Radar-lidar synergy on HALO

Target discrimination and cloud properties

Florian Ewald[1], Silke Groß[1], Martin Wirth[1], Julien Delanoë[2], Clémantyne Aubry[2]

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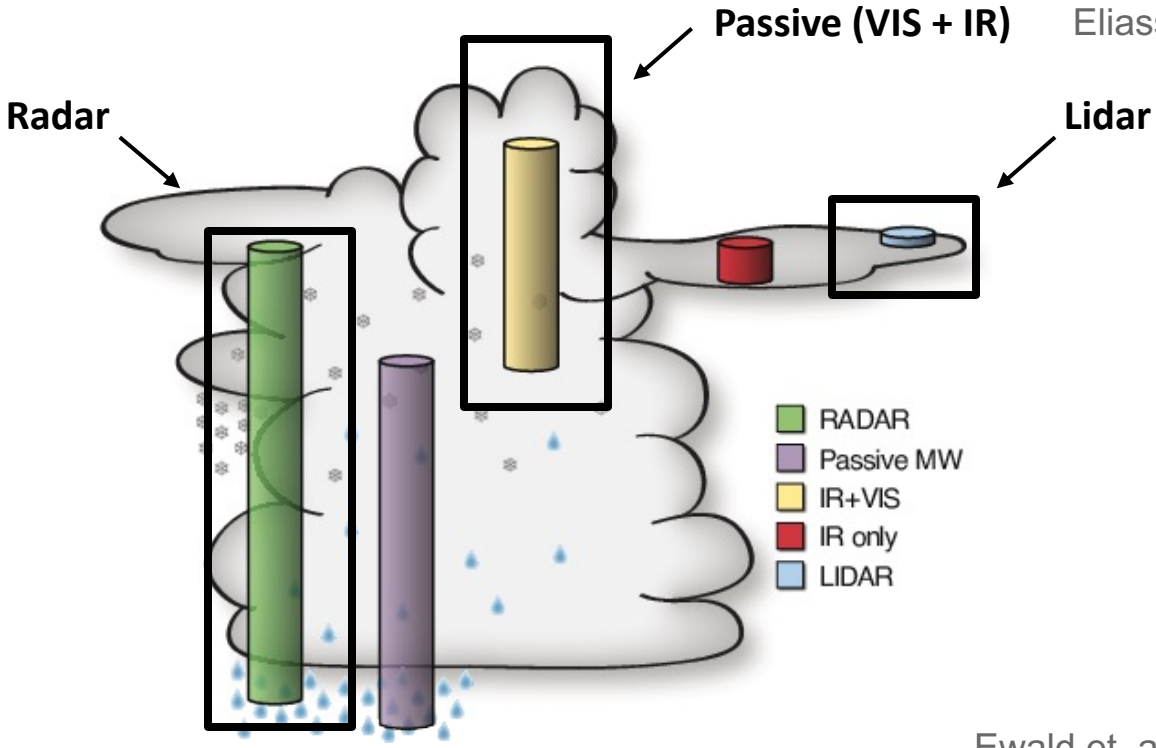
2) LATMOS/IPSL/UVSQ/CNRS, Guyancourt, France

HALO-(AC)3 – 1st quicklook meeting
26 March 2022 – Kiruna, Sweden

Our approach – Combining different sensitivities

Different penetration depths of existing remote sensing methods



Eliassen et. al. (2011)

Ewald et. al. (2021)

Atmos. Meas. Tech., 14, 5029–5047, 2021
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
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[4]Meteorologisches Institut, Ludwig-Maximilians-Universität, Munich, Germany

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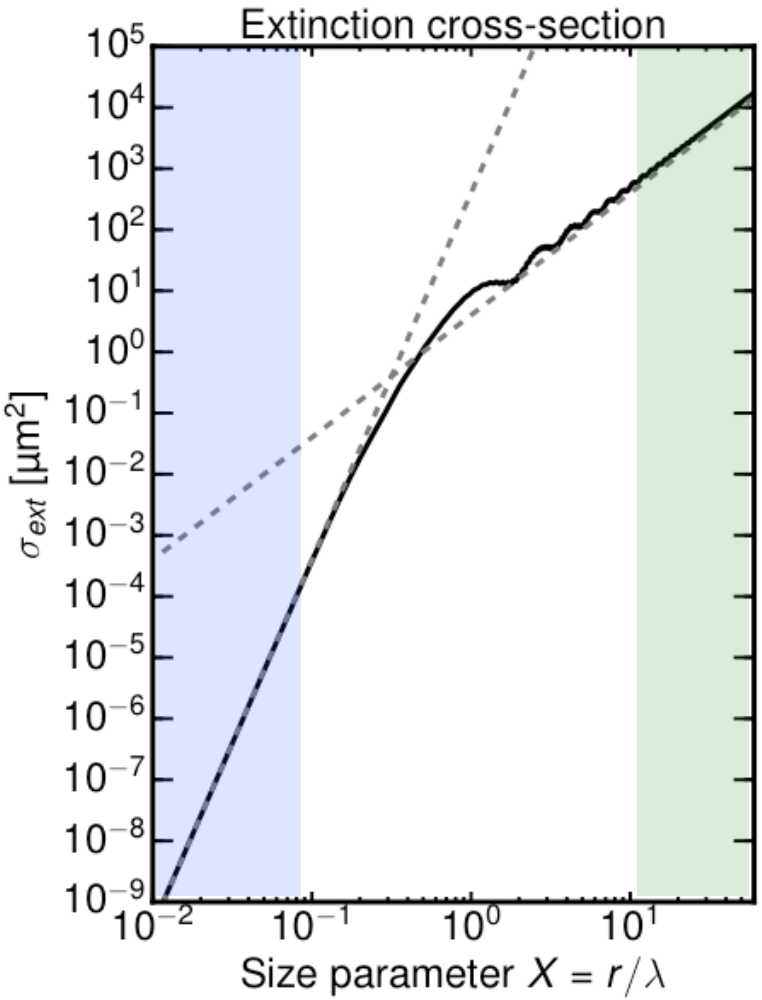
Combined ice cloud retrieval: Physical basis

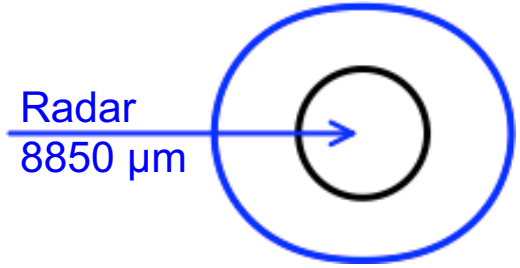
Exploting different scattering regimes by using different wavelengths



Ice Cloud Crystals: 5 ~ 1000 µm

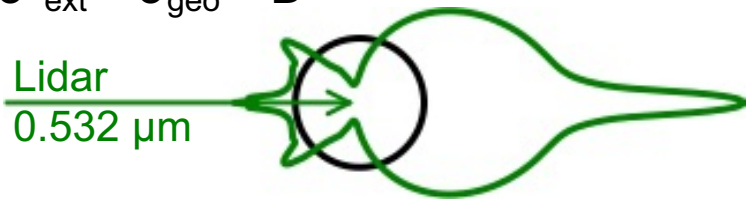
Rayleigh

$\sigma^R_{ext} \sim (\sum p)^2 \sim V^2 \sim D^6$



Mie

$\sigma^L_{ext} \sim \sigma_{geo} \sim D^2$



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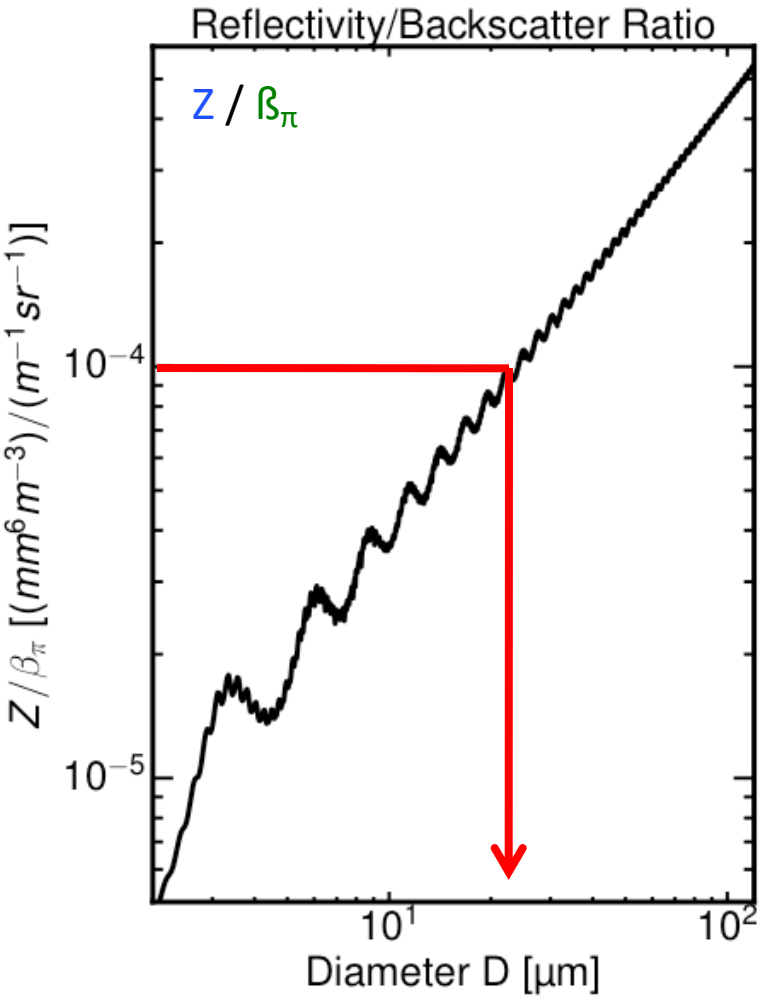


