

National Aeronautics and
Space Administration



**EARTH
SYSTEM**
OBSERVATORY

Overview of the Earth System Observatory—Atmosphere Observing System (AOS)

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Current concept achieves Aerosol and CCP science

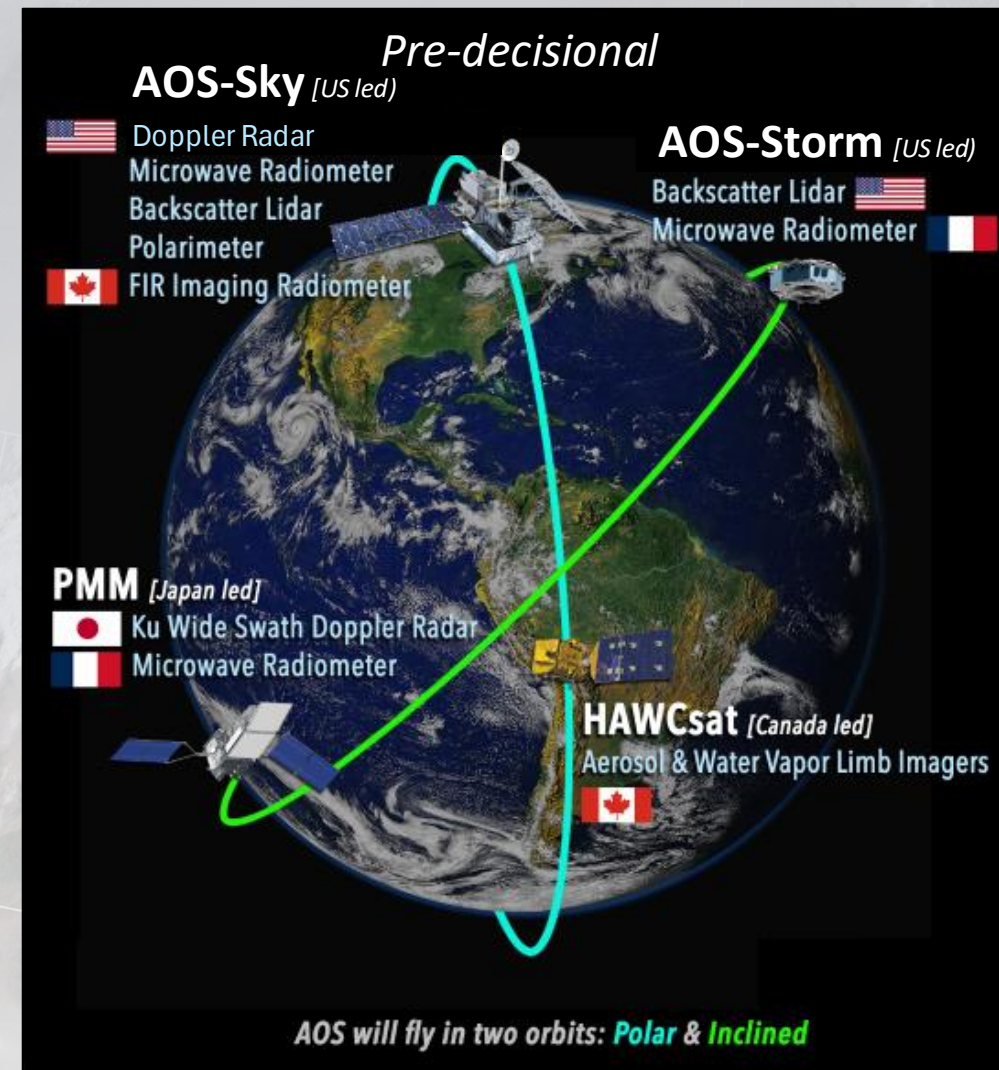
- Delivers globally distributed measurements over a range of temporal scales
- Complemented by sub-orbital element (e.g., science & cal/val)

AOS-Sky satellite represents Decadal Survey Minimum candidate architecture

- Conducting Pre-formulation study with ASI on a lidar separate from AOS-Sky
- CSA HAWCsat adds information on aerosol and moisture profiles

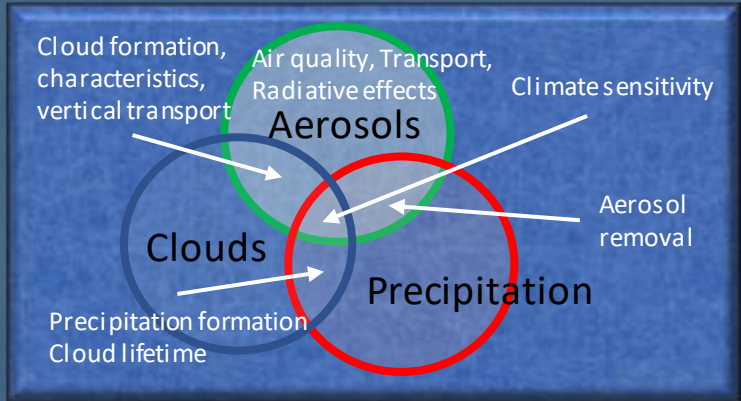
Generous contributions from JAXA and CNES enable critical science over varying times of day

- Addresses DS stated importance of diurnally varying measurements for CCP
- Provides continuity with TRMM/GPM with Doppler capability and new time-differenced radiometer measurements
- U.S. backscatter lidar adds aerosol and cloud detection as well as PBL height information



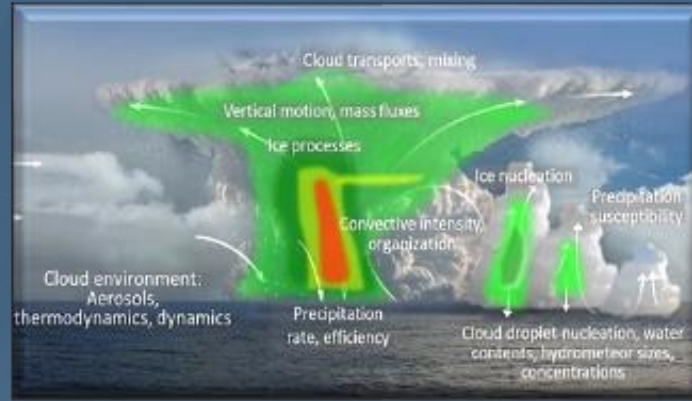
Graphic reflects initial architecture concept directed at KDP-A. Additional direction was provided to study architecture changes, which are still on-going.

