EGU22-12287
https://doi.org/10.5194/egusphere-egu22-12287
EGU General Assembly 2022

Decadal Oscillations in Southern Ocean Air-Sea Exchange Arises from Zonal Asymmetries in the Atmospheric Circulation

F. Alexander Haumann[1], Ivana Cerovečki[2], Graeme A. MacGilchrist[1], and Jorge L. Sarmiento[1]
[1]Atmospheric and Oceanic Sciences Program, Princeton University, Princeton, United States of America
[2]Scripps Institution of Oceanography, University of California San Diego, San Diego, United States of America

Air-sea exchange of heat, freshwater, and carbon dioxide in the Southern Ocean exhibits large anomalies on decadal time scales. In particular, anomalies in the exchange of carbon-dioxide between the atmosphere and the ocean are dominated by decadal fluctuations. Since known modes of Southern Ocean climate variability, like the Southern Annular Mode, cannot explain these fluctuations, previous studies have suggested a strong link to decadal variability in the tropics. Here, we show that these fluctuations mainly arise from zonal sea-level pressure gradients between 35°S and 63°S that only correlates with tropical climate variability on regional scales. An atmospheric state of increased zonal pressure gradients leads to a stronger meridional exchange of heat and moisture. Such an enhanced meridional exchange favors air-sea fluxes either through a direct modification of the air-sea temperature and humidity gradients, or through resulting changes in ocean mixing and water-mass transformation. The latter changes have profound influences on the surface partial pressure of carbon dioxide in the surface ocean, which controls the surface carbon-dioxide flux. In order to capture this decadal mode of variability in the atmospheric circulation, we define a Southern Decadal Oscillation (SDO) index that is based on the zonal sea-level pressure gradients. This index explains more than two thirds of the variance in the total Southern Ocean carbon-dioxide flux and also dominates the variance in the surface heat and freshwater fluxes on time scales longer than five years. Our results provide an important step in understanding variations in the Southern Ocean surface climate on decadal time scales and imply that the surface ocean buoyancy forcing may control decadal variations in the water masses formed in this region.