surface ocean solas lower atmosphere study

Report for the year 2017 and future activities

SOLAS *'Belgium'*
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This report has two parts:

***- Part 1:** reporting of activities in the period of January 2017 – Jan-Feb 2018*
***- Part 2:** reporting on planned activities for 2018/2019 and 2020.*

The information provided will be used for reporting, fundraising, networking, strategic development and updating of the live web-based implementation plan. As much as possible, please indicate the specific SOLAS 2015-2025 Science Plan Themes addressed by each activity **or specify an overlap between Themes or Cross-Cutting Themes.**

1 Greenhouse gases and the oceans;
2 Air-sea interfaces and fluxes of mass and energy;
3 Atmospheric deposition and ocean biogeochemistry;
4 Interconnections between aerosols, clouds, and marine ecosystems;
5 Ocean biogeochemical control on atmospheric chemistry;
Integrated studies;
Environmental impacts of geoengineering;
Science and society**.**

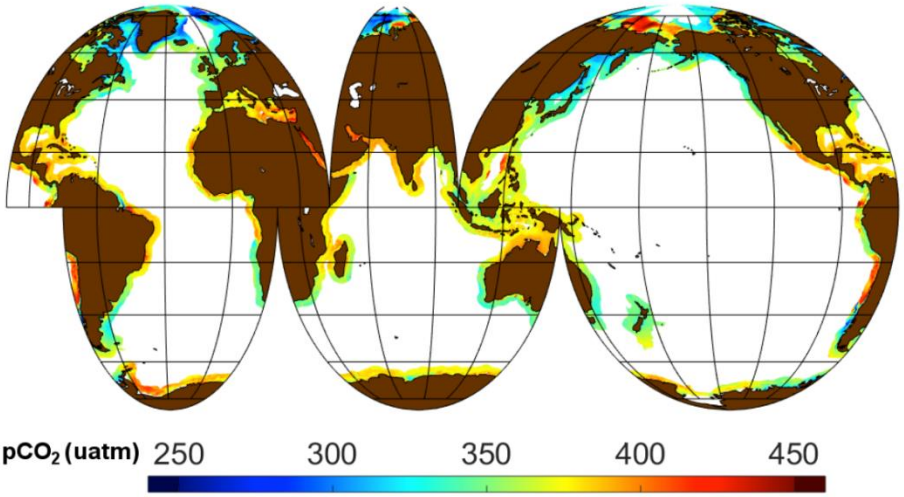
***IMPORTANT**: This report should reflect the efforts of the SOLAS community in the **entire country** you are representing (all universities, institutes, lab, units, groups, cities).*

PART 1 - Activities from January 2017 to Jan/Feb 2018

1. Scientific highlight

Highlight 1 (theme 1 and 2) : Global high-resolution monthly pCO_2 climatology for the coastal ocean derived from neural network interpolation

In spite of the recent strong increase in the number of measurements of the partial pressure of CO_2 in the surface ocean (pCO_2), the air–sea CO_2 balance of the continental shelf seas remains poorly quantified. This is a consequence of these regions remaining strongly under-sampled in both time and space and of surface pCO_2 exhibiting much higher temporal and spatial variability in these regions compared to the open ocean. Here, we use a modified version of a two-step artificial neural network method (to interpolate the pCO_2 data along the continental margins with a spatial resolution of 0.25° and with monthly resolution from 1998 to 2015. The most important modifications compared to the original SOM-FFN method are (i) the much higher spatial resolution and (ii) the inclusion of sea ice and wind speed as predictors of pCO_2. The SOM-FFN is first trained with pCO_2 measurements extracted from the SOCATv4 database. Then, the validity of our interpolation, in both space and time, is assessed by comparing the generated pCO_2 field with independent data extracted from the LDVEO2015 database. The new coastal pCO_2 product confirms a previously suggested general meridional trend of the annual mean pCO_2 in all the continental shelves with high values in the tropics and dropping to values beneath those of the atmosphere at higher latitudes. The monthly resolution of our data product permits us to reveal significant differences in the seasonality of pCO_2 across the ocean basins. The shelves of the western and northern Pacific, as well as the shelves in the temperate northern Atlantic, display particularly pronounced seasonal variations in pCO_2, while the shelves in the southeastern Atlantic and in the southern Pacific reveal a much smaller seasonality. The calculation of temperature normalized pCO_2 for several latitudes in different oceanic basins confirms that the seasonality in shelf pCO_2 cannot solely be explained by temperature-induced changes in solubility but are also the result of seasonal changes in circulation, mixing and biological productivity. Our results also reveal that the amplitudes of both thermal and nonthermal seasonal variations in pCO_2 are significantly larger at high latitudes. Finally, because this product's spatial extent includes parts of the open ocean as well, it can be readily merged with existing global open-ocean products to produce a true global perspective of the spatial and temporal variability of surface ocean pCO_2.



