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Observations of changes in the dissolved CO_2 system in the North Sea, in four summers of the 2001-2011 decade

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Since the industrial revolution, atmospheric concentrations of carbon dioxide (CO_2) have risen dramatically, largely due to the combustion of fossil fuels, changes in land-use patterns and the production of cement. The oceans have absorbed a large amount of this CO_2, with resulting impacts on ocean chemistry. Coastal seas play a significant role in the mitigation of anthropogenic atmospheric CO_2 as they contribute approximately 10-30% of global primary productivity despite accounting for only 7% of the surface area. The North Sea is a perfect natural laboratory in which to study the CO_2 system as it consists of two biogeochemically distinct regions displaying both oceanic and relatively coastal behaviour. It has also been identified as a continental shelf pump with respect to CO_2, transporting it to the deeper waters of the North Atlantic. Large scale forcing has been shown to have a significant impact on the CO_2 system over varying time scales, often masking the effects of anthropogenic influence. Here, we present data from the North Sea spanning the 2001-2011 decade. In order to investigate the dynamics of the dissolved CO_2 system in this region in the face of climate change, four basin-wide cruises were conducted during the summers of 2001, 2005, 2008 and 2011. The acquired Dissolved Inorganic Carbon (DIC) and alkalinity data were then used to fully resolve the carbon system in order to assess trends over the 2001-2011 decade. We find significant interannual variability, but with a consistent, notable trend in decreasing pH. We found that surface alkalinity remained relatively constant over the decade, whereas DIC increased, indicating that the pH decline is DIC-driven. We also found that the partial pressure of CO_2 (pCO_2) increased faster than concurrent atmospheric CO_2 concentrations, and that the CO_2 buffering capacity of the North Sea decreased over the decade, with implications for future CO_2 uptake.