Atmosphere Observing System (AOS): Science Status

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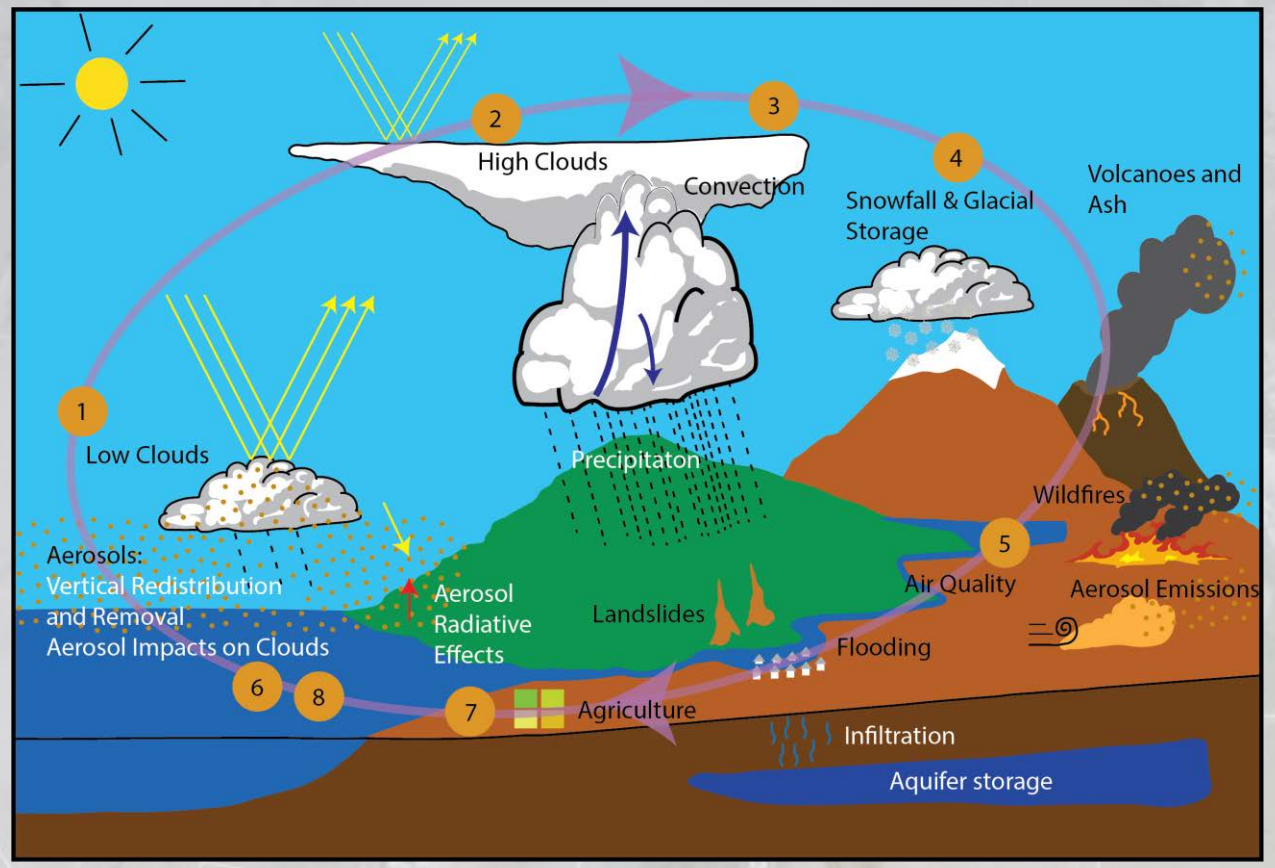
Major Science Priorities for AOS

AOS provides an observing system that focuses on measurements addressing major Decadal Survey (DS) science themes tied to coupled aerosol-cloud-precipitation processes

AOS addresses priority science called out by *multiple* ESAS DS panels and related to *three* targeted observables

- **TO-1: Aerosol & Cloud Radiative Properties**
- **TO-2: Aerosol Vertical Profiles**
- **TO-5: Clouds, Convection, & Precipitation**



