NASA Science Mission Directorate
Research Opportunities in Space and Earth Sciences – 2019 NNH19ZDA001N-OSST
A.10 Ocean Salinity Science Team

This program element selected members for the Ocean Salinity Science Team (OSST) to support the salinity science within NASA's Physical Oceanography Program. The goals of the OSST is to support basic research associated with production, improvement, and understanding of satellite-derived ocean salinity data, as well as to demonstrate the Earth science and applications arising from analyses of the ocean surface salinity datasets. NASA received 30 proposals and selected 11 with funding of ~$6M over three years.

Annette deCharon/Odysea LLC.
Salinity Continuity - Optimizing Relevance & Engagement
19-OSST19-0014

Salinity Continuity - Optimizing Relevance & Engagement (SCORE) will serve the needs of NASA, the science community, and the public. By emphasizing the societally relevant aspects of ocean salinity, SCORE will expand the appreciation of NASA's Physical Oceanography program and the Ocean Salinity Science Team (OSST). In addition, the proposal team will support the Soil Moisture Active Passive (SMAP) salinity calibration and validation (Cal/Val) team.

A women-owned small business, ODYSEA LLC specializes in supporting public engagement efforts for NASA Earth Science missions and programs. For this proposed effort, it will expand upon the effective practices and infrastructure that support the current OSST, including the NASA Salinity website (https://salinity.oceansciences.org). ODYSEA LLC will: (1) Continue to support the OSST and SMAP Cal/Val teams; (2) Emphasize the continuity and consistency between NASA's salinity sensors, Aquarius and SMAP; (3) Augment existing content and incorporate interactivity; (4) Focus on opportunities for improved integration of satellite-derived salinity; (5) Create resources for emergent scientists; and (6) Leverage NASA social media and other opportunities to broaden impact.

The custom content management system developed for NASA Salinity will be used to update images, videos, data maps, news, and events. SCORE will also archive presentations from OSST meetings, salinity sessions at select conferences (e.g., American Geophysical Union, AGU), and other important meetings (e.g., Global Ocean Salinity and the Water Cycle Workshops). To capture notable NASA Salinity milestones within a "bigger picture" context, an interactive timeline will be built. This feature will illustrate the evolution of salinity observations from historical in-situ sensors through the advent of satellite sea surface salinity (SSS) observations.

Given the importance of connecting science with people's interests, SCORE will deliver content focused on salinity's ties to climate, ocean circulation, and the water cycle. These

efforts will follow widely accepted practices for effective communication in terms of being relevant, memorable, repeatable, and adjustable to meet the needs of various audiences. Electronic brochures and thematic "Highlights" (see https://salinity.oceansciences.org/highlights01.htm) are two examples of products that are planned to be developed.

A new section, tentatively titled "Synergies," will be added to the NASA Salinity website. It will draw attention to the in-water and satellite measurements that are used in conjunction with SSS. SCORE will develop new materials that highlight the complementary relationship between SSS and Argo, the near-global array of over 3,800 profiling floats that provide a "backbone data set to evaluate satellite SSS" (Lee, 2016). SCORE will also repurpose novel software developed for the Salinity Processes in the Upper-ocean Regional Study (SPURS) (https://salinity.oceansciences.org/science-spurs-datatool.htm) to depict other types of data with synergistic connections to SSS.

To achieve the goal of SSS integration into global observing system and climate models, ocean salinity researchers will continue to improve the quality of data retrievals and error budget estimates. SCORE will help keep the broad ocean community informed of the OSST's progress towards more meaningful integration of SSS data. Moreover, the proposed effort will include creating resources such as "case studies" for emergent researchers, addressing the question: "Which Salinity Data are Best for You?"

SCORE will add social media sharing functionality on items in the NASA Salinity media gallery to optimize engagement. Also, the proposal team will provide high-quality content to NASA Media, Communications, and Public Affairs in support of their regular slate of outreach endeavors conducted for Earth Day, World Oceans Day, and key scientific conferences.

