CloudSat & thoughts for next steps

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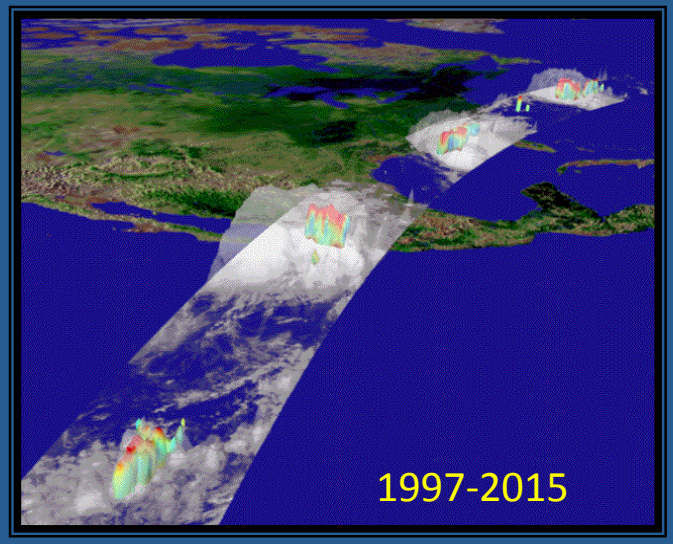
CloudSat status – June 2016

- CloudSat continues to fly in formation with CALIPSO in the A-Train.
  - The goal is to overlap radar and lidar footprints within +/-4km of the groundtrack (Prior to 2012, the goal was to overlap within +/-2km).
  - In 2015, CALIPSO's lidar was within 4km of CloudSat's radar groundtrack **88%** of the time.
  - In 2016, CALIPSO's lidar was within 4km of CloudSat's radar groundtrack **87%** of the time.
- CloudSat operational longevity:
  - The Daylight-Only Operational Mode (DO-Op) continues to provide reliable performance.
  - Spacecraft battery is slowly aging, but good power margins exist
  - No life-limiting issues with any other spacecraft subsystems.
  - The CloudSat radar is still operating on Side A of the high power amplifier. A switch to Side B may be needed sometime in the next 1-2 years.
  - Fuel is not a life-limiting concern. CloudSat has sufficient remaining delta-V capacity for at least 5 more years of operational lifetime (~2021).
- CloudSat will propose to the NASA Senior Review process next Spring to continue operations to 2021.

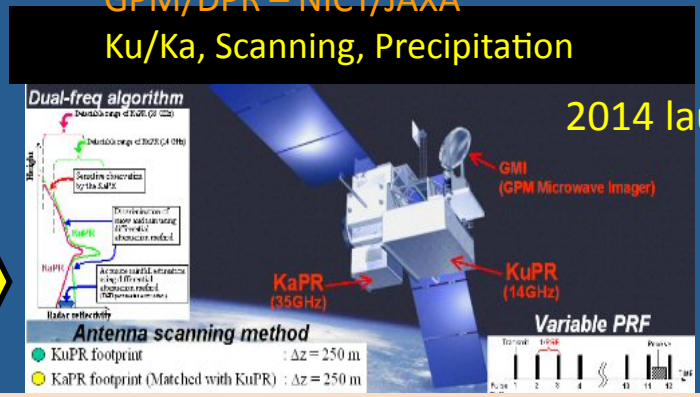
Big observations constructed from a number of smaller parts

