Retrieval of highly resolved near-surface Chl-a from underway observations of IOPs in the Fram Strait, Arctic Ocean

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Introduction

Ocean color remote sensing is greatly limited in the Arctic region because of cloud cover, sea ice and low solar elevations etc. The lack of in situ Chl-a data aggravates the difficulty in satellite data validation. The shipboard underway flow-through system equipped with a WETlabs AC-S markedly facilitates the provision of IOPs with improved time and space resolution, showing great potential in retrieving resolved Chl-a. However, data quality control remains challenging.

In this study, an AC-S data correction scheme based on Slade et al. (2010) was modified and adapted for the Fram Strait to obtain hyperspectral particulate absorption. Continuous near-surface Chl-a was then retrieved. The AC-S based Chl-a was used to validate MODIS-Aqua, -Terra and VIRRS L2 Chl-a products. In addition, Chl-a data derived from the L1 products of Sentinel-3 sensor OLCI with POLYMER atmospheric correction method were validated.

Method

Cruises tracks with *R.V. Polarstern*

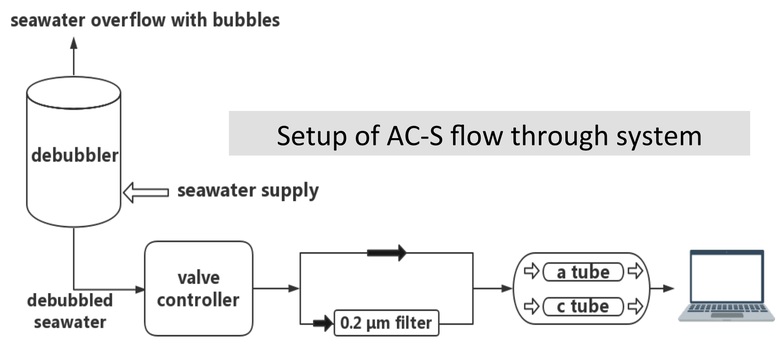
PS 93.2: Jul.-Aug. 2015, Svalbard – Fram Strait
PS 99.1: Jun. 2016, North Sea – Svalbard
PS 99.2: Jun.-Jul. 2016, Svalbard – Fram Strait

Data

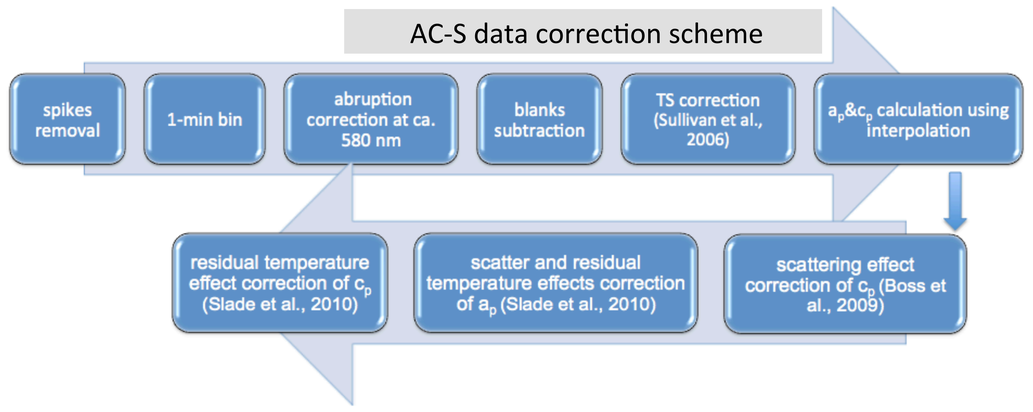
1 Discrete water sampling every 3h
- PS 93.2: a_p&a_{ph} (), Chl-a (HPLC)
- PS 99.1: a_p&a_{ph} (QFT-ICAM), Chl-a (HPLC)
- PS 99.2: a_p&a_{ph} (QFT-ICAM), Chl-a (HPLC)