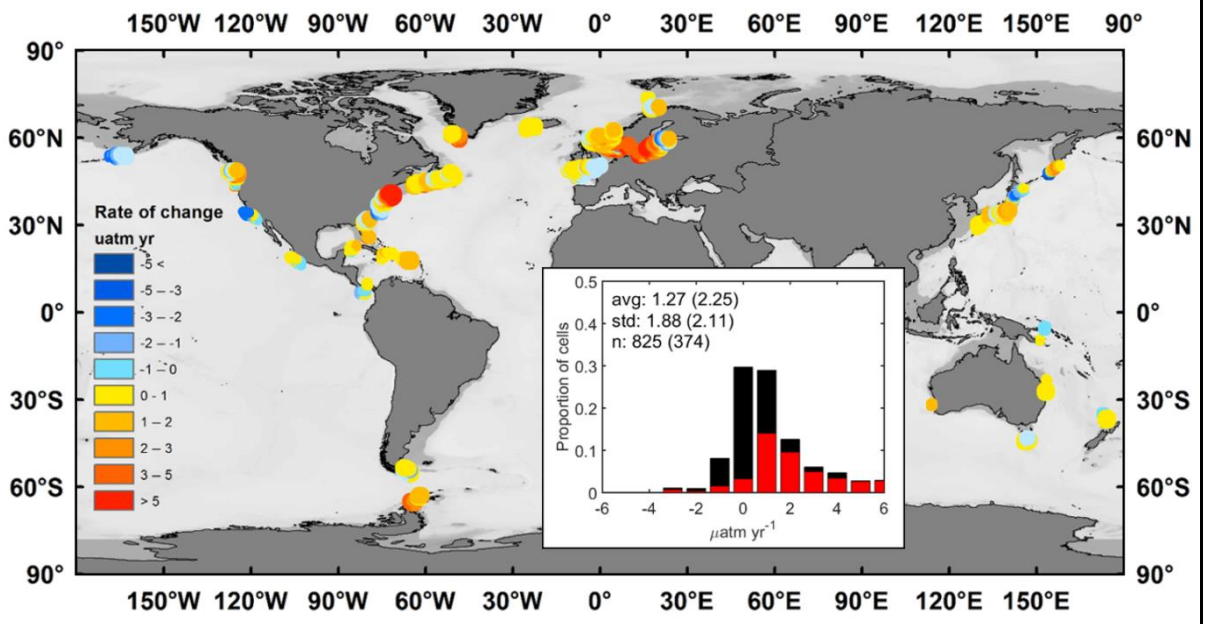
Annually averaged coastal pCO2 climatology at 0.25° resolution. The general meridional trend of the annual mean pCO_2 is ian important feature in all the continental shelves.

Citation : G. Laruelle, P. Landschützer, N. Gruber, JL. Tison, B. Delille, and P. Regnier (2017). Global high-resolution monthly pCO2 climatology for the coastal ocean derived from neural network interpolation. Biogeosciences, 14, 4545–4561, doi: 10.5194/bg-14-4545-2017.

Highlight 2 (theme 1 and 2): Continental shelves as a variable but increasing global sink for atmospheric carbon dioxide

It has been speculated that the partial pressure of carbon dioxide (pCO2) in shelf waters may lag the rise in atmospheric CO2. Here, we show that this is the case across many shelf regions, implying a

tendency for enhanced shelf uptake of atmospheric CO2. This result is based on analysis of long-term trends in the air-sea pCO2 gradient (ΔpCO2) using a global surface ocean pCO2 database spanning a period of up to 35 years. Using wintertime data only, we find that ΔpCO2 increased in 653 of the 825 0.5° cells for which a trend could be calculated, with 325 of these cells showing a significant increase in excess of +0.5 µatm yr-1 ($p<0.05$). Although noisier, the deseasonalized annual data suggest similar results. If this were a global trend, it would support the idea that shelves might have switched from a source to a sink of CO2 during the last century.



