# Progress Report
# Evaluating the Ocean Observing System: Sea Surface Velocity (SSV)

Period of Activity: 01 October 2020 – 30 September 2021


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**Budget Summary**
FY 2021: $20,000 (FY 2020: $31,668)

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## 1. Project Summary

The Integrated Ocean Observing System (IOOS) includes an array of moored and drifting buoys that measure SST and near-surface currents throughout the world's oceans. The success of the IOOS in resolving SST variations and reducing satellite SST bias is quantified in a quarterly report (Zhang et al., 2004). However, until this project was initiated, no comparable evaluation was performed for surface currents even though surface currents carry massive amounts of heat from the tropics to subpolar latitudes, leading (and improving prediction potential of) SST anomalies. Current anomalies can also be an early indicator of phase shifts in the ENSO, NAO, and possibly other climate cycles. The GOOS/GCOS (1999) report specified that the IOOS should resolve surface currents at 2 cm/s accuracy, with one observation per month at a spatial resolution of 600 km. There is currently no requirement for potential satellite bias in surface currents.

The primary goal of this project is to maintain a quarterly "Observing System Status Report for Surface Currents", which evaluates how well the IOOS satisfied the GOOS/GCOS requirements, and evaluate the evolution of the globally averaged potential satellite bias. This product is being used as a guide for future drifter deployments in conjunction with NOAA/AOML's Drifter Operations Center, a component of the Global Drifter Program, and may demonstrate where future moored observations are necessary in order to meet these requirements. These reports are made available at ftp://ftp.aoml.noaa.gov/phod/pub/lumpkin/eval_sfc_currents/.

The secondary goal of this project is to exploit recent research developments in order to derive high quality surface current products for the research community and general public. Specifics will evolve from year to year, and will be provided in the annual reports and work plans.

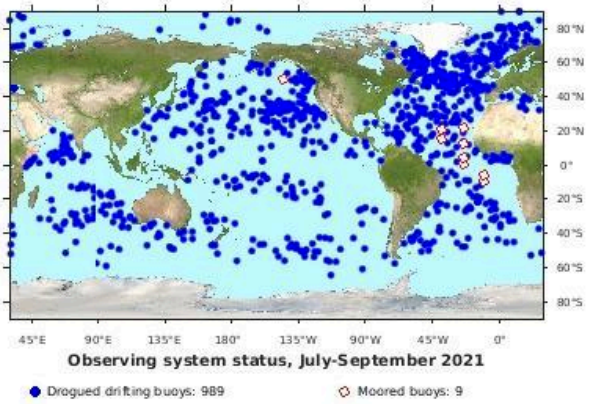
## 2. Scientific and Observing System Accomplishments

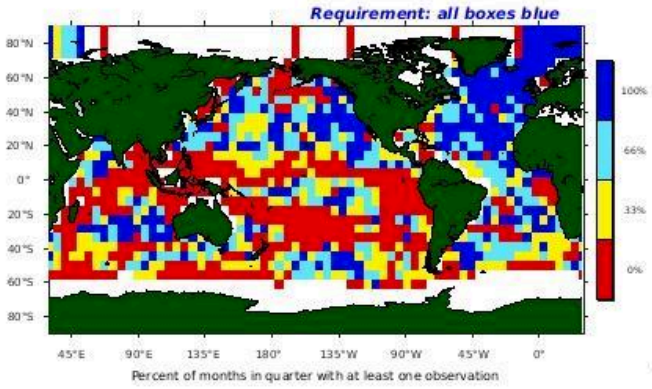
- Progress on the milestones and performance measures

