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ESA Sea Level Climate Change Initiative

Product user guide

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Acronyms

ALES Adaptive Leading Edge Subwaveform

CLS Collecte Localisation Satellites

CTOH Centre of Topography of the Oceans and Hydrosphere

DAC Dry Atmospheric Correction

DGFI-TUM Deutsches Geodätisches Forschungsinstitut - Technische Universität München

ESA European Space Agency

GDR Geophysical Data Record

GPD+ GNSS derived Path Delay

GSHHG Global Self-consistent, Hierarchical, High-resolution Geography database

L2P Level 2 Plus

LEGOS Laboratoire d'Études en Géophysique et Océanographie Spatiales

NetCDF Network Common Data Form

NOC National Oceanography Center

RADS Radar Altimeter Database System

SLA Sea Level Anomaly

SSB Sea State Bias

SSH Sea Surface Height

WTC Wet Tropospheric Correction

Chronology of issues:

Issue:	**Date:**	**Reason for change:**	Author:
1.0	30/09/19	Initial version	F. Léger (LEGOS)
1.1	18/11/19	ESA review comments	J.-F. Legeais (CLS)
1.2	05/01/20	Extension with Jason-3 (J3)	F. Léger (LEGOS)
1.3	25/05/20	SLA and trends product at selected sites	Y. Gouzènes (LEGOS)
1.4	11/03/21	Temporal J3 extension + new zones	F. Léger (LEGOS)
1.5	15/04/21	Addition of Envisat and SARAL/AltiKa	F. Léger (LEGOS)
1.6	24/01/22	New coastal product v2.1: update of along-track coastal sea level time series and trends with temporal extension up to Dec. 2019 and addition of American coasts, plus some new regions around Africa; New data selection and creation of a new set of virtual coastal stations	Y. Gouzènes, A. Cazenave, F. Léger (LEGOS)
1.7	03/01/23	New coastal product v2.2: update of the v2.1 product based on a few minor improvements brought to the data	Y. Gouzènes, A. Cazenave (LEGOS)
1.8	10/01/24	New coastal product v2.3: temporal extension up to June 2021, use of GDR-F for J3, slight improvement of the SSB editing at 20 Hz and improvement of the coast detection associated with a strong editing during the post processing	L. Leclercq, A. Cazenave, F. Léger (LEGOS)
1.9	06/11/24	New coastal product v2.4: improvement of the post-processing and addition of the averaged SLA in the 10 first points variable: `sla_mean_10pts`	L. Leclercq, A. Cazenave (LEGOS)
2.0	04/07/25	New coastal product v3.0: geographical extension to other coastlines and to small tropical islands of low elevation. Reorganisation of the production chain and small improvements of the post-processing. Addition of the filtered variable of the averaged SLA in the 10 first points variable: `sla_mean_10pts_filt`	L. Leclercq, A. Cazenave (LEGOS)

3.0	03/11/26	New coastal products v3.1 and v4.0: Slight improvement of the outliers detection. Addition of the variable 90 percent confidence interval on sea level anomaly trend: `u_local_sla_trend` for v3.1. Addition of the seasonal component variable `sla_seasonal`.	L. Leclercq, A. Cazenave, L. Tolu, F. Nino (LEGOS)

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1 Introduction

In the context of the European Space Agency's (ESA) Climate Change Initiative sea-level project, the project partners (CTOH, LEGOS, DGFI-TUM, NOC and CLS) have produced a Level 2 Plus (L2P) multi-mission altimeter along-track time series and associated trends product in the world coastal regions. The product benefits from the spatial resolution provided by high-rate along-track data (20 Hz, i.e. ≈350 m resolution), the Adaptive Leading Edge Subwaveform retracking (ALES, Passaro et al. (2014, 2015, 2018b)) and the post-processing strategy of the X-Track algorithm developed at CTOH/LEGOS (Birol et al. 2017), adapted to 20 Hz data and using the best possible set of geophysical corrections (update of Birol and Delebecque (2014)).

The main objective of this coastal sea level product is to provide accurate altimeter Sea Level Anomaly (SLA) time series as close as possible to the coast. By merging X-Track and ALES altimetry processing tools, we have computed 20 Hz along-track Sea Surface Height (SSH) time series for Jason-1, Jason-2 and Jason-3 missions covering the January 2002 to June 2021 time span for the v3.1 version. The v4.0 is temporally extended using Sentinel-3A until December 2024. The X-Track software reprocesses geophysical corrections and parameters from delayed-time Geophysical Data Record (GDR) products provided by space agencies and combines them with the ALES retracked waveforms (range, sigma0 and Sea State Bias (SSB)) to compute 20 Hz along-track SSH time series, after a robust editing of the measurements and corrections (described in Birol et al. (2017)). The full data processing is detailed in Birol et al. (2021), The Climate Change Initiative Coastal Sea Level Team et al. (2020) and Cazenave et al. (2022).

The present document provides the information about the latest coastal sea level products and how to use them. The new updated version (v3.1 and v4.0; November 2026) of along-track coastal sea level time series and associated trends from January 2002 to June 2021 for v3.1 and to December 2024 for v4.0 is presented below. The v3.1 dataset differs from the previous v3.0 product (released in July 2025) by adding the uncertainty component (`u_local_sla_trend` variable). The v4.0 dataset contains the regression-based trend error `local_sla_trend_error` variable described in section 4. For both datasets SLAs are corrected for GIA Peltier et al. (2015). There has been a slight change in the editing (outlier removal) and addition of the seasonal component removed from the SLAs time series in the `sla_seasonal` variable.

We strongly recommend to the users to use the v4.0 product as it provides the longest temporal coverage until December 2024. If realistic trend uncertainties are needed they are available in the v3.1 product but data are only provided until June 2021.

Section 3 describes the altimeter standards used for the SLAs computation. Section 4 describes the different variables of the dataset. Section 5 presents the updates brought to the v3.1 and v4.0 products.

The v3.1 and v4.0 coastal sea level products provide a set of respectively 1660 and 1653 altimetry-based virtual coastal stations and associated sea level data which can be used for studying long-term coastal sea level trends. Figure 1 shows the regions (R1 to R20) covered by this version.

