Global Drifter Program (GDP)

Drifting buoy measurements of Sea Surface Temperature, Mixed Layer Currents, Atmospheric Pressure and Winds
http://www.aoml.noaa.gov/phod/dac/gdp.html

23rd Data Buoy Cooperation Panel session
October 15-19, 2007
Jeju, Republic of Korea
GDP: 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 DBCP.

**Objectives:**

**Maintain** a global 5ºx5º array of 1250 ARGOS-tracked Lagrangian surface drifting buoys to meet the need for an accurate and globally dense set of in-situ observations: mixed layer currents, SST, atmospheric pressure, winds, and salinity.  
**Provide** data processing system for scientific use of these data.

These data support short-term (seasonal-to-interannual) climate predictions as well as climate research and monitoring.
The GDP is managed with close cooperation between:

- **Manufacturers** in private industry: build the drifters according to closely monitored specifications.

- NOAA’s Atlantic Oceanographic and Meteorological Laboratory (*AOML*): coordinates deployments, processes the data, archives data at AOML and at MEDS (Canada), maintains META files describing each drifter deployed, develops and distributes data-based products, updates the GDP website.

- NOAA’s Joint Institute of Marine Observations (*JIMO*): supervises the industry, upgrades the technology, develops enhanced data sets.

Drifter purchases and liaisons with individual researchers: both JIMO and AOML.
IOOS milestones
(from OceanOps2004, M.Johnson and E. Harrison)

### Multi-year Phased Implementation Plan

<table>
<thead>
<tr>
<th>Year</th>
<th>Tide Gauges</th>
<th>Surface Drifting Buoys</th>
<th>Tropical Moored Buoys</th>
<th>Ships of Opportunity</th>
<th>Argo Floats</th>
<th>Reference Stations</th>
<th>Coastal Moorings</th>
<th>Ocean Carbon Network</th>
<th>Dedicated Ship Time</th>
<th>System Evaluation</th>
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- **GPS/DORIS Stations**: Initial GCOS Subset
- **Number of buoys**
- **Number of moorings**
- **Number of floats**
- **Number of flux moorings**
- **Moorings with climate sensors**
- **Repeat Sections Committed, One inventory per 10 years**
- **Days at sea (NOAA contribution)**
- **Product evaluation and feedback loops implemented (NOAA contribution)**
2007 deployments

North Atlantic: 219
Tropical Atlantic: 169
South Atlantic: 152
North Pacific: 63
Equatorial Pacific: 206
South Pacific: 41
Indian Ocean: 147
Mediterranean Sea: 6
TOTAL 1003

Drifter Operations Center:
Shaun Dolk (Miami, FL USA)
Shaun.Dolk@noaa.gov
Deployment highlight:
work with Korean colleagues

15 deployments so far, expecting 35-40 more within the next 12 months
Deployment highlight:
high latitude deployments (IPY)

45 deployments planned for the Drake Passage, January—March 2008, in collaboration with NOAA/NMFS.
Deployment highlight: high latitude deployments (IPY)

150 deployments planned in 2008—2009 in the Nordic Seas (PI: Kjell Orvik, Bergen, Norway).
Deployment highlights:
Gulf of Guinea


Deployments in a historically poorly sampled region.

72 total drifter deployments (+10 Argo floats).


Plans to continue (if a success)
SST measurements quantified by “Equivalent Buoy Density”. 

Top: EBD from ships, moored buoys and drifters. 
**Green**: square well sampled for SST. 
**Yellow**: marginal. 
**Red**: poorly sampled.

Bottom: no drifters (ships and moorings only). 

Figure courtesy Huai-min Zhang, NOAA/NCDC
drifter measurements:
Mixed layer currents

**Black Bullets**: location of all (984) drogued drifters.

**Open pink**: drifters without drogues, still measuring SST.
August 2007: 298 drifters in Tropical Pacific, 84% with drogues attached.

Shading: AVISO gridded sea level anomaly (-30 to 30 cm).

Drogued drifter velocities during August 2007 (black) and for climatological August (grey).

Velocity anomalies (August 2007 minus climatological August).
Observing System Status: 2007, Q2. **Surface Currents** (experimental)

- Requirement: 2 cm/s accuracy (drogue on); 500 km resolution; 1 sample per month (GOOS/GCOS, 1999)
- Performance measure: reduce the error in global measurement of surface velocity

**Goal:**
100% Global Coverage

**Observing system status, April–June 2007**

- Drogued drifting buoys: 1183
- Moored buoys: 27
2007 Hurricane array drifter deployments

Array of 12 Minimet and ADOS (thermistor chain) drifters deployed in front of major hurricane “Dean”, August 2007.

Upper Ocean Heat Content

Top: Sea surface temperature (shading, °C) and winds (arrows) measured by the hurricane drifter array at top. Bottom: subsurface temperatures at a depth of 100m.
sea surface salinity

2005 COSMOS deployments:
17 drifters in Bay of Biscay

Figure 1: photograph of METEOcean drifter 52197 in December 2005, roughly one week after its recovery during the CONGAS2 cruise. The subsurface sensor area is shown with noticeable algal fouling near the sensors.

