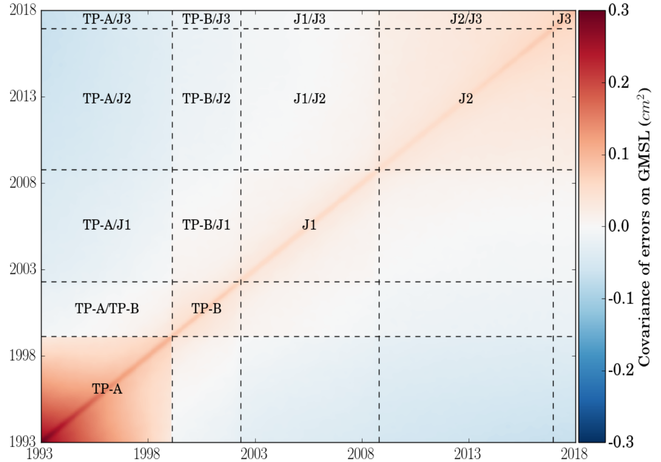
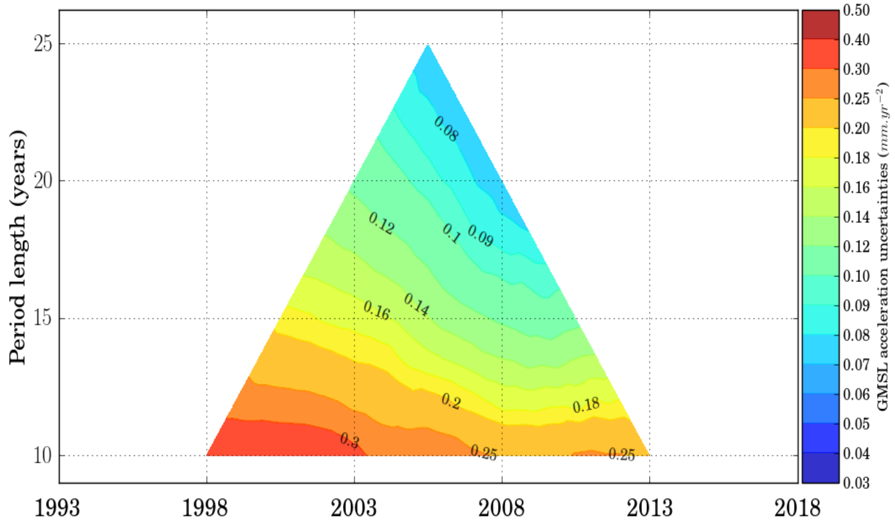
Uncertainty in Global mean sea level from Satellite Altimetry

***Approach**: estimate directly the GMSL error variance-covariance matrix from an error budget of the altimetry system. Then use the matrix to evaluate the uncertainty on some metrics like sea level trends and sea level acceleration (context: ESA climate change Initiative coastal sea Level project)*

