TAKUVIK research activity
-Tracing biogeochemical processes of changing Arctic Ocean-

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Takuvik Joint International Laboratory

(CNRS – Université Laval)

TAKUVIK

UNIVERSITÉ LAVAL

Ville de Québec - Canada

cnrs

Plan

Major activity in *Takuvik* Laboratory

With focus on

- Primary production
- Phytoplankton phenology
- POC export to the Arctic ocean
- DOC export to the Arctic ocean
- Water sources discrimination

Overview of ongoing projects/programs

Summary and perspectives

Major Arctic campaigns

Launched by M. Babin, Takuvik			
Campaigne		**Year**	**Area**
MALINA		2009	S. Beaufort Sea
Green Edge		2015-2016	Baffin Bay
ArcticNet		2004-2017	Beaufort Sea/Baffin Bay
Others (collaborations)			
ICESCAPE		2010-2011	Chukchi/ Beaufort Sea
TARA Arctic		2013	Circumpolar Arctic
SUBICE		2014	Chukchi/ Beaufort Sea
BaySys		2017	Hudson Bay
NUNATARYUK		TBD	Beaufort Sea

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BaySys		**2017**	**Hudson Bay**
NUNATARYUK		**TBD**	**Beaufort Sea**

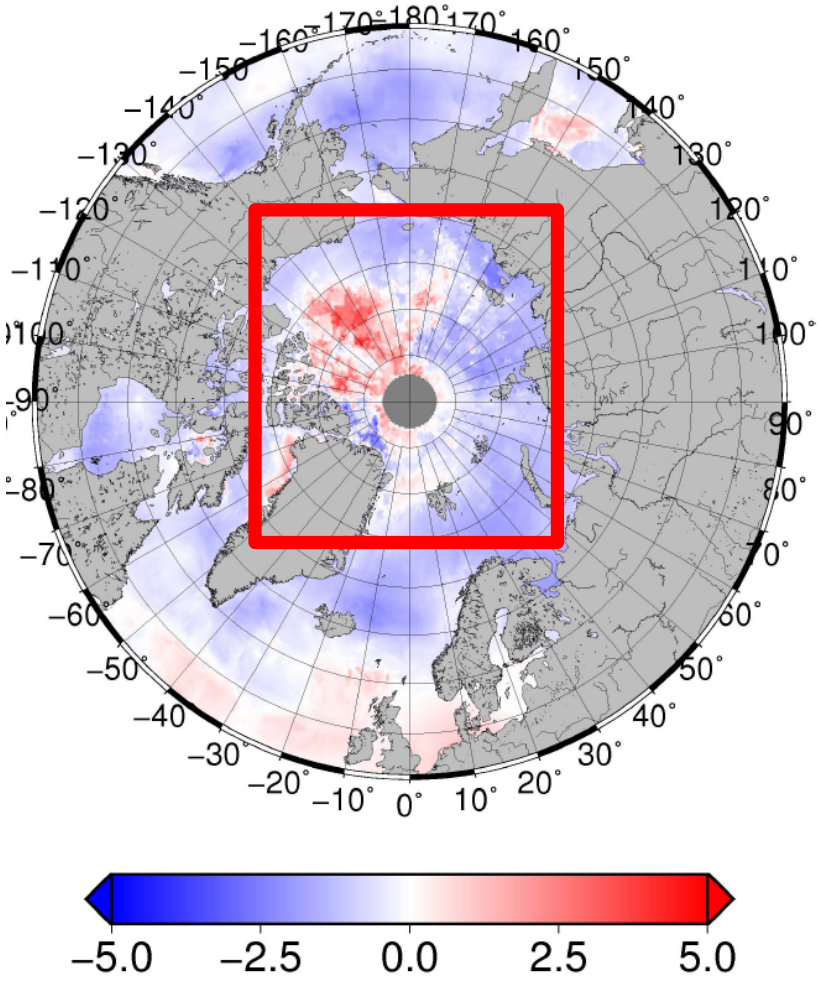
Marie-Hélène's talk

Sentinel North
(interdisciplinary research program created by Laval University)

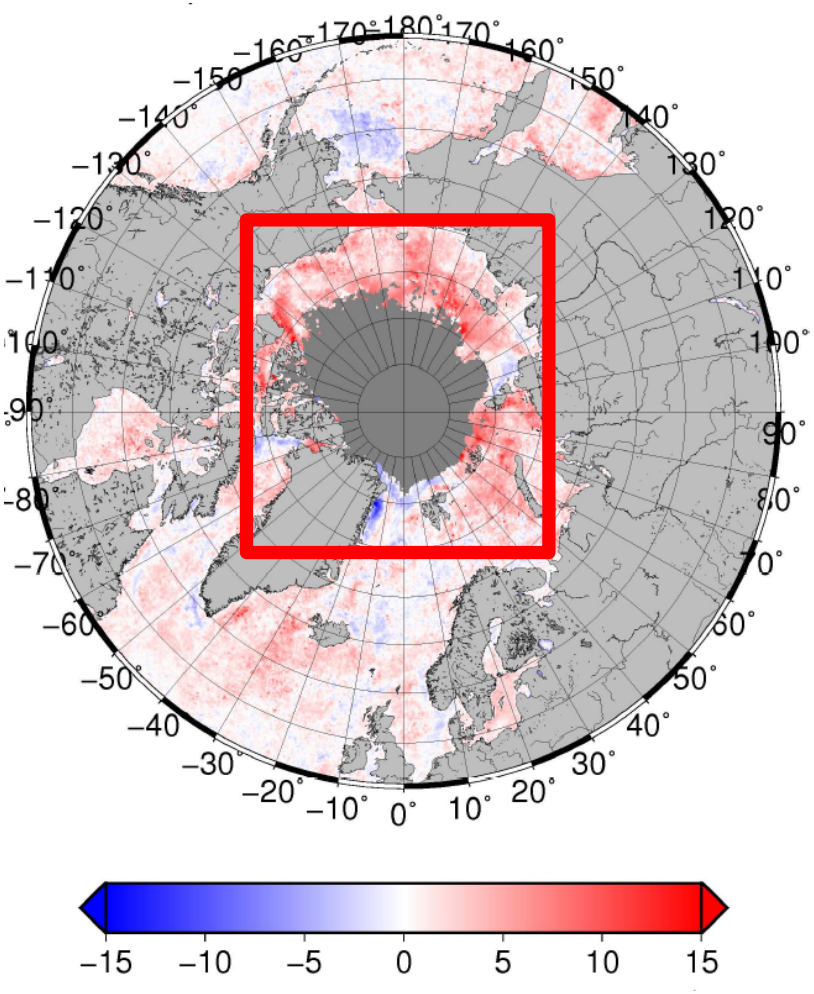
Trend in primary production

PP (1/3)	Phyto. Phenology (0/4)	POC export (0/3)	DOC export (0/3)	Water sources discrimination(0/3)

PAR(0+) trend (% yr^{-1})



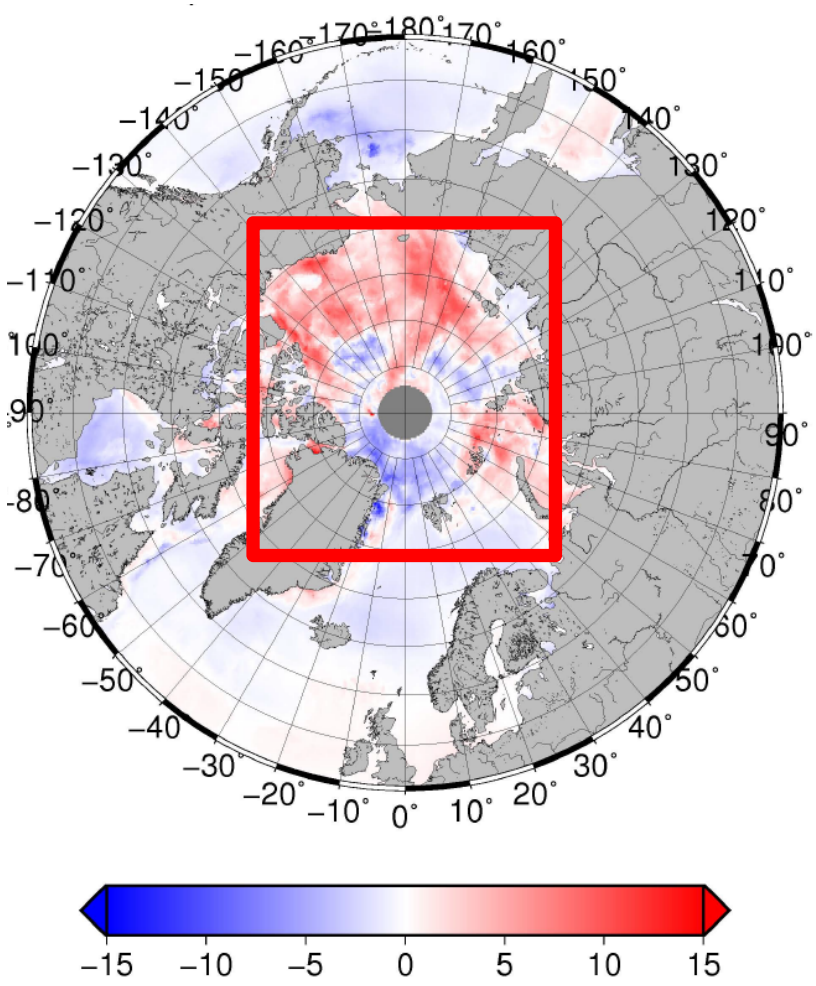
PP trend (% yr^{-1})



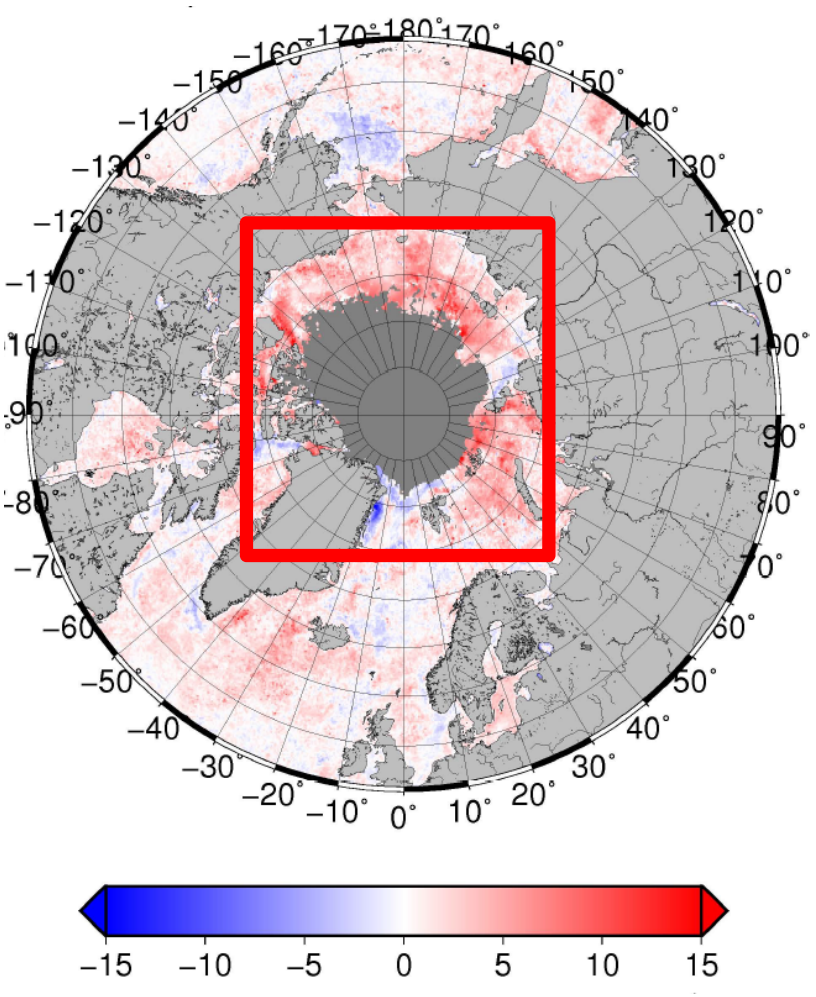
(Bélanger et al., 2013, BG)

