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兰州冰川冻土研究所集刊

第8号

MEMOIRS OF LANZHOU INSTITUTE OF GLACIOLOGY AND GEOCRYOLOGY, CHINESE ACADEMY OF SCIENCES

No. 8

中国科学院兰州冰川冻土研究所　编辑

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MEMOIRS OF LANZHOU INSTITUTE OF GLACIOLOGY AND GEOCRYOLOGY, CHINESE ACADEMY OF SCIENCES

No. 8

（雪灾遥感监测与寒区信息系统研究专辑）

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内 容 简 介

本专辑汇集了国家"八·五"攻关课题"重大自然灾害遥感监测与评估"中"我国主要牧区雪灾遥感监测"专题及中国科学院"八·五"重点课题"WDC-D数据系统研究与应用"、中国科学院"八·五"特别支持项目"冰冻圈动态监测基础研究"等课题的部分研究成果，共收录论文24篇。内容包括三个部分，第一部分论述了NOAA/AVHRR卫星雪盖信息的提取和对雪灾背景数据库的更新与操作方法，以及我国雪灾的基本特征及在西藏那曲地理信息系统支持下利用遥感资料对雪灾进行灾情判别、趋势预测与损失评估的定量模型分析与应用技术；第二部分介绍了冰川、积雪及冻土信息系统的研究与应用；第三部分介绍了甘肃省"八·五"攻关课题"敦煌壁画计算机存贮与管理系统研究"的文物壁画数字图像处理与存贮管理等。

本号集刊可供从事自然地理、地理信息系统、冰川、积雪、冻土及雪灾遥感监测与评估等方面研究的科技人员及高等院校有关专业的师生参考和使用。

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前　言

自本世纪70年代迅速兴起的遥感、地理信息系统和全球定位系统技术，为地球科学各领域研究提供了新的技术和方法。目前地学研究正在酝酿一场更为深刻的变革，冰川学和冻土学是地球科学重要的研究领域，也是以遥感、地理信息系统和全球定位系统技术为核心的对地观测技术最具应用前景和潜力的领域之一。

在“六·五”和“七·五”期间，通过国家及中国科学院各项遥感任务的实施，使我所的遥感工作从无到有，从小到大逐步发展起来，培养了一支业务素质较高的、以中青年为骨干的冰川、积雪和冻土遥感技术队伍，取得了一批具有实际应用价值的成果，在黄河上游水力发电和甘肃河西地区农业灌溉等应用中，收到了显著的社会效益和经济效益；并建成了光学和微机数字图像处理系统，为促进冰川学和冻土学的发展做出了贡献。

进入90年代，我所寒区遥感应用研究室又积极承担和参与国家“八·五”科技攻关课题“牧区雪灾遥感监测与评价”(85-724-01-05)、攀登计划A“青藏高原冰川、积雪、冻土与气候变化研究”(85-29-03-03)、中国科学院重大课题“全国再生资源遥感调查、动态变化及遥感前沿研究”(Kg-85-13-14-02)、中国科学院重点基金项目“高亚洲冰冻圈动态基础研究”、“WDC-D冰川积雪冻土数据系统的研究与应用”，以及“甘肃省敦煌莫高窟壁画图像处理与文物计算机管理系统”、“南水北调西线工程通天河—雅砻江调水区冻土遥感调查研究”等课题，并先后通过国家科委和中国科学院组织的中期评估及委托部门的成果验收，开拓了利用卫星遥感数据与地理信息系统技术相结合，进行大范围积雪、湖冰动态监测以及牧区雪灾灾情判别、趋势预测及损失评估的新途径；同时，还与美国合作，利用星载合成孔径雷达(SAR)和被动微波数据研究山区高原积雪及冰川特性等，取得了一定进展。此外，在中国科学院的支持下，建成了除南沙群岛以外覆盖全国陆地及邻近海域的极轨气象卫星接收、处理系统，引进了以Sun工作站为主体的图形、图像处理系统以及ARC/INFO地理信息系统及ERDAS数字图像处理等应用软件。“八·五”期间，我所遥感工作在遥感信息获取、数字图像处理以及地理信息系统技术开发、应用等方面都有了长足的进步，在冰、雪、冻土遥感及地理信息系统的研究与应用等方面取得了一系列阶段性成果，其中除了有15篇论文分别在《GEOSCIENCE AND REMOTE SENSING》、《自然灾害学报》和《冰川冻土》等国内外学术刊物以及北京国际地理信息学术会议(1993年)、干旱-半干旱地区遥感应用国际会议(1993年，兰州)等论文集发表和宣读外，在本号集刊中汇集了24篇有关研究论文和报告，其内容主要涉及以下三方面：

