Air-sea CO_2 flux monitoring in a coastal region influenced by freshwater: is the CO_2 sink changing?

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Background

In general, continental shelves are thought to be important sinks for CO_2 via consumption of dissolved inorganic carbon (DIC) from terrestrial/anthropogenic sources (*1*, *2*) and trapping organic matter delivered to the coast via rivers (*3*). Marginal seas provide vital ecosystem services, such as fisheries habitats, ecotourism, and act as buffers to the open ocean trapping inorganic nutrients; yet it is the close proximity to land that also makes these ecosystem move vulnerable to climate changes (*4*) and increased anthropogenic CO_2. Estimating coastal carbon budgets is particularly challenging as CO_2 is difficult to model (*5*) and we are just beginning to understand the complex processes that influence CO_2 dynamics. Specifically, off the southeast US coast, in the South Atlantic Bight (**SAB**) this is the longest continuous time series analysis of coastal air-sea CO_2 fluxes (**FCO_2**) to date.

Objectives

1. Estimate the annual net CO_2 source/sink.
2. Determine if the annual net source/sink is changing over time and what processes may contribute to variability.

Hypothesis

With increased pCO_2 concentrations at the GR mooring the potential CO_2 sink, of typical coastal margins, is likely decreasing. The most likely source of increased pCO_2 is from freshwater inputs and increased net biological activity. The dynamic terrestrial hydrologic cycle likely influences coastal CO_2 dynamics.

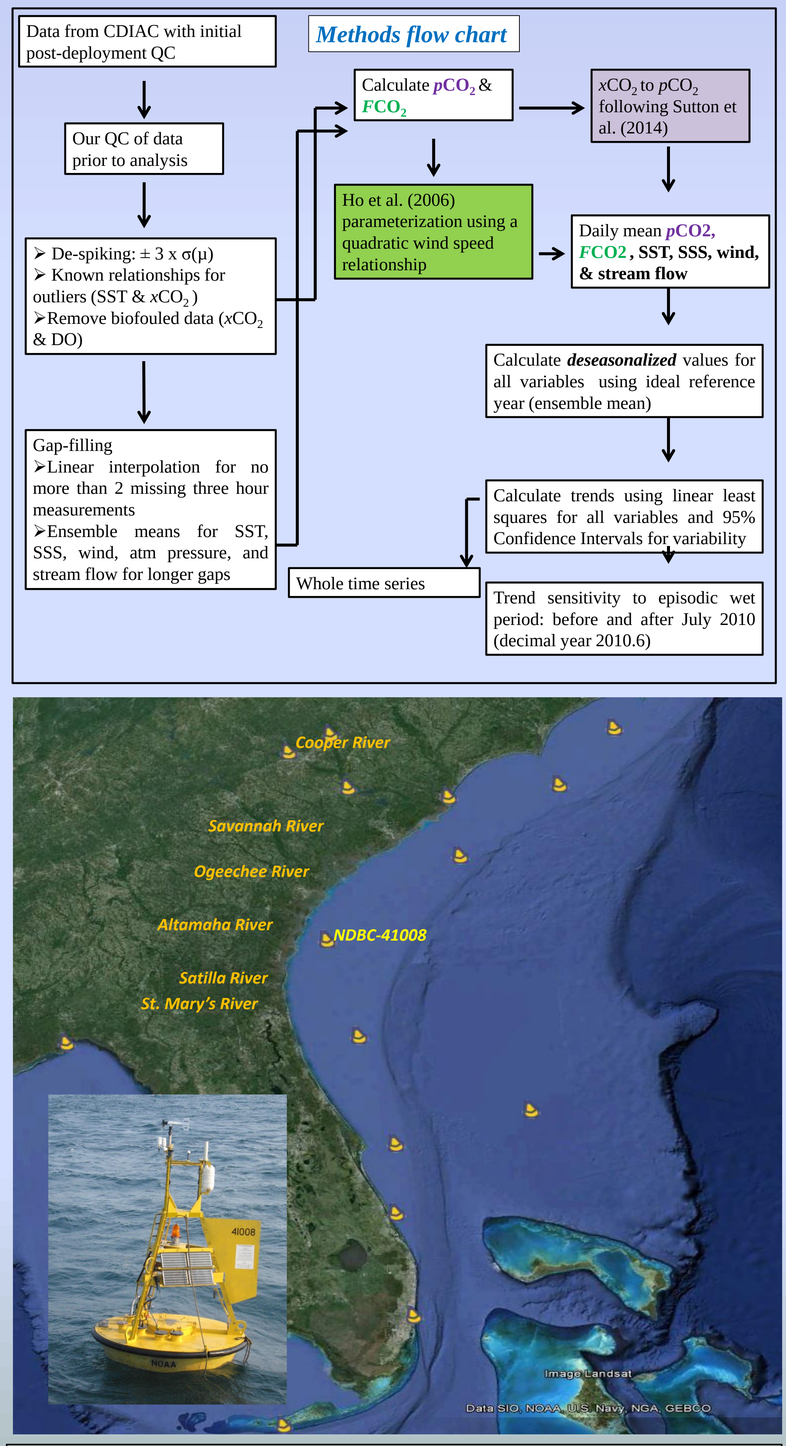

Figure 1. The SAB is a region influenced by both coastal freshwater discharge (river outflow, groundwater discharge, and exchange with salt marshes) and onshore incursions of the Gulf Stream (GS) (*8*). The Gray's Reef mooring is located at the ~20 m isobath, which in this particular region of the SAB, is the boundary between coastal (circulation dominated by river runoff) and oceanic conditions (GS dominated) (*9*).

