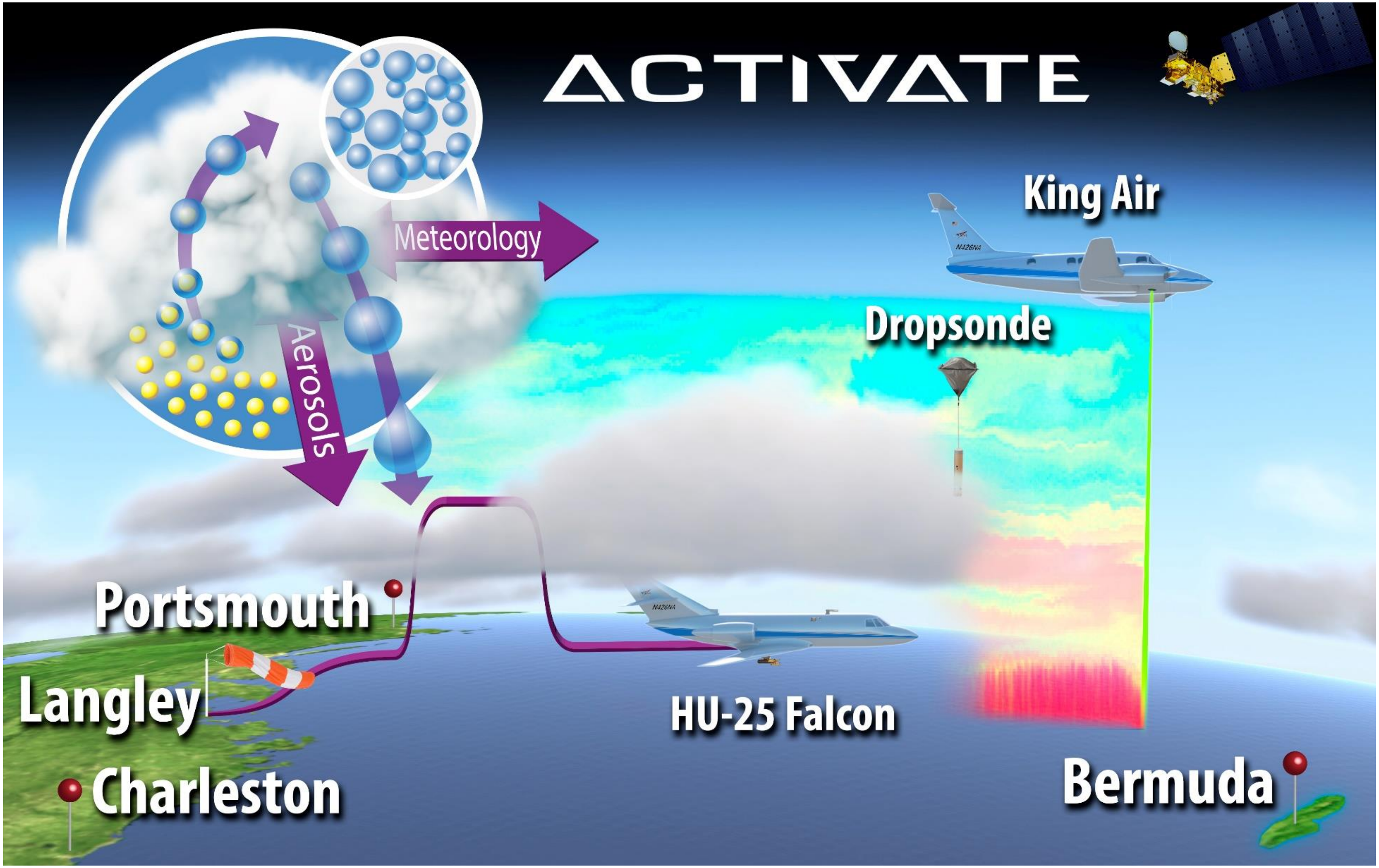
The Aerosol Cloud meTeorology Interactions oVer the western ATlantic Experiment (ACTIVATE)



Open Data Workshop
20-21 October 2021

Outline

Day 1
- Workshop Goals
- ACTIVATE Concept and Progress
- Data Access and Usage
- Case Study 1
- Discussion

Day 2
- Case Study 2
- Discussion

Motivation

IPCC 5th Assessment (2013)

- "Clouds and aerosols continue to contribute the largest uncertainty to estimates and interpretations of the Earth's changing energy budget.“
- “Aerosols and their interactions with clouds contribute to the largest uncertainty to the total radiative forcing estimate”

NAS Decadal Study Report (2018)

