NATIONAL ACADEMIES *Sciences Engineering Medicine*

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

Study Co-Chairs:

Christian Kummerow, *Colorado State University*
Anna Michalak, *Carnegie Institution for Science*

Download the report and report resources:
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Study Statement of Task (Abridged)

- Highlight the **most significant advances and relevant programmatic changes** since the publication of the decadal survey.
- Assess **whether NASA, NOAA, and USGS's programs address decadal survey priorities** and the progress toward realizing those priorities.
- Recommend actions that the agencies should undertake to **prepare for the next decadal survey**.
- For NASA in particular:
  - Assess impact and effectiveness of Earth science programs in implementing the decadal survey recommendations, synergies, and portfolio balance.
  - Recommend actions that could be taken to optimize the full breadth of NASA's Earth science programs during the remaining decadal interval.
  - Comment on NASA efforts to enhance the vitality and diversity of the scientists and engineers who work on ESD-sponsored programs and recommend actions that might be taken to enhance progress in these areas.
- ***The committee was asked not to revisit or redefine the scientific priorities or recommended targeted observables, unless indicated by superseding legislative or national policy directives.***

Study Committee

- **Co-Chair: Christian D. Kummerow, Colorado State University***
- **Co-Chair: Anna M. Michalak, Carnegie Institution for Science**
- Stacey W. Boland, Jet Propulsion Laboratory*
- Francisco P. Chavez, Monterey Bay Aquarium Research Institute*
- William E. Dietrich (NAS), University of California, Berkeley*
- Deanna Hence, University of Illinois Urbana-Champaign
- Daniel J. Jacob, Harvard University*
- Dennis P. Lettenmaier (NAE), University of California, Los Angeles
- Kathleen (Kass) O'Neill Green, Kass Green and Associates
- Lesley E. Ott, NASA Goddard Space Flight Center*
- David T. Sandwell (NAS), Scripps Institution of Oceanography*
- Susan L. Ustin, University of California, Davis*
- Isabella Velicogna, University of California, Irvine
- Xubin Zeng, University of Arizona*

* Served on 2017 Decadal Survey

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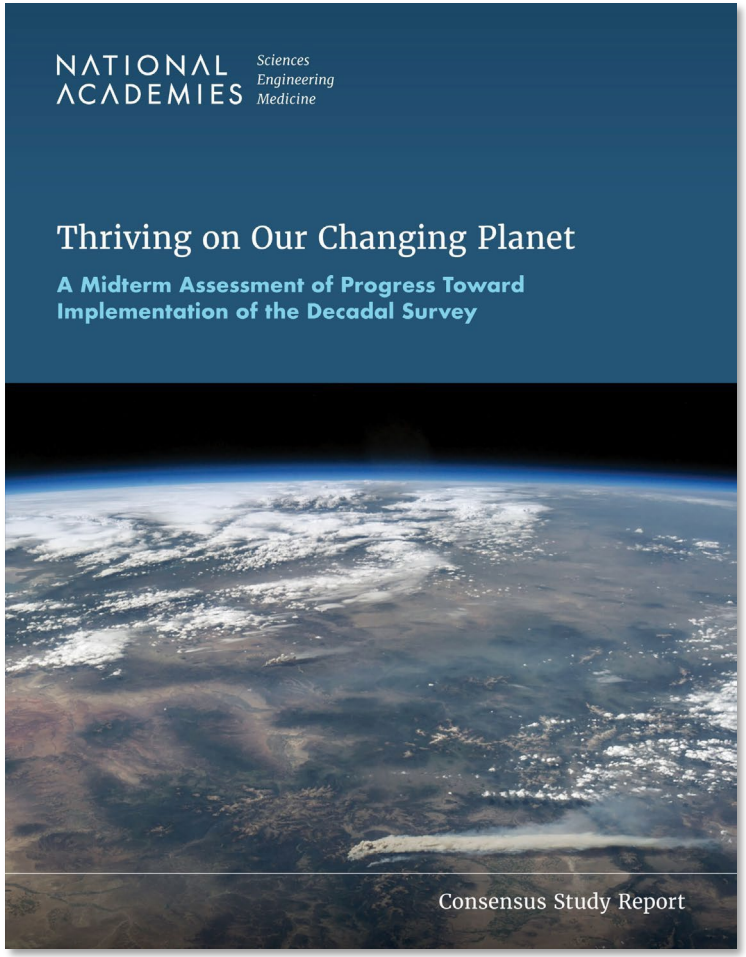
Study Process

- First meeting on August 27, 2023
- Information gathering from August 2023 to January 2024
  - Had community RFI open from September to December 2023 (132 responses)
- Open Meetings:
  - September 28-29, 2023: Washington, DC
  - November 2-3, 2023: Irvine, CA
  - December 4, 2023: Virtual
  - January 25-26, 2024: Irvine, CA
- Briefings to NASA, NOAA, USGS, and Congressional Staffers: June 26 – July 9, 2024
- Report release: July 10, 2024

About the Report – Key Takeaways

- NASA, USGS, and NOAA have **launched innovative science-driven missions** that have provided valuable new data and generated significant excitement from the research and applications community.
- Due to a variety of factors, however, **NASA has made limited progress** toward implementing the new missions recommended by the decadal survey.
- The report identifies potential strategies for managing the NASA ESD portfolio, with the goal of **maintaining programmatic balance and improving alignment with decadal survey priorities**.



