First results from the HALO PERCUSION campaign

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1st ESA-JAXA EarthCARE In-Orbit Validation Workshop

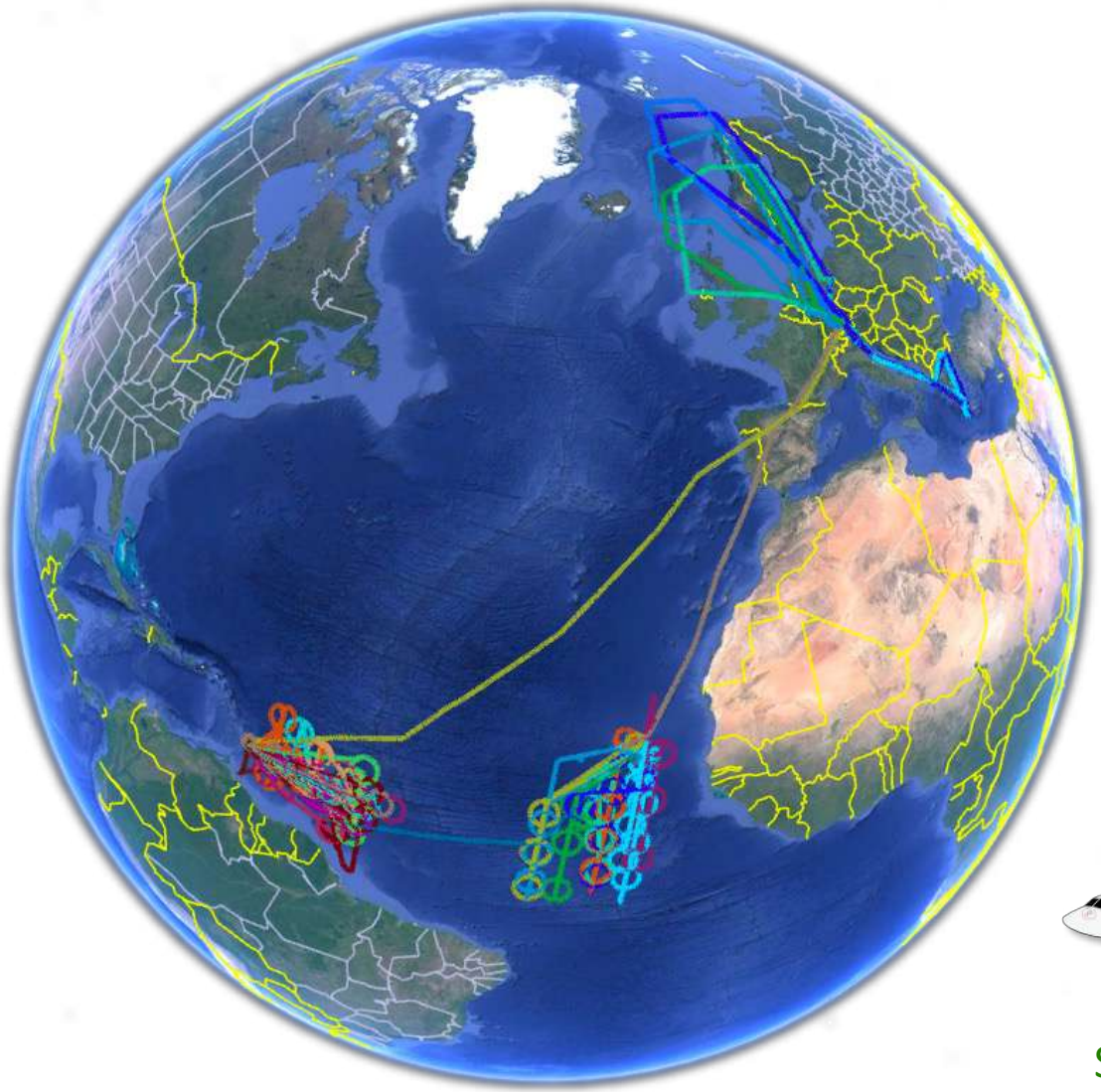
14 – 17 January 2025 | VIRTUAL EVENT

PERCUSION

Persistent EarthCARE underflight studies of the ITCZ and organized convection

PERCUSION – A campaign with a focus on validation

Persistent EarthCARE underflight studies of the ITCZ and organized convection



Campaign period

09 Aug – 19 Nov 2024

Campaign locations

- Cape Verde / Sal: ITCZ, Aerosol
- Barbados: ITCZ, Convective organization
- Germany: Dedicated validation flights

Campaign duration – 9 weeks

- 296 flight hours (incl. transfer and certification)
- 28 Scientific flights: 11 (Sal), 10 (Barbados), 7 (Germany)
- 33 EarthCARE / 4 PACE underpasses
- Embedded within the *ORCESTRA* campaign:

MAESTRO

SAFIRE ATR-42

CELLO

INCAS King Air

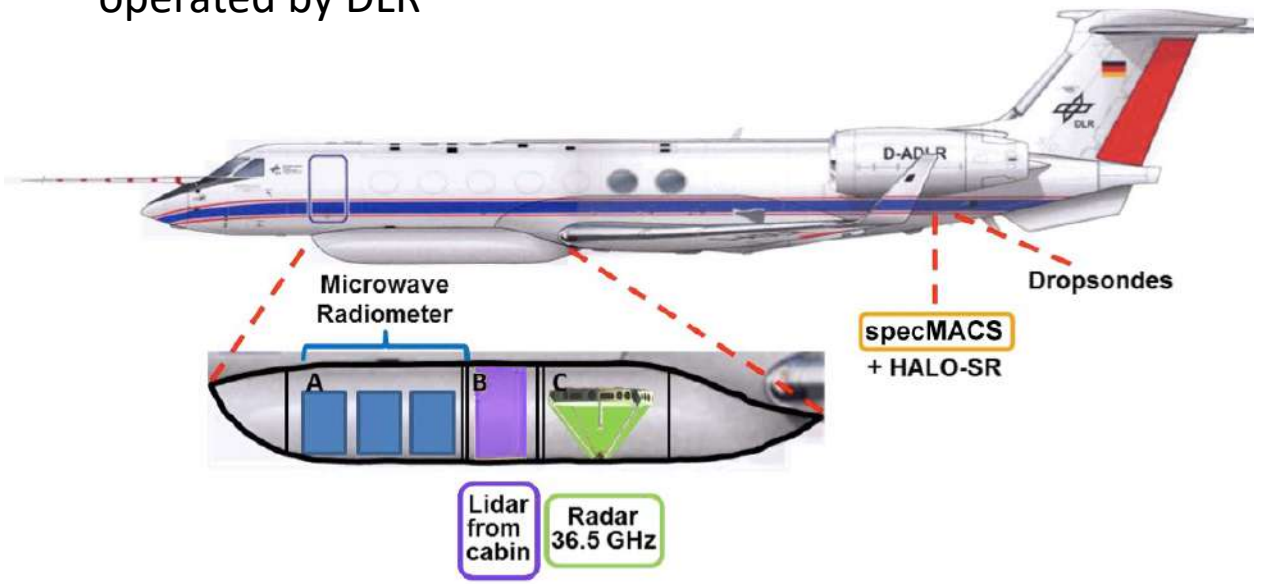
BOW-TIE / PICCOLO

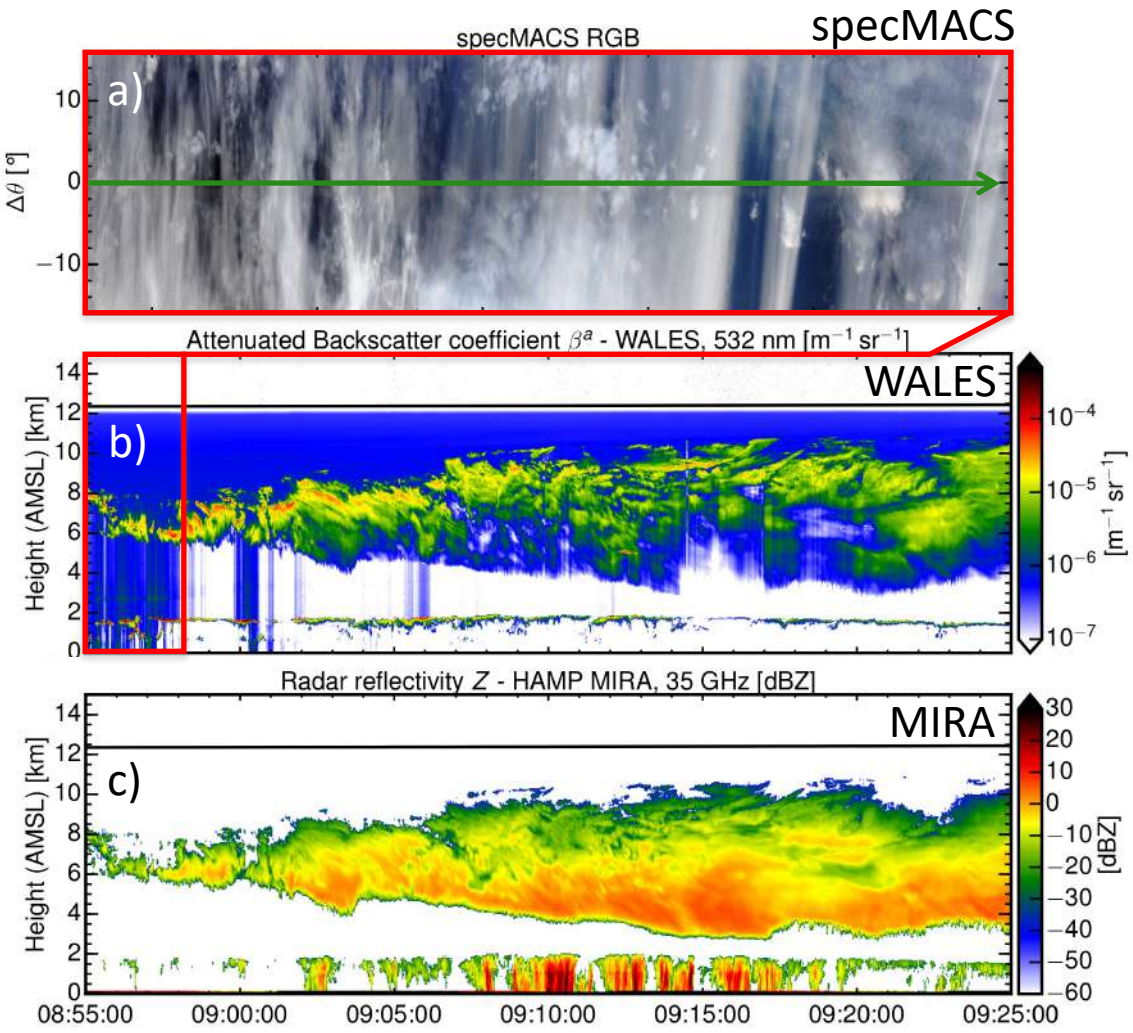
RV METEOR / SEA-Pol

The platform – the High Altitude and long Range Aircraft

The HALO remote sensing payload – a unique validation asset

- G550, max. alt 15 km / max. range: 8000 km
- In operation since 2012
- operated by DLR





Scientific Instruments

HSRL-Lidar (WALES, 532 nm – Wirth et al. 2009)

Cloud Radar (HAMP MIRA, 35 GHz – Ewald et al. 2019)

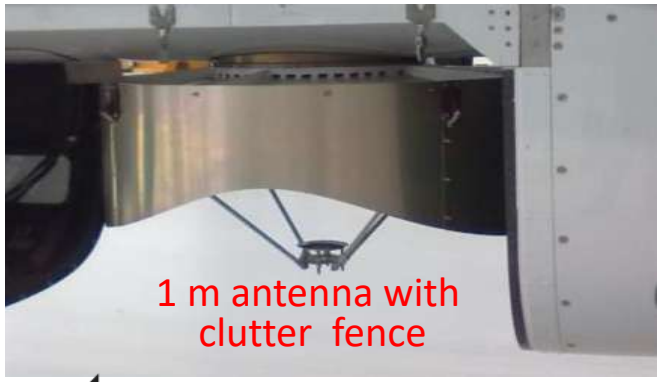
Hyper-Spektral Imager (specMACS – Ewald et al. 2016)

Microwave Radiometer (HAMP passive – Mech et al. 2014)

