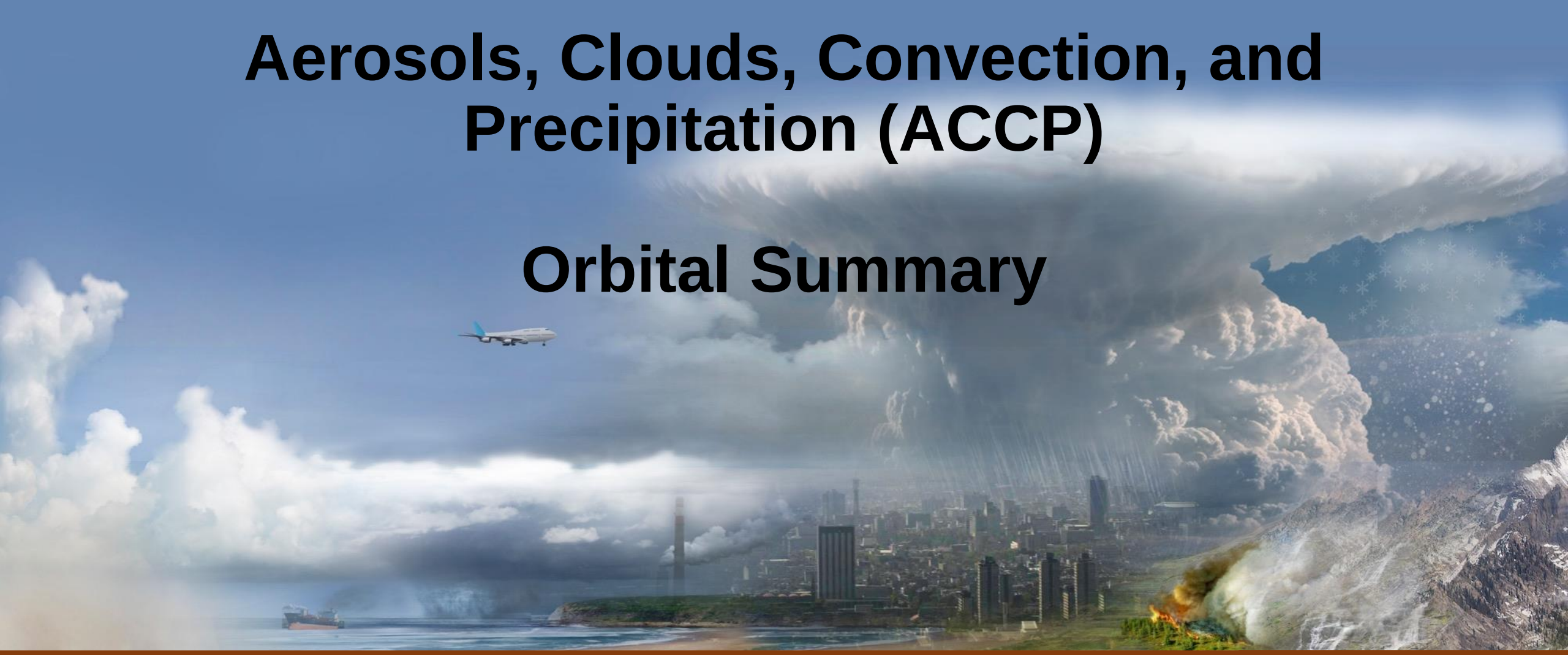
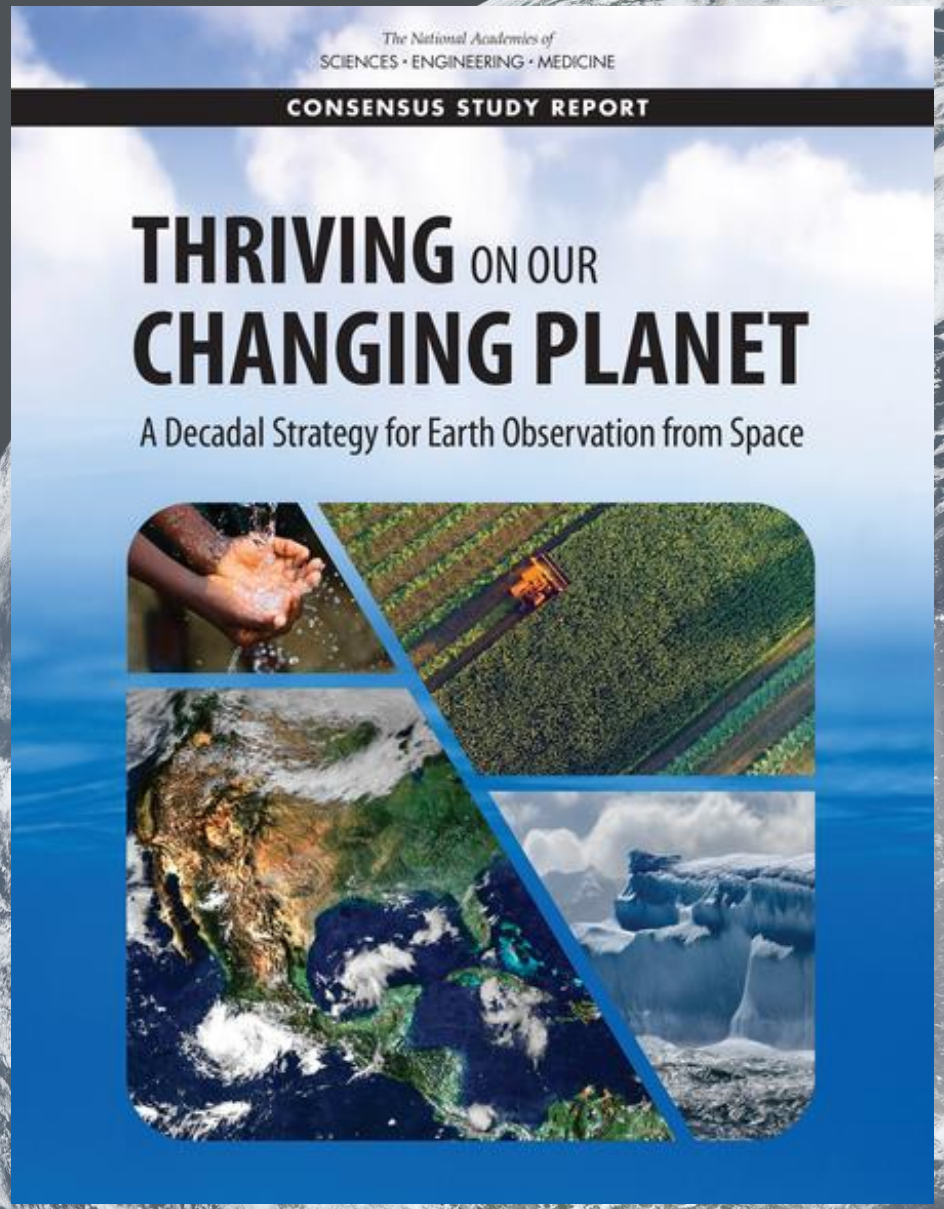
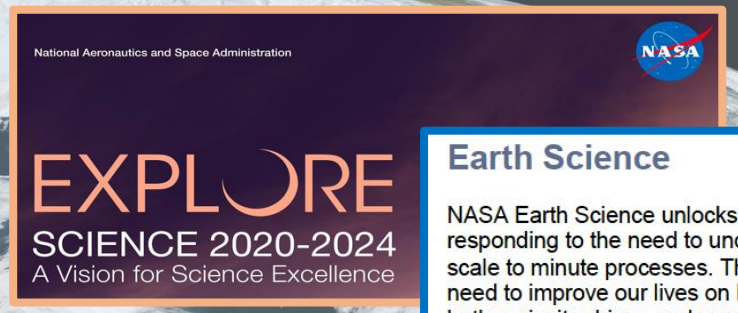
# Aerosols, Clouds, Convection, and Precipitation (ACCP)