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Science Successes

The fleet of existing and recently launched satellites and instruments has provided **new capabilities to track and understand**:

- methane leaks
- sea-level rise
- groundwater pumping
- deforestation
- wildfires
- ocean surface topography
- ocean primary productivity
- glacial outburst floods

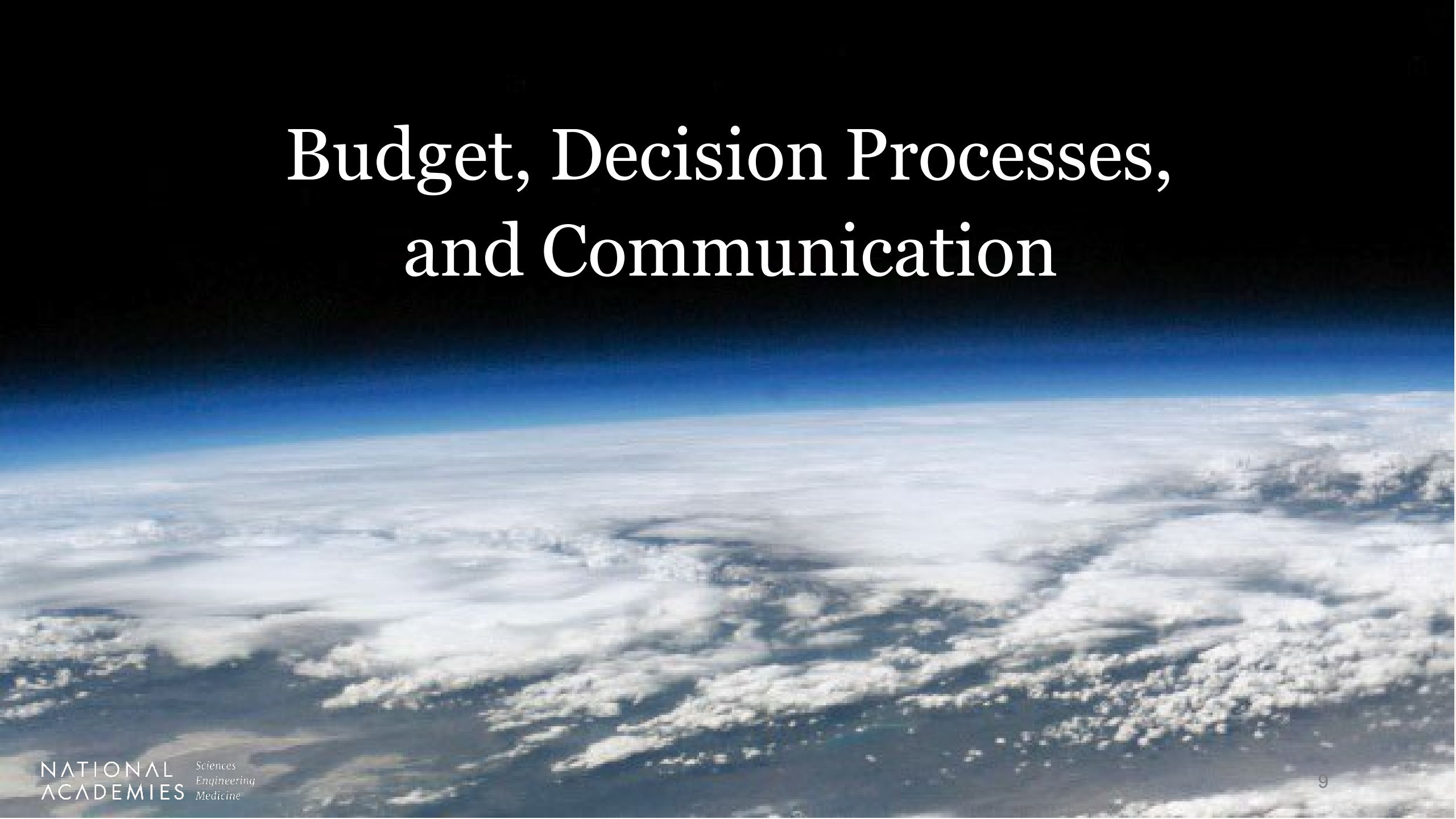
These observations have helped **advance a variety of applications**, including:

- wildfire management
- conservation of water resources
- risk reduction of extreme heat, flooding, and landslides

Recurring Themes

- Challenges arising from budgetary constraints
- NASA's best way forward to preserve the enthusiasm of the scientific community
- The increasing tension between the need for continuing measurements vs innovation

Budget, Decision Processes, and Communication



Investment in Decadal Survey Priorities is Vital

Findings:

- The need for **actionable information** based on Earth observations is increasing rapidly.
- However, NASA ESD has had an essentially **flat budget since 2015**, while mission costs are increasing.
- Priorities for science and technology **innovation directly compete with needs to continue observations of Earth's changing climate** which originally resulted from such innovation.