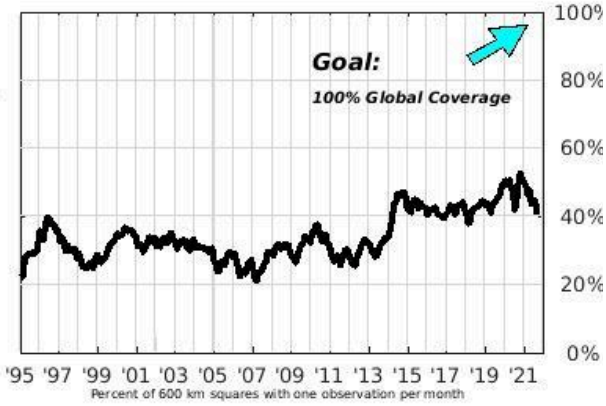
**Observing System Status: 2021, Q3.**
**Surface Currents**

Requirement: 2 cm/s accuracy (drogue on);
600 km resolution;
1 sample per month (GOOS/GCOS, 1999)

Performance measure: reduce the error in global measurement of surface velocity




*GOMO Required Performance Measures:*

- Quarterly reports on the state of the GOOS for surface current measurements. **Status: accomplished**
- Updates of a quarter-degree, monthly climatology of ocean surface currents, including error estimates, at https://www.aoml.noaa.gov/phod/gdp/mean_velocity.php. **Status: accomplished.**

- Notable observing achievements during FY 2021

During FY21, the global drifter array was maintained at an average size of 1501 drifters with a standard deviation of 83 drifters. On average, 79% of all relevant 5°x5° bins were sampled by at least one drifter. A total of 921 deployments were coordinated with national and international partners during FY21.

- Scientific advances and significance of your work (For multi-institution proposals, provide your top 2 or 3 advances)

PI Lumpkin served as lead editor of the Oceans chapter of the BAMS "State of the Climate in 2020" report, and was lead author of two sections of this report, including a section on Surface Currents (R. Lumpkin, R. Dominguies, and G. Goni). This report documented changes in surface currents during the year, anomalies with respect to 2019 and to climatology, and represents an OAR transition to NOAA/Climate Prediction Center.

The Drifter DAC contributed to the monthly "Climate Diagnostics Bulletin" published by NOAA/NCEP's Climate Prediction Center.

PI Lumpkin served on the Data Buoy Cooperation Panel executive board. He also served as chair of the DBCP Global Drifter Program and co-chair of the instrument best practices working group.

AOML generates a monthly climatology of ocean surface currents derived from the drifter data at http://www.aoml.noaa.gov/phod/gdp/mean_velocity.php. This product is now updated to version number 3.07, released 19 November 2021, including drifter data through July 2021.

- Instrumental records of Essential Ocean Variables , Essential Climate Variables, and related ocean attributes that are relevant for 1) Routine delivery of a range of societally relevant services (e.g. products, forecasts, etc.) and 2) advancing climate, ocean, and related research

Drifters provide observations of sea surface temperature (SST), sea surface velocity (SSV), and sea level pressure (SLP). A smaller number provide sea surface salinity (SSS), directional wave spectrum measurements, winds, and subsurface temperature profiles.

- Issues related to funding that affect progress (e.g., reductions, delays)

Due to reduced funding from FY20 to FY21 in response to increased Iridium transmission charges, less PI time could be dedicated to this effort compared to earlier years. This resulted in delays in generating the report, the surface current climatology, and updates to the project web site.

- Website for your program

Results from this project can be found at ftp://ftp.aoml.noaa.gov/phod/pub/lumpkin/eval_sfc_currents/ and are included in AOML's "State of the Ocean Observing System" pages at http://www.aoml.noaa.gov/phod/soto/index.php.

## 3. Outreach and Education

- The Global Drifter Program has an outreach web page at http://www.aoml.noaa.gov/phod/gdp/outreach.php. This page highlights partnerships with programs like Adopt-A-Drifter, the Seakeepers, and the Ocean Race that have a significant outreach component.
- PI Rick Lumpkin was interviewed by The Sargassum Podcast (http://marinefrontiers.org/sargassum), and described how he used Global Drifter Program drifters to understand how the Great Sargassum Belt was created. The interview can be seen at https://youtu.be/7iyD66ytN5k.