AOS Science Objectives

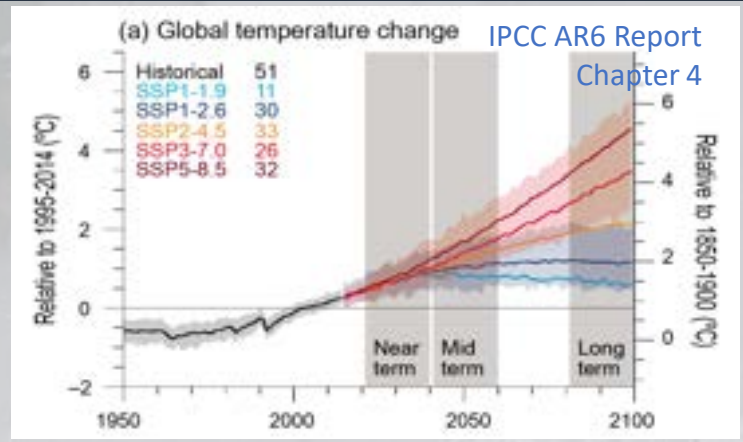
1. Low cloud feedbacks
2. High cloud feedbacks
3. Convective storm processes
4. Cold clouds & precipitation
5. Aerosol attribution and air quality
6. Aerosol redistribution and removal
7. Aerosol direct effect
8. Aerosol indirect effect

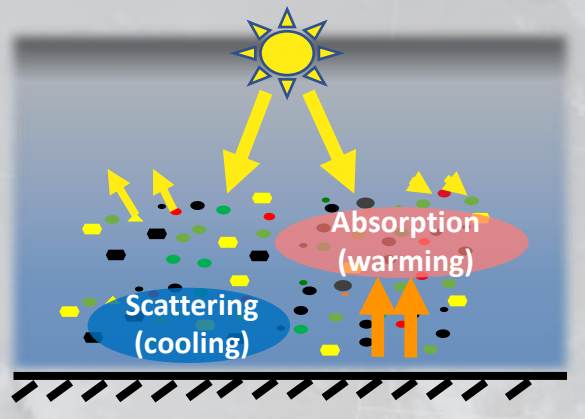
Pre-Decisional – AOS is in Phase A and NASA makes no commitments on the final design of the mission or instruments

AOS Objectives Focus on Three Themes

Climate sensitivity and feedbacks

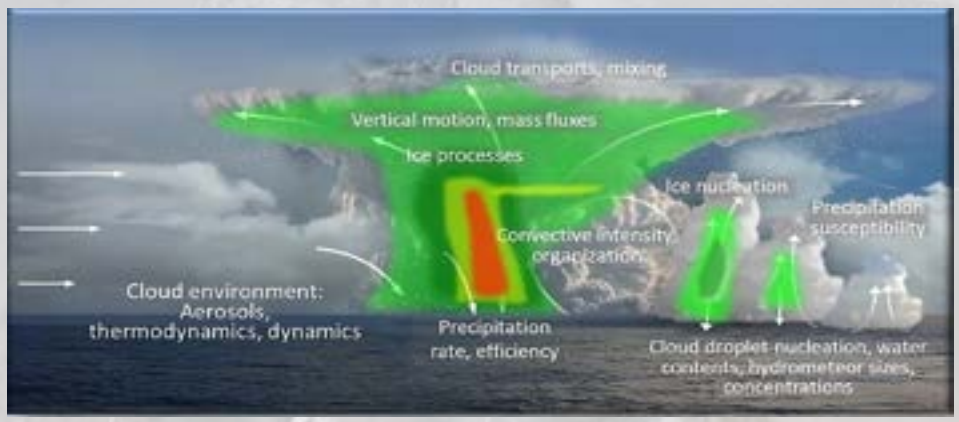
- Low and high cloud feedbacks
- Aerosol direct & indirect effects
- Cold clouds and precipitation





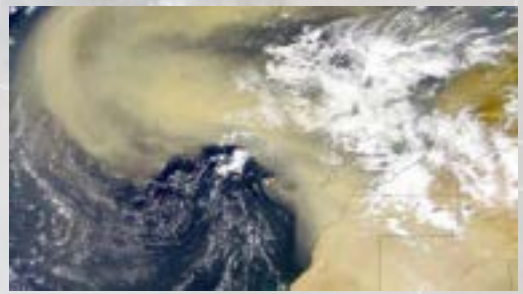
Convective Storm Formation Processes

- Coupled storm dynamics and microphysics
- Importance of diurnal cycle
- High cloud properties



