The NASA Decadal Survey Observing-System Study for Aerosols and Clouds, Convection, and Precipitation (ACCP)

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AGU Session H21E – Space-based precipitation observations, estimation, and applications: A centennial Perspective

ACCP Overview

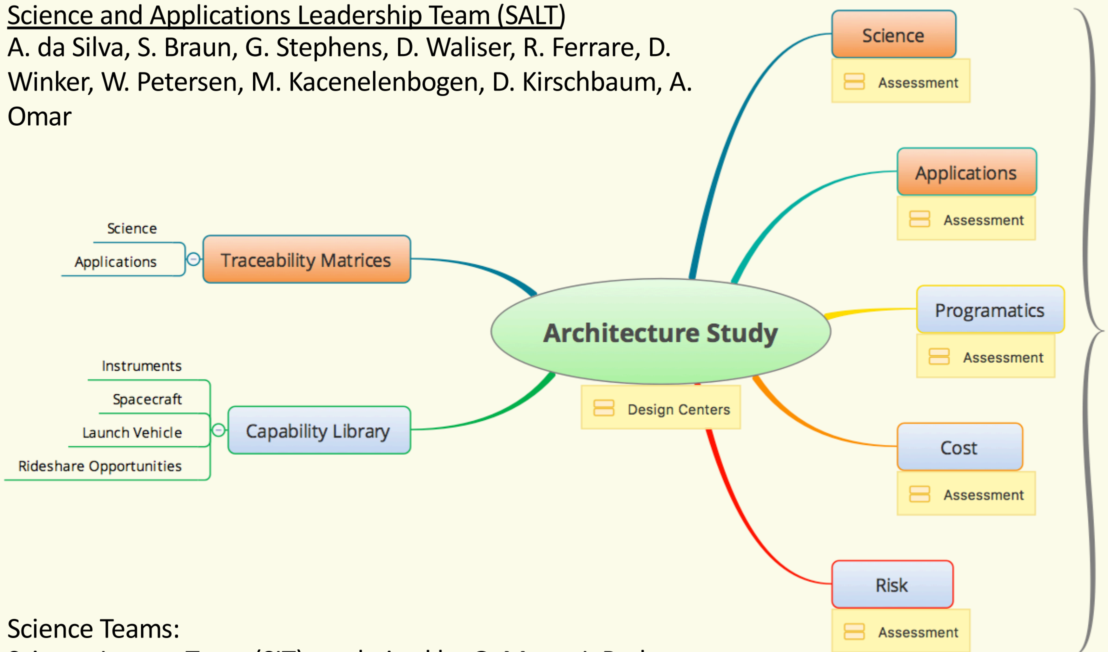
The *2017 Decadal Survey* (DS) recommended cost-capped missions with specified caps, creating challenge for team to envision new science but ensure an implementable observing system

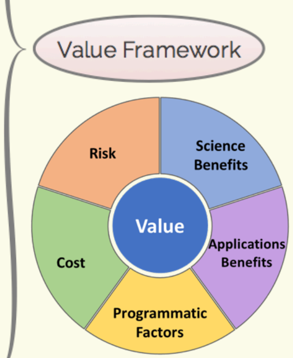
	Aerosols	Clouds, Convection, and Precipitation
Observable Priorities	Aerosol properties, aerosol vertical profiles, and cloud properties to understand their effects on climate and air quality	Coupled cloud-precipitation state and dynamics for monitoring global hydrological cycle and understanding contributing 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

ACCP Study Organization

Other teams:
- Study Management Team
- Systems Engineering Team
- Value Framework Team
- Science Community Committee

<u>Science and Applications Leadership Team (SALT)</u>
A. da Silva, S. Braun, G. Stephens, D. Waliser, R. Ferrare, D. Winker, W. Petersen, M. Kacenelenbogen, D. Kirschbaum, A. Omar

