Sea Surface Temperature Influence on Ocean Carbon Cycle

GHRSST at Qingdao, 6/17

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- CO_2 partial pressure
- Acidification (if time allows)

- Ocean carbon system and acidification are usually described by 4 parameters, pCO_2, TA, dissolved inorganic carbon, and pH. Knowing two can resolve all through chemical equations. We started retrieving pCO_2, and then TA.
- CO_2 flux has been parameterized to a piston velocity and ΔpCO_2. pCO_2 is critical in evaluating the accumulation atmospheric greenhouse gas. Long time series has climate significance, but is difficult to compile using spacebased data.
- pCO_2 is important factors of governing acidification and its deleterious effect to marine ecosystems. Space data provide the spatial-temporal resolutions from intraseasonal to interannual scales and global coverge.

- **pCO2 has been estimated through surrogates (drivers)**
- **Sea surface temperature (SST) governs thermodynamics and solubility**
- **Biological productivity is represented by chlorophyll. Photosythesis and respiration deplete and add carbon.**
- **Water inputs (rain and river), in term of salinity, affect alkalinity and pCO2**
- **Correlation between pCO2 and drivers could turn from positive and negative at various regions and seasons**

Relation between $pCO2_{sea}$ and other co-incident data on cruises were developed

SST alone

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

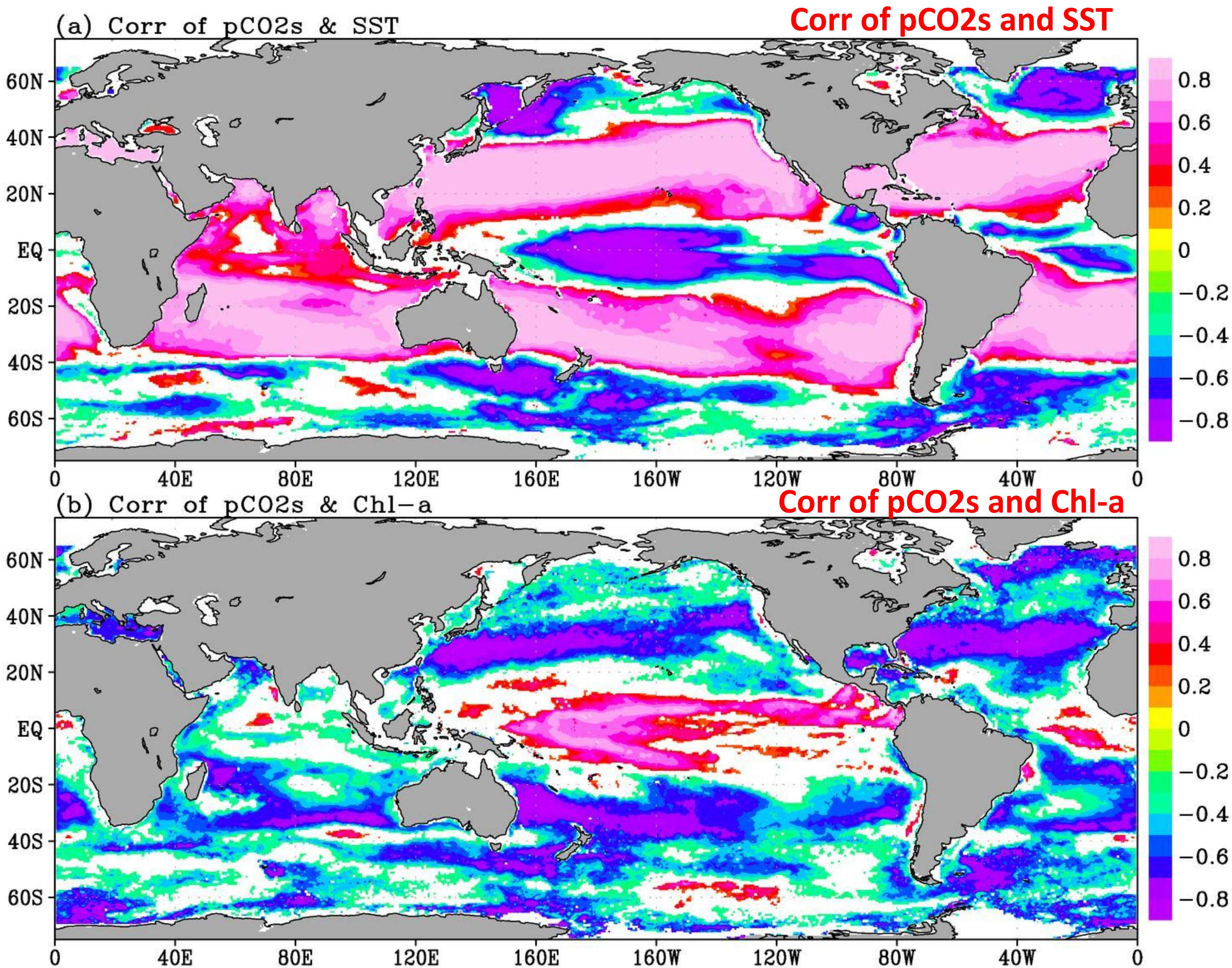
Cosca et al. (2001) Equatorial Pacific

With additional Chl-a

Zhu et al. (2009) South China Sea

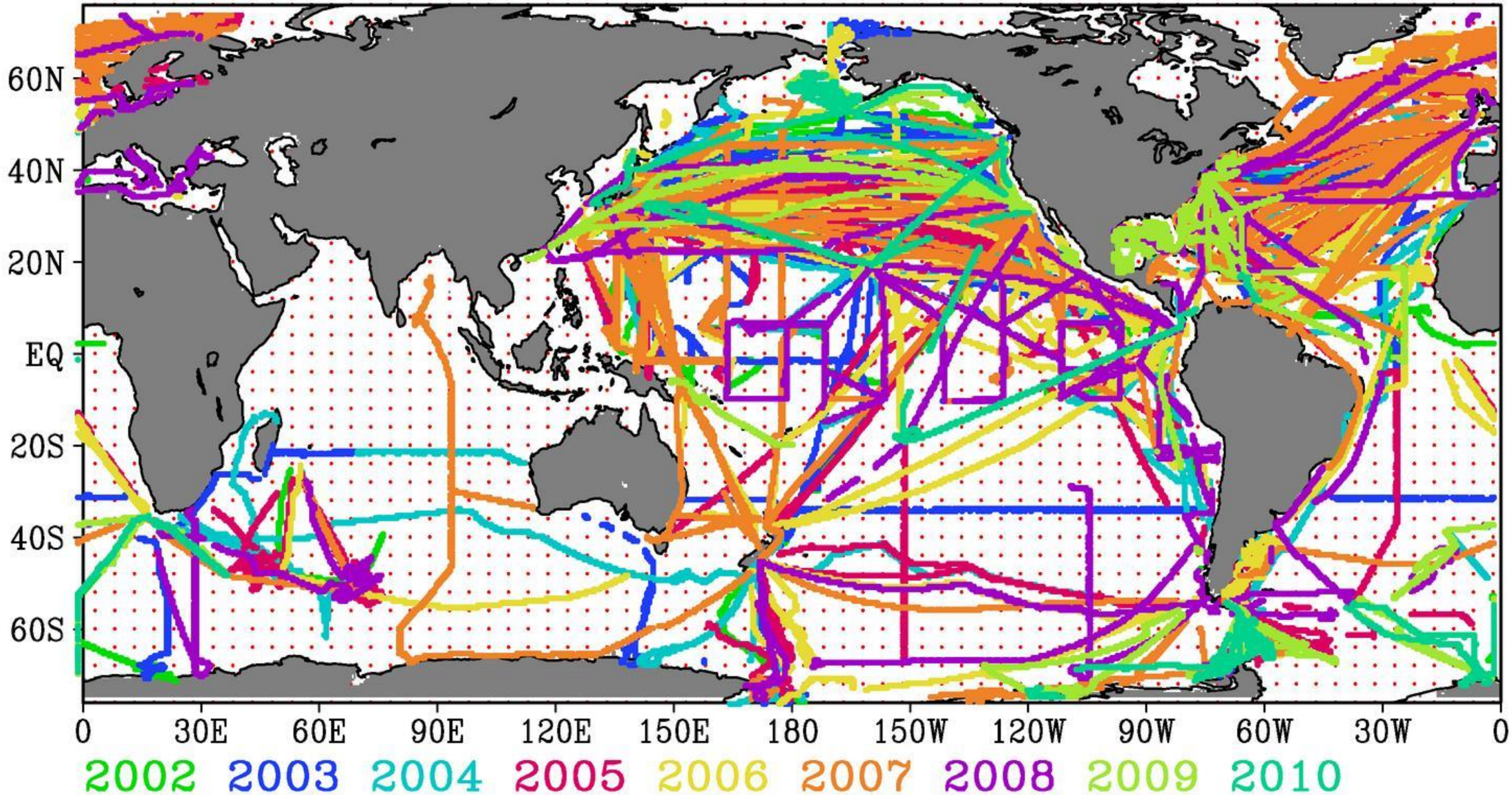
Padin et al. (2009) Biscay Bay

The drivers are only seasonally and regionally significant.



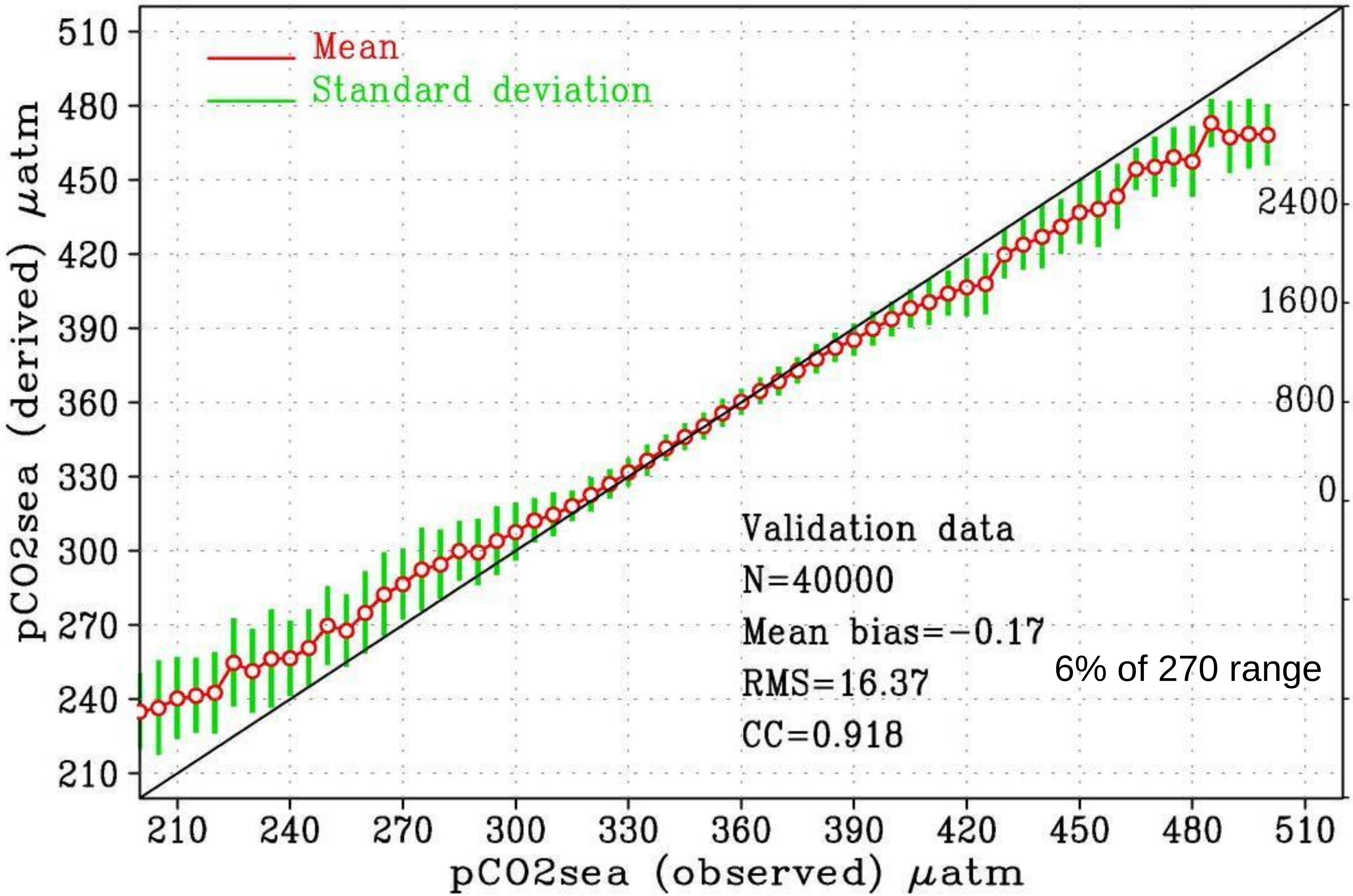
Corr of pCO2s and SST
(a) Corr of pCO2s & SST
60N
40N
20N
EQ
20S
40S
60S
0
40E
80E
120E
160E
160W
120W
80W
40W
0.8
0.6
0.4
0.2
0
−0.2
−0.4
−0.6
−0.8
Corr of pCO2s and Chl-a
(b) Corr of pCO2s & Chl−a
60N
40N
20N
EQ
20S
40S
60S
0
40E
80E
120E
160E
160W
120W
80W
40W
0.8
0.6
0.4
0.2
0
−0.2
−0.4
−0.6
−0.8

