Geophysical Research Abstracts
Vol. 12, EGU2010-14174, 2010
EGU General Assembly 2010

Sea ice and its effect on mass transport between the atmosphere and the Southern Ocean interior

Brice Loose (1) and Peter Schlosser (2,3,4)

(1) now at: Woods Hole Oceanographic Institution, Marine Chemistry and Geochemistry, Woods Hole, MA 02543, (2) Lamont-Doherty Earth Observatory, Columbia University, Palisades, NY 10964, (3) Department of Earth and Environmental Science, Columbia University, New York, NY 10027, (4) Department of Earth and Environmental Engineering, Columbia University, New York, NY 10027

We examine gas exchange in the presence of sea ice in the Southern Ocean using tracer data and simple models of the oceanic surface layer. Convective cooling leads to sea ice formation over much of the ocean surface, precisely when the water column is most turbulent and has the greatest ability to exchange mass across the air-sea interface. It is this asynchrony of sea ice advance and retreat, versus mixed-layer convection and stratification that determines the net physical flux of gases between the atmosphere and the abyssal ocean interior.

However, there is very little antecedent knowledge of the gas transfer velocity, k, through ice-covered waters. The only known estimate, using the radon-deficit method in the Barents Sea, yielded a value of k_{660} = 6 cm h^{-1} under ca. 90% ice cover. Here we attempt a second estimate using an isopycnal inventory of three water column tracers measured during the 1992 Ice Station Weddell drift: ^{3}He, CFC-11 and salinity. This effort produced a mean value of 0.9 cm h^{-1} through ca. 92% ice cover, which is markedly reduced, despite the apparent similarity in ice cover. However, it is difficult to assess the turbulent forcing conditions in both estimates, and therefore we lack a complete basis for comparison.

We use these disparate estimates to formulate alternative scenarios for gas ventilation through the seasonal ice zone in the Southern Ocean, by applying them to the Robin boundary condition on a reactive transport model for inorganic carbon. The results show that CO_2 flux through sea ice represents 13-34% of the net annual air-sea flux, depending on the relationship between sea ice cover and k. However, the model also indicates that more restriction of natural CO_2 in winter produces greater ventilation in the springtime marginal ice zone, with fluxes increasing by 200-700% over the winter value, despite photosynthetic activity. These results highlight the importance of understanding the physical, as well as biological, processes that regulate gas exchange in the marginal ice zone. These include stratification, surface wave reflection/damping by ice floes, and turbulence production in the ice-water boundary layer.