

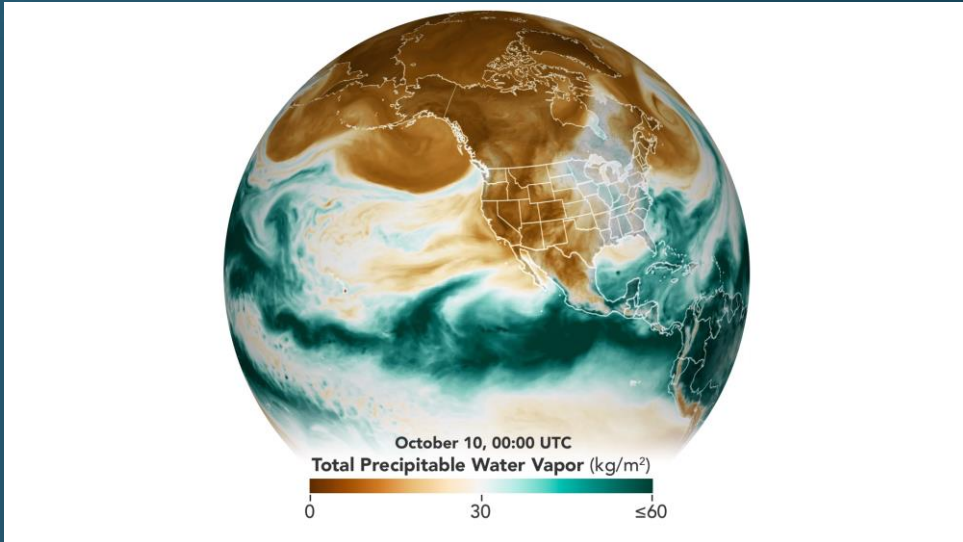


EXPLORE EARTH

Briefing to the Committee on Earth Science and Applications from Space (CESAS)

Karen St. Germain, PhD
Director, Earth Science Division
Science Mission Directorate, NASA

November 1, 2021



Earth Science Strategic Objectives

Advancing Earth System Science

- End-to-end capability, from launch to science to applications, delivering actionable science to decisionmakers at every level
- Highlights of Earth Science

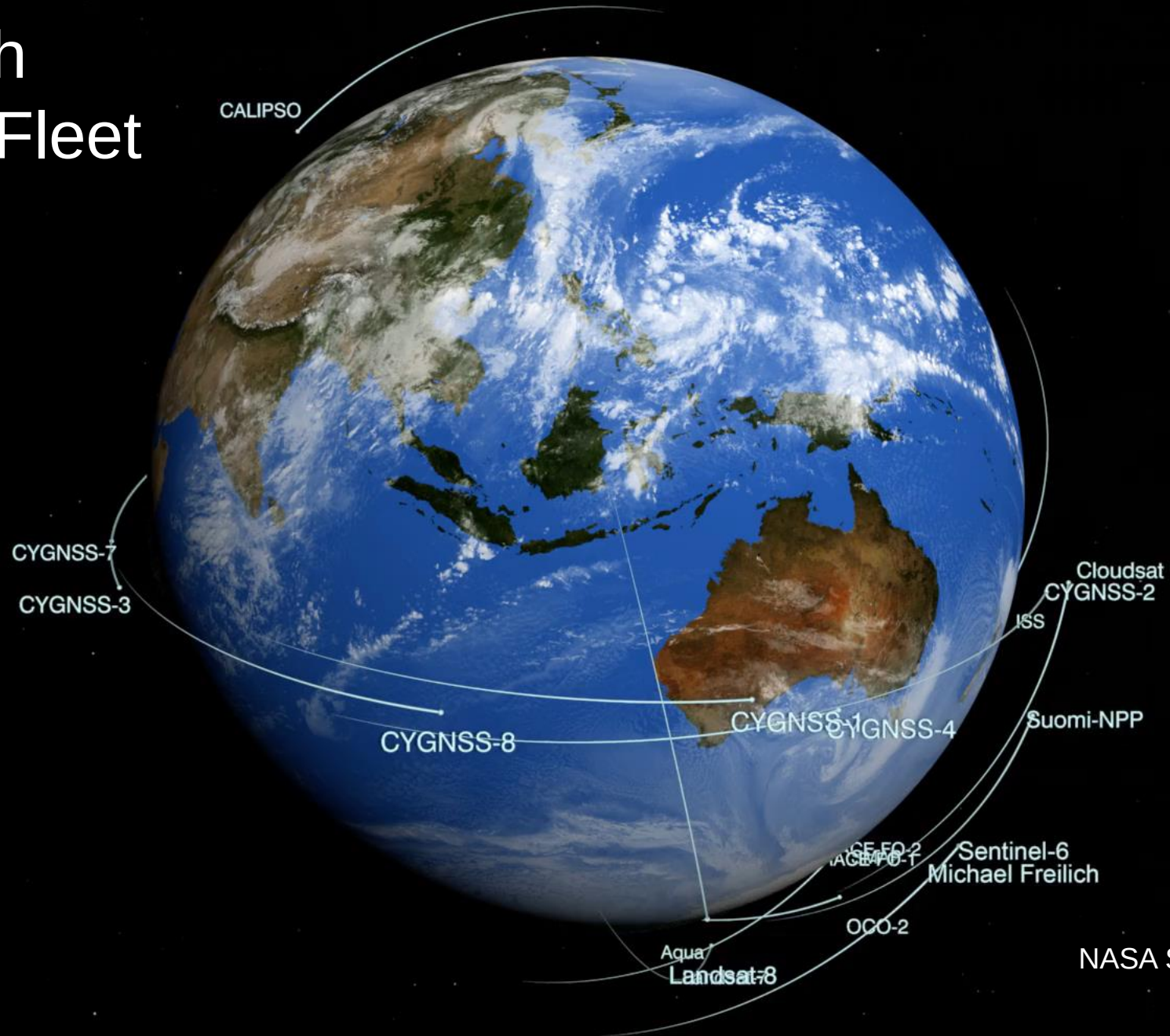
Strategic Objectives

- Delivering on Our Commitments: Flight
- Developing Next-Gen Capabilities: ESO & Tech Investments
- Building Bridges: Open-Source Science Initiative
- Power of Partnership: Accelerating Uptake of Applications

The background of the slide is a composite of two cosmic images. The top half features a dark blue and black space scene with a bright, glowing blue nebula on the right side and several distant stars. The bottom half shows a vibrant orange and yellow nebula on the left, transitioning into a greenish-blue space with more stars on the right. A dark blue horizontal band spans the middle of the image, containing the title text.