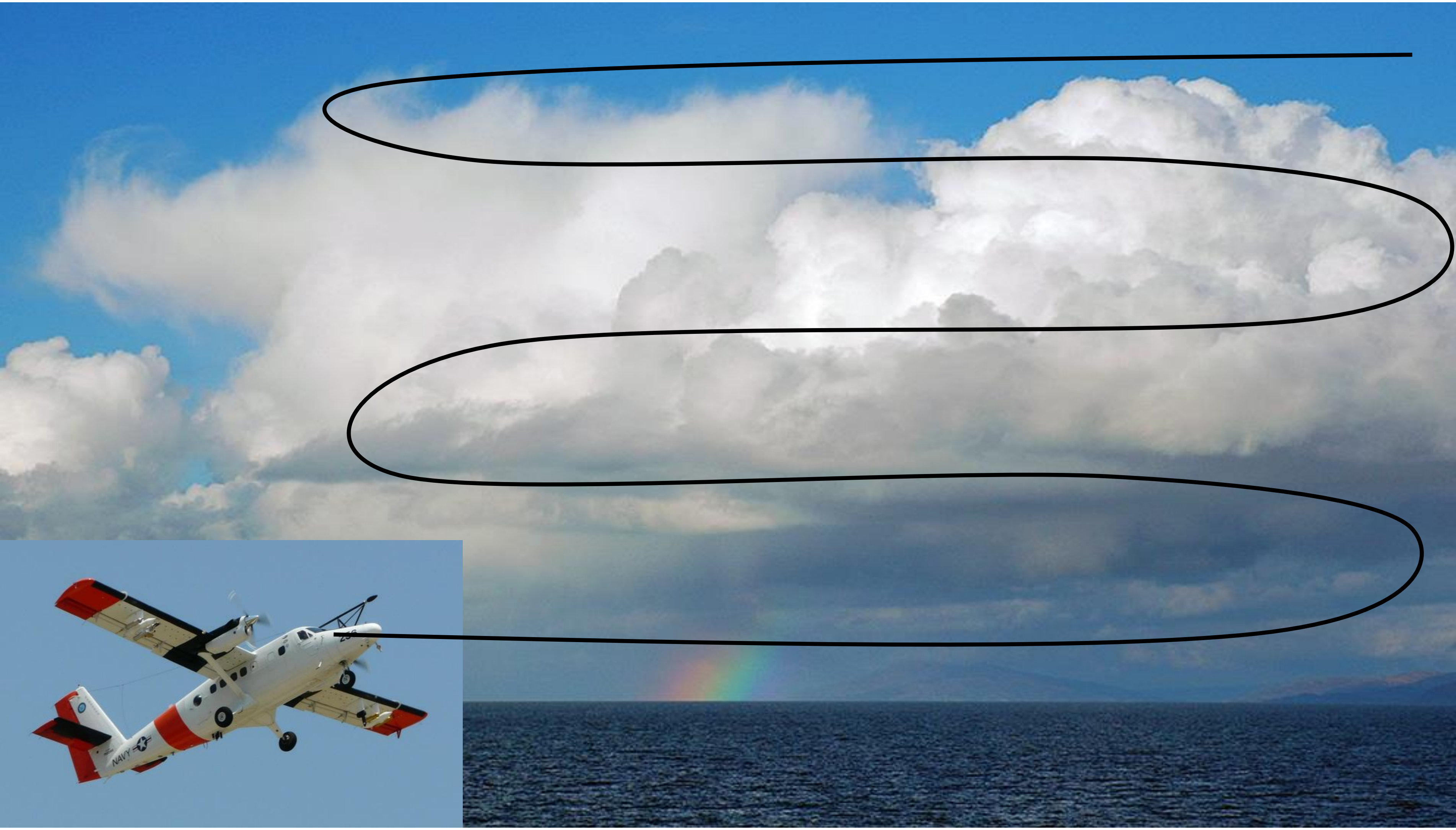
- “Improving our understanding will require measurements capable of examining aerosol and cloud vertical profiles and sizes. Vertical profiles of aerosols are also essential for determining how and whether aerosols affect cloud microphysical properties.”
- “It is likely that only such a combination of platforms (models, in situ observations, space-based platforms) would resolve the roles of the naturally-occurring and anthropogenic aerosols on clouds.”

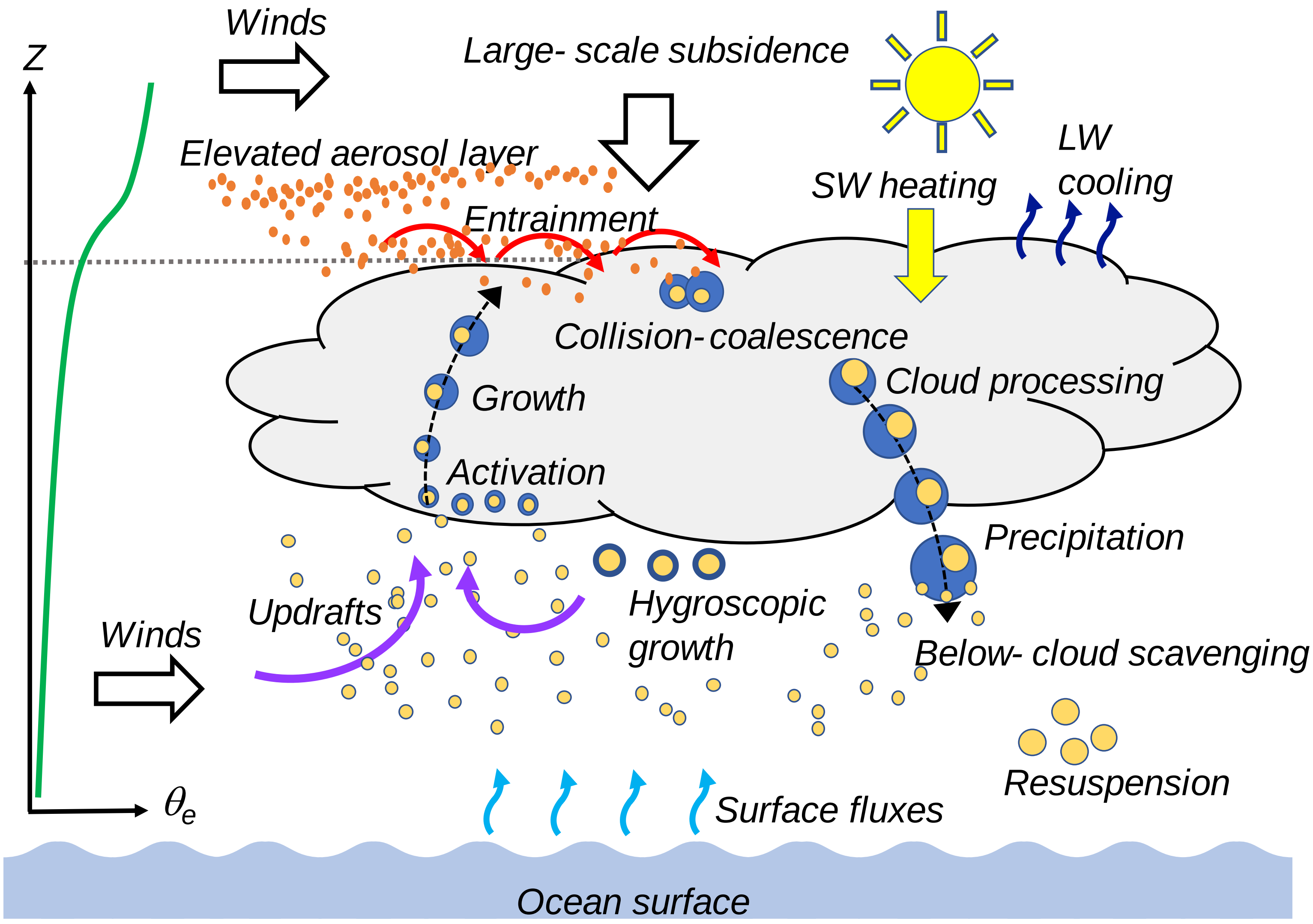
NASA A-CCP/AOS Study (ongoing)

