

# Satellite Observations of the Arctic

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NASA Goddard Space Flight Center

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# NASA/GSFC Polar Data Sets

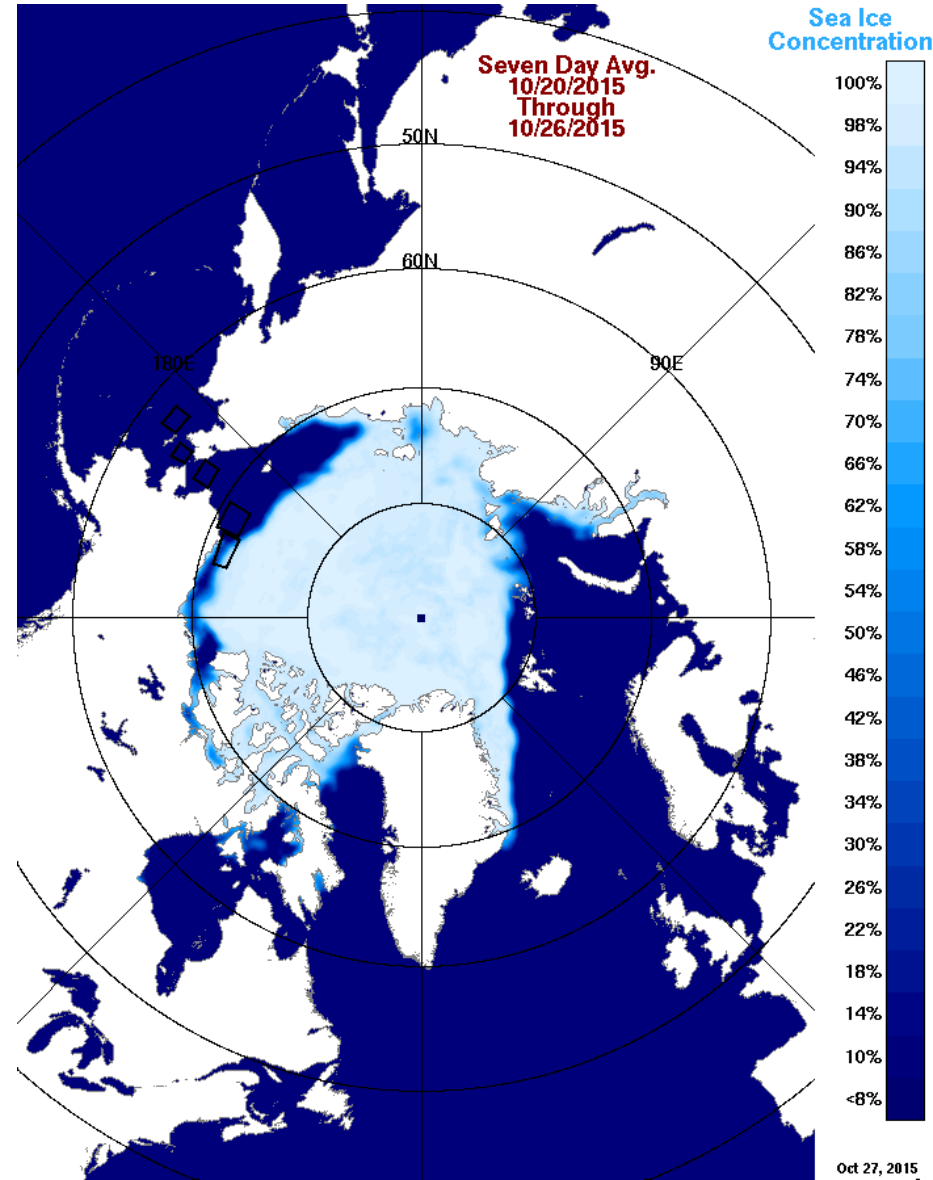
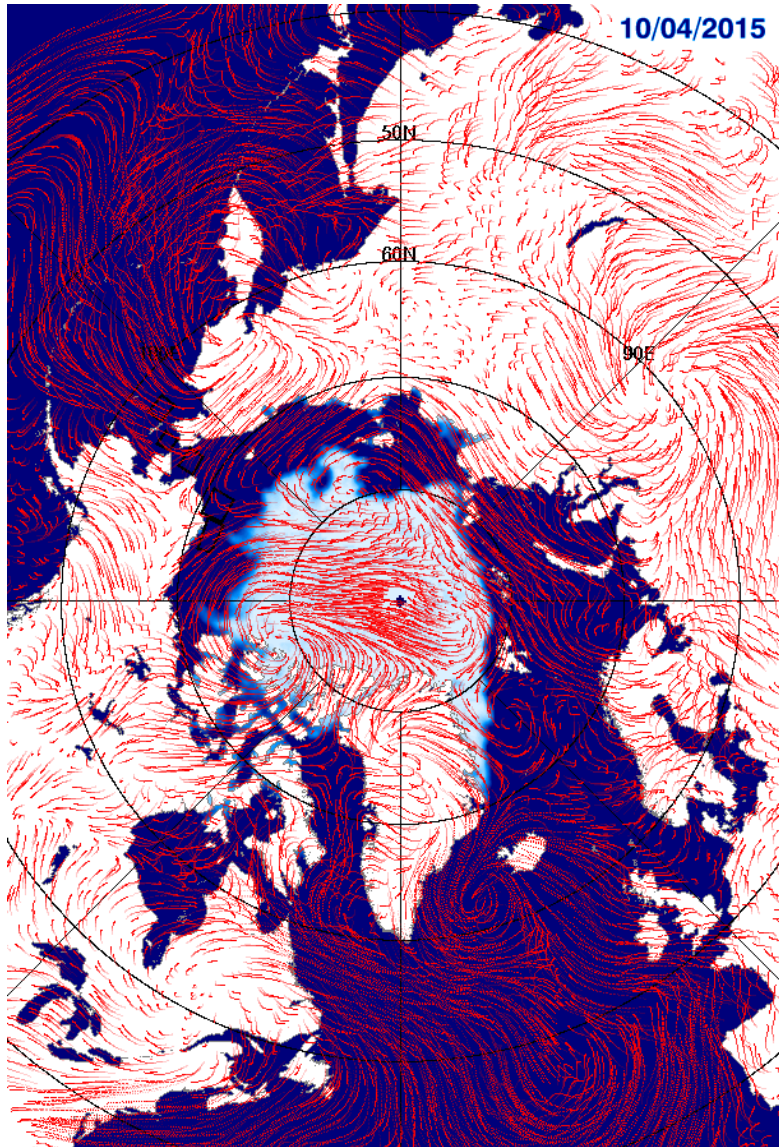
- Brightness Temperatures (ESMR, SMMR, SSM/I, AMSR)
- Radiances, Surface Reflectivity (AVHRR, MODIS, VIIRS)
- Ice Concentration, Ice Extent and Ice Area
- Ocean Color (CZCS, SeaWiFS, MODIS, VIIRS, Landsat8)
- Surface Temperature (THIR, AVHRR, MODIS, VIIRS, Landsat)
- NDVI/Arctic Vegetation (AVHRR, MODIS, Landsat)
- Cloud Fraction (AVHRR, MODIS, VIIRS, Landsat)
- Snow Cover (AVHRR, MODIS, SMMR, SSM/I, AMSR)
- Ice Freeboard (IceSAT1, CryoSat2, IceBridge, Others)
- Ice Sheet Topography (IceSat1, CryoSat2, etc.)
- Surface Salinity (Aquarius, SMOS, SMAP)
- High Resolution Data (Landsat, SAR, SPOT, IKONOS, Worldview, TerraSar, etc)
- Aircraft and Field Data

# DBO Website at NASA

[www.neptune.gsfc.nasa.gov](http://www.neptune.gsfc.nasa.gov)

- Animated maps for current week on sea ice and winds, surface temperature, chlorophyll concentration
- Weekly averages for the most recent week of sea ice, SST, Chlorophyll, cloud fraction, winds and sea level pressure
- Plots of the various parameters

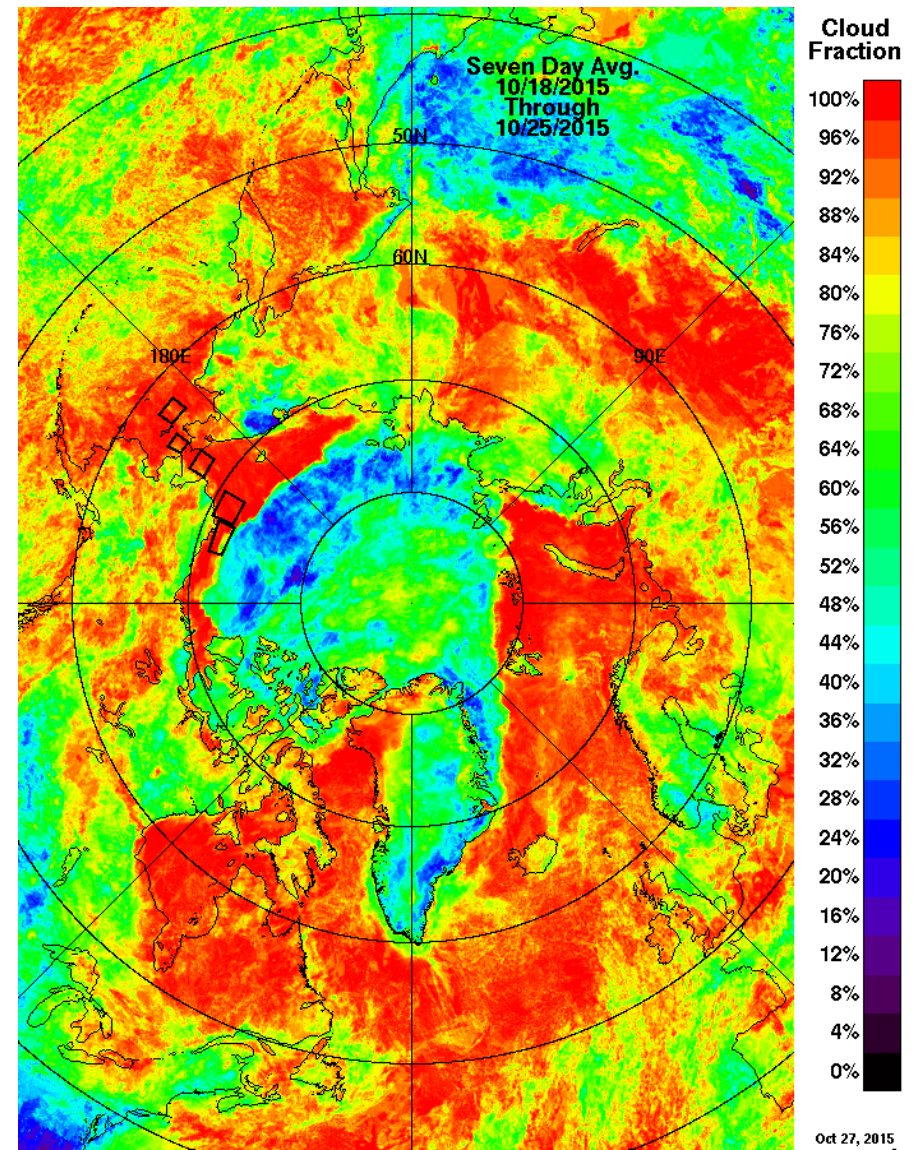
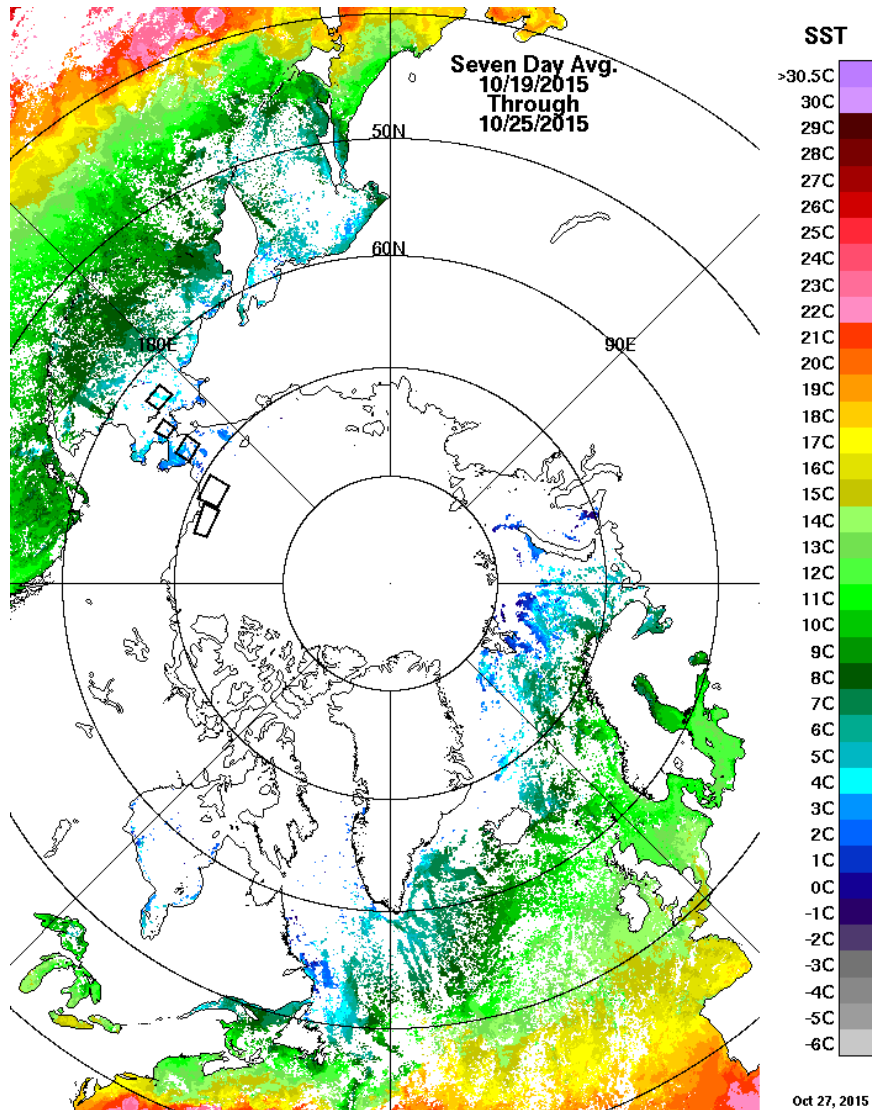
# Animated sea ice and winds and weekly sea ice average



