

National Aeronautics and
Space Administration

NASA earth

BDEF

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EARTH FLEET

Key

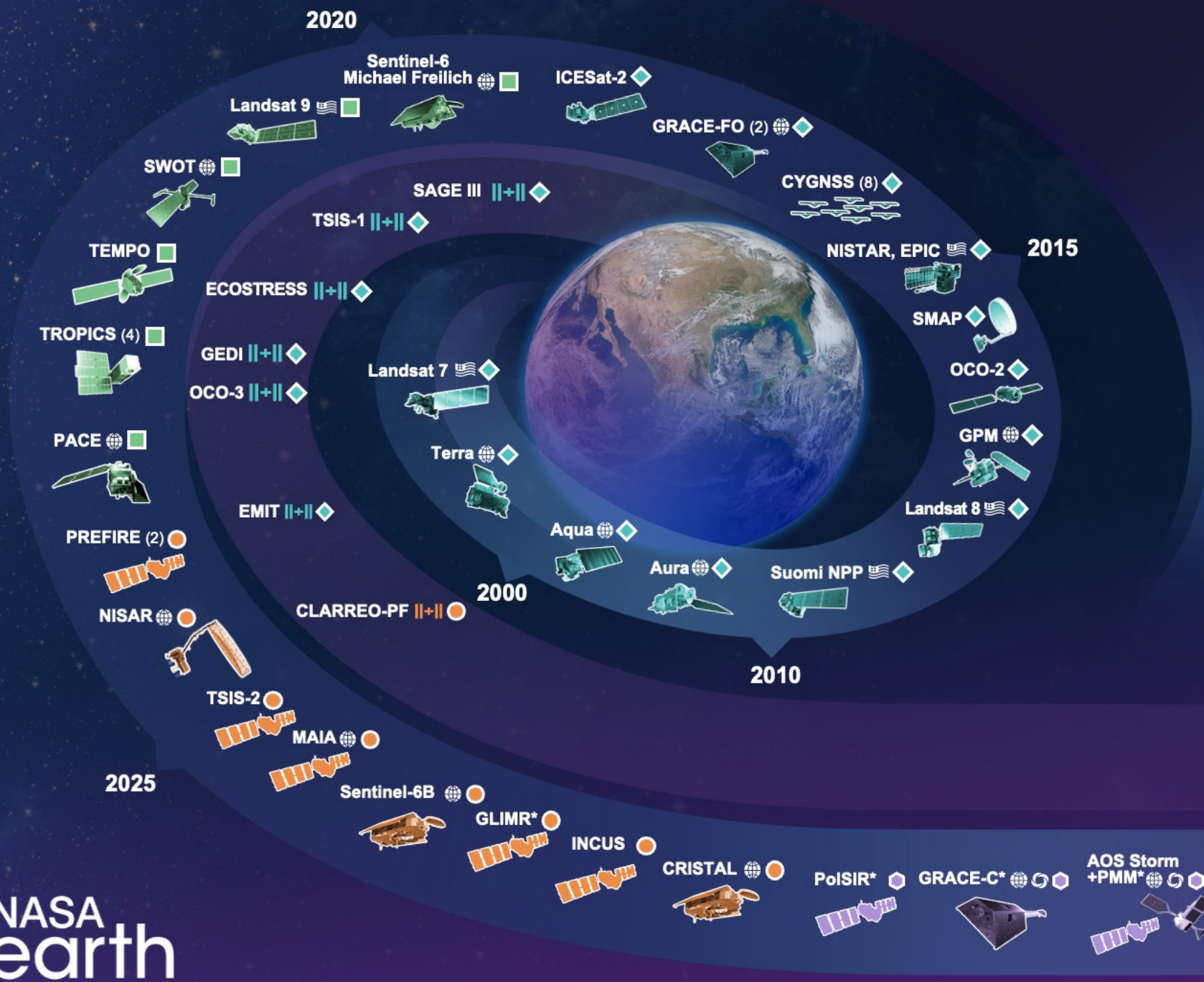
- International Partners: 🌐
- U.S. Partner: 🇺🇸
- ISS Instrument: ||+||
- JPSS Instrument: +-
- Cubesat: 📦
- Launch Date TBD: ☆
- Earth System Observatory Mission (Pre) Formulation: 🌀
- Implementation: ○
- Operating: 🟩
- Extended: 🔹

