Spatial Analysis of Abyssal Temperature Variations Observed From the ALOHA Cabled Observatory and WHOTS Moorings

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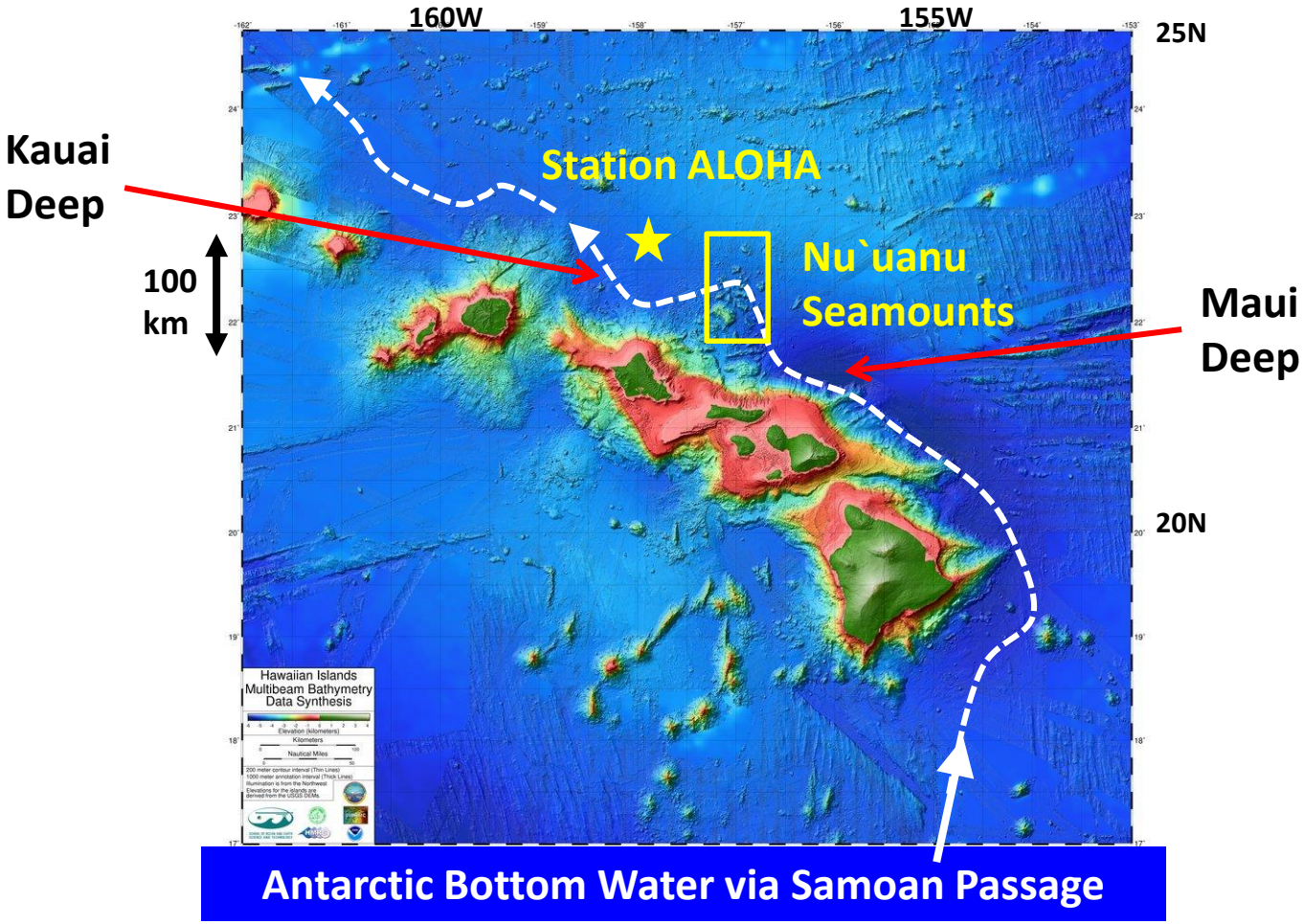
2016 Ocean Sciences Meeting

- Introduction/Motivation
  - Background on abyssal circulation
  - Cold events and oscillations. Hawaii Ocean Time-series (HOT)
- Temperature calibrations and accuracy
- Temporal character of temperature differences. ALOHA Cabled Observatory (ACO)
- Spatial character of temperature differences. WHOTS mooring data
- Discussion/Summary

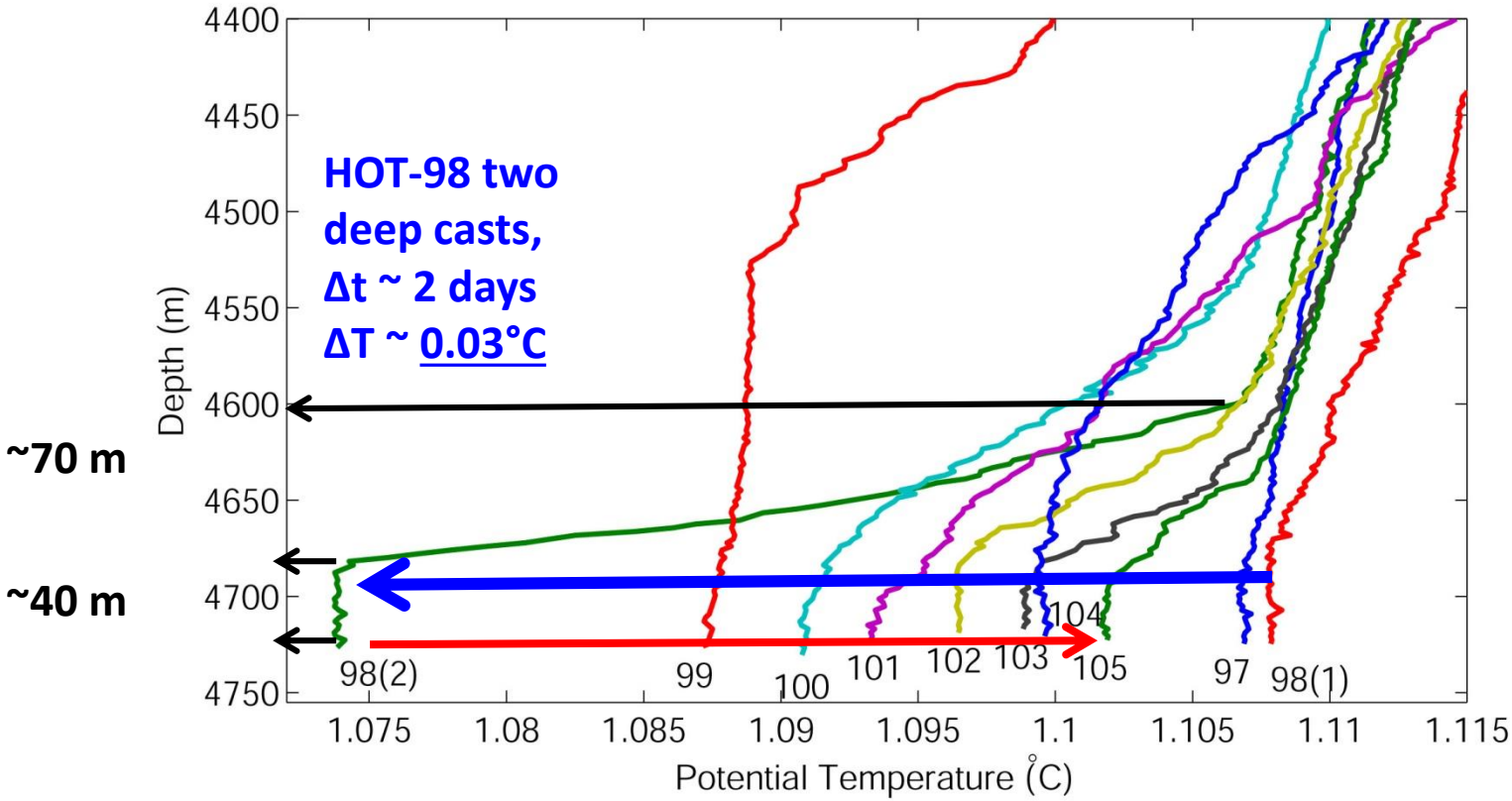
Central North Pacific AABW Circulation and Topographic Constraints