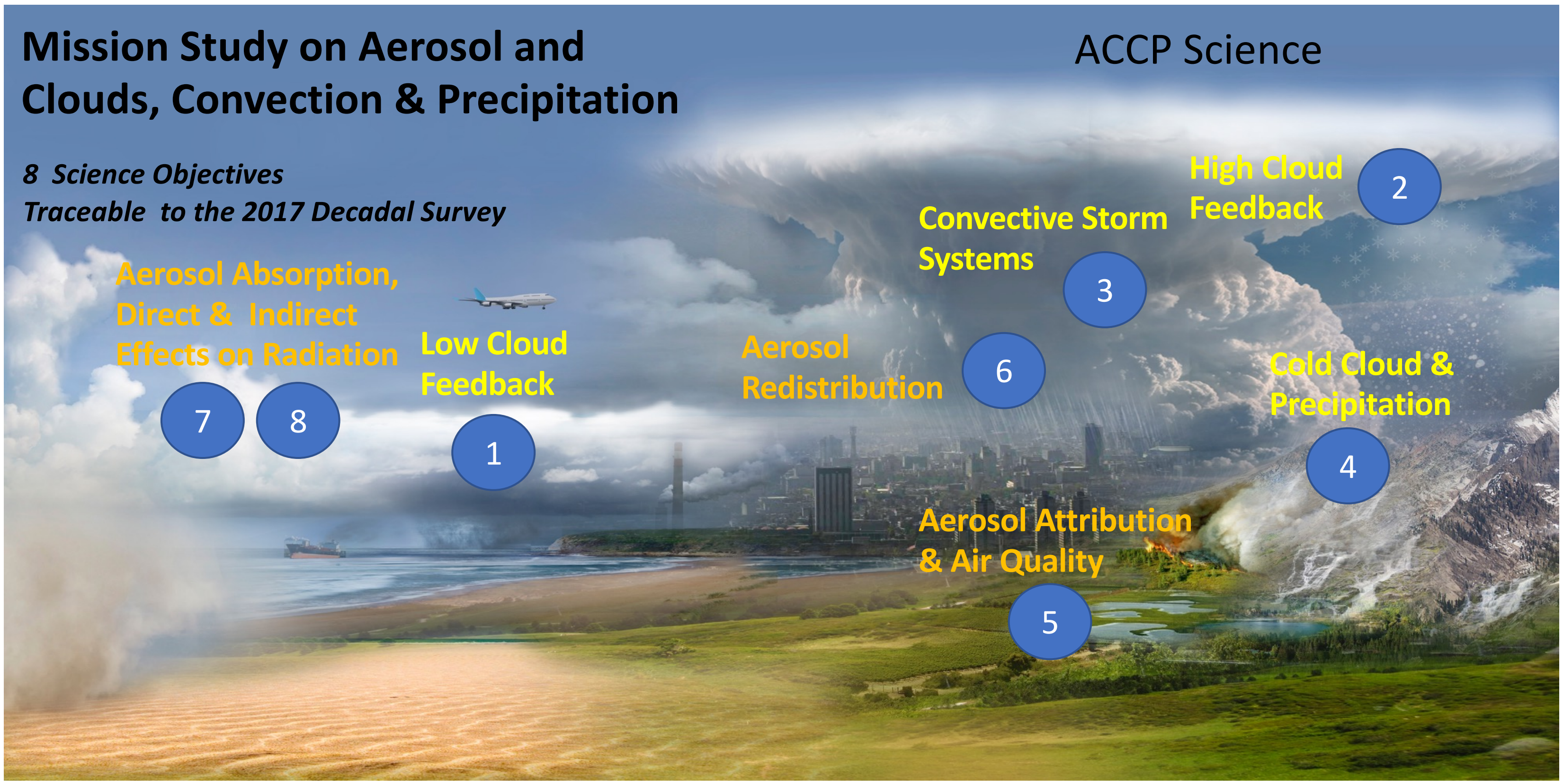




Science Teams:
Science Impact Team (SIT) co-chaired by G. Mace, J. Redemann
Applications Impact Team (AIT) co-chaired by D. Kirschbaum, A. Omar

