Trends in Hail and Severe Storms in Tibetan Plateau during 1980-2012

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Abstract

The long-term trend of hail in Tibetan Plateau (TP) is essential for us to understand the impact of global climate change on local weather extremes. Based on the surface observations over TP during the warm season (from June to September) from 1980 to 2012, it is found that the occurrence of severe storm is decreasing with great speed. Features of several atmospheric fields, which are favorable to the development of severe storm during the same period have been analyzed. The results show that the decreasing of severe storms in Naqu is relevant to the missing of days with MKI larger than 14.7, which is the first quartile of MKI. And the number of hail days drops as a consequence of significantly higher FLH and weaker VWS.

Datasets

station observations and soundings

∗ **hail data**
the recordings of every hail events

○ **GTS data**
the recordings of every weather phenomenon

- Thunderstorm
- Hail
- Strong wind
- Lightning
- Squall
- Tornado

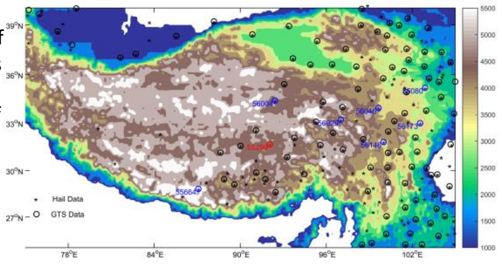


Fig.1 The locations of surface stations for different databases. The colored labels mark the stations with sounding

Definitions

hail day(HD)
a day during which hail is recorded at each station

storm day(SD)
a day during which at least one type of severe storm phenomena mentioned above occurs at each station

no storm day(NSD)
a day during which none of severe storm occurs at each station

Modified K index(MKI)

$$(T_{500}-T_{300})+T_{d\,500}-(T-T_d)_{400}$$

Precipitable water(PW)

$$PW=\frac{1}{\rho g}\int_{ground}^{200hPa} q\,dp$$

Freezing level height(FLH)
the height above which air temperature becomes below zero

Vertical wind shear(VWS)

$$VWS=\overrightarrow{v_{500}}-\overrightarrow{v_{ground}}$$

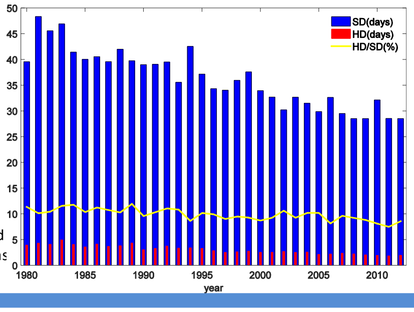
Conclusion

During the period 1980-2012 in TP, the number of mean hail day in warm season has reduced together with a decrease of the number of storm day. The variation of MKI resulted in the decreasing of SD, but during the shift years from El Nino to La Nina, the impact of MKI was not dominant. Under this circumstance, as the product of severe storms, hail presented a downward trend as well. And owing to the higher FLH and weaker VWS.

Result I

trends of HD & SD

Fig.2 The time series of warm season mean HD (red bars), SD (blue bars), and the ratio of HD to SD (solid line).
The annual mean HD and SD in warm season in TP both declined from 1980 to 2012 and the trends were statistically significant at the 99% confidence level. Specifically, the rates of decay were 0.79 days per decade and 5.9 days per decade for hail and severe storm, respectively. However, almost 59% of hail disappeared over TP, and the proportion for storm was only 40%.



Result II

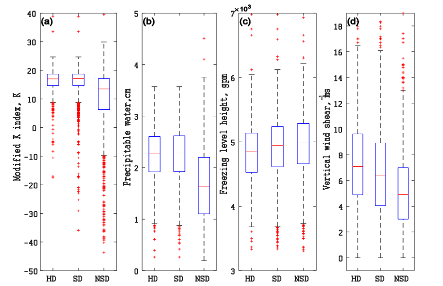


Fig.3 Box and whisker plots of (a)MKI, (b)PW, (c)FLH, (d)VWS on HD, SD and NSD. The variation of MKI on HD and SD was the smallest, which provided an effective index to define the favorable condition for severe storm. The variation of the other three parameters on three different kinds of days were similar, but there were statistically significant differences. For example, PW on HD and SD was higher than NSD, and FLH was the lowest on HD while VWS was the highest on HD.

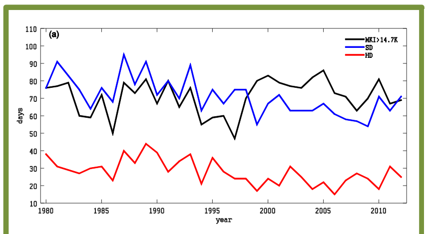


Fig.4 The time series of MKID, the number of days with MKI over 14.7K, which is the first quartile of MKI(black lines), and SD(blue lines) and HD(red lines) in NAQU. Owing to the abrupt change of MKI in 1997/98, the coefficient between SD and MKID was weak during the entire studied period, while it was over 0.8 from 1980 to 1996, and was 0.5 from 2001 to 2012. The reason for the abnormal change between 1997 and 2000 may be the impact of a shift from the El Nino phase to La Nina phase.

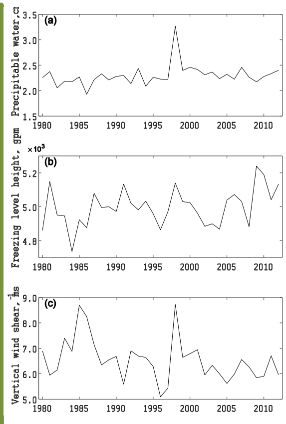


Fig.5 The time series of annual mean of (b)FLH and (c)VWS on MKID. .With global warming , FLH was increasing, which was bad for the growth of hail. Moreover, the weaker vertical wind shear contributed to less HD.

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