EARTH SYSTEM EXPLORERS

National Aeronautics and Space Administration

Science Overview

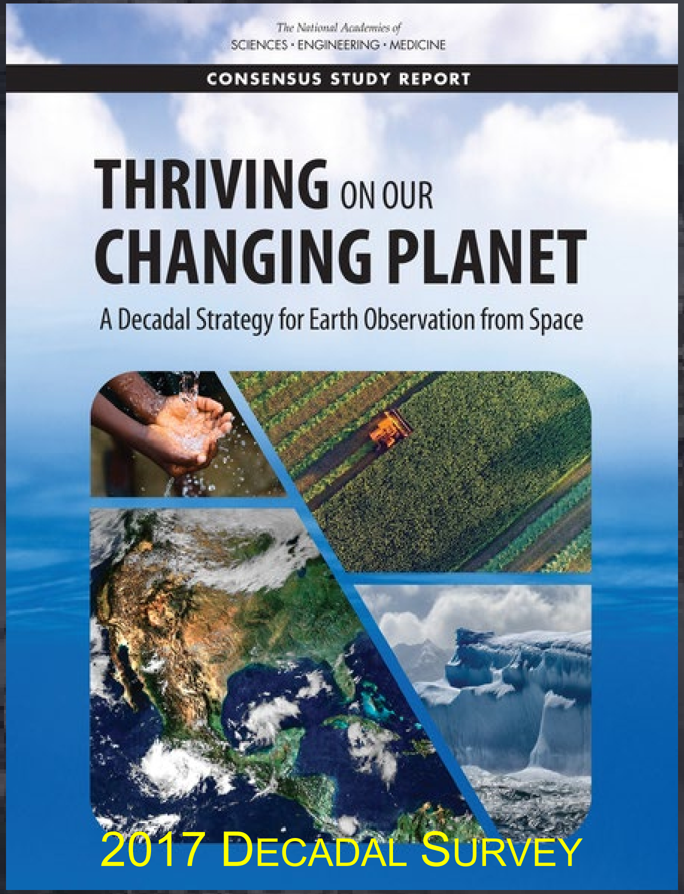
NASA Strategic Goals

NASA's Strategic Goal 1 is to Expand Human Knowledge Through New Scientific Discoveries and Strategic Objective 1.1 is to Understand the Earth system and its climate. Further information on NASA's strategic goals may be found in NASA Policy Directive (NPD) 1001.0, *The NASA 2022 Strategic Plan* (https://www.nasa.gov/sites/default/files/atoms/files/fy_22_strategic_plan.pdf).

The NASA Science Mission Directorate (SMD) is addressing this strategic goal through strategies identified under Priority 1 Exploration and Scientific Discovery, in *2020-2024: A Vision of Scientific Excellence, Year 2021-2022 Update*

Earth System Explorers Goals and Objectives

- The Earth System Explorers program conducts Principal Investigator (PI)-led space science missions as recommended by National Academies of Sciences, Engineering, and Medicine 2017 *Decadal Survey for Earth Science and Applications from Space.*
- Earth System Explorers program is designed to enable high-quality Earth system science investigations by developing missions that take measurements of one or more observables identified as Earth System Explorers Targeted Observables (TO).



- Endorsed the Program of Record
- Identified measurement observables
- **Called for EV Continuity missions**

