The Impact of Deployment Height and Ship Speed on XBT Fall Rate Computations

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5th XBT Science Meeting

Tokyo, 5-7 October, 2016

Objectives

To present results from experiments to study the impact of the **deployment height** and the **ship speed** on the XBT fall rate:

- Collect simultaneous XBT/CTD profiles, with XBTs deployed from different heights with the ship at rest
- Collect XBT profiles with XBTs deployed from different heights with the ship moving
- Determine the effect of the deployment height and the ship speed in the determination of $z(t)$ using the FRE $\boldsymbol{z(t) = at - bt^2}$
- Verify and quantify the depth offset caused by the deployment height

Depth offset in XBT profiles

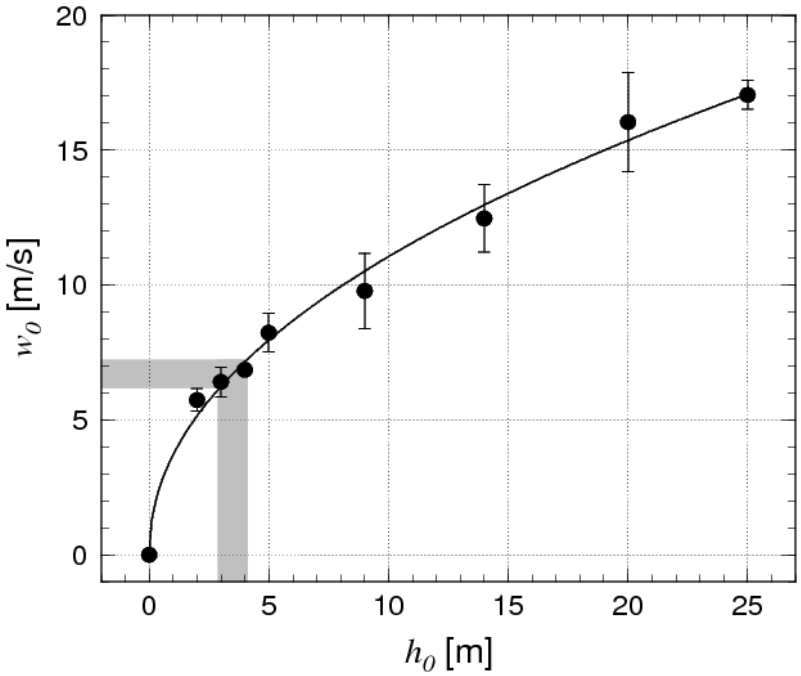
Depth offset in XBT profiles originates from:

- A time offset in the recording system
- The position of the probe at entry
- Different deployment heights

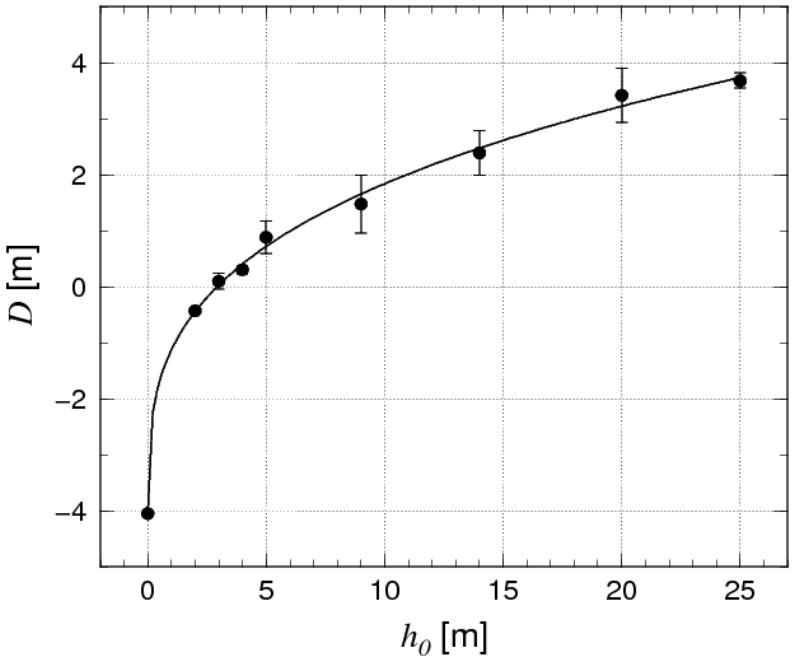
} different initial velocities of the XBTs in the water

