

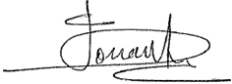


SLBC_cci+

SEA LEVEL BUDGET CLOSURE - CLIMATE CHANGE INITIATIVE +

PRODUCT USER GUIDE (PUG)

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Document evolution sheet

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1	1	17/06/2025	ESA feedback	
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Contents

1. Introduction	5
1.1. Scope and objective	5
1.2. Document structure	5
1.3. Related documents	5
1.3.1. Applicable documents	5
1.4. Acronyms	6
2. Product specification	7
2.1. File format	7
2.2. Spatial information	7
2.3. Temporal information	7
2.4. File naming convention	7
2.5. Dimensions	8
2.6. Metadata	8
2.7. Variables	8
3. Frequently asked questions	14
3.1. What is the ESA CCI SLBC project?	14
3.2. Why would you want to use this dataset?	14
3.3. Where can I access the data?	15
3.4. What other documents should I read to help me understand this data?	15
3.5. How do I cite this data when using it for research?	16
3.6. Who can I contact for support?	16

List of figures and tables

Table 1 List of applicable documents.	5
Table 2 List of abbreviations and acronyms.	6
Table 3: Variables of the unconstrained SLB product	8
Table 4: Variables of the constrained SLB product	12

1. Introduction

1.1. Scope and objective

This document is the Product User Guide (PUG) of the SLBC_cci+ project supported by ESA. The PUG is dedicated to the content and format description of the SLBC_cci+ product. This product gathers estimates of the different components of the sea level budget at global and regional scale as well as their uncertainties and the budget residuals obtained.

This is the primary document that users should read before handling the products. It provides an overview of processing algorithms, technical product content and format and main validation results. Details on the algorithms are given in the Algorithm theoretical baseline document (ATBD) [AD1].

1.2. Document structure

In addition to this introduction, the document is organised as follows:

- Section 2 presents SLBC_cci+ product's content and specifications.
- Section 3 presents the frequently asked questions

1.3. Related documents

1.3.1. Applicable documents

Table 1 *List of applicable documents.*

Id.	Ref.	Description
[AD1]	SLBC_CCI-DT-041-MAG_ATBD	SEA LEVEL BUDGET CLOSURE_CCI+ Algorithm Theoretical Baseline Document (ATBD)
[AD2]	SLBC_CCI-DT-039-MAG_PSD_D2-1	SEA LEVEL BUDGET CLOSURE_CCI+ Product Specification Document (PSD)
[AD3]	SLBC_CCI-DT-040-MAG_DARD_D2-2	SEA LEVEL BUDGET CLOSURE_CCI+ Data Access Requirement Document (DARD)
[AD4]	SLBC_CCI-DT-076-MAG_UCR	SEA LEVEL BUDGET CLOSURE_CCI+

		Uncertainty Characterisation Report (UCR)
[AD5]	SLBC_CCI-DT-075-MAG_PVIR	SEA LEVEL BUDGET CLOSURE_CCI+ Product Validation and Intercomparison Report (PVIR)

1.4. Acronyms

Table 2 *List of abbreviations and acronyms.*

Acronyms	Description
CCI	The ESA Climate Change Initiative
ESA	European Space Agency
RSL	Relative Sea Level
SLBC_cci	Sea Level Budget Closure of the ESA Climate Change Initiative (first phase)
SLBC_cci+	Sea Level Budget Closure of the ESA Climate Change Initiative (second phase, this activity)
w.r.t	With respect to

2. Product specification

The SLBC_cci+ dataset is divided into 2 separate netCDF files. The first one contains the SLB components from the unconstrained approach and the second one contains the SLB components from the objectively constrained approach (see ATBD section 3 [\[AD1\]](#)).

2.1. File format

The product is delivered as Network Common Data Form version 4 (netCDF4) file with metadata attributes compliant with version 1.7 of the Climate & Forecast conventions (CF V1.7).

2.2. Spatial information

All 2-D fields of the product are displayed on a 1° longitude-latitude grid (WGS84). As the product is focused on the Global Ocean, the spatial coverage is restricted between 180°W to 180°E longitude and 90°S to 90°N latitude.

2.3. Temporal information

Time dependent fields are displayed at monthly resolution for every component.

