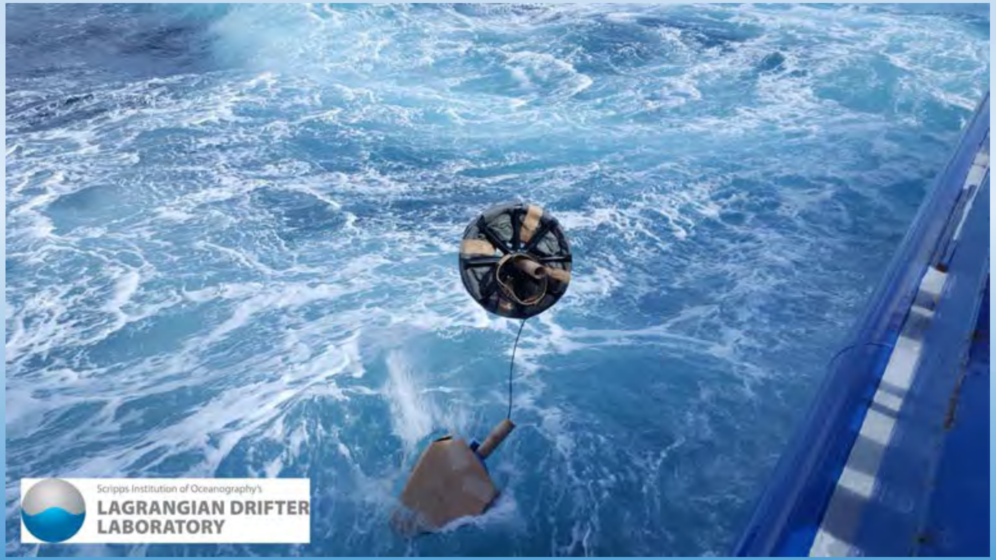
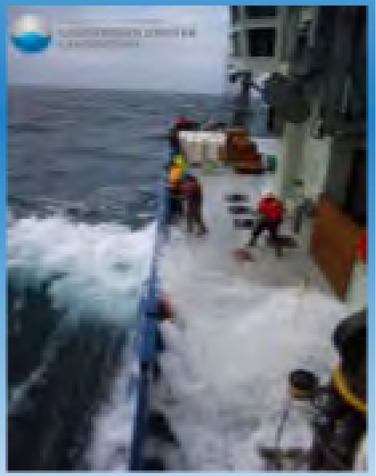
Accurate Surface Wind Observations from SVPW^{TM} (Minimet^{TM}) Drifters

Scripps Institution of Oceanography's
LAGRANGIAN DRIFTER LABORATORY

Credit: USAF 53rd WRS




Credit: USAF 53rd WRS



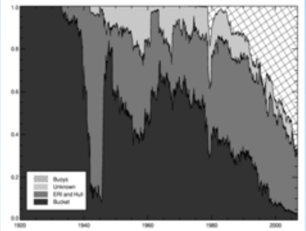
Luca Centurioni
Director, Lagrangian Drifter Laboratory
Principal Investigator, Global Drifter Program
Scripps Institution of Oceanography
La Jolla, California, USA
http://gdp.ucsd.edu/

**DBCP 38 S&T Workshop,
Geneva, November 1, 2022**

The Global Drifter Program in a Nutshell

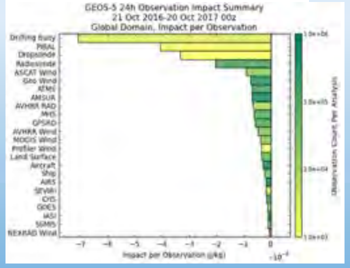
The Only Global Scientific Project for In-Situ Ocean Observing at the Air-Sea Interface

Main Critical Impact Areas



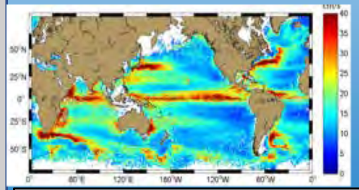
SST From Space Cal/Val

Left: Fractional contribution of SST data by platforms (buoys refers primarily to drifters, that provide more SST data than all the other sources combined). From Kennedy et al, 2011, JGR. Drifters provide X100 daily SST obs than Argo.



SLP for NWP and Climate Indices

Left: Drifters SLP data have the largest positive impact per observations (Centurioni et al. 2016, BAMS). Both forecasting and climate studies benefit from drifter data, especially in the southern ocean where the drifters are essentially the only source of in-situ SLP data.



Science

Over 1,100 paper published to date use drifter data directly

***Overarching Goals*:**

-Further our scientific understanding of the ocean, atmosphere and climate by observing surface physical processes in the global ocean.

-Maintain a global 5ºx5º array of surface drifting buoys to meet the needs for an accurate and globally dense set of in-situ observations: **mixed layer currents, SST**, **atmospheric pressure**, winds, and salinity.

-Build a *collaboration* with the international community to maintain the drifter array.

Metrics:

- Full 5 X 5 array
- Real time data distribution on ERDDAP and GTS
- Global data accessibility
- Verified Lagrangian characteristics
- Quality-controlled data, archived

The GDP provides publicly available (FAIR-O) observational baselines in the upper-ocean mixed-layer and fills a unique role in the Global Ocean and Climate Observing System. **The positive impacts of the GDP data fore research and operations are large and well documented**

See https://gdp.ucsd.edu/ldl/global-drifter-program/ for a complete description of the GDP

