Chester River Hydrodynamic and Water Quality Modeling using SCHISM/HEM3D

by

Harry Wang*, Zhengui Wang, Joseph Zhang, and Fei Ye

Virginia Institute of Marine Science, College of William and Mary
Gloucester Point VA 23062
Ph: 804-684-7215;email: hvwang@vims.edu

Presentation for EPA Chesapeake Bay Program, 2/10/2016

VIMS | William & Mary
Virginia Institute of Marine Science
1940-2015 75 Years

Outline:

I. Modeling grid and watershed loading in the Chester River

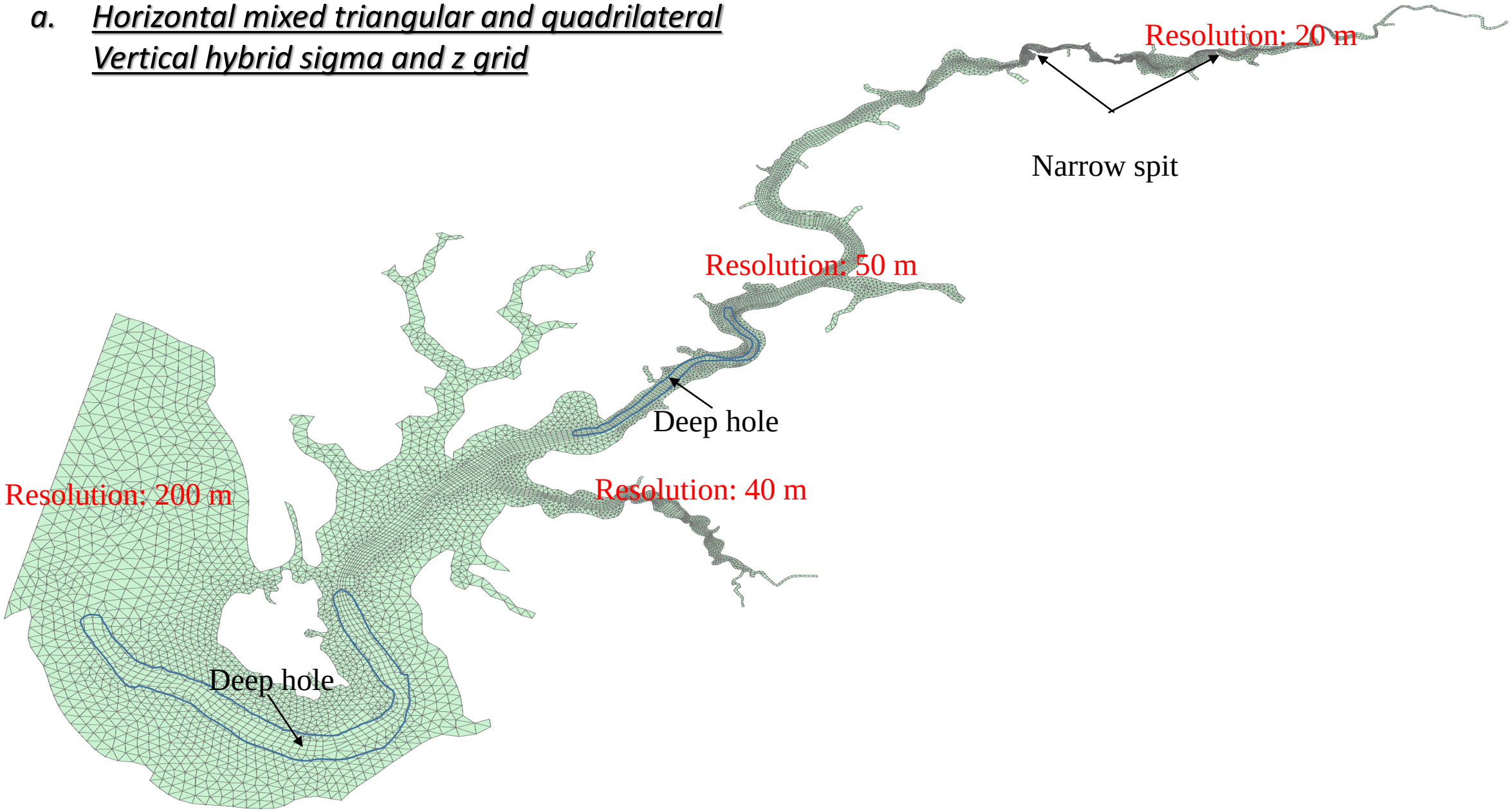
II. Modeling setup - field stations and parameters specification

III. Water quality modeling results

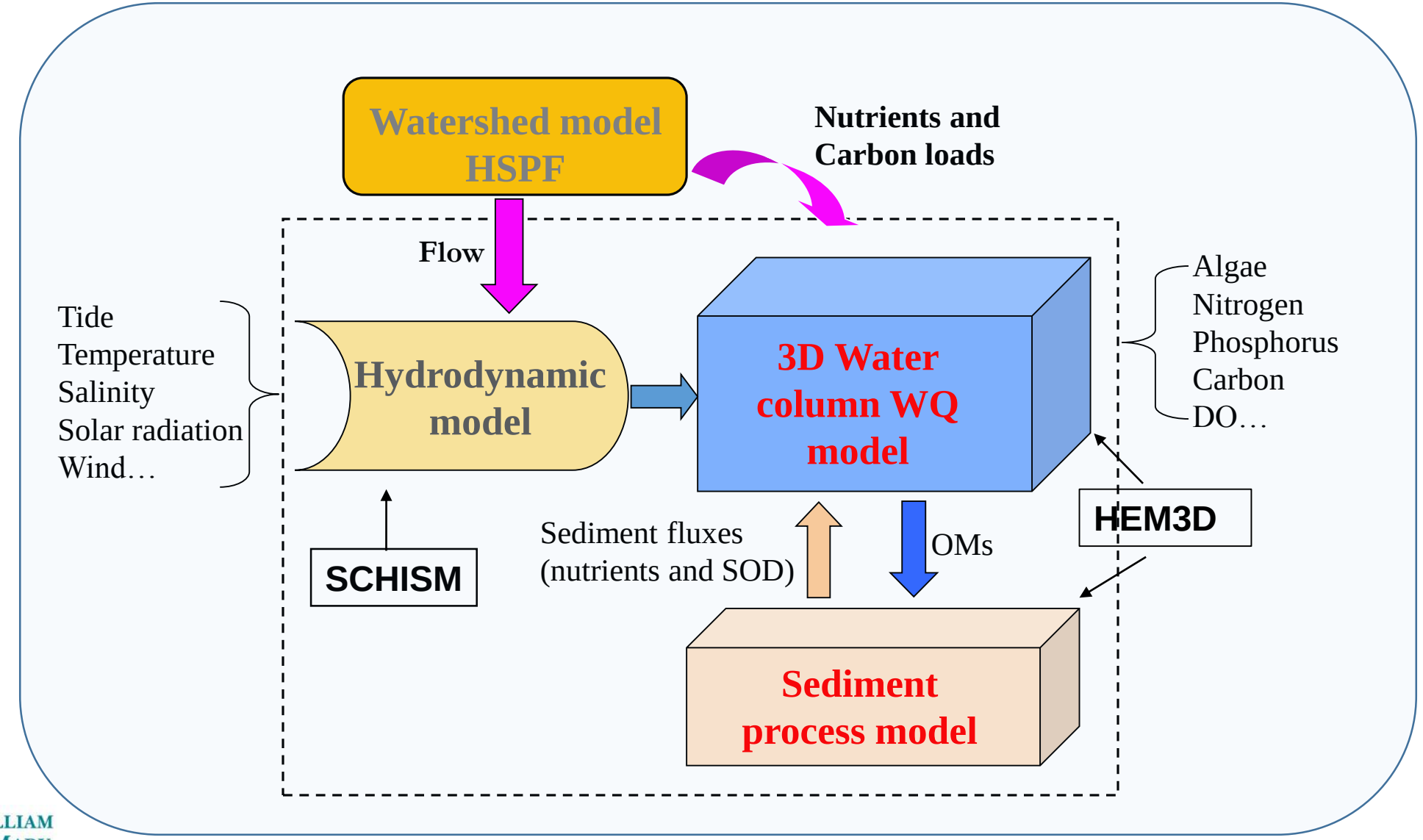
IV. Computation performance and future work

I.1 Modeling Grid

a. ***Horizontal mixed triangular and quadrilateral***
Vertical hybrid sigma and z grid

