BUNDESAMT FÜR SEESCHIFFFAHRT UND HYDROGRAPHIE

Detecting climate signals in Argo: Are the data good enough? For what?

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Introduction

Original goals of Argo:

- Detect climate variability on seasonal to decadal scales
- Deliver information needed for calibration of satellites
- Provide data for initialization and constraints for climate models

Array design:

- Measure temperature and salinity down to 2000 m every 10 days
- Global spacing of 3x3° in ice free areas ->3000 floats
- Formal global surface temperature error of <0.5 °C
- Corresponding error of 15 W/m^2 in monthy surface heat flux

Initial error targets:

0.01 °C in temperature, 0.02 psu in salinity <5dbar in pressure

Introduction

How to ‚define good' enough?

The accuracy requirements depend on the specific scientific application and need to be determined by the user.

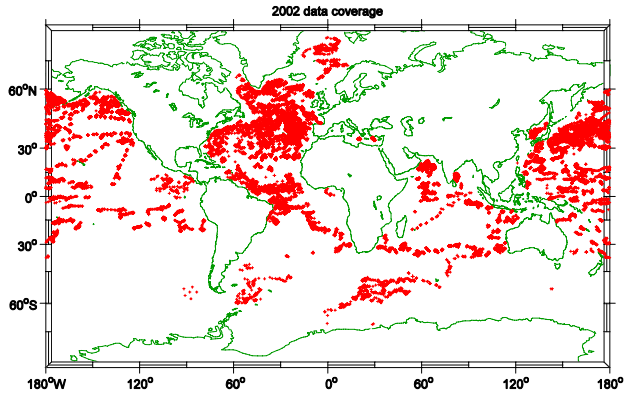
Guidelines by GCOS (Global Climate Observing System):

	Horiz. Res.			Vert. Res.			Obs Cycle			Delay of Avail.			Accuracy		
	GL	B/T	T/H	GL	B/T	T/H	GL	B/T	T/H	GL	B/T	T/H	GL	B/T	T/H
Temperature	1 km	6 km	300 km	1 m	2 m	10 m	1 day	2 days	10 days	0.5 hrs	0.6 hrs	1 hrs	.001 K	.002 K	.01 K
Salinity	15 km	40 km	300 km	1 m	2 m	10 m	1 day	2 days	10 days	0.5 hrs	0.6 hrs	1 hrs	0.001	0.002	0.01

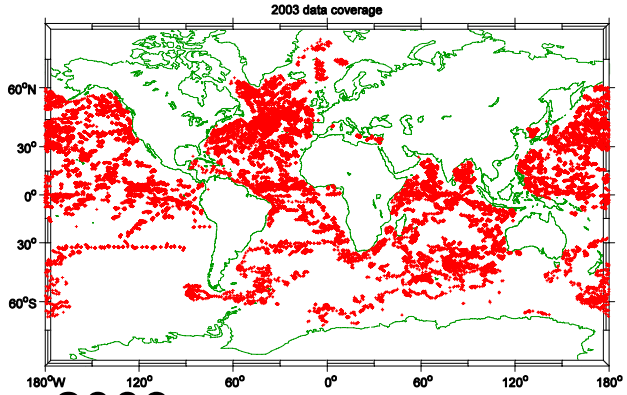
Available at http://www.wmo.int/pages/prog/gcos/.

- the "threshold" is the minimum requirement to be met to ensure that data are useful
- the "goal" is an ideal requirement above which further improvements are not necessary
- the "breakthrough" is an intermediate level between "threshold" and "goal" which, if achieved, would result in a significant improvement for the targeted application.

