CLIC-related research activities in Belgium

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The Second Multiannual Scientific Support Plan for a Sustainable Development Policy funded by the Belgian Federal Science Policy Office (BELSPO) is the main driver of the scientific activities concerning climate and cryosphere in Belgium. In addition, it supports the network BE-POLES, a virtual Belgian Polar Institute regrouping all Belgian polar scientists. The four main CLIC-related projects funded by BELSPO are AMICS, MILMO, BELCANTO and LAQUAN (http://www.belspo.be/antar/).

AMICS: Antarctic ice-sheet dynamics and climate change: modelling and ice-composition studies

Coordinator: H Decleir
PI's: H. Decleir & F. Pattyn (Vrije Universiteit Brussel, Brussels), R. Lorrain & R. Souchez (Université Libre de Bruxelles, Brussels)
Website: http://homepages.vub.ac.be/~fpattyn/amics/

The objective of **AMICS** is to contribute to the international research effort leading to an improved understanding of the **dynamic behavior of the Antarctic ice sheet resulting from climatic change**, through a better knowledge of the internal ice dynamics and the ice sheet's interactions with the subglacial environment (Fig.1). To clarify these dynamic interactions a new thermomechanical ice-sheet model was developed, including higher-order stress gradients. Such a model is capable of properly simulating the ice flow in areas characterized by complex basal interaction such as ice streams or subglacial lakes.

A comprehensive effort to improve our understanding of the physical processes at the interface between a lake and a cold-based glacier allowed to explain the complex formation of the lake ice cover. It showed how sediments become trapped in lake ice and how this lake has contributed to the formation of the basal ice layer of the adjacent damming glacier. Moreover, an isotopic model has been elaborated for basal freeze-on associated with subglacial upward flow of pore water.

The AMICS project has demonstrated that basal processes play an important - if not crucial - role in the ice flow of the vast interior of the ice sheet, a zone which was previously thought of being unconditionally stable. Subglacial interactions determine the onset of fast-flowing areas such as ice streams, which has its consequence for the stability of the Antarctic ice sheet with changing climate

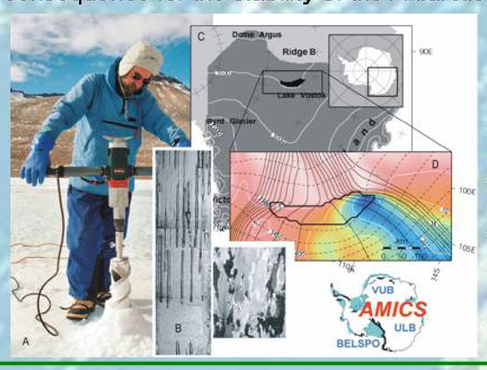

Fig.1.(A) Ice coring from the surface of Lake Victoria Upper (Victoria Valley, Antarctica); (B) Different vertical sections cut in a lake ice core: vertical cylindrical bubbles (left) and elongated crystals with irregular boundaries (right). Other parameter investigated are ionic and isotopic composition, gas content and composition; (C+D): dynamic interaction between the ice sheet and a subglacial lake leads to an anomaly in ice flow due to the reduced friction. Lake Vostok (shown here) thus forms a potential onset (blue area) of fast and/or enhanced ice flow deep in the interior of the Antarctic ice sheet

MILMO: Modelling the evolution of climate and sea level over the third millennium

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PI's : H. Decleir and P. Huybrechts (Vrije Universiteit Brussel, Brussels), T. Fichefet (Université Catholique de Louvain, Louvain-la-Neuve), G. Munhoven and A. Mouchet (Université de Liège, Liège)
Website: http:www.astr.ucl.ac.be/research/MILMO/

The overall objective of **MILMO** is to improve projections of **global climate and sea-level changes** for the 21st century and to profoundly investigate processes and dynamic feedbacks in the climate system as well as the likelihood of abrupt climate and sea-level changes during the 3rd and 4th millennia. The approach is to implement and use an efficient three-dimensional atmosphere–vegetation–sea-ice–ocean model coupled with a model of the oceanic carbon cycle and improved thermomechanical models of the Greenland and Antarctic ice sheets. With the coupled model (named LOVECLIM), we study climate and sea-level changes for the periods 1750–2000, 2000–2100, and 2000–4000 (Fig.4). A series of sensitivity experiments assess the importance of including interactive ice-sheet, land-vegetation, and carbon-cycle representations in the model.

