汶川地震灾害遥感图集

Atlas of Remote Sensing for Wenchuan Earthquake Disaster

中国科学院汶川地震灾害
遥感监测与灾情评估工作组
郭华东 主编

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内 容 简 介

2008年5月12日汶川8级地震给国家和当地人民造成重大的生命财产损失，本图集为该地震灾情的遥感记录。图集在简要介绍震区遥感数据后，从地质灾害、江河堰塞、房屋倒塌、道路损坏、农林损毁和工程破坏6个方面详细叙述了地震造成的灾害损失情况，并以文明延续为题，揭示了都江堰水利工程虽经大震仍能发挥水利功能，从而保持成都平原生机盎然的美好景象。

本图集是汶川地震灾害遥感监测与灾情评估工作的科学性、系统性总结；既有直观表述，又有深入分析；可供地震、地理、地质、遥感等地球科学领域的科研、教学人员参考使用，也可供减灾、防灾及相关业务部门人员参考。

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CHINESE ACADEMY OF SCIENCES

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Institute of Remote Sensing Applications, CAS

Institute of Geographic Sciences and Natural Resources Research, CAS

Institute of Geology and Geophysics, CAS

Institute of Mountain Hazards and Environment, CAS

Research Center for Eco-Environmental Sciences, CAS

序

2008年5月12日发生在四川汶川的 8 级特大地震，给国家和人民群众的生命财产造成了重大损失。地震刚刚发生时，道路不通，交通中断，次生灾害频发，气象条件恶劣，使得及时获取受灾现场信息异常困难，情况不明成为当时抢险救灾决策面临的重大难题。紧急开展地震灾害监测与灾情评估，对及时了解和掌握受灾情况、为抢险救灾决策提供科学支持显得十分紧迫和重要。

中国科学院发挥遥感综合监测技术和人才队伍优势，迅速成立抗震救灾遥感应急指挥部，并成立由中国科学院对地观测与数字地球科学中心、电子所、遥感所、地理资源所、地质地球所、成都山地所、生态环境中心 7 个单位科技人员组成的“中国科学院汶川地震灾害遥感监测与灾情评估工作组”，全面开展灾情遥感工作。在第一时间紧急启动卫星遥感数据获取程序，启动雷达和光学两架高空遥感飞机获取高分辨率数据，及时进行实地考察，构成天、空、地一体化的监测网络，形成全天候、全天时观测体系；灾情分析人员夜以继日奋战，使遥感数据的采集、传输、解译、分析环环相扣，快速形成灾区遥感影像和系列分析报告，及时报送给党中央、国务院抗震救灾指挥部、国家有关部门和四川省抗震救灾指挥部，为汶川大地震抗震救灾指挥工作提供了有力的咨询服务和决策依据，受到国务院抗震救灾指挥部和有关部门的高度重视和好评。

科技积累是未来工作的宝贵基础资源，科学总结是科技活动的一项重要环节。汶川地震灾害遥感工作组及时将救灾工作中积累的数据和影像进行科学研析，编制出版《汶川地震灾害遥感图集》，这项工作很有意义。图集以翔实的资料和数据，通过科技人员的深度分析，再现了地震灾害原貌，从地质灾害、江河堰塞、房屋倒塌、道路损坏、农林损毁、工程破坏 6 个方面展示了受灾情况，并以文明延续为题，叙述了伟大工程都江堰历经2000年遇 8 级特大地震而不倒、保持成都平原充满生机的美好景象。我相信，这本图集的出版，必将受到各界的欢迎，也必将对汶川震后重建、对区域发展发挥重要作用，对地震等研究也有重要参考价值。