PP (2/3)	Phyto. Phenology (0/4)	POC export (0/3)	DOC export (0/3)	Water sources discrimination(0/3)

PAR(0-) trend (% yr^{-1})



PP trend (% yr^{-1})



(Bélanger et al., 2013, BG)

PP (3/3)	Phyto. Phenology (0/4)	POC export (0/3)	DOC export (0/3)	Water sources discrimination(0/3)

Circumpolar-Arctic

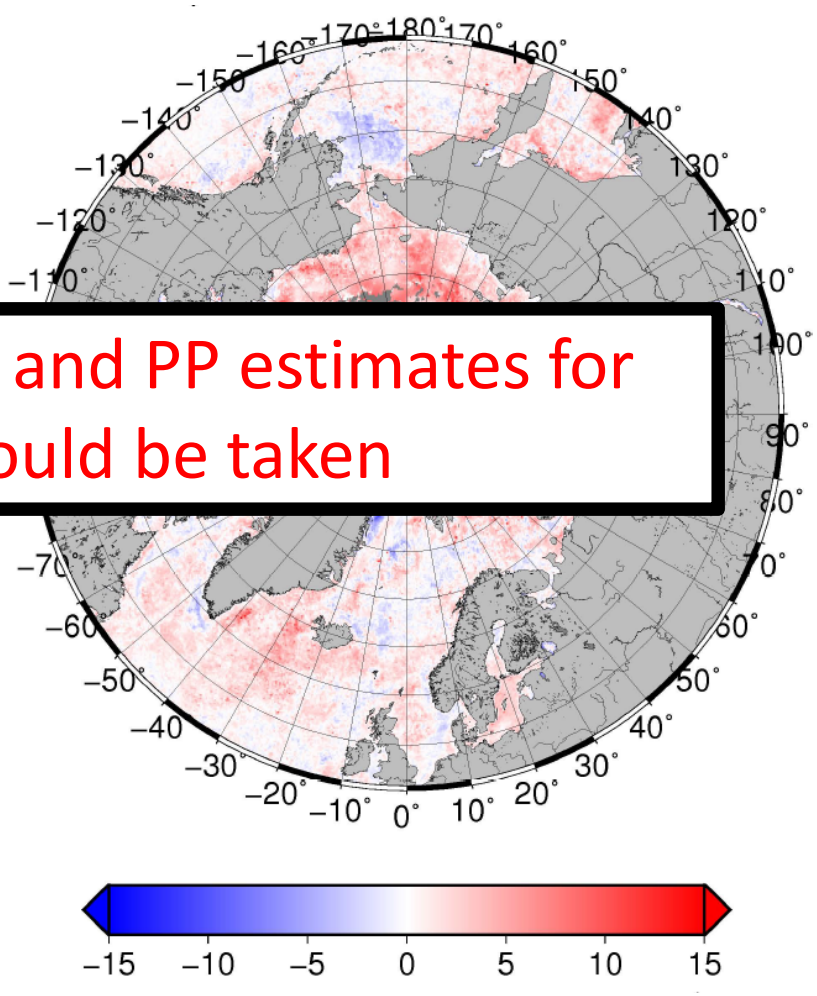
Increase in PP: +2.8 Tg C yr^{-1} (+14 % $decade^{-1}$)

Period considered: 1998-2010

- ✓ Decrease in PAR (0+) by increasing cloudiness
- ✓ Increase in PAR (0-) along the sea ice margin
- ov

Special attention for chl *a* and PP estimates for coastal waters should be taken

A major part of PP increase can be accounted for by changing ocean optical properties than by increase in light availability due to sea ice loss (local true though)



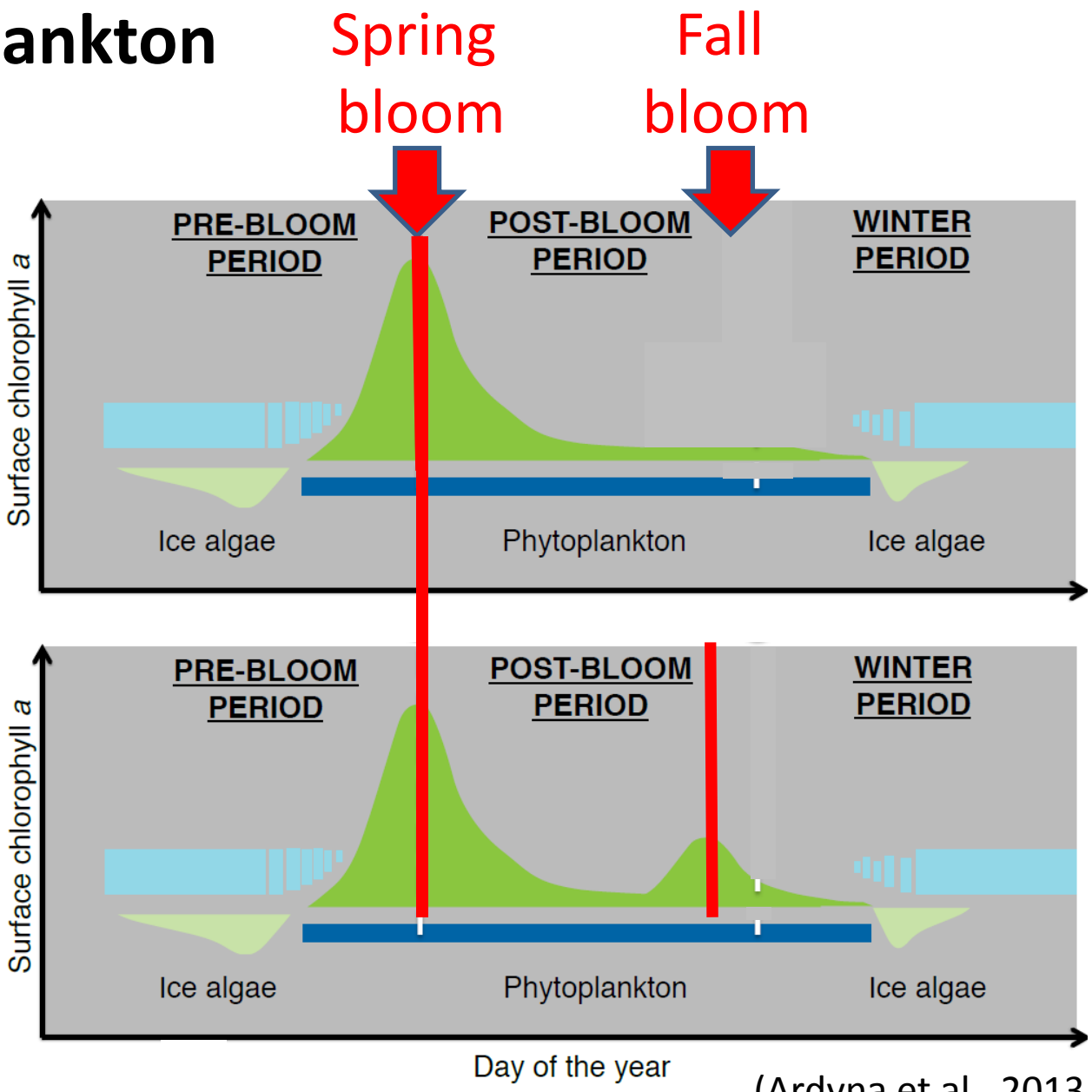
(Bélanger et al., 2013, BG)