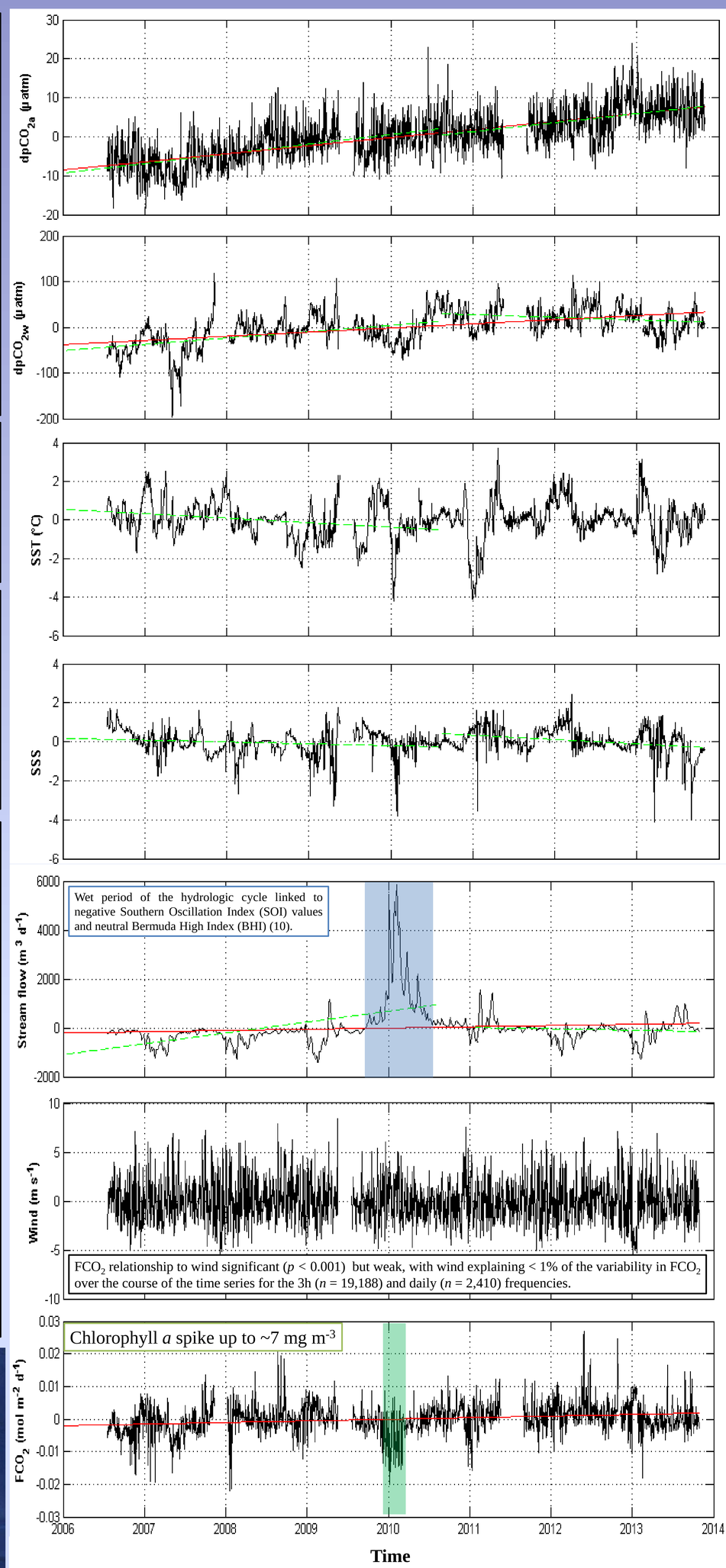

Figure 2. Trend analysis for deseasonalized FCO_2 and potential contributing factors for the length of the time series (red line) and before and after 2010.6 (green line). Over the course of the time series there is a secular increase in pCO_{2w} (9.1 ± 1.5 μatm y^{-1}) and pCO_{2a} (2.0 ± 0.20 μatm y^{-1}) and Altamaha River stream flow (51 ± 29 m^3 y^{-1}) as a proxy for freshwater input. Prior to 2010.6 there is an increase in Altamaha River flow, and SSS that could contribute to the pCO_{2w} increase during this time. By separating the influence of thermal versus non-thermal components of pCO_{2w} (*10*) Reimer et al. (in prep) determined that there was no thermal influence on pCO_{2w} prior to 2010.6 even though there is a significant decreasing trend, and that the likely source of increase pCO_{2w} is increased organic matter respiration away from the coast, eutrophication, and increased production at the GR mooring due to freshwater input to the SAB. With no change in wind speed in conjunction with the lack of a thermal influence on pCO_{2w}, the increase in FCO_2 is likely due to supersaturation of pCO_{2w} with respect to pCO_{2a}. Even though there appears to be a response in pCO_{2w} to anomalously high freshwater inputs (green lines) we do not see this same response in FCO_2. This is likely due to the complex interplay of *in situ* processes in this heterogeneous region. Episodic FCO_2 drawdown may be linked to increased winter freshwater inputs.