Ice Cloud Crystals: 5 ~ 1000 µm

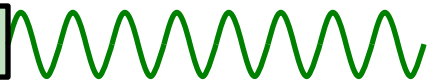
Rayleigh

$\sigma^R_{ext} \sim (\sum p)^2 \sim V^2 \sim D^6$

$Z \sim \alpha^R / 8.3 \sim N\ D^6$

Radar Reflectivity

Mie



$\sigma^L_{ext} \sim \sigma_{geo} \sim D^2$

$ß_\pi = \alpha^L / S(D) \sim N\ D^2$

Lidar Backscatter

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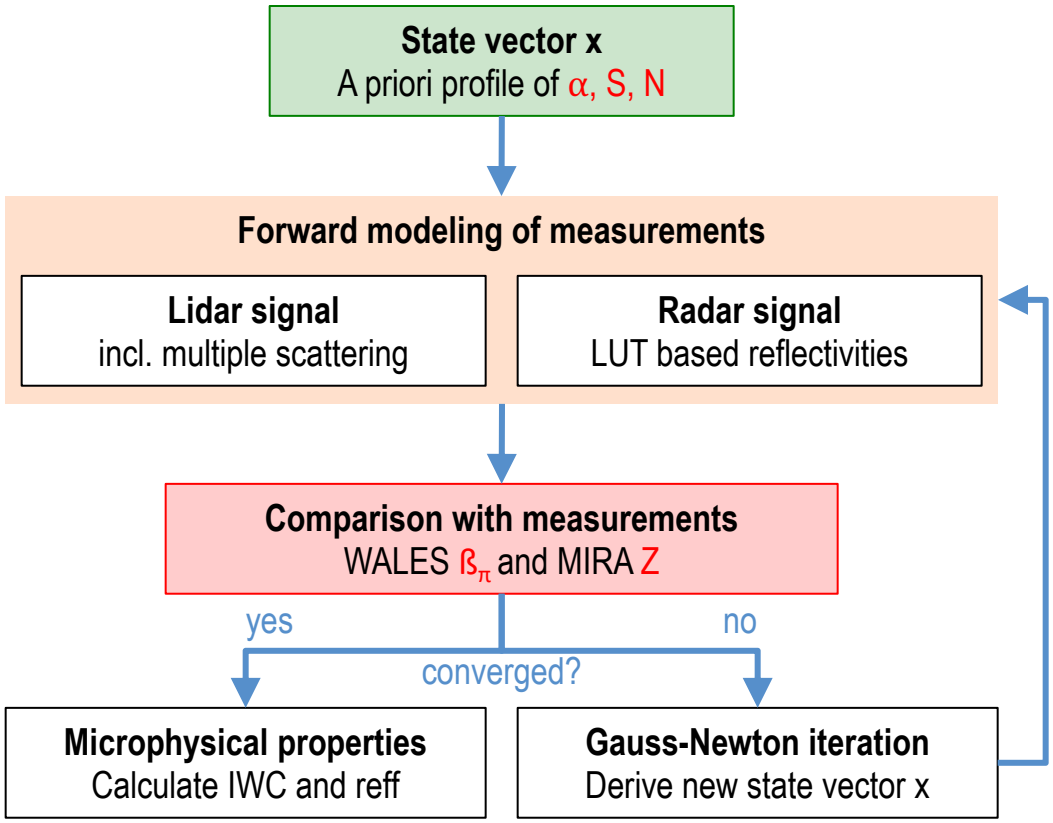
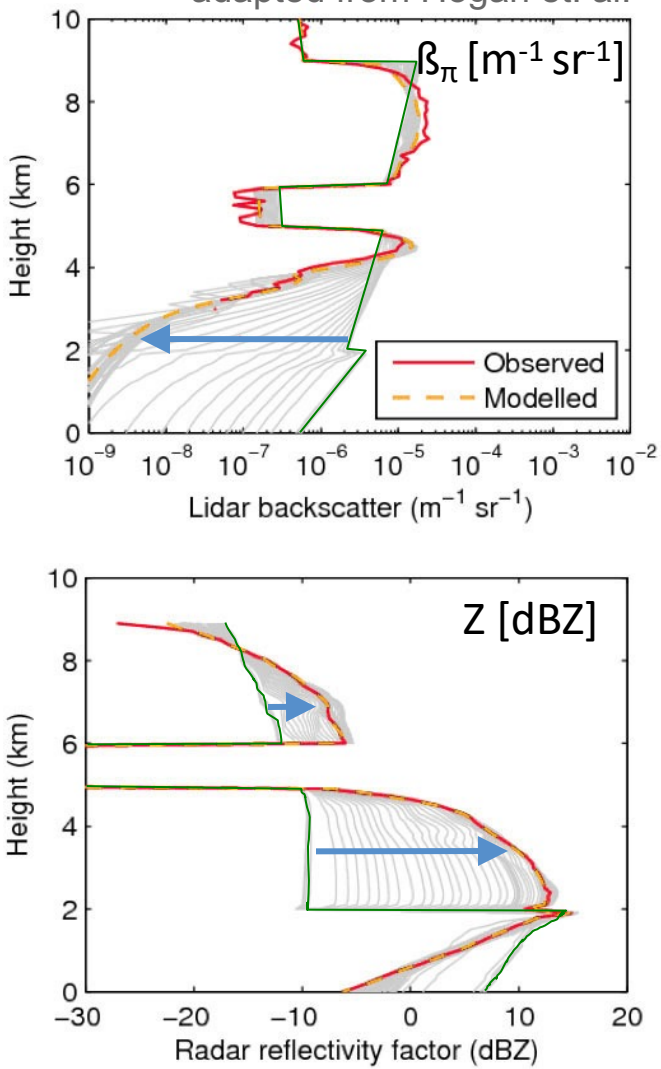
Combined ice cloud retrieval: The algorithm

Comparing the measured with forward modeled signals

Optimal estimate approach of Delanoe et al., 2008:



adapted from Hogan et. al.



