The Radiative Trap: How River Water Modulates Equatorial Ocean Heat Uptake

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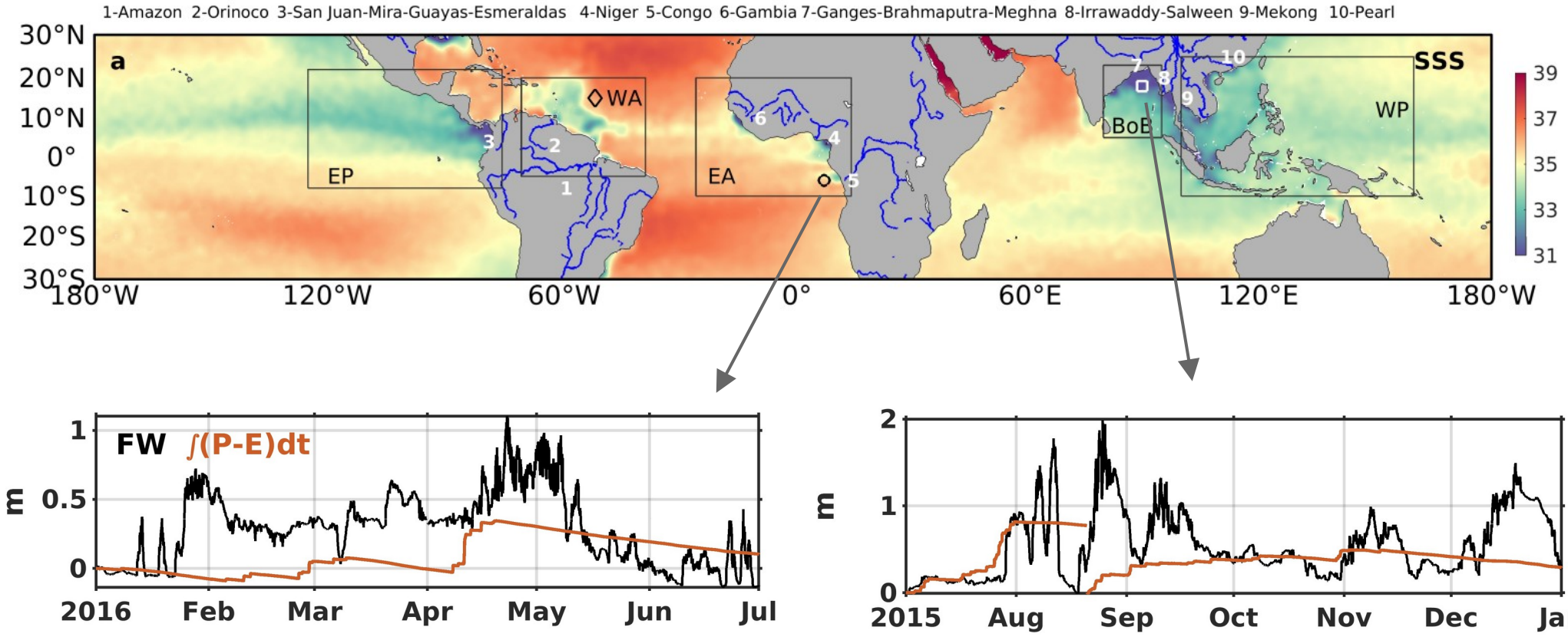
- ***River water creates persistent low-salinity regions in the open ocean***
- ***River water exhibits distinct optical and thermal signatures***
- ***Optically rich river water absorbs more solar radiation and becomes warmer***
- ***This reveals a direct pathway linking rivers, optics, SST, and climate***

