NASA Science Mission Directorate

Research Opportunities in Space and Earth Sciences

NNH20ZDA001N-CSESP

A. 41 Citizen Science for Earth Systems Program

The Citizen Science for Earth Systems Program (CSESP) solicits projects that aim to develop and implement capabilities to harness voluntary contributions from members of the general public to advance understanding of the Earth as a system. The 2020 CSESP announcement sought proposals to advance the use of citizen science in scientific research about the Earth by directly supporting citizen science activities, as well as by supporting activities to analyze or enhance NASA citizen science data. Areas of investigation could include any of the Earth Science focus areas: Atmospheric Composition, Weather and Atmospheric Dynamics, Climate Variability and Change, Water and Energy Cycle, Carbon Cycle and Ecosystems, or Earth Surface and Interior. All projects address real-world problems in concert with NASA Earth observing system data.

A total of 67 proposals were received for this announcement. All proposals were peer evaluated using expert panel reviews. The Earth Science Division of NASA's Science Mission Directorate selected 1 proposal for an 18 month analysis and enhancement of legacy NASA citizen science data and 7 proposals for an 18 month prototype phase of a citizen science data gathering project pending satisfactory budget and work plan negotiations. The total first-year funding for all proposals is approximately 2.3 million dollars. After the first year of work, the prototype phase of the 7 citizen science data gathering projects will be evaluated and some will be selected for an implementation phase; with funding of up to three additional years.

Information about this down-selection has been added to the end of this document.

Marile Colon Robles/Science Systems And Applications, Inc.
Community Science Project Leveraging Online and User Data through GLOBE And Zooniverse Engagement (CLOUD GAZE)
20-CSESP2020-0031

This proposal will leverage the strength of the GLOBE and Zooniverse citizen science platforms to generate a new data set of ground-visual cloud observations collocated to multiple satellite data. The NASA GLOBE Clouds team produces data sets of these ground-visual cloud observations collocated to satellite data (Rogerson et al., 2020). We propose the use of the Zooniverse platform to run the photographs included with the sky reports to add data quality values to the observations.

Ground-visual cloud observations collected by citizen scientists can support multiple research areas including identification of cloud types and contrail types, comparison to global computer modeled total cloud cover data, and identification of dust, smoke and haze events particularly in overcast conditions. Cloud observations reported through The GLOBE Program include reports of total cloud cover, cloud type, opacity, as well as obscuration reports like dust, smoke and haze. Intense observation periods, like cloud challenges (Colón Robles et al., 2020) increase the number of observations reported around the world. The NASA GLOBE Clouds team at NASA Langley Research Center currently collocates ground-visual cloud observations submitted by GLOBE citizen scientists, when possible, to the nearest overpass times of geostationary satellites (GOES-17, Meteosat-8, Meteosat-11, or Himawari 8), CERES instruments onboard Aqua and Terra, or the CALIPSO satellite (Colón Robles et al., 2019). Since the launch of the GLOBE Observer app, GLOBE volunteers have submitted 200,000 photographs with their cloud reports (Amos et al., 2020).

We propose adding additional scientific data and quality flags to the GLOBE clouds dataset using the Zooniverse web portal where volunteers analyze images. Zooniverse citizen scientists will identify the presence and absence of clouds, dust, smoke plumes, and haze layers, as well as identify cloud types, by analyzing GLOBE cloud photographs. The combination of ground-visual cloud observations with satellite collocations and data quality values will be made available to researchers looking to use these observations to compare with other meteorological datasets. The photograph analysis through the Zooniverse platform will provide the ability to add data quality flags, add additional information pulled from the images, and increase citizen science participation opportunities for those unable to actively make GLOBE observations. Dodson et al. (2019) tested the robustness of GLOBE cloud observations collected during the 2017 North America total solar eclipse. They demonstrated the importance of a methodology that takes advantage of the large volume of observations. This proposal would also increase the volume of ground-cloud observations leading to stronger robustness of the data.

During the pilot implementation phase, we will collaborate with the Zooniverse team, develop an automated system to send a subset of photographs and test the output received from the platform. We will also form a science focus group to promote the new data set and receive feedback from researchers in related areas. The team will include a person in the cloud research community to develop data quality flags, choose the best datasets to collocate with satellite imagery, and to come up with new ideas of using the Zooniverse platform to produce value added information for the GLOBE cloud observations.