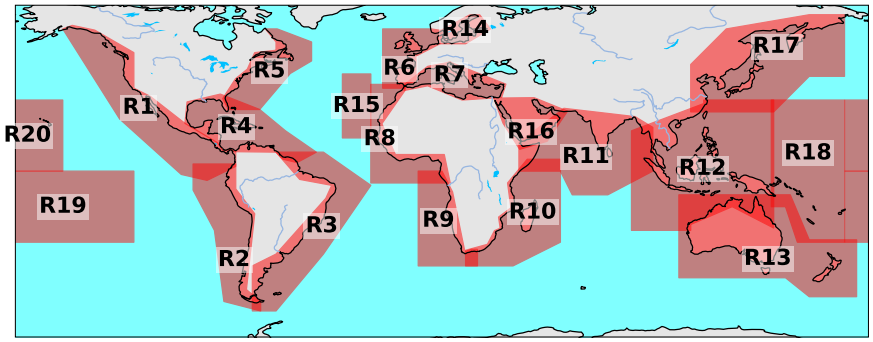


Figure 1: The regions covered by the along-track coastal sea level product v3.1 and v4.0. R labels refer to the regions numbers (see section 5.5.1)

2 Frequently Asked Questions

2.1 What is the ESA CCI Sea Level Virtual Coastal Network?

It is a network of coastal sites located at the intersection of the satellite tracks and the coast.

2.2 What does this product provide?

The product provides coastal sea level time series and associated trends.

2.3 Which version should I use: v3.1 or v4.0?

v4.0 is the most complete version in terms of temporal coverage. Otherwise the v3.1 and v4.0 versions are identical in terms of spatial extension and data processing. However only v3.1 provides realistic trend uncertainties.

2.4 How do I identify a station from its filename?

A station is identified by the satellite track number, the track segment number and the region.

2.5 Do the observations extend all the way to the coastline?

On average the virtual stations are located about 4 km from the coast but in several cases at less than 1 km. This corresponds to the closest valid sea level data to the coast.

2.6 What sort of uncertainty estimations are included in the products?

In v4.0, trend uncertainties are based on the least-squares fit of the sea level time series. In v3.1, more realistic uncertainties are computed considering errors in the geophysical corrections.

2.7 Which variables should I use for time series and trend profiles?

For sea level time series, the variable to be used is `sla_mean_10pts_filt`. Other versions (e.g., non filtered data) are also provided. For trends, the variable to be used is `local_sla_trend`.

2.8 What does `sla_seasonal` represent?

`sla_seasonal` is the seasonal cycle extracted from the time series. It is provided when the SLA time series with the seasonal cycle needs to be considered. Add `sla_seasonal` to the `sla` variable to retrieve the SLA time series with the seasonal signal.

2.9 Are the two versions' trend-error variables equivalent?

No, see FAQ 2.6.

2.10 In what format are the files supplied?

Files are supplied in NetCDF format.

2.11 Where can I download the data?

Data are distributed on SEANOE: https://www.seanoe.org/data/00631/74354/ and on the CEDA archive: https://catalogue.ceda.ac.uk/uuid/56c94cb1410f4f2b8a41729c0e558617/

3 Altimeter standards used for v3.1 and v4.0

The Jason-1, Jason-2, Jason-3 and Sentinel-6A data used by the X-Track software are based, respectively, on the GDR-E, GDR-D, GDR-F and GDR-F08/09 products of each mission. The altimeter range and SSB correction are provided by the ALES retracker product. The ocean tide correction and the Dry Atmospheric Correction (DAC) come from the Radar Altimeter Database System (RADS). The Wet Tropospheric Correction (WTC) used is the GNSS derived Path Delay (GPD+) (Fernandes and Lázaro 2016), provided by the University of Porto for the Jason 1/2/3 missions and the onboard radiometer for Sentinel-6A mission. The list of the parameters used in the computation of the SSH data is provided in the table 2. Note that the mean sea surface used to compute the SLAs is an area-averaged SSH and is thus not considered as an input dataset.

Parameters	Source	Jason-1	Jason-2	Jason-3	Sentinel-6A
L2 standards	GDR	GDR-E	GDR-D	GDR-F	GDR-F08 (cycle 1 to 122) GDR-F09 (from cycle 123)
Altitude	GDR	Altitude of satellite			
Range	ALES	20 Hz Ku band ALES corrected altimeter range (Passaro et al. 2014)			
Ionoshere	GDR	From dual-frequency altimeter range measurements, further filtered by X-Track			
DAC	GDR	From ECMWF operational model			
WTC	GPD+/GDR	GPD+ radiometer correction (Fernandes and Lázaro 2016)			Onboard radiometer
SSB	ALES	Sea state bias correction in Ku band, ALES retracking (Passaro et al. 2018a)			
Solid tide	RADS	From tide potential model (Cartwright and Tayler 1971; Cartwright and Edden 1973)			
Pole tide	GDR	From Wahr (1985)		From Desai et al. (2015)	
Loading effect	CNES	From FES 2022 Lyard et al. in prep.			
Atmospheric correction	RADS	From MOG2D-G high frequencies (Carrère and Lyard 2003) + inverse barometer			
Ocean tide	CNES	From FES 2022 Lyard et al. in prep. including ocean tide, long period equilibrium tide, S1 tide			

Table 2: Parameters used in the computation of the SSH

4 Data variables

Variables	Description
lat	Latitude of each 20 Hz point
lon	Longitude of each 20 Hz point
nbpoints	Index of each point (start from 1)
distance_to_coast	Distance to a reference point at the coast of each 20 Hz point. This reference point is the point of the track closest to the coastline (from GSHHG).
nbmonths	Index of time (start from 1)
time	Time of measurements (days since 1950-01-01)
sla	Monthly SLA time series over 1 January 2002 to 30 June 2021 for v3.1 and to 31 December 2024 for v4.0 derived from the original 10-day X-Track/ALES SLAs after post-processing at each 20 Hz point along-track (from 20 km offshore to the coast). Annual and inter-annual signals have been removed.
sla_mean_10pts	Averaged SLA time series over the first 10 nearest points to the coast.
sla_mean_10pts_filt	Averaged SLA time series over the first 10 nearest points to the coast with a 6 months rolling mean filter.
sla_seasonal	Monthly SLA seasonal signal removed from the SLA time series.
local_sla_trend	Sea level trend computed from the monthly SLAs time series at each 20 Hz point in the along-track direction (from 20 km offshore to the coast).
local_sla_trend_error (v4.0 only)	Sea level trend error at each 20 Hz point in the along-track direction, based on the standard error of the slope regression coefficient (computed as the root square of the diagonal of the covariance matrix of the regression coefficient).
u_local_sla_trend (v3.1 only)	90 percent confidence interval on sea level anomaly trend, computed at each 20 Hz point in the along-track direction. It is obtained by using an extended least square approach for the estimation of the sea level trend distribution, allowing to take into account the error variance-covariance matrix (more details in Tolu et al. (2026)).

5 Along-track coastal sea level anomalies and trends

5.1 v3.1: January 2002 - June 2021

Figure 2 shows the distribution of the computed trends and associated errors, as well as distance to coast of the virtual stations. The average distance of the first valid point for the whole set of 1660 virtual stations is 3.9 km with 331 sites at less than 2 km and 531 sites at less than 3 km from the coast (Fig. 3).

