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Changes in Surface Icing Duration over North China during 1961-2015

Yu Yu and Zhihua Ren
National Meteorological Information Centre, Beijing, China (yuyu@cma.gov.cn)

Climate change has accelerated in recent decades as manifested by changes in a number of climate variables. In previous studies, analyses of global or regional frost days and ice days were all based on daily air temperature measurements. However, in this study, we utilized daily surface icing measurements recorded by meteorological observers at Chinese weather stations, defined as the presence of ice in evaporation pans, lakes, or rivers in the open air. Such surface icing, which is independent from temperature observations, can be regarded as a new and different indicator for changes in extreme climate events. After screening out the stations with unusually low numbers of annual icing days, we developed a set of surface icing series at 346 weather stations over north China (north of latitude 35^o N) from 1961-2015 with high quality and good integrity. We then defined the surface icing duration (SID) along with its annual start and end date, and used the latitude cosine value of the center point of the $2.5^o \times 2.5^o$ grid as its weight to interpolate the station data. A comprehensive analysis of the temporal and spatial variations in these data showed that as the start date trended later and the end date trended earlier in north China, the SID decreased by 2.6 days per decade from 1961 to 2015 and the slope became steeper by -4.8 days/decade during the most recent 25 years. We also analyzed the annual number of frost days (FD), a temperature-related extreme index proposed by ETCCDI. The regional mean of annual SID has a high correlation coefficient of 0.97 with FD while there were some discrepancies between them. The annual FD of north China was always larger than SID. As surface icing is closely related to temperature, this work illustrates the impacts of climate change from a distinct perspective, and these results contribute to a better understanding of changes in climatic extremes related to global climate change.