HAMP MIRA – cloud radar characteristics

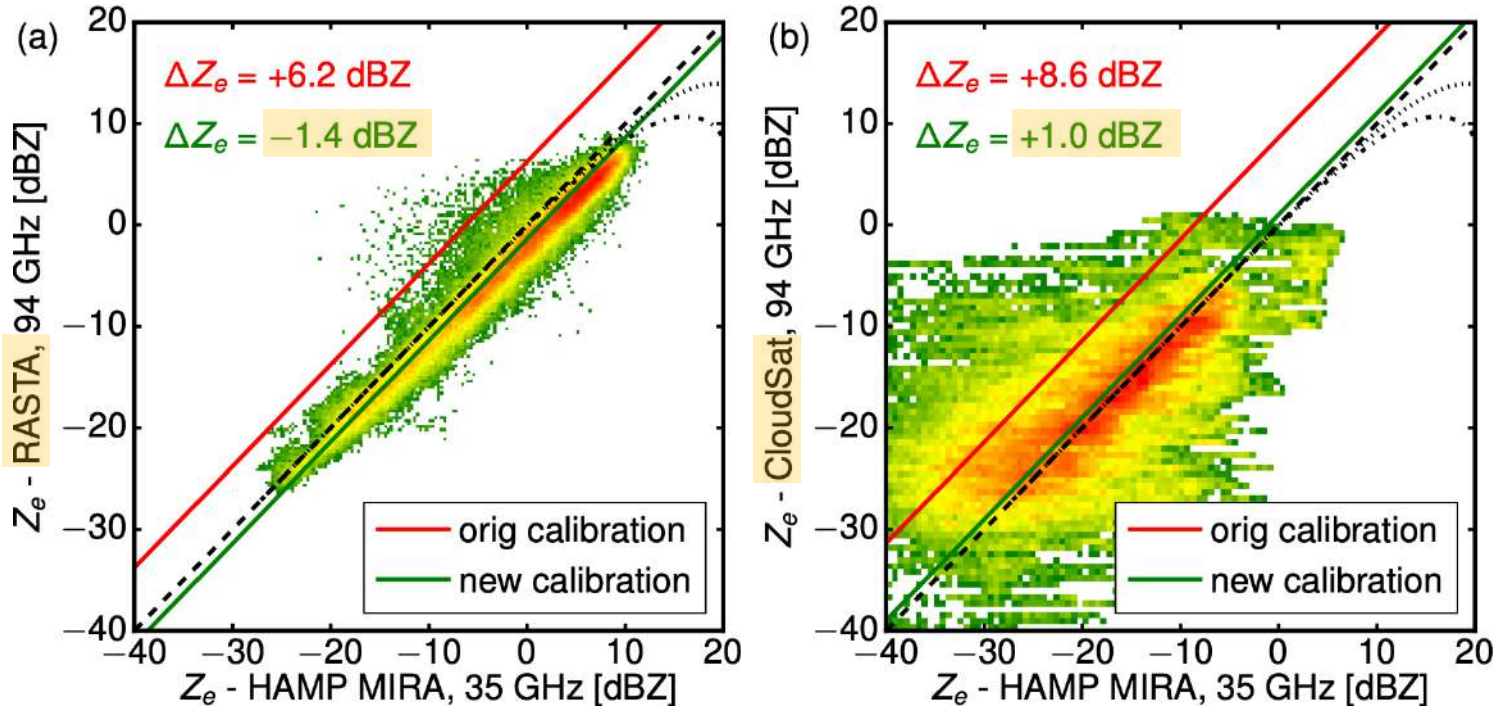
HALO Microwave Package

HAMP MIRA	
Frequency	35.2 GHz
Pulse power	30 kW
Repetition rate	7.5 kHz
Range resolution	30 m
Antenna diameter	1 m
Beam width	0.6°
Footprint @ 10km	100 m
Min. detect. signal @ 10 km, 1 s integration	-42 dBZ
Effective sensitivity @ 10 km, 1 s, 200 m/s, 3° pitch	-34 dBZ



1 m antenna with clutter fence

DLR | Max-Planck-Institut für Meteorologie | UH



Atmos. Meas. Tech., 12, 1815–1839, 2019
https://doi.org/10.5194/amt-12-1815-2019

Atmospheric Measurement Techniques
Open Access
EGU

Calibration of a 35 GHz airborne cloud radar: lessons learned and intercomparisons with 94 GHz cloud radars

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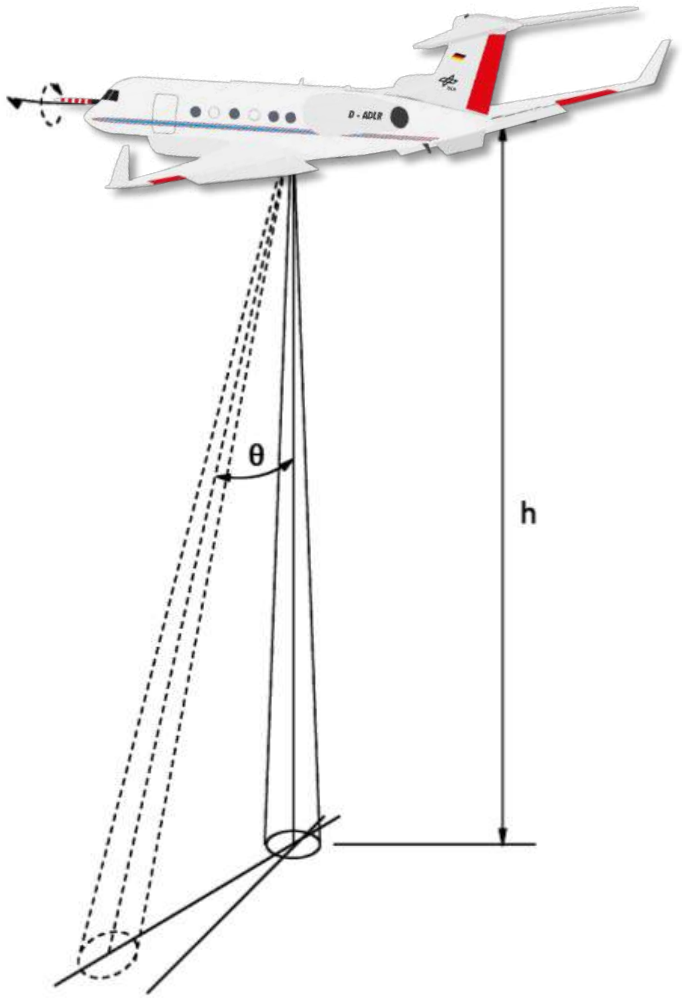
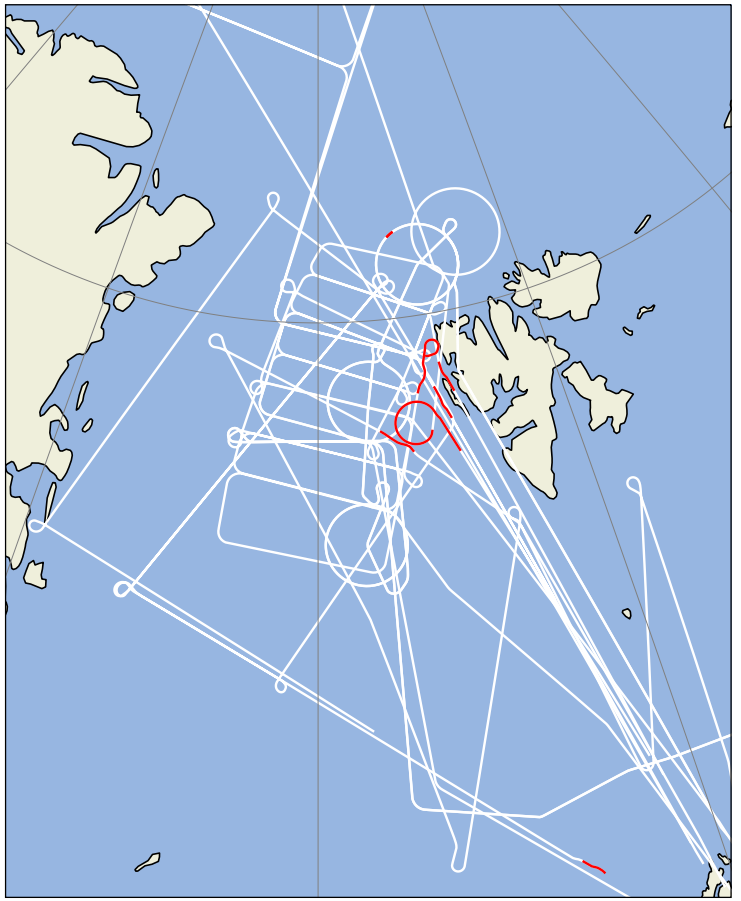
[2]Max-Planck-Institute for Meteorology, Hamburg, Germany

HAMP MIRA – absolut calibration during HALO-(AC)3

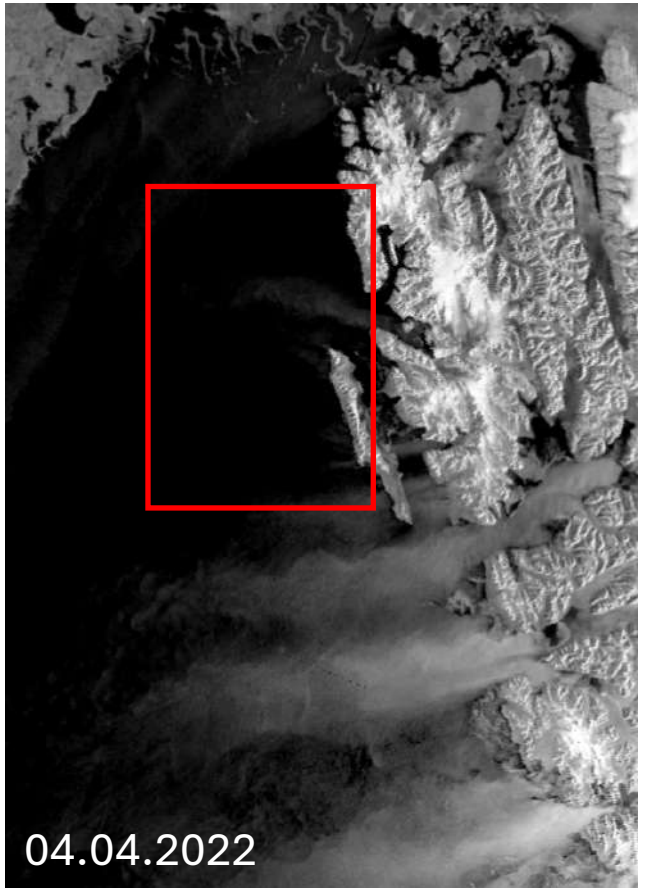
Summary of all flight segments suitable for radar calibration



