Accurate Temperature Measurements of GHRSST Quality from Global Drifter Program Drifters

By

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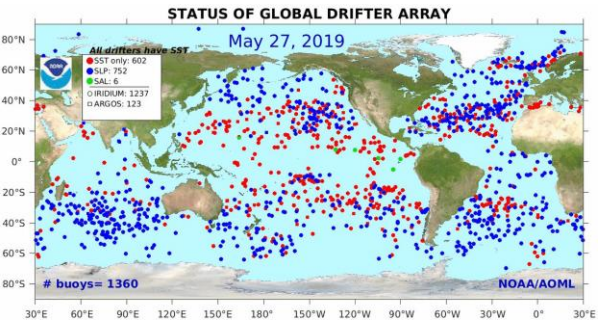
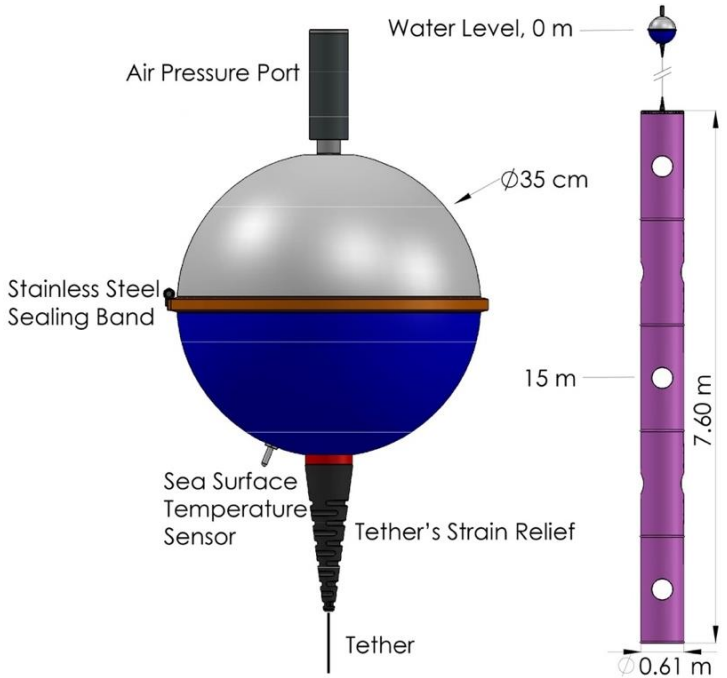


What is a Surface Drifter and How is Temperature Measured

THE **LAGRANGIAN DRIFTER LABORATORY** MINI BAROMETER DRIFTER



Global observations of currents, SST, air pressure. Other observations include SSS, wind, Waves, Solar radiation, subsurface temperature

- **LDL/SIO is the birthplace of the Global Drifter Program**
- **In-house production and testing allows complete control of the instrument**

….and, yes, it is digital…..

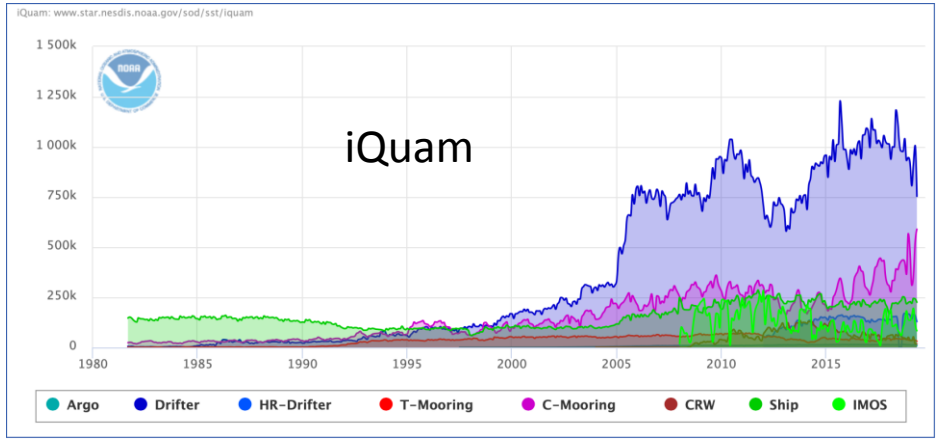
SST is measured at a nominal depth of approximately 20 cm with in house produced integrated resistor bridge.

