ATMOSPHERE

National Aeronautics and Space Administration

NASA

EARTH SYSTEM OBSERVATORY

AOS
The Atmosphere Observing System

Synergistic Aerosol, Cloud, Convection and Precipitation Measurement and Modeling Systems

Arlindo da Silva, NASA GSFC Code 610.1

On behalf of the AOS Science Team

Session A42G – AGU Fall Meeting 2021

Thursday, 16 December 2021 – 10:50–10:55 AM

https://aos.gsfc.nasa.gov

National Aeronautics and Space Administration

NASA

EARTH SYSTEM OBSERVATORY

Outline

1. Scientific and Programmatic Basis
2. AOS Science
3. The AOS Constellation
4. The AOS Sub-orbital component
5. Applications for the Benefit of Society
6. Modeling and Data Assimilation
7. Open-Source Science at NASA
8. Summary

Other AOS-related AGU Presentations:
https://tinyurl.com/3dkr7393

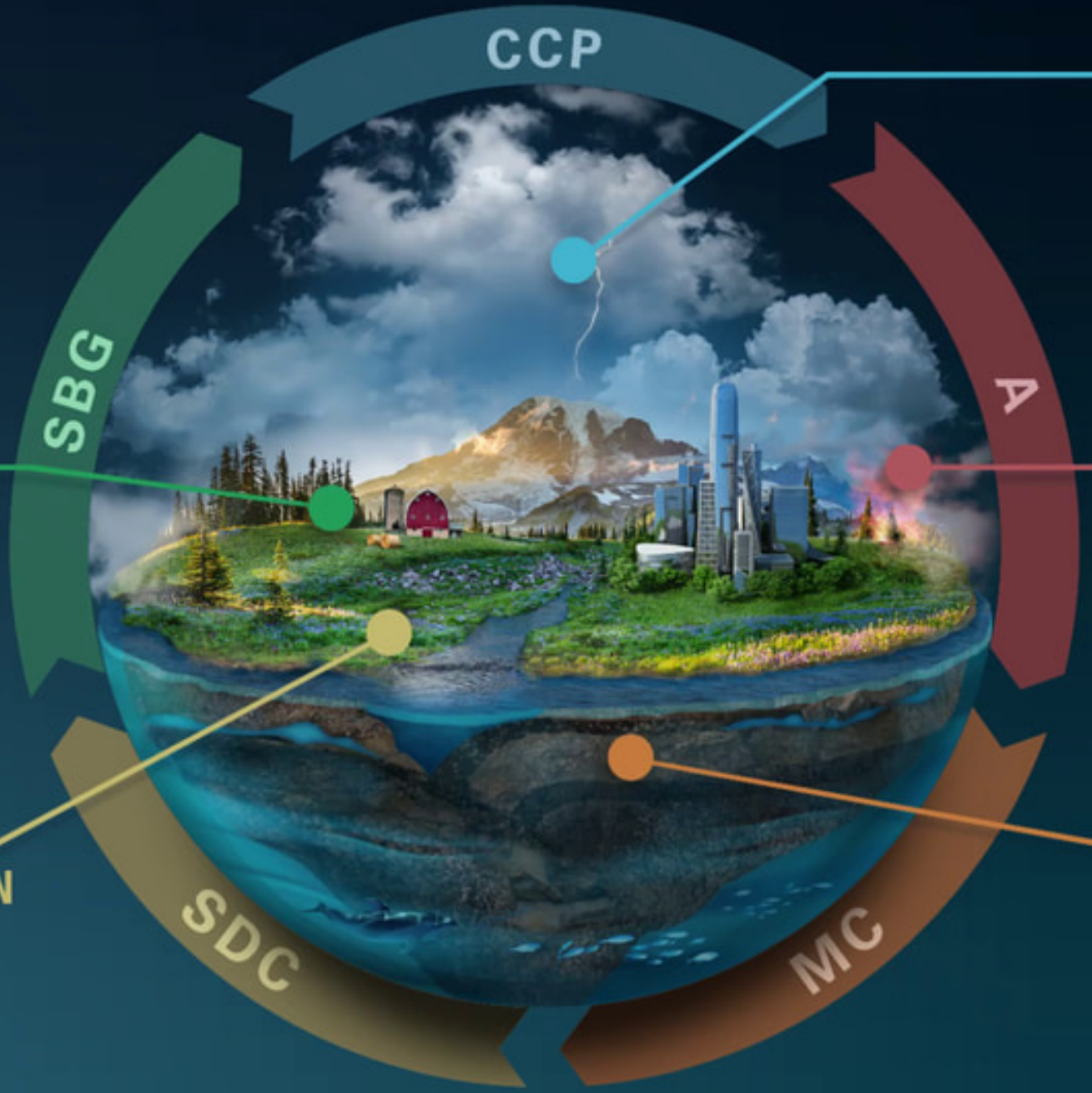
Thriving on Our Changing Planet

A Decadal Strategy for Earth Observation from Space

Available from http://sites.nationalacademies.org/DEPS/ESAS2017

EARTH SYSTEM OBSERVATORY

INTERCONNECTED CORE MISSIONS



CLOUDS, CONVECTION AND PRECIPITATION

Water and Energy in the Atmosphere

AEROSOLS

Particles in the Atmosphere

MASS CHANGE

Large-scale Mass Redistribution

SURFACE DEFORMATION AND CHANGE

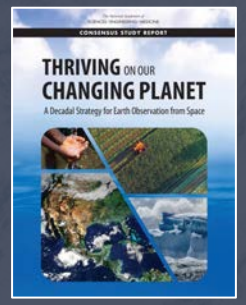
Earth Surface Dynamics

SURFACE BIOLOGY AND GEOLOGY

Earth Surface and Ecosystems

Atmosphere (AOS)

Scientific and Programmatic Basis



- The 2017 Decadal Survey recommended a new program element called *Designated Observables* with cost-caped missions to provide measurements essential to a comprehensive collection of Earth Science questions.
