Research Center for Digital Mountain and Remote Sensing Application, Institute of Mountain Hazards and Environment

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MountainPlatform

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The Research Center for Digital Mountain and Remote Sensing Application at the Institute of Mountain Hazards and Environment (IMHE), Chinese Academy of Sciences (CAS), is a research unit specially focusing on developing key geospatial techniques based on geographic information systems and remote sensing methods. The purpose of this research is to dynamically monitor, evaluate, and assess the mountain eco-environment, especially in the mountain areas of southwest China, but also extending to the whole of South Asia. By applying multisource remote sensing observations at different spatial scales (point, local, regional, and continental) and using different data sources (in-situ measured, air-based, and space-based), the Center aims to develop key quantitative remote sensing methods for mountain areas and to construct an integrated platform for mountain geo-information sharing and application. Based on these tools and activities, it seeks to provide scientific evidence and technical support for related research in the fields of mountain eco-environment, mountain geohazards, and mountain development in China.

Brief introduction

The beginning of the Research Center for Digital Mountain and Remote Sensing Application was founded in 1965. At the beginning, the establishment of this unit aimed to scientifically support the economic and social development of southwest China, especially through map design and production. During the 1970s to 1990s, with the development of satellite remote sensing and geoinformatic techniques, it was generally realized that earth observation has an unparalleled advantage over traditional field measurements in monitoring of mountain eco-environments at different spatial and temporal scales. Therefore, key scientific issues related to mountain remote sensing and digital mountain techniques have gradually become the Center's major concerns since 2002. Given the rather striking differences in topographic characteristics and the various special ecosystem structures and functions of mountains, the application of spatial information technology in mountain areas still faces many challenges worldwide. The development of spatial information techniques and their application in mountain areas has become the core of the Center's studies.

The Research Center has 18 faculty members (Box 1). It has a very young research team with an average age of about 38 years. The Center shows great academic activity and always seeks to provide technical support for sustainable development and eco-environmental conservation in mountainous areas. Currently, it offers an extensive educational program, including a Master's program in Cartography and Geographical Information Systems, a doctoral program in Mountain Remote Sensing, and postdoctoral positions. All the educational programs are open to both Chinese and international students.

Major research directions

The Center's goals are to (1) build a data storage, processing, analysis, and sharing platform for basic spatial information on mountainous regions in China, (2) develop comprehensive and integrated research methods based on geospatial information science and technology, and (3) provide a scientific basis for mountain development and support the implementation of the national mountain development strategy for promoting harmony, progress, and prosperity in mountain areas. Currently, the Center's major research foci are the following:

1. Mountain remote sensing modeling, mapping, and monitoring technologies;
2. Creation of a digital platform for integrative studies focusing on the interrelations between mountain environments, geohazards, and economic, social, and environmental sustainability;
3. Unmanned aerial vehicle (UAV) remote sensing technology and

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Box 1: Staff composition

- **Professors (2)**
  Including a winner of the Ten Thousand Plan, a high-level national talent-support plan; and a member of the One Hundred Talents Project of the Chinese Academy of Sciences.
- **Associate professors (5)**
  Including a candidate of the One Hundred Young Talents Program of the Institute of Mountain Hazards and Environment and 2 Western Light Scholars of the Chinese Academy of Sciences.
- **Assistant professors and research assistants (10)**
- **Administrative staff (1)**