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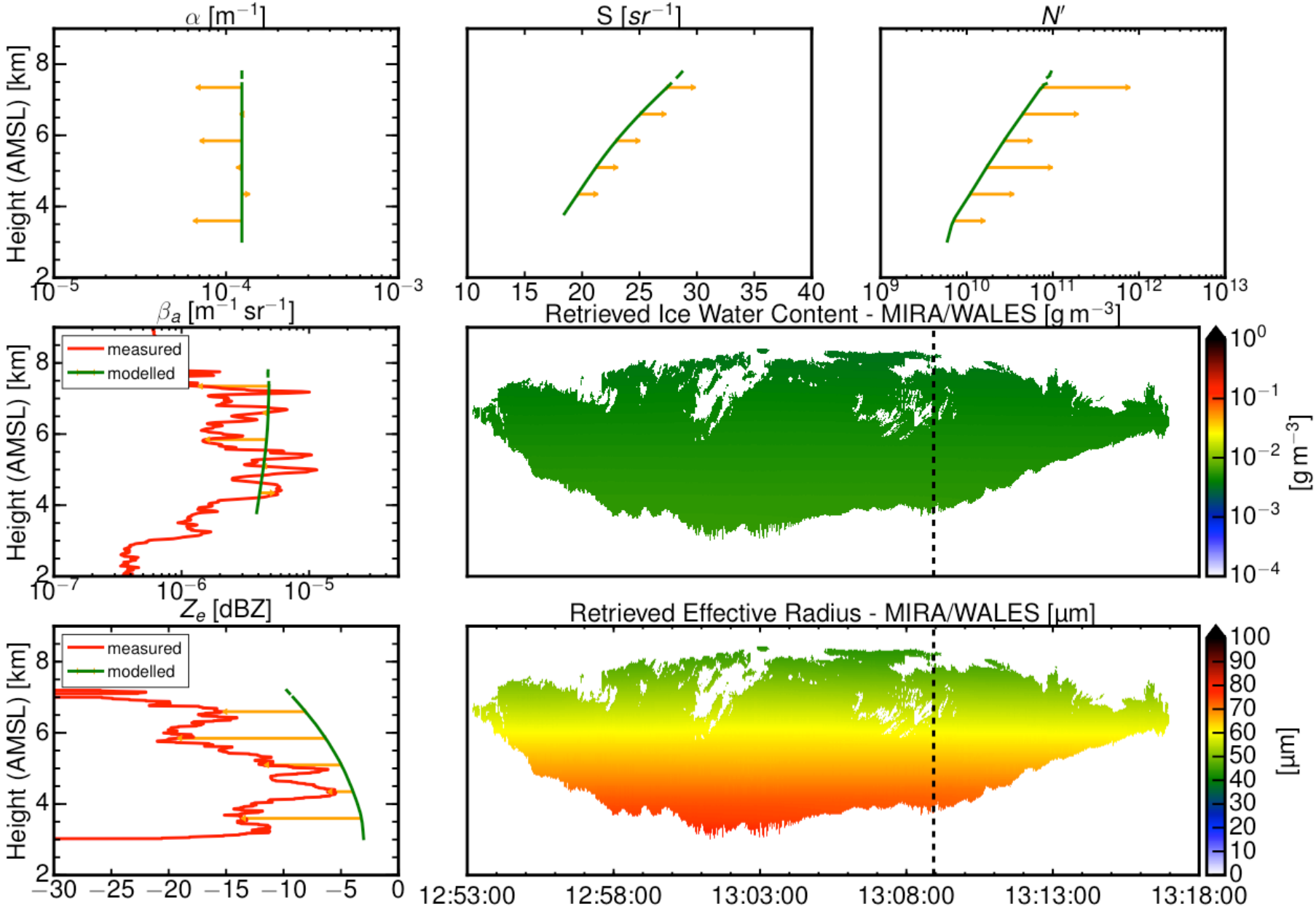
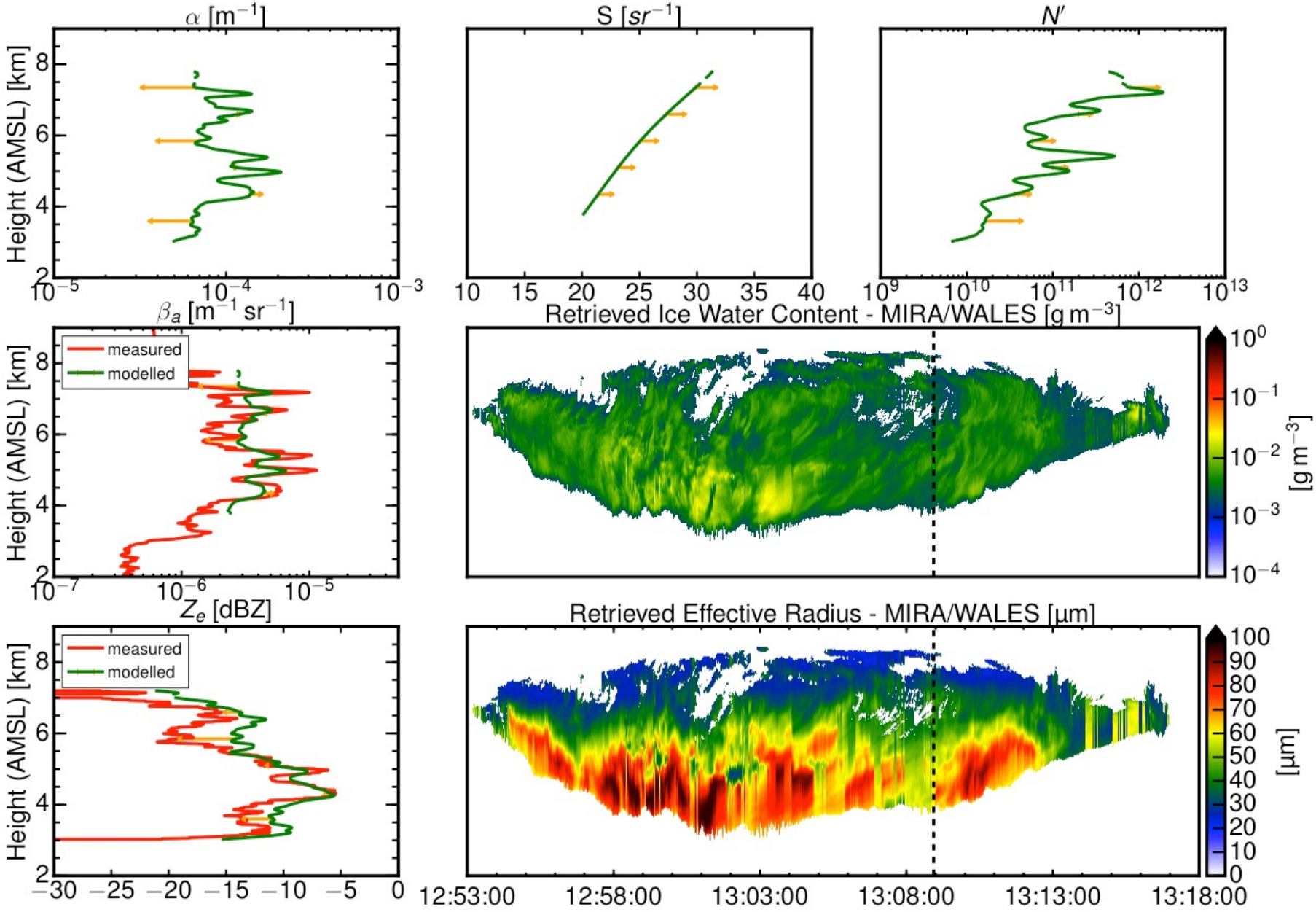
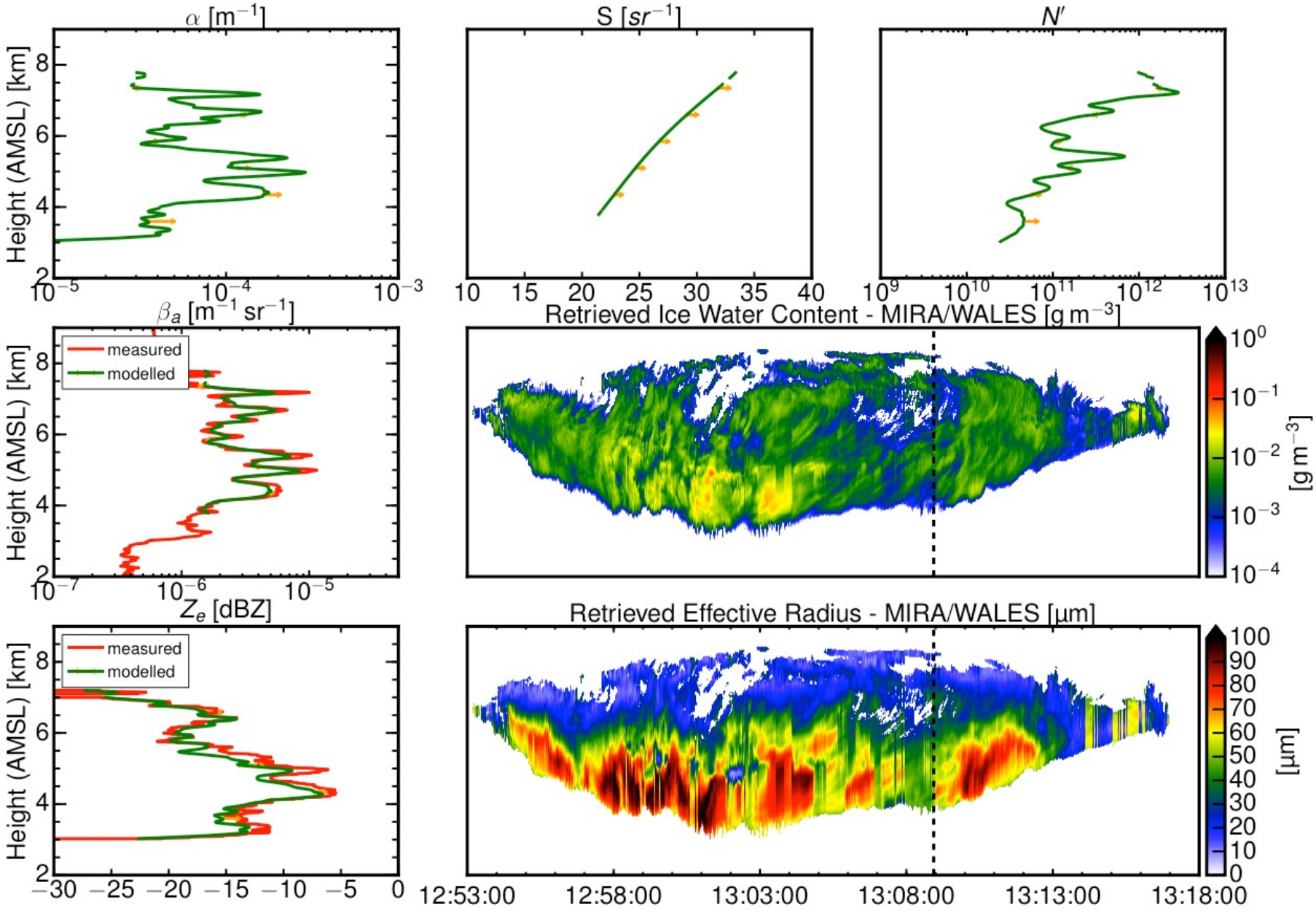

α [m⁻¹]
S [sr⁻¹]
N′
Height (AMSL) [km]
βa [m⁻¹ sr⁻¹]
measured
modelled
Ze [dBZ]
Retrieved Ice Water Content - MIRA/WALES [g m⁻³]
[g m⁻³]
Retrieved Effective Radius - MIRA/WALES [µm]
[µm]
12:53:00
12:58:00
13:03:00
13:08:00
13:13:00
13:18:00