Ewald et al., 2019



Sentinel-1 HH decibel σ_0

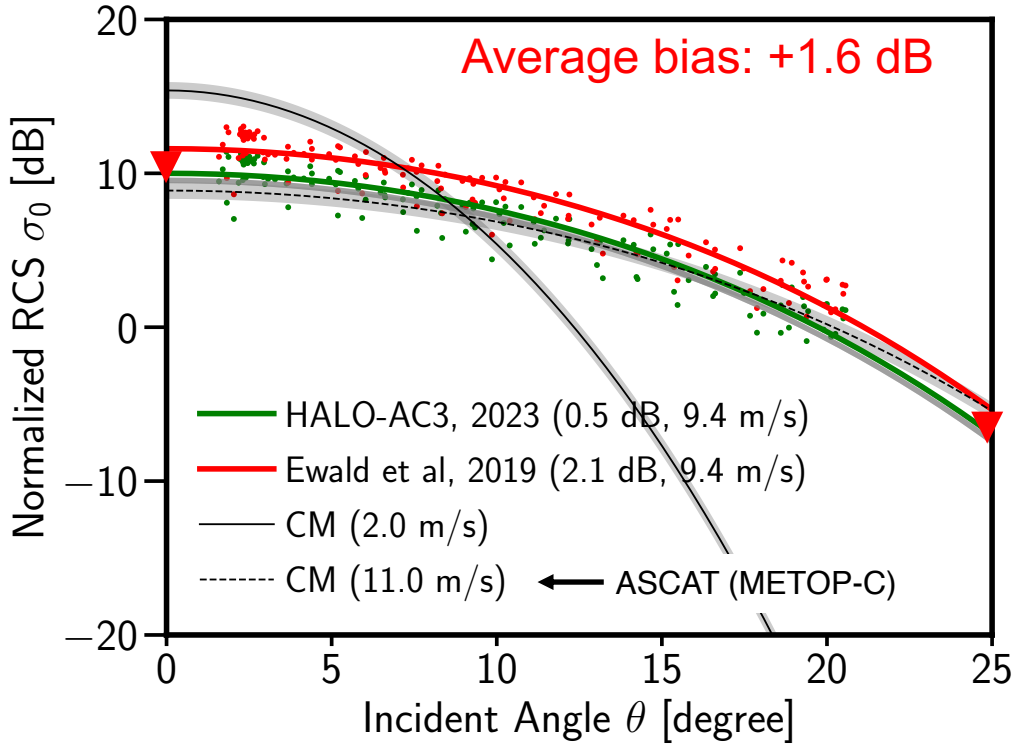


→ ***6 successful roll*** *flight patterns for radar calibration available*

→ *Calibration finalized - unified HALO data can now be finalized*

HAMP MIRA – absolut calibration during HALO-(AC)3

Summary of all flight segments suitable for radar calibration



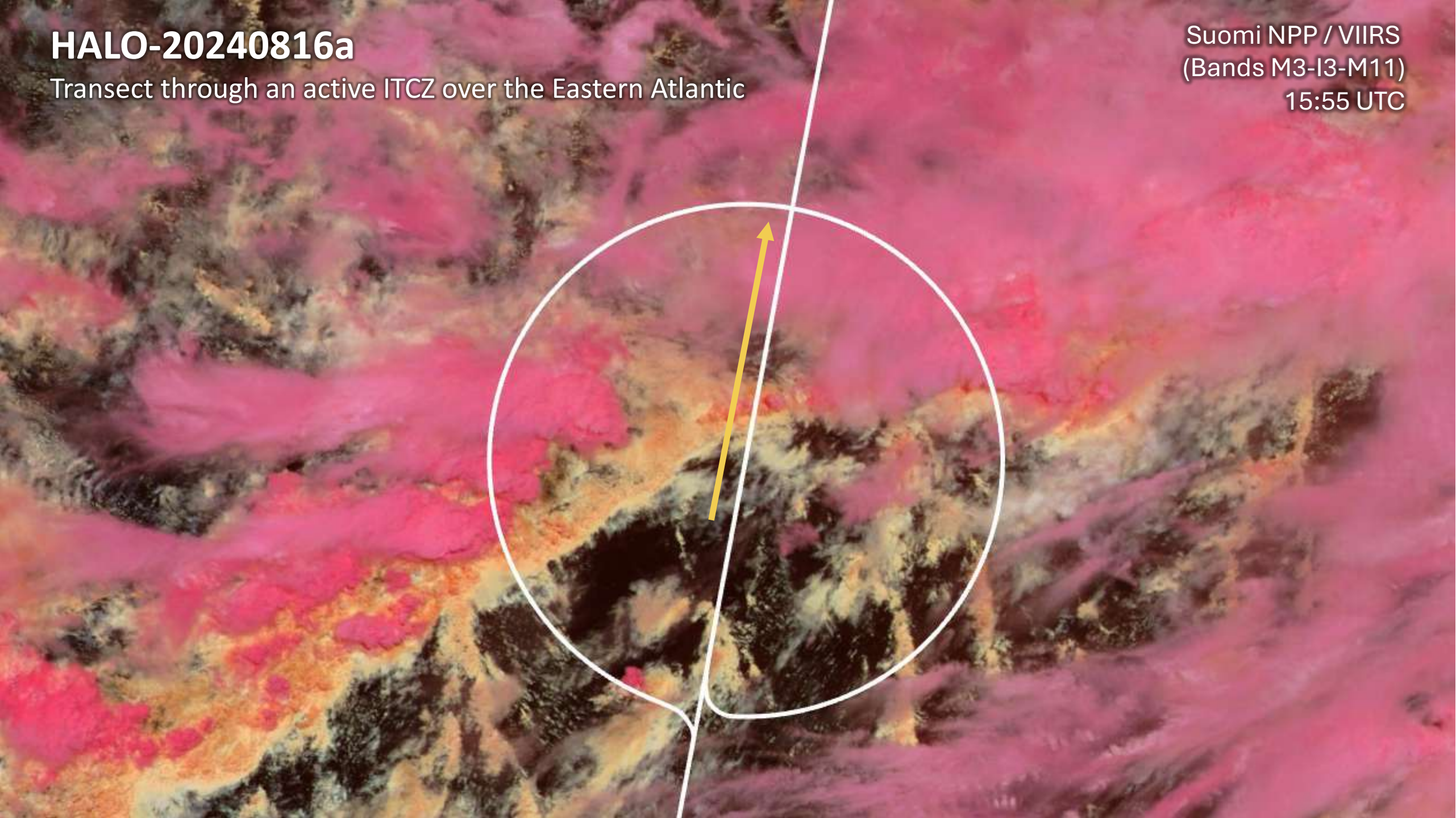
	date	$\Delta\sigma_0$ [dB]	$\Delta\sigma_0$ [dB]	u_{Fit} [m/s]	u_{Drop} [m/s]
RF01	220311	+2.06	+0.46	9.4	-
RF09	200128	+2.13	+0.53	5.1	8.6
RF12	220401	+1.17	-0.43	8.3	5.2
RF13	220404	+1.60	+0.00	5.8	7.7
RF16	220410	+1.12	-0.47	6.8	7.1
RF17	220411	+1.35	-0.25	5.0	10.2
	avg.	**+1.6**	**+0.0**		**Δu = -1.3**

→ *Current radar reflectivity bias of +1.6 dB (RMSE: 0.4 dB), checked receiver bandwidth (diff. DSP)*

→ *Fitted wind speed (U10) bias of -1.3 m/s (RMSE: 2.8 m/s) vs. last dropsonde height (ca. 10 – 25 m)*

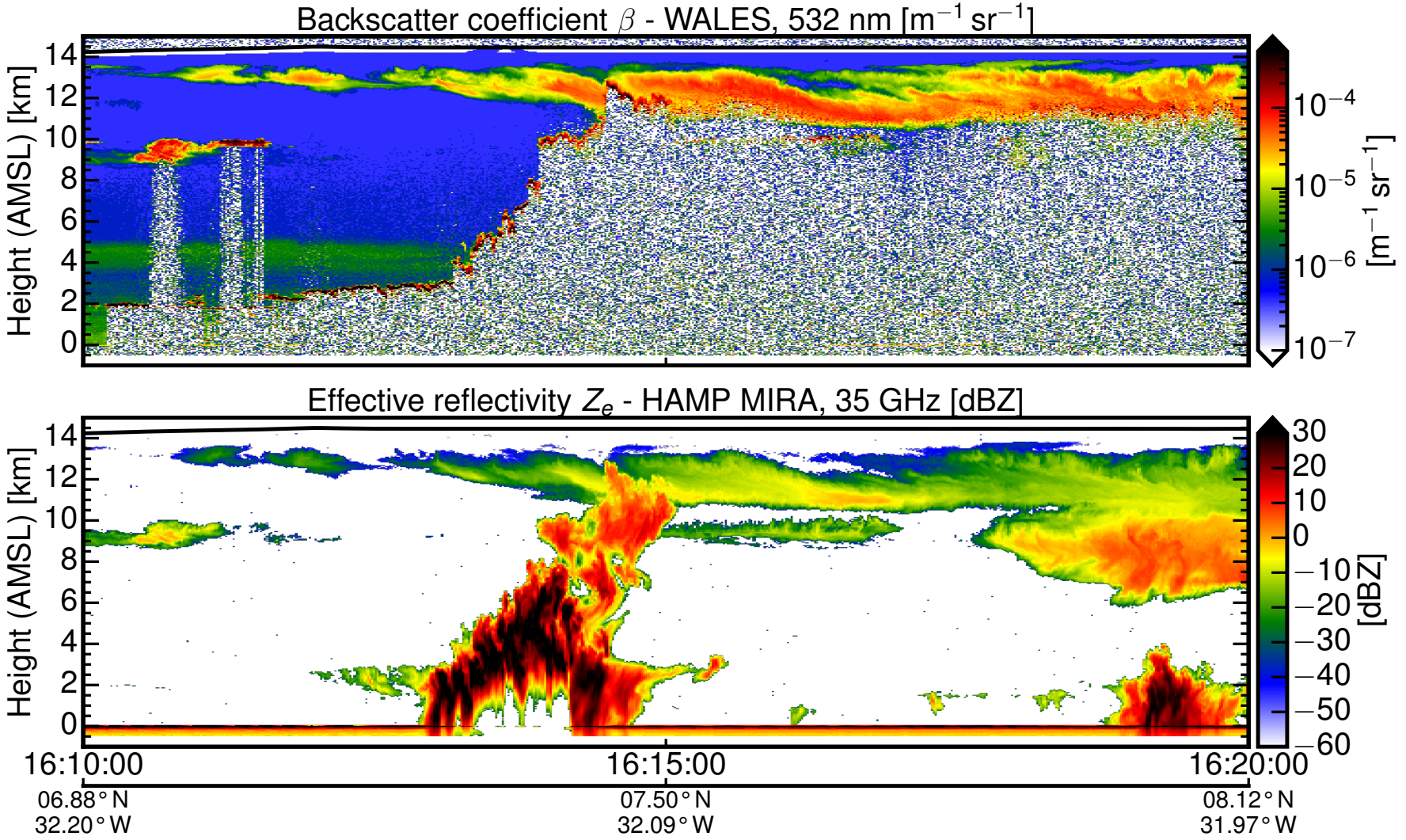
CPR Validation

A first glimpse into our CPR comparisons


HALO-20240816a
Transect through an active ITCZ over the Eastern Atlantic
Suomi NPP / VIIRS
(Bands M3-I3-M11)
15:55 UTC

