National Aeronautics and Space Administration

EVID26: Calibration and Validation of EarthCARE's Cloud Profiling Radar Data Products using NASA/JPL assets

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INTRODUCTION

EarthCARE's Cloud Profiling Radar (ECPR): 1st spaceborne profiling **Doppler** radar to characterize atmospheric dynamics.

Current and upcoming activities of **NASA's Jet Propulsion Laboratory (JPL)** have multiple **synergies** with **ECPR**:

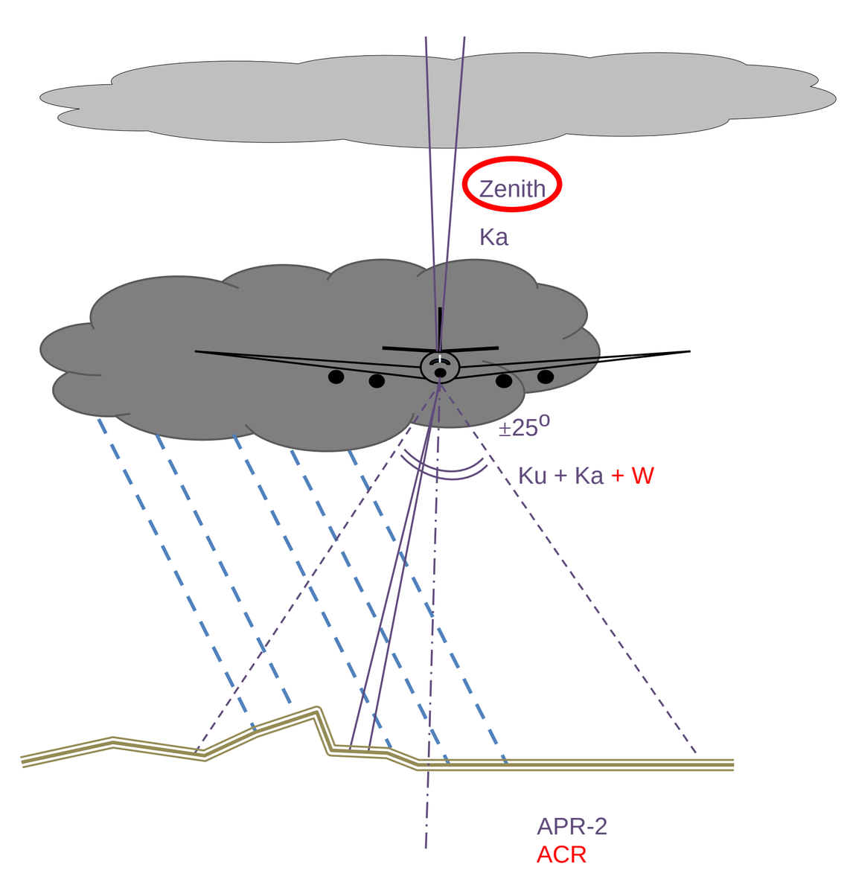
1. JPL's **airborne Doppler radars** successfully operating: a) **Airborne Precipitation & cloud Radar (APR3:** Ku/Ka/**W)**
   b) **CloudCube** (Ka/**W**/G)
2. **INCUS** mission (launch NET 2026): constellation of **Radars in SmallSats** with heritage from **RainCube**
3. **Numerical tools**: NEOS[3] (OSSEs), HiDReSS (Sub-Orbital to Orbital Doppler), Radar/in situ (microphysical analyses)