Invest/CubeSats

- NACHOS 2022: 🟩
- CTIM 2022: 🟩
- NACHOS-2 2022: 🟩
- MURI-FD 2023: 🟩
- SNOOPI* 2024: 🟩
- HYTI* 2024: 🟡
- ARGOS* 2024: 🟡

JPSS Instruments

- OMPS-LIMB 2022: +- 🇺🇸
- LIBERA 2027: +- 🇺🇸
- OMPS-LIMB 2027: +- 🇺🇸
- OMPS-LIMB 2032: +- 🇺🇸



ISS INSTRUMENTS

MISSIONS

EARTH SYSTEM OBSERVATORY

INTERCONNECTED CORE MISSIONS

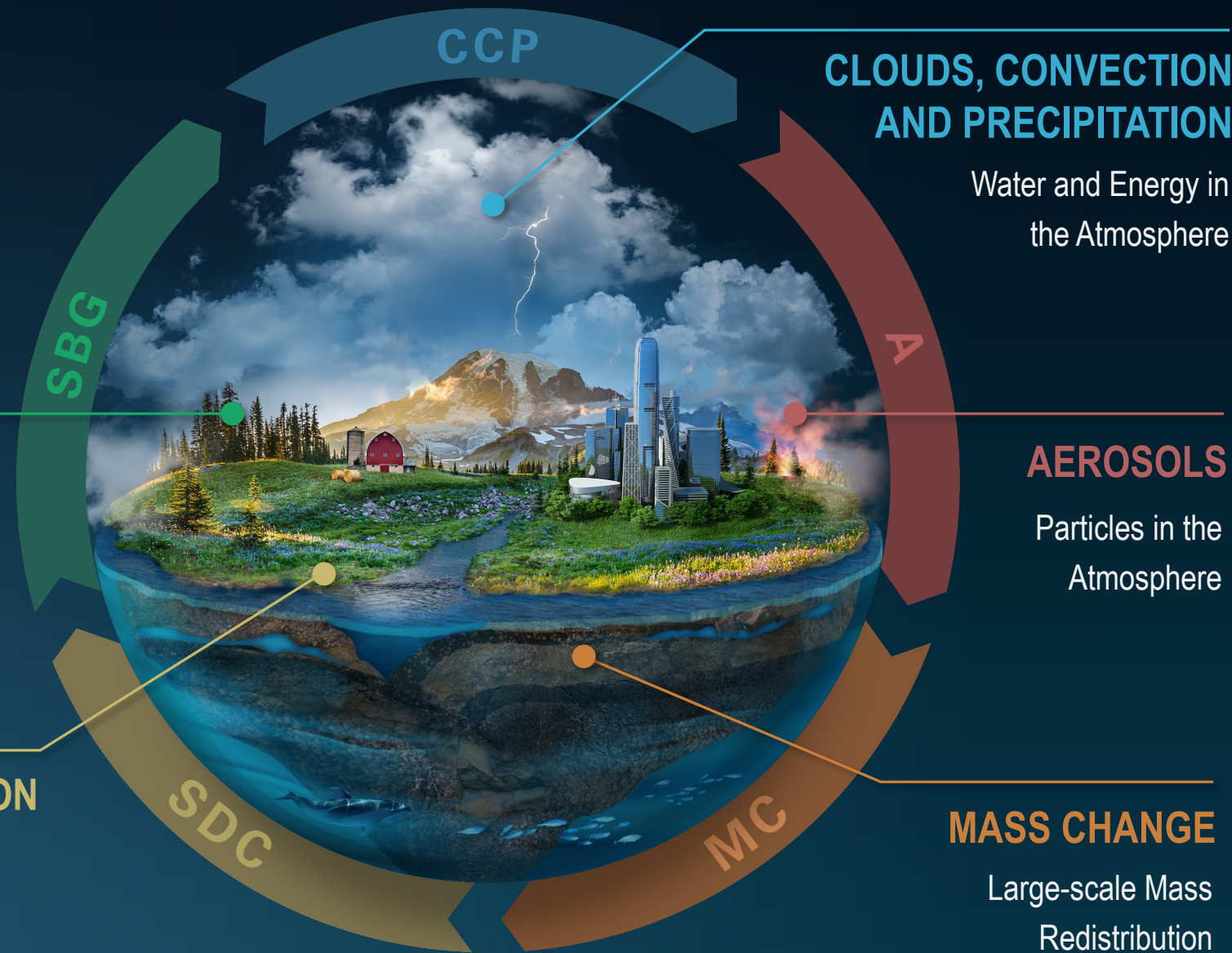
SURFACE BIOLOGY AND GEOLOGY
Earth Surface & Ecosystems