FIGURE 1 Land cover map of southwest China in 2010.
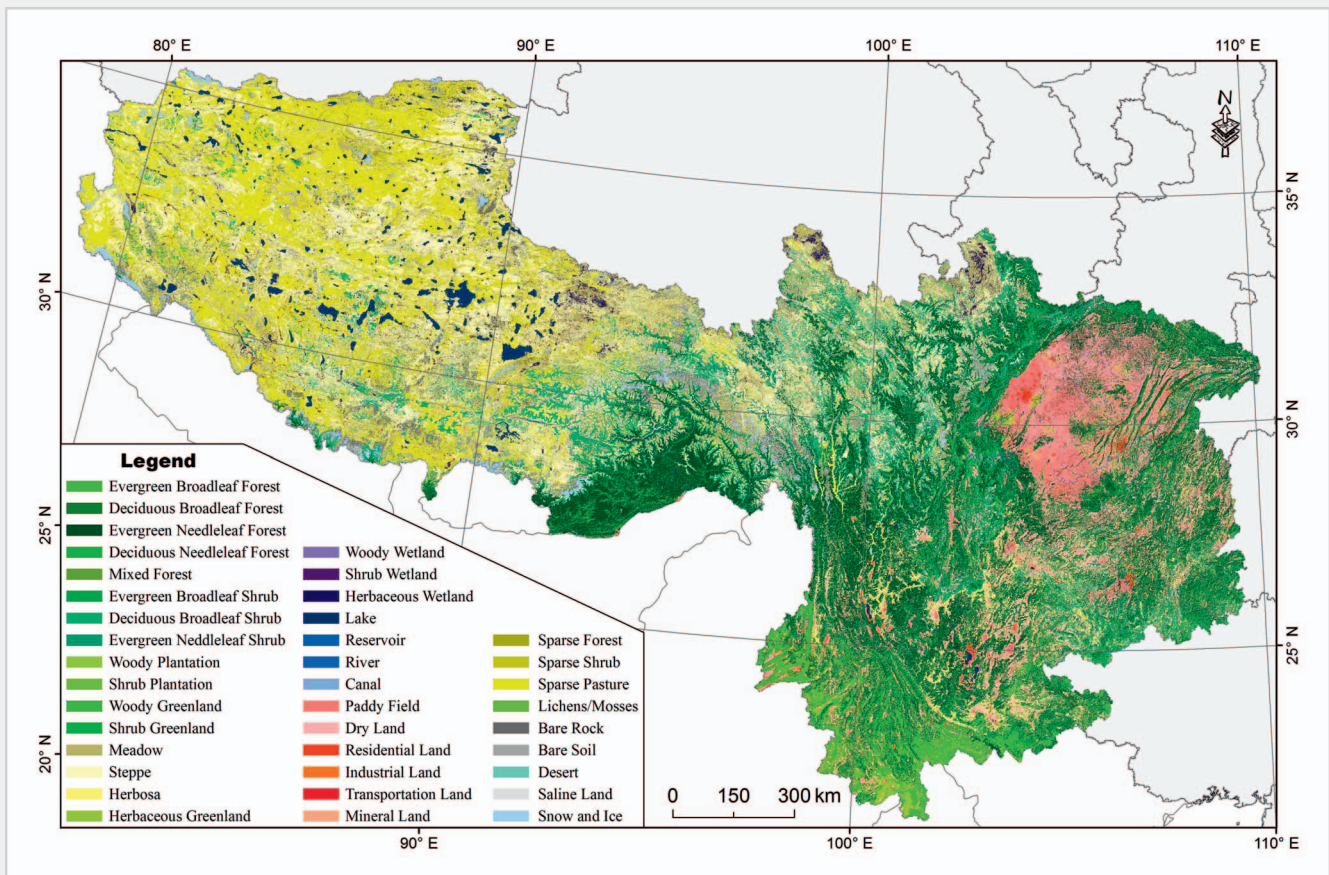
application over mountainous areas;
4. Integration, sharing, and visualization of geospatial information for mountain areas.