Aerosol processes and distributions

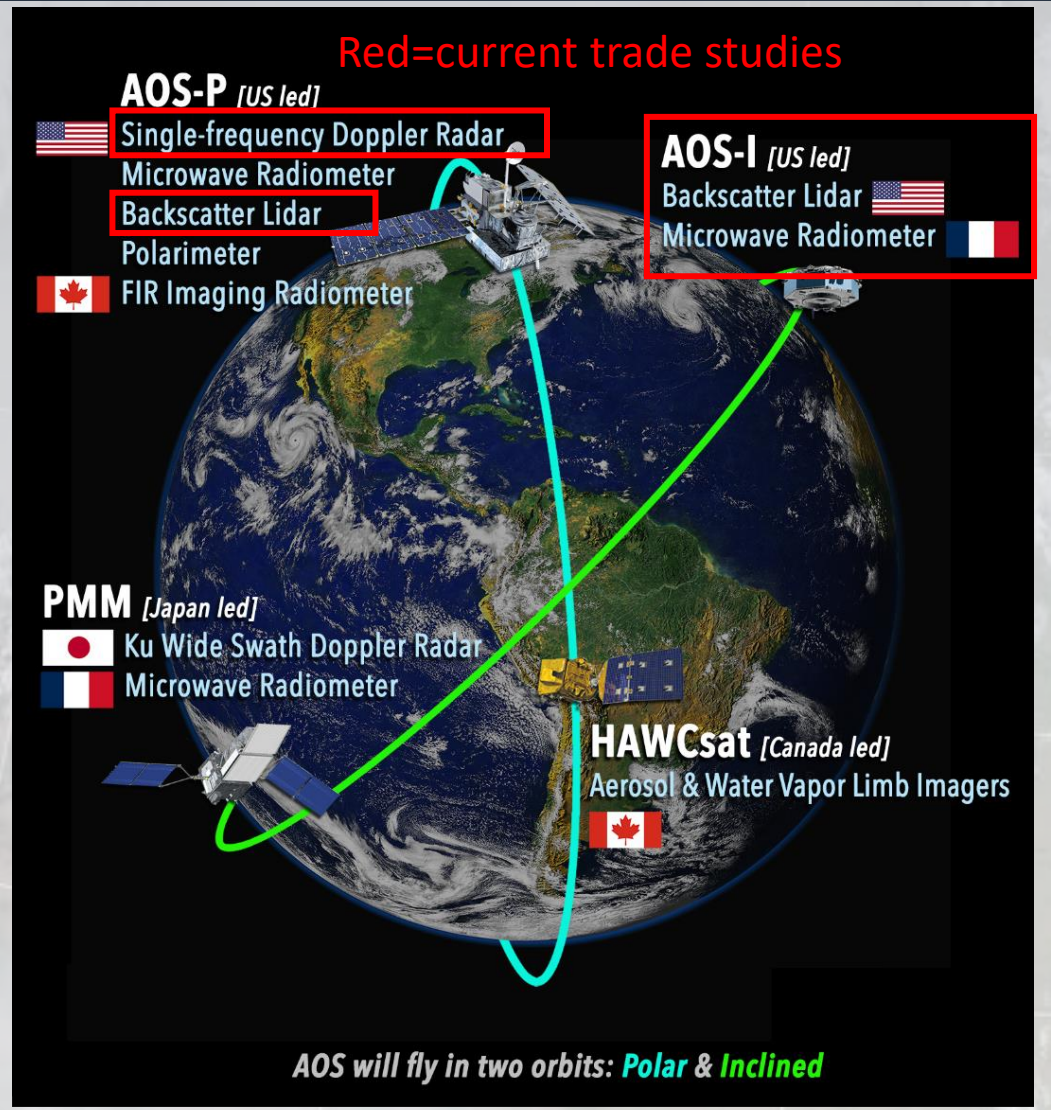
- Air quality and aerosol attribution
- Aerosol vertical redistribution and processing (from emission to removal)