- AOS (formerly ACCP) combines 2 Designated Observables

	Aerosols	**Clouds, Convection, and Precipitation**
Observable Priorities	Aerosol properties, aerosol vertical profiles, and cloud properties to understand their effects on climate and air quality	Coupled cloud-precipitation state and dynamics for monitoring global hydrological cycle and understanding contributing processes including cloud feedback
Desired Observables	Backscatter lidar and multi-channel, multi-angle imaging polarimeter	Radar(s), with Doppler, with multi-frequency passive microwave and sub-mm radiometer

AOS Science Objectives

National Aeronautics and Space Administration

NASA

EARTH SYSTEM OBSERVATORY

The AOS Constellation

- Mission and science objectives are defined at the constellation level
- Polar orbit essential for meeting almost all objectives
- Inclined orbit targets important processes tied to sub-daily variability
- Suborbital component addresses science not achievable from space
- Applications explore how the AOS synergistic measurements can best benefit public health, weather and climate predictions.

One Observing System
Two Synergistic Segments

National Aeronautics and Space Administration

EARTH SYSTEM OBSERVATORY

Extremely Valuable International Contributions

Partner	Instrument	Science it Addresses	Status
CSA	TICFIRE	Links of aerosol and cloud microphysics to radiation	On AOS-P
	ALI	Aerosol transport to UTLS	Under Study
	SHOW	Moistening of the UTLS	
JAXA	Wide Swath Doppler Ku Radar	Precipitation context for measurements of convection	
CNES	Pair of mw radiometers	Information on short time scale convective processes	

