

## NASA Response to Thriving on Our Changing Planet: A Midterm Assessment of Progress Toward Implementation of the Decadal Survey

**Recommendation:** NASA should clearly articulate the substantial societal value and urgency of implementing the full set of the 2017 Earth science and applications from space decadal survey (NASEM 2018) priorities as well as its need for appropriate resources to do so. It is imperative that NASA's Earth Science Division develop the framework to quickly assess and communicate what must be sacrificed when requirements imposed by its other stakeholders supplant the science and applications community's priorities as expressed in the decadal survey. (p 30)

**Response:** NASA partially concurs with this recommendation. NASA agrees that it is important that NASA (and others) continue to clearly articulate the substantial societal value and urgency of implementing the full set of the 2017 Earth science and applications from space decadal survey (NASEM 2018) priorities. However, NASA must respond to multiple constituencies, including Administration priorities, Congressional direction, and Agency partners. NASA is embargoed from consulting or communicating with the community directly when significant changes occur as part of budget processes, and relies on community-developed documents, including the decadal survey and Science and Applications Team products to inform those decisions. We will explore expanding a timeline of engagement events that increase community awareness about decisions made and underlying drivers.

**Recommendation:** NASA should expand funding opportunities for U.S. investigators to participate in and exploit data from international, interagency, and commercial endeavors. (p 32)

**Response:** NASA concurs with the recommendation. The Earth Science Division (ESD) will clarify the many opportunities for science that is agnostic to data source in addition to mission-specific science. Future implementation of integrated science approaches to the Earth System Observatory missions will expand opportunities and also address this recommendation.

**Finding:** Growth in individual program elements, without top-line budget growth, does not support the healthy programmatic balance called for in the decadal survey. (p 35)

**Recommendation:** Consistent with the 2017 Earth science and applications from space decadal survey (NASEM 2018) and the Earth System Observatory Independent Review Board recommendations (ESO IRB 2022; NASA 2022, response 23), NASA's Earth Science Division should seek advice from the National Academies' Committee on Earth Science and Applications from Space prior to adding or substantially modifying individual program elements to ensure appropriate consideration of program balance and decadal survey priorities. (p 35)

**Response:** NASA concurs with the importance of program balance as called for in the decadal survey.

In addition to continuing to formally seek advice from the National Academies' Committee on Earth Science and Applications from Space (CESAS) through commissioned studies for specific purposes, NASA welcomes the opportunity to work with the committee to allow more interchange and engagement in

meetings, and to find acceptable ways to get rapid feedback from the committee when information is not subject to embargo.

**Finding:** NASA has been uneven in its response to decadal survey recommendations and has not followed the decadal survey's decision rules regarding how to respond to budget pressures. (p 37)

**Response:** NASA does not believe this finding reflects the extent that it followed the decision rules from the decadal in responding to budget pressures wherever possible. Unfortunately, the budget and cost challenges have exceeded any that were foreseen. As a supporting example, the 2022 Earth System Observatory Independent Review Board included members who were also very knowledgeable on the development of the decadal survey. They noted in their report (ESO IRB 2022), NASA ESD has "employed all cost mitigation strategies laid out by the decadal survey's decision rules to manage budget challenges, except for flying less capable missions than those presented." To the extent possible, NASA will continue to engage with the National Academies in discussion of the response to decadal survey recommendations.

**Finding:** Lacking resources to implement the recommended program in its entirety, NASA ESD has remained in analysis and evaluation mode rather than having made timely decisions to enable progress on what is implementable. (p 37)

**Response:** NASA believes this finding does not reflect fully the progress made within the portfolio. NASA ESD has advanced multiple missions through their lifecycles, including moving Gravity Recovery and Climate Experiment-Continuity (GRACE-C) into Phase C implementation, Surface Biology and Geology-Thermal Infrared (SBG-TIR) into Phase B formulation, and SBG-Visible to Short Wavelength Infrared (VSWIR) as well as Landsat Next into Phase A formulation, including the recent instrument suite award for Landsat Next.

**Recommendation:** NASA's Earth Science Division should take full advantage of its meetings with National Academies' Committee on Earth Science and Applications from Space to seek feedback on its implementation plans to facilitate more timely decisions and maintain alignment with the Earth science and applications from space decadal survey recommendations, even as its budget fluctuates from year to year. (p 37)

**Response:** NASA concurs with this recommendation to the extent allowed by government and National Academies processes.

