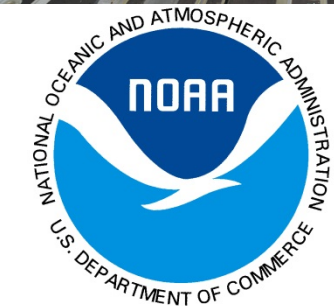


Surface Current Observations with Satellite-Tracked Drifting Buoys



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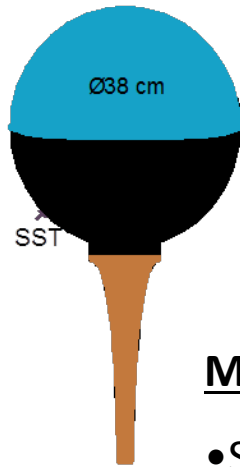
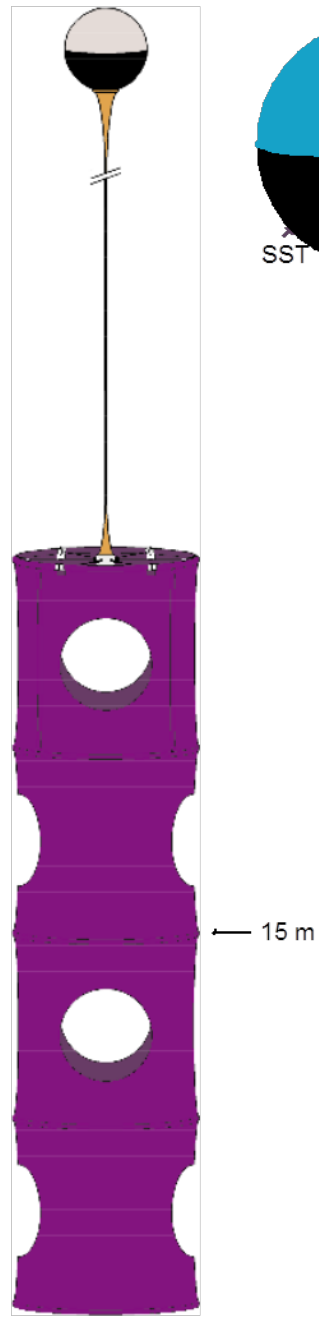


Outline

- The Global Drifter Program, Motivations, Goals and Status
- The Motion of Marine Debris vs Drifters
- Technical Developments Important for Tracking and Modeling the Dispersion of Marine Debris

The Basics: What is a Drifter?

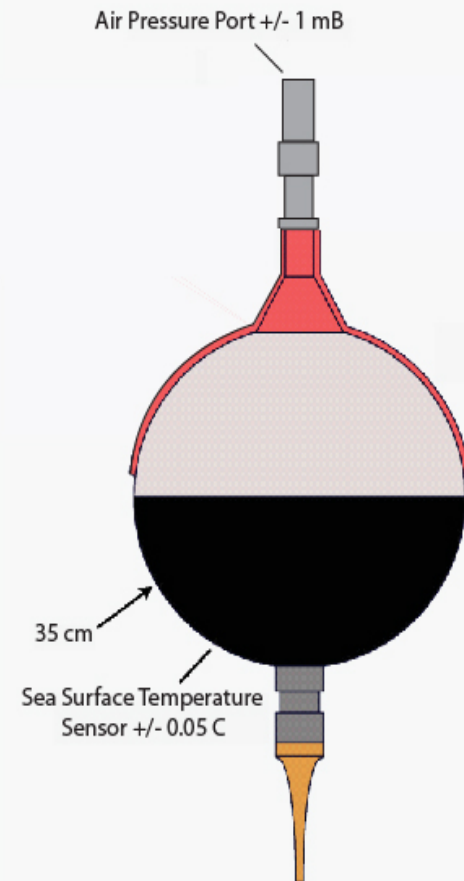
SVPB



THE WORKHORSE: THE MINI SVP(B). VELOCITY SST and SLP.

