Mapping of Upper Ocean Heat Content

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Upper Ocean Heat Content (Anomaly)

Uncertainties in Ocean Heat Content (OHC) calculations are mainly because of the systematic bias in temperature measurements, insufficient coverage of in-situ measurements, methodologies such as climatology and quality control of the in-situ data.

$$OHCA = \int_0^z \rho_{clim}\ C\ (T(z) - T_{clim})\ dz$$

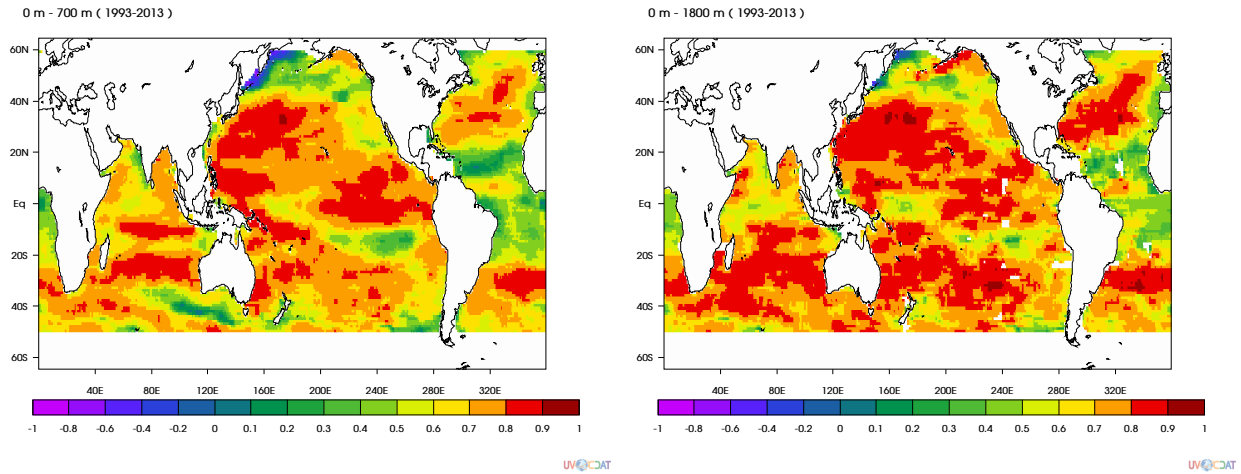
– *This is the local change of Heat in the Ocean w.r.t the Climatological Temperature.*

– *Annual mean OHCA using hydrographic profiles from 1993 - 2013, when Altimetric Sea Surface Height (Anomaly) measurements are available (AVISO).*

T(z) : Potential Temperature profile with depth (EN4 Hadley centre dataset including ARGO, XBTS, ...)

Objective Mapping of Heat Content

Significant correlations exist between the SSHA and the Ocean Heat Content in most of the Global Ocean.



$\Psi_{est}(\mathbf{x})$, *the estimated value of the field at a grid-point from a set of observations* $\Psi_{obs}\ (\mathbf{x_s})$ is,

$$\Psi_{est}(\mathbf{x}) = \widetilde{\theta} + \sum_{r=1}^{N} C_{xr} \left(\sum_{s=1}^{N} A_{rs}^{-1} \left(\Psi_{obs}\ (\mathbf{x_s}) - \widetilde{\theta} \right) \right.$$

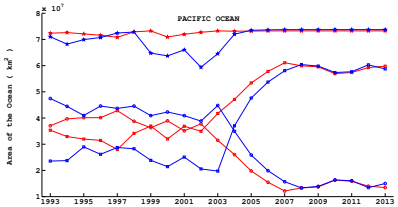
$$A_{rs} = \langle \Psi_{obs}(\mathbf{x_r})\ \Psi_{obs}(\mathbf{x_s}) \rangle, C_{xr} = \langle \Psi(\mathbf{x})\ \Psi_{obs}(\mathbf{x_r}) \rangle$$