In the implementation stage, we will increase contributed citizen science data by expanding the number of photographs submitted through the Zooniverse platform to analyze the entire collection, broadening the opportunity, and establishing a unique focus for the photographs. The NASA GLOBE Clouds team will also expand the satellite platforms collocated to ground-cloud observations to include VIIRS, GOES 18-20, and ACCP.

Prakash Doraiswamy/Research Triangle Institute
Can Citizen Science and Low-Cost Sensors Help Improve Earth System Data? Assessing High Frequency Geostationary Air Quality Observations
20-CSESP2020-0068

Our overarching goal is to increase the value of National Aeronautics and Space Administration (NASA) Earth Science products for monitoring fine particulate matter (PM2.5) near the Earth's surface at high spatial and temporal resolutions. Surface PM2.5 can be predicted from satellite aerosol optical depth (AOD), a column metric, by incorporating data from ground monitors but remains highly uncertain because of limited point measurements. As part of our ongoing work funded by the NASA Citizen Science for Earth Systems Program (CSESP), we are assessing spatial gradients derived from once-per-day satellite observations from missions such as Moderate-Resolution Imaging Spectroradiometer (MODIS) and spatially dense surface PM2.5 data collected by citizen scientists. Our objective is to build on that work and address temporal variabilities using high-frequency observations from operational geostationary satellites. This is significant because it will generate spatially and temporally validated satellite-based surface PM2.5 estimates.

In our current CSESP project, we have used citizen scientists to deploy low-cost sensor networks in three regions representing low (Raleigh, NC), moderate (Los Angeles, CA), and high (Delhi, India) PM2.5 loadings. Each region will have at least 100 or more PurpleAir (PA) sensors (PA-II model) deployed by the end of the project–400 to 500 sensors in total, offering a spatially and temporally rich dataset for more in-depth analysis. A significant focus of our work is developing standardized protocols and quality assurance procedures to ensure a high-quality dataset. Sensors were evaluated against robust reference PM2.5 monitors in each of the three regions to develop region-specific calibration (bias correction) of sensor data. In addition, we are in the process of collecting additional metadata from citizen scientists to help analyze and interpret the sensor data. Our preliminary analysis relating surface PM2.5 sensor data and AOD has already demonstrated the value of such low-cost sensor networks in improving spatial gradients in satellite-derived estimates. With more data being collected during the upcoming year, we will improve the spatial model and fine-tune region-specific interpretation of satellite data for PM2.5 monitoring.

Expanding on our current work that characterizes spatial variability and gradients, we propose to assess high temporal frequency (5-minute) observations. Specifically, we will add in aerosol retrievals from the Geostationary Operational Environmental Satellite (GOES)-R series (East and West) satellites. By examining and improving both spatial gradients (current work) and temporal distributions (proposed work), we are increasing the value and utility of the satellite data for various applications. We will focus on our two U.S.-based sensor networks (Los Angeles and Raleigh) to use both GOES datasets. We will utilize the bias-corrected sensor data, publicly available reference monitor data from the U.S. Environmental Protection Agency, and the GOES-R data to compare and assess sensor- versus satellite-derived surface PM2.5 estimates, temporal variability, and

differences at the surface (i.e., PM2.5) and in the atmospheric column (i.e., AOD). Building on our current work, we will develop new machine learning models to derive PM2.5 at high temporal resolution using GOES-R data.
This project will lead to a new or improved aerosol product from geostationary satellites. The improved scientific understanding from this project will improve the value of air quality datasets from NASA's current and future geostationary satellites (GOES-East, GOES-West, TEMPO), and other missions around the globe. Geostationary satellites with increased spatial and temporal resolutions are being launched by nations across the world, and the proposed work will provide a framework to quickly incorporate those data to enable spatially and temporally refined surface estimates across the globe.