1. **The Global Drifter Program is the principal component of the International Global Surface Drifter Array**
2. **SVP drifters are widely used as *in-situ* reference SST data**
3. **We need to fully understand the accuracy of the temperature observations, including error sources related to the methodology**

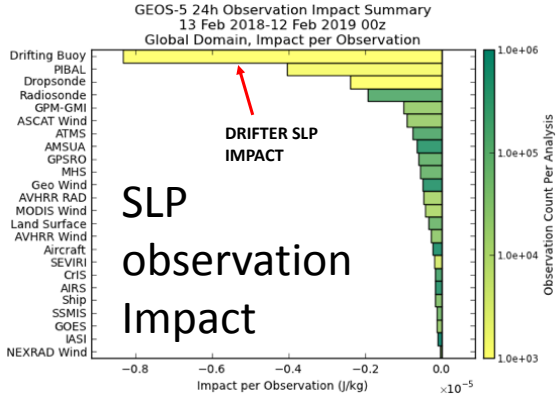
Over 25,000 drifters have been deployed globally in various configurations since 1979, most of them with temperature sensors just below the water line

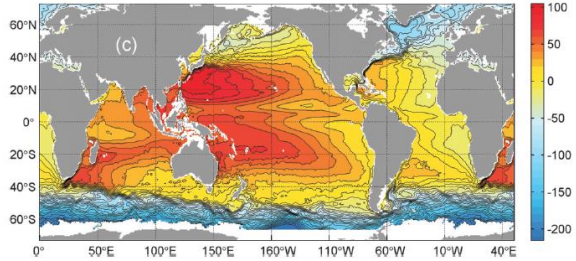
Main Applications and Impacts of SVP Drifters

- Largest source of global oceanic *in-situ* SST
  - **SVP drifters have a hourly duty cycle, and return much more and better distributed SST observations than any other source of in-situ data, X4-ships and coastal moorings, X50-tropical moorings and X100-Argo floats (see Centurioni et al. Oceanobs' 19 cwp)**



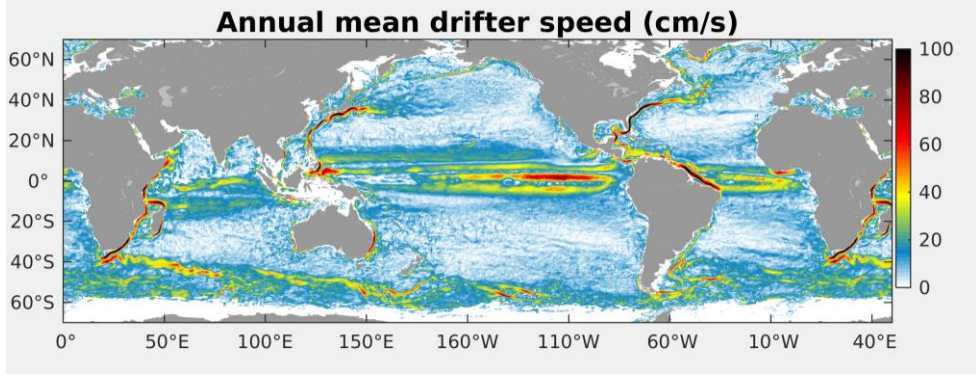
- Largest Source of global oceanic *in-situ* SLP
  - **Drifters SLP data have the largest positive impact per observations. Both forecasting and climate studies benefit from drifter data, especially in the southern ocean where the drifters are essentially the only source of in-situ SLP data.** See also Centurioni, et al (2016). Bulletin of the American Meteorological Society **98**(2): 231-238
  - **Inverse Barometer Effect, from SLP reanalysis, important for altimetry correction**





Dynamic Topography, Maximenko et al. 2009

- Largest Source of global *in-situ* ocean currents
  - **Drifters' ocean current data are primarily used for research, but the use for operational ocean forecasting products is increasing**

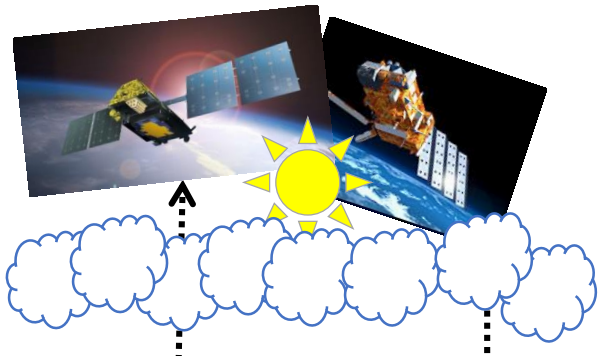


Courtesy of R. Lumpkin

Drifters are multitasking ➔ shared and limited real-estate

Real-time Processing, Distribution and Statistics

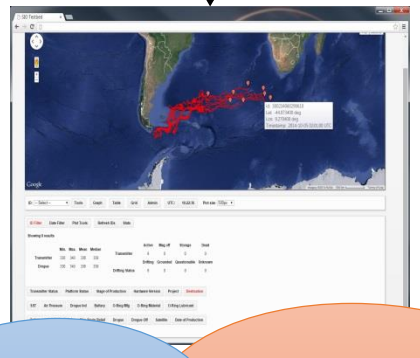
Real-Time Data Relay Structure



GROUND STATION

DATA COLLECTION

SIO Data Server



REAL-TIME STATISTICS

WEB APP DATA VIEWER

INVENTORY TRACKING

DATA RELAY AND DISTRIBUTION

GTS

AOML

OTHERS

Real-time data relay, including GTS posting is handled at SIO, in close collaboration/synergy with Meteo France and UK Met Office. We can provide help for BUFR/7 digits transition

