



Second DBO Data Workshop:  
**Satellite Data Coverage  
across the Distributed  
Biological Observatory**

29–31 October 2014  
PMEL/NOAA, Bldg 3, Oceanographer Room  
7600 Sand Point Way NE, Seattle, Washington, USA

# Large scale variability of Arctic sea ice, clouds and primary productivity

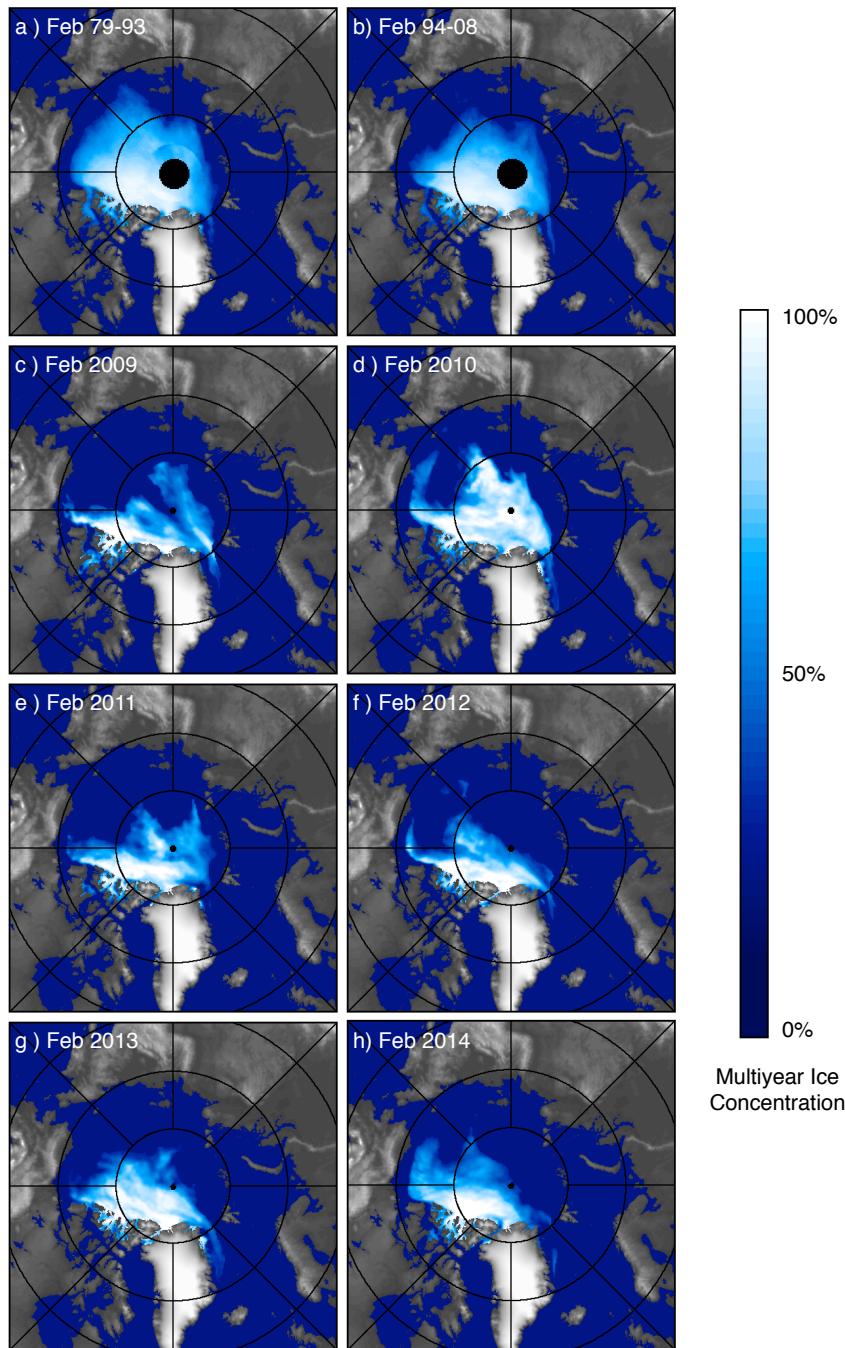
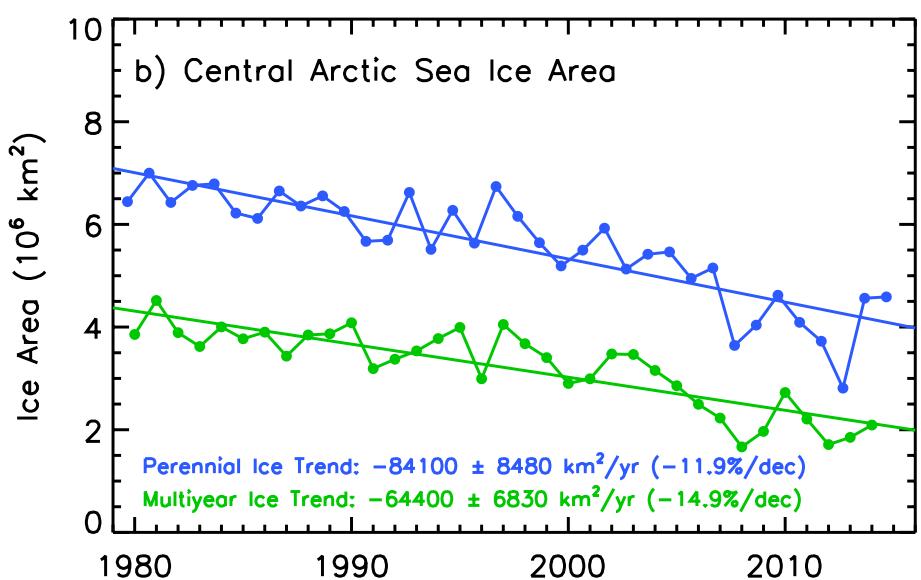
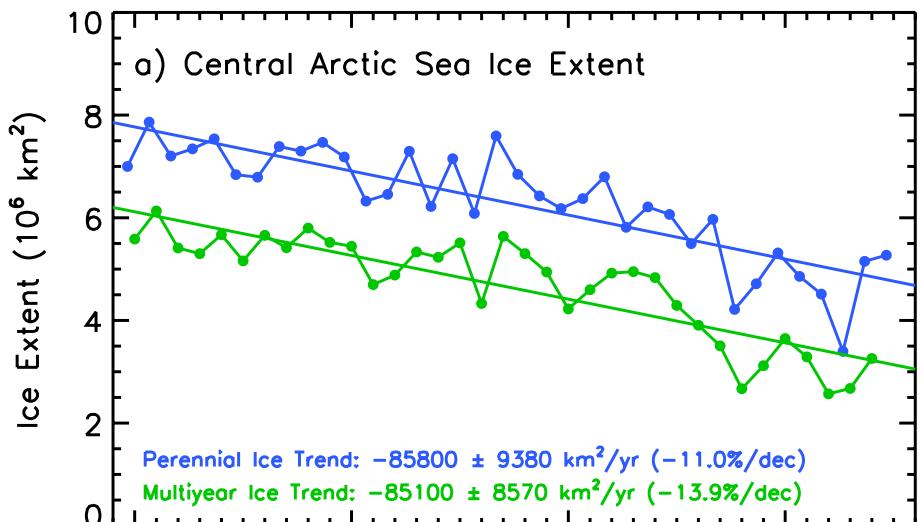
Josefino C. Comiso  
NASA Goddard Space Flight Center

DBO Workshop, PMEL, Seattle, WA  
29-31 October 2014

# Rapid Decline of Arctic Thick Ice

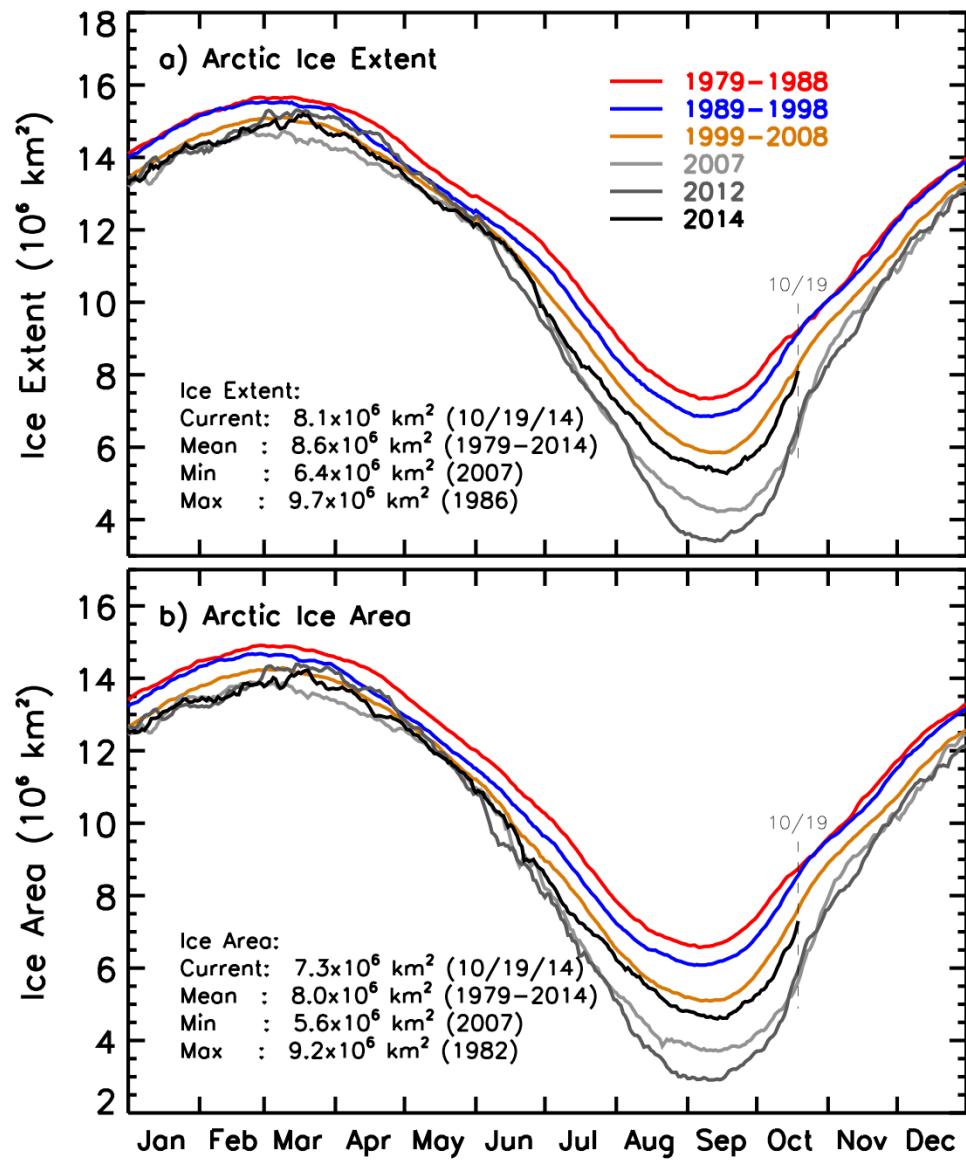
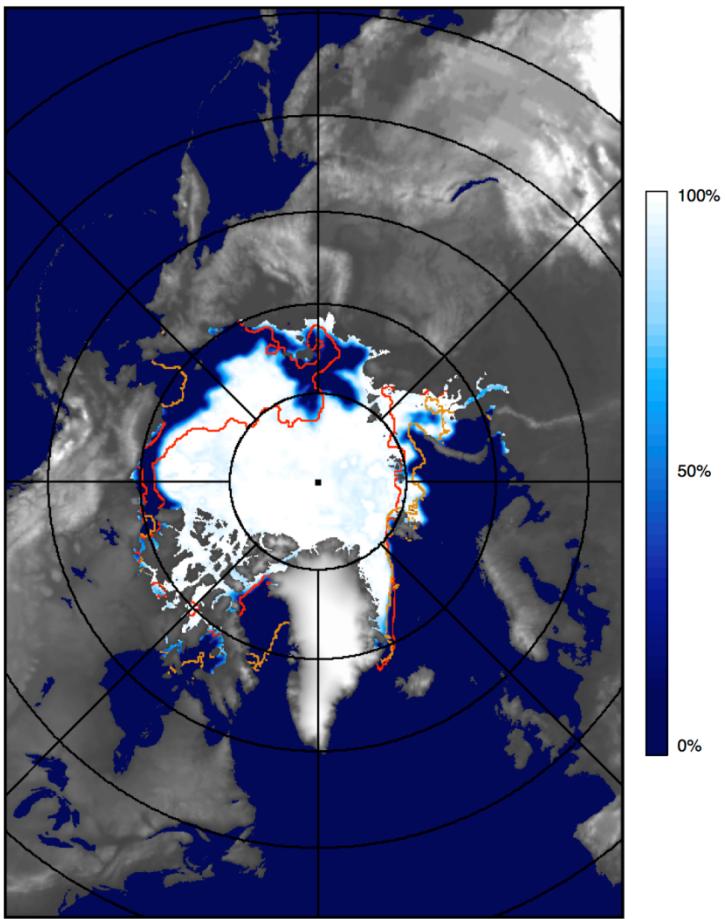
Comiso, J (2002) A rapidly declining perennial ice cover, *Geophys Rev Letts.* 29(20), 1956, doi:10.1029/2002GL015650, 2002.

Comiso, J (2011) Large decadal decline of the Arctic multiyear ice cover, *J Climate*, 25, 1176-1193.

