Sensor Stability

Summarized by Breck Owens
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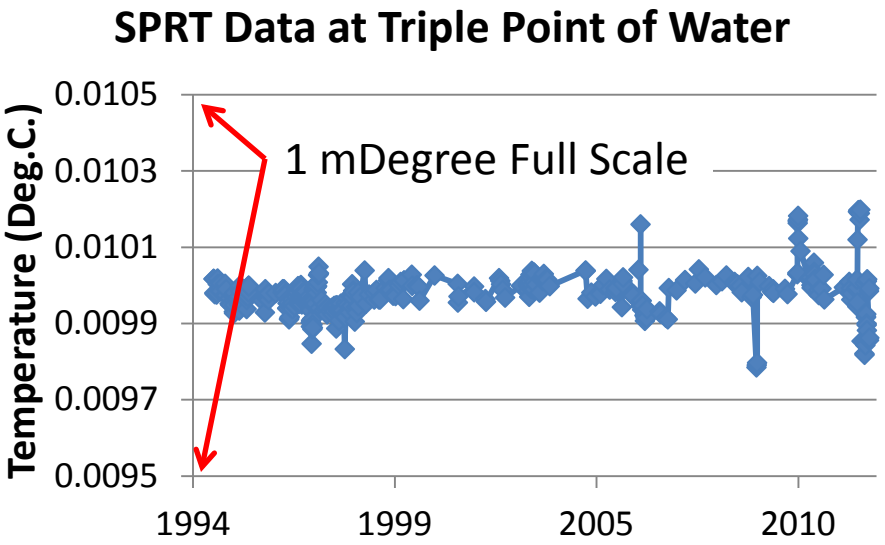
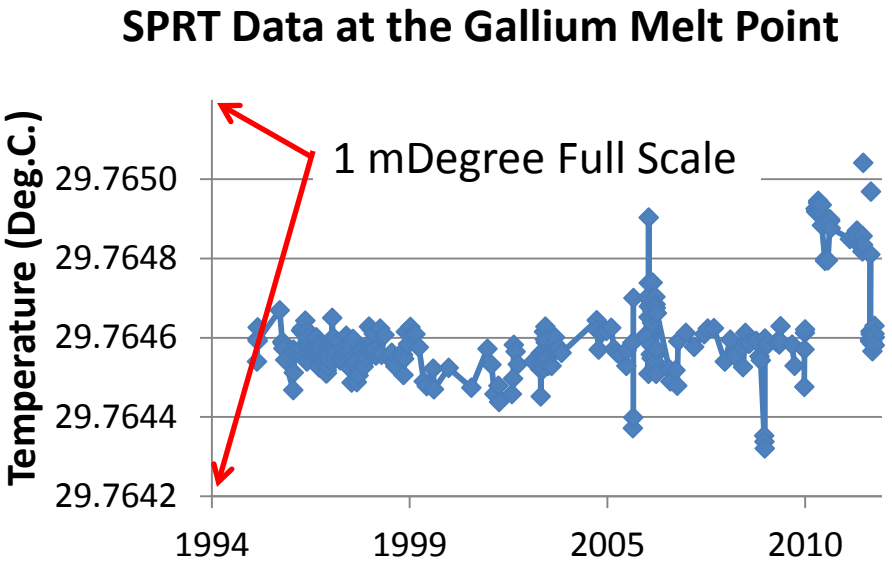
AST-14
Wellington March 18-21

Physical Standards are the Foundation of Temperature Accuracy

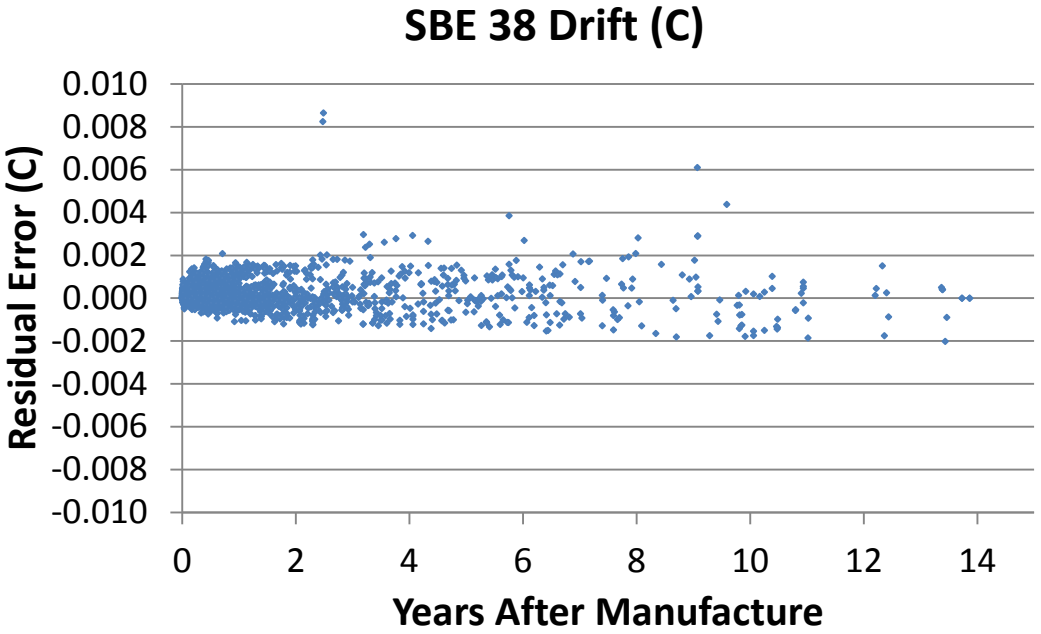
- Standards grade platinum thermometer (SPRT) is calibrated against physical standards
- Each data point represents 1 – 2 days work and more than 1000 measurements
- 200 µC jump in Ga melt is caused by NIST calibration of standard resistor