bathymetry from Hawaii Mapping Research Group/SOEST/UH

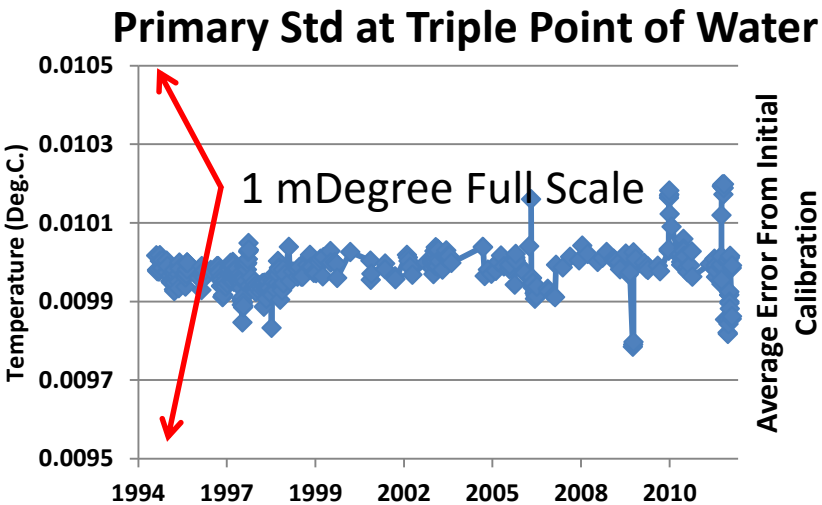
Rapid Cold Event Onset and Slow Recovery

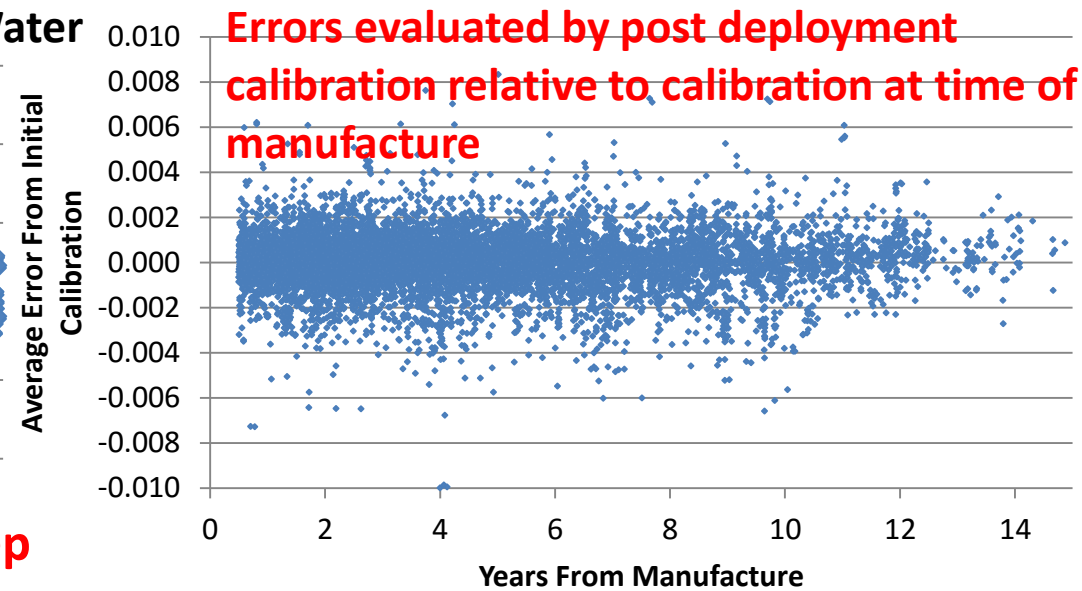
Hawaii Ocean Time-series deep Sea-Bird 911+CTD profiles, dual SBE-3F temperature sensors calibrated to better than 1 mK after every cruise @ Sea-Bird



