CMIP6 Model Documentation

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Documentation Contents

1 Key Properties

Ocean Biogeochemistry key properties

1.1.1 Top level properties

Ocean Biogeochemistry key properties

1.1.1.1 Name *

Name of ocnbgchem model code

Pelagic Interaction Scheme for Carbon and Ecosystem Studies model volume 2 version trace gases (PISCESv2-gas)

1.1.1.2 Keywords *

Keywords associated with ocnbgchem model code

Enter COMMA SEPARATED list:

1.1.1.3 Overview *

Overview of ocnbgchem model.

Pelagic Interaction Scheme for Carbon and Ecosystem Studies model volume 2 version trace gases (PISCESv2-gas) derives from PISCESv2 as described in Aumont et al. (2015). PISCESv2-gas simulates the cycling of carbon, oxygen, and of the major nutrients determining phytoplankton growth (phosphate, nitrate, ammonium, iron and silicic acid). PISCESv2-gas also simulates dimethylsulfide (DMS) and nitrous oxide (N2O) tracers (see Berthet et al. 2019). The carbon chemistry of the model is based on the Ocean Carbon Model Intercomparison Project (OMIP) protocol and the parametrization proposed by Wanninkhof (2014) is used to compute air-sea gas exchange of CO2, O2, DMS and N2O. PISCES includes a simple representation of the marine ecosystem with two phytoplankton size classes, representing nanophytoplankton and diatoms, as well as two zooplankton size classes, representing microzooplankton and mesozooplankton. Phytoplankton growth is limited by the availability of nutrients, temperature, and light. There are three non-living components of organic carbon in the model: semi-labile dissolved organic carbon (DOC), with a lifetime of several weeks to years, as well as large and small detrital particles, which are fuelled by mortality, aggregation, fecal pellet production and grazing. Biogenic silica and calcite particles are also included Nutrients and/or carbon are supplied to the ocean from three different sources: atmospheric deposition, rivers and sediment mobilization. These sources are explicitly included and vary in time apart the iron input of sediment. Atmospheric deposition of Fe, P and Si has been estimated from the INCA model and the one of N is coming from the Input4MIPS database. Riverine inputs are interactive in CNRM-ESM2-1 because the litter and soil carbon leaching in SURFEXv8.0 (see Section 2.4 for further details), is routed as dissolved organic carbon in CTRIP and supplied to the oceans as organic carbon by rivers in PISCESv2-gas. Since only the routing of dissolved organic carbon (DOC) is bounded in CNRM-ESM2-1, the supply of the other nutrients has been parameterized using the global average ratios of nitrogen-to-DOC (0.72), phosphorus-to-DOC (0.59), silicon-to-DOC (0.15) from Mayorga et al. (2010) and the global average ratios of DIC-to-DOC (1.48) and Alk-to-DOC (1.11) from Ludwig et al. (1996).River discharge of carbon and nutrients is taken from GlobalNews in NEMO standalone mode. Iron input from sediment mobilization has been parameterized as in Aumont et al. (2015). Nutrients and/or carbon are supplied to the ocean from three different sources: atmospheric deposition, rivers and sediment mobilization. These sources are explicitly included but do not vary in time apart from a climatological seasonal cycle for the atmospheric input. Atmospheric deposition (Fe, N, P and Si) has been estimated from the INCA model (Aumont et al, 2008). River discharge of carbon and nutrients is taken from Ludwig et al (1996). Iron input from sediment mobilization has been parameterized as in Aumont and Bopp (2006). PISCES is used here not only to compute air-sea

fluxes of carbon, but also to compute the effect of a biophysical coupling: the chlorophyll concentration produced by the biological component retroacts on the ocean heat budget by modulating the absorption of light as well as the oceanic heating rate (see Lengaigne et al (2007) for a detailed description).

