How accurate is the historical hydrographic database for the purpose of estimation of the global ocean temperature trends?

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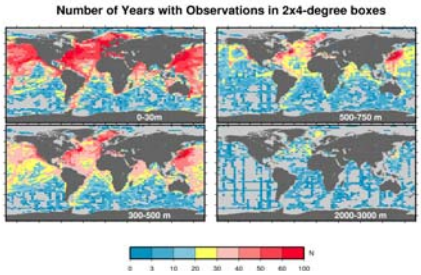
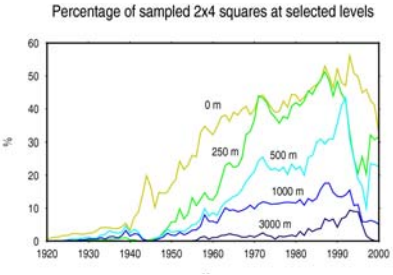
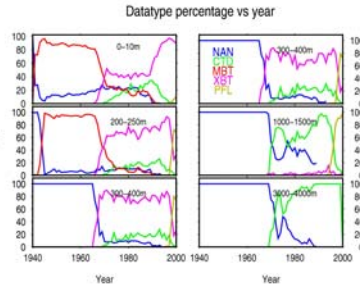
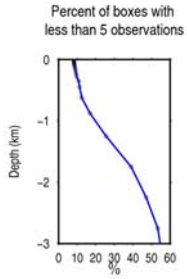
Data basis: WOA01 collection + WOCE dataset. Analysed time period is 1920-2000. The Nansen and CTD cast data have been quality controlled and used to calculate the WOCE Global Hydrographic Climatology (*Gouretski&Koltermann, 2004*).
Limitations: **(1)** A very irregular and sparse spatial/temporal coverage: out of a total of $129 \cdot 10^6$ T-observations only $2 \cdot 10^6$ are from below 1000m; **(2)** datatype inhomogeneity (5 datatypes): Nansen casts (NAN), CTD casts, mechanical bathytermographs (MBT), expandable bathytermographs (XBT), Profiling floats (PFL).









Method: Each observation is compared with the respective local climatological temperature to obtain a point temperature anomaly. All data from a 10-year base period 1987-1996 are used to calculate climatological T-values. To exclude seasonal cycle above 200 meters the reference data from the respective month only are used.
A binning procedure is first applied to point anomalies. Ocean is subdivided in 22 layers. Within each layer yearly anomalies are calculated first for 2x4-degree boxes. Globally averaged yearly anomalies ΔT are obtained by averaging box anomalies δT with weights proportional to the box volume (vol):

$$\Delta T = \left(\sum vol_i \cdot \delta T_i + \sum vol_j \cdot \delta T_j \right) / \left(\sum vol_i + \sum vol_j \right); \quad i=1,\ldots,N; \quad j=1,\ldots,M$$

In our calculations only boxes with observations (i) are used. Not-sampled boxes (j) have no influence (M=0)

Datatype biases. T-anomaly calculations were performed separately for all types of data revealing significant offsets between the different instruments. Mechanical bathythermographs and expandable batythermographs data dominate within the upper 250 m (MBT) and 400 m (XBT) layers. Bathythermograph data of both types were found to be positively biased relative to the Nansen cast and CTD data. These biases cause an additional artificial increase in the long-term temperature rise. Also a positive temperature anomaly near 1980, indicated by the XBT data does not show up in the curve based on the Nansen bottle and CTD data alone.