HALO-20240816a – HALO measurements

WALES HSRL backscatter coefficient and HAMP MIRA radar reflectivity

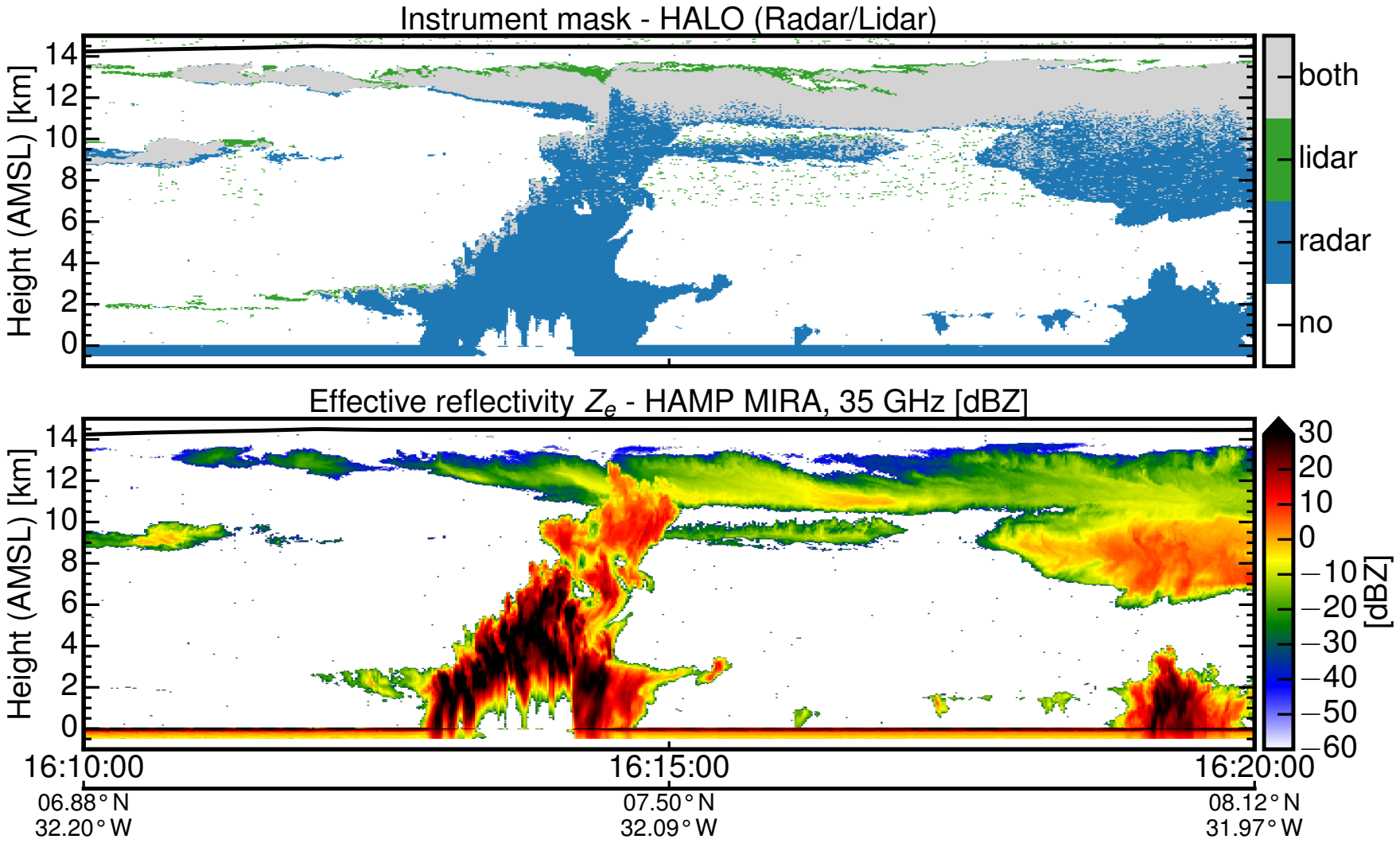


WALES
HSRL
Backscatter

MIRA
Radar
reflectivity

HALO-20240816a – HALO measurements

Radar-lidar instrument overlap on HALO

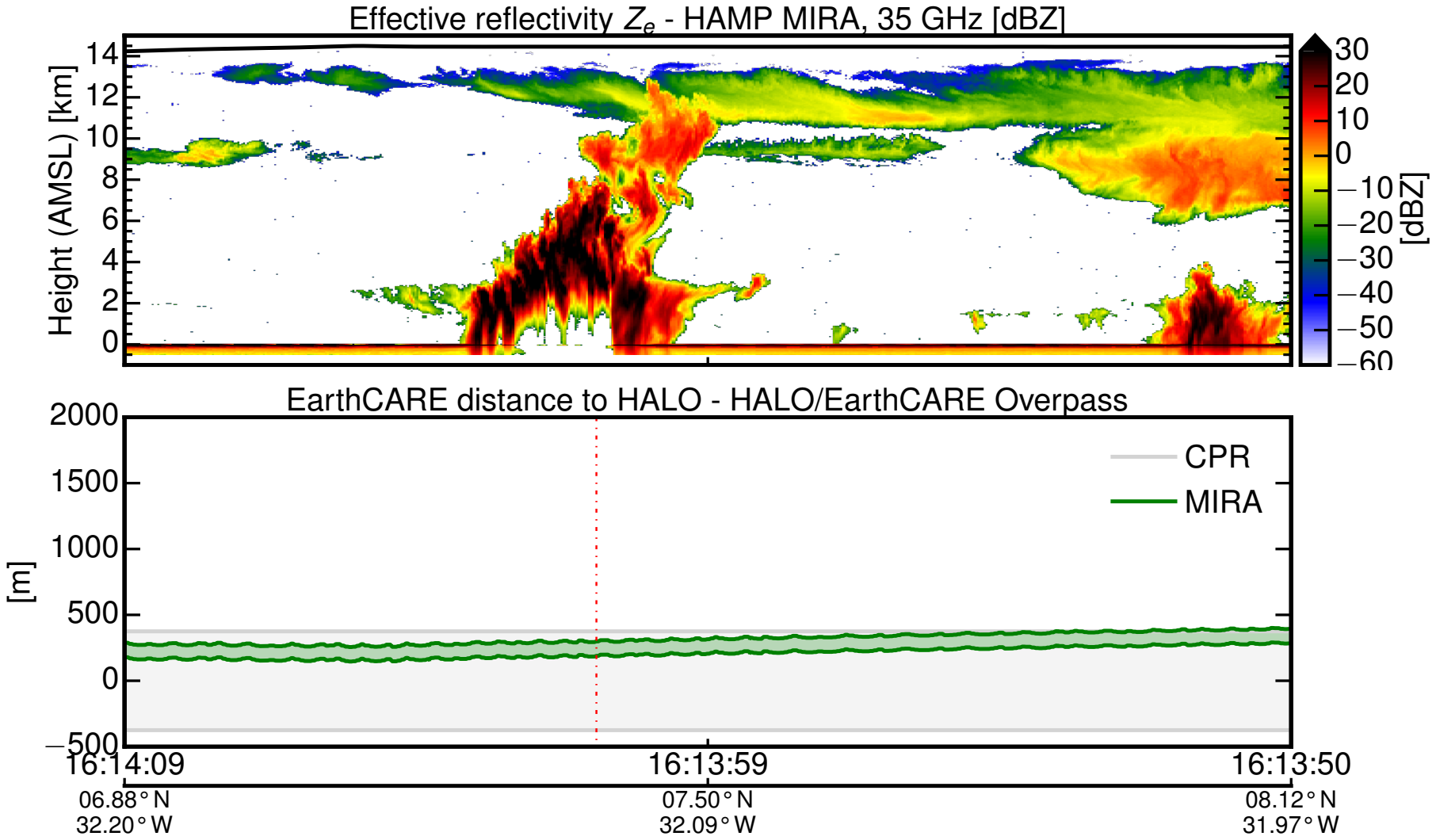


Synergy
Instrument overlapp

MIRA
Radar reflectivity

HALO-20240816a – CPR comparison

Radar reflecitivty from HAMP MIRA and underpass precision

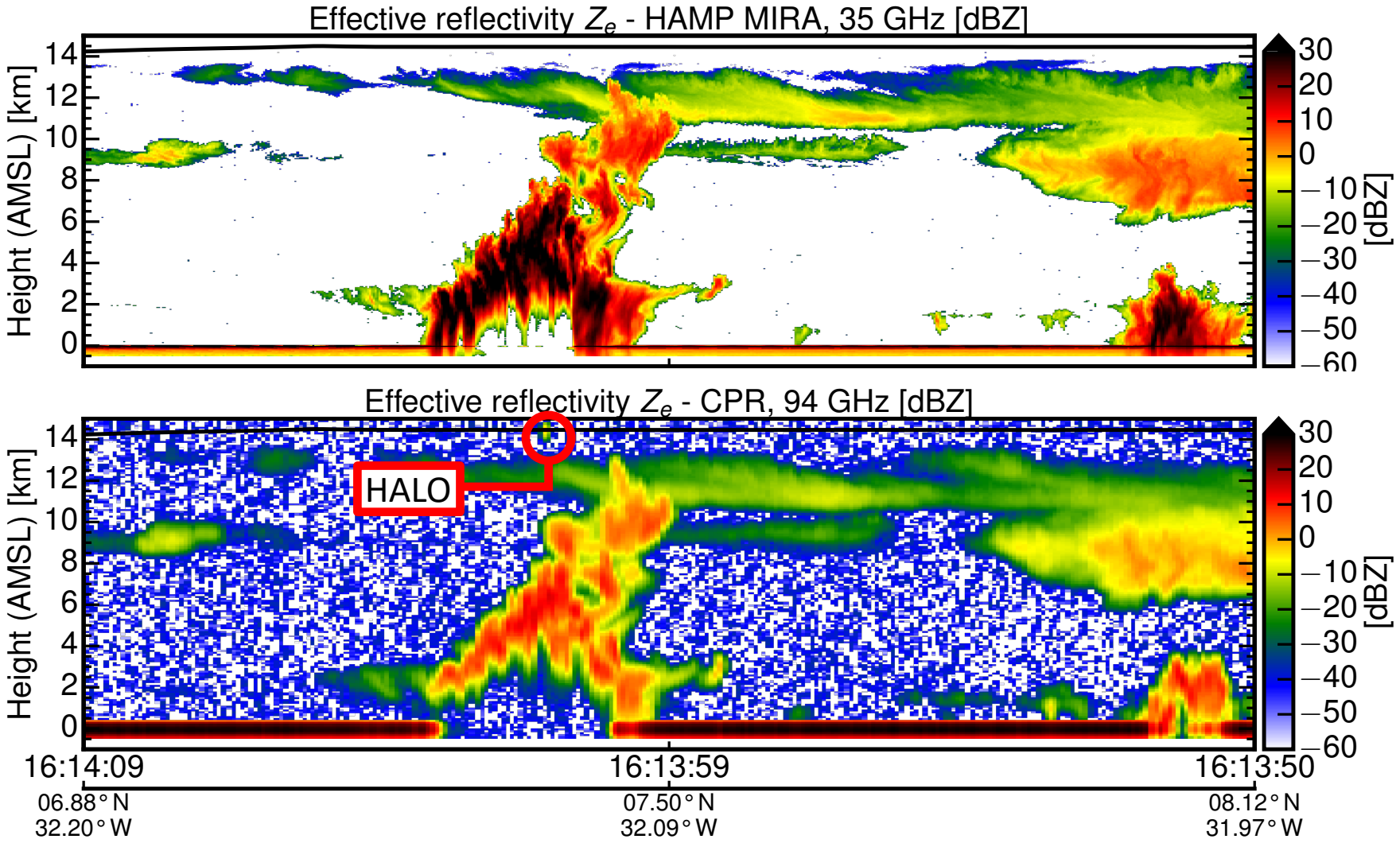


MIRA
Radar reflectivity

EC Track
Lateral deviation

HALO-20240816a – CPR comparison

Radar reflecitivty from HAMP MIRA and CPR

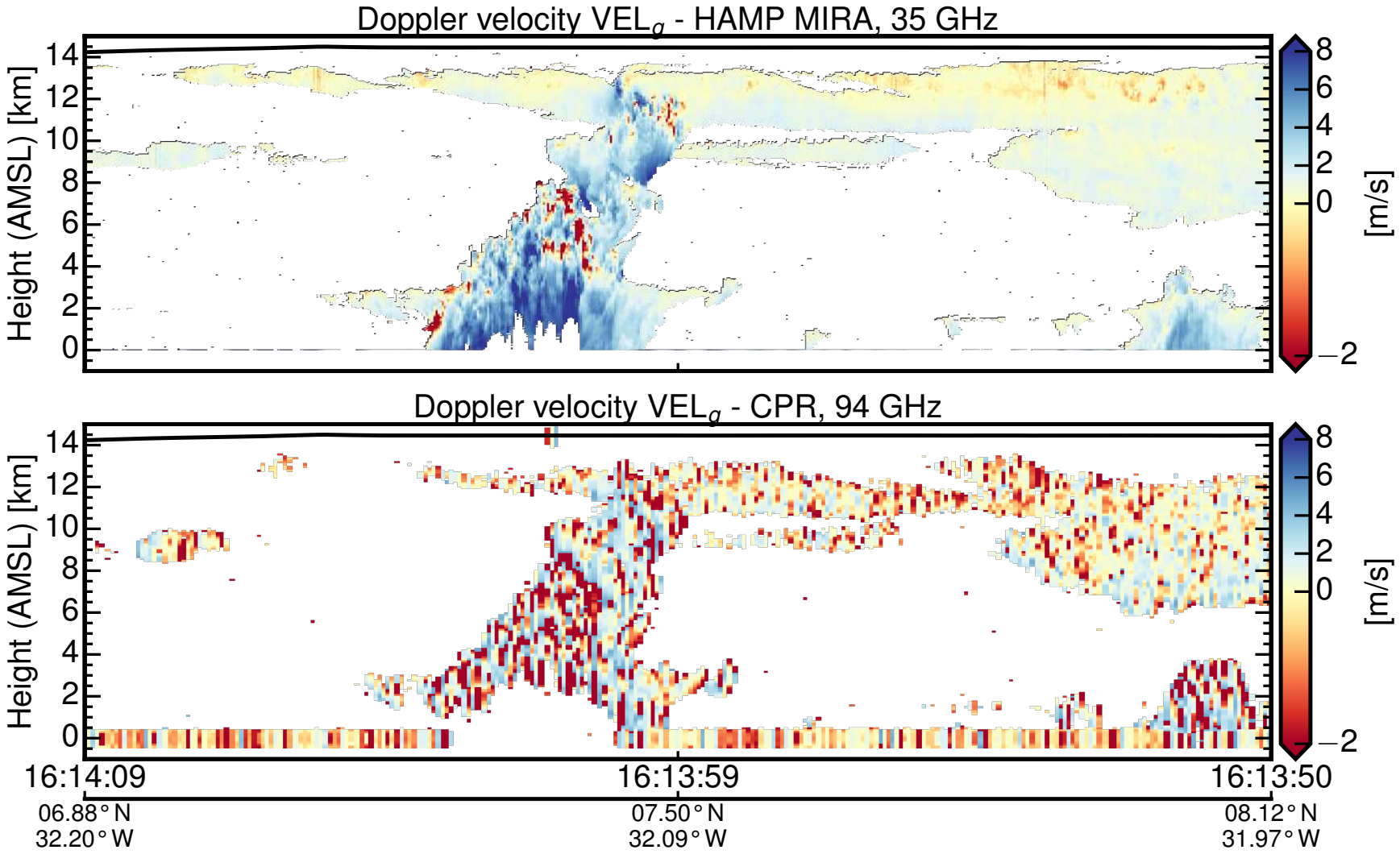


MIRA
Radar reflectivity

CPR
Radar reflectivity (BA baseline)

