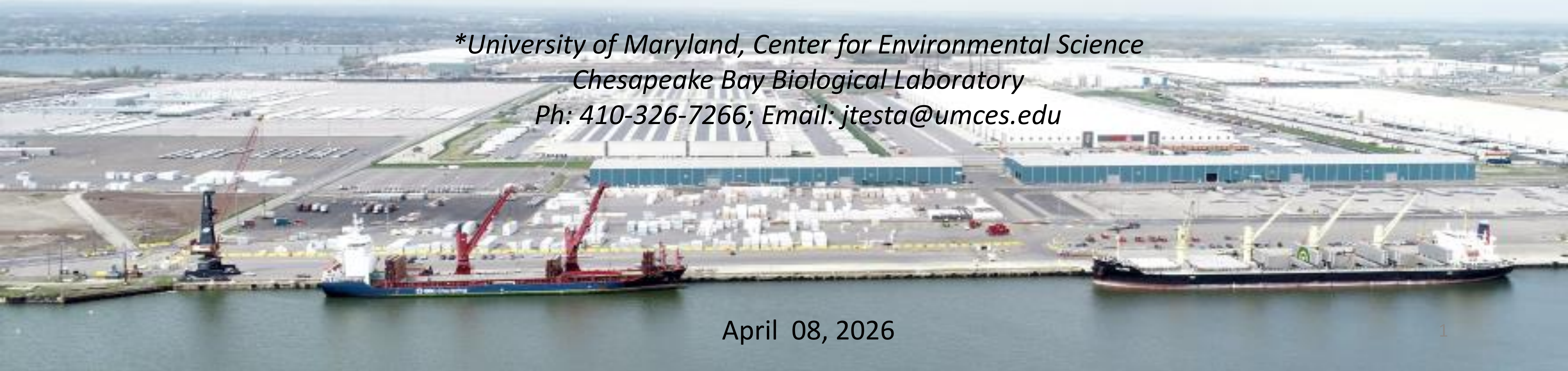
# Review of progress for 2th Quarter of Year 2 on the Patapsco/Back MTM Program


Harry Wang, *Jeremy Testa, Breanna Maldonado, and David Forrest

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

**University of Maryland, Center for Environmental Science*
*Chesapeake Bay Biological Laboratory*
*Ph: 410-326-7266; Email: jtesta@umces.edu*

April 08, 2026

# Outline:

I. MTM Updated – SCHISM (v5.x), phase 7 loading, partition coefficient for phytoplankton matter goes to C, N, P etc.

II. Calibration 1 – Hybrid phase 6 versus phase 7

III. Calibration 2 – Subcycle = 12 (MBM) versus 24 (MTM) for stability condition

IV. The pH-mediated phosphorus release – a data-driven approach

V. Summary

# I. MTM Patapsco/Back River updated

As MBM's calibration has extensively refined, so has MTM's calibration.

(A) SCHISM (v5.10): upgraded version of SCHISM with a new input xxx.nml and recommended compiling with –O2 optimization

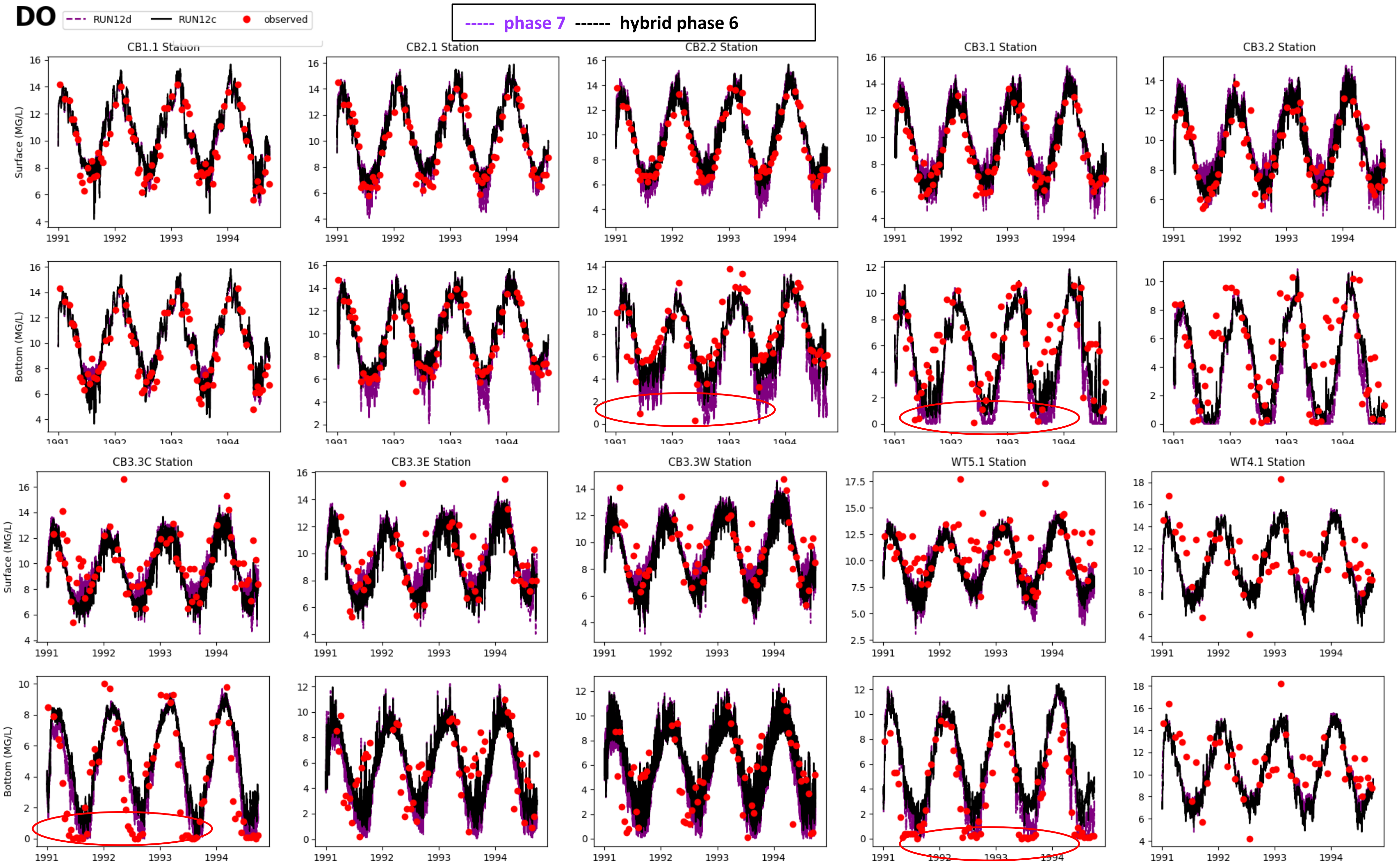
(B) SAV is included in physical modeling for simulating form-drag associated with vegetation in the Upper Chesapeake Bay

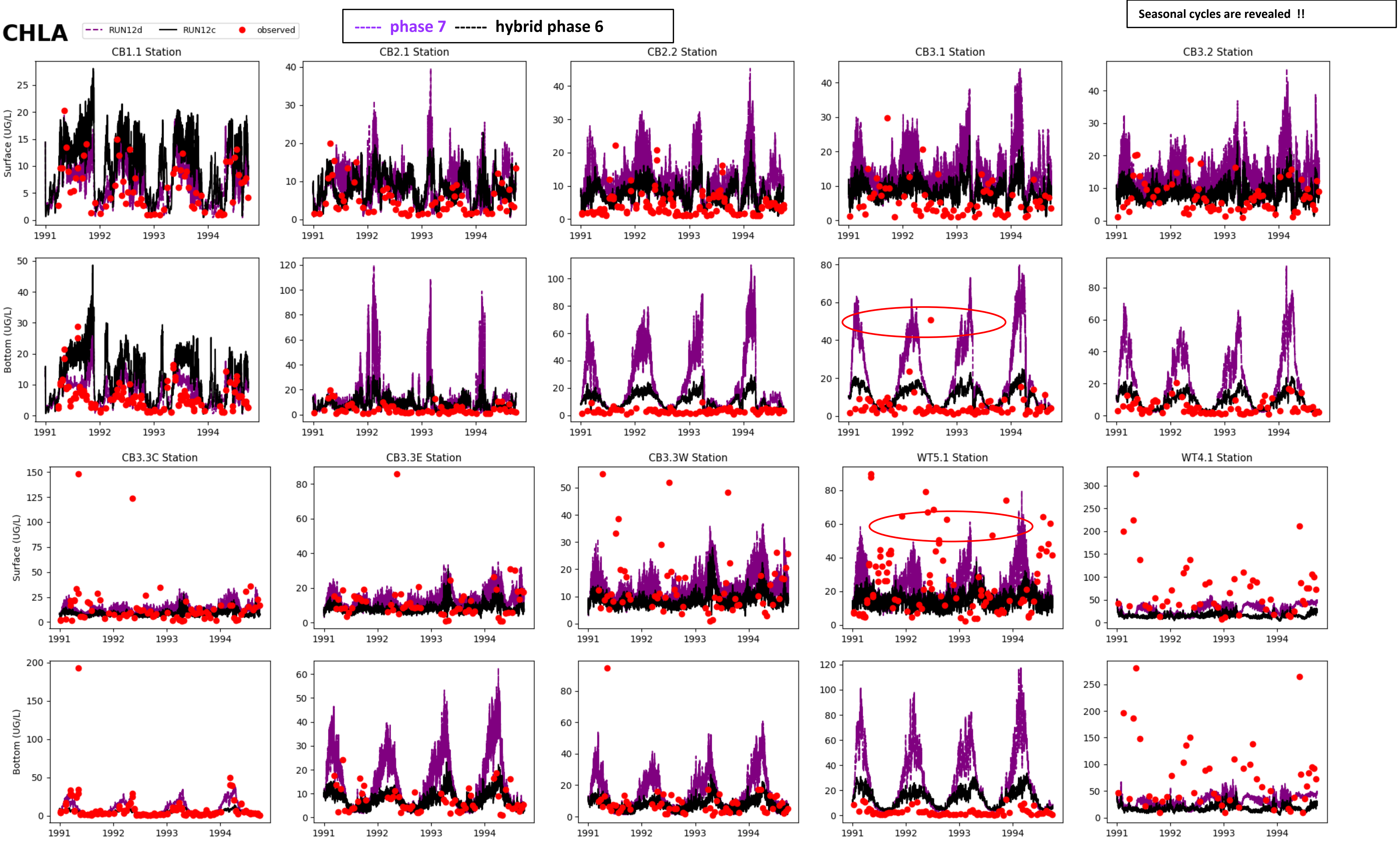
(C) Updated watershed Loading from hybrid Phase 6 to Phase 7