One Observing System Two Synergistic Segments

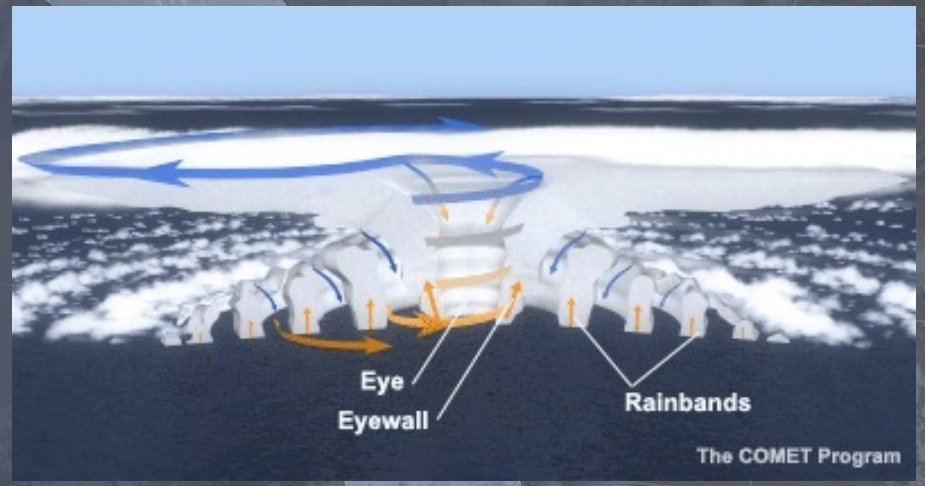
National Aeronautics and Space Administration

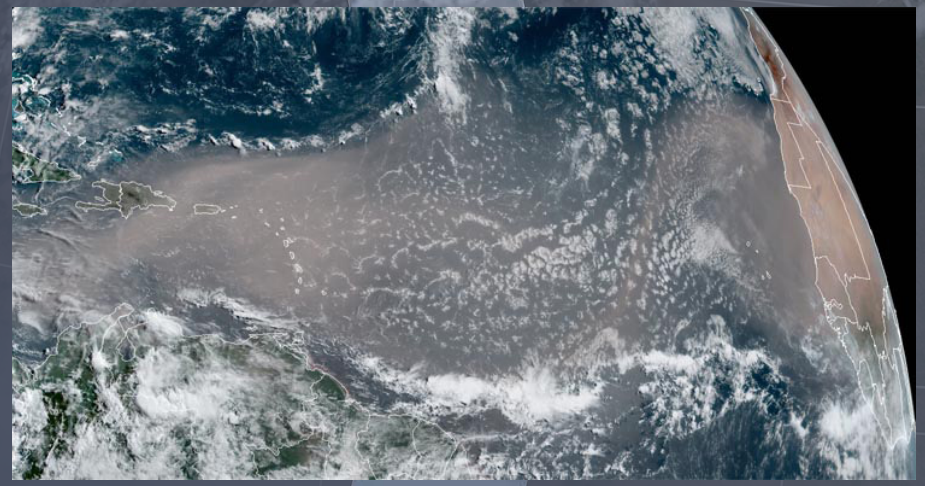
NASA

EARTH SYSTEM OBSERVATORY

The 5 First-Evers of AOS

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





National Aeronautics and Space Administration

NASA

EARTH SYSTEM OBSERVATORY

AOS Suborbital Focus

Science Investigations that …

- are best, better, or only possible from sub-orbital
- provide priors for or are useful to algorithms
- provide synergies with calibration / validation
- bridge gaps between Program of Record and/or launch schedule
- fill gaps that result from descopes in the orbital missions

AOS Suborbital Science Themes and Modules

EARTH SYSTEM OBSERVATORY

	Low Cloud/ACI	Convection and High Cloud	Aerosol ACI, Attrib./Redistrib.
Science Themes			
Modules	• Precipitation initiation in shallow Cumulus • Open/Close cell transitions in marine stratocumulus • Ice precipitation process in cold marine PBL clouds	• Convective core processes and environment controls • Convective detrainment • Anvil cirrus lifecycle	• Vertically-resolved aerosol effects on cloud formation • Impact of convection on aerosol redistribution and removal • Influence of PBL on aerosol attribution and vertical redistribution

