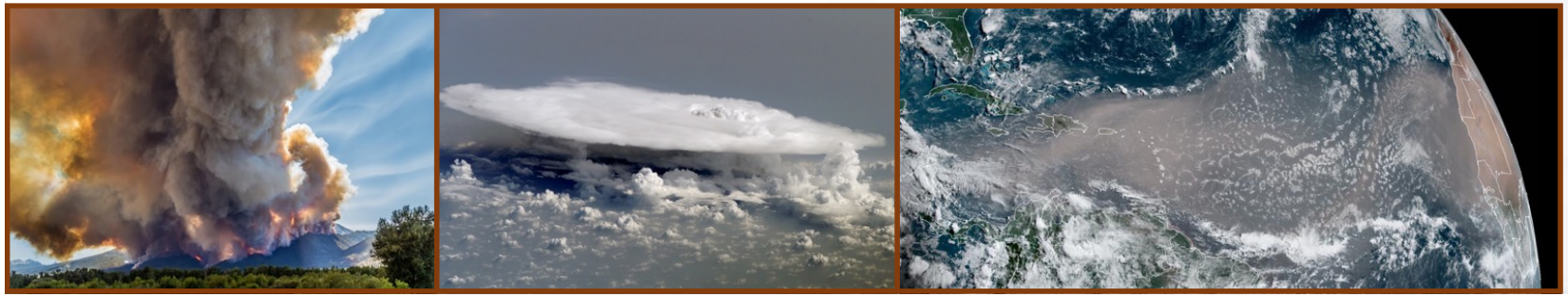
NASA's Decadal Survey Observing-System for Aerosols, Clouds, Convection, and Precipitation (ACCP): The Atmosphere Observing System

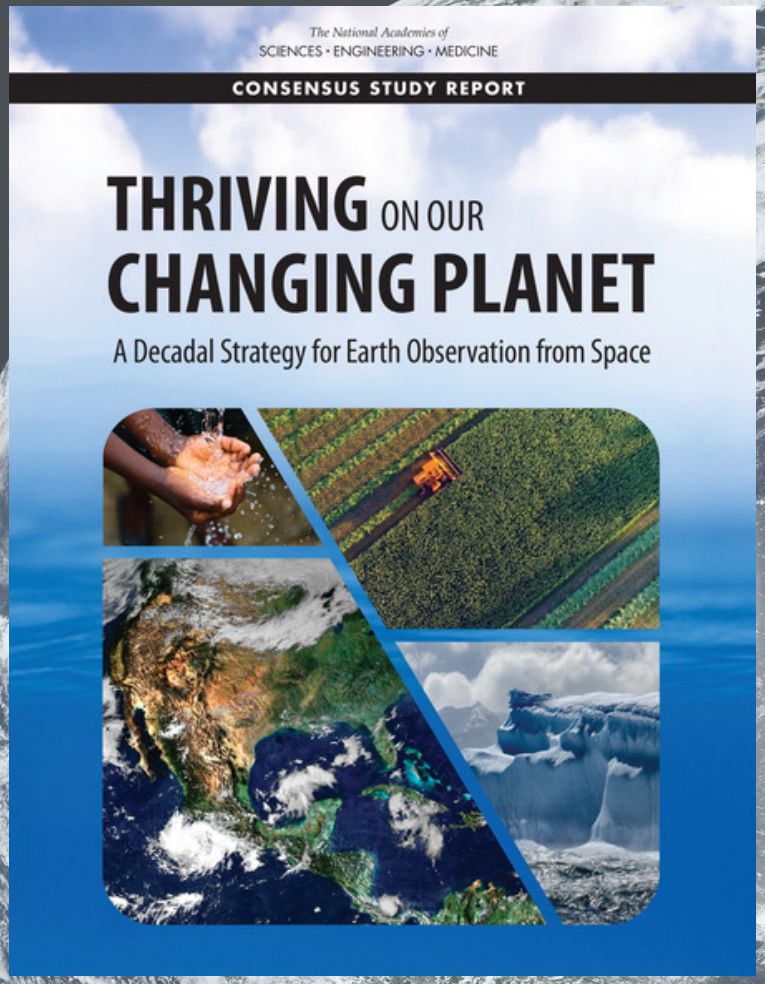
Scott A. Braun, AOS Project Scientist, NASA/GSFC

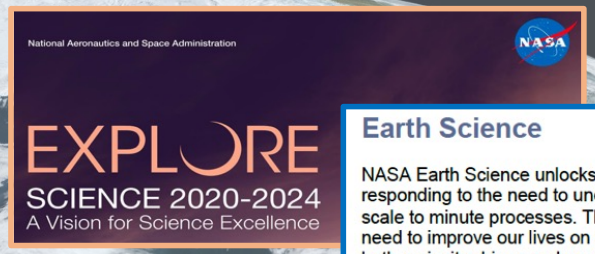
John Yorks (GSFC), Tyler Thorsen (LaRC), Daniel Cecil (MSFC), Arlindo da Silva (GSFC), Richard Ferrare (LaRC), Meloë Kacenelebogen (ARC), Walter Petersen (MSFC), Graeme Stephens (JPL), Duane Waliser (JPL), and David Winker (LaRC)



EUMETSAT Meteorological Satellite Conference 2021

20-24 September 2021





Earth Science

NASA Earth Science unlocks the mysteries of our planet, exploring, discovering, and responding to the need to understand our planet's interconnected systems, from a global scale to minute processes. This knowledge and understanding serves the fundamental need to improve our lives on Earth, advancing this frontier for all humanity. NASA pursues both curiosity-driven and practically focused Earth science because our ability to thrive on our home planet is undeniably tied to our scientific understanding and predictive capability of its dynamics and phenomena.