Severine Fournier/Jet Propulsion Laboratory
Satellite Sea Surface Salinity Sampling Error
19-OSST19-0007

Evaluating and validating satellite sea surface salinity (SSS) measurements is fundamental for scientific applications and future satellite mission designs. There are two types of errors in satellite SSS. One is the measurement error associated with the observation itself, noise in the instrument, problems in the retrieval process etc. The other is the sampling error due to the unrepresentativeness in the way that the sea surface is sampled in time and space. In situ gridded products and satellite snapshots and gridded products are all subject to sampling errors. Moreover, sampling differences affect the evaluation and validation of satellite SSS performed through comparisons with individual pointwise in situ near-surface measurements and with gridded in situ salinity products. The sampling difference reflects the inability of satellite SSS to represent SSS at the spatiotemporal scales measured in situ, and vice versa. The main goal of the proposed work is to understand and quantify the effect of sampling errors on satellite-in situ SSS consistency over various spatial and temporal scales. This will help to improve the

validation of SSS, the robustness of scientific applications and the design of future salinity missions.

We will build on previous work by examining two different causes of sampling error and difference: sub-footprint variability and temporal aliasing. In situ observations are individual pointwise measurements whereas a satellite measures salinity as a spatial average over the satellite's footprint, which ranges in size from 40 to 150 km. The consequent difference between them is error due to sub-footprint variability or representativeness. Because of the satellite repeat cycle and the sparseness of in situ data, some high frequency salinity features can be captured differently by the satellite and in situ instruments. In regions where there is a strong spatial and temporal salinity variability, differences between in situ and satellite salinity observations are expected to be large and complicate the validation and calibration of salinity satellites. Another complication is the way that collocation (or matchup) is done when comparisons are carried out, which can introduce additional sampling uncertainty.

In this work, we propose to use the 14-month high-resolution 1/48° ocean model in order to conduct a focused investigation of sampling errors. First, we will deliver a simulator of L2 and L3 Aquarius, SMAP and SMOS SSS data and of individual Argo observations and gridded Argo products based on the model. Then, using the model and the simulated data, we will evaluate and quantify the sampling errors of satellite and in situ measurements as well as the sampling differences on the satellite-in situ SSS consistency associated with sub-footprint variability and with temporal aliasing. We will also explore the impact of different matchup schemes on the validation process of satellite SSS against individual in situ observations. Finally, we will investigate the spatial scale of the SSS signal using the HR model as well as the spatial scale of the sampling error through a wavenumber spectrum analysis.

This work is directly related to two specific objectives of the Ocean Salinity Science Team call: (1) Improve estimates of total error budget for SMAP and Aquarius SSS for more meaningful integration of satellite SSS into global observing system and climate models and (2) Evaluation and improvement of Aquarius and SMAP SSS products. On top of being of major importance to the Ocean Salinity Science Team, our work will be useful to the effort for an enhanced validation of satellite SSS and products assessment and scientific process studies over the ocean under the umbrella of the Pilot-Mission Exploitation Platform (Pi-MEP), endorsed by the NASA-ESA Joint Program Working Group (JPPG). The proposed work provides important information to develop and refine the definition of future satellite SSS mission requirements.

Eric Hackert/Goddard Space Flight Center
Towards Full Utilization of Satellite Sea Surface Salinity for El Niño/Southern Oscillation Prediction
19-OSST19-0009

The El Niño/Southern Oscillation (ENSO) phenomena has a significant impact on climate variability throughout the world and so has been the key focus for improving

coupled forecasts. Assimilation of satellite sea level from altimetry and subsurface temperature and salinity from (mostly) Argo help to improve the initialization of the thermocline, while satellite SST aids in specifying surface heat-flux forcing, leading to improved short-term forecasts of the coupled system. However, much less emphasis has been given to examining the impact of the near-surface ocean density structure and mixed-layer processes on air-sea coupled prediction. A continuous stream of nearly 10 years of high-resolution satellite SSS (SMOS, Aquarius, and now SMAP) now allows us to rigorously evaluate the impact of satellite SSS on air-sea coupling and ENSO predictions and develop mixed-layer density models to improve our understanding of skin to bulk salinity and SSS error estimation.

