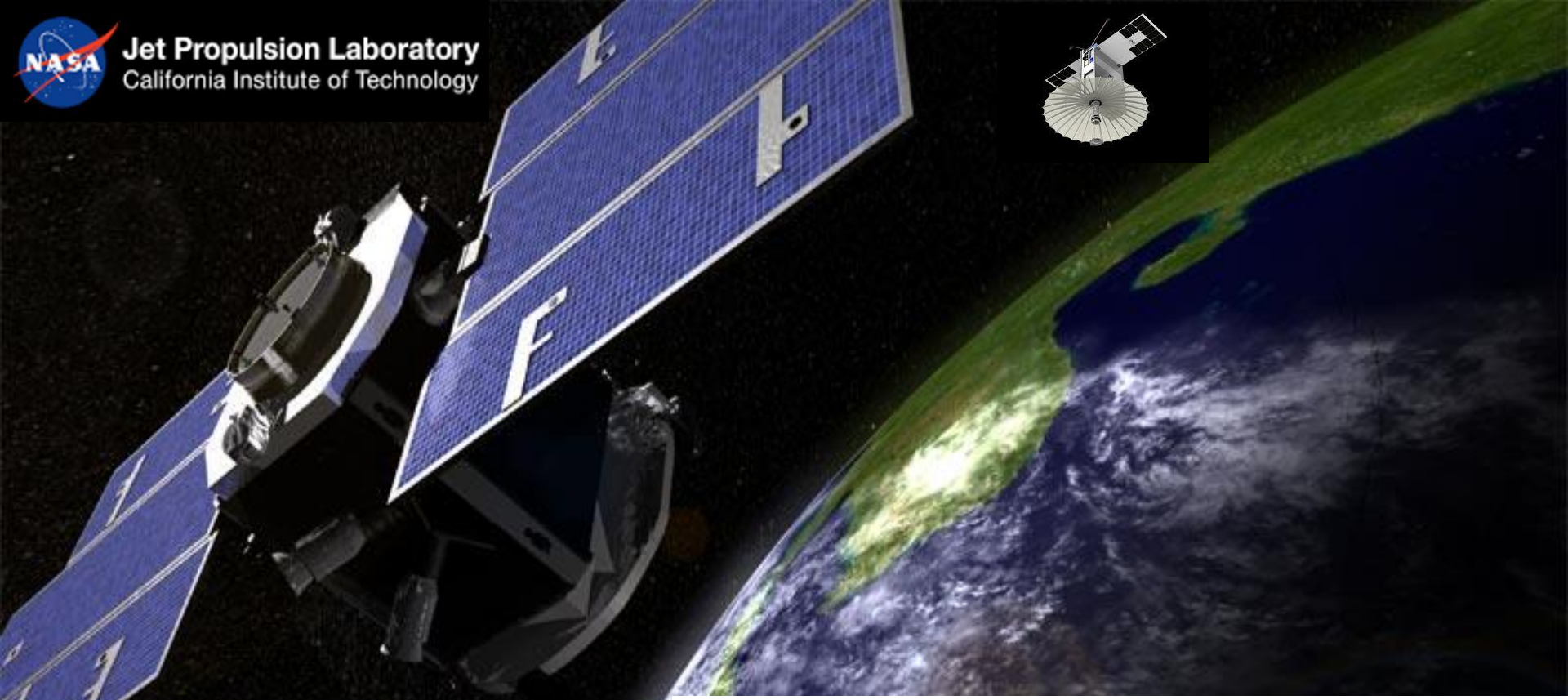
Jet Propulsion Laboratory
California Institute of Technology