The GDP Expansion Is Supported by Engineering Developments

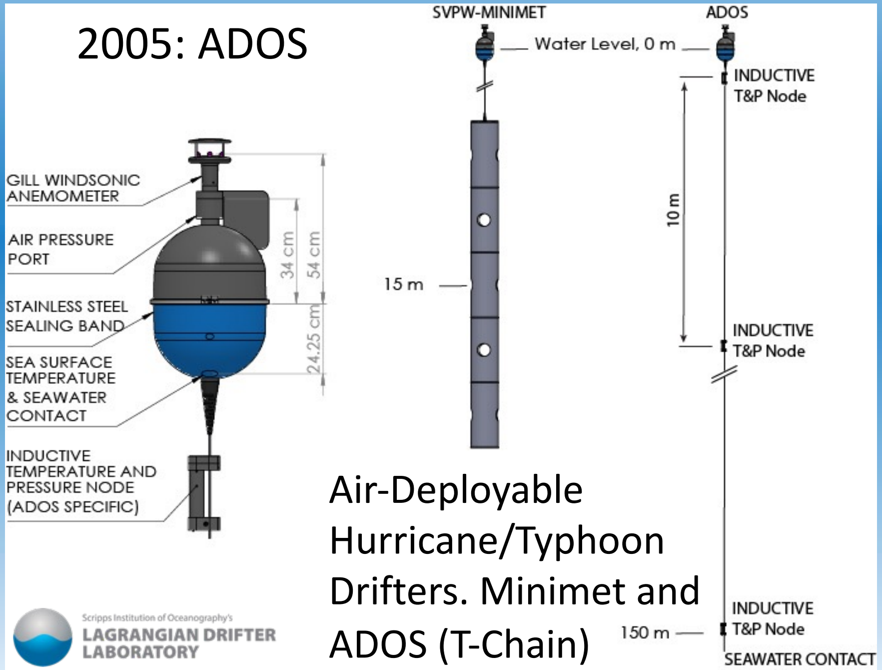
1980, SIO: TriStar Drifter

2021, SIO: Air deployable Wave Drifter

Maintaining a program for over 40 years requires the modernization of the observing technology and the continuous development of new instruments to address the evolving scientific needs

2007: Salinity Drifter (SVPS)

2005: ADOS



Air-Deployable Hurricane/Typhoon Drifters. Minimet and ADOS (T-Chain)

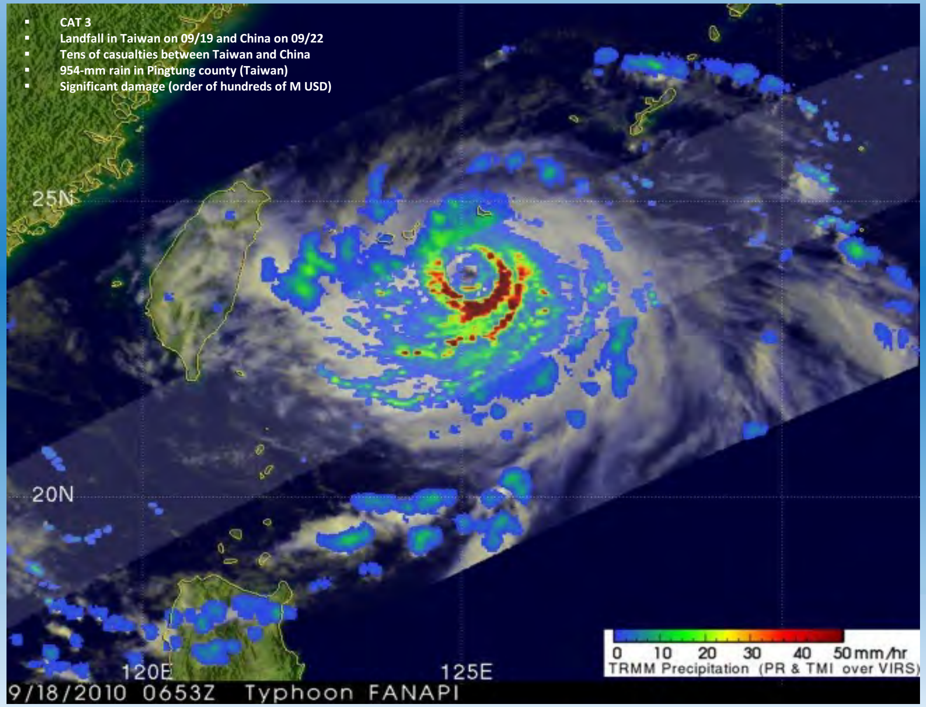
The GDP, based at Scripps, includes an engineering and technical team to address its evolving observing needs

Why Measuring In-Situ Wind Is Important

At a fundamental level, the winds sets the three-dimensional ageostrophic ocean circulation that is directly observed or inferred by the GDP drifters. This departure from the geostrophic balance includes the vertical circulation that, for example, supports exchanges of gases, nutrients and pollutants between the surface and the deeper “layers”

In-situ wind observations are needed for:

- Basic science
- Tropical cyclones monitoring and research
- Calibration/Validation of Satellite Products
- Validation of Reanalysis Products