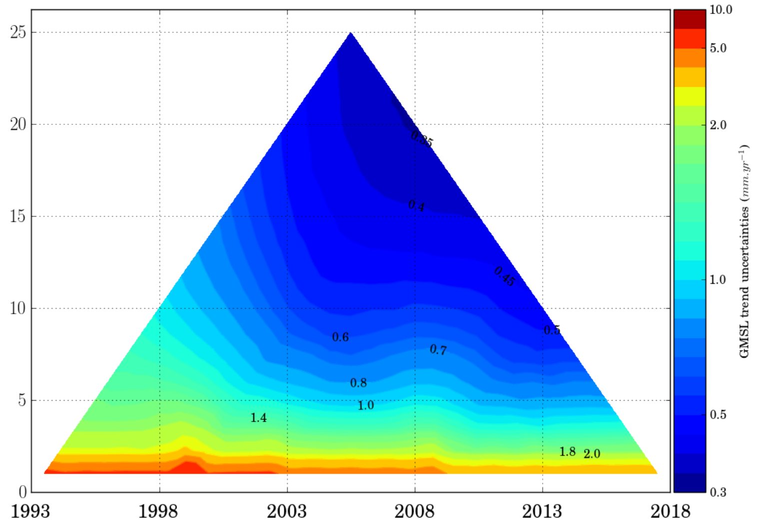


Error Variance-covariance matrix over 1993-2018



Center of the period over which accelerations are estimated

Uncertainty in sea level