SMAP, OI SST, Aqua-MODIS, Glider, Moorings

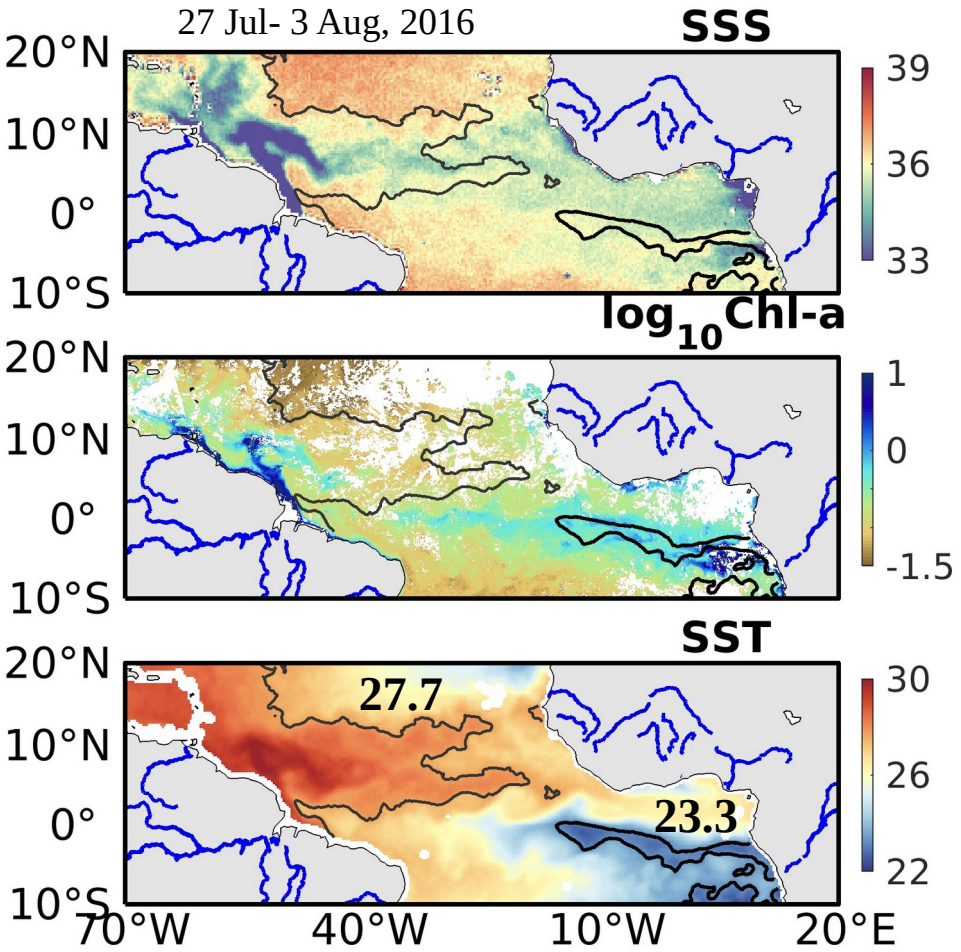
River Water in the Tropics

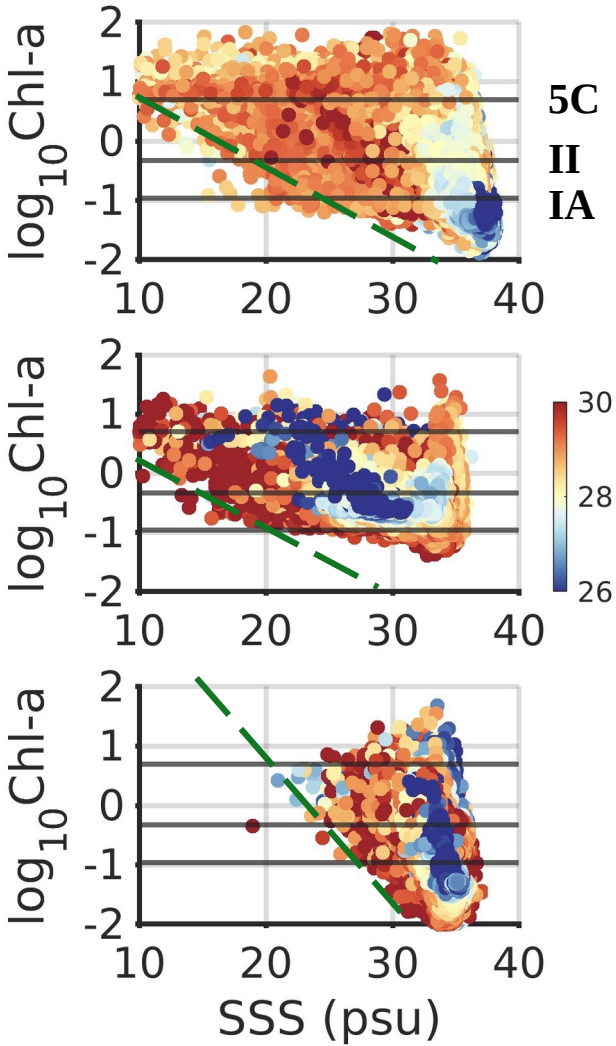


$$FWC = \int_{-10}^{0} 1 - \frac{S}{S_{ref}} dz$$

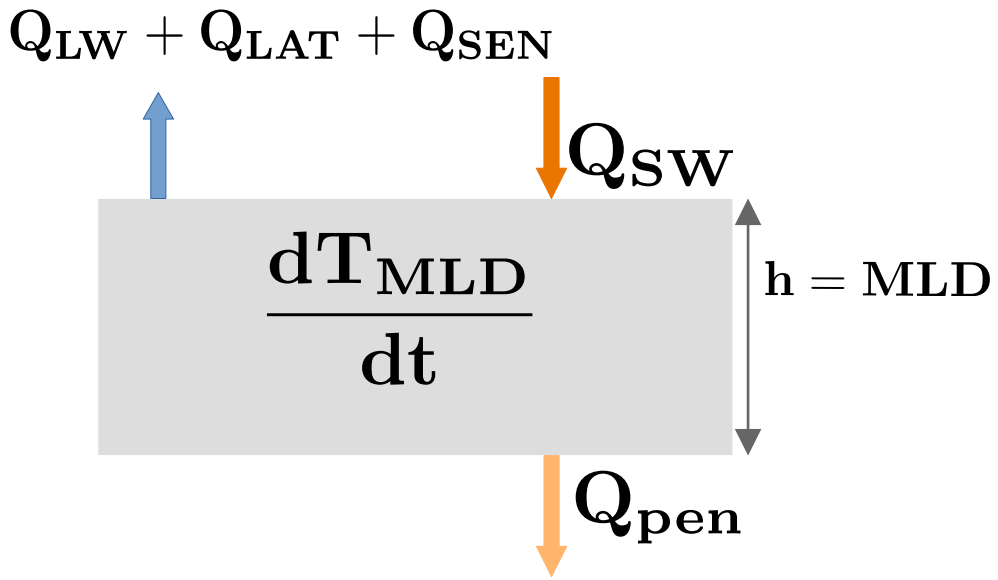
Advected river water creates large freshwater anomalies in the open ocean

River Water Exhibits Distinct Optical and Thermal Signatures





River Water Absorbs More Shortwave Radiation



$$h = 10m$$

Type-I **Type-IB**

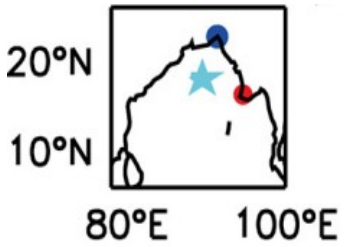
72% Q_{SW} **82%**

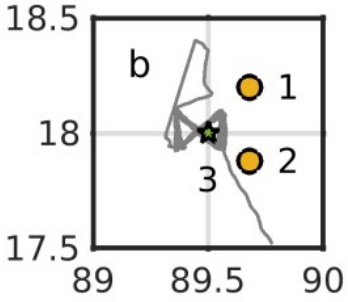
$$Q_N = Q_{SW} - Q_{pen} - Q_{LW} - Q_{LAT} - Q_{SEN}$$

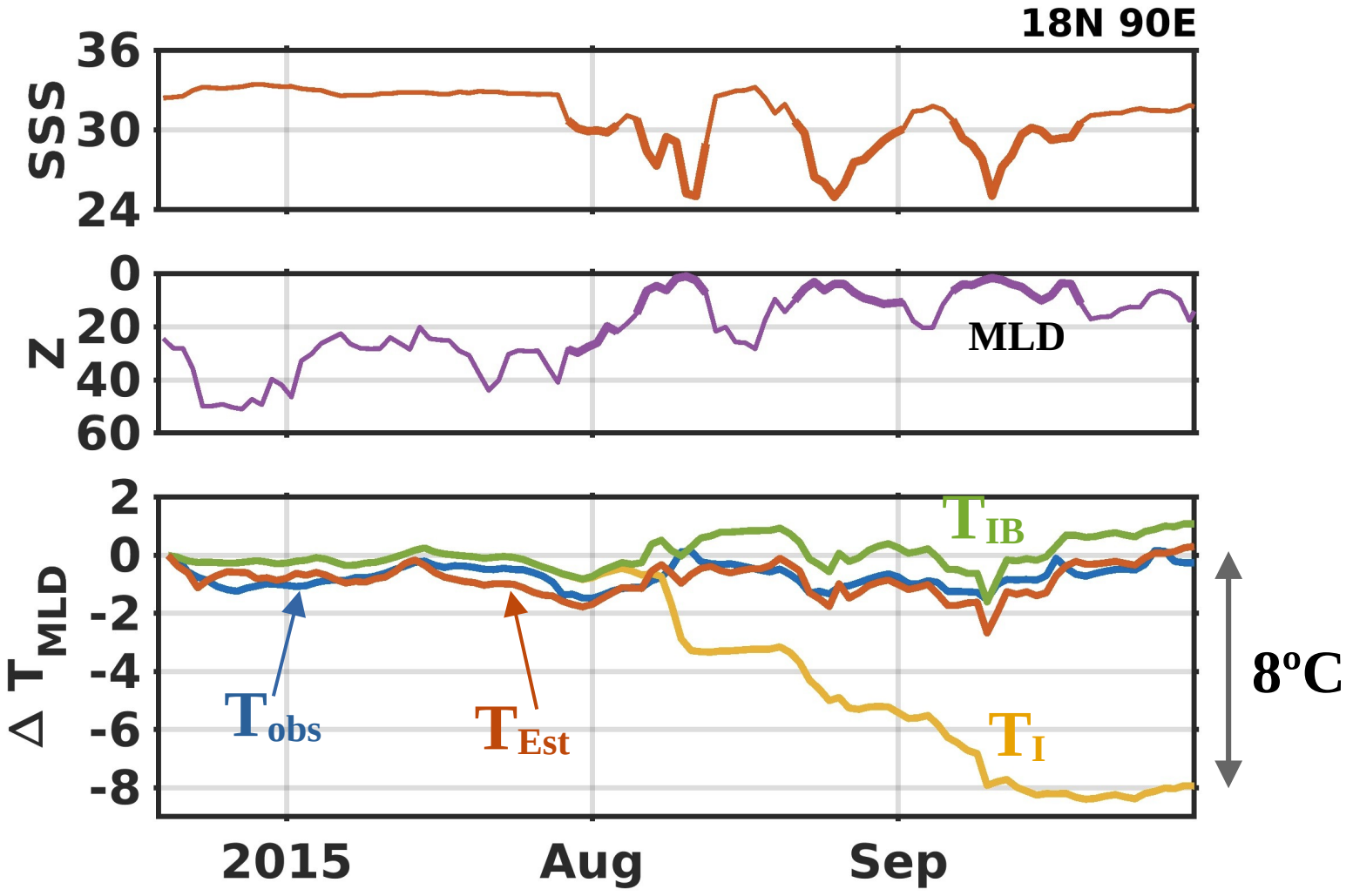
$$\frac{dT_{MLD}}{dt} = \frac{Q_N}{\rho C_P h}$$

Penetrative radiation varies with water type, altering how much heat is retained in the mixed-layer