- In response to NASA’s *Designated Observables Guidance for Multi-Center Study Plans*

Why such high uncertainty?
Complexity of clouds and difficulty in untangling influences from aerosols and meteorology.

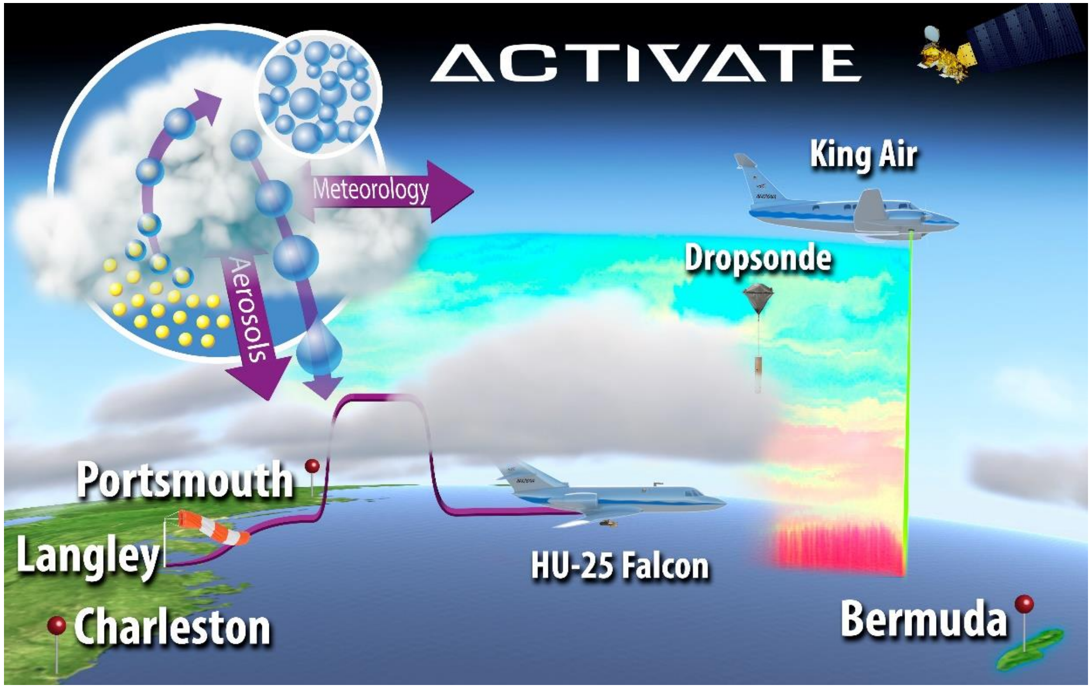
Why ACTIVATE?
Will quantify relationships between aerosols, clouds, and meteorology with a new experimental approach.


NAVY



Winds
Large- scale subsidence
Z
Elevated aerosol layer
LW
cooling
SW heating
Entrainment
Collision-coalescence
Growth
Cloud processing
Activation
Precipitation
Hygroscopic
growth
Updrafts
Winds
Below- cloud scavenging
Resuspension
θ_e
Surface fluxes
Ocean surface