Trend in phytoplankton phenology

Classic Phytoplankton phenology

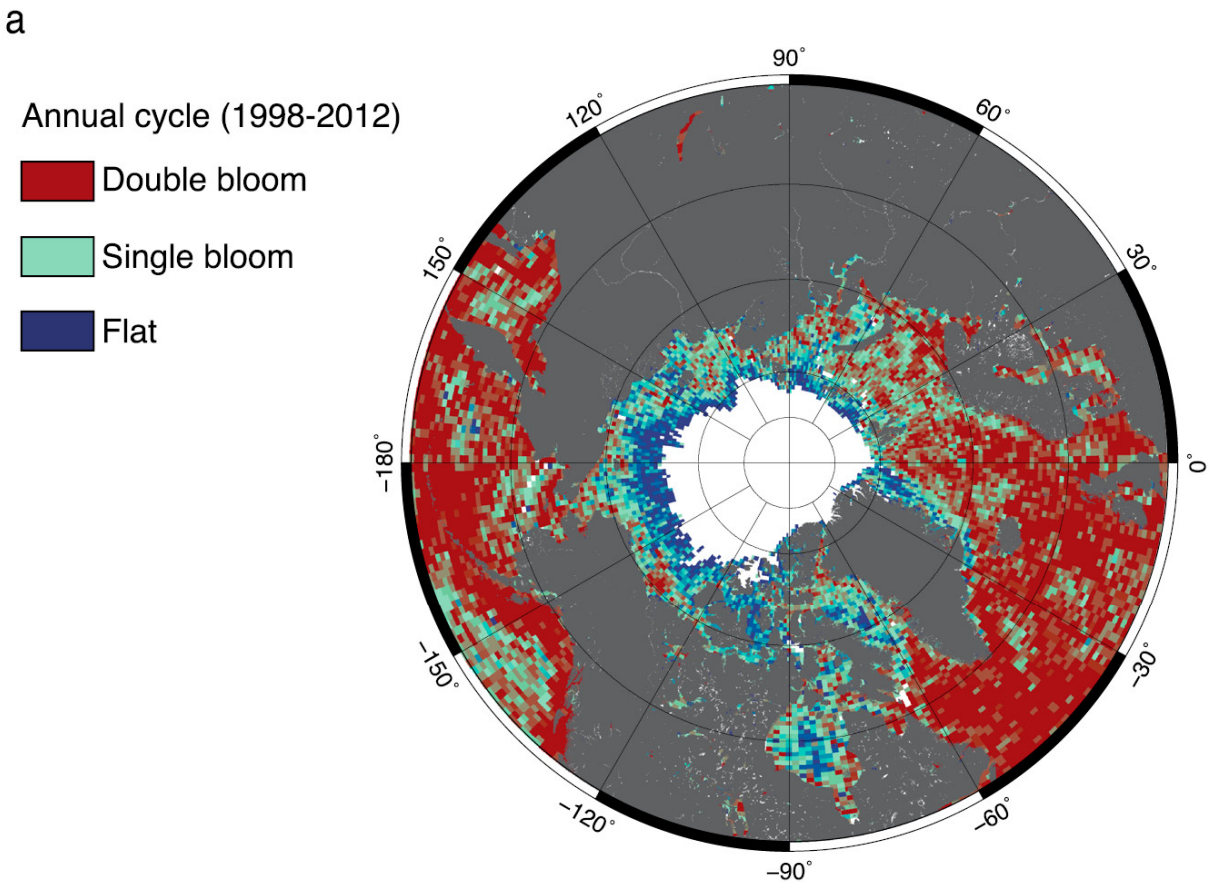
High latitudes

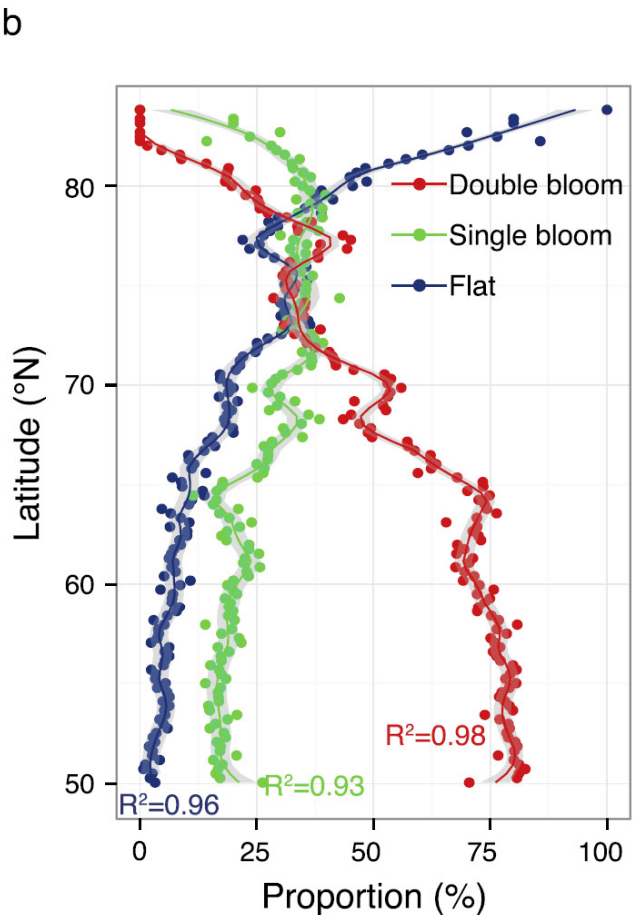
Lower latitudes



(Ardyna et al., 2013, BG)

Phenology as a function of latitudes

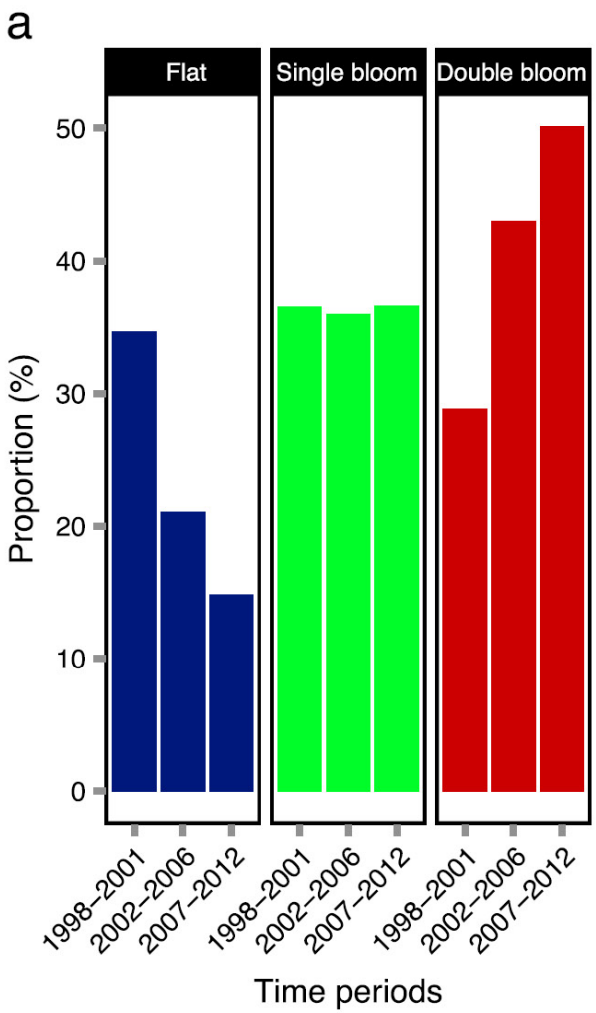


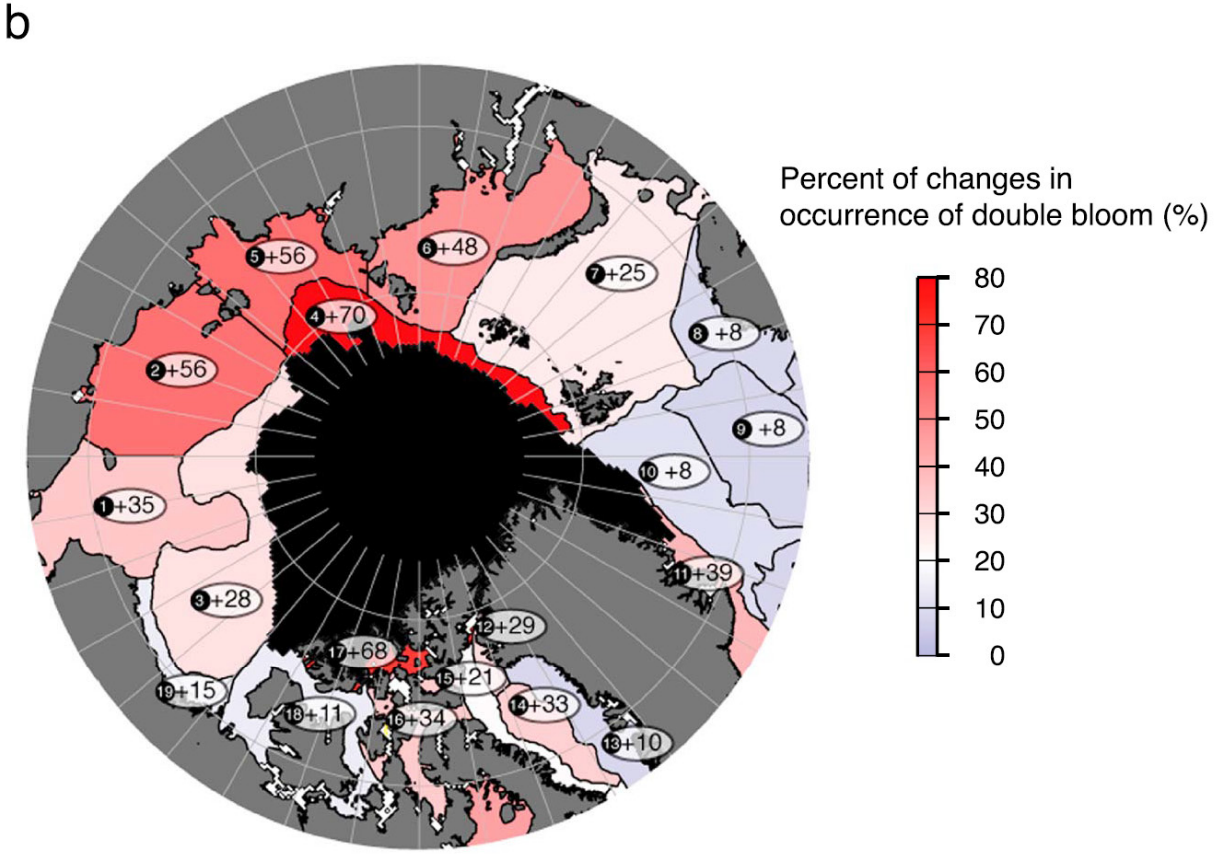


(Ardyna et al., 2014, GRL)

PP (3/3)	Phyto. Phenology (3/3)	POC export (0/3)	DOC export (0/3)	Water sources discrimination(0/3)

An increase in double bloom in circumpolar Arctic region

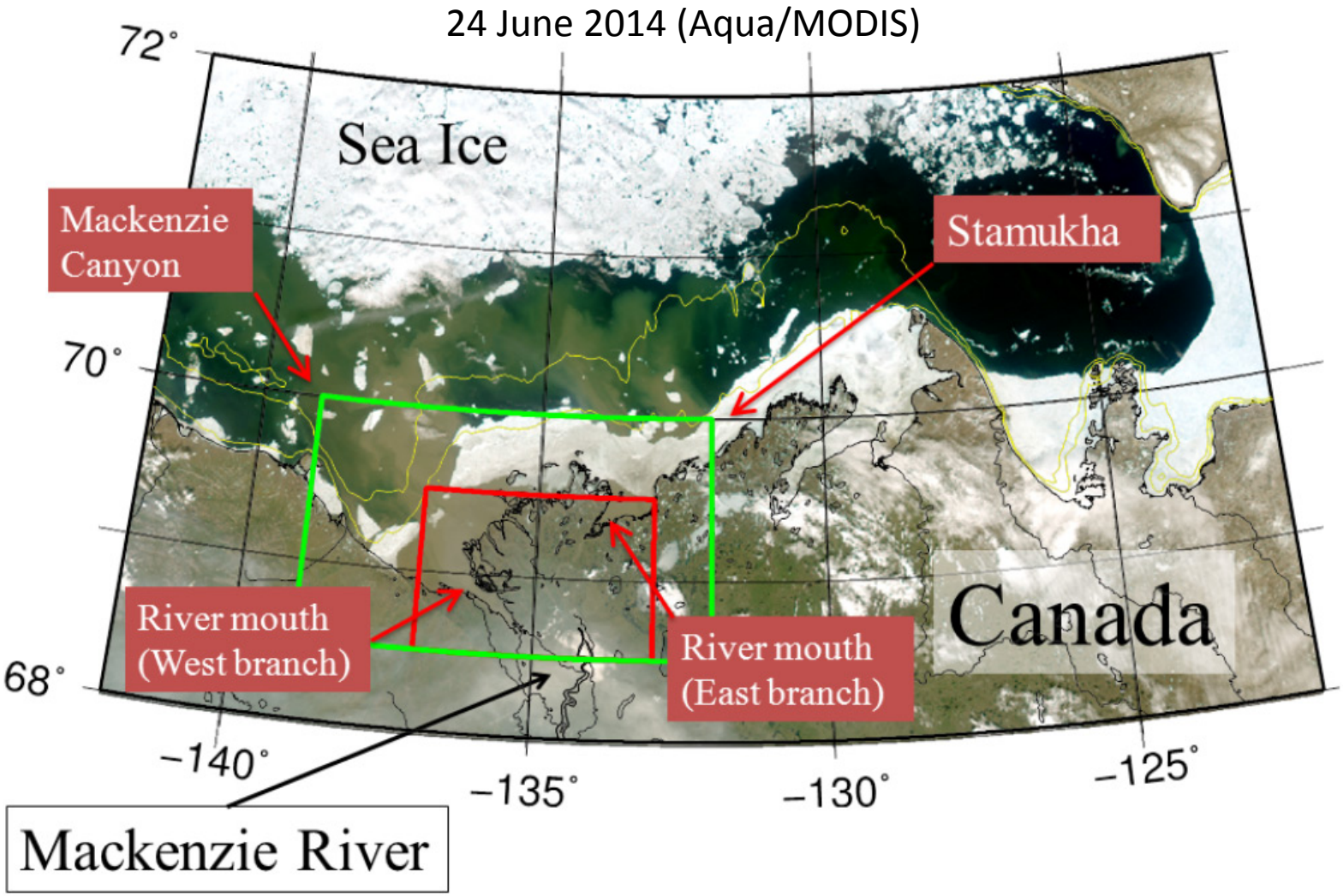




(Ardyna et al., 2014, GRL)