Changes Since MCR: IRB/KDP-A Recommendations

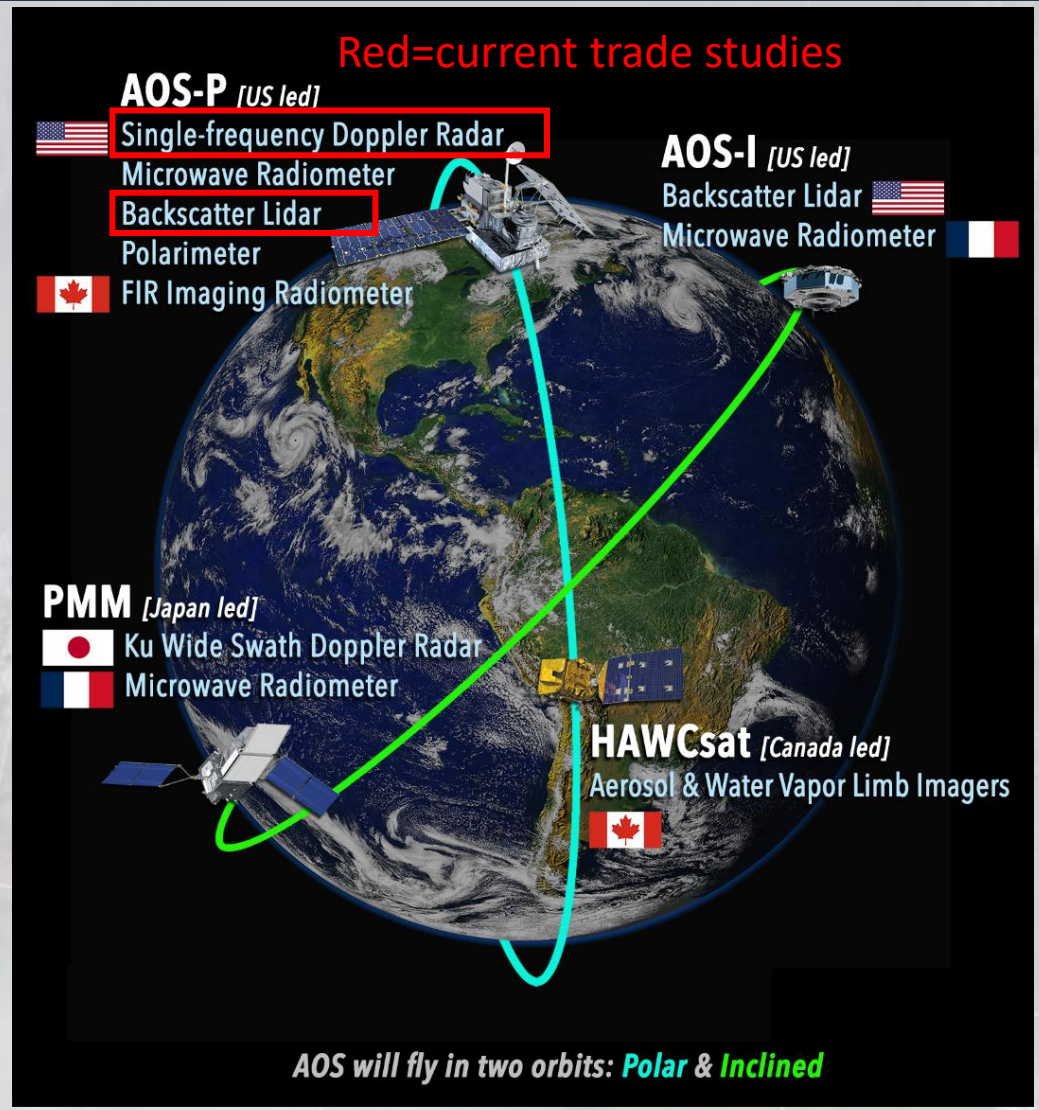
AOS Polar Project

- IRB identified technical and cost risks associated with the active sensors in polar
- KDP-A guidance:
  - Change HSRL to backscatter lidar
  - Change dual-frequency radar to single frequency
  - Negotiated with HQ that radar requirement must include cloud profiling capability
  - Fit within more constrained budget