(1)牧区雪灾遥感监测与评价。牧区雪灾是制约我国西部少数民族地区社会经济发展

的主要自然灾害。根据观测资料、历史灾情记载及已有的研究成果，系统分析了我国牧区雪灾形成的条件及时、空分布规律，初步提出了我国牧区雪灾危险程度的分级指标体系，编绘了1∶400万“中国积雪强度评估图”和“中国积雪灾害危险程度图”。在此基础上，选择西藏自治区那曲地区为试验区，以诺阿(NOAA)气象卫星的AVHRR为主要遥感信息源并与地面观测资料相结合，在地理信息系统的支持下，发展了雪灾判别模型、雪灾发展趋势预测模型和灾情损失评估模型等，建立了适用于微机运行环境的、可操作的牧区雪灾遥感监测与评价系统。经1993年、1994年的模拟运行和1995年2—3月的实际运行，结果表明，该系统具有运行速度快、雪灾判别与灾情发展趋势预测准确等特点，损失(牲畜死亡)评估较切合实际，可在我国西部牧区及周边国家进一步推广应用。

(2)地理信息系统技术开发与应用。遥感与地理信息系统技术相结合是当前遥感应用研究的发展方向。“七·五”期间，我所首次在黄河上游建立了冰雪水资源信息系统，提高了融雪径流预报精度，继而在“武威市国土资源信息系统研究”中又开发了部分地理信息系统软件。“八·五”期间，地理信息系统和数字地形模型(DTM)等技术，除了成功地应用于“牧区雪灾遥感监测与评价”外，在“青藏高原积雪监测”、“冰冻圈动态基础研究”和“天山1号冰川及邻近地区各种地形条件下太阳辐射计算”等课题研究的应用中都取得了较大的进展。

(3)其它方面。受甘肃省科委和敦煌研究院的委托，首次将图像处理和信息系统技术应用于敦煌莫高窟壁画图像处理、存储及保护研究。选择莫高窟045号洞作试验，通过近景摄影和摄影图像的数字化，在各种应用软件的支持下，完成了数字图像的几何纠正和彩色校正。同时，收集该洞的文物研究历史资料，建立了敦煌壁画图像处理和文物资料的计算机管理系统，为敦煌文物保护、壁画与雕塑复原以及资料查询、更新等提供服务。此外，在利用陆地卫星TM影像开展甘肃省秦王川第四纪地质地貌调查以及若干光学图像处理与应用研究等方面也取得了一定的进展。

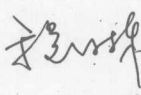
更为可喜的是一批年轻有为的冰、雪及冻土遥感科技工作者茁壮成长，他们工作热情、思想解放、敢于创新，是21世纪我所遥感研究事业的希望所在。愿他们戒骄戒躁，奋力拼搏。

展望21世纪，我所遥感工作应当围绕西北干旱-半干旱地区水资源合理调配和高效利用、冰冻圈动态、青藏高原隆起与全球变化，以及冰雪灾害防治对策等重大课题的研究，加速建成以卫星遥感为主要信息源，以地理信息系统和全球定位系统为依托的高亚洲冰冻圈动态监测系统以及寒区再生资源与环境信息系统，深入开展微波遥感在冰、雪及冻土中的应用研究，努力完成“9.21”各项任务。与此同时，应当根据科技工作面向国民经济建设的方针，“以任务带学科”，“以市场为导向”，促进有应用前景的成果商品化，并与地方政府和生产部门相结合，选择若干典型地区，建成可操作的牧区雪灾遥感监测与评价系统以及西部山区积雪卫星监测与融雪径流预报业务运行系统等，并推向市场，以期取得更大的

社会效益和经济效益，加强遥感与地理信息系统技术在区域开发和城市管理等方面的应用研究，为西北地区经济发展做出贡献。

由于业务水平有限，各文中错误在所难免，敬请读者指正。

本专辑由冯学智负责集稿、组织审稿和统稿，由袁远荣、刘子东负责编辑和出版，由王丽红微机录入。刘子东参与微机排版，李玉芳、金冬梅清绘插图。

中国科学院 院士  （研究员）

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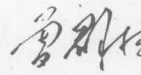
主任  （研究员）