2 Underway AC-S measurements

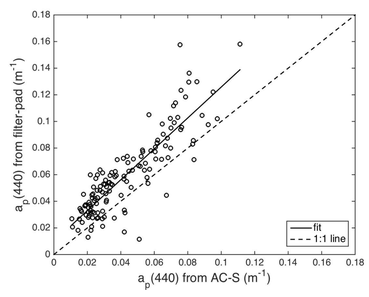
3 Satellite ocean color data
- MODIS-Aqua L2 OC
- OLCI L2 OC (1st reprocessing OC4&C2R)
- OLCI L2 OC (Polymer AC algorithm v4.1 from Steinmetz et al. 2016)



Setup of AC-S flow through system

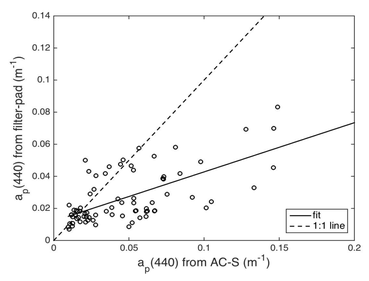


$a_p(440)$: AC-S v.s. filter pad



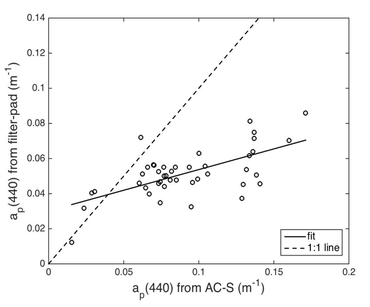
fit: y=1.1603x +0.0098

N	134
R^2	0.75
RMSE	0.023
p	<0.00



fit: y=0.3068x +0.0121

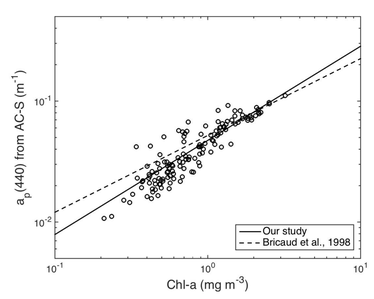
N	77
R^2	0.48
RMSE	0.038
p	<0.00

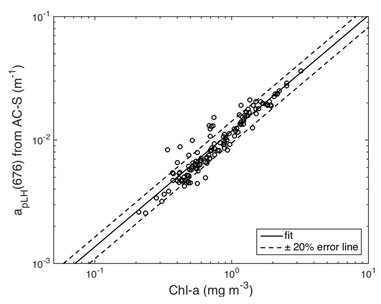


fit: y=0.2355x +0.0301

N	43
R^2	0.480
RMSE	0.050
p	<0.00

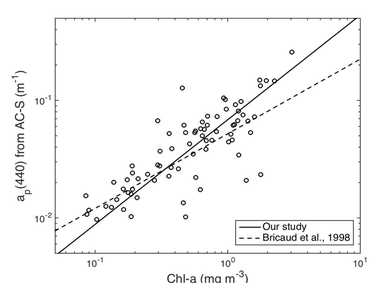
$a_p(440)$ & $a_{pLH}(676)$ from AC-S v.s. HPLC Chl-a