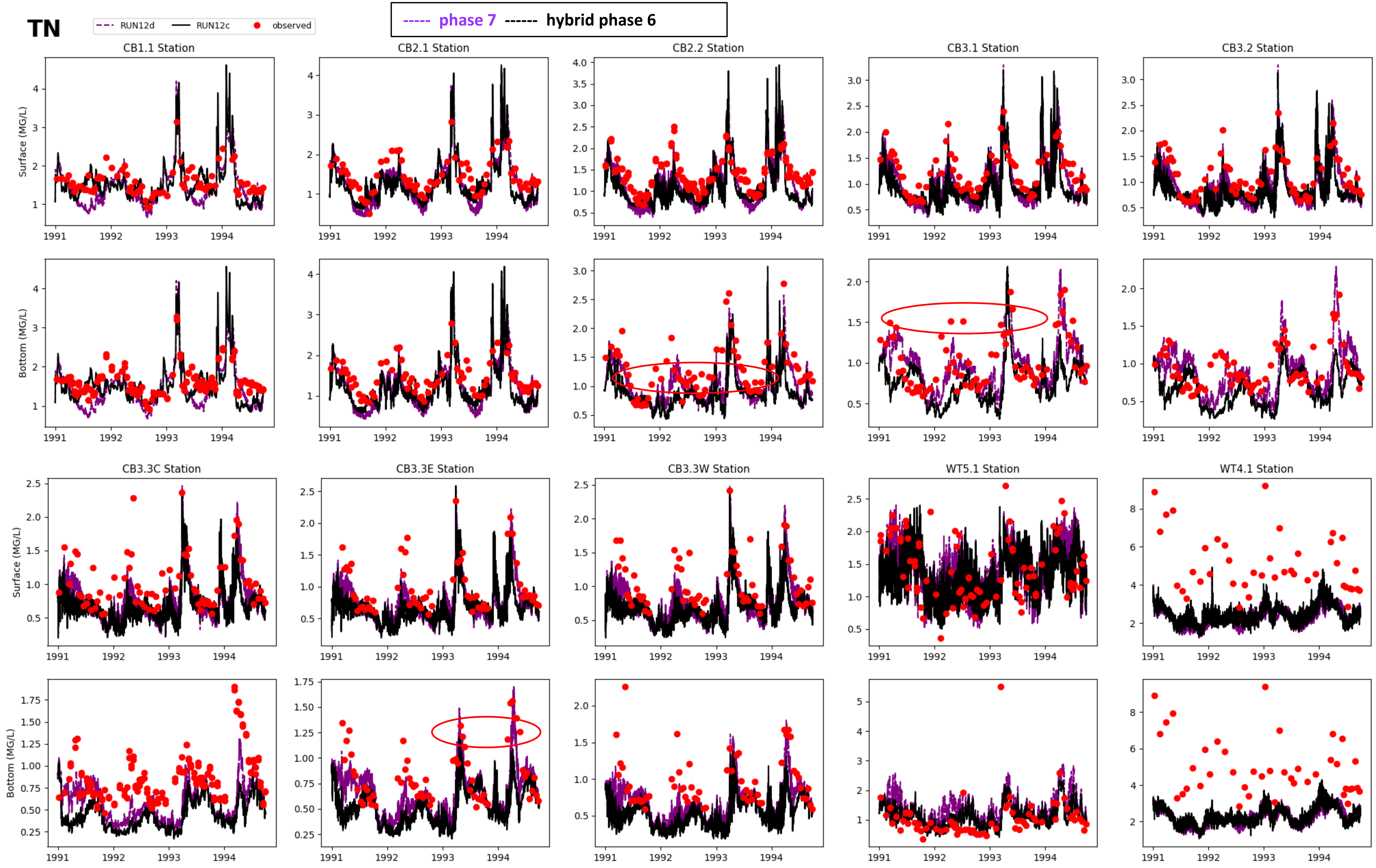
(D) As part of the MBM effort, MTM is provided with updated water quality open boundary condition

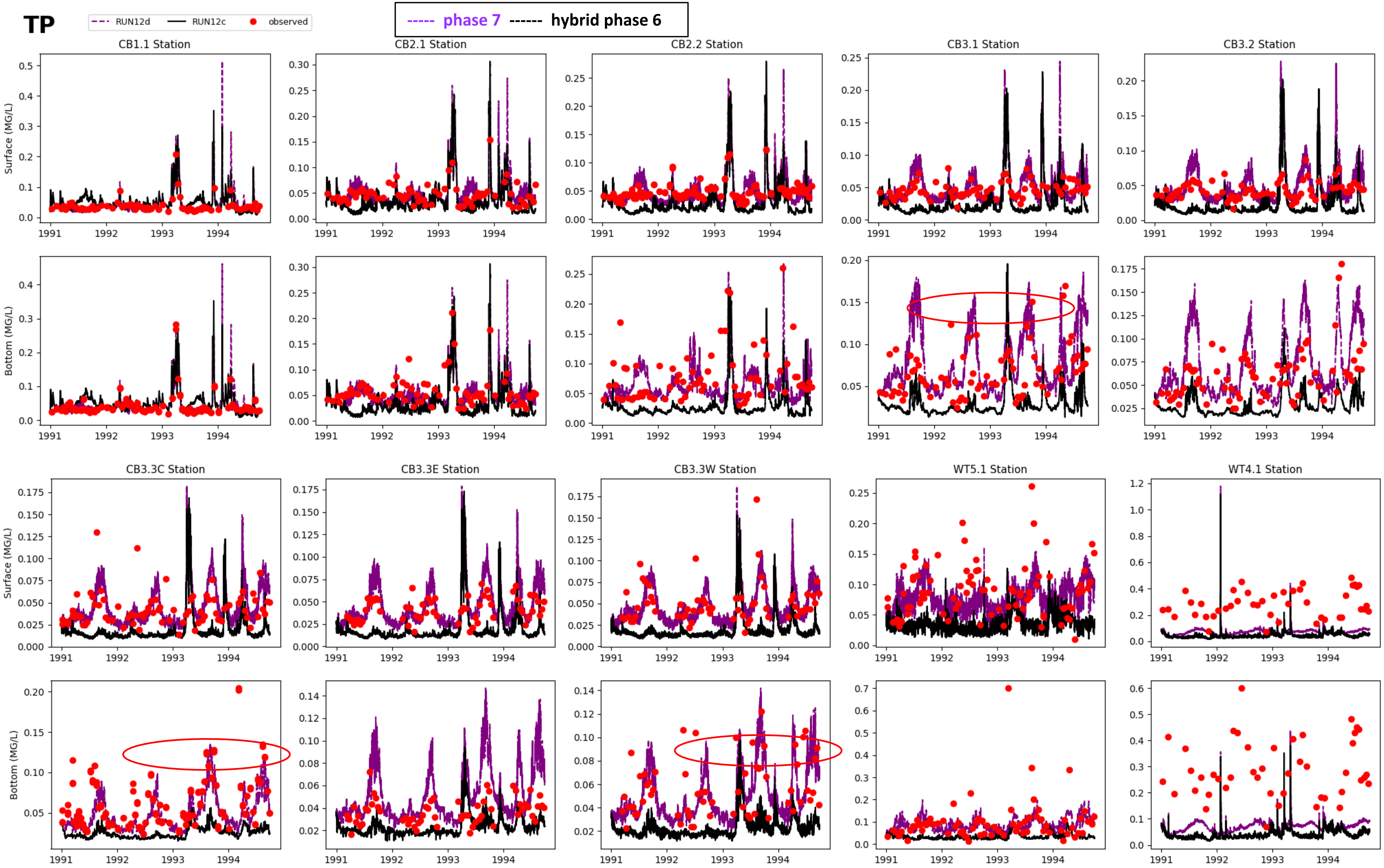
(E) In water quality modeling, the partition coefficient from phytoplankton matter to C, N, P is refined.

