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Surface Energy Budget Closure at Arctic Terrestrial Sites over Different Temporal Scales

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Long-term near continuous measurements of the hourly averaged surface fluxes (turbulent, radiative, and ground heat) and other ancillary surface/snow/permafrost data made at two research observatories near the coast of the Arctic Ocean are used to study the surface energy budget (SEB) over different temporal scales. One site, Eureka (80.0N; Nunavut, Canada), is located in complex topography near a fjord about 200 km from the Arctic Ocean. The other site, Tiksi (71.6N; Russian East Siberia), is located on a relatively flat coastal plain less than 1 km from the shore of Tiksi Bay, a branch of the Arctic Ocean. An accurate determination of energy balance closure and all components of the SEB at the air-surface interface are required in a wide variety of applications including atmosphere-land/snow simulations and validation of the surface fluxes predicted by numerical models over different spatial and temporal scales. This study analyzes and discusses SEB closure averaged to hourly, daily, weekly, monthly, and seasonal timescales based on in-situ measurements made at these two Arctic terrestrial sites in summertime and compares those with a mid-latitude site located in the Columbia River Basin (Oregon) in an area of complex terrain. Our hourly direct measurements of energy balance for both Arctic sites show that the sum of the turbulent sensible and latent heat fluxes and the ground (conductive) heat flux systematically underestimate positive net radiation by about 20-30% during local daytime and overestimate negative net radiation at local night. This SEB imbalance is comparable to other terrestrial sites including the Columbia River Gorge. Although, increasing the averaging time to daily and longer time intervals substantially reduces the SEB imbalance on average at mid-latitude terrestrial sites, the SEB closure shows different behavior at the Arctic sites. According to our data, extending the averaging time consistently from hourly to daily, weekly, monthly, and seasonal timescales does not significantly improve the energy balance at the high Arctic site Eureka in summertime. The SEB closure at different temporal scales in Tiksi located at lower latitude than Eureka, shows mixed behavior but, in any case, the SEB imbalance in Tiksi during Arctic summer falls more slowly with increasing averaging times than for the Oregon site. These noticeable differences in the SEB between these locations are associated primarily with the latitudinal variations of net solar radiation and 24 hours of continuous daylight in summer within the Arctic Circle.