Assessing Unstoppable Change: Ocean Heat Storage and Antarctic Glacial Ice Melt

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Our project focused on assessing meridional heat transport towards the Antarctic continent. As in past years, we have continued to focus on the Pacific Meridional Overturning Circulation, because of its sensitivity to El Niño forcing, and because the most rapid melting of the Antarctic continent has been reported in the southeastern Pacific sector of Antarctica. The advent of high-quality Argo trajectory data now provides usable reference velocity information, which has opened new avenues for assessing meridional overturning. These data, together with data from the Palmer Antarctic Long-Time Ecological Record (LTER), have provided us with a broad perspective on meridional overturning circulation in the South Pacific Ocean and have extended our analysis to consider a broad range of contributors to the meridional overturning circulation.

Recent results

Argo float trajectories significantly influence our estimates of meridional transport at 32°S in the Pacific Ocean. We see evidence for enhanced meridional transport along the western flank of the East Pacific Rise. Overall this enhanced topographically driven transport gives us a refined estimate of the net meridional transport in the South Pacific (Zilberman et al. 2014) and suggests a significant modification to the meridional overturning in the ocean interior that would be inferred from a constant depth reference velocity (Zilberman et al, in preparation). At 32°S, meridional transport in the western boundary current is correlated with the Southern Annular Mode (SAM), but not with changes in El Niño and Southern Oscillation (ENSO), as measured by the Niño 3.4 index. In contrast, at latitudes north and south of 32°S, we see a stronger link to ENSO, implying regional modulations to the meridional transport. Figure 1 shows that under high SAM conditions, the wind-stress curl varies substantially along the western boundary of the Pacific basin, resulting in spatially varying patterns of variability.

The frontal jets that comprise the Antarctic Circumpolar Current (ACC) are often hypothesized to vary in response to the wind, and in previous studies, satellite altimeter data have been used to infer a large-scale poleward shift in the position of the ACC frontal features in response to a large-scale poleward shift in winds over the Southern Ocean, associated with an intensification of the SAM. For this study, we used altimeter data to define an index of the mean latitude of water transported by the ACC. In contrast with the sea surface height trends, the transport-latitude index indicates no long-term trend, implying a possibility that the long-term trends in sea surface height are indicative of steric expansion of the ocean and not of a poleward shift in geostrophic jets (Gille 2014).

Analyses of hydrographic data near West Antarctica indicate that Upper Circumpolar Deep Water (UCDW) is warming in parallel with the Southern Ocean as a whole. This suggests that UCDW warming originates in the Southern Ocean, and may reach the Antarctic margin as an eddy driven transport. This water is a response to oceanic processes and local wind-stress curl, rather than being a response to atmospheric warming. Data from the LTER and a six-year analysis based on the Southern Ocean State Estimate both underscore the importance of locally-forced input to the shelf (Martinson and McKee 2012; Gilroy et al, in preparation).