Biotic-HOWTO

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This document provides step-by-step guidelines to make the so-called “nutrient-restoring” runs for phosphate, oxygen, dissolved organic phosphorus, dissolved inorganic carbon and alkalinity according to the standard OCMIP-2 protocols.

Contents

1 Recuperation of OCMIP-2 files by ftp:

To comply with OCMIP-2 guidelines, all modelers must make simulations according to OCMIP-2 standard boundary conditions. To do so, one must first recuperate the following files via this Web page (you can save a file to disk by clicking a link while holding down the Shift key)

- Files concerning gas exchange (same for all OCMIP-2 runs)
  - rgasx_ocmip2.f
  - gasx_ocmip2.nc.gz
  - vgasx_ocmip2.jnl
- Files concerning phosphate maps
  - README.po4maps
  - po4mapnew.dat.gz
  - readmap.f
  - nutrient-doc
  - feb0m.ps
  - aug0m.ps
  - dif0m.ps
- Files concerning common biotic model
  - bio.f
  - bio.h
  - jbio.f
  - co2flux.f
  - o2flux.f
  - o2sato.f
  - scco2.f
  - sco2.f
- Files concerning standard carbonate chemistry (same for all OCMIP-2 carbon runs)
  - README.Cchem
  - Makefile
  - co2calc.f
  - drtsafe.f
  - ta_iter_1.f
  - test.r

– test.out.gz

After transfer, the files containing the OCMIP-2 boundary conditions for gas exchange (gasx_ocmip2.nc.gz) and phosphate restoring po4map.dat.gz should be uncompressed as follows:

```
gunzip gasx_ocmip2.nc
gunzip po4mapnew.dat
```

Other files are text and need no special treatment after transfer. Use of these files is described below.

2 Model runs

2.1 Surface phosphate restoring

F. Louanchi has created a monthly climatology of phosphate in the upper ocean that is to be used to nudge the model towards observations in the upper 75 m. These data are on a 2 x 2 degree grid for the six following depth levels: 0, 10, 20, 30, 50 and 75 m. The data are in the file po4mapnew.dat.gz. See the files README.po4maps, readmap.f, and nutrient-doc for further information. All modelers are required to linearly interpolate the phosphate maps spatially and temporally to their model grid. Units of the phosphate maps are mmol/mˆ3 and these will have to be converted by each group to model units of mol/mˆ3.

2.2 Conservation equations

There are five tracers carried in this run: phosphate (PO4), dissolved organic phosphorus (DOP), oxygen (O2), dissolved inorganic carbon (DIC) and alkalinity (Alk). The corresponding conservation equations are

(1a) **d[PO4]/dt = L([PO4]) + JbPO4**

(1b) **d[DOP]/dt = L([DOP]) + JbDOP**

(1c) **d[O2]/dt = L([O2]) + JbO2 + JgO2**

(1d) **d[DIC]/dt = L([DIC]) + JbDIC + JgDIC + JvDIC**

(1e) **d[Alk]/dt = L([Alk]) + JbAlk + JvAlk**

where

- **L** is the 3-D transport operator, which represents effects due to advection, diffusion, and convection;
- **[]** or ”square brackets” indicate concentrations in moles/mˆ3 (or eq/mˆ3 for Alk);
- **JbX** is the biological source sink term for X;
- **JvDIC** and **JvAlk** are the ”virtual” source-sink terms for changes in surface DIC and Alk, respectively, due to evaporation and precipitation; and
- **JgDIC** and **JgO2** are the source-sink terms due to air-sea exchange of CO2 and O2, respectively.

The source-sink terms **JvDIC**, **JvAlk**, **JgDIC**, and **JgO2** are added only as surface boundary conditions. That is they are equal to zero in all subsurface layers. These source-sink terms are equivalent to the fluxes, described below, divided by the surface layer thickness **dz1**.