# II. Calibration 1 – Hybrid phase 6 versus phase 7



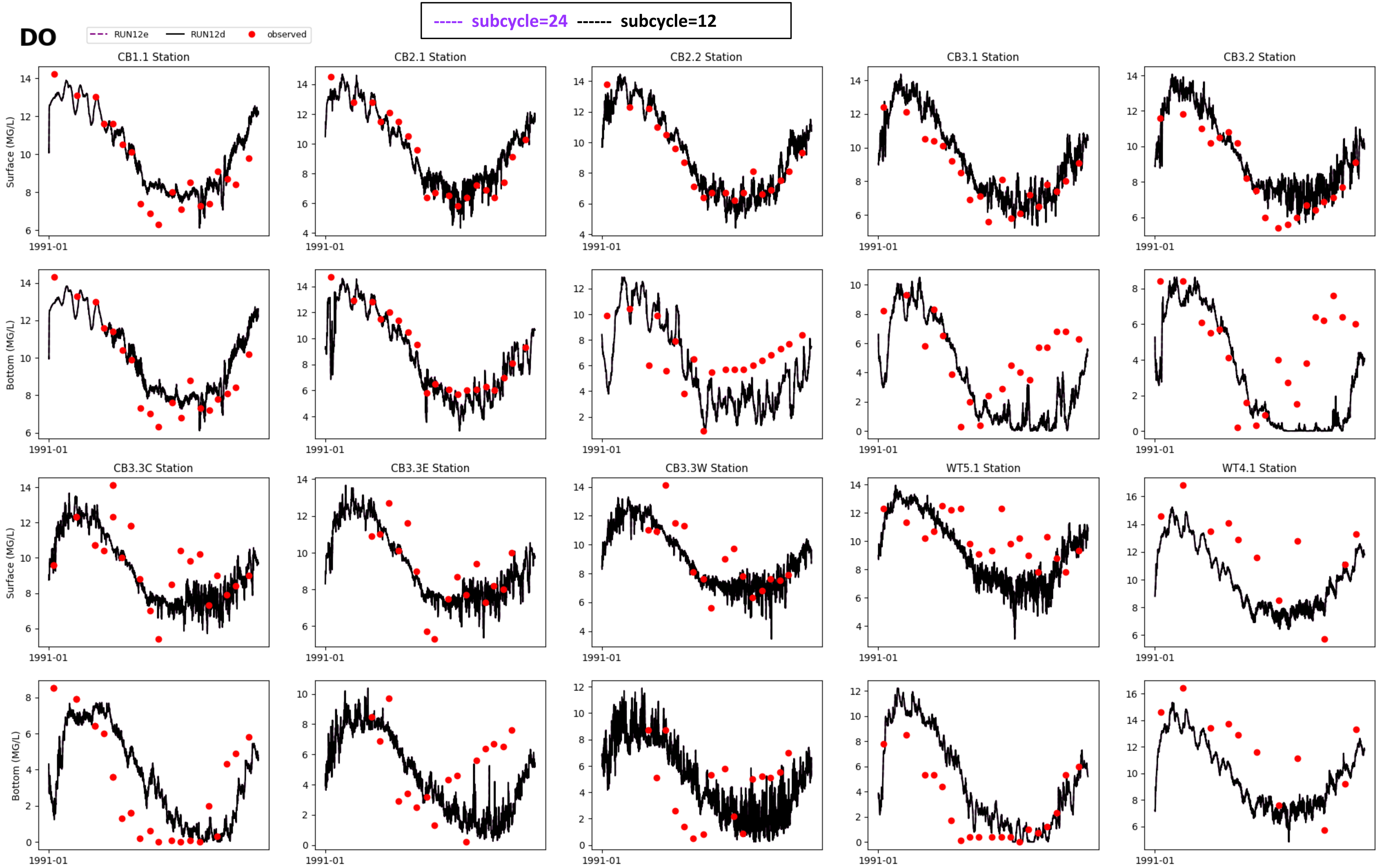

CHLA
RUN12d
RUN12c
observed
----- phase 7 ------ hybrid phase 6
Seasonal cycles are revealed !!
CB1.1 Station
CB2.1 Station
CB2.2 Station
CB3.1 Station
CB3.2 Station
CB3.3C Station
CB3.3E Station
CB3.3W Station
WT5.1 Station
WT4.1 Station
Surface (UG/L)
Bottom (UG/L)
1991
1992
1993
1994

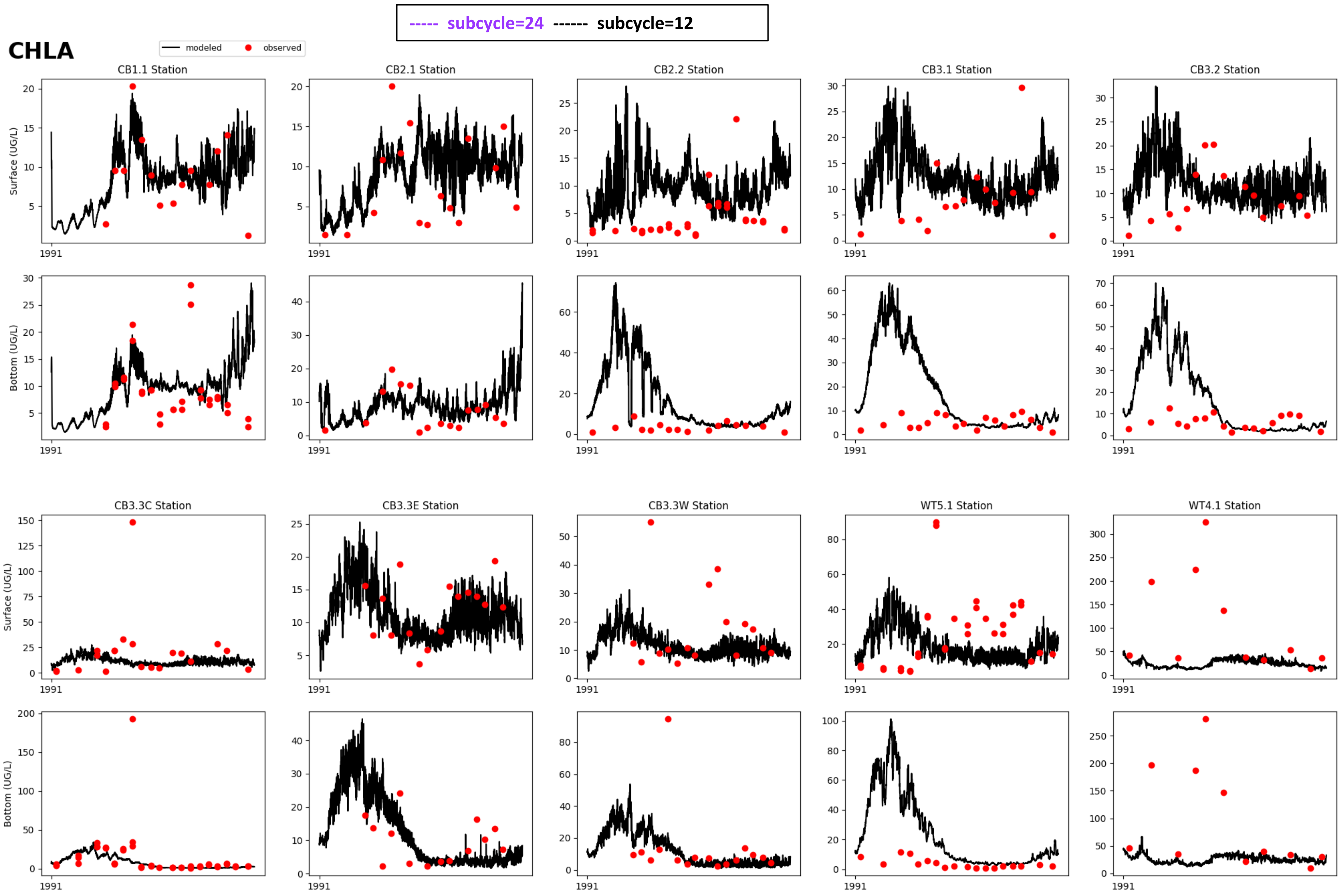

TN
RUN12d
RUN12c
observed
----- phase 7 ------ hybrid phase 6
CB1.1 Station
CB2.1 Station
CB2.2 Station
CB3.1 Station
CB3.2 Station
CB3.3C Station
CB3.3E Station
CB3.3W Station
WT5.1 Station
WT4.1 Station
Surface (MG/L)
Bottom (MG/L)
1991
1992
1993
1994