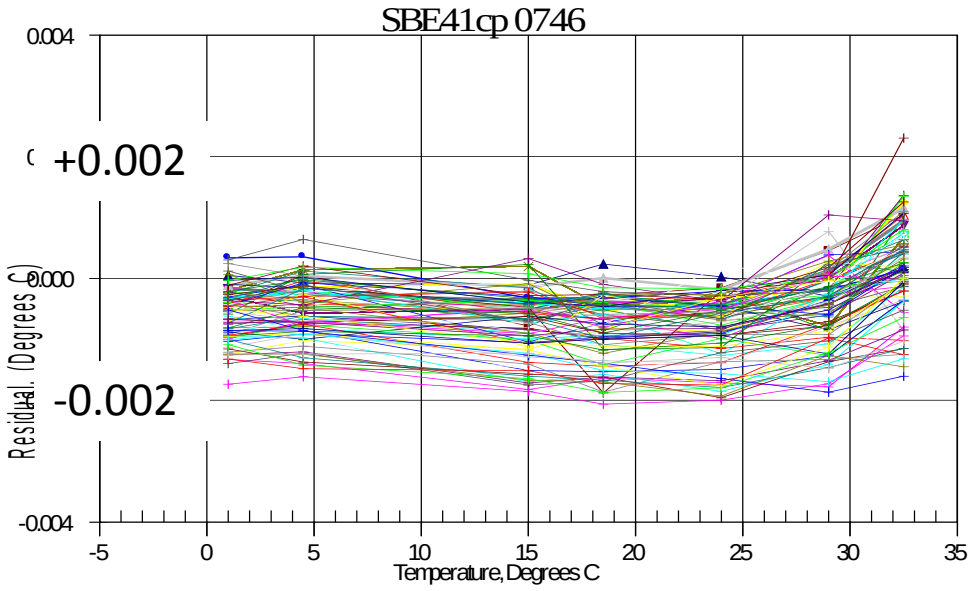




Estimating Temperature Stability

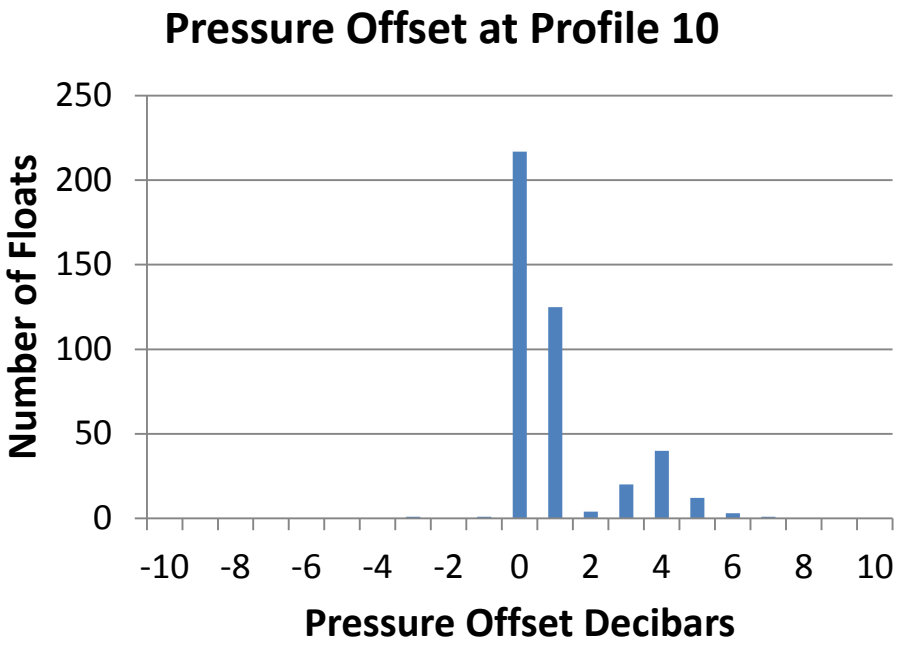
- SBE 38 Proxy:
  - Calibration history of 411 SBE 38s
  - Average error over -1.5 – 32.5 degree range
  - Shares thermistor and circuit with Argo CTD
- Argo CTD:
  - 96 calibrations of Argo CTD 2004 – 2013
  - This one will never see the ocean

