Spatiotemporal dynamics of sea surface pCO_2 and its flux in the East China Sea during warm periods

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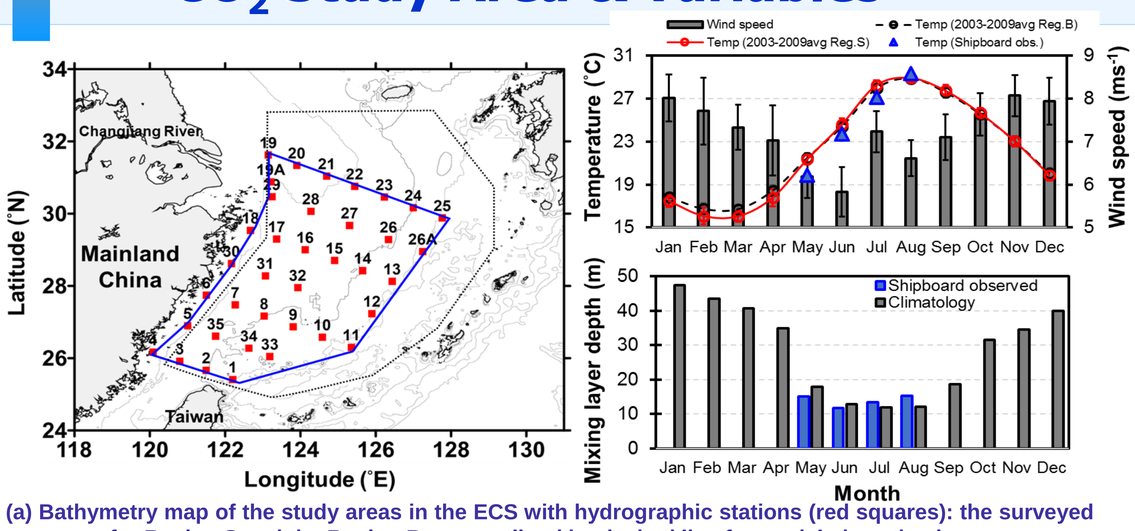
Air-sea CO_2 exchange in the East China Sea (ECS)

The East China Sea (ECS) is situated between the low- and mid-latitudes (between 25°N-34°N) with estimated overall CO_2 sink strength of 1~3 mol C m^{-2} yr^{-1} (Tseng et al., 2014). As a whole, the ECS (~0.2% of global ocean area) could yield annual carbon uptake of 0.01~0.03 Gt C, representing 0.5~2.0% of the global uptake. This implies a relatively high CO_2 uptake rate compared to other ocean regions. Previously reported air-sea CO_2 fluxes were, however, biased by inadequate spatial and/or temporal coverage. Sea surface pCO_2 (pCO_{2w}) distribution in the ECS are spatially/temporally variable as a result of interactions among the seasonal thermal cycle, net community production/respiration, surface/subsurface sea waters and river waters. The dominant processes in the ECS vary by seasons and regions, with typically active biological uptake of CO_2 in warm periods and intensely physical mixing and solubility of CO_2 in the cold seasons (Tseng et al., 2011, 2014, Chou et al., 2011). In addition, pCO_{2w} distribution is subjected to mixing of varied water masses which are characterized by the nutrient-rich and less saline Changjiang Diluted water (CDW, waters within 31 ‰ isohaline) and warm, saline and nutrient-depleted Kuroshio (KW), shelf mixed (SMW) and Taiwan Warm Current (TWC) waters (Fig.3). Further, various circulation regimes lead to the shelf-edge processes for material exchange between the East China Sea Shelf and the adjoining Kuroshio. Thus, to enable better quantification of the ECS CO_2 uptake capacity reiterates the need of greater spatial and temporal resolutions in observational data, which are needed for accurate estimation of air-sea CO_2 fluxes in the ECS.