GDP data are posted in real-time to the GTS. More details at http://gdp.ucsd.edu

Where are we with respect to the GHRSST wish list

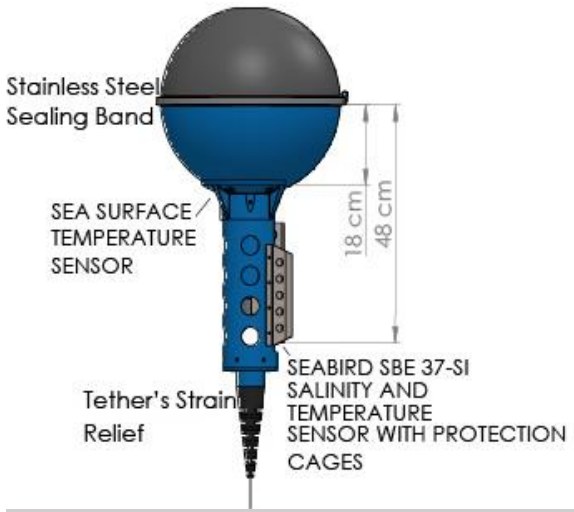
GHRSST requirement	Legacy Argos Drifter	New Generation Iridium Drifters
Hourly Reporting	✗	✓
SST depth reporting	✗	✗(1) Partially addressed in this talk
Geolocation within 0.5 Km	✗	✓
SST accuracy of 0.05K or better	✗	✓(2) Subject of this talk
SST resolution of 0.01 K	✗	✓
Data in NetCDF CF-1.3**	N/A	N/A(3)
SST timestamp within 300 s	✗	✓

(1) Is the depth measurement really necessary?

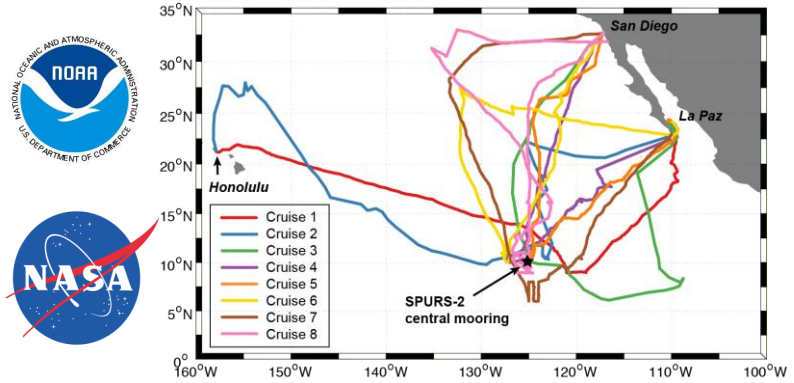
(2) Approximately 2/3 of the drifters deployed by the US GDP satisfy such requirement. That is ~ 600/year

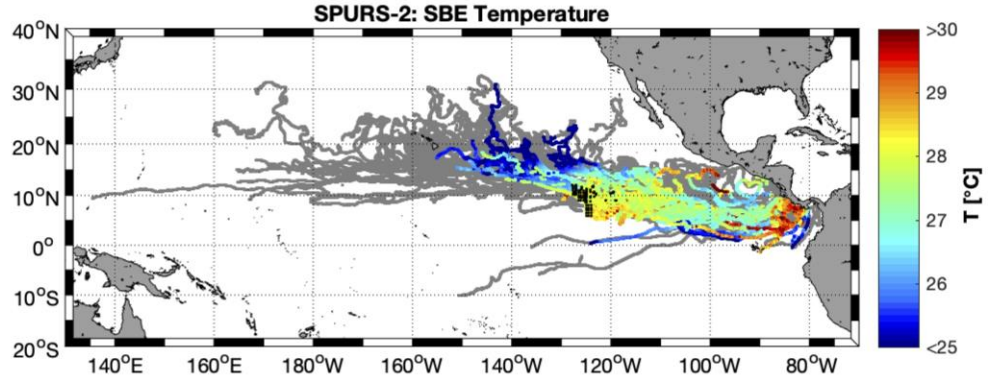
(3) The golden standard for data distribution is the GTS in BUFR format. A parallel data stream can be arranged if very important.

The Instrument and the Experiments

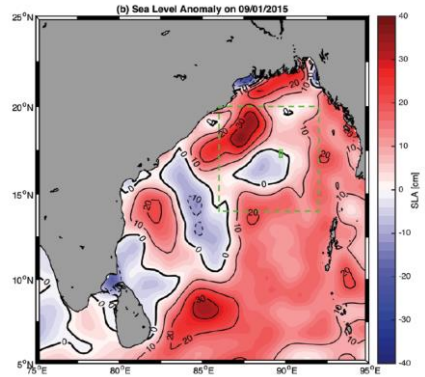


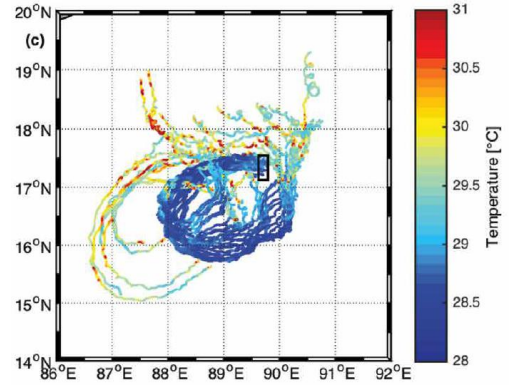
Vertical Distance between the two sensors: 20 cm





