Space-Based Precipitation Measurements in Tropical Cyclones: Past, Present, and Future

SCOTT BRAUN

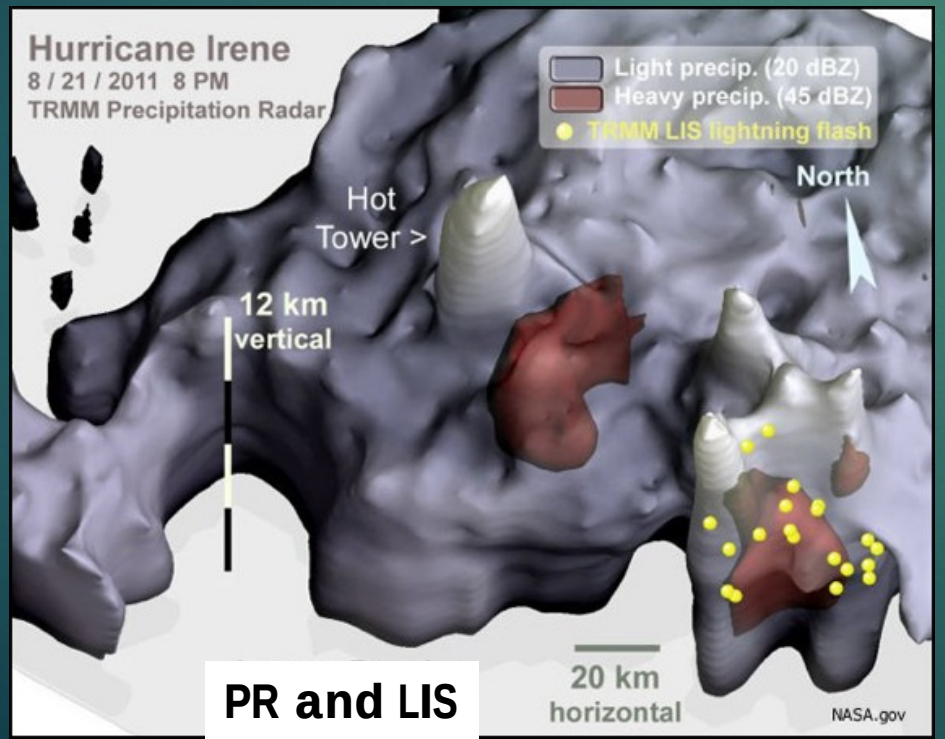
NASA GODDARD SPACE FLIGHT CENTER

Background

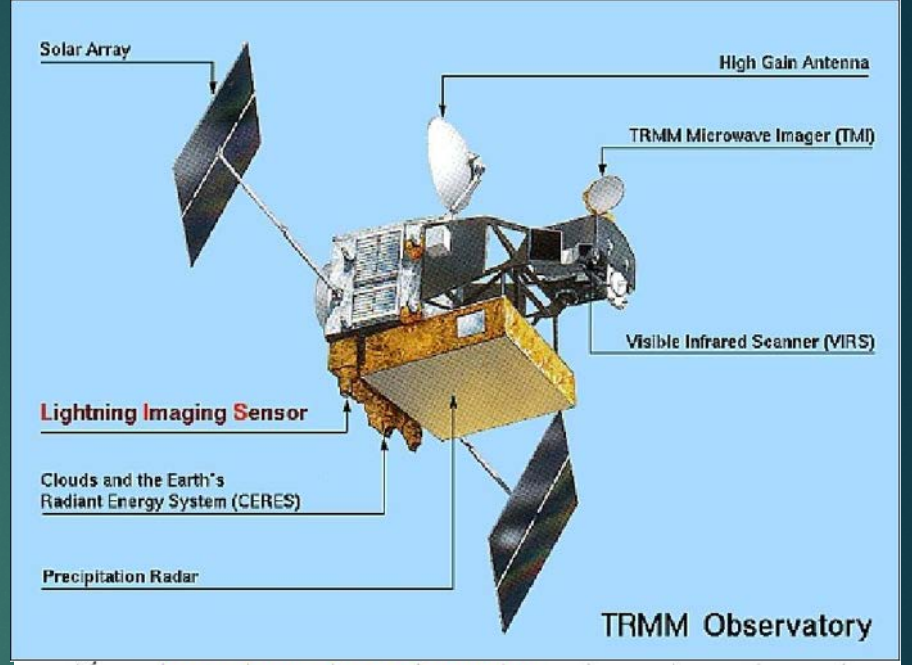
- TRMM
- GPM
- TROPICS
- NASA Decadal Survey Aerosols and Clouds, Convection, and Precipitation observing system study

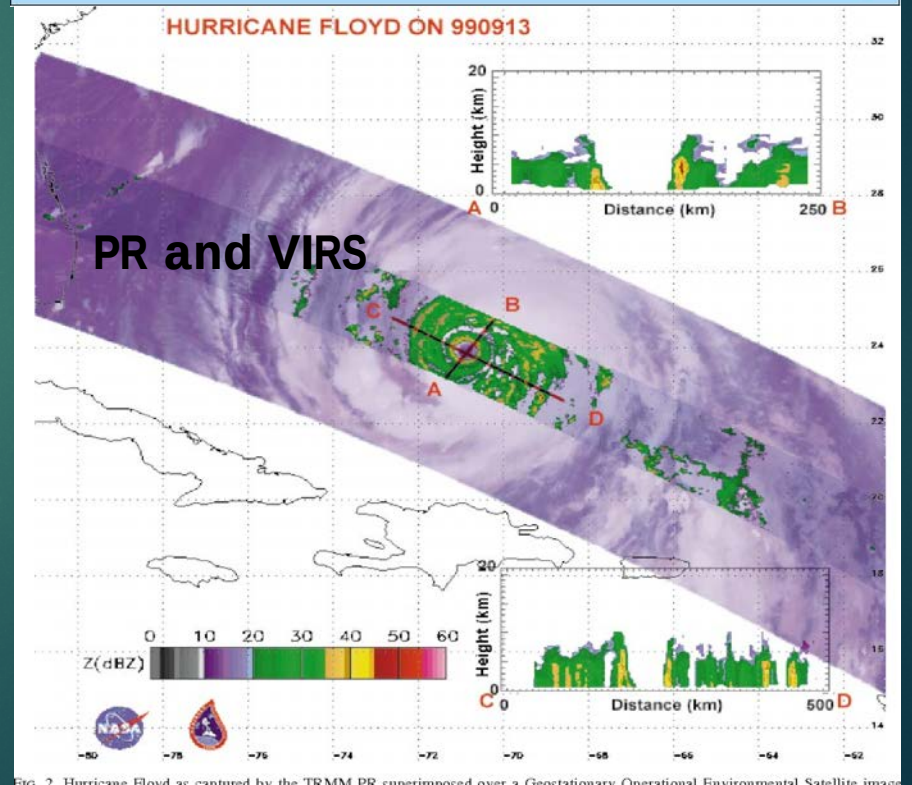
TRMM Summary

- Launched November 1997, ended April 2015
- 35° inclination orbit
- First spaced-based precipitation radar
- Combined radar, radiometer, vis/IR, lightning, and radiation budget sensors