SBG-TIR
SBG-VSWIR

SURFACE DEFORMATION AND CHANGE

Earth Surface Dynamics

Met by **NISAR** launch in 2024



CLOUDS, CONVECTION AND PRECIPITATION

Water and Energy in the Atmosphere

AEROSOLS

Particles in the Atmosphere

MASS CHANGE

Large-scale Mass Redistribution

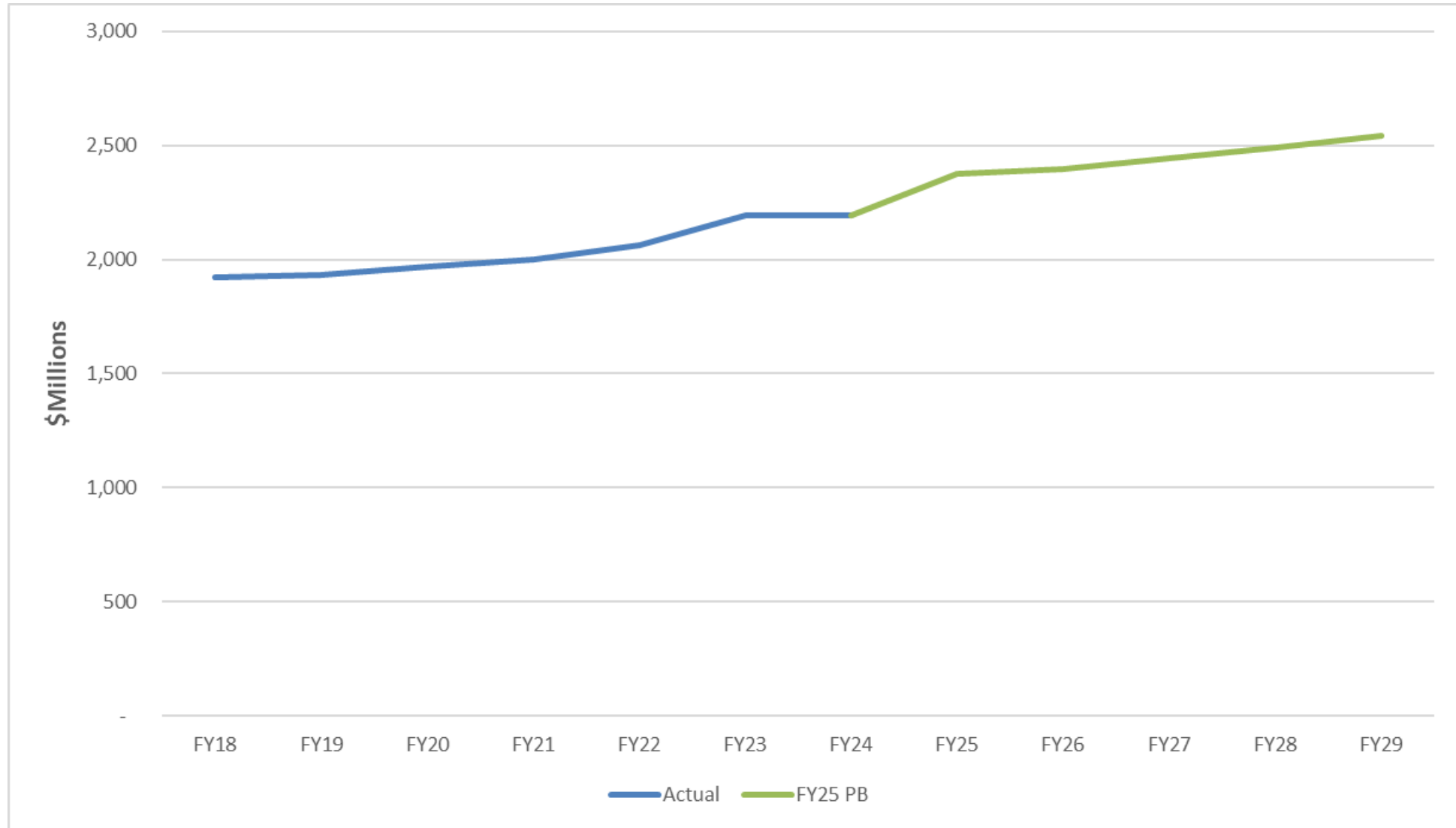
GRACE-C

ATMOSPHERIC SCIENCE MISSIONS

PMM
Competed Mission
Directed Mission
Partner Missions

Observables now in Mission Formulation

ESD Budget In Context



Earth Science Budget Priorities

Explore/Innovate/Partner/Inspire

Achieve high priority science objectives within a cost constrained environment through the integrated missions of the **Earth System Observatory** and provide continuity and advancement of the capabilities of economically critical **Landsat Next**.

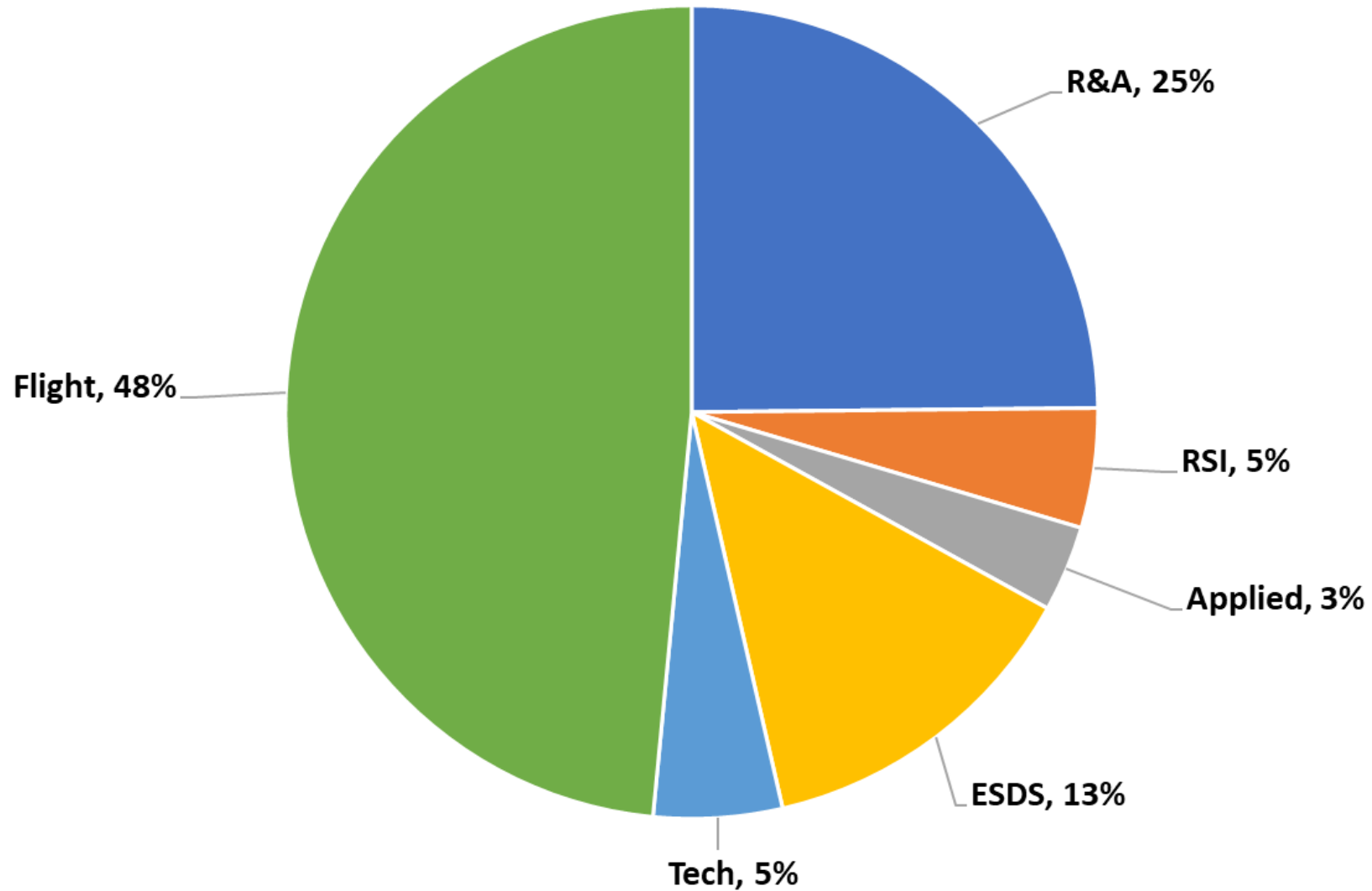
Adapt implementation of **Earth Venture** and **Senior Review** process to ensure their sustainability, in response to National Academies review