Ageostrophic Jets in the California Current System Meanders

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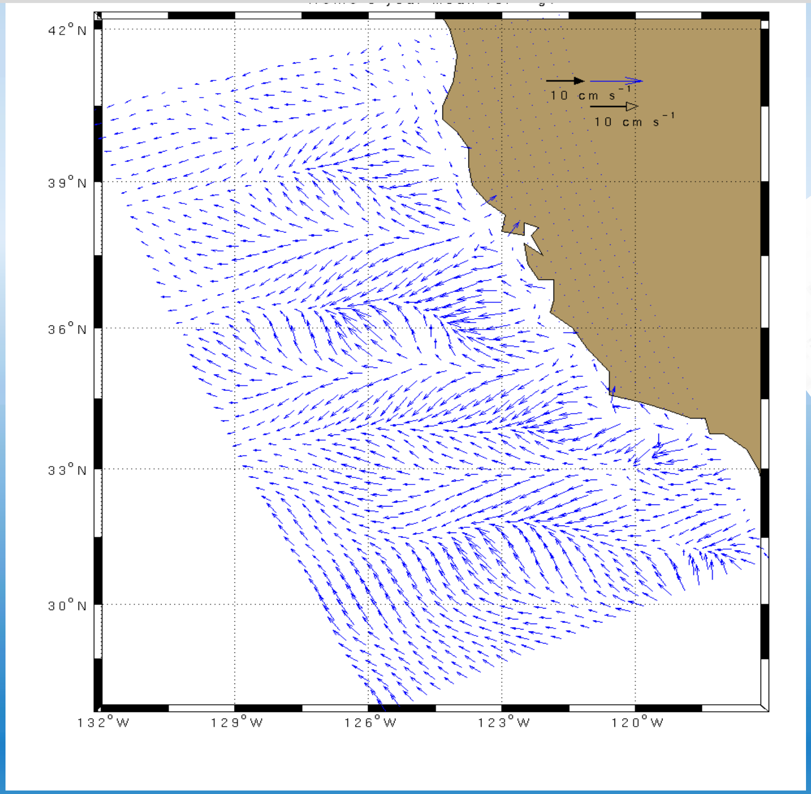
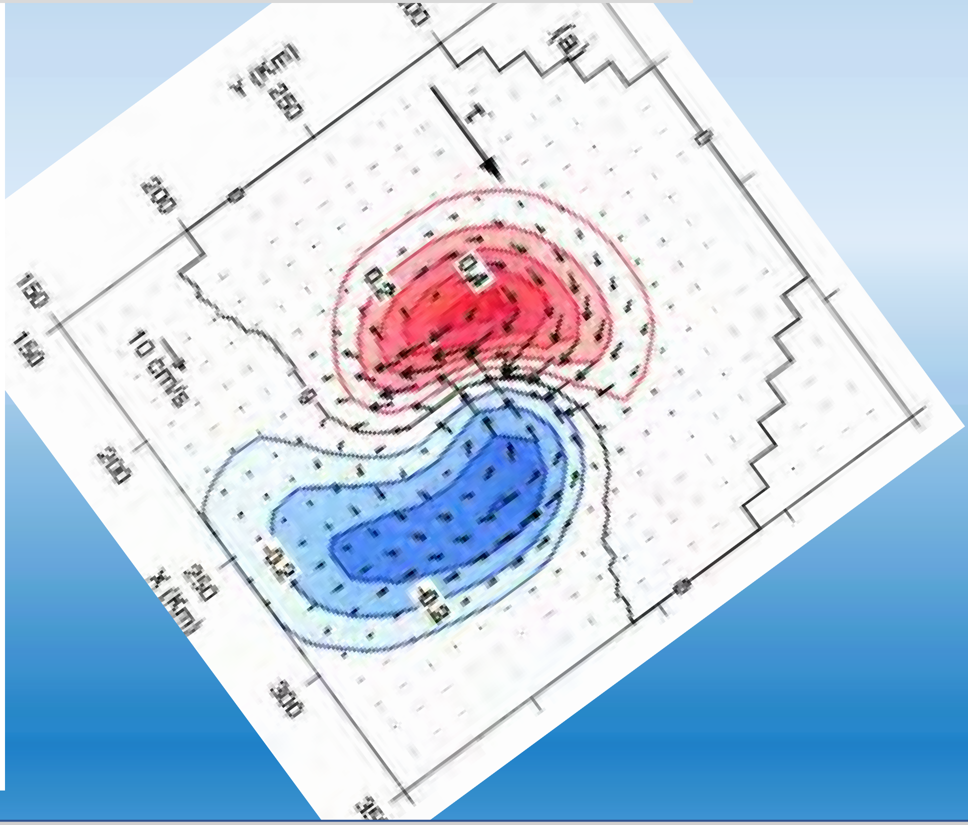


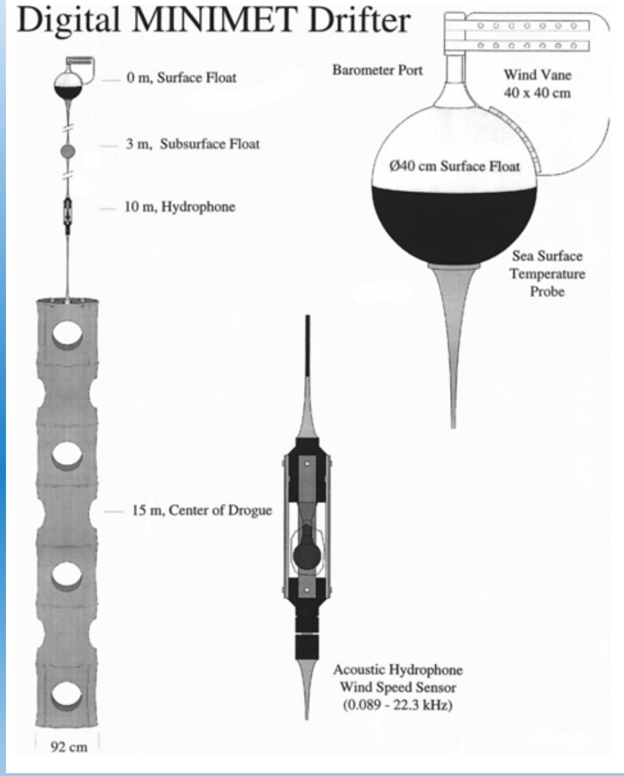


A more "subtle" reason to measure both the circulation and the wind correctly: southward alongshore wind blowing over the eddying CCS can cause secondary upwelling and downwelling and a-geostrophic offshore transport. This mechanism is important for replenishing the euphotic zone with nutrients and for offshore transport:

Left: a-geostrophic velocity in ROMS model are co-located with the observed meanders. Right: and a simple model of a cold/cyclonic eddy interacting with wind shows the underlying physics (Lee and Niiler 1998). Contours are temperature anomalies. From: Centurioni, L. R., J. C. Ohlmann and P. P. Niiler (2008). "Permanent Meanders in the California Current System." Journal of Physical Oceanography **38**(8): 1690–1710.