DELIVERING ON OUR COMMITMENTS: Advancing Earth Science Program of Record

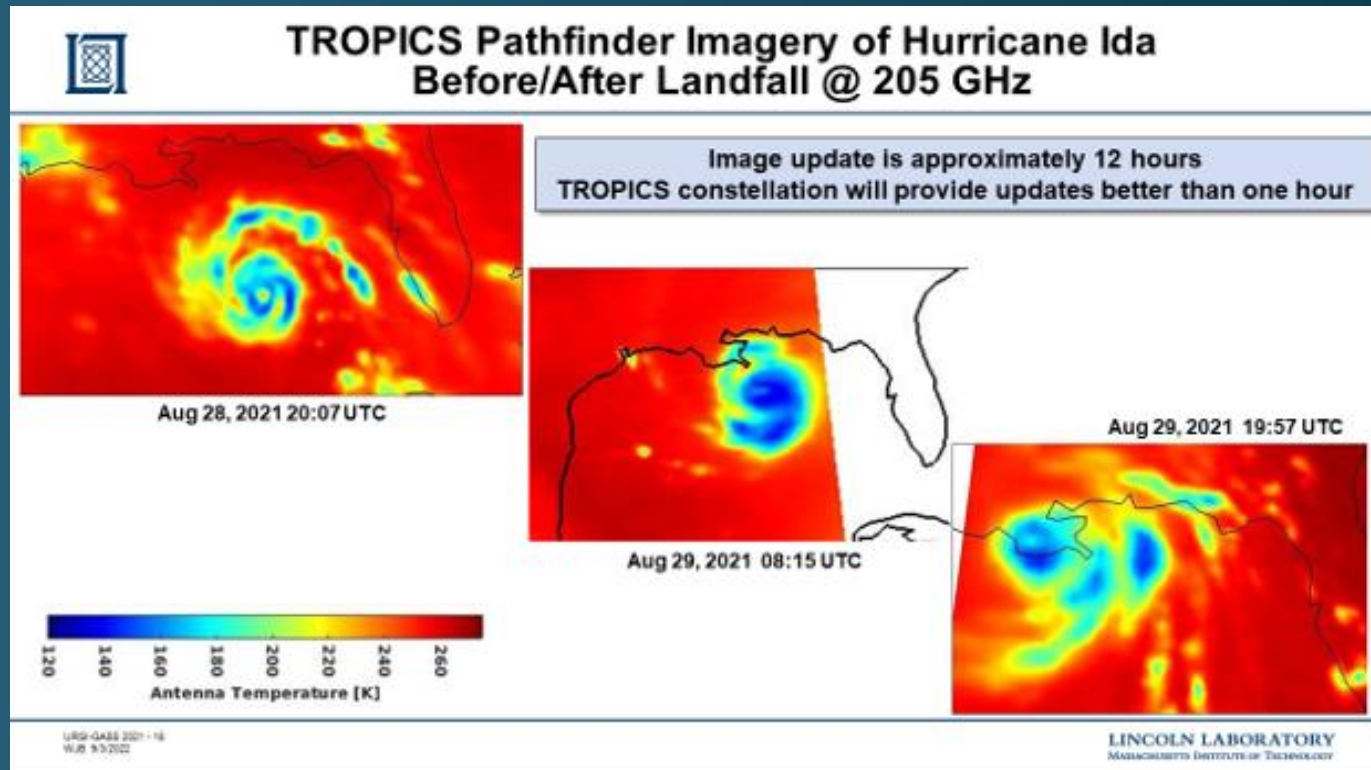
NASA Earth Observing Fleet



August 2021

NASA Scientific Visualization Studio
svs.gsfc.nasa.gov/4931

TROPICS Pathfinder Launched June 30



- Launched June 30, 2021; global first light images Aug. 8
- Captured images inside Hurricane Ida before and after landfall
- Six-constellation TROPICS mission to launch in 2022

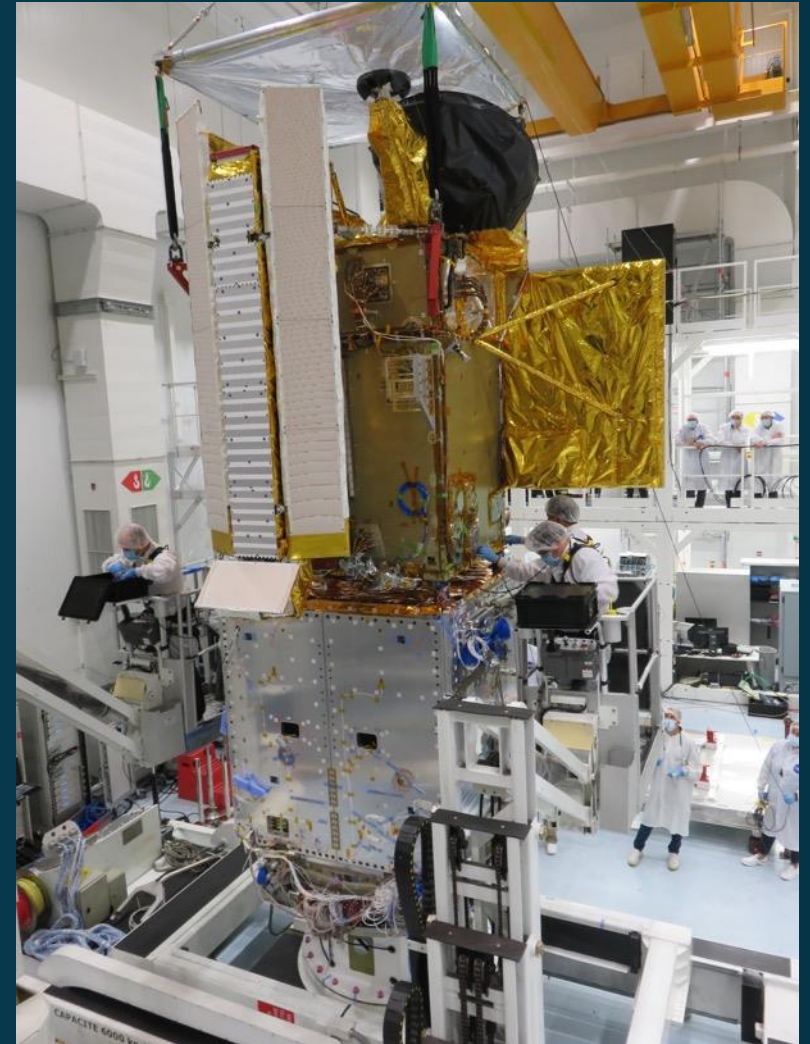
Landsat 9 Launched Sept. 27, 2021



- Launched Sept. 27 from Vandenberg Space Force Base
- On-orbit checkout continues with Oct. 2 power-up of its two instruments, OLI-2 and TIRS-2
- Continues nearly 50-year legacy of our most economically impactful mission with our USGS partners

SWOT Observatory I&T

- JPL payload left March AFB on a C-17 on June 27, arriving in Nice, France, on June 29 (stopover in Portsmouth, NH)
- Completed mechanical mating of the JPL payload to the Thales spacecraft bus on August 11
- Completed electrical integration in September, and progressing to environmental testing