acceleration deduced from the var-covar matrix

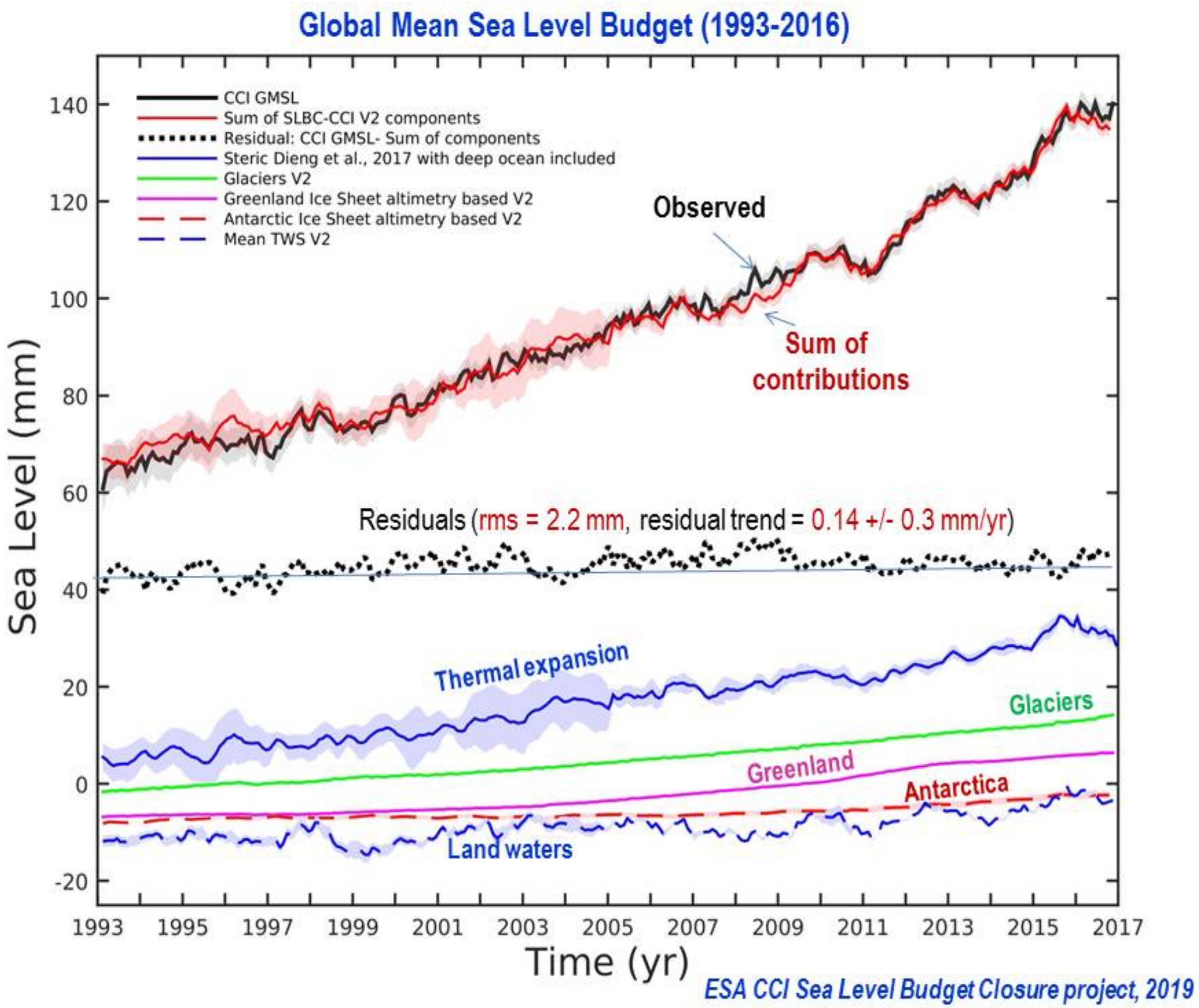


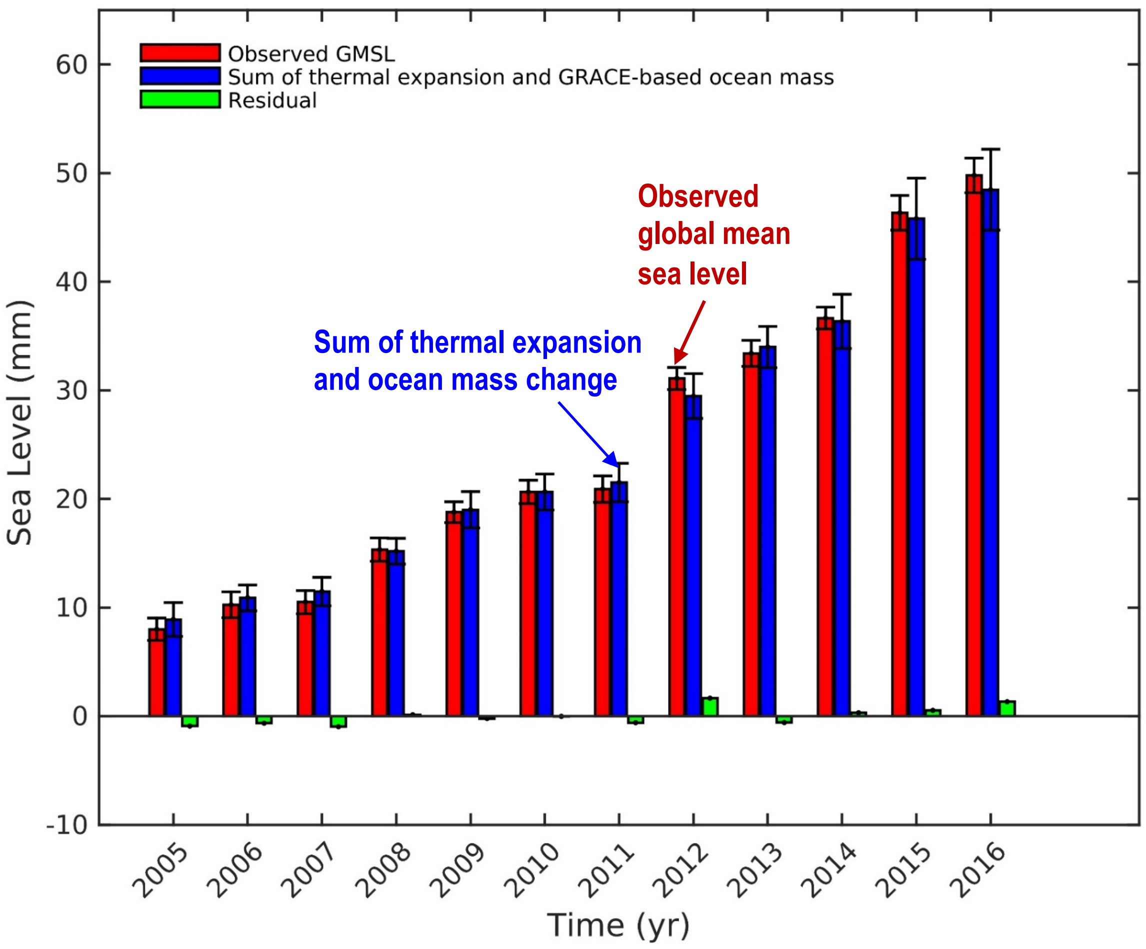
Center of the period over which trends are estimated