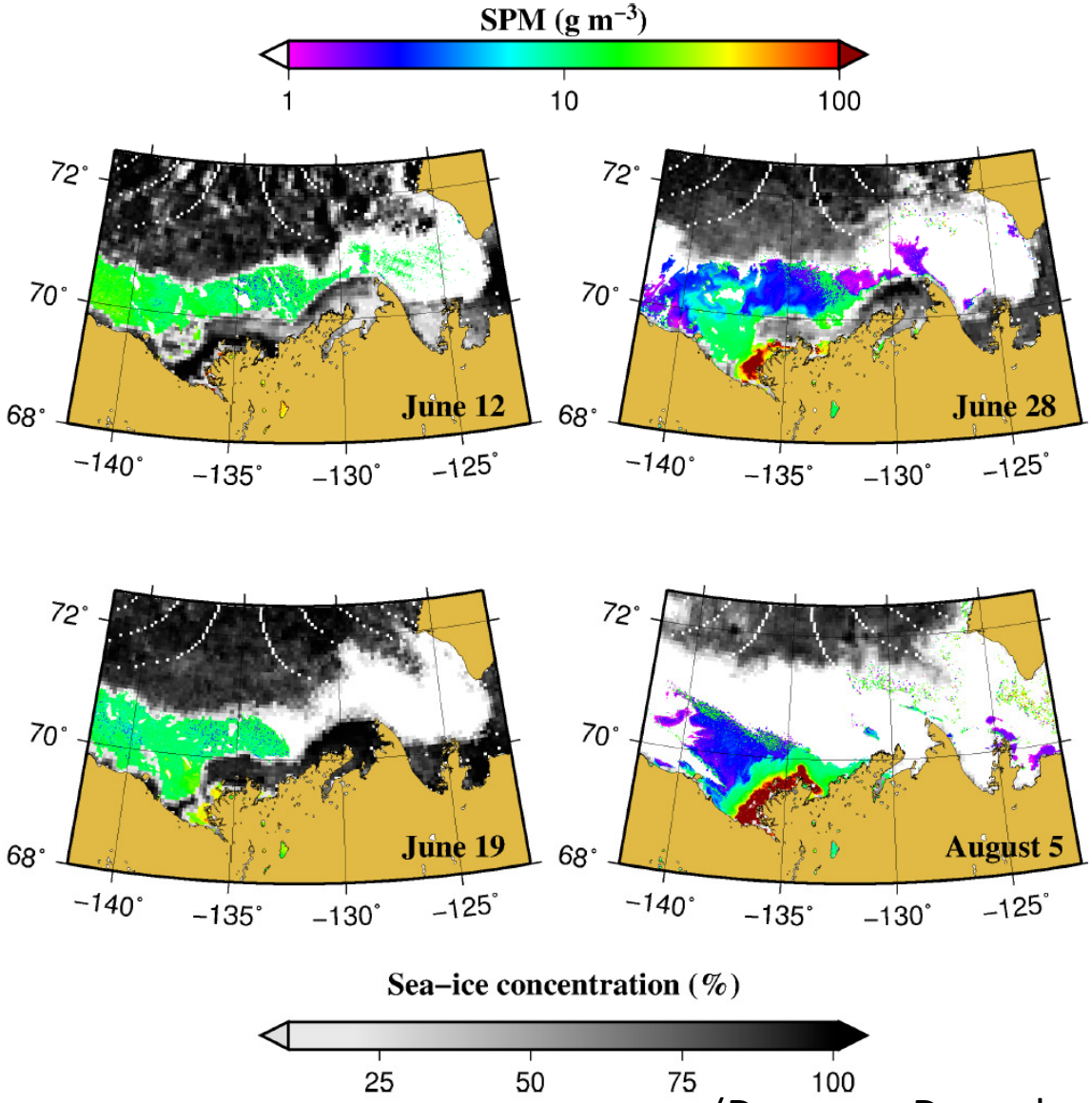
Terrestrial SPM export to the ocean (implication for POC export)

SPM (POC) export: A case study for Southern Beaufort Sea



(Doxaran , Devred, and Babin, 2015, BG)

Spatio-temporal variability in SPM concentrations

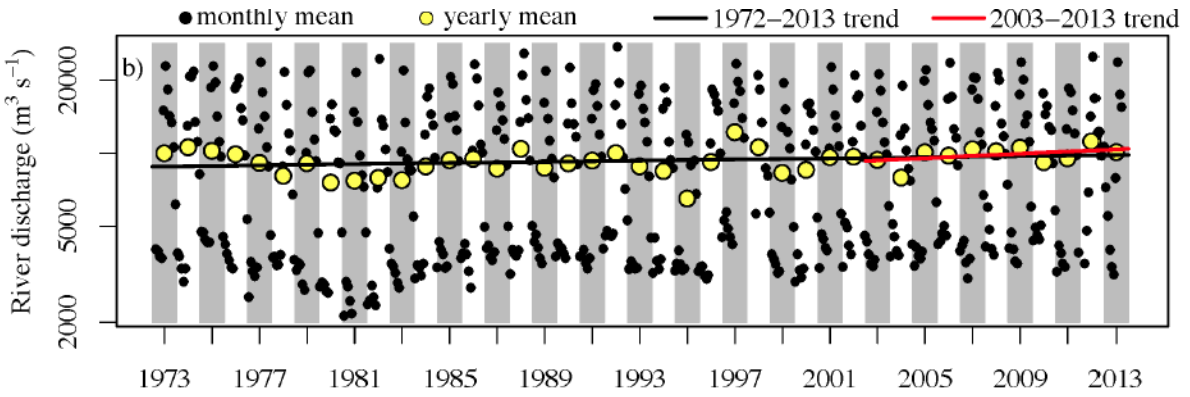


Uncertainty :
±25 %

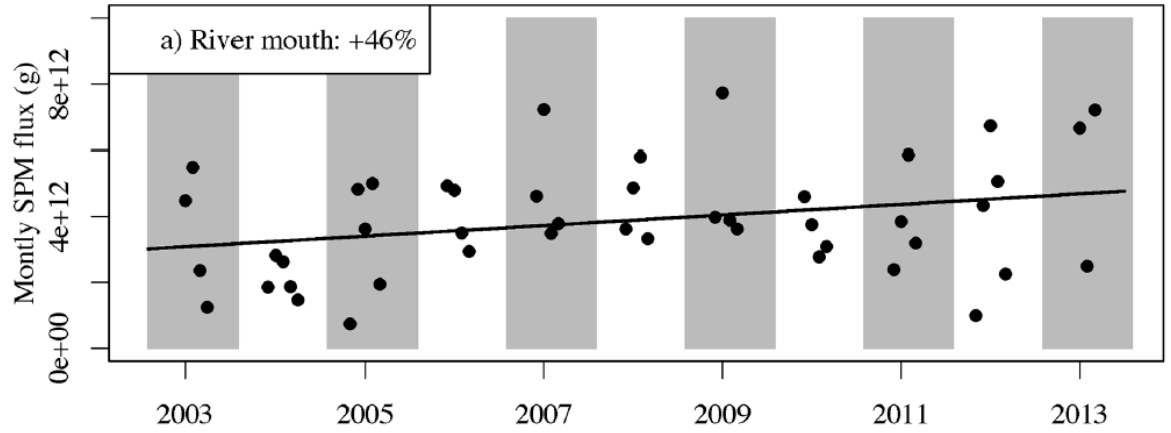
(Doxaran , Devred, and Babin, 2015, BG)

A 50 % increase in the mass of terrestrial particles

Increase in river discharge from 2003 to 2013



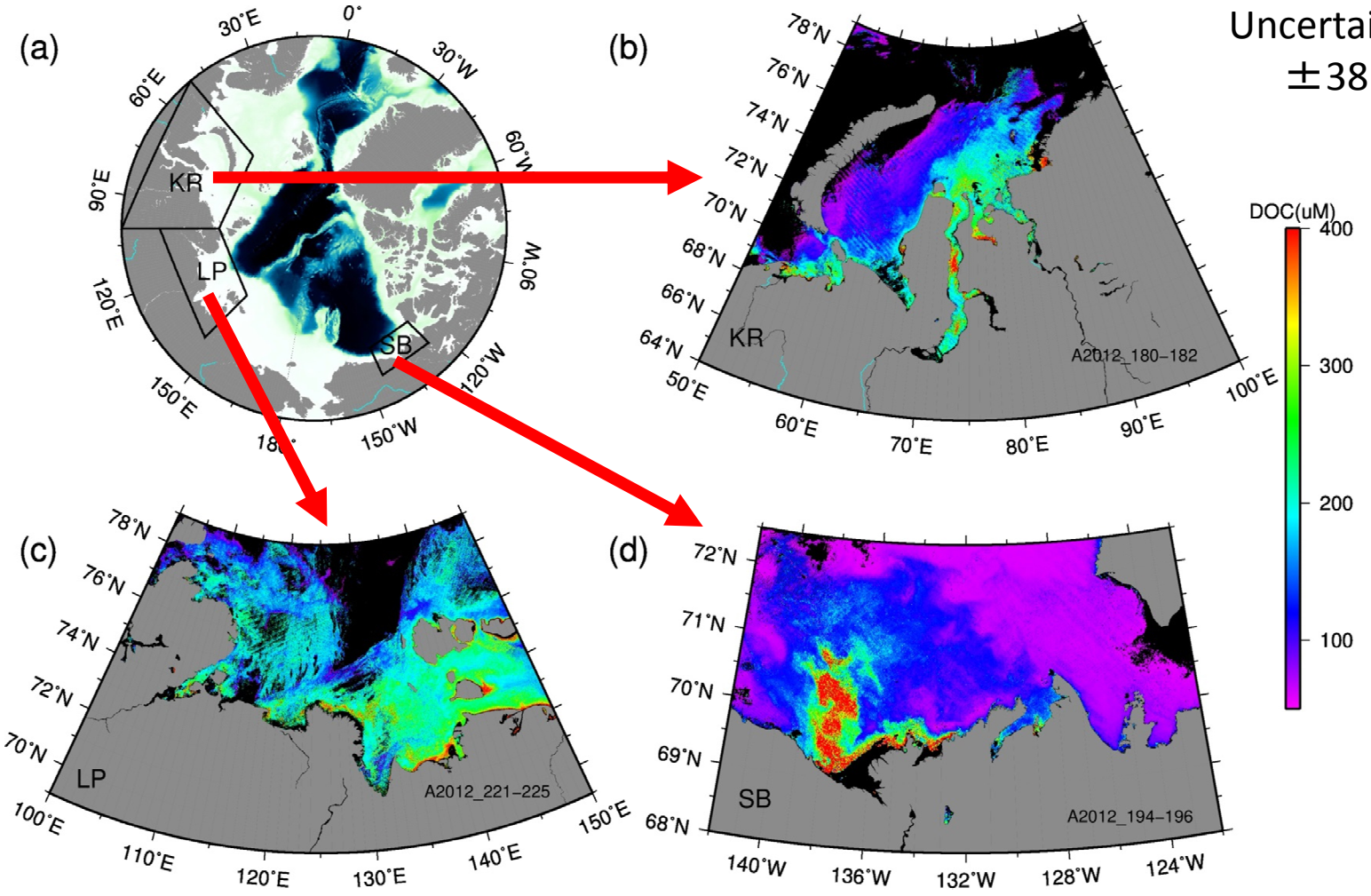
Significant increase in SPM flux from 2003 to 2013