Community Assessment Report

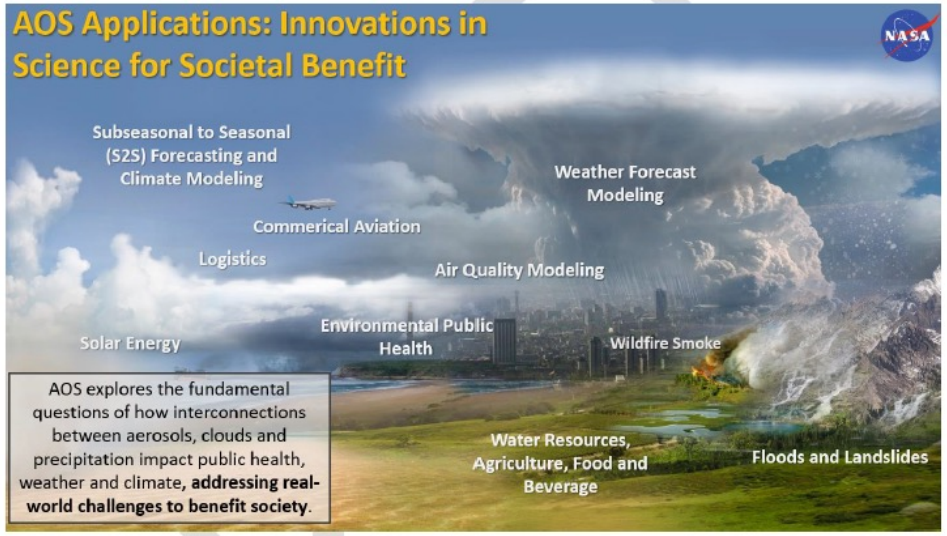
- CAR serves to document and synthesize information and needs from applications communities relevant to AOS that include communities of practice and potential
- CAR makes recommendations and provides suggested guidelines for how components of the AOS mission may be optimized for enhanced applications value
- CAR is a living document and is currently in draft form for internal review

