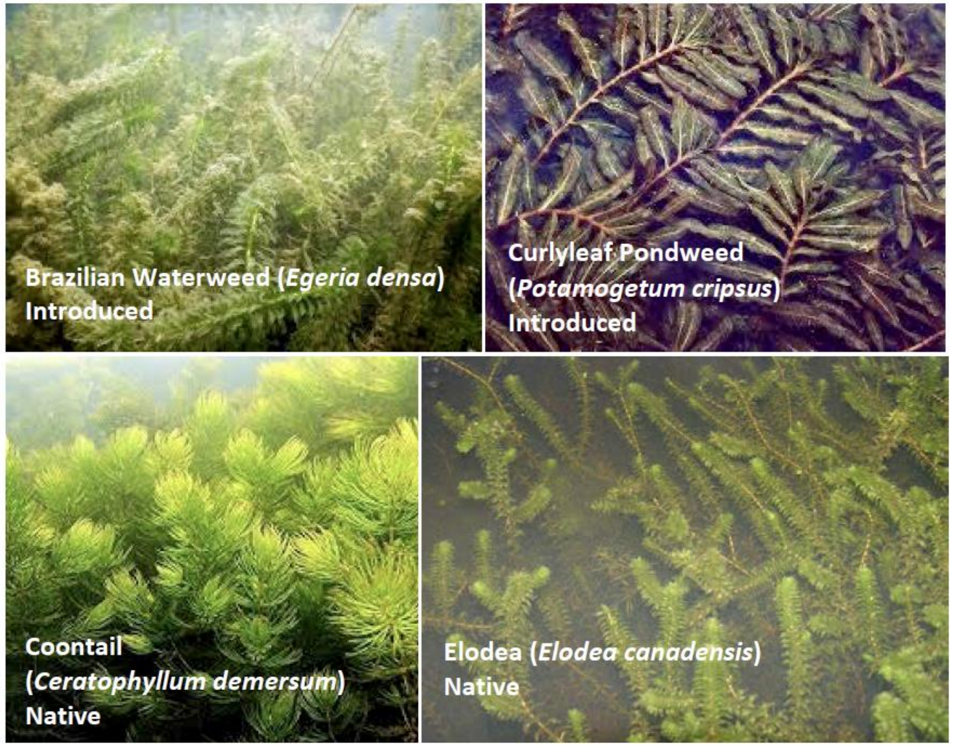
Modeling SAV in Bay Delta

Jiabi Du (jdu@tamug.edu)
Zhengui Wang
Joseph Zhang
Jian Shen

Funding support from Delta Stewardship Council

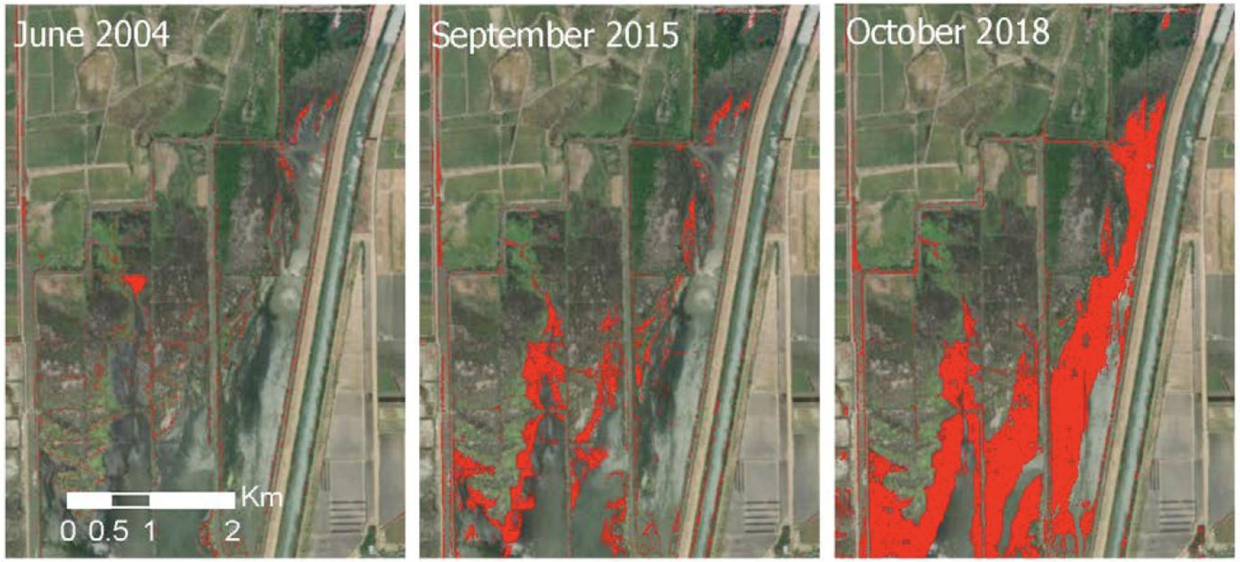
SAV in Bay Delta

Major intrusive SAV – the "ecosystem engineers"



Rasmussen et al., 2020

Quick expansion of SAV in the northern Liberty Island



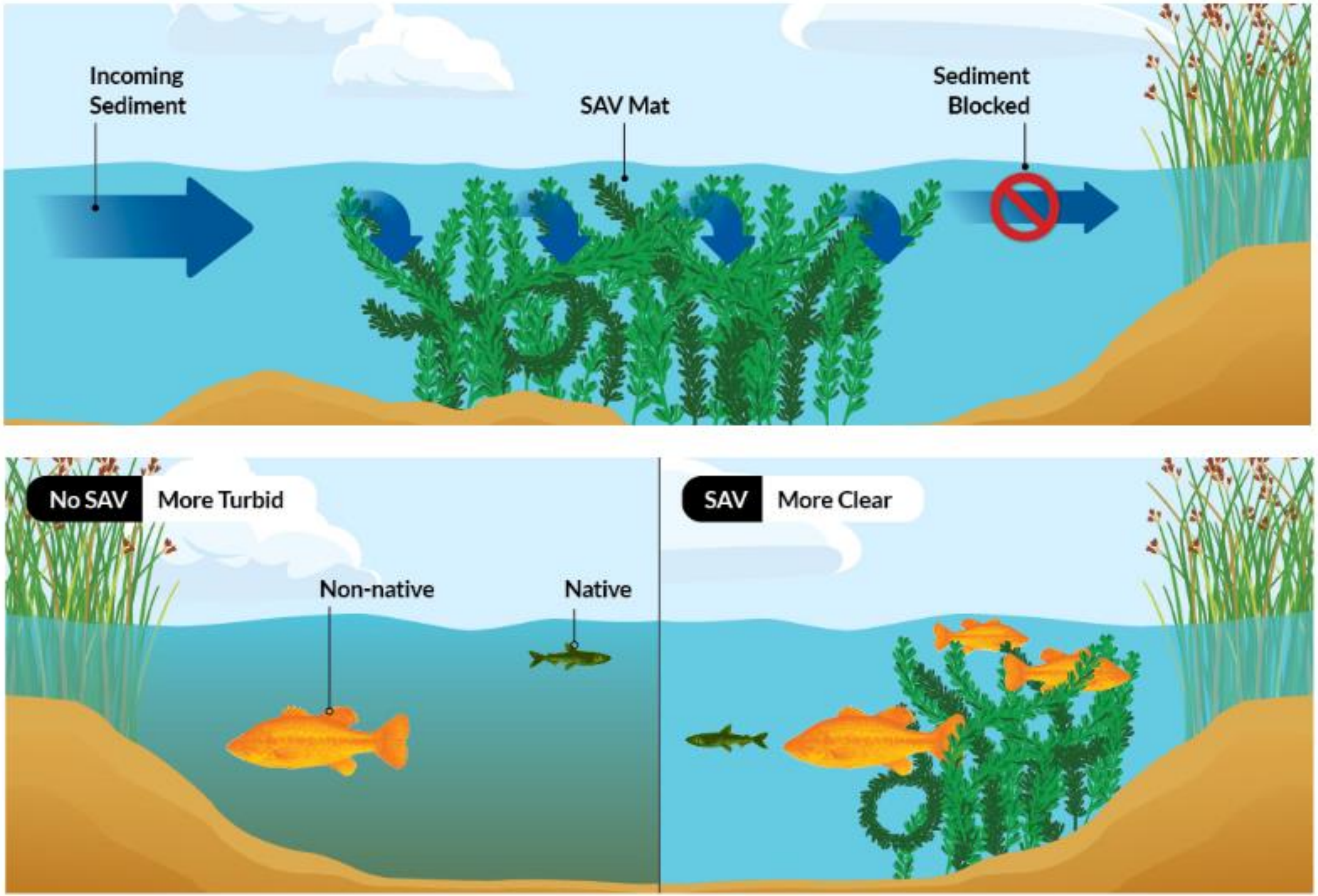
- In 2018, SAV covered 10,500 acres across regions of Liberty Island and the Central Delta
- Equivalent to 1/3 of the area of the waterways (Ustin et al. 2019)

Intrusive SAV's impact

- Decrease turbidity, detrimental to pelagic fish species
- Slows water movement and water exchange
- Alters the biological community
  - Support non-native fishes
  - Compete with phytoplankton
- Undermine large-scale tidal wetland restoration efforts that are designed to support Delta Smelt and Chinook Salmon

Intrusion of aquatic weeds is regarded as one reason for extinction of delta smelt (*Hypomesus transpacificus*)

Photo by Peter Johnsen, US Fish and Wildlife Service



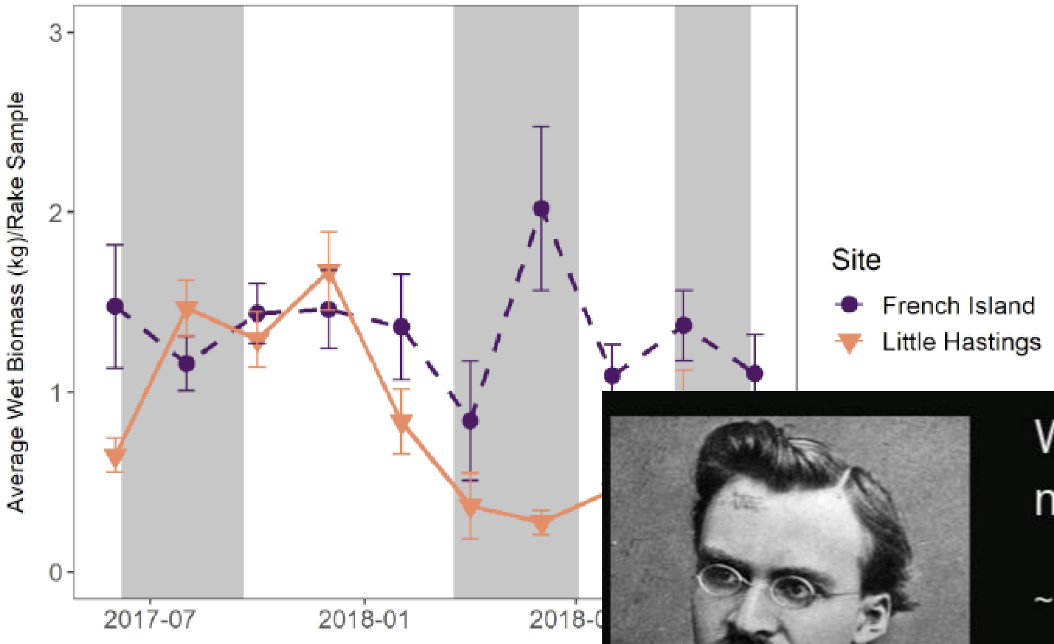
Christman et al., 2023

SAV control in the Bay Delta

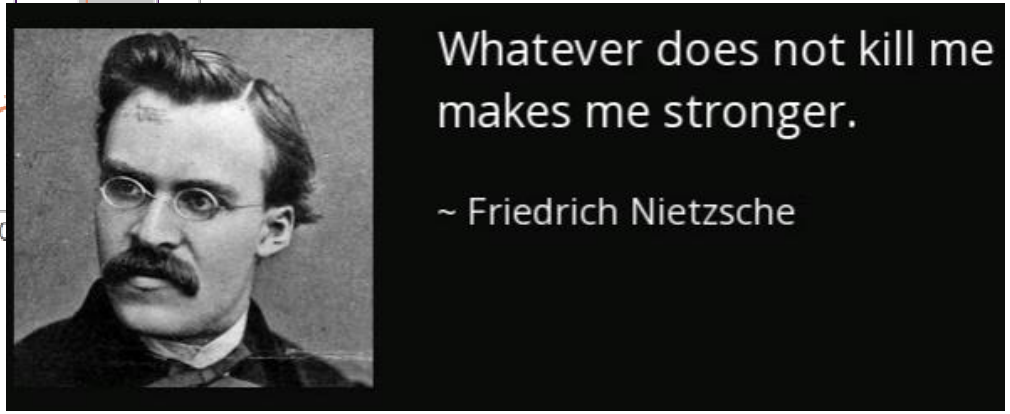
Major species: Brazilian Waterweed and Coontail