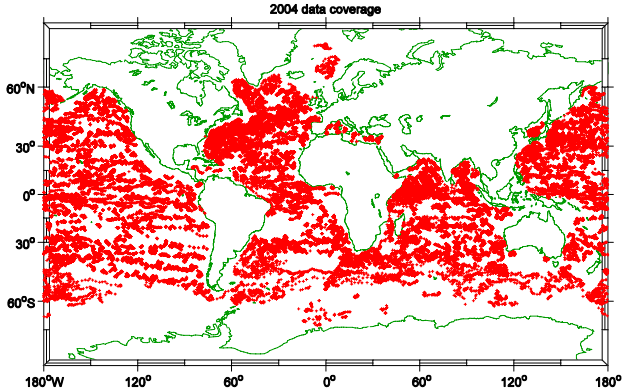
Introduction: Spatial coverage



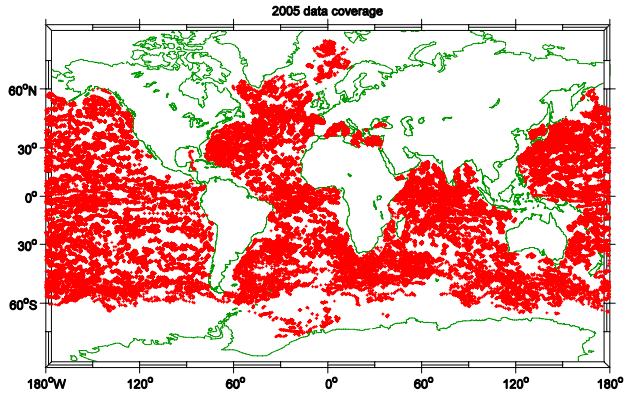
2002



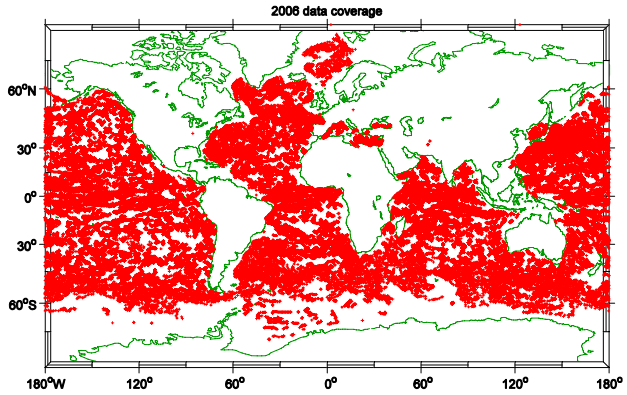
2003



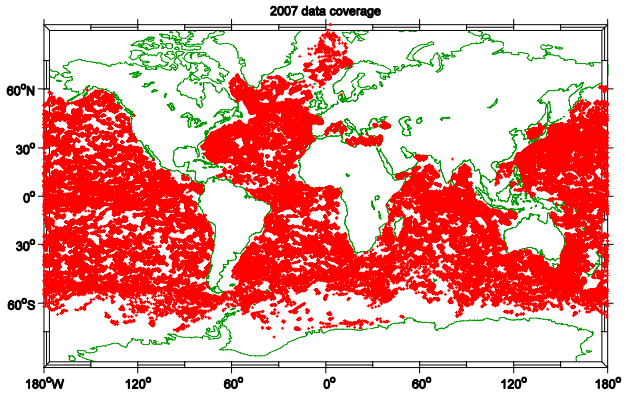
2004



2005



2006

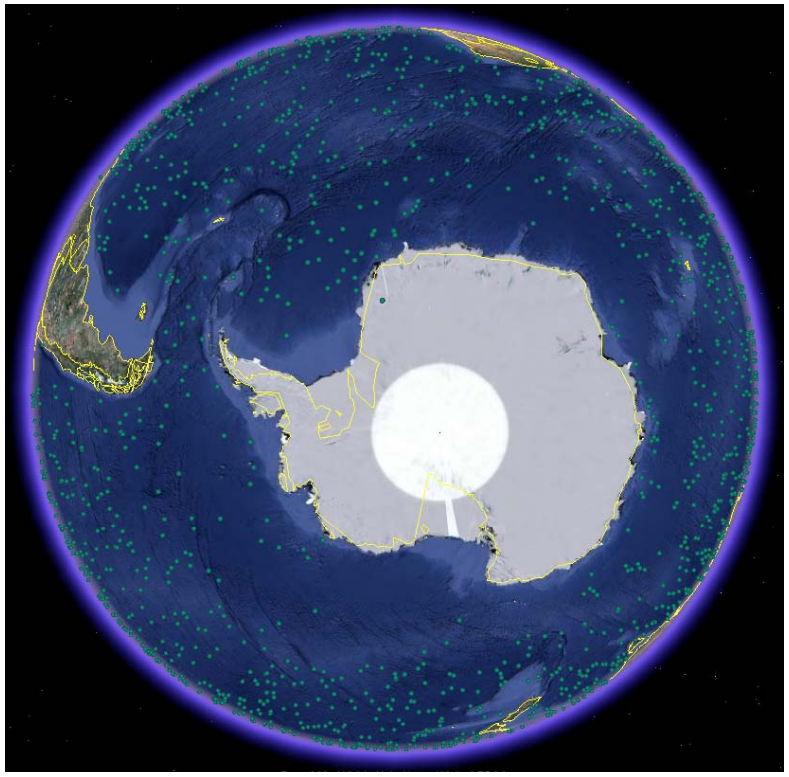


2007

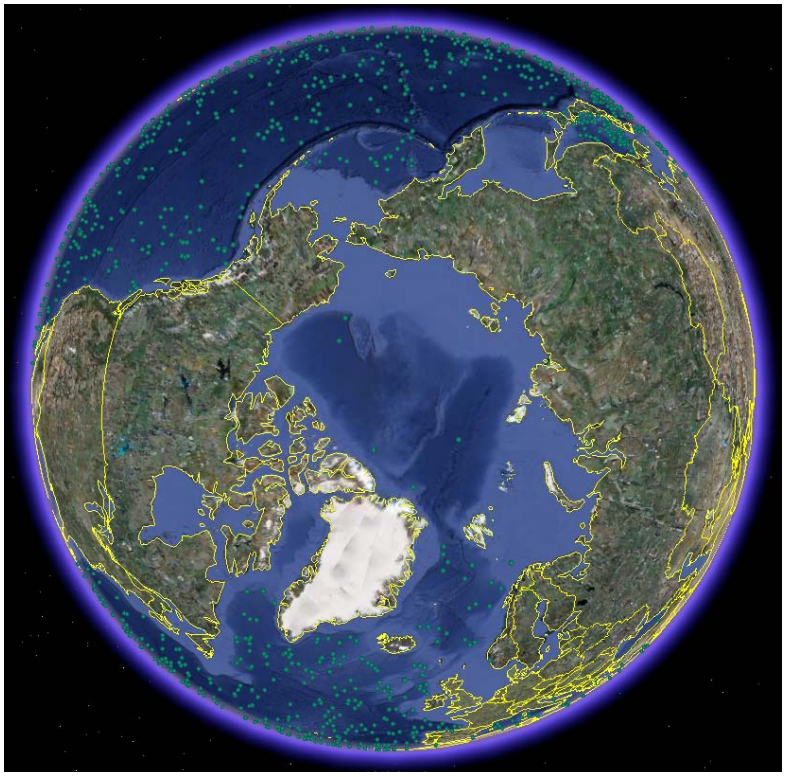
Sufficient areal coverage after 2004 -> short timeseries, interannual variability still dominates

Spatial and temporal coverage

Antarctic float coverage



Arctic float coverage



Basic considerations for accuracy

Quality control of input data is essential

Is a quality control existing for the data set, is it aiming at accuracy levels for climate change studies?
To ensure the quality needs for your analysis a dedicated quality control is needed

