The Global Drifter Program

Drifter Measurements of Surface Velocity, SST, SSS, Winds and Air Pressure

Peter Niiler
The Scripps Institution of Oceanography, La Jolla CA

Table of Contents

1. Abstract 1
2. Project Summary 1
3. Scientific Accomplishments 4
4. Education and Outreach 7
5. Publications and Reports 8
   5.1. Publications by Principal Investigators 8
   5.2. Other Relevant Publications 9

1. Abstract

The "*Global Drifter Program*" (*GDP*) is the principal international component of the Joint Commission of Marine Measurements (JCOMM) "*Global Surface Drifting Buoy Array*". It is a "Scientific Project" of the Data Buoy Cooperation Panel (DBCP) of World Meteorological Organization (WMO)/International Ocean Commission (IOC). It is a near-operational ocean-observing network that, through the ARGOS satellite system and the Global Telecommunication System (GTS), returns real time data on ocean near-surface currents, Sea Surface Temperature (SST) and air pressure (and winds, subsurface temperature - T(z), and Sea Surface Salinity (SSS)) and provides a data processing system for scientific utilization of these data. The international protocols for these data exchanges and sensor additions are worked out each year by DBCP. The principal technical achievement in '09 was the continuation of the 4th continuous year of maintenance of the 1250 element global drifter array. The principal scientific accomplishments were the discovery of semi-permanent, mesoscale structures and convergences (garbage patches) in the global ocean, including in the California Current System. Analysis of the air-deployed Hurricane drifter data shows that significant changes of the wind-drag coefficient under tropical cyclones must be implemented in Hurricane prediction models.

2. Project Summary

The principal scientific questions of the role of the ocean in climate change are how well can we describe or model the ocean circulation today and how well can these descriptions or models predict the evolution of future climates. Climate time scale changes in SST directly force changes in the air temperature and habitability conditions over a large part of the globe. On these

climate evolution time scales, SST depends on ocean circulation, ocean diffusivities as well as air-sea interaction. A global array of drifters provide the operational instrumental data sets for SST and ocean near surface circulation and their evolutions and these data are used for testing climate models and enhancing long-range weather prediction.

Additional ocean surface sensor data for climate studies that measure SSS are critical to determining the oceans' fresh water cycle and onset of deep-water renewals. Air pressures measurements are assimilated into weather prediction models and are used by operational meteorological agencies to discern severe weather conditions over the oceans. Sea level air pressure data also contribute significantly to the calculation of the inverted barometer effect on global sea level rise as measured from satallite altimeters. Wind sensor and subsurface temperature chain data are used to improve models for prediction of tropical storms and hurricanes. Drifters designed and built and deployed by *GDP* that is administered by the joint efforts of the Joint Institute of Marine Observations (JIMO) at the Scripps Institution of Oceanography (SIO) and the Atlantic Oceanographic and Meteorological Laboratory (AOML) of the National Oceanographic and Atmospheric Administration (NOAA) have proven to be reliable, autonomous platforms for obtaining climate and operational weather data from the global oceans.

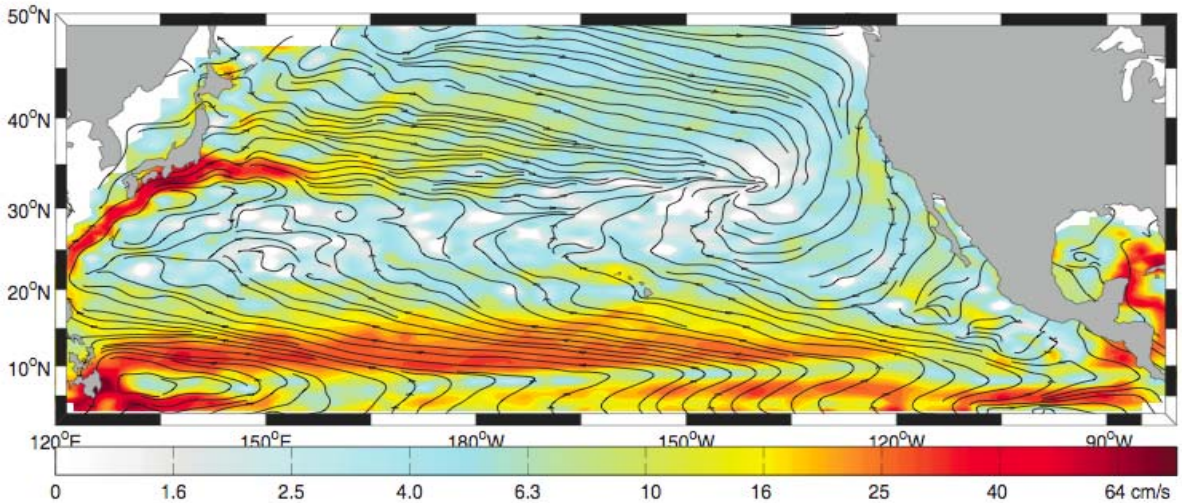
The scientific objectives of the *GDP*, and its operational and research partners, are:

1) Provide to GTS a near-operational, near-real time data stream of drifter position, SST, and sea level air pressure. GTS compatible data on winds, T(z) and SSS are also provided on operational basis when these sensors are mounted on the drifters.

2) Observe the 15m depth velocity on a global basis with 5.0° resolution and, jointly with satellite altimeter data, produce circulation charts of the world ocean at 0.5º resolution that can be used to trace pollution laden particles (Figure 1) or turbulent dispersion of vorticity and thermal energy due to the tropical eddy field (Figure 2).

3) Develop and introduce into the drifter construction technological advances in sensors, electronics, power, methods of assembly and deployment packaging. In the past two years, these technological advances have introduced new drifter wind sensors, drogue-on sensors (strain gauges) and improved air pressure ports.

4) Provide enhanced research quality data sets of ocean circulation that include drifter data from individual research programs. Gridded, global data sets of SST, near surface circulation and dynamic topography, or absolute sea level, are available on line for assimilation into and use in the verification of the processes, such as wind-driven Ekman currents and spatial patterns of the seasonal circulation in ocean climate models.



1.

Figure 1. Streamlines based on drifter velocity observations that show a large convergent swirl at 140ºW, 32ºN that is now well recognized as the North Pacific "Garbage Patch". *GDP* is cooperating with a number of environmentally concerned entities in describing its location. Color designates speed of the mean flow and black lines designate the direction of flow.

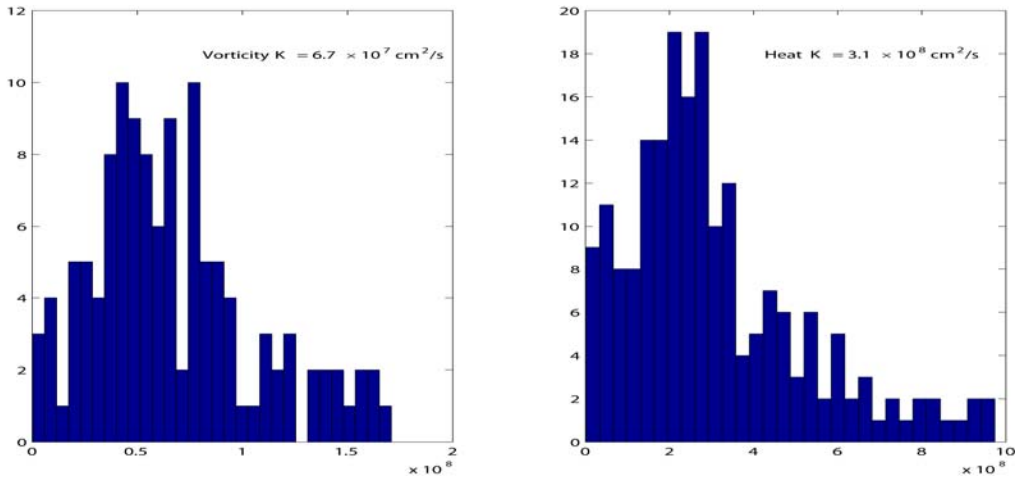


Figure 2. The distribution functions of eddy diffusion coefficients of vorticity (left panel) and thermal energy (right panel) that transfer vorticty and thermal energy down their mean surface gradients. These are computed from Eulerian interpretation of observations of time variable drifter motions within 5º Latitude of the Pacific equator (Niiler, Invited Dec. 2008 AGU meeting presentation). These newly estimated diffusivity values are comparable in magnitude to

Lagrangian single particle diffusivities computed previously from Lagrangian drifter observations.

