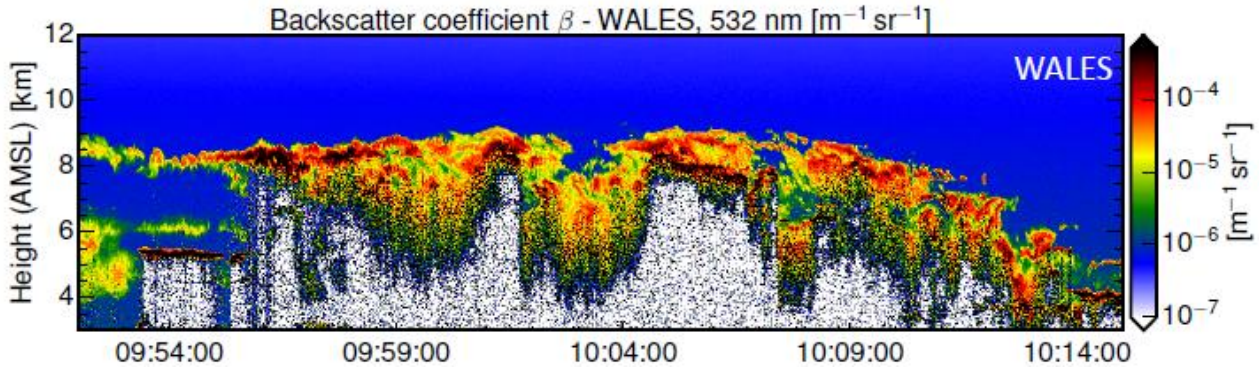
Ewald et al., 2021

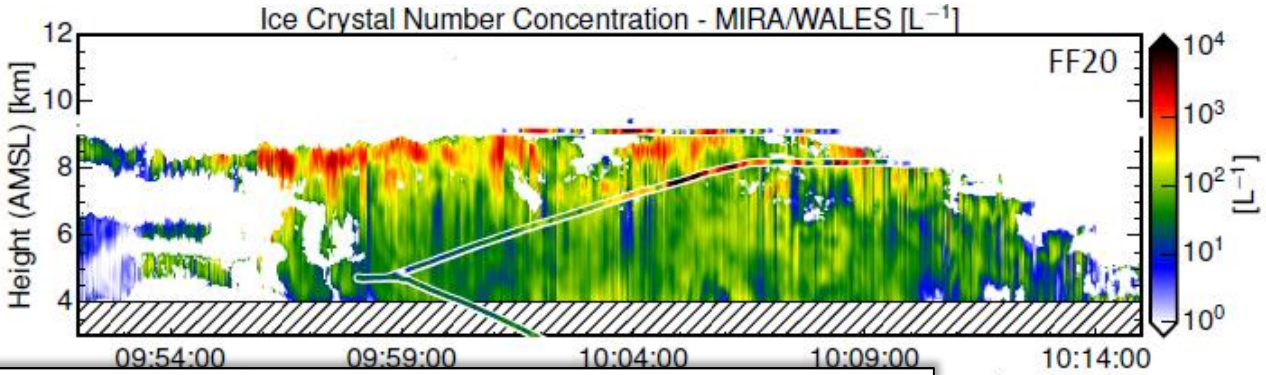
Closure study

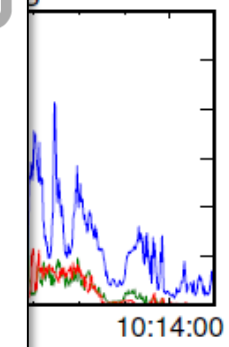
Radar-Lidar vs. specMACS – 14 October 2016



NO agreement of simu
spectral radianc







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https://doi.org/10.5194/amt-14-5029-2021

Atmospheric Measurement Techniques
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Why we need radar, lidar, and solar radiance observations to constrain ice cloud microphysics