Consolidate our strategy to improve the impact and management of our support of information about changes in the Earth system across Federal and international partners through the realigned **Responsive Science Initiatives** program.

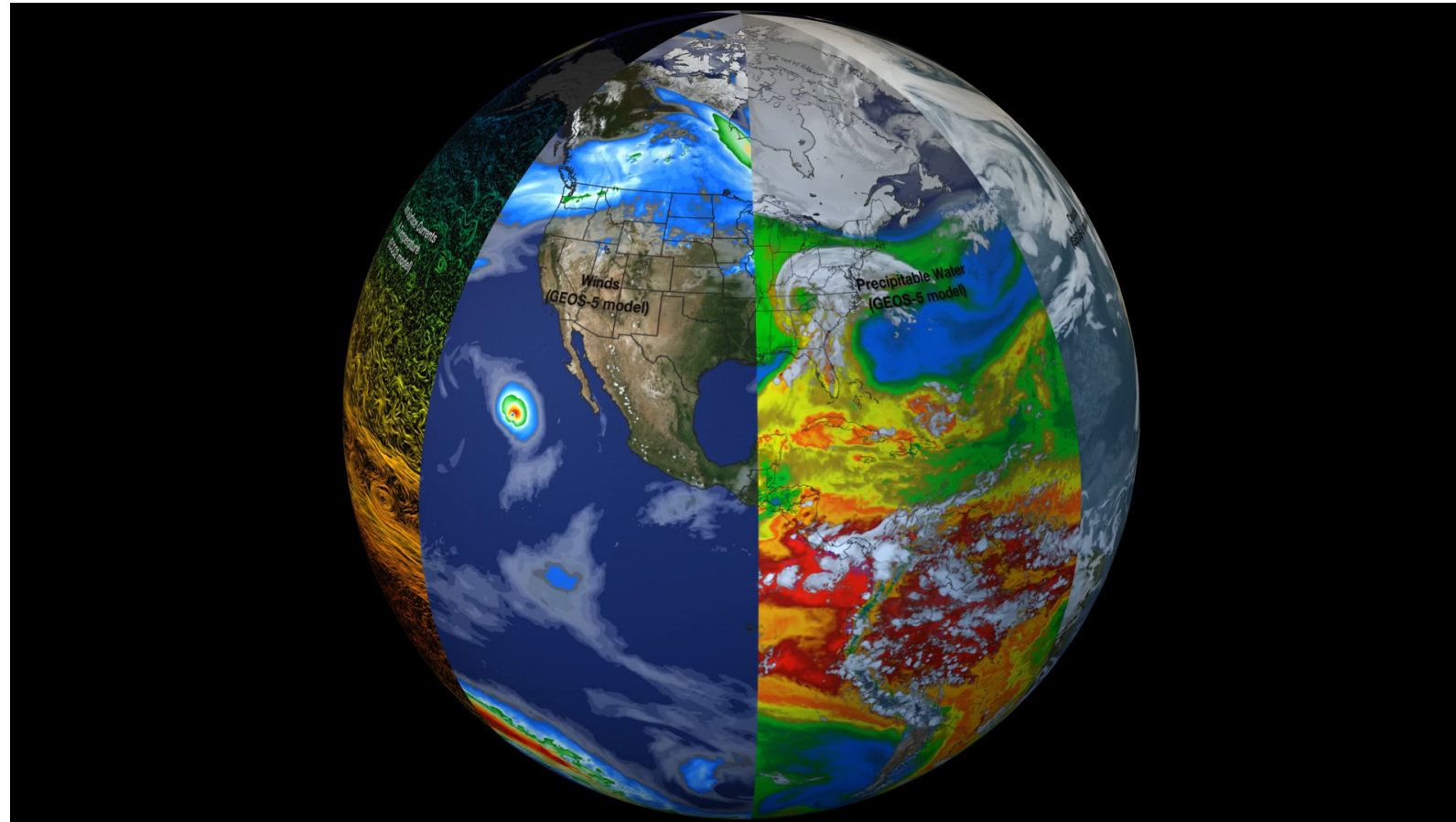
FY25 ESD President's Budget Request by Program