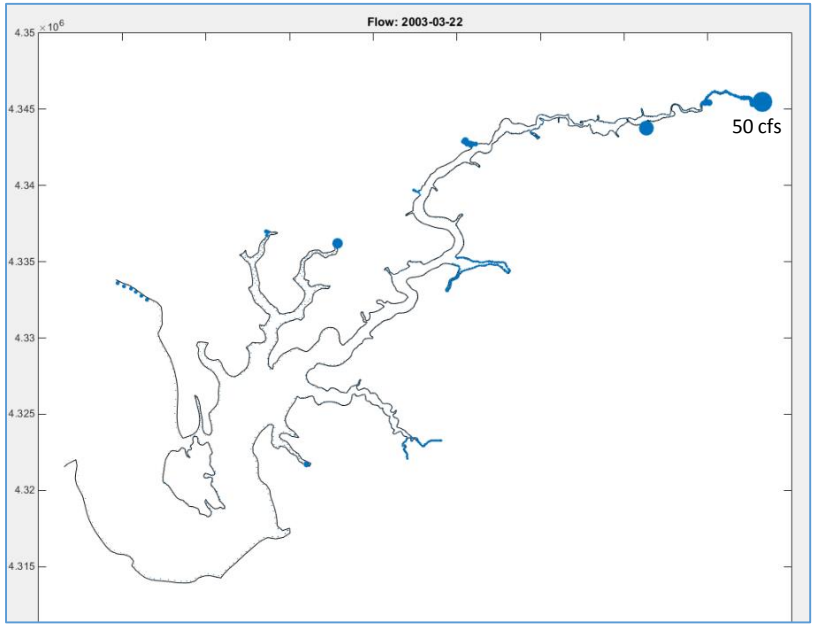


b. Modeling framework

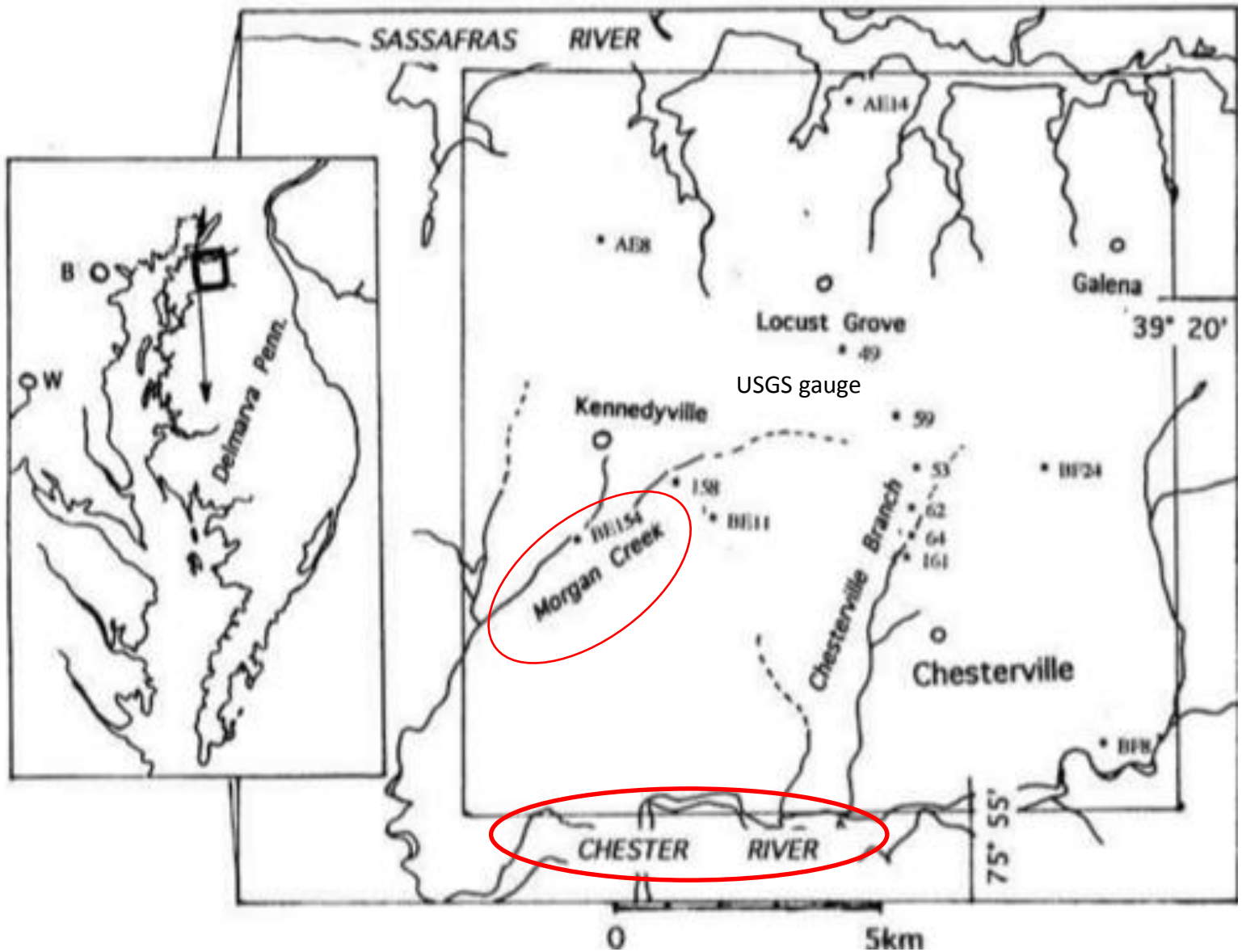


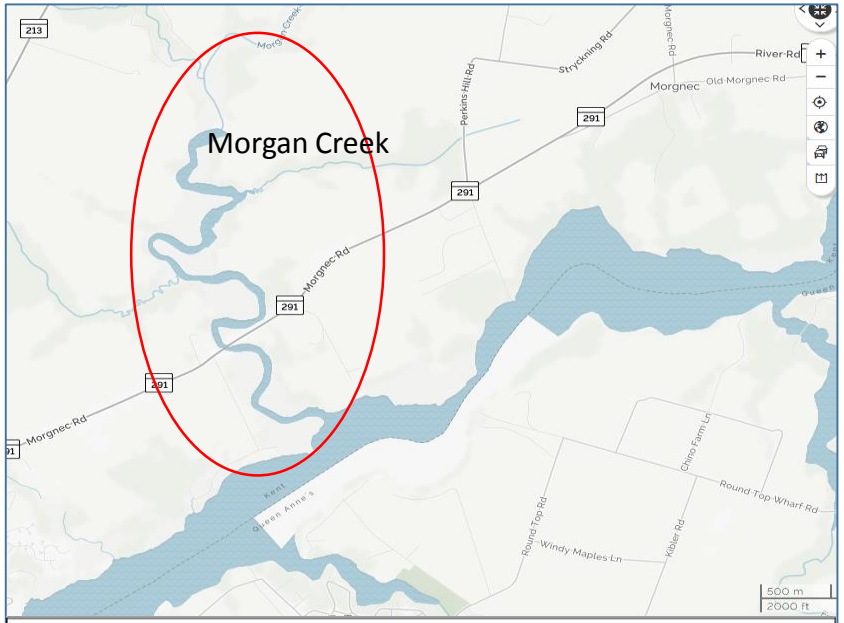
I.2 Watershed delineation

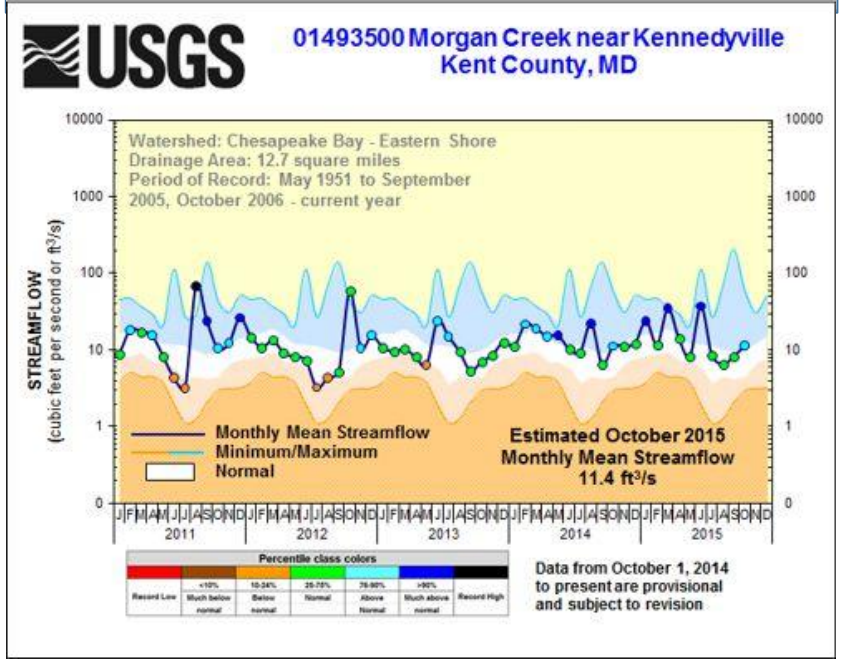
Example of watershed daily flow distribution



Morgan Creek Ground water discharge







Ref: Phillip, O. M (2003): Groundwater flow patterns in extensive shallow aquifers with gentile relief, Water Resources Research, Vol. 39. No. 6, p1149