HALO-20240816a – CPR comparison

Radar reflecitivty from HAMP MIRA and CPR



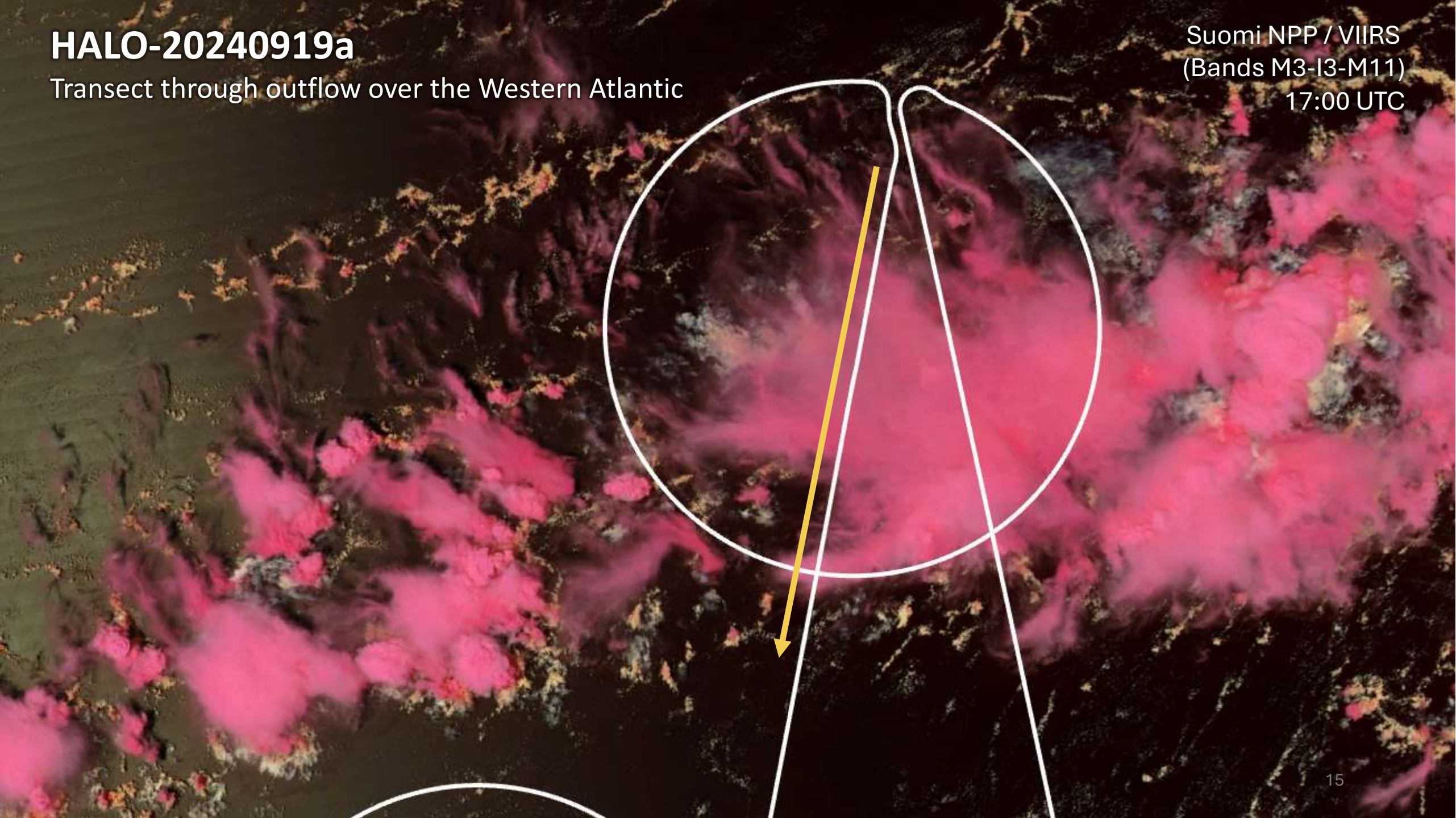
MIRA
Radar reflectivity

CPR
Radar reflectivity (BA baseline)

HALO-20240919a

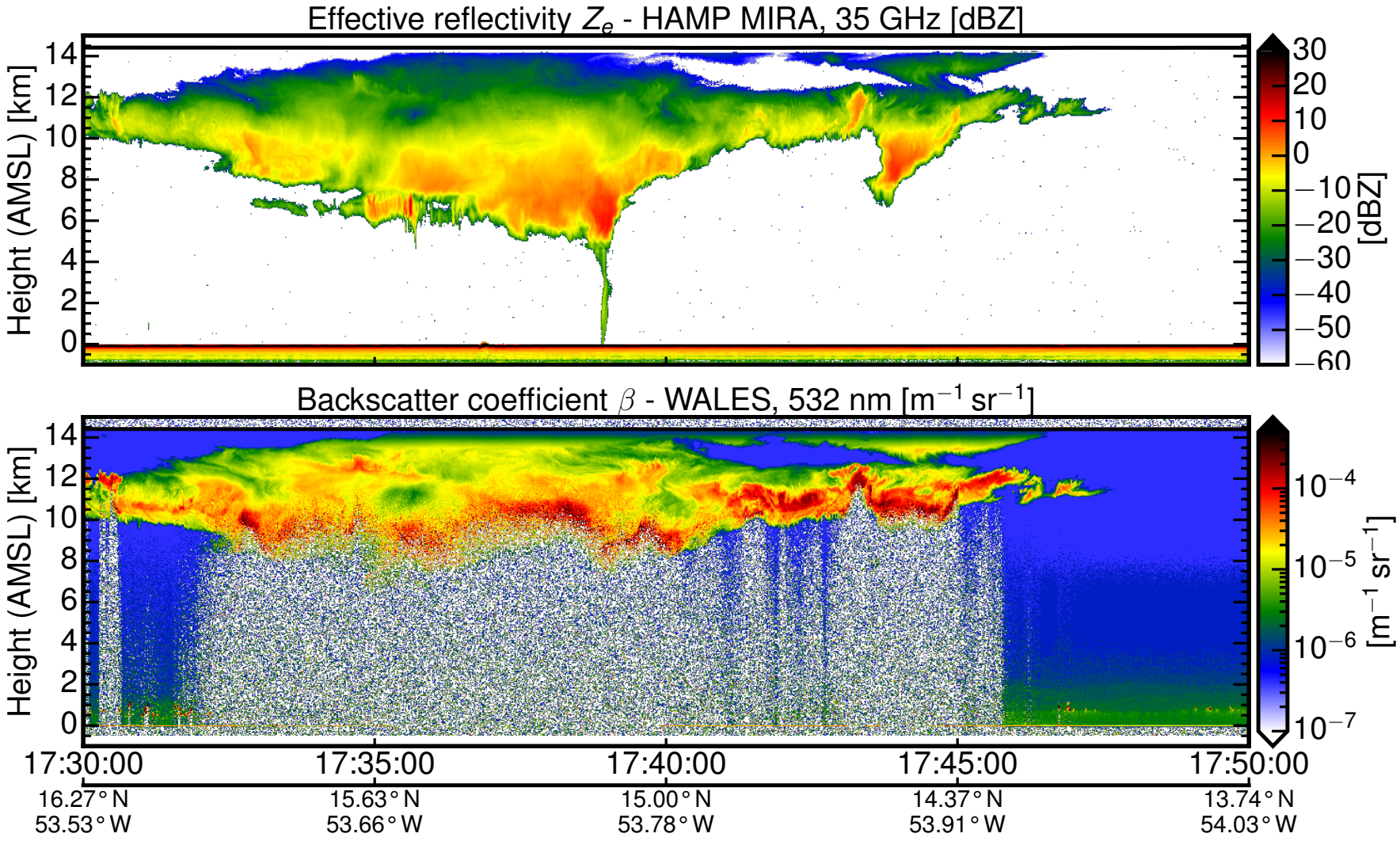
Transect through outflow over the Western Atlantic