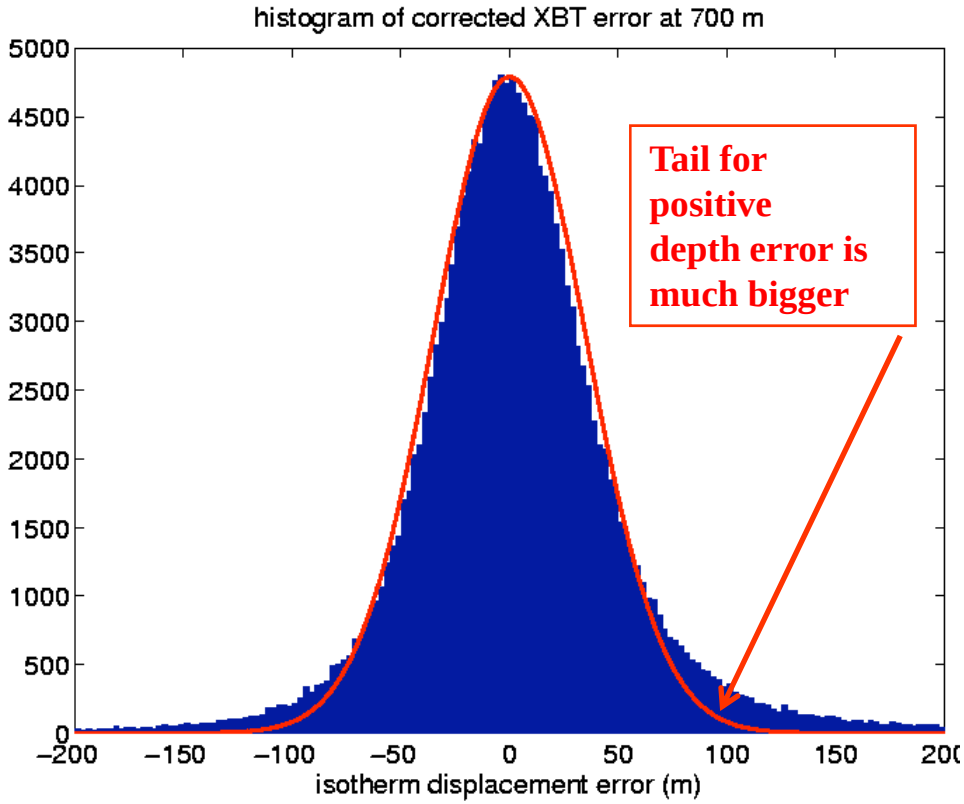
Identification and correction of data biases is needed

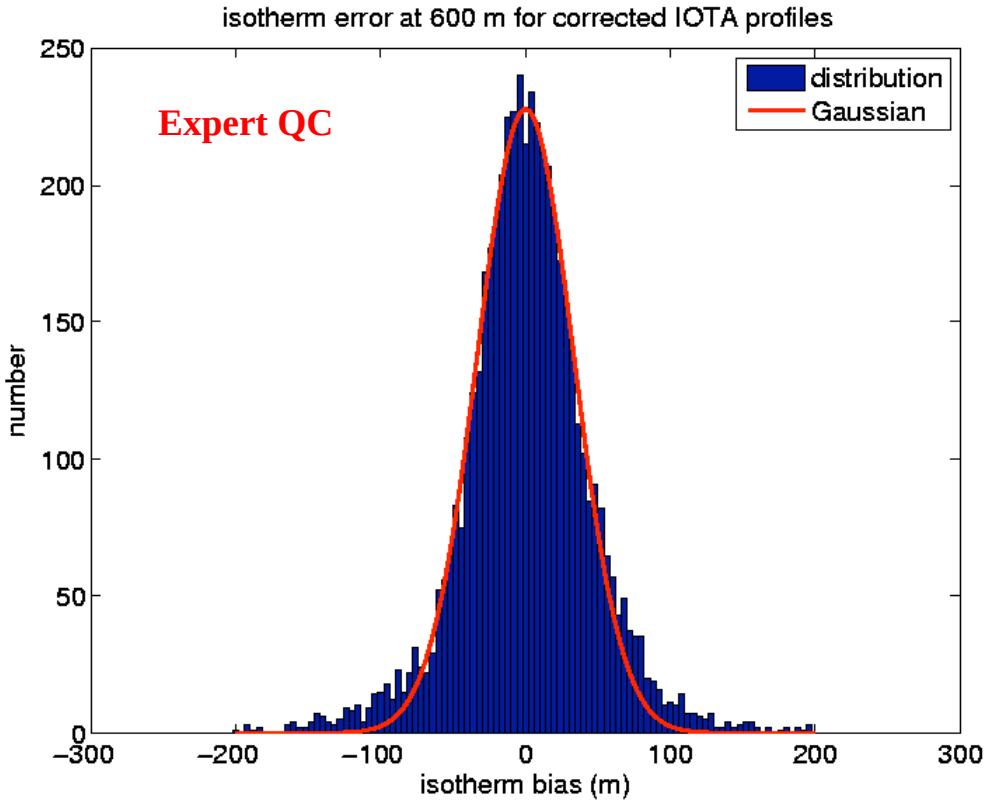
Technology advances have the potential for introducing systematic biases. Mixed data sets should be examined for systematic biases

Infilling assumptions will continue to be important when global means are calculated

Irregular sampling in space and time influences the analysis and has to be treated properly,errors have to be estimated.

