

Upper-ocean thermosteric sea level (heat content): Exploring the sensitivity of the CSIRO-ACE CRC-IMAS estimates to 10 XBT bias corrections.

CLIVAR2016 XBT poster: http://www.theclimatehunt.com/science/xbt_poster.pdf

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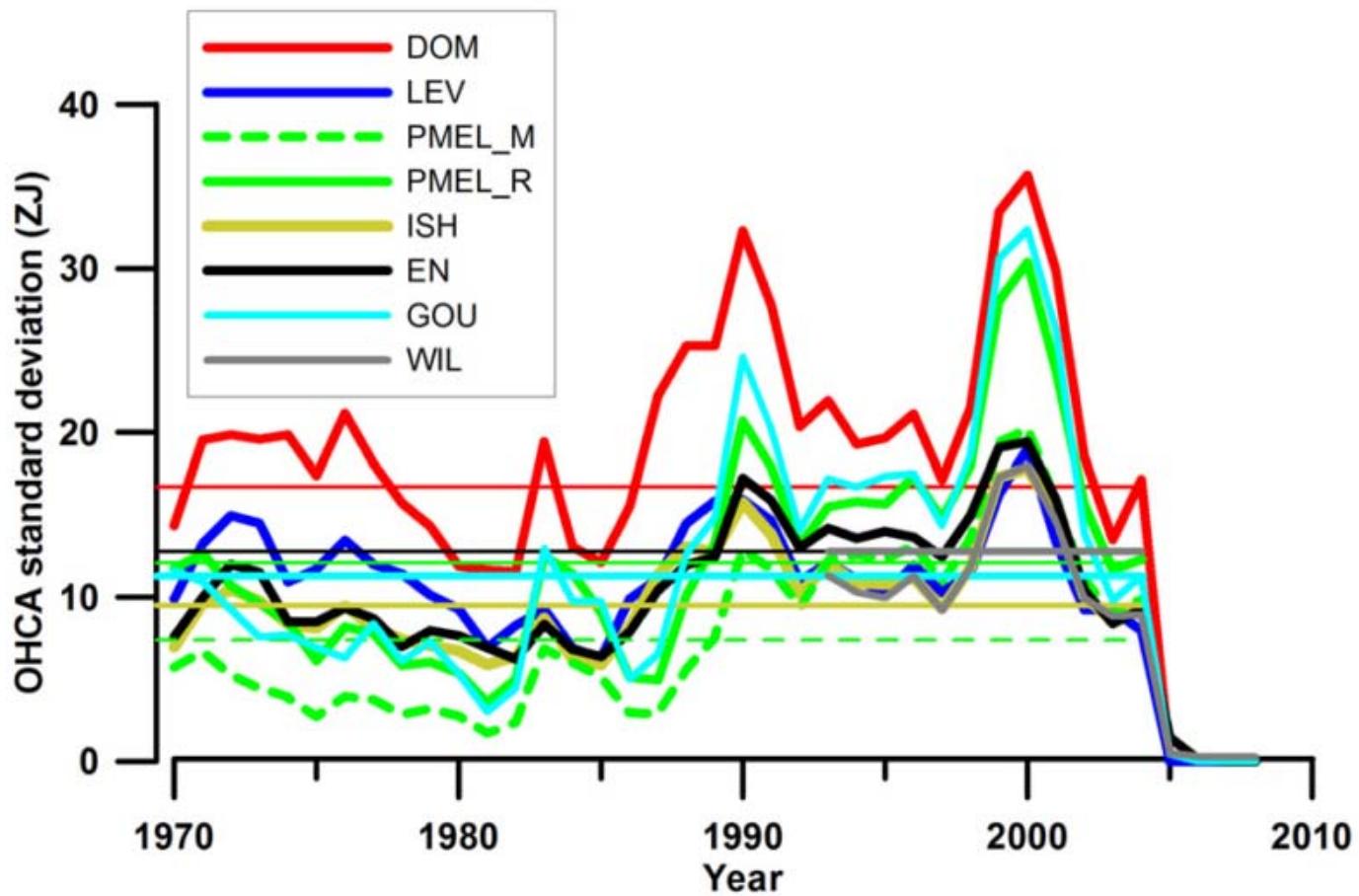
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³ Antarctic Climate and Ecosystems Cooperative Research Centre (ACE CRC)

⁴ Commonwealth Scientific and Industrial Research Organisation (CSIRO)