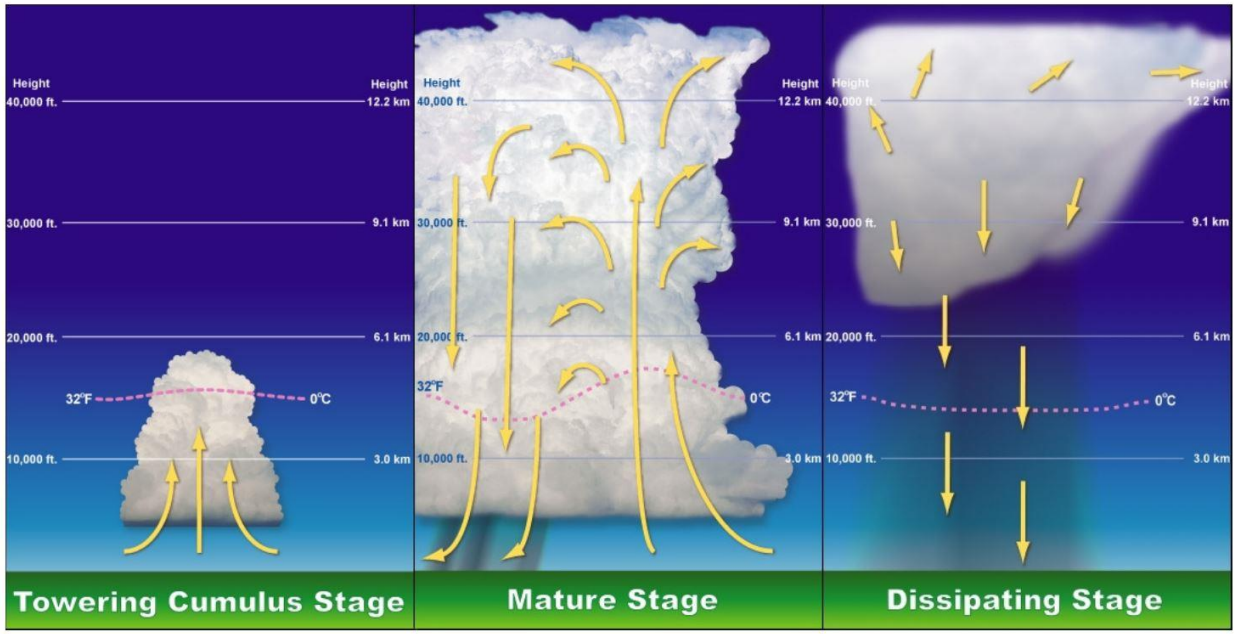
RainCube: In-Flight Results, Science, Future Plans

Ousmane O. Sy, E. Peral, S. Tanelli, E. Im, G.F. Sacco,
Z.S. Haddad, S.L. Durden, S. Joshi, G. Dobrowalski

Radar Science & Engineering Section
Jet Propulsion Laboratory, California Institute of Technology

© 2019, California Institute of Technology. Government sponsorship acknowledged.

Spaceborne cloud radar and time



(Lifecycle of a thunder storm). Credit: NOAA

	Cloudsat (2006)	GPM (2014)
Max size/ weight	5.1 m/995 kg	13 m/3850 kg
Swath [km]	nadir	125–250
I_{orbit} [°]	98	65
Altitude [km]	705	407
Revisit time	$\sim$ 16 days	$\sim$ 3 hours

Lifetime

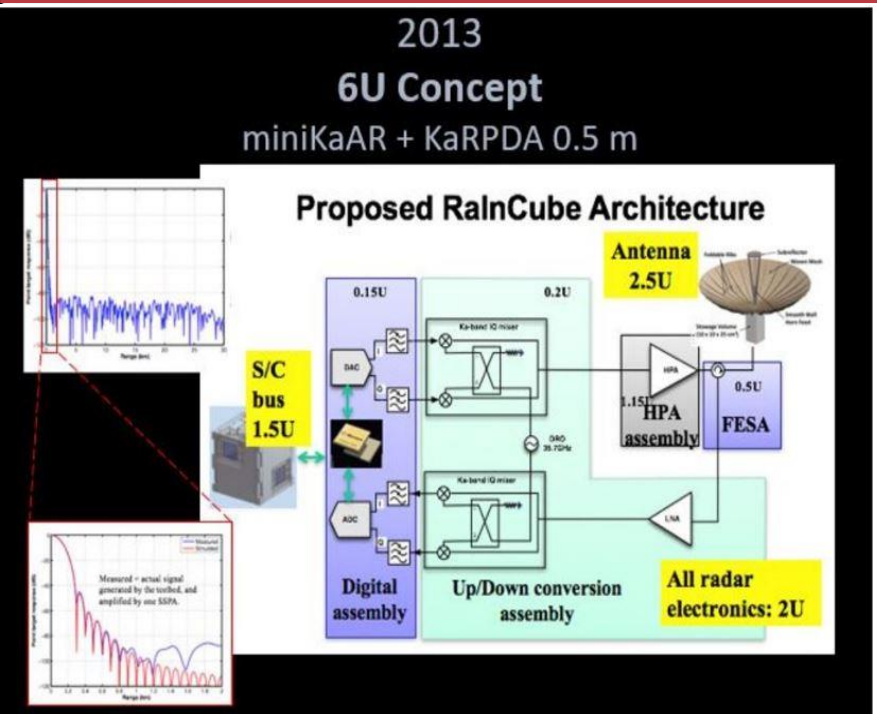
Single cell 30 mins

Multi-cell: few hours

Possible options

- GEO
- Doppler in space
- Constellation of radars

RainCube: 1st Radar in a CubeSat: Dr. Eva Peral (PI, JPL)



- NASA ESTO InVEST program
- NASA Earth Science Division's Flight and R&A Programs

