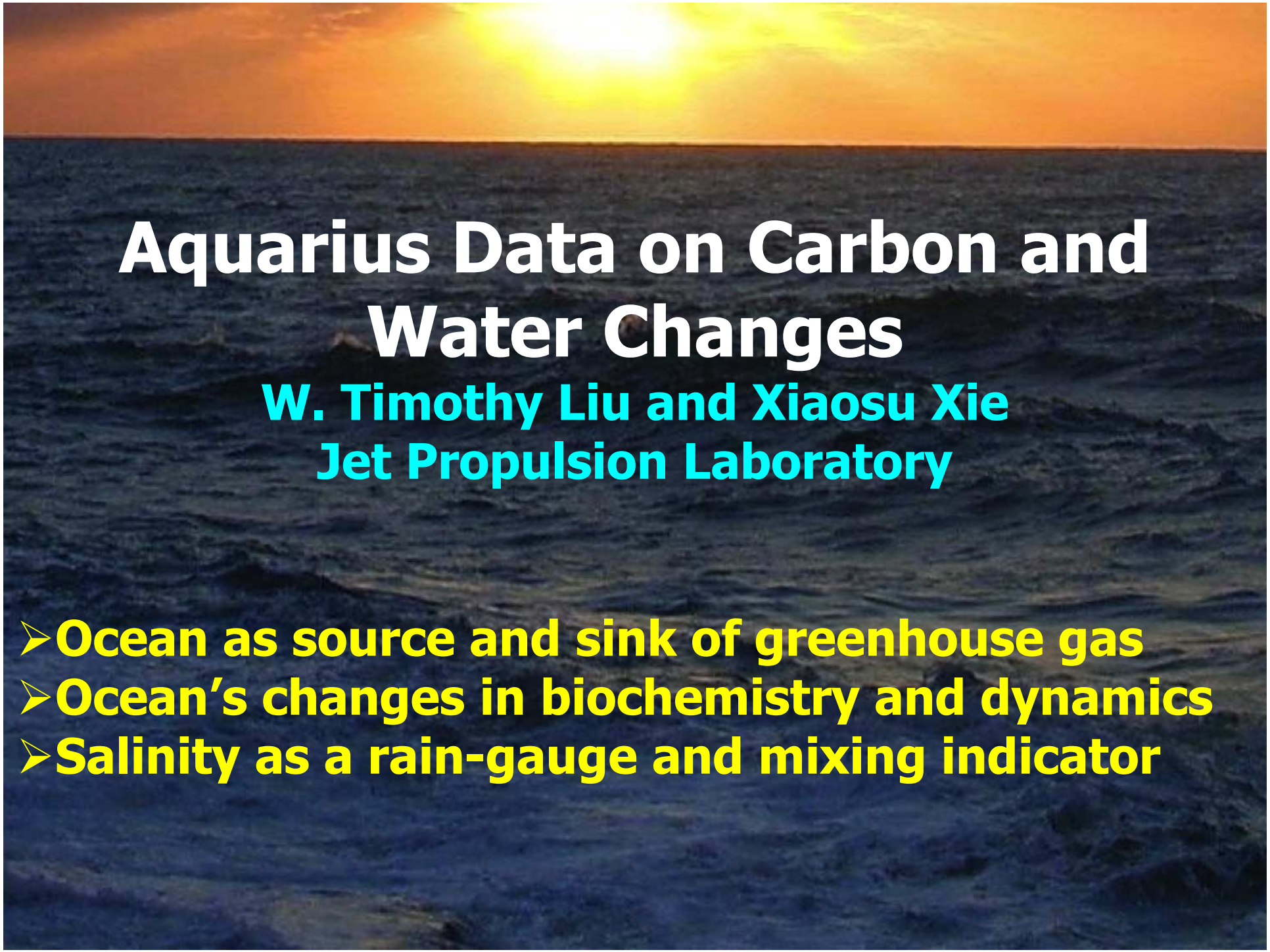

Aquarius Data on Carbon and Water Changes

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Jet Propulsion Laboratory

- Ocean as source and sink of greenhouse gas
- Ocean's changes in biochemistry and dynamics
- Salinity as a rain-gauge and mixing indicator

The air-sea exchange in CO2 (F) is

$$F = k\alpha(\Delta pCO_2)$$

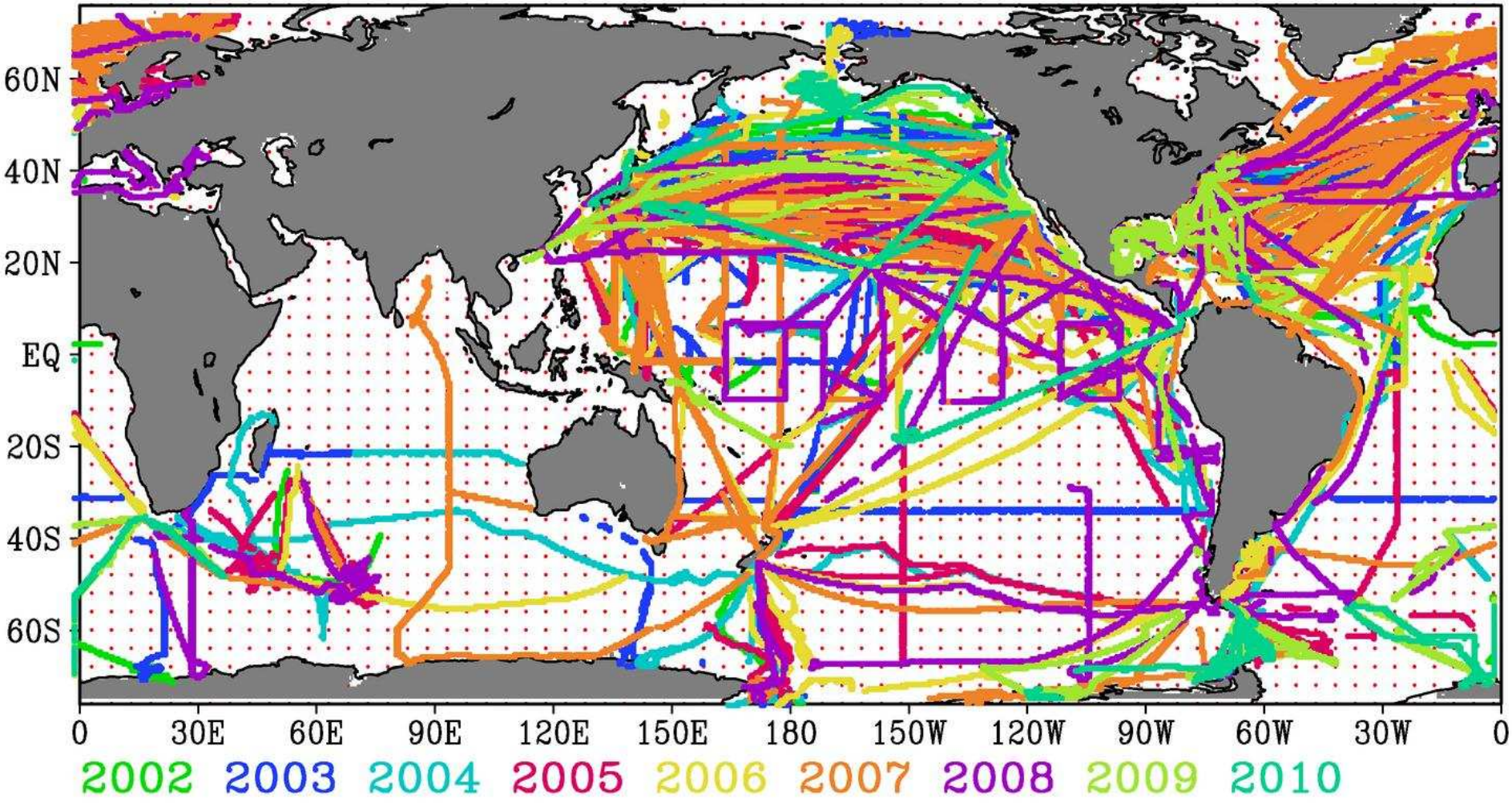
k: CO2 gas transfer (piston) velocity

α: solubility of CO2 in seawater

$(\Delta pCO_2) = pCO_{2sea} - pCO_{2air}$

- The variation of $pCO2_{air}$ is much smaller than $pCO2_{sea}$
- k is modeled in term of wind speed, but stress and roughness are what really counts.
- Scatterometer measures roughness and turbulent (stress and transfer velocity).
- Many recent cruises measured $pCO2_{sea}$, adding to past WOCE and JGOLF data, but still no sufficient coverage.