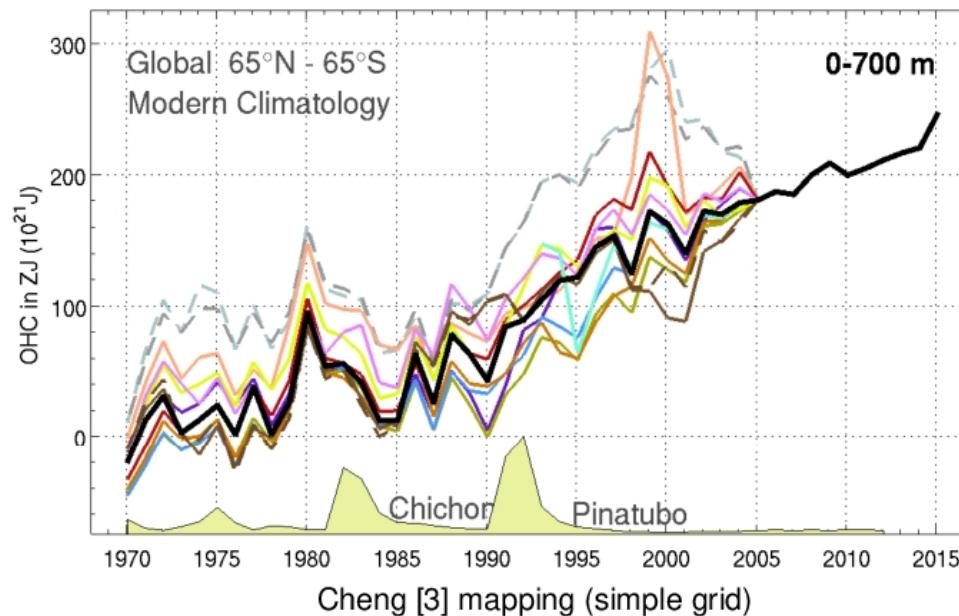


Boyer et al. 2016

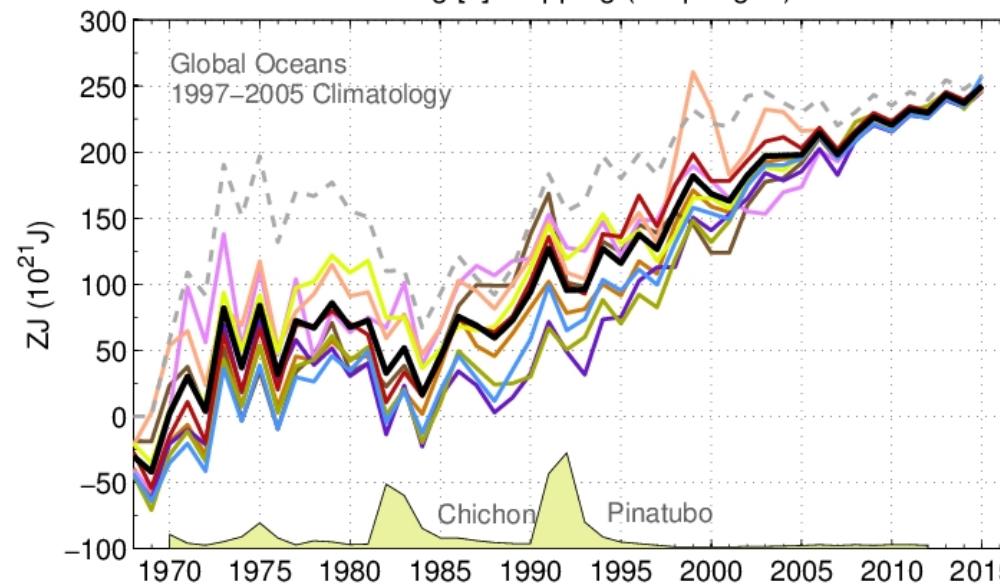
Factors		Cheng et al. 2014	Gouretski & Reseghetti 2010	Levitus et al. 2009	Gouretski 2012	Hamon et al. 2012	Good 2011	Cowley et al. 2013	Cowley et al. 2013 CH	Ishii and Kimio, 2009	Wijffels et al. 2008
Pure temperature bias	Pure temperature bias correction	✓	✓	✓	✓	✓		✓	✓		
	Time-variable	✓	✓		✓	✓		✓	✓		
	Temperature dependency	✓	✓				☒ Cold & warm water				
Depth bias	Depth bias correction	✓	✓		✓	✓	✓	✓	✓	✓	✓
	Time-variable	✓	✓		✓	✓	✓	✓	✓	✓	✓
	Surface depth bias	✓	✓		✓	✓		✓	✓		
	Temperature dependency	✓	☒								
Probe Type	Sippican	T7/DB; T4/T6; T5; T10	T4/T6; T7/DB		T10; T4/T6; T7/DB	Deep; Shallow	T4; T7; T10	T4/T6; T7/DB	T4/T6; T7/DB;	T7; T4; T6; T5; T10; FD;	Deep; Shallow
	TSK	T4/T6; T5; T7					TSK	TSK	TSK	T4; T6; T7	
	Unknown	Deep Unknown; Shallow Unknown			Deep Unknown; Shallow Unknown		Unknown				

Cheng et al. 2015

CSIRO-ACECRC-IMAS mapping



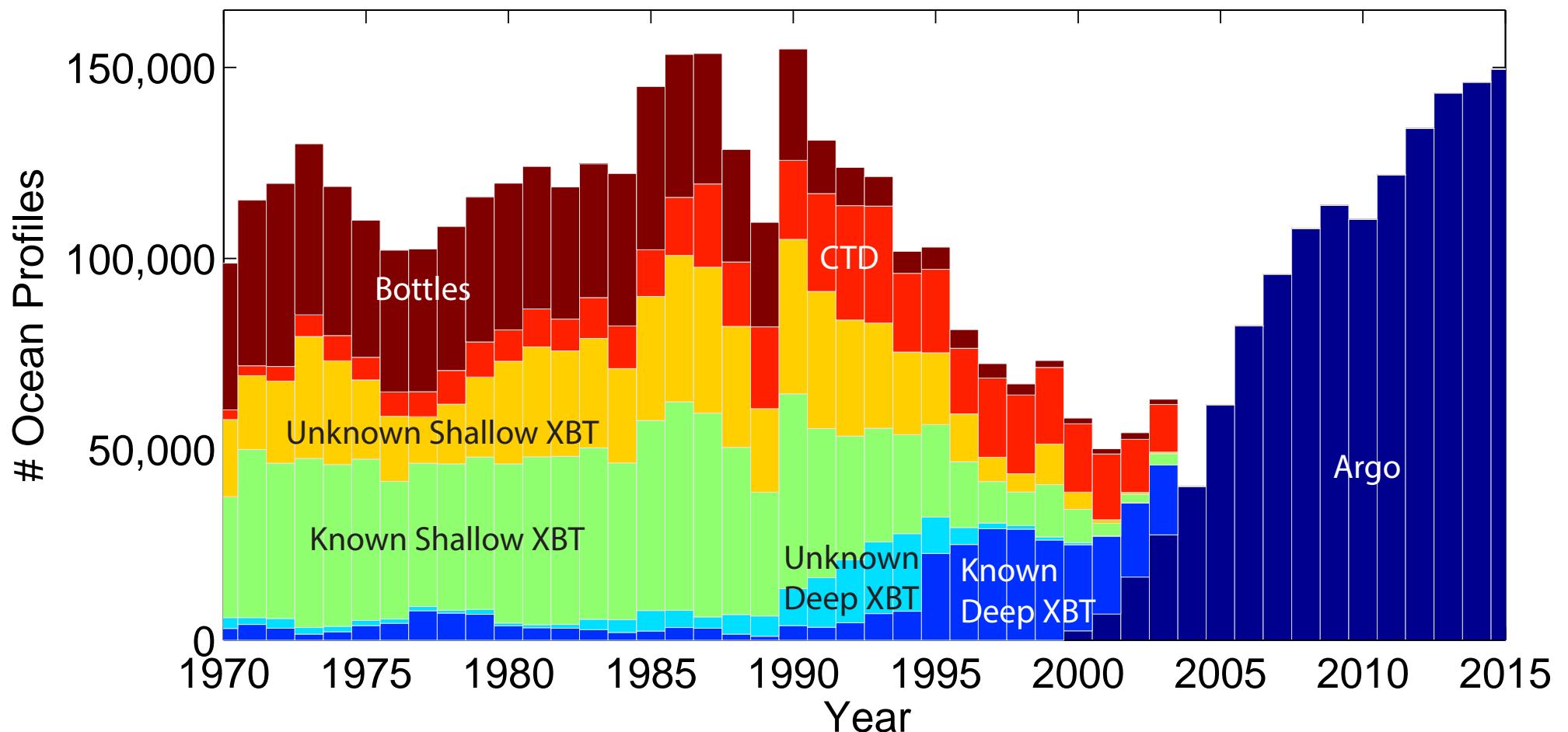
Cheng [3] mapping (simple grid)



