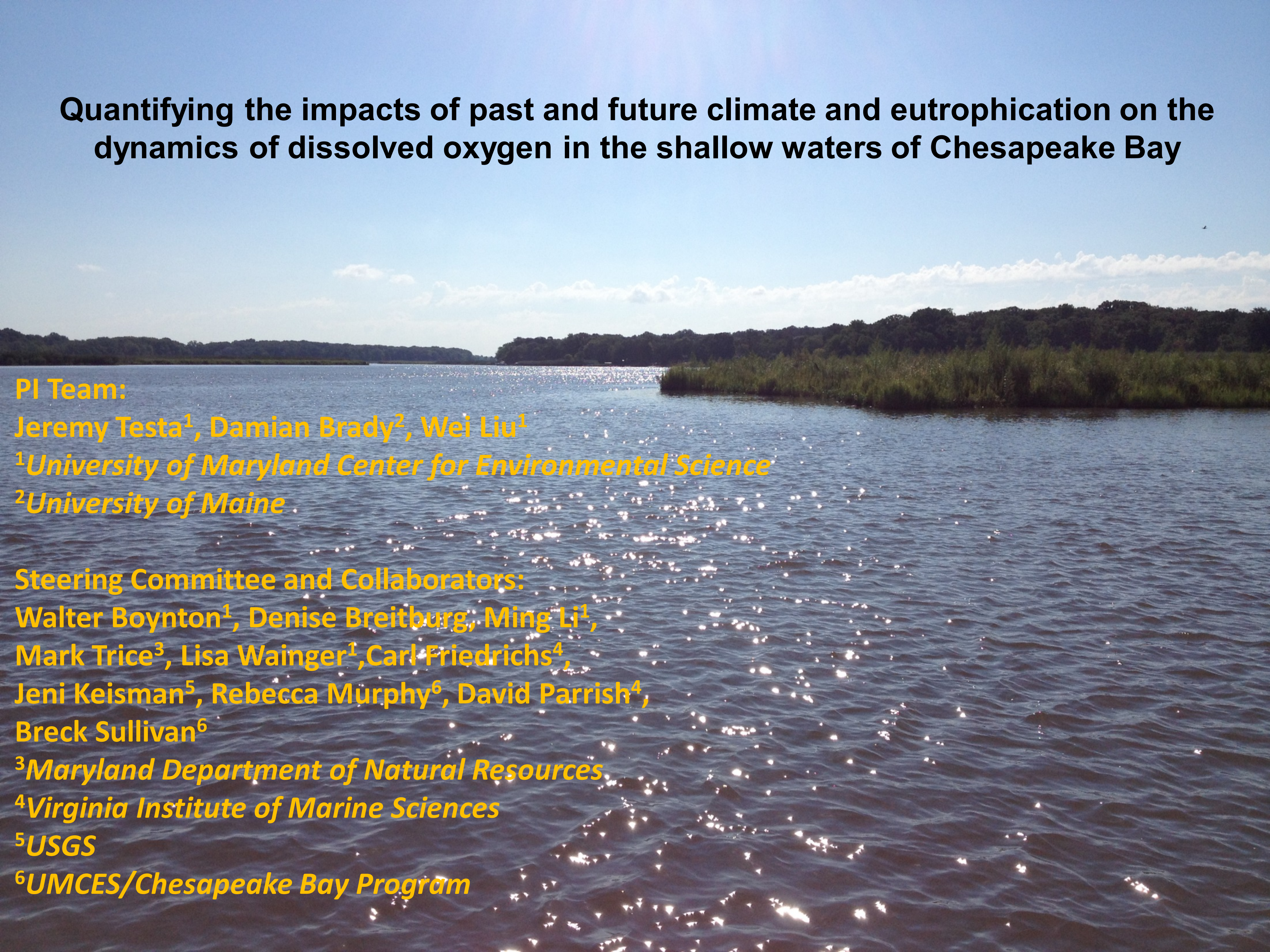

Quantifying the impacts of past and future climate and eutrophication on the dynamics of dissolved oxygen in the shallow waters of Chesapeake Bay

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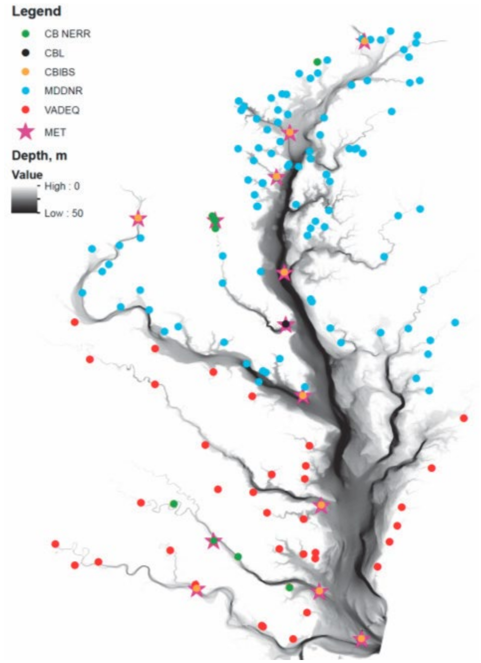
Goals

- Utilize the vast, high-frequency datasets in MD and VA for dissolved oxygen (DO) to understand controlling variables, the time-scale of control, and how controls vary over space
- Discern magnitude and spatial variation in physical influence (salinity, temperature) versus biological influence (Chl-a)
- Develop or enhance statistical and numerical models to be predictive of shallow-water DO

Schematic of Analysis Design

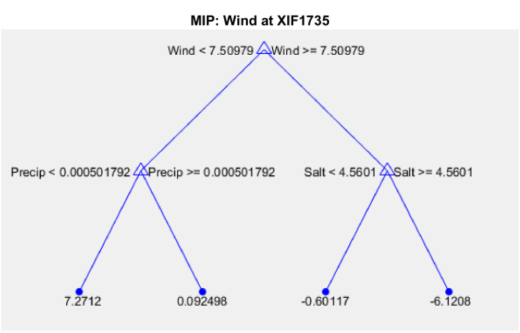
High-Frequency Oxygen Observations



Decompose tidal contribution, isolate residual (biological?) contribution

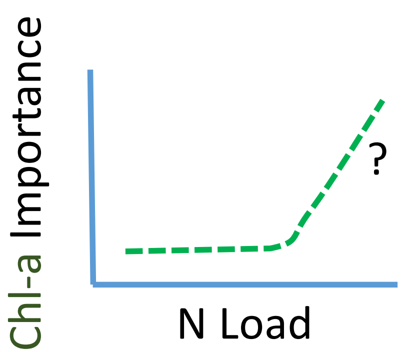
$$C_{DO}(t) = \overline{C_{DO}} + \sum_{n=1}^{N} A_n \cos(\omega_n t - \theta_n) + R(t)$$

Use CART to link control variables to non-tidal DO variations



Temp
PAR
CHL-a
Turbidity
Salinity
Precip.
Wind

Associate local conditions (load, metabolism, physical setting) with DO variation



Quantitative analysis to separate sinusoidal component from non-sinusoidal components in DO time series

