Integrated Study of Southern Ocean Biogeochemistry and Climate Interactions in the Anthropocene (BELCANTO III)

Duration of the project: Phase 1: 15/12/2005 – 14/12/2007
Phase 2: 15/12/2007 – 14/12/2009
Budget phase 1: 862.278€
Keywords: Climate change; Southern Ocean; ice-ocean biogeochemical model; Air-sea CO2 fluxes; C, N, Si, Fe cycles; Export and mesopelagic remineralisation.

Context

The Southern Ocean (SO) ecosystem is crucial in global biogeochemical cycles (C, N, Si, P, Fe) and climate regulation, notably through its capacity to absorb atmospheric CO_2, a major greenhouse gas. Current ocean biogeochemical models describing the contribution of the modern SO to the global oceanic CO_2 sink diverge significantly. Such differences between model results are attributed to physical and biogeochemical processes being inadequately resolved.
Reducing the uncertainty of model predictions requires a thorough understanding of the factors regulating ocean-atmosphere interactions, oceanic circulation and biogeochemical processes.

Project description

Objectives

The overall objective of BELCANTO III is to conduct targeted process studies and develop new proxies to construct and validate a realistic 3D ice-ocean biogeochemical model for the area south of latitude 30°S, based on improved understanding of factors regulating interactions between the atmosphere, ocean circulation and biogeochemical cycles and on synthesis/collection of existing/new data sets. When properly validated the model will (i) reduce uncertainty linked to the assessment of the role of the SO as source/sink of atmospheric CO_2 and estimate the related impact on biogeochemical cycles and (ii) improve our capability to predict the SO response to future increase of atmospheric CO_2 and temperature, acidification and changes in oceanic circulation.

Methodology

The BELCANTO (Belgian research on Carbon uptake in the Antarctic Ocean) methodology iteratively combines process-level studies under laboratory-controlled conditions; field work in key SO areas involving direct measurements of core biogeochemical parameters along with an original use of multi-proxies and rate measurements; and numerical development and experimentation. In this methodology, the new 3D NEMO- SWAMCO coupled ice-ocean biogeochemical model plays a central role as integrator of new knowledge synthesised from experimental studies. These include

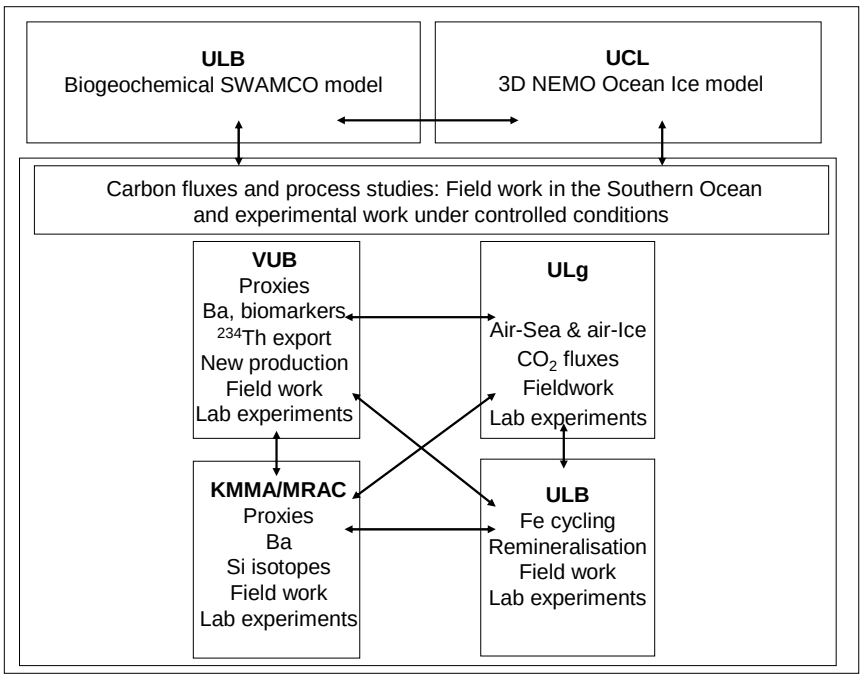
(i) Process-level studies to improve the understanding of iron cycling focusing on the interaction between organic matter and bio-available iron
(ii) Field investigations of organic matter degradation in the mesopelagic layer, based on combined measurements of mesopelagic particulate Ba and bacterial mineralization rates (oxygen consumption) at different depths in the twilight zone and making use of new sampling devices such as IRS sediment traps to sort particles according to their settling velocity and/or size class.

