

Report for the year 2019 and future activities

SOLAS BELGIUM

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This report has two parts:

- **Part 1:** reporting of activities in the period of January 2019 - Jan/Feb 2020
- **Part 2:** reporting on planned activities for 2020 and 2021.

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 of high sensitivity systems;
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).*

First things first...Please tell us what the IPO may do to help you in your current and future SOLAS activities. ?

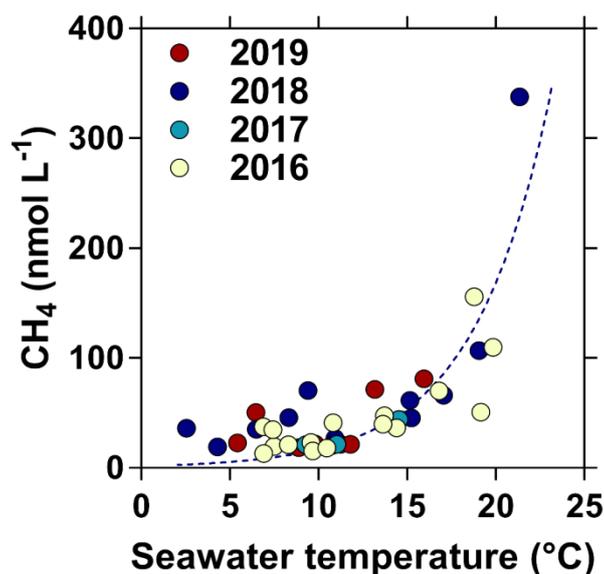
PART 1 - Activities from January 2019 to Jan/Feb 2020

1. Scientific highlight

1. Marine methane dissolved concentrations and emissions in the Southern North Sea in 2018

During the European heatwave of 2018 that led to record-breaking temperatures in many countries across northern and central Europe, average seawater temperature in

July was 2.5°C higher than the mean from 2004 to 2017 for same month in the Belgian coastal zone (BCZ) (Southern Bight of the North Sea). The mean dissolved CH₄ concentration in surface waters in July 2018 (338 nmol L⁻¹) was three times higher than in July 2016 (110 nmol L⁻¹), and an extremely high dissolved CH₄ concentration in surface waters (1,607 nmol L⁻¹) was observed at one near-shore station. The high dissolved CH₄ concentrations in surface waters in the BCZ in July 2018 seemed to be due to a combination of enhancement of methanogenesis and of release of CH₄ from gassy sediments, both most likely related to warmer conditions. The emission of CH₄ from the BCZ to the atmosphere was higher in 2018 compared to 2016 by 57% in July (599 versus 382 μmol m⁻² d⁻¹) and by 37% at annual scale (221 versus 161 μmol m⁻² d⁻¹). The European heatwave of 2018 seems to have led to a major increase of CH₄ concentrations in surface waters and CH₄ emissions to the atmosphere in the BCZ.



in the tropics, with annual mean CO₂ flux densities comparable in magnitude and pattern to those of the adjacent open ocean with the exception of river-dominated systems. The seasonal variations in FCO₂ are large, often exceeding 2 mol C m⁻² year⁻¹, a magnitude similar to the variations exhibited across latitudes. The majority of these seasonal variations stems from the air-sea pCO₂ difference, although changes in wind speed and sea ice cover can also be significant regionally. Globally integrated, the coastal seas act currently as a CO₂ sink of -0.20 ± 0.02 Pg C year⁻¹, with a more intense uptake occurring in summer because of the disproportionate influence of high-latitude shelves in the Northern Hemisphere. Combined with estimates of the carbon sinks in the open ocean and the Arctic, this gives for the global ocean, averaged over the 1998 to 2015 period an annual net CO₂ uptake of -1.7 ± 0.3 Pg C year⁻¹.

