'98 REMOTE SENSING FOR 1998 FLOODS IN CHINA

中国特大洪灾遥感图集

国家遥感中心 编

NATIONAL REMOTE SENSING CENTER OF CHINA

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科学技术部 国家遥感中心 编

NATIONAL REMOTE SENSING CENTER OF CHINA MOST

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序言
PREFACE

中国东部广袤的泛滥平原上，人口、城市高度密集，工农产业迅猛增长。长江、黄河和松花江的中下游河段，两岸大都修建了高出平地的大堤，用来防范江河洪水和调剂内涝，以保障湿地生态、农田灌溉、城市供水和航运的畅通。其规模之宏伟、工程之艰巨，不亚于万里长城。

然而，东亚季风气候、全球变化带来的许多不确定因素，严重地影响着我国不同地区的降水周期和变率，形成洪涝与干旱交替出现的严峻局面。1991年江淮持续雨涝，经济损失估计达1220亿元（人民币）；1994年华南洪涝和黄河大旱，估计损失达1876亿元；1997年厄尔尼诺事件，估计损失达1975亿元；1998年长江和东北地区遭受百年一遇的特大洪涝灾害，估计经济损失超过2600亿元以上。20年来，随着国民经济的增长，洪涝灾害的损失与日俱增。江河洪涝灾害造成的经济损失，已占各种自然灾害损失总额的70%，相当于国民经济总产值的3‰～6‰。

20年来，国家遥感中心负责组织、协调有关部门的洪涝灾害遥感监测工作，为建设我国江河洪涝预警和评估信息系统作出了不懈的努力，组建多种功能的航空遥感快速反应系统，促进国际遥感卫星接收站的建设和我国气象卫星和资源卫星的研制和发射，支持国家水土保持工程与洪涝预警、评估信息系统的大型实验等等。通过一系列的科技攻关和应用实验项目的实施，为我国集成灾情遥感监测运行系统，并延伸到灾情评估、救灾规划（重建家园）打下了初步基础。

面临1998年特大洪灾的挑战，遥感监测工作者们接受了又一次考验，提交了又一份合格的答卷。国家遥感中心主任郑立中教授主编的这部图集，精选出1998年特大洪涝期间，从气象卫星、资源卫星和航空遥感所获取的近百幅遥感图像。它们既是值得珍藏的历史档案，又是推广遥感信息应用于自然灾害监测的范例，既是洪涝遥感监测技术的检阅和交流；又是希望加强防灾、救灾基础设施能力建设的呼吁。抛砖引玉，有可能会得到国内有关领导和同行们的关注和指教；也有可能再次受到亚洲季风国家和地区专家们的欢迎和切磋。

陳述彭

中国科学院院士、国家遥感中心顾问

一九九八年十一月

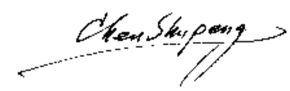
In the vast expanse of flood plains in Eastern China, which is dotted with densely populated towns and cities, industry and agriculture are rapidly developing. To prevent river flooding and moderate water logging, preserve wet land ecology, ensure agricultural irrigation and water supplies in urban areas, long dykes higher than the surrounding land have been built along the middle and lower reaches of the Yangtze River, the Yellow River and the Songhuajiang River. To say that the construction of these dykes matches that of the Great Wall in its grandness and toughness is by no means an exaggeration.

However, uncertain factors related to Easter Asia monsoon climate and global climatic change heavily affect the rainfall cycle and period and variability in China, leading to the formation of a situation in which floods, water logging and drought occur in different regions alternately. In 1991, persistent water logging in the Yangtze and Huaihe River basin cost 122 billion RMB yuan in economic loss. In 1994, the economic loss was estimated at 187.6 billion owing to the flood and water logging in Southern China and the drought in Eastern

China plains. In 1997, the economic loss was put at around 197.5 billion yuan on account of El NINO effects. In 1998, the Yangtze River and Northeastern China plains registered the biggest flood in a century, which brought about 260 billion RMB yuan in economic loss, In the last 20 years, such losses have been growing with the growth of economy, accounting for 70% of all natural disaster related losses, and 3%-6% of gross national product.

In the past twenty years, National Remote Sensing Centre of China has been placed in charge of organizing and coordinating remote sensing monitor of flood and water logging. Since then great efforts have been made to establish an information system for flood and water logging prediction and evaluation, and set up various airborne remote sensing prompt reaction systems. At the same time, vigorous measures have also been taken to promote the establishment of international remote sensing satellite receiving stations and the development and launch of national meteorological satellites and resources satellites and to conduct large scale national experimentation on water and soil conservation, flood and water logging advance warning and disaster evaluation information systems. Series of science and technology study programs and experimental application projects have laid a foundation for integrating disaster remote sensing monitor operating system. This system may extend to disaster evaluation, relief planning and homeland reconstruction.

