

# Changing Arctic Carbon cycle in the Coastal Ocean Near-shore (CACOON)



**NERC**  
SCIENCE OF THE ENVIRONMENT



Bundesministerium  
für Bildung  
und Forschung



**Northumbria University**  
NEWCASTLE



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**PML**

Plymouth Marine  
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Norwegian Institute for Water Research



WOODS HOLE  
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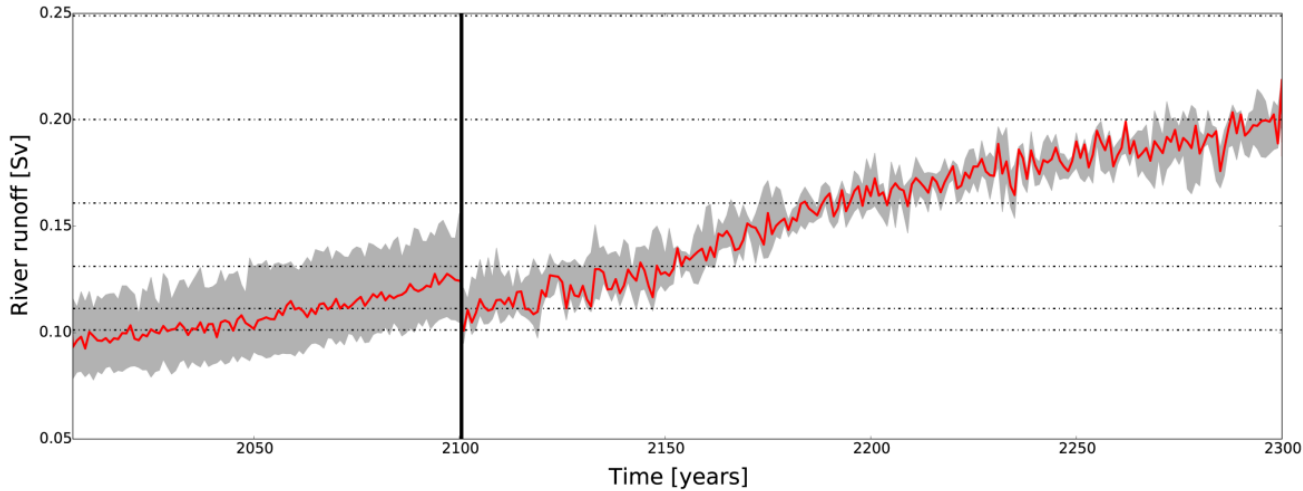
# Who are we all?



- Multinational: 11 scientists with 8 different nationalities are involved in the core group
- Multidisciplinary: marine geochemistry, terrestrial geology and multi-scale modelling

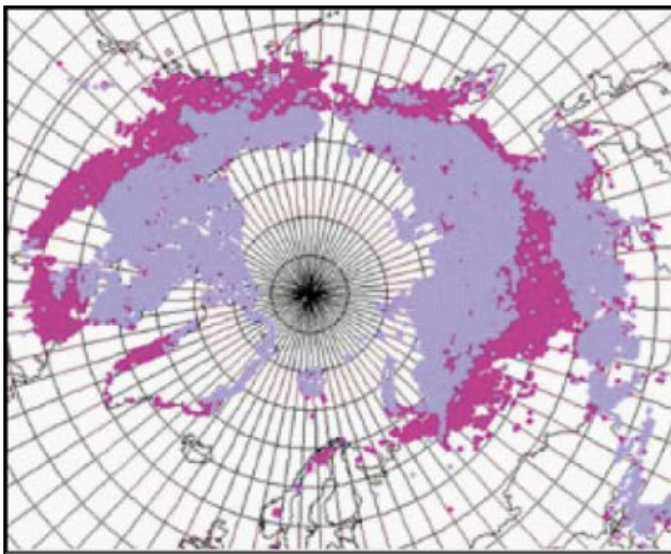
# Rationale behind CACOON?

## Increased runoff



Expected annual mean runoff to the AO based on CMIP5 models using RCP 8.5. Red = ensemble median. Left 2005 - 2100. Right 2100 - 2300.

## Increased permafrost thaw



- Permafrost
- Predicted permafrost loss (2100)

Expected permafrost lost until 2100. Grey area shows the recent permafrost distribution

Schaefer et al. 2011; McGuire et al. 2009; Euskirchen et al. 2006

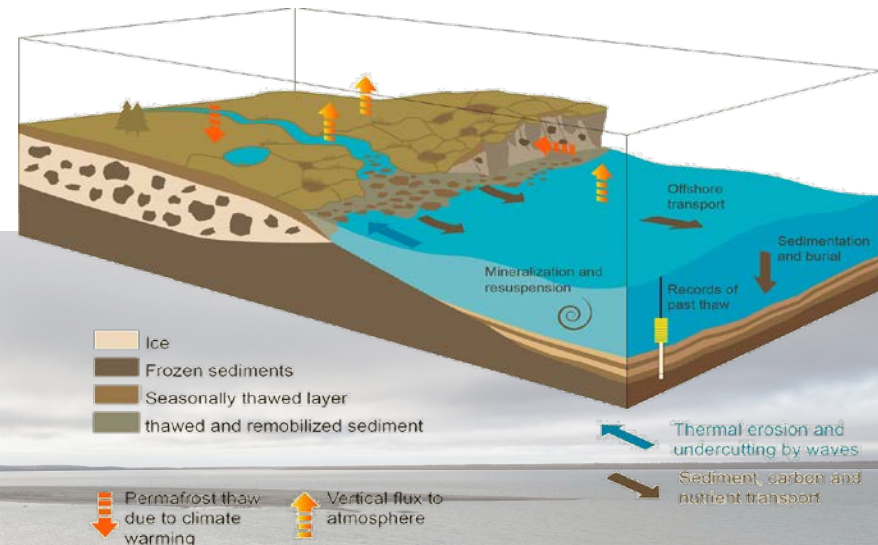
# “core” CACOON aims:

Quantify effect of:

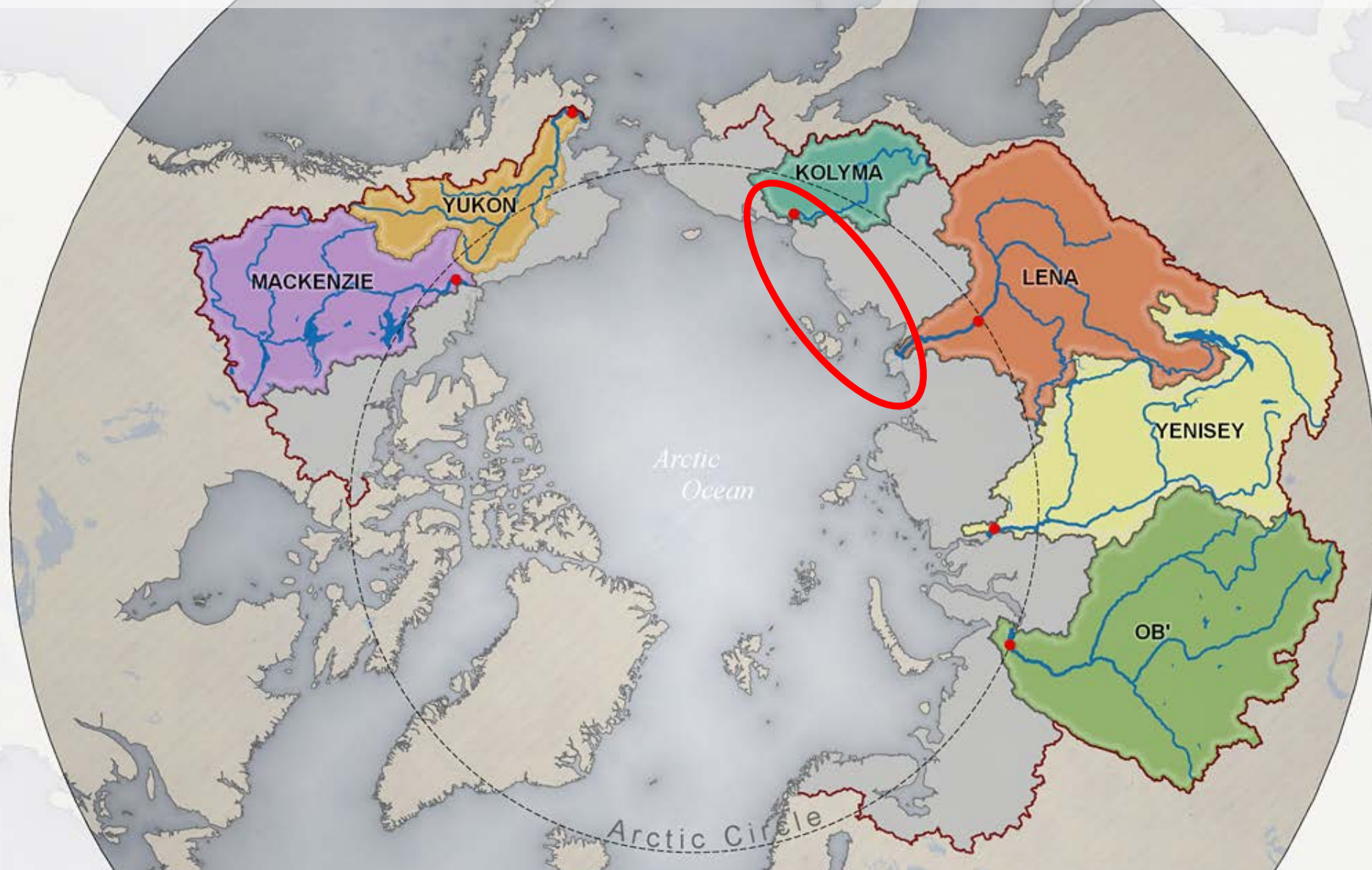
- **changing freshwater export & terrestrial permafrost thaw on organic matter delivered to AO**