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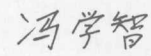
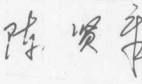
副主任  （研究员）

副主任  （副研究员）

1995年5月25日

PREFACE

The rapid rising of remote sensing techniques, Geographic Information System (GIS) and Global Positioning System (GPS) have been offering the new technologies and methods for the scientific research work in the fields of geoscience since 1970s. A deeper revolution in the researches of geoscience is being incubated and sprung up. As important research branches of the geoscience, the glaciology and geocryology have also been of wide prospects and potentialities in the applications of air-to-ground and ground-to-ground observational technologies, which are mainly made up of remote sensing, GIS and GPS. From 1981 to 1990 the research work of remote sensing developed gradually in Lanzhou Institute of Glaciology and Geocryology (LIGG), Chinese Academy of Sciences (CAS), growing out of nothing and expanding from a small to a large force, based on the implementation of various remote sensing projects from Chinese government and CAS respectively. The technical team dealing with remote sensing of glacier, snow and permafrost was formed in these periods with the higher-quality professional skills and the mainstay of young and middle-aged scientific rescarchers. Some research achievements had been taken and offered for applications to the hydroelectric management of the reservoirs in the upper reaches of the Huanghe River and to the watering adjustment of agricultural irregation in the Hexi region of Gansu Province, which had got outstanding social and economical benefits. Meanwhile, the optical and PC-computer-oriented digital image processing system had been built up in the Institute. All of these above had played an important role in the promoting development of glaciology and geocryology.

Entering into 1990s, the Division of Remote Sensing Application (DRSA) of the Institute has actively undertaken and taken part in some research projects, such as the project (No. 85-724-01-05) "Snow Disaster Monitering and Assessment Using Remote Sensing in Main Pastoral Areas of China", one of the national key scientific and technological projects during the period of 1991—1995, the project (No. 85-29-03-03) "The Studies on Glacier, Snow, Permafrost and Climate Change in the Qinghai-Xizang Plateau", one of the "Chinese Pandeng Plan A", the project (No. Kg-85-13-14-02) "The Investigation of Renewable Resources in China and Studies on Their Dynamics Using Remote Sensing and on the Front Technology of Remote Sensing", which belongs to the key projects of CAS, the project "The Fundamental Studies on Dynamics of High-Asia Geocryospher" and the project "The Studies and Applications of Data System of Ice, Snow and Permafrost in WDC-D", which belong to the natural science foundation

projects of CAS, as well as the project "Digital Image Processing of Dunhuang Wall-paintings and Computer-aided Cultural Relic Data Management System", and the project "The Investigation of Permafrost Using Remote Sensing in the Tongtian River—Yalong River Diversion Region in the West-line of the Diversion work from South to North". Some of the achievements of these projects have passed the mid-range appraisement and check sponsored by State Science and Technology Commission of China, CAS and the relevant entrusted departments respectively. The new ways of the dynamic monitoring of snow and lake-ice in a large-scale as well as of the distinguishing of snow disaster, forecasting of its developing situation and assessment of losses caused by the disaster using the combination of remote sensing data and GIS techniques have been developed based on these research work. At the same time, the research work on the characteristics of snow and glacier in mountains and plateau areas using the data of Synthetic Aperture Radar (SAR) and passive microwave remote sensing has been further developed in cooperation with the scholars of U. S. A. During this period, the NOAA Polar-orbiting Meteorological Satellite Receiving and Processing System and Digital Image Processing System have been established based on Sun SPARC Station with the softwares of ARC/INFO and ERDAS IMAGING in support of CAS. Based on the projects mentioned above, the research work of remote sensing is making good progress in the Institute, especially in the aspects of information extraction from remote sensing images, digital image processing, development of GIS techniques and their applications. A series of research achievements have been taken, which also mainly involved in the remote sensing of ice, snow and permafrost, development of GIS and their applications. Besides 15 research articles published in academic publications, such as *GEOSCIENCE AND REMOTE SENSING*, *JOURNAL OF NATURAL DISASTERS*, *JOURNAL OF GLACIOLOGY AND GEOCRYOLOGY*, Proceedings of '93 Beijing GIS International Symposium and Proceedings of International Symposium on Remote Sensing in Arid and Semi-arid Regions (1993, Lanzhou), there are 24 papers collected in this Memoir. The contents are mainly involved with the following aspects:

1. Snow disaster monitoring and assessment using remote sensing in pastoral areas

The snow disaster is one of main natural disasters in the pastoral areas of China, which seriously obstructs the steady social and economical development in these areas. The formative conditions and the temporal and spatial regular patterns of the snow disaster in China were analyzed according to the observational data, historical records of the disaster and existing achievements. The system of grading-criteria for the dangerous extent of snow disaster in pastoral areas of China was put forward preparatively. *The Map of Evaluation of Snow Intensity in China* and *The Map of Dangerous Extent of Snow Disaster in China* were finished in a scale of 1 : 4 000 000. Based on the results,

the Nagqu Prefecture of the northern plateau of Xizang (Tibet) Autonomous Region was selected as one of the test areas. The Operational System for Snow Disaster Monitoring and Assessment (SDMAOS) was established for the test area, which combined NOAA/AVHRR data and observational ground data, and could be updated using remote sensing data. With the help of spatial analysis and operation of the GIS softwares, the models of distinguishing, forecasting and assessment of snow disaster were developed respectively based on the theories and methods of statistical analysis, gray system and systematic engineering. The simulated results of 1993 and 1994 and actual operational results of Feb. —March, 1995 showed that the SDMAOS had the extraordinary features in fast operational speed and higher-accuracy of distinguishing and forecasting snow disaster. The results of loss assessment was approximately identical with real statistical data. The achievements could be further spread and applied to wide pastoral areas in wastern China and neighbouring countries.

2. the technical developments and applications of GIS

The combination of remote sensing and GIS techniques is one of the developmental aspects in the research of remote sensing applications. During the period of 1986—1990, the Information System on Ice, Snow and Water Resources (ISWRIS) in the upper reaches of the Huanghe River had been first established in the Institute, which was mainly used for the satellite snowcover monitoring and snowmelt runoff forecasting. Subsequently, some softwares related to GIS were developed and designed based on the project of "Studies on Wuwei Territorial Resources Information System". During the period of 1991—1995, the techniques of GIS and Digital Terrain Model (DTM) have been successfully used to the research projects of "Snow Disaster Monitoring and Assessment Using Remote Sensing in Main Pastoral Areas of China", "Snow Monitoring in the Qinghai-Xizang Plateau" and "the Fundamental Studies on Dynamics of High-Asia Geocryospher". Besides these, they have also been used to calculate the influences of various terrain obstruction towards solor radiation on the No. 1 Glacier in the Tianshan Mountains and neighbouring areas. These research work have developed quickly in the Institute.

3. Other aspects

The techniques of image processing and information system have been first used in the project of "Studies on the Processing, Storage and Conservation of the Images of Wallpaintings", one of the key projects of the Eighth Five-year Plan (from 1991—1995) of Gansu Province, and entrusted by the Science and Technology Commission of Gansu Province in cooperation with Dunhuang Research Institute. In the project, the No. 045 Cave of the Mogao Grottoes was selected as one of the typical experiments.

With some assistant application softwares, the methods of geometric correction and colour rectification for the images of wallpaintings have been developed according to the digitized close-range photogrammetric photos. Meanwhile, the Computer-aided System for the Images of Wallpaintings Processing and Cultural Relic Data Management was established based on the collected historical research data of the cave, which could be served for the conservation, retrievement, querying and updating of the images of wallpaintings and cultural relic data. The work of investigation and mapping of the Quaternary geology and geomorphology in Qinwangchuan area of Gansu Province using the Landsat TM data had been finished. Moreover, the Institute has extended progress in some research work on optical image processing and its applications.

It is more gratifying that a number of young scientists engaging in the research of remote sensing of ice, snow and permafrost have been growing sturdily. They are working enthusiastically with the opening ideas and having the courage to make innovations. They will be the rising generation of carrying on the research of remote sensing and its applications in the Institute in the 21st century. Here we wish them to avoid conceit and impetuosity and to spare no efforts to struggle in the fields.