First Two Generations of Spaceborne Weather Radars

TRMM/PR – NICT/JAXA
Ku, Scanning, Tropical Rain

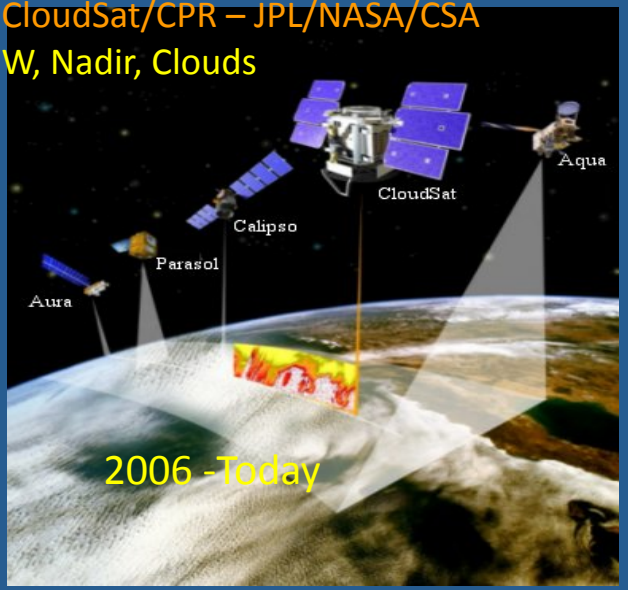


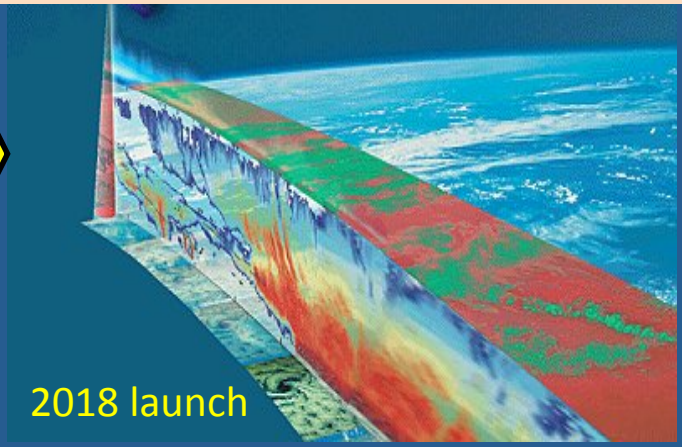
GPM/DPR – NICT/JAXA
Ku/Ka, Scanning, Precipitation



TRMM, CloudSat and CALIPSO have clearly demonstrated that active sensors are robust and just as reliable as passive systems

CloudSat/CPR – JPL/NASA/CSA
W, Nadir, Clouds



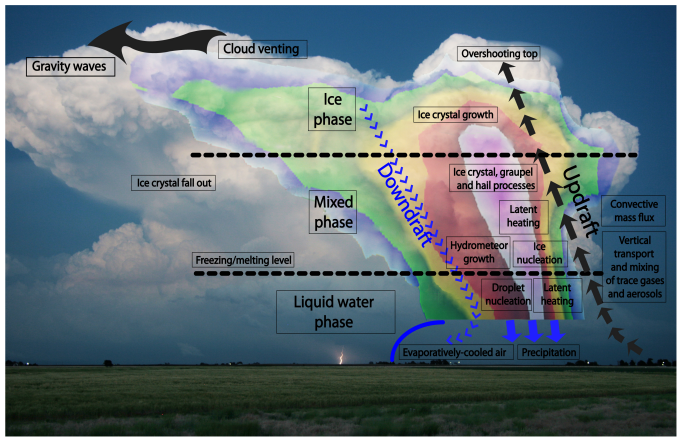


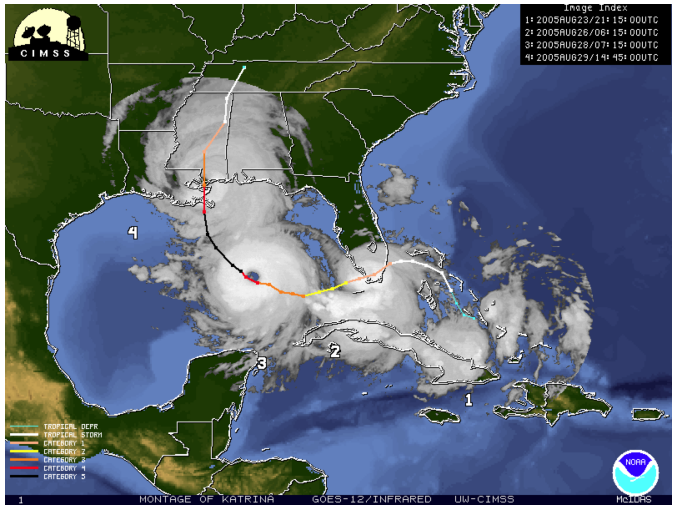
Earth science aspirations

- ❑ **Explain the Past**
- ❑ **Understand the Present**
- ❑ **Predict the Future**

