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# The anthropogenic $CO_2$ increase and $^{13}C$ Suess effect in the northern North Atlantic

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The behaviour of the northern North Atlantic as a sink for anthropogenic $CO_2$has received growing attention over recent years. Observations from the sub-polar North Atlantic have revealed that surface ocean $pCO_2$ has increased at a greater rate than the atmospheric $pCO_2$over the last twenty years (Lefévre et al., 2004, Friis et al., 2005). As shown in simple model calculations, this effect can come around as a result of northwards advection and cooling of water loaded with anthropogenic carbon (Wallace, 2001, Anderson and Olsen, 2002). Indeed, anthropogenic carbon transport estimates reveal a large northward transport of anthropogenic $CO_2$ in the North Atlantic (e.g. Macdonald et al., 2003).

Here we present results from two recent studies that address these issues. Firstly, we have reconstructed the time history of the air-sea $CO_2$ disequilibrium and its rate of change in the eastern subpolar North Atlantic between 1972 and 1989 (Omar & Olsen, 2006). This reconstruction show that the air-sea $CO_2$ disequilibrum decreased over the time period. In the second study the anthropogenic changes of $CO_2$ and $\delta^{13}C$ in the Nordic Seas since 1981 has been evaluated by comparing data collected during the TTO-NAS of 1981 with data collected during two recent surveys in the region (Olsen et al., 2006). The estimated $\Delta\delta^{13}C_{ant}$ and $\Delta C_{ant}$ and their relationship to each other and to water mass distribution suggest that the Atlantic Water that enters the Nordic Seas is equilibrated with the present atmospheric anthropogenic $CO_2$ levels, leaving little or no room for further direct uptake from the atmosphere. In fact, the upper ocean $pCO_2$ in these waters appears to have increased at a greater rate than the atmospheric $pCO_2$ over the last two decades, as also seen futher south.

Based on these and previous results we suggest that the northern North Atlantic acts as an efficient conduit of $C_{ant}$ from surface to depth, important for sustaining the ocean carbon sink. The air-sea flux of anthropogenic $CO_2$ within this region is, however, limited, as most of the $C_{ant}$ is advected into the region from further south.

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