Photo: Michael Field, 2011.

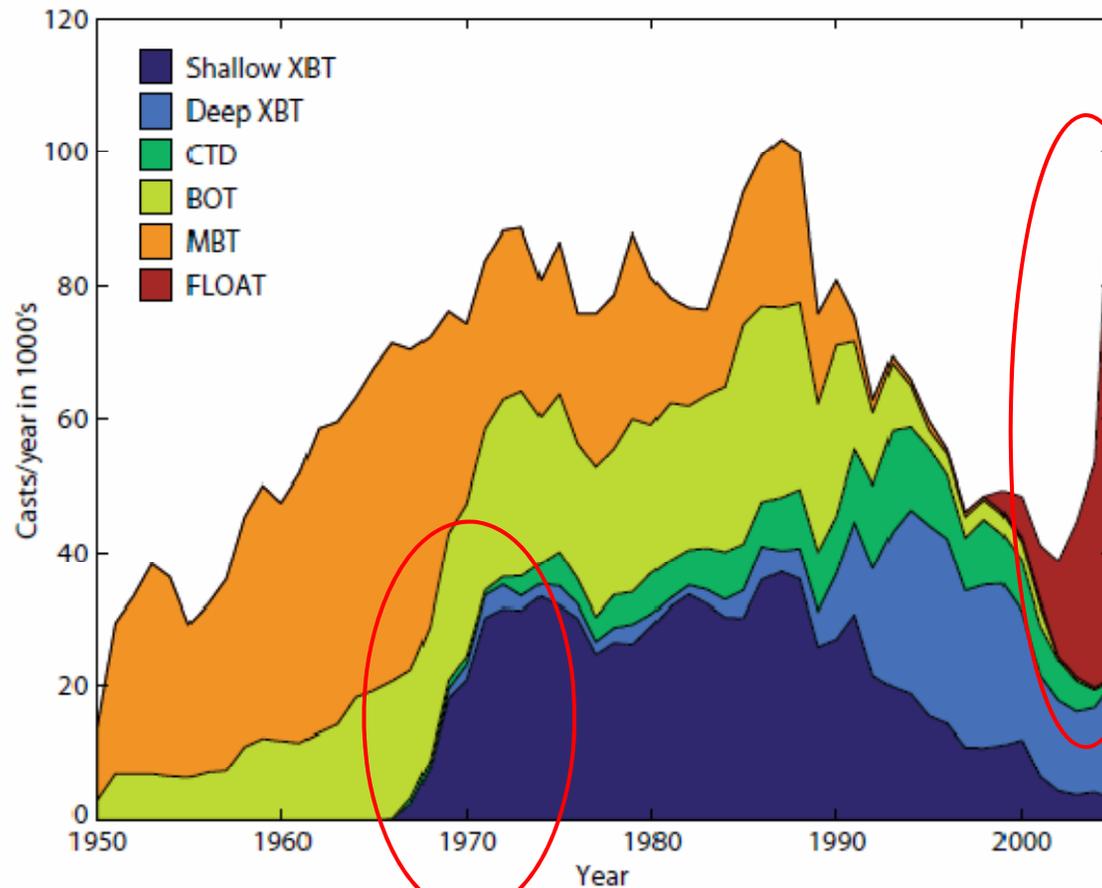# A new view of biases in historical Expendable BathyThermograph (XBT) data based on side-by-side comparisons

Rebecca Cowley, Susan Wijffels (CSIRO)

Lijing Cheng (Chinese Academy of Sciences)

Tim Boyer (NODC, NOAA)

Shoichi Kizu (Tohoku University, Japan)

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XBTs and global observations

~30% of available ocean temperature data is XBT data

From 1970 to mid 1990's, XBTs comprise ~50% of data, excluding MBTs whic are low accuracy.

