CBERS Radiometric Calibration and Validation in IRSA

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Outline

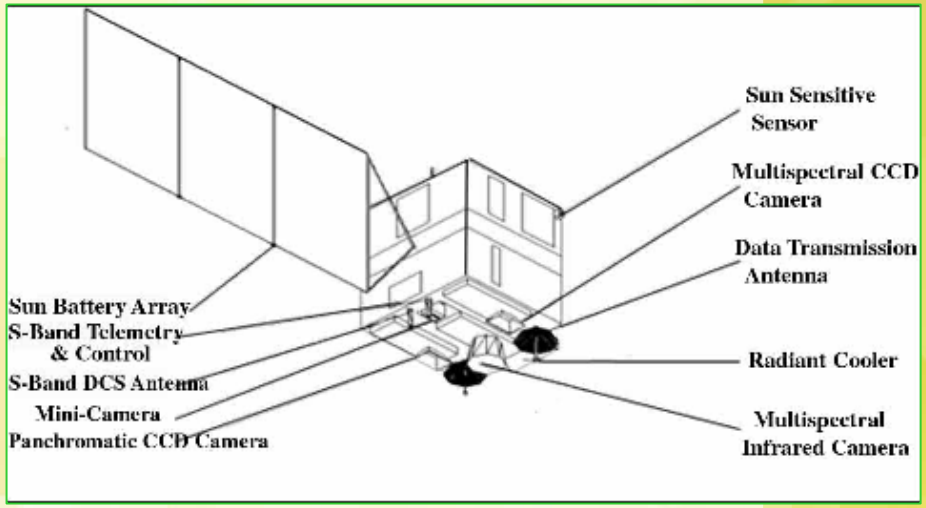
1. CBERS Introduction
2. Calibration Work
3. Field experiment for CBERS02B Validation
4. Quantitative Application for CBERS

1 CBERS Introduction

- The China-Brazil Earth Resources Satellite (CBERS) was jointly developed by China and Brazil since 1988.
  - ➢The first CBERS (CBRES-01) was successfully launched on October 14, 1999 .
  - ➢The second one (CBERS-02) was on October 21, 2003.
  - ➢CBERS-02B was successfully launched on September 19, 2007.
- All these satellites were relegated to China Center for Resources Satellite Data and Applications (CRESDA) and switched to application and routine operation stage

Characteristics of Satellite

- Orbit: sun-synchronous recurrent and frozen orbit
- Mean altitude: 778Km
- Local time at descending node: 10:30 AM
- Repeat cycle :26 day
- Repeat cycle: 100.26 min
- Revolution/Day: 14+9/26
- Inter-track distance: 107.4 Km
- Time interval between adjacent track: 3 days



Payloads on CBERS-02 and CBERS-02B

Camera	Spatial Resolution	Swath Width	Band	Repeated period
CCD	20m	113km	4 VIR/NIR bands 1 PAN band	26day
WFI	258m	890km	2 VIR/NIR bands	5day
IRMSS	78m 156m(TIR)	119.5 km	3 VIR/NIR/SIR bands 1 TIR band	26day
HR	2.36m	27km	0.5-0.8 μ m	104day

See: http://www.cresda.com/cn/products.htm

2 Calibration for CBERS in IRSA

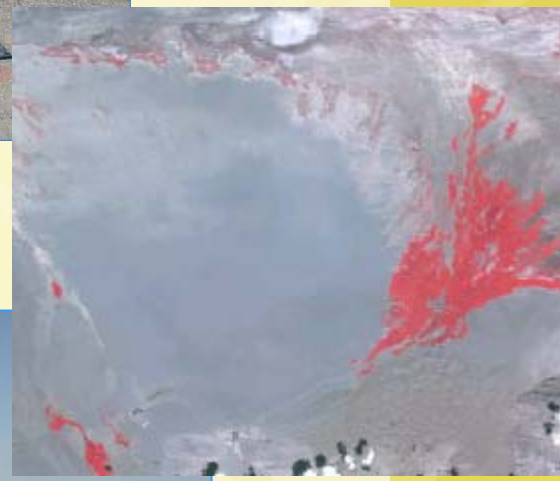
- 2.1 Vicarious Calibration for CBERS
  - CCD
  - IRMSS
  - Vicarious calibration results of CCD and IRMSS
- 2.2 Cross-Calibration for CBERS
  - CCD
  - WFI
  - IRMSS
- 2.3 MTF measurement and compensation for CBERS
  - CCD
  - WFI
- 2.4 Calibration accomplishment

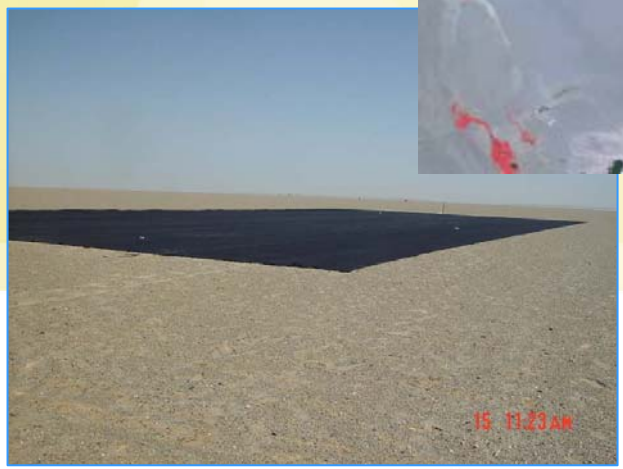
2.1 Vicarious Calibration for CBERS

CCD

Joined with CRESDA, Vicarious calibration was performed at Dunhuang site in Gansu province on Aug. 18 and Aug. 25, 2004.

The Dunhuang test site used in this work is located in 20 km northwest of Dunhuang in Gansu province. The coordinates of it are 40.08° N latitude and 94.38° E longitude. It has been in use for vicarious calibration since the mid-1990s.





In-situ measurement at Dunhang on August 18, 2004

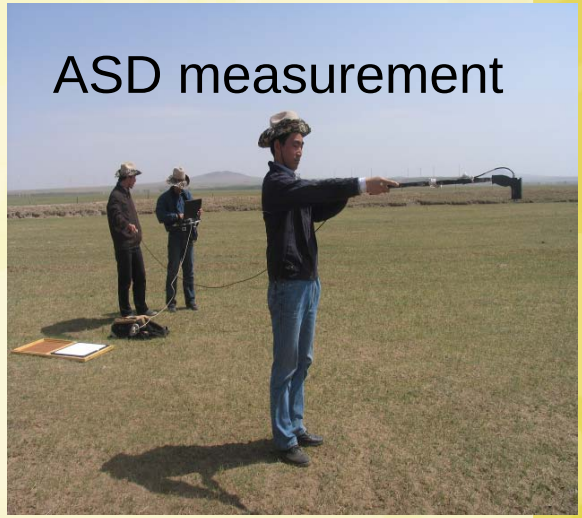
2.1 Vicarious Calibration for CBERS

- **Huailai test site was built by IRSA near to Beijing. Coordinates: 40.4° N, 115.7° E**

In-situ measurement at Huailai in Hebei province on May 4, 2004 and on June 18, 2005

2.1 Vicarious Calibration for CBERS

- **DaliLake, Gonggeer, Sunite Zuoqi and Erlianhaote in Inner Mongolia were chosen as potential test sites for C&V science research because of good atmospheric conditions and surface lambert condition, and convenient traffic. (near to Beijing)**

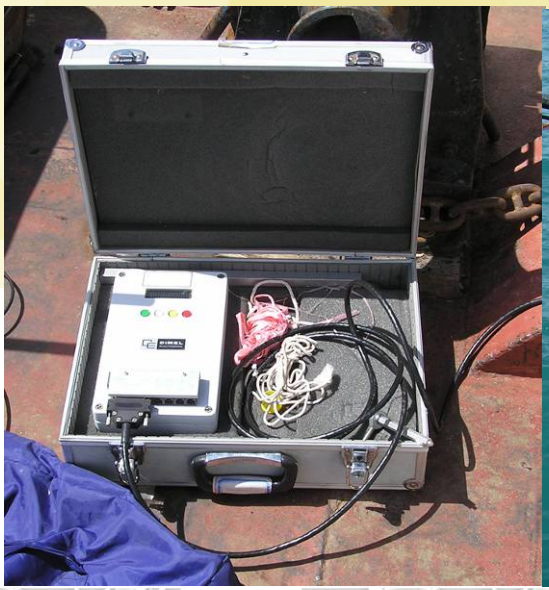


Site surveying and measurement in Inner Mongolia

2.1 Vicarious Calibration for CBERS

IRMSS TIR band

- Qinghai Lake is used as a test site for IRMSS.
- It has a good lambertian feature, dry atmosphere and high visibility.
- The coordinates of it are 36.75° N latitude and 100.37° E longitude.



