ITU Green standards week

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The feasibility of Measuring Abyssal Ocean Temperature with Thermometers Embedded in the Trans-Ocean Communication Cables

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The Feasibility of Measuring Abyssal Ocean Temperatures with Thermometers Embedded in Trans-Ocean Communication Cables

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Points of Discussion

- We are interested in two things
  - Accurately measuring ocean temperature at the seafloor
  - Accurately estimating the rate of warming or cooling of the deep ocean
- What accuracy and measurement drift performance do we need?
  - Are we able to meet these requirements? (yes)
- A seafloor data example to consider

What Are We Interested in Measuring?

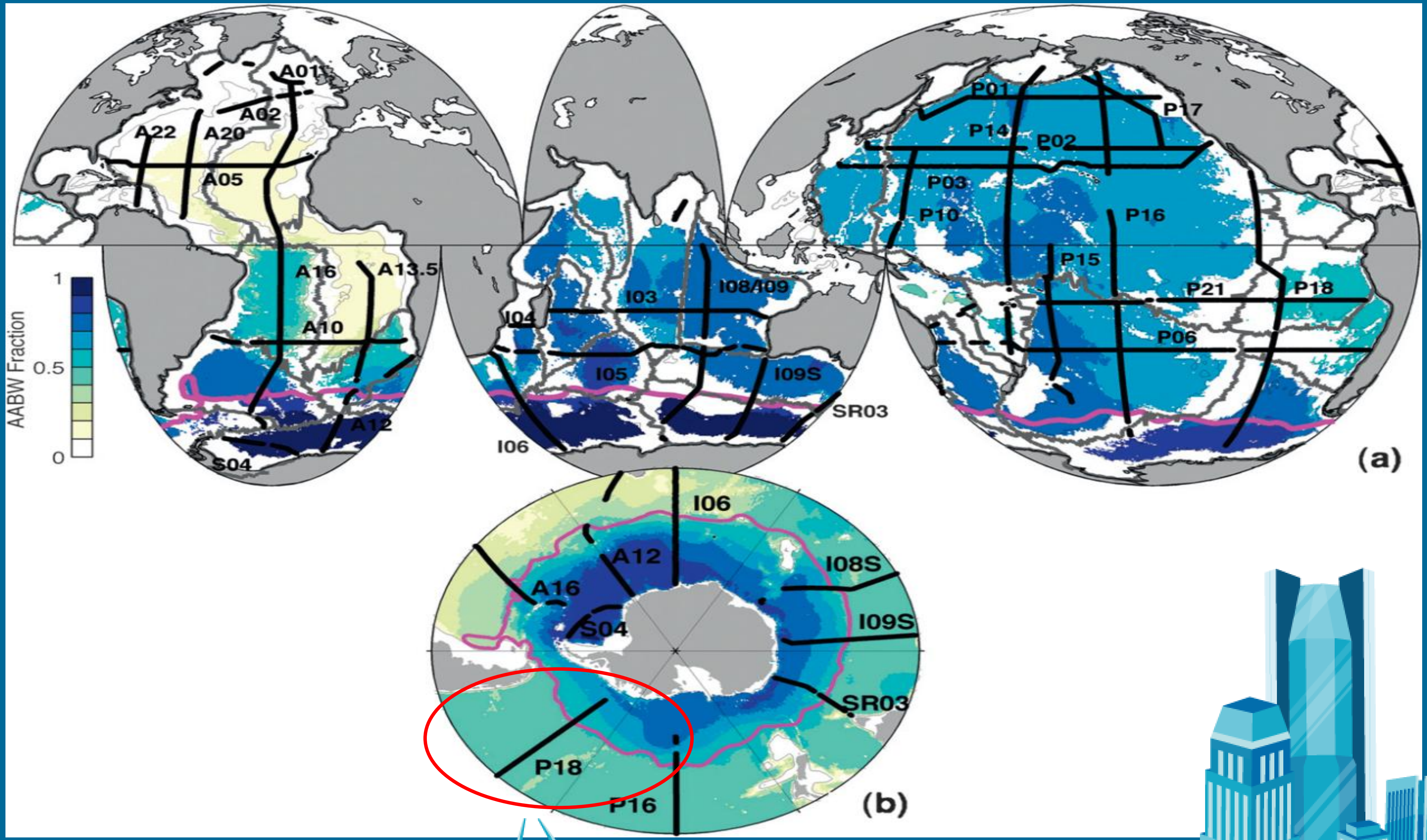
- Will discuss an example from:

  Purkey, S., G. Johnson, 2010: “Warming of Global Abyssal and Deep Southern Ocean Waters between the 1990s and 2000s: Contributions to Global Heat and Sea Level Rise Budgets” Journal of Climate, Vol 23, pp 6336 – 6351.

