中國科学院光电研究院
ACADEMY OF OPTO-ELECTRONICS,CHINESE ACADEMY OF SCIENCES

Introduction to Academy of Opto-Electronics (AOE), Chinese Academy of Sciences(CAS)

Chuan-rong Li

Vice President

Academy of Opto-Electronics (AOE),
Chinese Academy of Sciences (CAS)

May 13, 2013

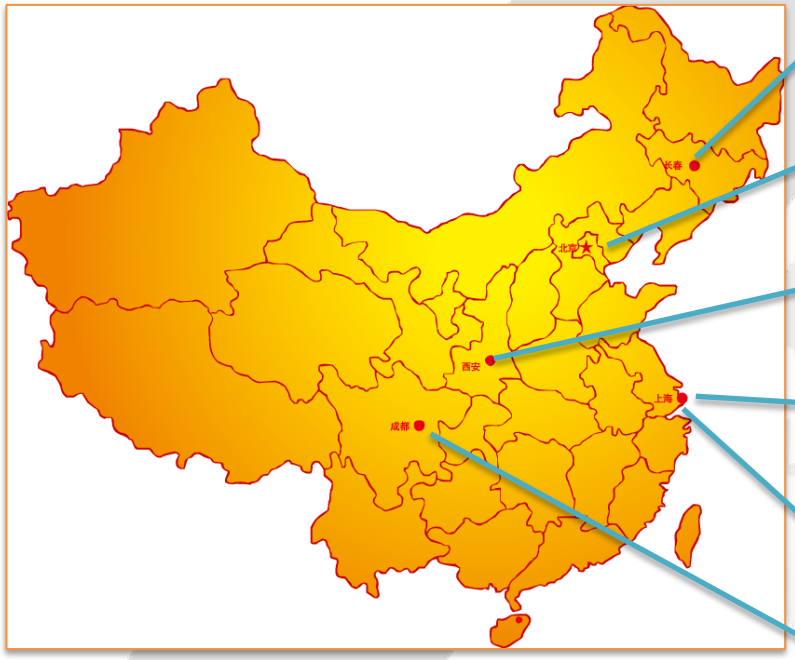
Outline

- **Brief Introduction**
- EO Research Activities in AOE
- Prospect

- In order to enhance the development of space and opto-electronic science and technology, Chinese Academy of Sciences (CAS) decided to establish a new research institute in 2003, named as Academy of Opto-Electronics (AOE).
- AOE has research and experiment facilities in two buildings with total area of 31160m^2 in the Beijing Advanced Technology Facility of CAS. Another building about 22000m^2 is in process.

中国科学院北京新技术基地光电研究院气球实验楼项目

- One of AOE's mandates is to coordinate and collaborate with other five brother opto-electronical research institutes in four other cities of China.

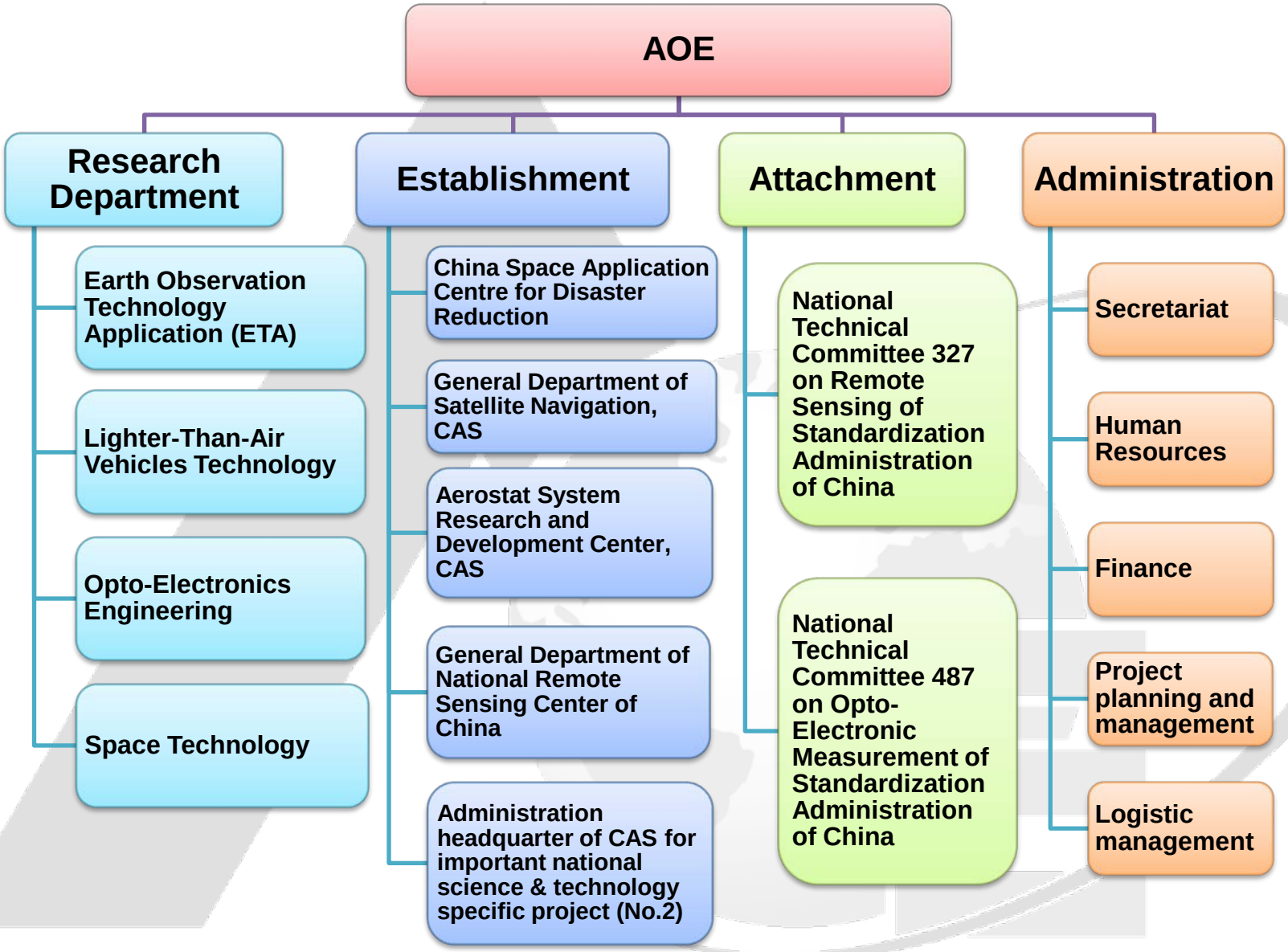


- Changchun Institute of Optics, Fine Mechanics Physics
- Academy of Opto-Electronics
- Xi' an Institute of Optics & Precision Mechanics
- Shanghai Institute of Technical Physics
- Shanghai Institute of Optics & Fine Mechanics
- Chengdu Institute of Optics & Electronics

VIR

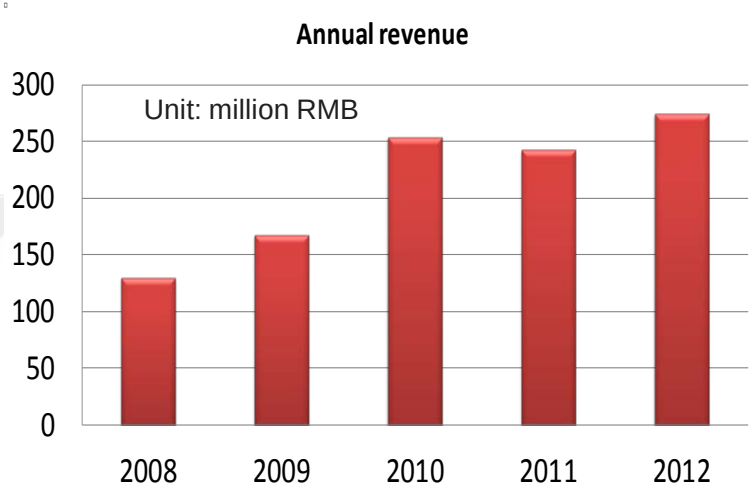
Charg'e-1
CCD/Imaging spectrometer
/Laser altimeter

Brief Introduction



Personnel Structure and Revenue

- At present, there are about 300 staff and 177 postgraduate students.