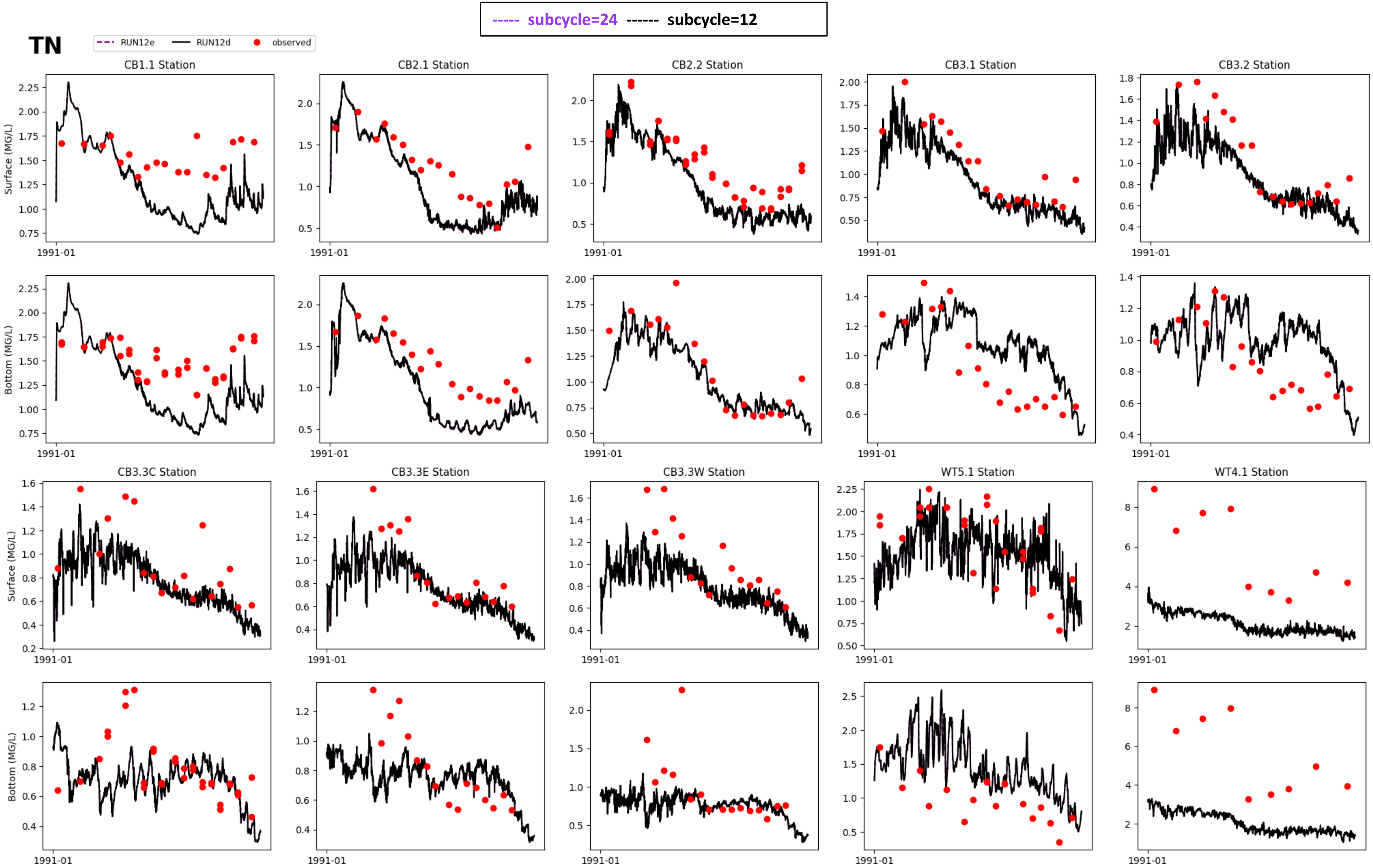


TP
RUN12d
RUN12c
observed
----- phase 7 ------ hybrid phase 6
CB1.1 Station
CB2.1 Station
CB2.2 Station
CB3.1 Station
CB3.2 Station
CB3.3C Station
CB3.3E Station
CB3.3W Station
WT5.1 Station
WT4.1 Station
Surface (MG/L)
Bottom (MG/L)
1991
1992
1993
1994

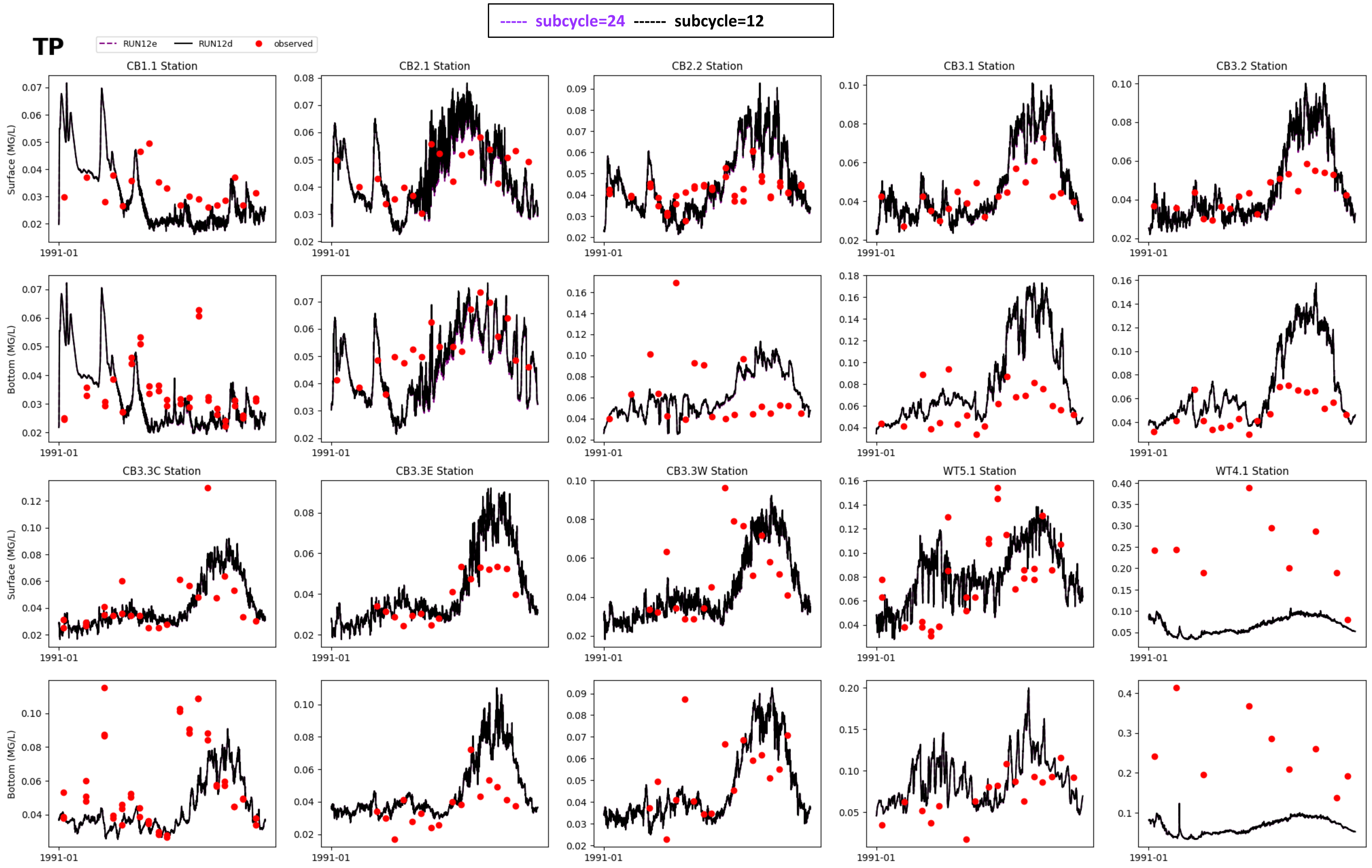
# III. Calibration 2 – Subcycle = 12 (MBM) versus 24 (MTM) – for stability condition




----- subcycle=24 ------ subcycle=12
CHLA
modeled
observed
CB1.1 Station
CB2.1 Station
CB2.2 Station
CB3.1 Station
CB3.2 Station
Surface (UG/L)
Bottom (UG/L)
CB3.3C Station
CB3.3E Station
CB3.3W Station
WT5.1 Station
WT4.1 Station
Surface (UG/L)
Bottom (UG/L)
1991



----- subcycle=24 ------ subcycle=12
TN
RUN12e
RUN12d
observed
CB1.1 Station
CB2.1 Station
CB2.2 Station
CB3.1 Station
CB3.2 Station
CB3.3C Station
CB3.3E Station
CB3.3W Station
WT5.1 Station
WT4.1 Station
Surface (MG/L)
Bottom (MG/L)
1991-01



----- subcycle=24 ------ subcycle=12
TP
RUN12e
RUN12d
observed
CB1.1 Station
CB2.1 Station
CB2.2 Station
CB3.1 Station
CB3.2 Station
CB3.3C Station
CB3.3E Station
CB3.3W Station
WT5.1 Station
WT4.1 Station
Surface (MG/L)
Bottom (MG/L)
1991-01