## 4. Publications and Reports

All publications satisfy NOAA's Public Access to Research Results (PARR) requirements, including submitting a digital copy of final pre-publication manuscripts to the NOAA Institutional Repository once accepted for publication and the final pre-publication copy is available.

- Published


Chidichimo, M. P., A. R. Piola, C. S. Meinen, R. C. Perez, E. J. D. Campos, S. Dong, R. Lumpkin, and S. L. Garzoli, 2021: Brazil Current volume transport variability during 2009-2015 from a long-term moored array. *Journal of Geophysical Research – Oceans*, **126**, e2020JC017146, https://doi.org/10.1029/2020JC017146.

Elipot, S., L. Centurioni, B. Haines, R. Lumpkin, and J. K. Willis, 2021: Measuring Global-Mean Sea-Level Rise with Surface Drifting Buoys. *Marine Techn. Soc. J.*, **55** (3), 66-67, https://doi.org/10.4031/MTSJ.55.3.12.

Johnson, G. C. and R. Lumpkin, 2021: Overview [in "State of the Climate in 2020"]. *Bull. Amer. Meteor. Soc*., **102** (8), Chapter 3, https://doi.org/10.1175/BAMS-D-21-0083.1.

Lumpkin, R., R. Domingues, and G. Goni, 2021: Surface Currents [in "State of the Climate in 2020"]. *Bull. Amer. Meteor. Soc*., **102** (8), Chapter 3, https://doi.org/10.1175/BAMS-D-21-0083.1.

Miron, P., M. J. Olascoaga, F.J. Beron-Vera, N.F. Putman, J. Triñanes, R. Lumpkin, and G. J. Goni, 2020: Clustering of marine-debris- and *Sargassum*-like drifters explained by inertial particle dynamics. *Geophys. Res. Lett*., **47**, e2020GL089874. https://doi.org/10.1029/2020GL089874.

van Sebille, E., E. Zettler, N. Wienders, L. Amaral-Zettler, S. Elipot, and R. Lumpkin, 2021: Dispersion of surface drifters in the Tropical Atlantic. *Frontiers in Marine Science*, **15** January 2021, https://doi.org/10.3389/fmars.2020.607426.

Zhao, M., R. M. Ponte, O. Wang, and R. Lumpkin, 2021: Using Drifter Velocity Measurements to Assess and Constrain Coarse-Resolution Ocean Models. *J. Atm. Ocean. Techn.*, **38**(4), 909-919, https://doi.org/10.1175/JTECH-D-20-0159.1.

### *4.1. Other Relevant Publications*


Androulidakis, Yannis & Kourafalou, Villy & Olascoaga, Maria & Beron-Vera, Francisco & Le Henaff, Matthieu & Kang, Heesook & Ntaganou, Nektaria. 2021: Impact of Caribbean Anticyclones on Loop Current variability. *Ocean Dynamics*. **71**, https://doi.org/10.1007/s10236-021-01474-9.

Cardoso, Cláudio & Caldeira, Rui. 2021: Modeling the Exposure of the Macaronesia Islands (NE Atlantic) to Marine Plastic Pollution. *Frontiers in Marine Science*, **8**, https://doi.org/10.3389/fmars.2021.653502.

Duyck, E., & De Jong, M. F., 2021: Circulation over the south-east Greenland shelf and potential for liquid freshwater export: A drifter study. *Geophysical Research Letters*, **48**, e2020JB020886. https://doi.org/10.1029/2020GL091948.

Hsu, P.-C., Centurioni, L., Shao, H.-J., Zheng, Q., Lu, C.-Y., Hsu, T.-W., & Tseng, R.-S. (2021). Surface Current Variations and Oceanic Fronts in the Southern East China Sea: Drifter Experiments, Coastal Radar Applications, and Satellite Observations. *Journal of Geophysical Research: Oceans*, **126**, e2021JC017373. https://doi.org/10.1029/2021JC017373.

