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The Twenty-First Century Arctic atmospheric energy budget from coupled model simulations and numerical reanalyses

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Analysis of the atmospheric energy budget has been invoked as a method to better understand recent changes in Arctic climate including the dramatic reduction in perennial sea ice cover. A quantification of the atmospheric budget would provide a better understanding of the mechanisms resulting in sea ice reductions, and how the flow of energy in the polar cap is subsequently reorganized. Studies of the recent decrease in sea ice cover have indicated a strengthening of the Beaufort High and an accompanying increase in the net solar radiative flux in summer, while earlier studies have shown a consistent relation between sea ice anomalies and the downwelling longwave radiative flux. Numerical reanalyses are imperfect tools for investigating changes to the atmospheric energy budget and surface balance due in part to sparse observations in polar regions and inadequate representations of physical processes in the assimilating models. Alternatively, coupled models represent an integration of our knowledge of the processes that are associated with the Arctic climate system, and are essential for prognostic assessments. In this study, components of the atmospheric energy budget produced from decadal simulations of the NASA Goddard Earth Observing System Model, version 5 (GEOS-5) are assessed over the north polar cap using available in situ observations and contemporary reanalyses from the Climate Forecast Center (CFSR), the Interim Re-Analyses of the European Centre for Medium Range Weather Forecasts (ERA-I), and the NASA Modern-Era Retrospective analysis for Research and Applications (MERRA). The GEOS-5 is a state-of-the-art coupled model consisting of the GEOS-5 finite-volume AGCM, the Modular Ocean Program (MOM4p1), and the Los Alamos Community Ice CodE (CICE) version 4.1. Five-member decadal-length ensembles have been performed with initializations at five year intervals beginning in 1984 and including simulations for the period 1999-2009. Some questions addressed by this study are as follows. - How well do numerical reanalyses agree with each other and with available observations of the Arctic atmospheric energy budget, and how well do GEOS-5 simulations reproduce the general characteristics of the budget? - What are perceived trends in the surface energy budget over the 21st Century in reanalyses and GEOS-5 simulations? - Can differences between coupled model simulations and reanalyses be attributed to particular limitations in either?