

## SNOW HAZARD REGIONALIZATION IN CHINA

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**ABSTRACT:** For the zoning of snow hazard in China, on the principles of (a) comprehensive analysis integrated with dominant factors, (b) multi-level division, and (c) serving the agriculture and stock-raising, transportation and communication, we first classified China into two large zones according to the situation of snow or no snow distribution. Secondly, based on the climate and landform, properties of snow cover and main features of snow hazard, the large zone of snow hazard can be classified into three second-level regions. In order to obviously reflect the difference of snow cover quantity and snow hazard type as well as hazardous degree, twenty subregions (third-level) of snow hazard are further divided in detail. In addition, the boundaries and the principal features of the differences between the various snow hazard regions are provided.

**KEY WORDS:** snow hazard, regionalization

### I. INTRODUCTION

The area of snow cover in China is approximately  $9 \times 10^6 \text{ km}^2$ , in which the permanent snow cover is about  $6 \times 10^4 \text{ km}^2$  distributed mainly over the glaciated region of modern glacier and high mountains in the whole western mountainous region of China. Seasonal snow cover is widely present in China, its south boundary at about  $25^\circ \text{ N}$ . In comparison with the countries of the same latitude in the world, the south boundary of snow cover in China is relatively low in latitude.

According to the data of snow cover duration from more than 1700 meteorological stations and observation stations, the distribution of permanent snow cover of China may be seen from Fig.1.

The regions with the maximum duration of snow cover period in China, except the western mountains and the permanent snow covered regions above snow line in the Qinghai-Xizang Plateau, are distributed mainly in the northern part of the Da Hinggan

