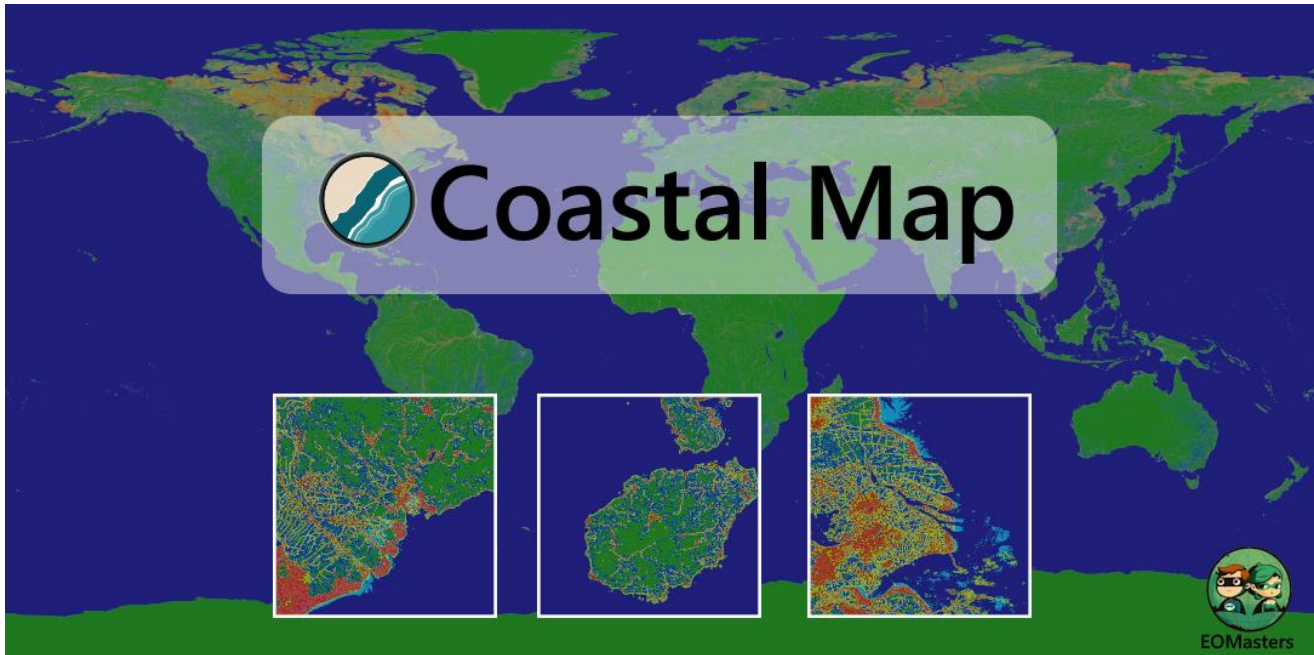




Document Ref
Issue Date
Issue

EOM-Global_Coastal_Map-1.0.0
17/07/2024
1.0.0



Title: Coastal Map – Global High-Resolution Coastal Areas Map

Author(s): Marco Peters

Affiliation: EOMasters (www.eomasters.org)

Issue: 1.0.0

Date: 17/07/2024

DOI: [10.5281/zenodo.10548225](https://doi.org/10.5281/zenodo.10548225)



Issue: 1.0.0 – 17/07/2024

Coastal Map – Global High-Resolution Coastal Areas Map

Table of Contents

1	Introduction	3
2	Data Generation	4
2.1	Land-Water Indicator	4
2.2	Coastline Indicator	5
2.3	Intertidal Area Indicator	6
2.4	Vicinity Indicator	6
3	Data Format	8
4	Data Access	9
5	Licence & Citation	9
6	Contact	10
7	References	10
8	Changelog	10



Coastal Map – Global High-Resolution Coastal Areas Map

1 Introduction

Coastal areas are crucial ecosystems, supporting a diverse range of plants and animals. Monitoring these areas via satellites allows for better exploration and protection. The Coastal Map presented in this document provides high-resolution data (approximately 10 meters) essential for analysing and processing information about coastal zones. It uses the WSG84 projection and is divided into 3x3 degree grid files, significantly reducing the workload and processing time for ecological assessments.

The map provides 4 important indicators for coastal areas.