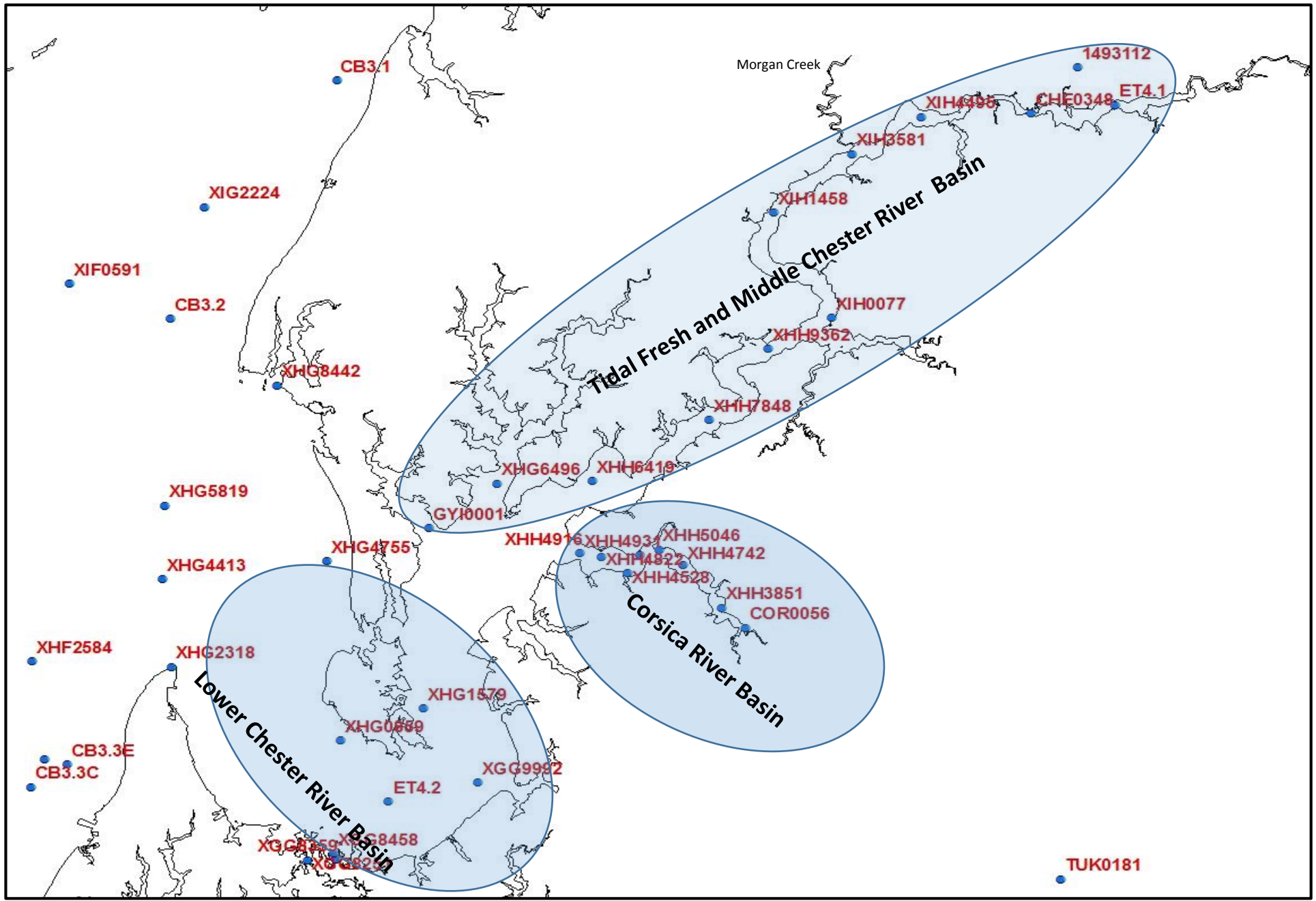
II.1 Monitoring setup

Field Station Map

Divided into three major basins

1. Tidal fresh and middle Chester River basin
2. Corsica River basin
3. Lower Chester River basin

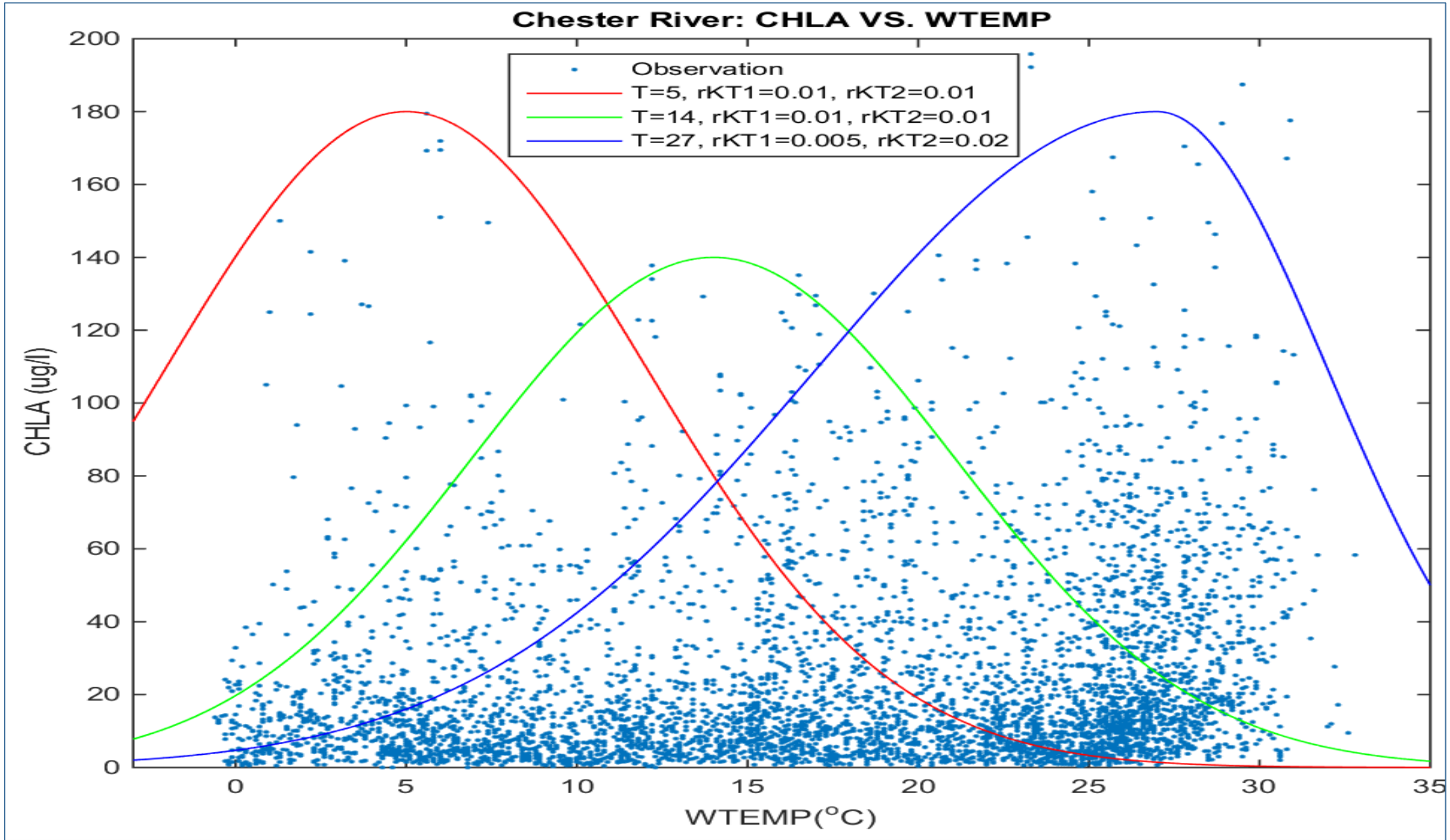
(used later for presenting modeling results)

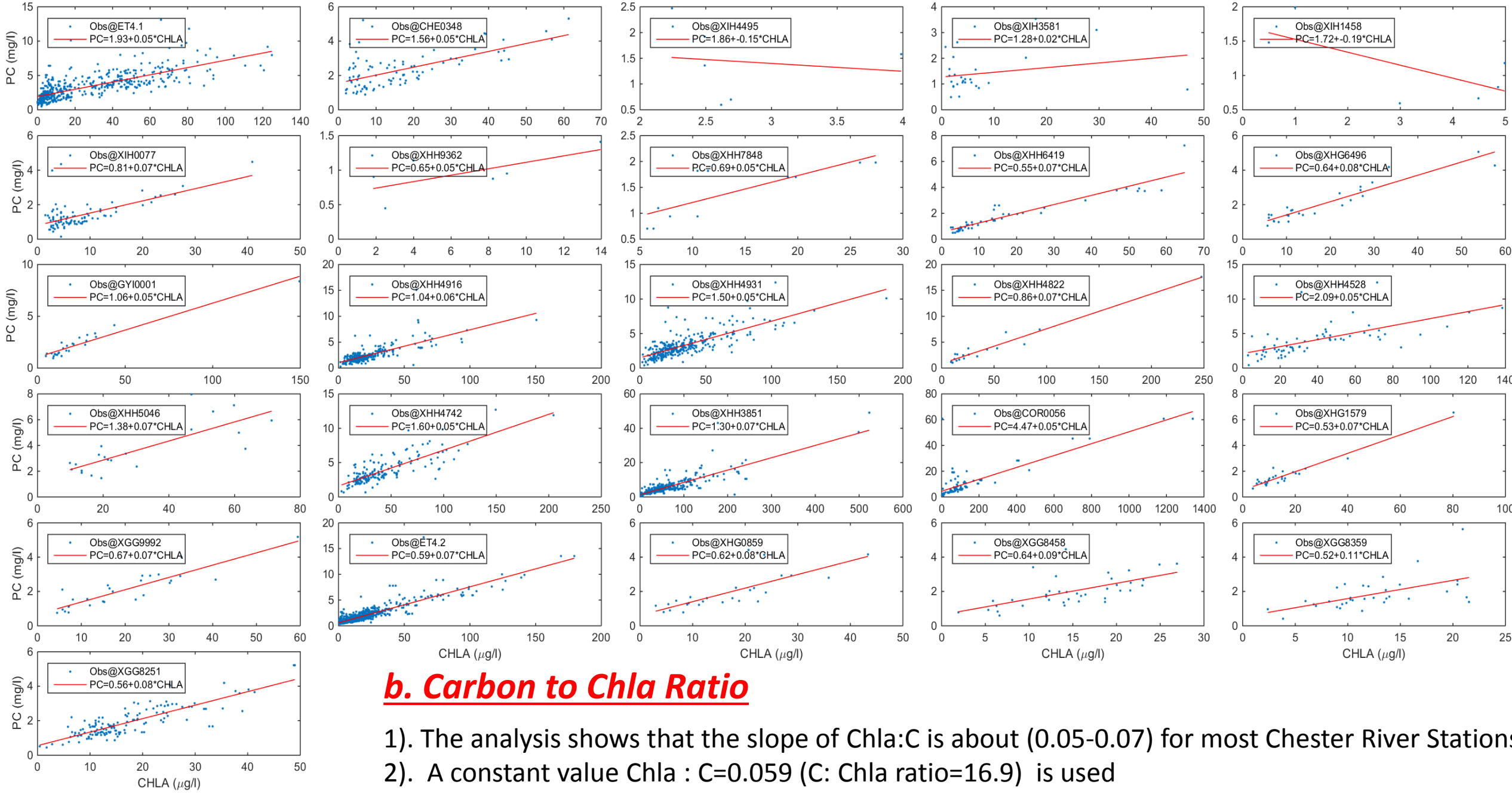


VIMS | William & Mary
Virginia Institute of Marine Science

II.2 Parameter specification

a. Optimal temperature for algal bloom





b. Carbon to Chla Ratio

1). The analysis shows that the slope of Chla:C is about (0.05-0.07) for most Chester River Stations

2). A constant value Chla : C=0.059 (C: Chla ratio=16.9) is used

c. Light attenuation

The formulation for light attenuation is as follows:

$$Ke = a_0 + a_1 * \mathrm{CHLA} + a_2 * \mathrm{TSS}$$

Ke: light attenuation (m^{-1})

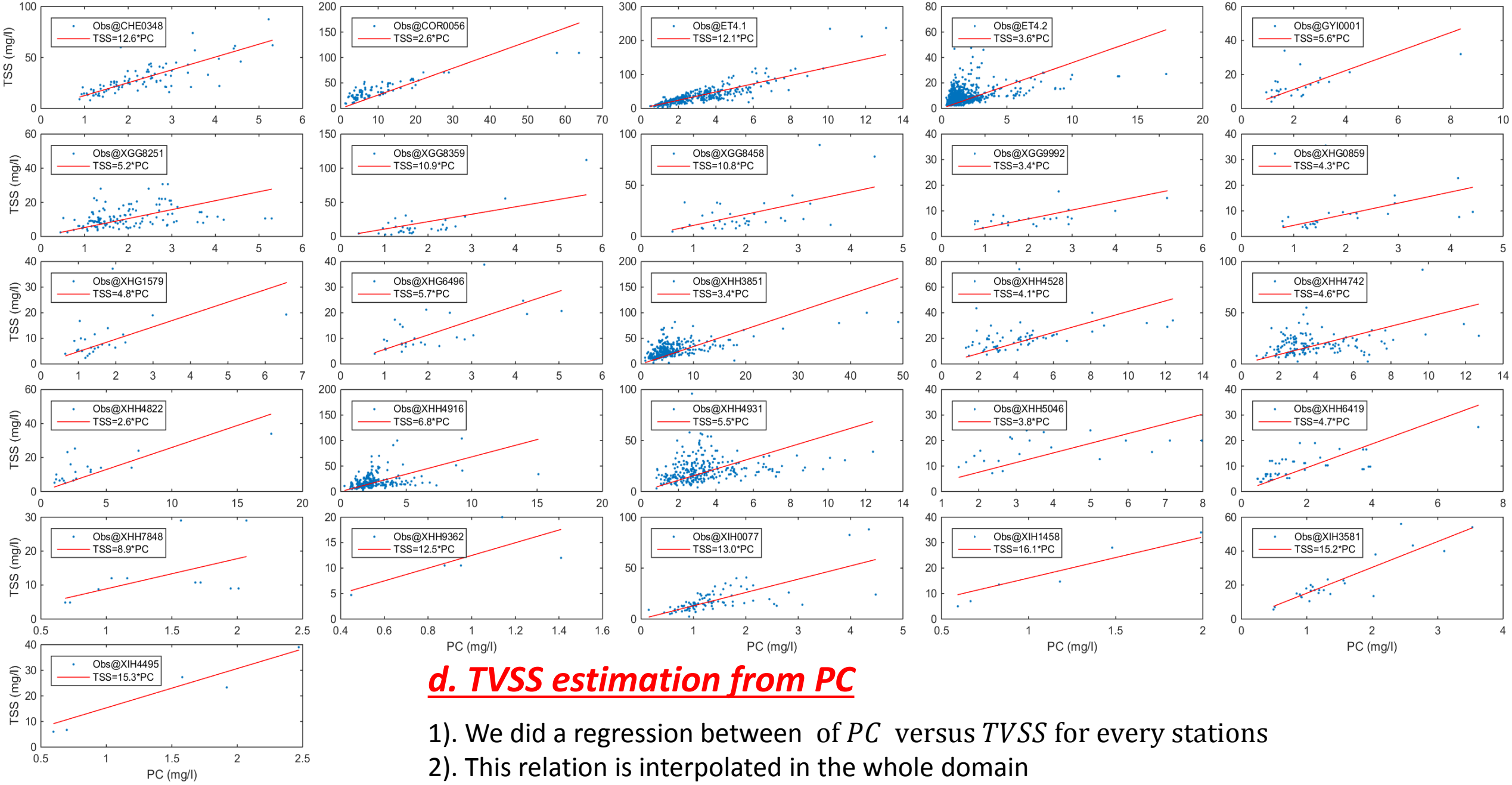
a_0: background attenuation (m^{-1})

a_1 : attenuation coefficient for CHLA ($\frac{m^2}{mg}$)

a_2 : attenuation coefficient for TSS ($\frac{m^2}{g}$)

where a0=0.26 ; a1=0.017; a2=0.07;