Quantify

- **resultant changes on ecosystem functioning in the coastal AO**

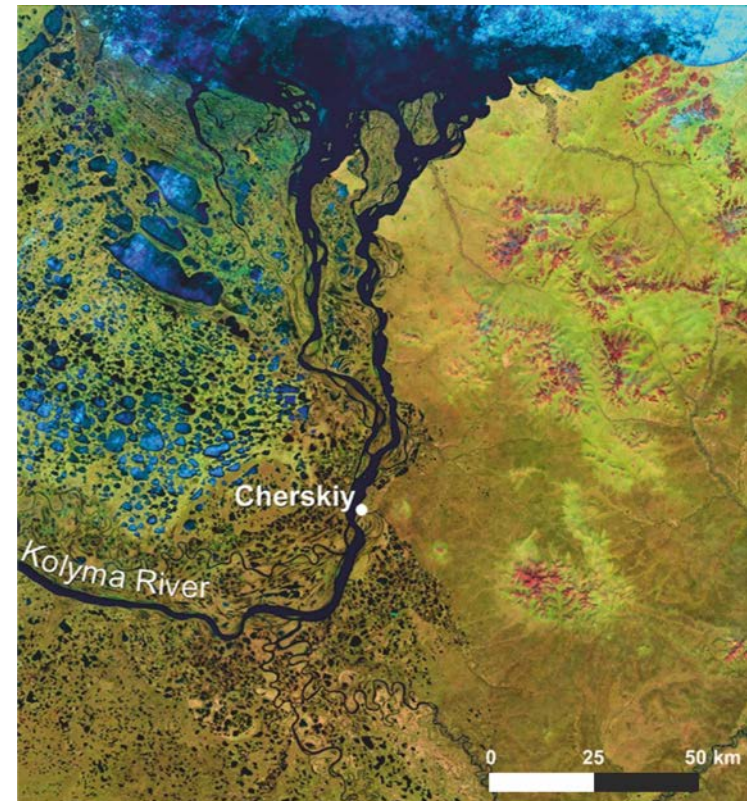
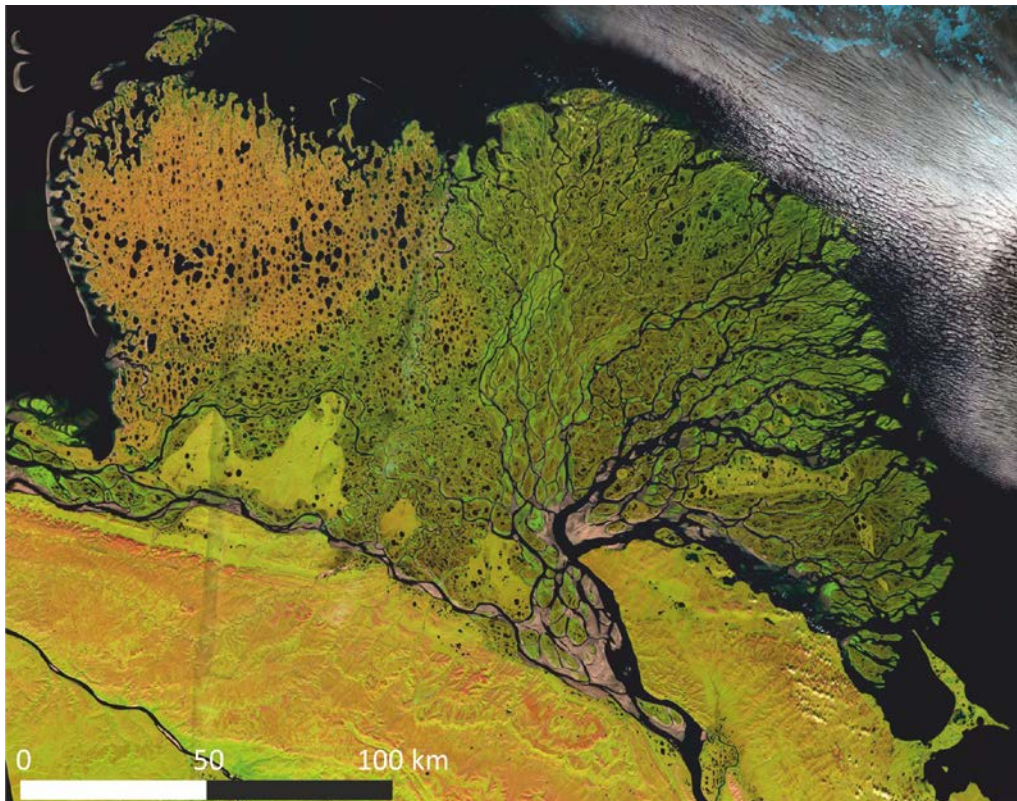


# CACOON focus region



# CACOON field work program 2019

- March/April: Lena Delta, CACOON **ice** expedition
- July/August: Lena Delta: inner-to-outer Delta traverse
- June September: Kolyma Delta



# Next milestone: CACOON ice expedition

- Departing Potsdam/Newcastle on 20.03, back on 09.04.
- 14 field days (starting from our logistical base Tiksi) with Vezdekhod (Russian all terrain vehicle) and cabin on sledges (balok) including tractor
- Staff: 4 scientists, 3 driver