2.4. File naming convention

The product follows this naming standard:

ESACCI+_SLBC_SeaLevelBudgetElements_<unconstrained/constrained>_<version>.nc

where:

- <unconstrained/constrained> indicates if the product is coming from the unconstrained or constrained approach.
- <VERSION> is the four-digit version number, starting with 'V1-0' for the first major version. The first digit changes each time a major version is released ('V2-0', 'V3-0'), while changes in the second digit indicate reprocessing versions or minor versions ('V1-2', 'V1-3').

- .nc: standard NetCDF filename extension.

2.5. Dimensions

4 dimensions are defined:

- latitude
- longitude
- time: time dimension for global mean variables
- time_grid: time dimension for gridded variables
- time_covar: time dimension for error covariance matrices of global mean variables
- time_covar_1: time dimension for error covariance matrices of global mean variables (same as time_covar)
- time_covar_grid: time dimension for error covariance matrices of gridded variables
- time_covar_grid_1: time dimension for error covariance matrices of gridded variables (same as time_covar_grid)

2.6. Metadata

The netCDF file contains some metadata at the file-level, at the layer-level and at the level of the dimensions. These metadata inform for example about the variable units, the variable ranges, etc...

2.7. Variables

All variables are expressed in terms of anomalies (in millimetres of equivalent global mean sea level).

The first dataset containing the variables for the unconstrained approach is described in the following table.

Table 3: *Variables of the unconstrained SLB product*

Variables (dimensions)	Description	Units	Data Type
------------------------	-------------	-------	-----------

time(time)	Time of global mean variables (monthly timestep)	days since 1950-01-01 00:00:00 UTC	double
time_grid(time_grid)	Time of gridded variables (monthly timestep)	days since 1950-01-01 00:00:00 UTC	double
time_covar(time_covar)	Time vector of global mean covariance matrices	days since 1950-01-01 00:00:00 UTC	double
time_covar_1(time_covar_1)	Time vector of global mean covariance matrices	days since 1950-01-01 00:00:00 UTC	double
time_covar_grid(time_covar_grid)	Time vector of gridded covariance matrices	days since 1950-01-01 00:00:00 UTC	double
time_covar_grid_1(time_covar_grid_1)	Time vector of gridded covariance matrices	days since 1950-01-01 00:00:00 UTC	double
latitude(latitude)	Latitude of data	degrees_north	double
longitude(longitude)	Longitude of data	degrees_east	double
gm_rsl(time)	Global Mean Relative Sea Level computed as absolute sea level corrected for GIA and vertical land motion (FP)	mm	double
gm_tsl(time)	Global Mean Thermosteric Sea Level	mm	double
basl_sat(time)	Barystatic Sea Level from the satellite gravimetry (GRACE/GRACE-FO) corrected for GIA	mm	double
basl_mass_contrib(time)	Barystatic Sea Level from the sum	mm	double

	of individual components		
gm_lws(time)	Global Mean contribution of Land water storage Sea Level	mm	double
gm_glaciers(time)	Global Mean of Glaciers contribution to the barystatic Sea Level	mm	double
gm_gis(time)	Greenland Ice Sheet Contribution to the barystatic Sea Level	mm	double
gm_ais(time)	Antarctic Ice Sheet Contribution to the barystatic Sea Level	mm	double
gm_awv(time)	Atmospheric Water Vapor Contribution to the barystatic Sea Level	mm	double
sum_basl_sat(time)	Sum of contributions using Barystatic Sea Level from the satellite gravimetry GRACE/GRACE-FO (sum_basl_sat = basl_sat + gm_tsl)	mm	double
sum_basl_mass_contrib(time)	Sum of contributions using Barystatic Sea Level from the sum of individual components (sum_basl_mass_contrib = basl_mass_contrib + gm_tsl)	mm	double
gm_rsl_covar(time_covar, time_covar_1)	Covariance matrix for global mean relative sea level	mm*mm	double
gm_tsl_covar(time_covar, time_covar_1)	Covariance matrix for global mean thermosteric sea level	mm*mm	double
basl_sat_covar(time_covar, time_covar_1)	Covariance matrix for barystatic sea level from satellite gravimetry	mm*mm	double
gm_lws_covar(time_covar,	Covariance matrix for barystatic	mm*mm	double