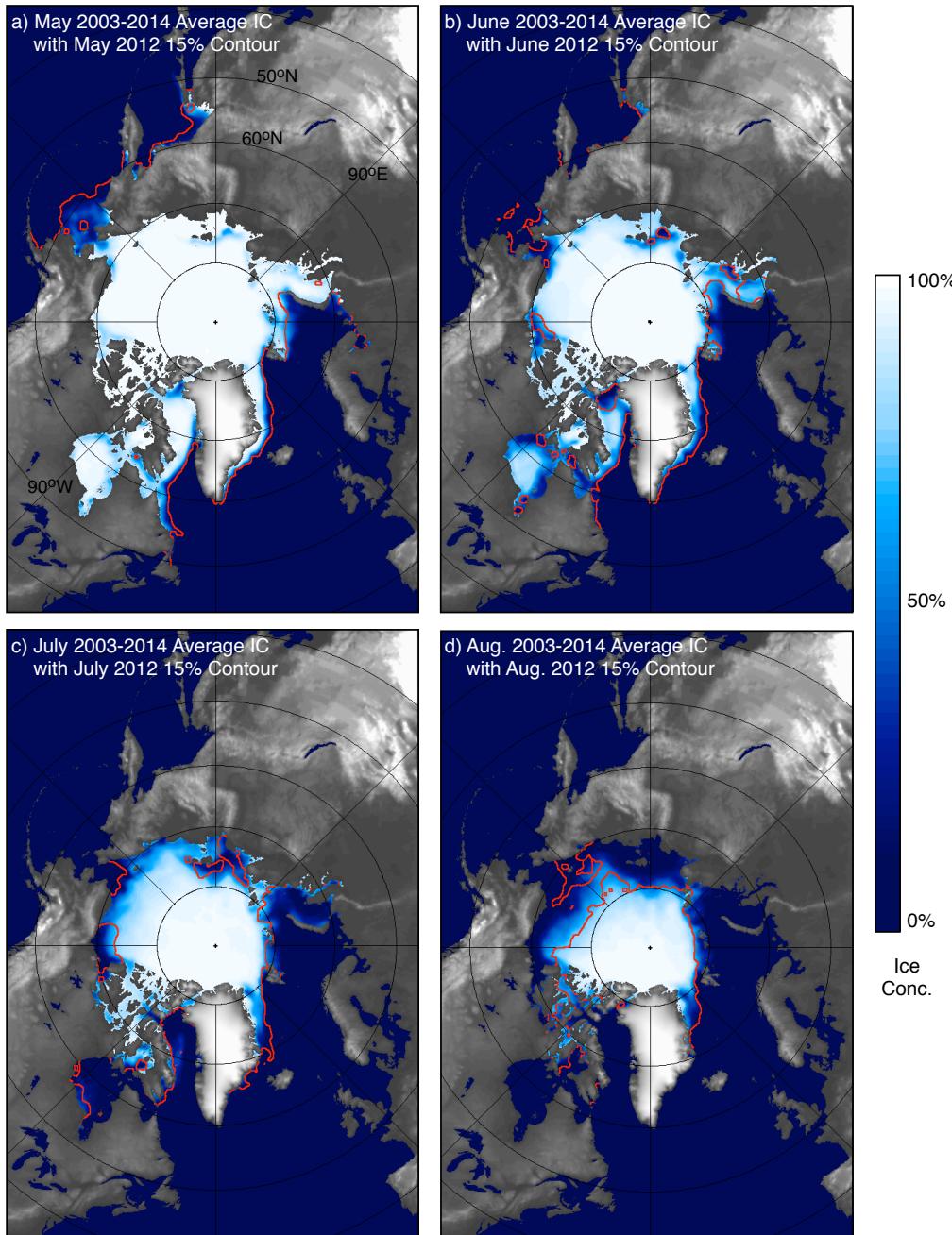


# Seasonal Changes in the Arctic Sea Ice Cover and Current Ice Cover

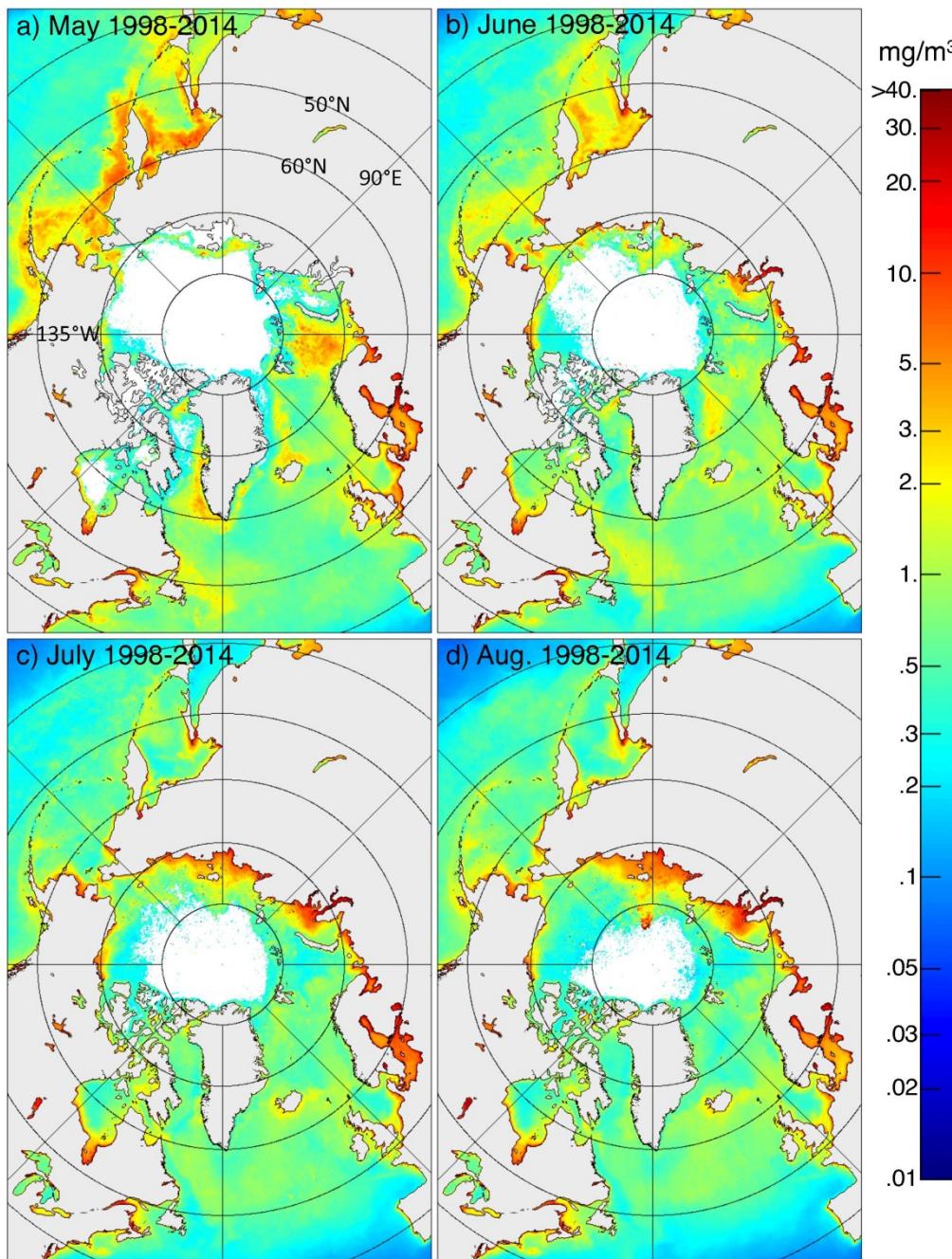
Northern Hemisphere, October 19, 2014



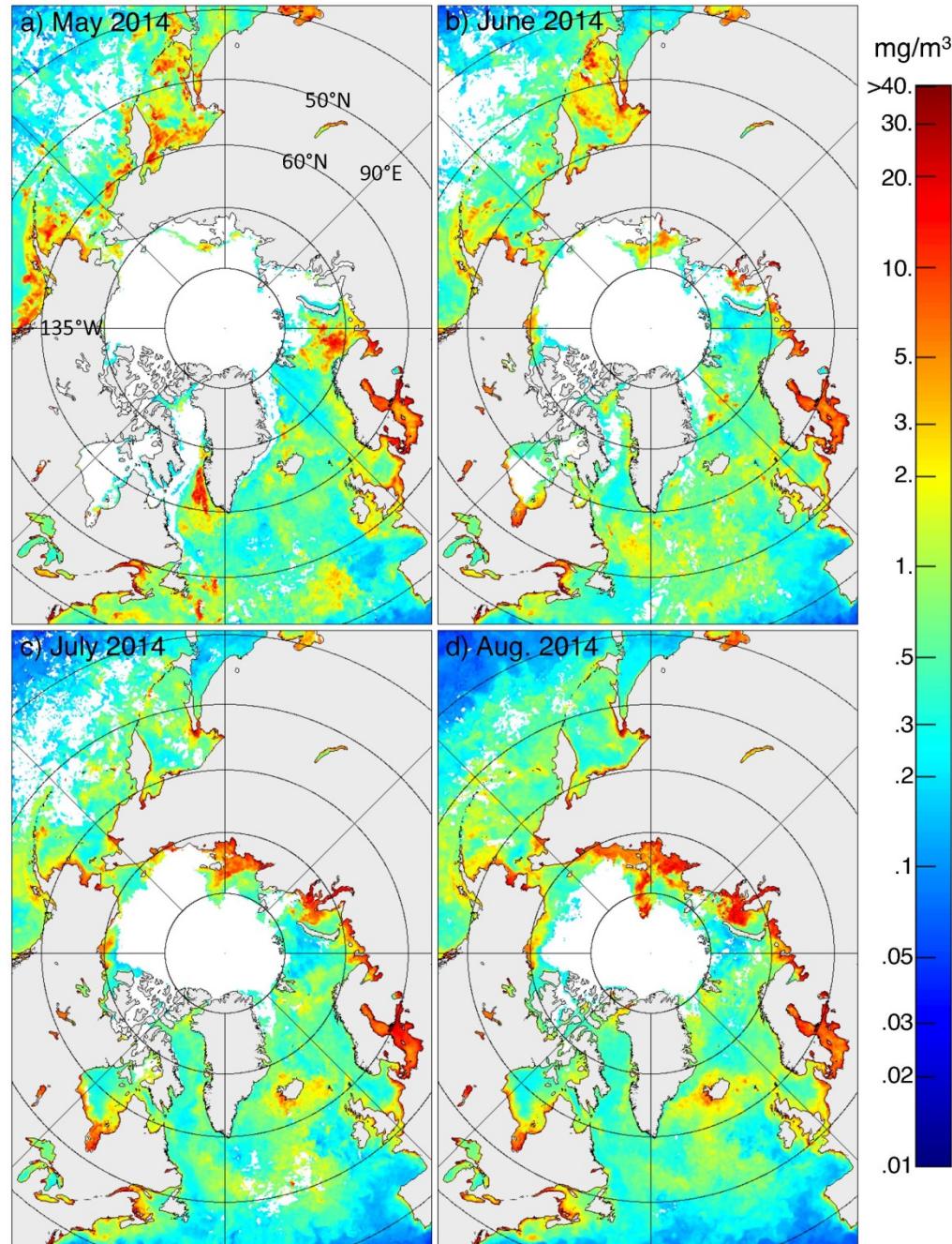
# Arctic Sea Ice Concentration Climatology



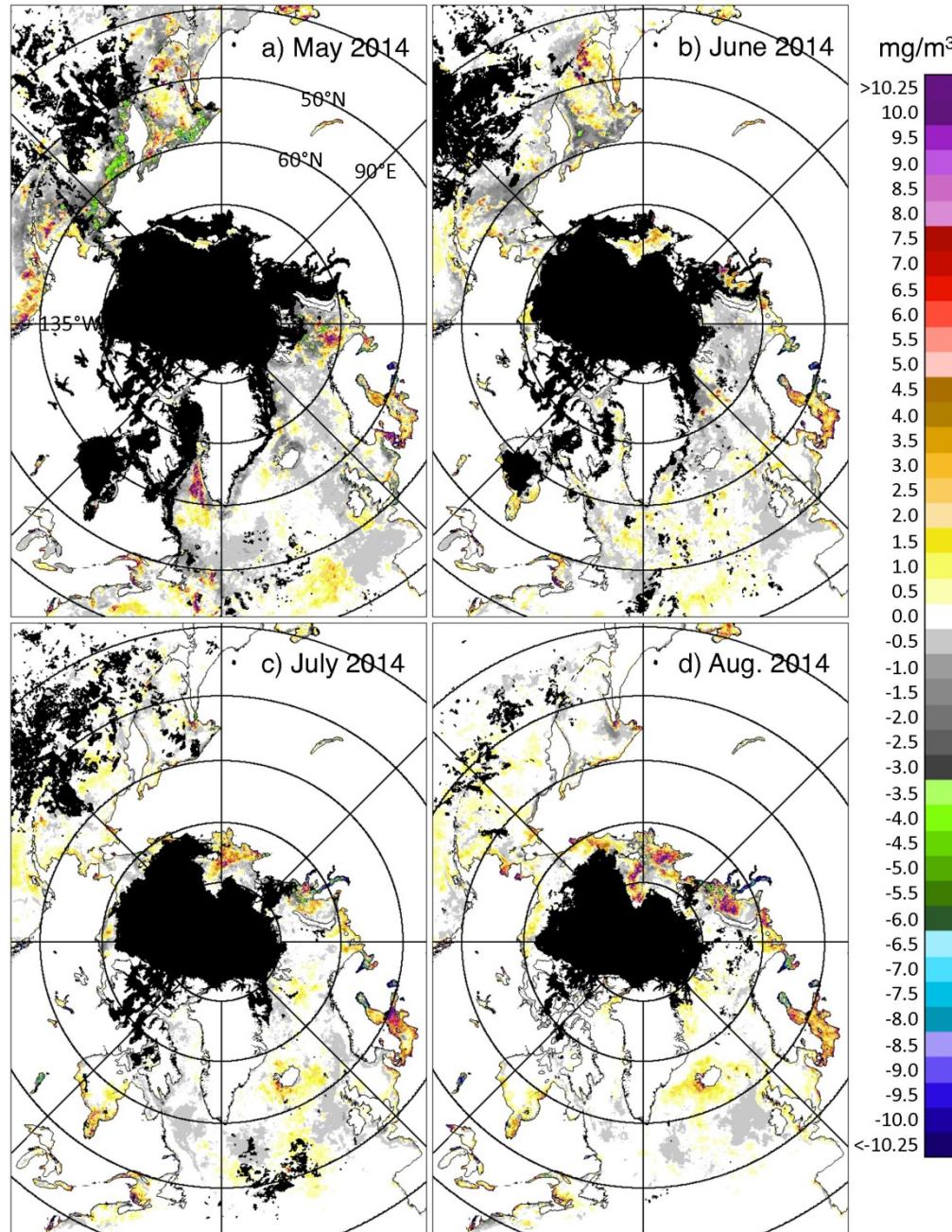
# Arctic Chlorophyll *a* Monthly Climatology



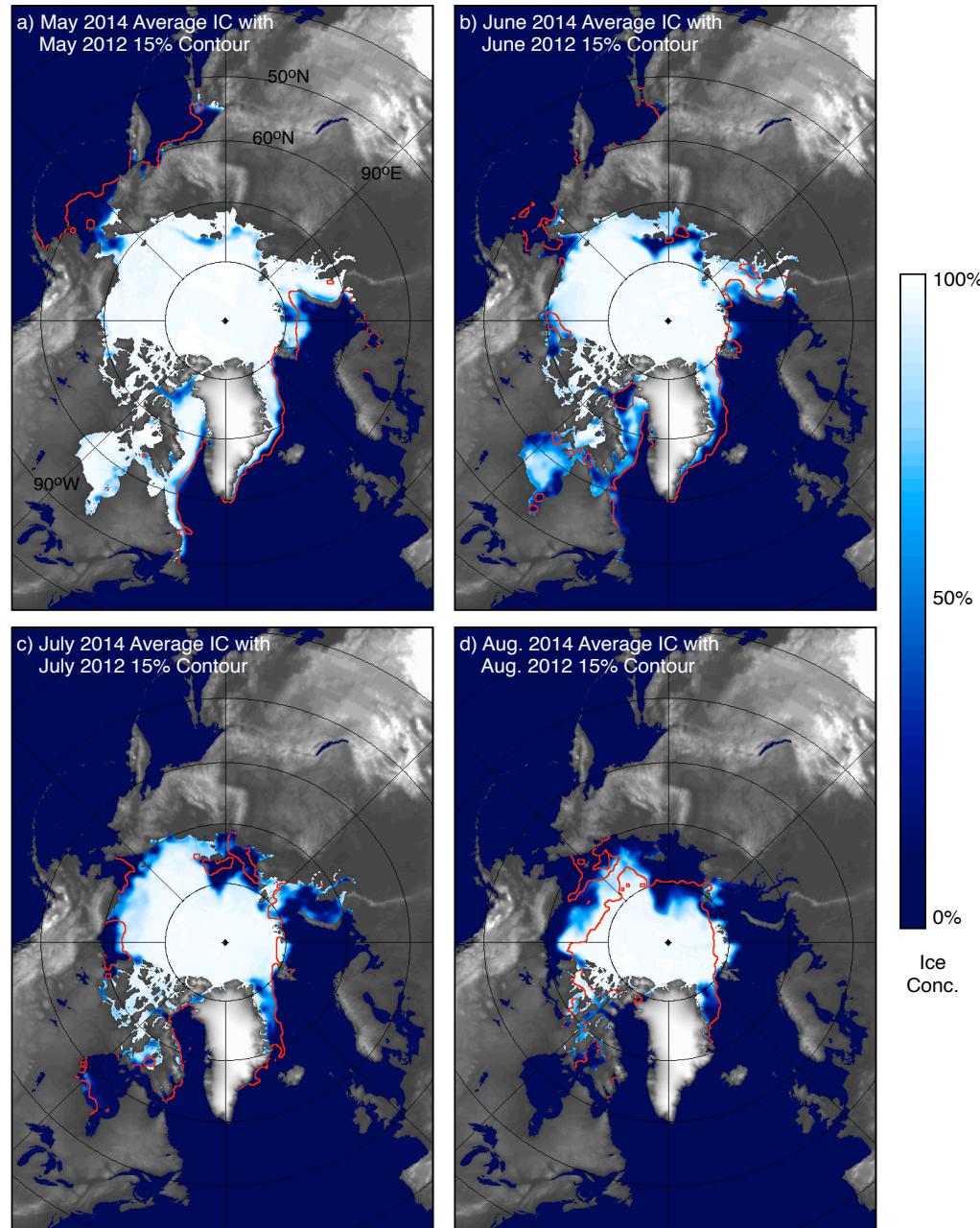
# Arctic Chlorophyll *a* Monthly Average in 2014



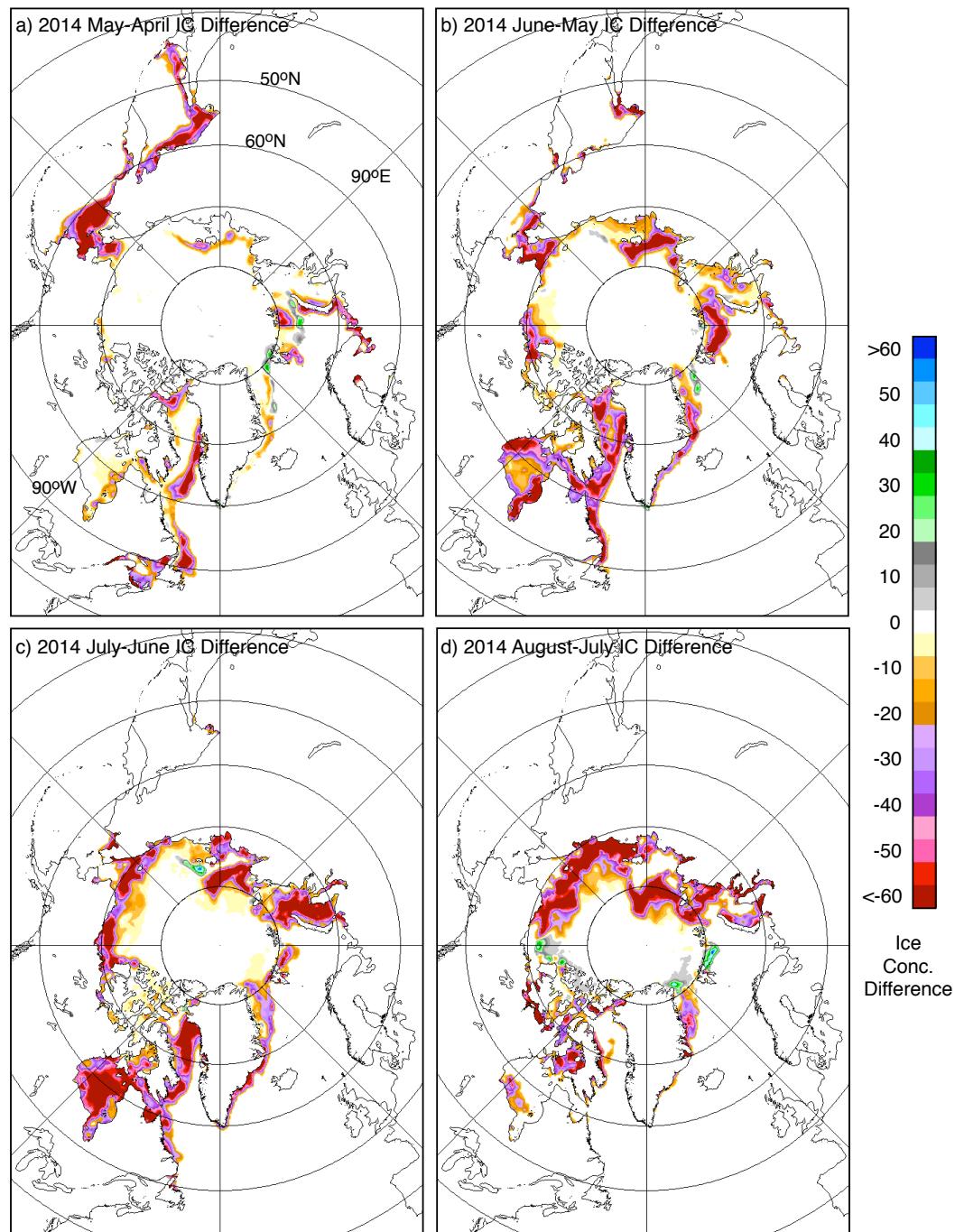
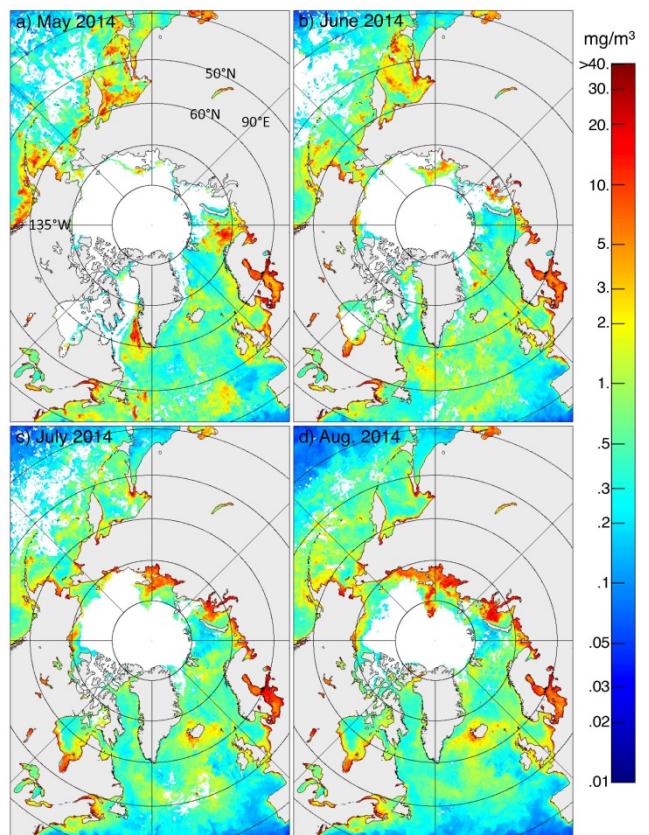
# Anomalies of Chlorophyll *a* in 2014



