EXPLORE EARTH

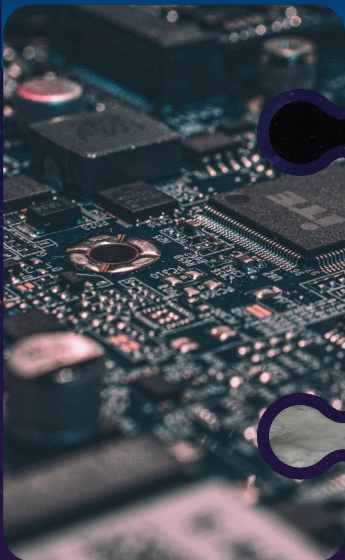**NASA's Earth Science Program**

Jack A. Kaye

Associate Director for Research

NASA Earth Science Division

July 8, 2024

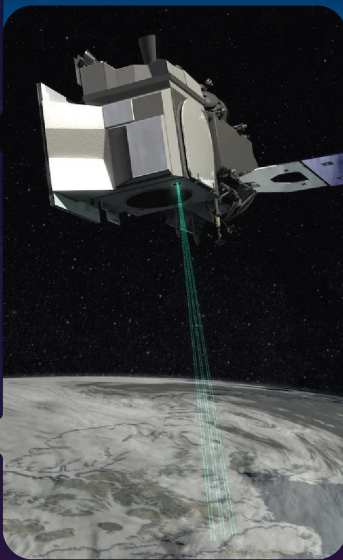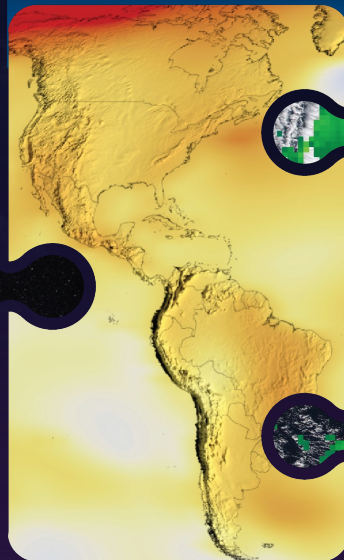# Advancing Earth System Science End-to-end

Technology

Flight
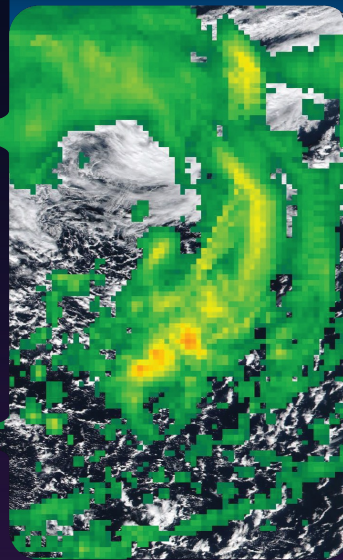
Research and Analysis

Data and Modeling

Earth Action

NASA
earth

Earth Science to Action Strategy

Earth Science to Action

Virtuous Cycle
- User needs inform next iteration of programs, missions and initiatives

Public Understanding & Exchange
- Put more scientific understanding into public sphere
- Deliver applied science to users
- Participate in multi-way info exchange
- Use input to inform subsequent work

Solutions & Societal Value
- Offer models, scientific findings and info through Open-Source Science principles
- Support climate services
- Provide science applications and tools to inform decisions

Earth System Science & Applied Research
- Grow scientific understanding of Earth's systems
- Develop predictive modeling for science applications and tools to mitigate, adapt and respond to climate change

Foundational Knowledge, Technology, Missions & Data
- Technology innovation
- Earth observations missions
- Data collected from space, air and ground

NASA
earth
05.01.2024

Integration of Vantage Points and Approaches

- Satellite Missions
  - Directed/Competed
  - Free-Flying/International Space Station
  - Single Large Satellite/Small Satellite Constellations
  - Science Focused/Technology Focused
  - NASA-only/Interagency Collaboration/International Collaboration

- Airborne Science (platforms/sensors/systems/people/opportunities)