Once again remote sensing monitor scientists stood a severe test, when confronted with the challenge of the extraordinarily heavy flood in 1998. This atlas, of which Professor Zheng Lizhong, Deputy Director-General of National Remote Sensing Center of China, is Editor in Chief, contains nearly one hundred images of 1998' flood obtained by meteorological satellites, resources satellites and aerial remote sensing. It is not only a document of historic importance worth collecting, but also a shining example of applying remote sensing technology to monitoring natural disasters .This atlas serves to review the application of remote sensing technology to monitoring floods and water logging and as an appeal to intensify infrastructure capability building for disaster prevention and relief. In this sense the publication of the Atlas may well serve as a sprat thrown out to catch a whale, so to speak, and to draw the attention of the relevant leaders and colleagues in the field. And it is not unlikely the Atlas will once again meet with warm response as well as favorable comments from monsoon-affected countries in Asia and experts in the region.



Academician
Chinese Academy of Sciences

Advisor
National Remote Sensing
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November, 1998

前言
FOREWORD

1957年第一颗人造地球卫星进入太空，标志着人类从外层空间观测地球、探索宇宙时代的到来。从此，人类以崭新的视野认识自己赖以生存的地球。作为太空时代的高新技术，遥感以其空间观测范围大、探测光谱范围广、可远离被观测物体进行全天候观测等特点，在世界范围内的环境与灾害监测中一直是各国优先选用的高技术之一。从80年代中期开始，我国科学家即开始了遥感技术在洪涝灾害监测中的应用研究。经过“七五”、“八五”、“九五”计划的科技攻关和十余年的应用试验，逐步完善了遥感监测的技术手段，已经形成了从卫星到飞机、从初级数据处理到综合性信息提取的灵活、高效的遥感监测技术体系。这些高新技术，通过我国科技部门、各产业部门及解放军空军、海军航空兵等的通力合作，在今年全国上下抗御特大洪涝灾害的实践中，初步显示其巨大的威力。

1998年夏季，我国长江流域、嫩江－松花江流域发生了特大洪涝灾害。抗洪救灾期间，国家遥感中心各部通力合作，应用遥感（RS）、地理信息系统（GIS）和全球定位系统（GPS）技术（简称3S技术）开展了大量的灾情监测和评估工作。从6月19日开始，即通过6颗卫星，采用多光谱尤其是具有云层穿透能力的微波雷达成像技术对灾区进行了全方位的遥感监测，共处理全国范围的气象卫星数据近百个时相，接收加拿大、日本、美国等国以及欧洲空间局的遥感卫星数据12次，对各灾区进行了5至7次的覆盖，总覆盖面积累计达765万平方千米。动用国家863计划机载雷达系统、国家攻关计划“机－星－地”系统、国家测绘局的航测遥感系统等三套航空遥感监测系统，飞行20多架次，获取数十万平方千米灾区的实况图像，形成遥感监测图像100多幅，灾情分析报告近100篇，迅速送往国家和受灾各省的有关部门，及时而有力地支援了各灾区的抗洪救灾工作。同时，这些珍贵的遥感图像，也为灾后重建和今后的防洪水利规划与建设提供了科学的依据。

1998年百万大军坚守防洪大堤达数月之久的壮举唤起了全国军民极大的爱国热情和忧患意识，留给人们更多的深沉反思。对未来行动的科学规划与决策来源于对已发灾害的正确认识。我们必须采取有效的措施，预防灾害的发生，减轻灾害造成的损失。空间遥感信息实时地记录了灾害发生、发展的全过程，是防洪救灾管理、规划和对策研究的科学依据。对灾害全过程遥感信息的分析、处理、提炼和有效应用，是一项具有深远历史意义和重要现实意义的工作，也是一项极为艰巨细致的任务。作为此项工作的一部分，国家遥感中心组织有关部门，选择1998年洪水期间获取的有代表性的遥感影像及其灾情分析成果图近百幅，编辑成集。我殷切地希望本图集的出版能帮助人们加深对洪灾危害的认识，加强对科技救灾特别是3S技术在防灾抗灾救灾中应用的了解，从而有助于我国在该领域及其相关方面的进一步深入研究，有效地控制灾害的发生和发展，保护人民的生命和财产。

本图集是在科学技术部、国家防汛抗旱总指挥部、水利部、国土资源部、国家测绘局、中国气象局、中国科学院、国务院秘书局等部门领导的关怀下，国家遥感中心各部以及北京大学出版社的大力支持和有效配合下完成的。在此，谨向这些部门及有关领导和专家表示衷心的感谢和敬意。

遥感是综合性的高新技术，虽然在我国已有近30年的研究和发展，但与世界先进水平相比，仍有相当大的差距。我国科技工作者在相对较少的投入下，发奋努力，一

些单项技术尤其是某些应用技术已开始走在世界的前列，但在我国建成世界一流的自然灾害监测与评估运行系统，为我国长远的防灾救灾提供强有力的技术支持，还任重道远。而按照自然灾害链发的一般规律，大水年后常伴随大旱，因此做好明年自然灾害特别是春旱的监测准备工作，已刻不容缓。