SPURS2 (2016-2108): 75 drifters. In-tank Secondary, Traceable Calibration



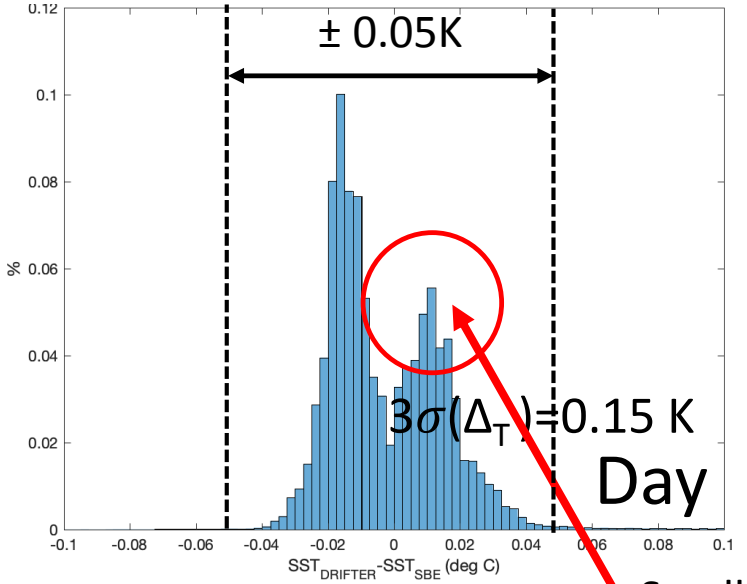


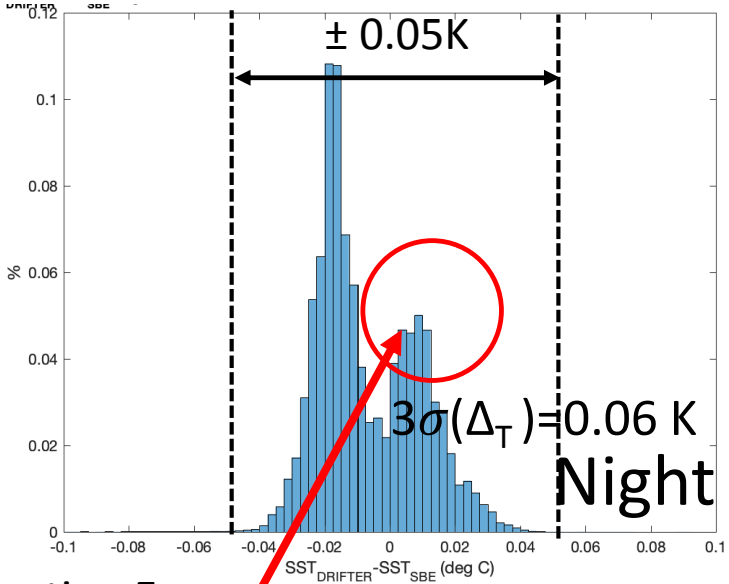
- Dual sensor drifters
- **SBE37:** accuracy, ±0.002K. Drift: 0.002K/year. Response time: ~5 s
- NIST traceable secondary calibration
- Slow sampling, 300 s average

- **LDL T** sensor: accuracy , ±0.05K. Drift: 0.001K/year. Response time: ~30 s
- NIST traceable secondary calibration or NIST traceable components
- Fast sampling, 2s average
- Manufactured by the Lagrangian Drifter laboratory at SIO

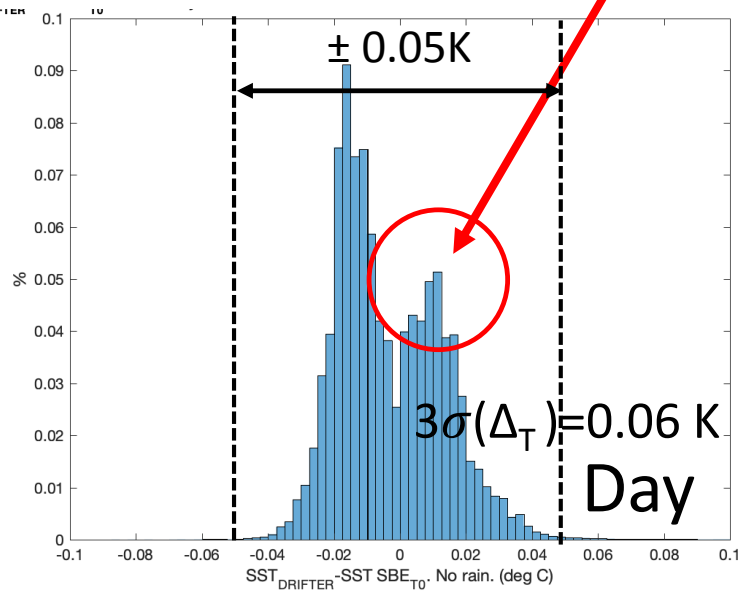
ASIRI (2015): 32 drifters. NIST traceable components. No tank calibration