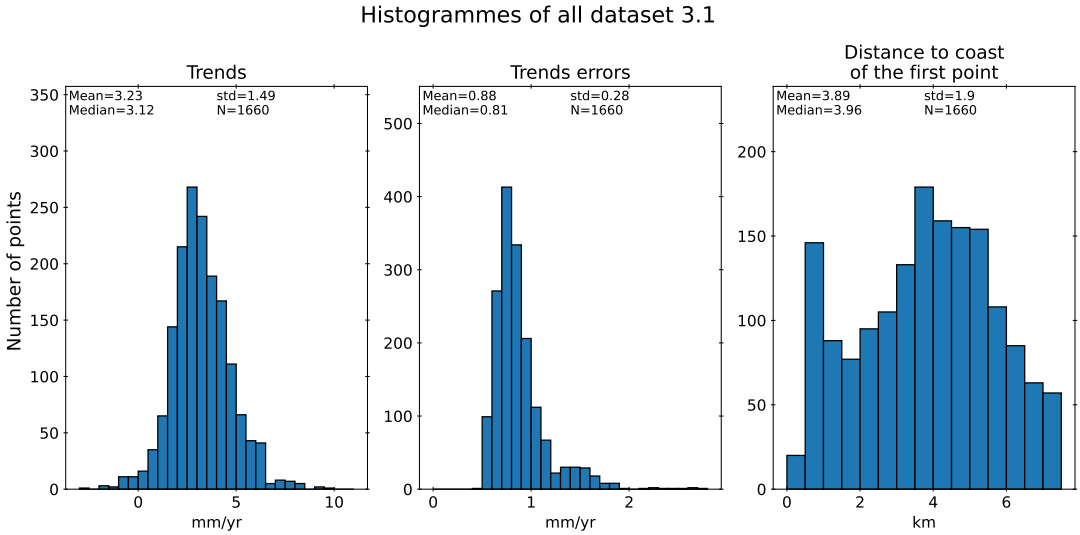


Figure 2: Histograms: trends and associated errors along-track averaged over 2 km from the closest valid point to the coast, and distance to coast of the first valid point, for each virtual stations of the v3.1 dataset.

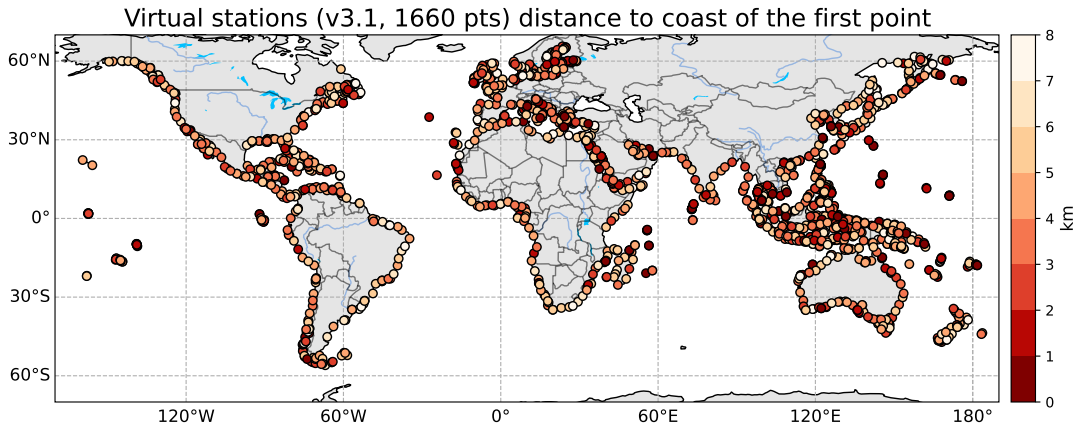


Figure 3: Map of the distance to coast of the first valid point for each virtual stations of the v3.1 dataset.

5.2 v4.0: January 2002 - December 2024

Figure 4 shows the distribution of the computed trends and associated errors, as well as distance to coast of the virtual stations. The average distance of the first valid point for the whole set of

1653 virtual stations is 3.9 km with 335 sites at less than 2 km and 520 sites at less than 3 km from the coast (Fig. 5).

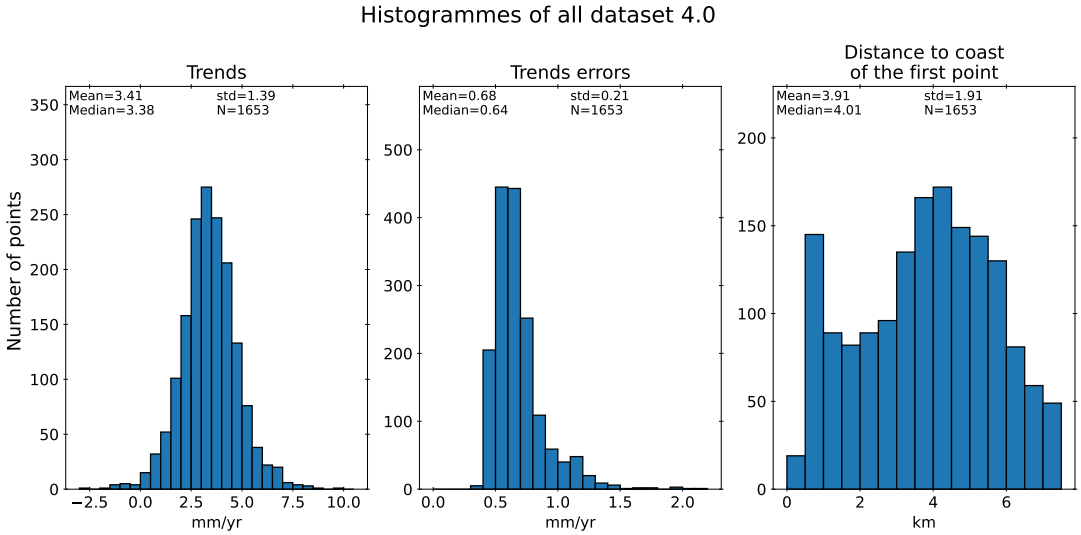


Figure 4: Histograms: trends and associated errors along-track averaged over 2 km from the closest valid point to the coast, and distance to coast of the first valid point, for each virtual stations of the v4.0 dataset