- Surface-Based Measurement Networks

- Computational Modeling/Scientific Computing

National Aeronautics and Space Administration

NASA

EARTH FLEET

Key

International Partners 🌐
U.S. Partner 🏴
ISS Instrument ‖+‖
JPSS Instrument ✈━
Cubesat ⬡
Launch Date TBD ★
Earth System Observatory Mission ↻
(Pre) Formulation 🟪
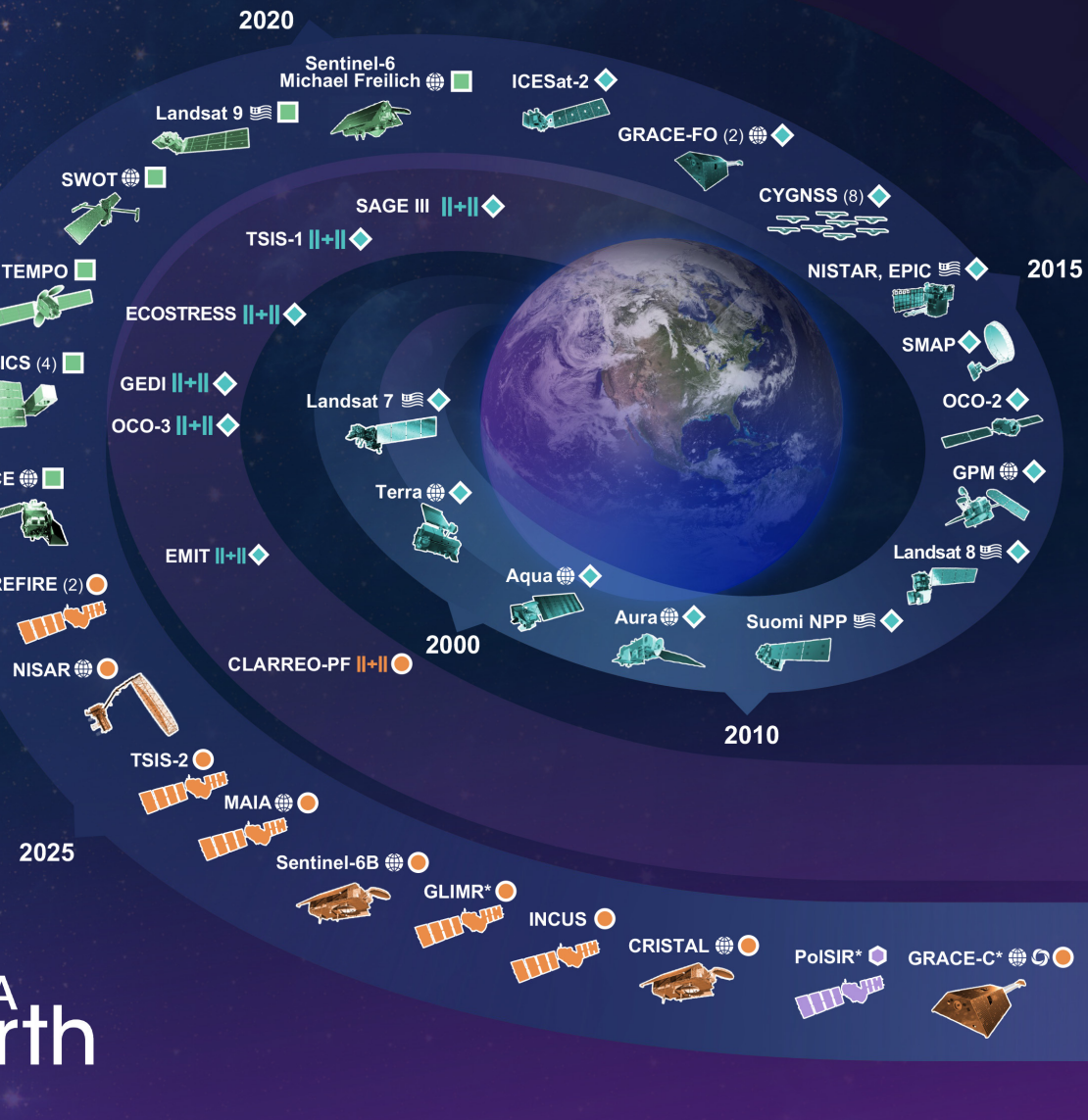Implementation 🟠
Operating 🟩
Extended 🔷