ACCP Aerosols and Clouds, Convection & Precipitation Study

ACCP Science Objectives



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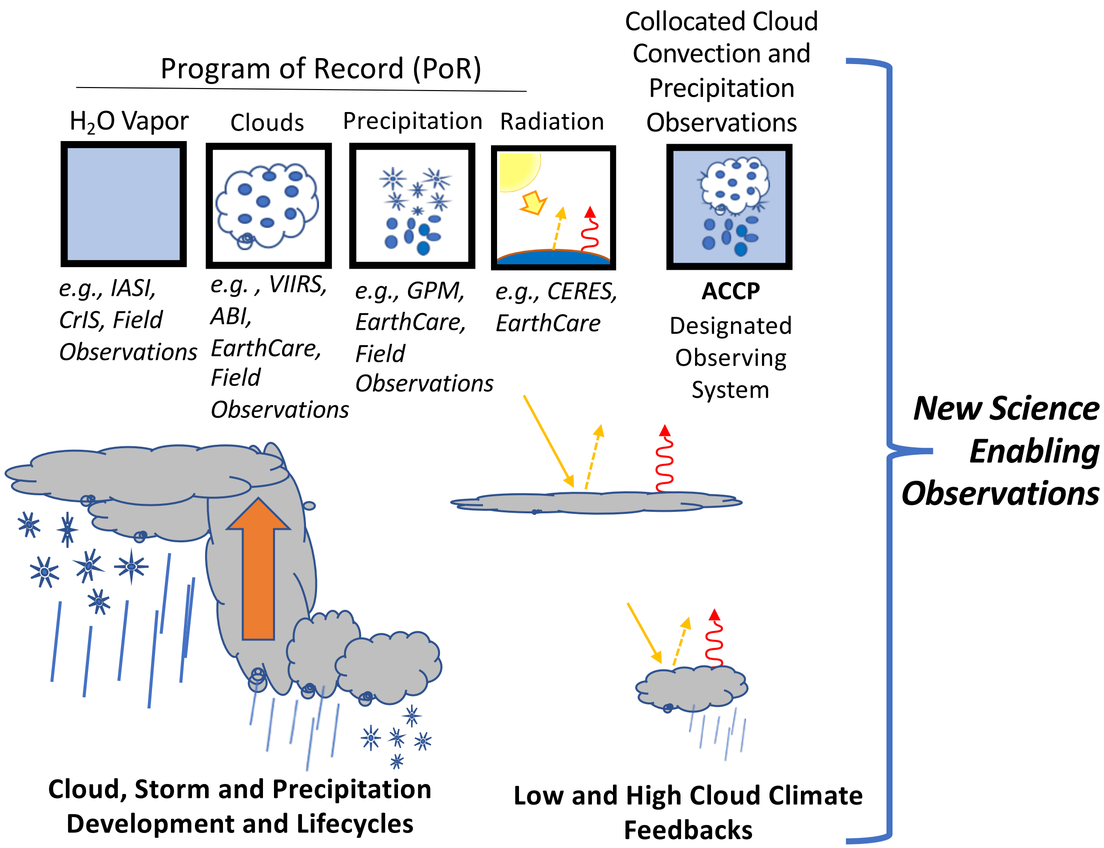
Clouds, Convection and Precipitation



1. WATER VAPOR + CLOUDS + PRECIPITATION + RADIATION

Previous / PoR measurements have not provided collocated measurements of clouds and precipitation; combined with PoR water vapor & radiation, these measurements are key to understanding:

- **Low Cloud Climate Feedback**
- **High Cloud Climate Feedback**
- **Cloud and Precipitation Development**
- **Atmospheric Water Cycle**

2. VERTICAL MOTION IN CONVECTIVE STORMS

There are no global measurements of vertical motion inside convective storms; these are key to understanding:

- **Storm Development & Life Cycle**
- **Hydration of the Upper Troposphere**
- **Precipitation Extremes**

3. HIGH LATITUDE CLOUDS AND SNOWFALL

Previous / PoR measurements provide inadequate information to constrain snowfall estimates. Relevant to:

- **Polar Hydrometeorology**
- **Sea Ice and Ice Sheet Surface Mass Balance**

ACCP Aerosols and Clouds, Convection & Precipitation Study

Aerosols

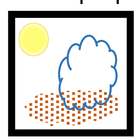
Program of Record (PoR)

Aerosol DIstribution | Aerosol Properties | Trace Gases

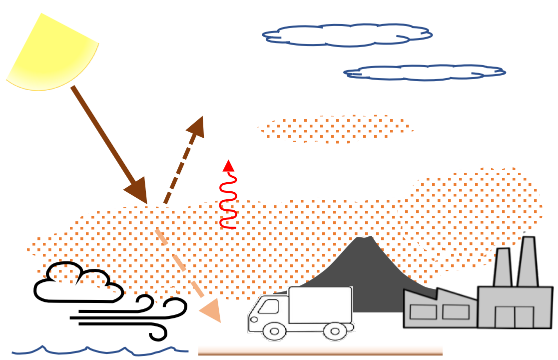
e.g. ABI,AHI VIIRS | e.g. 3MI PACE | e.g. Trop-OMI TEMPO

Aerosol DO

Vertical Profiles
Enhanced properties



Lidar
Polarimeter



ACCP will <u>augment</u> the future Program of Record (PoR)

