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Multi-seasonal, multi-site, surface meteorological and energy-balance variation at Vestari-Hagafellsjökull, Langjökull, Iceland

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The purpose of the work reported here is to help understand spatial and temporal variations in the contemporary climate forcing of the Langjökull ice cap in Iceland (the main source, via groundwater, of water for the city of Reykjavík). Automatic Weather Stations (AWS) were established at two locations on the Vestari-Hagafellsjökull outlet glacier on the ice cap's southern side:

(1) 64˚ 30' N, 20˚ 25' W, 597 m a.s.l., data acquired continuously from 25/04/2003–08/08/2004 (471 days).

(2) 64˚ 34' N, 20˚ 25' W, 998 m a.s.l., data acquired continuously from 30/11/2002–20/10/2003 (324 days).

Aside from the fundamental seasonal cycling, there is relatively limited meteorological variation over the surface of the glacier and across the seasons. The air temperature lapse rate in the period during which both AWS were operating simultaneously (25/04/03–20/10/03) was 0.61$\pm$0.35˚ C 100 m^{-1}, falling marginally to 0.47$\pm$0.29˚ C 100 m^{-1} when the summer period only is considered (01/06/03–31/08/03). The summer wind speeds are not significantly different at the two locations, being 5.2$\pm$2.1 m s^{-1} at 597 m a.s.l. and 4.9$\pm$2.6 m s^{-1} at 998 m a.s.l. Further, although higher maximum wind speeds were recorded during winter (maximum 27.2 m s^{-1}), mean wind speeds were not significantly different from season to season. In fact, Principal Com-

ponents (PC) Analysis reveals significant seasonal persistence in the structure of the meteorological data sets, for example (from 597 m a.s.l.):

(1) Winter (December–February, mean air temperature –4.3˚ C)

PC1 = 0.66T + 0.65R – 0.03W – 0.38G

(2) Summer (June–August, mean air temperature +4.9˚ C)

PC1 = 0.61T – 0.64R + 0.23W + 0.41G

where T is air temperature (˚C), R is relative humidity (%), W is wind speed (m s^{-1}), G is global radiation (W m^{-2}). High loadings on temperature are consistent with the inland location, and high loadings on radiation reflect the typical dominance of solar radiation in glacial energy budgets. PC2 has its greatest loading on wind speed in both winter and summer, but while the prevailing summer wind direction is katabatic (north-easterly), the prevailing winter direction is south-easterly. There is a corresponding gradient of accumulation, which increases from the east to the west margin of Vetsari-Hagafellsjökull, as well as with elevation. Understanding the spatial and seasonal variation of meteorology at Langjökull, as at other ice masses, is important in context of the increasing application of downscaled, gridded climate data for model validation and for the prediction of ice mass evolution. For instance, wind speed is generally regarded as one of least reliable outputs of gridded datasets. While wind speed does not vary significantly either spatially or seasonally, it is still highly variable at shorter timescales, it dominates PC2 and it exhibits seasonal direction-switching: these are important sub-grid-scale features it is currently difficult to model effectively.