HOT cruise # indicated below each profile

Accuracy and Stability of Thermometers used in SBE-37 Microcats, SBE-16 Seacats

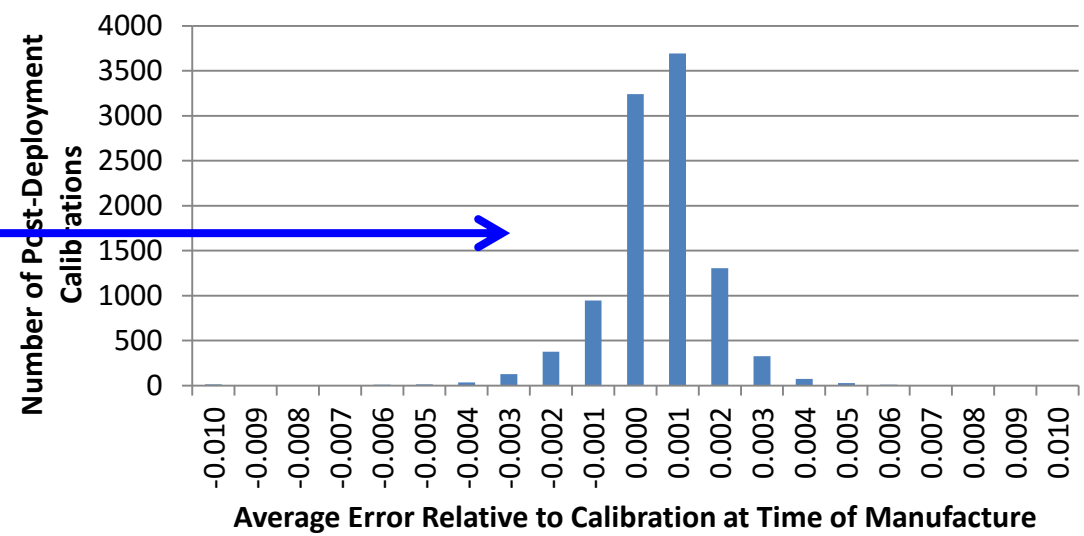




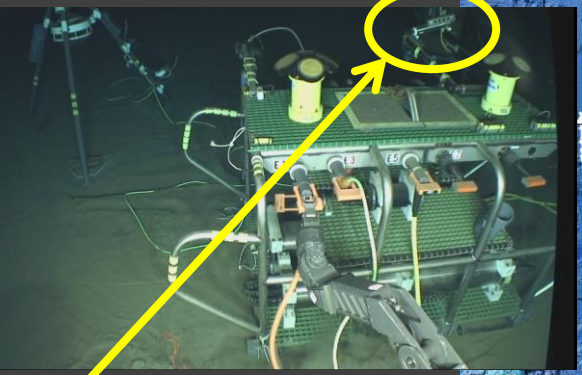
Calibration standard used for deep ocean temperatures; shows the stability of the calibration

Histogram of the upper right plot. Average error is calculated for each calibration across the calibration range of -1.0 – 32.5 C

High accuracy and stability

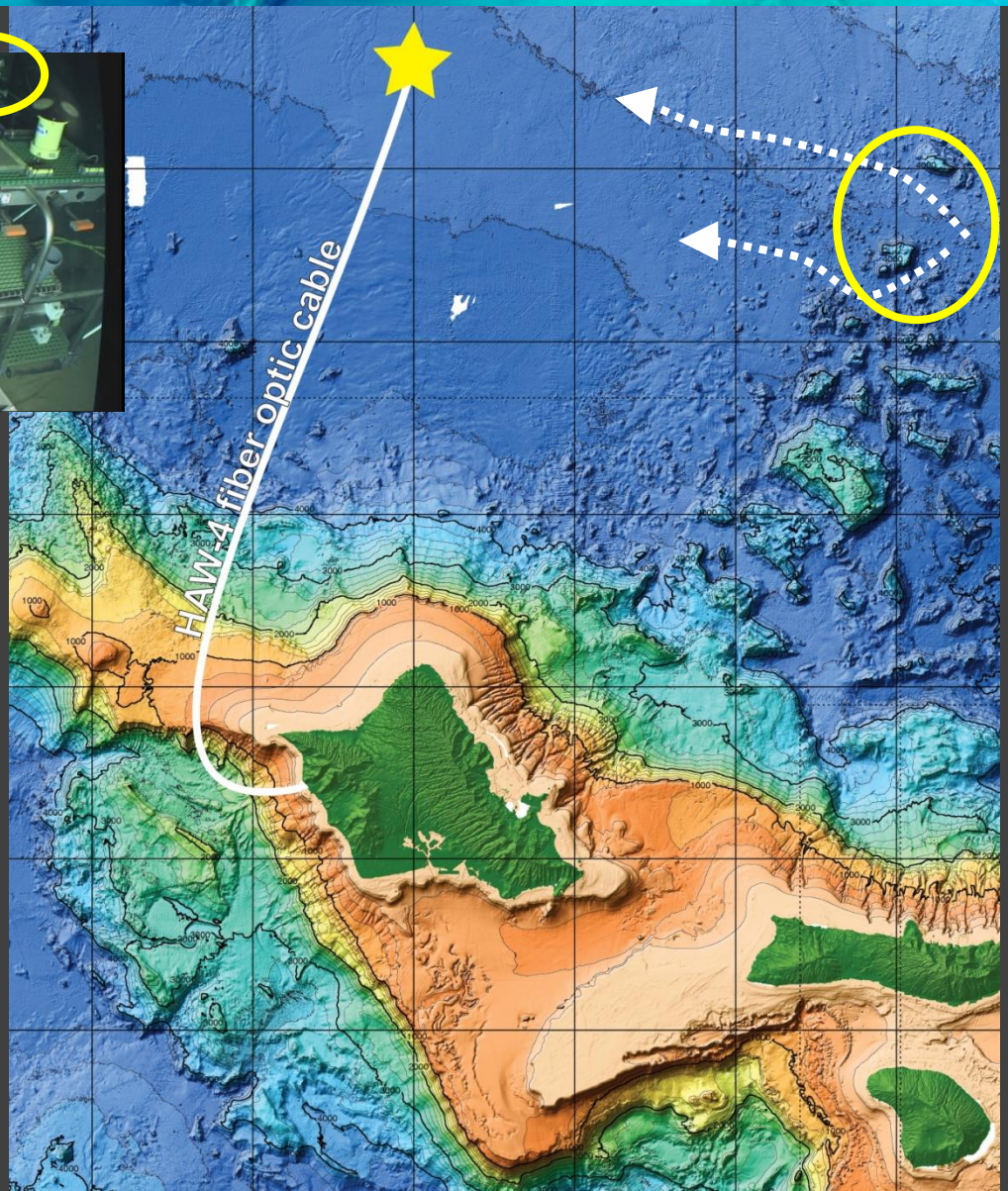


ALOHA Cabled Observatory



SBE-37 on outrigger from Observatory module

(see Howe et al. OD11A-04)