1) CHLA is calculated from the model.
2) TSS is estimated based by PC (particulate carbon)



d. TVSS estimation from PC

1). We did a regression between of PC versus $TVSS$ for every stations

2). This relation is interpolated in the whole domain

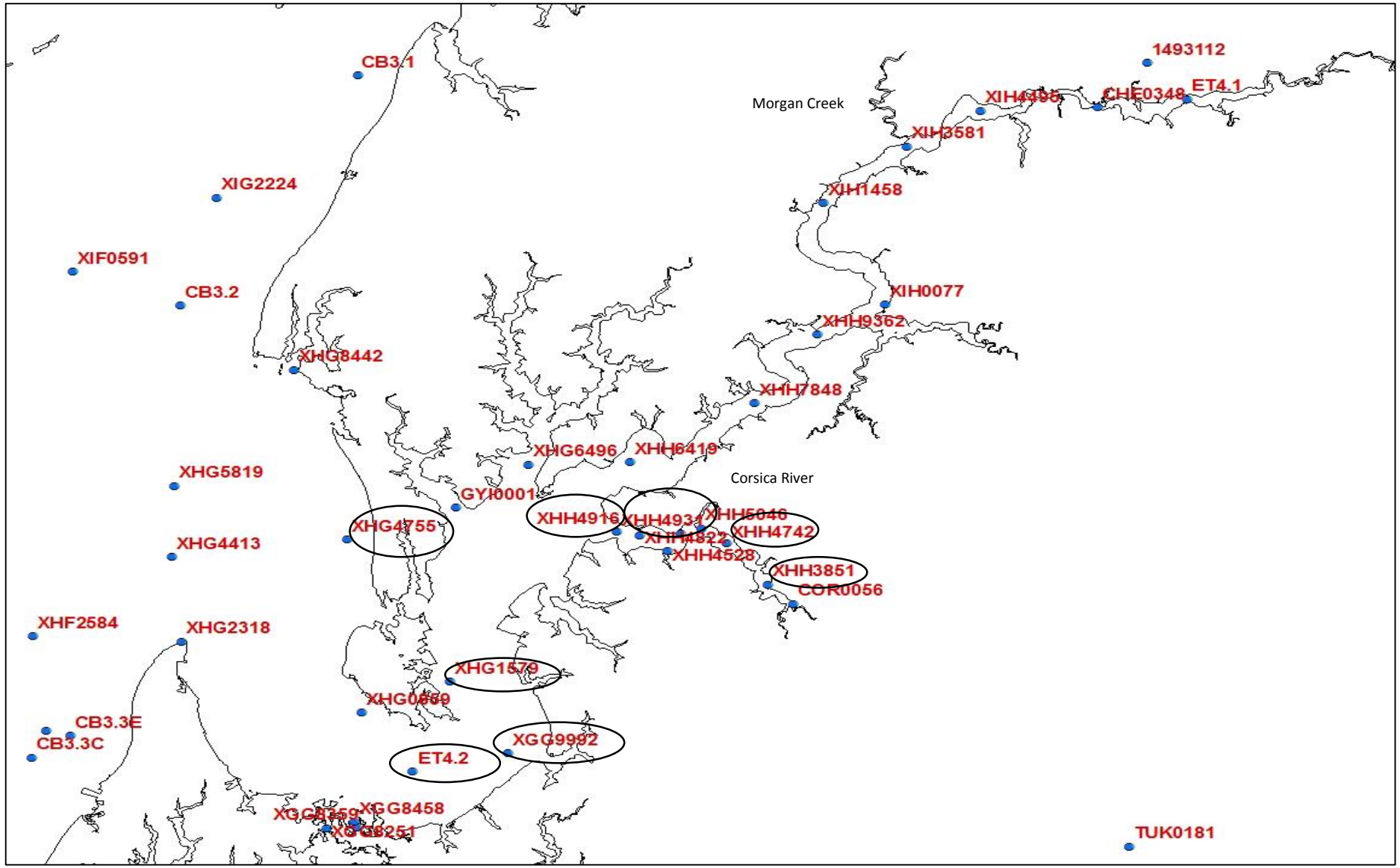
3)* Eventually, TSS will be provided by SCHISM sediment transport model directly

III. Water quality modeling results

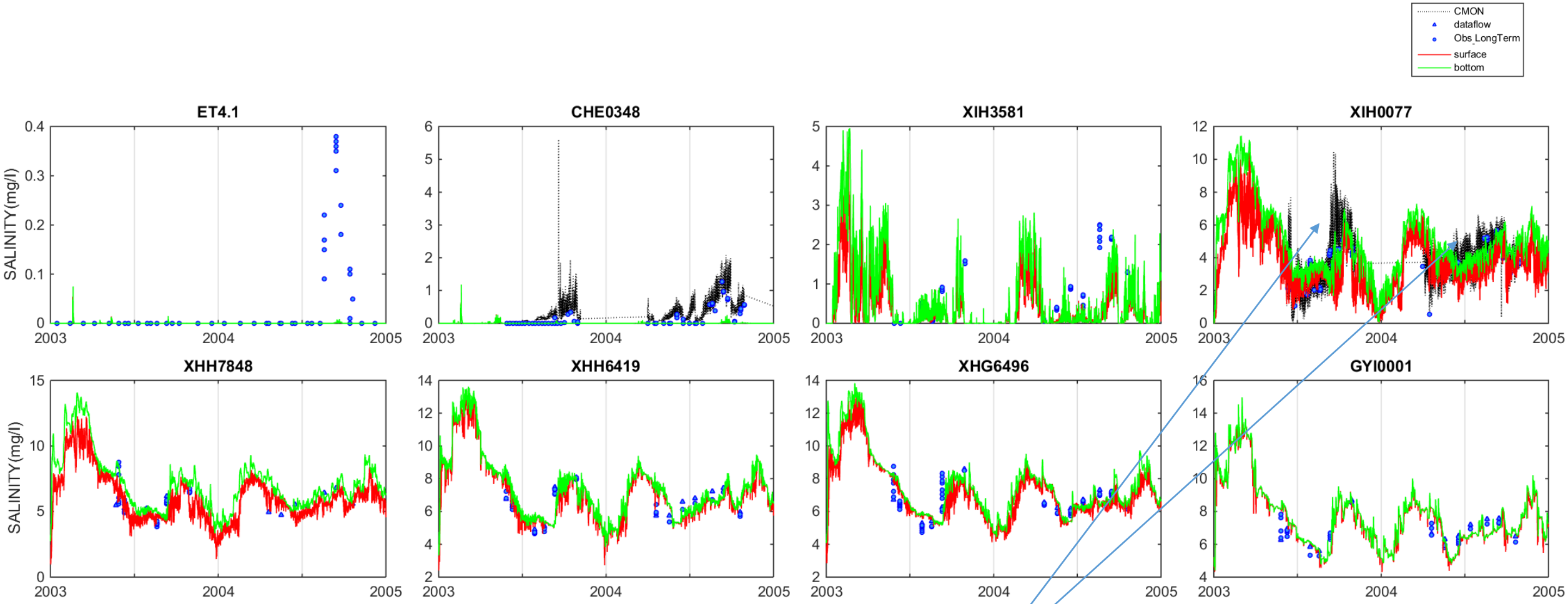
1. The water quality model is executed directly coupling with SCHISM. The time step used for both model is 120 sec.
2. Water quality model has been verified by simulating consecutive years of 2003 and 2004