DLR LATMOS


α [m^{-1}]
S [sr^{-1}]
N′
Height (AMSL) [km]
β_a [m^{-1} sr^{-1}]
measured
modelled
Z_e [dBZ]
Retrieved Ice Water Content - MIRA/WALES [g m^{-3}]
[g m^{-3}]
Retrieved Effective Radius - MIRA/WALES [µm]
[µm]
12:53:00
12:58:00
13:03:00
13:08:00
13:13:00
13:18:00

DLR LATMOS


α [m^{-1}]
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N′
Height (AMSL) [km]
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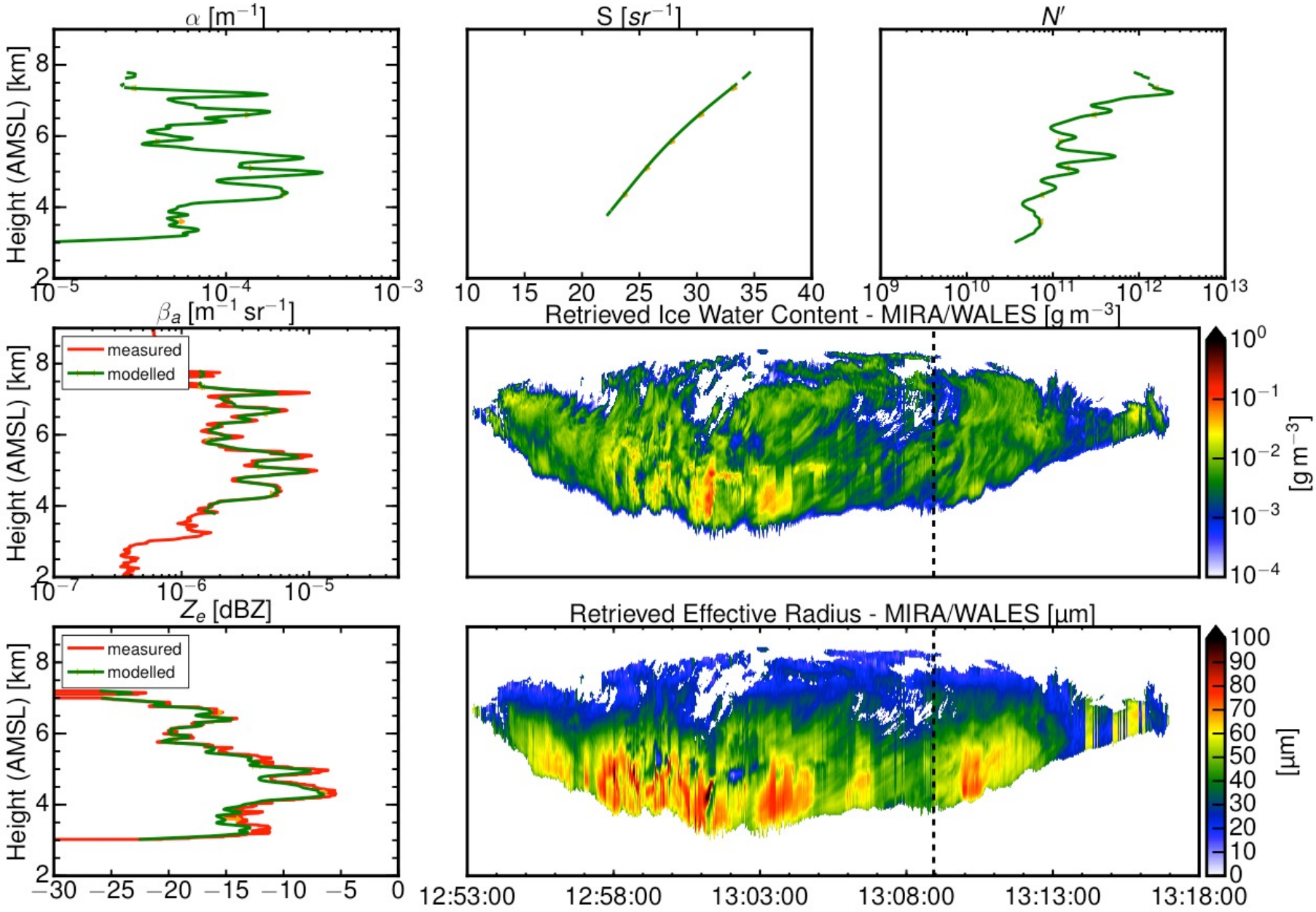
α [m^{-1}]
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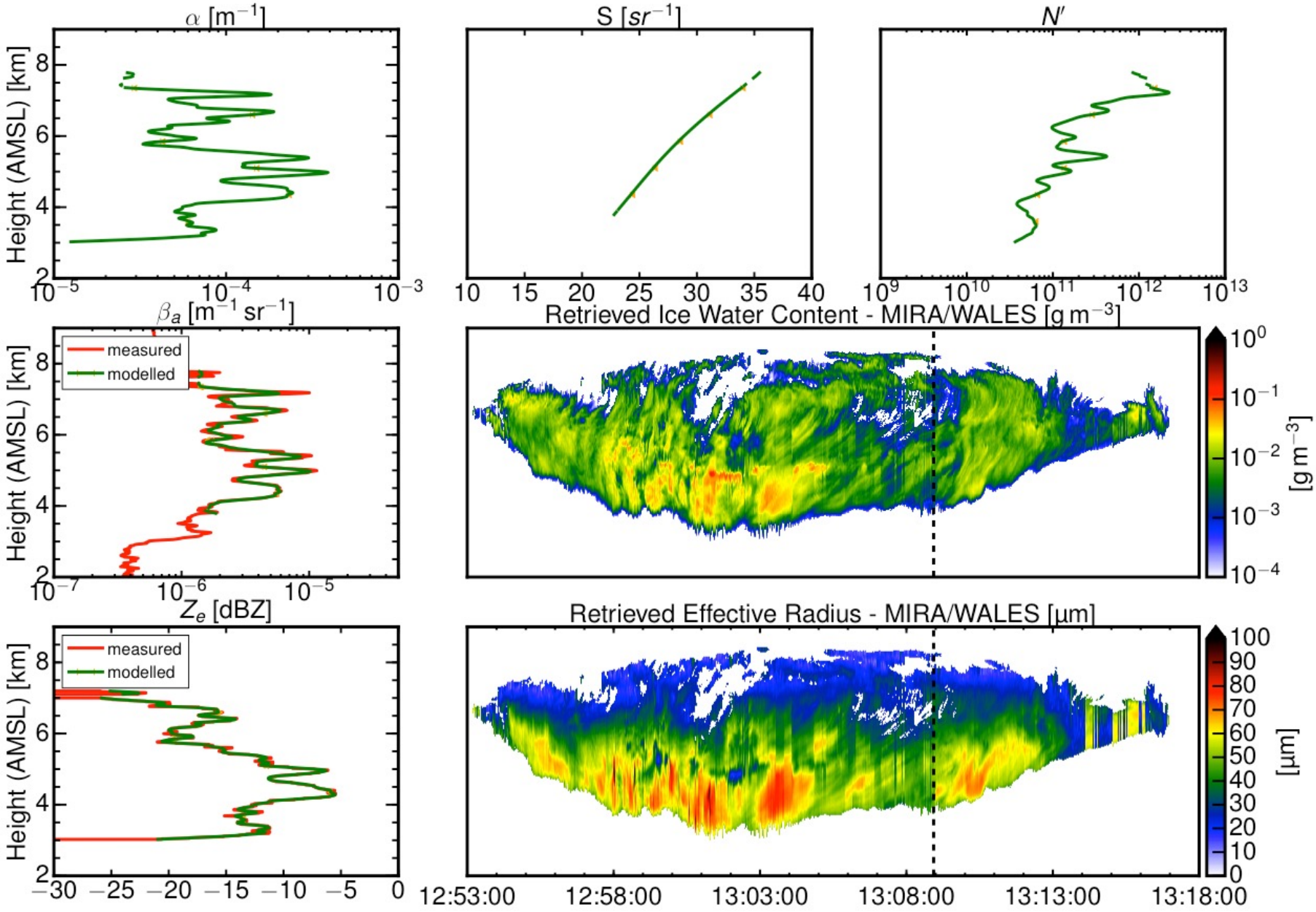
α [m^{-1}]
S [sr^{-1}]
N′
Height (AMSL) [km]
β_a [m^{-1} sr^{-1}]
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[g m^{-3}]
[µm]
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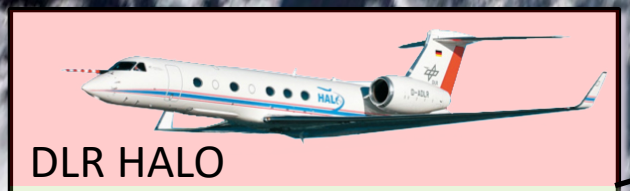
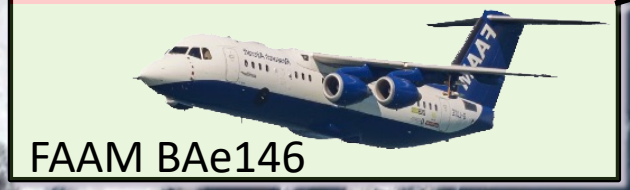
Common flight
RF06 2016/03/16