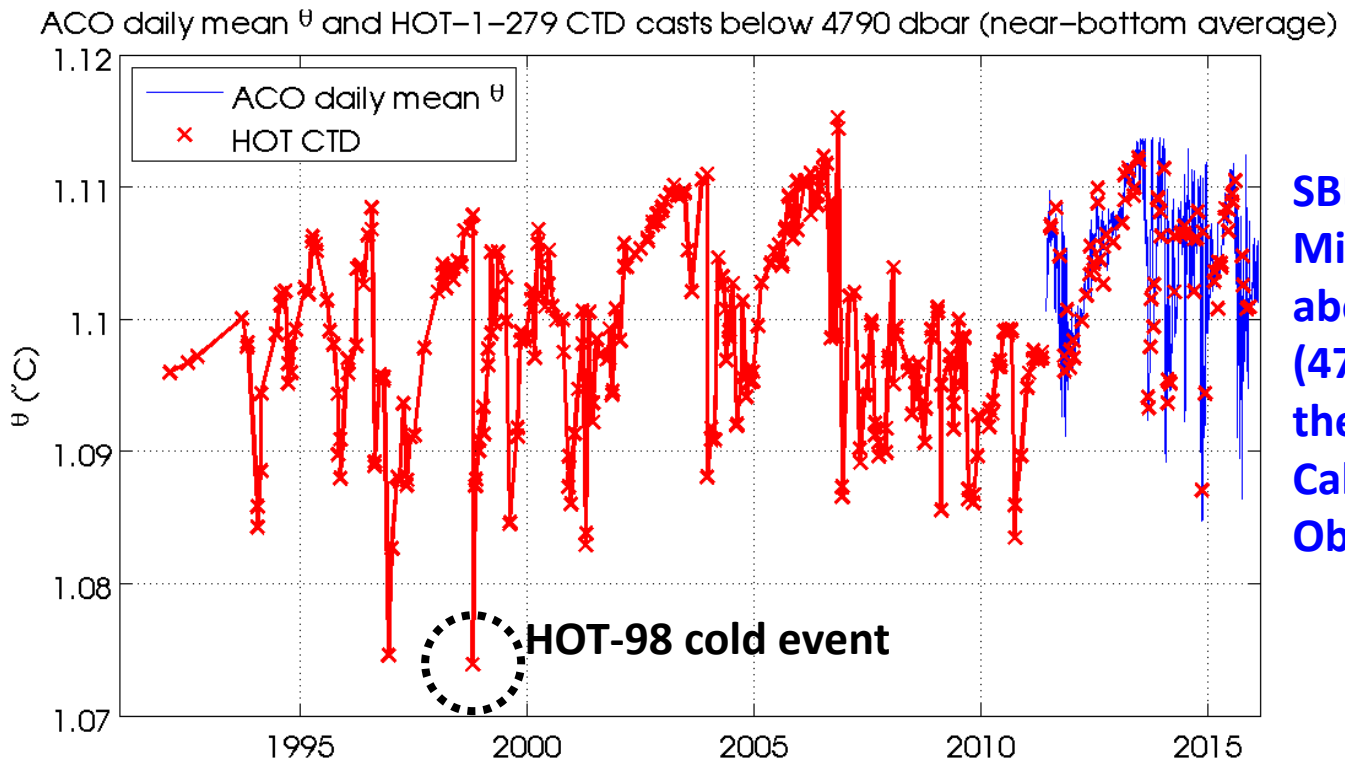
bottom water overflow pathways

(see Deppe et al. poster 90302)

History of Cold Bottom Water Events at Station ALOHA

Hawaii Ocean Time-series (Lukas et al., 2001)
and ALOHA Cabled Observatory (Alford et al., 2011)

SBE-911+ CTD with SBE-3F T-sensors



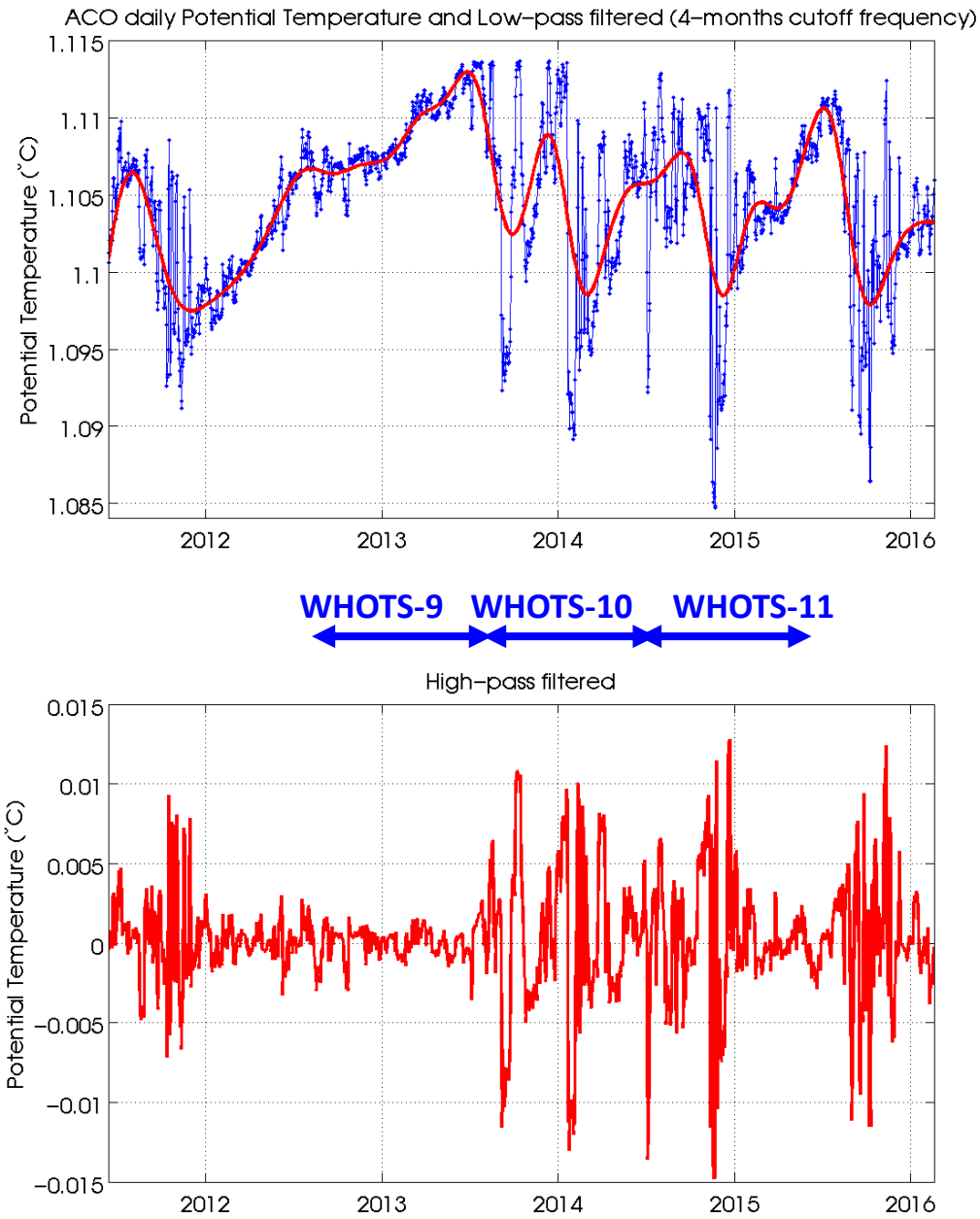
SBE-37 Microcat 1.8 m above bottom (4728 m) on the ALOHA Cabled Observatory