In summary, the scientific and technological objectives of *GDP* are to provide an array of low cost, robust, satellite fixed platforms and calibrated sensors for ocean surface and simultaneous sea level air observations. These instrumental data are used for scientific evaluation of, not only how ocean surface climate changes, but also for evaluating the processes that give rise to these changes. The principal uses of drifter data are:

1) The drifter SST forms the principal data set for enhancing SST observations of the Southern Oceans because of the dearth of Volunteer Observing Ships in this 60% of the ocean area. In all oceans there is a need to provide continued, accurate (+/-0.1ºC) calibration data for satellite SST observations.
2) The air pressure data reveals a multiplicity of severe, small spatial scale, but intense storm systems that that the operational satellite sensors do not capture. Canadian, European and the Southern Ocean Meteorological agencies (and other members of WMO) rely on these data for early warnings when ships leave these severe weather conditions.
3) The surface velocity data, and the absolute sea level these provide, are used for testing ocean climate model verity as well as for providing an assimilation data set for model initial conditions. This velocity data set is essential to document the physical processes that are the causes of climate change of ocean surface conditions (Figures 1 And 2).

3. Scientific Accomplishments

The primary objective at *GDP* at JIMO each year is to deliver an array of drifters for deployment into the global ocean. In this endeavor, a close relationship is maintained with three primary US manufacturers of drifter components. In FY'09 NOAA Grants Office funding of the *GDP* through JIMO occurred in the fourth week of September 2009. This is a report of what was accomplished with both the FY'08 and FY'09 funding during the period of October 1, 2008 – November 20, 2009:

With the FY'08 funds 920 drifters with SST sensors were manufactured and were delivered to AOML for deployment in the calendar year 2009. With the FY'09 funds, 920 drifters were ordered in October 2009 and will be delivered to AOML for deployments during the calendar year 2010. With the FY'2009 funds, the composition of the drifter order in October 2009 to industry was:

a) A total of 480 SVP drifters were ordered from Clearwater Instruments, Inc., Pacific Gyre, Inc. and Technocean, Inc. These are now being delivered to AOML for deployment.
b) A total of 440 SVP-B drifters were ordered from Clearwater Instruments, Inc., Technocean, Inc. and Pacific Gyre, Inc. These are now being delivered to AOML for deployment.
c) A total of 12 SVP-W wind-drifters (Minimet) and 8 SVP-W-T(z) wind and chain drifters (ADOS), fully rigged for air deployment, were ordered from Pacific Gyre, Inc. This is the

fourth year that an industrial firm will build, calibrate and rig for air-deployment a full suite of hurricane drifters. All 20 units will be delivered the 53rd Air Force Reserve "Hurricane Hunter Squadron" at Keesler AFB, MS before July 1, 2010. Dr. Rick Lumpkin and Dr. Eric Uhlhorn of AOML will direct the deployments in the North Atlantic during the 2010 Hurricane season.

Service Argos, Inc., within 2 hours of measurement, applies a quality control to the drifter data from the array of 1250 units and distributes these on GTS for operational applications. Within six months, AOML Drifter Data Center performs a re-analysis of the data and distributes the six hourly interpolated observations upon request to the international scientific community. JIMO maintains files for surface current in which a wind slip correction has been applied and these are distributed also upon request. All levels of the instrumental and META data are filed at MEDS, Canada, the WMO responsible data center for ocean buoys. Every year, AOML files a "Global Drifter Program Report" on the statistics of survivability of power, drogues and sensors with the DBCP, which report is available on the DBCP web site.

The drifter data is the most extensive and accurate, *in situ* instrumental data set of SST that is used as the ground truth for the construction of the 7-day average SST maps of the ice-free oceans (i.e. the 'Reynolds' SST maps). This product is used globally for analysis of climate, long-range weather prediction and for initialization and verification of ocean circulation models. There is no systematic accounting maintained on the number of research papers, reports or practical products that result from the use of 'Reynolds' data. The Global Drifter Data Center web site each year updates the peer-reviewed publications that use the drifter velocity data (http://www.aoml.noaa.gov/phod/dac/gdp_biblio.html). Results are too many to review in this report, however several relevant publications by the principal investigator, Peter Niiler, are included as addendums.