We have collected 206,265 daily data points collocated with space data



Compiled from SOCAT+all other sources through CDIAC

Relation between $pCO2_{sea}$ and other parameters are developed with co-incident measurements on cruises

Stephen et al. (1995)-9 cruises in Pacific in 6 years
Goyet et al. (1998) Arabian Sea
Hood et al. (1999) Greenland Sea
Nelson et al. (2001) Sargasso Sea
Cosca et al. (2001) Equatorial Pacific
Zhu et al. (2009) South China Sea
Padin et al. (2009) Biscay Bay

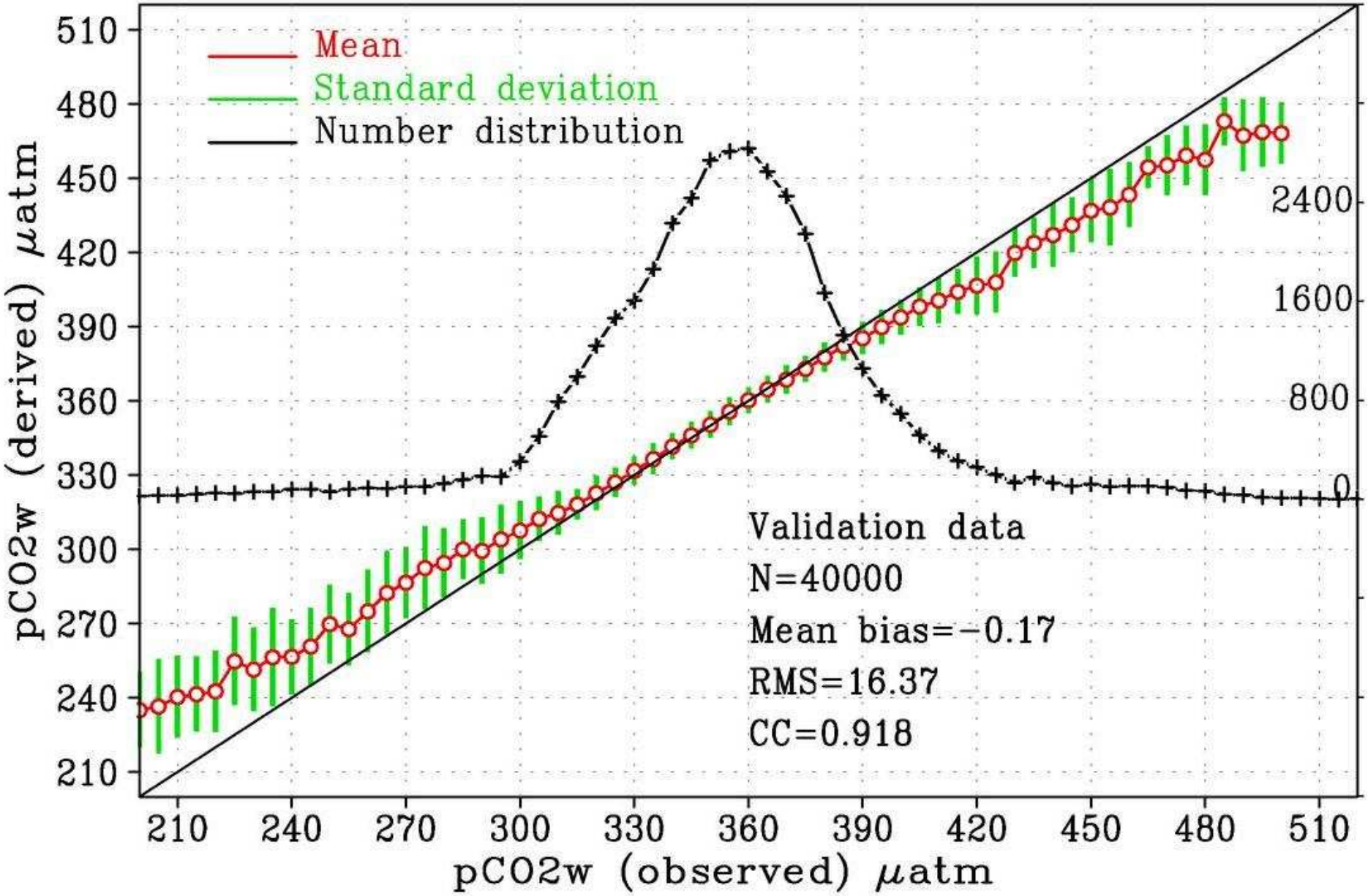
The drivers (temperature, salinity, productivity, and mixing) are only seasonally and regionally significant.

- **Statistical model was developed using support vector regression**
- **Input (3-day): sin(day), cos(day), lat, sin(lon), cos(lon), SST (AMSR-E) , Chl-a (SeaWiFS+MODIS TERRA+MODIS Aqua), SSS (Levitus climatology), Mixed layer depth (GODAS).**
- **206265 data groups found 2002-2010**