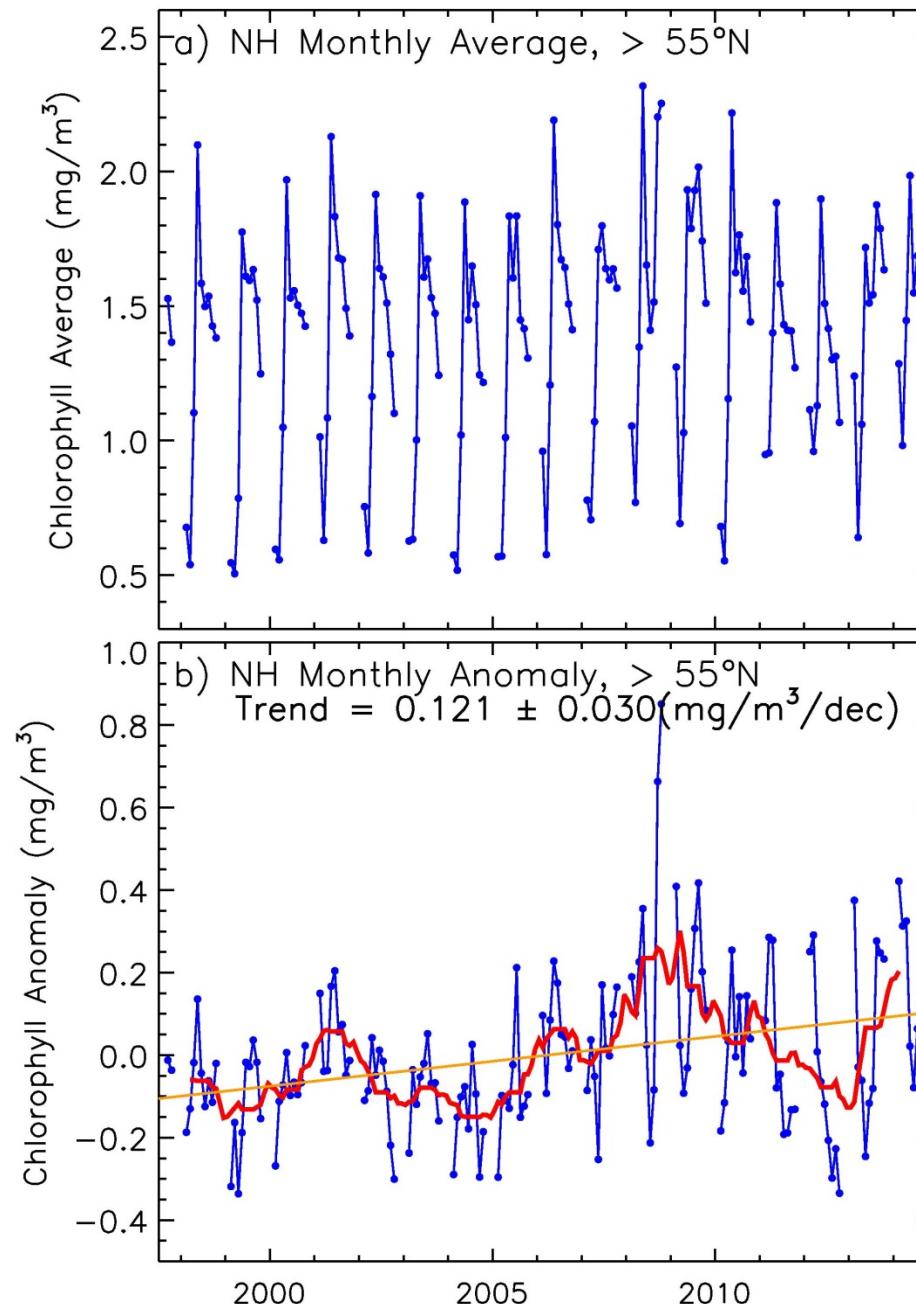
# Monthly Sea Ice Concentrations in 2014



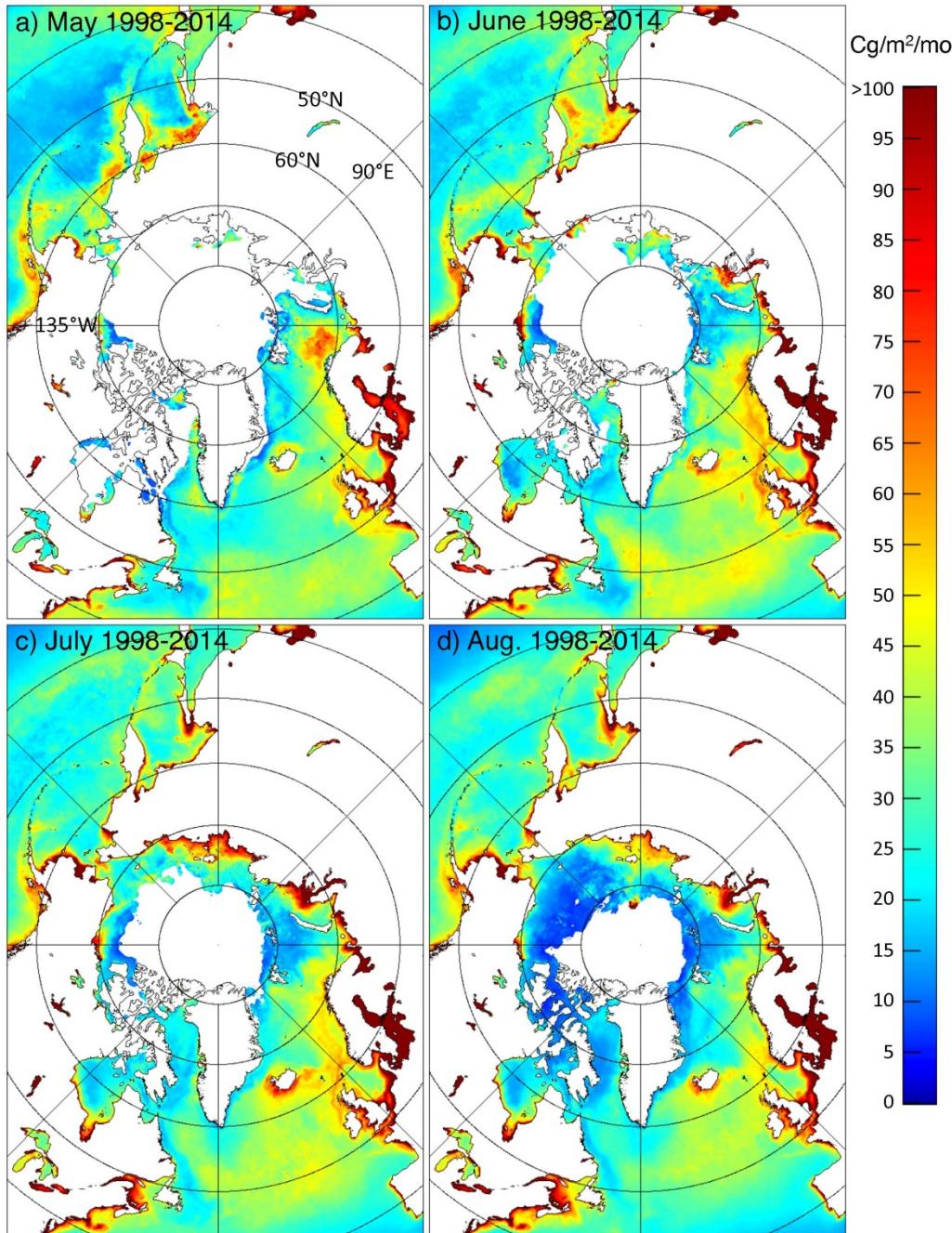
# Monthly Meltwater Production in 2014



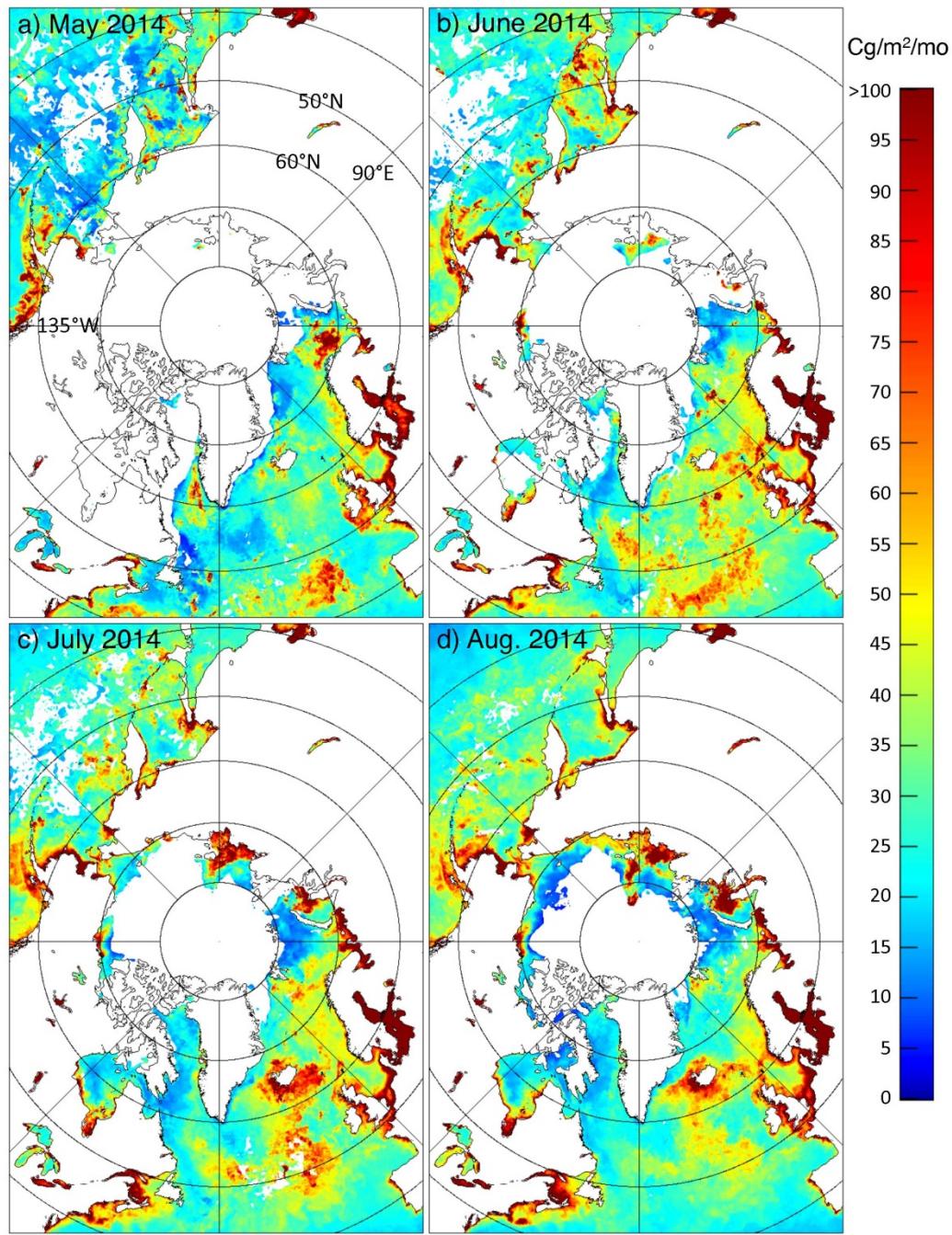
# Monthly Averages, Anomalies and Trend



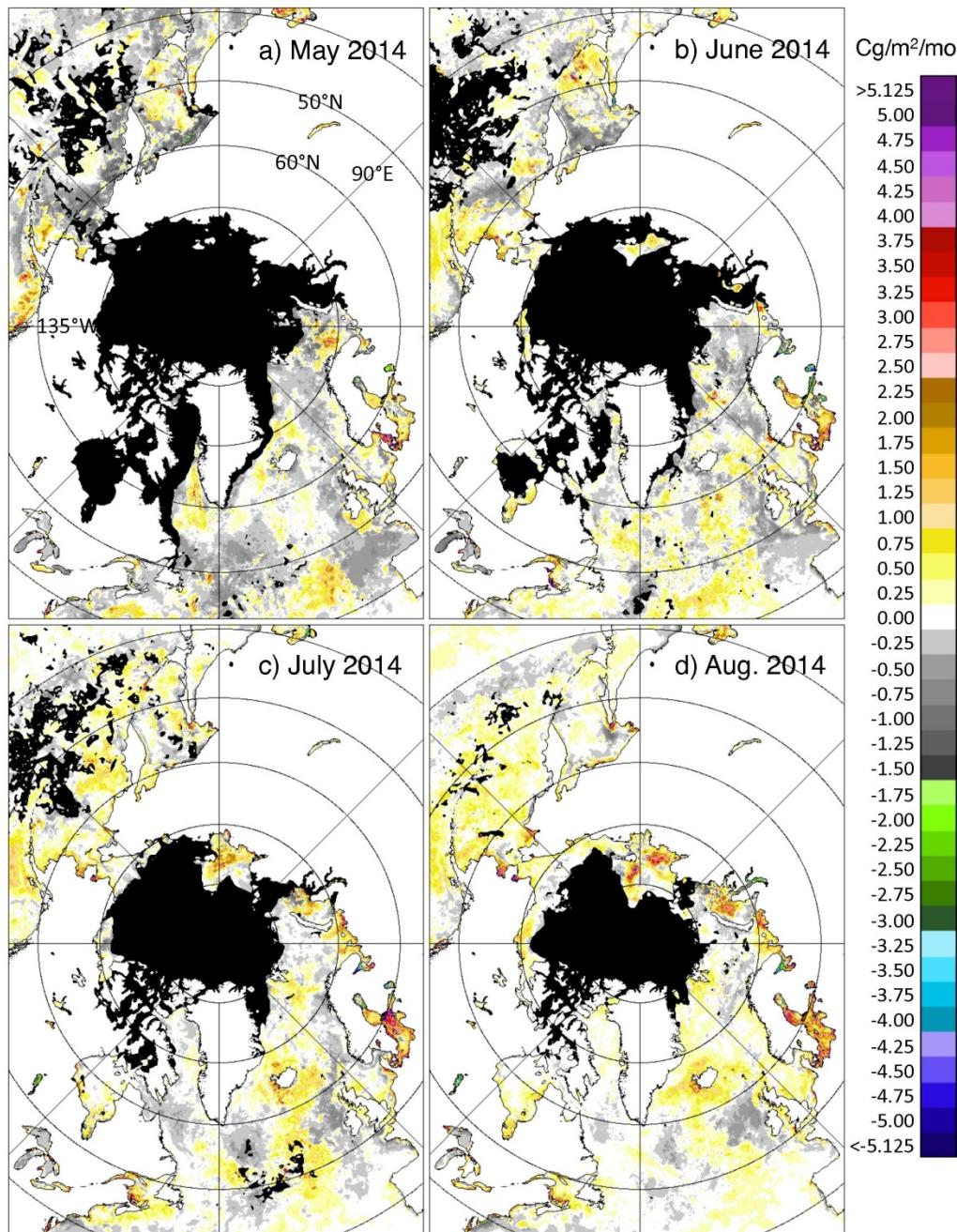
# Arctic Climatological Net Primary Productivity



