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An Idealized Model of Ocean Gyres near Pine Island Ice Shelf and Thwaites Ice Shelf

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Floating ice shelves buttress the Antarctic Ice Sheet, which is losing mass rapidly mainly due to oceanic melting and the associated disruption to glacial dynamics. The local oceanic circulation near ice shelves is therefore important for the prediction of future ice mass loss and related sea-level rise as it determines the water mass exchange, heat transport under the ice shelf, and the resultant melting. However, the dynamics controlling the near-coastal circulation are not fully understood, particularly relating to seasonal and interannual changes in wind stress curl and ice cover. A gyre circulation (27 km radius, cyclonic) in front of the Pine Island Ice Shelf has been identified in both numerical models and velocity observations. In 2019 in the west of Thwaites Ice Shelf, for the first time in this habitually ice-covered region, another gyre circulation rotating in a different direction (13 km, anticyclonic) was detected by velocity observations. Here we use an idealised configuration of MITgcm, with idealised forcing based on ERA-5 climatological wind fields and simplified sea ice conditions from MODIS satellite images, to reproduce key features of the observed gyres near Pine Island Ice Shelf and Thwaites Ice Shelf. A barotropic version of the model is able to reproduce the gyres driven solely by the wind. We show that the modelled gyre direction depends upon the angle between the wind direction and the sea ice front. Gyres generated by wind in sea-ice-free conditions have directions controlled by the wind stress curl. When sea ice is present, the wind stress exerted on the sea surface is reduced, leading to a modified wind stress curl and a resultant change in gyre direction.