Qinghai Lake

Vicarious calibration results of CCD

		Band 1	Band 2	Band 3	Band 4
2004-5-4	DN	96.4	154.05	84.05	147.05
	radiance	132.02	115.31	100.5	76.478
	coefficient	0.7302	1.3360	0.8363	1.9228
2004-8-19	DN	96.830	163.105	91	132.524
	radiance	101.3236	98.40311	90.80449	63.50325
	coefficient	0.9480	1.6459	0.9969	2.0788
2004-8-25	DN	96.663	162.833	91.08	132.25
	radiance	102.5888	98.22565	90.48051	60.99888
	coefficient	0.9422	1.6577	1.0066	2.1681

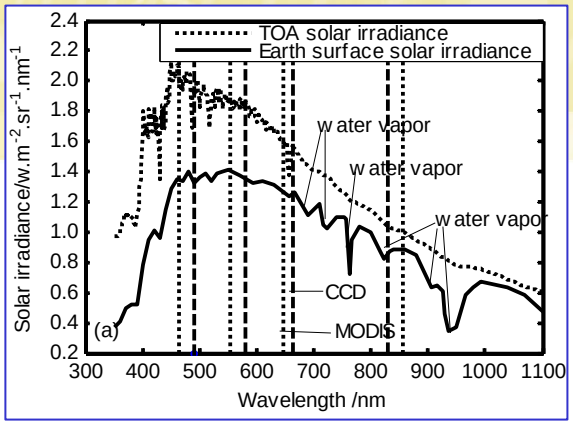
2.2 Cross Calibration for CBERS

CCD

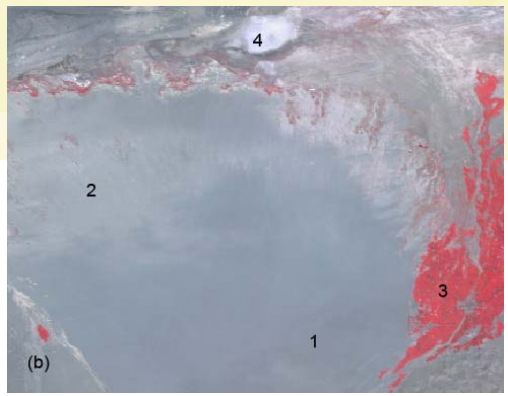
- **Radiometric cross-calibration of the CBERS-02 CCD camera with the TERRA MODIS using the images acquired over Dunhang on August 19, 2004**

CCD spectral bands corresponding to MODIS

CCD bands	Spectral bands/nm	Center Wave-length /nm	Resolution /meters	MODIS bands	Spectral bands /nm	Center Wave-length /nm	Resolution /meters
1	450～520	490.48	19.5	3	459～479	465.74	500
2	520～590	581.73	19.5	4	545～565	553.74	500
3	630～690	662.41	19.5	1	620～670	646.3	250
4	770～890	830.29	19.5	2	841～876	856.48	250



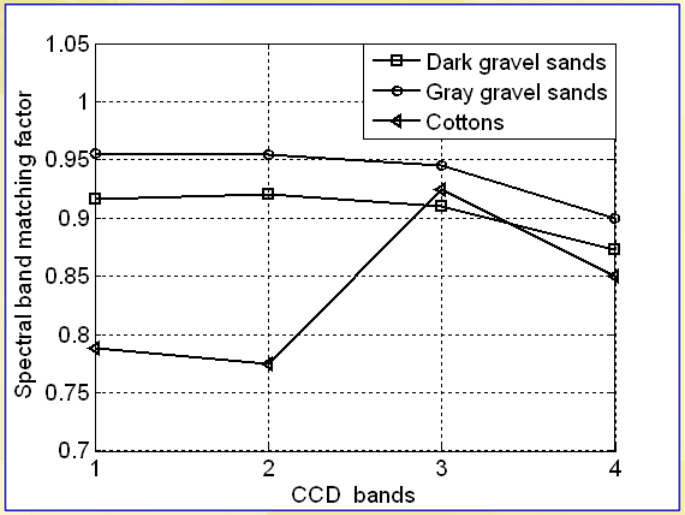
Center wavelengths of the CCD and MODIS spectral band.



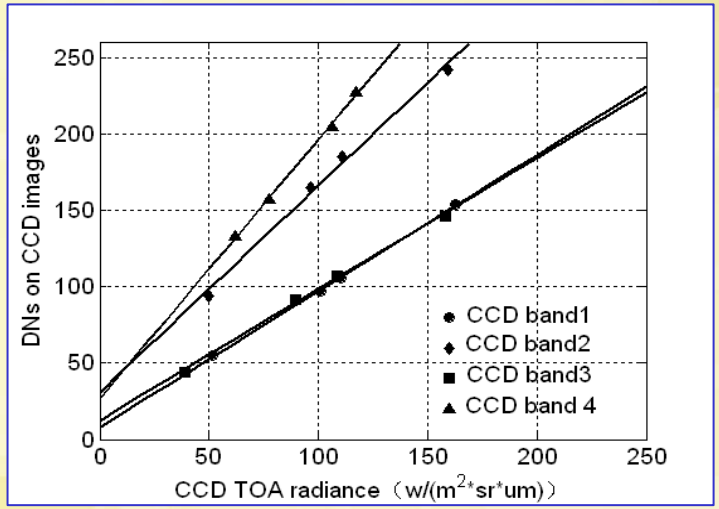
Targets used to do the cross-calibration

1. Dark gravel sand ;2. Gray gravel sands;3. Cottons; 4.Bright sands

2.2 Cross Calibration for CBERS



Spectral band matching factor for CCD and MODIS



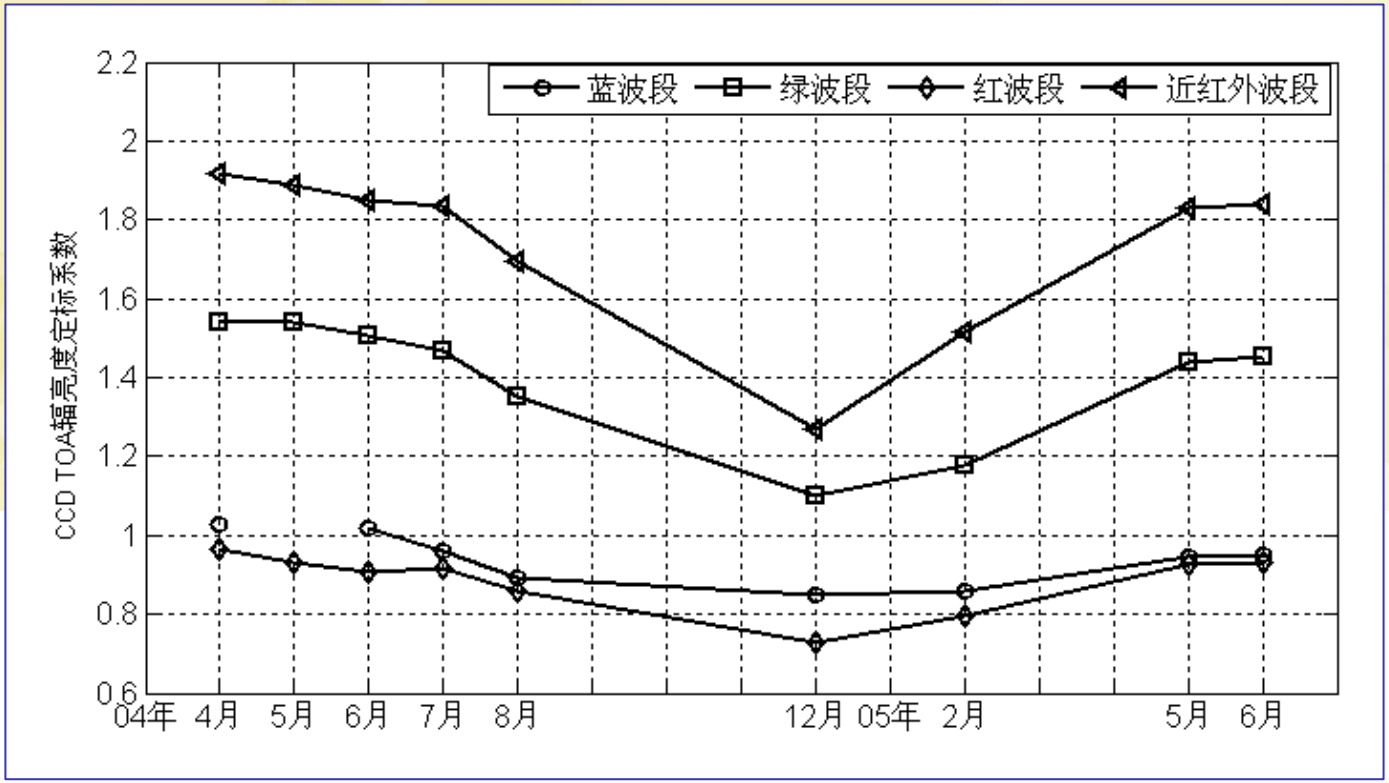
Results of cross-calibration for CCD spectral band TOA radiance

	CCD1	*CCD2*	*CCD3*	*CCD4*
Radiance coefficients	**0.892**	**1.353**	**0.861**	**1.696**
Reflection coefficients	**458.361**	**639.659**	**353.302**	**473.216**
Offsets	**8.0160**	**31.0704**	**12.475**	**27.086**

The research demonstrated that the traditional method with single calibration site was inappropriate for CCD camera, since its four spectral bands have offsets .

