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Interactive comment on “Influence of seasonal monsoons on net primary production and CO₂ in subtropical Hong Kong coastal waters” by X. C. Yuan et al.

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RC: The manuscript by Yuan et al. BGD deals with the control of air-sea CO₂ fluxes and net primary production during seasonal monsoons in subtropical waters off Hong-Kong. The area studied here is largely impacted by anthropogenic inputs of nutrients and organic matter. The authors discuss the link between the trophic state of the ecosystem and the direction of the air-sea CO₂ fluxes by considering the impact of the physical mixing during dry and wet seasons. They show that the trophic state of the coastal waters shifted from heterotrophic to autotrophic from the dry to the wet season. For the autotrophic period the authors argue that upwelling of DIC rich wa-

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ters during the wet season maintained the efflux of CO₂ from the surface waters to the atmosphere. Thus, they address the issue of using air-sea CO₂ fluxes as an indicator of the trophic status of subtropical coastal ecosystems. However, their results are limited to a rather small area and the authors do not convincingly extend their findings to other subtropical ecosystems. Given the broad impact of papers published in Biogeosciences, I would suggest that the authors consider a different journal, which focuses more specifically on coastal ecosystems dynamics, to submit their manuscript. Below, several additional comments that would need to be addressed to improve the manuscript for future submission.

Response: Whether the studies are conducted in the small or large area should not be the criteria of the MS quality and its significance. While our study focuses on a relative small area around H.K., we emphasize that our purpose is to discuss how monsoon induced physical processes (upwelling and downwelling) affect biological production/respiration and these would affect O₂ and CO₂ dynamics. Our paper is unique in reporting both biological properties and CO₂ properties and is very different from other papers reporting mainly CO₂ dynamics.

Specific comments: RC: Overall, the figures are of good quality, figure 3 should be enlarged in future submission. The manuscript is well written except for specific sections mentioned below.

Response: This figure is enlarged.

RC: Abstract: The abstract summarizes well the manuscript. Introduction: Introduces well the topic and summarizes well the work previously done in the area. The data presented here were partly presented in Yuan et al. (2010) AME, particularly the air-sea CO₂ fluxes. Section 2.3. The pCO₂ data were calculated using DIC and pH measurements. Since the pH measurements were made using an electrode calibrated with NBS buffers, their precision is limited (0.01). Thus the precision and accuracy of the pCO₂ calculated values should be discussed in more details. This is important

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since, for example, the authors rely on statistical values to test the seasonal variability for pCO₂ in regions VH and EW (section 3.2).

Response: The precision of pH measurements is enough for our purpose. The 0.01 pH error will result in the uncertainties of $\pm 3\%$ pCO₂ (ca. $15 \pm 6 \mu\text{atm CO}_2$) and $\pm 10\%$ CO₂ fluxes (ca. $3 \pm 2 \text{ mmol C m}^{-2} \text{ d}^{-1}$), which does not considerably affect our conclusion due to high pCO₂ in Hong Kong waters.

RC: Section 2.4: For air-sea CO₂ calculations, the authors should consider using atmospheric pCO₂ values measured in the vicinity of their stations. Indeed, the dominant northeast winds during the dry season might transport some air enriched in atmospheric pCO₂ above Hong-Kong, thus impacting the air-sea CO₂ fluxes computations. In general, the impact of the low precision of the pCO₂ measurements and the highly variable atmospheric pCO₂ values encountered in this coastal area on the overall computed air-sea CO₂ fluxes should be discussed in more details.

Response: Incorporating the reviewer's concern, we now added a discussion on the uncertainty of unknown atmospheric pCO₂ value: The atmospheric pCO₂ has been reported to be in the range of 349 to 372 μatm in inner shelf/coastal areas adjacent to the Pearl River plume (Zhai et al., 2005), and $\sim 358 \mu\text{atm}$ in offshore waters (Zhai et al., 2009). Since our sampling sites are very close to a mega city (Hong Kong), the land mass influence may result in higher atmospheric pCO₂, especially in the dry season when northeast winds were dominant. A large range of the atmospheric pCO₂ (349 to 460 μatm , and averaged 400 μatm) was reported in Randers Fjord, Scheldt, and Thames (Borges et al. 2004), where sampling sites were also close to anthropogenic influences. The average atmospheric pCO₂ (400 μatm) is used for the calculation of the air-sea flux of CO₂ in our studies. The variations in atmospheric pCO₂ (349 to 460 μatm) would quantitatively result in the estimates of average CO₂ effluxes ($-20 \text{ mmol C m}^{-2} \text{ d}^{-1}$) varying from -12 to $-25 \text{ mmol C m}^{-2} \text{ d}^{-1}$.

RC: Section 3.2: Rephrase last sentence, not clear.

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Response: Rephrase as: CO₂ value was mainly positive (degassing) and O₂ negative (ingassing).

RC: Section 4.2: In the last paragraph, the authors explain that besides biological control, mixing should be considered as a major process controlling dynamics of pCO₂ and O₂. This paragraph should be rewritten to clarify their idea.

Response: It is rewritten. Revived as: Therefore, although the biological control considerably affected O₂ and CO₂ fluxes, other processes (e.g. the CO₂ diffusion due to upwelling and lateral inputs of rich DIC waters from the PRE) should also be taken into account.

Section 4.3: RC: My main concern about the assessment of the monsoonal influence on the NPP and air-sea CO₂ fluxes is about the mixing term during the wet season. Page 5634, the authors argue that “The negative mixing contribution to CO₂ in the wet season suggested that bottom offshore waters increased DIC concentrations due to upwelling in Hong Kong waters”. Since the water column is stratified during the wet season, shouldn't this mixing term be considered as a “diffusion” term at the halocline and thermocline? If so and given the short residence time of the water mass (2 days), could diffusion alone be responsible for a 230 mmol C m⁻² d⁻¹ increase in DIC? Given the strong halocline shown on Figure 3, the author should also consider the lateral inputs of rich DIC waters directly from the Pearl river estuary in their mixing term for stations 1 to 6. Once quantified, this lateral “mixing” term should be included to Figure 7b.

Response: It was considered as a “diffusion” term. We added an estimates of the contributions of the influence of the Pearl river estuary with equation: $PPRE = (S - SPRE) / (Soceanic - SPRE)$, where PPRE is the proportion of water masses from the PRE, and S, SPRE and Soceanic are the salinities in specific waters, the Pearl River estuary and oceanic waters. Hence, lateral inputs of rich DIC were estimated.

RC: Page 5634, line 12-14: rephrase sentence, not clear.

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Response: Rephrase as: The mixing contribution to DIC was seasonally variable as the mixing resulted in a decrease in DIC the dry season and increase in the wet season

RC: Section 4.4: Last sentence of the first paragraph. "In contrast to the relative consensus...". This statement should be revised in view of the recent work by Chen and Borges (2009) who introduced the concept of inner coastal ecosystems (estuaries, mangroves, etc...) as source of CO₂ and continental shelf seas as sink of CO₂ for the atmosphere. Note that this concept seemed to be supported by the results presented in the manuscript for the inner stations 1 to 7.

Response: We now added a discussion: However, more recent studies have addressed whether coastal waters are CO₂ sinks or sources (Borges et al., 2005; Cai et al., 2006; Chen and Borges, 2009; Laruelle et al., 2010). For example, the synthesis of worldwide measurements of the partial pressure of CO₂ (pCO₂) indicates that most inner estuaries and near-shore coastal areas are over-saturated with respect to atmospheric CO₂ (Chen and Borges, 2009).

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