We have collected 206,265 daily data points collocated with space data in 2012



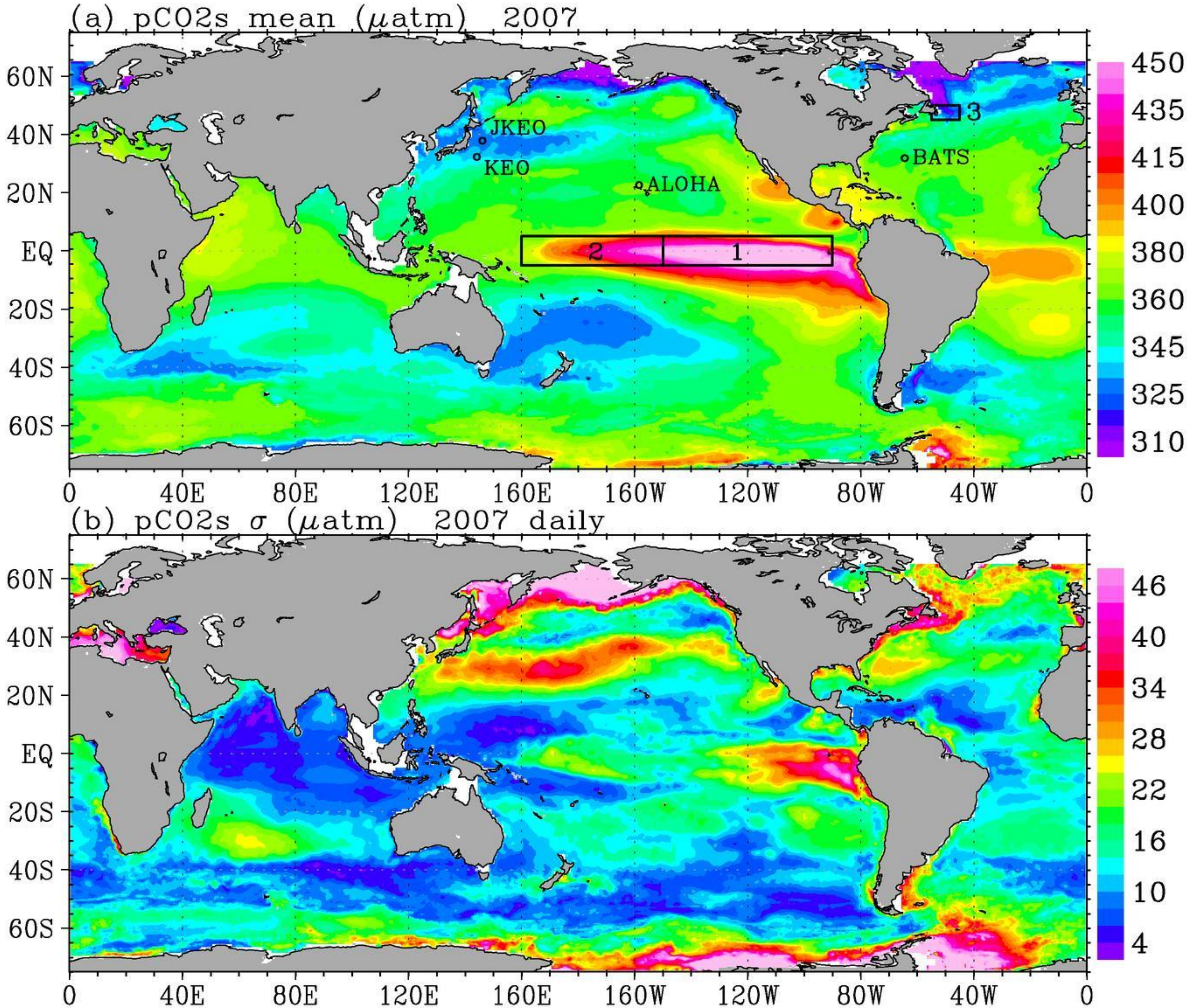
Compiled from many sources through CDIAC

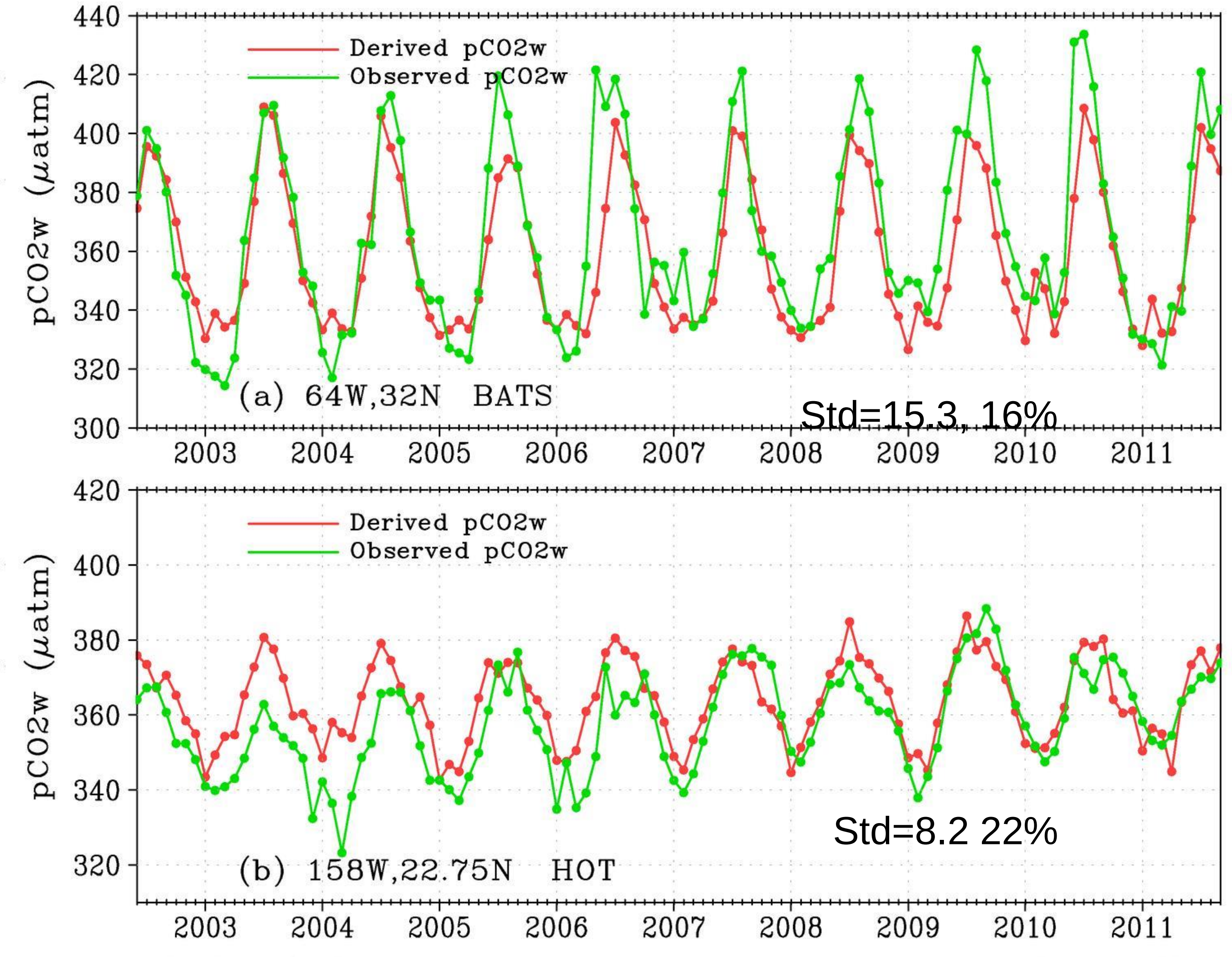
- **Statistical model $pCO2_{sea}$ developed using support vector regression (SVR)**
- **Input: sin(day), cos(day), lat, sin(lon), cos(lon), SST (AMSR-E) , Chl-a (SeaWiFS+MODIS), SSS (Levitus climatology)**
- **206265 data groups found 2002-2010 40,000 randomly selected for training and 40,000 for validation**
- **Output: 9 year at 0.5°, 3-day resolution**
- https://airsea.jpl.nasa.gov/DATA/seaflux/pco2/



