Understanding weathering feedbacks under CO$_2$ and orbital forcing in the cGENIE Earth System Model of Intermediate Complexity

Fiona Rochholz (1), Sandra Kirtland Turner (2), Pam Vervoort (2), Andy Ridgwell (2), and Heiko Pälike (1)
(1) MARUM, Universität Bremen, Bremen, Germany (frochholz@marum.de), (2) Department of Earth Sciences, University of California, Riverside, California

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 ($T_{\text{Eff}}$) arising only due to orbital variations. Our results show that $T_{\text{Eff}}$ 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 $T_{\text{Eff}}$ variations caused by orbital and CO$_2$ variations can then also be advected and modified by ocean circulation.