  – Published by the American Meteorological Society

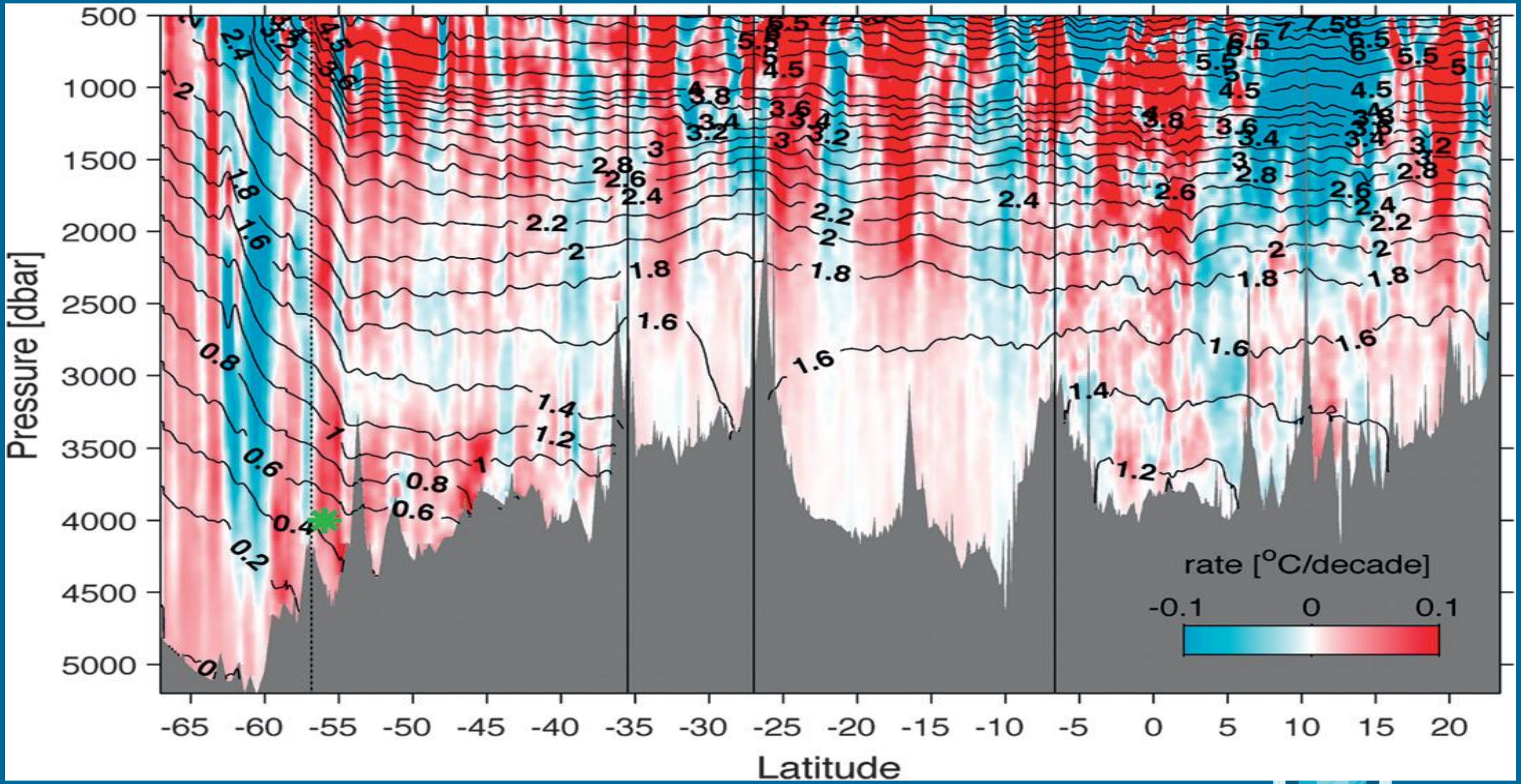
Data Source

- Instrumentation lowered from ships along tracks shown on the right
- Measurements repeated through 1990s and 2000s, continue to present
- Data collected by international science programs: WOCE, CLIVAR, *et. al.*



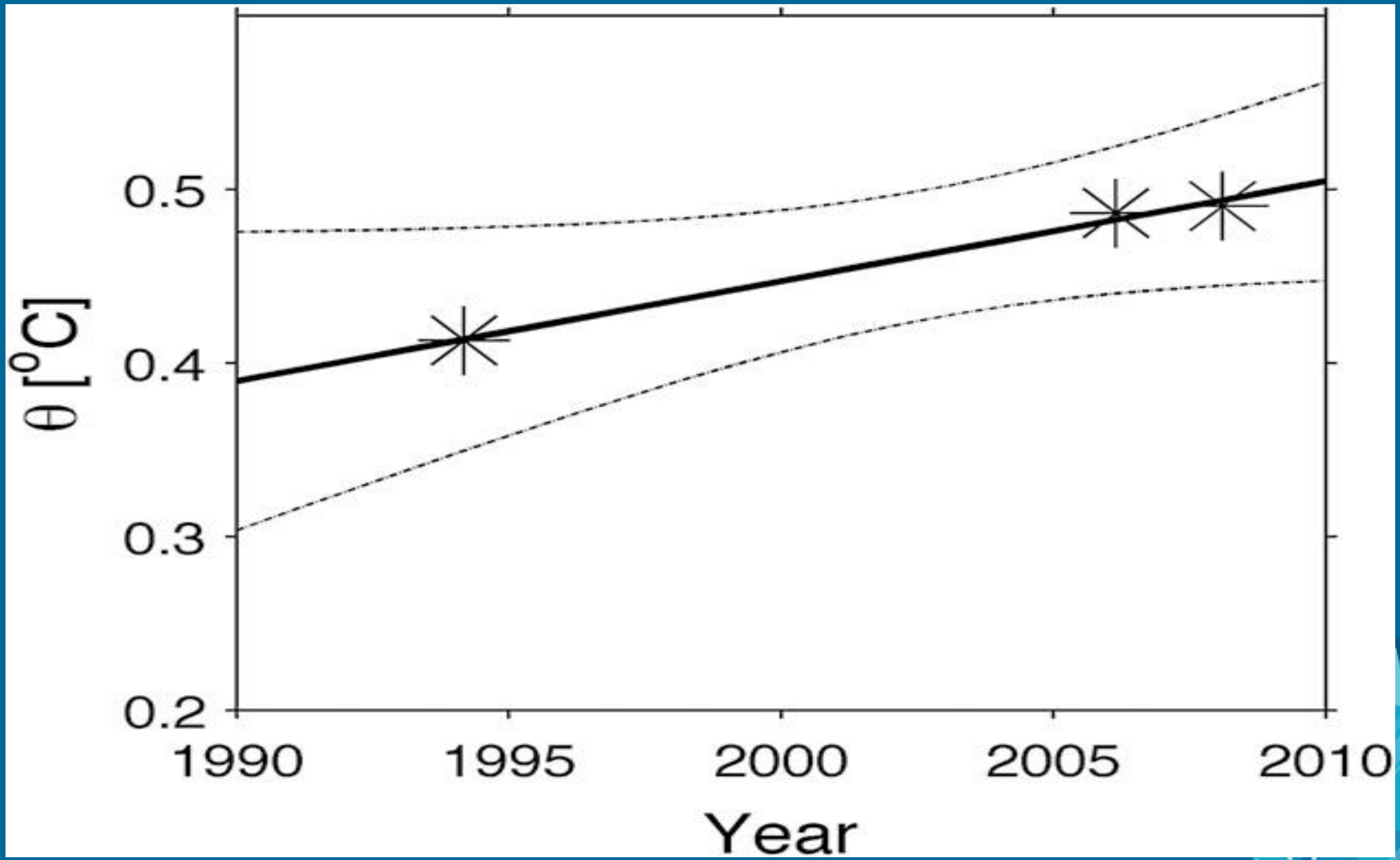
Observed Warming Rates in Southern Ocean

