Accessing Chinese Satellite Data Products for Land Applications

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Outline

- Project overview
- Satellite sensors & data characteristics
- Summary of our recent activities
- Preliminary results of assessing HJ-1 and FY3 satellite data radiometric calibration
- Project web page

Overview

- The overarching goal of our research is to actively participate in three Chinese satellite programs, evaluate and improve their satellite data products, and make them more accessible to the U.S. Earth science community.
- We are focusing on various land products generated by:
  - China-Brazil Earth Resources Satellites (CBERS)
  - Huan Jing (HJ) satellites
  - Feng Yun (FY) satellites

Overview

- For the U.S. Earth Science community to use Chinese satellite data products effectively, we have to first assess their quality. This involves:
  - Inter-calibration (radiometric, comparison with other sensors, simulation of TOA)
  - Data inter-comparison
  - Assessment of high-level product generation algorithms
  - Product inter-comparison and validation

Characteristics of Relevant Satellites & Sensors

CBERS Satellites

- Our research focuses on the sensors that are specific to generating land products.
- For the CBERS satellites, the sensors include:
  - High Resolution CCD
  - Infrared Multispectral Scanner (IRMSS)
  - Wide Field Imager (WFI)
  - High Resolution Panchromatic Camera (HRC)

HJ Satellites

- The specific sensors of the HJ satellites that we are concerned with are:
  - Optical CCD camera
  - Hyperspectral Optical Camera
  - Infrared Multispectral Camera
- Note: Optical CCD data is quite comparable to Landsat data; this will be quite useful for filling in data gaps while waiting for Landsat Data Continuity Mission to come online

HJ-1A/B

Technical Specifications of Payloads of HJ-1A Satellite

Satellite	Payload	Band no.	Spectral range (μm)	Spatial resolution (m)	Swath width (km)	Side-looking ability	Repetition cylce (days)	Data transmission rate (Mbps)
HJ-1A	CCD Camera	1	0.43~0.52	30	720		4	120
		2	0.52~0.60					
		3	0.63~0.69					
		4	0.76~0.90					
	Hyperspectral Imager	-	0.45~0.95 (110-128 bands)	100	50	±30º	4	

Technical Specifications of Payloads of HJ-1B Satellite

Satellite	Payload	Band no.	Spectral range (μm)	Spatial resolution (m)	Swath width (km)	Side-looking ability	Repetition cylce (days)	Data transmission rate (Mbps)
HJ-1B	CCD Camera	1	0.43~0.52	30	700		4	60
		2	0.52~0.60					
		3	0.63~0.69					
		4	0.76~0.9					
	Infrared Multispectral Camera	5	0.75~1.10	150	720		4	
		6	1.55~1.75					
		7	3.50~3.90					
		8	10.5~12.5	300				

Sensor specification table for HJ-1A/B

FY satellites

- The specific FY3 sensors of our focus include:
  - Visible and Infrared Radiometer (VIRR)
  - Earth Radiation Measurement (ERM)
  - Medium Resolution Spectral Imager (MESRI)

FY-3

Sensor Specific Data Products

Name	Performance Parameters	Detection Objective
Visible and Infrared Scan Radiometer (VIRR)	Spectral Range: 0.43µm ~ 12.5µm Number of channels: 10 Scanning range: ±55.4º Ground resolution: 1.1 KM	Cloud Imagery, Vegetation, Sediment, Cirrus and Cloud Phase, Snow, Ice, Surface temperature, Sea Surface tempearture total Water Vapor, etc.
MEdium Resolution Spectral Imager (MESRI)	Frequency Range: 0.40µm, ~ 12.5µm Number of channels: 20 Scan area: ±55.4º Ground Resolution: 0.25 ~ 1KM	Ocean Color, Aerosol, Water Vapor, Cloud Features, Vegetation, Ground Features, Surface Temperatures, Sea Ice, Snow, Ice, etc.
Earth Radiation Measurement (ERM)	Spectral Range: 0.2 ~ 50µm or 0.2 ~ 3.8µm Number of channels: 2 narrow FOV and 2 wide FOV Scane area: ±50º (narrow field of view) Sensitivity: 0.4m^{-2} sr^{-1}	Earth Radiation

Sensor specification table for FY-3

Summary of our recent activities

- Participating in Chinese Satellite programs
- Assessing Chinese satellite data quality
- Exploring data sharing policies
- Developing the project web site

Participation in Chinese satellite programs

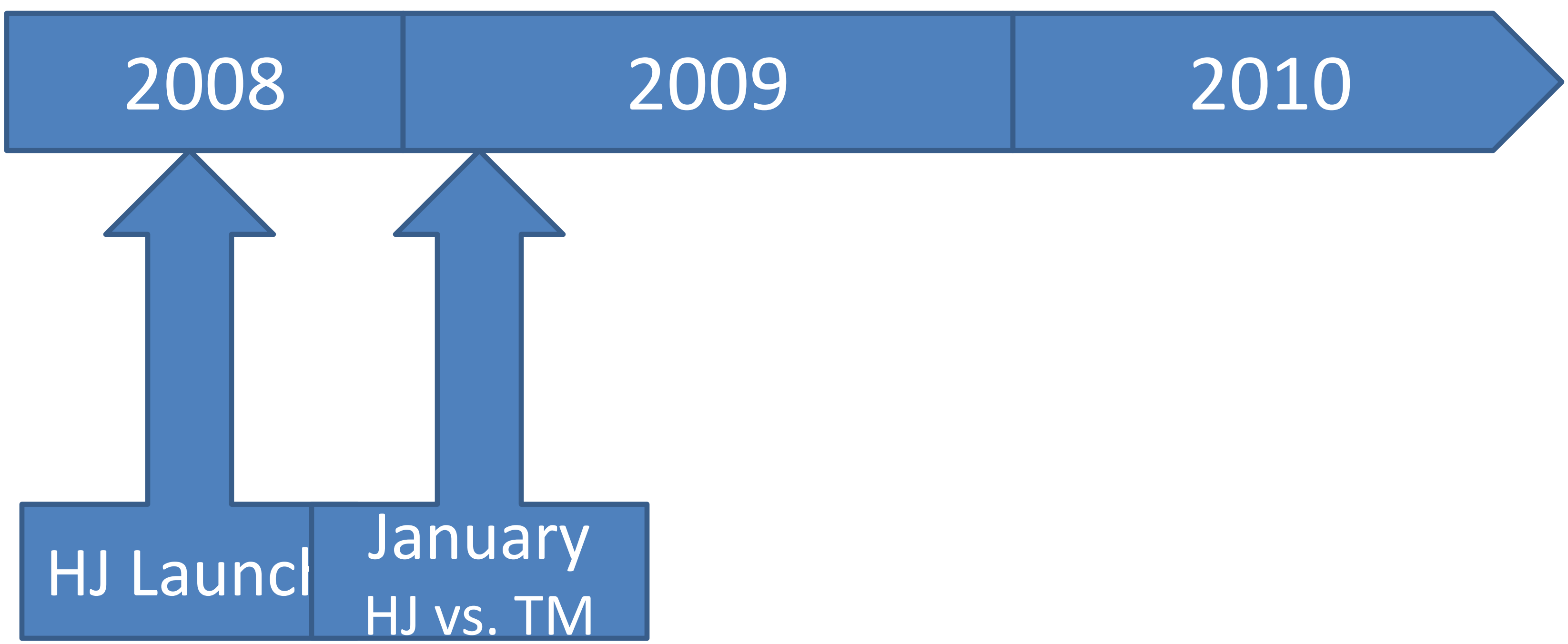
- In the past year, both Drs. Liang and Townshend travelled to China several times, met and discussed with the Chinese colleagues.
- Dr. Liang visited CRESDA for several times and talked to Director Xu, Deputy Directors Yu and Ming ,and the director of the Engineering division about our participation in their satellite programs and collaborations.
- Last April, Dr. Townshend led to organize an international workshop on forest monitoring using satellite data in Beijing.
- Last July, Dr. Liang led to organize a workshop on remote sensing inversion algorithms and the 2nd Summer School on land observation, modeling and data assimilation in Beijing Normal University.

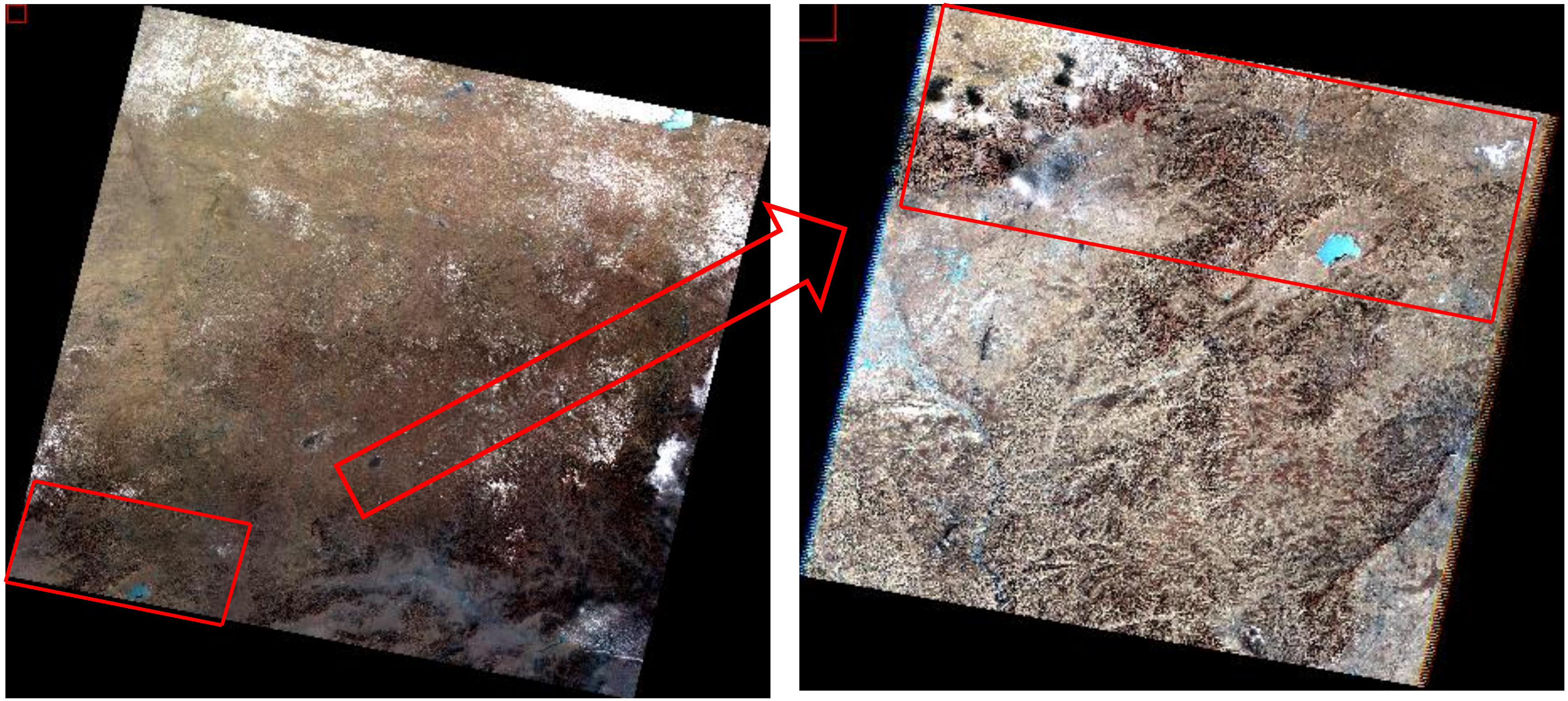
Investigating data quality

- Visually examine the imagery quality, and
- Assess radiometric calibration
  - HJ CCD data & TM/ALI
  - FY3 MESRI & MODIS