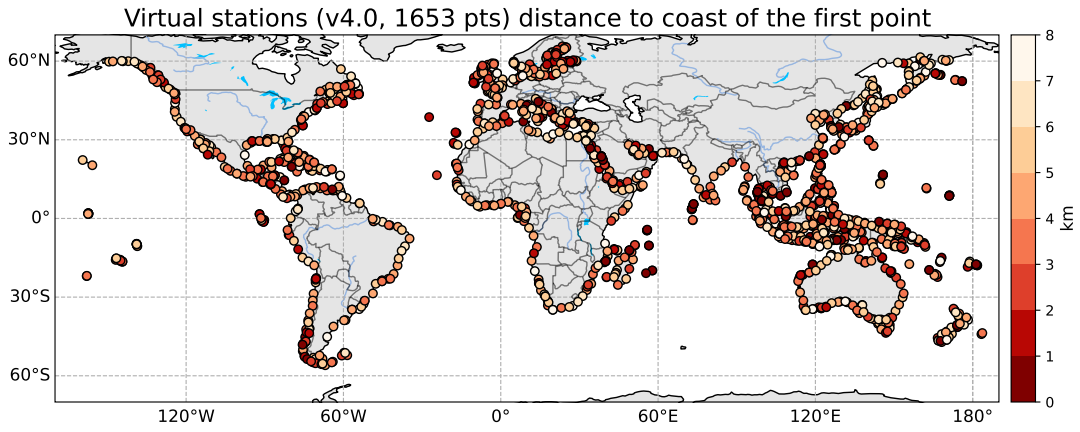


Figure 5: Map of the distance to coast of the first valid point for each virtual stations of the v4.0 dataset

5.3 Improvement of the post-processing

The outliers removal is slightly modified by implementing parametric variance function based on the approach from (Cleveland 1979). See also: `https://stats.stackexchange.com/questions/561120/predicition-interval-for-loess-smoothed-data`. This leads to removing data out of the interval:

$$\hat{E}(y|x) \pm 3 * \sqrt{\widehat{Var}(y|x)} \quad (1)$$

Where $\hat{E}(y|x)$ is the rolling mean over 12 months of the time series and $\sqrt{\widehat{Var}(y|x)}$ is the standard deviation function. We obtain the squared deviation from the rolling mean estimate:

$$\hat{e}^2 = (y - \hat{E}(y|x))^2 \tag{2}$$

The variance function is:

$$\widehat{Var}(y|x) = \hat{E}(\hat{e}^2|x) \tag{3}$$

With:

$$\hat{E}(\hat{e}^2|x) = roll_mean((y - \hat{E}(y|x))^2) \tag{4}$$

5.4 New variable : confidence interval on sea level anomaly trend (v3.1 only)

The variable `u_local_sla_trend` provides the 90 percent confidence interval on the sea level anomaly trend, and corresponds to the uncertainty of the variable `local_sla_trend`. It is computed following the Ablain et al. (2019) method, adapted to along-track coastal data: different errors are characterized as biases, drifts, or noise. Values for biases and drifts are taken from Prandi et al. (2021). Noise values are computed based on a round robin study on coastal altimetry data (Birol et al. 2025). From these factors, an error variance covariance matrix is computed, and used in an extended least square regression model to provide an estimator of the SLA trend. This estimator is constructed using a normal distribution, so that confidence intervals can be calculated using the quantiles of a two-tailed t-distribution. This variable gives the values associated to the 90% quantile. More details can be found in Tolu et al. (2026).

In the figures below we present some statistics associated with this variable. In the Figure 6 are represented the mean confidence intervals on SLA trends for each one of the 1660 virtual stations (as color-coded points near the coast). The bottom panel shows the associated histogram of the confidence interval, using all available stations, and the mean value is 1.6 mm/year.

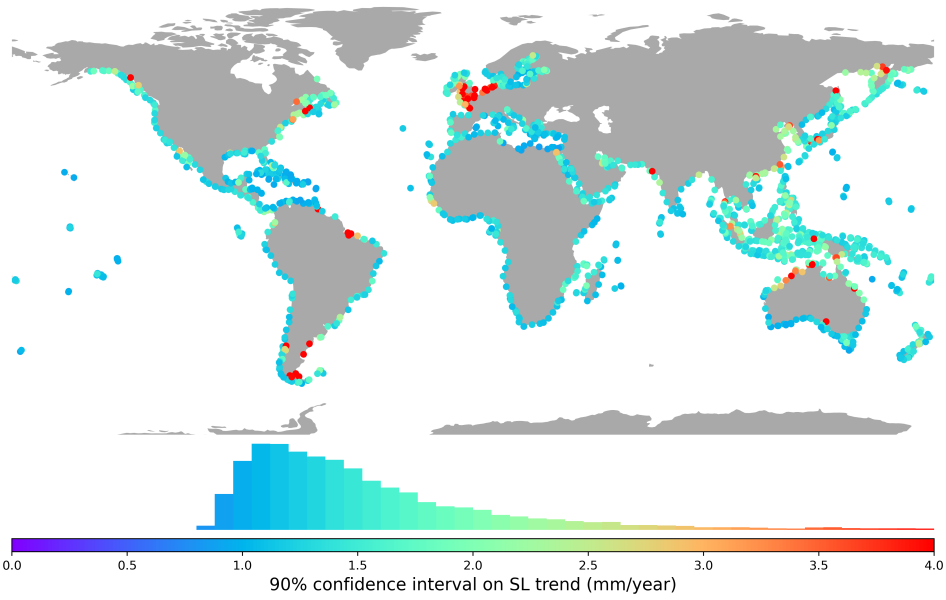


Figure 6: Map of 90% confidence interval on sea level trend, and associated histogram. Each point of the map represents the average confidence interval of the station's points. The histogram is built by taking into account all the virtual stations points.

In the Figure 7 are represented the mean confidence intervals on all the stations as a function of the distance to the coast.

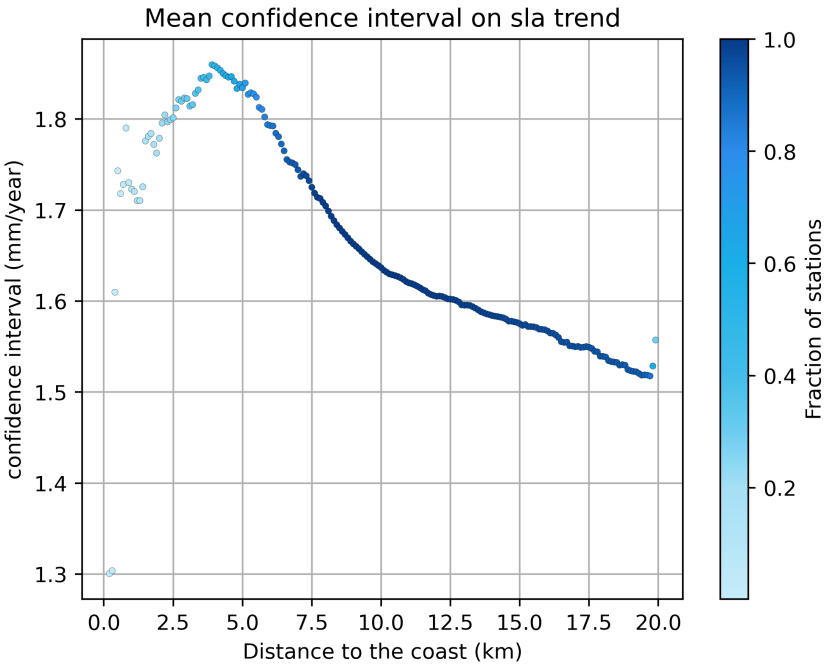


Figure 7: Mean confidence interval against distance to the coast. The color at a specific distance represents the fraction of the 1660 stations that contains points at this distance.