Hallock and Teague. *J. Atmos. Oceanic Technol.* 9, 470-483 (1992)
Kizu and Hanawa. *Deep-Sea Res. I*, 49, 935–940 (2002)
Gouretski and Reseghetti. *Deep-Sea Res.* I, 57, 812–833 (2010)
Cowley et. al. *J. Atmos. Oceanic Technol.*, 30, 1195–1225 (2013)
Abraham et al. *Ocean Eng.*, 76, 1–9 (2014)
Cheng et al. *J. Atmos. Oceanic Technol.*, 31, 1793–1825 (2014)
Shepard et al. *J. Geophys. Remote Sens.*, 3, 129 (2014)
Thresher (2014). Available on-line at *http://2014xbtworkshop.csp.escience.cn*
Bringas and Goni. *J. Atmos. Oceanic Technol.*, 32, 2253–2263 (2015)

Deployment height Experiments in fresh water



Initial velocity of the XBTs in the water (w_0) as a function of the deployment height (h_0)



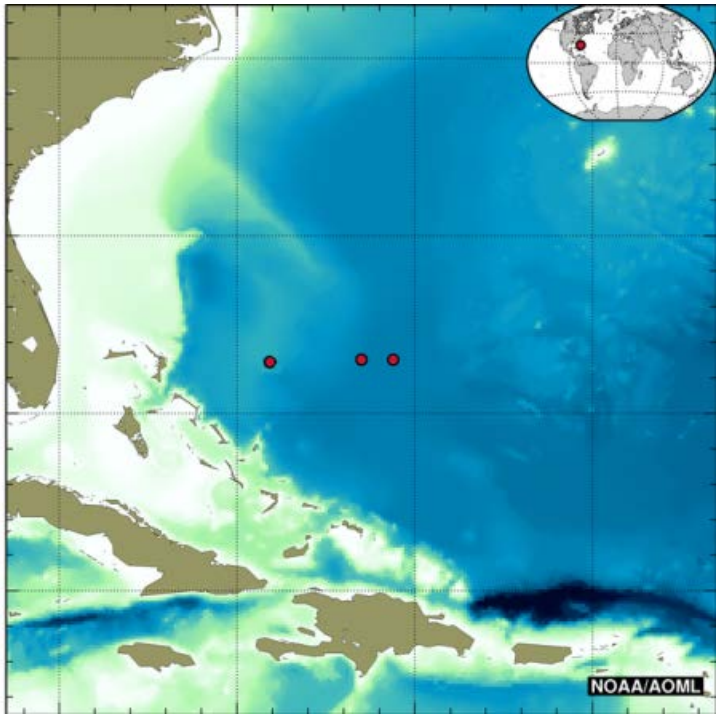
Maximum depth offset (D) in the FRE compared to H95 as a function of the deployment height (h_0)