Fluridone treat study by DWR

Fluoridone treatment has impacts on SAV biomass, but not long-lasting



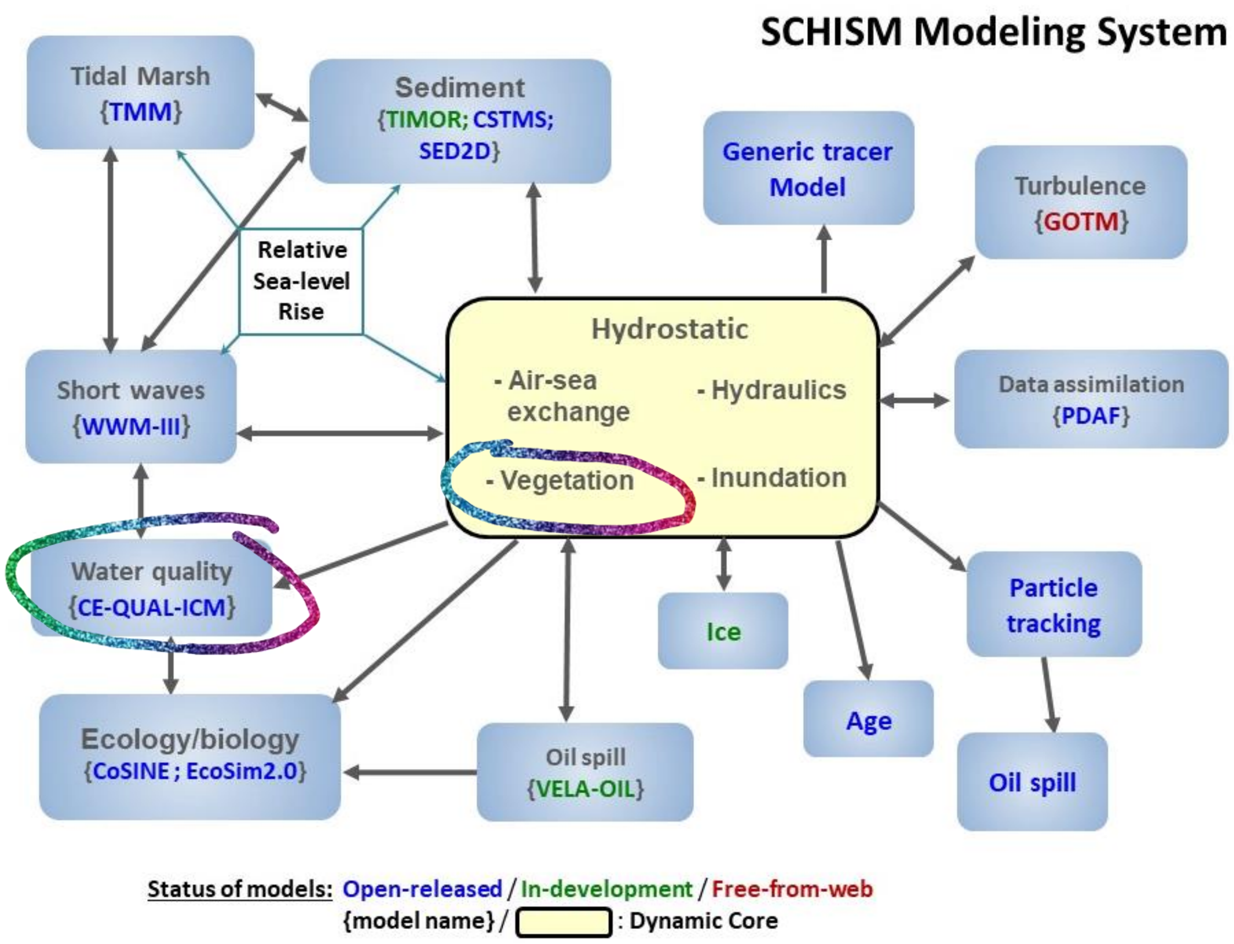
Rasmussen et al., 2020



Challenges in modeling SAV

- Error in hydrodynamic and water quality model
- Two way coupling with hydrodynamics
- Uncertainty in nutrient sources
- Parameterization of light limitation

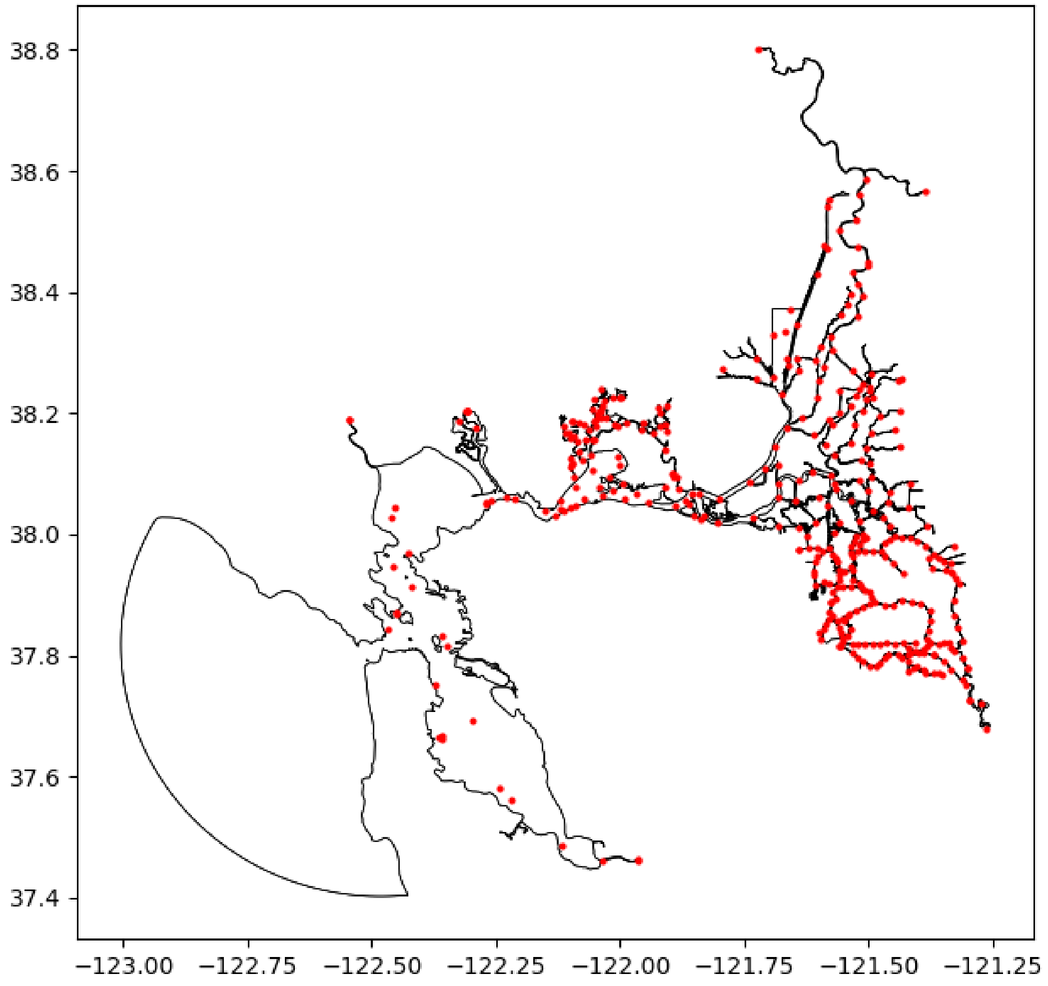
A fully coupled Hydro-ICM-SAV model



SAV module in SCHISM

- The SAV module is currently embedded in the ICM water quality model
- Two-way coupling

Hydro and Water quality model



Model domain and Nutrient loading point sources (red dots)

Hydro: 2018, set up from DWR

BGC (Biogeochemical) open boundary condition: another larger-domain BGC model (CoSiNE model) of the Pacific Ocean.

BGC initial condition: based on observation from multiple sources including USGS, Water Data Library from DWR, and California Environmental Monitoring Program.

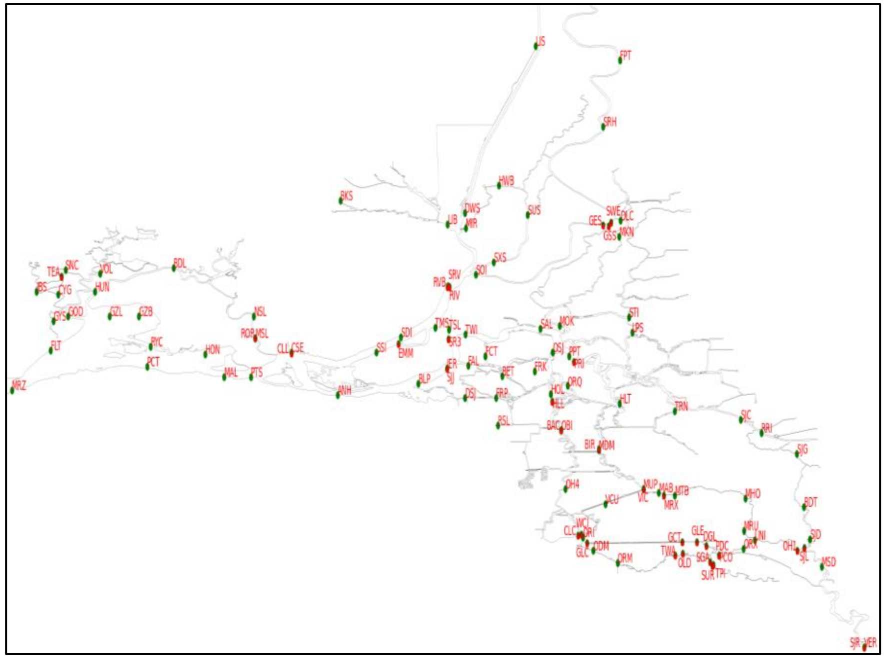
Nutrient load from Waste Water Treatment Plants and many DICUs are included. Including major rivers, there are in total of 392 point sources.