Invest/CubeSats

MURI-FD 2023
SNOOPI 2024
HYTI 2024
ARGOS* 2024
ARCSTONE* 2025
GRITSS* 2025
GRATTIS* 2026

JPSS Instruments

OMPS-LIMB 2022 ✈━ 🏴
LIBERA 2027 🟠━ 🏴
OMPS-LIMB 2027 🟠━ 🏴
OMPS-LIMB 2032 ✈━ 🏴

2020

Sentinel-6 Michael Freilich 🌐 🟩
Landsat 9 🏴 🟩
ICESat-2 🔷
GRACE-FO (2) 🌐 🔷
SWOT 🌐 🟩
SAGE III ‖+‖ 🔷
TSIS-1 ‖+‖ 🔷
CYGNSS (8) 🔷
TEMPO 🟩
NISTAR, EPIC 🏴
2015
ECOSTRESS ‖+‖
SMAP 🔷
TROPICS (4) 🟩
OCO-2 🔷
GEDI ‖+‖
OCO-3 ‖+‖
Landsat 7 🏴 🔷
GPM 🌐 🔷
PACE 🌐 🟩
Terra 🌐 🔷
Landsat 8 🏴
EMIT ‖+‖ 🔷
Aqua 🌐 🔷
PREFIRE (2) 🟠
Aura 🌐 🔷
Suomi NPP 🏴
NISAR 🌐 🟠
CLARREO-PF ‖+‖ 🟠
2000
2010
TSIS-2 🟠
MAIA 🌐 🟠
2025
Sentinel-6B 🌐 🟠
GLIMR* 🌐 🟠
INCUS 🟠
CRISTAL 🌐 🟠

ISS INSTRUMENTS

PolSIR* 🟪
GRACE-C* 🌐 ↻ 🟠
PMM* 🌐 ↻ 🟪
SBG* 🌐 ↻ 🟪
AOS Sky* 🌐 ↻ 🟪
Landsat Next* 🏴 🟪

MISSIONS

NASA earth

06.07.2024

2030

WATER AND ENERGY CYCLE FLEET

National Aeronautics and Space Administration

NASA earth
05.21.2024

2020
- Sentinel-6 Michael Freilich
- Landsat 9
- ICESat-2
- GRACE-FO (2)
- CYGNSS (8)
- **2015**
- SWOT
- SMAP
- OCO-2
- ECOSTRESS
- TROPICS (4)
- Landsat 7
- OCO-3
- GPM
- Terra
- EMIT
- Landsat 8
- PACE
- Aqua
- NISAR
- Aura
- Suomi NPP
- **2000**
- **2010**
- **2025**
- Sentinel-6B
- GLIMR*
- INCUS
- CRISTAL
- PolSIR*
- GRACE-C*
- PMM*
- SBG*
- AOS Sky*
- Landsat Next*
- **2030**

Key
- International Partners
- U.S. Partner
- ISS Instrument
- JPSS Instrument
- Cubesat
- Launch Date TBD
- Earth System Observatory Mission
- (Pre) Formulation
- Implementation
- Operating
- Extended