Technology demonstration

Frequency	35.75 GHz
Antenna size	0.5 m
Volume	6U ($10 \times 20 \times 30$ cm^3)
Mass	5.5 kg
RF Power	10 W
Processing	PC & Offset (I,Q) modul.
Beams	1 (nadir)
Hor. Resolution	8 km
Range Res	250 m

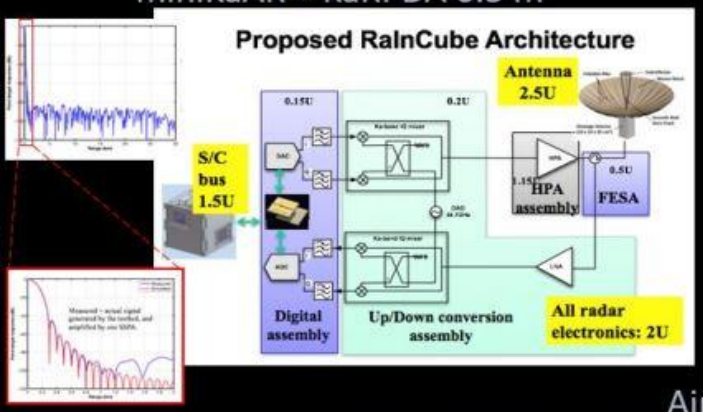
E. Peral et al., "Radar Technologies for Earth Remote Sensing From CubeSat Platforms," in *Proceedings of the IEEE*, vol. 106, no. 3, pp. 404-418, March 2018