## Orbital Summary






## 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.

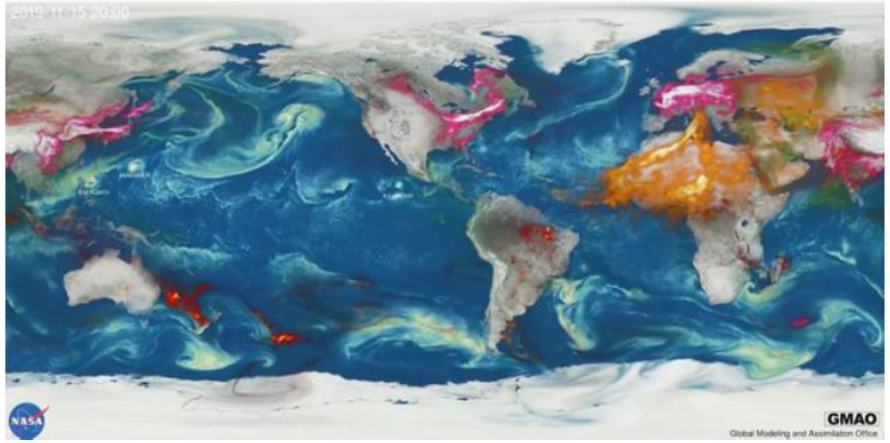



**Photo Credit:** *NASA's Goddard Space Flight Center*
NASA's Global Modeling and Assimilation Office used Earth science data gathered from multiple missions to visualize several high impact events across the globe between August 2019 and January 2020, including Hurricane Dorian (August to September 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

# Traceability to 2017 NASA Decadal Survey

| Weather & Air Quality Panel | Climate Variability and Change Panel | Hydrological Cycle Panel |
|---|---|---|
| **W-1 (MI): Planetary Boundary Layer Dynamics.** | **C-2 (MI): Climate Feedbacks and Forcings.** | **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.** | | |

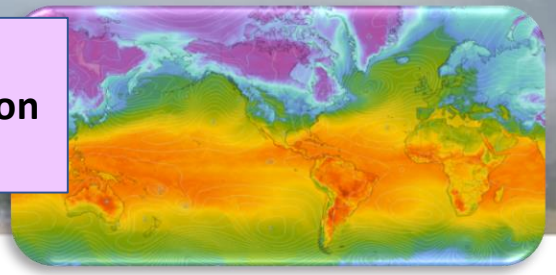
**Most Important**

**Very Important**

**Important**

# ACCP at a Glance

**Overarching Goal**
**Characterize the Role of Aerosols, Clouds, & Precipitation in Weather, Climate, and Air Quality Prediction**



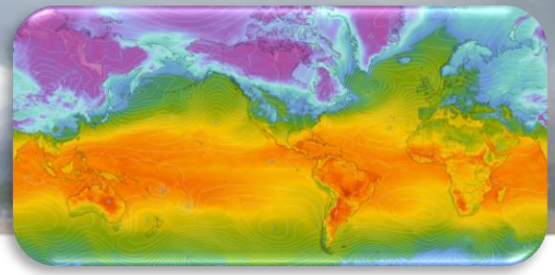
**W-4 Convective Storm Processes**

**W-5 Air Quality Processes and Distribution**

**C-2 Climate Sensitivity: Cloud Feedback, Aerosol Forcing**

DS Science Themes

# ACCP at a Glance



Condensation
Collision/Coalescence
Riming/Freezing
Precipitation


Emissions
Humidification
(Chemical Transformations)

Nucleation, Condensation
Collision/Coalescence
Precipitation

Radiative Heating
Nucleation

Wet Removal
Redistribution

Nucleation

Wet Removal
Redistribution

**W-4 Convective Storm Processes**

**W-5 Air Quality Processes and Distribution**

**C-2 Climate Sensitivity: Cloud Feedback, Aerosol Forcing**

Small Scale Processes

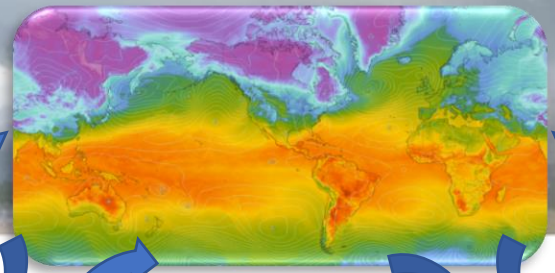
DS Science Questions

# ACCP at a Glance

Large Scale Processes

Small Scale Processes

DS Science Questions



Circulation
Vertical Transport
Detrainment

Large-scale Control

Global
Air-quality

Large-scale
Transport

Cloud & Aerosol
Radiative Effects
on Circulation

Large-scale control

Condensation
Collision/Coalescence
Riming/Freezing
Precipitation

Emissions
Humidification
(Chemical Transformations)