40,000 randomly selected for training and 40,000 for validation

- **Output: 9 year $pCO2_{sea}$ at 0.5°, 3-day resolution**

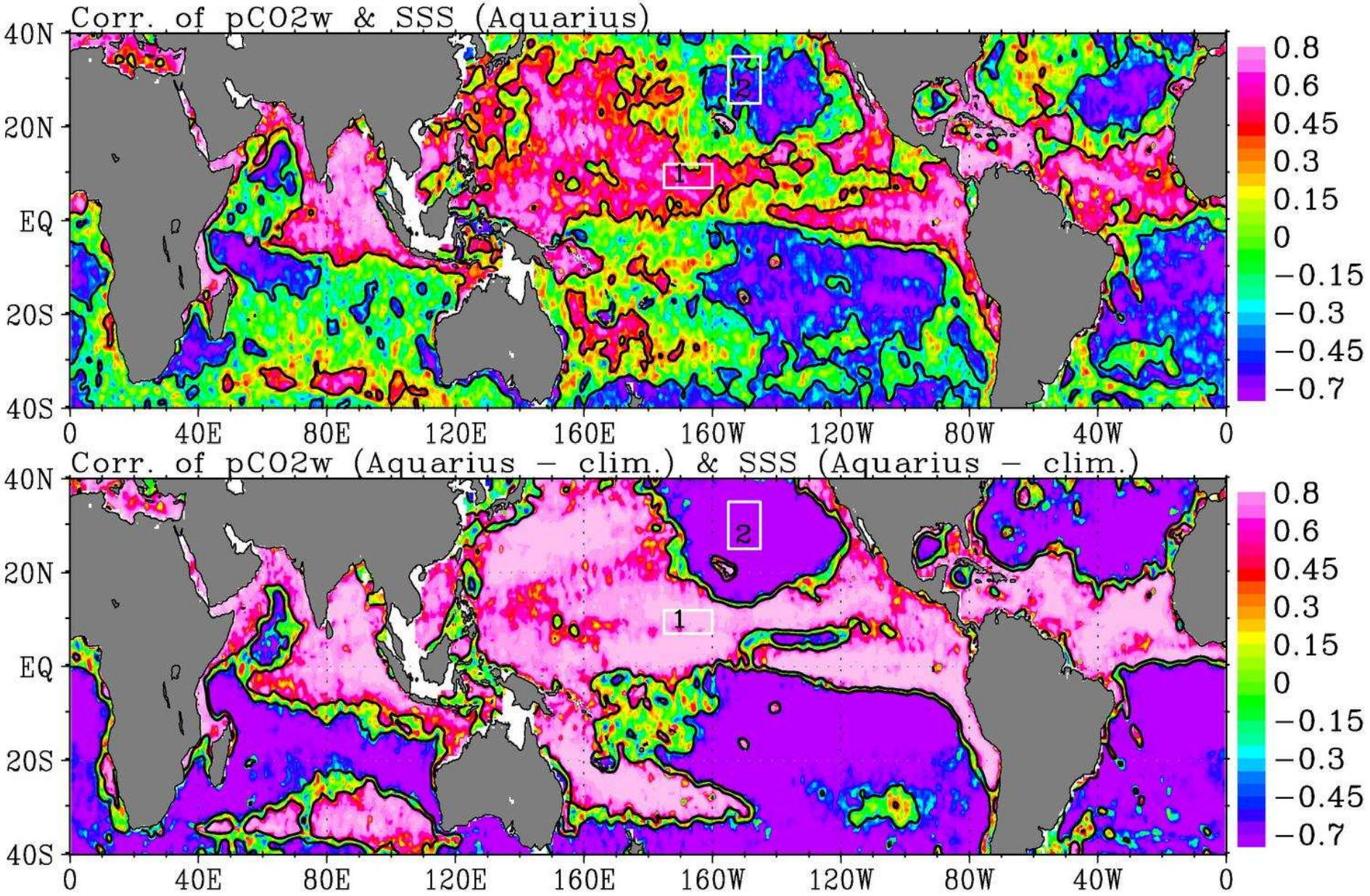
Global validation



Derived data pick up well-known seasonal cycles, El Nino and PDO signals

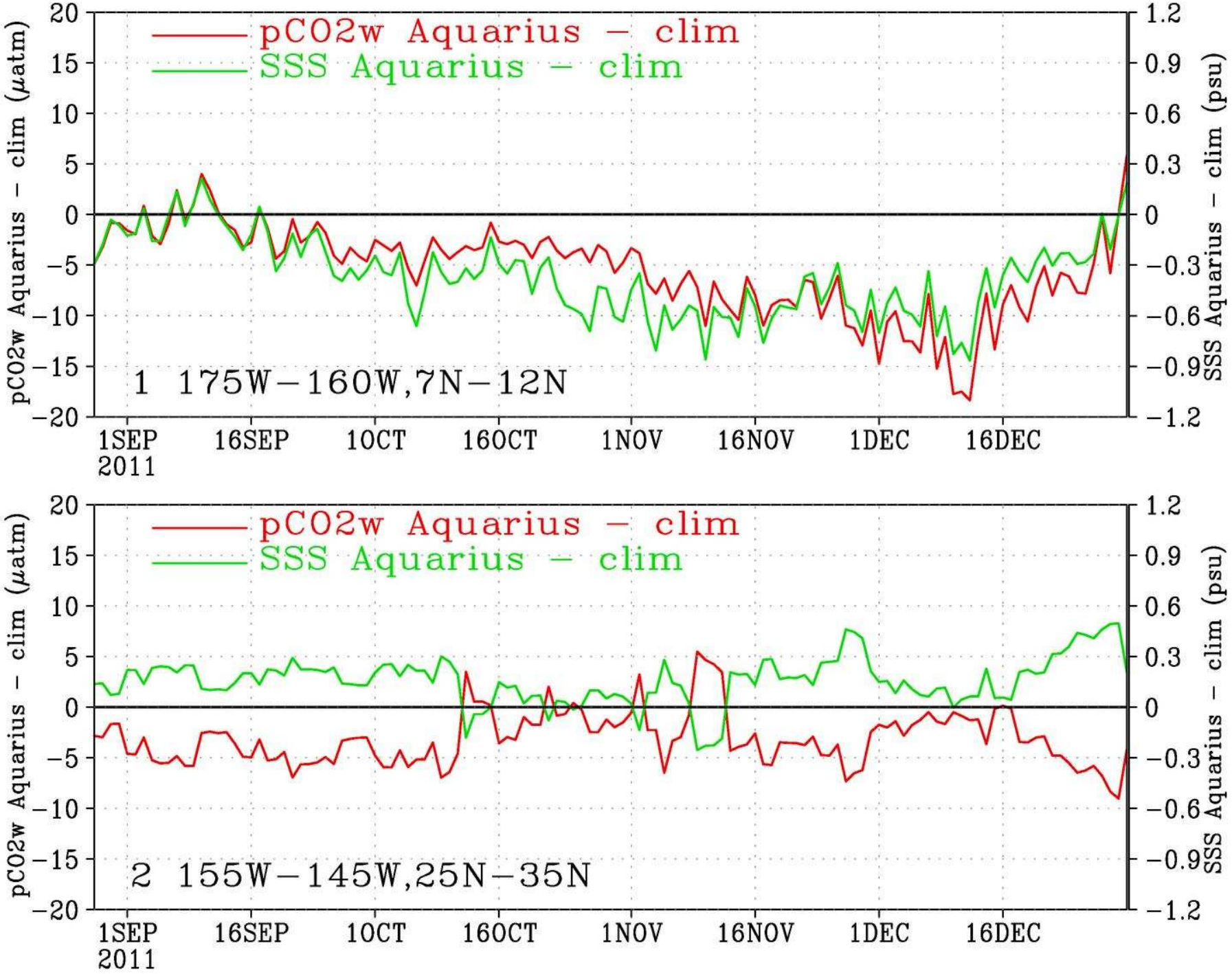
Ocean Chemistry Handbooks have formula of pCO_2 as functions of dissolved inorganic carbon and akalinity, which are, in turn, functions of temperature and salinity.

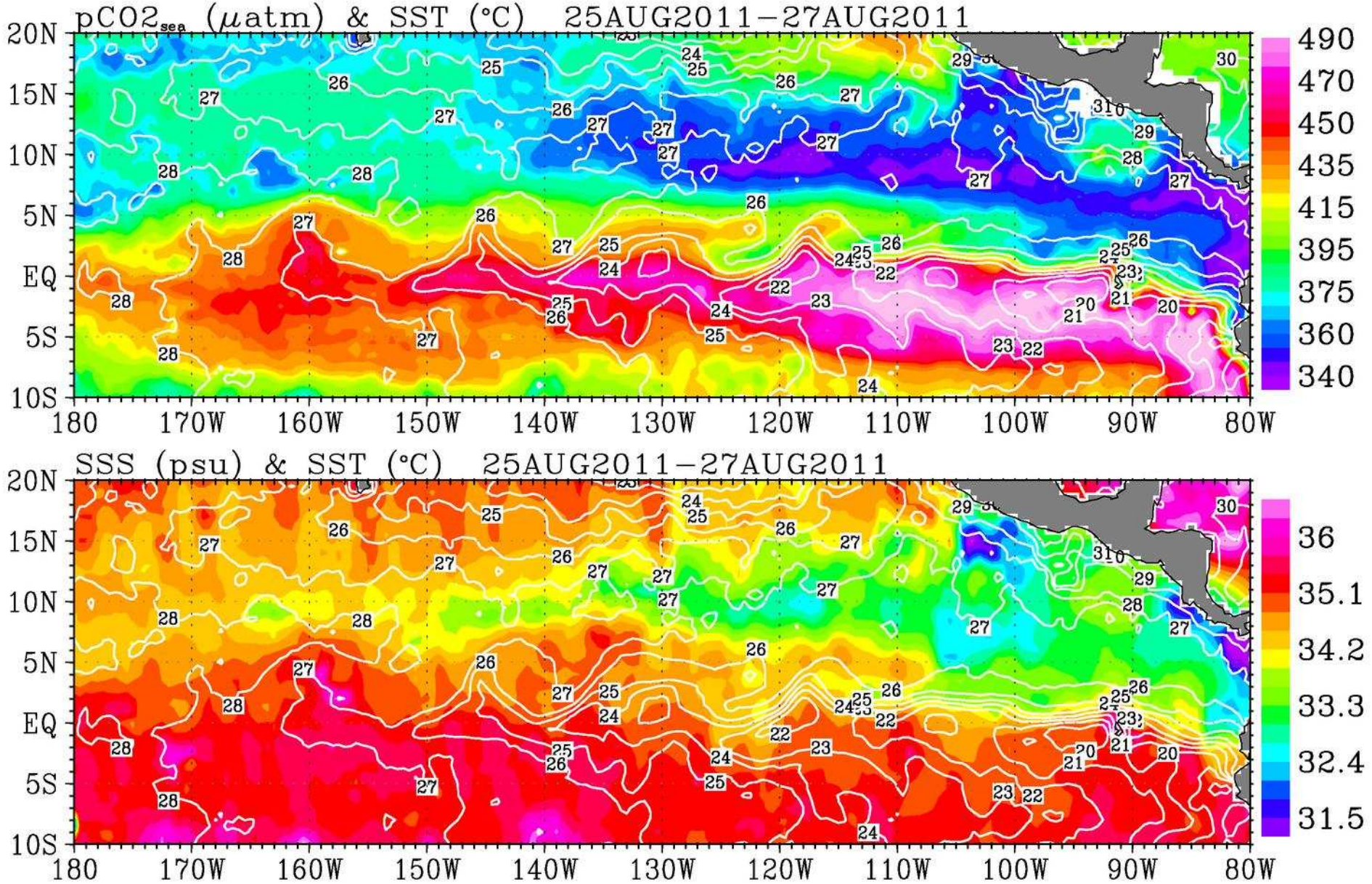
Four months of 3-day averaged Aquarius data are used to examine the relation between salinity and pCO_2

