Factors influencing sea-surface pCO₂ variability in the western Gulf of Maine

J. Salisbury, D. Vandemark, C. W. Hunt, S. Shellito and J. Irish (UNH), Chris Sabine (PMEL), Wade McGillis (LDEO), Mark Green (St. Joseph's College)

Introduction:
Coastal and marginal seas are regions of intense CO₂ variability that impact the global carbon cycle by linking terrestrial, oceanic and atmospheric carbon reservoirs [Garranes et al., 1998]. Due to their latitudinal and longitudinal range, these regions exhibit a wide range of processes that are not the same, and subject to the cumulative effects of changes in local fluvial, hydrologic, climatic and atmospheric circulation and chemistry (Borges, 2011). We present an oceanographic model that describes the effects of strengthening and winning of the mechanism controlling surface-air dissolved CO₂ within a marginal shelf sea, the northwestern US and Canadian coast (Fig. 1). This model is designed to account for processes as well as continuous data in 10km, 20km and 50km (Fig. 2) and used to simulate a daily mixed layer depth. These data are combined with continuous P CO₂ measurements (air and sea surface, Fig. 2) by Bay B. Electro chemical system measurements in the vicinity of the coastal upwelling zone. The shelf is a major source of dissolved CO₂ to the atmosphere [Liss, 1980; Sabine et al., 2004].

The model is based on a series of processes that are not the same, and subject to the cumulative effects of changes in local fluvial, hydrologic, climatic and atmospheric circulation and chemistry (Borges, 2011). We present an oceanographic model that describes the effects of strengthening and winning of the mechanism controlling surface-air dissolved CO₂ within a marginal shelf sea, the northwestern US and Canadian coast (Fig. 1). This model is designed to account for processes as well as continuous data in 10km, 20km and 50km (Fig. 2) and used to simulate a daily mixed layer depth. These data are combined with continuous P CO₂ measurements (air and sea surface, Fig. 2) by Bay B. Electro chemical system measurements in the vicinity of the coastal upwelling zone. The shelf is a major source of dissolved CO₂ to the atmosphere [Liss, 1980; Sabine et al., 2004].

Results:
The data and derived products shown in Table 1 were applied to the models as described above. The results are shown in the right side of Figure 4. Figure 4A shows the daily effect of pCO₂ caused by DIC and P CO₂ exchange between the sea surface and atmosphere. In Figure 4B (blue) the effects of seasonal advection demonstrate the effects of springtime mixing of low DIC over winter and a process (not yet fully understood) that tends to increase pCO₂ from fall to winter. Also shown in Figure 4B (red) is the impact of entrainment of high DIC water from below, as the mixed layer deepens from fall to winter. The daily effect of changing pCO₂ is shown in Figure 4C (blue). The commonly used simple mixing model of temperature is also shown for comparison (red) where the effect has been accounted for each deployment. The daily sum of effects of air-sea exchange, horizontal and vertical mixing processes and daily temperature variability is shown in Figure 4D (blue) and the difference between pCO₂ and pCO₂ (also daily pCO₂) is shown in red. The difference between these terms is NCP, which is shown in Figure 4E (red) along with a 10-day smoothing curve shown in blue. NCP is pronounced in response to the highest values occurring during spring, coinciding with the annual bloom event. However it is notable that positive NCP trends persist well into the fall.

Table 1. Variables used in model application

We are grateful for the support received by the National Science Foundation OCE-0851447 and OCE-0961825, NOAA grants NAO-OSOS7431206 and NA160C2740, and NASA Earth Science Division grant NNX08AL80G. We also acknowledge the support and expertise of our outstanding captain Bryan Soars and first mate Deb Brewitt.