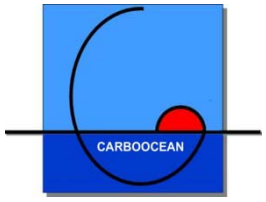
Estimating ocean acidification variables from underway fCO_2 measurements:

a case study from western Norwegian fjords

[1:] Uni Research Climate, [2:] Bjerknes Centre for Climate Research, [3:] University of Bergen, Bergen, Norway.



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Outline

- Oceanic inorganic carbon system
  - Some definitions & processes
- Estimating OA variables from underway fCO_2
- Case study from the Norwegian fjords
  - Study area and data
  - Spatiotemporal variations
  - Drivers of seasonal changes
  - Summary
- Further work
  - Analyses of existing data
  - Monitoring of OA in the fjords

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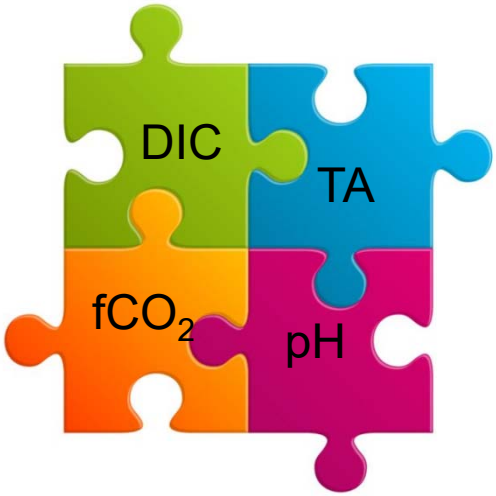
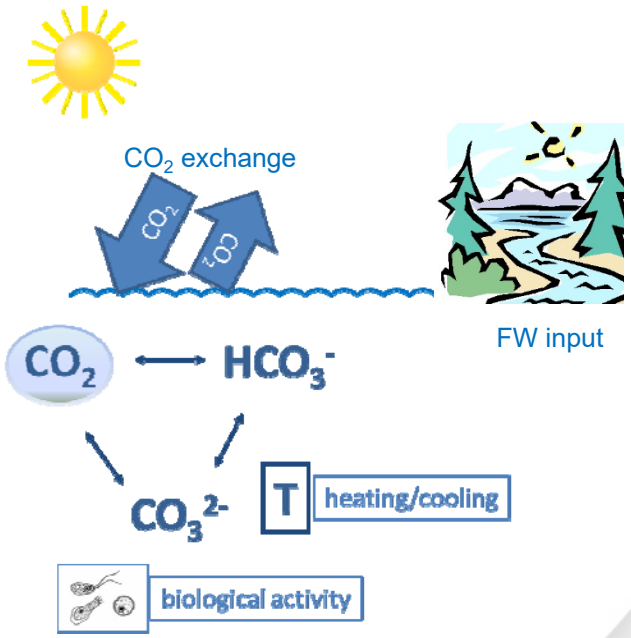
Oceanic inorganic carbon system

Four master variables



Minimum two (plus ancillary variables: T, S, nutrients) are needed for a complete description

Some driving processes



Uptake of CO_2 reduces **pH** and saturation state (Ω) for calcium carbonate = Ocean Acidification (OA).

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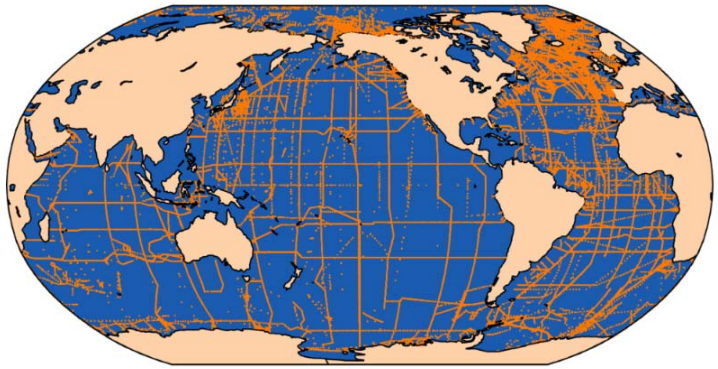
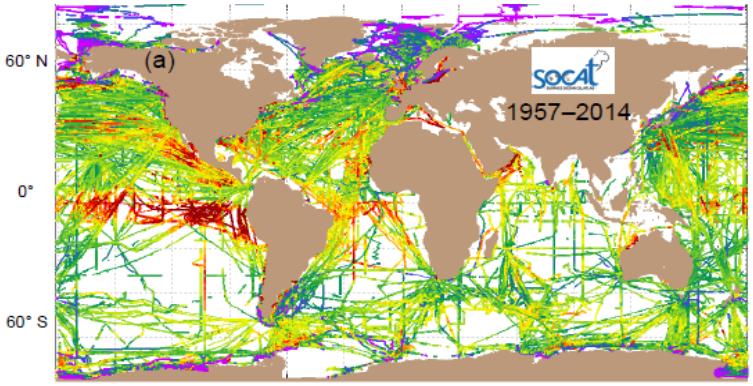
Estimating OA variables from underway fCO_2