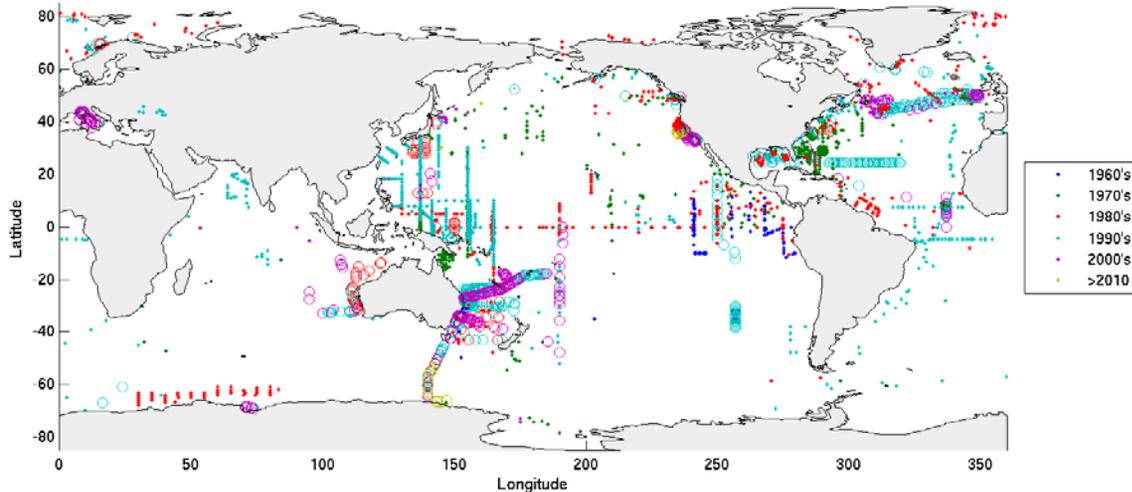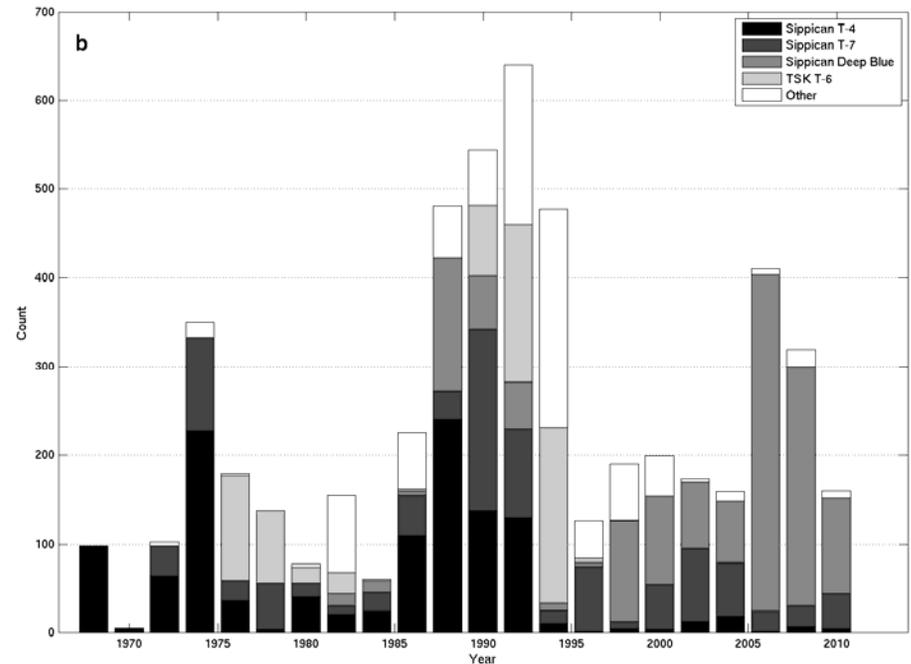# The role of XBTs in heat content and sea level estimates

Ocean heat content and sea level estimates have shown a 'hump' during the 1970's to 1980's