Recommendation: NASA should clearly **articulate the substantial societal value and urgency** of implementing the full set of 2017 Earth science and applications from space decadal survey priorities as well as its need for appropriate resources to do so. It is imperative that the NASA 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.

Expanding Collaboration Opportunities

Findings:

- At current levels of funding, **NASA cannot be expected to deliver on the needs for both providing long-term measurement continuity and new improved observation**s.
- The decadal survey outlined steps to be taken if budgets for recommended program elements grew beyond their allocated targets, but it **could not account for new requirements** levied upon the agencies by stakeholders other than the science and applications community.
- NASA has effectively leveraged collaboration with international agencies for the greater benefit of the scientific community and society at large.

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

NASA Should Pursue Funding for Landsat Next

Findings:

- **Communication of Landsat's importance and budget priority is not well-coordinated** with communication of the larger NASA Earth science program's importance or budget.
- This can significantly and negatively impact other elements within NASA's Earth science program when Landsat's budget is directed to increase without an increase in the NASA ESD top line budget.

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. Otherwise, the increased Landsat Next budget substantially limits resources available to achieve the Earth science vision laid out in the 2017 decadal survey.

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Maintaining Alignment with Decadal Survey Priorities

Findings:

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

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

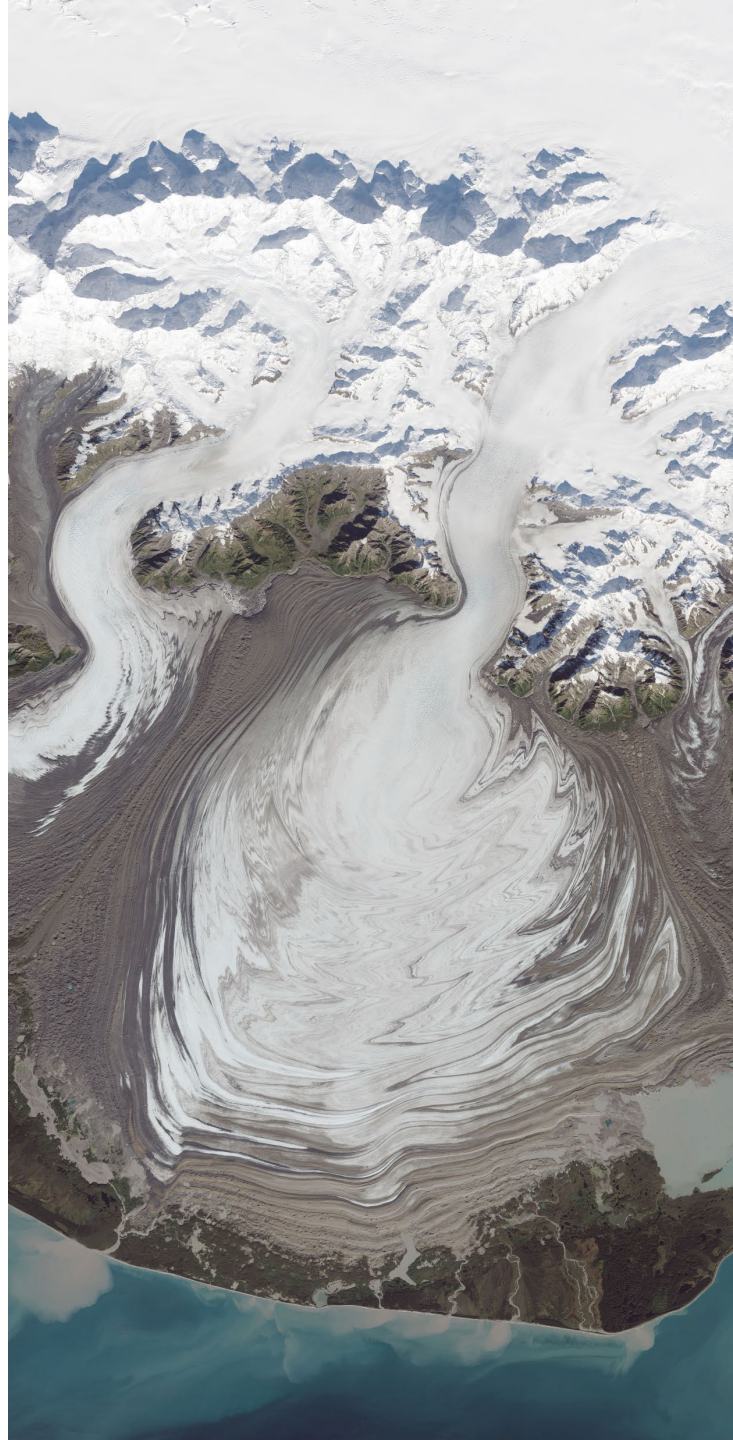
Recommendation: Consistent with the 2017 Earth science and applications from space decadal survey and the Earth System Observatory Independent Review Board (IRB) recommendations, NASA's Earth Science Division should **seek advice from the National Academies' CESAS prior to adding or substantially modifying individual program elements** to ensure appropriate consideration of program balance and decadal survey priorities.