Representative achievements in the past 10 years

During the past 50 years, the Center has successfully filled many important scientific gaps and won recognition and praise from domestic and foreign counterparts. In the past 10 years, it achieved significant progress in scientific research related to frontier issues in mountain remote sensing and has extended its studies in different aspects (Li et al 2016; Li, Bian, et al 2018), including (1) mechanisms of interaction between electromagnetic signals and mountain land surfaces and related modeling theory; (2) spatial–
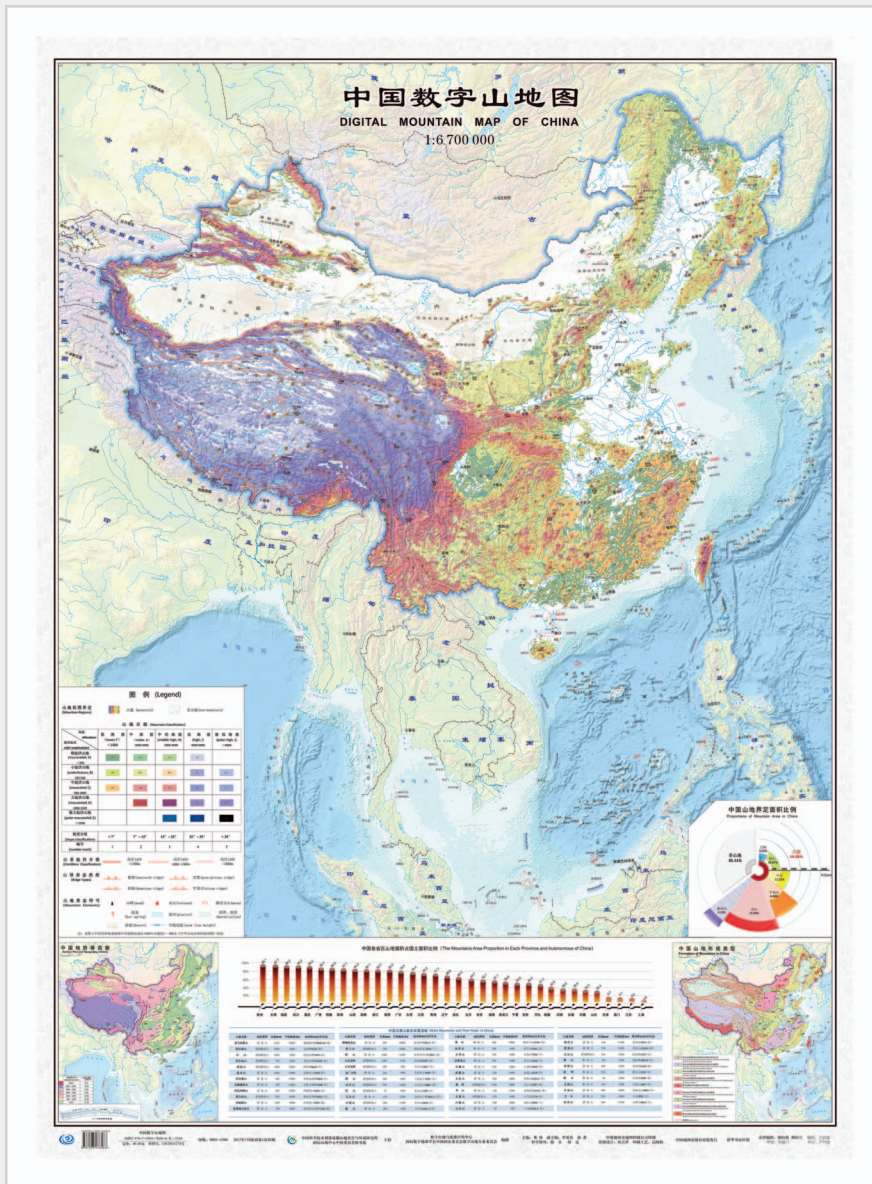
temporal–spectral normalization methodologies for remote sensing data over mountains; (3) remote sensing modeling, retrieval, and assimilation methodologies for land surface information in mountain areas; (4) scaling effects and validation of remote sensing products in mountain areas; and (5) integrated applications of remote sensing information for mountain studies. This progress is described in more detail below.

1. From 2010 to 2018, the Center established a series of mountain radiometric transfer models and algorithms for image spatial, temporal, spectral, and angle normalization. It broke the setting of model boundaries and the assuming of flat scenes in the existing radiation transmission model, modeled the special mechanism of radiometric transfer

on slope surfaces, and improved the spatio-temporal consistency, continuity, and usability of remote sensing images in mountain areas.
2. Since 2017, the Center has conducted research on retrieving key ecological parameters such as the leaf area index (LAI) and net primary productivity (NPP) in mountain areas by choosing different topographic gradients and vegetation backgrounds, evaluating their spatio-temporal representativeness, and analyzing the influence of complex terrain on remote sensing signals and remote sensing products; it expects to achieve a breakthrough in the theory and methodology of retrieving ecological parameters in mountain areas.
3. From 2010 to 2016, the Center established a series of new land cover classifiers and mapping approaches for mountain areas.

FIGURE 2 Digital mountain map of China.

5. Southwest China has experienced a number of natural disasters, including catastrophic earthquakes and landslides, leading to tremendous loss of life and property in local communities. Since 2008, the Center has made great efforts to support disaster risk mitigation, including by offering high-resolution UAV observation and mapping, distributing geospatial information and remote sensing data, providing a post-earthquake inventory of secondary disasters, and developing an eco-environmental assessment of disaster areas.
6. The center has also published more than 5 monographs with atlases, including *Mountain Remote Sensing, Geography of South Asia, Land Cover Change and Its Eco-environmental Responses in Nepal, Walking into the World of Maps*, and *Digital Mountain Map of China* (Figure 2).

International cooperation

In recent years, the Center has built a strong academic cooperation relationship with universities and institutes from more than 20 countries and regions. Cooperative agreements have been signed with universities or research units, including Tribhuvan University in Nepal, the International Centre for Integrated Mountain Development (ICIMOD) in Nepal, the Institute of Space Technology in Pakistan, the University of Dhaka in Bangladesh, the Mizoram University (Central) in India, and the Institute of Information Technology in Sri Lanka. With the development of the BAR initiative, the Center will promote international cooperation with countries along the BAR economic corridors. In November 2018, the Center organized the first international workshop in South Asia on eco-environmental monitoring and assessment along these corridors.

