

# RECCAP2-ocean: Protocol for observation-based products

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## Overview

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Deadline for submission of data: **End Feb, 2021**

The majority of this protocol is based on the [RECCAP2 model protocol](#) to ensure congruence between data sets. Thus, if in doubt, consult the modelling protocol for naming conventions, file formatting, etc. Many of the data and data products that will be used in RECCAP2 already exist. These products should be formatted to match the RECCAP2 protocol by the relevant author/data provider if required. In addition, the data provider should add documentation as specified later in this section.

RECCAP2 ocean data will include the product categories as listed below (see the RECCAP2 ocean scoping document for details).

- Surface ocean pCO<sub>2</sub> products - e.g., CMEMS-FFNN by Denvil-Sommer et al. (2019)
- Ocean interior products - e.g., MOBO-DIC\_MPIM by Keppler et al. (2020)

## Product specific protocols

Below we detail the protocols for each of the categories. For protocols common to all products, see the [File specifications](#) section. Note that each product should also include a product description (a.k.a. README) file - requirements for this description is also listed under each product.

## Surface ocean pCO<sub>2</sub> products

The pCO<sub>2</sub> product must meet the following requirements to be included in RECCAP-2:

- be available from 1985 to 2018 (exceptions can be made)
- 90% of the ice free ocean must be available for all time steps of the product (using the provided ice mask)
- Contain all variables that are listed as Priority 1 in the table below

We strongly encourage data submitters to also include variables that are listed as Priority 2.

*Note that fluxes should be positive for uptake and negative for outgassing. Also note that the dimensions are [lon, lat, time] which may differ from the usual [time, lat, lon].*

| Variable Name     | Units                                  | Output frequency | Shape | Priority | Long name   |
|-------------------|--|------------------|-------|----------|---|
| <b>fgco2_glob</b> | Pg C yr <sup>-1</sup>                  | monthly          | T     | 1        | Globally integrated air-sea CO <sub>2</sub> flux ( <b>positive downward</b> )   |
| <b>fgco2_reg</b>  | Pg C yr <sup>-1</sup>                  | monthly          | iT    | 1        | Regionally integrated air-sea CO <sub>2</sub> flux ( <b>positive downward</b> ). Basin scale; i = number of basins. ( <a href="#">Masks available on the website</a> )                                      |
| <b>fgco2</b>      | mol m <sup>-2</sup> s <sup>-1</sup>    | monthly          | XYT   | 1        | Flux density of the total air-sea CO <sub>2</sub> exchange ( <b>positive downward</b> )   |
| <b>spco2</b>      | μatm                                   | monthly          | XYT   | 1        | Surface ocean pCO <sub>2</sub>  |
| <b>fice</b>       | -                                      | monthly          | XYT   | 1        | fractional ice-cover (=sea-ice concentration) used for the computation of the air-sea exchange flux [0-1]   |
| <b>area</b>       | m <sup>2</sup>                         |                  | XY    | 1        | Total surface area of each grid cell  |
| <b>Kw</b>         | m s <sup>-1</sup>                      | monthly          | XYT   | 2        | Air-sea piston velocity   |
| <b>pco2atm</b>    | μatm                                   | monthly          | XYT   | 2        | Atmospheric pCO <sub>2</sub> ('pco2atm' [uatm] will vary spatially, as opposed to the spatially uniform 'xco2atm' [ppm] atm CO <sub>2</sub> forcing due to corrections for atm pressure and vapor pressure) |
| <b>alpha</b>      | mol m <sup>-3</sup> μatm <sup>-1</sup> | monthly          | XYT   | 2        | CO <sub>2</sub> solubility  |
| <b>tos</b>        | degC                                   | monthly          | XYT   | 3        | sea-surface temp  |
| <b>sos</b>        | -                                      | monthly          | XYT   | 3        | sea-surface salinity  |

### Requirements for **README**:

- Original study citation and dataset citation if applicable
- Gas transfer velocity (*Kw*) formulation used (e.g. Nightingale et al. 2000). What wind product was used. What was the scaling factor for *Kw*
- The temperature, salinity, and wind products used to calculate *Kw* and *alpha* should be listed.
- Handling of sea-ice with respect to air-sea CO<sub>2</sub> fluxes (product and application).
- The procedure used to calculate *pco2atm* with details of the following: xCO<sub>2</sub> product, interpolation, pH<sub>2</sub>O correction used and pressure product.

- Other comments or idiosyncrasies in the dataset that will affect global or regional comparison

### Watson et al. (2020) approach

Watson et al. (2020) present an approach to adjust  $p\text{CO}_2$  to the vertical gradients of temperature in the water column between the ship intake depth and the skin temperature measured by satellites.  $FCO_2$  is calculated from the adjusted atmospheric and seawater  $p\text{CO}_2$ . We do not require that  $p\text{CO}_2$  data product providers submit a second version calculated with this approach, but we would welcome these results. Below is a brief summary of how to calculate  $FCO_2$  as done in Watson et al. (2020):

1. correct SOCAT intake  $pCO_2^{sea}$  to the subskin (satellite) temperature using for example the takahashi rule of thumb as in the Holding et al product. Interpolations of  $pCO_2^{sea}$  are performed on these corrected data.
2. calculate  $C_{sea} = S_{subskin} \cdot pCO_2^{sea}$  at subskin T, where  $S_{subskin}$  ( $\alpha$  in table above) is calculated at the subskin temperature and salinity.
3. Calculate  $C_{atm} = S_{skin} \cdot pCO_2^{atm}$  where  $S_{skin}$  is calculated at the skin temperature and salinity.
4. calculate flux  $FCO_2 = K_w \cdot (C_{sea} - C_{atm})$  where  $K_w$  is the gas exchange coefficient.