汶川特大地震警示我们，自然灾害已成为人类必须共同面对的重大挑战。进入新世纪以来，重大自然灾害频发，仅地震、海啸、洪水和飓风就造成了数以万计的人员伤亡和重大的经济损失，给人类社会带来了巨大的创伤。有效防范和抵御自然灾害，将自然灾害造成的损失减少到最低程度，已经成为我们必须面对的现实而紧迫的重大课题。科技创新要为防灾减灾提供有力支撑。不同类型的自然灾害对防灾减灾提出了不同的要求，需要发展新的技术手段、方法和设备。要建立综合对地观测体系，及时捕捉各种异常现象的发生，严密跟踪其发生发展过程和变化趋势。加强灾害的监测预警和防灾减灾，重点围绕对我国危害重大的气象、地质、地震等灾害，研发相关科学模型，开展灾害模拟及对策研究，提高我国对重大灾害的监测预警和防灾减灾水平，并为全球灾害研究作出贡献。

近期，胡锦涛主席就防灾减灾向科技界提出要求，明确指出要加快遥感、地理信息系统、全球定位系统、网络通信技术的应用以及防灾减灾高技术成果转化和综合集成，建立国家综合减灾和风险管理信息共享平台，完善国家和地方灾情监测、预警、评估、应急救助指挥体系。总书记对遥感减灾的高度重视提示我们，科技创新永无止境，科技创新任重道远，遥感减灾科技大有作为。

我衷心希望广大遥感和地学科技工作者，勇挑时代重担，不负国家赋予我们的光荣使命，围绕重大自然灾害问题，积极探索和认知灾害的机理和规律，发展监测预警、防灾减灾的关键技术，提出系统解决方案，为提升我国防灾减灾能力、保障国家和人民生命财产安全提供有力的科技支撑，做出无愧于时代的贡献。

全国人大常委会副委员长
中国科学院院长　路甬祥

2008年9月

PREFACE

On 12 May 2008, Wenchuan County in Sichuan experienced a severe earthquake of magnitude of 8.0 on the Richter scale, causing heavy losses in human life and property. Gaining immediate information from the disaster area and obtaining first-hand data was exceedingly difficult when the tremor first hit, as the roads were blocked, communications went down, many secondary disasters occurred, and weather conditions were very bad. The lack of information was a serious problem for disaster rescue decision-making since urgent monitoring and disaster assessment were vital if scientific support were to be provided for the search and rescue operations.

The Chinese Academy of Sciences (CAS) gave full play to its comprehensive remote sensing techniques and talented scientists by immediately launching the Emergency Headquarter of Remote Sensing for Earthquake Resistance and Disaster Relief. The Project Team of Remote Sensing Monitoring and Assessment of Wenchuan Earthquake was set up by experts from seven CAS institutes, including Center for Earth Observation and Digital Earth, Institute of Electronics, Institute of Remote Sensing Applications, Institute of Geographic Sciences and Natural Resources Research, Institute of Geology and Geophysics, Chengdu Institute of Mountain Hazards and Environment, and Research Center for Eco-Environmental Sciences. Thus remote sensing on the quake disaster was extended on all fronts. A program was immediately initiated to acquire data from earth observation satellites and two high-altitude airplanes took off for obtaining high-resolution optical and radar data. On-the-spot investigations were carried out promptly. Therefore, a unified, all-weather day and night monitoring grid was formed with space, air and in-situ observing capacities. Disaster analyzing personnel did not spare any efforts day-in and day-out, collecting, transferring, processing, interpreting remote sensing data and images, and promptly completing series analysis reports. Those reports were immediately submitted to the Headquarters for Earthquake Resistance and Disaster Relief of governments at national, ministerial and provincial levels. The dedicated work provided convincing evidence for decision-making.

Accumulated knowledge in science and technology is a treasured fundamental resource for future progress, and summarizing knowledge scientifically is an important part in scientific and technological activities. Based on the accumulated data and images collected by the Project Team during quake relief, *Atlas of Remote Sensing for Wenchuan Earthquake Disaster* is now edited and published. Through *the Atlas*, the original appearances of quake-hit areas have been reconstructed thanks to rich materials and deep analysis of researchers. *The Atlas* exhibits disaster from six aspects, including geological disasters, barrier lakes, collapsed buildings and houses, damaged roads, destroyed farmland and forests, and demolished infrastructure. *The Atlas* also demonstrates that Dujiangyan Irrigation Project, which has been standing up for 2000 years, remains fully functioning and keeps Chengdu Plain full of vitality even after encountering an 8.0 magnitude earthquake. I believe that the publication will be

welcomed by all circles, and play an important role in Wenchuan re-construction and regional development. Morever, I hope *the Atlas* can also serve as an informative reference for earthquake research.