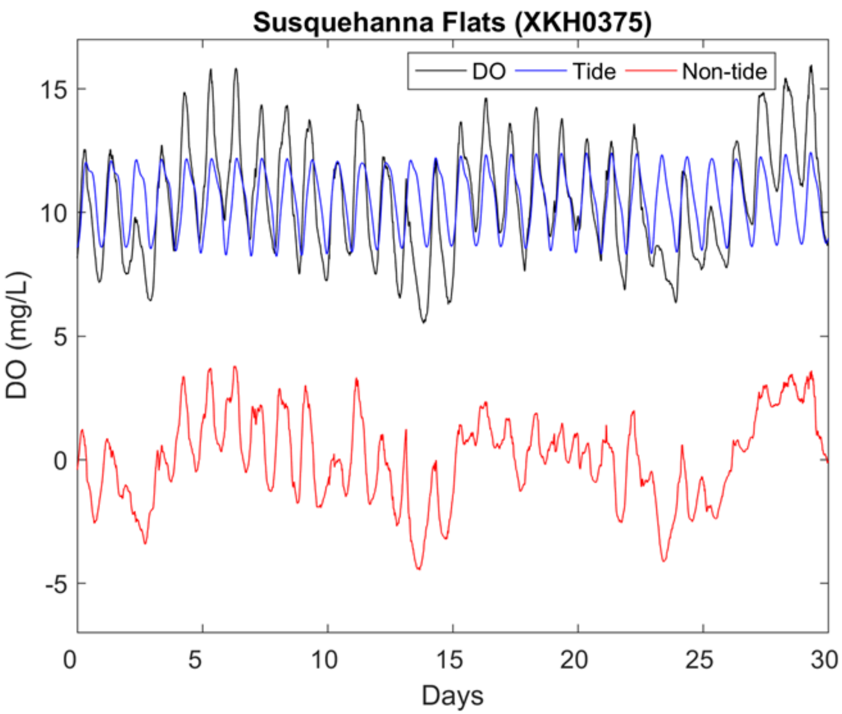
$$C_{DO}(t) = \overline{C_{DO}} + \sum_{n=1}^{N} A_n \cos(\omega_n t - \theta_n) + \boxed{R(t)}$$

“non-tidal” variations

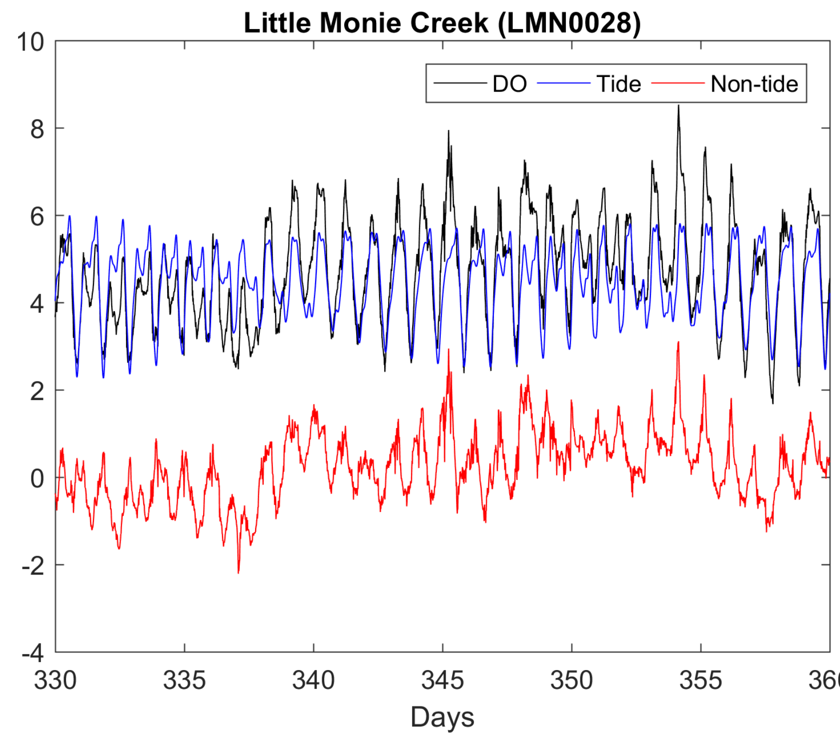
- $C_{DO}(t)$ is the concentration of DO at time t;
- $\overline{C_{DO}}$ is the mean concentration;
- $R(t)$ is non − sinusoidal residual component at time t;
- $\sum_{n=1}^{N} A_n \cos(\omega_n t - \theta_n)$ is sinusoidal part including tidal induced DO variation for a total of N tidal constituents;
- A_n is the amplitude of DO variation due to nth tidal constituent with a frequency of ω_n and a phase of θ_n.
- Least squares method is used for solving this equation. 35 tidal constituents and their frequencies are considered in solving this equation

(Solved with windows of 1, 7, 14, 30 and 90 days)

DO time series decomposed into tidal and non-tidal components



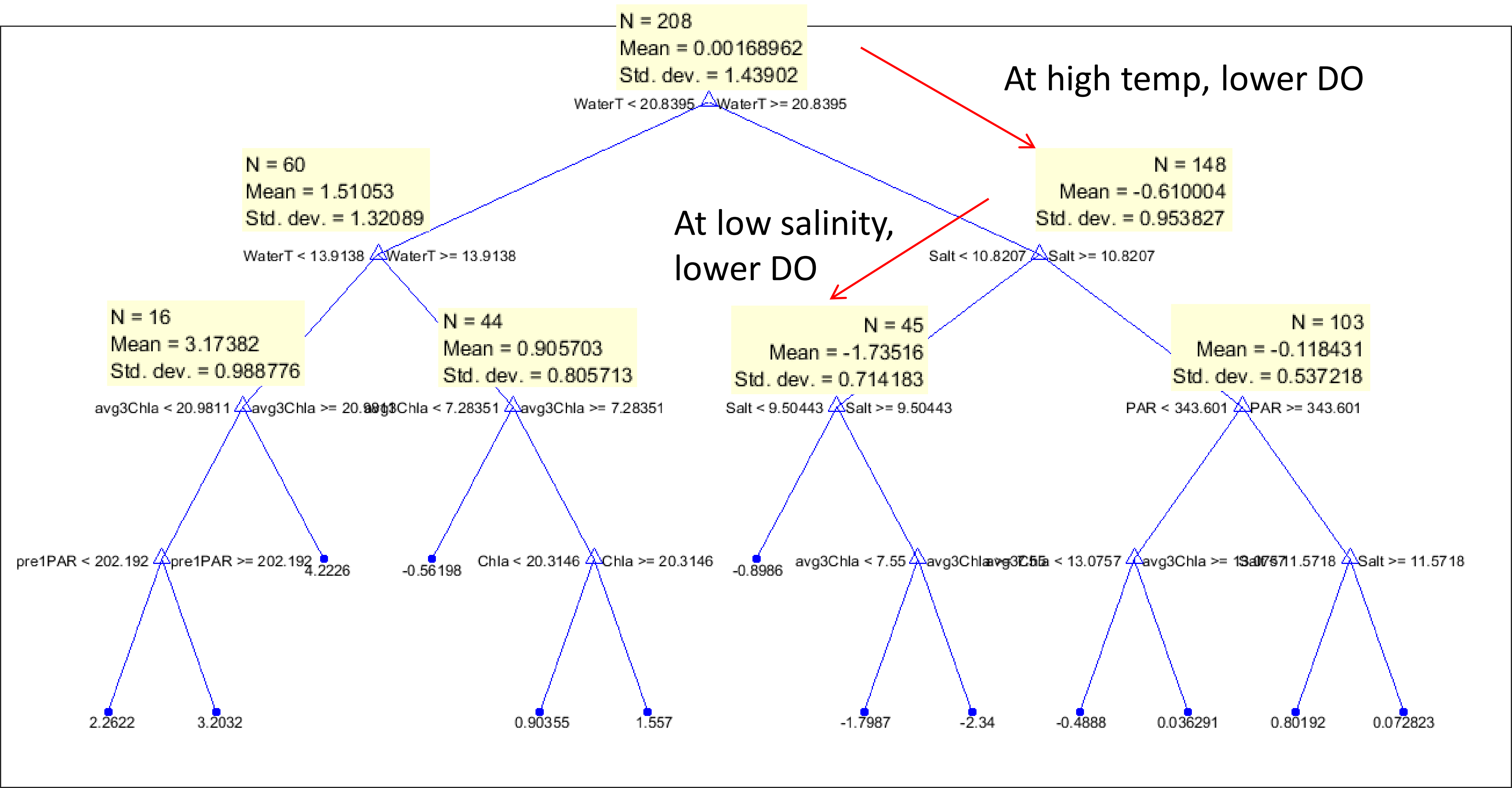
Tidal = 39%, 61% non-tidal



Tidal = 58%, 42% non-tidal

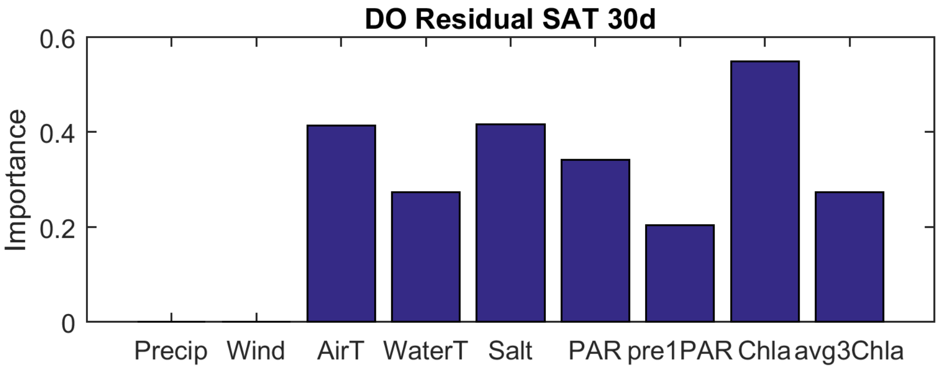
CART to Discern Key Variables Driving Residual DO