Keith Jennings/Lynker Technologies LLC
Using Citizen Science Observations to Monitor the Rain-Snow Transition of the Western US and Improve Satellite Estimates of Precipitation Phase
20-CSESP2020-0038

Despite the importance of snowfall to regional water resources in the western US and the threat posed by climate change, there are relatively few observations of precipitation phase (i.e., rain vs. snow vs. mixed). Oftentimes models are used to address this shortcoming by applying spatially uniform phase partitioning methods to observed or gridded meteorological data. However, these approaches suffer from marked inaccuracies at air temperatures near freezing in addition to the spatial variability in the rain-snow transition air temperature.

Remote sensing products should aid in the acquisition of more accurate estimates of rain-snow proportions, but algorithms to date have struggled in deconvolving the signals of rain vs. snow at the land surface. NASA's Global Precipitation Measurement (GPM) mission, which provides gridded values of precipitation intensity and phase, relies on near-surface wet bulb temperature to estimate the probability of liquid precipitation in its Integrated Multi-satellitE Retrievals for GPM (IMERG) product. In addition to IMERG, GPM products also include output from the Dual-frequency Precipitation Radar (DPR), which attempts to classify precipitation phase from retrieval algorithms. However, previous research has shown that DPR misclassifies precipitation phase, particularly in areas near the rain-snow transition line.

Much of this can be ascribed to the difficulty of parsing rain and snow signals from raw GPM data at various intensities. Additionally, the lack of ground-based observations, particularly in mountain regions, makes it difficult to validate satellite estimates of precipitation phase. Our proposed research aims to fill this knowledge gap through the application of citizen science data collected in mountain ranges across the western United States.

The project is proposed in two phases. The Pilot phase has the following six objectives:
1. Develop and deploy a mobile application for collecting precipitation phase observations (rain, snow, and mixed) across the mountainous western US.

2. Engage and retain citizen scientists.
3. Create a quality-controlled precipitation phase dataset plus data synthesis products.
4. Develop an online map and graphical interface with observations of precipitation phase.
5. Use the citizen science data for initial validation of GPM precipitation phase estimates.
6. Evaluate success of Pilot phase objectives before down-selection.

In the Implementation phase, we propose four additional objectives:
7. Expand engagement of citizen scientists to collect data over larger spatiotemporal extents.
8. Perform extensive validation and refinement of GPM precipitation phase estimates, plus additional analyses of MERRA-2 and NLDAS-2 data products.
9. Detect and map rain-on-snow events across elevation gradients to better characterize snowpack properties that affect key snow cover remote sensing capabilities.
10. Create improved estimates of storm-based temperature lapse rates and rain-snow elevations across the mountainous western United States.

In 2020, Arienzo, Collins, and Jennings ran a seed version of this project with over 200 observers, funded by the Nevada NASA EPSCoR program. We created an app-based survey, developed effective practices for citizen scientist engagement, and collected over 1000 precipitation phase observations in the Lake Tahoe area.

We aim to build upon the success of this initial citizen science project through this proposal. We feel our project is well suited to the primary goal of this in RFP in that we will ""enhance NASA scientific data and capacity through voluntary observations, interpretations, or other direct participation by members of the general public to advance understanding of the Earth as a system." The accomplishment of our proposed objectives will ideally lead to improved GPM precipitation phase predictions, which will help better quantify rain and snow in the western US and snowy regions globally.

Nikolai Maximenko/University of Hawaii, Honolulu
Collaboration with Citizen Scientists to Enhance Open Ocean and Coastal Observations and Sampling and to Augment Impacts and Utility of Remote Sensing for Physical, Biological, Ecological, and Environmental Studies and Applications
20-CSESP2020-0059

Open ocean observations and sampling remain sparse, especially those of transient small-scale motions and features playing critical roles in the marine ecosystem and ocean dynamics. We propose to use the current network of partners, volunteers, and citizen scientists and greatly expand it to facilitate collection of data, samples, and deployment of scientific instruments to advance understanding of physical, biological, and biogeochemical processes and interpretation of in situ observations and satellite imaging.

