Project information

Keywords
Arctic Ocean, Oceanography, Sea-ice, Biogeochemistry, Tracer, Pacific, Atlantic, Inflow, Outflow #trimodalFRAM

Project title
TRIMODAL: Using Tracers, Atmospheric Indices and Model Output to explain changes in the Arctic Ocean Inflow and Outflow through Fram Strait

Year
2016

Project leader
Paul Dodd, Norwegian Polar Institute, paul.dodd@npolar.no

Geographical localization of the research project in decimal degrees (max 5 per project, ex. 70,662°N and 23,707°E)
Fram Strait: N 78° 50°, W 015° 00' to N 78° 50', E 010° 00'

Participants

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Flagship
Arctic Ocean

Funding Source

1 000 000 NOK from the Fram Centre Arctic Ocean Flagship, plus 757 000 NOK in-kind contributions from NPI, IMR and the OA-State project in the form of ship time and laboratory and data analysis time.

Summary of Results

- 31 sections of historical N:P measurements (1984-2015) across Fram Strait were collated and passed QC checks.
- Derived Pacific water fractions in Fram Strait reveal distinct high and low Pacific water regimes lasting several years.
- Comparison of observations in Fram Strait and in remote locations suggests that a strong, coherent pulse of Pacific water travelled past the North Pole, though Fram Strait and on to Denmark Strait in 2011/2012
- Early results of NAOSIM model experiments including a Pacific water tracer compare favourably with observations of Pacific water in Fram Strait and reval new information about the pathways of Pacific water in the Arctic Ocean. The results suggest NOASIM experiments will improve understanding of the upstream drivers of changes observed in Fram Strait and will be continued.

Tables 1-3 below list the progress made with each of the tasks described in the 2016 proposal.

WP1: Identification of freshwater sources, optimizing and extending the time series of freshwater tracers and fractional freshwater transport estimates *Paul Dodd*, Post-doctoral research assistant, Mats Granskog, Agneta Fransson, Melissa Chierici, Laura de Steur*				
Q1 2016	Recruit post-doctoral research assistant (9 month position)	**Contract shortened** Due to reduced funding an assistant without a PhD was employed for 5.5 months: August – December 2016	PD	
Q1-Q2 2016	Develop a method to estimate precipitation using $\delta^{18}O$ & A_T	**Completed** Paper describing method circulated within TRIMODAL project.	PD, MG, AF, MC	
Q2-Q3 2016	Collate the 25-yr series of nutrient measurements and produce a time series of the Pacific water fraction in Fram Strait.	**Completed** Additional historical data collated. Better than expected.	NN	
Q3-Q4 2016	Collate the 15-yr series of $\delta^{18}O$ measurements and produce a time series of run-off and sea-ice meltwater fractions in Fram Strait	**Completed** Completed as expected.	NN	
Q2-Q3 2016	Assessment of fractional transports using currents and tracer fractions	**Expected Q4 2016** The shortened research assistant contract has slightly delayed this task.	LdS	
Q4 2016	Write paper (1) Composition and Quantity of Freshwater Exported from the Arctic Ocean Though Fram Strait (1982-present). Submission to JGR-Oceans	**On schedule** The paper will focus on Pacific freshwater and factors affecting its path through the Arctic Ocean.	PD, NN, LdS	**<Deliverable 1**
Q4 2016	Deliver time series of fractional freshwater transports to WP2 & WP3	**On schedule**	NN, PD, LdS	**<Deliverable 2**
Q1 2017	Project Workshop in Tromsø	**On schedule** 2-day kick-off workshop with international partner: June 2016 ½ day WP1 meeting with international partner: October 2016		
Q1-Q2 2017	Calculate 4-year time series of weekly freshwater fractions at 8°W in Fram Strait using data from moored samplers deployed from 2010 to 2014	**Dropped** Due to reduced research assistant contract.	PD	
Continuous	Organize $\delta^{18}O$, N:P & A_T sample collection during annual cruises and subsequent measurements to extend the time series	**On schedule** 2016 sampling completed. Laboratory analysis of d18o, At and nutrients in progress	PD, MG, LdS, MC	