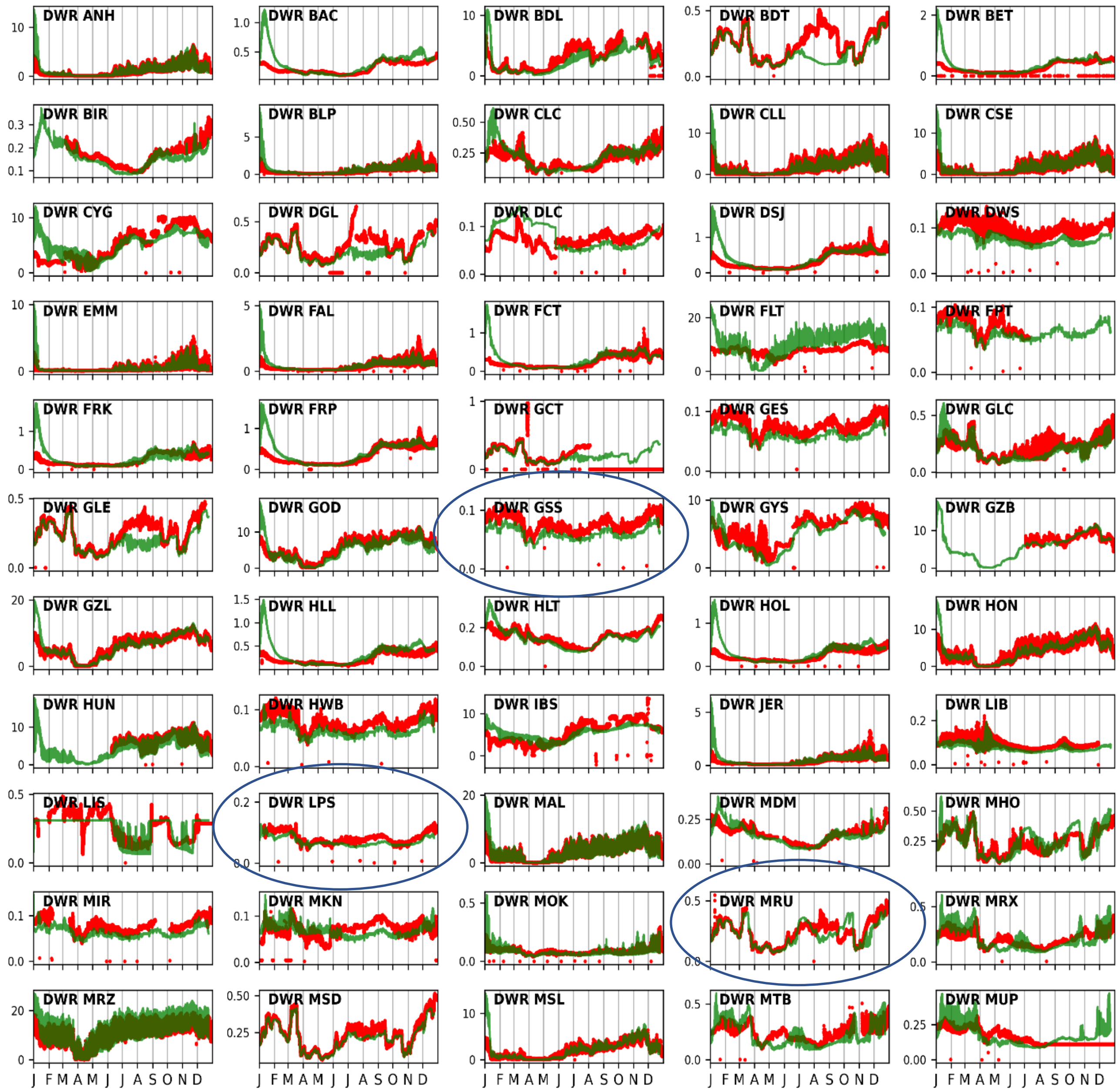
SAV initial condition: constant on simulated regions
Computational efficiency: 36 hr for one-year run with 560 cores on FRONTER

Salinity comparison between model and observation

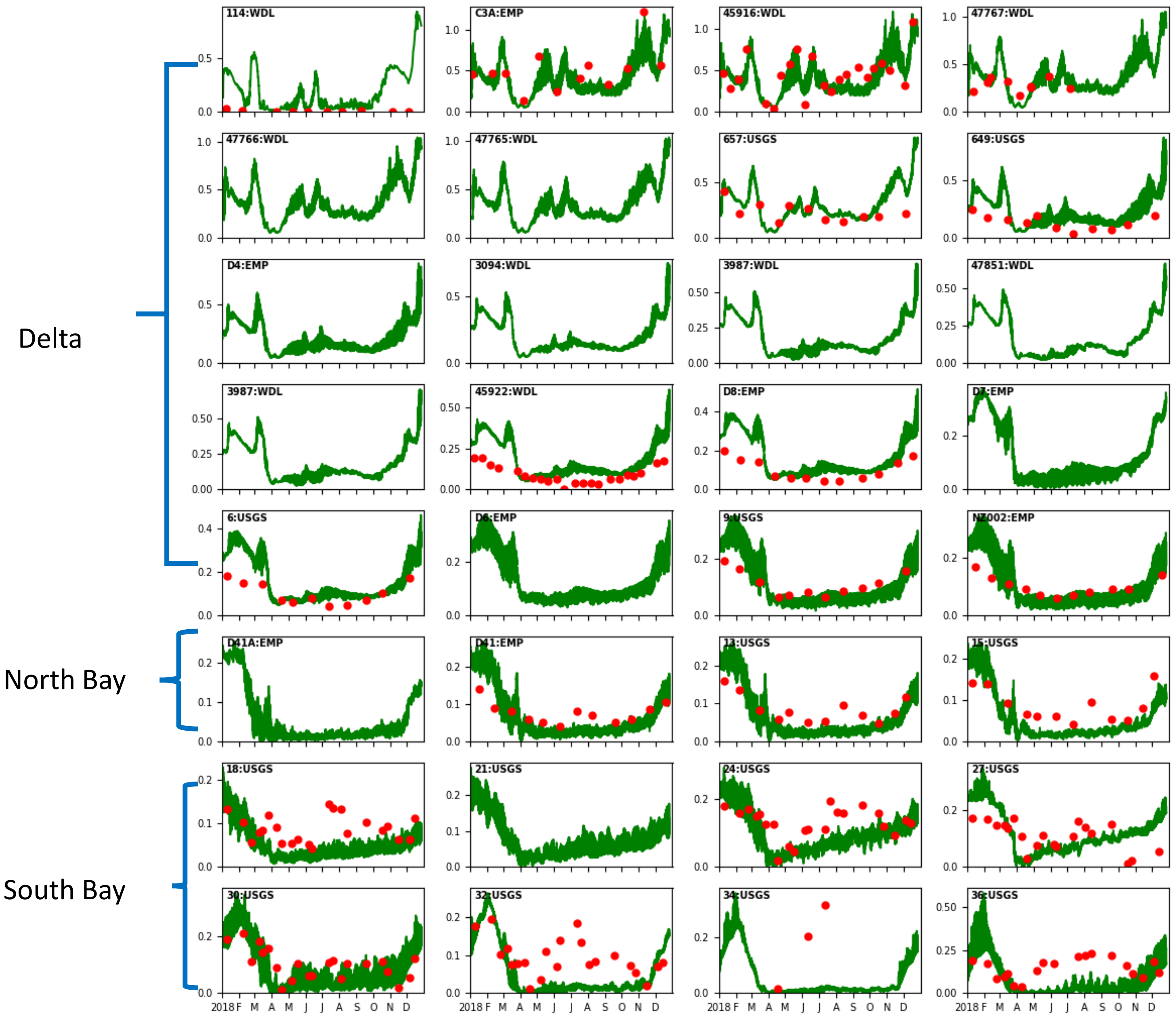
Data from ~100 stations are compared (50 stations shown here). Model gives overall satisfactory performance in salinity.