2.2 Cross Calibration for CBERS

Based on the offsets achieved by the cross-calibration for image acquired on August 19, 2004. Cross-calibration method was used to calibrate the historical data of CCD from Apr. 2004 to May 2005.



2.2 Cross Calibration for CBERS

WFI

- **With the MODIS as a reference sensor, the radiometric cross-calibration was performed for CBERS-02 WFI based on the images acquired over Huailai on May 4, 2004 using four targets.**

The calibration results for WFI

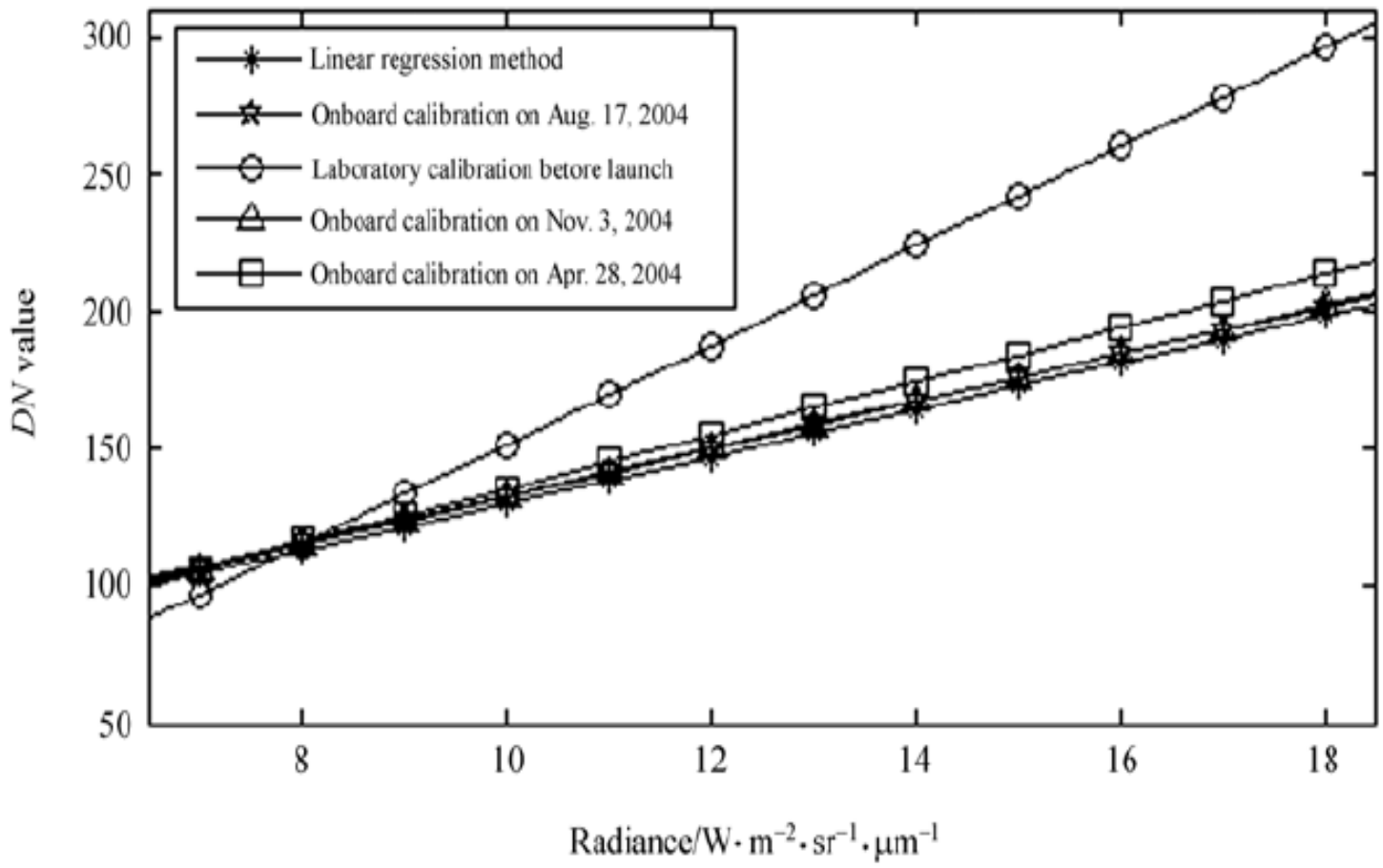
	WFI band1	WFI band2
Radiance coefficients	2.0275	1.7672
Reflection coefficients	870.12	508.27
Offsets	42.33	21.023

2.2 Cross Calibration for CBERS

IRMSS

- **Absolute radiometric calibration of CBERS-02 IRMSS thermal band**
- **The radiometric cross- calibration against TERRA MODIS corresponding channel and the in-flight field calibration at Lake Qinghai: water surface radiometric calibration test site of China on Aug. 17, 2004 are carried out in this research.**
- **Radiometric cross-calibration of CBERS-02 IRMSS thermal band against TERRA MODIS selected 6 times synchronous images of two sensors passing through Lake Qinghai and Lake Taihu from August to December, 2004 to compute the cross calibration data.**

Calibration Results of IRMSS TIR band



Absolute radiometric calibration results obtained from different methods and dates.

2.3 MTF Compensation for CBERS

MTF measurement and compensation for CCD

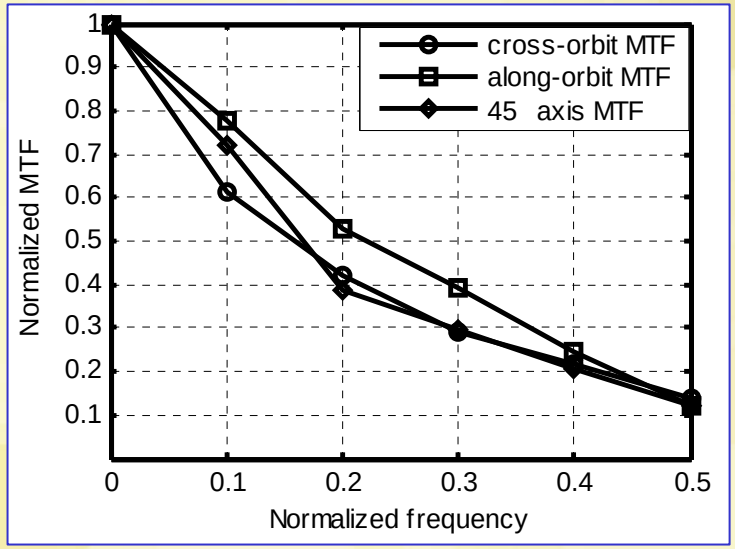
A new approach was presented to determine the in-flight MTF of CCD camera on CBERS-02 by constructing ideal tarps scene and MTF resulted from this method were compared to those of other common methods

The technique of simulating ideal tarps

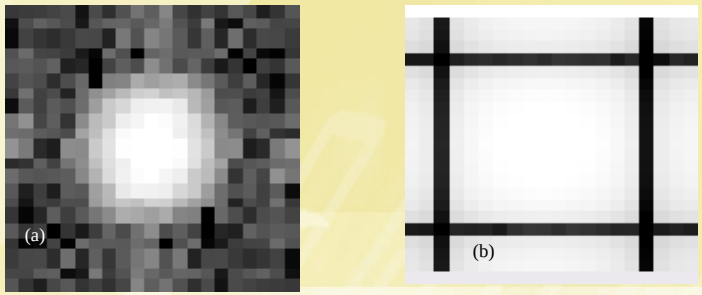
This new technique is similar to the technique of two-image comparison. However, instead of using a high resolution image, it uses a simulated an ideal tarps image .

During the synchro field work at Dunhuang calibration site on August 19, 2004, a black tarp was designed to be imaged as 3×3 pixels on CCD image. Surface spectral data were sampled for the tarp and the gravel sands at Dunhuang site, which were used to simulate the ideal tarp scene.

(a) Sub CCD image; (b) Simulated ideal tarp scene image



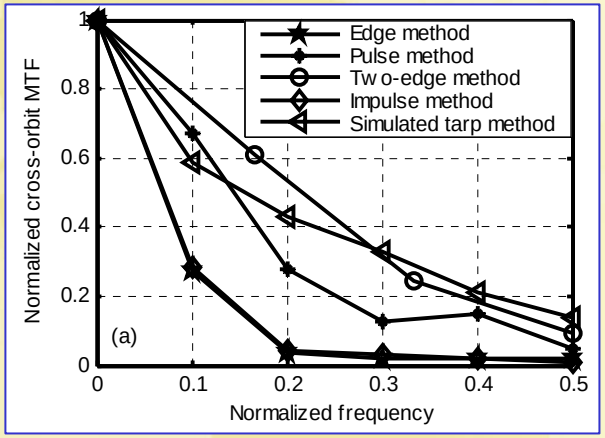
The MTF determined by the technique of simulating ideal tarp

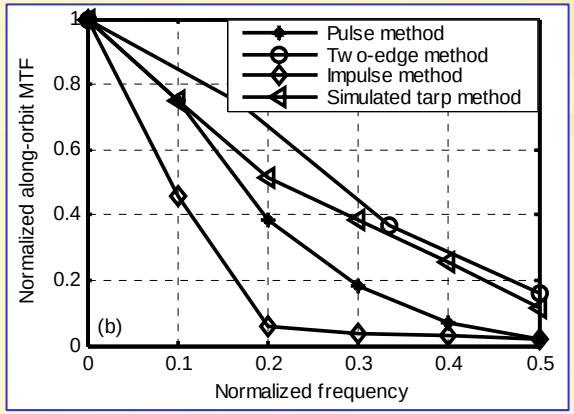


Their FFT transform

At the same time, we use Edge method , Impulse method , Pulse method and Two-edge method to measure MTF for CCD images.