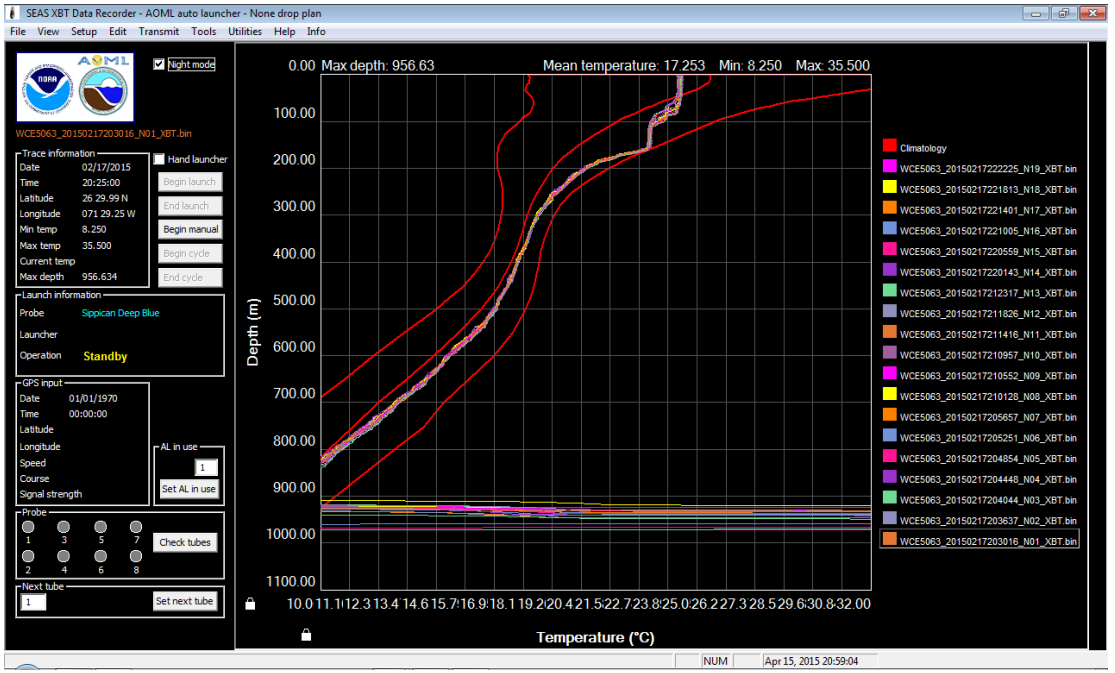
H95: Hanawa et al. *Deep-Sea Res.*, 42, 1423–1451 (1995)
Bringas, F. and G. Goni. *J. Atmos. Oceanic Technol.*, 32, 2253–2263 (2015)

At-sea Experiments

An in-situ experiment was carried during an AOML cruise in February, 2015:

- Simultaneous (Deep Blue) XBT + CTD (ship speed ~ 0)
- XBTs deployed from 2 different heights: 2.5 m and 8 m
- XBTs deployed from the same heights at ship speed ~ 9 kn