Bay of Bengal Observatory

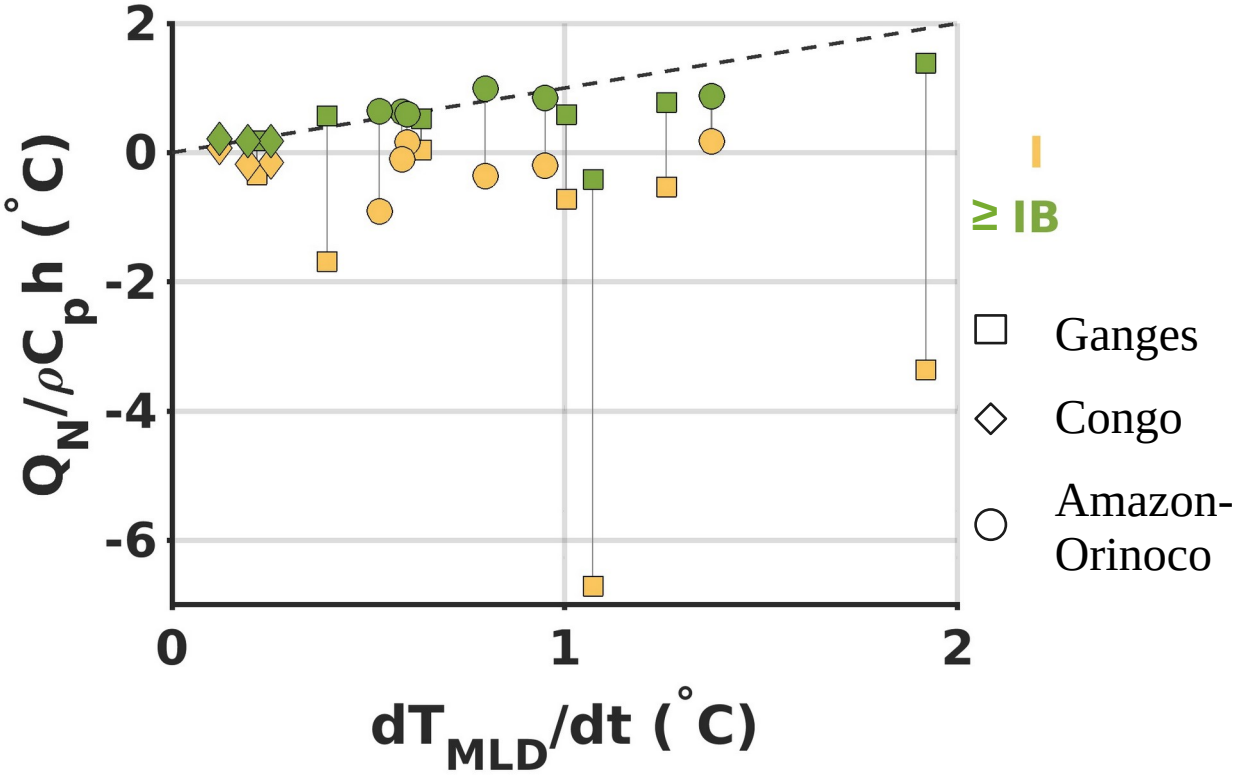


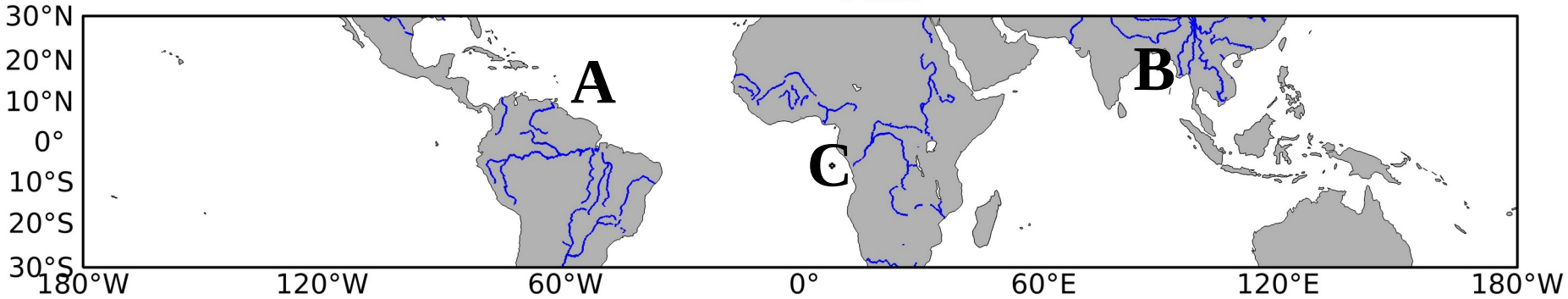




Multi-Basin Validation

Including river-water optics improves heat-budget estimates

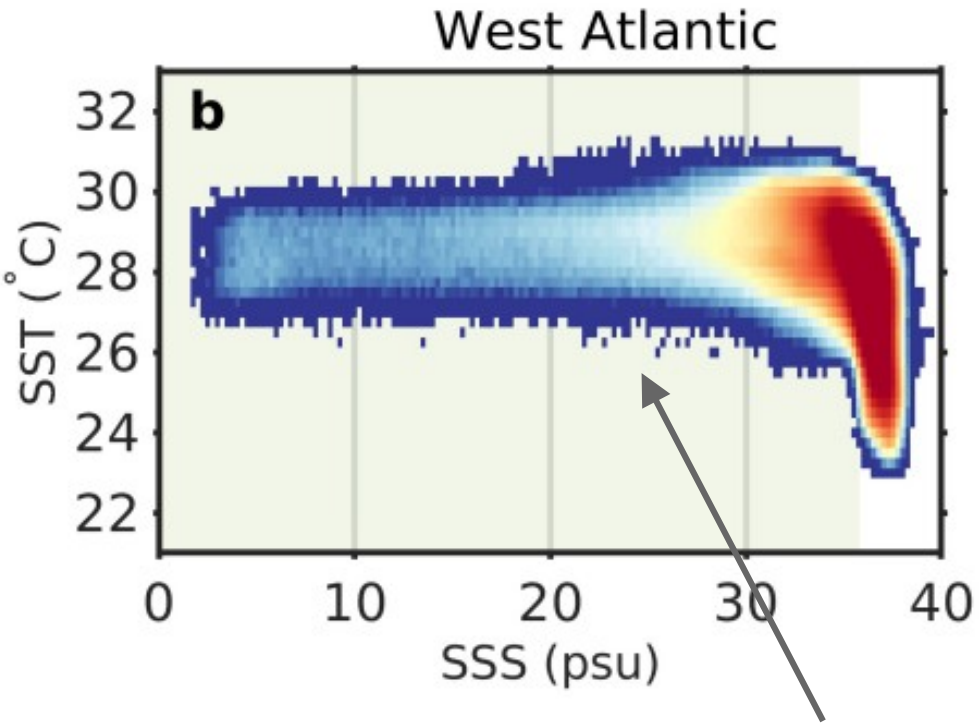


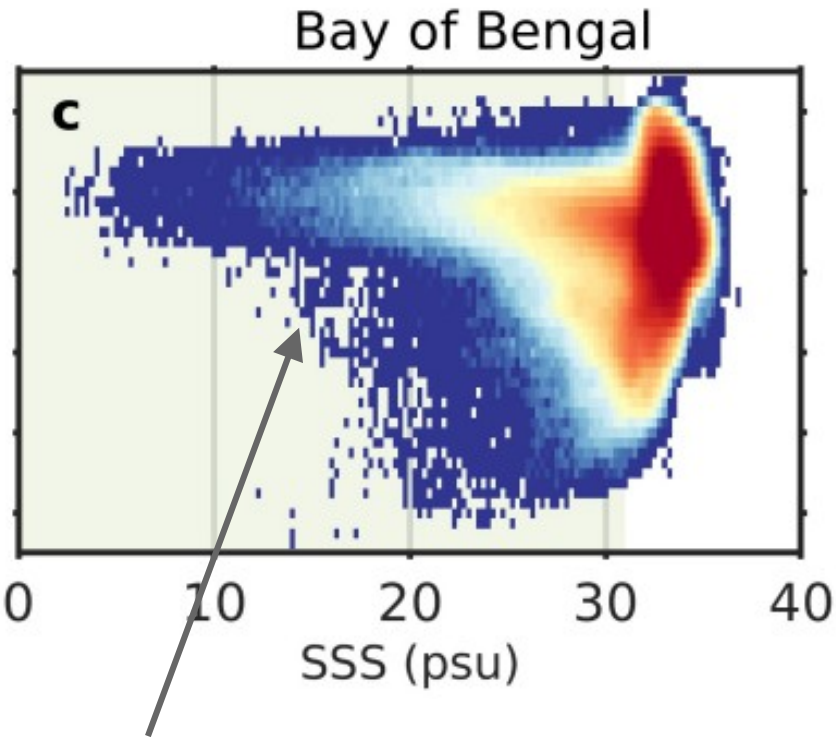


Conclusions

- ***River water creates persistent low-salinity regions in the open ocean***
- ***River water exhibits distinct optical and thermal signatures***
- ***Optically rich river water absorbs more solar radiation and becomes warmer***
- ***This reveals a direct pathway linking rivers, optics, SST, and climate***

