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The Weddell Gyre: Warm Deep Water circulation and fluxes of heat derived from Argo floats

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The Weddell Gyre is a fundamental component of the global climate system, in that it supplies heat to underneath the Antarctic ice shelves, and regulates the density of water masses that feed the deepest limb of the global overturning circulation. Here we utilise Argo float profile and trajectory data spanning the entire Weddell Gyre from 2002 to 2016, in order to determine the large-scale mean horizontal circulation and heat distribution within the upper Weddell Gyre. An elongated, double-cell, cyclonic circulation is revealed, where the eastern cell is stronger than the western cell. The transport of heat within the Warm Deep Water layer, which is the primary heat source to the Weddell Gyre, is demonstrated by diagnosing the heat budget for a 1000 m thick layer encompassing the core of Warm Deep Water. While the heat budget does not close at the resolution of the grid cells, it does close when integrated over large areas, within the range of uncertainty provided by a range of values for horizontal and vertical diffusivity. In the southern limb of the gyre, heat transport convergence due to mean horizontal advection balances with divergence due to horizontal turbulent diffusion (representative of eddy processes). In contrast, within the interior circulation cell of the Weddell Gyre, heat transport divergence due to mean horizontal advection balances with convergence due to horizontal turbulent diffusion. We show that heat is advected into the Weddell Gyre along the southern limb, some of which is diffused northwards into the interior circulation cell, while some is diffused southwards towards the shelf seas. This implies that horizontal turbulent diffusion plays a role in transporting heat towards the ice shelves. Horizontal turbulent diffusion is also a mechanism by which heat can enter the Weddell Gyre across the open northern boundary. This work highlights the importance of understanding the role of eddy processes in redistributing heat throughout the Weddell Gyre, in particular within the vicinity of the ice shelves, where basal ice melt can contribute to rising sea levels.