(\$K)	Actual	Plan	Request	Outyears			
	FY23	FY24	FY25	FY26	FY27	FY28	FY29
Total Earth Science	2,194,000	2,251,635	2,378,651	2,396,300	2,446,100	2,489,700	2,543,400
Earth Systematic Missions	914,956	771,336	854,432	868,694	888,155	869,878	757,827
Earth System Science Pathfinder	232,116	245,474	251,726	245,979	202,066	224,988	308,934
Earth System Explorers	2,459	22,064	19,581	58,969	99,491	130,638	194,710
Earth Science Data Systems	365,087	392,341	263,236	257,569	268,340	269,798	276,340
Earth Science Technology	102,181	105,349	147,248	109,392	110,596	111,812	113,040
Applied Sciences	75,205	87,560	68,591	73,344	73,470	75,804	75,901
Earth Science Research	501,996	627,511	606,152	608,425	627,558	628,848	637,188
Responsive Science Initiatives	-	-	167,685	173,928	176,424	177,934	179,460

FY25 ESD President's Budget Request Program Balance



NASA Earth System Science



Atmospheric Composition
Water and Energy Cycle
Carbon Cycle and Ecosystems

Earth Surface and Interior
Weather and Atmospheric Dynamics
Climate Variability and Change

NASA Scientific Visualization Studio: svs.gsfc.nasa.gov/30701

Research Program Structure

- Core R&A Programs (Discipline Budgets, Cross Disciplinary)
- Related Competed and Directed Science Lines in R&A (e.g., IDS, Ozone Trends Science, etc.)
- Competed Science Teams (in EOS, ESM, ESSP Research, plus OSTST, OVWST, PMM)
- Enabling Capabilities (Airborne Science, Space Geodesy, Scientific Computing, HECC, GLOBE)

Also to note:

- Budget is not just in R&A budget (competed science teams are in ESM and ESSP)
- HECC is for entire agency and should not be considered as “within ESD trade space”
 - this really should be considered at directorate and agency levels
- Includes mostly competed but some directed funding
- Competed science team funding for new missions should kick in ~ 1 year after launch with typical annual amounts - \$5M for directed, \$2.0-\$2.5M for large competed, and \$1M for small competed missions; for current missions is more variable

Recent R&A Supported Major Field Campaigns

Campaign	Discipline(s)	Location (S)	Platform(s)	Year(s)
FIREX-AQ	Trop. Chem., NOAA	Boise, ID, Salina, KS	DC-8, ER-2 (Boise only)	2019
CAMP2Ex	Radiation Sci.	Philippines	P-3, ...	2019
SASSIE	Physical Ocean.	Arctic Ocean	Ships, Buoys, Planes	2022
EXPORTS	Ocean Biol./Biogeochem.	Pacific, Atlantic	Ships	20xx
ABoVE	Terrestrial Ecol.	Alaska, NW Canada	Planes, Surface	20xx
SnowEx	Terrestrial Hydrol.	Colorado, Alaska	Planes, Snow Pits	20xx
ACCLIP	Upper Atmos. Res.	Korea	WB-57	2022
WDTS	Pre-SBG, etc.	Palmdate/AFRC	ER-2	20xx
UAS Demo. Flights	Cryospheric Sci.	Canada, ...	Vanilla	20xx
STAQS/AEROMMA	Trop. Comp., NOAA	Palmale, Dayton	DC-8, G-III, G-V	2023
BioSCape	Biodiversity	Capetown, Souh Africa	G-III, G-V	2023
AfriSAT-2	Pre-NISAR/BIOMASS	Africa	G-III, ...	2023, 2024
ASIA AQ	Trop. Comp.	Asia (3 countries + ...)	DC-8, G-III	2024
ARCSIX	Radiation Sci., Cryo Sci.	Greenland, Arctic Ocean	P-3, B-200, Lear Jet	2024
WHYMSie	W&AD, NOAA	AFRC	ER-2	2024
AVIRIS/HyTES JPPG/ISRO	NASA/ESA, NASA/ISRO Coop.	Multiple	Twin Otter, etc.	20xx

ROSES-23 Selections (all of ESD!)

