Linking fall-line sediment and chlorophyll-a inputs to estuarine water clarity

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Goals

(1) Describe spatial and seasonal variability in Secchi Depth, kd and related variables

(2) Cluster Bay monitoring stations with similar temporal variability

(3) Quantify relationships between loads of nutrients/sediment and Secchi depth/kd across space and time

Approach Details:

(1) Spearman's rank correlation between variables (load v constituent, constituent vs constituent)

(2) Window-approach to account for lab/method changes

(3) Clustering of stations with similar variability

(4) Analysis of deviations of long-term mean, station-specific climatology

Next Steps (from last meeting)

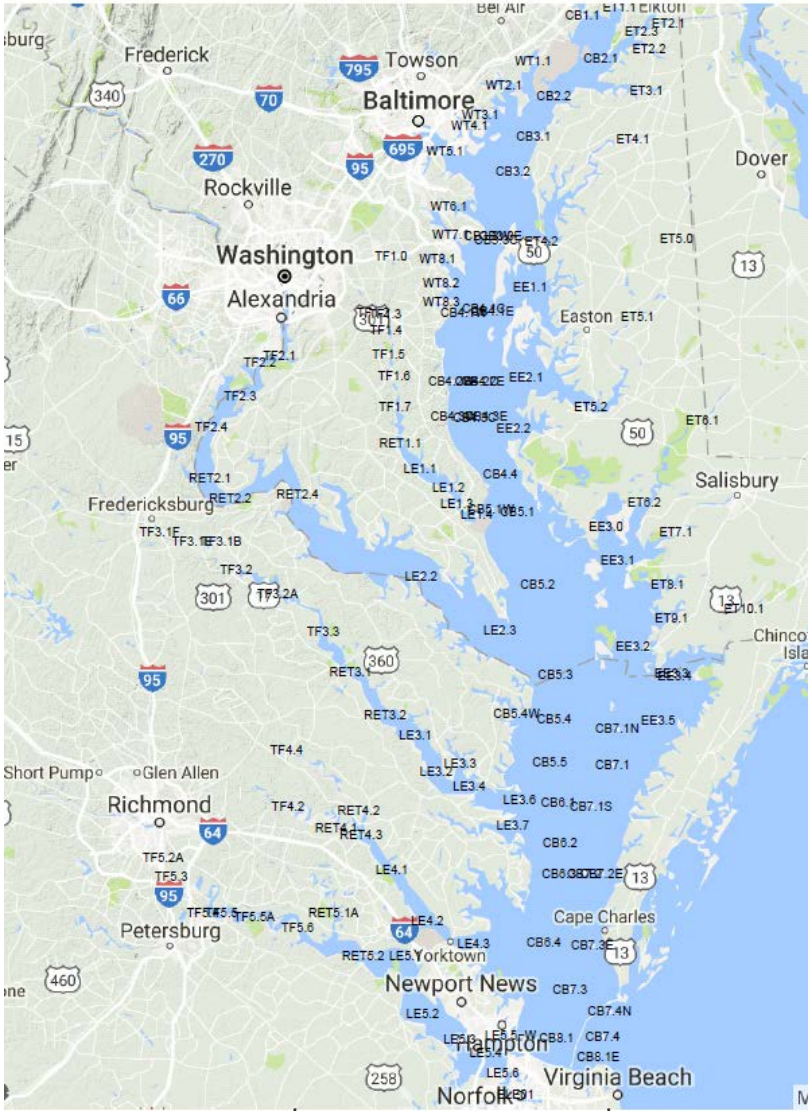
(1) Continue clustering (TRUST) analysis for Secchi Depth, others

(2) Examine intra-seasonal relationships between input and clarity

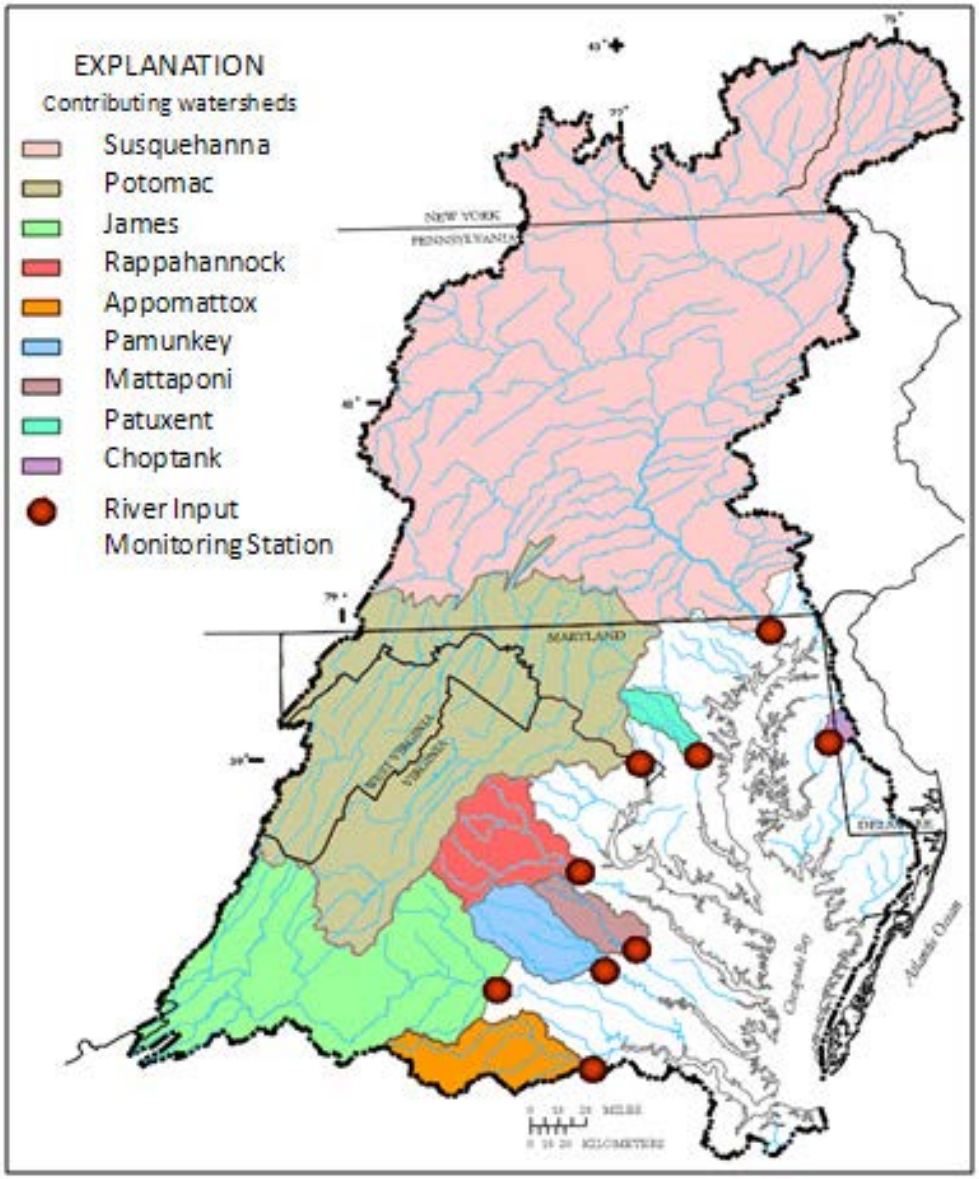
(3) Multi-variate approach: clarity = f(load, temperature, etc)

(4) Examine role of nutrient loading

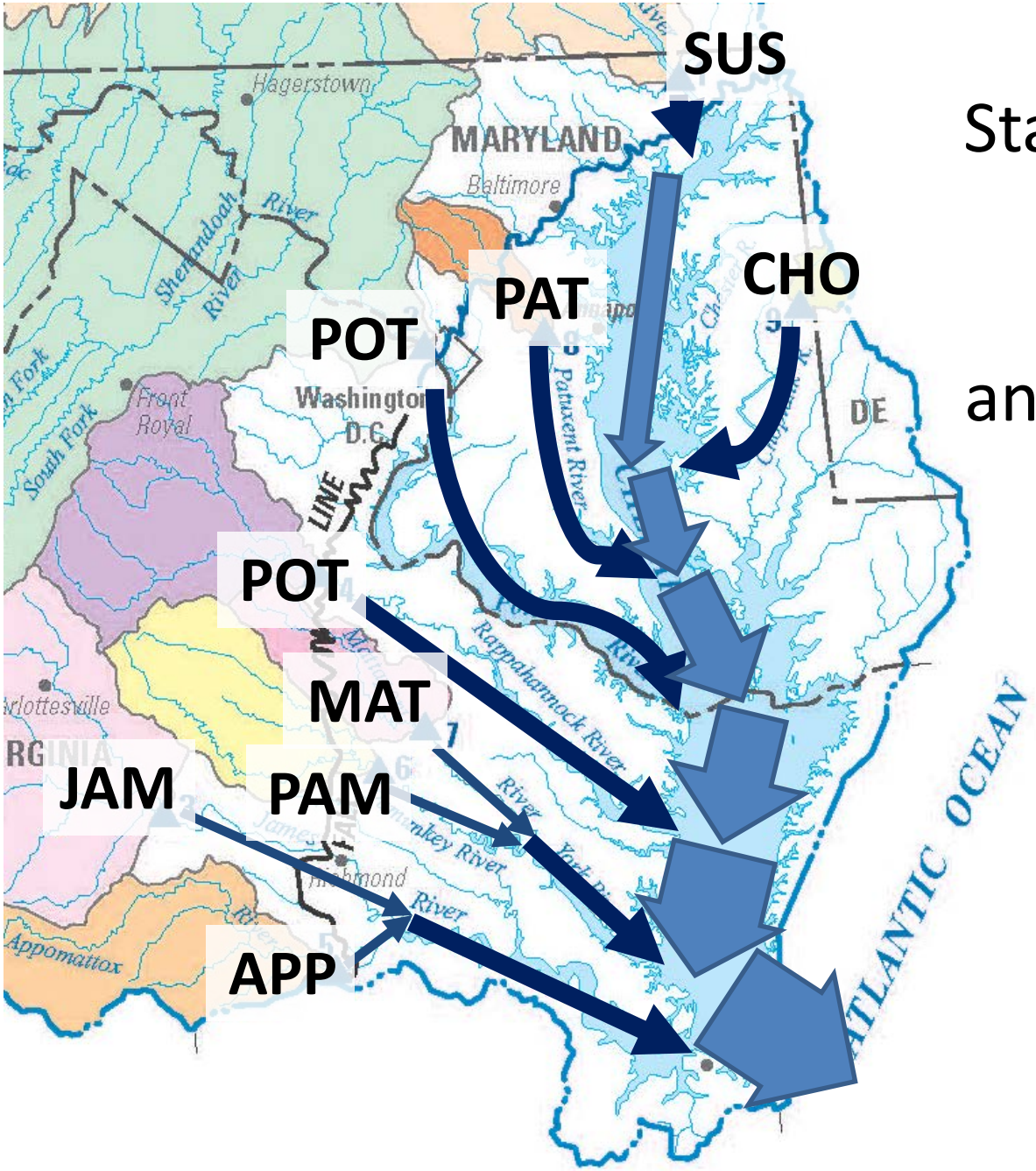
Datasets



Long-Term, Fixed WQ Stations
(Z_{sd}, k_d, nutrients, TSS, salinity, Chl-a)



WRTDS-based loads at RIM stations
(TSS, FineSS, TN, TP, freshwater)



Approach:
Statistical Relationship Between RIM Inputs and Station-by-Station Variables

Moyer et al. (2012)