- Since 2008, the average annual revenue of AOE reached over 200 million RMB.

Outline

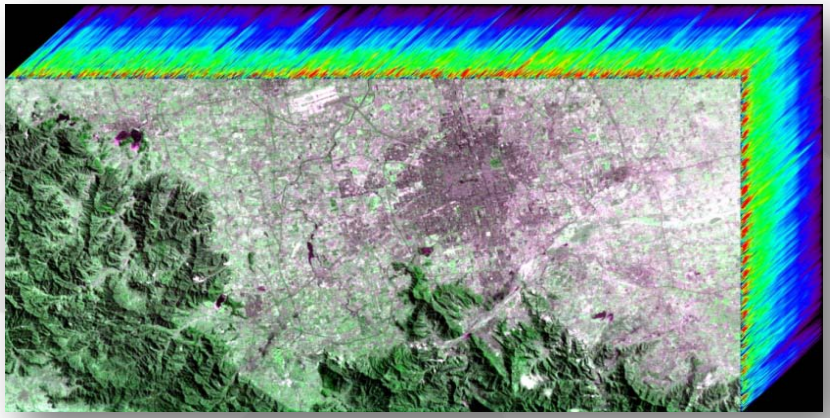
- Brief Introduction
- **EO Research Activities**
- Prospect

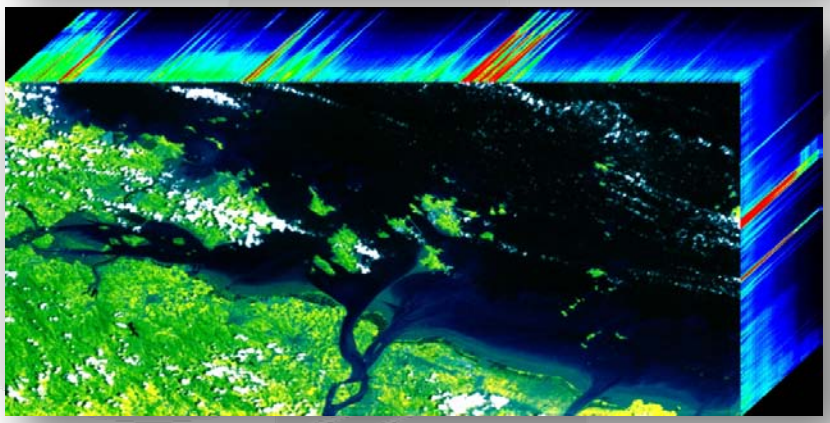
Remote sensing platform — Lighter-Than-Air Vehicles Technology

- Tethered balloon and high altitude balloon system design and manufacture
- Stratosphere airboat technology

Advanced Imaging Technology — HJ-1A satellite hyperspectral imager

HJ-1A satellite hyperspectral imager is Chinese first spaceborne hyperspectral imager, and also the world's first civilian spaceborne imaging Fourier Transform Spectrometer by spatial modulation of the interferometric mechanism.



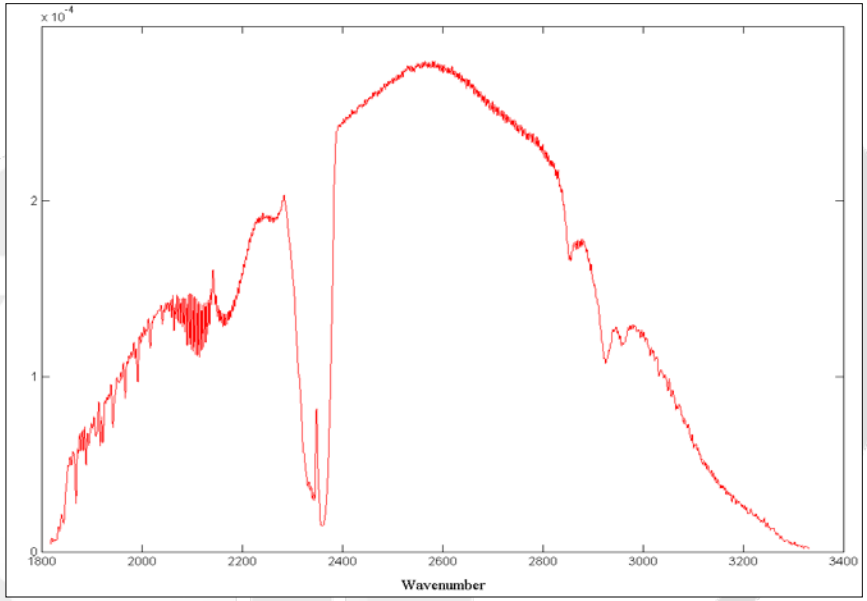


- **Swath width** 50km
- **GSD** 100m
- **Spectral Rang** 0.45~0.95μm
- **Bands number** 115
- **Launch time** 2008.9.6

Advanced Imaging Technology — Fourier Transform Spectroscopy

High spectral resolution Fourier transform spectroscopy, with high stabilization.

Fourier transform spectrometer



Absorption spectrum of the CO

Advanced Imaging Technology — Light Field Imaging

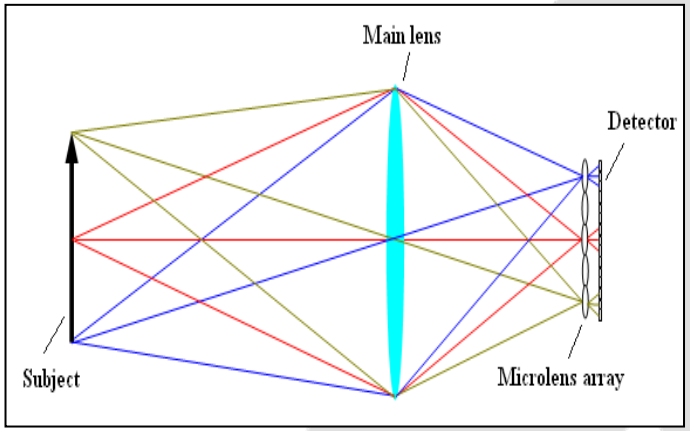
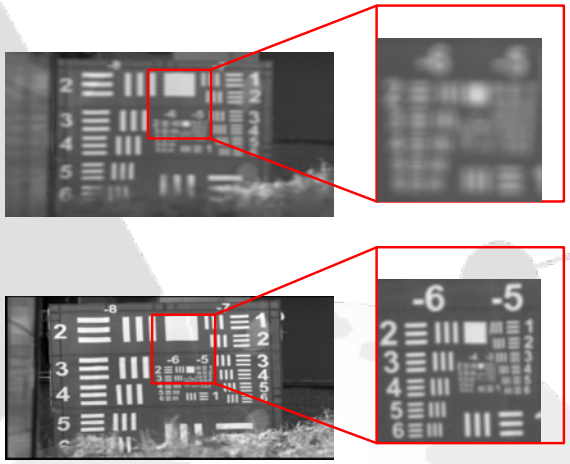