PR and LIS

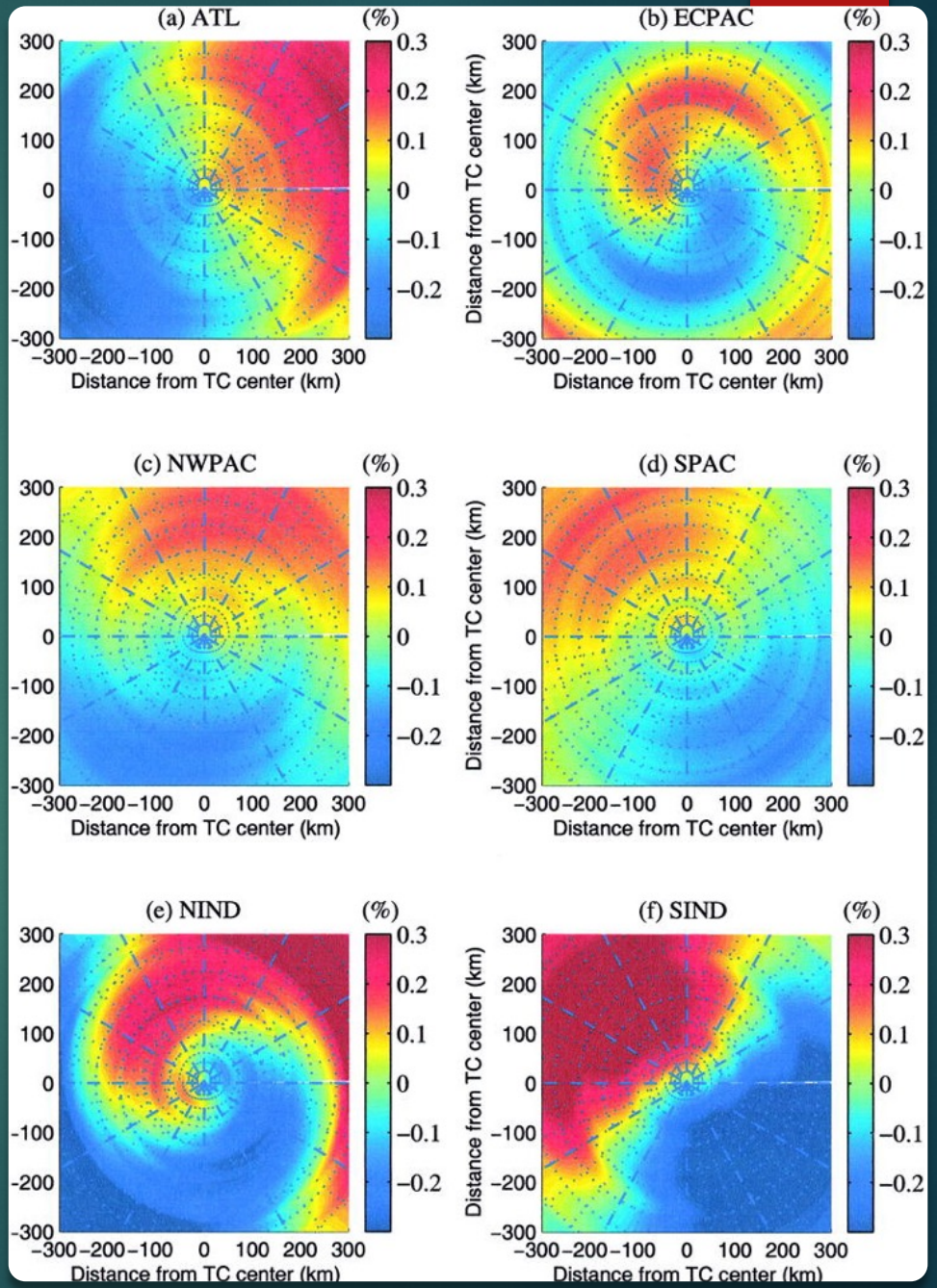




TRMM TC Observations

- ~500-600 center fixes per year
- Rainfall climatologies in hurricanes
  - Radial distribution
  - Shear and motion induced asymmetries
- Eyewall and rainband vertical structure and lightning
- Storm total rainfall accumulations and associated applications

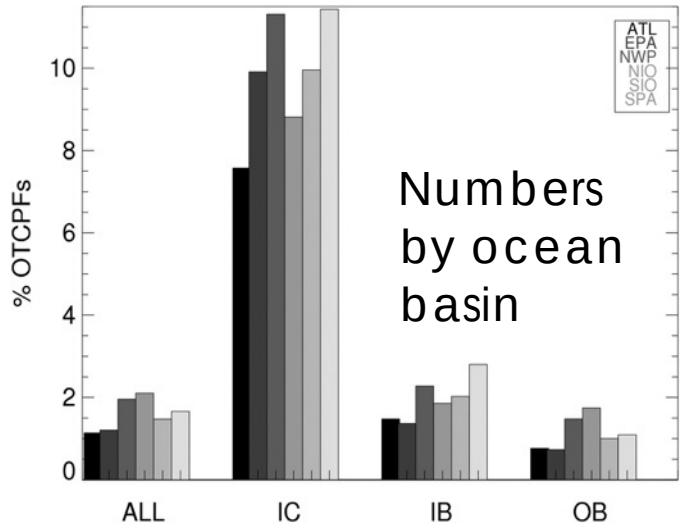
Lonfat et al. (2004)