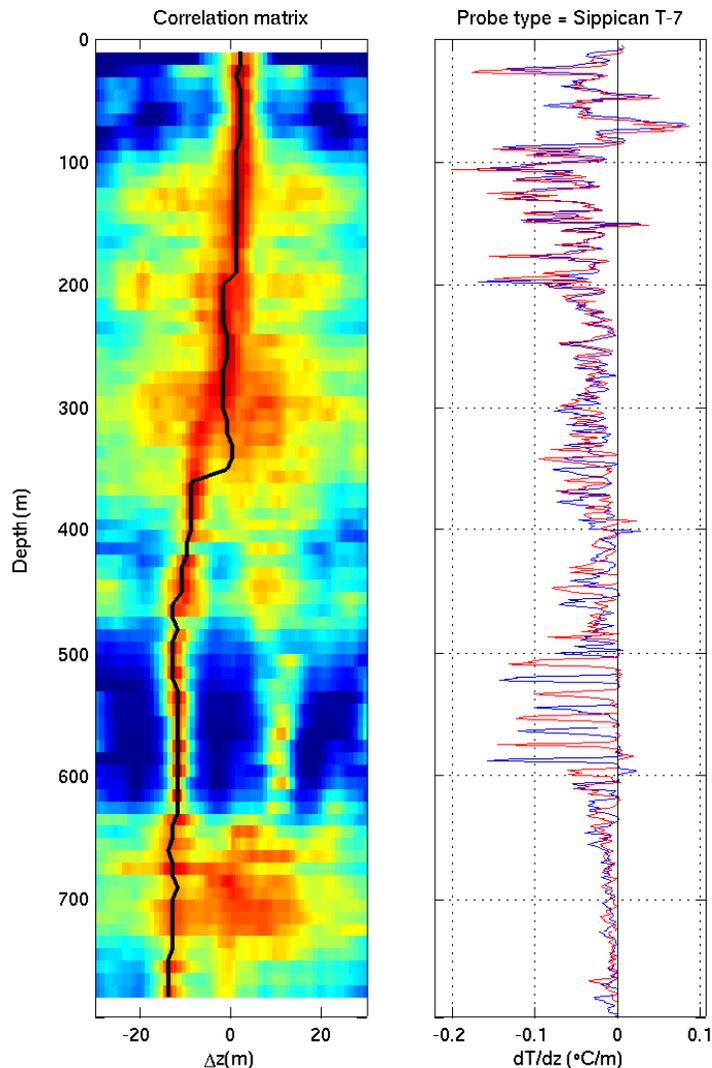When the warm bias in XBT data is accounted for, the 'hump' is reduced.
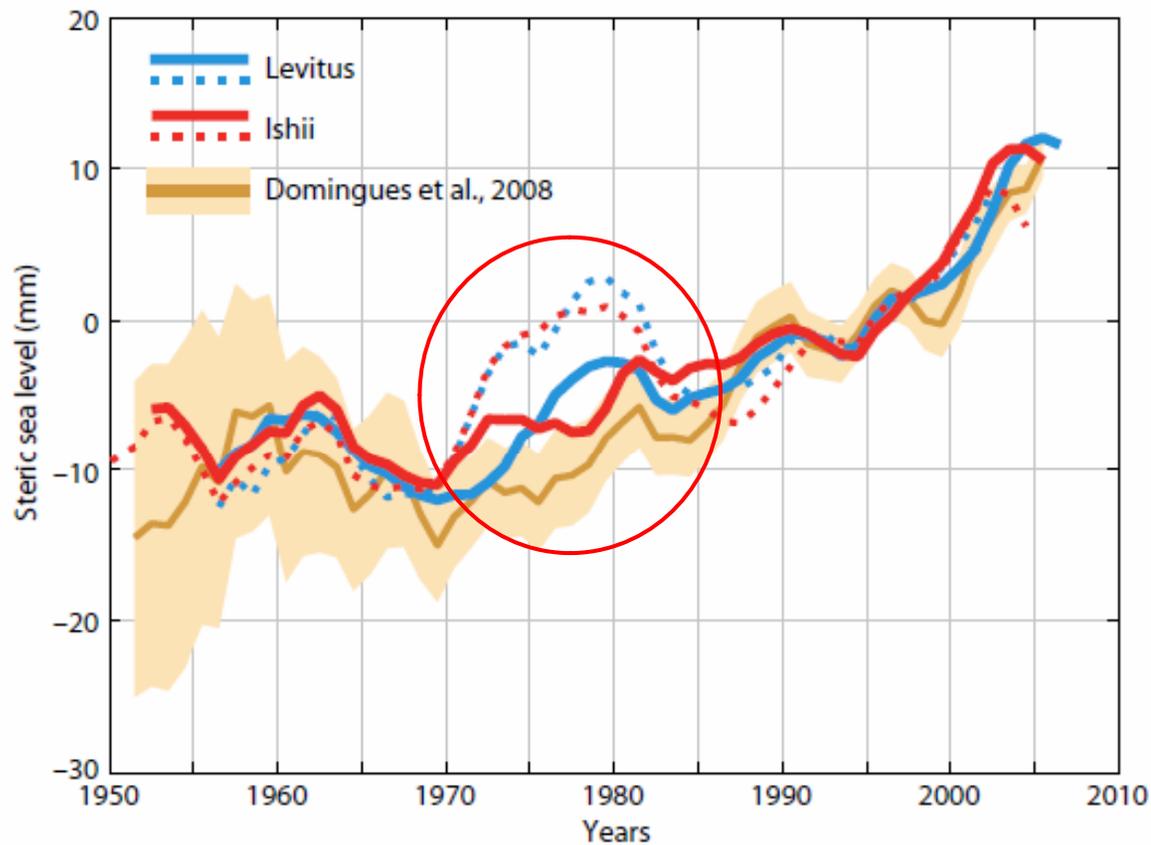
CTD/XBT pair locations & temporal distribution

Data was sourced from:
World Ocean Database,
CSIRO Archives,
BSH (Germany),
AOML (US)

5,267 pairs
3,162 low resolution (dots),
2,105 high resolution
(circles)

Methodology

- **We can use the fine-scale temperature matches in each XBT and CTD pair to determine**
    - **depth error** for each XBT by using a linear fit to get a **slope** and **offset** term
    - any remaining **thermal bias** in the XBT after the depth has been corrected

