What's a drifter? (modified by D. Reed)

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This page is an overview of the modern satellite-tracked surface drifting buoy ("drifter"). For a more detailed description, see Lumpkin and Pazos (2006). If you wish to cite this page, please reference:

Lumpkin, R. and M. Pazos, 2006: Measuring surface currents with Surface Velocity Program drifters: the instrument, its data, and some recent results. Chapter two of Lagrangian Analysis and Prediction of Coastal and Ocean Dynamics (LAPCOD) ed. A. Griffa, A. D. Kirwan, A. J. Mariano, T. Ozgokmen, and T. Rossby.

Overview

The modern drifter is a high-tech version of the "message in a bottle". It consists of a surface buoy and a subsurface drogue (sea anchor), attached by a long, thin tether. The buoy measures temperature and other properties, and has a transmitter to send the data to passing satellites. The drogue dominates the total area of the instrument and is centered at a depth of 15 meters beneath the sea surface.

Have I found a drifter?

Determine if you have found a drifter, as opposed to some other floating device.
The spherical float is 30-40 cm in diameter, is always made of plastic or fiberglass, and will have an identification number on it (usually five digits). The color of the float is not standardized: it could be bicolor, like the drifters shown on the top of this page, or it could be solid black or blue.

History

For many years, ocean currents have been estimated by how they carry objects. For example, sailors measured the speed of their ship through the water using the ship log. They measured their absolute position by celestial navigation (in the good old days, pre-GPS!). The difference between the absolute speed and the speed through the water gave the speed of the currents. Very strong currents, such as the Gulf Stream of the North American east coast, made a big difference in how long it takes to travel south versus north! Large-scale currents were also inferred when an object dropped at one place eventually washed ashore on a distant beach. Glass balls used by Japanese fishermen ended up on a beach in California, carried by the vast clockwise-swirling North Pacific gyre.

More recently, researchers began tracking objects while they were drifting. This tracking was first done visually (from a coastline or anchored ship,) then using radio, and most recently using satellites. During the 1970s, when satellite tracking became possible, many competing drifter designs were proposed, built and deployed in various studies around the world.

In 1982 the World Climate Research Program (WCRP) recognized that a global array of drifting buoys ("drifters") would be invaluable for oceanographic and climate research, so declared that a standardized, low-cost, lightweight, easily-deployed drifter should be developed.

This development took place under the Surface Velocity Program (SVP) of the Tropical Ocean Global Atmosphere (TOGA) experiment and the World Ocean Circulation Experiment. Funding was provided by the US Office of Naval Research, the National Oceanic and Atmospheric Administration (NOAA), and the National Science Foundation. A uniform design for the modern SVP drifter was proposed in 1992 (Sybrandy and Niiler, 1992) with a spherical surface buoy and a semi-rigid drogue that maintains its shape in high-shear flows.

Drifters with holey-sock drogues were first deployed by NOAA's Atlantic Oceanographic and Meteorological Laboratory in February 1979 as part of the TOGA/Equatorial Pacific Ocean Circulation Experiment (EPOCS). Large-scale deployments of the first modern SVP drifters took place in 1988 (WCRP, 1988) with the goal of mapping the tropical Pacific Ocean's surface circulation. This effort was expanded to global scale as part of WOCE and the Atlantic Climate Change Program (ACCP), in which the array of SVP drifters was extended to cover the Pacific and North Atlantic Oceans by 1992 and the Southern and Indian Oceans by 1994 (Niiler, 2001). The array spanned the tropical and South Atlantic Ocean by 2004 (Lumpkin and Garzoli, 2005).

Design

There are two basic sizes of SVP drifters: the original, relatively heavy SVP drifter and the newer "mini" version. The less expensive, easier-to-deploy mini design was proposed in 2002 and is currently produced alongside original SVP drifters by several manufacturers. Manufacturers of SVP drifters include Clearwater Instrumentation (Watertown, MA USA), Marlin-Yug (Sevastopol, Ukraine), Metocean Data Systems (Dartmouth, Nova Scotia, Canada), Pacific Gyre (Oceanside, CA USA), and Technocean (Cape Coral, FL USA).

The surface float ranges from 30.5 cm to 40 cm in diameter. It contains: batteries in 4-5 packs, each with 7-9 alkaline D-cell batteries; a transmitter; a thermistor to measure sea surface temperature; and possibly other instruments measuring barometric pressure, wind speed and direction, salinity, and/or ocean color. They also have a submergence sensor or a tether strain sensor to verify the presence of the drogue.