Nucleation, Condensation
Collision/Coalescence
Precipitation

Radiative Heating
Nucleation

Wet Removal
Redistribution

Nucleation

Wet Removal
Redistribution

**W-4 Convective Storm Processes**

**W-5 Air Quality Processes and Distribution**

**C-2 Climate Sensitivity:
Cloud Feedback, Aerosol Forcing**

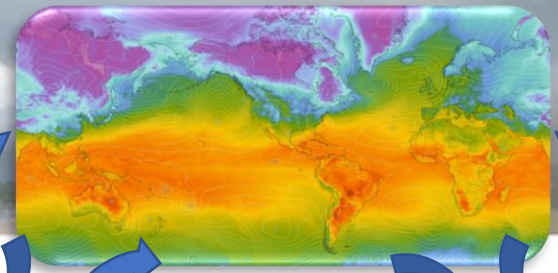
Measurement Needs

Large Scale Processes

Small Scale Processes

DS Science Questions

# ACCP at a Glance



Circulation
Vertical Transport
Detrainment

Cloud & Aerosol
Radiative Effects
on Circulation

Vertical Motion
Cloud &
Precipitation Properties
Rainfall Extremes
Latent Heating

Large-scale Control

Global
Air-quality

Large-scale
Transport

Large-scale control

Aerosol Properties
Cloud/Precipitation Properties
Radiative Fluxes

Aerosol Microphysical
and Radiative Properties

Condensation
Collision/Coalescence
Riming/Freezing
Precipitation

Emissions
Humidification
(Chemical Transformations)

Nucleation, Condensation
Collision/Coalescence
Precipitation

Radiative Heating
Nucleation

Wet Removal
Redistribution

Nucleation

Wet Removal
Redistribution

**W-4 Convective Storm Processes**

**W-5 Air Quality Processes and Distribution**

**C-2 Climate Sensitivity: Cloud Feedback, Aerosol Forcing**

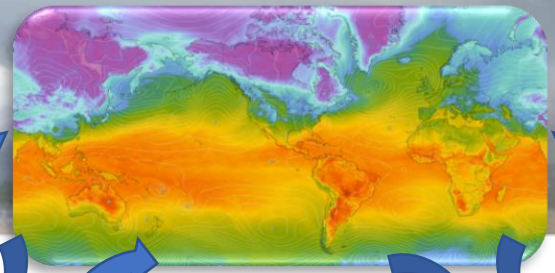
# ACCP at a Glance

Measurement Needs

Large Scale Processes

Small Scale Processes

DS Science Questions



Circulation
Vertical Transport
Detrainment

Cloud & Aerosol
Radiative Effects
on Circulation

Vertical Motion
Cloud &
Precipitation Properties
Rainfall Extremes
Latent Heating

Large-scale Control

Global
Air-quality

Large-scale
Transport

Large-scale control

Aerosol Properties
Cloud/Precipitation Properties
Radiative Fluxes

Aerosol Microphysical
and Radiative Properties

Condensation
Collision/Coalescence
Riming/Freezing
Precipitation

Emissions
Humidification
(Chemical Transformations)

Nucleation, Condensation
Collision/Coalescence
Precipitation

Radiative Heating
Nucleation

Wet Removal
Redistribution

Nucleation

Wet Removal
Redistribution

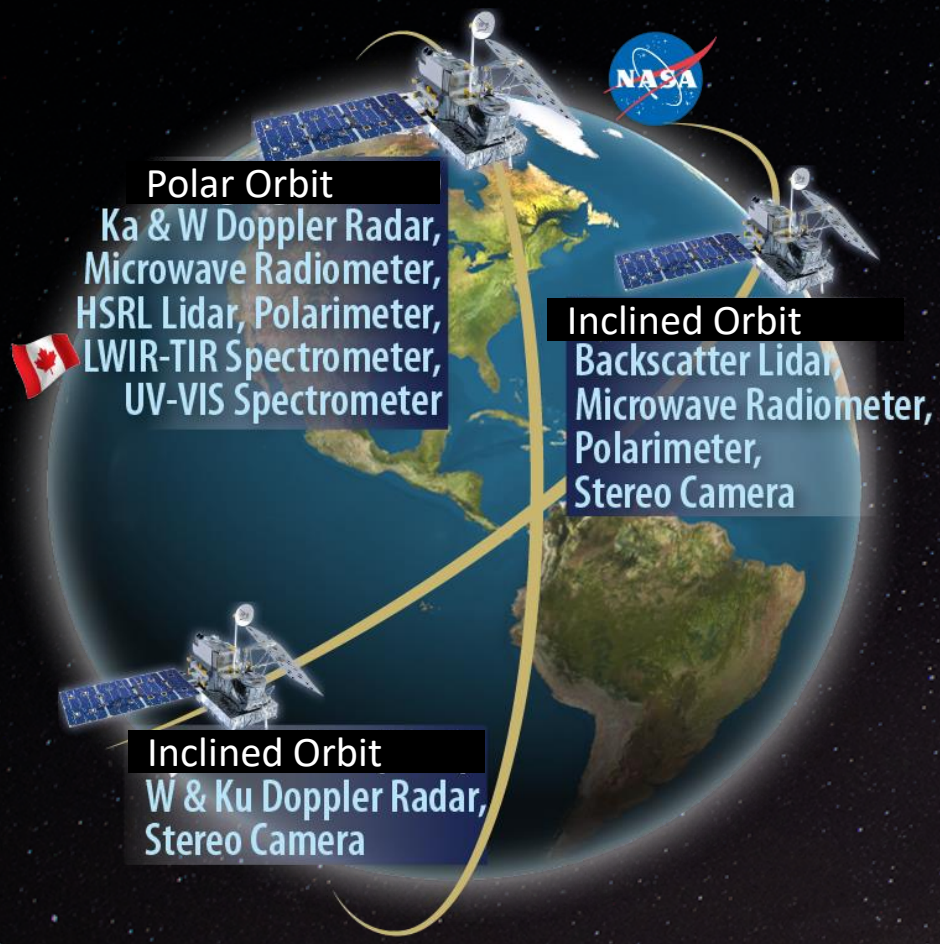
**W-4 Convective Storm Processes**

**W-5 Air Quality Processes and Distribution**

**C-2 Climate Sensitivity:
Cloud Feedback, Aerosol Forcing**

second minute hour day week month year century

# Architecture Recommendation—Dual Orbit Constellation




Inclined Orbit
- W-, Ku-band Doppler radar
- Microwave radiometer (118-880 GHz)
- 532 and 1064 nm backscatter lidar
- Polarimeter (> 5 angles, > 6 channels)
- Time-differenced tandem stereo camera