Location of 0.5° cells for which the decadal trend in winter ΔpCO2 is calculated. Large dots correspond to cells shallower than 200 m and small dots correspond to cells located within 100 km from the coast or depth less than 500 m. The distribution of d(ΔpCO2)/dt for our narrow definition of the continental shelf is displayed as histogram. The black bars report the distribution of all cells while the red bars report the distribution of cells for which the trend was deemed statistically significant using an F-test with $p < 0.05$. Here, ΔpCO2 = pCO2,air—pCO2. Thus, positive values in d(ΔpCO2)/dt indicate slower increase in water pCO2 than pCO2,air

Citation : Laruelle, G. G., Cai, W.-J., Hu, X., Gruber, N., MacKenzie F.T. and Regnier P. Continental shelves as a variable but increasing global sink for atmospheric carbon dioxide. Nature Communications 9, 454 DOI: 10.1038/s41467-017-02738-z, 2018.

Highlight 3 : Biogeochemical impact of snow cover and cyclonic intrusions on the winter Weddell Sea ice pack

Weddell sea in winter experience warm sea ice cover due to the combined effect of larger snow thickness and the frequent occurrence of warm cyclonic events penetrating far south in the Weddell sea towards the Antarctic coast. These conditions favors high ice permeability and cyclic events of brine movements within the ice cover. These physical settings lead to the formation of "brine tubes" and favor relatively high chl-*a* concentrations mainly related to internal communities. Algal activity continues all through the winter. Overall, permeability of Weddell Sea pack ice appears to be high enough to allow biogeochemical processes to develop during winter, contrasting with Arctic sea ice that is colder and less permeable (Tison et al., 2017).