(Doxaran , Devred, and Babin, 2015, BG)

Terrestrial DOC export to the ocean

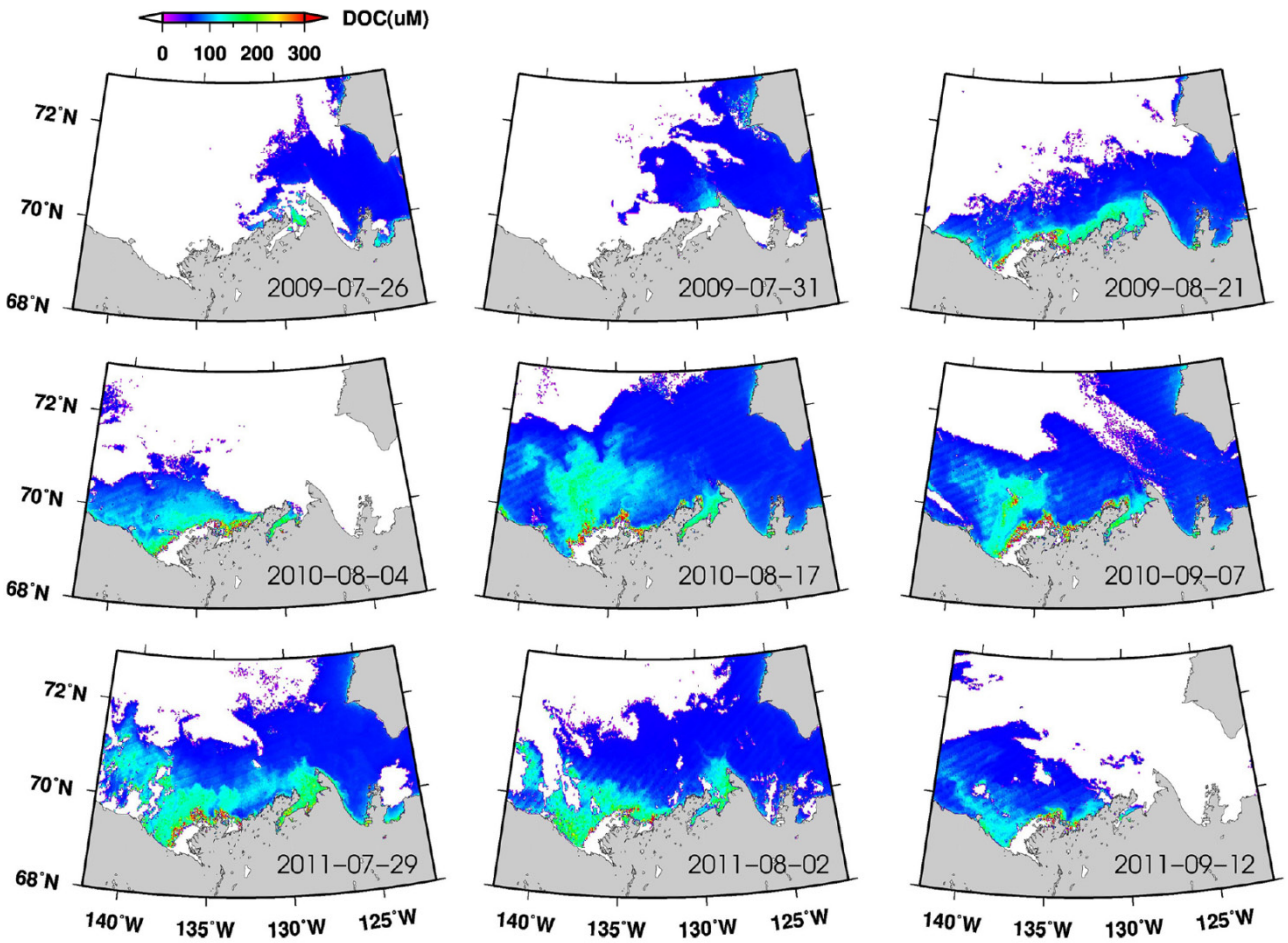
Spatio-temporal variability in DOC concentrations



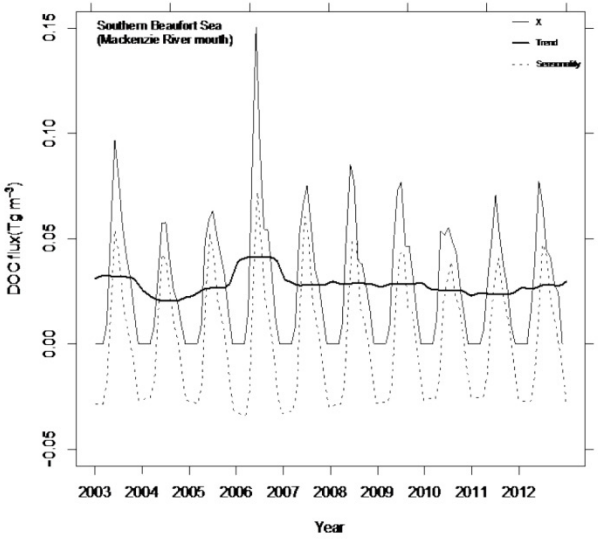
Uncertainty :
±38 %

(**Matsuoka** et al., 2013, 2014, both in BG;
Matsuoka, Boss, Babin et al., to be submitted)

Recent trend in DOC flux for Mackenzie river mouth



(**Matsuoka** et al., 2014, BG)



X: DOC conc. from space
T: Inter-annual trend
S: Seasonal trend

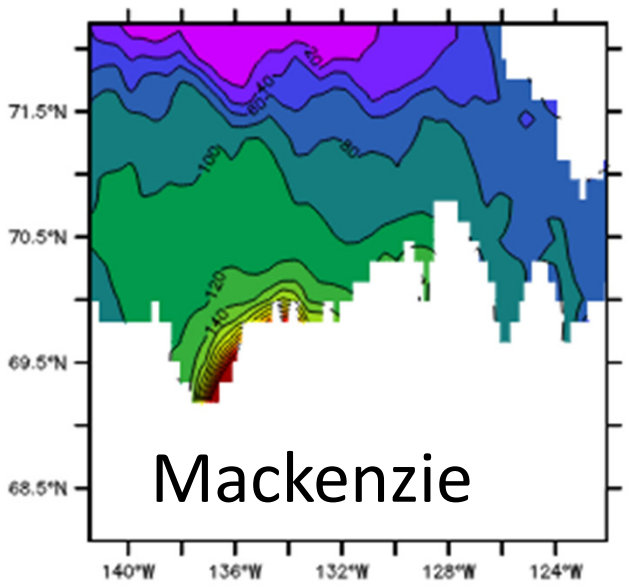
(**Matsuoka** and Babin, to be submitted)

Comparison of satellite estimates with modeling results : A case study for Mackenzie river mouth

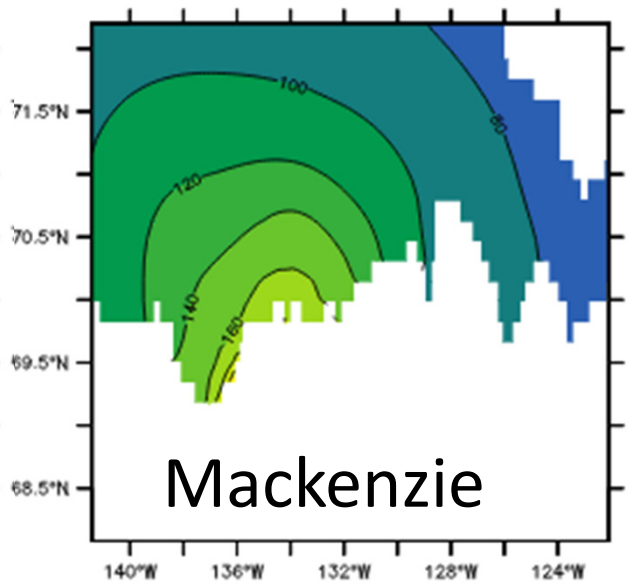
An example in July (Climatology of 2003-2011)

MITgcm coupled with biogeochemical components

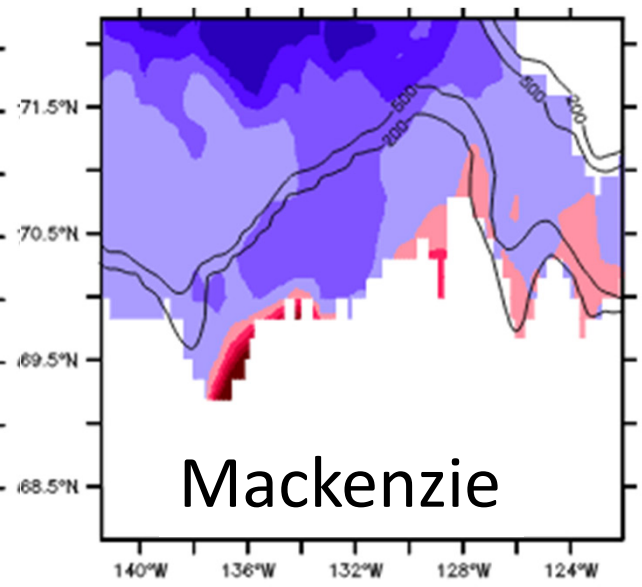
Satellite



Model



Difference



(Le Fouest, **Matsuoka**, Manizza, Tremblay, and Babin, to be submitted)

Water sources discrimination algorithm using MODIS ocean color and SMOS salinity sensors

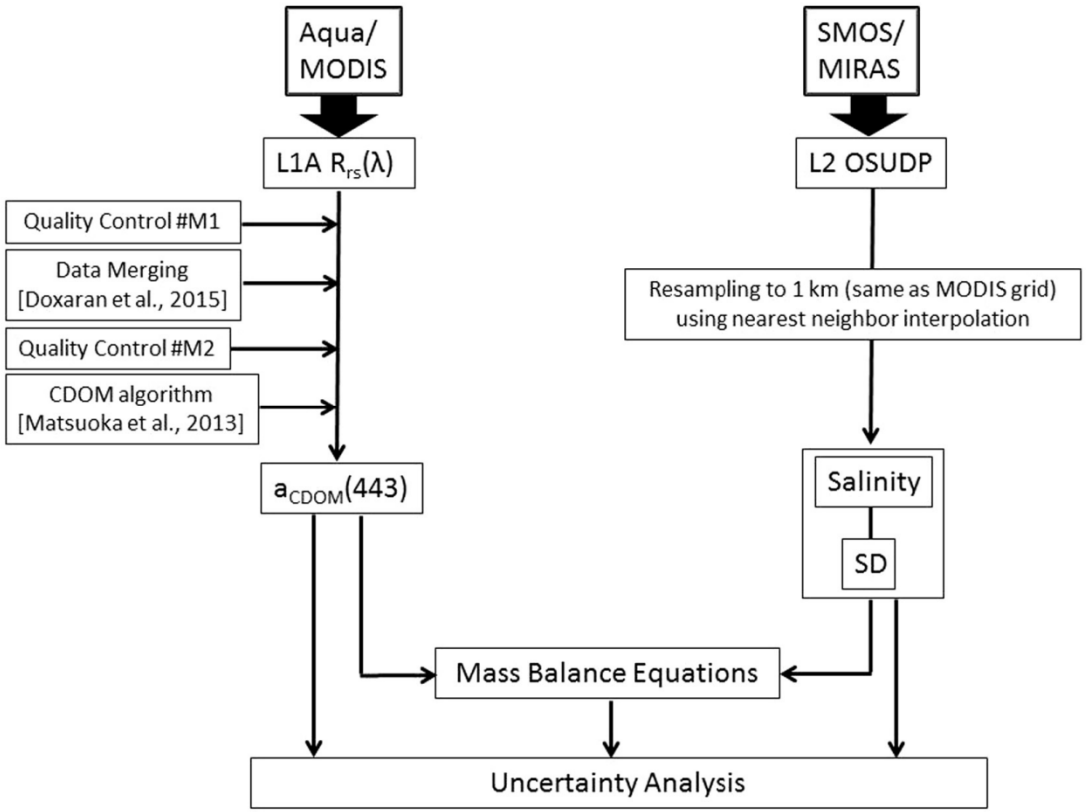
Contents lists available at ScienceDirect