Changes Since MCR: Polar Trades

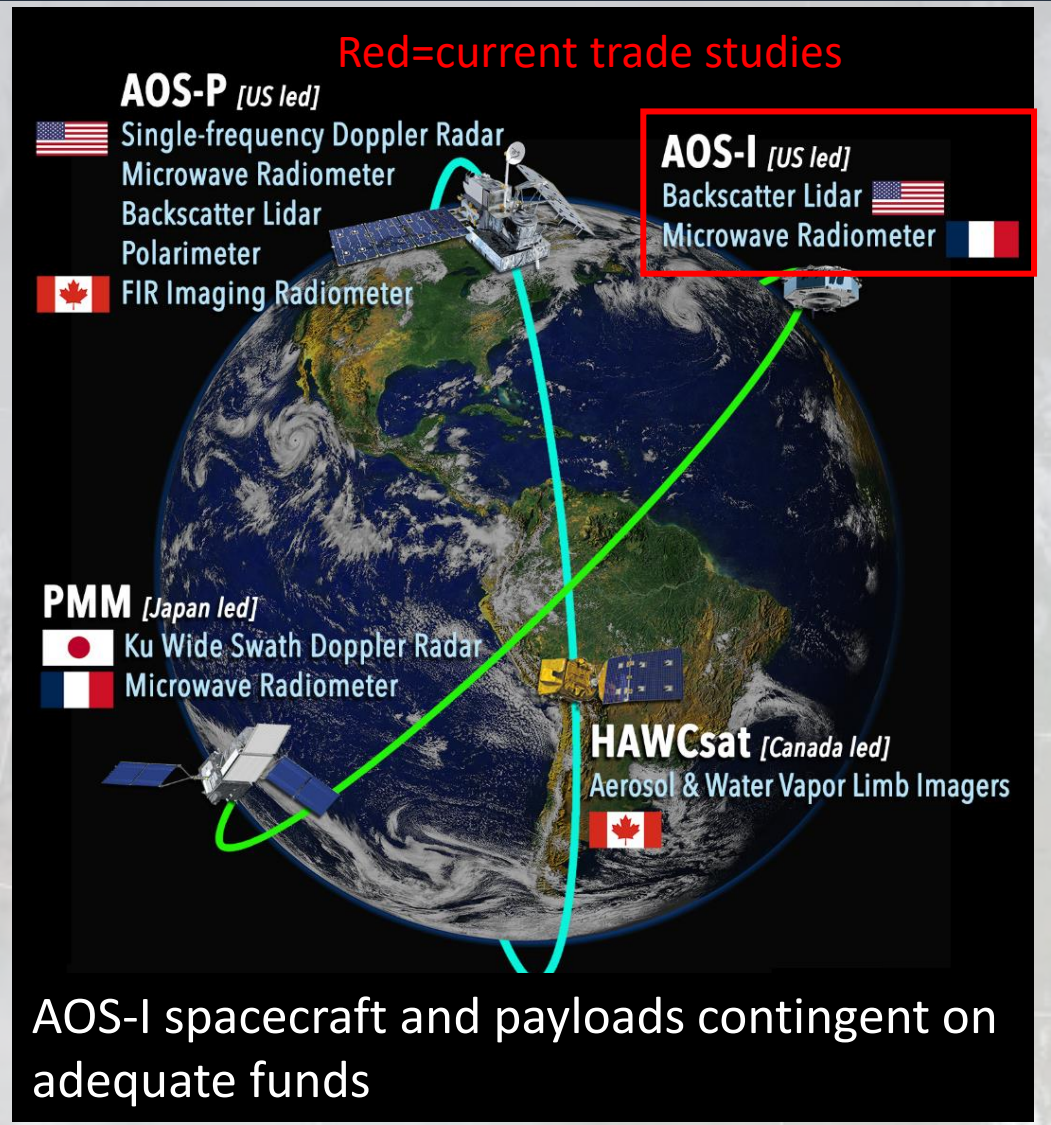
- Trades for polar lidar
  - Target for industry: CALIOP-like capability with daytime SNR equivalent to CALIOP nighttime SNR
  - Potential partnership with Italian Space Agency (ASI) for 3-wavelength lidar flying in formation with AOS-P
- Trades for radar
  - Single-frequency cloud-profiling radar with sensitivity equivalent to MCR measurement requirements
  - Frequency agnostic; can be accomplished with either W or Ka band
    - Ka provides less attenuation
    - W required for cloud liquid water path
  - Dual-frequency should still be in trade space since descope does not impact technical/cost risk