Responding to Budgetary Pressures

Findings:

- 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.**
- Neither the decadal survey nor the IRB recommendations have been consistently implemented across the Designated program element.

Recommendation: To address budgetary challenges, NASA should follow the guidance provided in the 2017 Earth science and applications from space decadal survey, **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.



Program Elements

Surface Biology and Geology

Findings:

- The success of EMIT (VSWIR) and ECOSTRESS (Thermal Infrared [TIR]) onboard the International Space Station have demonstrated the promise of SBG.
- NASA is proceeding to address the decadal survey's SBG recommendation through two missions: SBG-VSWIR and SBG-TIR. The latter is to be implemented as a partnership with the Italian space agency (Agenzia Spaziale Italiana [ASI]). SBG-TIR is proceeding while SBG-VSWIR is being delayed.
- It would be more cost-effective and maximize science benefits to proceed with both SBG-VSWIR and SBG-TIR missions without further delay.

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

Atmospheric Observing System

Findings:

- The AOS baseline capabilities exceed those required to meet the decadal survey recommendations, resulting in higher costs to the program which could negatively impact other decadal survey priorities.

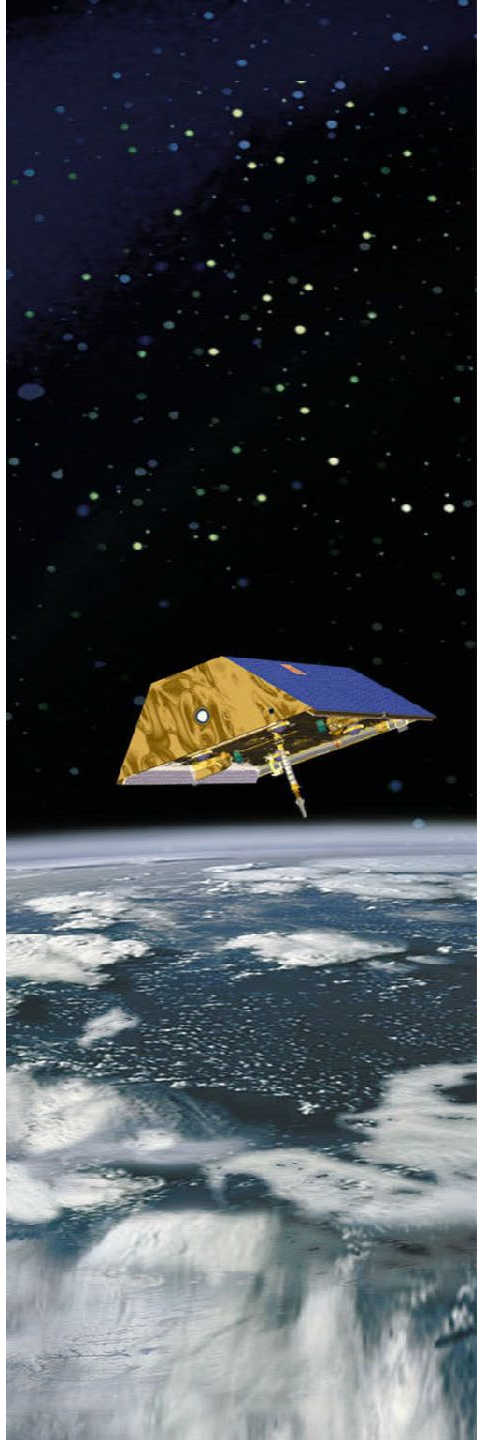
Recommendation: NASA should fully implement the 2017 Earth science and applications from space decadal survey's prescribed descopes for the Aerosols and Clouds, Convection, and Precipitation Targeted Observables, adding two Earth System Explorer solicitations to the program with Targeted Observable 1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

Gravity Recovery and Climate Experiment - Continuity

Findings:

- Costs for GRACE-C are higher than the maximum decadal survey recommended investment for the Mass Change Targeted Observable. Some cost growth was driven by increased performance demands from stakeholders owing to the missions' large number of applications and others by IRB recommendations to reduce risk.