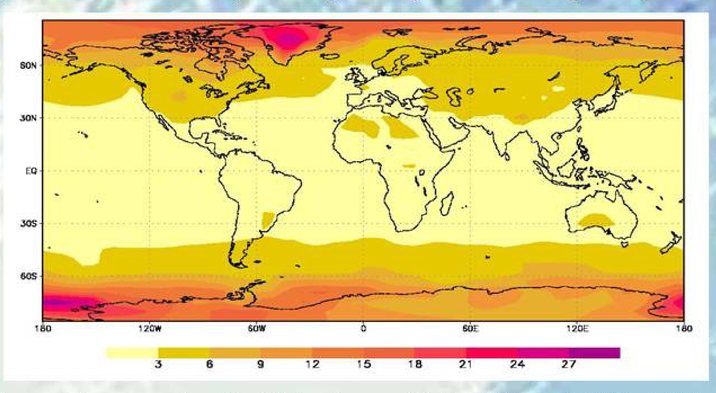

Fig. 2. Changes in surface air temperature (in °C) between 3970–4000 and 1970–2000 as simulated by LOVECLIM. In this experiment, LOVECLIM is driven by the IPCC SRES A2 scenario for greenhouse-gas concentrations and sulphate-aerosol load until 2100 with subsequent stabilisation. In 3970–4000, the Greenland ice sheet has completely disappeared in the simulation, and the Antarctic ice-sheet volume is reduced by about 10% compared to 1970–2000.

BELCANTO: Assessing the sensitivity of the Southern Ocean's biological pump to climate change

Coordinator: F. Dehairs
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BELCANTO network aims at quantifying the current **CO_2 uptake by the iron-limited Southern Ocean** (SO) and its controlling mechanisms and, through a 3D ice-ocean biogeochemical model, predicts its response to a twofold increase of atmospheric CO_2. The research methodology includes and combines field biogeochemical observations, process-level studies of iron control of autotrophic and heterotrophic activities (Becquevort, Schoemann, unpubl. data), physical (Lefebvre et al., 2004, J. Geophys. Res., 109, C09005) and biogeochemical modeling (Pasquer et al., 2005. J. Sea Res. 53, 93-108).

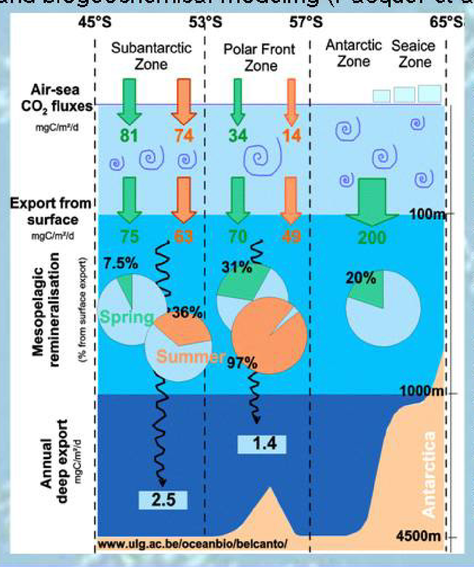

Fig.3 illustrates carbon fluxes along a longitudinal transect in spring (green) vs. summer (orange) as based on a multi-proxy study at 142-144°E. Air-sea CO_2 fluxes are averaged over the whole Indian sector of the SO. There is a fairly good agreement between C fluxes estimates from air-sea exchange and export organic C fluxes from the surface ocean layer. We observe a relatively high particulate organic carbon export to the deep sea in the absence of strong remineralisation in the SAZ and relatively low deep export with stronger remineralisation further south. Summer C remineralisation rates are systematically larger than during spring.

Air-sea CO_2 fluxes are from B.Delille (unpubl.data). Carbon export fluxes from the surface have been estimated from N-uptake experiments (Savoye et al., 2004, Geophys. Res. Lett., 31, L03301), mesopelagic C remineralisation from Ba_{xs} proxy and deep C fluxes from sediment traps (Cardinal et al., Deep-Sea Res. I, 52, 355-370).

LAQUAN: Late Quaternary climate history of coastal Antarctic environments: a multi-proxy approach

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Website: http://allserv.rug.ac.be/%7Erdassevi/laquan/index.htm

Coastal Antarctic sediments are archives of historical variations in ice-sheet dynamics and record environmental change in the terrestrial and marine environment due to their unique position at the boundary between the cryosphere (ice sheet, ice shelves and sea ice) and the Southern Ocean.

One of the aims of **LAQUAN** is to infer **historical changes in sea-ice dynamics** using fossil pigments and siliceous microfossils in marine sediments from isolation lakes. Combining both proxies allowed us to quantify differences in diatom production among habitats (benthic, and planktonic/sea-ice; Fig. 4). Radiocarbon dating of transitions in ecosystem state (marine versus freshwater) in these lakes furthermore provided the basis for the construction of a relative sea-level curve (RSL) in the Lambert Glacier region that is useful to reconstruct historical changes in the volume of the east Antarctic ice sheet near the largest glacier on Earth. The various proxies are illustrated in Fig. 5.