AOS's Focus on Three DS Themes



1. CLIMATE: How can we improve our ability to predict local and regional climate response to natural and anthropogenic forcings and reduce the uncertainty in global climate sensitivity?

Requires global coverage, particularly of rapidly changing polar regions → necessitates polar sun-synchronous orbit



2. CONVECTION: Why do convective storms, heavy precipitation, and clouds occur exactly when and where they do? How do microphysical properties relate to storm dynamics?

Requires sampling at varying times of day for convection → necessitates an inclined precessing orbit



3. AEROSOLS: What processes determine the spatio-temporal structure of important air pollutants and their concomitant adverse impacts on human health, agriculture, and ecosystems?

Emphasis on global observations but can benefit from varying-time-of-day measurements

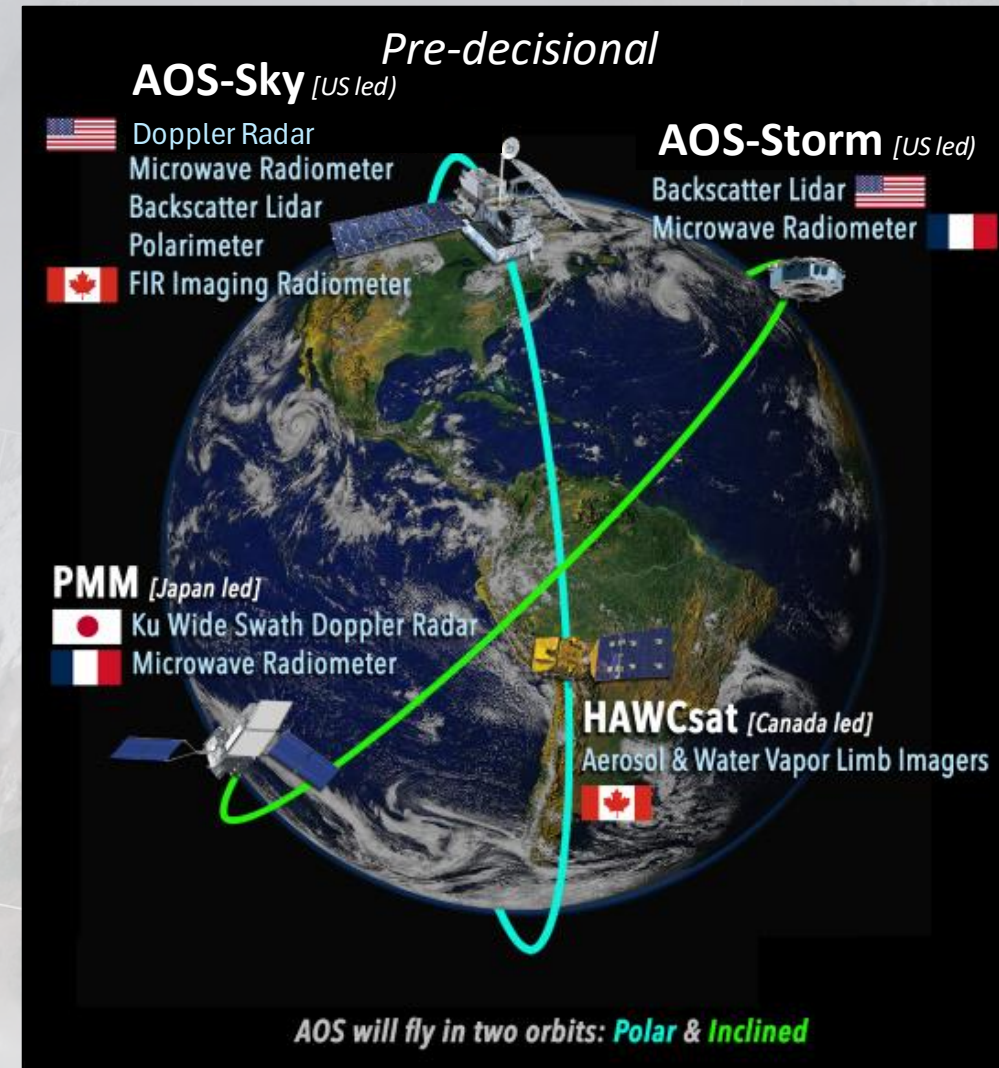
Next slides:

- **AOS-Storm Capabilities**

- JAXA PMM Radar (T. Kubota presentation)
- CNES C2OMODO tandem radiometers
- ALICAT backscatter lidar

- **AOS-Sky Capabilities**

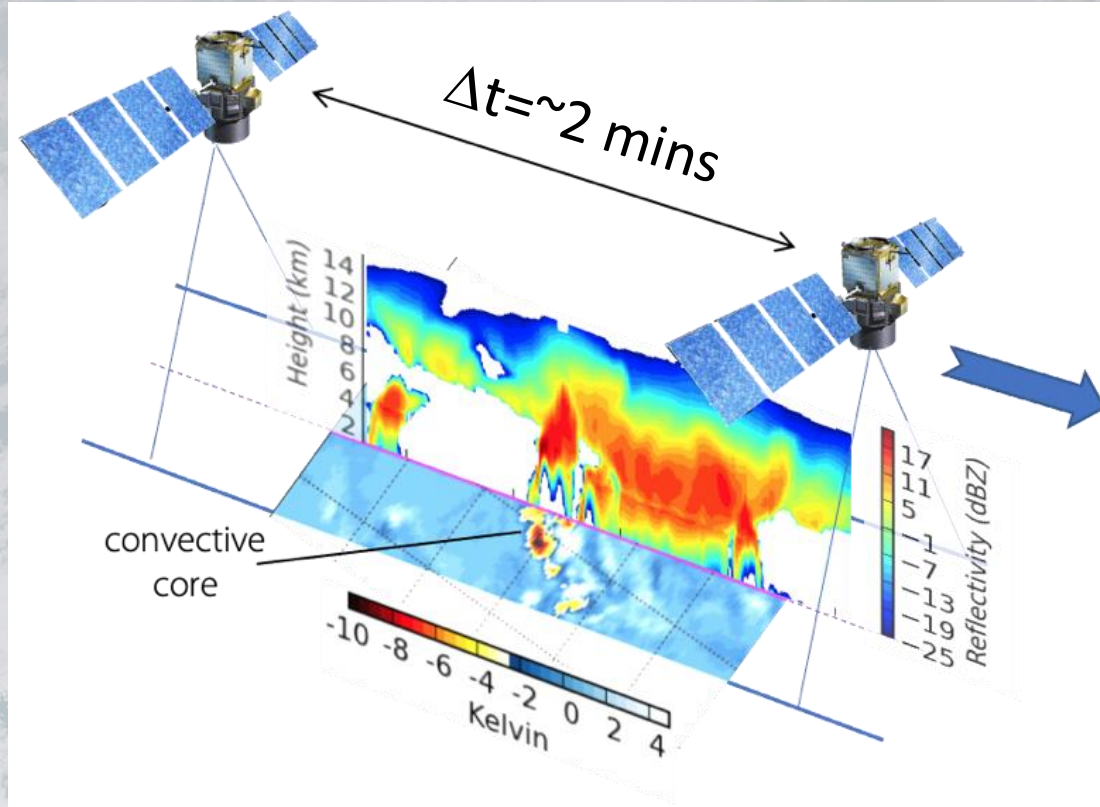
- Backscatter lidar
- Doppler radar
- Passive microwave radiometer
- Polarimeter
- CSA Thin Ice Cloud Imaging Radiometer and aerosol and moisture limb imagers