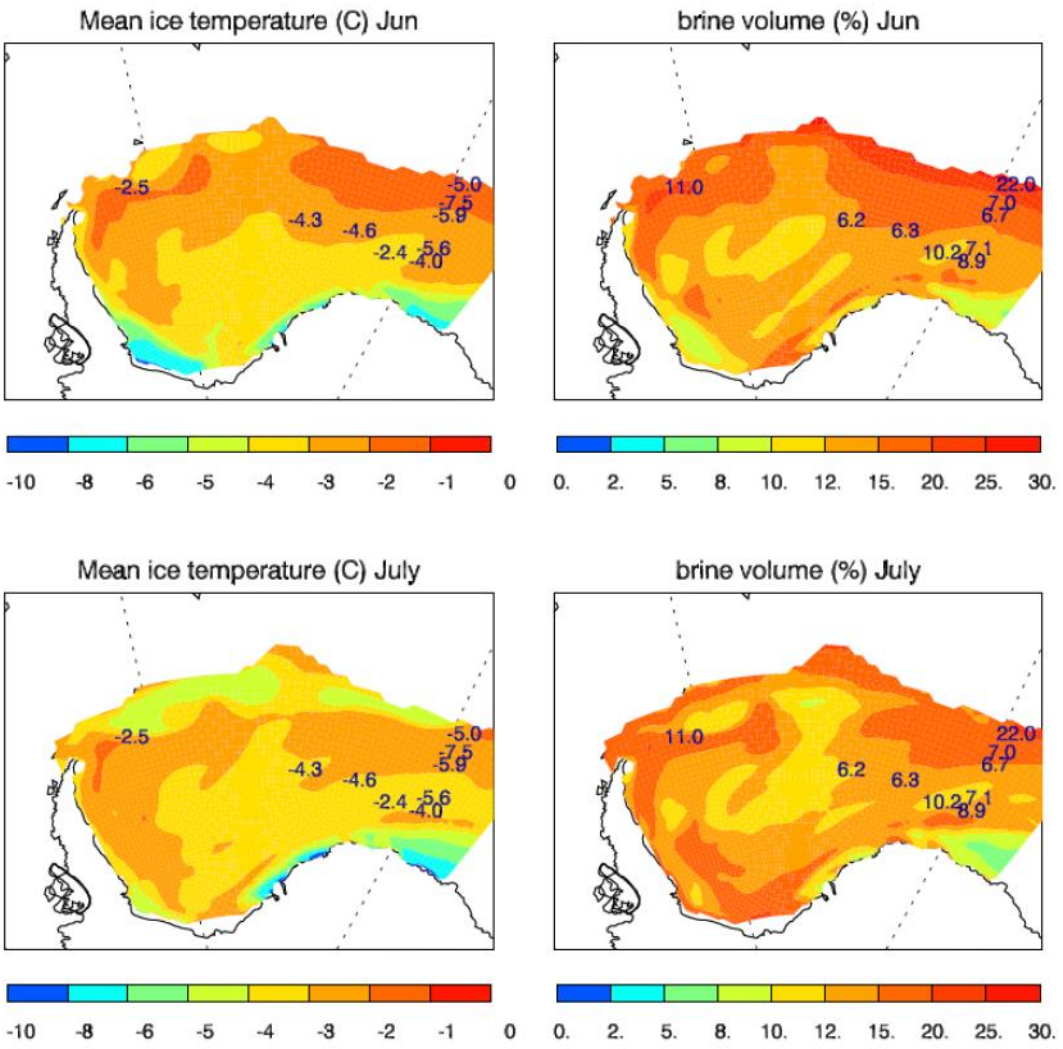
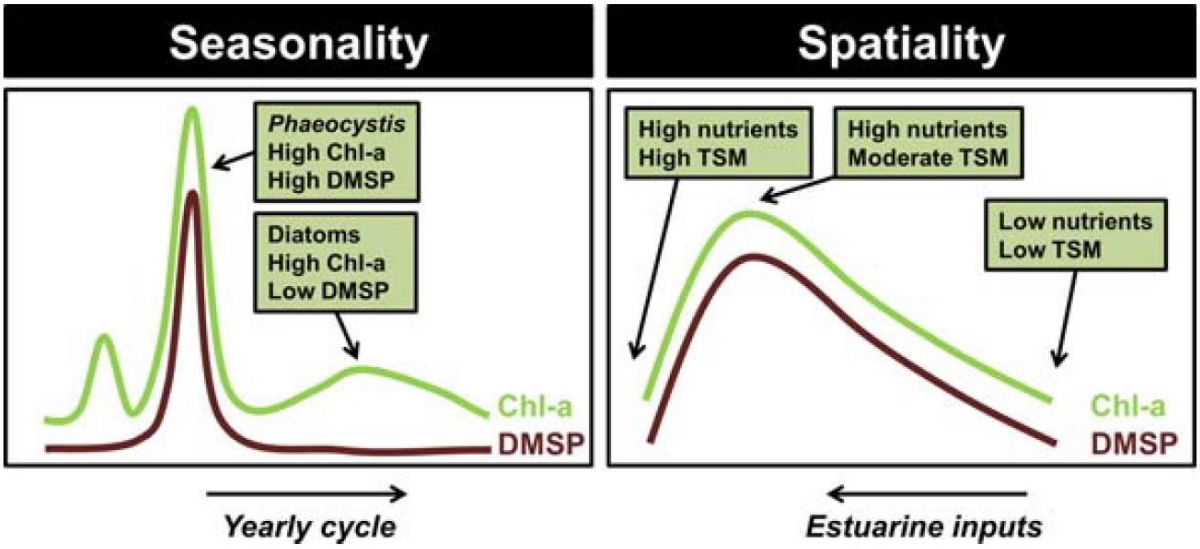


Figure 1 NEMO LIM3simulations of mean ice temperature,and mean brine volume in the Weddell Sea for July 2013 with observations from the AWECS cruise

Citation: Tison, J.-L., Schwegmann, S., Dieckmann, G.S., Rintala, J.-M., Meyer, H., Moreau, S., Vancoppenolle, M., Nomura, D., Engberg, S., Bloomster, L.J., Heindricks, S., Uhlig, C., Luhtanen, A.-M., de Jong, J., Janssens, J., Carnat, G., Zhou, J., Delille, B., 2017. Biogeochemical impact of snow cover and cyclonic intrusions on the winter Weddell Sea ice pack, Journal of Geophysical Research Ocean, 119, 8109–8121. doi:10.1002/2017JC013288

Highlight 4 (theme 1 and 2, 3): Annual cycle of dimethylsulfoniopropionate (DMSP) and dimethylsulfoxide (DMSO) related to phytoplankton succession in the Southern North Sea