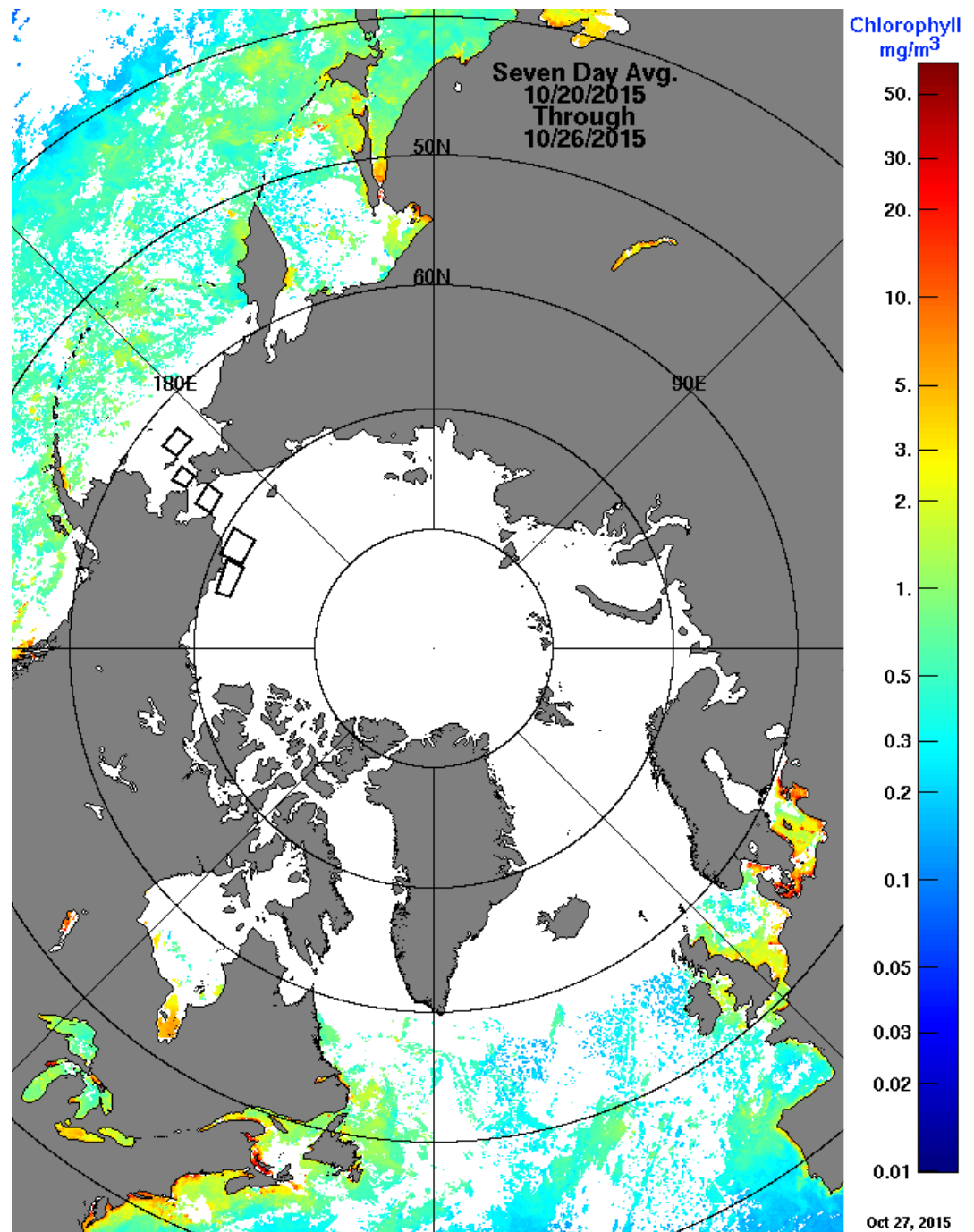


# Weekly SST and Cloud Fraction

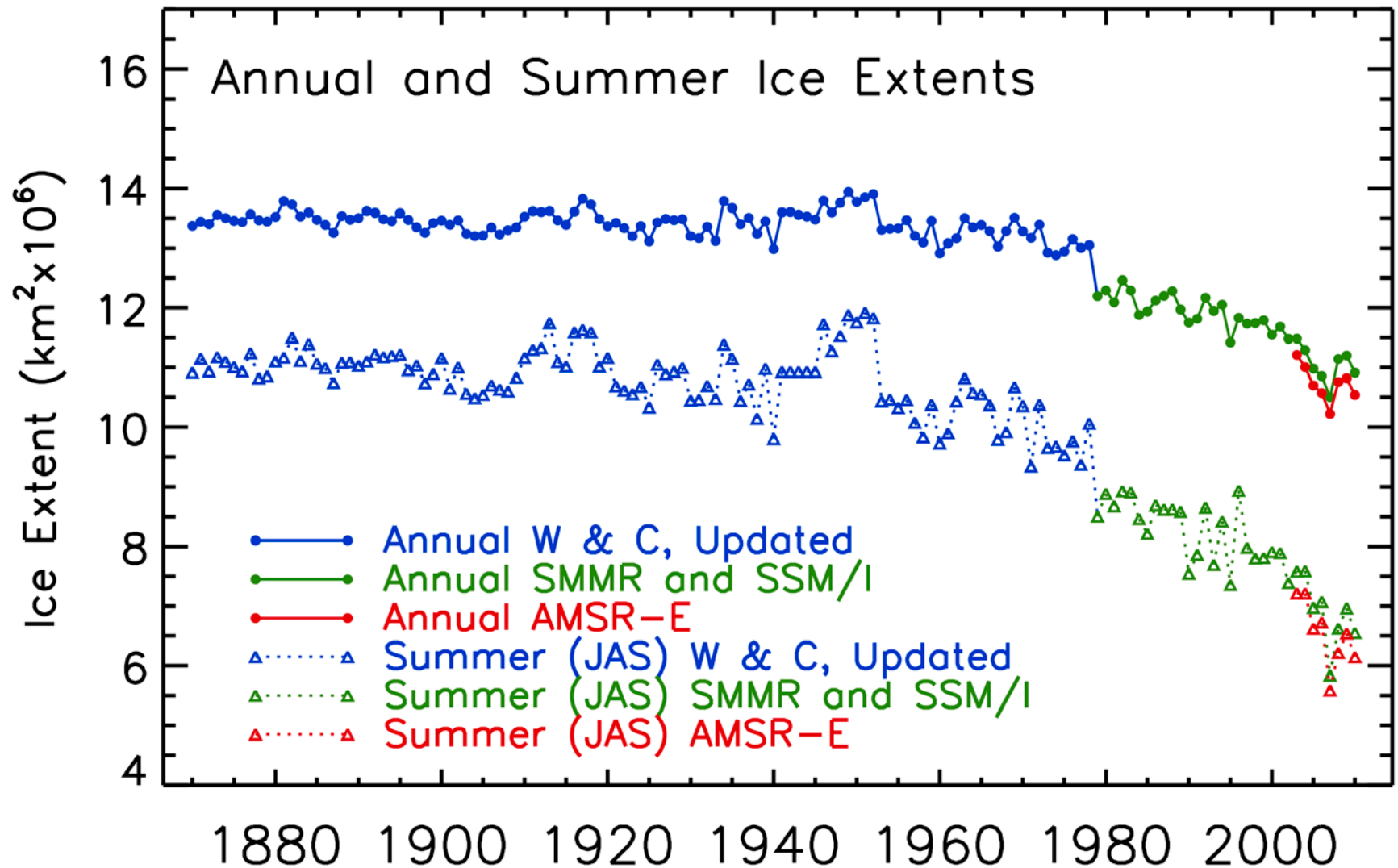
## 19-25 October 2015



# October 20- 26, 2015 average of Chlorophyll Concentration



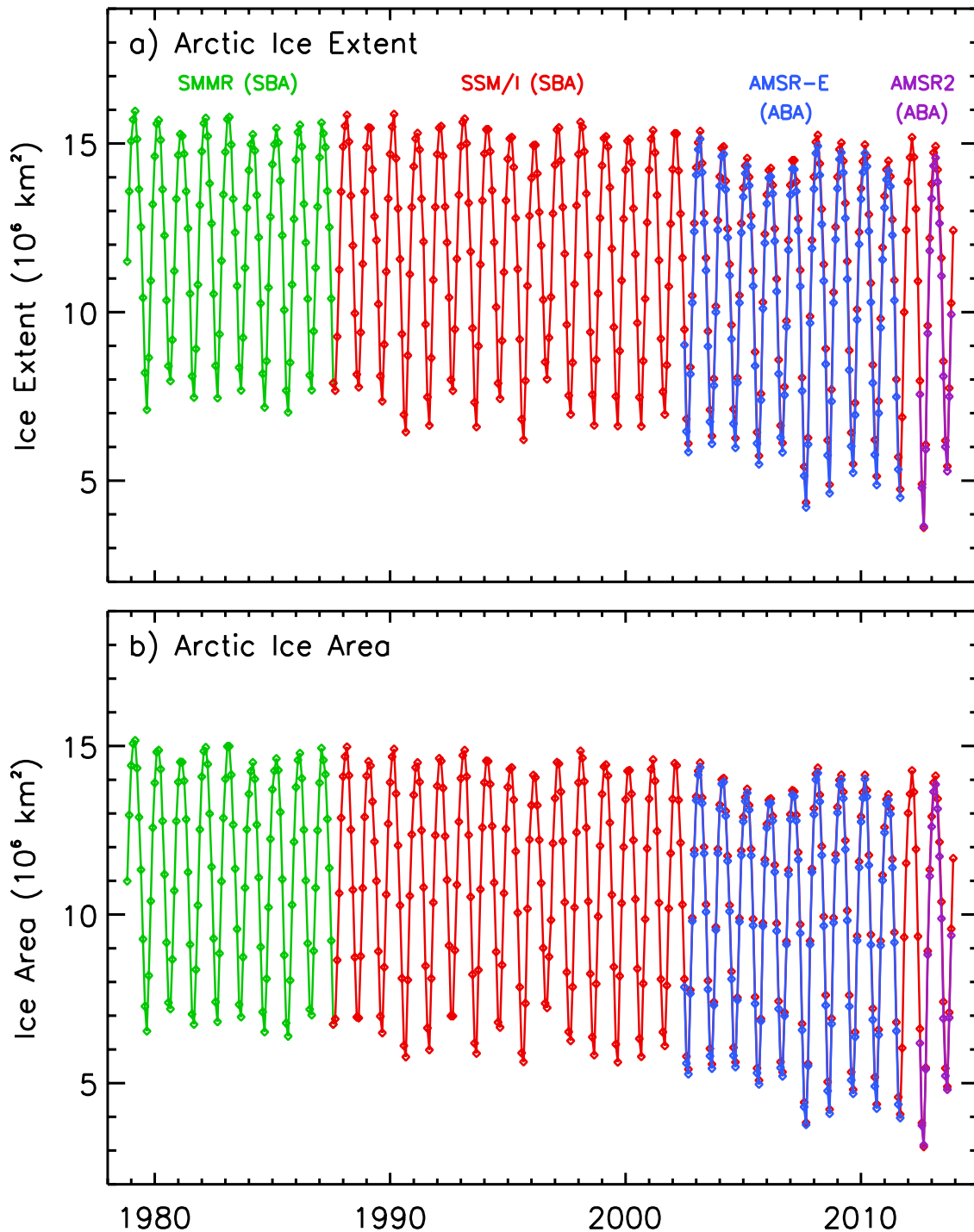
# Historical In Situ and Satellite Data



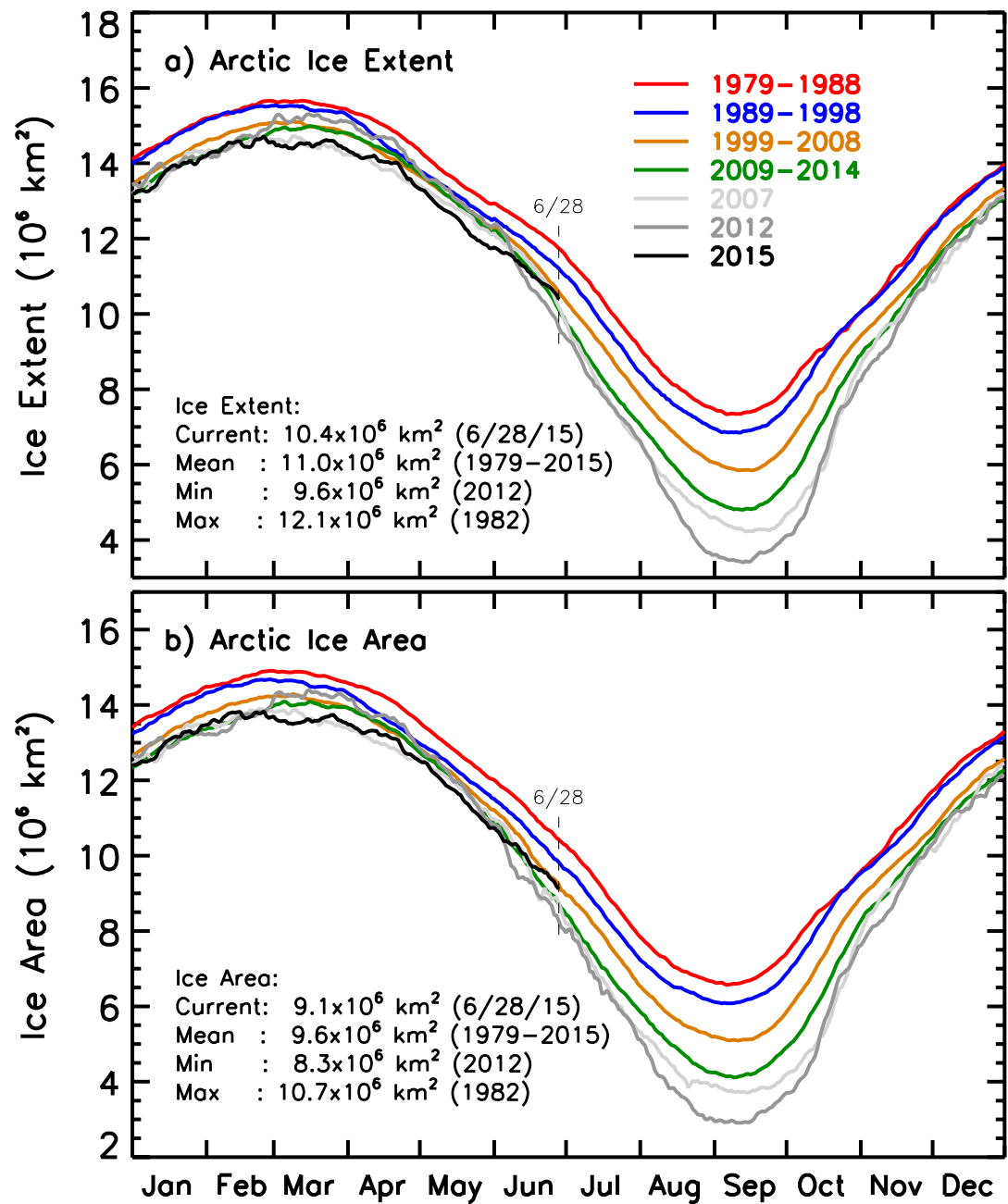


# Historical Satellite Ice Extent and Ice Area in the Arctic

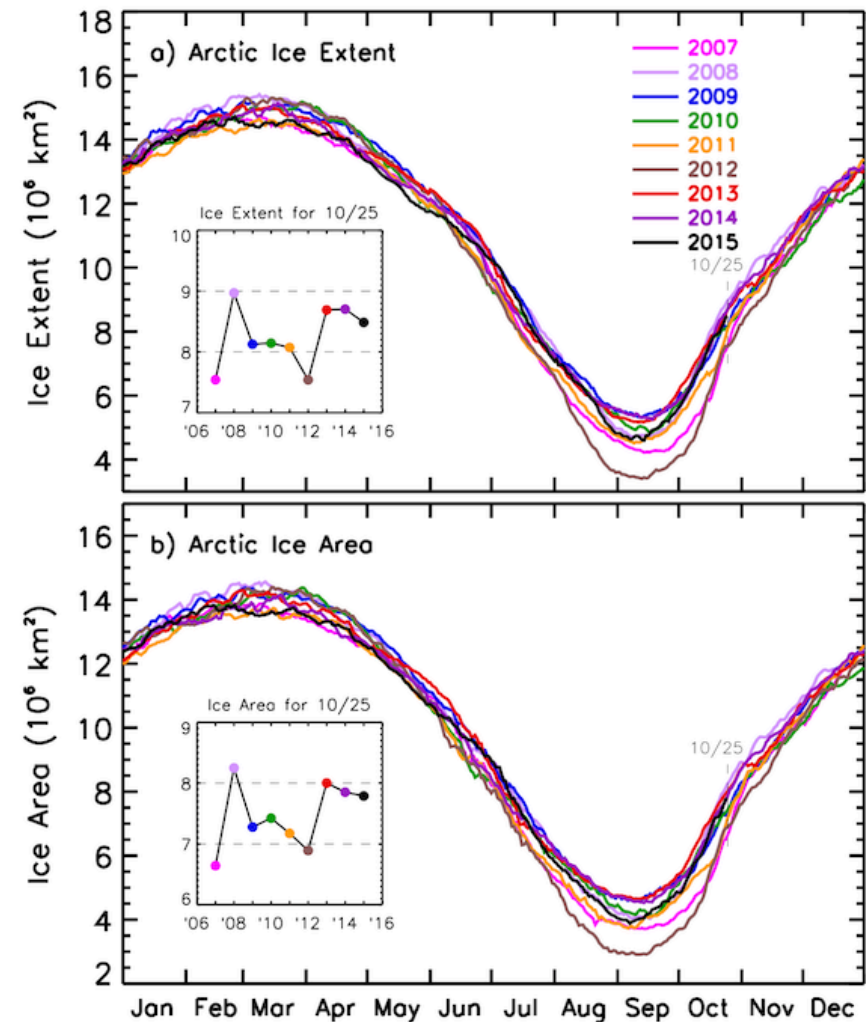