ACTIVATE

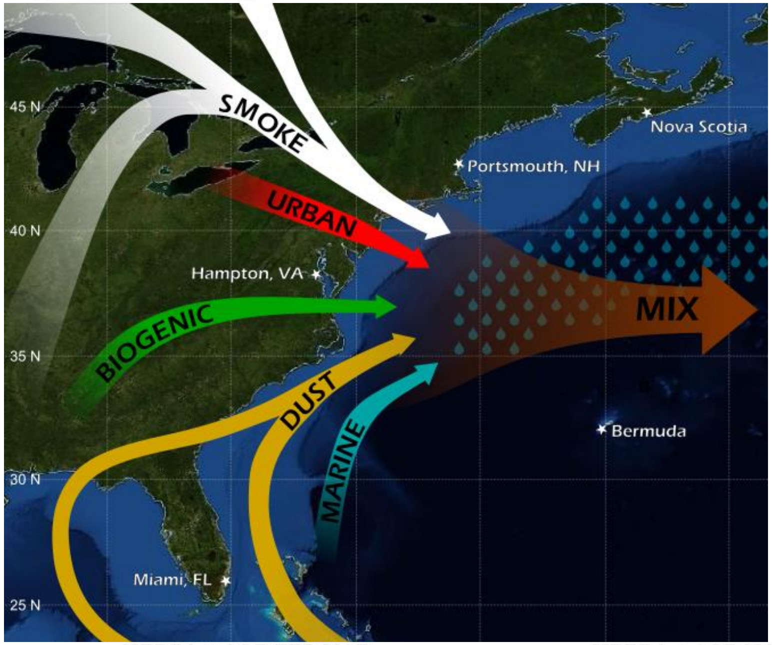


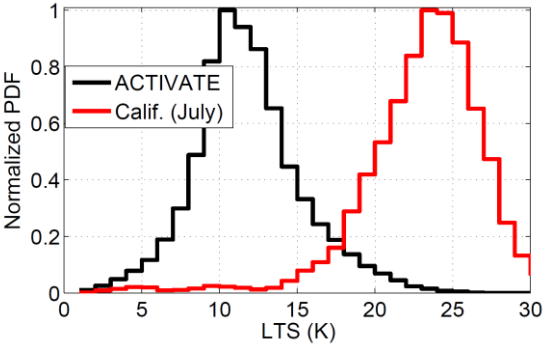
Science: Build **unprecedented dataset** to better understand aerosol-cloud-meteorology interactions, improve physical parameterizations for Earth system and weather forecasting models, assess remote sensing retrieval algorithms, and guide plans for future satellite missions.

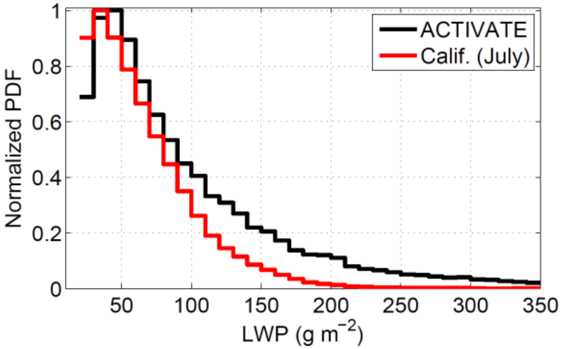
- PI: Armin Sorooshian (U. Arizona)
- Project Scientist: John Hair (NASA LaRC)
- NASA Earth Venture Sub-orbital (EVS-3) Mission
- Partnering Institutions: U. Arizona, NASA LaRC, NASA GISS, NCAR, SSAI, NIA, PNNL, BNL, BAERI, U. Miami, College of William & Mary, Bermuda Institute of Ocean Sciences, DLR (Germany)
  - **Hoping to gain partners and collaboration**

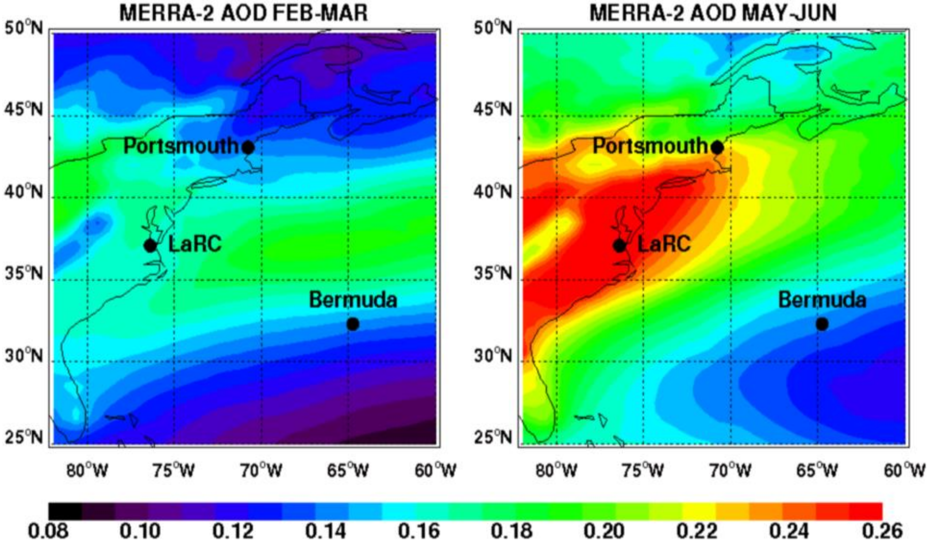
- Platforms: HU-25 Falcon + UC-12 King Air
- 150 joint airplane missions (~600 hrs per plane) over western North Atlantic Ocean
- Based out of NASA LaRC, Hampton, VA
- Measurements: In situ and remote sensing measurements of aerosol and cloud distributions and properties, atmospheric state

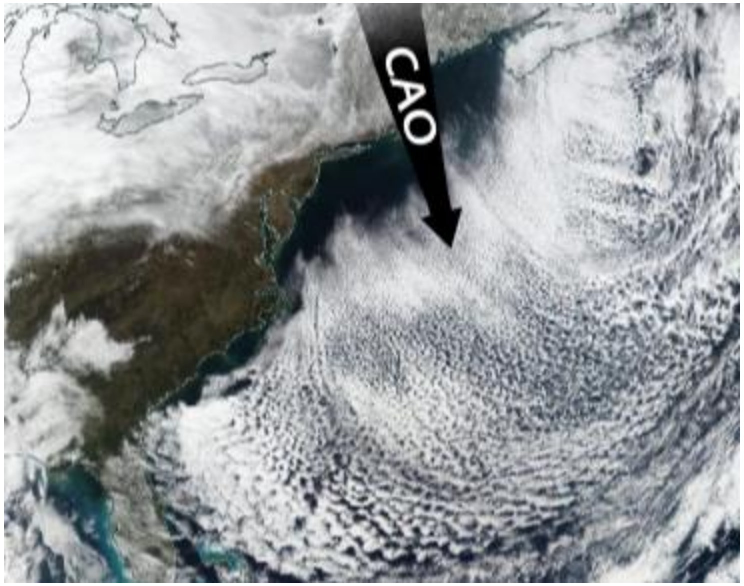
Why Western N. Atlantic Ocean?











