# 1    Hardware and Software Requirement

The Carbon-Generic Estuarine Model (C-GEM) is written in the programming language C and runs on PC or a cluster using a GNU GCC Compiler. The use of the cross platform C++ IDE Code::Blocks, which can be downloaded for free from http://www.codeblocks.org (last access on July 2013), is recommended by the authors. A minimum random access memory (RAM) of 512 MB is required. The model simulates 90 days of real time (e.g. the steady-state simulation presented in the manuscript) in about 4 minutes on a standard pc with a processor clocked at 2.60 GHz and requires about 100 MB of disk space.

# 2    Download C-GEM

A package named *"C-GEM"*, containing the source code of C-GEM as well as the model project, is available as supplementary material. The package contains 2 sub-folders:

1) sub-folder named *"model"*, where the model project is stored (*C-GEM.cbp*) and where model output files will be saved

2) sub-folder named *"code"*, where 13 source code files, listed below, are stored:

- *define.h*
- *variables.h*
- *main.c*
- *hyd.c*
- *transport.c*
- *init.c*
- *fun.c*
- *schemes.c*
- *tridag.c*
- *uphyd.c*
- *biogeo.c*
- *sed.c*
- *file.c*

The default settings of the model correspond to the steady-state simulation presented in our manuscript (lateral loads and the Rupel's network are not included).

## 3 Source Code Files Description

This section provides a brief description of all source code files present in the sub-folder *"code"* using direct references to the corresponding protocol steps described in our manuscript:

*define.h*

- Specification of estuarine geometry (**protocol step 1**) and physical parameters, such as pure water density and gravity acceleration
- Specification of hydrodynamic and sediment parameters (**protocol steps 2.1 and 4.1**)
- Specification of biogeochemical parameters (**protocol step 5.2**)
- Specification of external forcing (**protocol step 5.4**)
- Specification of mathematical constants (Euler's constant, number Pi), setup of model resolution (time, space, warm up period for biogeochemistry) and specification of libraries

*variables.h*

- List of model routines and sub-routines
- List and description of all model variables

*main.c*

- Main model routine

*hyd.c*

- Main hydrodynamic routine

*transport.c*

- Main transport routine

*init.c*

- Logical expression for minimum and maximum values
- Flag to use a variable or a constant estuarine depth. The user can decide to use a variable depth (*include_constant_depth=0*) as in the simulations presented in our study or a constant depth (*include_constant_depth=1*).

  If:

  · *include_constant_depth=0*. The tidally-averaged water depth decreases linearly in the upstream direction and the Chézy coefficient, as well as the critical shear for erosion and deposition are constant until a set distance. Further upstream, they increase linearly towards the inland boundary. In this case, the user needs to specify in *define.c* the number of grid points (parameter named *distance*) corresponding to this distance.

  · *include_constant_depth=1*. The tidally-averaged water depth is constant along the estuarine domain and two different constant values, one for the saline estuary

(downstream of *distance*) and one for the tidal river (downstream of *distance*), are assigned to the Chézy coefficient and the critical shear stress for erosion and deposition.

- Formulation of dispersion coefficient $D$ (**protocol step 3.1**)
- Formulation of estuarine convergence length (**protocol step 1**)
- Initializing numerical arrays for hydrodynamics, transport and biogeochemical reaction network
- Specification of boundary conditions for salinity, chemical species and SPM (**protocol steps 3.2, 4.2, 5.3**)
- Saving salinity and chemical species and SPM concentrations in outputs files. All variables considered in our manuscript are written in output files

*fun.c*

- Formulation of piston velocity for $O_2$ exchange across air-water interface
- Formulation of tidal elevation, absolute temperature and light intensity (**protocol step 5.4**)
- Formulation of temperature-dependence for heterotrophic reactions and nitrification

*schemes.c*

- Formulations of advection and dispersion numerical schemes

*tridag.c*

- Solution of the tridiagonal matrix

*uphyd.c*

- Update hydrodynamic variables

*biogeo.c*

- Formulation of underwater light field and nutrient dependence for primary production
- Formulation of biogeochemical reaction network (**protocol step 5.1**)
- Update of biogeochemical state variables. Note that phytoplankton concentration is referred as diatom concentration (*DIA*)
- Saving biogeochemical process rates in outputs files. All biogeochemical processes considered in our manuscript are written in output files

*sed.c*

- Formulation of longitudinal variation in SPM parameters (**protocol step 4.1**)
- Formulation of SPM erosion and deposition rates
- Update of SPM concentrations

*file.c*

- Saving geometrical variables in output files
- Format specification for concentration and biogeochemical reaction rate output files

## 4    Model Operation

Double click on *C-GEM.cbp* file in the sub-folder *"model"* to open the model project. If required, implement and save changes to the source code files. Use the "build" button to compile the model. After compilation, use the "run" button to start a simulation. During the simulation, the number of simulated days is printed on the screen.  At the end of simulation, simulation results are written in output files that are saved in the sub-folder *"model"*.

## 5    Handling Output Files

C-GEM output data are printed in *\*.dat* type files. Output files, produced by default by C-GEM, with specification of the corresponding modeled data are:

- *depth.dat*: water depth data
- *width.dat*: estuarine width data
- *S.dat*: salinity data
- *SPM.dat*: suspended particulate matter concentrations
- *DIA.dat*: diatoms concentrations
- *NH4.dat*: ammonium concentrations
- *NO3.dat*: nitrate concentrations
- *O2.dat*: oxygen concentrations
- *PO4.dat*: phosphate concentrations
- *DSi.dat*: dissolved silica concentrations
- *TOC.dat*: total organic carbon concentrations
- *NPP.dat*: Net Primary Production rates
- *aer_deg.dat*: aerobic degradation rates
- *denit.dat*: denitrification rates
- *nit.dat*: nitrification rates
- *O2_ex.dat*: air-water $O_2$ exchange rates
- *NEM.dat*: Net Ecosystem Metabolism rates

The first column of the output file corresponds to the time expressed in second and other columns correspond to the selected data along the estuarine length from the mouth of the estuary to the

upstream cell. The default setting corresponds to a steady-state simulation of 90 days using 3 days as warm up period and saving data every 30 minutes.