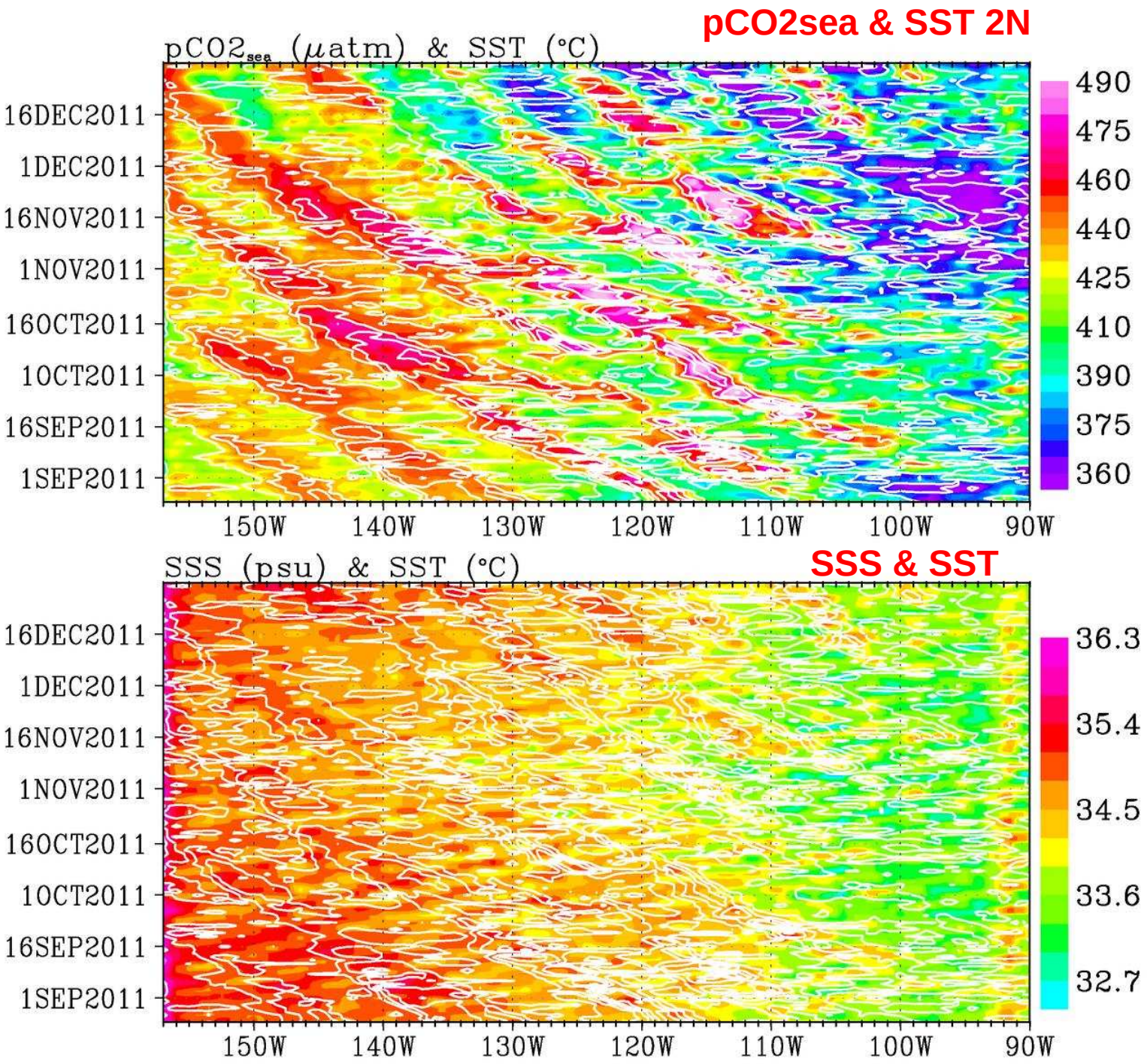


8/28-12/31/2011, 3 day averages, total records 42

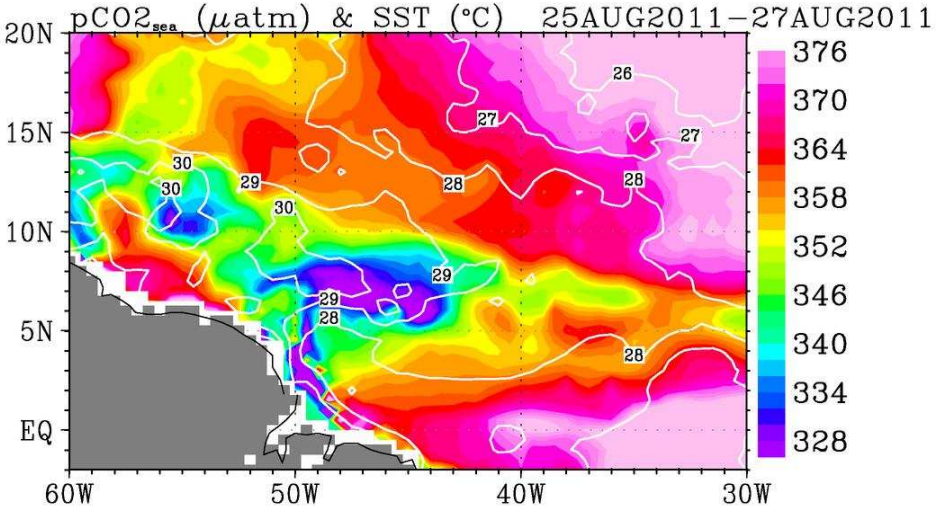
Black lines are 95% confidence level (0.3)


pCO2w Aquarius − clim
SSS Aquarius − clim
pCO2w Aquarius − clim (μatm)
SSS Aquarius − clim (psu)
1 175W−160W,7N−12N
2 155W−145W,25N−35N
1SEP
2011
16SEP
1OCT
16OCT
1NOV
16NOV
1DEC
16DEC

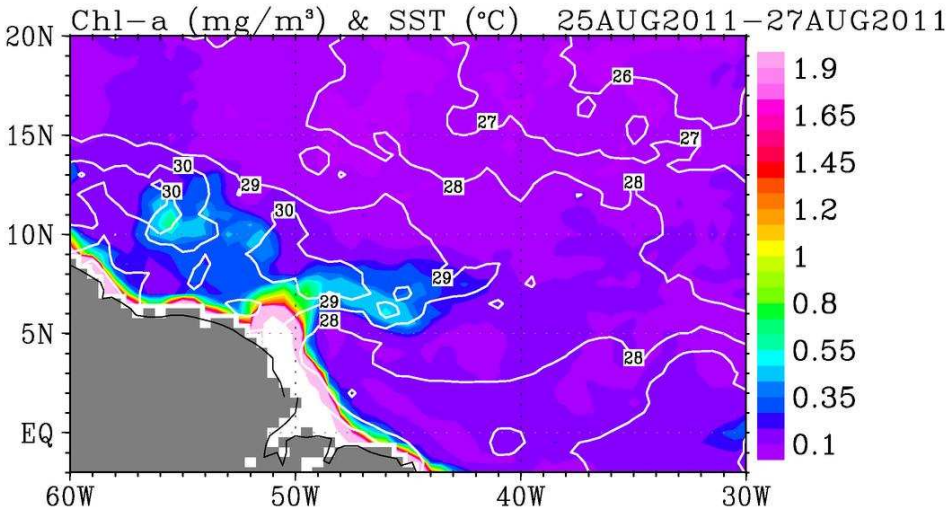

pCO2sea (μatm) & SST (°C) 25AUG2011–27AUG2011
490
470
450
435
415
395
375
360
340
SSS (psu) & SST (°C) 25AUG2011–27AUG2011
36
35.1
34.2
33.3
32.4
31.5
20N
15N
10N
5N
EQ
5S
10S
180
170W
160W
150W
140W
130W
120W
110W
100W
90W
80W

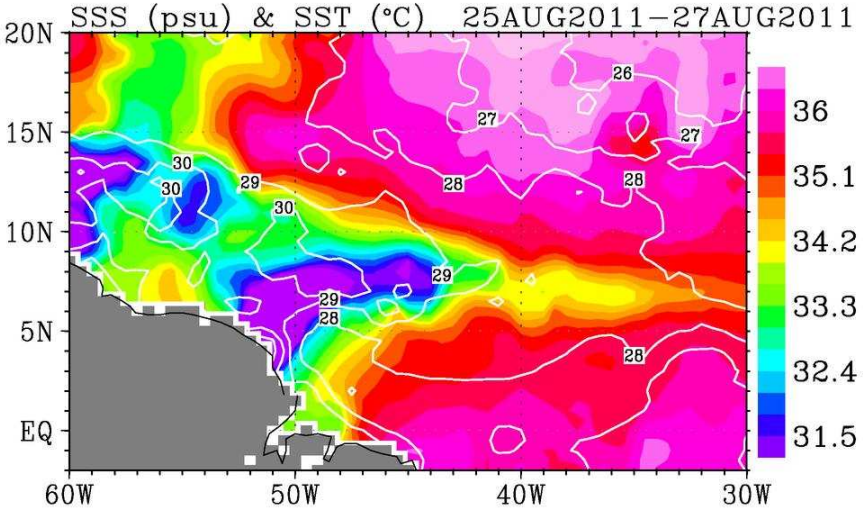

pCO2sea & SST 2N
pCO2sea (μatm) & SST (°C)
16DEC2011
1DEC2011
16NOV2011
1NOV2011
16OCT2011
1OCT2011
16SEP2011
1SEP2011
150W
140W
130W
120W
110W
100W
90W
490
475
460
440
425
410
390
375
360
SSS & SST
SSS (psu) & SST (°C)
16DEC2011
1DEC2011
16NOV2011
1NOV2011
16OCT2011
1OCT2011
16SEP2011
1SEP2011
150W
140W
130W
120W
110W
100W
90W
36.3
35.4
34.5
33.6
32.7