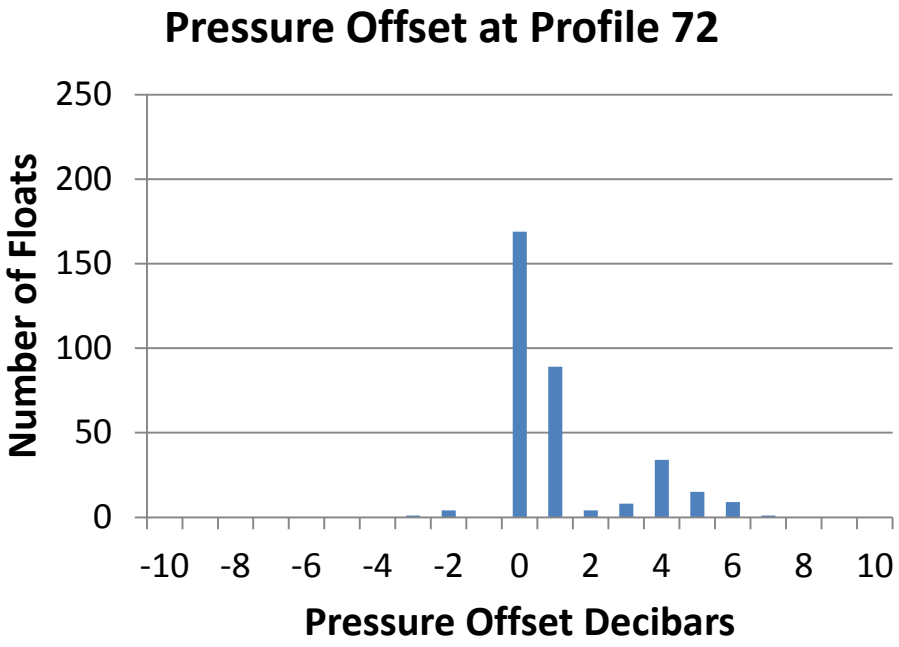




Estimating Pressure Stability

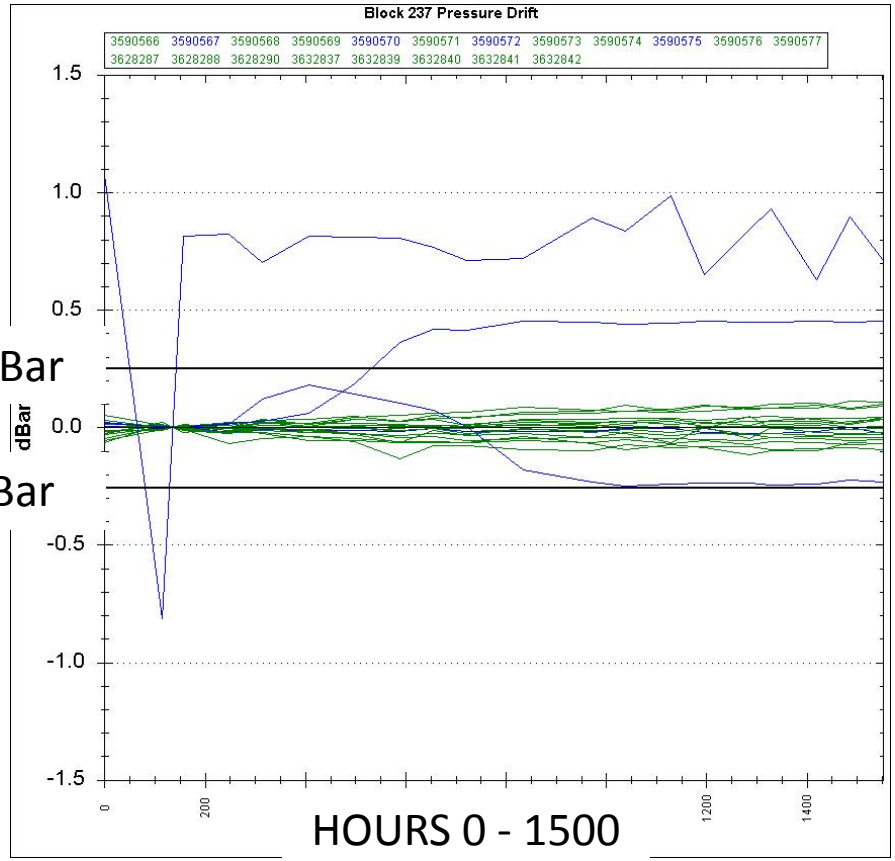
- Past hurdles
  - Electro-static discharge sensitivity
  - Failed glass metal seals
- Plots below are for an initial 424 floats
  - Most have very small offset after 72 profiles
  - Mode at 4 decibars possibly induced by seal failure





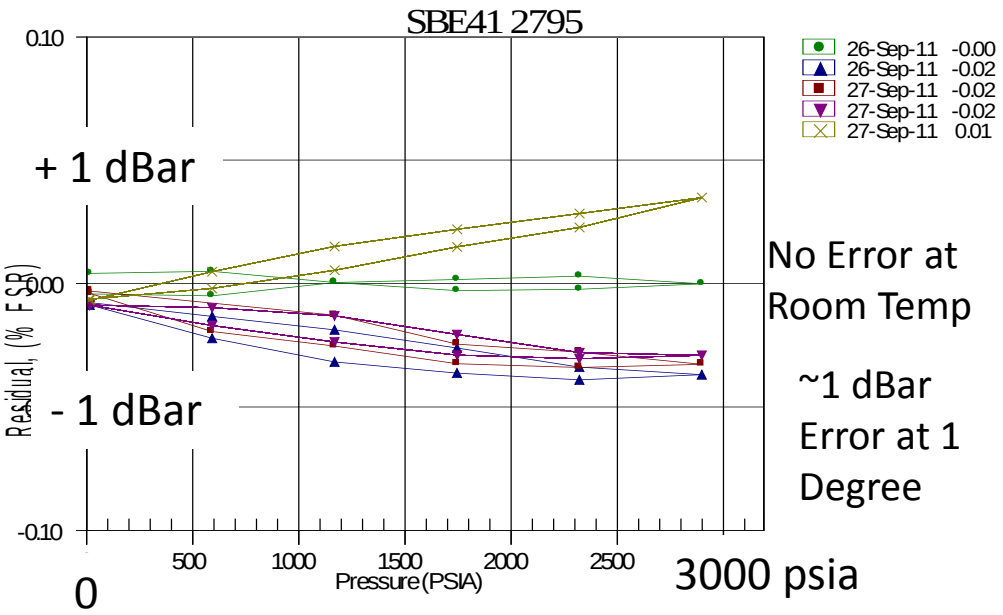
CTD Pressure Sensor Screening Process

- Starting in 2009
  - Accelerated testing for seal failure
  - method developed in collaboration with Druck
- 50 pressure cycles 0 – 3000 psia
- 1500 hours at 4000 psia and 40 °C
  - Twice a week pressure vented
  - Offset measured against barometric pressure
  - Returned to 4000 psia
- Hand selected after infant drift
  - Drift must be within +/- 0.25 decibar



Reducing Pressure Span Error Over Operating Temperature Range

- Dana Swift reports errors of as much as 3 dBars at 2000 dBars
- Provoked investigation with CTD 2795
- Currently sensor span temperature error is corrected with data at -1 and 35 degrees C with data from Druck