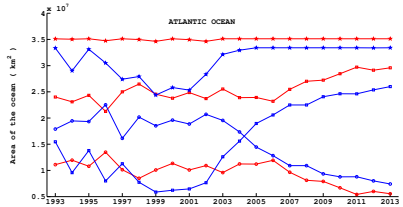
$\langle HCA \rangle_{estimate}$, the estimated value of the mean HCA for a particular year on the SSHA grid is : $\langle HCA \rangle_{estimate} = \langle HCA - \alpha\ SSHA \rangle + \overline{\alpha\ SSHA}$,

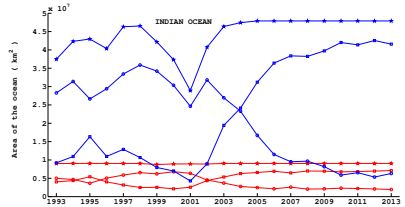
(Willis et al. 2003, 2004), where α is the regression of HCA on SSHA.

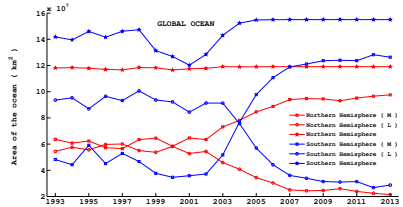
Observed Area and Sampling error from SSHA as a proxy

Observed (Objectively mapped) area



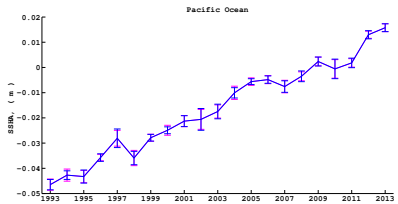


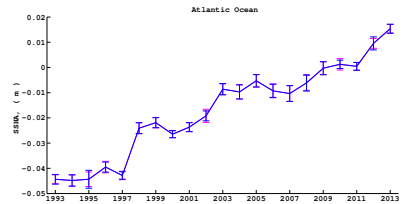


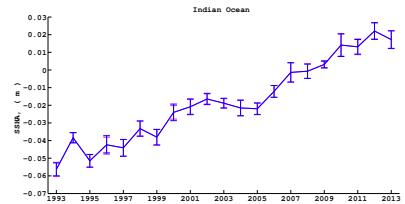


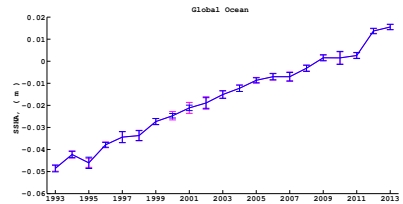
The Sampling error for a year N is ,

$$\text{Sampling\_error\_N} = \left[\frac{\sum_{i=1993}^{2013} [SSHA_{total}(i) - SSHA_N(i)]^2}{21} \right]^{1/2}$$

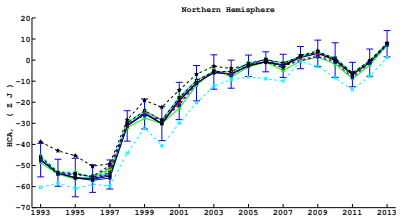


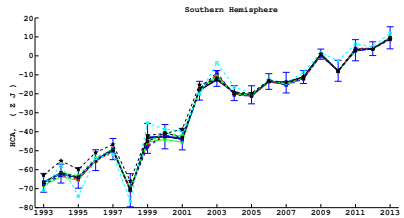


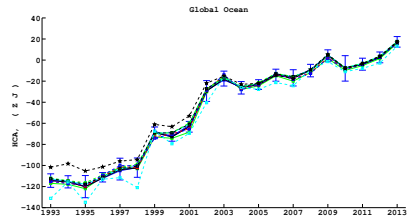


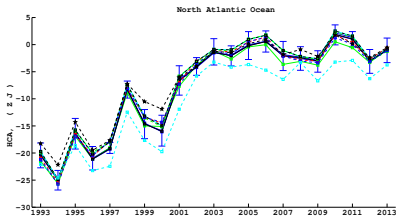


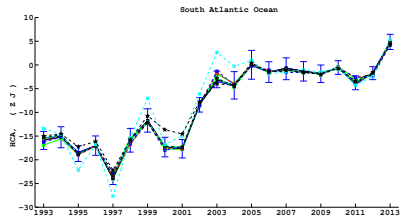
0 - 700 m HCA Time series for the Global Ocean, Atlantic Ocean, Indian Ocean and Pacific Ocean

