Atmospheric zonal-mean meridional circulation and midlatitude oceanic fronts

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It is known that, in the zonal-mean tropospheric circulation, diabatic heating drives a thermally direct meridional overturning circulation (MOC) called the Hadley cell. While in the midlatitudes, zonal-mean vertical motion is driven mainly by atmospheric eddies, forming a thermally indirect MOC called the Ferrel cell where warmer (cooler) air apparently sinks (rises) in lower (higher) latitudes. Here we found a thermally-direct, shallow MOC embedded in the downward branch of the zonal mean Ferrel cell in the wintertime northern hemisphere in most of the latest generation reanalysis datasets. AGCM simulations reveal that this local MOC, made of upward (downward) motion around latitudes to the equatorward (poleward) side of midlatitude oceanic fronts, is driven by differential diabatic heating across the ocean fronts due to surface turbulent heat flux from the ocean and precipitation brought by synoptic-scale eddies. The compensating meridional flow in the lowermost atmosphere is northerlies, which decelerates surface westerlies just over the oceanic fronts through the Coriolis force. The decelerated surface westerlies by oceanic fronts in turn exert wind-stress curl forcing that tends to weaken oceanic subpolar and subtropical gyres, indicative of an air-sea coupled feedback that would destruct, rather than maintain, the oceanic fronts.

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