Linking Aquarius Salinity Measurements to River Discharges and Ocean Surface Carbon Dioxide Fugacity

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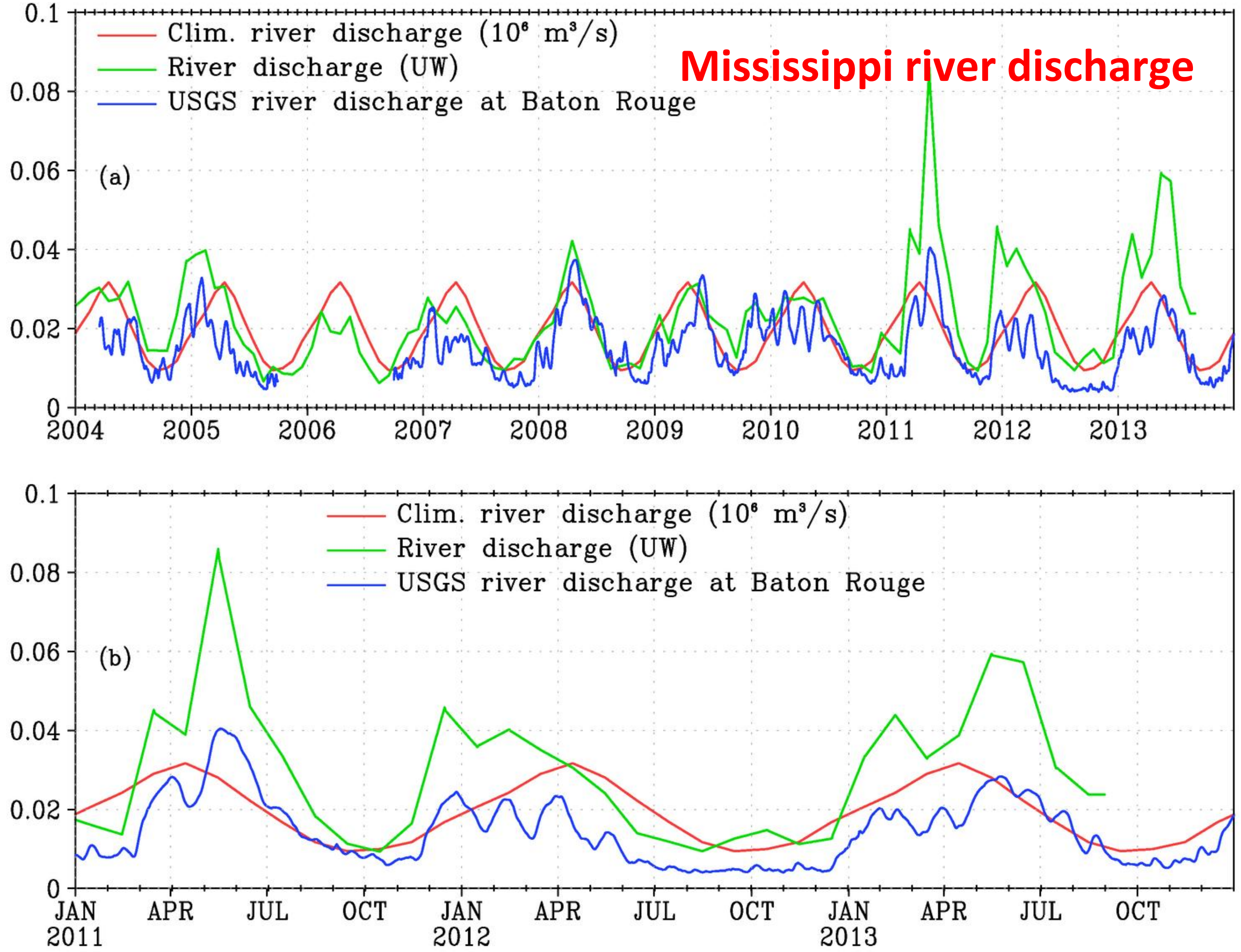
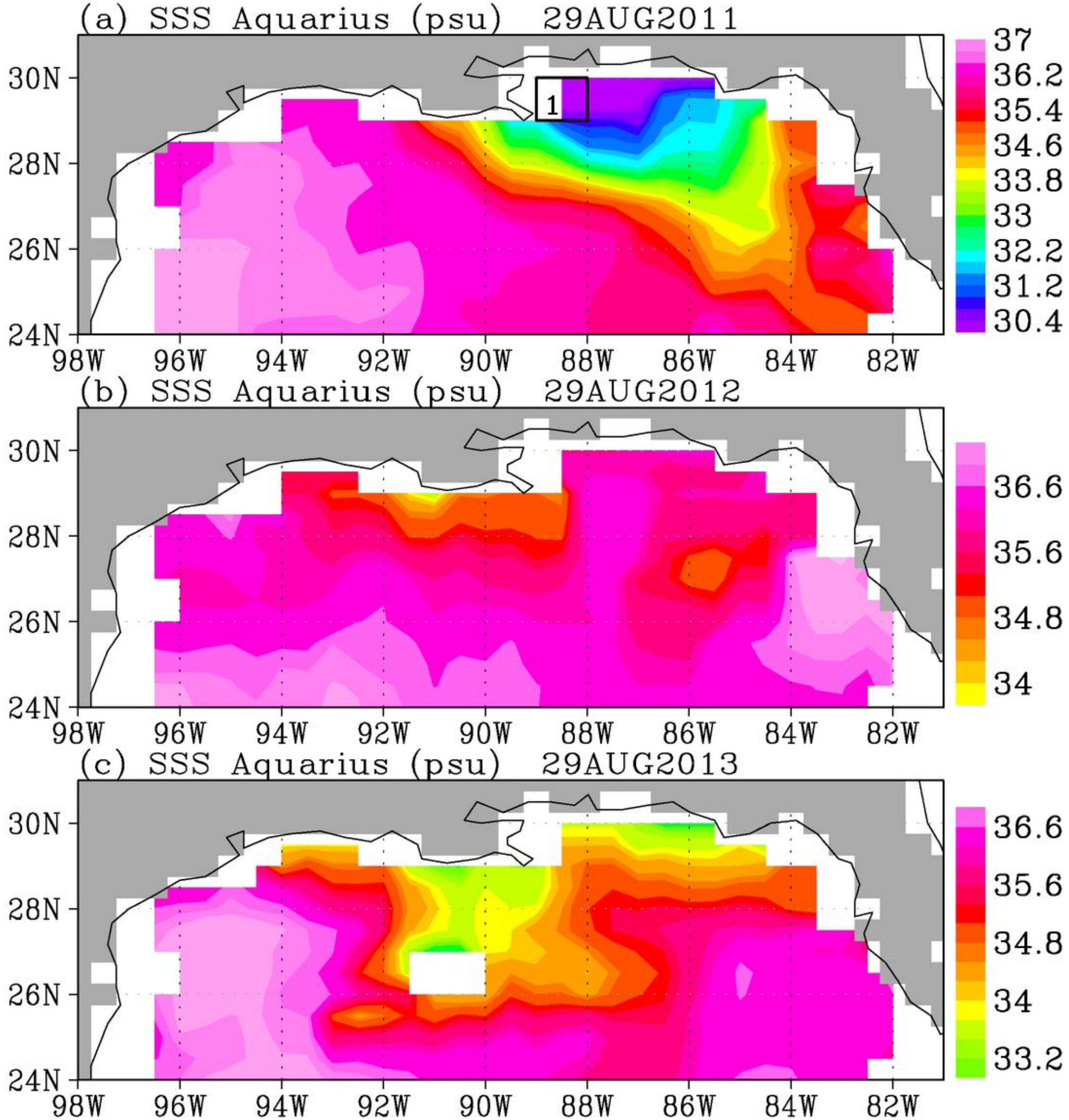
- **Linking Aquarius salinity to river discharge (project of NEWS program)**
- **Salinity impact on ocean carbon cycle**