Polar Orbit
- W- & Ka-band Doppler radar
- Microwave radiometer (118-880 GHz)
- 532 nm HSRL, 1064 nm backscatter lidar
- Polarimeter (550 km swath, 0.5 km resolution)
- Spectrometers (UV-VIS-NIR-SWIR, LWIR-FIR)

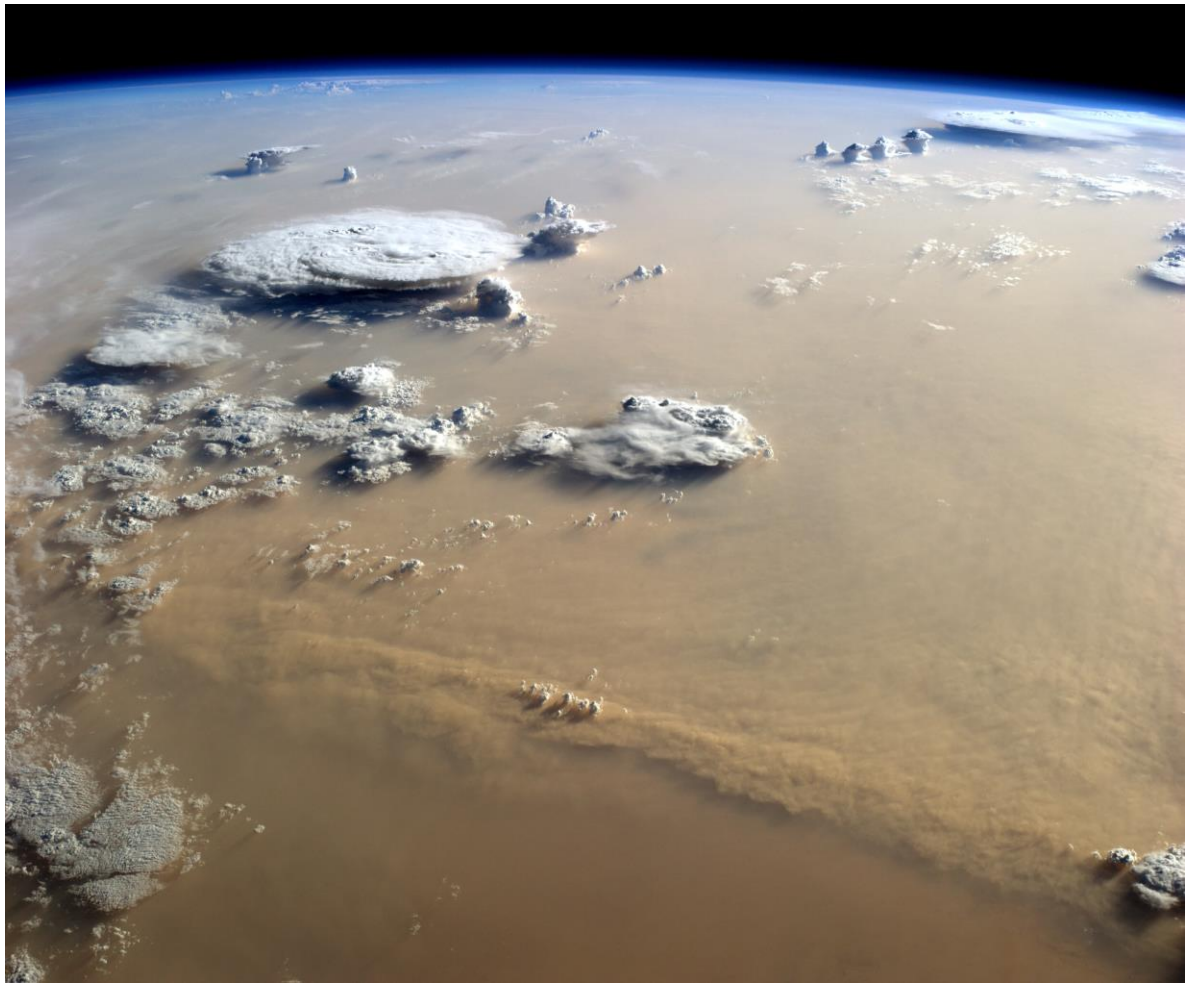
→ LWIR-FIR Spec. contributed by CSA

*1st launch of inclined orbit ~2028*

*2nd launch of polar orbit ~2029-30*

# The 5 “First-Evers” of ACCP

1. Global Observations of Convective Vertical Motion
2. Global Profiles of Aerosol Properties (absorption, type, size, number)
3. Co-located Dynamics, Cloud AND Precipitation Microphysics and Aerosol Characteristics
4. Low Cloud and Aerosol Plume Dynamics
5. Diurnal Variability of Clouds and Aerosols

