A.11 SWOT SCIENCE TEAM

NOTICE: Amended May 22, 2023. This Amendment releases the final text for this program element, which was previously listed as TBD. Notices of Intent are requested by November 9, 2023, and proposals are due December 15, 2023.

1. Background

Surface Water and Ocean Topography (SWOT) is the first satellite mission to measure the elevation of nearly all water on Earth's surface. As a global survey, SWOT will create detailed maps of the water surface topography over the open and coastal oceans, lakes and rivers, reservoirs, and other bodies of water. After two decades of preparation for the mission since its conception by the Wide Swath Ocean Altimeter group in the early 2000s (e.g., *Fu and Rodrigues 2003*; *Alsdorf and Lettenmaier, 2003*), SWOT was launched on December 16th 2022, illuminating the night skies of central California at the Vandenberg Space Force Base and commencing a new era in high-resolution satellite remote sensing of Earth's ocean and inland surface waters.

The SWOT observatory uses a combination of radar altimetry and interferometry and was jointly developed by NASA and the Centre National d'Etudes Spatiales (French Space Agency, CNES), with contributions from the Canadian and the United Kingdom Space Agencies. The key instrument on board the SWOT satellite is the Ka-band Radar Interferometer (KaRIn). KaRIn is a first-in-flight demonstration of wide-swath SAR (Synthetic Aperture Radar) interferometry and paves the way for more accurate and comprehensive mapping of Earth's surface water from space. Using interferometric principles, KaRIn combines multiple radar signals to generate high-resolution 3D maps of the water surface over a wide (120-km) swath. As a result, SWOT observes the location, shape, and evolution of the ocean surface at about 15-km horizontal resolution, which is ten-times finer than the previous Jason-class altimeters; over land SWOT surveys millions of lakes larger than 250 m x 250 m and rivers wider than 100 m across the globe. The first images of Earth's ocean and inland waters sent by SWOT revealed promising results and indicated higher-than anticipated instrument accuracy.

SWOT's highly anticipated data are expected to advance a range of Earth science applications, including land hydrology, ocean physics, water and energy cycle, and broader climate science. SWOT will also provide practical information for water resource management, infrastructure planning and development, disaster and hazard response, and other decision-making contexts ranging from agriculture to energy and geopolitics.

Via twin, jointly-released solicitations, NASA and CNES seek studies that will demonstrate the potential of the SWOT's innovative wide-swath SAR interferometry, while recognizing the complexity and novelty of the measurement system as we begin to learn about SWOT's capabilities in the coming years. As a critical piece in assessing the mission's scientific success, the main charge for the SWOT Science Team is to provide robust evidence of how SWOT's new technological capabilities that provide high-resolution and high-precision mapping enable new discoveries across a wide range of Earth science and applications.

2. Scope of Program

The goal of this program element is to select U.S. members of the international SWOT Science Team that will function from 2024 through 2028. Only U.S.-based organizations are eligible to propose to this program element. U.S.-based proposals may include unfunded participants affiliated with foreign organizations. NASA selection of U.S.-proposals will be coordinated with CNES selection of proposals from foreign organizations, to ensure continued growth of the international SWOT community, which today includes science team members from 17 countries spanning five continents across the globe that were selected from a previous competition. NASA will provide funding for the selected proposals from U.S.-based institutions and CNES will be responsible for the selection of the international projects. The solicitation of proposals from French and other international investigators will be conducted via its Terre-Océan-Surfaces Continentales-Atmosphère (TOSCA) process.

The overarching objective of the SWOT Science Team is to demonstrate the potential of the SWOT observing capabilities in societally-relevant Earth science studies. To encourage scientific creativity while recognizing the novelty of the SWOT system, the following priorities for the next phase of the SWOT Science Team are listed here and expanded upon in the Sections 2.1-2.2 below:

(1) Understanding measurement physics and data challenges to improve the utility of SWOT data products
(2) Novel Earth science and research applications with SWOT observations

To be considered responsive to this call, proposers must address one or both SWOT Science Team priorities as detailed below.