Mean
Standard deviation
pCO2sea (derived) μatm
pCO2sea (observed) μatm
510
480
450
420
390
360
330
300
270
240
210
2400
1600
800
0
Validation data
N=40000
Mean bias=−0.17
RMS=16.37
CC=0.918
6% of 270 range

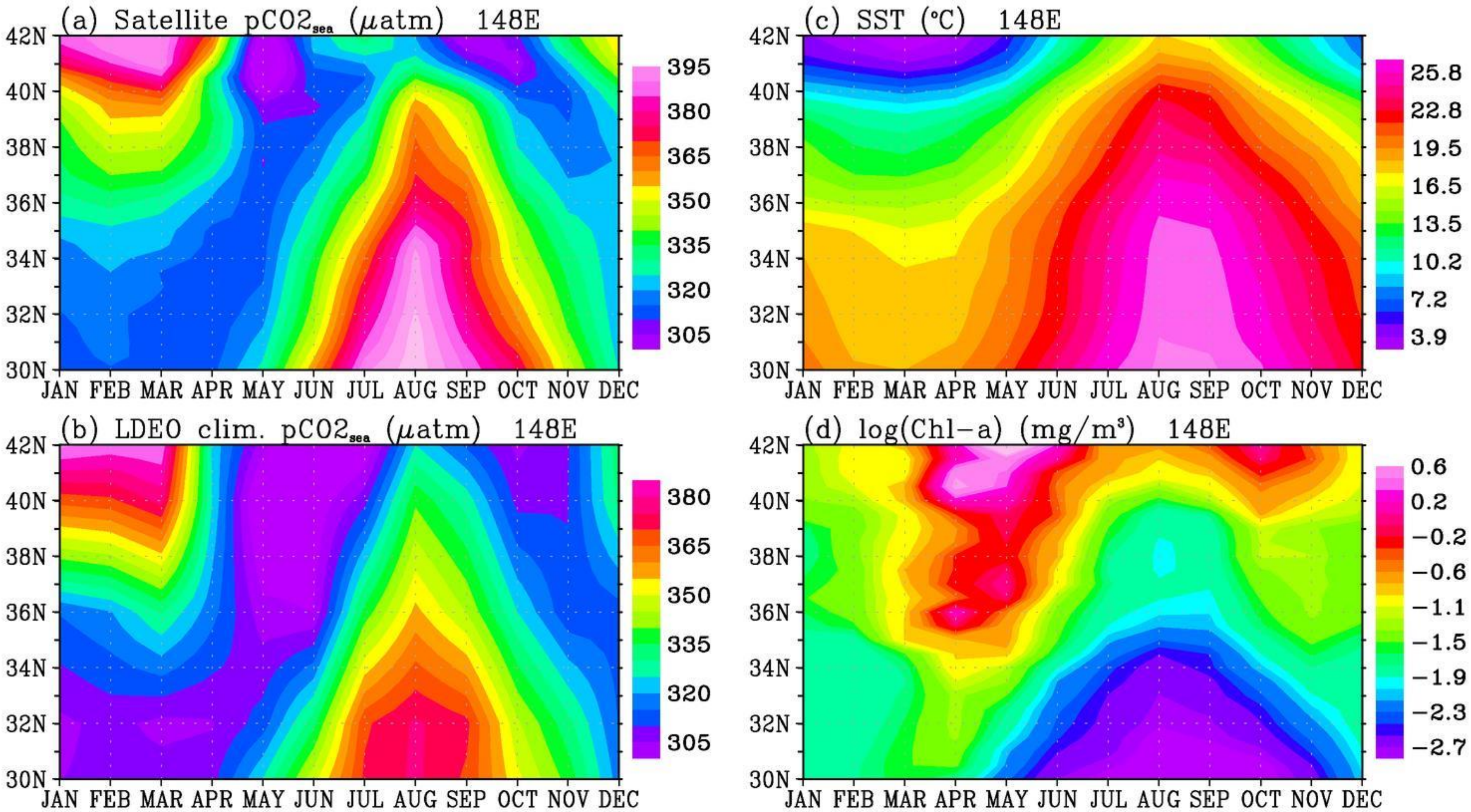
Mean and standard deviation of satellite pCO2s for 2007