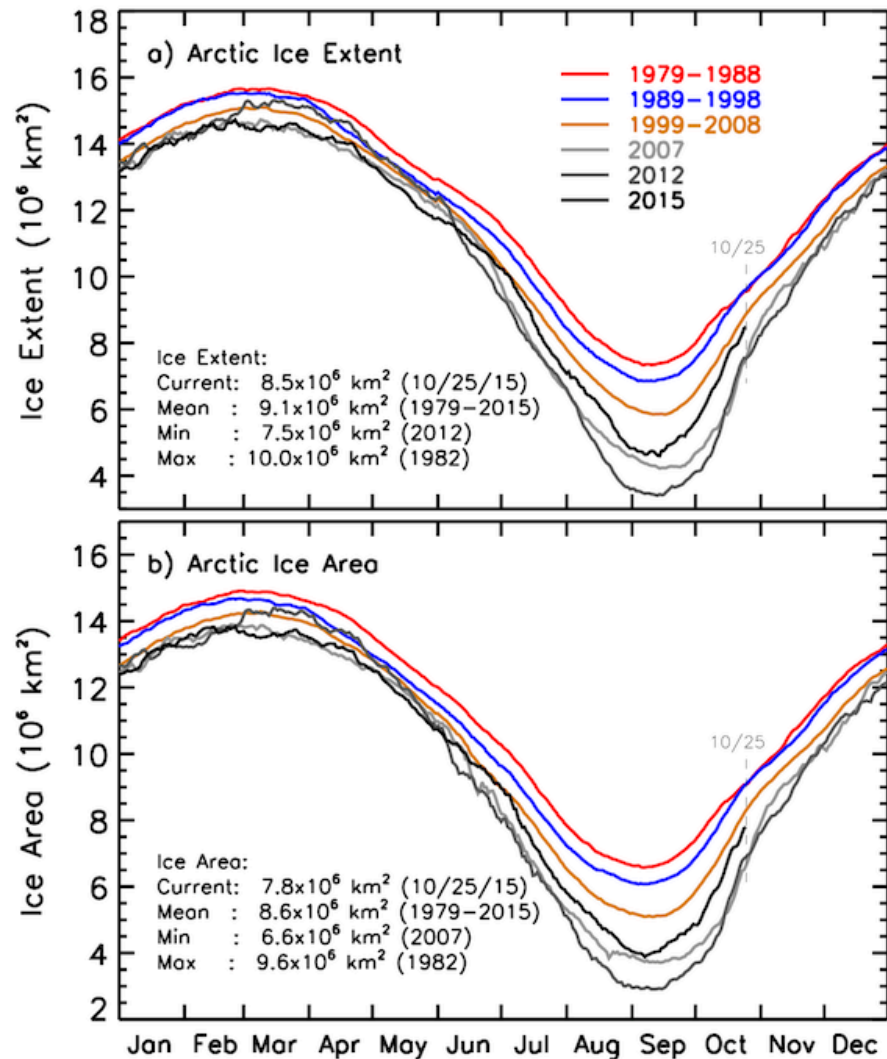
Source: Passive  
Microwave sensors:  
SMMR, SSM/I,  
AMSR-E and  
AMSR2



# Decadal changes in ice extent and area



# Decadal and yearly changes in seasonality

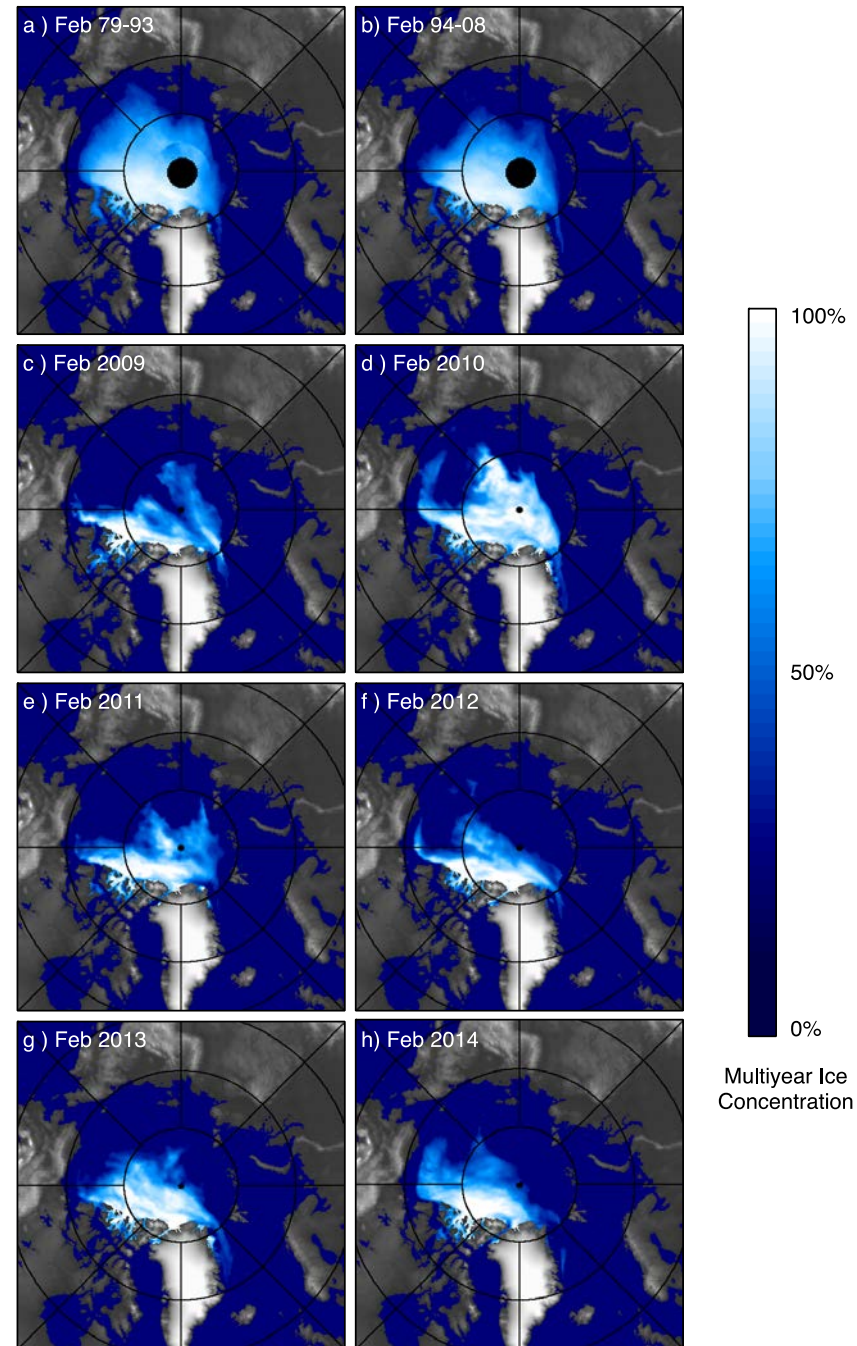
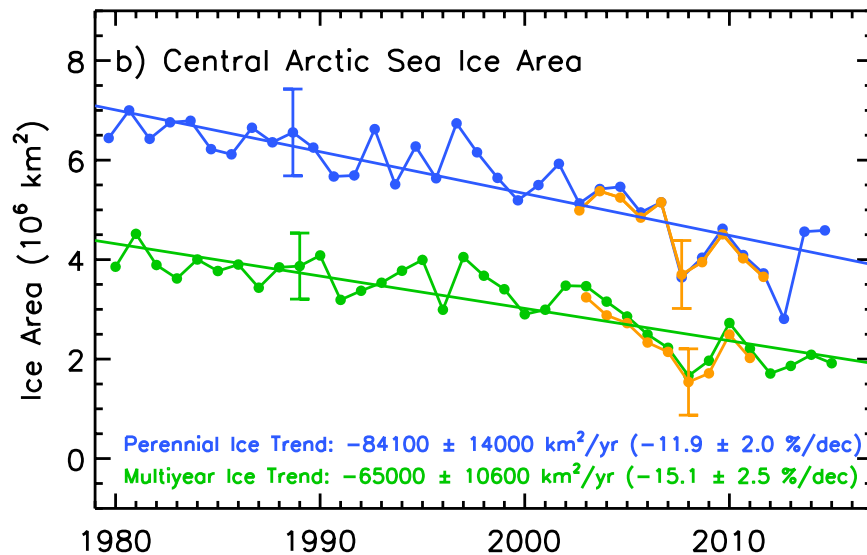
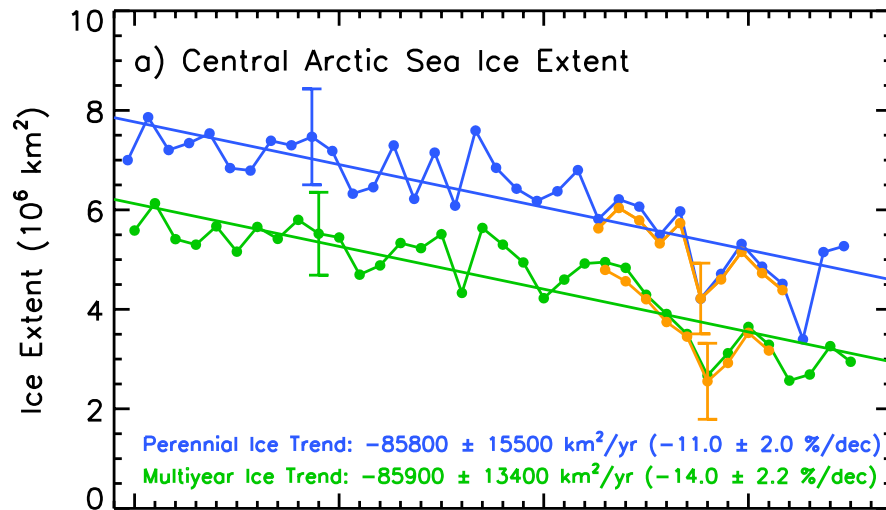




