

Project information

Keywords

Arctic Ocean acidification, fjords, sea ice

Project title

Biogeochemical drivers and climate change on OA – OA DRIVER

Year

2016

Project leader

Agneta Fransson (NPI) and Melissa Chierici (IMR)

Geographical localization of the research project in decimal degrees (max 5 per project, ex. 70,662°N and 23,707°E)

83N 19E, 79N 15W to 10E, Ny Ålesund,

Participants

Participants: Mats Granskog (NPI),

Collaborators:

Eva Falck (UNIS)

Daiki Nomura (Hokkaido University, Japan)

Ellen Damm (AWI, Germany)

Gernot Nehrke (AWI), Gerhard Dieckman (AWI)

Flagship

Ocean Acidification

Funding Source

Shared budget with WP1-OA1 OASTATE

Summary of Results

Results from previously collected samples on sea ice and water column from Kongsfjorden, Tempelfjorden and Fram Strait in 2012-2015 have been published in manuscripts and conference abstracts/posters/oral presentations. Data from Van Mijenfjorden (April 2015) was interpreted and added to the Svalbard data set. New samples were collected in Kongsfjorden and Fram Strait in 2016. Sea ice samples collected for the determination of methane was analysed and added to the data set. All data have been quality checked, data interpreted and included in manuscripts and conference abstracts. Large emphasis in 2016 has been several field expeditions such as the Kongsfjorden and Fram Strait studies and continuation of the

interpretation of N-ICE 2015 data covering winter to spring data of sea ice and water column.

We also published results from previous years (2012-2015) of studies in the Kongsfjorden and Tempelfjorden.

All the water samples were analysed for dissolved inorganic carbon (DIC), total alkalinity ( $A_T$ ), phosphate, silicate, nitrate, and stable isotopic ratio of oxygen ( $\delta^{18}O$ ).

In 2016, we published the findings that the two contrasting years in atmospheric and fjord hydrographical conditions resulted in large interannual differences in in the sea ice and under the sea ice in all parameters as an effect of glacial runoff water and Atlantic water. Influence of glacial water was mainly observed at the stations near the glacier, affecting pH, aragonite saturation and ocean acidification (OA) state.

Thorough analysis of data confirmed previous findings and publications have been sent for peer-review focusing on:

Influence of freshwater such as glacial meltwater and sea ice melt in Svalbard fjords on the carbonate chemistry and ocean acidification (OA)

Effect of sea ice processes on  $CO_2$ -driving processes and OA state

Development of sea ice carbonate chemistry and sea-ice-air  $CO_2$  fluxes (N-ICE)

Seasonal study in Kongsfjorden using automated  $CO_2$  sensor on mooring

## Seasonal studies of the surface water $f\text{CO}_2$ in the Arctic and around Svalbard using automated $f\text{CO}_2$ instrumentation

### Highlights

- Kongsfjorden had critical aragonite saturation levels for pteropod *Limacina helicina* in winter
- Influence of glacial meltwater in Kongsfjorden increased ocean acidification, particularly near the glacier front
- Increased freshwater leads to decreasing  $\text{CaCO}_3$  saturation ( $\Omega$ ) and OA state (Templece).
- Large ocean  $\text{CO}_2$  uptake in winter due to strong winds and open leads in winter ice cover (N-ICE)
- Ocean  $f\text{CO}_2$  largely decreased in spring due to large under-ice bloom (N-ICE)
- Successful measurements of the surface water  $f\text{CO}_2$  in the Arctic and around Svalbard using automated  $f\text{CO}_2$  instrumentation on RV Lance

The results obtained are used for the (i) future field studies planning, (ii) database work and (iii) the models validation.

Master and PhD-students involved in the project

Ylva Ericson, PhD student, UNIS

- Glacial drainage water (freshening) in Spitsbergen fjords decreases calcium carbonate saturation and pH and increases ocean acidification.
  - Aragonite saturation close to critical limit for the pteropod *Limacina helicina* in Kongsfjorden due to freshening
  - Sea ice contributes to alkalinity during melting in spring, hence partly mitigates OA and increases the potential for more ocean uptake of atmospheric CO<sub>2</sub>
  - Large sea-air CO<sub>2</sub> fluxes in Arctic winter due to storm events and open water as leads in the ice cover
  - Large fCO<sub>2</sub> undersaturation under the Arctic sea ice due to large under-ice bloom in spring
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- OA studies in Svalbard fjords in collaboration with Monitoring of Svalbard and Jan Mayen-MOSJ project (NPI), shows large variability of pH and OA state in the fjord-water column. Necessary to continue to fill in data gaps to increase knowledge on biological and chemical coupling for calcifiers in the fjord.
  - Competence and expertise for sea ice chemistry studies has advanced rapidly at Fram centre. Contribute with knowledge transfer to other science fields.

All projects produce data necessary for data bases, models and validations.

Published Results/Planned Publications

Planned publications/in preparation

Fransson A. et al., Seasonal impact of sea-ice processes and freshwater on calcium carbonate

saturation in the Svalbard fjords. In prep.

