In search of long term trends of arctic ocean color observations from the late 70's to present: impact of receding sea ice

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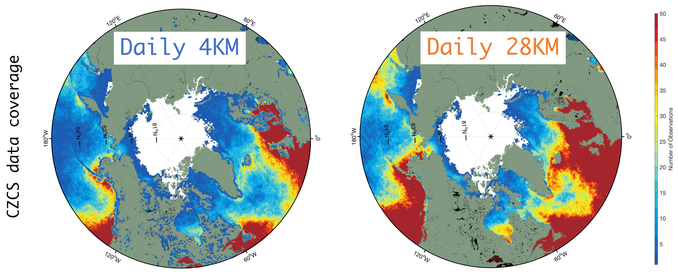
INTRODUCTION

Remotely-sensed Ocean color data offer a unique opportunity for studying phytoplankton dynamics in the Arctic ocean, where in situ data are sparse, in response to change in ice cover and warming temperatures (Figure 1). Ocean Color data collected by SeaWiFs, MODIS and VIIRS offer a 20-year time series (1997-2017).

While many efforts are carried out to inter-calibrate these sensors in order to provide homogeneous time-series (e.g.: CCI, GlobColour), we extend it by merging data from the Coastal Zone Color Scanner (CZCS, 1979-1986) with recent ones. We apply a regional algorithm and produce for the first time a consistent Arctic-adapted time series to witness changes in phytoplankton biomass and primary productivity over the last 4 decades in relation with climate forcings. Here, as a first step, we present preliminary results assessing the quality of the time series and first trend estimates.

FILLING THE GAPS

Missing data are an issue when working with satellite ocean color, especially in the Arctic due to a combination of sea ice, clouds cover and poor spatial coverage of CZCS.
In order to minimize the impacts of missing data when deriving trends, composite maps of 8- and 30-day binned data projected onto a sinusoidal 28-km resolution grid were calculated to increase significantly the data coverage by a factor 10.



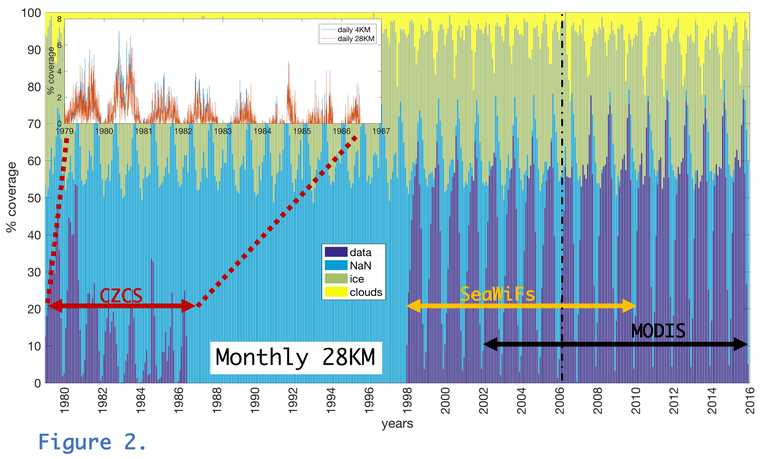


Figure 2.

OBJECTIVES

1. Produce an arctic-adapted-homogeneous time-series from 1979 to present time by adding CZCS data to "modern-era" sensors, namely SeaWiFs, MODIS, VIIRS.
2. Derive PP and Chl *a* trends
3. Identify the phytoplankton baseline in the 70s
4. Estimate the impact of sea-ice decline on phytoplankton dynamics.

METHOD

- Process all modern sensors "like CZCS" ➔ atmospheric correction based on an iteration using a unique IR wavelength[1, 3] ⚠
- Estimate errors of: Rrs *standard* **vs.** Rrs *'CZCS-like'* (a.), $[Chl\ a]_{SeaWiFs}$ vs. $[Chl\ a]_{MODIS}$ (b.)
- Assess performance of retrieved [Chl *a*] algorithms (c.) and Primary Production models (d.).

FIRST TREND ESTIMATES

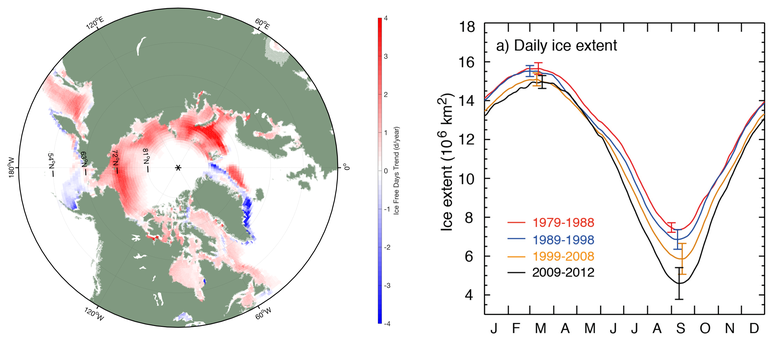


Figure 1.

Bio-regions

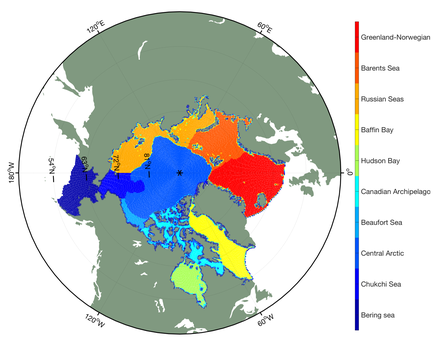
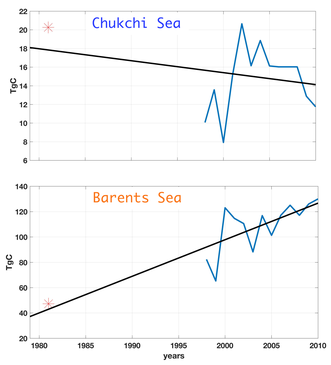


Figure 3.