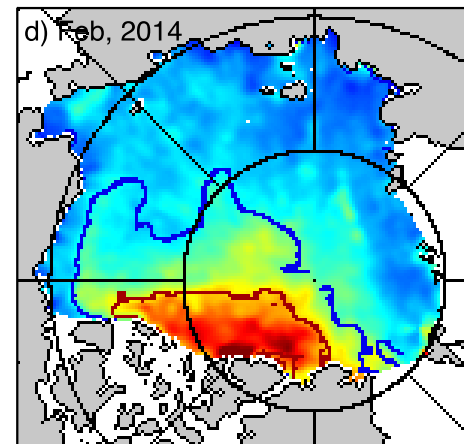
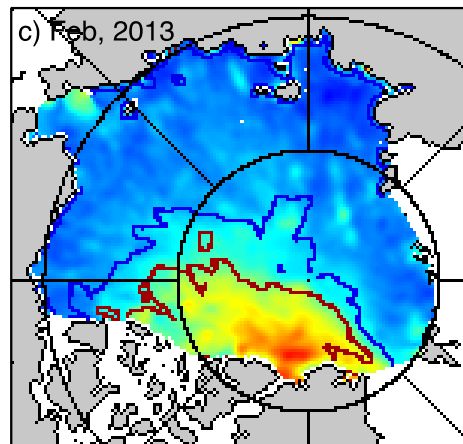
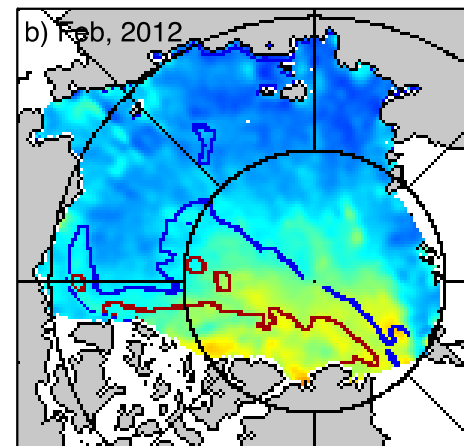
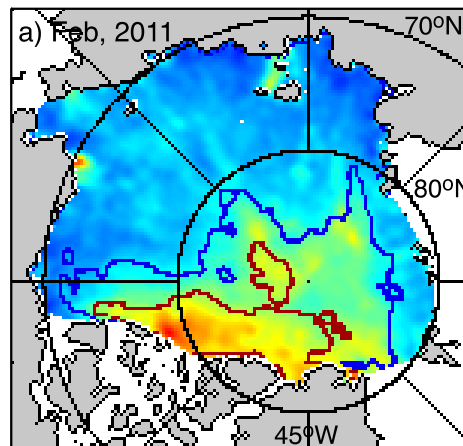
# Rapid decline of Arctic Thick Ice

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

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



# Cryosat2 Ice Thickness and PM Multiyear Ice Contours



— 80% MY ice contour  
— 40% MY ice contour

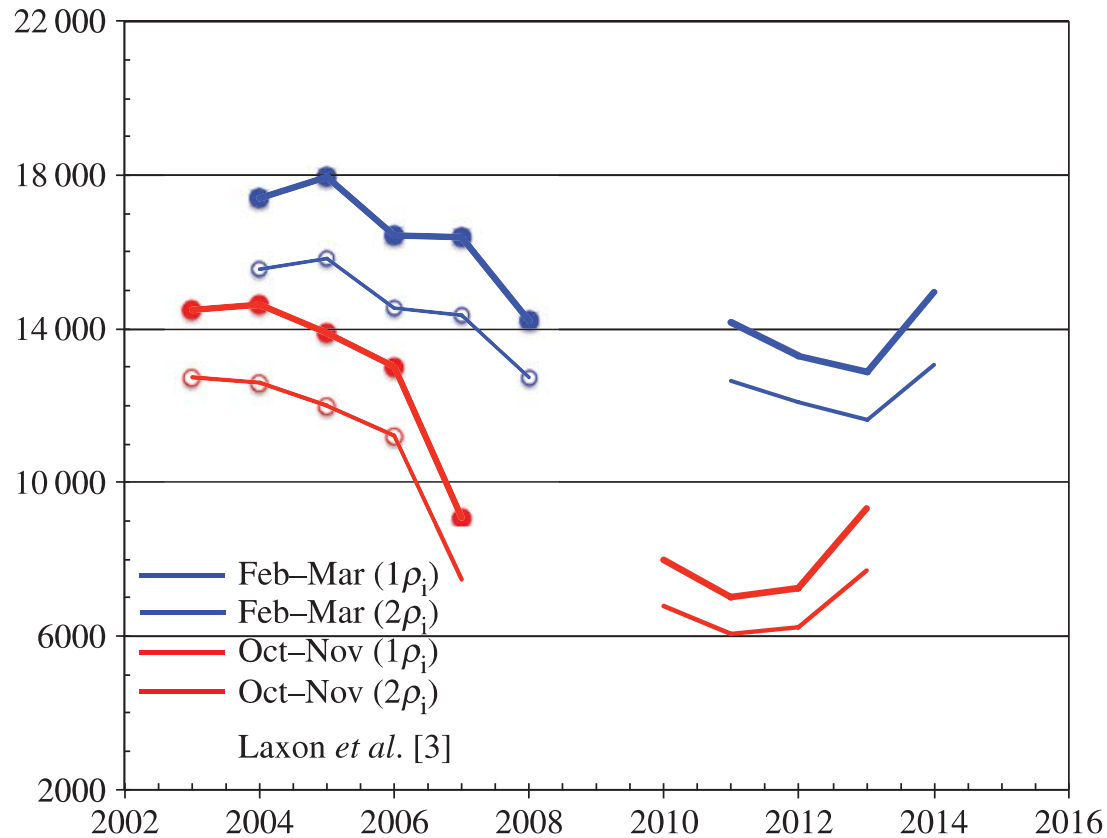


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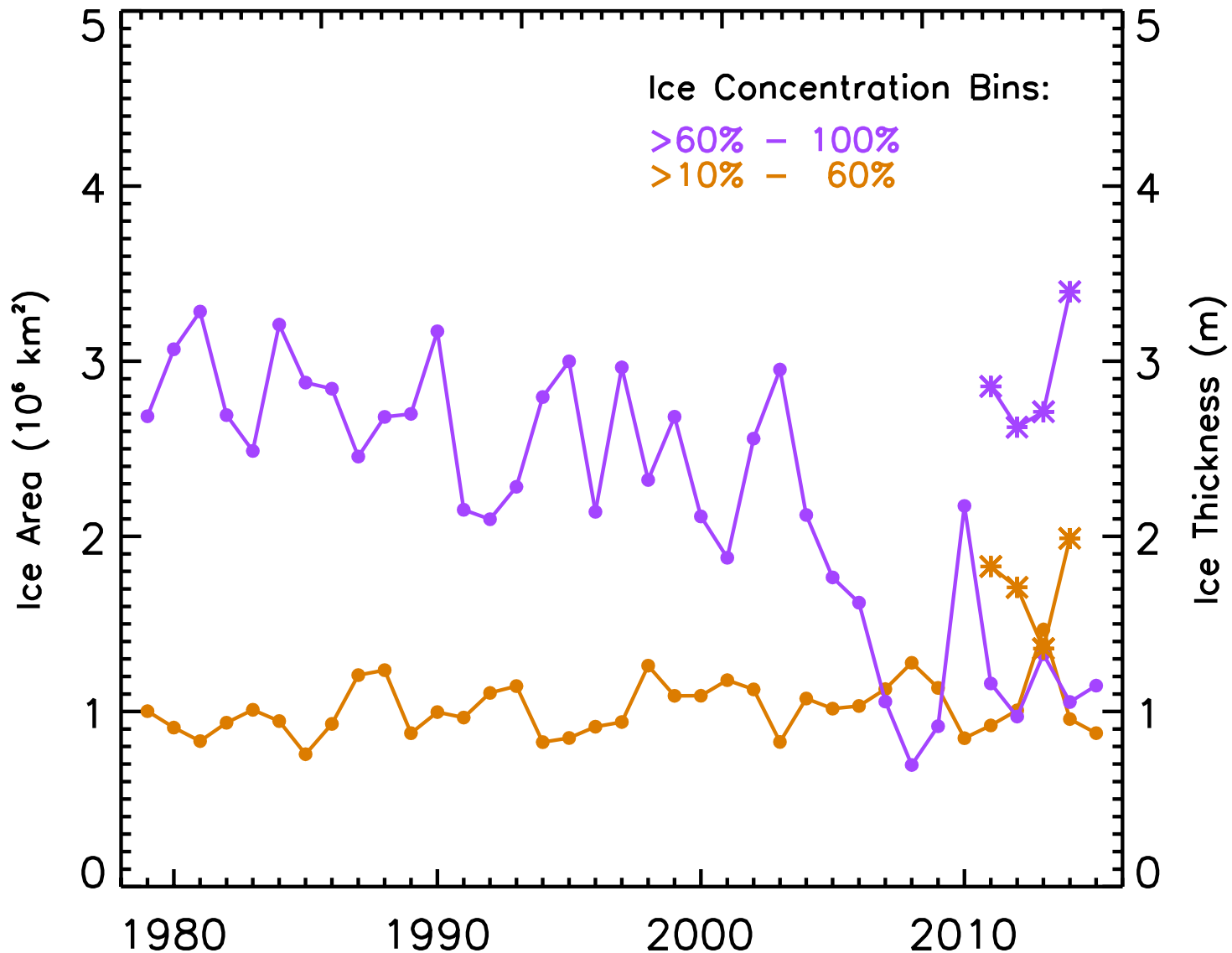
Ice Thickness (m)

