Direct Comparisons of EarthCARE CPR and Airborne Cloud Radar System (CRS) Reflectivity and Doppler Data

EarthCARE Science and Validation Workshop 2025, Tokyo, Japan
December 4, 2025

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GLOVE Field Campaign

GSFC Lidar Observation and Validation Experiment

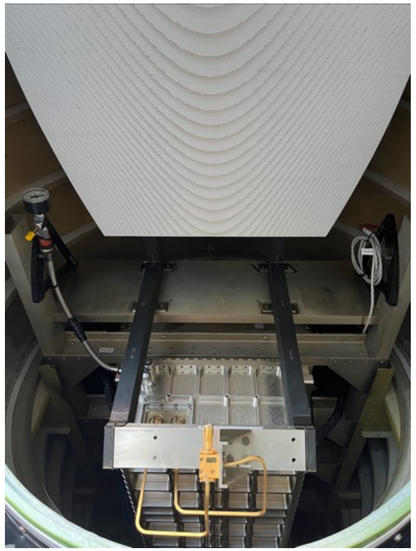
GLOVE Details:

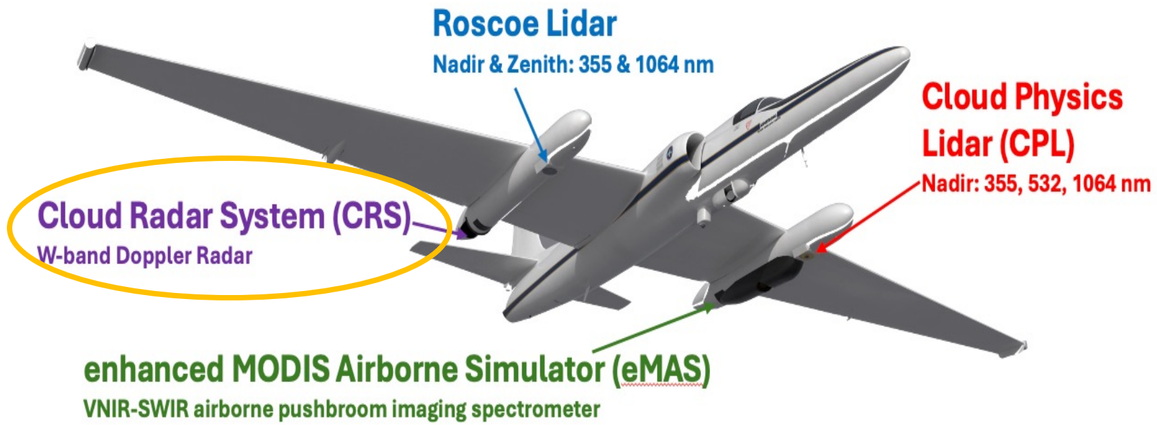
When: 27 Jan. to 28 Feb. 2025
Where: Edwards AFB, California, USA
Objectives: (1) validate new ICESat-2 research atmospheric data products, **(2) validate EarthCARE lidar, radar, spectrometer data products,** (3) test Roscoe receiver alignment.
PI: John Yorks/GSFC
Funded by ICESat-2 Mission and NASA ESD.

Cloud Radar System (CRS)

W-band airborne radar built & operated by NASA/Goddard Space Flight Center. Flies on the NASA ER-2 as well as other aircraft.