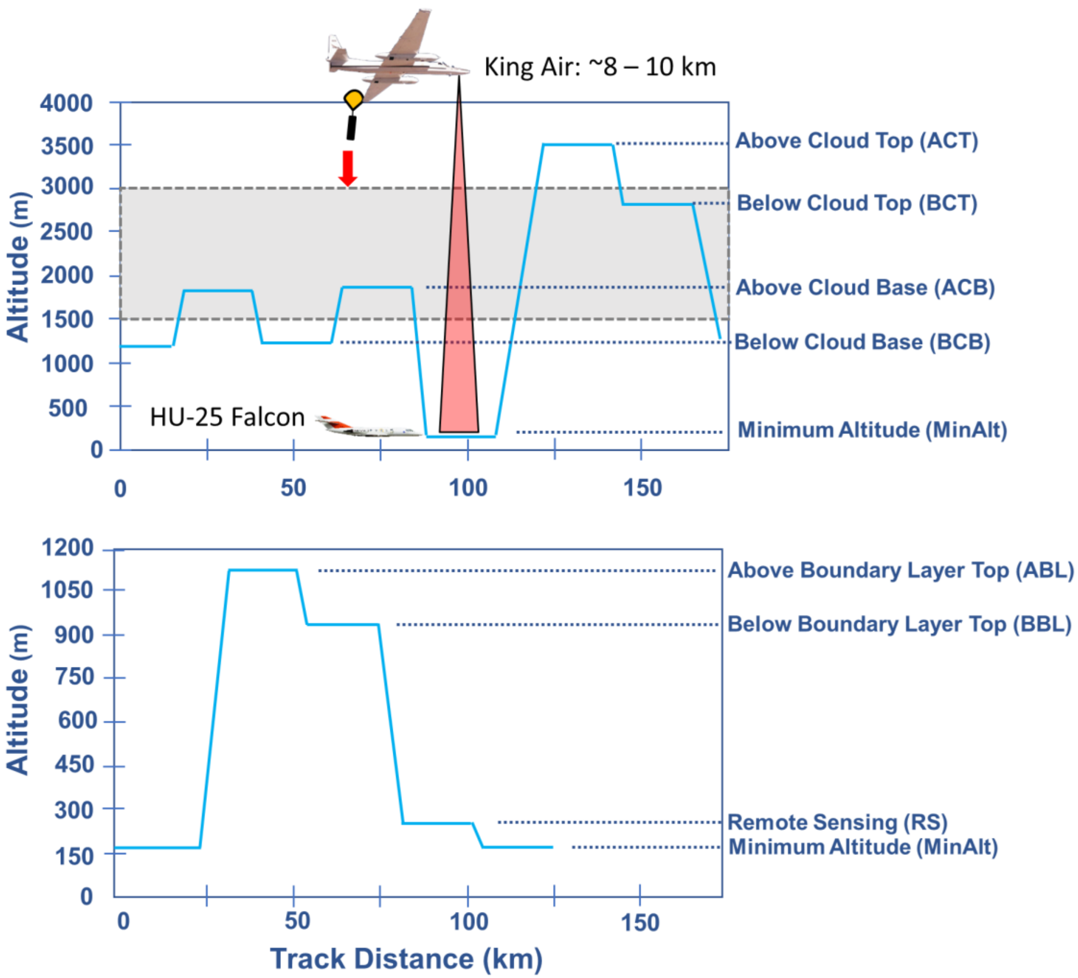
Science Objectives

Objective 1: Quantify relationships between aerosols, cloud condensation nuclei (CCN), and cloud drops and reduce uncertainty in model parameterizations of cloud droplet activation.

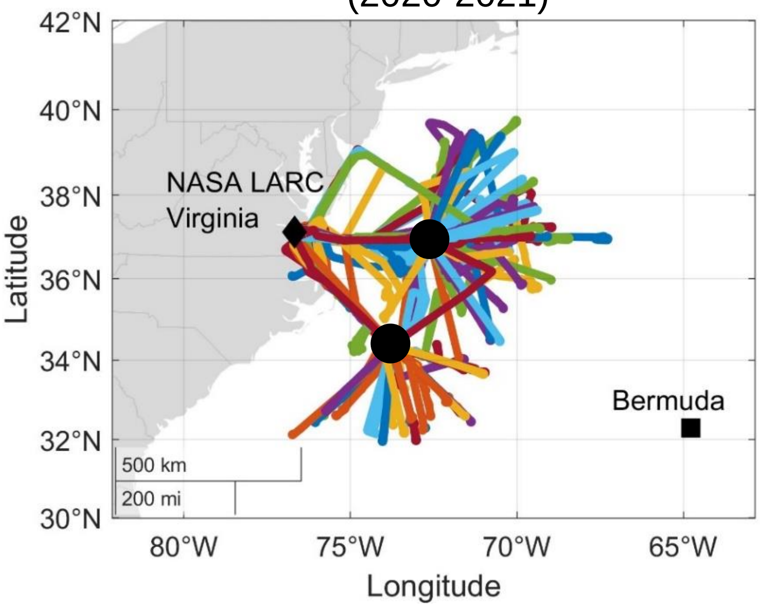
Objective 2: Improve process-level understanding and model representation of factors governing cloud micro/macro-physical properties and how they couple with cloud effects on aerosol.

Objective 3: Assess advanced remote sensing capabilities for retrieving aerosol and cloud properties related to aerosol-cloud interactions.