Related Talk: A53B-05
https://tinyurl.com/yc5wh8v7

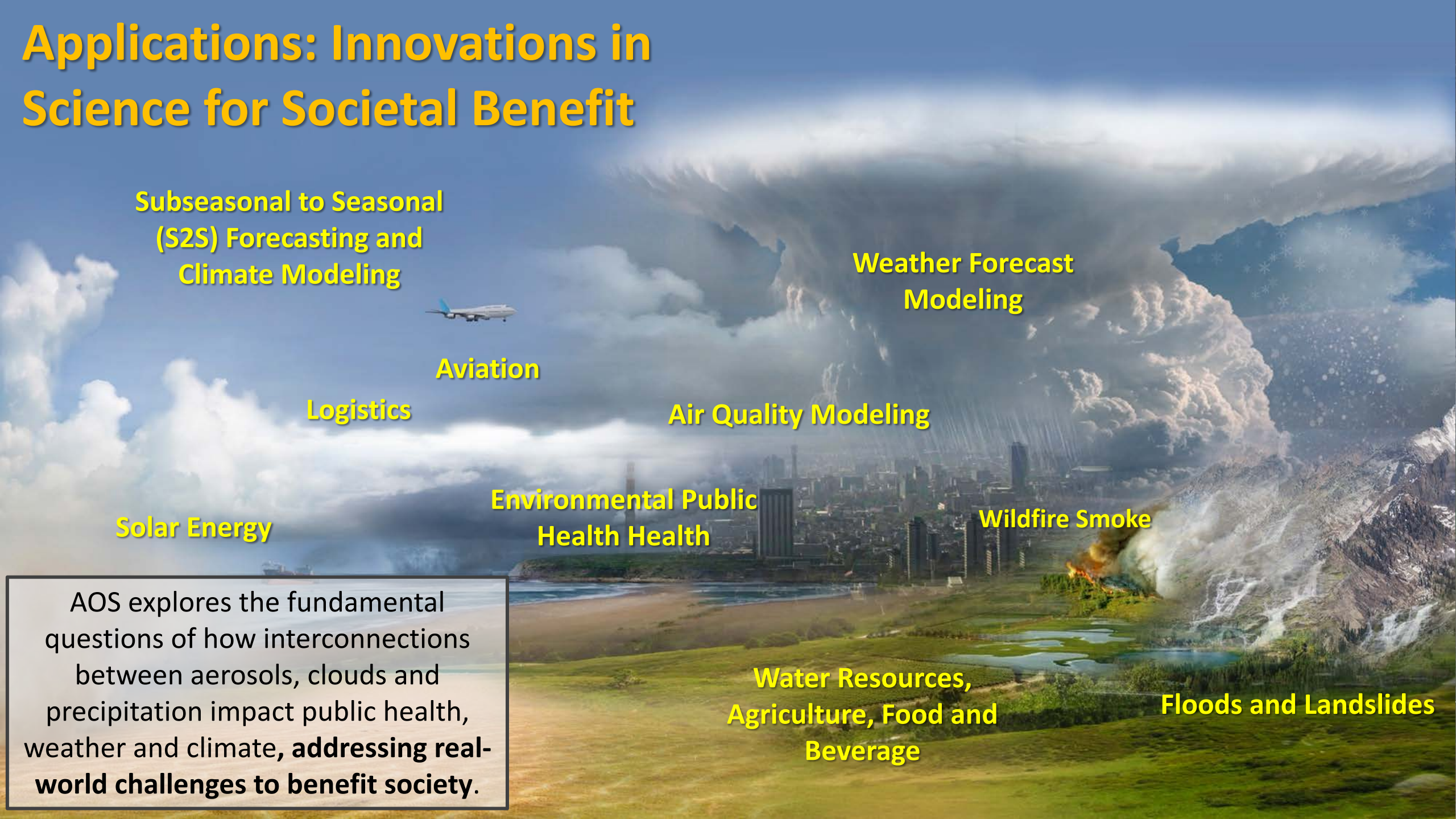
EARTH SYSTEM OBSERVATORY

Atmosphere Observing System (AOS) Community Assessment Report (CAR)

The objective of this Community Assessment Report (CAR) is to provide an overview of key stakeholder communities' needs relevant to the Atmosphere Observing System (AOS) in terms of their current use and potential application of data products for decision making. This report is based solidly on input from stakeholders and serves as a reference to articulate stakeholder needs as well as provide guidelines for how to optimize the applications benefit to communities of practice and communities of potential that may use the suite of AOS products.



Applications: Innovations in Science for Societal Benefit



AOS explores the fundamental questions of how interconnections between aerosols, clouds and precipitation impact public health, weather and climate**, addressing real-world challenges to benefit society**.

