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The impact of greenhouse gas and ozone forcing on the Southern Hemisphere climate system

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Anthropogenic climate change in the Southern Hemisphere is driven by two forces, the greenhouse gas emissions and the stratospheric ozone levels. In the past, the combination of increasing greenhouse gas emissions and ozone depletion over Antarctica worked together leading to an increase in sea surface temperatures and a poleward shift of the storm tracks. With the ozone expected to recover by mid-century, however, the greenhouse gas and ozone forces will oppose each other and the changes observed previously will begin to weaken or reverse. The role the greenhouse gases and the ozone recovery play in the Southern Hemisphere climate system are examined using Community Climate System Model, version 4 (CCSM4) coupled ocean eddy-parameterized and eddy-resolving simulations. The greenhouse gas emissions and ozone levels are specified independently to represent the two extremes, peak greenhouse gas emissions and a recovered ozone. In the eddy-parameterized simulations, the ozone recovery signal is found to be stronger on average. In the case of the eddy-resolving simulations, however, the increase in greenhouse gases is stronger especially in eddy-rich regions like western boundary current regions and the Antarctic Circumpolar Current. The volume transport is also calculated for the Southern Hemisphere western boundary currents (Agulhas, Brazil, and East Australian Currents) and the two external forces are found to not play an important role in the mean transports, but the model resolution does. The eddy-parameterizing simulations yield a more accurate transport than the eddy-resolving simulations. The eddy-resolving simulations however, are able to resolve a more accurate eddy field in these highly active regions. The relationship between the sea surface temperatures in the western boundary currents and regional precipitation over nearby South Africa, South America, and Australia is then analyzed in greater detail.