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Surface temperature lapse rate variability and implications for mass balance modelling on the Prince of Wales Icefield, Ellesmere Island, Canada

S.J. Marshall and M.J. Sharp

(1) Shawn Marshall, University of Calgary, ES 356, 2500 University Dr NW, Calgary AB, T2N 1N4, Canada (shawn.marshall@ucalgary.ca / FAX: 1-403-282-6561). (2) Martin Sharp, 1-26 Earth Sciences Building, University of Alberta, Edmonton, AB, T6G 2E3, Canada

Screen temperatures were monitored from May 2001 to April 2003 in an array of 25 sites on the Prince of Wales Icefield, Ellesmere Island, Canada. The observational network covered an area of ca. 15,650 km^2 and spanned an altitude range of 130 m to 2010 m above sea level. Daily and monthly average temperatures from the spatial array provide a record of near-surface temperature lapse rates and mesoscale temperature variability on the Icefield. Daily lapse rates in the two-year record have a broad but unimodal distribution, with a mean of $-3.1^{\circ}C\,km^{-1}$. Summer lapse rates averaged $-4.4^{\circ}C\,km^{-1}$ over the two years, while winter and spring lapse rates averaged $-2.1^{\circ}C\,km^{-1}$. Surface temperature lapse rates at the site were therefore systematically less than the free-air lapse rates that are typically adopted for extrapolations of sea-level temperature to higher altitudes. This has important implications for regional-scale downscaling or extrapolation of surface temperature for modelling snow and ice melt. We present evidence for synoptic controls of this lapse-rate variability and its importance for modelling glacier mass balance at the site. Snow and ice melt are systematically underestimated with standard free-atmosphere lapse rates. Large differences between summer mass balance in 2001 and 2002 on the Icefield were also observed, despite very similar sea-level temperatures each summer. The difference can be attributed to significant differences in synoptic system frequencies each summer and their effects on both precipitation and surface lapse rates.