Photo Credit: *NASA's Goddard Space Flight Center*
NASA's Global Modeling and Assimilation Office used Earth science data gathered from multiple missions to visualize several high impact events across the globe between August 2019 and January 2020, including Hurricane Dorian (August to September 2019), major fire events in South America and Indonesia (August to September 2019), and extreme wildfires in Australia (December 2019 to January 2020). The model helps demonstrate how different events interact and the environmental impacts they can have around the globe.

NASA Earth Science explores our rapidly changing world, where natural and human factors interact, following an interdisciplinary, Earth systems approach that examines the interplay among the atmospheric, ocean, land, and ice systems. Using the recommendations of the 2017 NASA Earth Science Decadal Survey, *Thriving on Our Changing Planet a Decadal Strategy for Earth Observation from Space*, as a compass, NASA Earth Science is developing the observing systems that will answer the most important science and application questions of the next decade across the following focus areas:

- Coupling of the water and energy cycles ✓
- Ecosystem change
- Extending and improving weather and air quality forecasts ✓
- Reducing climate uncertainty and informing societal response ✓
- Sea-level rise
- Surface dynamics, geological hazards and disasters

DS Science Questions Related to ACCP

Earth System Observatory
AOS
Atmosphere Observing System

Weather & Air Quality Panel	Climate Variability and Change Panel	Hydrological Cycle Panel
W-1 (MI): Planetary Boundary Layer Dynamics.	**C-2 (MI): Climate Feedback and Sensitivity.**	**H-1 (MI): Coupling the Water and Energy Cycles.**
W-2 (MI): Larger Range Environmental Predictions.	**C-5 (I-VI): Aerosols and Aerosol Cloud Interactions.**	**C-8 (I): Causes and Effects of Polar Amplification.**
W-4 (MI): Convective Storm Formation Processes.		
W-5 (MI): Air Pollution Processes and Distribution.		
W-6 (I): Air Pollution Processes and Trends.		
W-9 (I): Role of Cloud Microphysical Processes.		
W-10 (I): Clouds and Radiative Forcing.		

Most Important

Very Important

Important

DS Science Questions Related to ACCP

Earth System Observatory
AOS
Atmosphere Observing System

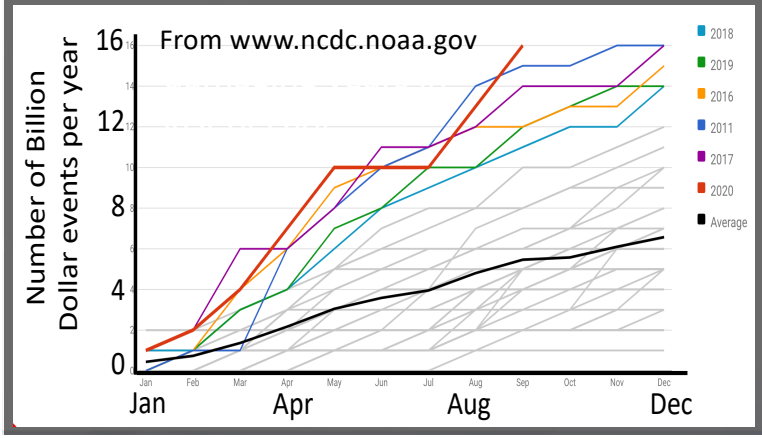
Weather & Air Quality Panel

W-1 (MI): Planetary Boundary Layer Dynamics.

W-2 (MI): Larger Range Environmental Predictions.

W-4 (MI): Convective Storm Formation Processes.

W-5 (MI): Air Pollution Processes and Distribution.



Climate Variability and Change Panel

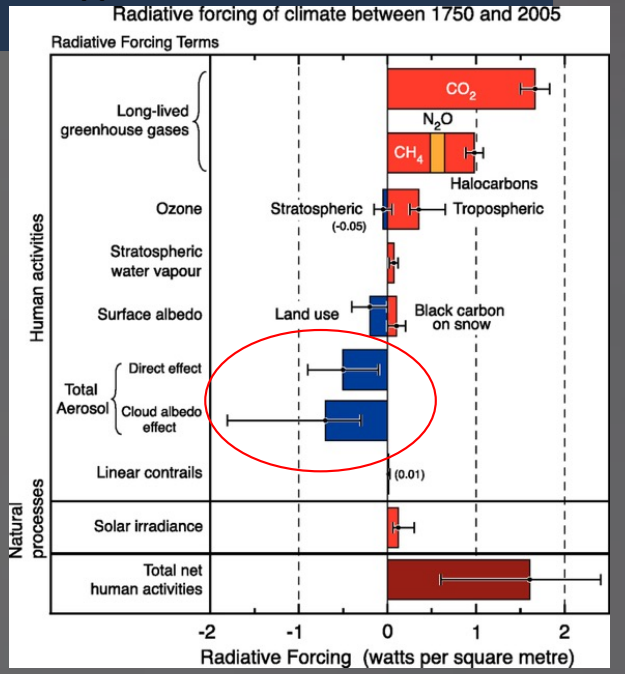
C-2 (MI): Climate Feedback and Sensitivity.