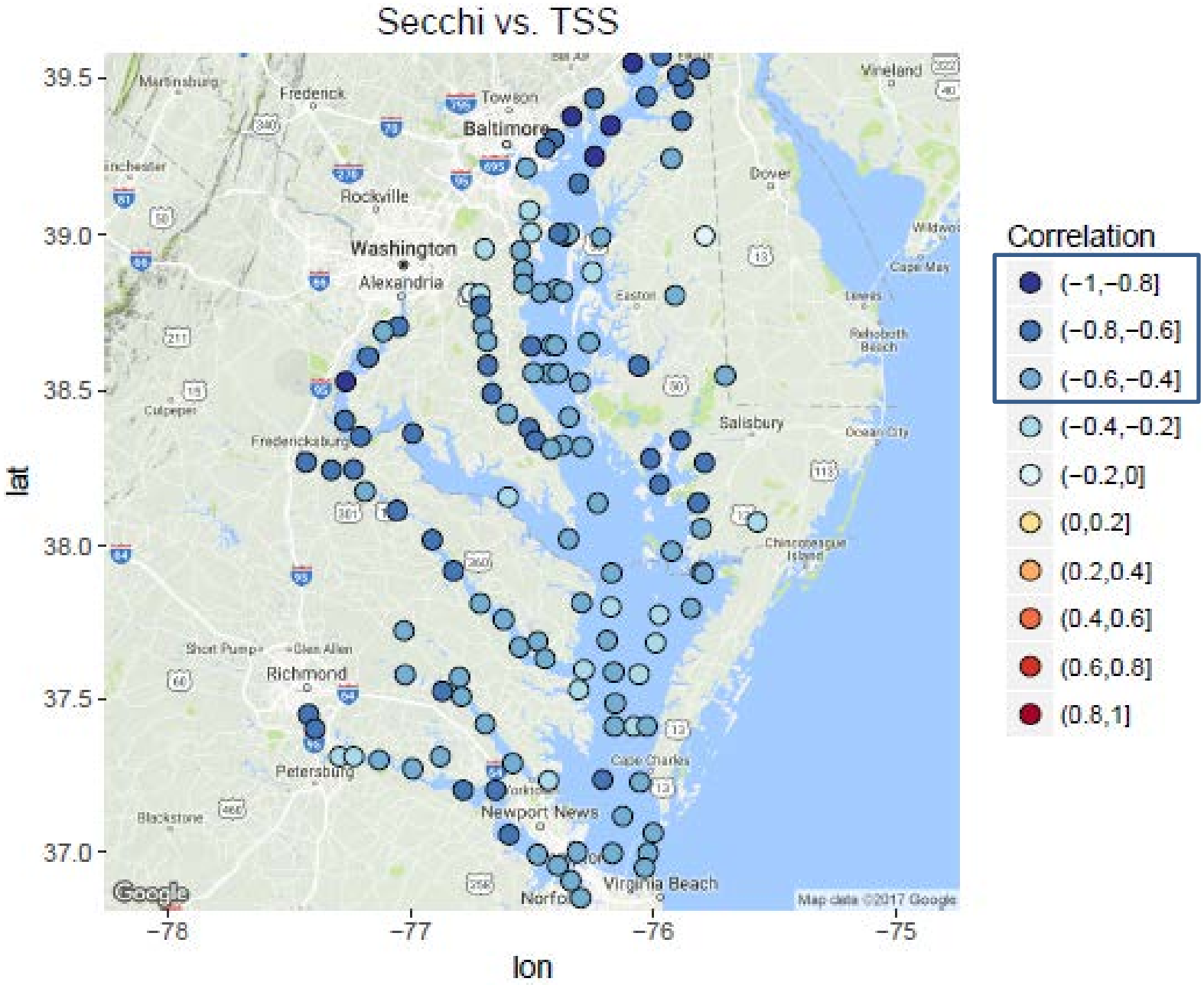
Water Year	Annual-Mean Streamflow to Bay	Flow Classification	Relative Magnitude of Streamflow
2017 (current)	--	--	
2016	71600	Normal	
2015	63500	Below Normal	
2014	81300	Normal	
2013	76000	Normal	
2012	80000	Normal	
2011	113000	Above Normal	
2010	79900	Normal	
2009	63400	Below Normal	
2008	74300	Normal	
2007	79500	Normal	
2006	77500	Normal	
2005	87600	Normal	
2004	118000	Above Normal	
2003	119000	Above Normal	
2002	45400	Below Normal	
2001	52600	Below Normal	
2000	70600	Normal	
1999	45600	Below Normal	
1998	106000	Above Normal	
1997	89800	Above Normal	
1996	115000	Above Normal	
1995	59900	Below Normal	
1994	107000	Above Normal	
1993	101000	Above Normal	
1992	60400	Below Normal	
1991	84000	Normal	
1990	75600	Normal	
1989	76400	Normal	
1988	59300	Below Normal	
1987	78100	Normal	
1986	78100	Normal	
1985	56800	Below Normal	
1984	108000	Above Normal	
1983	75900	Normal	
1982	75100	Normal	
1981	49200	Below Normal	
1980	86000	Normal	

'Average'

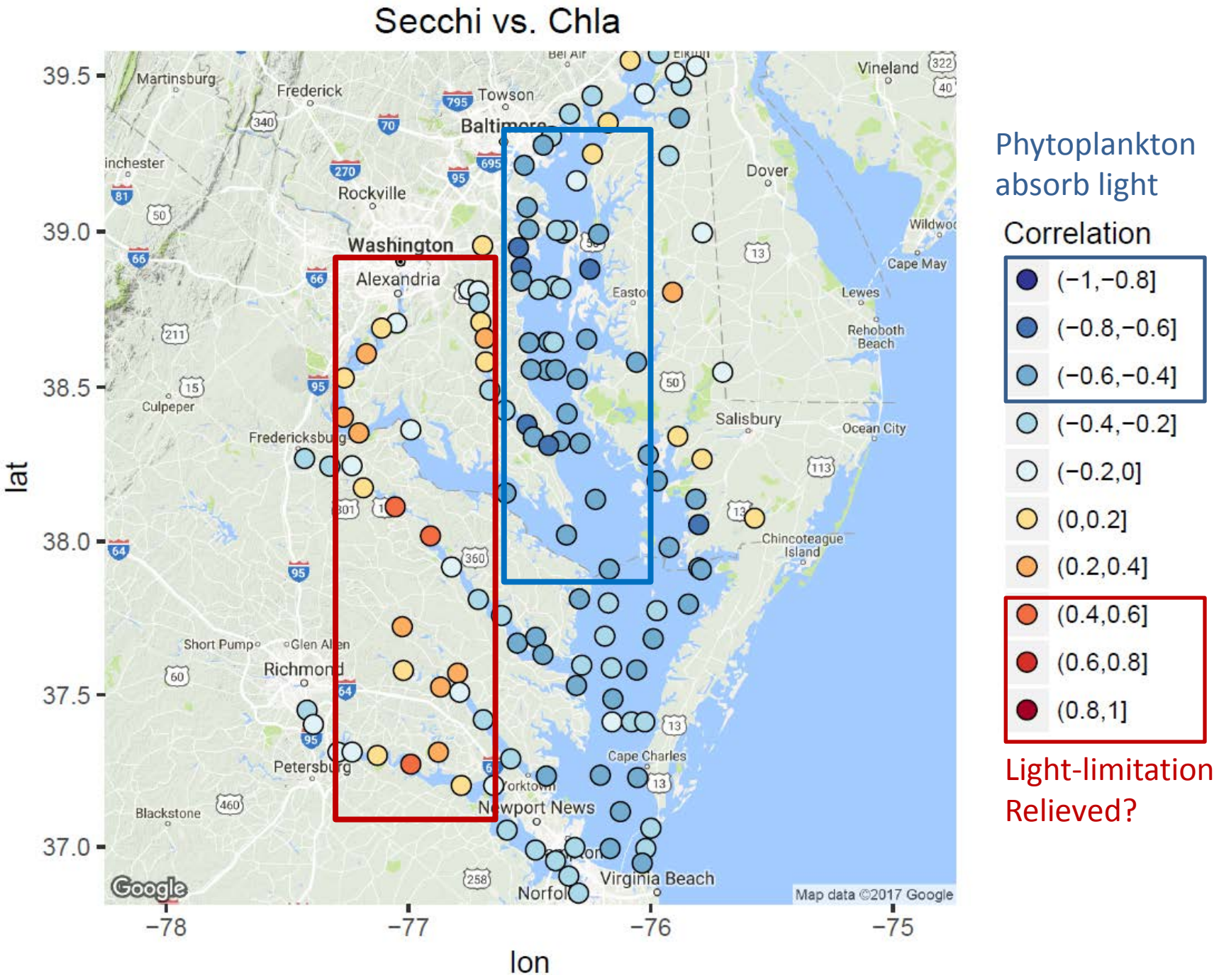
'Wet-Dry'

'Average'

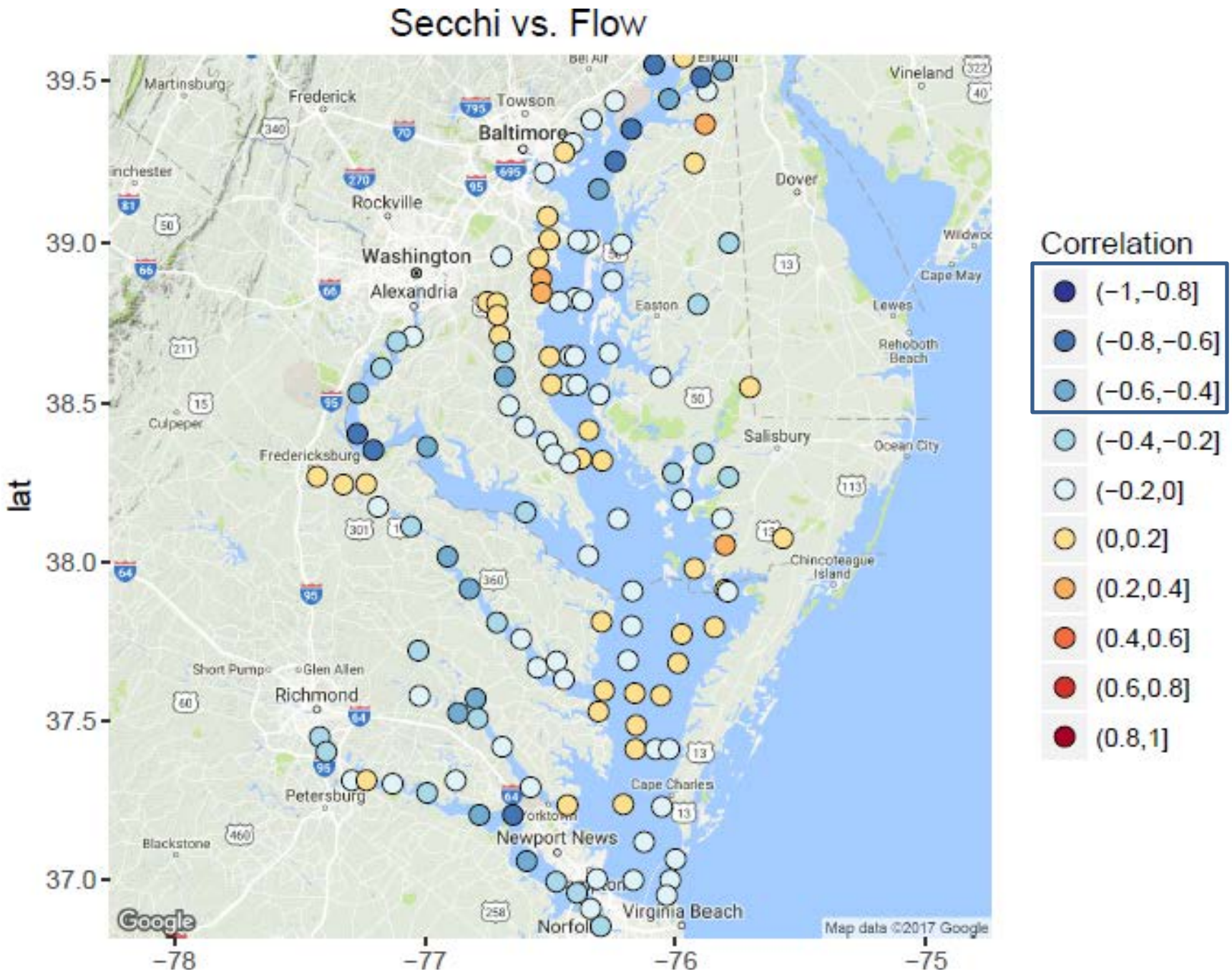
Relationship Between Loads and Estuary (quick overview of last presentation)