Example: Regression Tree for ***DO residual*** (mg/L) at Little Monie Creek

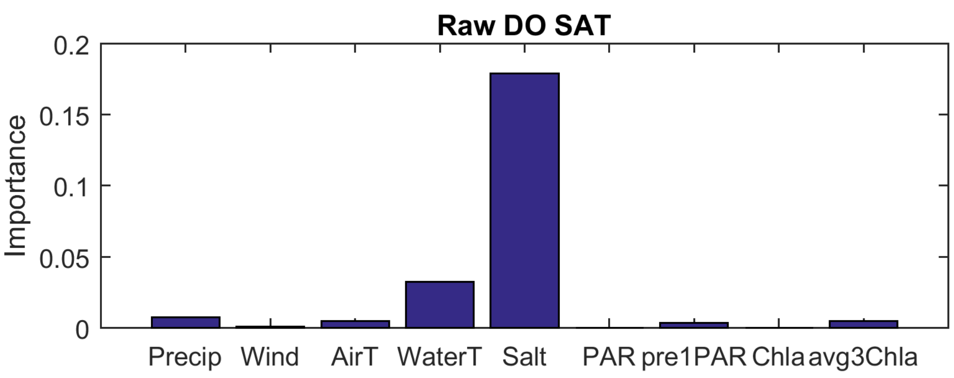


"Importance" of CART Variable Alters with Removal of Tidal Variations

Little Monie Creek

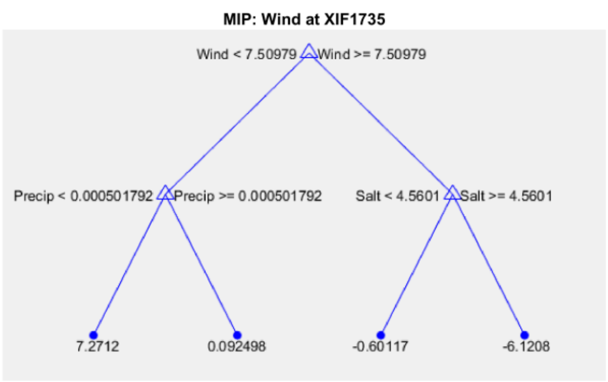


For ***residual*** data, **multiple variables** emerge, including chlorophyll-a

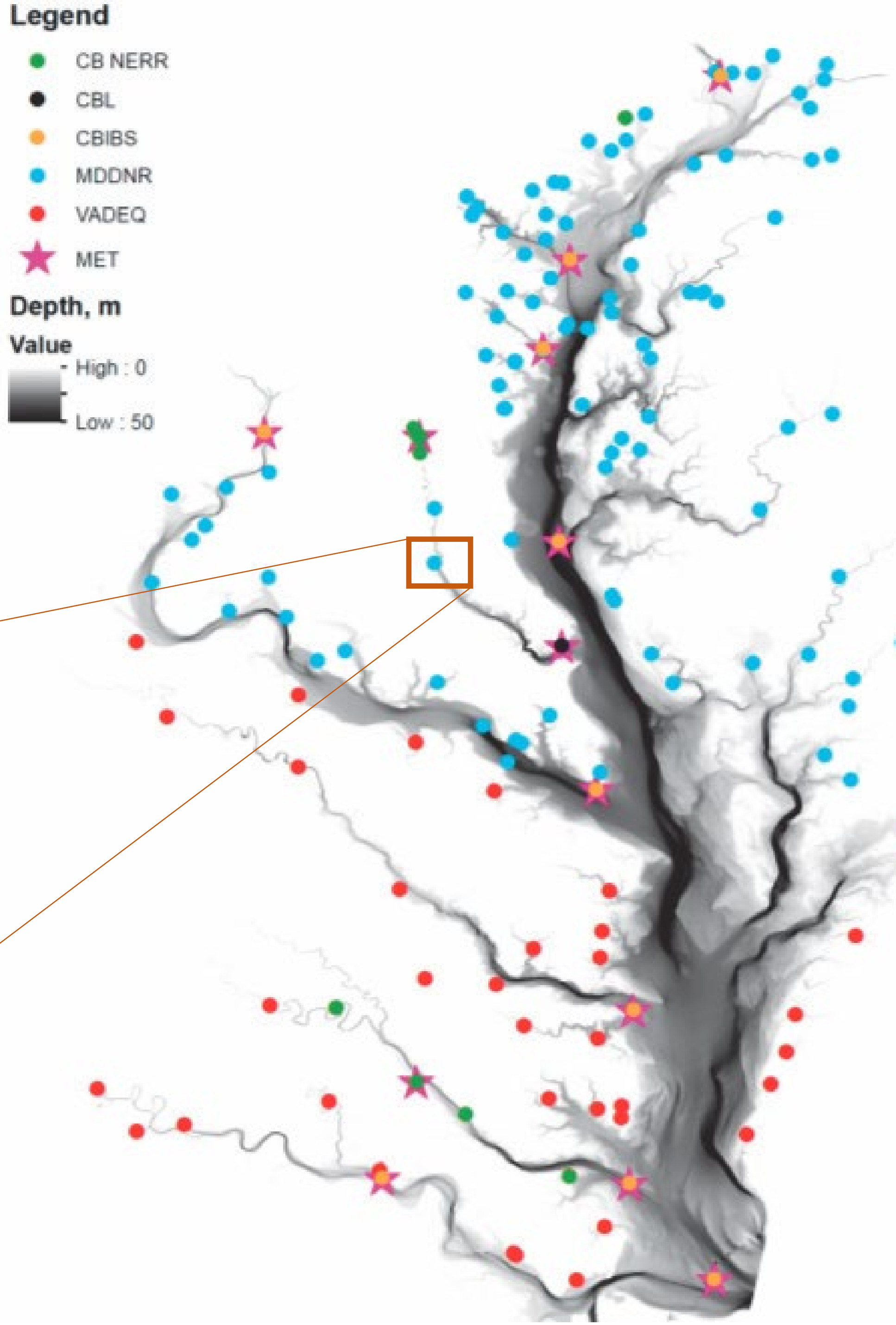


For ***raw*** data, salinity variations dominate = **tidal variations key**

Application of CART Across Stations