1.1.1.4 Model Type *

Type of ocean biogeochemistry model

- [ ] Geochemical - No living compartments
- [ ] NPZD - No plankton types
- [x] PFT - Several plankton types
- [ ] Other - please specify:

1.1.1.5 Elemental Stoichiometry *

Describe elemental stoichiometry (fixed, variable, mix of the two)

- [ ] Fixed - Fixed stoichiometry
- [ ] Variable - Variable stoichiometry
- [x] Mix of both - Both fixed and mixed stoichiometry

1.1.1.6 Elemental Stoichiometry Details *

Describe which elements have fixed/variable stoichiometry

C, N, P fixed. Fe, Si variable.

1.1.1.7 Prognostic Variables *

List of all prognostic tracer variables in the ocean biogeochemistry component

Dissolved inorganic carbon, Total alkalinity, dissolved oxygen, Calcite, Phosphate, Small particulate organic carbone, silicate, Nanophytoplankton, Microzooplankton, Semi-labile dissolved organic carbon, Diatoms, Mesozooplankton, Silicon content of the diatoms, Dissolved iron, Iron in the big particles, Big particulate organic carbone, Iron in the small particles, Iron content of the diatoms, Sinking biogenic silica, Iron content of the nanophytoplankton, Chlorophyll of the nanophytoplankton, Chlorophyll of the diatoms, Nitrate, Ammonium

1.1.1.8 Diagnostic Variables *

List of all diagnotic tracer variables in the ocean biogeochemistry component (derived from prognostic variables

Enter COMMA SEPARATED list:

1.1.1.9 Damping

Describe any tracer damping used (such as artificial correction or relaxation to climatology,...)

Annual relaxation to annual global mean of alkalinity, Nitrate, Phosphorous, Silicate.

1.1.2 Passive Tracers Transport

Time stepping method for passive tracers transport in ocean biogeochemistry

1.1.2.1 Method *

Time stepping framework for passive tracers

- [x] Use ocean model transport time step
- [ ] Use specific time step

1.1.2.2 Timestep If Not From Ocean

Time step for passive tracers (if different from ocean)

Enter INTEGER value:

1.1.3 Biology Sources Sinks

Time stepping framework for biology sources and sinks in ocean biogeochemistry

1.1.3.1 Method *

Time stepping framework for biology sources and sinks

- [x] Use ocean model transport time step
- [ ] Use specific time step

1.1.3.2 Timestep If Not From Ocean

Time step for biology sources and sinks (if different from ocean)

Enter INTEGER value:

1.2.1 Transport Scheme

Transport scheme in ocean biogeochemistry

1.2.1.1 Type *

Type of transport scheme

- [ ] Offline
- [x] Online

1.2.1.2 Scheme *

Transport scheme used

- [ ] Use that of ocean model
- [ ] Other - please specify:

1.2.1.3 Use Different Scheme

Decribe transport scheme if different than that of ocean model

MUSCL advection scheme.

1.3.1 Boundary Forcing

Properties of biogeochemistry boundary forcing

1.3.1.1 Atmospheric Deposition *

Describe how atmospheric deposition is modeled

☐ From file (climatology)

☒ From file (interannual variations)

☐ From Atmospheric Chemistry model

1.3.1.2 River Input *

Describe how river input is modeled

☐ From file (climatology)

☐ From file (interannual variations)

☒ From Land Surface model

1.3.1.3 Sediments From Boundary Conditions

List which sediments are speficied from boundary condition

Input Iron from sediments.

1.3.1.4 Sediments From Explicit Model

List which sediments are speficied from explicit sediment model

Enter COMMA SEPARATED list:

1.4.1 Gas Exchange

Properties of gas exchange in ocean biogeochemistry

1.4.1.1 CO2 Exchange Present *

Is CO2 gas exchange modeled ?

☐ True ☐ False

1.4.1.2 CO2 Exchange Type

Describe CO2 gas exchange

- [x] OMIP protocol
- [ ] Other - please specify:

1.4.1.3 O2 Exchange Present *

Is O2 gas exchange modeled ?

- [ ] True
- [ ] False

1.4.1.4 O2 Exchange Type

Describe O2 gas exchange

- [x] OMIP protocol
- [ ] Other - please specify:

1.4.1.5 DMS Exchange Present *

Is DMS gas exchange modeled ?