ESE Targeted Observables

Targeted Observable	Science/Applications Summary	Candidate Measurement Approach
Greenhouse Gases	CO2 and methane fluxes and trends, global and regional with quantification of point sources and identification of sources & sinks	Multispectral shortwave IR and thermal IR sounders; or lidar*
Ice Elevation	Global ice characterization including elevation change of land ice to assess sea-level contributions and freeboard height of sea ice to assess sea ice/ocean/atmosphere interaction	Lidar
Ocean Surface Winds and Currents	Coincident high-accuracy currents and vector winds to assess air-sea momentum exchange and to infer upwelling, upper ocean mixing, and sea-ice drift	Doppler scatterometer
Ozone and Trace Gases	Vertical profiles of ozone and trace gases (including water vapor, CO, NO2, methane, and N2O) globally & with high spatial resolution	UV/VIS/IR microwave limb/nadir sounding and UV/VIS/IR solar/stellar occultation
Snow Depth and Snow Water Equivalent	Snow depth and snow water equivalent, including high spatial resolution in mountain areas	Radar (Ka/Ku band) altimeter; or lidar*
Terrestrial Ecosystem Structure	3D structure of terrestrial ecosystem including forest canopy and above ground biomass and changes in above ground carbon stock from processes such as deforestation & forest degradation	Lidar*
Atmospheric Winds**	3D winds in troposphere/planetary boundary layer (PBL) for transport of pollutants/carbon/aerosol and water vapor, wind energy, cloud dynamics and convection, & large-scale circulation	Active sensing (lidar, radar, scatterometer); or passive imagery or radiometry-based atmospheric motion vectors tracking; or lidar*

- The Decadal Survey states:
    - “The Earth System Explorers program element is recommended in part because the science priorities identified are of sufficiently similar importance that the key discriminators on what should go forward are those that will emerge through competition addressing cost, scope, technical performance, technical readiness, and programmatic capabilities.”
- Proposed missions can target one or more of the observables listed above
- However, at least one of the estimated four selected proposals will prioritize Greenhouse Gases as one of its Targeted Observables

Decadal Survey Appendix B: Science and Application Traceability Matrix

TABLE B.1 ESAS 2017 Consolidated Science and Applications Traceability Matrix

KEY: **Square brackets:** Nonspace observations or related commitments
Curly brackets: Space observations with non-NASAS/NOAA/USGS assets, such as non-U.S. or databuys

GLOBAL HYDROLOGICAL CYCLES AND WATER RESOURCES PANEL

SCIENCE			MEASUREMENT				
Societal or Science Question/Goal	**Earth Science/Application Objective**	**Science/Application Importance**	**Geophysical Observable**	**Measurement Parameters**	**Example Measurement Approaches Method**	**POR**	**TO**
QUESTION H-1. **Coupling the Water and Energy Cycle.** How is the water cycle changing? Are changes in evapotranspiration and precipitation accelerating, with greater rates of evapotranspiration and thereby precipitation, and how are these changes expressed in the space-time distribution of rainfall, snowfall, evapotranspiration, and the frequency and magnitude of extremes such as droughts and floods?	**H-1a.** Develop and evaluate an integrated Earth system analysis with sufficient observational input to accurately quantify the components of the water and energy cycles and their interactions, and to close the water balance from headwater catchments to continental-scale river basins.	**Most Important**	Energy and water fluxes in the boundary or surface layer: solar (direct and reflected) and longwave radiation (downwelling and emitted), sensible and latent heat exchange, and soil heat flux.	Surface solar and longwave radiation balances, which are needed to estimate the other energy balance parameters, to within 10 W/m^2 accuracy at 1 km resolution globally, four times daily.	Downscale CERES-like observations to finer spatial resolutions (1 km) and eliminate systematic errors. See H-1b and H-1c.	POR-1, 3, 10, 20, 21, 23, 24, 25	TO-17, 18
					Model and data integration with capabilities to estimate moist processes in atmosphere, land and terrestrial biosphere.	POR-1, 6, 9	TO-13
	H-1b. Quantify rates of precipitation and its phase (rain and snow/ice) worldwide at convective and orographic scales suitable to capture flash floods and beyond.	**Most Important**	Precipitation rate and phase (rain or snow).	Diurnal cycle of precipitation at 1 (desirable) or 4 km (needed) scales (rain and snow) with accuracy of 0.2 mm/hr for rainfall and 1 mm/hr for snow, at finer scales in selected areas such as mountainous regions.	Multi-frequency radar and radiometer system similar to GPM/CloudSat as well as aerosol capabilities for continued improvement in precipitation process understanding, precipitation rate observations, and long term monitoring for change detection.	POR-4, 23, 25	TO-5, 13
	H-1c. Quantify rates of snow accumulation, snowmelt, ice melt, and sublimation from snow and ice worldwide at scales driven by topographic variability.	**Most Important**	Snow water equivalent (SWE).	Global SWE at 1 (desirable) or 4 km (needed) resolution every 3-5 days, to 10% accuracy for SWE values to 1 m.	Existing passive microwave for global scale okay for SWE values to ~200 mm. Problematic for deep snow in heterogeneous terrain.	POR-23	TO-16, 19
				In mountains, SWE at ~100 m resolution suitable for SWE values to 2.5 m.	In mountains, measure depth (Ka-band radar or laser altimeter) and density (SAR).	POR-17 (KaRIn, SWOT)	TO-16, 19
			Snow and glacier albedo and temperature.	Spectral albedo of subpixel snow and glaciers at weekly intervals to an accuracy to estimate absorption of solar radiation to 10%. Ice/snow surface temperature to ±1 K. At spatial resolution of 30 to 100 m.	Imaging spectrometer to understand seasonal variability. Develop methods and calibration for multispectral sensors for weekly worldwide coverage. Panchromatic multiangle radiometer. Thermal emission radiometer for temperature.	POR-22	TO-18
QUESTION H-2. **Prediction of Changes.** How do anthropogenic changes in climate, land	**H-2a.** Quantify how changes in land use, water use, and water storage affect evapotranspiration rates, and how these in turn	**Very Important**	Latent heat flux at 3 (desirable) to 6 hour (useful) resolution during daytime intervals and at 1 km spatial scale with better than 10	Temperature of soil and vegetation separately, 40-100 m spatial resolution, accuracy of ±1 K, at a temporal frequency to resolve the diurnal cycle.	Emitted infrared radiation in 4 µm and 11 µm wavelength regions, possibly free flyers to get desired frequency of four times daily.	POR-3, 9, 10, 20, 24, 25	TO-13, 18