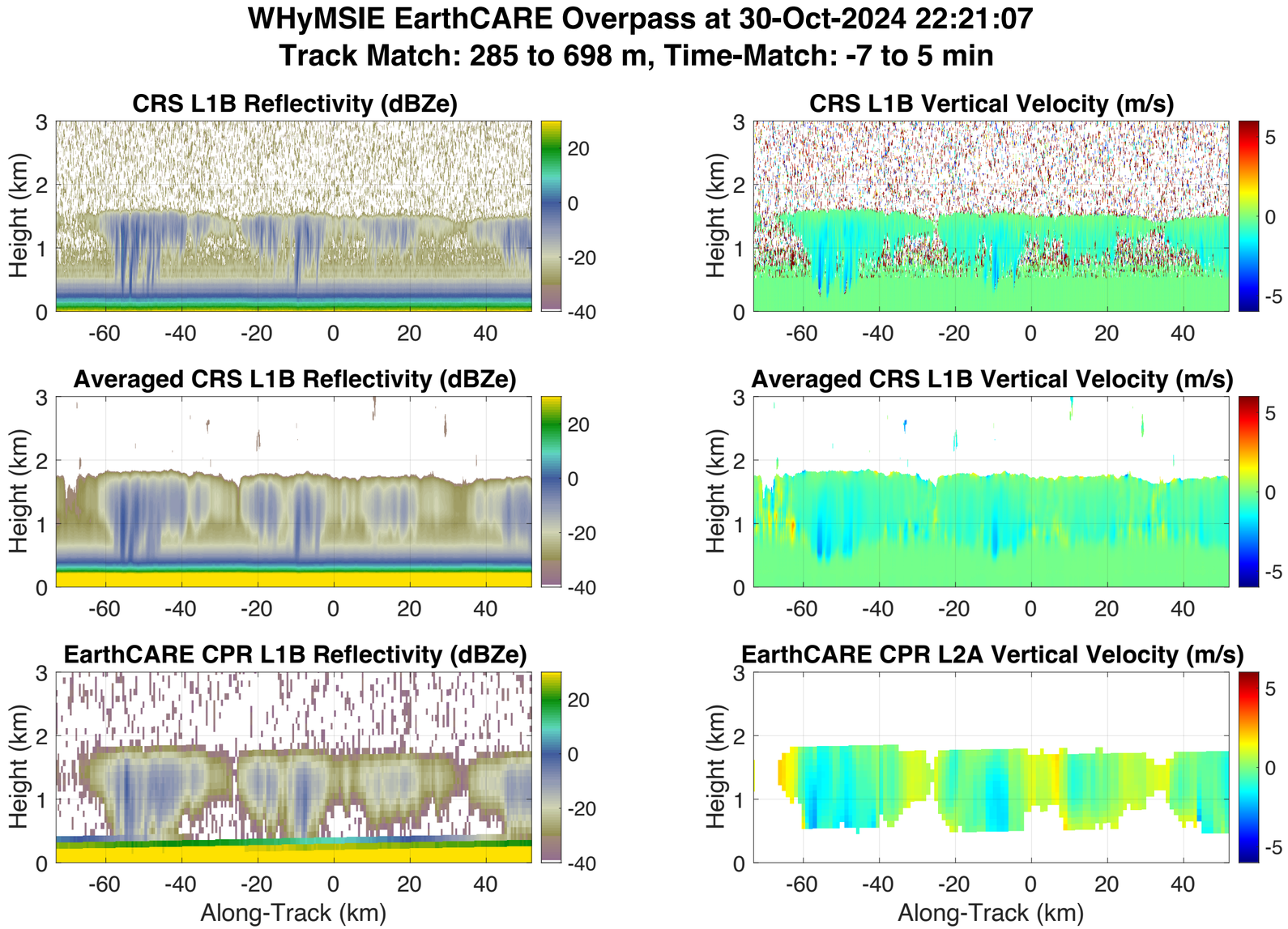
PI: Matt Walker McLinden





Instrument Characteristic	CRS	EarthCARE CPR
Altitude	20 km	393 km
Frequency	94 GHz	94.05 GHz
Vertical Resolution	115 m	500 m
Horizontal Resolution	185 to 225 m	750+ m
Sensitivity	-35 to -29 dBZe	-35 dBZe
Doppler Velocity Range	+/- 14 m/s	+/- 10 m/s
Transmitter	Pulse-Compressed Solid-State Power Amplifier	Extended Interaction Klystron (EIK)
Peak Power	50 W	1500 W

2024-10-30: Scattered Showers



Scattered rain over ocean.

This dataset was actually taken during the WH2yMSIE field campaign

PI: Antonia Gambacorta/GSFC
https://earth.gsfc.nasa.gov/climate/campaigns/WHyMSIE, funding from NASA and NOAA.

CRS data are available at:
https://har.gsfc.nasa.gov/index.php?section=75

EarthCARE CPR data shows error in areas of light reflectivity due to a resolved hardware issue.