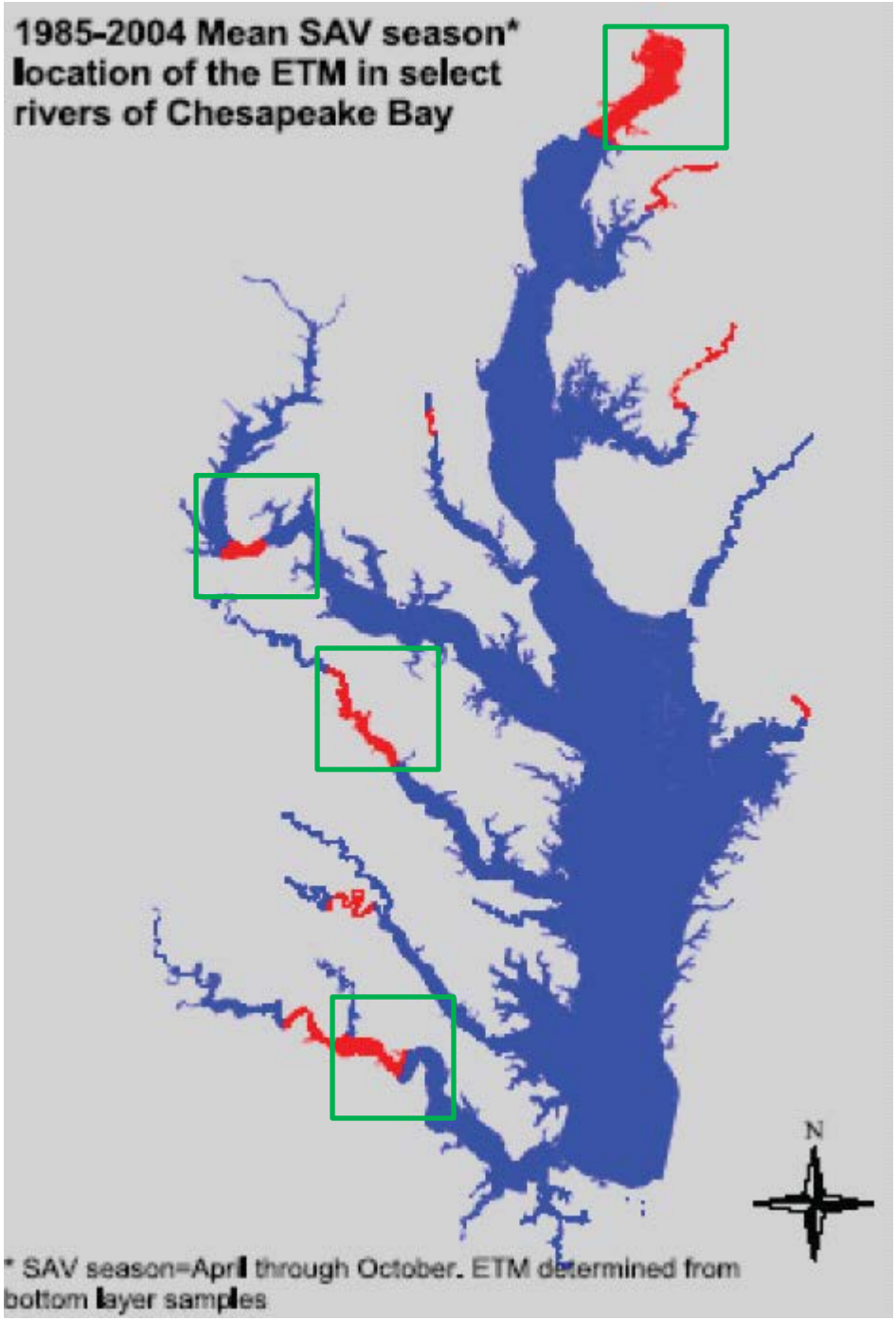
TSS and Secchi Consistently negatively correlated, strongest correlations in low salinity



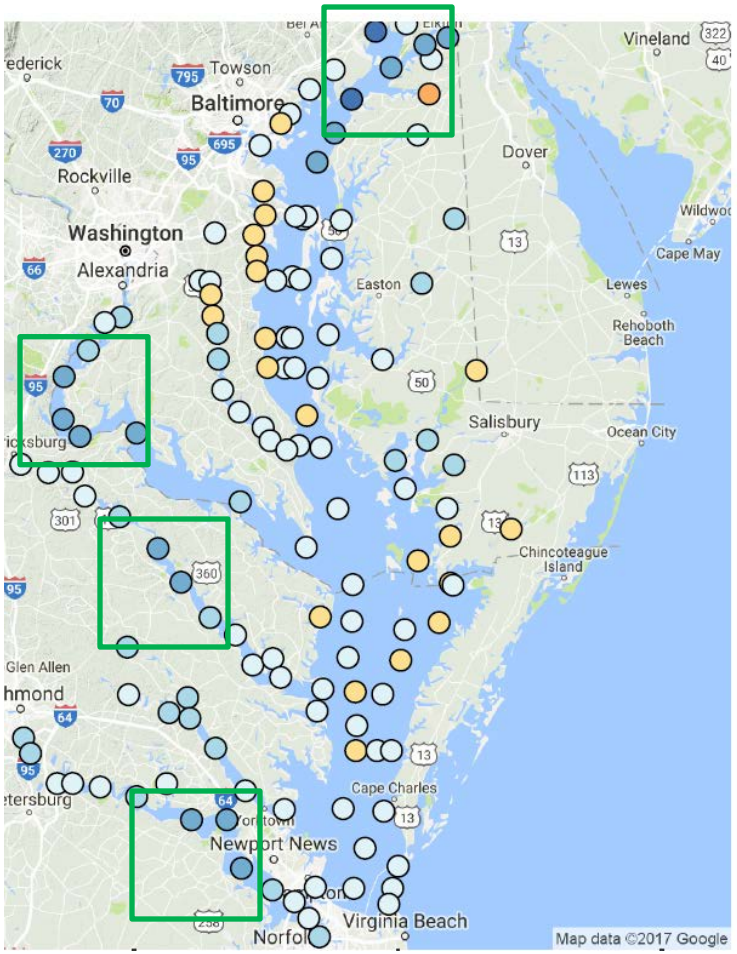
Chl-a and Secchi negatively correlated in mainstem, opposite is true in tribs