Uncertainty in sea level trends deduced from the var-covar matrix

Ablain et al., *ESSD*, 2019, Prandi et al, *Nature Scientific Data*, in revision

Closure of the Global Mean Sea Level Budget over the Altimetry Era

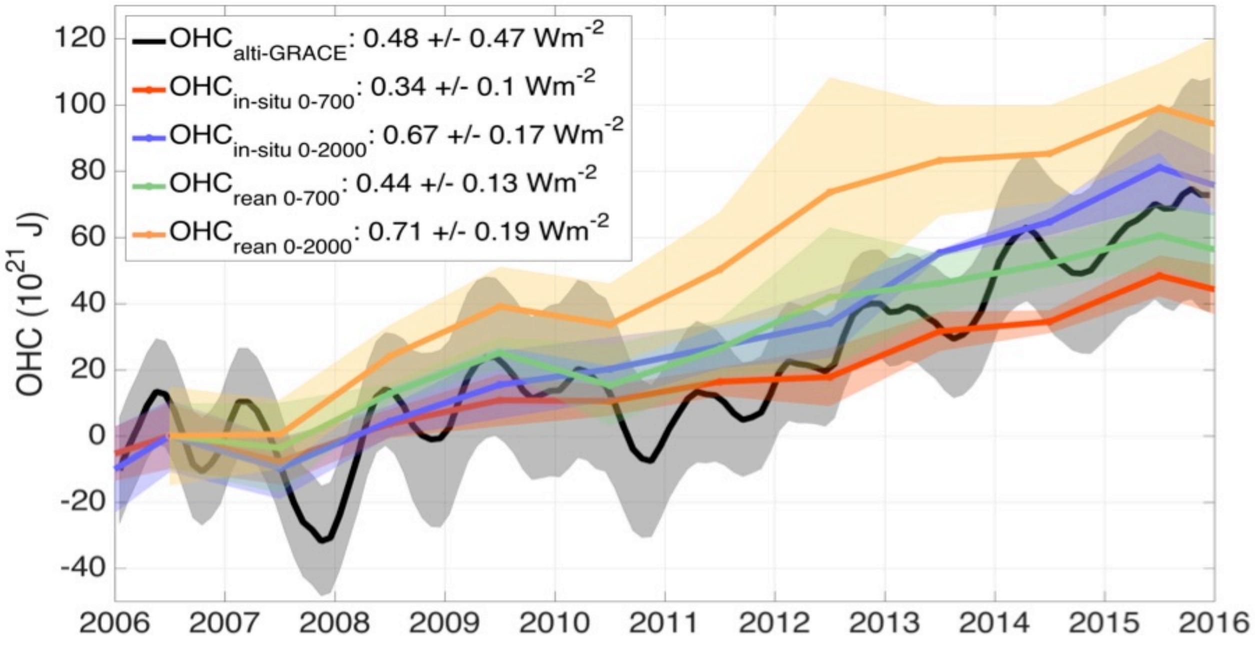




Dieng et al., *GRL*, 2017, Cazenave et al., *ASR*, 2018; The WCRP Global Mean Sea Level Team, *ESSD*, 2018; The ESA Sea Level Budget Closure project, Horwath et al., in preparation, 2020

Estimate of the Earth energy imbalance

***Approach**: estimate the global steric sea level from the difference between GMSL estimated by altimetry and ocean mass estimated by GRACE. Then estimate the global ocean heat content, which is a precise proxy of the Earth energy imbalance, by estimating the expansion efficiency of heat and multiplying it with the global steric sea level*