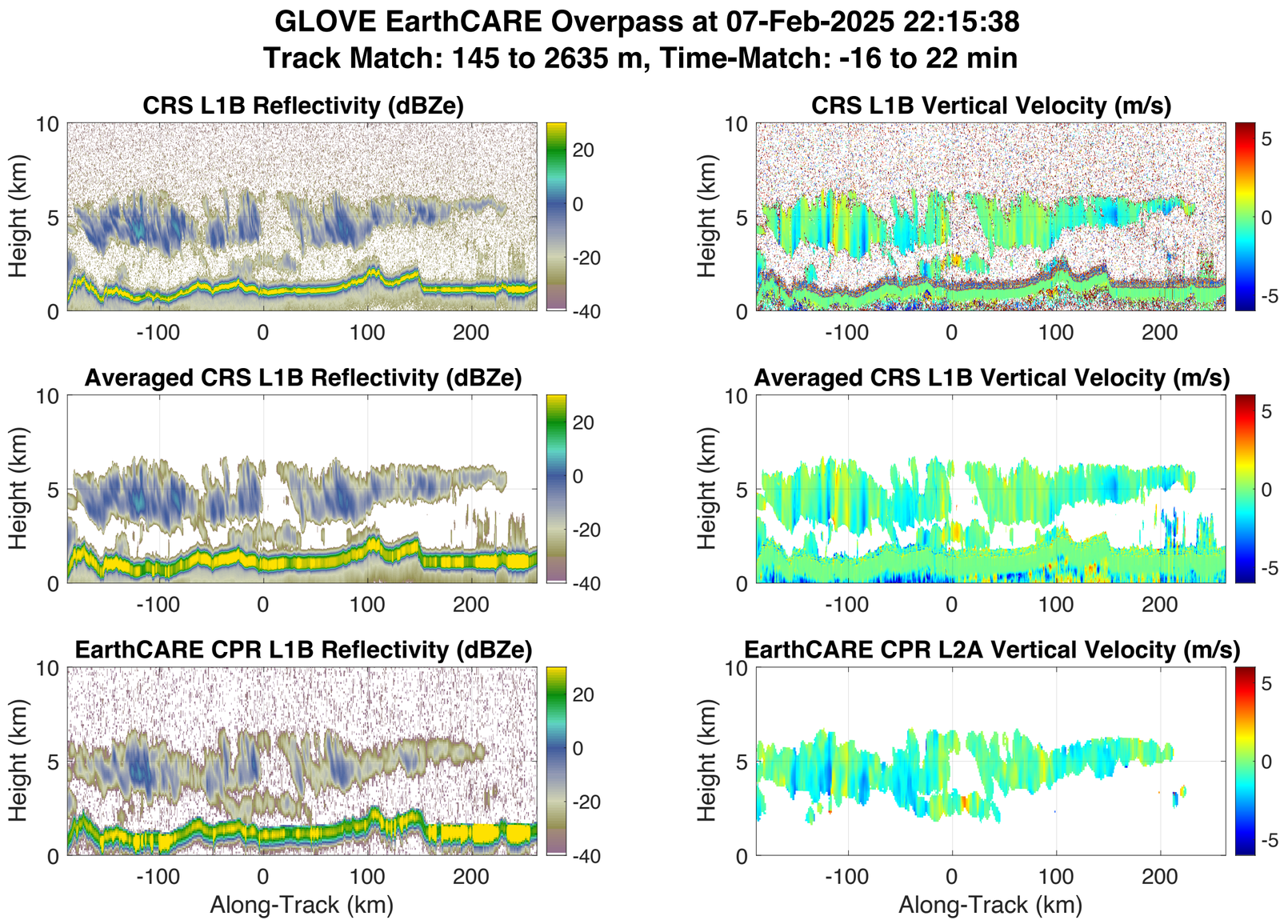
EarthCARE correctly captures areas of light rain.

Cloud tops are mismatched due to differences in vertical resolution.

ECA_JXCA_CPR_NOM_1B_20241030T221030Z_20250205T073410Z_02411D.h5

ECA_MXAC_CPR_CD__2A_20241030T221030Z_20250628T191647Z_02411D.h5

2025-02-07: Gravity Waves



Thick clouds with gravity waves over terrain in Eastern Oregon, USA.

EarthCARE Coincidence: 22:15:38 UTC
Flight Scientist: Kenneth Christian

Data are available at:
https://har.gsfc.nasa.gov/index.php?section=77

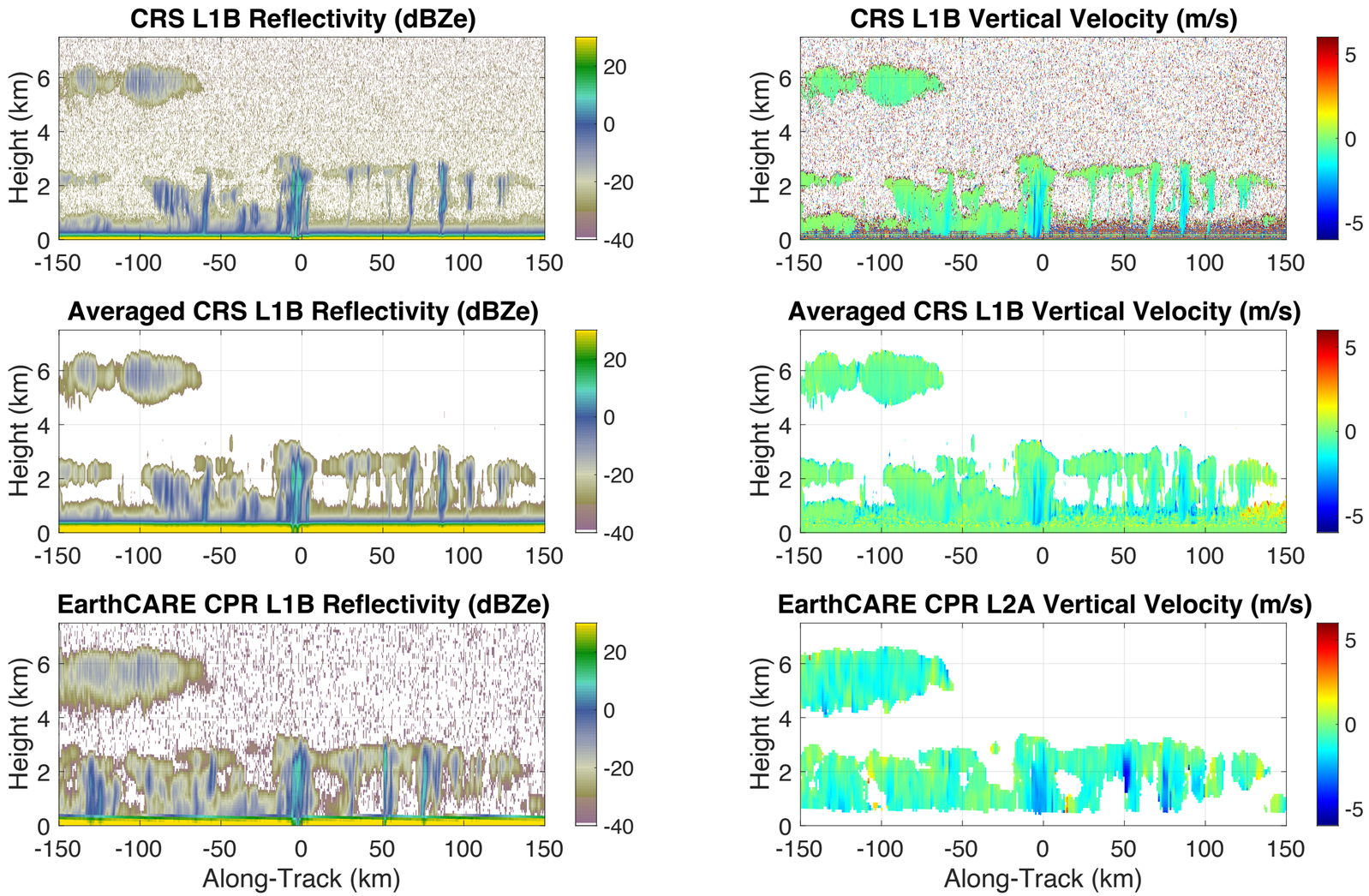
EarthCARE CPR shows gravity waves also detected by CRS.