Low-pass filtered (120-day cutoff) ACO signals are 15 mK peak-to-peak

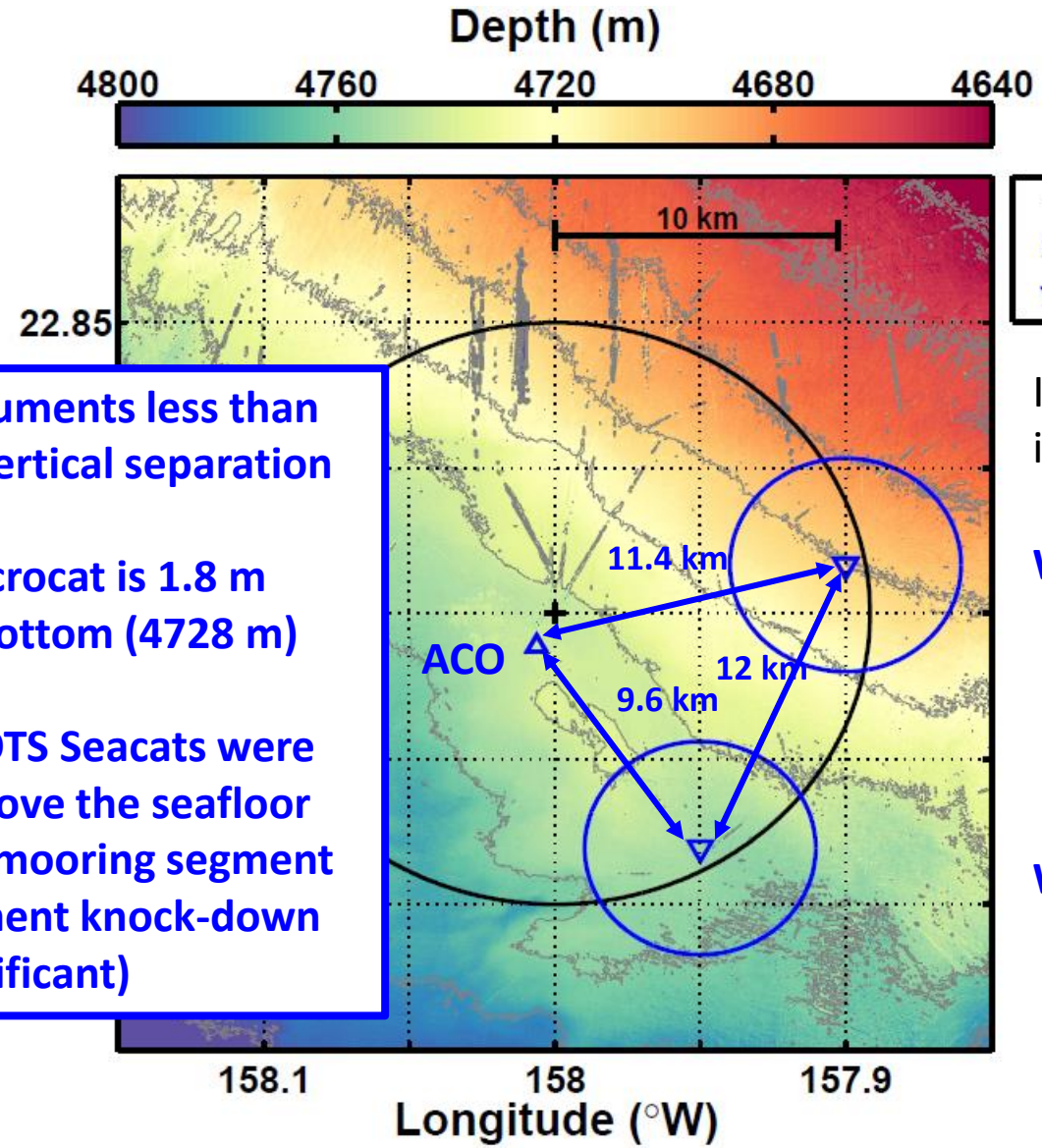
WHOI-Hawaii Ocean Time-series Site moorings with dual SBE-16 Seacats 37 m above bottom

High-passed variability 27.6 mK p-p

Cold events show increased variance an order of magnitude larger than measurement uncertainty



Station ALOHA bathymetry and instrument locations



+ Station ALOHA
△ ACO
▽ WHOTS stations

Isobaths at 20 m intervals

WHOTS-9 & -11 anchor locations and buoy watch circles

WHOTS-10

All instruments less than 100 m vertical separation

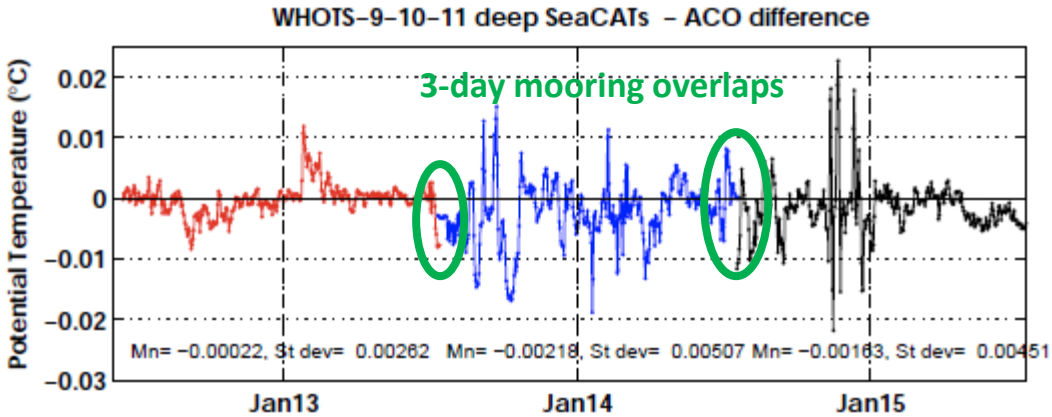
ACO Microcat is 1.8 m above bottom (4728 m)

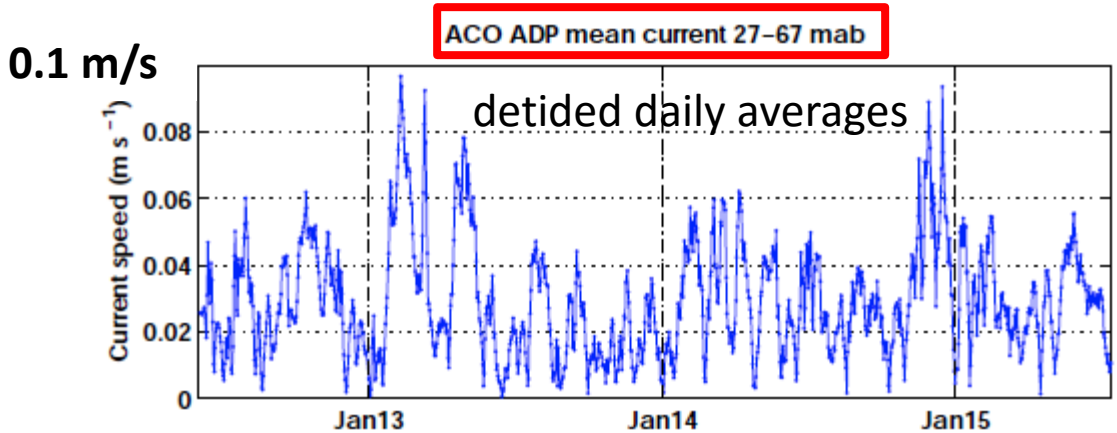
All WHOTS Seacats were 37 m above the seafloor on taut mooring segment (instrument knock-down not significant)