time_covar_1)	sea level from satellite gravimetry		
gm_glaciers_covar(time_covar, time_covar_1)	Covariance matrix for the Glaciers	mm*mm	double
gm_gis_covar(time_covar, time_covar_1)	Covariance matrix for the Greenland Ice Sheet	mm*mm	double
gm_ais_covar(time_covar, time_covar_1)	Covariance matrix for the Antarctic Ice Sheet	mm*mm	double
gm_awv_covar(time_covar, time_covar_1)	Covariance matrix for the Atmospheric Water Vapor	mm*mm	double
sum_basl_sat_covar(time_covar, time_covar_1)	Covariance matrix for the Sum of contributions using Barystatic Sea Level from the satellite gravimetry (GRACE/GRACE-FO)	mm*mm	double
sum_basl_mass_contrib_covar(time_covar, time_covar_1)	Covariance matrix for the Sum of contributions using Barystatic Sea Level from the sum of individual components	mm*mm	double
mask(latitude, longitude)	Binary mask indicating which grid cells are used to compute the global mean (1=used, 0=excluded)	binary	double
rsl(time_grid, latitude, longitude)	Relative sea level computed as absolute sea level corrected for GIA and vertical land motion (FP)	mm	double
manosl(time_grid, latitude, longitude)	Manometric sea level corrected for GIA	mm	double
tsl(time_grid, latitude, longitude)	Thermosteric sea level	mm	double
hsl(time_grid, latitude, longitude)	Halosteric sea level	mm	double
sum_of_components(time_gr	Sum of all contributions to sea	mm	double

id, latitude, longitude)	level (sum_of_components = manosl + tsl + hsl)		
rsl_error_cov(latitude, longitude, time_covar_grid, time_covar_grid_1)	Relative sea level component error covariance matrix	mm*mm	double
manosl_error_cov(latitude, longitude, time_covar_grid, time_covar_grid_1)	Manometric sea level component error covariance matrix	mm*mm	double
thermo_error_cov(latitude, longitude, time_covar_grid, time_covar_grid_1)	Thermosteric component error covariance matrix	mm*mm	double
halo_error_cov(latitude, longitude, time_covar_grid, time_covar_grid_1)	Halosteric component error covariance matrix	mm*mm	double

The second dataset containing the variables for the constrained approach is described in the following table.

Table 4: *Variables of the constrained SLB product*

Variables (dimensions)	Description	Units	Data Type
time(time)	Time (monthly timestep)	days since 1950-01-01 00:00:00 UTC	double
time_covar(time_covar)	Time vector of regional covariance matrices (monthly timestep)	days since 1950-01-01 00:00:00 UTC	double
time_covar_1(time_covar)	Time vector of regional covariance matrices (monthly timestep)	days since 1950-01-01 00:00:00 UTC	double
gm_rsl(time)	Global Mean Relative Sea Level	mm	double
basl(time)	Barystatic Sea Level	mm	double
gm_tsl(time)	Global Mean Thermosteric Sea Level	mm	double
gm_rsl_covar(time_covar , time_covar_1)	Global Mean Sea Level Covariance Matrix	mm*mm	double
basl_covar(time_covar, time_covar_1)	Barystatic Sea Level Covariance Matric	mm*mm	double
gm_tsl_covar(time_covar, time_covar_1)	Global Mean Thermosteric Sea Level Covariance Matrix	mm*mm	double

3. Frequently asked questions

3.1. What is the ESA CCI SLBC project?

The ESA CCI SLBC project intends to analyse in an integrative context recent results obtained by the ESA CCI programme for the sea level, glaciers and ice sheets Essential Climate Variables (ECV), with additional account for assessments of the ocean thermal expansion component which utilise the CCI Sea Surface Temperature ECV. Among other objectives, an important task will consist of assessing the quality of the CCI products involved in the sea level budget.

The first phase of this project covered the precise altimetry era (starting in 1993) with a special focus given to the period 2003/2005 to 2015, coinciding with the availability of GRACE space gravimetry data and Argo drifter data.