During previous NASA OSST funded research, our team demonstrated that assimilation of satellite SSS into our Intermediate Complexity Coupled Model (ICCM) led to improved coupled forecasts for 2-12 month lead times (Hackert et al., 2019). More recently, we confirmed that including along-track Aquarius, SMAP, and SMOS SSS into initialization of the GMAO Seasonal Prediction System (GMAO SPS) significantly improved the mixed-layer density structure leading to improved large-scale ocean Kelvin wave response and more accurate ENSO forecasts for the 2017 La Niña and the 2018 El Niño. The impact of SSS observations from multiple satellites (e.g. overlapping Aquarius and SMAP) also led to improved forecasts especially for the large 2015 El Niño. In the current proposal, we intend to broaden this research beyond particular case studies to include the full period of available satellite SSS (i.e. SMOS – 2010 to present, Aquarius 2011-2015, and SMAP 2015-present). These satellite SSS products will be assimilated into forecast initializations of the GMAO SPS to examine the effect on ENSO seasonal to interannual variability/prediction.

Due to the lack of a robust model for skin to bulk salinity, we currently assimilate satellite skin SSS as if it were bulk salinity into the GMAO SPS (i.e. SSS is assimilated into the first layer of our ocean model at z=5m). We plan to develop a model using in situ (bulk) and satellite (skin) salinities, which is consistent with the existing relationship for heat, momentum, and fresh water fluxes, and incorporate this model into our GMAO SPS coupled model and ocean data assimilation system. Our proposed approach will also allow us to estimate error-bars on modeled and assimilated SSS. Although we have shown assimilating SSS as bulk salinity has improved coupled ENSO forecasts, a near-surface model for density is required to extract the fullest possible air/sea coupled information from the satellite SSS and SST. In addition, we expect that this skin/bulk salinity model will pave the way for direct assimilation of brightness temperatures and development of techniques for coupled air/sea assimilation which will improve our understanding of near-surface salinity impacts on density and mixed-layer processes.

As an integral part of this research proposal, we will continue our calibration/validation efforts for the OSST by evaluating Aquarius, SMAP, and SMOS algorithm changes. Rather than evaluating collocations of all available in situ salinity observations (like e.g. Kao et al., 2017 for the Aquarius V5), we utilize our realistic ICCM as a transfer function to test if more mature SSS model algorithms actually improve ENSO forecast skill. So far, we have reported to the OSST and the Cal/Val team that more mature SSS model

algorithms generally improve ENSO forecasts and multiple satellite SSS helps to extend useful forecasts. We intend to continue our validation efforts using our ICCM for any new SSS algorithms from the OSST.

Hsun-Ying Kao/Earth And Space Research
Global Salinity Signatures Study from Aquarius to SMAP
19-OSST19-0029

The proposed work introduces new objectives and approaches to the scientific analysis of satellite-derived surface salinity, the auxiliary fields used in the processing, and derived fields generated from satellite salinity remote sensing. This work is founded on the prior NASA-supported salinity science, as carried out by Earth & Space Research (ESR). It is intended to enhance the consistency of the Aquarius/SAC-D sea surface salinity (SSS) data products with the subsequent Soil Moisture Active Passive (SMAP) mission, in order to obtain a continuous and more homogeneous estimate of surface salinity. For this, the differences between the missions' spatial resolution and sampling, particularly those introduced by the large, conically scanning mesh antenna utilized by SMAP instead of the fixed, solid reflector used for Aquarius, will be considered carefully in science study combining both satellite data.

The project is comprised of these principal tasks:

- Develop and evaluate SSS gradient and fronts analyses computed during Level-3 grid processing which shows enhanced resolution of fronts compared with gradients computed directly from Level-3 field
- Cover regional to basin scales, and produce a global SSS gradient database combining Aquarius and SMAP data for science community open-access
- Address SSS gradients and fronts, and their relation to other satellite-derived ocean parameters (surface currents, sea surface temperature, density, spiciness and ocean color)
- The implementation for satellite-derived sea surface density and spiciness data on ESR website, as well as comparisons between Aquarius and SMAP
- Perform regional studies where SSS gradients are likely to influence ocean dynamics and air-sea interactions on synoptic to climate time scales, including Gulf Stream, Eastern and western tropical Pacific, Agulhas retroflection currents, Amazon-Orinoco river plume
- Produce near-real-time analyses for above key regions for open access monitoring by other researchers

The proposed work is directly relevant to the identified topic 1 in the OSST solicitation (ROSES A.10) "Exploitation of NASA satellite SSS measurements to investigate SSS variability, its influence on ocean circulation, and the linkage with climate and water cycle." The salinity fronts signatures will be used to compare with other better studied variables, including SST, ocean currents and ocean color to understand the roles of salinity gradients in several interested areas. The goal by the end of the study is to have a "near-real-time" data resource.