二十一世纪是知识经济大发展的时代，以包括遥感、地理信息系统和全球定位系统等高新技术在内的地球空间信息技术的发展，将为人类文明和繁荣昌盛作出新的贡献。我们真诚地希望我国遥感界的科技工作者继续发扬艰苦奋斗、自力更生的光荣传统，齐心协力、集思广益，为在我国建立起高效、实用、可运行的自然灾害监测、评价与减灾决策支持系统而努力，也希望社会各界一如既往地关心、支持我们的工作。

李　健

科学技术部高新技术发展及产业化司司长、国家遥感中心主任

一九九八年十一月

The first satellite launched in 1957 marked the arrival of the era for observing the earth and exploring the cosmos from the space. From that time, the human beings have a brand new vision to understand our global. As a high technology of the space era, remote sensing is one of the high technologies selected preferentially in worldwide environmental and disaster monitoring, thanks to its unique characteristics of large spatial observing areas, wide spectrum ranges, imaging far away from the targets and all weather imaging capabilities. From the mid-1980s', Chinese scientists have conducted application research of remote sensing in flood and drought monitoring. Through the scientific key research programs in the Seventh, Eighth and Ninth Five-Year (1986-1990, 1991-1995, 1996-2000, respectively) plans and more than ten years application experiments, the techniques of remote sensing monitoring are gradually perfect. A flexible and high efficient remote sensing monitoring system has been formed, from satellite to aircraft and from preliminary data processing to comprehensive information extraction. These high techniques have initially shown their tremendous usefulness in the applications for the severe flooding events in 1998, through the collaborations of the national governmental departments, scientific and research institutions, industrial organizations, the air forces and Navy of the People's Liberation Army, and other agencies.

This summer, an extraordinary severe flood event was occurred along the Yangtze River and Nenjiang-Songhuajiang River areas. During the periods of fighting against flood and disaster relief, with fully cooperation of different departments of the National Remote Sensing Center of China, extensive works have been conducted on the disaster situation monitoring and loss assessment by means of remote sensing (RS), Geographical Information System (GIS) and Global Positioning System (GIS) techniques (also known as 3S). From June 19, six satellite data have been used. Multi-spectral sensors, in particular microwave imaging radar capable of penetrating clouds and rains, have been applied in remote sensing monitoring for the flooded areas. Meteorological satellite data covering the whole country have been obtained and processed more than 100 times. The remote sensing data from satellites of Canada, Japan, United States and European Space Agency were received twelve times, which had five to seven times of coverage and total area is up to 7.65 million km^2. Three sets of airborne remote sensing monitoring systems, which are national high technological plan (863-308) developed airborne SAR system, national key scientific plan developed "aircraft-satellite-earth" system, and aerial surveying remote sensing system developed by National Bureau of Surveying and Mapping, were flown over more than 20 sorties. Remote sensing data of the flooded areas about several hundred thousands km^2 were acquired, and more than 100 scenes of images and about 100 disaster analysis reports were produced. These results were quickly sent to the relevant departments of the country and disaster suffered provinces, promptly giving the strongest supports to fight against floods and to provide better relief for the disasters. Meanwhile, these precious remotely sensed data also provide scientific bases on reconstruction after the disaster, hydraulic planning and project construction for flood prevention in the future.

The heroic feat of millions of people guarding the dikes for several months during the flooding period has greatly aroused the people's patriotic enthusiasm and the feelings related to the flooding situation. The flooding events also worth to be thought deeply. Scientific planning and reasonable decision-making for the future depend on our correct understanding to the disasters having been occurred. We must take effective measures to prevent the future occurrences of the disasters and to mitigate loss caused by the disasters. Space remote sensing information which record the full process of the disaster's occurrence and development in real-time is a scientific basis for management, planning and decision making to prevent future disasters. The analyzing, processing, refining and efficient applications of remote sensing information acquired during the whole process of the flooding events are important works with profound historic and realistic significance, the work is also an arduous task. As a part of this task, the National Remote Sensing Center of China organized relevant departments to compile the atlas, and about 100 typical remote sensing images and analytical results were selected into this atlas. I expect the publication of the atlas could help us to better understand the flooding hazards, to increase our knowledge about science and technology on disaster relief, particularly for 3S technology applications to flood prevention, fighting, and disaster relief. This will help to advance the future research in this field and other relevant fields in China, and effectively control the occurrence and development of the disasters, so that to better protect people's life and property.

Under the care of the leaders from the Ministry of Science and Technology, Secretary Bureau of State Council, National Headquarters of Flood Prevention and Fighting Drought, Chinese Academy of Sciences, Ministry of Water Resources, National Bureau of Surveying and Mapping, Chinese Meteorological Bureau, and others, and also under the strong support and efficient cooperation of all departments of NRSCC and Peking University Press, the atlas was compiled successfully. Hereon, we would like to express our heartfelt gratitude to the concerned departments, leaders and experts.

As a comprehensive high technology, although remote sensing has been researched and developed for some 30 years in China, there are still some distance in comparison with the advanced level in the world. Under the condition of less investment, the scientific researchers in China have achieved considerable results, such as some individual items, in particular some application techniques have been ahead in the world. To build up a first class natural hazard monitoring and assessment operational system in China in order to provide a long term and strong technical support for preventing flood and disaster relief, there is still a long way to go and we must work hard towards this goal. According to a common rule of the natural disasters, severe drought always follows the flood, therefore, a well preparation to monitor natural disaster, especially the drought in the spring of next year must be made and it should be given more attentions.