Flow and Secchi negatively correlated in turbid regions



Secchi vs. loadSS

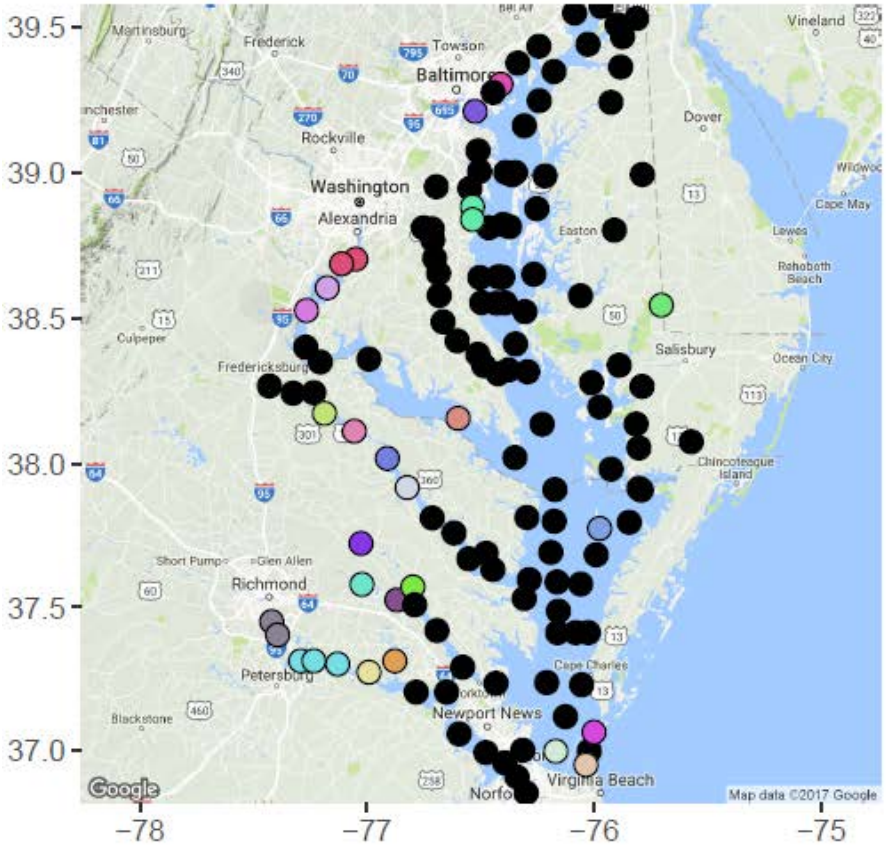


*No difference for fine SS

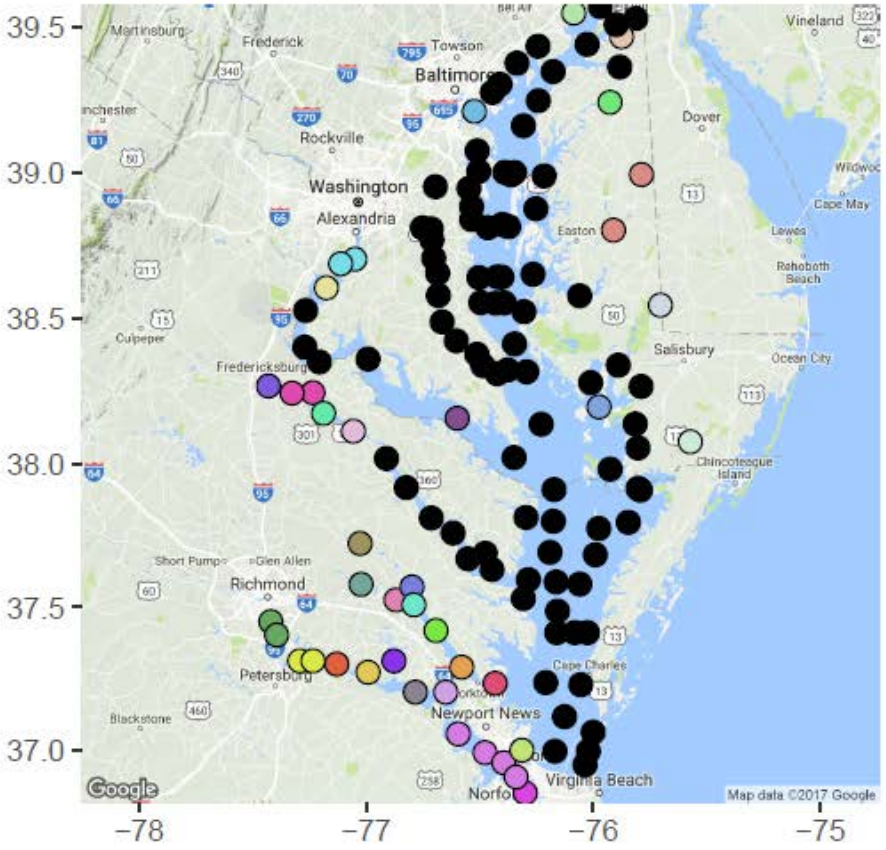
Dynamic Clustering of Secchi Data

Dynamic clustering of scaled monthly average Secchi depth values

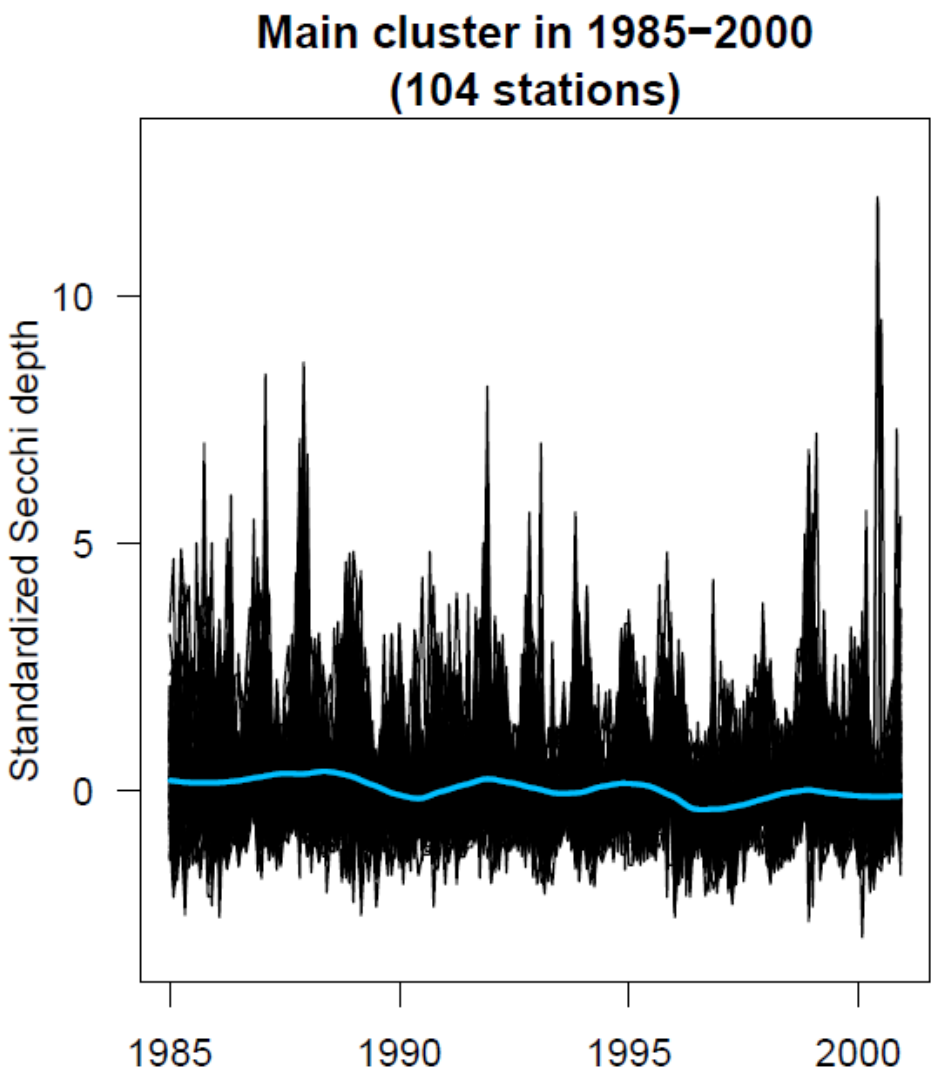
1985–2000

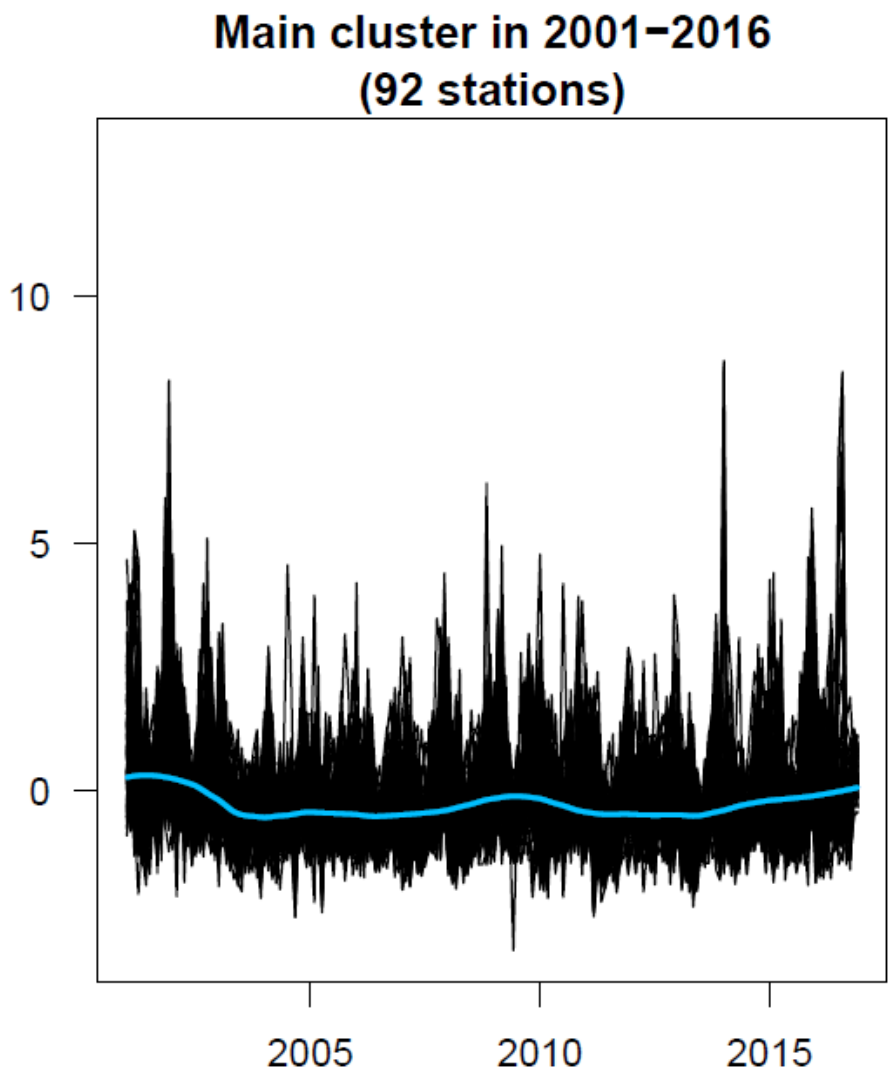


2001–2016

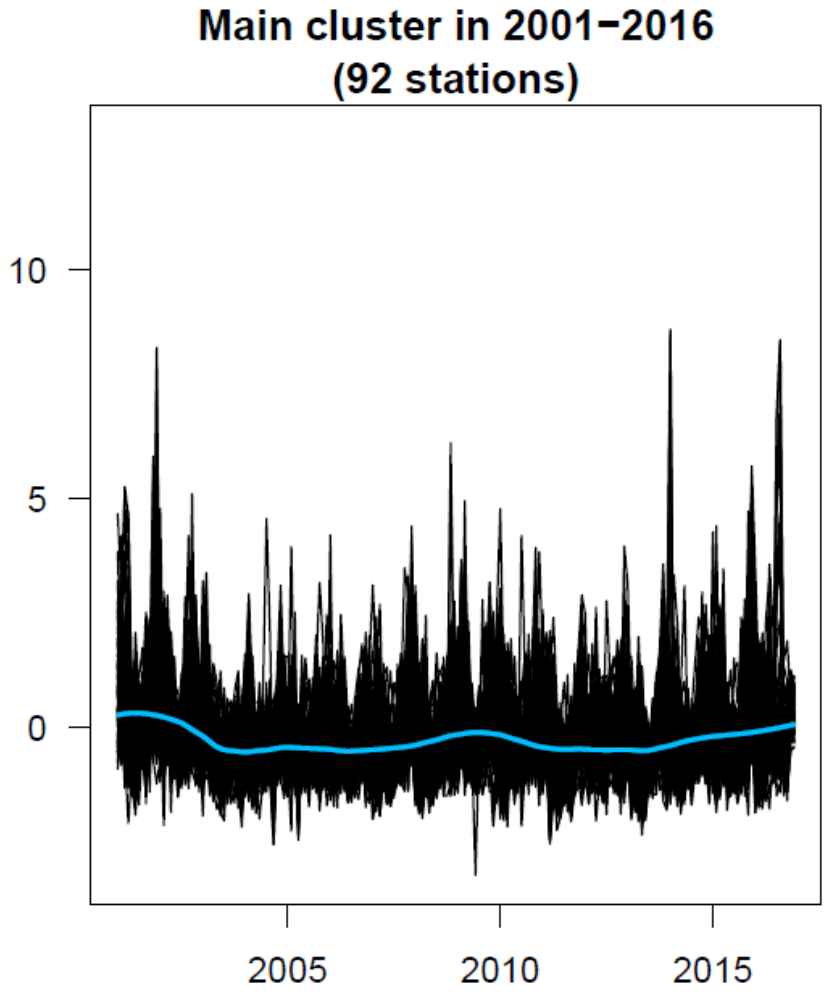