The Wenchuan earthquake has warned us that natural disasters pose great challenges that humankind must face together. The natural disasters have occurred frequently in recent years. Earthquakes, tsunamis, floods and hurricanes have claimed tens of thousands of lives and caused heavy economic losses, which has brought great trauma to human society. Effectively preventing natural disasters and reducing losses to a minimum have become real and pressingly important issues. Scientific and technological innovations should provide powerful support for disaster prevention and reduction. Different types of natural disasters require different solutions, thus development of new technical approaches, methods, and facilities are in great demand. Comprehensive earth observation system has to be established to capture abnormal phenomena in real time and near real time. We must monitor closely the occurrence and development of potential disasters, and improve disaster warning ability. We should pay much attention to meteorological, geological, and seismological disasters that could cause serious damages to society. We will develop scientific models and carry out research on disaster simulation to raise our disaster warning ability and make contributions to global disaster research.

President Hu Jintao has recently set tasks for scientific community on disaster prevention and mitigation. He has pledged to accelerate the applications of remote sensing, geographic information system, global positioning system and information communication technology, and urged the speeding up of transferring and integration of high technologies for disaster prevention and mitigation. He has also called for setting up a national platform to share information on disaster mitigation and risk management, and to improve disaster monitoring, warning, assessment, and emergency rescue systems at both national and local levels.

It is my sincere hope that scientists and engineers in fields of remote sensing and geosciences should courageously assume these important tasks, and carry out the glorious mission that our country has bestowed upon us. I expect that professionals should focus on disaster mitigation issues, actively explore and recognize disaster mechanism, develop key technologies for disaster monitoring, warning and prevention, offer effective solutions, provide strong scientific support that will safeguard human life and property, and make contributions worthy of our time.

LU Yongxiang

Vice Chairman, the Standing Committee of the National People's Congress, People's Republic of China

President, Chinese Academy of Sciences

September, 2008

前 言

随着多平台、多波段、多模式和高空间、高光谱、高时间分辨率对地观测技术的迅速发展，这项技术在应对自然灾害中的作用越来越重要。近年来，由70多个国家和40余个国际组织参加的全球综合对地观测系统计划把减灾列为对地观测 9 个社会受益领域之首，多国空间组织建立了旨在重大自然灾害中协调利用空间设施的“减灾合作宪章”机制，我国对减轻自然灾害中空间技术的应用也给予了充分重视。

“5.12”汶川大地震发生后，中国科学院领导在第一时间作出了地震灾害遥感的部署，成立了由阴和俊副院长为总指挥的“中国科学院汶川地震遥感应急指挥部”和由院属7个研究机构科技人员组成的“中国科学院汶川地震灾害遥感监测与灾情评估工作组”，全方位展开灾情遥感工作。在一个月的时间里，利用遥感卫星地面站和高空遥感飞机两个大科学装置，发挥全天时、全天候快速获取信息的能力和优势，按照数据获取－信息处理－灾害分析－灾情评估－情况专报的流程和模式，为中央和地方政府决策提供了大量数据、信息和建议。同时，在科技部和中国科学院的共同组织下，建立了由13个部委代表参加的汶川地震灾害空间数据共享机制，依托对地观测与数字地球科学中心形成会商制度，实现震区遥感数据的共享共用。

遥感技术在汶川地震灾害监测与灾情评估中发挥了积极作用，遥感数据也永恒记录了不可再现的震前和震后景观。出于对成果进行系统性总结的考虑，基于加强学术交流和普及地震灾害遥感监测知识的目的，并希望在更大范围内实现灾区遥感数据的共享，成为编制本图集的初衷。

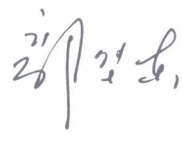
本图集共分八章。第 1 章：遥感数据，介绍通过航空和航天遥感获取的灾区光学与雷达遥感数据情况；第 2 章：地质灾害，描述滑坡、崩塌、碎屑流和断裂引发的系列灾害；第 3 章：江河堰塞，叙述本次地震最严重灾害之一堰塞湖的分布和危害；第 4 章：房屋倒塌，分析城镇与农村被损房屋的空间展布与倒塌程度；第 5 章：道路损坏，给出