Visible Spectral

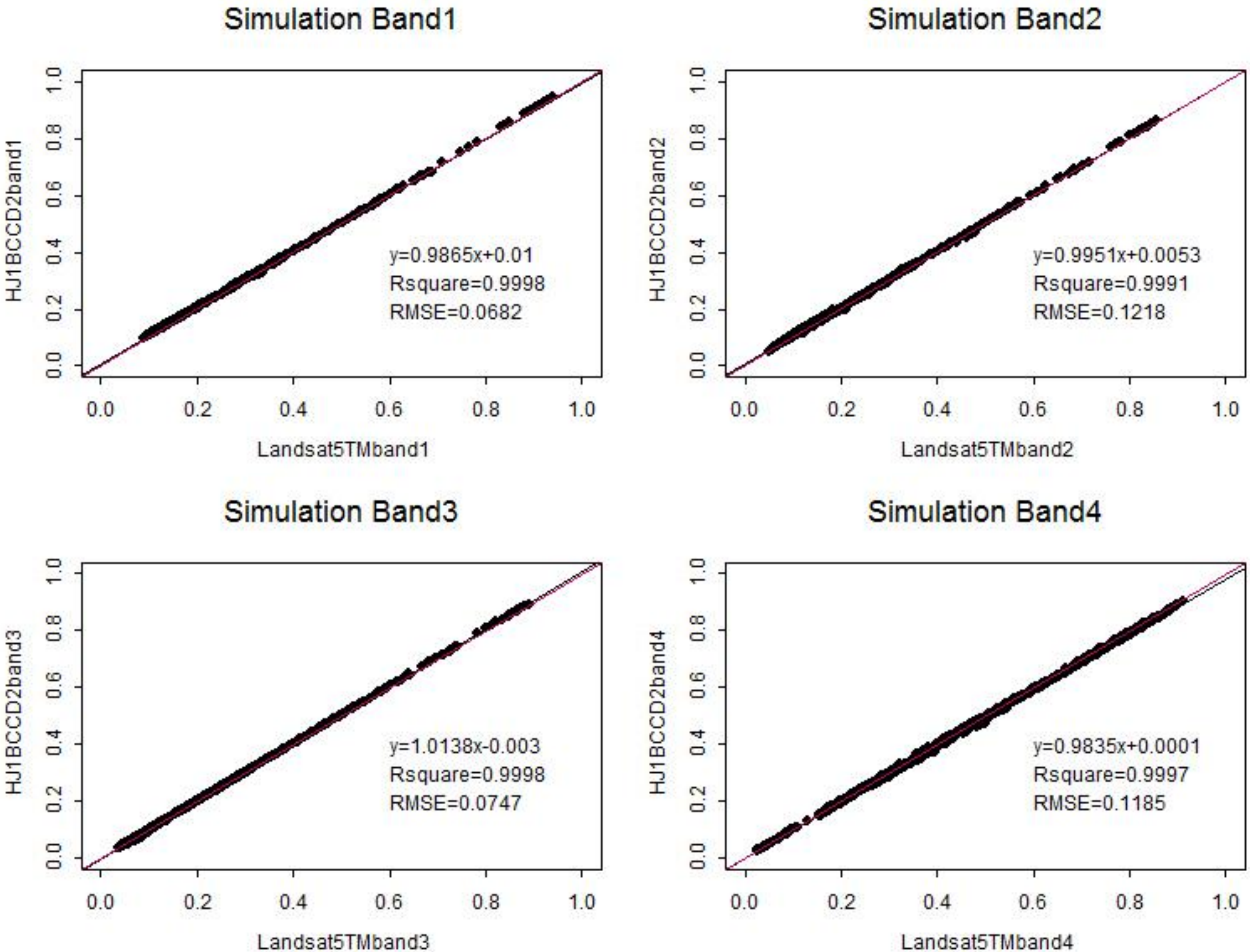
Landsat5 TM sensor		
Band	Spectral range (nm)	Spatial resolution(m)
1	430-560	30
2	500-605	30
3	580-740	30
4	740-950	30
EO-1 ALI sensor		
PAN	480-690	10
1’	433-453	30
1	450-515	30
2	525-606	30
3	630-690	30
4	775-805	30
4’	845-890	30

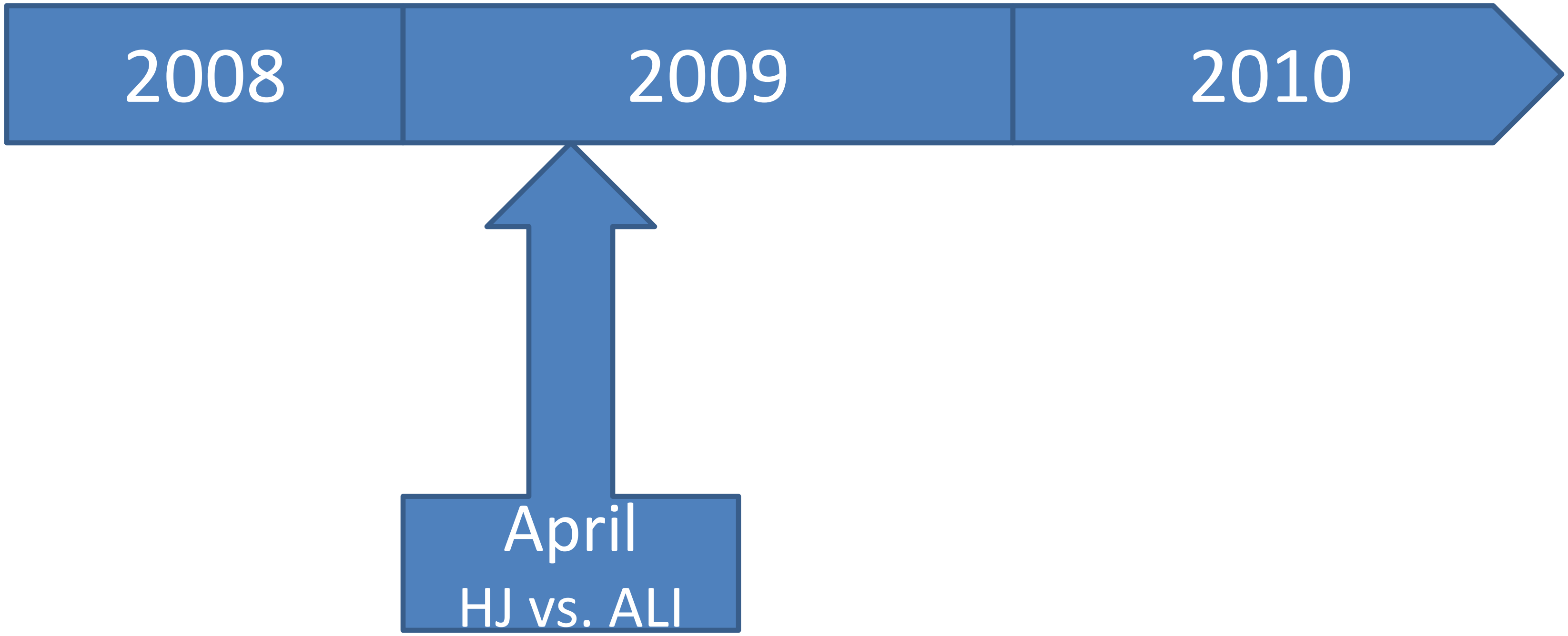

2008
2009
2010
HJ Launc
January
HJ vs. TM

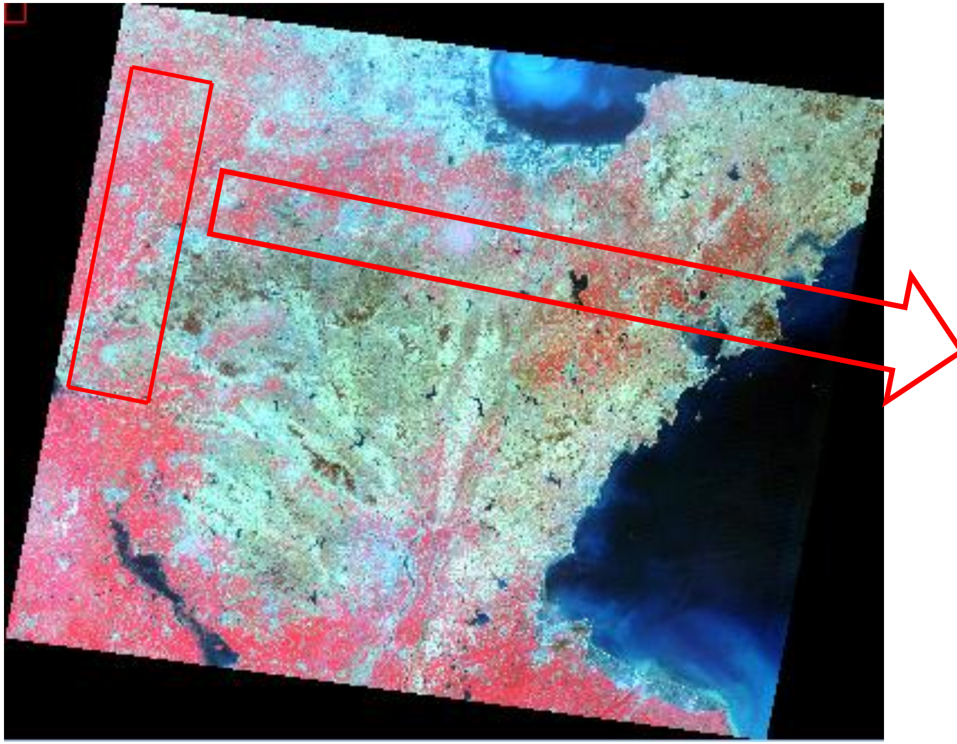


(a) (b)