RainCube development

2013

6U Concept

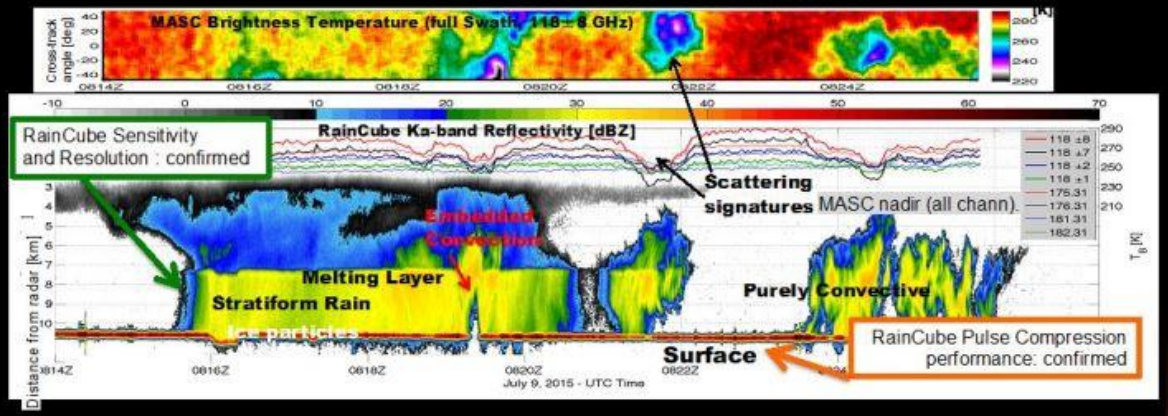
miniKaAR + KaRPDA 0.5 m



2015

PECAN

Airborne Demo of miniKaAR

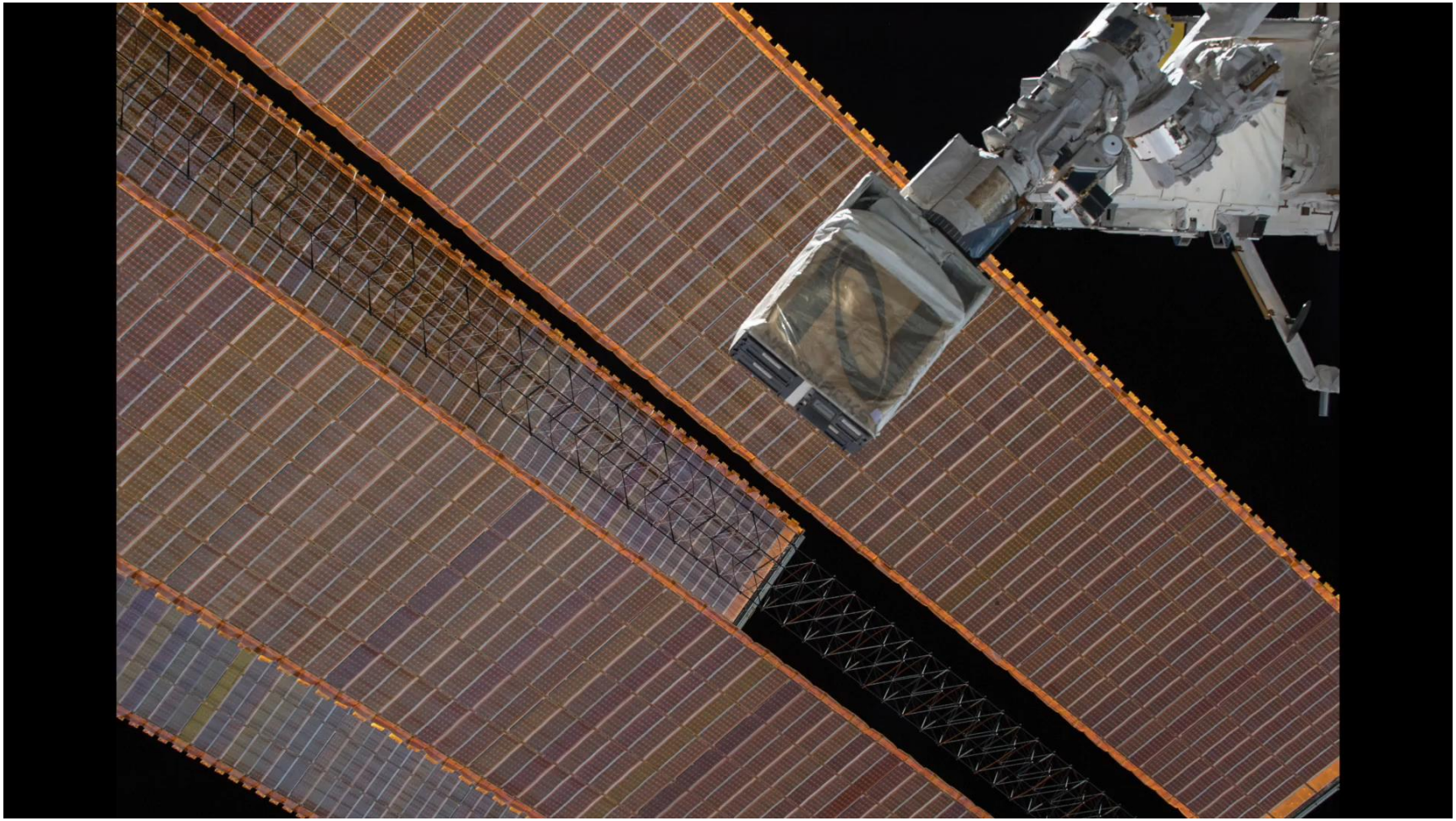