- **Steps:**
    1. Depth correct pair by pair
    2. Look at remaining thermal bias
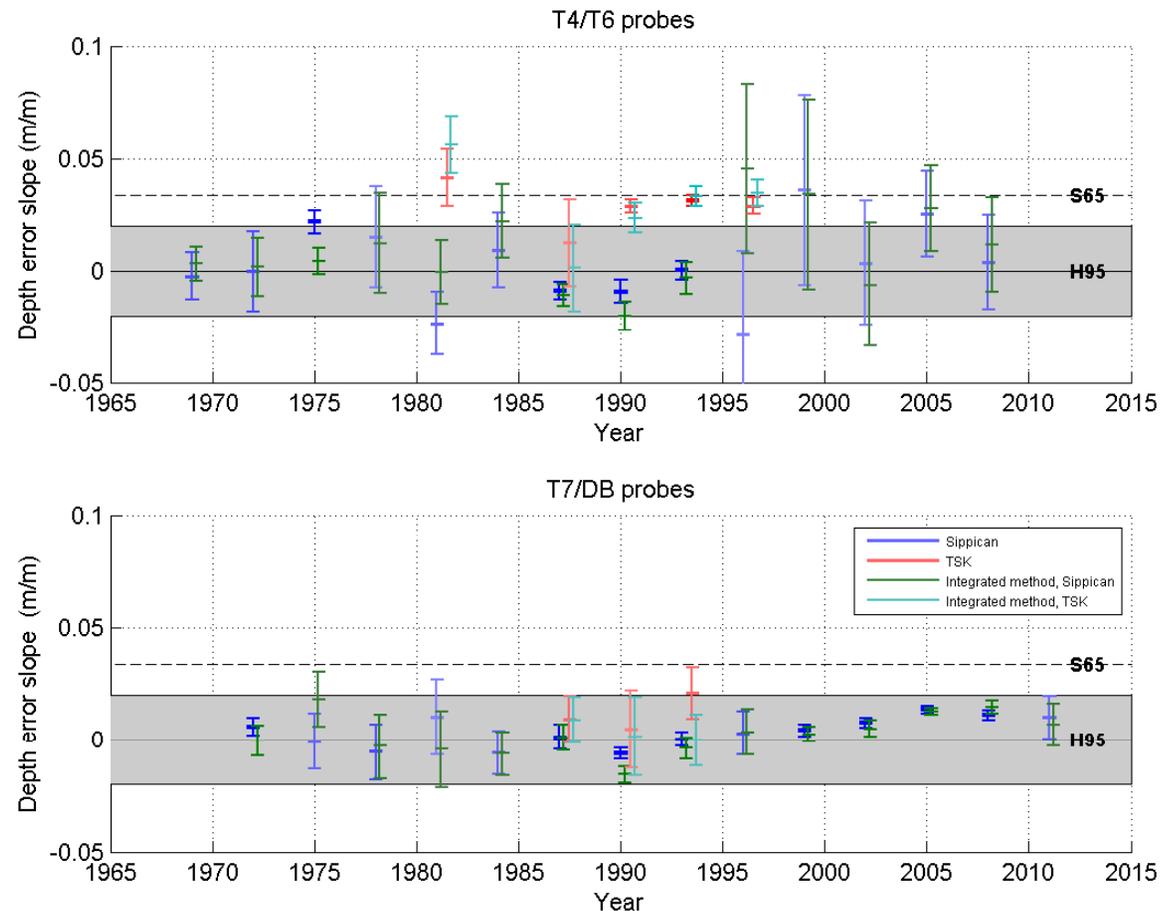
What the thermal bias looks like