The 21th century is the era of fast development of knowledge economy. The development of geo-spatial information technology including remote sensing, geographical information system, and global positioning system will contribute to the human being's civilization and prosperous. We sincerely hope that the scientific researchers of the remote sensing field in China continuous to keep the glorious tradition of arduous struggle and self-reliance, make concerted efforts, pool the wisdom of the masses, and strive to construct a high efficiency, practical and operational supporting system for natural disaster monitoring, assessment, and mitigation decision making in our country. We also wish that the various classes of the society stick to the old practice so as to continuously give more care and support to our works.

Li Jian

Director

Department of High Technology Development and Industrialization
and
National Remote sensing Center of China

Ministry of Science and Technology

November, 1998

第一部分 PART ONE 气象卫星遥感系统

METEOROLOGICAL SATELLITE REMOTE SENSING SYSTEM

气象卫星成功发射于本世纪六十年代初，至今已发射了数十颗卫星，广泛应用于气象和非气象领域。按其运行轨道可将气象卫星分为静止卫星和极轨卫星。其中，静止气象卫星定位于赤道上空35800 km处，以半小时或1小时的间隔对地观测，其获取资料的有效覆盖范围约为地球面积的1/3，主要用于天气系统的监测及其变化研究；极轨气象卫星是从太空约900km高度对地进行观测，其东西向每条轨道平均有效覆盖范围在25个经距以上，对同一地区的观测周期为每天2次，主要用于环境的监测，故又称环境监测卫星。目前，可接收处理资料的气象卫星主要有我国的FY-2、美国的NOAA-14和NOAA-15、日本的GMS-5和欧盟的METSAT-5等。我国还将于1999年5月发射FY-1C极轨气象卫星。气象卫星在环境遥感和灾害监测方面有着广泛的应用前景。如人们所熟悉的对洪水、森林（草场）火灾、作物长势、河口泥沙、海冰、海温、积雪、城市热岛、沙尘暴、植被等的监测以及作物估产等。

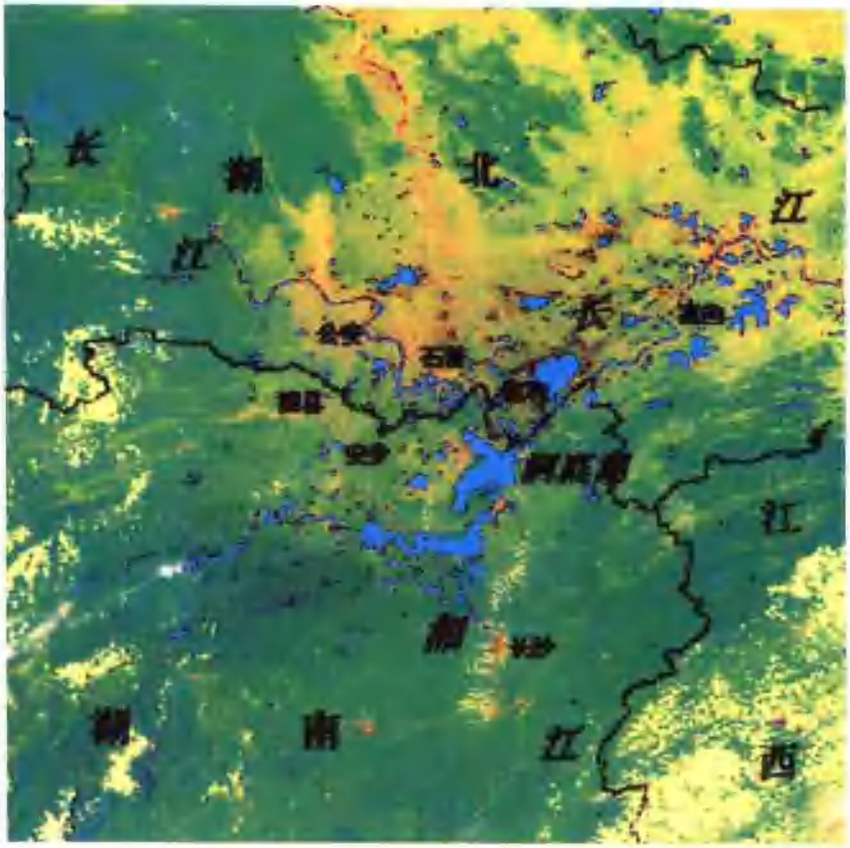
气象卫星信息具有覆盖范围广、时间分辨率高和使用成本低等特点，为开展大范围自然灾害宏观动态监测提供了有效的手段。1998年，我国长江流域和东北嫩江流域均发生的特大洪水灾害中，从5月开始国家遥感中心便利用气象卫星运行系统对七大江河流域进行日常水情动态监测。在无云和少云的情况下，利用地理信息系统和图像处理技术对卫星资料进行快速处理，并将动态监测报告和专题图像及时送交有关部门，为抗洪救灾宏观决策提供了必要的依据。整个汛期共接收气象卫星200余条轨道的监测图像，生成有效图像80余幅，提交监测报告近70个，在防洪救灾中发挥了重要作用。