ESD meets with CESAS twice per year to present status and engage in discussion with the committee. ESD also participated in the first CESAS monthly telecon in August 2024. During these public meetings, NASA receives questions and comments from individual committee members; Under the rules in place for CESAS, NASA cannot receive committee-wide advice during or following these meetings outside the context of a sponsored study.

NASA looks forward to discussing with the National Academies how to make the best use of CESAS's meetings and telecons for engaging with the CESAS members more regularly.

**Recommendation:** NASA's Earth Science Division should pursue funding needed to cover the increase in Landsat Next's scope and budget that was not anticipated at the time of the 2017 Earth science and applications from space decadal survey (NASEM 2018). Otherwise, the increased Landsat Next budget substantially limits resources available to achieve the Earth science vision laid out in the 2017 decadal survey plan. (p 46)

**Response:** NASA concurs with this recommendation. NASA has requested the funding necessary to cover the increase in Landsat Next's scope and budget as part of the President's Budget Request (PBR). However, congressional appropriations ultimately determine the funding available for all ESD programs.

NASA also agrees that the increase in desired capability of Landsat without a corresponding increase in the top line budget has impacted implementation of the missions envisioned in the 2017 decadal survey. ESD continues to examine ways to manage Landsat Next costs as the program proceeds in Phase A.

**Recommendation:** To address budgetary challenges, NASA should follow the guidance provided in the 2017 Earth science and applications from space decadal survey (NASEM 2018), retaining competitive opportunities in the Earth System Explorer and Earth Venture lines, and implementing the Designated program element missions to the extent possible within current constraints and consistent with the decadal survey's identified descopes. (p 50)

**Response:** NASA concurs with this recommendation. NASA strongly values the Principal Investigator (PI) development pipeline inherent in the Earth Venture (EV) and Earth System Explorer (ESE) structure. Following the Decadal decision rules, ESD has maintained funding for Earth Venture, and added funding through the Explorers program, even as constrained budgets have led to changes in directed missions and some adjustments in Announcement of Opportunity (AO) cadence. ESD has not taken from competed mission funding to support directed missions.

NASA has adopted a two-year EV AO cadence beginning in 2026, allowing us to modify the cost cap of any given AO to stay within the available budget while maintaining a routine solicitation cadence. Interleaving the next ESE and Earth Venture Suborbital (EVS) opportunities, ESD has planned a cadence of one opportunity per year for years 2026 through 2030. While we were not able to provide opportunities in 2024 and 2025 due to constrained budgets, ESD is planning a competitive opportunity for 6 of 8 years between 2023 and 2030. ESD will notify proposers of competitive opportunity details as early as possible to enable advance planning.

NASA also continues to maintain a steady cadence of other small flight opportunities in Research Opportunities in Space and Earth Science (ROSES) solicitations, even increasing Earth Science Technology Office (ESTO) Advanced Component Technology (ACT), Instrument Incubation Program (IIP) opportunities within annual ROSES calls as well as the In-Space Validation of Earth Science Technologies (InVEST) flight program.

**Recommendation:** NASA's Earth Science Division should proceed with both the Surface Biology and Geology (SBG)-Visible to ShortWave InfraRed and the SBG-Thermal Infrared missions without further delay in order to minimize cost and maximize achievable overlap. (p 52)

**Response:** NASA agrees with the scientific value of maximizing the overlap of the two instruments. The international partner commitment for SBG-TIR does not allow a delay of that launch, and the budget does not support development of SBG-VSWIR to be ready for launch in the same year as SBG-TIR. NASA will continue to explore opportunities to maximize the concurrent measurements of SBG-TIR and SBG-VSWIR.

The VSWIR team is preserving the capability to move launch readiness sooner should funds become available. Per the Decadal decision rules, ESD will not take funds from competed mission lines to enable earlier VSWIR launch readiness.

