National Aeronautics and Space Administration

NASA earth

# NASA Water and Energy Cycle Focus Area Support for Snow Remote Sensing Science

**Craig Ferguson and Jared Entin**
Earth Science Division R&A Program

**NASA Community Snow Meeting**
August 14, 2024

# NASA HQ Earth Science Division Leadership

**Karen St. Germain**
Division Director

**Julie Robinson**
Deputy Director

**Sid Boukabara**
Senior Program Scientist, Strategy

**Lawrence Friedl**
Senior Engagement Officer

**Wendy Mihm**
Communications Lead

## ELEMENTS

### Earth Science Technology Office

**Michael Seablom**
Associate Director

**Vacant**
Deputy Associate Director

### Flight Programs

**Scott Schwinger**
Associate Director (Acting)

**Antonios Seas**
Deputy Associate Director

### Earth Science Data Systems

**Katie Baynes**
Earth Data Officer

**Vacant**
Deputy Earth Data Officer

### Research & Analysis

**Jack Kaye**
Associate Director

**Lucia Tsaoussi**
Deputy Associate Director

**David Considine**
Rotational Deputy

### Earth Action

**Thomas Wagner**
Associate Director

**Emily Sylak-Glassman**
Deputy Associate Director

NASA earth

04.17.2024

Jared, Craig, +16


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

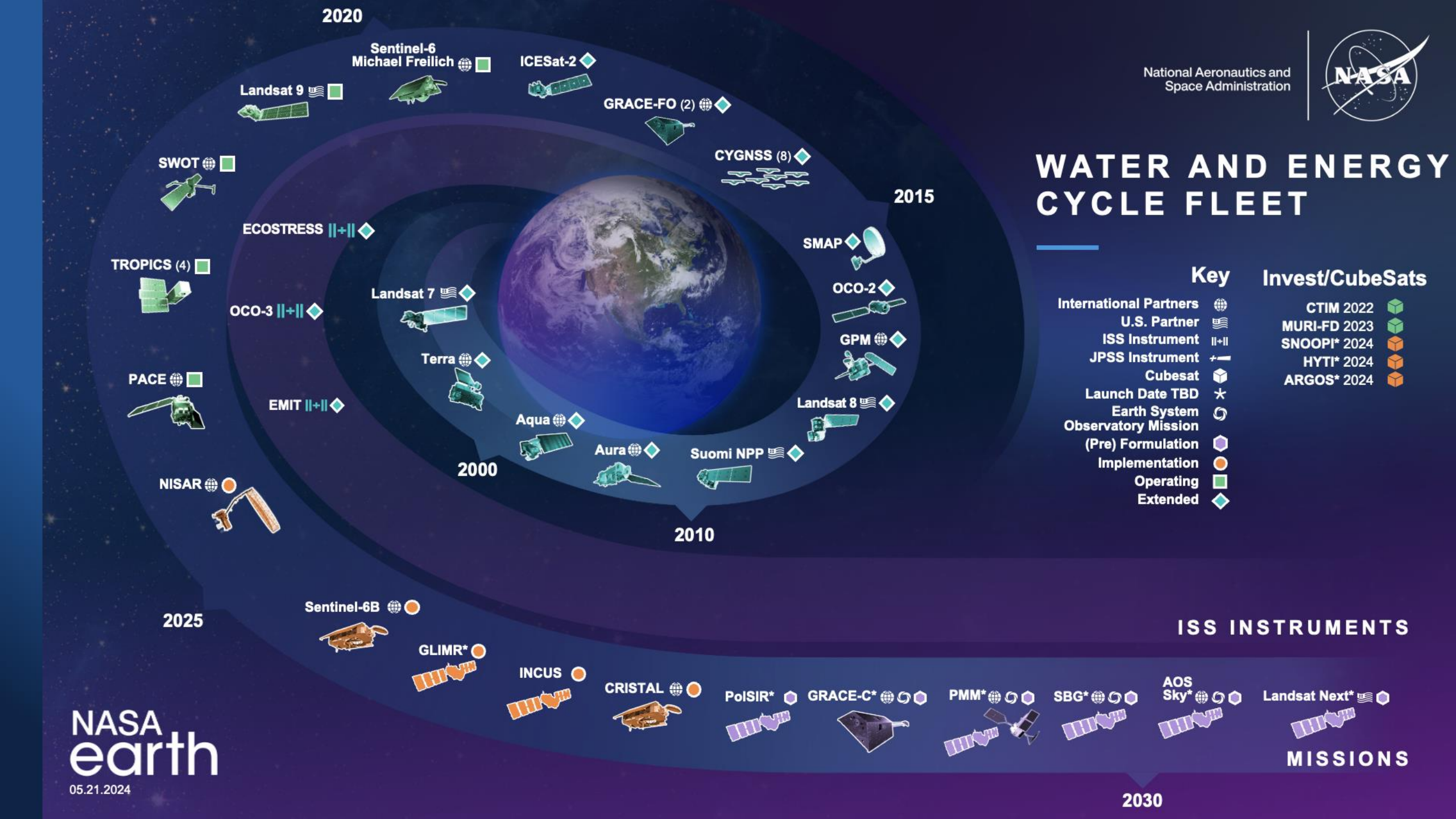
- MURI-FD 2023
- SNOOPI 2024
- ARGOS* 2024
- ARCSTONE* 2025
- GRITSS* 2025
- GRATTIS* 2026