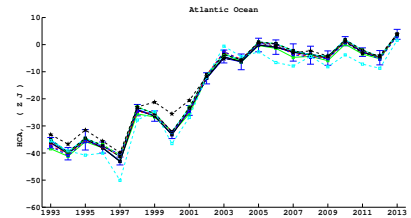


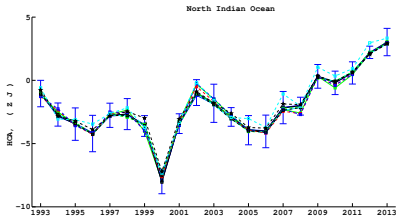


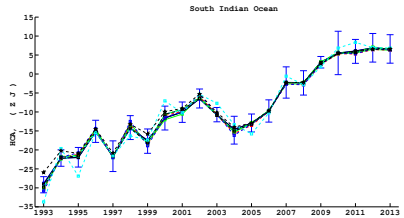


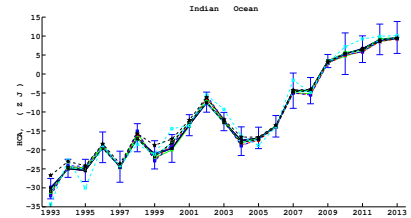


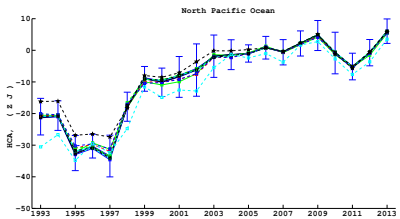


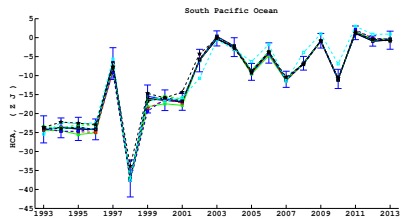


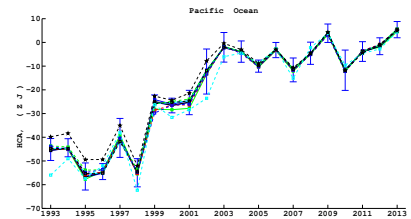




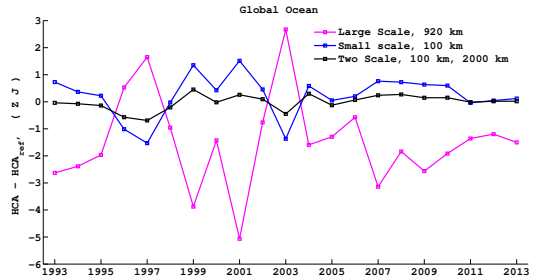


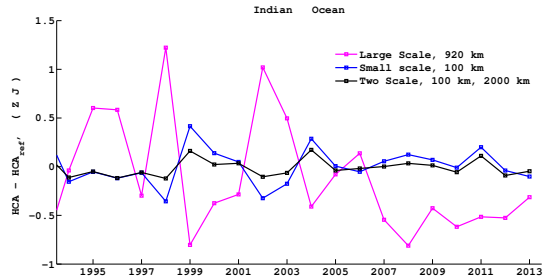




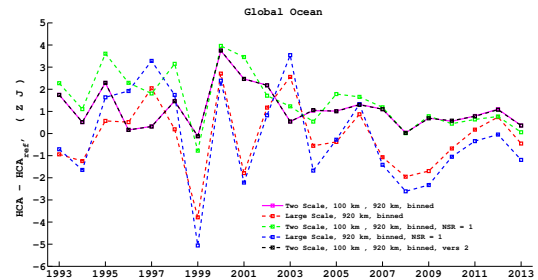