Note that the model can accurately capture the small salinity variations



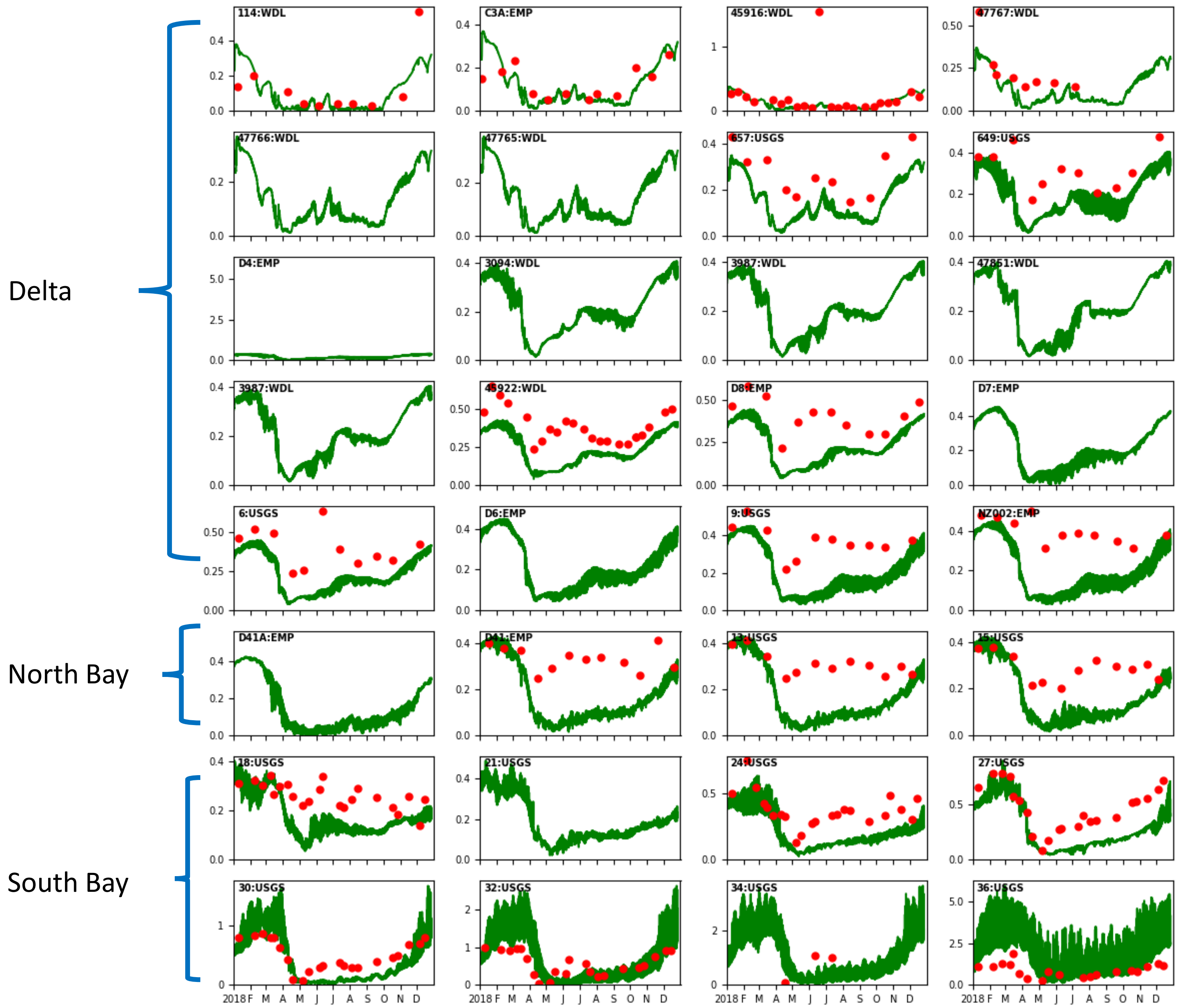


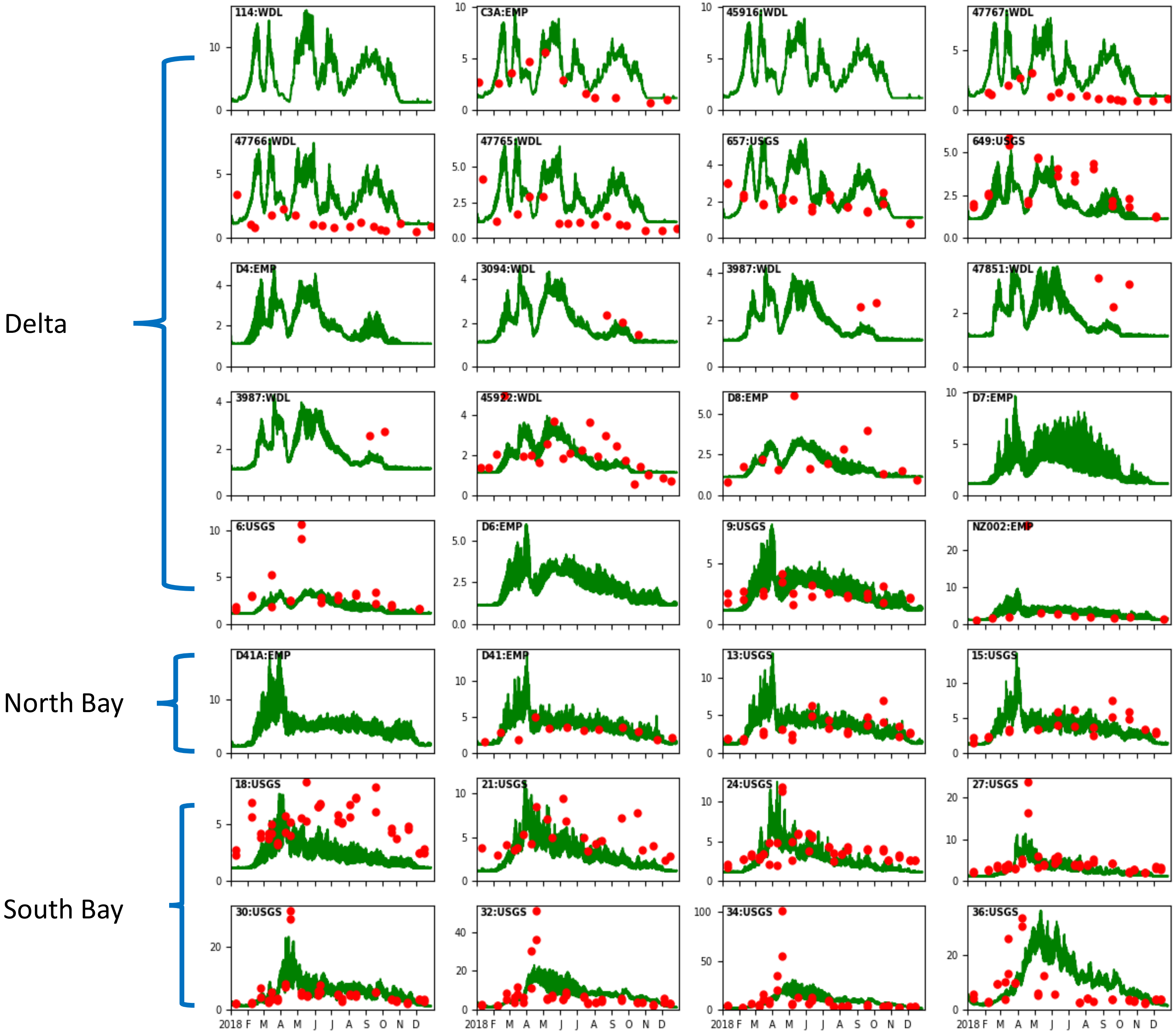
NH4: Model vs Observation



- Overall agreement of the seasonal variations
- Room for improvement

NO3: Model vs Observation



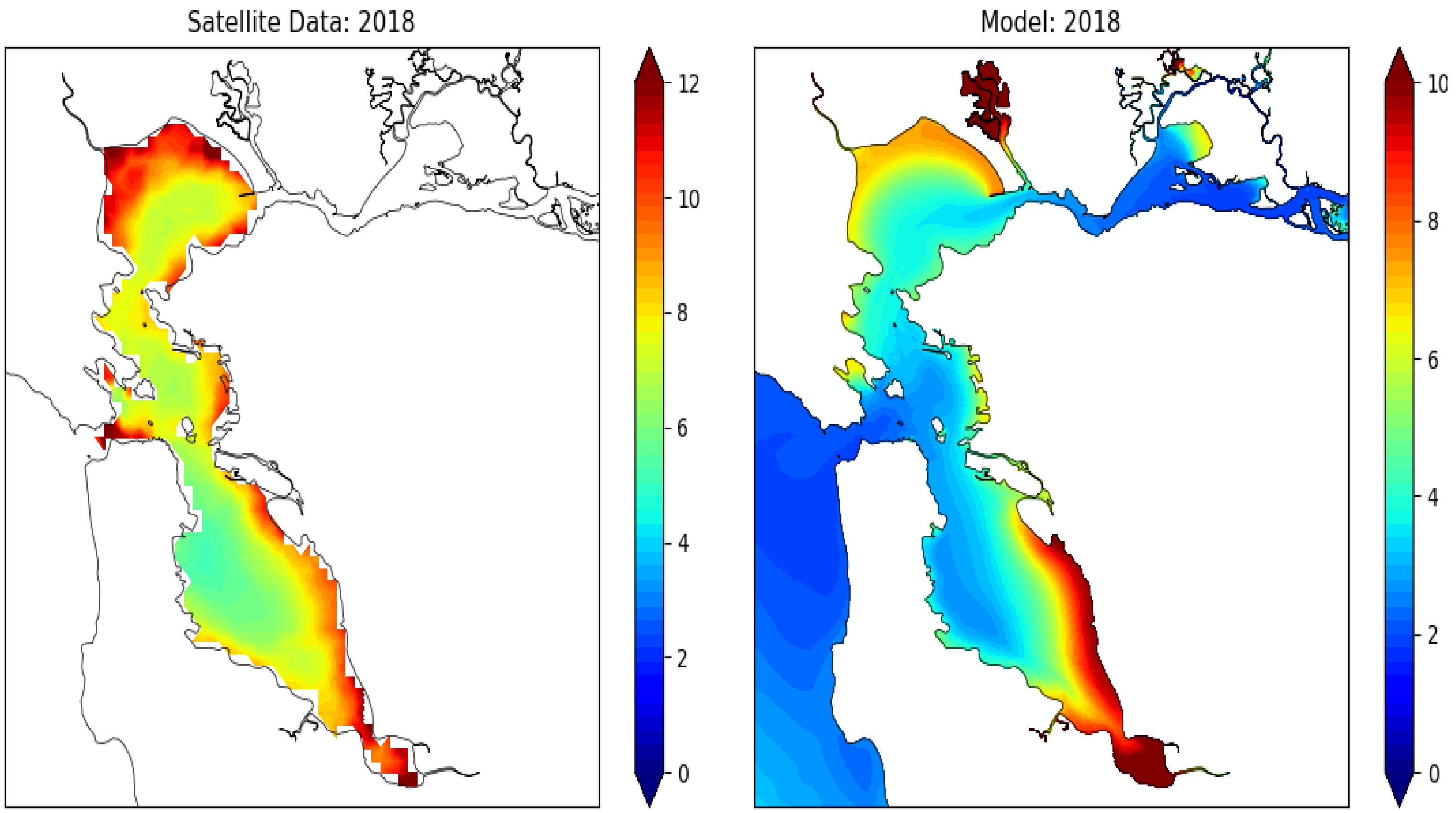


Chla: Model vs Observation

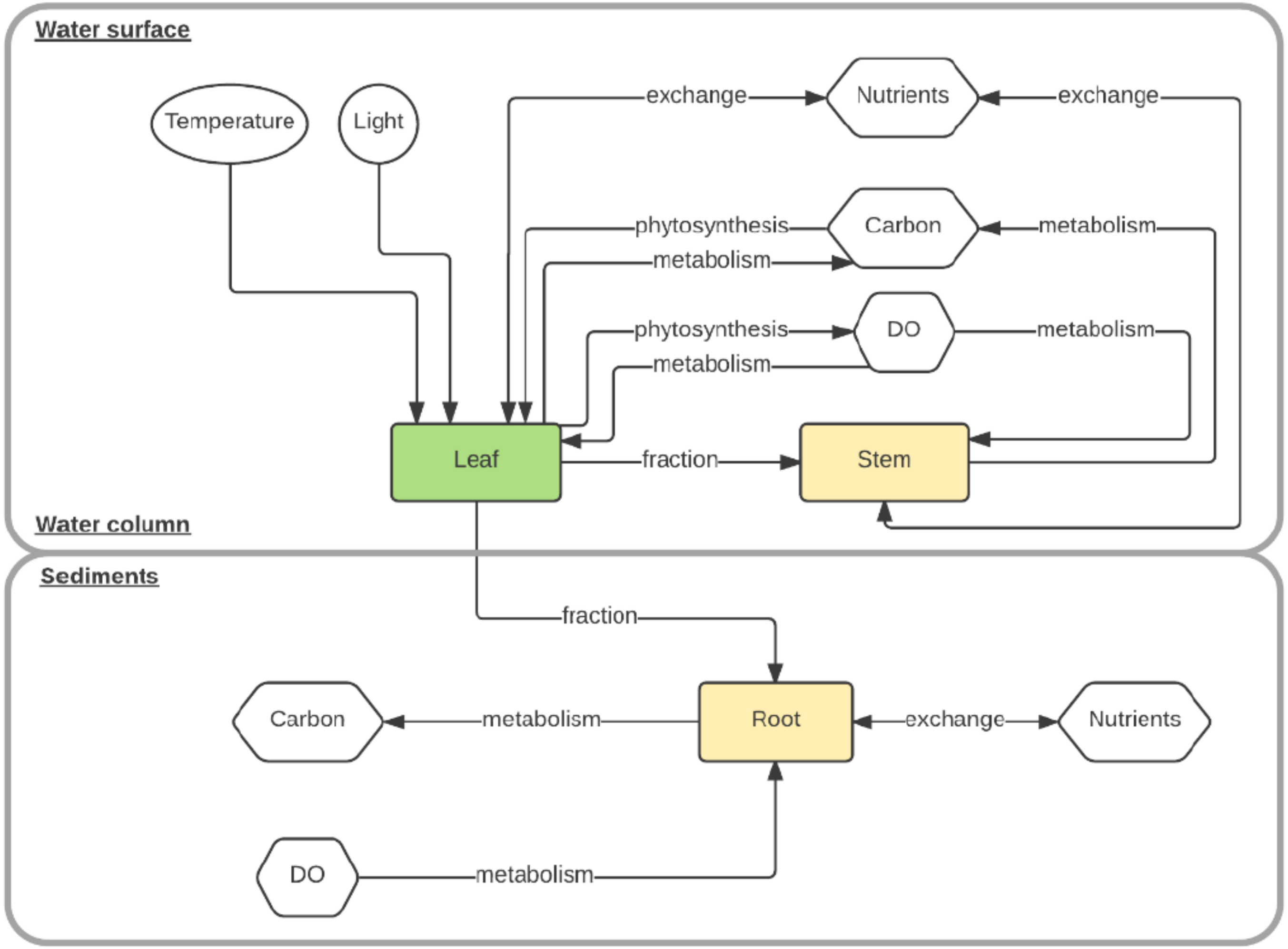
Reasonably reproduce the magnitude and seasonal variations of Chla