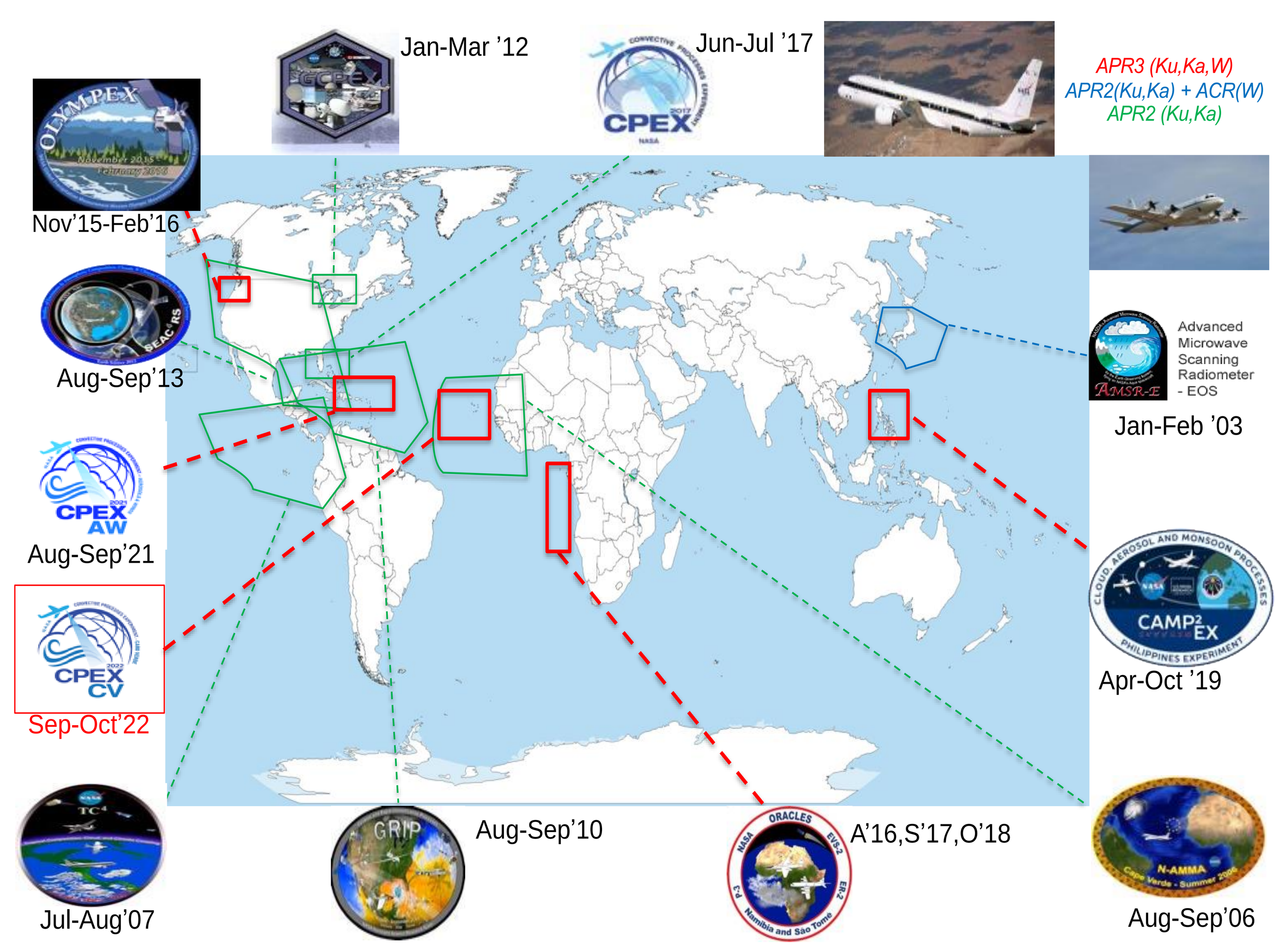
θ_{point}	nadir
Freq	94.05 GHz
θ_{3dB}	0.095°
PRF	6.1-7.5 kHz
τ	3.333 µs
L_{Pulse}	500 m