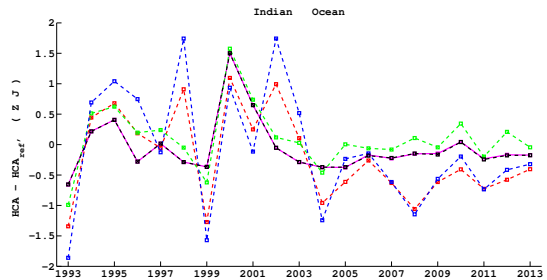
Effect of mapping parameters (1993 - 2013 w.r.t. the reference run)



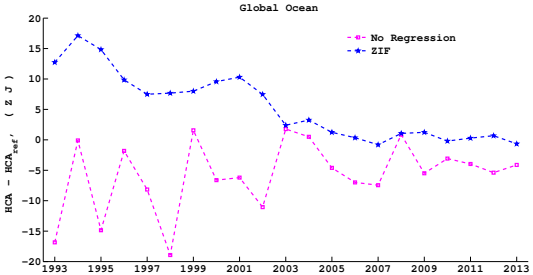


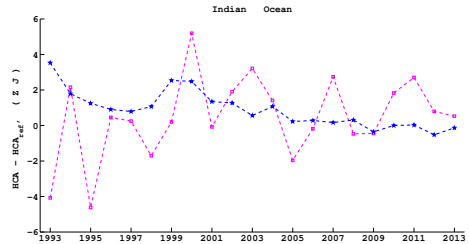
Correlation scales
max $\sim$ 1 - 2 ZJ





Binning, Noise to Signal Ratio
max $\sim$ 4 ZJ ,
$\sim$ 1 - 2 ZJ



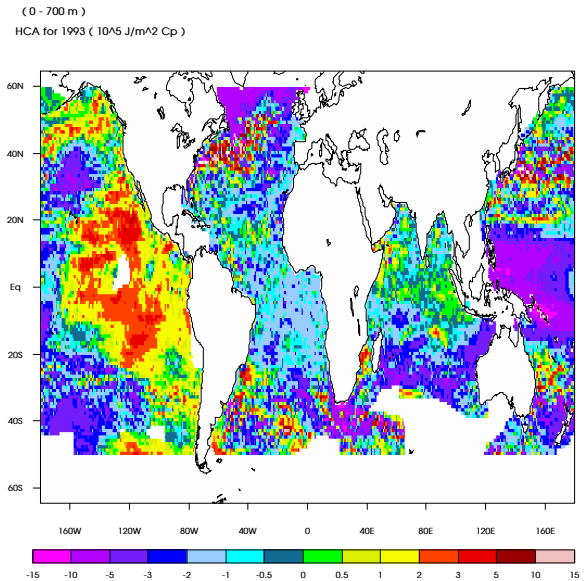


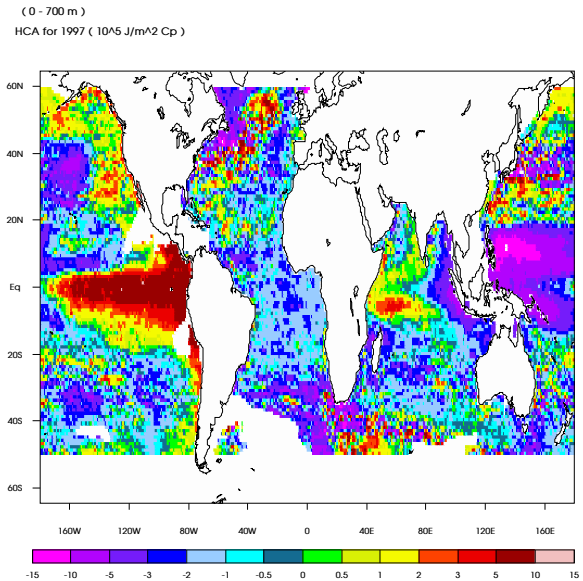
Regression of HCA on SSHA, Zero infilling
max $\sim$ 17 ZJ, $\sim$ 17 ZJ