JvDIC= FvDIC/dz1

JvAlk = FvAlk/dz1

JgDIC = FgDIC/dz1

JgO2 = FgO2/dz1

The **Jb** terms are rather detailed and are described in the OCMIP-2 simulation design document; they are not repeated here. We have supplied some Fortran code, found in the files bio.h, bio.f, and jbio.f. This code should be used to compute the Jb terms. However, this code serves only as a template, which must be modified by each group to suit their particular model.

2.3 Virtual fluxes (FvDIC and FvAlk)

In models where surface salinity is restored to observed values, this results in a surface flux of salt, not a surface flux of water as in the real world. Such surface salt fluxes are typically found in models with a rigid lid, and even in some models with a free surface (e.g., the OGCM from Louvain-la-Neuve). For simplicity, we categorize both classes of models as ”rigid-lid-like”. Conversely, non-rigid-lid-like models have a free surface and restore surface salinity by an equivalent flux of water leading to dilution or concentration (e.g., the MPI LSG model). Salinity in the latter type of free-surface model is conserved; E-P fluxes are taken into account by the velocity fields and thus do not need to be explicitly formulated in the transport model.

Yet for all rigid-lid-like models, we must explicitly take into account the concentration-dilution effect of E-P (Evaporation minus Precipitation), which changes surface **[DIC]** and **[Alk]**. Thus we add the virtual flux to the surface layer, each time step according to

(2a) **FvDIC = DICg * (E-P)**

(2b) **FvAlk = Alkg * (E-P)**

where DICg and Alkg are the model’s globally averaged surface concentrations of DIC and Alk, respectively. Both global averages must be computed at least every five years. For rigid-lid-like models with only salinity restoring, we suggest that (P - E) be computed as

(3) **P - E =** $(S - S')/Sg$ *** dz1 /Tau**

where **S’** is the observed local salinity to which modeled local salinity **S** is being restored, **Sg** is the model’s globally averaged surface salinity, **dz1** is the top layer thickness, and **Tau** is the restoring time scale for salinity. For rigid-lid models (or free surface models) which in addition include explicit P - E water fluxes, that term must of course also be added to eq (3).

IMPORTANT: It is critical that the virtual fluxes do not result in a net flux of alkalinity to or from the model. There are at least two ways of getting around this. One possibility is to insure that the global mean of E -P used in equations (2a) and (2b) is equal to zero. This could be achieved by subtracting off the global mean E - P before computing the virtual flux. A second possibility is to update the inventory of alkalinity periodically so that the inventory of alkalinity + 16*phosphate is at its initial value. See also Section 3.

2.4 Air-sea gas exchange fluxes (FgDIC and FgO2)

For simulations of DIC and O2, OCMIP-2 simulations will directly model the finite air-sea fluxes **FgDIC** and **FgO2**, respectively. Modelers must use the formulation for the standard OCMIP-2 air-to-sea flux:

(4a) **FgDIC = KwCO2 (CO2sat - CO2surf)**

(4b) **FgO2 = KwO2 (O2sat - O2surf)**

with

(5a) **CO2sat = alphaC*pCO2atm *P/Po**

(5b) **O2sat = O2sato*P/Po**

where

- **KwCO2** and **KwO2** are the CO2 and O2 gas transfer (piston) velocities [m/s], respectively;
- **CO2surf** is the surface aqueous CO2 concentration [mol/mˆ3], which is computed from the model's surface [DIC], T, S, [Alk], and [PO4]; (see section 2.6);
- **O2surf** is the surface O2 concentration [mol/mˆ3] computed by the model;
- **alphaC** is the CO2 solubility for water-vapor saturated air [mol/(mˆ3 * uatm)];
- **pCO2atm** is the partial pressure of CO2 in dry air at one atmosphere total pressure [in uatm], which is the same as the dry air mixing ratio of CO2 multiplied by 10ˆ6 ;
- **O2sato** is the O2 saturation concentration at one atmosphere total pressure for water saturated air [mol/mˆ3];
- **P** is the total air pressure at sea level [atm], locally; and
- **Po** is 1 atm.