In this project we will reach, train, equip, and guide citizen scientists to acquire a broad variety of information complimentary to the NASA Earth-observing system, including:

- Visual reports and boat- and drone-based photo/video material from surveys of select ocean sites, particular ocean features (such as windrows, biological slicks, fronts, eddies, and chlorophyll blooms), large floating marine debris objects (such as derelict fishing gear) and aggregations of small debris, as well as biota colonizing this debris and neustonic species.
- Collection of biological, debris, and water samples.
- Observations of opportunity will be guided through the areas of interests and, when feasible, synchronized with satellite flybys.
- Large objects and ocean features will be tagged and marked with low-cost satellite trackers. This will allow their extensive study using remote sensing and follow-up inspections.
- Open ocean activity will be complemented by long-term monitoring of select shorelines and crowdsourcing opportunistic reports from coastal environmental groups and volunteers.
- While analyzing the collected data, we will synthesize them with satellite products, numerical models and theoretical concepts.

Funding is requested for instruments (such as trackers, drones, and cameras) and supplies (sample collection and preservation kits) to be provided to citizen science and to partly compensate for their time and expenses during the project operations. We also reserve funding for the team to ensure that the high quality data are collected and shared in a timely manner as well as for outreach coordination to recruit citizen scientists.

Our team includes highly qualified physicists, biologists, satellite experts, and an expert in the use of sailing ships, yachts, and research vessels who have extensive experience and conduct active research in other relevant projects. We propose to build on this experience and plan to advance the NASA Earth-observing system and broader scientific understanding and applications by:
- Creating or dramatically improving satellite spectral libraries of marine debris.
- Characterizing the composition and distribution of biodiversity present in the upper ocean, and associated with debris.
- Facilitating calibration of satellite sensors using ship-borne instruments and drones.
- Tracking marine debris and ocean features.
- Enriching sample collections of marine debris and biological species in the pelagic ocean.
- Collecting coastal observations and samples to link the coastal ecosystem to its pelagic counterpart.
- Evaluating ecosystem properties (chemical composition, colored dissolved organic matter, food quality, etc.) associated with open ocean, near and away from debris, ocean features, and blooms.

These plans build on the close involvement of citizen scientists and are directly relevant to and significant for this solicitation and other NASA programs (such as Ocean Biology and Biogeochemistry, Biodiversity and Ecological Forecasting, Surface Water and Ocean Topography, Physical Oceanography, etc.).

This is a Type I proposal; we are eager to demonstrate the feasibility and importance of the data collected by citizen scientists in the first 18 months and are aiming to implement, expand, and sustain our the citizen science networks thereafter.

Patrick Neale/Smithsonian Institution
Engaging Citizen Scientists to Monitor Water Quality in Chesapeake Bay
20-CSESP2020-0019

To protect our natural resources, state and federal agencies have been working on improving methods for monitoring and forecasting the biological integrity, trophic state, and recreational suitability of nearshore waters. As part of these efforts, water-quality monitoring programs have identified a suite of indicators, including biological indicators like chlorophyll a, physical indicators like water-clarity, and chemical indicators like colored dissolved organic matter (CDOM) that provide information about overall ecosystem conditions. NASA's high resolution satellite sensors, including Landsat-8/OLI (a collaboration between NASA and the U.S. Geological Survey, USGS), the upcoming Surface Biology and Geology (SBG) Designated Observable, and the recently selected GLIMR (Geostationary Littoral Imaging and Monitoring Radiometer) Earth Venture Instrument, provide a unique capability to capture water quality changes in highly vulnerable and economically valuable nearshore and estuarine habitats. Yet, they also require extensive (spatially and temporally) in situ measurements to validate and inform the development of appropriate water quality algorithms.

The goal of this project is to engage citizen scientists in Chesapeake Bay to ground-truth Landsat-8/OLI satellite imagery and data products for water quality applications. We propose to partner with Riverkeeper and boating organizations in Chesapeake Bay to collect samples from boats, as well as public or private docks, in sub-estuaries and in Chesapeake Bay. Citizen scientists will be provided with data collection kits, including low-cost portable photometers (e.g. CALITOO SunPhotometer) for measurements relevant to atmospheric correction of ocean color data, secchi disks, and materials to collect samples for CDOM, chlorophyll a, and turbidity. Boaters will also be trained to use an open-source smartphone app (Hydrocolor) that acquires water and sky reflectance data relevant to the interpretation of remotely sensed water reflectance. Water clarity shore-based data (primarily secchi disk observations) would also be obtained from other sites in the region through the Chesapeake Monitoring Cooperative, a partnership to aggregate data and document protocols of Chesapeake Bay government, academic, and community data quality monitoring programs.