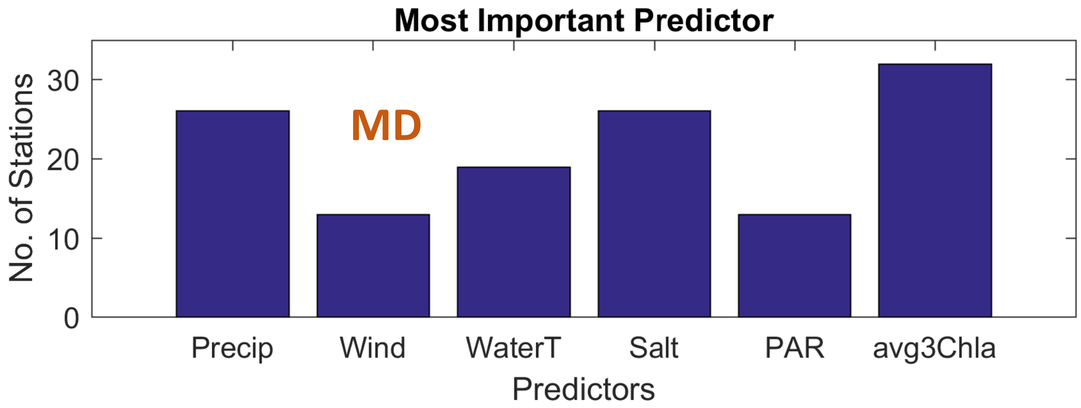


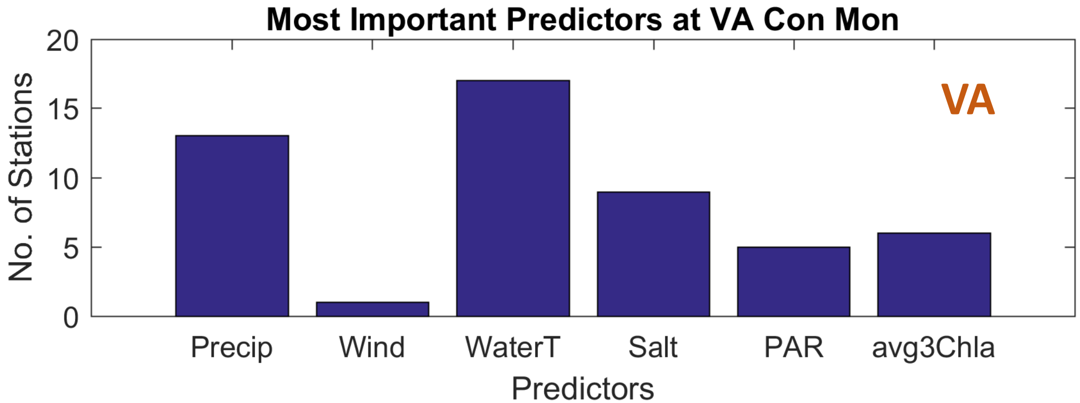
Temp
PAR
CHL-a
Turbidity
Salinity
Precip.
Wind



CART Applied Across all Chesapeake ConMon Stations

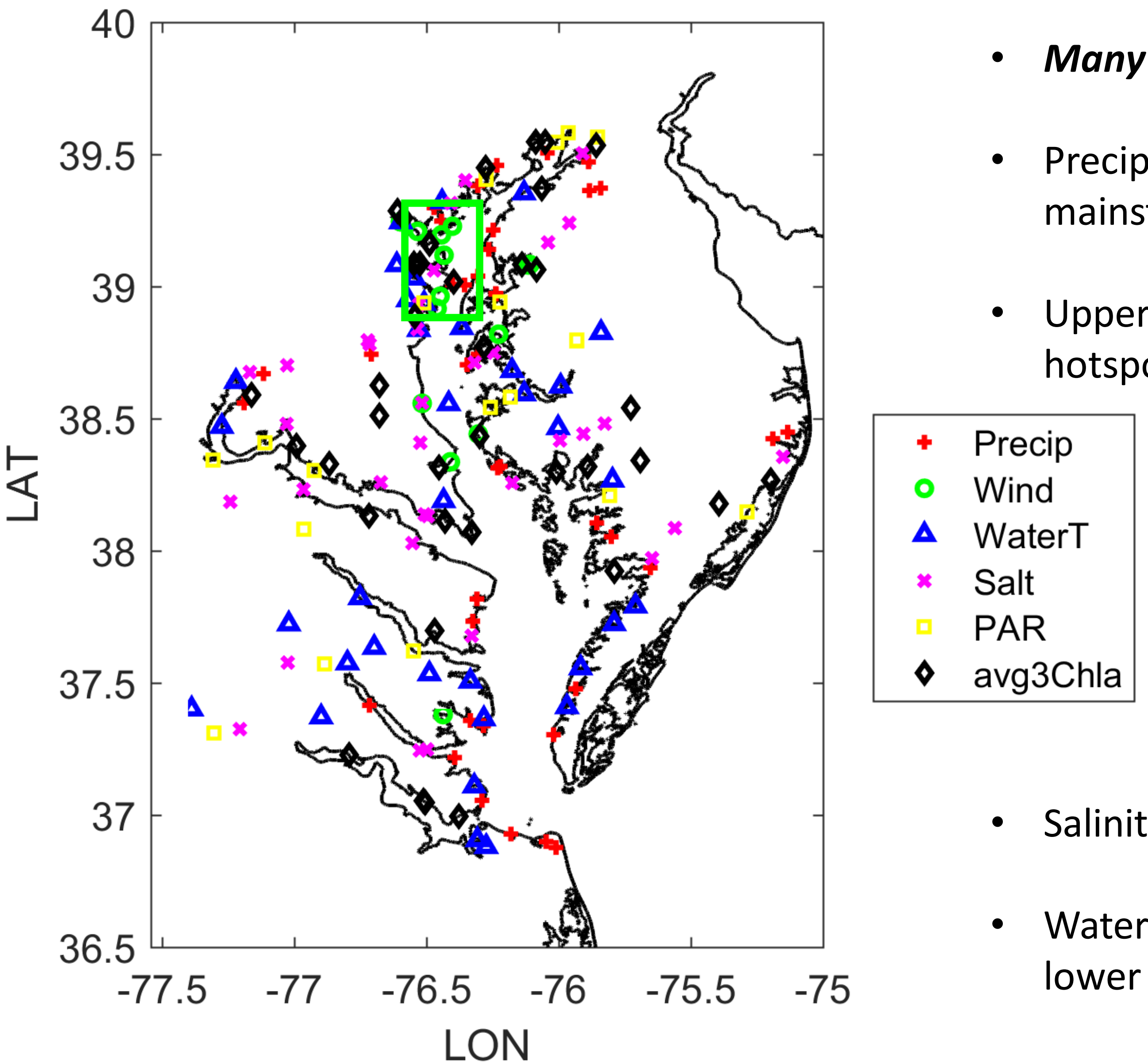
Cross-station CART analysis: DO-SAT Residual (%)





- CART applied to the entire multi-year time series of DO and predictors to identify the most important predictors at each site

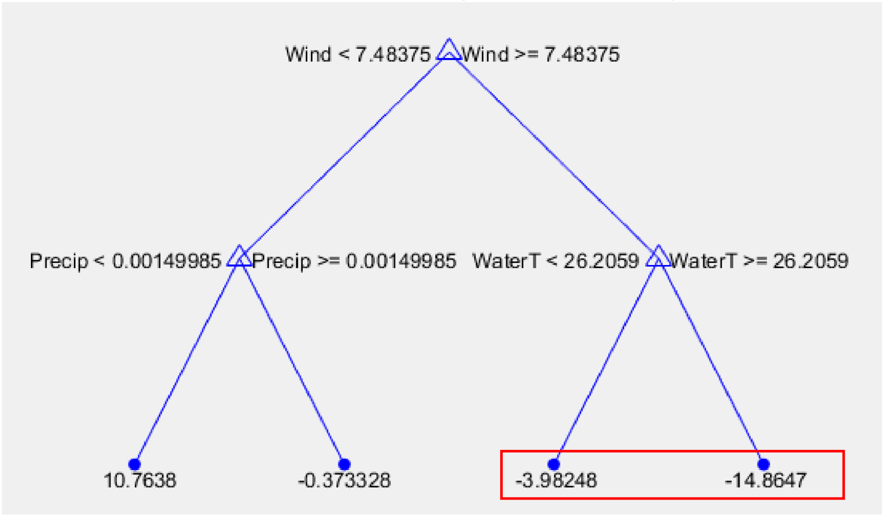
Most important predictors for DO-SAT residual (%)