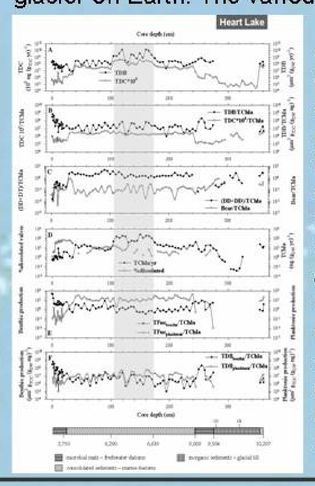

Fig.4: Proxy reconstructions of environmental changes in Heart Lake. Total diatom carotenoids (TDC) analysed using HPLC and total diatom biomass (TDB) assessed using light microscopy were significantly correlated in the marine section of the core. These results indicate that both proxies are well-preserved in the sediments. High diatom production, probably as a result of prolonged open water conditions, was inferred near Broknes (Larsemann Hills) between 6,300 and 6,650 cal. yr BP.

Fig.5 : Proxies used to reconstruct environmental changes: lake-sediment core from Lake Nella with well-preserved pigments, SEM pictures of diatoms, light microscopy pictures of cyanobacteria that contribute fossil pigments and DNA.

Another project, not financed by BELSPO, addresses the impacts of **former ice streams on the Antarctic continental shelf**, the erosional and depositional processes associated with former ice streams and the timing and mode of retreat of LGM ice streams in post-glacial times. This is a bilateral collaboration with the University of Barcelona (Spain) and the Osservatorio Geofisico Sperimentale at Trieste (Italy) that involves multibeam bathymetric mapping of large segments of the Antarctic Peninsula continental shelf (on board of B.I.O. Hesperides) and acquisition of grids of high- and very-high-resolution reflection seismic profiles. The Belgian task is mostly focussed on the interpretation of the seismic data in terms of glacial history.

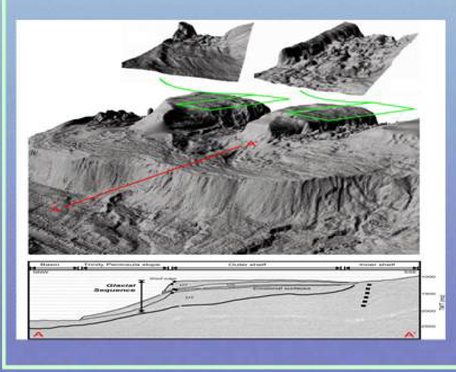

Fig. 6. Above: Three-dimensional views of the modern sea floor of the outer shelf in Bransfield Basin (Antarctic Peninsula) once occupied by ice streams and governed by subglacial erosional and sedimentary processes: a general view and two detailed views showing drumlin topography and sea-floor bundle structures marking the flow directions of former ice streams (after Canals et al., 2002, Geology, 30, 603-606). Multibeam bathymetry data: courtesy of the University of Barcelona.

Below: Seismic cross-section A-A' showing the subsurface structure of the continental margin as it was built out during a succession of glacial advances and retreats

SIBClim: Sea Ice Biogeochemistry in a Climate Change Perspective

Communauté Française de Belgique

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PIs: C. Lancelot (ULB), L. Chou (ULB)

SIBClim (Sea Ice Biogeochemistry in a Climate Change Perspective) is a project funded by the « Communauté Française de Belgique ». Its main goal is to assess the **role of ice- covered regions of the northern and southern polar oceans in regulating the Earth's climate**. It focuses on carbon, iron and sulphur biogeochemical interactions between sea ice, ocean and atmosphere and their controlling mechanisms, and uses field studies, laboratory experiments and modeling. More details are given in poster 100.

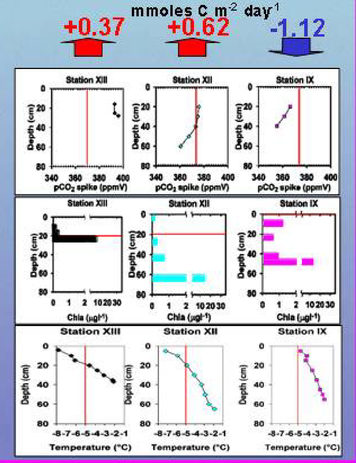

Fig.7: Temperature (bottom), Chla (middle), air pCO_2 in brine holes at incremented depth (top) and CO_2 fluxes (arrows) for three spring stations during the ARISE Antarctic cruise in the Wilkes Land sector (sept-oct 2003). Temperature controls the permeability of the ice and therefore the ability of the primary production to counterbalance high pCO_2 levels in the ice inherited from winter physico-chemical processes. As a result, sea ice is not impermeable and switches from atmospheric CO_2 « source » to « sink » as it warms up.