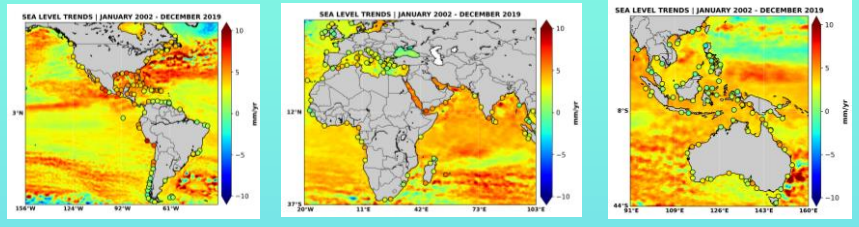
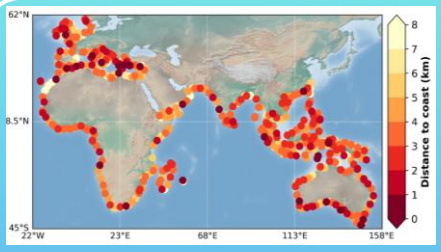
Sea level along the world's coastlines can be measured by a network of virtual altimetry stations

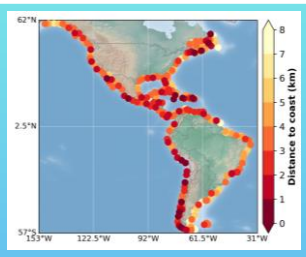
Summary: Until recently, classical radar altimetry could not provide reliable sea level data within 15 km to the coast. However dedicated reprocessing of radar waveforms together with geophysical corrections adapted for the coastal regions now allows to fill this gap at a large number of coastal sites. In the context of the ESA Climate Change Initiative (CCI) Sea Level project, we have recently performed a complete reprocessing of along-track, high resolution (20 Hz, i.e. 350m resolution along-track) altimetry data of the Jason-1, Jason-2 and Jason-3 missions over 2002-2020 along the coastal zones of Northeast Atlantic, Mediterranean Sea, whole African continent, North Indian Ocean, Southeast Asia, Australia, and America. This reprocessing has provided valid sea level data in the 0-15 km band from the coast. A total of 756 altimetry-based virtual coastal stations (distance <6 km from coast) have been selected for all regions. Sea level anomaly time series, together with associated coastal sea level trends, have been computed over the 2002-2020 time span. In the coastal regions devoid from tide gauges (e.g., African coastlines), these virtual stations offer a unique tool for estimating sea level change close to the coast (typically up to 3 km to the coast, but in many instances up to 1 km or less). Results show that at about 20% of the 756 selected sites, coastal sea level trends are either larger or smaller in the last 4-6 km to the coast compared to open ocean sea level trends. Understanding such a behavior will need further investigation. This new data set is freely available.

Study regions of the CCI Coastal Sea Level project

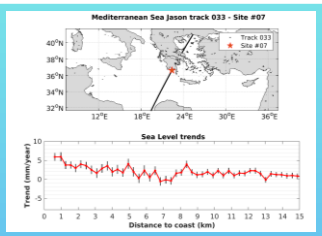


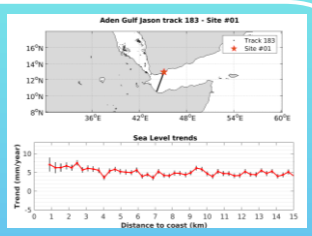
The altimetry-based virtual coastal stations (distance to coast < 3 km) (*Colors represent coastal sea level trends in mm/yr over 2002-2020*)



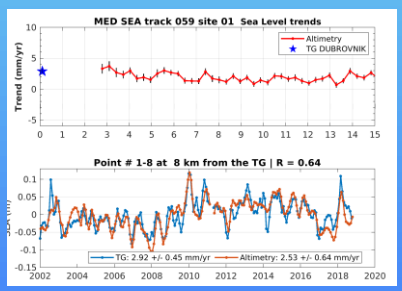


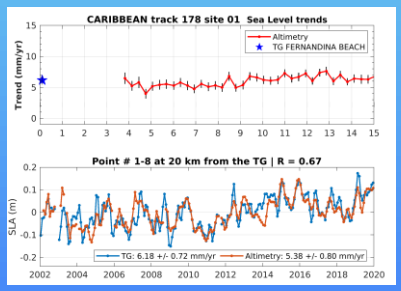
Closest distance (km) to the coast of the first valid point along the Jason track for all 756 virtual stations (distance to coast <6 km)