Fransson A. et al., Export of sea-ice inorganic carbon from Arctic Ocean: implication for ocean acidification. In prep.

Chierici et al., Progress in ocean acidification in the Arctic Outflow waters.

Chierici et al., Drivers of OA state and Net community production in Arctic waters.

#### Conferences/workshops abstracts 2016

Fransson A., M. Chierici, M. P. Assmy, P. Dodd, M. Fernandez-Mendez, M. Granskog, A. Meyer, D. Nomura, A. Rösel, A. Silyakova, H. Steen. Winter-to-spring evolution of Arctic Ocean acidification state in under-ice water and effect of sea-ice processes during N-ICE2015 ice drift project. Submitted in 2016, Abstract to Arctic Frontier 2017.

Fransson, Chierici, Granskog, Nomura et al Winter-time sea-ice carbonate chemistry and effect of glacial meltwater in a Spitsbergen fjord during two contrasting years. Norwegian-Russian workshop November 2016, Tromsø

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Assmy P. M. Fernandez-Mendez, P. Duarte, A. Meyer, M. Chierici, A. Fransson, M. Granskog et al. Leads in Arctic pack ice enable early phytoplankton blooms below snow covered sea ice during N-ICE2015. Norske Havforskeres Forening møte Nov., Bergen 2016

Fransson A. M. Chierici, D. Nomura, M. A. Granskog, S. Kristiansen, T. Martma, G.

Nehrke. Effect of glacial drainage water on the CO<sub>2</sub> system and ocean acidification state in an Arctic tidewater-glacier fjord during two contrasting years (Arctic Frontiers, Tromsø, 2016)

Fransson A., M. Chierici, M. Granskog, D. Nomura, P. Assmy, M. Fernandez-Mendez, P.

Dodd, A. Meyer, A. Rösel, A. Silyakova, H. Steen. Winter-to-spring evolution of Arctic

Ocean acidification state in under-ice water and effect of sea-ice dynamics during N-ICE

2015 ice drift project, (OA Ocean in High CO<sub>2</sub> world, Hobart, 2016)

Chierici, M., Fransson, et al., Advancement of OA monitoring in AO and Norwegian waters, 4<sup>th</sup> Ocean in a high CO<sub>2</sub>-world, 2-7<sup>th</sup> of May 2016, Hobart, AUS oral presentation

Chierici, M., A. Fransson, H. Hop., A. Wold., H. Findlay., 2016. Seasonal variability of OA state and implications for calcifiers in Kongsfjorden, oral presentation 4<sup>th</sup> Ocean in a high CO<sub>2</sub>-world, 2-7<sup>th</sup> of May 2016, Hobart, AUS oral presentation

Fransson A. M. Chierici, D. Nomura, M. A. Granskog, S. Kristiansen, T. Martma, G.

Nehrke. Wintertime sea-ice carbonate system and influence of sea-ice processes and glacial freshwater discharge during two contrasting years in a West-Spitsbergen fjord. (ESSAS, March, Yokohama, Japan + Goldschmidt, Yokohama, Japan, June 2016)

Granskog MA., P. Assmy, P. Duarte, M. Fernandez-Mendez, A. Fransson, H. Kauko, L.M.

Olsen, M. Chierici, D. Nomura, C. J. Mundy, H. Steen. Observations of Arctic sea ice and ocean biogeochemistry in the new thinner ice era: the N-ICE2015 drift ice expedition (N- ICE biogeochemistry Goldschmidt, June, Japan 2016)

Assmy, P., A. Fransson., M. Chierici., A. Wold., H. Hop., et al., Phytoplankton spring bloom beneath heavily snow-covered arctic sea ice during the N-ICE2015. 2016. Abstract accepted in Session CR5.4/OS1.24 Marginal ice zone processes, EGU2016-17254

Dodd, P., A., Fransson., M. Chierici., M. Granskog., C. Stedmon et al., Changes in the Composition of the Fram Strait Freshwater Outflow. 2016. abstract accepted in Session IE4.3/OS1.2 Changes in the Arctic Ocean and Sea Ice System: Observations, Models and Perspectives EGU2016-14193

Yasunaka, S., Akihiko Murata., Eiji Watanabe., Melissa Chierici., Agneta Fransson., Steven van Heuven., Mario Hoppema., Masao Ishii., Truls Johannessen., Naohiro Kosugi., Siv K. Lauvset., Jeremy T. Mathis., Shigeto Nishino., Abdirahman M. Omar., Are Olsen.,

Daisuke Sasano., Taro Takahashi., Rik Wanninkhof. 2016. Mapping of the air–sea CO<sub>2</sub> flux in the Arctic Ocean and its surrounding seas: Basin-wide distribution and seasonal to interannual variability, abstract for the NIPR Polar Symposium, GRENE-Arctic project, 3-4 March 2016, Tokyo, Japan.