Figure 2: Two daily cycles (June 1 and June 2 2005) during a period of weak wind and low cloudiness for three close-by drifters (SIO drifters: 56364, 56368; Meteocean drifter: 42656).
Technological development, Research, etc.
Spooled thermistor chain drifters  
(work with G. Williams)

P-3 deployable
150m long thermistor-chain
Built for P. Niiler by Clearwater Instruments, Inc. with NOAA support. The subsurface temperature data is sent up via digital induction through a 1/8” dia cable that is presently used to attach all drogues to the 1000 SVP drifters built each year for the “Global Drifter Program”.
Drogue detection

NOAA/AOML’s drifter Data Assembly Center (DAC) completed a drogue status reevaluation on 1 May. Many changes in time of “drogue off”: some earlier, a few later.

Ongoing interpretation of drogue status is now based on what the DAC has learned during this process.

Differences in how submergence is counted, differences in sensitivity, and other factors all require manufacturer-dependent interpretation. This has prevented the DAC from implementing automatic drogue detection for the 1250-buoy array. Very sensitive submergence sensors appear to produce short-term spurious high or low values, preventing accurate real-time assessment (need to examine the long-term behavior).

Based on the DAC’s experience, tether strain is the easiest record with which drogue presence can be determined. Automatic detection seems straightforward to implement here, based on a standard deviation criterion accompanied by a drop in strain.
March 2006 DBCP Data Users and Technology workshop recommendation: SST measured “on the hour, every hour.”

Motivation: calibration and validation of satellite observations.

Update from manufacturers:

Drifters currently measure SST every 60-90 seconds, and report average over 15-30 minutes.
Clock starts upon drifter activation.
Extremely accurate time tag comes with Argos message.
Clock stability: current technology keeps time to 10 ppm, ~5 min in a year.

**Issues:**
- Implementing a more stable clock adds to drifter cost – e.g., controller with Temperature Compensated Crystal Oscillator, ±1 min/yr at 0—40ºC.
- Alternative strategy: use GPS time and location – added cost, but also added location accuracy and frequency.
- Regardless of approach, these hourly reports will not be in real time with the current Argos satellite system.
- What is an “hourly” SST value? Instantaneous value at top of hour, average over surrounding 15 minutes, or 60 minutes?
March 2006 DBCP “Data Users and Technology” workshop recommendation: SST measured “on the hour, every hour.”
Oceanographic and climate research

Distribution of size (left) and strength (right) of anticyclonic (red) and cyclonic (blue) eddies in the Aegean Sea, derived from drifter observations (Olson et al, 2007).

Relative dispersion of 60 drifter pairs in the Gulf Stream region, deployed in February–March 2007 as part of the CLIVAR Mode Water Dynamics Experiment (R. Lumpkin).
Climate Model Testing: Calibration and Validation

The drifter mean geostrophic velocity of the California Current (left panel) and mean sea level from ROMS model (right panel, courtesy of J. C. McWilliams). In both drifter and model data appear four heretofore-unknown, semi-permanent meanders.
2008: Goals and plans

*Deploy 1000 Drifters in the period between October 2007 and September 2008.*

*International Polar Year: focus on high latitudes.*

*MAINTAIN 1250 drifters, continue to improve resolution (5° x 5° resolution).*
In 2007, international partners maintained about 10% or 120, “others” were 50 in 2006 and 5 in 2007. NOAA has maintained about 1150 since Sept 2005. Increased commitment is sought from international partners.
Our appreciation to the following Operational Partners for their contributions to GDP activities

Voluntary Observation Ships (VOS) program
International Ice Patrol
Institut de Recherche pour le Développement; Météo-France (France)
Leibniz-Institut für Meereswissenschaften an der Universität Kiel (Germany)
New Zealand Met. Service
Australian Bureau of Meteorology
Fundação Universidade Federal do Rio Grande; Instituto Nacional de Metereologia; Centro de Hydrografia de Marinha; INPE (Nacional Space Institute); Brazilian Navy (Brazil)
Fisheries Research Institute; Servicio de Hidrografía Naval (Argentina)
Instituto Canario de Ciencias Marinas; Universidad de Las Palmas de Gran Canaria (Spain)
Instituto Nazionale di Oceanografia e di Geofisica Sperimentale (Italy)
National Institute of Oceanography; National Institute of Ocean Technology (India)

Centro de Investigacion Cientifica y de Educacion Superior de Ensenada (Mexico)
National Oceanographic Research Institute; Ministry of Maritime Affairs and Fisheries (Korea)
Tristan da Cunha Administration, Tristan Island
United Kingdom Met Office
Environment Canada
University of Cape Town; South African Weather Service (South Africa)
Scripps Institution of Oceanography, Woods HoleOceanographic Institution, Oregon State University, NOAA/Pacific Marine Environmental Laboratory
United States Air Force
Marine Resources Research Institute
US Naval Oceanographic Office
United States Coast Guard
Raytheon Polar Services