- a land-water indicator
- a coastline indicator
- a tidal flat indicator
- a vicinity indicator for land close to water and water close to land.

The final map (Figure 1) utilizes ten different masks to implement these indicators.

Name	Colour	Description
EOM_LAND	Green	Land pixels
EOM_WATER	Blue	Water pixels
EOM_COASTLINE	White	Coastline pixels
EOM_INTERTIDAL	Cyan	Intertidal pixels
EOM_COASTAL_WATER_VICINITY_LOW	Blue	Low vicinity score for water pixels
EOM_COASTAL_WATER_VICINITY_MID	Yellow	Intermediate vicinity score for water pixels
EOM_COASTAL_WATER_VICINITY_HIGH	Red	High vicinity score for water pixels
EOM_COASTAL_LAND_VICINITY_LOW	Green	Low vicinity score for land pixels
EOM_COASTAL_LAND_VICINITY_MID	Yellow	Intermediate vicinity score for land pixels
EOM_COASTAL_LAND_VICINITY_HIGH	Red	High vicinity score for land pixels

Table 1 The masks used along with the default colour and a description.

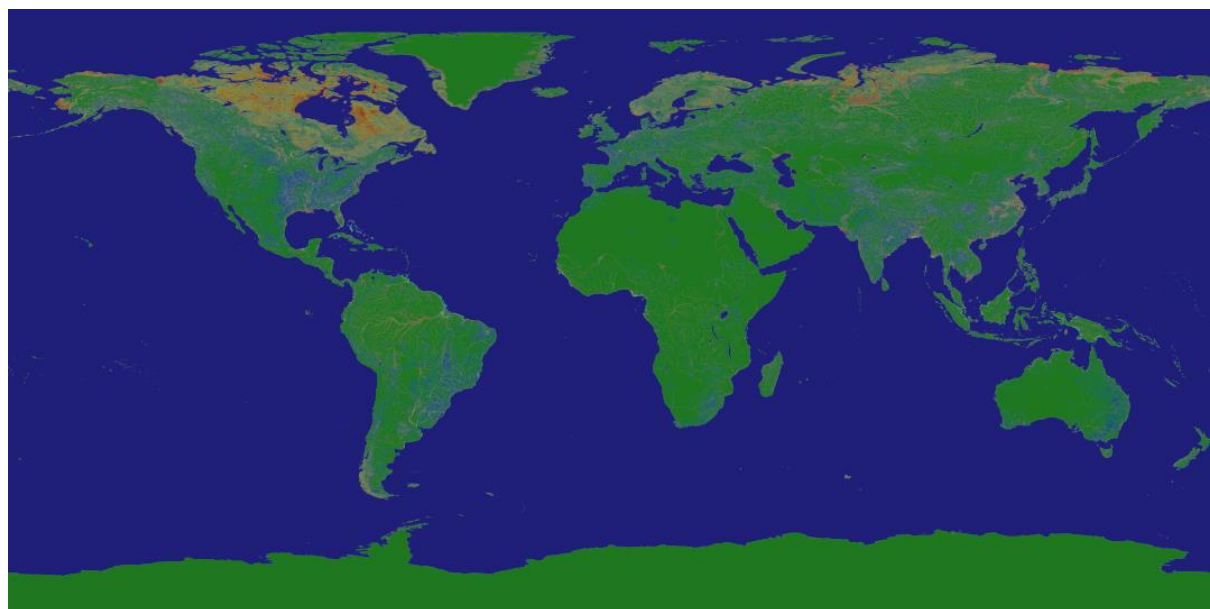


Figure 1 The global masks provided by the Coastal Map

The following sections will provide information on how each indicator has been generated.



Coastal Map – Global High-Resolution Coastal Areas Map

2 Data Generation

The Coastal Map is derived from three primary data sources, each providing critical information essential for constructing the indicators:

- **ESA WorldCover 10m 2021** (Zanaga, 2022): This dataset offers global land cover information at a 10-meter resolution, making it highly suitable for identifying land and water bodies. The high resolution and comprehensive coverage enable detailed and accurate representation of various land cover types, which are crucial for creating the Land-Water Indicator.
- **BAS Antarctica Seamask 2023** (Ireland, 2023): Developed by the British Antarctic Survey, this high-resolution vector polygon seamask provides detailed coverage of the Antarctic region south of 60°S. The data helps in accurately mapping coastal areas in Antarctica, where traditional land cover datasets may lack precision due to challenging conditions and limited accessibility.
- **Global Intertidal Change Map 2019** (Murray, 2022): This map presents changes in Earth's tidal wetlands, with high-resolution data on tidal wetland probabilities. It is instrumental in defining intertidal areas, aiding in the creation of the Intertidal Area Indicator by delineating areas that experience regular tidal influence.