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[2]LATMOS/UVSQ/IPSL/CNRS, Guyancourt, France
[3]Met Office, FitzRoy Road, Exeter, EX1 3PB, UK
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Ewald et al., 2021

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The Challenge – Heterogeneity of clouds

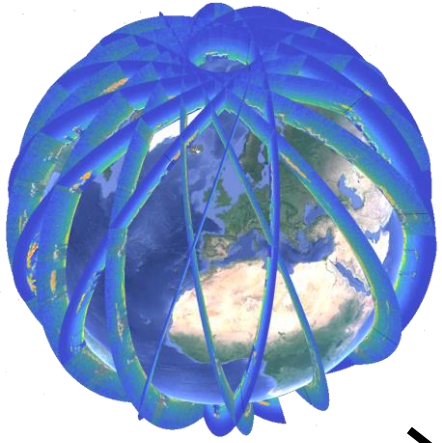
Comparing remote sensing measurement and model results

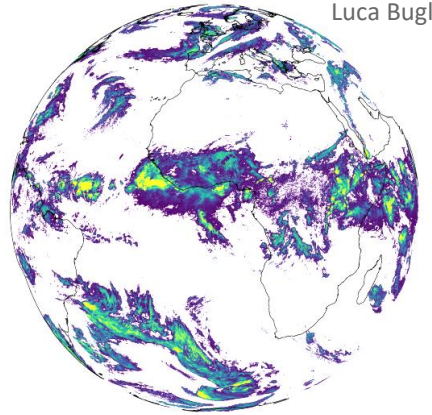
Active (Radar+Lidar)

Retrieval comparison

Passive (Meteosat)

with courtesy of Luca Bugliaro



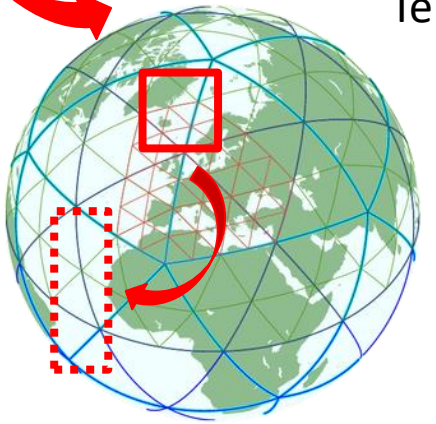


Comparison with models

ERA5 (Reanalysis)

Profile

Spatial
Temporal



DARDAR (A-Train)

+ global coverage
+ profile coverage
- no spatial coverage
- 1x day (noon)

APICS/CiPS (MeteoS)

+ spatial coverage
+ temporal coverage
- no profile
- signal saturation

Work in collaboration with U. Burkhardt (DLR) and L. Bugliaro (DLR)