Stations selected in Tidal fresh and middle Chester River stations

Stations selected in Corsica River and lower Chester River

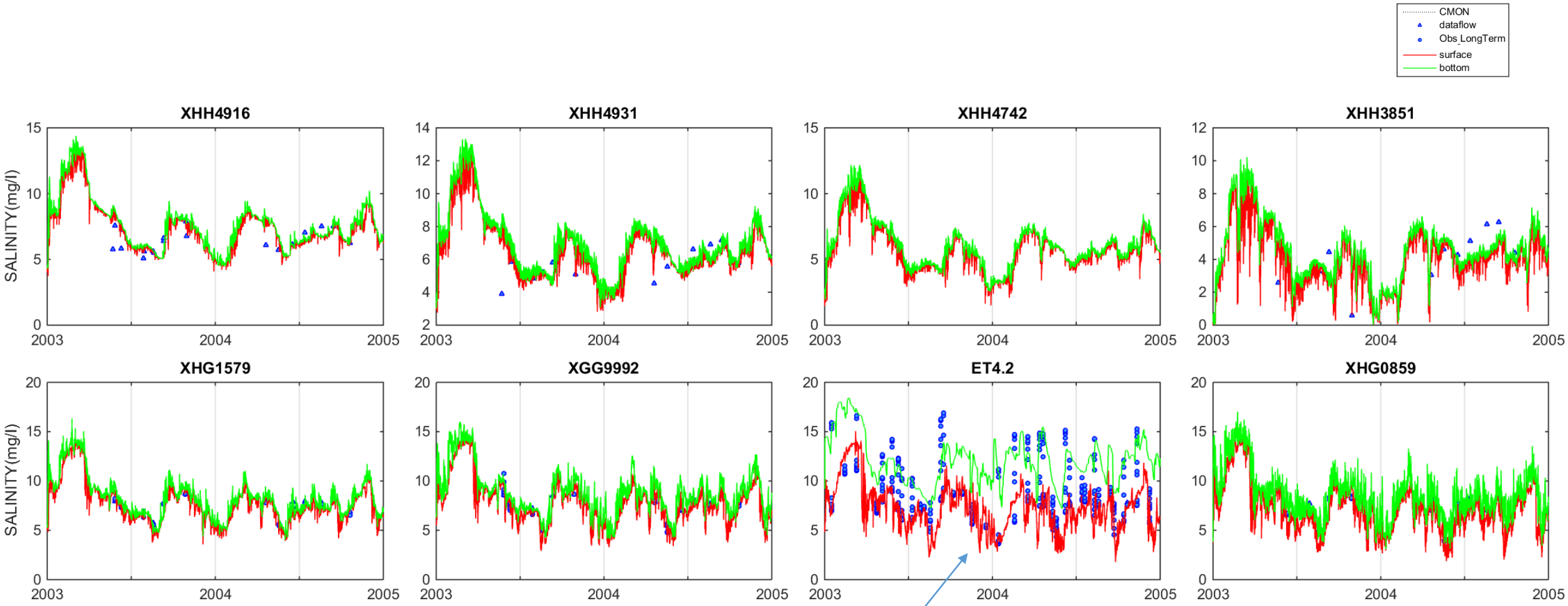


Salinity in the tidal fresh and middle Chester River



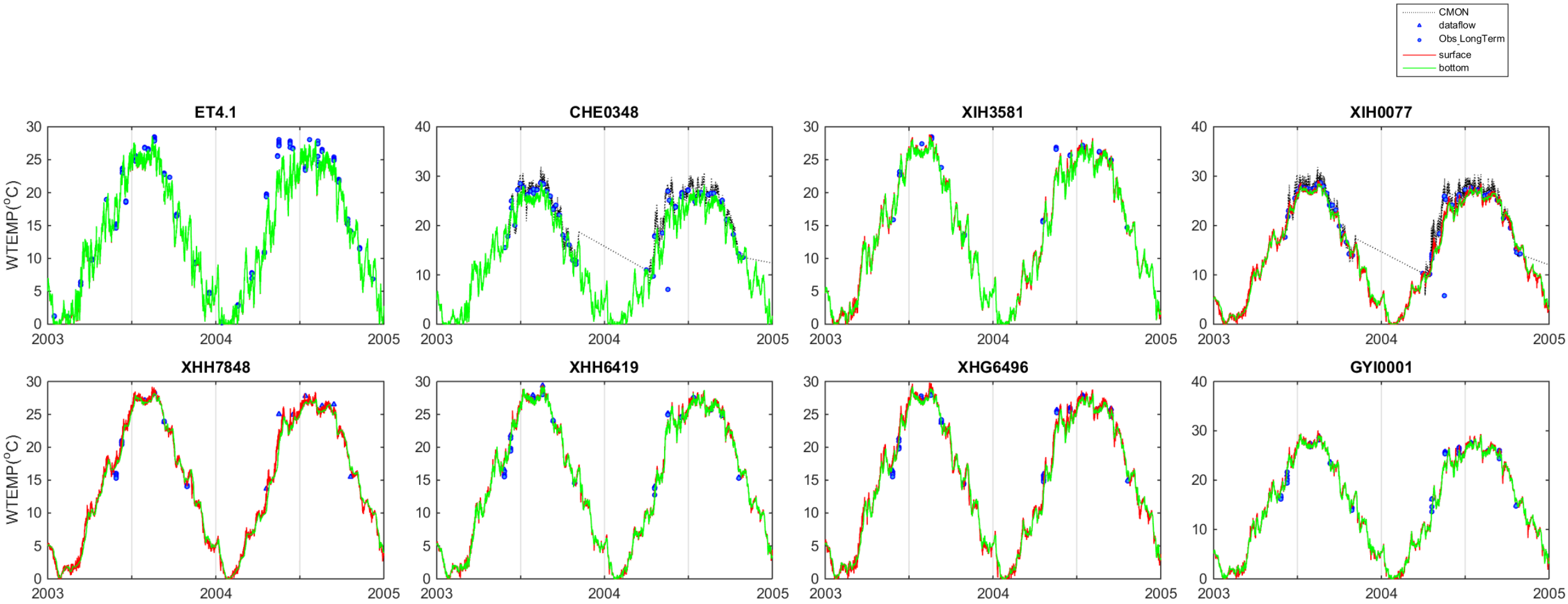
Salt intrusion prediction was better

Salinity in the Corsica River and lower Chester River

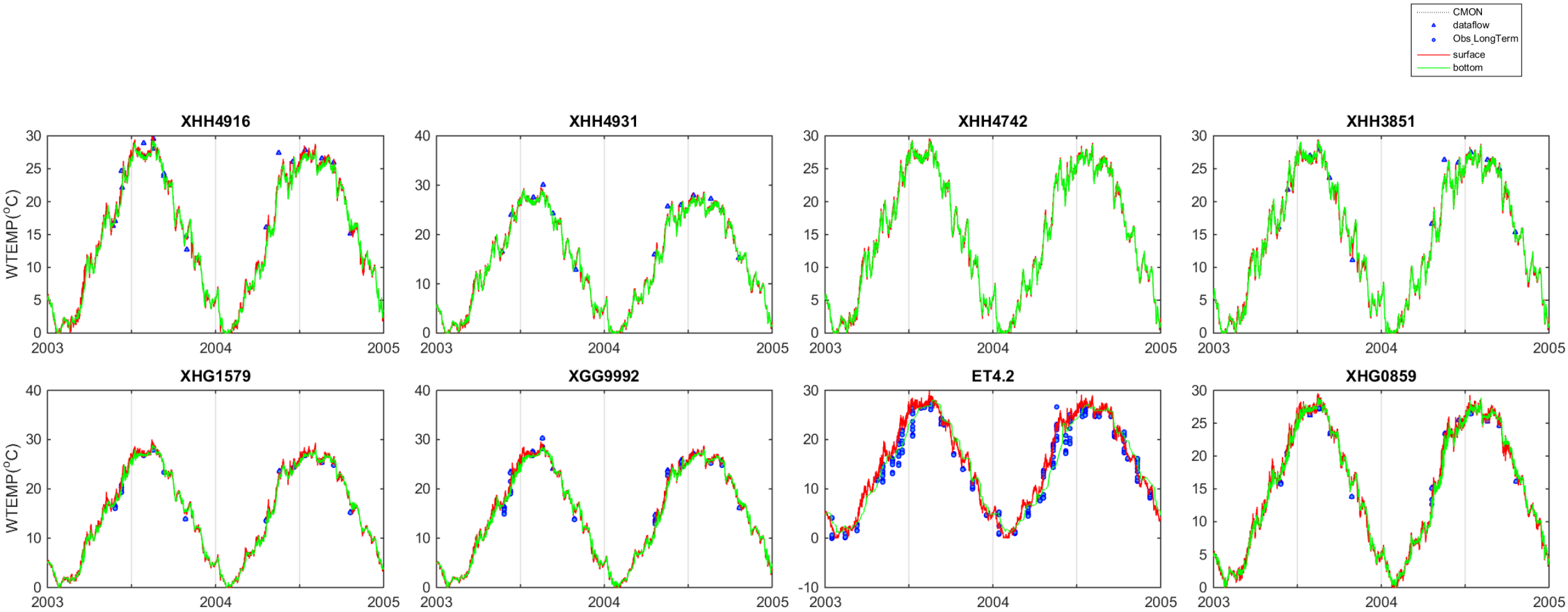


Salt intrusion prediction was better

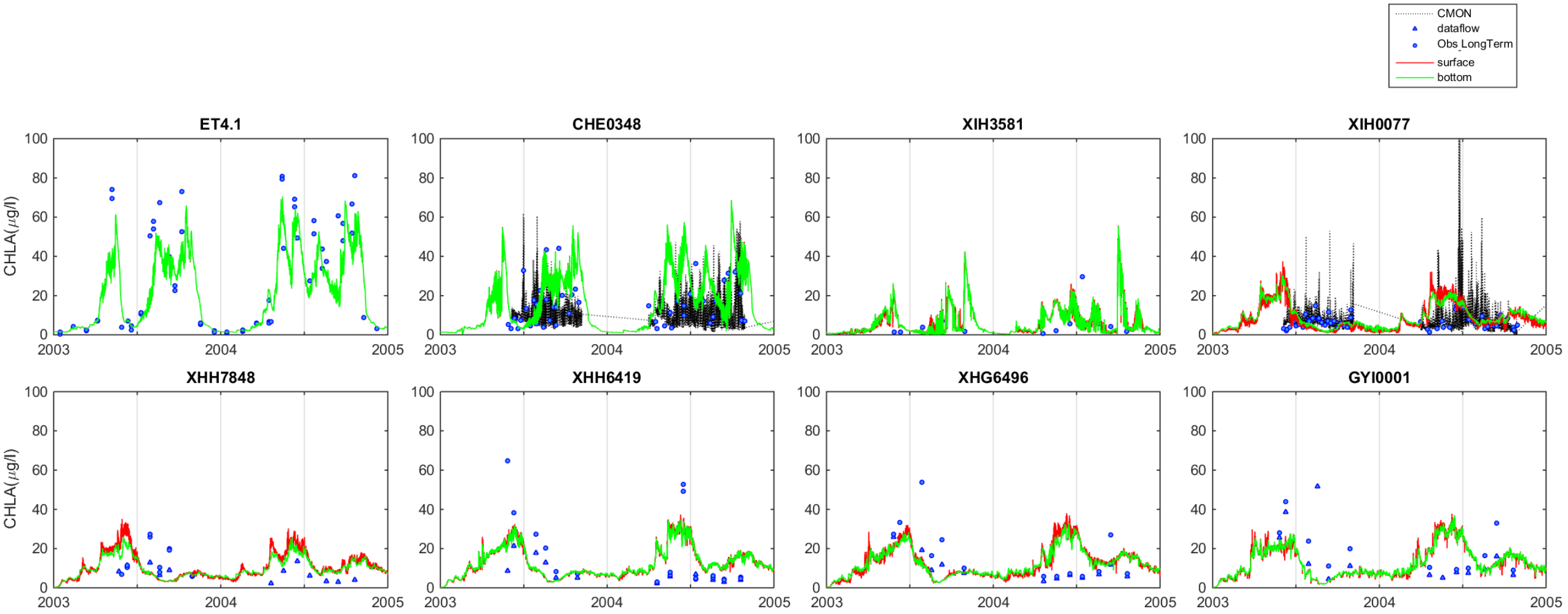
Temperature in the tidal fresh and middle Chester River