Earth Science Flight Opportunities

Open solicitation/In review

Completed solicitation

Mission	Mission Type	Release	Selection	Major Milestone
EVS-1 (EV-1) (AirMoss, ATTREX, CARVE, DISCOVER-AQ, HS3)	5 Suborbital Airborne Campaigns	2009	2010	Completed KDP-F
EVM-1 (CYGNSS)	Class D SmallSat Constellation	2011	2012	Launched Dec. 2016
EVI-1 (TEMPO)	Class C Geostationary Hosted Instrument	2012	2012	Delivered to storage Dec. 2018
EVI-2 (ECOSTRESS & GEDI)	Class C & Class D ISS-hosted Instruments	2013	2014	Launched June & Dec. 2018
EVS-2 (ACT-America, ATOM, NAAMES, ORACLES, OMG, CORAL)	6 Suborbital Airborne Campaigns	2013	2014	CORAL, NAAMES, ORACLES completed KDP-F
EVI-3 (MAIA & TROPICS)	Class C LEO Hosted Instrument & Class D CubeSat Constellation	2015	2016	MAIA Delivery 2022; TROPICS Launch 2022
EVM-2 (GeoCarb)	Class D Geostationary Hosted Instrument	2015	2016	Launch TBD
EVI-4 (EMIT & PREFIRE)	Class C ISS-hosted Instrument & Class D Twin CubeSats	2016	2018	Delivery NLT 2021
EVS-3 (ACTIVATE, DCOTTS, IMPACTS, Delta-X, SMODE)	5 Suborbital Airborne Campaigns	2017	2018	Passed Initial Confirmation Review, 2 began deployments
EVI-5 (GLIMR)	Class C Geostationary Hosted Instrument	2018	2019	Delivery NLT 2024
EVC-1 (Libera)	Class C JPSS-Hosted Radiation Budget Instrument	2018	2020	Delivery NLT 2025
EVM-3	Full Orbital	2020	2021	Launch ~2026
EVI-6	Instrument Only	2021	2022	Delivery NLT 2027
ESE	Explorer Mission	2022	2024	Launch ~2029 & ~2031
EVC-2	Continuity Measurements	2023	2024	Delivery NLT 2028
EVS-4	Suborbital Airborne Campaigns	2023	2024	N/A
ESE	Explorer Mission	2024	2026	Launch TBD
EVI-7	Instrument Only	2024	2025	Delivery NLT 2030
EVM-4	Full Orbital	2024	2025	Launch ~2030
EVC-3	Continuity Measurements	2026	2027	Delivery NLT 2031
EVS-5	Suborbital Airborne Campaigns	2027	2028	N/A

EVS

Sustained sub-orbital investigations
(~4 years)

EVM

Complete, self-contained, small missions
(~4 years)

EVI

Full function, facility-class instruments Missions of Opportunity (MoO)
(~3 years)

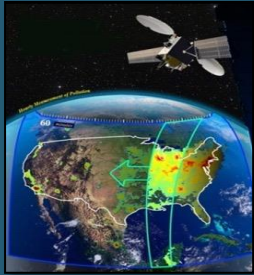
EVC

Complete missions or hosted instruments targeting “continuity” measurements
(~3 years)

ESE (NEW)

Medium-size instruments and missions
(~2 years)

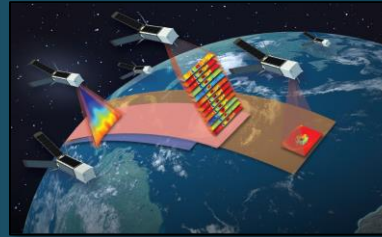
Earth Science Flight Opportunities



EVI-1
TEMPO



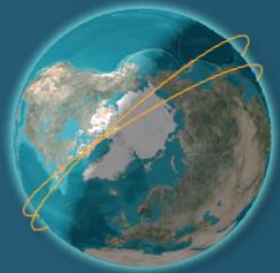
EVI-2
GEDI & ECOSTRESS



EVI-3
TROPICS



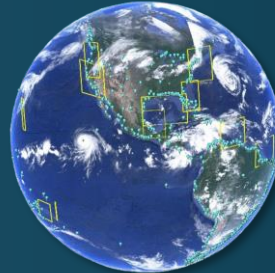
EVI-3
MAIA



EVI-4
PREFIRE



EVI-4
EMIT



EVI-5
GLIMR

EVI-6

- PI-Managed Mission Cost (PIMMC) cap of \$37M (FY24 \$)
- NASA will determine platform/launch vehicle
- Solicits only Class D Instrument and CubeSat proposals

The background of the slide is a cosmic scene. The top half features a dark blue space with a bright blue nebula on the right and several stars. The bottom half is a gradient of orange and yellow, also filled with stars and some faint nebulae. A dark blue horizontal band across the middle contains the title text.