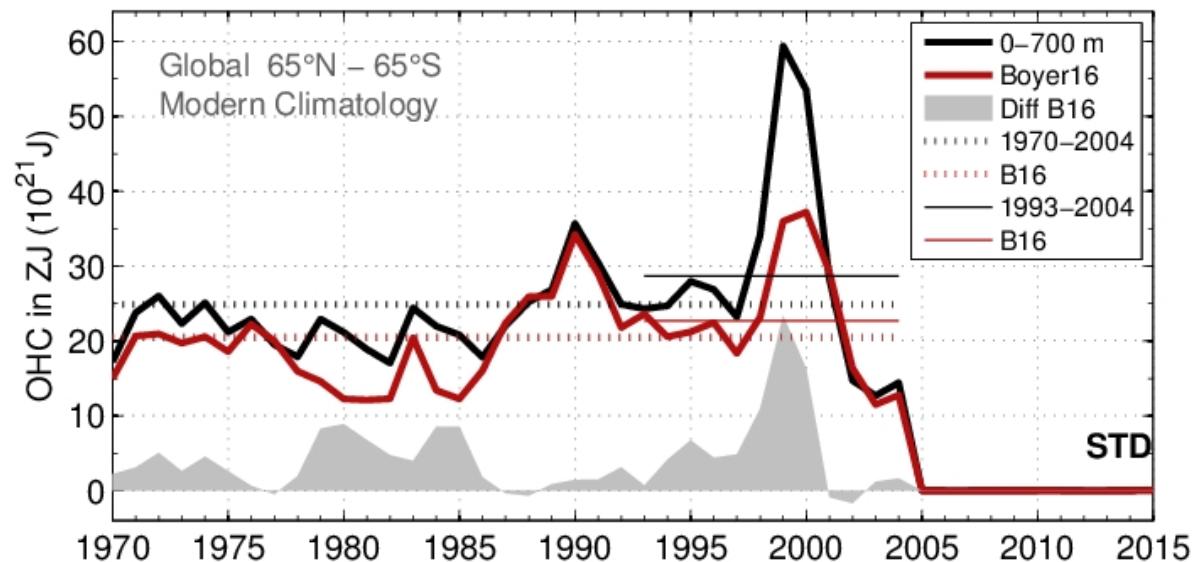
- EN3v2a (uncorrected)
- Wijffels et al. 2008
- Levitus et al. 2009
- Ishii & Kimoto 2009
- Good 2011
- Gouretski 2012
- Cowley et al. 2013
- - EN3v1d (uncorrected)
- Gouretski & Reseghetti 2010
- Hamon et al. 2012
- Cheng et al. 2014
- Willis et al. 2008
- - Wijffels et al. EN3v1d
- Mean

Profiles used in this study

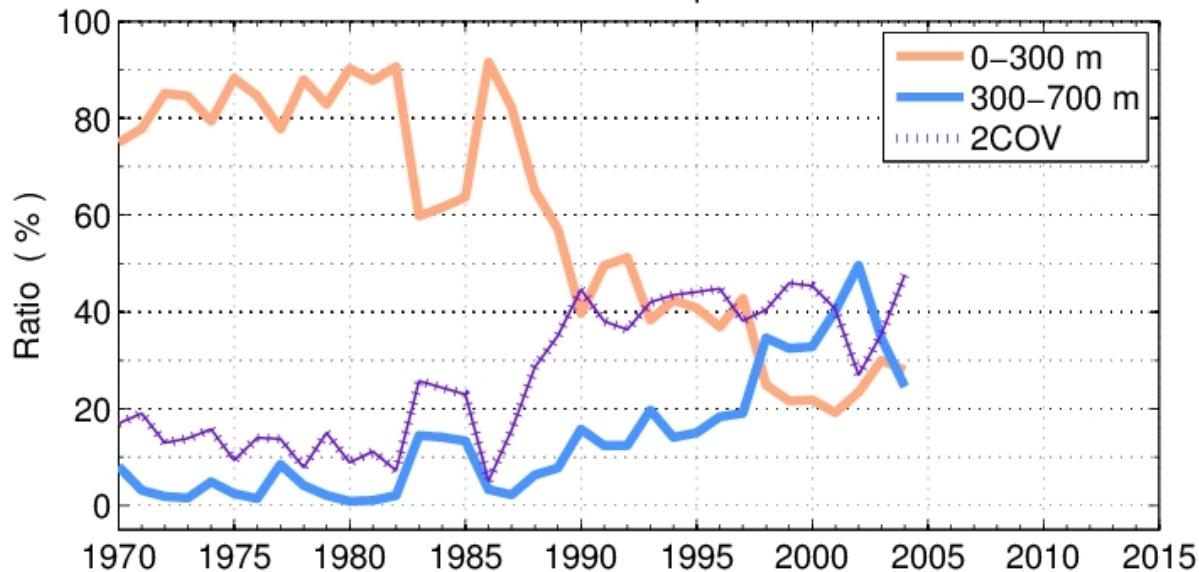
Changes in ocean measurement systems since 1970