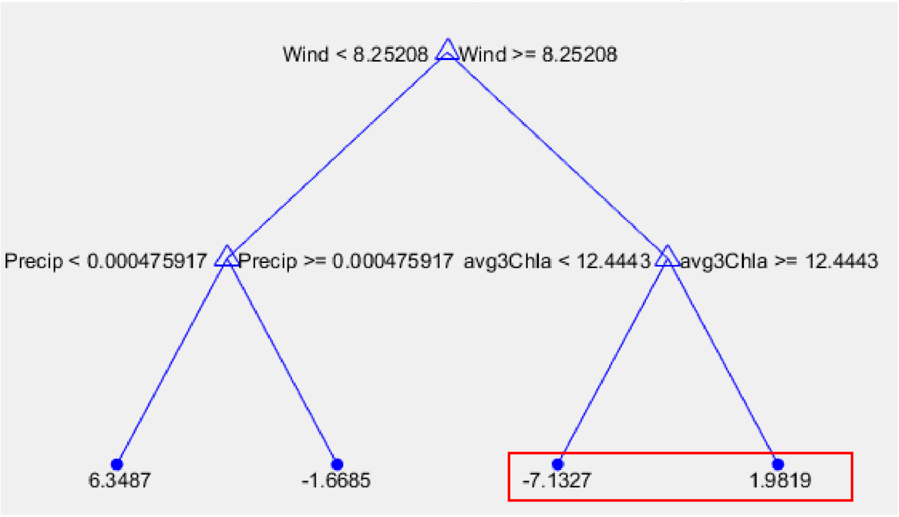
- ***Many Variables Important***
- Precipitation is important along mainstem fringe
- Upper-western shore wind hotspot
- Salinity key within the tributaries
- Water Temp. is predominant in lower bay

Example Trees Where Wind is the MIP
Vicinity of Patapsco, Annapolis

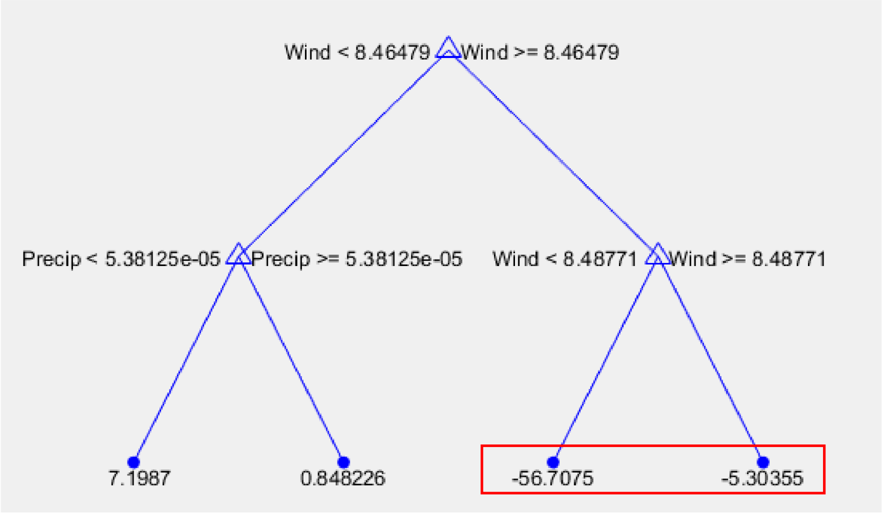
MIP: Wind at XHF6841 (2009-2010.54-2011)



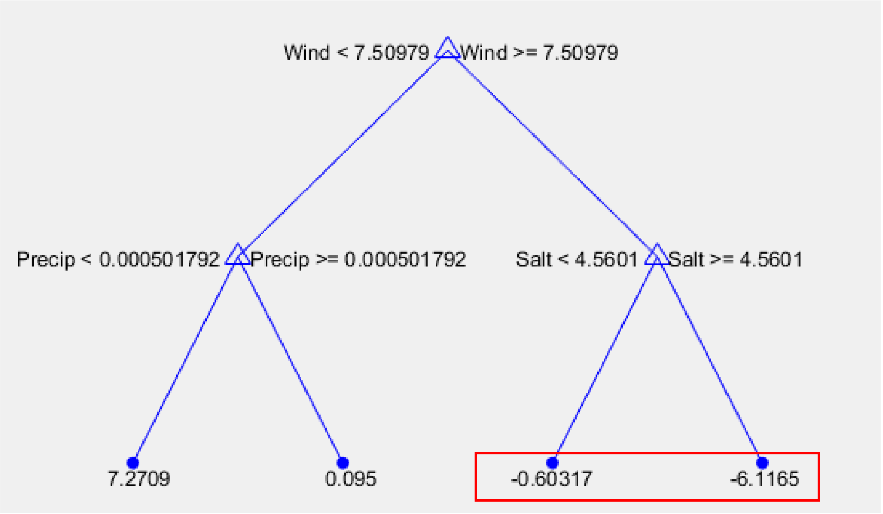
MIP: Wind at XGF7832 (2011-2012.04-2012)



MIP: Wind at XGF5025 (2017-2018.04-2018)

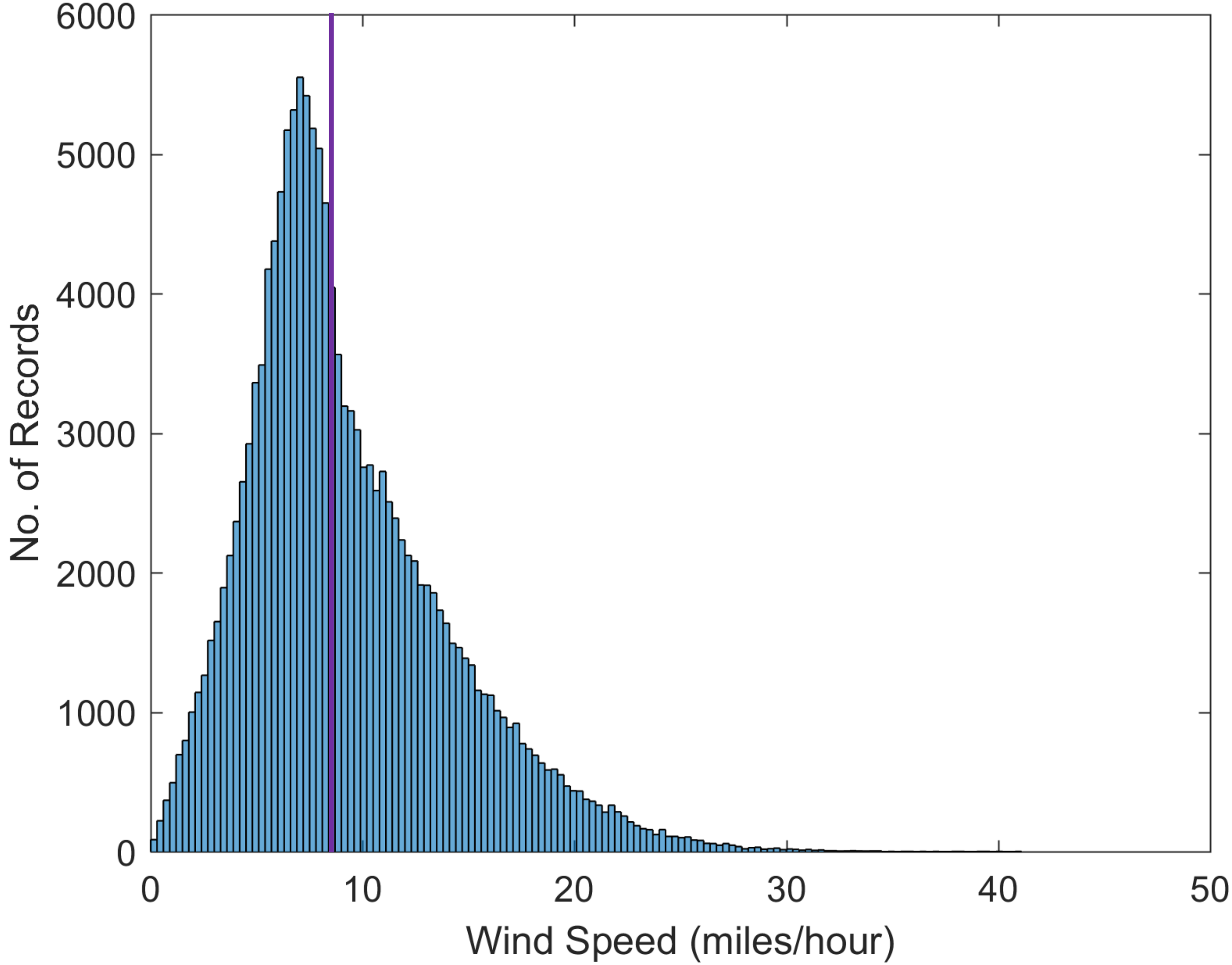


MIP: Wind at XIF1735 (2009-2010.54-2011)