国道、省道、县道和乡间道路四类道路的五级受损情况；第 6 章：农林损毁，评估由地震引发的次生地质灾害造成的森林植被、农田耕地等损毁情况；第 7 章：工程破坏，展示了相关水利工程、矿区工程和输电工程遭受破坏的现状；第 8 章：文明延续，伟大的工程都江堰历经两千年，遭遇里氏8.0级地震而坚固如初，运作顺畅，昭示了地震灾害可以改变山河、可以阻断道路、可以损毁楼房、可以破坏农田，但摧毁不了四川乃至全国人民抗震救灾和重建家园的坚强决心，中华民族创建的文明将永远延续。

震后我们到了灾区，先后赴都江堰、汶川、北川、绵阳、绵竹等地对遥感分析结果进行实地考察与验证。汶川地震灾害遥感工作给我们留下了深刻的记忆，也促使我们认真地思考：应进一步建立具备先进、实用、快速、可靠技术能力的灾害遥感应急监测系统，实现遥感信息获取、处理、传输、分析、报送一体化，其核心是提高应急反应能力和技术稳定性；应在政策和机制上保障权威指挥机构的“国家调度权”，使其在应急状态下可有效协调国家、部门关键空间基础设施，并实现数据的高度共享；地球已有45亿年的历史，被人类认作灾害的事件的发生仅仅是其长期演化过程中的自然现象，因此灾害会与地球同在，有人类的存在就会有自然灾害的伴随，人类要与自然灾害作斗争，更要在面对自然灾害时秉承人与自然和谐相处的理念。

抗震救灾期间，中共中央政治局委员、国务委员刘延东，全国人大常委会副委员长、中国科学院院长路甬祥，中国科学院常务副院长、院抗震救灾领导小组组长白春礼等多位领导以及科技部有关领导亲临汶川地震灾害遥感监测与灾情评估工作组视察、组织、指导工作并设立专门项目予以支持；中国科学院对地观测与数字地球科学中心，电子学研究所，遥感应用研究所、地理科学与资源研究所、地质与地球物理研究所、成都山地灾害与环境研究所、生态环境研究中心等 7 个研究机构和领导对工作组给予了大力支持；来自不同单位、不同学科领域的工作组成员怀着为国分忧、贡献灾区的强烈信念，齐心协力，夜以继日，努力奋战。图集编制期间，路甬祥院长亲自为图集作序，以陈述彭院士、马宗晋院士为首的图集顾问委员会以多种形式进行科学指导，编委会同仁以一丝不苟的精神默默耕耘，科学出版社以高度负责的态度精心编辑。谨代表工作组和图集编委会向各位领导、专家、同事表示衷心感谢并致崇高敬意。

这是特定时间条件下出版的一本图集，水平不足，能力有限，难免会留下许多缺陷乃至遗憾，祈望读者予以批评、指正。



2008年9月

FOREWORD

Earth Observation has played an increasingly important role in natural disaster mitigation with the rapid development of multi-platform, multi-frequency, multi-mode, high-spatial, ultra-spectral and high-temporal resolution technological capabilities. In recent years, reduction and prevention of disaster has been listed as the first among nine societal benefits by Global Earth Observation System of Systems (GEOSS), participated by more than 70 countries and over 40 international organizations. In addition, the International Charter on Disaster Reduction and Cooperation was set up by multi-nation space organizations to provide a unified system of space data acquisition and delivery when facing major natural disasters. China has also attached great importance to application of space technology for natural disaster relief.