May 2018

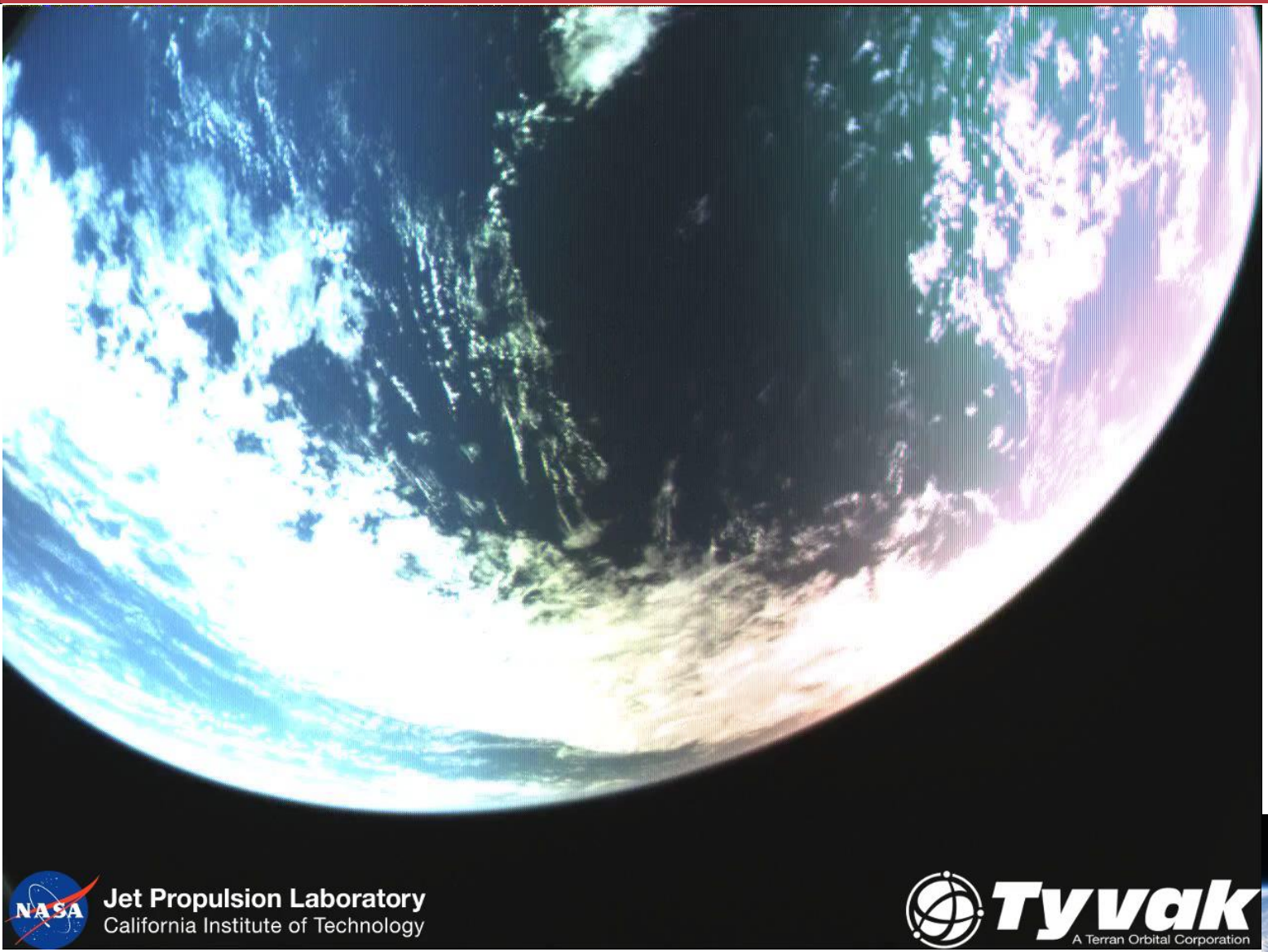
RainCube 6U

Launched to ISS

ISS Deployment: July 13th, 2018

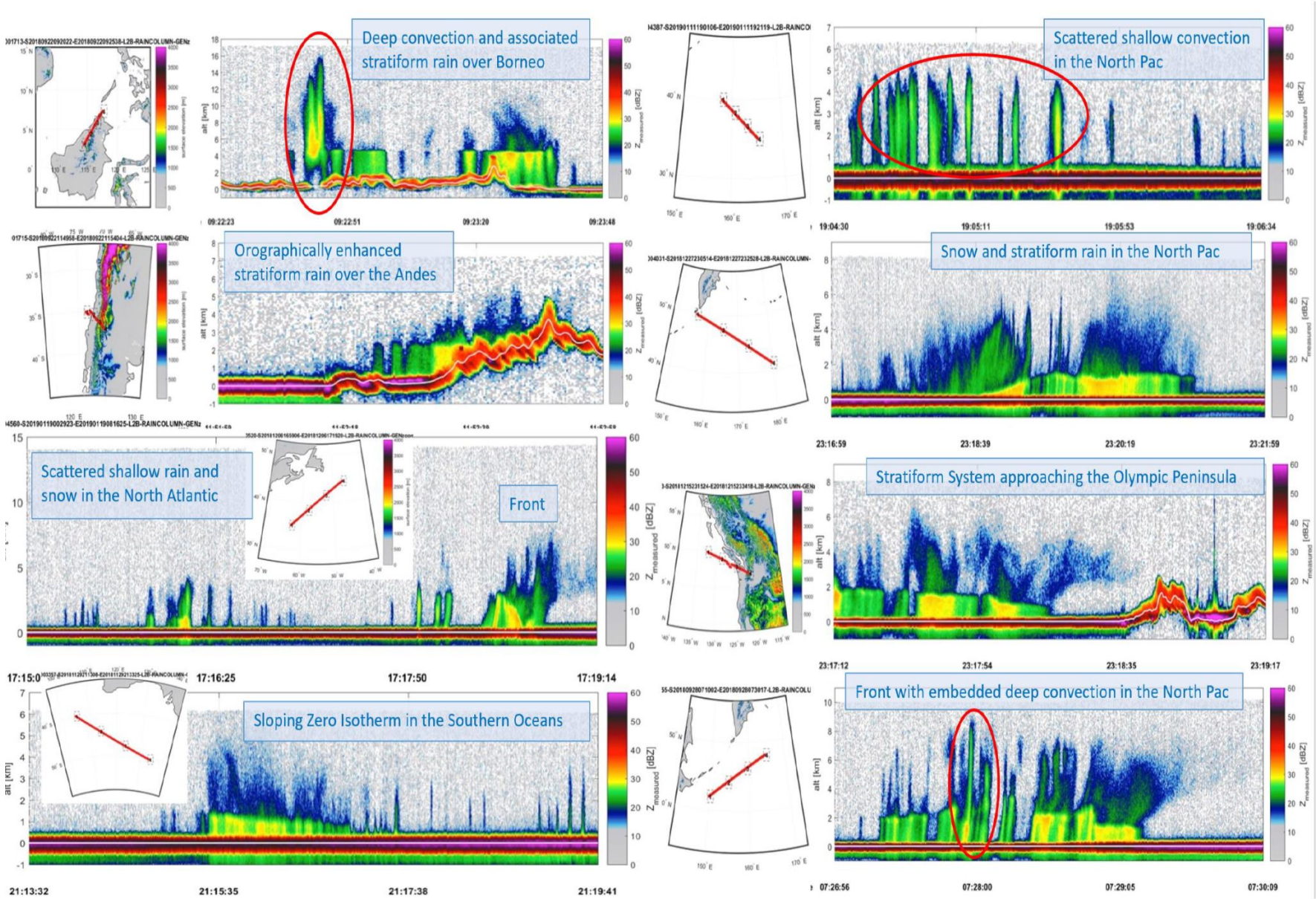


Antenna Deployment: July 28th, 2018