DEVELOPING NEXT-GEN CAPABILITIES: Earth System Observatory & Tech Investments

EARTH SYSTEM OBSERVATORY

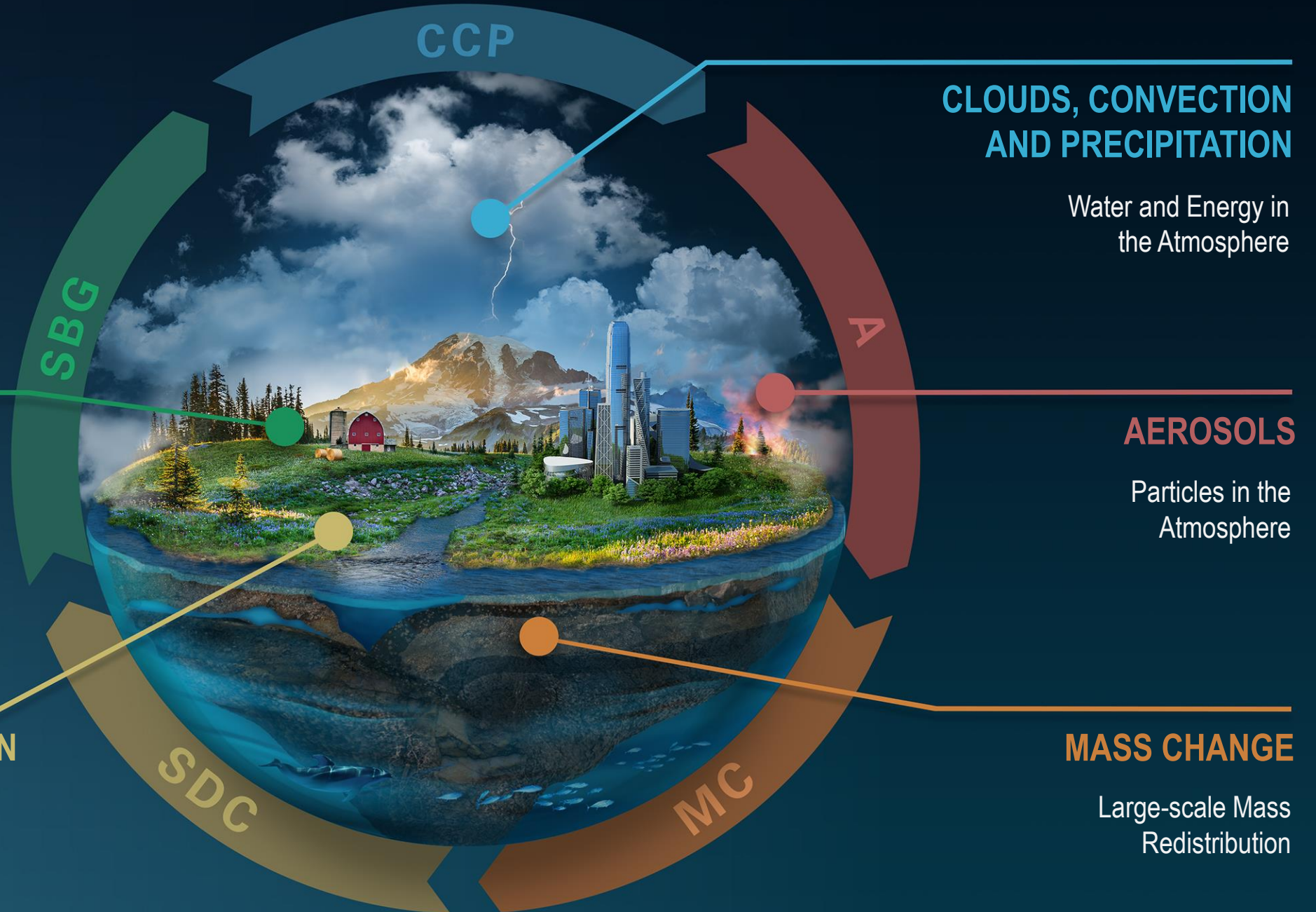
INTERCONNECTED
CORE MISSIONS

SURFACE BIOLOGY AND GEOLOGY

Earth Surface &
Ecosystems

SURFACE DEFORMATION AND CHANGE

Earth Surface Dynamics



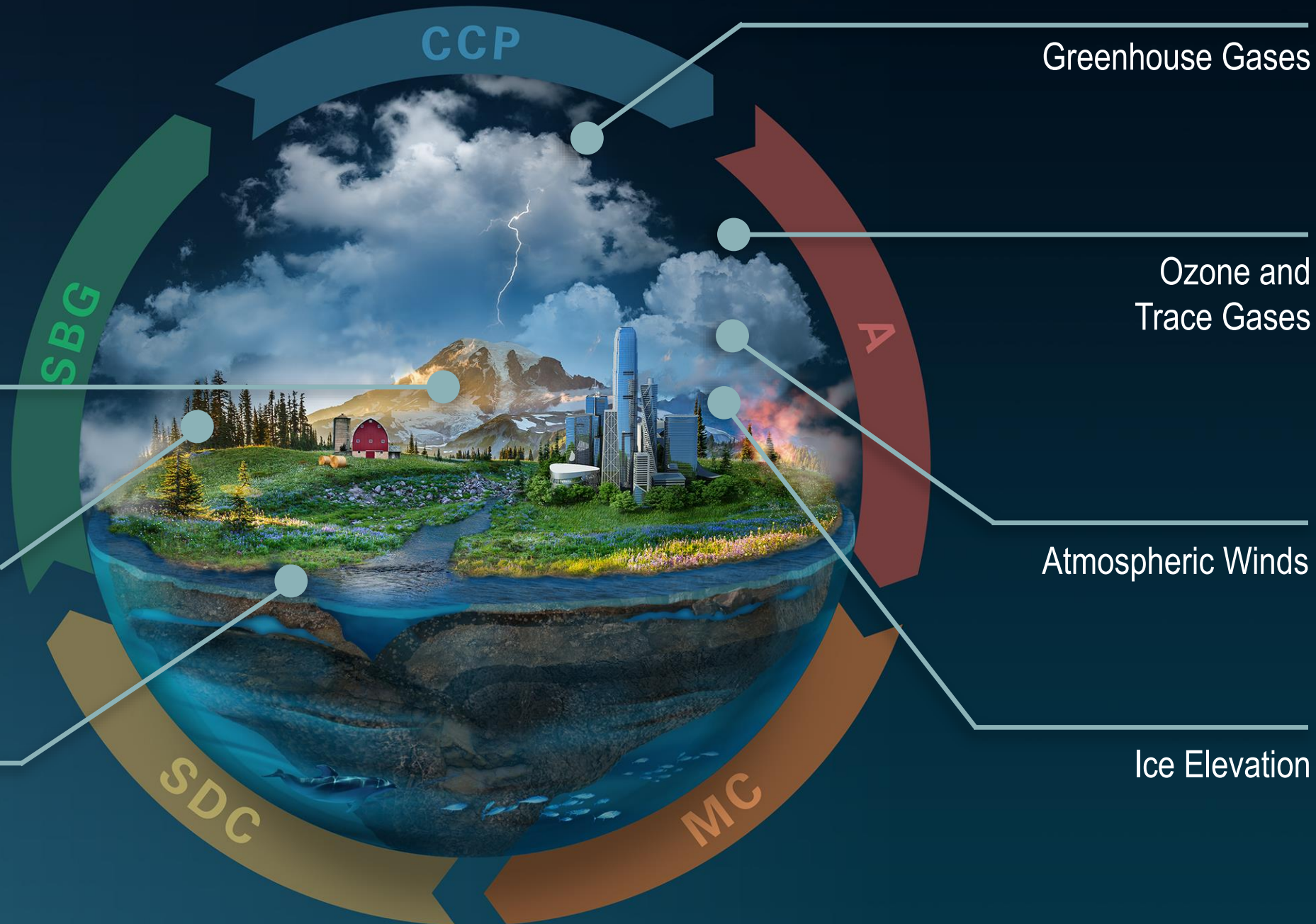
EARTH SYSTEM OBSERVATORY

INNOVATION & COMPETITION
EARTH EXPLORER MISSIONS

Snow Depth and
Water Content

3D Ecosystem
Structure

Ocean Surface
Winds and Currents



The background of the slide features a deep blue space scene. On the left side, there is a vertical sequence of celestial bodies: a yellow planet with rings (Saturn) at the top, followed by a reddish-brown planet (Mars), and a grey, cratered planet (the Moon) below it. At the bottom left, a portion of the Earth's blue and white horizon is visible. A bright yellow sun is partially obscured by the Earth's curve. The right side of the slide is a solid dark blue area where the text is located.