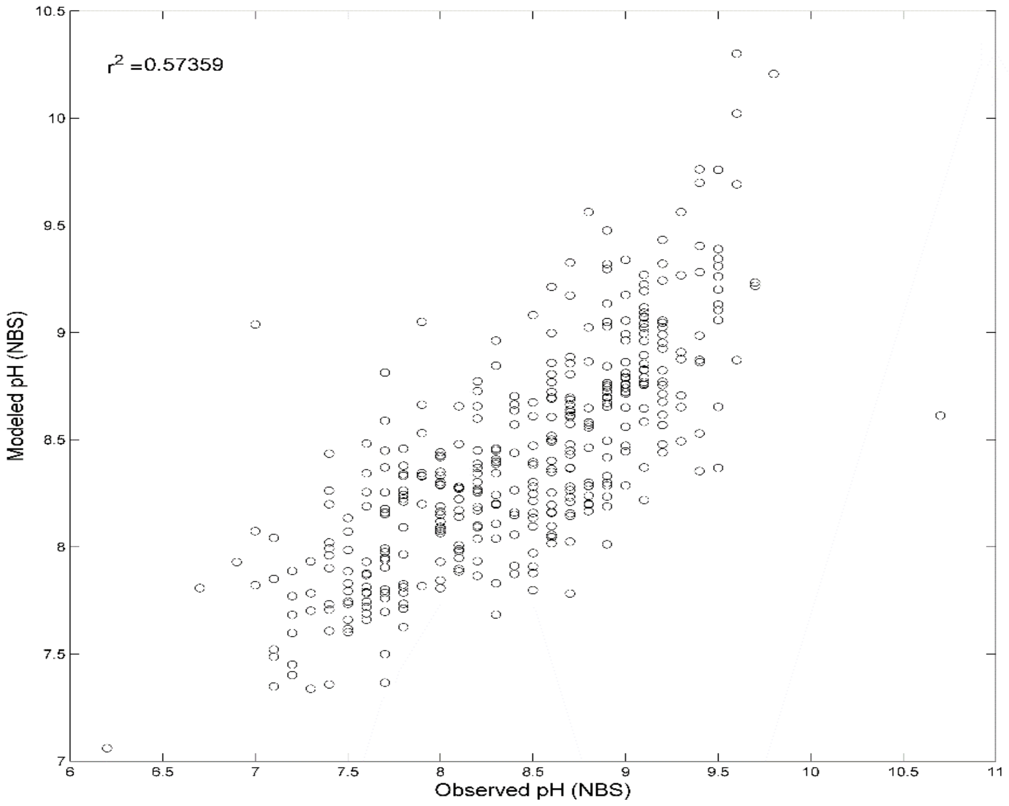
# IV. The pH-mediated phosphorus release – a data-driven approach

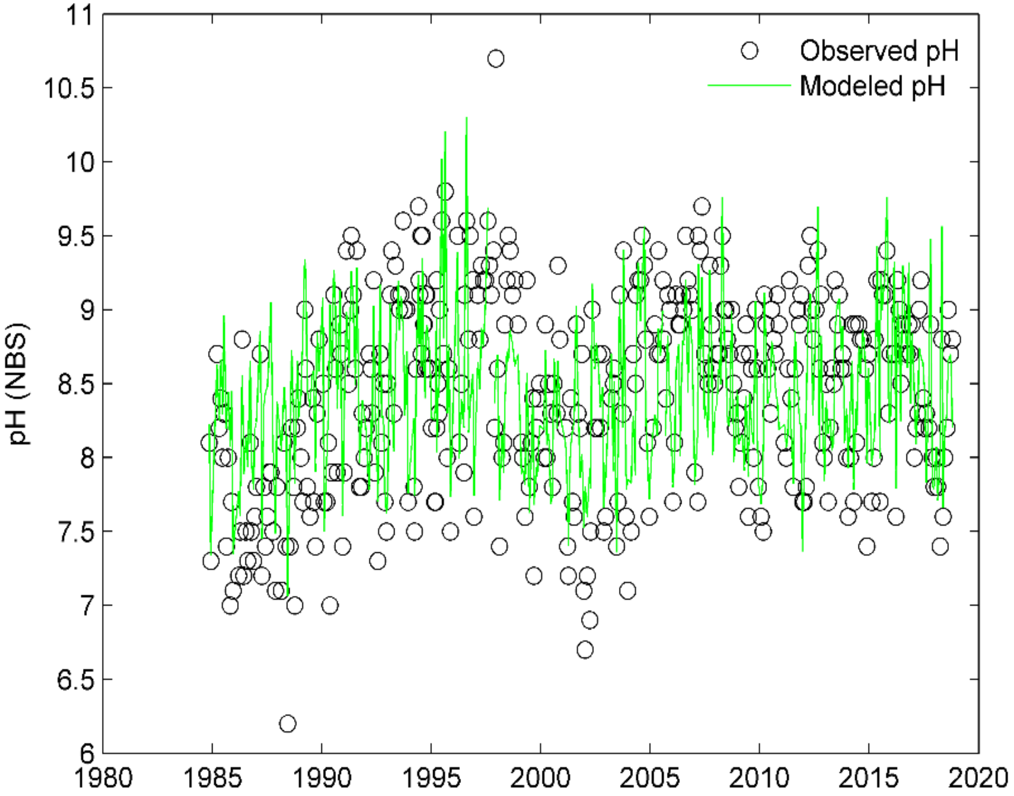
A simple statistical model was proposed by **Jeramey Testa** for calculating pH

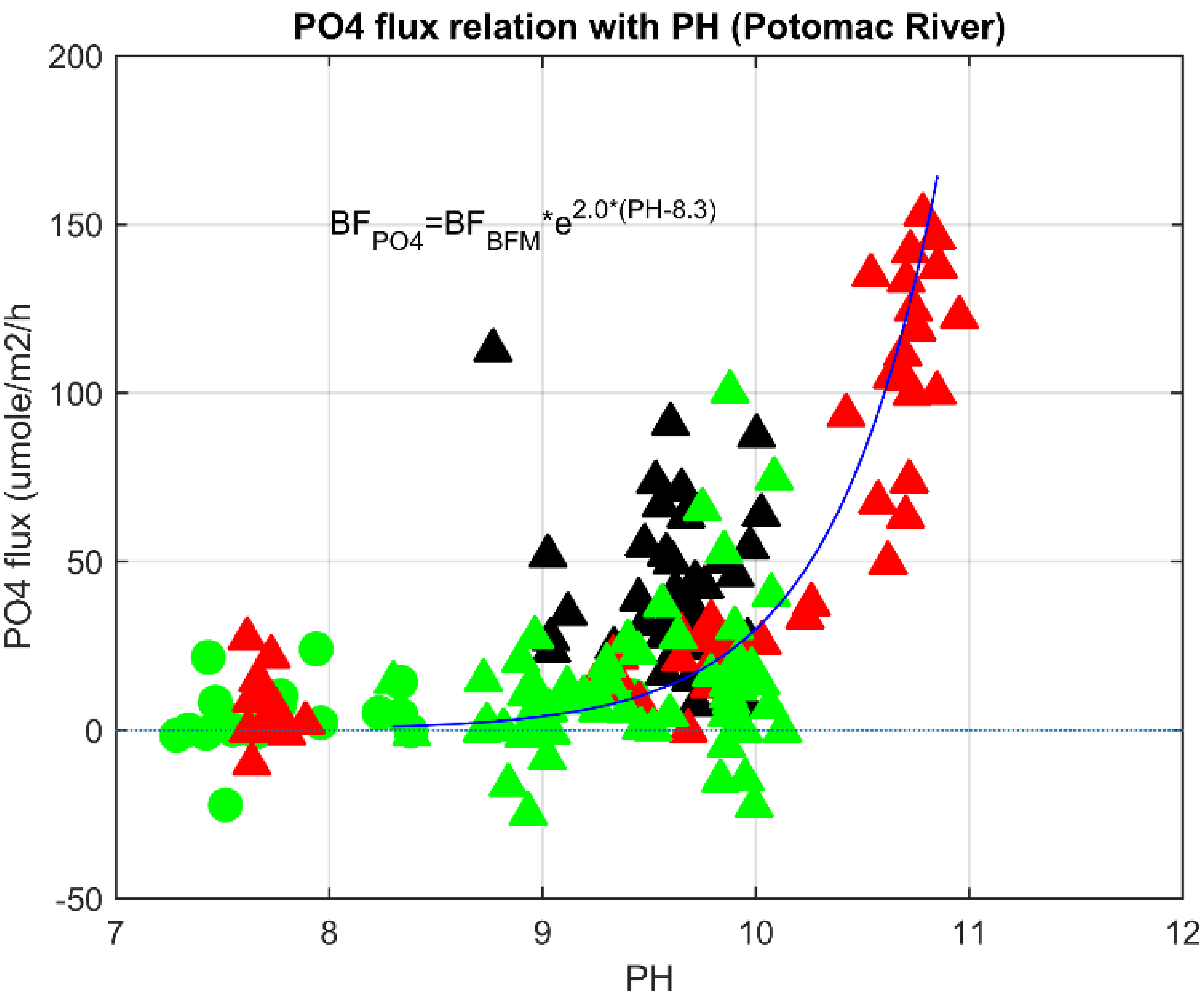
**Model 1**: I developed a multiple linear regression model to predict pH from the discrete (monthly scale) surface water data from WT4.1. The model predicts pH from dissolved oxygen, water temperature, and chlorophyll-a:

**pH_mod = 5.39 + 0.0009*Chla + 0.056*Temp + 0.189*DO**

The resulting model has an r2 of 0.57 and predicts 54 or 81 events where pH was above 9 over the 1985-2018 period.