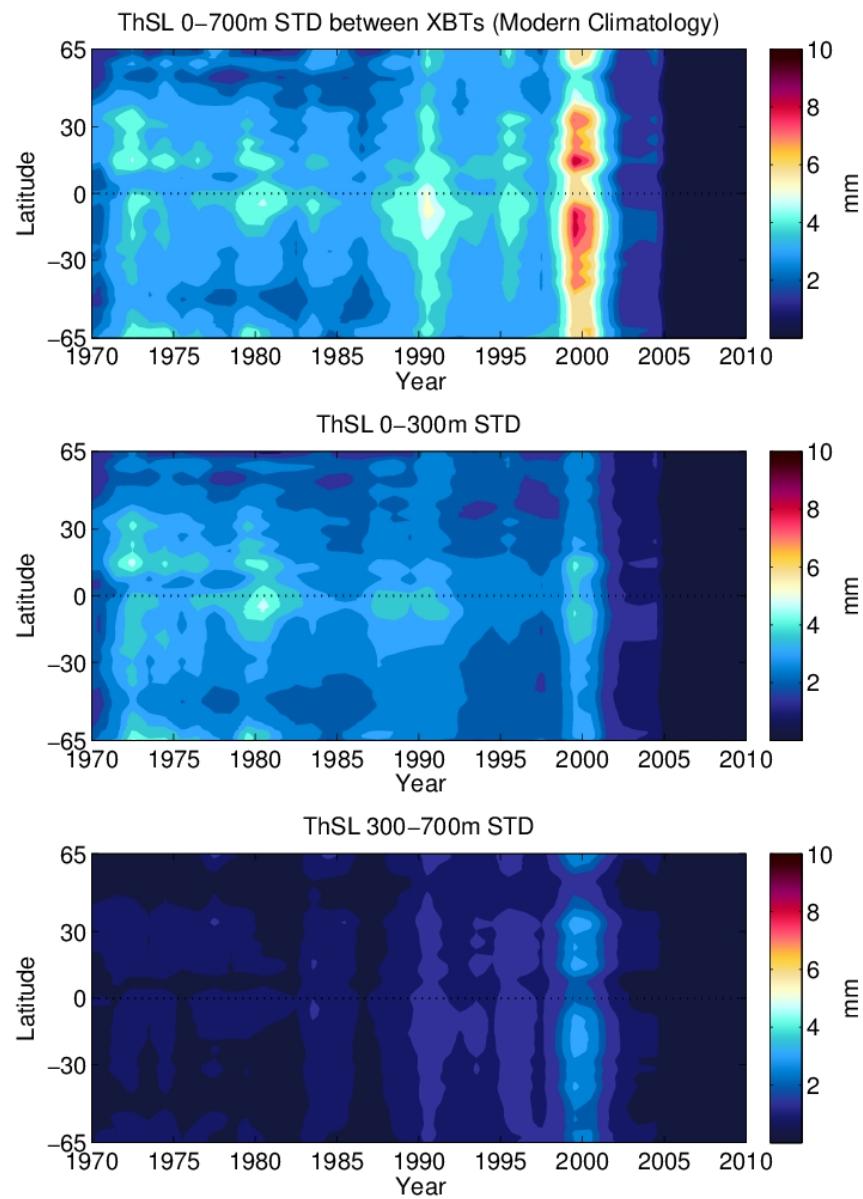


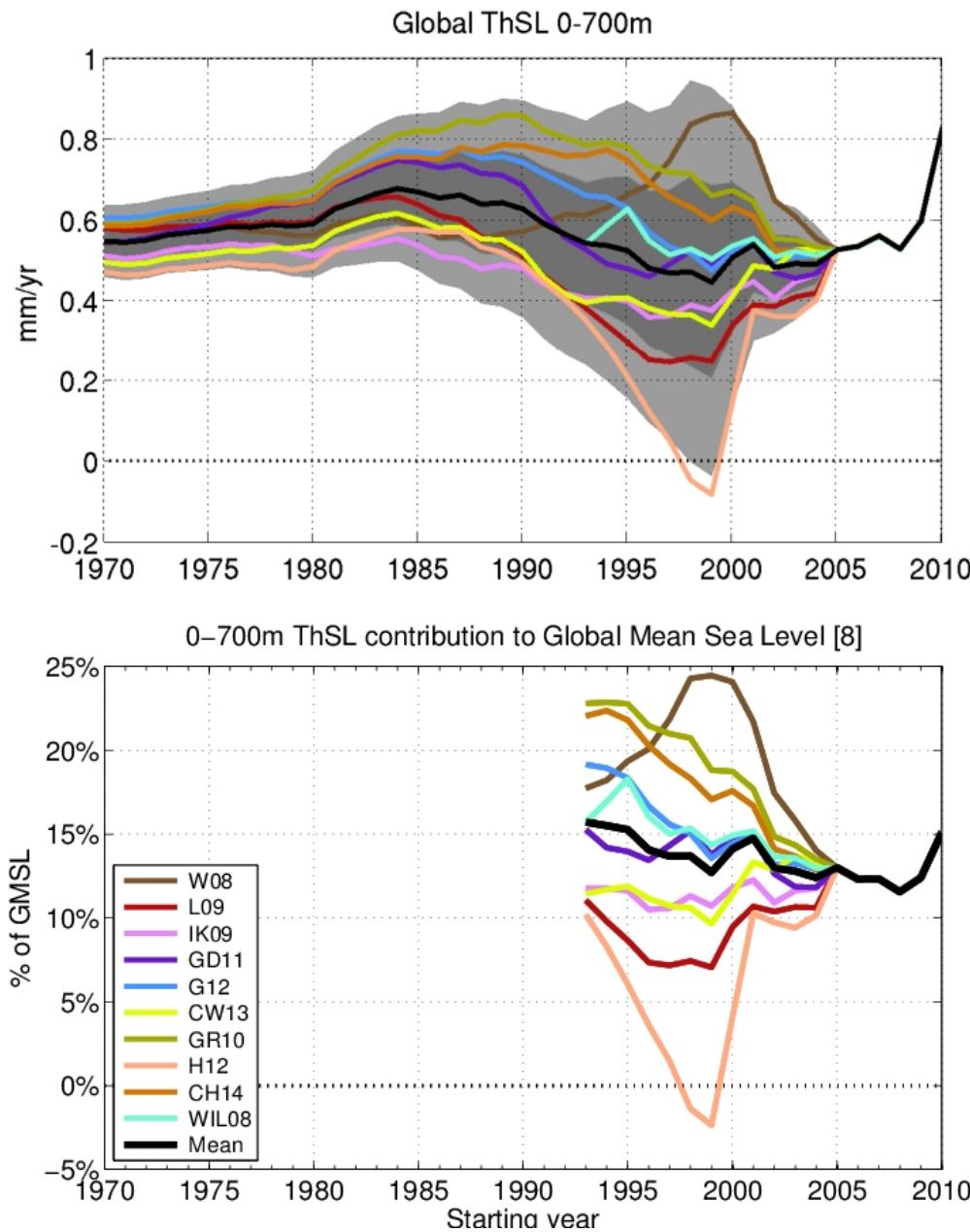
Spread due to XBT corrections



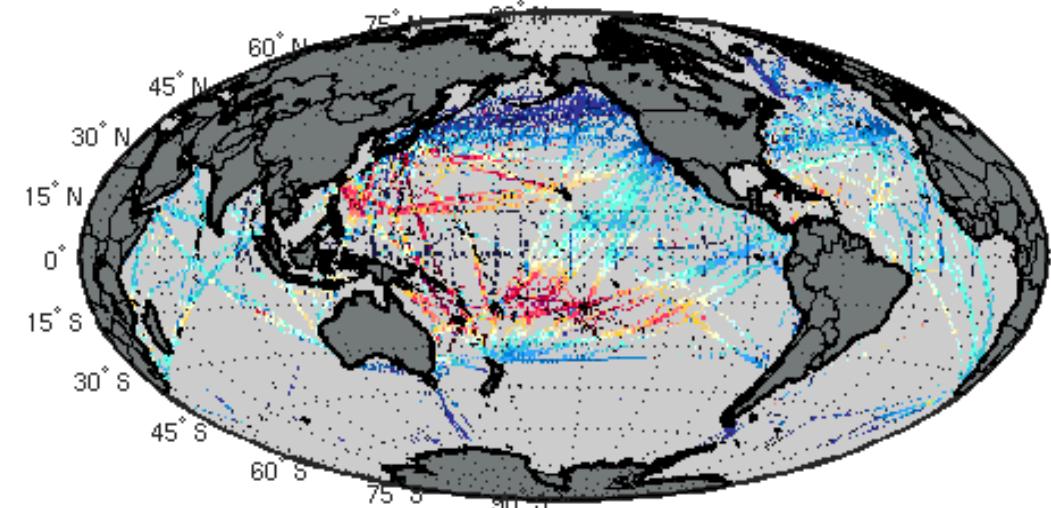
In-situ ocean observations used to produce ThSL/OHC estimates