Elem. #	Element Name	Prog. Comp.	# Selected /# Received	\$/year
A.2	LCLUC (step 2)	R&A/ESM Res.	7 of 25	1.7
A.33	High Mountain Asia	R&A	Sel. Pending (due 5/23/23)	
A.46	Ecological Conservation	Appl. Sci.	4 of 7	0.5
A.29	GNSS Research	R&A	Sel. Pending (due 6/2/23)	
A.31	Sci. Team for OCO Missions	R&A/ESSP Res.	16 of 37	3.5
A.14	Modeling, Analysis, and Pred.	R&A	Sel. Complete but not Posted	
A.24	Earth Surface and Interior	R&A	13 of 53	2.6
A.29	GRACE-FO Science Team	R&AESSP Res.	16 of 35	3.0
A.32	EMIT Investigation Science Team	R&A/ESSP Res.	16 of 51	2.8
A.16	Solar Irradiance Science Team	R&A/ESSP Res.	Sel. Complete but not Posted	
A.39	Early Career Investigation Prog.	R&A	36 of 209	3.5
A.22	SMAP Science Team	R&A/ESM Res.	Sel. Pending (due 8/17/23)	
A.60	GEDI Science Team	R&A/ESSP Res.	16 of 39	2.6
A.55	InVEST	ESTO	Sel. Complete but not Posted	
A.15	Cryospheric Science	R&A	Sel. Complete but not Posted	
A.10	Sea Level Change Science Team	R&A	Sel. Pending (due 10/19/23)	
A.30	SAGE III/ISS Science Team	R&A/ESM Res.	10 of 21	1.6
A;38	PACE Science and Appl. Team	ESM/PACE	Sel. Pending (due 12/5/23)	
A.11	SWOT Science Team	R&A/ESM Res./ESM	Sel. Pending (due 12/15/23)	
A.40	The GLOBE Implementation Office	R&A/GLOBE	Sel. Complete but not Posted	
A,36	CYGNSS Competed Sci. Team	R&A/ESSP Res.	Sel. Pending (due 1/17/24)	
A.65	FireSense Implementation Team	Multiple	Sel. Pending (due 1/18/24)	
A.66	CYGNSS for Action Phase 1	ESSP	Sel. Pending (due 1/23/24)	
A.51	Comm. Smallsat Dat Acq. NVOE	Earth Action	Sel. Pending (due 2/21/24)	
A.27	NISAR Mission Oper. Sci. Team	R&A/ESM Res.	Sel. Pending (due 2/28/24)	
A.6	Carbon Monitoring System	R&A	Sel. Pending (due 3/13/24)	
A.47	Earth Sci. Appl. Equity & Env. Jus.	Earth Action	Sel. Pending (due 3/14/24)	
A.53	Instrument Incubator Program	ESTO	Sel. Pending (due 4/2/24)	
A.58	Advanced Inf. Syst. Tech.	ESTO	Sel. Pending (step 2 due 4/4/24)	
A.67	Earth Act.: Supp. Climate Resil. Commun.	Earth Action	Proposals due 5/3	
A.59	FireTech	ESTO	No due date	
A.25	Rapid Response & Novel ES	R&A/all	No due date	

Competed Research: Research Opportunities in Space and Earth Science (ROSES) 2024 (all of Earth Science Division)

Elem. #	Element Name	Prog. Comp.	Due Date
A.50	Citizen Sci. for Earth Sci. Prog.	ESDS	5/14/24
A.45	Earth Action: Ecol. Cons. Imp. Assess.	Earth Action	5/15/24
A.58	Inc. Part. Of MSIs in Surf. Meas. Networks	Earth Action	5/20/24
A.47	Earth Action: Wildland Fires	Earth Action	5/24/24
A.8	Physical Oceanography	R&A	5/29/24
A.2	LCLUC	R&A	5530/24 (S2)
A.7	Biodiversity and Ecological Conservation	R&A	6/13/24
A.42	Earth Act.: Disaster, Risk, Recov., Resil.	Earth Action	6/14/24
A.25	Earth Surface and Interior	R&A	6/21/24
A.15	Modeling, Analysis, and Prediction	R&A	7/1/24
A.3	Ocean Biology and Biogeochemistry	R&A	7/3/24
A.44	Earth Action: Health and Air Qua. App.; ST	Earth Action	7/9/24
A.34	U. S. Participating Investigator	R&A	7/19/24
A.43	Earth Action: Health and Air Quality	Earth Action	8/6/24
A.23	Terrestrial Hydrology	R&A	8/8/24
A.19	Atmos. Comp. Modeling & Anal. Program	R&A	8/16/24
A.28	Remote Sensing Theory for Earth Science	R&A	9/16/24
A.17	Upper Atmosphere Composition Observ.	R&A	9/19/24
A.41	SERVIR Applied Sciences Team	Earth Action	102/24 (S1)
A.16	Cryospheric Science	R&A	10/16/24
A.12	Ocean Surface Topography Sci. Team	R&A/Ocean Sci. Res.	10/17/24
A.27	NISAR Res. & Appl.. Sci. Team	R&A/ESM Res.	2/14/25
A.26	Rapid Response and Novel Earth Science	R&A/multiple	No Due
Da			

Elem. #	TBD Element Name	Prog. Comp.
A4	Terrestrial Ecology	R&A
A5	Carbon Cycle Science	R&A
A14	Integrated SWOT Water Field Campaign	R&A/SWOT
A21	TEMPO Science Team	R&A/ESSP Res.
A22	NASA Energy and Water Cycle Study	R&A
A24	Weather and Atmospheric Dynamics	R&A
A30	Understanding Changes in High Mtn. Asia	R&A
A31	Earth Science Imaging/Sounding Data Anal.	R&A/ESM Res.
A32	Precipitation Meas. Mission and C/C ST	R&A/ESM Res./ESSP Res.
A36	The Science of PACE	R&A/ESM Res.
A48	Commercial Smallsat Data Acquis. NVOE	Earth Action
A55	Decadal Survey Incubation Prog.: Sci./Tech.	ESTO
A59	New or Modified GLOBE Protocols	R&A

Those in red will be using Dual Anonymous Peer Review (DAPR)

MEaSUREs Principles

A competitive program to provide an opportunity for the research community to participate in the development and generation of data products, which complement and augment the NASA produced and distributed Earth science data products available to the research community and other stakeholders.

