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Early Eocene perturbed parameter simulations: multiple methods of proxy-model comparison

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Geological proxy data for the early Eocene, ∼55 million years ago, indicate widespread greenhouse conditions across the Earth. High latitude early Eocene temperature estimates inferred from a variety of proxy data are much warmer than their modern counterparts (∼10-20°C), whilst low latitude early Eocene temperature estimates where available (∼30-35°C) are only slightly warmer than their modern equivalent. This implies a reduced pole to equator temperature gradient during the early Eocene.

Climate models are unable to simulate the low latitudinal temperature gradients seen in the early Eocene. The mechanisms for transporting and maintaining heat at high latitudes in order to achieve these reduced gradients are still uncertain although several hypotheses have been proposed. We are interested in reducing this model-data discrepancy by considering both climate model and proxy data uncertainty.

A comprehensive study by Murphy et al. 20041 identified a subset of 29 parameters within the UK Hadley centre climate model (HadCM3) whose values cannot be accurately determined from observations. These 29 parameters were identified as being responsible for controlling key physical characteristics of sub-grid scale atmospheric and surface processes by modelling experts. Using a subset of 12 of the uncertain parameters identified by Murphy et al. 2004, we have run climate model experiments perturbing these parameters singly and jointly, within a realistic range, in order to understand the spectrum of climates that result. We use the model, FAMOUS (Fast Met Office/UK Universities Simulator), a low resolution emulator of HadCM3 for our experiments. The relatively low computing time of FAMOUS makes it ideal for long paleoclimate studies. We use an early Eocene paleogeography and run our simulations at 560 ppm, (2 x pre-industrial CO_2.) The solar constant for the early Eocene is set to 1359.5 Wm-2.

The climate proxy dataset (terrestrial and marine) available for the early Eocene is limited and there are many uncertainties associated with interpreting absolute climate values from it. In order to make best use of the data and its availability we have used several model-data approaches. First, rather than using the absolute values deduced from the proxy data we use them as a reference dataset against which changes in the parameter simulations can be compared. Secondly, in acknowledging the large uncertainties associated with temperature and precipitation values we target areas which have a large model anomaly signal. Finally we incorporate qualitative geological data to extend the spatial coverage of our comparison.

1. Murphy et al., 2004, Quantification of modelling uncertainties in a large ensemble of climate change simulations paper, Nature 430, 768-772