Table 1: Progress summary for WP1

WP2: Identification of Atlantic water masses *Justin Gwynn*, Katrin Bluhm, Laura de Steur, Michael Karcher*				
Q3-Q4 2016	Interpretation of new (2016) and existing ^{129}I and ^{127}I speciation data	**On schedule**	JG, KB	
Q1 2017	Project Workshop in Tromsø	Work planned to begin in 2017		
Q1-Q3 2017	Assess observational data for ^{129}I and ^{127}I speciation with other hydrographic tracers provided by WP1	Work planned to begin in 2017	JG, KB	
Q3-Q4 2017	Write paper (2) The (iodine) Tracer Properties of Inflowing, Outflowing and Re-circulating Atlantic Water in Fram Strait and Residence Times in the Arctic Ocean. For submission to Marine Chemistry	Work planned to begin in 2017	JG, KB, LdS	**<Deliverable 3**
Q4 2017	Provide ^{129}I source term function and observations to WP3	Work planned to begin in 2017	JG	**<Deliverable 4**
Q1 2018	Identify key areas for further targeted sampling using model outputs from WP3.	Work planned to begin in 2017	MK, JG	
Continuous	Organize ^{129}I and ^{127}I speciation sample collection during annual cruises subsequent laboratory analysis to extend the time series	**On schedule.** 2016 sampling completed. 127I Sample analysis complete 129I Samples under lab analysis.	JG, KB	

Table 2: Progress summary for WP2

WP3: Studying regional and basin scale drivers of variability using observations and modeling *Tore Hattermann*, Frank Gaarsted, Michael Karcher, Justin Gwynn, Paul Dodd, Laura de Steur, Mats Granskog*				
Q2-Q4 2016	Complete new multiyear runs within the on-going Fram Centre ModOIE project coordinated with the needs of this project and deliver output.	**On schedule** New model runs covering a multiyear time period until present are currently in preparation in collaboration with MET	TH,FG	
Q1 2017	Project Workshop in Tromsø	Work planned to begin in 2017		
Q1-Q2 2017	Compute climatic indices from atmospheric reanalysis and correlate with tracer time series to test existing and new mechanistic transport hypotheses	**Ahead of schedule** Large scale climatic indices obtained / computed. Comparison with Pacific water tracer time series in progress. Main Work planned to begin in 2017	PD, LdS	
Q2-Q4 2017	Obtain passive tracer and Eulerian velocity fields from NAOSIM and implement Lagrangian tracer algorithm for ROMS and NAOSIM	**Ahead of schedule** Pacific water tracer fields extracted from NAOSIM and compared with time series of observations in Fram Strait Main work planned to begin in 2017	TH, FG, MK	**<Deliverable 5**
Q1-Q2 2018	Analyze model output to validate mechanistic hypotheses on drivers of transport variability found from time series analysis	Work planned to begin in 2018	TH, MK, PD +others	
Q3-Q4 2018	Write paper (3) Comparison of Modeled Transports of Freshwater Fractions and Tracer-Derived Observations of Freshwater Fractions under various atmospheric conditions. Journal to be decided.	Work planned to begin in 2018	TH, PD +others	**<Deliverable 6**
Q3-Q4-2018	Write paper (4) Atmospheric forcing of freshwater transport in the Arctic Ocean evaluated using observations and model simulations of the Fram Strait Freshwater Outflow. For submission to JGR-Oceans	Work planned to begin in 2018	PD, TH +others	**<Deliverable 7**

Table 3: Progress summary for WP3

Master and PhD-students involved in the project

In 2016 TRIMODAL paid travels costs so that Phillip Anhaus (Masters Student, UiB), Silje Smith-Johnsen (PhD student, UiB) and Antonia Doncilla (PhD Student, University of Edinburgh, UK) could join NPI's 2016 Fram Strait cruise to assist with tracer sampling. These students received one-to-one hands-on training in setup and use of standard oceanographic instruments (ADCP, CTD, salinometer) and initial data processing.

Torgeir Blæsterdalen was employed at a research assistant for 5.5 months within TRIMODAL in August 2016 immediately after finishing his master thesis at UiT and has received training in the use of biogeochemical tracer techniques.

For the Management

TRIMODAL will identify important processes affecting the Arctic Ocean circulation and deliver essential new knowledge that will improve ocean and sea-ice predictions. In 2016 the project combined new and existing tracer measurements from Fram Strait to provide a continuous 31-year time series that is now being used to identify processes driving variations in currents flowing in and out of the Arctic Ocean in conjunction with early results from model simulations. In 2017 & 2018 the long time series of observations will be compared with results from two different numerical models to investigate how the changing atmosphere, declining sea-ice cover and the internal response of the Arctic Ocean influence circulation.

Published Results/Planned Publications

The following publications are planned for the 3-year project period:

(1) Composition and Quantity of Freshwater Exported from the Arctic Ocean Though Fram Strait (1982-present). Submission to JGR-Oceans Q4 2016. (In preparation, the paper will focus on changes in Pacific freshwater fractions and factors affecting the path of Pacific water through the Arctic Ocean).
(2) The (iodine) Tracer Properties of Inflowing, Outflowing and Re-circulating Atlantic Water in Fram Strait and Residence Times in the Arctic Ocean. For submission to Marine Chemistry Q4 2017. (Work to begin 2017).
(3) Comparison of Modeled Transports of Freshwater Fractions and Tracer-Derived Observations of Freshwater Fractions under various atmospheric conditions. For submission Q4 2018 (Work to begin 2018).
(4) Atmospheric forcing of freshwater transport in the Arctic Ocean evaluated using observations and model simulations of the Fram Strait Freshwater Outflow. For submission to JGR-Oceans Q4 2018. (Work to begin 2018).