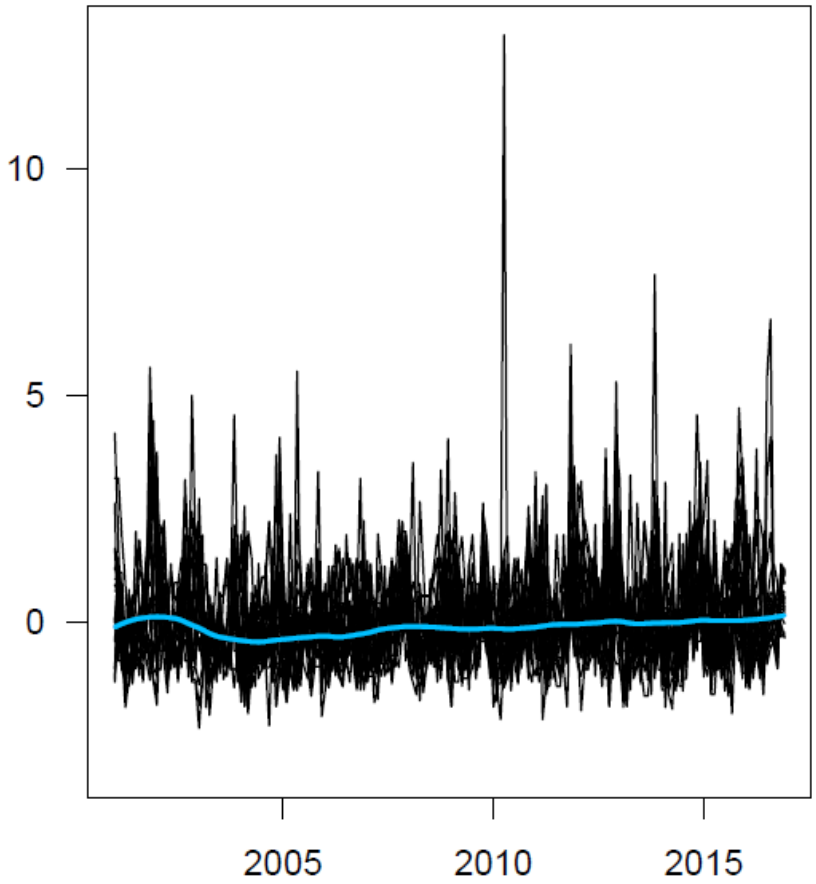
Main cluster dynamics



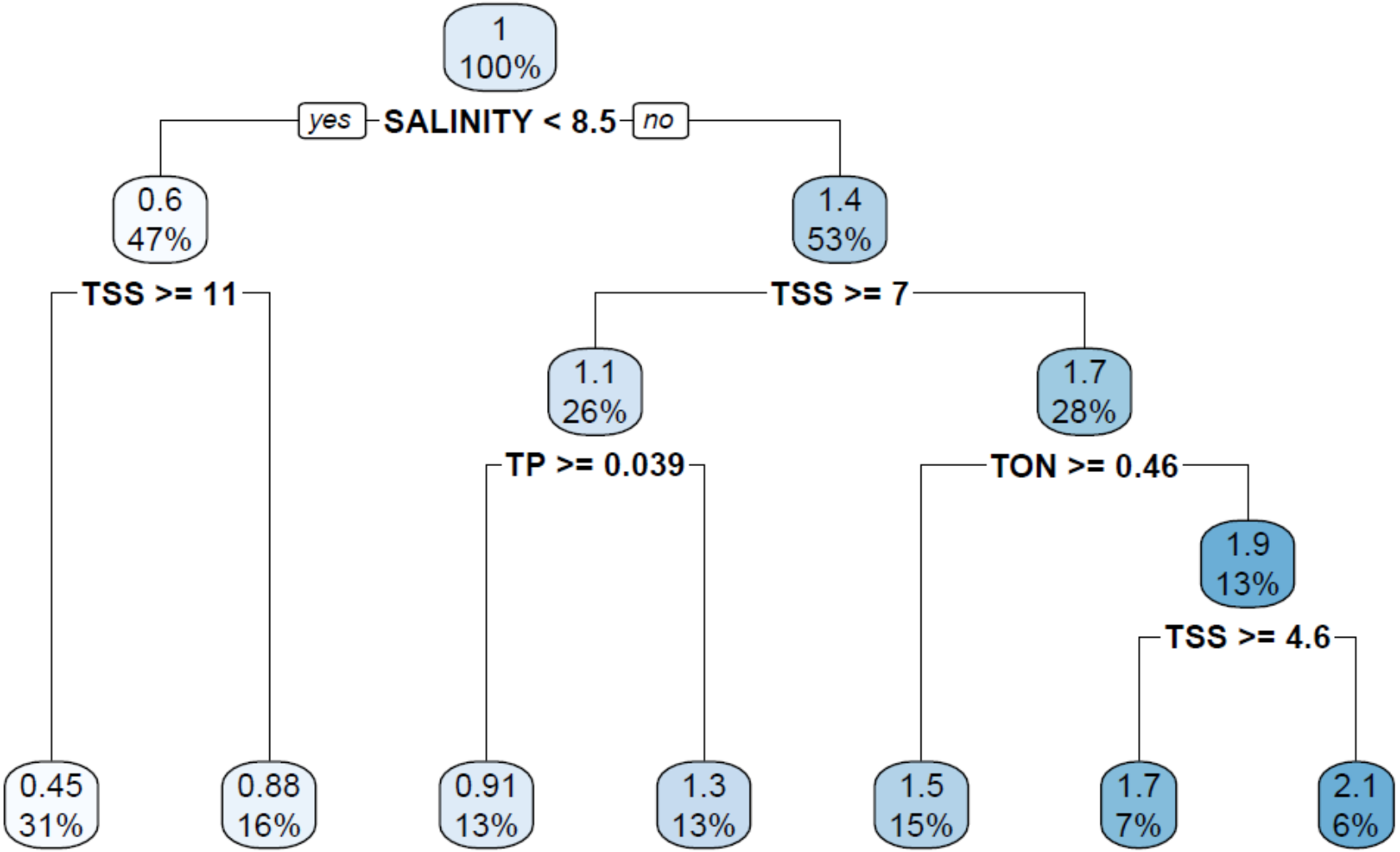


Main cluster and stations that exit it in 2001 - 2016

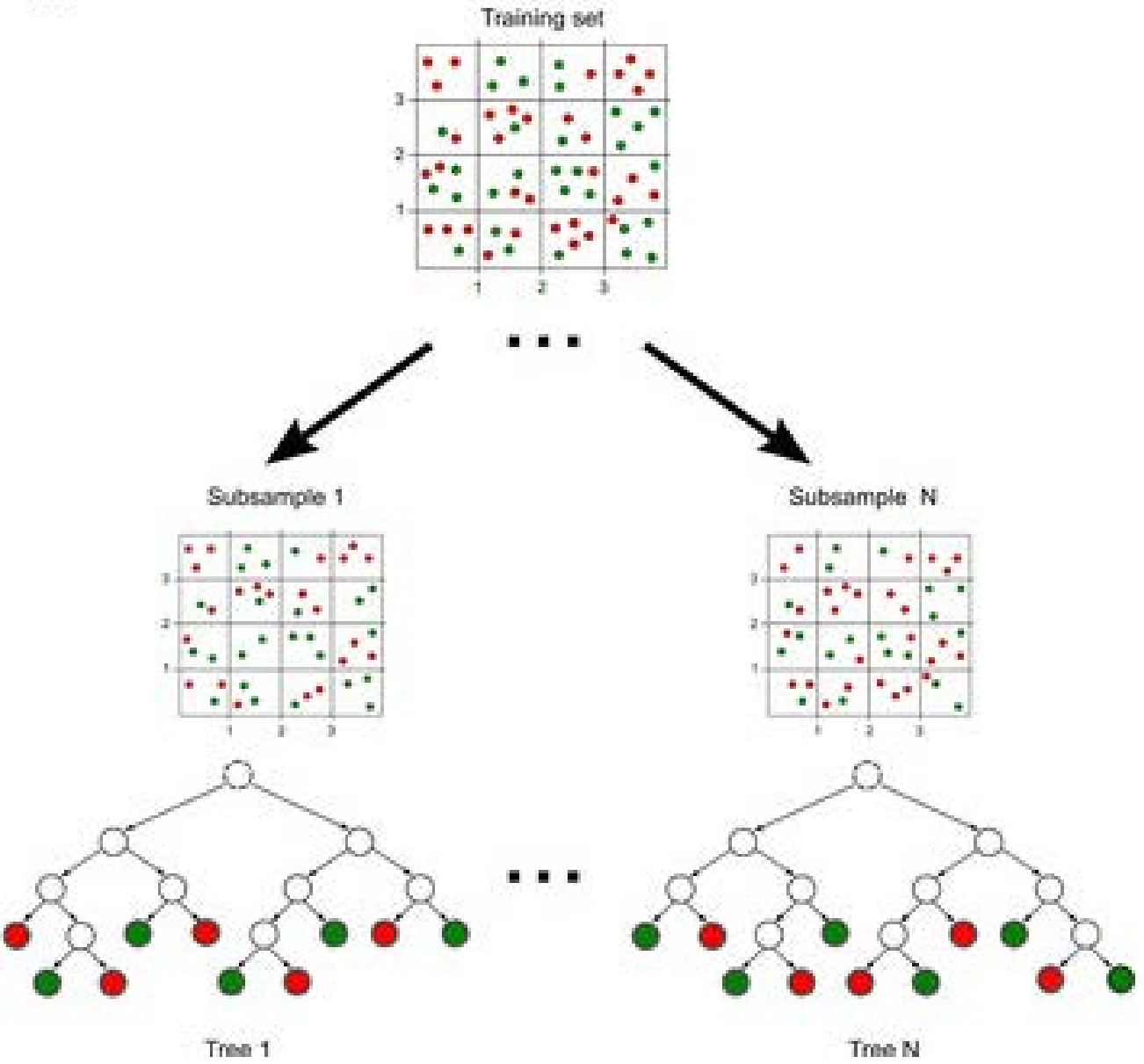




CART: Classification And Regression Tree

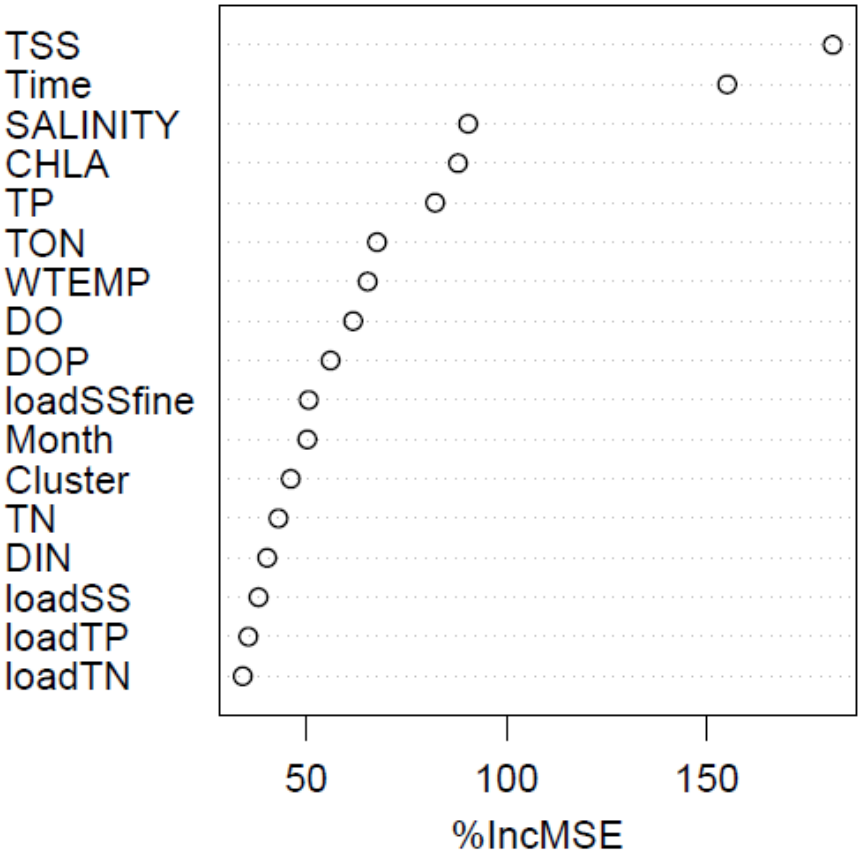


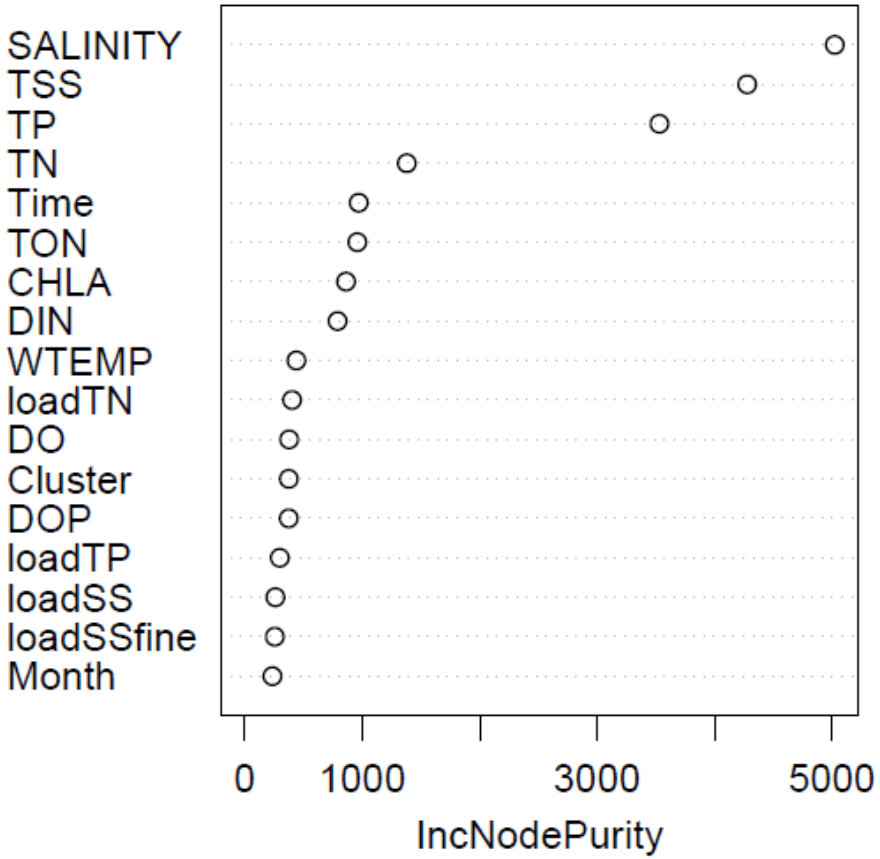
Random forest: Many trees



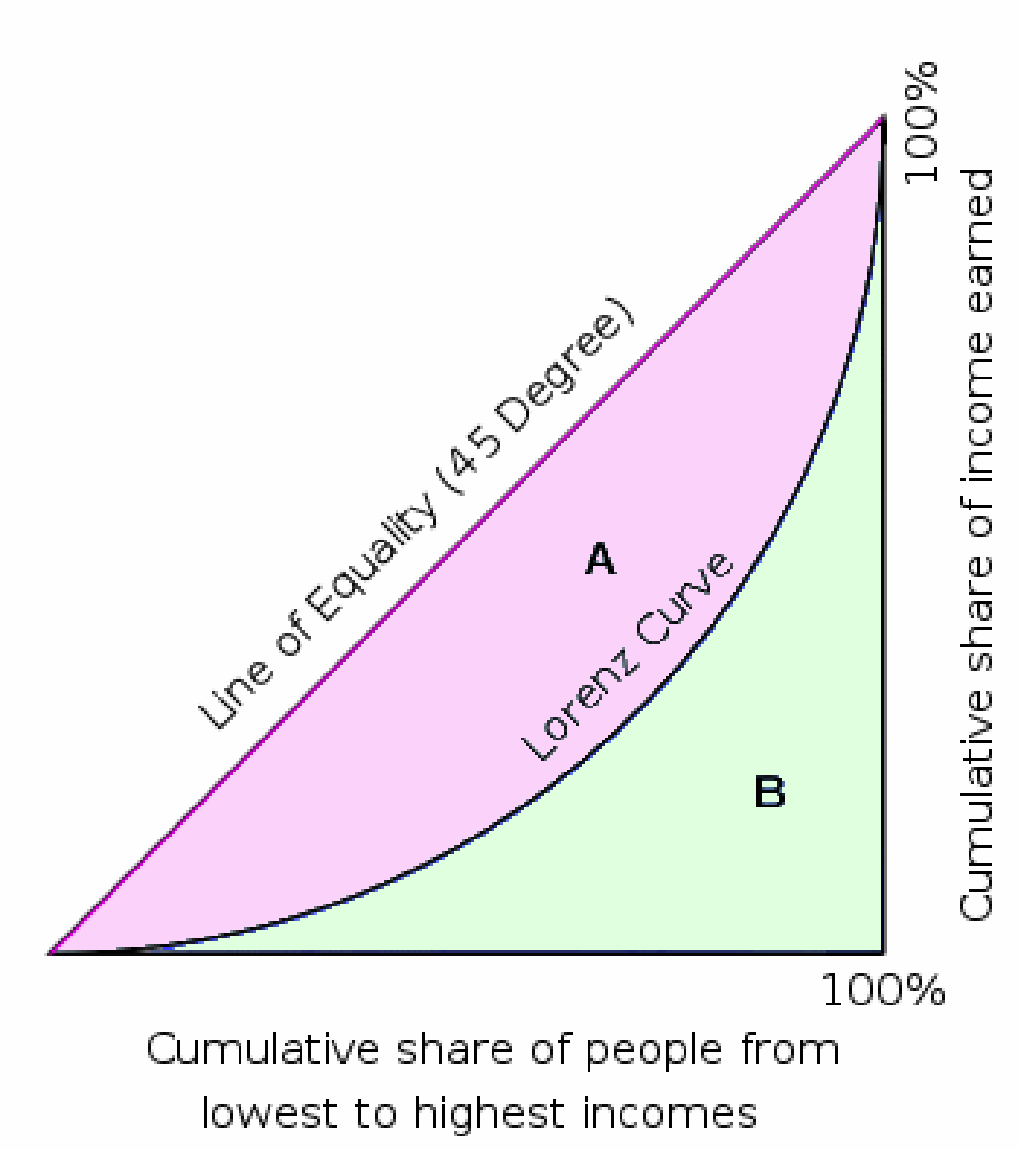
Random forest:

Relative variable importance



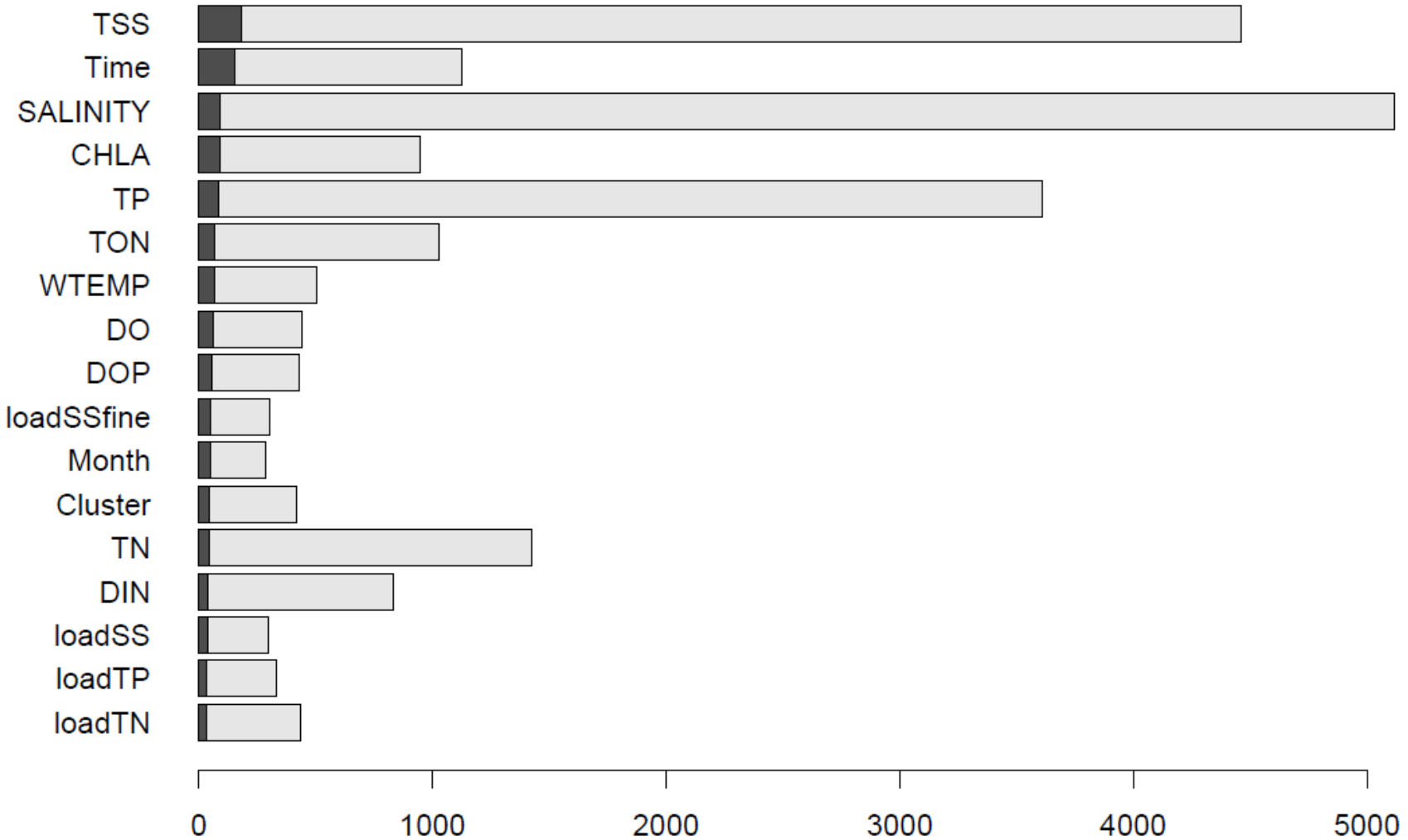


Gini coefficient = $\frac{A}{A+B}$



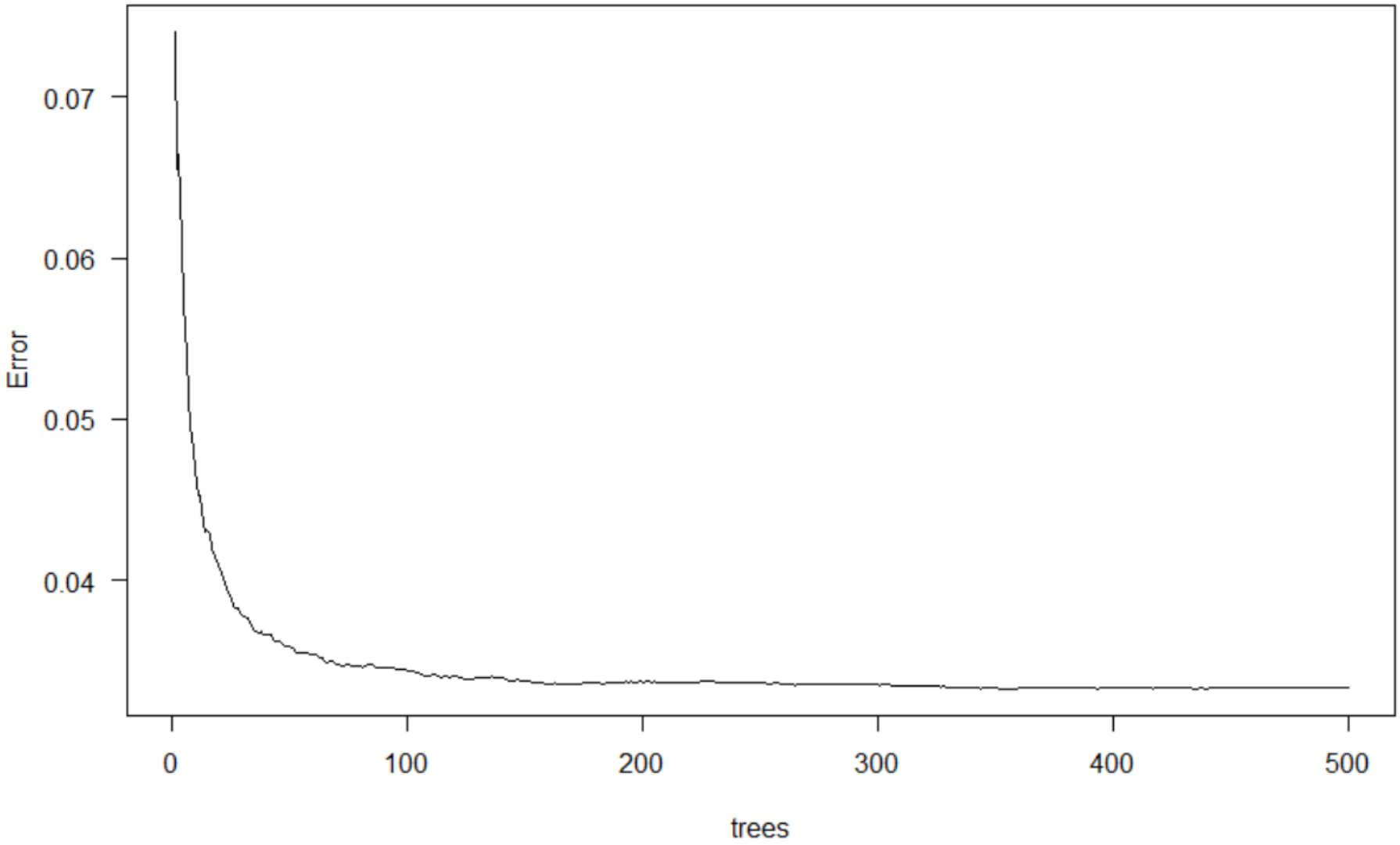
Random forest:

Relative variable importance (just different layout)



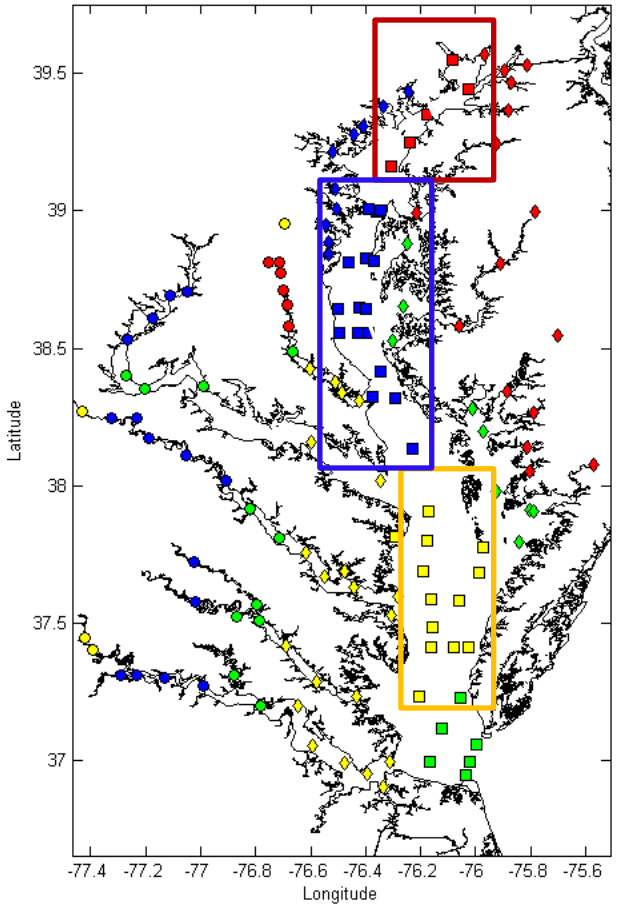
Random forest:

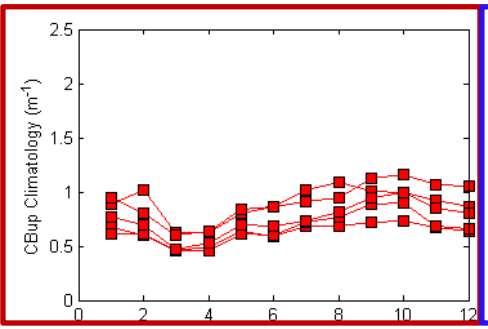
RMSE for different number of trees

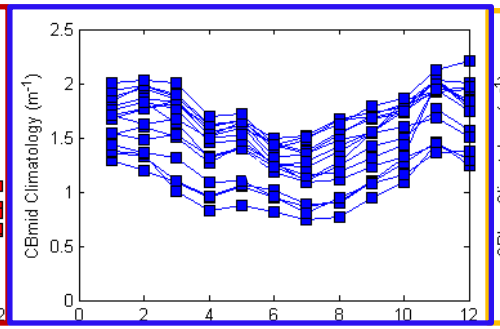


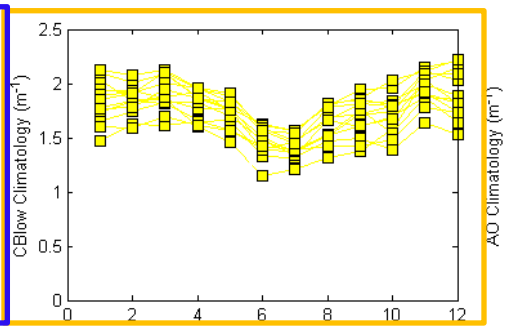
Seasonal and Spatial Dependence of Long-Term Change