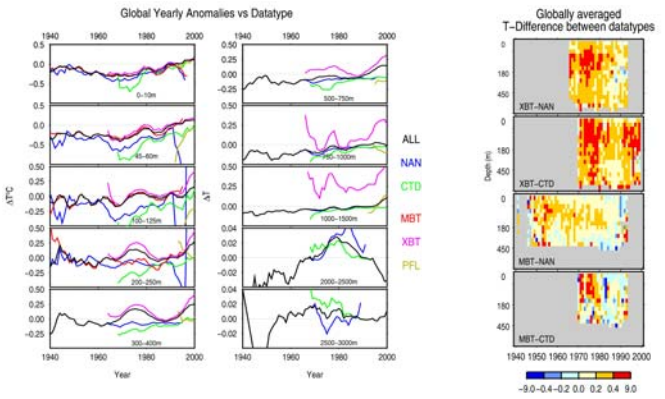
Conclusions and comparison with Levitus, Antonov, Boyer (2005) results

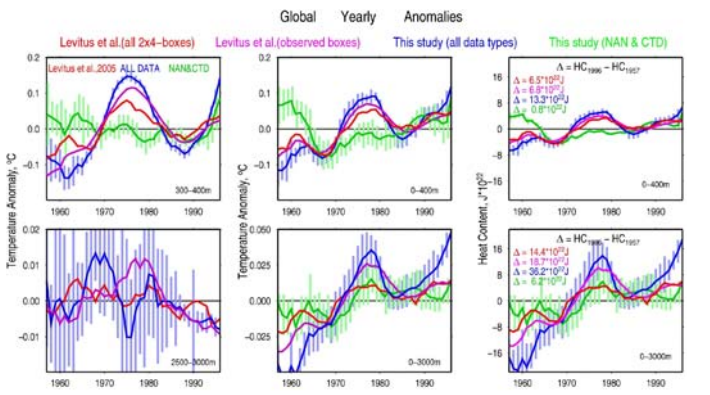
1) LAB analysis scheme obviously leads to an underestimation of the global temperature variations possibly due to the use of a zero-anomaly first-guess field for the areas with no data.

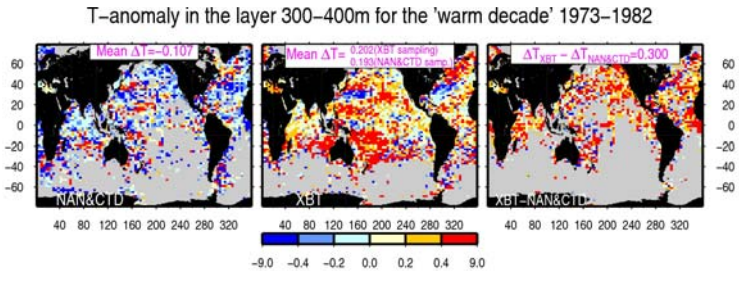
2) Evaluations based only on the NAN and CTD data exhibit quite different patterns of the global temperature evolution. A 1980 warm anomaly completely vanished compared to the all data case, with the overall warming between 1957 and 1996 being reduced to a value of $0.8 \cdot 10^{22}$ J, not significantly different from zero for the calculated error bars.

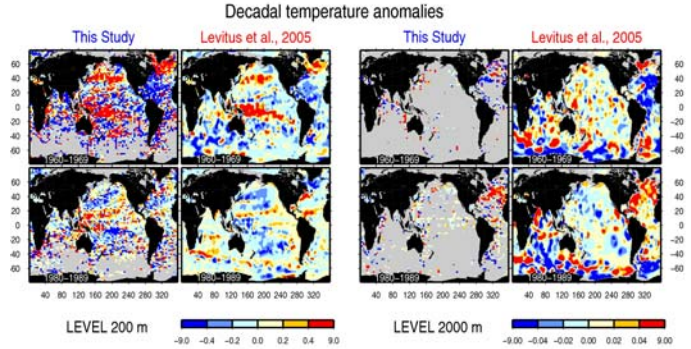
3) Heat content and T-anomaly estimates for the deep layers are subject to large errors due to irregular and sparse data distribution. Since the1960s adequate sampling was achieved probably only for the upper 200-400 meters.

4) A further quality assessment of the composite historical hydrographic dataset is needed to reduce the uncertainty in the large-scale anomaly averages.









Instrumental bias seems to be responsible for the „warm decade“

Use of not sampled boxes may significantly influence large scale averages