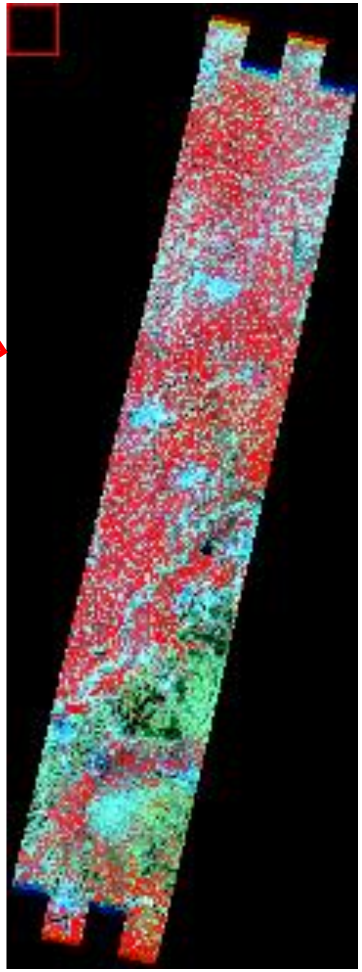
	Image (a)	Image (b)
Sensor	HJ1BCCD2	Landsat5TM
Date	2009-01-31 03:13:53.90	2009-01-30 04:31:51.03
Path/Row	3/64	140/38
Solar Zenith	61.431°	63.11°
Location	Inner Mongolia, China	Inner Mongolia, China
Projection	WGS84,UTM 49N	WGS84,UTM 50N


Simulation Band1
HJ1BCCD2band1
Landsat5TMband1
y=0.9865x+0.01
Rsquare=0.9998
RMSE=0.0682
Simulation Band2
HJ1BCCD2band2
Landsat5TMband2
y=0.9951x+0.0053
Rsquare=0.9991
RMSE=0.1218
Simulation Band3
HJ1BCCD2band3
Landsat5TMband3
y=1.0138x-0.003
Rsquare=0.9998
RMSE=0.0747
Simulation Band4
HJ1BCCD2band4
Landsat5TMband4
y=0.9835x+0.0001
Rsquare=0.9997
RMSE=0.1185
0.0
0.2
0.4
0.6
0.8
1.0


2008
2009
2010
April
HJ vs. ALI

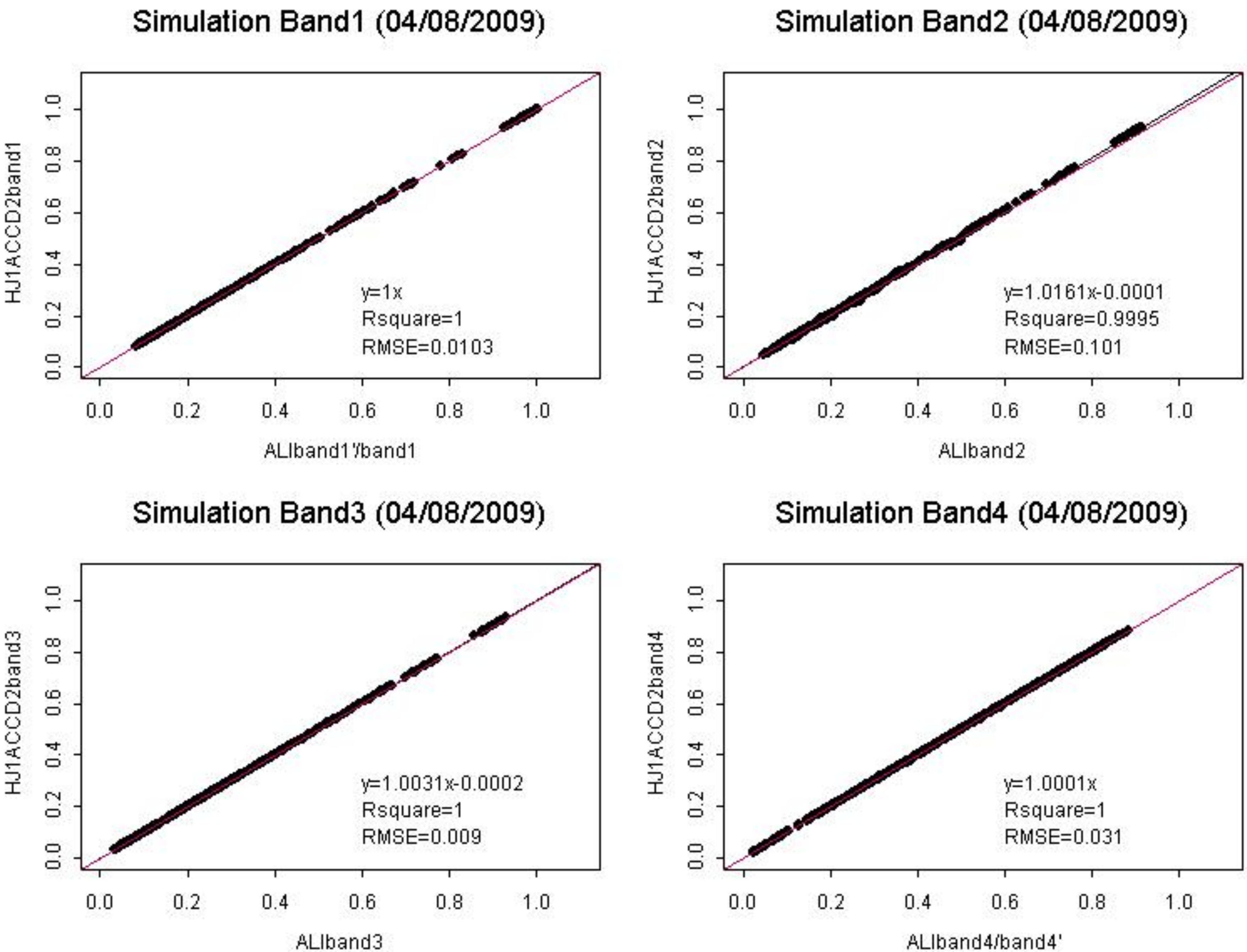


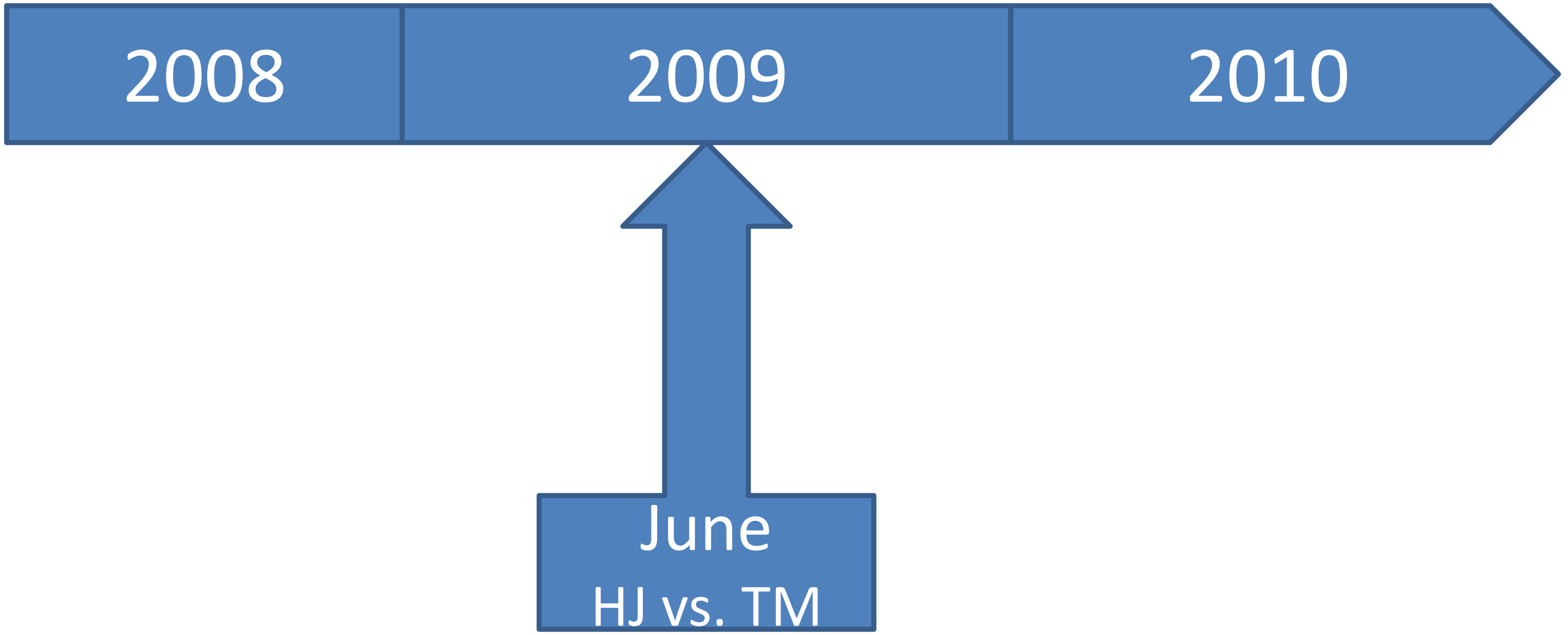
(a)