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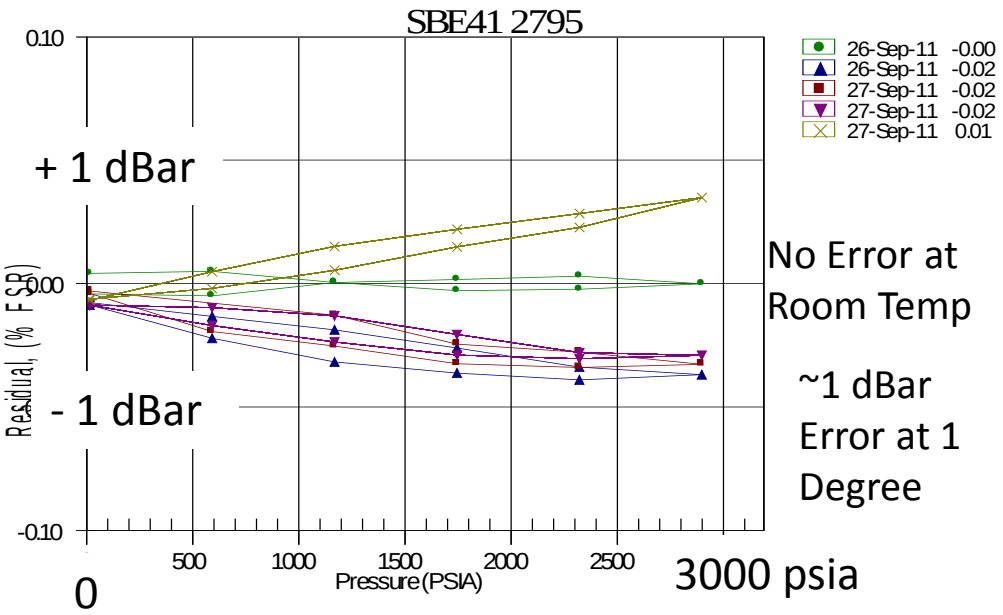
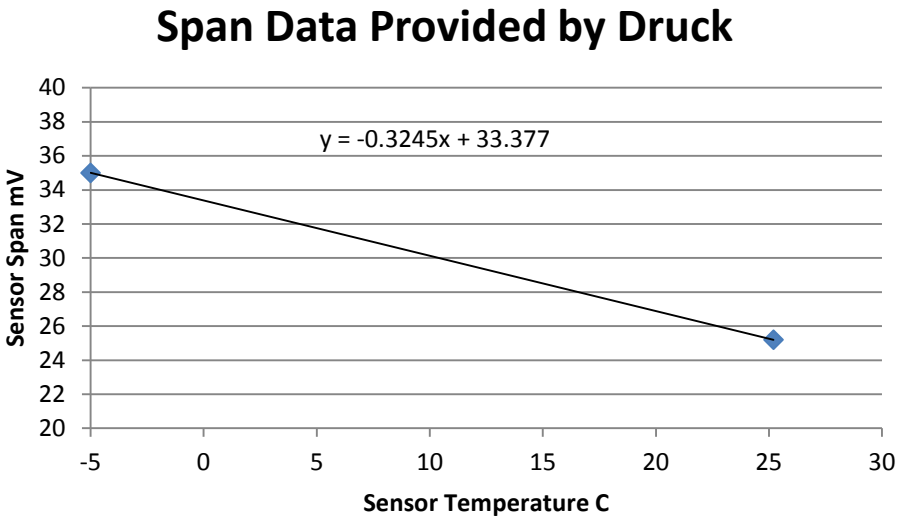
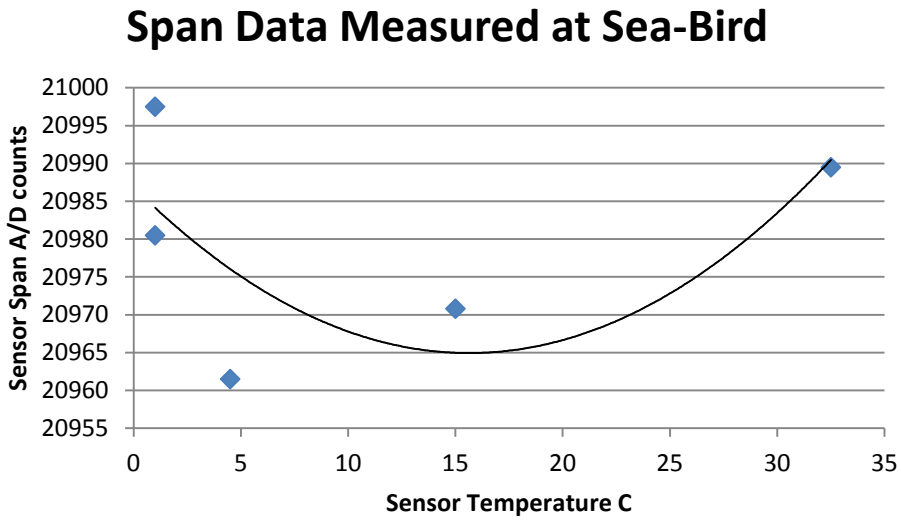