ECA_JXCA_CPR_NOM_1B_20250207T220907Z_20250207T234837Z_03967D.h5
Version CA

ECA_MXAC_CPR_CD__2A_20250207T220907Z_20250628T234130Z_03967D.h5

2025-02-12: Scattered Rain

GLOVE EarthCARE Overpass at 12-Feb-2025 22:36:36
Track Match: 481 to 1010 m, Time-Match: -13 to 13 min



Scattered precipitation in the Eastern Pacific with a rain shower at the coincident time.

EarthCARE Coincidence: 22:36:36 UTC
Flight Scientist: Charles (Chip) Helms

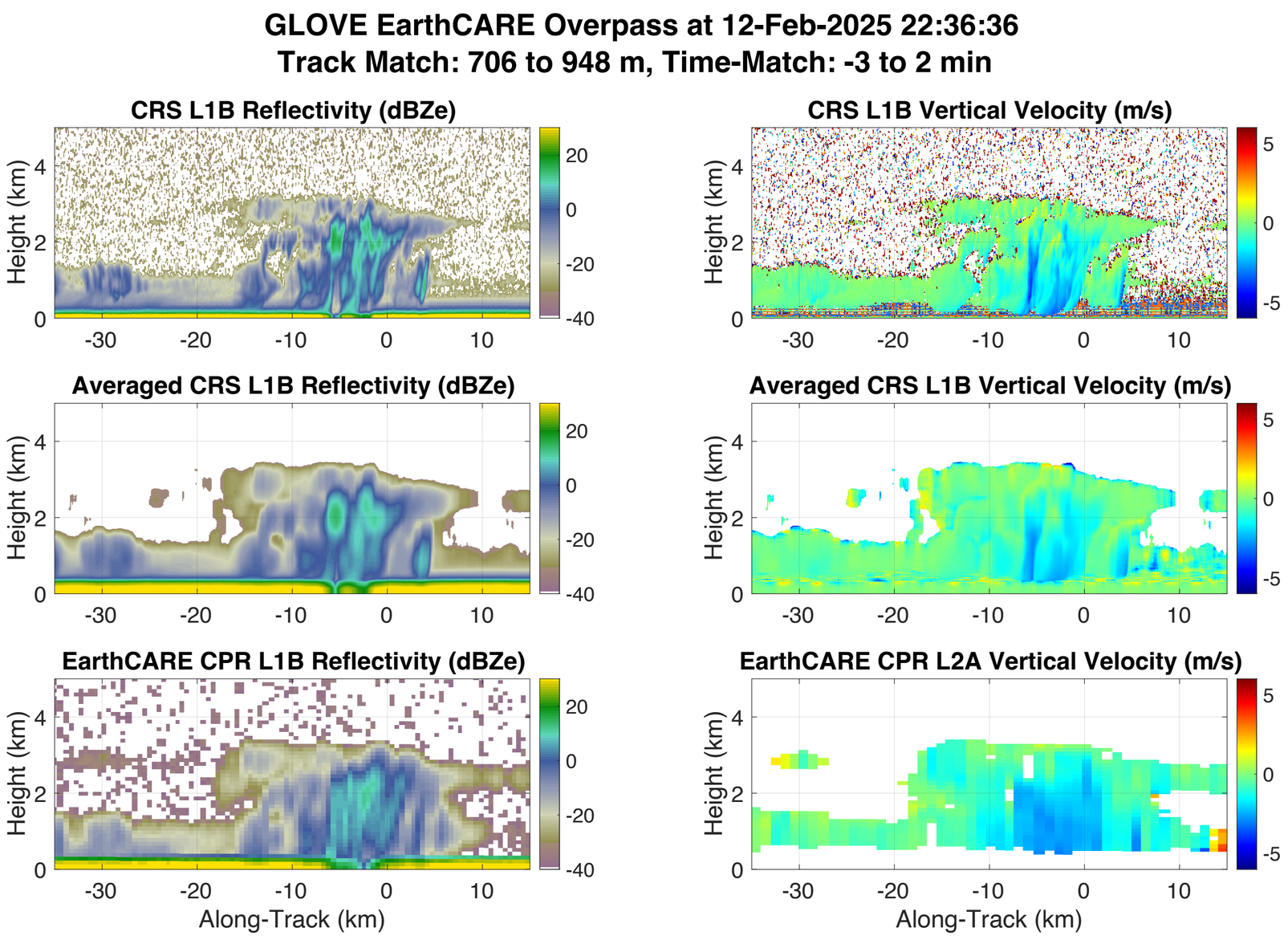
Data are available at:
https://har.gsfc.nasa.gov/index.php?section=77