Five things to know about the ESO

- Before the end of this decade, NASA will put into orbit the Earth System Observatory
 - A single observation system comprised of five core satellite missions and three Earth Explorer missions
- The ESO is the heart of our implementation strategy for the Decadal Survey, addressing the most pressing questions about our changing planet posed by the Earth Science community through the National Academies' Decadal process
- The ESO builds on the capabilities of ESD's 23 operating missions and the 18 in development that make up the program of record
- Competitively selected Earth Explorer missions will bring innovation and additional key observations to the ESO
 - The private sector, academic community, and international space agencies will have significant roles in ESO success
- NISAR serves as a “trailblazer” for the ESO, addressing one of the five core observables, involving substantial international partnership, advancing open source science, and strongly coupling research and applied sciences

ESO and ESE Updates

ESE Community Announcement Issued Oct. 6, with Draft AO targeted for December

ACCP, MC and SBG continue in Pre-Phase A

- Conducting instrument RFIs (Requests for Information) and Mission Design Labs
- Meeting with international partners
- Preparing for Pre-ASMs (Acquisition Strategy Meetings)

Mission Concept Reviews

- MC scheduled for Feb 2022
- ACCP and SBG likely in Apr-Jun 2022

Earth System Explorers (ESE) *NEW*

- PI-Managed Mission Cost (PIMMC) cap of \$310M (FY24 \$)
- NASA will provide launch vehicle services
- Two-step selection process currently planned

Step 1 Selection

- 4 Proposals
- 9-month Phase A concept studies



Step 2 Selection

- 2 Missions
- Staggered phasing and funding

Earth Science Technology Opportunities

ESTO Opportunities in ROSES

CURRENT

IIP-21 (Instrument Incubator Program) closed; awards expected to be announced mid-Nov. 2021
Parminder Ghuman, Program Manager

DSI-21 (Decadal Survey Incubation) proposals received October 14th. Awards expected to be announced in Spring 2022
Bob Bauer, Program Manager

AIST-21 (Advanced Information Systems Technologies) Step-2 proposals due Nov. 30, 2021
Jacqueline Le Moigne, Program Manager

UPCOMING - Solicitations targeted for ROSES-22 release

ACT-22 (Advanced Component Technologies) Amber Emory, Program Manager

SLIT-22 (Sustainable Land Imaging Technology) Sachi Babu, Program Manager

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BUILDING BRIDGES: Open-Source Science Initiative

OPEN SCIENCE

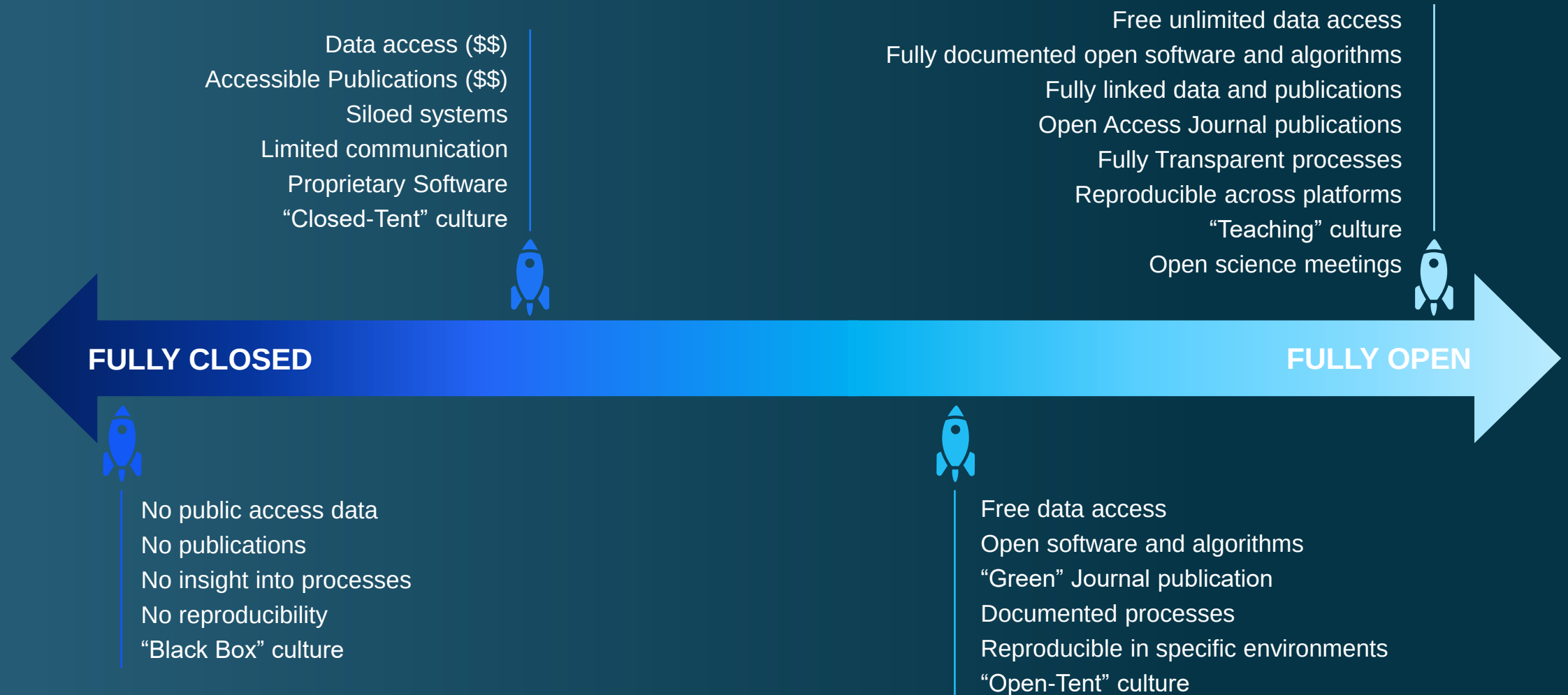
A collaborative culture of science to accelerate research and understanding, empowered by the open sharing of data, information, and knowledge



OPEN-SOURCE SCIENCE

Applying the concept of Open-Source Software to the scientific process, accelerating discovery by openly conducting science from project initiation through implementation

A Continuum of Open-Source Science





Recent Activities

- SMD Policy Directive-41 Released
- Developed Open-Source Science requirements for ESO mission
- Conducted 7 meetings with potential ESO partners
- Open Source Science Initiative Workshop (October 14, 2021)
- ESO Processing Study Workshop #1 (October 19-20, 2021)
- Environmental Justice Workshop (October 20, 2021)
- TOPS Github: <https://github.com/nasa/Transform-to-Open-Science>

Upcoming Activities

- RFI for SMD Policy Directive-41 amendments
- ESO Open-Source Science Workshops #2 (February 2022) and #3 (August 2022)

Open-Source Science Policy for Earth System Observatory

- A. All mission data, metadata, software, databases, publications, and documentation shall be available on a full, free, open, and unrestricted basis starting in Phase B with no period of exclusive access.
- B. Science workshops and meetings shall be open to broad participation and documented in public repositories.