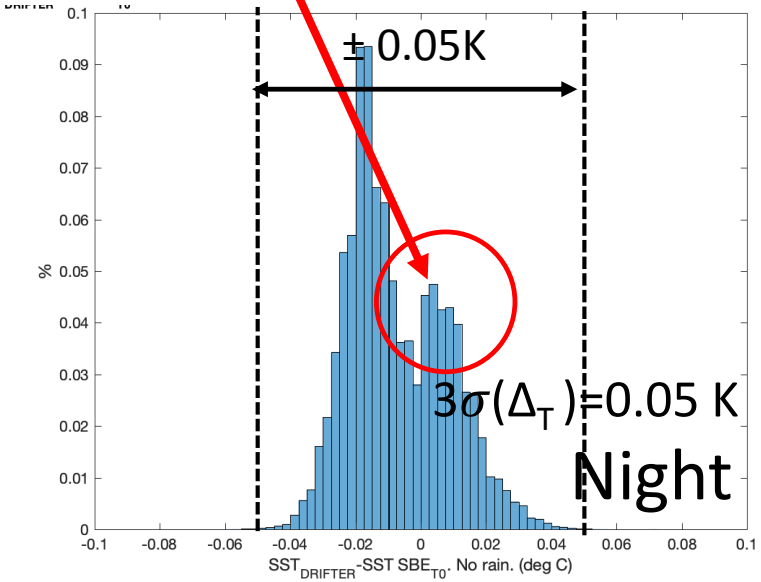
SPURS-2. $\Delta_T = SST_d - SST_{SBE}$.





Small Calibration Error





FILTER GROSS ERRORS ONLY:

1) SST_d<20 ℃ -> unrealistic

2) $\sigma(SSS_{obs}) > 3\ \sigma(SSS_{all})$ -> Excessive scatter

Number of Observations: 524,737

FILTER GROSS ERRORS AND RAIN:

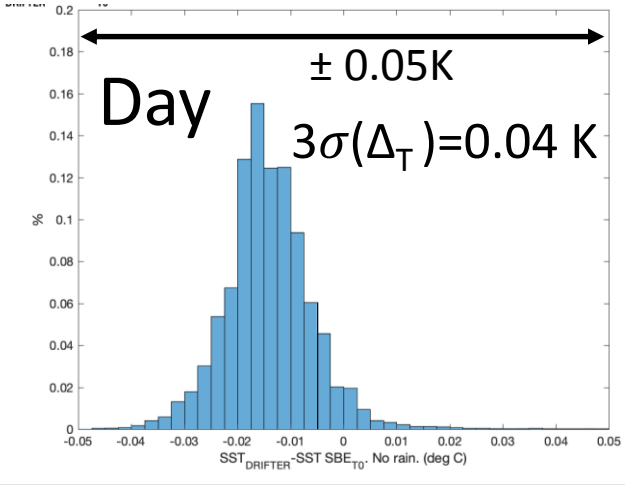
3) Median Filter, 100 point (~2 days) wide, SSS spike larger that SSS median is removed

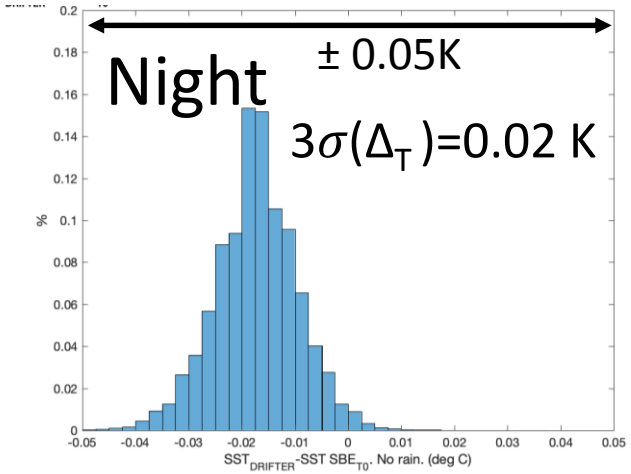
Number of Observations: 307,482

CONCLUSION 1: Daytime rain events Increase the stratification and are responsible for larger SST differences.