Changes Since MCR: Inclined Orbit Trades

AOS Inclined Project

- Focused on convection, high clouds, aerosol profiles and variations over the day
- Potential changes: AOS-I spacecraft & payloads may not fit within revised budget, considering options through augmented budgets
  - Option #1: Add ALICAT on propulsive ESPA spacecraft
  - Option #2: Add ALICAT and CNES radiometers
  - Option #3: Add CNES radiometers only



AOS-I spacecraft and payloads contingent on adequate funds

Science Impacts of Options

Budget Augmentation Option	Summary	Science Priority	Science Addressed
Option #1	Adding lidar on small spacecraft to inclined orbit	Higher priority	• Adds profiling of clouds/aerosols, • Diurnal sampling of aerosols to understand air quality changes and fire/smoke impacts, and ability to connect multiple lidar missions into long-term time series • Has high applications value
Option #2	Adding small spacecraft for second CNES radiometer to inclined orbit	Lower priority	• Second CNES radiometer adds short-term changes in ice water path and ice mass flux through time-differenced observations • Note: Single radiometer on JAXA PMM spacecraft is high priority
Option #3	Adding lidar and smallsats for both lidar and CNES radiometer	Highest priority	Combines benefits from Options 1 and 2

AOS Suborbital Element

Low Clouds: *Microphysics, precipitation initiation*

Convection/High Clouds: *Microphysics and dynamics, anvil cirrus lifecycle.*

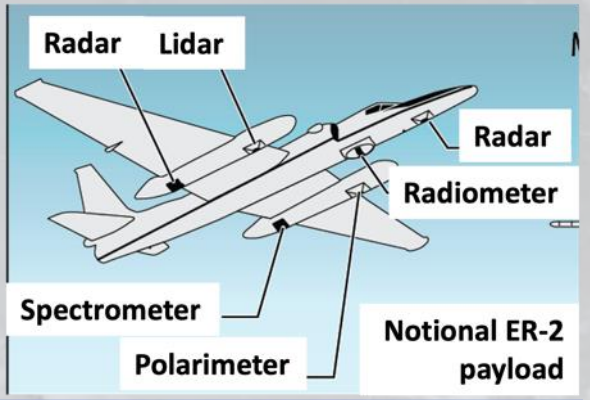
Aerosol-Cloud-Radiation Interactions: *Vertically resolved aerosol-cloud-radiation interaction processes and lifecycle.*

Large airborne campaigns

- **Mid-latitude continental, 2029 or 2030**
- **Oceanic, 2032-2033**

Campaigns after launch to enable cal-val

Payloads depicted are notional… instruments to be prioritized / deconflicted for each campaign