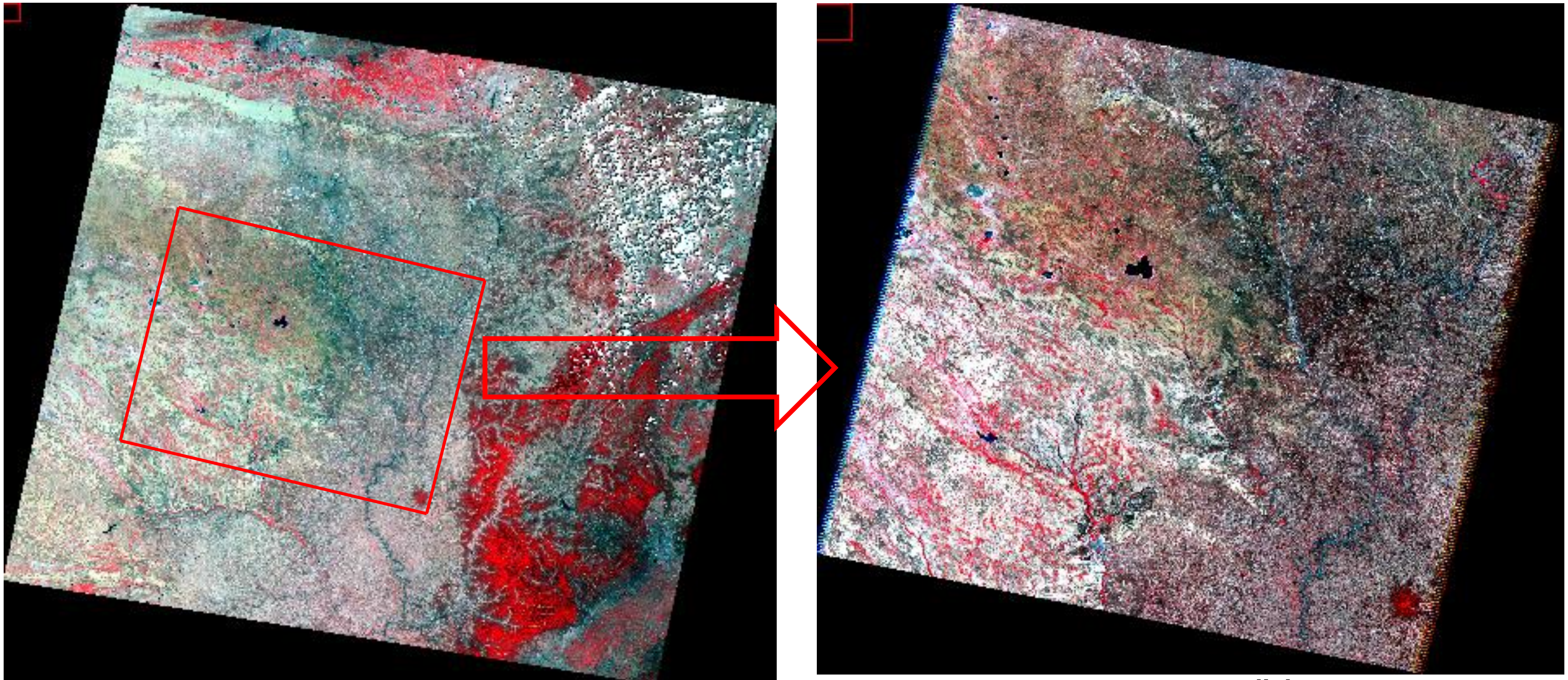


(b)

	Image (a)	Image (b)
Sensor	HJ1ACCD2	EO-1 ALI
Date	2009-04-08	2009-04-08
Path/Row	453/72	122/34
Solar Zenith	32.982°	37.413°
Location	Shandong, China	Shandong, China
Projection	WGS84,UTM 50N	WGS84,UTM 50N

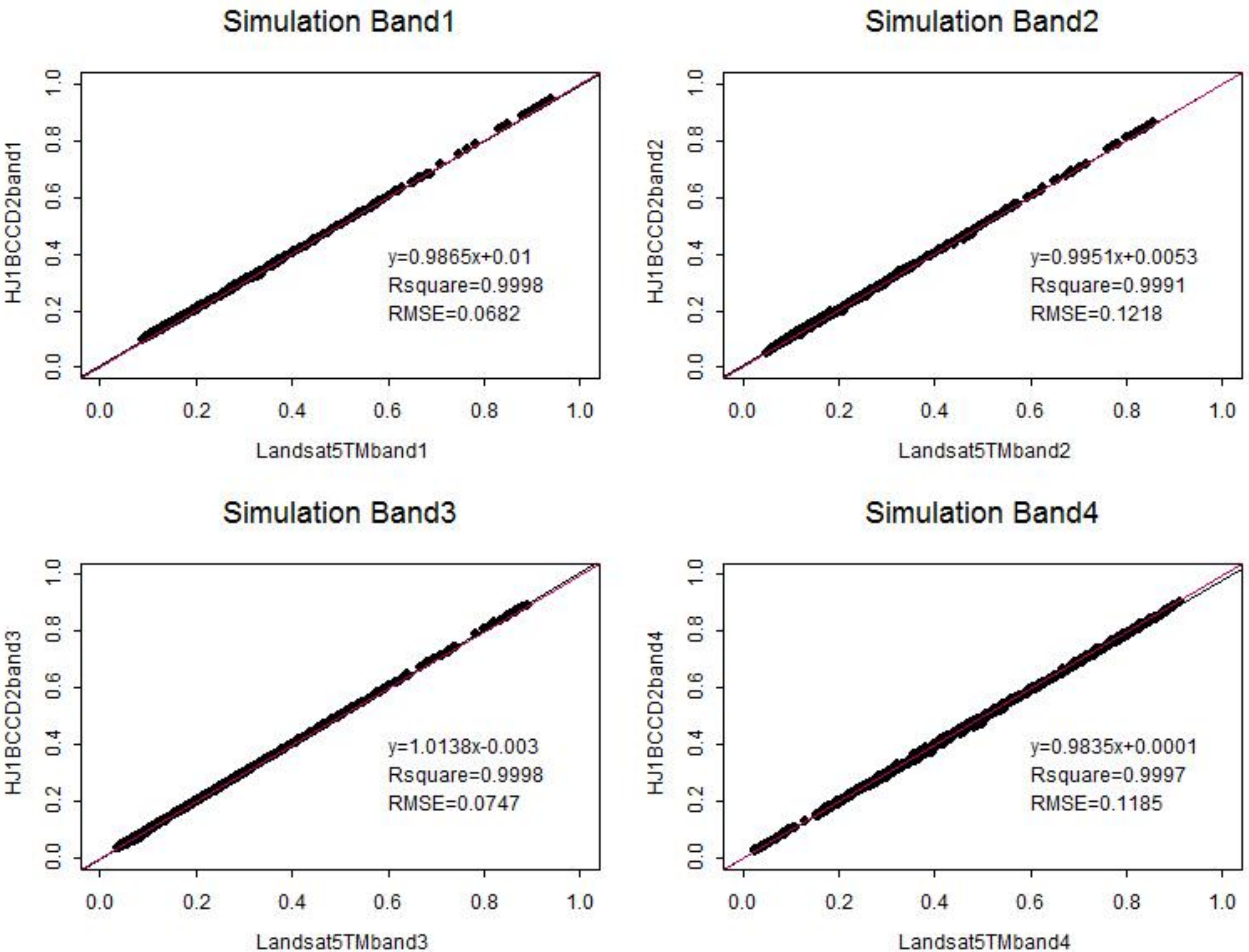

Simulation Band1 (04/08/2009)
y=1x
Rsquare=1
RMSE=0.0103
HJ1ACCD2band1
ALIband1'/band1
Simulation Band2 (04/08/2009)
y=1.0161x-0.0001
Rsquare=0.9995
RMSE=0.101
HJ1ACCD2band2
ALIband2
Simulation Band3 (04/08/2009)
y=1.0031x-0.0002
Rsquare=1
RMSE=0.009
HJ1ACCD2band3
ALIband3
Simulation Band4 (04/08/2009)
y=1.0001x
Rsquare=1
RMSE=0.031
HJ1ACCD2band4
ALIband4/band4'