Water column data



Surface data



Low-frequency, but fully determine the inorganic carbon system (two or more variables) e.g. Glodap v2, http://cdiac.ornl.gov

High-frequency data, but only underway fCO_2, SST (& SSS) http://www.socat.info/

- Use water column data to identify TA = *a*SSS+*b* and *a*pply to UW SSS
- Combine resulting 'UW' TA with UW fCO_2 & SST to determine the complete oceanic CO_2-system (e.g. *Lauvset et al, 2015. Biogeosciences*)

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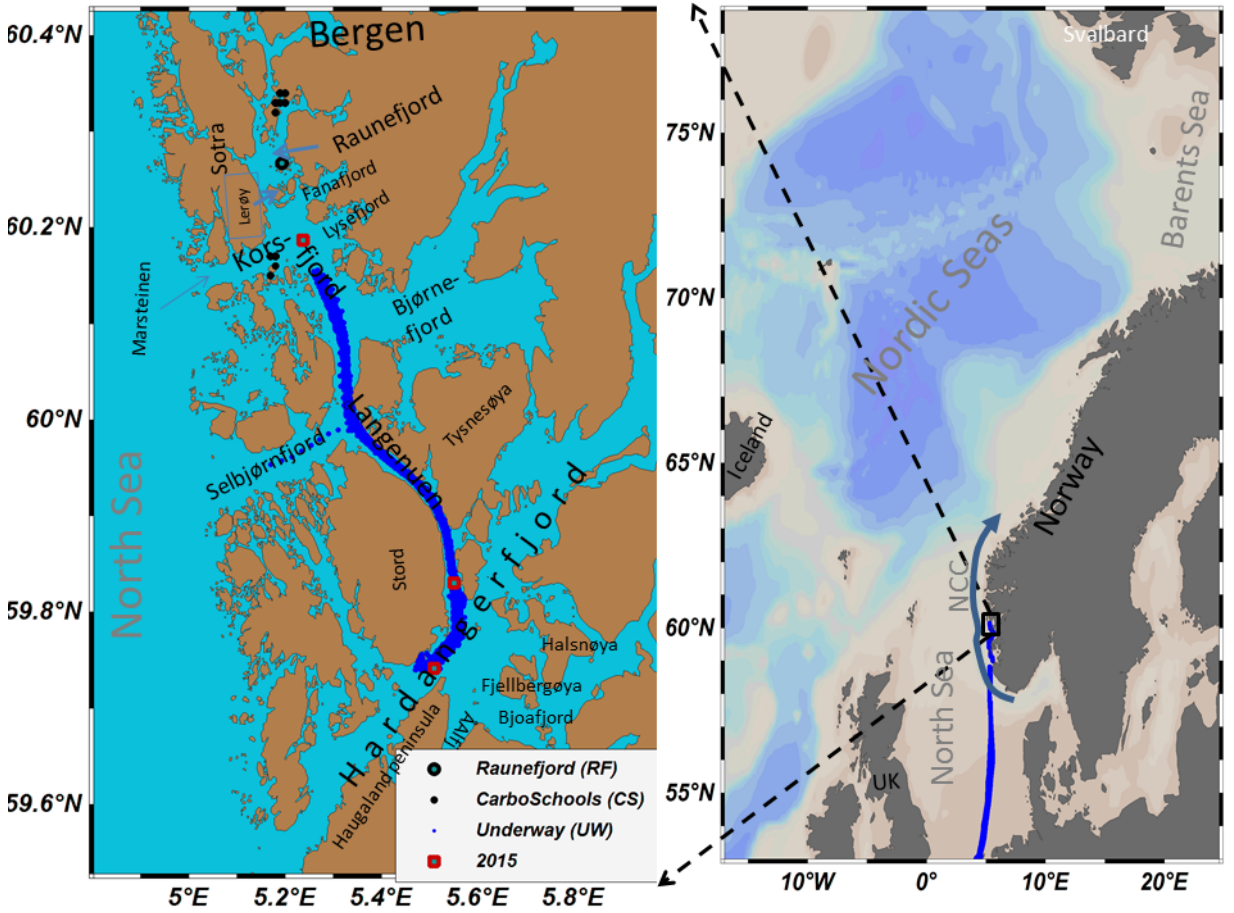
Study are and data

