EFFECTS OF LOCAL CLIMATIC FORCING ON CO_2 DYNAMICS AND AIR-SEA EXCHANGE IN SOUTHERN KANEOHE BAY, OAHU, HAWAI'I

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ABSTRACT

Human activities throughout the past 300 years have broadly changed the landscape of our environment. Changes in land use and fossil fuel burning associated with global industrialization have led to large increases in the atmospheric content of greenhouse gases and are now widely thought to cause global warming. It is also thought that climate change may increase the frequency of storms. The latter facilitate the transfer of nutrients, sediment, and pollutants from rivers into coastal ecosystems, potentially contributing to changes in how the coastal area responds to natural forcing mechanisms. There is mounting evidence that increased oceanic CO_2 concentrations lower the saturation state of seawater with respect to carbonate minerals, cause "ocean acidification" and, it has been argued by some, negatively impact calcification (e.g., Kleypas et al., 1999; Orr et al., 2005). Coastal areas and estuaries, however, may be either net annual sources or sinks of atmospheric CO_2 (-41 to 7.3 Mole C m^{-2} yr^{-1}, Mackenzie and Lerman, 2006), depending on local conditions.

The present study was focused on investigating the effects of local climatic changes on air-sea CO_2 flux in a coastal zone, on interannual as well as shorter timescales, such as those of storm events. The work presented here is based upon two years of observations from CRIMP-CO_2, a collaborative effort in Kaneohe Bay, Hawaii between UH Manoa and NOAA/PMEL. This buoy was the first coastal buoy of the NOAA/PMEL-CO_2 program, and represents the first high-temporal resolution time series of CO_2 in a subtropical embayment. CRIMP-CO_2 has documented the response of bay waters to pulsed inputs throughout a La Niña winter season (2005-06) and a much drier subsequent winter (2006-07).

Temperature appears to be the primary control on seasonal changes in seawater pCO_2, whereas organic matter production and respiration seem to be the primary control during storm periods. Southern Kaneohe Bay often becomes a CO_2 sink following storm inputs, with flux rates of up to 0.7 m Mole C m^{-2} hr^{-1}, due to rain-enhanced land and river runoff of nutrients and subsequent stimulation of phytoplankton production. Despite this temporary sink behavior, the southern bay remained a net annual source of CO_2 to the atmosphere (-2.25 – -1.26 Mole C m^{-2} yr^{-1}) during both years of this study. Storm

frequency, intensity and/or duration throughout the year has a strong effect on net annual air-sea CO_2 exchange, whereby bay waters exhibited a dampened source of CO_2 to the atmosphere during an abnormally wet year and a stronger source of CO_2 during a relatively dry year.

Throughout the study, atmospheric CO_2 concentrations at CRIMP-CO_2 were seen to vary rapidly and to a large extent due to shifts in wind direction and magnitude. This observation demonstrates the importance of considering variations in air pCO_2 due to proximity to land and human influences when looking at local air-sea CO_2 exchange. The results from this study show that CO_2 dynamics at CRIMP-CO_2 are highly affected by local climatic forcings, particularly atmospheric advection and variability associated with storm events. In addition, calculations using the CO_2-carbonic acid system parameters during the study period indicated that dissolution of high Mg-calcites is likely occurring in the water column at CRIMP-CO_2. This work, and that of Fagan and Mackenzie (2007), supports the need for high temporal and spatial resolution of CO_2 measurements in dynamic, heterogeneous environments such as Kaneohe Bay.