Excess and imbalanced nutrient loads modify the carbon sink in the Southern North Sea: a model study over 50 years

Belgian Science Policy

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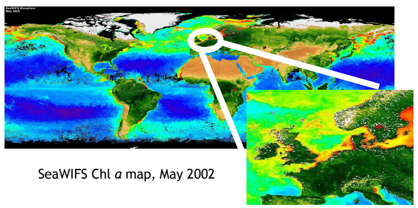
Project TIMOTHY
(http://www.climate.be/timothy)

PURPOSE

The coupled river-coastal sea model RIVERSTRAHLER-MIRO-CO_2 (R-MIRO-CO_2) is used to appraise how the contemporary increased atmospheric CO_2 and changing nutrient loads are affecting air-sea CO_2 exchanges in the Southern North Sea coastal area.

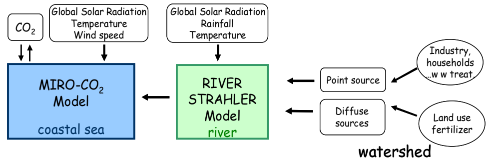
THE BELGIAN COASTAL ZONE

The Belgian coastal waters (BCZ, Southern North Sea) result from the mixing between Atlantic waters and freshwater waters and nutrient loads from anthropized rivers. This eutrophied area is an interesting case for investigating the effect of changing anthropogenic activities on the capability of coastal waters to absorb atmospheric CO_2.



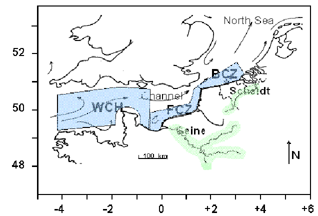
SeaWIFS Chl *a* map, May 2002

MODEL DESCRIPTION & IMPLEMENTATION



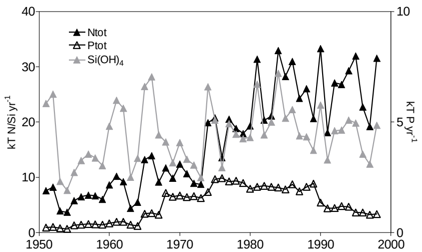
Description: The coupled **R-MIRO-CO_2** model results of the offline coupling between the **RIVERSTRAHLER** model describing C, N, P and Si transformations along the river system as a function of meteorological conditions and human activities and the **MIRO-CO_2** model of C,N,P, Si cycles in the coastal area.

Implementation: 0D multi-box from the Eastern Channel (WCH) to the Southern North Sea (BCZ)
Model simulations: 1951 to 1998
Forcings: land use modifications: every 10 years
urban and industrial waste waters: every 5 years
daily SST, wind speed and monthly Atm. CO_2 ;
(http://www.cmdl.noaa.gov)

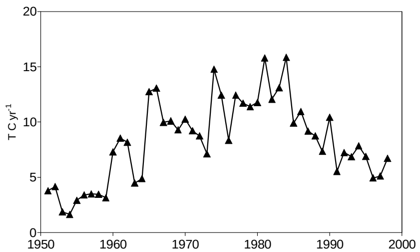


MODEL SIMULATIONS: 1951-1998 EVOLUTION

Annual inorganic nutrient Scheldt loads



Annual organic carbon Scheldt loads



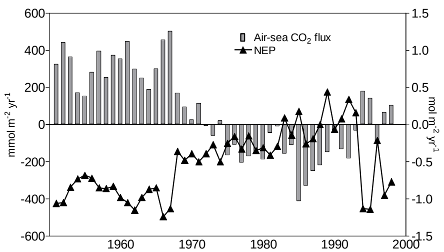
Annual Net Ecosystem Production (NEP) and air-sea CO_2 flux

1951 => 1967: moderate and well-balanced nutrient loads, heterotrophic ecosystem, CO_2 source

1968 => 1985: increase of N and P loadings, shift from heterotrophy to autotrophy, shift from CO_2 source to sink

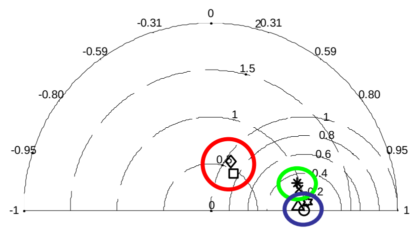
1985 => 1993: decrease of P loadings (removal P from washing powders) but sustained N loadings, ecosystem metabolic status is close to equilibrium, CO_2 sink decrease

1994 => 1998: severe unbalanced nutrient river loads (N:P>25), shift back to heterotrophy, shift back to CO_2 source.



LONG-TERM TRENDS DRIVERS

Taylor's diagram is used to estimate the main drivers (SST, wind speed, atmospheric CO_2 and river loads) of the 1951-1998 long-term trends of air-sea CO2 fluxes in BCZ. The impact of each forcing is estimated by comparison between:
-reference results
-results obtained using 1951 values of SST (*), wind speed (X), atmospheric CO_2 (Δ), organic carbon (☆) and inorganic N (◊)and P (□) river loads for each year of the considered period



No impact: atmospheric CO_2, organic C river loads

Moderate impact: Wind speed, SST

Main drivers: N and P river loads

CONCLUSION

In the BCZ, from 1950 to 1998, nutrient rivers loads control and have pronfundly changed the status of CO_2 sink or source of coastal waters which alternately act as a source or a sink for atmospheric CO_2. Elevated and well-balanced nutrient loads increase the CO_2 uptake capacity of the BCZ. Low or unbalanced (high N:P ratio) inorganic nutrient inputs limit coastal primary production and the BCZ acts as a source for atmospheric CO_2.