SPURS2 and ASIRI. Δ_T=SST_d-SST_{SBE}. Gross Errors and Rain Removed

SPURS-2

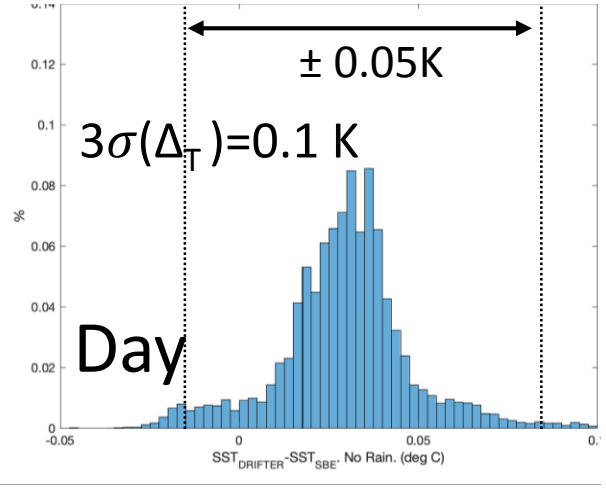


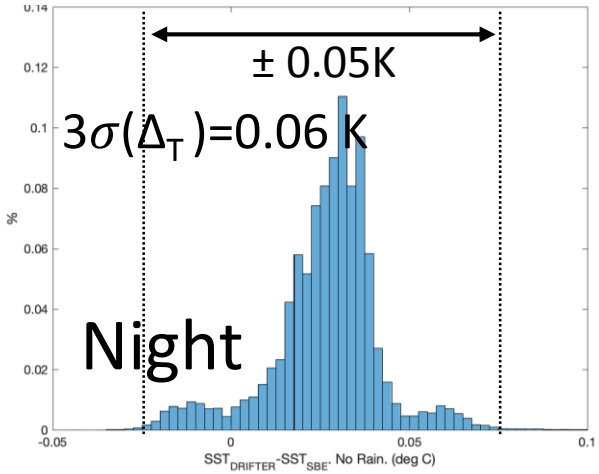


Gross Error, Rain, and Small Calibration Error Removed. 217,013 data points. SBE37 SI and LDL T, both calibrated, traceable calibration

Gross Error, Rain, and Small Calibration Error Removed. 244,426 data points. SBE37 both calibrated, traceable calibration, LDL-T NIST traceable components/bridge