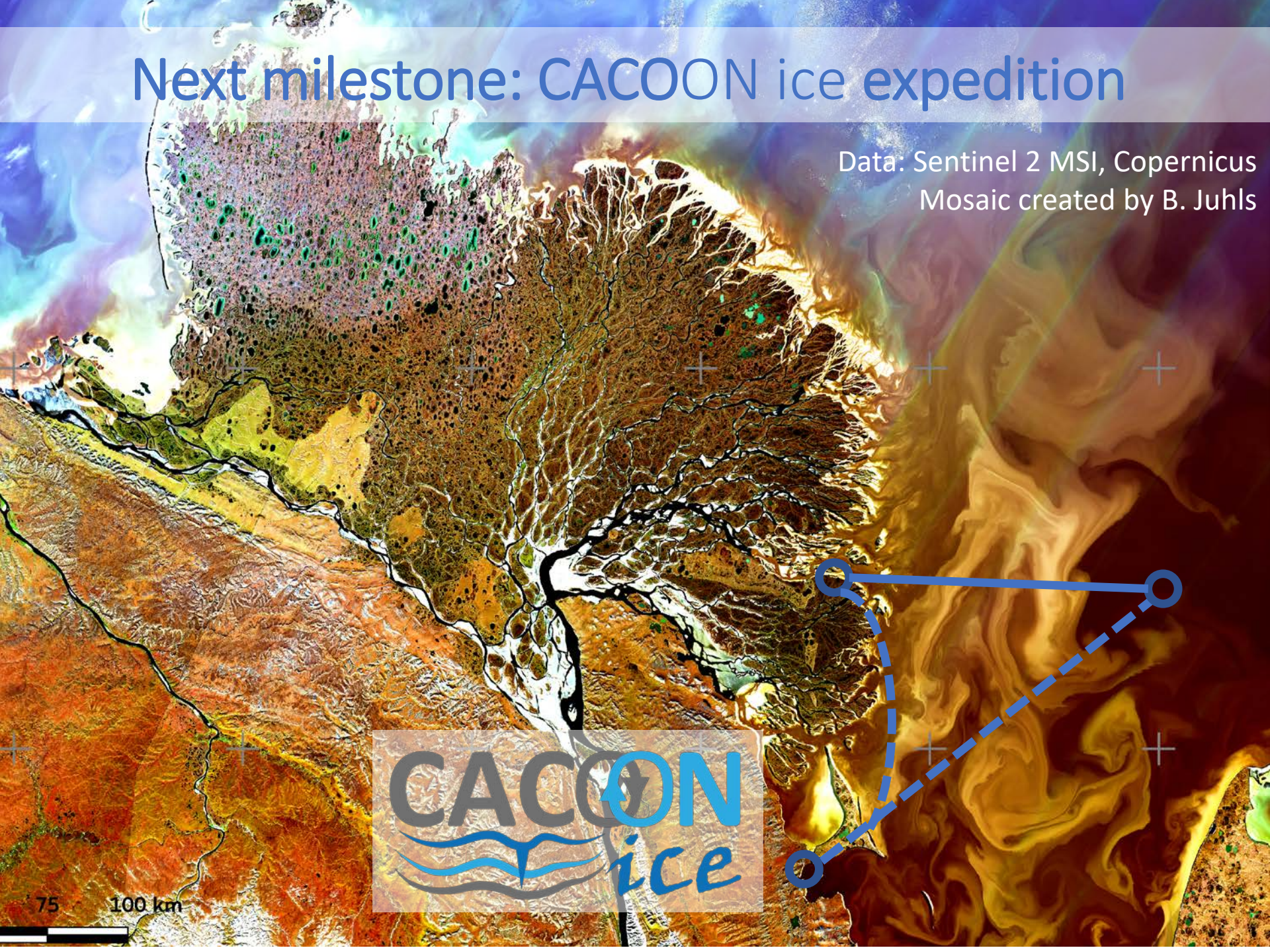
Planned sampling:

- water profile below ~2m
- 2 m ice cores
- sediment cores (surface sed.)



# Next milestone: CACOON ice expedition

Data: Sentinel 2 MSI, Copernicus  
Mosaic created by B. Juhls



75 100 km



# CACOON Lena Delta traverse

Data: Sentinel 2 MSI, Copernicus  
Mosaic created by B. Juhls



# CACOON Kolyma Delta



Cherskiy

## Planned sampling:

- Water across salinity gradient
- Repeat under ice (coast)
- Sediment samples
- Light profile across gulf

# Impact of changing DOM and freshwater

*Arctic ERSEM –*

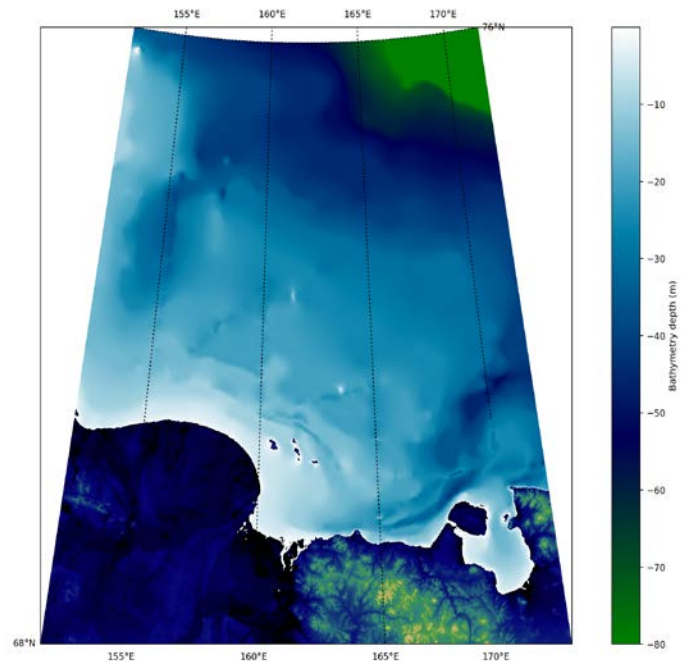
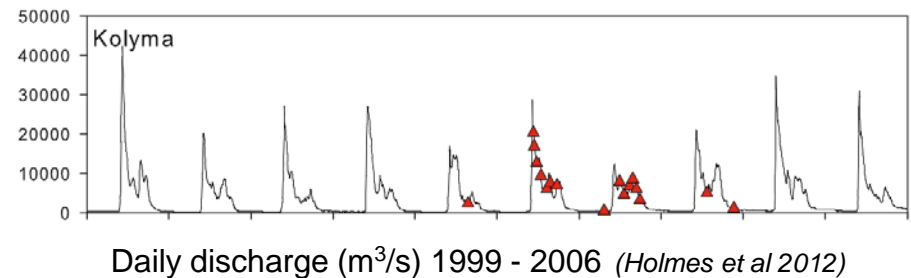
Requires: coupled modelling system of hydrodynamics, sediments, and biogeochemistry