FAAM BAe-146
HALO

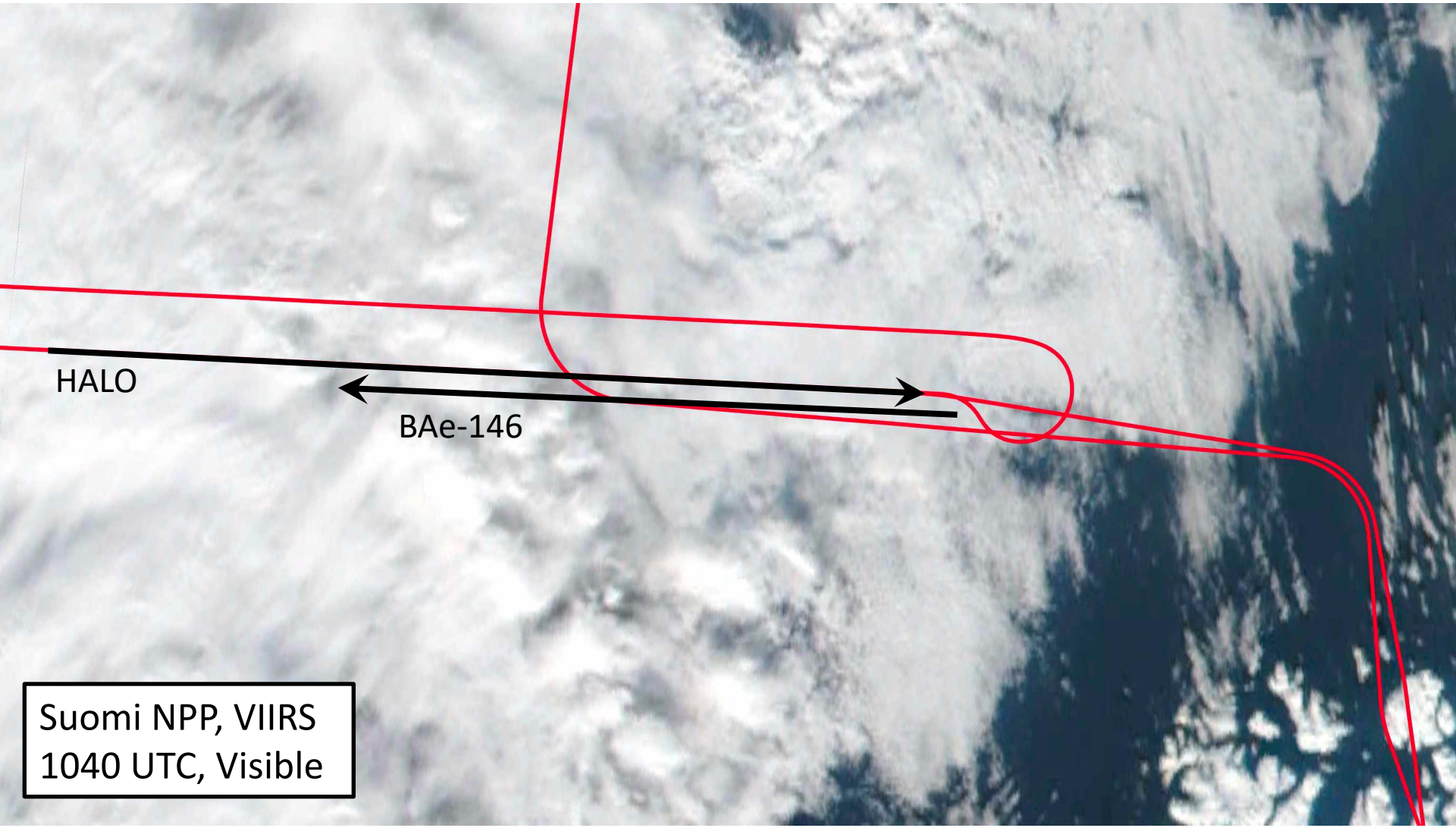




Suomi NPP, VIIRS
1040 UTC, Visible

Common flight – HALO and FAAM BAe-146

HALO-(AC)3 RF06, 2022/03/16



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Common flight – HALO and FAAM BAe-146

HALO-(AC)3 RF06, 2022/03/16

HALO

BAe-146

Suomi NPP, VIIRS
1040 UTC, SWIR

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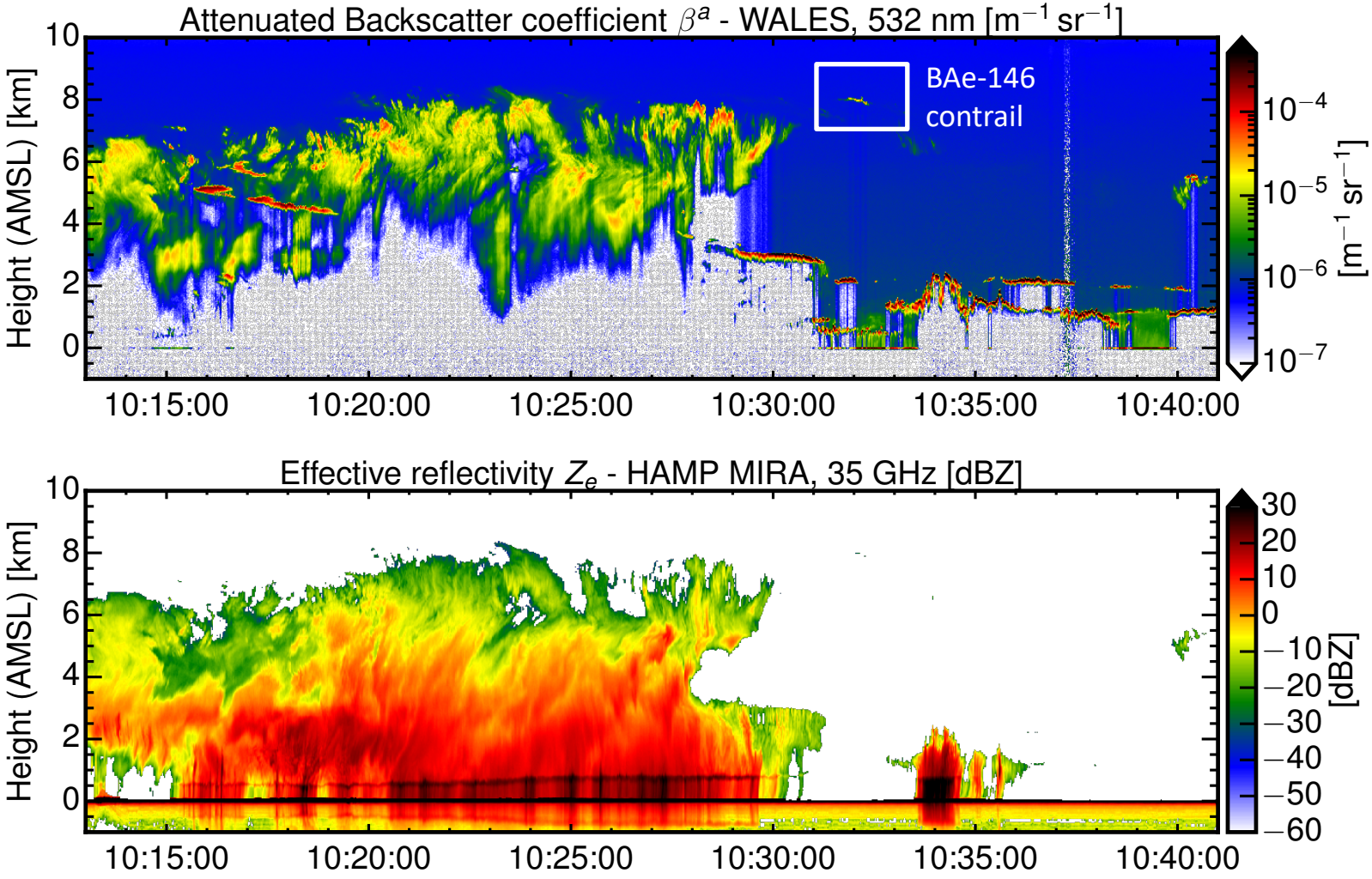
Varcloud input – WALES and MIRA measurements

HALO-(AC)3 RF06, 2022/03/16



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Varcloud input – WALES and MIRA measurements