1 CO_2 Study Area & Variables

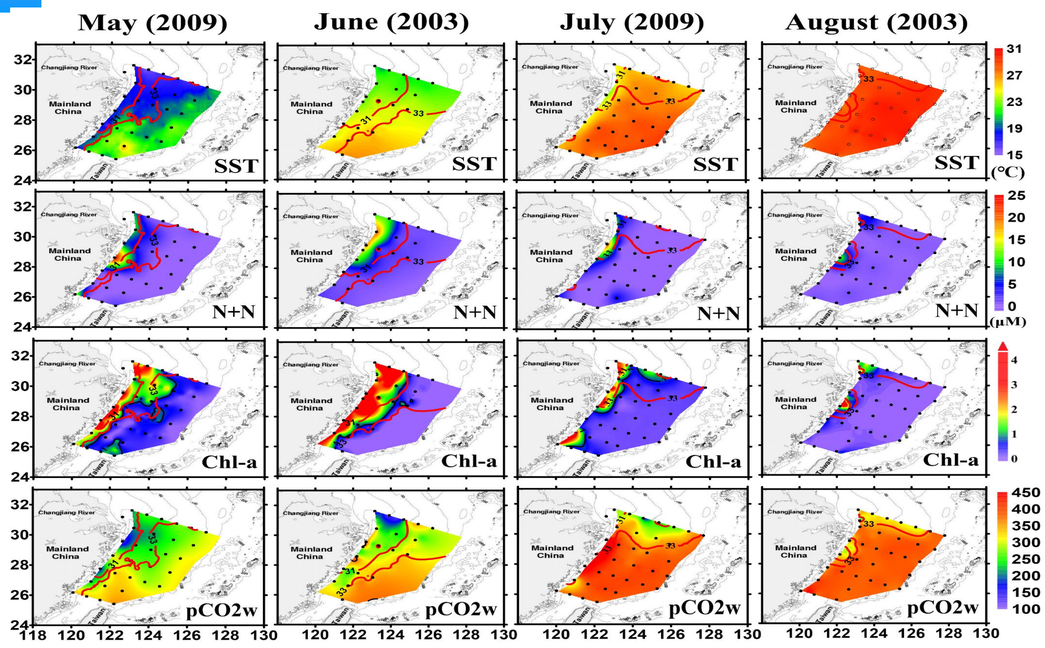


(a) Bathymetry map of the study areas in the ECS with hydrographic stations (red squares): the surveyed area for Region S and the Region B area outlined by dashed line for modeled synthesis.

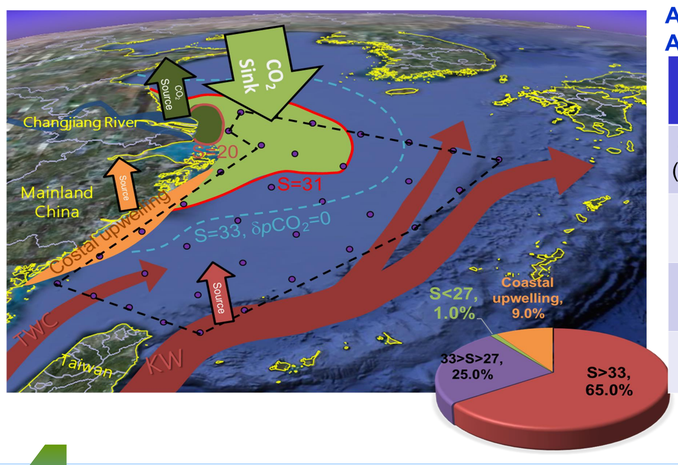
(b) Areal mean AVHRR SST in Region S (red line) and B (black line) from 2003 to 2010, and shipboard-observed SST (blue triangle)

(c) Comparison the MLDs observed from field with those from climatology

2 Distributions of pCO_2 & Hydrography



3 CO_2 Dynamics related to Water Masses

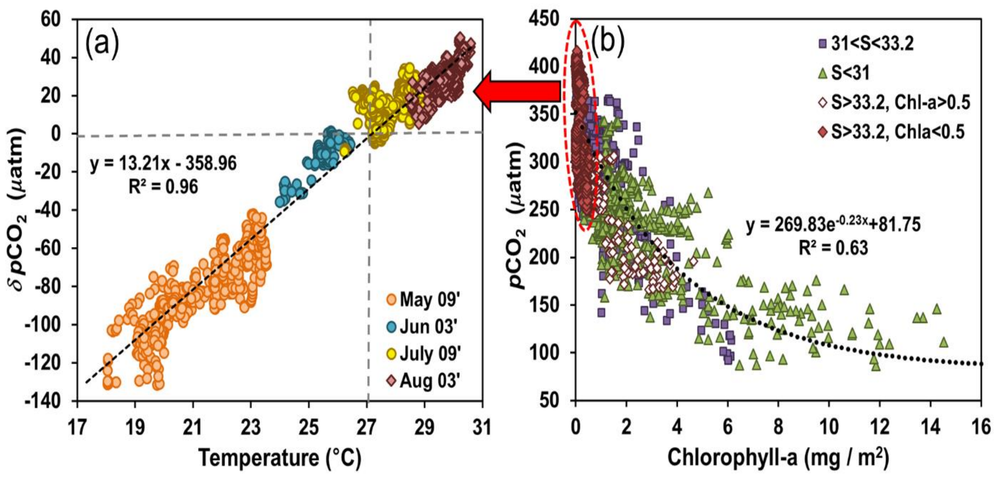


Air-Sea CO_2 Exchange Fluxes Associated with Varied Water Masses

	May (09)	June (03)	July (09)	Aug (03)	Avg.
S>33 (area%)	-3.4 (66%)	-0.6 (52%)	0.9 (59%)	1.2 (81%)	-0.5 (65%)
S<33	-5.2 (25%)	-3.5 (39%)	-4.2 (32%)	-3.2 (10%)	-4.0 (26%)
CW	-1.5 (9%)	-0.3 (9%)	0.8 (9%)	1.3 (9%)	~ 0 (9%)
Total	-3.7	-1.7	-0.7	0.8	-1.3