## JPSS Instruments

- OMPS-LIMB 2022
- LIBERA 2027
- OMPS-LIMB 2027
- OMPS-LIMB 2032

NASA earth

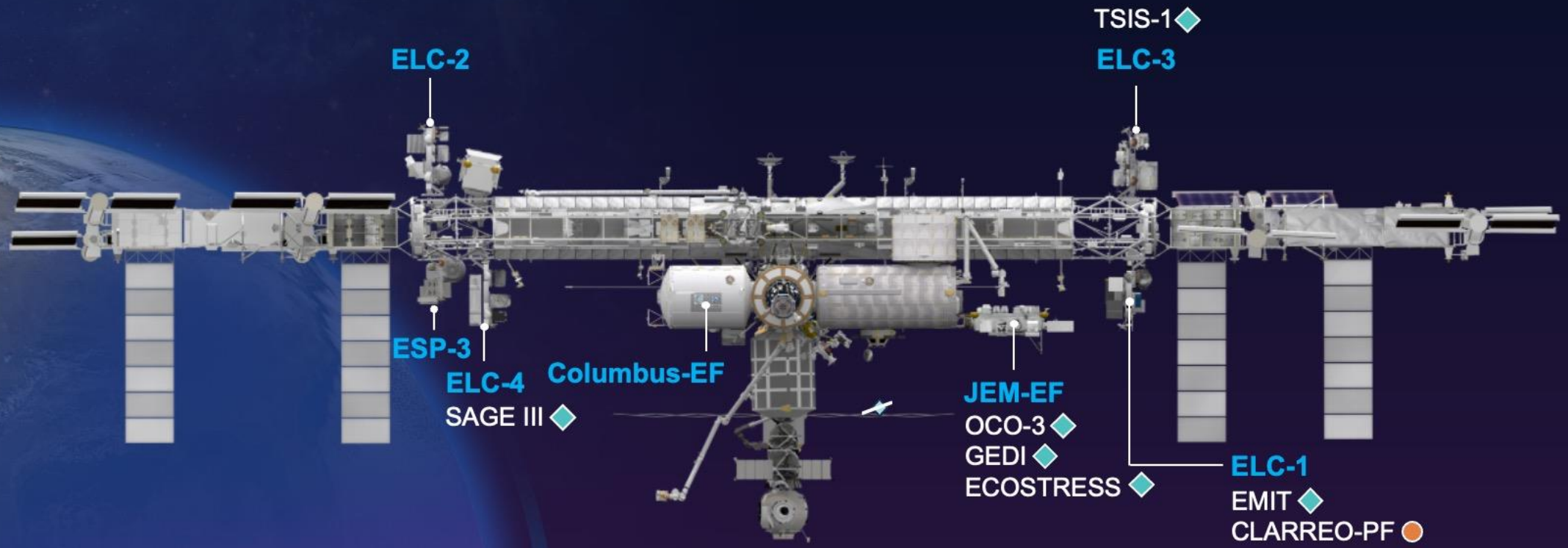
07.11.2024


2020
Sentinel-6 Michael Freilich
ICESat-2
Landsat 9
GRACE-FO (2)
CYGNSS (8)
SWOT
2015
ECOSTRESS
SMAP
TROPICS (4)
OCO-2
Landsat 7
OCO-3
GPM
Terra
PACE
Landsat 8
EMIT
Aqua
Aura
Suomi NPP
2000
NISAR
2010
2025
Sentinel-6B
GLIMR*
INCUS
CRISTAL
PolSIR*
GRACE-C*
PMM*
SBG*
AOS Sky*
Landsat Next*
ISS INSTRUMENTS
MISSIONS
2030
National Aeronautics and Space Administration
NASA
WATER AND ENERGY CYCLE 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
CTIM 2022
MURI-FD 2023
SNOOPI* 2024
HYTI* 2024
ARGOS* 2024
NASA earth
05.21.2024