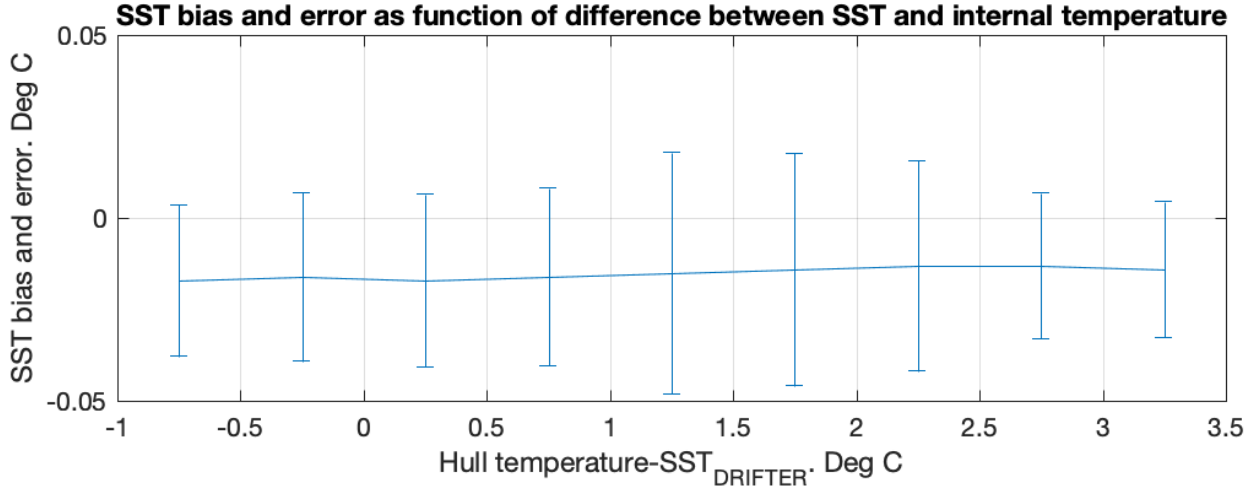
ASIRI

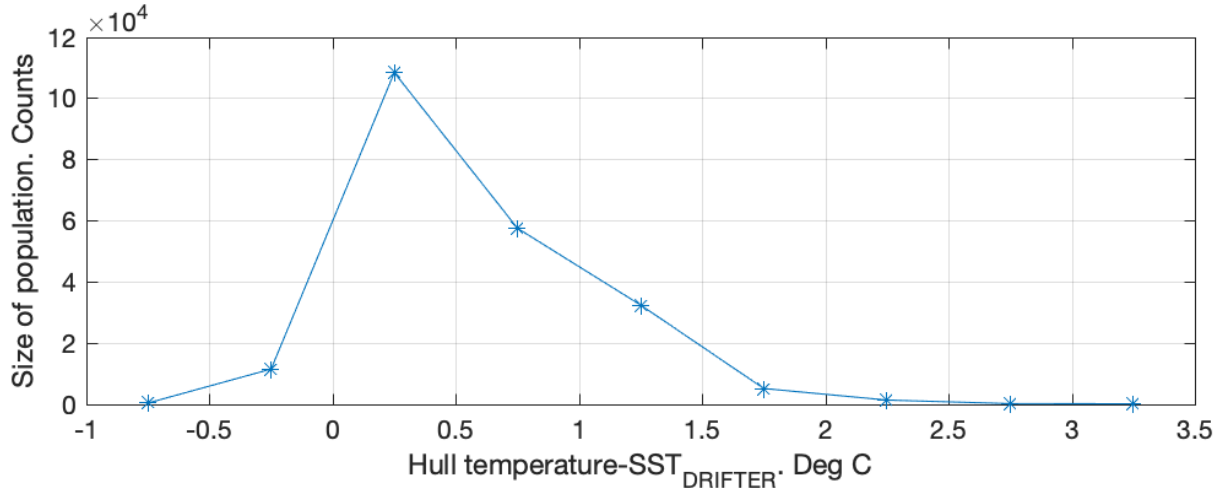


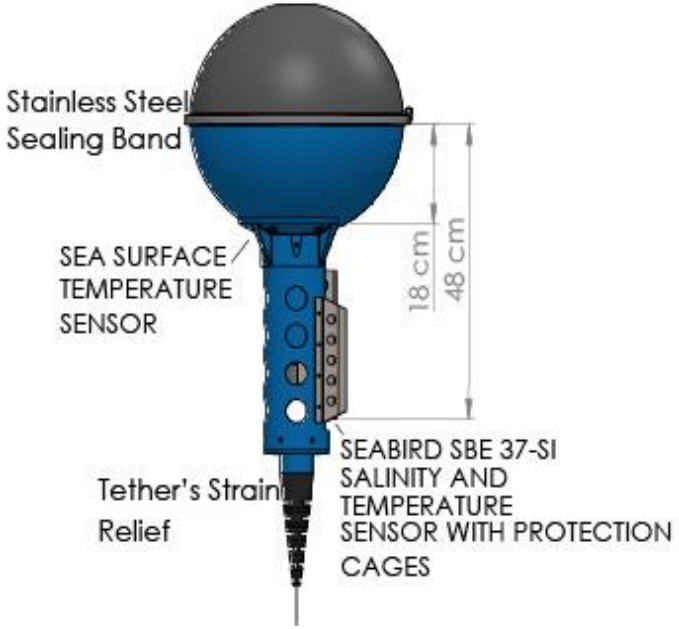


Conclusion 2:
In tank calibration provides GHRSST compliant SST with 99.7% confidence leve NIST traceable components can potentially provide GHRSST compliant in-situ obs.

Internal Heating Bias. Q: Does an Overheated Hull Bias SST Obs?