Carboocean (UW):
UW fCO2 & SST, 2005-2009

CarboSchools (CS):
CTD bottle samples for DIC, Alk, S & T, 2007-2010

Biological station (RF):
CTD bottle samples for S & T, 2007-2008



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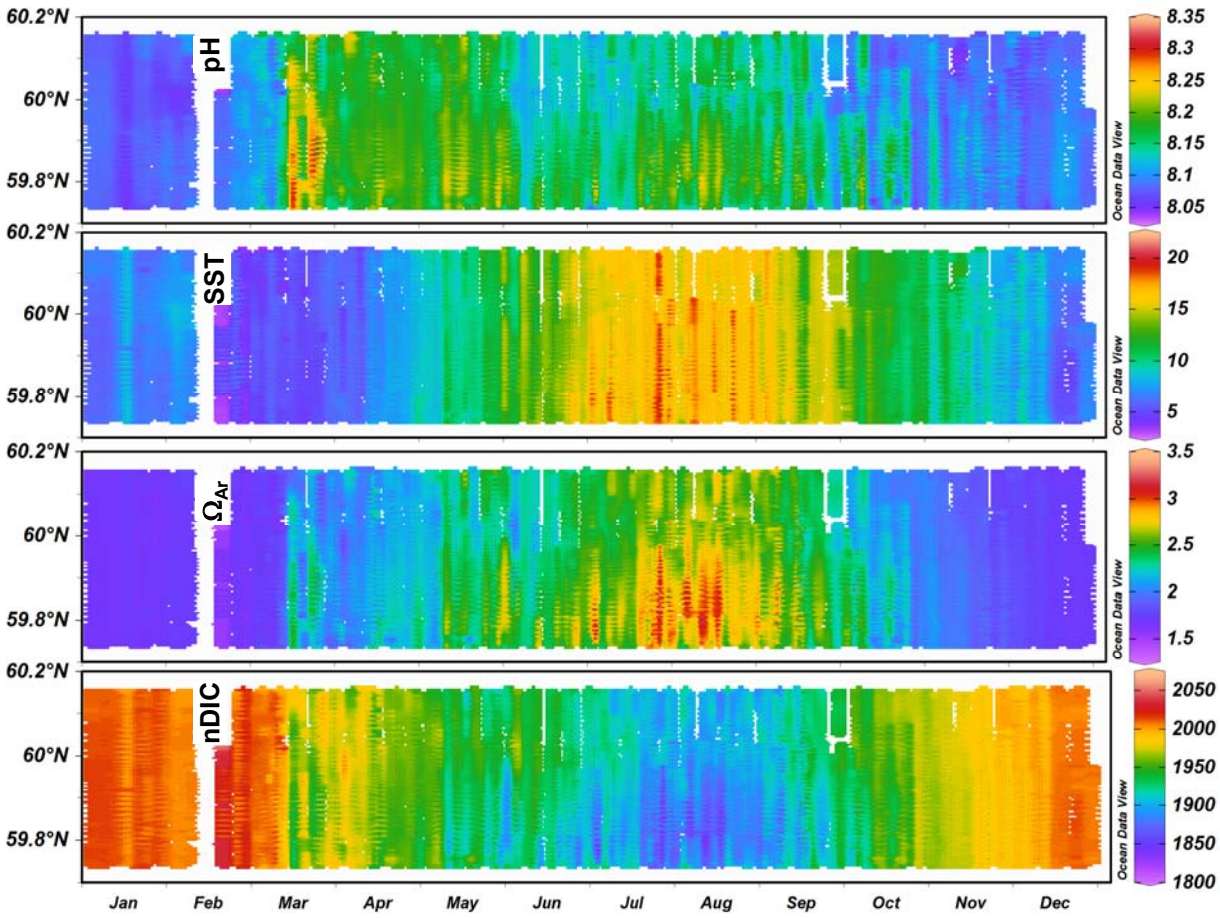
Results: spatiotemporal variations