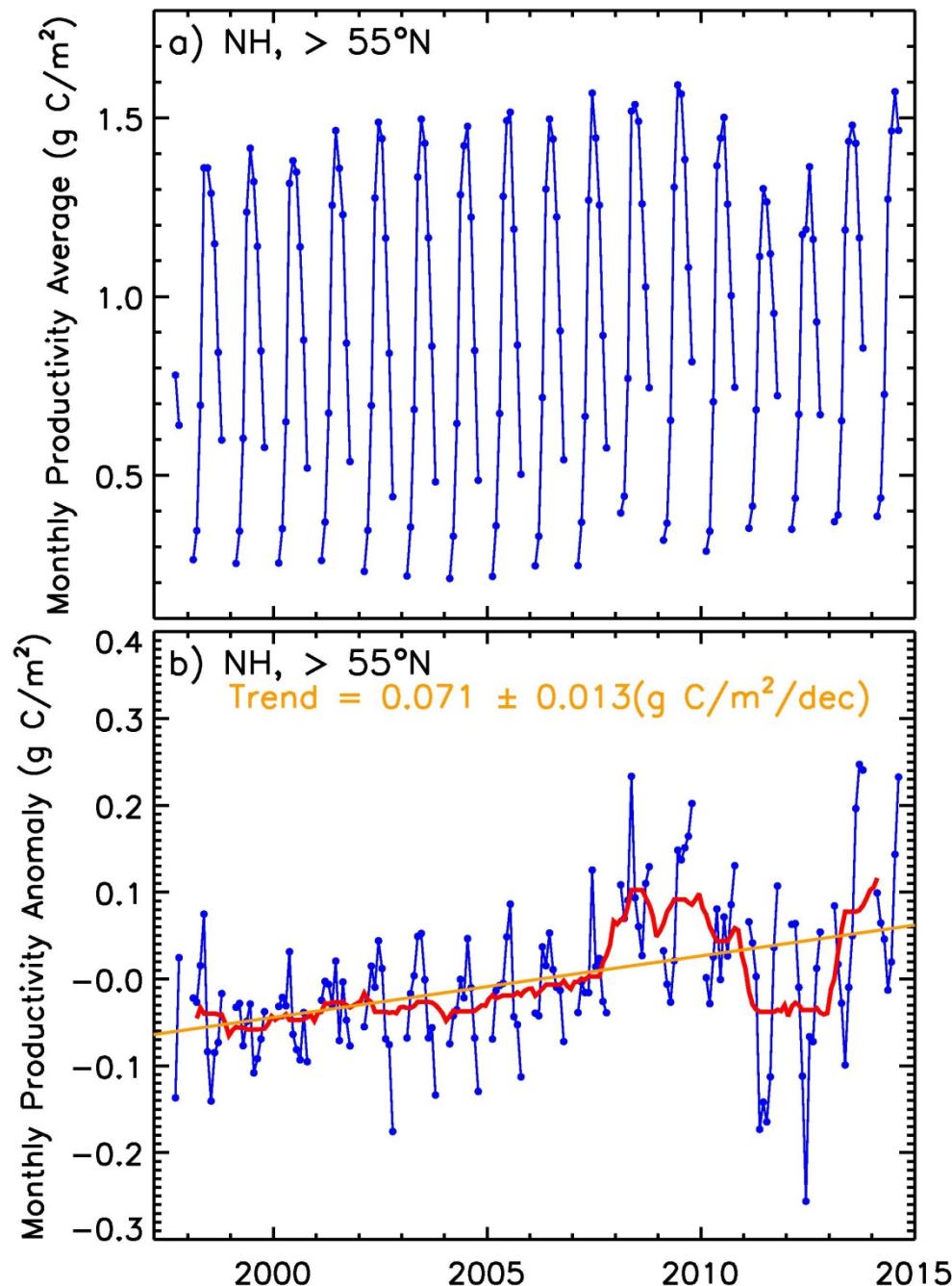
# Arctic Net Primary Productivity in 2014



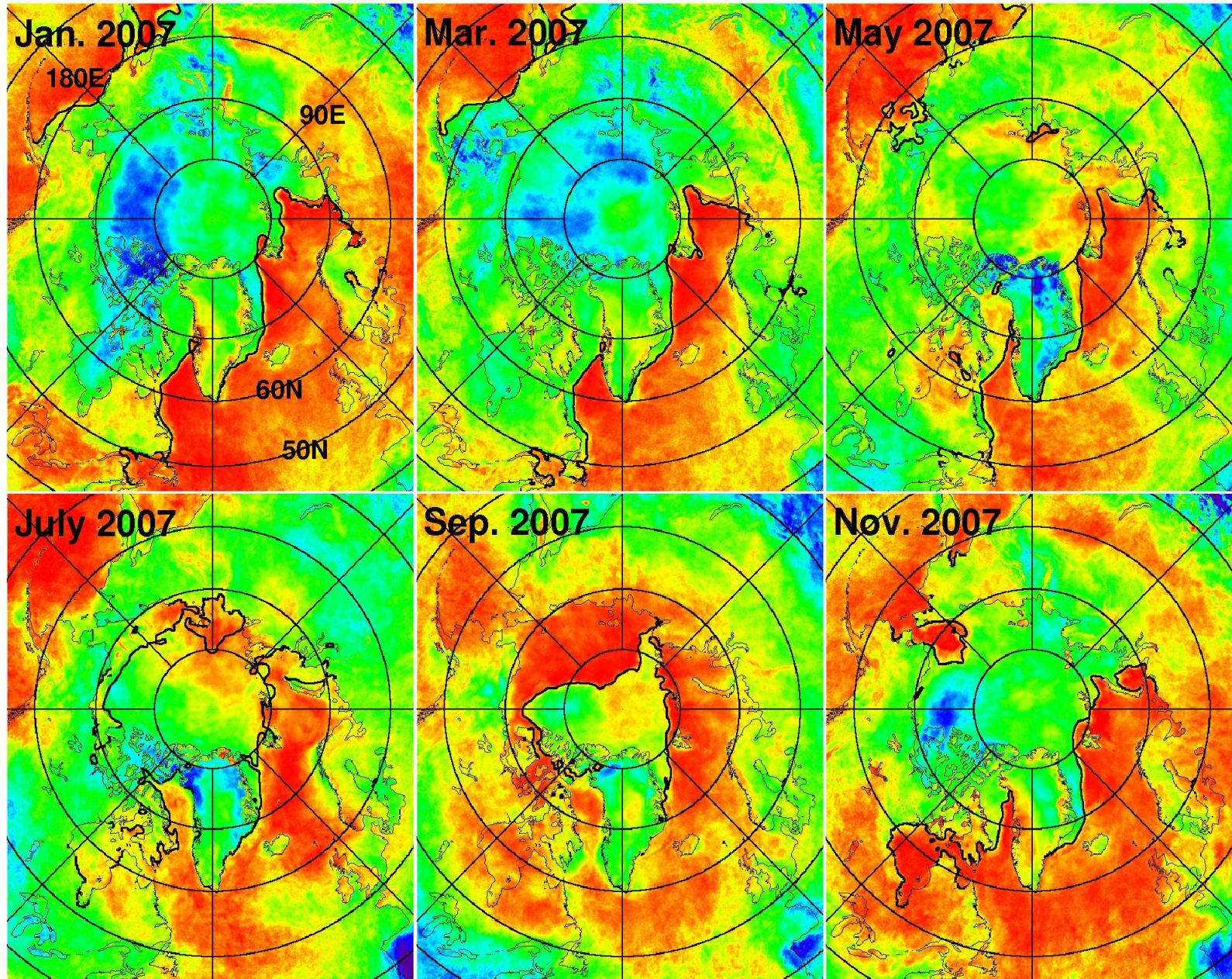
# Anomalies in Net Primary Productivity in 2014



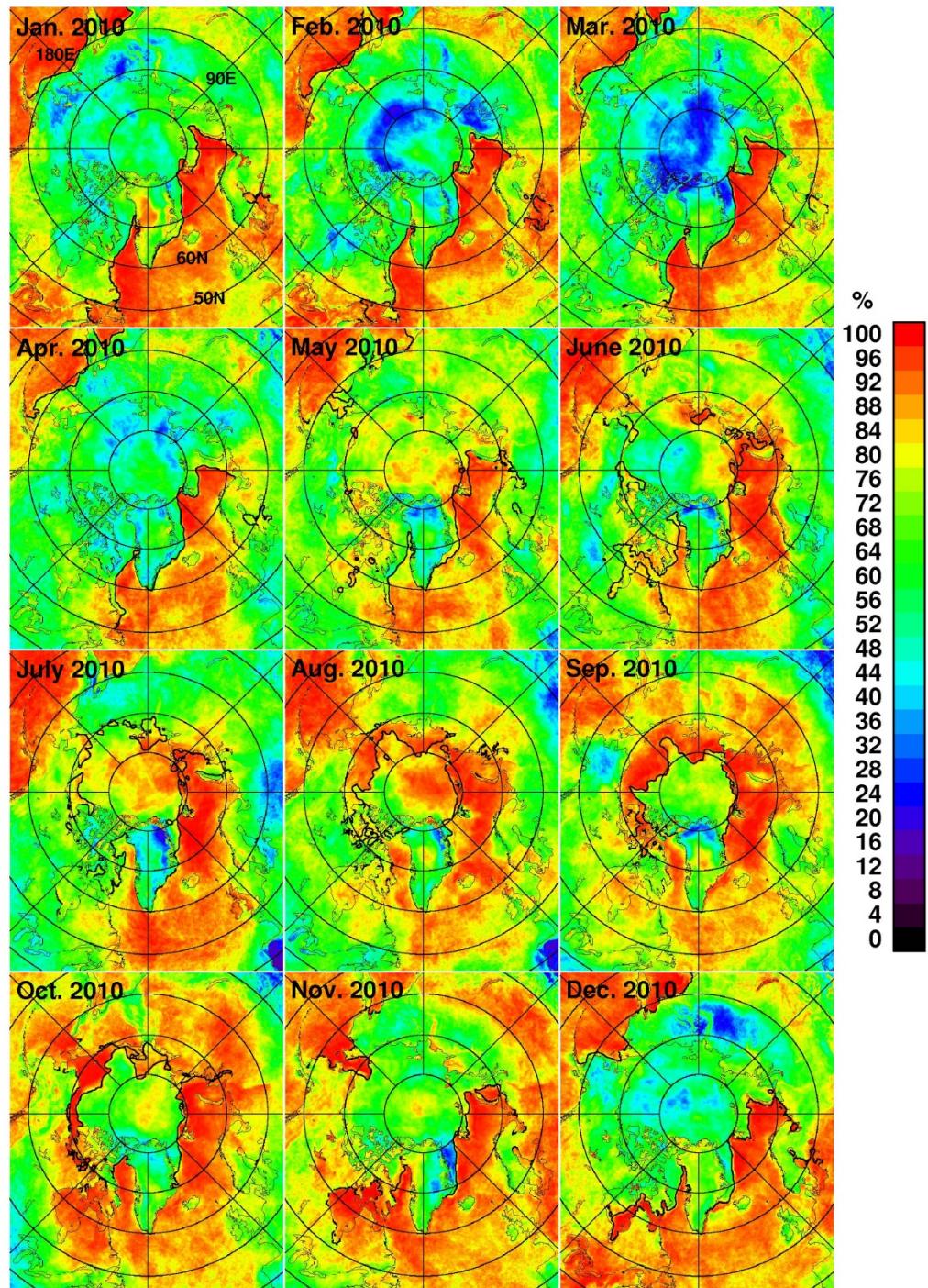
# Monthly averages of Net Primary Productivity



# Monthly Cloud Fraction in 2007

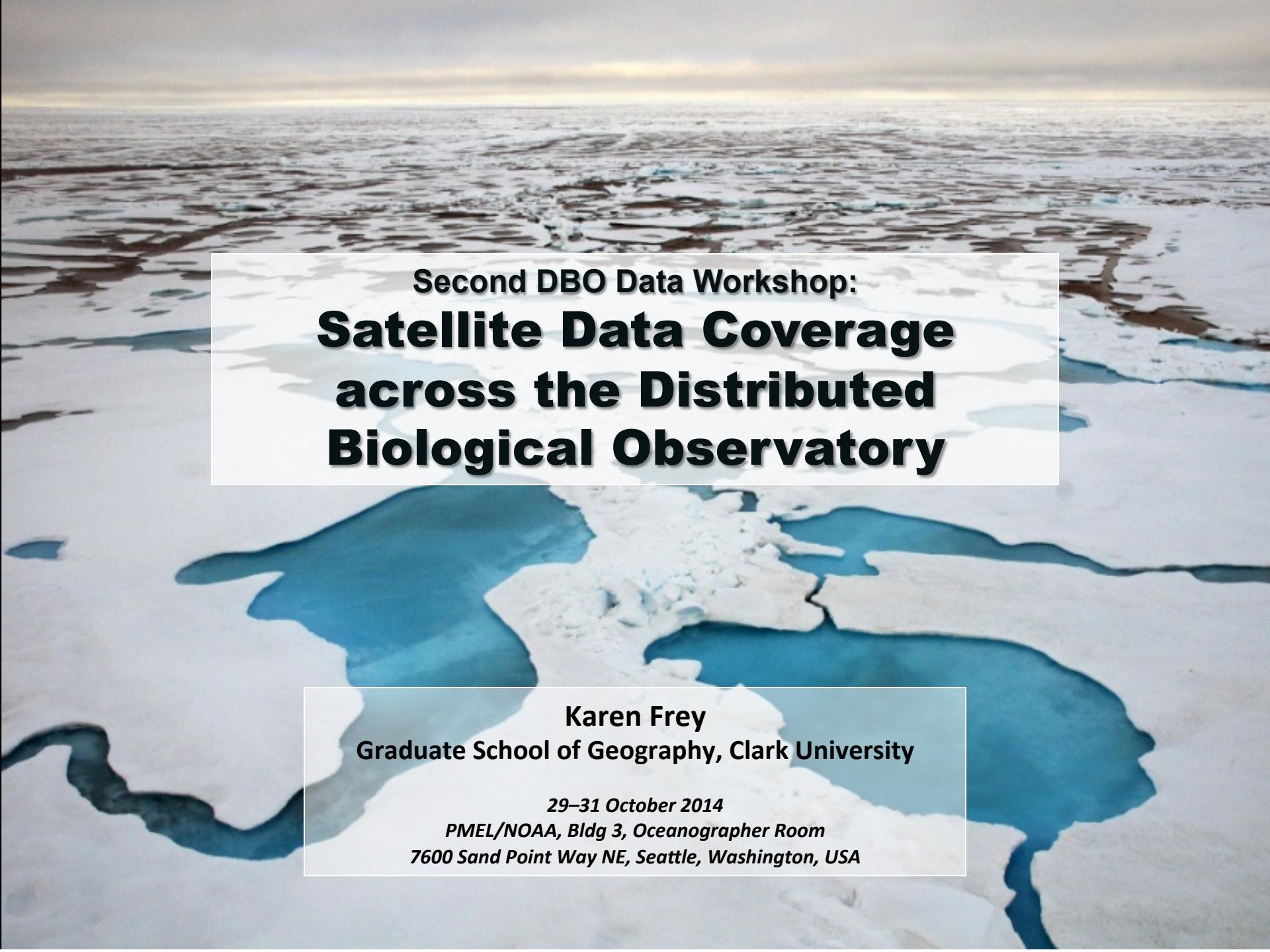


# Monthly Cloud Fraction in 2010



## Summary and Conclusions

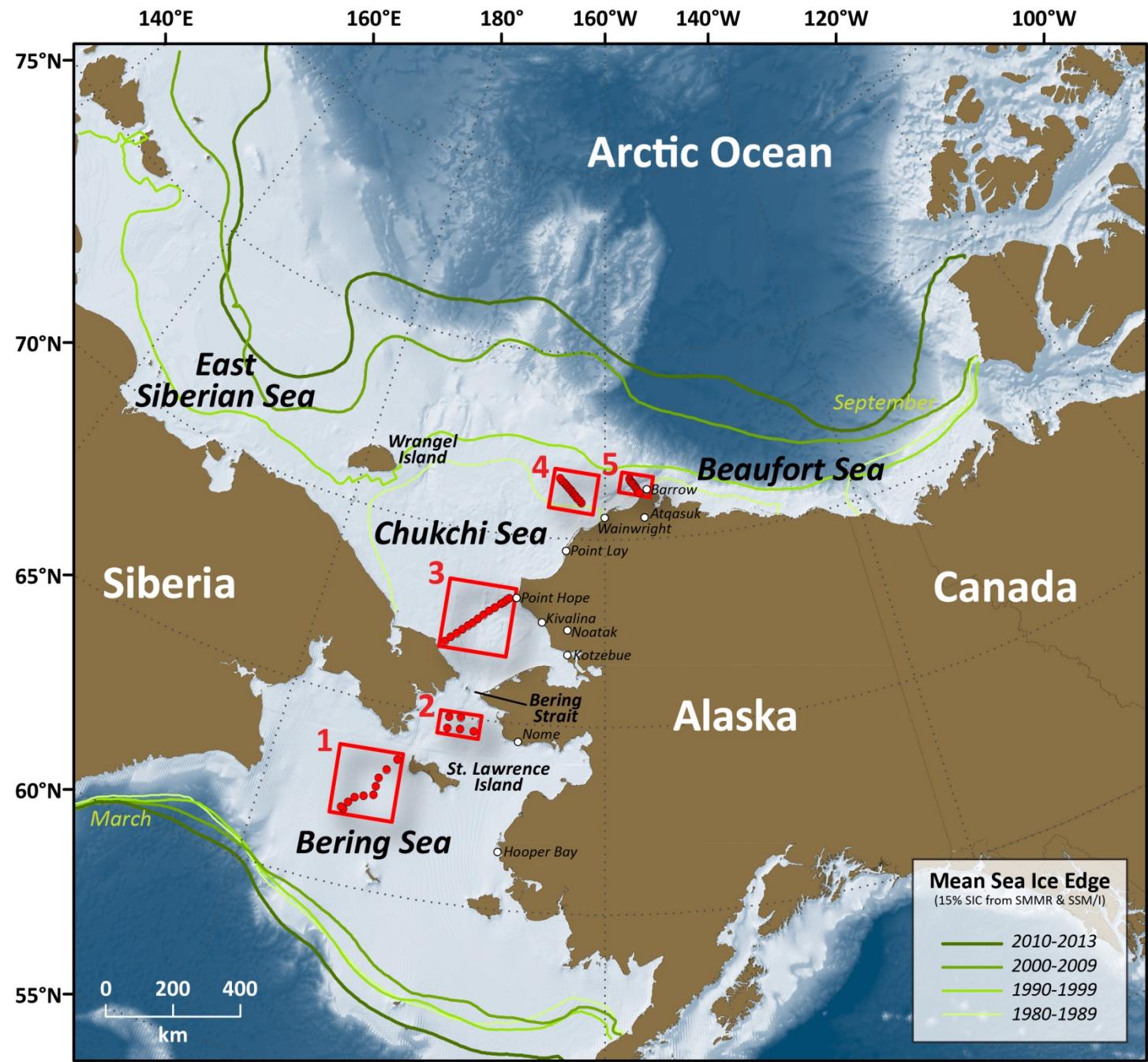
- Arctic productivity is changing but trends are basically difficult to interpret at this time.
- DBO and other data are needed to improve accuracy of retrieved chlorophyll a concentration estimates.
- Satellite data provides the means to look at the large scale distribution of plankton concentration and identify the location and spatial extent of the hot spots.