5.5 Nomenclature update

5.5.1 Region naming

The nomenclature used for those products is the following:

ESACCI-SEALEVEL-IND-MSLTR-MERGED-<ZONE>_JA_<PassNumber>_<StationNumber>-<ProductionDateYYYYMMDD>-v3.1.nc

Where <ZONE> is one of:

R1, for Northwest America, -3.9°N /61.5°N, -150°E /-77°E
R2, for Southwest America, -59°N /3°N, -95°E /66.5°E
R3, for Southeast America, -59°N /8°N, -70°E /-20°E
R4, for Caribbean region including Gulf of Mexico, 3.6°N /32.5°N, -98.45°E /-43°E
R5, for Northeast America, 26°N /60°N, -82.5°E /-45°E
R6, for the North East Atlantic Ocean, 35°N/60°N, -15°E/10°E
R7, for the Mediterranean Sea, 30°N/46°N, -6°E/37°E
R8, for West Africa, -5°N /36.6°N, -20°E /13.5°E
R9, for Southwest Africa, -40°N/0°N, 0°E/25°E
R10, for Southeast Africa, -40°N /5°N, 20°E /60°E
R11, for North Indian Ocean, 0°N/26,5°N, 42,5°E/99°E
R12, for Southeast Asia, -25°N/30°N, 90°E/150°E
R13, for South Australia, -45°N/-15°N, 105°E/160°E
R14, for Baltic Sea, 53.75°N/66.9°N, 9°E/30.5°E
R15, for Azores islands, 14°N/41°N, -20°E/32°E
R16, for Red Sea and Persic Gulf, 9°N/31°N, 31.9°N/54.4°N
R17, for North West Pacific Ocean, 25.25°N/66°N, 115°N/179.9°N
R18, for Western tropical Pacific Ocean, -30°N/30°N, 149°N/179.9°N
R19, for central Pacific Ocean, -30°N/0°N, -179.9°N/-120°N
R20, for Hawaii islands, 0°N/30°N, -179.9°N/-150°N

<PassNumber> is the Jason track number

<StationNumber> is the site number on the track numbered from north to south

For example, the time series data associated with track 011 part number 02 in the Southeast America, produced on 2026/10/20 is found in a file whose name is:

ESACCI-SEALEVEL-IND-MSLTR-MERGED-R3_JA_011_02-20261020-v3.1.nc

5.5.2 Global attributes

v3.1

```
// global attributes:
:title = "SL_cci+ L3 X-TRACK/ALES Altimeter Sea Level Anomaly in the region R1" ;
:institution = "ESA, CTOH/LEGOS, Toulouse Univ., CNRS, IRD, CNES, UPS, France" ;
:source = "Jason-1 GDR-E, Jason-2 GDR-D, Jason-3 GDR-F, RADS 4.0 (J1, J2),
RADS 4.2 (J3), ALES, CNES database" ;
:history = "2026-10-20 generated by cci_sealevel processing chain git tag
cci_20261020" ;
:references = "https://climate.esa.int/en/projects/sea-level/data/" ;
:tracking_id = "5d554d14-5b4b-4fdf-897e-9b09a8c3a717" ;
:Conventions = "CF-1.11" ;
:pass_number = "002" ;
:part_number = "07" ;
```

```
:product_version = "3.1" ;
:keywords = "satellite, ocean, coastal altimetry" ;
:id = "ESACCI-SEALEVEL-IND-MSLTR-MERGED-R1_JA_002_07-20261020-v3.1.nc" ;
:naming_authority = "ESA CCI+" ;
:keywords_vocabulary = "NetCDF COARDS Climate and Forecast Standard Names" ;
:cdm_data_type = "Trajectory" ;
:date_created = "2026-10-20" ;
:creator_name = "CTOH/LEGOS, Toulouse Univ., CNRS, IRD, CNES, UPS, France" ;
:creator_url = "https://climate.esa.int/en/projects/sea-level/data/" ;
:creator_email = "info-sealevel@esa-sealevel-cci.org" ;
string :project = "Sea Level Climate Change Initiative - European Space Agency" ;
:geospatial_lat_min = "16.937" ;
:geospatial_lat_max = "17.069" ;
:geospatial_lon_min = "-100.582" ;
:geospatial_lon_max = "-100.529" ;
:time_coverage_start = "2002-01" ;
:time_coverage_end = "2021-06" ;
:time_coverage_duration = "P19.5Y" ;
:time_coverage_resolution = "P1M" ;
:standard_name_vocabulary = "NetCDF Climate and Forecast (CF) Metadata Convention
Standard Name Table v91" ;
:license = "ESA CCI Data Policy: free and open access" ;
:platform = "Jason-1, Jason-2 and Jason-3" ;
:sensor = "Poseidon-2, Poseidon-3 and Poseidon-3B" ;
:spatial_resolution = "350m" ;
:geospatial_lat_units = "degrees_north" ;
:geospatial_lon_units = "degrees_east" ;
:key_variables = "sla" ;
:comment = "These data were produced at LEGOS as part of the ESA SL_CCI+ project" ;
:summary = "This dataset contains 20 Hz regional sea level trends computed from
monthly sea level anomalies combining ALES retracker and post-processing strategy of
X-TRACK from 20 km offshore to the coast" ;
```