C-5 (I-VI): Aerosols and Aerosol Cloud Interactions.

Hydrological Cycle Panel

H-1 (MI): Coupling the Water and Energy Cycles.

C-8 (I): Causes and Effects of



Forster et al. (2007)

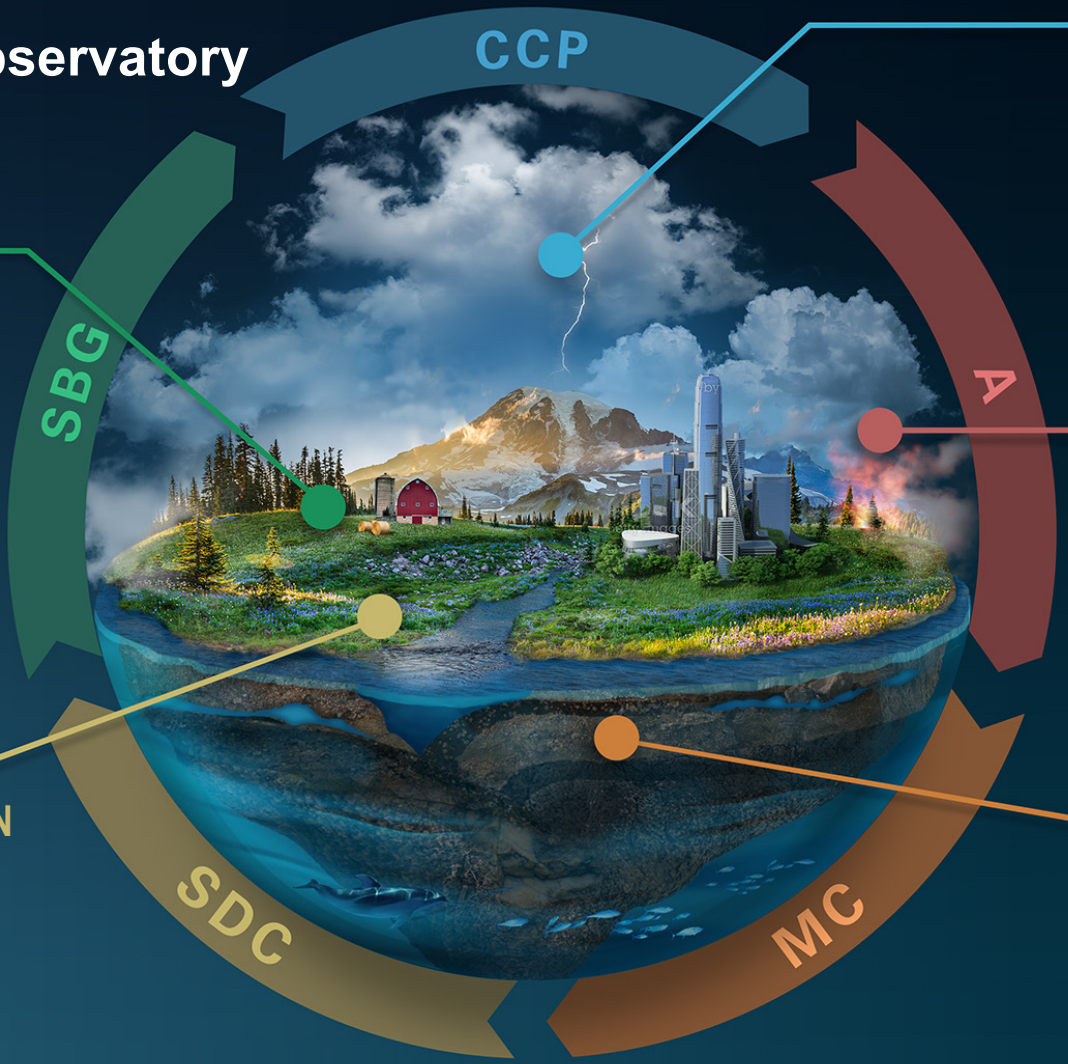
Mapping Top DS Questions to ACCP/AOS Goals

Earth System Observatory AOS Atmosphere Observing System

Key MI DS Questions	Linked ACCP Goals
W-4 (MI): Convective Storm Formation Processes.	**G2** Storm Dynamics *Improve our physical understanding and model representations of cloud, precipitation and dynamical processes within convective storms*
W-5 (MI): Air Pollution Processes and Distribution.	**G4** Aerosol Processes *Reduce uncertainty in key processes that link aerosols to weather, climate and air quality related impacts.*
C-2 (I-MI): Climate Feedback and Sensitivity.	**G1** Cloud Feedbacks *Reduce the uncertainty in low- and high-cloud climate feedbacks by advancing our ability to predict the properties of low and high clouds* **G3** Cold Cloud and Precipitation *Improve understanding of cold (supercooled liquid, ice, and mixed phase) cloud processes and associated precipitation and their coupling to mid-to-high latitude water and energy cycles* **G5** Aerosol Impacts on Radiation *Reduce the uncertainty in Direct (D) and Indirect (I) aerosol-related radiative forcing of the climate system.*