Each year JIMO introduces new technology and sensors into the drifter construction. In 2008, all manufacturers adopted the strain gauge method of sensing whether the drogue was attached. They met at JIMO in December 2008 and exchanged information on the methodology of attaching tethers to the surface float and drogues with the intent of improving drogue retention as new, lower cost plastic components were being introduced. Drifters with the decided upon improvements are presently being deployed at sea and statistics on their survivability and changes in 'drogue on' sensing will emerge in 2010.

The measurement of ambient noise for wind speed sensing in SVP-W drifters was not reliable from sensor to sensor or single sensor performance at hurricane strength wind. In 2009 JIMO, working together with Pacific Gyre, Inc., designed, built and tested Gill sonic wind speed sensors for the hurricane drifters. The Gill sonic wind sensor is designed to operate in winds up to 200 knts and in heavy rain. Comparison of wind speed sensor performance, as compared to QSCAT satellite scatterometer data shows excellent performance (Figure 3,4). Hurricane drifters delivered to Keesler AFB in 2009 and 2010 all have new sonic wind speed sensors.

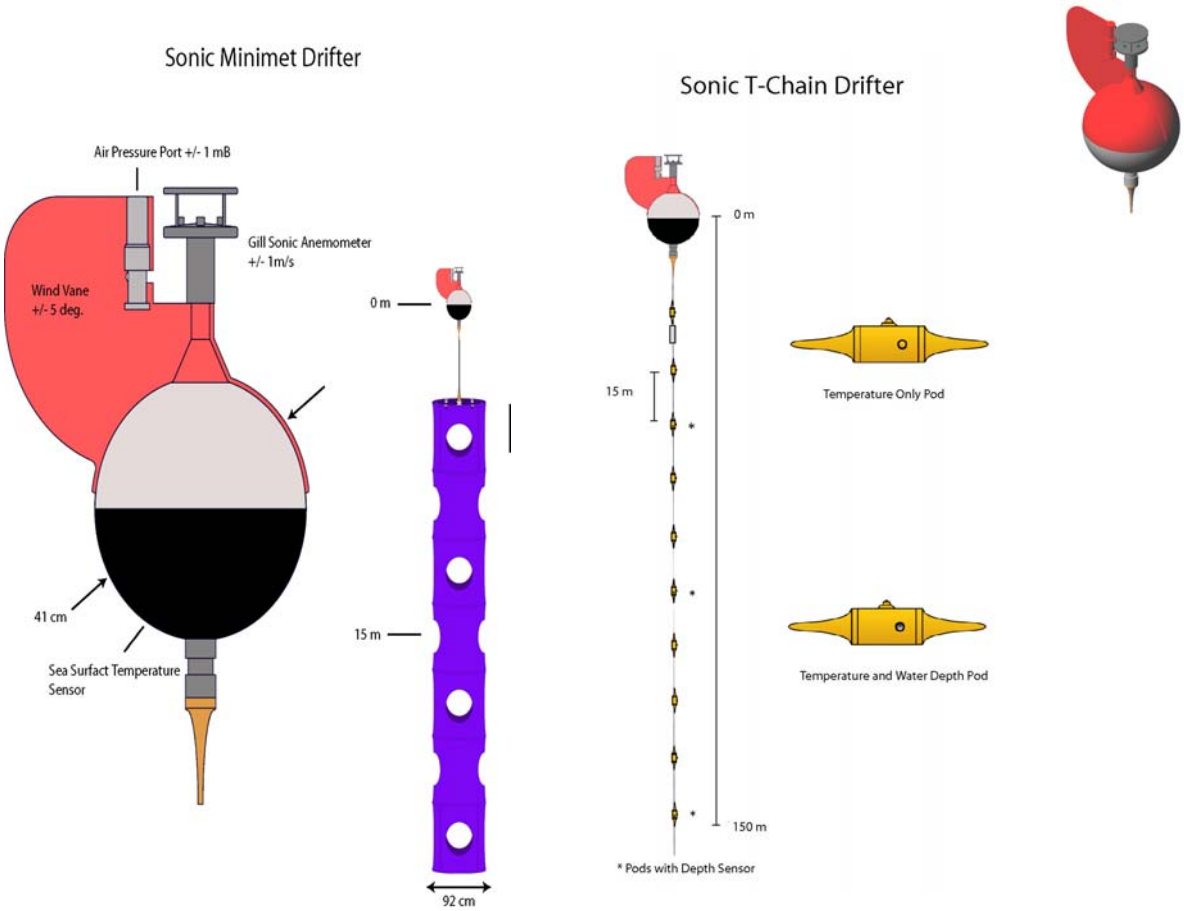


Figure 3. Schematic drawings of the new SVP-W (Wind) drifter (left panel) and the new SVP-T(z) (Temperature chain) drifter (right panel)

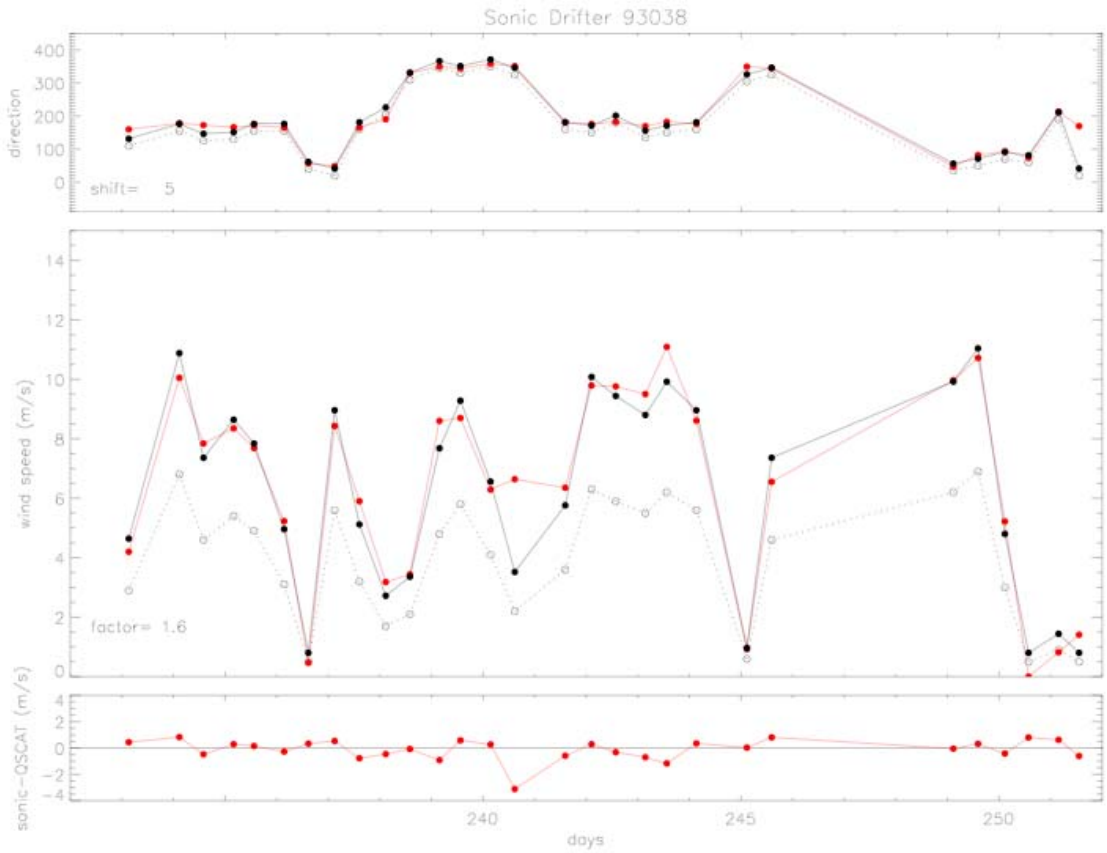


Figure 4. The comparison of wind direction and wind speed observations from QSCAT (red) and SVP-W (#93038) with a sonic anemometer (black and grey) off the coast of Oregon. The grey circles in the center panel, which are wind speed observed 45 cm above the ocean surface, are adjusted to 10m height winds that are observed by QSCAT by multiplying by a factor of 1.63, to achieve the black circles. Two SVP-W sonic anemometer drifters (#93037, #93038) have identical correction factors and since these have been operating well since September 21, 2009, their hourly sampled location, SST, air pressure, wind speed and wind direction data are now on GTS.