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.**

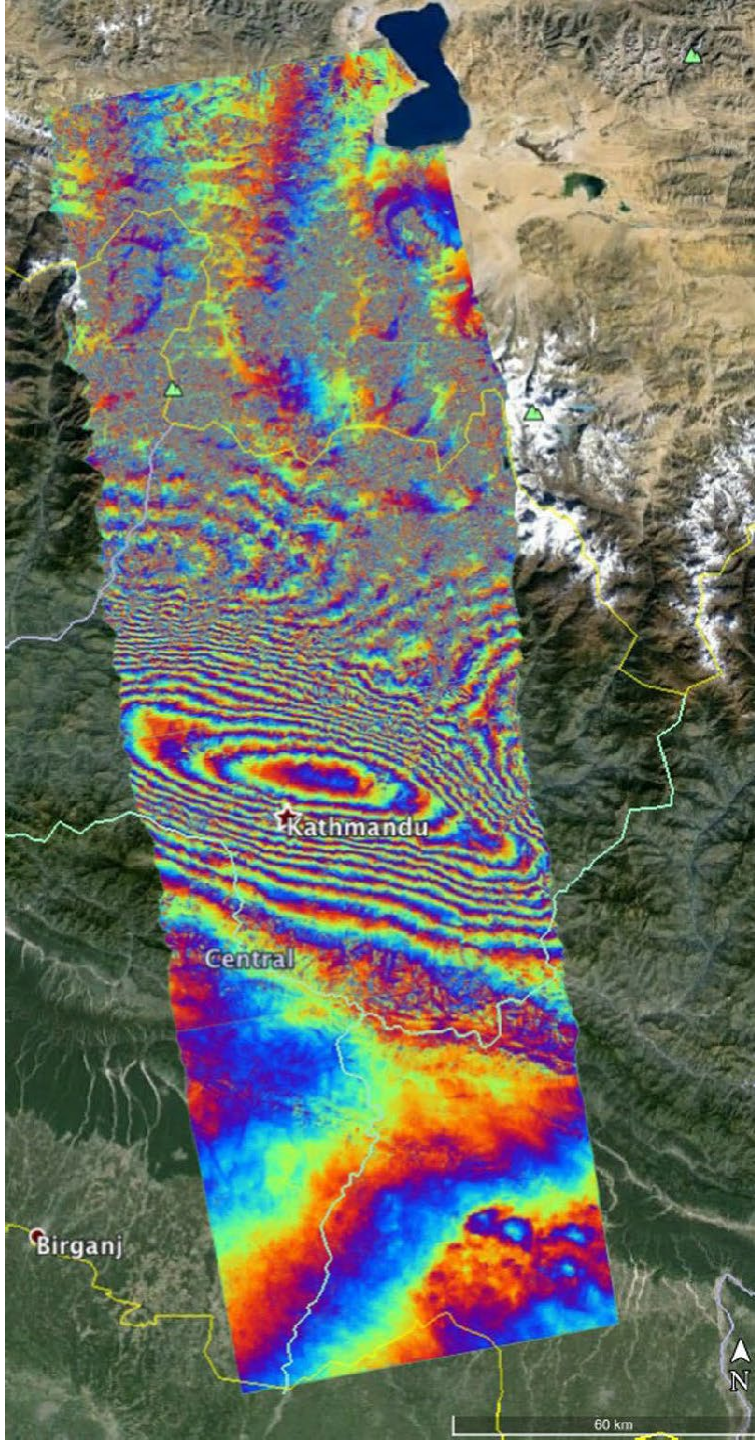


Surface Deformation and Change

Findings:

- The mission architecture for addressing the SDC Targeted Observable following the NISAR mission remains undefined because no options identified to date meet the cost cap while also addressing the decadal survey's priority science and applications objectives.

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 becomes available.



Earth System Explorers, Venture Class and Incubation

Findings:

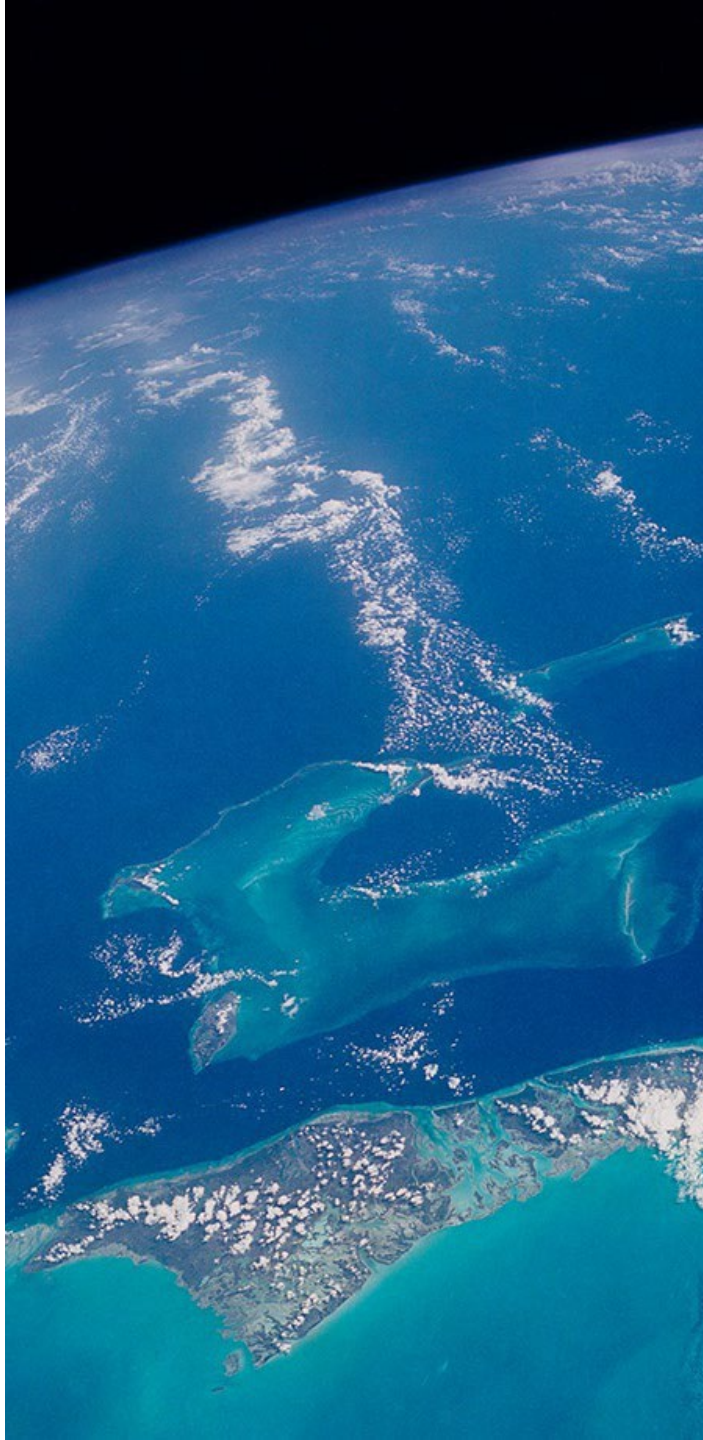
- The cadence of NASA's Earth System Explorer solicitation opportunities is not consistent with decadal survey recommendations. Instead of three solicitation spaced throughout the decade, NASA is planning to select two missions from a single solicitation.
- **Reducing the number of solicitation Earth Venture class missions and waiting to define them until closer to solicitation time provides programmatic flexibility but does not serve to provide the community with either routine, frequent open call opportunities, or an ability to plan ahead.** The lack of opportunity of competing for Earth Venture and Earth System Explorer missions in 2024 and 2025 also makes it difficult to sustain a culture of innovation and creativity among the Earth observations from the space community, as recommended in the decadal survey.
- Incubation programs for the PBL and STV Targeted Observables are worthwhile and working well overall.

Planning Ahead

Preparing for the Next Decadal Survey

Recommendation (paraphrased): 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.