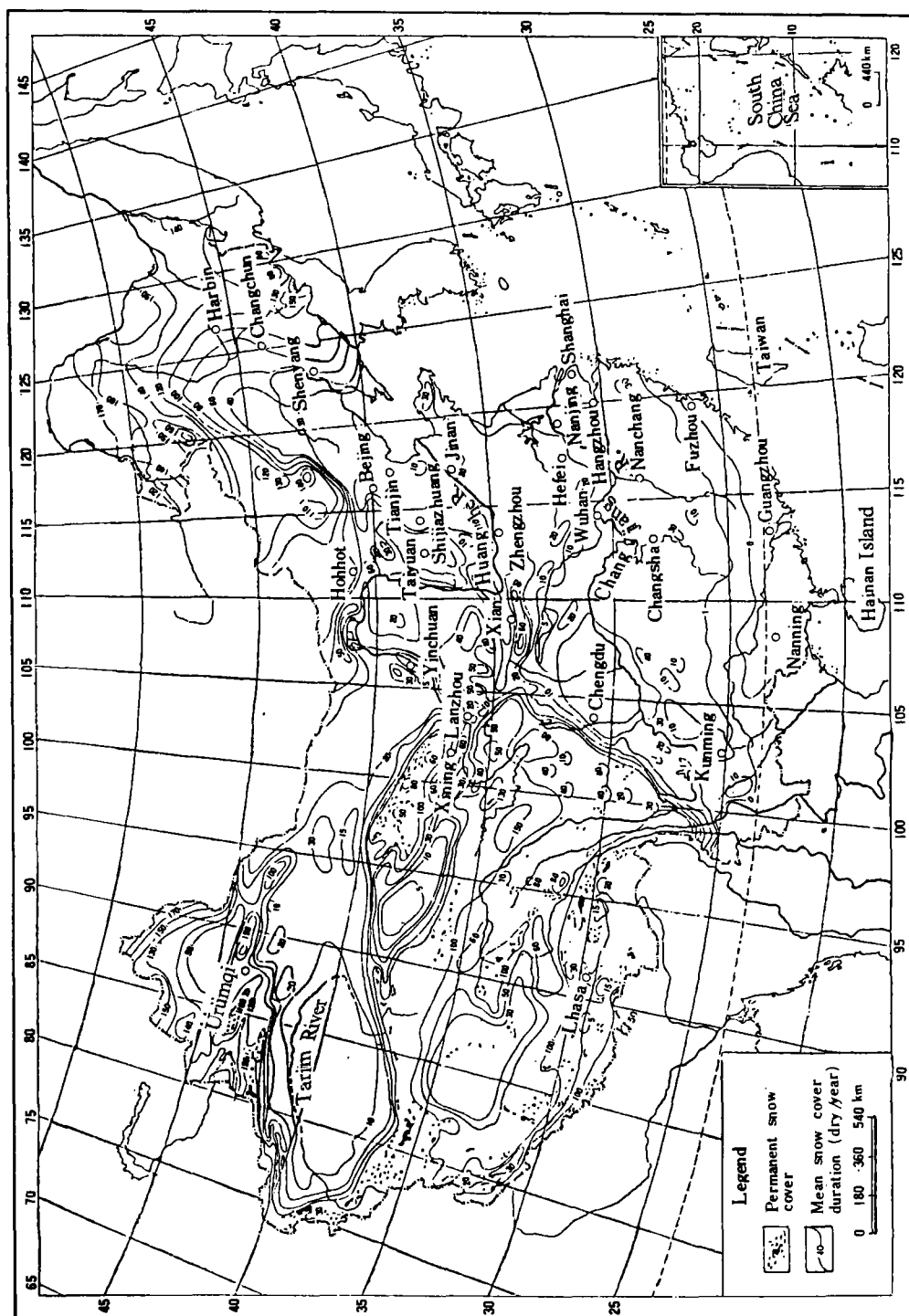


Fig.1 The Distribution map of snow cover in China

and the Xiao Hinggan mountains in Northeast China, the Altay Mountains and the western Tianshan Mountains. Snowfall takes about 30% of the total precipitation. The duration of snow cover may last some 160 days, and decreases rapidly from north to south. It has 25–50 days in the southeast part of northeast China, 15–30 days in North China, 10 days or less in Jianghuai Valley and south of Hanshui River. In general, there is no snow cover at southern flank of 25° N.

The maximum snow covered areas in China are the Altay Mountain, the western Tianshan Mountain, southeast flank of the Qinghai–Xizang Plateau, north and east parts of northeast China, and the piedmont in North Xinjiang etc. The maximum depth of snow cover in these regions generally ranges from 50 to 100 cm.<sup>[2]</sup>

Generally speaking, the maximum depth of snow cover in China increases gradually from south to north, decreases from west to east; in plains, basins and valleys the snow cover is less than in the surrounding areas. In the intermontane basins and the central part of plains the snow cover is even less; in mountainous regions, the snow cover obeys obviously the law of increasing with vertical rising in latitude.

## II. PRINCIPLES OF SNOW HAZARD ZONING AND CLASSIFICATION

Snow hazard is meant unfavorable growing condition for agriculture, and natural disasters for highway traffic and stock-raising caused by snow cover. We took the following principles as the classification unit system for snow hazard regionalization in China:

- (a) principle of comprehensive analysis integrated with dominant factors;
- (b) principle of multi-level division;
- (c) principle of serving the agriculture and stock-raising, communication and transportation.

For the zoning of snow hazard, the climatic and topographical factors were first taken into account for differentiating similarity and diversity of different regions. Taking zone–region–subregion represent the three level of zoning.

In order to have a convenient practical application, it is necessary to reflect the relationship between snow hazard and physio-geographic condition, and to approach the advantageous and disadvantageous relations between snow cover and productive construction so as to provide scientific methods and information for snow hazard protection. In semi-arid and arid regions of China, especially in North Xinjiang and the northwestern part of Gansu Province, the expansion of sown area of winter wheat towards the desert area, to a certain extent, depends on storage of snow cover, duration time, melting rate and its utilization degree. Snow cover is a nourishing source, at the same time, it would bring about difficulties to the agriculture and stock-raising production, e.g. avalanche and drifting snow will block highway, ruin houses and mines, harm human being and cattles and wreck forests.

### III. ZONING RESULTS

According to the situation of snow cover or without snow cover and snow hazard, the continent of China can be classified into two zones (first-level region, Fig.2) with 25° N as the boundary, to the south is the "South China Snow Cover and Snow Hazard Free Zone", and to the north is "North China Snow Cover and Snow Hazard Zone". Based on the difference of general circulation systems, latitude, geographical position, landform and properties of snow cover as well as the major features of snow hazard and the impacts of human activities on snow cover, the large zone of snow hazard can be classified into three "Snow Cover and Snow Hazard Regions" (second-level regions). In order to obviously reflect the difference of snow cover quantity, snow hazard type and hazardous degree as well as past and present situation of snow cover utilization, twenty third-level subregions of snow hazard are further divided in detail (Table 1).

Table 1 Snow hazard regionalization in China

Snow hazard zone	1, Eastern monsoon region (drifting snow hazard region)	(1) Northeast mountainous region and hilly lands —Serious drifting snow hazard region (2) Loess Plateau and North China Plain Winter crops safely overwinter region (3) Qinling and Daba Mountains—Snowy region (4) Jianghui Plain—Temporal snow hazard region (5) Sichuan Basin—Rare snow hazard region (6) South China low mountain and hilly lands Rare snow hazard region (7) Kunming—Sleet region
	2, Western region (avalanche hazard region)	(8) Inner Mongol Plateau —Serious drifting snow hazard region (9) Alxa Plateau—Less snow hazard region (10) Altay Mountain—Serious avalanche hazard region (11) Jungar Basin—Snow hazard region (12) Tianshan Mountain —Serious avalanche hazard region (13) Yili Valley—Snow hazard region (14) Tarim Basin—Rare snow hazard region
	3. Qinghai—Xizang Plateau (avalanche and drifting snow hazard region)	(15) Kunlun and Qilian Mts.—Avalanche hazard region (16) Qaidam Basin—Rare snow hazard region (17) Southeast and south Tibet mountainous region —Serious avalanche hazard region (18) Ali Plateau—Drifting snow hazard region
No snow hazard zone		(19) Lingnan hilly lands and Yunnan—Guizhou Plateau —No snow cover region (20) South Tibet Yadong Valley—No snow cover region