# International Space Station

## Earth Science Operating Missions

(Pre) Formulation
Implementation
Primary Ops
Extended Ops




EXPRESS Logistics Carriers: ELC-1, ELC-2, ELC-3
External Stowage Platforms: ESP-3
Columbus External Payload Facility: Columbus-EF
Kibo External Payload Facility: JEM-EF

NASA earth

07.11.2024

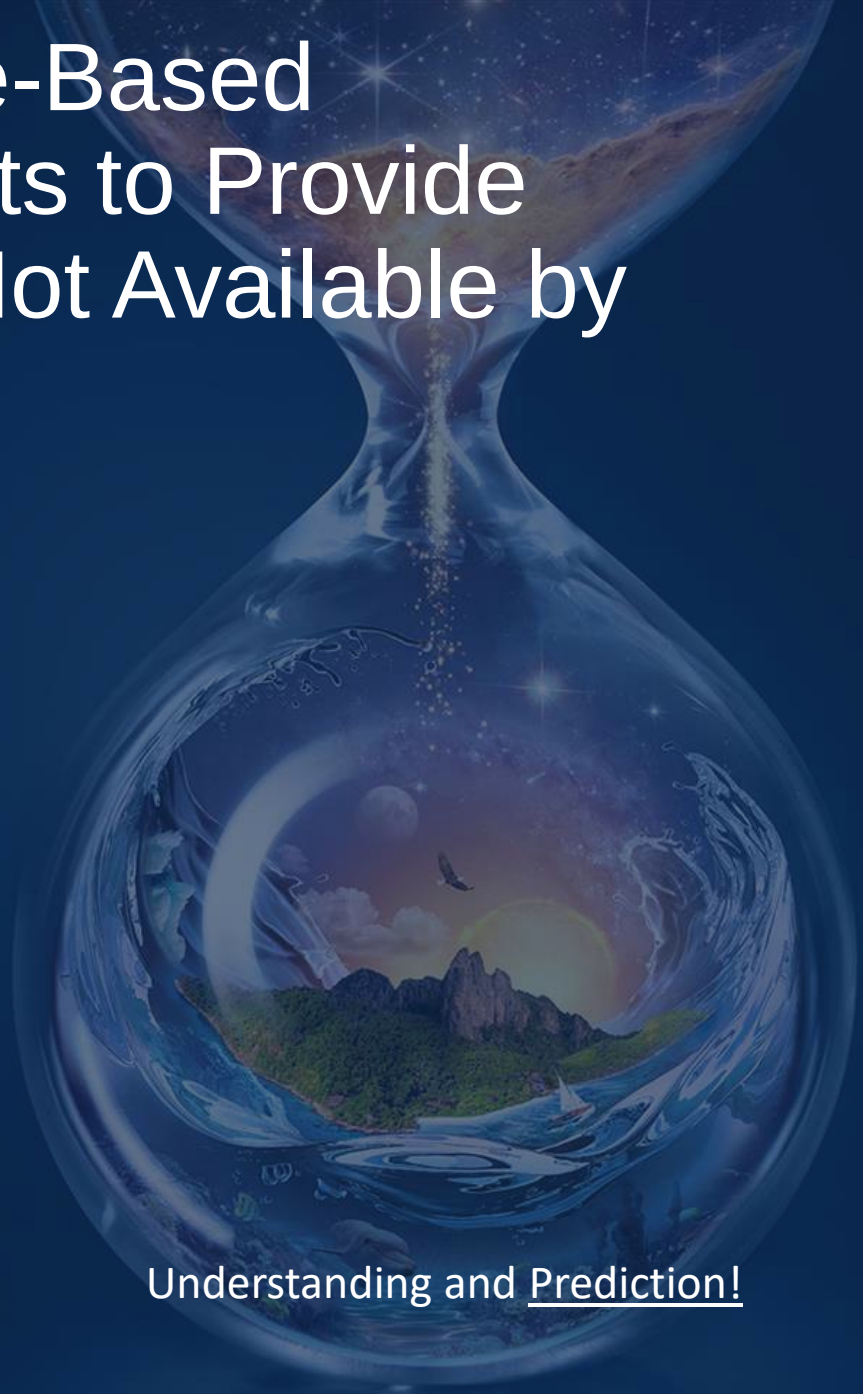
# NASA Earth Science Airborne Fleet

Newest Addition to Fleet – B-777– will replace DC-8 after retirement!