The first meteorological satellite was launched successfully in the beginning of 1960s. Since then, dozen meteorological satellites have been operated and applied in meteorological and non-meteorological fields. There are two types according to operating orbits. One is geostationary meteorological satellite, which is located at 35800km above the equator, and scans the earth once one or half an hour. The data covers about one third of the earth surface, and the major objective is to monitor and research weather system. The other is polar orbit meteorological satellite, which scans the earth from the altitude of about 900km twice a day for a given area. The effective coverage in east-west direction is more than 25 longitude degrees. It is intended for environment monitoring, so also called environment monitoring satellite. At present, the available data in China can be received and precessed from FY-2 (China), GMS-5 (Japan), METSAT-5 (Europe), NOAA-14、NOAA-15 (USA), etc. In May 1999, the third Chinese polar orbit meteorological satellite (FY-1C) will be launched. The satellite data may play an important role in environment remote sensing and natural disaster monitoring, such as the monitoring of flood, forest fire, sea ice, snow cover, urban hot island, dust storm, vegetation, sea surface temperature detection, crop monitoring and production estimation, etc.

With the advantages of large coverage, high temporal resolution and low cost in use, meteorological satellite is a very useful tool for monitoring natural disaster dynamically. In the summer of 1998, severe floods happened in the Yangtze River and Nenjiang River. From the beginning of May, National Remote Sensing Center of China began to use meteo-satellite remote sensing system to monitor floods in the seven major river areas every day. In the clear or less cloudy conditions, satellite data were quickly processed based on GIS and image processing techniques. Thematic pictures and reports produced by the system were sent to the decision-making departments in real time. During flooding period in 1998, satellite data of more than 200 orbits were received and about 80 usable images were conducted to produce about 70 reports. The system played an important role in flood monitoring.

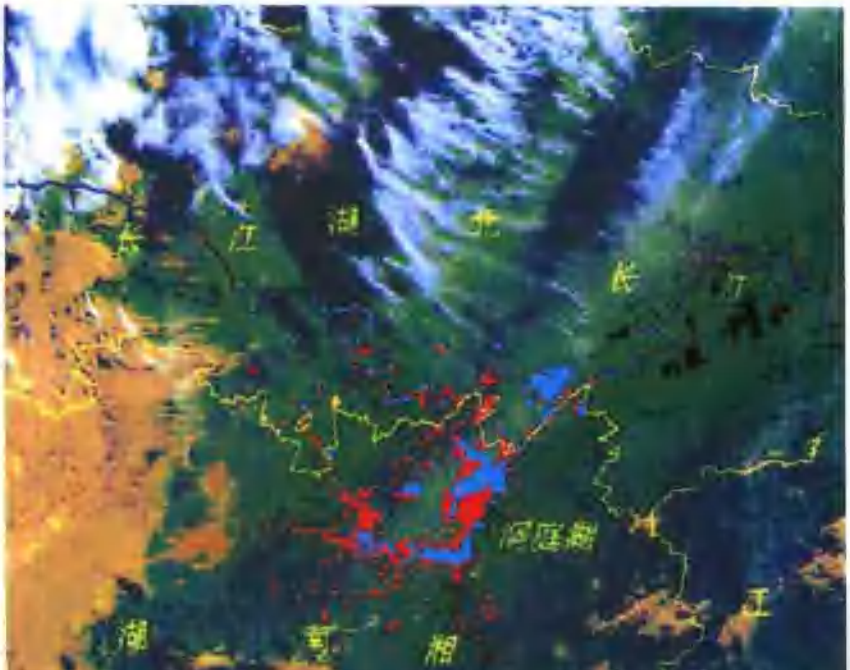
1-1/1998年5月25日气象卫星对洞庭湖地区的水情监测图。图中蓝色为水体范围。