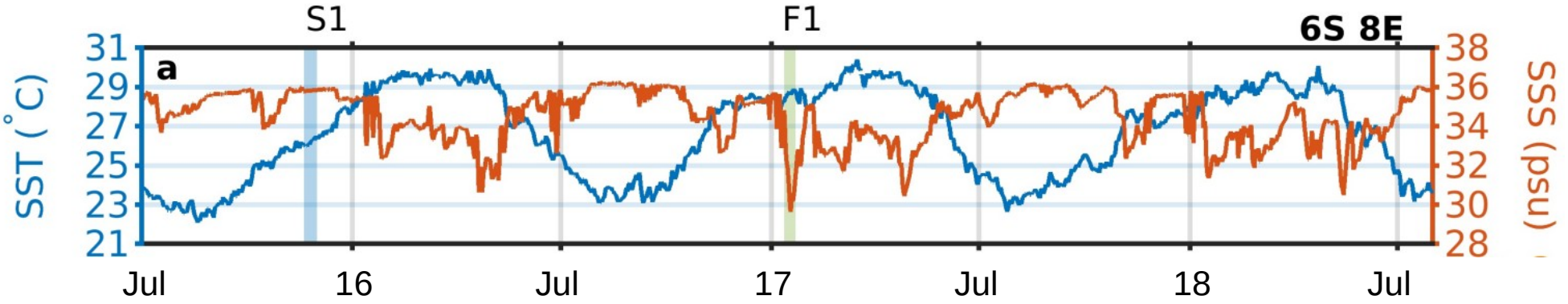
Contrasting SST-SSS Structure: River vs Oligotrophic Waters



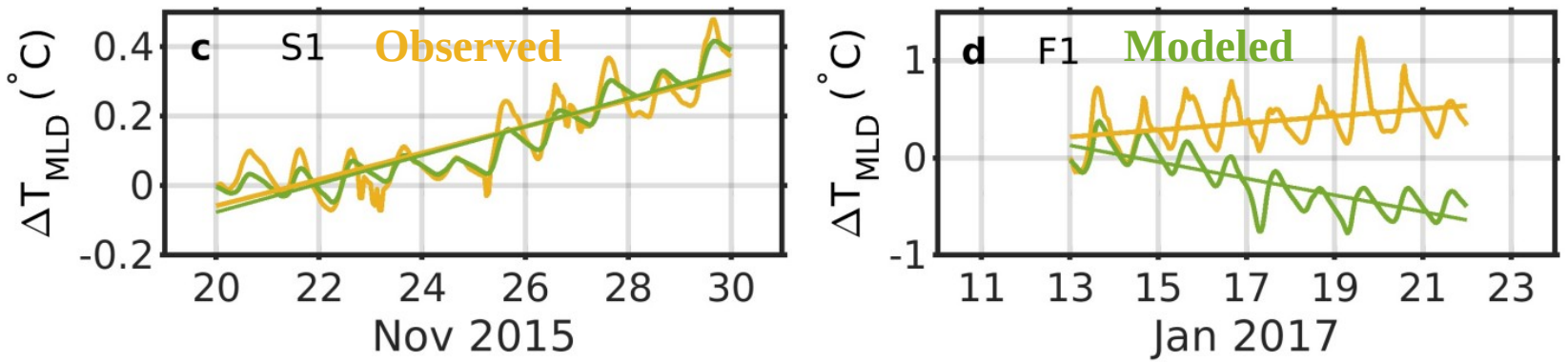


SST tends to plateau at lower salinity

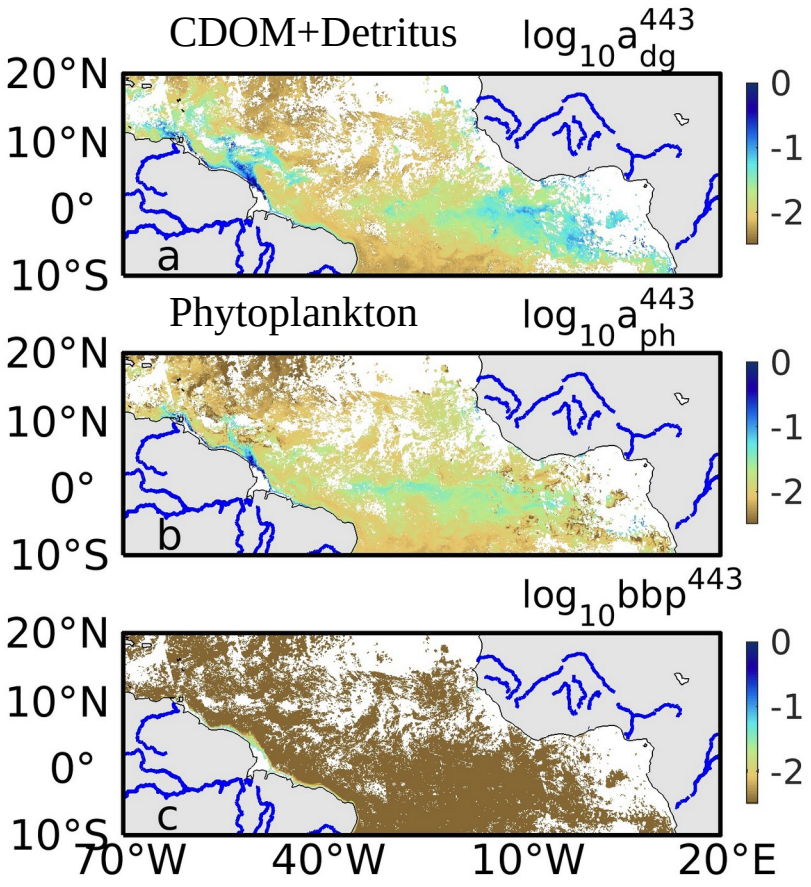
Why Does the Heat Budget Fail in Riverwater?