The new project phase (SBLC_cci+) aims to improve the closure of the global mean sea level budget by: 1) lengthening the time series, 2) assessing budget closure at global and regional scales, 3) providing an explanation of temporal and spatial variability at global and local scales. Depending on the availability of the various elements, the global sea level budget will be updated up to 2022/2023. In addition, the project will address the regional variability of sea level and sea surface temperature, and investigate the contributions of natural/internal climate variability and anthropogenic forcing (detection/attribution) to the associated spatial trends. By extending to regional spatial scales, we can pinpoint areas where the sea level budget does not close, resulting in a regional breakdown of the assessment of the items that accounts for a significant portion of the individual components used.

3.2. Why would you want to use this dataset?

This dataset provides the latest scientific estimates of sea level budget components. It includes global estimates for each component from 1993-2023 (the altimetry era) and regional estimates from 2002-2023 (the gravimetry era). Further details on these components can be found in the ATBD ([\[AD1\]](#)) and in the PSD ([\[AD2\]](#)).

Significant effort has been made to characterize the uncertainties associated with each component. These uncertainties are provided as variance-covariance matrices, available at a monthly timescale for both global and regional scales. These matrices enable the estimation of uncertainties in trends and acceleration across any timescales. Comprehensive information on uncertainties is described in the UCR ([\[AD4\]](#)).

The dataset is organized into two distinct files:

- `ESACCI+_SLBC_SeaLevelBudgetElements_unconstrained_v1.nc` contains sea level components derived from the unconstrained approach.
- `ESACCI+_SLBC_SeaLevelBudgetElements_constrained_v1.nc` contains sea level components derived from the constrained approach.

More details about these two approaches are provided in section 3.4 of the ATBD.

3.3. Where can I access the data?

The data product (NetCDF file), together with all the documentation associated is available on the ESA CCI webpage of the project:

<https://climate.esa.int/en/projects/sea-level-budget-closure/>

Once downloaded, NetCDF data can be browsed and used through a number of software, like:

- ncBrowse: <https://www.pmel.noaa.gov/epic/java/ncBrowse/>
- NetCDF Operator (NCO): <http://nco.sourceforge.net/>
- Panoply: <https://www.giss.nasa.gov/tools/panoply/>
- IDL, Matlab, GMT, Python...

Useful information on UNIDATA: <http://www.unidata.ucar.edu/software/netcdf/>

3.4. What other documents should I read to help me understand this data?

The other document that could help you to understand this dataset are:

- **Algorithm Theoretical Baseline Document (ATBD)**: describes the algorithms used for the estimation of the different SL components
- **Product Specification Document (PSD)**: aims at specifying datasets of individual sea level components that will be generated as an input to the sea level budget.

- **Data Access Requirement Document (DARD):** aims at describing the data access for each SL component and their specifications
- **Uncertainty Characterisation Report (UCR):** aims to describe the uncertainties provided for every component of the SLB as well as the uncertainty assessment of the budget
- **Product Validation and Intercomparison Report (PVIR):** is dedicated to the validation and intercomparison of each SLB component against other datasets. It also shows the results of the budget itself at global mean and regional scale.

3.5. How do I cite this data when using it for research?

By accessing ESA SLBC CCI data, you agree to cite both the dataset and a journal article describing the dataset when publishing results obtained in whole or in part by use of ESA SLBC CCI products.

The dataset citation should reference the "ESA SLBC CCI" project, and from where the data were obtained. Full dataset citations are provided in the catalogue entries of the Open Data Portal and CEDA archive. DOIs are recorded in the file metadata so you may easily find the catalogue entry from the files you are using.

All the information about the project are available on the project website:
<https://climate.esa.int/en/projects/sea-level-budget-closure/>

Use of these data is covered by the following licence(s):
https://artefacts.ceda.ac.uk/licences/specific_licences/esacci_slbc_terms_and_conditions.pdf

When using these data you must cite them correctly using the citation given on the catalogue record.

3.6. Who can I contact for support?

For any technical issues or additional information related to the SLBC_cci+ product, users are advised to contact the project team:

- Robin Fraudeau (technical coordinator) : robin.fraudeau@magellium.fr
- Benoit Meyssignac (science lead) : benoit.meyssignac@legos.obs-mip.fr
- Michaël Ablain (project manager) : michael.ablain@magellium.fr
- Sarah Connors (Technical officer): sarah.connors@esa.int

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