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Meteorological conditions associated with severe regional debris flows in China

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Abstract In this paper, the frequency of severe debris flows, floods over a large area and the synoptic meteorological processes of 10 severe regional debris flows which occurred in groups in China from 1950 to 1990 are analysed. It is found that this sort of severe debris flow, despite its short duration, is usually accompanied by anomalous precipitation and general circulation of atmosphere on some temporal and spatial scales; these scales may be a month and several hundred kilometres. A schematic model of the meteorological conditions favourable for severe regional debris flows is presented.

INTRODUCTION

Precipitation is the most important factor in the occurrence of debris flows. A local debris flow over a small area may be related to only a localized heavy rainfall event, but severe regional debris flows should be related to some major atmospheric variations. In this paper, research on meteorological conditions of the atmosphere is discussed.

THE FREQUENCY OF SEVERE DEBRIS FLOWS AND PRECIPITATION ANOMALIES OVER A LARGE AREA

Figure 1 shows the annual number of severe debris flows, and the area of farmland that was flooded, during the period 1950-1990. The variations of the two diagrams do not appear to be correlated. For a number of years when heavy precipitation over a large area resulted in flooding over vast areas of farmland, frequently occurring debris flows did not occur. The frequency of severe debris flows does not seem to be closely related to large-scale precipitation anomalies.

THE FREQUENCY OF SEVERE DEBRIS FLOWS AND MESOSCALE PRECIPITATION ANOMALIES

From a survey of monthly rainfalls for many years, their departure from the

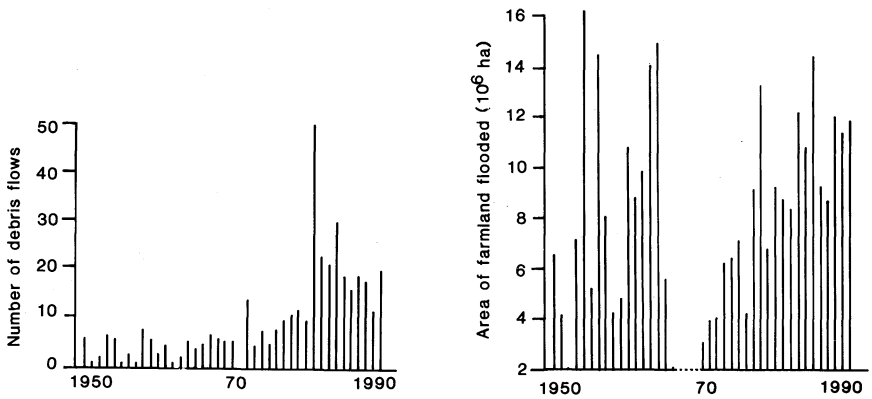

Fig. 1 Annual number of severe debris flows and the area of farmland in China that suffered floods during the period 1950-1990.

mean and severe debris flow events occurring on a regional scale (over several counties), it is found that severe debris flows are closely related to mesoscale (covering an area which is several hundreds of kilometres wide) precipitation anomalies. Therefore the 10 most severe debris flow events were investigated further and the results are shown in Table 1. The table shows that most of the severe regional debris flows, despite their short duration, are accompanied by increases of usually more than 50% in mean monthly rainfall on a mesoscale. In about half of the cases, an increase in mean monthly rainfall occurred also in the previous month and usually exceeded 30%. The monthly rainfall is

Table 1 Severe regional debris flows and monthly precipitation in the same area.

Date	Location of debris flow	Rainfall in current month:		Rainfall in previous month:	
		(mm)	Departure(%) from mean	(mm)	Departure (%) from mean
16/8/76-24/8/76	Pingwu, Songpan, Lixian[a]	250-300	50-60	150	0
16/7/77-17/7/77	Songpan, Wenchuan[a]	200	30	100	-20
12/7/78	Many sites along the railway from Baoji[b] to Tianshui[c]	150-200	60-80	50	-15
22/10/80-25/10/80	Dongchuan[d], Zhaojue[a]	150-200	100-120	120-200	0-30
19/8/81-22/8/81	Many sites in southern Shanxi and Gansu and in northern Sichuan	200-500	80-300	100-300	0-100
20/7/83-29/7/83	Rangtang, Jinchuan, Heishui[a]	250	100	230	50
12/7/84-18/7/84	Hanzhong[b], Wenchuan[a], Nanping[a]	250-300	30-90	100	0
26/7/85	Dongchuan[d]	250	40	350	50
14/8/87-20/8/87	Dandong, Fuxian[e]	250-300	20-50	170-230	-20 to -10
6/7/88-14/7/88	Dangchang, Zhuoni, Jingxi[c]	140-170	50-70	100	50

[a]Sichuan Province
[b]Shanxi province
[c]Gansu Province
[d]Yunnan Province
[e]Liaoning Province

usually more than 150-200 mm for this type of debris flow to occur. It is indicated that the cause of these debris flows is due mainly to above-normal monthly precipitation on a mesoscale in an area with favourable geological conditions. The duration of above-normal precipitation may be longer than a month.

METEOROLOGICAL CONDITIONS IN THE MIDDLE AND LOWER TROPOSPHERE FOR SEVERE REGIONAL DEBRIS FLOWS

The above-mentioned mesoscale precipitation anomaly must be reflected in the general circulation of the atmosphere and accompanied by characteristic synoptic meteorological processes. This has been investigated and the findings are now summarized.

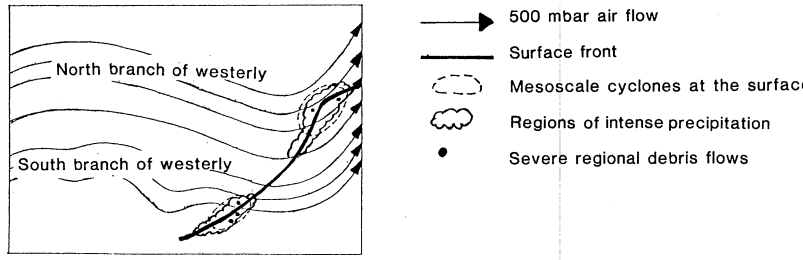

Fig. 2 Schematic model of the meteorological conditions favourable for severe regional debris flows.

In the middle troposphere, e.g. 500 mb, shortwave troughs in the south branch of westerlies are active and frequently occur when debris flows occur. On the mean monthly 500 mb chart, a weak below-normal height is observed in the regions where debris flows happen. The activity of the shortwave troughs causes the southwest vortex (a kind of cyclonic vortex originating in south-western China) and other vortices in lower troposphere to develop and move eastwards. Minor waves of mesoscale cyclones on the surface front successively occur and intense regional precipitation results. Severe regional debris flows then occur in areas with favourable geological conditions.

Some of these findings are shown in the schematic model presented in Fig. 2.

CONCLUSION

The above analysis of mesoscale precipitation anomalies and meteorological conditions in the lower and middle troposphere indicated that severe regional

debris flows, in spite of their short duration, are usually accompanied by an anomaly in precipitation and general atmospheric circulation. These anomalies are usually on a mesoscale, and they usually last a month.

The anomaly in the general atmospheric circulation is that the shortwave troughs in the south branch of westerlies frequently result in a decrease of height in the mean monthly 500 mb chart and consequently cyclonic vortices successively emerge to produce above-normal anomalies in monthly rainfall on a mesoscale.

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