3D MODELLING OF THE BLACK SEA NORTH WESTERN SHELF ECOSYSTEM

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Monthly RIVERS fluxes and nutrients flows (from SESAME & A. Cociasu)

6h-atmospheric forcings from ECMWF (1.125°). (from ERA40)

The Model

36 States variables

Physics (5)
- Currents, T°, Salinity,
- Surface elevation, Turbulence

Oxygen and Dissolved Inorganic Carbon (2)

Inorganic nutrients (5)
- SiO, NO3, NH4, PO4, ”Reducers”

3 Phytoplankton (6) (free C/N)
- Diatoms, Flagellates, Small Flagellates

Zooplankton (2)
- Micro, Meso.

Gelatinous zooplankton (2)
- Omnivorous, Carnivorous

Detrital matter (8)
- Particulate, Semi-labile and Labile forms
- Silicious Detritus, Aggregates

Bacteria (1)

Sediments (5 2D)
- Fast and slow decaying C and S pool, Ncratio

31 double-sigma layer
Model's Specificity

**No data assimilation**: Necessity to construct specific Bosphorus representation to ensure conservation of volume and total salt content.

**Anoxic waters**: The biological model explicitly includes anoxic chemistry through the use of a variable 'Oxygen demanding Units', as a proxy for reducers acting in the anoxic zone.

**Sediments coupling**: Due to the importance of sediments dynamics for the shelf area we had to include a parametrisation of sediments taking into accounts deposit history, and bottom concentrations to express remineralisation fluxes.
Validation : Biology-climatic run
Spatio-temporal repartition of point-2-point statistics

Atmospheric and river forcings are averaged on decadal periods in order to construct a “climatological” seasonal cycles.

Those climatic runs are run under repetition of those seasonal forcings, in order to study equilibrium states in response to some typical environmental conditions.

This allow us to better analyse the interannual runs

Validation of those runs is done by gathering in-situ data from those decades, and comparing each data by its model spatio-temporal equivalent.
Validation: Horizontal

Dissolved Oxygen

- Region 1 -200to0
- Region 2 -200to0
- Region 3 -200to0
- Region 4 -200to0

Graphs showing observed (obs) and modeled (mod) data with various metrics such as RMS, BIAS, CORR, CHI, and NASH.
Outputs:
“inter-climatology” evolution of ecosystem conditions

Bottom Dissolved Oxygen [mg/l] Bottom Dissolved Oxygen [mg/l] Bottom Dissolved Oxygen [mg/l]

June

1960-1970

1980-1990

1990-2000
Oxygen Dynamics

The model allows to analyse different parts of an element's dynamic.

Annual mean of oxygen fluxes, vertically integrated. Units: mmolO/m²
Interannual Run
Dissolved Oxygen Comparison for the Shelf Area

mmolO/m³

RMS 68
BIAS 14
CORR 0.55
CHI 0.73
NASH 0.27

Jan85 Apr85 Jul85 Oct85 Jan86 Apr86 Jul86 Oct86 Jan87 Apr87 Jul87 Oct87 Jan88 Apr88 Jul88 Oct88 Jan89 Apr89 Jul89 Oct89 Jan90 Apr90 Jul90 Oct90

Bottom diss. oxygen

Particulate and Dissolved Organic Carbon

mgl

mg/l

mmolC/m²

Jan85 Jan86 Jan87 Jan88 Jan89 Jan90 Jan91 Jan92

Jan85 Jan86 Jan87 Jan88 Jan89 Jan90 Jan91 Jan92

global shelf average
@ sevastopol eddie

shelf average
@ sevastopol
Surface Elevation principal modes

Mode 1: % of expl. var. = 67.8059, cum. = 67.8059

Mode 2: % of expl. var. = 14.9906, cum. = 82.7965

Mode 3: % of expl. var. = 4.298, cum. = 87.0945

Mode 4: % of expl. var. = 3.0961, cum. = 90.1926
Conclusions

- Once validated (!), 3D models allow to get an useful insight in detailed dynamics of the ecosystems.

- As 3D complex models generate a big amount of data, climatologic run help to identify relevant indices to analyse interannual run.
Thanks for patience, attention and for your questions

The Black Sea, P. Alechinsky
Validation BIO SFD 6

LCHL JAN

depth[m]

LCHL FEB

mmol/m²

LCHL MAR

mmol/m²

LCHL APR

mmol/m²

LCHL MAY

depth[m]

LCHL JUN

LCHL JUL

depth[m]

LCHL AUG

mmol/m²

LCHL SEP

mmol/m²

LCHL OCT

depth[m]

LCHL NOV

mmol/m²

LCHL DEC
Validation BIO

SIOregio 1 -200to0

SIOregio 2 -200to0

SIOregio 3 -200to0

SIOregio 4 -200to0
Validation: Physics

Comparison of SST climatologies from model and satellite

Interranual run
85 to 90
Validation: Physics (interannual run 85 to 90)
Comparison of SST modes of interannual variability with satellite

Model EOF
%var.: 73.7877

Satellite EOF
%var.: 77.3041

%var.: 7.3833

%var.: 7.4342

%var.: 3.1611

%var.: 3.4889

%var.: 2.4794

%var.: 1.9541

χ² = 0.16
corr. = 0.97

χ² = 0.62
corr. = 0.61

χ² = 0.86
corr. = 0.43

χ² = 0.68
corr. = 0.57
Reduction in anoxic water

\[(CH_2O)_x (NH_3)_y (H_3PO_4) + 2xMnO_2 + 4xH^+ \rightarrow 2xMn^{2+} + xCO_2 + yNH_3 + H_3PO_4 + 3xH_2O\]
\[2xH_2O + 2xMn^{2+} + xO_2 \rightarrow 2xMnO_2 + 4xH^+\]
\[(CH_2O)_x (NH_3)_y (H_3PO_4) + 2xFe_2O_3 + 8xH^+ \rightarrow 4xFe^{2+} + xCO_2 + yNH_3 + H_3PO_4 + 5xH_2O\]
\[4xH_2O + 4xFe^{2+} + xO_2 \rightarrow 2xFe_2O_3 + 8xH^+\]
\[(CH_2O)_x (NH_3)_y (H_3PO_4) + 0.5xSO_4^{2-} \rightarrow 0.5xS^{2-} + xCO_2 + yNH_3 + H_3PO_4 + xH_2O\]
\[0.5xS^{2-} + xO_2 \rightarrow 0.5xSO_4^{2-}\]
\[(CH_2O)_x (NH_3)_y (H_3PO_4) + \text{An oxidant} \rightarrow xODU + xCO_2 + yNH_3 + H_3PO_4 + xH_2O\]
\[ODU + xO_2 \rightarrow \text{An oxidant}\]

(OxygenDemanding Unit = 0.5H2S + 2Mn2+ + 4Fe2+ ).

Validation : Biology-climatic run
Spatio-temporal repartition of point-2-point statistics

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Validation BIO

**LCHLregio 1 - 200to0**

- **obs**
- **mod**

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