Invest/CubeSats
- CTIM 2022
- MURI-FD 2023
- SNOOPI* 2024
- HYTI* 2024
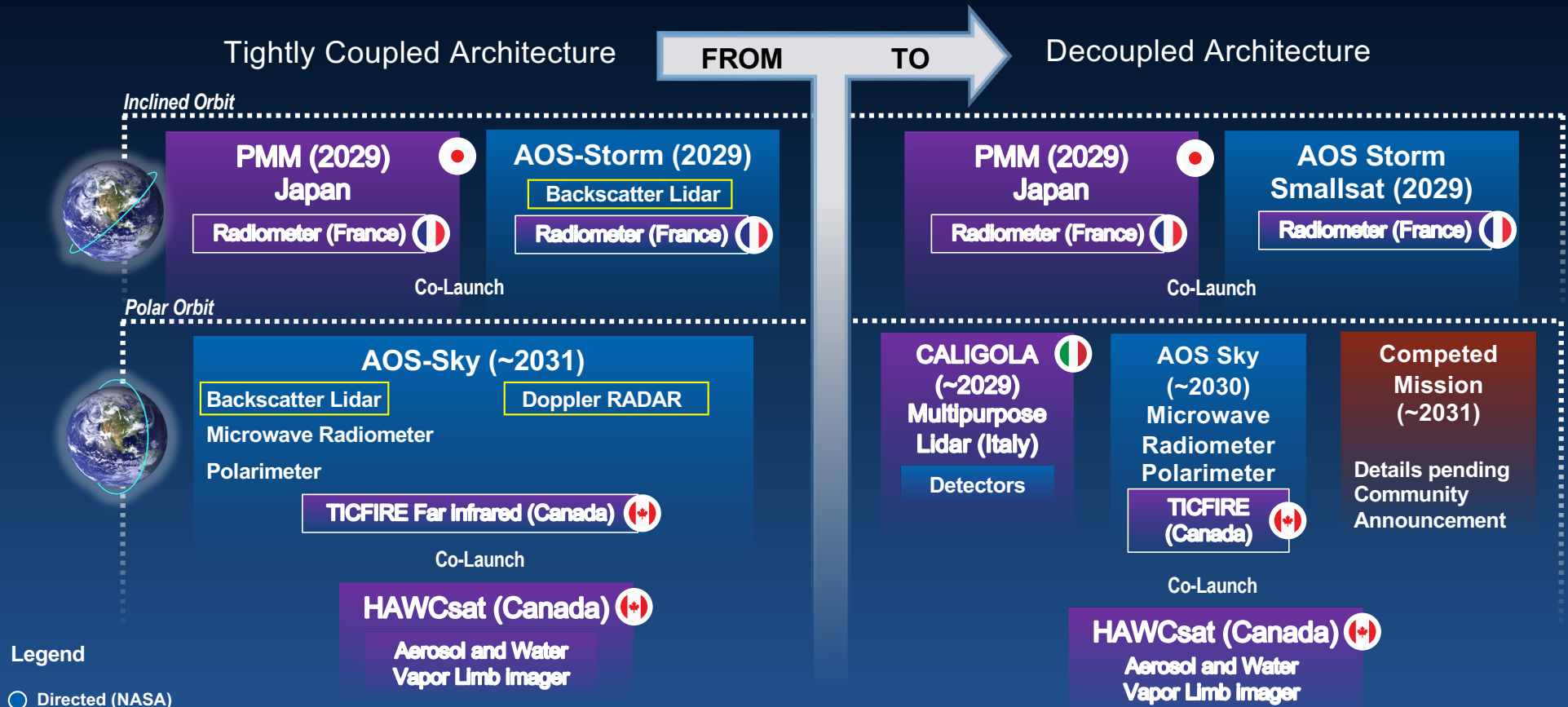- ARGOS* 2024
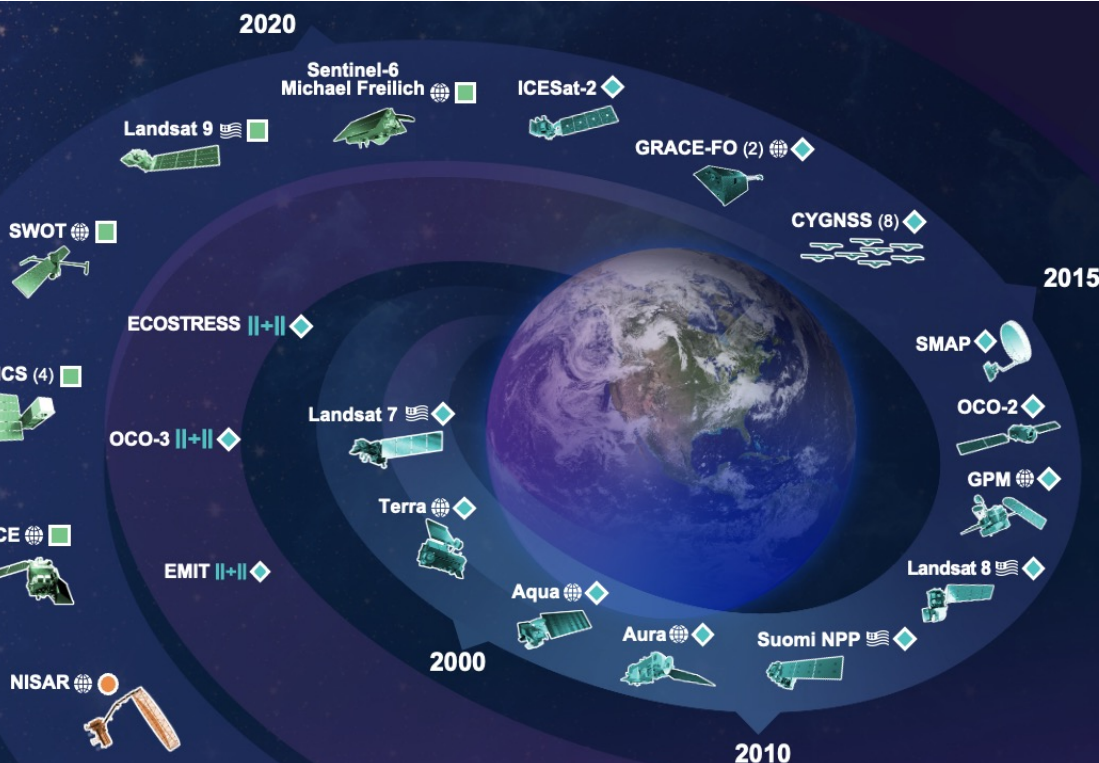
ISS INSTRUMENTS