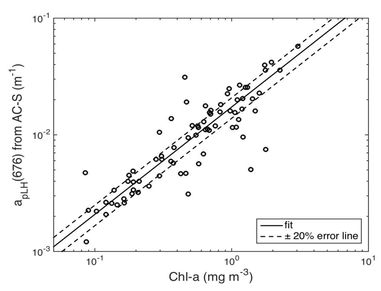




fit: $y=0.0118x^{0.9374}$

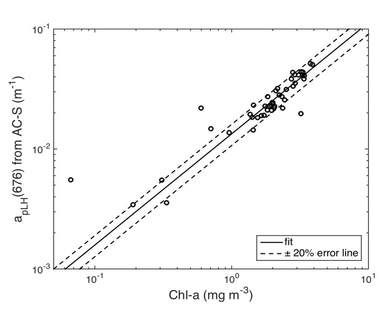
N	134
R^2	0.93
RMSE	0.0017
p	<0.00





fit: $y=0.0173x^{0.9203}$

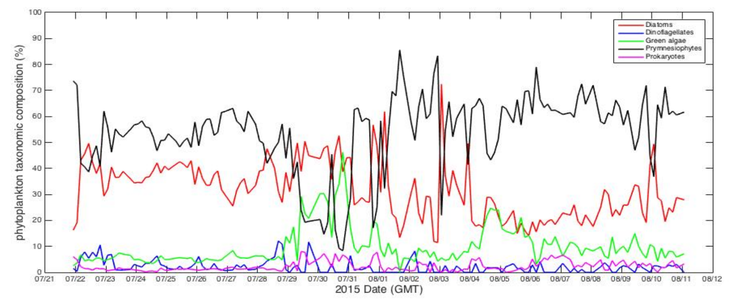
N	77
R^2	0.70
RMSE	0.0059
p	<0.00

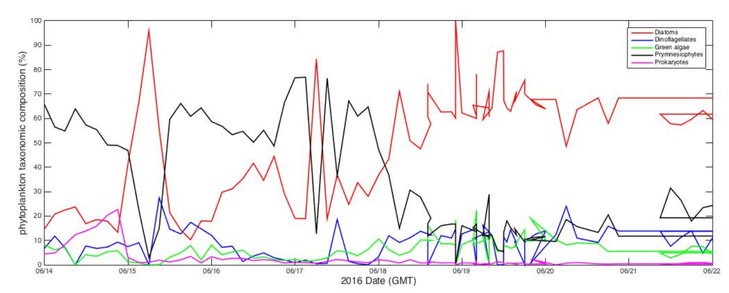


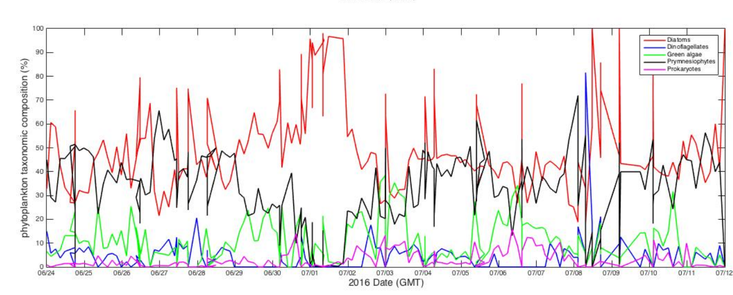
fit: $y=0.0134x^{0.9267}$

N	46
R^2	0.83
RMSE	0.0049
p	<0.00

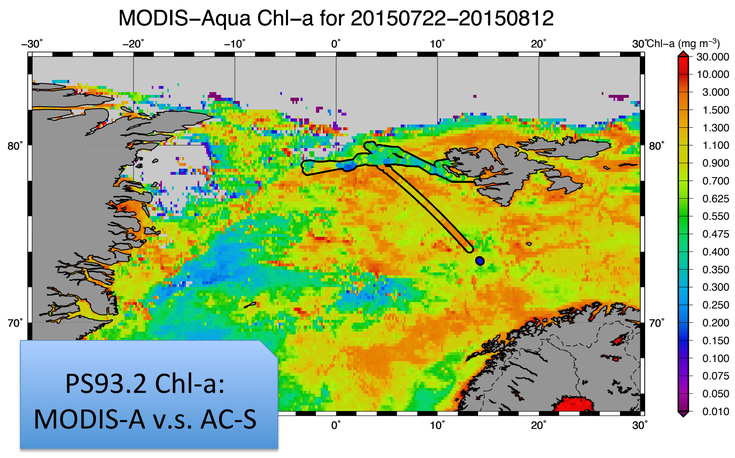
Phytoplankton Community Composition



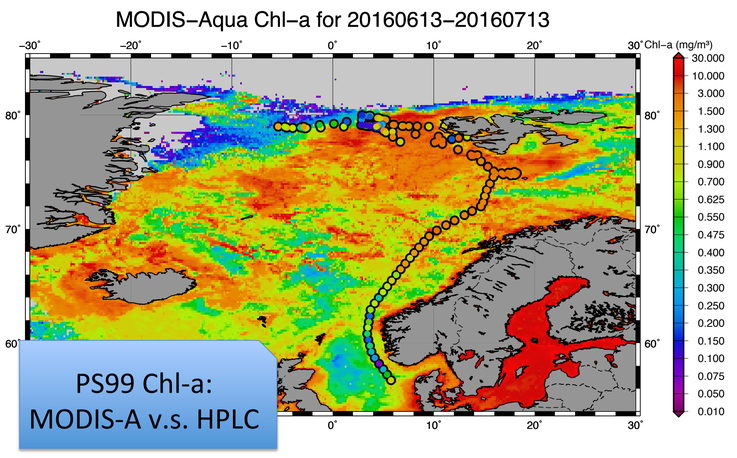




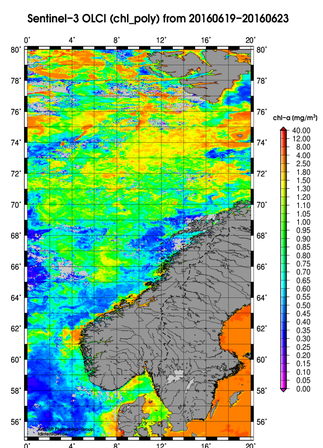
Satellite Validation

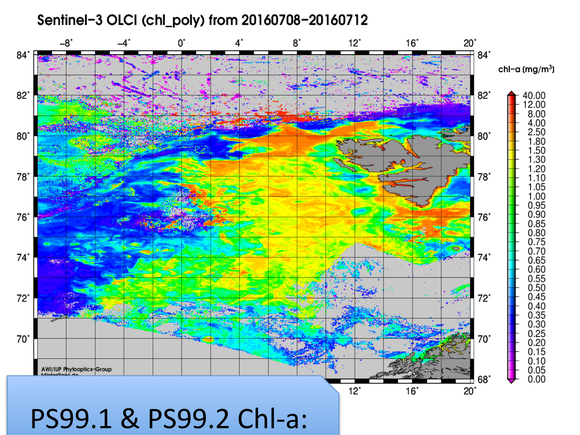


PS93.2 Chl-a: MODIS-A v.s. AC-S



PS99 Chl-a: MODIS-A v.s. HPLC





PS99.1 & PS99.2 Chl-a: OLCI (Polymer)

Satellite sensors	MODIS-A		MODIS-A	OLCI (OC4)	OLCI (C2R)	OLCI (Polymer)		OLCI (OC4)	OLCI (C2R)	OLCI (Polymer)	
	PS 93.2		PS 99.2					PS 99.1			
Chl-a from:	HPLC	AC-S	HPLC	HPLC	HPLC	HPLC	AC-S	HPLC	HPLC	HPLC	AC-S
collocation	1x1	1x1	1x1	3x3	3x3	3x3	3x3	3x3	3x3	3x3	3x3
R^2	0.97	0.89	0.55	0.72	0.51	0.75	0.76	0.02	0.11	0.41	0.27
MAE	0.27	0.38	0.38	0.47	0.47	0.27	0.23	0.83	3.89	0.64	0.23
RMSE	0.35	0.46	0.47	0.45	0.74	0.26	0.29	1.23	5.43	0.77	0.28
Bias	0.252	0.238	-0.33	0.047	0.43	-0.064	-0.13	0.40	-2.40	0.32	0.20
p	<0.000	<0.000	<0.000	<0.000	<0.000	<0.000	<0.000	0.47	0.13	0.02	<0.000
N	9	923	47	35	35	48	98497	28	23	30	42691

Conclusion

- AC-S hyperspectral IOPs measurements can be used to retrieve Chl-a on large spatial scale in the Fram Strait.
- The AC-S based Chl-a is proven to be a much more adequate data source for MODIS-A & OLCI validation by providing more collocations both to satellite overpass and within a single satellite pixel.

Outlook

- Extract information of major phytoplankton groups types from AC-S hyperspectral absorption spectra using several methods such as inverse modelling, Gaussian band or EOF methods (Moisan et al. 2015, Chase et al. 2013, Bracher et al. 2015).

Acknowledgement: We thank the captain and crew of the R.V. Polarstern for its support during all cruises. This work was supported by HGF Infrastructure project "FRontiers in Arctic marine Monitoring" and German Science Foundation. We also thank Chinese Scholarship Council and the POLMAR Helmholtz Graduate School for Polar and Marine Research at the Alfred Wegener Institute for their collaborative support.

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