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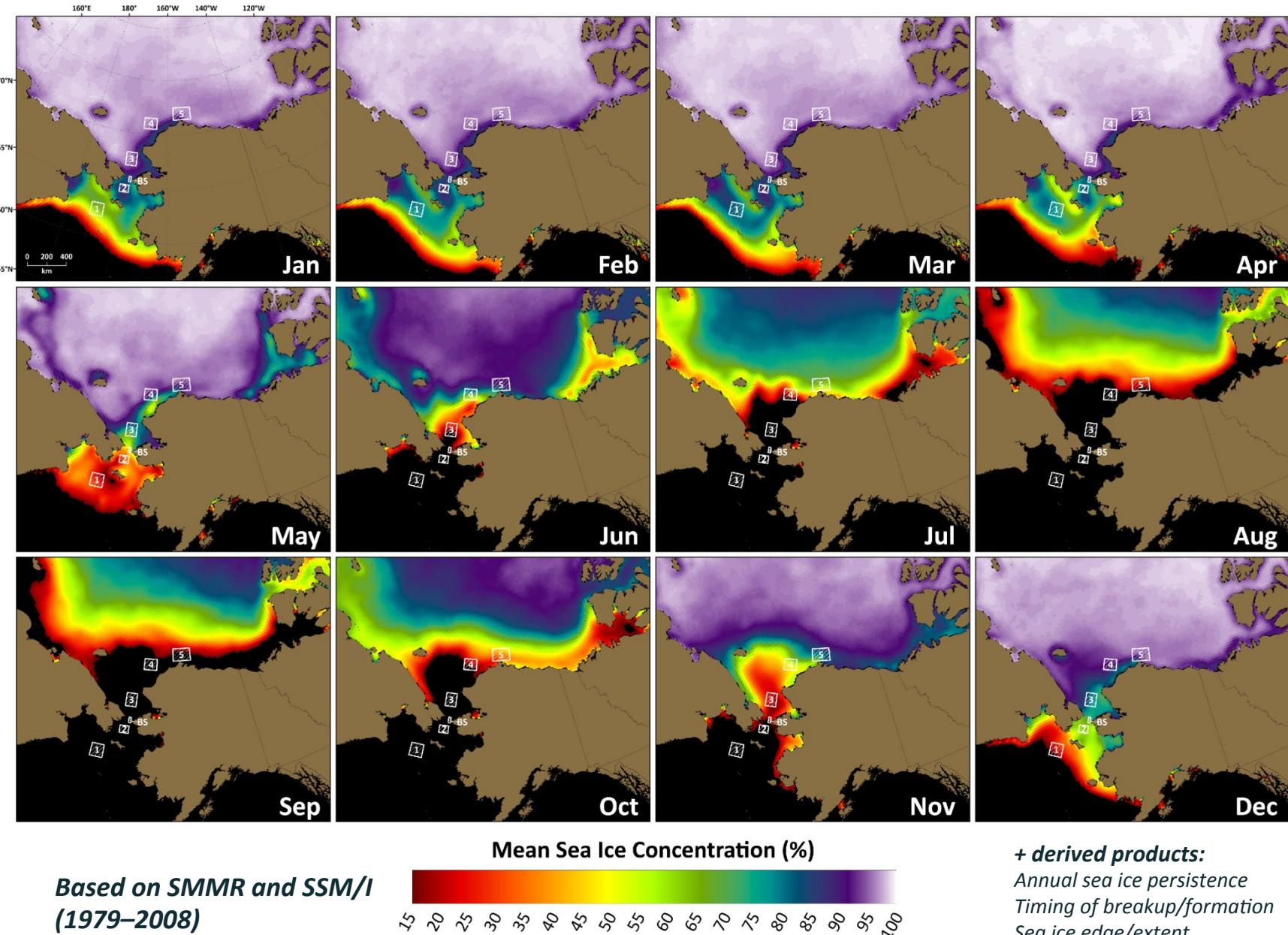
Karen Frey  
Graduate School of Geography, Clark University

*29–31 October 2014  
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7600 Sand Point Way NE, Seattle, Washington, USA*



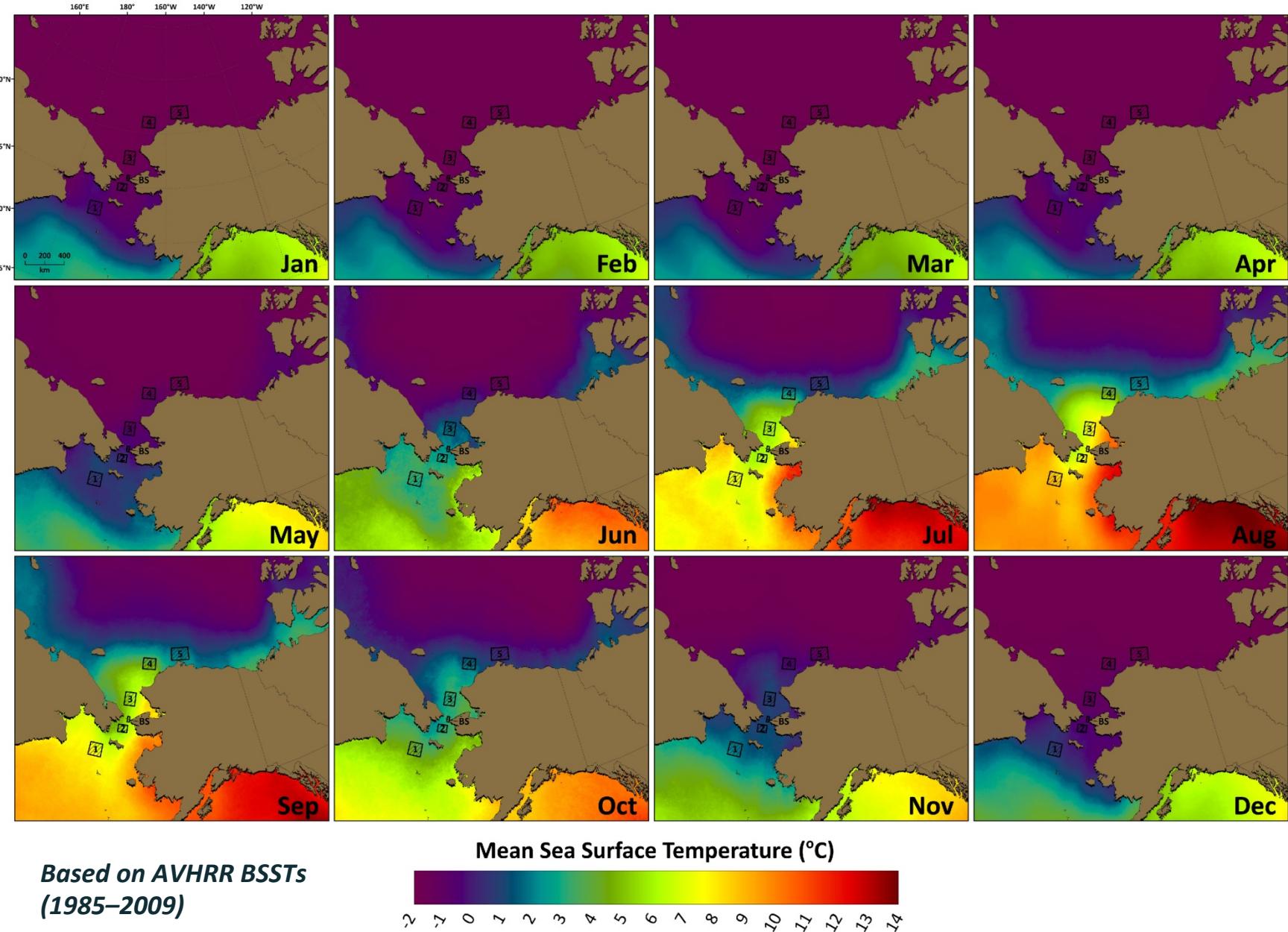
# Gridded Satellite Products

## Mean Sea Ice Concentration

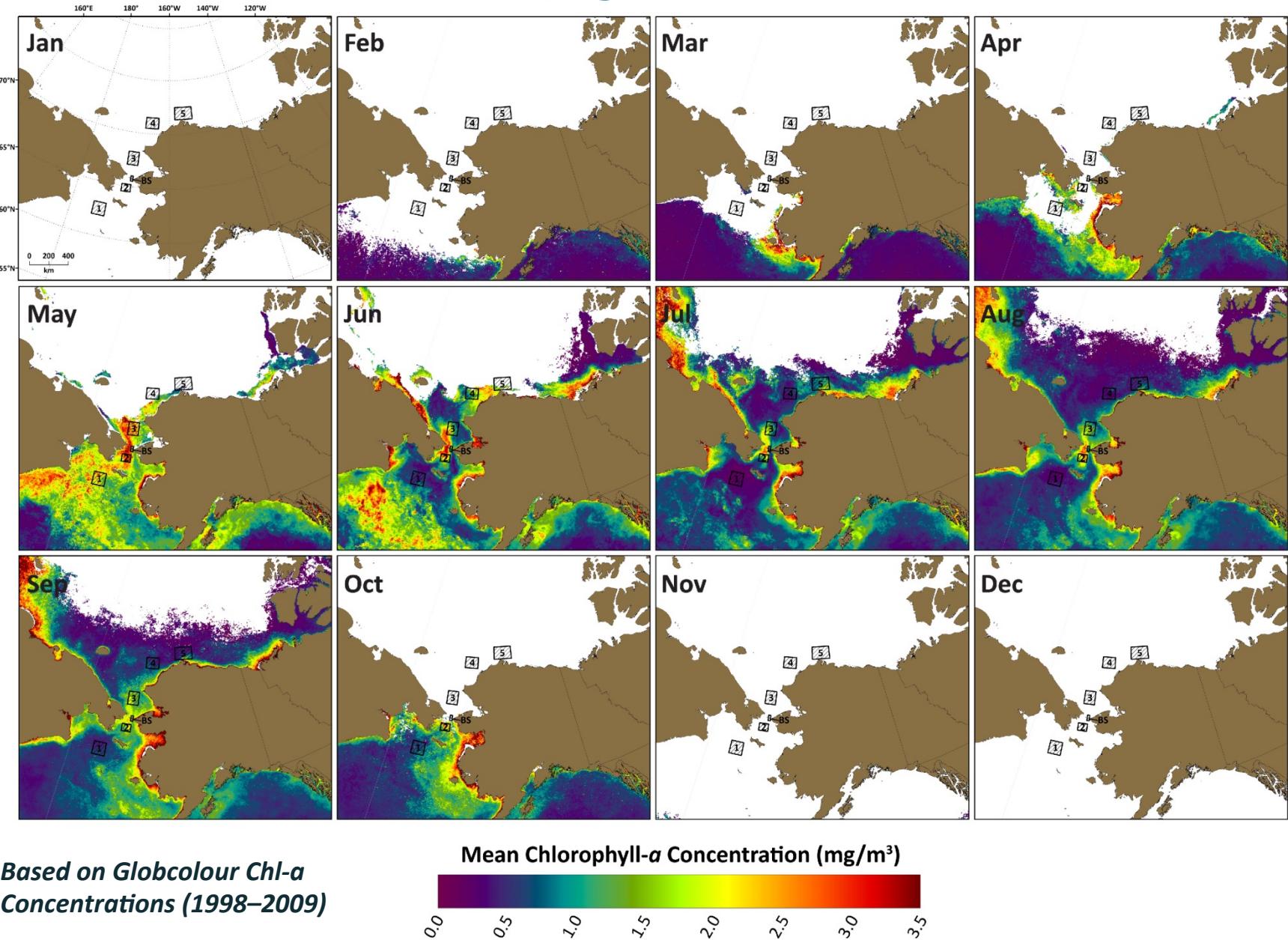


# Gridded Satellite Products

## Mean Sea Surface Temperatures



# Gridded Satellite Products: Mean Chlorophyll-a Concentrations



# A Climatology of the DBO Sites

**Sea Surface Temperature (AVHRR)**

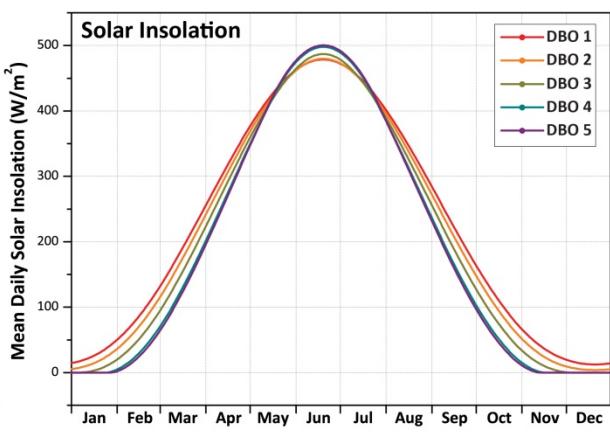
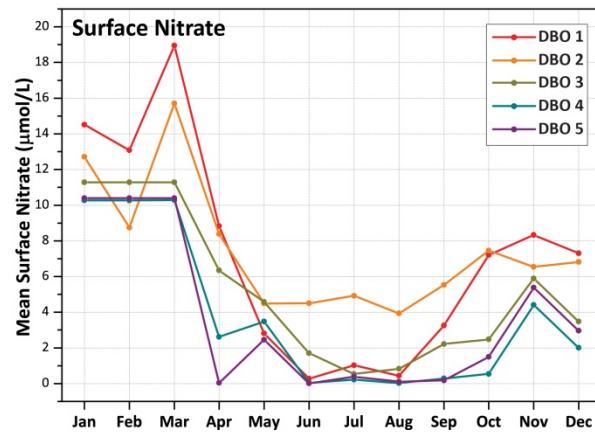
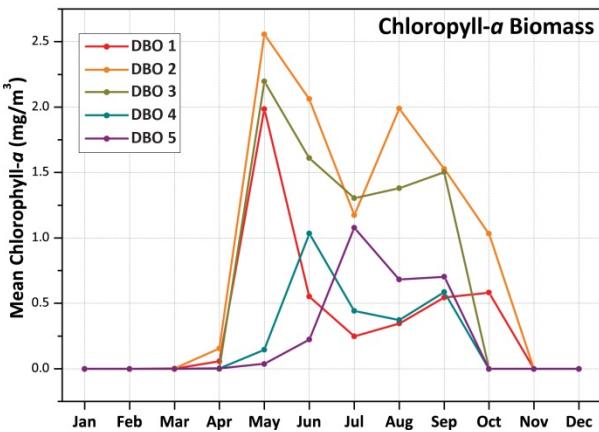
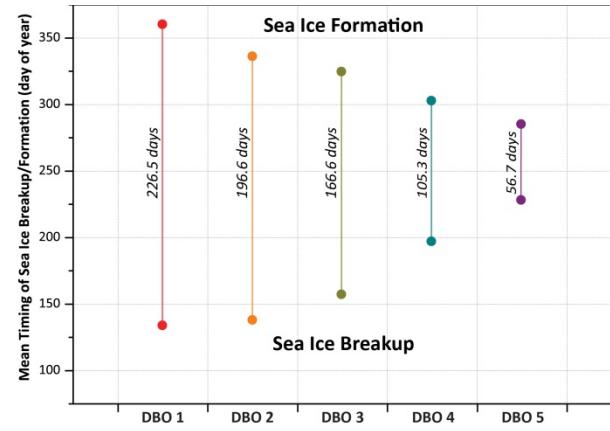
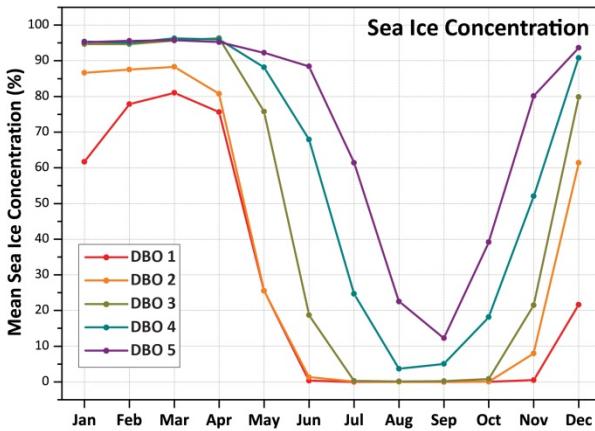
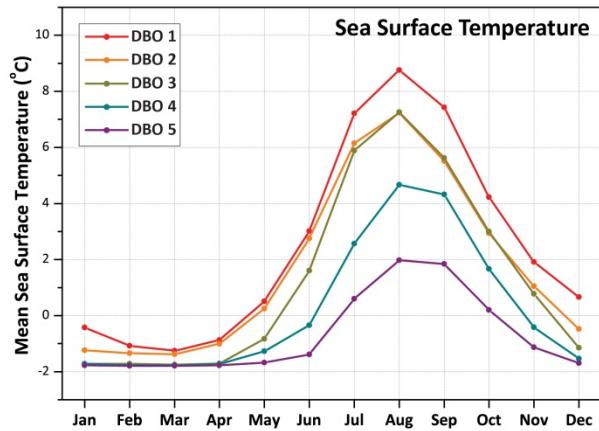
**Sea Ice Concentration (SMMR/SSMI)**