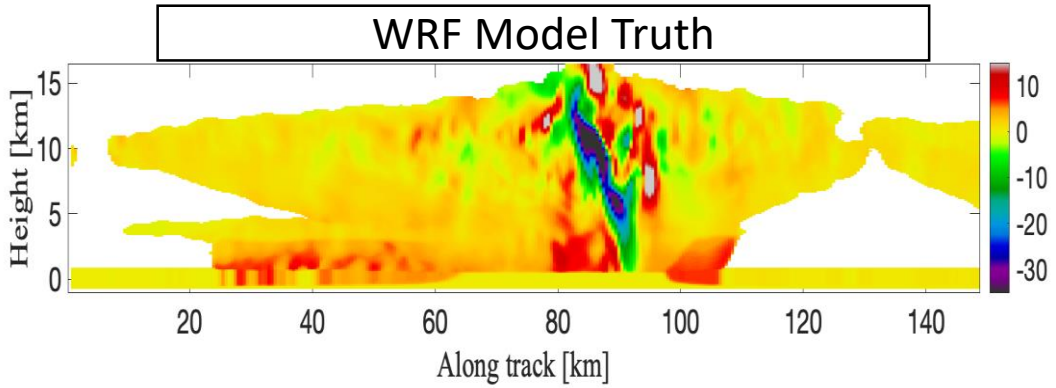


# Doppler Capabilities

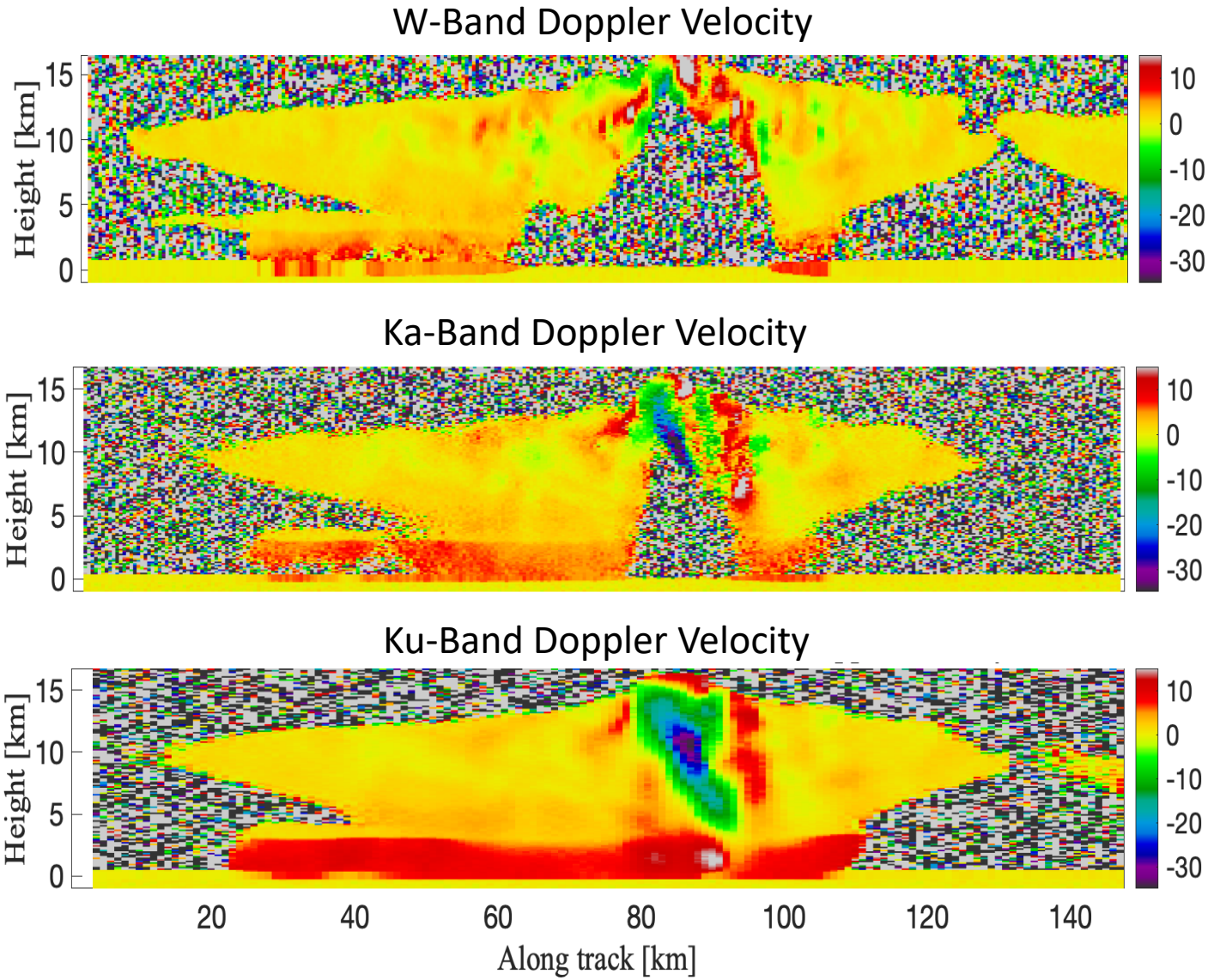
Next generation Doppler technology

Polar: WD, KaD band with dual antennas (displaced phase center antenna)

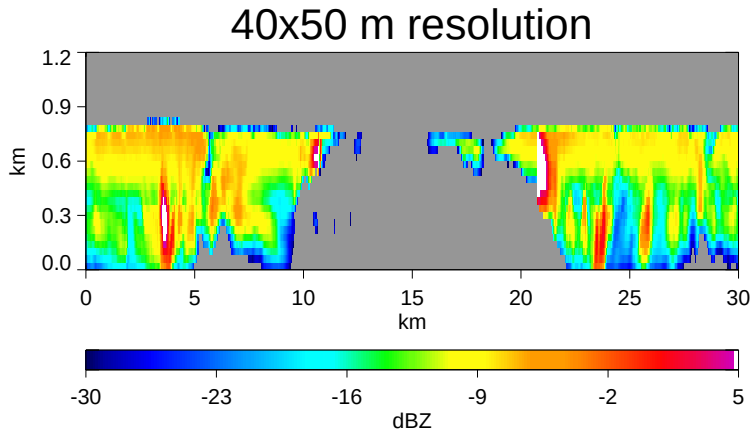
Inclined: W (single antenna), KuD (DPCA)