Comparison for different MTF determined





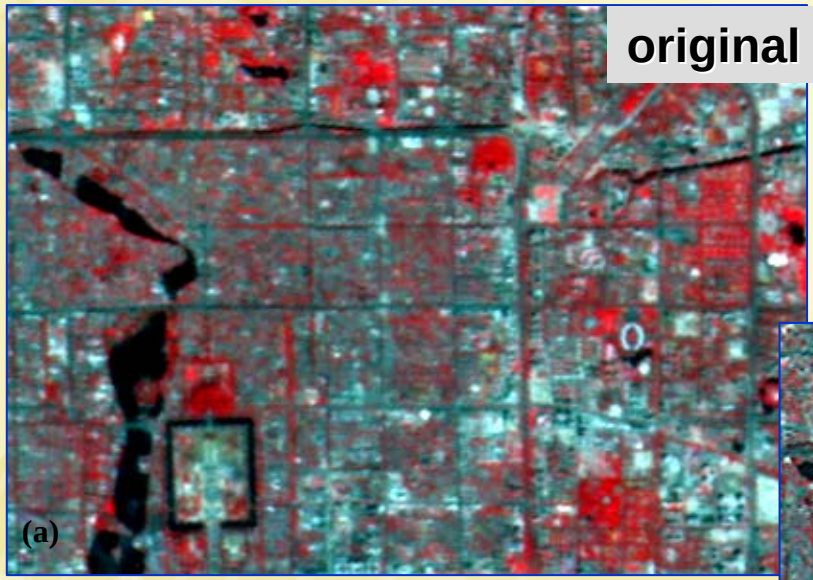
Comparison for different MTFs determined.
(a) Cross-orbit; (b) Along-orbit

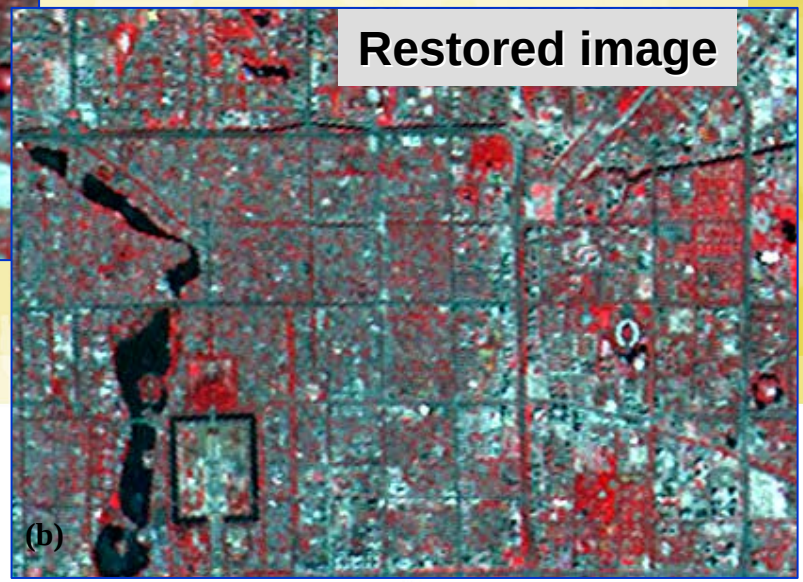
Table Comparison for MTFs determined from different techniques

Normalized Frequency		Edge method	Impulse method	Pulse method	Two-edge method	Simulating ideal tarp
Cross orbit MTF	0.1	0.27	0.285	0.672	0.773	0.612
	0.2	0.035	0.041	0.279	0.529	0.423
	0.3	0.018	0.033	0.128	0.308	0.290
	0.5	0.022	0.011	0.045	0.092	0.140
Along orbit MTF	0.1	—	0.455	0.749	0.824	0.778
	0.2	—	0.057	0.386	0.616	0.527
	0.3	—	0.038	0.180	0.412	0.394
	0.5	—	0.021	0.021	0.158	0.124

2.3 MTF Compensation for CBERS

Results of pixel level radiometric calibration for CCD





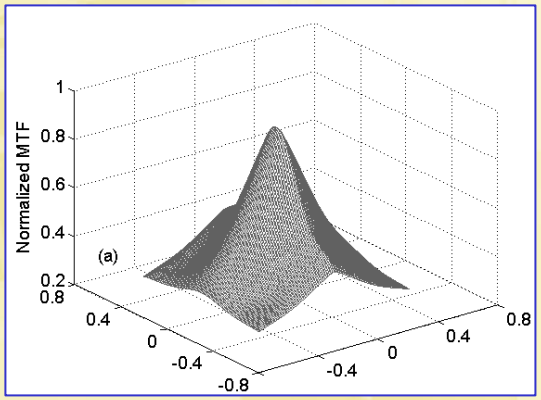
Combination of band 4, 3, 2 of CCD camera

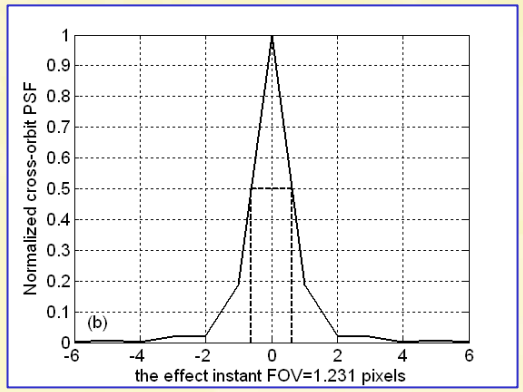
2.3 MTF Compensation for CBERS

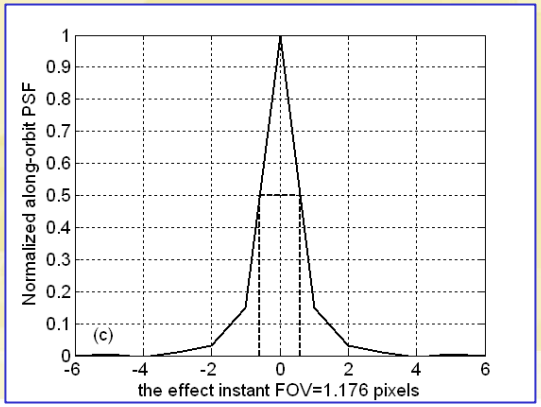
MTF measurement and compensation for WFI

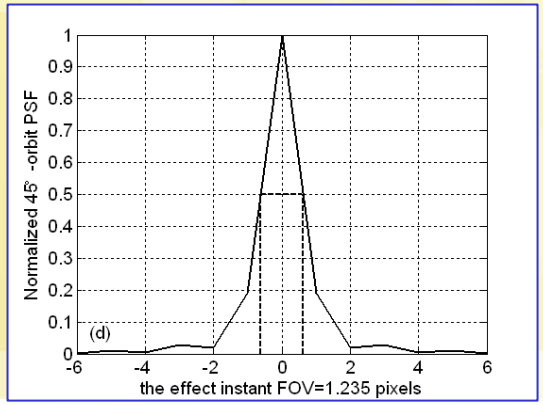
The WFI's MTF was determined by comparing many pairs of WFI and CCD images with different scene. (The CCD camera was on the same platform CBERS-02 with the WFI imager.)

