Observations for Climate: NOAA's Global Drifter Program

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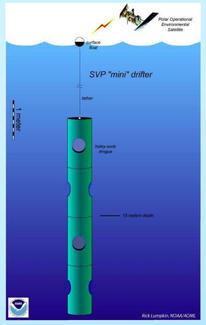


Introduction

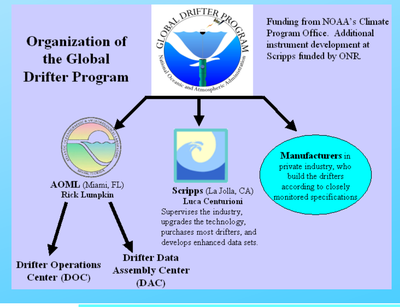
NOAA's Global Drifter Program (GDP) is the principal component of the *Global Surface Drifting Buoy Array*, a branch of NOAA's *Global Ocean Observing System* (GOOS) and *Global Climate Observing System* (GCOS) and a scientific project of the Data Buoy Cooperation Panel. Its objectives are to:

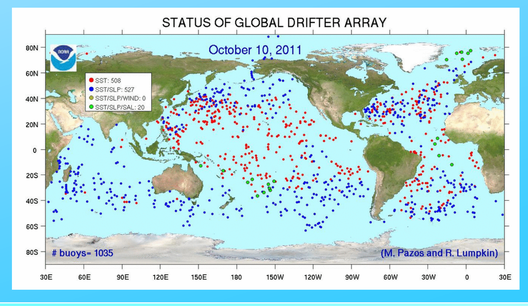
Maintain a global 5ºx5º array of ~1250 satellite-tracked Lagrangian surface drifting buoys to meet the need for an accurate and globally dense set of in-situ observations in real time for numerical weather forecasting efforts; and ***Provide*** a data processing system for the scientific use of these data.

These data support short-term (seasonal-to-interannual) climate predictions as well as climate research and monitoring.

In September 2005, the global drifter array reached the target size of 1250 drifters and became the first completed component of the GOOS. Since then, the array size has been maintained at an annual average of ~1250 drifters.

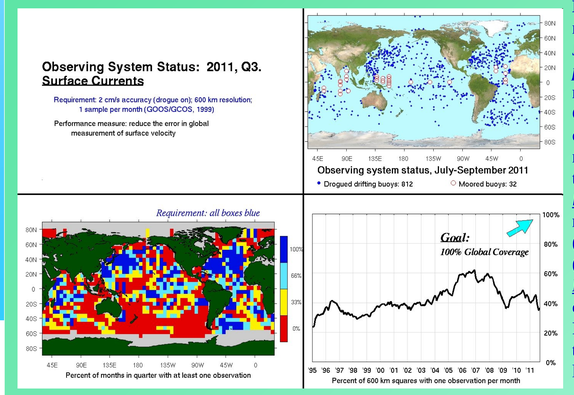
Left: organization of the GDP. **Right**: status of the global drifter array as of October 10, 2011.





Mixed layer velocity measurements

A surface drifter has a holey-sock drogue centered at a depth of 15m for measuring mixed layer currents with a downwind slip of less than 1 cm/s in 10 m/s wind. The global array has measured ocean currents and their variations since its inception in the tropical Pacific in 1979.

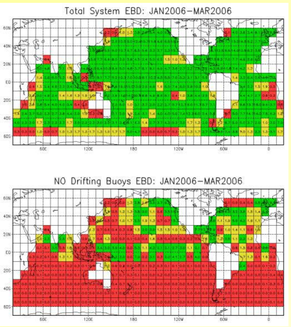


Left: Evaluation of surface current measurements by the GOOS for July—September 2011. *Top left panel*: the GOOS/GCOS requirements. *Top right* shows the GOOS in 2011 Q3 for surface currents. Undrogued drifters are not included as they do not meet the accuracy requirement. *Bottom left*: 5x5° bins that met the requirements for 0 (red), 1 (yellow), 2 (light blue) or all 3 (dark blue) months of the quarter. *Bottom right*: fraction of world covered by the GOOS. Reevaluation of drogue presence in the period 2005—2008 will likely lower the curve there in the future.

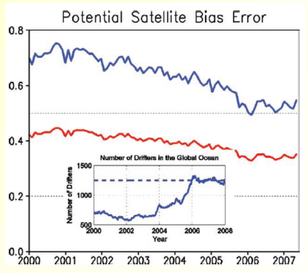
Sea surface temperature and upper ocean heat

Sea Surface Temperature: All drifters measure temperature ~20 cm beneath the sea surface at approximately hourly resolution, with an accuracy of 0.1°C. These data are disseminated on the Global Telecommunication System within two hours of reception for use in numerical weather forecasting and operational SST analysis. Drifters cover a larger fraction of the ocean's surface area than any other in-situ component of the Global Ocean Observing System. These data are used to assess and remove biases in satellite-based observation.

NOAA evaluates how well the GOOS is measuring SST using an "Equivalent Buoy Density" which weighs the relative value of the different in-situ measurements. In the absence of drifters, GOOS coverage is particularly poor in regions such as the Southern Ocean.

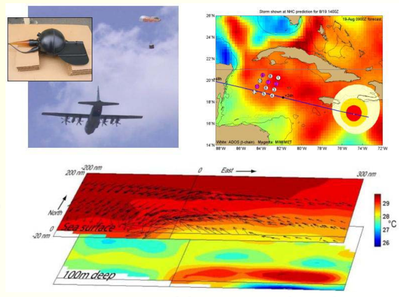


Left: Top: Equivalent buoy density (EBD) in January—March 2006, the first quarter after the drifter array reached its goal of 1250 drifters. Bottom: EBD in the absence of the drifter array. Figure courtesy H.-M. Zhang.