2.1 Understanding Measurement Physics and Data Challenges to Improve the Utility of SWOT Data Products

The SWOT mission project team is responsible for the development and distribution of the best-possible standard data products, including sea surface height, river and lake height and area, and river slope. To complement the efforts of the SWOT mission project team in the area of data product definition, calibration, and validation, NASA and CNES solicit proposals to improve our understanding of the physics of the novel and complex measurements of the SWOT's KaRIn instrument. Examples of data challenges and desired solutions include the removal of errors in sea surface height due to the presence of ocean waves and sea-state bias across the swath, correction of the electromagnetic bias at the Ka-band frequency and other known sources of signal contamination, errors in the mean sea surface and other geophysical corrections, the prediction and separation of ocean tides and internal tides at these new scales, as well as improved classification of terrestrial hydrologic features based on enhanced understanding of SWOT phenomenology.

The results of studies in this category are expected to increase robustness of the SWOT standard data products, including sea surface height and anomaly, ocean wind speed and significant wave height, river parameters including water elevation, slope, width, derived discharge and inundation extent, or lake attributes such as water elevation, area, and derived storage change as described in SWOT description documents.

In addition to improving standard data products through characterization of measurement physics, NASA and CNES seek innovative ideas to develop useful methods and data products that address other known challenges, such as temporal sampling, separation of balanced ocean motions, internal gravity waves and long ocean swell, river-floodplain interactions, etc. Examples of community-driven product development can include Level 3 or valued-added Level 4 products on regular space and time grids; assimilation of SWOT data into regional or global modeling frameworks (coupled, ocean, hydrologic or hydrodynamic models); exploration of relevant data-integration and digital twin efforts, particularly those targeting coastal regions and river deltas; development of data products based on information from SWOT and other satellite missions, such as riverine sediment transport, ocean currents or products that jointly exploit the global KaRIn radar backscatter and heights in various applications (e.g., air-sea interaction processes or improved lake storage estimates); development of new mean sea surface estimates; improving ocean tide and internal tide models including nonstationary tides; improved representation of tidal effects in rivers and estuaries, and other useful data products that will advance the utility and broaden the range of science applications and users of SWOT data. Please note that while the list of examples is broad, selection of the proposals will be constrained by the total amount of funding available as well as by the need to ensure a diversity of data products.

To ensure robustness of data products, proposers to this category are encouraged to take advantage of the relevant surface measurements collected during a series of distributed field campaigns conducted during the mission's calibration and validation phase. Measurements include *in situ* and airborne observations in multiple rivers, lakes, open-ocean, and coastal environments and will be made publicly available upon completion of the campaigns; see SWOT website for details.

2.2 Novel Earth Science and Research Applications with SWOT

The major objective of the SWOT Science Team is to demonstrate how the novel type of measurements and detailed maps of Earth's surface water provided by SWOT are essential for understanding ongoing changes of the Earth's water and energy cycles. The ultimate goal is to use this information to help humanity better manage our planet's water resources today and in the future. To achieve thisgoal, NASA and CNES solicit compelling proposals incorporating SWOT measurements to track and predict the movement, distribution, and storage of water around the world. Given SWOT's unique design to monitor the entire water supply-demand chain, from water origin in the ocean to water sinks and storage on land, studies exploring Earth's water cycle as a global and complete system are of high priority. Understanding and articulating SWOT's unique contribution within the NASA, CNES and/or global water-observing satellite fleet is an important metric of the mission's scientific impact, with implications for the development of future missions with similar capabilities. Therefore, synergistic use of SWOT data with other water-focused satellite missions to understand and predict the change in the global water cycle, including pattern amplification and intensification of hydroclimatic extremes, are sought here. More generally, studies demonstrating how SWOT's novel high-resolution views of Earth's water enhance our knowledge of other fundamental Earth cycles (e.g., energy, mass, carbon) and interactions within the

Earth's ocean-atmosphere-land-cryosphere-biosphere-human system are also of high programmatic relevance.

