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Surface energy balance closure at ten sites over the Tibetan plateau

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Using observed surface-heat fluxes to evaluate land-surface models (LSMs) is an important step to improving their capability. There are significant uncertainties in measured surface-energy budgets, especially for the heterogeneous Tibetan Plateau (TP) region where the observation conditions are harsh. In this study, summer (July-October 2016) flux data were obtained from ten sites over the TP during the Third Tibetan Plateau Atmospheric Scientific Experiments. Data analysis was performed to assess the surface-energy balance ratio (SEBR) and associated uncertainties across various land-cover types and elevation heights. Measured latent heat fluxes are positive during nighttime and exhibit substantially greater uncertainty than sensible heat fluxes. The ten-site averaged SEBR is 74.2±5.4%, largely on par with reported SEBR for other regions. SEBR values are similar among homogeneous sites, and the averaged SEBR (93.4%) for those sites is better than that (67.3%) for the heterogeneous sites. The soil-heat storage term represents the most significant source of uncertainty (8.2%) than the canopy storage term (0.22%) to closing the surface energy budget. The SEBR shows a strong diurnal cycle and the midday (10:00∼15:00 local time) values are higher than those nearest sunrise and sunset time. The late-night SEBR (00:00∼6:00 local time) at sites located at higher elevations are more reliable than those at lower elevation sites, because of the frequent occurrence of neutral conditions (instead of stable or very stable conditions) at high terrains. The relationships between SEBR and surface-layer turbulent parameters (ξ, u*,θ*) and wind direction were investigated. An uncertainty range for measured surface heat fluxes was derived to provide a meaningful guidance for applying these observations in evaluating LSMs.