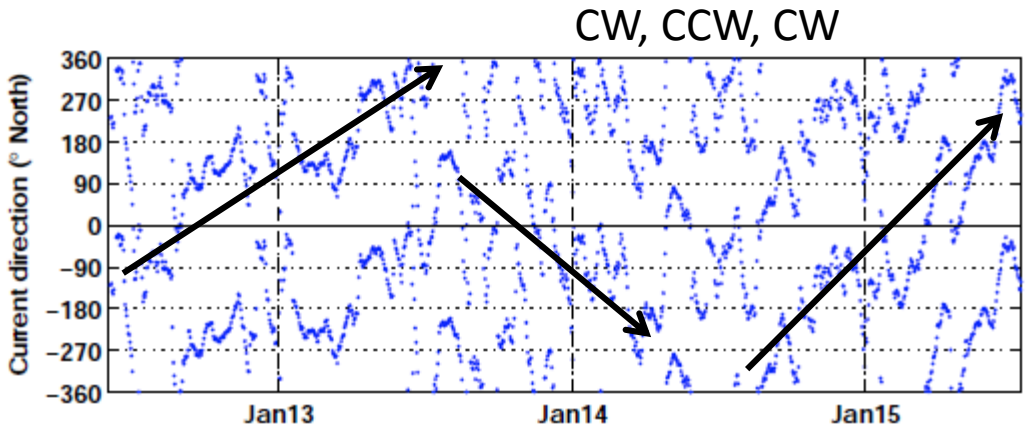
Three WHOTS mooring deployments each with dual SBE-16 Seacats above anchor releases, 37 m above bottom

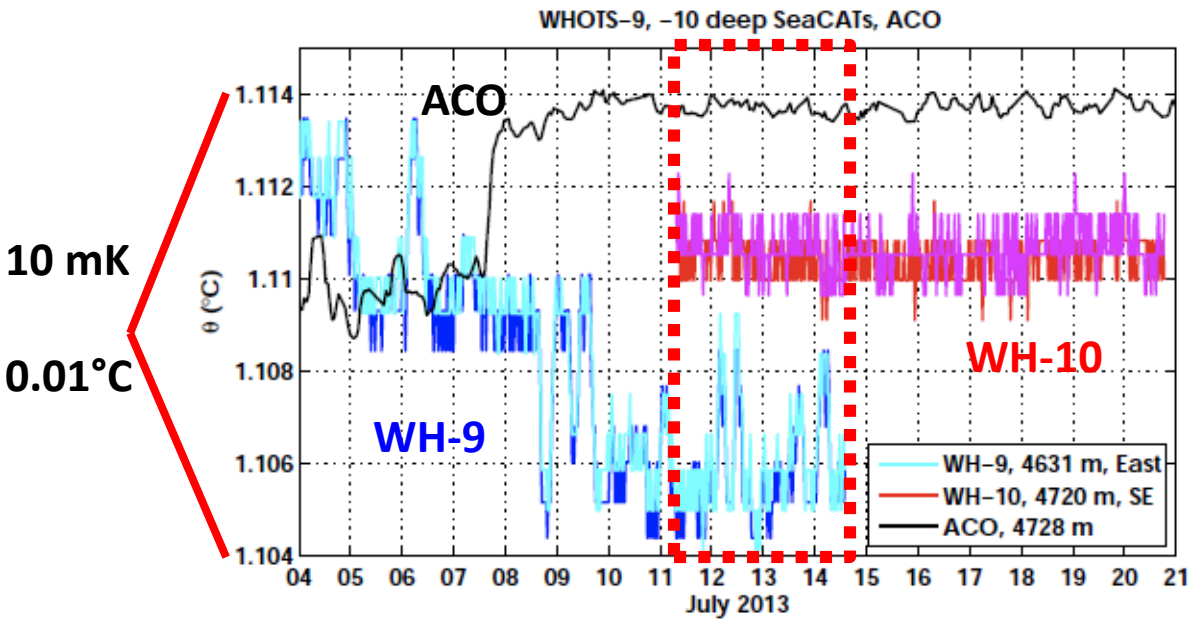
Potential temperature differences from ACO reach more than ±0.02°C (20 mK).