Sub-image pair from Korea scene image pair acquired on March 19 (a) CCD; (b) WFI



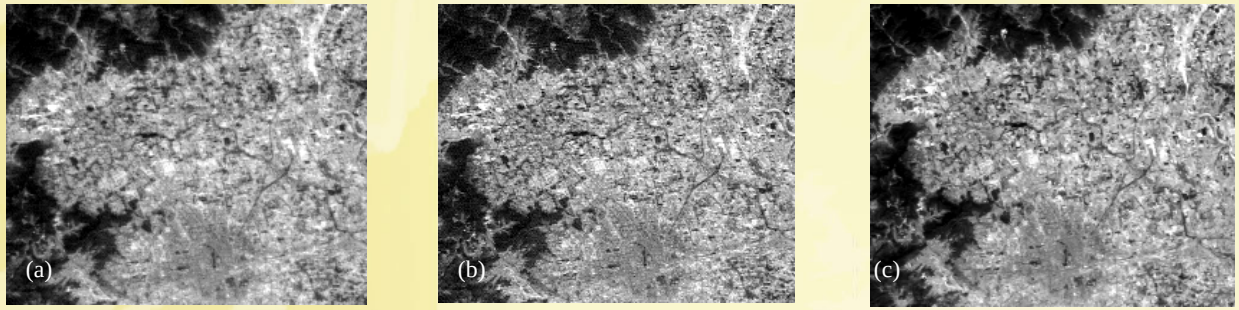




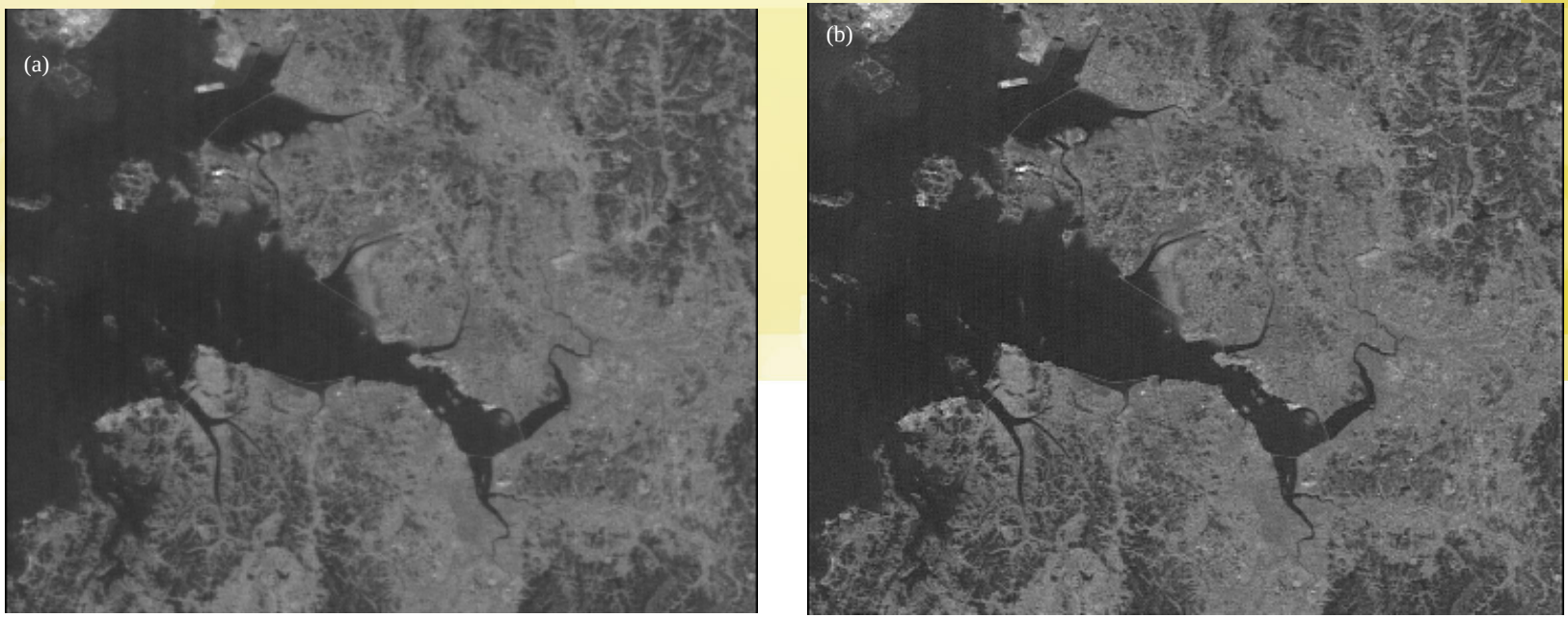


(a) Two dimensional MTF; (b) The half bandwidth in the cross-orbit direction;
(c) The half bandwidth in the along-orbit direction; (b) The half bandwidth in the 45°-orbit direction

MTF compensation for WFI using Weiner filter



Sub-image of Huailai image (a) Original image; (b) Restored image; (c) MODIS image



Sub-image of Korea image (a) Original image; (b) Restored image

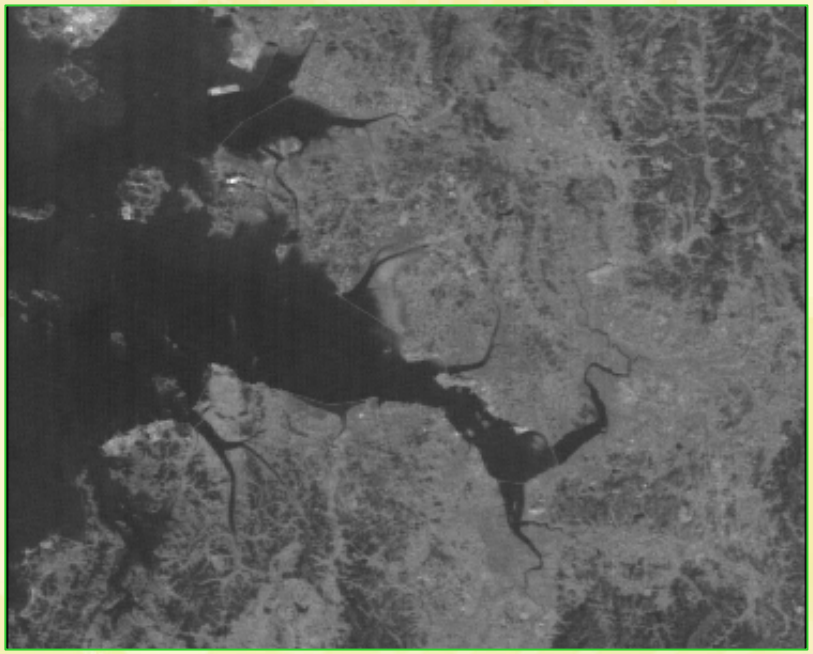
2.3 MTF Compensation for CBERS

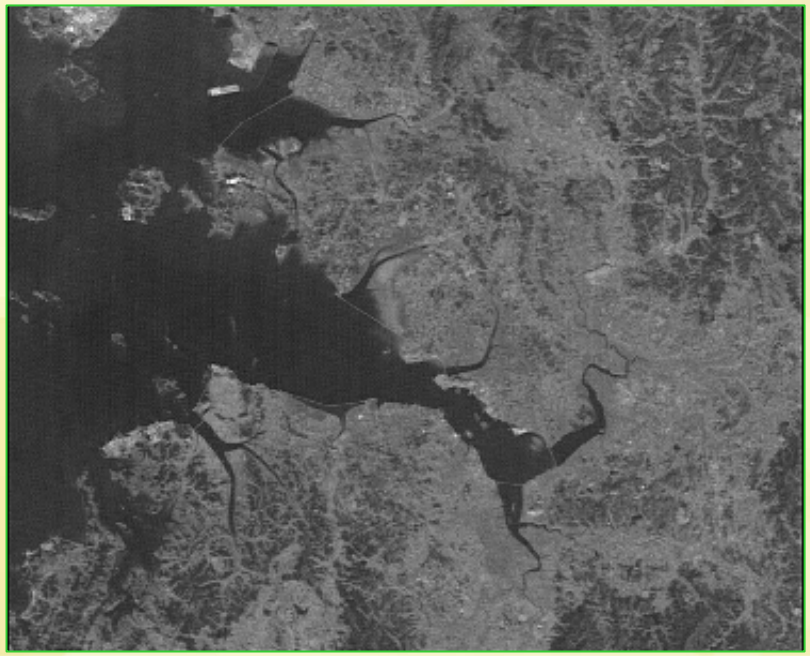
MTF Calibration for WFI

- The MTF values determined from the Korea scene image pair were applied to calculate the half bandwidths of the WFI imager and perform the MTF compensation for WFI images, since the image had richest information and had little relief.
- Results demonstrated that the instant field view of the WFI were 317m, 304m and 320m in the cross-orbit, along-orbit and 45º-orbit directions respectively. And as expected, the restored image contained more details than the original one.

2.3 MTF Compensation for CBERS

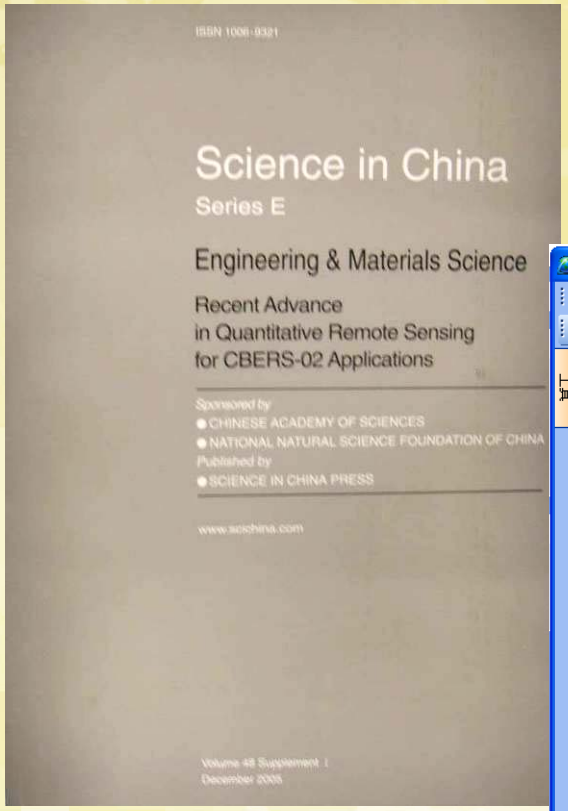
Results of pixel level radiometric calibration for WFI