5

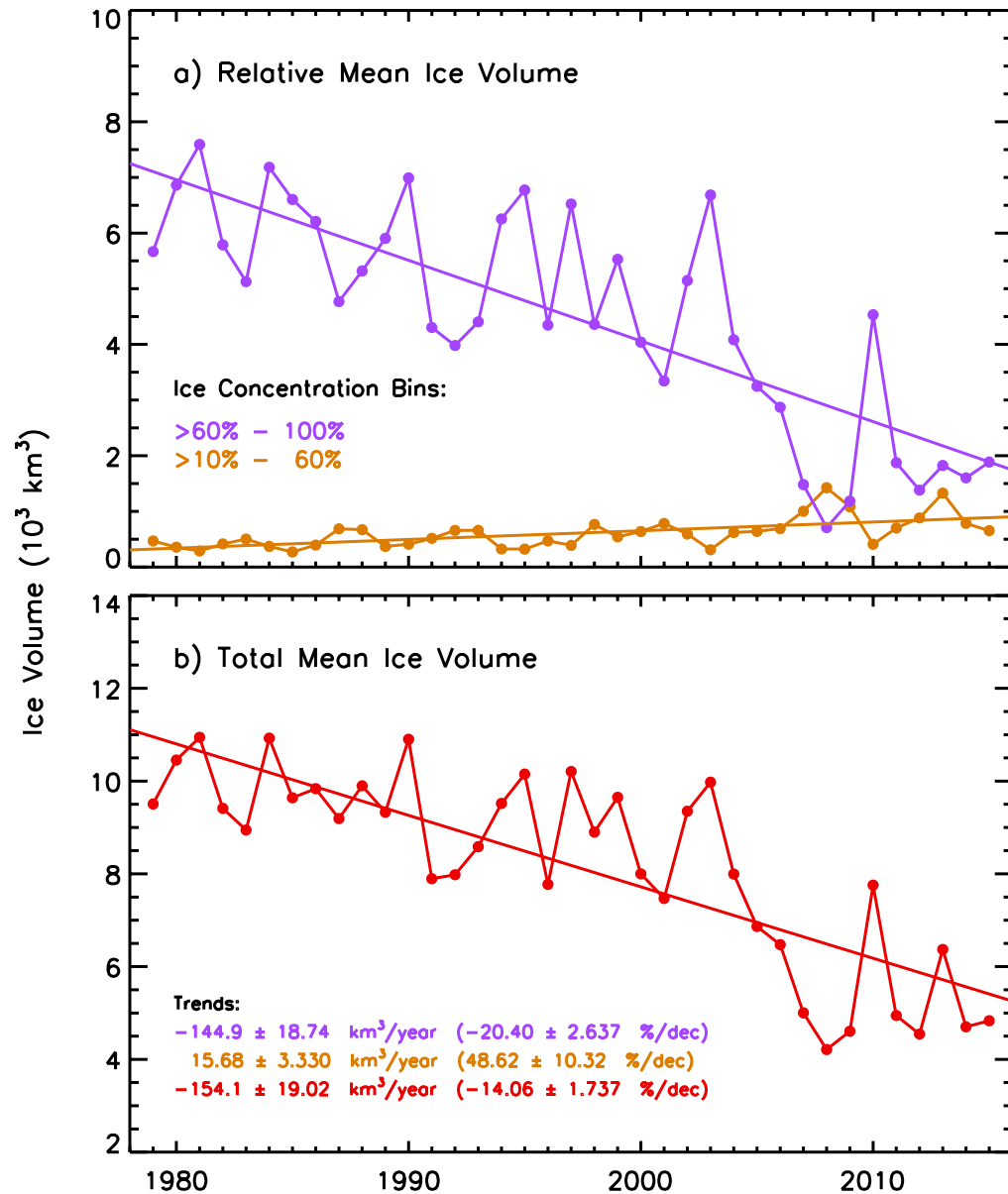
# Change in Ice Volume from 2003 to 2013



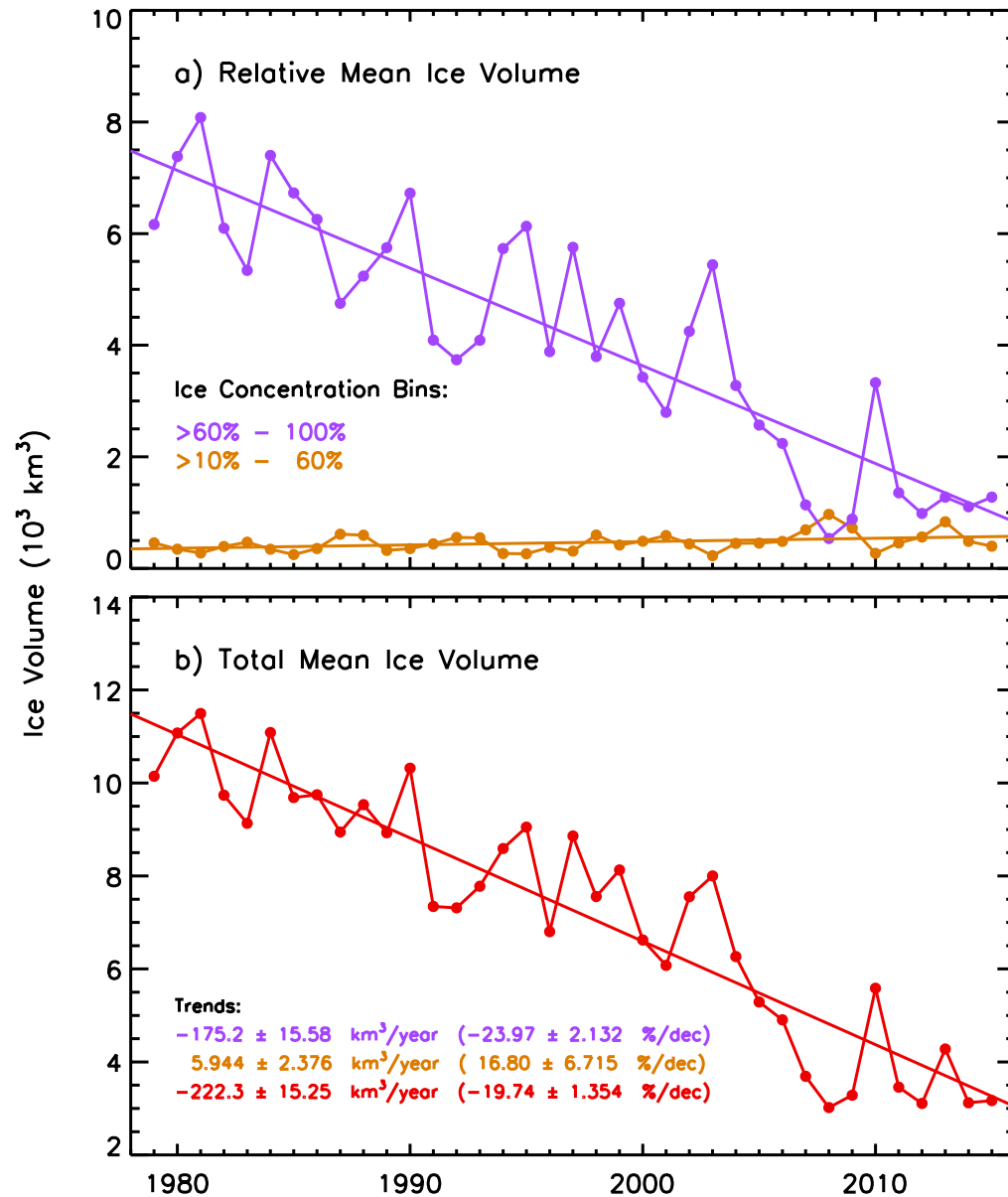
# Arctic Multiyear Ice Area and Cryosat 2 Thickness



# Decadal change in ice volume with no change in thickness



# Change in ice volume, using satellite trends in thickness

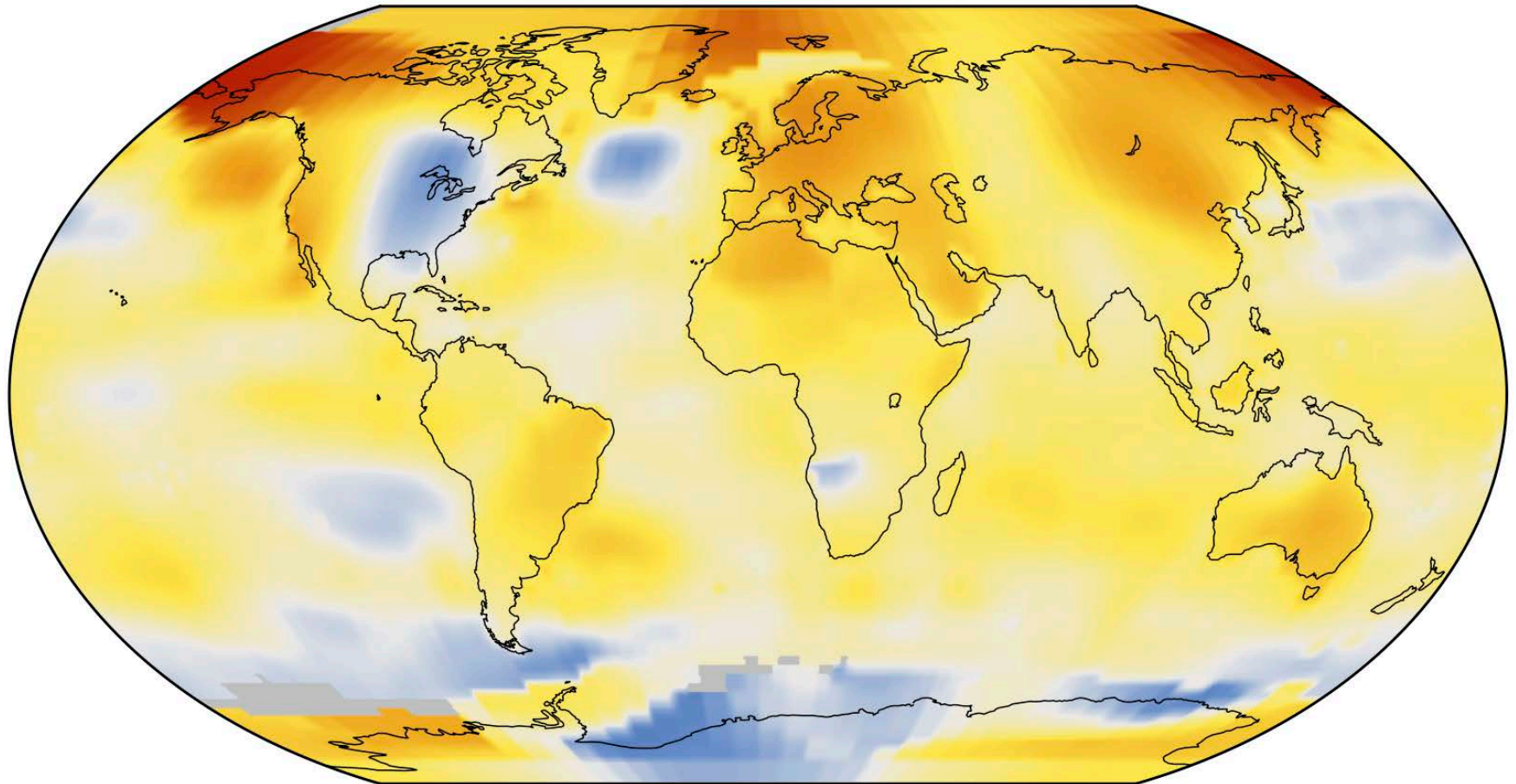




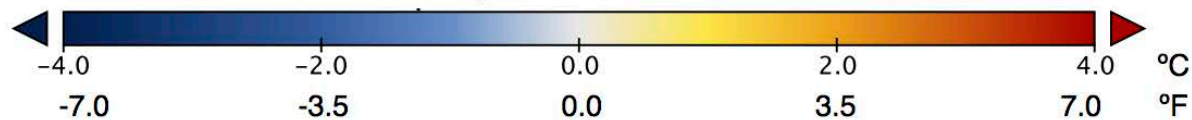
# Record High Temperature in 2014:

Temperature Anomaly in a non-ENSO year with respect to 1951-1980 (from GISS)

with respect to 1951-1980

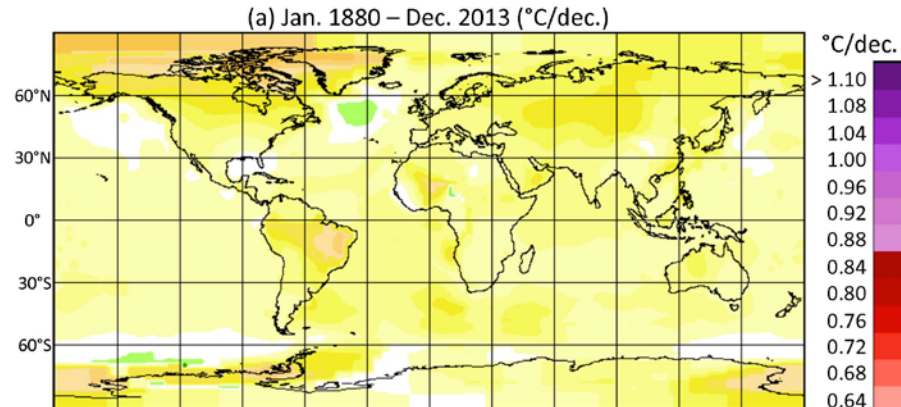


Temperature Difference

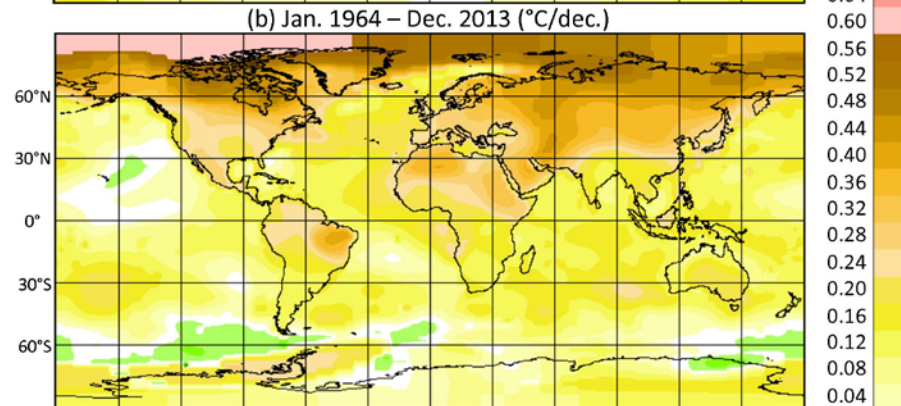


# Global Temperature Trends:

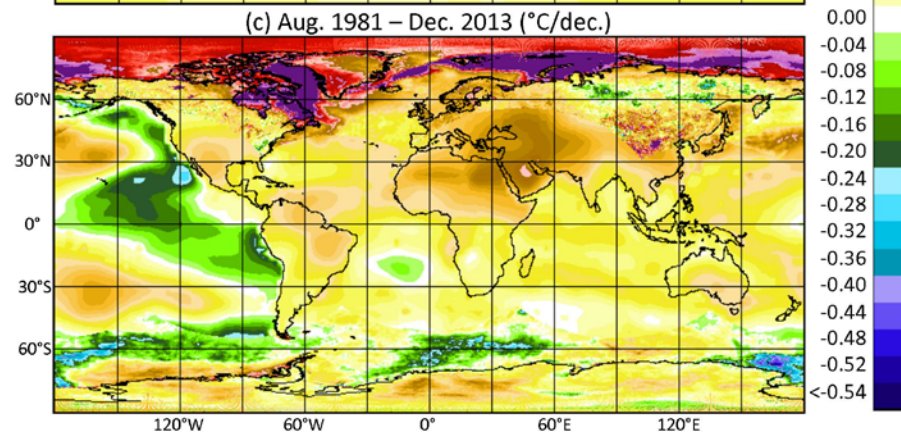
(a) 1880-2013



(b) 1964-2013

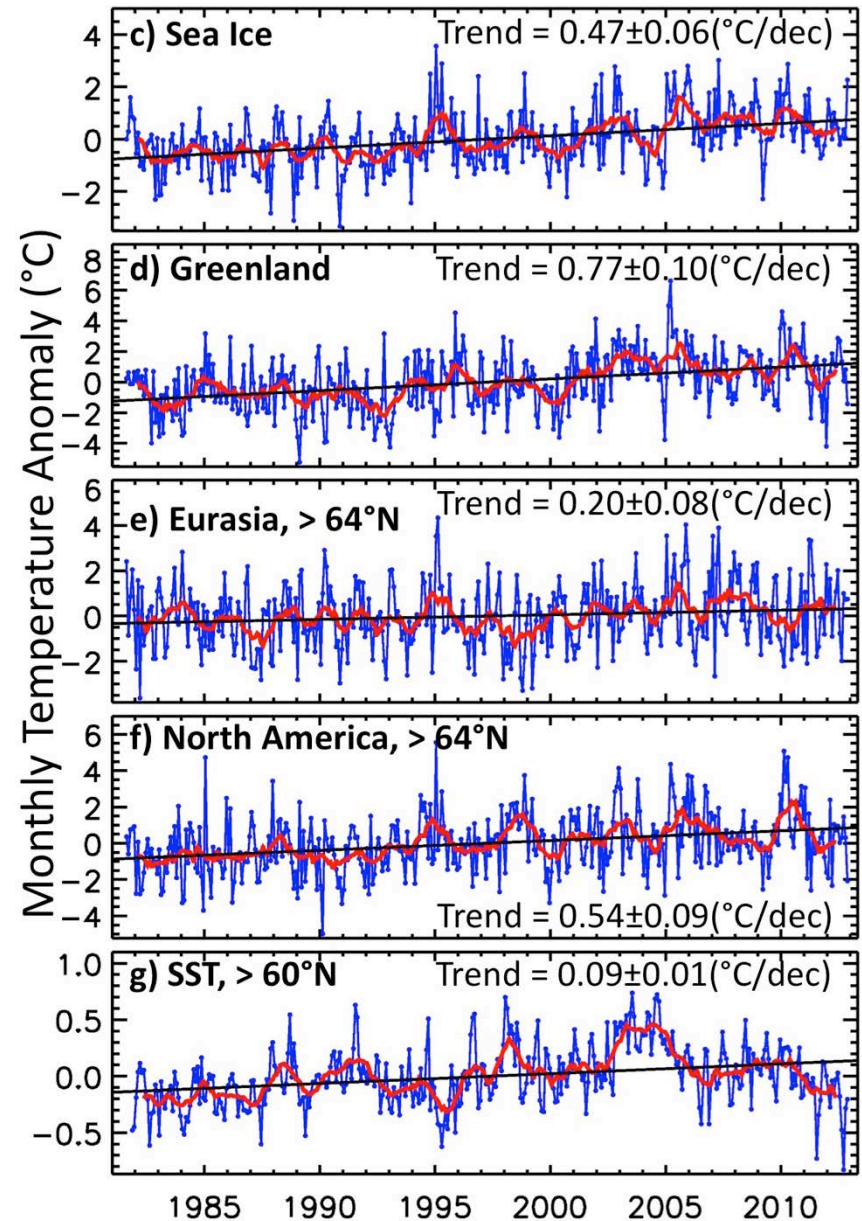
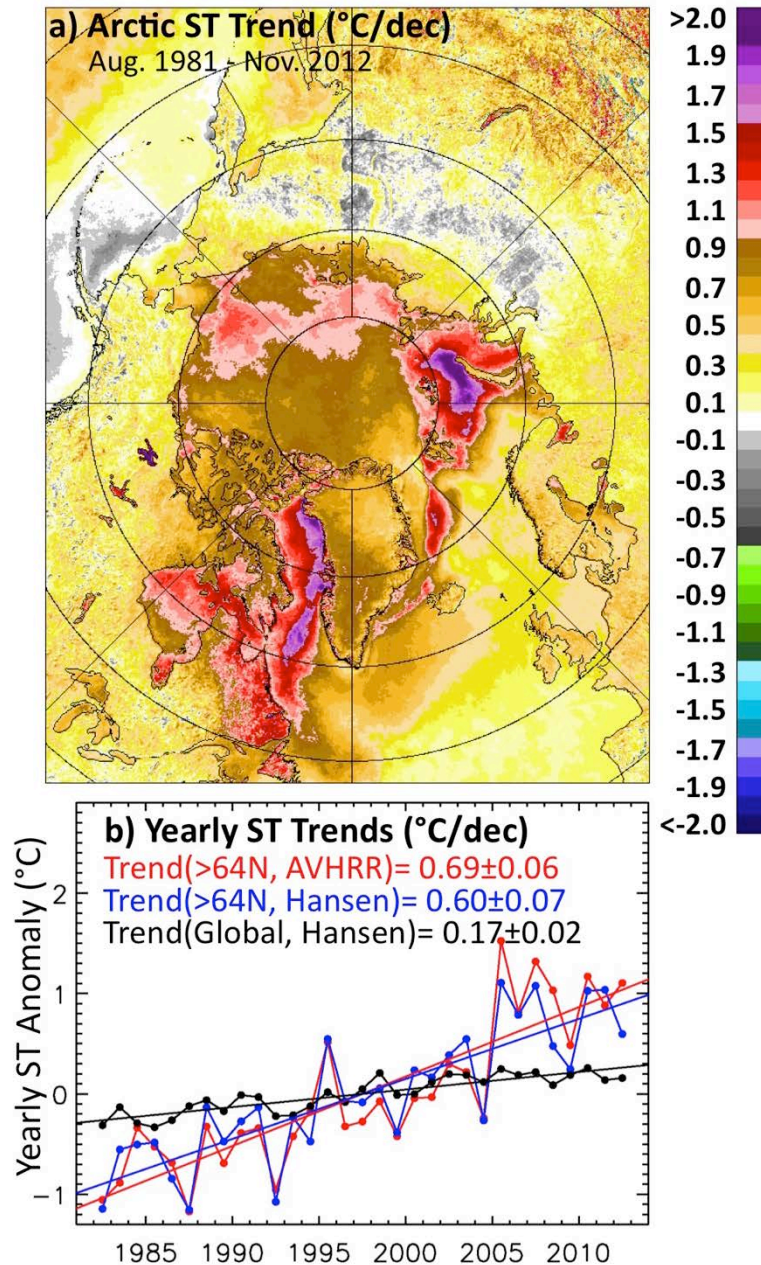


(c) 1981-2013 - Large spatial variability and accelerated warming.



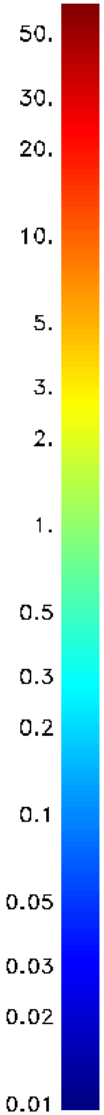
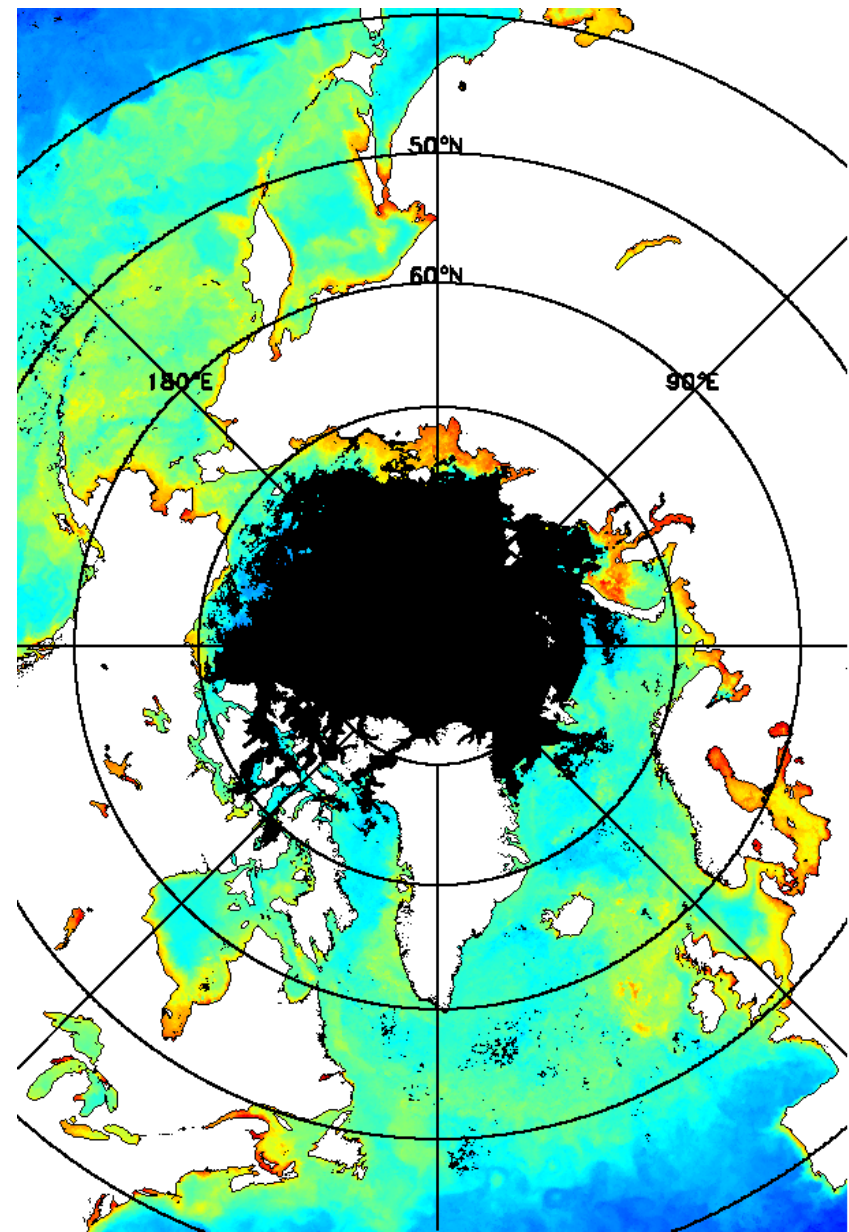
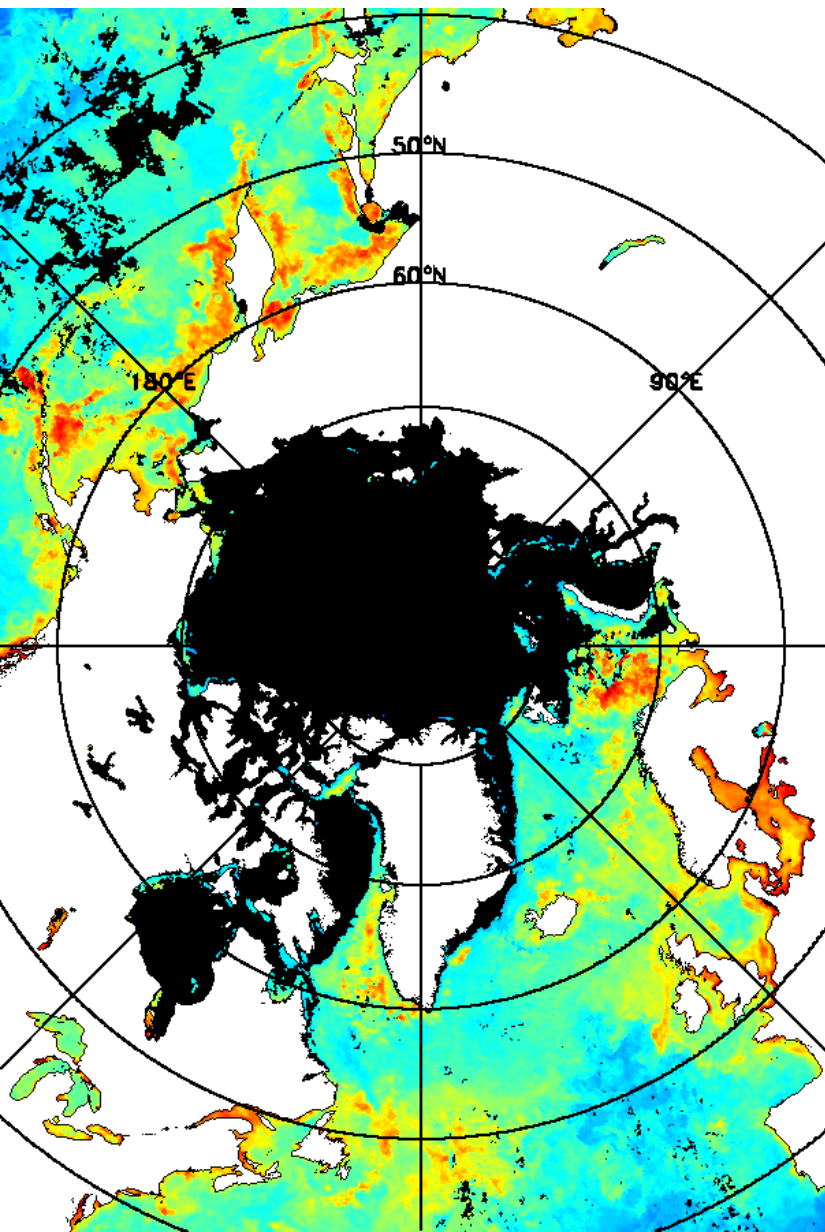