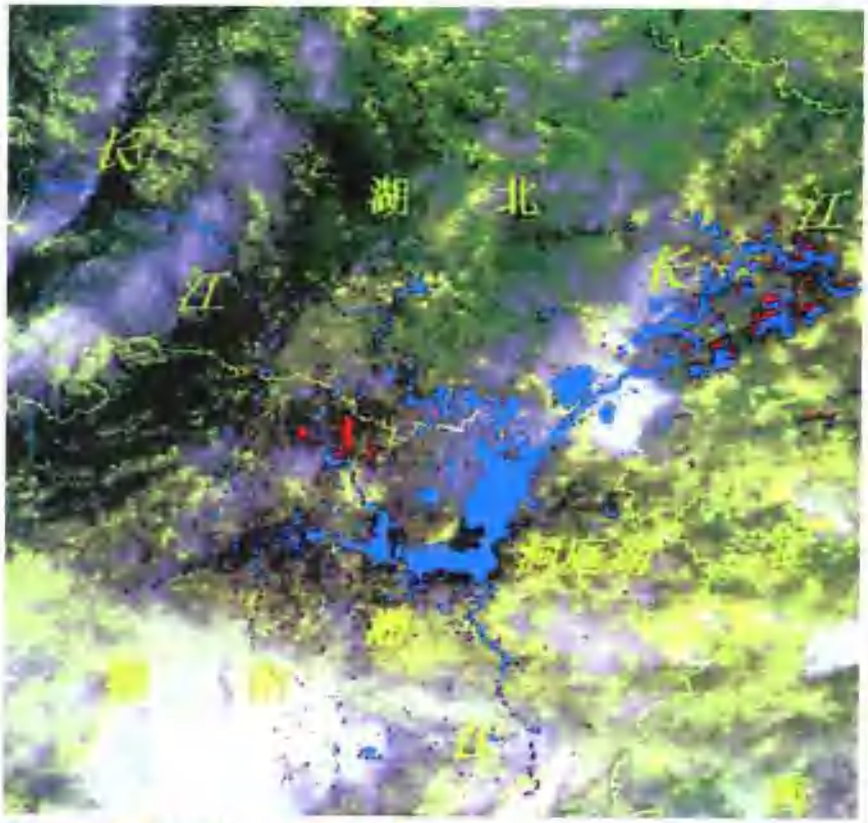
1-1/ Water monitoring in Dongting Lake area with NOAA/AVHRR data (May 25,1998). Blue color represents water body.



1-2/1998年7月6日7时气象卫星对洞庭湖地区的水情监测图。与1998年5月25日该地区气象卫星水情图相比，洞庭湖及周围地区的水体范围明显增加，水体增大面积约为2364km²(红色)。

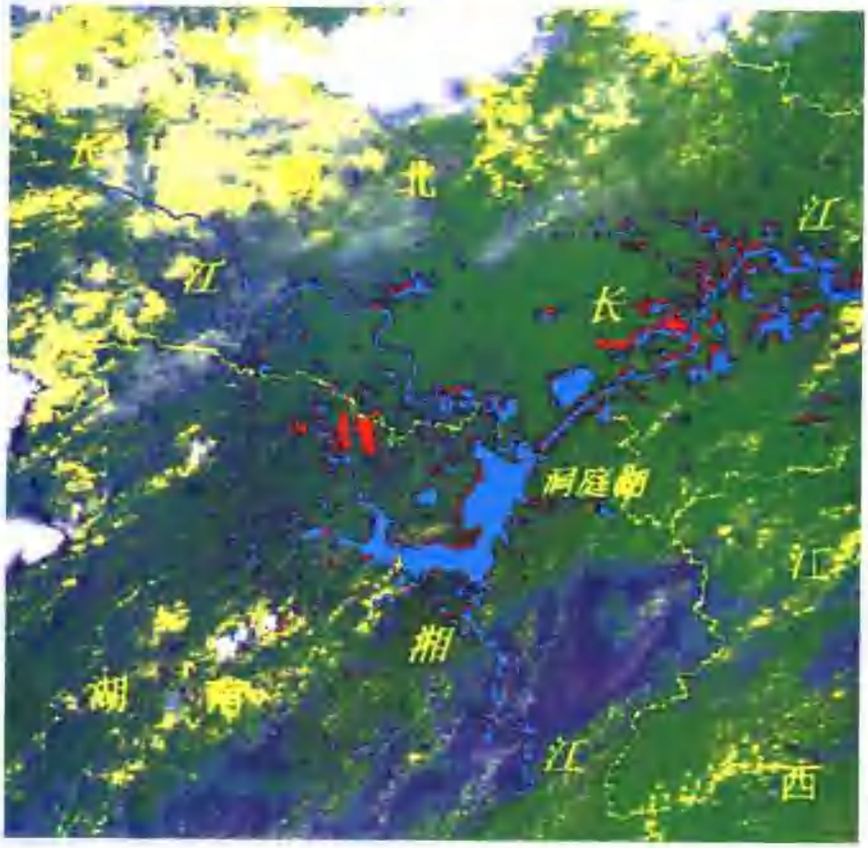
1-2/ Water monitoring in Dongting Lake area with NOAA/AVHRR data (July 7, 1998). Compared with the image 1-1 (May 25,1998), water area is increased (red color).