An Earth System Data Record (ESDR) is defined as a unified and coherent set of observations of a given parameter of the Earth system, which is optimized to meet specific requirements in addressing science questions.

understanding Earth System processes;

assessing variability, long-term trends, and change in the Earth System; and

providing input and validation means to modeling efforts.

Emphasis is placed into linking together multiple satellites into a constellation, developing the means of utilizing a multitude of data sources to form coherent time series, and facilitating the use of extensive data in the development of comprehensive Earth system models. **MUST utilize at least one satellite data set, preferably NASA sponsored data set.**

Program Implementation

In addition to the individual project milestones, the MEaSUREs projects:

- Identify the Earth Science research needs, potential utility and expected scientific impact for the ESDR/CDR. Cite documentation of key measurement needs found in Decadal Surveys, etc.
- Document ESDR/CDR community establishment and maturity level, citing established calibration/validation, peer reviewed publications for algorithms, and product quality and usage summaries.
- Identify all challenges in the development and production of the proposed ESDR/CDR and describe the effort required. Characterize uncertainties and quantify errors associated with the ESDRs.
- Address the feasibility of transitioning their proposed data production, via delivering the developed code and auxiliary information, to a NASA processing system, other institution and other investigators.
- Provide representation on one or more Earth Science Data System Working Groups (DSWGs).
- "Continuation" projects must document the utility and scientific impact of the produced ESDRs/CDRs, citing peer reviewed publications and a quantitative assessment of the data utilization by the research community and other stakeholders.

A.28 REMOTE SENSING THEORY FOR EARTH SCIENCE IN ROSES 2024

The objective of the Remote Sensing Theory (RST) program element, a multidisciplinary/interdisciplinary program is to enable major steps in algorithm and future technology development that will ultimately lead to significant advances in remote sensing Earth observing. The program will support **fundamental scientific, non-incremental advances in remote sensing theory** and radiative transfer, including advancement of retrieval algorithms to be used for space-based remote sensing of the Earth's atmosphere, oceans, biosphere, cryosphere, land surface, and/or Earth interior.

Specific areas of interest are described below, but these are not exclusive nor are they predetermined priorities for this solicitation.

Theoretical algorithm advances: research to develop fundamental advances to radiative transfer theory and calculations. Advances should be non-incremental and proposers should identify the limitations that may be surpassed. Studies applicable to remote sensing in regions of high heterogeneity, in which existing horizontal and/or vertical variability cannot yet be fully resolved by available or planned remote sensors, but will likely have significant effects on retrievals.

A.28 REMOTE SENSING THEORY FOR EARTH SCIENCE IN ROSES2024

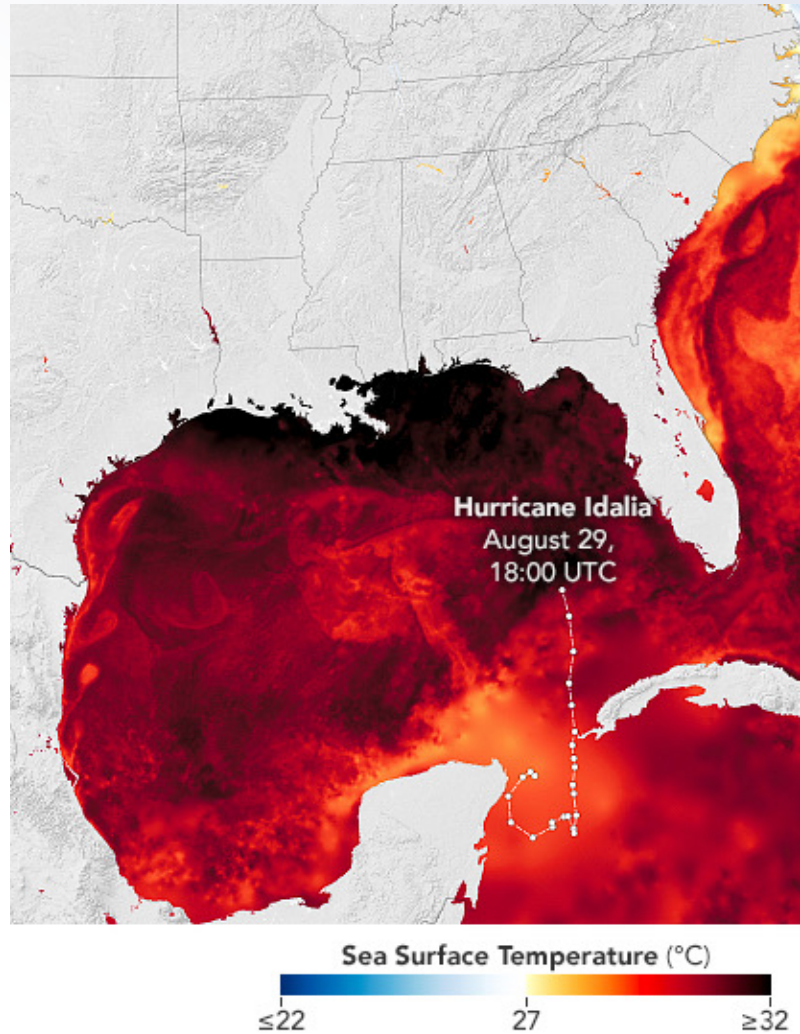
- Data "fusion": research to develop new approaches for integrative analysis of disparate remote sensing data sets. Innovative concepts and methodologies that merge, combine, or otherwise integrate data of different types (from different satellite sensors, from different wavelength regions, and/or of varying temporal and spatial resolutions).
- Advanced corrections: research to develop improved approaches and/or algorithms for correcting satellite data, in order to take into account known confounding effects. Of special interest are studies that address atmospheric and other corrections for active sensors, including those relevant to observables described in the National Academy of Sciences, Engineering, and Medicine 2017 Decadal Survey, "Thriving on Our Changing Planet: A Decadal Strategy for Earth Observations from Space." Corrections relevant to remote sensing which could be carried out through all types of missions (e.g., those involving constellations of small satellites, hosted payloads, and cubesats), may also be proposed in response to this element.