These were successfully applied in the development of national-level land cover mapping of areas such as southwest China, Nepal, and Pakistan, leading to the most integrative and accurate land cover map to date for this region (Figure 1).
4. Since 2016, the Center has been providing spatial information services for South Asia cooperation and eco-environmental monitori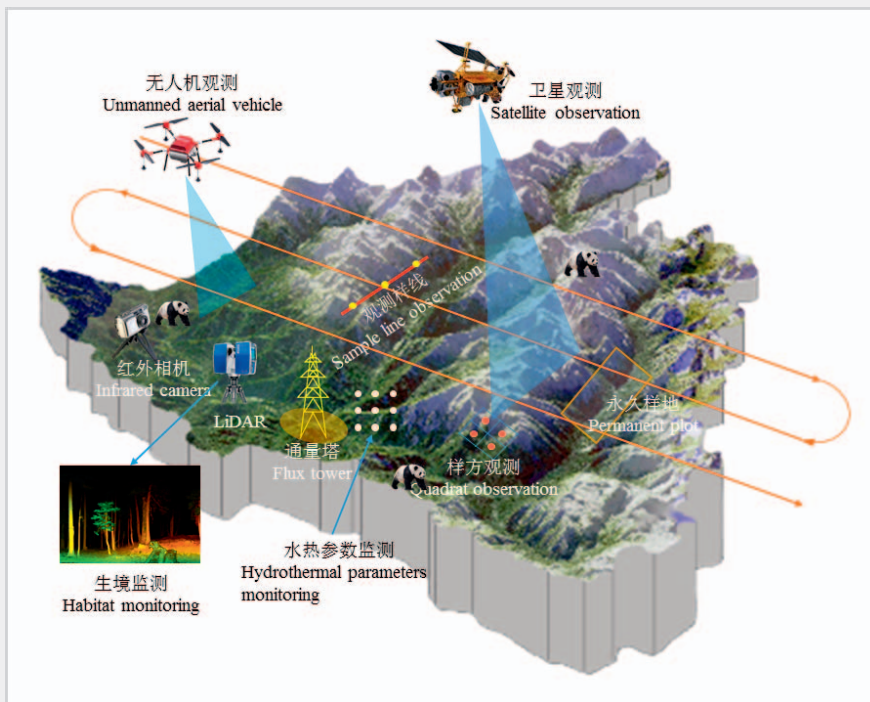ng along the key economic corridors of the Belt and Road (BAR) Initiative. The Center is producing high-quality eco-environmental parameter datasets and quantitatively assessing the structure, quality, function, eco-services, changes, and risks of the major ecosystems along these economic corridors. It will finally build a platform and offer a spatial information service for eco-environmental monitoring along the corridors.

FIGURE 3 Conceptual design of the Wanglang integrated observation and experimental station, which incorporates integrated space-, air-, and field-based remote-sensing observation.

Center for Digital Mountain and Remote Sensing Application has made great progress in competing for scientific projects, publishing high-quality academic papers, training personnel, and facilitating scientific research cooperation. In the future, the laboratory will continue to strive toward the following objectives:

- Deepening research in mountain remote sensing theories and methods;
- Enhancing the application of remote sensing to topics in the field of mountain eco-environment and hazards;
- Establishing an international base or a scientific platform for digital mountains;
- Finally, serving the aims of national mountain ecological security construction and sustainable development in mountain areas.

Scientists from South Asia exchanged ideas about the eco-environmental status, key issues, and monitoring and assessment technologies in South Asia.

Integrated field observation station for mountain remote sensing

To accelerate the technical development of mountain remote sensing theories and methods and increase the ability of remote sensing to effectively monitor mountain eco-environment, the Center established the first integrated field platform for mountain remote sensing in China, the Wanglang integrated observation and experimental station for mountain ecological remote sensing (Li, Yin, et al 2018).

The station is located in the Wanglang Nature Reserve, one of China's first nature reserves, established to protect the giant panda in 1965. The reserve covers about 320 km^2 with elevations ranging between 2000 and 5000 m. The average yearly rainfall is 862.5 mm, with the a mean low air temperature of −6.1°C in January and a mean high air temperature of 12.7°C in July. The major vegetation types include deciduous forest, mixed conifer-deciduous forest, and conifer forest.

Currently, continuous field measurements of biophysical variables (including carbon flux, leaf area index, fractional vegetation cover, and fraction of absorbed photosynthetically active radiation) is being carried out to support the parameterization, calibration, and validation of the remote sensing and land surface process models. The station has multiple observation systems, including field-based, tower-based, air-based, and space-based—involving different footprints (Figure 3). The station will be an ideal platform for analyzing interaction mechanisms for mountain eco-environmental monitoring and assessment.

Perspectives

Under the leadership of Professor Ainong Li, its director, the Research

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