Very close in space/time (<1 km, <60 s) of precipitation. Other features (5+ min out) show significant changes between observations.

ECA_JXCA_CPR_NOM_1B_20250212T222744Z_20250213T001444Z_04045D.h5
Version CA

ECA_MXAC_CPR_CD__2A_20250212T222744Z_20250628T235715Z_04045D.h5

2025-02-12: Scattered Rain (Zoomed In)



Scattered precipitation in the Eastern Pacific with a rain shower at the coincident time.

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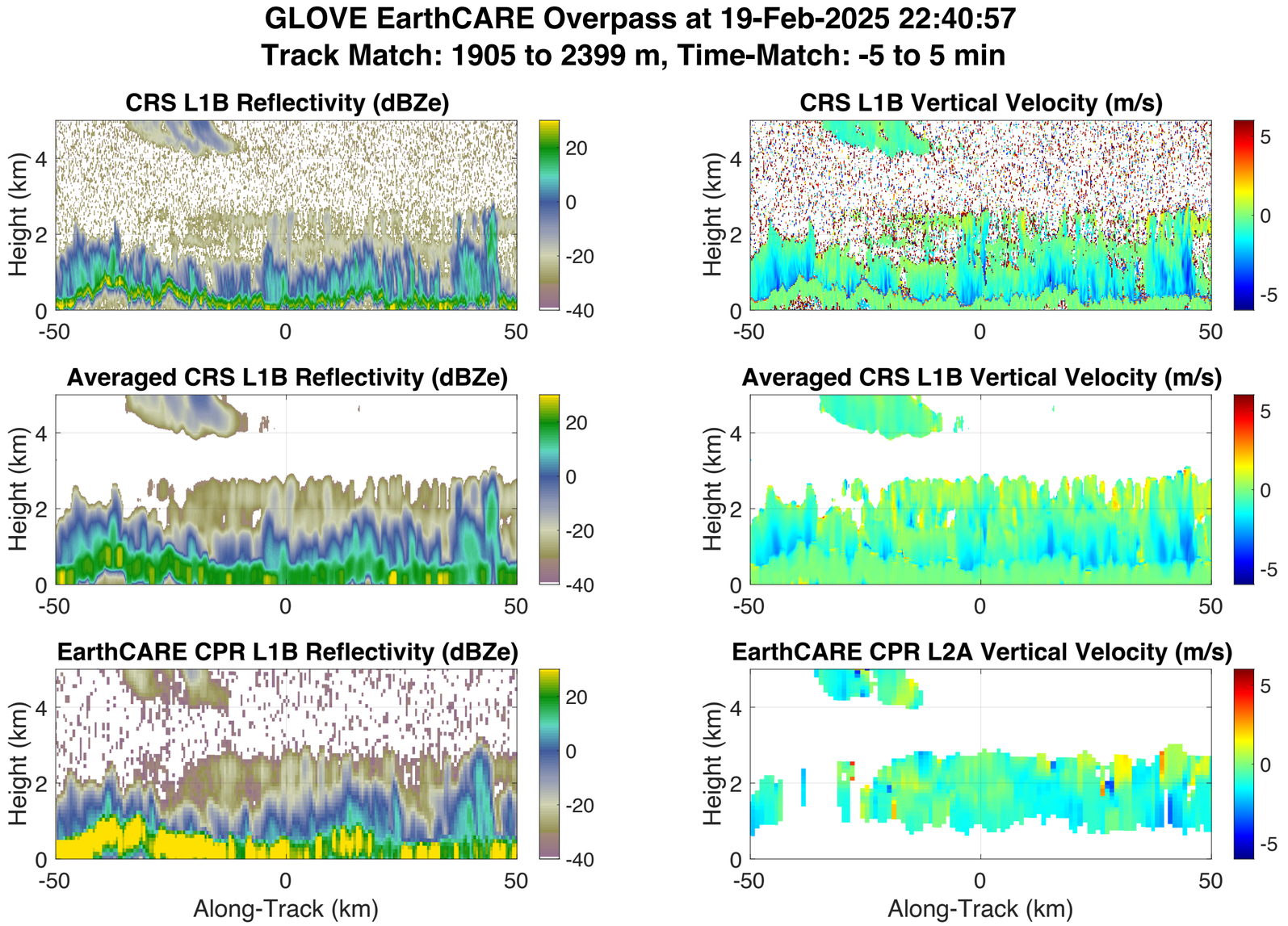
This is a zoom-in of the rain cloud showing reasonable agreement in reflectivity and Doppler. Some differences can be attributed to the different resolutions and ~800 m horizontal offset.