PO4 flux relation with PH (Potomac River)
$BF_{PO4}=BF_{BFM}*e^{2.0*(PH-8.3)}$
PO4 flux (umole/m2/h)
PH
200
150
100
50
0
-50
7
8
9
10
11
12

# Algorithm implemented in icm_sfm.f90 in SCHIS/ICM model

```
sediment flux model (two-layer)
!-----------------------------------------------------------------------
  use schism_glbl, only : rkind,errmsg,ielg,tau_bot_node,nea,i34,elnode, &
                    & idry_e,eta2,dpe,nvrt
  use schism_msgp, only : myrank,parallel_abort
  use icm_mod
  use icm_interface
  implicit none
  integer,intent(in) :: id,kb,it,isub
  real(rkind),intent(in) :: tdep,wdz

  !local variables
  integer :: i,j,k,m,ierr,iPBS(3)
  real(rkind) :: stc,Kd,Kp,j1,j2,k1,k2,fd0,fd1,fd2,SA1,SA2,PO41,PO42
  real(rkind) :: wTSS,wtemp,wsalt,wPBS(3),wRPOC,wLPOC,wRPON,wLPON,wRPOP,wLPOP,wPH
  real(rkind) :: wSRPOC,wSRPON,wSRPOP,wPIP,wPO4,wNH4,wNO3,wDOX,wCOD,wSU,wSA,wPO4d,wPO4p,wSAd
  real(rkind) :: XJC,XJN,XJP,rKTC(3),rKTN(3),rKTP(3),rKTS,FPOC(3),FPON(3),FPOP(3),FPOS
  real(rkind) :: fSTR,SODrt,tau,erate,edfrac(2),swild(50)
  character(len=10) :: snames(50)
  real(rkind),pointer :: dz,Tp,To,STR
  type(brent_var) :: P

  dz=>bdz !for future development coupling with SED3D
  !-----------------------------------------------------------------------
  !bottom water concs. and other variables
  !-----------------------------------------------------------------------
  wTSS =TSS(kb+1);   wtemp=temp(kb+1); wsalt=salt(kb+1)
  wPBS =PBS(:,kb+1); wRPOC=RPOC(kb+1); wLPOC=LPOC(kb+1)
  wRPON=RPON(kb+1);  wLPON=LPON(kb+1); wRPOP=RPOP(kb+1)
  wLPOP=LPOP(kb+1);  wPO4 =PO4(kb+1);  wNH4 =NH4(kb+1)
  wNO3 =NO3(kb+1);   wCOD =COD(kb+1);  wDOX =min(max(DOX(kb+1),1.d-2),50.d0)
  fd0=1.0/(1.0+KPO4p*wTSS); wPO4d=fd0*wPO4; wPO4p=(1.0-fd0)*wPO4
  !wPH=max(3.0d0,min(12.0d0,6.51+0.0395*wsalt+0.0275*wtemp+0.1334*wDOX))
  wPH=5.39+0.0009*sum(wPBS/c2chl)+0.056*wtemp+0.189*wDOX        !simple pH formulation from Jeremy
  if(iSRM==1) then
    wSRPOC=SRPOC(kb+1); wSRPON=SRPON(kb+1); wSRPOP=SRPOP(kb+1); wPIP=PIP(kb+1)
  endif
```

```
……………………………………………………………………

……………………………………………………………………

!-------------------------------------------------------------------
  !mass balance equation for PO4
  !-----------------------------------------------------------------
  if(wsalt<=bsaltp) then
    fd1=1.0/(1.0+bpiePO4*bKOPO4f**min(wDOX/bDOc_PO4,1.d0)*bsolid(1))
  else
    fd1=1.0/(1.0+bpiePO4*bKOPO4s**min(wDOX/bDOc_PO4,1.d0)*bsolid(1))
  endif
  fd2=1.0/(1.0+bpiePO4*bsolid(2))
  j1=0.0;  j2=XJP+WSPn(iPO4)*wPO4p
  k1=0.0;  k2=0.0  !no reactions
  call sfm_eq(2,PO41,PO42,wPO4d,bPO4(id),stc,Kd,Kp,fd1,fd2,j1,j2,k1,k2)
  JPO4(id)=stc*(fd1*PO41-wPO4d);  bPO4(id)=PO42
  if(wPH>8.3d0) JPO4(id)=JPO4(id)*exp(2.d0*(wPH-8.3d0))
                                          !additonal PO4 release under high pH condition
```

