Diapycnal transports in the Southern Ocean are studied using a box inverse model constrained by hydrographic data from nine sections and intermediate-depth velocities estimated from subsurface floats. The hydrographic sections were occupied in the WOCE period (1980s) and in the 2000s. The 1980s and 2000s data are used to obtain a realistic description of the Southern Ocean circulation for these periods. A novel aspect of the inverse model is the inclusion of a near-surface box (0-300m) to represent the mixed layer, such that the diapycnal transports within the mixed layer and the interior Southern Ocean are estimated separately. The use of the box model enables estimates of the mixed layer budgets even in the seasonal sea-ice region.

The diapycnal transport within the mixed layer is found an order of magnitude larger than the diapycnal transport in the interior ocean. The mixed-layer diapycnal transport has three components: geostrophic, equatorward Ekman, and poleward eddy transports. None of them is negligible. The equatorward Ekman transport is circumpolarly almost uniform, but the opposing eddy transport varies by basin. The eddy transports explain the strong upwelling of Upper Circumpolar Deep Water in the Indian sector and subduction of Antarctic Bottom Water in the Pacific and Atlantic sectors.