Looking into the 21st century, the remote sensing work in the Institute will focus on some key research projects, mainly taking aim at the research on reasonable adjustment and efficacious utilization of water resources in arid and semi-arid regions of Northwestern China, dynamic studies of Geocryospher, studies on swelling of the Qinghai-Xizang Plateau and global change, as well as studies on the counter measures of preventing and controling ice and snow disasters. The Dynamic Monitoring System of High-Asia Geocryospher and The Information System for Renewable Resources and Environment in Cold Regions will be established acceleratively. The applied research on microwave remote sensing of ice, snow and permafrost will be expanded widely. Meanwhile, according to the policy of "scientific and technological work should meet the needs of economical construction", some applied achievements will be turned into the commercialization. The Operational System for Snow Disaster Monitoring and Assessment Using Remote Sensing Data in the Main Pastoral Areas as well as the Operational System for Satellite Snowcover Monitoring and Snowmelt Runoff Forecasting in the western Mountainous Regions will be popularized to more selected typical areas and transformed to the markets in conjunction with the local governments and producing departments, so as to win the much more social and economical benefits. The applications of remote sensing and GIS techniques to the regional development and civic management will also be strengthened so that the Institute can devote its more achievements to promoting economical development of Northwestern China.

Professor Feng Xuezhi is responsible for soliciting contributions, organizing the examination and approval of the manuscripts and finalizing the manuscripts in the Memoir.

Professor Editor Yuan Yuanrong, the Editorial Department of Book and Memoir, LIGG, CAS, is responsible for the compilation in the Memoir. Liu Zidong also takes part in the compilation. Wang Lihong and Liu Zidong are responsible for the computer-assisted composition. Li Yufang and Jin Dongmei are responsible for mapping of some illustrations in the Memoir. We must not fail to acknowledge their offers to the Memoir.

Academician of CAS

Director of LIGG, CAS Zhang Guodong (Professor)

Chief of DRSA, LIGG, CAS Zeng Qunghui (Professor)

Vice-chief of DRSA, LIGG, CAS Feng Xuezhi (Professor)

Vice-chief of DRSA, LIGG, CAS Chen Xianzhang (Associate Professor)

May 25, 1995

中国科学院兰州冰川冻土研究所集刊

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（雪灾遥感监测与寒区信息系统研究专辑）

目　　录

MEMOIRS OF LANZHOU INSTITUTE OF GLACIOLOGY AND GEOCYOLOGY, CHINESE ACADEMY OF SCIENCES

NO. 8

(THE MONITORING OF SNOW DISASTER USING REMOTE SENSING AND THE STUDIES ON THE INFORMATION SYSTEM IN COLD REGIONS)

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我国积雪强度特征和牧区雪灾的分级标准、危险程度研究*

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摘要 我国地域辽阔，地形复杂，降雪的天气系统不同，因此积雪分布极不均匀，大体形成青藏高原及毗邻山地积雪区，新疆及内蒙古西部荒漠山地积雪区，东北及内蒙古东部草原积雪区，以及华北、华中及其它积雪区等四个积雪类型区域。按积雪稳定性程度，将我国积雪强度分为永久积雪区、稳定积雪区、不稳定积雪区、瞬时积雪区和无雪区等五个级别。选取冬季降雪量，积雪深度与牧草高度之比，雪灾积雪的影响范围及降温大风等指标作为牧区雪灾的分级指标，并将牧区雪灾划分为轻度雪灾(L)、中度雪灾(M)、严重雪灾(H)和特大雪灾(S)四级。以积雪强度(雪深和持续时间)和雪灾发生频率作为评价雪灾危险程度的主要指标。稳定积雪区是发生牧区雪灾最危险的地区，其次是不稳定积雪区。雪灾发生频率是雪灾危险程度的综合指标。0次/10年或偶尔年份可能发生雪灾为无积雪灾害危险区，<1次/10年为轻度积雪灾害危险区，1—3次/10年为中度积雪灾害危险区，>3次/10年为严重积雪灾害危险区。我国积雪灾害主要集中在东北大部、内蒙古中部和东部，以及西部高原地区，而这些地区正是我国主要牧区的所在地，因此，我国牧区雪灾是较为严重的。

关键词 积雪 雪灾指标 危险程度

一、前 言

积雪是寒冷地区或寒冷季节的特殊自然现象和天气现象。它是影响气候变化的重要因子，又是可贵的淡水资源。融雪径流是我国北方河流春汛重要的径流补给。适度的积雪对农区土壤墒情、作物越冬和春播有益无害，所谓“瑞雪兆丰年”的意义就在于此。