Comparison of chlorophyll-a (ug/L) between model results (green line) and observations (red dots) along Sacramento River and inside San Francisco Bay (SCR-Bay)

Yearly averaged surface Chla



SAV model

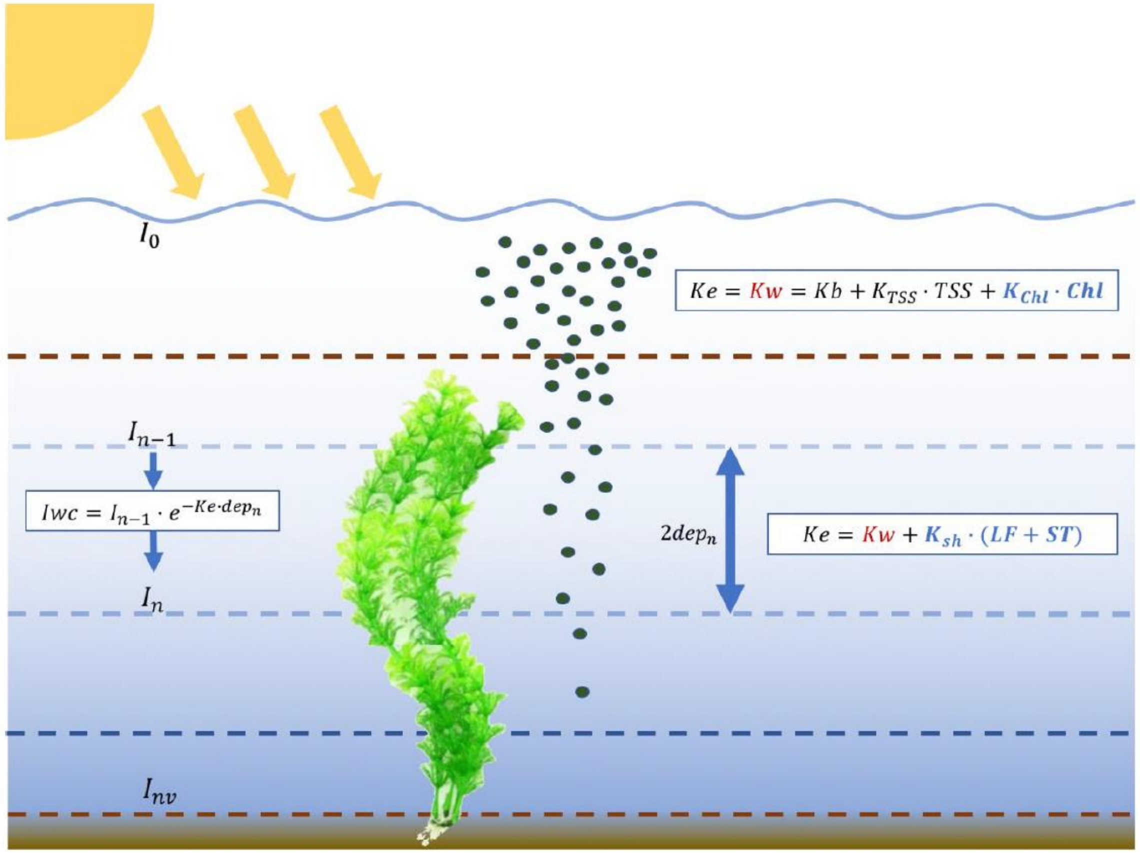


Cai, 2018

Following Cerco and Moore (2001) and Cerco et al. (2004)

- 1D model, no advection or diffusion
- Biomasses of leaf, stem, and root are computed separately
- Key controlling factors include light, nutrient, and temperature
- Nutrient sources: water column and sediment

Lesson learned: Important of light condition



Cai, 2018

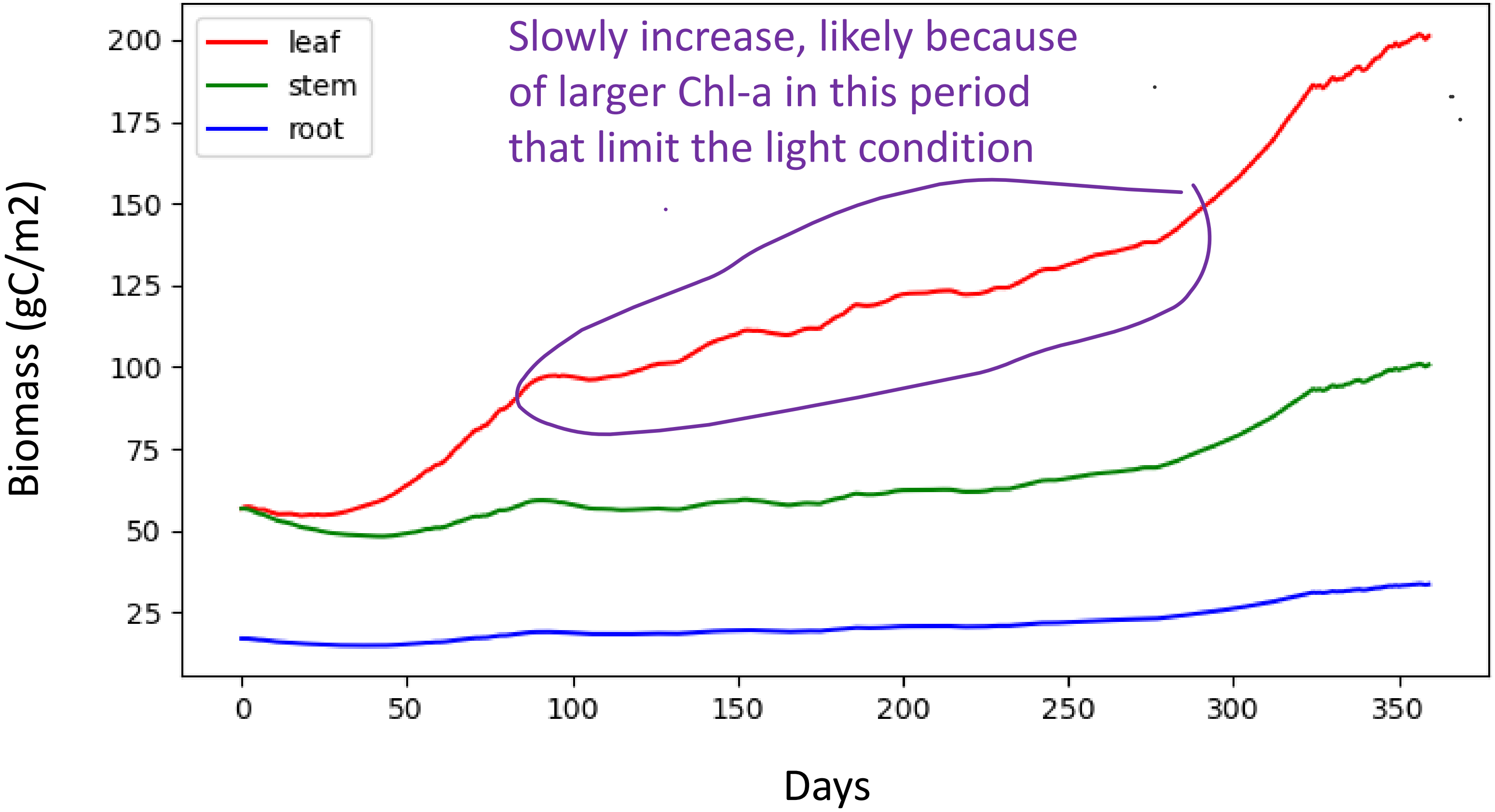
Light condition above/below the canopy is treated differently

Light attenuation below the canopy is determined by

- Total suspended sediment concentration
- Chl-a concentration
- Self shading (canopy height can exceed the surface)

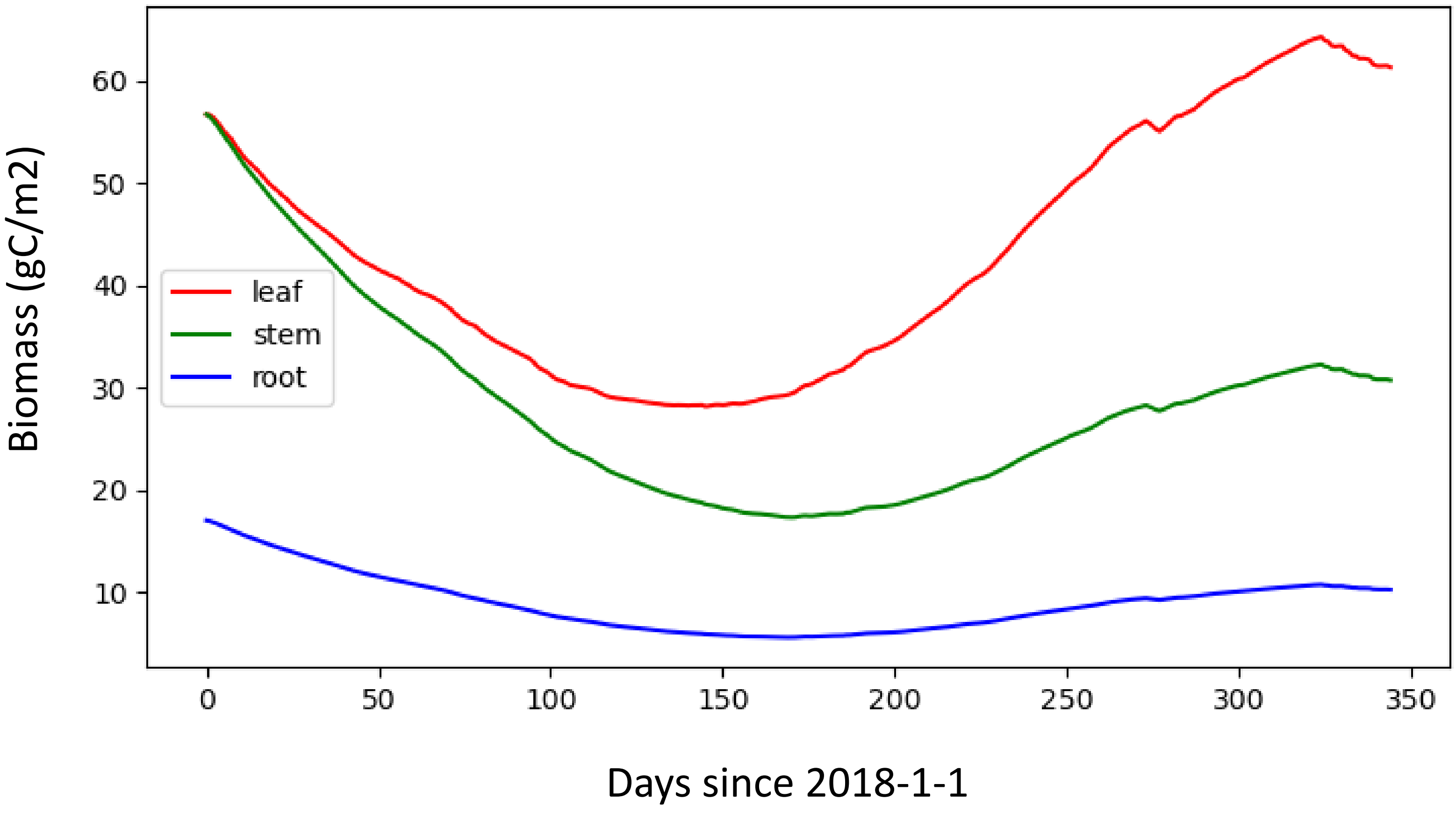
Lesson learned: Important of light condition