# Trends- Arctic and adjacent Regions



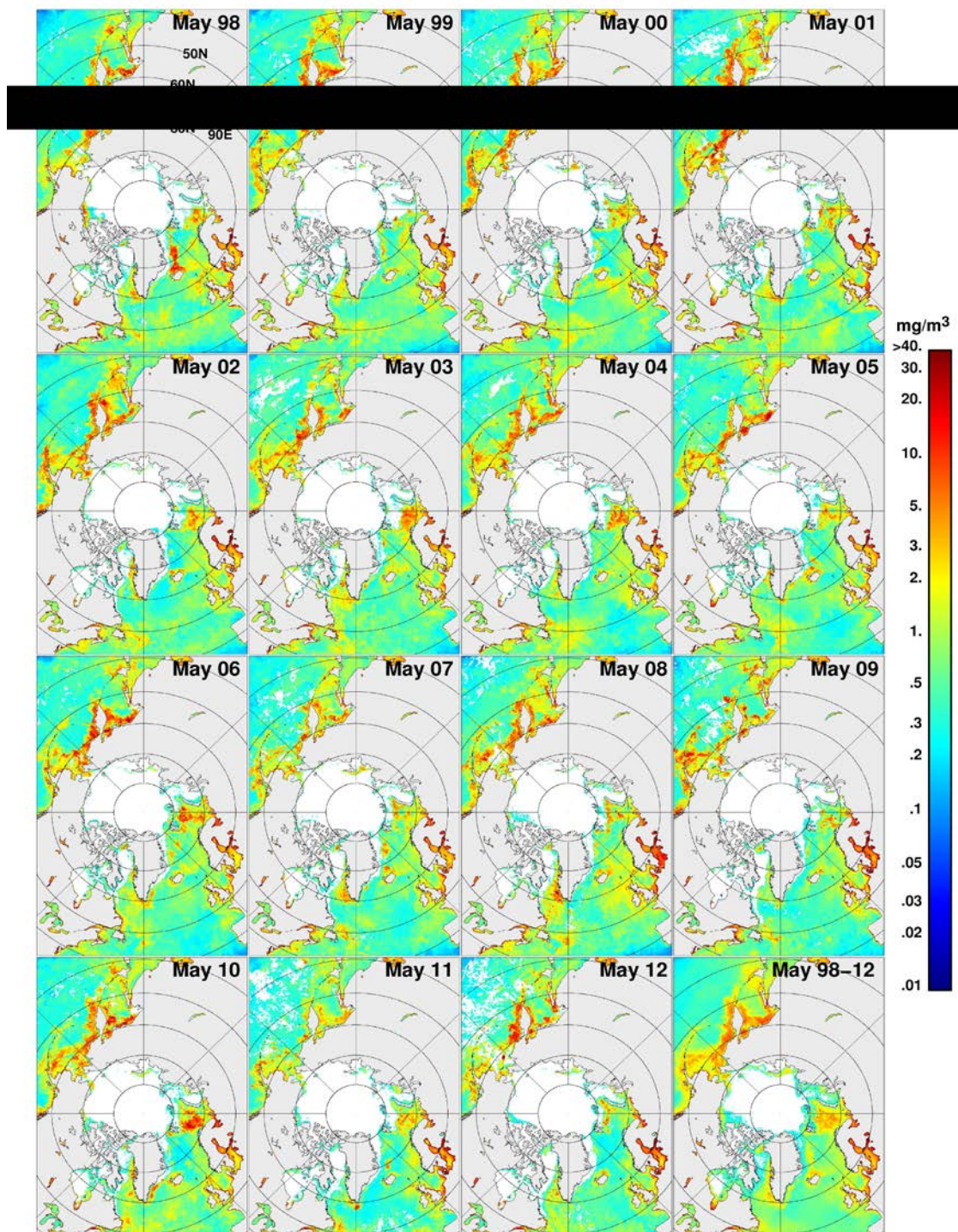


# Chlorophyll concentrations in May and September 2004



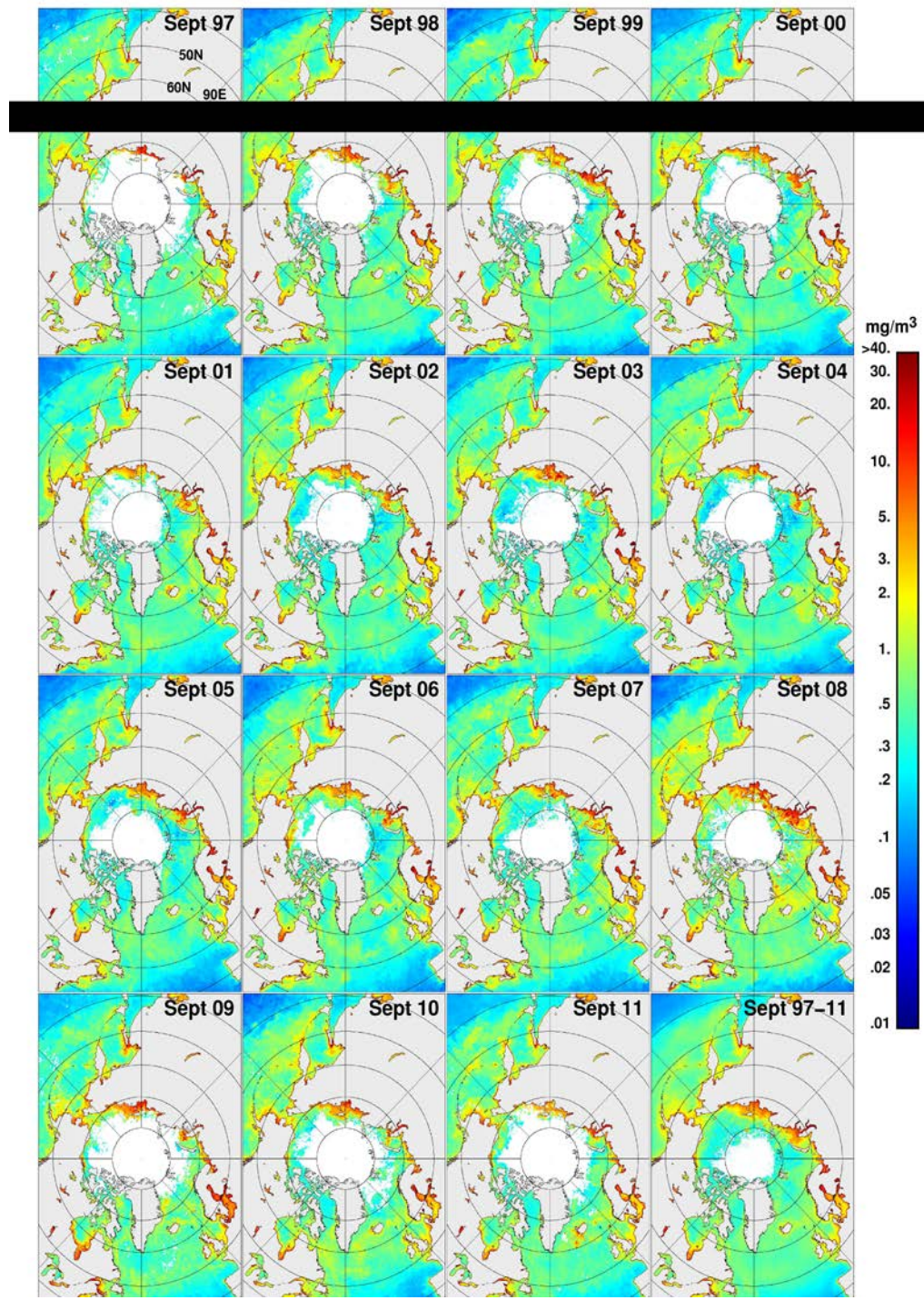


Monthly average  
plankton  
concentrations in  
May  
  
(1998 to 2012)