**Sea Ice Breakup/Formacion Timing (SMMR/SSMI)**

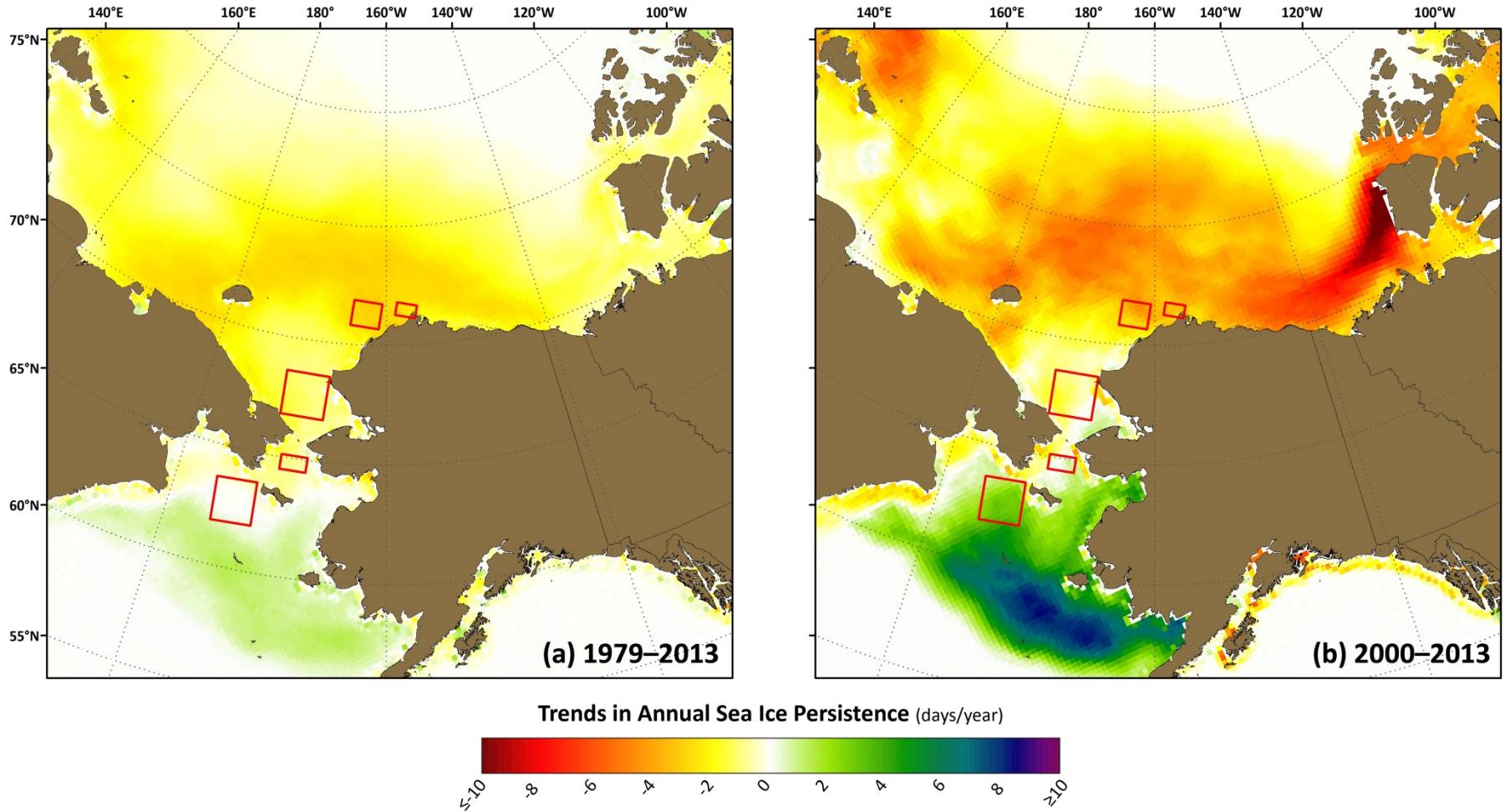
**Chlorophyll- $\alpha$  Biomass (Globcolour)**

**Surface Nitrate (World Ocean Atlas)**

**Solar Insolation (NASA)**

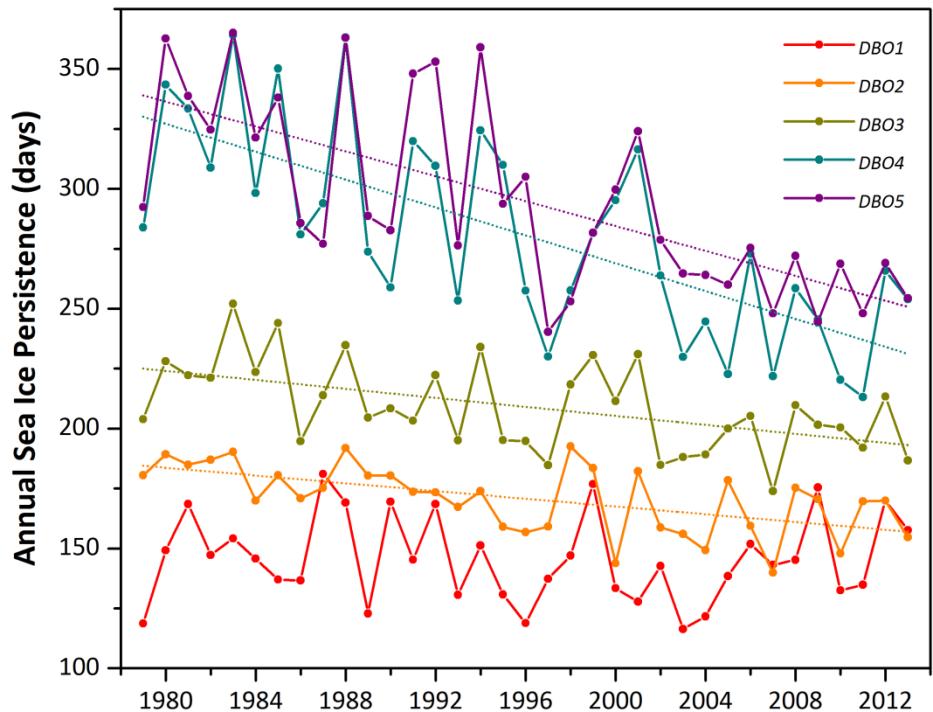


# Trends in Annual Sea Ice Persistence



Based on SMMR and SSM/I  
(1979–2013)

# Trends in Annual Sea Ice Persistence



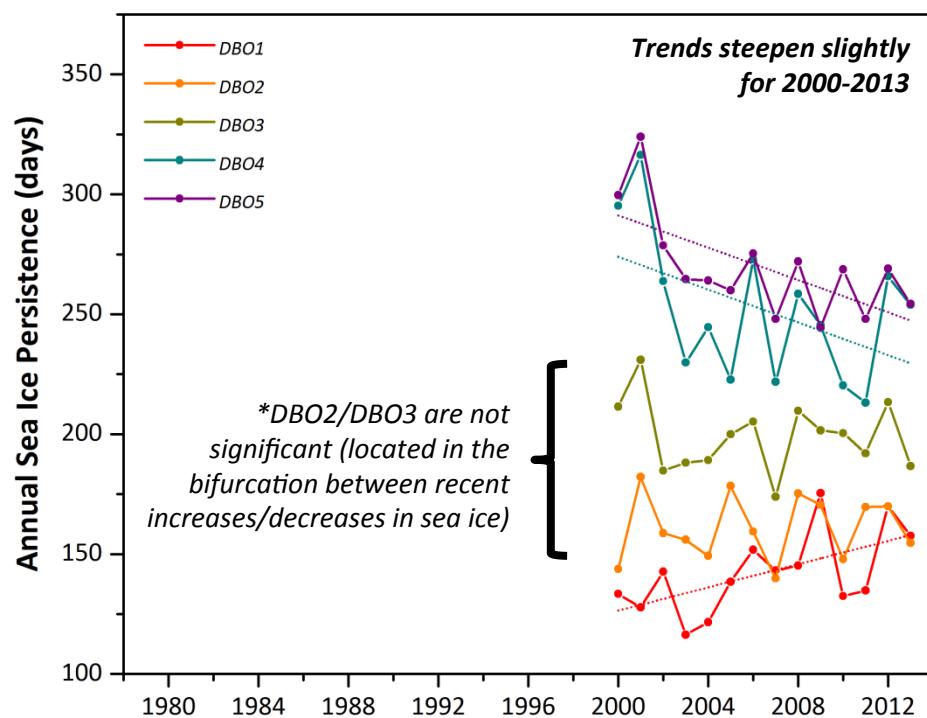
## Trends 2000–2013:

*DBO1: +24.2 days/decade*  
*DBO2: Not Significant*  
*DBO3: Not Significant*  
*DBO4: -34.2 days/decade*  
*DBO5: -33.7 days/decade*

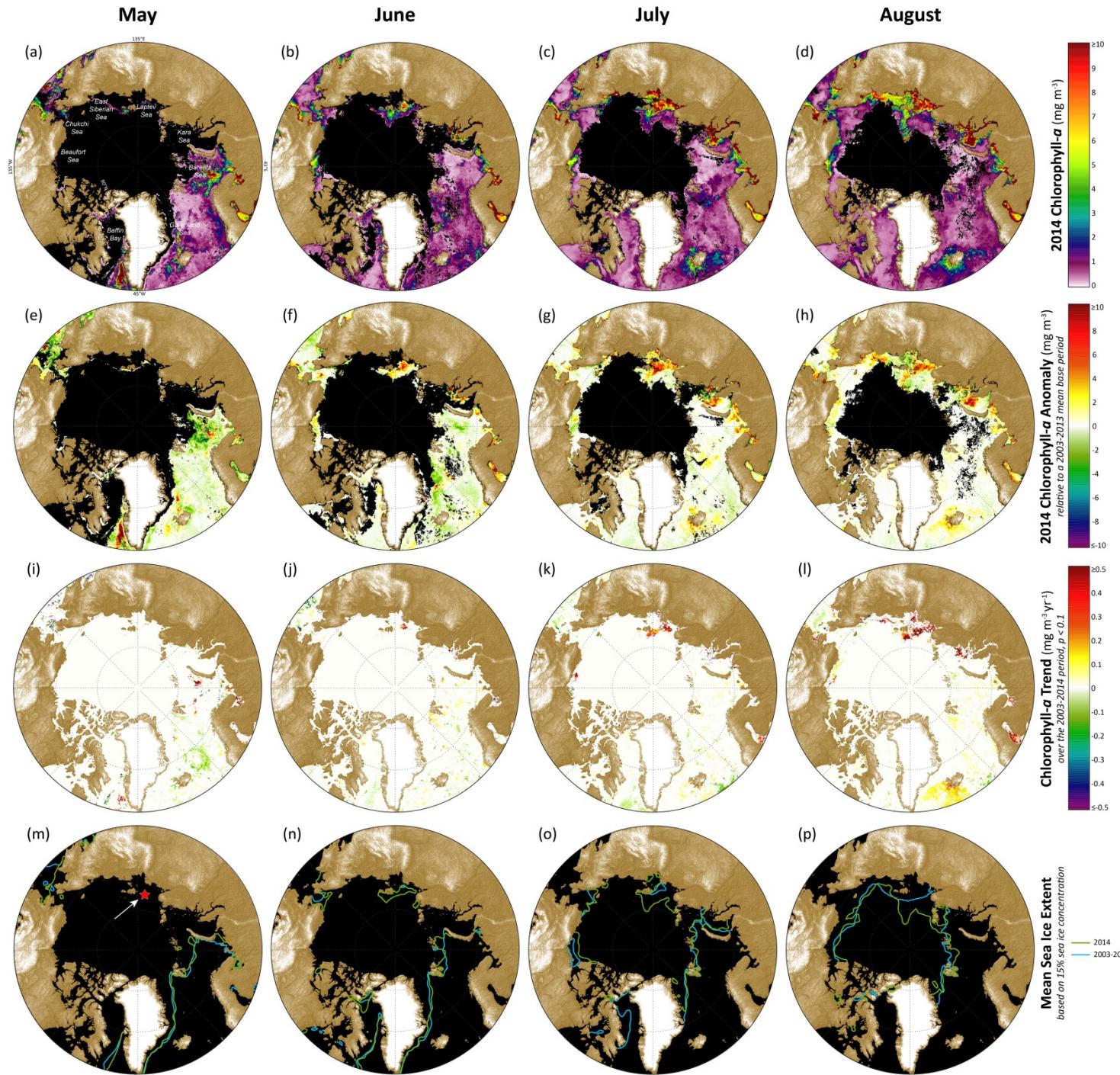
*Based on SMMR and SSM/I  
(1979–2013)*

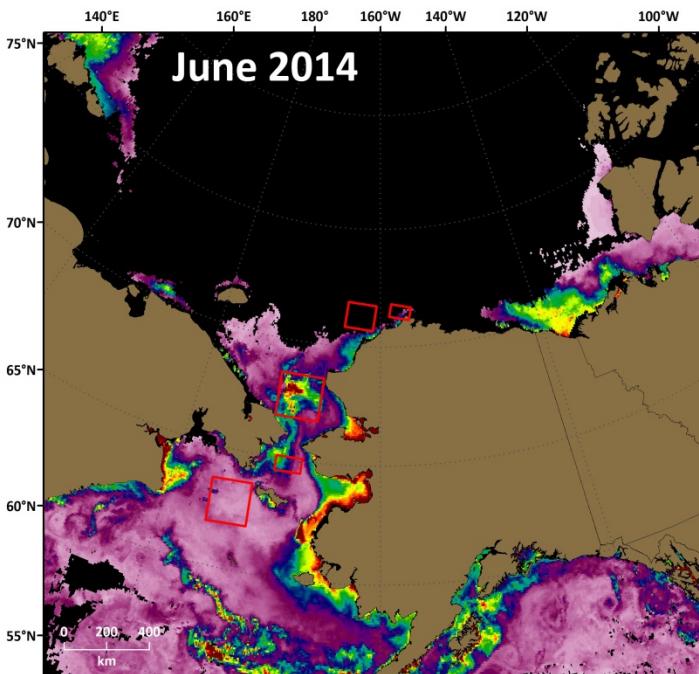
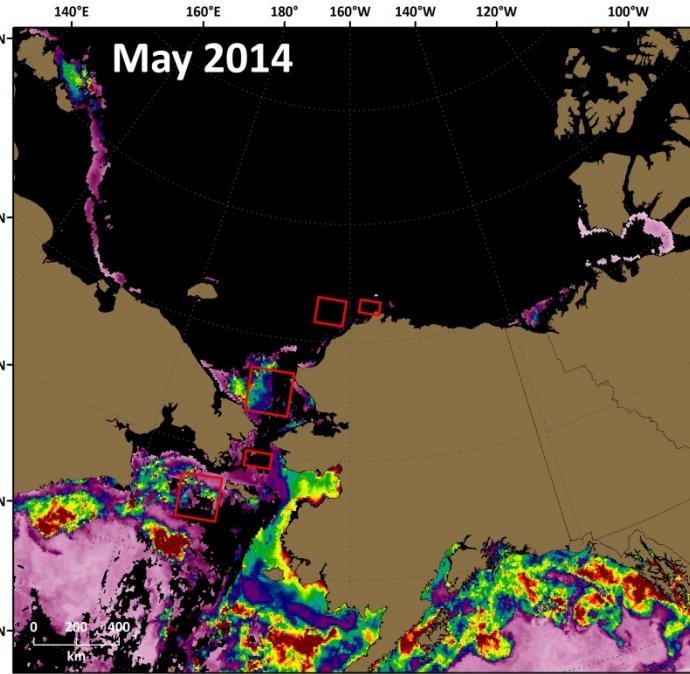
## Trends 1979–2013:

*DBO1: Not Significant*  
*DBO2: -8.1 days/decade*  
*DBO3: -9.4 days/decade*  
*DBO4: -29.1 days/decade*  
*DBO5: -25.9 days/decade*