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Ice water content

Results along the HALO flight path

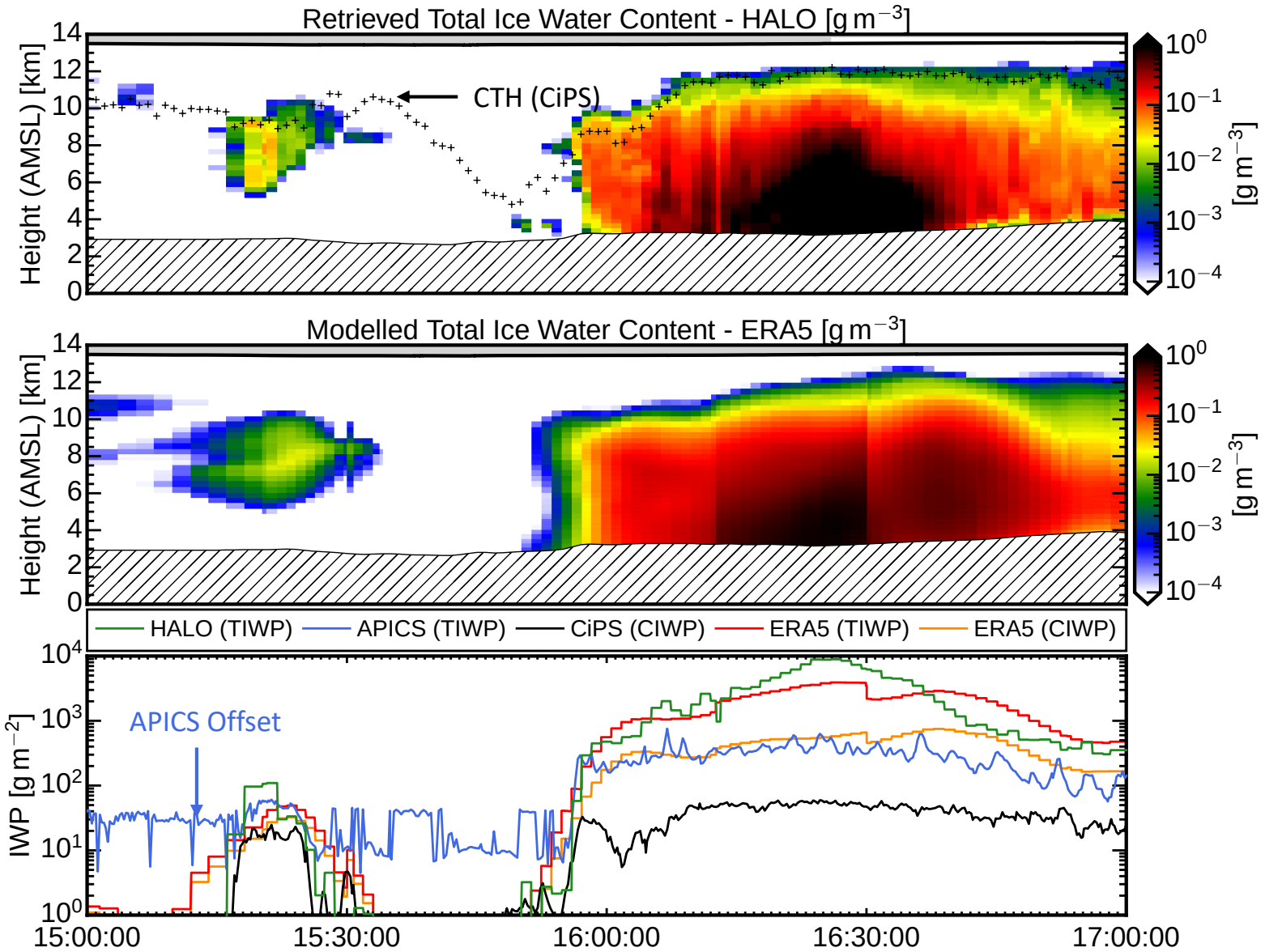
HALO
VarCloud
(IWC)

Direct comparison between HALO, Model and MSG

(NAWDEX RF02 – 21 Sept. 2016)

Model
ERA5
(Ice + Snow)