1

Software shall be developed openly in a publicly accessible, version-controlled platform using a **permissive software license allowing for community use and contributions.**

4

Scientific data, metadata, software, publications and documentation **shall be archived and made available by NASA and/or [Partner] starting in Phase B.**

2

Manuscripts shall be published with open access licenses; versions of as-accepted manuscripts shall be made available as open preprints and deposited in a NASA or [Partner] **repository upon publication.**

5

NASA and [Partner] software, documentation and data shall be properly marked, cited, and/or attributed. Metrics to measure and acknowledge open-source science contributions will be developed.

3

All mission **data, calibration information, and simulated products supporting development and validation of algorithms shall be made available without any conditions to use.**

6

NASA and [Partner] will mutually develop an Open-Source Science Plan that specifies details of collaboration.

* Projects should release all information with open licenses unless exceptions are granted based on laws or regulations, including classified, ITAR, EAR and CUI restrictions. CSDO evaluates and approves or declines deviation requests by projects for NASA.

Transform to OPen Science (TOPS)



A 5-year effort focused on capacity building, partner engagement, and incentives to help accelerate scientific discovery through open science

Public Engagement

- **Designate 2023 as Year of Open Science**
- Partnering with professional orgs., publishing TOPS articles in high-impact journals
- Engage early with historically excluded communities
- TOPS GitHub

Capacity Building

- Create FAIR - Analysis-Ready Cloud-Optimized (ARCO) data
- Develop learning resources
- TOPS JupyterHub
- Host and sponsor events (summer schools, multi-day trainings, massive open online courses)

Incentives

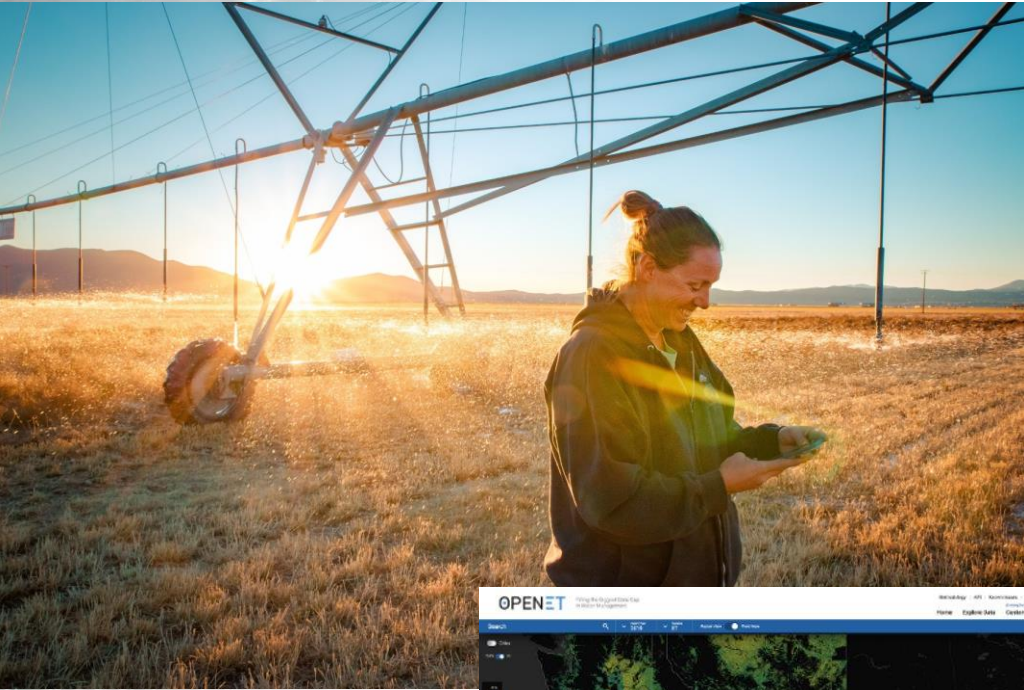
- Develop NASA Open-Source Science Awards program
- Leverage prizes and challenges and cross-division science use cases
- Increased citizen science activities



POWER OF PARTNERSHIP: Accelerating Uptake of Applications

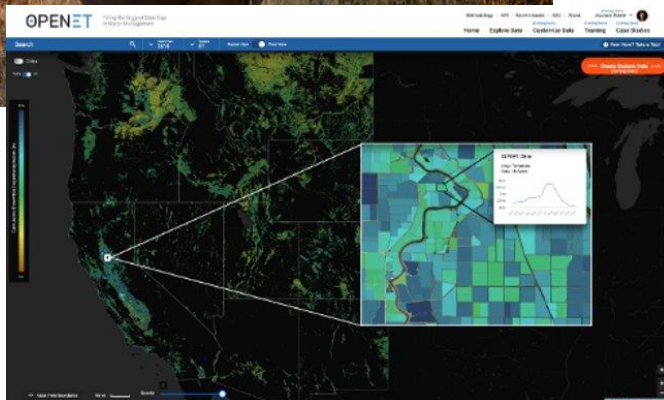


Filling the Biggest Data Gap in Water Management in the Western US



Above: Nevada farmer Denise Moyle will use OpenET to plan irrigation of her alfalfa fields

Right: Screenshot of OpenET platform



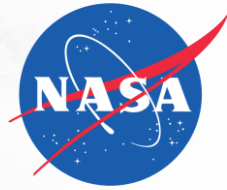
An operational system of freely-available NASA Earth data on evapotranspiration (ET) now in the hands of farmers and water resource managers

Also supports incentive-driven conservation programs and demand management in the Colorado River Basin and groundwater management in California