MISSIONS

Earth System Explorers (ESE)
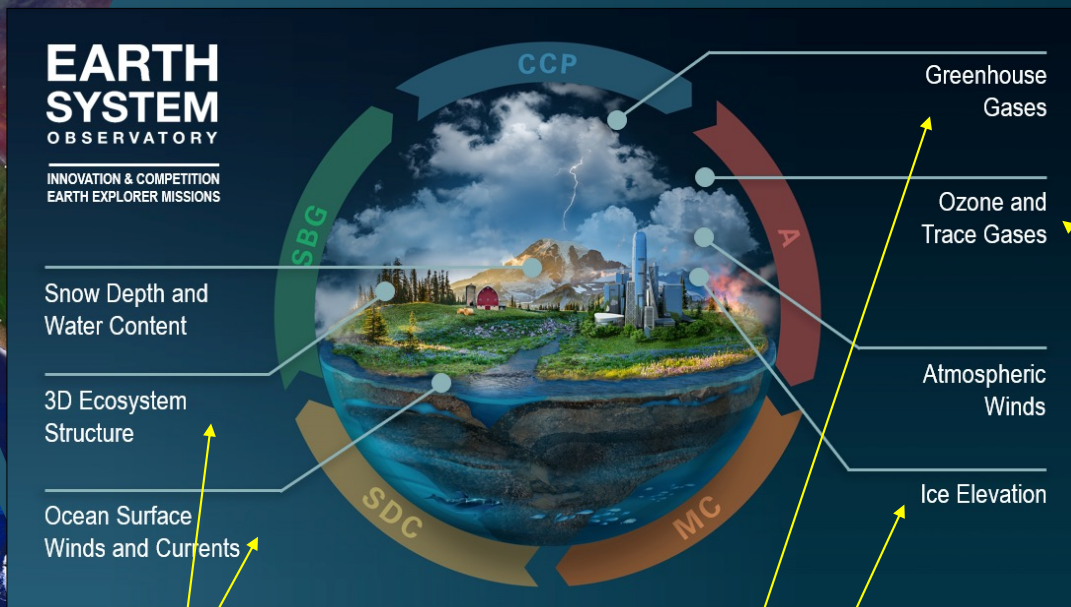
EARTH SYSTEM OBSERVATORY

- Draft Announcement of Opportunity (AO) released on Dec 6, 2022
- Final AO was released May 2, 2023
- PI-Managed Mission Cost (PIMMC) cap of $310M (FY24 $)
- NASA will provide launch vehicle services
- Two-step selection process
- Initial selection announced May 7, 2024:

The Stratosphere Troposphere Response using Infrared Vertically-Resolved Light Explorer (STRIVE)
The Ocean Dynamics and Surface Exchange with the Atmosphere (ODYSEA)
Earth Dynamics Geodetic Explorer (EDGE)
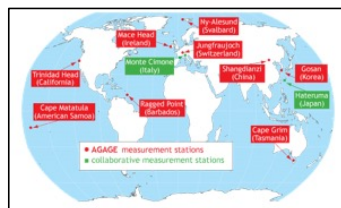**The Carbon Investigation (Carbon-I)**