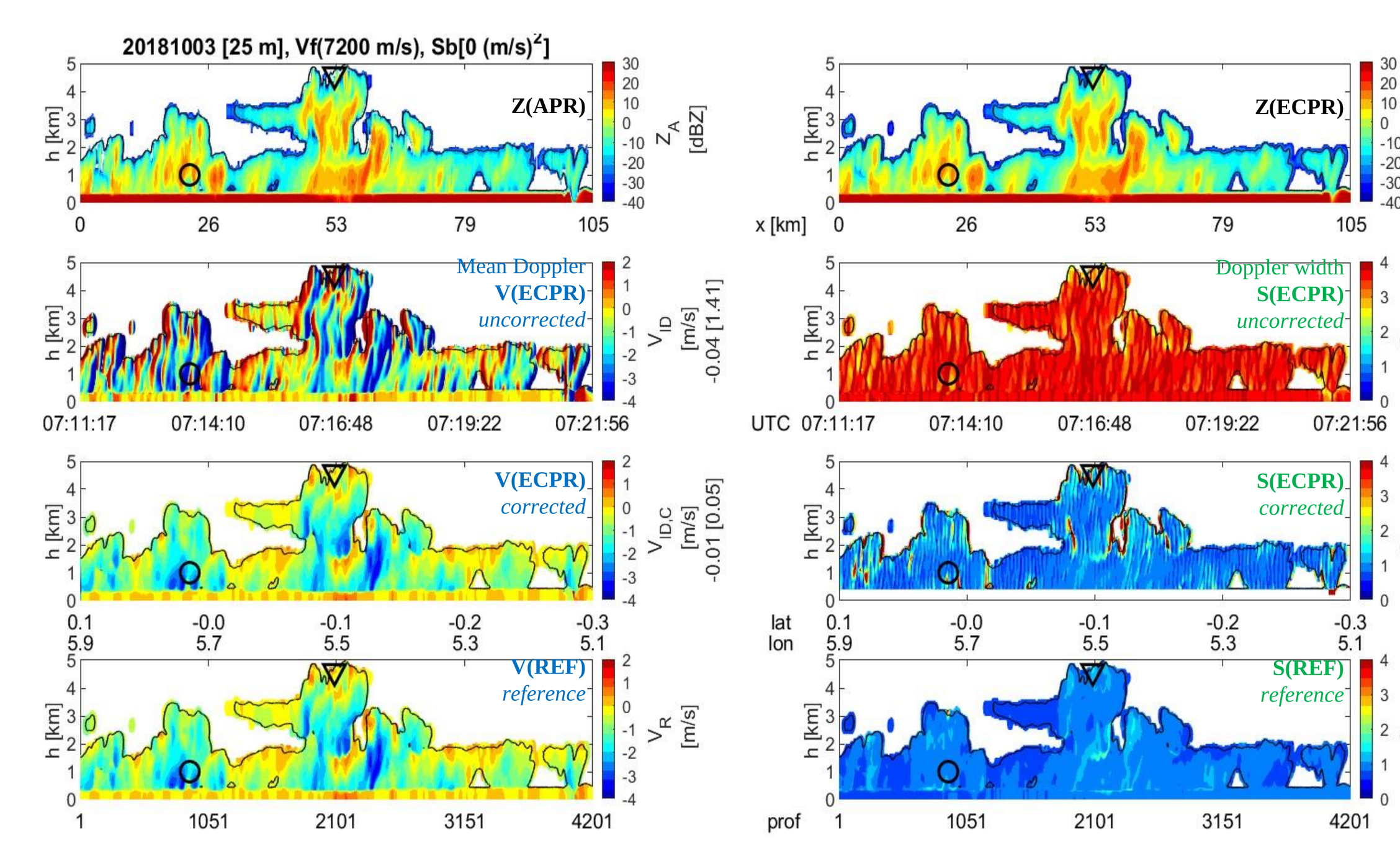
APR-3

- Airborne Precipitation & cloud Radar 3rd gen. (APR3)
- PI**:** Dr. **R. Rodriguez-Monje**
- **(Ku,Ka,W) bands** collimated on nadir port
- Ka-band at zenith port
- supports science of GPM, CloudSat, RainCube, EarthCARE, ...

Parameters	Ku-band	Ka-band	W- band
Frequency(GHz)	13.4	35.6	94
Polarization	HH, HV	HH	HH
Antenna eff. diameter	0.4 m	0.14 m	0.3 m
Antenna gain	34 dBi	34 dBi	50 dBi
Antenna sidelobe	-30 dB	-30 dB	-30 dB
Antenna scan angle	±25°	±25°	±25°
Polarization isolation	-25 dB	-	-
Peak power	200 W	500 W	1400 W
Bandwidth	4 MHz	4 MHz	4 MHz
Pulsewidth	3 - 20 ms	3 - 20 ms	0.25,0.5, 1ms
PRF (pulse rep. freq.)	5 kHz	5 kHz	5 kHz
Vertical resolution	60 m	60 m	50, 80, 150m
Hor.res.(@10 km alt.)	800 m	1000 m	200 m
Ground Swath	10 km	10 km	10 km
Sens.(@10km range)	10 dBZ	-10 dBZ	-35 dBZ
Doppler precision	0.3 m/s	0.3 m/s	0.3 m/s