SAV's biomass in French Island, when background light attenuation is set to zero



Lesson learned: Important of light condition

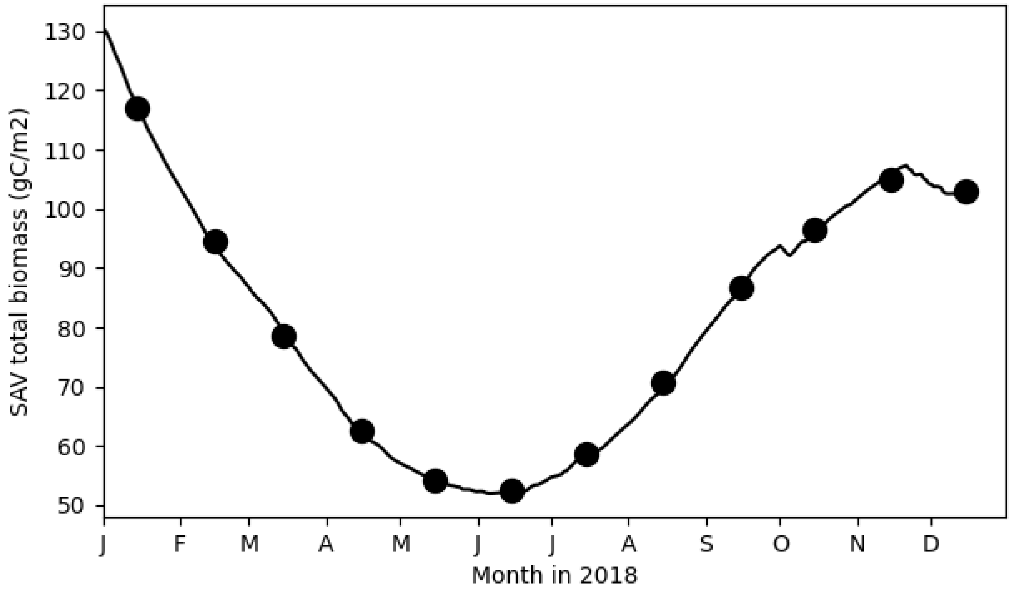
By tuning the background light attenuation, the model qualitatively reproduce the seasonal variations.



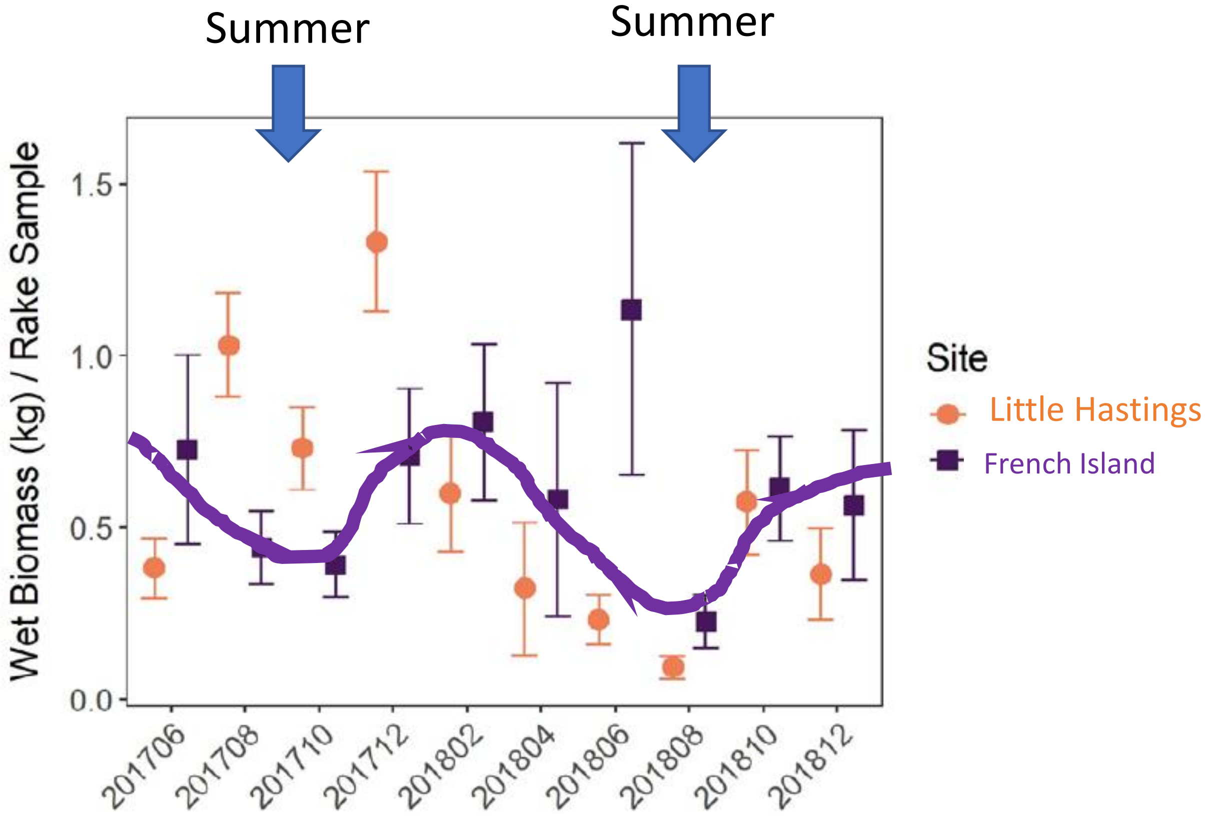
Lesson learned: Important of light condition

- Consistent seasonal cycle
- Ratio of minimum to maximum biomass ~ 1:2

Modeled SAV total biomass in French Island (untreated)