The drogue is centered at 15 meters beneath the surface to measure mixed layer currents in the upper ocean. The outer surface of the drogue is made of nylon cloth. Throughout the drogue, rigid rings with spokes support the drogue's cylindrical shape. The drogue is a "holey-sock": each drogue section contains two opposing holes, which are rotated 90 degrees from one section to the next. These holes act like the dimples of a golf ball by disrupting the formation of organized lee vortices.

Once deployed, a modern SVP drifter lives an average of around 400 days before ceasing transmission. Occasionally, drifters are picked up by fishermen or lose their drogue and run aground.

Deployment

Original-design SVP drifters weigh 45 kg (100 lbs) each. Mini drifters weigh 20 kg (44 lbs) each. Before deployment, the drogue and tether are bound with paper tape, which dissolves in the water, and the tether is sometimes wrapped around a water-soluble cardboard tube to protect it from kinking. The drifter is deployed by throwing it from the stern of a vessel, preferably from the lowest deck and within 10 m of the sea surface. Successful deployments have been made from ships steaming at up to 25 knots. After deployment, it may take up to an hour for the paper tape to dissolve and trapped air bubbles to be released, so that the drogue sinks to the target depth (15 m).

Drifters have been air-deployed out of Lockheed C-130 Hercules, operated by the Air Force Reserve Hurricane Hunters (53d Weather Reconnaissance Squadron, 403d Wing, Keesler Air Force Base), and by the Naval Oceanographic Office which conducts surveys supporting naval operations primarily in the northern hemisphere. Deployments have also been conducted from a C-141 Starlifter.

During the one-year period September 2003 August 2004, a total of 658 drifters were deployed in NOAA's contribution to the Global Drifter Program. Of these, 440 were deployed off research vessels, 201 off voluntary observation ships, and 17 were air-deployed.

Data transmission and drifter location

The drifter sensors measure data such as sea surface temperature, average the data over a window (typically 90 seconds), and transmit the sensor data at 401.65 MHz. Each drifter transmitter is assigned a Platform Terminal Transmitter (PTT) code, often referred to as the drifter ID.

Argos is a satellite-based system for collecting, processing and distributing data. It is operated by Collecte Localisation Satellites in Toulouse, France with a subsidiary (Service Argos, Inc.) in Largo, Maryland USA. Since 1978, the Argos system has been carried on the US Polar Orbiting Environmental Satellites to obtain global coverage. A second-generation Argos system was carried aboard the Japanese Advanced Earth Observing Satellite II (ADEOS-II), launched in December 2002. This joint Argos/ADEOS-II program ("Argos Next") was declared operational on 5 May 2003; unfortunately, the satellite failed on 25 October 2003. Future launches with next generation Argos systems are planned aboard the European METOP satellites, beginning in the last quarter of 2005.

The position of a drifter is not usually given by the familiar Global Positioning System (GPS). Instead, it is inferred from the Doppler shift of its transmission as seen by the satellite and described in the Argos Users Manual. Argos specifies the accuracy of position fixes according to a location class: class one (350-1000 meters error), class two (150-350 meter error) and class three (less than 150 meter error).

Drifter data: quality control, interpolation and coverage

Drifter locations are estimated from 16-20 satellite fixes per day, per drifter. AOML's Drifter Data Assembly Center (DAC) assembles these raw data, applies quality control procedures, and interpolates them to regular 1/4-day intervals. The raw observations and processed data are archived at the DAC and at Canada's Marine Environmental Data Service.

Interpolation

The raw fixes are interpolated to uniform six hour intervals using an optimal interpolation procedure known as kriging. For more information, see Hansen and Poulain (1996). Latitude, longitude and temperature are interpolated independently.

Along with the interpolated positions, the DAC provides formal error bars on the positions. These error bars identify large gaps (as long as two weeks) across which the data have been interpolated.

Data coverage

SVP drifter observations now cover most areas of the world's oceans at sufficient density to map mean currents at one degree resolution. All of the major western boundary currents (Gulf Stream, Philippines/ Kuroshio, Brazil, North Brazil, East Australian, Mozambique/Agulhas and Somali) are seen in both mean current speed and eddy energy. Tropical currents such as the northern South Equatorial Current and North Equatorial Countercurrent are prominent features, as are the monsoon-driven currents in the equatorial Indian Ocean.

From 1998 to 2003, drifter coverage has increased in all basins shown in the figure above, except the North Pacific. Recent air deployments by NAVOCEANO south of the Aleutian Islands, along with future deployments from voluntary observation ships running the great circle route between Japan and California, are addressing this gap.

Velocity observations

SVP drifters do not perfectly follow the water column averaged over the drogue depth. For example, water can downwell (sink to great depths from the surface), while the drifter is forced to stay at the sea surface. Also, the drifter can "slip" through the water. The resulting speed of the drifter is thus a combination of the large-scale currents at 15 meters depth, plus the upper-ocean wind-driven flow, plus the slip.