Quality control of input data



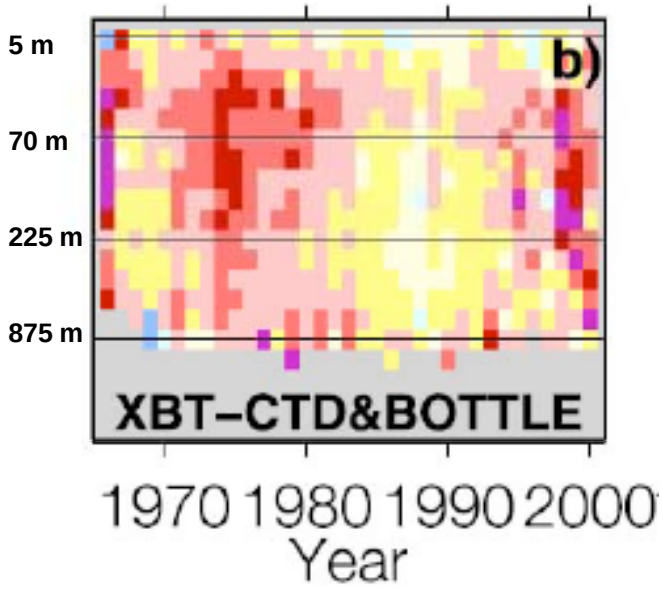


Poor QC of XBT data results in a bias error skewing the mean

John Wilson&Ann Thresher

Sytematic biases: XBT problem

Temperature difference between co-located XBT and CTD data

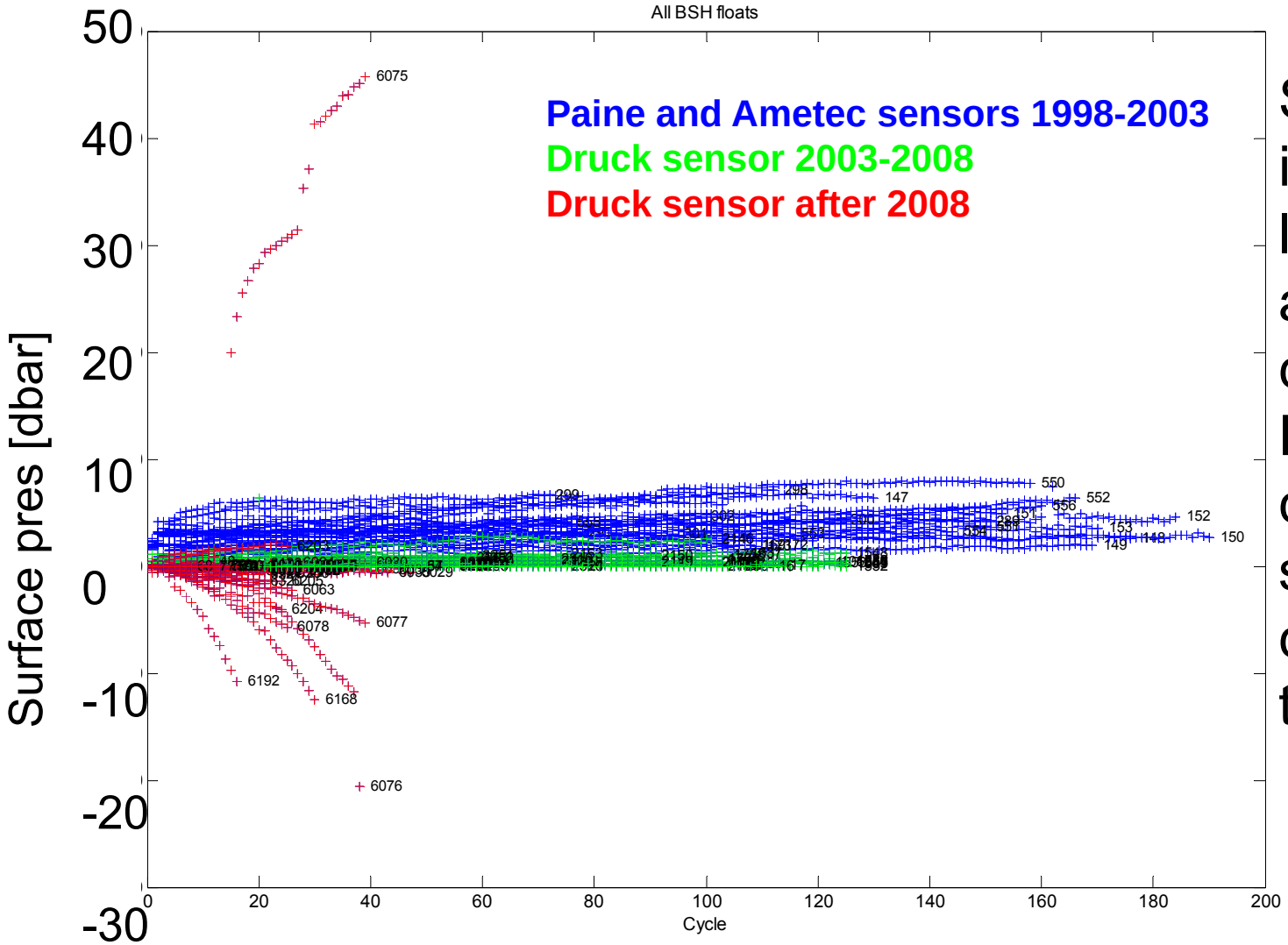


From Gouretski & Koltermann, 2006

Warm bias in 1975-1980 and after 1995 caused by XBT data

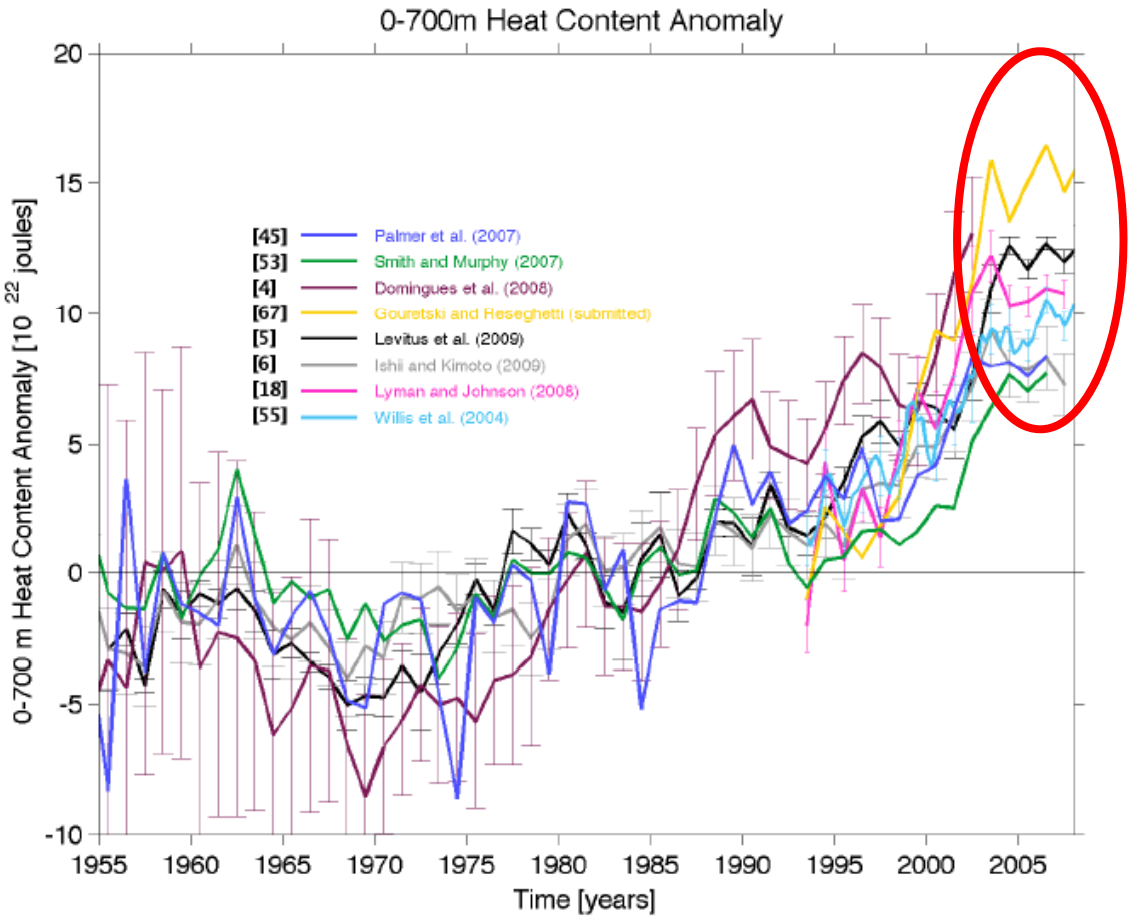
Correction of time-varying warm bias in XBT necessary, problem with fall rates to be solved