Diagram of light field imaging



Top: defocused image
Bottom: recovered sharp image

Light Field Imaging

Shoot first, focus later

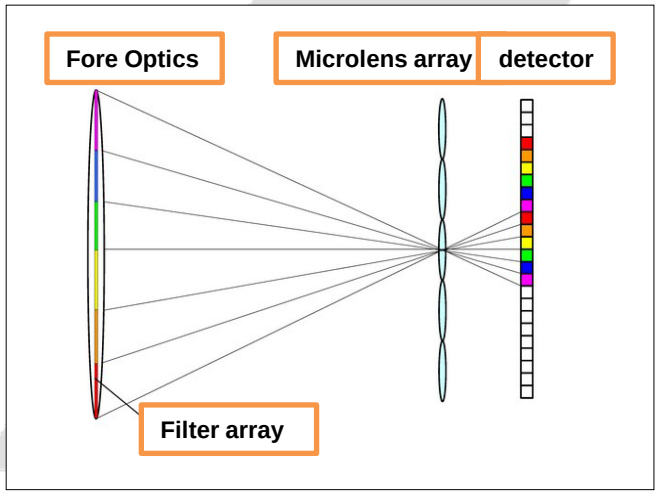


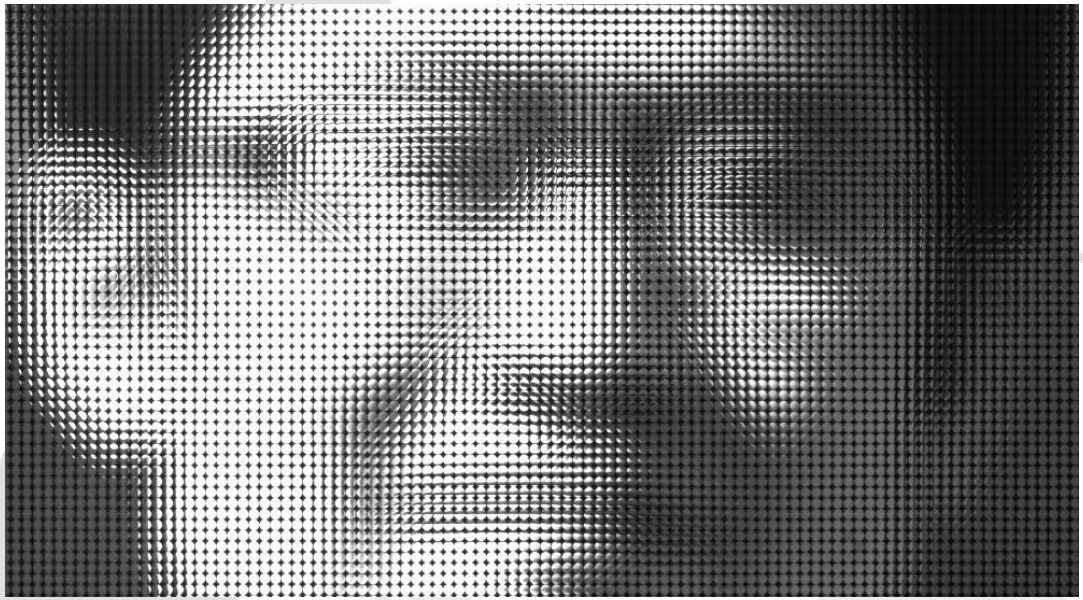
Diagram of light field spectral imaging

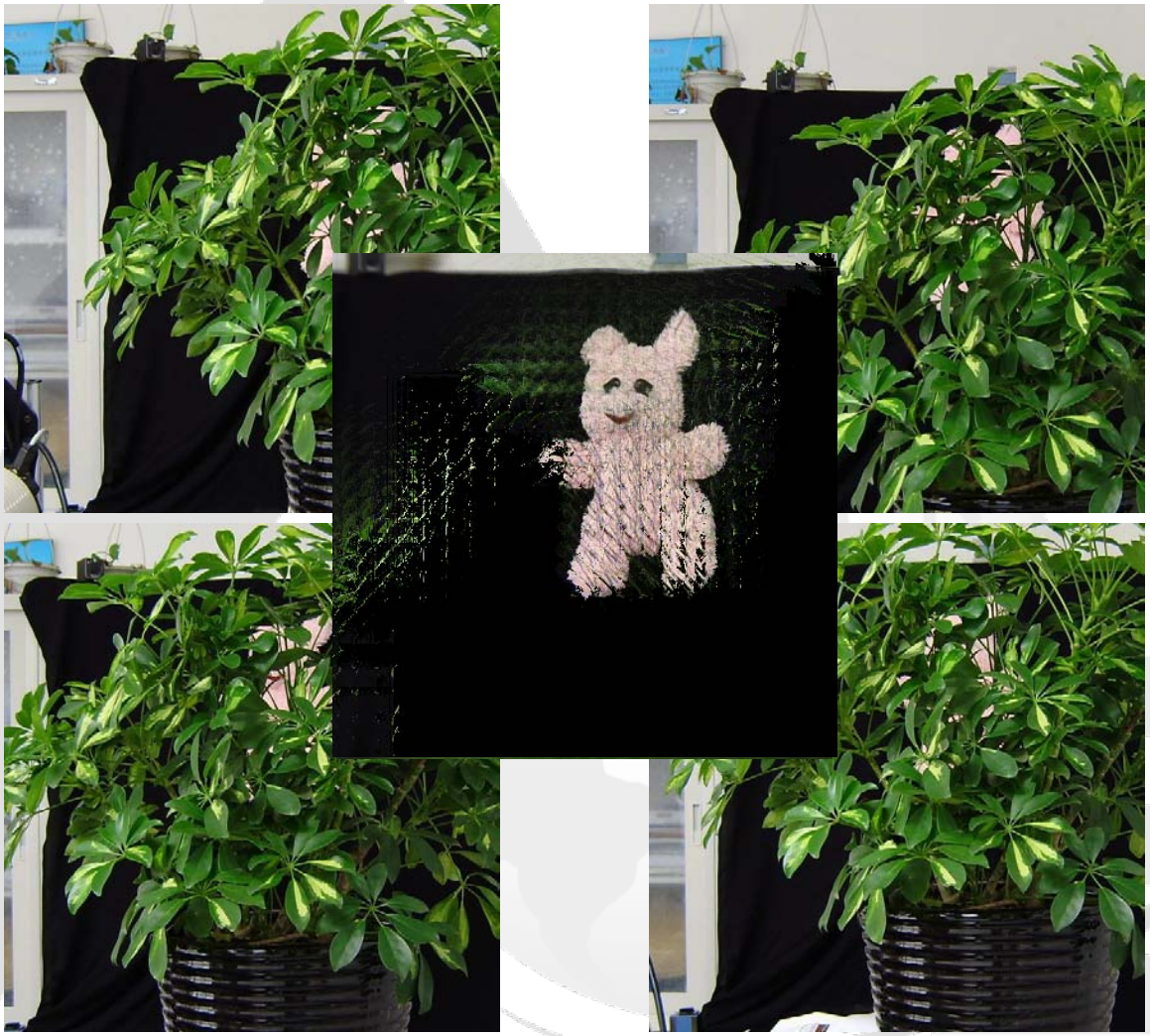
Recovered spectral images

Light Field Spectral Imaging

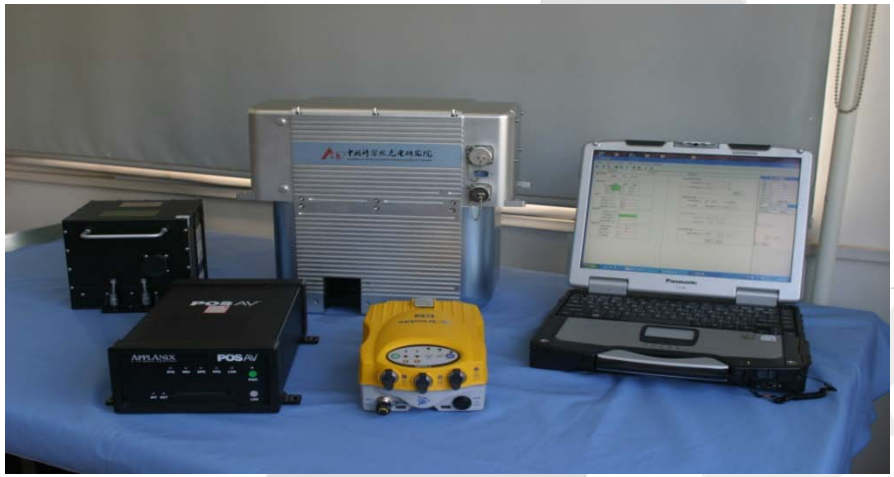
Snapshot spectral imaging, using light field theory.