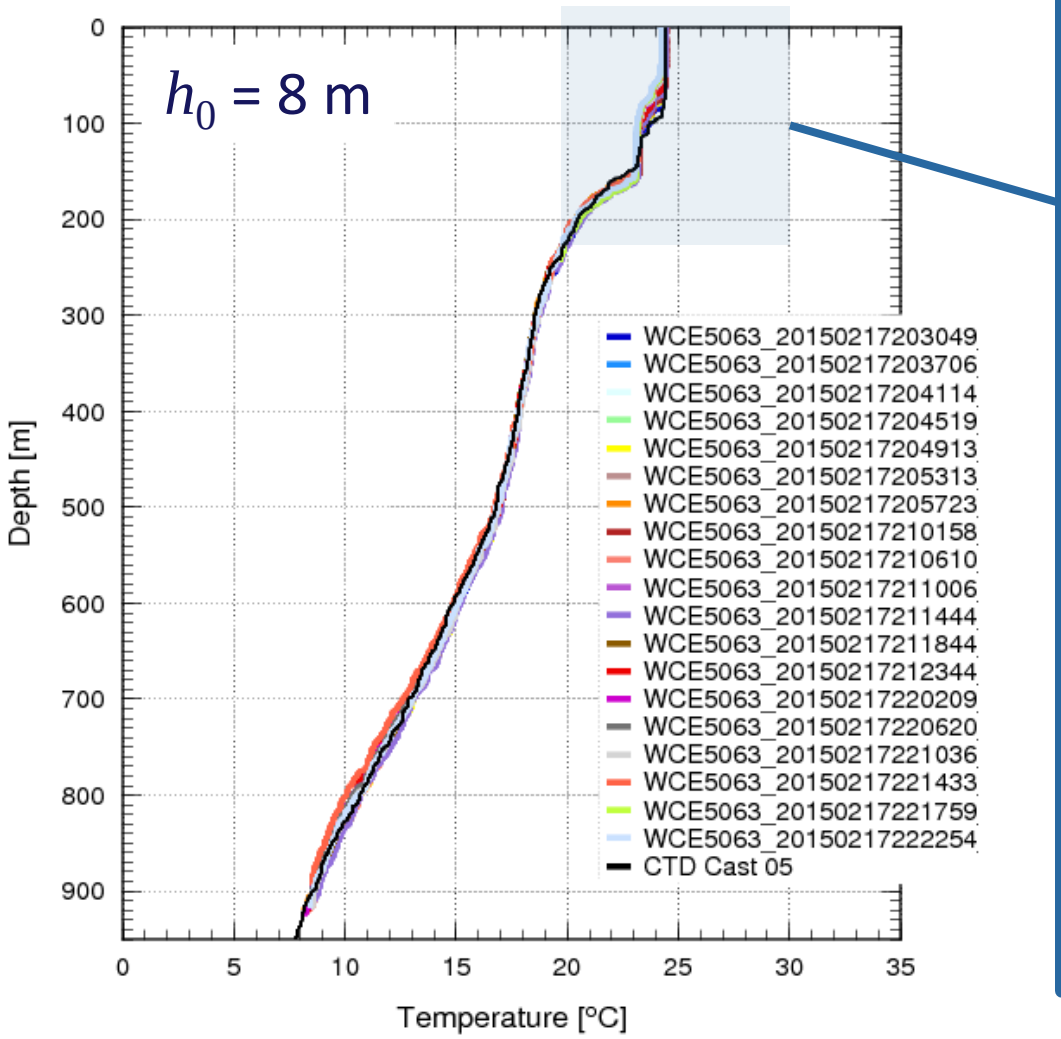
At-Sea Experiment with XBT/CTD deployments

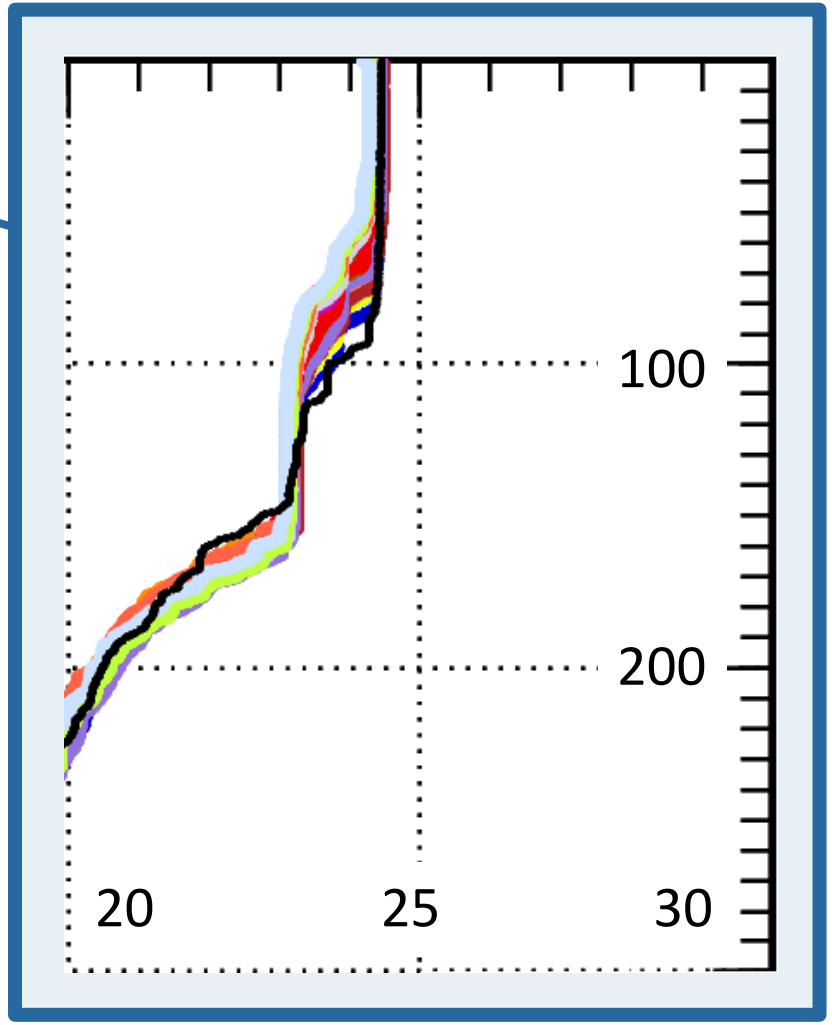
- 20 XBTs were deployed during 3 CTD stations from two different heights: 2 m and 8 m (120 XBTs deployed)
- During two ship transit between CTD stations, 20 XBTs were deployed from 2 m and 8 m (80 XBTs deployed).
- Temperature profiles were linearly interpolated to a 0.1 m resolution and the temperature gradients were determined.
- A 10-order Butterworth filter with dx = 0.1 m and cf = 0.5 m was applied to remove high frequency/low intensity peaks.
- The corresponding 4 more intense peaks in the $grad(T)$ of the XBT and CTD profiles were identified and the depth difference computed, using 3 FREs for XBTs: H95, CH14, and HT92.