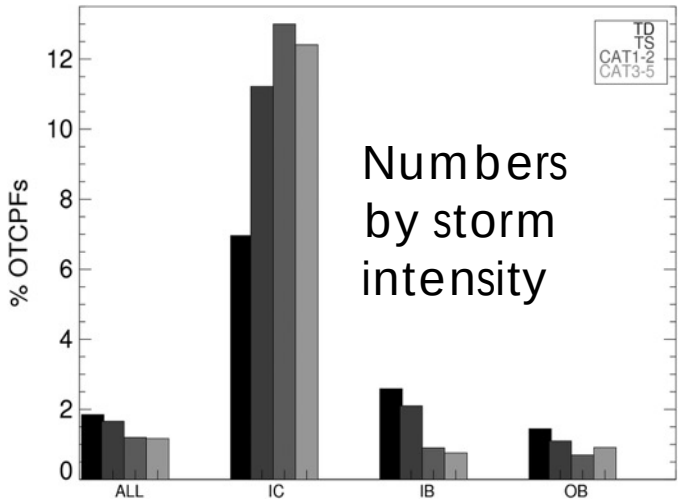


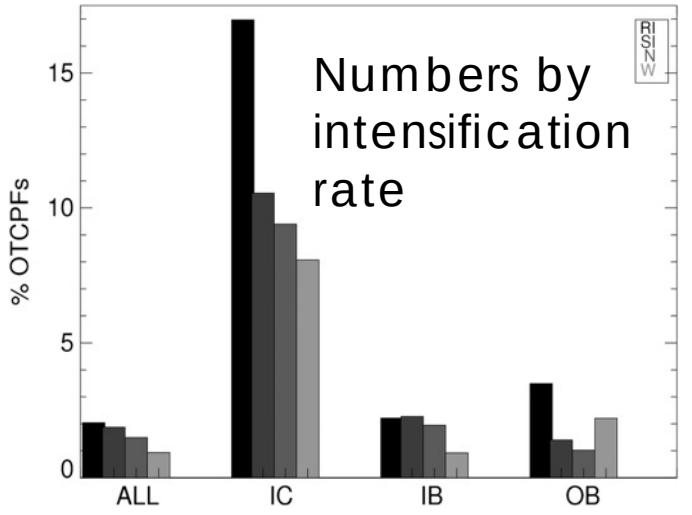
TC Precipitation Feature Database Findings on TC Eyewall and Rainbands

- Precipitation Feature Database associated with TCs
- Includes information from PR, TMI, VIRS, and LIS

%OTCPFs =
% of TCPF that have overshooting tops





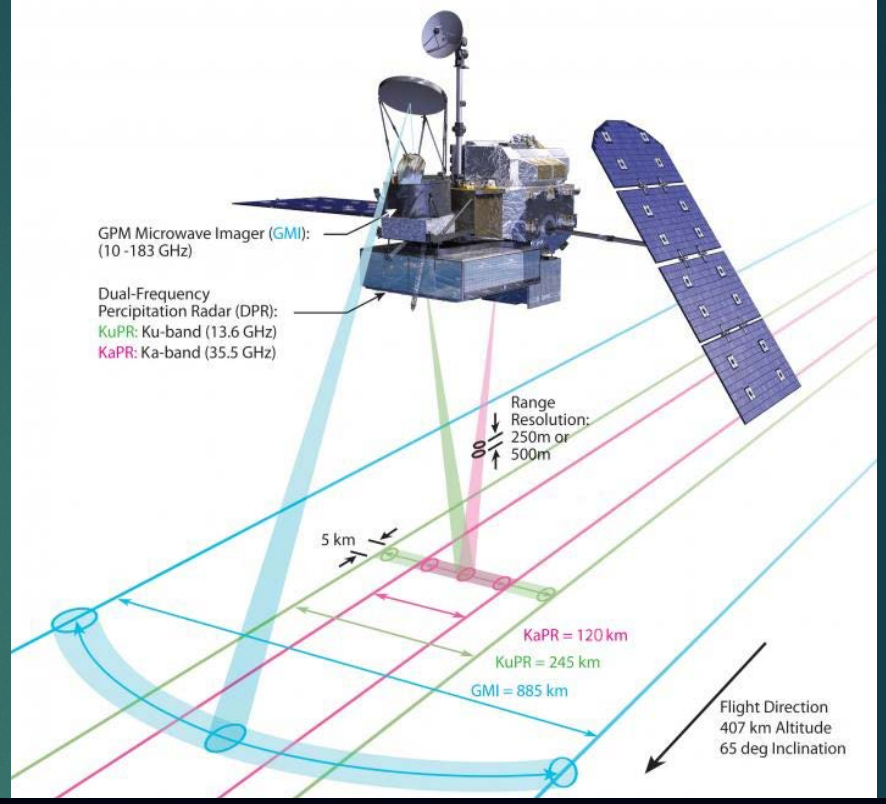


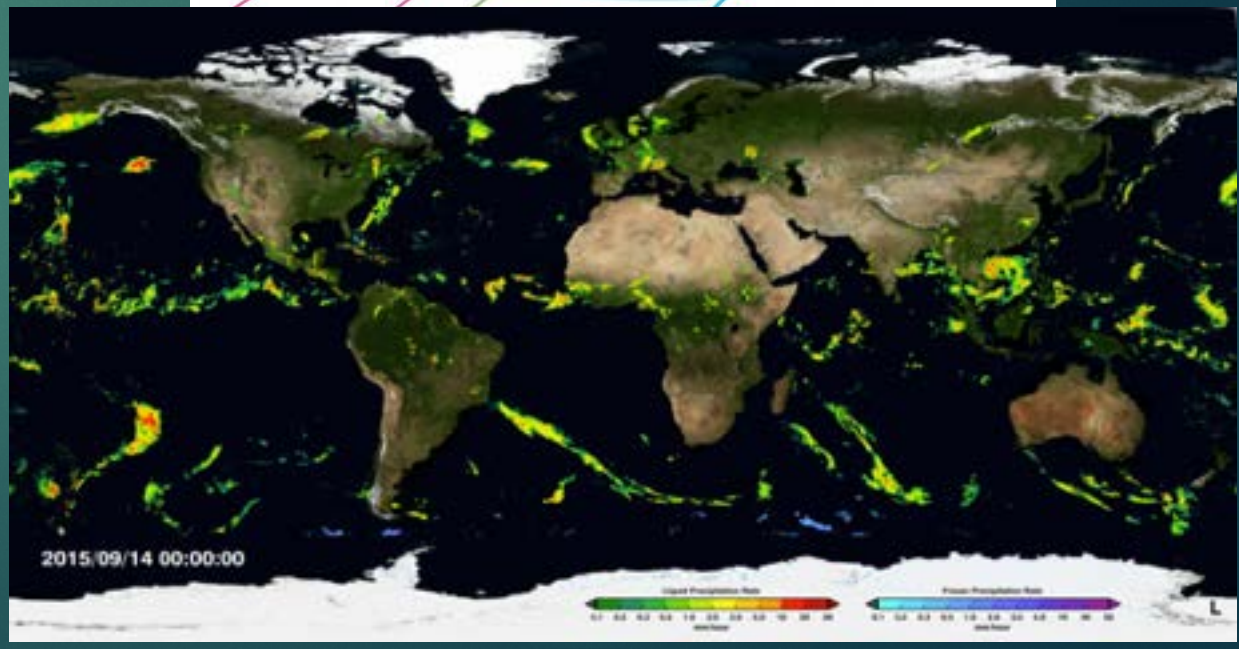
OTCPF=Overshooting TC PFs
IC=Inner core (eyewall)
IB=Inner bands
OB=Outer bands