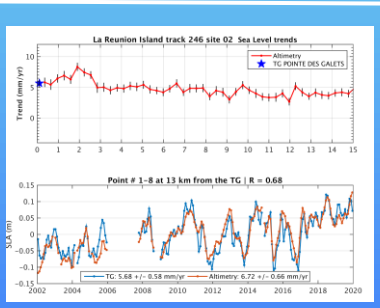


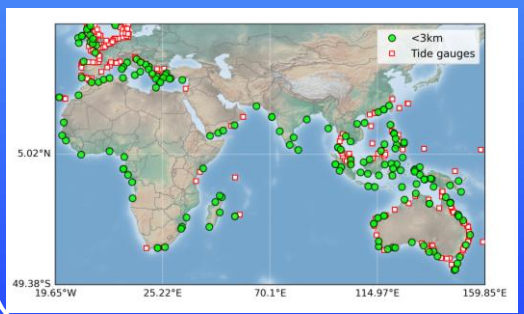


examples of coastal sea level trends (2002-2020) from retracked Jason-1, 2, 3
Upper panel: location of the Jason track (black line) and of the virtual station (red star)
Lower panel: sea level trend computed over 2002-2020 against distance to the coast



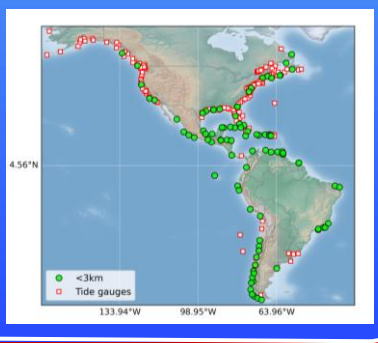






Comparison of altimetry-based coastal sea level with tide gauges
Upper panel: sea level trend (2002-2020) against distance to coast (red curve); tide gauge-based sea level trend (blue star)
Lower panel: Sea level time series over 2002-2020 from coastal Altimetry (orange curve) and closest tide gauge (within 20 km) (blue curve)

Virtual stations at less than 3 km from the coast (green dots)
with tide gauge sites superimposed (with at most 24 month missing data over 2002-2020)
(white/red squares)



Synthesis: Our results show that at most sites, no significant difference (within +/-1 mm/yr) is noticed between sea level trends of the open ocean (here assumed ~ 15 km away from the coast) and of the coastal zone (the first few km from the coast). However, this is not always true. At a few sites, we observe a larger trend close to the coast compared to offshore, with an increase of 2-3 mm/yr in the last 4-6 km to the coast. In a number of cases, we rather note a decrease in trend as the distance to the coast decreases. Although it had been expected that coastal processes (e.g., coastal currents, wind & waves, fresh water input in river estuaries) may cause significant discrepancy in coastal sea level trends compared to the open ocean, the results presented here show no significant difference at the coast compared to offshore, in about 80% of our selected sites. However, at the remaining 20% studied sites, coastal trends can significantly differ from offshore. Small-scale processes possibly causing this nearshore behavior are currently under investigation.
This new coastal sea level data set (sea level anomalies and trends) –version v2.1- will be shortly available. It will update the previous version available from the SEANOE repository → https://doi.org/10.17882/74354 (The CCI Coastal Sea Level Team; *Nature Scientific Data*, published online 20 October 2020).

Gouzenes et al, Coastal sea level change at Senetosa, Ocean Sciences, 2020; Benveniste et al., Coastal sea level anomalies and associated trends from Jason satellite altimetry over 2002-2018, Nature Scientific Data, 2020; Birol et al., The X-TRACK/ALES multi-mission processing system: new advances in altimetry towards the coast. *ASR, 2021*; Dieng et al., Trends and inter-annual variability of coastal sea level in the Mediterranean Sea, *Advances in Space Research*, 2021; Cazenave et al., Sea level along the world's coastlines can be measured by a network of virtual altimetry stations, *Nature Communication Earth and Environment*, published online 16 May 2022. https://doi.org/10.1038/s43247-022-00448-z, 2022.