RECCAP2-ocean

Glossary or "How to … ?"

Latest update: 2022-11-02

Content

Recommended core analysis

The following core analysis are recommended with priority 1 and 2, for each regional and the global ocean chapter. The instructions for computation distinguish between the two product classes (models and surface flux products), if necessary.

Priority 1

Spatially integrated air-sea flux in terms of Fnet at global, regional and biome level

Instructions for computation

- General instructions
  - use 2D fgco2 fields with monthly resolution
  - spatially integrate fgco2 using the provided area files and the RECCAP2-ocean region mask
  - compute annual mean values
- Model specific instructions
  - use 2D fgco2 fields from simA to derive flux time series
  - account for potential model drift
    - calculate a linear trend through time-series of fgco2 in simB
    - subtract this trend (=drift) from the time-series in simA.
    - Note: This only works for models that use a climatology or single repeated year forcing and not if looping over a full cycle of interannual varying forcing.
  - optional: add river flux adjustment provided through RECCAP2-ocean, spatially integrated at global, regional and biome level[1]
- Surface-flux product specific instructions
  - use 2D fgco2 fields as provided, without any adjustments

Reporting of results

- Long-term mean flux for 1985 - 2018, as ensemble mean and standard deviation for each product class
- Time series of annual mean values
  - Ensemble mean for each product class
  - Indicator of spread of ensemble members, e.g. the standard deviation or individual lines for each product
- Linear regression trends for the full time period vs pre/post 2000, reported as mean trend ± Std across all individual products of each product class

Surface maps of the ensemble mean air-sea CO2 flux in terms of Fnet

Instructions for computation

- General instructions

[1] Irrespective of whether river flux adjustment are applied or not, it is recommended that the spatially integrated river flux component is explicitly included in any figure or table, such that the reader can interpret the differences between the models and surface flux products in the light of the provided river flux data

    - use 2D fgco2 fields
    - calculate ensemble-mean fgco2 for the period 1985 - 2018 per product class
- Model specific instructions
    - use 2D fgco2 fields from simA without adjustments
- Surface-flux product specific instructions
    - use fgco2 as provided, without adjustments

Reporting of results
- plot map of ensemble-mean fgco2 for each product class
- show region and biome boundaries, to achieve a connection to the integrated flux time series

Maps of column inventory changes of Cant (=Fant,ss+ns) for 1994-2007 (models only)

Instructions for computation
- Model specific instructions
    - use 3D dissic fields for years 1994 and 2007
    - subtract dissic simD from dissic simA to compute total Cant in each year
    - subtract total Cant 1994 from total Cant 2007 to compute delta Cant
    - multiply delta Cant with provided grid-cell volume
    - integrate delta Cant across the full water column
    - divide by provided surface area to get column inventory in mol / m^2

Reporting of results
- plot delta Cant column inventory maps for
    - model ensemble-mean
    - observation based estimates by Gruber et al (2019)[2] and OCIM-v2021

Priority 2

Separating CO2 and climate effects on mean, spatially integrated air-sea flux (models only)

Instructions for computation
- Model specific instructions
    - use 2D fgco2 fields
    - calculate regionally integrated, long-term mean fgco2 for the period 1985 - 2018 for each model in simA, simB and simC
    - calculate the CO2 and climate effects for each model
        - CO2 effect (Fant,ss): simC minus simB
        - climate effect (Fnat,ns + Fant,ns): simA minus simC
        - Note: the separation of flux components is also illustrated in the following chapter of this glossary

[2] Cant inventory changes reported by Gruber et al. (2019) are only integrated to 3000m water depth. Differences between their estimates and the models should also be discussed taking into account the modelled Cant accumulation below 3000m water depth

Reporting of results

- ensemble mean trend ± Std separately for CO2 effect and climate effects
    - could be a table, bar plot or just reported within the text

Calculation of flux components from model simulations

As a reminder, in the protocol model simulations are defined as:

	Simulation A	Simulation B 'ctrl'	Simulation C	Simulation D
Request level	Mandatory, Tier 1	Mandatory for global models, Tier 1	Tier 2	Tier 2
Atmospheric CO_2	Increasing	Constant, preindustrial	Increasing	Constant preindustrial
Atmospheric forcing (wind, fluxes of heat and freshwater)	Variable, reanalysis	climatological	climatological	Variable, reanalysis
Considered components(1)	$Flux_{ant}^{ss} + Flux_{ant}^{ns} + Flux_{nat}^{ss} + Flux_{nat}^{ns}$	$Flux_{nat}^{ss}$	$Flux_{ant}^{ss} + Flux_{nat}^{ss}$	$Flux_{nat}^{ss} + Flux_{nat}^{ns}$