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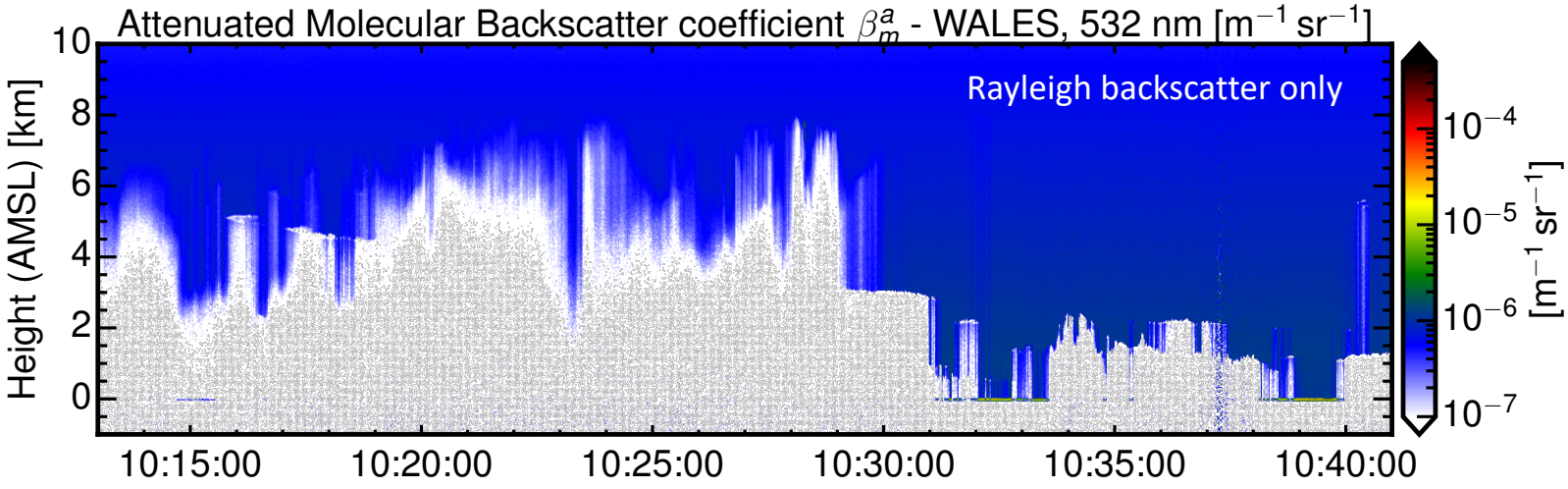

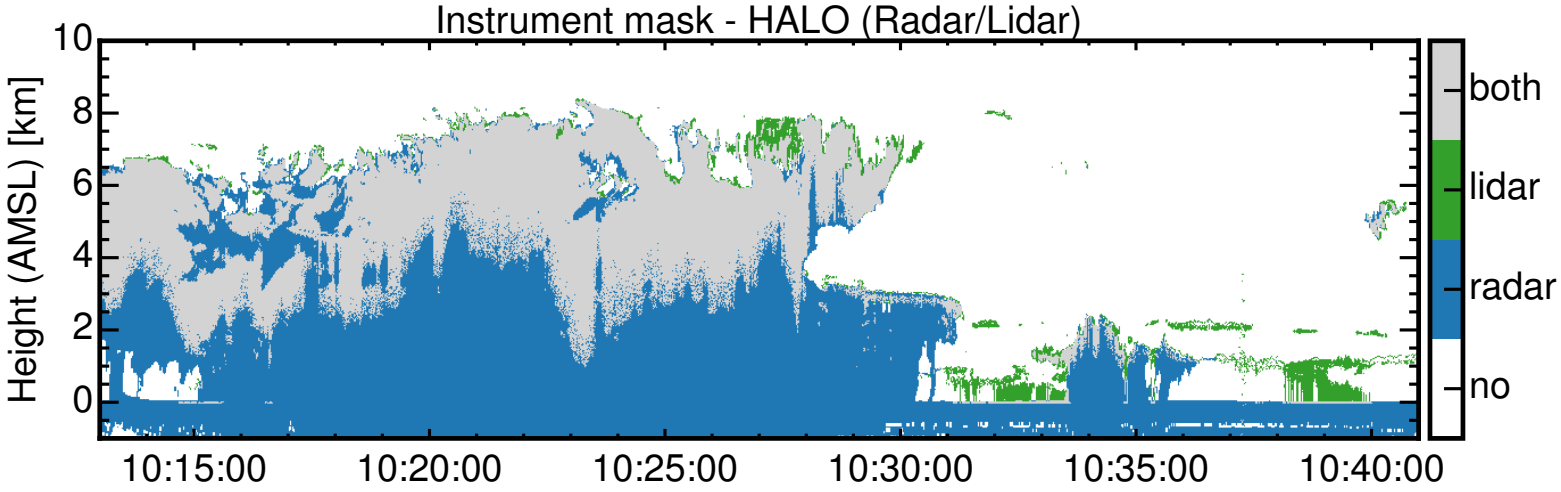

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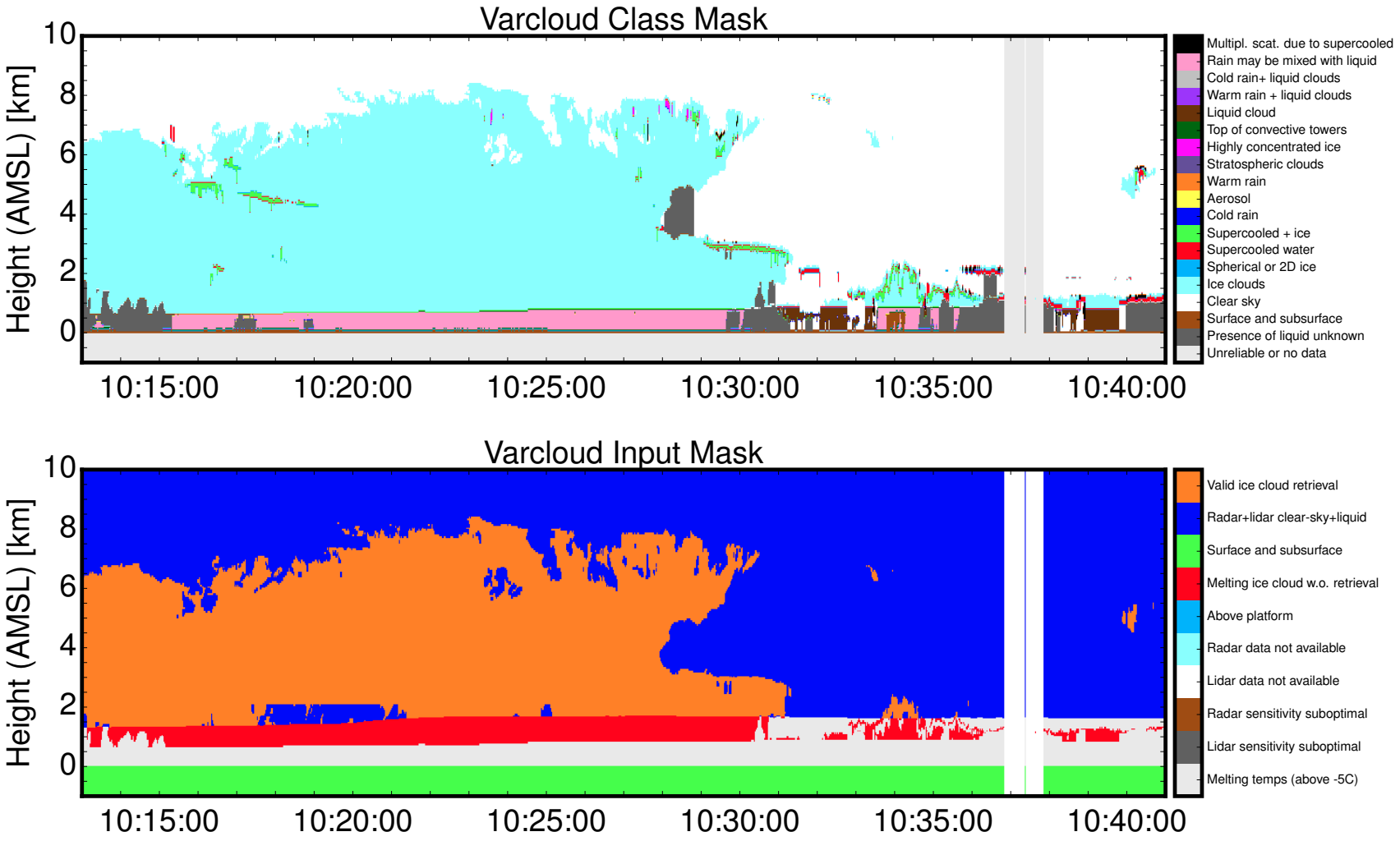
Varcloud mask – Input mask and target discrimination