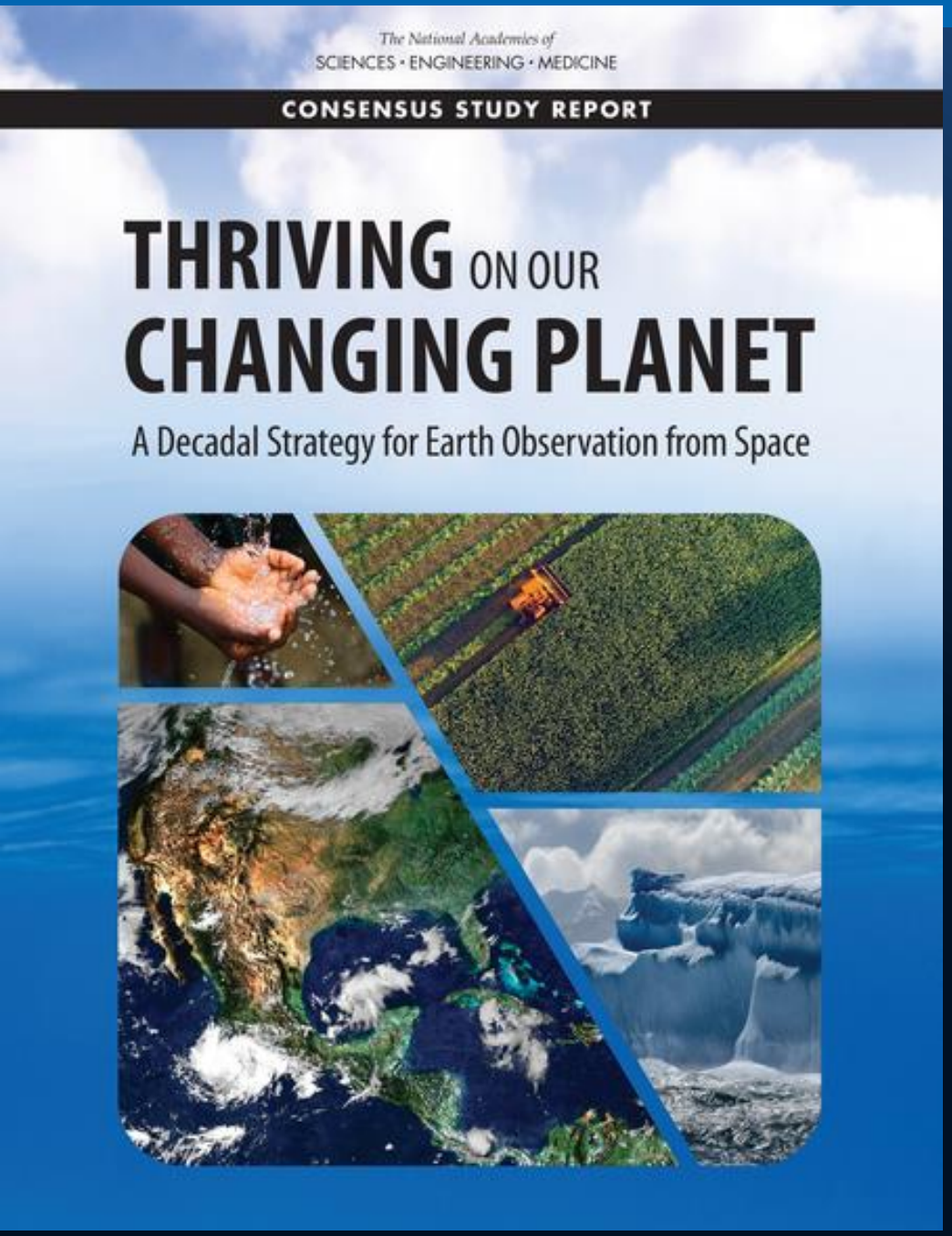
# Use of Space-Based Measurements to Provide Information Not Available by Other Means

Improving:

- Understanding changes in Earth's radiation balance
- Prediction of weather and climate extremes
- Detection and prediction of changes in Earth's ecosystems
- Prediction of the coupled global water, carbon, and energy cycle response to climate change and variability
- Predict interactions and feedbacks between ocean, atmosphere, land, and ice
- Benefit to society



Understanding and Prediction!




