The oceans slow the rate of climate change by absorbing about 25% of the CO2 released to the atmosphere by human activities. The Southern Ocean makes a substantial contribution to this oceanic sink: more than 40% of the global oceanic inventory of anthropogenic CO2 has entered the ocean south of 40S. However, the physical mechanisms by which anthropogenic CO2 is transferred from the surface layer into the interior of the ocean are not well understood. Here we quantify the transport of anthropogenic CO2 into the Southern Ocean by combining carbon observations with new estimates of the subduction of surface waters. Ekman and eddy transports largely compensate each other. Lateral induction, resulting from changes in mixed layer depth along mean streamlines, essentially determines the regional distribution of subduction of anthropogenic CO2. The net transport of anthropogenic CO2 into the ocean interior occurs in particular locations and not over broad scales as previously assumed. The inferred subduction regions are consistent with the observed distribution of anthropogenic CO2 in the ocean interior. Our results highlight the dependence of carbon sequestration on mixed layer depth and upper ocean currents as well as wind and eddies, properties that are sensitive to climate variability and change. Indeed, we analysed temperature and salinity data from Argo profiling floats to show that the Southern Annular Mode (SAM), the dominant mode of atmospheric variability in the Southern Hemisphere, leads to large-scale anomalies in mixed-layer depth that are zonally asymmetric.