Graphic reflects initial architecture concept directed at KDP-A. Additional direction was provided to study architecture changes, which are still on-going.

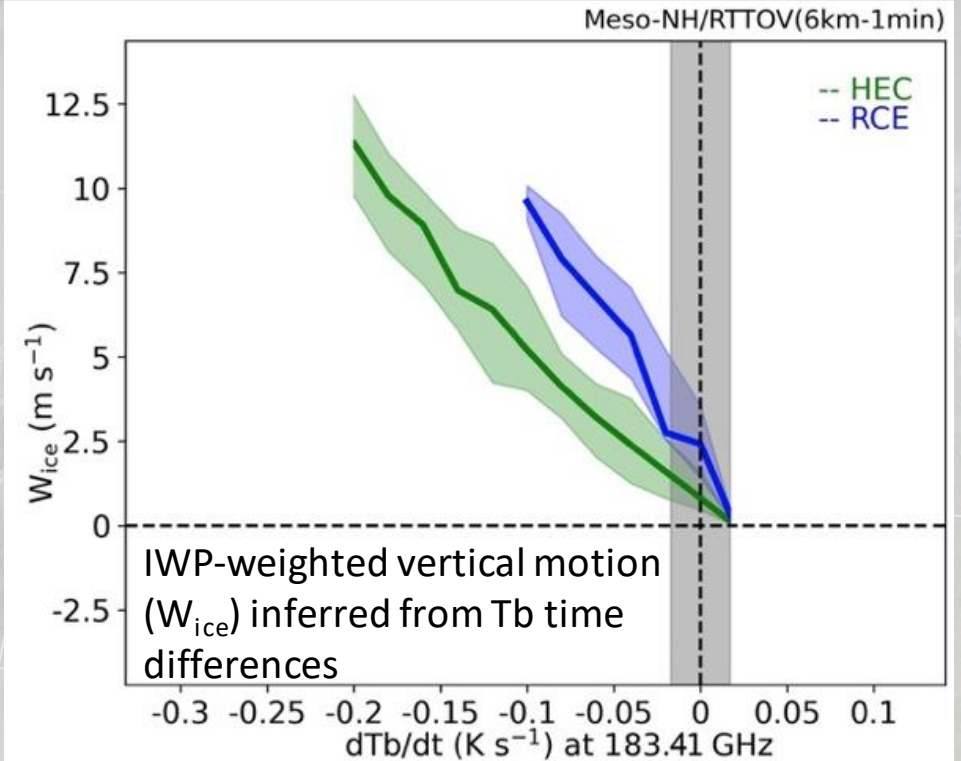
CNES C2OMODO Contribution

CNES C2OMODO Mission Concept (Brogniez et al. 2022)



C2OMODO: Convective Core Observations through MicrOwave Derivatives in the trOpics

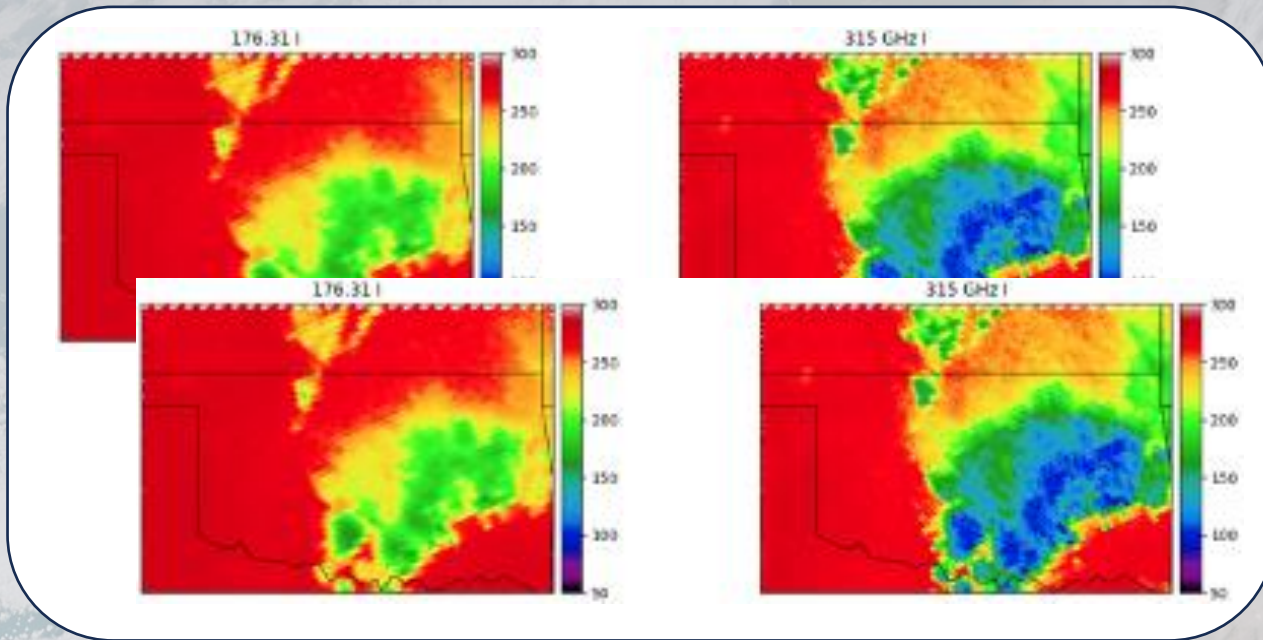
Time-differenced radiometer measurements contain information on convective vertical motions



Results from simulations of two convective systems: Overland “Hector” storms and oceanic convection in radiative-convective equilibrium