Meteosat
APICS
CiPS



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Ideas for future validation

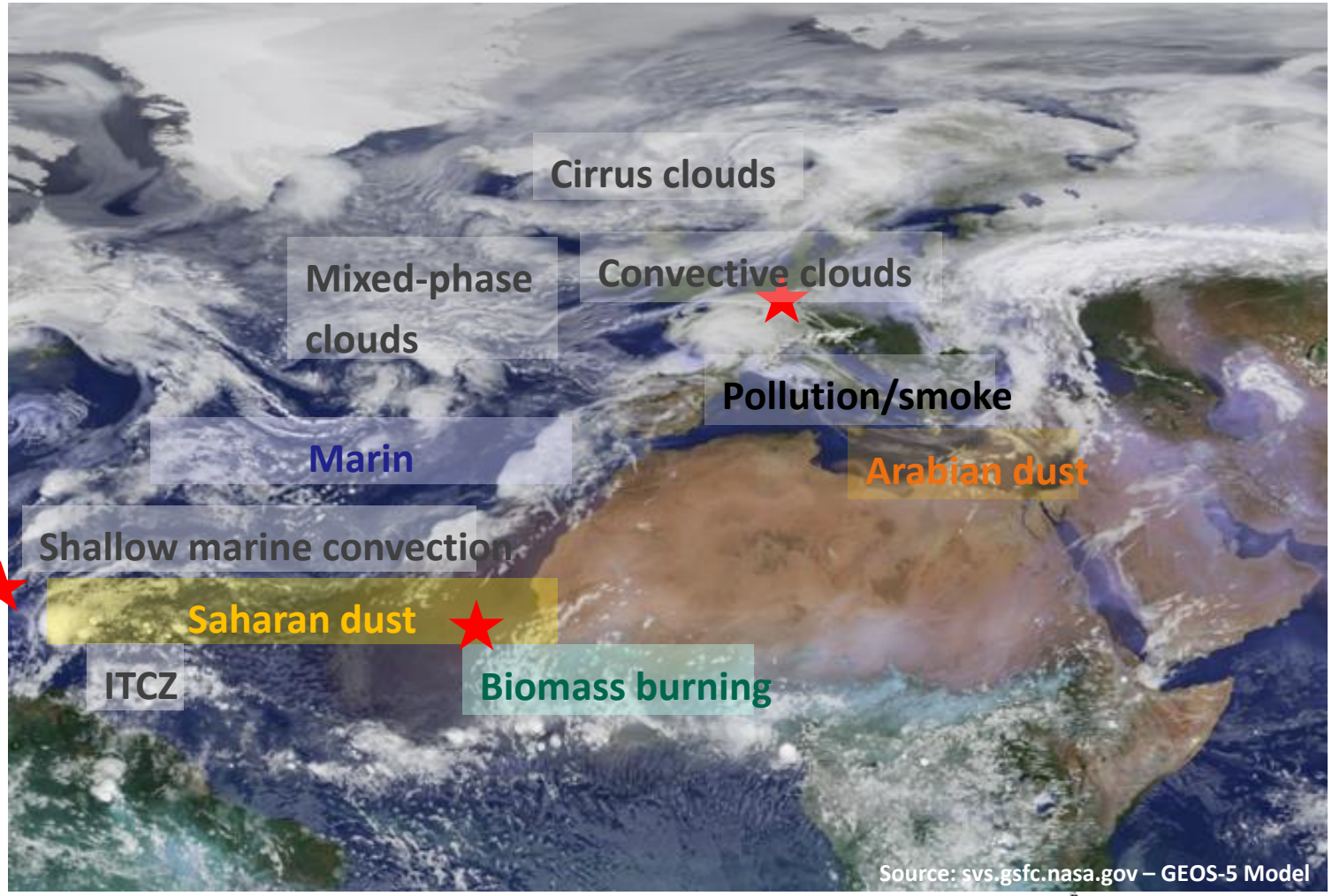
Campaign period – Second half of 2024

Campaign locations

- Germany: Dedicated validation flights
- Barbados: ITCZ, Trades
- Cape Verde: ITCZ, Trades

Campaign duration:
9 weeks of active measurements

- ~246 flight hours (incl. transfer)
- ~ 6 flights / 50 flight hours from Oberpaffenhofen (6 underpasses)
- ~ 10 flights / 100 flight hours from Barbados (6 underpasses)
- ~ 10 flights / 96 flight hours from Cape Verde (6 underpasses)