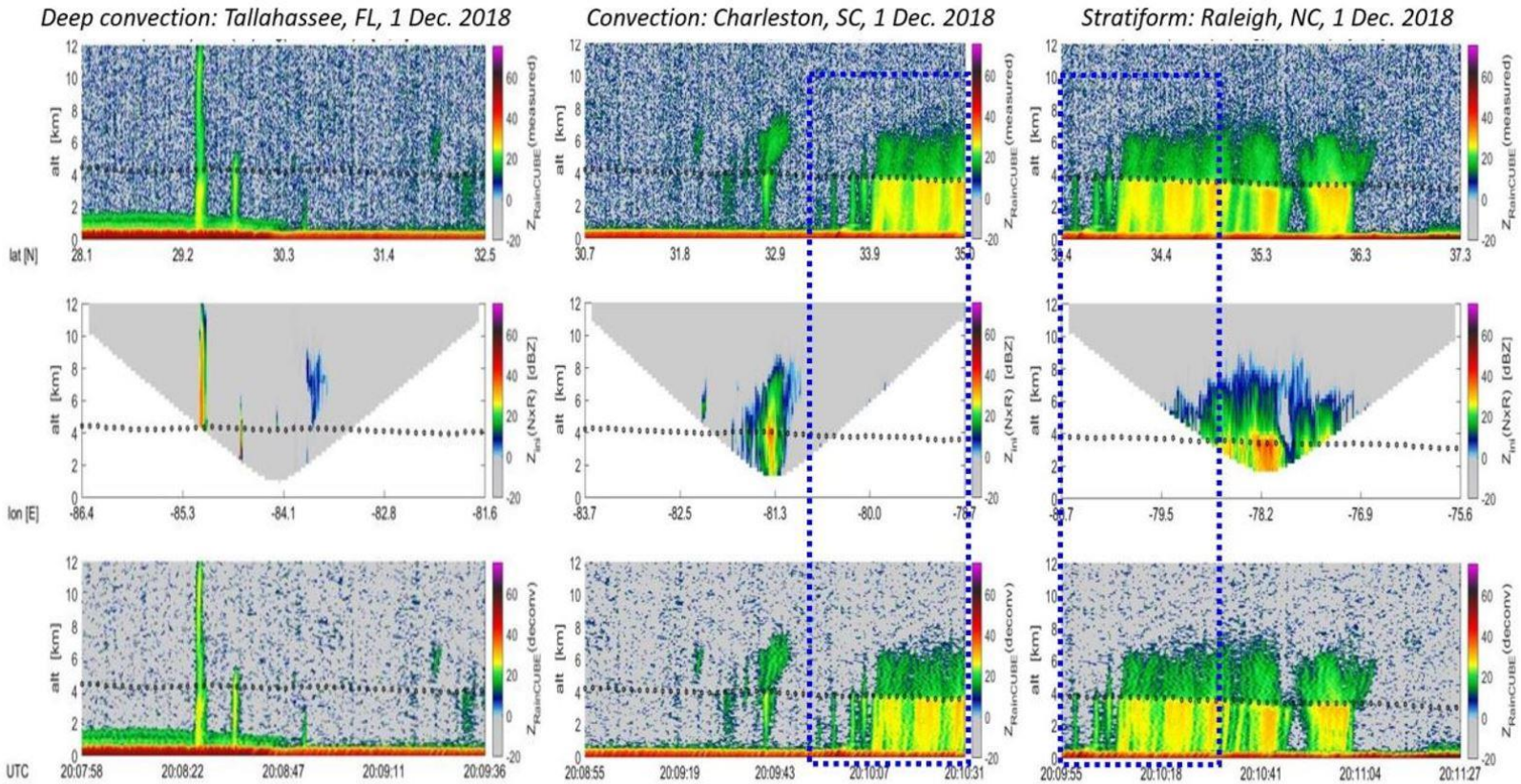


Artist concept

A Collection of RainCube Storms



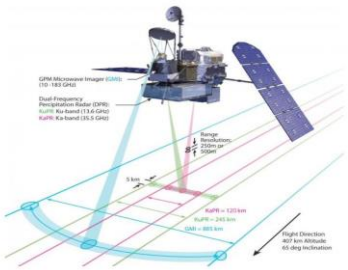
Co-location to NexRAD (NOAA, NWS)