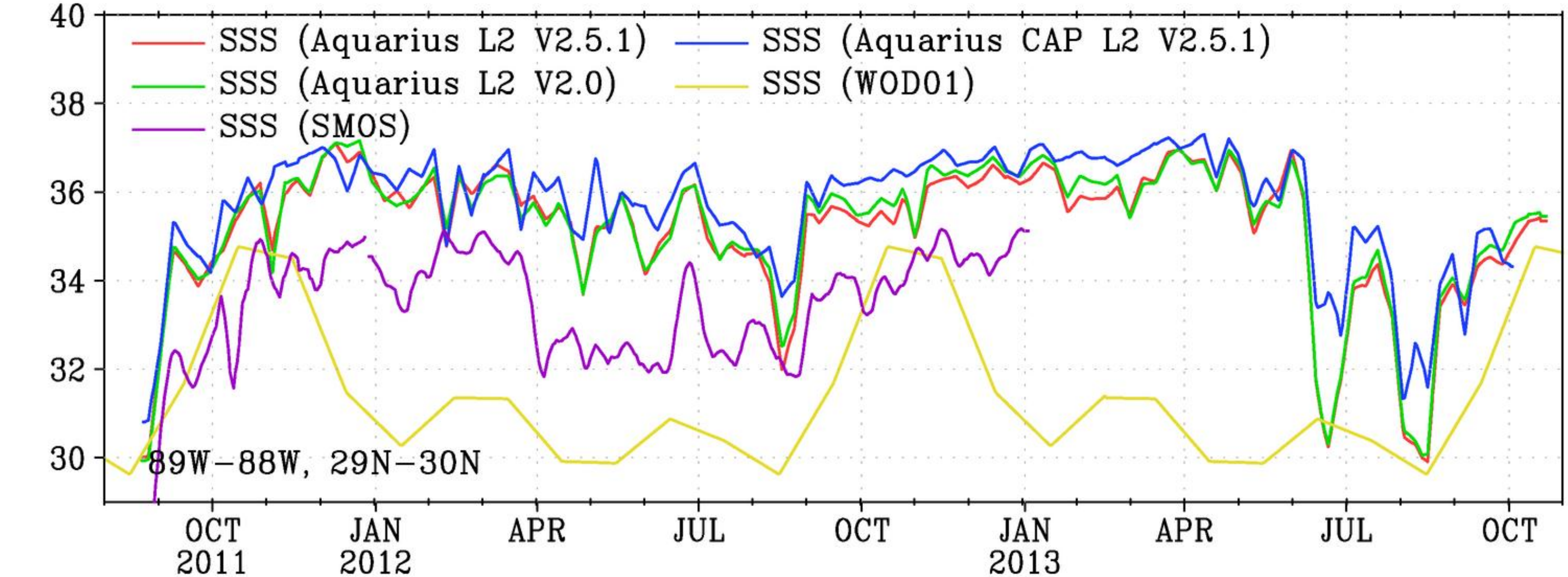
Mississippi river discharge

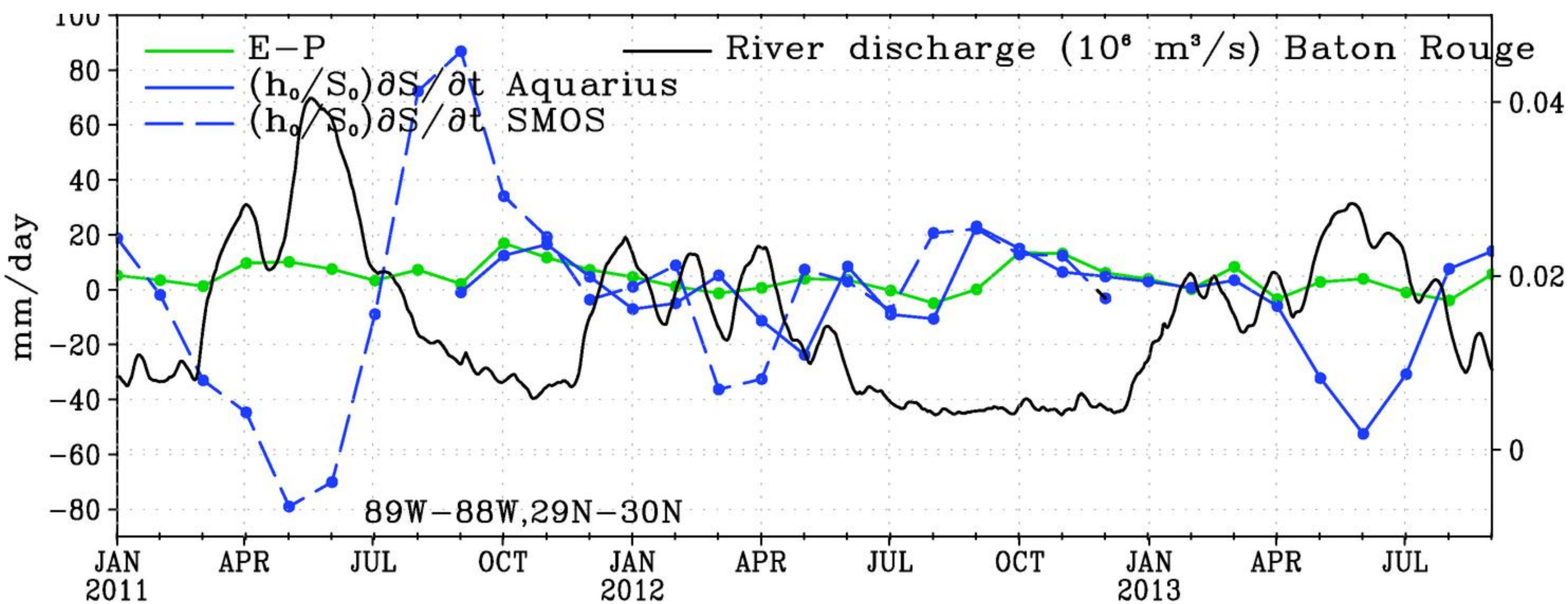


Peak discharge occurs between May and June for most years. In 2005, 2007, 2010, and 2012, peak occurs in the beginning of the year.

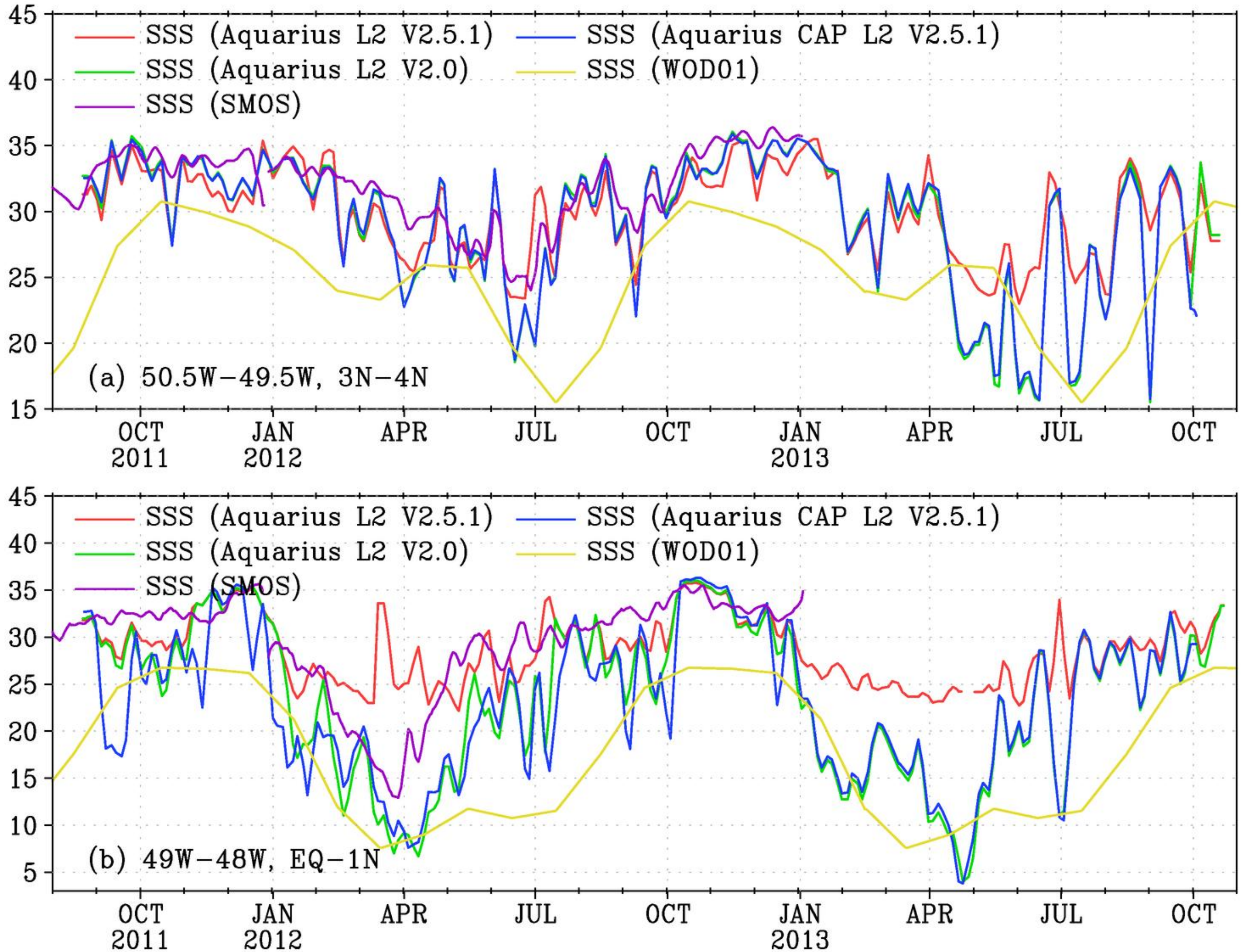


Low salinity occurs at the mouth of Mississippi in August, a few months after the maximum river discharges. 2011 has the strongest river discharge.

