High Frequency CO₂ variability in North American coastal waters

Christopher L. Sabine¹, Don Conlee², Wei-Jun Cai³, Doug Vandemark⁴, Burke Hales³, and Stacy Maenner¹

Introduction
In 2006, three Moored Autonomous pCO₂ (MAPCO₂) systems were built at PMEL and deployed on surface moorings in coastal waters representing three very different biogeographic provinces of the North American coast. Although these moorings have been in the water for less than a year, they are already demonstrating significant differences in the patterns of variability over a range of timescales. Here we examine the similarities and differences in surface water CO₂ at these three sites to illustrate the importance of evaluating the high frequency CO₂ variability in coastal waters. These data demonstrate the need for an array of coastal CO₂ moorings to quantify the role of the continental margins in the continental and global carbon cycle.

Washington

Working with NOAA’s National Data Buoy Center (NDBC), a PMEL MAPCO₂ system was deployed on an R/V Thompson (34008) in the Strait of Juan de Fuca. The site is located approximately 34 km west of the western tip of Whidbey Island, WA, and is in a region characterized by a narrow, shallow shelf. Although the mooring is the only one of the three that is far from the coast break, it is in a region that may be occasionally influenced by outflow from the Columbia River.

The WA mooring was deployed in mid-June 2006. This site acted as a net sink for atmospheric CO₂ for most of the summer months, but surface water CO₂ values were extremely variable. Since October the surface water CO₂ values have remained relatively stable at values close to atmospheric. Surface water temperature (SST) has ranged from a high of about 14°C in the summer to a low of 10°C in the winter. Surface salinity has ranged from 20.8 to 21.5.

The largest CO₂ variations observed at the WA site are very high frequency changes in the summer lasting 1–3 days. Most of this variability is thought to be due to a mixing event at the surface. The water temperature has been shown to be a key factor in the observed variability.

The WA site does not show a strong regular diurnal signal in the summer. Although there is variability on time scales of 1–3 days, there is no clear pattern of changing CO₂ values over this period. The strongest activity occurs during winter months, when the surface temperature is lower and the air temperature is higher. The CO₂ signal becomes stronger during winter months and weaker during summer months.

Georgia

A PMEL MAPCO₂ system was deployed at the Savannah River Site, GA, located within the Gray’s Reef Marine Reserve. The site is in a region characterized by a narrow, shallow shelf. Although the mooring is the only one of the three that is far from the coast break, it is in a region that may be occasionally influenced by outflow from the Savannah River.

The GA mooring shows a clear seasonal cycle in surface water CO₂ during the observed period. The site is a small source of CO₂ to the atmosphere in the summer months and a small sink in the fall. Most of the observed trend is driven by a seasonal drop in surface temperature from nearly 30°C in the summer to about 16°C in the winter. Surface salinity is fairly constant at 35.33.6.

Although the seasonal temperature cycle is the dominant control of the 200 ppm seasonal CO₂ range, there is some CO₂ variability on time scales of days to weeks. These variations are typically less than 15 ppm. While some are associated with variations in temperature, others are not significant.

New Hampshire

In collaboration with investigators at the Gulf of Maine Ocean Observing System (GoMOOS), a PMEL MAPCO₂ system was deployed at the western Gulf of Maine near Portsmouth, NH. The site is far from the coast break, but the bottom is significantly deeper than off the WA and GA moorings. The site is far from the shelf break so the GA mooring has a much higher contribution from the deep ocean. The NH site is far from the shelf break so the NH site is in a region that may be occasionally influenced by outflow from the Savannah River.

The NH mooring shows a mixture between a very small seasonal cycle and large short-term events that significantly impact the CO₂ trends. The area is a small source of CO₂ to the atmosphere in the shallow area of the Gulf of Maine. The NH site is a small source of CO₂ to the atmosphere in the summer and a small sink in the fall. Most of the observed trend is driven by a seasonal drop in surface temperature from nearly 30°C in the summer to about 16°C in the winter. Surface salinity is fairly constant at 35.33.6.

The two dominant sub-seasonal events in the NH mooring are the very low CO₂ values at the beginning of the record and the very high CO₂ values at the end of the record. The NH mooring is the only one of the three that is far from the coast break, but the bottom is significantly deeper than off the WA and GA moorings. The NH site is far from the shelf break so the NH site is in a region that may be occasionally influenced by outflow from the Savannah River.

The NH site shows a clear diurnal signal in CO₂ during the summer. The CO₂ values are generally positively correlated with the temperature changes, but the magnitude of the temperature changes is not large enough to account for all of the observed CO₂ changes. The highest CO₂ values usually occur in the morning, probably associated with tidal fluctuations, that are not generally seen in the CO₂ data. The moon’s 12-hour period is the same as the 12-hour period of the diurnal tide, but the CO₂ signal is not as strong as the tidal signal. The NH site shows a clear diurnal signal in CO₂ during the summer. The CO₂ values are generally positively correlated with the temperature changes, but the magnitude of the temperature changes is not large enough to account for all of the observed CO₂ changes. The highest CO₂ values usually occur in the morning, probably associated with tidal fluctuations, that are not generally seen in the CO₂ data. The moon’s 12-hour period is the same as the 12-hour period of the diurnal tide, but the CO₂ signal is not as strong as the tidal signal.

1. Ocean Climate Research Division, NOAA, PMEL, Seattle, WA; 2. National Data Buoy Center, Stennis Space Center, MS; 3. University of Georgia, Athens, GA; 4. University of New Hampshire, Durham, NH; 5. Oregon State University, Corvallis, OR.