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Feedback analysis on physics parameter ensembles of a single model and on multi-model in LGM and increased CO_2 experiments

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Climate sensitivity is one of the most important metrics for the basis of future climate projections, and paleoclimate has been used to constrain its uncertainty. The potential of paleoclimate as a guide for the future climate change needs to be demonstrated based not only on mathematical correlations between the past and future temperature change but also on sound physical understanding of the change. The intensive focus has been paid to the last glacial maximum when rich proxy records are available with large signal (externally forced change) to noise (unforced internal variability) ratio. A previous study investigated similarity and differences in the feedback process of LGM and doubled CO_2 experiments conducted by four different atmosphere-ocean GCMs under the Paleoclimate Modelling Intercomparison Project phase 2 (PMIP2). In the current study, we first present the results of feedback analysis for physics parameter ensembles of a single model MIROC. It is shown that the feedback and climate sensitivity parameters depend on the nature of the forcing and background climate state. The forcing dependency arises through the shortwave cloud feedback while the state dependency arises through the combined water vapor and lapse rate feedback. The forcing dependency is, however, weakened when the feedback is estimated from the forcing that includes tropospheric adjustments. Despite these dependencies, past climate can still be used to provide a useful constraint on climate sensitivity as long as the limitation is properly taken into account because the strength of each feedback correlates reasonably well between the ensembles. It is, however, shown that the physics parameter ensemble of a single model does not cover the range of results simulated by structurally different models, which suggests the need for further study exploring both structural and parameter uncertainties. We then extend the same analysis to the newly archived Coupled Model Intercomparison Project phase 5 (CMIP5)/PMIP3 AOGCMs, and present the results of the feedback analysis.