(iii) New methodological development to study bioavailability of organically complexed iron, determine plankton-group specific biochemical compounds with their stable isotopic composition and estimate silica production- dissolution (^{30}Si isotopes).

(iv) Laboratory bioassays to assess and parameterize micro-organism responses to future expectation of increased temperature and acidification.

The construction of a joint data base archiving new field data as well as those collected during BELCANTO I and II is planned for the budget estimates as well as calibration and validation of 3D NEMO-SWAMCO. Of particular importance is the assessment of the model capability to simulate atmospheric CO_2 uptake, export production from the surface layer, bacterial degradation in the mesopelagic and the stoichiometric signature of exported matter and subducted water.

Interaction between the different partners



Link with international programmes

BELCANTO objectives and products are relevant to the following international programmes:

- SOLAS (Surface ocean lower atmosphere study) supported by IGBP(international Geosphere-Biosphere programme), SCOR (Scientific Committee on Oceanic Research), WCRP (World Climate Research Programme) and CACGP (Commission on Atmospheric Chemistry and Global pollution)
- IMBER (Integrated Marine Biogeochemistry and Ecosystem Research) supported by IGBP and SCOR
- GCP (Global Carbon Project) supported by the IGBP, IHDP (International Human Dimensions Programme on Global Environmental Change), WCRP and Diversitas
- CLIVAR (Climate Variability and Predictability) as a part of WCRP dedicated to global changes.

BELCANTO III is also highly relevant to the theme 'Biogeochemistry' and the system 'Southern Ocean' of the EU Network of excellence EUR-OCEANS. Through EUR-OCEANS, a close link exists with ICED-IPY (Integrated Analysis of circumpolar Climate Interactions and Ecosystem Dynamics in the Southern Ocean and GEOTRACES-IPY (An International Study of the Marine Biogeochemical Cycles of Trace Elements and their Isotopes) in the framework of the International Polar Year. Several partners are involved in EU Carbocean IP

Expected results and/or products

- An improved understanding of the iron cycling in the Southern Ocean
- An improved understanding of mesopelagic remineralisation
- An improved assessment of nutrient (N, Si) phytoplankton consumption and control by Fe limitation
- An improved assessment of carbon export to the deep sea and validation through comparison with air-sea CO_2 fluxes
- The characterisation of exported biogenic particles to the deep sea and the assessment of their reactivity
- Model simulations of biogeochemical cycles in the modern Southern Ocean and assessment of mechanisms controlling air-sea CO_2 exchanges
  Model prediction of SO capacity in absorbing increased CO_2
- Assessment of future climate change impact on the functioning of the SO ecosystem

Partners

Activities

- VUB: Expertise in isotope dilution experiments and modelling to assess N and Si fluxes associated with phytoplankton activity; stable C, N isotope ratio and trace element analysis; ^{234}Th activity assessment.
- ULB: Expertise in assessing trace metal (Fe) impact on phytoplankton and bacterial processes; biogeochemical modelling.
- MRAC: Expertise in trace element analysis; stable Si isotope ratio analysis.
- UCL: Expertise in modelling of ocean circulation and ocean –ice interactions.
- ULg: Expertise in inorganic carbon dynamics and air-sea CO_2 fluxes.

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