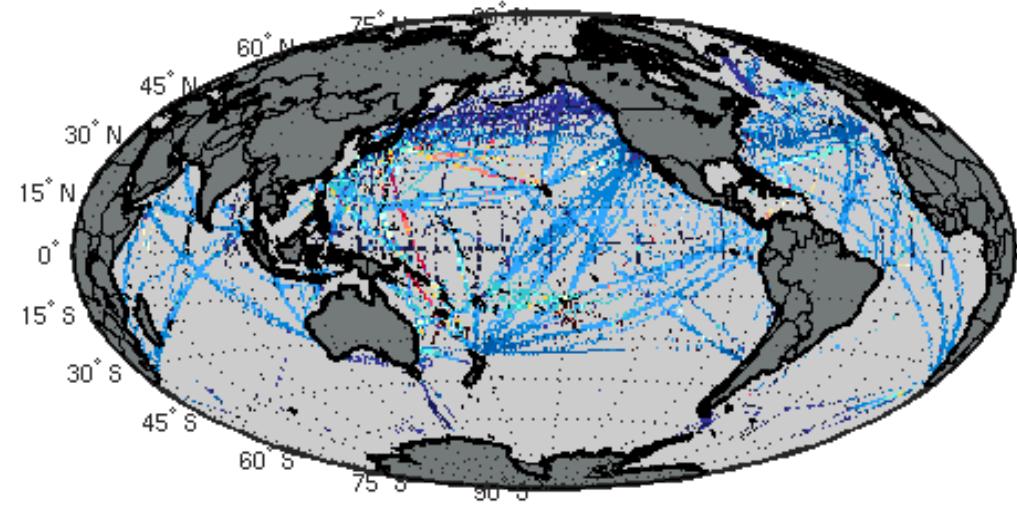




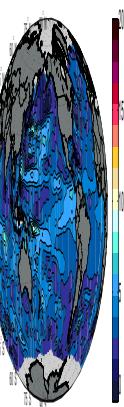
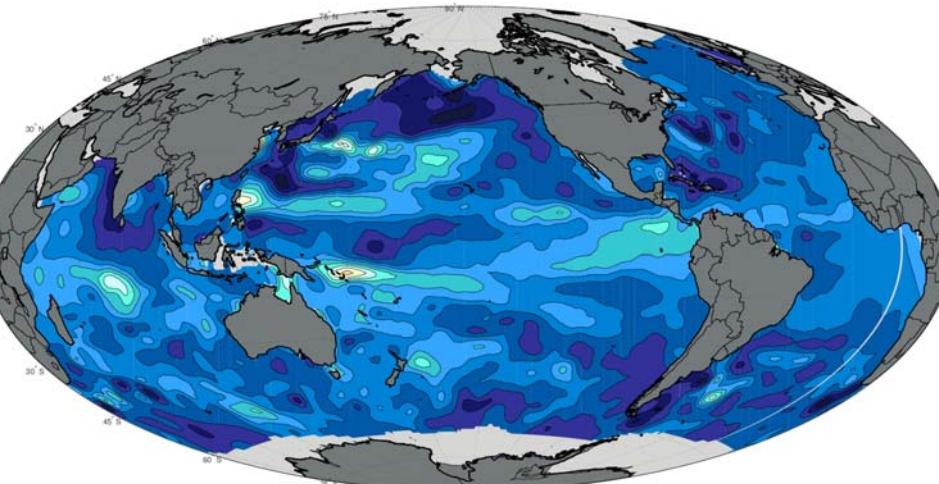
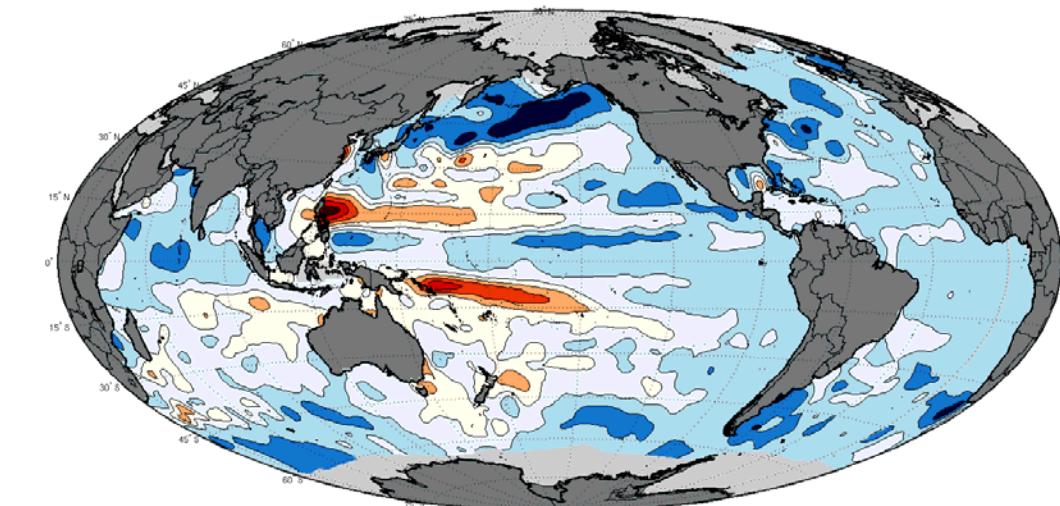
Observations (STD): 1999 w/ outliers



Without Hamon + Wijfells Outliers

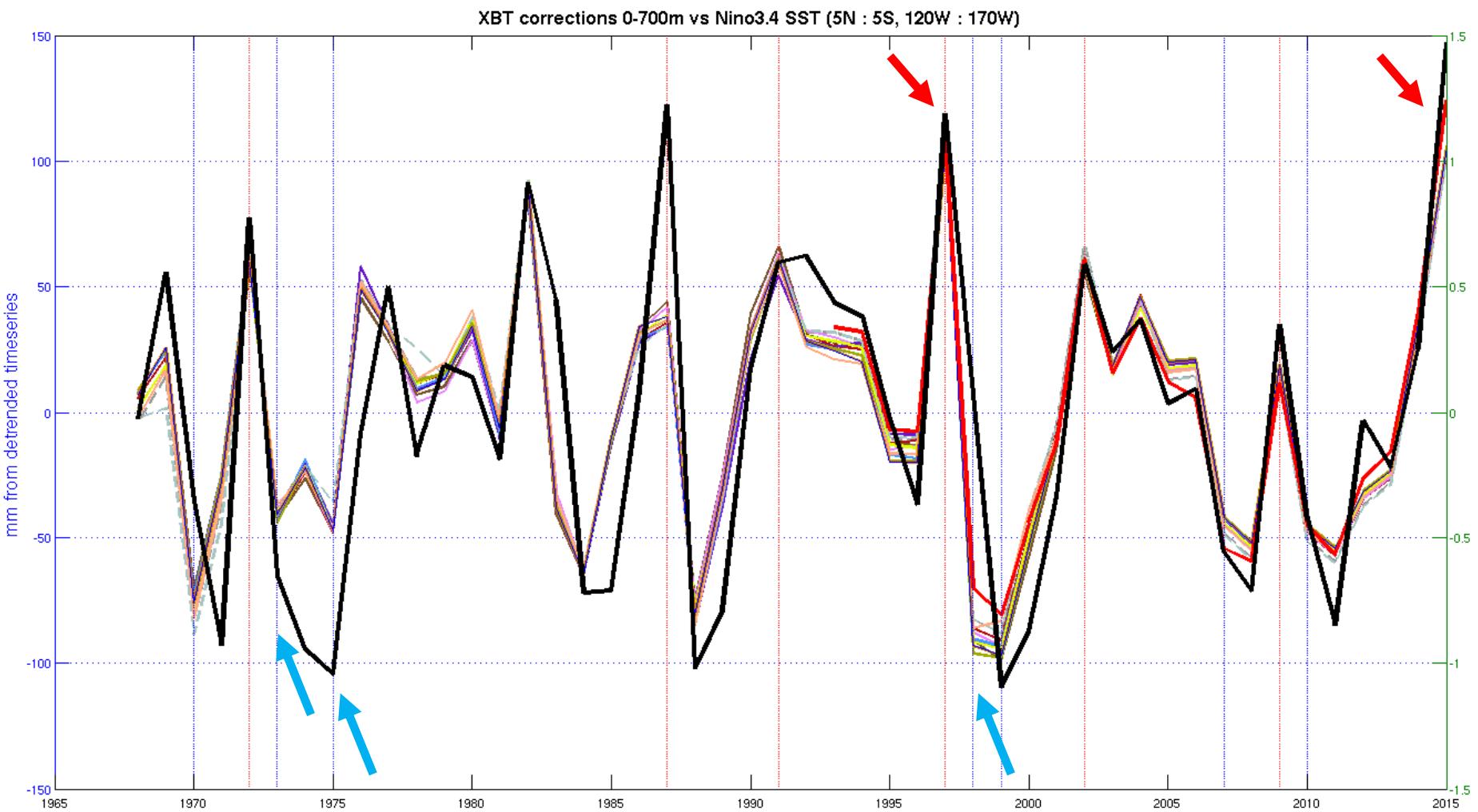


Reconstruction (STD)

