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The influence of land ice and CO_2 on polar amplification and specific equilibrium climate sensitivity during the past 5 million years

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Polar amplification and specific equilibrium climate sensitivity (S) have been the subject of many paleoclimate studies. While earlier studies inferred them as single constant parameters of the climate system, there are now indications that both are conditioned by the type of forcing. Moreover, they might be affected by fast feedback mechanisms that have different strengths depending on the background climate. Here, we use the intermediate complexity climate model CLIMBER-2 to study the influence of land ice and CO_2 on polar amplification and S. We perform transient five-million-year simulations, forced by different combinations of insolation, land ice and CO_2. We find that land ice and CO_2 changes have separate effects on temperature, both on the global mean and the meridional distribution. Land ice changes are mainly manifested in the high latitudes of the Northern Hemisphere. They lead to 77% higher northern polar amplification, 38% lower southern polar amplification, and 42% lower S than homogeneously distributed CO_2 changes. Furthermore, towards colder climates northern polar amplification increases, and consequently southern polar amplification decreases, due to the albedo-temperature feedback. As an effect, a global average temperature change calculated from high-latitude temperatures by using a constant polar amplification would lead to errors of up to 0.6 K in our model set-up. We conclude that to constrain feedback strengths and climate sensitivity in climate models by paleoclimate data, the underlying forcing mechanisms and background climate states have to be taken into consideration.