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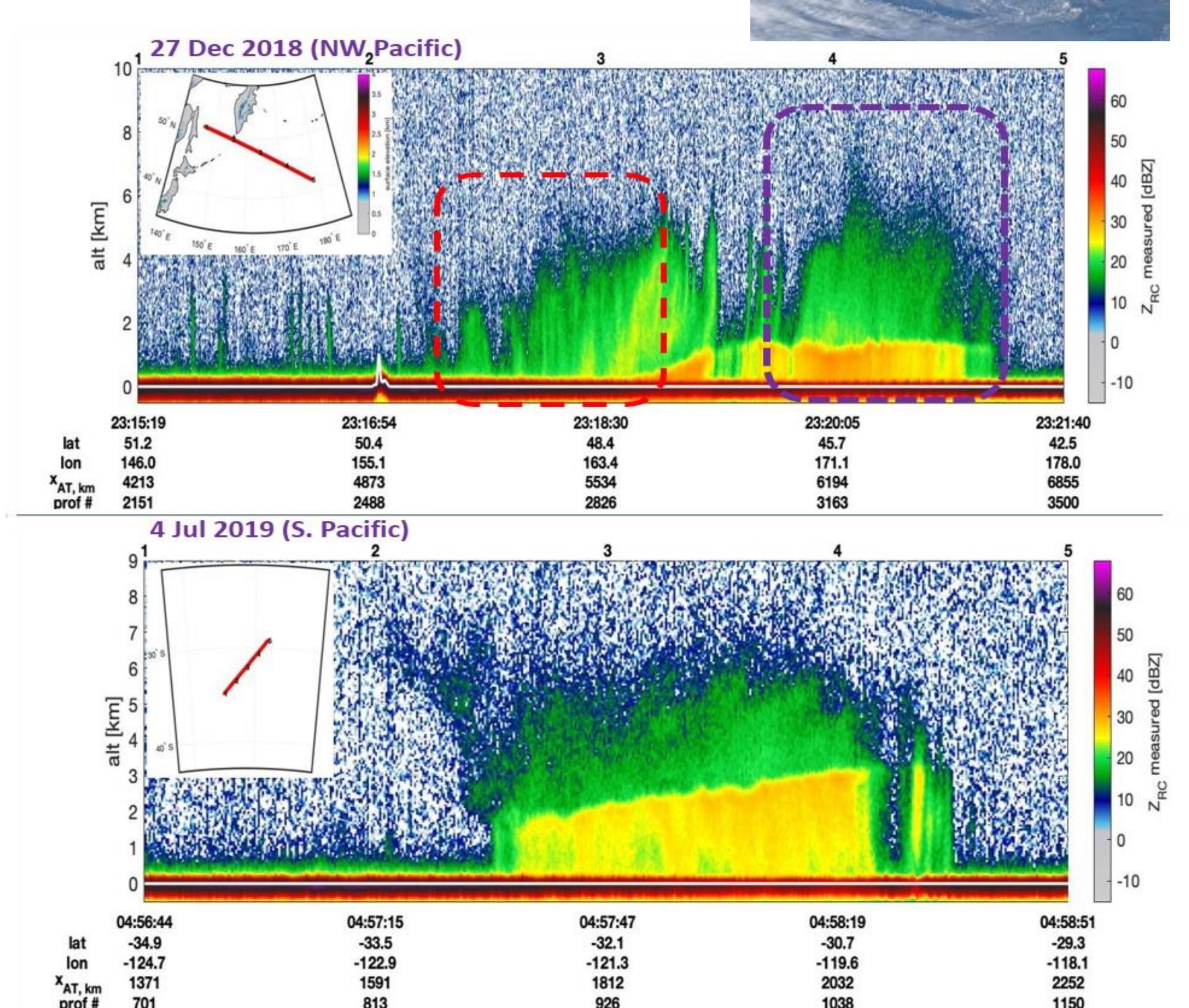
RAINCUBE to INCUS

Radar-In-a-CubeSat

- NASA-JPL ESTO Technology demo
  - 1st Profiling radar in a **6U CubeSat**
  - **0.5 m** parabolic reflector **antenna**
- Launch: May 2018,
- Operations: **Aug. 2018 - Dec.2020**
- PI: **Dr. Eva Peral** (JPL)

- Payload: **miniKaAR radar**
  - **35.75 GHz**;
  - **1 beam;**
  - **Mass: 5.5 kg**
  - Volume: 6U (10x20x30 cm³)
  - RF Power: 10 W
  - Resolution hor. ~8 km
  - Sampling hor. ~2 km
  - Resolution vert.: 240 m
  - Sampling vert.: 60 m