Systematic biases: pressure drift in Argo data



Systematic errors in pressure are limiting the accuracy of heat content calculations Errors of 1 dbar could be masking small global change signals in the upper ocean

Biases: Ocean heat content anomaly



1992-2002 mean removed

Lyman and Johnson, 2008

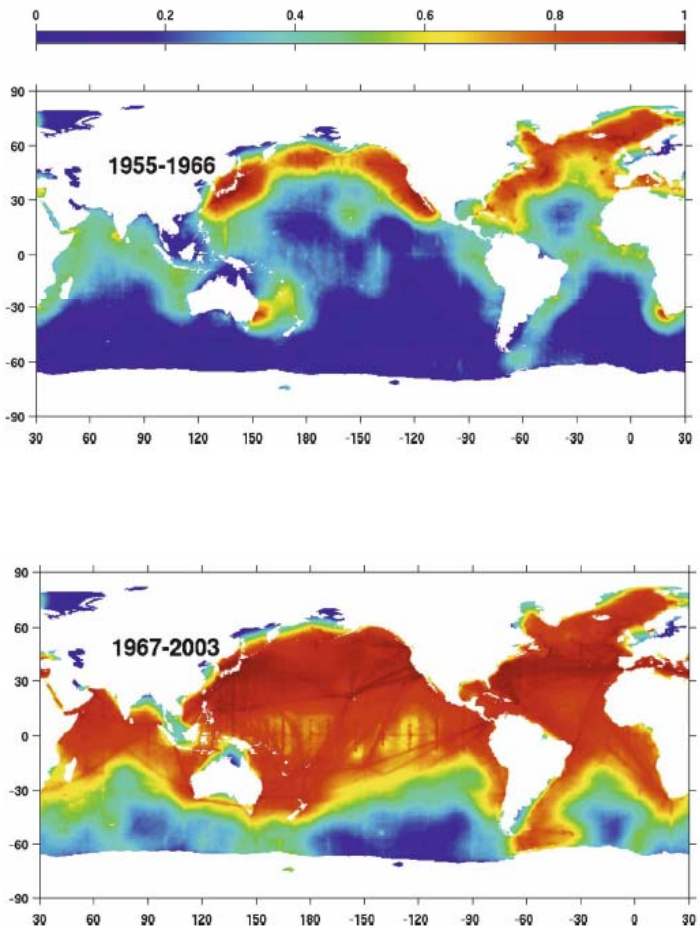
Ocean heat content is important
Close energy budget of the planet -> quantify oceanic heat uptake

Differences are due to quality control, gridding and infilling methods, bias corrections, choice of climatology

Problem: Flat part of OHCA after 2004 with the advent of Argo, sea level curves still increase, could be increased ice melt but energy budget is not closed. Needs further investigation

Infilling assumptions

Annual `observed area coverage`



Annual mean sampling to 750 m

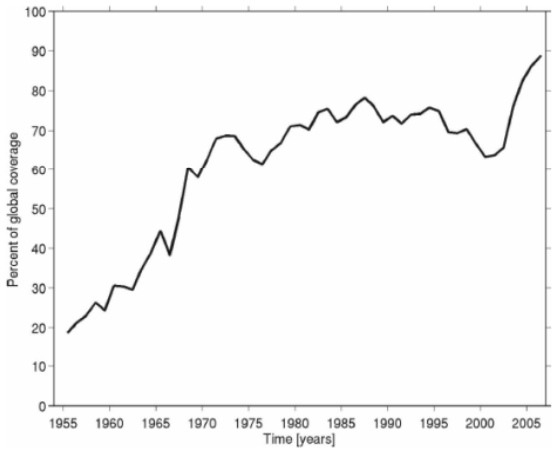
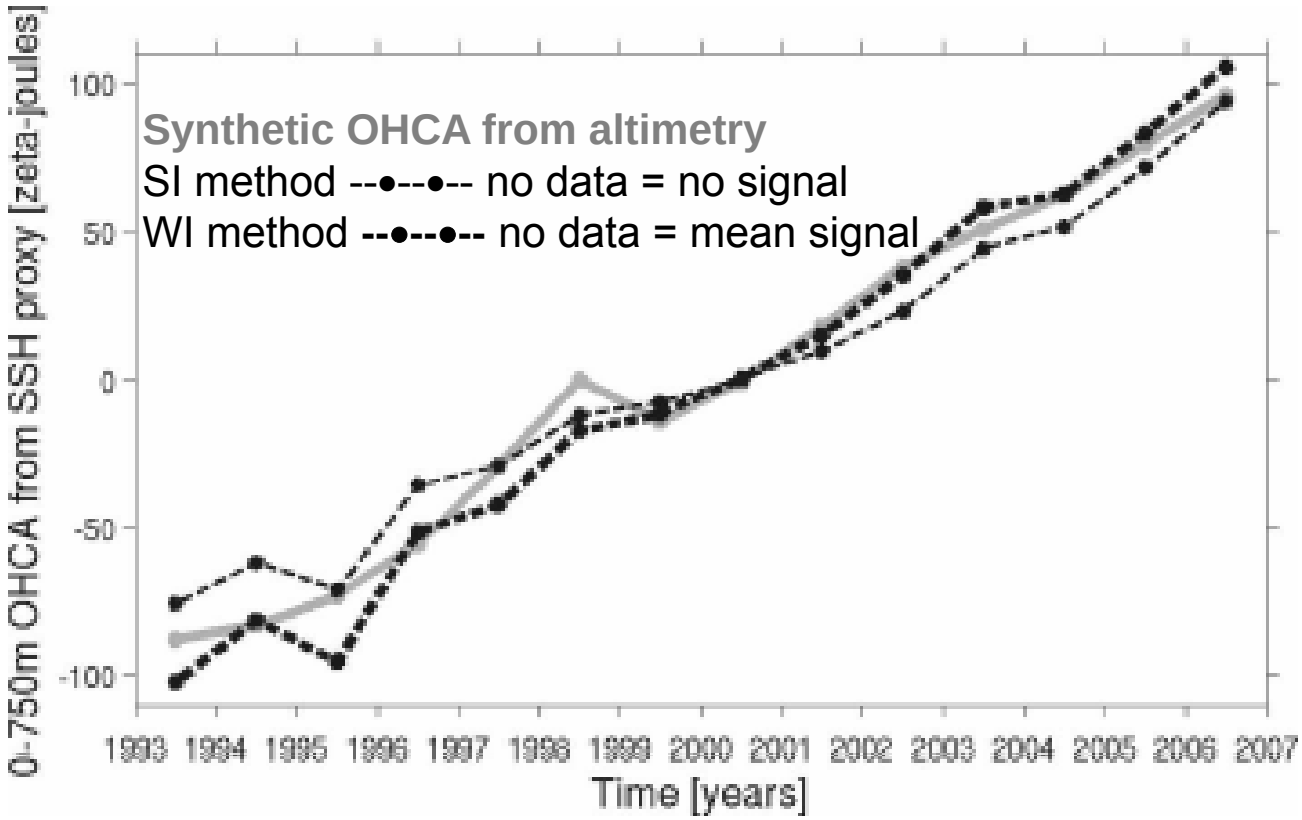