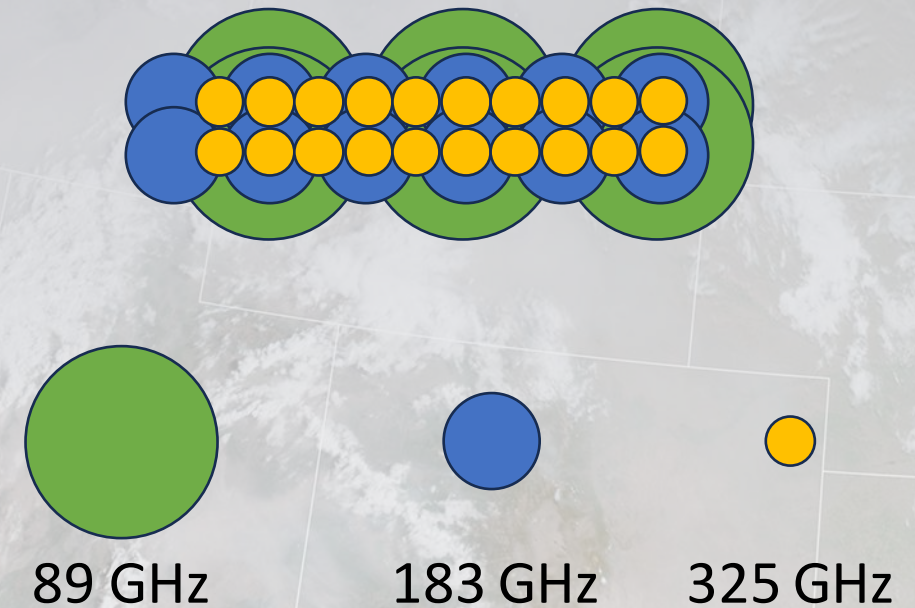
C2OMODO Radiometer Capabilities

CNES Microwave Radiometers (89, 183, 325 GHz)



89 GHz	10 km FOV	1 channel	Nyquist sampling
183.31 GHz	5 km FOV	6 channels	Nyquist sampling
325.15 GHz	3 km FOV	3 channels	Continuous sampling