2.5 The Piston Velocities (KwCO2 and KwO2)

For simulations of DIC and O2, modelers must use the standard OCMIP-2 formulation for the piston velocities of CO2 (**KwCO2**) and O2 (**KwO2**). The monthly climatologies of **KwCO2** and **KwO2** are to be interpolated linearly in time by each modeling group. They are computed with the following equations adapted from Wannikhof (1992, eq. 3):

(6a) **Kw = (1 - Fice) [Xconv * a *(u2 + v)] (ScCO2/660)**-1/2**

(6b) **Kw = (1 - Fice) [Xconv * a *(u2 + v)] (ScO2/660)**-1/2**

where

- **Fice** is the fraction of the sea surface covered with ice, which varies from 0.0 to 1.0, and is given as monthly averages from the Walsh (1978) and Zwally et al. (1983) climatology (OCMIP-2 modelers must reset **Fice** values less than 0.2 to zero, after interpolation to their model grid)

- **u2** is the instantaneous SSMI wind speed, averaged for each month, then squared, and subsequently averaged over the same month of all years to give the monthly climatology. (see the OCMIP-1 README.satdat for further details);
- **v** is the variance of the instantaneous SSMI wind speed computed over one month temporal resolution and 2.5 degree spatial resolution, and subsequently averaged over the same month of all years to give the monthly climatology. Again, see the OCMIP-1 README.satdat for further details.
- **a** is the coefficient of 0.337, consistent with a piston velocity in cm/hr. We adjusted the coefficient **a** for OCMIP-2, in order to obtain Broecker et al.'s (1986) radiocarbon-calibrated, global CO2 gas exchange of 0.061 mol CO2 /(mˆ2 * yr * uatm), when using the satellite SSMI wind information (**u2 + v**) from Boutin and Etcheto (pers. comm.). Our computed value for **a** is similar to that determined by Wanninkhof (**a** = 0.31), who used a different wind speed data set and assumptions about wind speed variance; we use the observed variance.
- **Xconv** = 1/3.6e+05, is a constant factor to convert the piston velocity from [cm/hr] to [m/s]. This conversion factor is already included in the forcing field **xKw,** provided below.
- **ScCO2** and **ScO2** are the Schmidt numbers for CO2 and O2, respectively. They are to be computed using the formulation of Wannikhof (1992) for CO2 and Keeling et al. (1998) for O2. The corresponding Fortran functions are scco2.f and sco2.f. Both **ScCO2** and **ScO2** are unitless.

Practically speaking, to use equations (4) and (6), each group will interpolate the OCMIP-2 standard information to their own model grid. The standard information is provided by IPSL/LSCE as a monthly climatology on the 1 x 1 degree grid of Levitus (1982) in netCDF format (in file gasx_ocmip2.nc). Gridded variables in that file include

- the variable **Fice**,
- the second term, **[Xconv * a * (u2 + v)]**, denoted as **xKw** [m/s]
- the mask **Tmask** (1 if ocean; 0 if land),
- the total atmospheric pressure at sea level **P** [atm]
- the longitude **Lon** at the center of each 1 x 1 degree grid box,
- the latitude **Lat** at the center of each 1 x 1 degree grid box.

For the variables **Fice** and **xKw**, continents on the 1 x 1 degree standard grid have been flooded with adjacent ocean values. Such an approach avoids discontinuities at land-sea boundaries during interpolation. See the Fortran program rgasx_ocmip2.f for an example of how to read the information in `gasx_ocmip2.nc` into your interpolation routines. After compilation, to link and use `rgasx_ocmip2.f`, one must have already installed netCDF.

