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Climate Sensitivity, Ocean Heat Uptake and Time-dependent Climate Change

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Due to the computational expense, no fully coupled AOGCMs have yet been run to full equilibrium with CO2 doubling or quadrupling. In order to gain a more comprehensive understanding of the climate response to atmospheric CO2 forcing, we integrate an AOGCM (ECHAM5/MPIOM) to equilibrium under atmospheric CO2 quadrupling. We evaluate several methods for diagnosing the equilibrium climate response, among them the method to estimate climate sensitivity from the transient response as proposed by Gregory et al. (2004). Our preliminary results show that Gregory et al.'s method overestimates the equilibrium response to CO2 quadrupling because it ignores the ocean heat uptake. The equilibrium in surface air temperature is reached when the net TOA radiation heat flux is balanced by the ocean heat uptake, rather than when the net TOA radiation heat flux goes to zero. The overestimation occurs when neglecting the role of ocean heat uptake. The true equilibrium climate response to CO2 quadrupling in our model is 11.0 K.We also compare the results from the AOGCM with those from a AGCM-slab ocean model (ECHAM5/SOM). The equilibrium climate response in ECHAM5/MPIOM is higher than the response in ECHAM5/SOM, which is 8.0 K. The reason for this discrepancy is still under investigation.