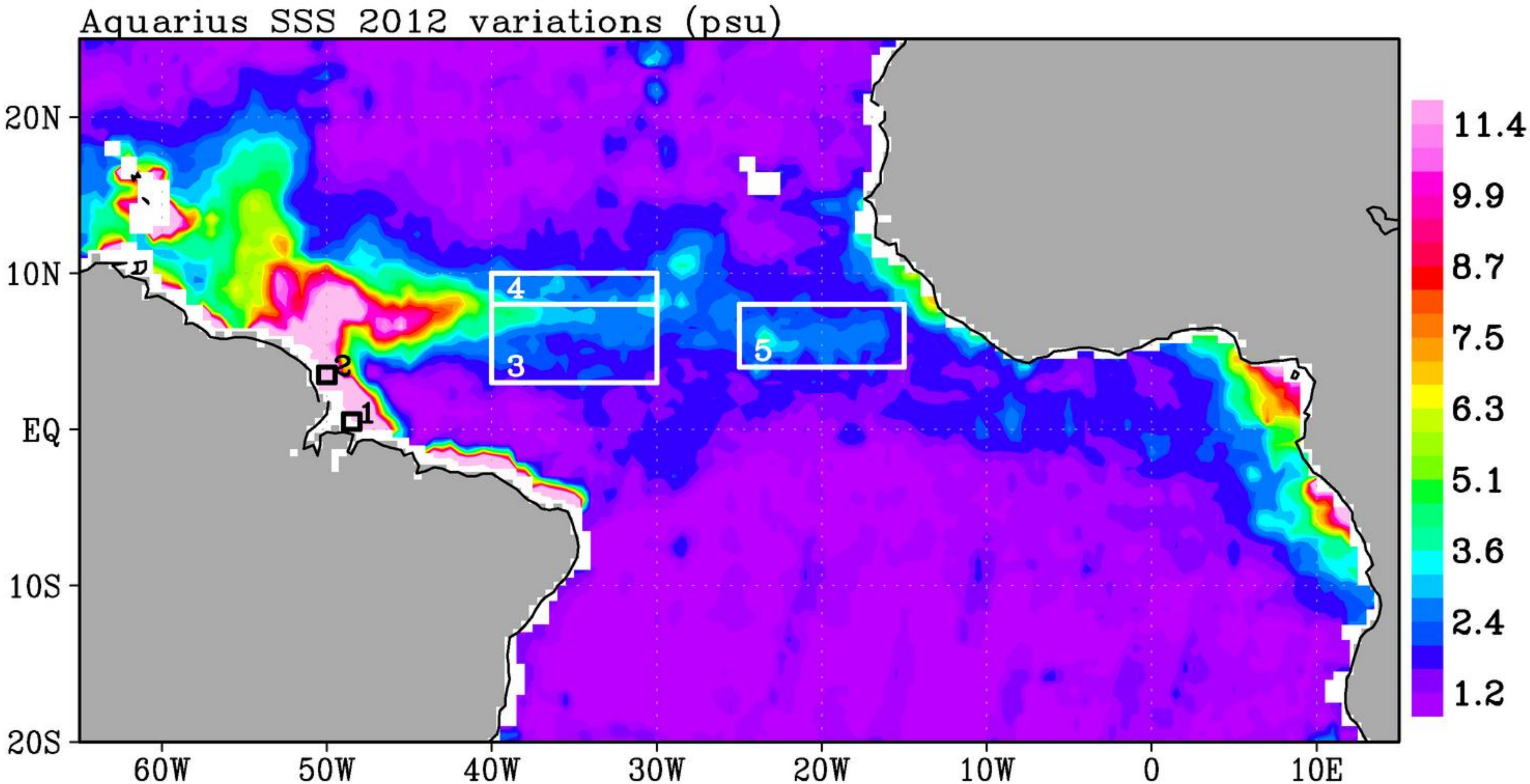




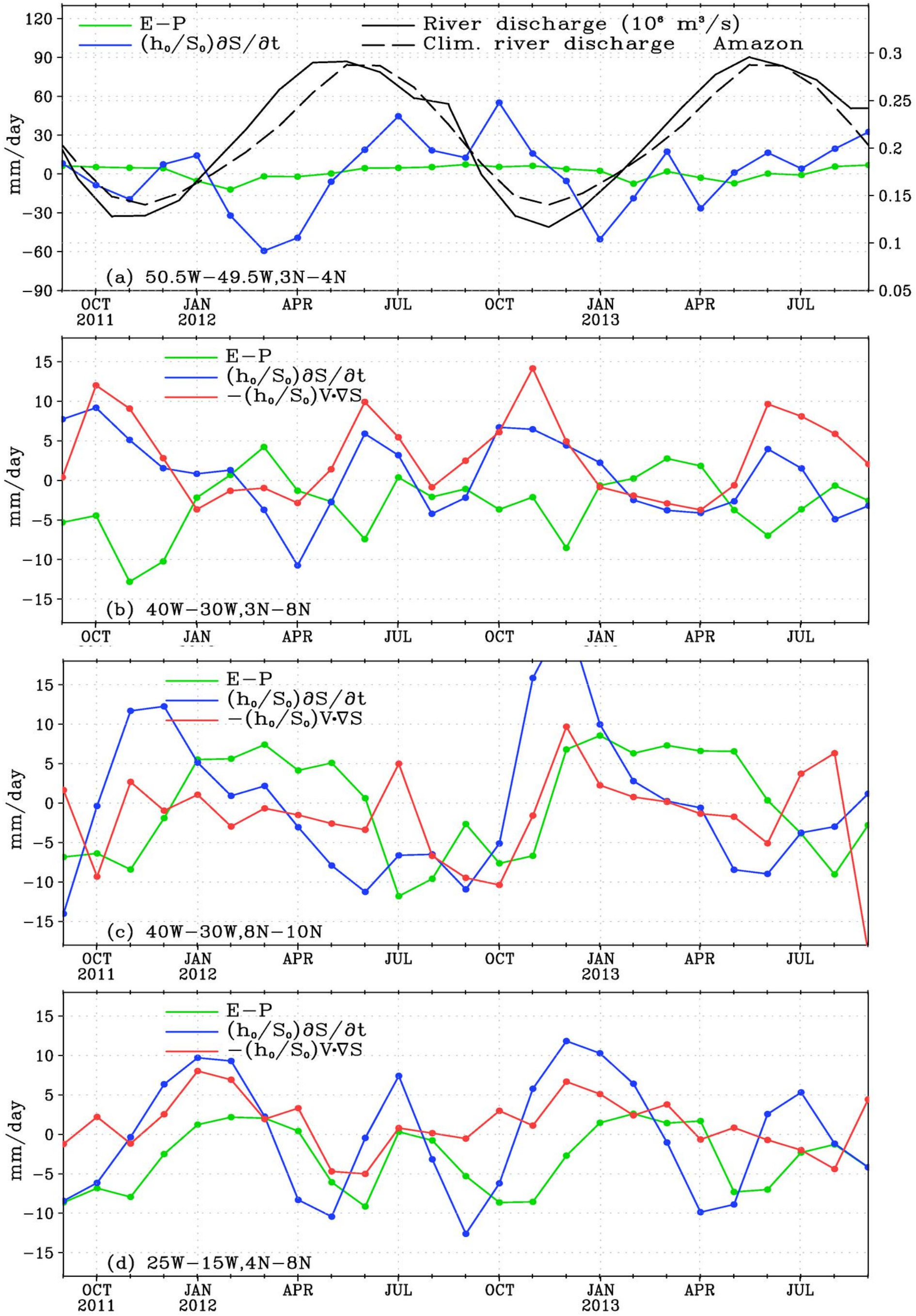
Three Aquarius products agree well; SMOS data are biased lower by 2 psu. Large river discharge events coincide with the fastest reduction of salinity in May/June 2011 and 2013.



To the east of the river mouth, the lowest salinity in April is earlier than the peak river discharge. To the north, the lowest salinity is in June. Aquarius V2.5.1 is significantly saltier.



Aquarius SSS 2012 variations (psu)
20N
10N
EQ
10S
20S
60W
50W
40W
30W
20W
10W
0
10E
1
2
3
4
5
11.4
9.9
8.7
7.5
6.3
5.1
3.6
2.4
1.2

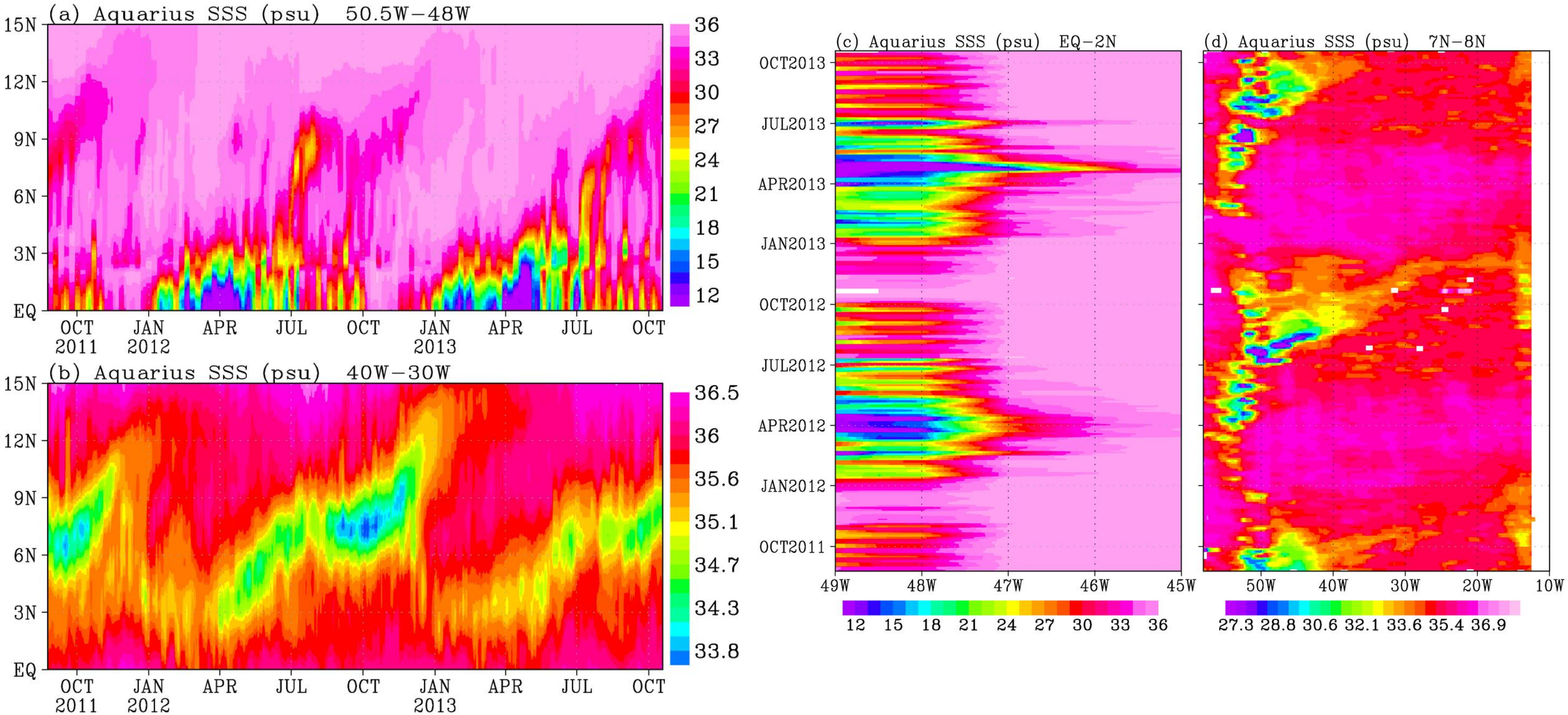


The largest salinity drop occurs in January/March, three months prior to the peak river discharge.

SSS tendency follows the advection closely, with semi-annual cycle, maximum in June/October, and minimum in April/August. E-P is out of phase with the SSS tendency.

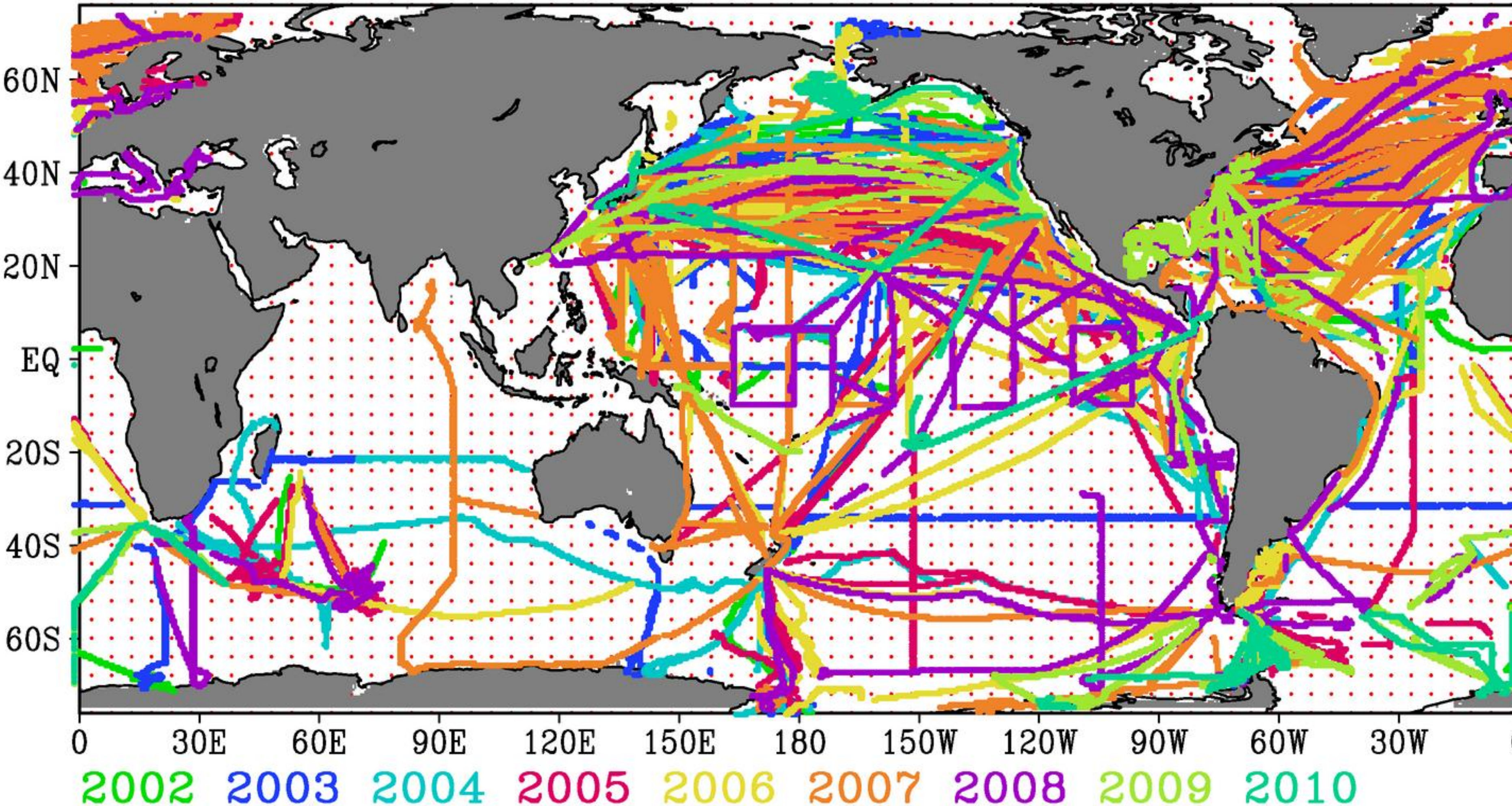
Dominated by the annual cycle. Tendency and advection are in phase, E-P lags 1-3 months.

Dominated by semi-annual cycle, with E-P lagging by one month.