- Grey shading indicates ocean floor
- As in all models of climate change, some places get warmer, some colder
- Note very high spatial variability, instrumented cable address this
- Note scale at the bottom, +/- 0.1°C/decade
- Will focus on area with green asterisk



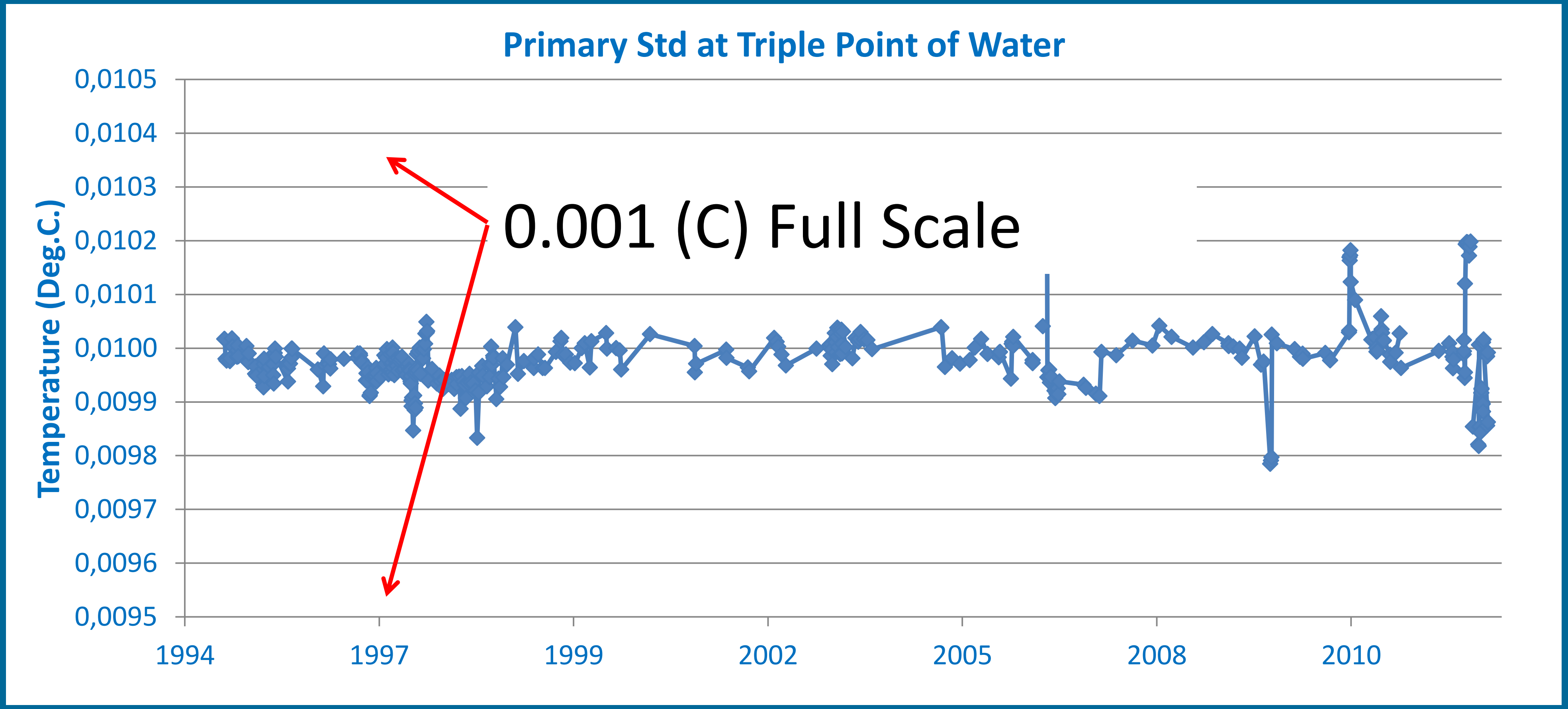
Observed Warming Rate Near Ocean Floor at 4000 Meters Depth

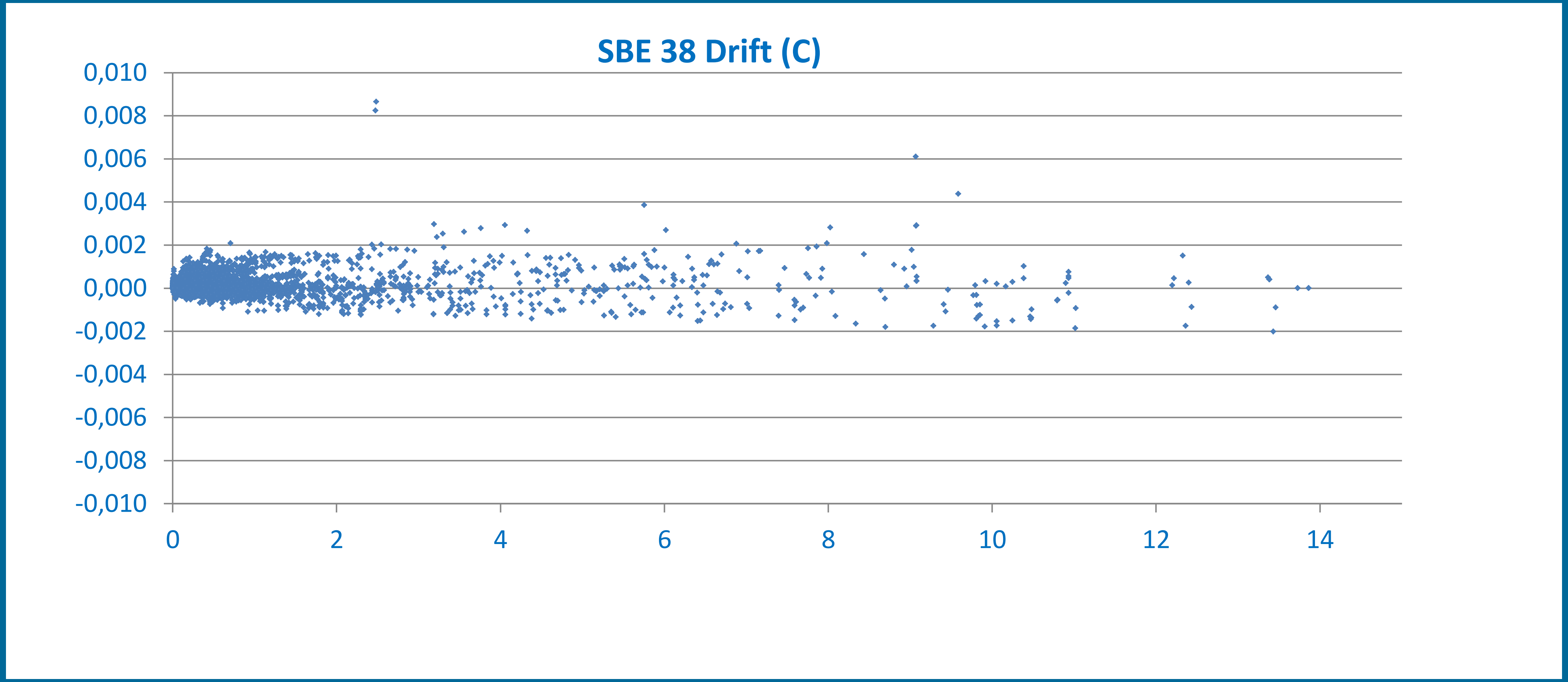
- Estimated warming rate 0.1°C/20 years
- 0.005 °C/ year
- Dotted lines are 95% confidence level, estimated from spatial variance – **not temporal variance**
- Instrumenting cables will address this shortcoming by providing a time series of measurements in many locations