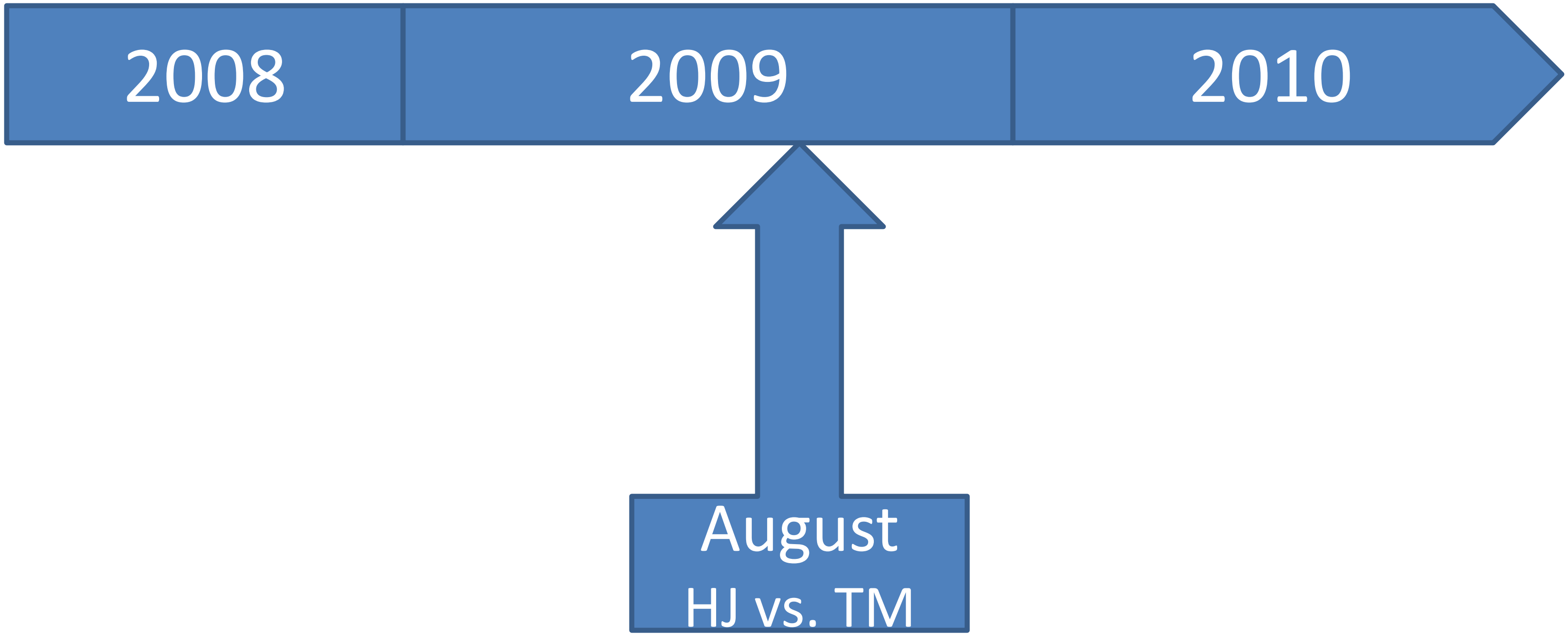

2008
2009
2010
June
HJ vs. TM

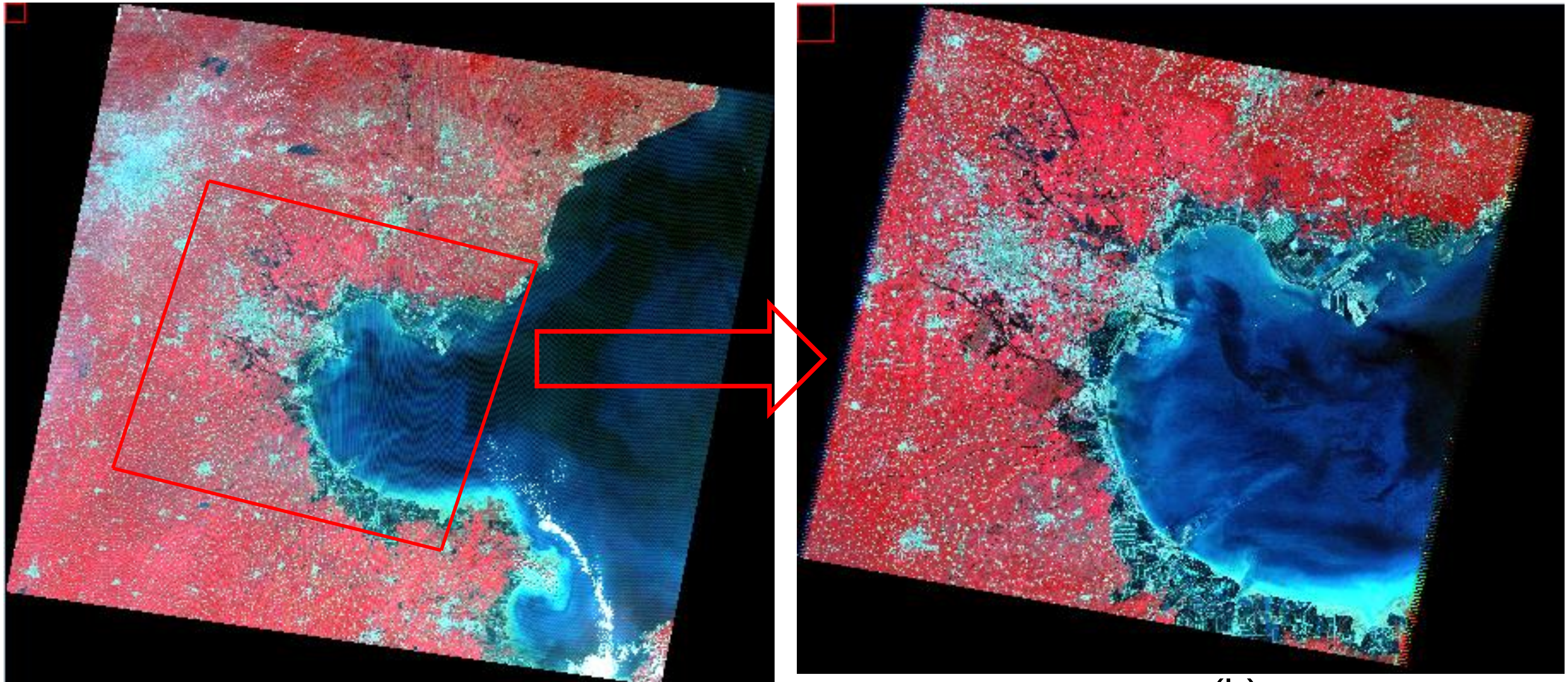


(a) (b)

	Image (a)	Image (b)
Sensor	HJ1ACCD2	Landsat5TM
Date	2009-06-30 03:27:14.28	2009-06-30 03:07:13.73
Path/Row	8/68	127/33
Solar Zenith	21.61	25.767
Location	Shanxi, China	Shanxi, China
Projection	WGS84,UTM 49N	WGS84,UTM 49N

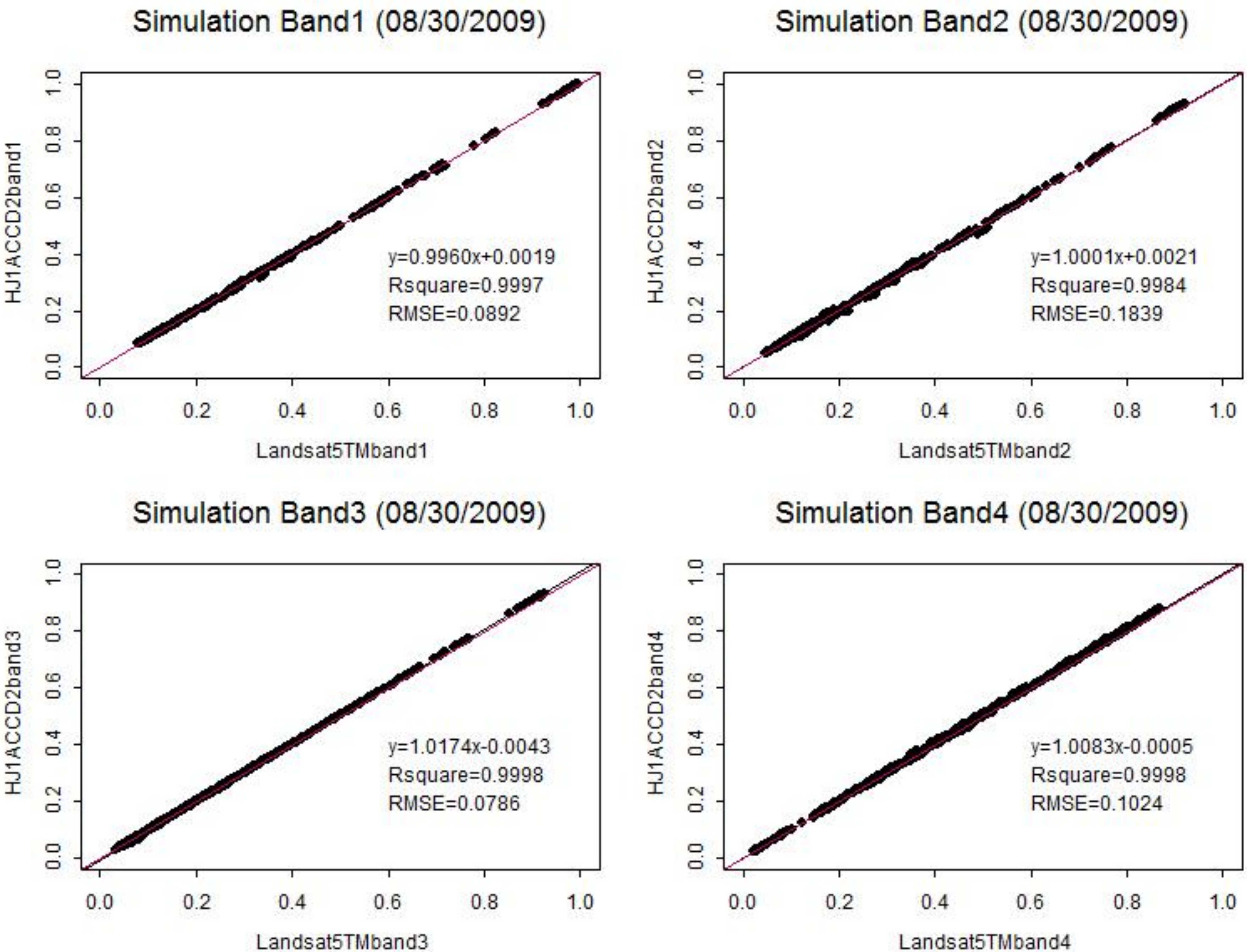

Simulation Band1
HJ1BCCD2band1
Landsat5TMband1
y=0.9865x+0.01
Rsquare=0.9998
RMSE=0.0682
Simulation Band2
HJ1BCCD2band2
Landsat5TMband2
y=0.9951x+0.0053
Rsquare=0.9991
RMSE=0.1218
Simulation Band3
HJ1BCCD2band3
Landsat5TMband3
y=1.0138x-0.003
Rsquare=0.9998
RMSE=0.0747
Simulation Band4
HJ1BCCD2band4
Landsat5TMband4
y=0.9835x+0.0001
Rsquare=0.9997
RMSE=0.1185