Nikolai Maximenko/University of Hawaii, Honolulu
Sea Surface Sources and Physics of Salty and Fresh Plumes in the Ocean Interior
19-OSST19-0028

This project will study the dynamics of anisotropic features in the ocean interior that extend over long distances and have in their cores persistent low- or high-salinity signals relative to the surrounding waters. These salinity plumes will be identified using advanced techniques applied to the improved climatology of Argo data.

The techniques will be based on search of salinity extremes (maxima and minima) on vertical trans-sections perpendicular to the lines of a guiding variable. In most cases, the guiding role will be played by a three-dimensional absolute dynamic topography (ADT), calculated from Argo profiles as a dynamic height referenced to ADT at the ocean surface, which, in turn, will be derived from the improved mean dynamic topography (MDT) and altimetry-measured sea level anomaly. This methodology is justified with several preliminary examples, such as “salty tongues” extending from subtropical salinity maxima, demonstrating that axes of the plumes closely follow isolines of intermediate-depth ADT. In some other instances the coordinate system will follow isolines of the oversmoothed salinity field, which will be iteratively refined to reveal smaller-scale features.

After their detection in the open ocean, the plumes will be traced along their trajectories from the origin to complete dissipation.

At the origin, presumably located at the sea surface or near the coast (including islands), the surface footprint of the plume will be studied using the wealth of satellite and in situ observations synthesized with the output of ocean model in order to determine physical processes responsible for formation of the plume.

Among other processes we will consider the local Ekman pumping and subduction coupled with anomalous sea water freshening or salinification. We will also analyze plumes’ association with beta-plumes, striations, and preferred eddy paths, all of which are well studied on the ocean surface. When plumes are embedded in layers of water masses with the same (as plumes) sign of salinity anomaly (such as fresh plumes in the layer of low-salinity North Pacific Intermediate Water), we will also investigate whether salinity plumes are generated by the same processes as ones responsible for the formation of the watermasses.

The global pattern of the plumes, traced over long distances, will outline “teleconnections” between remote regions and, possibly, between different ocean features and phenomena. It will also improve knowledge of the poorly measured mid-depth ocean circulation.

Output of the ocean model GLORYS will be used to verify the consistency of observed signal of the plumes with model variables as well as to derive dynamical balances. The detected discrepancies will be used to identify possible errors and biases in the satellite SSS data and to find ways of their correction. Salinity fluxes associated with the plumes will help improve climate models.

The proposed project is directly relevant to all three topics listed in the NASA OSST call for proposals:

1. We will exploit NASA satellite sea surface salinity (SSS) measurements to investigate SSS variability and its interaction with ocean circulation.
2. We will synthesize NASA SSS measurements (Aquarius and SMAP) with in situ (Argo) data in our investigations.
3. We will interpret our results using output of the GLORYS model. By analyzing dynamical balances we will evaluate quality of SSS products and estimate their accuracy. This comparison with in situ and OGCM data will prepare future integration of SSS satellites into global observing system and climate models.

Oleg Melnichenko/University of Hawaii, Honolulu
Multi Satellite High Resolution SSS Data Products for Ocean Research and Applications
19-OSST19-0006

This proposal continues the development of continuous and consistent, high-quality, high-resolution SSS time series from multi-satellite measurements. The work requires continuous validation and verification of the satellite data to provide consistency across time and space scales as well as development of algorithms for merging together data from different satellites. The University of Hawaii team has demonstrated the capability to generate high-quality gridded SSS products from Aquarius and SMAP satellite measurements with uncertainty estimates. In collaboration with researchers at Remote Sensing Systems (RSS), the proposed project seeks to continue this work, adding tasks to improve resolution of Aquarius-based products and to fill temporal gaps in SMAP observations. To fulfill these specific tasks we will use SMOS satellite data. The primary goals of the project are:

1. Provide a comprehensive error analysis over a full range of temporal/spatial scales resolved by Aquarius and SMAP measurements including spurious trends and time-dependent biases to optimize the utility of the data for scientific research and to remove any spurious drifts and jumps. It is anticipated that this activity would also contribute to improvements in Aquarius and SMAP retrieval algorithms.