然而，大范围的过量积雪，会堵塞交通，威胁牧区牲畜的安全过冬，形成所谓“白灾”。冬季积雪过少或无雪，草原干旱，牲畜在漫长的冬季饮水困难，会使牲畜大批死亡，形成所谓“黑灾”，而且严重影响次年草场的生长，形成灾害。本文仅限于牧区雪灾研究。

我国草地资源面积约60亿亩，占世界草地面积约13%，占国土面积40%，其中牧区

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草地面积为47亿亩[1]，主要分布在西藏、青海、新疆、内蒙古、甘肃等省区，每年向国家提供大量肉食、乳制品和皮毛等产品，对我国国民经济建设和人民生活改善做出了重要贡献。但与世界发达国家相比，我国畜牧业的水平相当落后。究其原因，一方面我国牧区大多分布在高纬度、高海拔和气候严寒干旱的高原或偏远山区，环境恶劣，经济落后，交通闭塞，科学管理水平低。多数地区依然是“逐水草而居”，“靠天养畜”的落后的生产方式；另一方面，广大牧区自然灾害频繁，尤其是雪灾威胁最大。每年秋末冬春，我国上述牧区都有程度不同的雪灾发生，素有“十年一大灾，五年两头灾，三年一小灾”之说。每当雪灾发生，大批牲畜挨饿受冻死亡，严重阻碍着我国牧区经济的发展。而且中央和地方政府每年都要拿出相当可观的经费用于牧区的救灾抗灾。

因此，开展对我国积雪强度评估和积雪灾害危险程度的研究，并编制相应的图件，旨在客观地、较准确地反映我国积雪强度的分布特征和发生积雪灾害危险程度的一般规律，这对于指导我国主要牧区区域经济发展战略的制定，积雪灾害的评估，以及畜牧业生产的科学管理都有重要的指导意义。而且结合我国实际，建立适用于我国国情的雪灾分类、分级标准和危险程度评价的指标体系，为我国牧区抗灾、救灾对策提供依据。

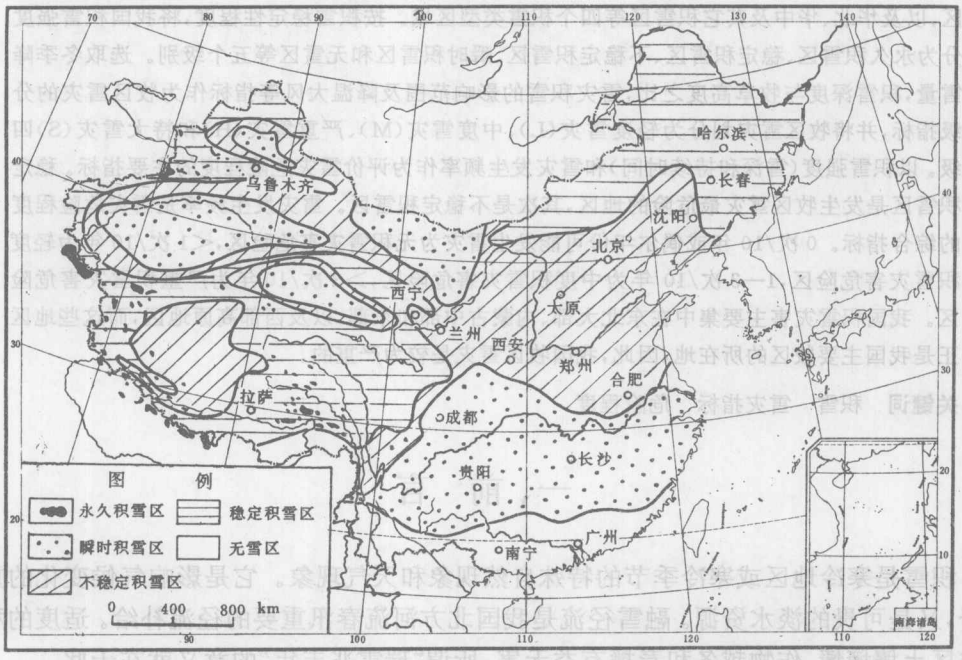

图1 中国积雪强度评估图

Fig. 1 The map of intensity evaluation of snow in China

多年来，我国气象部门结合中长期天气预报，开展牧区雪灾预测预报研究工作，取得了重要进展，为牧区冬季抗灾减灾提供了可靠的依据。畜牧业部门在内蒙古等地进行各类牲畜抗灾能力试验取得了一系列成果，积累了大量第一手资料，为保护牲畜抗灾越冬做出