FIG. 1. Percentage of global ice-free ocean sampled for in situ upper (0–750 m) OHCA for each calendar year defined by Eq. (A8).

1955-1966: very poor coverage rises from 20% to 40%
1967: start of XBT usage -> rise to 48%
Rise to ~63% in WOCE period
And 89% coverage with the advent of ARGO

From Lyman and Johnson, 2008

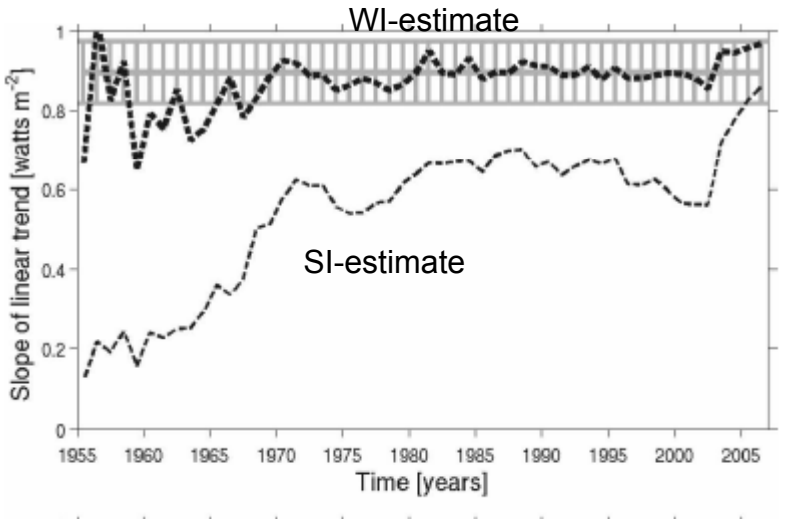
Errors in estimates of ocean heat content anomaly

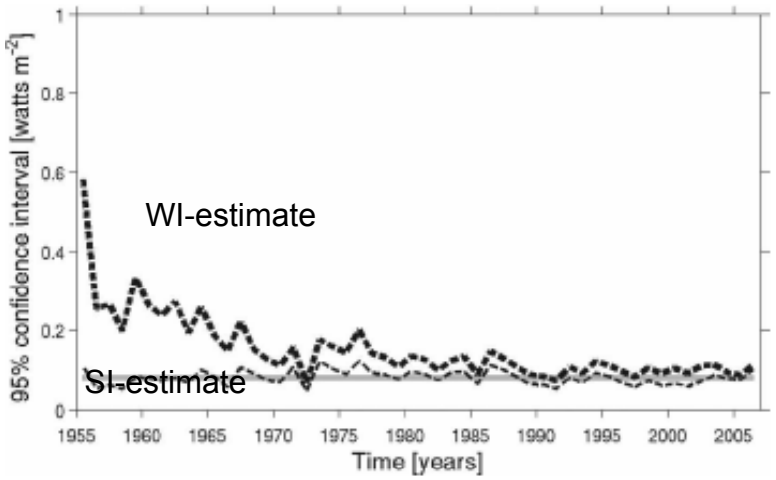


From Lyman and Johnson, 2008

Infilling assumptions

Study the effects of the irregular data distributions and the methods used to map data:
Use AVISO SSH data as synthetic data set and sub-sample it to annual distributions
Compare simple integrals (SI) with zero anomaly in data sparse region vs.
Weighted area integrals (WI) With mean anomaly in data sparse regions





From Lyman and Johnson, 2008

Estimates of global mean sea level rise

Mean sea level rise has order of magnitude (mm/year). What requirements are posed on data or model output if this should be determined with an error of less than 10%?

Changes in voluem/mass:

$(10^{-3}/3800)$ /year = $3\ 10^{-7}$ /year result, an error < 10% will lead to **$3\ 10^{-8}$ /year**

Changes in temperature:

$h_t = \alpha - Th_0$ corresponds to temperature changes of $1.5\ 10^{-3}$ °C/year and a detection limit of **$1.5\ 10^{-4}$ °C/year**

Changes in salinity:

$h_m = 1/S_o\ (\beta \Delta S)$ corresponds to salinity changes of 10^{-5} /year and a detection limit of **10^{-6} /year**

⇒very ambitious goals, precaution have to be taken to eliminate all possible error sources, longer time series might be necessary.

