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A Decomposition of Feedback Contributions to the Arctic Temperature Biases in the CMIP5 Climate Models

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The systematic temperature biases over the Arctic Sea in the CMIP5 models are decomposed into partial biases due to physical and dynamical processes, based upon the climate feedback-responses analysis method (CFRAM). In the frame of the CFRAM, physical processes are also divided into water vapor, cloud, and albedo feedbacks. Though the Arctic temperature biases largely depend on models, considerable cold bias are found in most of models and ensemble mean. Overall, temperature biases corresponding to physical and dynamical processes tend to cancel each other out and total biases equal to their sums are geographically similar to those related to physical processes. For the physics-related biases, a contribution of albedo feedback is the largest, followed by cloud and water vapor feedbacks in turn. Quantitative contributions of the processes to temperature biases are evaluated from area-mean values over the entire Arctic Sea, Barents-Kara Sea, and Beaufort Sea. While relationships between total and partial biases over the Arctic Sea show the large model-dependency, in the local-scale, total temperature biases over Barents-Kara Sea and Beaufort Sea are made from consistent contributions among models. An overestimate (underestimate) of specific humidity and cloud fraction in models are responsible for an overall warm (cold) biases through longwave heating rates of the greenhouse effect. Shortwave cloud forcing by cloud fraction biases offsets a substantial part of biases related to longwave cloud forcing, while shortwave effect of specific humidity bias plays a minor role on water vapor feedback. The fact that geographical distribution of sea-ice biases is mostly opposite to that of partial temperature bias due to albedo feedback indicates that the biased simulation of sea-ice in models are the main contributors in albedo feedback.