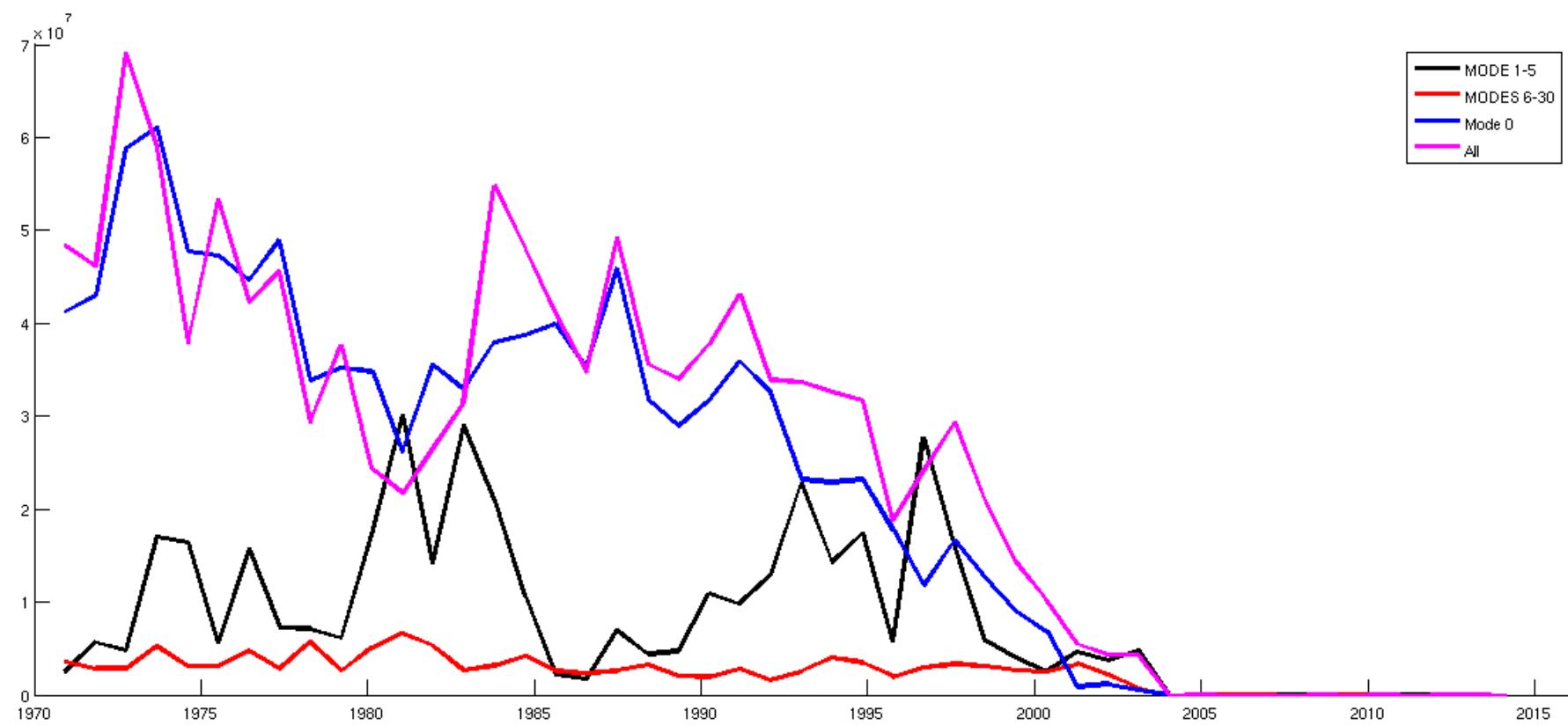


mm
(STD)