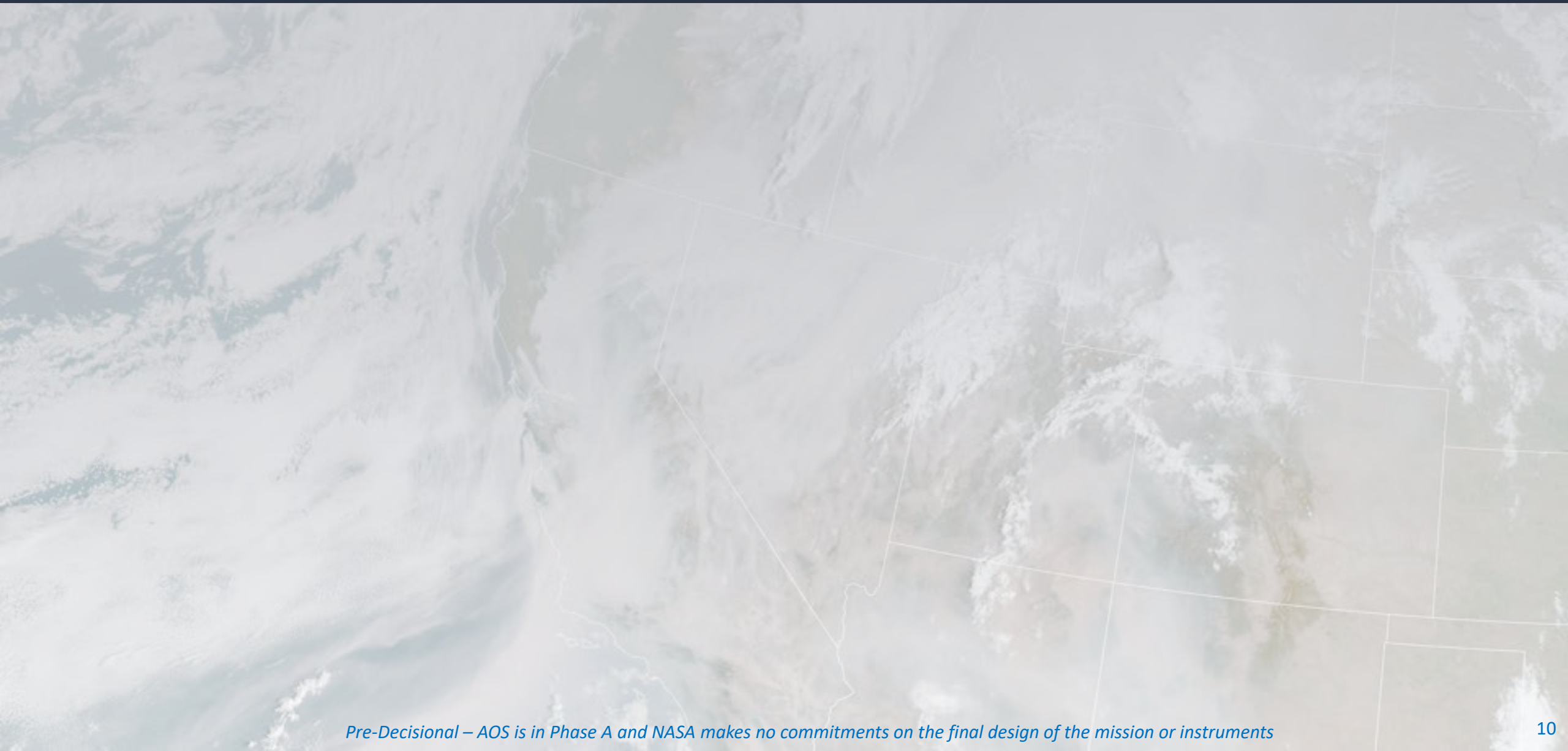


Key Take Aways

- AOS is a complex mission targeting aerosol-cloud-precipitation interactions
- AOS faces a number of challenges (IRB recommendations, budget)
- AOS has an engaged team exploring ways to maximize science benefit within constraints (trades, partnerships)
- AOS can benefit from strong support from this community

AOS Website:
https://aos.gsfc.nasa.gov

Email: scott.a.braun@nasa.gov



Extra Slides

Science Impacts of IRB/KDP-A Recommendations

Change	Summary	Science Impacts
HSRL to backscatter lidar	Clio instrument (HSRL at 532, backscatter at 1064 nm) changed to CALIOP-like backscatter lidar (backscatter at 532 and 1064 nm)	Large increase in systematic errors in profile, especially near surface and when high clouds present, with large impact on air quality; reduced detection of tenuous aerosol; significantly reduced capability to identify aerosol type and intrinsic properties like aerosol size
Dual frequency to single frequency radar	JPL W-, Ka-band radar changed to frequency agnostic cloud-profiling radar	Inability to determine particle size, reduced Doppler quality/range; if W band, significant impact of attenuation in moderate precipitation; if Ka band, loss of cloud liquid water path