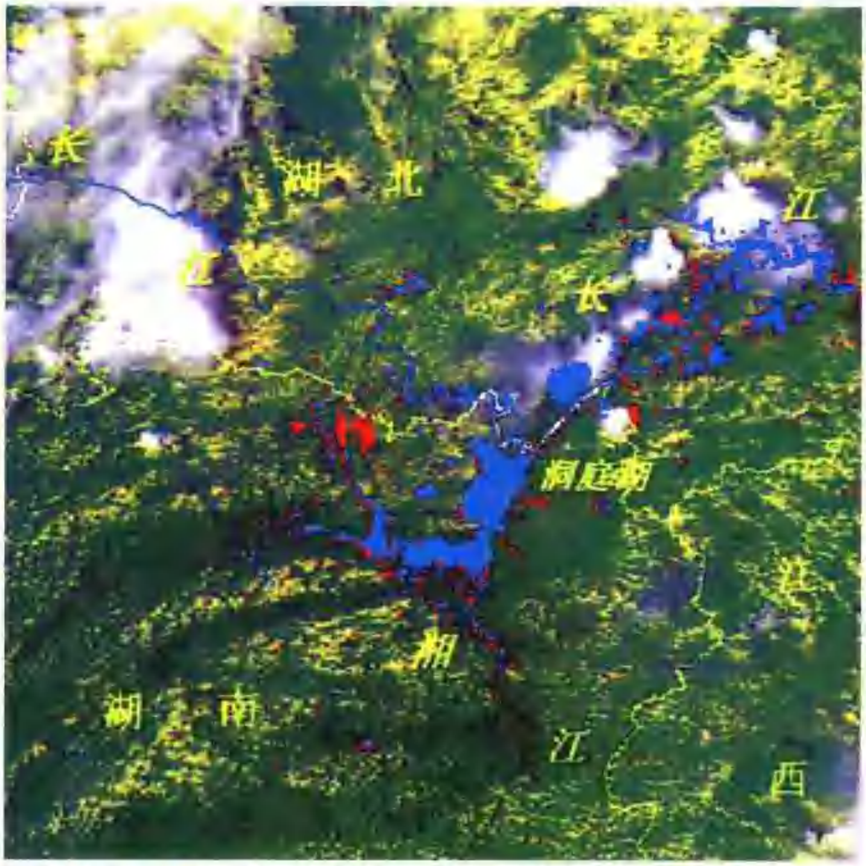
1-3/1998年7月26日15时12分气象卫星对洞庭湖地区的水情监测图。与1998年7月9日该地区气象卫星水情图相比，图中洞庭湖晴空部分水体没有明显扩大。在洞庭湖地区西北部和湖北省长江南面的水体增大范围较为明显。图中，蓝色为1998年7月9日水体范围，红色为1998年7月26日较7月9日水体扩大部分。

1-3/ Water monitoring in Dongting Lake area with NOAA/AVHRR data (July 26, 1998). Compared with the water area July 9,1998 (blue color), it is increased and marked with red color.



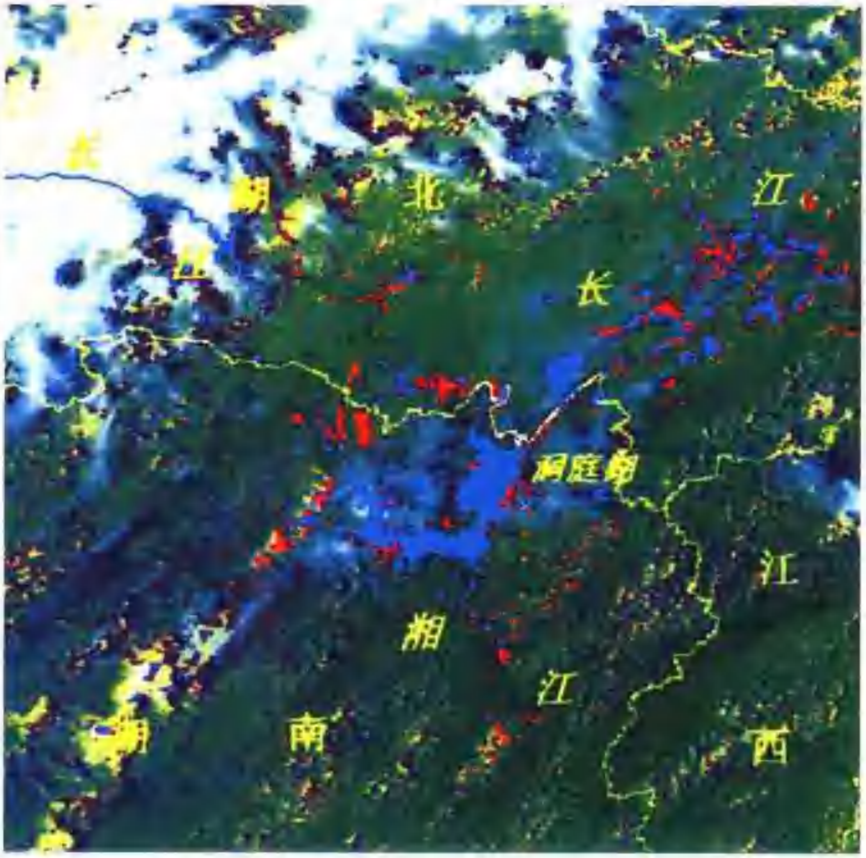
1-4/1998年8月4日15时12分气象卫星对洞庭湖地区的水情监测图。与7月9日该地区气象卫星水情图相比，洞庭湖水体略有增加，增加面积约250km²，但在洞庭湖地区西北方向（常德地区北部）有两块明显增加的水体，面积约365km²。图中蓝色为1998年7月9日水体范围，红色为1998年8月4日较7月9日水体扩大部分。

1-4/ Water monitoring in Dongting Lake area with NOAA/AVHRR data (August 4, 1998). Compared with the water body on July 9,1998 (blue color,), it is enlarged. Red color means the increasing water body.



