RECCAP2: Ocean Modeling Protocol

Deadline for submission of simulations: July 15, 2020

Goal: To provide model output to the Regional Carbon Cycle Assessment and Processes (RECCAP2) global and regional papers.

The protocol defined here follows, in spirit, that of the Global Carbon Budget, in that the modeling groups are free to use their own forcing and parameterizations, as well as their own initialization and spinup procedures. This contrasts with the specificity of OMIP (Orr et al., 2017), where many of these elements are specified. We do, however, request substantially more information and data than GCB, and also encourage the modelers to perform and analyze more simulations. The protocol is written for both global and regional models.

Analysis period: The analysis period is 1980 through 2018.

Simulations

We encourage, particularly the global modelers, to conduct a total of 4 simulations, i.e. A through D) (Table 2). These four simulations vary in terms of their atmospheric CO_2 (increasing vs preindustrial), and in terms of their atmospheric forcing (time varying versus climatological). Simulation A is mandatory for all participating groups, and simulation B is mandatory for all global modelling groups, whereas C and D are encouraged. Models that include a separate tracer for anthropogenic CO_2 can skip simulations B and D.

Simulation B is necessary to judge model drift. Simulation D is required to compute the fluxes and change in storage of anthropogenic CO_2.

Regional modelers need to conduct and report at least A, although a run that permits to decipher the drift in the model, i.e., some form of a modified run B is encouraged.

(Note A corresponds in RECCAPv1 to ANTH, D to PIND, and C to ACO2); compare also to the nomenclature of the Trendy project, S0 ≈ B, S1 ≈ C, S2 ≈ A)

Table 2: *Summary of simulations*

	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., $\Delta DIC = \Delta DIC_{ant}^{ss} + \Delta DIC_{ant}^{ns} + \Delta DIC_{nat}^{ss} + \Delta DIC_{nat}^{n}$

The simulation A should reproduce the interannual variability and trend in the ocean carbon uptake in response to changes in both atmospheric CO_2 and climate. Thus models should be forced by observed climate (e.g. from reanalysis products) and observed atmospheric CO_2 throughout the entire time period. While there are no specified products recommended, we require continuity in forcing, i.e. only one forcing data should be used for the full time-series of the analysis period, i.e., 1980 through 2018. Available forcing data sets for the full time-series are for example NCEP/NCAR R1 and JRA55 (link to JRA data) or JRA55-do (link to JRA55-do data).

The simulations with constant atmospheric forcing (B) should *be consistent* with the variable climate simulations (A), for example by using a climatology calculated from the variable forcing or looping over a certain year.

You can use your own atmospheric CO_2 time-series, but you are encouraged to use a common time-series provided following the link below to facilitate model simulations. The data represents the average atmospheric CO_2 (dry mixing ratio) (ppm) between MLO and SPO from 1959, and is from Joos and Spahni (PNAS 2008).

https://drive.google.com/file/d/14rP7rLazeYRJXFxh8MmRveotzmtMzRge/view

and thus will have to be converted to partial pressure (including total pressure and air humidity) according to each model's protocol. In the simulations with constant atmospheric CO_2, i.e., B and D, atmospheric CO_2 should be kept constant at preindustrial levels (recommendation: 278 ppm) and it should be started from the spin-up or from another simulation with constant CO_2 (at 278 ppm) and not from a simulation with increasing atmospheric CO_2. Using a constant CO_2 value other than 278 ppm is accepted if well documented (roughly plus/minus 10 ppm).

Initialization and Spinup:

Two strategies can be pursued for the initialization and the spinup.

Strategy 1 (Regional models): Initialization from observations for the 1960s, followed by a short spinup. This strategy will be used primarily by the regional models. This strategy will typically involve an initialization of the ocean interior distributions for the late 1960s or early 1970s, followed by spinup phase for the 1970s, during which atmospheric CO_2 rises according to the observations. From 1980 onward, the simulation is then continued until 2018, providing the basis for the analyses. Only simulation A can be provided if this strategy is selected, although a modified version of simulation B is encouraged in order to determine the drift of the model.