$$PO4 = PO4 * EXP(2*(WPH - 8.3))$$

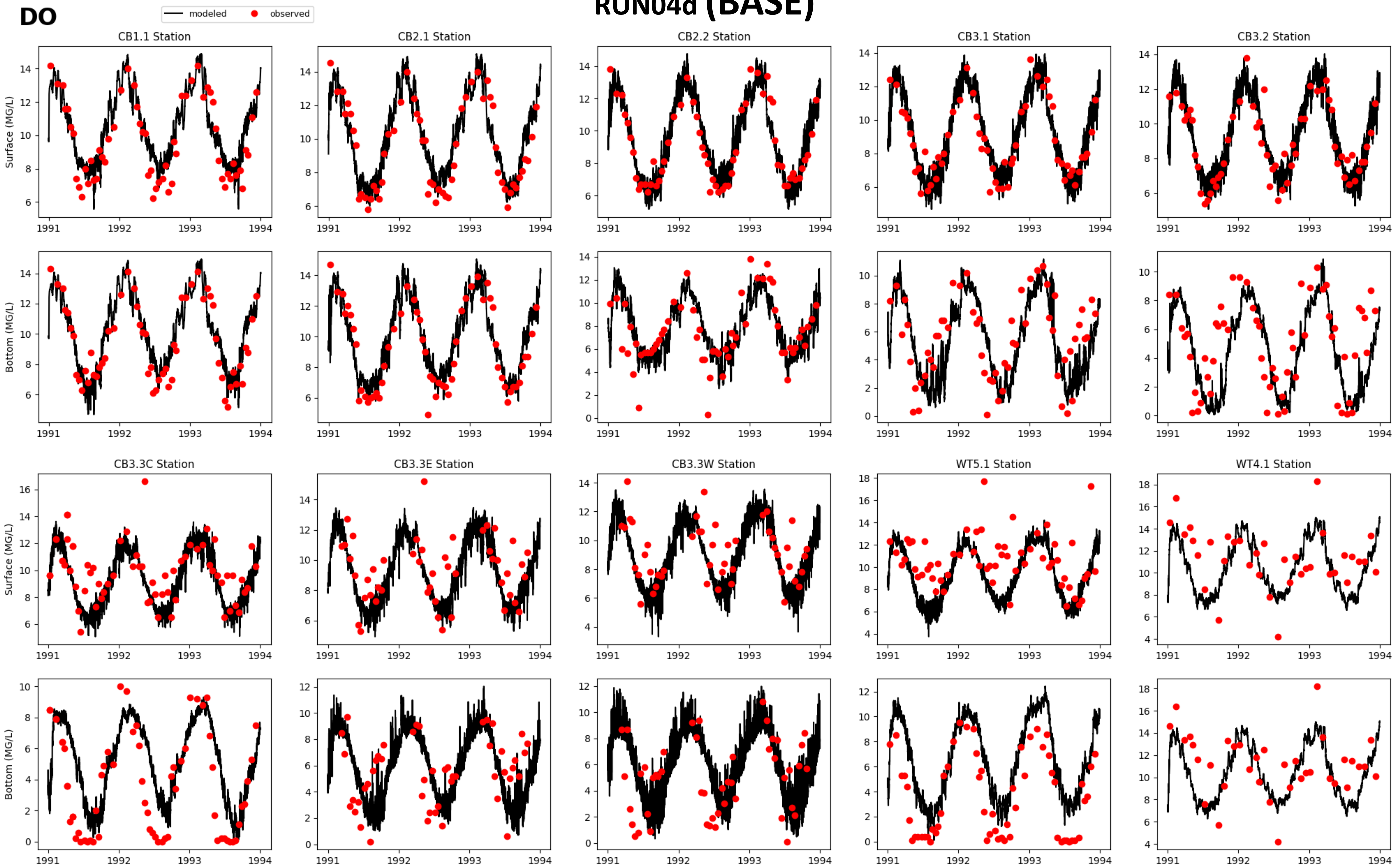
# DO and Chl Comparison

## Base vs. Test

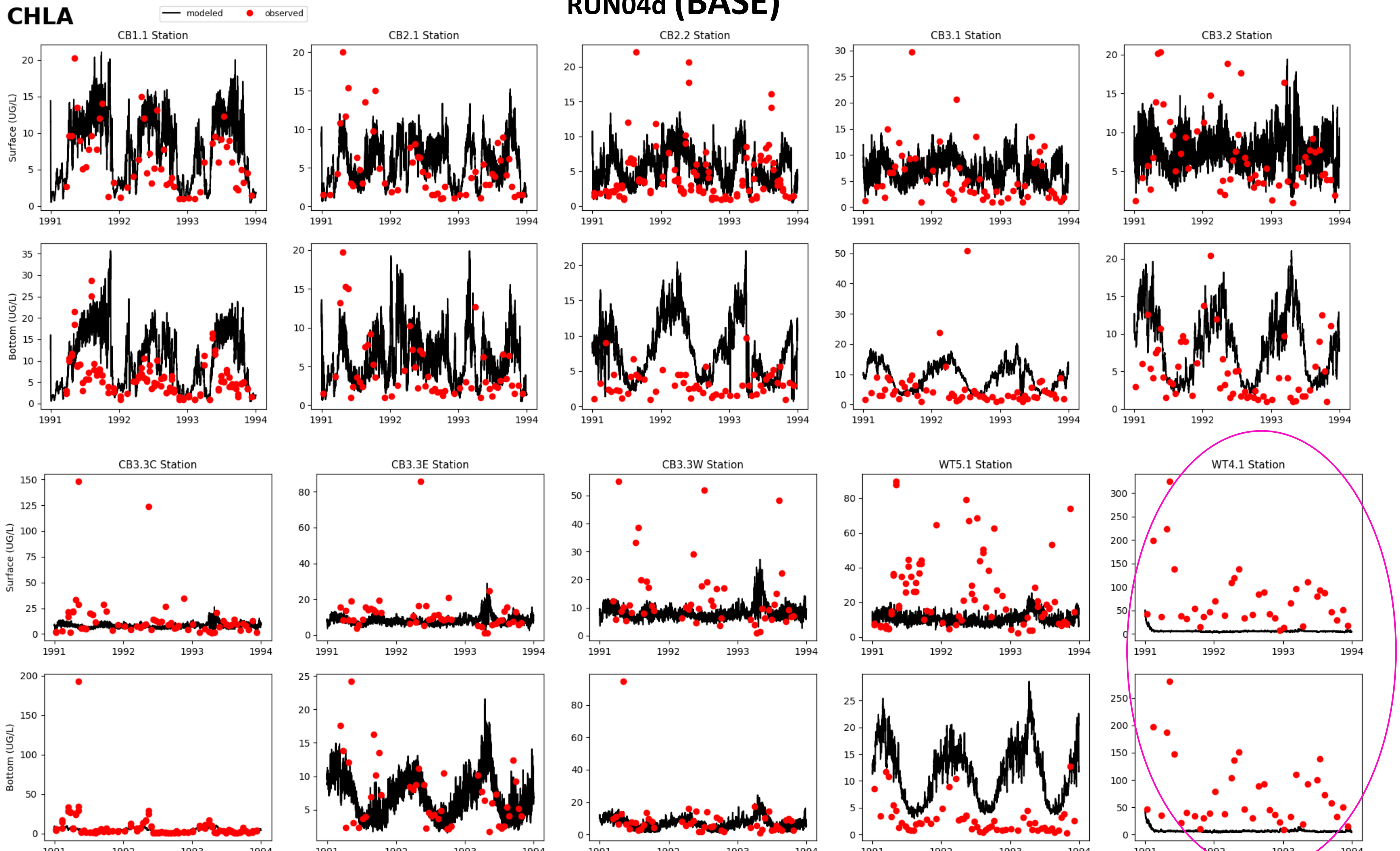
Base – using SCHISM master

Test – using SCHISM ICM_simple_pH git branch

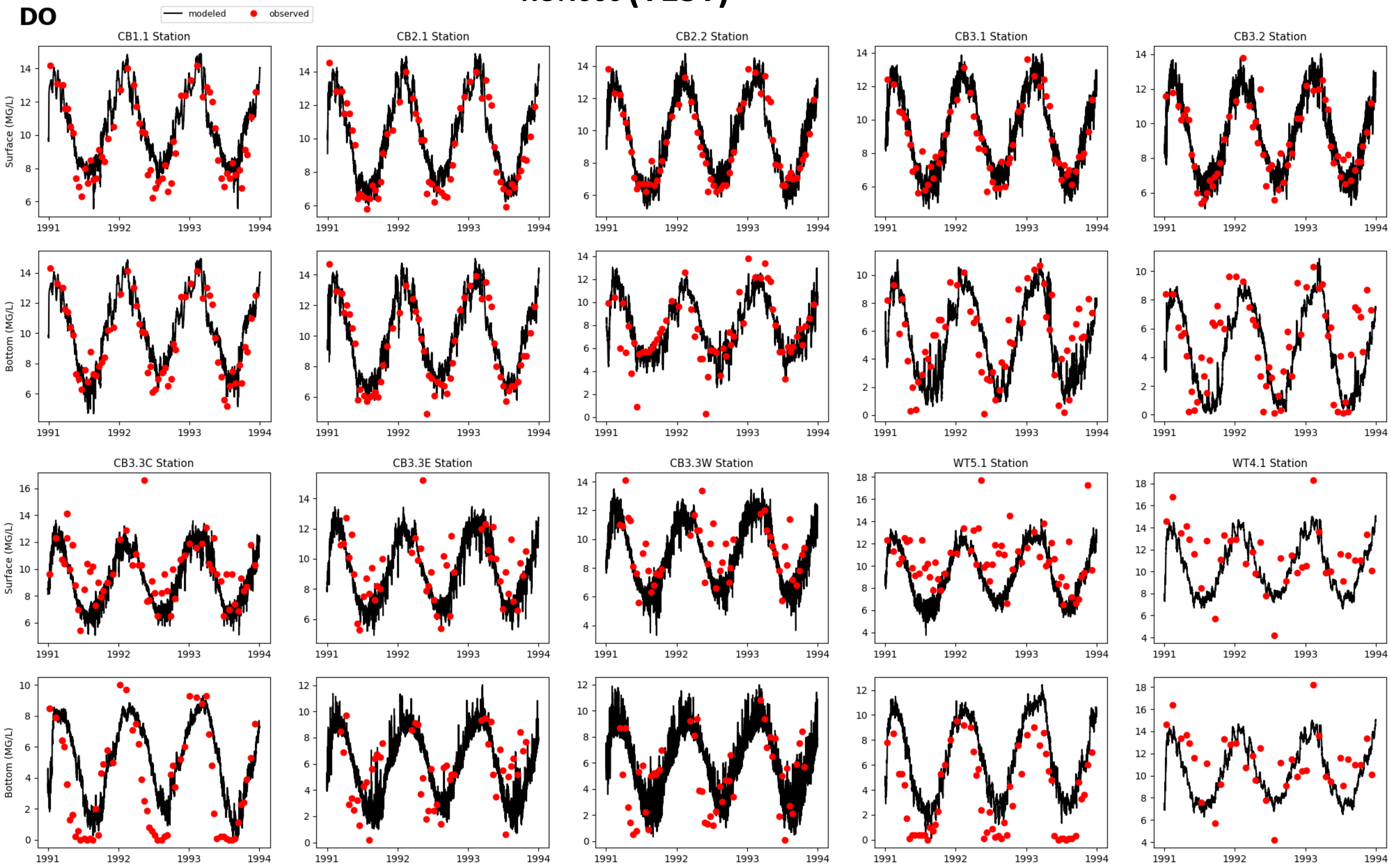
# RUN04d (BASE)


DO
modeled
observed
CB1.1 Station
CB2.1 Station
CB2.2 Station
CB3.1 Station
CB3.2 Station
CB3.3C Station
CB3.3E Station
CB3.3W Station
WT5.1 Station
WT4.1 Station
Surface (MG/L)
Bottom (MG/L)
1991
1992
1993
1994