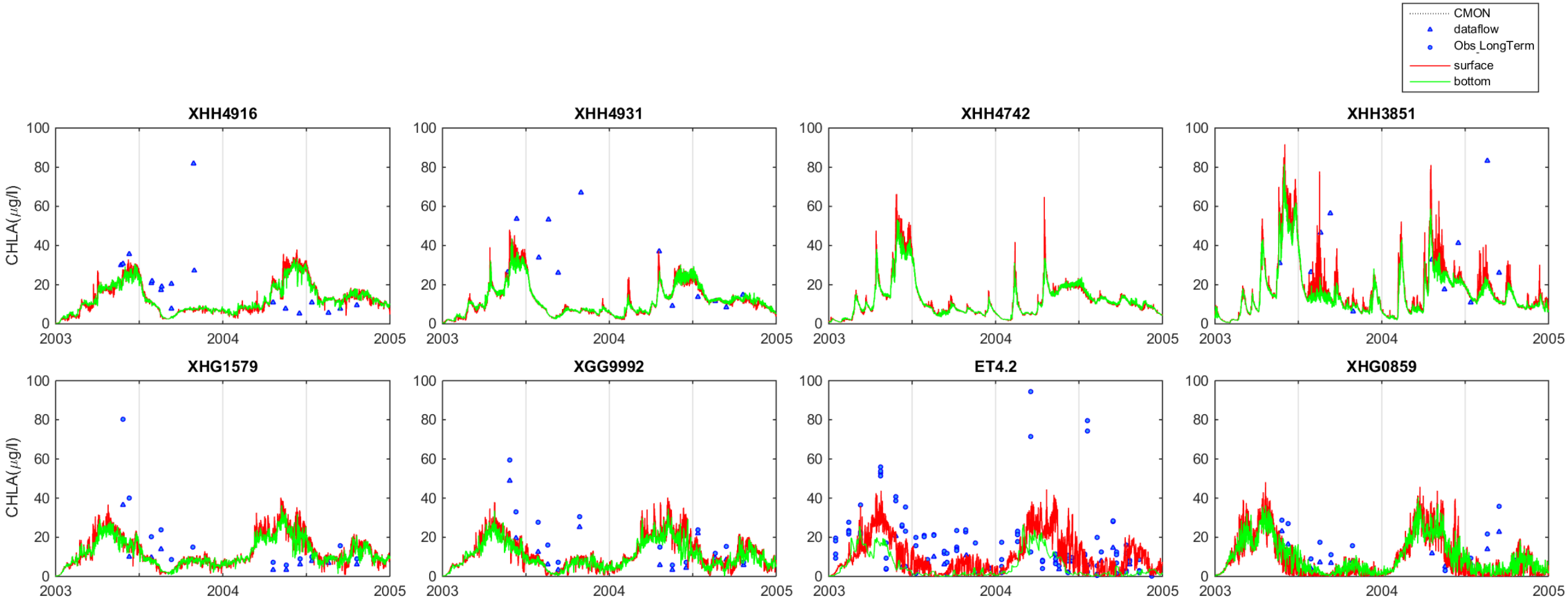
Temperature in the Corsica River and lower Chester River



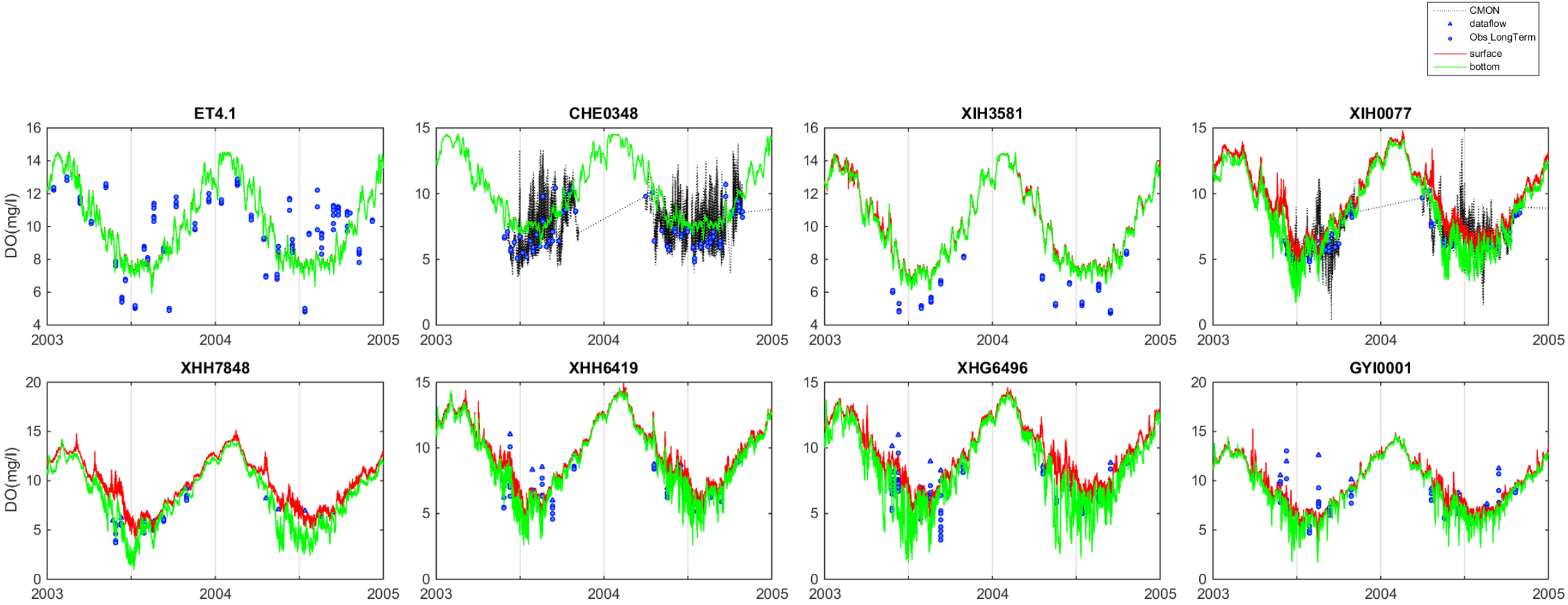
Chlorophyll in the tidal fresh and middle Chester River



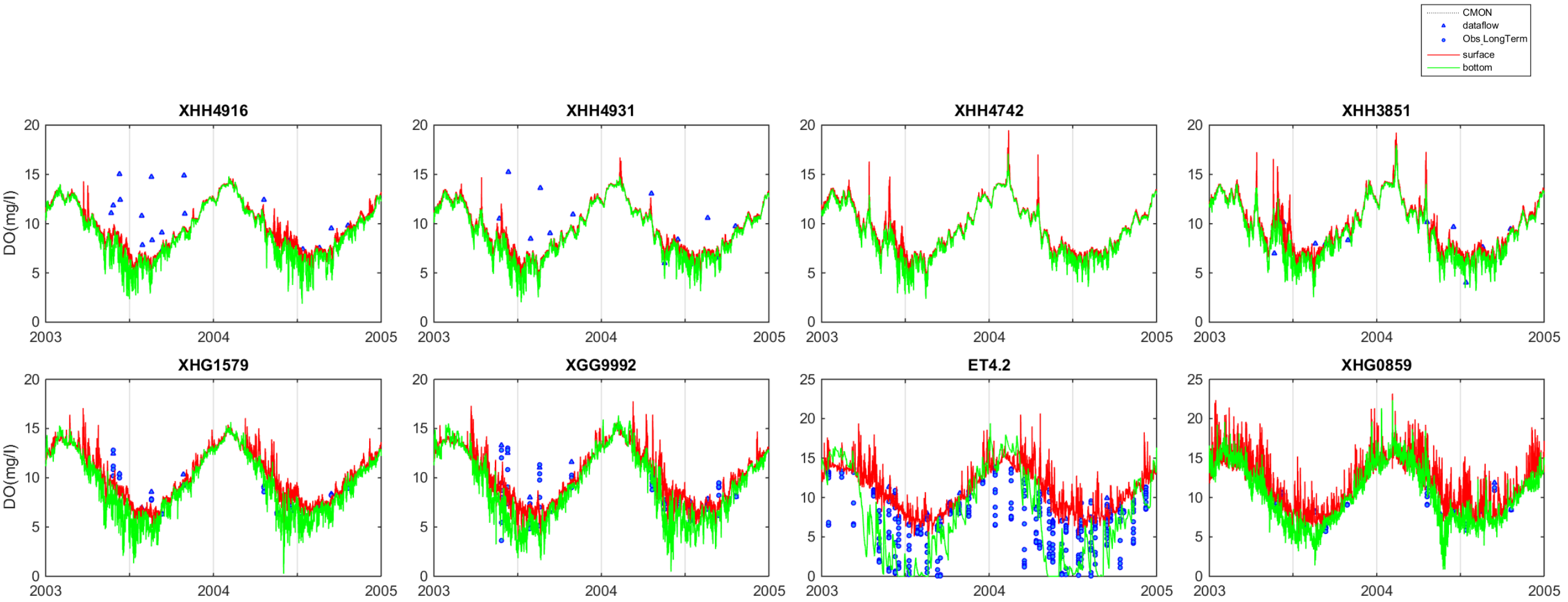
Chlorophyll in the Corsica River and lower Chester River



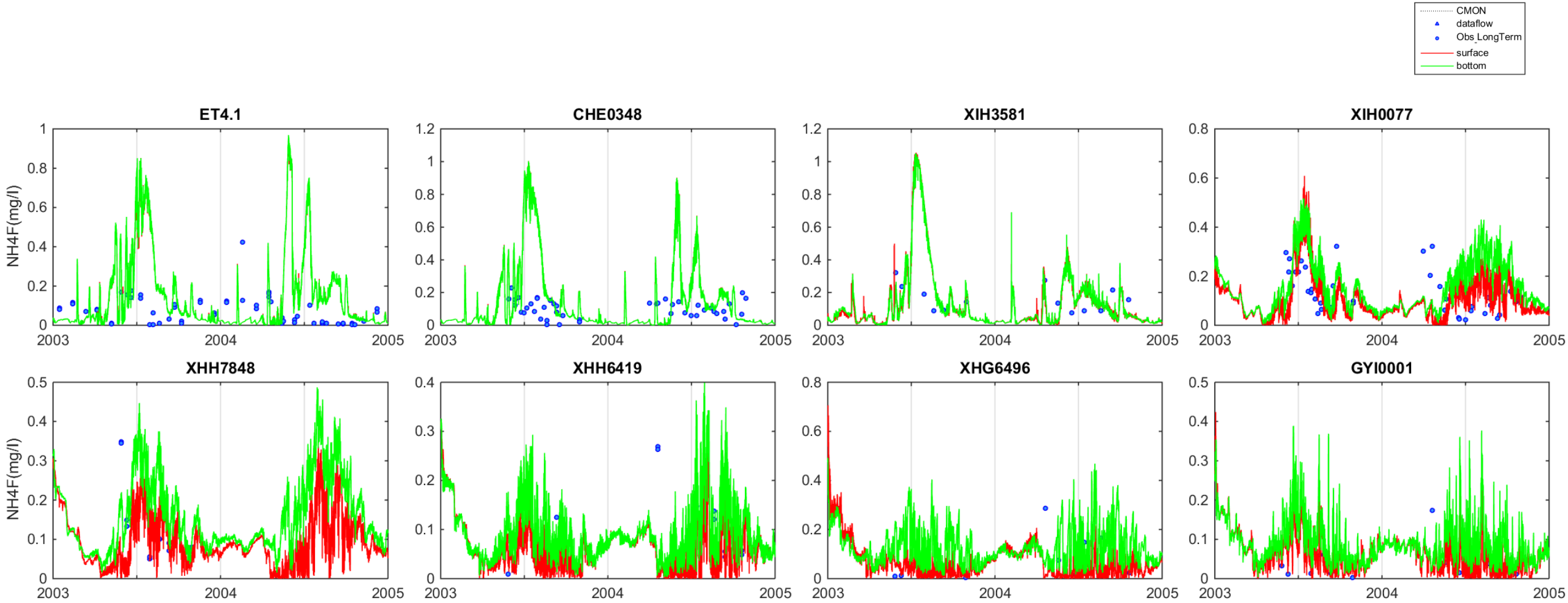
Dissolve oxygen in the tidal fresh and middle Chester River