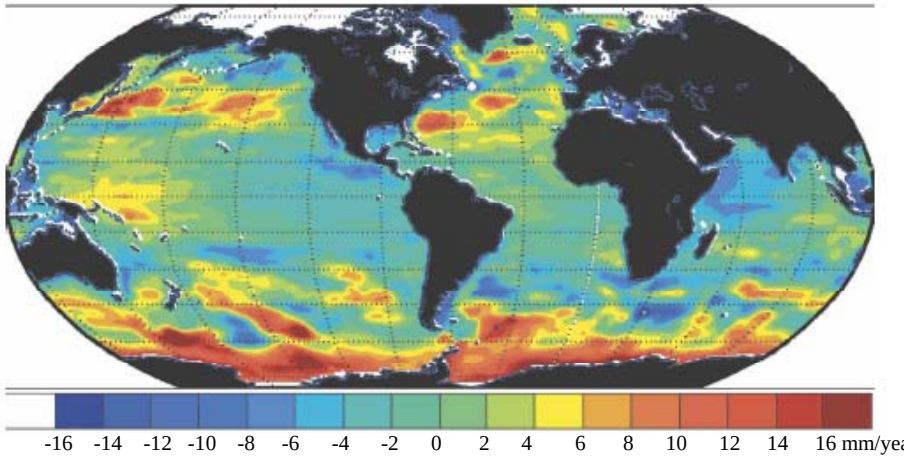
Estimates of global mean sea level rise

Ocean state estimation with ECCO

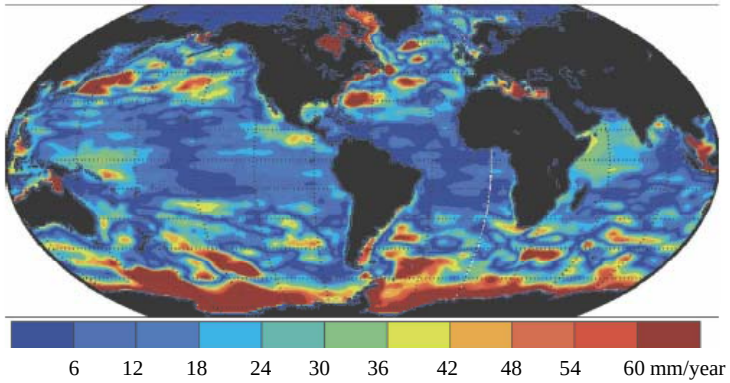
Numerical problems and the choice of physical approximations become important

Sources of errrors: Boundary conditons for heat and freshwater, Boussinesq approximation, linearisation of eq. of state, model drift on long time scales, missing horizontal resolution and impact on eddies