(1) Total Flux = $Flux_{ant}^{ss} + Flux_{ant}^{ns} + Flux_{nat}^{ss} + Flux_{nat}^{ns}$, where $Flux_{ant}$ is the air-sea flux of anthropogenic CO_2, and $Flux_{nat}$ that of natural CO_2. "ss" refers to steady-state and "ns" to non-steady state, i.e., the variability component imposed on natural and anthropogenic CO_2 by all non-seasonal variability. The same differentiation applies also to the change in ocean interior DIC, i.e., $\Delta DIC = \Delta DIC_{ant}^{ss} + \Delta DIC_{ant}^{ns} + \Delta DIC_{nat}^{ss} + \Delta DIC_{nat}^{n}$

According to the definition of the model simulations above, different carbon flux components should be calculated as follows:

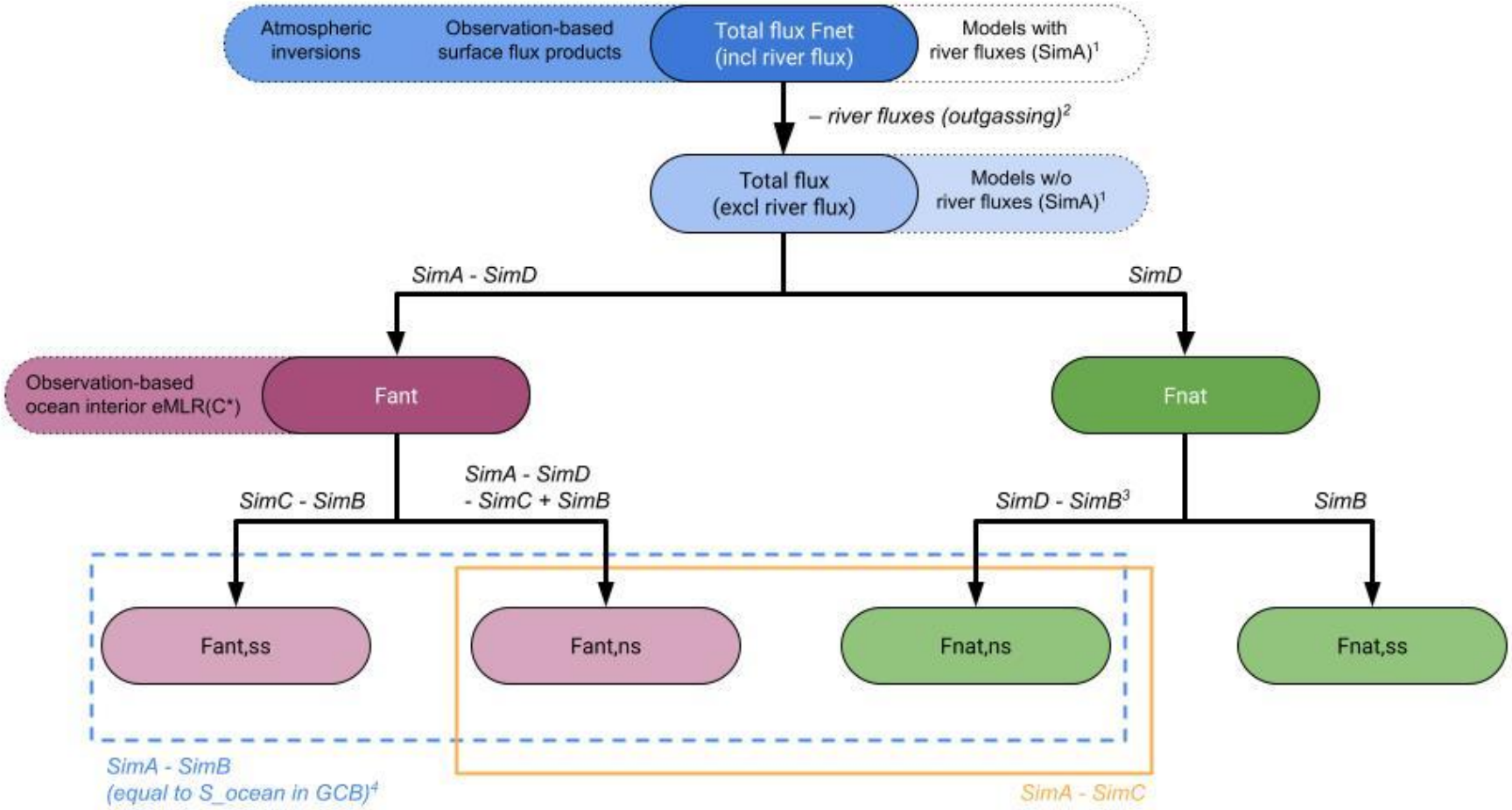
Fant,ss = SimC - SimB
This is equivalent to the effect of rising CO_2 alone on the ocean carbon sink.