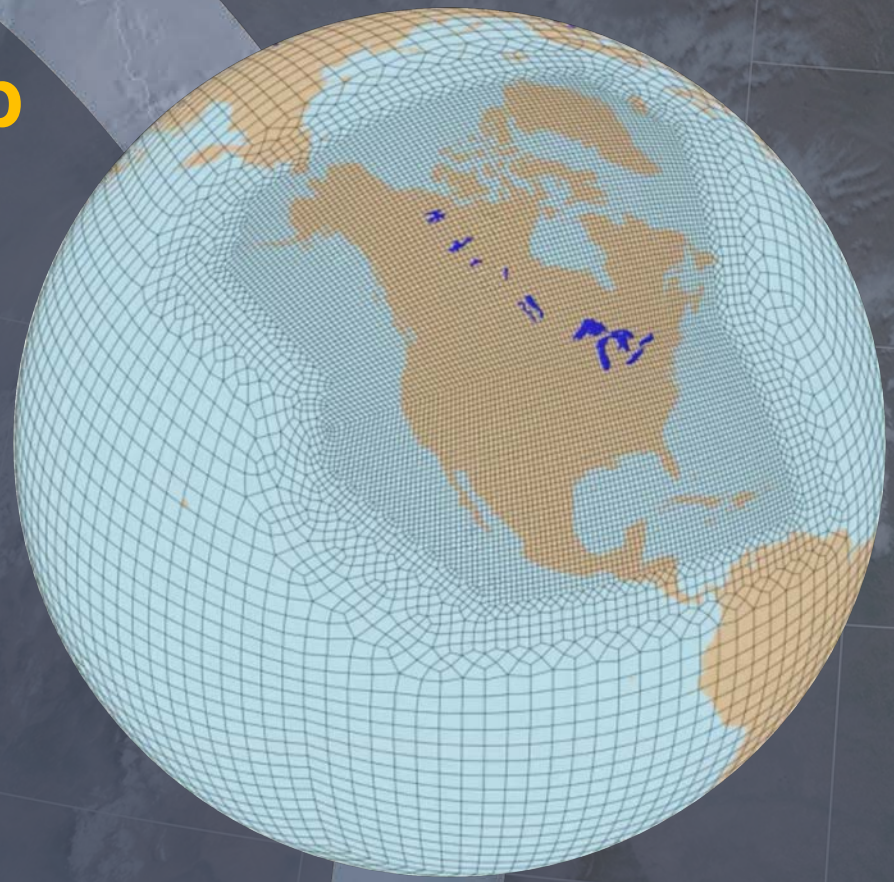
National Aeronautics and Space Administration

NASA

EARTH SYSTEM OBSERVATORY

2020 AOS Modeling Workshop

1. Survey the modeling community for where models may be in 10 years
2. Understand the state of the art for analysis and assimilation of earth observations
3. Enhance interactions between satellite and modeling experts for cloud and aerosol science by challenging the community to think about new methods for model-satellite observation synergies.



BAMS Paper

URL: https://www.cgd.ucar.edu/events/2020/ACCP

2020 ACCP Modeling and Assimilation Workshop

Key Findings

- Couple models and observations more tightly
- Use multi sensor data to compare to models in new ways, many approach processes
  - Advantages of joint PDFs of multiple variables, process fingerprints
  - Relationships between instantaneous parameters to inform underlying processes
  - Composites in time
- Importance of Geostationary data (Program of Record)

Key Recommendation

Need a concerted, sustained *pre-launch* effort for integrating aerosol, clouds and precipitation modeling with AOS observations (including the PoR)

- Retrieval and assimilation operator development
- Satellite Simulator development
- Explore simulated AOS observations from OSSE systems
- Develop DA capabilities for AOS

EARTH SCIENCE DATA SYSTEMS

NASA

Open Source Science

Expanding participation, improving reproducibility, and accelerating scientific discovery for societal benefit.

