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Estimating Return Intervals for Extreme Climate Conditions Related to Winter Disasters and Livestock Mortality in Mongolia

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Abstract: Mass livestock mortality events during severe winters, a phenomenon that Mongolians call dzud, cause the country significant socioeconomic problems. Dzud is an example of a compound event, meaning that multiple climatic and social drivers contribute to the risk of occurrence. Existing studies argue that the frequency and intensity of dzud are rising due to the combined effects of climate change and variability, most notably summer drought and severe winter conditions, on top of socioeconomic dynamics such as overgrazing. Summer droughts are a precondition for dzud because scarce grasses cause malnutrition, which in turn makes livestock more vulnerable to harsh winter conditions. However, these studies typically look at a short time frame (i.e., after 1940); few have investigated either the risk or the recurrence of dzud over a century-scale climate record. This study aims to fill the gaps in technical knowledge about the recurrence probability of dzud by estimating the return levels of relevant climatic variables: summer drought conditions and winter minimum temperature. We divide the country into three regions (Northwest, Southwest, and East Mongolia) based on the mortality index at the soum (county) level. For droughts, our study uses as a proxy the tree-ring reconstructed Palmer Drought Severity Index (PDSI) for three regions between 1700-2013. For winter severity, our study uses observational data of winter minimum temperature after 1901 while inferring winter minimum temperature in Mongolia from instrumental data in Siberia that extends to the early 19th century. The Generalized Extreme Value (i.e., the statistical method to infer the probability of very rare or extreme events) shows that the return levels of drought conditions are changing over time, with variability increasing for all the regions. Winter severity, however, is constant. The median 100-year return levels of the winter minimum temperature in Mongolia have been, over the past 300 years, -26.08°C for the Southwest, -27.99°C for the Northwest, and -25.31°C for the East. This study thus suggests that continued summer drought would lead to increased vulnerability and malnutrition. Here, we link meteorological characteristics to socioeconomic impacts related to livestock populations and draws attention to the need for livestock index insurance.

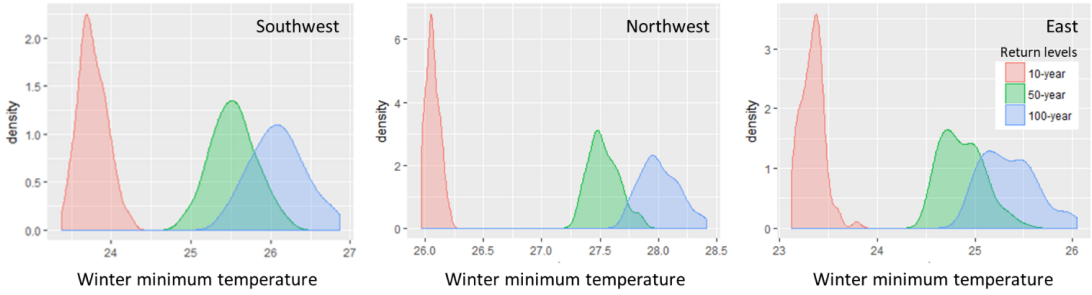

Figure 1: Density plots of 10, 50, and 100-year return levels of the winter minimum temperatures in the Southwest, Northwest, and East of Mongolia with 90% confidence intervals.