Strategy 2 (Global models): Initialization from preindustrial conditions, followed by a long spinup. This strategy will be used primarily by the global models. Here, the ocean is initialized from (reconstructed) preindustrial conditions and then spun up for several decades to centuries in order to ensure minimal drift in the surface fluxes. The models are then brought forward in time to the analysis period using either constant atmospheric forcing until the reanalysis period begins or by cycling through the atmospheric forcing time-series (the latter strategy is the one recommended by OMIP, see Orr et al., 2017)).

We will assume that no drift correction and other post-processing (e.g. correction for riverine outgassing) has been applied unless you let us know otherwise.

Output

In addition to providing the globally-integrated air-sea CO_2 flux time-series calculated on the native model grid, we request that the raw output of the models is regridded by each group to a standard 1x1 latitude longitude grid (see below for grid convention), and that the resulting regridded data are provided at the indicated frequency for the following fields:

Naming conventions and units should follow largely Orr et al. (2017)

Table 3: *List of requested output, for the period 1980-2018*

Variable Name	Units	Output frequency	Shape	Priority	Long name
Surface ocean or 2D properties					
fgco2_glob	Pg C yr^{-1}	monthly	T	1	Globally integrated air-sea CO_2 flux (positive upward)
fgco2_reg	Pg C yr^{-1}	monthly	iT	1	Regionally integrated air-sea CO_2 flux (positive upward) (using regional bounds), i: number of regions
fgco2	mol m^{-2} s^{-1}	monthly	XYT	1	Flux density of the total air-sea CO2 exchange (positive upward)
spco2	µatm	monthly	XYT	1	Surface ocean pCO2
siconc	-	Monthly	XYT	1	fractional ice-cover (=sea-ice concentration) used for the computation of the air-sea exchange flux [0-1]
intpp	mol m^{-2} s^{-1}	monthly	XYT	1	vertically-integrated net primary production
epc100	mol m-2 s-1	monthly	XYT	1	Particle flux of POC at 100 m

epc1000	mol m-2 s-1	monthly	XYT	2	Particle flux POC at 1000 m
epc100*type* / epc1000*type*	mol m-2 s-1	monthly	XYT	2	particle fluxes at 100 and 1000 m for different particle types (e.g. slow, fast or small, large)
epcalc100	mol m-2 s-1	monthly	XYT	1	Export flux of CaCO3 at 100 m
Kw	mol m^{-2} s^{-1}	monthly	XYT	2	Air-sea piston velocity
pco2atm	µatm	monthly	XYT	2	Atmospheric pCO2 ('pco2atm' [uatm] will vary spatially, as opposed to the spatially uniform 'xco2atm' [ppm] atm CO2 forcing due to corrections for atm pressure and vapor pressure)
alpha	mol kg^{-1} atm^{-1}	monthly	XYT	3	CO2 solubility
tos	degC	monthly	XYT	1	sea-surface temp
sos	-	monthly	XYT	1	sea-surface salinity (PSS-78)
dissicos	mol m^{-3}	monthly	XYT	1	sea-surface DIC
talkos	mol m^{-3}	monthly	XYT	1	sea-surface Alkalinity
no3os	mol m^{-3}	monthly	XYT	2	Surface Dissolved Nitrate Concentration
po4os	mol m^{-3}	monthly	XYT	2	Surface Total Dissolved Inorganic Phosphorus Concentration
sios	mol m^{-3}	monthly	XYT	2	Surface Total Dissolved Inorganic Silicic acid Concentration
dfeos	mol m-3	monthly	XYT	2	Surface Dissolved Iron Concentration
o2os	mol m^{-3}	monthly	XYT	2	Surface Dissolved Oxygen Concentration
intphyc	mol C m-2	monthly	XYT	1	Vertically-integrated Concentration of total phytoplankton expressed in carbon units
intphynd	mol C m-2	monthly	XYT	2	Vertically-integrated Concentration of non-diatom phytoplankton expressed in carbon units (if available)
intdiac	mol C m-2	monthly	XYT	2	Vertically-integrated Concentration of diatom Phytoplankton expressed in carbon units (if available)
intzooc	mol C m-2	monthly	XYT	1	Vertically-integrated concentration of total zooplankton expressed in carbon units
chlos	kg m-3	monthly	XYT	1	Surface Mass Concentration of Total Phytoplankton expressed as Chlorophyll in Sea Water
mld	m	monthly	XYT	1	user-defined mixed layer depth
zeu	m	monthly	XYT	1	user-defined euphotic zone depth
Interior ocean or 3D properties					
dissic	mol m^{-3}	annual	XYZT	1	Dissolved inorganic carbon
talk	mol m^{-3}	annual	XYZT	1	Total Alkalinity
thetao	degC	annual	XYZT	1	seawater potential temperature
so	-	annual	XYZT	1	Salinity (PSS-78)
epc	mol m-2 s-1	annual	XYZT	1	3D field of particle flux of POC
no3	mol m^{-3}	annual	XYZT	2	Dissolved Nitrate Concentration