`<http://www.unidata.ucar.edu/packages/netcdf/>`

The file `gasx_ocmip2.nc` may also be inspected with software that uses netCDF format, such as ncdump or Ferret. Ferret will be used for some of the analysis during OCMIP-2. We encourage participants to become familiar with Ferret now.

`<http://ferret.wrc.noaa.gov/Ferret/>`

After installation, one can visualize maps of the standard information in gasx_ocmip2.nc, by using the Ferret script vgasx_ocmip2.jnl.

After launching Ferret, simply issue the following command (at Ferret's "yes?" prompt)

```
yes? go vgasx_ocmip2.jnl
```

2.6 Oceanic and Atmospheric Components

Apart from Kw, there are other terms that require further development to simulate air-sea gas exchange.

2.6.1 Ocean

The oceanic term **CO2surf** [in mol/mˆ3] is not carried as a tracer, so it must be computed each timestep to determine gas exchange.

CO2surf is the surface [CO2] concentration, which is computed from the model's surface **[DIC]**, **[Alk]**, **T**, **S**, and **[PO4]** through the equations and constants found in the subroutine co2calc.f. Silicate is also needed as an input, as it affects the equilibria; for that, we use its global mean surface value of 7.5 umol/kg.

IMPORTANT: The carbonate chemistry subroutine co2calc.f was originally designed to require tracer input (**[DIC]**, **[Alk]**, **[PO4]**, and **[SiO2]**) on a per mass basis (umol/kg); however, for OCMIP-2 co2calc.f has been modified to pass tracer concentrations on a per volume basis (mol/mˆ3), as carried in ocean models. To do so, we use the mean surface density of the ocean (1024.5 kg/mˆ3) as a constant conversion factor; we do NOT use model-predicted densities. Output arguments *co2star* (**CO2surf**) and *dco2star* (**CO2sat - CO2surf**) are also returned in mol/mˆ3.

2.6.2 Atmosphere

The atmospheric components **CO2sat** and **O2sat** in equations (4a) and (4b) are specified *a priori* via four remaining terms:

1. **alphaC**: The CO2 solubility **alphaC** is to be computed using modeled SST and SSS, both of which vary in time at each grid point. For OCMIP-2 we use the solubility formulation of Weiss (1974), corrected for the contribution of water vapor to the total pressure (Weiss and Price, 1980, Table IV for solubility in [mol/(l * atm)]). The solubility **alphaC** is calculated within the routine co2calc.f.

2. **pCO2atm**: This is held constant at 278 ppm. For the OCMIP-2 simulations, modelers should pass **pCO2atm** as one of the the input arguments (xco2) to co2flux.f in units of ppm. This in turn is passed to co2calc.f.

3. **O2sato**: This is computed from the model T and S in units of mol/mˆ3, using the formulation of Garcia and Gordon (1992). The subroutine o2sato.f performs this function.

4. **P**: Is the total atmospheric pressure [atm] from the monthly mean climatology of Esbensen and Kushnir (1981). The latter, was given originally on a 4 x 5 degree grid (latitude x longitude) in bars. We converted **P** to atm by multiplying it by (1/1.101325). Land and sea ice values in the original data set were filled with average values from adjacent ocean points. These monthly mean arrays were then linearly interpolated to the 1 x 1 degree grid

of Levitus (see netCDF file gasx_ocmip2.nc). The atmospheric pressure, is passed as an input argument, in atm, to both co2flux.f and o2flux.f.

3 Initialization and duration of simulations

It is up to the discretion of the modeler as to how to initialize their simulations, but the following criteria must be upheld:

1. The global mean inventory of alkalinity + 16*phosphate must be initialized to 2370 + 16*2.17 ueq/kg = 2404.72 ueq/kg (or 2.4636 eq/mˆ3) and maintained at that level.
2. The global mean PO4 + DOP concentration must be set equal to 2.17 + 0.02 = 2.19 umol/kg (or 0.002245 mol/mˆ3)

As for the duration of simulations, the biotic equilibrium simulation should be continued at least until the globally integrated air-sea CO2 flux is less than 0.01 Pg C/yr. For most models, this criterion can be reached only after an integration of at least a few thousand model years.