The SVPW^{TM} (Minimet^{TM}) Technology

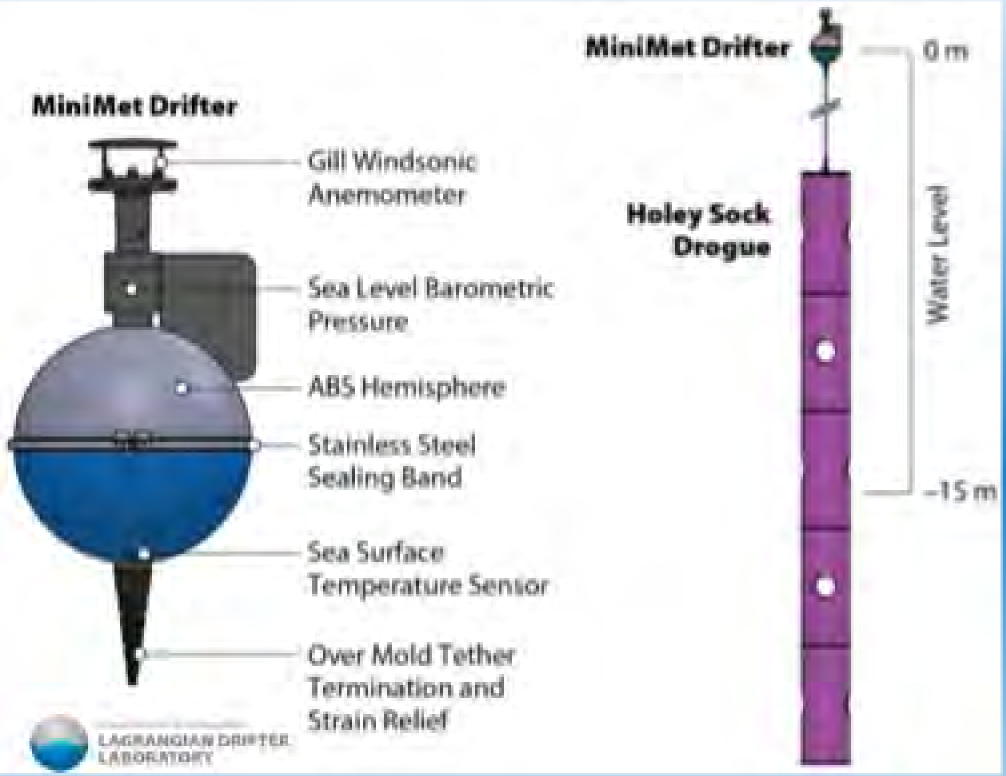
2000 Version



- Ambient sound wind speed detection
- Argos telemetry
- In-house developed algorithm
- Full-size SVP layout
- Rated for hurricane conditions
- ABS plastic

Milliff et al, 2003.

2015 Version



- Acoustic anemometer
- Iridium telemetry two-way comms
- In-house developed algorithm
- Mini-SVP layout
- Rated for hurricane conditions
- Air-deployable
- Available in bio-plastic

Centurioni, 2018

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Quality of SVPW™ (Minimet™) Data

2000 Version

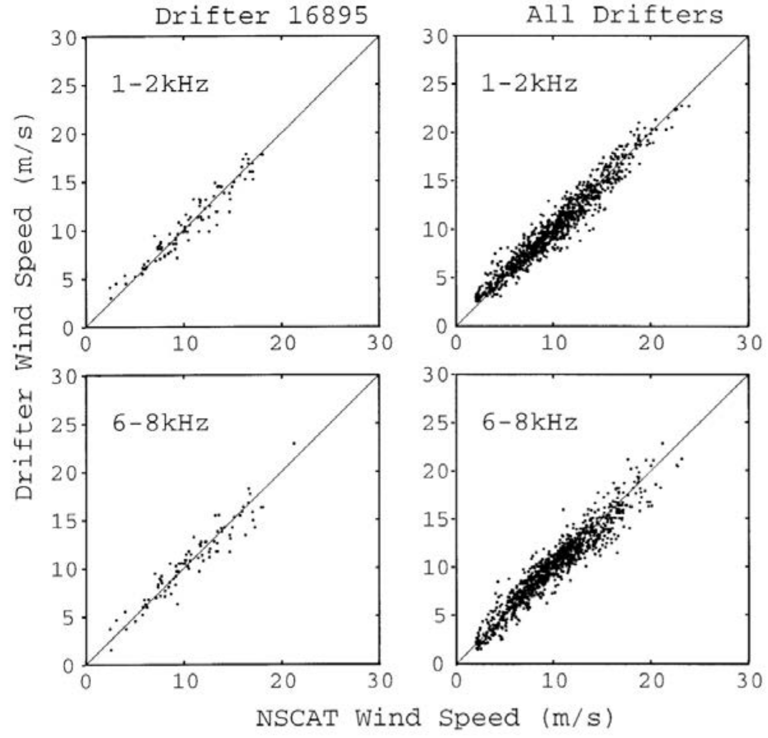


FIG. 5. Minimet wind speed calibration scatterplot comparisons with NSCAT wind speeds derived from the NSCAT–Ku2000 GMF. (left) Comparisons for Minimet drifter 16895 in the sound frequency bands (top) 1–2 kHz and (bottom) 6–8 kHz. (right) The combined scatterplots for all Minimet drifters in the Labrador Sea deployments.

WIND SPEED (0-10 m/s)

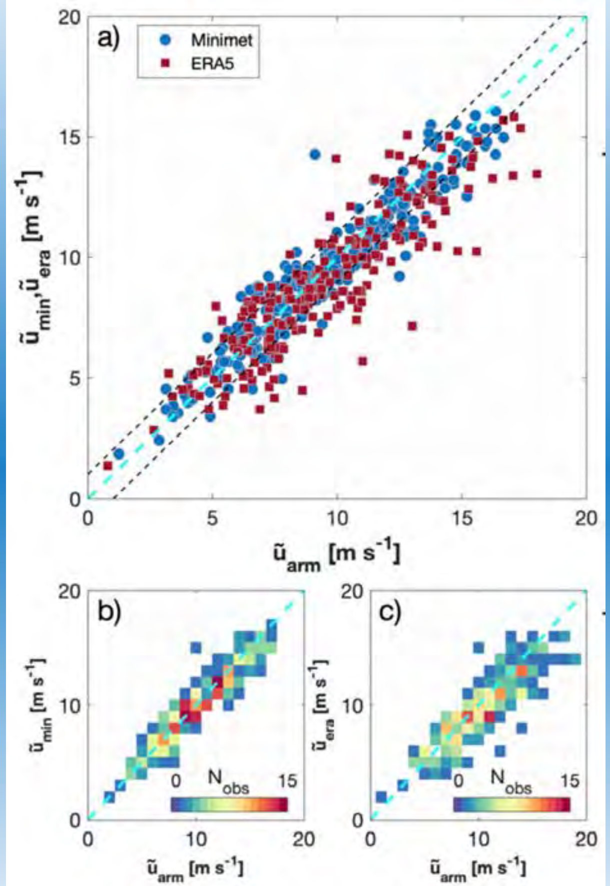
- Bias: 0.1 m/s
- RMSE: 2 m/s

WIND DIRECTION

- Bias: 1.4°
- RMSE: 33°

Milliff et al 2003

2015 Version



WIND SPEED (0-60 m/s)