2. Create a continuous and consistent, long-term, high-quality SSS data record from multi-satellite measurements. This includes identification, characterization, and minimization of random errors and systematic biases in the derived products to help users establish uncertainty levels and understand if the data sets are suitable for their

applications. All the products generated during the study will be validated with respect to available ground data and made available to the scientific community.

The data products generated during the study, together with other satellite and in-situ data, will also be used to investigate outstanding scientific questions in regions of particular interest and challenges. We will focus on the South China Sea and Maritime Continent where freshwater fluxes are critically important for water mass transformation and potentially impact air-sea interaction. The region has huge oceanographic and climatic significance, yet is poorly observed by in-situ observing systems, partly because of the complex topography and unavailability of Argo buoy observations over shallow marginal seas. The merged SSS dataset will be examined in its accuracy and appropriateness for studying surface salinity in the marginal seas focusing on the upper ocean freshwater budget.

The proposed work responds directly to the NASA solicitation objectives in two specific ways. The project will contribute to the research theme 2: "Evaluation and improvement of Aquarius and SMAP SSS products" and to "work to assure the continuity and consistency of the SSS products across the two missions". By investigating SSS variability in the South China Sea and Indonesian Seas using satellite SSS and other satellite and in-situ data, the proposed project will contribute to the research theme 1, "Exploitation of NASA satellite SSS measurements to investigate SSS variability, its influence on ocean circulation, and the linkage with climate and water cycle".

Luc Rainville/University of Washington, Seattle
Quantifying Variability and Errors in Satellite and In-Situ Ocean Salinity Estimates in Highly Dynamical Regions
19-OSST19-0004

Global maps of sea surface salinity are now available from satellite L-band microwave radiometry. These maps reveal several regions with a large surface salinity variability signal, primarily due to physical processes happening in key regions. The overall objective of this proposal is to quantify the space and time characteristics of surface salinity in several regions of high-salinity variations. We propose to use existing autonomous glider observations along repeated sections to estimate these decorrelations scales, and therefore understand better the representation of small-scale or rapidly-varying processes in the satellite estimates. While much less global in scope than previous studies using the Argo float network, glider data offer great time and space resolution in a few key sites. We believe that the proposed project is a good complement the existing comparative studies.

The focus of this study is on understanding errors in the measurements of salinity from Seagliders (measurement error) as well as gain an understanding of the sampling error caused by a varying salinity field sampled a single profile (e.g., Argo) and satellite derived estimates. In order to do so, a statistical analysis of the spatial and temporal

correlation scales from the glider regional data sets will reveal what processes, and what scales are responsible for the observed variance.

This project responds to the A.10 call for the Ocean Salinity Science Team to aims to advance understanding of near-surface salinity, integrating innovative uses of in situ observations and remote sensing. In particular, it exploits the use of NASA satellite SSS measurements to investigate SSS variability, and aims to improve the estimates of total error budget for SMAP and Aquarius SSS for more meaningful integration of satellite SSS into global observing system. Through sharing our results with the rest of the team, this work will also contribute to improving our understanding of the impact of small-scale and short time scales variations for SSS retrieval algorithms.

Richard Small/University Corporation For Atmospheric Research
The Role of Salinity in the Subantarctic Mode Water Formation and Variability
19-OSST19-0012

Subantarctic mode water (SAMW) is a voluminous, weakly stratified water mass that ventilates the upper pycnocline of the Southern Hemisphere subtropical Indian, Pacific and Atlantic oceans over a narrow range of densities. Models suggest that SAMW plays a crucial role in modulating the oceanic uptake of heat and carbon in response to anthropogenic emissions, and therefore global climate change. However, our understanding of SAMW properties and dynamics has been hampered by limited observations of both surface and subsurface salinity and density. In addition, results derived from models are uncertain due to large model biases and significant variance in model projections in future scenarios.

Although SAMW has been studied for many decades, the advent of relatively data-dense global salinity and density observing systems in the last 10-15 years, in the form of both satellite sensors and the in-situ Argo array, has transformed our ability to quantify and understand the properties of SAMW. In particular, recent results highlight the unexpectedly large diversity and heterogeneity of SAMW, and suggest a key but poorly-understood and poorly-simulated role for salinity in SAMW dynamics.