Remote Sensing of Environment

journal homepage: www.elsevier.com/locate/rse

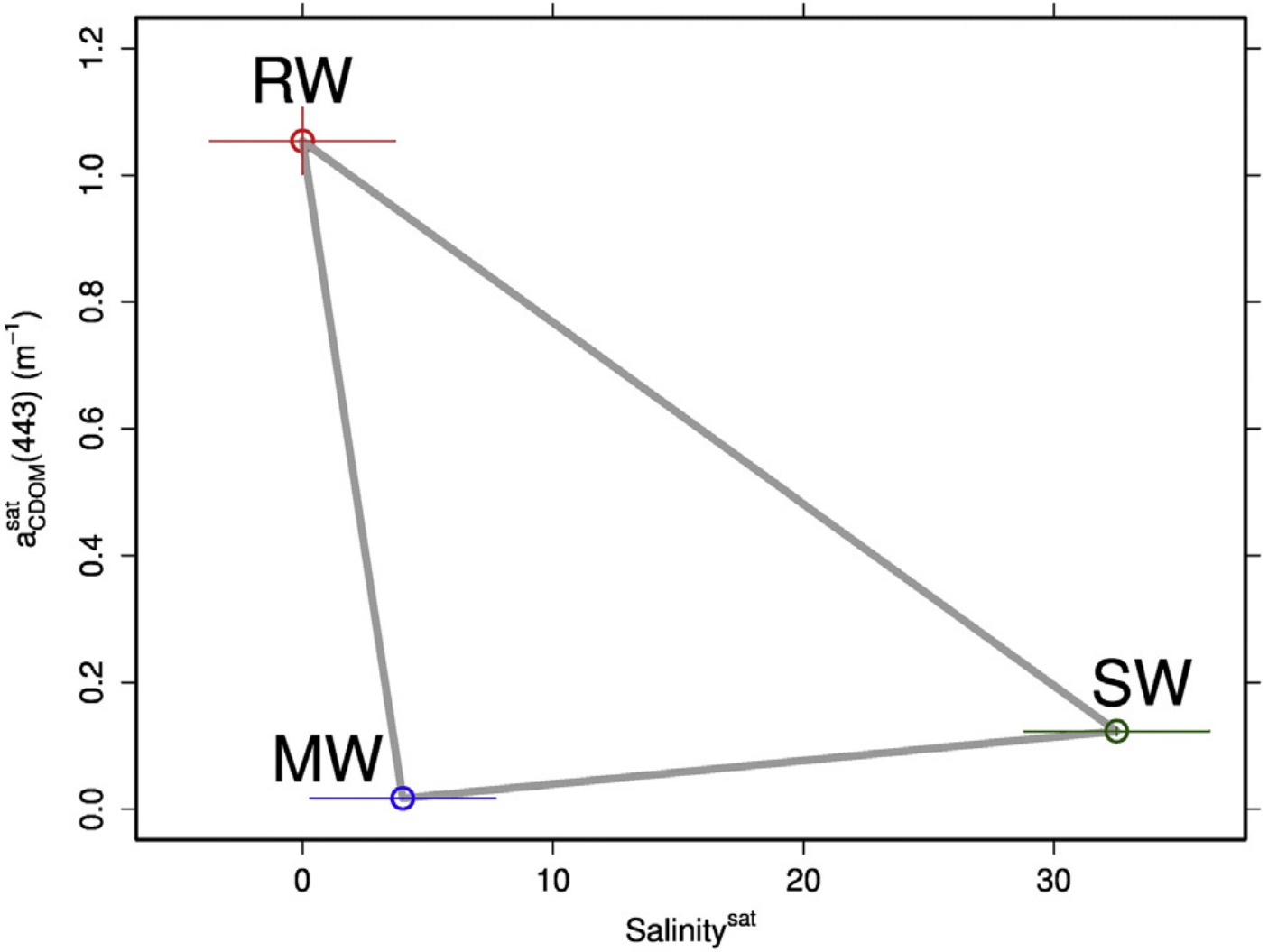
A new algorithm for discriminating water sources from space: A case study for the southern Beaufort Sea using MODIS ocean color and SMOS salinity data

Atsushi Matsuoka *, Marcel Babin, Emmanuel C. Devred



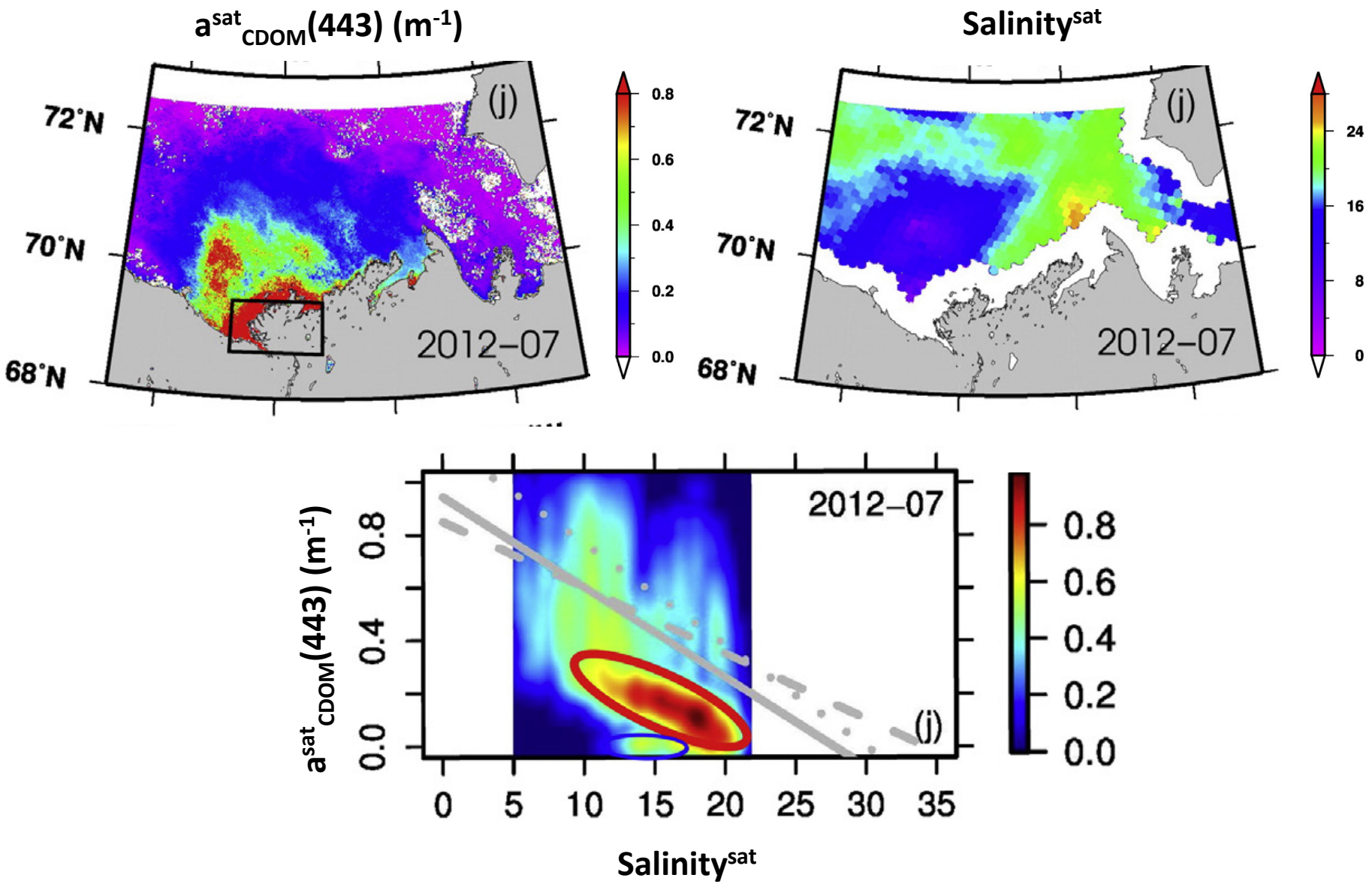
(**Matsuoka**, Babin, and Devred, 2016, RSE)

Mass balance equations regarding $a^{sat}_{CDOM}(443)$ and $salinity^{sat}$



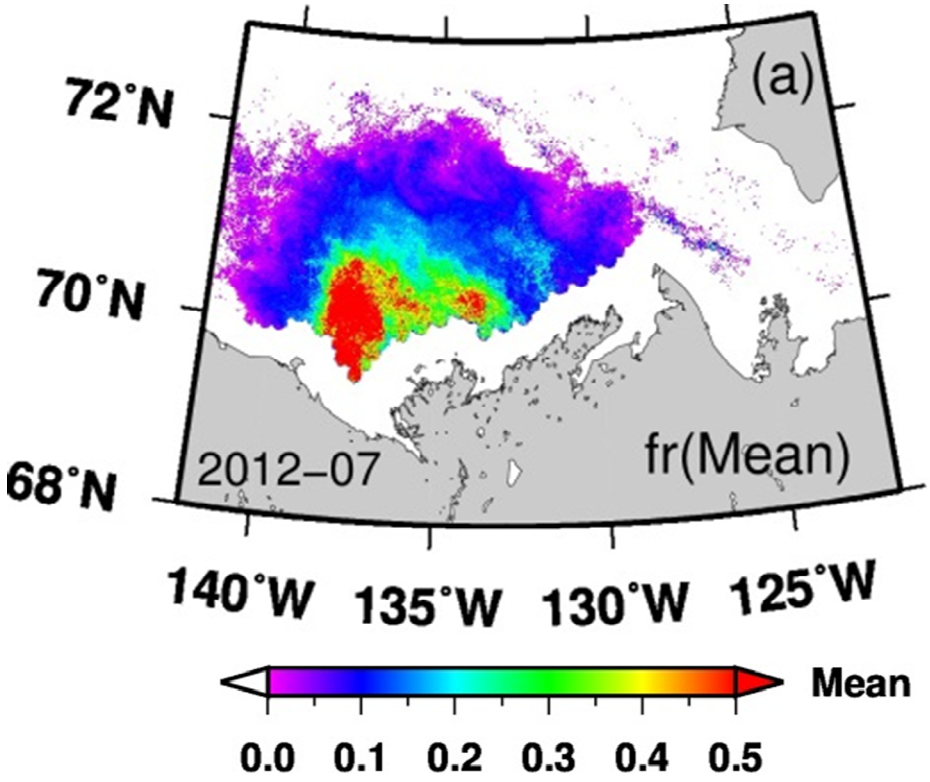
(**Matsuoka**, Babin, and Devred, 2016, RSE)