SSH Trend for 1993-2004

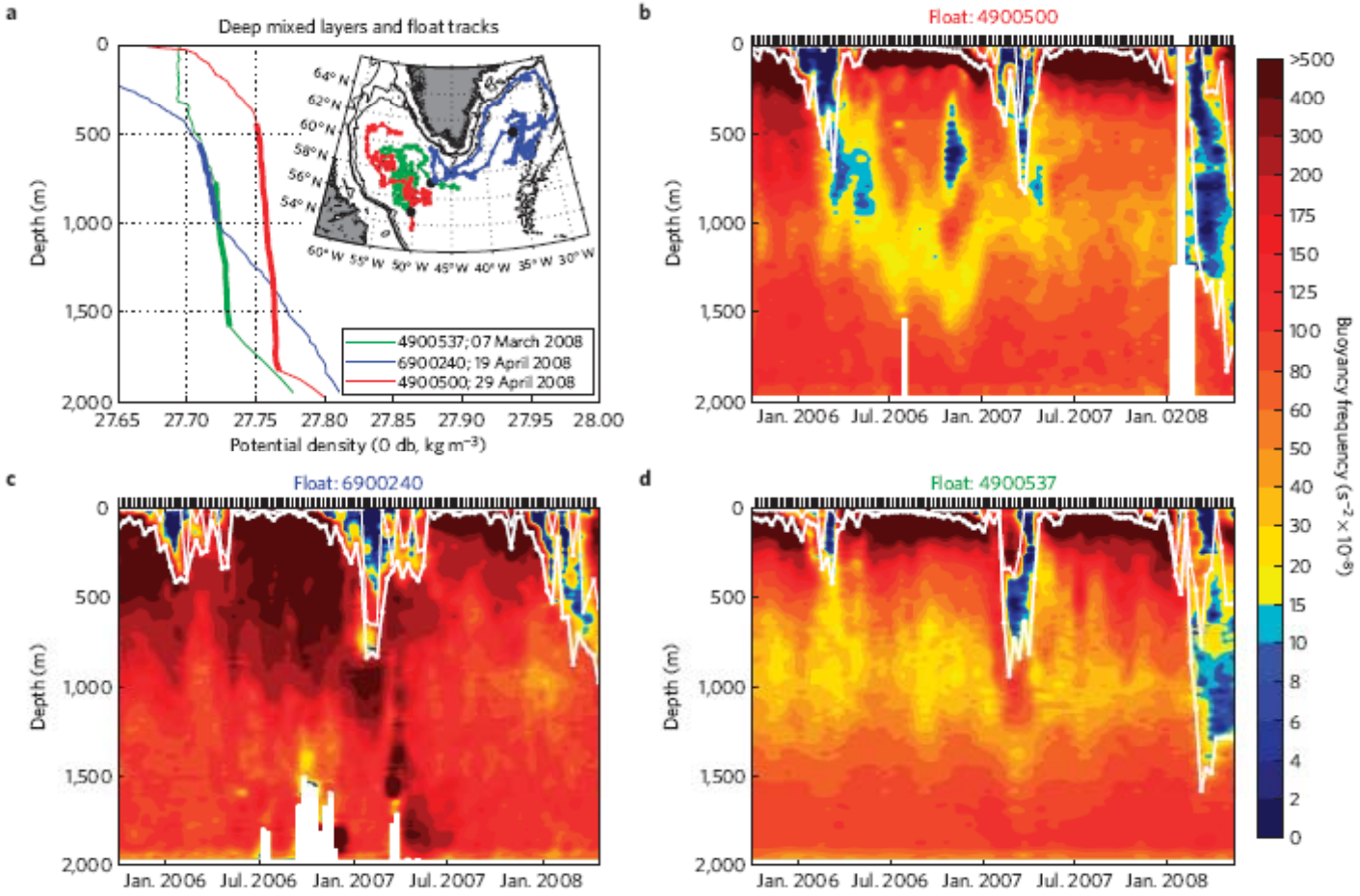


Model error for 1993-2004



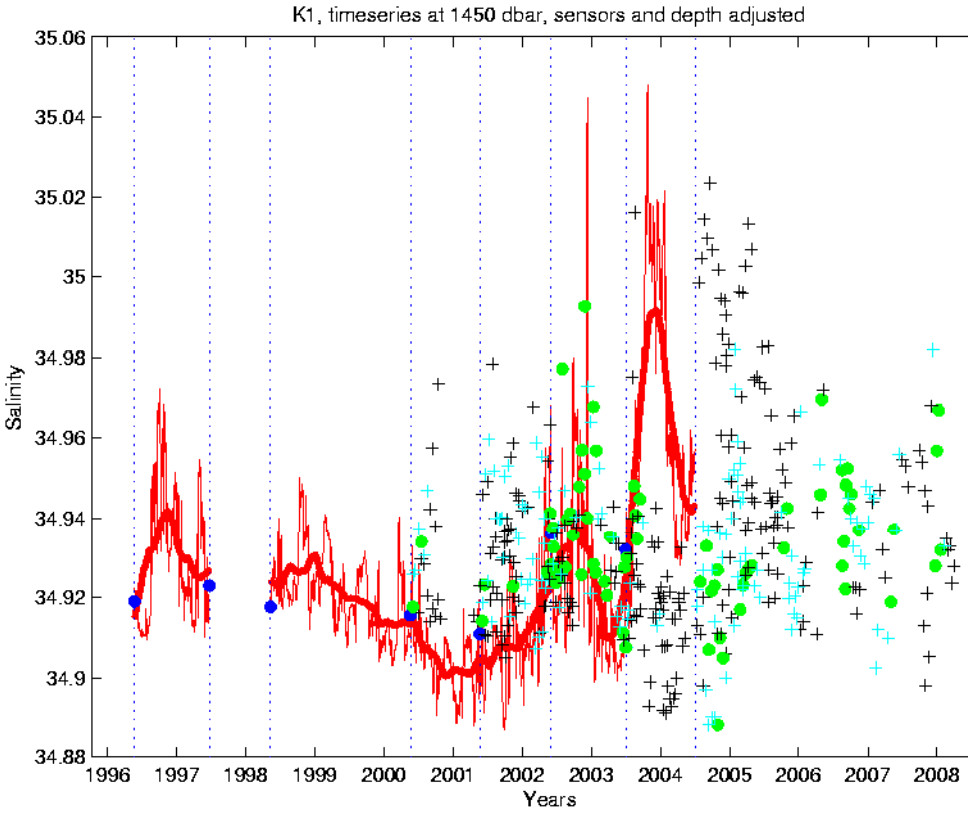
Wunsch et al., 2007

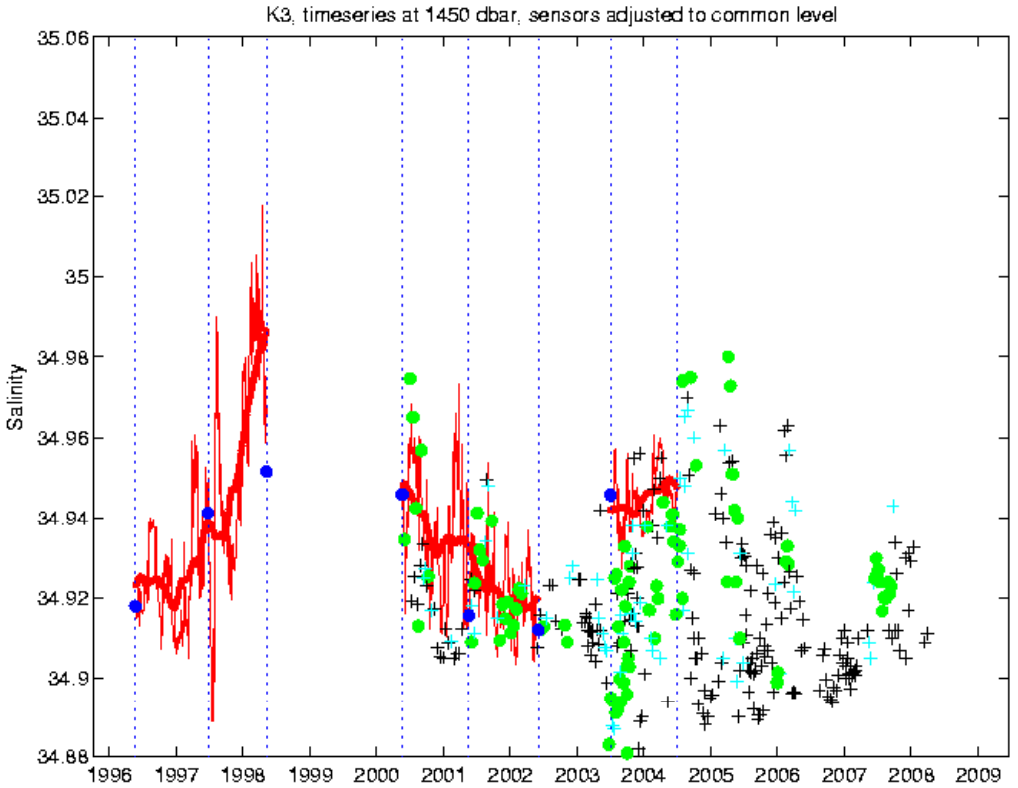
Process studies: Deep water formation



Vage et al., 2008

Process studies: combining Argo with moored records





Mooring data mooring data smoothed argo float <80 km argo floats <100 km + argo floats <220 km

Good luck with your own analyses

and

don‘t forget the errors!!