Proposed New Span (slope) correction

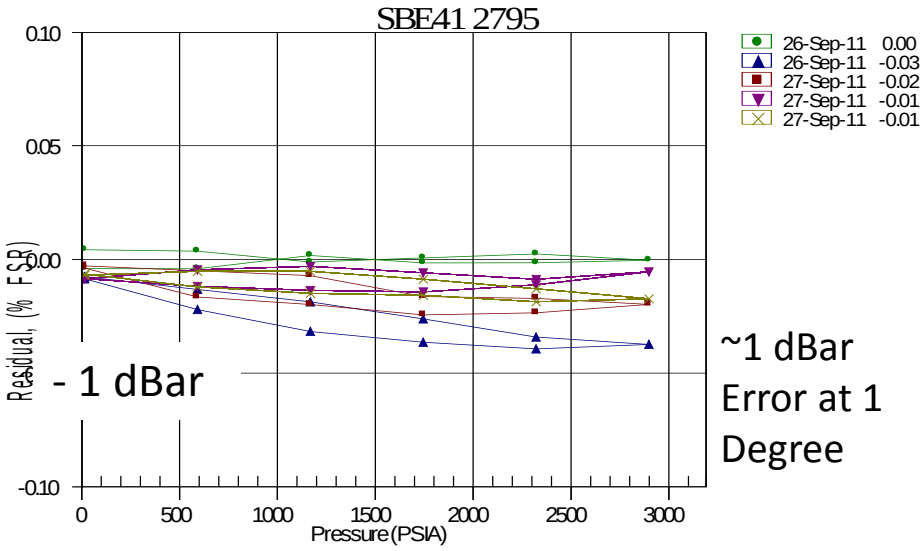


Seabird proposing to implement quadratic temperature correction.



Pressure Sensor Span Sensitivity Not Linear

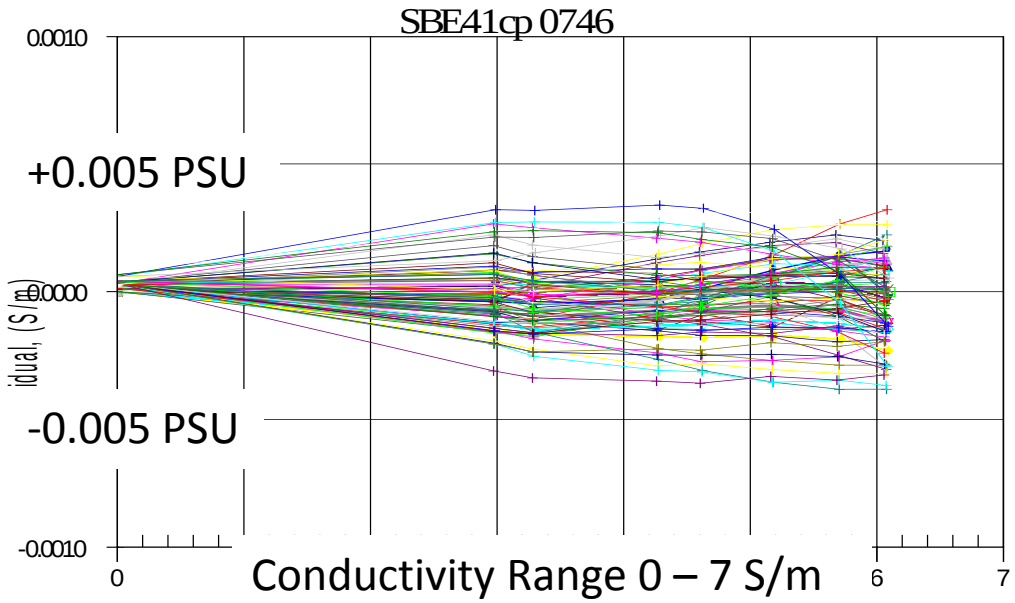
- Try multi-temperature Point Pressure Span Correction
- Improves error for mid range temperatures



Quadratic fit of slope as a function of temperature, where largest changes are at higher temperatures. This should be corrected, but how will this affect estimates of climate drift?

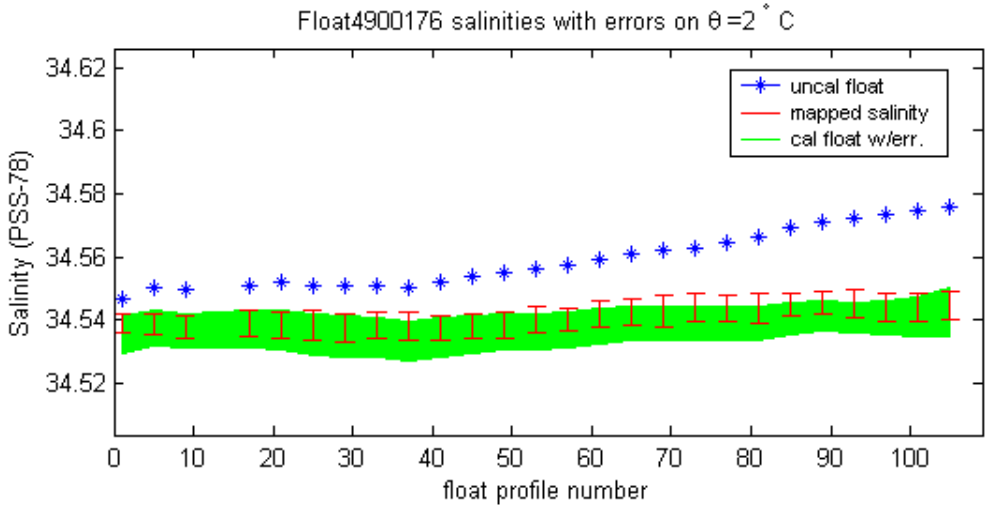
Salinity / Conductivity Performance in the Laboratory

- 97 calibrations 2004 – 2013
- Error less than +/- 0.005 PSU equivalent



Investigating Conductivity (Salinity) Stability

- Salinity performance measured against climatology
  - PMEL reports 25% of their floats require salinity correction
  - UW reports 5% require correction
- Salinity drifting fresh or negative typical of cell fouling
- Salinity drifting salty or positive not well understood
- Error at 2.0 degrees
  - 0.0323 PSU
  - 0.00263 S/m



Salinity Error Sources

- Error evaluated at potential temperature of 2.0 degrees, P and C are dependent variables
- Possible sources of salinity error
  - Pressure error