pCO2sea & SST

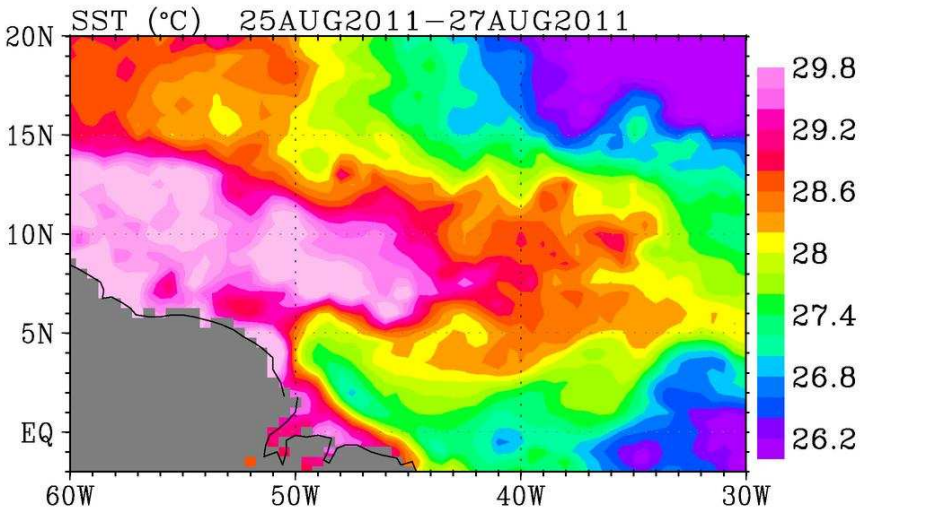


Chl-a & SST

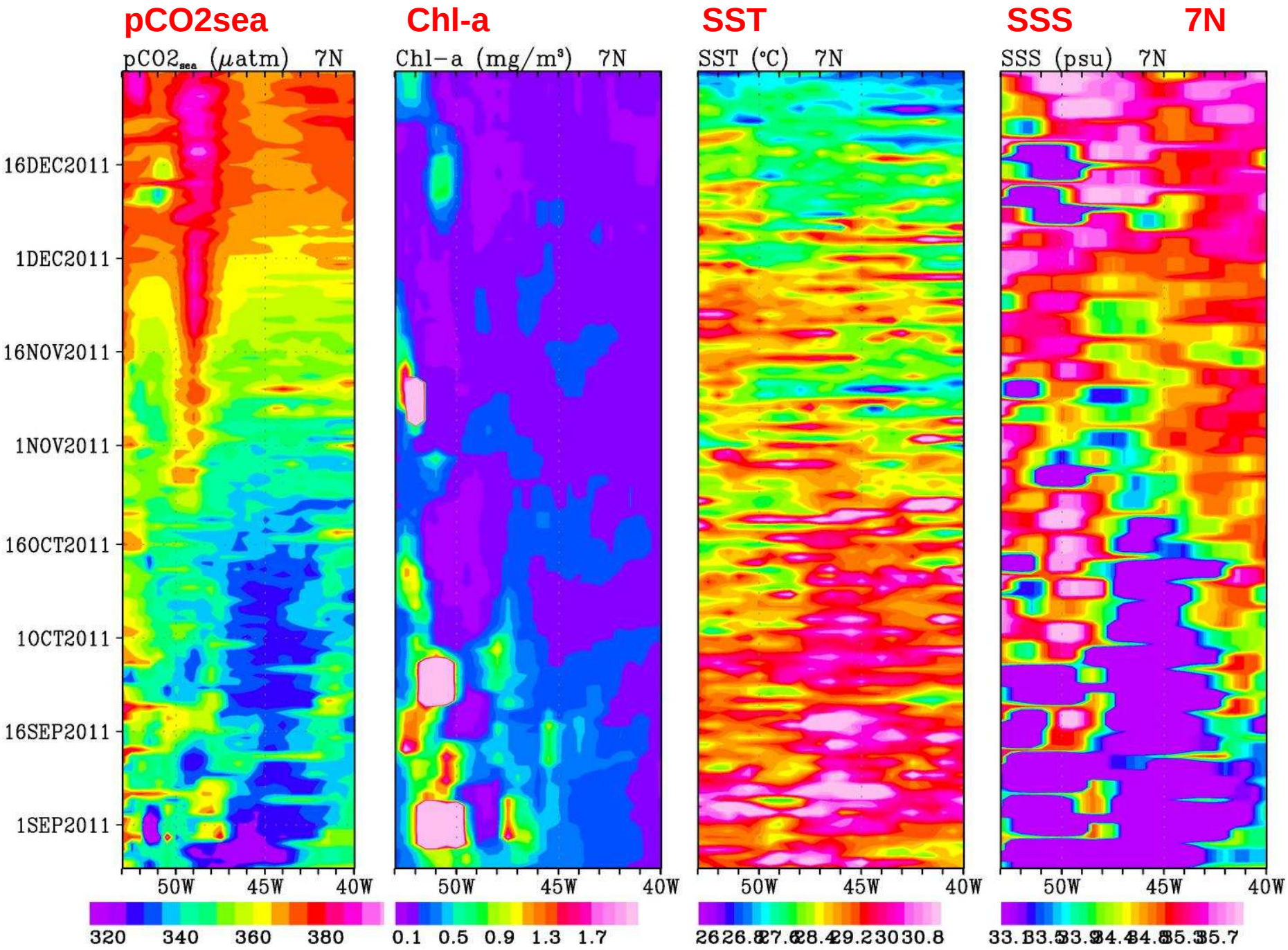




SSS & SST

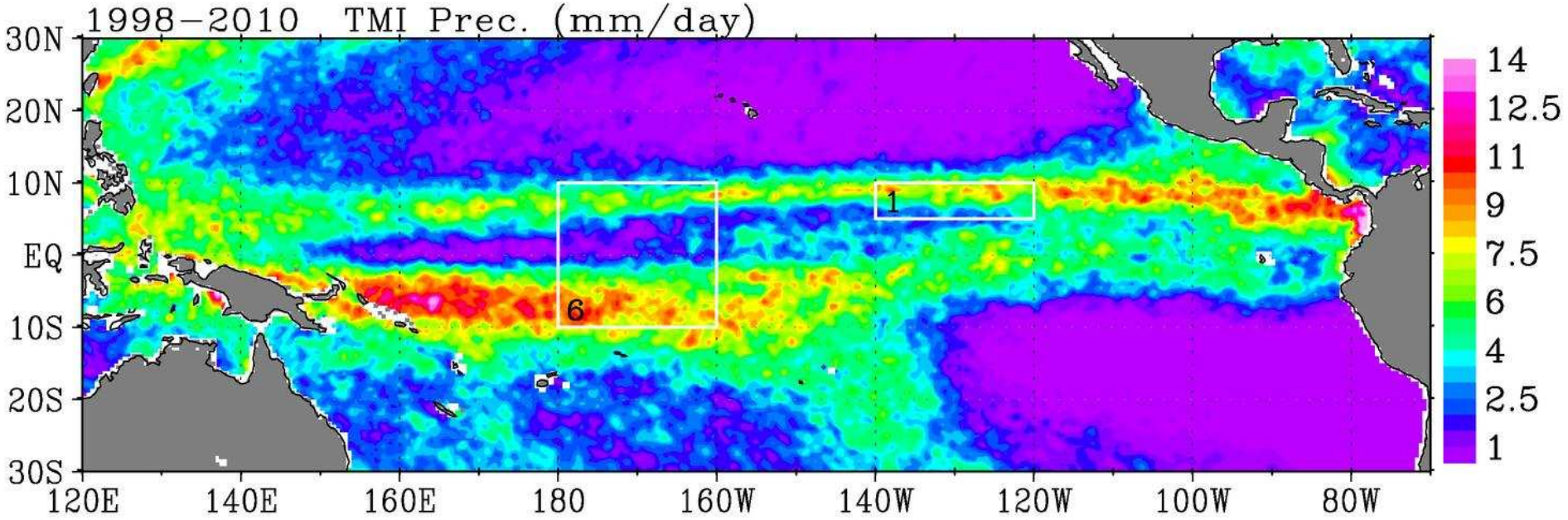


SST

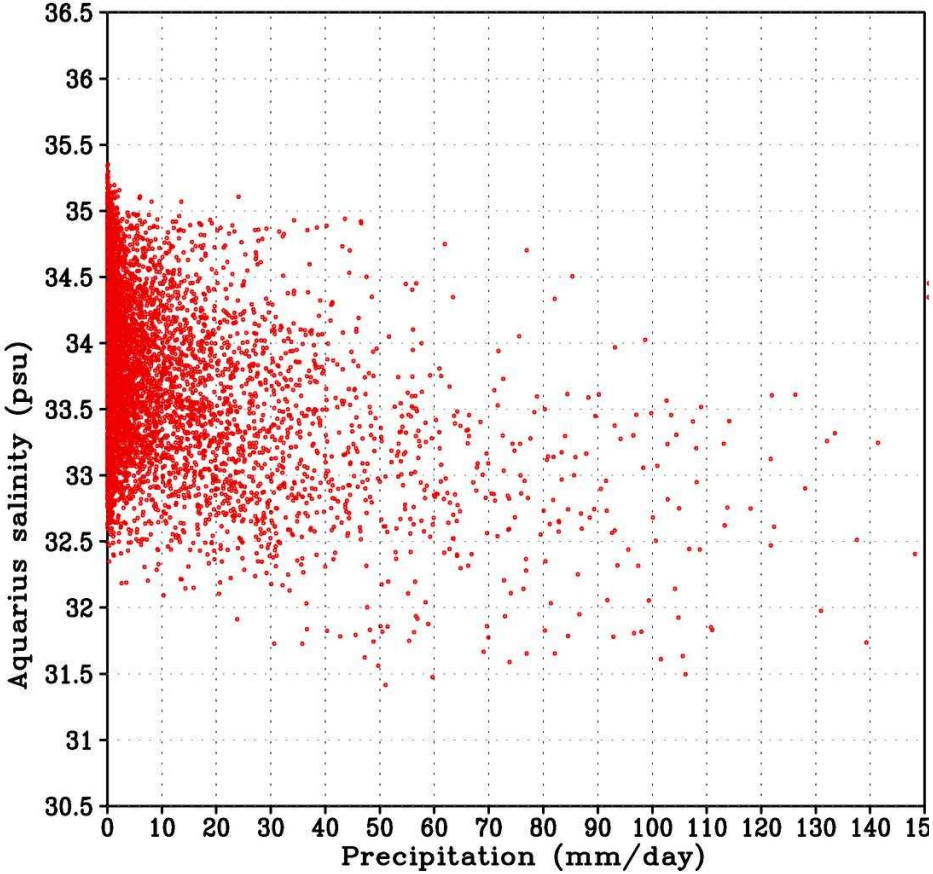

pCO2sea
Chl-a
SST
SSS
7N
pCO2sea (μatm) 7N
Chl-a (mg/m³) 7N
SST (°C) 7N
SSS (psu) 7N
16DEC2011
1DEC2011
16NOV2011
1NOV2011
16OCT2011
1OCT2011
16SEP2011
1SEP2011
50W
45W
40W
320 340 360 380
0.1 0.5 0.9 1.3 1.7
26 26.8 27.6 28.4 29.2 30 30.8
33.1 33.5 33.9 34.4 34.8 35.3 35.7