Model pick up magnitude and phase of annual cycle, lower range less long trend

Satellite $pCO2_{sea}$ **SST**

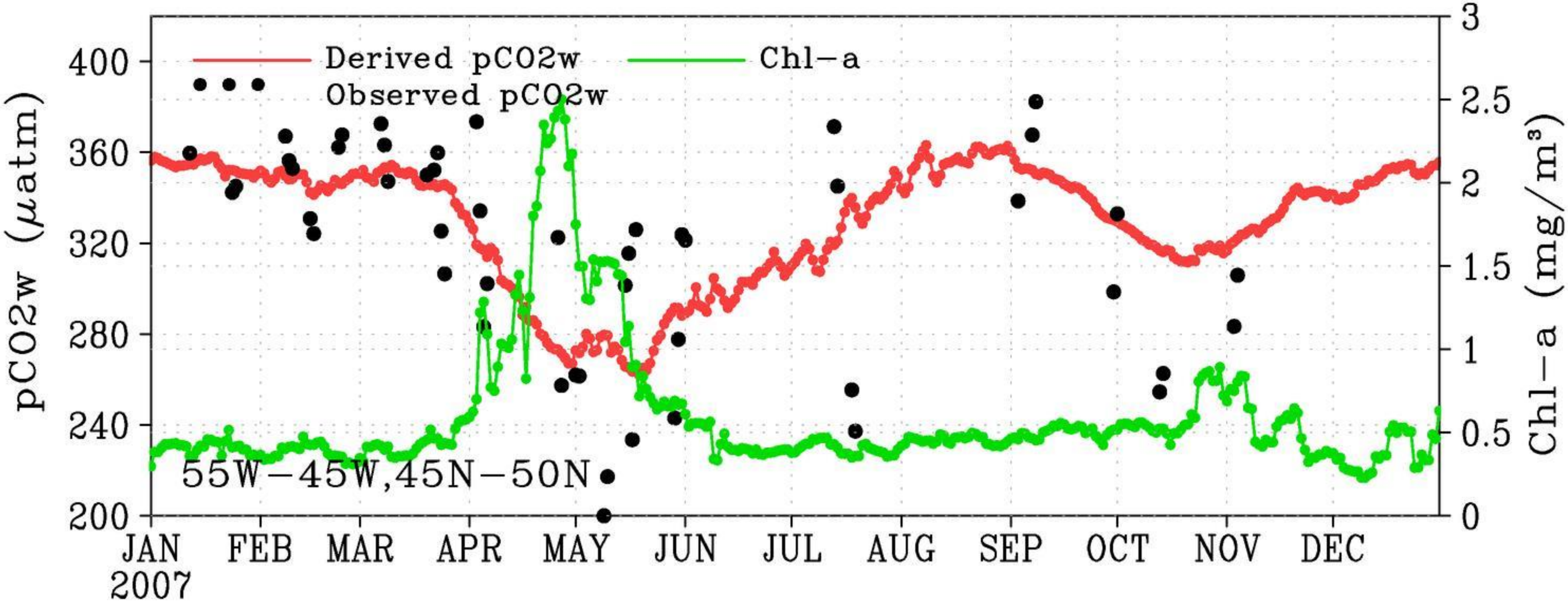


Takahashi $pCO2_{sea}$ clim. **log(Chl-a)**

South of 34°N, pCO2 is high in Aug-Sep and low in FEB-Mar. SST is in phase, and Chl-a is out of phase with pCO2

To the north, pCO2 has two peaks, in Feb and Aug, that coincide with low Chl-a. SST has only one peak

Spring bloom in North Atlantic end of April with high Chl-a and suppressed $pCO2_{sea}$