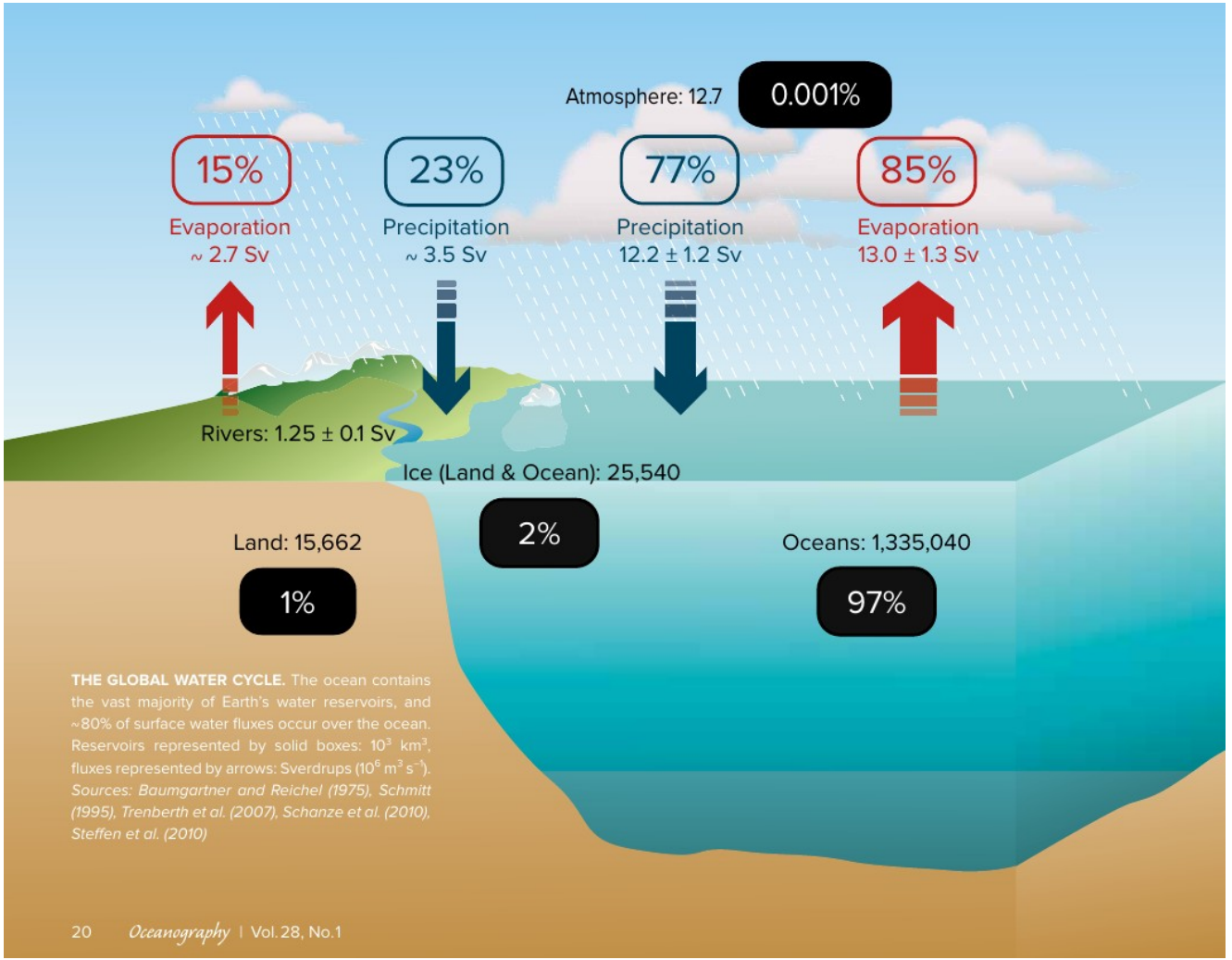
$$\Delta T_{MLD} = \int T_{MLD} = \int \frac{Q_N}{\rho C_p h} dt$$



Surface heat flux underestimates warming in riverwater


CDOM+Detritus
$\log_{10} a_{dg}^{443}$
Phytoplankton
$\log_{10} a_{ph}^{443}$
$\log_{10} bbp^{443}$
20°N
10°N
0°
10°S
a
b
c
0
-1
-2
70°W
40°W
10°W
20°E

The Global Water Cycle



Amount P/R ≈ **10**

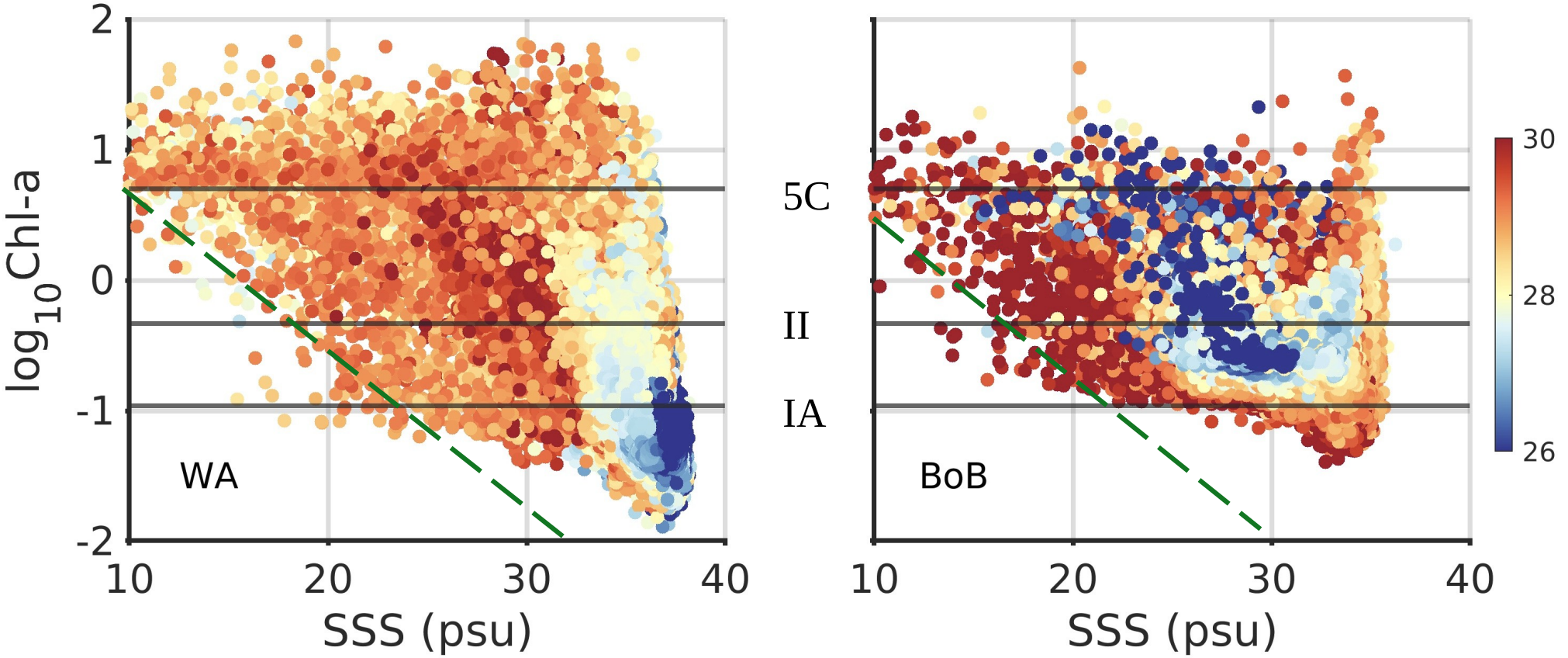
Amazon-Orinoco	**– 0.26 Sv**
Ganges-Brahmaputra -Meghna	**– 0.043 Sv**
Congo	**– 0.041 Sv**