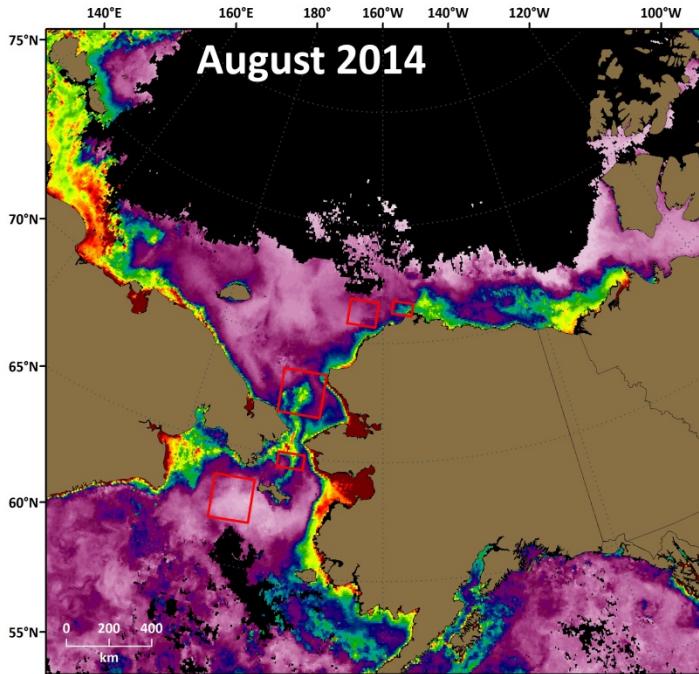
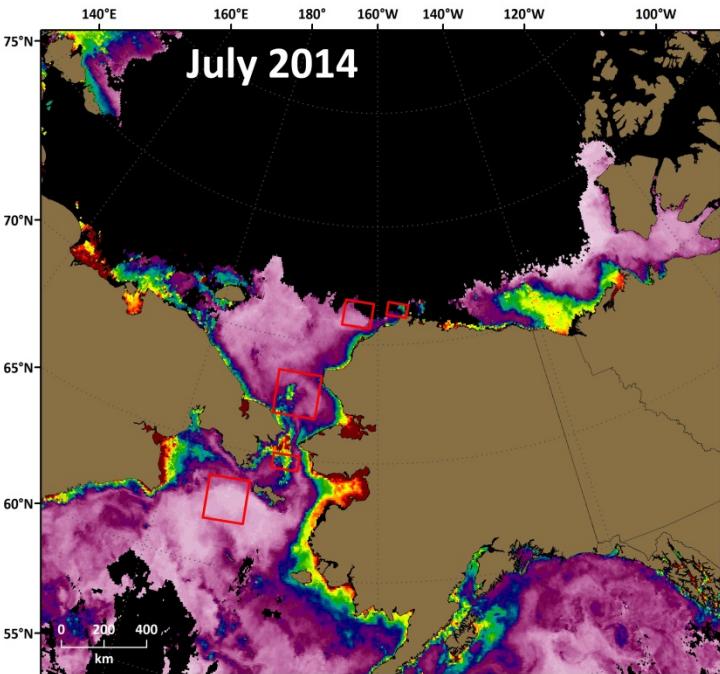
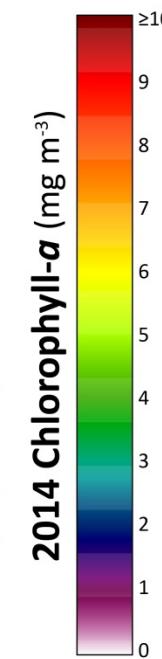


# Anomalies & Trends in Satellite-Based Chl-a



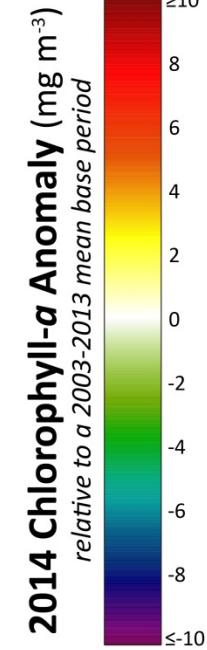


Monthly Mean  
2014 Chl-a  
concentrations

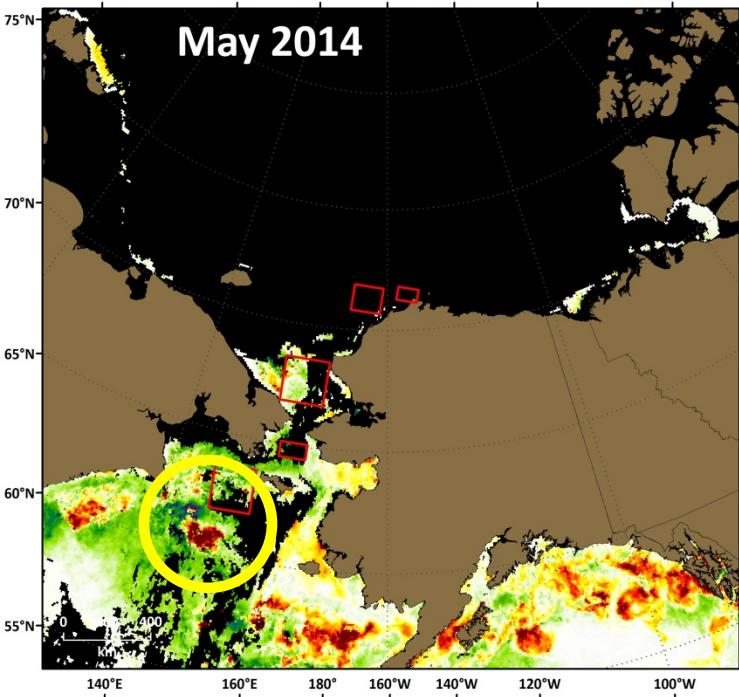


(MODIS-Aqua)

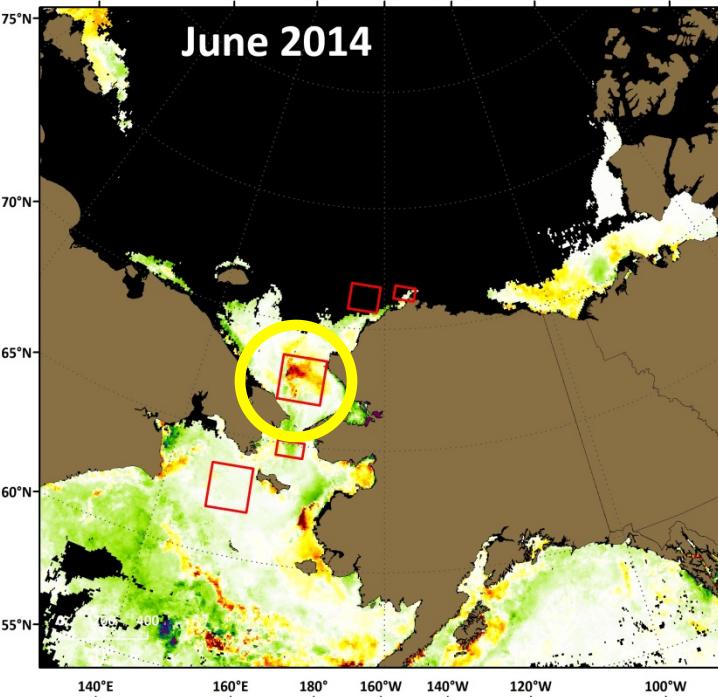
# 2014 Chl-a Anomalies



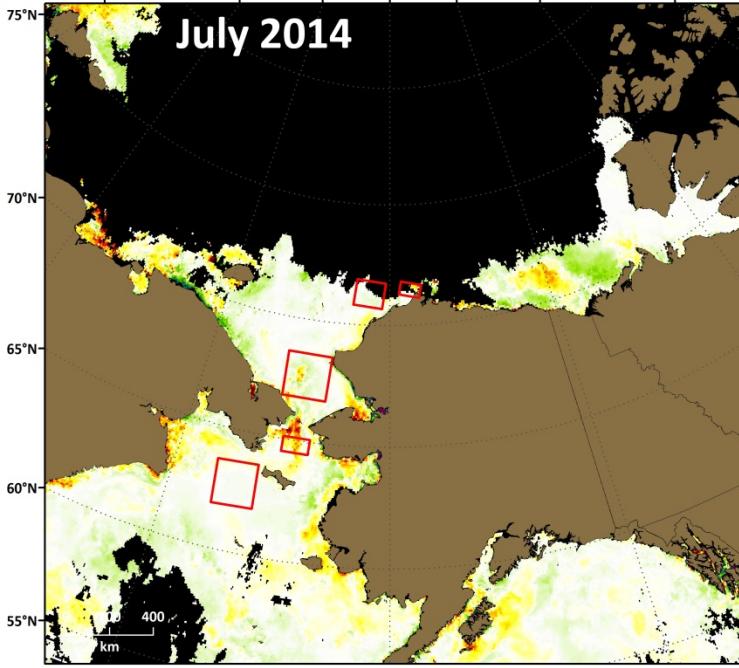
May 2014



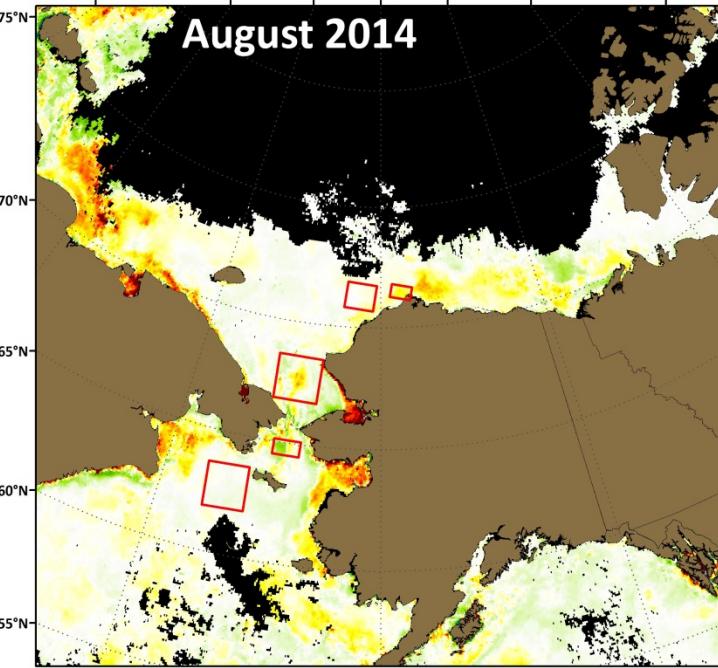
June 2014



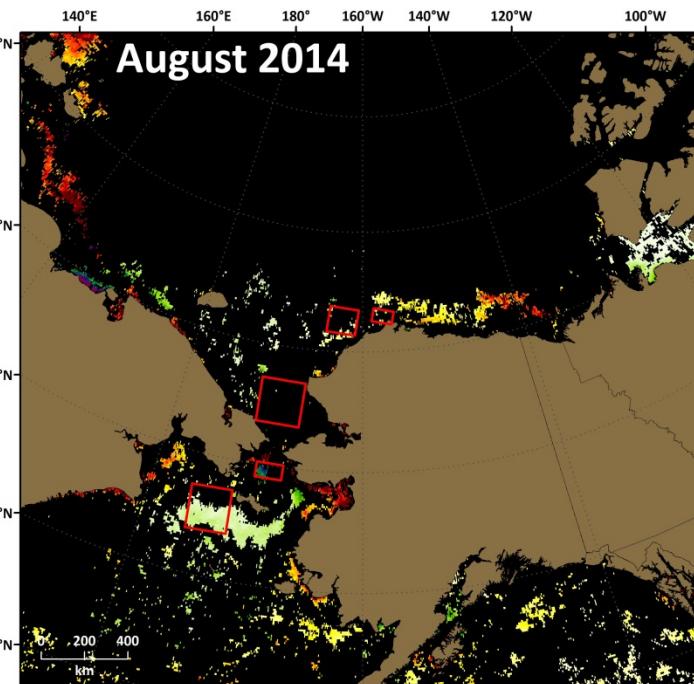
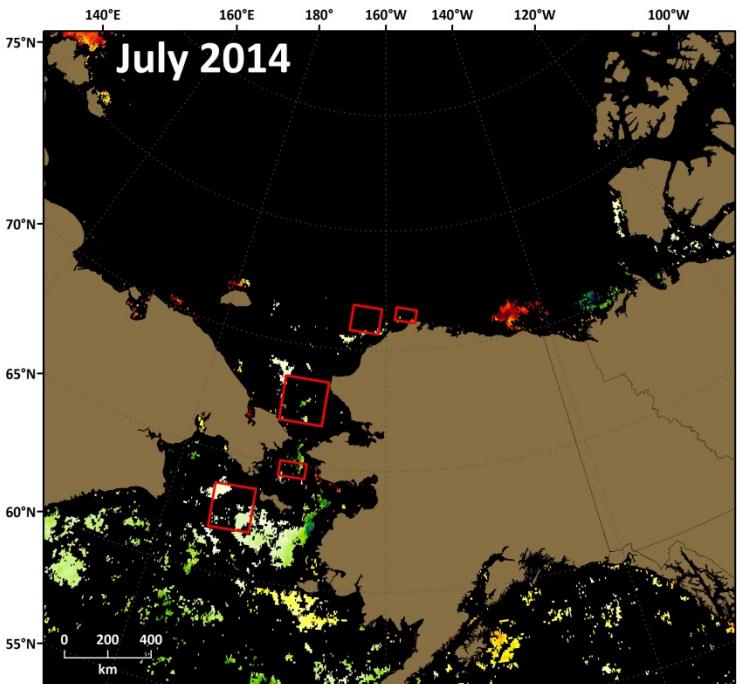
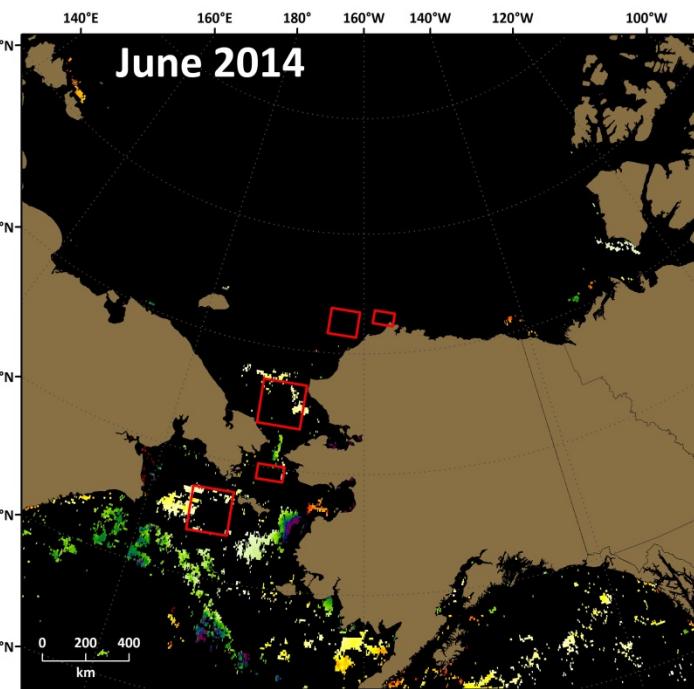
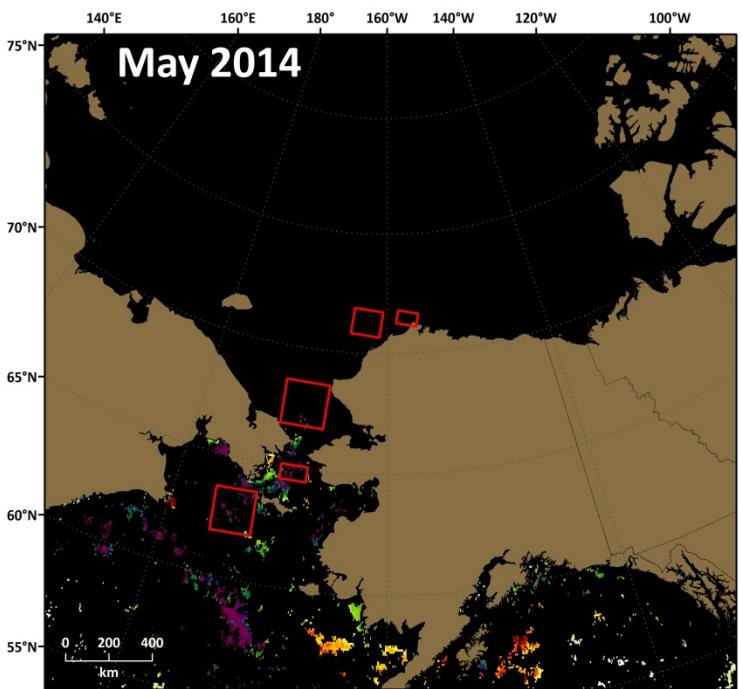
July 2014



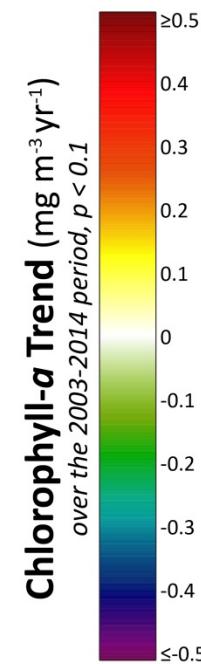
August 2014



(MODIS-Aqua)