To approach equilibrium more rapidly, some modelers use the acceleration technique where the timestep increases in deeper layers (Bryan, 1984). When modelers use this technique, one complication is that the global inventory of certain biogeochemical tracers (those without external sources or sinks) cannot be conserved. As a fix, those at NCAR suggest that modelers who use such a technique should periodically adjust global tracer inventories to their initial values. In any case, some method must be used to avoid losing mass from the system. Furthermore, we strongly recommend that the deep acceleration method be switched off and that the model be run for at least an additional 500 years, before final ”equilibrium” output is stored for later OCMIP-2 analysis.

4 Output type and frequency

The Biotic simulation represents only one equilibrium run per model. Therefore only time-averaged fields of the seasonal cycle of the final ”steady-state” solution need be saved. Modelers must submit results based on an average of the last 10 years of the simulation. Below are listed the required fields. The spatial dimension is indicated in square brackets; another dimension must be added for time, i.e., 12 months per year):

3-D Monthly mean tracer concentrations for both active tracers: potential temperature T (degrees C) and salinity S (psu);

3-D Monthly mean tracer concentrations for all five passive tracers (**[PO4]**, **[DOP]**, **[O2]**, **[DIC]**, and **[Alk]**) for the whole water column (mol/mˆ3);

2-D Monthly mean **pCO2surf = CO2surf/alphaC** (uatm);

2-D Monthly mean **dpCO2 = (CO2surf - CO2sat*P/Po)** (uatm);

2-D Monthly mean air-sea CO2 flux **FgDIC** (mol/mˆ2/s);

2-D Monthly mean air-sea O2 flux **FgO2** (mol/mˆ2/s);

2-D Monthly mean virtual DIC flux **FvDIC** (mol/mˆ2/s);

2-D Monthly mean virtual flux of total Alkalinity **FvAlk** (eq/mˆ2/s);

2-D Monthly mean downward flux of particulate organic phosphorus interpolated to the compensation depth (75 m) **PnewPOP** (mol/mˆ2/s);

2-D Monthly mean total downward flux of dissolved organic phosphorus (DOP) interpolated to the compensation depth (75 m) **PnewDOP** (mol/mˆ2/s);

2-D Monthly mean advective net downward flux of DOP interpolated to the compensation depth (75 m) **PnewDOPa** (mol/mˆ2/s);

2-D Monthly mean diffusive net downward flux of DOP interpolated to the compensation depth (75 m) **PnewDOPd** (mol/mˆ2/s); and

2-D Monthly mean convective net downward flux of DOP interpolated to the compensation depth (75 m) **PnewDOPc** (mol/mˆ2/s).

5 Output Format

Each modeling group must provide their output in the standard OCMIP-2 format. Model output that does not follow these formatting conventions cannot be included for analysis during OCMIP-2. Model groups must use the standard routines that we have developed specifically for writing output in standard form for OCMIP-2.

If this is the first OCMIP-2 simulation you have made, you will need to recuperate the routine write_nc_MaskAreaBathy.f to write out characteristics of your model grid, mask, and bathymetry using the standard OCMIP-2 format. Use of this routine is detailed in the CFC HOWTO (section 5.1).

Otherwise if you have submitted OCMIP-2 model output previously, you will only need to resubmit the output file produced by write_nc_MaskAreaBathy.f under two conditions:

1. either your model's grid, mask, or bathymetry have changed; or
2. you have been notified by the OCMIP-2 analysis center at IPSL that your output file from this subroutine did not pass the routine integrity tests.

5.1 Biotic-run output routines

For the Biotic simulation, each modeling group will need to store both their active and passive tracer output in OCMIP-2 standard format. Thus modelers need to call two additional routines. They should be called just once each. Those output routines and the fields which are passed as arguments are detailed in the following table.