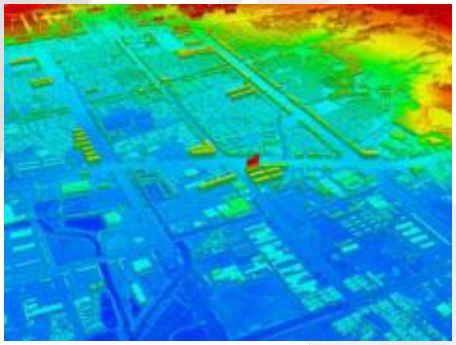
EO Research Activities





Advanced Imaging Technology — Light mini Laser Radar System



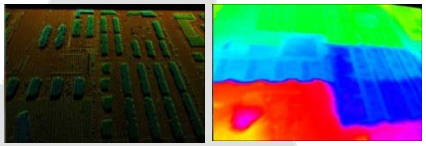


Light mini laser radar systems, compared to mainframe LIDAR is more adapted to China's mountainous topography and efficient aerial operations.

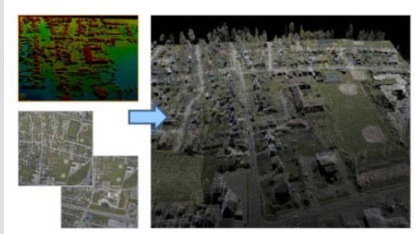
- Its simple shape, can be placed in a small box;
- Light weight and easy to carry by one person;
- High integration, integration of inertial navigation system installed including unmanned aircraft, airships and other flying platform.

Advanced Imaging Technology — Active/passive remote sensing multi-dimensional imaging

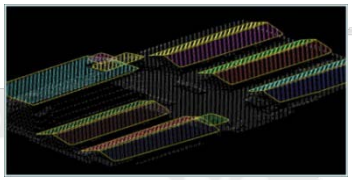
- DEM, target detection, target extraction, 3D reconstruction
- Airborne LiDAR data preprocessing, LiDAR data stripe mosaic with image constraint, DEM generation



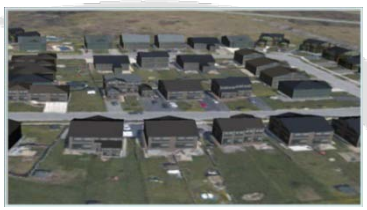
DEM extraction



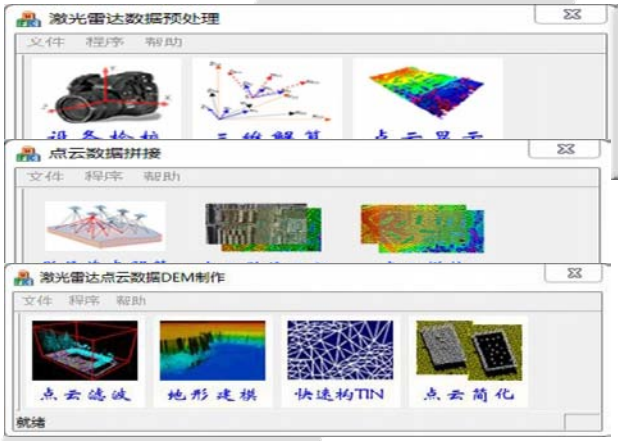
Point cloud/CCD image registration



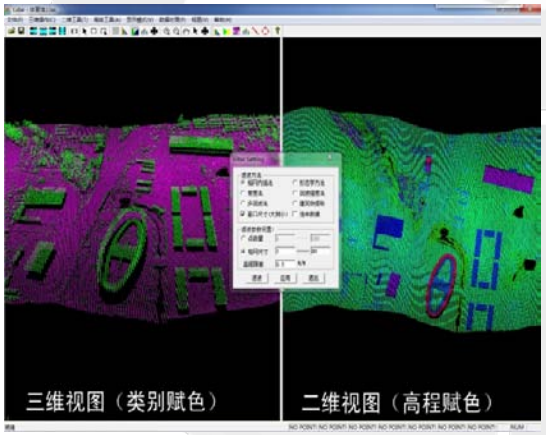
Target extraction



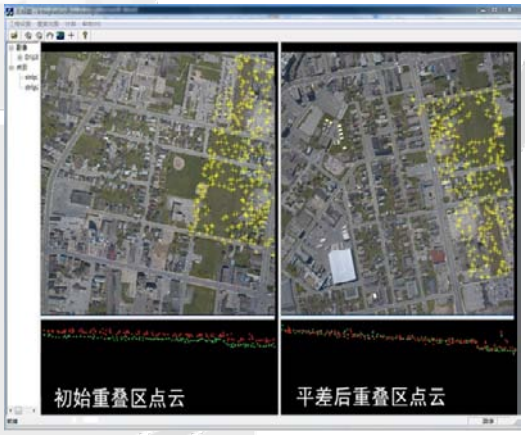
3D scene reconstruction



Airborne LiDAR data processing system



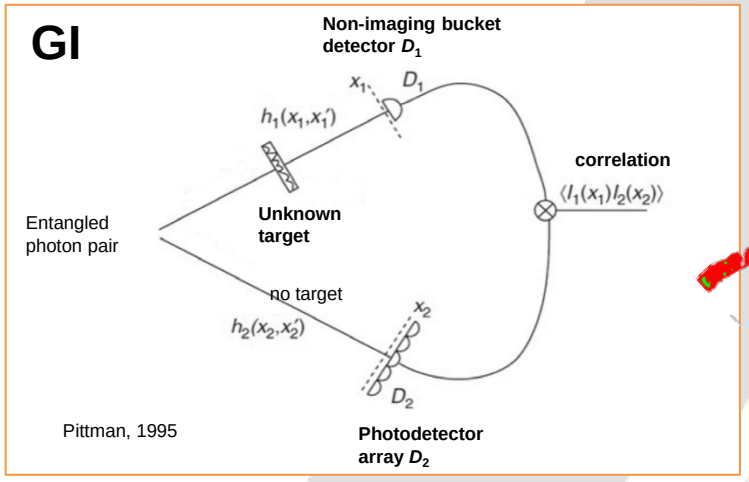
Point cloud data filtering



Point cloud data mosaic with image constraint

Advanced Imaging Technology — Intensity Correlation Imaging

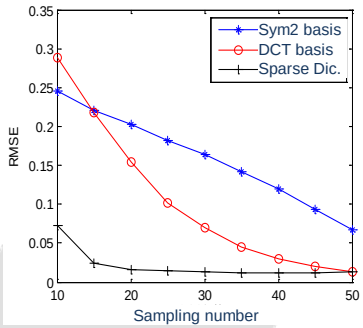
- **An extension from Ghost Imaging, with the advantage of breaking Nyquist sampling limit.**



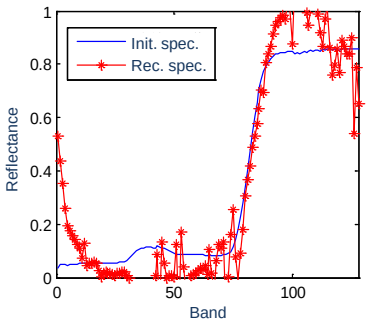
Imaging results at different measurement samples

Single pixel camera setup and results

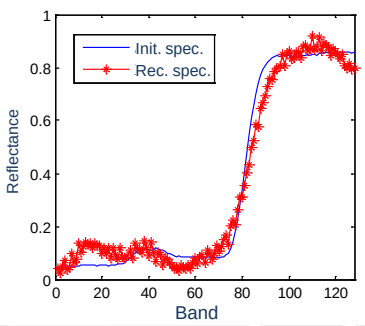
Intensity correlation imaging in the spectrum domain