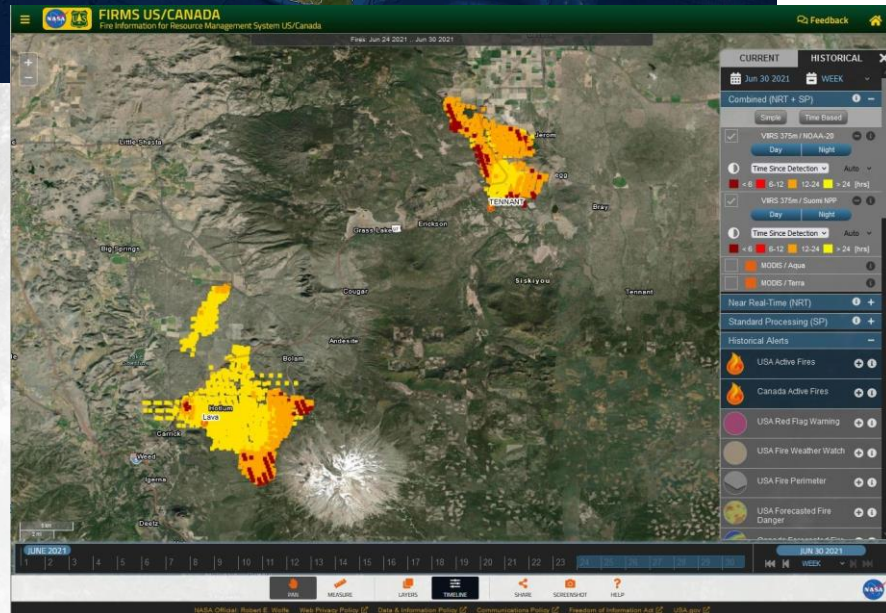
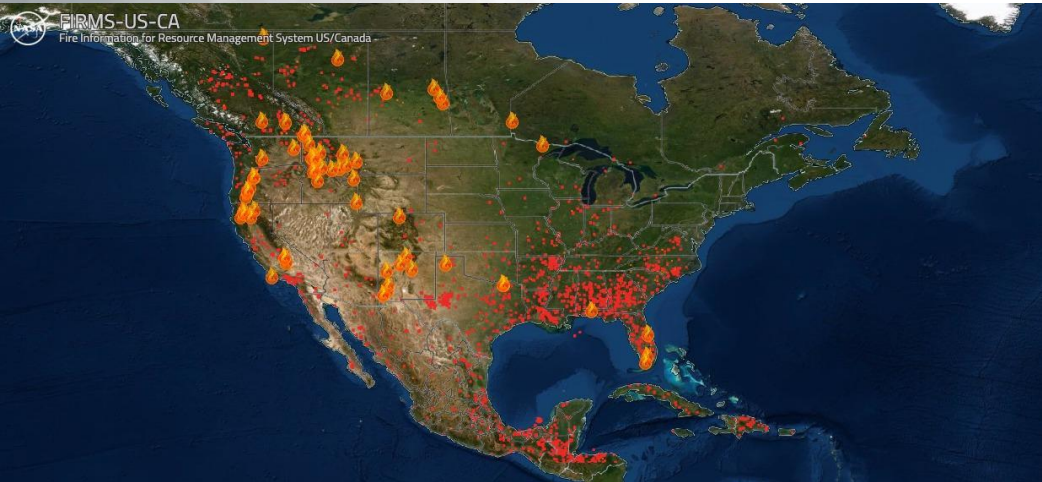
Provides data, primarily from the Landsat mission, at:

- daily, monthly and annual timesteps
- a spatial resolution of about one field, 30m x 30m





Helping to Identify the Location, Extent and Intensity of Wildfire Activity



Above: FIRMS screenshot of North America as of October 27, 2021

Right: SNPP and NOAA-20 VIIRS active fire detection locations in Northern California symbolized by their time since detection as of June 30, 2021

FIRMS (Fire Information for Resource Management System) tools and applications provide geospatial data, products and services to support strategic fire management needs and inform the general public.

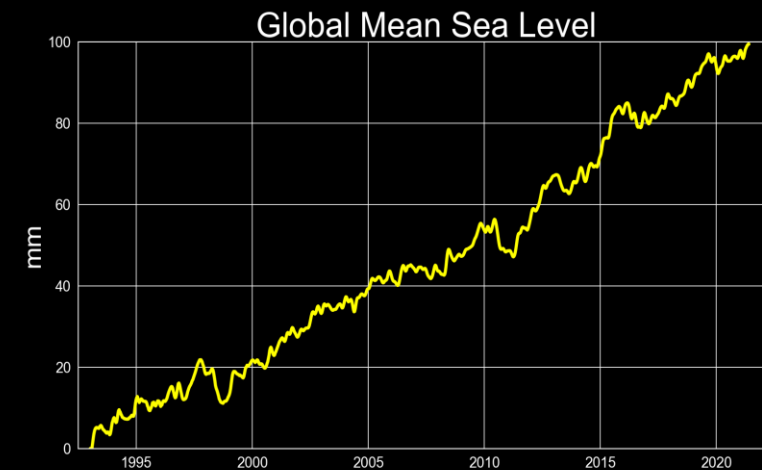
Enabled by NASA's Earth Observing System Data and Information System (EOSDIS), including NASA's Land, Atmosphere Near real-time Capability for EOS (LANCER), as well as data from the direct readout community.

- Joint effort by NASA and USDA Forest Service

Evidence of climate change: sea level

Rising seas are a major consequence of climate change, impacting coastal communities, infrastructure, and economy.

Source:
NASA/CNES/NOAA/EUMETSAT/ESA
TOPEX/Poseidon, Jason-1, 2, & 3,
Sentinel-6MF

