NASA SBIR 2021 Phase I Solicitation

S1.08 Suborbital Instruments and Sensor Systems for Earth Science Measurements

Lead Center: LaRC

Participating Center(s): ARC, GSFC, JPL

Scope Title:

Sensors and Sensor Systems Targeting Aerosols and Clouds

Scope Description:

Earth science measurements from space are considerably enhanced by observations from generally far less costly suborbital instruments and sensor systems. These instruments and sensors support NASAâ€™s Earth Science Division (ESD) science, calibration/validation, and environmental monitoring activities by providing ancillary data for satellite calibration and validation,Â algorithm development/refinement,Â and finer scale process studies. NASA seeks measurement capabilities that support current satellite and model validation, advancement of surface-based remote-sensing networks, and targeted Airborne Science Program and ship-based field campaign activities as discussed in the Research Opportunities in Space and Earth Science (ROSES) solicitation. Data from such sensors also inform process studies to improve our scientific understanding of the Earth System. In situ sensor systems (airborne, land, and water-based) can comprise stand-alone instrument and data packages; instrument systems configured for integration on ship-based (or alternate surface-based platform) and in-water deployments, NASAâ€™s Airborne Science aircraft fleet or commercial providers, UAS, balloons, ground networks; or end-to-end solutions providing needed data products from mated sensor and airborne/surface/subsurface platforms. An important goal is to create sustainable measurement capabilities to support NASAâ€™s Earth science objectives, with infusion of new technologies and systems into current/future NASA research programs. Instrument prototypes as a deliverable in Phase II proposals and/or field demonstrations are highly encouraged.

Complete instrument systems are generally desired, including features such as remote/unattended operation and data acquisitionÂ as well asÂ minimum size, weight, and power consumption. All proposals must summarize the current state of the art and demonstrate how the proposed sensor or sensor system represents a significant improvement over the state.

Specific desired sensors or mated platform/sensors include:

- Combined aerosol absorption and scattering/extinction of atmospheric aerosols with calibrated accuracy and a particular emphasis on the ultraviolet (UV) or near-UV wavelengths.
- Spectrally resolved aerosol absorption, scattering, or extinction (UV to near-

infrared (NIR) wavelengths).
- Aerosol scattering as a function of scattering angle (phase function or, preferably, phase matrix).
- Aerosol complex refractive index.
- Aerosols and cloud particle number and size distribution covering the diameter size range of 0.01 to 200 ÂµmÂ with 10% accuracy. Probes targeting cloud particles in the lower end of this size range (0.01 to 5 Âµm) are particularly encouraged.
- Cloud probes able to differentiate and quantify nonsphericity and phase of cloud particles.
- Liquid and ice water content in clouds with calibrated accuracy and precision.
- Liquid and ice water path in relevant tropical, midlatitude, and/or polar environments, including data inversion and analysis software.
- Spectrally resolved cloud extinction.
- Static air temperature measured from aircraft to better than 0.1Â ÂºC accuracy.
- A well-calibrated airborne hyperspectral imager with spectral sensitivity in the UV to visible (VIS)Â (340 to 900 nm; preferably 320 to 1,080 nm) with spectral sampling of at least 2.5 nm, spectral resolution of at least 5 nm, and a wide dynamic range and sensitivity spanning from ocean radiances to cloud radiances for use in comparison to the PACE Ocean Color Instrument and other sensors.
- Portable hyperspectral UV-VIS-NIR (340 to 900 nm; preferably 320 to 1,100 nm) radiometric calibration system with a stabilized optical light source for verification of field radiometer stability by traceable National Institute of Standards and Technology (NIST) standards with variable flux levels.Â
  System must include thermal stabilization for the instrument to be independent of the ambient temperature for evaluation of radiometric stability as a function of time.
- Innovative, high-value sensors directly targeting a stated NASA need (including trace gases and ocean) may also be considered. Proposals responding to this specific bullet are strongly encouraged to identify at least one relevant NASA subject matter expert.

Expected TRL or TRL Range at completion of the Project:Â 4 to 7Â
Primary Technology Taxonomy:Â
Level 1: TX 08 Sensors and InstrumentsÂ
Level 2: TX 08.3 In-Situ Instruments/Sensor**Â**
Desired Deliverables of Phase I and Phase II:

- Prototype
- Hardware
- Software

Desired Deliverables Description:

The ideal Phase I proposalÂ would demonstrate a clear idea of the problem to be solved, potential solutions to this problem, and an appreciation for potential risks or stumbling blocks that might jeopardize the success of the Phase I and II projects.Â The

ideal Phase I effort would then address and hopefully overcome any major challenges to (1) demonstrate feasibility of the proposed solutionÂ and (2) clear the way for the Phase II effort. These accomplishments would be detailed in the Phase I final report and serve as the foundation for a Phase II proposal.