Tao and Jiang (2013)

GPM Overview

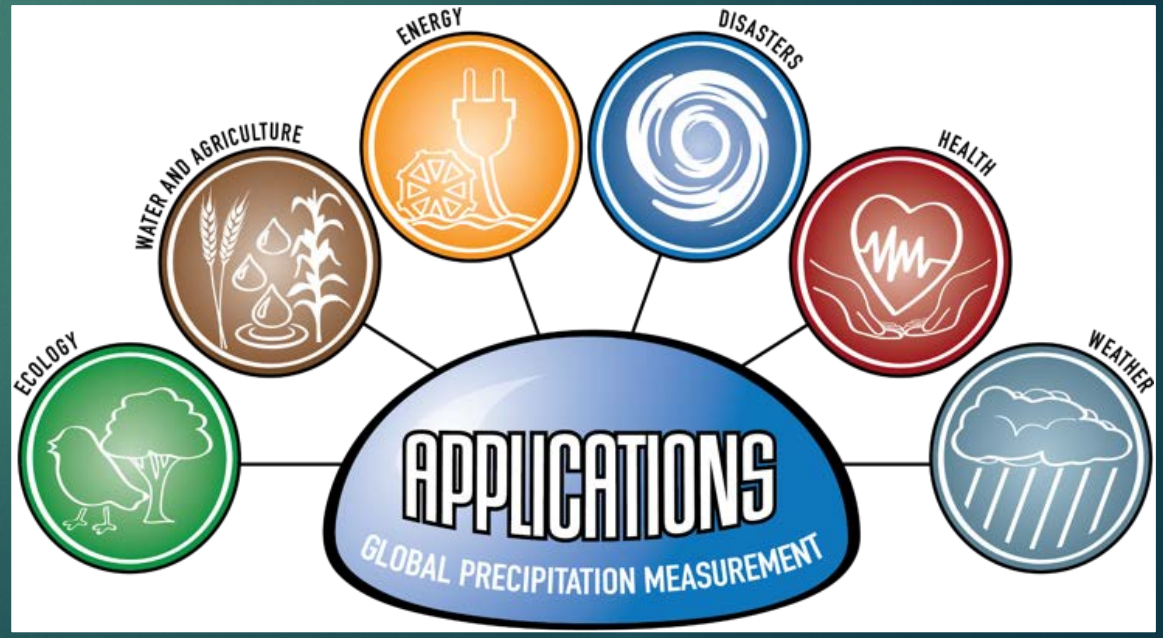
- Launched in Feb. 2014
- Dual-frequency radar and high-resolution and high-accuracy radiometer
- 65° inclination orbit for higher latitude observations
- GPM core satellite used as a calibration reference for a constellation of partner radiometers





GPM Applications

- Used in NWP data assimilation systems
  - European Centre for Medium-range Weather Forecasts
  - Joint Center for Satellite Data Assimilation
  - NASA Global Modeling and Assimilation Office
- As with TRMM, microwave imager useful for tracking storm position and structure
  - Available for display in AWIPS
  - Naval Research Lab Tropical Cyclone Web Page
- Used in flood/landslide detection applications
- Re-insurance
- Post-storm disease tracking

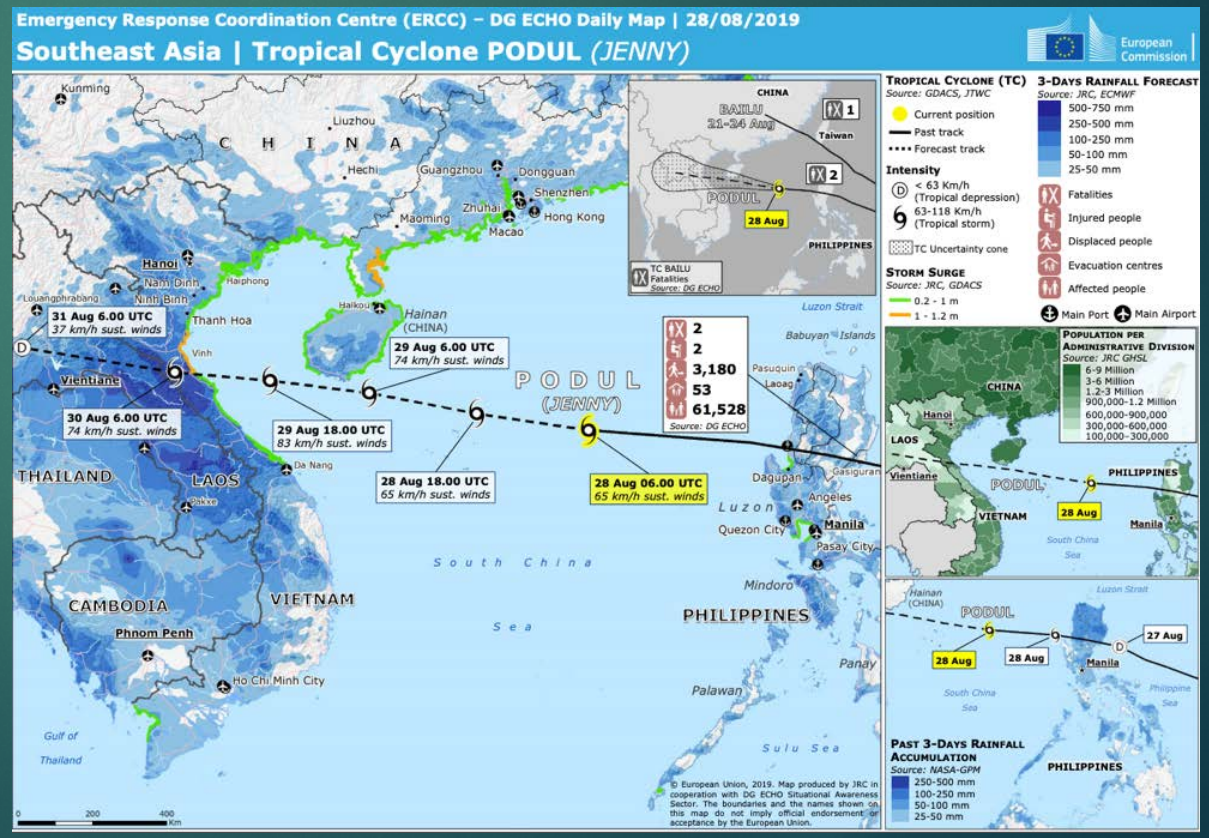


Emergency Response Tools

The Global Disaster Alert and Coordination System (GDACS) uses GPM IMERG data to distribute information about a storm's impact across countries. In turn, GDACS' data is used by several relief organizations to provide humanitarian aid where needed.