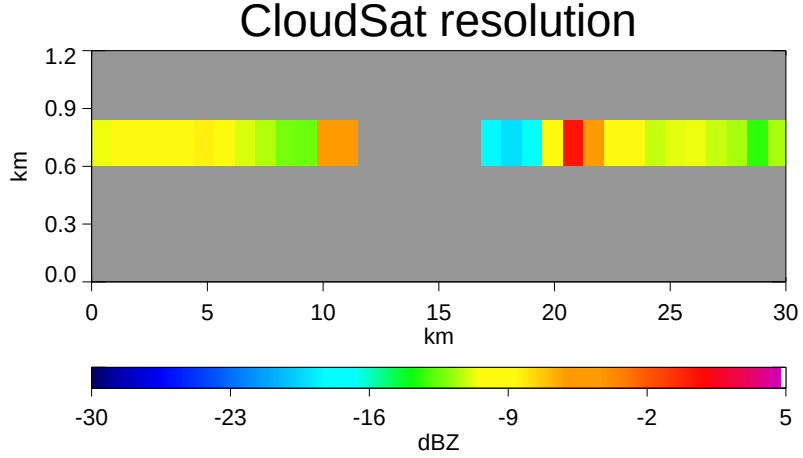


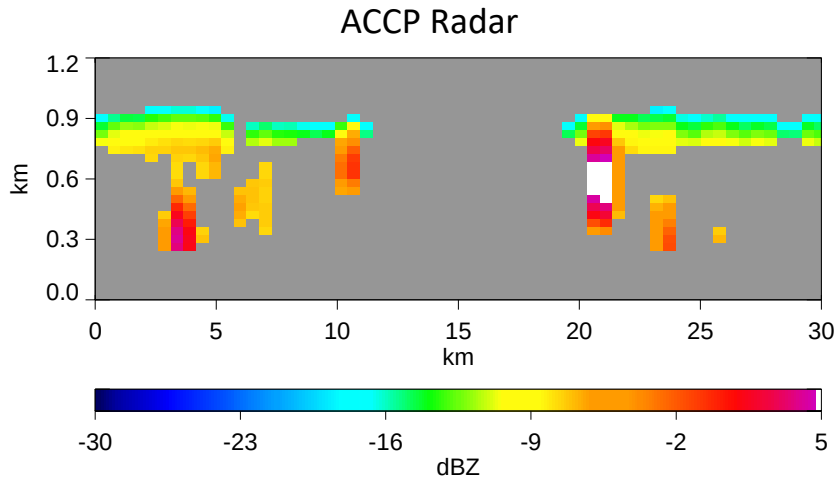

Radar simulations performed by Pavlos Kollias



# Radar: Profiling Near-Surface Precipitation

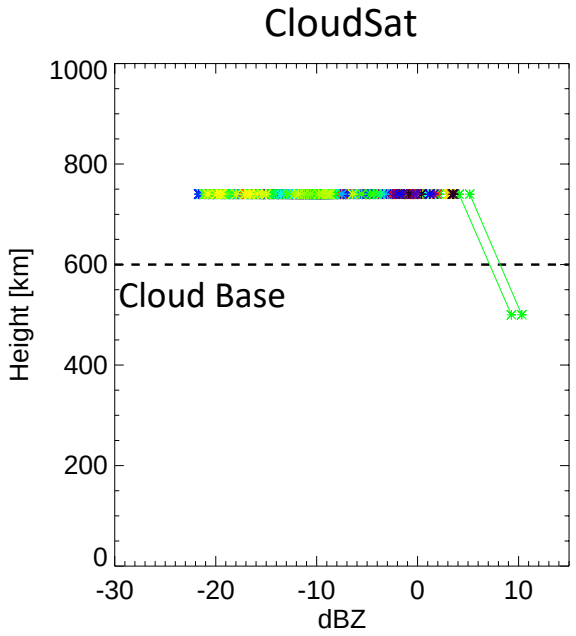


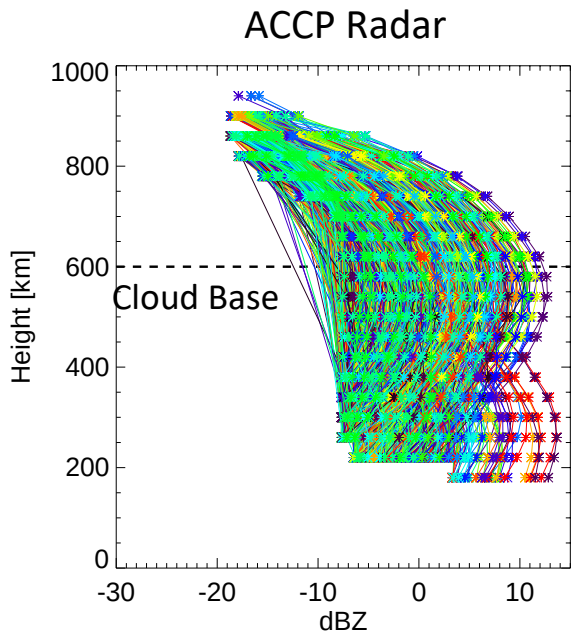




Simulation of CloudSat and candidate A/CCP radar sampling for a DYCOMS-II RF02

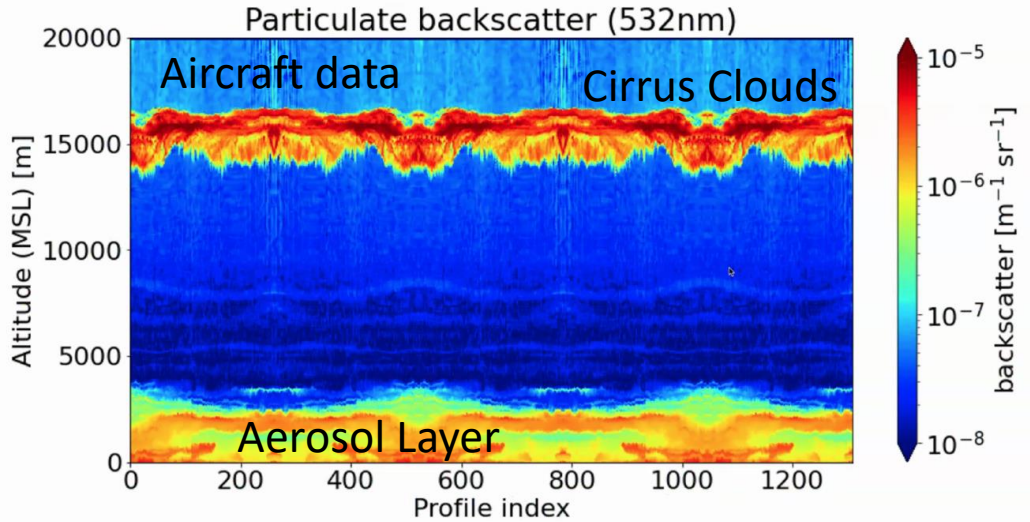
Sacrificing detection sensitivity to achieve higher resolution improves near surface profiling