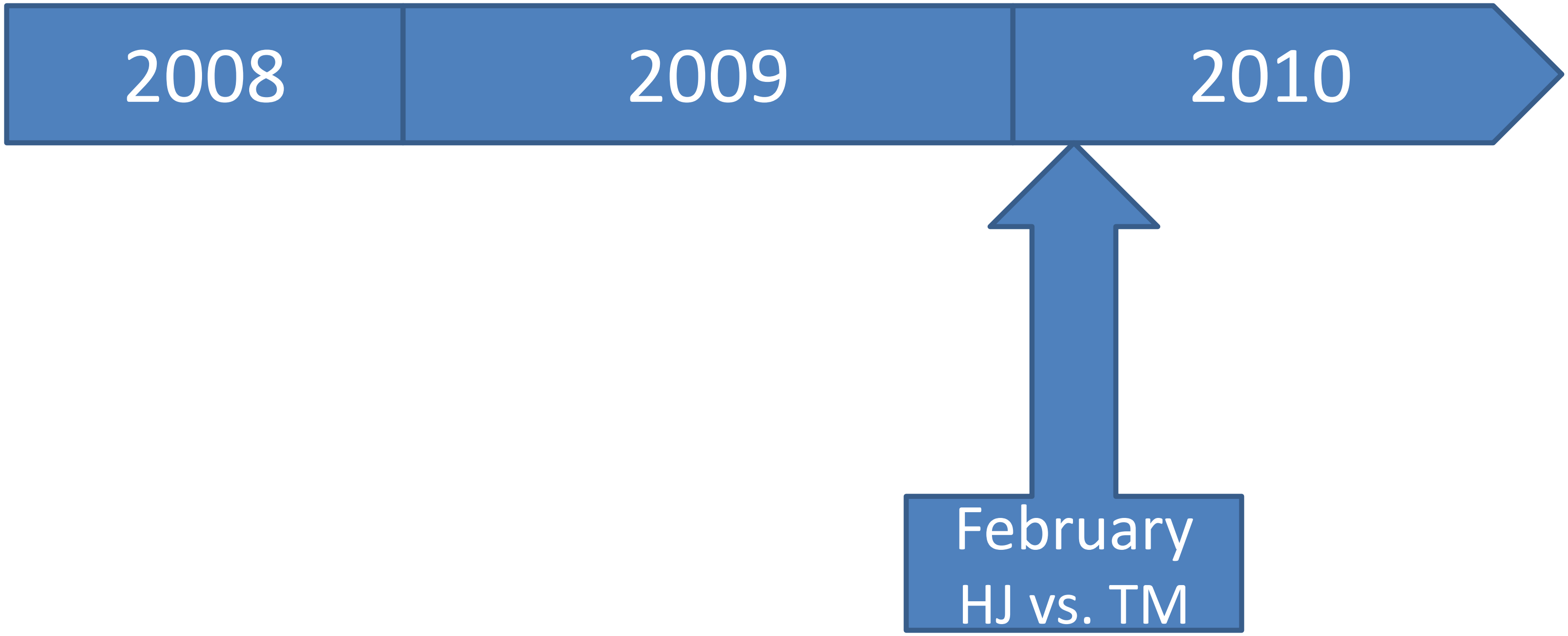

2008
2009
2010
August
HJ vs. TM



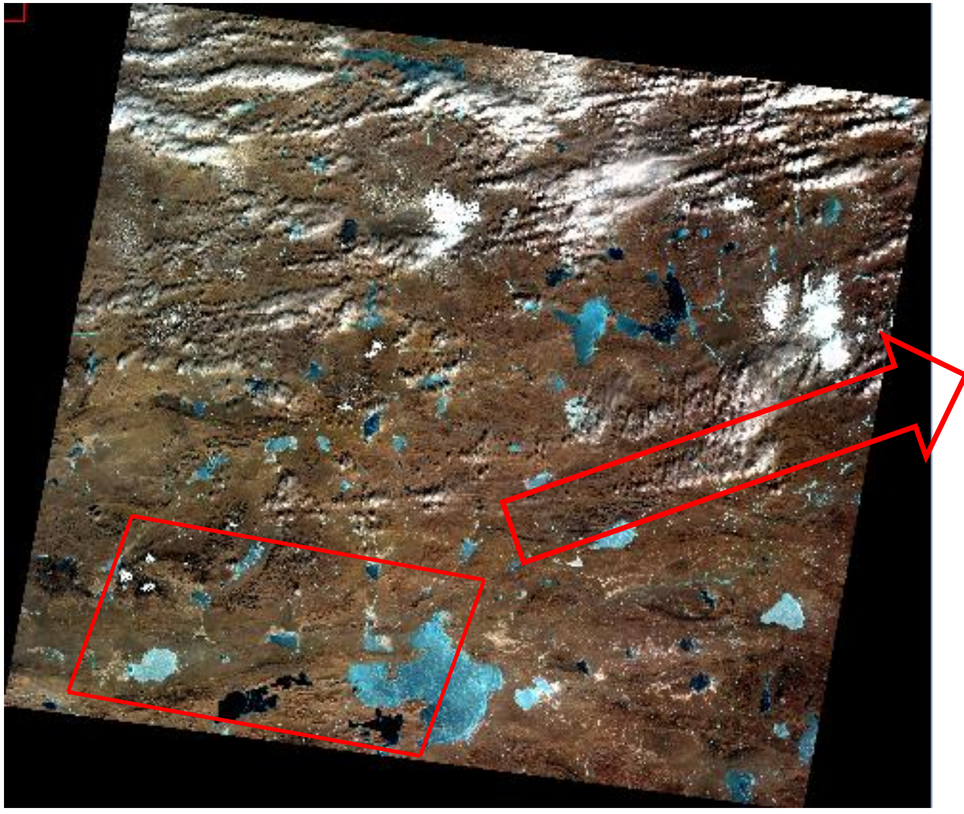
(a) (b)

	Image (a)	Image (b)
Sensor	HJ1ACCD2	Landsat5TM
Date	2009-08-30 02:57:31.63	2009-08-30 02:37:16.63
Path/Row	455/68	122/33
Solar Zenith	43.945°	46.355°
Location	Shandong, China	Shandong, China
Projection	WGS84,UTM 50N	WGS84,UTM 50N

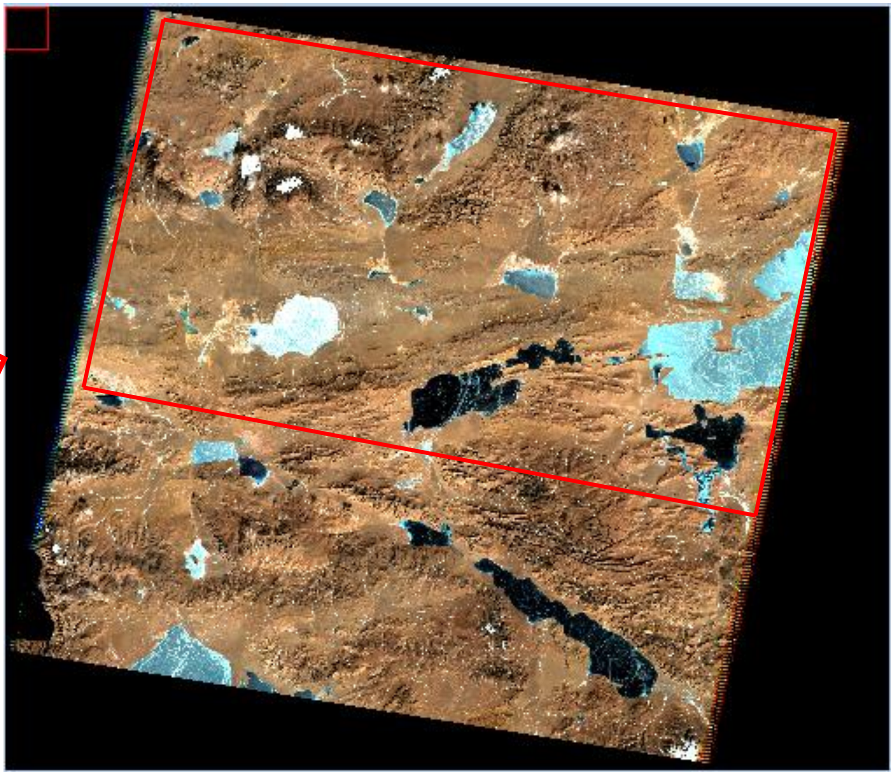

Simulation Band1 (08/30/2009)
HJ1ACCD2band1
Landsat5TMband1
y=0.9960x+0.0019
Rsquare=0.9997
RMSE=0.0892
Simulation Band2 (08/30/2009)
HJ1ACCD2band2
Landsat5TMband2
y=1.0001x+0.0021
Rsquare=0.9984
RMSE=0.1839
Simulation Band3 (08/30/2009)
HJ1ACCD2band3
Landsat5TMband3
y=1.0174x-0.0043
Rsquare=0.9998
RMSE=0.0786
Simulation Band4 (08/30/2009)
HJ1ACCD2band4
Landsat5TMband4
y=1.0083x-0.0005
Rsquare=0.9998
RMSE=0.1024
0.0
0.2
0.4
0.6
0.8
1.0



2008
2009
2010
February
HJ vs. TM

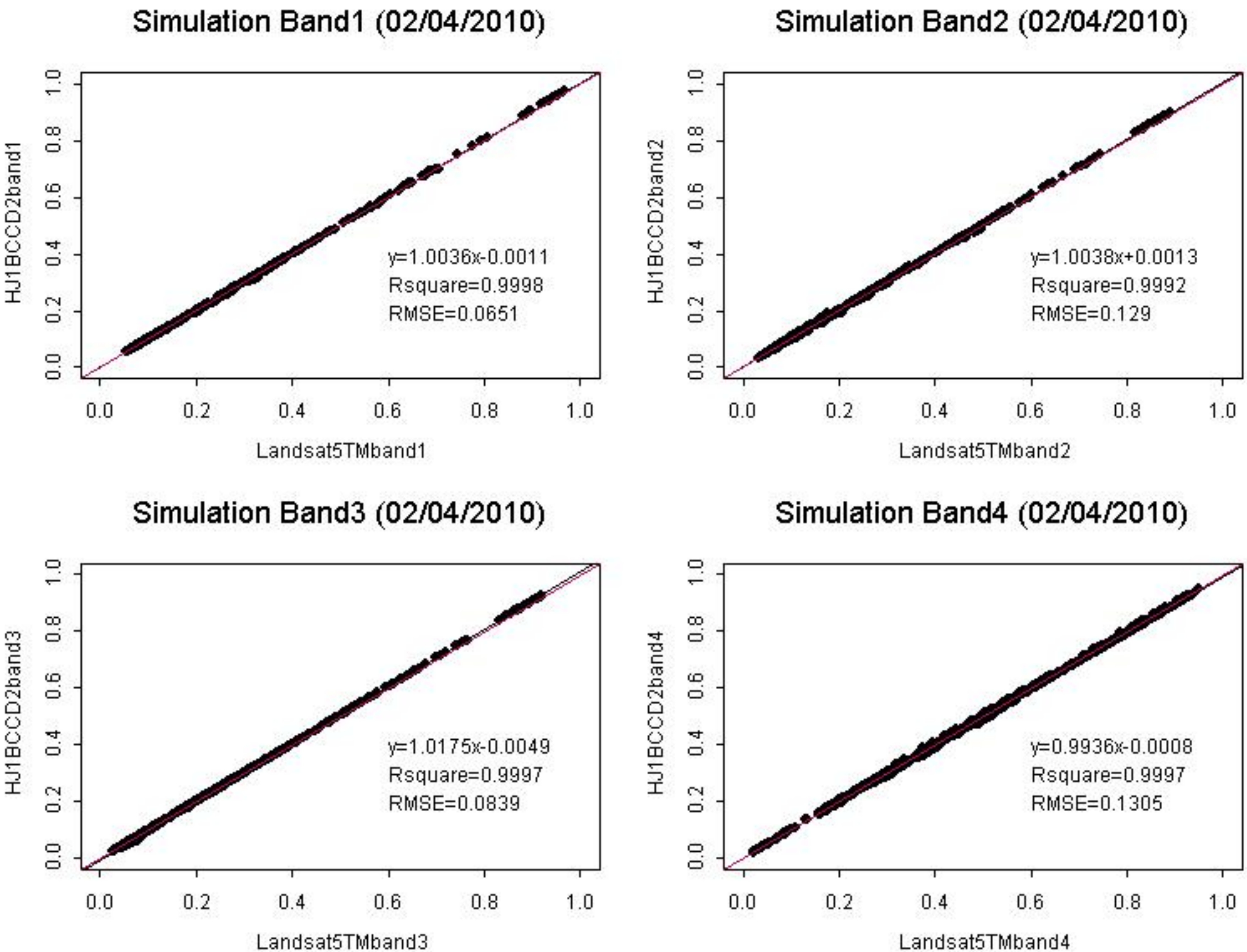


(a)