GDACS image for TC Podul on Aug. 28, 2019

3-day rainfall total shown in bottom right panel



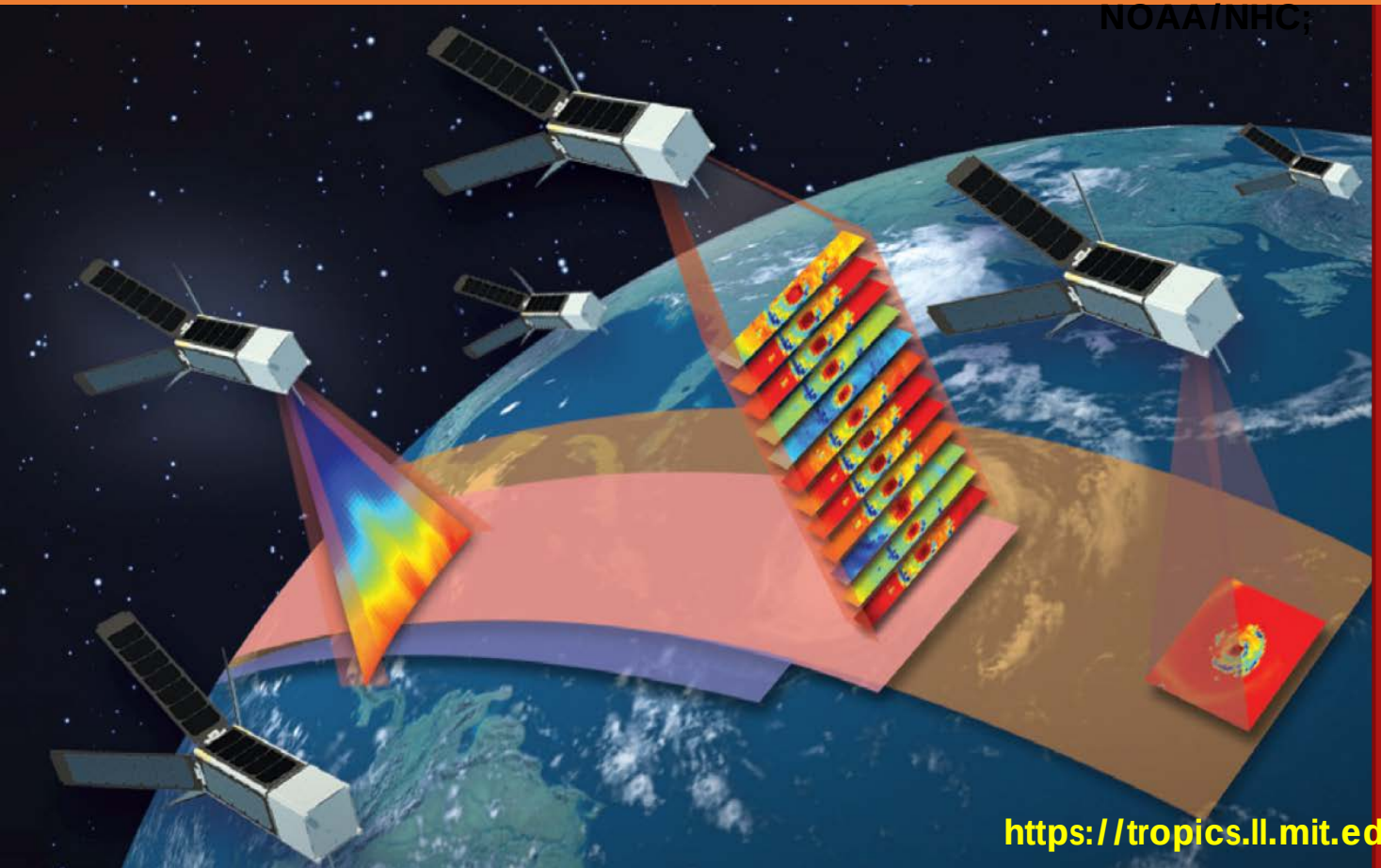
Time-Resolved Observations of Precipitation structure and storm Intensity with a Constellation of Smallsats

MIT Lincoln Laboratory (proposing organization)

William J. Blackwell, Principal Investigator, Scott Braun (NASA GSFC), Project Scientist

Science Team Members:

Ralph Bennartz, Vanderbilt U.; Chris Velden, U. Wisc.; Robert Rogers, Robert Atlas, Frank Marks, Jason Dunion, NOAA/HRD; Mark DeMaria, NOAA/NHC;