HALO-(AC)3 RF06, 2022/03/16



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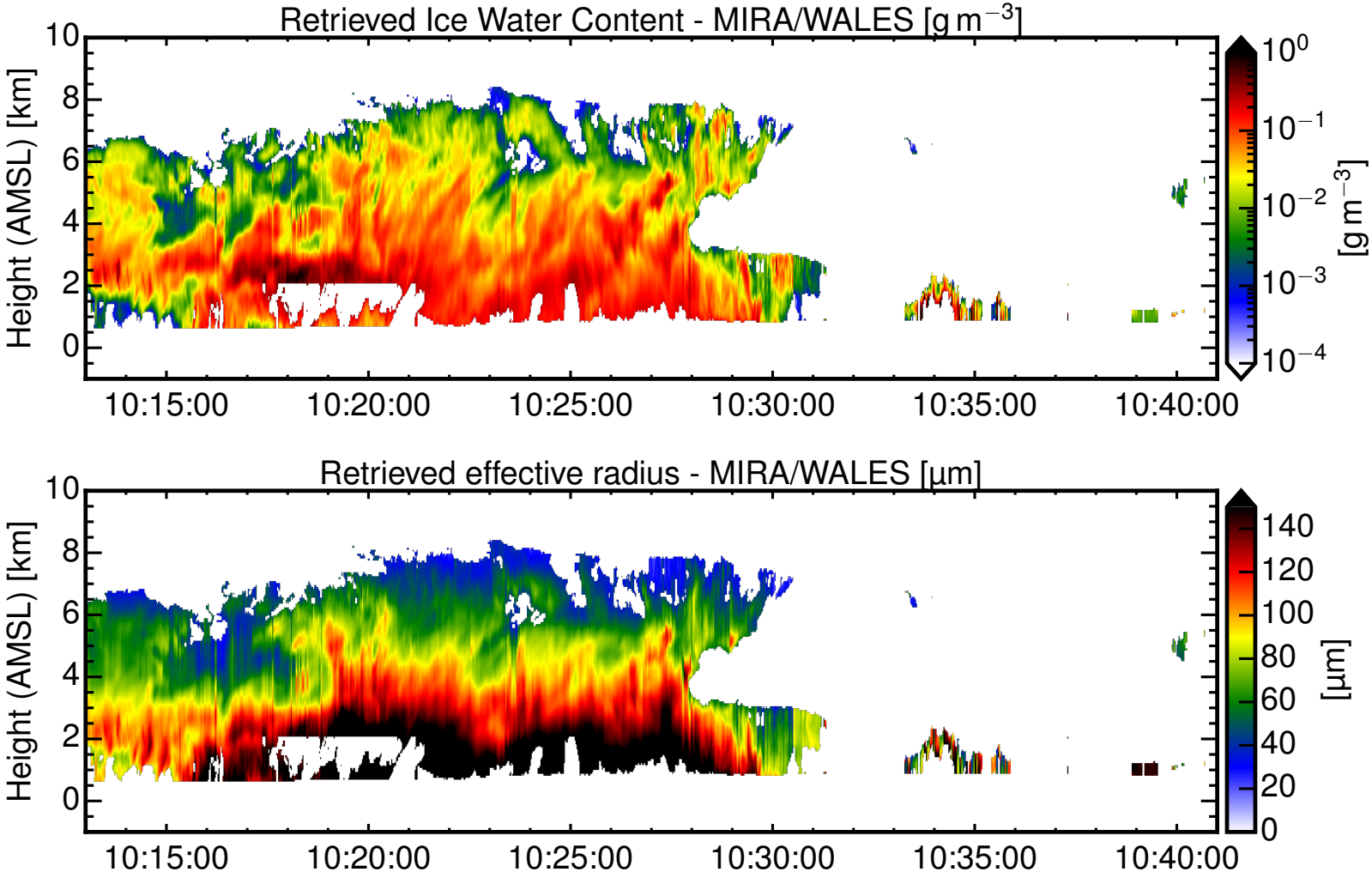
Varcloud result – Ice water content and effective radius

HALO-(AC)3 RF06, 2022/03/16



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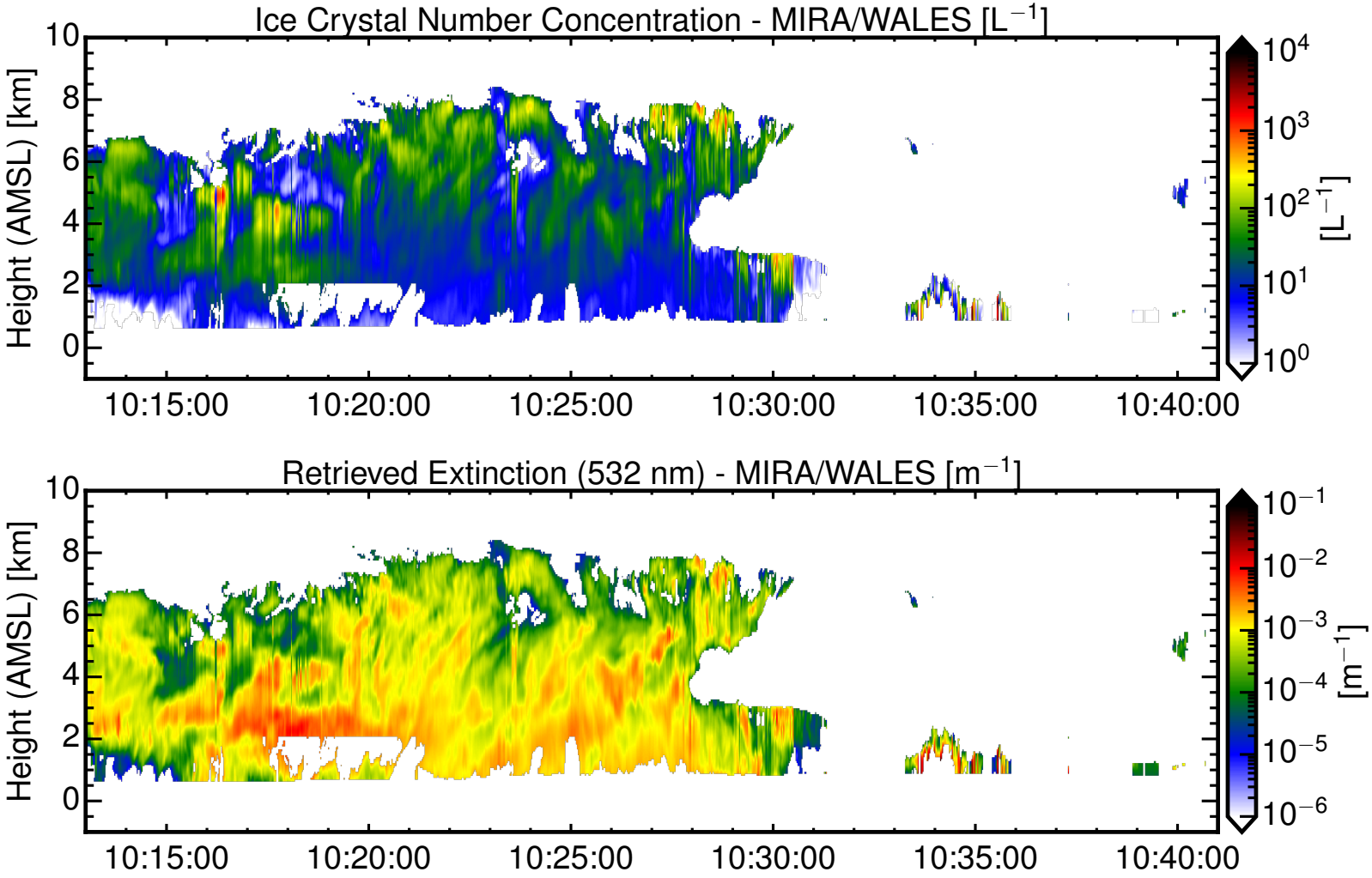

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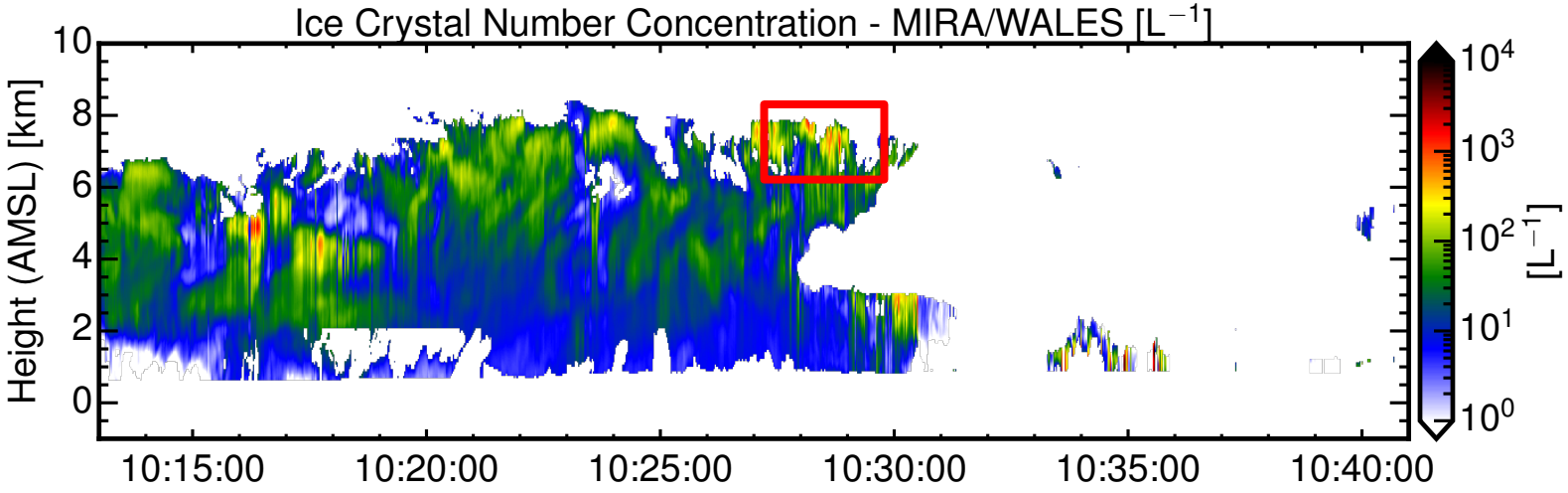
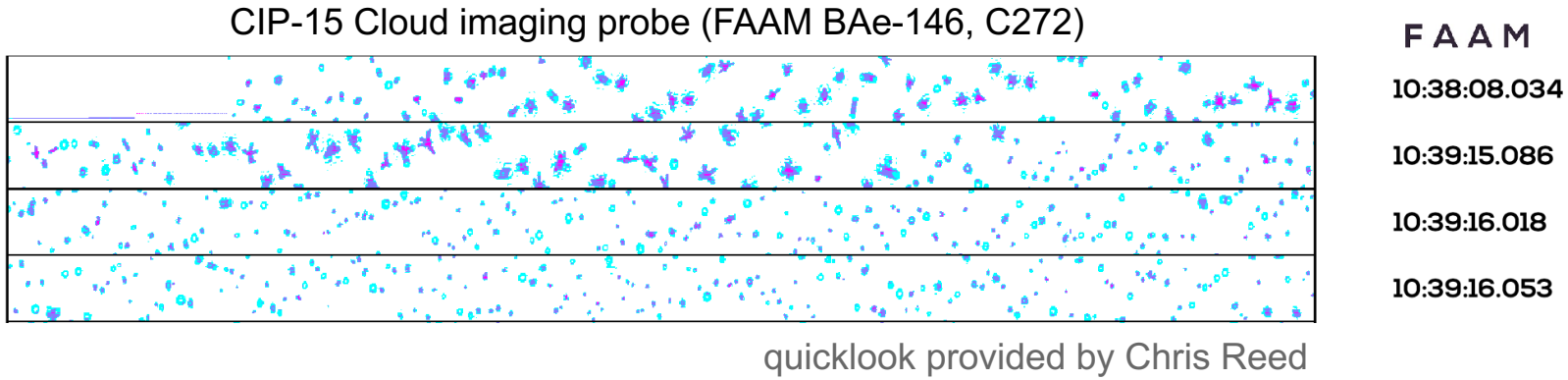
Varcloud result – Comparison to *in situ*