- Aquarius was promoted as an ocean rain-gauge
- Direct relation between rain and salinity is difficult to discern because of ocean mixing/transport
- CMORPH high frequency (3-hourly) rain data

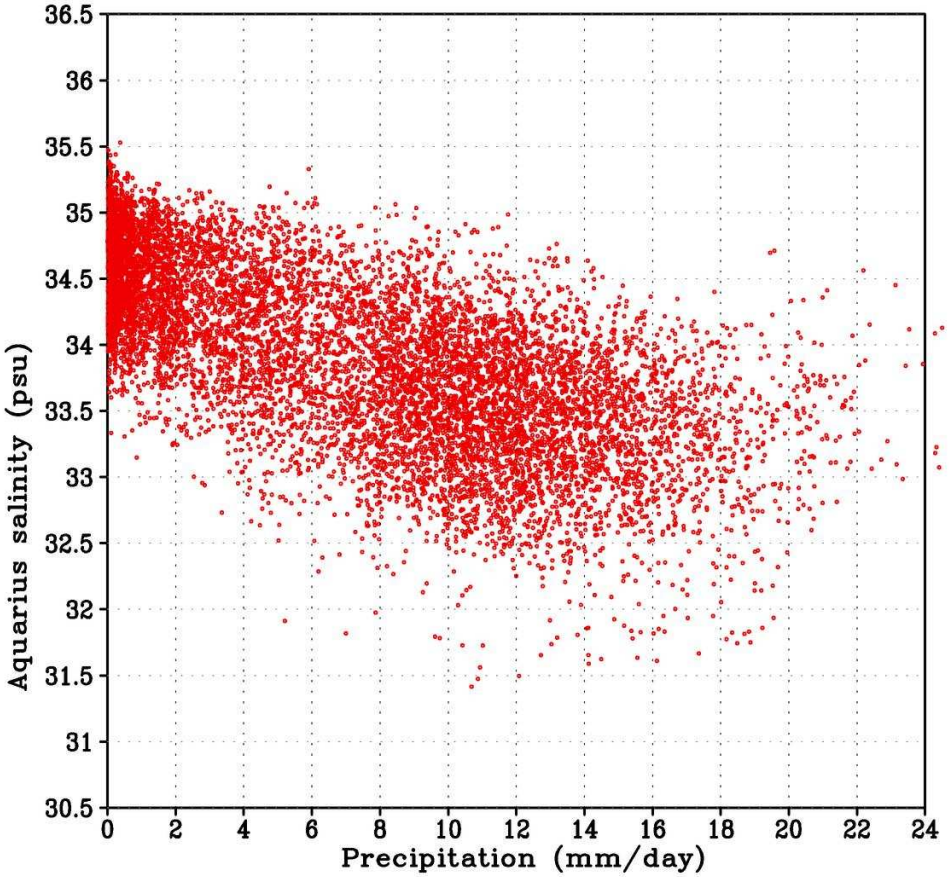
are correlated to Aquarius salinity


1998–2010 TMI Prec. (mm/day)
30N
20N
10N
EQ
10S
20S
30S
120E
140E
160E
180
160W
140W
120W
100W
80W
1
6
14
12.5
11
9
7.5
6
4
2.5
1

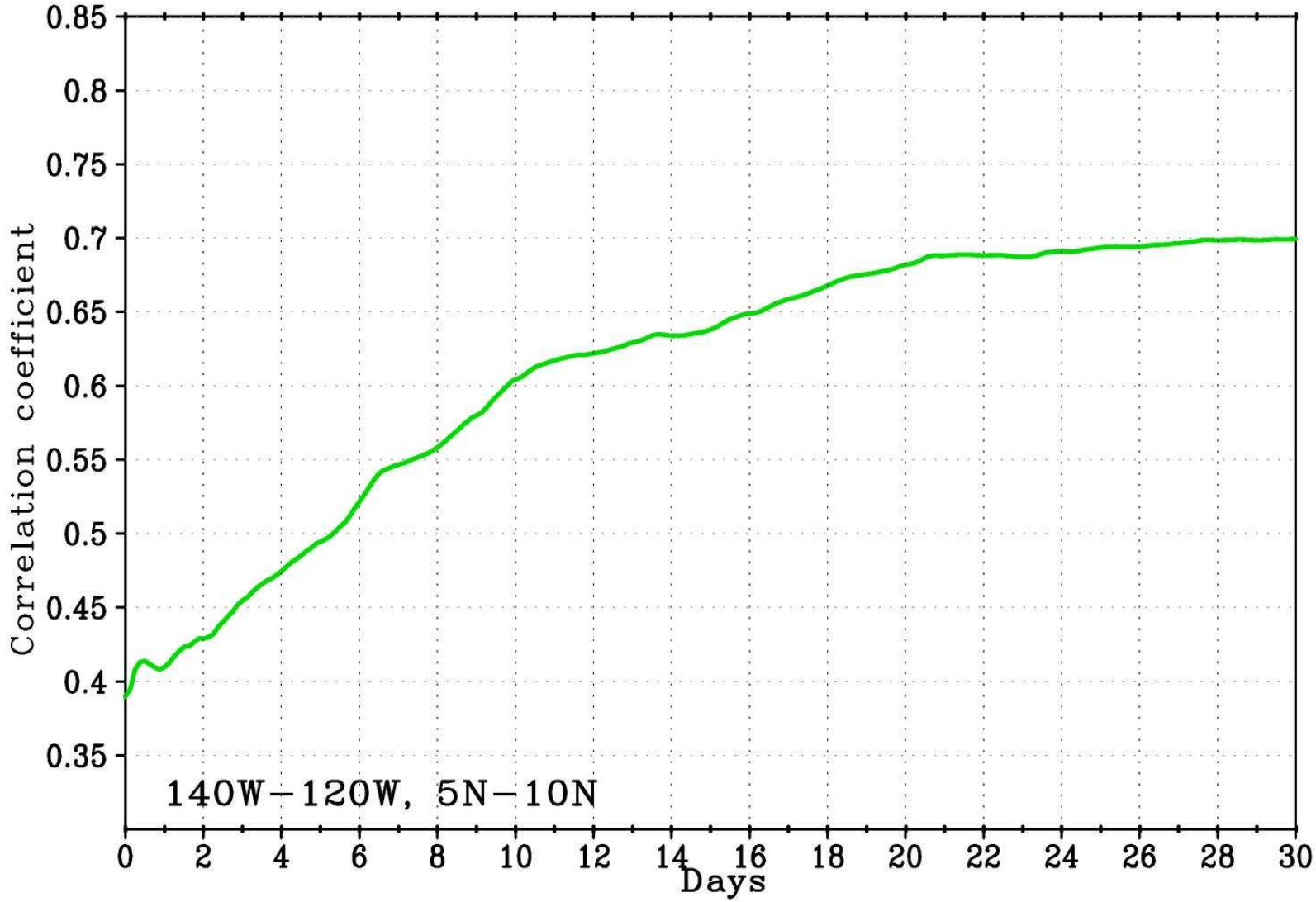
Correlation between salinity and accumulated rain