The proposed project would aim to provide a nuanced and comprehensive assessment of the role of salinity in controlling the properties and dynamics of all the diverse flavors of SAMW. To our knowledge, the proposed work would be the first to fully leverage the synergistic combination of satellite salinity observations, in situ observations, and ocean state estimates to study SAMW. The overarching hypothesis of the proposed work is that ocean transport of salinity plays a crucial (but poorly understood) role in the properties, variability, and dynamics of SAMW. The proposed work addresses this hypothesis via analysis of the observations, ocean state estimates, and free-running model output. In addition, a focused set of process ocean simulations is proposed to further isolate and elucidate the processes by which ocean transport of salinity impacts SAMW variability. Although the used observations are still too short (1-2 decades) to allow us to robustly

consider climate trends they provide unprecedented information on interannual variability.

Finally, in addition to building a fundamental understanding of SAMW, the proposed work represents a novel application of satellite salinity measurements at mid-latitudes, and the corresponding validations and uncertainty analysis that emerges from this project will help to pave the way for broader and more confident application of satellite salinity measurements in physical oceanography.

Brian Soden/University of Miami, Key Biscayne
Investigating Linkages Between Ocean Salinity, the Hydrological Cycle, and Climate Sensitivity
19-OSST19-0024

Spatial and temporal structure of sea surface salinity (SSS) plays an important role in modulating patterns of ocean surface warming through its impact on the ocean circulation. Global climate models have substantial biases in both the distribution of SSS and in their simulations of the pattern of Pacific surface warming over the past 50 years. In particular, observations show larger warming in the western tropical Pacific whereas models project greater warming in the eastern Pacific. The model bias in the simulation of this east-west gradient of surface warming has a substantial impact on their projected changes in the Walker circulation and tropical low-cloud feedbacks.

The premise of this proposal is that the distribution of ocean salinity in the sub-tropical Pacific plays an important role in regulating the pattern of ocean warming and, in turn, the response of the atmospheric circulation and cloud-circulation feedbacks to external forcing. Because the distribution and intensity of ocean surface subduction in the tropical Pacific is influenced by salinity, we hypothesize that the climatological distribution of SSS can directly influence both the pattern and intensity of ocean heat uptake and ocean surface warming. In a warming climate, the drying of subtropical oceans (P-E<0) increases SSS locally, resulting in more rapid subduction of subtropical Pacific ocean waters and further modulates the spatial pattern of ocean surface warming. This pattern of ocean surface warming, driven by changes in the hydrological cycle, can further modulate cloud feedbacks and patterns of ocean heat uptake through changes in the large-scale atmospheric circulation.

We propose to investigate these linkages by combining satellite and historical salinity observations with state-of-the-art coupled model simulations to investigate the following questions:

1) How does the climatological distribution of ocean surface salinity influence the pattern of ocean surface warming on interannual to decadal time scales?
2) How does the coupling between ocean salinity, the hydrological cycle and the atmospheric circulation modulate low-cloud feedback and climate sensitivity in the tropical Pacific?

3) How does nudging a coupled GCM to observed salinity changes impact its simulation of sub-seasonal to decadal variability in the tropical Pacific?

In accomplishing these tasks, this proposal addresses the first goal of the Ocean Salinity Science Team: "Exploitation of NASA satellite SSS measurements to investigate SSS variability, its influence on ocean circulation, and the linkage with climate and water cycle."

Douglas Vandemark/University of New Hampshire, Durham
Quantifying the Role of Salinity in NW Atlantic Shelf Circulation Dynamics
19-OSST19-0025