Right: evolution of the potential bias in global SST from satellites (red: normal; blue: worst-case scenario, such as during a volcanic eruption). The GOOS/GCOS goal is for the worst case to be <0.5°C. Figure from Zhang *et al*. (2009).

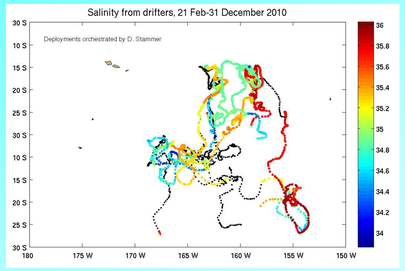
Tropical Cyclone intensity forecasting: Drifter observations can be used to constrain and improve models of tropical cyclone intensification. "Hurricane drifters" include surface barometric pressure, wind speed and direction, and subsurface temperatures every 10m to 150m depth, and are deployed from C-130 aircraft in the paths of the storms. These drifters resolve ocean and atmosphere changes during storm passage and the subsequent structure of the storm's oceanic wake.



Structure of the ocean's wake in the passage of hurricane Dean (2008).

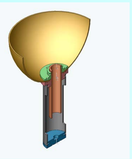
Sea surface salinity

Drifters can include a Seacat at ~30 cm beneath the sea surface to validate and calibrate surface salinity from the SMOS and Aquarius satellites. A number of these drifters are being deployed during 2012, including deployments in support of the Salinity Processes in the Upper ocean Regional Study (SPURS) campaign.



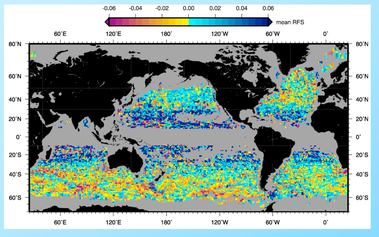
Left: trajectories of salinity drifters in the South Pacific during 2010, with colors indicating sea surface salinity measured by the drifters.

Right: Schematic showing Microcat mounting assembly at the base of the surface float of a salinity drifter.

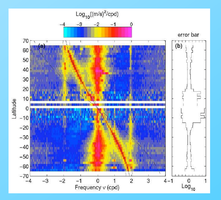


High-frequency observations

In January 2005, the tracking of GDP drifters switched from a service of two satellites to at least five satellites. As a consequence, the temporal resolution increased to approximately hourly, allowing global resolution of inertial and semidiurnal tidal oscillations.

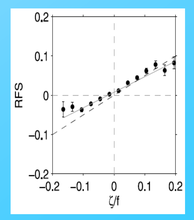


Right: spectral distribution of energy from high resolution drifter position data (Elipot and Lumpkin, 2008). The inertial and semidirunal peaks are clearly resolved. Geostrophic energy dominates at low frequencies.

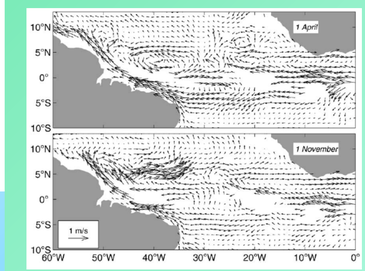


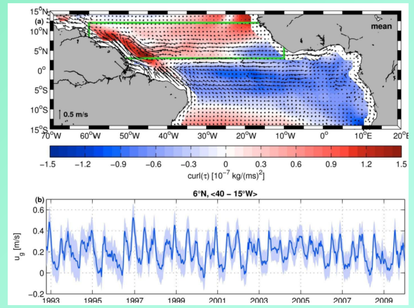
Above: relative frequency shift of near-inertial oscillations from the local inertial period (Elipot et al., 2010).

Right: relative frequency shift (vertical, from drifters) vs. background vorticity from altimetry (horizontal) (Elipot et al., 2010). The dashed line indicates the theoretical expectation (Kunze, 1985).



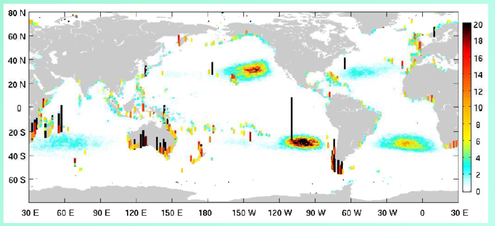
Drifter velocity measurements can be combined with satellite measurements of wind and surface topography to yield weekly maps of surface current variations at the resolution of satellite altimetry products. This approach has been applied to the Kuroshio Current system, the Brazil/Malvinas Confluence of the South Atlantic, and the North Equatorial Countercurrent in the tropical Atlantic.





Left: Seasonal variations of surface currents in the tropical Atlantic ocean, mapped from drifter observations (Lumpkin and Garzoli, 2005). **Right**: Interannual variations of the North Equatorial Countercurrent (in green box, superimposed on mean wind stress curl) from a synthesis of drifters, winds and altimetry (Hormann *et al*., submitted).

Drifter observations can also be used to estimate the downstream or upstream fate of passively advected particles like oil, plankton or marine floating debris. This can be done qualitatively by examining the trajectories of drifters, or quantitatively using various statistical or dynamical approaches which rely heavily on the behavior of the drifters.



Left: Distribution of the concentration of floating marine debris in arbitrary units, after 10 years of integration from an initially homogeneous distribution of concentration unity. Vertical bars indicate the concentration of material that has washed ashore, with color corresponding to 10X the value in the color bar. From Lumpkin *et al*. (submitted).