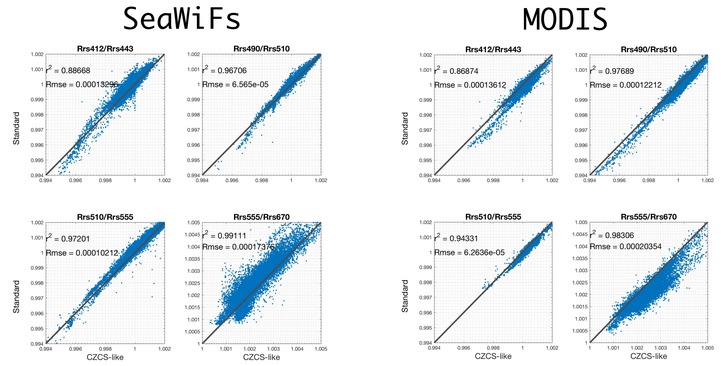
2 inflow shelves examples



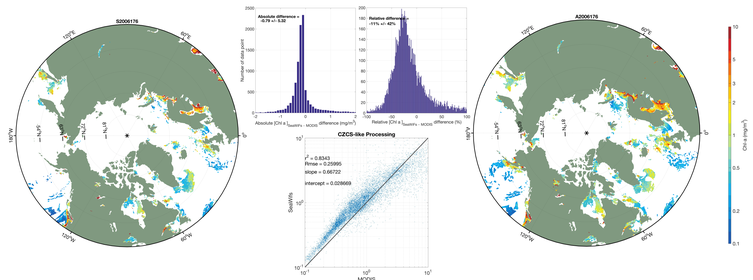
DATASET QUALITY

⚠ CZCS does not have a pair of infrared wavelength allowing a conventional atmospheric correction.
An iteration scheme using the 670nm is used instead.

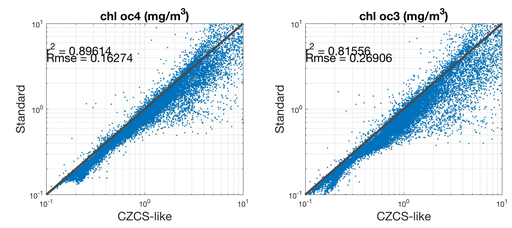
a. PROCESS modern sensors 'CZCS-like'



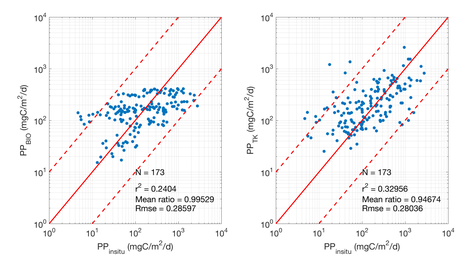
b. SeaWiFs vs. MODIS



c. Compare Chl *a* algorithms



d. Assess PP models efficiency



PP_{TK} is a model adapted from Takuvik (Bélanger et al. 2013; Huot et al. 2013) and *Ardyna et al. 2013*. PP_{BIO} is the model developped by *Platt et al., 1991* at the Bedford Institute of Oceanography (BIO).
DATABASE: NOW 1998, 1999; CASES 2003, 2004; MERICA 2005, 2006; CFL 2008; Malina 2009; ArcticNet 2005, 2006, 2007, 2008, 2010, 2011. *Ardyna et al. 2011.*

PRELIMINARY RESULTS

- Differences between $Rrs_{CZCS\text{-}like}$ and $Rrs_{Standard}$ are extremely small. Discrepancies in the IR wavelength Rrs_{670} are attributed to the CZCS-like atmospheric correction iteration scheme) (a.)
- The small differences (11%) observed between the SeaWiFs vs. MODIS estimated $[Chl\ a]^{OC3}$ (b.) insures good blending of the missions.
- Differences between [Chl *a*] $^{OC4\text{-}OC3}$ standard **vs.** CZCS-like algorithms remain small. However, we found that most of time $[Chl\ a]_{CZCS\text{-}like} < [Chl\ a]_{standard}$ especially when concentrations are high (i.e. in coastal areas). (c.)
- The two models PP_{BIO} and $PP_{TAKUVIK}$ showed both good performances when compared with in situ data. $PP_{TAKUVIK}$ is an Arctic-adapted model and performed slightly better than PP_{BIO}. (d.)
- CZCS shows appropriate data coverage when averaged in time and space (30 days at 28km or climatology, Figure 2).
- The addition of CZCS either confirm (i.e. Barents Sea) or invalidate (i.e Chukchi Sea) PP trends (Figure 3).

PERSPECTIVES

- Finish Processing MODIS and start VIIRS
- Quantify trends by bio-regions until present time prior to sea-ice increase melting

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MAIN REFERENCES: [1]***Antoine et al., 2005,*** *Bridging ocean color observations of the 1980s and 2000s in search of long-term trends.* [2]***D'Ortenzio et al., 2012,*** *Phenological changes of oceanic phytoplankton in the 1980s and 2000s as revealed by remotely sensed ocean-color observations.* [3]***Gregg et al. 2002,*** *NOAA-NASA Coastal Zone Color Scanner Reanalysis Effort.* [4]***Racault et al. 2014,*** *Impact of missing data on the estimation of ecological indicators from satellite ocean-colour time-series.*