GRDC

Rivers can induce more localized freshening than precipitation in the ocean

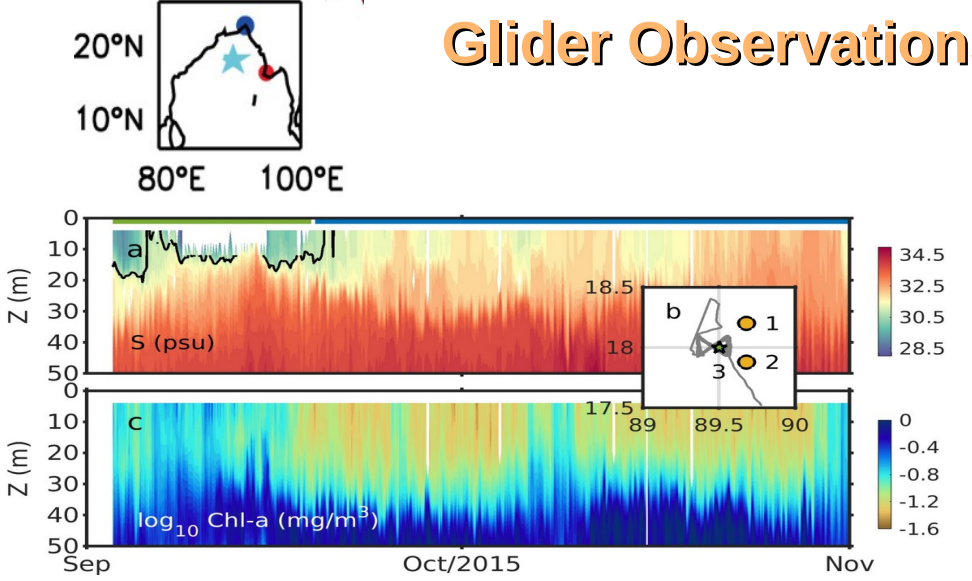
Durack 2015

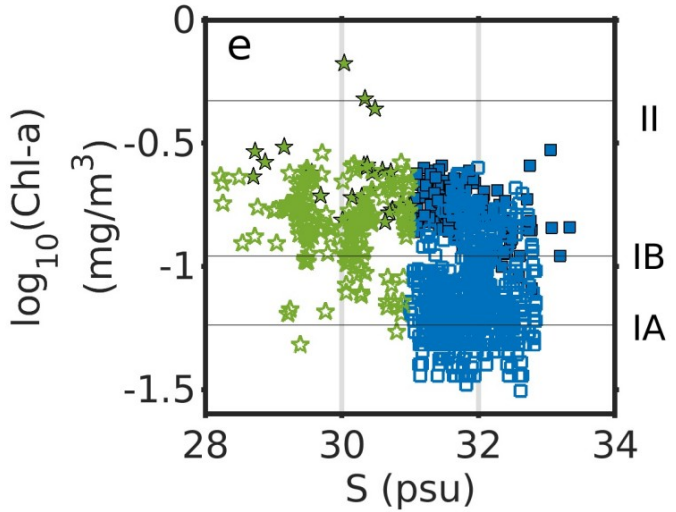
Signature of the Radiative Trap

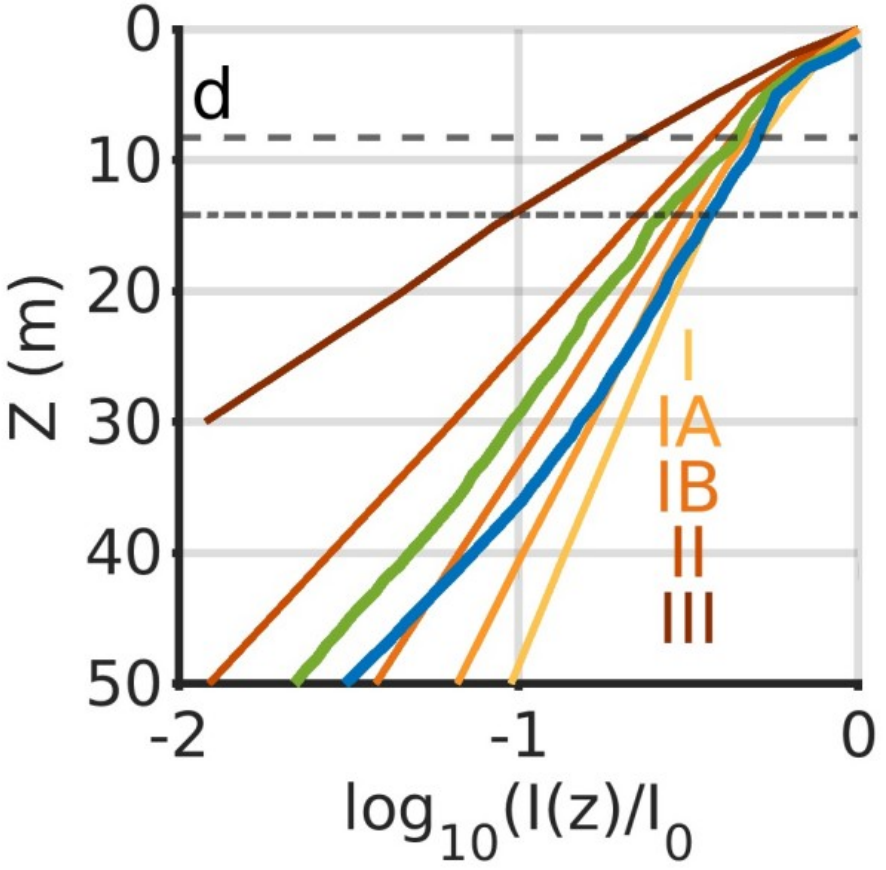