HALO-(AC)3 RF06, 2022/03/16





quicklook provided by Chris Reed

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Varcloud result – Comparison to *in situ*

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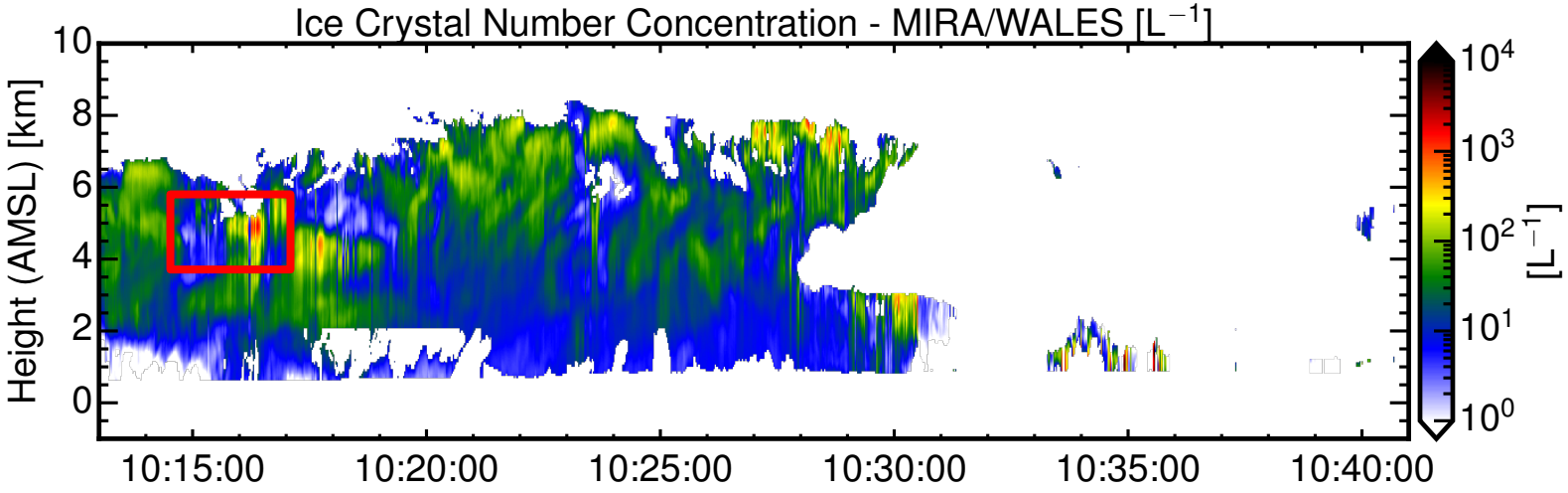

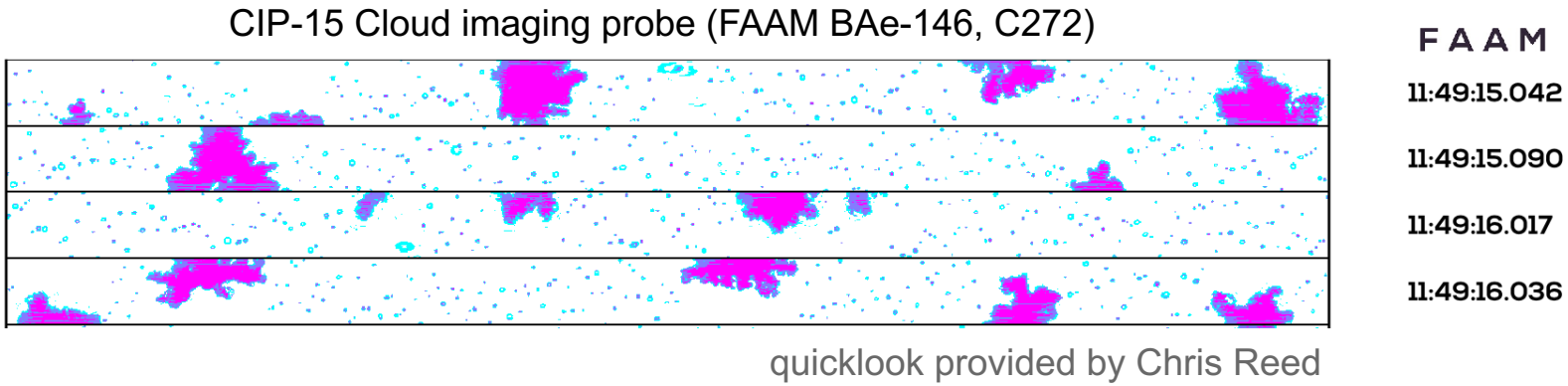

quicklook provided by Chris Reed

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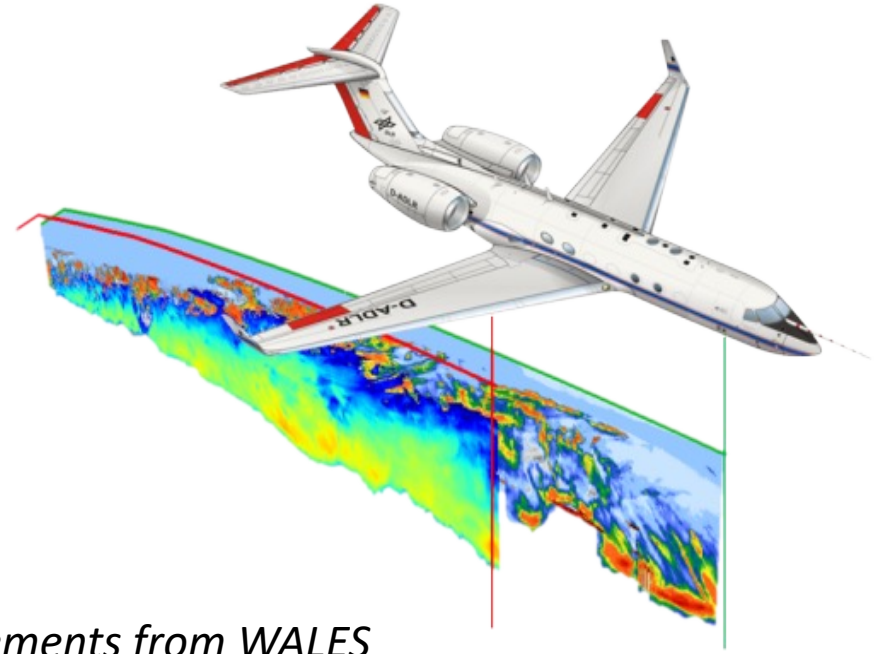
Radar-lidar synergy on HALO during HALO-(AC)3

Summary and outlook



Instrument masks / Target classification

- *Consolidated instrument mask for radar-lidar curtain*
- *Ice / mixed / supercooled discrimination*

Ice cloud microphysics

- *Retrieval of IWC, N_{ice}, reff*
- *Combined analysis with H_2O measurements from WALES*
  "How does enhanced moist transport into the Arctic change the ice cloud optical and micro-physical properties and the radiation budget?"

Further retrieval development towards EarthCARE

- *Microphysics in supercooled and mixed-phased regions*
- *Validation with collocated insitu from Polar/FAAM/ATR*
  ⟶ *PhD **Clémantyne Aubry** (LATMOS / DLR)*

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