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Stratospheric Impacts on Arctic Sea Ice

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Long-term circulation change in the stratosphere can have substantial effects on the oceans and their circulation. In this study we investigate whether and how sea ice at the ocean surface responds to intraseasonal stratospheric variability. Our main question is whether the surface impact of stratospheric sudden warmings (SSWs) is strong and long enough to affect sea ice. A related question is whether the increased frequency of SSWs during the 2000s contributed to the rapid decrease in Arctic sea ice during this time. To this end we analyze observations of sea ice, NCEP/NCAR reanalysis, and a long control integration with a stratospherically-enhanced version of the GFDL CM2.1 climate model. From both observations and the model we find that stratospheric extreme events have a demonstrable impact on the distribution of Arctic sea ice. The areas most affected are near the edge of the climatological ice line over the North Atlantic, North Pacific, and the Arctic Ocean. The absolute changes in sea ice coverage amount to +/-10 %. Areas and magnitudes of increase and decrease are about the same. It is thus unlikely that the increased SSW frequency during the 2000s contributed to the decline of sea ice during that period. The sea ice changes are consistent with the impacts of a negative NAO at the surface and can be understood in terms of (1) dynamical change due to altered surface wind stress and (2) thermodynamical change due to altered temperature advection. Both dynamical and thermodynamical change positively reinforce each other in producing sea change. A simple advection model is used to demonstrate that most of the sea ice change can be explained from the sea ice drift due to the anomalous surface wind stress. Changes in the production or melt of sea ice by thermodynamical effects are less important. Overall, this study adds to an increasing body of evidence that the stratosphere not only impacts weather and climate of the atmosphere but also the surface and interior of the oceans.