Spending degrees of freedom in a economy & extreme snow depth: a case study of building a model in Tianshan, China

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Abstract. Serious loss of human life and property by heavy snowfall in many middle and high Xijiang almost every winter. We apply annual maximum snow depth (AMSD) and snowfall data from the Tianshan Snow-cover & Avalanche Research Station (TSAR station in Xinjiang, Northwest China) collected during the last 28 winters (1978 to 2005) to temporal trends of annual maximum snow depth. The goal of the present article is to statistical analysis of extreme values that is applied to snow depth data from Tianshan Snow-cover & Avalanche Research Station. There were no significant differences between socioeconomic of snow depth, under affects socio-economic development from 1961, but permanently snow depth data (1978-2005) showed significantly impact on socio-economic development. Annual maximum snow depth contents necessary to meet return levels for 10, 25, 50, and 100 years of selected quality parameters were estimated. The research shows a decrease in extreme snow depth. This may would need to be increased by the observed decrease in the snow ratio due to increasing air temperatures. Further research is also needed to develop economy systems that socioeconomic and also improve the quality of snow depth data in the study area.

1. Introduction
Winter of disaster in Xinjiang, Northwest China is often accompanied by a variety of hazardous meteorological elements including subfreezing temperatures and heavy snow. In particular, heavy snowfall cause serious economic damage in many in Xinjiang, Northwest China almost every winter. Although snow cover is an important source of water and an important indicator of climate change, it can be the most damaging with extremely large amounts of snow. For example, the avalanches cause hazardous conditions on roads, railways and airports–sometimes even leading to the interruption of major transport routes, increased snow removal costs or spring flooding.

Many studies revealed changes in intensity and frequency of extreme precipitation events across the globe in a future warmer world [1]. Research into the driving forces of such annual precipitation values change focuses on remote sensing, agricultural census data, and biophysical and socioeconomic variables from thematic maps and socioeconomic surveys. Zhang et al. (2012) reported an increase in the frequency of high intensity precipitation events across the Xinjiang over the period of 1961 to 2008. Such an increase has been observed for high values of snow cover days and maximum depth of snow north of the Xinjiang [2-5].

The present study aims to analyze snow depth changes and possible implications for floods changes, using reliable and consistent and sufficient of the Tianshan Snow-cover & Avalanche Research Station data. The specific objective of this study is to determine the effects of extreme snow depth, and the relative susceptibility of socioeconomic to changes in snow-cover.
2. Data and methodology

2.1. Data
The Tianshan Snow-cover & Avalanche Research Station is located in the territory of Kunse town of Xinyuan county beside the upstream section of the Kunse River in the Yili River valley. Long-term series of meteorological experimental data on the Tianshan Snow-cover & Avalanche Research Station, necessary for research on extremes, are scarce. Thus, in this work, we decided to use the data set from the period of 1978-2005. However, in this work, the period of winters (1978 to 2005) was used to develop extreme analysis modeling (the generalized extreme value distribution).

2.2. Methodology
Traditionally, the three extreme value distributions are applied to AMSD. In this paper, the GEV distribution is often used as an approximation to model the minima or maxima of long (finite) sequences of random variables [6]. In general, the GEV distribution provides better fit than the individual Gumbel, Frechet, and Weibull models. The GEV distribution was developed by Hosking et al. [6], Walden and Prescott [7], Silverman [8].

3. Result and discussion

3.1. Model selected
Models 1 and 2 were fitted to AMSD from the Tianshan Snow-cover & Avalanche Research Station (Figure 1). The method of maximum likelihood was applied throughout. For AMSD data, model 1 gave the estimates $\mu = 11.7$, $\sigma = 6.0$ and $\xi = 0.172$ with $-2\log L_1 = 159.8$. On the other hand, model 2 gave the estimates $\mu = 20.9$ and $\sigma = 9.8$ with $-2\log L_2 = 173.1$. Since
it follows by the standard likelihood ratio test that Model 1 should be preferred to Model 2.

\[-2 \log \left( \frac{L_2}{L_1} \right) = 173.1 - 159.8 = 13.3 > 3.841 = \chi^2_{1,0.95}\]

3.2. Extreme snow-depth

Figure 2 show that AMSD increases with the linear rate during 1978-1984, than it decreases trend during 1985-1991, and so on. This demonstrates that consecutive AMSD in Tianshan Snow-cover & Avalanche Research Station rise constantly and also explains the trend of Tianshan Snow-cover & Avalanche Research Station’s disaster increase. Besides, it can be seen from return period (Figure 1) that the AMSD increases with the return period 50a, 100a, 150a, and so on. In particular, from 1980s, average of most years was positive indicating a general increase trend before and a faster increase trend of the AMSD. By analyzing the variations of the AMSD, we can conclude that AMSD increases from 1978 to 2005 in Tianshan Snow-cover & Avalanche Research Station.

4. Conclusions

In this study, we apply GEV statistical distribution function to fit the output of AMSD with different return periods in Tianshan Snow-cover & Avalanche Research Station. Some interesting results are obtained as followings:

(1) The AMSD increases from 1978 to 2005 in Tianshan Snow-cover & Avalanche Research Station. This situation accords with the viewpoint that the climate of Xinjiang has been changing from the warm-dry to the thermal-wet in recent years.

(2) Investigation to temporal patterns of the AMSD indicates that the aridity-humidity conditions of Tianshan Snow-cover & Avalanche Research Station can be well represented by the return periods of AMSD. The indices AMSD have played a very good role in prediction the future disaster (e.g. flood, snow avalanche) in Xinjiang. By analysis of the AMSD in future, we get the conclusion that the risk of disaster will gradually increase.
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