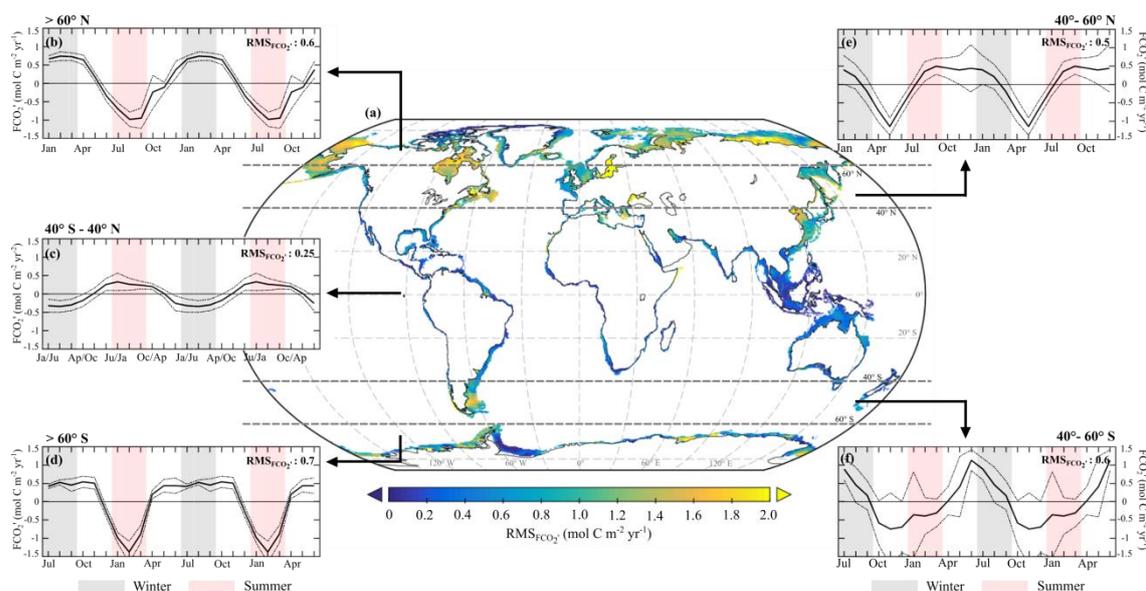


Figure 2: Spatial distribution of the amplitude of the seasonal FCO₂ variability (mol C m⁻² year⁻¹) (a) calculated as the root-mean-square (RMS) for each grid cell of the monthly FCO₂ anomalies (RMS_{FCO₂'}). (b–f) Seasonal FCO₂ anomaly (FCO₂' in mol C m⁻² year⁻¹, black lines) in different latitudinal bands calculated as the mean of the surface weighted average FCO₂' of all grid cells pertaining to that band. Dotted lines correspond to uncertainties (section 1.2.5 in Roobaert et al., 2019). For each panel, a positive value for a given month implies that the FCO₂ is a stronger source/weaker sink of CO₂ than the 18-year mean FCO₂ calculated for this latitudinal band. A negative value means a stronger sink/weaker source. Winter covers the months of January, February, and March in the Northern Hemisphere and of July, August, and September in the Southern Hemisphere. The seasonal FCO₂' profile is plotted twice for each latitudinal band in order to better visualize the temporal pattern. The RMS of the monthly FCO₂ anomalies is also calculated for each latitudinal bands (RMS_{FCO₂'}, mol C m⁻² year⁻¹) and differs from the RMS_{FCO₂'} in panel (a), which is calculated at the grid cell level.

Citation: Roobaert, A., Laruelle, G. G., Landschützer, P., Gruber, N., Chou, L., & Regnier, P. (2019). The spatiotemporal dynamics of the sources and sinks of CO₂ in the global coastal ocean. *Global Biogeochemical Cycles*. <https://doi.org/10.1029/2019GB006239>

3. DMSP and DMSO in seagrass meadows (collaboration between Belgium, France, Italy, Portugal, The Netherlands)

DMSP and related sulfonium compounds dimethyl sulphide (DMS) and dimethylsulfoxide (DMSO) constitute an integral part of the marine sulfur cycle and play an important role in the global sulfur budget. DMS, via transfer from the ocean to the atmosphere, could have a cooling effect on climate and could help to compensate for warming from “greenhouse effect”.

We recently added the seagrass *P. oceanica* to the short list of terrestrial and coastal magnoliophytes that have a high DMSP content. Our researches have also shown that the concentrations of DMSP and DMSO in *P. oceanica* are overall distinctly higher and exhibit a wider range of variations than other marine primary producers such as *Spartina alterniflora*, phytoplankton communities, epilithic Cyanobacteria and macroalgae.

Concentrations of both DMSP and DMSO in *P. oceanica* leaves decrease from a maximum in autumn to a minimum in summer and are strongly related to the leaf size, i.e., the leaf age. To explain the seasonal pattern of decreasing concentrations with leaf aging, we hypothesized two putative protection functions of DMSP in young leaves: antioxidant against reactive oxygen species and predator-deterrent. In addition, the similar variation of the two molecule concentrations suggest that DMSO content in *P. oceanica* leaves results from oxidation of DMSP.