Low-salinity, optically rich waters are warmer

Glider Observations in the Bay of Bengal



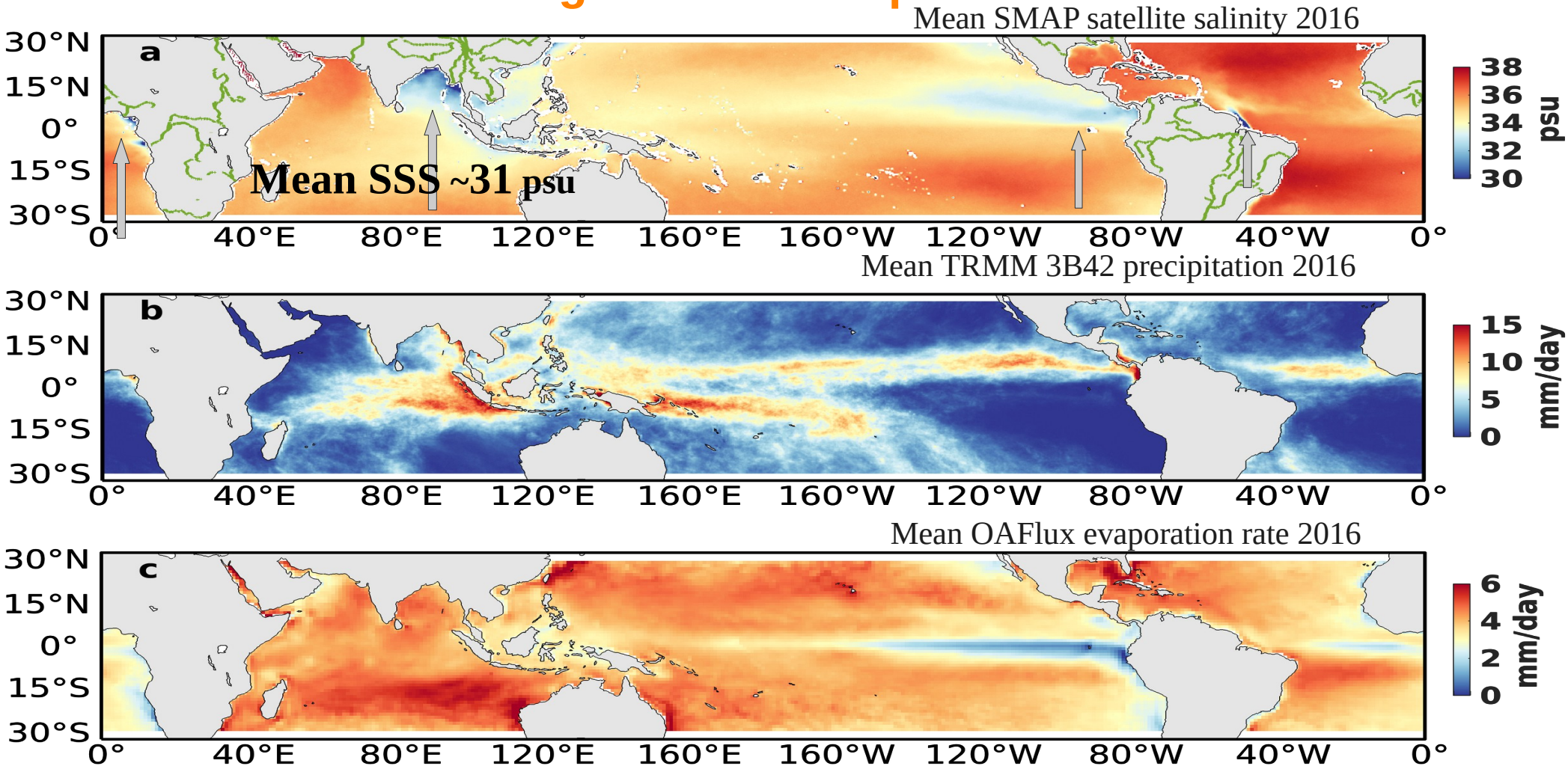


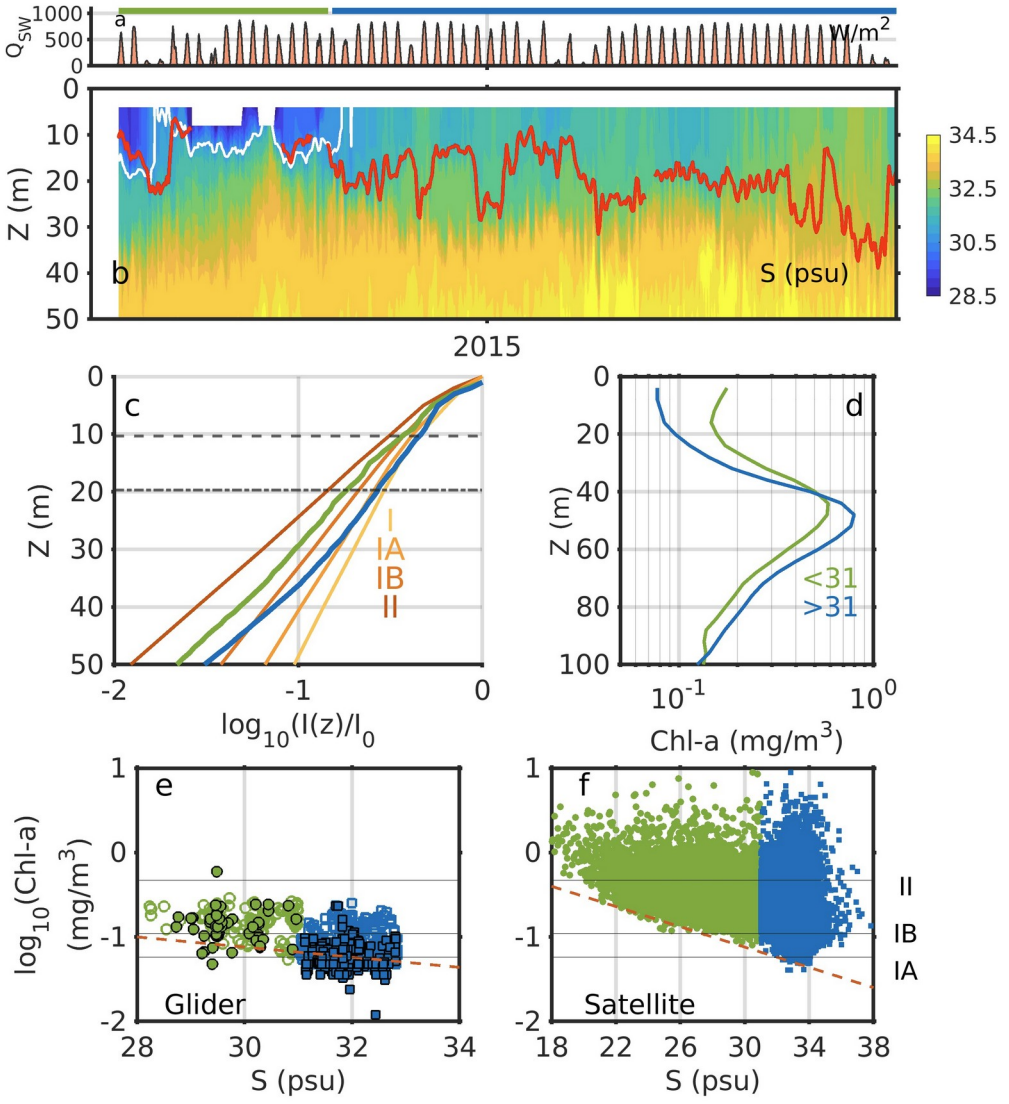


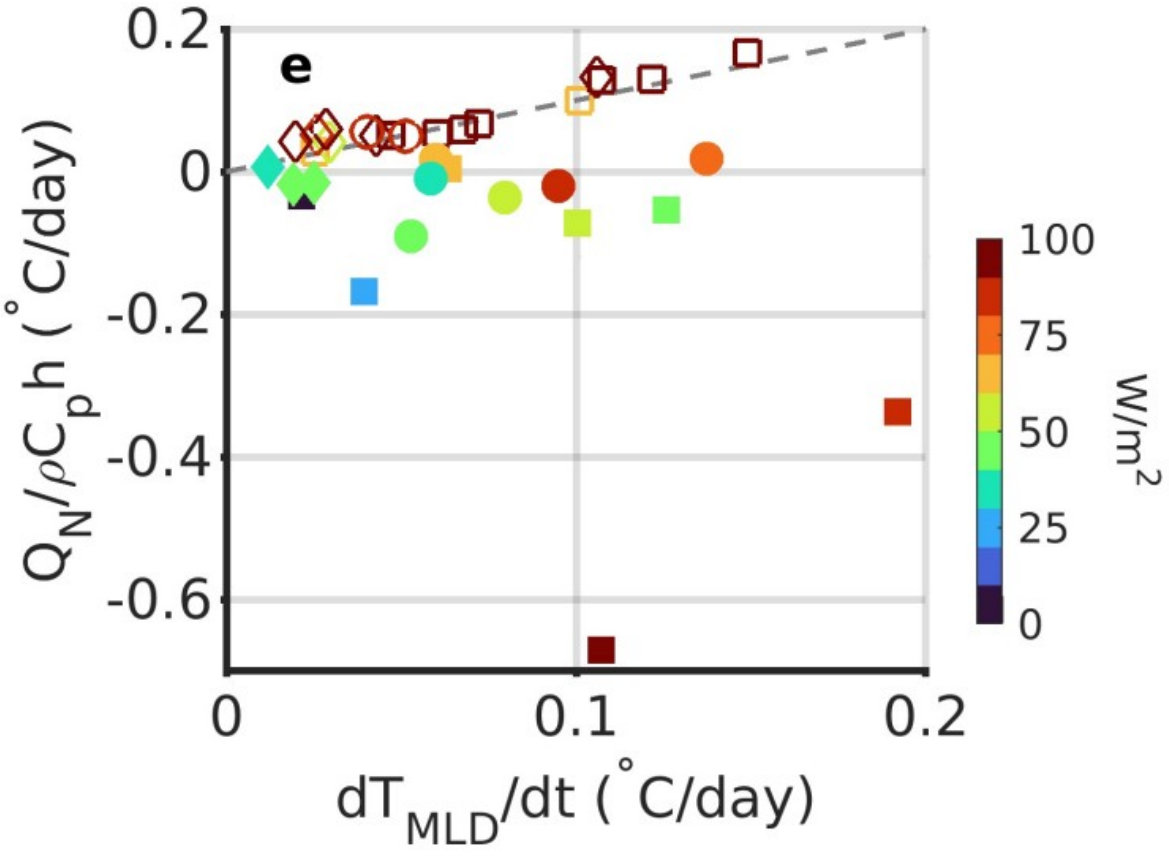
Solar radiation is rapidly attenuated in optically rich river waters