v4.0

```
// global attributes:
:title = "SL_cci+ L3 X-TRACK/ALES Altimeter Sea Level Anomaly in the region R1" ;
:institution = "ESA, CTOH/LEGOS, Toulouse Univ., CNRS, IRD, CNES, UPS, France" ;
:source = "Jason-1 GDR-E, Jason-2 GDR-D, Jason-3 GDR-F, Sentinel-6A GDR-F08/09,
RADS 4.0 (J1, J2), RADS 4.2 (J3, S6A), ALES, CNES database" ;
:history = "2026-10-20 generated by cci_sealevel processing chain git tag
cci_20261020" ;
:references = "https://climate.esa.int/en/projects/sea-level/data/" ;
:tracking_id = "d44b5948-0c78-4124-a4bb-617149f61076" ;
:Conventions = "CF-1.11" ;
:pass_number = "206" ;
:part_number = "10" ;
:product_version = "4.0" ;
:keywords = "satellite, ocean, coastal altimetry" ;
```

```
:id = "ESACCI-SEALEVEL-IND-MSLTR-MERGED-R1_JA_206_10-20261020-v4.0.nc" ;
:naming_authority = "ESA CCI+" ;
:keywords_vocabulary = "NetCDF COARDS Climate and Forecast Standard Names" ;
:cdm_data_type = "Trajectory" ;
:date_created = "2026-10-20" ;
:creator_name = "CTOH/LEGOS, Toulouse Univ., CNRS, IRD, CNES, UPS, France" ;
:creator_url = "https://climate.esa.int/en/projects/sea-level/data/" ;
:creator_email = "info-sealevel@esa-sealevel-cci.org" ;
string :project = "Sea Level Climate Change Initiative - European Space Agency" ;
:geospatial_lat_min = "33.318" ;
:geospatial_lat_max = "33.444" ;
:geospatial_lon_min = "-119.659" ;
:geospatial_lon_max = "-119.587" ;
:time_coverage_start = "2002-01" ;
:time_coverage_end = "2024-12" ;
:time_coverage_duration = "P23Y" ;
:time_coverage_resolution = "P1M" ;
:standard_name_vocabulary = "NetCDF Climate and Forecast (CF) Metadata Convention
Standard Name Table v91" ;
:license = "ESA CCI Data Policy: free and open access" ;
:platform = "Jason-1, Jason-2, Jason-3 and Sentinel 6A" ;
:sensor = "Poseidon-2, Poseidon-3, Poseidon-3B  and Poseidon-4" ;
:spatial_resolution = "350m" ;
:geospatial_lat_units = "degrees_north" ;
:geospatial_lon_units = "degrees_east" ;
:key_variables = "sla" ;
:comment = "These data were produced at LEGOS as part of the ESA SL_CCI+ project" ;
:summary = "This dataset contains 20 Hz regional sea level trends computed from
monthly sea level anomalies combining ALES retracker and post-processing strategy of
X-TRACK from 20 km offshore to the coast" ;
}
```

5.5.3 Variables attributes

v3.1

```
variables:
  int64 nbpoints(nbpoints) ;
    nbpoints:units = "count" ;
    nbpoints:long_name = "points number" ;
  float lat(nbpoints) ;
    lat:_FillValue = NaNf ;
    lat:long_name = "Latitude" ;
    lat:standard_name = "latitude" ;
    lat:units = "degrees_north" ;
    lat:lat_min = "16.937" ;
    lat:lat_max = "17.069" ;
  float lon(nbpoints) ;
```

```
    lon:_FillValue = NaNf ;
    lon:long_name = "Longitude" ;
    lon:standard_name = "longitude" ;
    lon:units = "degrees_east" ;
    lon:lon_min = "-100.582" ;
    lon:lon_max = "-100.529" ;
  double distance_to_coast(nbpoints) ;
    distance_to_coast:_FillValue = NaN ;
    distance_to_coast:long_name = "Distance to GSHHS 1.3 coastline" ;
    distance_to_coast:units = "m" ;
    distance_to_coast:distance_to_coast_min = "4320.250" ;
    distance_to_coast:distance_to_coast_max = "19986.109" ;
    distance_to_coast:comment = "Distance along track to a reference point at
    the coast" ;
  int64 nbmonths(nbmonths) ;
    nbmonths:units = "count" ;
    nbmonths:long_name = "months number" ;
  double sla(nbpoints, nbmonths) ;
    sla:_FillValue = NaN ;
    sla:units = "m" ;
    sla:long_name = "X-TRACK/ALES monthly sea level anomaly" ;
    sla:standard_name = "sea_surface_height_above_mean_sea_level" ;
    string sla:comment = "The sla are monthly averaged and annual and semi-
annual
    cycles are removed. sla = altitude of satellite - 20 Hz Ku band ALES
    corrected altimeter range (Passaro et al. 2014) - altimeter ionospheric
    correction on Ku band (From dual-frequency altimeter range measurements)
    - model dry tropospheric correction (From ECMWF model)
    - GPD+ wet tropospheric correction (Fernandes et al. 2016)
    - sea state bias correction in Ku band (ALES retracking, Passaro et al. 2014)
    - solid earth tide height (From RADS, tide potential model,
    Cartwright and Taylor 1971, Cartwright and Eden 1973) - geocentric ocean tide
    (FES 2022 from CNES) - geocentric pole tide height (Wahr 1985 (J1/2)
    and Desai 2015 (J3)) - Atmospheric correction (From RADS, Carrere and Lyard 2003)
    - X-TRACK mean sea surface (Birol et al. 2017) - ICE_6G_D GIA
    (Peltier et al. 2015).
    Each corrective term is edited following Birol et al. 2017." ;
  double local_sla_trend(nbpoints) ;
    local_sla_trend:_FillValue = NaN ;
    local_sla_trend:long_name = "Sea level anomaly trend as calculated by OLS
    regression" ;
    local_sla_trend:standard_name = "tendency_of_sea_surface_height_above_sea_level"
    local_sla_trend:units = "mm/year" ;
    local_sla_trend:comment = "Sea level trends computed from X-TRACK/ALES monthly
    sea level anomaly between 2002-01-01 and 2021-06-30, corrected from GIA ICE_6G_D
    (Peltier et al. 2015). Uncertainty components described by the unc_comps
    attribute" ;
    local_sla_trend:unc_comps = "u_local_sla_trend" ;
```

```
  double u_local_sla_trend(nbpoints) ;
    u_local_sla_trend:_FillValue = NaN ;
    u_local_sla_trend:long_name = "Uncertainty in local sea level trend estimation
    at the 90% confidence level" ;
    u_local_sla_trend:units = "mm/year" ;
  double sla_mean_10pts(nbmonths) ;
    sla_mean_10pts:_FillValue = NaN ;
    sla_mean_10pts:units = "m" ;
    sla_mean_10pts:long_name = "Sea level anomaly averaged over the 10 nearest
    points to the coast" ;
    sla_mean_10pts:standard_name = "sea_surface_height_above_mean_sea_level" ;
    sla_mean_10pts:comment = "X-Track/ALES monthly sea level anomaly averaged
    over the 10 first nearest point to the coast" ;
  double sla_mean_10pts_filt(nbmonths) ;
    sla_mean_10pts_filt:_FillValue = NaN ;
    sla_mean_10pts_filt:units = "m" ;
    sla_mean_10pts_filt:long_name = "Sea level anomaly averaged over the 10 nearest
    points to the coast with a 6 month filter" ;
    sla_mean_10pts_filt:standard_name = "sea_surface_height_above_mean_sea_level" ;
    sla_mean_10pts_filt:comment = "X-Track/ALES monthly sea level anomaly averaged
    over the 10 first nearest point to the coast with a 6 month rolling mean filter"
  int64 time(nbmonths) ;
    time:long_name = "Time" ;
    time:standard_name = "time" ;
    time:units_metadata = "leap_seconds: none" ;
    time:units = "days since 1950-01-01" ;
    time:calendar = "proleptic_gregorian" ;
```