- [ ] True
- [ ] False

1.4.1.6 DMS Exchange Type

Specify DMS gas exchange scheme type

Wanninkof2014

1.4.1.7 N2 Exchange Present *

Is N2 gas exchange modeled ?

- [ ] True
- [ ] False

1.4.1.8 N2 Exchange Type

Specify N2 gas exchange scheme type

Enter TEXT:

1.4.1.9 N2O Exchange Present *

Is N2O gas exchange modeled ?

- [ ] True
- [ ] False

1.4.1.10 N2O Exchange Type

Specify N2O gas exchange scheme type

Wanninkof2014

1.4.1.11 CFC11 Exchange Present *

Is CFC11 gas exchange modeled ?

☐ True ☐ False

1.4.1.12 CFC11 Exchange Type

Specify CFC11 gas exchange scheme type

Following OMIP protocol.

1.4.1.13 CFC12 Exchange Present *

Is CFC12 gas exchange modeled ?

☐ True ☐ False

1.4.1.14 CFC12 Exchange Type

Specify CFC12 gas exchange scheme type

Following OMIP protocol.

1.4.1.15 SF6 Exchange Present *

Is SF6 gas exchange modeled ?

☐ True ☐ False

1.4.1.16 SF6 Exchange Type

Specify SF6 gas exchange scheme type

Following OMIP protocol.

1.4.1.17 13CO2 Exchange Present *

Is 13CO2 gas exchange modeled ?

☐ True ☐ False

1.4.1.18 13CO2 Exchange Type

Specify 13CO2 gas exchange scheme type

Enter TEXT:

1.4.1.19 14CO2 Exchange Present *

Is 14CO2 gas exchange modeled ?

☐ True ☐ False

1.4.1.20 14CO2 Exchange Type

Specify 14CO2 gas exchange scheme type

Enter TEXT:

1.4.1.21 Other Gases

Specify any other gas exchange

Enter TEXT:

1.5.1 Carbon Chemistry

Properties of carbon chemistry biogeochemistry

1.5.1.1 Type *

Describe how carbon chemistry is modeled

☒ OMIP protocol

☐ Other protocol

1.5.1.2 Ph Scale

If NOT OMIP protocol, describe pH scale.

Select SINGLE option:

☐ Sea water

☐ Free

☐ Other - please specify:

1.5.1.3 Constants If Not OMIP

If NOT OMIP protocol, list carbon chemistry constants.

Enter COMMA SEPARATED list:

1.6.1 Tuning Applied

Tuning methodology for ocean biogeochemistry component

1.6.1.1 Description *

General overview description of tuning: explain and motivate the main targets and metrics retained. andDocument the relative weight given to climate performance metrics versus process oriented metrics, andand on the possible conflicts with parameterization level tuning. In particular describe any struggle andwith a parameter value that required pushing it to its limits to solve a particular model deficiency.

Enter TEXT:

1.6.1.2 Global Mean Metrics Used

List set of metrics of the global mean state used in tuning model/component

Enter COMMA SEPARATED list:

1.6.1.3 Regional Metrics Used

List of regional metrics of mean state used in tuning model/component

Enter COMMA SEPARATED list:

1.6.1.4 Trend Metrics Used

List observed trend metrics used in tuning model/component

Enter COMMA SEPARATED list:

2 Tracers

Ocean biogeochemistry tracers

2.1.1 Top level properties

Ocean biogeochemistry tracers

2.1.1.1 Name

Commonly used name for the tracers in ocnbgchem model.

Enter TEXT:

2.1.1.2 Overview

Overview of ocean biogeochemistry tracers in ocnbgchem model.

Enter TEXT:

2.1.1.3 Sulfur Cycle Present *

Is sulfur cycle modeled ?

☐ True ☐ False

2.1.1.4 Nutrients Present *

List nutrient species present in ocean biogeochemistry model

☒ Nitrogen (N)

☒ Phosphorous (P)

☒ Silicon (S)

☒ Iron (Fe)

☐ Other - please specify:

2.1.1.5 Nitrous Species If N

If nitrogen present, list nitrous species.