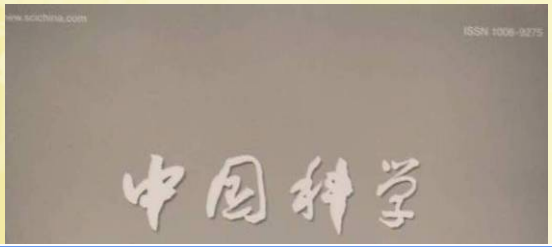




(a) Original image; (b) Restored image

2.4 Calibration accomplishment

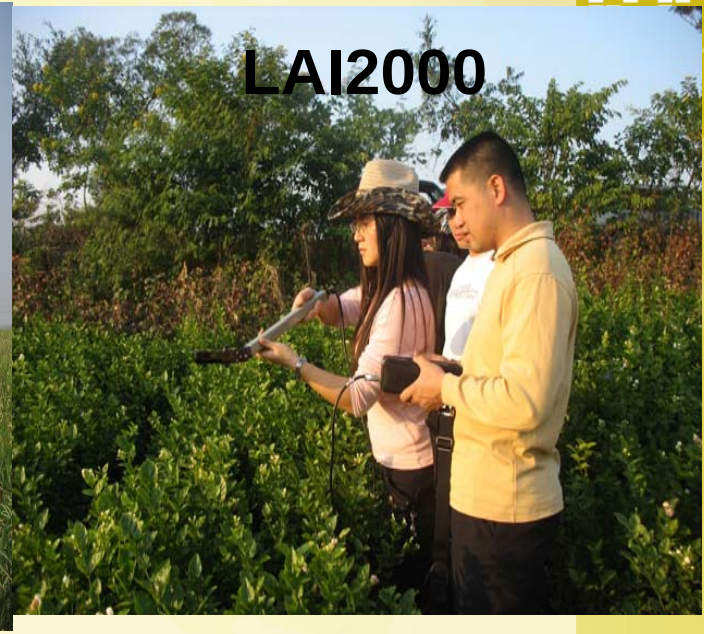




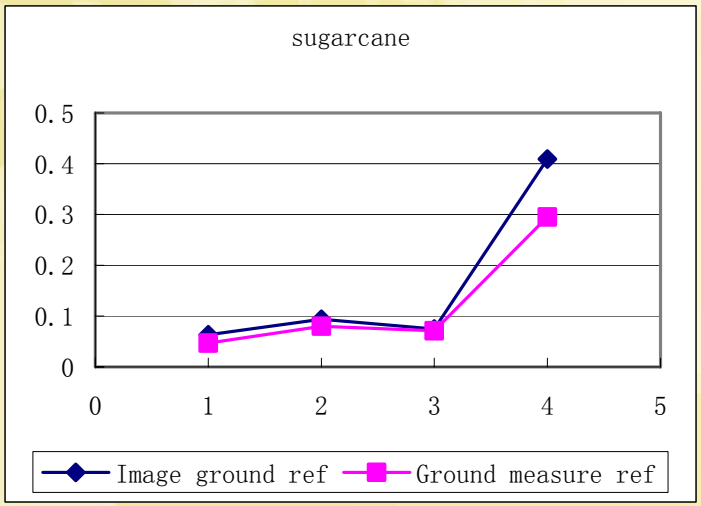
3. Field experiment for CBERS02B Validation

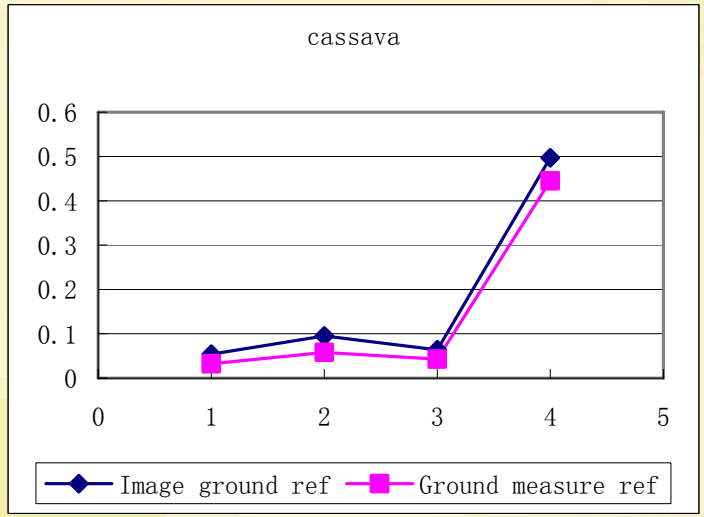
- After CBERS02B is successfully launched on September 19, a field experiment for reflectance and VIs (Vegetable Indexes) measurements was conducted in Binyang, of Guangxi municipality, China on Nov.8 - 12,2007.
- Spectrum and LAI of four crop and vegetable, including rice, sugarcane, cassava and jasmine, were measured using ASD and LAI2000.
- Comparison of VIs derivied from experiment and from CBERS02B image was conducted for validation.

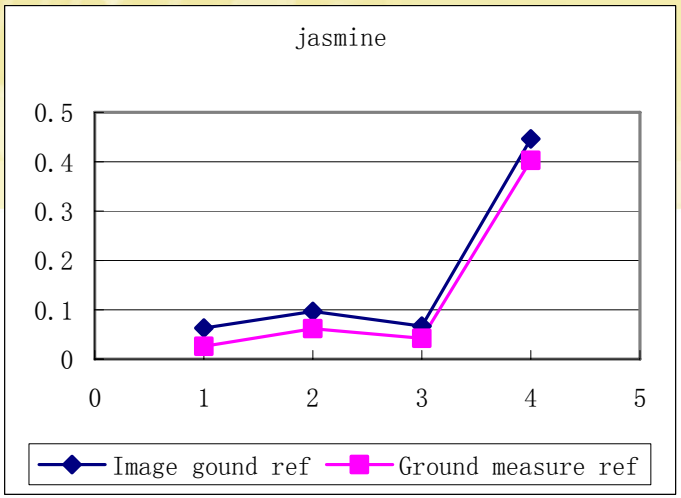
Spectrum measurements using ASD and LAI measurements

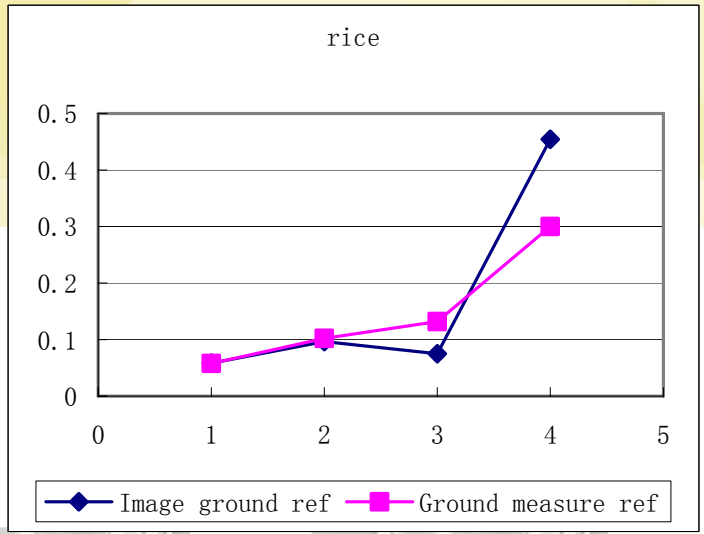


Comparison of reflectance between CBERS02B image and ground measurement.









4 Case of Quantitative Remote Sensing for CBERS -02 Application

- Signification of CBERS02 RS Application
  - In China the quantitative application research of satellites data is not profound enough. Thus, it is urgent to consider how to systematically construct the civil aeronautics remote sensing system, assimilate application requirements in the process of remote sensing quantification, and improve the earth observing ability and quantitative level.
  - CBERS02 RS Application can supply a reference and demonstration for the quantitative application researches of Chinese satellites data, such as FY, HY, Resources, HJ etc.
- Case of CBERS-02 Quantitative Application
  - ➢ Thin cloud removal for CBERS-02 image
  - ➢ Biomass estimation
  - ➢ Cotton pixel identification
  - ➢ Surface evapotranspiration estimation