DMSP and DMSO also show interannual variability of their contents in *P. oceanica* leaves, as reported from a four-year (2015-2018) monitoring survey. The remaining concentrations of the two molecules in seagrass leaves in summer could be related to the average high temperatures ($\geq 75^{\text{th}}$ percentile) of July-August (see Figure 3). DMSP and DMSO concentration dynamics in seagrasses therefore seem to depend on both plant-intrinsic and environmental factors.

The study of DMSP and DMSO in seagrasses is at its very beginning. Almost everything remains to be discovered, so further research is needed.

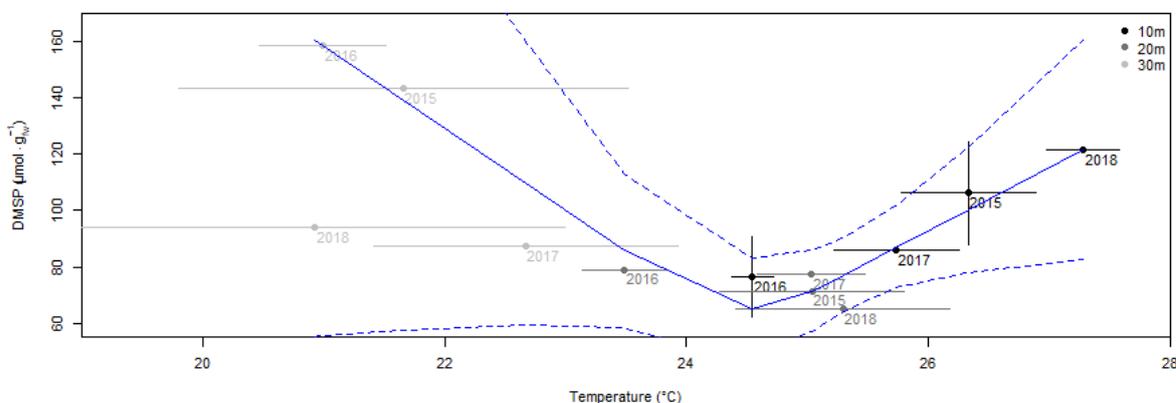


Figure 3: Relationship between average DMSP concentrations in *P. oceanica* leaves and average high temperatures ($\geq 75^{\text{th}}$ percentile) in July-August, for depths 10, 20 and 30m and years 2015 to 2018. Blue lines are prediction from median regression with restricted cubic spline function and 95% confidence interval.

Citation: Richir, J., Champenois, W., Engels, G., Abadie, A., Gobert, S., Lepoint, G., Silva, J., Santos, R., Sirjacobs, D., Borges, A. V., 2020. A 15-Month Survey of Dimethylsulfoniopropionate and Dimethylsulfoxide Content in *Posidonia oceanica*. Front. Ecol. Evol.

2. Activities/main accomplishments in 2019 (e.g., projects; field campaigns; workshops and conferences; model and data intercomparisons; capacity building; international collaborations; contributions to int. assessments such as IPCC; collaborations with social

sciences, humanities, medicine, economics and/or arts; interactions with policy makers, companies, and/or journalists and media).

- From April 2019, in the frame of Copernicus Marine Environment and Monitoring Service (CMEMS), the Modelling for Aquatic System (MAST) group from the Fresh and Oceanic systems Unit of research (FOCUS) of the Liege University is delivering in near real time and operational mode estimation of the air-sea flux of CO₂ in the Black Sea. The service will be extended to reanalysis in June 2020 back to 1992. Further information on the methods and products can be found here.
- Intercalibration experiment for measurement of carbonate system parameters and gases in sea ice at the Roland von Glasow air-sea-ice chamber of the University of East Anglia, Norwich, UK in the frame of ECV-ice SCOR working group with the support of the Eurochamp-2020 Infrastructure Activity. January 2020.
- Analysis of samples from a 5-month *in situ* shading experiment (performed in 2018) of seagrass meadow portions. All environmental and biological sample/data except DMSP and DMSO were analysed during year 2019.
- Participation (oral and poster communication, proceeding) to the 42nd CIESM Congress in Portugal.
- Collaboration with Italian scientists to test in aquaria the effect of nutrient and temperature increases on DMSP and DMSO production in *P. oceanica*.