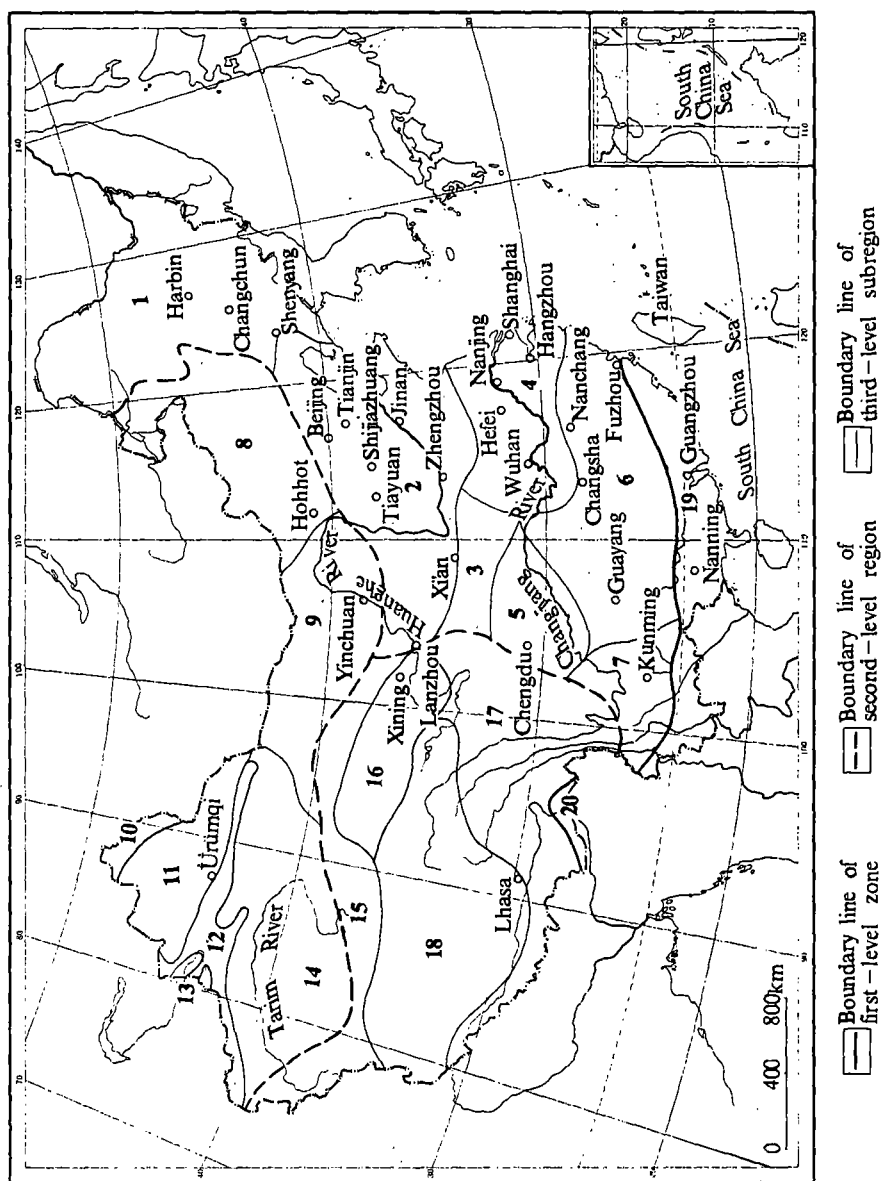


Fig.2 The snow hazard regionalization in China  
(Explanation of number see Table 1)

## 1. Eastern Monsoon Region (Subregions 1-7)

The boundary between this region and "Western-Avalanche hazard region" is approximately at the line along which the maximum thickness of snow cover may reach 20 cm; and the boundary between this region and frigid "Qinghai-Xizang" Plateau-Avalanche and drifting snow hazard region is the contour line of 3,000 m a.s.l.

The climate belongs to the frigid-temperate monsoon and temperate monsoon one, with plenty of water vapor, the climate is mild and humid. Winter season lasts long and snow cover is much thicker. Under the influence of landform and geographical location, the distribution of snow cover increases gradually from south to north, presenting a distribution pattern of three-high and three-low.

