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The relative roles of Arctic and Antarctic sea-ice loss in the response to greenhouse warming

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Antarctic sea ice has gradually increased in extent over the forty-year-long satellite record, in contrast with the clear decrease in sea-ice extent seen in the Arctic over the same time period. However, state-of-the-art climate models ubiquitously project Antarctic sea-ice to decrease over the coming century, much as they do for Arctic sea-ice. Several recent years have also seen record low Antarctic sea-ice. It is therefore of interest to understand what the climate response to Antarctic sea-ice loss will be.

We have carried out new fully coupled climate model simulations to assess the response to sea-ice loss in either hemisphere separately or coincidentally under different albedo parameter settings to determine the relative importance of each. By perturbing the albedo of the snow overlying the sea ice and the albedo of the bare sea ice, we obtain a suite of simulations to assess the linearity and additivity of sea-ice loss. We find the response to sea-ice loss in each hemisphere exhibits a high degree of additivity, and can simply be decomposed into responses due to loss in each hemisphere separately. We find that the response to Antarctic sea-ice loss exceeds that of Arctic sea-ice loss in the tropics, and that Antarctic sea-ice loss leads to statistically significant Arctic warming, while the opposite is not true.

With these new simulations and one in which CO_2 is instantaneously doubled , we can further characterize the response to sea-ice loss from each hemisphere using an extension to classical pattern scaling that includes three controlling parameters. This allows us to simultaneously compute the sensitivity patterns to Arctic sea-ice loss, Antarctic sea-ice loss, and to tropical warming. The statistically significant response to Antarctic sea-ice loss in the Northern Hemisphere extratropics is found to be mediated by tropical warming and small amounts of Arctic sea-ice loss.