Huang, B., Liu, C., Freeman, E., Graham, G., Smith, T., & Zhang, H., 2021: Assessment and Intercomparison of NOAA Daily Optimum Interpolation Sea Surface Temperature (DOISST) Version 2.1, *Journal of Climate*, **34**(18), 7421-7441, https://journals.ametsoc.org/view/journals/clim/34/18/JCLI-D-21-0001.1.xml.

Johns, William, Araujo, Moacyr, Balmaseda, Magdalen, Cjhang, Ping, Dandin, Philippe, Hill, Katherine, Keenlyside, Noel, Knight, Jeff, Kushnir, Yochanan, McPhaden, Michael, Richter, Ingo, Robinson, Carol, Rodrigues, Regina, Schmidt, Jörn, Simmons, Adrian, Smith, Neville, Stripling, Scott, Tanhua, Toste, Visbeck, Martin, 2021: Tropical Atlantic Observing System (TAOS) REVIEW REPORT Full Report Coordinating lead authors.

Lilly, Jonathan & Pérez-Brunius, Paula, 2021: A gridded surface current product for the Gulf of Mexico from consolidated drifter measurements. *Earth System Science Data*, **13**, 645-669. https://doi.org/10.5194/essd-13-645-2021.

Lilly, Jonathan & Pérez-Brunius, Paula, 2021: Extracting statistically significant eddy signals from large Lagrangian datasets using wavelet ridge analysis, with application to the Gulf of Mexico. *Nonlinear Processes in Geophysics*, **28**, 181-212. https://doi.org/10.5194/npg-28-181-2021.

Miron, Philippe & Beron-Vera, F., Helfmann, L. & Koltai, Péter, 2021: Transition paths of marine debris and the stability of the garbage patches. *Chaos: An Interdisciplinary Journal of Nonlinear Science*, **31**, 033101. https://doi.org/10.1063/5.0030535.

O'Malley, M., Sykulski, A. M., Laso-Jadart, R., & Madoui, M., 2021: Estimating the Travel Time and the Most Likely Path from Lagrangian Drifters. *Journal of Atmospheric and Oceanic Technology*, **38**(5), 1059-1073, https://journals.ametsoc.org/view/journals/atot/38/5/JTECH-D-20-0134.1.xml.

Paul, N., Sukhatme, J., Sengupta, D., & Gayen, B., 2021: Eddy induced trapping and homogenization of freshwater in the Bay of Bengal. *Journal of Geophysical Research: Oceans*, **126**, e2021JC017180. https://doi.org/10.1029/2021JC017180.

Peng, J., Dräger-Dietel, J., North, R. P., & Umlauf, L., 2021: Diurnal Variability of Frontal Dynamics, Instability, and Turbulence in a Submesoscale Upwelling Filament, *Journal of Physical Oceanography*, **51**(9), 2825-2843, https://journals.ametsoc.org/view/journals/phoc/51/9/JPO-D-21-0033.1.xml.

Phillipson, L., Li, Y., & Toumi, R., 2021: Strongly Coupled Assimilation of a Hypothetical Ocean Current Observing Network within a Regional Ocean–Atmosphere Coupled Model: An OSSE Case Study of Typhoon Hato, *Monthly Weather Review*, **149**(5), 1317-1336, https://journals.ametsoc.org/view/journals/mwre/149/5/MWR-D-20-0108.1.xml.

Sturges, W. (2021). On the Nongeostrophic Appearance of Some Mean Surface Velocity Observations in the Gulf of Mexico, *Journal of Physical Oceanography*, **51**(6), 1829-1833, https://journals.ametsoc.org/view/journals/phoc/51/6/JPO-D-20-0232.1.xml.