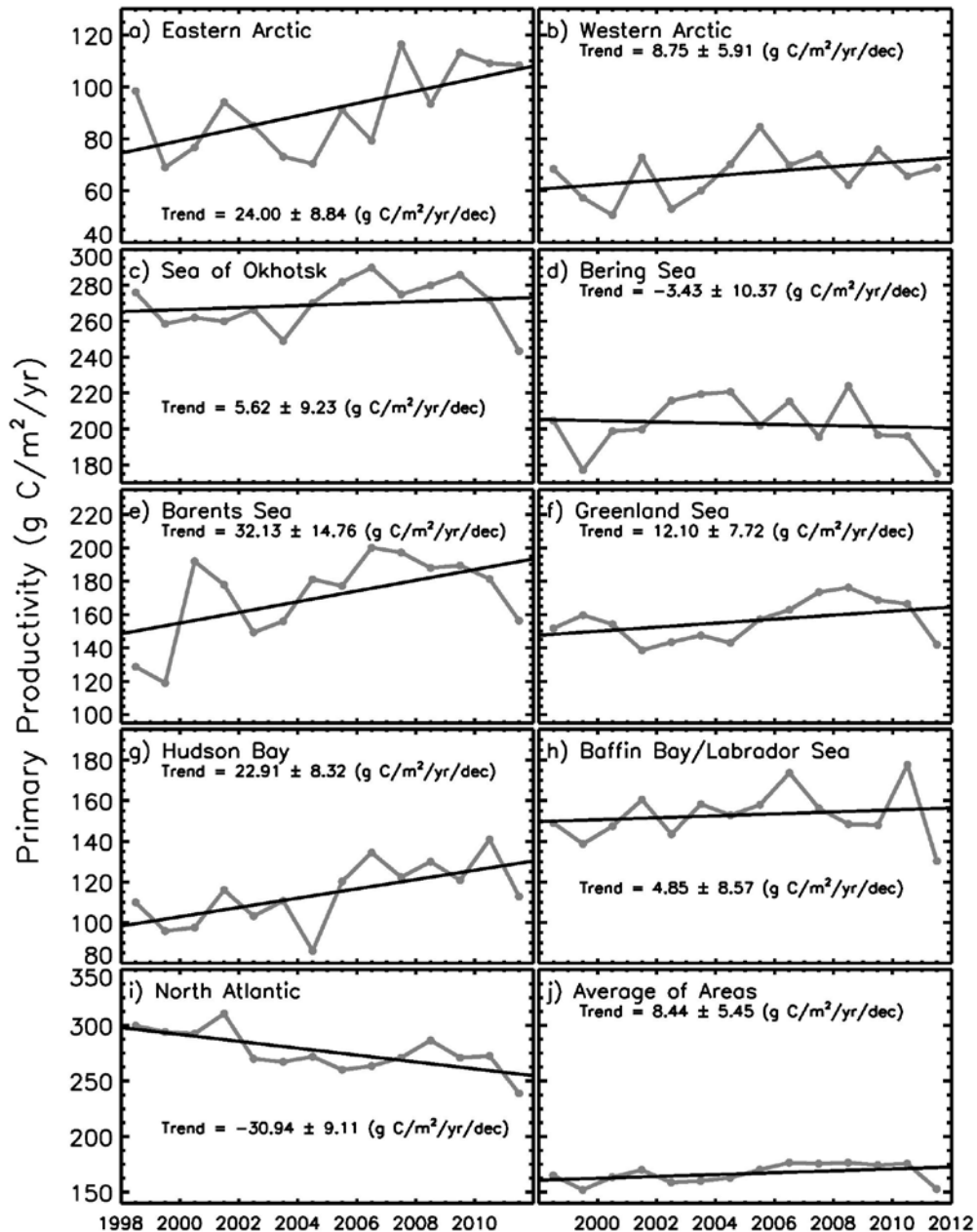


# Monthly Average plankton concentrations in September (1998 to 2012)

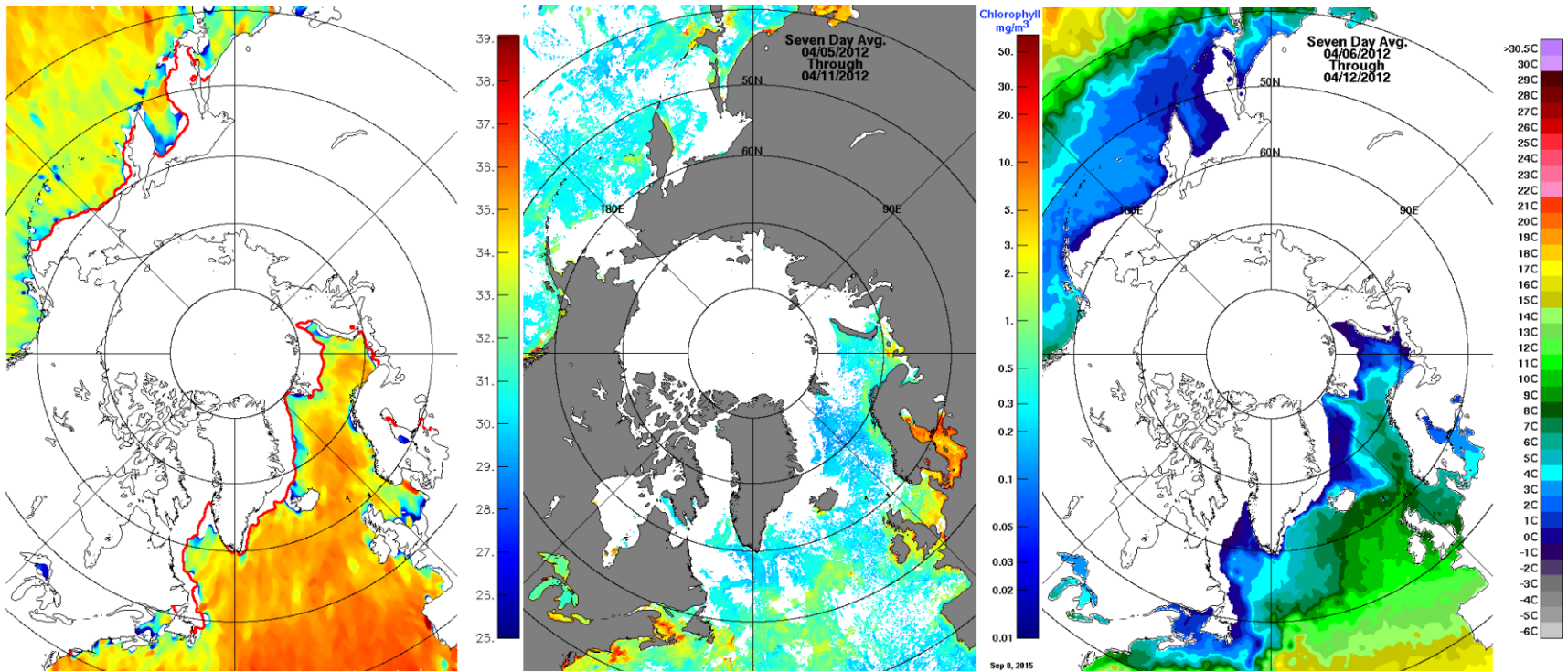




# Yearly Primary Productivity and Trends

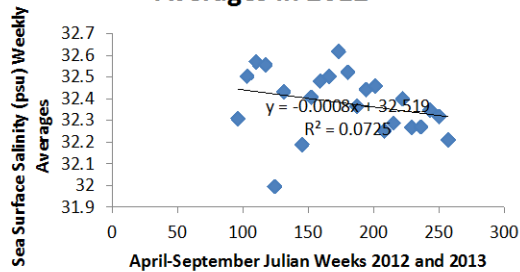


# Surface salinity, chlorophyll conc and SST

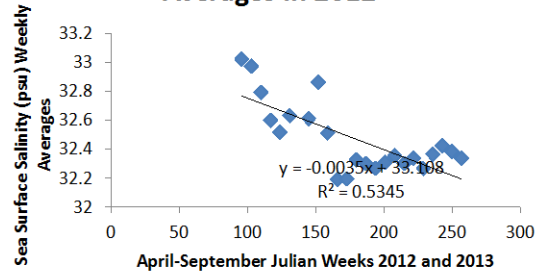


# Temporal changes in SSS

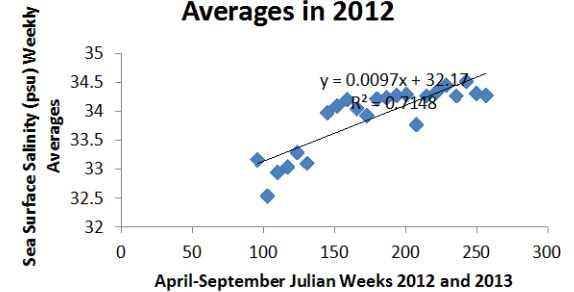
**Region 1: Sea of Okhotsk**  
**Sea Surface Salinity Weekly**  
**Averages in 2012**



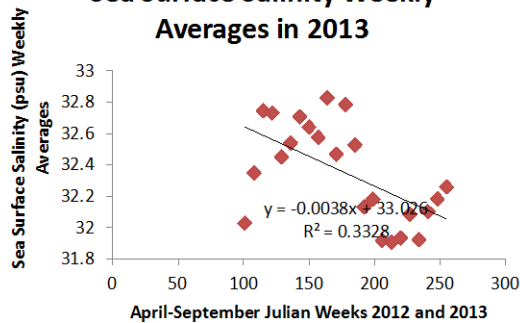
**Region 2: Bering Sea**  
**Sea Surface Salinity Weekly**  
**Averages in 2012**



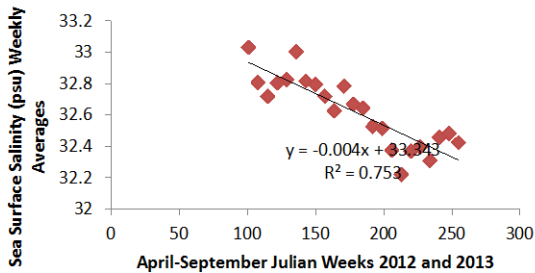
**Region 3: Barents Sea**  
**Sea Surface Salinity Weekly**  
**Averages in 2012**



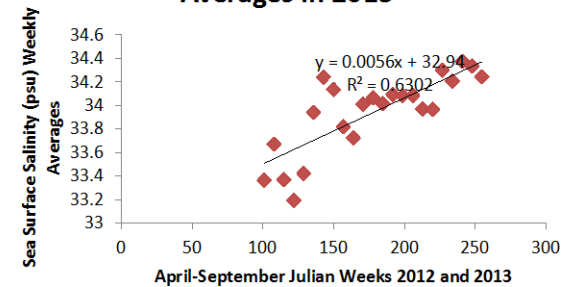
**Region 1: Sea of Okhotsk**  
**Sea Surface Salinity Weekly**  
**Averages in 2013**



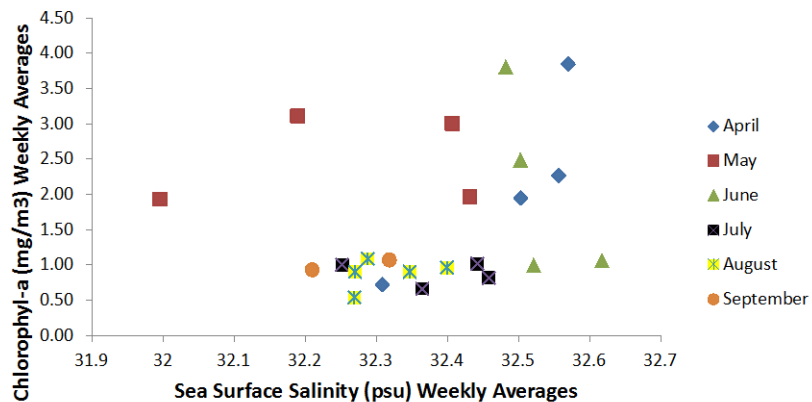
**Region 2: Bering Sea**  
**Sea Surface Salinity Weekly**  
**Averages in 2013**



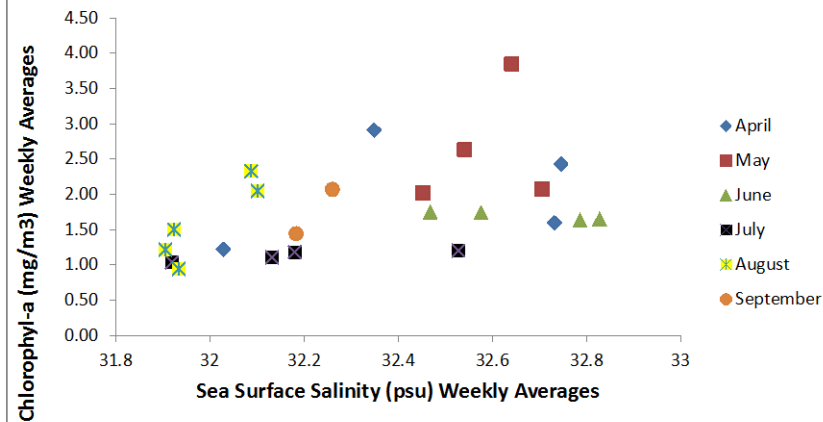
**Region 3: Barents Sea**  
**Sea Surface Salinity Weekly**  
**Averages in 2013**



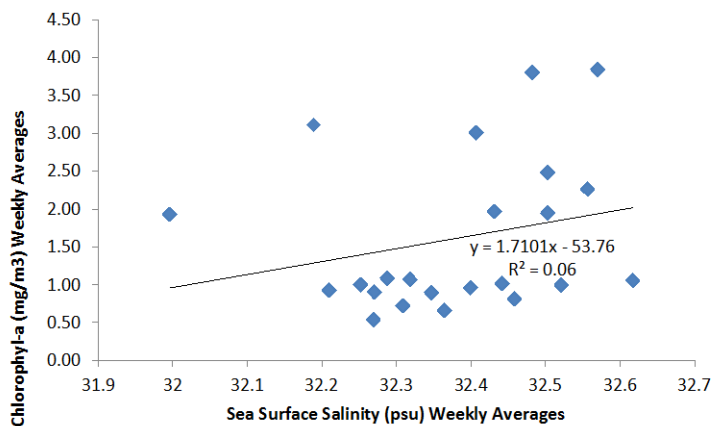
### SSS vs CHLA in Sea of Okhotsks in 2012



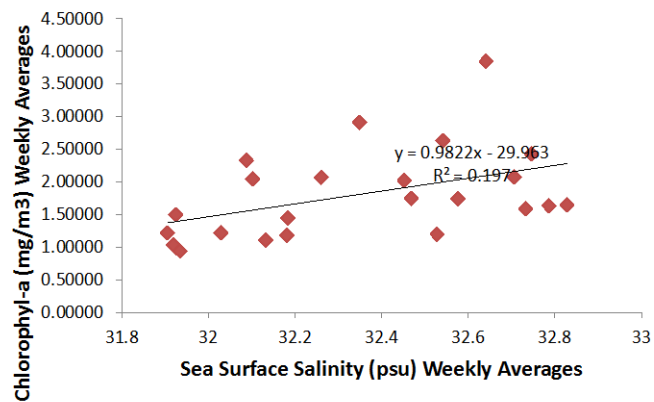
### SSS vs CHLA in Sea of Okhotsks in 2013



### SSS vs CHLA in Sea of Okhotsks in 2012



### SSS vs CHLA in Sea of Okhotsks in 2013



Statistics	Sea of Okhotsks		
	20 12	20 13	
Mean	32.38	32.35	32.36
SD	0.15	0.31	0.23
Max	32.62	32.83	32.72
Min	32.00	31.91	31.95
p-value	0.26	0.03	
slope	1.71	0.98	
R	0.24	0.44	
y-intercept	-53.76	-29.96	

# Summary

- Satellite observational data provides the temporal and spatial coverage needed for a complete understanding of processes in the Arctic.
- GSFC has had a long history of research and quality assessment of satellite data. Continuation of such activities is needed.
- As new or improved sensors are launched by many countries there should be a sharing of data sets for optimum utilization of capabilities.





# Arctic Storm- affected 2012 Per Ice