(b)

	Image (a)	Image (b)
Sensor	HJ1BCCD2	Landsat5TM
Date	2010-02-04 04:48:11.42	2010-02-04 04:31:51.03
Path/Row	33/76	140/38
Solar Zenith	52.486°	54.82°
Location	Tibet, China	Tibet, China
Projection	WGS84,UTM 45N	WGS84,UTM 45N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HJ1BCCD2band1
Landsat5TMband1
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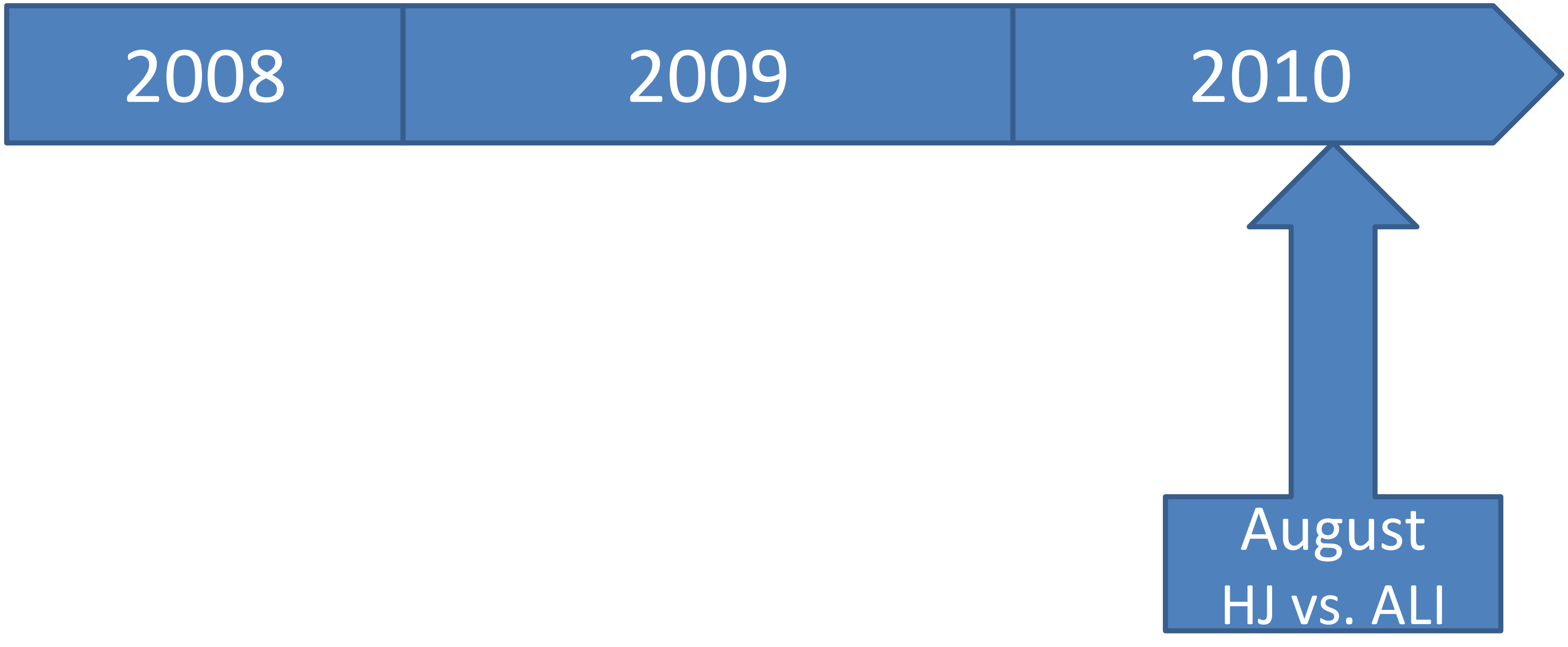
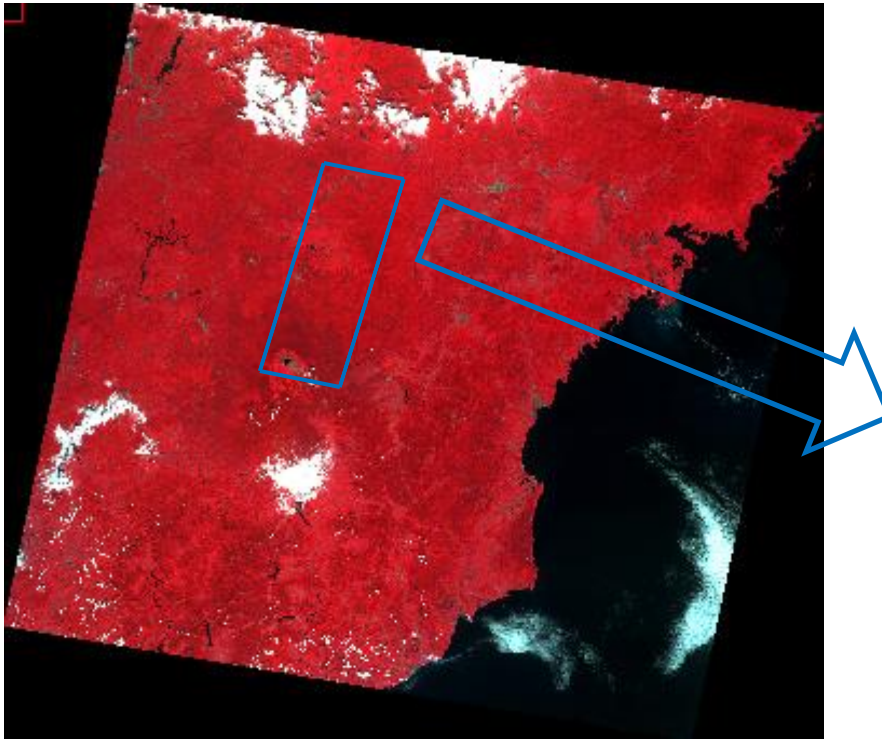
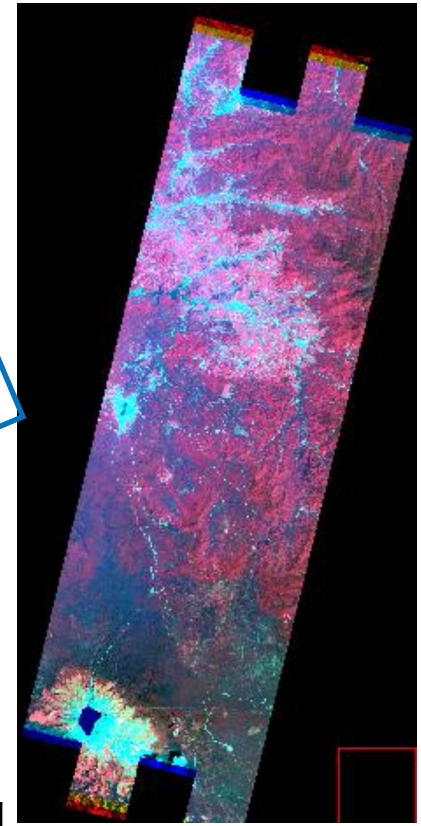
Rsquare=0.9998
RMSE=0.0651
Simulation Band2 (02/04/2010)
HJ1BCCD2band2
Landsat5TMband2
y=1.0038x+0.0013
Rsquare=0.9992
RMSE=0.129
Simulation Band3 (02/04/2010)
HJ1BCCD2band3
Landsat5TMband3
y=1.0175x-0.0049
Rsquare=0.9997
RMSE=0.0839
Simulation Band4 (02/04/2010)
HJ1BCCD2band4
Landsat5TMband4
y=0.9936x-0.0008
Rsquare=0.9997
RMSE=0.1305


2008
2009
2010
August
HJ vs. ALI

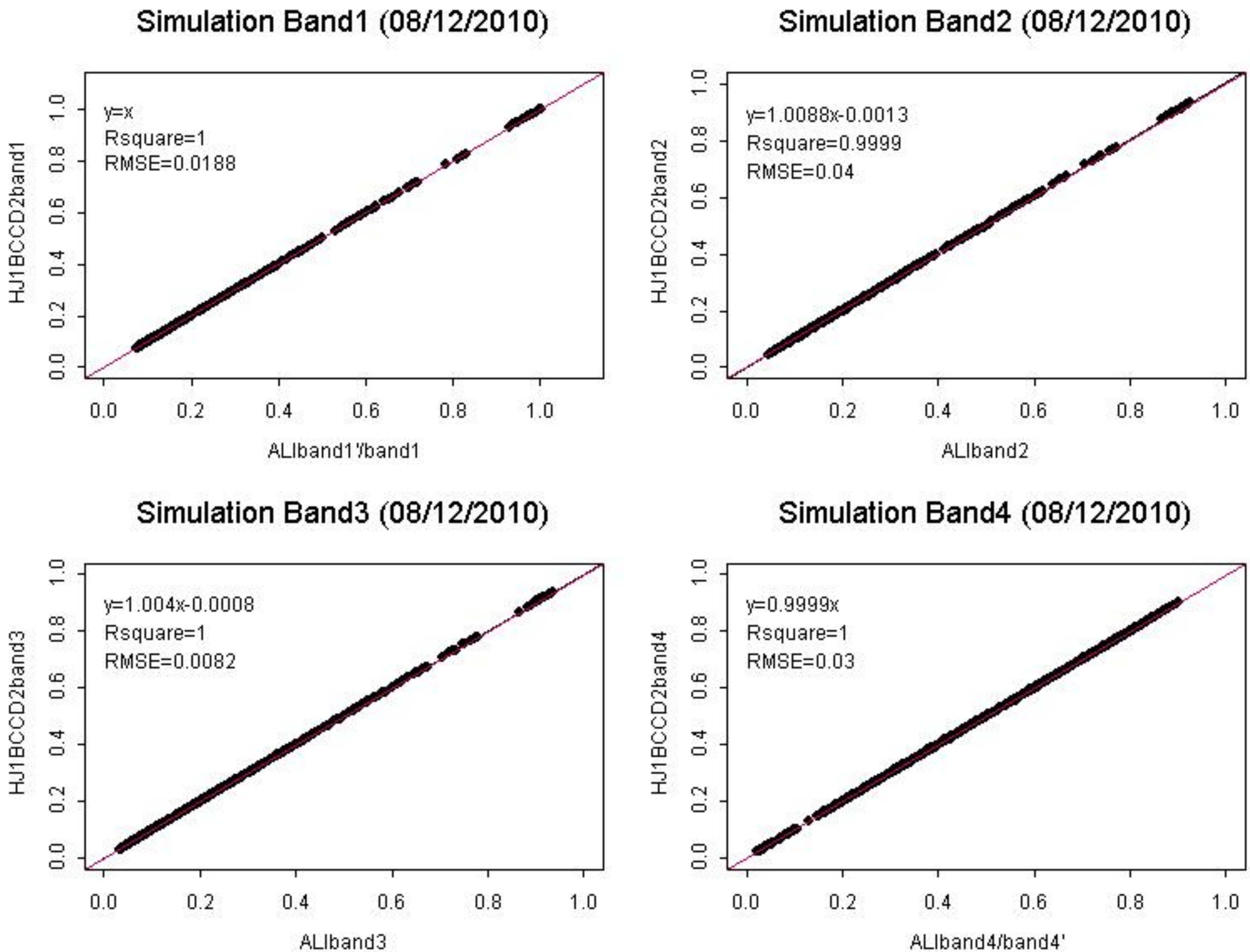


(a)