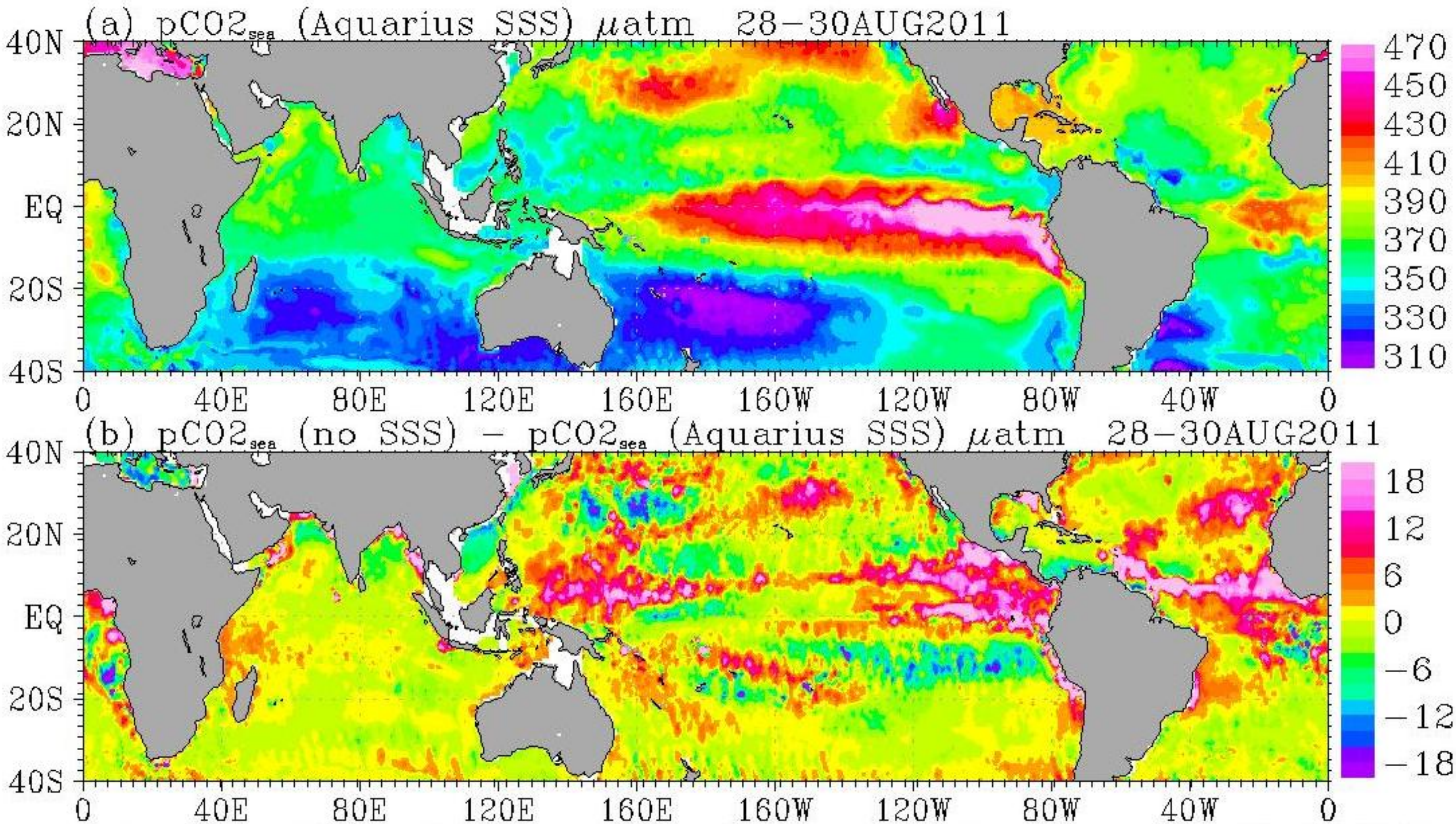


Fresh water moves north from the river mouth along the coast between January to September. Away from the river mouth, northward migration of fresh water tracks the seasonal march of ITCZ, with semi-annual variations between 5°N to 9°N. Fresh water spreads offshore towards eastward, reaching 45°W during March to May. At the NBC retroflection, fresh water plume is confined to the coastal area from January to June, and it moves eastward from July to December.

- Statistical model was developed using support vector regression
- Input: sin(day), cos(day), lat, sin(lon), cos(lon), AMSR-E SST, SeaWiFS+MODIS TERRA+MODIS Aqua Chl-a, climatological SSS
- 206265 data groups found 2002-2010 40,000 randomly selected for training and 40,000 for validation



Compiled from SOCAT+all other sources through CDIAC
206,265 colocated daily data points



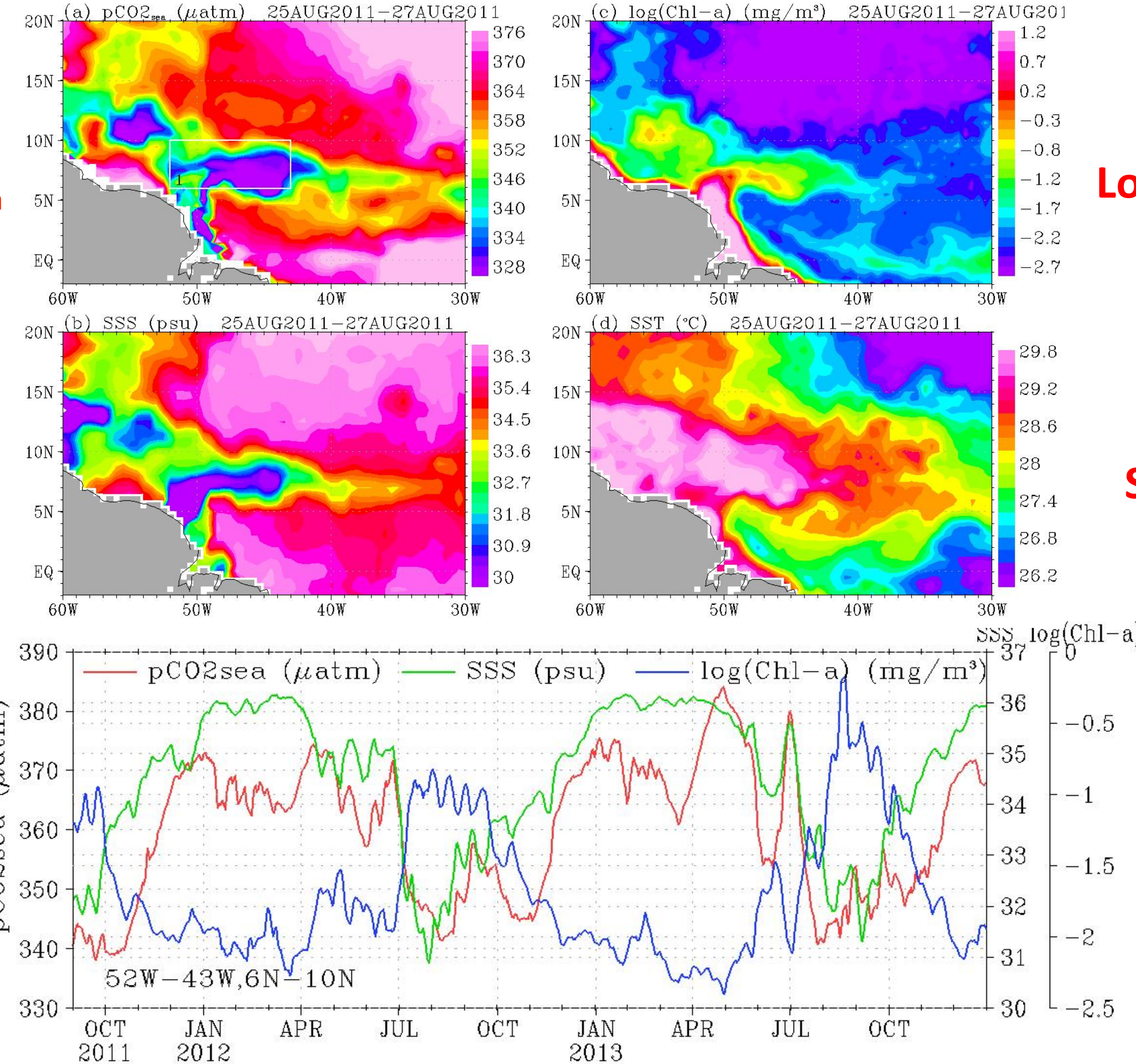
High $pCO2_{sea}$ in tropical central and eastern Pacific, low $pCO2_{sea}$ in southern oceans. Large impact of SSS on $pCO2_{sea}$ retrieval in the western Pacific warm pool, tropical eastern Pacific, and tropical Atlantic.

pCO2$_{sea}$

Log(Ch-a)

SSS

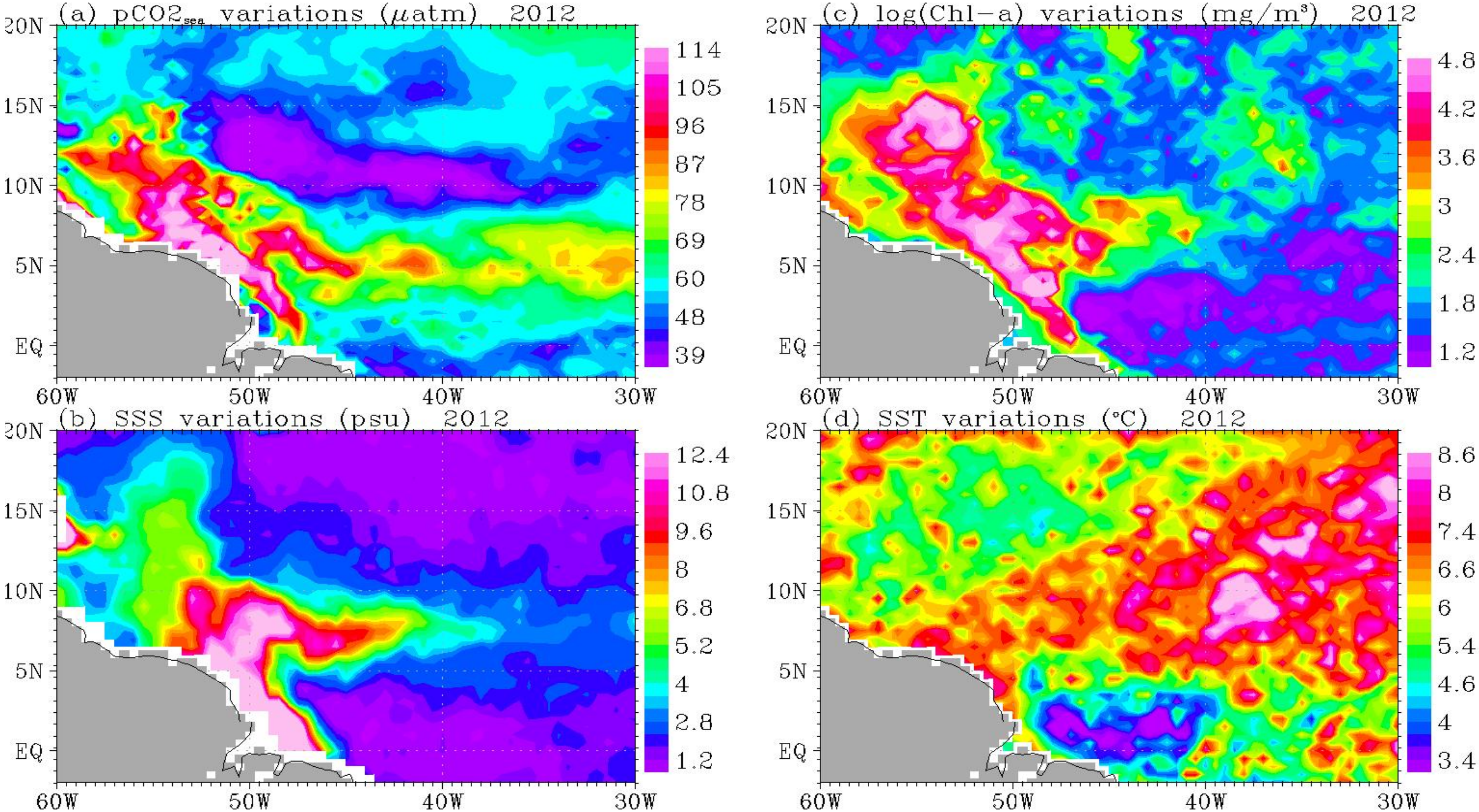
SST



Low pCO2$_{sea}$ in July/August, with fresh water and high productivity. High pCO2$_{sea}$ in December/January, April/May, and June/July, associated with low nutrient saline water.

