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## Ocean monitoring indicator (OMI) of the Copernicus marine environment monitoring service global yearly ocean CO<sub>2</sub> sink

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# Quality Information Document

Ocean Monitoring Indicator (OMI) of the  
Copernicus Marine Environment Monitoring Service

## Global yearly ocean CO<sub>2</sub> sink

Issue: 5.0

Contributors : Thi Tuyet Trang Chau, Marion Gehlen, Frédéric Chevallier

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### CHANGE RECORD

| Issue | Date    | §   | Description of Change  | Author   | Validated By          |
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| 1.0   | 2019/10 | all | Creation of the document   | Marion Gehlen, Thi Tuyet Trang Chau                            |                       |
| 2.0   | 2019/12 | /   | Update of Figure, references<br>Modification of method<br>description and validation | Thi Tuyet Trang Chau,<br>Marion Gehlen, Frédéric<br>Chevallier |                       |
| 3.0   | 2020/09 | /   | Update of Figure, references<br>Modification of evaluation<br>results                | Thi Tuyet Trang Chau,<br>Marion Gehlen, Frédéric<br>Chevallier |                       |
| 4.0   | 2021/09 | /   | Update of Figure, references<br>Modification of evaluation<br>results                | Thi Tuyet Trang Chau,<br>Marion Gehlen, Frédéric<br>Chevallier | Stéphanie<br>Guinehut |
| 4.1   | 2021/11 |     | Correction following MOi review  | Thi Tuyet Trang Chau,<br>Marion Gehlen, Frédéric<br>Chevallier | Sandrine<br>Mulet     |
| 5.0   | 2022/09 | /   | Update of Figure, references<br>Modification of evaluation<br>results                | Thi Tuyet Trang Chau,<br>Marion Gehlen, Frédéric<br>Chevallier | M.<br>Drevillon       |

|            |  |          |
|------------|--|----------|
| <b>I</b>   | <b>INTRODUCTION</b> .....                                      | <b>4</b> |
| <b>I.1</b> | <b>Product name</b> .....                                      | <b>4</b> |
| <b>I.2</b> | <b>Indicator evaluation method</b> .....                       | <b>4</b> |
| <b>I.3</b> | <b>CMEMS products used as input for the computations</b> ..... | <b>4</b> |
| <b>II</b>  | <b>SCIENTIFIC EVALUATION</b> .....                             | <b>5</b> |
| <b>III</b> | <b>REFERENCES</b> .....  | <b>7</b> |