Routine	Input	Units	Comments

write_nc_Biotic_equil.f	1) Conc. of PO4	mol/m^3	(*)
	2) Conc. of DOP	mol/m^3	
	3) Conc. of O2	mol/m^3	
	4) Conc. of DIC	mol/m^3	
	5) Conc. of Alk	eq/m^3	
	6) Surf. ocean pCO2	uatm	
	7) Delta pCO2 (dpCO2)	uatm	
	8) Mean Gas Flux of CO2	mol/(m^2*s)	
	9) Mean Gas Flux of O2	mol/(m^2*s)	
	10) Mean Virtual Flux of CO2	mol/(m^2*s)	
	11) Mean Virtual Flux of Alk	mol/(m^2*s)	
	12) Mean Downward flux of POP at compensation Z	mol/(m^2*s)	
	13) Mean Downward flux of DOP at compensation Z	mol/(m^2*s)	
	14) Mean Downward advective flux of DOP at compensation Z	mol/(m^2*s)	
	15) Mean Downward diffusive flux of DOP at compensation Z	mol/(m^2*s)	
	16) Mean Downward convective flux of DOP at compensation Z	mol/(m^2*s)	
write_nc_Biotic_TS_year.f	1) Potential temperature	degrees C	(*)
	2) Salinity	psu	

(*) For online models, all 2- and 3-D fields should be averaged for each month over the last 10 years of the simulation.

5.2 Downloading the output routines

The output routines can be transferred to your machine by clicking on the links below, while holding down the Shift key.

- write_nc_MaskAreaBathy.f
- write_nc_Biotic_equil.f
- write_nc_TS_year.f

- write_nc_Biotic_TS_year.f

You will also need to transfer the subroutine handle_errors.f to properly deal with errors while you are writing your netCDF files.

5.3 Compiling the output routines

Here is a an example of how you would compile one of the Biotic run output routines:

```
f77 -c -O -L/usr/local/lib -lnetcdf -I/usr/local/include \
     write_nc_Biotic_equil.f
```

Because we have made the OCMIP-2 output routines F77 compatible, you may need a function len_trim.f (from F90), which we also provide and which returns the length of a character string (after neglecting trailing blanks).

5.4 Using the output routines

The Biotic-run output routines store your model results following the naming and output conventions (netCDF, GDT version 1.2) chosen for OCMIP-2. The output filename is constructed automatically within each routine from three of the arguments: the tracer name, the year, and the *standard model code* `<http://www.ipsl.jussieu.fr/OCMIP/phase2/#modgroups>` used during OCMIP-2 to identify your group.

For example, after compiling and linking the OCMIP-2 output routines, we add the following code to the IPSL routines to store output in standard OCMIP-2 form

```
      call write_nc_Biotic_equil ("IPSL", "NGL46_SI",
     &  imt, jmt, kmt,
     &  60*60*24*365, 1200,
     &  MPO4, MDOP, MO2, MDIC, MAlk,
     &  MpCO2surf, MdpCO2,
     &  MFgDIC, MFgO2,
     &  MFvDIC, FvAlk,
     &  MPnewPOP, MPnewDOP,
     &  MPnewDOPa, MPnewDOPd, MPnewDOPc)
```

By line, the arguments to `write_nc_Biotic_equil` include

1. the OCMIP-2 *model code* AND your own *model version* indicator (in GDT 1.2 terminology, these 2 variables refer to the *institution* and *production*, respectively);
2. dimensions;
3. the number of seconds per year (in your model), and the number of timesteps per year;

4. the 12 monthly means for the 3-D tracer arrays for passive tracers PO4, DOP, O2, DIC, and Alk;
5. the 12 monthly means for the 2-D arrays for surface ocean pCO2 (pCO2surf) and the sea-air pCO2 difference (dpCO2).
6. the 12 monthly means for the 2-D arrays for the air-sea fluxes for CO2 and O2;
7. the 12 monthly means for the 2-D arrays for the surface "virtual" fluxes for DIC and Alk;
8. the 12 monthly means for the 2-D arrays for the total downward fluxes of POP and DOP (at the compensation depth); and
9. the 12 monthly means for the 2-D arrays for the advective, diffusive, and convective components of the downward flux of DOP (at the compensation depth).

