The response of Southern Ocean currents to surface wind forcing remains an unresolved issue in physical oceanography, and the zonal transport of the Antarctic Circumpolar Current continues to be a poorly constrained component of climate models. The transport in coarse-resolution models is often highly sensitive to the surface wind stress, while high-resolution model transport is largely insensitive to wind stress above some threshold, after which energy is transferred directly to the mesoscale eddy field. Because of the prohibitive computational cost of resolving mesoscale eddies, many coarse-resolution climate models impose a diffusive isopycnal mass transport, known as the Gent-McWilliams (GM) parameterisation, which emulates the restorative eddy fluxes from baroclinically unstable currents.

We utilise a high-resolution model of a wind-driven channel to examine the dynamical consequences of the GM parameterisation. The unparameterised solution equilibrates after transitioning from an Ekman layer balance to a form stress balance sustained by the mesoscale eddy field. However, the GM-parameterised solution remains trapped in the early stage of Ekman layer balance, referred to here as a state of “arrested development”. The parameterised transport exhibits a greater sensitivity to wind forcing than the unparameterised solution, and illustrates the importance of properly resolving the mesoscale in Southern Ocean simulations.