Mini SVP/SVPB technical specs:

- Spherical ABS float, 38 cm diameter, or large;
- Tether made of polyurethane impregnated wire;
- Holey sock drogue (length ~ 5m);
- Strain relief (carrots of urethane);
- SST (thermistor +/- 0.1-0.05° C);
- Drogue on/off sensor (strain gauge,)
- ARGOS telemetry and localization (accuracy: 150 – 1000 m)
- Iridium telemetry with GPS localization (accuracy: 50 m rms)
- Drag area ratio $(=C_{Ddr} d_{dr} h_{dr}/C_{Doth} A_{oth}) \sim 40$;

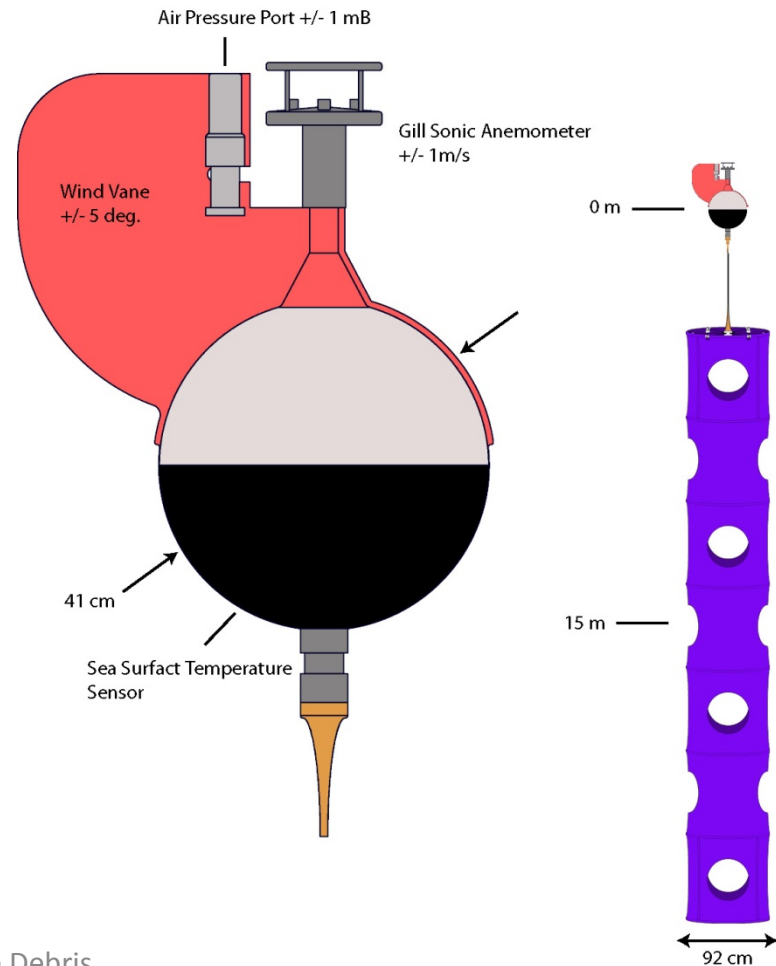


SVP Sonic Minimet Drifter

Drifters are designed to

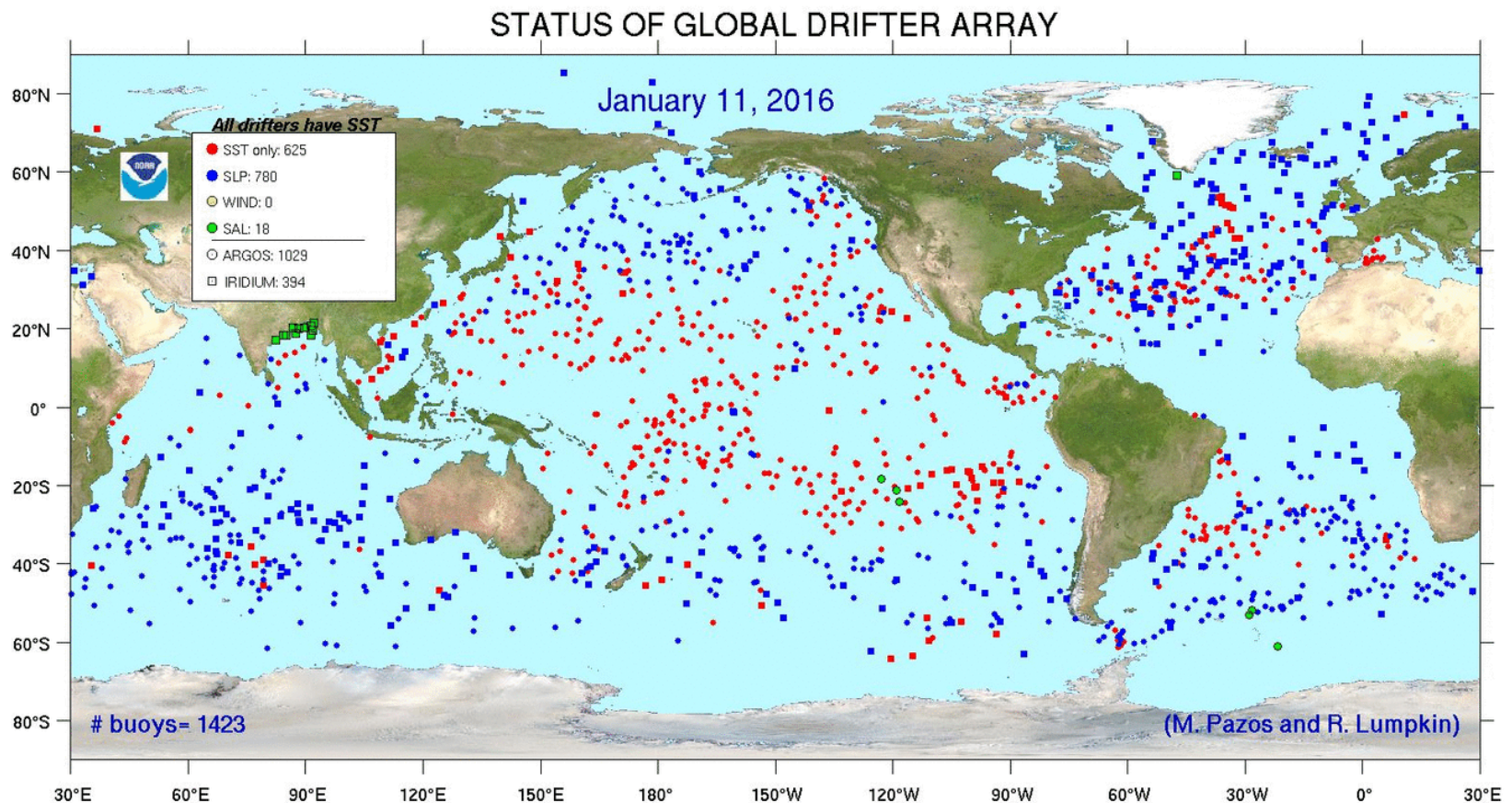
- measure ocean currents at a depth of 15 m;
- Minimize the action of surface waves on the surface buoy (i.e. the drifters are primarily driven by the action of the currents on the drogue located at a depth of 15 m)
- Minimize the action of the wind on the surface buoy. The wind (and probably wind waves) account for a $\sim 1\text{cm/s}$ downwind bias of the measured ocean currents in a 10 m/s wind

SVP drifter data are sub-optimal for studying the dispersion of floating debris but are very good for studying the fate of nearly neutrally buoyant debris that populate the upper ocean mixed layer. However, when drifters often lose the drogue, they essentially behave like marine debris floating at the surface of the ocean and their track is affected by ocean waves and wind as well.



What is the GDP?

The GDP is a global array of Lagrangian drifters that measure ocean currents at 15 m depth, Sea Surface Temperature and Sea-Level air Pressure, which are both Essential Climate Variables (ECV). The GDP was the first completed component (in 2005) of the Global Ocean Observing System. Over 20,000 drifters of various types have been deployed to date



Organization of the Global Drifter Program



FUNDING: NOAA's Climate Program Office



AOML (Miami, FL)
Rick Lumpkin

"SURFACE DRIFTER PROGRAM"

Drifter Purchase, Drifter Deployments, DAC and datasets

International Cooperation, Outreach

Manufacturers in private industry, who build the drifters according to closely monitored specifications



Scripps/CIMEC (La Jolla, CA)

Luca Centurioni

"GLOBAL DRIFTER PROGRAM"

Supervise the Industry, Fabricate/Design & Purchase, Deployments, RT Data Servers Enhanced Data Sets, International Cooperation, Education and Outreach