Flight Strategy



Flight Tracks from first 4 deployments (2020-2021)



2022 plans include secondary bases like Bermuda

Mission Progress

	Research Flights			Flight Hours		Joint Ensembles		Underflights			
	Falcon	King Air	Joint	Falcon	King Air	Cloudy	Clear	ASTER	CALIPSO	Process Study Flights	Dropsondes
Winter 2020	22	17	17	73	59	43	28	1		2	59
Summer 2020	18	18	18	60	67	58	36	1	3	2	108
Winter 2021	17	19	15	56	66	47	25	1	3		102
Summer 2021	32	32	32	106	108	103	74	1	1	2	150
Sum	***89***	***86***	***82***	***295***	***300***	***251***	***163***	***4***	***7***	***6***	***419***

- ~90% of flights are “statistical surveys”: out-and-back doing traditional ensembles
- ~10% of flights are “process studies”: specially designed for model intercomparisons and/or studying targets of opportunity requiring custom-flight design in areas of interest

Platforms

High-Altitude Remote Sensing
King Air

Range: 1,500 km
Altitude: 9 km
Airspeed: 120 m/s
Duration: ~4 hours

Low-Altitude In-situ
HU-25 Falcon

Range: 3,000 km
Altitudes: 0.15 - 3 km
Airspeed: 100-130 m/s
Duration: ~4 hours

Payload: Falcon External Probes

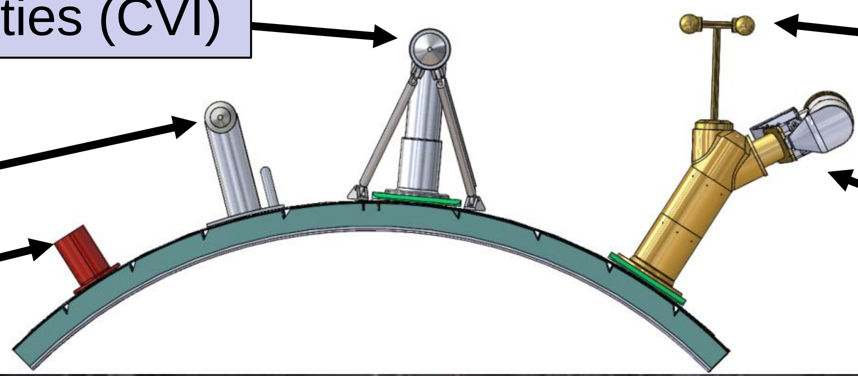
Cloud Residual Properties (CVI)

Cloud Droplet Probe

Isokinetic Aerosol Inlet

AC3 Cloud Collector

Trace Gases



Cloud Aerosol Precipitation Spectrometer (Langley)

Turbulent Air-Motion Measurement

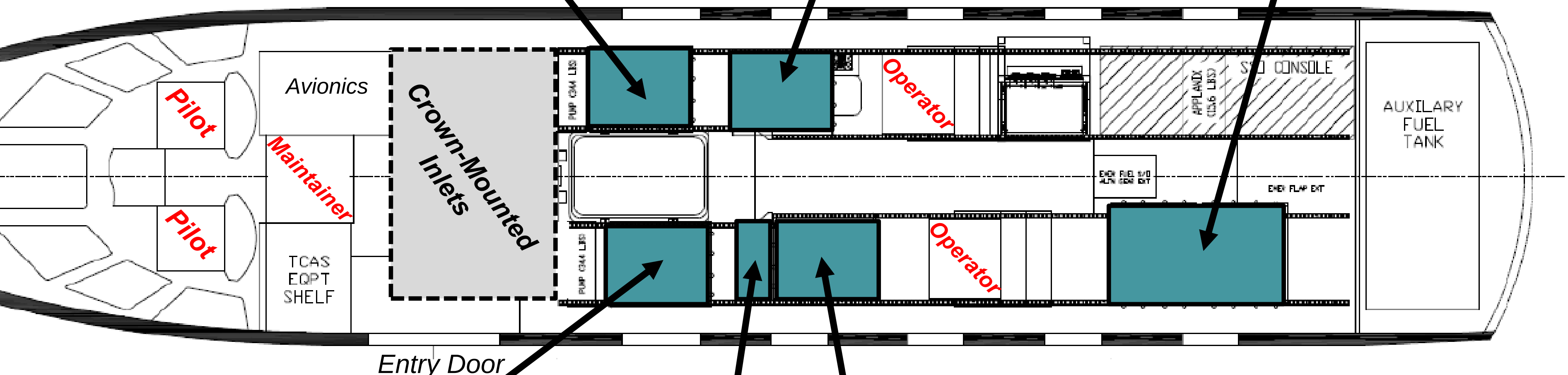
FCDP/2D-S Cloud probe (DLR)

Payload: Falcon In-Situ Measurements

Trace Gases
Ozone, CO, CO_2, H_2O

Aerosol Composition (PILS)

Aerosol Composition (HR-ToF-AMS)