During the pilot phase of the project, citizen scientists will be recruited in partnership with two local Riverkeeper groups, the Severn River Association and the Arundel Rivers Federation. These groups work closely with local boaters, dock owners, and marinas, and have existing water quality monitoring programs. Samples will be analyzed by citizen scientists at the Smithsonian Environmental Research Center (SERC). SERC has an existing citizen science program (~550 on-site volunteers per year), and would be able to

recruit and train volunteers to process samples. Citizen scientists involved in data collection would also be invited to participate in sample processing. We will also engage students from the Anne Arundel Community College Environmental Center that currently partners with the Severn River Association and Arundel Rivers Federation to analyze microbial water quality (Operation Clearwater). Through this grant, we would be able to expand that program to engage students in analysis of samples related to water quality. This pilot phase will enable us to develop and refine volunteer training protocols, sampling kits and data submission pathways, and create data visualizations that can be easily shared with participants and partners. During the full implementation phase, we will expand sampling to more locations around Chesapeake Bay. We will work with Riverkeeper organizations throughout Chesapeake Bay to recruit and train citizen scientists. All data collected by the project will be shared through the Chesapeake Monitoring Cooperative so that it is available to others.

Tamlin Pavelsky/University of North Carolina, Chapel Hill
Lake Observations from Citizen Scientists and Satellites: Validation of Satellite Altimetry to Support Hydrologic Science
20-CSESP2020-0036

Despite the importance of lakes in the Earth system, we have limited understanding of how they change over time. To address this limitation, we have developed the Lake Observations from Citizen Scientists and Satellites (LOCSS) project, which works with citizen scientists around the world to measure variations in lake water level using simple and intuitive gauges. We combine these data with satellite measurements of lake area to measure changes in volume. Since 2017, we have received nearly 8000 lake levels from more than 2100 citizen scientists. These data have helped us understand lake volume dynamics in the United States, Bangladesh, and France, and we continue to expand the network to India and Pakistan this year. We have found that LOCSS citizen science data is highly accurate, with a mean absolute error of 1.6 cm.

In this project, we propose to address the dearth of measurements in smaller lakes (<100 km2) by expanding our work with citizen scientists to validate satellite-measured water levels. As it is impossible to measure more than a small fraction of the world's millions of lakes in situ, the synthesis of NASA satellite measurements of lake levels is the way forward to reliably observe global lake water levels. Although satellites capable of measuring lake level are now well-established (e.g. Jason-2/3, Sentinel 3, and (soon) Sentinel 6 Michael Freilich), there has been no systematic evaluation of their capabilities over small lakes. Meanwhile, the SWOT mission, launching in 2022, will dramatically expand such measurements in lakes as small as 250 m x 250 m. This project will also engage citizen scientists in collecting measurements for validating SWOT inundation extent datasets, data similar to those collected by the SWOT project validation team but much more geographically extensive.

In the Pilot Phase, we will (1) expand our international network of LOCSS lake gauges by partnering with governments and other organizations within the U.S. and

internationally; (2) develop a prototype smart phone app for validating SWOT inundation extent data; and (3) use new and existing data to evaluate satellite water level measurements from the current suite of nadir altimeters and the SWOT fast sampling orbit. In the Continuation Phase, which coincides with the SWOT nominal science orbit, we will partner with citizen scientists to evaluate SWOT water surface elevations in lakes worldwide. We will also work with citizen scientists to collect data for validation of SWOT water detection algorithms. Finally, in regions where there are numerous lakes, we will seek to understand how spatiotemporal patterns in lake water levels drive design of long term monitoring systems. The proposal responds directly to the CSESP solicitation and to NASA's broader goal, summarized in the 2017 NASA Earth Science Decadal Survey, of "understanding the movement, distribution, and availability of water and how these are changing over time."