pCO2$_{sea}$ max-min

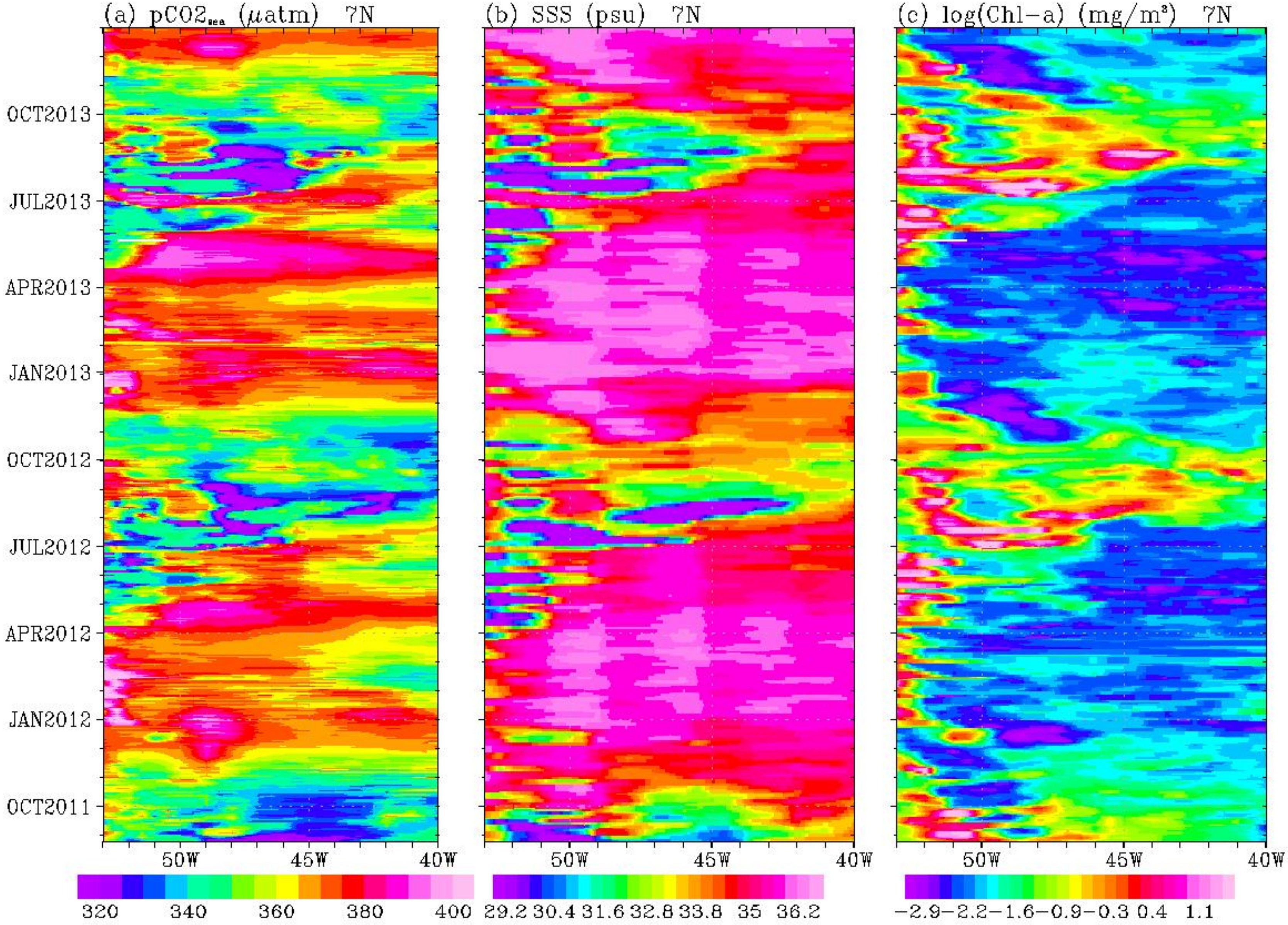
Log(Ch-a) max-min



SSS max-min

SST max-min

Coherent patterns of annual variation of pCO2$_{sea}$, SSS, and Ch-a.



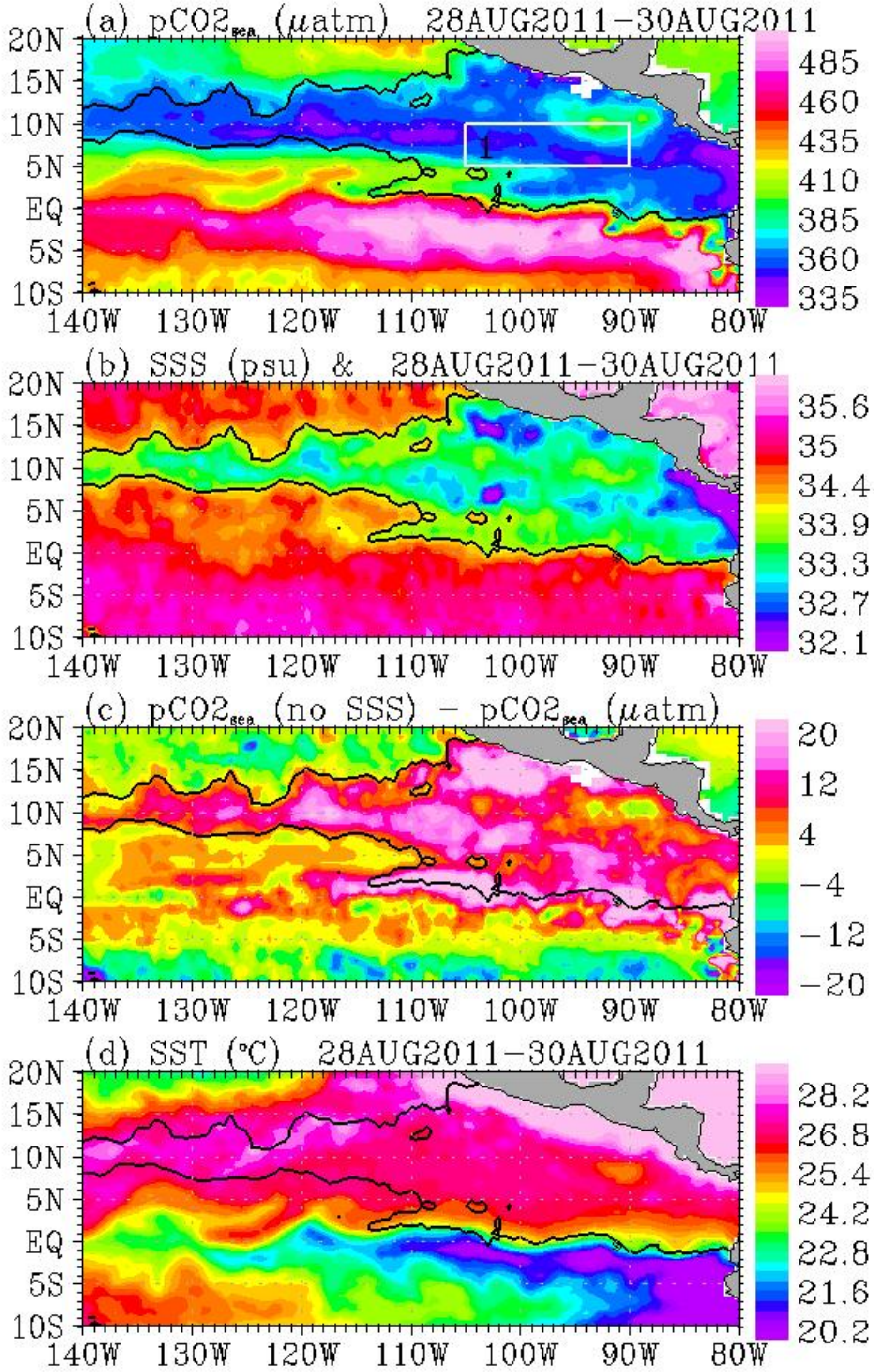
Low pCO2sea associated with the high nutrient, fresh water moves eastward from July to November, when the NECC and NBC retroflection are strong.