The NW Atlantic shelf is home to a robust marine economy that is highly dependent on sustained and predictable resources, and is routinely impacted by a changing shelf hydrography that modifies the temperature, salinity and nutrient-rich waters supplied from adjoining slope seas. This research is focused on the complementary roles that satellite salinity, sea level anomaly, temperature, and wind data can bring to improved understanding of NW Atlantic shelf dynamics. The primary project goal will be to document and demonstrate, using latest version SMAP data, the fundamental role that changing surface salinity signatures can provide to expand the observational observing system along the US eastern seaboard. In this, we address the OSST-19 announcement request for research that deals with "exploitation of NASA satellite SSS to investigate its variability and influence on ocean circulation in synergistic use with other satellite (SSH, SST) and in situ observations". Recent work by our team using SMAP salinity data in this region points to the feasibility of using satellite-derived salinity anomaly data quite near to the coast and along the shelf-break front. This follow-on project seeks to use satellite salinity data over the 2010-2020 time frame to quantify and better diagnose strong water mass advection variations associated with known alongshore and cross-shelf pathways that control the both ocean state and ecosystem variability from the Scotian Shelf south the mid-Atlantic Bight. As part of this effort, the team will make use of a broad range of in situ salinity observations from mooring, gliders, and shipboard TSG systems to help with ongoing improvement and validation of SMAP SSS data both near to the coast and in cold waters that challenge salinity measurement algorithms. In this, we expect to better document the strengths and limits and satellite SSS data products as well improve the validation approaches that involve these alternative (non-Argo float) coastal in situ datasets. Given the known complexity of regional coastal circulation dynamics, the proposed investigations will make synergistic use of SMAP spatial fields and a regional data-assimilating 3-D ocean circulation model to better diagnose the mechanisms driving observed shelf-slope water mass exchange events evident in the satellite data. In this, we intend to develop methods that use passive tracers in ocean model backward trajectories to provide a new means to exploit the time/space measurement capabilities that SMAP provides. Our studies will also use existing global eddy-resolving CESM ocean model simulations over a longer time period to examine broader links between salinity change along the shelf and upstream processes including wind forcing and freshwater advection the Gulf of St. Lawrence and the Grand Banks.

Simon Yueh/Jet Propulsion Laboratory
Improving Quality and Consistency of Satellite Sea Surface Salinity Products for Climate Data Record
19-OSST19-0021

The goal of the proposed research is to improve the Sea Surface Salinity (SSS) algorithms for NASA's Soil Moisture Active-Passive (SMAP) and Aquarius data and to improve agreement with the Soil Moisture and Ocean Salinity (SMOS) product so that a consistent time series of satellite SSS datasets from the three missions can be established and the differences can be characterized. The proposed effort significantly builds on the top of past and current NASA investments on the algorithms developed for the SMAP and Aquarius missions to ensure a consistency of data products. The proposed project will achieve the following specific objectives:

1. Improvement of SMAP/Aquarius SSS retrieval algorithms for global and coastal oceans, and
2. Estimation and reduction of systematic biases among the SMAP, Aquarius, and SMOS data to enable a long-term satellite sea surface salinity climate data record.

Our proposed activities include:

1) Intercomparison of SMAP and SMOS data to improve consistency and characterization of biases,
2) Development of a consistent geophysical model function using the ECMWF wind and wave analyses for matchup with Aquarius and SMAP data for modeling of surface roughness,
3) Improvement to correction of sea ice contamination for SSS retrieval,
4) Improved sun glint correction to SMAP data for better accuracy and reduction of ascending and descending biases,
5) Performing SSS retrievals from Aquarius, SMAP and SMOS data using consistent ancillary data and the same geophysical model function to account for the effects of wind, wave and sea surface temperature, and
6) Conducting rigorous validation analysis using in-situ SSS data from Argo, tropical moorings and ship data.

We have already been approved by the European Center for Medium Range Forecast (ECMWF) for data access to operational analyses; the ECMWF data since 2011 has been obtained for the development of ECMWF-based geophysical model functions for SMAP and Aquarius and hence resulting SSS products.

Our data processing will be based on the well-established JPL-CAP processing software for Aquarius and SMAP. The JPL-SMAP-CAP processing system is operational and has been producing delayed-mode as well as near real time (NRT) products. The delayed-mode products use the operational SMAP L1B TB product, while the NRT data products use the NRT SMAP TB product and have been distributed to NOAA NESDIS since 2015.

We have already been in compliance with the NASA ROSES requirement. JPL SMAP-CAP v4.0, approved by JPL for open source in 2018, has been installed at the LOCEAN

for processing of SMAP data. We will continue to make the updated SMAP-CAP versions open source for use by the general communities.

This proposal directly addresses one of the key focus areas indicated in the ROSES OSST call, “Evaluation and improvement of Aquarius and SMAP SSS products.” (focus topic 2). The proposed evaluation effort for inter-comparison of SMAP, Aquarius and SMOS products and in situ data will also enable “Improve estimates of total error budget for SMAP and Aquarius SSS” (focus topic 3).