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Late Cretaceous climate simulations with different CO_2 levels and subarctic gateway configurations: A model – data comparison

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We investigate the impact of different CO_2 levels and different subarctic gateway configurations on the surface temperatures during the latest Cretaceous using the Earth System Model COSMOS. The simulated temperatures are compared with the surface temperature reconstructions based on a recent compilation of the latest Cretaceous proxies. In our numerical experiments, the CO_2 level ranges from 1 to 6 x the pre-industrial (PI) CO_2 level of 280 ppm. On a global scale, the most reasonable match between modelling and proxy data is obtained for the experiments with 3 to 5 x PI CO_2 concentrations. However, the simulated low (high) latitude temperatures are too high (low) as compared to the proxy data. The moderate CO_2 levels scenarios might be more realistic, if we take into account proxy data and the dead zone effect criterion. Furthermore, we test if the model-data discrepancies can be caused by too simplistic proxy-data interpretations. This is distinctly seen at high latitudes, where most proxies are biased towards summer temperatures. Additional sensitivity experiments with different ocean gateway configurations and constant CO_2 level indicate only minor surface temperatures changes ($<\sim 1^{\circ}C$) on a global scale, with higher values (up to $\sim 8^{\circ}C$) on a regional scale. These findings imply that modelled and reconstructed temperature gradients are to a large degree only qualitatively comparable, providing challenges for the interpretation of proxy data and/or model sensitivity. With respect to the latter, our results suggest that an assessment of greenhouse worlds is best constrained by temperatures in the mid latitudes.