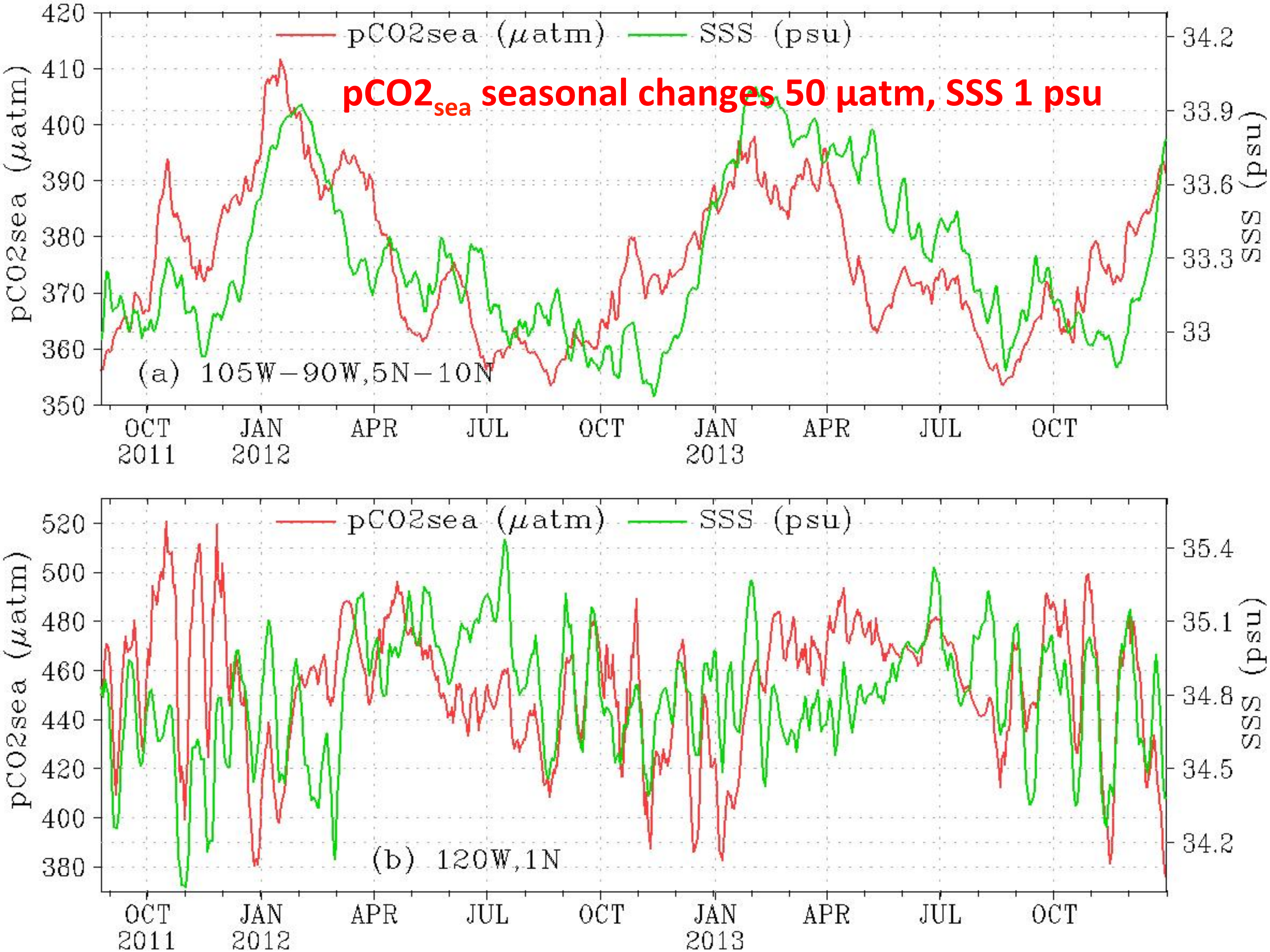
$pCO2_{sea}$

Contour line: SSS=34 psu

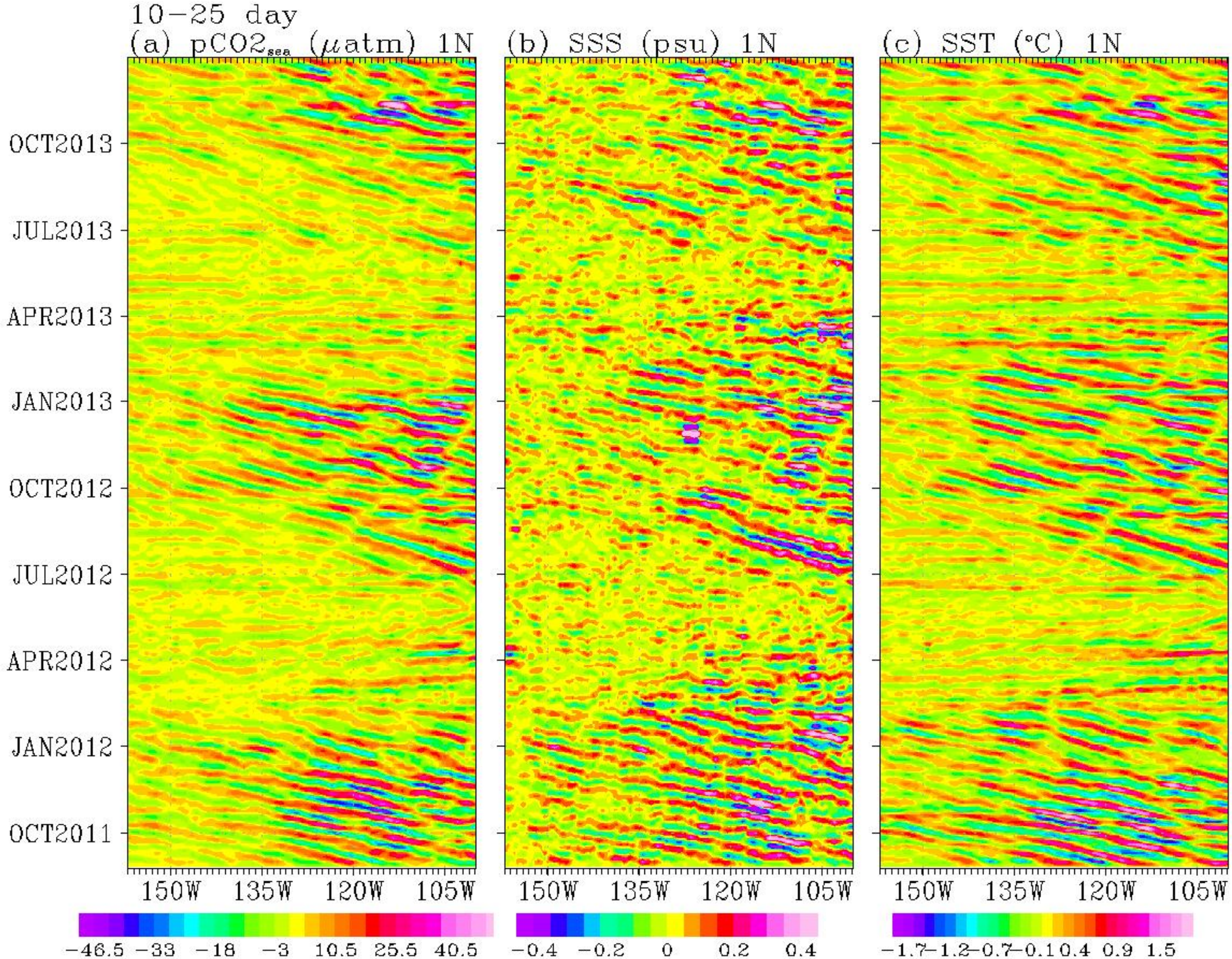
Difference of $pCO2_{sea}$ retrieved without and with SSS

SST

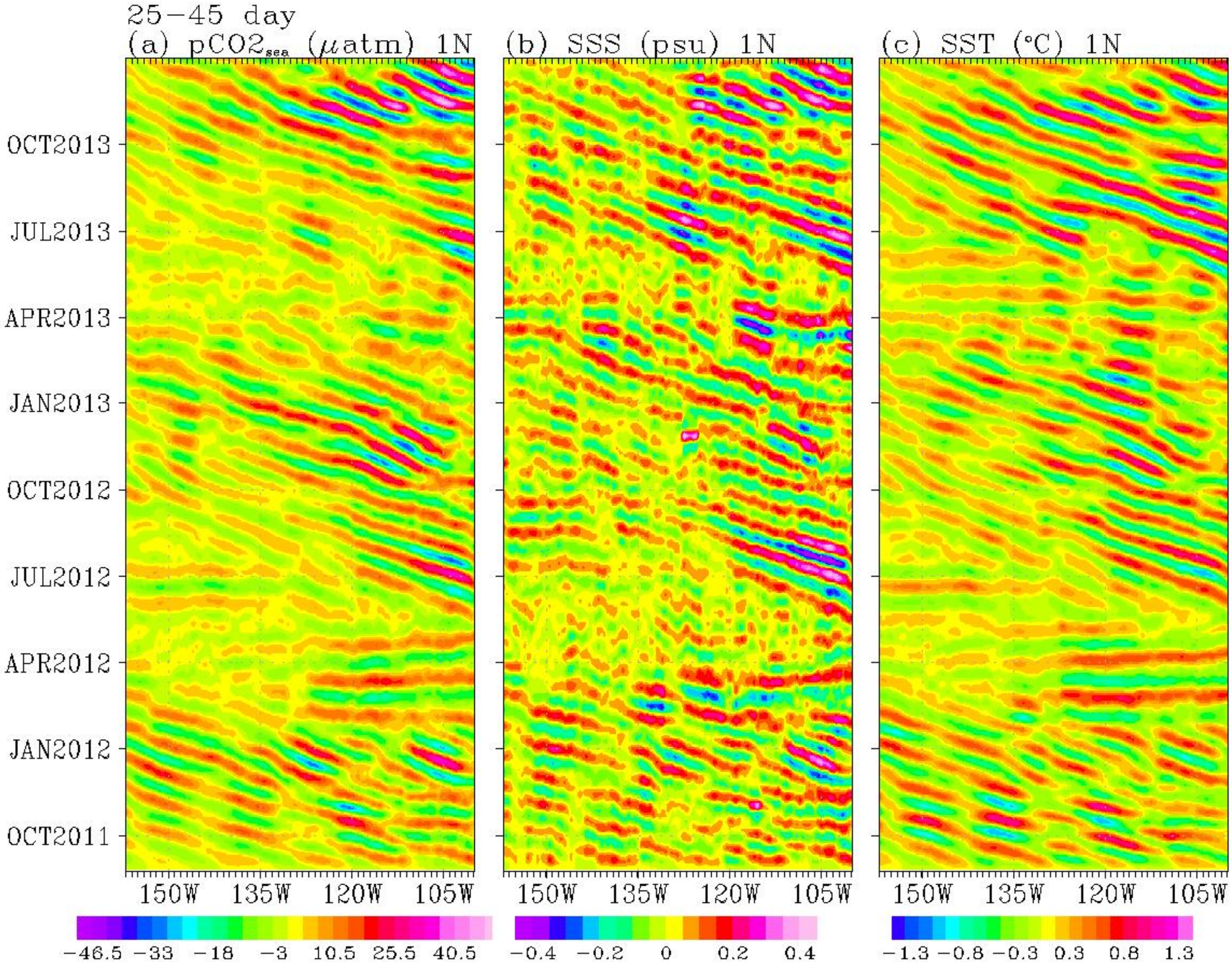




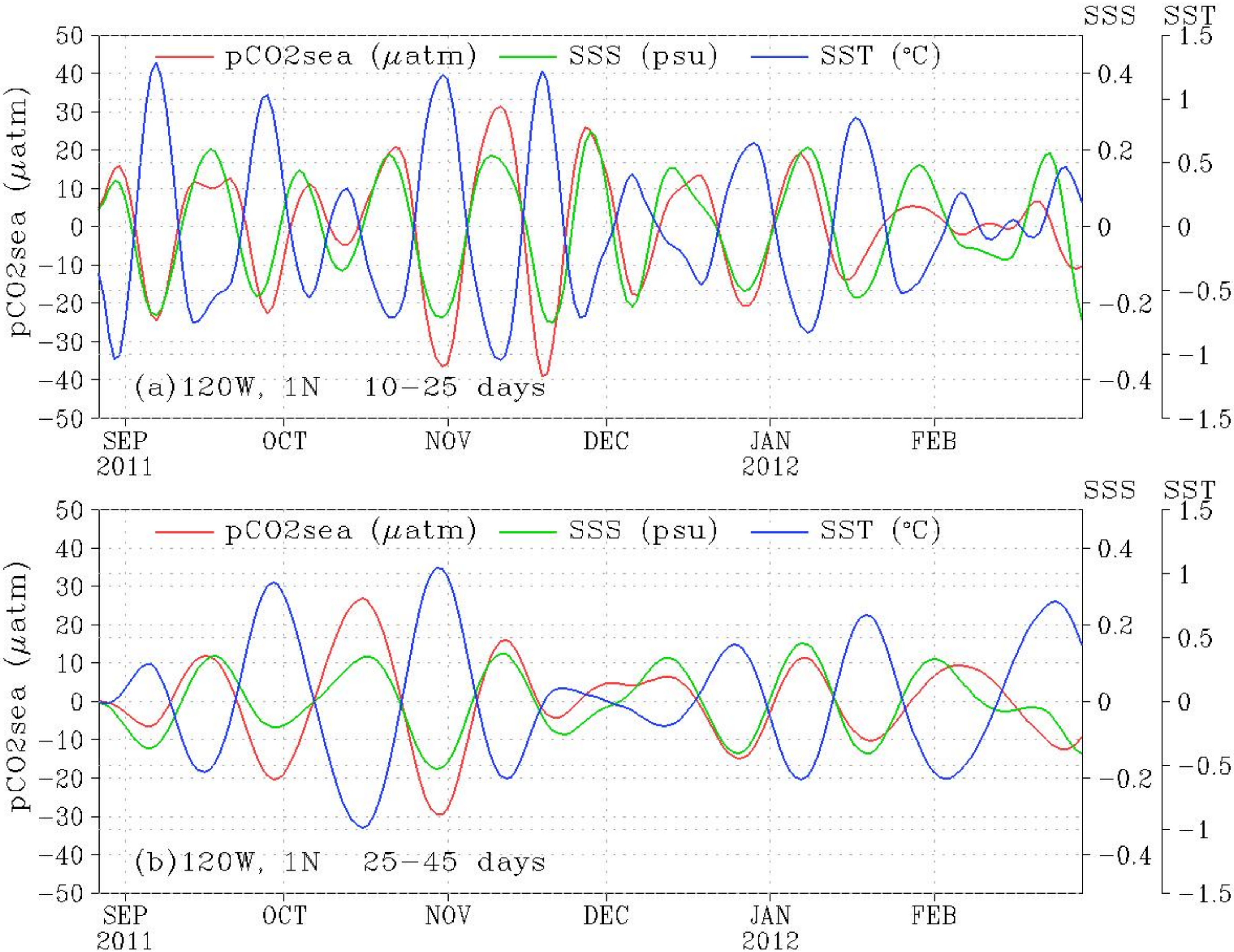
TIW: $pCO2_{sea}$ changes >100 µatm, SSS 1 psu, July-February



10−25 day
(a) pCO2sea (μatm) 1N
(b) SSS (psu) 1N
(c) SST (°C) 1N
OCT2013
JUL2013
APR2013
JAN2013
OCT2012
JUL2012
APR2012
JAN2012
OCT2011
150W 135W 120W 105W
−46.5 −33 −18 −3 10.5 25.5 40.5
−0.4 −0.2 0 0.2 0.4
−1.7−1.2−0.7−0.1 0.4 0.9 1.5



25−45 day
(a) pCO2sea (μatm) 1N
(b) SSS (psu) 1N
(c) SST (°C) 1N
OCT2013
JUL2013
APR2013
JAN2013
OCT2012
JUL2012
APR2012
JAN2012
OCT2011
150W
135W
120W
105W
−46.5 −33 −18 −3 10.5 25.5 40.5
−0.4 −0.2 0 0.2 0.4
−1.3 −0.8 −0.3 0.3 0.8 1.3