NASA Earth System Science
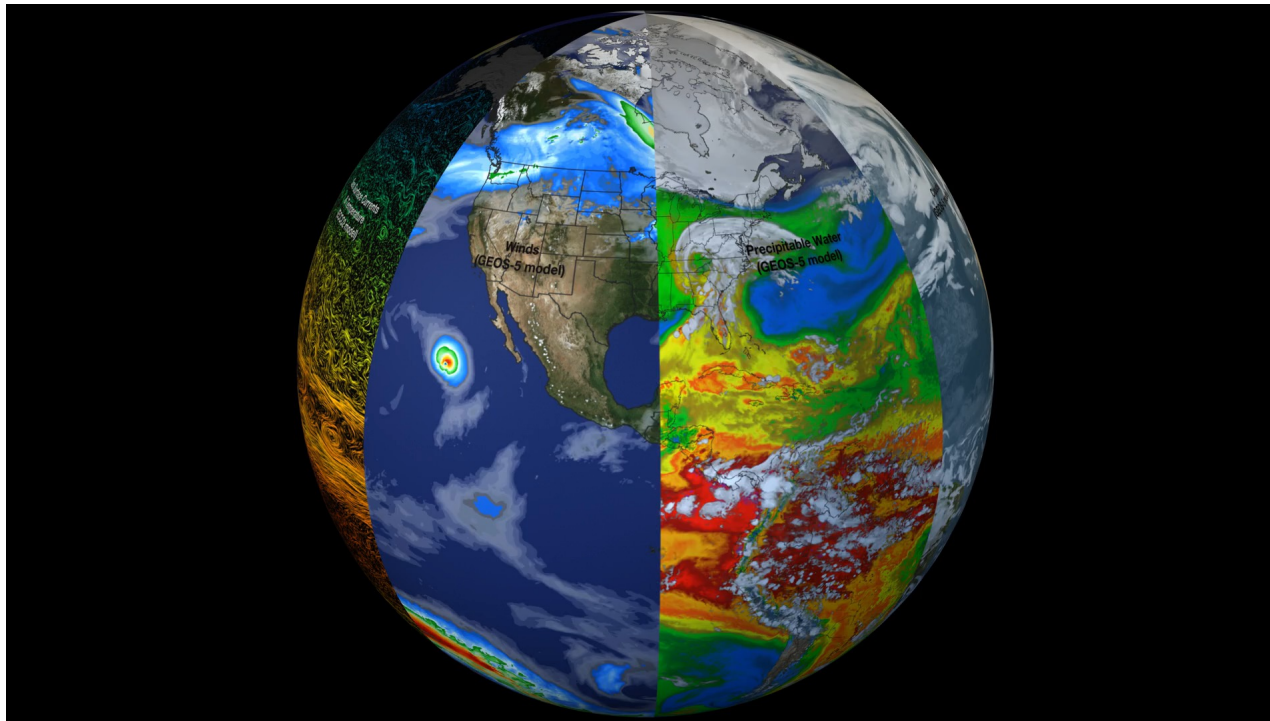
Atmospheric Composition   Earth Surface and Interior
Water and Energy Cycle   Weather and Atmospheric Dynamics
Carbon Cycle and Ecosystems   Climate Variability and Change
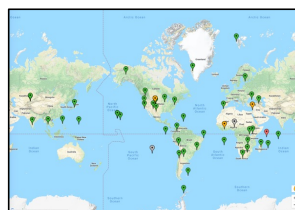NASA Scientific Visualization Studio svs.gsfc.nasa.gov/30701
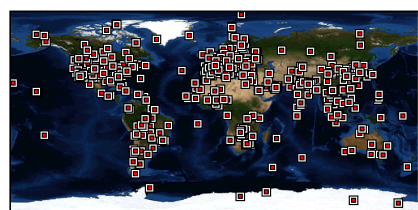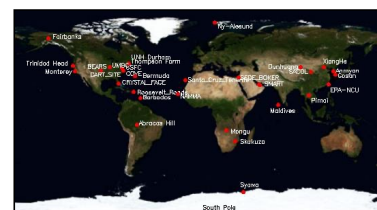
Examples of NASA-Supported Ground Networks
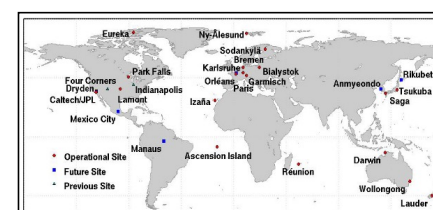
AGAGE