The investigators have successfully worked together on LOCSS for four years. T. Pavelsky will continue as PI, coordinating project goals and leading satellite validation efforts. He is the NASA Hydrology Science Lead on SWOT. Co-I Grant Parkins will lead coordination with citizen scientists. Co-I Faisal Hossain will work on satellite validation efforts and lead expansion of the project in South and SE Asia. Co-I Sheikh Ghafoor will lead development of the smart phone app. Collaborators J-F Cretaux, the French SWOT hydrology PI, and N. Picot will lead gauge installation in France. A. Haque, Director of the Bangladesh Water Development Board, and R. Biswas will lead an independently funded, collaborative effort in Bangladesh. M. Ashraf will lead efforts in Pakistan, and N. Thapa will do so in Nepal. In Canada, the Global Water Futures (led by J. Pomeroy) program and Environment Canada's National Hydrological Service (led by A. Pietroniro) will spearhead efforts in Canada through in-kind support.

Katie Spellman/University of Alaska, Fairbanks
Community Eyes on River Ice - Broadening Participation in Freshwater Ice Observation to Support Hydrologic Research, River Forecasting, and Winter Travel Safety
20-CSESP2020-0062

Goal and Objectives- Warmer winters have rapidly altered freshwater ice conditions in Alaskan river basins. Changes in ice thickness and the timing of freeze-up and break-up influence hydrology, ecosystems, winter travel safety, access to subsistence resources, and spring ice-jam flooding. Remote sensing enhances hydrologic research and forecasting in this vast region, but we are currently limited by the spatiotemporal extent of ground-based observations. Our project goal is to expand the existing freshwater ice monitoring efforts within Alaska using a culturally responsive citizen science model to increase the spatial extent and frequency of observations and expand the diversity of participants across Alaska. To do this, partners from University of Alaska Fairbanks (UAF), Tanana Chiefs Conference (TCC), National Weather Service Alaska Pacific River Forecast Center (NWS APRFC), and NASA GLOBE Observer (NASA GO) will collaborate on a pilot citizen science program with four central objectives:

1. Conduct a front-end assessment of ice concerns, local knowledge, research priorities, data product needs, and technological access across river communities in Alaska,
2. Use the needs assessment to inform the development of a citizen science freshwater ice photo observation app and scientific objectives,
3. Engage a diversity of citizen scientists in collecting photo observations of fall freeze-up, winter open-water areas, and spring breakup throughout the state,
4. Integrate the citizen science photo observations with satellite remote sensing of ice conditions to support hydrologic research, river forecasting, and winter travel safety.

During spring river break up 2020, ice jam flooding risk was high, but the COVID19 pandemic had reduced the number of ground-based observations being collected for flood forecasts. Through a novel partnership, NWS APRFC Alaska RiverWatch program and UAF Fresh Eyes on Ice program responded by rapidly launching a rough photo-observation app. We successfully increased data volume and participation, and this has motivated us to formalize a citizen science initiative for ice observing in Alaska.

Methods- The front-end assessment will be guided by UAF, TCC, and NWS APRFC, and carried out by Goldstream Group LLC, an Alaska-based evaluation firm. This assessment will be used to inform app development, and program design in collaboration with the NASA GLOBE Observer program. Photographic data collected for this effort will contribute to NWS flood forecasting and safety assessments and TCC community-based research to support small Alaska Native communities in the riparian zone of freshwater rivers. UAF researchers will use these community observations for ground-truthing satellite imagery in order to understand changes in ice phenology (building on prior research in the NASA Arctic Boreal Vulnerability Experiment) and to map winter ice conditions for traveler safety and spring flood threats. The program design will build on UAF's prior work in the NASA Science Mission Directorate Science Activation education program "Arctic and Earth STEM Integrating GLOBE and NASA Assets" developing a model for culturally responsive citizen science in Alaska's remote indigenous communities using NASA's GLOBE and GLOBE Observer.

Significance to NASA objectives- This type 1 proposal will advance NASA Earth System Science research by contributing to our understanding of the influence of climate variability and change on freshwater ice conditions in river basins. It will further the use of Earth system science research and monitoring to inform safety decisions and provide social benefits by increasing the diversity of observers and expanding the geographic network of observations for forecasting ice-jam floods and mapping winter ice hazards in routinely used transportation corridors among Alaskan river communities.