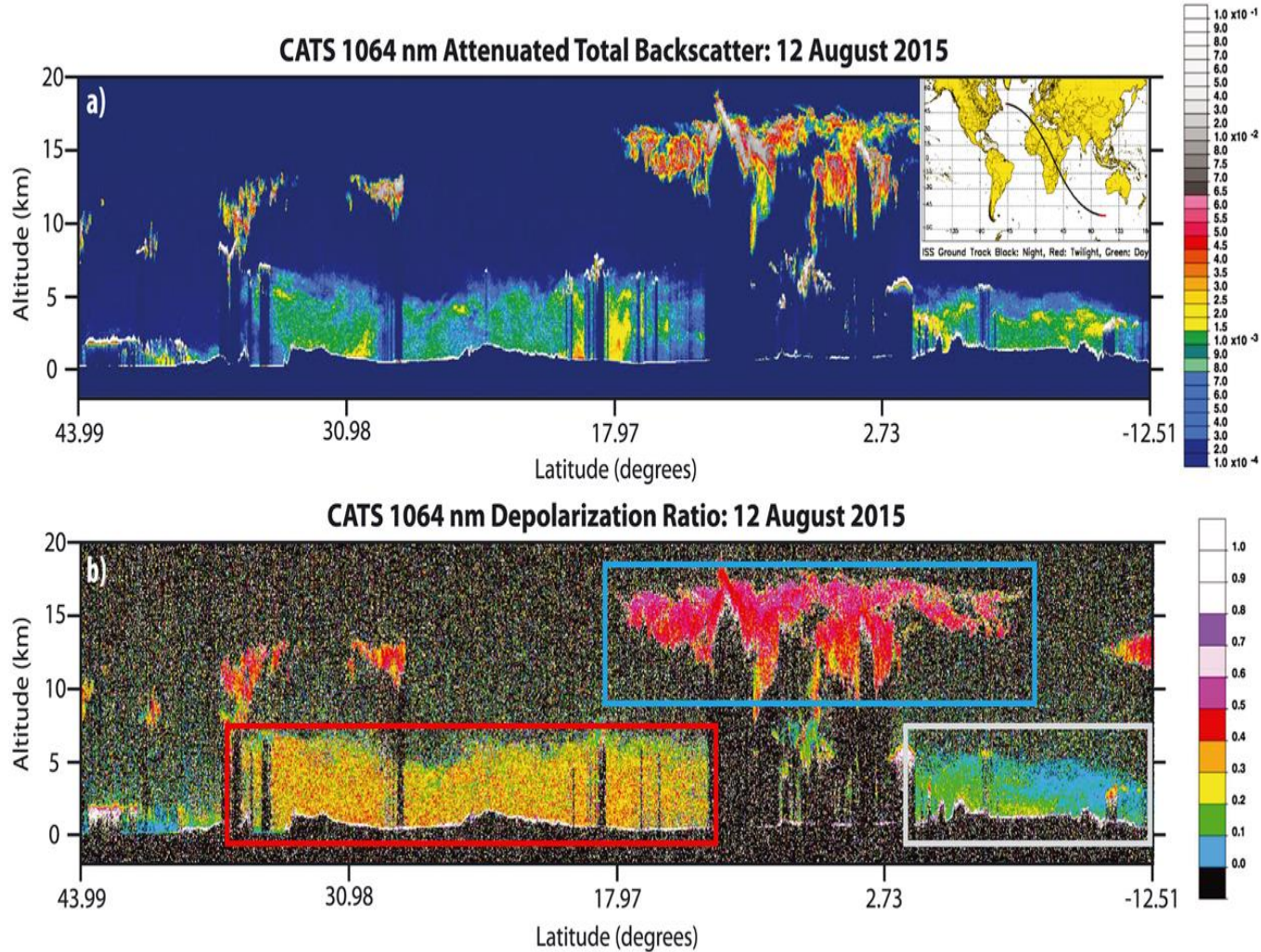
CNES Radiometer Scan Pattern Near Nadir



Common swath across all channels > 720 km

ALICAT Lidar Capabilities

CATS Backscatter Lidar Example



ALICAT: Atmospheric Lidar for Cloud and Aerosol Transport

Low pulse energy, high pulse repetition frequency

Frequencies: 532, 1064 nm

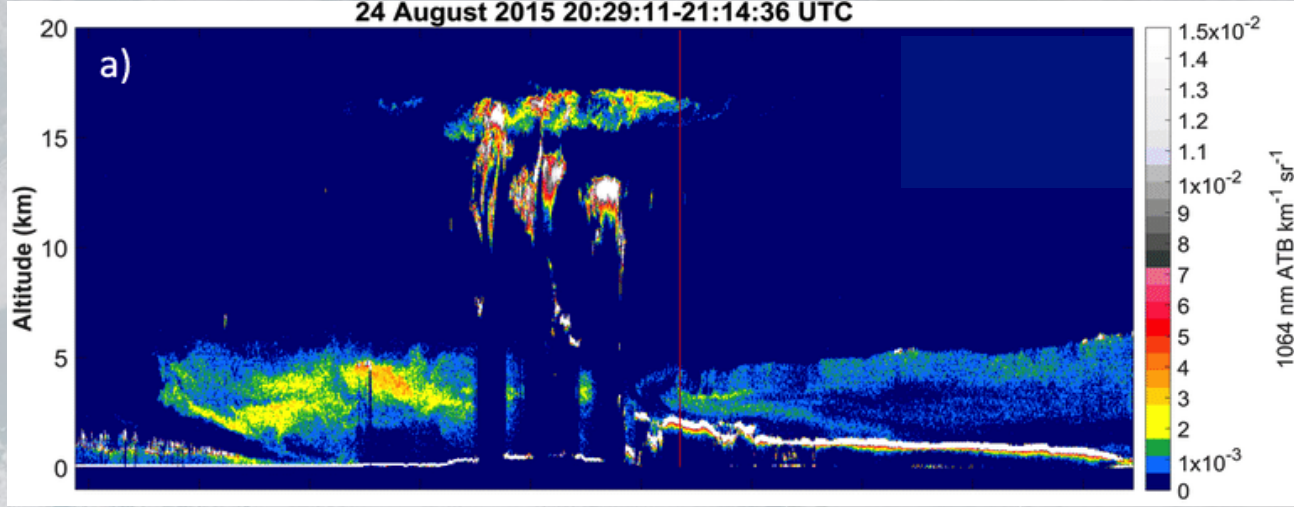
Provides total attenuated backscatter and depolarization at both frequencies

Heritage: Cloud Physics Lidar, Cloud-Aerosol Transport System (CATS)