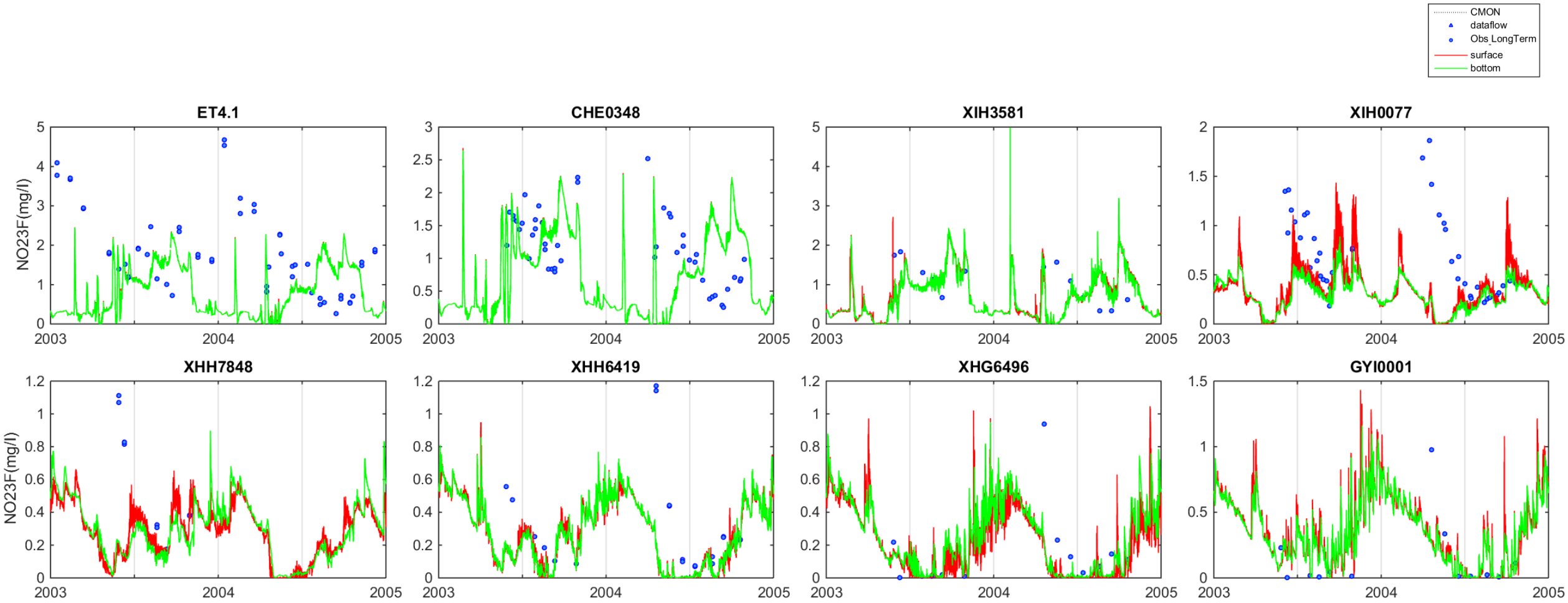
Dissolve oxygen in the Corsica River and lower Chester River



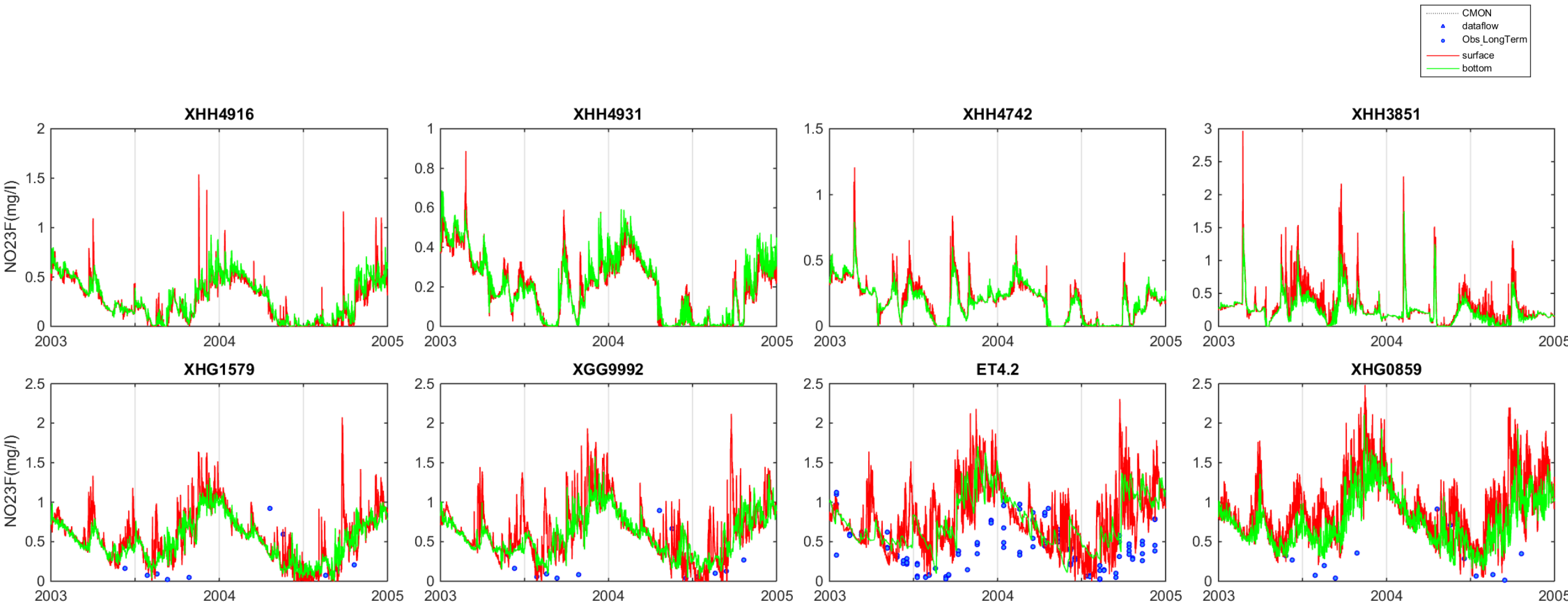
Ammonia in the tidal fresh and middle Chester River



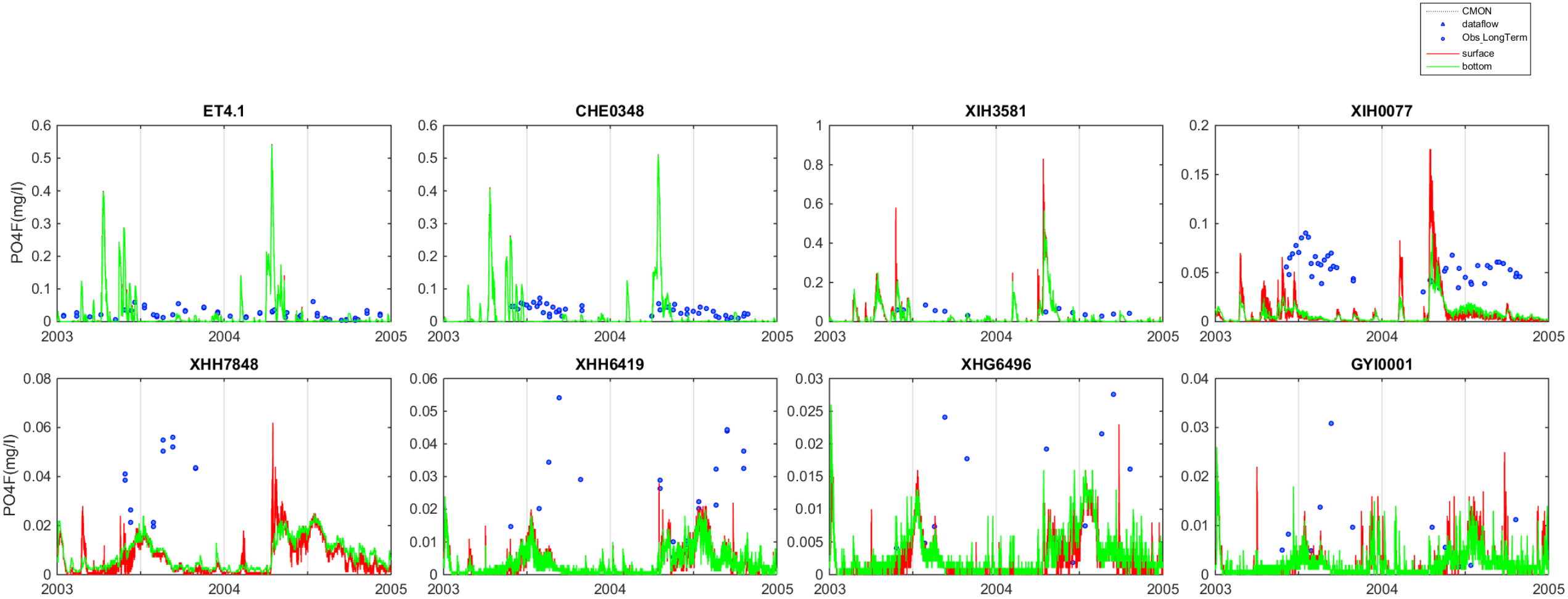
Nitrite/nitrate in the tidal fresh and middle Chester River