## I INTRODUCTION

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### I.1 Product name

GLOBAL\_OMI\_HEALTH\_carbon\_co2\_flux\_integrated

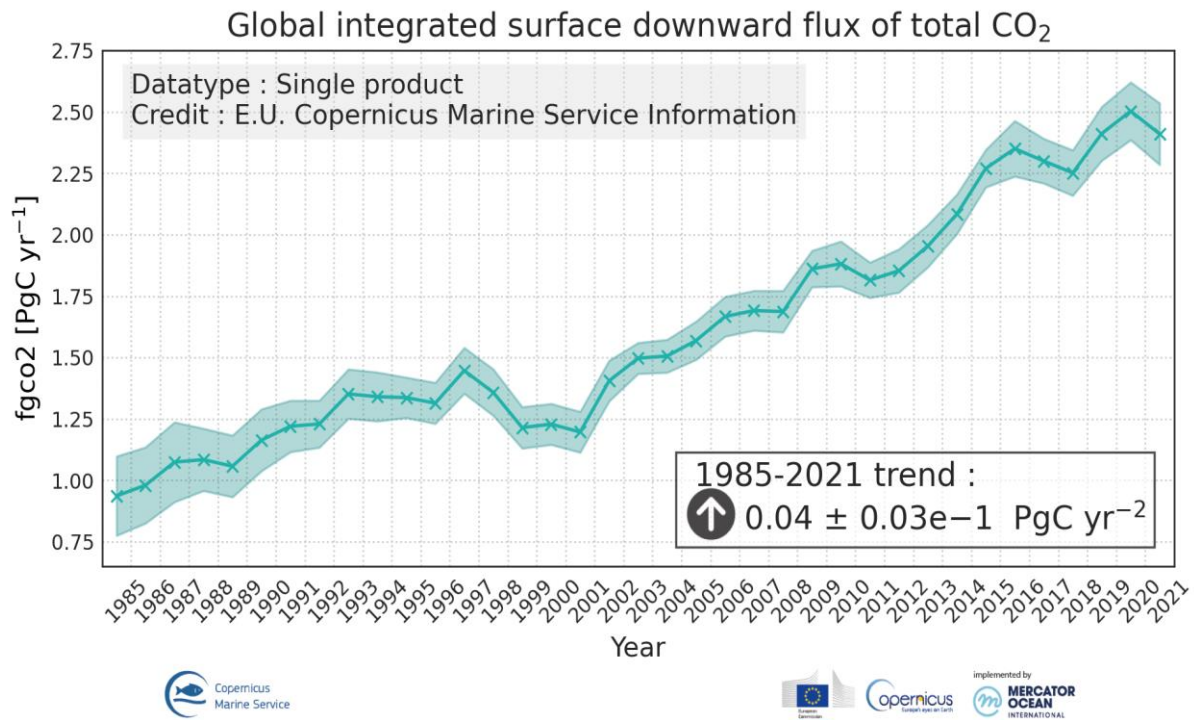
### I.2 Indicator evaluation method

The OMI global yearly ocean CO<sub>2</sub> sink represents the ocean uptake of CO<sub>2</sub> from the atmosphere computed over the whole ocean. It is computed by multiplying the 12-month running mean of the surface ocean downward CO<sub>2</sub> mass flux (fgco2) [molC m<sup>-2</sup> yr<sup>-1</sup>], a variable from the MULTIOBS\_GLO\_BIO\_CARBON\_SURFACE\_REP\_015\_008 product, by the area of each grid cell, and then taking the sum over all cells. The unit is finally converted to PgC per year (Figure 1). The yearly estimate of the ocean CO<sub>2</sub> sink corresponds to the mean of a 100-member ensemble (see the method described in Chau et al. (2022) and in the QUID for GLOBAL\_OMI\_HEALTH\_carbon\_ph\_area\_averaged). In line with Friedlingstein et al. (2022), yearly uncertainties are estimated as their corresponding ensemble standard deviation (1 $\sigma$ ).

### I.3 CMEMS products used as input for the computations

| Product name (and Type)                     | Documentation  |
|---|--|
| MULTIOBS_GLO_BIO_CARBON_SURFACE_REP_015_008 | <p>QUID:<br/><a href="https://catalogue.marine.copernicus.eu/documents/QUID/CMEMS-MOB-QUID-015-008.pdf">https://catalogue.marine.copernicus.eu/documents/QUID/CMEMS-MOB-QUID-015-008.pdf</a></p> <p>PUM:<br/><a href="https://catalogue.marine.copernicus.eu/documents/PUM/CMEMS-MOB-PUM-015-008.pdf">https://catalogue.marine.copernicus.eu/documents/PUM/CMEMS-MOB-PUM-015-008.pdf</a></p> |

## II SCIENTIFIC EVALUATION



**Figure 1: Area-integrated yearly surface downward flux of total CO<sub>2</sub> for 1985-2021. Plain line: mean of 100 samples; range: empirical 68 % confidence interval (mean estimate  $\pm$  standard deviation) computed from 100 samples. Trend and uncertainty are defined as the slope and its residual standard deviation estimated with a linear least-squares regression.**

The global ocean CO<sub>2</sub> sink corresponds to the global integral of fgco2 over space and time. The rate of uptake increases by  $0.04 \pm 0.03e-1$  PgC/yr<sup>2</sup> over the full period. The yearly flux time series presents a plateau in the 90s followed by an increasing growth rate of  $0.06 \pm 0.04e-1$  PgC/yr<sup>2</sup> since 2000. In 2021 [resp. 2020], the global ocean CO<sub>2</sub> sink was  $2.41 \pm 0.13$  [resp.  $2.50 \pm 0.12$ ] PgC/yr (Figure 1). The average of yearly contemporary fluxes over the full period 1985-2020 is  $1.61 \pm 0.10$  PgC/yr with an interannual variability (temporal standard deviation) of 0.46 PgC/yr.