- 3 models (FVCOM, CSTM, ERSEM) and a coupler (FABM)

This modelling system

- baseline simulation (present day)
- future scenario of increased freshwater and terrestrial DOM input

***Examine resultant changes on ecosystem functioning in the coastal AO***



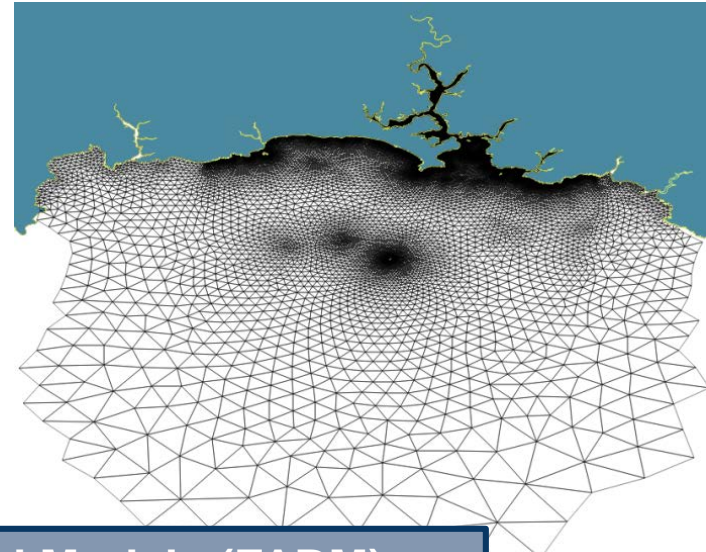
Shelf bathymetry adjacent to Kolyma river (from IBCAO, Jakobsson et al 2012)

# Model structure

## Hydrodynamics

### FVCOM

- unstructured grid model to allow resolving of complex coastlines and estuaries
- simple ice model using prescribed ice extents

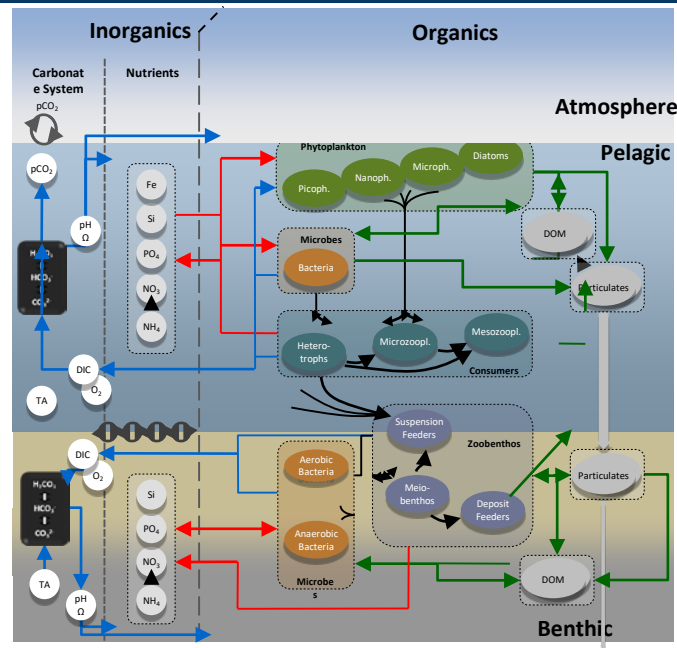


## Framework for Aquatic Biogeochemical Models (FABM)

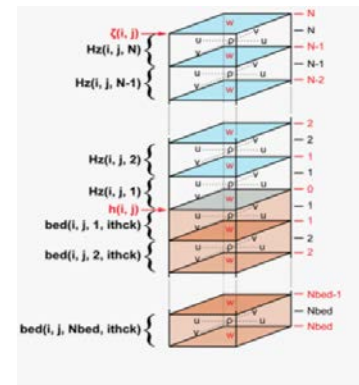
## Biogeochemistry

### ERSEM

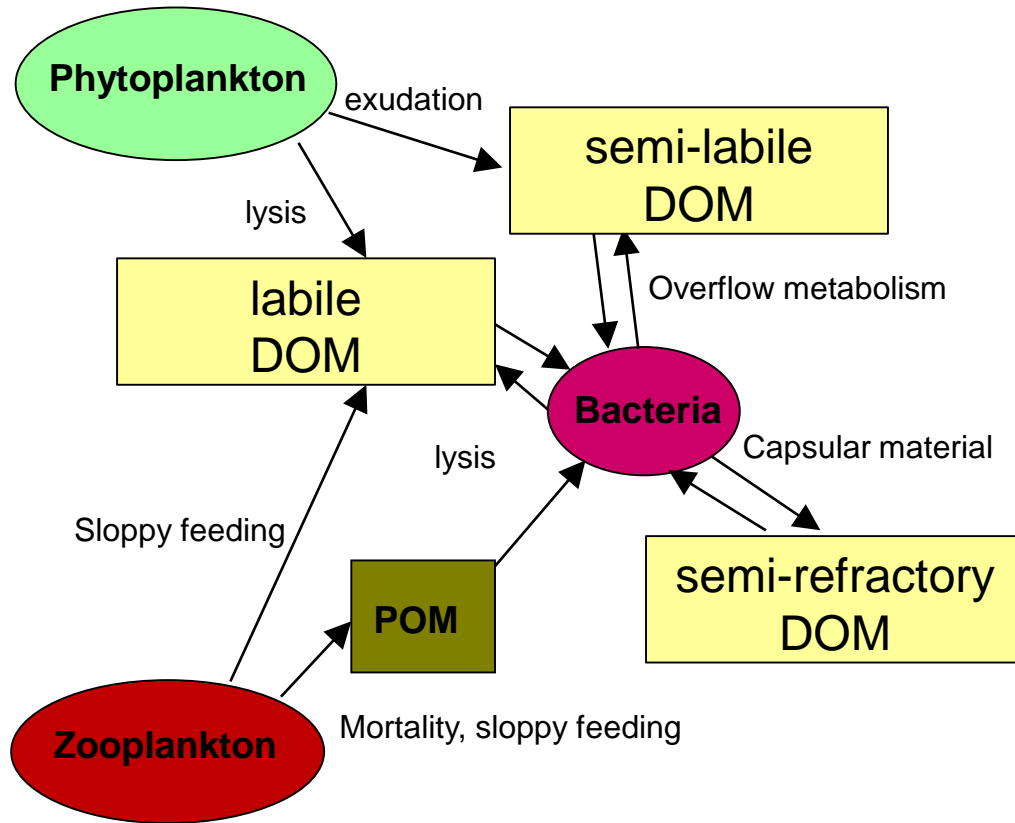
- variable stoichiometry
- resolves DOM processing and the major biogeochemical cycles