2.1 Land-Water Indicator



Figure 2 ESA WorldCover Map 2021

The Land-Water Indicator is created using the ESA WorldCover map and the BAS Antarctica Seamask. The WorldCover map's values (zero for no-data and 80 for water bodies) are designated as water, with all other values representing land. For the Antarctic region, the inverted and reprojected BAS Antarctica Seamask is used.



Coastal Map – Global High-Resolution Coastal Areas Map

Algorithm (pseudo code):

```
var world_cover = loadWorldCover()
var antarctica_seamask = loadAntarctica()
var land_water
if (currentLat > -60) {
  land_water = (world_cover == 80 || world_cover == 0) ? 0 : 1
} else {
  land_water = antarctica_seamask == 1 ? 0 : 1
}
```

2.2 Coastline Indicator

The coastline indicator is derived by applying a convolution image filter on the Land-Water indicator. The SOBEL edge detection is used to perform image filtering on the data by using four kernels. A SOBEL_NORTH, SOBEL_EAST, SOBEL_SOUTH, SOBEL_WEST are applied to the land-water data and the results are converted to their absolute values, summed up and normalised to zero and one values. This results in a two-pixel broad coastline. One pixel over land the other over water.

Sobel Kernel

-1	-2	-1
0	0	0
+1	+2	+1

North

+1	0	-1
+2	0	-2
+1	0	-1

East

+1	+2	+1
0	0	0
-1	-2	-1

South

-1	0	+1
-2	0	+2
-1	0	+1

West

Figure 3 Overview of the 4 applied Sobel kernel.



Coastal Map – Global High-Resolution Coastal Areas Map

Algorithm (pseudo code):

```
var land_water = ...
var sobel_n = apply(SOBEL_NORTH, land_water)
var sobel_e = apply(SOBEL_EAST, land_water)
var sobel_s = apply(SOBEL_SOUTH, land_water)
var sobel_w = apply(SOBEL_WEST, land_water)
var sobel_sum = sum(sobel_n, sobel_e, sobel_s, sobel_w)
var coastline = divide(sobel_sum, sobel_sum)
```

2.3 Intertidal Area Indicator

The Global Intertidal Change Map 2019 (Murray, 2022) does not only provide the change map but also a Tidal wetland probability map which represents the likelihood on a scale of 0-100 that a pixel is correctly classified as tidal wetland (defined as either mangrove, tidal marsh, or tidal flat).

In order to determine the intertidal area on the basis of these probabilities, two different empirical threshold values had to be defined. The threshold value for the intertidal water areas has been set to 20. The threshold for intertidal land areas is set to 50. If the probability is greater than or equal to the threshold, the pixel is considered to belong to an intertidal area.

Algorithm (pseudo code):

```
var land_water = ...
var intertidal_prob = loadIntertidalProbability()
var intertidal_area
if (land_water == 0) {
    intertidal_area = intertidal_prob >= TIDAL_WATER_THR ? 1 : 0
} else {
    intertidal_area = intertidal_prob >= TIDAL_LAND_THR ? 1 : 0
}
```

2.4 Vicinity Indicator

Instead, then just providing a distance measure for coastal pixels, the coastal map provides a vicinity indicator. It is based on a vicinity score which measures the mutual influence of water and land pixels based on their proximity and abundance. For a water pixel, the score indicates how much the pixel may be influenced by nearby land pixels. For a land pixel, it is the opposite, the score reflects how much it may be influenced by water pixels.



Issue: 1.0.0 – 17/07/2024

Coastal Map – Global High-Resolution Coastal Areas Map

The vicinity indicator is provided for a corridor of 200 pixels along the coastline. 100 pixels over water and 100 pixels over land.