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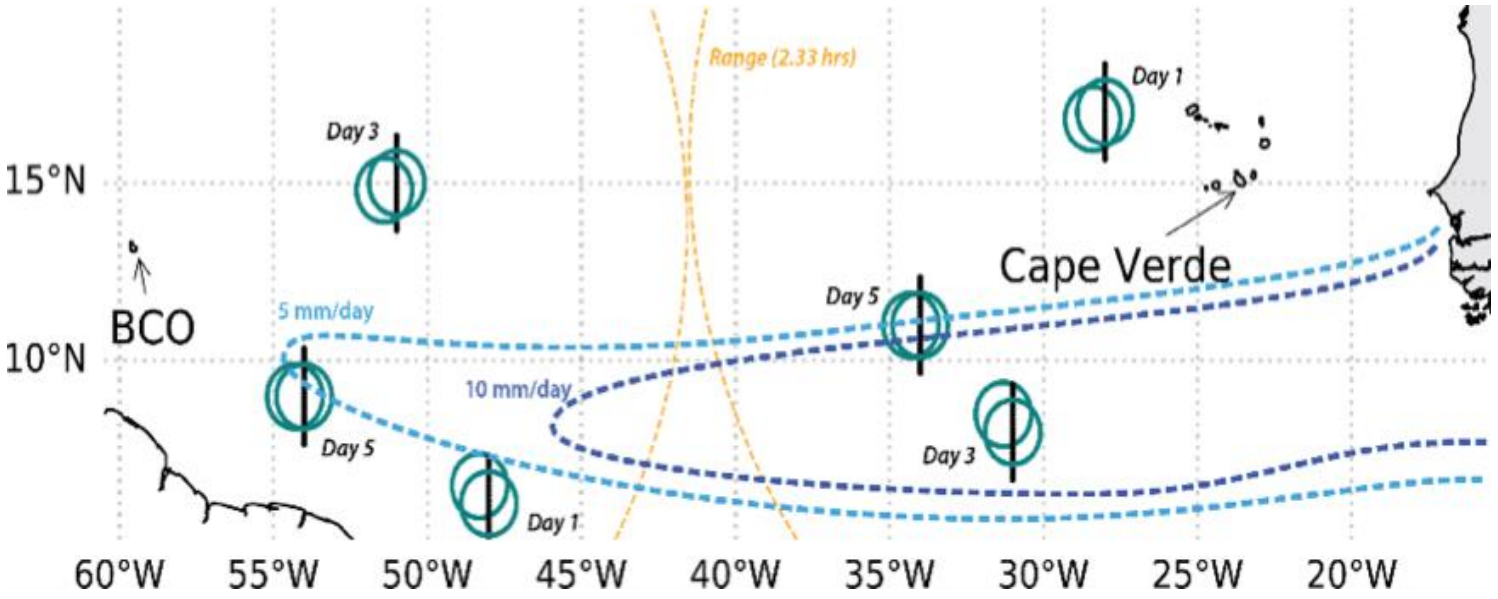
Validation strategy in tropics / sub-tropics

Each flight will incorporate an EarthCare underflight, complemented by 4-5 circles following airmasses: i) in; ii) poleward, or iii) equatorward of the ITCZ (near 8N).



→ **It is planned to have co-located flights with French ATR out of Cape Verde.**
→ **ATR will be equipped with radar-lidar + in-situ payload**
→ **Additionally, we have co-located flights out of OP/Toulouse during 'European part'**

Summary and Outlook

- EarthCARE-like **airborne measurements** are crucial to **prepare for EarthCARE** mission
  - Test and **further development of algorithms (multi-wavelength capability, different resolution)**
  - Rehearsal for **EarthCARE cal/val activities**
- Investigate **benefit and limitation** of future EarthCARE measurements
  - Effects due to **resolution or sensitivity**
- Test and develop ideas to **use EarthCARE data**

Outlook

- Further **EarthCARE-like measurements on HALO planned** for preparation and validation studies
  - **HALO-AC3 in March/April 2022** (extra-tropical North-Atlantic, Arctic)
  - **EC-TOOC** in second half of 2024 (tropics, sub-tropics, extra-tropics / mid-latitudes)

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