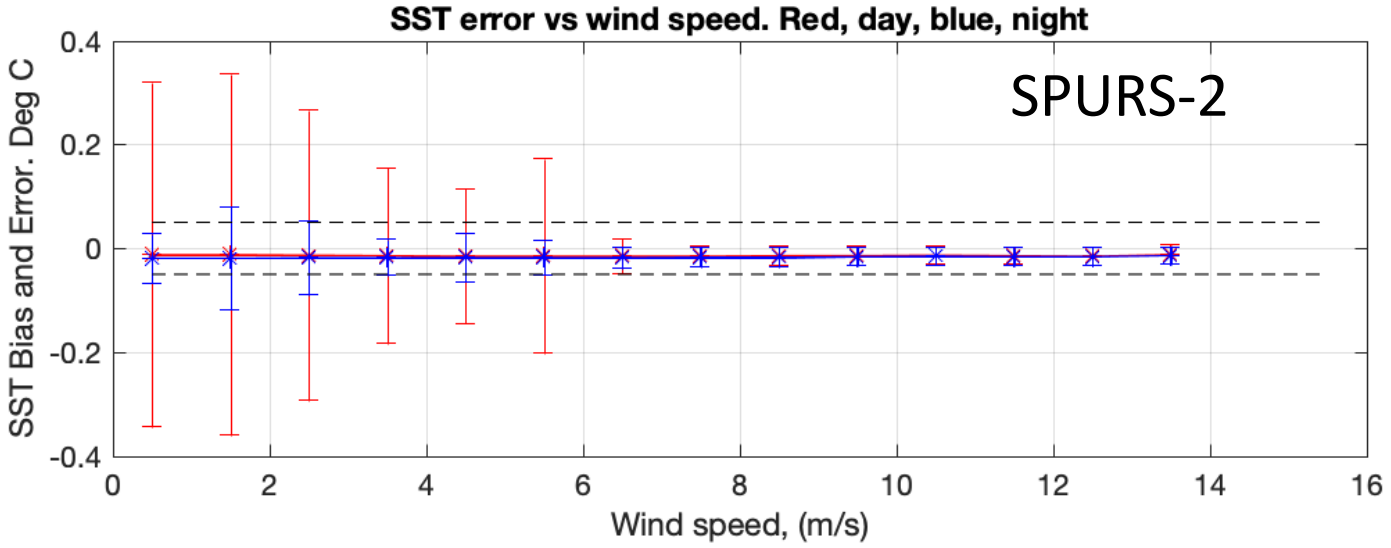


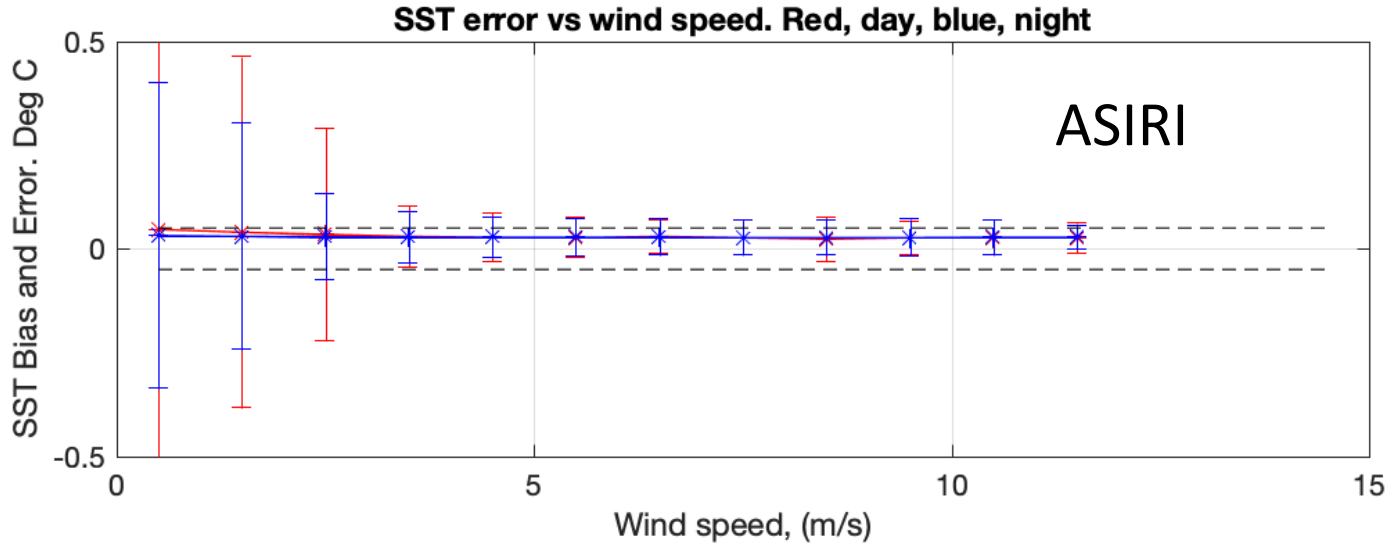


RECALL:
1) the SBE37 sensor is self-contained, external to hull
2) the SBE37 digitizes the signal independently and the communication is serial
3) the LDL drifter also measure the hull temperature

Conclusion 3:
Temperature differences between drifter hulls and SST have little effect on the accuracy of drifter SST

A Closer Look at the Effect of the Stratification
The Observed Δ_T Scales with the Wind Speed!





- ECMWF reanalysis wind
- Large wind speeds imply waves and well mixed upper layer
- Differences at low wind speeds should be be due to geophysical effects (circulation, freshwater input, temperature stratification)

Conclusion 4:
Geophysical induced variability is minimized at wind speed in excess of 2.5-5.5 m/s, depending on the nature of the stratification

Conclusions

1. With in tank calibration, SVP drifters provide GHRSST quality SST data.
2. NIST certified and traceable components need to be used. Alternatives to in-tank calibration can be used. Protocols/assurance certificates should be discussed and agreed upon (the FRM angle)
3. The SVP drifter design does not introduce an temperature measurement bias when the drifter's hull overheats
4. The observed rms temperature errors between two sensors scale with wind speed, over 20 cm vertical scale. A depth sensor, may be useful in calm seas, may not be needed for wind speeds > 5-6 m/s. The use of match-ups at large wind speeds is recommended for now

Data Quality and Sustainability Considerations

SVP drifters are used for a variety of missions such us:

- Satellite SST cal/val
- Global Atmospheric Sea Level Pressure for Numerical Weather Prediction and Climate Services
- Ocean Currents for Ocean State Forecasting and Scientific Research
- Directional Wave Spectra, for Wave Forecasting, Climate Services, Scientific Research

Two issues must be considered:

1. Design Related and Power Budgets. GHRSST Specification need to be harmonized with existing Global Surface Drifter Array/GDP mission
2. Cost and Sustainability. Drifters are expendable and have fast turnover. A sustainable funding structure is needed (i.e. SBE37 sensors, although of the required accuracy, are not a sustainable option for drifters)

Where do we go from here? A Buy-in Program?

- Oceanographers and Meteorologists collaborate through the barometer upgrade program. With $1,000/unit they can install an approved technology on a US funded GDP drifters
- A similar structure can be proposed/envisioned once the technical requirements are finalized