The ideal Phase II effort would build, characterize, and deliver a prototype instrument to NASA including necessary hardware and operating software. The prototype would be fully functional, but the packaging may be more utilitarian (i.e., less polished) than a commercial model.

State of the Art and Critical Gaps:

The S1.08 subtopic is and remains highly relevant to NASA Science Mission Directorate (SMD) and Earth Science research programs, in particular the Earth Science Atmospheric Composition, Climate Variability & Change, and Carbon Cycle and Ecosystems focus areas. Suborbital in situ and remote sensorsÂ sensors inform NASA ground, ship, and airborne science campaigns led by these programs and provide important validation of the current and next generation of satellite-based sensors (e.g., PACE, OCO-2, TEMPO, SGB, and A-CCP; see links in References). The solicited measurements will be highly relevant to current and future NASA campaigns with objectives and observing strategies similar to past campaigns;Â e.g., ACTIVATE, NAAMES, EXPORTS, CAMP2EX, FIREX-AQ, KORUS-AQ, DISCOVER-AQ (see links in References).

Relevance / Science Traceability:

The S1.08 subtopic is and remains highly relevant to NASA SMD and Earth Science research programs, in particular the Earth Science Atmospheric Composition, Climate Variability & Change, and Carbon Cycle and Ecosystems focus areas. In situ and ground-based sensors inform NASA ship and airborne science campaigns led by these programs and provide important validation of the current and next generation of satellite-based sensors (e.g., PACE, OCO-2, TEMPO, and A-CCPâ€”see links in references). The solicited measurements will be highly relevant future NASA campaigns with objectives and observing strategies similar to past campaigns;Â e.g., NAAMES, EXPORTS, CAMP2EX, FIREX-AQ, KORUS-AQ, DISCOVER-AQ (see links in references).Â The need horizon of the subtopic sensors and sensors systems is BOTH near term (<5 yr) and midterm (5 to 10 yr).

Relevant Programs and Program Officers include:

- NASA ESD Ocean Biology and Biogeochemistry Program (Paula Bontempi and Laura Lorenzoni, HQ Program Managers)
- NASA ESD Tropospheric Composition Program (Barry Lefer, HQ Program Manager)
- NASA ESD Radiation Sciences Program (Hal Maring, HQ Program Manager)
- NASA ESD Airborne Science Program (Bruce Tagg, HQ Program Manager)

References:

Relevant current and past satellite missions and field campaigns include:

- Decadal Survey Recommended ACCP Mission focusing on aerosols, clouds, convection, and precipitation:Â https://science.nasa.gov/earth-science/decadal-surveys
- TEMPO Satellite Mission focusing on geostationary observations of air quality over North America:Â http://tempo.si.edu/overview.html
- CAMP2Ex airborne field campaign focusing on tropical meteorology and aerosol science:Â https://espo.nasa.gov/camp2ex
- FIREX-AQ airborne and ground-based field campaign targeting wildfire and agricultural burning emissions in the United States:Â https://www.esrl.noaa.gov/csd/projects/firex-aq/
- KORUS-AQ airborne and ground-based field campaign focusing on pollution and air quality in the vicinity of the Korean Peninsula:Â https://espo.nasa.gov/korus-aq/content/KORUS-AQ
- DISCOVER-AQ airborne and ground-based campaign targeting pollution and air quality in four areas of the United States:Â https://discover-aq.larc.nasa.gov/
- NAAMES Earth Venture Suborbital field campaign targeting the North Atlantic phytoplankton bloom cycle and impacts on atmospheric aerosols, trace gases, and clouds:Â https://naames.larc.nasa.gov
- AToM airborne field campaign mapping the global distribution of aerosols and trace gases from pole-to-pole:Â https://espo.nasa.gov/atom/content/ATom
- PACE Satellite Mission, scheduled to launch in 2022, that focuses on observations of ocean biology, aerosols, and clouds:Â Â https://pace.gsfc.nasa.gov/
- EXPORTS field campaign targeting the export and fate of upper ocean net primary production using satellite observations and surface-based measurements:Â https://oceanexports.org
- OCO-2 Satellite Mission that targets spaceborne observations of carbon dioxide and the Earthâ€™s carbon cycle:Â https://www.nasa.gov/mission_pages/oco2/index.html

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