Maria Vernet/University of California, San Diego
FjordPhyto: Engaging Tourists to Understand Polar Phytoplankton Dynamics Using Field and Satellite Observations

20-CSESP2020-0039

We propose a Type 1 project to the Citizen Science for Earth Systems Program to examine the impacts of increasing glacier meltwater on local ecosystems at the ice-ocean interface of the western Antarctic Peninsula (WAP). The proposed citizen science module, entitled FjordPhyto, builds upon an existing collaboration with the International Association of Antarctic Tour Operators (IAATO). Citizen scientists will participate in a "validation safari" in which satellite data will inform sampling of physical and biological oceanographic measurements to validate and refine a new ocean color algorithm to detect the glacial meltwater content of seawater from space. The in situ measurements from citizen scientists will be combined with remote sensing data products to address scientific questions related to the impacts of glacial meltwater on phytoplankton community abundance and taxonomic composition during the austral growing season. This project will support a Ph.D. student to develop the remote sensing citizen science module, incorporate new field sampling techniques into the program, and conduct analyses of phytoplankton diversity through a genomics approach.

The air and ocean warming in Antarctica is most noticeable in the WAP where glaciers show positive and statistically significant trends in duration of melting conditions. A net input of freshwater occurs in nearshore waters during austral summer influencing phytoplankton biomass, diversity, and primary production. The scientific goals of this Citizen Science project are to determine the spatial extent of glacial meltwater through the seasons, and identify concomitant shifts in phytoplankton abundance and community diversity in coastal Antarctic waters affected by glacial melting, expected to increase in the coming decades. Sampling of this region from October through March along 3-6 degrees of latitude (62S to 65S and up to 68S) is only feasible with tourist ships, or through remote sensing. The addition of a remote sensing component, validated by citizen scientists, is crucial for describing long-term synoptic trends and variability in the abundance and spatio-temporal extent of phytoplankton in this region, and for discerning how these patterns are likely to alter in response to changes in climate.

During the Pilot Phase, we will develop a new sampling module and documentation for satellite remote sensing of the ocean and integrate it into the FjordPhyto citizen science program. The sampling module will add new measurements related to glacial meltwater fraction of seawater, phytoplankton abundance through chlorophyll-a fluorescence, and genomic sampling of phytoplankton community composition. Field sampling by volunteer citizen scientists will occur in October to March of 2021-2022, and supplemented with remote sensing data products to examine the seasonal evolution of glacial meltwater extent and phytoplankton community response. If selected for the Implementation Phase, an additional 3-years of citizen science sampling in conjunction with analysis of long-term time series of satellite data products will be used to examine interannual variability in these patterns and the role of climate-related environmental indices. As no internet is available in Antarctic tourist ships, the networking with large citizen science sites like iNaturalist will be supported as an after-cruise activity and through social media. Questionnaires will be employed to obtain evaluation of the program by citizen scientists and help refine the new variables collected during the

‘validation safaris’ in support of NASA ocean color mission. This study will provide a foundation to better understand phytoplankton diversity under current and potential future ocean conditions, and lead to more robust predictions on potential impacts to upper trophic levels and biogeochemical cycling within this rapidly changing ecosystem.

2022 Down-selection

A scheduled down-selection was done in 2022. Of the seven 18 month projects funded in 2020, five were selected to continue on to full implementation with an additional three years of funding.

2022 Projects Selected for Continuation

- Community Eyes on River Ice - Broadening participation in freshwater ice observation to support hydrologic research, river forecasting, and winter travel safety; Katie Spellman/University of Alaska, Fairbanks
- Engaging Citizen Scientists to Monitor Water Quality in Chesapeake Bay; Patrick Neale, Smithsonian Institution
- FjordPhyto: Engaging Tourists in Field and Satellite Observations to Understand Polar Phytoplankton Dynamics –
- Implementation Phase; Maria Vernet/University of California, San Diego
- Lake Observations from Citizen Scientists and Satellites: Validation of Satellite Altimetry to Support Hydrologic Science Continuation Phase; Tamlin Pavelsky/University of North Carolina, Chapel Hill
- Mountain Rain or Snow — A Citizen Science Project; Keith Jennings/Lynker Technologies LLC