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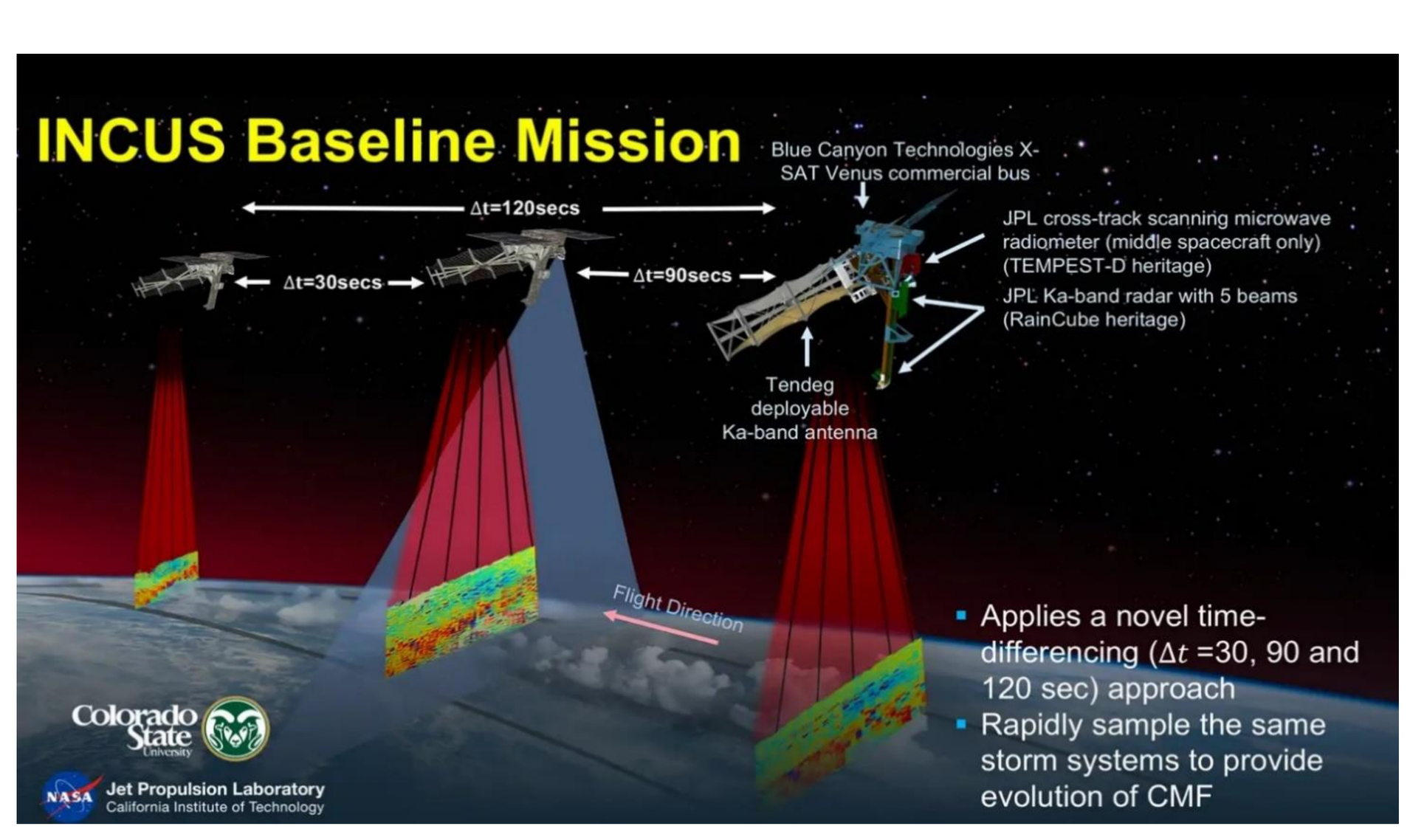
INCUS

Investigation of Convective Updrafts

- NASA Earth Ventures Mission (Nov. **2021**, in **Phase B** as of 13 Nov. 2023)
- Launch: NET **2026**
- PI: **Prof. Susan van den Heever** (CSU)

- Payload:
  - **3 DAR**: radars (*RainCube-like*)
    - **Ka-band;**
    - **1.6 m antenna (7 beams)**
    - **Mass: 7 kg**
    - resolution: 3 km (H), 240 m (V)
    - swath: 9 km
  - **1 DMR**: radiometer (*Tempest-D-like*)
    - **(87, 165, 174, 178, 181±0.5) GHz**
    - **Mass: 3.8 kg**
    - resolution: 16 km
    - swath: 1000 km