Suomi NPP / VIIRS
(Bands M3-I3-M11)
17:00 UTC



HALO-20240919a – HALO measurements

Radar reflectivity from HAMP MIRA and WALES HSRL backscatter coefficient

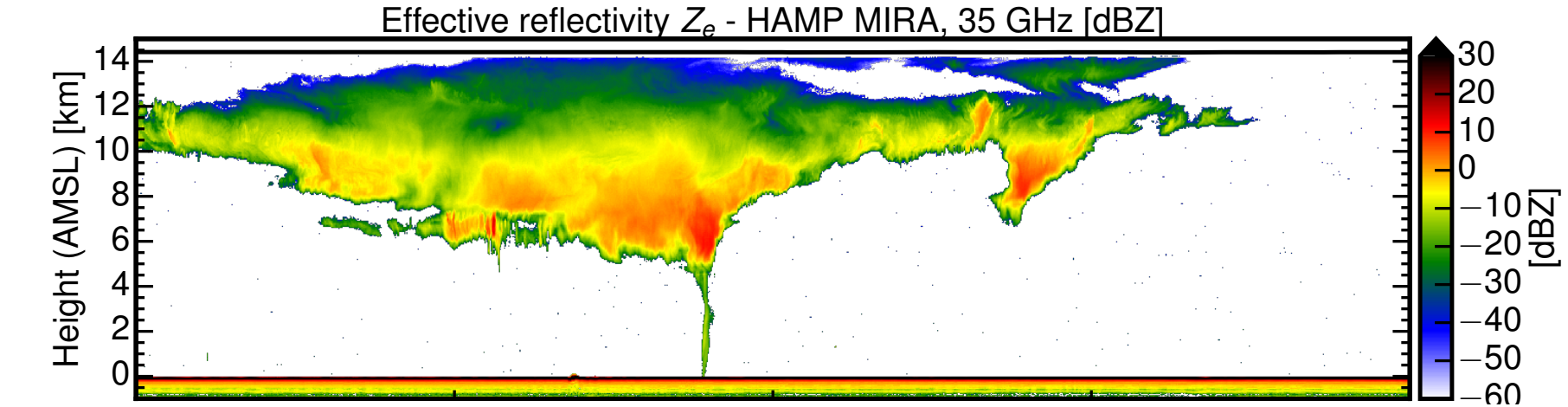


MIRA
Radar
reflectivity

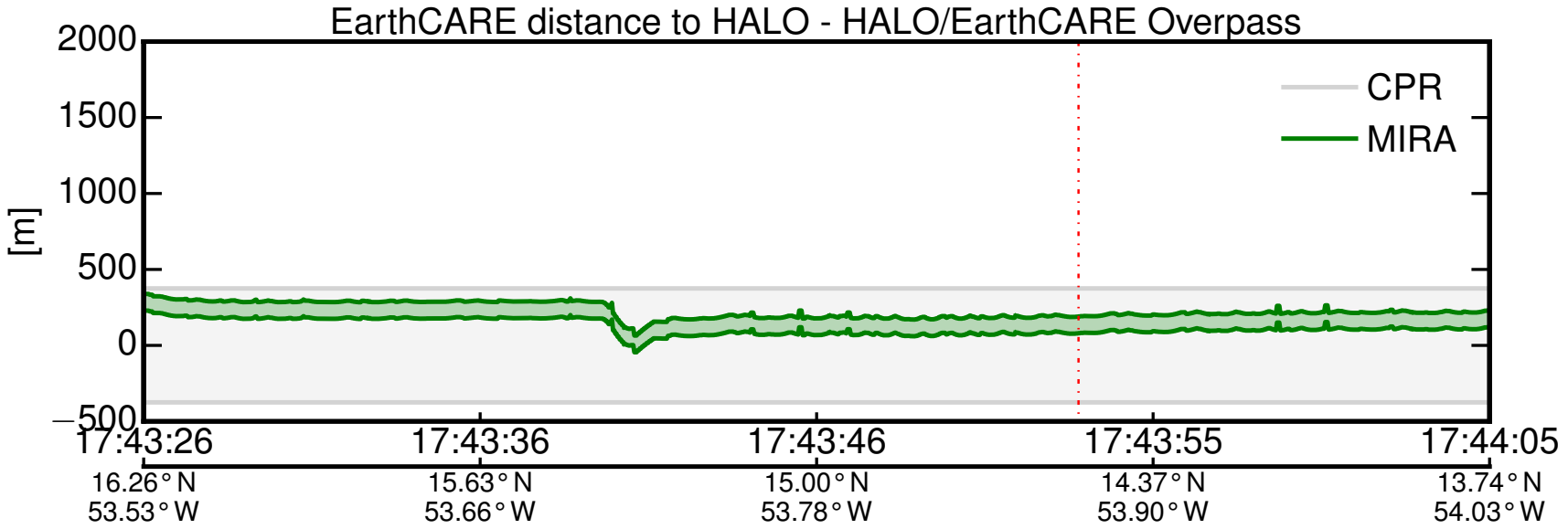
WALES
HSRL
Backscatter

HALO-20240919a – CPR comparison

Radar reflectivity from HAMP MIRA and underpass precision



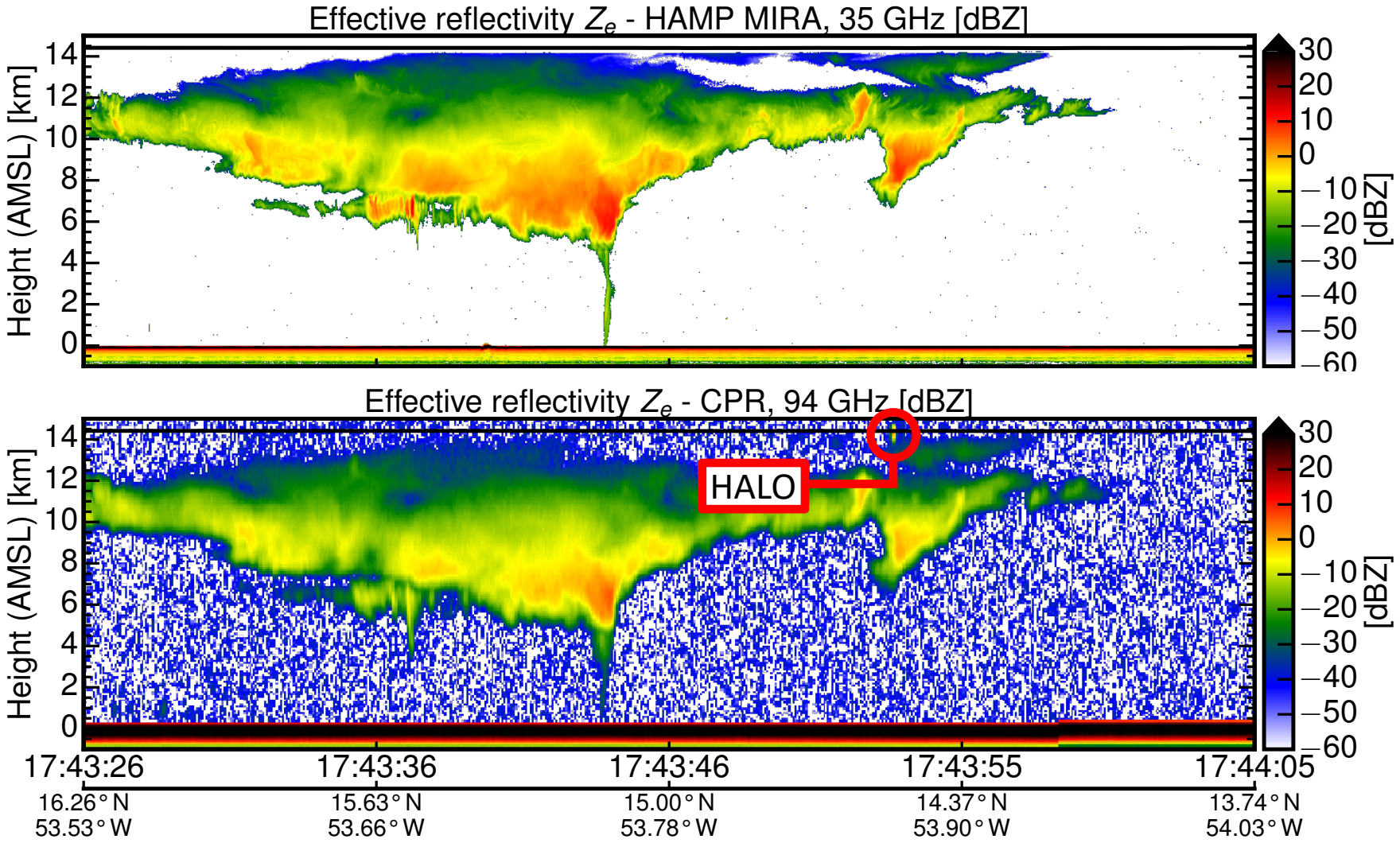
MIRA
Radar reflectivity



EC Track
Lateral deviation

HALO-20240919a – CPR comparison

Radar reflectivity from HAMP MIRA and CPR

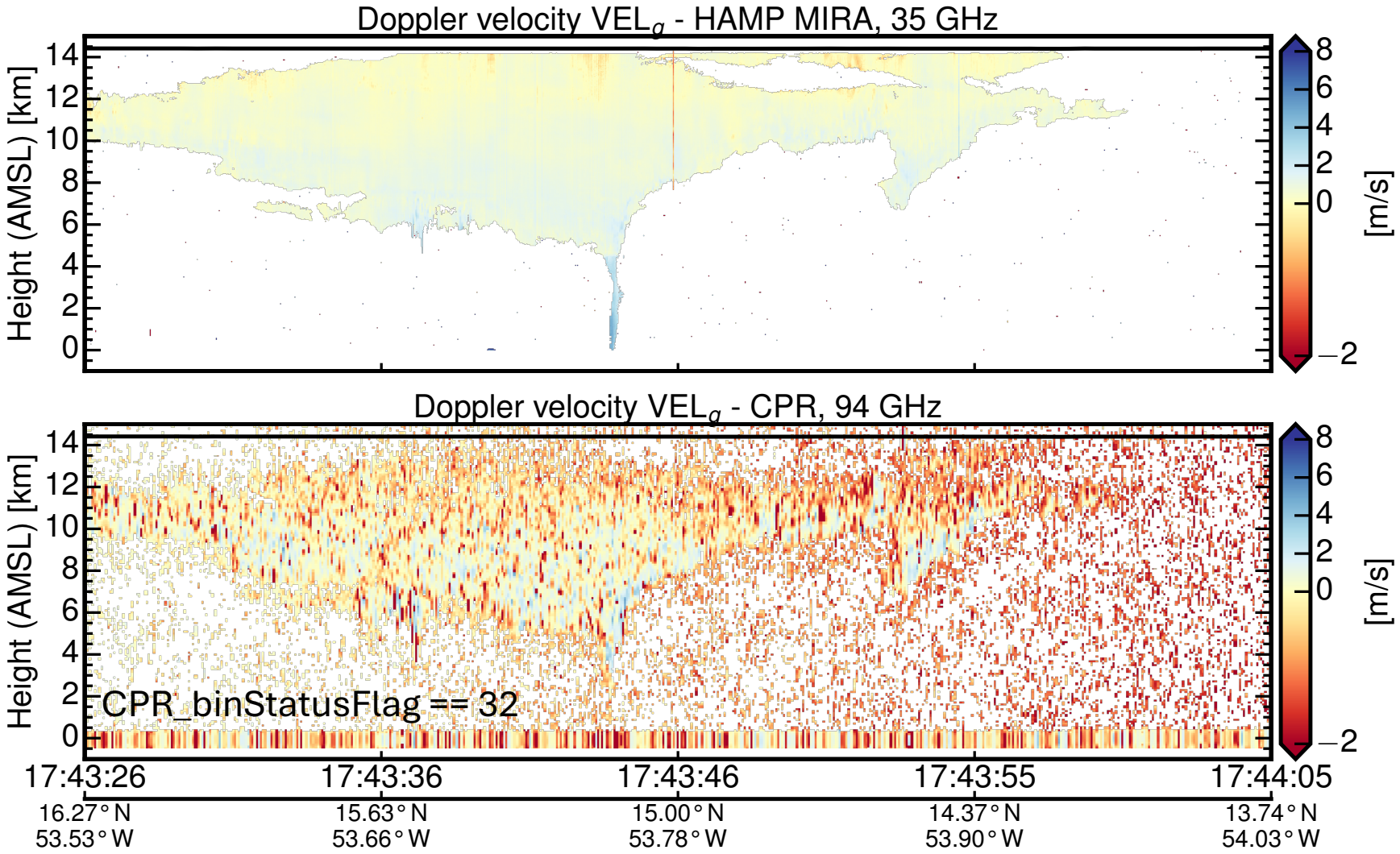


MIRA
Radar reflectivity

CPR
Radar reflectivity (BA baseline)

HALO-20240919a – CPR comparison

Doppler velcoity from HAMP MIRA and CPR

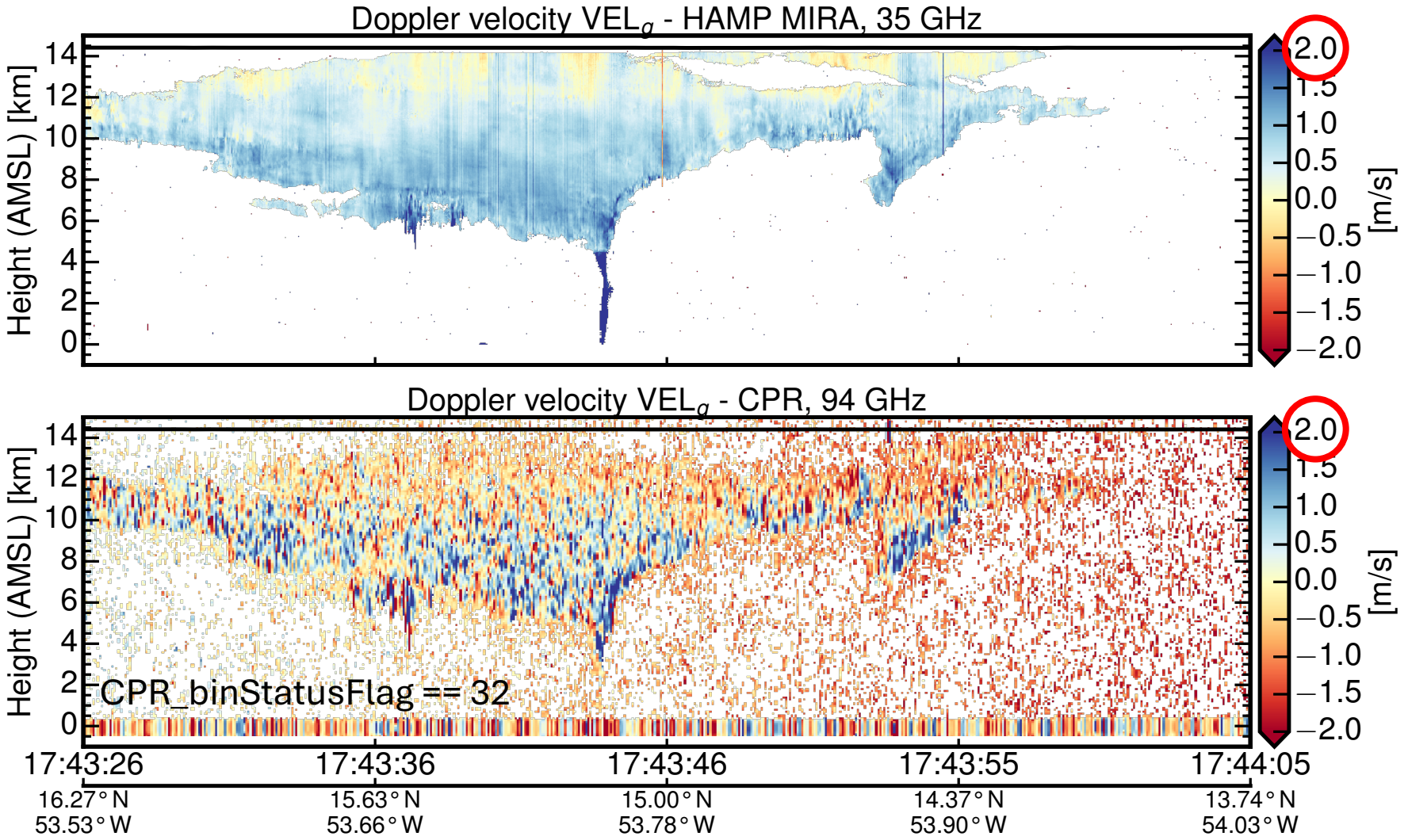


MIRA
Doppler velocity

CPR
Doppler velocity (BA baseline)

HALO-20240919a – CPR comparison

Doppler velcoity from HAMP MIRA and CPR



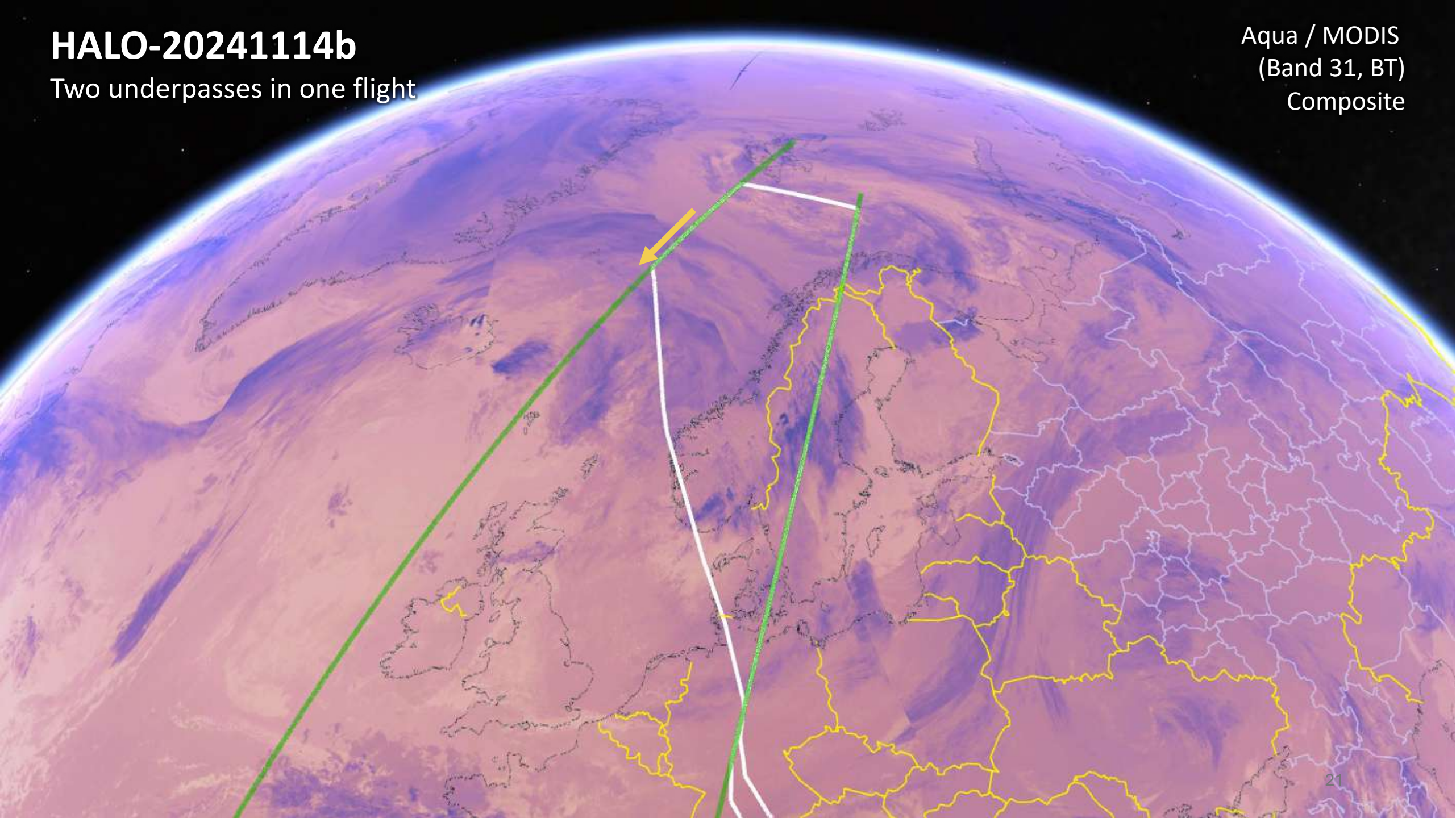
MIRA
Doppler velocity

CPR
Doppler velocity (BA baseline)