- ± 1.2 m/s

WIND DIRECTION

- ± 2.5°

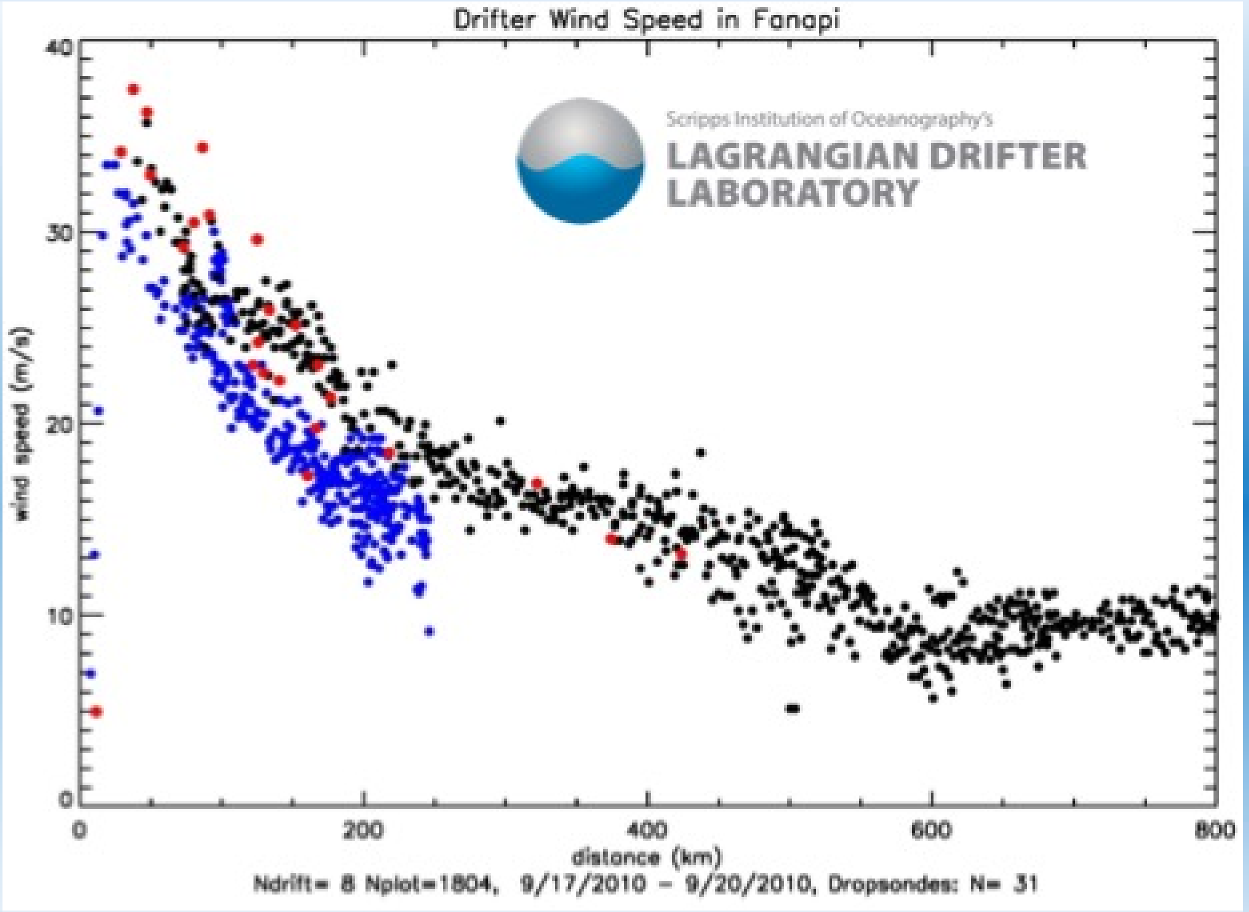
VERIFIED WRT to R/V ARMSTRONG MET STATIONS