- Depth correction reduces the spread of thermal bias in both high and low resolution profiles (solid lines)
- Depth correction reduces the thermal bias, but does not remove it, XBTs are warm
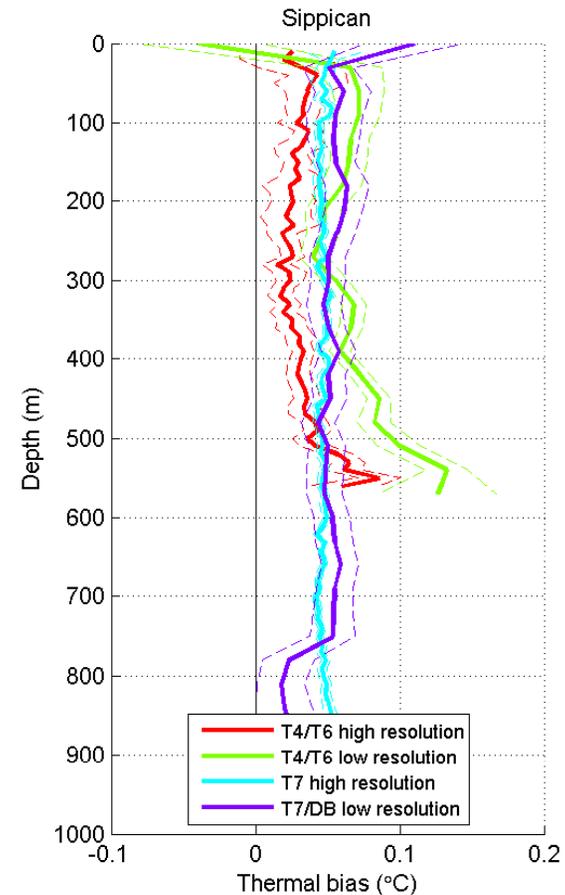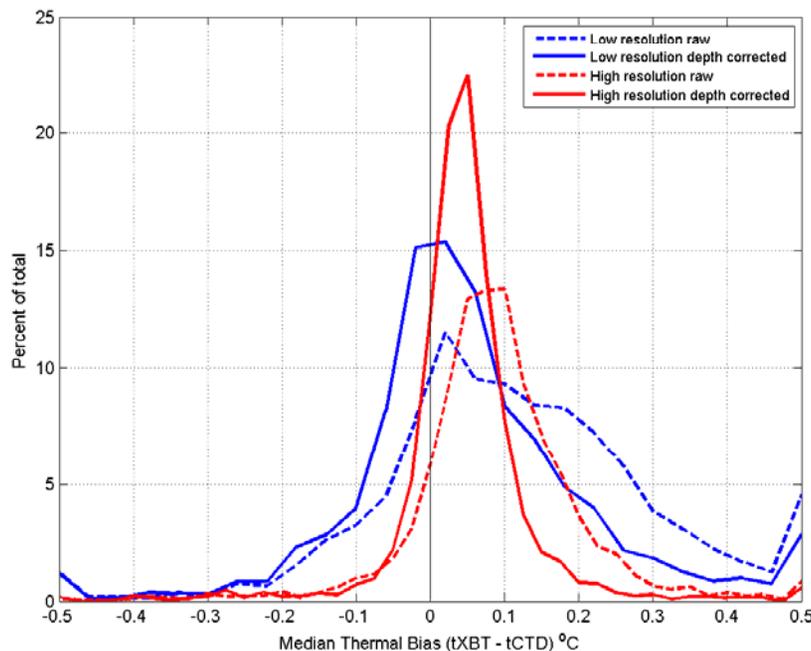
- Constant with depth for all Sippican probe types
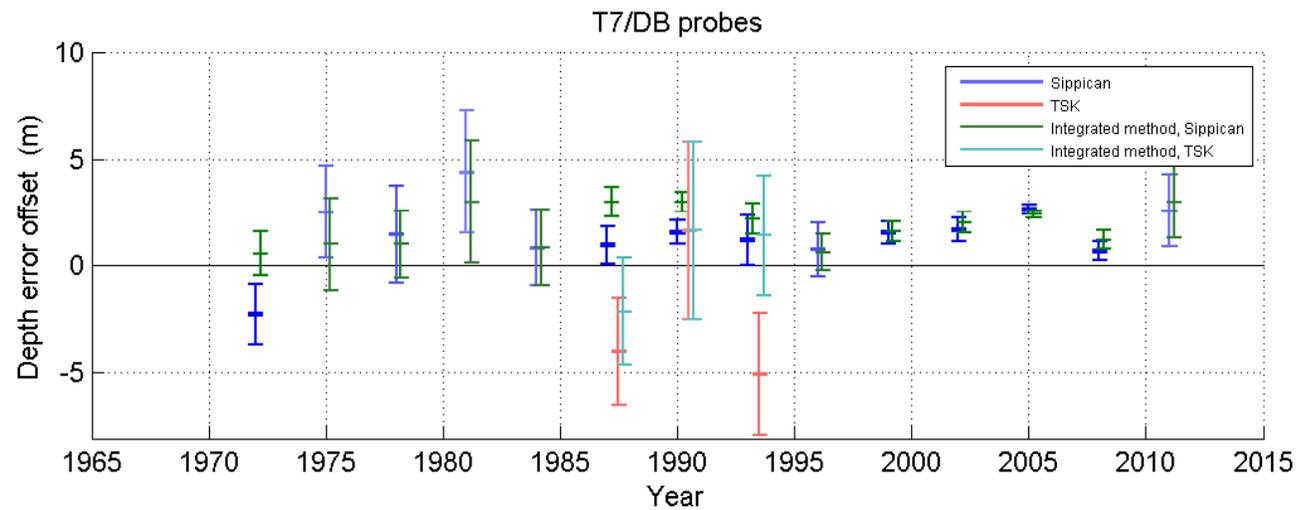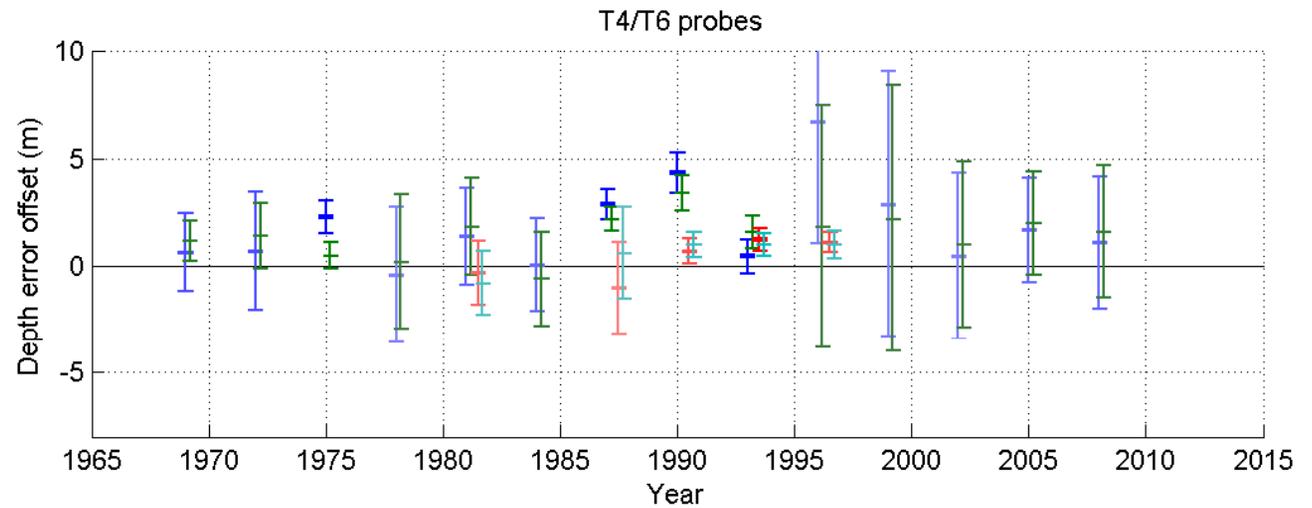
Depth error (slope term)

- T4/T6 profiles dominate the early records: The 'hump' in the 70's/80's is not apparent in our results

- T7/DB Sippican probes show an increase in depth error from the 1990's to now, but the H95 fall rate suits the data from 1966 to ~1995.

- TSK T6 probes show a slower fall rate.

