Oceanic heat and vorticity budgets of the Antarctic circumpolar wave

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We seek to utilize satellite estimates of sea level height, sea surface temperature, and winds, together with NCEP air-sea fluxes of heat, momentum, and kinetic energy, to understand ocean-atmosphere coupling physics of the Antarctic Circumpolar Wave in the Southern Ocean.

We diagnose atmospheric-driven heat and vorticity budgets in the upper ocean associated with the Antarctic Circumpolar Wave (ACW) [White and Peterson, 1996; Peterson and White, 1998; White et al., 1998; White 2000; Gloersen and White, 2001] along its path around the Southern Ocean utilizing TOPEX/ POSEIDON sea level height (SLH) anomalies and National Centers for Climate Prediction (NCEP) sea surface temperature (SST), sea level pressure (SLP), air-sea heat flux (Q), and air-sea momentum flux (τ) anomalies from 1993 to 1999.
We find SLH and SST anomalies in the ACW overlying one another (figure 1), acting to constrain the oceanic physics of the climate change phenomenon. The SLH anomalies derive from two components; pycnocline depth anomalies and diabatic heat storage in the layer above the main pycnocline, the former conserving vorticity and the latter conserving heat. We conduct a least squares analysis, attempting to close upper ocean heat and vorticity budgets simultaneously. This minimization process yields estimates of the depth of the upper layer above the main pycnocline and the vertical mixing of heat through it.

We find the anomalous SLH tendency in the ACW balanced almost exclusively by Ekman pumping, with meridional advection of planetary vorticity offset by the zonal advection of potential vorticity by the Antarctic Circumpolar Current (ACC). We find the anomalous SST tendency in the ACW balanced by the sum of anomalous zonal heat advection by the ACC and by surface air temperature induced sensible-plus-latent heat flux anomalies, the latter displaced to the east of SST anomalies and explaining their eastward phase propagation.
The maintenance of SST anomalies against the loss of anomalous SST-induced sensible-plus-latent heat flux to the atmosphere is maintained by anomalous meridional Ekman heat advection. Magnitudes of anomalous meridional geostrophic heat advection and shortwave-minus-longwave radiative heat flux anomalies are 1/3 to 1/2 those of sensible-plus-latent heat flux anomalies, but they act in phase with the latter to instigate eastward phase propagation.

The correspondence of SLH and SST anomalies arises because anomalous SLH and SST tendencies are both associated with high (low) SLP anomalies, the former linked to anticyclonic (cyclonic) wind stress curl and the latter linked to warm (cool) air temperature anomalies, both occurring simulteneously in the warm (cold) core high (low) sea level pressure anomaly patterns associated with the ACW.

Over this next year, we shall adress two questions. How deep the ACW extends and its coupling with the overlying atmosphere. Preliminary results indicate that the ACW does not follow the core of the Antarctic Circumpolar Current, but rather follows the path of the principal storm track across the Southern Ocean, along which coupling is maximized, the latter needed to maintain the ACW against dissipation. Moreover, we find the ACW in the western Pacific sector of the Southern Ocean forced by meridional teleconnections from the tropics, but thereafter its propagation over the remainder of the Southern Ocean arises from the air-sea coupling [White, Chen, and Allan, 2000]. We will examine these coupling physics by linking the vorticity and heat budgets of the upper ocean to those in the lower atmosphere.

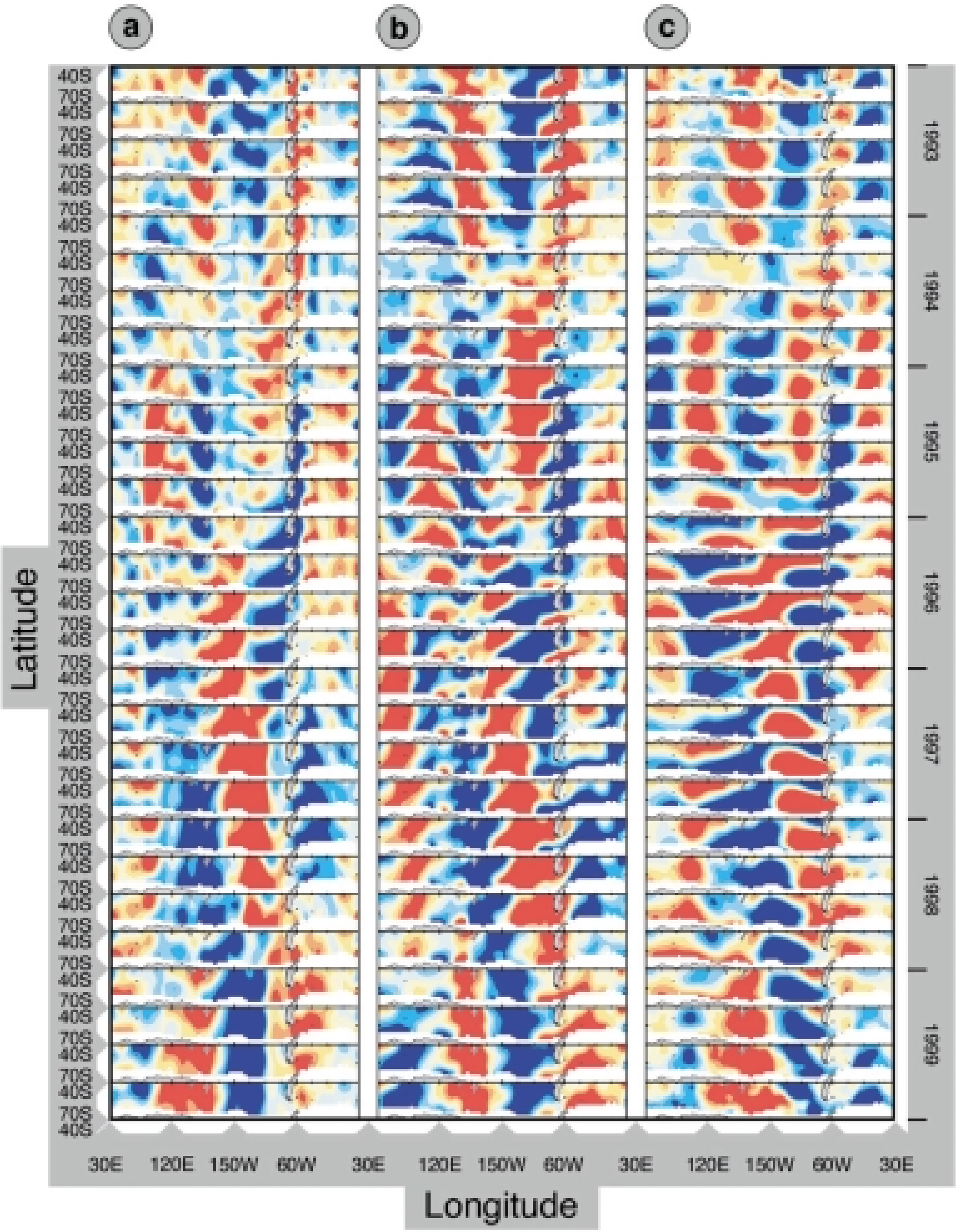

Figure 1: Animation sequences of (a) SLH, (b) SST, and (c) SLP anomalies over the Southern Ocean, filtered for interannual period scales ranging from 3 to 6 years, displaying the slow eastward propagation of the Antarctic Circumpolar Wave (ACW) in all three variables from 1995 through 1999.

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