Immediately after Wenchuan earthquake on May 12, 2008, the Chinese Academy of Sciences (CAS) deployed its earthquake remote sensing resources, setting up the CAS Emergency Headquarter of Remote Sensing for Earthquake Resistance and Disaster Relief, headed by CAS Vice President Yin Hejun. The CAS Project Team of Remote Sensing Monitoring and Assessment of Wenchuan Earthquake was established by researchers from seven CAS institutes. Afterwards, remote sensing on quake-hit areas was fully extended. Within a month, the Project Team had taken advantage of two mega-science facilities of the remote sensing satellite ground station and the high-altitude remote sensing airplanes to give full play to the strengths and abilities at their command. The Project Team provided large amount of data, information and suggestions for decision-makers at central and local government level, following the procedure of data-acquiring, information processing, disaster analysis and assessment, and report submission. At the same time, co-organized by the Ministry of Science and Technology (MOST) and Chinese Academy of Sciences, a data sharing mechanism was formed at a meeting attended by representatives from 13 ministries, and consultation meetings hosted by the Center for Earth Observation and Digital Earth (CEODE) were organized.

Remote sensing technology has played an active role in Wenchuan earthquake monitoring and assessment. Remote sensing data recorded lasting and irreplaceable instantaneous pre- and post-quake landscapes. The original intention of editing *the Atlas* is to systematically summarize the scientific results, promote academic exchange, popularize remote sensing knowledge for disaster monitoring, as well as to realize data sharing in a larger scope.

The Atlas consists of eight chapters. The first chapter, "Remote Sensing Data" introduces optical and radar data on quake-hit areas acquired through airborne and spaceborne remote sensing. The second chapter, "Geological Disasters" describes disasters caused by landslides, avalanches, detritus flows and fractures. The third chapter, "Barrier Lakes" narrates the distribution and dangers of the barrier lakes, one of the most serious secondary disasters caused by the earthquake. The fourth chapter, "Collapsed Buildings and Houses" analyzes spatial

distribution and degree of damage of crushed buildings in urban and rural areas. The fifth chapter, "Damaged Roads" illustrates the five-level damage classification for national and provincial highways, county roads, and rural paths. The sixth chapter, "Destroyed Farmlands and Forests" assesses damaged conditions of forest vegetation and farmland resulting from the secondary geological disasters caused by the earthquake. The seventh chapter, "Demolished Infrastructure" shows the damage to hydrological engineering systems, mining area constructions and power transmission projects. The eighth chapter, "Continuing Civilization" depicts a two-thousand-year old Dujiangyan Irrigation Project, which has been functioning even after encountering an 8.0 magnitude earthquake.

After the earthquake, we carried out a field investigation in quake-hit areas including Dujiangyan, Wenchuan, Beichuan, Mianyang, and Mianzhu to validate remote sensing results. Our experience has made us reflect deeply on disaster relief work. Firstly, an emergency disaster monitoring system with advanced, practical, fast and reliable technical ability should be further established. Secondly, in an emergency, an authoritative institution should be guaranteed with "scientific dispatching system" so that it could effectively coordinate key space infrastructures to achieve a high degree of data sharing among different agencies. Thirdly, the Earth has existed for 4.5 billion years, and some natural events, regarded as disasters by human beings, were merely natural phenomena in the Earth' s long-term evolutionary process. Therefore the existence of mankind is always in concomitance with natural calamities; we must wage our struggles with natural disasters in accordance with the idea that mankind should coexist harmoniously with nature.

During the earthquake resistance and disaster relief period, Ms. Liu Yandong, member of Political Bureau of the CPC Central Committee and State Councilor; Prof. Lu Yongxiang, Vice Chairman of the Standing Committee of the National People's Congress and CAS President; Prof. Bai Chunli, CAS Executive Vice-President and Head of the Leading Group of CAS Earthquake Resistance and Disaster Relief and other CAS senior administrators as well as leaders from MOST came to the CAS Project Team to coordinate work and grant the projects. Our team colleagues worked shoulder by shoulder, day in and day out. During the period of compiling *the Atlas*, advisory committee of *the Atlas* headed by Prof. Chen Shupeng and Prof. Ma Zongjin offered scientific directions in various ways, and colleagues of editorial board worked meticulously and conscientiously. On behalf of the Project Team and editorial board, I sincerely express my heartfelt thanks and extend my highest respects to everybody.

GUO Huadong

September, 2008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