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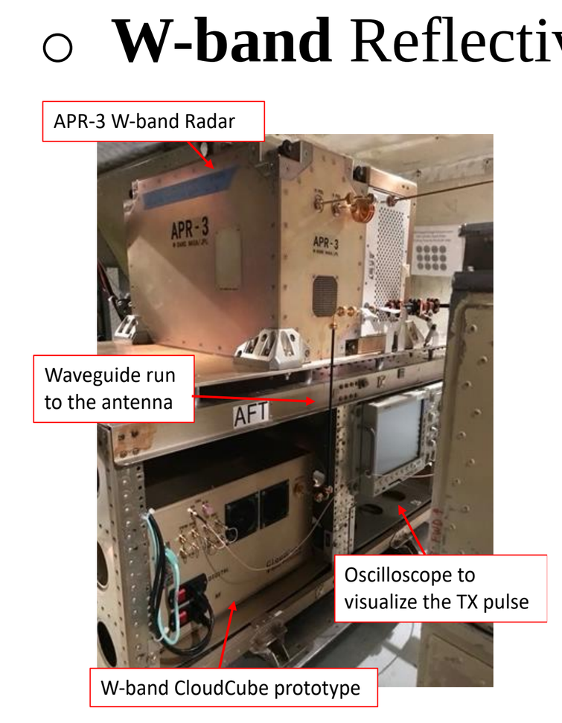
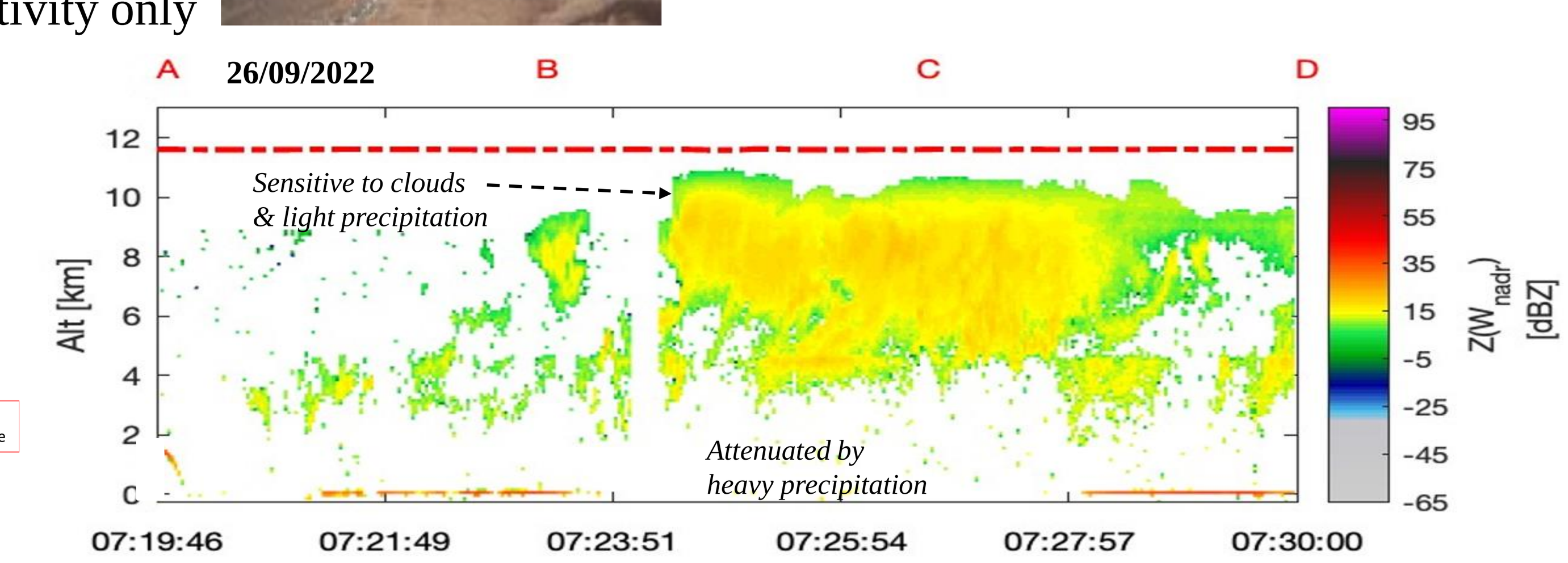
CLOUDCUBE