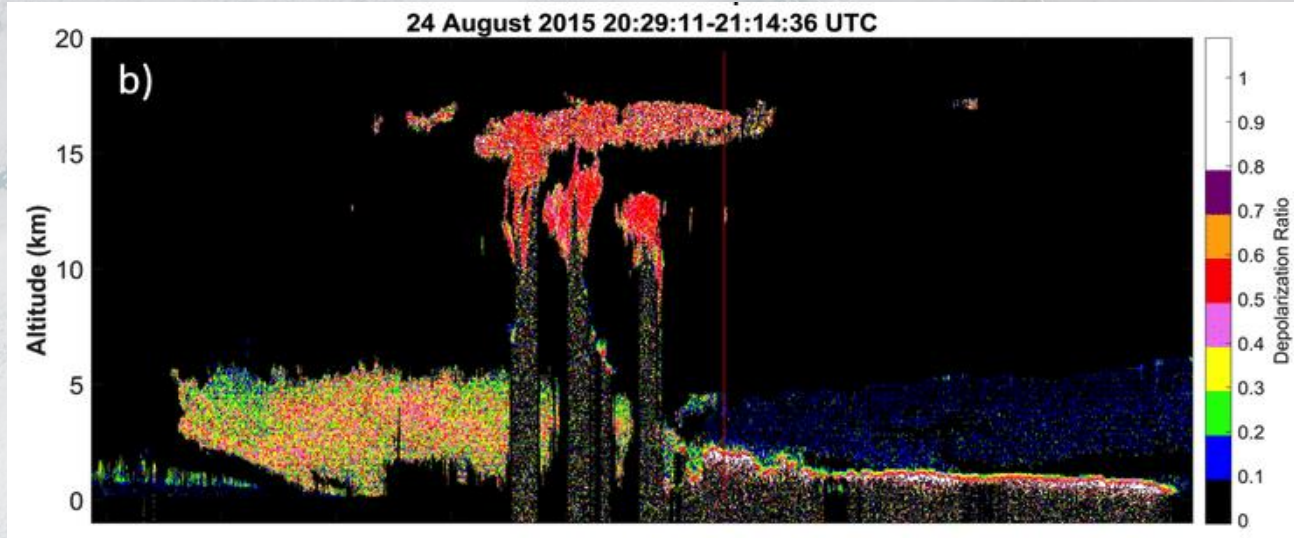
AOS-Sky Lidar

532 nm, 1064 Backscatter Lidar

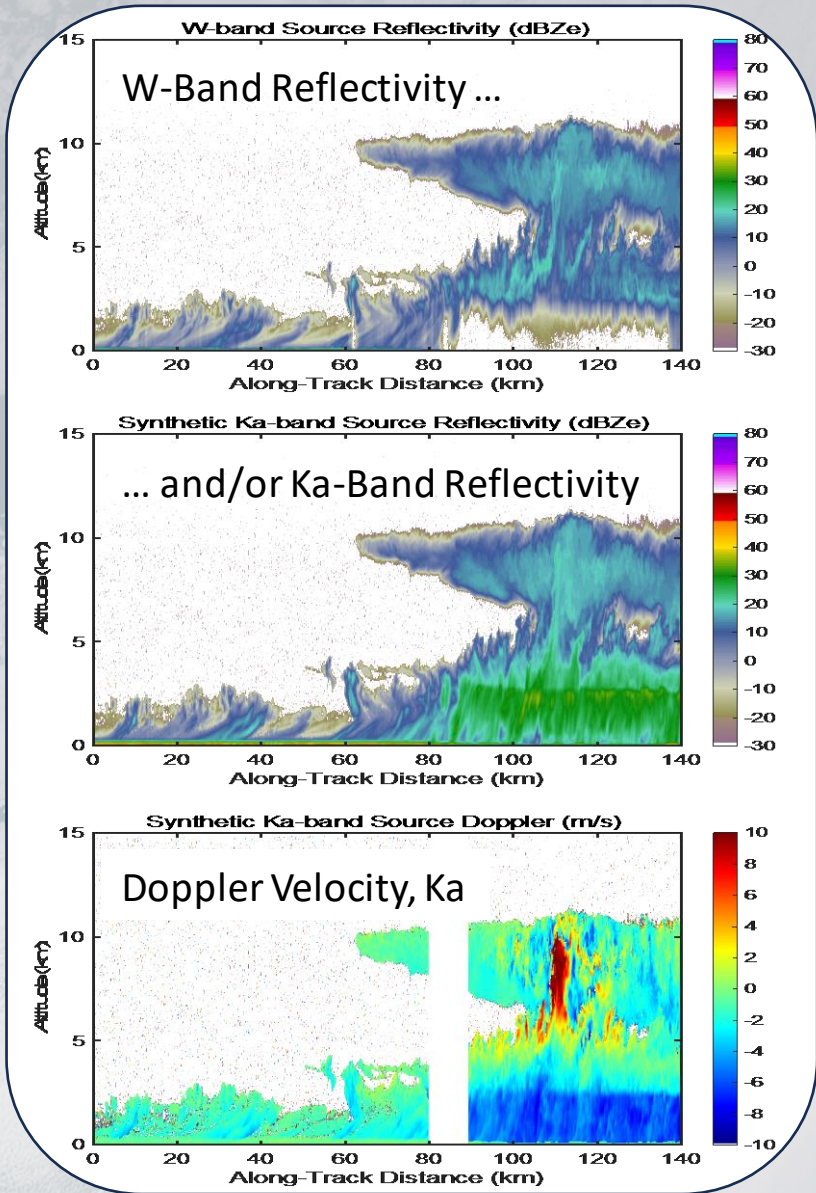
24 August 2015 20:29:11-21:14:36 UTC



24 August 2015 20:29:11-21:14:36 UTC



- Target requirement of daytime SNR equivalent to CALIPSO night SNR
- HQ has initiated study of partnership with Italian Space Agency (ASI)
 - 355, 532, 1064 nm
 - Raman channels at 355 nm provide extinction
- Requires formation flying of AOS-Sky and ASI lidar
- Substantial savings that better position AOS for success



Baseline Requirements

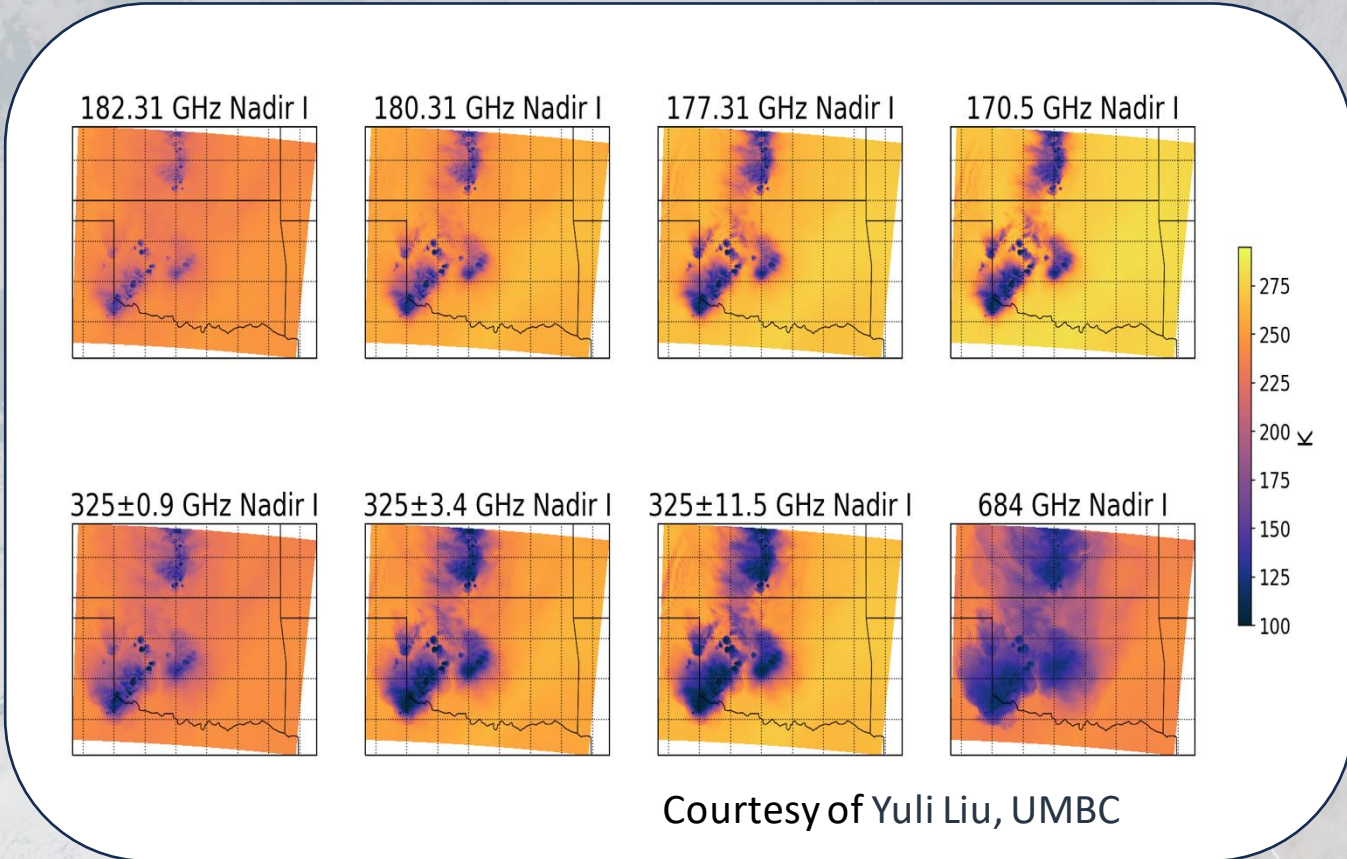
Quantity	Resolution @ altitude	Accuracy	Sensitivity @ altitude
Radar reflectivity, cloud-profiling	Horiz.: 2.0 km Vert.: 300 m @ 0.5 – 1.0 km 300 m @ 1.0 - 2.5 km 500 m @ 2.5 – 6 km 500 m @ 6 – 20 km	1.5 dB *	≤-5 dBZ @ 0.5 km – 1 km ≤-15 dBZ @ 1 km – 2.5 km ≤-20 dBZ @ 2.5 km – 6 km ≤-24 dBZ @ 6 km – 20 km

- KDP-A: Examine radar trades with industry with capabilities meeting Decadal Survey threshold requirements
- Currently conducting trades with 2 vendors
- Enhancements to be studied: Second frequency, narrow swath, passive measurements if Ka band, LDR