# NASA ESD Responds to NASEM 2017 Decadal Survey

- Increase the impact of Earth science for the response to climate change (ES2A)

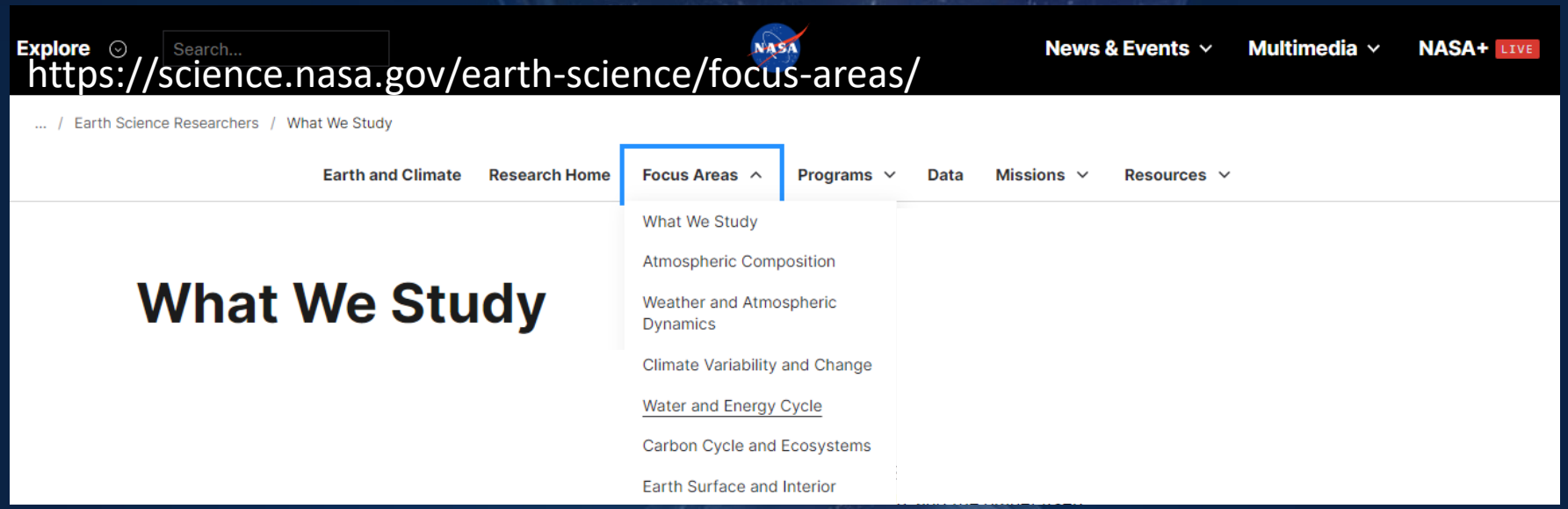
- "Pursue increasingly ambitious objectives and innovative solutions that enhance and accelerate the science/applications value of space-based Earth observations and analysis to the nation and the world in a way that delivers great value, even when resources are constrained, and ensures that further investment will pay substantial dividends."

Snow albedo is "Designated", hence SBG
Snow depth and SWE are "Explorer" Observables, hence ESE

- *- Thriving on Our Changing Planet: A Decadal Survey for Earth Observations from Space, 2017*

NASA earth

# Water and Energy Cycle Focus Area





Program Managers
Jared Entin and Craig Ferguson


## Programs

Terrestrial Hydrology
High Mountain Asia
S2S Hydrometeorological Prediction
NASA Energy and Water Cycle Study

## Current Missions

NISAR (launch early 2025)
GPM
GRACE-FO
SMAP
SWOT
SNOOPI*

## Recent Field Campaigns

SMAPVEX
SnowEX
SLAP-LIAISE

## Related Programs (non-exhaustive)

Modeling, Analysis, and Prediction
Earth Science U.S. Participating Investor
Remote Sensing Theory
Making Earth Science Data Records for Use in Research Environments (MEaSUREs)
NASA Interdisciplinary Research in Earth Science (IDS)
Earth Action: Water Resources
Earth Action: Agriculture
Future Investigators in NASA Earth and Space Science and Technology (FINESST)

GEWEX International Project Office Support
NASA Goddard Institute for Space Studies (GISS) Climate Model
NASA Global Modeling and Assimilation Office GEOS S2S Model and MERRA Reanalysis

NASA earth

# Water and Energy Cycle Focus Area

"Resolving all fluxes of water and the corresponding energy fluxes involved with phase changes."