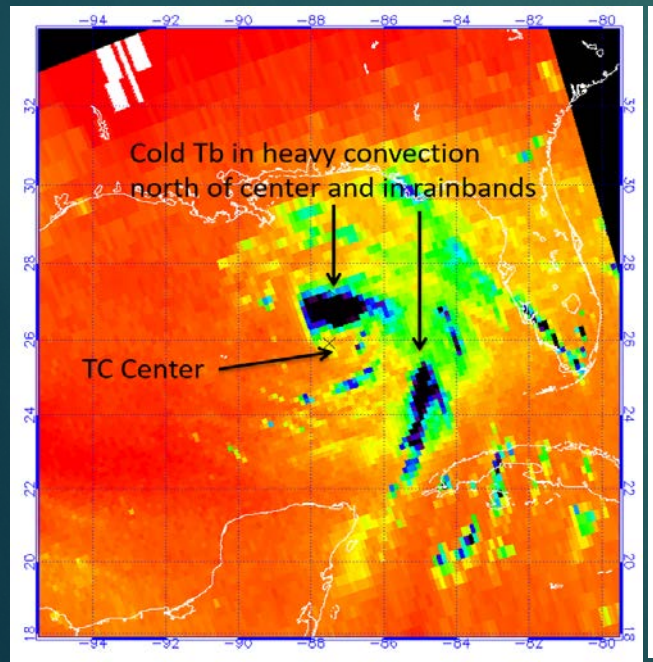
https://tropics.ll.mit.edu

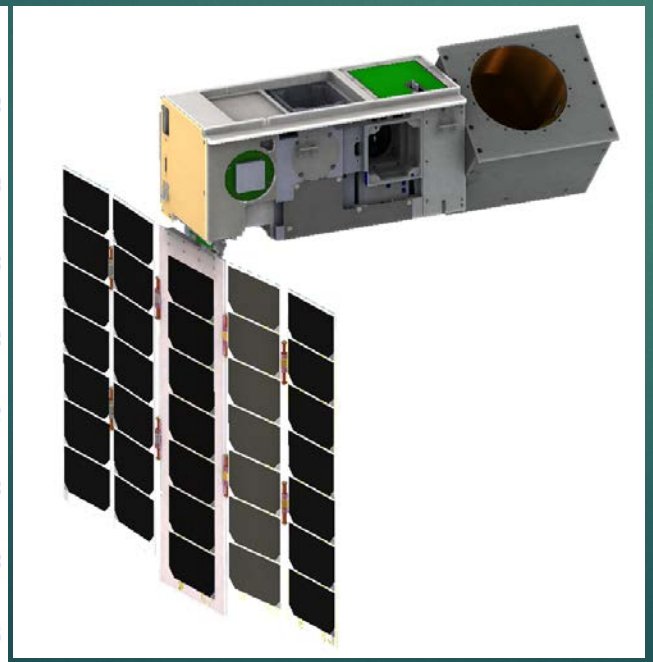
Science Objectives

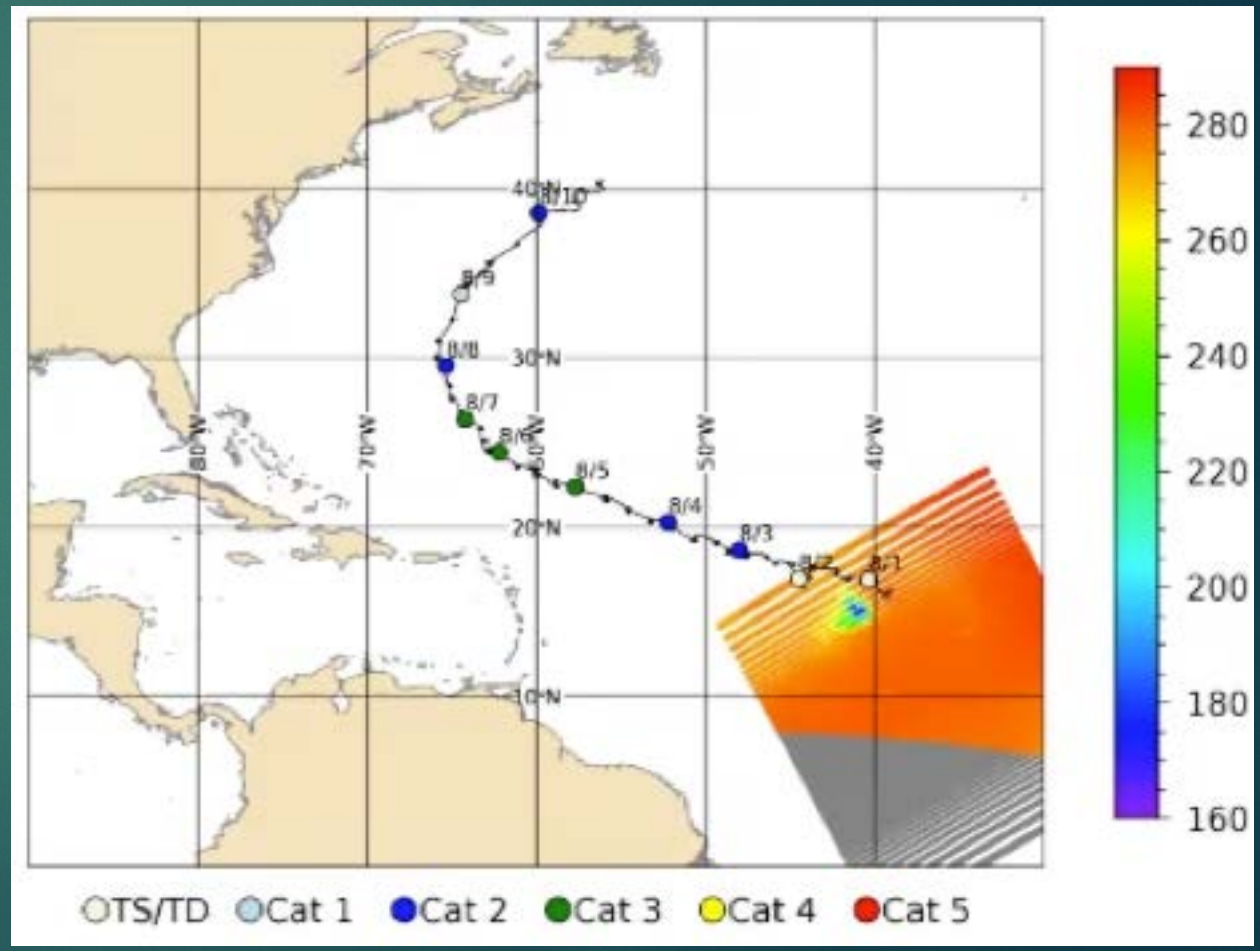
- Precipitation, warm core, and intensity co-evolution
- Role of convective bursts
- Impacts of dry air
- Impact on numerical/statistical models

TROPICS Summary

- 12 channels (7 near 118 GHz, 3 near 183 GHz, imaging at 92 and 205 GHz)
- ATMS-like horizontal resolution
- GPROF rain algorithm
- Median revisit times < 50 mins
- Spacecraft build complete, launch TBD (~1-3 years out)