3. Top 5 publications in 2019 (only PUBLISHED articles) and if any, weblinks to models, datasets, products, etc.

1. Borges A.V., C. Royer, J. Lapeyra Martin, W. Champenois, N. Gypens (2019). Response of marine methane dissolved concentrations and emissions in the Southern North Sea to the European 2018 heatwave, Continental Shelf Research 190, 104004, <https://doi.org/10.1016/j.csr.2019.104004>
2. Speeckaert G., A. V. Borges, N. Gypens (2019). Salinity and growth effects on dimethylsulfoniopropionate (DMSP) and dimethylsulfoxide (DMSO) cell quotas of *Skeletonema costatum*, *Phaeocystis globosa* and *Heterocapsa triquetra*. Estuarine, Coastal and Shelf Science, 226, 106275, <https://doi.org/10.1016/j.ecss.2019.106275>
3. Crabeck O, Galley R J, Mercury L, Delille B, Tison J-L and Rysgaard S. (2019) Evidence of freezing pressure in sea ice discrete brine inclusions and its impact on aqueous-gaseous equilibrium. Journal of Geophysical Research Ocean, 124, 10.1029/2018JC014597
4. Thomas J.L., Stutz J, Frey M M, Bartels-Rausch T, Altieri K, Baladima F, Browse J., Dall'Osto M., Marelle L., Mouginit J, Murphy J G, Nomura D, Pratt KA, Willis MD, Zieger P., Abbatt J., Douglas T A, Facchini M C, France J, Jones A E, Kim K, Matrai P, McNeill VF, Saiz-Lopez A, Shepson P, Steiner N, Law K S, Arnold S R, Delille B, Schmale J, Sonke J E, Dommergue A, Voisin D, Melamed M L, Gier J, (2019). Fostering multidisciplinary research on interactions between chemistry, biology, and physics within the coupled cryosphere-atmosphere system. Elementa Science of the Anthropocene 7, 58. doi:10.1525/elementa.396
5. Swart S., Gille S T, Delille B, Josey S, Mazloff M, Newman L, Thompson A F, Thomson J, Ward B, du Plessis M D, Kent E C, Girton J, Gregor L, Heil P, Hyder

P, Pezzi L P, de Souza R B, Tamsitt V, Weller R A and Zappa C J, (2019). Constraining Southern Ocean air-sea-ice fluxes through enhanced observations, *Frontiers in Marine Science*. 6:421. doi:10.3389/fmars.2019.00421

4. Did you engage any stakeholders/societal partners/external research users in order to co-produce knowledge in 2019? If yes, who? How did you engage?

PART 2 - Planned activities for 2019/2020 and 2021

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

- MOASIC, Leg 6, International Arctic Drift Expedition on the RV Polarstern led by AWI.
- Analyzing samples from the 5-month *in situ* shading experiment for DMSP and DMSO contents (spring 2020; in collaboration with France)
- Analyzing samples from the aquarium experiment on nutrient and temperature increases for DMSP and DMSO contents (spring 2020; in collaboration with Italy)
- Writing a paper on the variability of DMSP and DMSO contents in *P. oceanica* leaves.

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

- 52nd Liège Colloquium on Ocean Dynamics – Towards understanding and assessing human impacts on coastal marine environments. Liège, Belgium – 25th to 29th May 2020

3. Funded national and international projects/activities underway.

- 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)
- Multidisciplinary drifting Observatory for the Study of Arctic Climate

(MOSAiC, CDR J.0051.20, 2020-2021) Research Project funded by the F.R.S.-FNRS

- Main funding for researches on *P. oceanica* is from the Belgian *Fonds National de la Recherche Scientifique* (FNRS) (Fellowship-Grant 1237018F and contract 2.4.637.10).

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

- The global aim of *P. oceanica* researches is to describe factors that drive DMSP and DMSO production in seagrasses, to quantify their role as provider of the dissolved DMS(P)(O) pool in the above water column and the DMS sea-air transfer and to study the ecological functions these molecules play in seagrass beds. This is being done in collaboration with European academic partners (FNRS as main funding agency; no submission dates at this state, there are just intentions).

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 task group on Air-Sea Fluxes
- CATCH (The Cryosphere and Atmospheric Chemistry)

Comments