Geophysical Research Abstracts
Vol. 21, EGU2019-16804, 2019
EGU General Assembly 2019

Improved estimates of the coupled Arctic energy budget

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The long-term average and mean annual cycle of the coupled (atmosphere-ocean-sea-ice) energy budget of the Arctic are of great scientific interest, but data paucity has hampered comprehensive quantitative assessments in the past. Here we draw on novel observational products, state-of-the-art reanalyses as well as improved diagnostic methods to present an updated estimate of the Arctic energy budget, including flux and storage terms. Many crucial terms of the budget can be independently estimated to complement estimates from ERA5 and ORAS5 and other reanalyses. For example, we additionally use unique mooring-derived oceanic heat transport estimates for the main oceanic straits into the Arctic, radiative fluxes from satellites, and novel satellite-based data of sea ice volume.

Results show that the long-term average radiative, atmospheric, and oceanic energy fluxes into the Arctic ocean taken from independent data products agree remarkably well in the sense that their sum closely matches the observed rate of long-term heat accumulation of ∼1 Wm-2 in that region. The latter value is similar to current estimates of the global ocean warming rate.

Larger discrepancies are found for the closure of the mean annual cycle of the coupled energy budget, with an RMS value of the monthly budget residual of ∼7 Wm-2. However, this represents a reduction of the residual of almost 50% compared to earlier studies. The main remaining sources of uncertainty for the annual cycle are ocean heat content, which suffers from the lack of in-situ observations, and latent heat associated with sea ice melt and freeze. For the latter, reliable sea ice thickness observations and their assimilation into reanalyses will be an important step towards further reduction of uncertainty.