HALO-20241114b

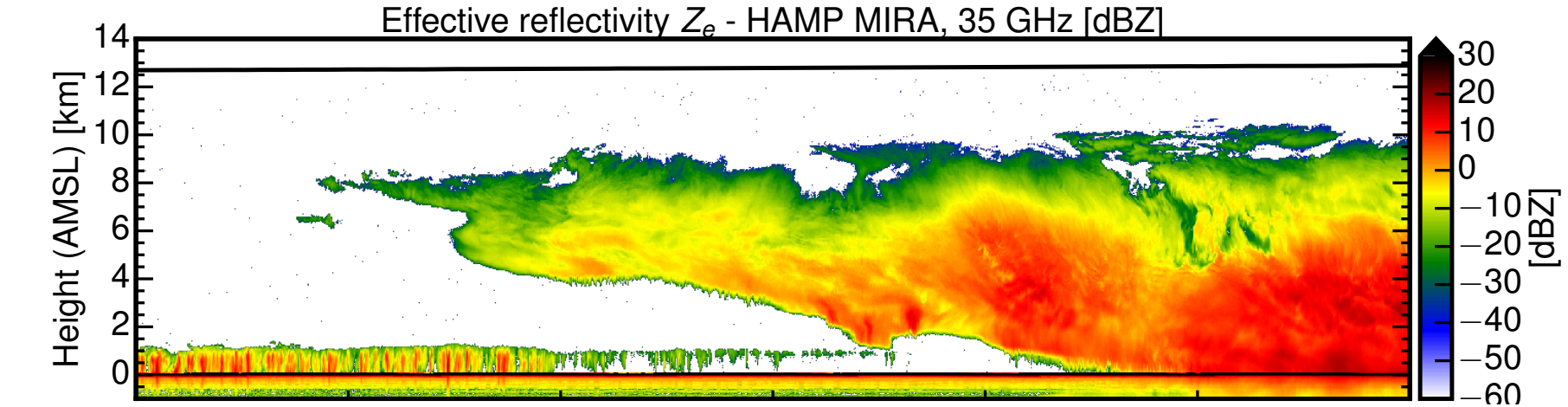
Two underpasses in one flight

Aqua / MODIS
(Band 31, BT)
Composite

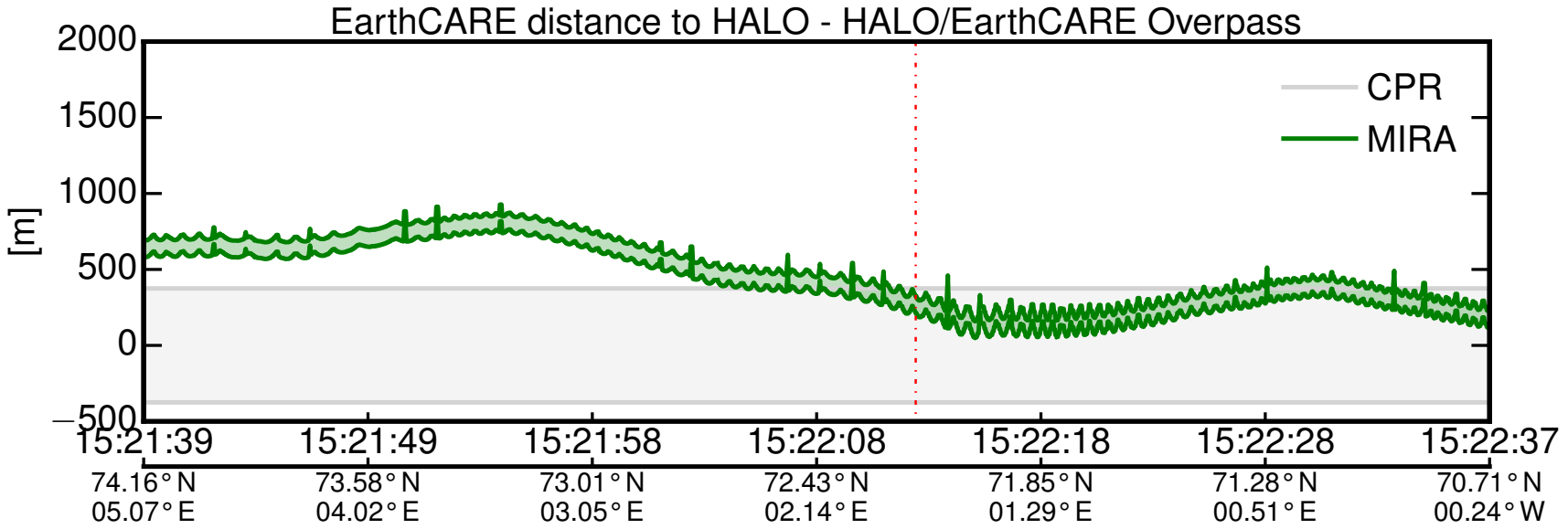


HALO-20241114b – HALO measurements (2nd underpass)

Radar reflectivity from HAMP MIRA and underpass precision



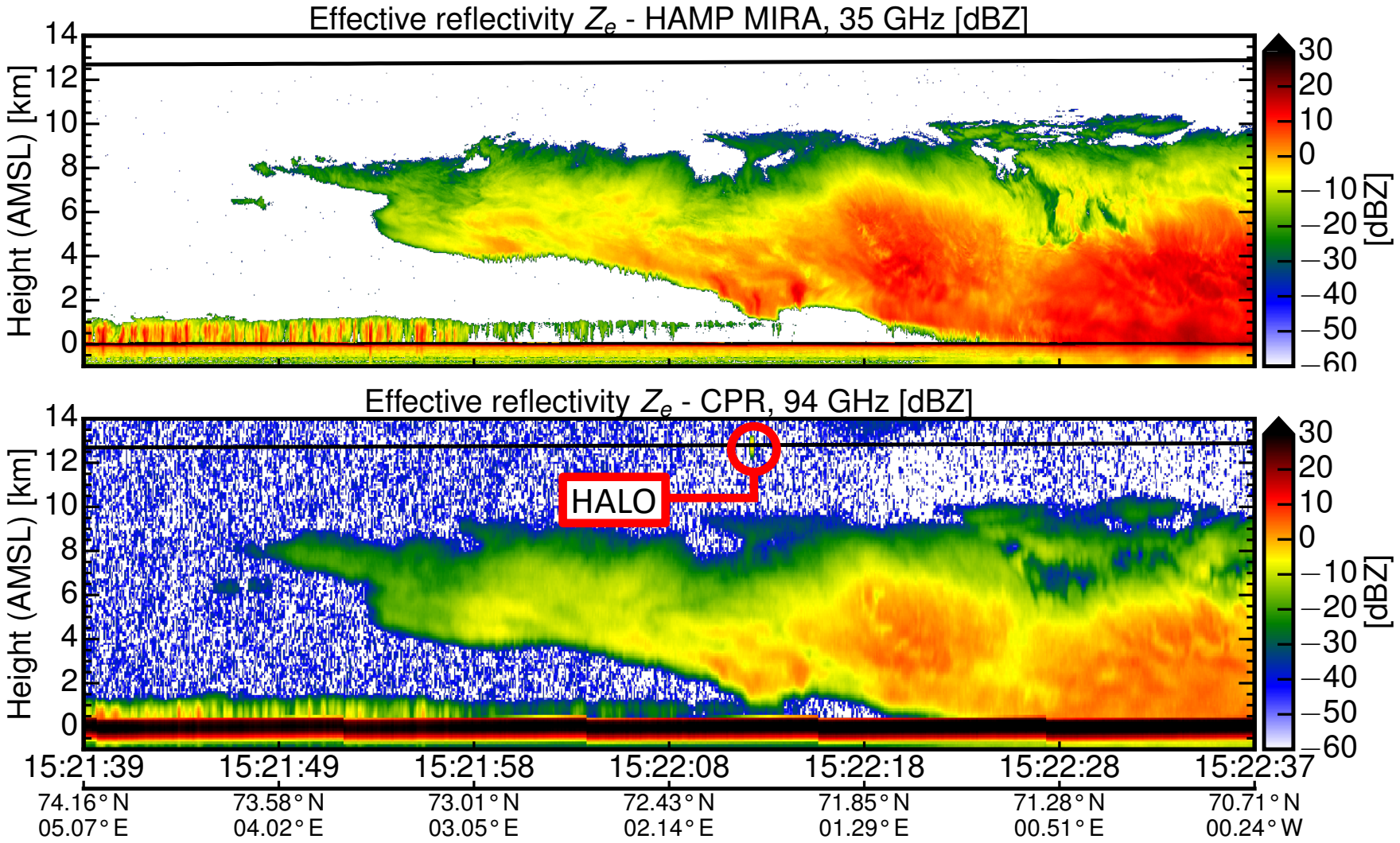
MIRA
Radar reflectivity



EC Track
Lateral deviation

HALO-20241114b – CPR comparison (2nd underpass)

Radar reflectivity from HAMP MIRA and CPR

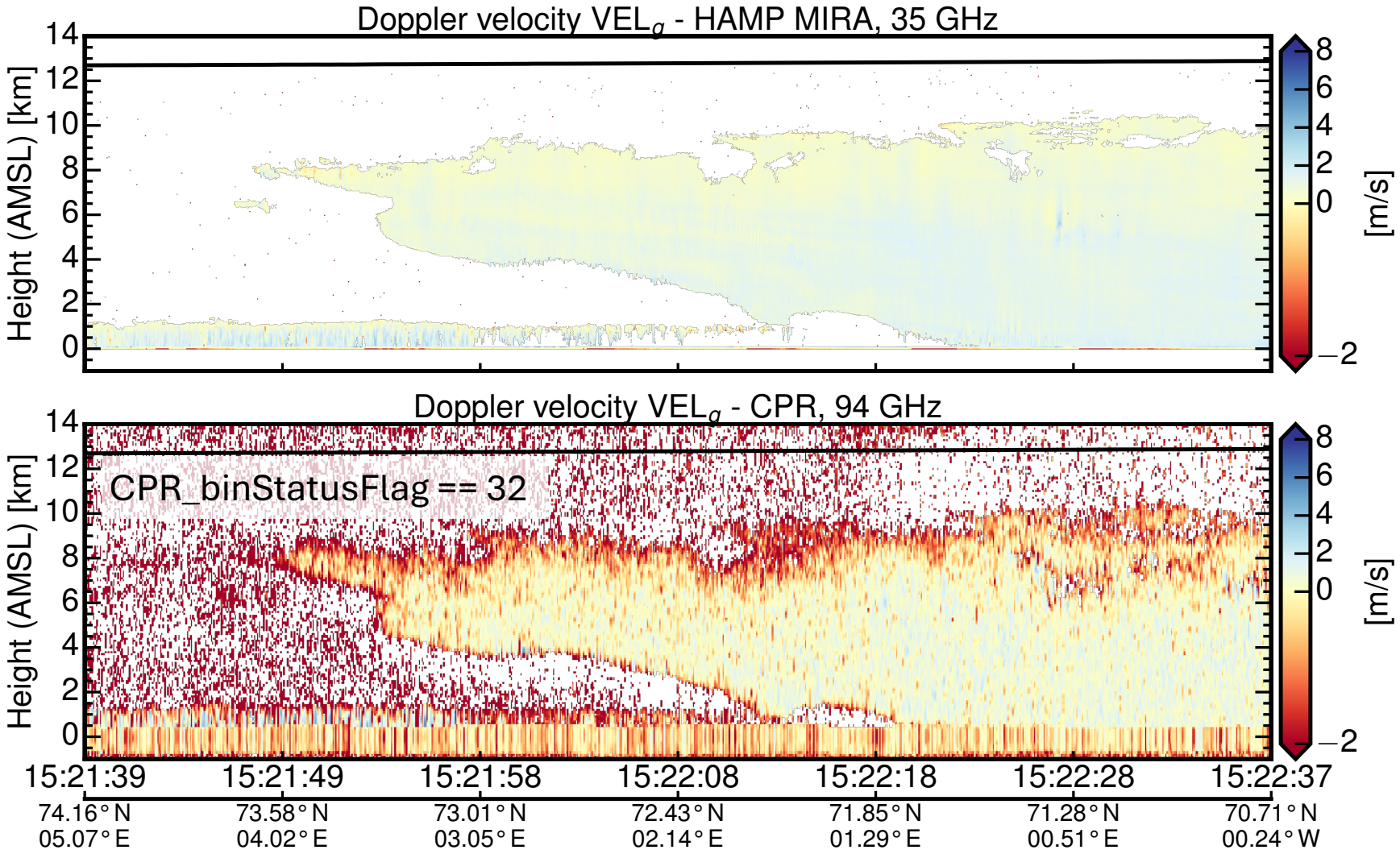


MIRA
Radar reflectivity

CPR
Radar reflectivity (BA)

