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Time-mean flow as the prevailing contribution to the poleward heat flux across the southern flank of the Antarctic Circumpolar Current: A case study in the Fawn Trough, Kerguelen Plateau

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The major mechanisms of the poleward oceanic heat flux in the Southern Ocean are still in debate. The long standing belief stipulates that the poleward heat flux across the Antarctic Circumpolar Current (ACC) is mainly due to mesoscale transient eddies, and the cross-stream heat flux by time-mean flow is insignificant. This belief has recently been challenged by several numerical modelling studies which stress the importance of mean flow for the meridional heat flux in the Southern Ocean, south of 60°. The goal of this study is to improve our knowledge of the mechanisms transporting heat across the Southern Flank of the ACC and resolve the conflict between the two views.

To conduct the study, a set of moored current meter data obtained recently in the Fawn Trough, Kerguelen Plateau, was used. The time series of velocity and temperature over the year 2009 are only the second such dataset collected in the Southern ACC Front (SACCF) and the first over the Kerguelen Plateau. In the study, the variability and vertical structure of the southern ACC front at the Fawn Trough site are analysed. The structure across the SACCF was found to be non-equivalent barotropic and generating significant bottom upwelling over the Fawn Trough. The poleward heat flux due to the time-mean flow and to transient eddies is estimated, and the impact of each mechanism on the global heat balance in the Southern Ocean is analysed. It is shown that the eddy heat flux in this southern part of the ACC is negligible, while that due to the mean flow is overwhelming by two orders of magnitude.

Results suggest then a new mechanism of the cross-stream poleward heat flux by time-mean flow across the southern ACC front. This is due to the unusual anticlockwise turning of currents with decreasing depth, which is associated with significant bottom upwelling engendered by strong bottom currents flowing over the sloping topography of the trough. The circumpolar implications of these local observations are discussed in terms of the depth-integrated linear vorticity budget, which suggests that the six topographic features along the southern flank of the ACC equivalent to the Fawn Trough case would yield sufficient poleward heat flux to balance the oceanic heat loss in the subpolar region. As eddy activity on the southern flank of the ACC is too weak to transport sufficient heat poleward, the non-equivalent barotropic structure of the mean flow in several topographically constricted passages should accomplish the required task.