Impact of deep ocean mixing on transient climate response

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To improve climate change understanding and modeling, it is required to identify the key mechanisms that determine the climate response to the CO_2 concentration increase in the atmosphere. Diapycnal diffusivity in the ocean is well known to determine the strength and pattern of the global ocean overturning circulation, that redistributes the uptaken atmospheric heat all over the world ocean. In this study, employing each of two diapycnal diffusivity distributions, a traditional one-dimensional one (CTRL) and a three-dimensional one derived from the conversion rate of barotropic tide to internal tide energy (TED), we run an atmosphere-ocean coupled general circulation model of which value of CO_2 concentration is increased by 1% yr^{-1}. Our results show that with CTRL deep convective overturning reaches 4000 m depth in the Southern Ocean. With TED, on the other hand, the sea ice in the Southern Ocean prevents the transfer of heat from the ocean to the atmosphere, leading to the shallower mixed layer, less bottom water formation, and lower air temperature. When CO_2 concentration is quadrupled at the 141st year, because of deep convective overturning, water temperature in the deep layers with CTRL increases by ~0.5°C in the Southern Ocean. With TED, due to weak convective overturning, the increase in water temperature in the upper layers in the Southern Ocean is much larger than with CTRL, causing the larger air temperature increase. The increment of globally averaged surface air temperature with TED then is about 0.5°C larger than that with CTRL, suggesting no negligible role of ocean mixing on climate response.

キーワード：鉛直拡散係数、過渡気候応答、大気海洋結合モデル
Keywords: diapycnal diffusivity, transient climate response, AOGCM

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