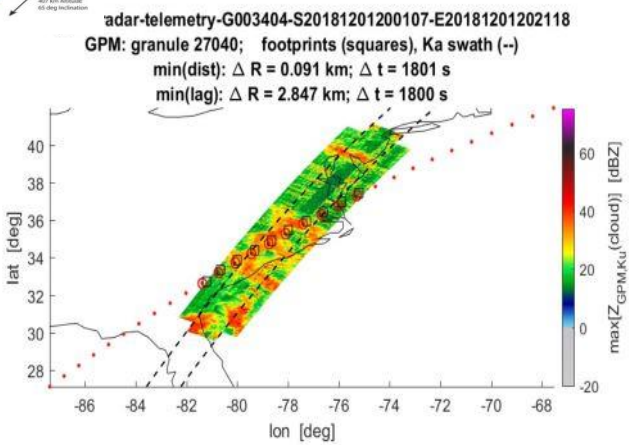


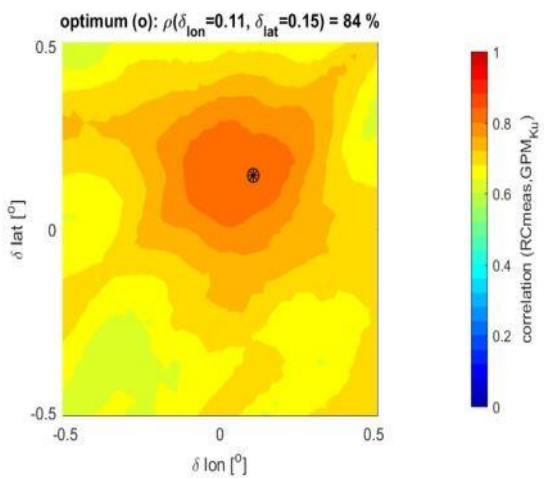
Complementarity $\neq$ viewing geometries, $\neq$ frequencies

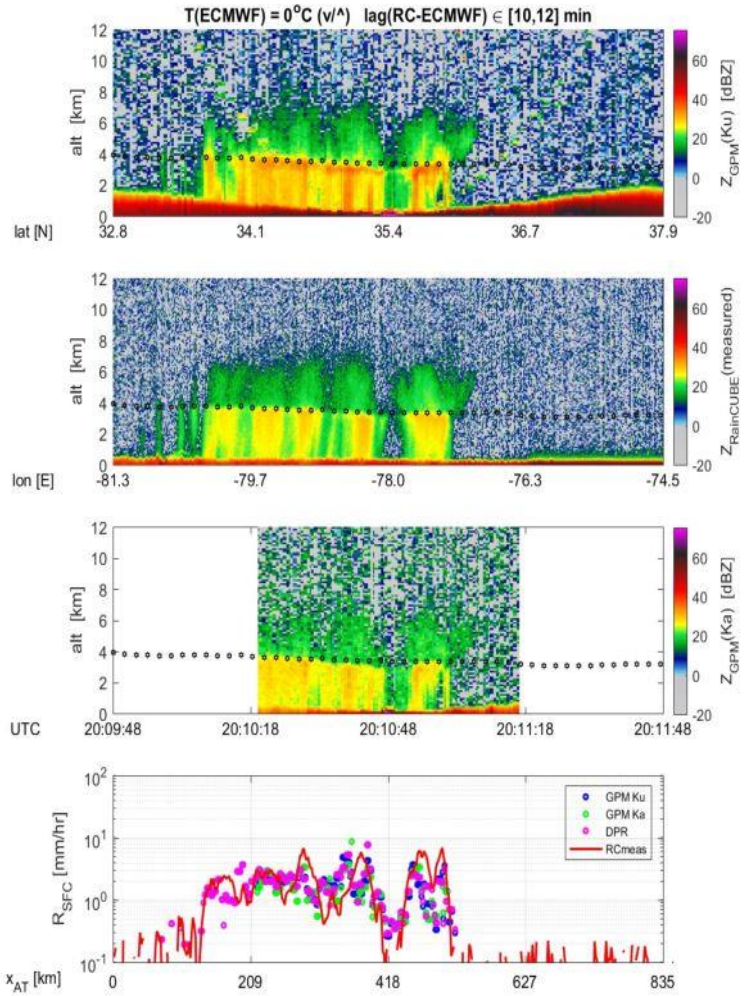
Co-location to GPM DPR (NASA-JAXA)

https://pmm.nasa.gov/gpm









GPM(Ku)