ACO current speed and direction reveal complex dynamics





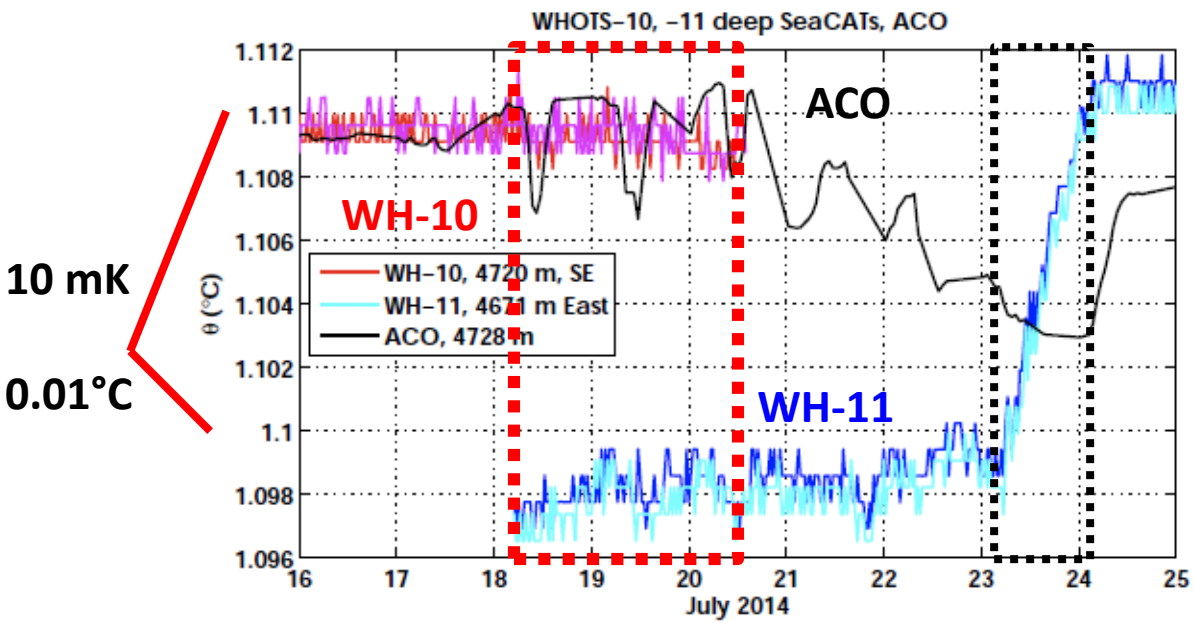




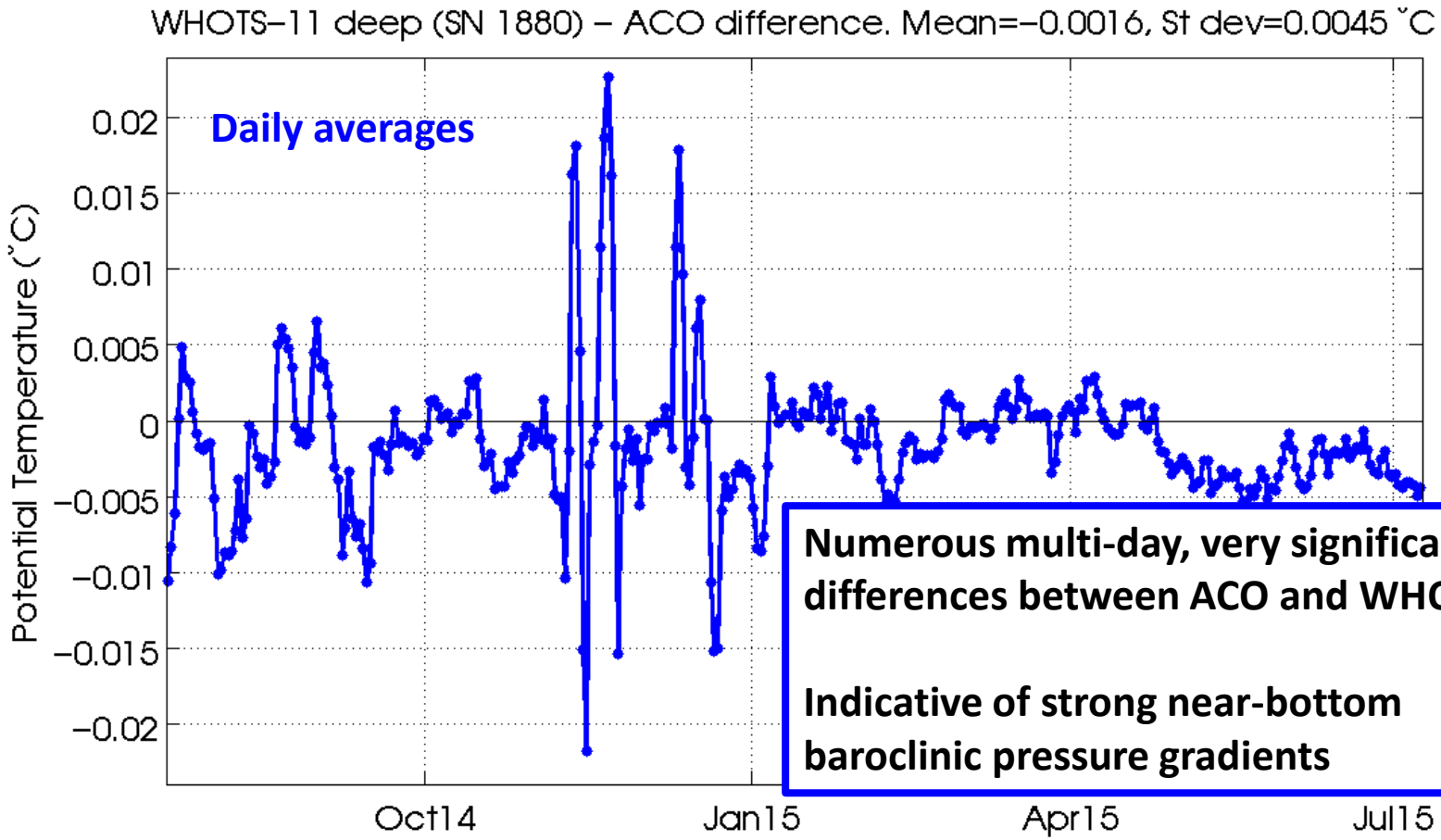
Simultaneous θ differences across 10-12 km over three days

WHOTS-ACO differences 0-11 mK, WHOTS colder (9.6-11.4 km separation ~along isobaths)

WHOTS-WHOTS differences 2-11 mK (12 km separation across isobaths)



11 mK warming in one day at WH-11

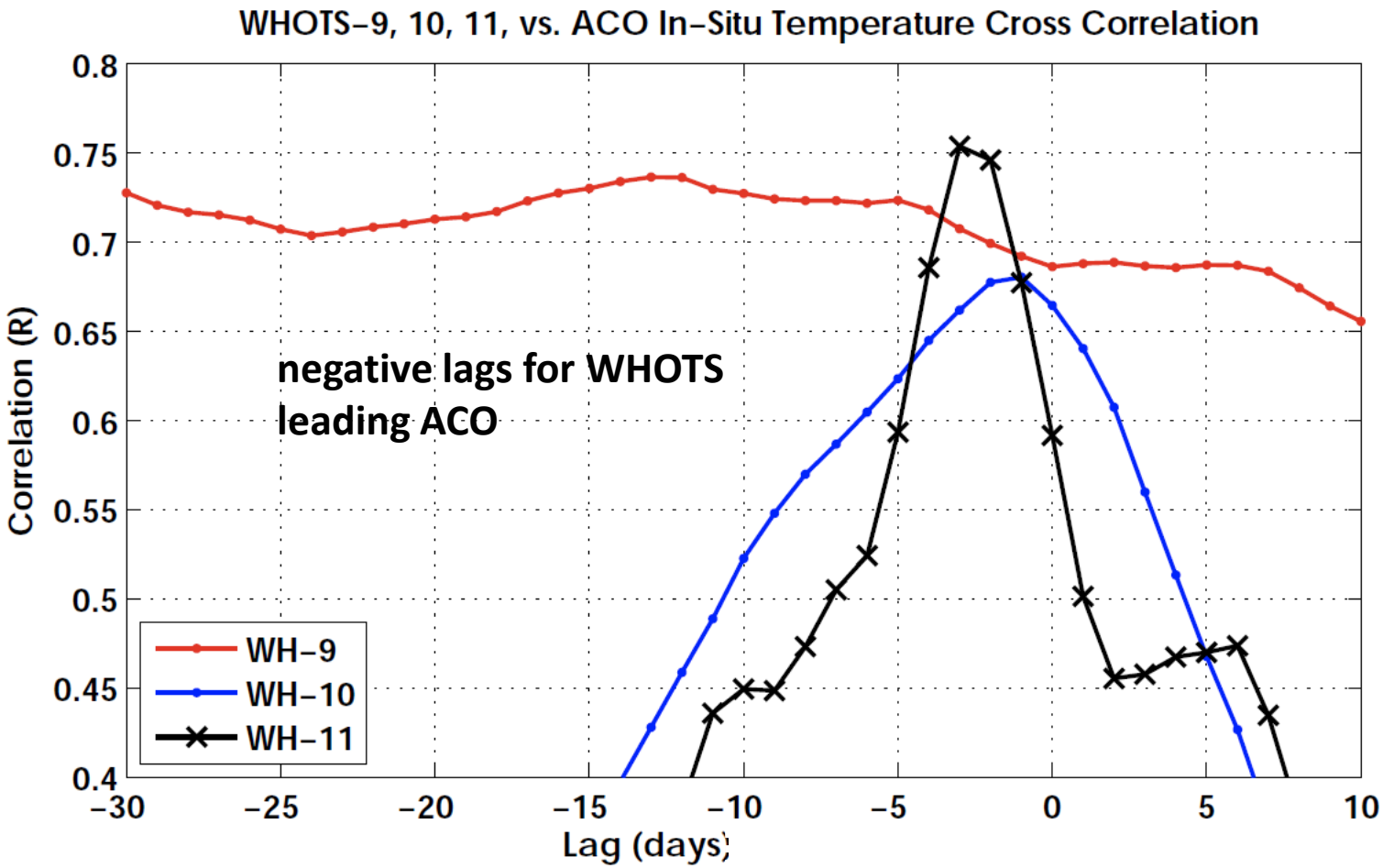


Numerous multi-day, very significant differences between ACO and WHOTS-11

Indicative of strong near-bottom baroclinic pressure gradients

WHOTS-9 tracks ACO very closely except for one month-long event.

