3rd International Conference on Earth System Modelling
Vol. , 3ICESM-101, 2012
3rd International Conference on Earth System Modelling

Deep-ocean heat uptake and equilibrium climate response

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We integrate ECHAM5/MPIOM to equilibrium under atmospheric CO_2 quadrupling. The equilibrium global-mean surface-temperature change is 10.8K. The surface equilibrates within about 1200 years, the deep ocean within 5000 years. The impact of the deep ocean on the equilibrium surface-temperature response is illustrated by the difference between ECHAM5/MPIOM and ECHAM5 coupled with slab ocean model (ECHAM5/SOM). The equilibrium global-mean surface temperature response is 11.1K in ECHAM5/SOM and is thus 0.3K higher than in ECHAM5/MPIOM. ECHAM5/MPIOM shows less warming over the northern-hemisphere mid and high latitudes, but larger warming over the tropical ocean and especially over the southern-hemisphere high latitudes. ECHAM5/MPIOM shows similar polar amplification in both the Arctic and the Antarctic, in contrast to ECHAM5/SOM, which shows stronger polar amplification in the northern hemisphere. The southern polar warming in ECHAM5/MPIOM is greatly delayed by Antarctic deep-ocean warming due to convective and isopycnal mixing. The equilibrium ocean temperature warming under CO_2 quadrupling is around 8.0K and is near-uniform with depth. The global-mean steric sea-level rise is 5.8m in equilibrium; of this, 2.3m are due to the deep-ocean warming after the surface temperature has almost equilibrated. This result suggests that the surface temperature change is a poor predictor for steric sea-level change in the long term. The effective climate response method described in Gregory et al. (2004) is evaluated with our simulation, which shows that their method to estimate the equilibrium climate response is accurate to within 10%.