po4	mol m^{-3}	annual	XYZT	2	Total Dissolved Inorganic Phosphorus Concentration
si	mol m^{-3}	annual	XYZT	2	Total Dissolved Inorganic Silicic Concentration
o2	mol m^{-3}	annual	XYZT	2	Dissolved Oxygen Concentration

In order to optimally work with the submitted data, we require each group to submit also the following ancillary information:

Table 4*: List of requested ancillary data.*

Variable Name	Units	Shape	Priority	Long name
area	m^2	XY	1	Total surface area of each grid cell
volume	m^3	XYZ	1	Total volume of each grid cell
mask_sfc	-	XY	1	Field indicating the fraction of presence of ocean in a grid cell [0-1]; fraction of surface area
mask_vol	-	XYZ	1	Field indicating the fraction of presence of ocean in a grid cell [0-1] fraction of volume
Area_tot_native	M2		1	Total surface ocean area covered by native grid
Vol_tot_native	M3		1	Total ocean volume covered by native grid
Atm_CO2	ppm	T	1	Time-series of atmospheric CO2 used to drive the model.

<mark>Open Issues to be further discussed.</mark>

Some of the analysts are interested in the following additional data: (Priority 3)

Monthly (*annual or decadal***) mean transports (volume and natural and anthropogenic carbon) at the OVIDE-A25 (**[See map](#)**) section (***Mean Jun-Jul of 2002, 2004, 2006, 2008, 2010, 2012, 2014 and 2016***), 24N (**[See map](#)**) (***Mean Jul-Aug of ***1992,*** Mean Jan-Feb of ***1998,*** Mean Apr-May of ***2004,*** Mean Jan-Feb of ***2010,*** Mean Feb-Mar of ***2011,*** Mean Dec ***2015*** with Jan of ***2016)**, 7.5ºN (**[See map](#)**)(***Mean Feb-Mar of ***1993,*** Mean Apr-May of ***2010)**, 24S (**[See map](#)**) (***Mean Mar-Apr of ***2009 and 2018)**, 35S (**[See map](#)**) (***Mean Jan ***1993,*** Mean Nov of ***2003,*** Mean Oct of ***2011 **and *** Mean Jan of ***2017)**, Pacific: 64N, 18 S/N, 44S and Indonesian Throughflow.**

File format:

We request the data in netcdf format (preferably following the CF convention as currently adopted for CMIP, http://cfconventions.org/) on the following coordinate system:

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

Vertical: z-coordinate system (vertical depth axis). Model groups that do NOT use z-coordinates will need to interpolate their results to standard z depth levels. Depth: positive downwards

Time: seconds since Jan 1, 1980. 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.

File names: Groups are encouraged to follow the CMIP naming convention for file names (https://docs.google.com/document/d/1h0r8RZr_f3-8egBMMh7aqLwy3snpD6_MrDz1q8n5XUk/edit), the file name can be constructed consistent with the following template

file name = <variable_id>_<model_id>_<experiment_id
>_<member_id>_<grid_label>_<time_range>.nc

Documentation needed:

See Appendix 1 for documentation requirement.

Data policy

We will use the Fair Use Policy of RECCAPv2 Oceans (see below)

Instructions for Output

UPDATE: Please send the annual mean output by email and provide a link to the gridded data to XX

PLEASE update model description tables and nominate author