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More precise projections of regional climate change using ensemble change factor regression: Arctic and Antarctic surface warming over the 21st Century from the CMIP3 multi-model ensemble

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Multi-model and perturbed physics ensembles of couple atmosphere-ocean climate models are now used widely for estimating future changes in climate. For some locations and parameters there is a strong inter-model relationship between present-day bias and projected future change in the CMIP3 multi-model ensemble. Here we develop a new statistical framework, ensemble change factor regression (ECFR), which uses these relationships to give more precise projections climate change at the local (grid-box) scale. It also allows for the identification of overly influential ensemble members and can be used to determine the minimum number of ensemble members required. Where winter surface air temperature biases are negative (positive) compared to observations, the ECFR method gives less (more) winter warming under the SRES A1B future emissions scenario than the equal-weight multi-model average (AVG_eq). For the Arctic significantly less winter warming is predicted by the ECFR method over the Sea of Okhotsk, Bering Sea and Barents Sea. The reduction in estimated 21st century warming is largest over the Barents Sea (up to 4^{o}C), due to excessive sea ice in most of the CMIP3 models. Around the Antarctic at approximately 60^{o}S, significantly more (less) winter warming is predicted between approximately 35oW and 20oE (110^{o}W and 70^{o}W). A cross-validation test was conducted, in which each model in the CMIP3 ensemble is used as pseudo truth against which predictions from the remaining CMIP3 models could be compared. For grid-points near the boundary between sea ice and open ocean, the ECFR method gives smaller cross-validation errors than the AVG_eq method. These reductions are largest in the winter season, up to 60% at some locations such as the Labrador Sea and parts of the Southern Ocean. The ECFR cross-validation error statistics were also found to be robust to reducing the ensemble size to approximately 16. Reductions in cross-validation error over the AVGeq method were found for ensemble sizes of between 6 and 10 depending on the region considered. Results based on available CMIP5 model output will also be shown.