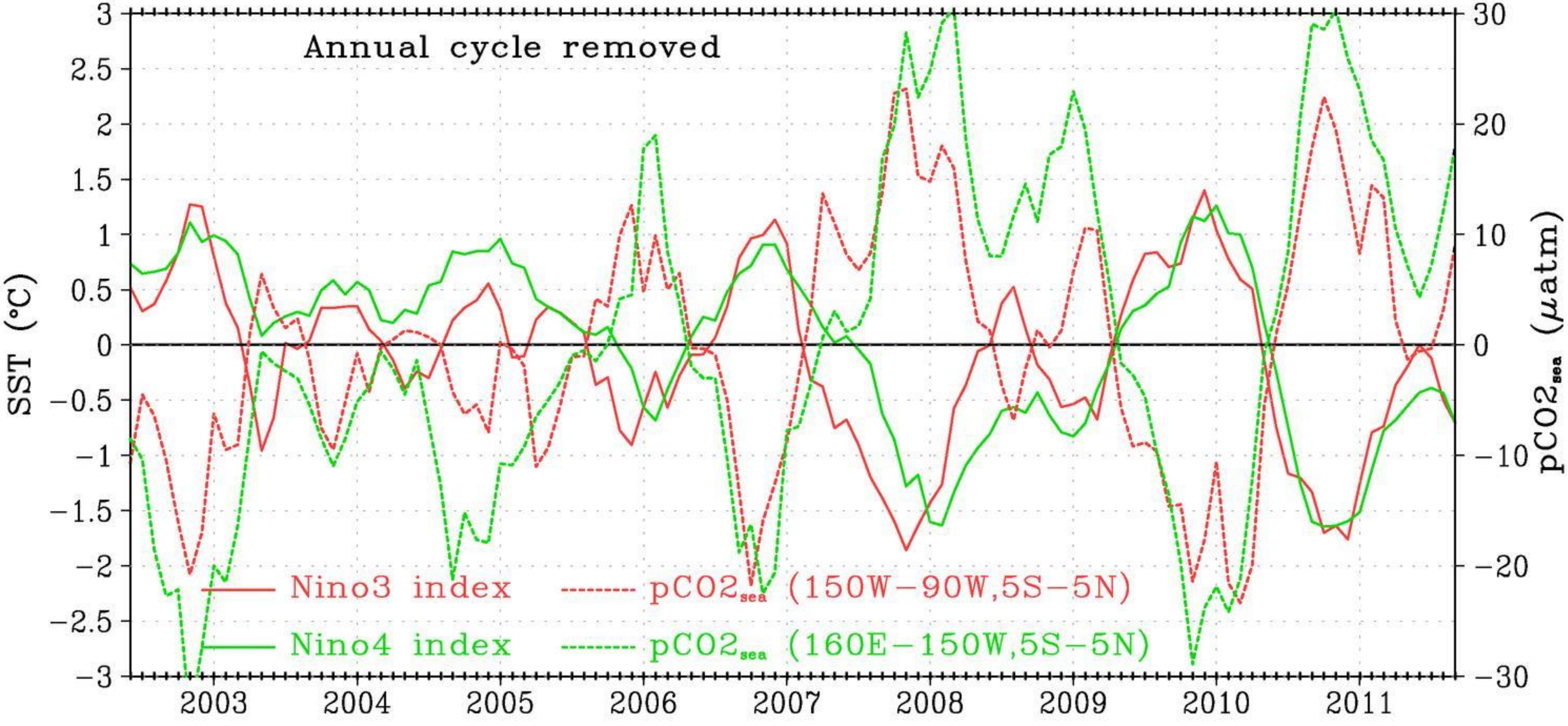


Satellite $pCO2_{sea}$

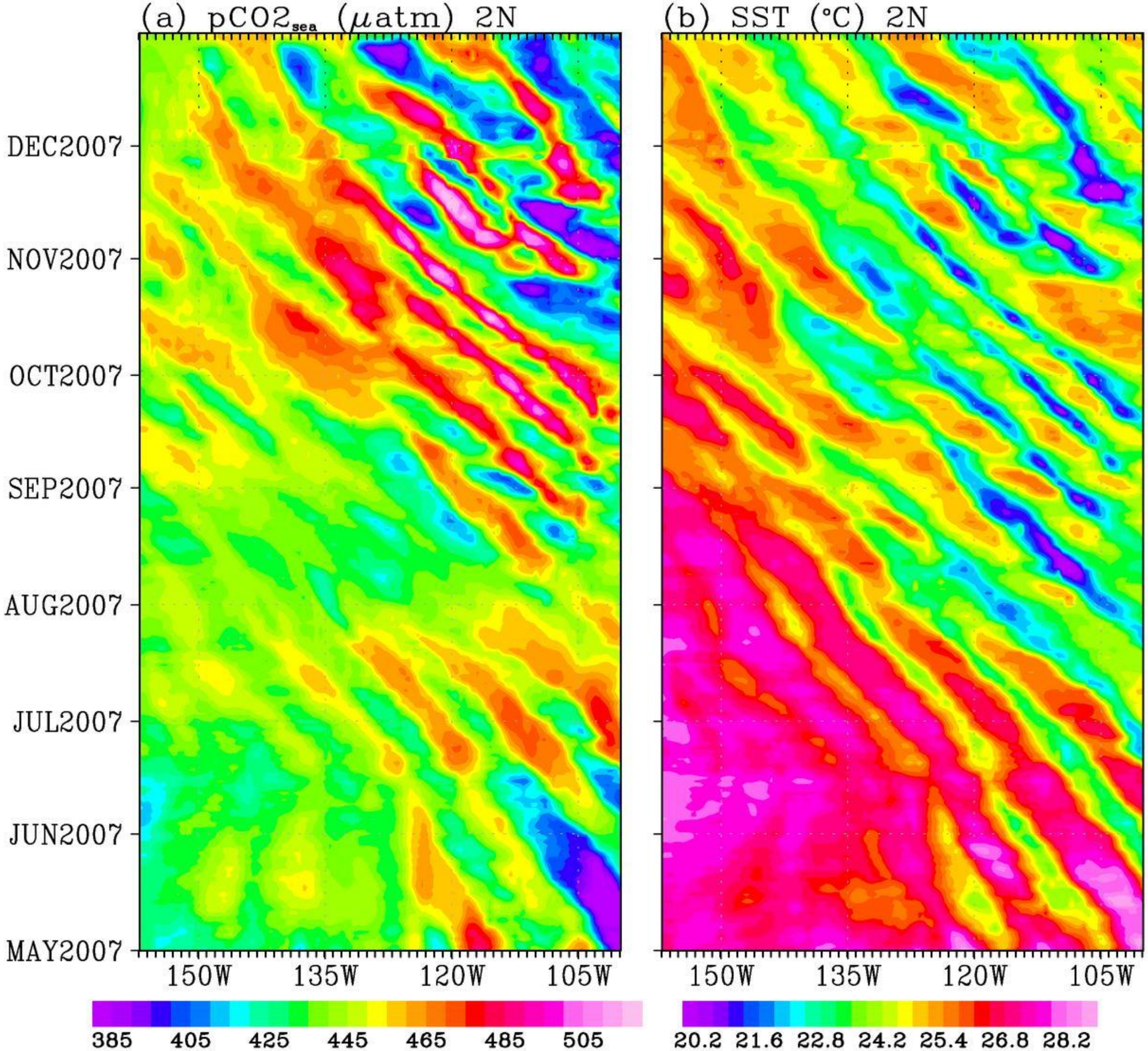
Observed $pCO2_{sea}$