WHOTS-10 and -11 differences from ACO are larger and <u>lead</u> ACO by 1-day and 2-3 days respectively. 10-12 km separation, so ~0.13 m/s propagation speed (faster than mean currents).



WHOTS-ACO
Potential Temperature Differences

WHOTS-ACO	WHOTS-9	WHOTS-10	WHOTS-11
Mean Δ	-0.22 mK	-2.18 mK	-1.63 mK
RMS Δ	2.62 mK	5.07 mK	4.51 mK

All instruments near bottom, with vertical separation < 100 m

~one-year mooring deployments

Mean θ differences from ACO highly significant for WHOTS-10 and -11, with WHOTS sites to east and southeast of ACO colder

Magnitude and variability of WHOTS-ACO θ differences changed markedly between WHOTS-9 and subsequent period

Discussion

- Large dynamic abyssal temperature signals in the Kauai Deep — cold overflow events and oscillations — much greater than instrumental uncertainty

- One-year mean θ differences are real and significant;

WHOTS colder than ACO is consistent with bottom water source to east — the Maui Deep

- RMS ACO-WHOTS differences ~5 mK during 2014-2015 (~10 km separation)

Simultaneous WHOTS-ACO differences exceed 1 mK/km over several days

Strong near-bottom baroclinic pressure gradients

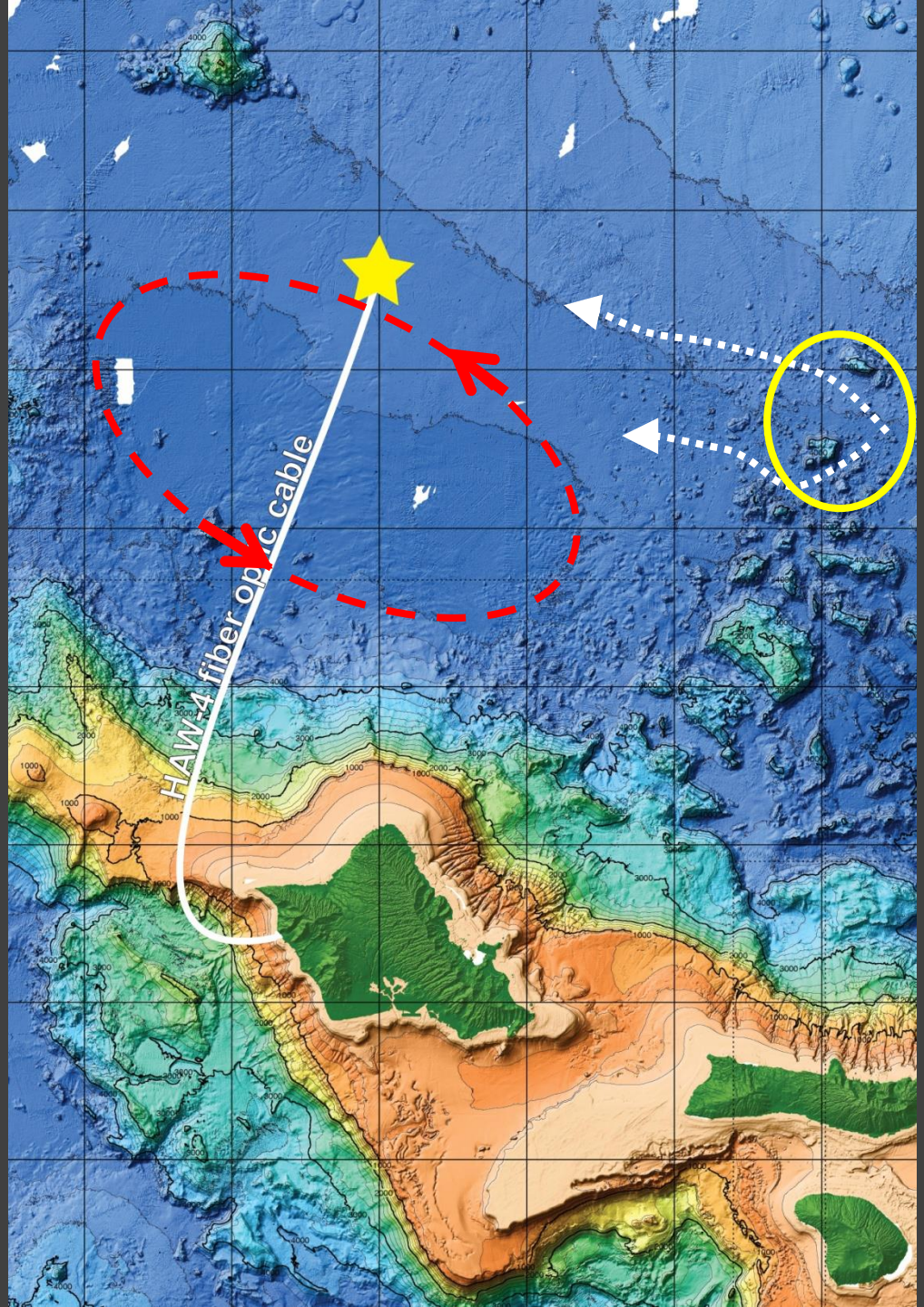
Discussion

Signals propagate from east to west on average, faster than the daily mean near-bottom flow @ the ALOHA Cabled Observatory

Internal Kelvin waves with periods of days to weeks?

Consistent with westward propagation at ALOHA (i.e. counterclockwise propagation around Kauai Deep)

Internal
Kelvin wave
propagation ?



bottom water
overflow
pathways

(see Deppe et al.
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Discussion

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Internal Kelvin waves with periods of days to weeks?

Consistent with westward propagation at ALOHA (i.e. counterclockwise propagation around Kauai Deep)

Forcing?: May be from above (surface weather; baroclinic eddies) or by overflow gravity currents overshooting levels of neutral buoyancy

Issues: Internal Rossby radius of deformation depends on stratification, which depends on frequency and magnitude of cold overflows

Summary

- Temperature measurements accurate to better than 0.001°C across multiple Sea-Bird instruments, both in calibration lab and deployed in the abyss
- Large dynamic signals (cold overflow events; oscillations) in the Kauai Deep: Signal/noise ratio > 10
- Simultaneous WHOTS-ACO differences exceed 1 mK/km over several days; one-year mean differences are much larger than measurement uncertainty
- Signals propagate along isobaths from east to west at ALOHA
- Such non-tidal dynamics are likely occurring at many other locations along abyssal circulation pathways

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