Suitable Deep Sea Thermometer

- Top plot is calibration standard used for deep ocean temperatures
  - Shows the stability of the calibration
- Bottom plot is drift history of candidate thermometer
  - Shows the stability of the thermometer in the field



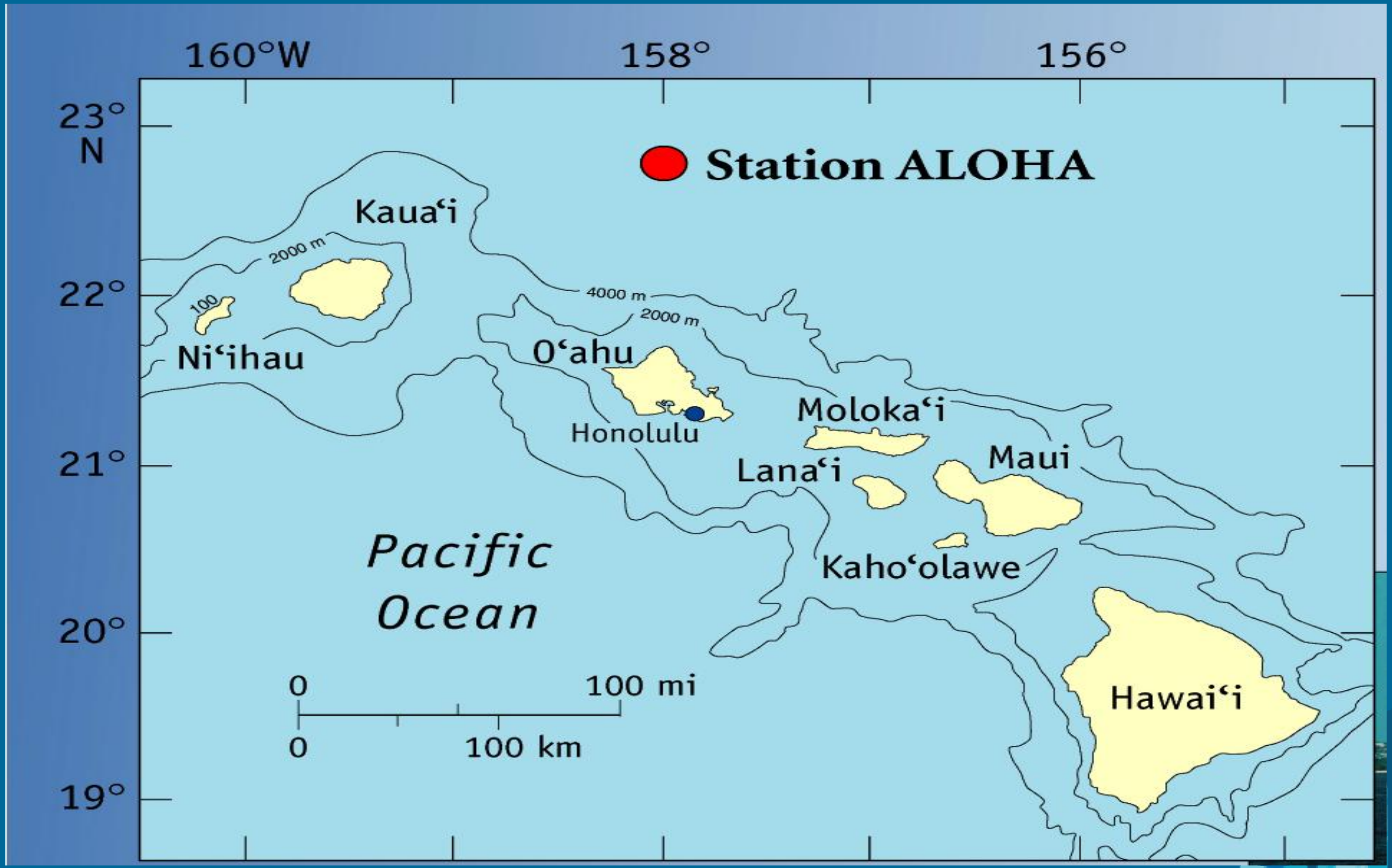


Problems We Face

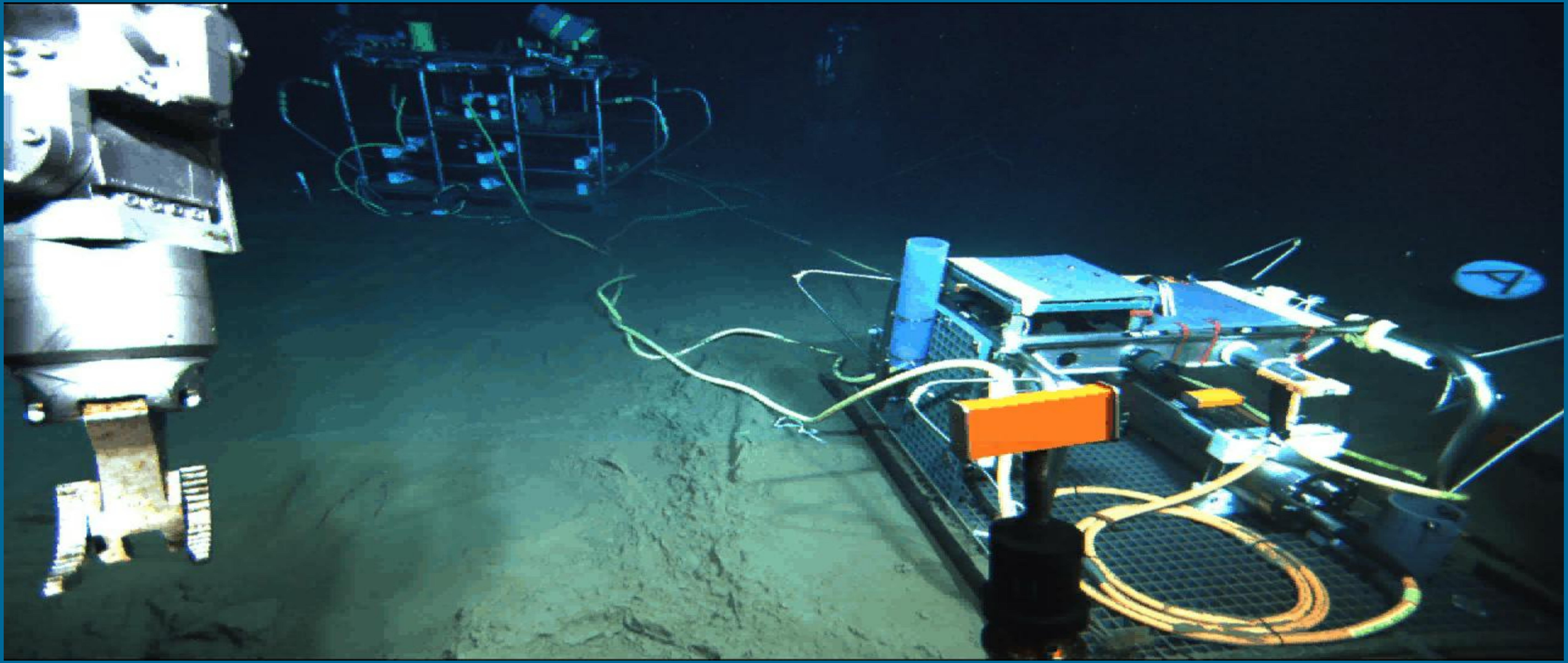
- Cable repeaters dissipate power (heat) continuously into the seawater environment
  - 56 Watts maximum
  - 25 – 30 Watts typical
- Power wire in cable dissipates power (heat) continuously
  - 1 Amp DC constant supply current