S65 = Sippican fall rate, 1965
H95 = Hanawa et al fall rate, 1995

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Depth error (offset term)

- Offset term is constant over time (~2m)

T4/T6 probes

T7/DB probes

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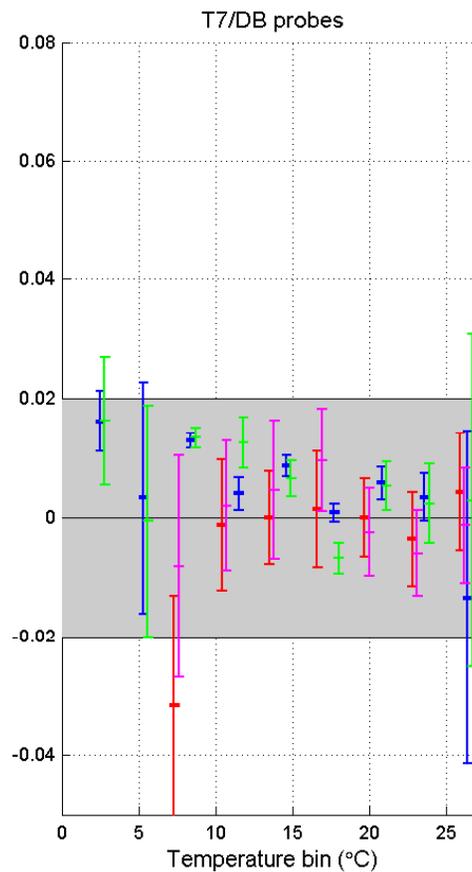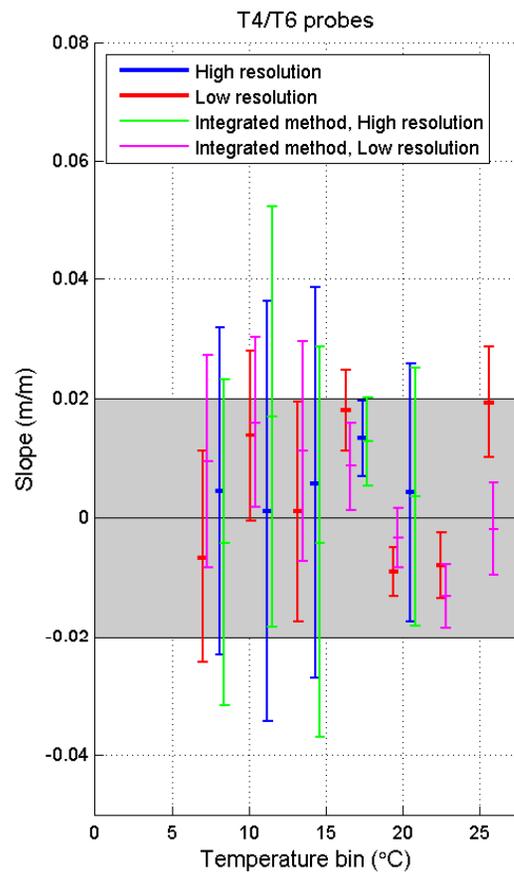FLAGSHIPS
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Thermal bias variation over time

- Thermal bias after depth correction is greater in the pre-1990's data

- Compares well with Gouretski & Reseghetti (2010)

- Consistent result for independent time bins

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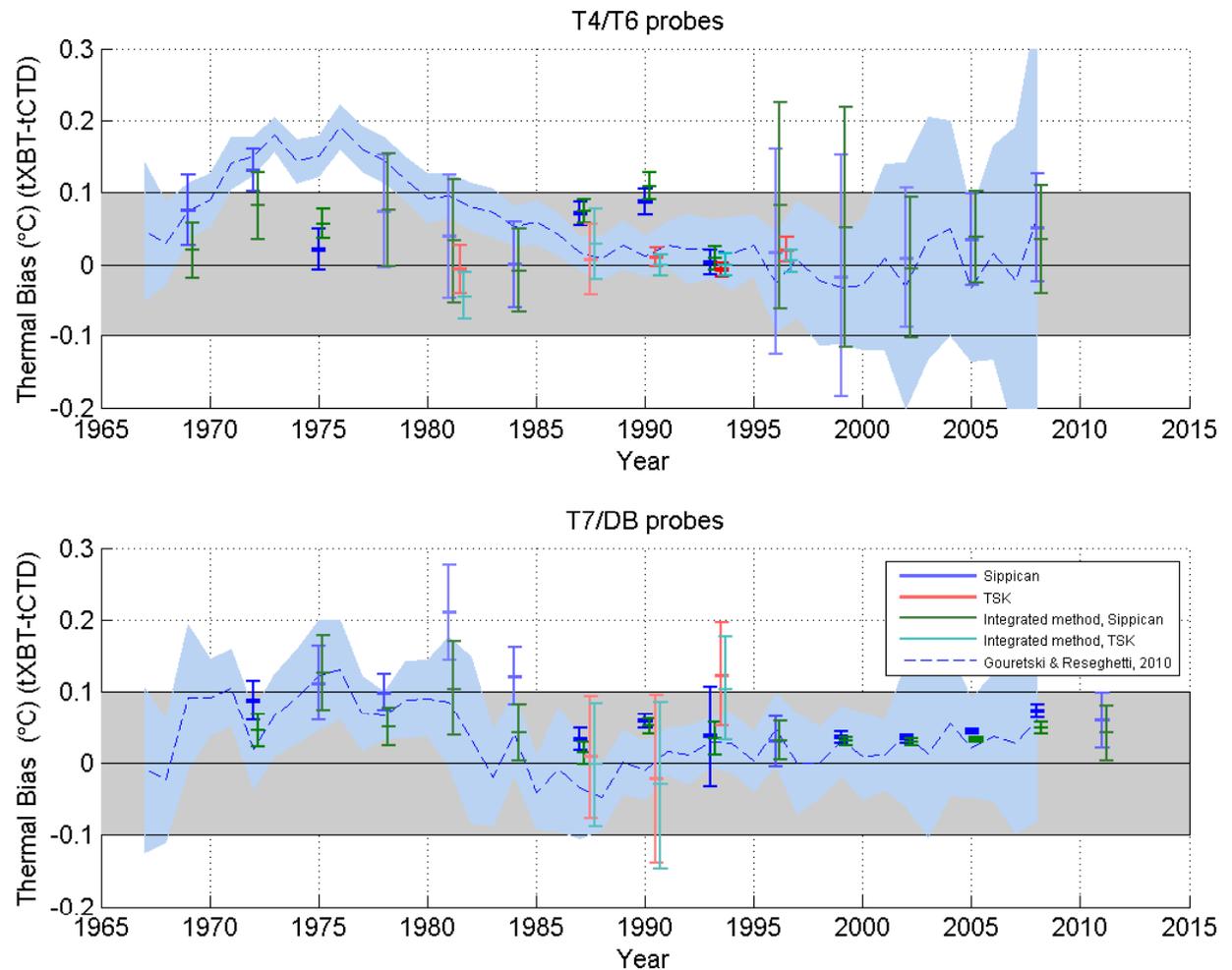
The effect of temperature on fall rate