HALO-20241114b – CPR comparison (2nd underpass)

Doppler velcoity from HAMP MIRA and CPR

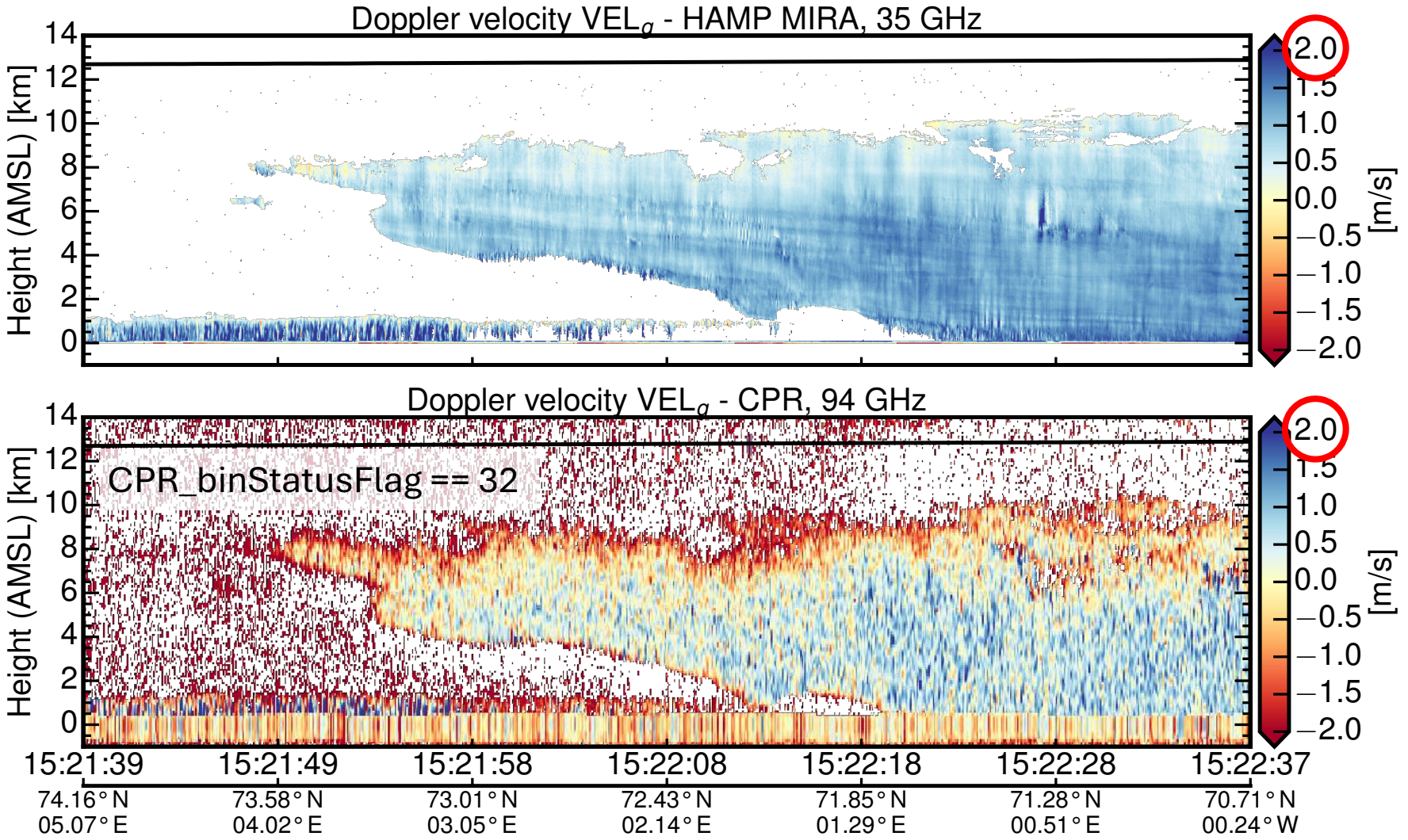


MIRA
Doppler velocity

CPR
Doppler velocity (BA baseline)

HALO-20241114b – CPR comparison (2nd underpass)

Doppler velcoity from HAMP MIRA and CPR

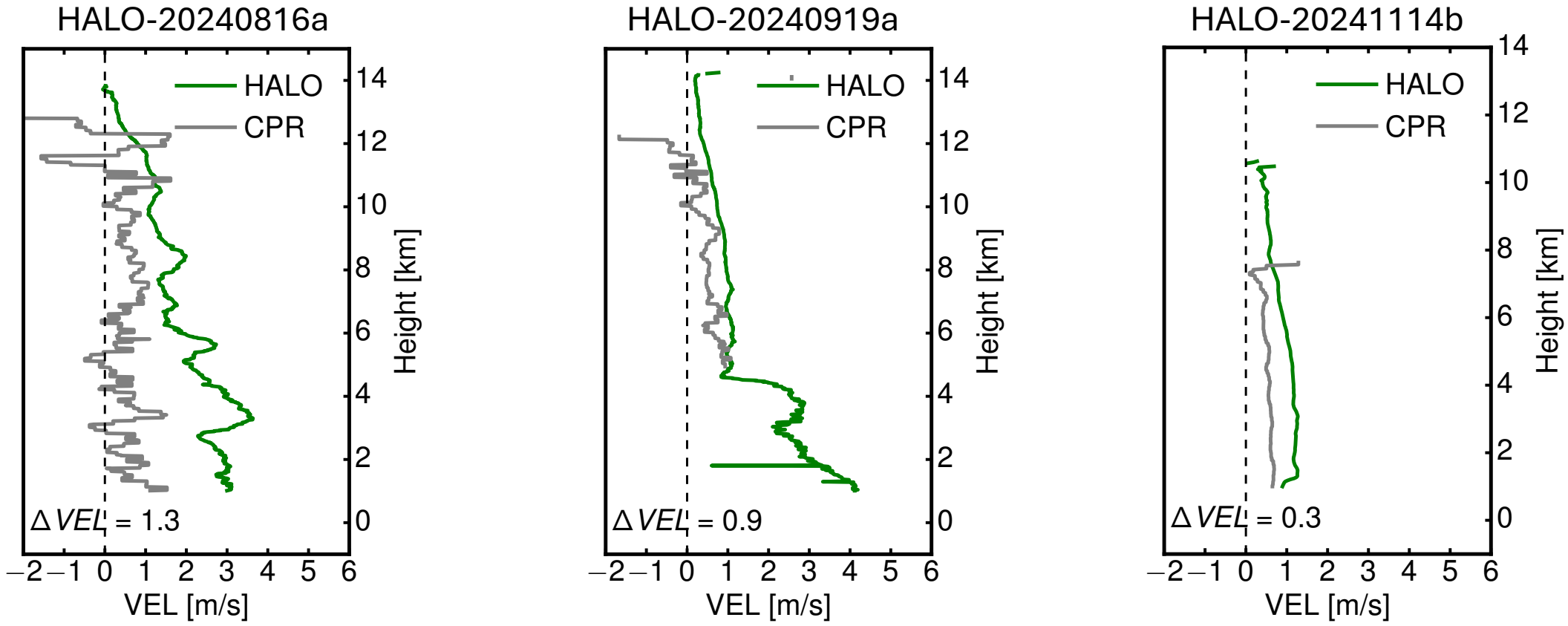


MIRA
Doppler velocity

CPR
Doppler velocity (BA baseline)

PERCUSION – Validation of CPR velocities (BA baseline)

Sligthly negative VEL bias of CPR in-line with findings by Puidgomènech et al



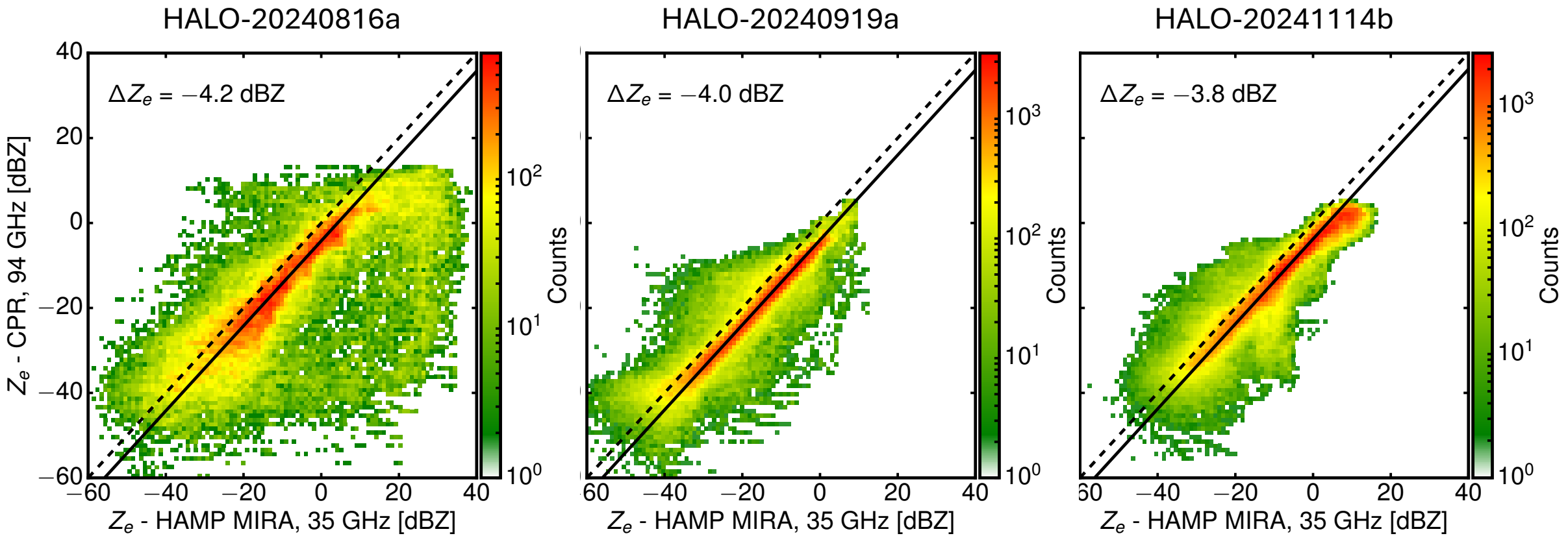
→ *Very noisy VELs in AUG, better quality in SEP/NOV*

→ *Negative bias of CPR velocities (see antenna misp.)*

→ ***Current VEL bias of CPR: -0.9 – -0.3 m/s***
(in-line with findings of Puidgomènech et al)

PERCUSION – Validation of CPR radar reflectivity (BA baseline)

Too low Z_e bias agrees well with fist analysis from ECMWF / Kollias et al.



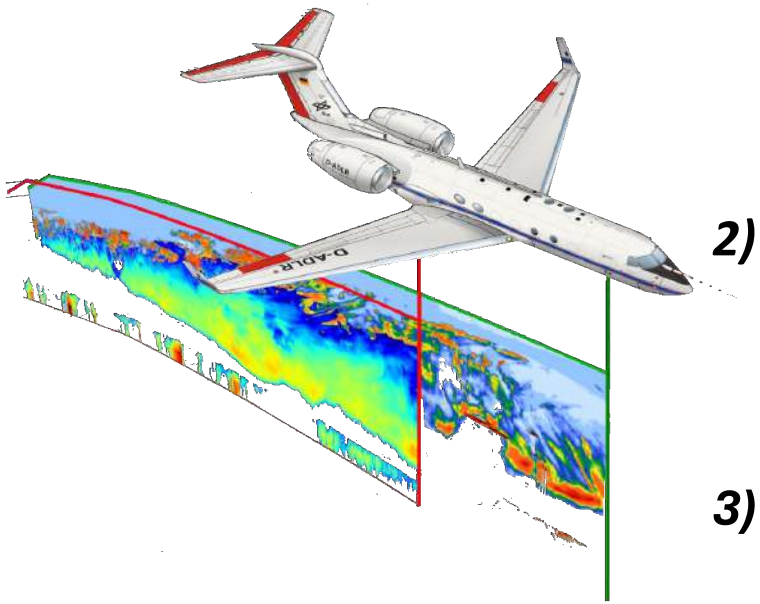
→ *Consistent and stable negative Z_e bias on CPR*

→ *HAMP MIRA calibration in progress, likely +1.6 dB*

→ ***Current Z_e bias of CPR: -4 dB***

Summary – First findings for CPR from PERCUSION

… what we found so far and what to expect next



1) ***Impressive sensitivity of CPR almost on par with airborne cloud radar***

   → *"Much more thin cirrus and low-level clouds visible compared to CloudSat, **nominal CPR sensitivity of -36 dBZ seems plausible**"*

2) ***Negative bias of CPR radar reflectivity (BA baseline) of -4 dB***

   → *"Very stable CPR bias troughout campaign periode, absolute calibration constant of HAMP MIRA very similar to previous campaign"*

3) ***Doppler velocities biased between -0.9 – -0.3 m/s, noisy at first***

   → *"Results are only valid for SPU-A, improved SNR for SEP/NOV, velocity bias in-line with antenna mispointing found by Puidgomènech et al."*