Black dots are monthly mean

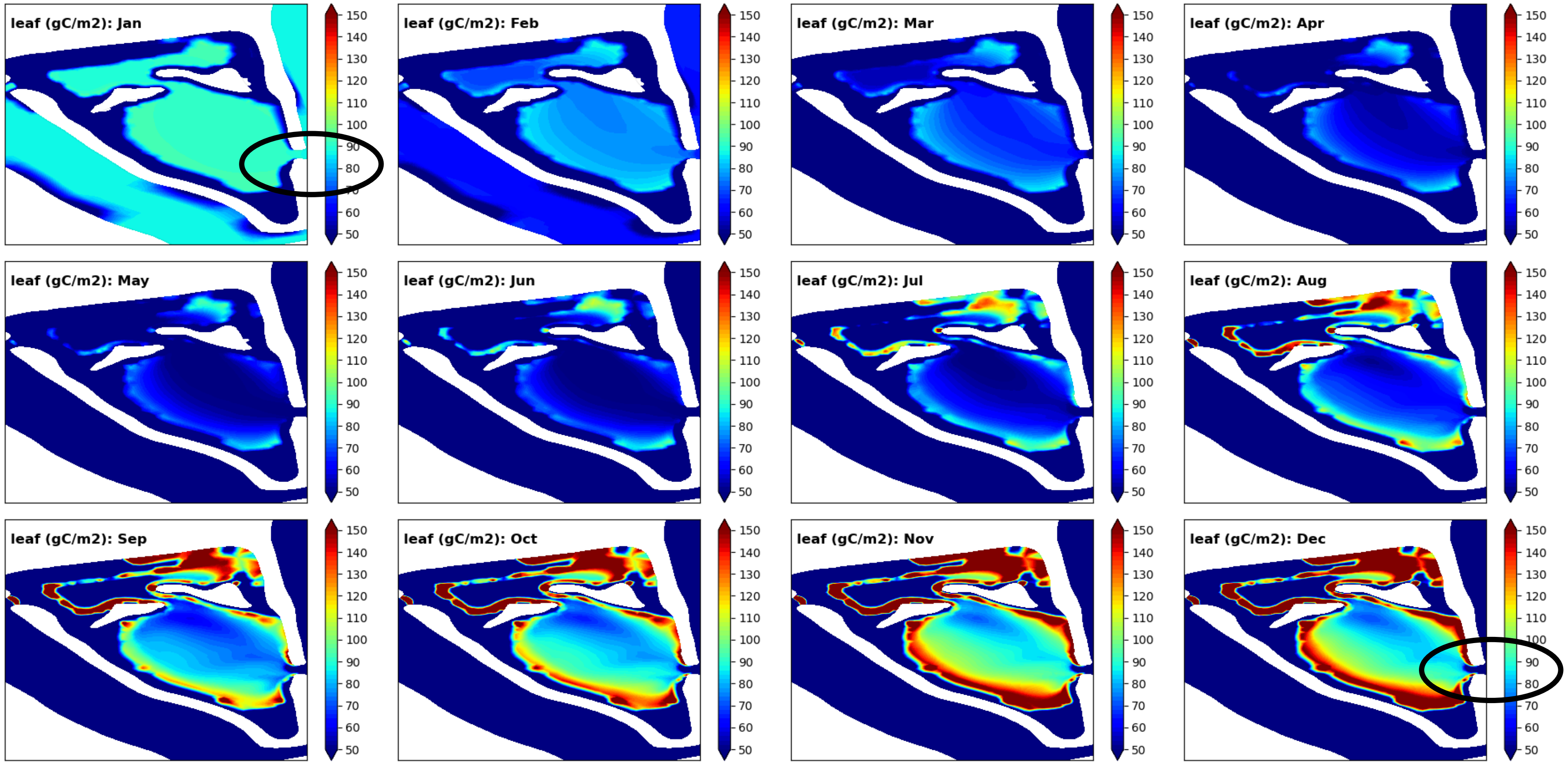


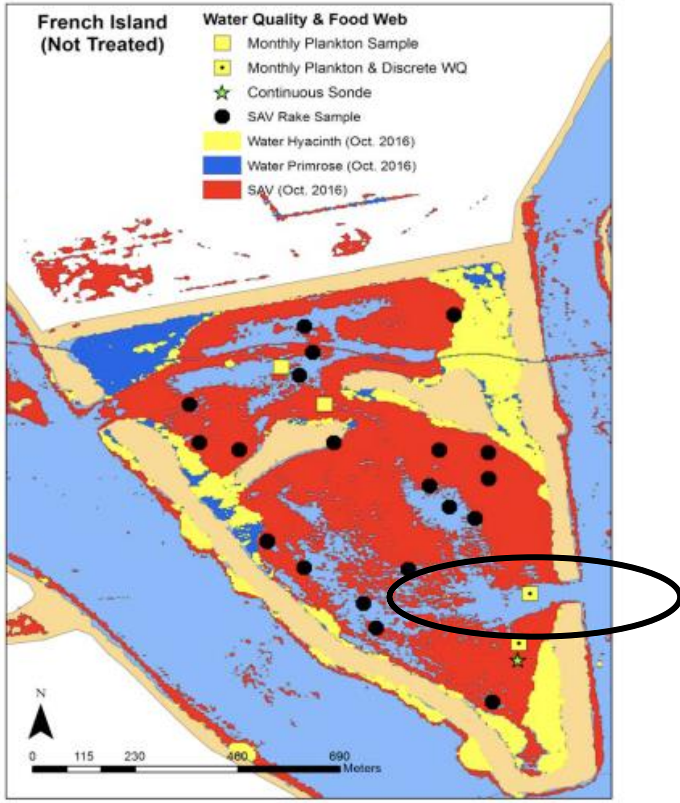
Rasmussen et al., 2020

Lesson learned: Important of light condition

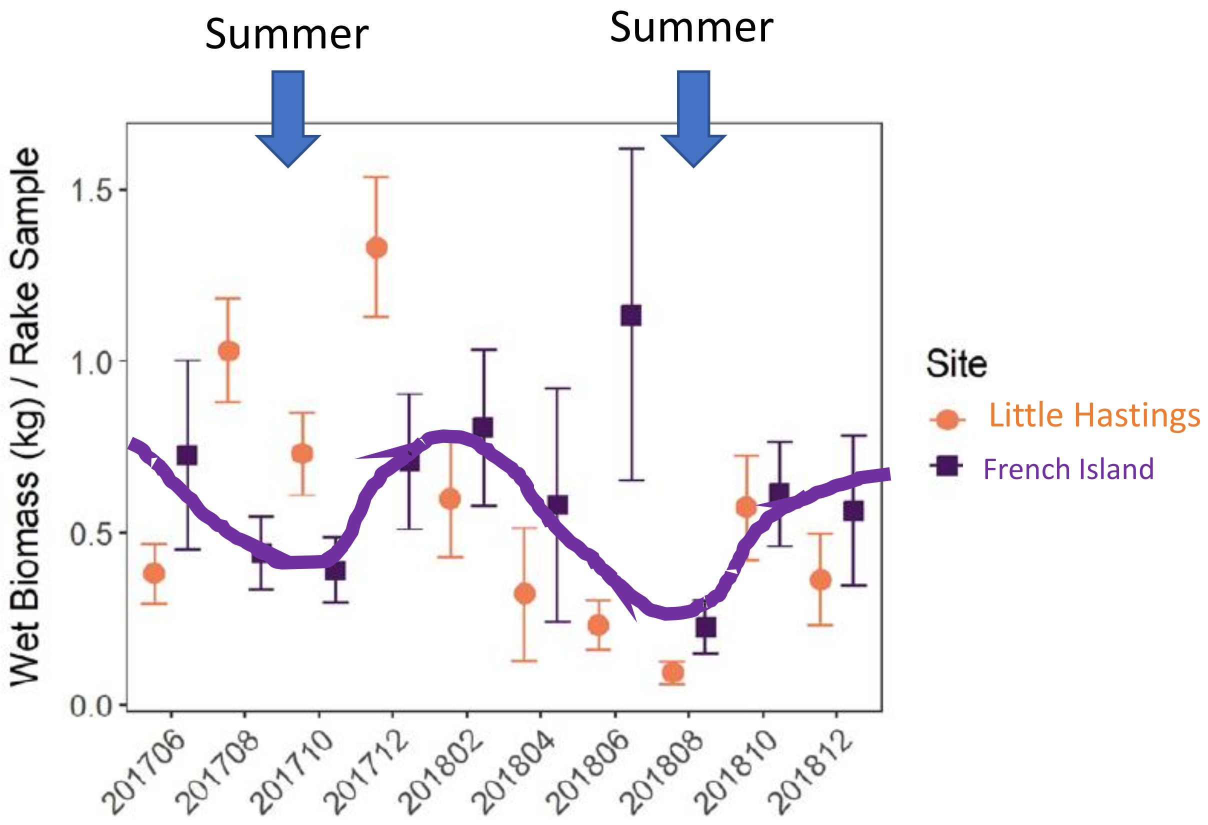
NO SAV at the inlet

- Larger depth
- Limited light condition





Seasonal growth of SAV



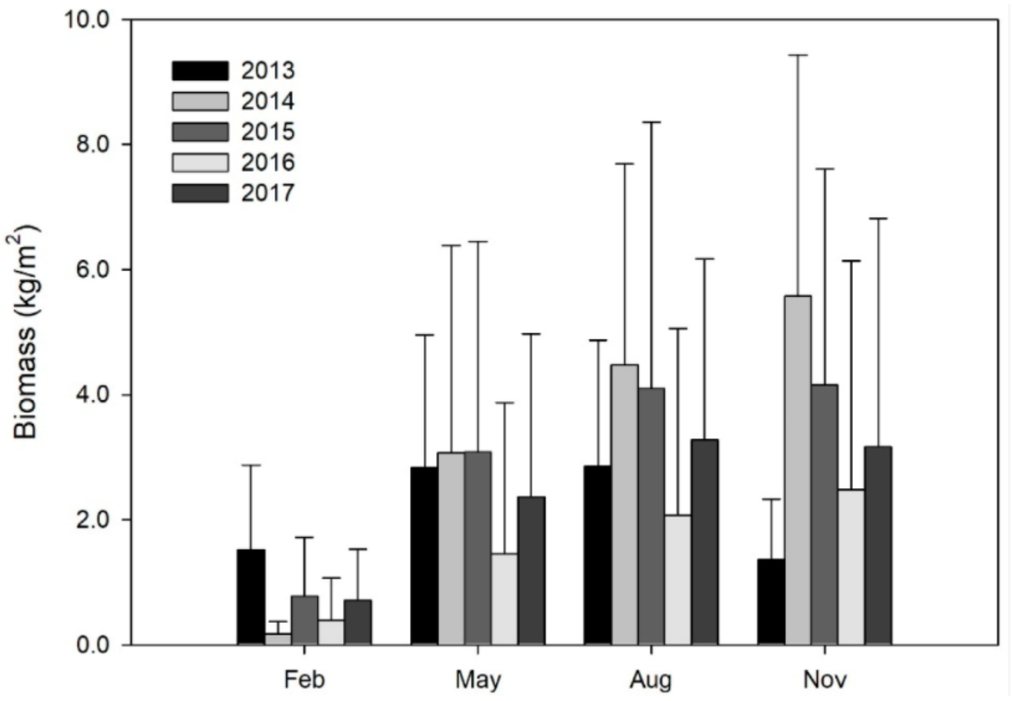
Rasmussen et al., 2020

Observation data at French Island (untreated) show notable seasonality.

- Lowest biomass in summer
- Summer is the season when fast growth begin
- Biomass peaks in winter
- Different from phytoplankton dynamics

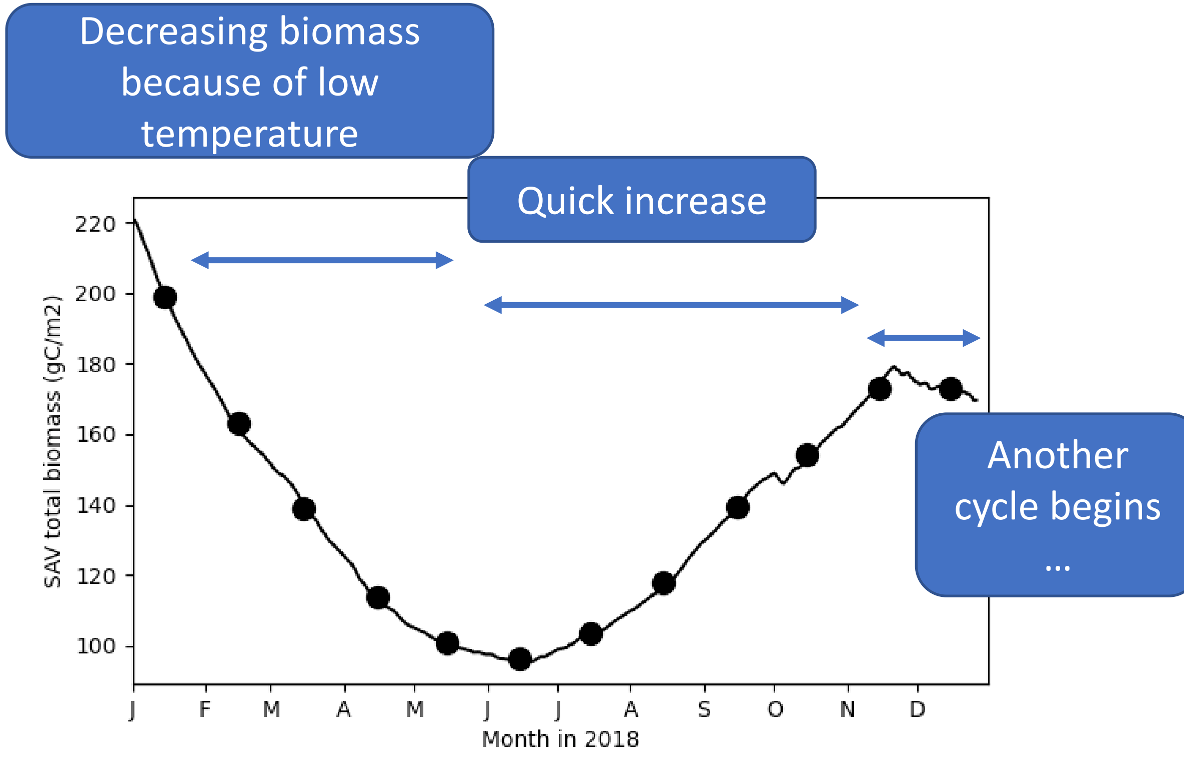
Seasonal growth of SAV

- Similar seasonality occurs to SAV in other areas
- SAV biomass in Lake Taihu peaks in the winter