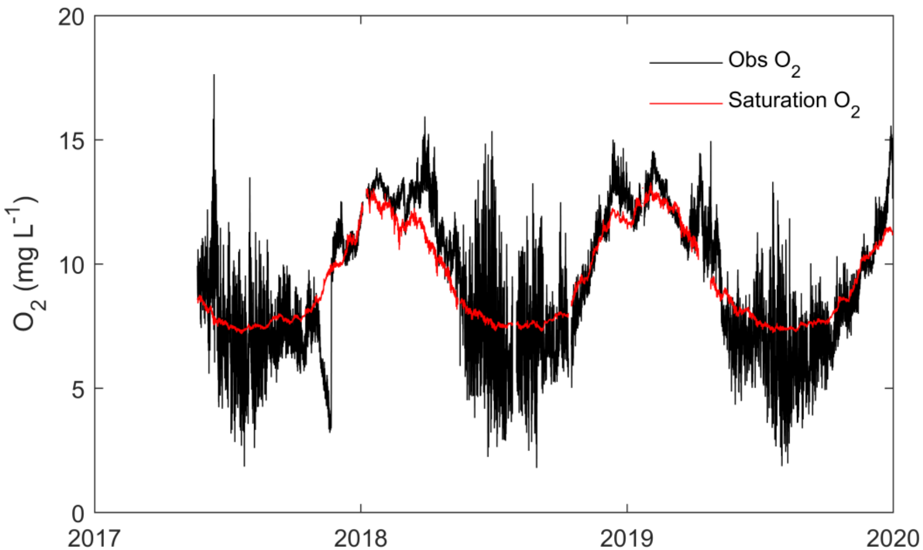


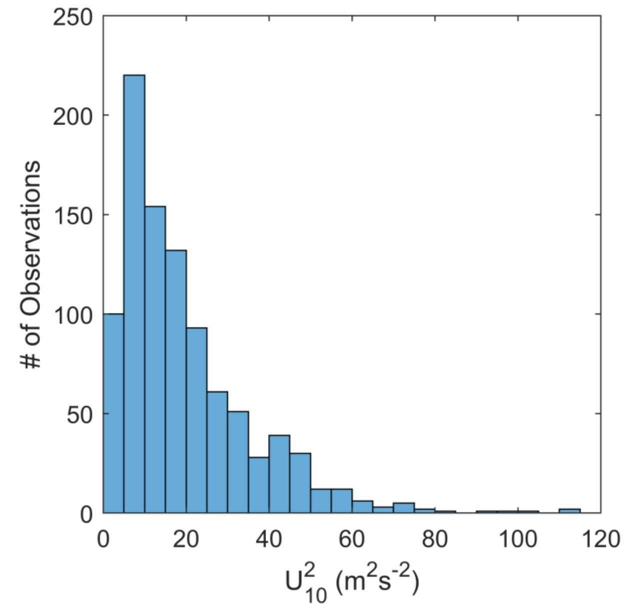
Lower Residuals (lower DO) with high winds

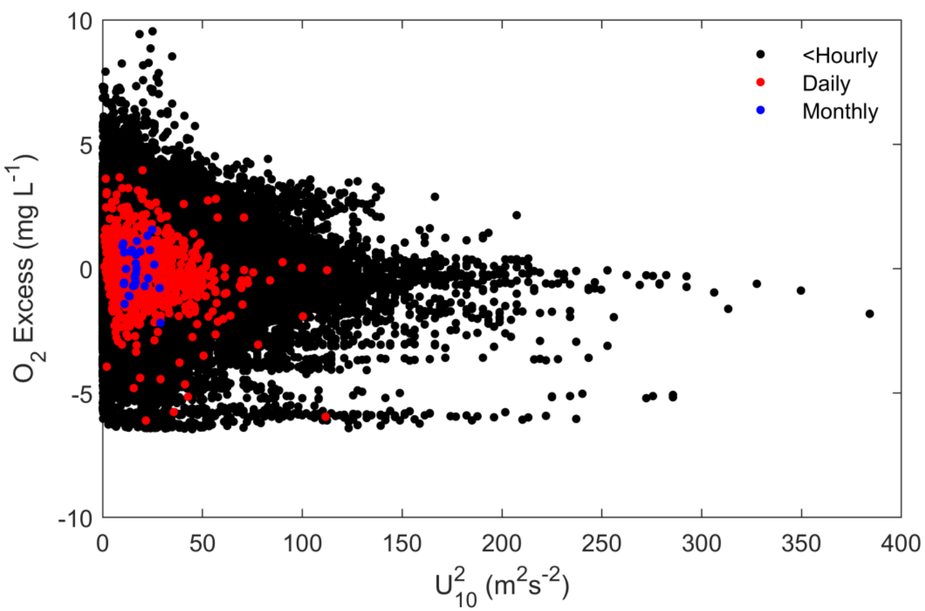
Histogram of Wind Speed Across Time-Series