- How are global precipitation, evaporation, and cycling of water changing?
- What are the effects of clouds and surface hydrologic processes on Earth's climate?
- How are variations in local weather, precipitation, and water resources related to global climate variation?
- What are the consequences of land cover and land use change for human societies and sustainability of ecosystems?
- How can weather forecast duration and reliability be improved?
- How can prediction of climate variability and change be improved?
- How will water cycle dynamics change in the future?

Time →

Weather and Atmospheric Dynamics → Water and Energy Cycle → Climate Variability and Change

Diurnal cycle, but seasonal to interannual variability

# Earth Science to Action Strategy (April 2024 → )


**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

0213.2024

# Expected Outcomes of the Community Snow Workshop

Community Meeting Report in *EOS*

DS white paper team building

- Review lessons learned through SnowEx and the two ESE proposals, maintain community organization and momentum
- Identify and prioritize untapped SnowEx data analysis opportunities; continue to demonstrate NASA return on investment
- Roadmap and renewed justification for a snow depth/SWE mission. Define how it is “NASA unique”
  - Clarify future of SWESARR (or similar) and build consensus on priority future airborne field campaigns/instrument development/instrument demonstrations→concept maturity
  - Revisit science and applications (ES2A) measurement requirements; work with JPL and NASA engineering teams on design matrix; hone mission in the context of Integrated Earth Observing System and Earth System prediction
  - Participate in related international snow mission development; build interdisciplinary partnerships/activities to broaden support base and elevate mission priority (i.e., GEWEX, CLIC)

# Future opportunities (or diversions) for the U.S. Snow Remote Sensing Community

## 1. NASA EOS

2025: NASA-ISRO L-band SAR (**NISAR**)

2028, 2032: **SBG TIR** and **VSWIR**

## 2. NASA Earth System Explorers 2030-2032 (2025/26 down-select)

Phase 1: Earth Dynamics Geodetic Explorer (**EDGE**) Observe the three-dimensional structure of terrestrial ecosystems and the surface topography of glaciers, ice sheets, and sea ice as they are changing in response to climate and human activity. The mission would provide a continuation of such measurements that are currently measured from space by ICESat-2 and GEDI (Global Ecosystem Dynamics Investigation).

## 3. ESA Earth Explorer Program 2033-2034 (2026 down-select)

**CryoRad** low-frequency passive-microwave brightness temperatures using a novel broadband radiometer to estimate: temperature profile of ice shelves, sea-ice thickness and sea-surface salinity. The mission would complement the upcoming Copernicus CIMR (SST, sea ice, salinity), CRISTAL (sea ice thickness) and ROSE-L missions (sea ice, glaciers).

## 4. CSA Terrestrial Snow Mass Mission (TSMM; Derksen et al.) dual-frequency Ku-band synthetic aperture radar

## 5. Quantum Compute Snow Lidar (Yongxiang Hu et al.)

ESTO EARTH SCIENCE TECHNOLOGY OFFICE

## 6. Commercial snow missions

## 7. 2027 Decadal Survey

# 2027 Decadal Survey

?

How will Snow depth and SWE be prioritized?

- No 2017 Decadal missions have launched yet. Just had the midterm review.
- Have any Earth observational priorities and/or technologies changed?
- Unknown DS format, but more applications (ES2A)-driven prioritization is to be expected based on new CNES and ESA EOS Strategy Documents
- Also, more competed missions expected and commercial satellite data buys (that are more internationally coordinated)

# Future NASA Funding Opportunities (non-exhaustive)

R&A
1. Terrestrial Hydrology Program
2. Early Career Investigator Program
3. Earth Science U.S. Participating Investigator Program
4. Modeling, Analysis and Prediction Program
5. NISAR Science and Applications Team
6. SBG Science and Applications Team

Earth Action Water Resources

Earth Science Technology Office
1. In-Space Validation of Earth Science Technologies
2. Instrument Incubator Program

SMD-wide
1. FINESST
2. TWSC
3. NPP

Available for further discussion @
Craig.R.Ferguson@nasa.gov

NASA earth

science.nasa.gov/earth

Your Home. Our Mission.