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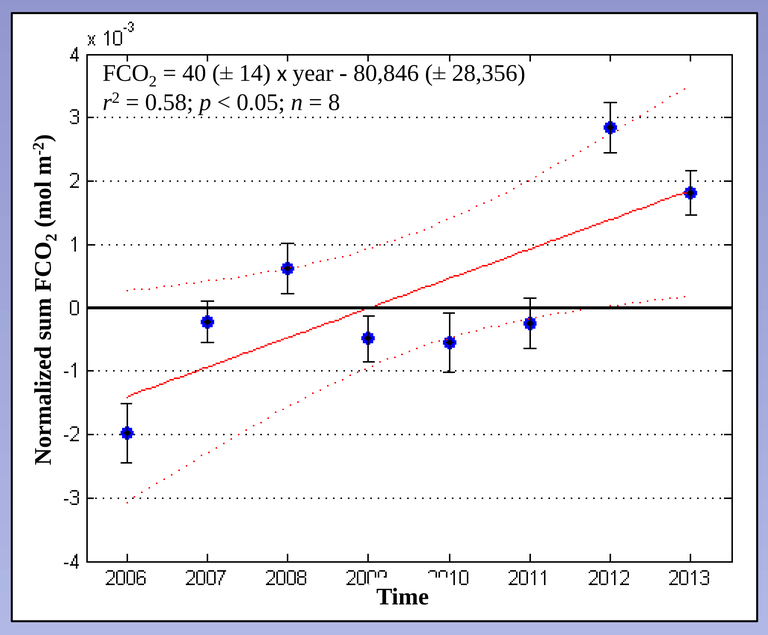

Figure 3. Annual net sum of FCO_2 flux normalized to the number of days for which there are observations. While it appears that there is an increase in the annual net sum over time, the trend (40 ± 60 mol m^{-2} y^{-1}) is highly uncertain and may not be statistically different than zero. This uncertainty is likely due to the low sample size (n = 8) and large variability. We do find, however, that the site switches between a source and a sink for CO_2.

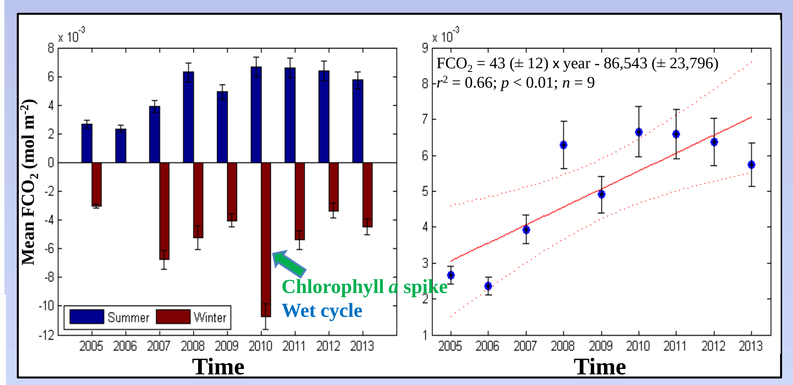

Figure 4. Mean summer and winter FCO_2 (left), and the trend in summer FCO_2 (right); the mean winter trend is not significant. This analysis includes underway observations from cruises in January, February, and August 2005. Due to the large 95% confidence interval this trend may also not be significantly different than zero due to low sample size and high variability. This apparent increase reflects a summer increase in $pCO2$ (results not shown), and is likely due to supersaturation with respect to the atmosphere.

Conclusions

➢GR mooring site switches from an annual net sink to a source. Other studies have modeled this region as a net sink (*12*), this however, may not be the case.

➢Contrary to pCO_{2w}, FCO_2 does not appear to be influenced by the same episodic increase in stream flow during the wet cycle (2009-2010).

➢FCO_2 may be more influenced by biological drawdown than wind induced evasion.

➢The wet-dry cycle, which has been found to influence pCO_2, may play a different role in air-sea flux dynamics. Where biological production may first draw CO_2 into the water column, however, decreased winds may still trap CO_2 in the surface water. For example, summer 2010 – anomalously high pCO_2, low winds, lower than expected annual sum (negative).

What's next…

1. Determine the sources of variability of FCO_2 at the GR mooring
2. Determine the influence of extreme events (storms, hydrologic wet-dry cycle) on FCO_2 at the GR mooring

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