The influence of abiotic and biotic variables on the concentration of dimethyl sulfide (DMS), dimethylsulfoniopropionate (DMSP), and dimethylsulfoxide (DMSO), were investigated during an annual cycle in 2016 in the Belgian Coastal Zone (BCZ, North Sea). We reported strong seasonal variations in the concentration of these compounds linked to the phytoplankton succession with high DMS(P,O) producers (mainly Phaeocystis globosa) occurring in spring and low DMS(P,O) producers (various diatoms species) occurring in early spring and autumn. Spatial gradients of DMS and DMSP were related to those of phytoplankton biomass itself related to the inputs of nutrients from the Scheldt estuary. However, the use of a relationship with Chlorophyll-a (Chl-a) concentration is not sufficient to predict DMSP. Accounting for the phytoplankton composition, two different DMSP versus Chl-a correlations could be established, one for diatoms and another one for Phaeocystis colonies. We also reported high nearshore DMSO concentrations uncoupled to Chl-a and DMSP concentrations but linked to high suspended particulate matter (SPM) presumably coming from the Scheldt estuary as indicated by the positive relationship between annual average SPM and salinity.



Citation: Speeckaert G., A. V. Borges, W. Champenois, C. Royer, N. Gypens, 2018. Annual cycle of dimethylsulfoniopropionate (DMSP) and dimethylsulfoxide (DMSO) related to phytoplankton succession in the Southern North Sea, Science of The Total Environment 622-623:362–372

2. Activities/main accomplishments in 2017 (projects, field campaigns, events, model and data intercomparisons, capacity building, international collaborations, contributions to int. assessments such as IPCC, interactions with policy makers or socio-economics circles, social sciences, and media).

- PIPERS (Ice Production and its Seasonal Evolution in the Ross Sea) cruise in the Ross Sea on the NB PALMER funded by the NSF and led by S. Ackley and S Stammerjohn (Apr-June 2017). The PIPERS cruise was a rare opportunity to investigate sea ice biogeochemistry in the Southern Ocean in winter. We were able to sample first stages of sea ice formation (i.e. frazil ice, unconsolidated ice), Terra Nova Bay polynya for sea ice biogeochemistry, including biogases and micronutrients. Belgian Partner Bruno Delille (Université de Liège) and Jean-Louis Tison, Gauthier Carnat, Célia Sapart (Université Libre de Bruxelles).
- Optimist 2017 sea ice survey in Storefjord in April 2017. This survey was carried out in in the frame of the project OPTIMIST-bio (Observing Processes impacting The sea Ice Mass balance from In Situ Measurements: from physics to its impacts on biology) funded by the CNRS (France) and led by F. Viviers. We measured greenhouse gases (CO2, CH4, N2O) concentration and air-ice fluxes. We also collect sea ice for measurement of related physical and biogeochemical parameters. Belgian Partner Bruno Delille (Université de Liège)
- We have been involved in a RSV Aurora Australis V2 cruise that covered Dalton, Mertz and Ninnis Polynyas (Jan 2017) led by Will Hobbs and Delphine Lannuzel and supported by Will Hobbs and Dr Delphine Lannuzel University of Tasmania, the ARC-funded Antarctic Gateway Partnership, the Antarctic Climate and Ecosystems CRC, the Australian Antarctic Division, CSIRO. We get CH4 and N2O samples in sea ice and the water column. Belgian Partner Bruno Delille (Université de Liège) and Jean-Louis Tison (Université Libre de Bruxelles)
- We have been involved in a RV Xuelong cruise in Pridz Bay and Ross sea (Nov 2017- Feb 2018) Polynyas (Dec 2017) supported by the State Oceanic Administration in collaboration with Liyang Zhan. We will focus on Nitrogen cycle (including N2O) in sea ice and the water column. Belgian Partner Bruno Delille (Université de Liège), Frank Dehairs (Vrije Universiteit Brussel) and Jean-Louis Tison (Université Libre de Bruxelles).