CO_2 flux unit: mol m^{-2} yr^{-1}

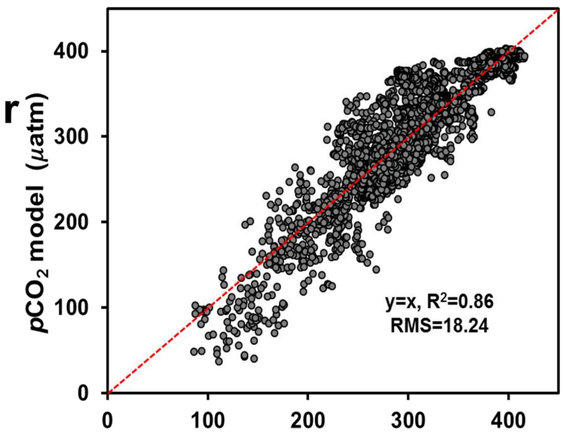
4 Controlling Factors on pCO_2 change



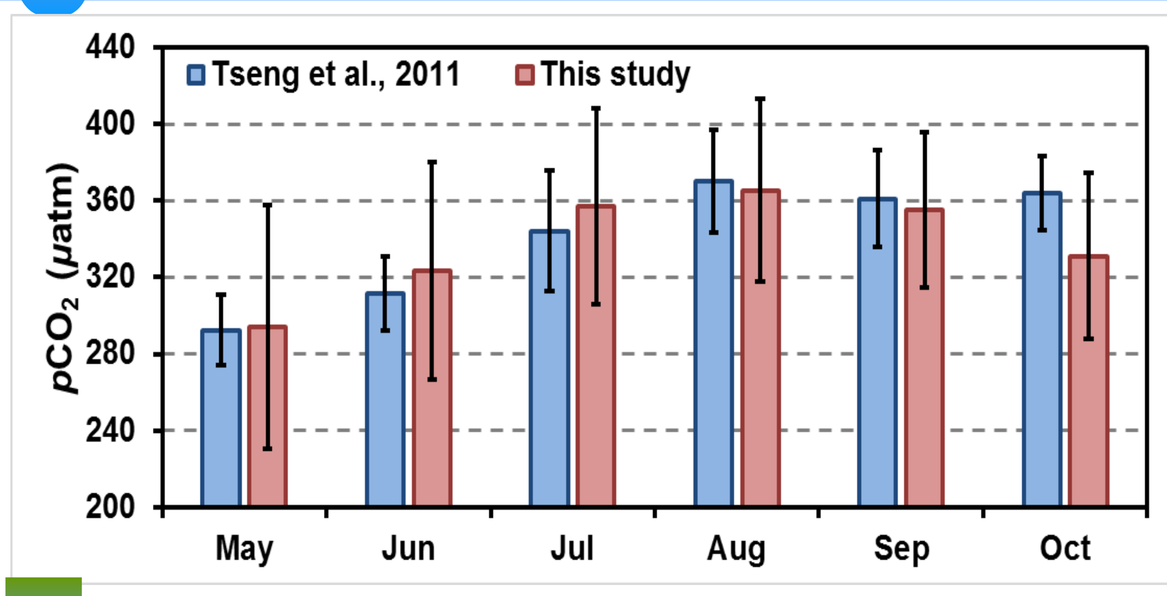
5 Empirical Algorithms vs. Observations

$$pCO_{2temp} = (A \times Temp. + B) + pCO_2air$$
$$A = 13.21、B = -358.96$$

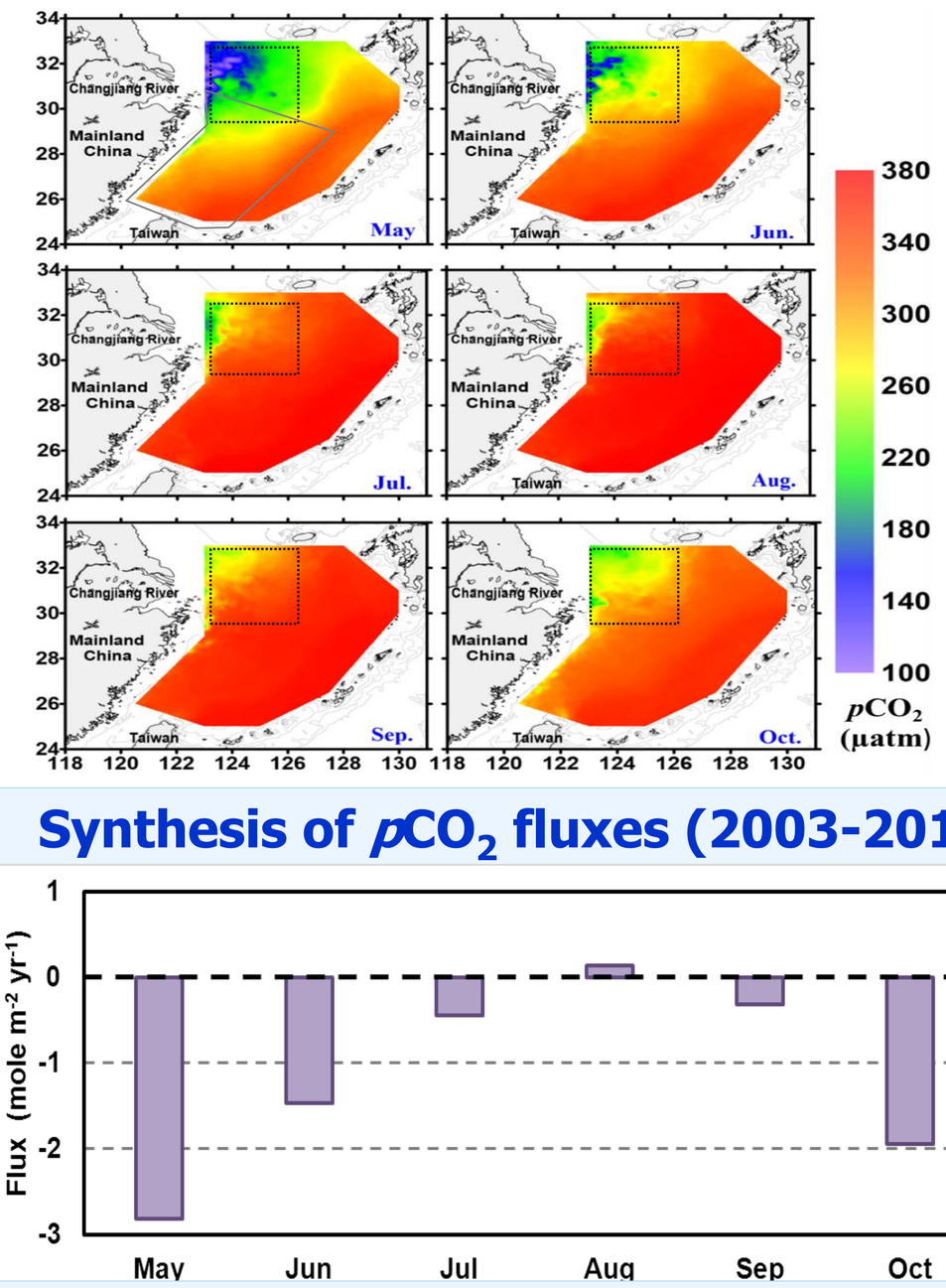
$$pCO_2w = pCO_{2temp} \times e^{(C \times Chl\text{-}a)} + D$$
$$C = -0.16、D = 11.09$$



6 Comparison with Previous Literatures (2003-2010)



7 Synthesis of pCO_2 Distribution (2003-2010)



8 Synthesis of pCO_2 fluxes (2003-2010)

ECS CO_2 studies-Findings

The spring-summer pCO_2 distribution in the East China Sea (ECS) was associated with the mixing of varied water masses, which had their own dominant governing factor of pCO_2. pCO_2 changes in the Kuroshio Waters (KW) and Taiwan Current Warm Waters (TCWW) were, for instance, mainly controlled by temperature effect, in the Changjiang Diluted Waters (CDW) by biological activity and in coastal waters (offshore < 100 km) by vertical mixing, respectively. A multivariate regression relationship was established (R^2 = 0.86, Fig. 5) according to temperature and chlorophyll-a as major controlling variables. Moreover, model relation as a polynomial of two parameters was applied to the areas of offshore >100 km by using remotely sensed data of temperature and chlorophyll-a (2003 ~ 2010). The model results showed that the concentration gradients of pCO_2w were found i.e., an increasing trend from the CDW to TCWW and KW(Fig. 7). The ECS overall acted as an atmospheric CO_2 sink between May and October (-2.8 ~ -0.3 mole C m^{-2} yr^{-1}), except in August as a source (~ 0.1 mole C m^{-2} yr^{-1}). Finally, based on the model pCO2w data, the ECS was capable of absorbing atmospheric CO_2 at a rate of 0.0042 Gt C yr^{-1} about 30% of the total in warm seasons (May ~ October, Fig. 3, 8).