    60 dbar errpr => 0.03 PSU error
  - Temperature error

    30 milliDeg error => 0.03 PSU error
  - Conductivity error

Conductivity as Source of Salinity Error

- Error sources
  - Conductivity Cell
    - Fouling – Negative Drift
      - Reduces cell radius
      - Electrode degradation
    - Cell damage
      - Can show positive drift
      - Typically magnitude of error is high
  - Conductivity Sensor Circuit
    - Frequency of oscillation dependent on circuit components (resistors and capacitors)
    - Indeterminate direction of drift

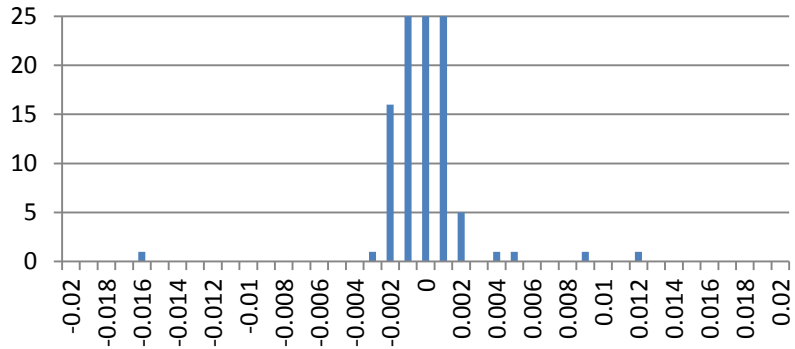
Plausible Mechanism

- Presume that fouling dominates negative drift and will not discuss further
- Identifying conductivity circuitry as a likely source for the positive salinity drift does not explain why some investigators are more impacted.
- Strategies:
  - Investigate difference in climatology and CTD for clues for plausible mechanism for positive drift
  - Use next to the bottom bin for each profile of each float
    - If bin depth greater than 900 decibars
    - Next to bottom bin assures flushed and equilibrated cell

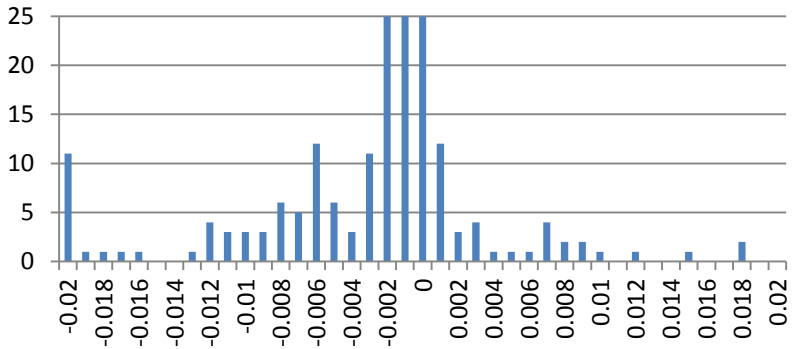
ARGO Salinity Error Profile 10 Compared to Profile 72

- Histograms are scaled to show distribution of corrections, number of floats corrected +/- 0.002 ranges to 500