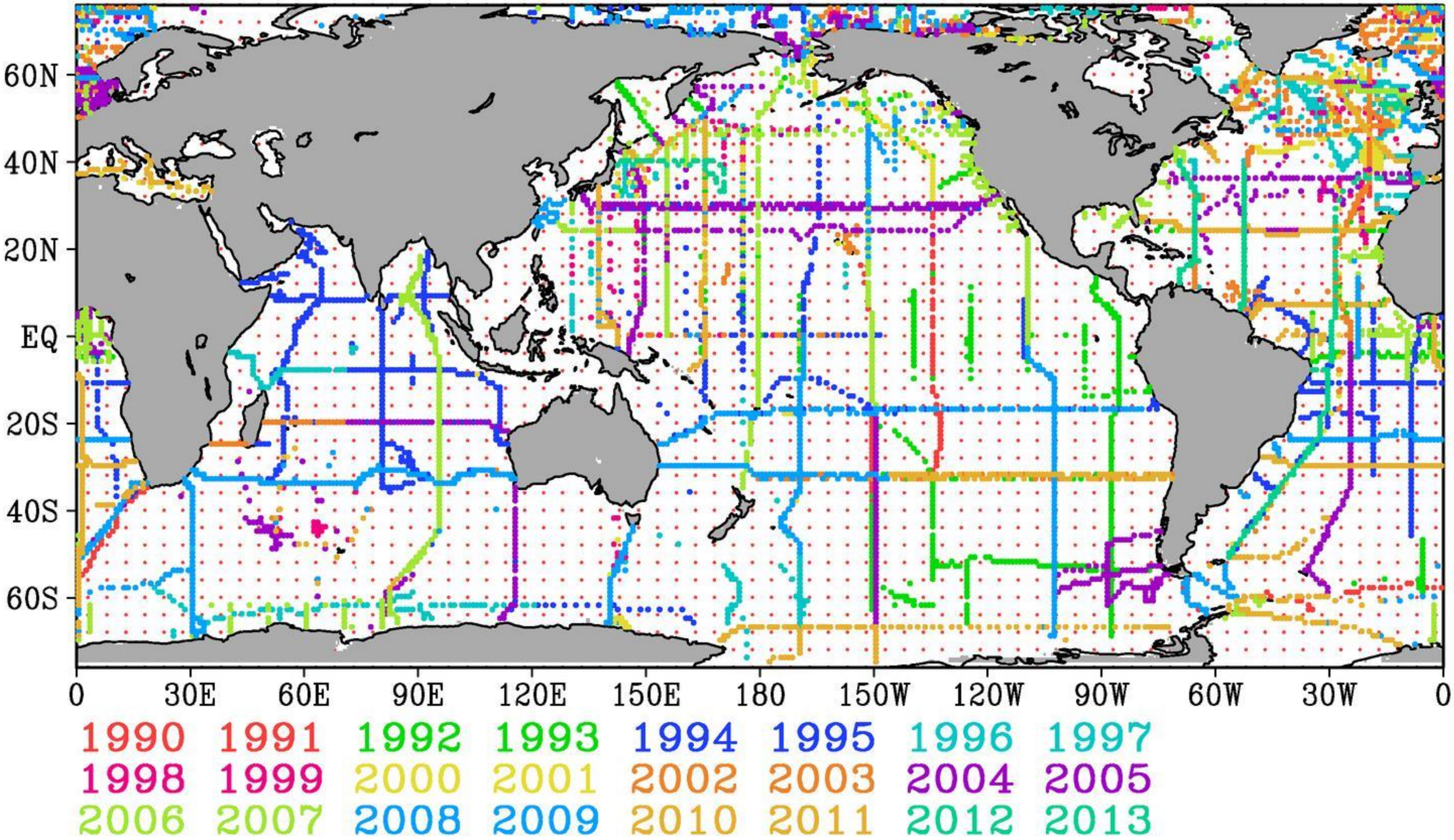
Chl-a

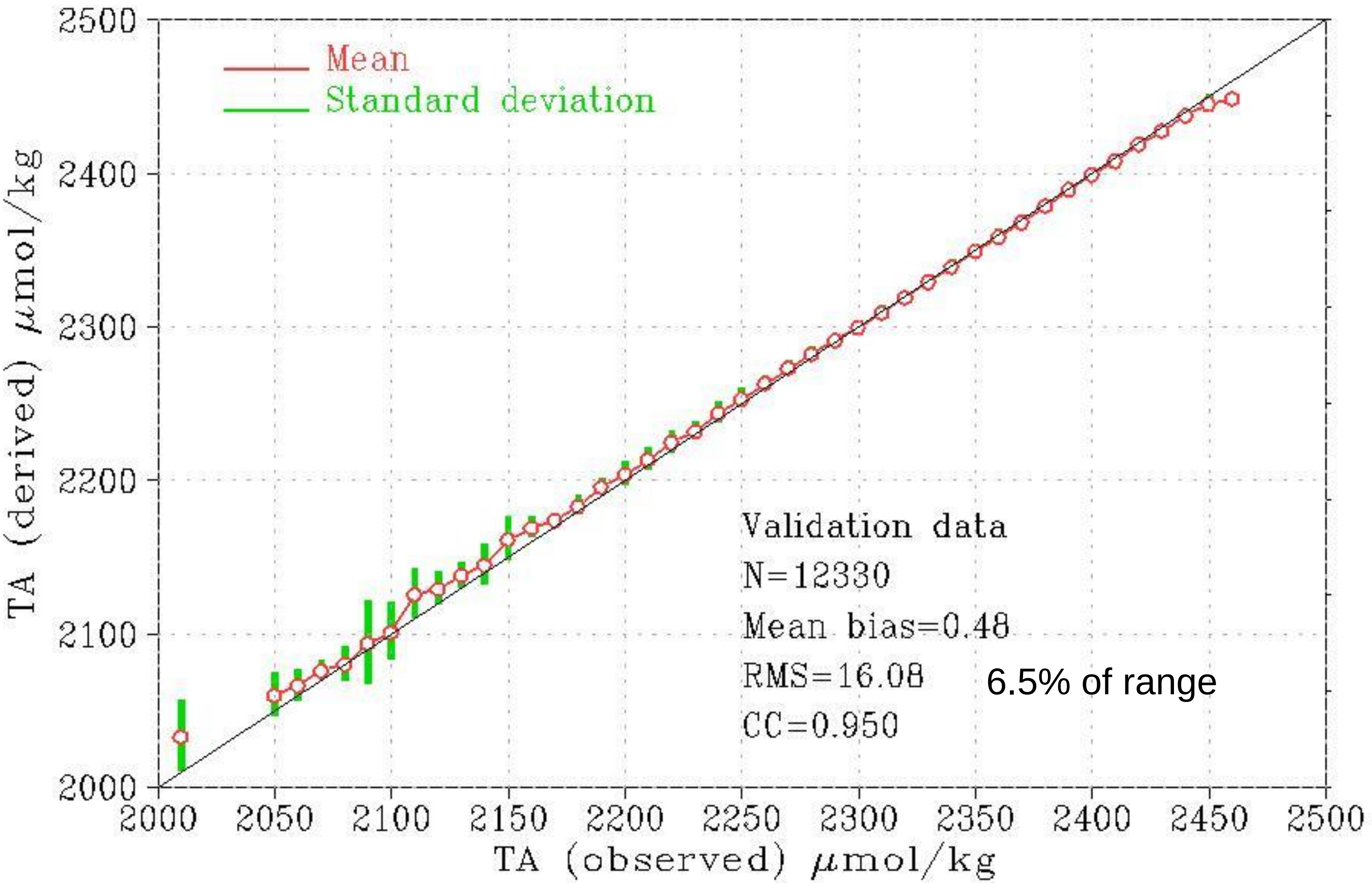
Enhanced $pCO2_{sea}$ during La Nino and suppressed $pCO2_{sea}$ during El Nino

