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What caused Earth's temperature variations during the last 800,000 years? Data-based evidences on radiative forcing and constraints on climate sensitivity

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The temperature on Earth varied largely in the Pleistocene from cold glacials to warmer than present interglacials. To contribute to an understanding of the underlying causes of these changes we compile various environmental records (and model-based interpretations of some of them) in order to calculate the direct effect of various processes on Earth's radiative budget and, thus, on global annual mean surface temperature over the last 800,000 years. The importance of orbital variations, of the greenhouse gases cO_2, CH_4 and N_2O, of the albedo of land ice sheets, sea ice area and vegetation, and of the radiative perturbation of mineral dust in the atmosphere are investigated. Furthermore, changes in annual mean snow cover on surface albedo and of ice sheet elevation and sea level change on orography are considered as additional contributors to glacial cooling. Increased Antarctic temperatures in Marine Isotope Stages 5.5, 7.5, 9.3 and 11.3 are difficult to explain. The unaccounted feedbacks would, if taken at present day feedback strengths, ask for another cooling at the LGM of 2 to 10 K. If compared with other studies, such as PMIP2, this gives supporting evidence that the feedback strength themselves are not constant, but depend on the mean climate state. The best estimate and uncertainty for the reconstructed radiative forcing and LGM cooling support a present day climate sensitivity (excluding the ice sheet and vegetation components) between 1.3 and 5.2 K, with a most likely value near 2.3 K, somewhat smaller than other methods but consistent with the consensus range of $2 - 4.5$ K derived from other lines of evidence. Climate sensitivities above 6 K are difficult to reconcile with LGM econstructions.