ECA_JXCA_CPR_NOM_1B_20250212T222744Z_20250213T001444Z_04045D.h5
Version CA

ECA_MXAC_CPR_CD__2A_20250212T222744Z_20250628T235715Z_04045D.h5

2025-02-19: Boundary Layer Precip over Land



Boundary-layer Precipitation (<1 km) over rugged terrain in Western Oregon, USA.

EarthCARE Coincidence: 22:40:57
Flight Scientists: Natalie Midzak and Joe Finlon

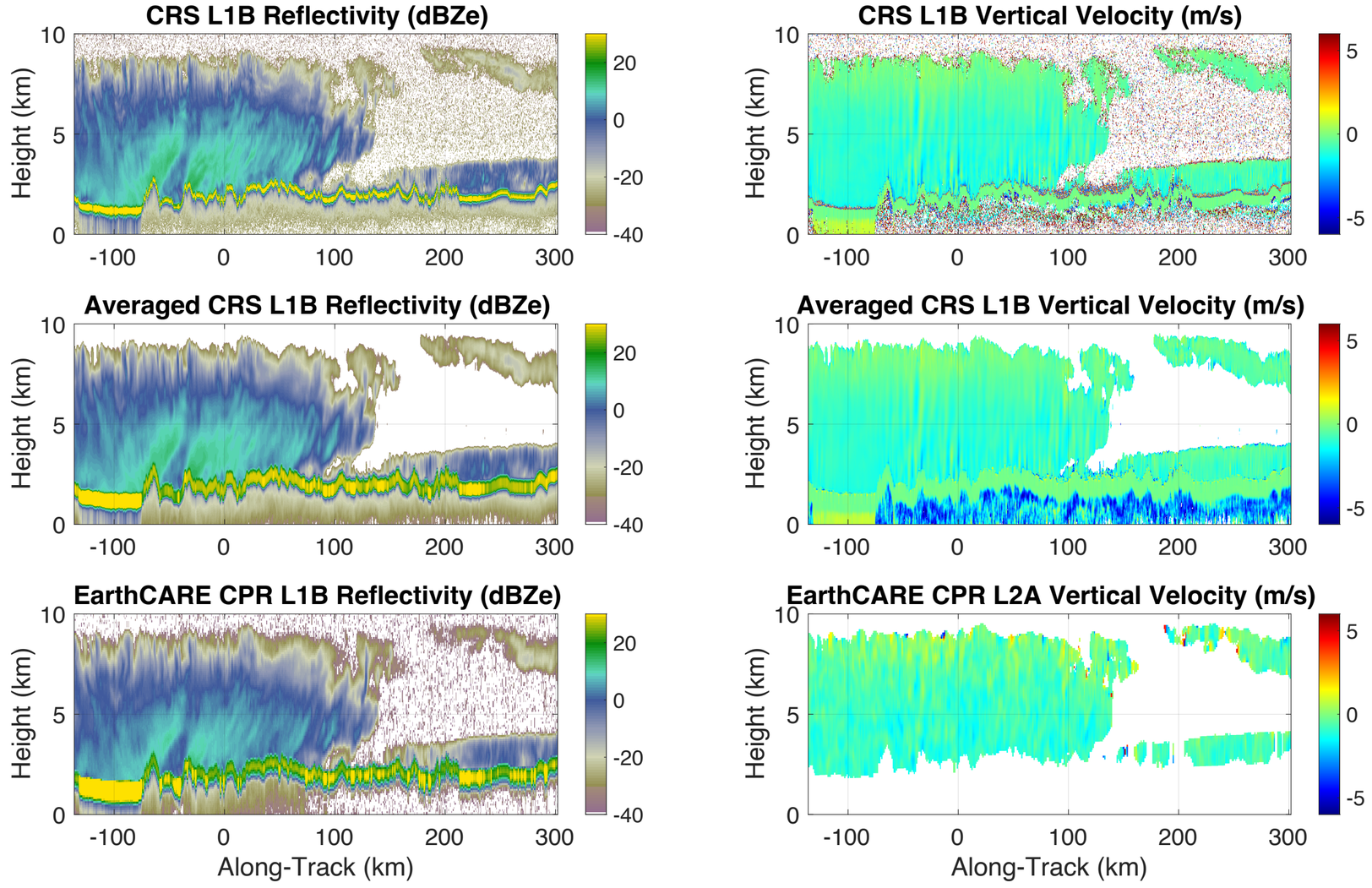
CRS measured pockets of <1 km precipitation in mountainous terrain. Much of this precipitation is below the minimum altitude of EarthCARE Doppler but may be useful as a test-case for near-surface algorithms.