Science Impacts of Lidar Trades

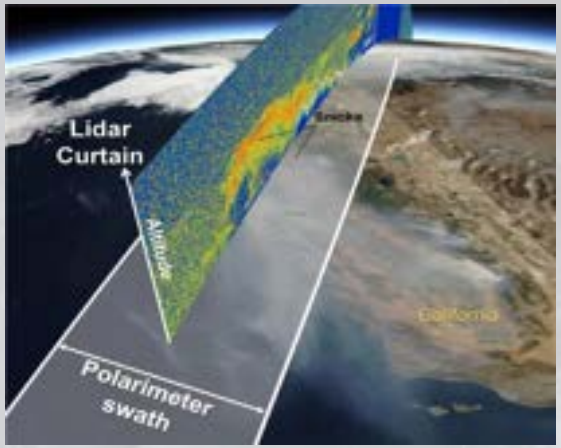
Change	Summary	Science Priority	Science Impacts
Industry lidar	• CALIOP-like capability • Target SNR for daytime equivalent to CALIOP nighttime SNR	Medium	• Modest to significant increase in SNR due to lower altitude • Potential enhancements within budget constraints
ASI CALIGOLA lidar	• ASI/NASA partnership for lidar • Minimum 7 wavelength lidar (backscatter, depol at 355, 532, 1064 nm; extinction at 355 nm) • Considering up to 12 channels for atmosphere-ocean-land measurements	High	• Modest to significant increase in SNR due to lower altitude • 3 backscatter and depol frequencies instead of 2 • Nighttime (possibly daytime) extinction measurements for improved aerosol profiles and typing • Capable of ocean and land/snowfall measurements to enable multi-disciplinary science • Introduces science risk due to schedule and independent spacecraft

Science Impacts of Radar Trades

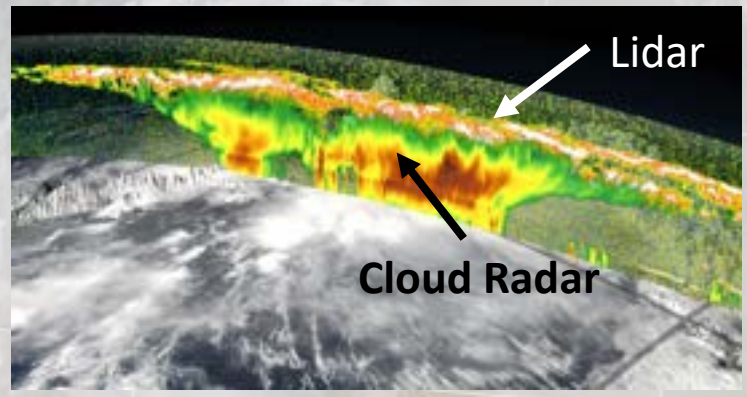
	Change	Summary	Science Priority	Science Addressed
Single band	JPL or Industry W band	W-band radar for cloud profiling	High	Provides full cloud profiling with accurate Doppler information, cloud liquid water path
	Industry Cloud-Profiling Ka band	Ka-band radar for cloud profiling	High	Provides full cloud profiling with accurate Doppler information, less attenuation at higher rainfall rates
Dual band	JPL W, Ka band	Cloud profiling at W band, precipitation at Ka band	Highest	Added Ka band provides enhanced Doppler information, precipitation over broader range, and precipitation particle size information, cloud liquid water path
	Industry Ka, Ku/X band	Cloud profiling at Ka band, precipitation profiling at Ka and Ku/X band	High	Added Ku or X band provides enhanced Doppler information, precipitation over broader range, and precipitation particle size information, less attenuation at highest rainfall rates

Building An Observing System

- Factors shaping the architecture during architecture construction and concept development phases (ACCP)
  - **Cost-capped** mission that utilizes relatively **mature** measurement capabilities
  - Microphysical understanding requires **synergistic** multi-instrument approaches
  - **International** partnerships
  - **Continuity** desired (but not required) to the extent practical
  - **Applications** considered from early stages
- Completed Mission Concept Review, May 2022
- Independent Review Board (IRB) study August-September 2022
- Key Decision Point A review, January 13, 2023



Lidar+polarimeter synergy for aerosols: *provides significant retrieval advances over lidar alone*



Doppler radar+lidar+passive sensor synergy: adds dynamical information to cloud/precipitation profiling and passive properties