- No clear relationship between depth error and temperature

- Sippican T7/DB show some increase in fall rate with increasing temperature, but this amount has a negligible effect on depth error over time

How many pairs?

- High resolution pairs: minimum of 30.
- Low resolution pairs: minimum of 50.

- Can be collected over an entire cruise.

- If collected from multiple cruises, the errors will be higher and more pairs are needed, ~50-60 high resolution pairs
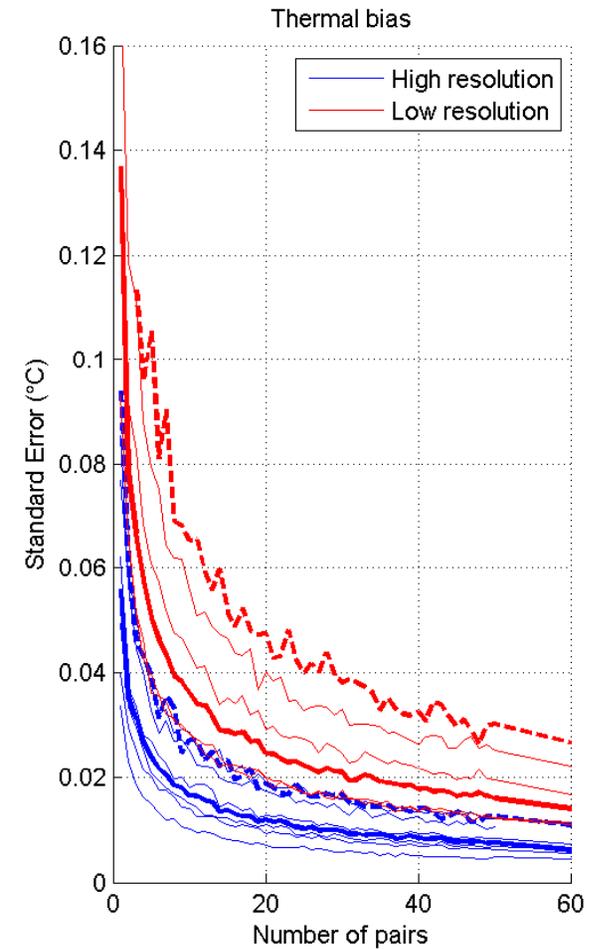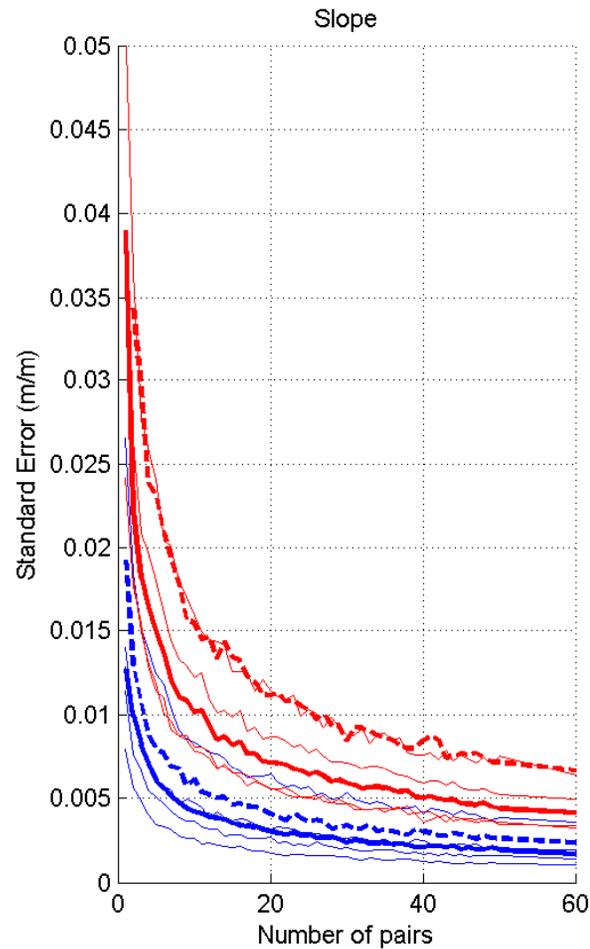
Broad-scale 'buddies' analysis