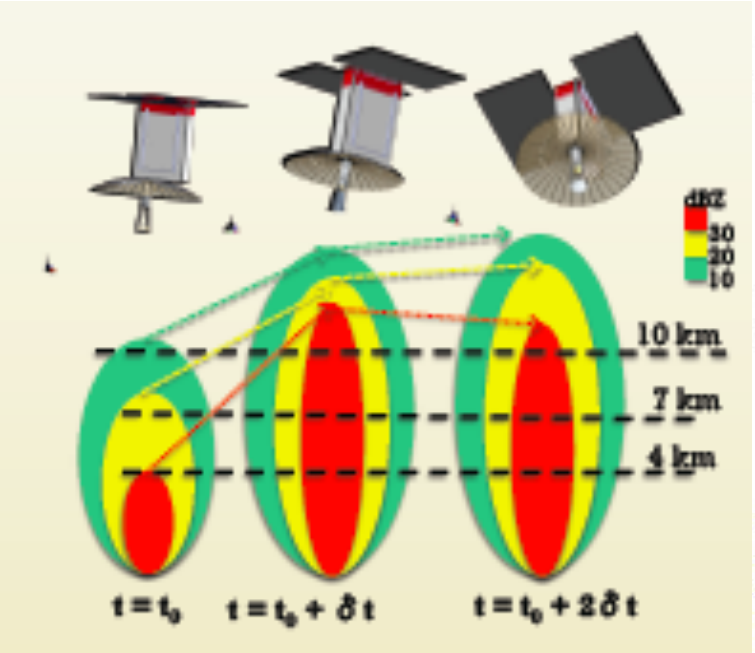
Science Driver on Next-Generation Atmos Radars – Process Study

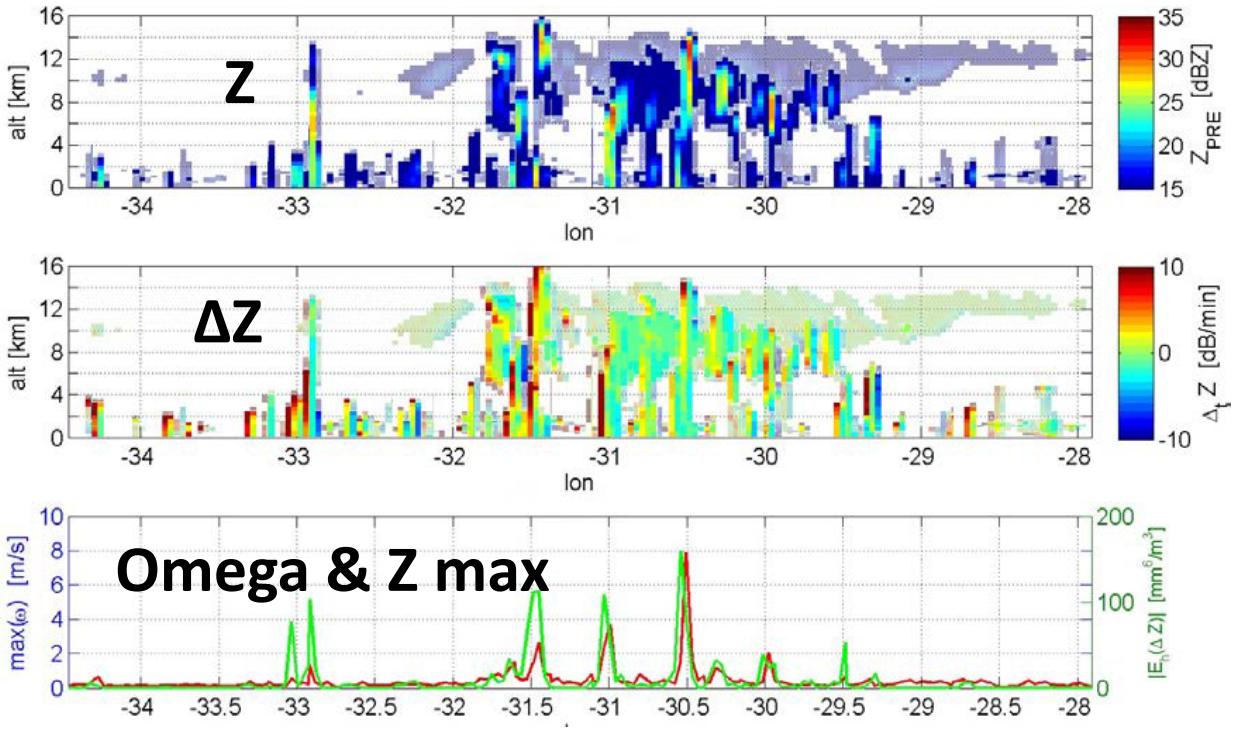
- CloudSat→EarthCARE and TRMM→GPM measure vertical profiles of two ‘types’ of hydrometeors (clouds and precipitation) separately.
- In recent community workshops/meetings it is generally recognized that the next set(s) of space measurements should put more emphasis on process studies (**understand & predict**)
  - Capture the comprehensive cloud/precip processess
  - Multi-frequency radar to increase measurement dynamic range (e.g. ACE, CAPMM)
  - Simultaneous measurements of Doppler velocity to associate dynamics to the hydrometeor contents (e.g ACE, CAPMM)
  - Capture time evolution processes
    - GEO radars for studying life cycle of cyclones
    - LEO radar constellation (emerging capability)
      - In train formation
      - In general constellation