- Strong seasonal and spatially coherent variations
- Changes in pH and Ω_{Ar} de-coupled.
- High Ω_{Ar} and intermediate pH values during summer. low Ω_{Ar} and pH values in winter.
- Typical IAVs of Ω_{Ar} and pH 0.015 and 0.1, respectively.
- No clear trend



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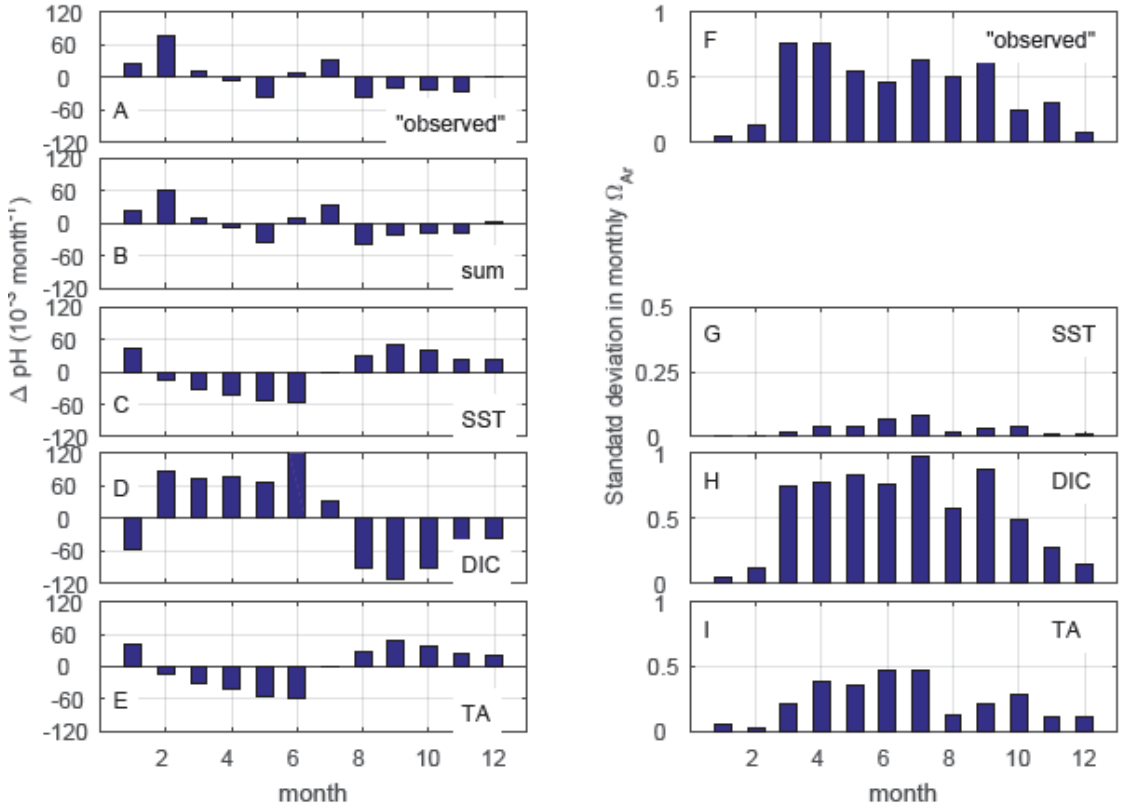
Results: drivers of seasonal changes

Seasonal changes in DIC and TA were the most important drivers of pH and Ω_{Ar} changes while SST also was an important driver for pH.



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Summary

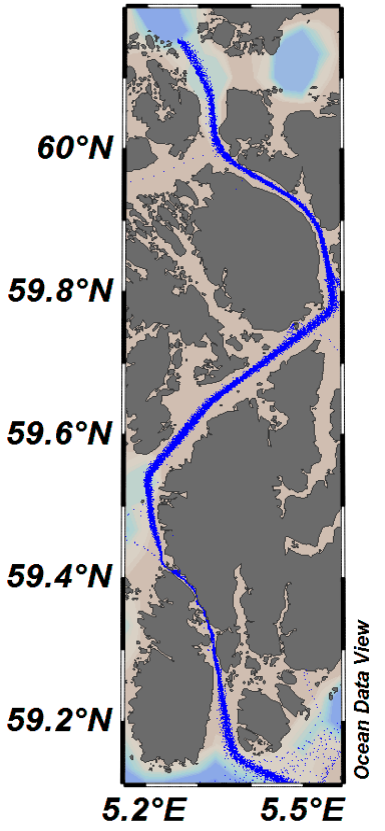
- We have been able to estimate the seasonal changes and drivers of pH and Ω_{Ar} across western Norwegian fjords using underway fCO_2 and SST data combined with data from research cruises and empirical relationships.