Drifter Observations and Marine Debris,
Honolulu, 1/20/2016

Using the Drifter Data to Infer the Motion of Marine Debris

- By and large, the huge, ever-growing, historical dataset of drifter derived ocean currents provides a first-order answer to the problem of reconstructing the fate of marine debris, whether they are floating at the surface or submerged and populating the upper ocean mixed layer.
- For example, the drifter data provided a correct timescale of ~ 2 years for the debris of the Sendai Tsunami to start washing-up in the US west coast (mainly Oregon and Washington, since off California the coastal flow is diverging)

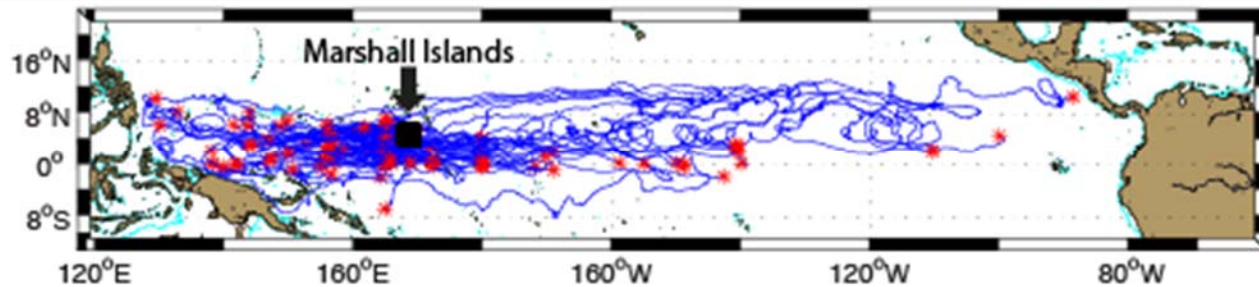
Another example: validation of the journey of Mr. Salvador “Chancha” Alvarenga

- Mr. Alvarenga, fisherman, was lost at sea after a storm crippled his boat and drifted on from the Gulf of Tehuantepec to the Marshall Islands. The journey took 438 days.
- His account of the adventure was met with skepticism. The recently published book “438 Days” by Mr. Jonathan Franklin, a journalist from the Guardian, gives an account of this incredible story
- Historical drifter data were used to show that indeed it is possible for an object drifting at the surface of the ocean to move from the coast of Mexico to the Marshall Islands under the action of ocean currents, surface waves and wind alone

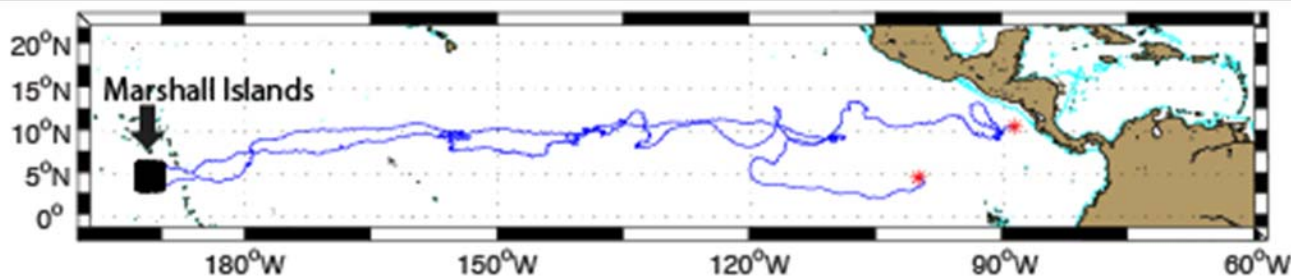
Validation of Mr. Alvarenga's Journey

Shown here are the tracks of drogued and undrogued drifters that were at some point along their track within 100 km from the Marshall Islands. Red asterisks denote the beginning of the track (i.e. where the drifters came from). Note the wide range of points of origin, showing large variability due to environmental factors and presence/lack of drogue

DROGUED AND UNDROGUED DRIFTER



UNDROGUED DRIFTERS ONLY



Two undrogued drifters (lower panel) followed a path consistent with Mr. Alvarenga journey. It took the drifters ~20 months to cover a distance similar to the one Alvarenga's boat covered in 438 days. Although this does not constitute a compelling proof of Mr. Alvarenga description of the events, it shows that it is possible for a flotsam to drift from off-shore Chiapas to the Marshall Islands