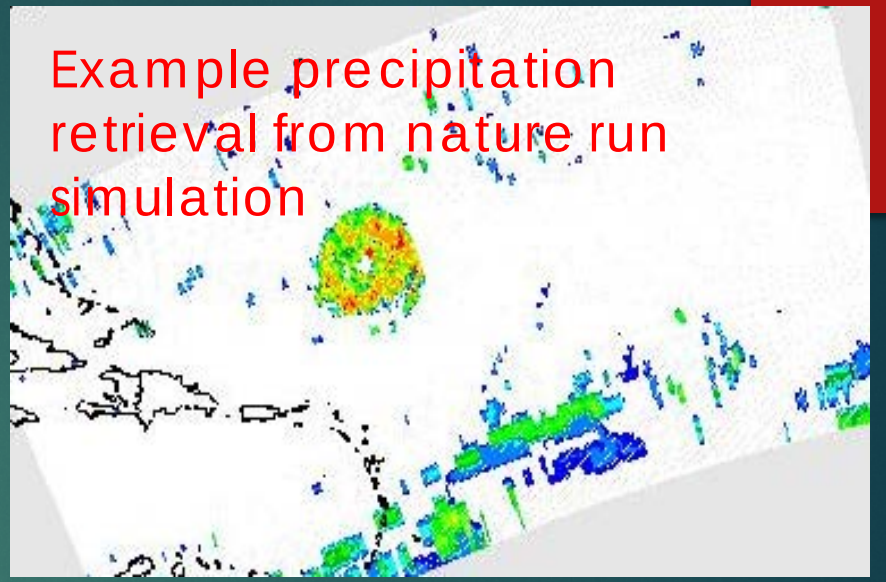


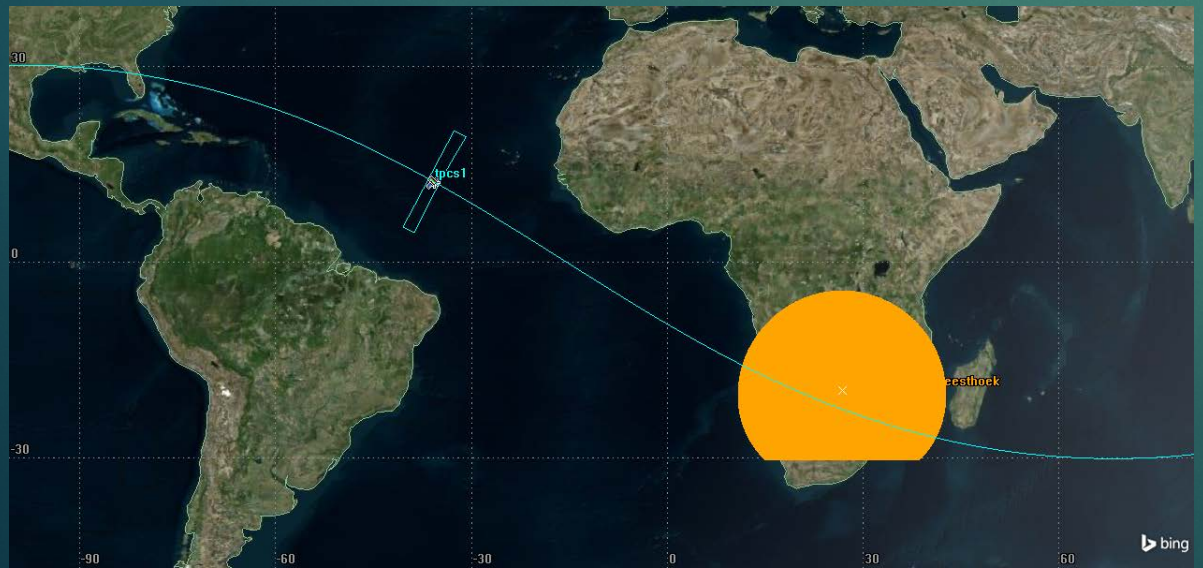


TROPICS Products

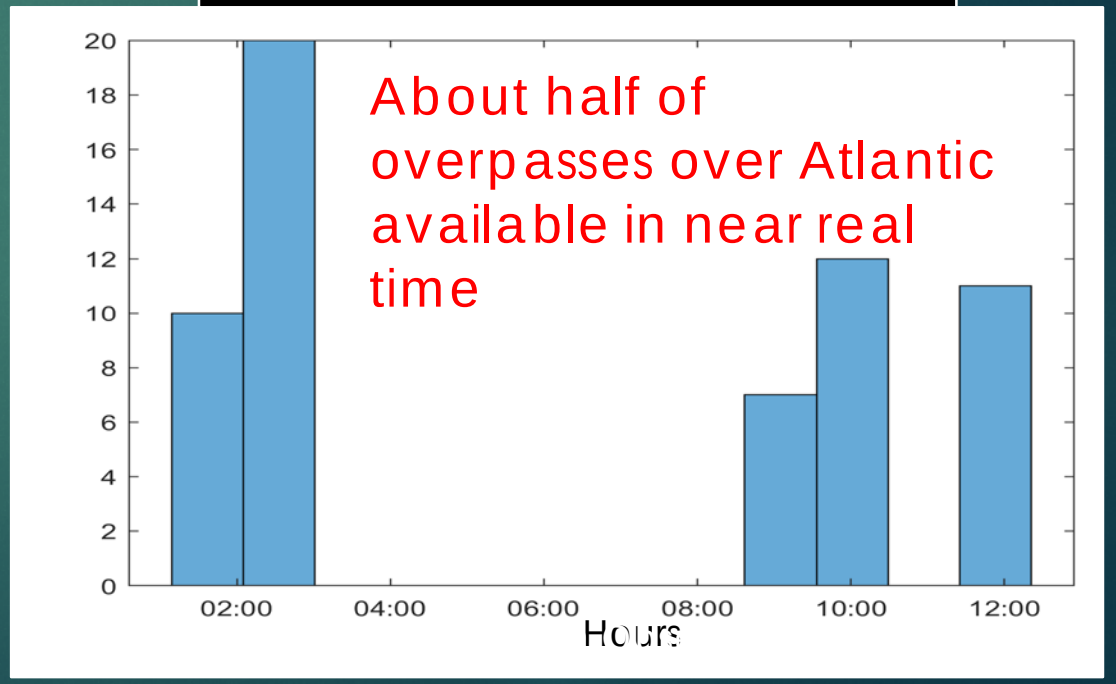
Data Products:

- Calibrated brightness temperatures
- Retrieved temperature/humidity profiles
- Precipitation rate/scattering index
- Storm intensity estimates





TROPICS Latency—N. Atlantic
2 contacts/day (1mo duration)