Earth System Observatory

Interconnected Missions



CLOUDS, CONVECTION AND PRECIPITATION

Water and Energy in the Atmosphere

AEROSOLS

Particles in the Atmosphere

MASS CHANGE

Large-scale Mass Redistribution

SURFACE BIOLOGY AND GEOLOGY

Earth Surface & Ecosystems

SURFACE DEFORMATION AND CHANGE

Earth Surface Dynamics

ATMOSPHERE OBSERVING SYSTEM

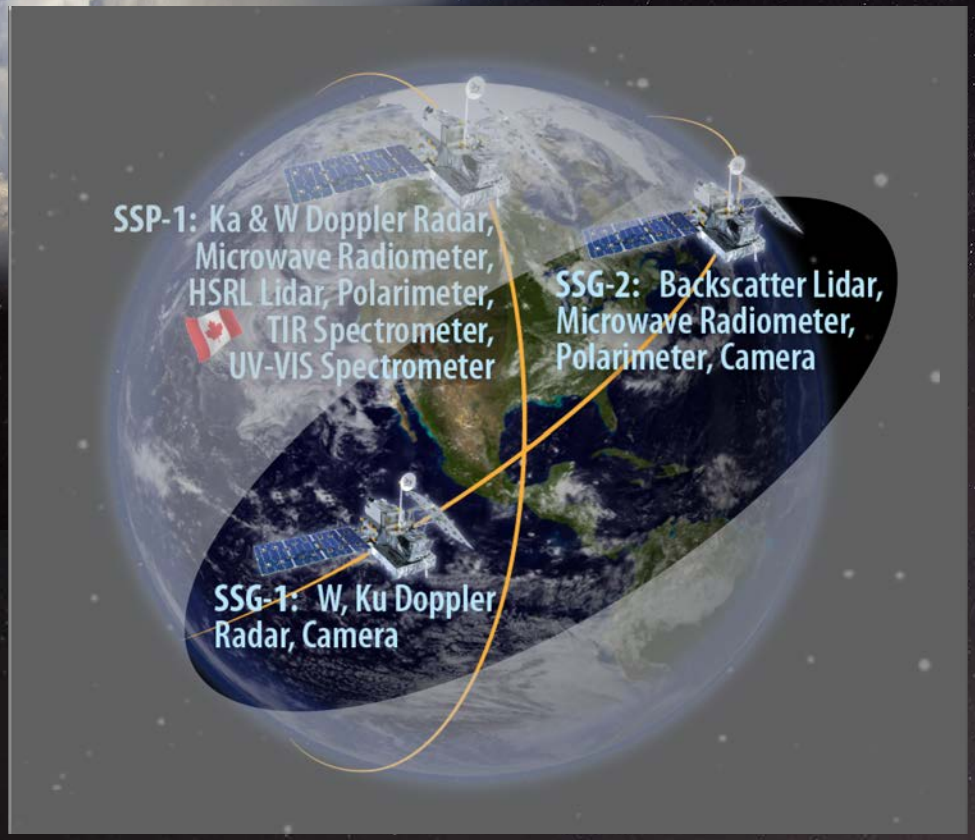
AOS
One Observing System, Two Synergistic Segments

Constellation

- Based on prioritization of measurements and balance of the climate, convection, and aerosol DS questions
- Polar and Inclined orbits
- Both have radar, lidar, radiometer, and polarimeter instruments

ATMOSPHERE OBSERVING SYSTEM

AOS
One Observing System, Two Synergistic Segments



Inclined Orbit

- Key Features: Information on diurnal variability, Ku radar, tandem stereo cameras
- Emphasizes diurnally varying convective clouds to explore connections between vertical air motion and cloud and precipitation processes
- Targets the dynamics of evolving low clouds are aerosol plumes
- Provides insight on sub-daily processes that influence the distribution of aerosols and their linkage to clouds-precipitation

