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Sea ice and climate feedbacks in the Southern Ocean

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Arctic sea ice is melting rapidly under the effects of climate change, but at the same time Antarctic sea ice is actually expanding overall. Understanding the reasons for this difference could provide significant insight into the workings of polar climate change. The behaviour of sea ice is not simple to understand because it is an integral part of the wider climate system, with many feedbacks affecting its evolution. For example, snow-covered sea ice is much more reflective than seawater, so if some ice is lost, the ice–ocean system will absorb more heat in summer, leading to further ice loss. There are several other important feedbacks, including examples associated with the insulating properties of sea ice, and the mixing of ocean heat up towards the surface as the ice forms. For example, during sea ice growth, the thickness of ice controls the growth rate, with the rate of growth decreasing as the ice thickens due to poorer heat conduction through the thick ice. On the other hand, increased melting of sea ice decreases the salinity of the mixed layer, therefore raising the freezing temperature of the seawater, making it easier to grow more sea ice.

It is important to understand these feedbacks in the Southern Ocean surrounding Antarctica for many reasons. The changes in Antarctic sea ice over the last thirty years have a strong seasonal dependence, and the way that these changes grow in spring and decay in autumn suggests that feedbacks are strongly involved. The changes might ultimately be caused by winds, atmospheric warming, snowfall changes, etc., but we cannot understand these forcings without first untangling the feedbacks. A highly simplified coupled sea ice-mixed layer model has been developed to investigate the impact of feedbacks on the behaviour of sea ice in the Southern Ocean. The latest generation of climate models are very poor at modelling Antarctic sea ice. Solving this problem is of crucial importance to predicting the response of Antarctic climate to greenhouse gases and the ozone hole.