- RMSE: ~1 m/s in the 0-17 m/s range

Klenz et al. 2022

Quality of SVPW™ (Minimet™) Data

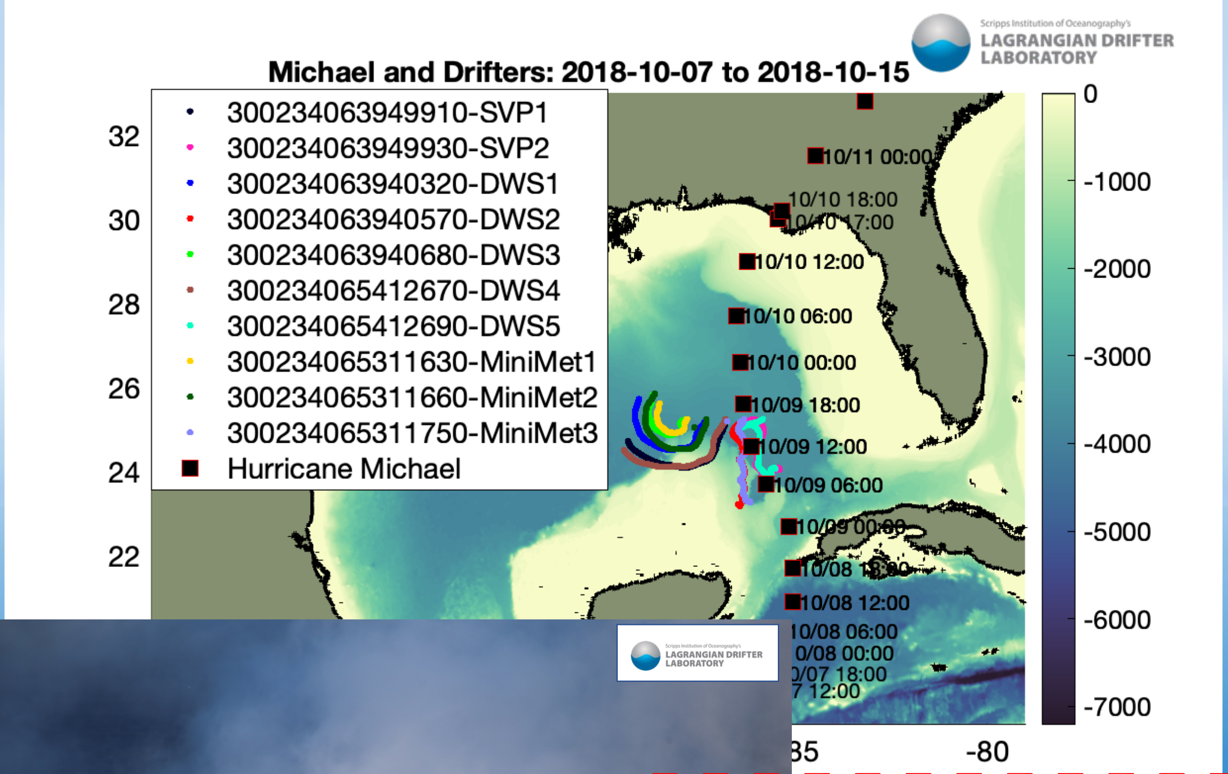
Comparison with Dropwindsondes
Typhoon Fanapi, September 2010

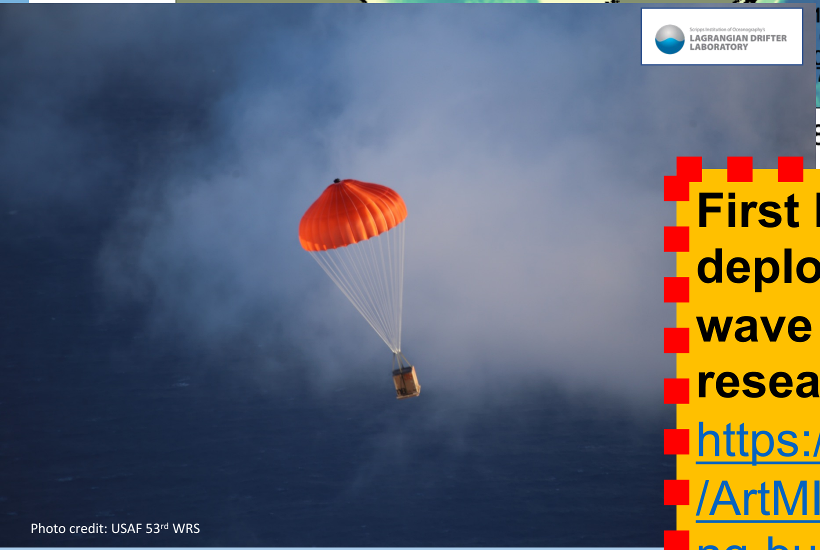


Conclusion

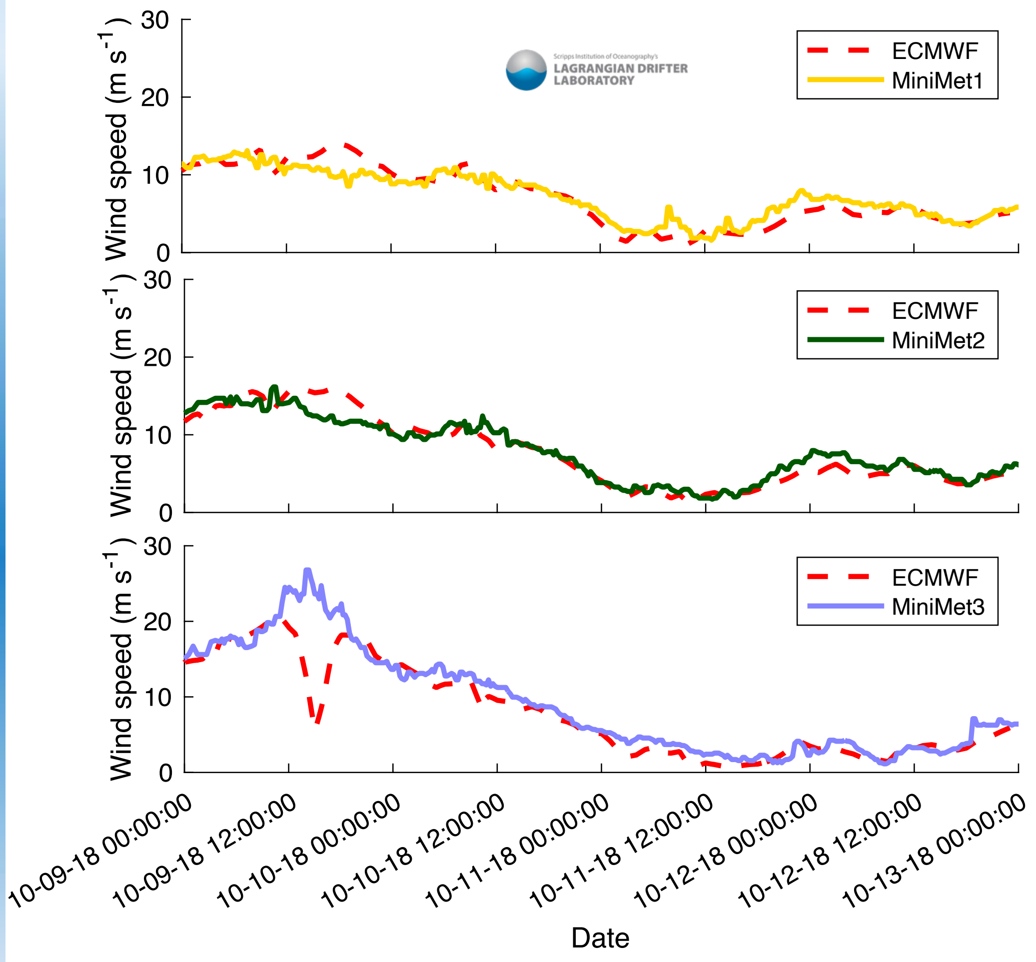
The SVPW™ measures the wind velocity with an accuracy comparable to that of the anemometer used on the drifter, meaning that the sampling methodology and our algorithm do not degrade the quality of the observations

