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Drivers of past and future Southern Ocean change: stratospheric ozone versus greenhouse gas impacts

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We study the separate impacts of changing atmospheric greenhouse gas (GHG) and stratospheric ozone concentrations on past (1960-2010) and future (2010-2100) Southern Ocean conditions. To this end we employ a coupled atmosphere-ocean model with interactive stratospheric chemistry. In our model we separately prescribe i) GHGs that monotonically increase to 2100 and ii) ozone depleting substances (ODSs) that rapidly increase to a maximum in 1995 and then slowly return to 1960 values around 2100, following moderate emission scenarios. Past GHG and ODS changes in our model drive, in about equal measure in the annual mean, poleward intensified surface winds which act to strengthen the sub polar meridional ocean circulation cell and Antarctic Circumpolar Current (ACC). Future GHG-induced oceanic changes continue nearly monotonically to 2100, while the ODS-induced ACC transport peaks, and then reverses, a couple of decades after the ODS maximum in 1995. The ODS impact on ACC transport exceeds the corresponding GHG impact up the second quarter of the 21st century, a result that highlights the importance of often-neglected stratospheric ozone trends for the simulation of the ocean circulation.