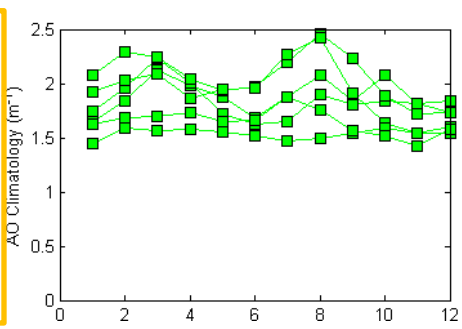
Bay Mainstem

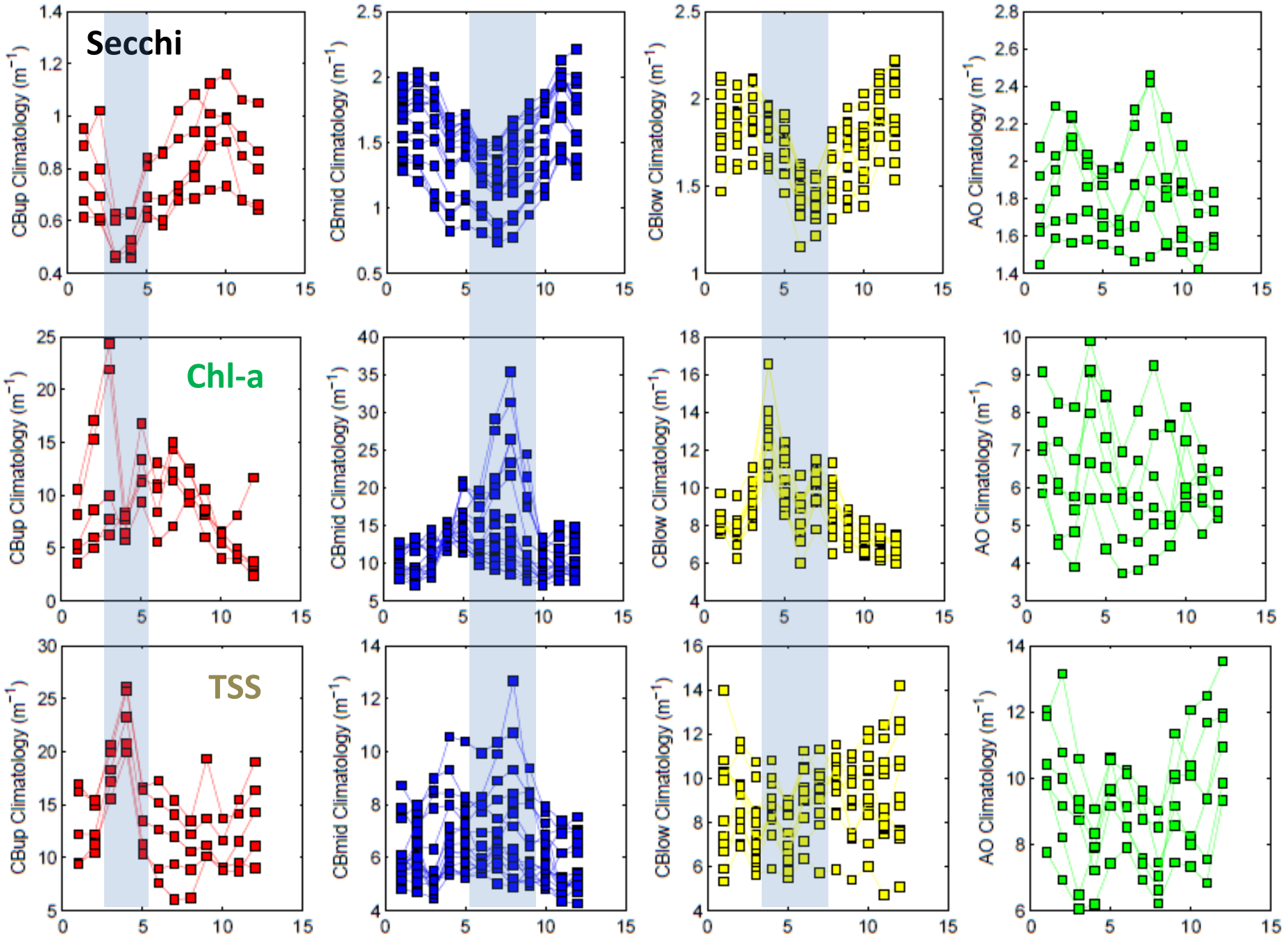




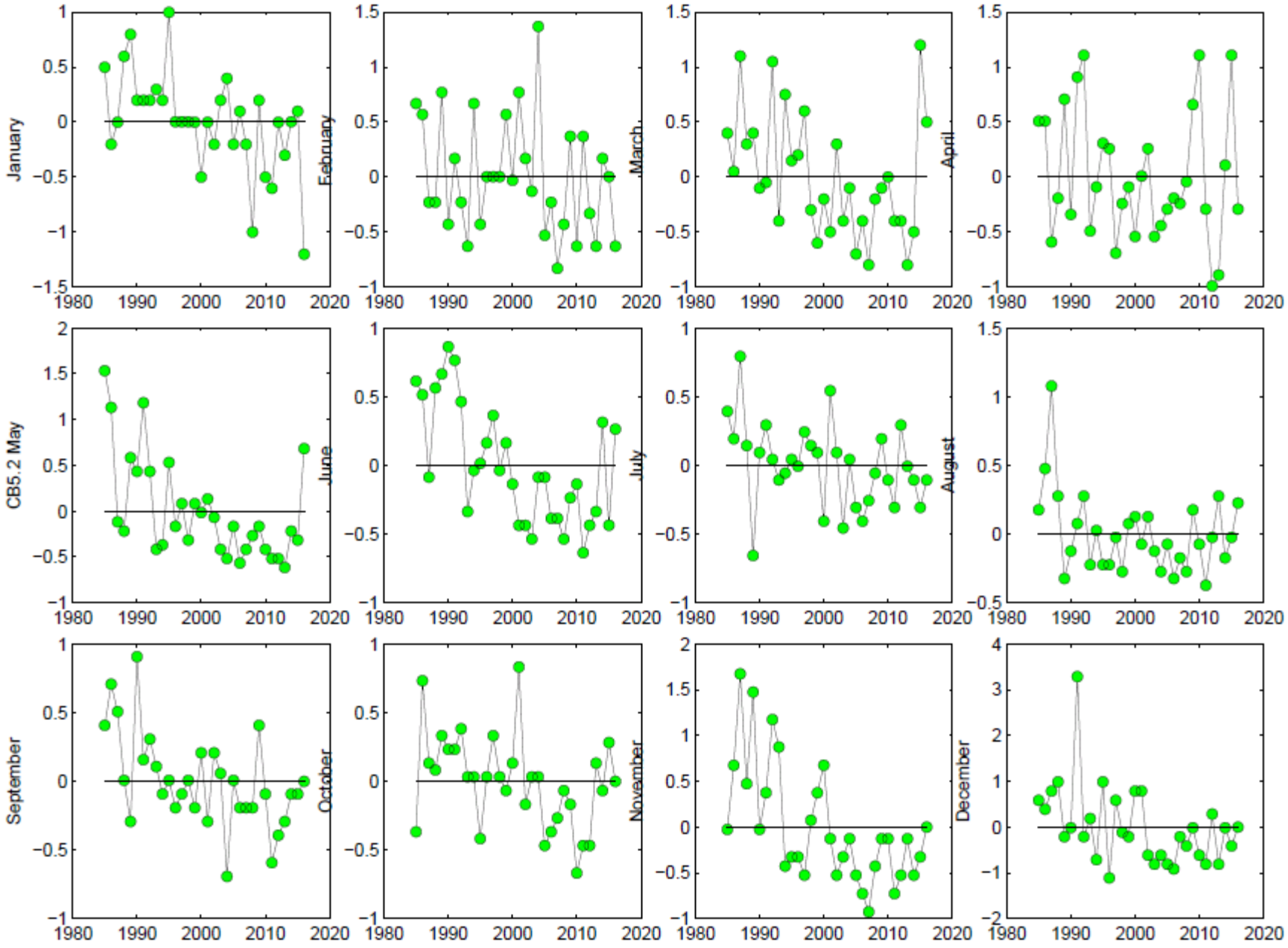




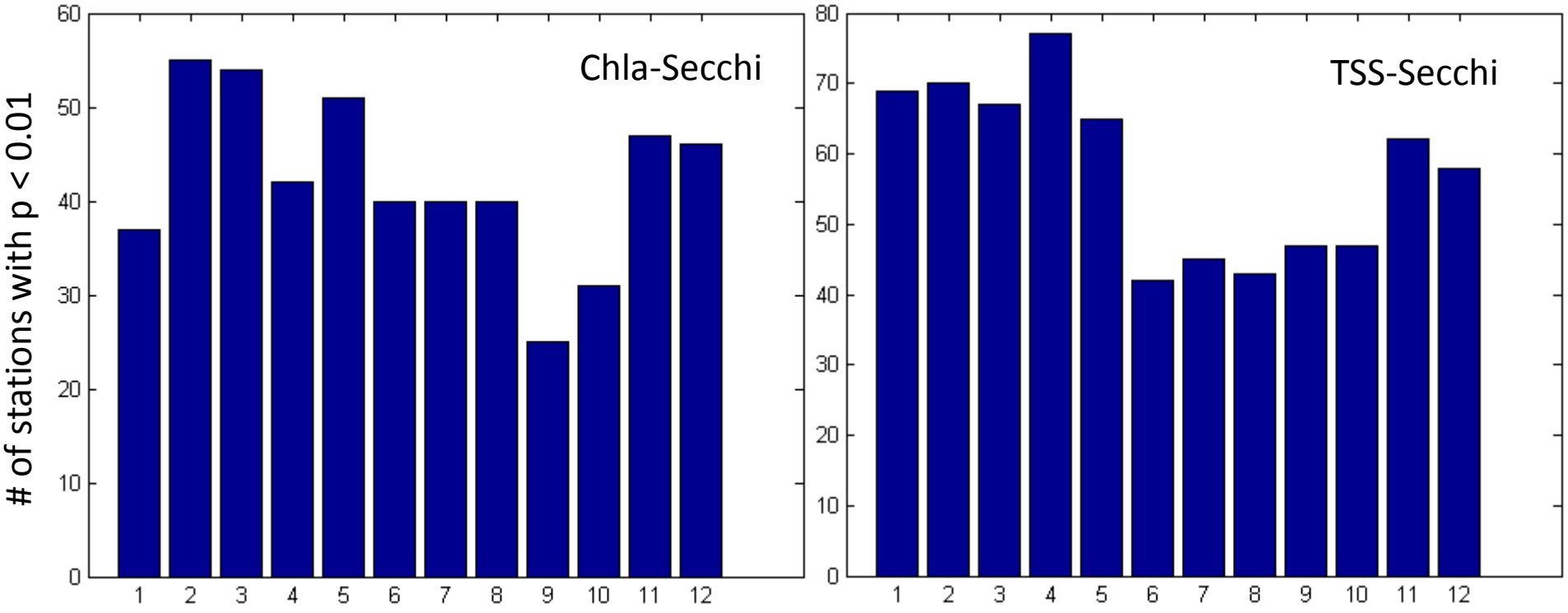



Secchi
Chl-a
TSS
CBup Climatology (m^{-1})
CBmid Climatology (m^{-1})
CBlow Climatology (m^{-1})
AO Climatology (m^{-1})

Deviation from Long-Term Mean by Month: Secchi Depth



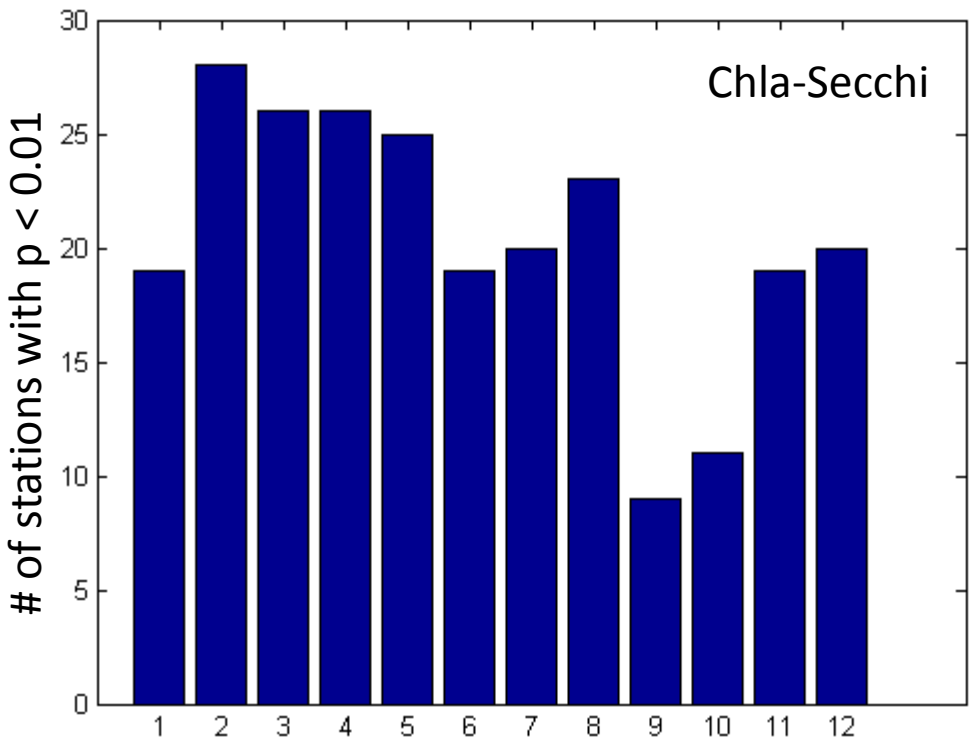
Prevalence of correlation between Secchi Depth and Chl-a/TSS deviation from long-term monthly means