Hoppe, C.J.M., L. Wischnewski, M. Nielsdóttir, E. Leu, I. Salter, D. Scholz, A C Kvenvik,

M. Chierici, A. Fransson, and B. Rost. Carbonate Chemistry measurements in the Arctic– activities by FRAM and FAABulous. 2016. Poster for the “Ocean Carbonate chemistry measurements workshop, Southampton, UK, 3-5 February 2016.

OA flagship meetings, Sept/Oct. 2016, NPI, IMR, NIVA, Akvaplan-Niva, UiT, NINA, NORUT.

N-ICE mini works shops at NPI every week, Sept to Dec 2016.

N-ICE workshop, November 2016, Tromsø, Norway.

Norske havforskermøte, November 2016, Bergen, Norway (oral presentation Assmy et al)

Norway-Russia workshop, November 2016, Tromsø (oral presentation Fransson et al)



BEPSII (Biogeochemical processes in sea ice) expert meeting in Feb. Paris 2016 (A. Fransson presentation)

BEPSII (Biogeochemical processes in sea ice) expert meeting in Amsterdam, Oct 2016 (A. Fransson presentation)

ICOS (Integrated carbon observing system) meeting in Bergen, Feb. 2016 (A. Fransson presentation)

Communicated Results

### Conferences/workshops 2016

ESSAS 1 poster Yokohama, Japan

Goldschmidt poster (Fransson) and oral (Granskog) Yokohama, Japan, June 2016

Ocean in a High CO<sub>2</sub> World, 1 poster (Fransson) and 2 oral (Chierici), Hobart, Tasmania 2016

FRAM Day (2 poster presentations)

N-ICE workshop, November 2016, Tromsø, Norway

Open section meeting presentation on Kongsjorden, carbonate chemistry and pteropods (A. Fransson), NPI, Tromsø Oct. 2016

N-ICE mini workshops, NPI, every week, Sept to Dec 2016

Norske havforskermøte, November 2016, Bergen, Norway (oral presentation Assmy et al)

Arctic Frontier (poster), January 2016

Norway-Russian workshop, November 2016, Tromsø (oral presentation A. Fransson et al)

BEPSII (Biogeochemical processes in sea ice) expert meeting in Feb. Paris 2016 (A. Fransson presentation)

BEPSII (Biogeochemical processes in sea ice) expert meeting in Amsterdam, Oct 2016 (A. Fransson presentation)

ICOS (Integrated carbon observing system) meeting in Bergen, Feb. 2016 (A. Fransson presentation)

Fransson A., P. Thor, A. Bailey, M. Chierici (2016) Ocean acidification in Kongsfjorden, Fram Forum, 2016

de Steur L, P.A. Dodd, S. Gerland, M. Granskog, A. Fransson, G. Spreen, M. Chierici (2016) Highlights from the Fram Strait Arctic Outflow Observatory, Fram Forum, 2016

#### Interdisciplinary Cooperation

Collaboration with the flagships “Sea-Ice in the Arctic Ocean, technology and agreements” for the MOSJ/ICE and NPI Fram Strait expeditions, and Fjord and Coast for the new project KongCarb, proposal submitted in 2016.

The project has had great benefit of the large collaboration between the natural science disciplines. In particular, inter-disciplinary cooperation between chemical and physical oceanographers and biologists in the Svalbard fjord studies and the N-ICE 2015 expedition offers a wide range of knowledge and contribution to the project. Only positive aspects.

For all studies (including Fram Strait expedition and N-ICE), we collaborated with biologists regarding nutrient availability. For the fjord studies of the sea ice, we also collaborated with biologists from University of Plymouth (GB) and UNIS (Svalbard). Only positive aspects.

N-ICE work was performed in collaboration with biologists, physical oceanographers and ice-physics specialists. Only positive aspects.

Collaborations on the sea-ice carbonate chemistry study with Japanese scientists at Hokkaido University. Extended collaboration with AWI for methane studies in sea ice and crystal content in sea ice. Very rewarding.

Budget in accordance to results

The project funding has been fundamental to implement this project. It supports the hiring of A. Fransson (project PI), and supports the high costs associated with Arctic field work and extensive sample analysis required in the work.

For the Svalbard fjord study, funding was used to support field activity in April, which could not have been performed without the funding. It also supported sampling and analysis of several chemical and physical parameters which are used as tracers for water mass composition.

Field work, travel costs for personal and instrumentation

Field equipment (partly)

Reagents and devices (electrodes, pipettes etc.)

Certified Reference Material, chemicals, sampling bottles, and transportation of equipment.

Could not have been performed without the funding.

Could results from the project be subject for any commercial utilization

No

Conclusions

Add chemical and biological sensors (e.g. pCO<sub>2</sub>, pH, O<sub>2</sub>, chl, CDOM) to moorings in Fram Strait and Svalbard fjords to investigate diurnal and seasonal variability in sea-ice carbonate dynamics and

biogeochemical drivers of carbon fluxes. New  $p\text{CO}_2$  sesnor deployed in Kongsfjorden in 2016 for autonomous measurements.