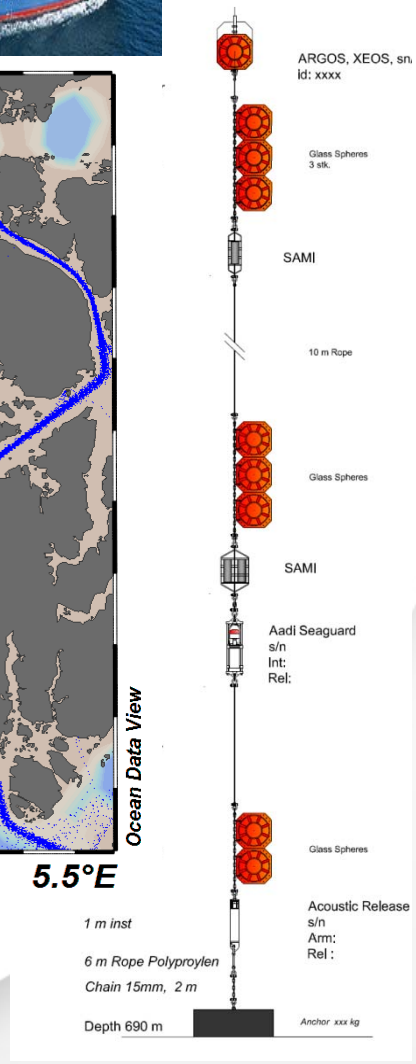
- During summertime the study area embodied warm surface water with high Ω_{Ar} and intermediate pH values. During winter, the surface water was cold with low Ω_{Ar} and pH values.

- Seasonal changes in DIC and TA were the most important drivers of pH and Ω_{Ar} changes. Additionally, SST was an important driver for pH.

- We have shown that the strong correlations of pH and Ω_{Ar} with fCO_2 and $fCO_{2@meanSST}$, respectively, provide an approach to interpolate pH and Ω_{Ar} values both seasonally and spatially.

Monitoring of OA in the fjords





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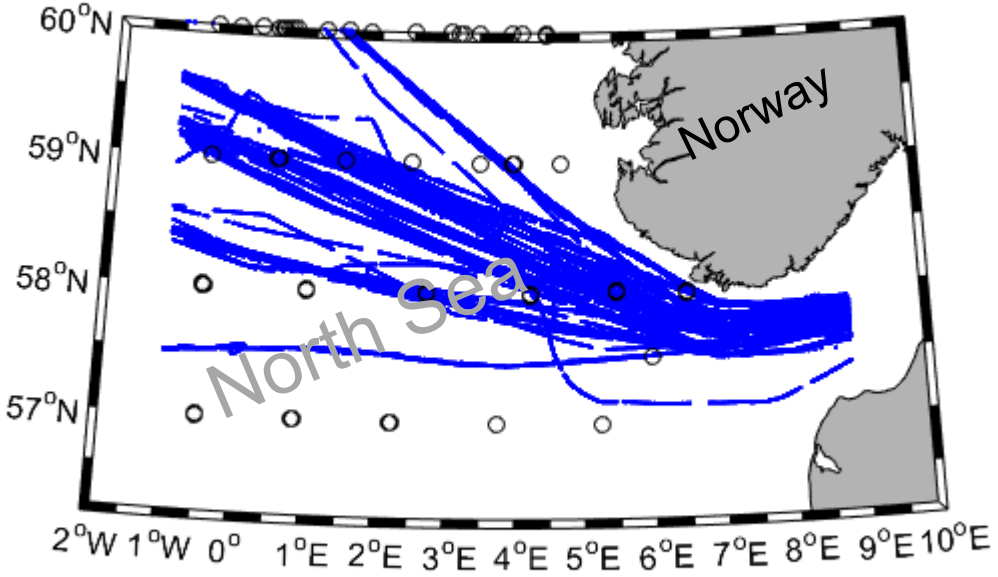
Analyses of North Sea data (ongoing)



Water column data: 2001/2002/2005/2008/2011
(Helmuth Thomas and co-workers)

Underway data (MS Nuka Arctica): 2005-2016

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Slide 10

AO1 Abdirahman Omar, 26-09-16

Thank you!

This work would not have been possible without the generosity and help of the liner company SeaTrans AS and the captains and crew of MS Trans Carrier.

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