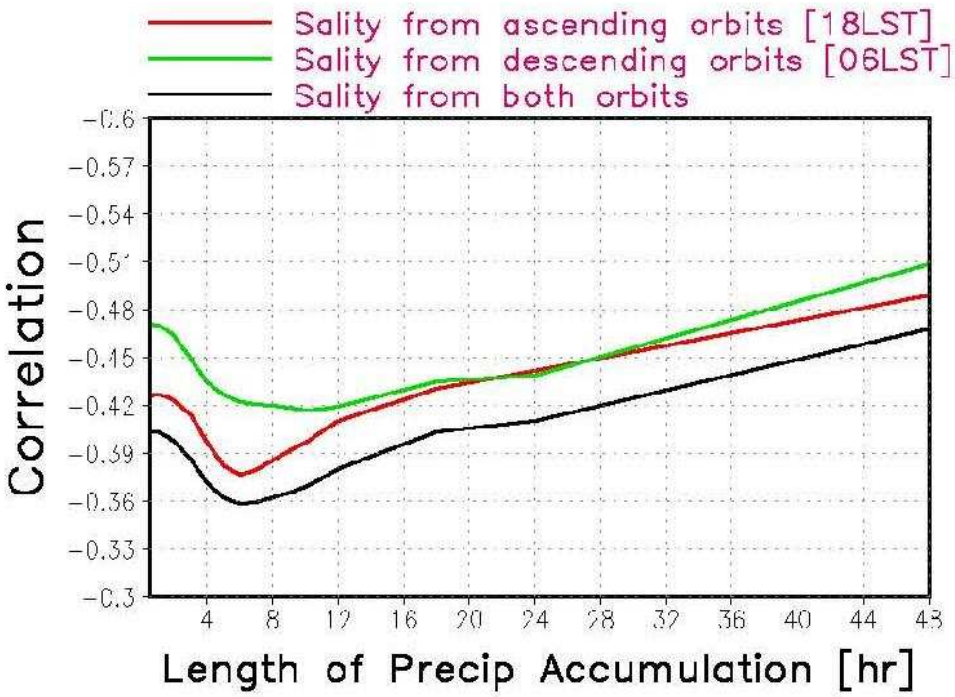


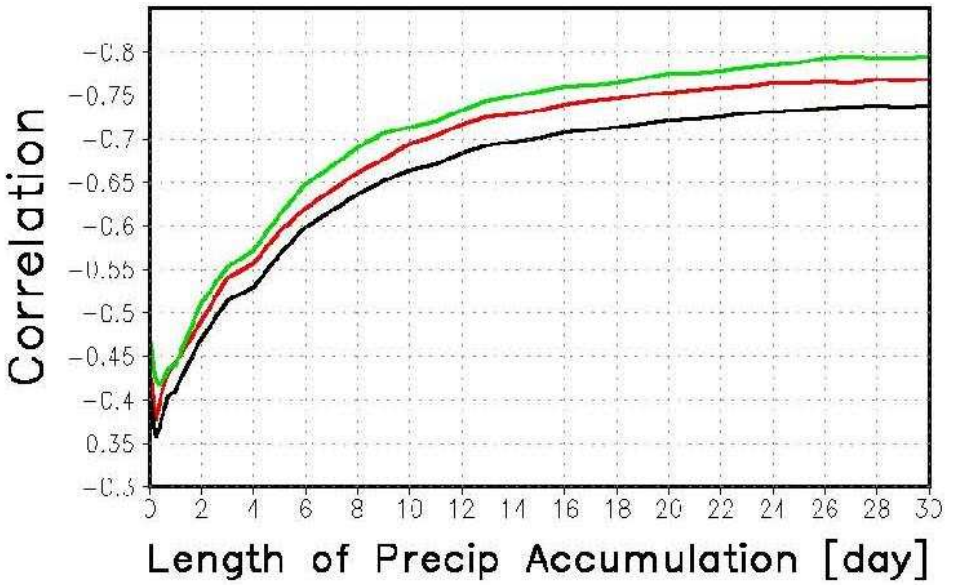
3 hour



30 day


0.85
0.8
0.75
0.7
0.65
0.6
0.55
0.5
0.45
0.4
0.35
Correlation coefficient
140W−120W, 5N−10N
0
2
4
6
8
10
12
14
16
18
20
22
24
26
28
30
Days