v4.0

```
variables:
  int64 nbpoints(nbpoints) ;
 nbpoints:units = "count" ;
    nbpoints:long_name = "points number" ;
  float lat(nbpoints) ;
    lat:_FillValue = NaNf ;
    lat:long_name = "Latitude" ;
    lat:standard_name = "latitude" ;
    lat:units = "degrees_north" ;
    lat:lat_min = "33.318" ;
    lat:lat_max = "33.444" ;
  float lon(nbpoints) ;
    lon:_FillValue = NaNf ;
    lon:long_name = "Longitude" ;
    lon:standard_name = "longitude" ;
    lon:units = "degrees_east" ;
    lon:lon_min = "-119.659" ;
    lon:lon_max = "-119.587" ;
  double distance_to_coast(nbpoints) ;
```

```
  distance_to_coast:_FillValue = NaN ;
  distance_to_coast:long_name = "Distance to GSHHS 1.3 coastline" ;
  distance_to_coast:units = "m" ;
  distance_to_coast:distance_to_coast_min = "4383.700" ;
  distance_to_coast:distance_to_coast_max = "19954.389" ;
  distance_to_coast:comment = "Distance along track to a reference point at
  the coast" ;
int64 nbmonths(nbmonths) ;
  nbmonths:units = "count" ;
  nbmonths:long_name = "months number" ;
double sla(nbpoints, nbmonths) ;
  sla:_FillValue = NaN ;
  sla:units = "m" ;
  sla:long_name = "X-TRACK/ALES monthly sea level anomaly" ;
  sla:standard_name = "sea_surface_height_above_mean_sea_level" ;
  sla:comment = "The SLA are monthly averaged and annual and semi-annual
  cycles are removed. sla = altitude of satellite - 20 Hz Ku band ALES
  corrected altimeter range (Passaro et al. 2014) - altimeter ionospheric
  correction on Ku band (From dual-frequency altimeter range measurements)
  - model dry tropospheric correction (From ECMWF model)
  - GPD+ wet tropospheric correction (Fernandes et al. 2016)
  - sea state bias correction in Ku band (ALES retracking, Passaro et al. 2014)
  - solid earth tide height (From RADS, tide potential model,
  Cartwright and Taylor 1971, Cartwright and Eden 1973) - geocentric ocean tide
  (FES 2014 from RADS, Lyard et al. 2021) - geocentric pole tide height (Wahr 1985)
  - Atmospheric correction (From RADS, Carrere and Lyard 2003)
  - X-TRACK mean sea surface (Birol et al. 2017)
  - ICE_6G_D GIA (Peltier et al. 2015).
  Each corrective term is edited following Birol et al. 2017." ;
double local_sla_trend(nbpoints) ;
  local_sla_trend:_FillValue = NaN ;
  local_sla_trend:long_name = "Sea level anomaly trend as calculated by OLS
  regression" ;
  local_sla_trend:standard_name = "tendency_of_sea_surface_height_above_sea_level"
  local_sla_trend:units = "mm/year" ;
  local_sla_trend:comment = "Sea level trends computed from X-TRACK/ALES monthly
  sea level anomalies between 2002-01-01 and 2024-12-31 corrected for GIA (
  Peltier et al. 2015)" ;
double local_sla_trend_error(nbpoints) ;
  local_sla_trend_error:_FillValue = NaN ;
  local_sla_trend_error:long_name = "Standard deviation of the OLS estimator of
  sea level trend" ;
  local_sla_trend_error:units = "mm/year" ;
double sla_mean_10pts(nbmonths) ;
  sla_mean_10pts:_FillValue = NaN ;
  sla_mean_10pts:units = "m" ;
  sla_mean_10pts:long_name = "Sea level anomaly averaged over the 10 nearest
  points to the coast" ;
```

```
  sla_mean_10pts:standard_name = "sea_surface_height_above_mean_sea_level" ;
  sla_mean_10pts:comment = "X-Track/ALES monthly sea level anomaly averaged over
  the 10 first nearest points to the coast" ;
double sla_mean_10pts_filt(nbmonths) ;
  sla_mean_10pts_filt:_FillValue = NaN ;
  sla_mean_10pts_filt:units = "m" ;
  sla_mean_10pts_filt:long_name = "Sea level anomaly averaged over the 10 nearest
  points to the coast with a 6 month filter" ;
  sla_mean_10pts_filt:standard_name = "sea_surface_height_above_mean_sea_level" ;
  sla_mean_10pts_filt:comment = "X-Track/ALES monthly sea level anomaly averaged
  over the 10 first nearest points to the coast with a 6 month rolling mean filter"
double sla_seasonal(nbpoints, nbmonths) ;
  sla_seasonal:_FillValue = NaN ;
  sla_seasonal:units = "m" ;
  sla_seasonal:long_name = "Seasonal signal (annual + semi-annual) removed from
  sea level anomaly" ;
  sla_seasonal:comment = "Annual and semi-annual cycles extracted by MSTL
  decomposition" ;
  sla_seasonal:standard_name = "sea_surface_height_above_mean_sea_level" ;
int64 time(nbmonths) ;
  time:long_name = "Time" ;
  time:standard_name = "time" ;
  time:units_metadata = "leap_seconds: none" ;
  time:units = "days since 1950-01-01" ;
  time:calendar = "proleptic_gregorian" ;
```