Background

Fresh Region in the Tropical Oceans



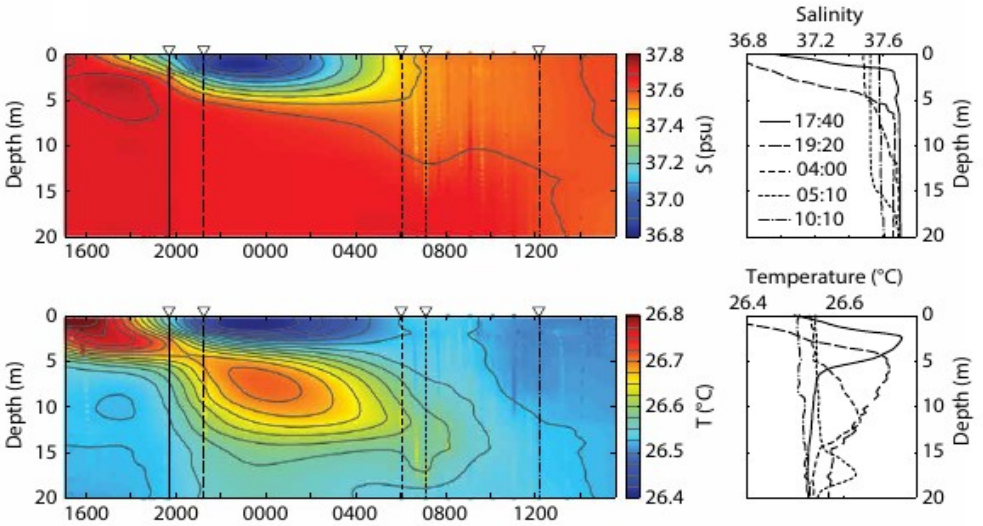

a
Q_{SW}
1000
500
0
W/m^2
b
Z (m)
0
10
20
30
40
50
S (psu)
34.5
32.5
30.5
28.5
2015
c
Z (m)
I
IA
IB
II
$\log_{10}(I(z)/I_0)$
d
Z (m)
<31
>31
Chl-a (mg/m^3)
e
$\log_{10}$(Chl-a) (mg/m^3)
Glider
S (psu)
f
Satellite
II
IB
IA
S (psu)


e
0.2
0
-0.2
-0.4
-0.6
0
0.1
0.2
$Q_N/\rho C_p h$ (˚C/day)
dT_{MLD}/dt (˚C/day)
100
75
50
25
0
W/m^2

Background

Upper Ocean Structure

Rain puddle



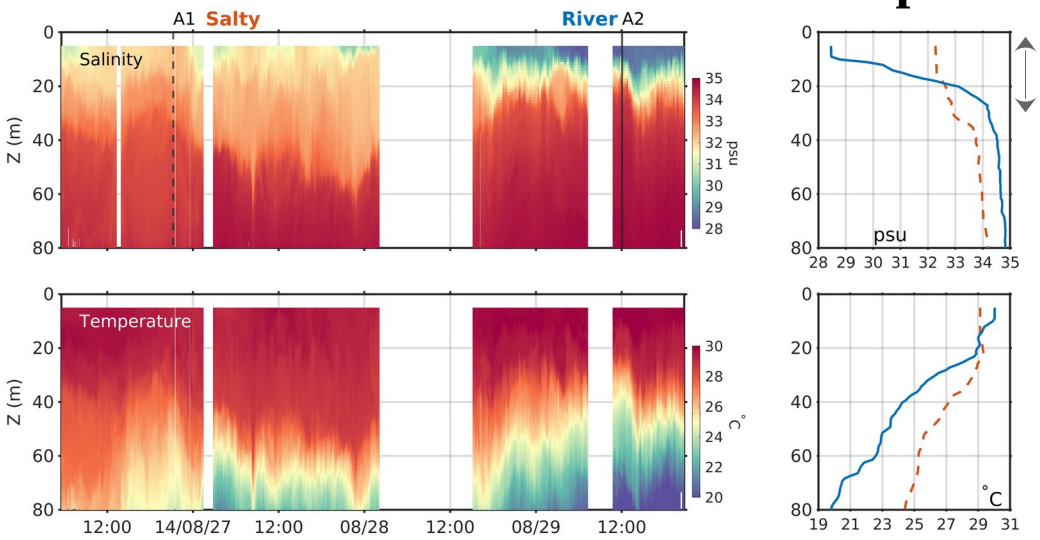
0.8 psu

Fresh and cold rainwater on top of warm layer

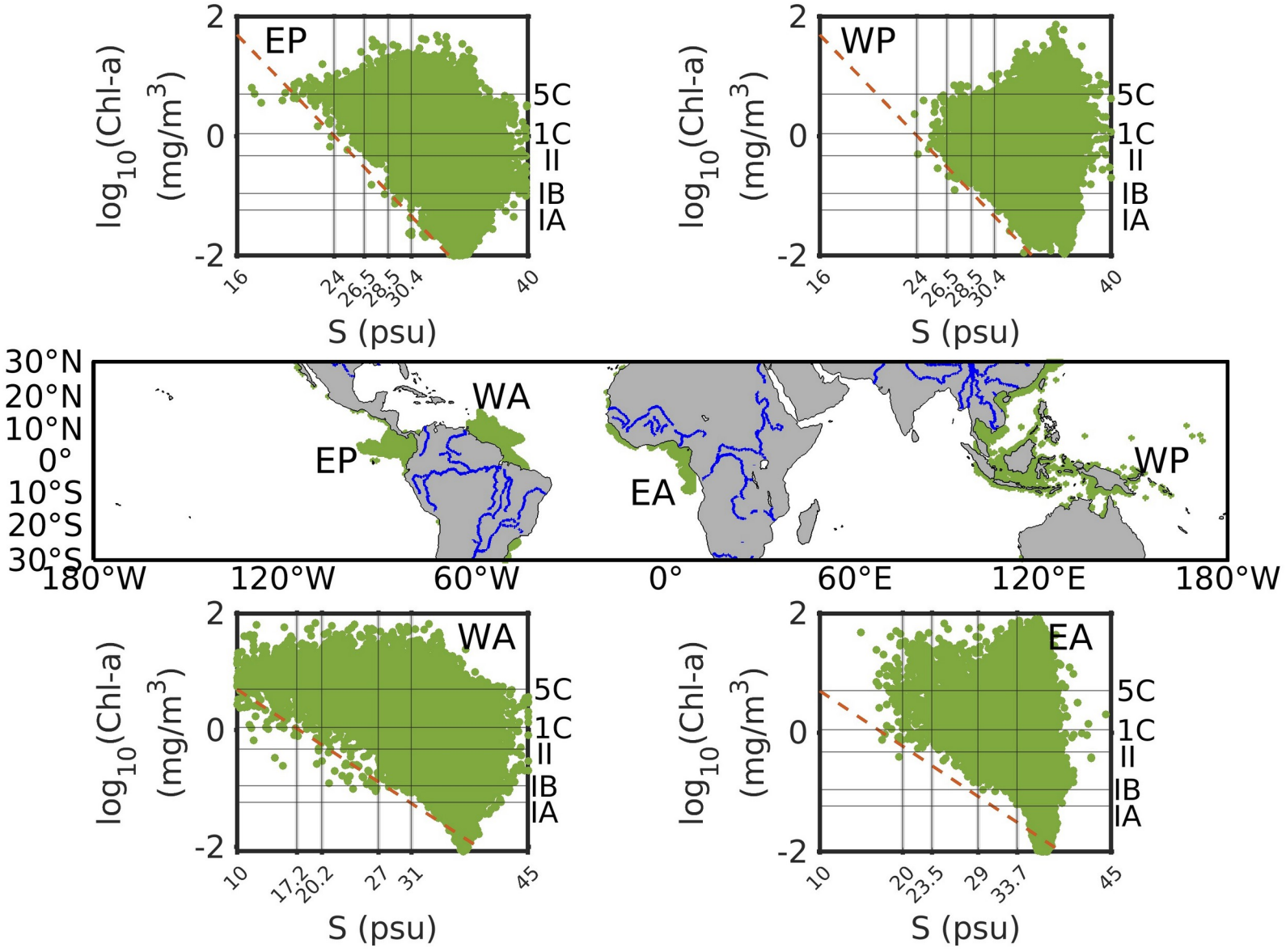
River water

Shallow halocline under river water

5.5 psu



Riser *et al.*, 2015


EP
WP
WA
EA
log10(Chl-a)
(mg/m3)
5C
1C
II
IB
IA
S (psu)
16
24
26.5
28.5
30.4
40
10
17.2
20.2
27
31
45
20
23.5
29
33.7
30°N
20°N
10°N
0°
10°S
20°S
30°S
180°W
120°W
60°W
0°
60°E
120°E
180°W