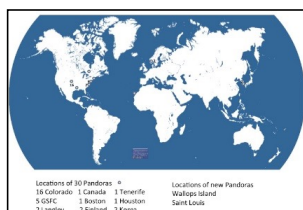GGN

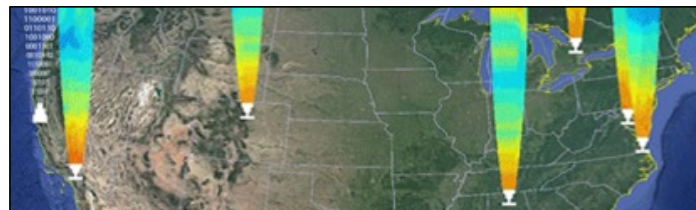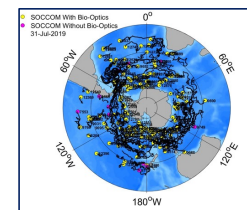NDACC

NSGN

AERONET

SHADOZ

MPLNet

TCCON

PANDORA

TOLNet

SOCCOM

Earth Venture Suborbital-4 Selected Mission Concepts

Mission	Focus Area	Location(s) Prop.	Platform(s) Prop.	Leadership Team	Size*
PYRocumulonimbus EXperiment (PYREX)	Weather and Atmospheric Dynamics	Palmdale, CA Boise, ID Cold Lake, Alberta	ER-2 WB-57 (or GV) (or perhaps all on B777)	PI: David A. Peterson, Naval Research Laboratory - Monterey, Mid-Career DPI: Neil Lareau, University of Nevada, Reno, Early Career DPI: Olga Kalashnikova, Jet Propulsion Laboratory, Late-Career.	Big
Snow4Flow	Climate Variability and Change	Alaska, Arctic Canada, Greenland and Svalbard	DHC-6 Twin Otter DC3-T Basler DHC-4T Turbo Caribou	PI: John W. Holt, University of Arizona, Late-Career DPI: Lauren C. Andrews, NASA Goddard Space Flight Center, Early-Career DPI: Joseph A. MacGregor, NASA Goddard Space Flight Center, Mid-Career	Big
Landslide Climate Change Experiment	Earth Surface and Interior	California and Alaska	GIII	PI: Alexander Handwerger, Jet Propulsion Laboratory, Early-Career DPI: Noah Finnegan, University of California, Santa Cruz, Mid-Career DPI: Seung-Bum Kim, Jet Propulsion Laboratory, Late-Career	Small
Hemispheric Airborne Measurements of Air Quality (HAMAQ)	Atmospheric Composition	Mexico (Veracruz Ariport) South Korea (Osan Air Base) Italy (Aviano Air Base)	GV P-3B (Y2/3), B777 (Y4)	PI , James H. Crawford, NASA Langley Research Center, Late Career DPI - Laura Judd, NASA Langley Research Center, Early Career DPI - Brian McDonald, NOAA Chemical Sciences Laboratory, Early Career	Small
Nitrogen and Carbon Terrestrial Fluxes: Agriculture, Atmospheric Composition, and Ecosystems (NTERFAACE)	Atmospheric Composition	Palmdale, CA Lincoln, NE	P-3 or B777 B200, C-23 Sherpa, or King Air	PI: Glenn Wolfe, NASA GSFC, Mid-Career DPI: Emily Fischer, Colorado State University, Mid-Career DPI: Jeffrey Geddes, Boston University, Early Career	Small
FORTE: Arctic Coastlines – Frontlines Of Rapidly Transforming Ecosystems	Carbon Cycle and Ecosystems	Fairbanks, AK UAS from Deadhorse, AK	GV GIII (B200, Twin Otter) Drones	PI: Maria Tzortziou, City University of New York, Mid Career DPI: Antonio Mannino, NASA Goddard Space Flight Center, Late Career DPI: J. Blake Clark, NASA GSFC/UMBC, Early Career	Small

* Proposals selected as small will likely not utilize all locations and/or platforms

Key Types of International Engagement

Observations

- Bilateral cooperation in missions and related science
- Multi-lateral organizationally-mediated cooperation
- Field work (airborne, balloon, surface, shipborne)
- Surface-based measurement networks

Research, Applications, and Assessment

- Research: WCRP*, Future Earth
- Applications: UN/SDGs, Disasters
- Assessment: IPCC, WMO/UNEP, IPBES, WOA, AMAP
- Internationally-Focused Opportunities

Education and Capacity Building

- Education: GLOBE
- Capacity Building: SERVIR, ARSET, others

Photo Credit: RCMRD

* NASA supports GEWEX IPO, co-supports CliC IPO (with NSF), and AIMES (Future Earth) IPO, and co-supports GLP IPO (Future Earth, with NSF)