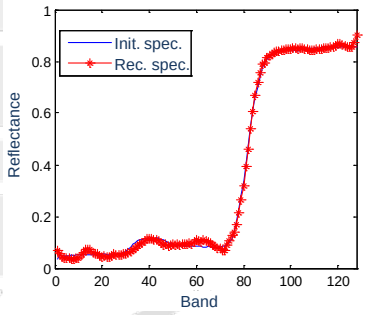
Reconstructed error under different sampling number



Reconstructed spectrum with sym2 wavelet basis



Reconstructed spectrum with DCT basis



Reconstructed spectrum with sparse dictionary

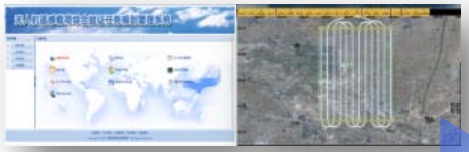
Red willow（20% sampling number） ⇨ Good reconstruction results

Remote Sensing Calibration – Development of Cal&Val system

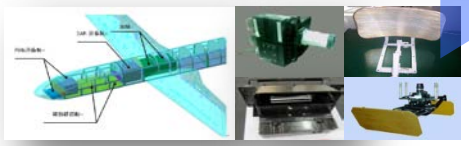
Under the support of 863 program "UAV-based Remote Sensing Payload Comprehensive Validation System", the Cal&Val technology for the remote sensing sensors has been continuously and rapidly developed.

- ✓ **UAV: low maintenance cost, flexible deploying capability**
- ✓ **System's major goal: precise validations for pre-launch sensors or on-orbit sensors**

Aerial Data Acquisition



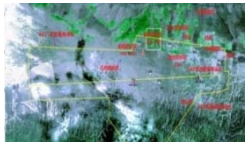
Campaign Planning and Management



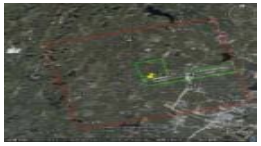
Flying platform

High Accuracy Standard Sensors

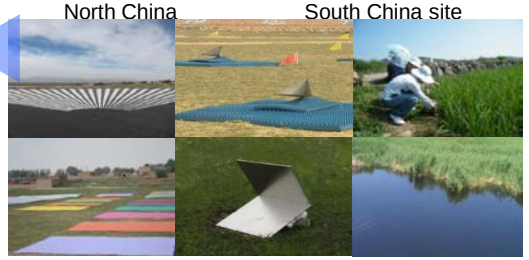
Comprehensive C&V test site



North China



South China site



Artificial and natural targets

Field & Meteorological Data Measurement

An omni-directional and multi-angle automatic observing systems

SVC Spectroradiometer

Automatic sun tracking photometer, CE318

LAI-2000 Plant Canopy Analyzer

Dynamet Weather Station

Leica TCR1202 Total Station

Payload/Calibration Performance Analysis and Product Validation

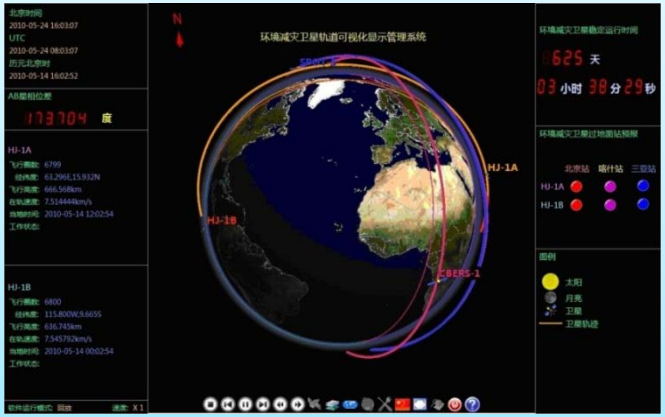
Data Processing and Analyzing System

Scientific Analysis Reports of Payload Performance

Remote Sensing Application – RS System design, development and integration

Multi-satellite resources visualization system

HJ-1 constellation 2D visualization



HJ-1 constellation 3D visualization

Operation management system

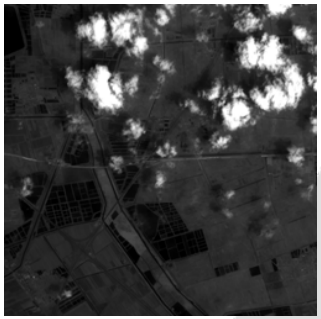
Main interface of the operation management subsystem for disaster reduction

Statistic results of task list of the operation management subsystem

Remote Sensing Application – RS System design, development and integration

Automatic Identification and Compression System of Smart Small Satellite

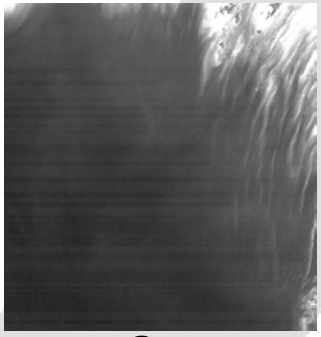
To meet the application requirements of smart earth observation for next generation small satellites, a prior imaging camera is designed and data processing hardware systems are designed for intelligent identification and compression.



