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Understanding weathering feedbacks under CO_2 and orbital forcing in the cGENIE Earth System Model of Intermediate Complexity

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While the general mechanisms driving Earth's climate variability on orbital timescales are well known, quantifying the spatial effects of orbital variations over time in a complex climate system remains difficult. The magnitude of the negative weathering feedback within the carbon cycle depends on the initial CO_2 concentration and size and position of continents. Variations in the intensity of the feedback and the resulting temperature impact on the system can alter the climate response to orbital forcing. We conduct model experiments with different levels of atmospheric CO_2(1x,~2.5x, ~10x preindustrial level) for an artificial (single) continent setup as well as a modern configuration in an Earth System Model of Intermediate Complexity (cGENIE). The experiments run with a carbon cycle in a closed state in the beginning and then stepwise increase in complexity to an open system without weathering, open system with carbonate (Ca) weathering, open system with Ca and silicate (Si) weathering, open system with Ca and Si weathering with a dependency of the weathering to terrestrial run-off and biosphere productivity. We run low resolution (18x18x8) sensitivity experiments establishing surface air temperature (T_{Eff}) arising only due to orbital variations. Our results show that T_{Eff} changes as a function of initial CO_2 concentrations are less pronounced when an open marine carbon cycle with the run-off and biosphere productivity dependent weathering component is included and act as negative feedback. In addition, we observe that ocean circulation plays a fundamental role in mitigating the response of the atmospheric CO_2 to orbital variation. Sensitivity experiments show that the initial T_{Eff} variations caused by orbital and CO_2 variations can then also be advected and modified by ocean circulation.