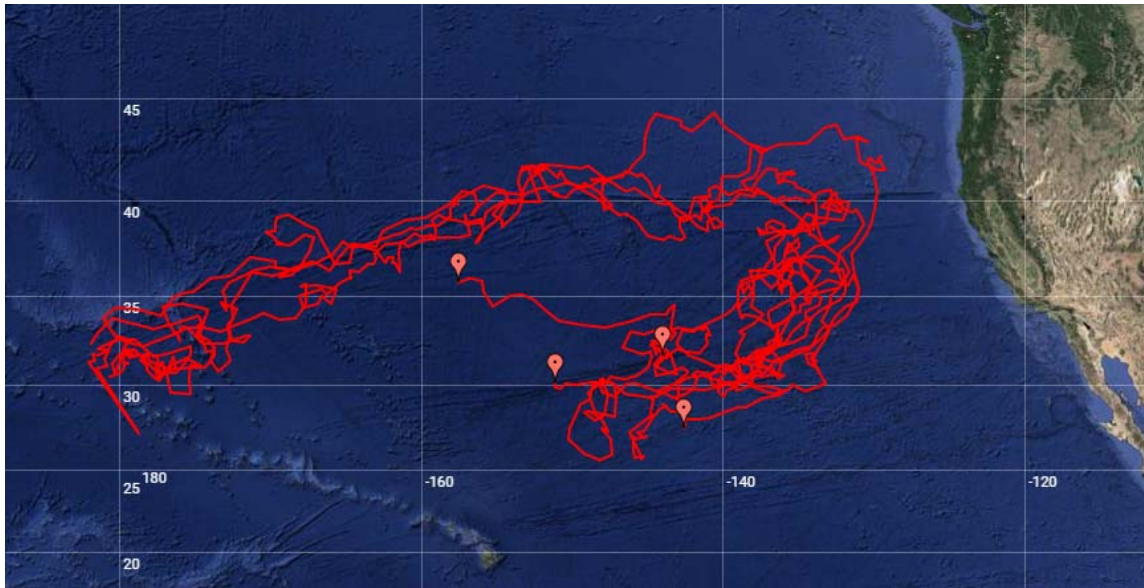
How Can the Drifter Data Contribute to this Problem

- An important step in managing the pollution of the ocean, requires validating models of the fate of debris once they are dumped in the ocean
- Models of debris are either based on real observations (primarily from drifters) or need to be constrained by data (Examples dynamical and statistical models). Validating such models, however, requires an independent dataset that has not been used, for example, for data assimilation or for providing the statistical basis of the model
- The Lagrangian information of the undrogued drifter data could be exploited to validate marine debris tracking models

Studying the motion of floating debris: observation based approach

- Both Argos and Iridium satellite technology make tracking actual debris or deploying objects (e.g. boxes, spheres) that are a good proxy for flotsam a very easy task.
- Experiments should be designed in which SVP drifters and actual debris should be deployed in a dense array and the dispersion of debris of different form factor and of drifters can be compared

Example: synthetic tsunami debris



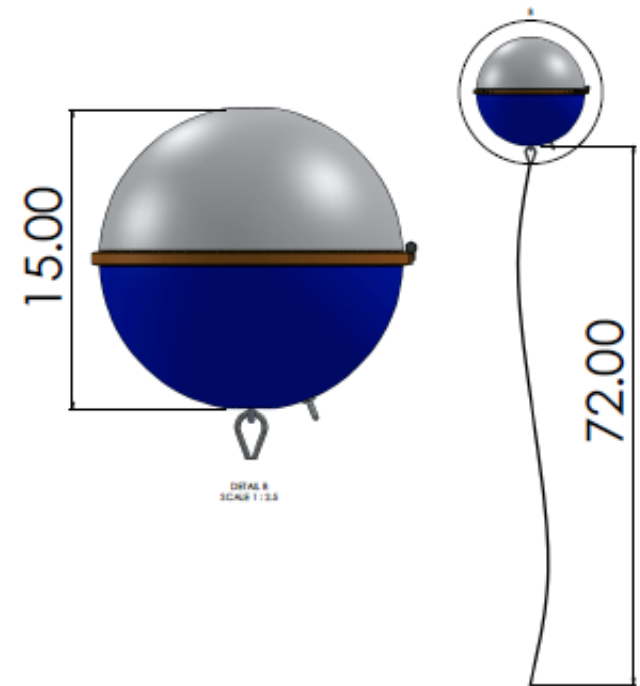
- Deployed at the end of October 2011 north of Midway
- Collaboration with N. Maximenko and Doug Woodring (ORA)
- 4 out of 6 trackers still working
- None run aground on the US west coast