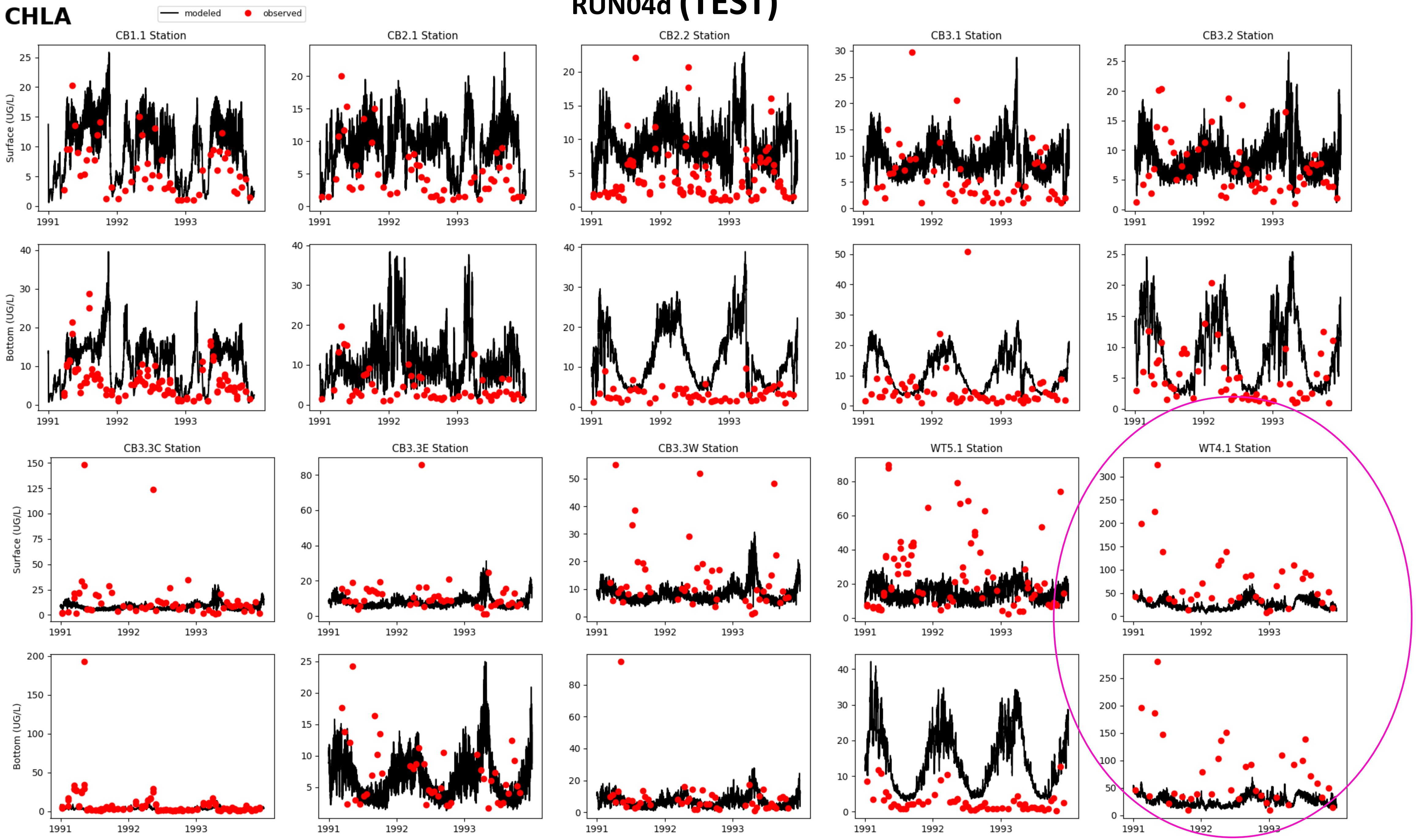
# RUN04d (BASE)


CHLA
modeled
observed
CB1.1 Station
CB2.1 Station
CB2.2 Station
CB3.1 Station
CB3.2 Station
CB3.3C Station
CB3.3E Station
CB3.3W Station
WT5.1 Station
WT4.1 Station
Surface (UG/L)
Bottom (UG/L)
1991
1992
1993
1994

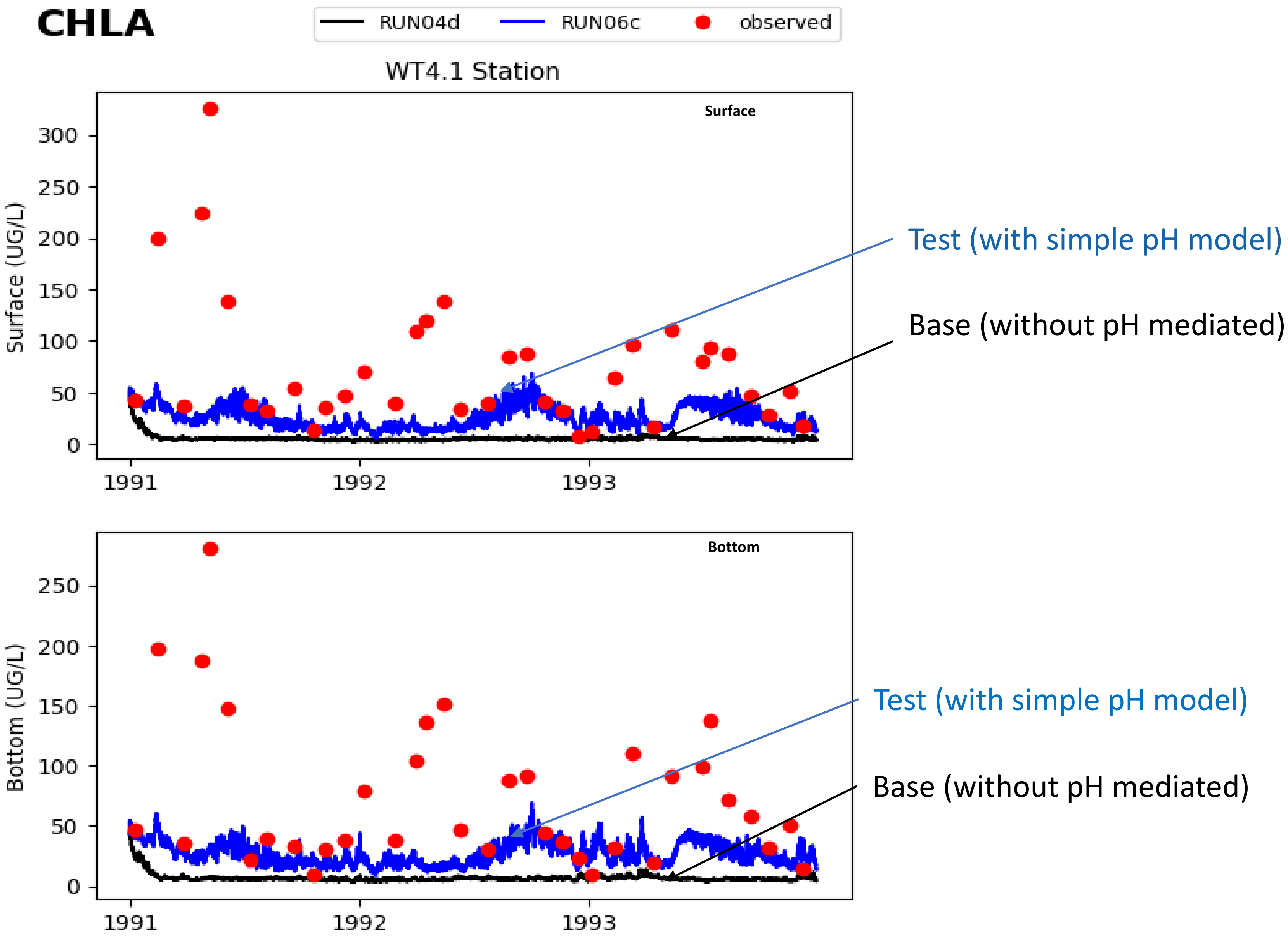
# RUN06c (TEST)


DO
modeled
observed
CB1.1 Station
CB2.1 Station
CB2.2 Station
CB3.1 Station
CB3.2 Station
CB3.3C Station
CB3.3E Station
CB3.3W Station
WT5.1 Station
WT4.1 Station
Surface (MG/L)
Bottom (MG/L)
1991
1992
1993
1994

# RUN04d (TEST)


CHLA
modeled
observed
CB1.1 Station
CB2.1 Station
CB2.2 Station
CB3.1 Station
CB3.2 Station
CB3.3C Station
CB3.3E Station
CB3.3W Station
WT5.1 Station
WT4.1 Station
Surface (UG/L)
Bottom (UG/L)
1991
1992
1993

# Compare chl at WT4.1: RUN04d (base) vs. RUN06c (test pH ICM)




**Surface Mean –**

RUN04d: 5.649 mg/l (base)
RUN06c: 25.76 mg/l (test)
Observation: 75.032 mg/l

**Bottom Mean –**

RUN04d: 6.615 mg/l (base)
RUN06c: 26.922 mg/l (test)
Observation: 74.076 mg/l

# V. Summary

1.. Extensive efforts were undertaken to upgrade the MTM (Patapsco/Back River) modeling system. Key enhancements included:
(A) adoption of an updated version of SCHISM,
(B) incorporation of SAV effects into the physical modeling,
(C) implementation of Phase 7 watershed loading, and
(D) inclusion of pH-mediated phosphorus release from the benthic layer.

2. Model results comparing hybrid Phase 6 and Phase 7 watershed loadings, along with updated boundary conditions from the MBM, indicate discernible improvements with Phase 7. These improvements are particularly evident in dissolved oxygen (DO), chlorophyll-a, and phosphorus simulations.

3. A sensitivity test comparing subcycling options—subcycle = 12 (WQ time step of 150 seconds) versus subcycle = 24 (75 seconds)—showed no significant differences in water quality results, suggesting that the coarser time step is adequate for current applications.

4. A simplified statistical pH model was implemented in *Icm_SFM.f90*, where pH is expressed as a function of chlorophyll-a, DO, and temperature, based on continuous monitoring (ContMon) data collected in Back River. The model response indicates a substantial increase in chlorophyll-a concentrations (approximately fivefold, from 5–6 µg/L to 25–26 µg/L). While this implementation significantly reduces mean bias, further refinement is needed to accurately capture the seasonal variability.