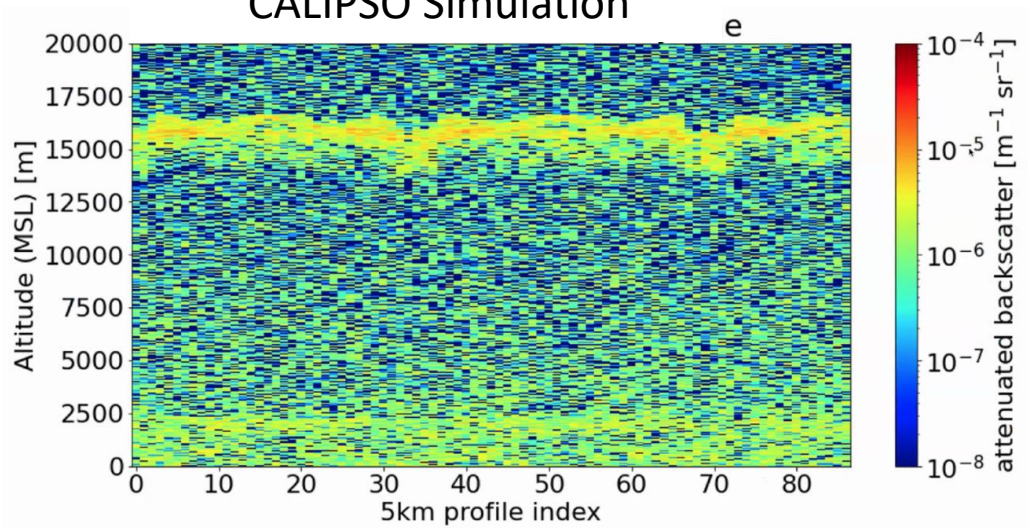




Courtesy of Matt Lebsock

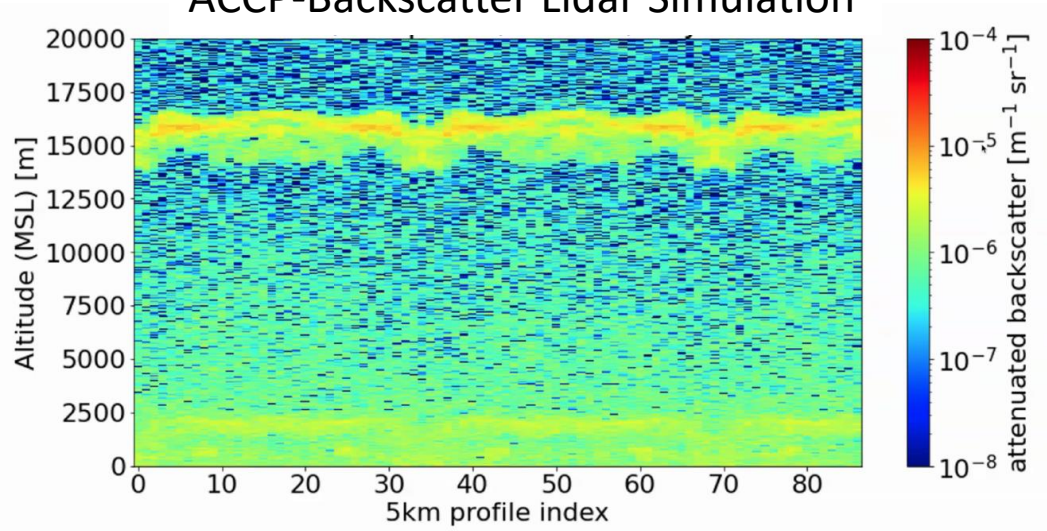
# Lidar Capabilities (Daytime)