  - Power line resistance depends on wire type and temperature, at 3 degrees C
    - 0.95 Ohm/km for SL17
    - 0.72 Ohm/km for SL21
  - Worst case I^2R power is 950 µW/m
- Thermistor in Sea-Bird products typically has self heating of ~ 3 µW
- Cables use seawater ground
  - No contribution to heat budget

Example: ALOHA Cabled Observatory

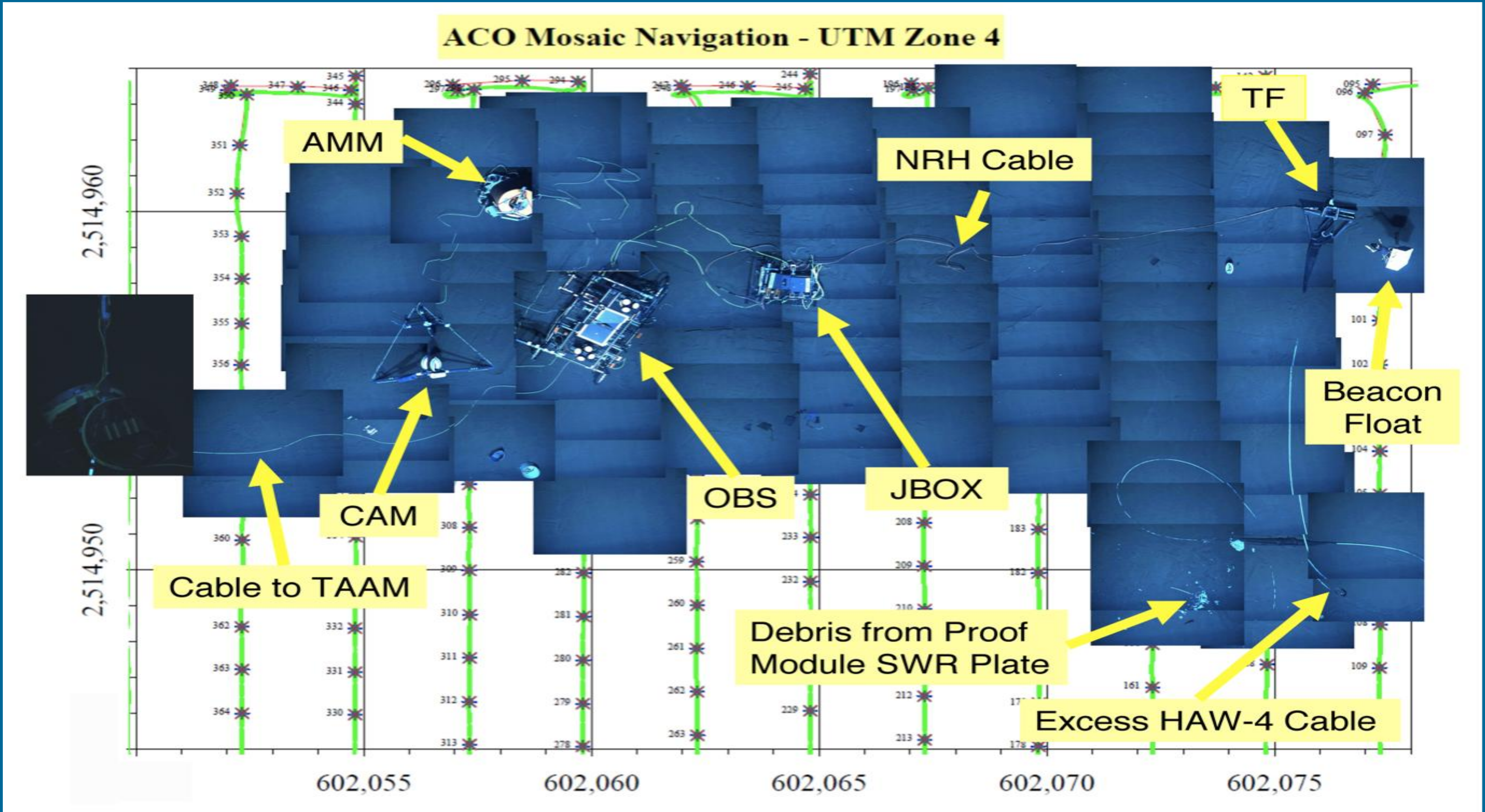
- Seafloor deployment of multi-parameter ocean observing system
- Power and data from repurposed communication cable
- System includes measurement of abyssal temperature