Fnat,ns + Fant,ns = SimA - Sim-C
This describes the effect of climate change and variability on the ocean carbon sink

S_ocean = SimA - SimB
This corresponds to S_ocean reported in the Global Carbon Budget and corrects for model drift (=trend in SimB) and biases (=Offset from zero in SimB). Note: This subtraction only works on a global scale, as the assumption that CO2 flux (without rivers) was zero does not hold on a regional scale.

Fnat,ns = SimD - SimB
This describes the climate change effect on the natural carbon flux.

Fant,ss + Fant,ns = SimA - SimD
This describes the total anthropogenic flux (comparable to Gruber et al. 2019)



Overview on C-flux components, their calculation and representation by product types. Footnotes indicate:

1. Please note that most RECCAP2-ocean models are run without riverine carbon input.
2. When outgassing of riverine C input is subtracted, the flux into the ocean increases.
3. Not applicable to OCIM models because there is no SimD.
4. S_ocean determined as SimA - SimB is only applicable to global models, and should not be interpreted based on regional models.

Adjustment of river fluxes

- Recommended global river flux adjustment:
    - 0.65 PgC/yr (Regnier et al., 2022)
- Recommended regional river flux adjustments
    - Spatial distribution is the gridded field from Lacroix et al. (2020). CAVEAT: The gridded field requires an upscaling from 0.2 to 0.65 PgC/yr because of too low carbon input to the ocean (P. Regnier, pers. comm.)
    - Upscaled river flux fields are available here: https://reccap2-ocean.github.io/river/
    - Please use our region and biome mask to integrate river fluxes spatially: https://reccap2-ocean.github.io/regions/
- Other useful river flux estimates include: Jacobson et al. (2007), Resplandy et al 2018, Table S1 below from the auxiliary material in Gruber et al. (2009), Aumont et al. (2001), and GCB papers.

Calculation of regional averages and integrals

Assignment of basins and subregions

- Link to basin mask file: https://reccap2-ocean.github.io/regions/
- Use of RECCAP2-ocean mask is mandatory on basin scale (i.e. for the definition of chapter boundaries)
- Use of the provided mask on the subregion scale is voluntary

Calculation of regionally averaged surface pCO2

- weight gridded spco2 by area of grid cell (from area file provided by data provider)
- take information on the fraction of cells filled with water into account if available
- Note: for the calculation of regionally averaged air-sea disequilibria, Kw (and thus wind speed) are usually taken into account. In this case, the difference between atmospheric pCO2 and regionally averaged spco2 as defined here, would not be identical to regionally averaged disequilibria.

Calculation of regionally integrated air-sea CO2 fluxes

- multiply fgco2 with area and sum up over region of interest
- take information on the fraction of cells filled with water into account if available
- convert from molC/s to PgC/yr
    - from per seconds to per year (* 365.25 * 24 * 60 * 60)
    - convert from moles C to grams C (* 12.011 g/mol)

Calculation of regional ocean interior integrals

- multiply concentration with volume grid provided by data provider
- take information on the fraction of cells filled with water into account if available

Use of observation-based surface pCO2 products and models (primarily data-assimilated models) that don't cover the full period

- for averages and integrals, exclude data sets from ensemble that do not cover full period
    - full period observations: 1985 to 2018
    - full period models: 1980 to 2018

Recommended units and terminology

Units

- Carbon inventory: PgC
- Carbon fluxes: PgC yr^{-1} (or TgC yr^{-1} if appropriate)
- Partial pressure of CO_2: µatm
- Carbon flux density: mol m-2 yr-1 (outgassing positive, Note: this is opposite to the protocol)

Terminology

Naming convention for product classes (+abbreviations) provided through RECCAP2-ocean database

- Models
    - Global/regional ocean biogeochemical hindcast models (GOBM/ROBM)
    - Ocean data-assimilation models (data-assimilation models)
- Observation-based products
    - Surface ocean pCO2-observation products (pCO2 products)
    - Ocean interior DIC-observation products (DIC products)
- Atmospheric inversion models (atmospheric inversions)

Carbon flux components

- Anthropogenic carbon inventory: C_{ant} (in analogy to the fluxes F_{ant})
- Natural carbon inventory: C_{nat} (in analogy to the fluxes F_{nat})

Overview of data sets and recommendations for use

Note: This information will be moved to a meta data table that is under construction.