Communicated Results

Updates from TRIMODAL's 2016 field campaign were disseminated through social media channels by the Oceans and Sea Ice group at the Norwegian Polar Institute on Instagram, Twitter and Facebook (@oceanseaicenpi). A hashtag #trimodalFRAM has been used to keep track of posts related to the project. Subscriptions to Hootsuite Pro and Iconosquare Plus social media content management systems allowed us to track available analytics for all social media channels, such as the geographic spread and age of the audience. Evaluation of performance of social media posts published on different days and time of the day helps to optimize social media posts and reach out larger audience. As a test, a Facebook promotion campaign was run for 2 weeks in order to evaluate its effectiveness for audience growth. Within the first three days of the campaign, the number of page likes doubled (> 1400 people),

thus, enlarging the audience of the project. Outcomes of the test of Facebook page promotion will be used for a planned manuscript, highlighting experience of our group in science communication and outreach via social media. Tentative submission of this manuscript is in December 2016

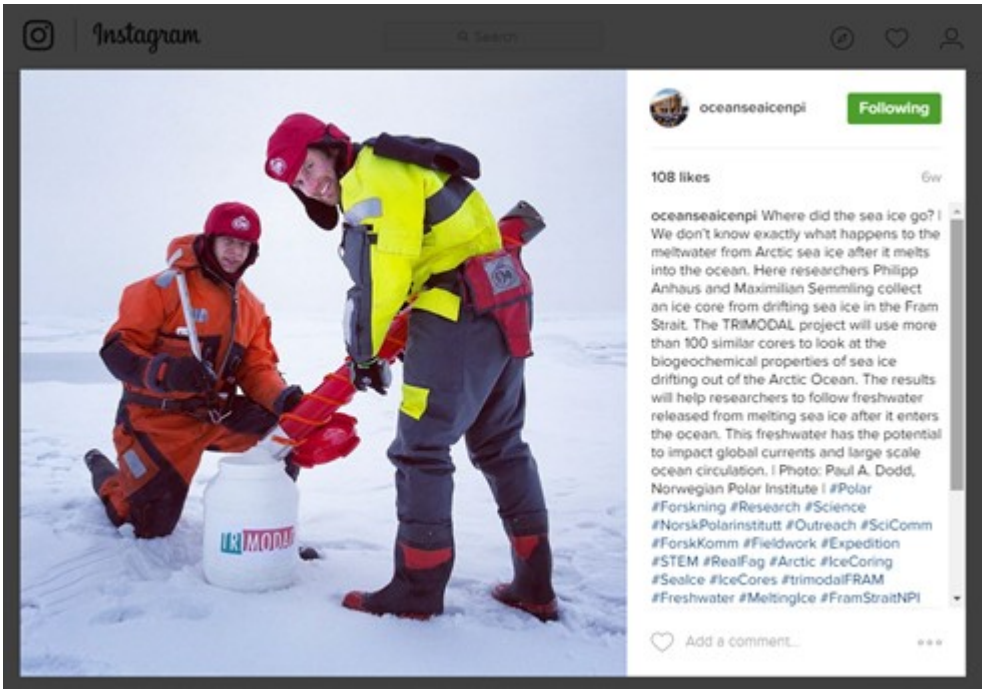

Figure 1: Example of a #trimodalFRAM social media post

Interdisciplinary Cooperation

TRIMODAL combines two different disciplines: long term observations and numerical model simulations. 25% of the partners identify themselves as numerical modellers, 75% as observationalists – the project aims to use techniques from both disciplines to investigate changes in the Arctic Ocean Inflow and Outflow.

Budget in accordance to results

Funding in 2016 was sufficient to carry out the planned sample collection and laboratory analysis, perform some basic NAOSIM model experiments and to employ a research assistant for 5.5 months from August to December.

In the 2016 proposal, we requested 9 months of research assistant time. If funding allows, we would like to re-employ the research assistant for 2 months in 2017 to ensure that observational data analysis can keep pace with the original project plan.

Given the promising early results of NAOSIM modelling experiments used to trace Pacific Water, we would like to conduct additional NAOSIM model experiments to trace river water and sea ice meltwater. These additional experiments will improve our understanding of the distinct dynamics of these two important components of freshwater export in Fram Strait and support the interpretation of observed data.

Could results from the project be subject for any commercial utilization

No

Conclusions

Progress in 2016 broadly followed the project plan - early results are very encouraging!