Open-Source Science

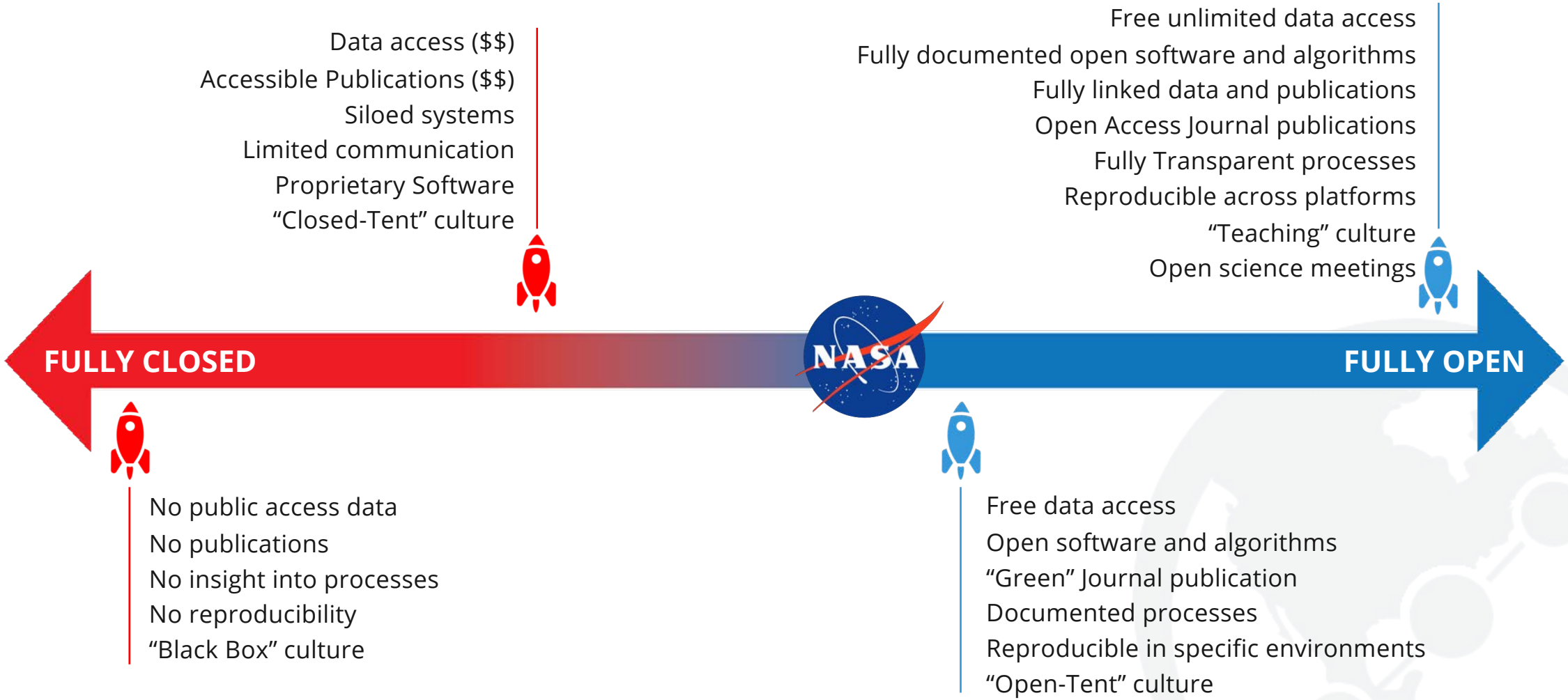
"We define open-source science as a collaborative culture enabled by technology that empowers the ***open sharing of data****,* ***information****,* ***and knowledge*** *within the scientific community and the wider public to accelerate scientific research and understanding."*

Ramachandran, R., Bugbee, K., & Murphy, K. J. Moving from Open Data to Open Science. Earth and Space Science, Wiley Publication https://doi.org/10.1029/2020EA001562

Building an Open Source Science Ecosystem

- **Initiate** new missions, research and applied activities as open-source science projects.
- **Implement clear policies** for software, publications and data.
- **Integrate and improve** data management, access, computing, analytics and scientific collaboration.
- **Build the community** through open science team meetings, training, workshops, competitions, awards and prizes.

A CONTINUUM OF OPEN-SOURCE SCIENCE



National Aeronautics and Space Administration

https://aos.gsfc.nasa.gov

EARTH SYSTEM OBSERVATORY

AOS
One Observing System
Two Synergistic Segments

- Science objectives addressed by the *constellation*
- Polar orbit essential for meeting almost all objectives
- Inclined orbit targets important processes tied to sub-daily variability
- Suborbital component addresses science not achievable from space
- AOS explores how interconnections between aerosols, clouds and precipitation impact public health, weather and climate

KDP-A planned for June 2022
Launches NET: 2028 (AOS-I), 2030 (AOS-P)