1. 4D AEROSOL SAMPLING & LIFE CYCLE

Previous PoR measurements have not provided collocated temporal and vertical measurements of aerosol distribution and properties; key to understanding:

- **Aerosol Sources and Transport**
- **Aerosol Processing**
- **Aerosol Removal and Redistribution**
- **Modeling and Forecast Skill**

New Science Enabling Observations

2. AEROSOL AMOUNT

Improved measurements of AOD, AAOD, and aerosol extinction profiles to advance understanding of:

- **Aerosol Direct Radiative Effects at TOA & Surface**
- **Air Quality**
- **Aerosol Atmospheric Heating & Hydrologic Sensitivity**

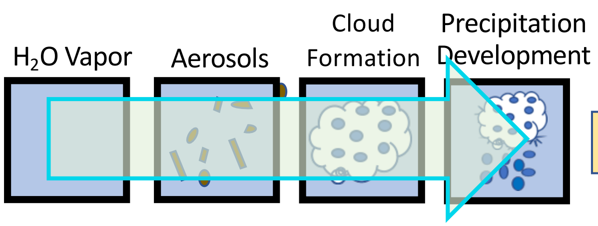
3. AEROSOL PROPERTIES

New and improved measurements of aerosol *single scatter albedo* and *size* to:

- **Discriminate Anthropogenic and Natural Aerosols**
- **Improve Understanding of Aerosol Sources**
- **Evaluate Modeling and Air Quality**

Links between ‘A’ & ‘CCP’

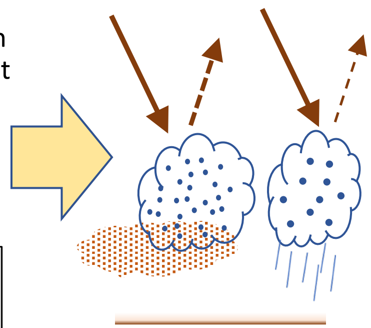
I. Aerosol Effects on Cloud Microphysics and Precip



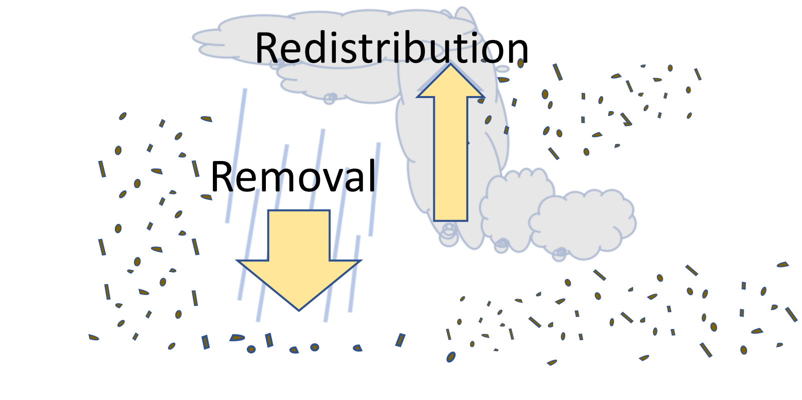
Aerosols are fundamental to the formation of clouds and precipitation, and thus relevant to all CCP objectives.

These aerosol impacts on clouds and precip lead to impacts on radiation, thus further linking Aerosol and CCP objectives.

II. Aerosol Indirect Radiative Effects



III. Aerosol Processing, Removal and Redistribution by Cloud

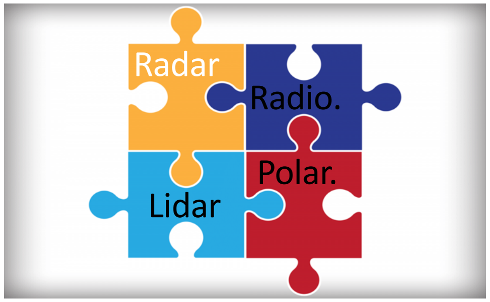


Precipitation removes aerosols, convection and storms loft and redistribute aerosols
Chemical processing of aerosol occurs within cloud droplets

ACCP Constraints

- Cost-capped observing system
- Define minimum and enhanced desired capabilities, not threshold and baseline requirements
- Instruments will be selected from existing capabilities rather than designed to desired science capabilities
  - Must be of sufficiently high technical readiness (TRL6) by mission preliminary design review
- Finding an observing system that meets objectives is ultimately dependent on knowledge of available capabilities (Instrument Library)

ACCP Architecture Study



Architecture Components:

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

Study instrument library includes a broad range of capabilities:

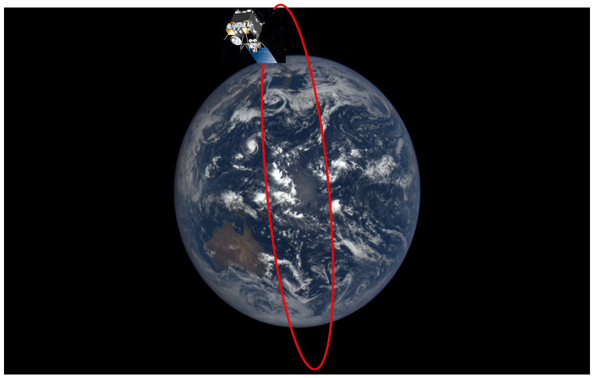
- Radars include W, Ka, Ku bands, Doppler and non-Doppler, scanning and nadir only
- Radiometers include cross-track and conically scanning, frequencies ranging from 10 to 883 GHz
- Lidars include 2 and 3 frequencies, backscatter and HSRL
- Polarimeters include varying channels (5 to hyperspectral) and angles (5 to 255)
- Spectrometers include VIS, NIR, SWIR, LWIR, TIR

Architecture Construction Workshops (ACWs)

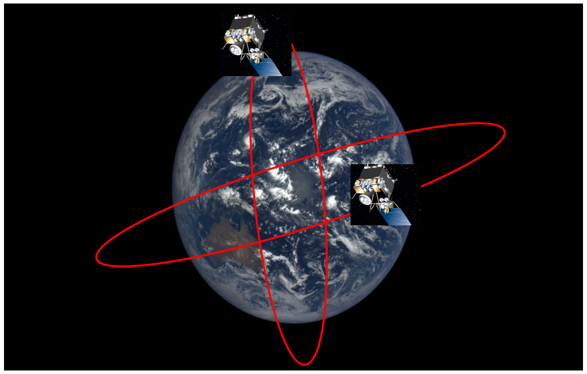
The ACWs generated ~32 architectures including

- Single- and dual- medium-to-large satellites
- Smallsat (<180 kg) systems
- Hybrid small/large satellite systems
- Constellations of cubesats
- Impacts of international contributions