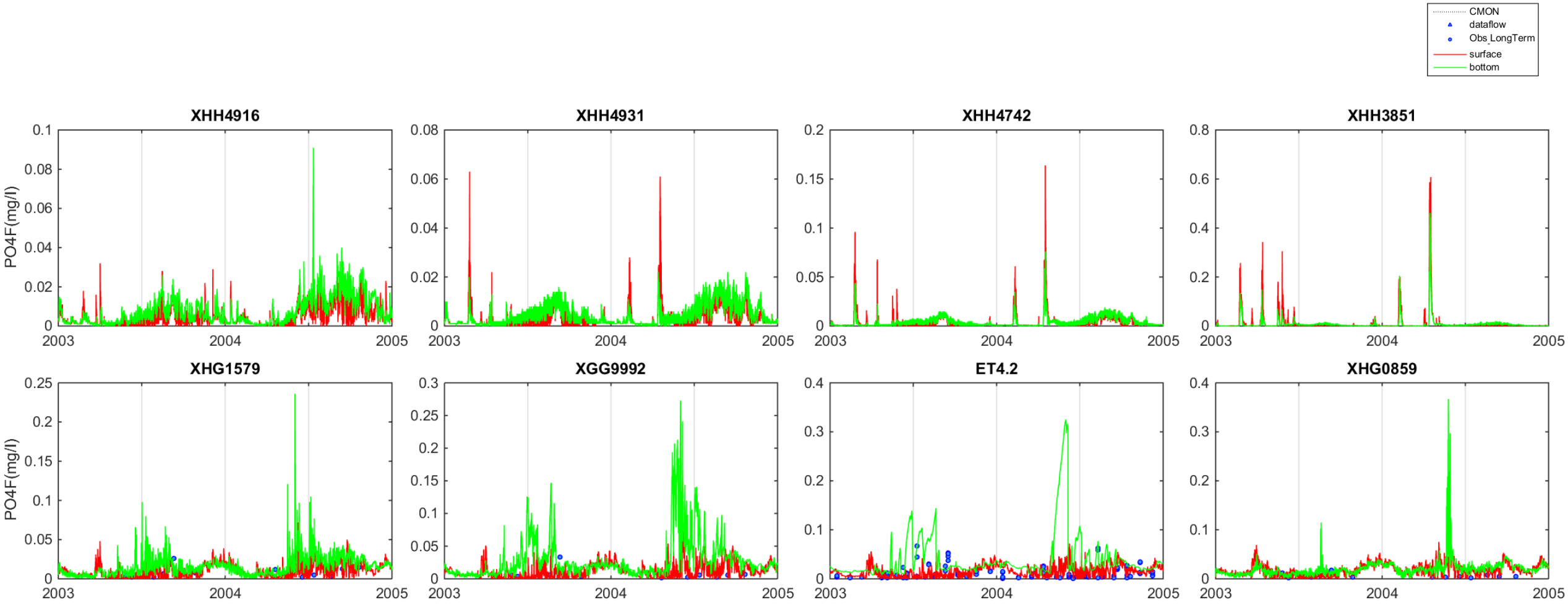
Nitrite/nitrate in the Corsica River and lower Chester River



Phosphate in the tidal fresh and middle Chester River

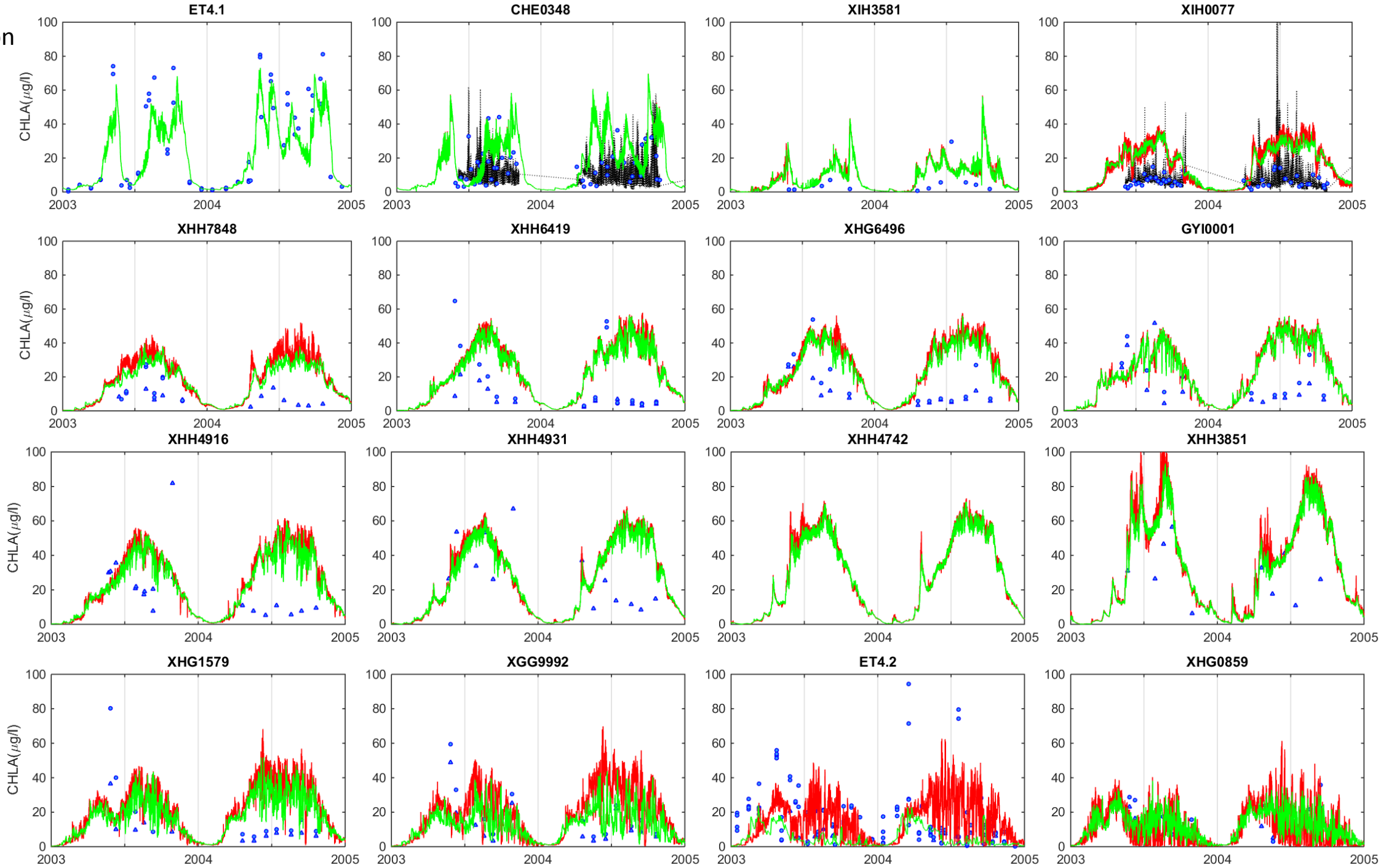


Phosphate in the Corsica River and lower Chester River



*Improvement on chlorophyll prediction :

BEFORE



Improvement on chlorophyll prediction:

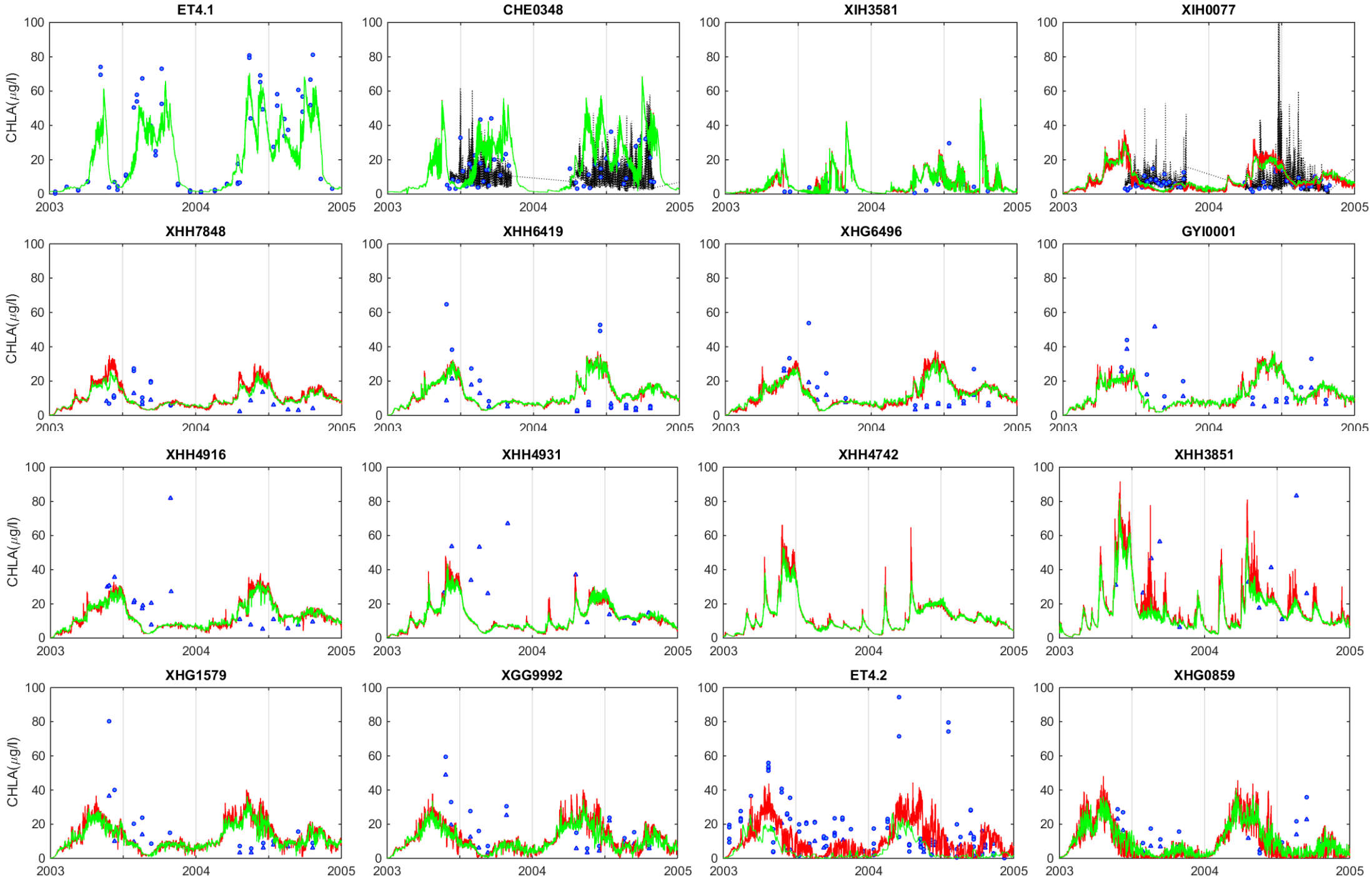
AFTER

Controlling Factors:

1. Adjusted optimal temperature for algal growth rate

2. Salinity toxicity applied on Cyano-bacteria

3. Increase discharge at Morgan creek by 50% (simulating groundwater contribution)



IV. Computation performance and future work

1). Total model grid node number: 9234, element number: 12737
2). Run time: 2-year simulation 56 hours using 48 parallel processors.
3). Facility: HPC cluster of College of William and Mary. Processor type: Xeon X5672; peak performance of 15 teraflops.

For more information: http://www.hpc.wm.edu/SciCloneTutorials/WhJTF

Future work:

1. Further improving phosphorus concentration simulation
2. Obtaining the sediment concentration for the water quality directly from hydrodynamic sediment transport model
3. Complete all the simulation years operationally

VIMS | William & Mary
Virginia Institute of Marine Science
1940-2015 75 Years