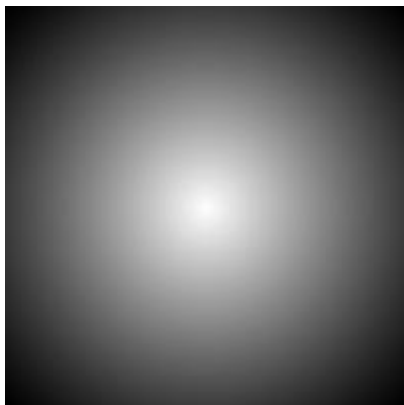


Figure 4 The kernel used calculate the vicinity

The calculation is done by using a data kernel when the pixel is marked as coastline and summing up its result with the already applied data to adjacent pixels. This is done separately for water and for land pixels. For land pixels the sign is inverted. At the end, both the water and land results are combined and form a value range from -100 to 100.

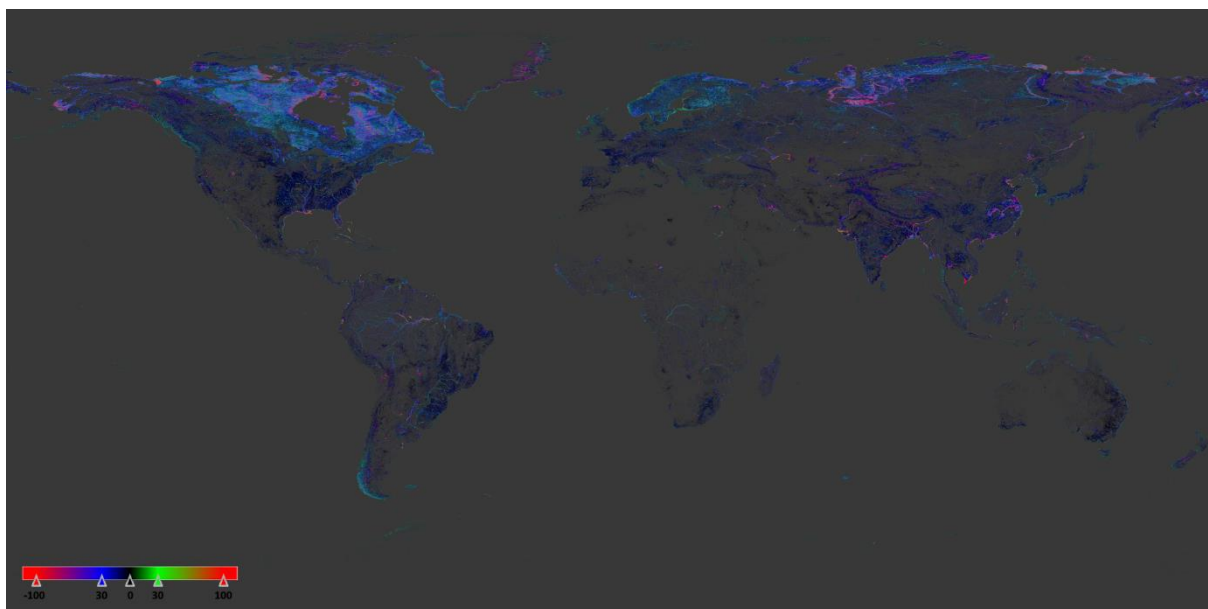


Figure 5 The global vicinity map. Values range from -100 to 100.

The result is categorised in 3 vicinity levels and provided as flags: low, intermediate, and high.

Categorisation of land vicinity for water pixel:

- low = $0 < \text{vicinity} \leq 30.0$
- mid = $30.0 < \text{vicinity} \leq 90.0$
- high = $90.0 < \text{vicinity} \leq 100.0$



Issue: 1.0.0 – 17/07/2024

Coastal Map – Global High-Resolution Coastal Areas Map

Categorisation of water vicinity for land pixel:

- low = $0 > \text{vicinity} \geq -30.0$
- mid = $-30.0 > \text{vicinity} \geq -90.0$
- high = $-90.0 > \text{vicinity} \geq -100.0$

Algorithm (pseudo code):

```
var land_water = ...
var coastline = ...
for_each_pixel {
    if(coastline == 1) {
        iterate_kernel_data {
            if(land_water == 1) {
                land_vicinity_xy -= kernel_data[i]
            } else {
                water_vicinity_xy += kernel_data[i]
            }
        }
    }
}
```

3 Data Format

The generated data is stored in a format named ZNAP (SNAP, ZNAP Format, 2024) and used by the Earth observation software named SNAP (SNAP, ESA Sentinel Application Platform v9, 2024). This is a fast and efficient format for storing Earth observation data. As underlying technology, the zarr (Alistair, 2023) data format is used. This also allows the reading of the data with other software packages and programming scripts like Python.