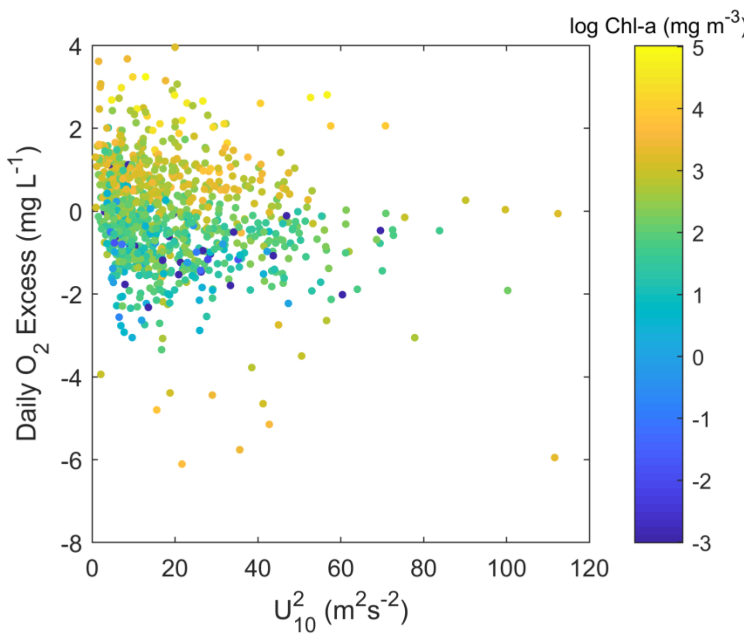


Wind-Chlorophyll-a Interactions: CBL Pier

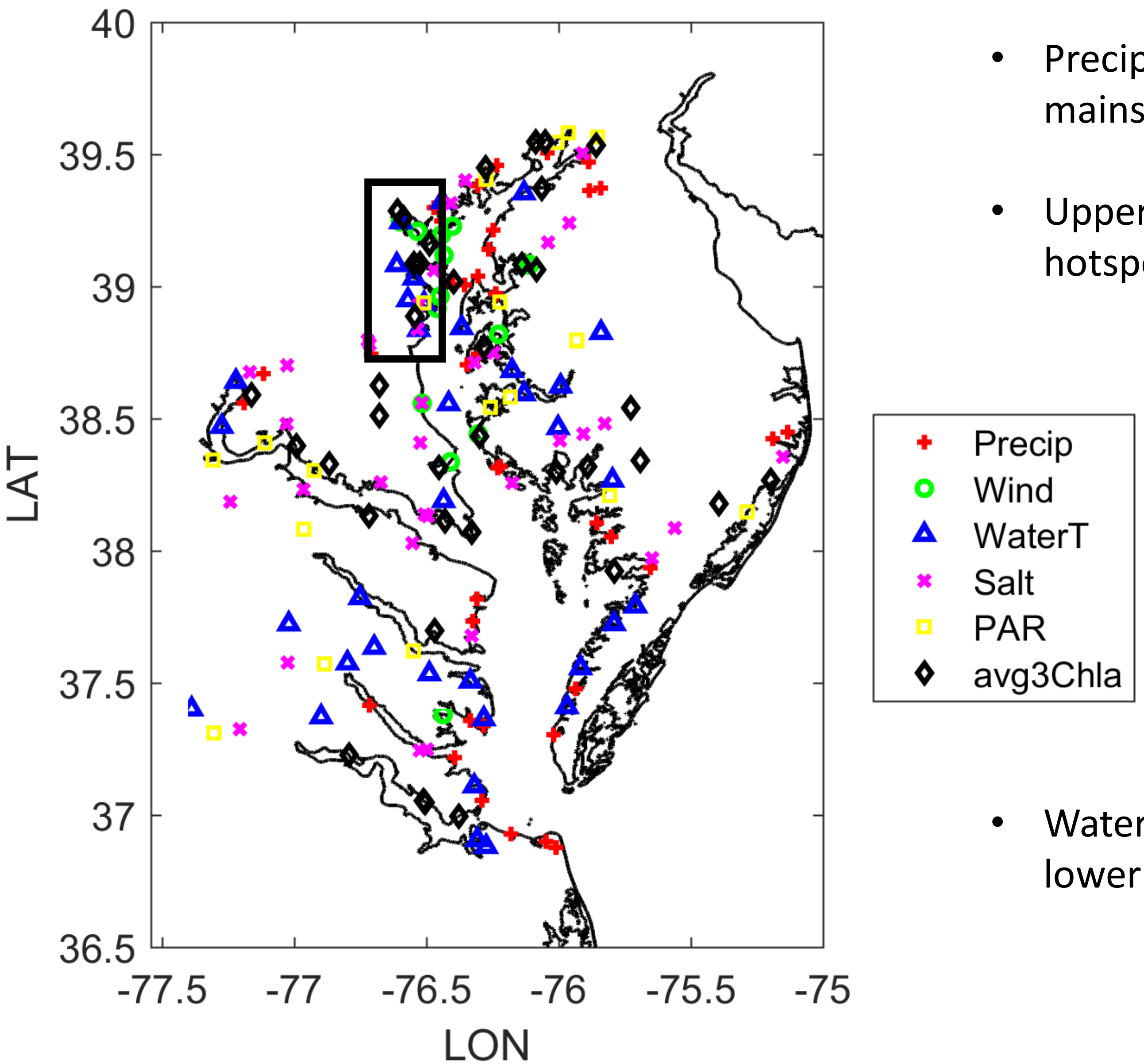








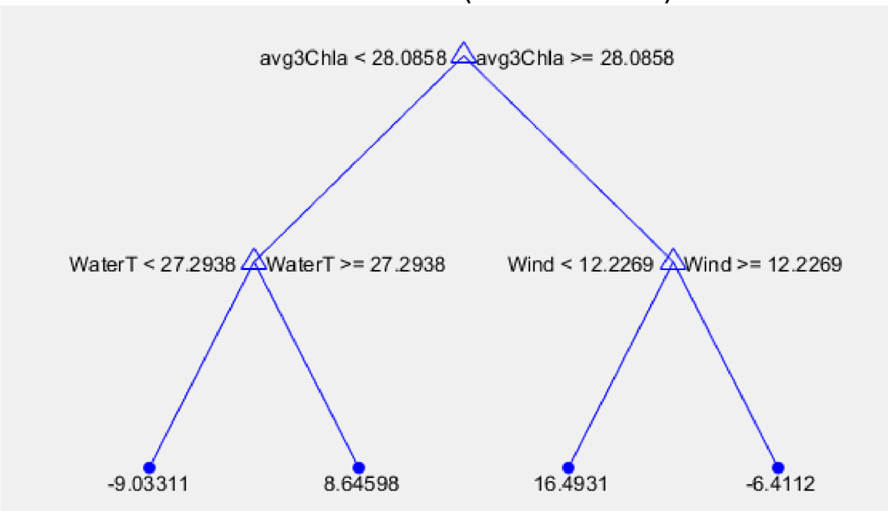
Most important predictors for DO-SAT residual (%)



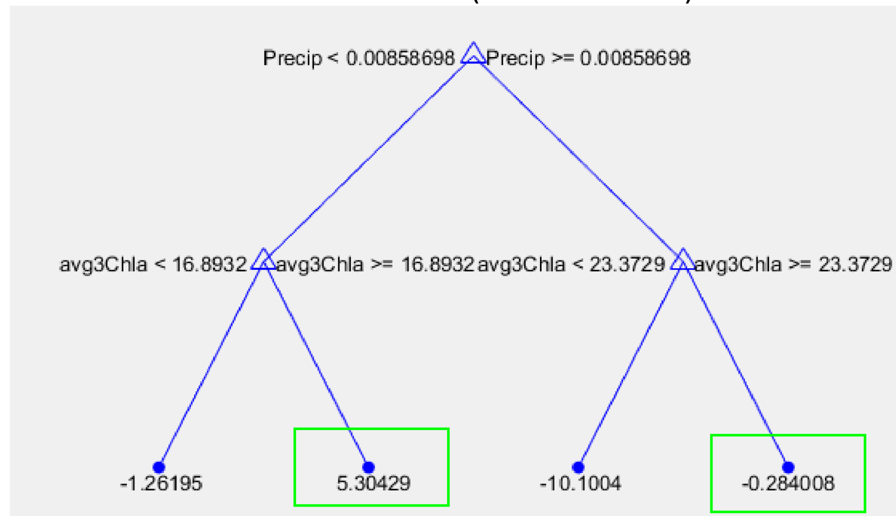
- Precipitation is important along mainstem fringe
- Upper-western shore wind hotspot
- Water Temp. is predominant in lower bay.

Example Trees Where Chl-a is the MIP

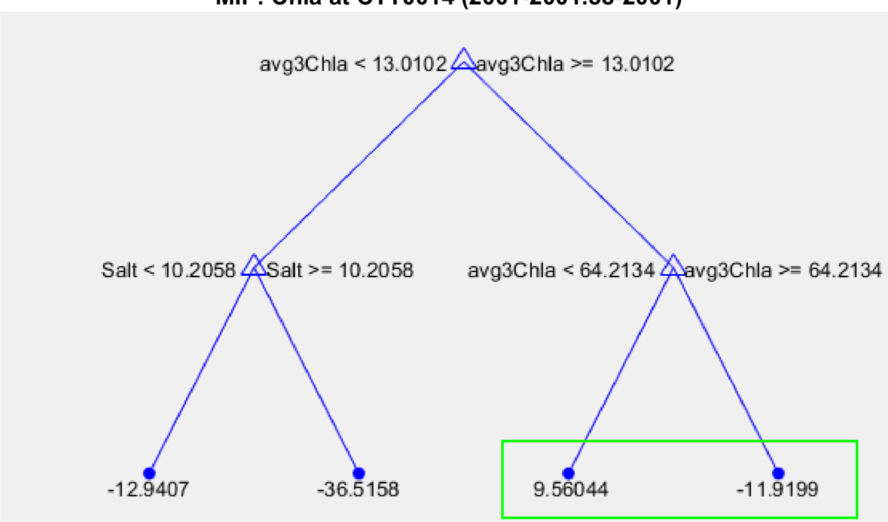
MIP: Chla at XIE7135 (2016-2017.6-2018)