- SIO/LDL designed tsunami debris trackers of very simple construction (Pelican case+ GPS/Iridium receiver/transmitter+batteries)
- Extremely ruggedized
- Power efficient (4+ years of operations)
- Very small windage
- No antifouling

Studying the motion of floating debris: observation based approach with enhanced drifters/debris trackers

- Since ocean currents are only a part of the problem in correctly predicting the fate of floating marine debris, using just drifter data is a limiting factor. Observations of in-situ wind and waves are also important
- In-situ wind observations are routinely obtained from drifters. These, together with surface wave observations can be can be obtained **concurrently** from low cost on devices designed for tracking debris. The response of different form factors to the physical forcing could be parameterized.

In situ directional wave spectra observations. The low-cost wave buoy.



The Technology: Sampling, Duty Cycle and On-Board Processing

~17 min long sampling of u , v , and w divided in ~4 min segments. 2 Hz sampling.

High pass filter, cutoff at 0.035 Hz, but can be pushed lower, probably to 0.01 Hz.

Optional: de-mean and/or de-trend (effectiveness tbd).

Power Spectral Density and Co-Spectra are Computed with FFT - Hamming window (tapered), give $a(f)$ and $b(f)$ coefficients

Shallow water correction (linear dispersion relation) for u and v .

Both u, v and w are used to compute the first 5 directional spectrum parameters;

The four computations of the five parameters are averaged and transmitted: these are a_0 , a_1, b_1, a_2 and b_2 (note: a_2 and b_2 are independent of w)

Wave parameters

Zero Moment: $m_0 = \pi \Delta f \sum_{i=1}^n a_{0,i}$

First Moment: $m_1 = \pi \Delta f \sum_{i=1}^n f_i \cdot a_{0,i}$

Second Moment: $m_2 = \pi \Delta f \sum_{i=1}^n f_i^2 \cdot a_{0,i}$

+ Significant Wave Height

$$H_{mo} = 4 \sqrt{m_0}$$

+ Average Period

$$T_{av} = \frac{m_0}{m_1}$$

+ Peak Period (estimated at max a_0)

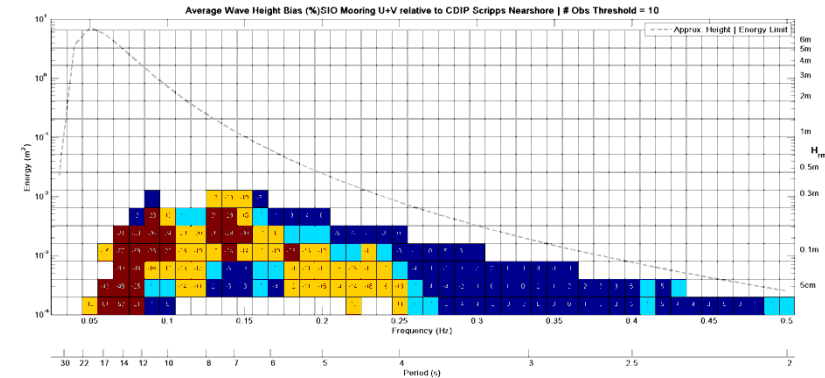
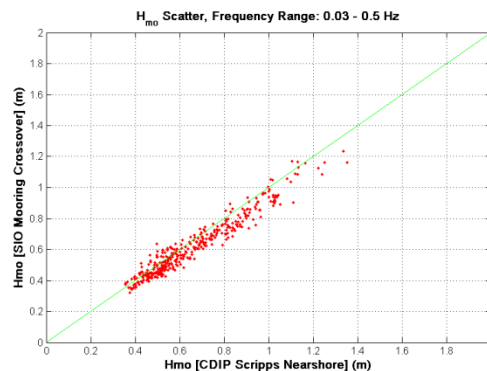
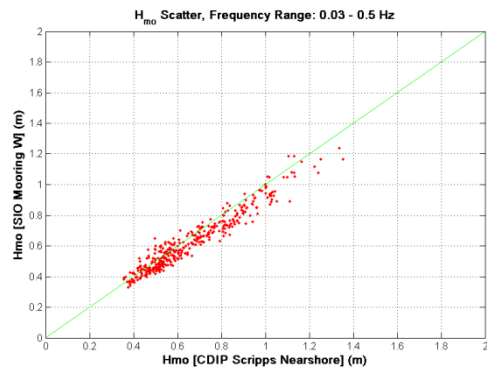
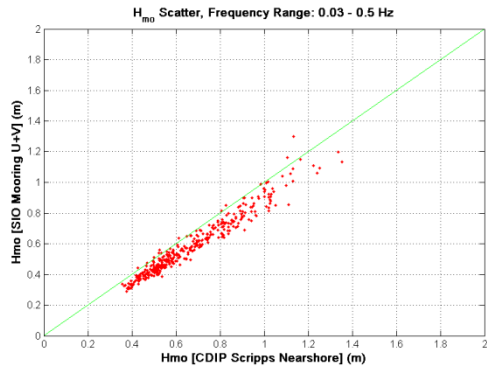
$$T_p = \frac{1}{f_{peak}}$$