ATMOSPHERE OBSERVING SYSTEM

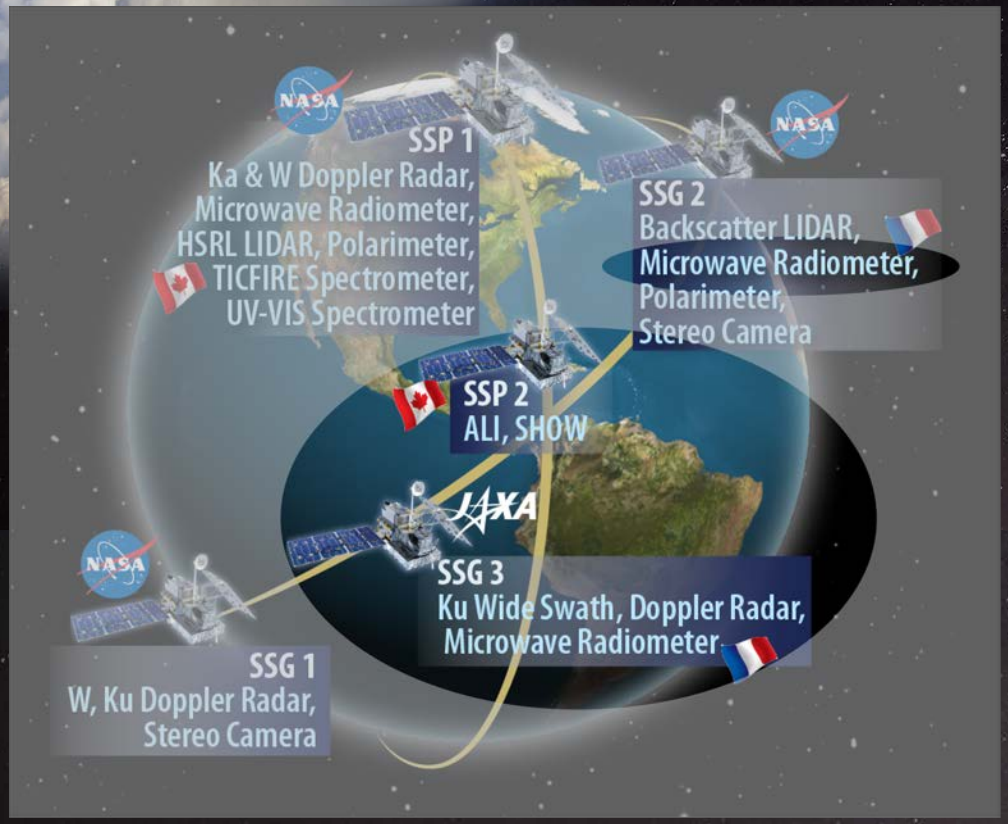
AOS
One Observing System, Two Synergistic Segments

Polar Orbit

- Key Features: Enhanced W-band Doppler capability, HSRL lidar, radiation
- Significantly advances our understanding of how clouds and aerosols interact with each other and with radiation to influence Earth's energy and water cycles
- Provides critical measurements on aerosol properties that will greatly aid air quality forecasts
- Emphasizes processes critical to aerosol forcing, cloud feedbacks, and air quality

ATMOSPHERE OBSERVING SYSTEM

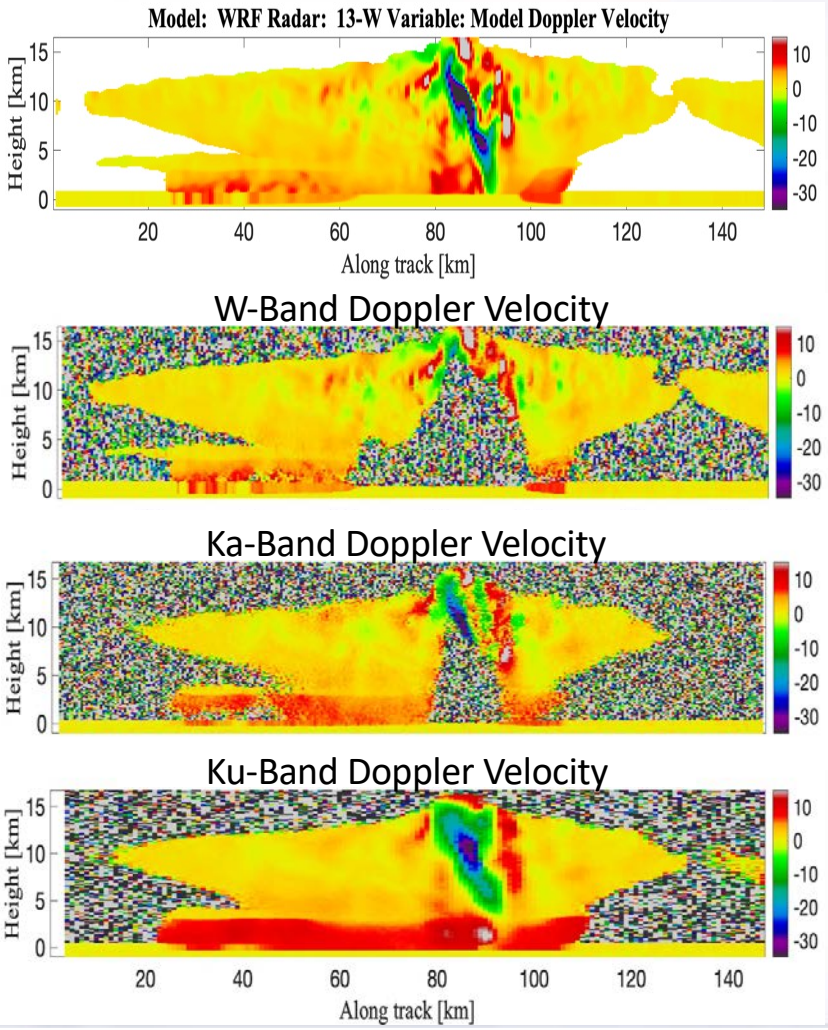
AOS
One Observing System, Two Synergistic Segments



