DOES THE POSITION OF THE SOUTHERN OCEAN WESTERLY WINDS REPRESENT A NEGATIVE FEEDBACK ON ANTHROPOGENIC CARBON DIOXIDE?

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ABSTRACT

Increasing ocean stratification associated with global warming has been posited to serve as a positive feedback on global warming, reducing the oceanic uptake of anthropogenic carbon dioxide. We suggest that a poleward shift of westerly winds combined with future increases in atmospheric carbon dioxide may drive an increase in the CO_2 uptake in the Southern Ocean, representing a negative feedback on atmospheric anthropogenic CO_2.

Over the last 30 years, the zone of strongest westerlies has shifted poleward by as much as 5° of latitude in the Southern Hemisphere. Some have linked these trends in the annular modes to tropospheric warming. Indeed, paleo-evidence suggests that an even larger poleward shift of the winds occurred during the period of warming at the end of the last ice age. In two coupled climate models (CM2.0 and CM2.1) developed at the Geophysical Fluid Dynamics Laboratory (GFDL) the air-sea heat flux and water fluxes are similar in the two models, but differences between the CM2.0 and CM2.1 control simulations' wind positions result in significant differences in the Southern Ocean circulation. Moreover, in both models, increasing atmospheric greenhouse gas levels result in a pronounced intensification of the westerlies over the Southern Ocean as the global climate warms.

To calculate an inferred anthropogenic CO_2 burden associated with a water parcel, we assume that water at the surface was in equilibrium with the atmosphere and use the ideal age, or time since the water was last at the surface, to calculate the inferred CO_2 uptake. As the atmospheric concentration of carbon dioxide increases, more deep waters will become undersaturated with respect to carbon dioxide and will begin to take up CO_2 when they are exposed to the atmosphere.

In CM2.1, where the westerlies are shifted poleward, the projected CO_2 uptake over the Southern Ocean becomes more important over time, despite the fact that the ventilation of deep waters slowly decreases due to warming and freshening. Thus the potential for a poleward shift and intensification of Southern Hemisphere winds represents an important feedback on atmospheric CO_2 levels that has been neglected in most climate discussions to date.