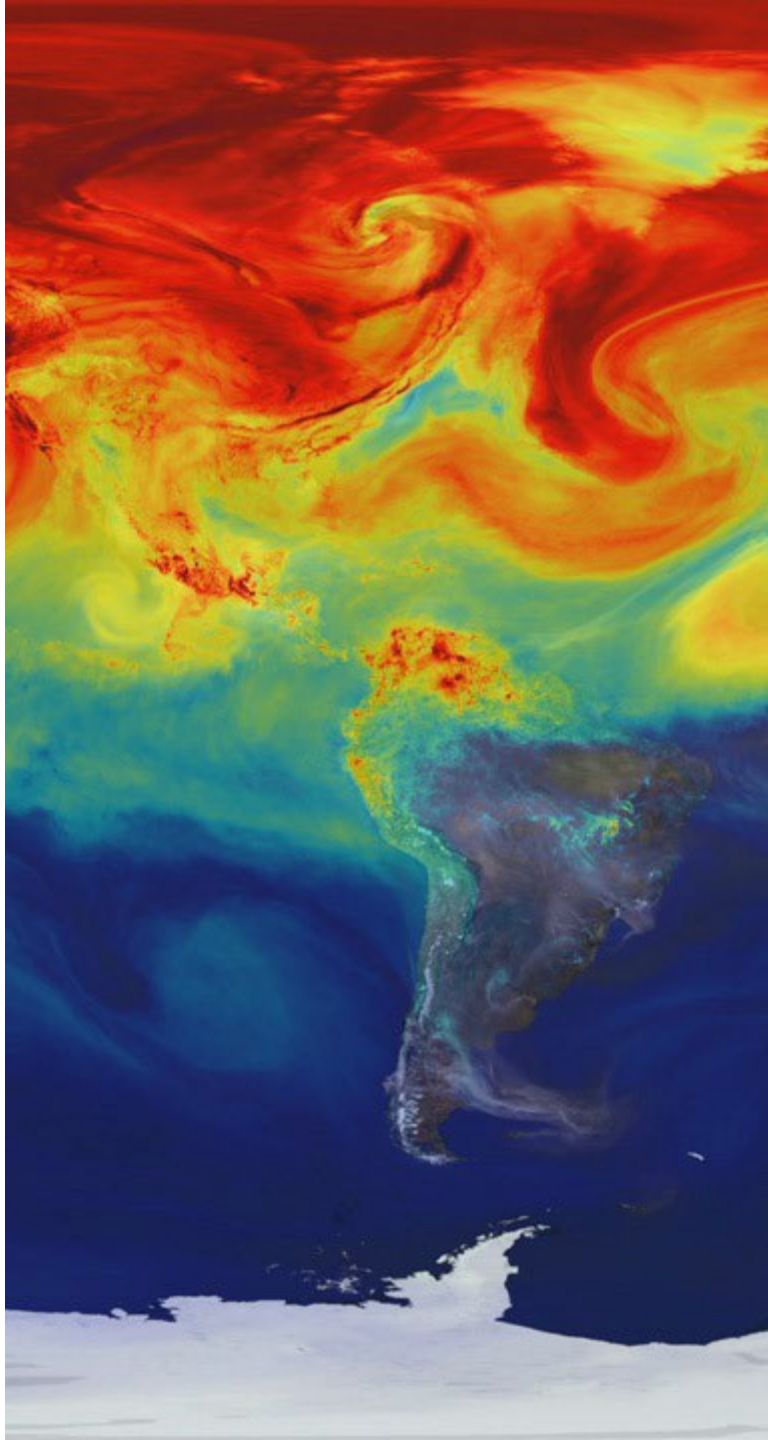


Engaging the Modeling Community

Findings:

- Strengthening the interaction between the flight planning, satellite data analysis, and Earth system modeling communities would enhance the use of satellite data.
- Engagement of the Earth system modeling communities is needed to ensure that future satellite missions enable improvements in prediction across the range of time and space scales that are influenced by climate-related and natural hazards.

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 more fully exploit existing and potential Earth observations for advancing model parameterizations and predictions.

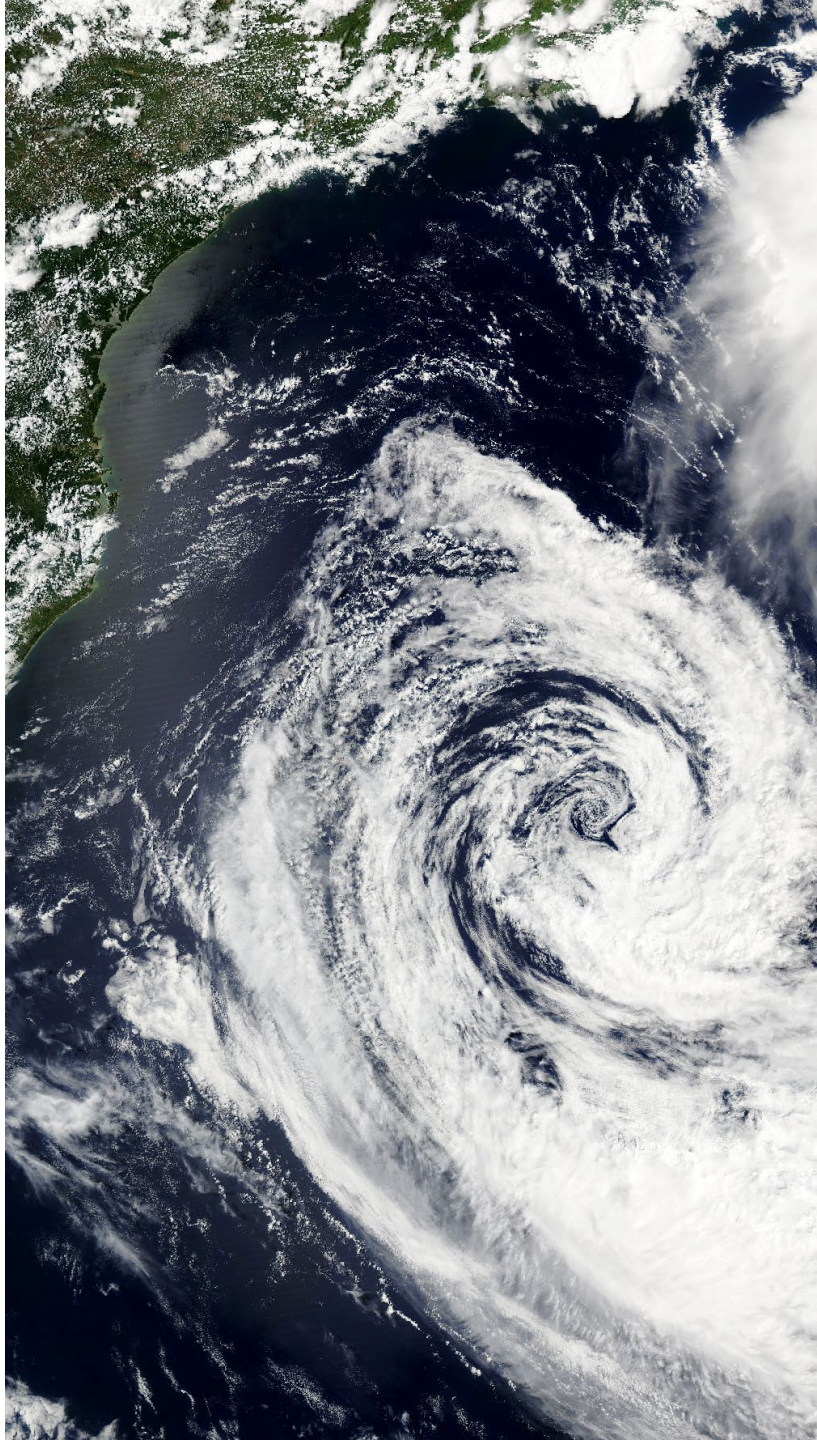


Developing Strategies for Observational Continuity

Findings:

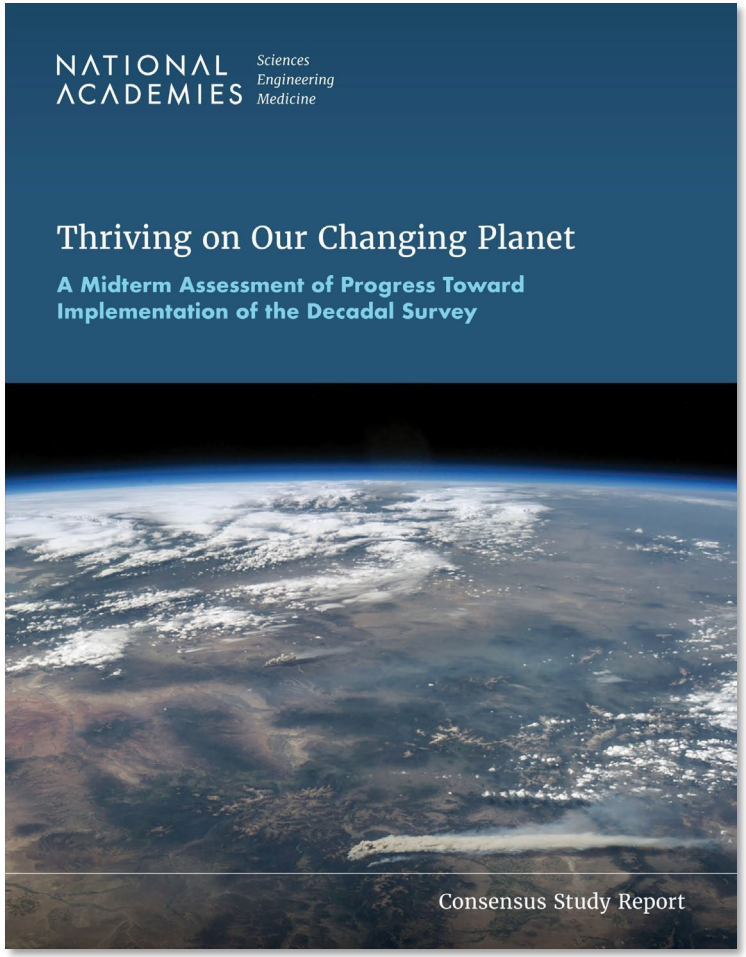
- Despite the decadal survey's recommendation that NASA ESD lead development of a more formal continuity decision process, current ESD decisions with regard to observation continuity remain ad hoc and do not generally communicate what future observations will be prioritized or how budgets need to expand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

The committee reiterates the 2017 decadal survey recommendation that there is an urgent need to "ensure that no flight program element is compromised by overruns in any other element" and "**lead development of a more formal continuity decision process to determine which satellite measurements have the highest priority for continuation**, then work with U.S. and international partners to develop an international strategy for obtaining and sharing those measurements."



Key Takeaways

- NASA, USGS, and NOAA have **launched innovative science-driven missions** that have provided valuable new data and generated significant excitement from the research and applications community.
- Due to a variety of factors, however, **NASA has made limited progress** toward implementing the new missions recommended by the decadal survey.
- The report identifies potential strategies for managing the NASA ESD portfolio, with the goal of **maintaining programmatic balance and improving alignment with decadal survey priorities**.
- The increasing urgency of reliable climate information will require **increased levels of funding to ensure that NASA, NOAA and USGS can implement a balanced portfolio** that invests in new technology while maturing existing observations and eventually transitions them into the applications needed to adapt to a changing climate



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Agency Responses

Highlights from NASA Response

From October 22 presentation given at ESD town hall

NASA grouped the report findings/recommendations and their responses into **four themes**:

- Engaging [Their] Community and Stakeholders
- Developing the Earth System Observatory (ESO) Through Budget Constraints
- Strategic Approaches for Continuity
- Strategic Approaches for Modeling

NASA also shared some "key topics for ongoing CESAS engagement/future discussion:

- "Given that substantial additional funding is unlikely in the near future, [NASA's] strategy is to maximize the impact of the existing resources
- **"What observations are we talking about and what are the essential attributes?**
  - Observations to enable breakthroughs
  - Sustained observations for understanding Earth system processes and change
  - Measurements that have broad application
  - Observations for operational purposes are very important
- "Structured analysis of risks and opportunities"

For more information, go to

https://science.nasa.gov/earth-science/esd-community-forum/

Thank You

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