What it looks like on the Seafloor

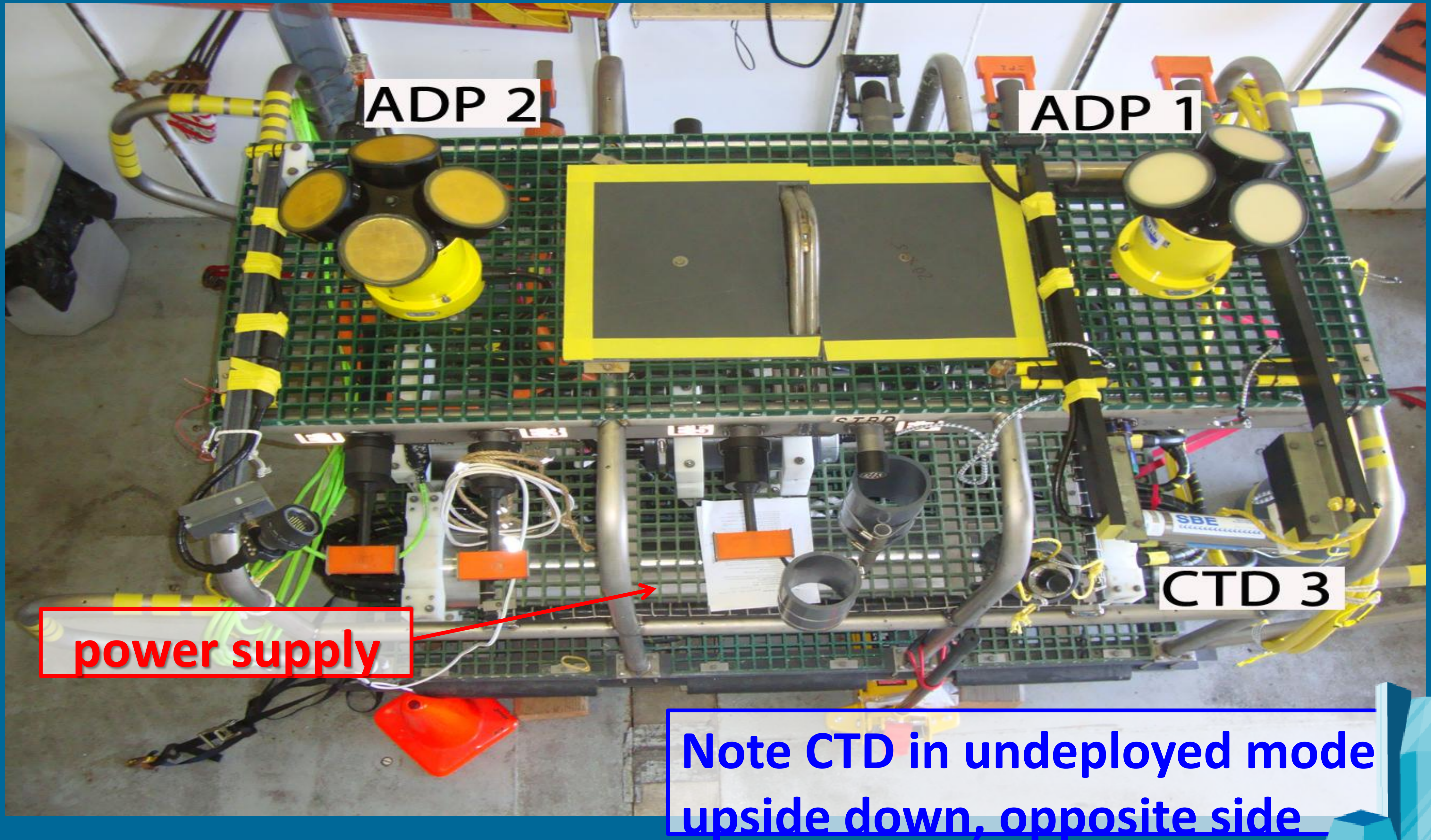


Mosaic of Seafloor Installation

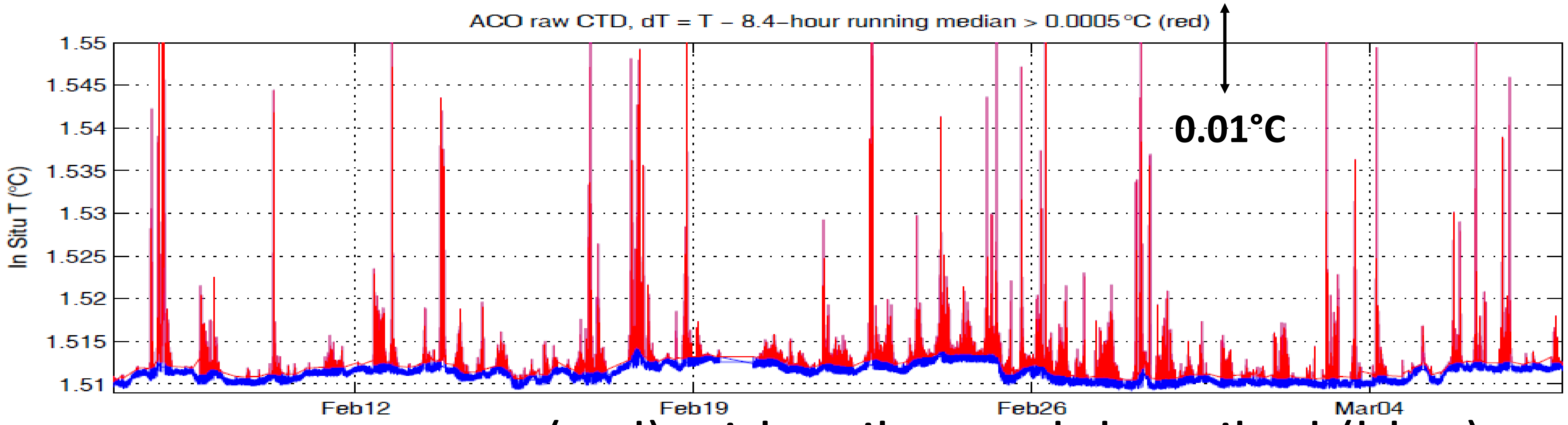


Position of Power Supply and Thermometer