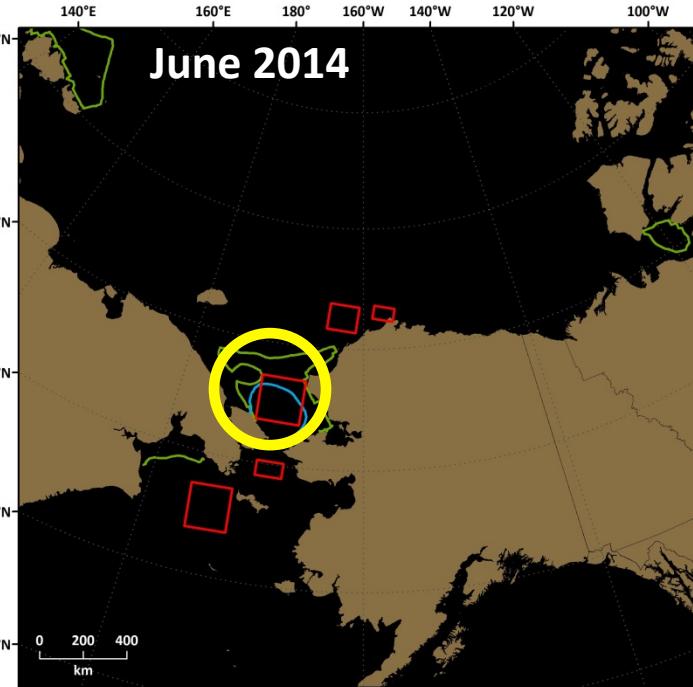
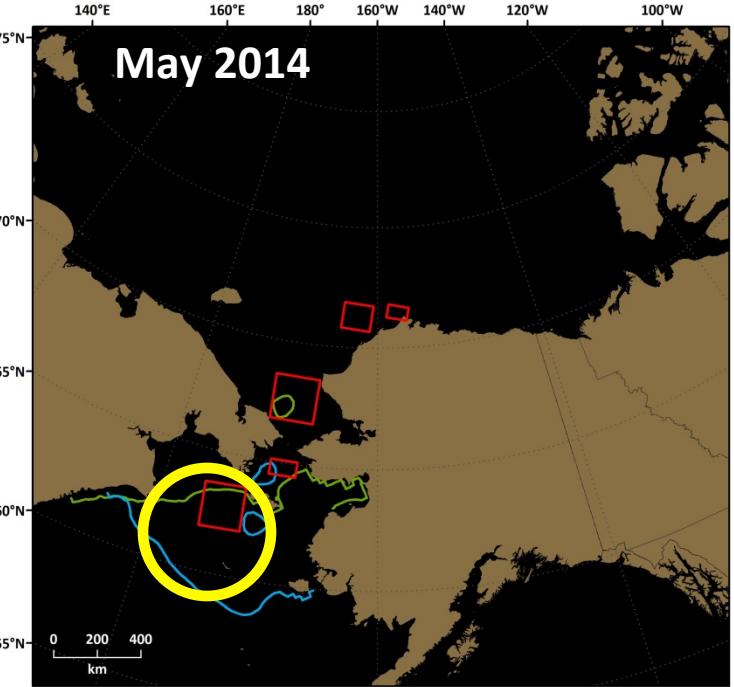


## Chl-a Trends 2003–2014



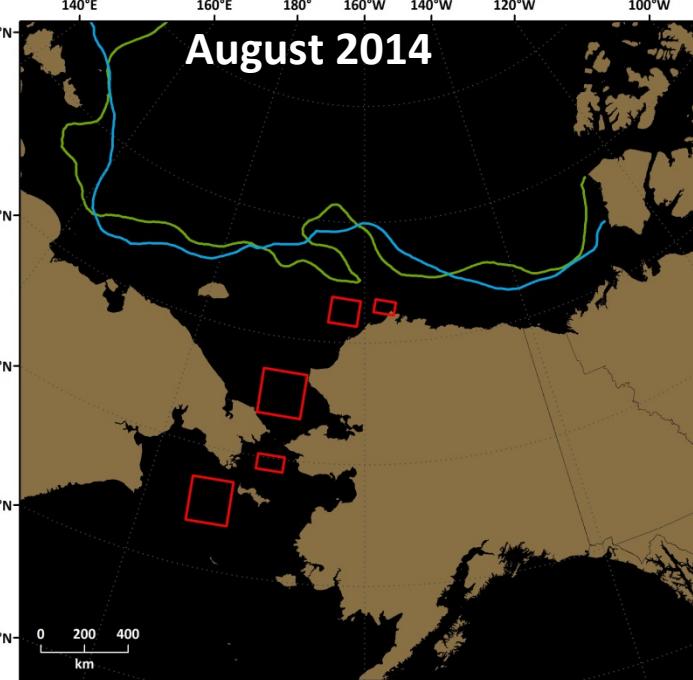
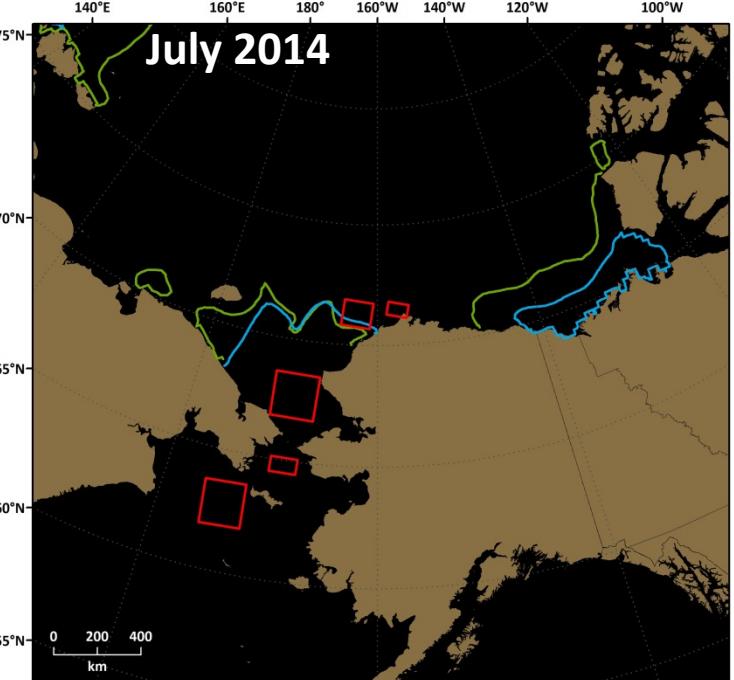
Only those trends that  
are statistically  
significant ( $p < 0.1$ ,  
Mann Kendall) are  
shown.

(MODIS-Aqua)



**Sea Ice Edge**

**2014 vs.  
2003–2013**



**Mean Sea Ice Extent**  
*based on 15% sea ice concentration*

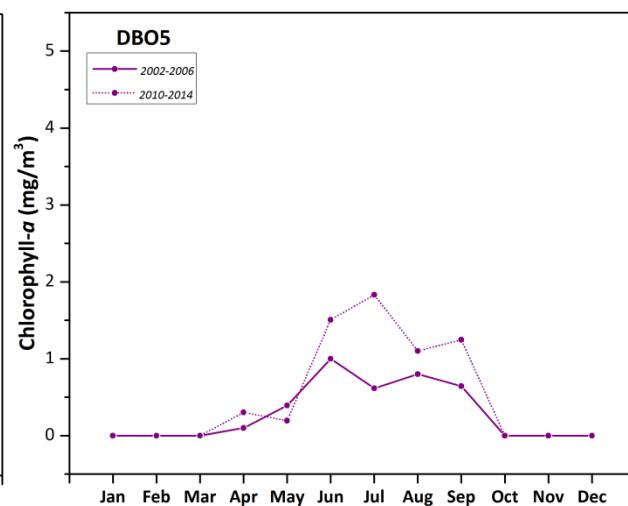
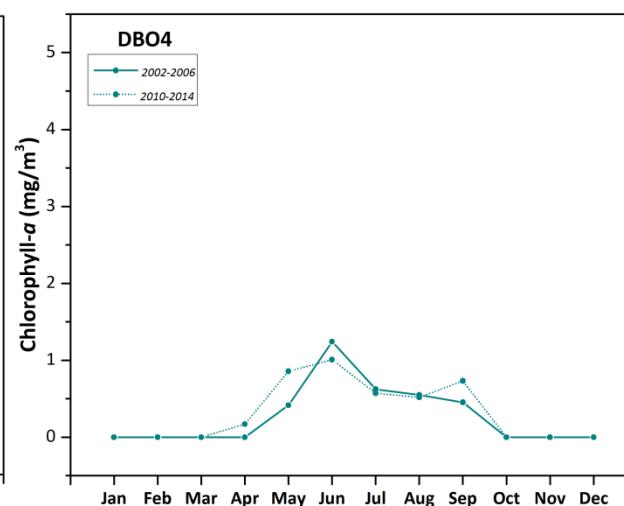
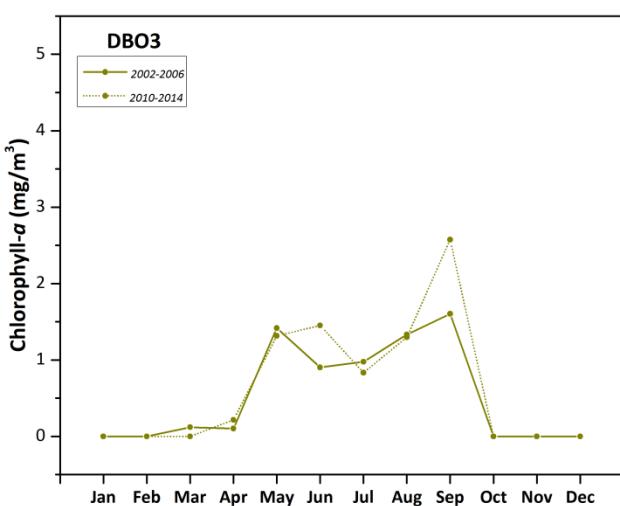
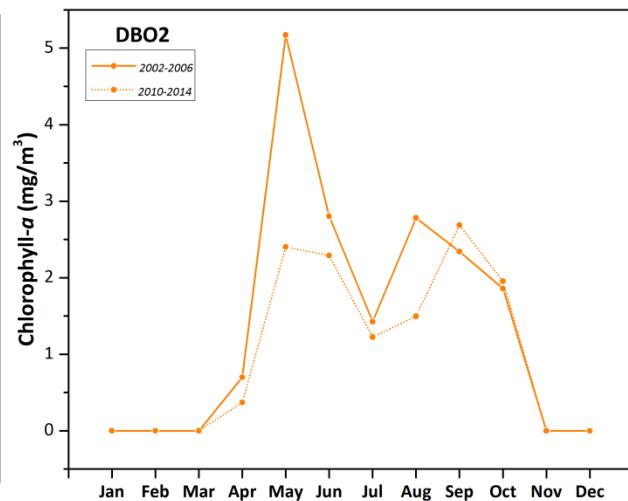
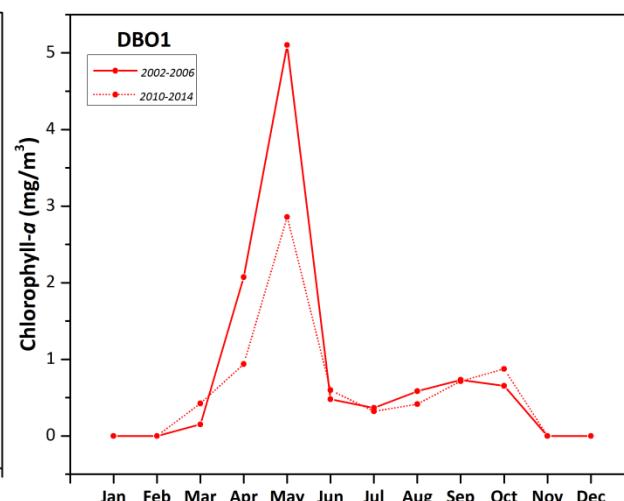
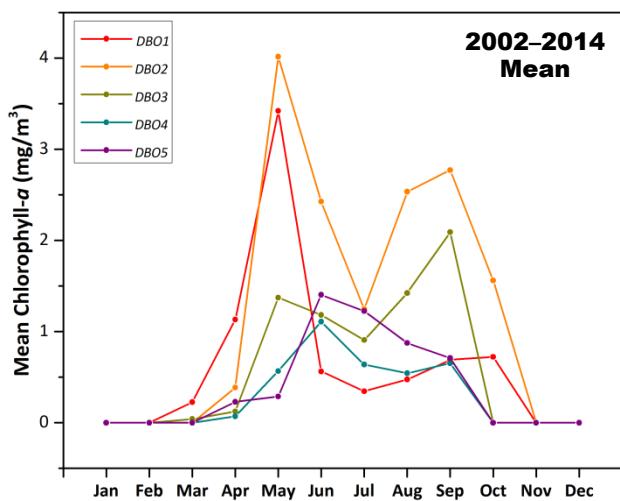
2014  
2003–2013

(SSM/I)

# MODIS-Aqua Chlorophyll-a Concentrations

2002–2014

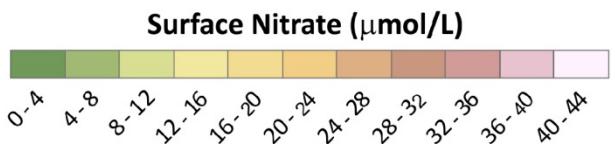
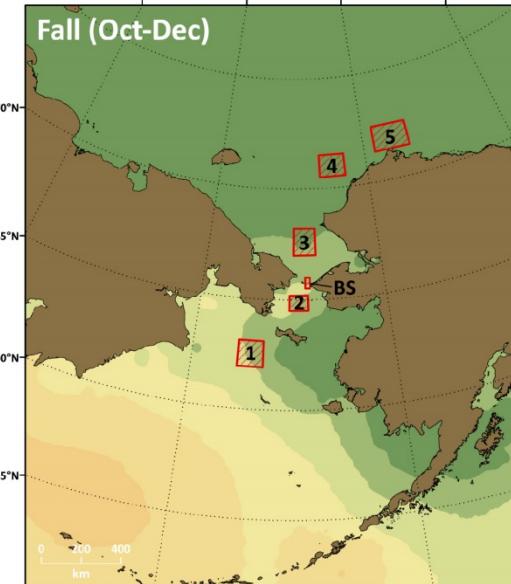
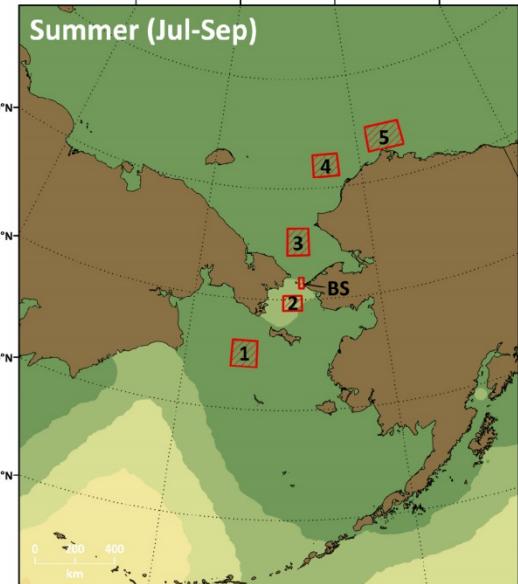
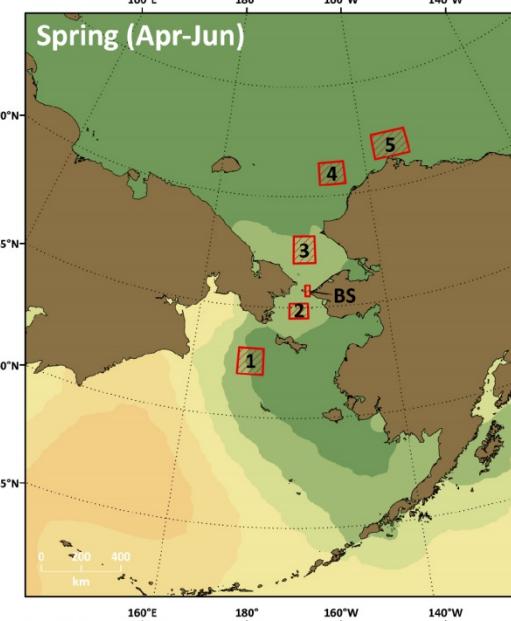
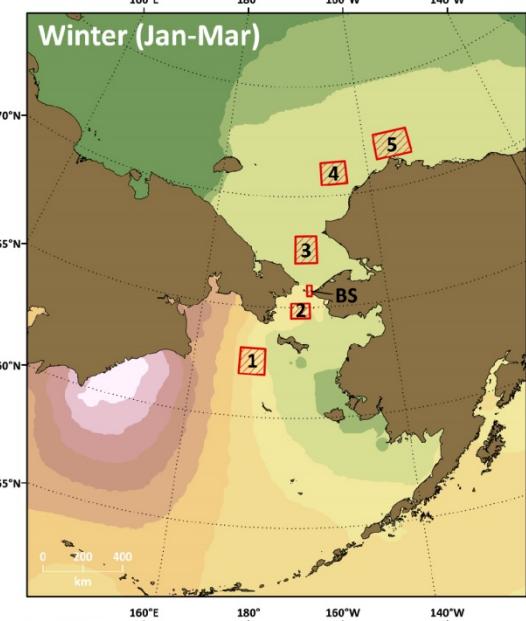
2002–2006 vs. 2010–2014



\*Development of a double bloom during autumn is critical to monitor

# Nutrient Distributions

*\*Although satellite-based observations of nutrients do not exist, creating a spatio-temporal database of nutrients through field observations (and incorporation into modeling efforts, etc.) is critical for understanding how primary production will respond to sea ice decline.*



Data from World Ocean Atlas



# Concluding Remarks:

- **Satellite products** are being compiled across the DBO (sea ice, sea surface temperature, chlorophyll-*a* concentrations, among others).
- ***In situ validation/calibration of satellite imagery is essential***
 for these regions, particularly for chlorophyll-*a*, chromophoric dissolved organic mater (CDOM), etc.- Satellite observations of **physical parameters show relatively obvious signs of change** (e.g., sea ice variability, sea surface temperature). Over the past ~decade, the DBO has bridged across regions exhibiting sea ice increases *and* decreases.
- Satellite observations of **biological parameters show more complexity** and do not currently show obvious/synoptic trends. Two reasons for this: Biology (by its nature) *is* more complex and is also more difficult to remotely sense.
- One major thing to keep an eye out for is a **shift in biological production during the autumn** (secondary blooms during fall are now more prevalent with delayed seasonal sea ice formation).
- Removal of sea ice and increased availability of photosynthetically active radiation is unlikely to impact primary production rates in the absence of sufficient nutrients for production.  
**Spatio-temporal knowledge of nutrient distributions across the DBO is critical** for understanding how climate warming, sea ice decline, and subsequent light availability will impact primary production in future scenarios.