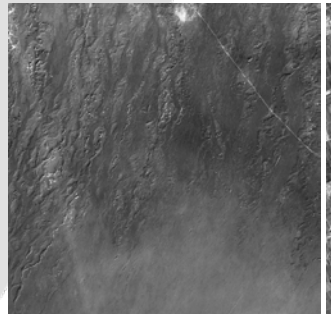
Cloud

Snow

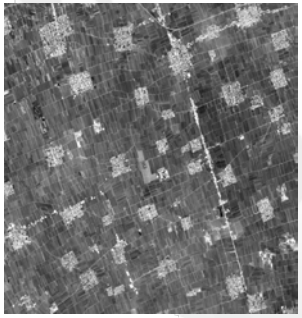
City



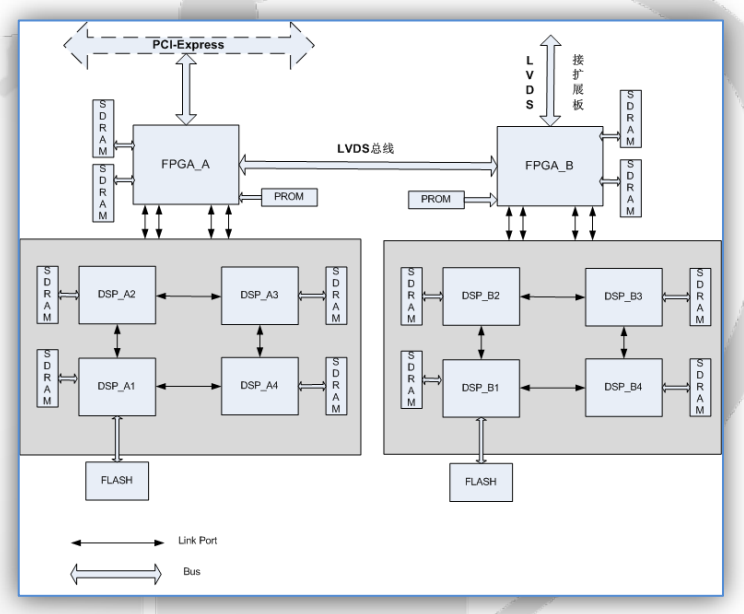
Sea



Bare Land



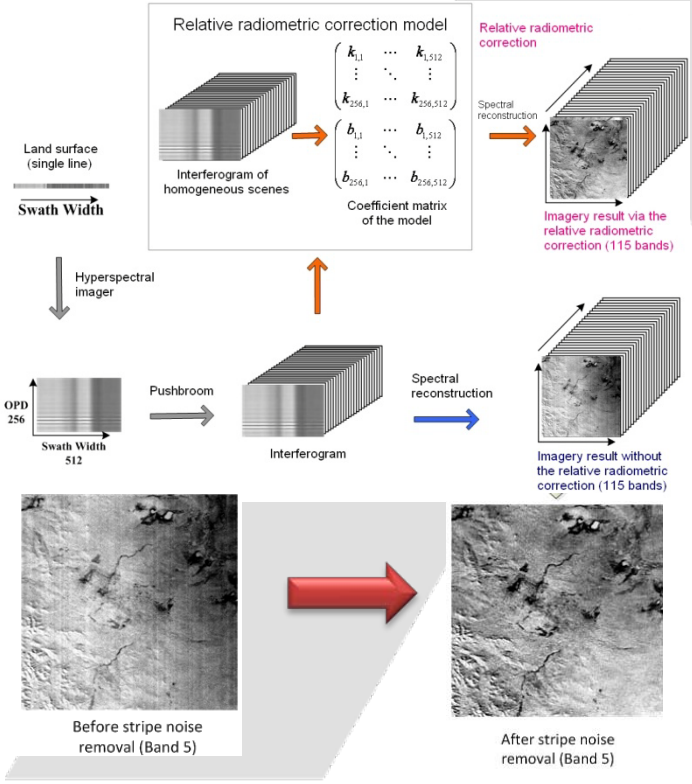
Vegetation

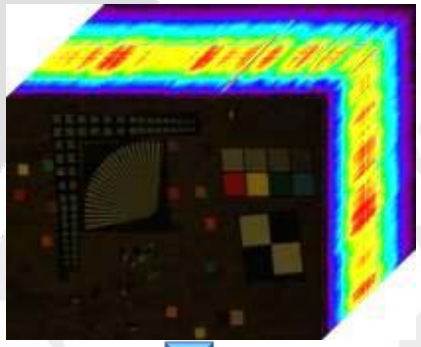


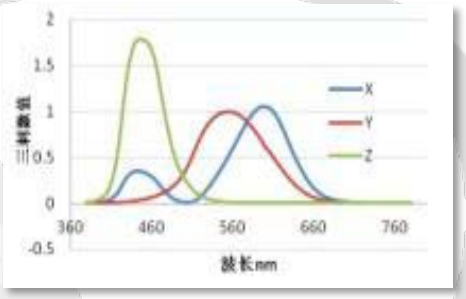
Parallel Structure of Hardware System

Remote Sensing Application – Hyperspectral data processing

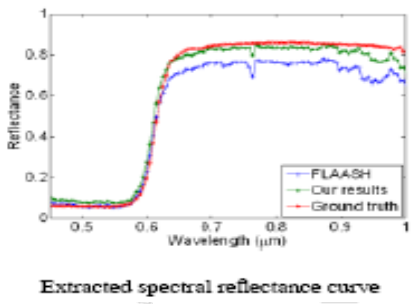
New approaches and models have been proposed, including a stripe noise removal method for the interferometric hyperspectral data, a true color calibration and correction model satisfying the human vision, a automatic scene-based hyperspectral reflectance retrieval model.







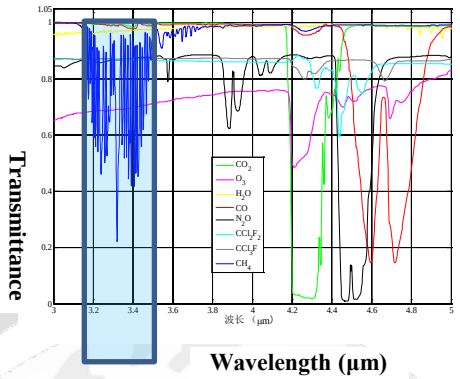
Human visual color matching function



Extracted spectral reflectance curve

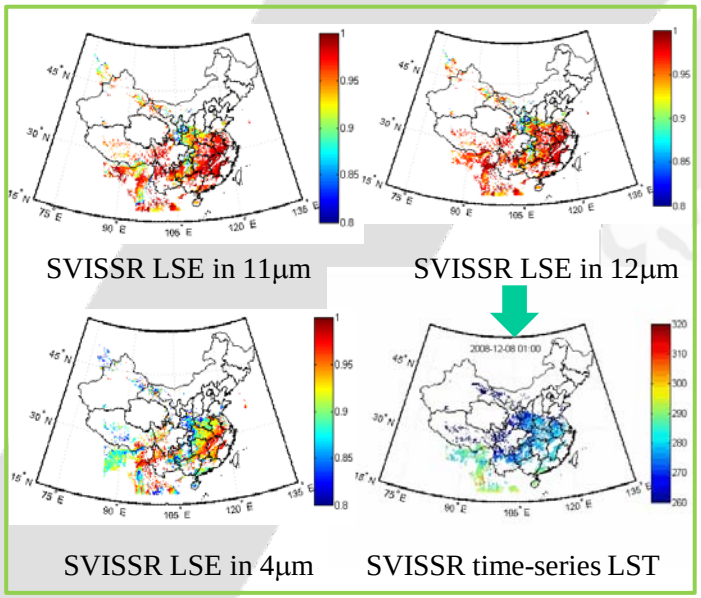
Remote Sensing Application – Infrared mechanism research and data processing

- A mid-infrared camera designed to capture the leak of methane.
- A retrieval method proposed to estimate the time-series LSTs and LSE from combined mid-/thermal-infrared data
- An neural network established to retrieve temperature, emissivity and atmospheric profiles from hyperspectral thermal infrared data

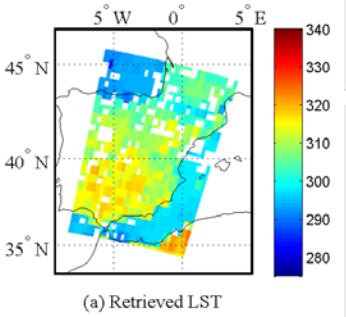


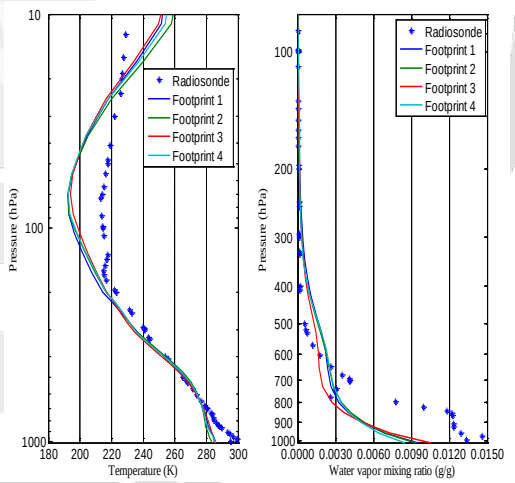
CH_4 has a strong absorption band around 3.3 μm

CH_4 leak imaging test



LST and LSE retrieval from combined MIR and TIR data





Surface temperature and atmospheric profiles retrieved from hyperspectral thermal infrared data

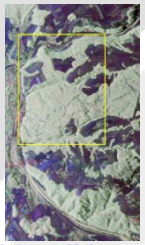
Remote Sensing Application – Microwave data application

Forest height estimation via PoI-InSAR

- Forest height estimation accuracy is affected by system errors and processing errors while using single baseline images.
- An estimation methods using dual-baseline images was proposed to improve the estimation accuracy.