- NASA-JPL ESTO IIP-19
- 1st ultracompact, pulsed-compression radar that combines (Ka/W/G)-bands
- PI: **Dr. Raquel Rodriguez Monje (JPL)**

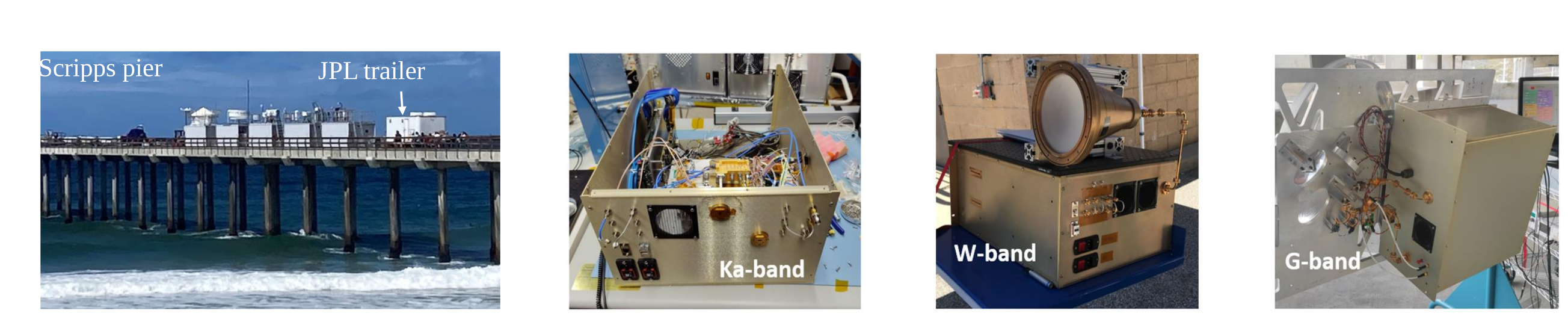
Parameters	Ka-band	W-band	G-band
Frequency (GHz)	35.7	94.9	238.5
Antenna eff. Diameter	0.30 m	0.30 m	0.2 m
Antenna gain	40 dBi	47 dBi	51 dBi
Peak Power	10 W	10 W	0.4 W
Bandwidth	2 MHz	2 MHz	2 MHz
Pulsewidth	10-20 us	10-20 us	10-20 us
PRF	0.5 kHz	0.5 kHz	0.5 kHz
Vertical resolution	75 m	75 m	75 m
X-track Hor. Res. (@10 Km alt.)	346 m	127 m	100 m
Sens. (@10km range)	-7.2 dBZ	-14.6 dBZ	-15.5 dBZ