Slip

Slip is the horizontal motion of a drifter that differs from the lateral motion of currents averaged over the drogue depth. Slip is caused by wind on the surface float, drag on the float and tether, and rectification of surface waves (Niiler et al., 1987; Geyer, 1989)

Other observations

Sea surface temperature (SST): All standard SVP drifters measure temperature 20-30 cm beneath the sea surface.

Barometric pressure: Many drifters, known as SVP-Bs, have been outfitted with a barometer to measure air pressure.

Wind: Some drifters include a hydrophone for noise level, which can be converted to wind speed and precipitation estimates, and a 25 cm by 20 cm wind vane mounted to the barometer port of the surface float (with accompanying two-axis tilt sensor in the float, and swivel connection for the tether) to measure wind direction.

Ocean color: Some drifters have included an upwelling radiance sensor mounted on the surface float just beneath the sea surface, along with a downwelling irradiance sensor. Their observations have been used to study chlorophyll variations in remote regions such as the Southern Ocean (Letelier et al., 1996).

Salinity: The first salinity-measuring drifters were developed at Scripps Institution of Oceanography (SIO) by attaching a SeaBird SeaCat (thermistor and conductivity) to the top of the drogue (11 m depth). In 1992-3, 72 of these drifters were deployed in the tropical Pacific and provided observations which compared favorably to the TAO mooring data (Kennan et al., 1998).

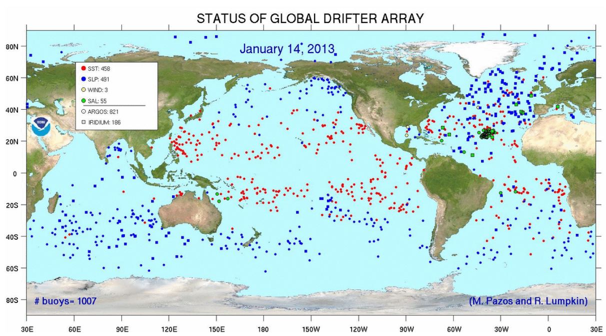
Subsurface temperature: Several drifter manufacturers are developing drifters with thermistor chains to measure temperature profiles of the ocean s upper O(100 m).

The future

The design of the SVP drifter has not stopped evolving - as demonstrated by the recent introduction of the mini drifter - while its qualitative characteristics and water-following properties have remained relatively steady since the earliest deployments. Incremental improvements in design and manufacturing will continue to increase drifter lifetime, and alternative methods for detecting drogue presence (such as tether strain) are being considered. New methodologies for drifter data analysis will continue to be developed, aided by increasing information from the ever-growing drifter array and from other sources of complimentary observations.

The quality of drifter data will also improve with updated interpolation schemes. As noted by Hansen and Poulain (1996), the kriging interpolation routines are optimized for tropical Pacific observations. Future interpolation schemes will be more global in scope, providing better error estimates of interpolated positions and velocity, and may improve estimates of the Lagrangian acceleration and diffusion.

In September 2005 the surface drifting buoy array of NOAA's Global Ocean Observing System and Global Climate Observing System consisted of 1250 SVP drifters at a nominal global resolution of 5 by 5 degrees. The major challenge facing AOML's Drifter Operations Center, which coordinates drifter deployments, is to arrange deployments in regions of surface water divergence and areas infrequently visited by research or voluntary observation vessels. This logistical challenge is being addressed by air deployments, increased international cooperation, and the development of tools to predict global drifter array coverage based on its present distribution and historical advection/dispersion. As the array grows, it provides invaluable observations of ocean dynamics, meteorological conditions and climate variations, and offers a platform to test experimental sensors measuring surface conductivity, rain rates, biochemical concentrations, and air-sea fluxes throughout the world's oceans.



Acknowledgements. The authors (R. Lumpkin and M. Pazos) would like to thank the worldwide group of Global Drifter Program operational partners, whose contributions have established a truly global array of surface drifters. We thank Craig Engler, Jessica Redman and Erik Valdes for their frequent assistance. Discussions with Jeff Wingenroth and Sergey Motyzhev were extremely valuable. We thank Peter Niiler for many enlightening conversations, and for his comments on this text which helped improve it tremendously. Additional comments by Claudia Schmid, Sang-Ki Lee and two anonymous reviewers were also valuable. NCEP Reanalysis 2 data are provided by the NOAA-CIRES Climate Diagnostics Center, Boulder, Colorado. This work was funded by NOAA's Office of Global Programs and the Atlantic Oceanographic and Meteorological Laboratory.