Thriving on Our Changing Planet

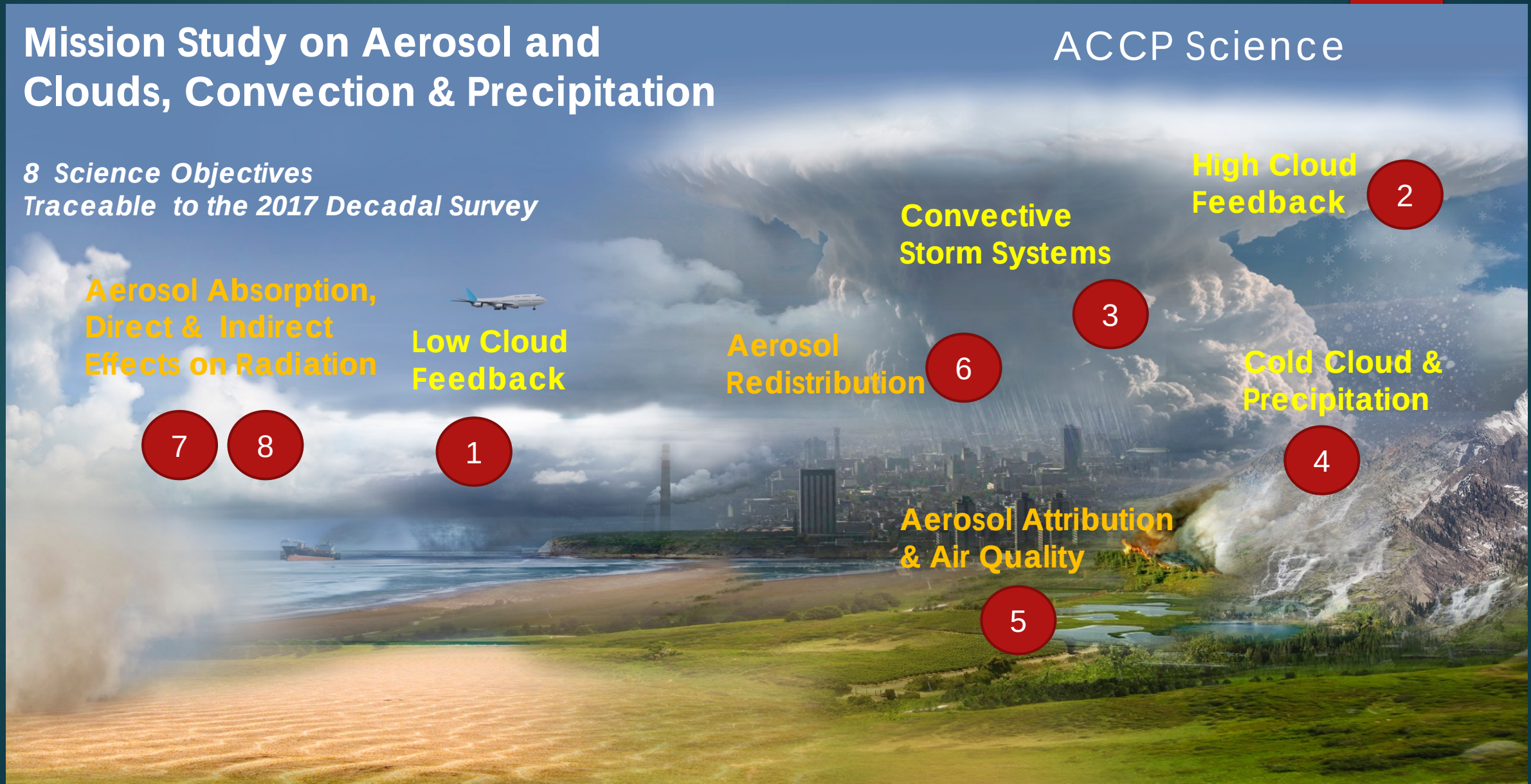
A Decadal Strategy for Earth Observation from Space

	Aerosols	Clouds, Convection, and Precipitation
Observable Priorities	Aerosol properties, aerosol vertical profiles, and cloud properties to understand their effects on climate and air quality	Coupled cloud-precipitation state and dynamics for monitoring global hydrological cycle and understanding contributing processes including cloud feedback
Desired Observables	Backscatter lidar and multichannel, multi-angle/polarization imaging radiometer	Radar(s), with multi-frequency passive microwave and sub-mm radiometer

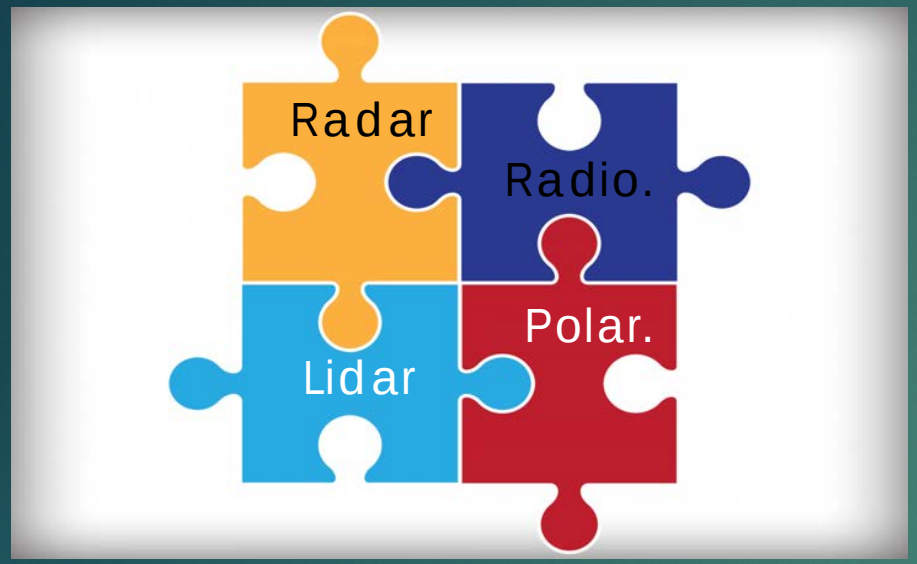
#EarthDecadal

The National Academies of SCIENCES ENGINEERING MEDICINE

ACCP Science Objectives



ACCP Architecture Studies



Architecture Components:

- Instruments
- Spacecraft buses
- Ground systems
- Launch vehicles
- Mission operations
- Suborbital observations/GV
- Science team

Highly desired capabilities:

- Radars, with W/Ka or W/Ku bands, with Doppler
- Microwave radiometers, frequencies ranging from ~89 to 883 GHz
- Lidars, HSRL at one frequency
- Multi-spectral, multi-angle polarimeter
- Complementary sensors
- Polar and inclined orbits

Summary

- TRMM created a long-term record that may never be surpassed.
- GPM operating nominally after ~6 years; focus on applications
- TROPICS to provide high-revisit-rate observations in the Tropics, expected to launch ~2022-2023
- ACCP exploring architectures for combined aerosol, cloud, and precipitation measurements, earliest possible launch likely in 2029