Courtesy of Matt McLinden

AOS-Sky Radiometer Requirements

Microwave Radiometer: 89-700 GHz

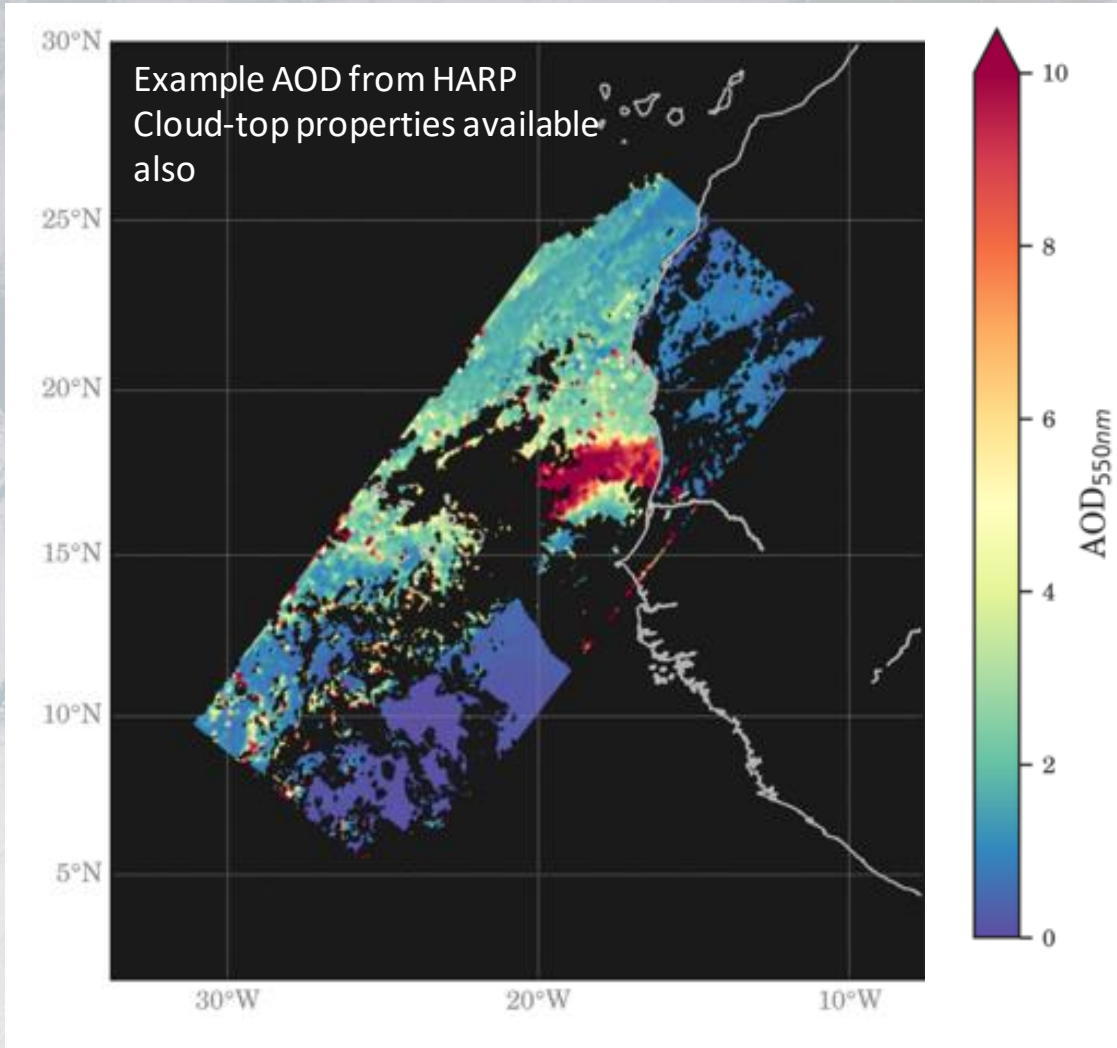


Baseline Requirements

Bands (# Channels)	Accuracy (K)	Polarization
89-113 GHz (1)	≤ 0.5 K	Target: Dual Minimum: Single
118 GHz (3)	≤ 0.75 K	
183.3 GHz (3)	≤ 0.75 K	Target: Dual Minimum: Single
165/205 GHz (1)	≤ 0.75 K	
310 GHz (3)	≤ 1.5 K	Target: Dual Minimum: Single
325.2 or 380.2 GHz (2)	≤ 1.5 K	
640-700 GHz (1)	≤ 1.5 K	Dual

Cross-track scanning, ≥750 km swath
 FOV ≤10 km at nadir, ≤20 km at edge of swath