1-5/1998年8月5日15时00分气象卫星对洞庭湖地区的水情监测图。与7月9日该地区气象卫星水情图相比,洞庭湖水体略有增加,但在洞庭湖地区西北方向(常德地区北部)仍有两块明显增加的水体,面积约360km²。图中,蓝色为1998年7月9日水体范围,红色为1998年8月5日较7月9日水体扩大部分。

1-5/ Water monitoring in Dongting Lake area with NOAA/AVHRR data (August 5, 1998). Compared with the water body on July 9,1998 (blue color), the water body is enlarged. Red color depicts the increasing water body.

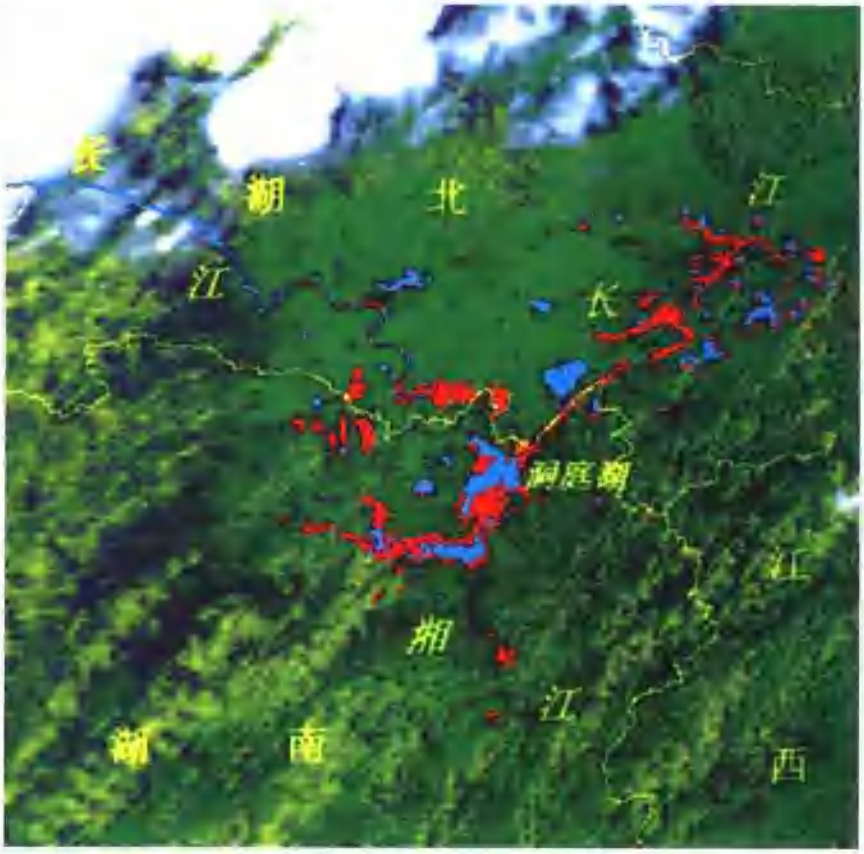


1-6/1998年8月8日14时27分气象卫星对洞庭湖地区的水情监测图。与7月9日该地区气象卫星水情图相比,湖北省荆州地区石首、监利、公安、江陵、仙桃等县,咸宁地区嘉鱼等县,湖南省常德地区北部澧县,安乡等县有明显增加的大片水体。反映了当地的洪涝情况。图中蓝色为1998年7月9日水体范围,红色为1998年8月8日较7月9日水体扩大部分。

1-6/ Water monitoring in Dongting Lake area with NOAA/AVHRR data (August 8, 1998). Compared with the water body on July 9,1998 (blue color), the increasing water body (red color) is very obvious.

1-7/1998年8月9日14时15分气象卫星对洞庭湖地区的水情监测图。与5月25日该地区气象卫星水情图相比,湖北省荆州地区石首、监利、公安、仙桃等县,咸宁地区嘉鱼等县,湖南省常德地区北部澧县、安乡等县有明显增加的大片水体。图中蓝色为1998年5月25日水体范围,红色为1998年8月9日较5月25日水体扩大部分。

1-7/ Water monitoring in Dongting Lake area with NOAA/AVHRR data (August 9, 1998). Compared with water area on May 25, 1998 (blue color), it is enlarged obviously. Red color depicts the increasing water body.



1-8/1998年8月10日14时05分气象卫星对洞庭湖地区的水情监测图。与8月4日该地区气象卫星水情图相比,洞庭湖水体无明显增加。湖北省监利县水体增大约64km²,石首县水体增大约53km²。图中蓝色为1998年8月4日水体范围,红色为1998年8月10日较8月4日水体扩大部分。

1-8/ Water monitoring in Dongting Lake area with NOAA/AVHRR data (August 10, 1998). Compared with the water area on August 4, 1998 (blue color), it is enlarged. Red color depicts the increasing water body.