Zhu et al., 2019

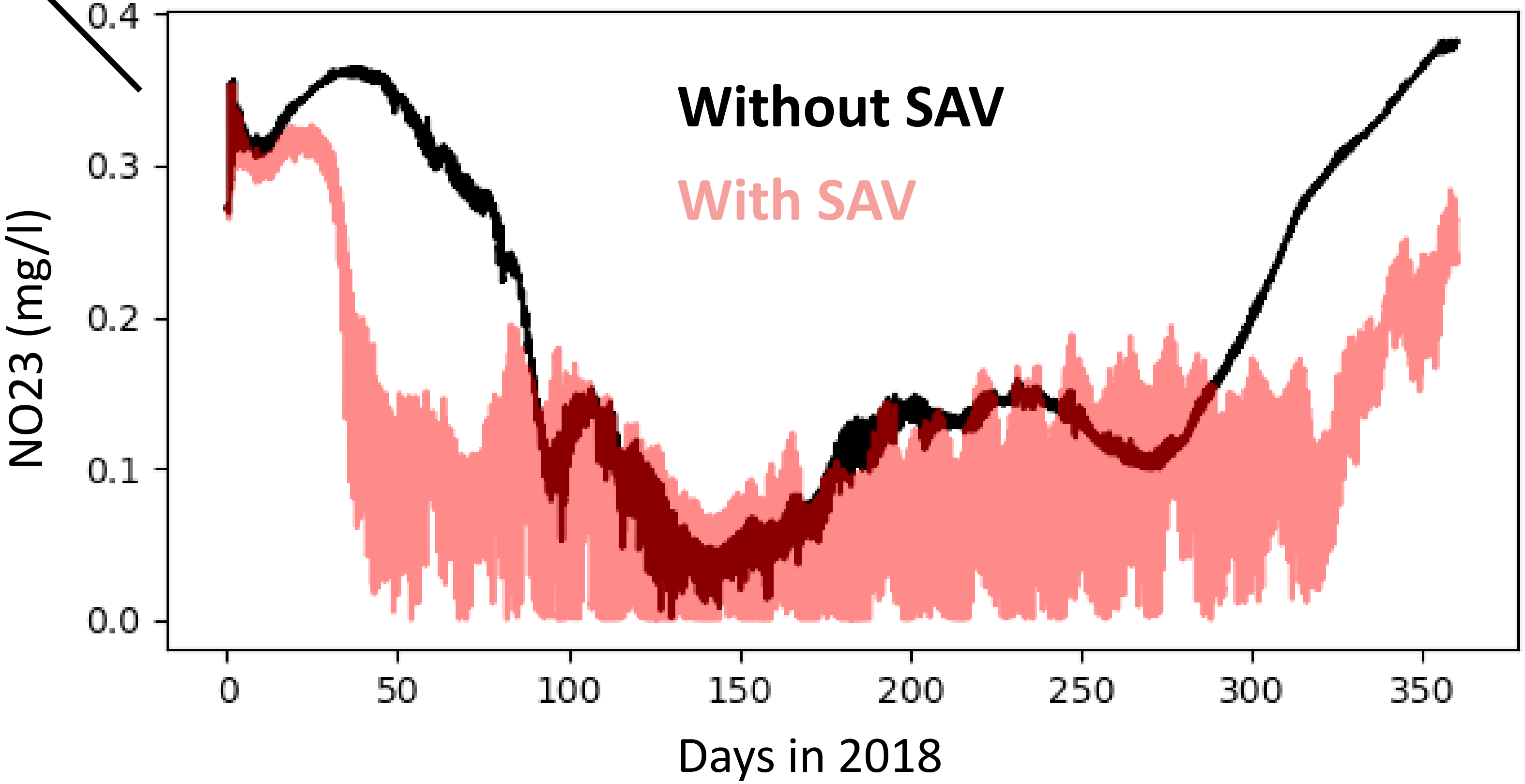
Modeled biomass at French Island



SAV's impact on water quality

Impact on dissolved inorganic nitrogen

- SAV depletes nutrient concentration in the water column
- SAV leads to nutrient gradient between SAV region and nearby non-SAV region
- The gradient, together with tidal current, results in larger tidal variability

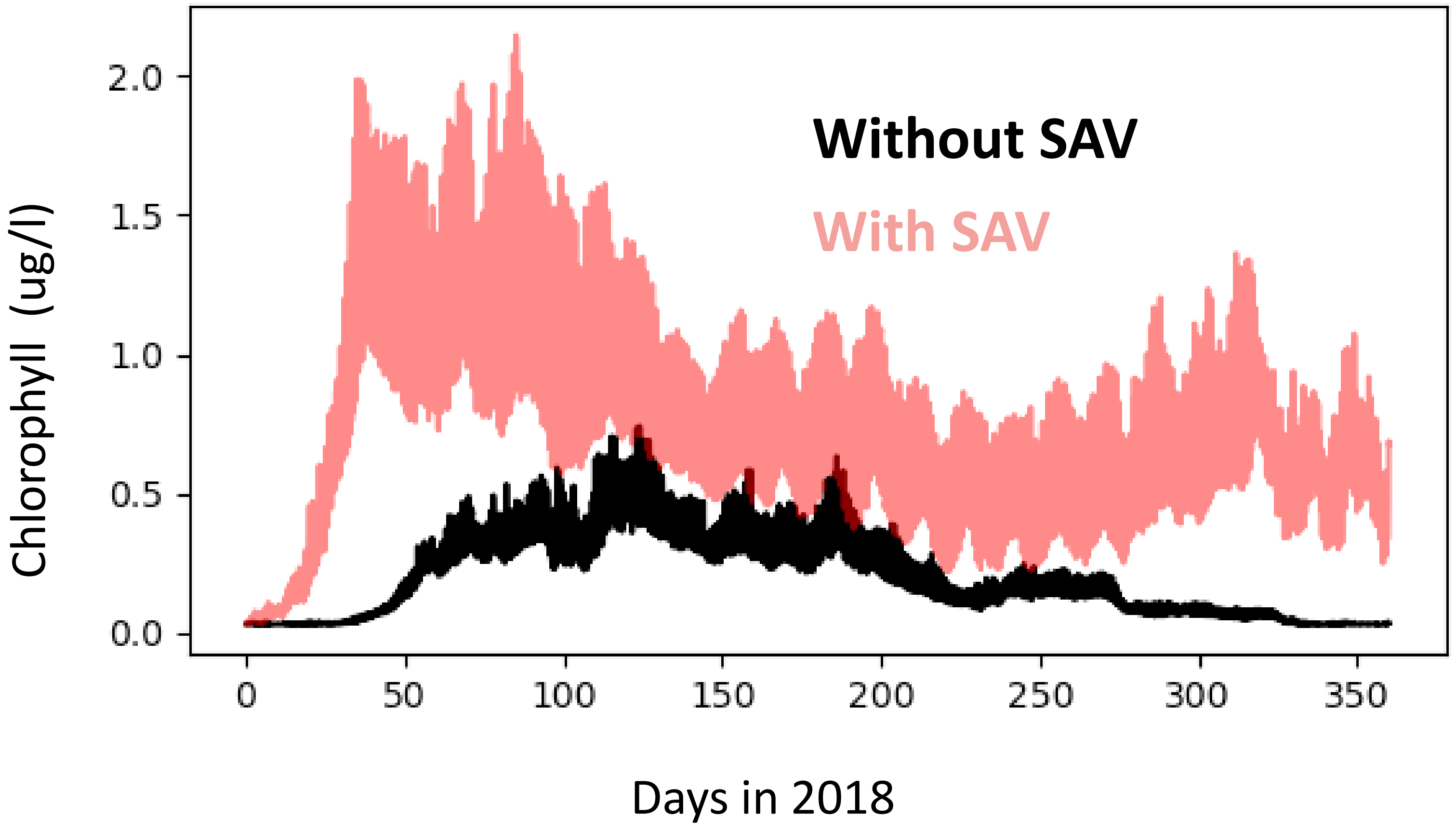


SAV's impact on water quality

On Chl-a

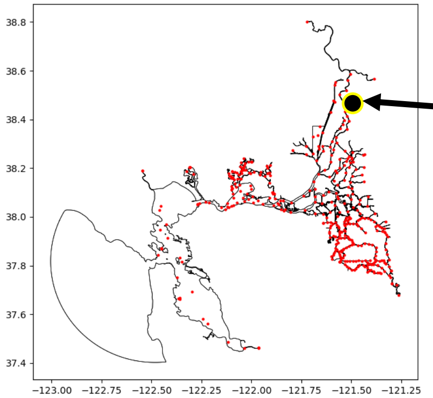
Less nutrient but more Chlorophyll

Possible Reason: slow water exchange enhances accumulation of phytoplankton



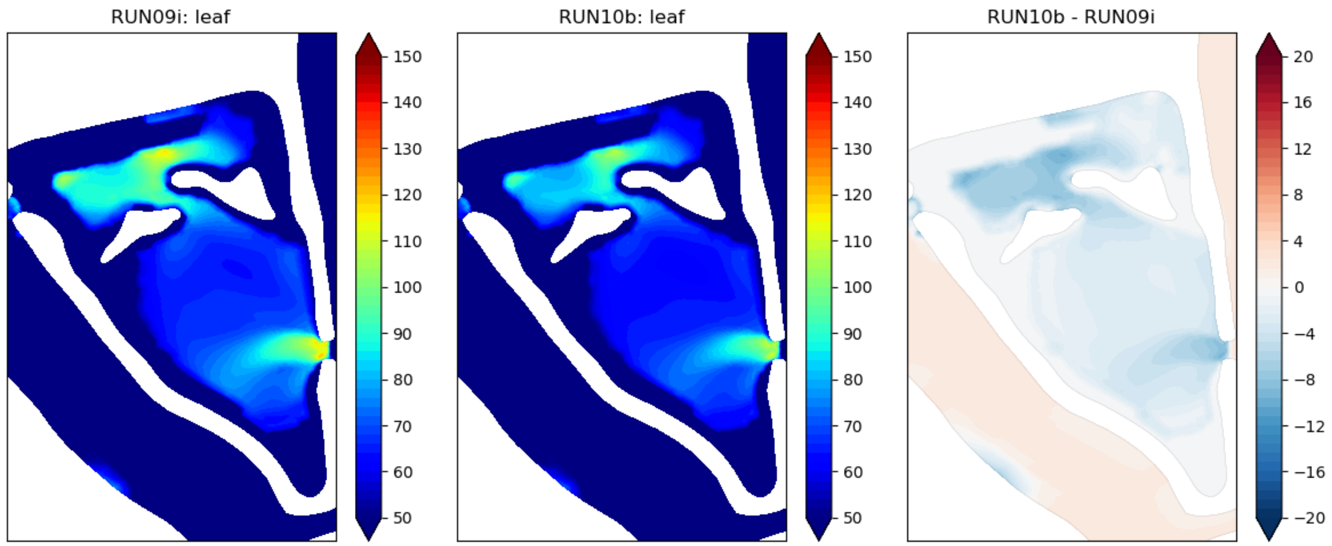
Response to Sac Regional nutrient reduction

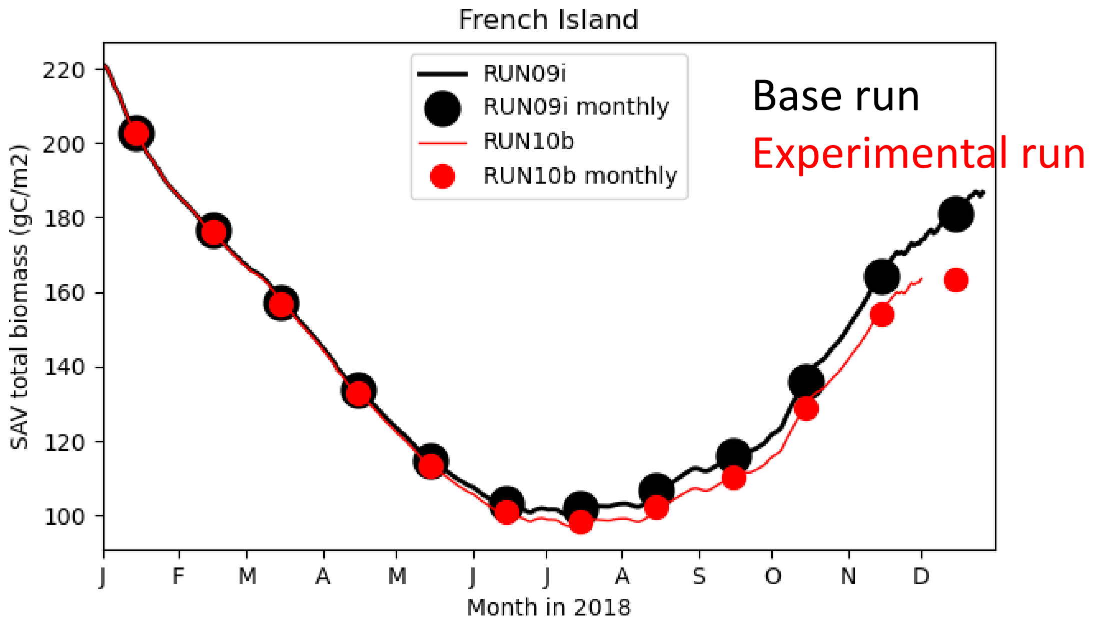
- 50% of NH4 reduction at Sac Reginal
- Slightly decreased of SAV, as nutrient in water column is reduced



Sac Regional Wastewater Treatment Plant

Yearly averaged SAV biomass





Conclusions

- A fully coupled Hydro-ICM-SAV model is applied for the Bay Delta and successfully simulates the seasonal variation of SAV biomass

- Light condition is critical important for SAV's growth

- Existing of SAV tends to deplete the water column nutrient but interesting increase the chl-a in the SAV region