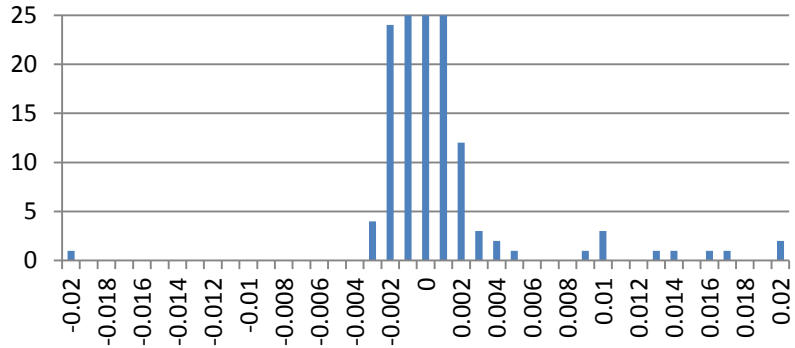
UW Profile 10 for 747 floats



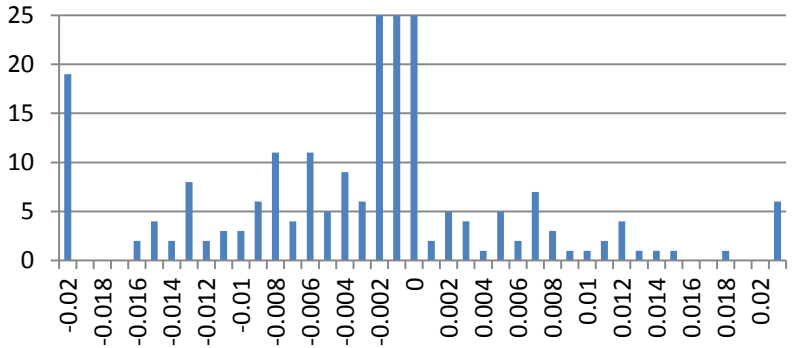
Scripps Profile 10 for 861 floats



UW Profile 72 for 687 floats



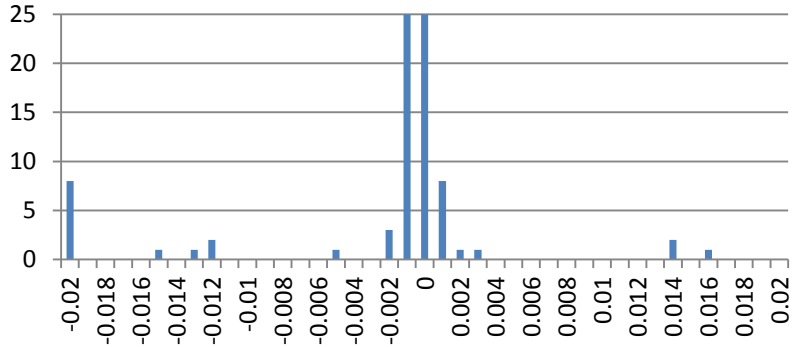
Scripps Profile 72 for 531 floats



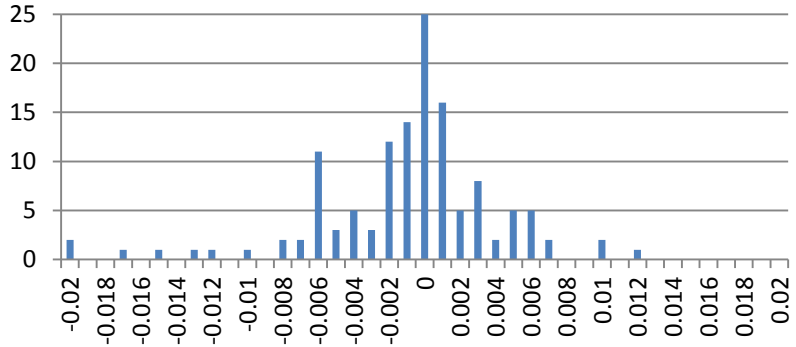
ARGO Salinity Error Profile 10 Compared to Profile 72

- Histograms are scaled to show distribution of corrections, number of floats corrected +/- 0.002 ranges to 300