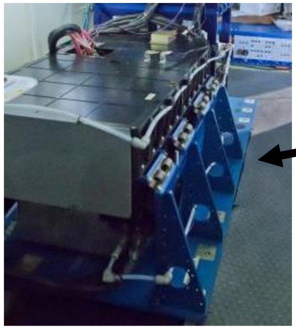


Aerosol Optical
Scattering, Absorption, Hygroscopicity

Cloud Condensation Nuclei

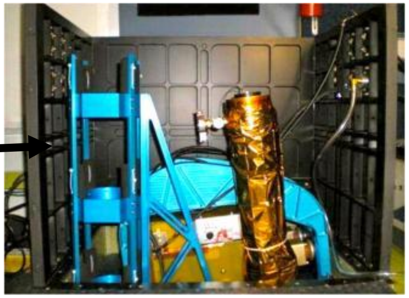
Aerosol Microphysics

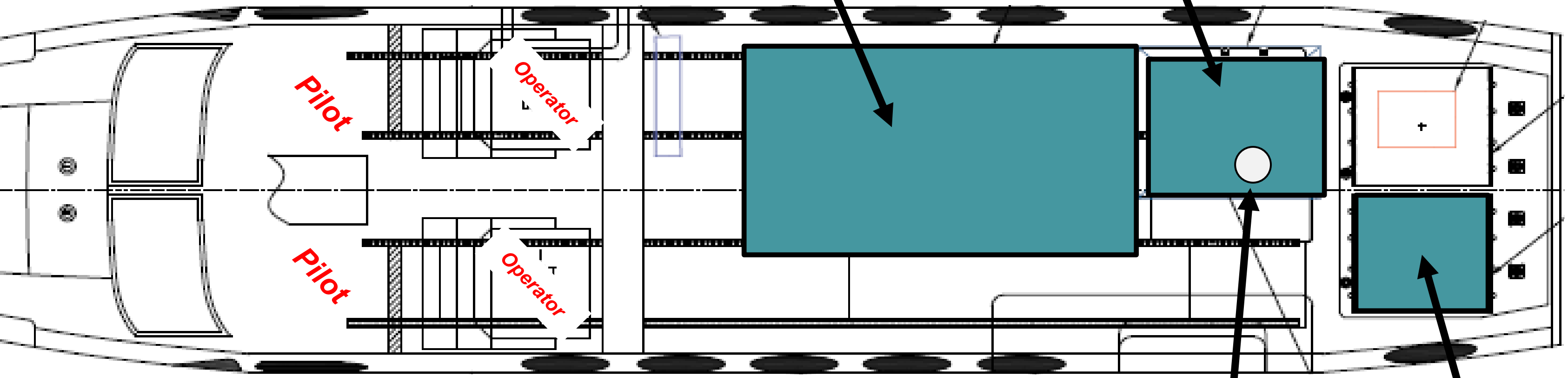
Payload: King Air

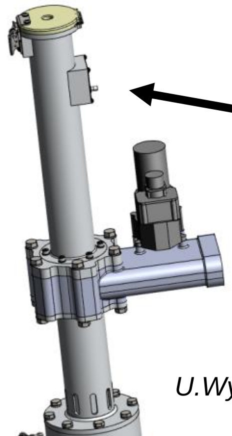


High Spectral Resolution Lidar (HSRL-2)

Research Scanning Polarimeter (RSP)