4. Education and Outreach

Because of the novelty of the results from combined altimeter and drifter analysis that revealed striations in ocean circulation and convergences at regions where ocean garbage patches have been reported by seafarers (viz. Publications enclosed) Peter Niiler has experienced a large number of requests for personal interviews with reporters from US and international radio, newspapers and television and phone interviews with reporters from science news magazines and film production companies. The Scripps Institution of Oceanography press office maintains the names and numbers of inquiries related to this work. GOOGLE reports 1770 incidents on 'peter

niiler and ocean stripes' and 1900 incidents on 'peter niiler and ocean garbage patches'. Peter Niiler served as a scientific adviser to a Scripps Institution of Oceanography graduate student cruise to the eastern North Pacific in September 2009 garbage patch and will be in front of TV cameras on 18 December, 2009. He was the co-adviser to a Masters Degree graduate student in physical oceanography in the calendar year 2008.

The following cooperative programs are part of the *GDP*/JIMO activities for 2008-2009:

iv) Typhoon drifter deployments in the western Pacific: With the cooperation of ONR, 24 hurricane drifters now stored in Keesler AFB were sent to Guam for deployment in the TCP-08 study of Typhoons in the western Pacific. AOML researchers and P. Niiler are cooperating in data analysis.

v) Circulation studies in Kuroshio Current System: In 2008, ONR funded P. Niiler and L. Centurioni to deploy 75 SVP drifters into the Kuroshio system over a period of 75 weeks; *GDP* provided and additional 75 SVP drifters for this purpose. Dr. Sen Jan of National Central University of Taiwan started deploying these in April 2008 with assistance from the Taiwan Coast Guard. The PTTs of these ONR funded drifters were placed into the *GDP* Argos Service account and all data is globally available in real time through GTS. This joint project with Taiwan is now completed. Continued deployments in the Southern Philippines Sea, jointly with ONR support, will begin in July 2010 and 48 drifters from *GDP* resources will be sent to the deployment vessel operating out of Busan, Korea. *GDP* will gain 48 additional drifters in each of three years 2010-2013 through this joint effort.

vi) Consortium for Ocean Research in Climate (CORC) deployments of drifters into the California Current System: GDP is cooperating with *CORC*/JIMO project to design a deployment scheme for the California Current System that will commence in 2009. The design has been completed and in July '09 and Nov'09 deployments of 13 SVP drifters each were accomplished; 26 drifters per year will be sent by *GDP* to CALCOFI ships for deployment.

5. Publications and Reports

5.1. Publications by Principal Investigators

Centurioni, L., C. Ohlmann AND P. Niiler: Permanent Meanders in the California Current System. *J. Phys. Oceanogr.* **38** (8), 1690-1710. (2008)

Maximenko N. A., O. V. Melnichenko, P. P. Niiler, H. Sasaki: Stationary mesoscale jet-like features in the ocean. *Geophys. Res. Lett.*, **35**, L08603, doi:10.1029/2008GL033267. (2008)

Zedler, S. E., P. P. Niiler, D. Stammer, E. Terrill, and J. Morzel (2009), Ocean's response to Hurricane Frances and its implications for drag coefficient parameterization at high wind speeds, *J. Geophys. Res.*, 114, C04016, doi:10.1029/2008JC005205.

Maximenko, N, P. Niiler, M-H Rio, O. Melnichenko, L. Centurioni, D. Chambers, V. lotnicki and B. Galperin: Man dynamic topography of th eoceans derived from satellite and drifting buoy data using three different techniques" *J.Atm.Oc.Tech.*, DOI:10.1175/2009JTECH0672 (2009)

5.2. Other Relevant Publications

Niiler, P: Ageostrophic Circulation in the Ocean. In: "Oceanography in 2025 - Proceedings of a Workshop". D. Glickson, ed. *National Research Council, National Academies Press, Washington D.C.* (2009)