6 Examples of along-track SLAs and trends (v4.0)

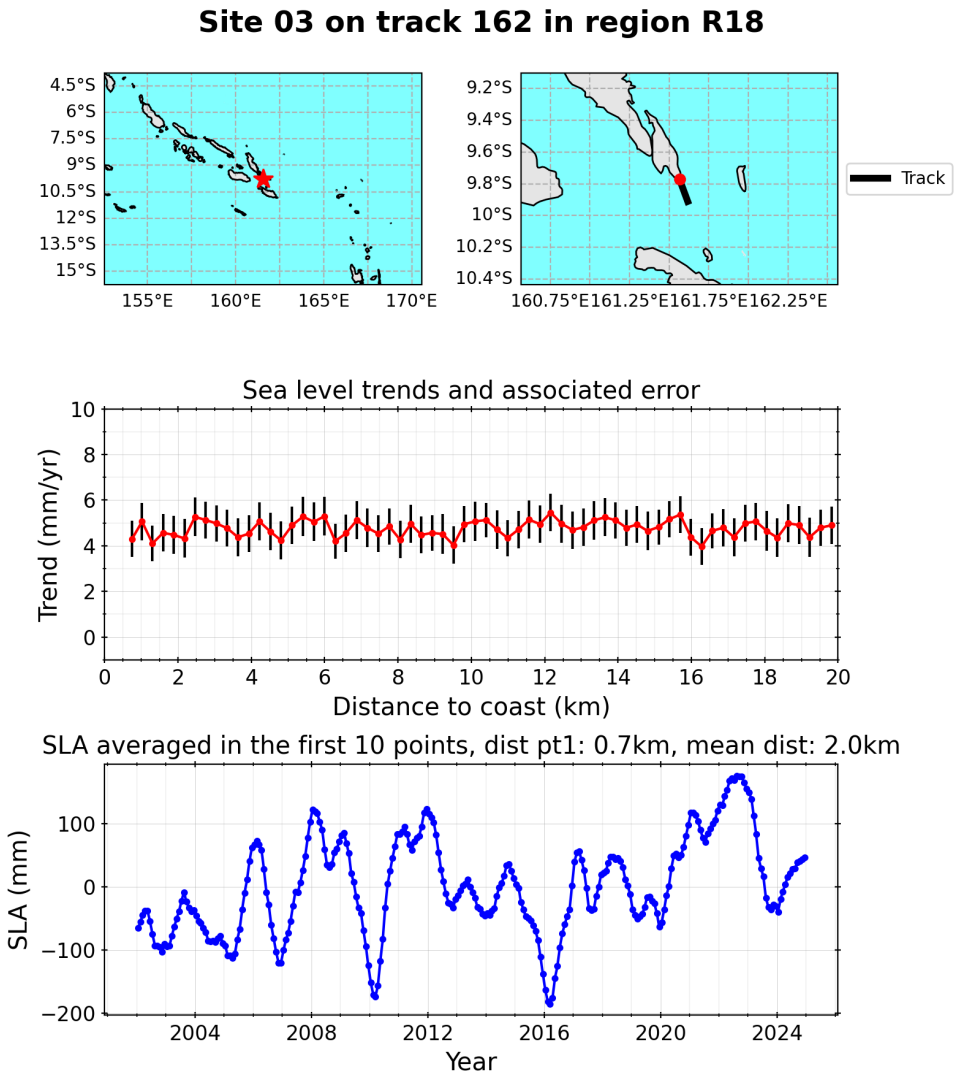


Figure 8: Example in the south of Malaita (Solomon Archipelago) (top panel): Sea level trends against distance to coast (middle panel) and SLA time series averaged over the first closest 10 points to the coast (bottom panel).

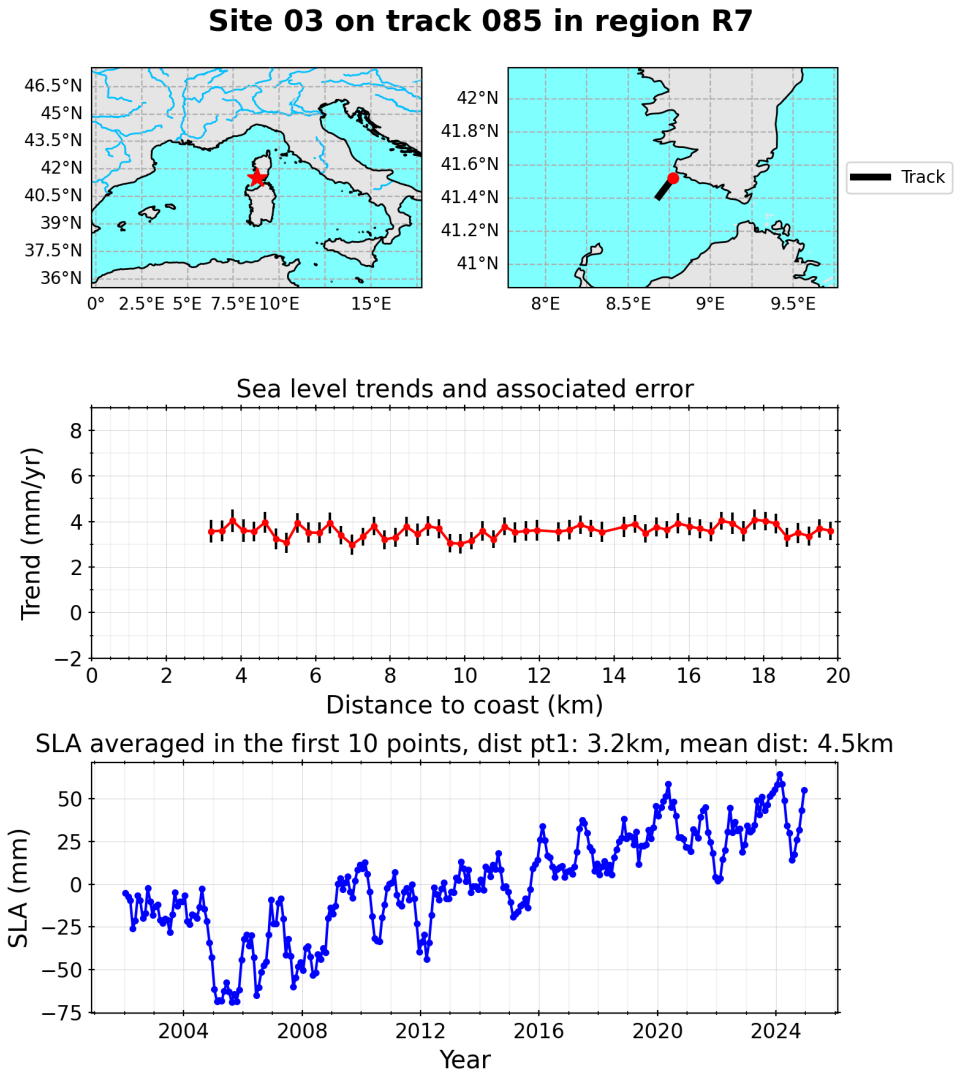


Figure 9: Example at the Senetosa site (south Corsica island): Sea level trends against distance to coast (middle panel) and SLA time series averaged over the first closest 10 points to the coast (bottom panel).

7 Format

Network Common Data Form (NetCDF) is an interface for array-oriented data access and a library that provides an implementation of the interface. The NetCDF library also defines a machine-independent format for representing scientific data. Together, the interface, library, and format support the creation, access, and sharing of scientific data. The NetCDF software was developed at the Unidata Program Center in Boulder, Colorado. Please see Unidata NetCDF pages for more information, and to retrieve NetCDF software on: `https://www.unidata.ucar.edu/software/netcdf/`

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