☒ Nitrates (NO3)

☒ Amonium (NH4)

☐ Other - please specify:

2.1.1.6 Nitrous Processes If N

If nitrogen present, list nitrous processes.

- [x] Dentrification
- [x] N fixation
- [ ] Other - please specify:

2.2.1 Ecosystem

Ecosystem properties in ocean biogeochemistry

2.2.1.1 Upper Trophic Levels Definition *

Describe how upper trophic levels are defined in model (e.g. based on size)

Implicit.

2.2.1.2 Upper Trophic Levels Treatment *

Describe how upper trophic levels are treated in model

Quadratic closure term assuming infinite food web length.

2.2.2 Phytoplankton

Phytoplankton properties in ocean biogeochemistry

2.2.2.1 Type *

Type of phytoplankton

- [ ] None
- [ ] Generic
- [ ] PFT including size based (specify both below) - Plankton functional type including size based
- [ ] Size based only (specify below)
- [x] PFT only (specify below)

2.2.2.2 Pft

Phytoplankton functional types (PFT) (if applicable)

- [x] Diatoms
- [ ] Nfixers
- [ ] Calcifiers
- [ ] Other - please specify:

2.2.2.3 Size Classes

Phytoplankton size classes (if applicable)

- ☐ Microphytoplankton
- ☒ Nanophytoplankton
- ☐ Picophytoplankton
- ☐ Other - please specify:

2.2.3 Zooplankton

Zooplankton properties in ocean biogeochemistry

2.2.3.1 Type *

Type of zooplankton

- ☐ None
- ☐ Generic
- ☒ Size based (specify below)
- ☐ Other - please specify:

2.2.3.2 Size Classes

Zooplankton size classes (if applicable)

- ☒ Microzooplankton
- ☒ Mesozooplankton
- ☐ Other - please specify:

2.3.1 Disolved Organic Matter

Disolved organic matter properties in ocean biogeochemistry

2.3.1.1 Bacteria Present *

Is there bacteria representation ?

☐ True ☐ False

2.3.1.2 Lability *

Describe treatment of lability in dissolved organic matter

- ☐ None
- ☐ Labile - Less than a few days

☒ Semi-labile - Few days to a few years

☐ Refractory - Over a few years

☐ Other - please specify:

2.4.1 Particules

Particulate carbon properties in ocean biogeochemistry

2.4.1.1 Method *

How is particulate carbon represented in ocean biogeochemistry?

☐ Diagnostic

☐ Diagnostic (Martin profile)

☐ Diagnostic (Balast)

☒ Prognostic

☐ Other - please specify:

2.4.1.2 Types If Prognostic

If prognostic, type(s) of particulate matter taken into account

☒ POC

☒ PIC (calcite)

☐ PIC (aragonite

☒ BSi

☐ Other - please specify:

2.4.1.3 Size If Prognostic

If prognostic, describe if a particule size spectrum is used to represent distribution of particules in water volume

☐ No size spectrum used

☐ Full size spectrum

☒ Discrete size classes (specify which below)

2.4.1.4 Size If Discrete

If prognostic and discrete size, describe which size classes are used

Small (1-100 m), big (100 m - 5 mm)

2.4.1.5 Sinking Speed If Prognostic

If prognostic, method for calculation of sinking speed of particules

- ☐ Constant
- ☒ Function of particule size
- ☐ Function of particule type (balast)
- ☐ Other - please specify:

2.5.1 Dic Alkalinity

DIC and alkalinity properties in ocean biogeochemistry

2.5.1.1 Carbon Isotopes *

Which carbon isotopes are modelled (C13, C14)?

Select MULTIPLE options:

- ☐ C13
- ☐ C14)

2.5.1.2 Abiotic Carbon *

Is abiotic carbon modelled ?

☐ True ☐ False

2.5.1.3 Alkalinity *

How is alkalinity modelled ?

Select SINGLE option:

- ☐ Prognostic
- ☐ Diagnostic)