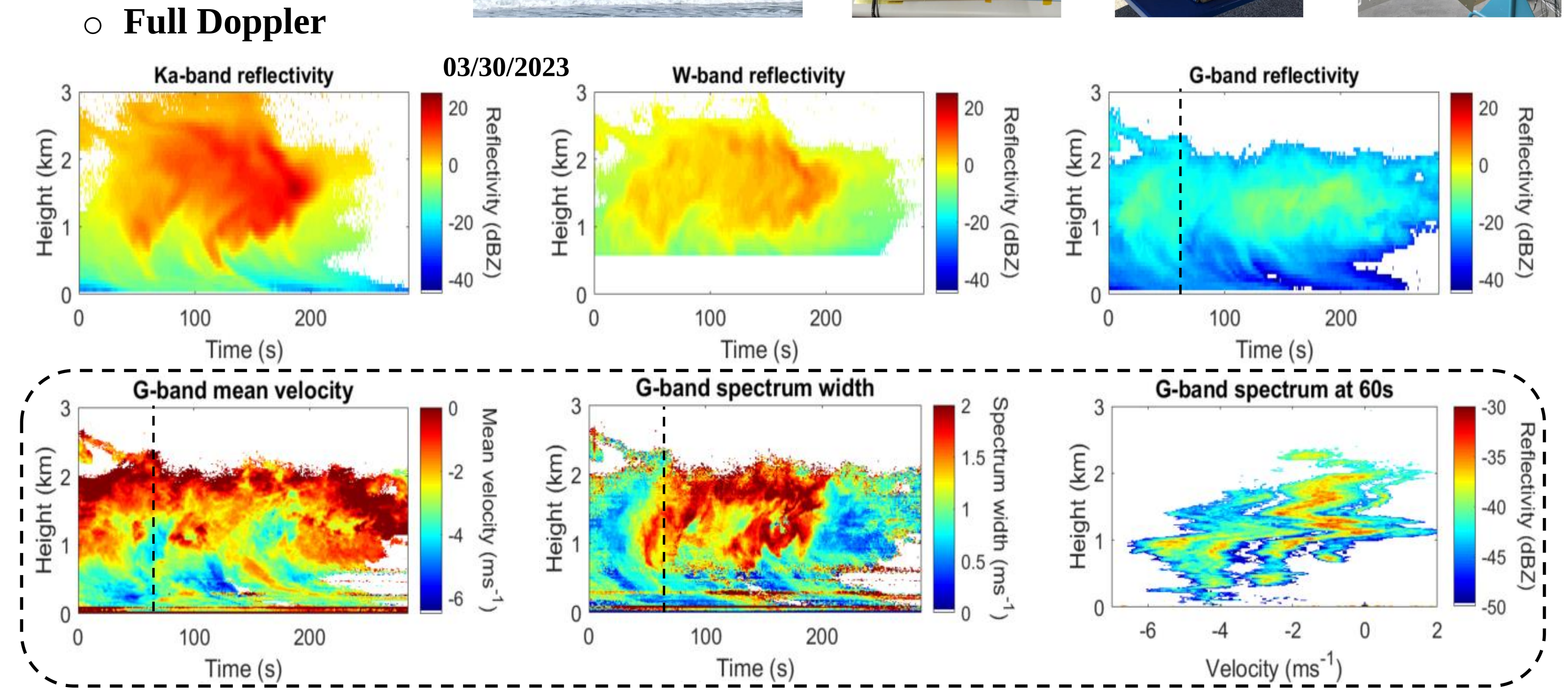
- Field-campaign participations
  - **CPEX-AW2021 & CV2022**
    - **Airborne**: NASA DC-8
    - **W-band** Reflectivity only





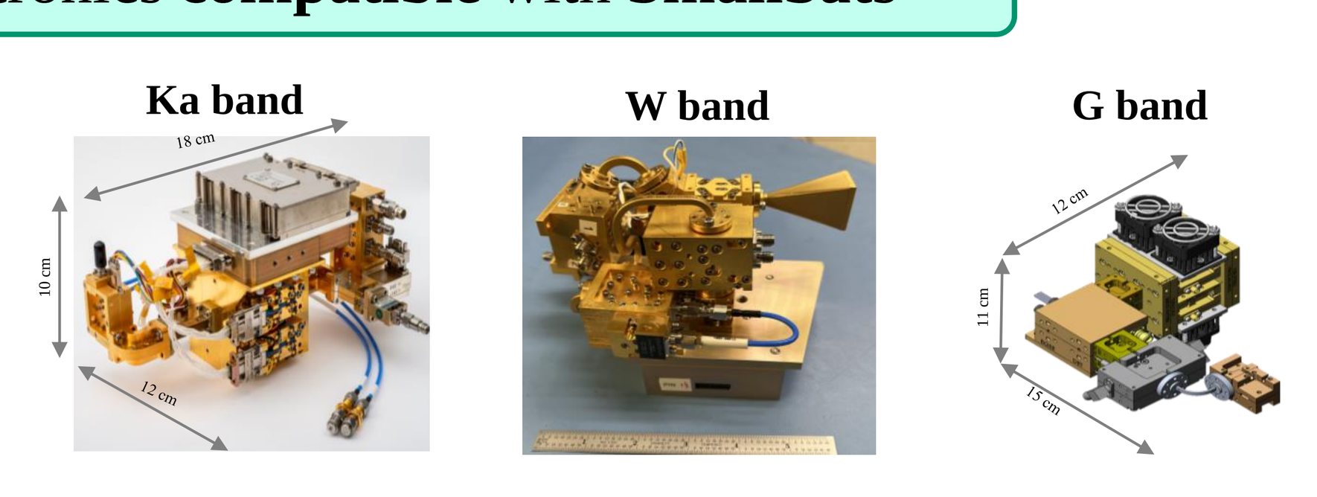
  - **EPCAPE 2023-2024**:
    - **Ground-based on trailer**
    - **Ka/W/G-band**
    - **Full Doppler**





Spaceborne CloudCube Radar Electronics **compatible** with **SmallSats**

- ✓ **Compact**: **<3U volume** per frequency channel
- ✓ **low power** RF electronics: **20-30W** DC power per frequency channel



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