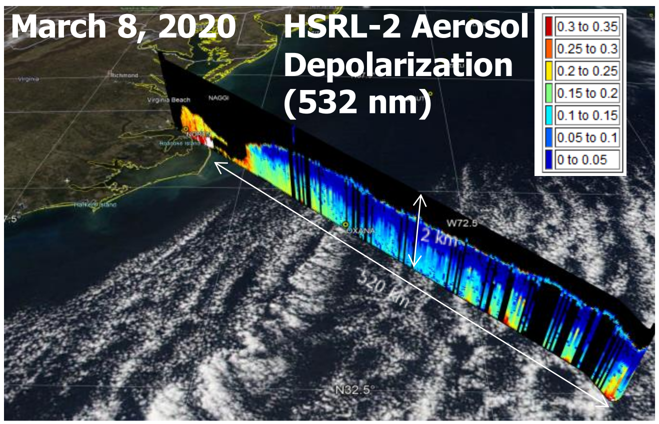


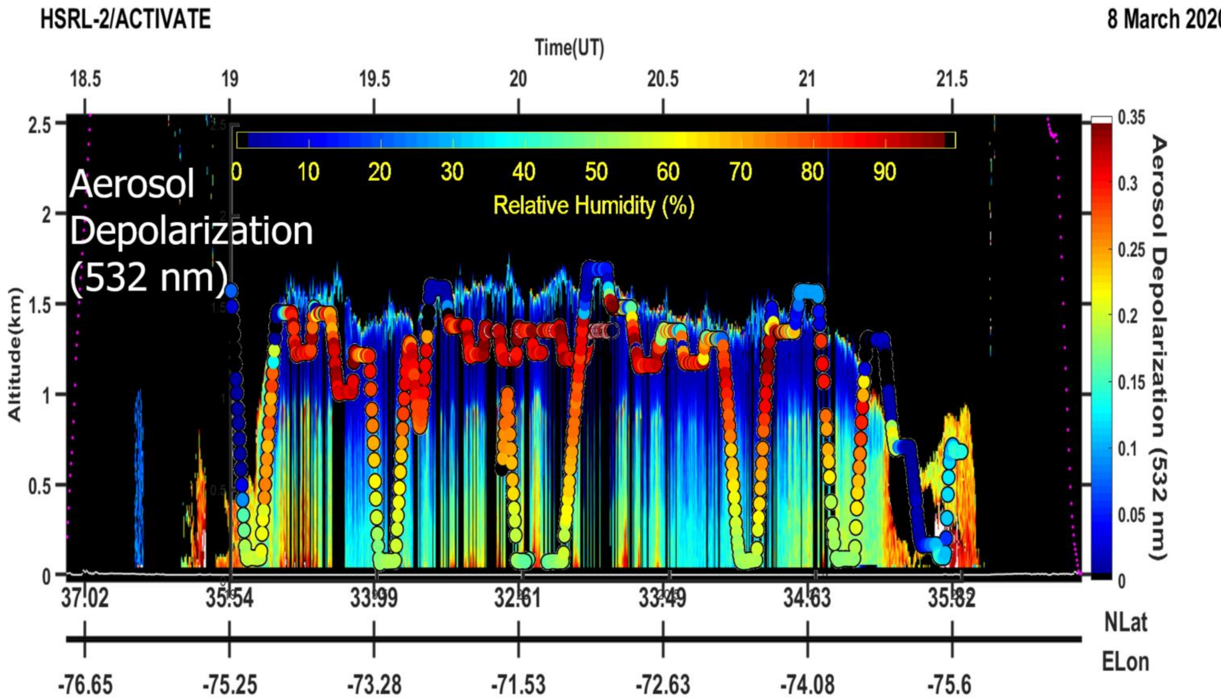
Dropsonde Tube Penetration

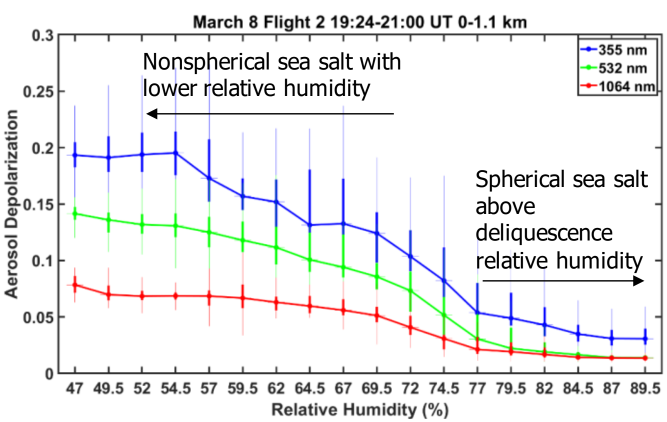
Dropsonde (AVAPS) and RSP support Electronics

U.Wyo B-200 Launcher

Example of Joint Flight Success: Enhanced Aerosol Depolarization Associated with Nonspherical Sea Salt particles

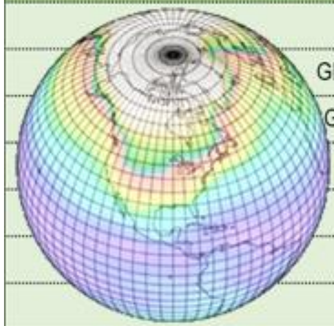






- Typically, lidars observe low (<5%) aerosol depolarization from spherical sea salt particles
- During several ACTIVATE flights in both winter and summer, airborne HSRL-2 observed enhanced (>15%) aerosol depolarization due to nonspherical sea salt particles associated with low relative humidity during cold air outbreaks
- Major Implication: nonspherical sea salt impacts CALIOP inferences of aerosol type and retrievals of aerosol extinction and aerosol optical thickness

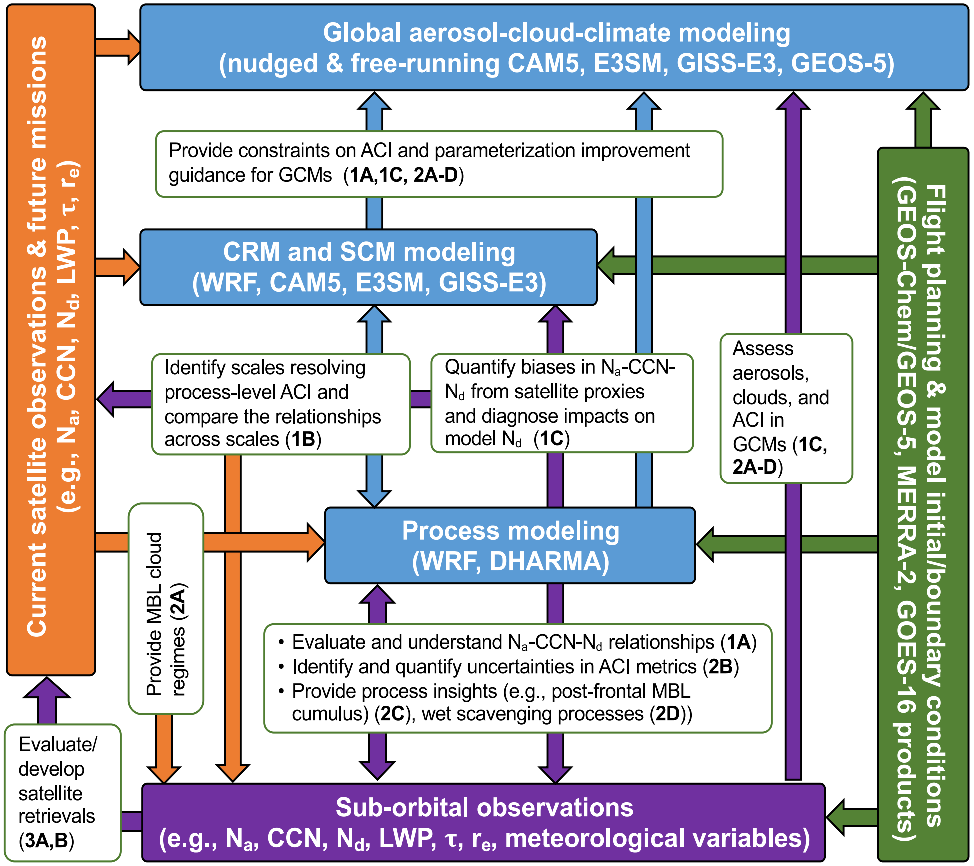
Modeling/Analysis Efforts



Models	Organization
DHARMA (LES)	NASA GISS
GISS-E3 (SCM and Global)	NASA GISS
GEOS-5 and GEOS-Chem	NIA/NASA LaRC
FLEXPART	NIA/NASA LaRC
WRF (LES and CRM)	PNNL
E3SM (SCM and Global)	PNNL
CAM5 (SCM and Global)	PNNL/UA

Global, regional, LES modeling

- Flight planning/guidance
- Post-flight field data analysis
- Parameterization development and testing
- Model-measurement intercomparisons



Mission Website

http://activate.larc.nasa.gov/

Dissemination of Science Findings

https://activate.larc.nasa.gov/publications/

Public Data

https://www-air.larc.nasa.gov/missions/activate/index.html