4.1 Thin cloud removal (by Jianwen MA, et al.)

the false color composite image of bands 4, 3, 2 before correction

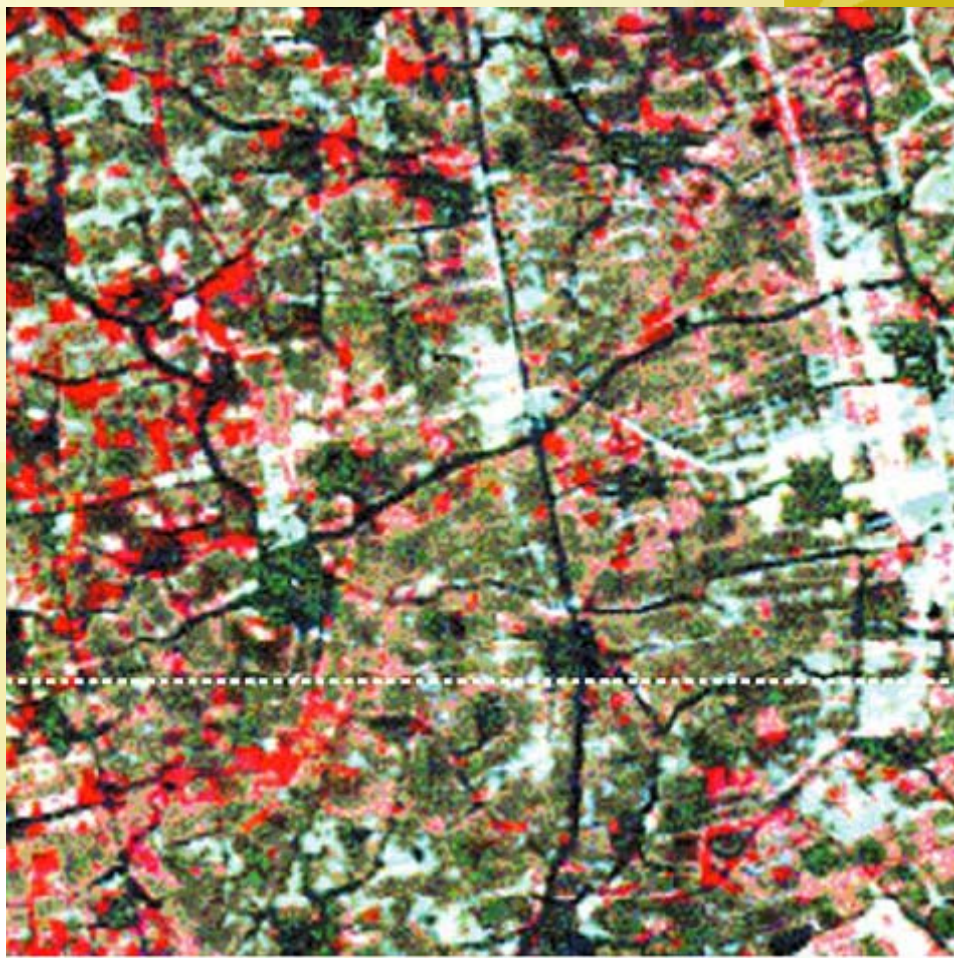
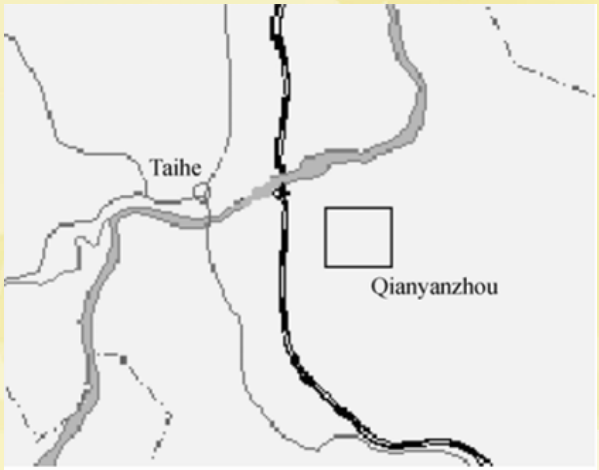


image after correction

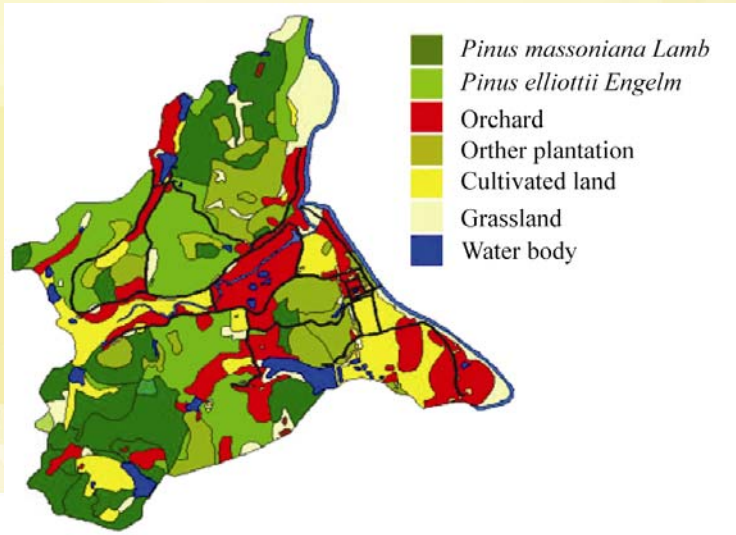
4.2 Biomass estimation (by Liangfu CHEN, et al.)

Based on CBERS-02 satellite data and field measurement, NDVI and biomass of two species of coniferous plantations is researched to build the biomass estimation models.



The location of study site.

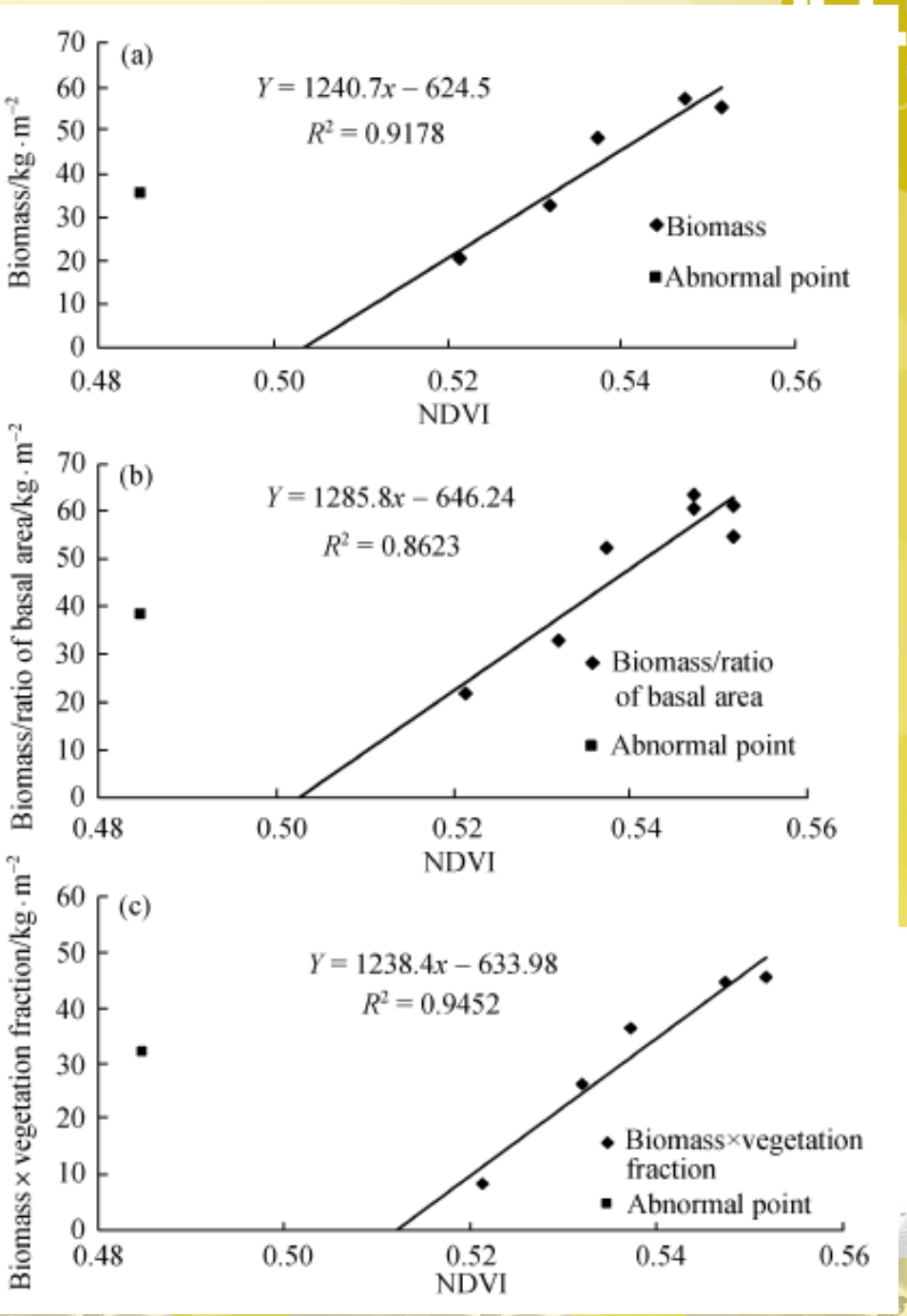
Qianyanzhou Test Site for validation of Biomass



Distribution map of vegetation in Qianyanzhou

4.2 Biomass estimation

- Our improved model
  - Fig a Biomass estimation model for *Pinus massoniana Lamb*.
  - Fig b Biomass estimation model improved by the ratio of basal area.
  - Fig c Biomass estimation model improved by vegetation fraction
- Regional biomass estimation using CBERS02 data with our improved model
  - the estimated biomass was 2.32 × 105 kg/ha for the whole Qianyanzhou
- Uncertainty analysis in estimating biomass

