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Climatological assessment of spatiotemporal trends in observational monthly snowfall totals and extremes over the Canadian Great Lakes Basin

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The Laurentian Great Lakes Basin (GLB) is susceptible to snowfall events that derive from extratropical cyclones and heavy lake effect snowfall (HLES). The former is generated by quasigeostropic forcing from positive temperature or vorticity advection associated with low-pressure centres. HLES is produced by planetary boundary layer (PBL) convection that is initiated as a result of cold and dry continental air mass advecting over relatively warm lakes and generating turbulent moisture and heat fluxes into the PBL. HLES events can have disastrous impacts on local communities such as the November 2014 Buffalo storm that caused 13 fatalities. Albeit the many HLES studies, most are focused on specific case study events with a discernible under examination of climatological HLES trend analyses for the Canadian GLB. The research objectives are to first determine the historical, climatological trends in monthly snowfall totals and to examine potential surface and atmospheric variables driving the resultant changes in HLES. The second aims to analyze the historical extremes in snowfall by assessing the intensity, frequency, and duration of snowfall within the domain of interest. Spatiotemporal snowfall and precipitation trends are computed for the 1982 to 2015 period using Daymet (Version 3) monthly gridded observational datasets from the Oak Ridge National Laboratory. The North American Regional Reanalysis (NARR), NOAA Optimum Interpolation Sea Surface Temperature (OISST), and the Canadian Ice Service (CIS) datasets are also used for evaluating trends in HLES driving variables such as air temperature, lake surface temperature (LST), ice cover concentration, omega, and vertical temperature gradient (VTGlst-850). Climatological trends in monthly snowfall totals show a significant decrease along the Ontario snowbelt of Lake Superior, Lake Huron and Georgian Bay at the 90 percent confidence level. These results are attributed to significant warming in LST, significant decrease in ice cover fraction, and an increase in VTGlst-850, which enhances evaporation into the lower PBL. It is suggested that inefficient moisture recycling and increase moisture storage in warmer air masses inhibits the development of HLES. The 99th percentile of snowfall events within the GLB suggests an extreme snowfall value equal to or exceeding 15 cm per day. Spatiotemporal snowfall patterns indicate that mostly lake effect processes and not extratropical cyclones drive the high intensity, frequency, and duration of these extreme events over the GLB. Furthermore, the Canadian snowbelt region of Lake Huron and Lake Superior exhibit different spatiotemporal trends in snowfall extremes but, even within a particular snowbelt region, trends in extreme snowfall are not spatially coherent. It is suggested that geographic location of the lakes, topography, lake bathymetry, and lake orientation can influence local and large scale surface-atmosphere variables.