## Sediments CSTMS



# ERSEM bacteria DOM sub-model



## Model characteristics:

- Variable stoichiometry (in bacteria and DOM)
- Labile, semi-labile and semi-refractory DOM
- *Bacteria RDOM production* and variable BGE

## CACOON related developments:

- Implement new terrestrial input DOM module (developed in NERC LOCATE project)
- Develop parameters for one or more permafrost DOM classes

(Allen et al 2002; Blackford et al., 2004; Polimene et al., 2006 and 2007)

# Modelling progress

Work on Laptev sea (Lena) model

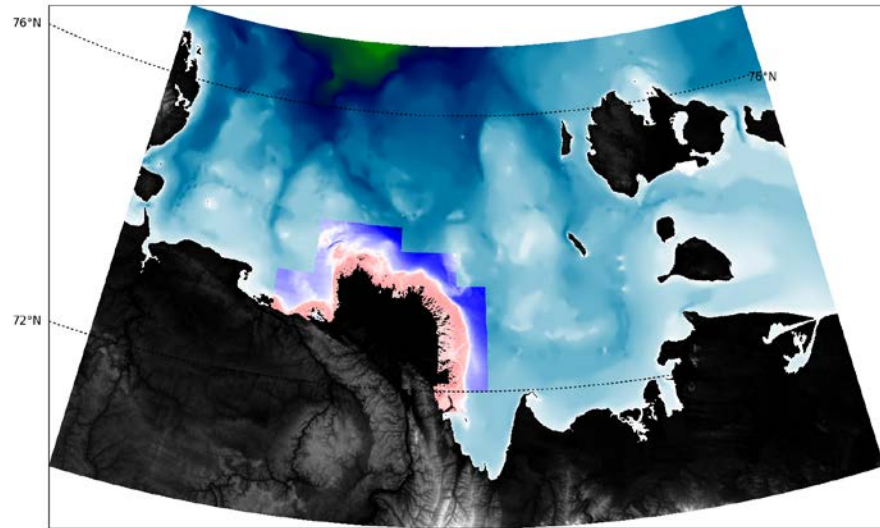
- Collating bathymetry
- Preparing forcing (river input, boundary tides, atmospheric forcing)
- Mesh generation

Terrigenous DOM code testing in 1-d ERSEM setup

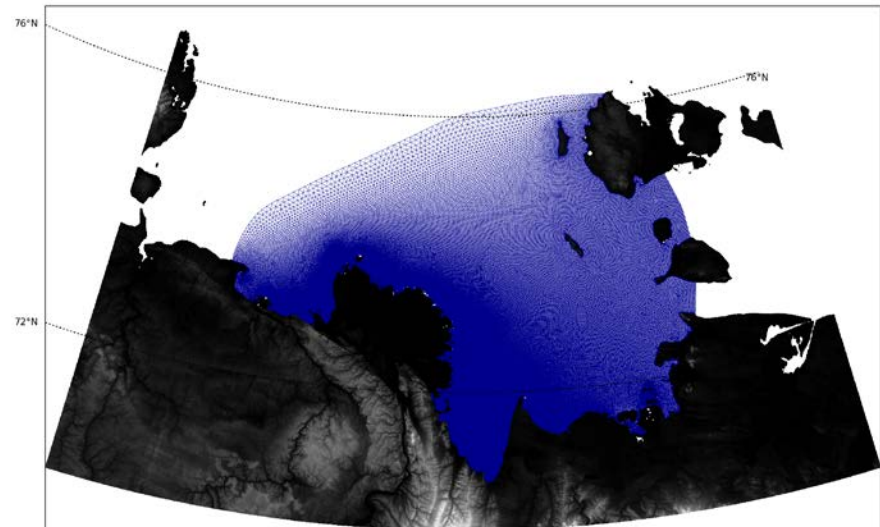
Next steps:

Refine Laptev sea mesh and run physics only simulation

Test terrigenous DOM code in 3-d setup



A) Collated bathymetry from chart data and IBCAO



B) Initial development of FVCOM model mesh for Laptev sea

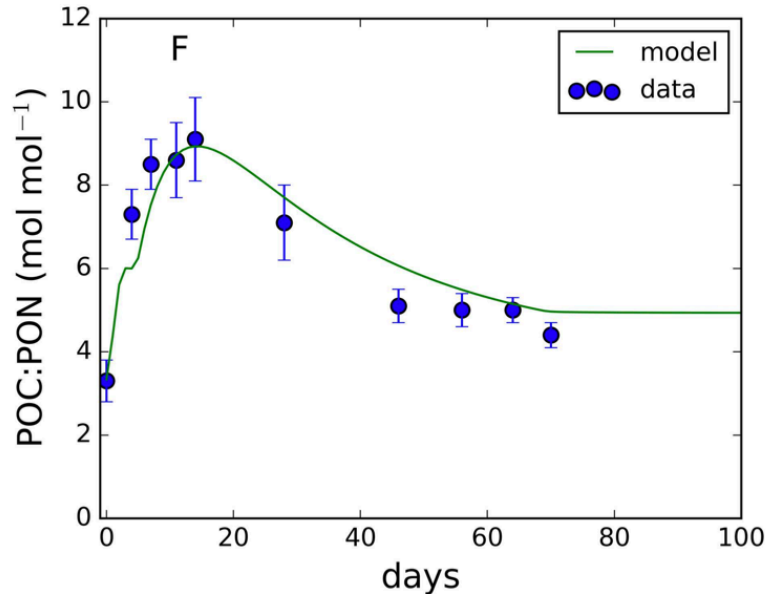
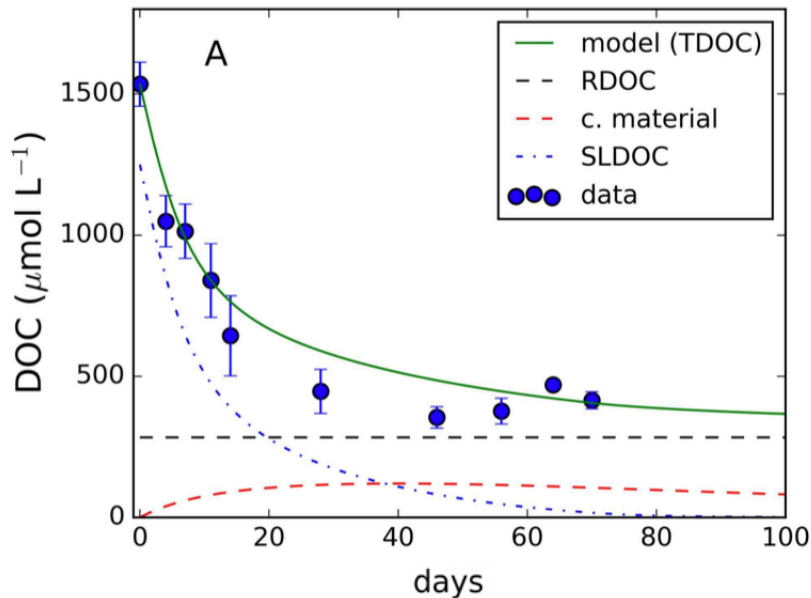
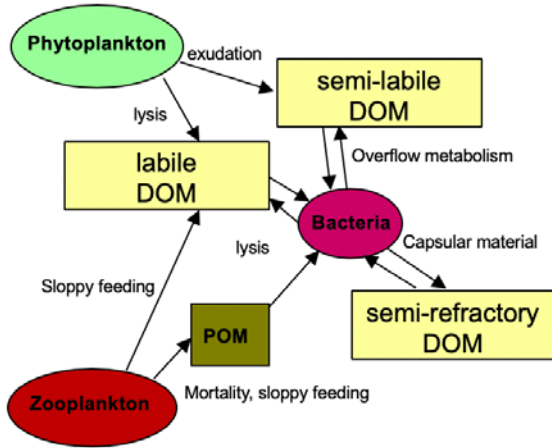


# Processes

Model parameters will be derived from field/ labwork:

- Key processes examined:

- Microbial degradation
- Photodegradation
- Flocculation



# Laboratory progress

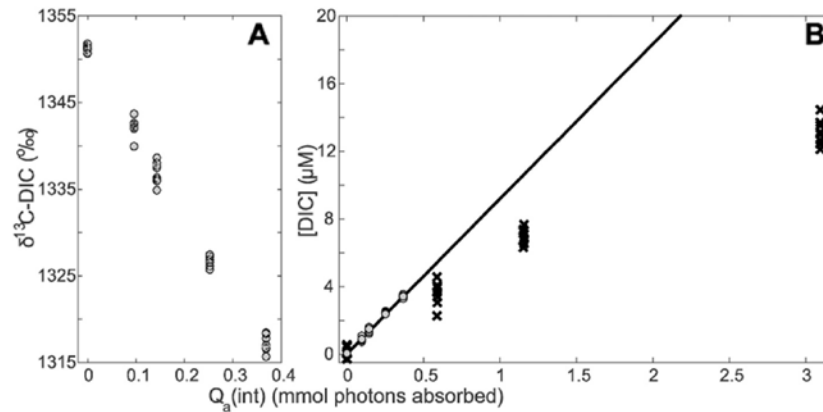
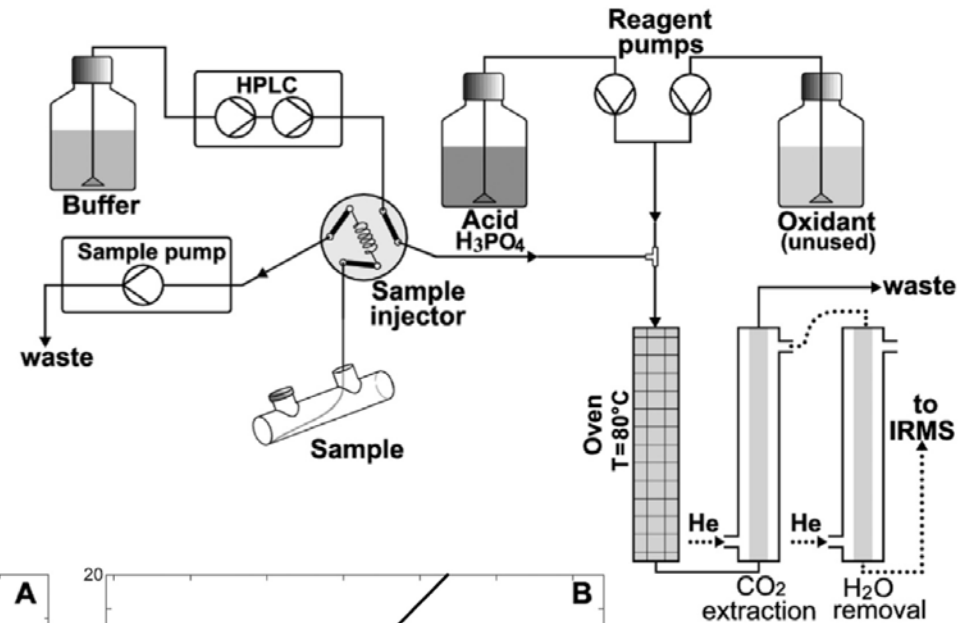
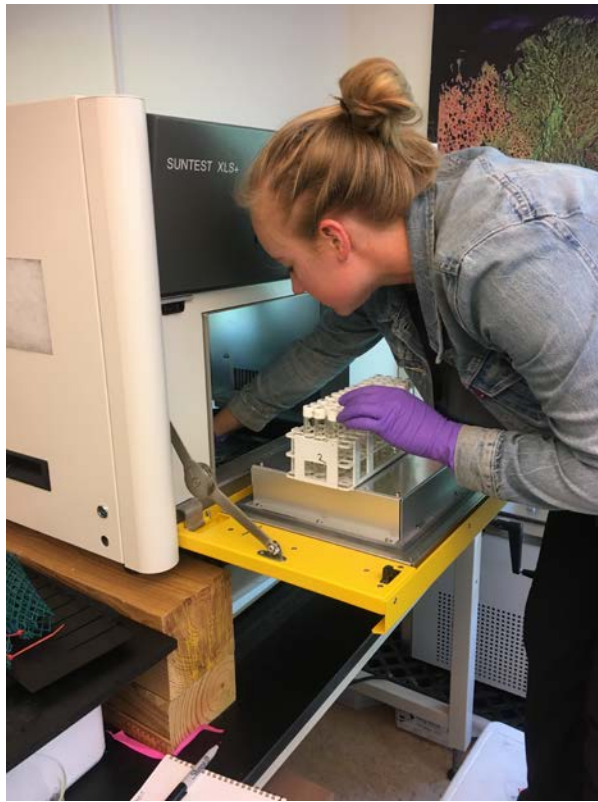
MoDIE: Moderate dissolved inorganic carbon (DI<sup>13</sup>C) isotope enrichment for improved evaluation of DIC photochemical production in natural waters



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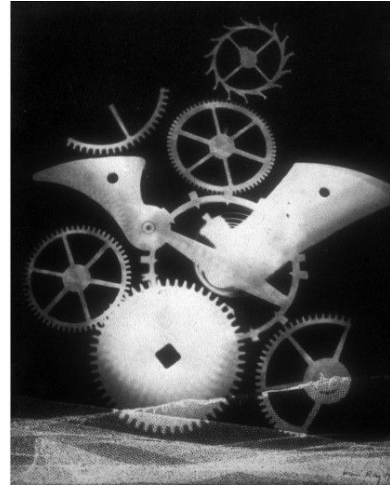




# STEM outreach

Developing workshops for 8-12 year olds

- Understand the impact of climate change on permafrost thaw in Siberia
- Use shadowgram techniques to interpret data (Man Ray- esque-*right*)



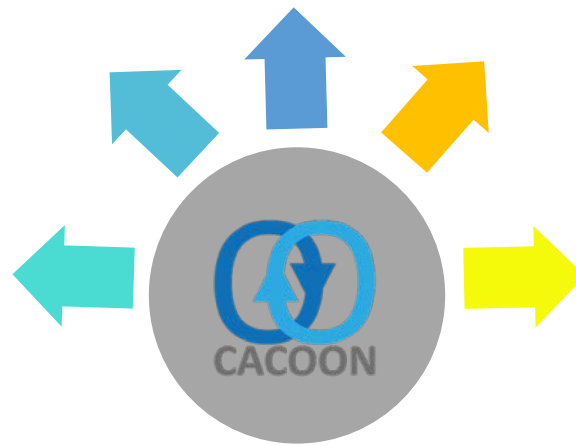
A) Example shadowgrams

3-d representation of Siberia river catchments for students to use



B) 3D printed model example

# Collaborations



<sup>1</sup>Free University, Amsterdam; <sup>2</sup>Jena University; <sup>3</sup>Potsdam Uni & AWI; <sup>4</sup>Free University, Berlin & AWI; <sup>5</sup>Massachusetts Institute of technology & Woods Hole Oceanographic Institution