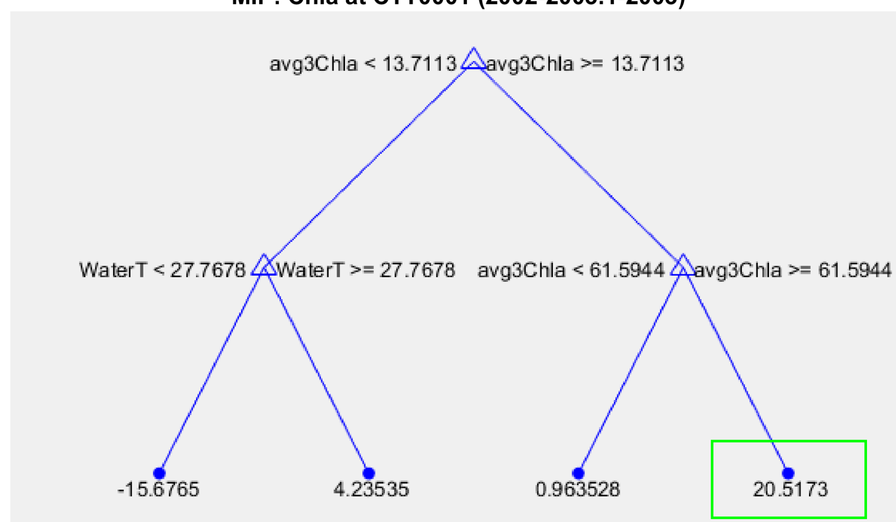
MIP: Chla at XHF9808 (2009-2010.54-2011)



MIP: Chla at CTT0014 (2001-2001.58-2001)



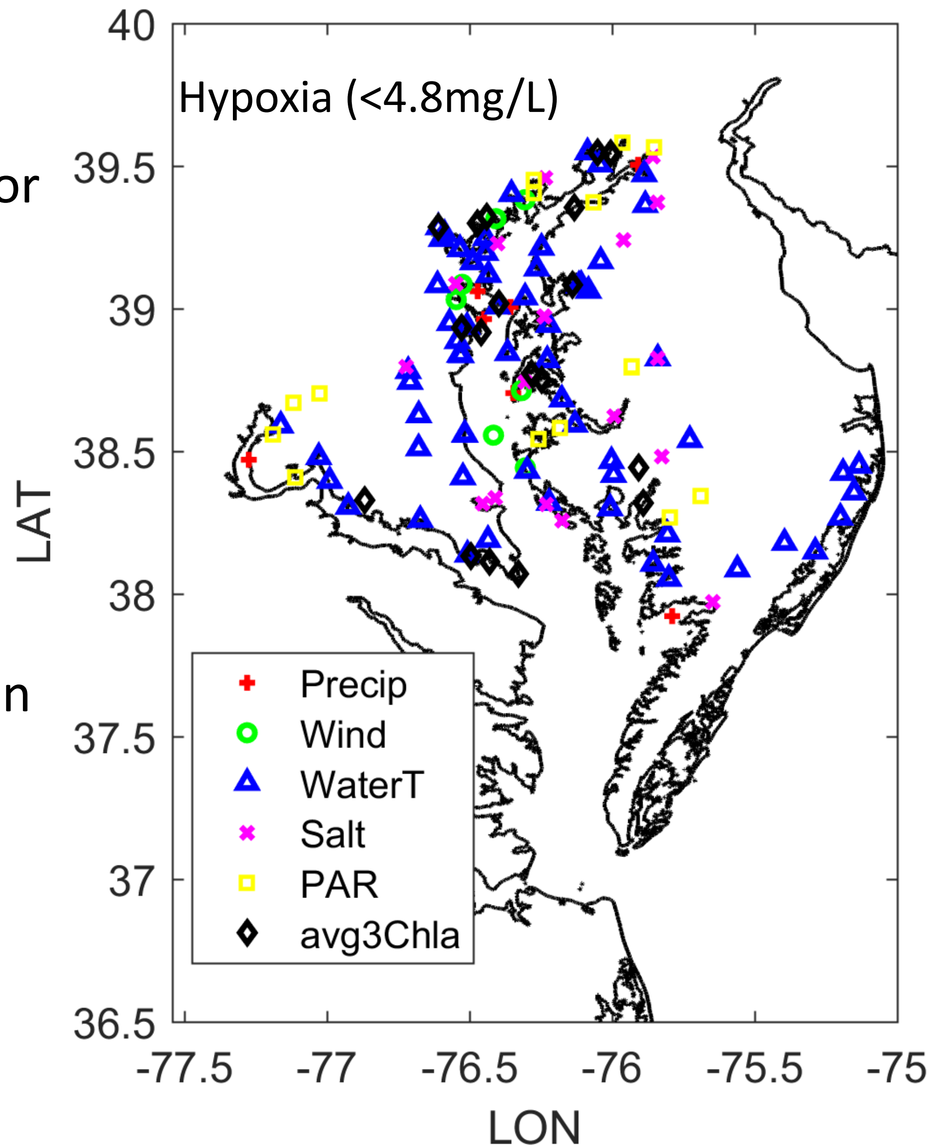
MIP: Chla at CTT0001 (2002-2003.1-2003)



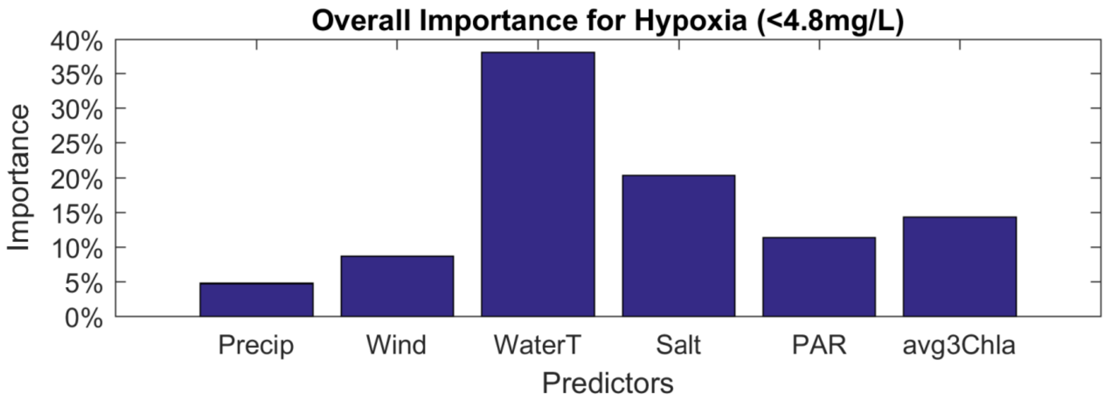
Higher Residuals (higher DO) with high chlorophyll-a

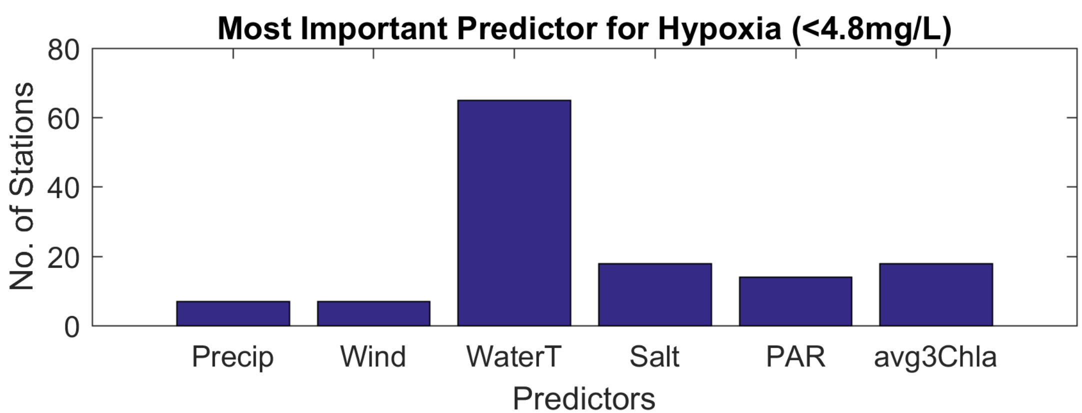
Most important predictors for duration of 'hypoxia'

- PAR is an important predictor in upper Bay/trib sites
- Water Temp. is dominant in controlling DO across all stations;
- Wind is important in the open bay.



Cross-station CART analysis: Hypoxia





Conclusions and Next Steps:

(1) CART suggests that there are many variables that can control oxygen variability, some emerging patterns. Chl-a and temperature are key drivers (also precipitation)

(2) Temperature is a key driver of hypoxia, pushes extremes >24 deg C

(3) Next steps – associate important variables with station-specific variables, such as nutrient load/concentration, salinity, depth, etc.

Questions or Comments?