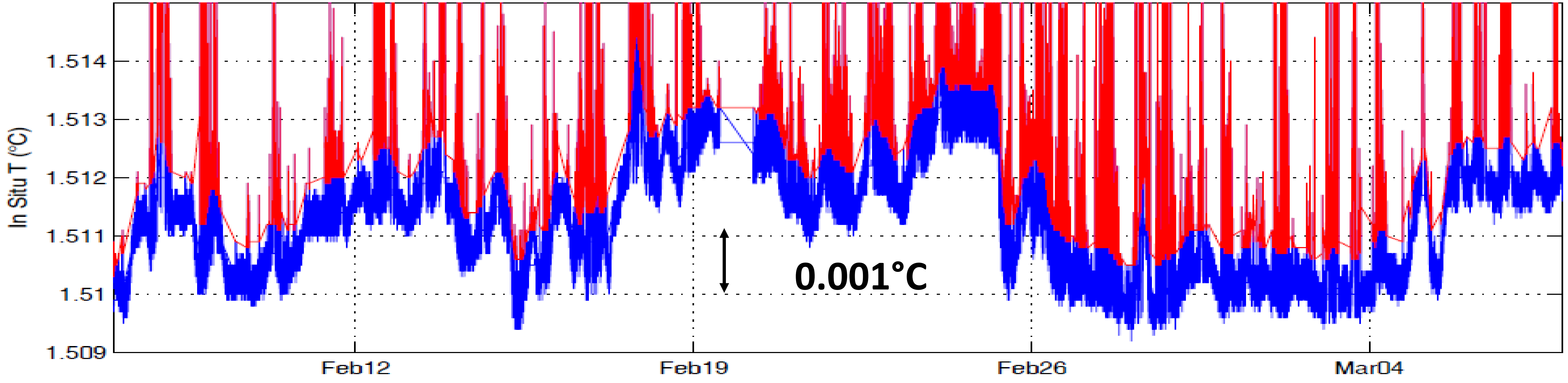
- CTD swings out of frame, up and over upon deployment



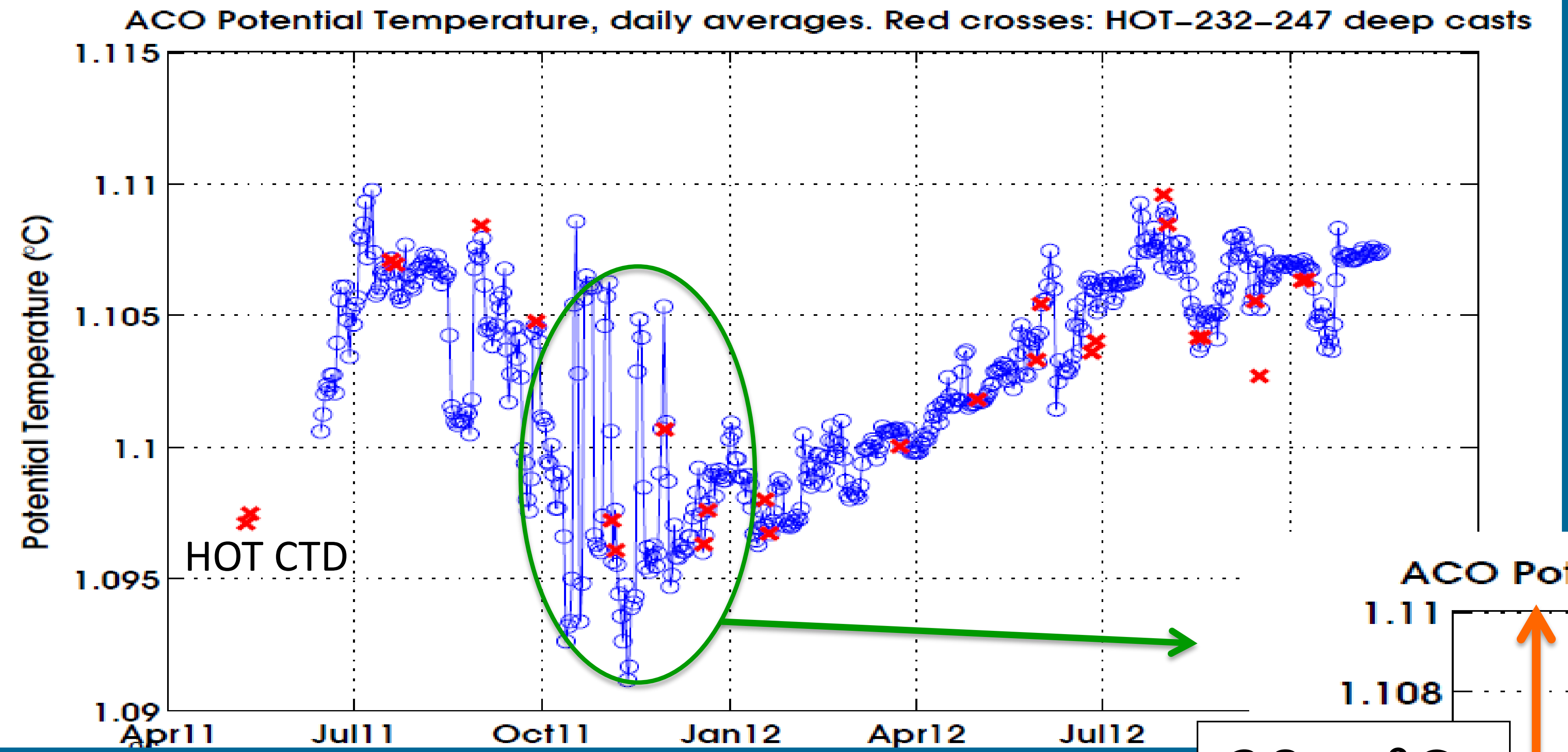
Seafloor Temperature Record – Spikes from heat of power supply