PP (4/4)	Phyto. Phenology (4/4)	POC export (3/3)	DOC export (3/3)	Water sources discrimination(2/3)

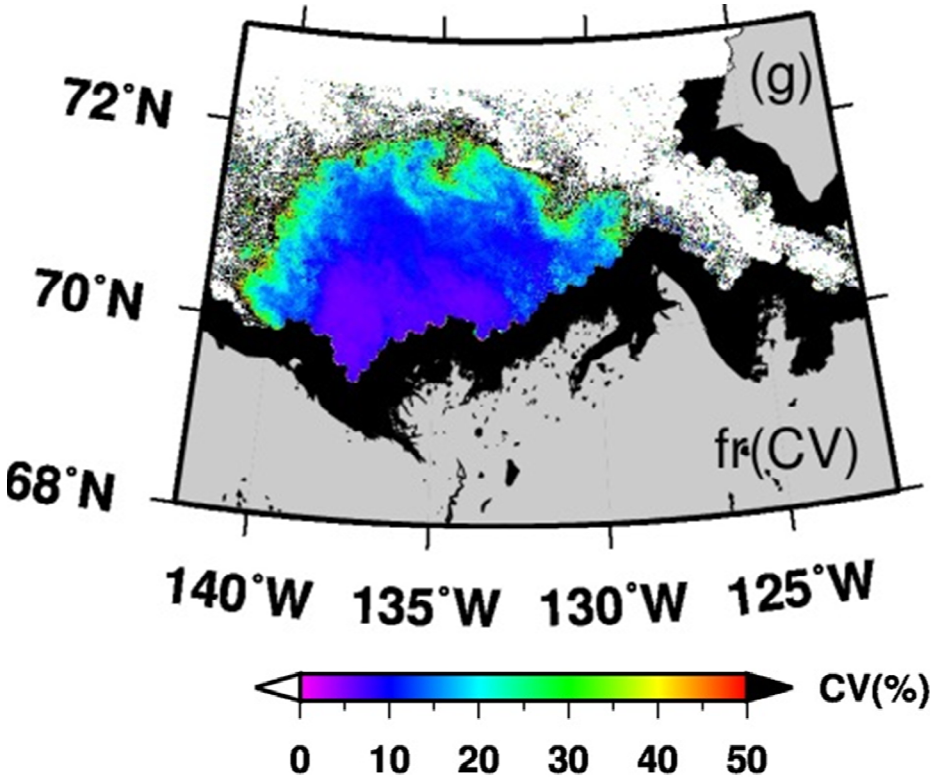


Fraction of river-influenced water derived from space

Mean

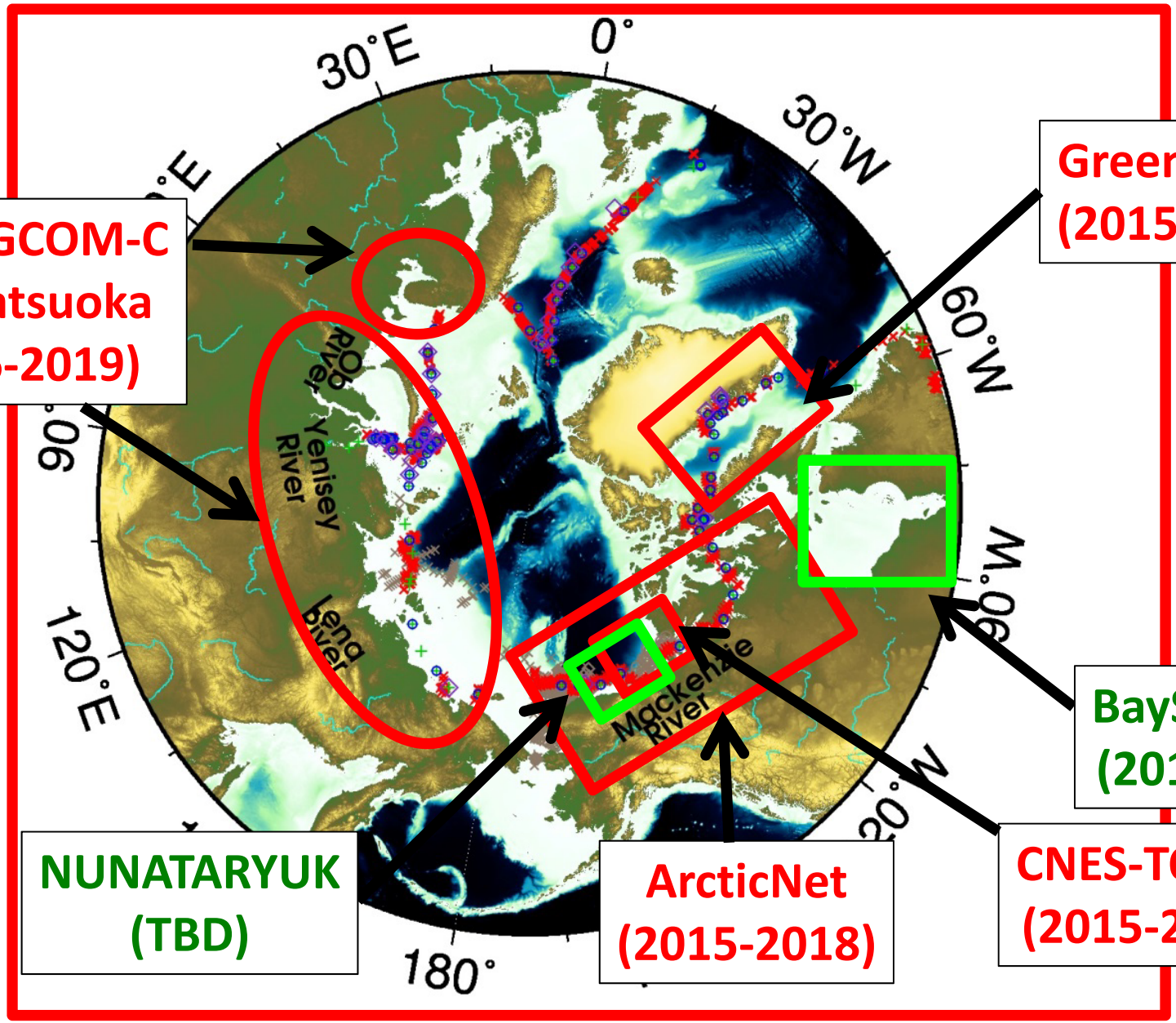


CV (error)



(**Matsuoka**, Babin, and Devred, 2016, RSE)

Overview of ongoing projects/programs



JAXA/GCOM-C
PI: Matsuoka
(2016-2019)

Green Edge
(2015-2017)

BaySys
(2017)

CNES-TOSCA
(2015-2017)

ArcticNet
(2015-2018)

NUNATARYUK
(TBD)

Summary

- Increase in PP in recent decade can be explained mainly by changes in ocean optical properties and partly (locally) by light availability due to sea ice loss
- Phytoplankton phenology in circumpolar Arctic is changing (single to double blooms)
- SPM (POC) export is likely increasing, coincident by an increase in river discharge for 2003-2013 period
- DOC export has not trend, probably because of quick microbial uptake in the river mouth
- Water discrimination algorithms allows to objectively trace modifications in POC and DOC budgets

Perspectives

- How do phytoplankton community compositions change?
- How will nutrient availability change?
- How do the quality and the quantity of DOC and POC change?
- What about the fates of DOC and POC?
- What about future modification in CO_2 budget and its impact on global scale?

Questions?

Q & A

Increase in PP for circumpolar-Arctic: +2.8 Tg C yr^{-1} (+14 % $decade^{-1}$)

PP model

$$PP = CHL \cdot P_m^B \int_{t=0}^{24\,h} \int_{z=0.1\,\%}^{100\,\%} 1 - e^{\frac{-PUR(z,t)}{E_k}} dz\,dt$$

(Platt et al., 1980, JMS)

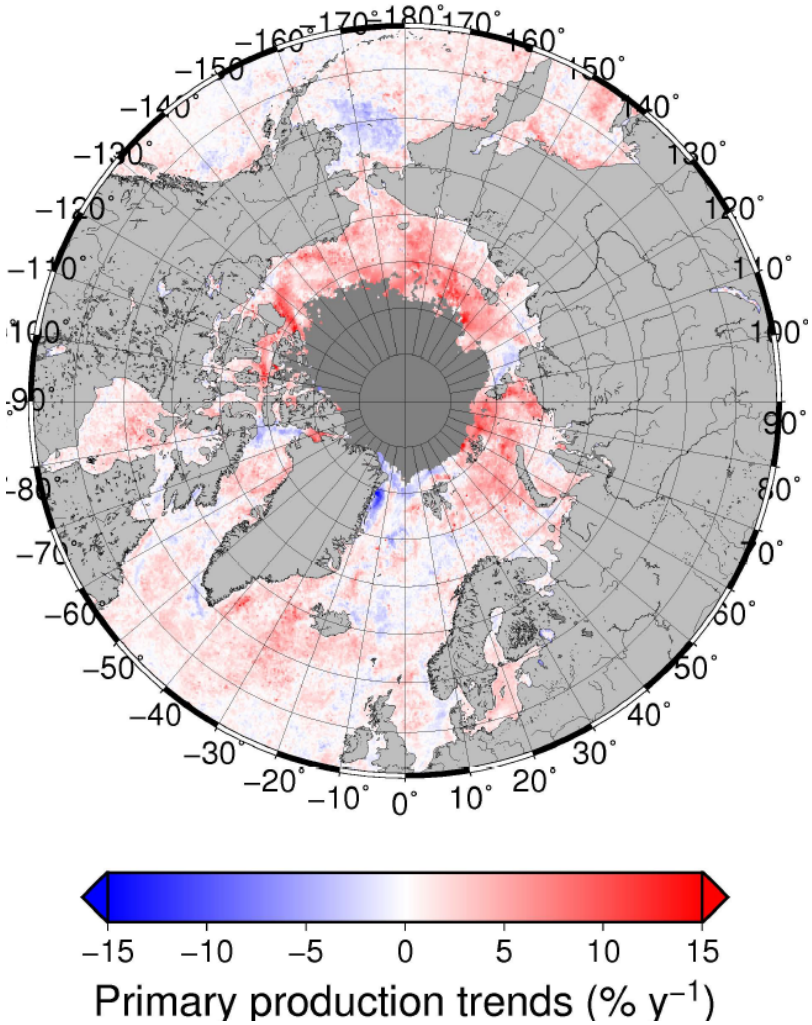
- CHL: Arctic-tuned GSM01 chl-*a* algorithm
  (Ben Mustapha et al., 2012, CJRS)
- P^B_m: Constant value of 2.0 mg C (mg CHL)$^{-1}$ h^{-1}
  (Harrison and Platt, 1986, PB; Huot et al., 2013, BG)
- PUR(z,t): $= \int^{700\,nm} E^0(\lambda, z, t) \cdot e^{-K_d(\lambda,t)z} \frac{a_{ph}(\lambda)}{a_{ph}(443)} d\lambda$
  (Morel, 1978, DSR; Matsuoka et al., 2011, JGR)
- E_k: High latitude model
  (Arrigo et al., 1998, JGR)

PAR model

PAR(0+): Integral of Ed(0+, λ, t) using a RTE (SBDART) with inputs of θ_s, O_3 conc., CF, and τ_{cl}

PAR(0-): PAR(0+) with Fresnel reflection and sea ice conc.