Validation data

DLR E-SAR

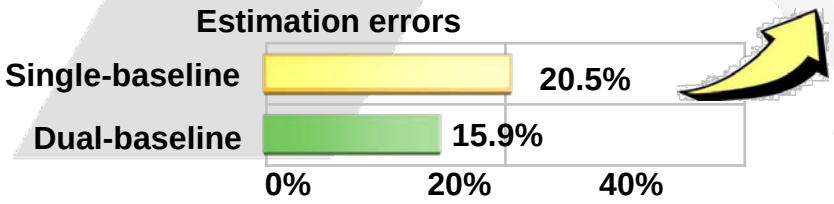


(a) Google Earth image (b) Pauli image

Results

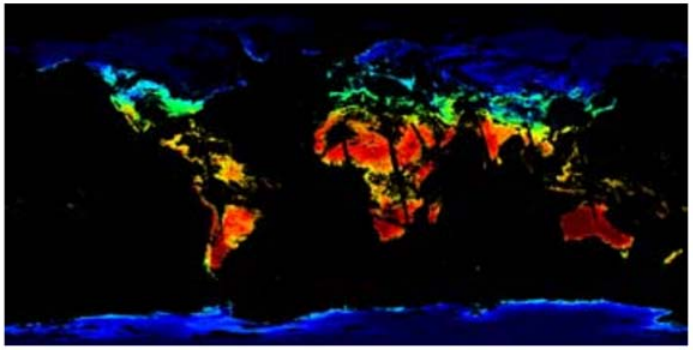
Inventory height Single-baseline results Dual-baseline results

Estimation error was reduced by 4.6% through the dual-baseline method



Land surface temperature retrieved from passive microwave data

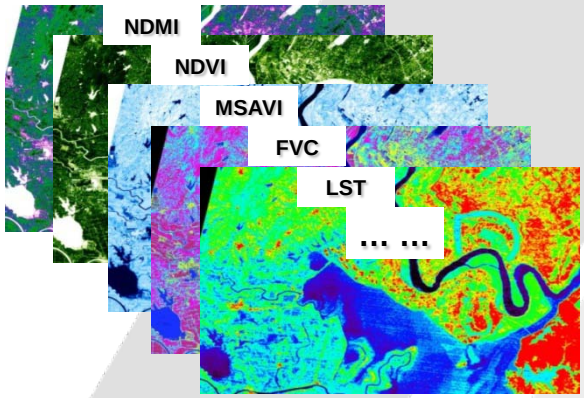
- To derive the land surface parameters, a radiative transfer model for simulating microwave brightness temperature over land surfaces was constructed by jointly considering the effect of soil, vegetation and atmosphere.
- And an algorithm for the retrieval of land surface temperature (LST) from passive microwave data was developed to produce the global all-weather LST.



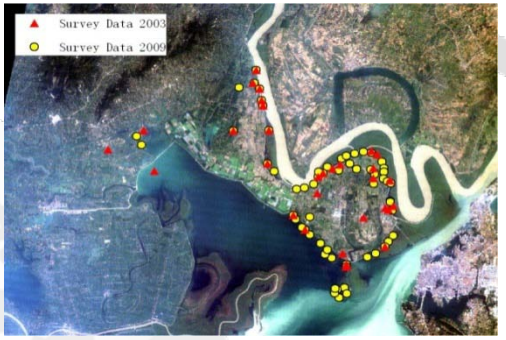
Global LST products from AMSR-E and MODIS data

Remote Sensing Application – Multi-source EO data application

Potential area of the intermediate host snail of schistosomiasis is analyzed before and after the Three Gorges Project (TGD), through the breeding environment retrieval from multi-source remote sensing data.

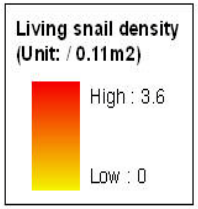


Retrieval environmental factors images



survey data of living snail density

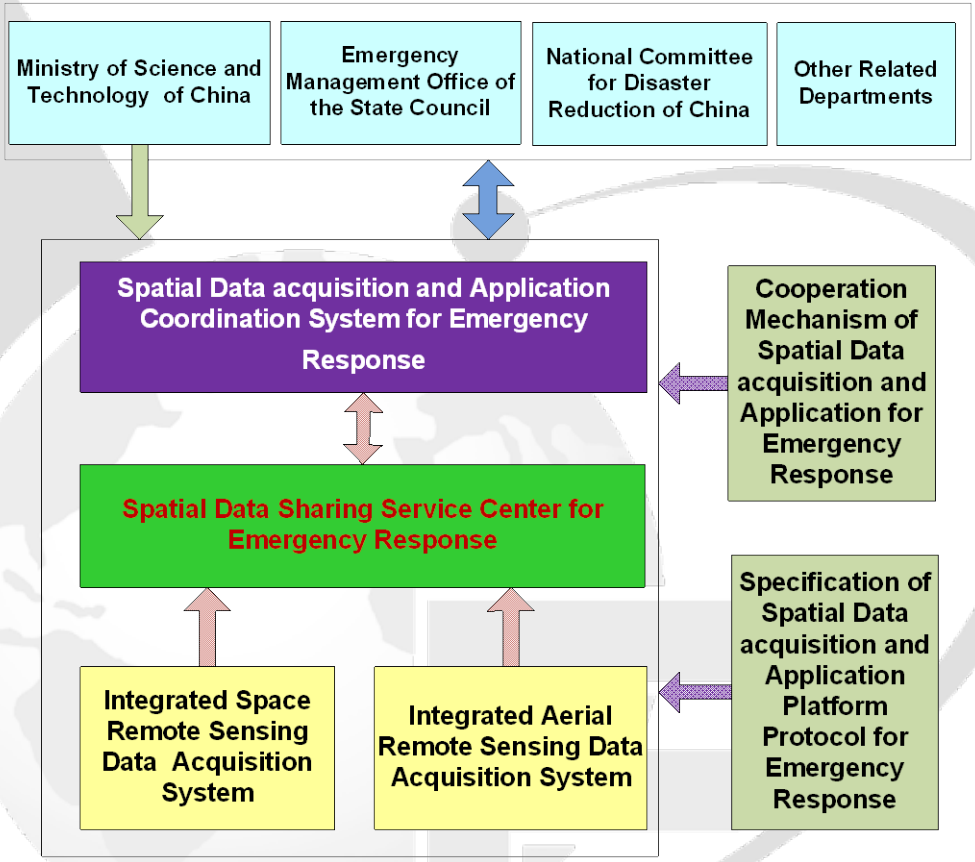
Before the TGD (2003)
Predicted potential area：146.45 km²



After TGD (2009)
Predicted potential area：138.84 km²

Remote Sensing Data Sharing – Aerospace application coordination system for emergency response and data sharing (ArcSer)

- ArcSer provides functions to schedule in harmony various civil aerospace resources to acquire aerospace remote sensing data of stricken area, and distributes the data to relevant institutions involved in disaster reduction as soon as possible.
- ETA acts as the Earth Observation Data Center for Emergency Response which is one of the most important supporting units of ArcSer.



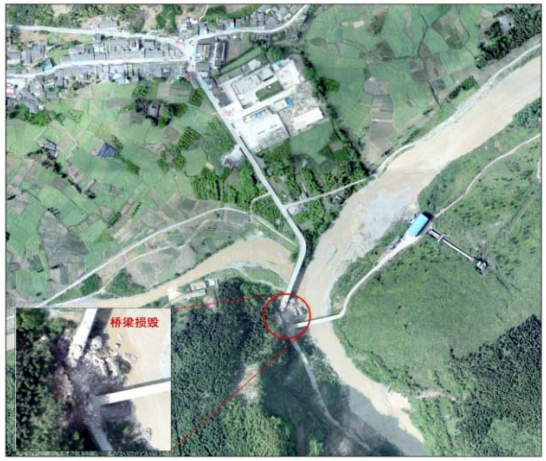
The structure of ArcSer

Remote Sensing Data Sharing – Aerospace application coordination system for emergency response and data sharing (ArcSer)

During the emergency response for the Ms7.0 earthquake happened in Lushan County of Ya'an, Sichuan Province at UTC 0:02 on April 20, 2013. AOE aggregated a huge amount of aerospace remote sensing data acquired before and after the earthquake, and distributed them to more than 45 institutions which are affiliated with 20 different Ministries.