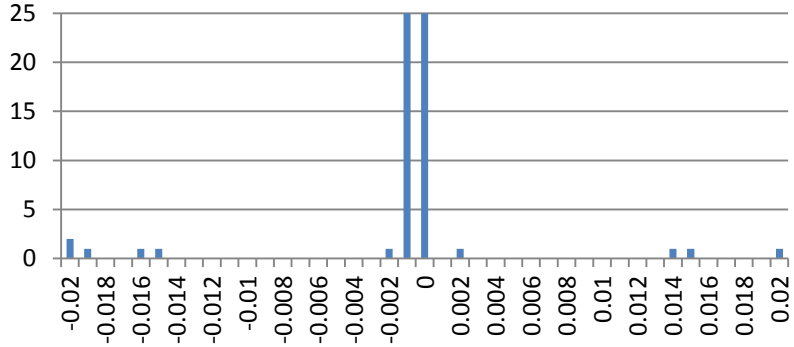
WHOI Profile 10 for 397 floats



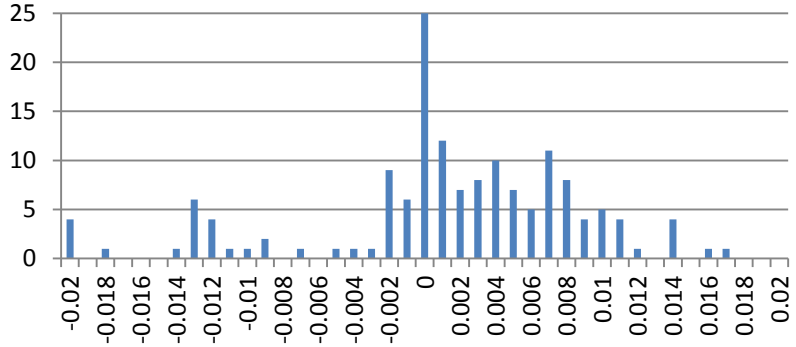
PMEL Profile 10 for 418 floats



WHOI Profile 72 for 253 floats

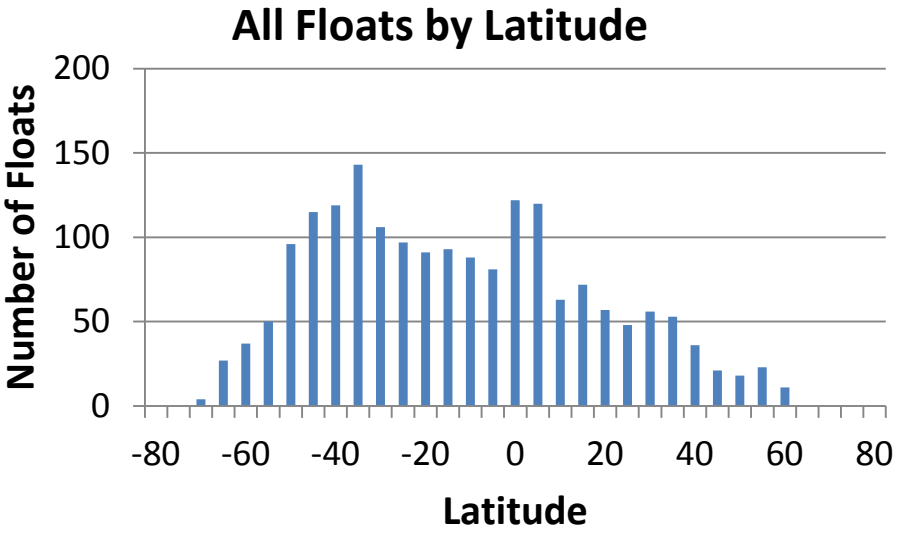


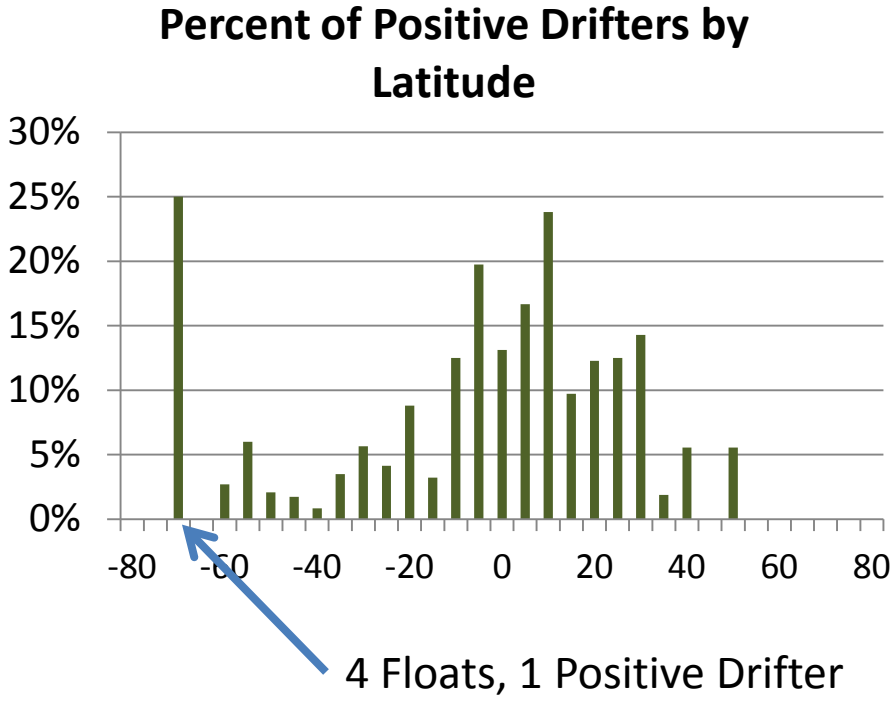
PMEL Profile 72 for 376 floats

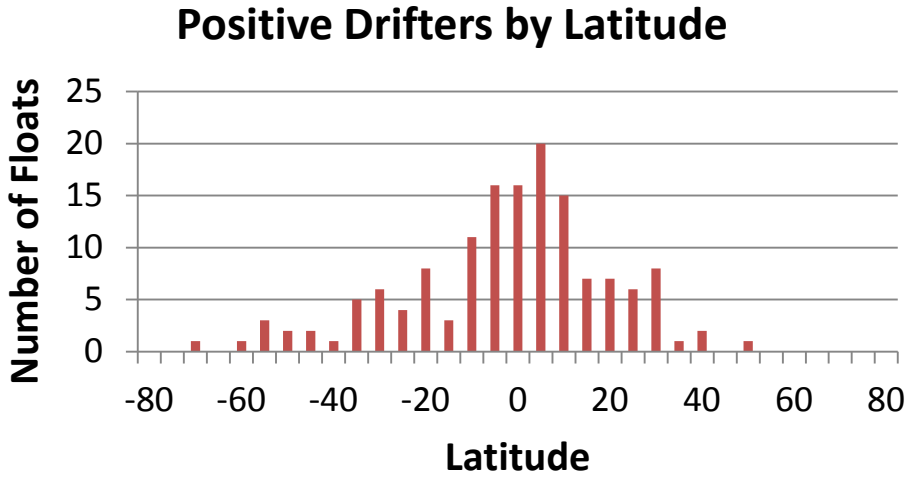


Positive Conductivity Drift Correlates with Low Latitude Deployments

- More likely, correlation is with mixed layer temperature



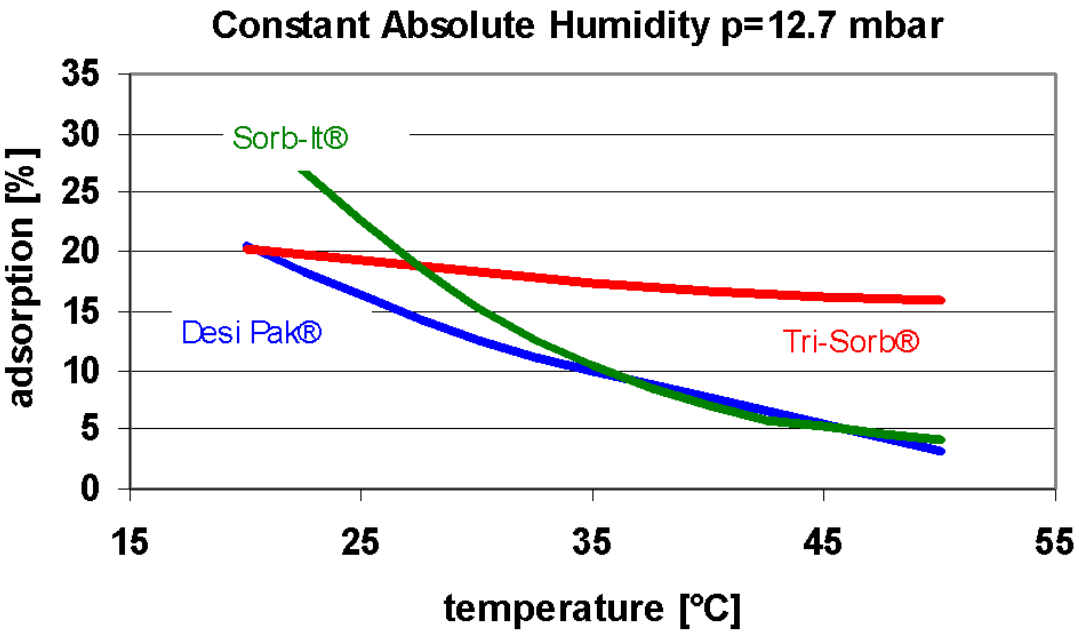




Possible Mechanism

- More water vapor inside floats at warmer latitudes
- Components on CTD circuit board effected by higher humidity
- Desiccants hold less water at warmer temperatures
  - Sud-Chemie, Inc 2011

Similar problems with slow leaking O-ring seals for moored instrumentation (Weller).



Work in Progress

- Work in progress
  - Humidity experiments to verify mechanism of positive conductivity drift
  - Acquisition of environmental chamber to calibrate pressure sensor span sensitivity to temperature
  - Qualification of Kistler 7000 dbar pressure sensors
- Work planned
  - Redesign of calibration bath to improve thermal noise
  - Comparison of SBE Microcat post deployment calibration to climatological correction