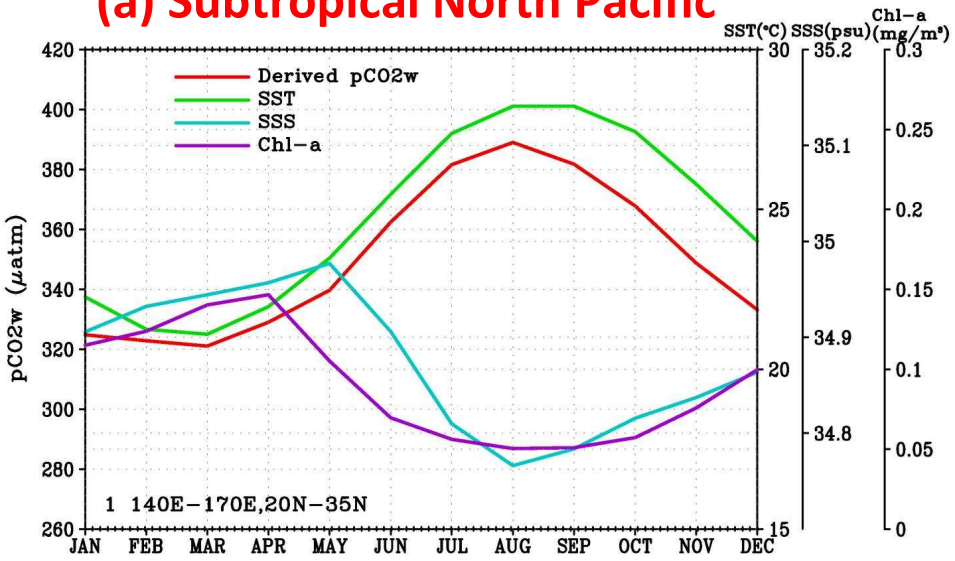
Courtesy of Ping-ping Xie

10S=10N,180-160W

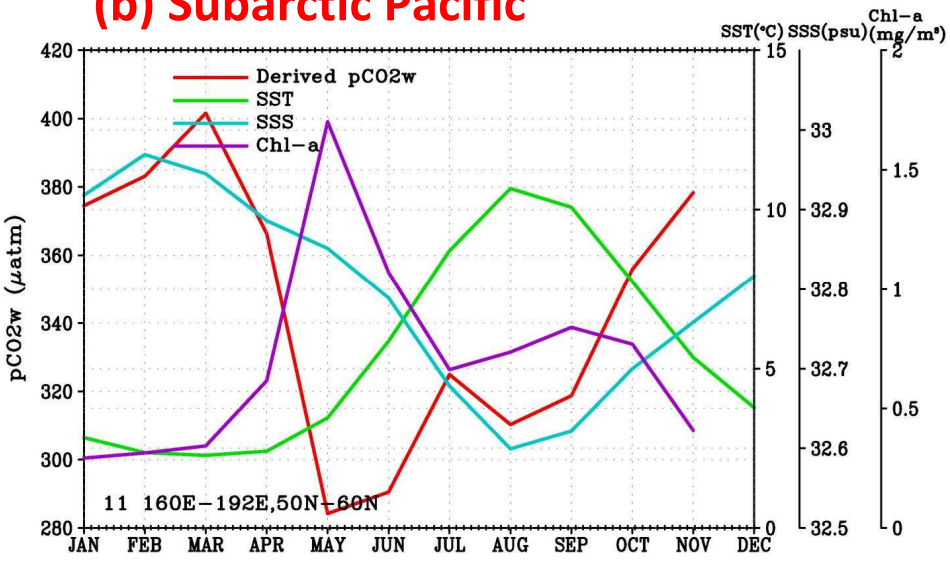
backup

Comparing seasonal variations with drivers

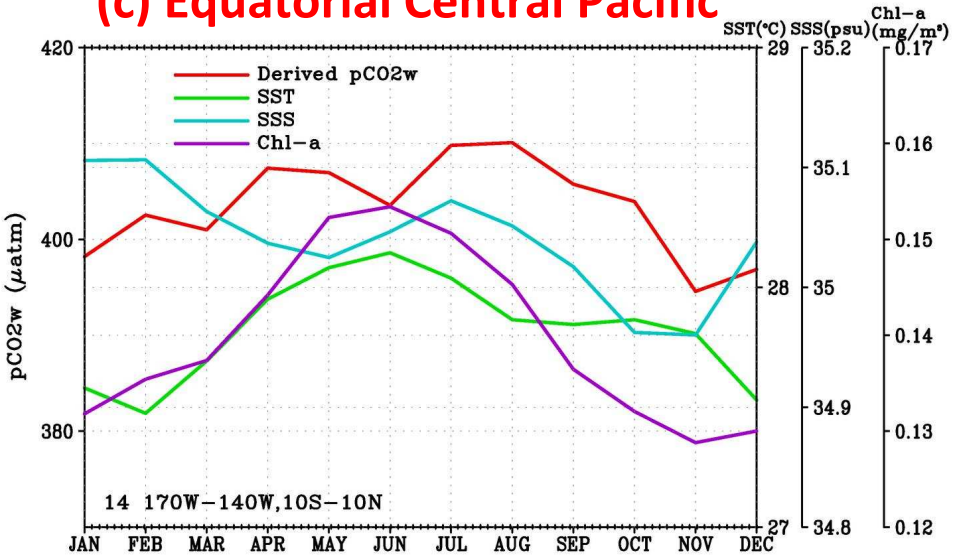
(a) Subtropical North Pacific



(b) Subarctic Pacific



(c) Equatorial Central Pacific

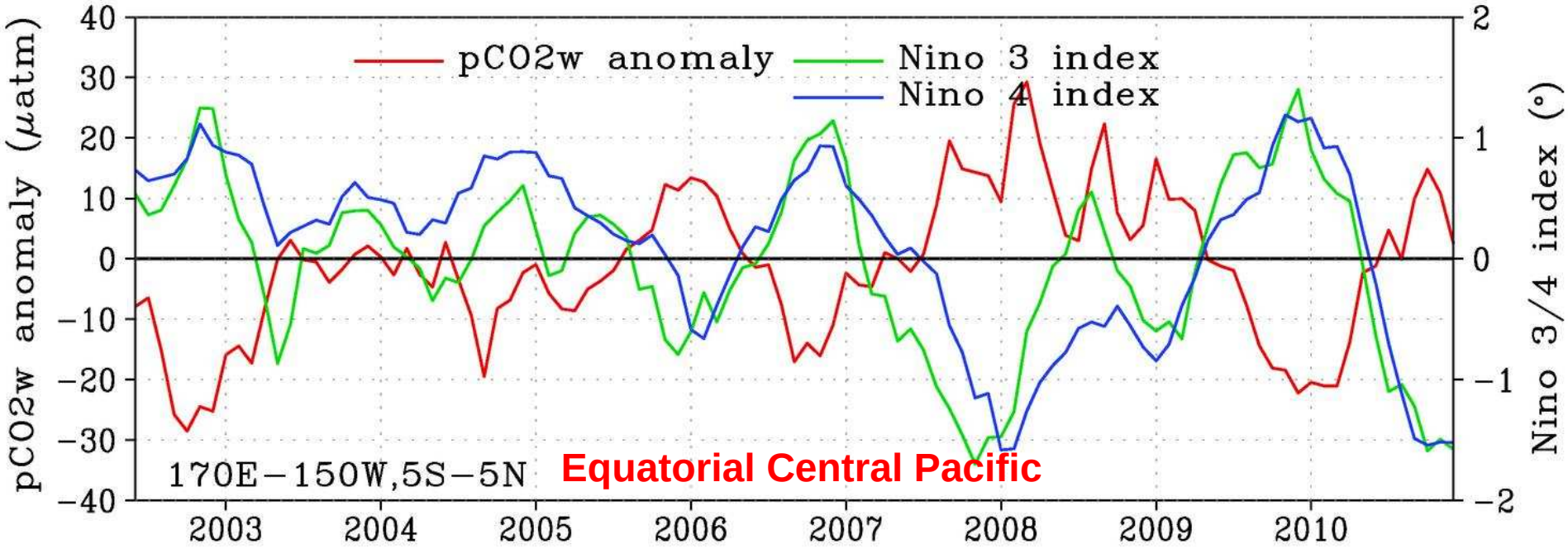


Annual cycle

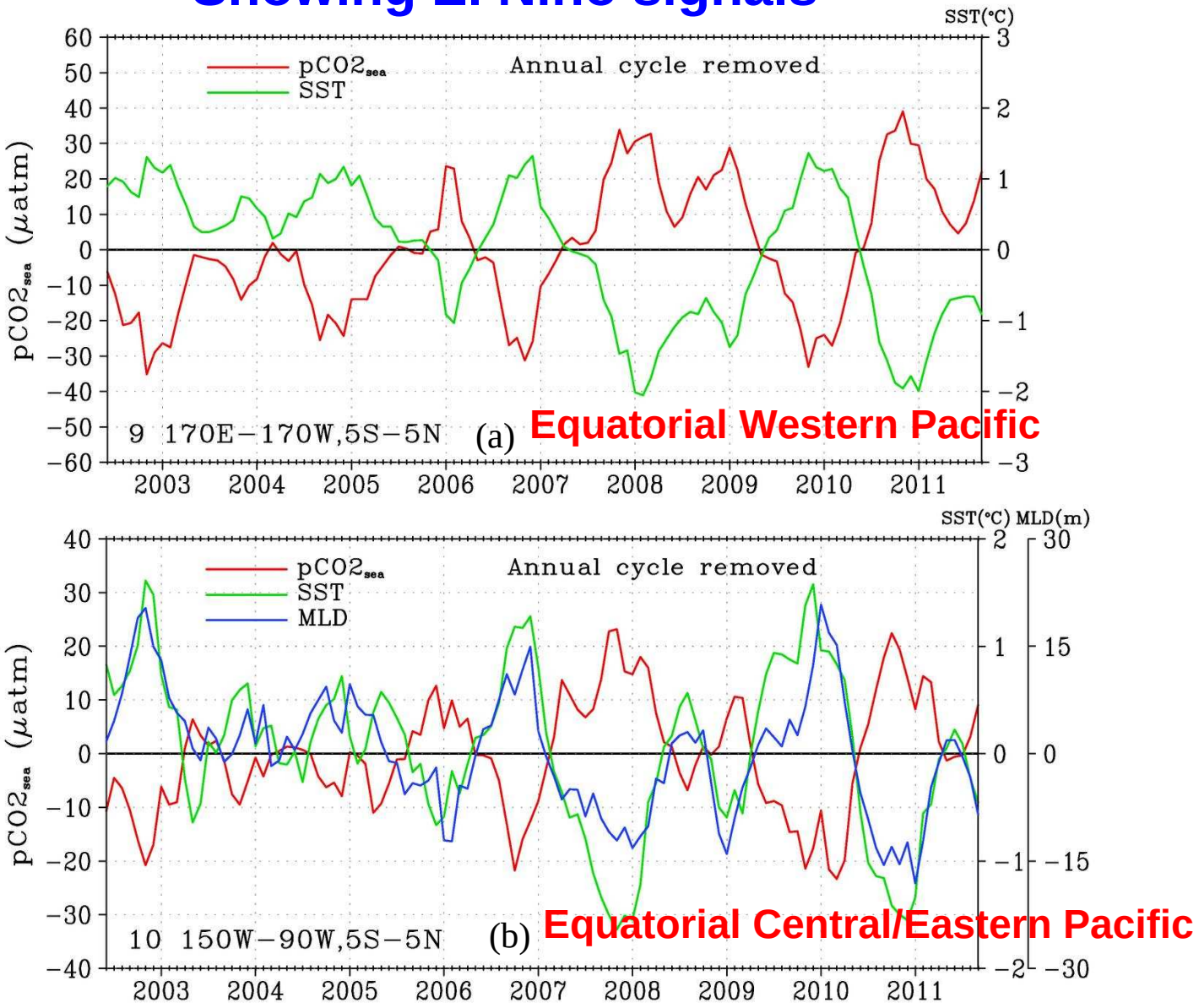
- **SST dominates pCO2w in subtropics**
- **Chl-a dominates pCO2w in subarctic oceans**
- **Small annual variations in tropics**

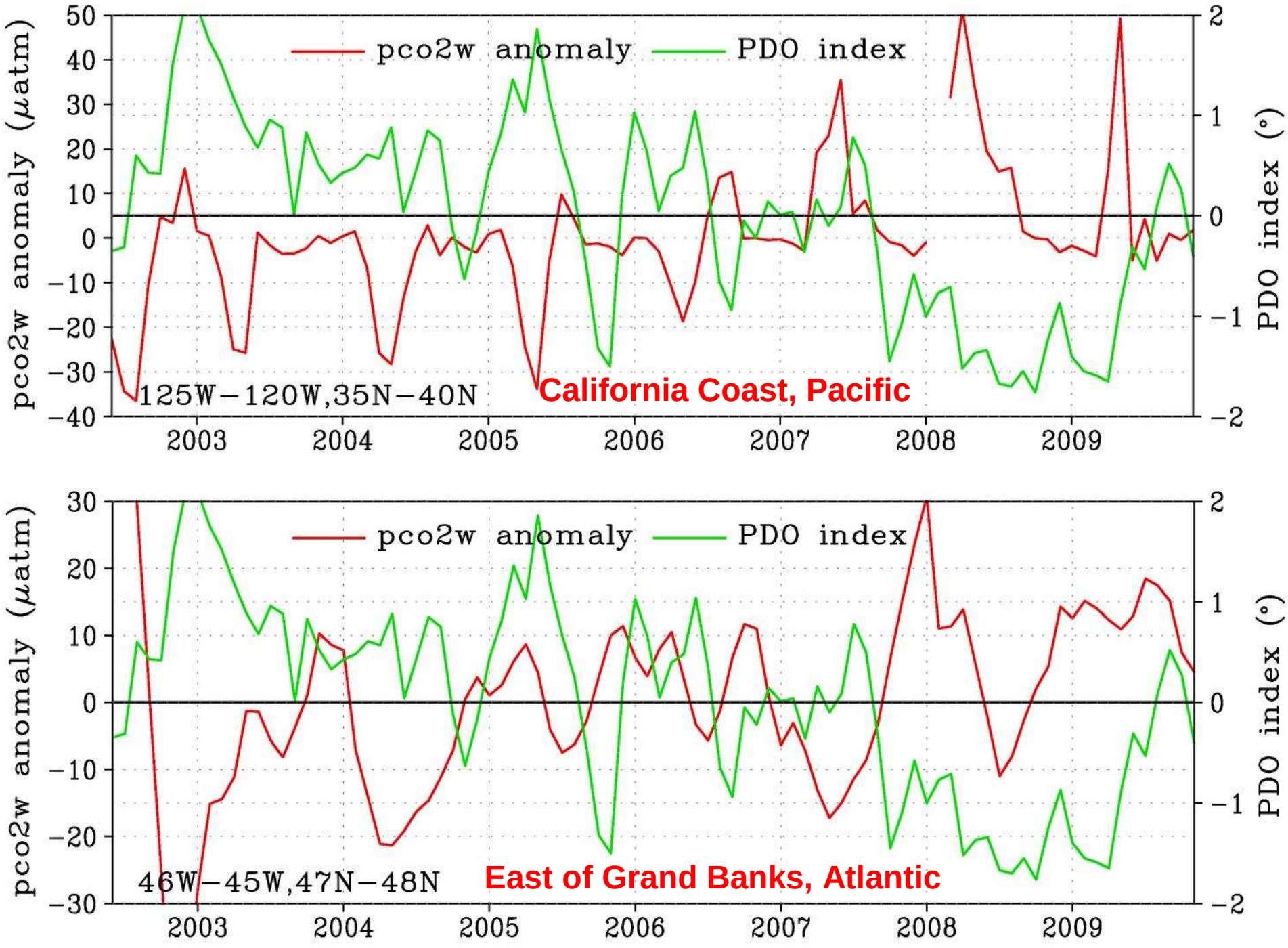
pCO2w derived from, SST, MLD, SSS, Chl-a

Showing El Nino signals



Showing El Nino signals




pco2w anomaly
PDO index
pco2w anomaly (μatm)
PDO index (°)
125W−120W,35N−40N
California Coast, Pacific
46W−45W,47N−48N
East of Grand Banks, Atlantic
2003
2004
2005
2006
2007
2008
2009

Time series comparison at ocean stations