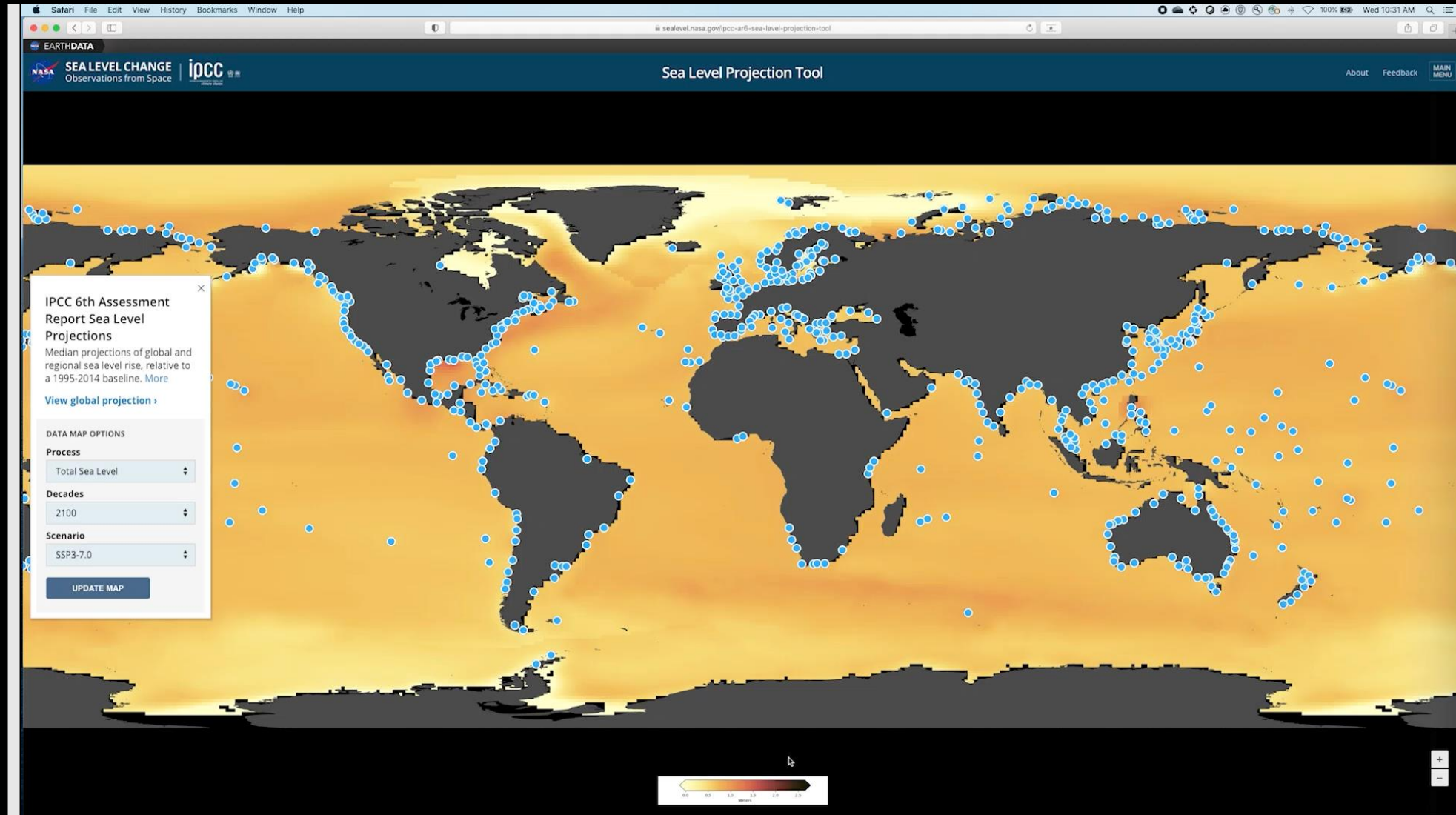


NASA Informs Actionable Climate Decision Making

NASA data and knowledge
are open and free, enabling
informed decision-making

Example: planning for sea
level rise on 10-100 year
horizons at your coastal city

<https://sealevel.nasa.gov>
(also at UNFCCC)

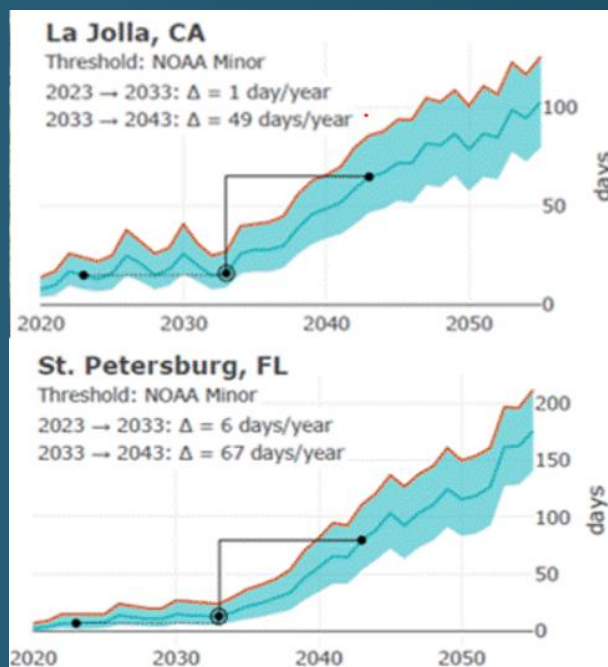


More Flooding Awaits U.S. Coastal Areas

Rising sea levels make “high-tide flooding” – when high tides spill into streets & lawns on sunny days – more likely & severe

A new study from the **University of Hawaii and JPL** predicts that a conjunction of tidal and ocean patterns, plus rising sea levels, will increase frequency of high-tide flooding for U.S. coastal areas in the 2030s and beyond

- An 18-year cycle in the Moon’s orbit will result in a greater pull on ocean tides, setting off the increase



The Takeaway:

- Slippery roads & flooded parking lots impact many aspects of life, from traffic to businesses
- City planners can use these forecasts to prepare, as the study predicts extreme months or seasons of continuous floods



P. Thompson, M. Widlansky, B. Hamlington et al. (2021): Rapid increases and extreme months in projections of United States high-tide flooding, *Nature Climate Change*, <https://doi.org/10.1038/s41558-021-01077-8>

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OTHER EARTH SCIENCE DEVELOPMENTS

NASA Releases Policy Statement on IDEA (Sept 30th) with definitions:

- **Diversity and Inclusion**
- We define diversity broadly as “the entire universe of differences and similarities” and inclusion as “the full participation, belonging, and contribution of organizations and individuals”
- **Equity**
- We define equity as “the consistent and systematic provision of fair, just, and impartial treatment to all individuals, including individuals who belong to underserved communities that have been denied such treatment”
- **Accessibility**
- We define accessibility as “the capability for full and independent use by all people, including people with disabilities, of technology, programs, and services through inclusive design, construction, development, and maintenance of facilities”

Read the entire [Policy Statement on Diversity, Equity, Inclusion, and Accessibility for NASA's Workforce and Workplaces](#)

IDEA Working Group Accomplishments and In-Progress Actions

Completed IDEAs (just a few!)

- Collected ROSES available demographic data
- SMD-wide Job Shadowing Pilot Program
- Created the IDEA In-Flight Action Board for working group members, advocates across divisions/branches/centers

In progress

- Overarching IDEA Strategy – incorporating into the updated Science Plan
- Climate survey looking at SMD culture
- Anonymous Comment box and dialogue sessions inside SMD
- Developing an HBCU/MSI engagement model and resources
- Monthly conversation series – internal learning development for SMD staff
- Code of conduct and standard inclusive language for ROSES (Initial language being used for ESD AOs)

Additional ESD Highlights

Space Apps Challenge, Oct. 2-3

- Largest global hackathon
- Smashed 2020 records in all categories
- 28,200+ participants; 323 local virtual events; 162 countries/territories; 4,534 teams; 2,814 projects; 28 challenges; 472 volunteers; 10 space agency partners worldwide



Commercial SmallSat Data Acquisition Program

- NASA has uplifted licenses for Planet and Spire data
- The USG license allows federal agencies and affiliates (contractors, grantees, etc.) to access data for scientific use
- Contact CSDA (<https://earthdata.nasa.gov/esds/csdap>) with any questions

Upcoming Events

- International Astronautical Congress
- CEOS Plenary
- UN Climate Conference (COP26)
- AGU Fall Meeting
- AMS Annual Meeting

For more information on NASA's Earth System Observatory,
please visit:

<https://science.nasa.gov/earth-science/earth-system-observatory>



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Earth

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Overview What We Study Elements Missions Science Questions Earth Data Resources Global Challenges

NASA Earth System Observatory

Addressing, Mitigating Climate Change

NASA will design a new set of Earth-focused missions to provide key information to guide efforts related to climate change, natural hazard mitigation, fighting forest fires, and improving real-time agricultural processes.

Each uniquely designed satellite in the [Earth System Observatory](#) will complement the others, working in tandem to create a 3D, holistic view of Earth, from bedrock to atmosphere.

Decadal Survey Resources

- > [Earth System Observatory](#)
- > [ESD Community Forum](#)
- > [Decadal Snapshot](#)
- > [Questions](#)

Decadal Designated Observable Studies





NASA EARTH
Your Home. Our Mission.