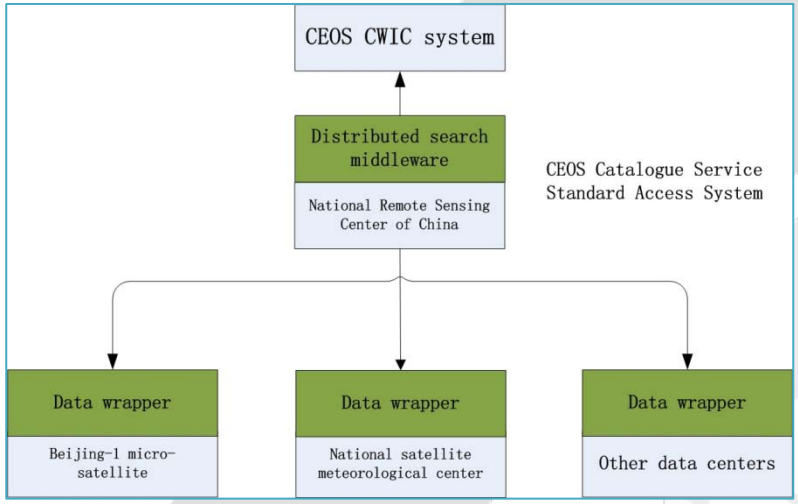
Demonstration and discussion

Before earthquake	After earthquake
• HJ-1A/1B/1C • ZY1-02C • ZY3 • SPOT2/4/5 • SJ-9 • Rapid eye • Radarsat-2	• HJ-1A/1B • UAV airborne image of YaAn • UAV airborne image of LuShan • RISAT • SJ-9

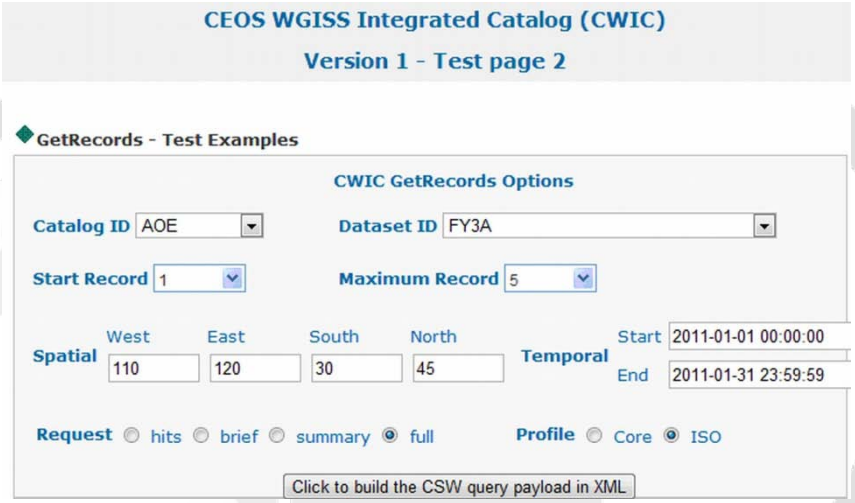


Remote Sensing Data Sharing – CEOS catalogue service standard access system

This system can integrate Chinese satellite data and provide information to CEOS/WGISS Integrated Catalogue (CWIC) System.



Distributed search framework of the CEOS Catalogue Service Standard Access System

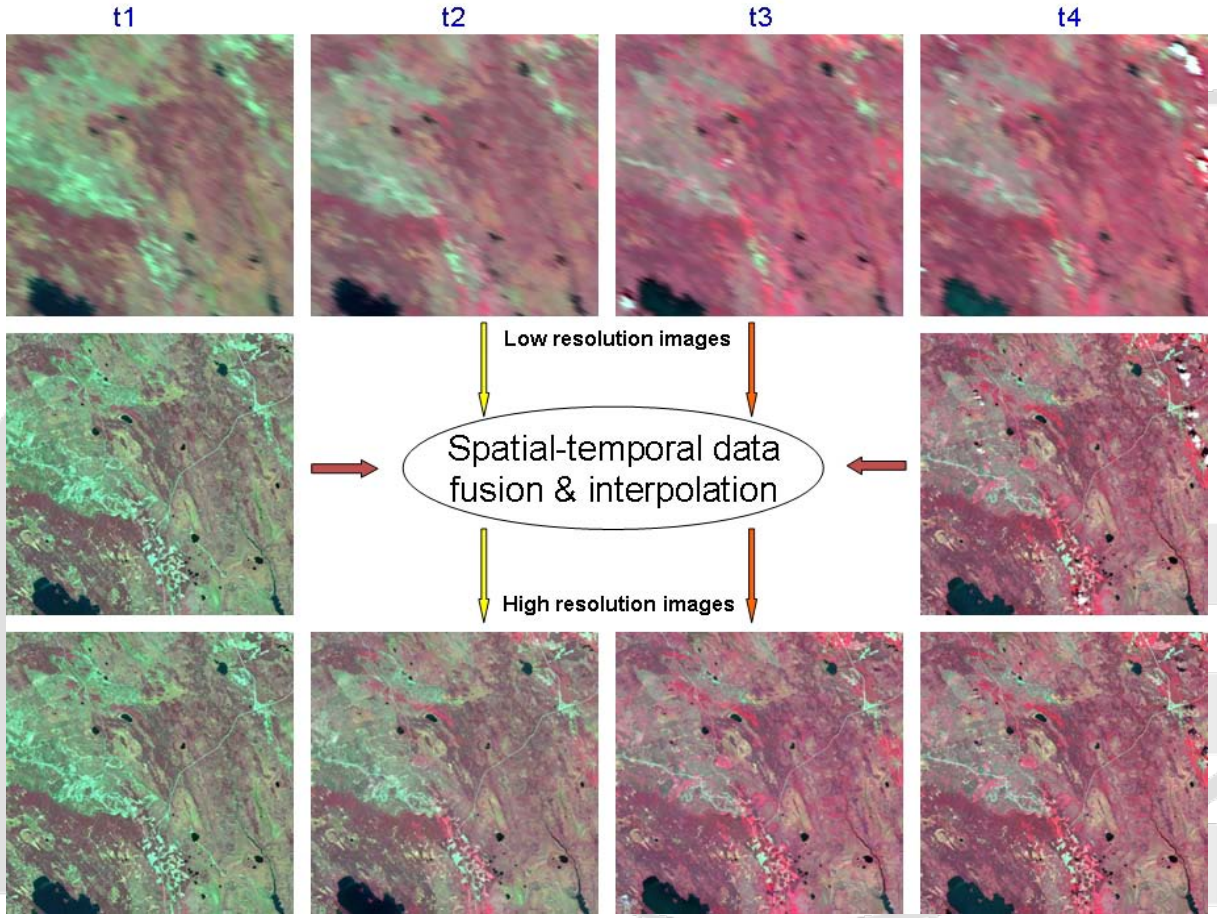


Integration to the CEOS CWIC System

- ✓ **Data service access system**
- ✓ **Conform to the OGC standards CSW and ISO 19115**
- ✓ **Promote international sharing and using of Chinese remote sensing satellite data**

Remote Sensing Data Sharing – Virtual Constellation Data Building

High spatial resolution fused image at a certain date was produced by combining low spatial resolution data resource with high revisit frequency and high spatial resolution images with low revisit frequency.



Outline

Brief Introduction

EO Research Activities

Prospect

Prospect

Develop the aerostat technology, while combining it with the remote sensing application, and promote its application in the field of earth observation.

Develop advanced remote sensing imaging technology, such as computational spectral imaging, computational light field imaging, intensity correlation imaging, and active-passive three dimensional imaging, lead the technological frontier and provide new technologies for EO application.

Investigate the key technology in comprehensive performance assessment and data quality control for opto-electronic payloads, and construct the comprehensive Cal&Val site, providing infrastructure construction for EO payloads performance and data quality assurance.


Thank you !