All arguments are input. The only output is the final netCDF file (`"IPSL_Biotic_equil.nc"`) which contains the information for analyzing the IPSL monthly results for the steady-state climatological solution.

Furthermore, we need monthly 3-D data for potential temperature T and salinity S from each model. Again as an example, we add the following code to the IPSL routines to store output in standard OCMIP-2 form.

```
      call write_nc_Biotic_TS_year("IPSL", "NGL46_SI",
     &  imt,jmt,kmt,
     &  year, 60*60*24*365, 1200,
     &  MT,MS)
```

where the arguments include

1. the OCMIP-2 *model code* AND your own *model version* indicator (in GDT 1.2 terminology, these 2 variables refer to the *institution* and *production*, respectively);
2. dimensions;
3. the year, the number of seconds per year (in your model), and the number of timesteps per year;
4. the 12 monthly means for the 3-D tracer arrays for potential temperature T and salinity S;

The only output is the final netCDF file (`"IPSL_Biotic_TS_year.nc"`) which contains the information for analyzing the IPSL monthly results for the steady-state climatological solution.

Both `"IPSL_Biotic_equil.nc"` and `"IPSL_Biotic_TS_year.nc"` should be 6. Filenames should NOT be changed. Subsequently at IPSL, files will be (1) tested for consistency, (2) included in the OCMIP-2 data base, and (3) processed for base analysis.

5.5 Need more details?

See `<http://www.ipsl.jussieu.fr/OCMIP/tech>` for additional information about the format netCDF and other conventions (COARDS, GDT) chosen for storing OCMIP-2 model output.

If you have other questions, please contact Patrick.Brockmann@ipsl.jussieu.fr or orr@cea.fr

6 Transfer of output

Both `IPSL_Biotic_equil.nc` and `IPSL_Biotic_TS_year.nc` should first be compressed

```
gzip IPSL_Biotic_equil.nc IPSL_Biotic_TS_year.nc
```

If gzip is not available on your machine, the alternative is to use `compress`. After compression, you should send your files to LSCE for processing and analysis. However, model output could be quite large depending upon model resolution. If output is larger than 300 Mb, you may wish to try to send it by ftp, but you should first send us e-mail to verify that enough disk space is available. If not, you'll need to write your output to tape (DDS, DDS2, Exabyte, or DLT) and mail it to

```
James ORR
LSCE, CEA Saclay
Unite mixte de recherche CEA-CNRS
Bat. 709, L'Orme des Merisiers
F-91191 Gif-sur-Yvette CEDEX
FRANCE
```

If smaller than 300 Mb, please first attempt to send this output via ftp:

```
ftp: ftp.cea.fr
user: anonymous
passwd: your full email
cd incoming2/ba9901/OCMIP
mkdir <your group name>
mkdir <your group name>/Biotic
cd <your group name>/Biotic
binary
prompt
mput <your group name>*nc*
```

Then e-mail us (Patrick.Brockmann@ipsl.jussieu.fr and orr@cea.fr) that your transfer is complete.

7 Who has submitted what?

For a record of who has submitted what model output, see
<http://www.ipsl.jussieu.fr/OCMIP/phase2/progress/>.

8 References

Broecker, W.S., J. R. Ledwell, T. Takahashi, R. Weiss, L. Merlivat, L. Memery, T.-H. Peng, B. Jahne, and K. O. Munnich, 1986. Isotopic versus micrometeorlogic ocean CO2 fluxes, J. Geophys. Res., 91, 10517-10527.

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