Clustered measurements: time differenced measurements probing processes

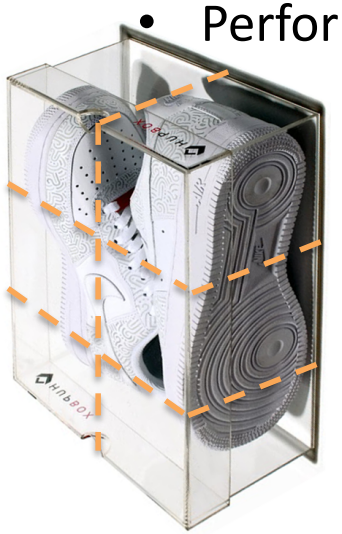


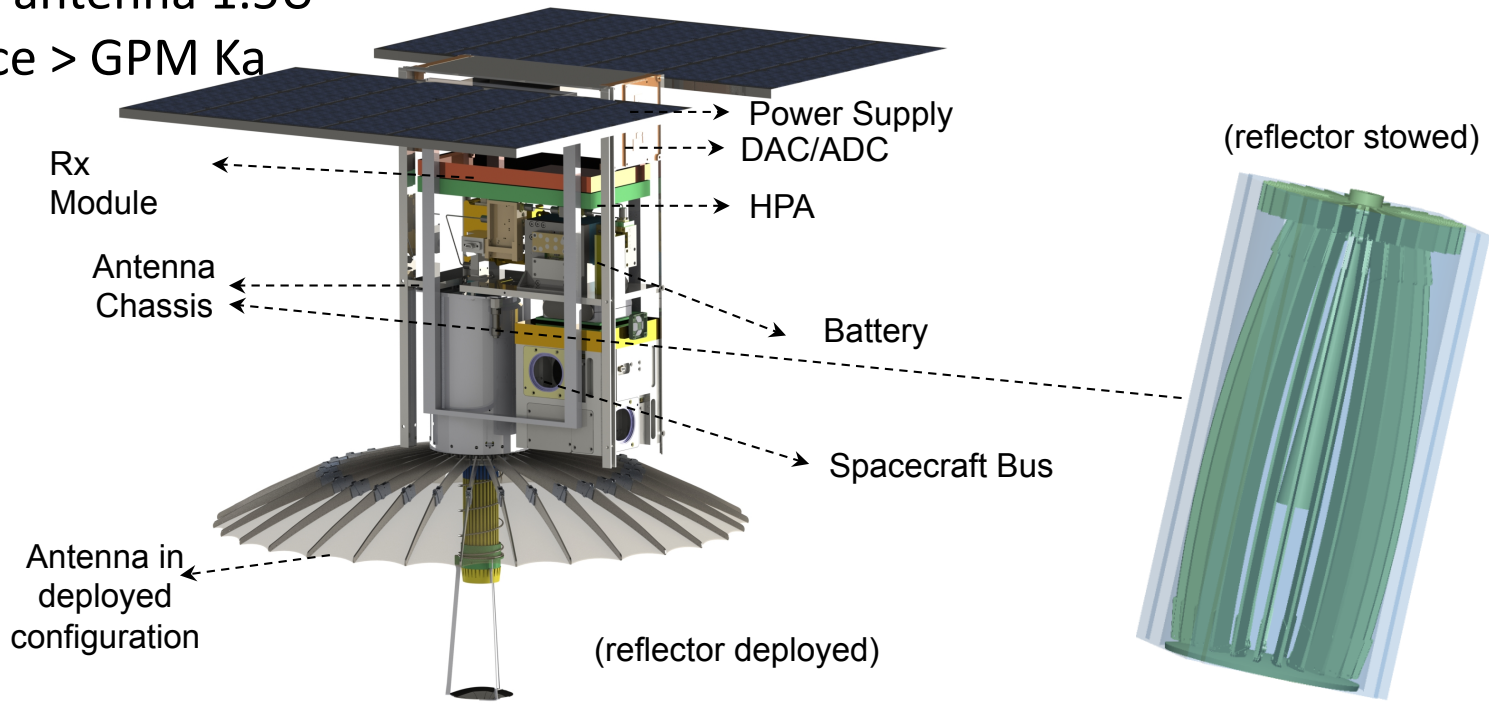


- Provides more accurate measures of condensed mass because biases get removed
- Provides methods to estimate mass flux, previously unthinkable

RainCube: Key to miniaturization and cost reduction

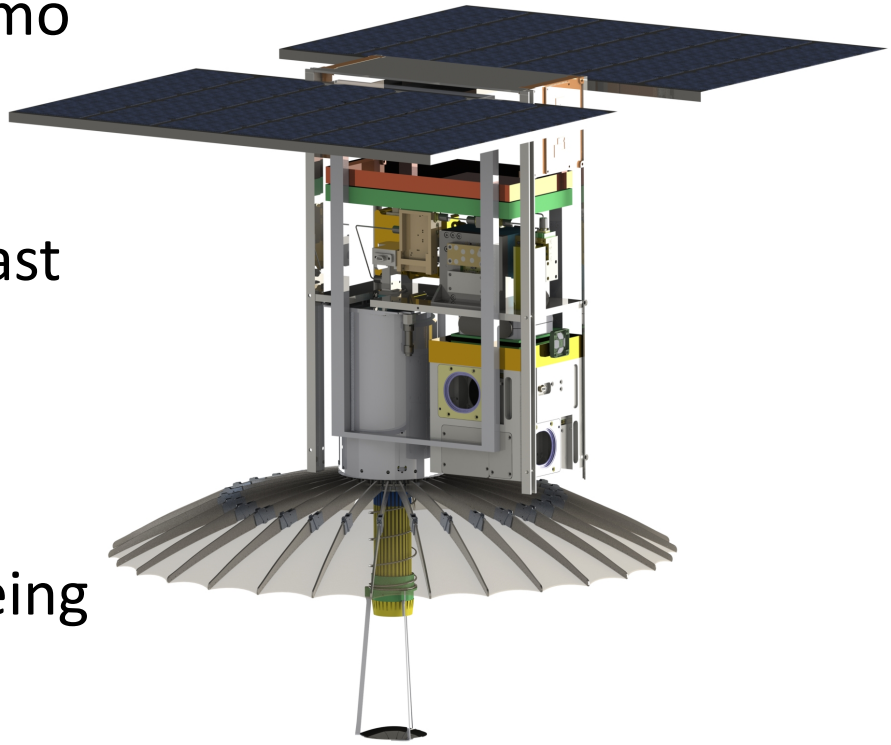
- JPL has developed a novel radar architecture (patent pending) for a Ka band (35.75 GHz) precipitation profiling radar for operation in a 6-U CubeSat platform
  - Digital electronics 0.5U
  - RF electronics 0.5U
  - SSPA 1U
  - Deployable antenna 1.5U
  - Performance > GPM Ka





RainCube Status

- The 1st-generation RainCube tech demo unit is being developed, and will be ready to launch in summer 2017
  - Plan for space operation for at least 6 months



- Technologies for Second- and third-generation RainCube concepts are being developed
  - 1-m or larger deployable
  - Cross-track scanning
  - Doppler
  - Adaptation to 6-12U cubsats, and smallsats.