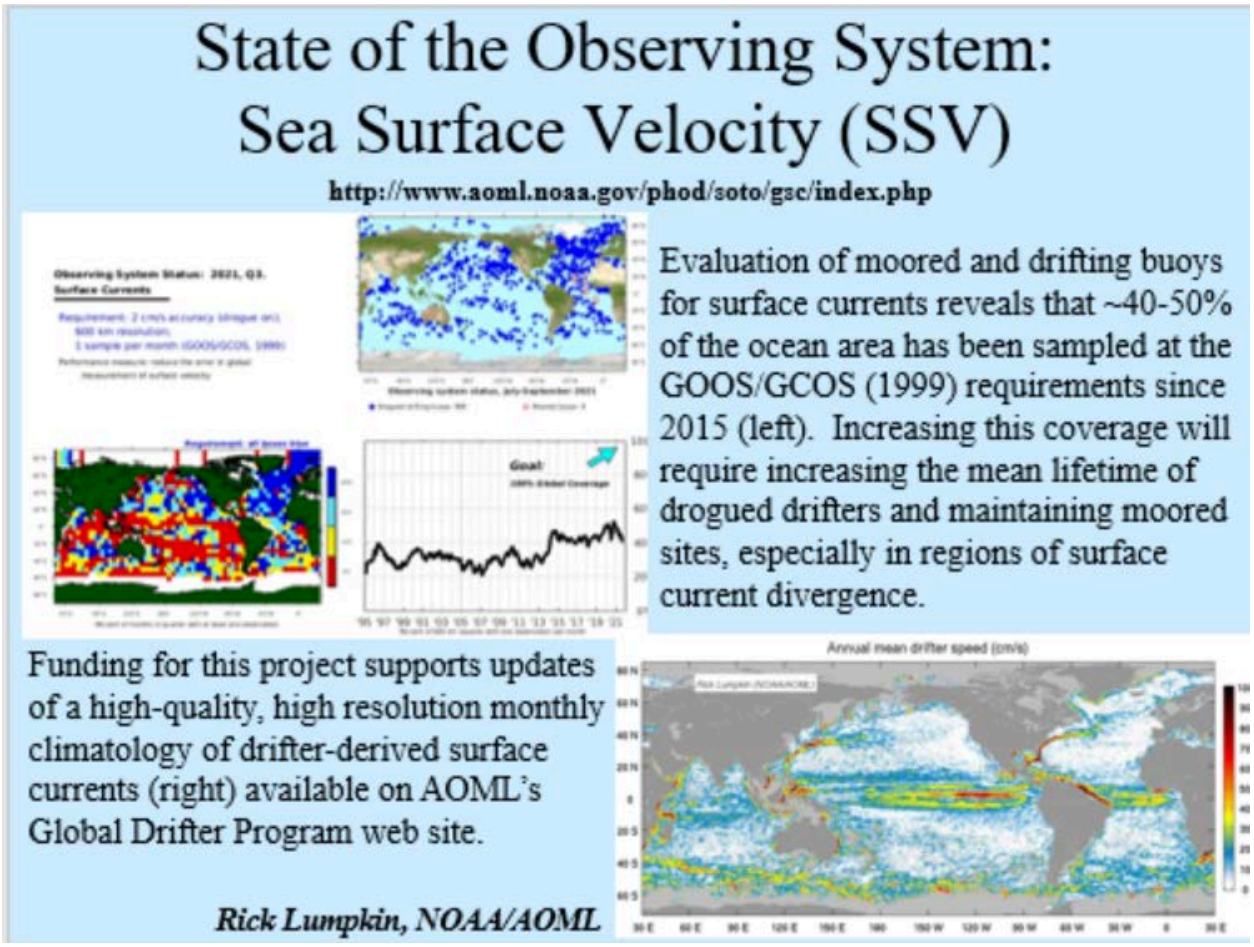
Zaiss, J., Boyd, P. W., Doney, S. C., Havenhand, J. N., & Levine, N. M., 2021: Impact of Lagrangian sea surface temperature variability on Southern Ocean phytoplankton community growth rates. *Global Biogeochemical Cycles*, **35**, e2020GB006880. https://doi.org/10.1029/2020GB006880.