The coastal indicators are combined in one raster component named 'eom_cm_flags' of data type byte. Where the bits are used as flags and indicate the different values.

There are 9 flags defined:

Flag Name	Flag Value	Flag Mask	Description
LAND_WATER	1 (0b00000001)	1 (0b00000001)	Land (1) / Water (0)
COASTLINE	2 (0b00000010)	2 (0b00000010)	Coastline
INTERTIDAL	4 (0b00000100)	4 (0b00000100)	Intertidal area



Coastal Map – Global High-Resolution Coastal Areas Map

COASTAL_WATER_VICINITY_LOW	8 (0b00001000)	24 (0b00011000)	Low vicinity score for water pixels
COASTAL_WATER_VICINITY_MID	16 (0b00010000)	24 (0b00011000)	Intermediate vicinity score for water pixels
COASTAL_WATER_VICINITY_HIGH	24 (0b00011000)	24 (0b00011000)	High vicinity score for water pixels
COASTAL_LAND_VICINITY_LOW	32 (0b00100000)	96 (0b01100000)	Low vicinity score for land pixels
COASTAL_LAND_VICINITY_MID	64 (0b01000000)	96 (0b01100000)	Intermediate vicinity score for land pixels
COASTAL_LAND_VICINITY_HIGH	96 (0b01100000)	96 (0b01100000)	High vicinity score for land pixels

4 Data Access

The data is provided as 3°x3° tiles like the WorldCover map. This means that 7200 tiles cover the whole globe. The Tiles are combined to tile sets. Each is a zip file containing 100 tiles covering an area of 30°x30° degree.

The file name of the tile sets follows the format:

EOM_CoastalMap_Flags_<upperleft-tile-id>-<lowerright-tile-id>.zip

The name of the single files contained in the tile sets are like:

EOM_CoastalMap_Flags_<tile-id>.znep.zip

The data is located on a S3 bucket at <https://coastalmap.s3-eu-central-1.ionoscloud.com>. Thus it can be accessed by the common [tools for S3 Object Storage](#).

5 Licence & Citation

The data is published under the CC-BY 4.0 license and can be freely used to create your own work based on the data, even for commercial use cases.

CC BY 4.0 - Attribution 4.0 International

This license requires that reusers give credit to the creator. It allows reusers to distribute, remix, adapt, and build upon the material in any medium or format, even for commercial purposes.

(<http://creativecommons.org/licenses/by/4.0>)

If you want to cite the data, please refer to the following citation example:

Peters, M. (2024). *Global High-Resolution Map for Coastal Areas*. EOMasters.
doi:10.5281/zenodo.10548225



Issue: 1.0.0 – 17/07/2024

Coastal Map – Global High-Resolution Coastal Areas Map

6 Contact

If you have any question or feedback regarding the data or the generation process, please contact me. The global flag map can be provided in other data formats, like GeoTiff or NetCdf. The global vicinity map used to derive the vicinity indicators can be provided too.

You can contact me at any time at marco@eomasters.org.

7 References

Alistair, M. (2023). zarr-developers/zarr-python. doi:10.5281/zenodo.8263439

Ireland, L. (2023). *High resolution vector polygon seamask for areas south of 60S (7.8)*. Scientific Committee on Antarctic Research, UK Polar Data Centre. British Antarctic Survey. doi:10.5285/352ab67d-a901-43f9-9216-3b69ff10626a

Murray, N. (2022). *High-resolution mapping of losses and gains of Earth's tidal wetlands*. Science. doi:10.1126/science.abm9583

SNAP. (2024). ESA Sentinel Application Platform v9. ESA. Retrieved from <http://step.esa.int>

SNAP. (2024). ZNAP Format. Retrieved from <https://step.esa.int/main/wp-content/help/?version=9.0.0&helpid=exportZnapProduct>

Zanaga, D. (2022). *ESA WorldCover 10 m 2021 v200*. Zenodo. doi:10.5281/zenodo.7254221

8 Changelog

Issue	Date	Editor	Change
1.0.0	17/07/2024	M. Peters	Initial Version