For an in-depth description please see the [linked pdf document](#) as described by Andrew Watson.

### Ocean interior products

The ocean interior products are diverse and thus the minimum requirements are not stringent.

At least one of the following variables is required in addition to the volume per grid cell:

- Dissolved inorganic carbon (*dissic*)
- Total alkalinity (*talk*)
- Anthropogenic carbon (*cant*)

The file formatting and naming conventions have to adhere to the table below and the [File/Grid specifications and naming](#) specifications. *Please note that the dimensions should be in the order [lon, lat, depth, time].*

| Variable Name | Units               | Output frequency | Shape | Priority | Long name  |
|---------------|---------------------|------------------|-------|----------|--|
| <b>dissic</b> | $\text{mol m}^{-3}$ | monthly          | XYZT  | (1)      | Dissolved inorganic carbon                         |
| <b>cant</b>   | $\text{mol m}^{-3}$ | periodic         | XYZT  | (1)      | Anthropogenic CO2                                  |
| <b>talk</b>   | $\text{mol m}^{-3}$ | monthly          | XYZT  | (1)      | Total Alkalinity                                   |
| <b>volume</b> | $\text{m}^3$        |                  | XYZ   | 1        | Total volume of each grid cell                     |
| <b>thetao</b> | degC                | monthly          | XYZT  | 3        | seawater potential temperature                     |
| <b>so</b>     | -                   | monthly          | XYZT  | 3        | Salinity (PSS-78)                                  |
| <b>no3</b>    | $\text{mol m}^{-3}$ | monthly          | XYZT  | 3        | Dissolved Nitrate Concentration                    |
| <b>po4</b>    | $\text{mol m}^{-3}$ | monthly          | XYZT  | 3        | Total Dissolved Inorganic Phosphorus Concentration |
| <b>si</b>     | $\text{mol m}^{-3}$ | monthly          | XYZT  | 3        | Total Dissolved Inorganic Silicic Concentration    |
| <b>o2</b>     | $\text{mol m}^{-3}$ | monthly          | XYZT  | 3        | Dissolved Oxygen Concentration                     |

## Requirements of the **README**:

- Original study citation and dataset citation if applicable
- Specify explicitly the reported variable w.r.t. the following formulation:  
$$\Delta DIC = \Delta DIC_{ant}^{ss} + \Delta DIC_{ant}^{ns} + \Delta DIC_{nat}^{ss} + \Delta DIC_{nat}^{ns}$$
- Other comments or idiosyncrasies in the dataset that will affect global or regional comparison
- Does the estimate include (or try to include) riverine input of DIC? If applicable, information about riverine dissolved organic carbon (DOC) and total alkalinity (TA) input should be added.

## File specifications

### Grid / Coordinate system

Lon, Lat: 1x1 degree grid (0.5 to 359.5°E longitude, -89.5 to 89.5°N latitude) Lon in °E, Lat: in °N

Depth: positive downwards in meters using. User specified depth levels.

Time: days since Jan 1, 1980, centered on the 15th 00:00:00 of each month.

### File naming

File name = <variable\_id>\_<product name>\_<start-end>\_<version\_id>.nc

*variable\_id*: e.g. *spco2*, *dissic* from tables.

*Product name*: e.g. CMEMS-FFNN, GLODAPv2

*start-end*: starting year and end year if applicable

*version\_id*: We suggest to use version numbering of your files, indicating the date of creation as vYYYYMMDD. Please keep track of the submitted versions in your readme file, briefly explaining the differences between versions.

Please create one file for full time-series per 2-D-variable. For 3-D variables, split in chunks as need be, but not more than one variable per file.

### Readme files

Products will be stored in a data repository with folder structure reflecting the naming convention. Apart from the data file (.nc), the readme file should sit in the same folder and carry the same name extended by \_readme.txt

### File tarring/compression

Please compress all files from a product into a single *tar* file. The tar file should thus contain several netCDF files with one variable each and a README file. The name of the product should be used for the compressed file: <product\_id>\_<version\_id>.tar

## Instructions for data submission through MPI-BGC FTP-server

### Uploading data

For RECCAP2-ocean data products, it is recommended to upload zipped or tar files using the FTP:

<ftp://ftp.bgc-jena.mpg.de/pub/incoming>

For FTP upload, please add a readme file with the file information: owner, version, description that should go in the file metadata (as defined under the product protocols).

Please notify [abastos@bgc-jena.mpg.de](mailto:abastos@bgc-jena.mpg.de) and [jensdaniel.mueller@usys.ethz.ch](mailto:jensdaniel.mueller@usys.ethz.ch) when uploading files.

For additional **information regarding data upload**, please refer to this document [[link](#)] provided by Ana Bastos.

### Data access

Data uploaded by various data providers through the MPI-BGC FTP-server, will be further compiled into single files. The compiled files will be made available through the following data portal:

<https://www.bgc-jena.mpg.de/geodb/projects/Home.php>

The download required authorization and registration. RECCAP2-ocean partners should already be authorized through their email, but still need to register upon first access. For additional information regarding registration, please refer to this document [[link](#)] provided by Ana Bastos.

### Data policy

We will use the Fair Use Policy of RECCAPv2-oceans (see [here](#))