The winter in the northern and eastern parts of northeast China is frigid, duration of snow cover may reach about 150 days, the mean depth of snow cover is about 30 cm. The snow cover belongs to wet-warm one, the mean density of snow varies between  $0.3 \text{ g/cm}^3$  and  $0.5 \text{ g/cm}^3$ . Drifting snow blocking highway is the prominent problem of this region. In 1934, more than 370 accidents of blocking traffic by drifting snow happened, and in the winter of 1957, more than 70 times occurred, the communication was affected seriously.

The main topographic types are hilly land, high plain and plain in this region. There is no permanent snow cover distributed, avalanche seldom occurred here. Using snow cover for preserving the moisture and temperature of the ground for the winter crops is the key problem of snow cover research work of the region.

The dominant factor to cause regional differences in interior of the region is temperature which varies with latitude changes. While the humidity decreases with increasing in continentality.

## 2. Western Region (Subregion 8-14)

The boundary between this region and "Eastern monsoon-Drifting snow hazard region" is the contour line of aridity ranging from 1.2 to 1.5;<sup>[3]</sup> and the boundary between this region and frigid "Qinghai-Xizang Plateau Avalanche and drifting snow hazard region" is the hilly land of the Kunlun Mountain, Altun and Qiliq mountains ranging along the edges of the Qinghai-Xizang Plateau. The main features of this region can be summarized as follows:

(1) Snow density of the region is lower than in the east part, and the physical mechanical strength is weaker, metamorphism is mainly temperature gradient-metamorphosed, snow cover belongs to typical "dry-frigid type". The representative feature is that the snow layer is particularly developed. Its maximum thickness may reach 90% of total snow layer.

(2) Rainfall mainly distributed over mountainous region is the prominent characteristic of the region. At the elevation of 1,776 m (The Tianshan Snow and Avalanche Research Station) in the middle zone of the eastern Tianshan Mountain, the mean annual precipita-

tion is 827.3 mm (maximum 1,139.7 mm); that of Xiaoquzi in the central part of the middle zone of the Tianshan Mountain is 534.2 mm (maximum 796.9 mm); that of Qincheng Station in the middle zone of the eastern Tianshan Mountain is 124.2 mm (maximum 201.7 mm). Similar to the rainfall, snowfall and snow cover are mainly concentrated in mountainous region. The snow cover with thickness of 30 cm may last 35.3 days (maximum 99 days) in Altay, 30.1 days (maximum 90 days) in Fuyun, and 15.6 days (maximum 75 days) in Yining and Yili. In mountainous regions, deep snow cover of winter provided the material source for the frequent avalanche occurrence. In this region, the accidents of blocking highway and damaging forests by avalanche occurred each year.

(3) Snow cover is an important water resource and good covering for winter crops.<sup>[4]</sup> Oases depends on melting water of snow from mountainous regions, vegetables and fruits may also be preserved by snow cooling.

(4) Snowstorm and drifting snow occurred occasionally in this region but the harmfulness is not so serious as avalanche, they occurred mainly in wind gap in Xinjiang and in the east and southeast parts of Inner Mongolia. This is related to the regional differences which are determined mainly by rainfall, while water vapor decreases sharply with the increasing of distance from vapor source.

### 3. Frigid Qinghai-Xizang Plateau (Subregion 15-18)

Under the influence of southeast monsoon, the climate is humid and the snowfall is abundant in the southeastern flank of the Qinghai-Xizang Plateau, the depth of snow cover is second only to that in the Altay Mountains of Xinjiang and mountainous region in the western Tianshan Mountains.

In the vast Plateau of the region, thin air, low temperature, intensive solar radiation and wind power cause the snow cover even more shallow in the interior area of the plateau. Snowstorm happened occasionally and drifting snow occurred frequently, directly affecting the communication and stock-raising production. For example, the extraordinary serious snow hazard happened in December 17-23, 1985 in south part of Qinghai Province caused 16 counties suffered greatly.

Unfavorable natural environmental condition has obviously restricted the production and daily life of the people. With the construction of highway linking Qinghai Province and Xizang, and the development of international communication between Xizang and Nepal, the investigation for drifting snow and avalanche control will be conducted in the plateau. Attentions should be paid to the investigation and research on snow cover and snow hazard.

In order to further illustrate the relationship between the duration of snow cover and the snow hazard, we prepared the Table 2 as follows:

**Table 2 Mean snow cover duration of snow hazard regions**

Hazard regions	Subregions	Mean snow cover duration (days/ year)
Avalanche hazard region (including temporal mountain snowdrift hazard)	10/ 12/ 15/ 17	80-365
Drifting snow hazard region	1/ 8/ 18	30-100
Snow hazard region	3/ 4/ 11/ 13	20-100
Rare snow hazard region	2/ 5/ 6/ 7/ 9/ 14/ 16	1-25
No snow hazard region	19/ 20	0

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