model_id (+ label for publication)	**Main features and recommendations for use**
Group: Global hindcast models *General remarks: Simulation A of hindcast models covers F_{CO2} = Fnat,ss + Fnat,ns + Fant,ss + Fant,ns . *Some models also include riverine fluxes (Friv), but often of small magnitude.*	
CESM-ETHZ	
CCSM-WHOI	Model output taken from coastal chapter. No specific formatting according to global/regional chapter protocol. Not qc'ed. Ends in 2017.
CNRM-ESM2-1*	
EC-Earth3*	
FESOM_REcoM_LR (FESOM-1.4-REcoM2-LR)	If a chapter would like to use only one FESOM-REcoM simulation, use LR, it has a longer spin-up and is more suitable for analysis of anthropogenic CO2 time-series
FESOM_REcoM_HR (FESOM-1.4-REcoM2-HR)	High-resolution, shorter spin-up, could be interesting in addition to LR for processes
MOM6-COBALT2-Princeton (MOM6-Princeton)	
MPIOM-HAMOCC	
MRI-ESM2-0	
NorESM-OC1.2	
ORCA025-GEOMAR	The model simulations have a large positive bias in pCO2 in the upwelling areas off South America and Africa. Consider interpreting the results accordingly, neglecting these areas from your analysis, or excluding this model completely.
ORCA1-LIM3-PISCES* (IPSL-NEMO-PISCES)	
Planktom12	
Group: Global data-assimilated models *General remarks: Suggest to not average them, but show individually as it is a small ensemble. They cover different years, and have quite different results. Global data-assimilated models cover F_{CO2} = Fnat,ss + Fnat,ns + Fant,ss + Fant,ns.*	
ECCO-Darwin	
OCIM-v2014-CTL	The OCIM models include simulations A, B, and C and can be treated in the same way as the other models. The point to be aware of is that OCIM is an abiotic model, so the natural fluxes are only the abiotic ones. Also, both OCIM versions have constant circulation. Useful for anthropogenic carbon (Fant,ss) and abiotic carbon. No river fluxes.

OCIM-v2021	Like OCIM-v2014, but using updated spatially-varying atmospheric pCO2 and time-varying SST and gas transfer velocity. Useful for anthropogenic carbon (Fant,ss) as well as the temperature-forced variability of natural carbon (Fnat,ns forced by temperature). No river fluxes.
Group: Regional hindcast models *General remarks: Regional models should only be used in the corresponding regional chapters.*	
B-SOSE	Southern Ocean (use only in SO chapter), group with data-assimilated models.
GOA-COBALT	Use only in Pacific chapter
INCOIS-BIO-ROMS	Use only in Indian Ocean chapter
ROMS-Southern Ocean-ETHZ	Had to be withdrawn due to errors in the initialization. Will be removed from the FTP server. Please do not use it!
ROMS-Pacific-ETHZ	Use only in Pacific chapter
ROMS-Atlantic-ETHZ	Use only in Atlantic chapter
ROMS-NYUAD	Use only in Indian Ocean chapter
Group: Surface CO_2 observation-based products *General remarks: Observation-based flux products measure the contemporary CO_2 flux Fnet = Fnat,ss + Fnat,ns + Fant,ss + Fant,ns + Friv,ss + Friv,ns*	
AOML_EXTRAT	Starts in ~1997 Suggestion: exclude from ensembles that average over the full time-period
CMEMS-LSCE-FFNN	
CSIRML6	
JENA-MLS (CarboScope)	
JMAMLR	
NIES-nn	
OceanSODAETHZ	
SOMFFN	Contains smoothened (labelled as spco2/fgco2) fields, which should be used for general analysis. Yet, raw output is also provided (labelled as spco2_raw/fgco2_raw).
spco2_LDEO_HPD	
LDEO_2021_clim_RECCAP2	Contains climatological fields only. Updated of Takahashi's pCO_2 climatology.
UOEX_WAT20	Applies adjustments to fCO2 data, hence a different type of data-product, don't average with the other data-products Uses CCMP wind data only available from 1988 on-wards. For 1985-87 it uses a wind climatology: don't use these years.
Group: Ocean interior observation-based products *General remarks:*	

dissic_MOBO-DIC-MPIM	Near-global ocean interior monthly climatology of DIC
dissicNNGv2LDEO	Global ocean interior monthly climatology of DIC
ETHZ_Cant_eMLR	Global ocean interior change in Cant storage 1994-2007.
UW_NOAA_Cant_Pacific	
Group: Atmospheric inversions *General remarks:*	

Others

- Recommended properties for plots
    - Color scales and ranges
        - outgassing red, uptake blue