In addition to global studies, proposals that convincingly demonstrate the utility of SWOT measurements in regional and/or domain applications are solicited. Examples of such proposals can include studies of water storage in lakes and reservoirs, their change over time and implications for the biosphere-ocean-human system; variations in river heights, slope, inundation, and discharge at sub-monthly, seasonal, and annual timescales and linkages with climate and risk management; understanding coastal environments using high-resolution (~50-m) coastal data and helping addressing urgent coastal challenges associated with sea level rise, coastal erosion, loss of freshwater, etc.; the role of ocean sub-mesoscales, fronts, and eddies in the Earth's regional or global energy and water budget; improving predictability of ocean tides and high-frequency motions; novel applications for cryospheric science; or improved mapping for marine geophysics; etc. The list of explorations and topics is open-ended. SWOT's new era in satellite remote sensing of Earth's water presents ample opportunities to have many first views. After two decades of waiting to get a new look at Earth's water with SWOT, the time is ripe to be bold and creative, innovating and inspiring.

Finally, per the recommendation of the 2017 Decadal Survey for the NASA Earth Science by the National Academies of Sciences, NASA is committed to amplify the cross benefits of science and applications (e.g., see NASA Applied Sciences Programs for details). To enhance societal benefits of the SWOT mission, NASA welcomes application incubation proposals that explore the utility of integrating SWOT information into practical applications, such as water resource management, coastal protection, climate resilience, weather prediction, etc. SWOT information can include, e.g., data products, derived quantities, data-assimilation/integrated or digital twin estimates, and any other SWOT-enabled products including those developed by other team members under category 2.1, as described above.

3. Programmatic Information and Other Requirements

All proposals must provide an "Open Science and Data Management Plan" (OSDMP) of up to two pages in length, immediately following the references and citations for the Science/Technical/Management section of the proposal. The OSDMP must address how publications, data, and software will be made available, see Section 1.1 of A.1 Earth Science Research Program Overview, the ROSES Open Science and Data Management Plan FAQ and the *SMD Open-Source Science Guidance*.

All data and information acquired and data products produced as part of the solicited research must be made publicly available, with no period of exclusive use, in compliance with the NASA Earth Science Data Policy. A template for the OSDMP may be found at Templates for ESD.

Proposers must budget for mandatory project representation at annual SWOT Science Team meetings, alternating years in Europe and in North America over a 4-year period. Selected proposers are expected to join the SWOT Science Team thematic Working Groups relevant to their proposed research objectives, and budget appropriate resources to participate in the monthly group discussions. For relevant topics, selected

members will be encouraged to interact with the Ocean Surface Topography Science Team (OSTST).

4. Summary of Key Information

Expected program budget for new awards	~$4.2M/year
Number of new awards pending adequate proposals of merit	~15-20
Maximum duration of awards	4 years
Due date for Notice of Intent to propose (NOI)	See Tables 2 and 3 of this ROSES NRA
Due date for proposals	See Tables 2 and 3 of this ROSES NRA
Planning date for start of investigation	6 months after the proposal due date
Page limit for the central technical section of the proposal	15 pp; see also Table 1 of *ROSES-2023* and *the NASA Proposer's Guide*.
Relevance	This program is relevant to the Earth Science questions and goals in the NASA Science Plan. Proposals that are relevant to this program are, by definition, relevant to NASA
General information and overview of this solicitation	See the *ROSES-2023 Summary of Solicitation*.
General requirements for content of proposals	See A.1 the Earth Science Research Program Overview, and Section IV and Table 1 of *the ROSES-2023 Summary of Solicitation*.
Detailed instructions for the preparation and submission of proposals	See NSPIRES Online Help, Sections 3.22-4.4 of the *NASA Proposer's Guide* and Section IV(b) of *the ROSES Summary of Solicitation*.
Submission medium	Electronic proposal submission is required; no hard copy is required or permitted.
Web site for submission of proposal via NSPIRES	http://nspires.nasaprs.com/ (help desk available at nspires-help@nasaprs.com or (202) 479-9376)
Web site for submission of proposal via Grants.gov	https://www.grants.gov/ (help desk available at support@grants.gov or (800) 518-4726)
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