Networking

Bruno Delille (Université de Liège), François Fripiat (Vrije Universiteit Brussel) and Jean-Louis Tison (Université Libre de Bruxelles) are strongly involved in:

- BEPSII (Biogeochemical Exchange processes at the Sea ice Interfaces) joint SOLAS-CLIC-IASC working group
- the new ECVice (Essential Climate Variable for sea ice) SCOR working group

3. Top 5 publications in 2017 (only PUBLISHED articles) and if any, weblinks to models, datasets, products, etc.

- Borges AV, G Speeckaert, W Champenois, M.I. Scranton & N Gypens (2017) Productivity and temperature as drivers of seasonal and spatial variations of dissolved methane in the Southern Bight of the North Sea, Ecosystems, DOI: 10.1007/s10021-017-0171-7

- Fripiat F, Meiners KM, Vancoppenolle M, Papadimitriou S, Thomas DN, Ackley SF, Arrigo KR, Carnat G, Cozzi S, Delille B, et al. (2017). Macro-nutrient concentrations in Antarctic pack ice: Overall patterns and overlooked processes. Elementa Science of the Anthropocene, 5, 10.1525/elementa.217

- Gypens N, A.V. Borges & C. Ghyoot (2017) How phosphorus limitation can control climate-active gas sources and sinks, Journal of Marine systems, doi: 10.1016/j.jmarsys.2017.02.002

- Laruelle G. G., Goossens N., Arndt S., Cai W.-J. and Regnier P. (2017). Air-water CO_2 evasion from U.S. East Coast estuaries, Biogeosciences, 14, 2441 doi:10.5194/bg-14-2441-2017

- Lecomte O., H. Goosse, T. Fichefet, C. de Lavergne, A. Barthélemy, V. Zunz (2017). Vertical ocean heat redistribution sustaining sea-ice concentration trends in the Ross Sea. Nature Communications 8, 258, doi: 10.1038/s41467-017-00347-4 (http://rdcu.be/u0r2).

4. Did you engage any stakeholders/societal partners/external research users in order to co-produce knowledge in 2017? If yes, who? How did you engage?

PART 2 - Planned activities for 2018/2019 and 2020

1. Planned major field studies and collaborative laboratory and modelling studies, national and international (incl. all information possible, dates, locations, teams, work, etc.).

- ECVice experiment in Saroma Lagoon (Japan) – Intercomparison of measurement of primary production in sea ice. Belgian Partner Bruno Delille (Université de Liège), Frank Dehairs (Vrije Universiteit Brussel and Jean-Louis Tison (Université Libre de Bruxelles).
- Optimist 2018 sea ice survey in Storefjord in April 2018. This survey was carried out in in the frame of the project OPTIMIST-bio (Observing Processes impacting The sea Ice Mass balance from In Situ Measurements: from physics to its impacts on biology) funded by the CNRS (France) and led by F. Viviers. We will measured greenhouse gases (CO2, CH4, N2O) concentration and air-ice fluxes. We will also collect sea ice for measurement of related physical and biogeochemical parameters. Belgian Partner Bruno Delille (Université de Liège)

2. Events like conferences, workshops, meetings, schools, capacity building etc. (incl. all information possible).

3. Funded national and international projects / activities underway.

Ongoing Projects:

- ISOtopic Investigation of Greenhouse GAses in Polar regions: An Ocean Ice-Atmosphere Continuum (ISOGGAP) funded by the FRS-FNRS (2016-2019, 432 kEur). This project covers the theme 8 "High Sensitivity Systems- HS2" but will focus on arctic systems. ISOGGAP will address: 1) Gas exchange monitoring and process studies; 2) Regional dynamics of stressors and their effect in sea ice systems; 3) Improvement of the representation of biogeochemistry in regional models of sea ice 4) Identification of the elements of HS² that are key parameters to global change and incorporate them into Earth System Models. Partners: Jean-Louis Tison (Univesité Libre de Bruxelles) Bruno Delille (Université de Liège)
- OCeANIC (nitrous Oxide and nitrogen Cycling in ANtarctic sea Ice Covered zone, BL/12/C63, 2016-2019, 250 kEur) funded by the Belgian Science Policy. Partners: Bruno Delille (Université de Liège), Frank Dehairs (Vrije Universiteit Brussel), Jean-Louis Tison (Université Libre de Bruxelles)
- Iodide and halocarbons Dynamics in sea IcE (IODInE, CDR J.0262.17, 2017-2018, 41 kEur) Research Project funded by the F.R.S.-FNRS, partners: Bruno Delille (Université de Liège)

4. Plans / ideas for future projects, programmes, proposals national or international etc. (please indicate the funding agencies and potential submission dates).

5. Engagements with other international projects, organisations, programmes etc.

- BEPSII (Biogeochemical Exchange processes at the Sea ice Interfaces) joint SOLAS-CLIC-IASC working group
- ECVice (Essential Climate Variable for sea ice) SCOR working group
- SOOS Air-Sea Fluxes

Comments