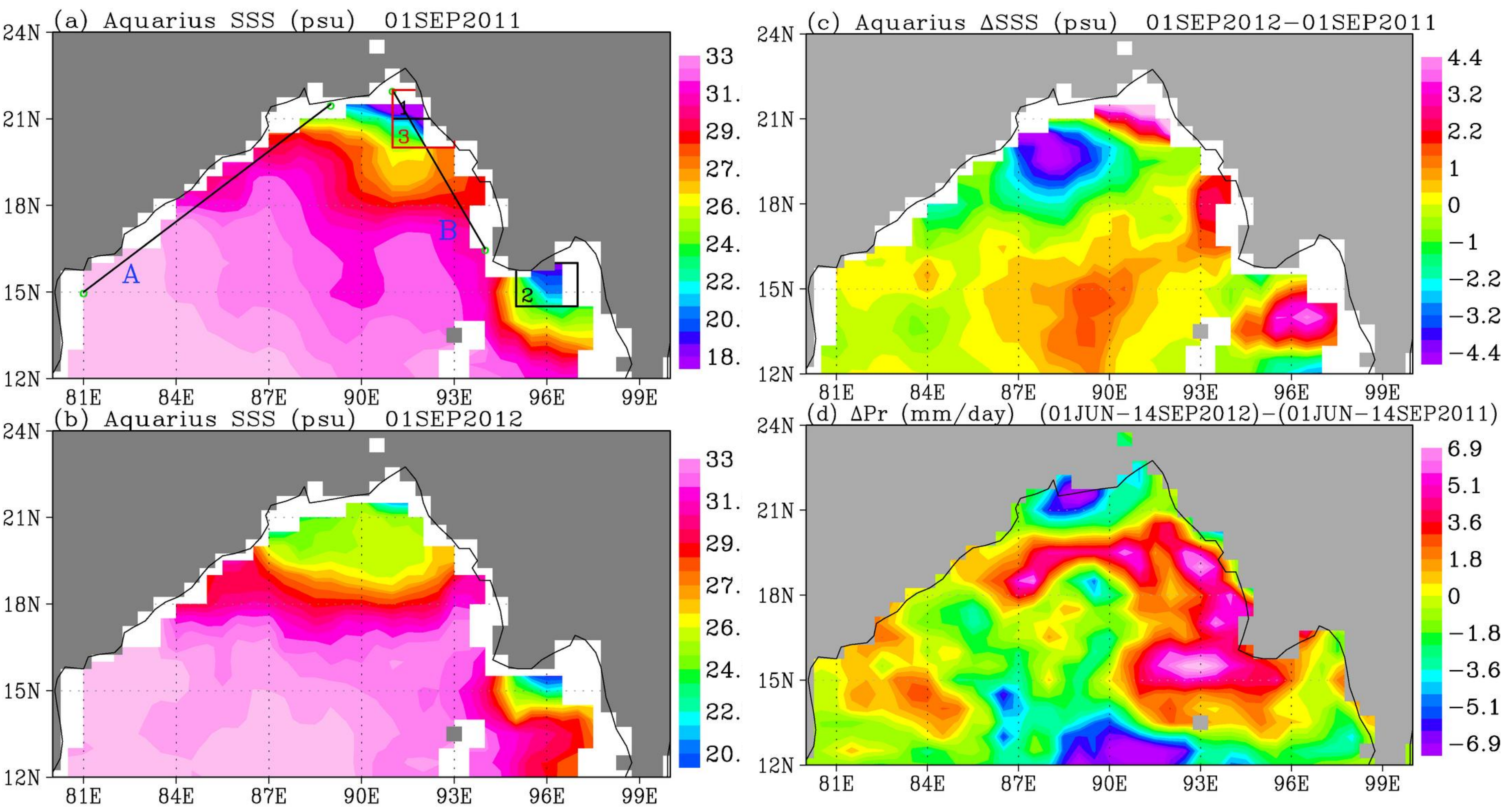
pCO2sea (μatm)
SSS (psu)
SST (°C)
SSS
SST
(a)120W, 1N 10−25 days
SEP 2011
OCT
NOV
DEC
JAN 2012
FEB
pCO2sea (μatm)
SSS (psu)
SST (°C)
SSS
SST
(b)120W, 1N 25−45 days
SEP 2011
OCT
NOV
DEC
JAN 2012
FEB

Summary

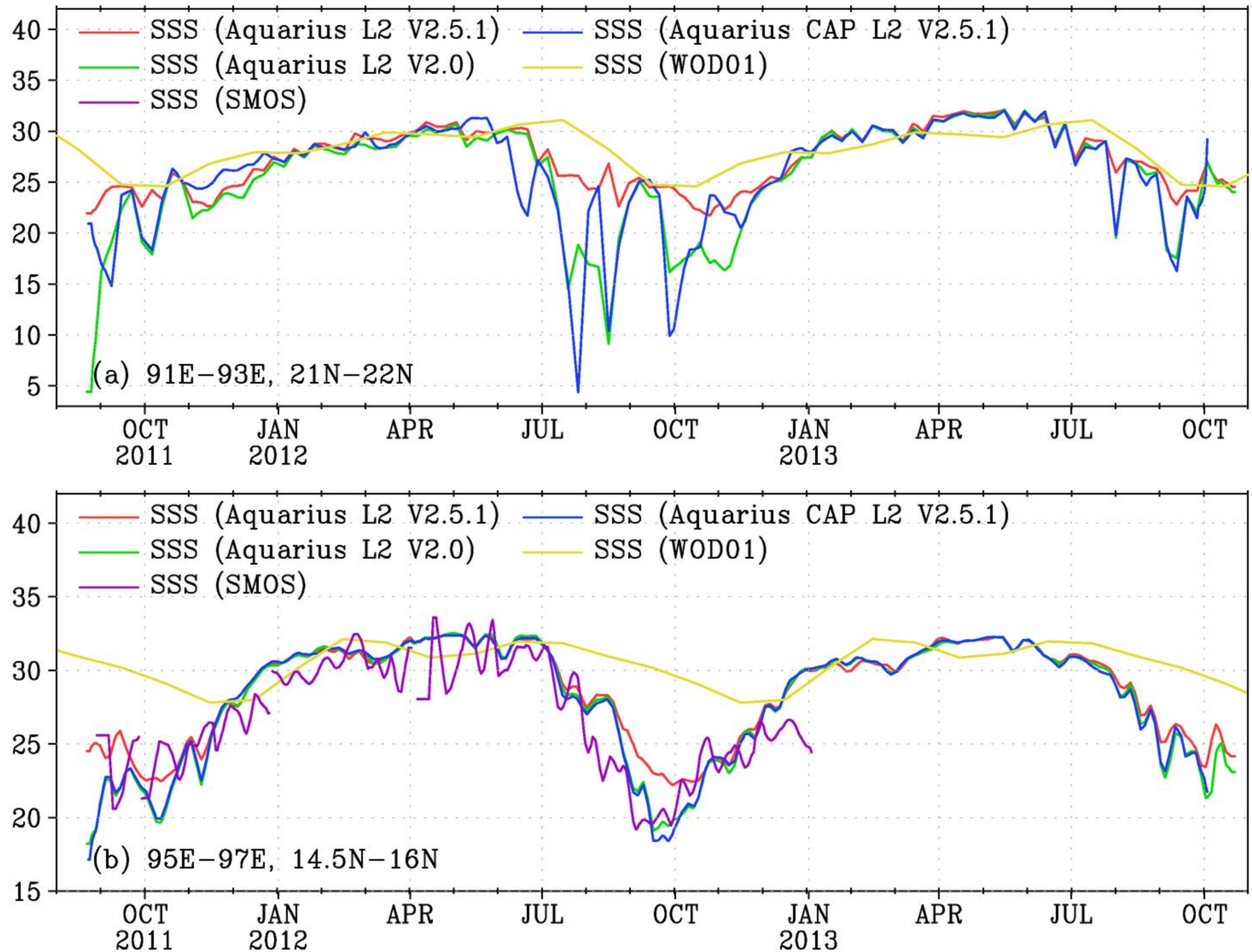
- SSS change around the river mouth is mainly driven by river discharge. Satellite measurements of SSS clearly track movements of the fresh water from river discharges.
- For the Mississippi and Amazon river mouths, and Atlantic ITCZ, E-P contributes little to the salinity seasonal change. In the central and eastern ITCZ, contribution of advection to the salinity tendency is more important.
- In the tropical western Atlantic, seasonal variations of $pCO2_{sea}$ are mainly determined by SSS and biological productivity.
- Strong impacts of salinity on $pCO2_{sea}$ are detected in the tropical eastern Pacific. Strong coupling among $pCO2_{sea}$, SSS, and SST is manifested by the TIW signatures. Varied from year to year, the 19 day wave is generally strongest near 1°N for all three parameters. The 30 day wave illustrates distinguished signals from 0.5°N to 4°N.

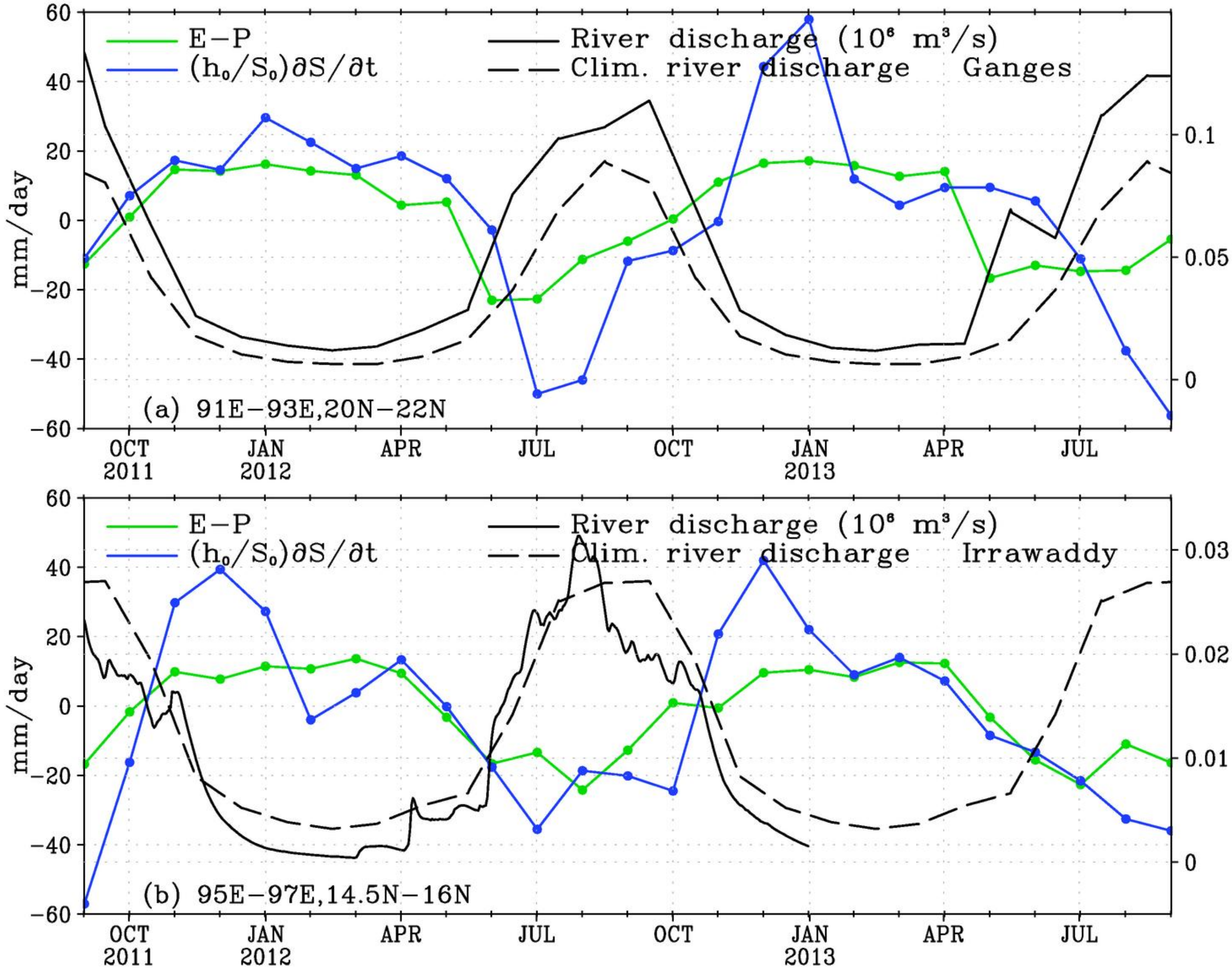
Future work:

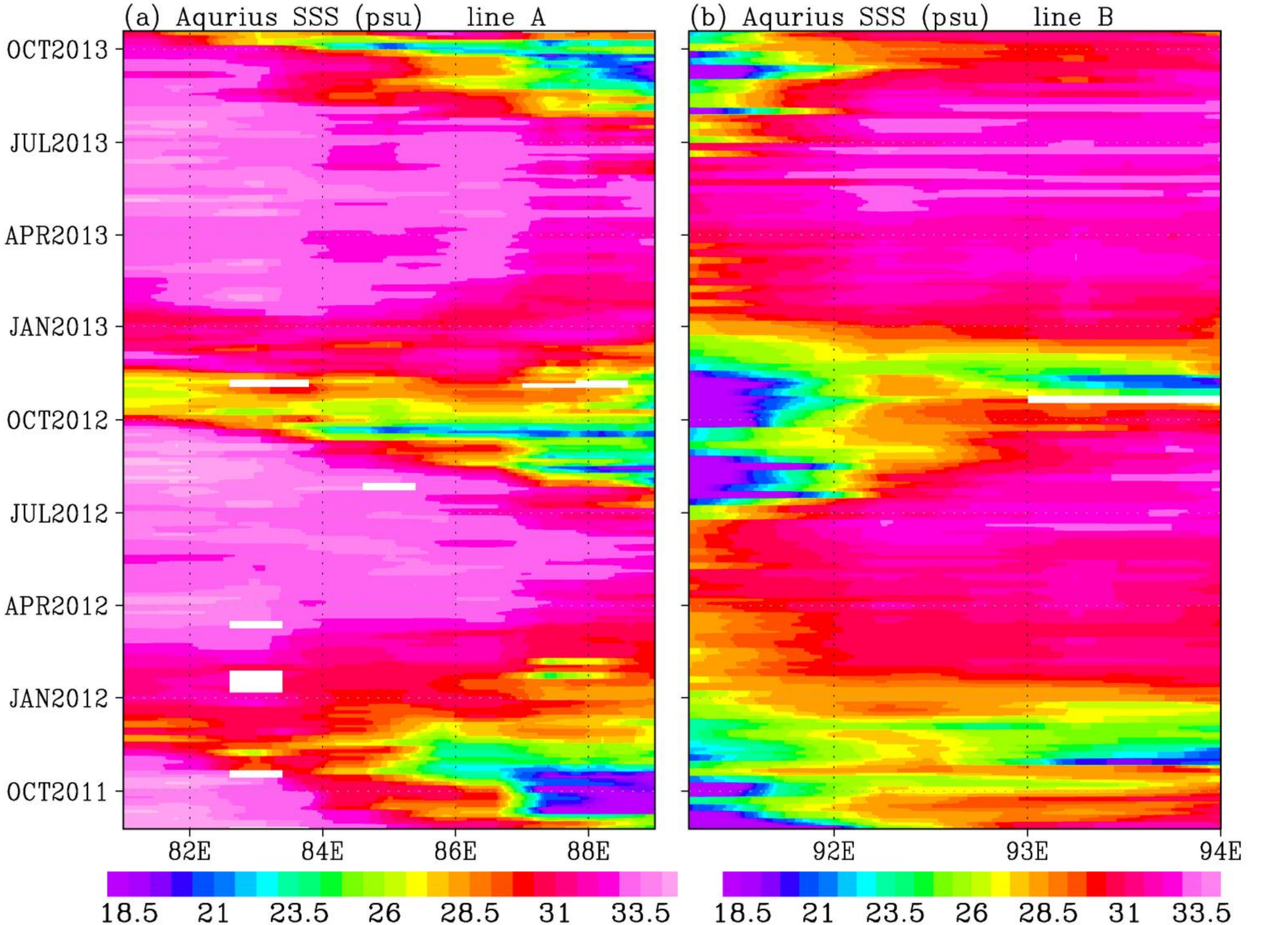
- ❑ **Investigate the causes (such as wind driven local circulation) of inconsistency between the maximum freshening near the Amazon river mouth and the peak river discharge.**
- ❑ **Quantify the pCO2sea changes due to SSS and SST in the tropical eastern Pacific.**
- ❑ **Study the SSS impact on global air-sea carbon dioxide flux estimation.**



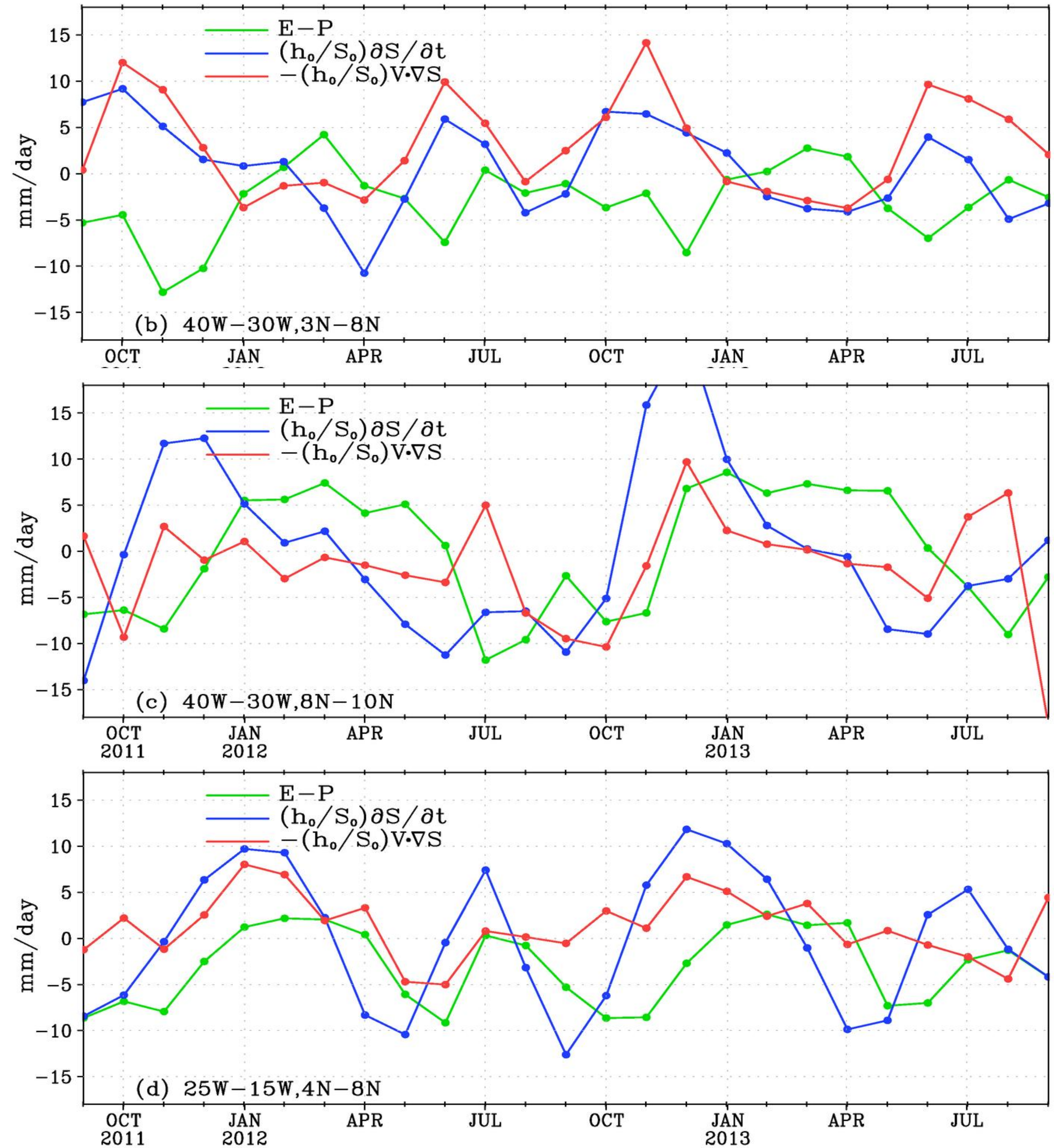
(a) Aquarius SSS (psu) 01SEP2011
(b) Aquarius SSS (psu) 01SEP2012
(c) Aquarius ΔSSS (psu) 01SEP2012−01SEP2011
(d) ΔPr (mm/day) (01JUN−14SEP2012)−(01JUN−14SEP2011)
A
B
1
2
3
24N
21N
18N
15N
12N
81E
84E
87E
90E
93E
96E
99E
33
31.
29.
27.
26.
24.
22.
20.
18.
4.4
3.2
2.2
1
0
−1
−2.2
−3.2
−4.4
6.9
5.1
3.6
1.8
0
−1.8
−3.6
−5.1
−6.9


SSS (Aquarius L2 V2.5.1)
SSS (Aquarius CAP L2 V2.5.1)
SSS (Aquarius L2 V2.0)
SSS (WOD01)
SSS (SMOS)
(a) 91E−93E, 21N−22N
(b) 95E−97E, 14.5N−16N
40
35
30
25
20
15
10
5
OCT
2011
JAN
2012
APR
JUL
OCT
JAN
2013
APR
JUL
OCT


E−P
$(h_0/S_0)\partial S/\partial t$
River discharge (10^6 m³/s)
Clim. river discharge Ganges
mm/day
(a) 91E−93E,20N−22N
OCT 2011
JAN 2012
APR
JUL
OCT
JAN 2013
APR
JUL
E−P
$(h_0/S_0)\partial S/\partial t$
River discharge (10^6 m³/s)
Clim. river discharge Irrawaddy
mm/day
(b) 95E−97E,14.5N−16N
OCT 2011
JAN 2012
APR
JUL
OCT
JAN 2013
APR
JUL



(a) Aqurius SSS (psu) line A
(b) Aqurius SSS (psu) line B
OCT2013
JUL2013
APR2013
JAN2013
OCT2012
JUL2012
APR2012
JAN2012
OCT2011
82E
84E
86E
88E
92E
93E
94E
18.5
21
23.5
26
28.5
31
33.5



E−P
$(h_o/S_o)\partial S/\partial t$
$-(h_o/S_o)V\cdot\nabla S$
mm/day
(b) 40W−30W,3N−8N
OCT
JAN
APR
JUL
OCT
JAN
APR
JUL
E−P
$(h_o/S_o)\partial S/\partial t$
$-(h_o/S_o)V\cdot\nabla S$
mm/day
(c) 40W−30W,8N−10N
OCT 2011
JAN 2012
APR
JUL
OCT
JAN 2013
APR
JUL
E−P
$(h_o/S_o)\partial S/\partial t$
$-(h_o/S_o)V\cdot\nabla S$
mm/day
(d) 25W−15W,4N−8N
OCT 2011
JAN 2012
APR
JUL
OCT
JAN 2013
APR
JUL