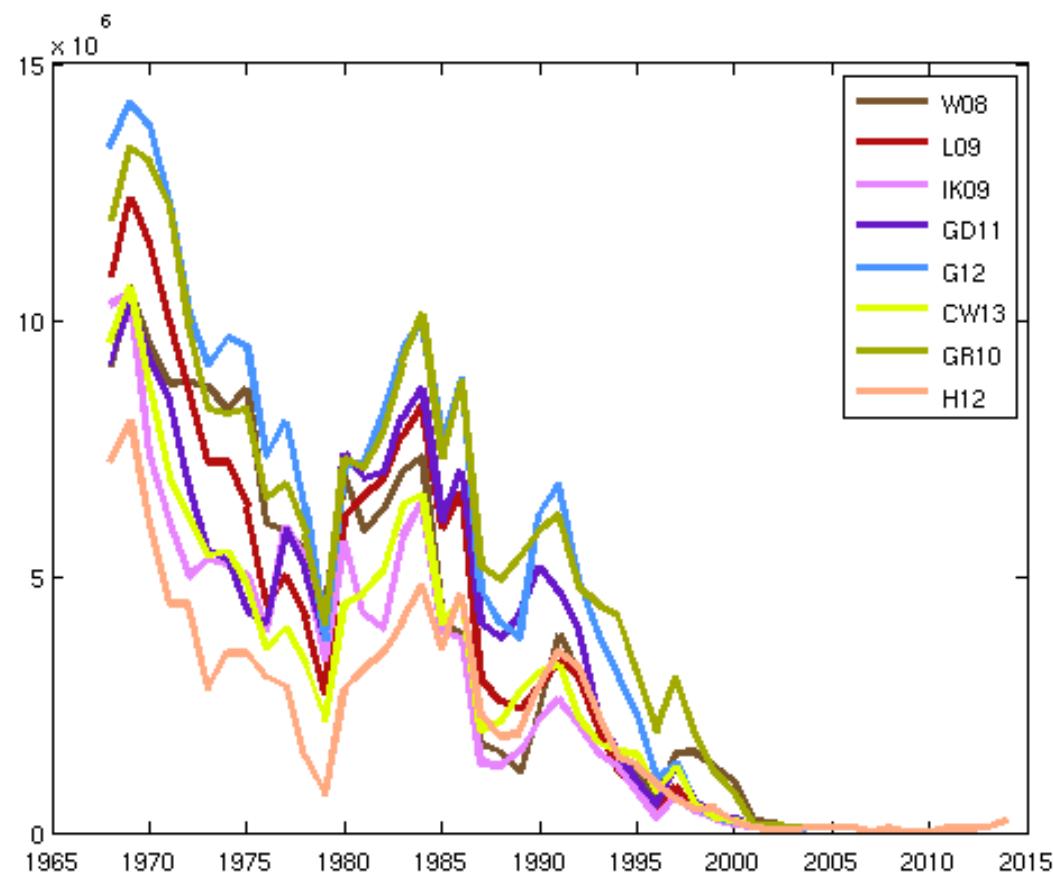
NINO3.4 SST, 0-700, satellite altimeter



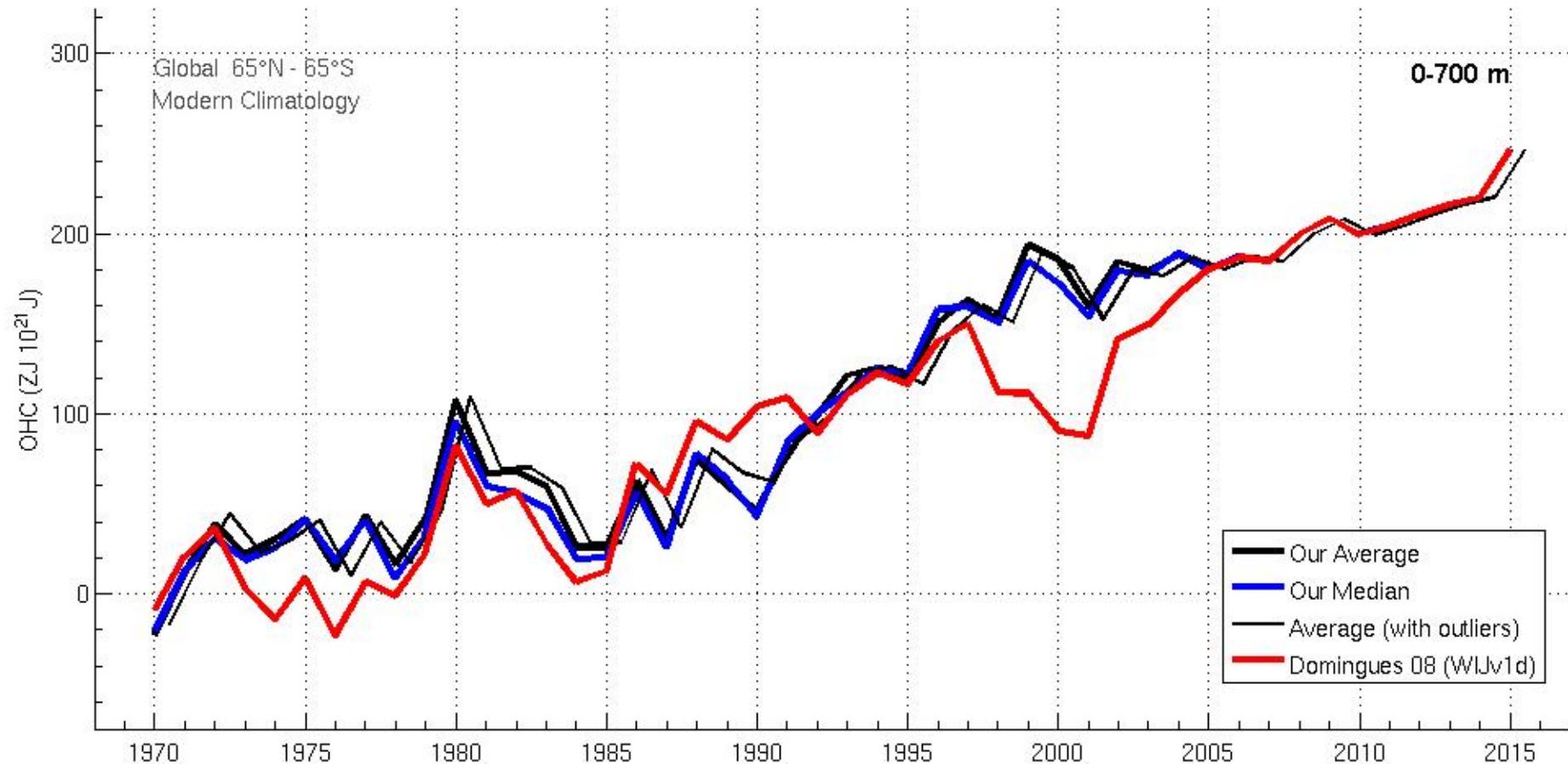
EOF Mode bins (STD between corrections)