International Contributions Under Study

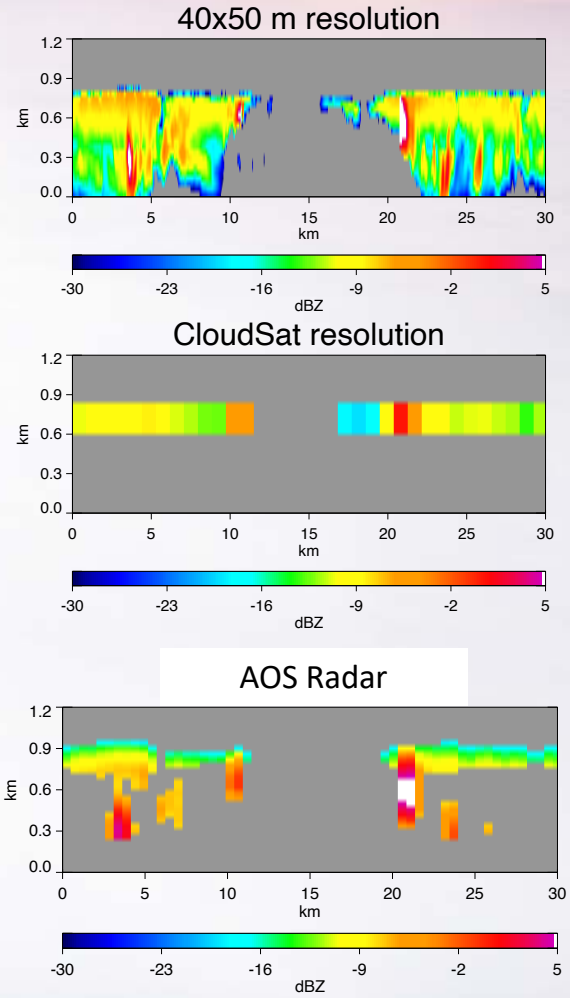
- JAXA wide-swath Ku-band Doppler radar for precipitation mapping and GPM continuity
- CNES tandem high-frequency (89, 183, 325 GHz) passive microwave radiometers for time-differenced measurements
- CSA limb sounders for upper tropospheric/ lower stratospheric aerosol and moisture sounding

Radar Capabilities To Be Transformative

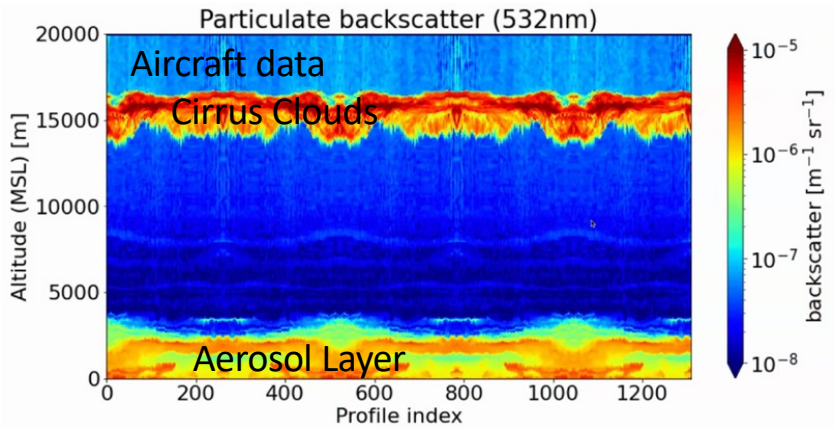


Doppler simulations (left) courtesy of Pavlos Kollias

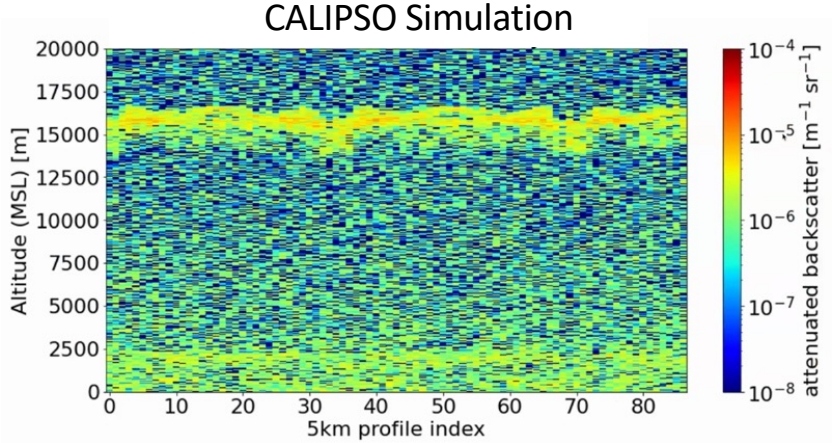
Low-level profiling results (right) courtesy of Matt Lebsock