Global ocean heat content from alti-Grace, Argo data and ocean reanalysis

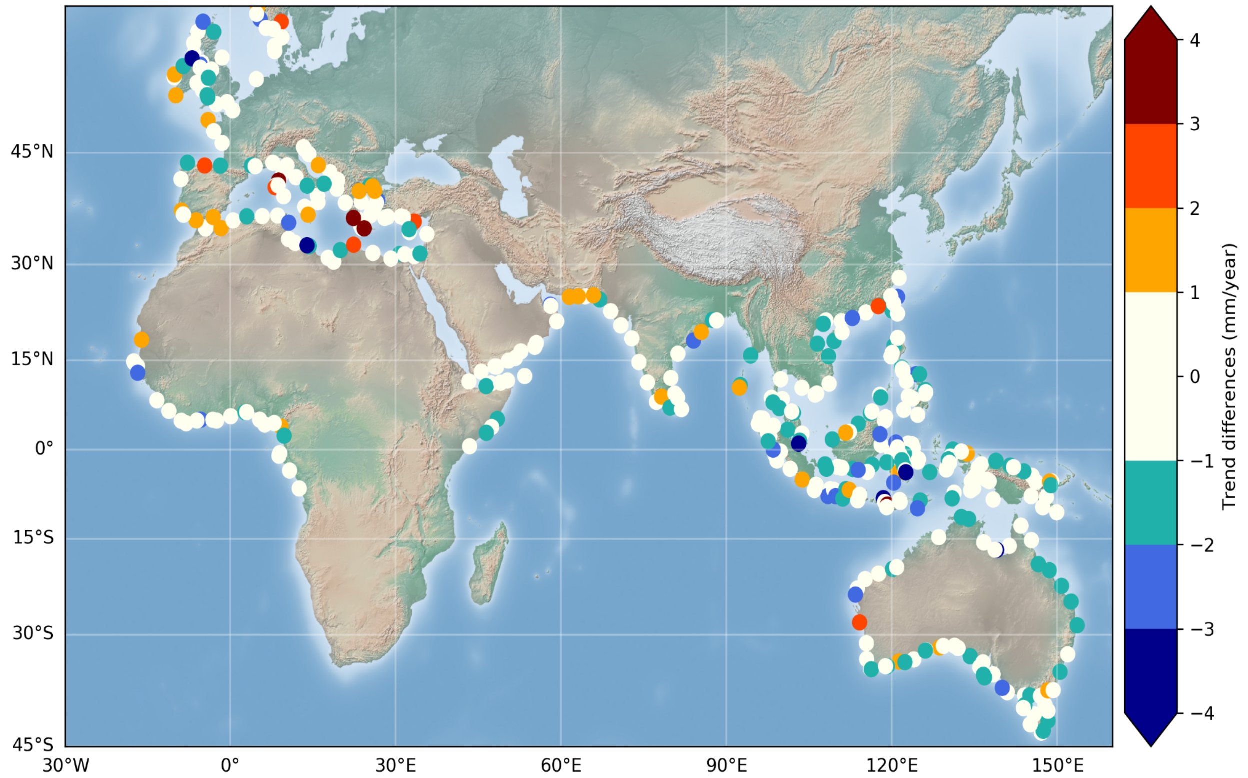
Ocean heat uptake	Time period	Spatial Coverage and/or depth range	mean in Wm^{-2}	Uncertainty in Wm^{-2} at the 5–95%CL	Correlation with CERES EBAF EEI	RMSE with CERES EBAF EEI Wm^{-2}
From *in situ* observations	2006-2015	0-2000m deep ocean contribution 0-bottom	0.61 (update of Johnson et al. 2018) [a] 0.04 (update of Purkey & Johnson, 2010). 0.65[c]	±0.1[b] ±0.04 (update of Purkey & Johnson, 2010); ±0.11[d]	0.44	0.40
	1993-2017	0-2000m (no marginal seas, no ice covered areas) deep ocean contribution (below 2000m, no ice covered areas) 0-bottom	0.62 (update of Johnson et al. 2018) [a] 0.04 (update of Purkey & Johnson, 2010); 0.66[c]	±0.22[e] ±0.04 (update of Purkey & Johnson, 2010); ±0.22[d]		
From surface net heat flux	2006-2015	Net ocean surface heat flux	10 to 15[f]	±15[g]		
From satellite altimetry and GRACE	2006-2015	0-bottom (no sea ice covered areas above 82°N)	0.53[h]	±0.38[i]	0.89	0.26
	2002-2016	0-bottom (no sea ice covered areas above 82°N)	0.57[j]	±0.29[k]		
From ocean reanalyses	2006-2015	0-2000m deep ocean contribution (below 2000m, no ice covered areas) 0-bottom	0.7 (update von Shuckmann et al. 2008)[l] 0.04 (update of Purkey & Johnson, 2010). 0.74[c]	±0.13 (update von Shuckmann et al. 2008)[m] ±0.04 (update of Purkey & Johnson, 2010); ±0.14[d]	0.50	0.41
	1993-2008	0-bottom	0.71 (from Palmer et al. 2017)	±0.7 (spread across 15 ocean reanalyses from Palmer et al. 2017)		
From CMIP5 climate model simulations	2000-2010	0-bottom	0.73 (from Smith et al. 2015)	±0.21 (spread across 21 CMIP5 climate model simulations, from Smith et al. 2015)		