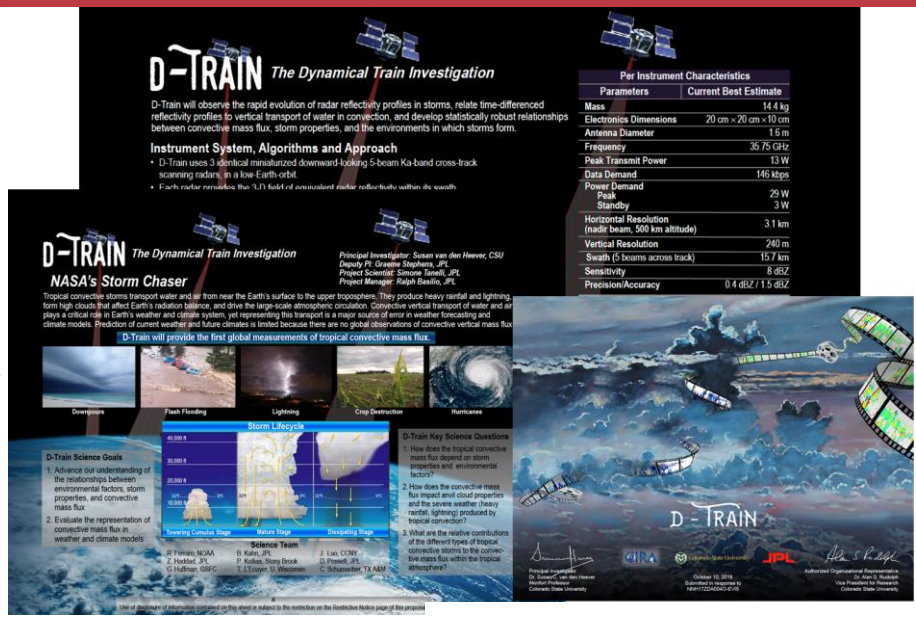
RainCube

GPM(Ka)

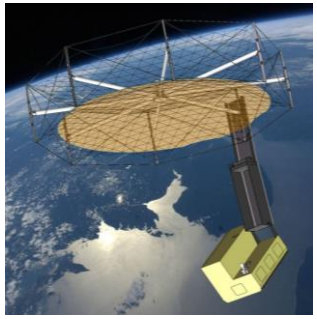
R_{SFC}

RainCube: Constellation mission concepts

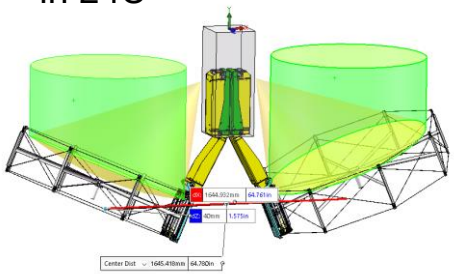
- Constellation with
  - → RainCube's "as is"
  - → with improved antennas & electronics:
    - * Extension to **W** and **G band**
    - *** DPCA** for Doppler, scanning, improved resolution & sensitivity



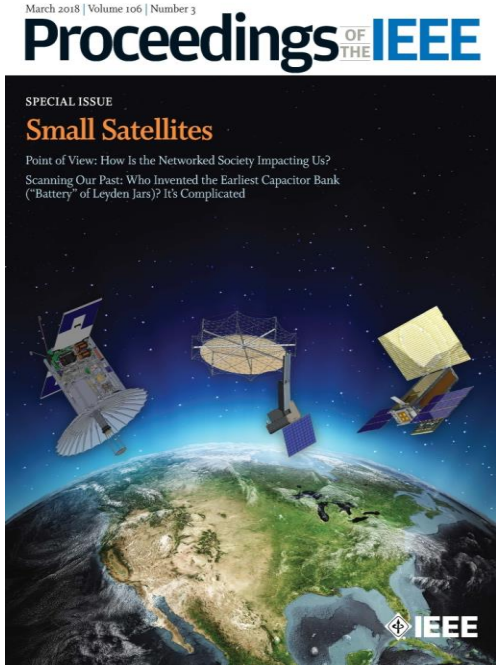
RainCube 1.0 m
in 12 U



RainCube 1.0 m DPCA
in 24U



TENDEG



- → with **Radiometers**

Ka-band ESTO InVEST and ACT programs

	6U	12 U	50 kg
Antenna size [m]	0.5	1.0	2.0
Sensitivity [dBZ]	15	5-10	0-5
Hor Resolution [km]	8	4	2
Range Res [m]		250	
Beams	1	1-3	1-5
RF Power [W]	10	10-20	10-40

Thank you!

For more information:

ousmane.o.sy@jpl.nasa.gov simone.tanelli@jpl.nasa.gov

- **RainCube:** Eva.Peral@jpl.nasa.gov
- **D-Train:** zsh@jpl.nasa.gov (Ziad Haddad)

RainCube data sets

https://tcis.jpl.nasa.gov/data/raincube/