UV-VIS-NIR-SWIR Multi-angle Polarimeter



Baseline Requirements

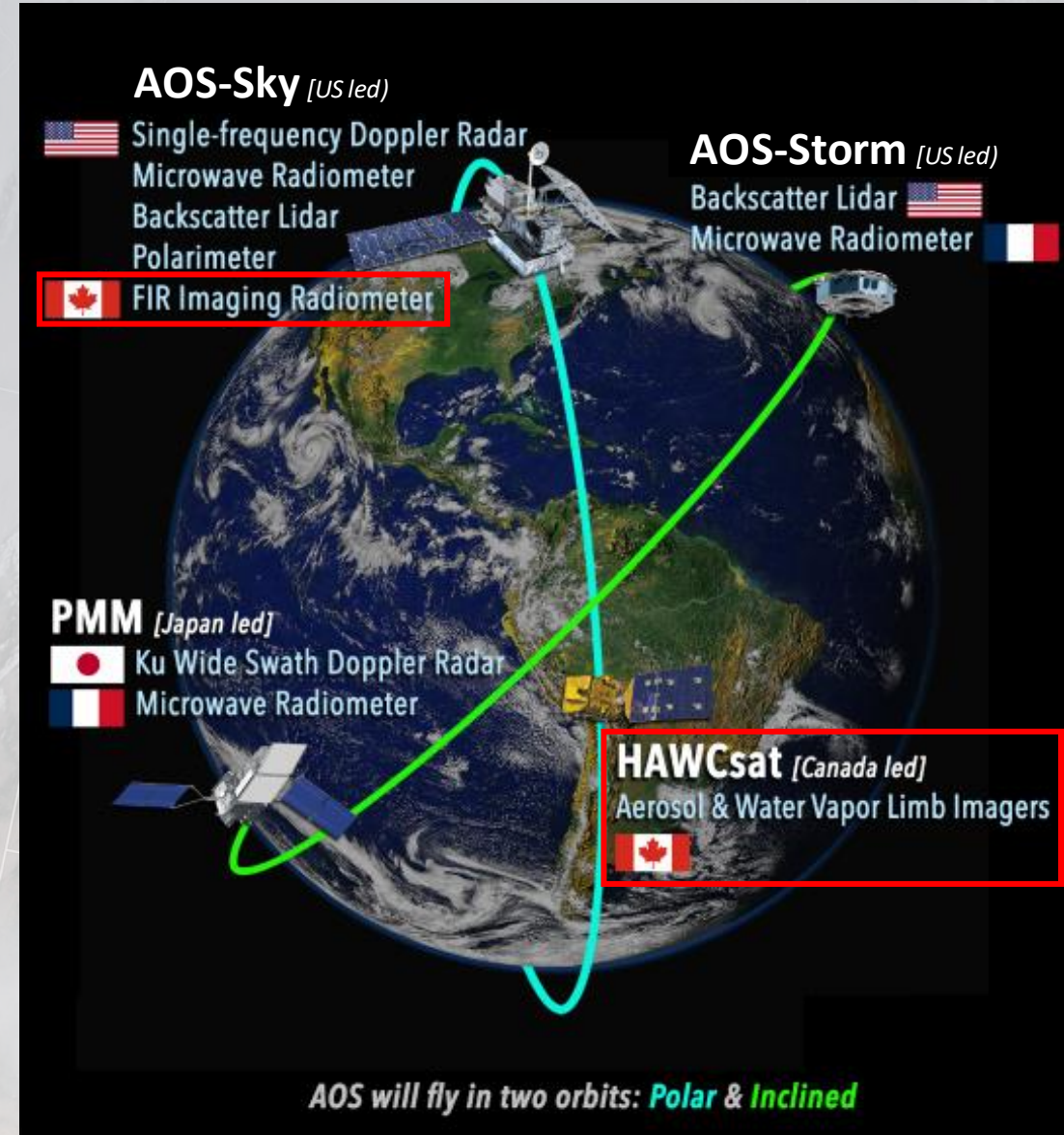
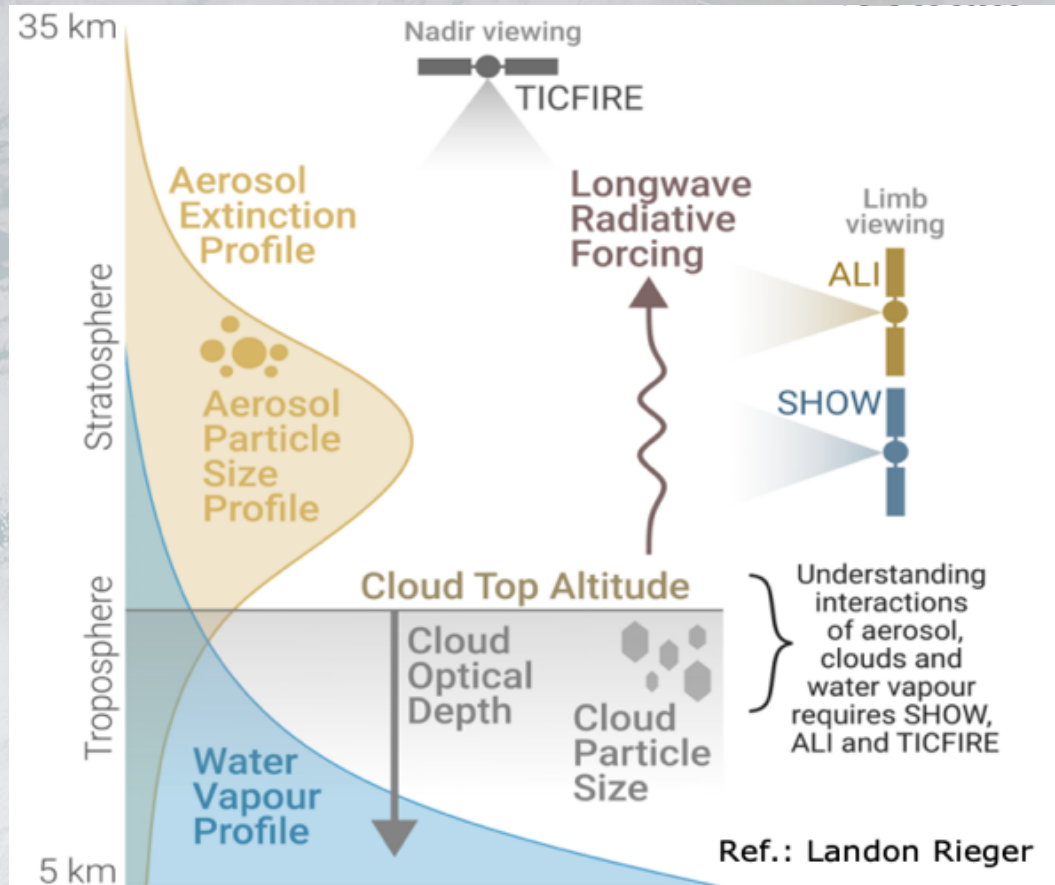
Type and/or Wavelength range (nm)	Number of spectral channels	Number of viewing angles per pixel
UV: 350 – 390 nm ¹	1	10
VIS: 410 – 750 nm	2	10
Hyperangle: 660 – 870 nm	1	60
Water Vapor: ~940nm	1	10
SWIR Cirrus: ~1380	1	10
VNIR-SWIR: 870 – 1570 nm	3	10

Swath width of 300 km
 IFOV of 0.5 km at nadir, ~0.9 km at swath edge

CSA Contributions



Canadian Space Agency Longwave-Far Infrared Imaging Radiometer (4-73 μm),
 Aerosol/Moisture Limb Sounding



AOS will fly in two orbits: **Polar** & **Inclined**

Key elements of the Earth-observing system of satellites related to atmospheric measurements are **coming to an end in the very near future.**



Polar

CloudSat/CALIPSO

earthcare Possible extended mission

AOS-Sky + HAWCsat Possible extended mission

Inclined

GPM

INCUS

PMM Possible extended mission

AOS-Storm Possible extended mission

JAXA CNES

End of GPM station keeping fuel

CSA

- AOS-Storm Working Group (Tri-lateral—NASA-JAXA-CNES)
 - When: TBD, likely monthly
 - Objective: Focus on single- and synergistic products and algorithms for AOS-Storm
 - Primary tasks:
 - Algorithm concept development
 - Product content and characteristics
 - ATBDs
 - Led on U.S. side by John Yorks (GSFC)
- AOS Town Halls at AGU Fall Meeting and AMS Annual Meeting
- System Requirements Review for AOS-Storm planned for May 2024