Polar orbit solutions

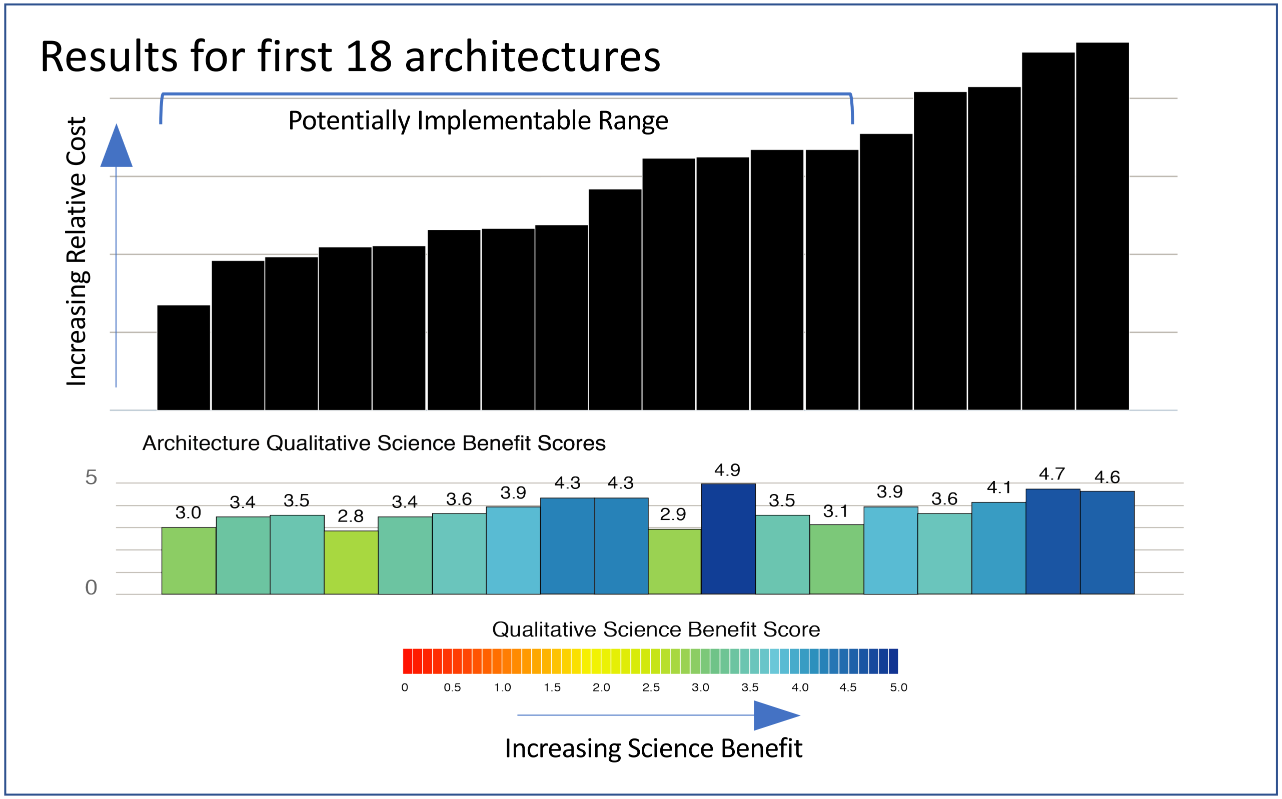


Inclined orbit additions



ACW General Findings

Relative costs and qualitative science benefit scores

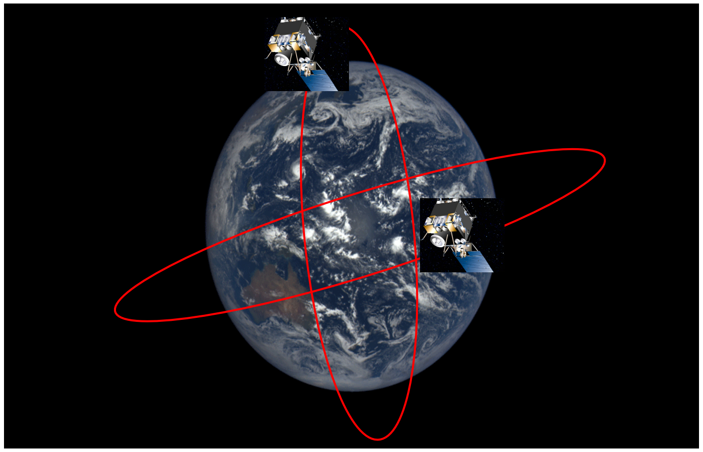


Collaborative Design Center Study #1 & #2

Dual-satellite, dual-orbit architecture with:

Polar satellite:
- W, Ka-band Doppler radars, swath of 12.5 km at Ka
- Radiometer with 118, 183 GHz, and several sub-mm channels
- Dual-wavelength lidar, HSRL @ 532 nm
- Thin ice cloud spectrometer (contributed)
- 60-angle polarimeter

GPM-orbit satellite:
- W, Ka-band Doppler radars, swath of 12.5 km at Ka
- Radiometers with 183/325/670 GHz
- Smallsat dual-wavelength backscatter lidar
- 60-angle polarimeter



CDC#2 breaks up this architecture into smaller components. Instead of 2 satellites, broken up into 4 (two per orbit).

Value Framework Scoring

Key parameters for assigning a science benefit score include the ***utility*** of geophysical variables for achieving the science objectives and the ***quality*** of the geophysical variables that are derived from each architecture.

The value framework will allow for a fairly objective cost-benefit assessment of the architectures considered within the observing system study.

An illustrative example of value framework scoring

$$B = \sum UQ$$

B = Family/Customer Satisfaction

TRADITIONAL HAMBURGER RECIPE

Ingredients	Utility	Quality
Patty	0.60	1.0 = ½ lbs, 100% Angus Beef, Charbroiled 0.4 = vegan "Impossible" burger
Bun	0.20	0.8 = sesame seed topped whole wheat bun 0.4 = small, white bread bun
Cheese	0.10	0.9 = Cheddar 0.6 = American 0.3 = Mozzarella
Tomato	0.04	etc
Lettuce	0.04	etc
Onions	0.01	etc
Ketchup	0.01	etc

Utility is the importance of the Ingredient to the Recipe
Quality is the quality of the given ingredient relative to a best possible
(NOTE: Utility is probably more subjective than Quality)

Study Summary

- Next CDC is in March and will consider JAXA Ku Doppler radar
- Three more CDC possible after March CDC
- March and June 2020: Suborbital workshops
- 2021: Modeling workshop possible to look at integration of observations with Earth System Models
- Earliest possible launch likely in 2029, likely in two phases due to expected budget profile