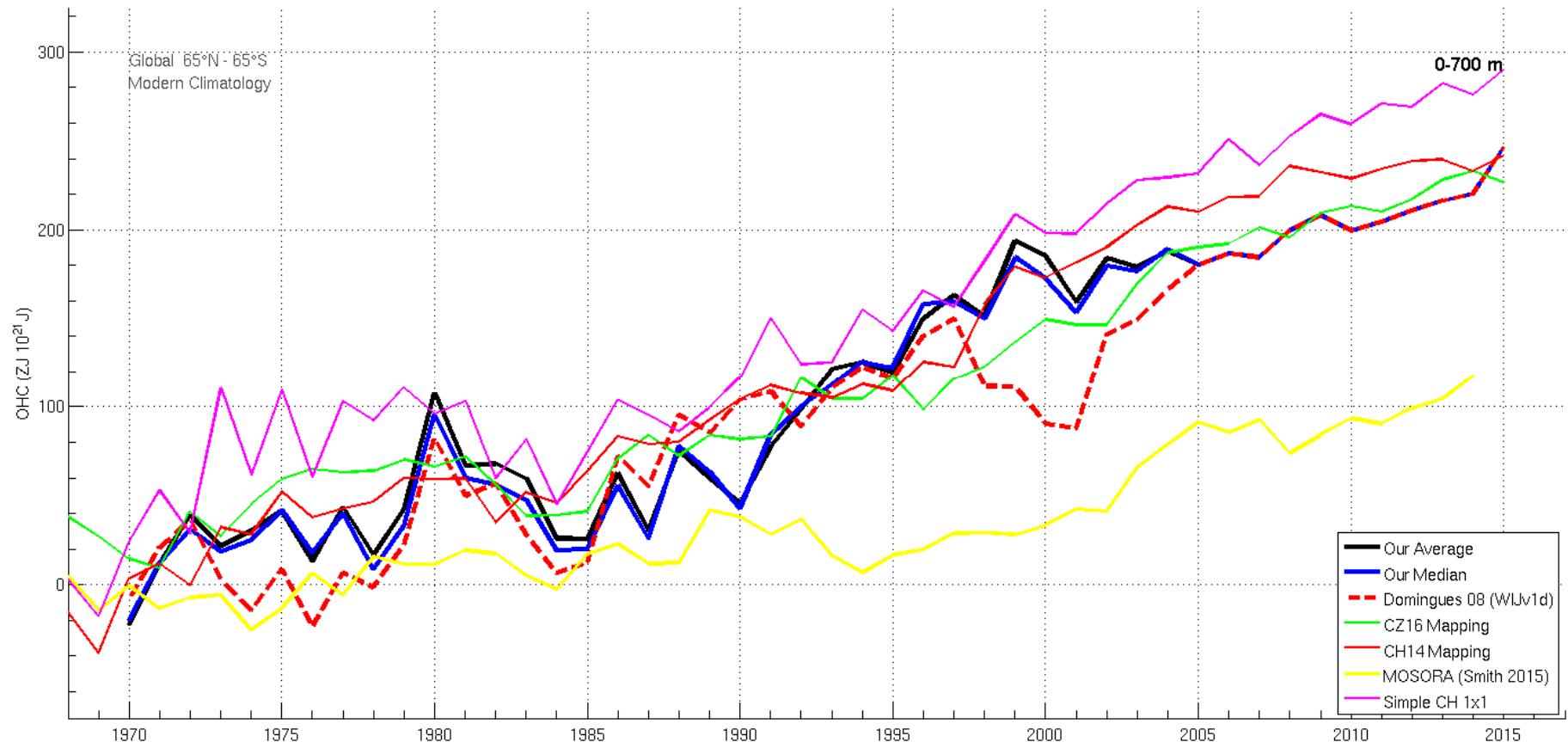
EOF Mode 0 between corrections



A Possible Solution

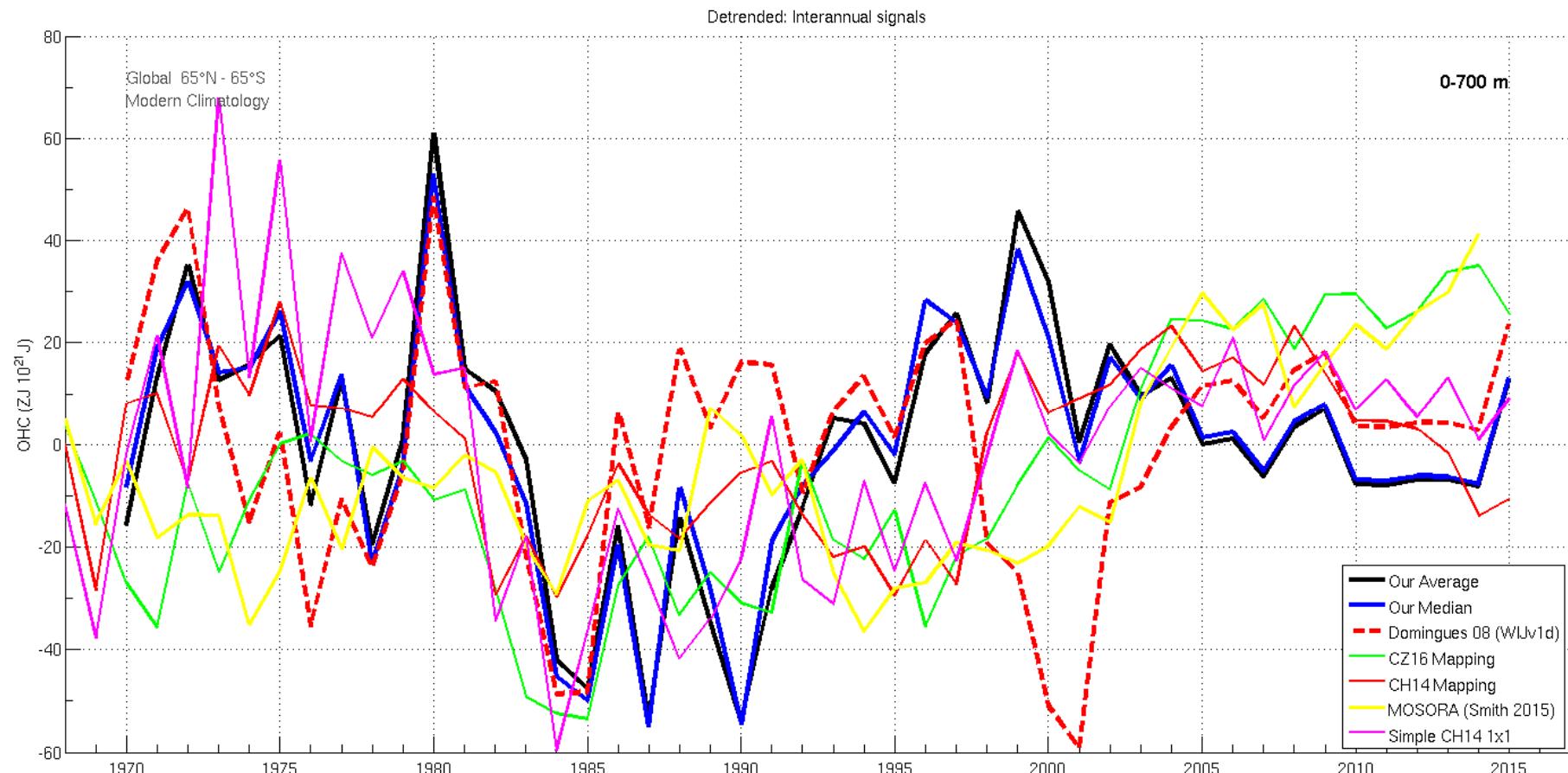


Solution Comparison



CZ16 method (EnOI-DE/CMIP5 method

Detrended Solution Comparison



Conclusions and future work

- A lot of spread between XBT corrections
- Driven by Mode 0, the global mean, but influenced during ENSO events.
 - More detail into EOF variability
- Gather some additional datasets to compare solution against (globally and regional; different ocean basins)
- Separate XBT types into bias correction category (Fall, Depth, All)
- Dataset Dependency?
- Anomaly as Celcius? Thermosteric mm? Joules 10^{21} or 2^2 or 2^3 ? Any preference?
 - I prefer mm thsl.

Thanks!

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- [2] Gouretski, V. and K. P. Koltermann (2007). "How much is the ocean really warming?" Geophysical Research Letters **34**(1).
- [3] Cheng, L., et al. (2015, updated). "XBT Science: assessment of instrumental biases and errors." Bulletin of the American Meteorological Society.
- [4] Domingues, C. M., et al. (2008). "Improved estimates of upper-ocean warming and multi-decadal sea-level rise." Nature **453**(7198): 1090-1093.
- [5] Kaplan, A., et al. (2000). "Reduced space optimal interpolation of historical marine sea level pressure: 1854-1992*." Journal of Climate **13**(16): 2987-3002.
- [6] Ingleby, B., and M. Huddleston, (2007) "Quality control of ocean temperature and salinity profiles - historical and real-time data." Journal of Marine Systems, 65, 158-175
- [7] Boyer, T., et al. (2016). "Sensitivity of Global Upper Ocean Heat Content Estimates to Mapping Methods, XBT Bias Corrections, and Baseline Climatologies " Journal of Climate.
- [8] GMSL (Satellite Altimetry 1993-2015), CSIRO: http://www.cmar.csiro.au/sealevel/sl_data_cmar.html (Legresy, B., 2015)
- [9] Volcanic Forcing Data, NASA: <http://data.giss.nasa.gov/modelforce/strataer/> (Sato M., 2014)

Data Sources

- Cheng L., and J. Zhu, 2014: Artefacts in variations of ocean heat content induced by the observation system changes, *Geophysical Research Letters*, 41(20), 7276-7283, DOI:10.1002/2014GL061881
- Cheng L., J. Zhu, and J. Abraham, 2015: Global upper ocean heat content estimation: recent progress and the remaining challenges. *Atmospheric and Oceanic Science Letters*, 8, 6, 333-338. DOI:10.3878/AOSL20150031.
- Cheng L. and J. Zhu, 2016, Benefits of CMIP5 multimodel ensemble in reconstructing historical ocean subsurface temperature variation, *Journal of Climate*. 29(15),5393-5416,doi:10.1175/JCLI-D-15-0730.1