ECA_JXCA_CPR_NOM_1B_20250219T223450Z_20250220T002246Z_04154D.h5
Version CA

ECA_MXAC_CPR_CD__2A_20250219T223450Z_20250629T001936Z_04154D.h5

2025-02-20: Snow with Orographic Features

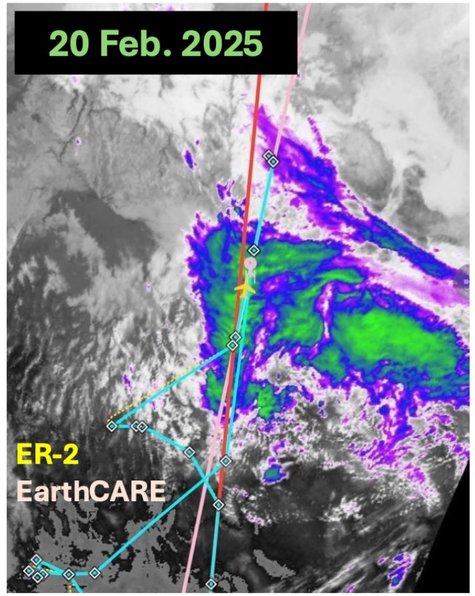
GLOVE EarthCARE Overpass at 20-Feb-2025 21:49:56
Track Match: 5 to 876 m, Time-Match: -12 to 26 min



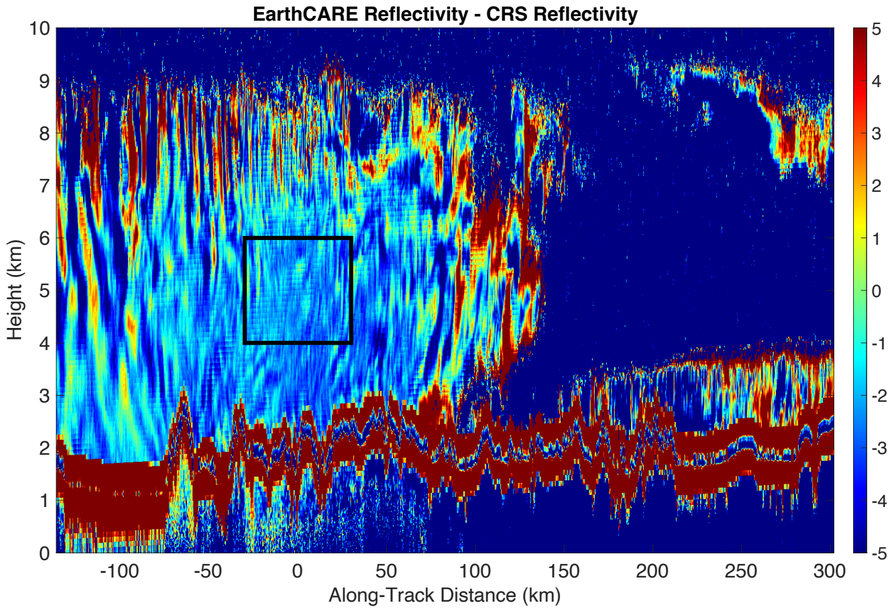
Widespread winter storm with orographic features. The large sections of relatively homogeneous reflectivity and Doppler make this a good test case for calibration and Doppler comparisons (see next page).

EarthCARE Coincidene: 21:49:56
Flight Scientists: Joe Finlon and Natalie Midzak

EarthCARE L1B Version CA



2025-02-20: Bulk dBZe & V comparison



Reflectivity:

VERSION CA (What I processed)