HT92: Z.R. Hallock and W.J. Teague. *J. Atmos. Oceanic Technol.* 9, 470-483 (1992)
CH14: Cheng et. al. *J. Atmos. Oceanic Technol.*, 31, 1793–1825 (2014)

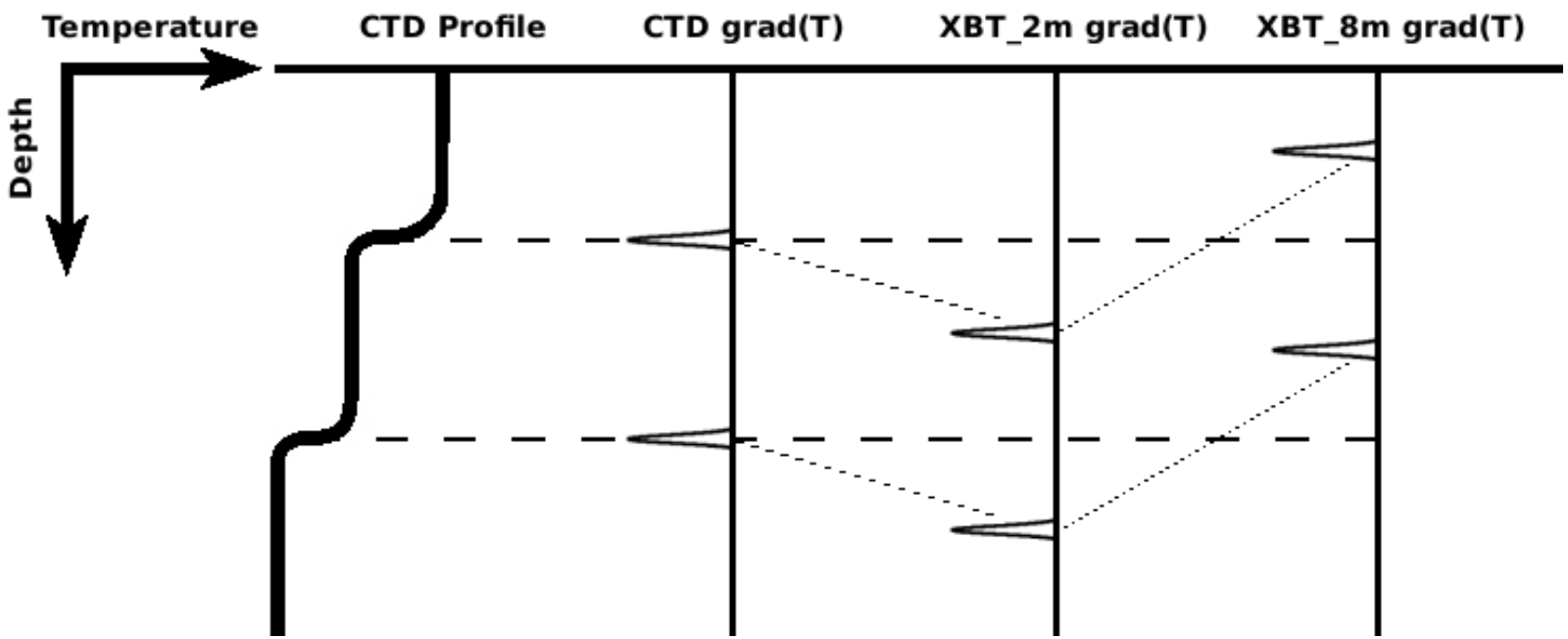
Results

XBTs and CTD profiles during 2nd CTD cast



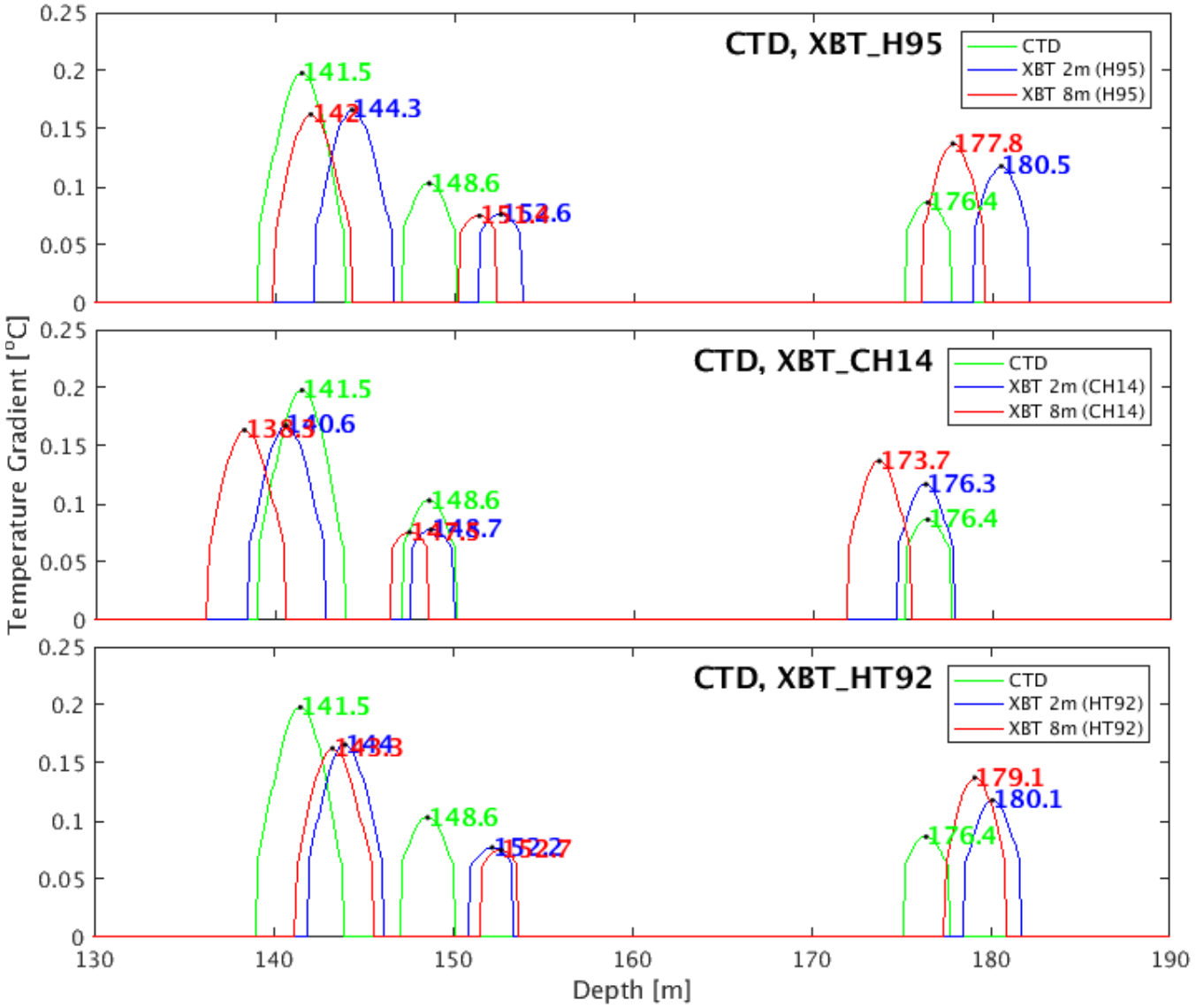


Results



$$z_{XBT\_8m} < z_{CTD} < z_{XBT\_2m}$$

Results



$z'_{2m} - z'_{8m} \approx 1.7$ m

$z_{CH14} < z_{H95}$

$z'_{2m} \approx z'_{8m}$

Results

Maximum depth offset for profiles with

a) $z_{XBT\_2m} > z_{XBT\_8m}$ ⟶ **(70% of all peaks)**

b) $z_{XBT\_2m} - z_{XBT\_8m} \leq 8m$ according to H95

XBT vs CTD (Ship speed ~ 0)

	$z_{CTD} - z_{XBT\_2m}$	$z_{CTD} - z_{XBT\_8m}$	$z_{XBT\_2m} - z_{XBT\_8m}$ (m)
(H95)	2.88 ± 3.71	1.25 ± 3.81	1.63 ± 0.97
(CH14)	-1.32 ± 3.77	-2.93 ± 3.83	1.61 ± 0.96
(HT92)	2.54 ± 3.70	2.58 ± 3.82	-0.05 ± 0.97

- $\Delta z_{XBT} = z_{XBT\_2m} - z_{XBT\_8m}$ = 1.6 m = D (consistent with previous experiments/results) when using H95 and CH14
- CH14 applies a constant (time and temperature dependent) depth offset term ≈ 4 m that may be too large
- HT92 provides a good correction for the simultaneous XBT profiles deployed from 2 and 8 m resulting in $D \approx 0$.

Results

Maximum depth offset for profiles with

a) $z_{XBT\_2m} > z_{XBT\_8m}$ ⟶ **(70% of all peaks)**

b) $z_{XBT\_2m} - z_{XBT\_8m} \leq 8m$ according to H95

XBT vs CTD (Ship speed ~ 0)

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XBT vs XBT (Ship speed ~ 9 kn)

	$z_{XBT\_2m} - z_{XBT\_8m}$ (m)
(H95)	1.61 ± 0.82
(CH14)	1.58 ± 0.85
(HT92)	-0.05 ± 0.84

Conclusions

- A depth offset $D \approx 1.6$ m was observed in temperature profiles of XBTs deployed from $h_0 = 8$ m, consistent with previous results from experiments in fresh water.
- The depth offset caused by the deployment height is not properly corrected by the statistical CH14 method. The constant term in the CH14 FRE ≈ 4 m seems to be too large in our results.
- The model by HT92 provides a reduction of the deployment height derived depth offset from 1.6 m to 0.05 m.
- In these preliminary results, no effect was observed in the depth offset of XBTs deployed from different heights at ship speeds ≈ 9 kn.