- Use a global XBT/CTD/Bottle pairs database (within 1° lat/long & 30 days)

- Remove the thermal bias from the XBTs and assess the remaining depth errors

- Why is the 'hump' apparent in global analyses, and not in our pairs database?
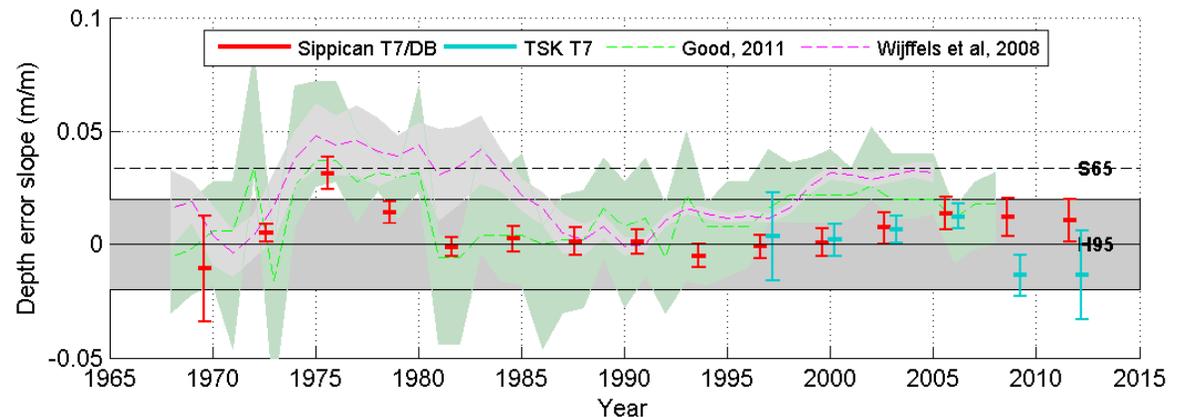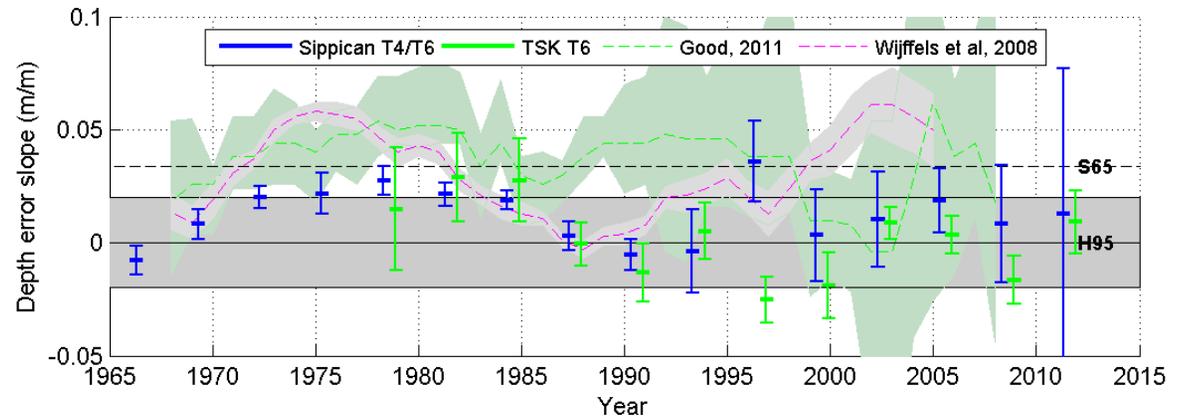
S65 = Sippican fall rate, 1965
H95 = Hanawa et al fall rate, 1995

Summary:

- We find a positive thermal bias of ~0.05°C for Sippican probes, ~0.04°C post 1985 and ~0.08°C pre 1985
  - the thermal bias is time variable, but consistent with depth

- Water temperature has a negligible effect on fall rate

- The 1970/80's 'hump' is not evident in our pairwise depth error results, but can be seen in the broadscale buddies analysis
  - Maybe due to poor quality control of XBT data in WOD?

- Around 30 to 40 XBT/CTD pairs are required to calculate XBT depth to the same accuracy as a CTD measurement (0.2%). Many studies in the literature don't meet this criteria and can present a confusing picture.

What could this mean for OHC and Sea Level?

- Thermal bias corrections can be applied to Ocean Heat Content and Sea Level calculations
    - Large errors occur where the 'humps' are in the 1970's/80's
- We have to apply depth error corrections with care, as these can have a large effect regionally (eg over-correction in regions with high temperature gradients)