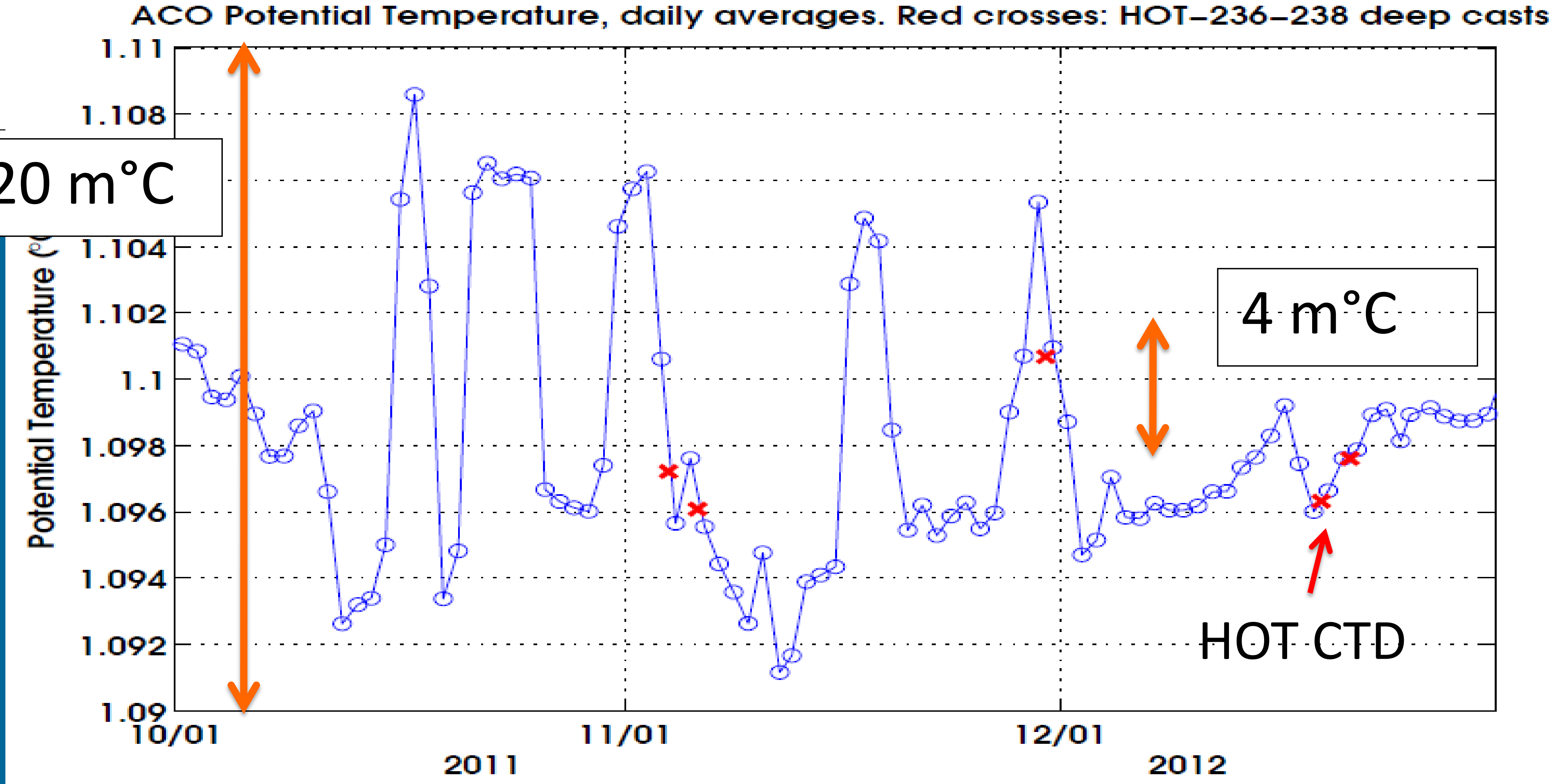
raw temperature (red) with spikes and de-spiked (blue)



Data Is Useful But Requires Manipulation



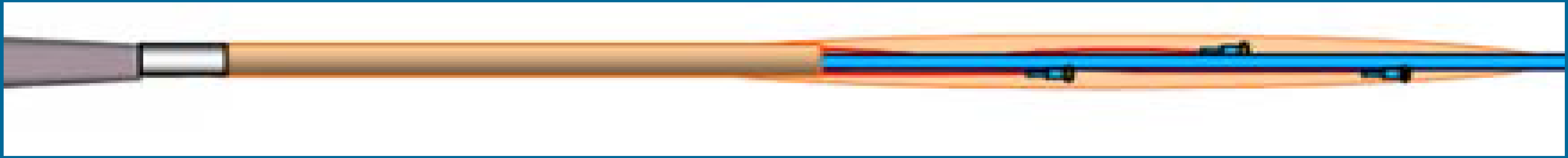
- Data is de-spiked and averaged daily
- Variations are real and not equipment induced artifact



- Red crosses are data from equipment lowered from ship ~ 1.2 km distant
- Ship's instruments measure for a few minutes at depth each monthly visit
- Continuous sampling yields much more information than intermittent data from ships

Design Challenges

- Embedding a thermometer in or very near a repeater will not yield useful data
- Embedding a thermometer in a cable at some distance from a repeater much more attractive
  - Must design to shield thermometer from heating within the cable from power wire
  - Need to model heat flow within the cable
  - Best design would have multiple thermometers at each repeater to avoid being buried in the mud
- Candidate designs should be tested *in-situ* at a site such as the ALOHA Cabled Observatory



Courtesy Peter Phibbs and TE Subcom

Thank you