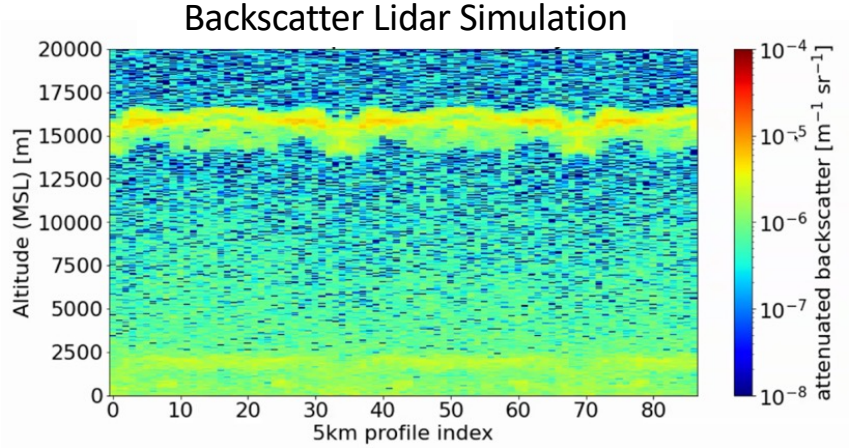
Lidar Capabilities—Daytime Capabilities



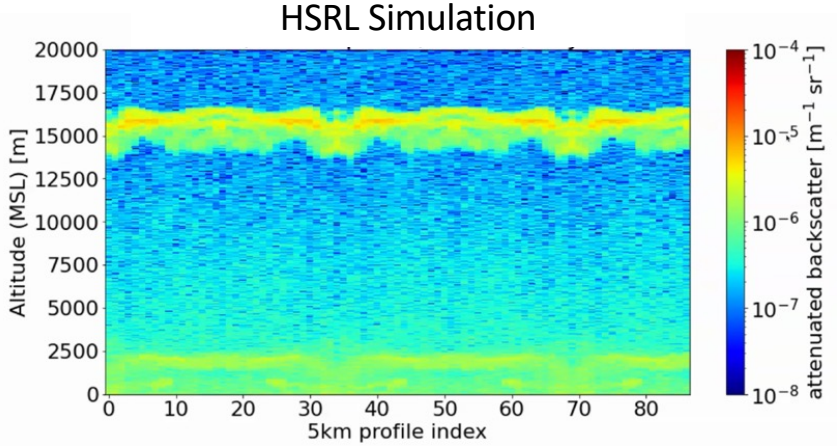
CALIPSO Simulation



Backscatter Lidar Simulation



HSRL Simulation



Simulations produced ACCP Lidar Working Group

AOS Science Team – Activities & Organization

The Science Team is charged with **defining orbital and suborbital requirements and products to implement ACCP science**

Teams

- *Science and Applications Transition Team (SATT)*: Science requirements and documentation
- *Algorithm Working Groups*: Products, algorithms, science traceability
- *Suborbital (SO) Working Group*: SO requirements definition
- *Applications Impact Team:* Assess community needs and priorities, latency requirements
- *Modeling & Data Assimilation Working Group*: Modeling and DA needs, forward models, OSSEs

Deliverables

- Finalize science traceability matrix
- Input on trade studies
- Program Level-1 Requirements Appendix
- Mission Concept Review package
- Community Assessment Report
- Draft of Project Applications Plan

Org Chart

Project Science, SATT Leads

Scott Braun, PS (GSFC)
John Yorks, DPS Inclined (GSFC)
Tyler Thorsen, DPS Polar (LaRC)
Daniel Cecil, DPS SO (MSFC)

SATT Members

- Graeme Stephens, Duane Waliser (JPL)
- Arlindo da Silva, Dalia Kirschbaum (GSFC)
- Dave Winker, Rich Ferrare (LaRC)
- Walter Petersen (MSFC)
- Meloë Kacenelenbogen (ARC)
- Jens Redemann (OU)
- Jay Mace (U. Utah)
- Ralf Bennartz (Vanderbilt)
- Greg Carmichael (U. Iowa)
- Susan van den Heever (CSU)

Modeling and DA Leads

Arlindo da Silva (GSFC)
Patricia Castellanos (GSFC)
Will McCarty (GSFC)
Derrek Posselt (JPL)

Applications Leads

Dalia Kirschbaum (GSFC)
Emily Berndt (MSFC)
Ali Omar (LaRC)

Algorithm Working Group

- Radiometer: Ian Adams (IS, GSFC), Joe Turk (JPL)
- Radar: S. Tanelli (IS, JPL), Matt Lebsock (IS, JPL), Pavlos Kollias (Stony Brook)
- Lidar: C. Hostettler (IS, LaRC), Ed Nowottnick (IS, GSFC), J. Yorks (GSFC), T. Thorsen (LaRC), R. Holz (U. Wisc.)
- Polarimeter: K. Knobelspiesse (IS), Brian Cairns (GISS)
- Cameras: Felix Seidel (IS, JPL), Roj Marchand (U. Wash.)
- Spectrometers: Kerry Meyer (IS, GSFC), Jean-Pierre Blanchet (IS, U. Quebec, Montreal), Seiji Kato (radiation, LaRC), Olga Kalashnikova (JPL)

Suborbital WG Leads

- Felix Seidel (JPL)
- Jens Redemann (OU)
- Jay Mace (U. Utah)
- Rich Ferrare (LaRC)

For More Information

- ACCP SATM:

https://vac.gsfc.nasa.gov/accp/docs/ACCP_SATM_Rel_Candidate_G.pdf

- ACCP Science Narrative:

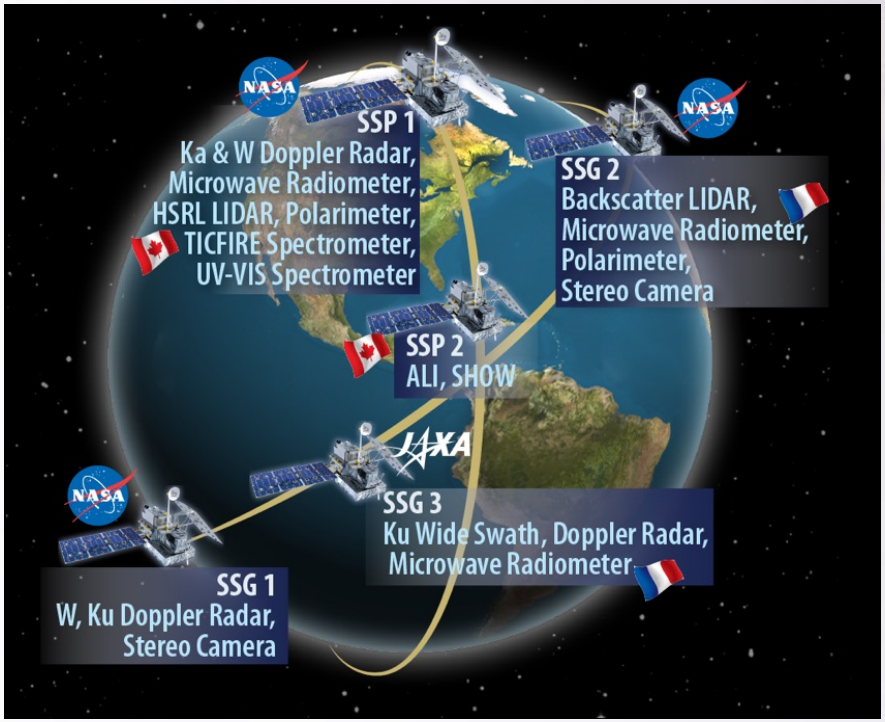
https://vac.gsfc.nasa.gov/accp/docs/ACCP_Science_Narrative-2021.07.19.pdf

- ACCP Final Architecture Recommendation Review:

https://vac.gsfc.nasa.gov/accp/docs/Architecture_Recommendation_Review.pdf

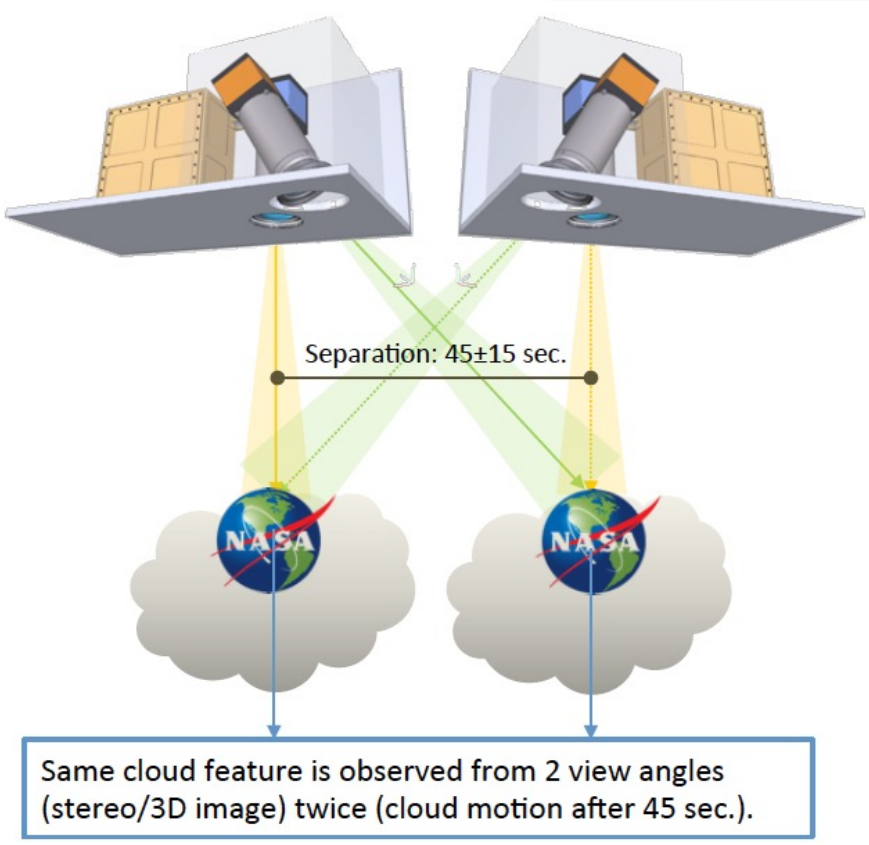
AOS Summary

- AOS is the key atmospheric part of the Earth System Observatory resulting from the Decadal Survey A & CCP designated observables
- Two-orbit design targeting sub-daily variability and climate-related processes
- Inclined and polar components to be separate projects under one AOS umbrella
- Currently in pre-Phase A (Concept phase) of mission



Extras

Time-Differenced Stereo Cameras



From R. Marchand, A. Davis, L. Forster, and M. Kurowski