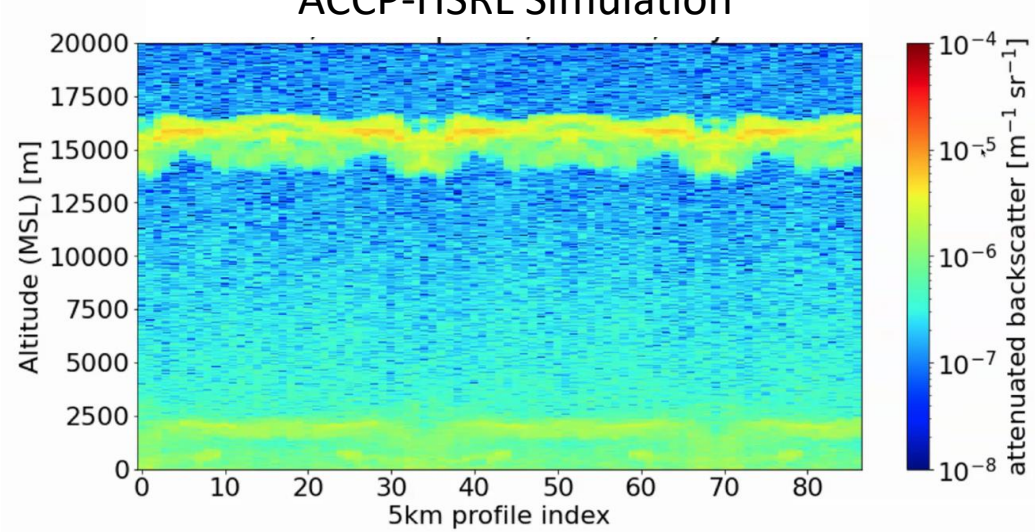

CALIPSO Simulation




ACCP-Backscatter Lidar Simulation

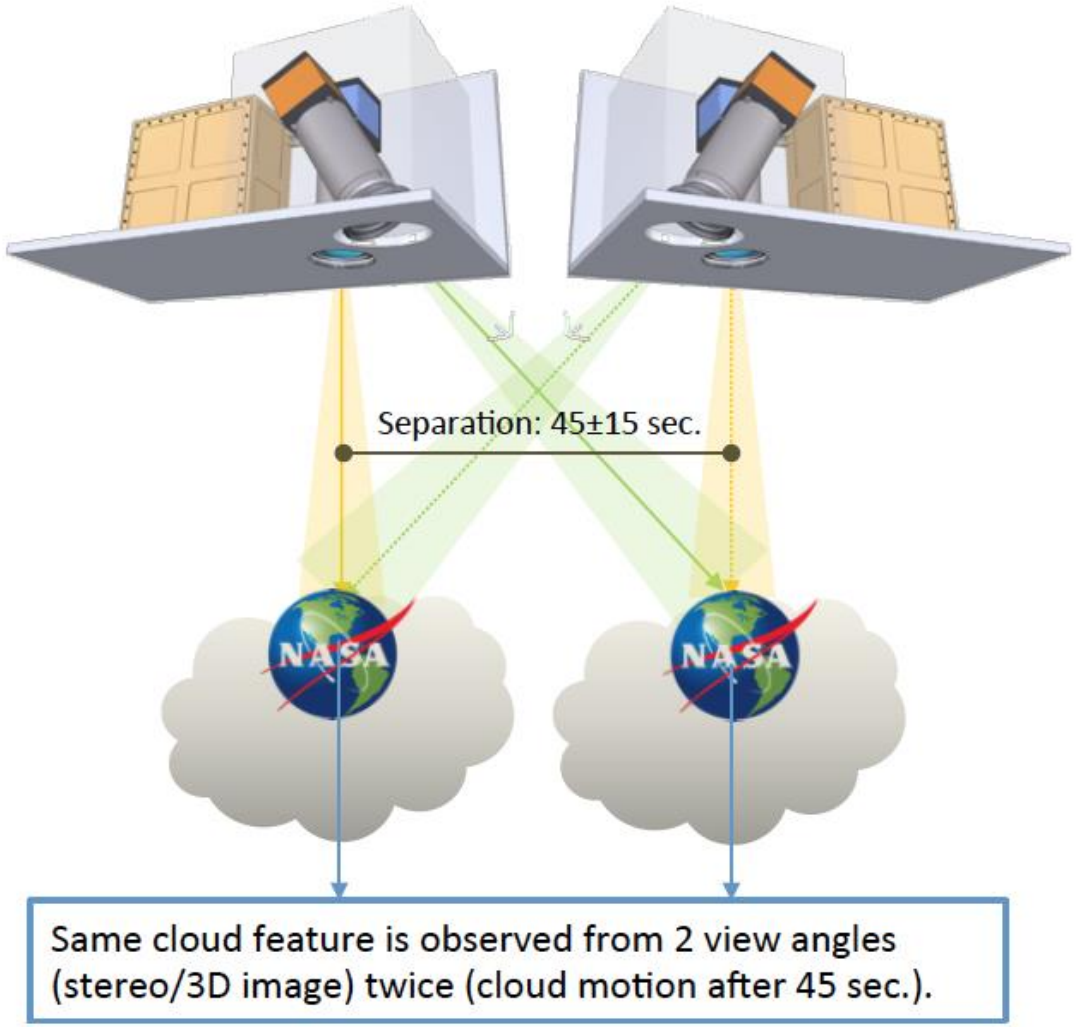



ACCP-HSRL Simulation

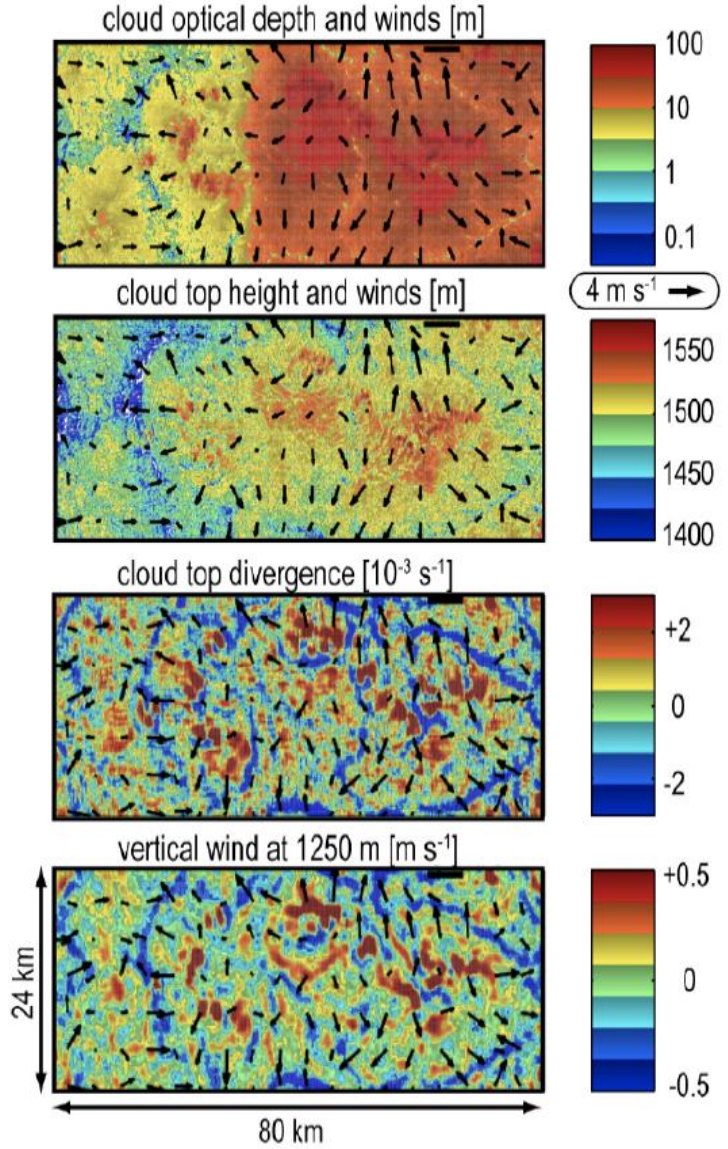



Simulations produced by ACCP Lidar Working Group

# Motion Field from Tandem Stereo Cameras




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




From time-differenced cloud-top measurements (40 meter footprint, 100 km swath):

Horizontal wind field

Horizontal divergence field

Cloud-top vertical motions

# Summary

- ACCP study initiated in 2018 with involvement of 5 NASA centers + academia
  - JAXA, CNES, CSA, and DLR also participated in the study
- Study concluded in April 2021
  - > 15 architecture concepts studied in some detail
  - Top 3 architectures submitted to NASA HQ with recommendation for dual-orbit concept
- Several ACCP elements:
  - Orbital
  - Sub-orbital
  - Modeling
- ACCP is envisioned as one element of an Earth Observing system, combined with:
  - PoR (Geo-Ring, etc)
  - Surface, Biology and Geology (SBG), Mass Change, Surface Deformation