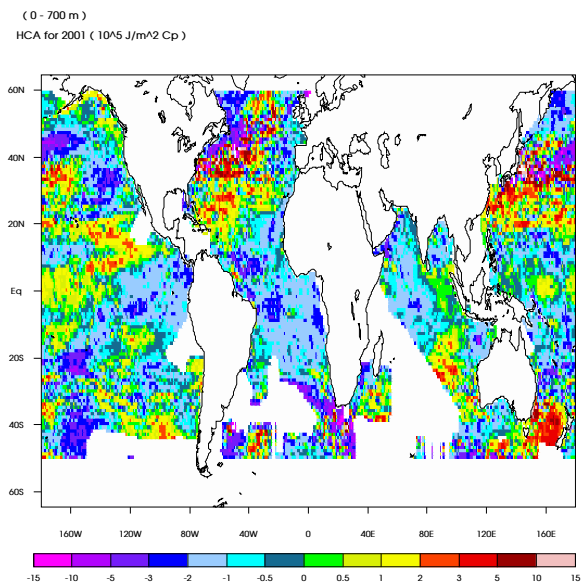
Sampling error using the SSHA as a proxy : max $\sim$10 ZJ.

* The major sources of uncertainty in OHCA estimates are : instrument biases $\sim$ 10.9 to 22.4 ZJ, differences in climatology $\sim$2.7 to 9.8 ZJ and choice of mapping method $\sim$ 17.1 ZJ for 1993 - 2008. (Boyer et al., 2016)

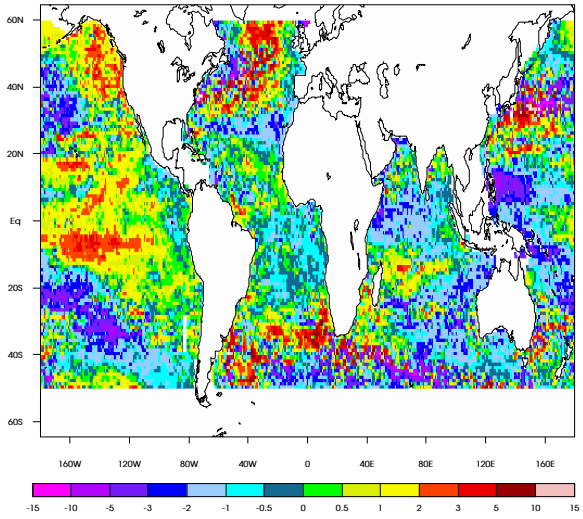
0 - 700 Ocean Heat Content from 1993 - 2013



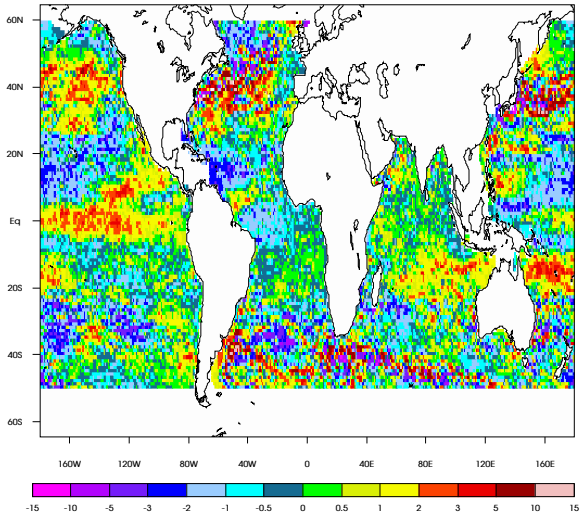




(0 - 700 m)
HCA for 2005 (10^5 J/m^2 Cp)



(0 - 700 m)
HCA for 2009 (10^5 J/m^2 Cp)



(0 - 700 m)
HCA for 2013 (10^5 J/m^2 Cp)