Poorly determined air-sea fluxes are a major impediment to modeling the Southern Ocean with adequate realism. Intermediate and deep water formation in this region exacerbate the issue by coupling the atmosphere to the interior ocean on relatively short time-scales. This coupling suggests, however, that atmospheric conditions may be relatively well constrained by knowledge of the ocean state. A model of the Southern Ocean for the years 2005-2007 has been constructed, and the air-sea fluxes that bring this model solution into consistency with the ocean observations (e.g. ARGO) are solved for via the adjoint method. These fluxes are discussed in a separate presentation given by I. Cerovecki. Here we use this model and its adjoint to assess the sensitivity of the mean Drake Passage transport to air-sea fluxes of momentum, freshwater, and heat. There are enhanced sensitivities in the southeastern subtropical gyres, and especially in the eastern boundary regions. The greatest sensitivity to air-sea buoyancy flux is found in the polar gyres, and the sensitivity to momentum flux is also substantial in this region. Three locations in the Antarctic Circumpolar Current stand out as being the most sensitive to air-sea fluxes: the Campbell Plateau, the Drake Passage, and the Kerguelen Plateau. Momentum flux sensitivities are of smaller scale, appearing to be more local, while heat and freshwater flux sensitivities are broader and have an up-stream signature. The adjoint model highlights locations where the ocean is especially responsive to the atmospheric state, and thus regions where an accurate determination of air-sea fluxes may greatly enhance ocean modeling efforts.