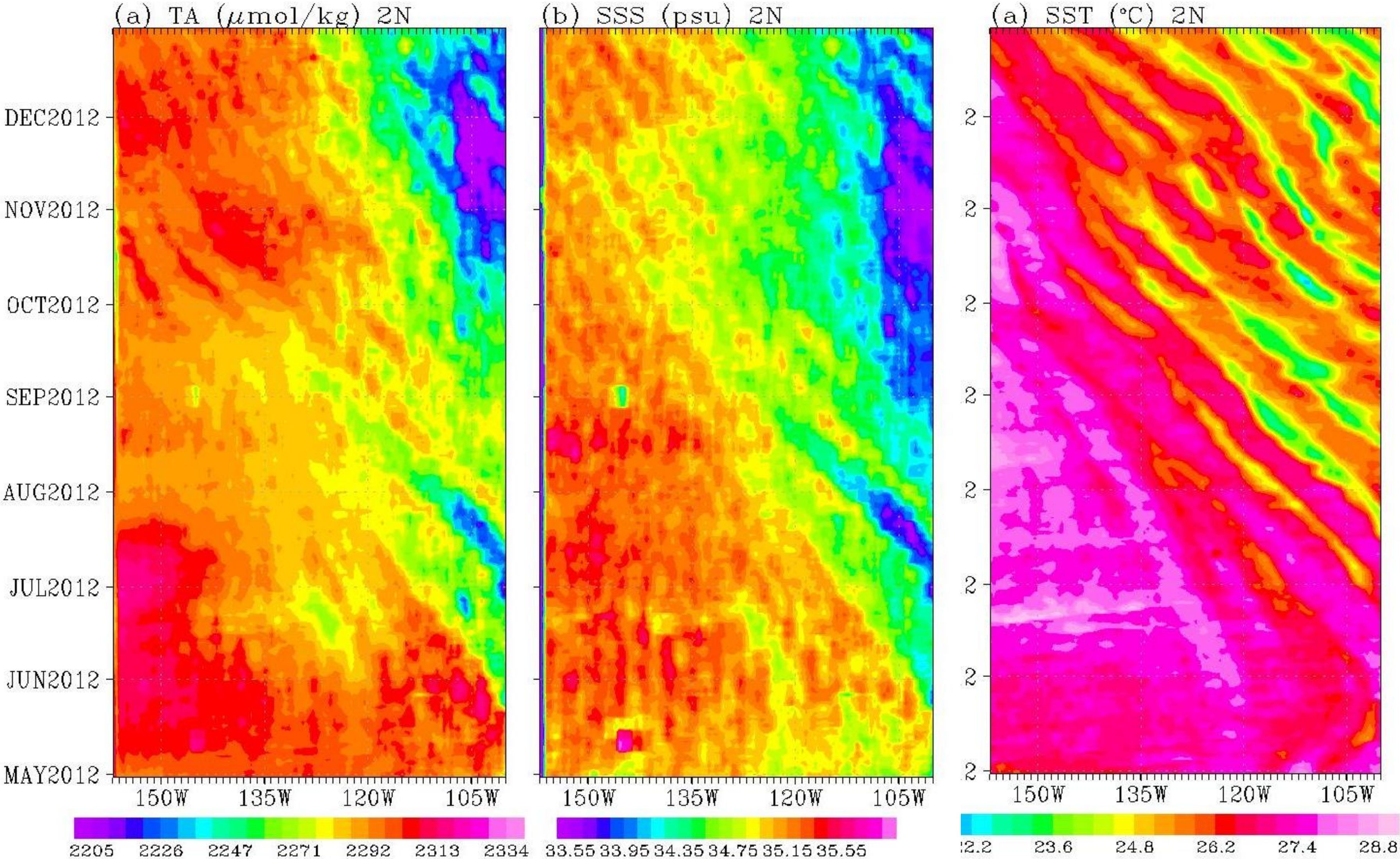


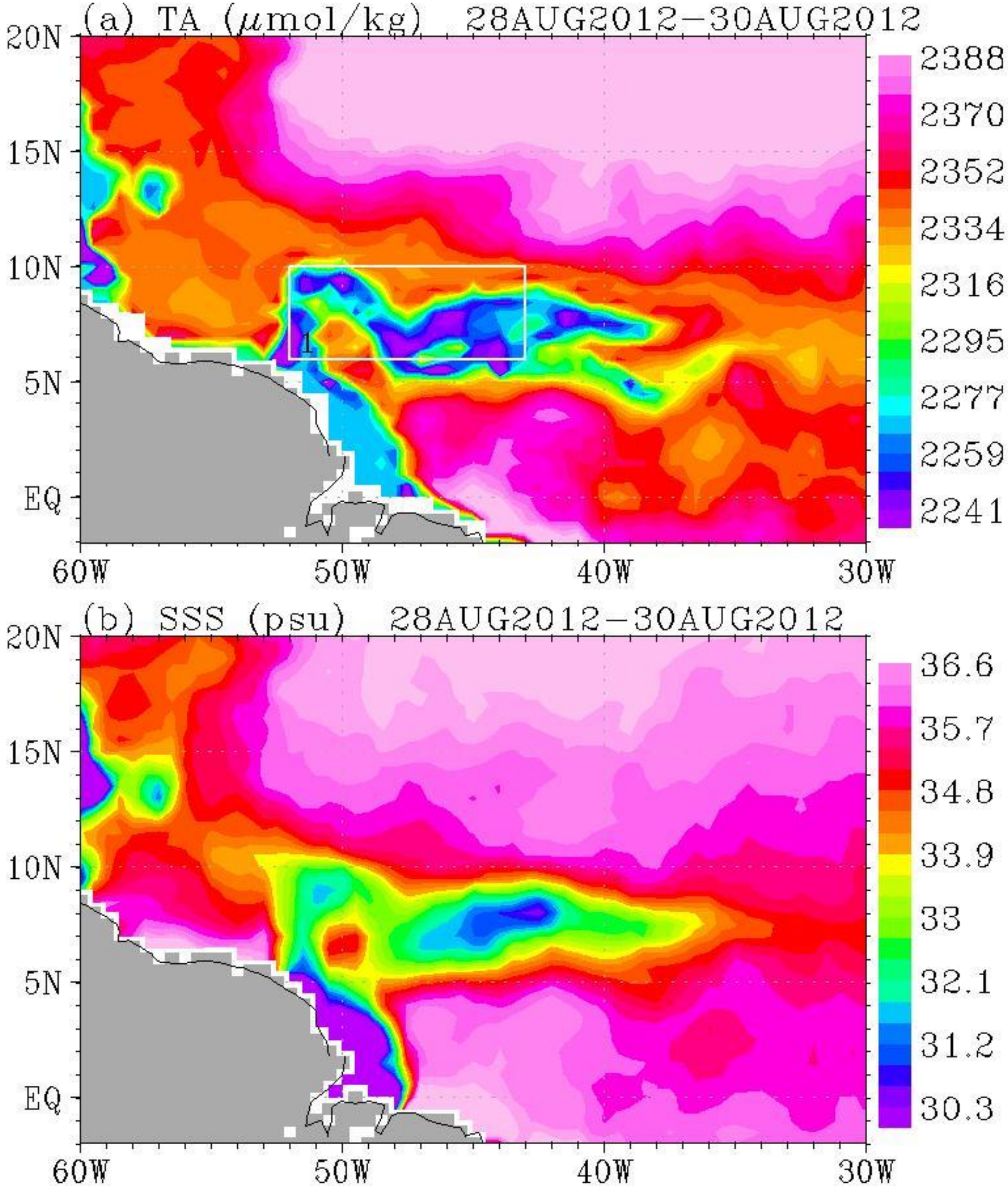
Tropical Instability waves in the equatorial eastern Pacific
$pCO2_{sea}$ out of phase with SST




60N
40N
20N
EQ
20S
40S
60S
0
30E
60E
90E
120E
150E
180
150W
120W
90W
60W
30W
0
1990 1991 1992 1993 1994 1995 1996 1997
1998 1999 2000 2001 2002 2003 2004 2005
2006 2007 2008 2009 2010 2011 2012 2013


Mean
Standard deviation
Validation data
N=12330
Mean bias=0.48
RMS=16.08
CC=0.950
6.5% of range
TA (derived) μmol/kg
TA (observed) μmol/kg
2000
2100
2200
2300
2400
2500
2050
2150
2250
2350
2450


(a) TA (μmol/kg) 2N
(b) SSS (psu) 2N
(a) SST (°C) 2N
DEC2012
NOV2012
OCT2012
SEP2012
AUG2012
JUL2012
JUN2012
MAY2012
150W
135W
120W
105W
2205 2226 2247 2271 2292 2313 2334
33.55 33.95 34.35 34.75 35.15 35.55
22.2 23.6 24.8 26.2 27.4 28.8



(a) TA (μmol/kg) 28AUG2012–30AUG2012
20N
15N
10N
5N
EQ
60W
50W
40W
30W
1
2388
2370
2352
2334
2316
2295
2277
2259
2241
(b) SSS (psu) 28AUG2012–30AUG2012
20N
15N
10N
5N
EQ
60W
50W
40W
30W
36.6
35.7
34.8
33.9
33
32.1
31.2
30.3

- Continuous coverage of pCO2 and TA over all oceans from a few days to a few years, using satellite data and a single model, is feasible.
- Ensemble validations show good accuracy, but only meaningful in regions with data.
- We found slightly less range in seasonal variation and no consistent long term trend in the tropical oceans
- Future improvement with data from SOCAT, salinity data from SMOS, Aquarius, SMAP, SST from AMSR-2, wind vector from ASCAT
- Should be complementary with OCO to determine surface source and sink of atmospheric CO2

Backup

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