Directional Spreads

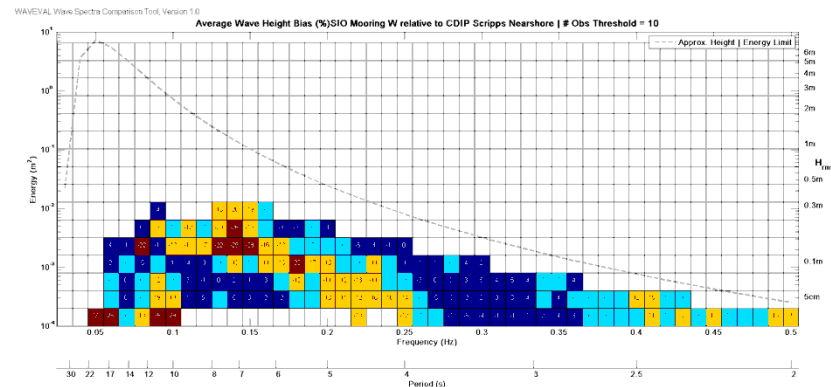
$$\theta_1 = \arctan \left(\frac{b_1}{a_1} \right)$$

$$\theta_2 = \frac{1}{2} \arctan \left(\frac{b_2}{a_2} \right)$$

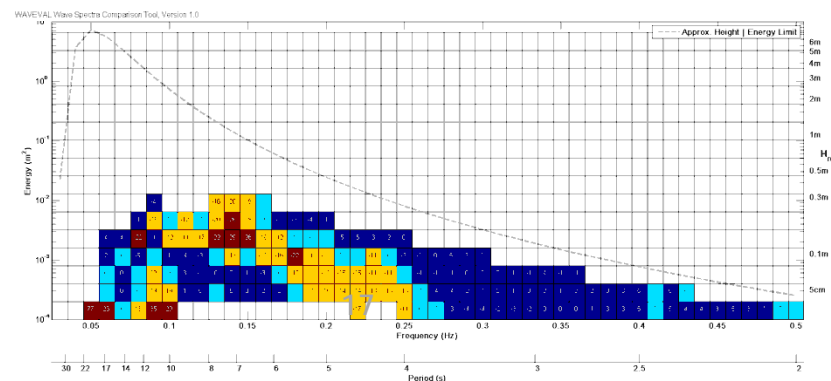
Validation: SIO drifter vs CDIP Datawell (gimbal version) with Waveval Tools. ~1month long



u, v, 2s-30s



w, 2s-30s



u, v, 2s-6s
w, 6s-30s

SUMMARY

- The existing dataset of ocean currents from Lagrangian drifters drogued at 15 m depth in the upper ocean provides a benchmark and the basis for modeling the dispersion of marine debris
- Such data are not an optimal proxy for flotsam, but drifters that have lost the drogue are
- Satellite tracking technology is becoming increasingly easy to implement either on objects that mimic the behavior of flotsam or on actual debris floating at the surface of the ocean
- Concurrent observations of debris displacements, in-situ wind and directional properties of surface gravity waves are possible, low-cost, and should be considered for planning a marine debris tracking experiment

QUESTIONS?

Please email them to
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