WebPanel 2. Complexities in gas exchange around sea ice

Sea ice is a partial barrier to atmosphere–ocean exchange, but convective and turbulent processes associated with formation, melting, or disturbance of fractured ice may enhance exchange. A lack of understanding on how processes combine and their natural variability, along with limited observations due to the inhospitable nature of polar waters, has led to conflicting predictions of their combined effect on surface gas exchange.

Non-negligible gas exchange through the ice itself has been observed, contradicting the view of ice as a simple barrier (eg Loose and Schlosser 2011). The impact of freezing and melting has been linked to enhanced gas exchange in the laboratory and field (eg Else *et al*. 2011), but is contradicted by other evidence from the field (Rutgers Van Der Loeff *et al*. 2014; Butterworth and Miller 2016; Prytherch *et al*. 2017). Recent eddy covariance measurements of CO_2 flux in marginal ice zones suggest that fluxes scale with the fraction of open water, whereas transfer velocity across ice-free patches is lower (Southern Ocean: Butterworth and Miller 2016) or similar (Arctic: Prytherch *et al*. 2017) to open ocean values at a similar wind speed. However, Loose *et al*. (2017) reported enhanced atmosphere–ocean gas exchange in ice-affected regions based on a large radon deficit dataset.

Differences in conditions may be the cause of apparently irreconcilable results. Among the contributing factors may be variations in ice type and age (Loose and Schlosser 2011), and the high spatiotemporal variability in meteorological and oceanographic conditions. Meteorology and oceanography can act on the partial pressure of CO_2 in the ocean through upwelling of either warm or cold water (Else *et al*. 2011), which could complicate micro-meteorological studies; however, Prytherch *et al*. (2017) demonstrated that this effect was minor. Work focusing on evaluating the specific (and potentially competing) ice processes affecting gas exchange (Loose *et al*. 2014; Butterworth and Miller 2016; Prytherch *et al*. 2017) may elucidate the topic, and enable more reliable regional and global estimates of gas exchange.

More generally, satellite observations hold the potential to help reconcile contrasting results from historical polar studies by providing assessments of critical synoptic-scale observations not observable in situ (WebTable 2); they will enable the spatial and net impact of conflicting conclusions to be assessed, and identify those geographical regions where scientific efforts should be focused.

WebReferences

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