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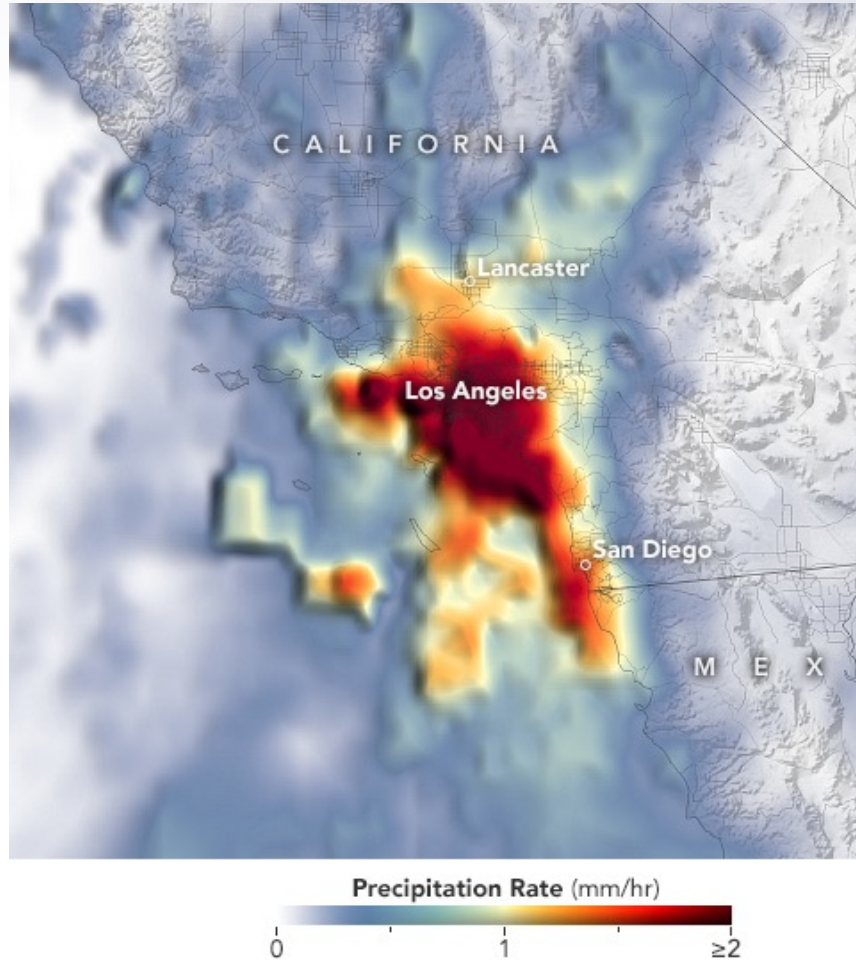


CAPTION – Hurricane Idalia track on August 29, 2023 superimposed over Multiscale Ultrahigh Resolution sea surface temperatures modeled from Terra MODIS data.

Earth Science Budget Highlights

- Extension of **Terra/Aqua/Aura** to end of life, all missions in extended operations through 2026, senior review wedge in 2027 bounds future cost growth
 - Supports critical **research, applications, data and technology** for mission schedules
 - Consolidation of some mission science teams and discipline research areas for greater synergies across fields
 - **Responsive Science Initiatives Program** realigns elements of research, tech, applied, and data programs and will focus on areas of national importance to work with interagency partners and provide products, information, and research with significant societal value
 - Includes a sustained budget increase for **Interagency Satellite Observation Needs** (responsive to Satellite Needs Working Group)
- Doubles the investment in **Geodesy** infrastructure, supporting NASA, civil space and national security needs for accurate Earth positioning
- New content in Earth Science Technology to begin developing the first space-borne **quantum gravity gradiometer (QGG)**.

Earth Science Budget Highlights



CAPTION – A potent storm drenches California on February, 5-6 2024, IMERG precipitation data as part of NASA-JAXA Global Precipitation Mission.

- **Earth System Observatory** used a “Decouple, Partner, and Compete” approach to follow Decadal Survey recommendations and significantly reduce cost and optimize scope while remaining on track to deliver new knowledge
 - **Atmospheric Science** restructure from Atmospheric Observing System (AOS) architecture—still includes high priority observables and multiple missions; now mix of directed and at least one competed mission, with decoupled schedules
 - **Precipitation Measurement Mission** in partnership with Japan
 - **Surface Biology and Geology** directed instrument contribution to an international mission plus a mission with industry partners, with decoupled schedules
 - **Surface Deformation and Change** no additional study, NISAR mission meets the observable
- **Landsat Next** proceeds to instrument procurement and supports agriculture, resource management
- **Venture & Explorer** cadence; better supports proposal development pacing