Adjusting marine proxy records to account for palaeogeographic change and plate movements – retrieving the carbon cycle signal

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During the period from approximately 150 to 35 million years ago, the Cretaceous–Paleocene–Eocene (CPE), the Earth was in a "greenhouse" state with little or no ice at either pole. It was also a period of considerable global change, from the warmest periods of the mid Cretaceous, to the threshold of icehouse conditions at the end of the Eocene. However, the relative contribution of palaeogeographic change, solar change, and carbon cycle change to these climatic variations is unknown. Here, making use of recent advances in computing power, and a set of unique palaeogeographic maps, we carry out an ensemble of 19 General Circulation Model simulations covering this period, one simulation per stratigraphic stage. By maintaining atmospheric CO_2 concentration constant across the simulations, we are able to identify the contribution from palaeogeographic and solar forcing to global change across the CPE, and explore the underlying mechanisms. The stratigraphic stage–stage transitions which exhibit greatest climatic change are associated with transitions in the mode of ocean circulation, themselves often associated with changes in ocean gateways, and amplified by feedbacks related to emissivity and albedo. Our results also have implications for the interpretation of single-site palaeo proxy records. In particular, our results allow the non-CO_2 (i.e. palaeogeographic and solar constant) components of proxy records to be removed, leaving a more global component associated with carbon cycle change. This "adjustment factor" is illustrated and applied to proxy data for a number of key sites in the CPE. The data is freely available so that similar adjustments can be made to any site and for any time period within the CPE.