The scientific evaluation relies on the comparison with estimates of the anthropogenic CO<sub>2</sub> uptake by the ocean that are published by the [Global Carbon Budget 2021](#) (GCB2021, Friedlingstein et al. 2022). The reconstructed field covers approximately 96.15% of the total ocean area (361.9e6 km<sup>2</sup>). In order to compare the present estimates to Friedlingstein et al. (2022), contemporary fluxes are corrected for the total area and the preindustrial outgassing of riverine carbon by adding 0.61 PgC/yr which is in between the estimate by Jacobson et al. (2007) ( $0.45 \pm 0.18$  PgC/yr) and the one by Resplandy et al. (2018) ( $0.78 \pm 0.41$  PgC/yr). This

adjustment yields an anthropogenic flux estimate of  $3.15 \pm 0.13$  [resp.  $3.25 \pm 0.12$ ] PgC/yr for 2021 [resp. 2020]. This is in line with the estimate by Friedlingstein et al. (2022) of  $2.9 \pm 0.4$  [resp.  $3.0 \pm 0.4$ ] PgC/yr.

The latter estimate corresponds to the mean of flux estimates from an ensemble of global ocean biogeochemical general circulation models (GOBMs) and an ensemble of data-based reconstruction methods. The GCB2021 uncertainty estimate combines random uncertainty (ensemble standard deviation of model- and data-based flux estimates) and systematic uncertainty (bias of model-based estimates in anthropogenic carbon cumulation). The new ensemble-based approach (Chau et al. 2022) yields spatio-temporal varying uncertainties which are lower than the previous published total estimate of  $\pm 0.4$  PgC/yr. The uncertainty estimates of the annual CO<sub>2</sub> uptake for the years in the 2000s are smaller than the uncertainties estimated for the years in the 1980s or recent years (Figure 1), as the sea surface spco2 observation network densifies. As shown in the following table, the somewhat higher anthropogenic flux estimates of the ensemble approach fall within the full range ( $\pm 3 \cdot$ ) of those by Friedlingstein et al. (2022). Further refinement of ocean C sink estimates relies on improved and sustained ocean observation efforts.

| Periods   | OMI_HEALTH_carbon_co2_flux_integrated [PgC/yr]<br>(Mean $\pm$ uncertainty) |   | Friedlingstein et al. (2022) - anthropogenic flux estimate [PgC/yr] |
|-----------|--|---|---|
|           | Contemporary flux estimate   | Anthropogenic flux estimate (see text for definition) |   |
| 2021      | $2.41 \pm 0.13$  | $3.15 \pm 0.13$                                       | $2.9 \pm 0.4$   |
| 2020      | $2.50 \pm 0.12$  | $3.25 \pm 0.12$                                       | $3.0 \pm 0.4$   |
| 2011-2020 | $2.18 \pm 0.09$  | $2.91 \pm 0.10$                                       | $2.8 \pm 0.4$   |
| 2000-2009 | $1.53 \pm 0.08$  | $2.22 \pm 0.08$                                       | $2.2 \pm 0.4$   |
| 1990-1999 | $1.30 \pm 0.10$  | $1.98 \pm 0.10$                                       | $2.0 \pm 0.4$   |
| 1985-1989 | $1.03 \pm 0.15$  | $1.69 \pm 0.16$                                       | -   |

A full discussion regarding this OMI can be found in section 2.10 of the Ocean State Report 4 (Gehlen et al., 2020) and in Chau et al. (2022).

### III REFERENCES

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