Uncertainty in Global ocean heat content and EEI from alti-Grace, Argo data and ocean reanalysis

Meyssignac et al. 2019, Frontiers in Marine Science

Coastal Sea Level Changes from Reprocessed Satellite Altimetry

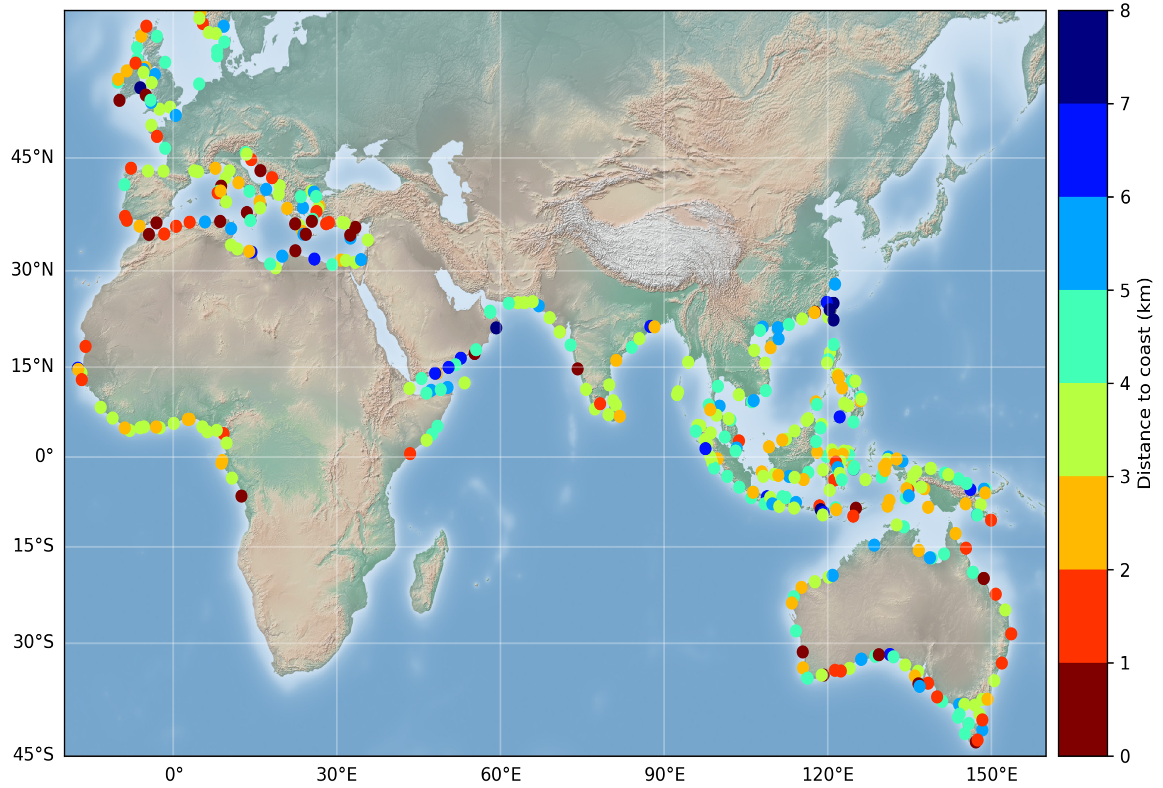
***Approach**: retracking of Jason-1, 2, 3, Envisat and Saral/AltiKa altimetry missions to estimate sea level trends in the world coastal zones (context: ESA climate change Initiative coastal sea Level project)*



Difference in sea level trends between open ocean and coast (mm/yr) (2002-2018)

→ In 20% of the sites, the costal trend significantly differs from open ocean trend

→ Coastal processes (e.g., T/S changes, currents, waves, fresh water input from rivers, etc.) are under investigation to explain this observation



Closest distance to coast (km) where reliable sea level trends can be estimated

Marti et al., *ASR*, 2019; Gouzenes et al., *Ocean Sciences*, 2020; The CCI Coastal Sea Level Team, *Nature Scientific Data*, 2020