CRS = EarthCARE + 2.2 dB

EXPECTED AFTER VER. CB

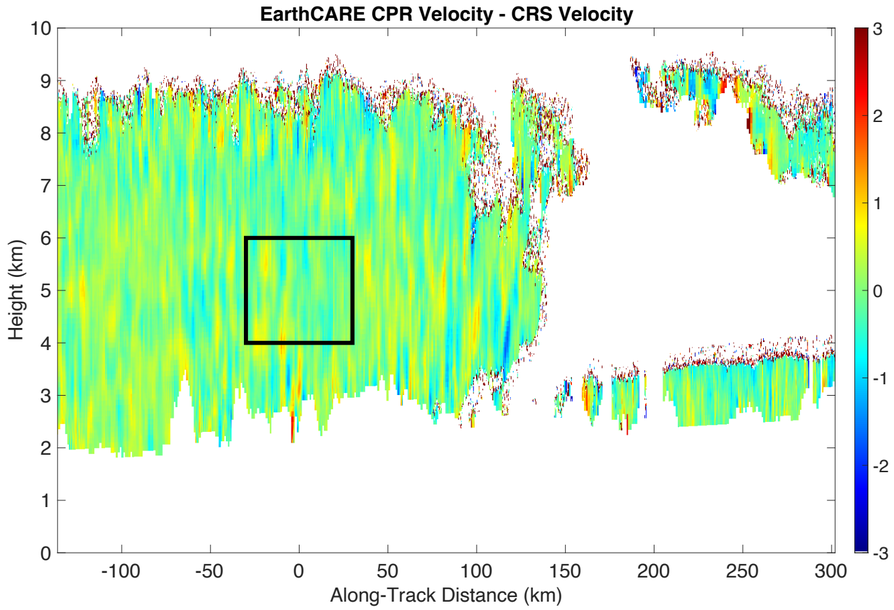
CRS = EarthCARE + 0.6 dB

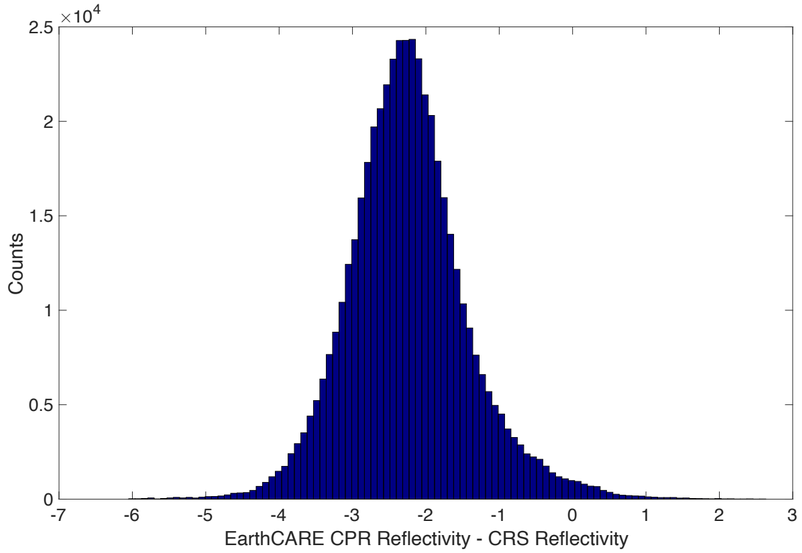
Standard Deviation: 0.8 dB

Doppler:

Match within 0.1 m/s

Standard Deviation: 0.3 m/s

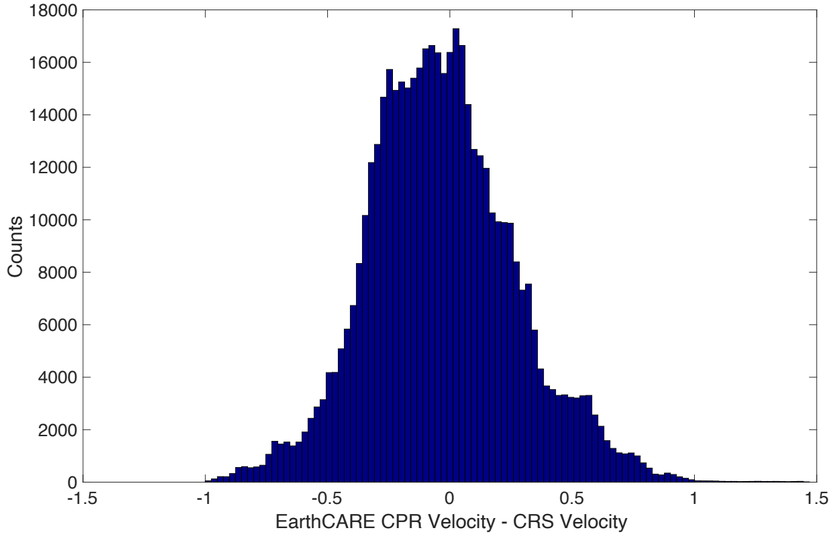




ECA_JXCA_CPR_NOM_1B_20250220T214303Z_20250220T231949Z_04169D.h5

Version CA

ECA_MXAC_CPR_CD__2A_20250220T214303Z_20250629T002241Z_04169D.h5



Processing and Comments

- **Please use these data!** You can reach out to the CRS PI, Matt Walker McLinden (matthew.l.mclinden@nasa.gov) for assistance with the data and processing.
- CRS reflectivity and Doppler data are taken from CRS L1B Rev- files. Data are thresholded at the noise 1-sigma level for a ~15% speckle. Additional despeckling has not been applied.
- Averaged CRS data are provided with a box-car convolution of 500 m x 1 km. The Doppler are reflectivity-weighted.
- EarthCARE CPR reflectivity data are taken from L1B files version CA. I masked the reflectivity data at the noise 1-sigma level for a ~15% speckle without any additional despeckling.
- EarthCARE CPR velocity data are taken from the L2A files indicated. The velocity sign has been flipped to match CRS such that a positive velocity indicates upward motion.
- Thanks to Robert Koopman/ESA for facilitating this coordination and Will McCarty/NASA HQ for the support.

NASA High-Altitude Radar (HAR)

https://**har.gsfc.nasa.gov**/index.php?section=77

Walker McLinden, M. L., L. Li, G. M. Heymsfield, M. Coon, and A. Emory, 2021: The NASA GSFC 94-GHz Airborne Solid-State Cloud Radar System (CRS), *Journal of Atmospheric and Oceanic Technology*, **38**, 1001-1017, https://doi.org/10.1175/JTECH-D-20-0127.1.