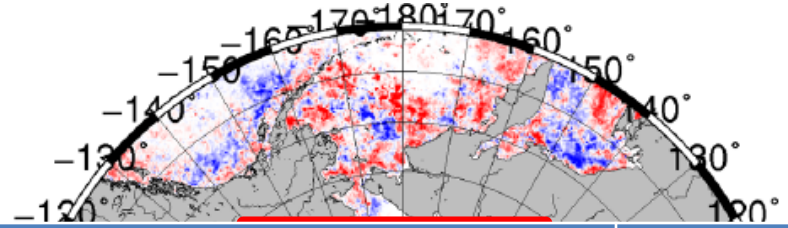
Period considered: 1998-2010



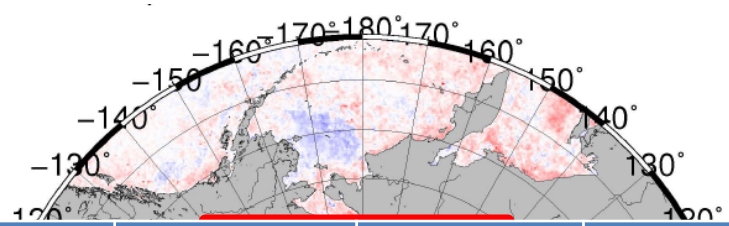
(Bélanger et al., 2013, BG)

Increase in PP for circumpolar-Arctic is mainly explained by changes in ocean optical properties

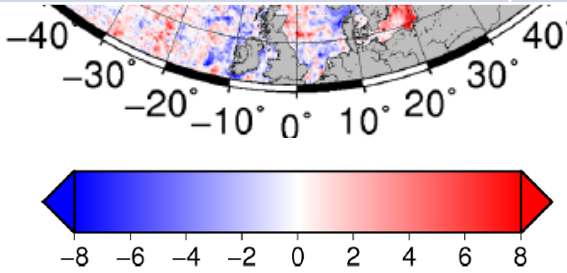
CHL/K_{PUR} trend
(% yr^{-1})

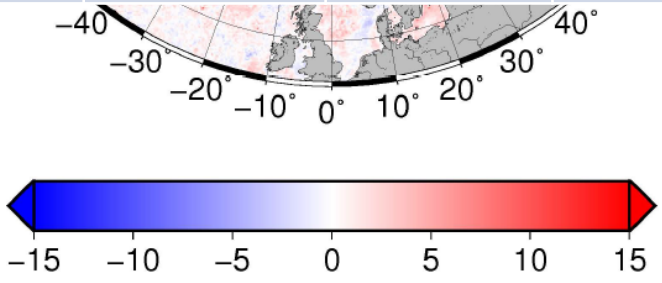


PP trend
(% yr^{-1})



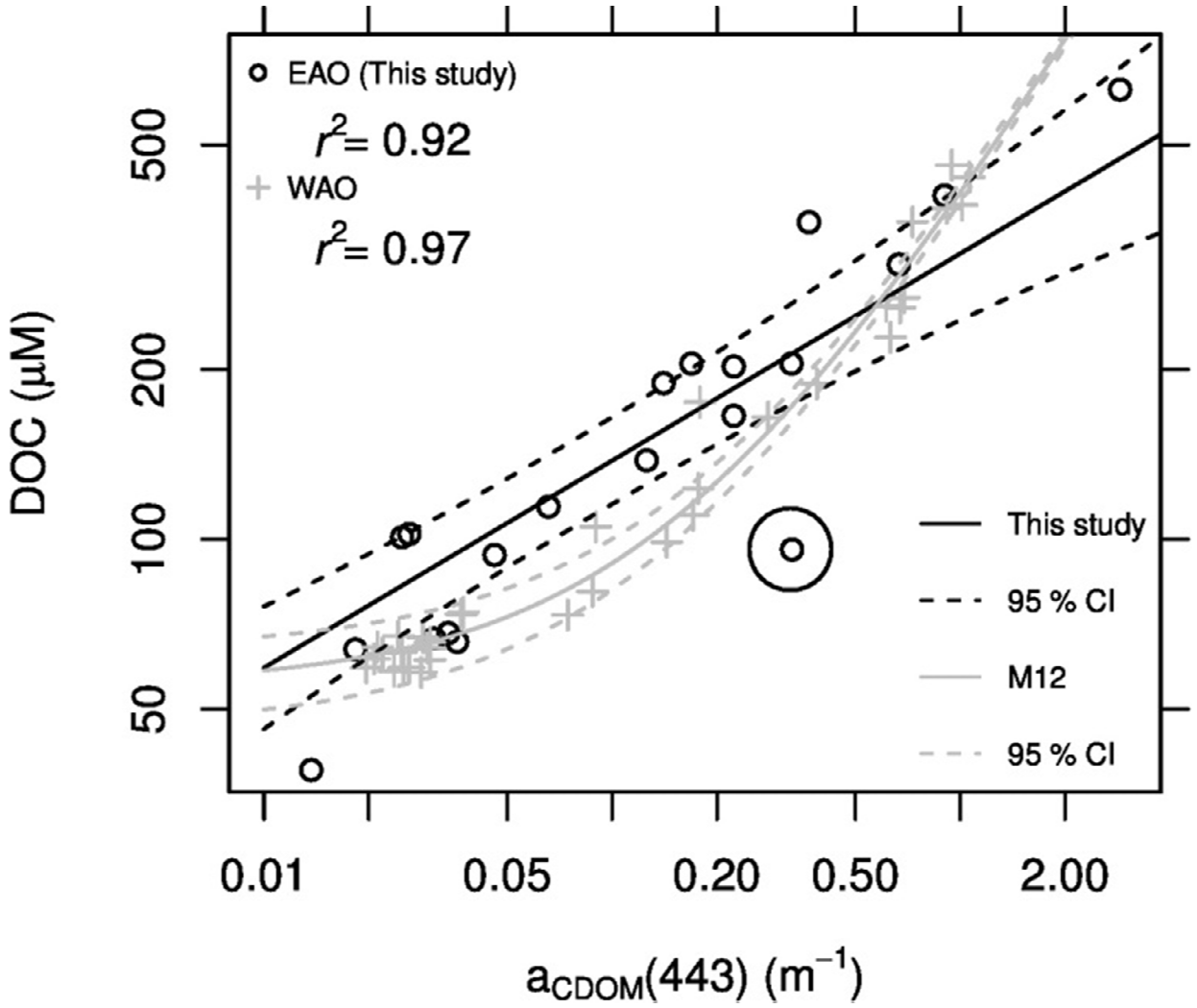
Region	May	June	July	August	September
Circumpolar Arctic Unit of CHL/K_{PUR} mg CHL m^{-2} (% yr^{-1})	5.17 (0.75)	3.93 (0.16)	3.54 (-0.02)	3.20 (0.09)	3.22 (0.05)





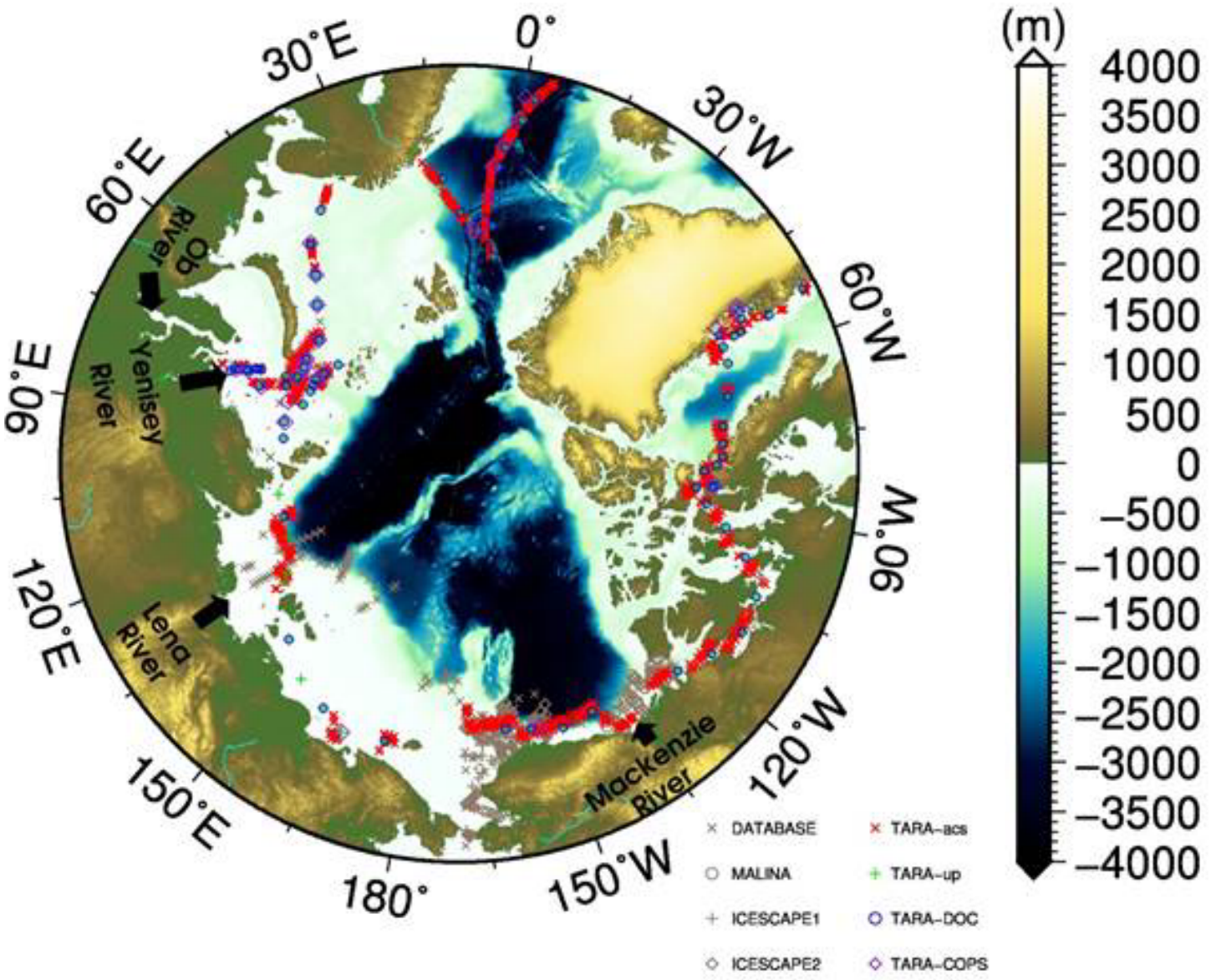
(Bélanger et al., 2013, BG)

DOC versus $a_{CDOM}(443)$ relationship from circumpolar TARA Arctic cruises



(**Matsuoka**, Boss, Babin et al., to be submitted)

Sampling locations during circumpolar TARA Arctic cruises



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