Zhang, H., Ignatov, A., & Hinshaw, D., 2021: Evaluation of the In Situ Sea Surface Temperature Quality Control in the NOAA In Situ SST Quality Monitor (iQuam) System, *Journal of Atmospheric and Oceanic Technology*, **38**(7), 1249-1263, https://journals.ametsoc.org/view/journals/atot/38/7/JTECH-D-20-0203.1.xml.

## 5. Data and Publication Sharing

All GDP data are transmitted on the GTS for near-real-time distribution. In delayed mode, the data are quality controlled and interpolated to regular 6-hourly values. The GTS and delayed mode QC data are archived at Canada's MEDS and NOAA/NCEI. QC data are also available from the GDP web page and are available and readily discoverable using NOAA's Observing System Monitoring Center (OSMC). For details, see http://www.aoml.noaa.gov/phod/gdp/real-time_data.php for real-time data access http://www.aoml.noaa.gov/phod/gdp/images/ERDDAP_Interpolated_Data.pdf for QC data access. The drifter data management plan is described in the OceanObs'09 Community White Paper "Data Management System for Drifting Buoys" by Keeley, Pazos and Bradshaw, available at www.oceanobs09.net/blog/?p=225.

## 6. Project Highlight Slides




Please ***attach*** slides using the attached template to show one important highlight from your project's progress (including relevant notes and credits) and one summary slide. The slides will be available to GOMO program managers in this Google folder also allowing PIs to make updates. *Note:* Information shared on slides may be shared with agency leadership, in interagency discussions, and occasional briefings in public settings.

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Length and Style: Submit your Progress Report in Word (not PDF). Limit your report length to no more than 10 pages, plus figures (which are encouraged) and tables. This is not a firm requirement as highly complex projects containing many components may require more space; if so, please exercise restraint in length. This translates into a request for information at a level of granularity that is appropriate to technical programmatic oversight; please do not simply refer us to research papers for the concepts, approaches, and findings, but, conversely, please do not repeat the level of detail of research publications either. Use Times New Roman, 12pt font size, left justified for the text in the main body of the report, and blocked paragraphs (no indent) with a blank line between them. Further stylistic details are given below. **Use the Progress Report template in this document; please overwrite the instructions under each heading.**

***NOTE*: Your progress report will be available on request**. The cover/signature page and funding amount, however, will not be distributed. Please be certain, therefore, to include project title/authors/ affiliations at the top of the first page of the report *in the format indicated in the template*.

***Please note the following:***

1. Please use this FY 2021 report template. ***Reports submitted using templates from previous years will be returned, as will documents in PDF***. *You will be asked to resubmit using the correct form and format.*

2. In order to spare us the task of reformatting your report prior to uploading to the web, please do not change the basic formatting of the report template.

3. Please observe the following style guidelines for the report:
    a. **Font**: Times New Roman
    b. **Body text**: 12 point, plain
    c. **Justification**: Left
    d. **Paragraphs**:
        i. Block (no indent)
        ii. Spacing before and after = 0
        iii. Insert one blank line between paragraphs
    e. **Margins**: 1 inch
    f. **Line Spacing**: Single
    g. **Sub-section Headers**: If you wish to add subsections that will appear in the Table of Contents, please assign to them a style of "Heading 2," or "Heading 3."
    h. **Title**: 14 point, bold, centered
    i. **Authors**: 12 point plain, left justified, use superscripts if more than one affiliation
    j. **Affiliations**: 12 point plain, left justified
4. Please be certain to add the title of your report to the footer, starting on page 2.

5. Please ensure that the Project Summary is as you would like it to appear as a separate, stand-alone document for the website.
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