Notable Applications (1/3): Hurricane/Typhoon Obs





Real-time, in-situ surface wind observations inside category 3 hurricane Michael (2018) and comparison with ECMWF wind



First hurricane air-deployment of LDL-GDP wave buoys ever. See NOAA research news: (2018)
https://research.noaa.gov/article/ArtMID/587/ArticleID/2388/Drifting-buoys-track-Hurricane-Michael-in-the-Gulf-of-Mexico

Schönau et al., GRL, in prep

Notable Applications (2/3): Direct Observations of Ocean/Atmosphere energy exchange

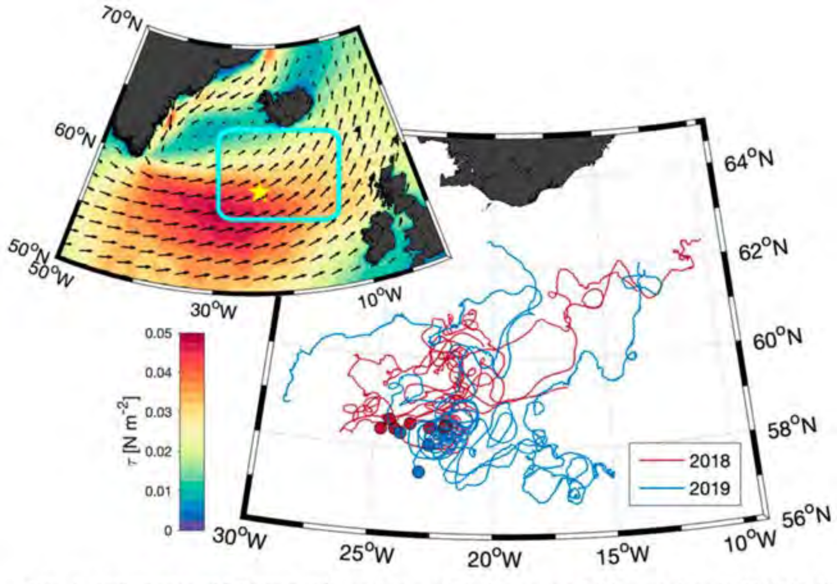


FIG. 1. Trajectories of Minimet drifters deployed during spring field campaigns in 2018 (red) and 2019 (blue). The inset shows the location of the study region and the time mean vector winds (arrows) and wind stress (colors) from ERA5 over the study period. Initial positions are shown by the colored dots and by the yellow star in the inset.

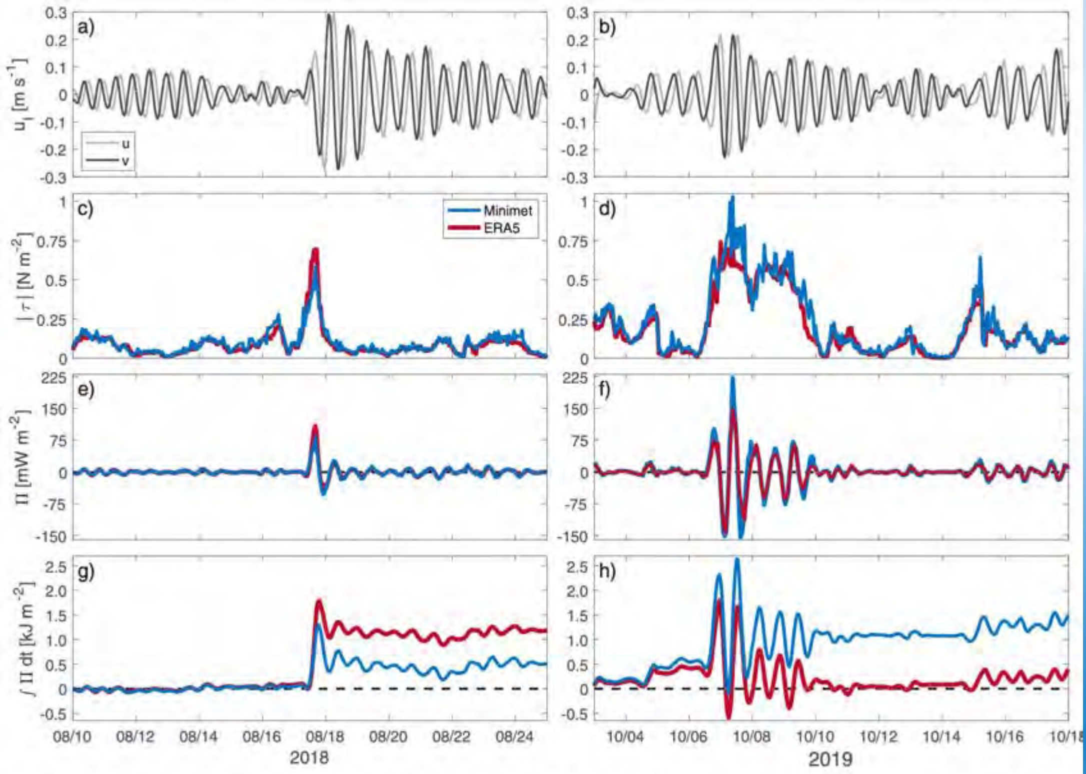


FIG. 7. Example time series for two wind events recorded in (left) August 2018 and (right) October 2019. Shown are (a),(b) bandpassed near-inertial currents from the Minimets, (c),(d) wind stress magnitude calculated from Minimet winds (blue) and ERA5 reanalysis winds (red), (e),(f) near-inertial wind power input, and (g),(h) energy input.