Proposers need to develop their mission specific Science and Application Traceability Matrix
Appendix B is only a guideline

Role of the Principal Investigator

For PI-led missions, the PI fills a challenging, multidisciplinary role, which demands excellent communication, team building, and management skills. The PI is responsible for all aspects of the successful implementation of the mission.

A proposal shall identify and designate one, and only one, PI as the individual in charge of the proposed investigation. Designation of a Deputy PI is recommended, however is not required.

Role of Co-Investigators and Collaborators

The identity, role, and necessity of all Co-Is and Collaborators must be provided in the proposal.

- "A Co-Investigator is defined as an investigator who plays a necessary role in the proposed investigation…the necessity of that role must be justified."
  - Experience shows that for each Co-I this requires more than a single sentence fragment plus a CV.
- "The identification of any unjustified Co-Is may result in the downgrading of an investigation..

- A collaborator is an individual who is less critical to the successful development of the investigation than a Co-I. A collaborator must not be funded by the Earth System Explorers Program.

The annual time commitments and funding source of all Co-Is and Collaborators must be specified.

- Proposers are strongly encouraged to include a table containing this information.

Societal Applications

The proposal shall describe:

(a) innovative and practical societal applications of the data that will be collected and disseminated;

(b) how users will be engaged;

(c) how the project will adapt to new societal applications opportunities that may emerge;

(d) how the project will coordinate societal applications activities with NASA;

(e) a budget for the implementation of the activities listed above.

In some science investigations, societal applications are not possible. In such cases, the proposer is required to explain and justify why there is no application dimension to the investigation.

Data Archival and Open Science

- All data returned shall be made available publicly available via a NASA Distributed Active Archive Center (DAAC)
- The DAAC(s) will be assigned by NASA in Phase B.

- The proposals needs to include an Open Science Data Management Plan (OSDMP) that is conform to the NASA Earth Science Data and Information Policy and the Open Source Science (OSS) Policy (SPD-41). See Section 5.2.14 for details.

Notice of Intent

- NOIs are mandatory and due May 31, 2023
- Please fill in your proposal team as complete as possible. This will help us putting the review panels together early in the process.