**Recommendation:** NASA should fully implement the 2017 Earth science and applications from space decadal survey's (NASEM 2018) prescribed descopes for the Aerosols and Clouds, Convection, and Precipitation Targeted Observables, adding two Earth System Explorer solicitations to the program with Targeted Observable 1 (TO-1) and TO-2 eligible to compete and pursuing a simpler single band radar mission responsive to TO-5. (p 52)

**Response:** NASA concurs with this recommendation and plans to implement an alternative architecture and acquisition approach for the Aerosol and Cloud, Convection and Precipitation (ACCP) Targeted Observables in response to budget challenges. NASA is pursuing a "Decouple, partner, and compete" strategy for the Atmosphere Observing Mission. This decoupled architecture was outlined in NASA FY2025 budget request and presented at the ESD townhall on March 13, 2024 ([community-forum-march-13-2024-1.pdf \(nasa.gov\)](#)). NASA will be continuing critical partnerships with the Japanese Space Exploration Agency (JAXA) and the Canadian Space Agency (CSA) in the inclined orbit, and CSA in the polar orbit, and investing in an additional partnership with the Italian Space Agency (ASI) for a polar lidar. Additionally, NASA plans to compete an explorer class mission. Information on this anticipated Announcement of Opportunity can be found at the following link: [Atmosphere Observing System – Cloud \(AOS-Cloud\) Announcement of Opportunity \(nasa.gov\)](#).

**Recommendation:** While it is appropriate to implement the GRACE-C (Gravity Recovery and Climate Experiment-Continuity) mission on its current timeline, NASA should identify a long-term solution for achieving measurement continuity beyond GRACE-C at lower cost to the agency. (p 53)

**Response:** NASA concurs with this recommendation. Note that NASA and the European Space Agency (ESA) are exploring a partnership on the Mass Change and Geosciences International Constellation (MAGIC), which is a concept for collaboration between NASA and ESA on a constellation consisting of the staggered deployment of the GRACE-C mission and the Next-Generation Gravity Mission (NGGM), an ESA mission.

NASA is also investing in the development of new capabilities for mid-term and long-term solutions for future gravity missions. In the 10-year time frame, improved optomechanical accelerometers are

expected to significantly reduce the cost, size, weight, and power and result in more cost-effective mission designs through miniaturized spacecraft and simplified architectures. In the longer term, NASA is developing a technology demonstration of a quantum gravity gradiometer as a pathfinder to providing high capability mass change measurements with a single spacecraft, enabling reduced cost.

**Recommendation:** NASA should engage with the European Copernicus program to explore ways to meet the science objectives tied to the Surface Deformation and Change Targeted Observable through a potential collaboration. Unmet science and continuity objectives should be re-evaluated once NISAR (NASA-ISRO [Indian Space Research Organization] Synthetic Aperture Radar) data become available. (p 53)

**Response:** NASA concurs with this recommendation. Note that the SDC Study Team and ESA started a joint Radar Observing System for Europe in L-band (ROSE-L) and SDC study (October 2023) that is exploring a variety of potential co-flyer architectures with ROSE-L.

The SDC Study Team is also funded to lead a “NISAR Lessons Learned” assessment that will evaluate which SDC science and applications objectives that can be met by the NISAR mission as well as new science and applications insights that NISAR will elucidate that may inform ESD’s observation strategy.

**Recommendation:** NASA’s Earth Science Division should improve its communication with the community to provide the rationale for the decisions it makes particularly in the face of inadequate resources, including providing timely information about program plans, budgets, and anticipated solicitation timelines through town halls, webinars, and via the NASA website. (p 54)

**Response:** NASA concurs with this recommendation and has already taken steps to expand communications. We will explore expanding the cadence of engagement events (community forums, industry days, and other events) that increase community awareness about decisions made and underlying drivers.

**Recommendation:** NASA’s Earth Science Division (ESD) should better coordinate systematic diversity, equity, inclusion, and accessibility plans across all of its program elements, to provide holistic end-to-end support for underrepresented groups in Earth system science and to ensure routine formal review. These plans should be supported by NASA’s ESD with appropriate and sustainable budget allocations and include ongoing opportunities for training, principal investigator development, mission engagement at all career and leadership levels, and sharing best practices. (p 56)

**Response:** NASA concurs with this recommendation. Creating holistic end-to-end support to diverse communities in Earth system science requires recognition that (1) ESD Diversity, Equity, Inclusion, and Accessibility (DEIA) efforts go beyond Earth Science Flight missions and extend to all ESD program elements (Technology, Data Systems, Research & Analysis, and Earth Action), and (2) building inclusive and diverse communities takes time and requires early engagement, continuous support, and retention efforts.

Since the release of the Decadal Survey in 2018, ESD has taken multiple steps to improve DEIA across the division and within the communities we serve. These efforts are applied across all ESD elements and include all career levels. Below are a few examples, and we look forward to discussing our full breadth of efforts with the Academies.