Wind power and energy input in the northern north Atlantic. Minimet vs ERA5.

Drifter-based measurements are of good quality and likely better than reanalysis. Co-located and concurrent wind/current measurements allow straightforward wind power input computation. Expansion to a larger scale will bring new understanding. From: Klenz, T., H. L. Simmons, L. Centurioni, J. M. Lilly, J. J. Early, and V. Hormann (2022), Estimates of Near-Inertial Wind Power Input [...], *J Phys Oceanogr*.

Notable Applications (3/3): Validation of Satellite Winds (2000 SVPW™ Version)

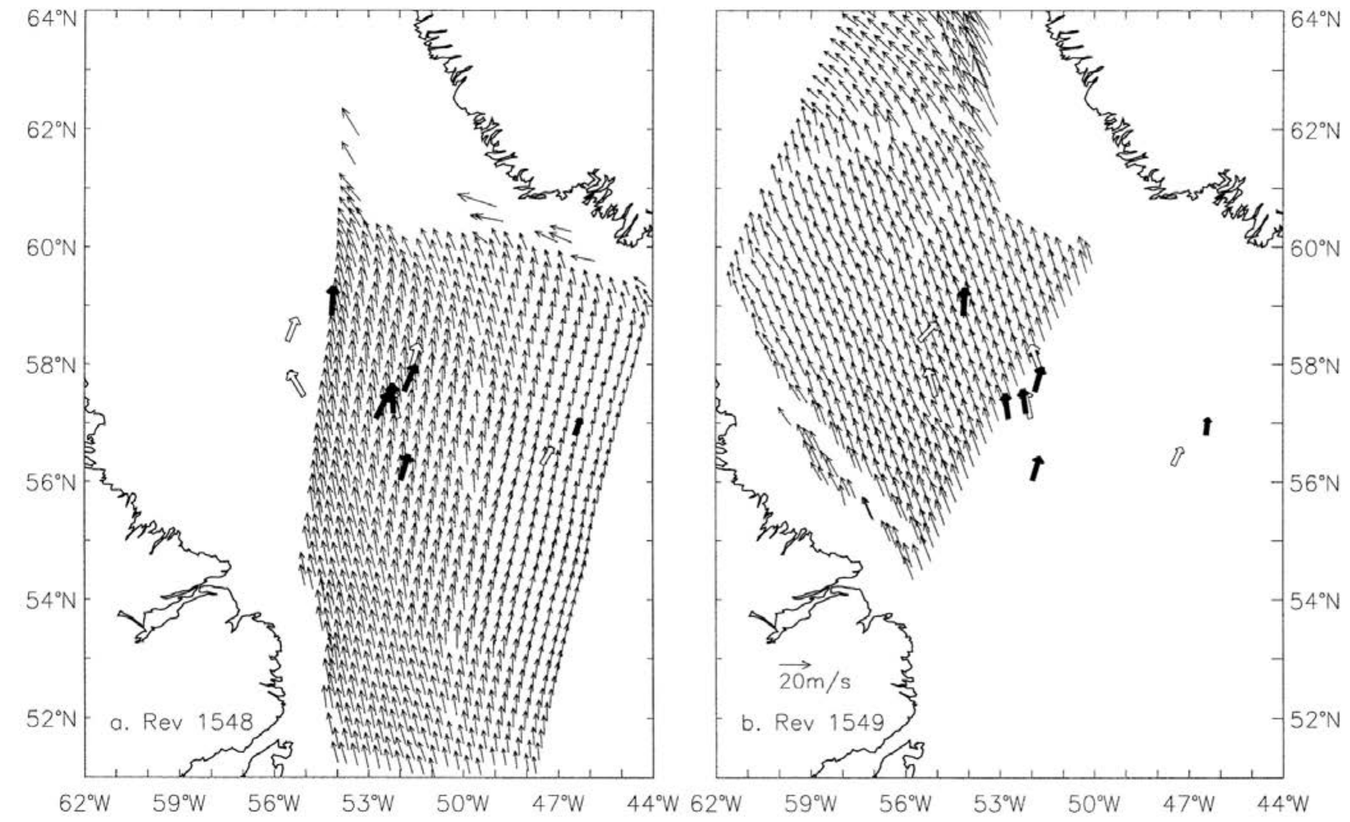


FIG. 6. Surface vector wind retrievals from consecutive NSCAT descending orbits and coincident Minimet drifters in the Labrador Sea on 3 Dec 1996 (a) at 1422 UTC for rev 1548, and (b) at 1603 UTC for rev 1549. In both panels the satellite moves from north to south. During rev 1548 the 600-km-wide right side of the swath (24 across-track WVC) covers most of the Labrador Sea. In the next revolution the left half of the swath overlaps with the previous swath. All 11 Minimets of the first Labrador Sea deployment are depicted in each panel. The Minimet observations all occurred within 37 min (before or after) of the first overpass, and again within 32 min of the second overpass. Filled vectors are data with drifter observed wind direction and speed, and unfilled vectors are observed drifter direction but nearest-neighbor NSCAT speed.

Left: NSCAT wind vector retrievals and co-located SVPW™ wind velocity. In-situ SVPW™ observations can be used to calibrate/validate satellite winds, similarly as with STT and other parameters observed by drifters.

From: Milliff, R. F., P. P. Niiler, J. Morzel, A. E. Sybrandy, D. Nychka, and W. G. Large (2003), Mesoscale correlation length scales from NSCAT and Minimet surface wind retrievals in the Labrador Sea, *J Atmos Ocean Tech*, *20*(4), 513-533.

Concluding Remarks

- *In-situ* surface wind observations are important for operational monitoring as well to support our understanding of ocean/atmosphere energy exchanges (forcing, feedback), which will have a profound impact for the next generation of coupled models.
- *In-sit*u surface wind can be measured from SVP drifters, including for most hurricane conditions
- Careful quantitative comparison of SVPW^{TM} and R/V Armstrong Wind velocity data confirmed that the SVPW^{TM} sampling methodology does not degrade the accuracy of the wind velocity observations (*Klenz et al., JPO, 2022*)