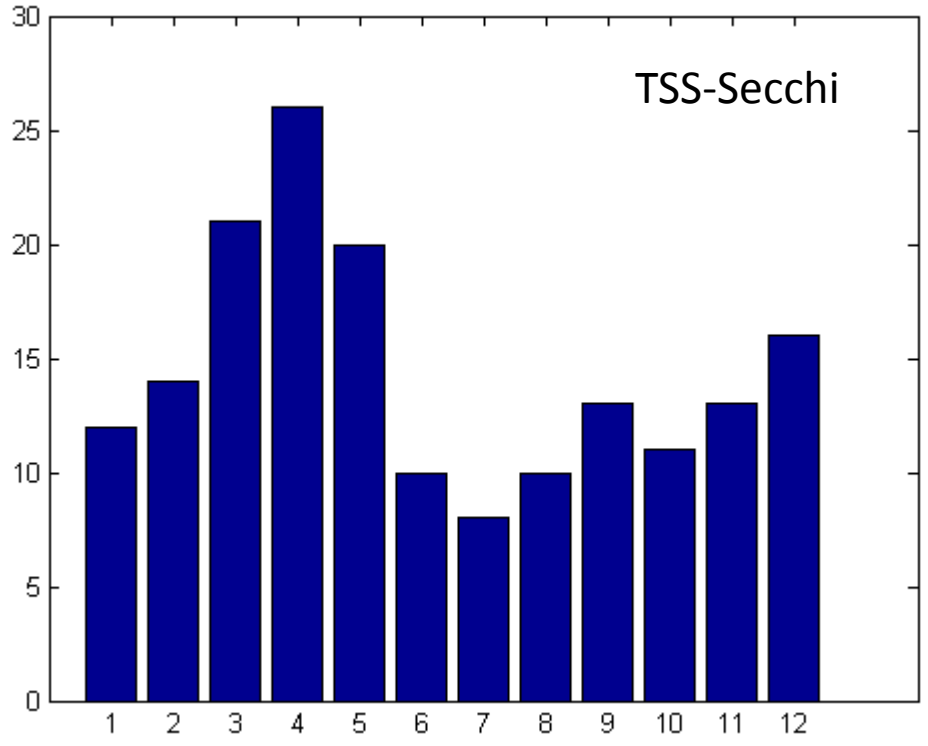


Overall, 50% of stations significant for TSS during January to May

For Chl-a, ~40% of stations significant in Feb, March, May, Nov, Dec

Prevalence of correlation between Secchi Depth and Chl-a/TSS deviation from long-term monthly means: Chesapeake Mainstem

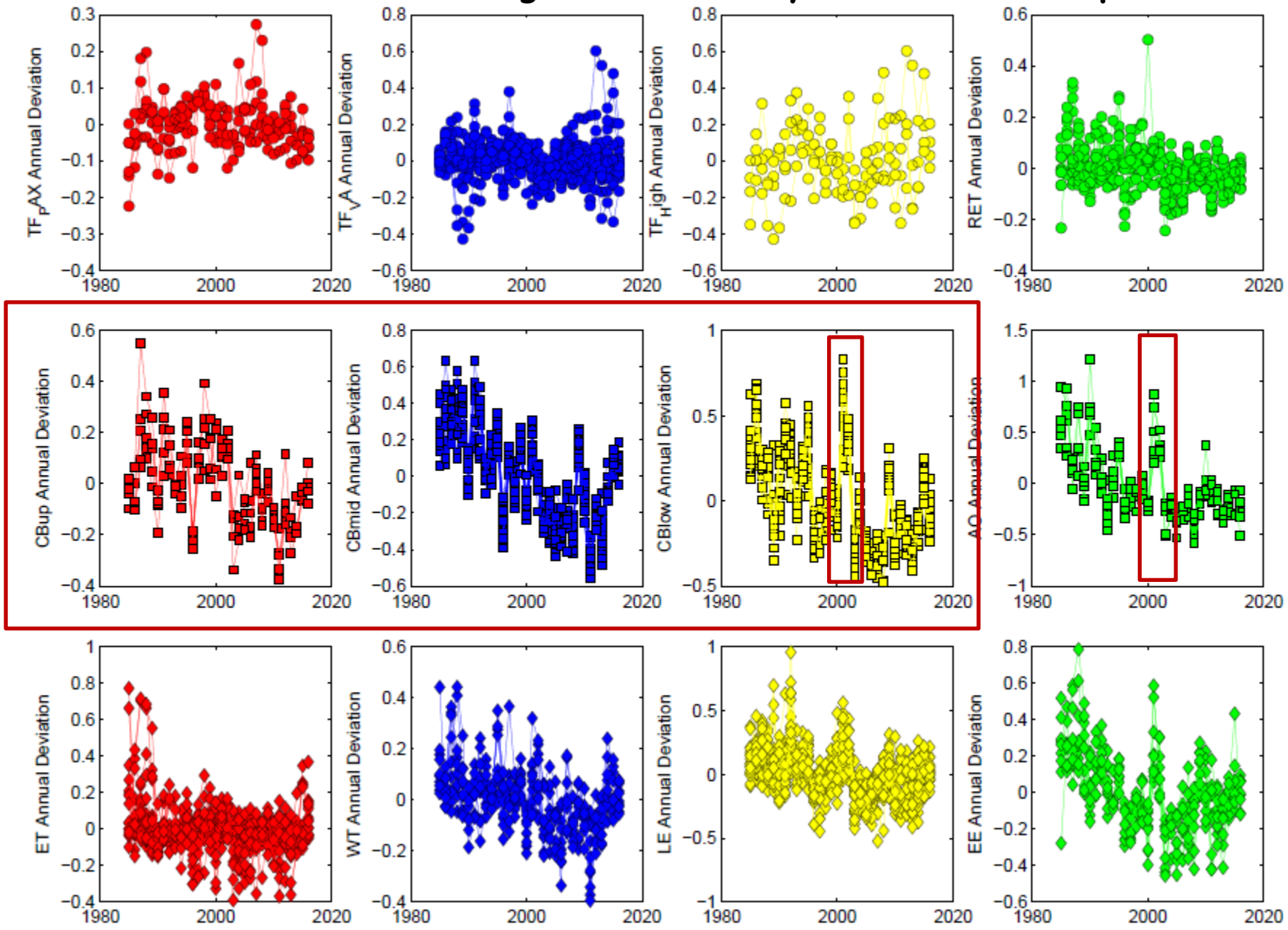


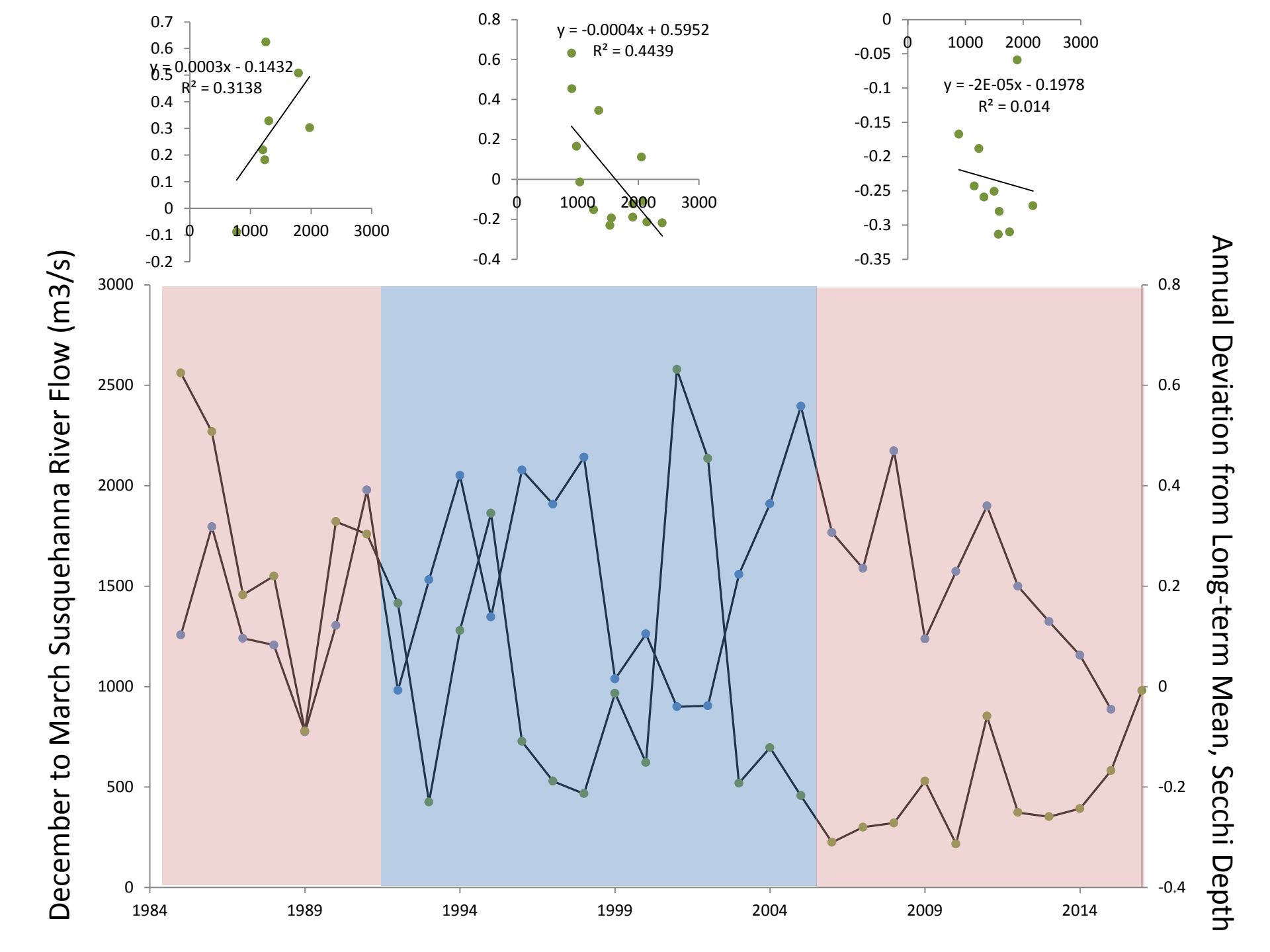


For Chl-a, 50-65% of stations significant during February to August

For TSS, ~50% of stations significant only in March to May

Deviation from Long-Term Mean by Year: Secchi Depth




y = 0.0003x - 0.1432
R² = 0.3138
y = -0.0004x + 0.5952
R² = 0.4439
y = -2E-05x - 0.1978
R² = 0.014
December to March Susquehanna River Flow (m3/s)
Annual Deviation from Long-term Mean, Secchi Depth
0
500
1000
1500
2000
2500
3000
-0.4
-0.2
0
0.2
0.4
0.6
0.8
1984
1989
1994
1999
2004
2009
2014

Continuing Thoughts

(1) Clear spatial dependence of the seasonality of Secchi
- the annual minimum can occur during winter, spring, or summer
- relationships between Chl/TSS and Secchi strongest in spring

(2) CHLA negatively correlated with Secchi in mesohaline regions, positively correlated with Secchi in turbid regions
-light limitation vs light attenuation, packaging?

(3) Overall, flow weakly correlated with Secchi, but TSS load stronger predictor, especially in ETM regions

(4) Clustering approach reveals tribs different from mainstem