Following guidance of SMD leadership, ESD has implemented [Dual Anonymous Peer Review \(DAPR\)](#) to ensure that the review of proposals is performed in an equitable and fair manner. ESD has also participated in SMD's [Inclusion Plan Pilot](#) to raise awareness of barriers to creating and sustaining positive, inclusive working environments, and to get PIs actively thinking about ways to foster diverse and inclusive practices. ESD has taken a leadership role in developing and implementing these processes by developing resources that support the writing, revision, and implementation of Inclusion Plans and conducting training in the DAPR process.

In 2023, ESD integrated all the major early career projects into the [Early Career Research \(ECR\) Program](#) to empower the next generation of Earth science researchers in all ESD program elements. DEIA practices have been incorporated into ECR, not only in the selection process to entrain new diverse awardees, but also to train new potential investigators into the mission science process.

ESD looks forward to briefing CESAS on these and other DEIA efforts across the division and within the community, especially those that we've initiated or expanded since the Midterm assessment began.

**Finding:** The lack of competed mission opportunities, including the reduced cadence of Earth Venture solicitations and the delay and reduction in number of Earth System Explorer calls, has limited opportunities to achieve or demonstrate progress on workforce development goals and DEIA objectives. (p 57)

**Response:** NASA offers the following clarification to add context to this finding. Note our previous response regarding the efforts being done to maintain a regular cadence of Earth Venture and Earth System Explorers opportunities. In addition, the Earth Venture Suborbital – 4 (EVS-4) solicitation and selection process was intentionally modified to promote workforce development goals and DEIA objectives by making opportunities more accessible to early career investigators, and to compete more opportunities.

For the ESE AO, DEIA objectives were an integral part of the solicitation, which had a specific requirement for a Diversity and Inclusion Plan.

**Recommendation:** Prior to the next decadal review, NASA, the National Oceanic and Atmospheric Administration, and the U.S. Geological Survey should engage a broader Earth sciences constituency by

- Identifying Earth observation stakeholders, improving understanding of their short and long-term needs, and encouraging participation of the community of stakeholders in the next decadal survey. These stakeholder groups should include both the scientific community and communities impacted by climate change, including historically marginalized and underrepresented groups that are often disproportionately impacted.

- Sponsoring workshops to engage the entire Earth system community to better address observational needs for interdisciplinary and crosscutting issues. The workshops should
  - Gather input on priorities,
  - Communicate expected program resource constraints to help set expectations,
  - Sensitize participants to the need for working within a holistic Earth system science rather than disciplinary framework when considering implementation options,
  - Support development of brief reports outlining community progress and expressing observation needs at discipline and crosscutting topic area levels (e.g., sea level, modeling), and

Ensure systematic representation of interdisciplinary topics to ensure they do not fall through the gaps in community organization. (p 58)

**Response:** NASA concurs with this recommendation. Our recently-published Earth Science to Action strategy highlights the significant importance of coalescing the Earth science communities and strengthening our existing partnership framework. It also points to the importance of capturing the needs of user communities in addition to the scientific community and including those needs in the Earth science enterprise to be addressed by future ESD missions and programs.

In coordination with our partner agencies, ESD proposes a working session with the Academies to identify pathways to engage the broader community leading up to the next Decadal Survey, including convening the community and reporting out on progress.

**Finding:** Despite the decadal survey's recommendation that NASA ESD lead development of a more formal continuity decision process, current ESD decisions with regard to observation continuity remain ad hoc and do not generally communicate what future observations will be prioritized or how budgets need to expand in order to accommodate new and sustained observations. (p 59)

**Response:** NASA acknowledges the challenge that continuity of measurements poses to the nation and the efforts undertaken throughout the community to address this topic. ESD plans to improve communications on continuity assessments, priorities, and the extent to which the Sustained Observations for Climate Future Missions budget line established in FY23 improves the outlook for sustained observations. NASA looks forward to working with the Academies to continue to address this national challenge going forward.

**Recommendation:** Through requests for information and workshops, NASA, the National Oceanic and Atmospheric Administration, and the U.S. Geological Survey should more actively engage the Earth system modeling community to devise strategies to exploit existing and potential Earth observations more fully for advancing model parameterizations and predictions. (p 60)

**Response:** NASA concurs with this recommendation. Through engaging the Earth system modeling community, NASA will develop a strategy to expand modeling capabilities and coordination and incorporate new approaches and observations. We will coordinate with other federal agencies, in particular NOAA and USGS, and we will engage the community and the Academies as we progress.