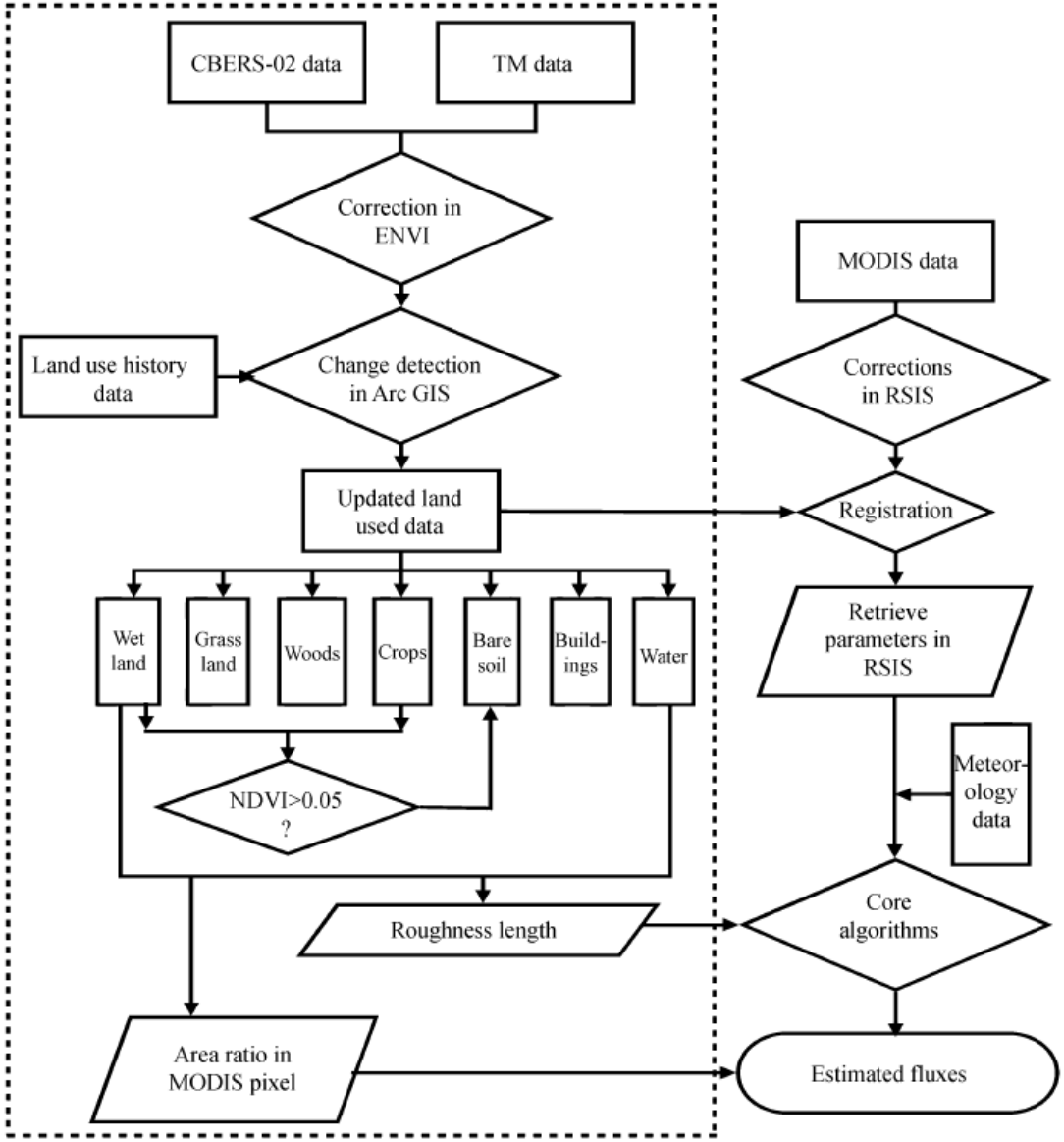


4.3 Cotton pixel identification (by Jing LI, et al.)

- The in-situ experiment data are collected from the Spectral Library to estimate the possible values of the primary structural parameters in each cotton growing season by statistics.
- Based on these values the spectra of the cotton major growing seasons were simulated and analyzed using the canopy reflectance model, SAILH.
- In this way the cotton pixel spectra corresponding to CBERS-02 CCD was simulated as the reference spectra for spectra fitting.
- Two spectra fitting methods, Mahalanobis distance and spectra angle, were used to identify cotton pixel from CBERS-02 CCD image of the study area.

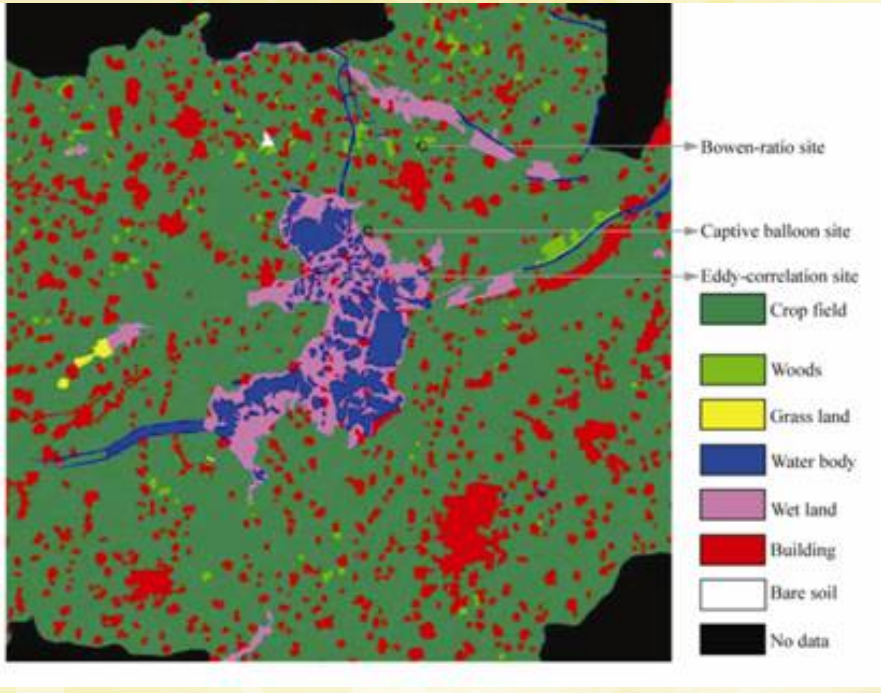
4.4 Surface evapotranspiration estimation (by Xiao. Xin, et al.)

- Land surface evapotranspiration is one of the most important components in water cycle between earth and atmosphere, and plays a very important role in the atmosphere, hydrosphere, and biosphere of the planet.
- Estimating surface evapotranspiration using combined MODIS and CBERS-02 data
  - CBERS-02 data were used to produce land use class
  - The area ratio of each class in MODIS pixel was calculated, and used to derive the heat fluxes of the mixed pixel.

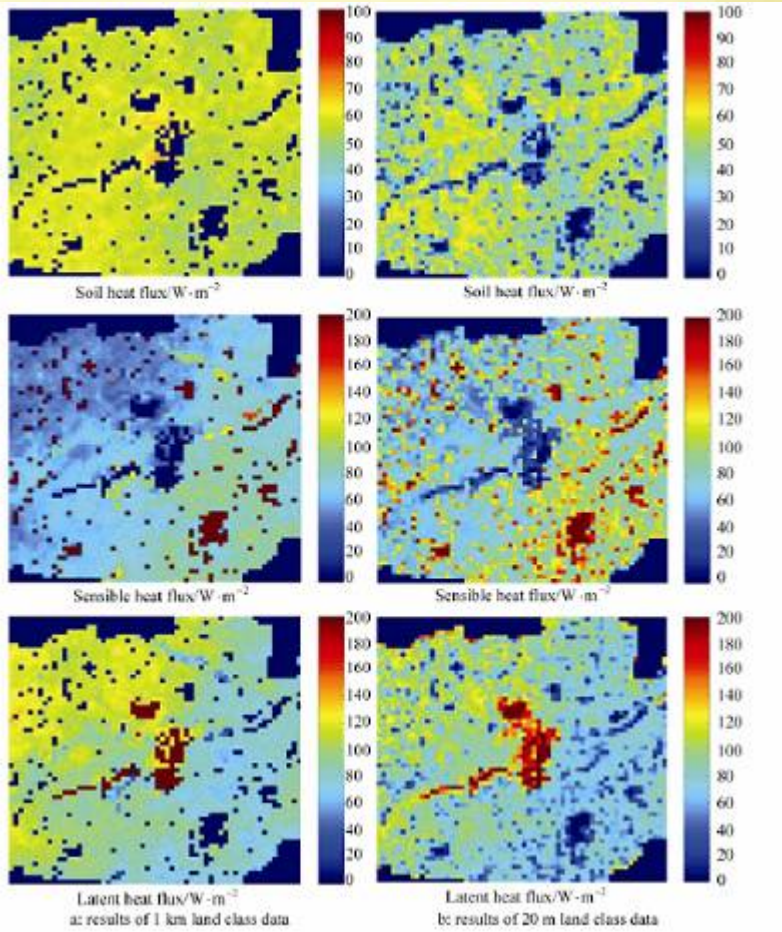


The routine of estimating land surface heat fluxes

4.4 Surface evapotranspiration estimation



The 20m resolution land use image of Baiyangdian area produced from CBERS02 image, the marks are the location of the ground observation sites.



Heat fluxes estimated using 1km (a) and 20m (b) land class data from MODIS data in Baiyangdian area on Nov,21,2004


Thanks
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