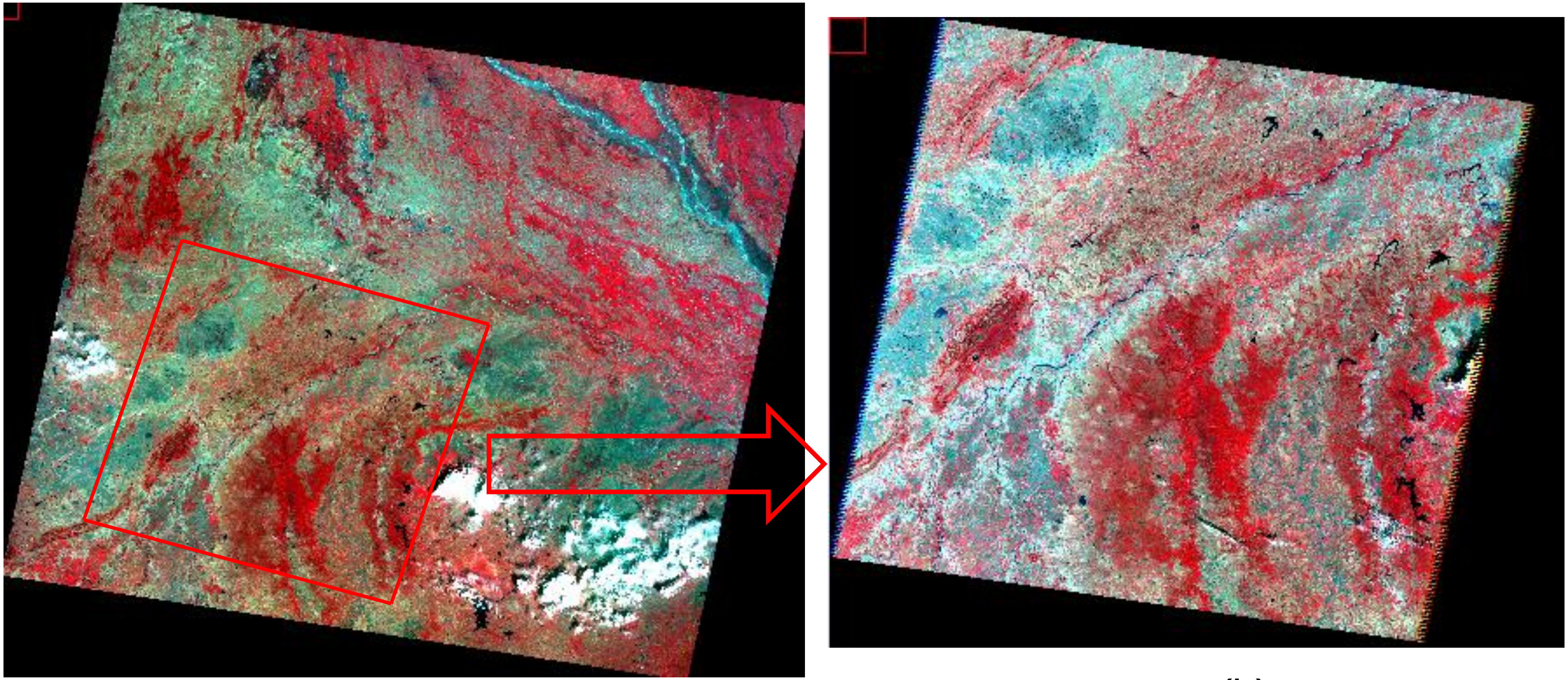


(b)

	Image (a)	Image (b)
Sensor	HJ1BCCD2	EO-1 ALI
Date	2010-08-12	2010-08-12
Path/Row	442/64	116/30
Solar Zenith	30.977°	34.7°
Location	Jilin, China	Jilin, China
Projection	WGS84,UTM 52N	WGS84,UTM 52N

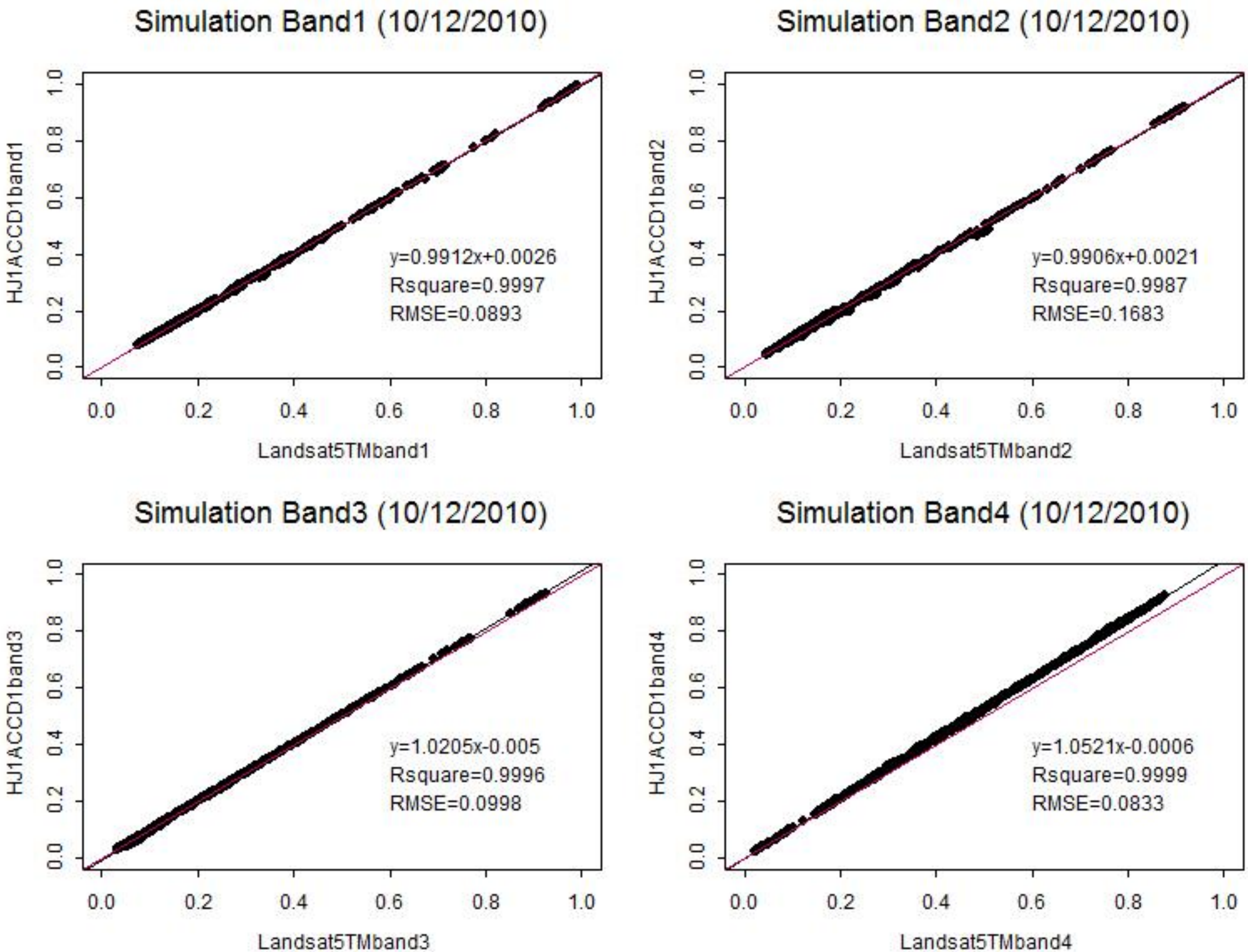

Simulation Band1 (08/12/2010)
y=x
Rsquare=1
RMSE=0.0188
HJ1BCCD2band1
ALIband1'/band1
0.0
0.2
0.4
0.6
0.8
1.0
Simulation Band2 (08/12/2010)
y=1.0088x-0.0013
Rsquare=0.9999
RMSE=0.04
HJ1BCCD2band2
ALIband2
Simulation Band3 (08/12/2010)
y=1.004x-0.0008
Rsquare=1
RMSE=0.0082
HJ1BCCD2band3
ALIband3
Simulation Band4 (08/12/2010)
y=0.9999x
Rsquare=1
RMSE=0.03
HJ1BCCD2band4
ALIband4/band4'


2008
2009
2010
October
HJ vs. TM



(a) (b)

	Image (a)	Image (b)
Sensor	HJ1ACCD1	Landsat5TM
Date	2010-10-12 05:42:07.99	2010-10-12 05:09:37.8
Path/Row	46/84	146/42
Solar Zenith	47.912°	39.677°
Location	India Northern	India Northern
Projection	WGS84,UTM 43N	WGS84,UTM 43N


Simulation Band1 (10/12/2010)
HJ1ACCD1band1
Landsat5TMband1
y=0.9912x+0.0026
Rsquare=0.9997
RMSE=0.0893
Simulation Band2 (10/12/2010)
HJ1ACCD1band2
Landsat5TMband2
y=0.9906x+0.0021
Rsquare=0.9987
RMSE=0.1683
Simulation Band3 (10/12/2010)
HJ1ACCD1band3
Landsat5TMband3
y=1.0205x-0.005
Rsquare=0.9996
RMSE=0.0998
Simulation Band4 (10/12/2010)
HJ1ACCD1band4
Landsat5TMband4
y=1.0521x-0.0006
Rsquare=0.9999
RMSE=0.0833
0.0
0.2
0.4
0.6
0.8
1.0

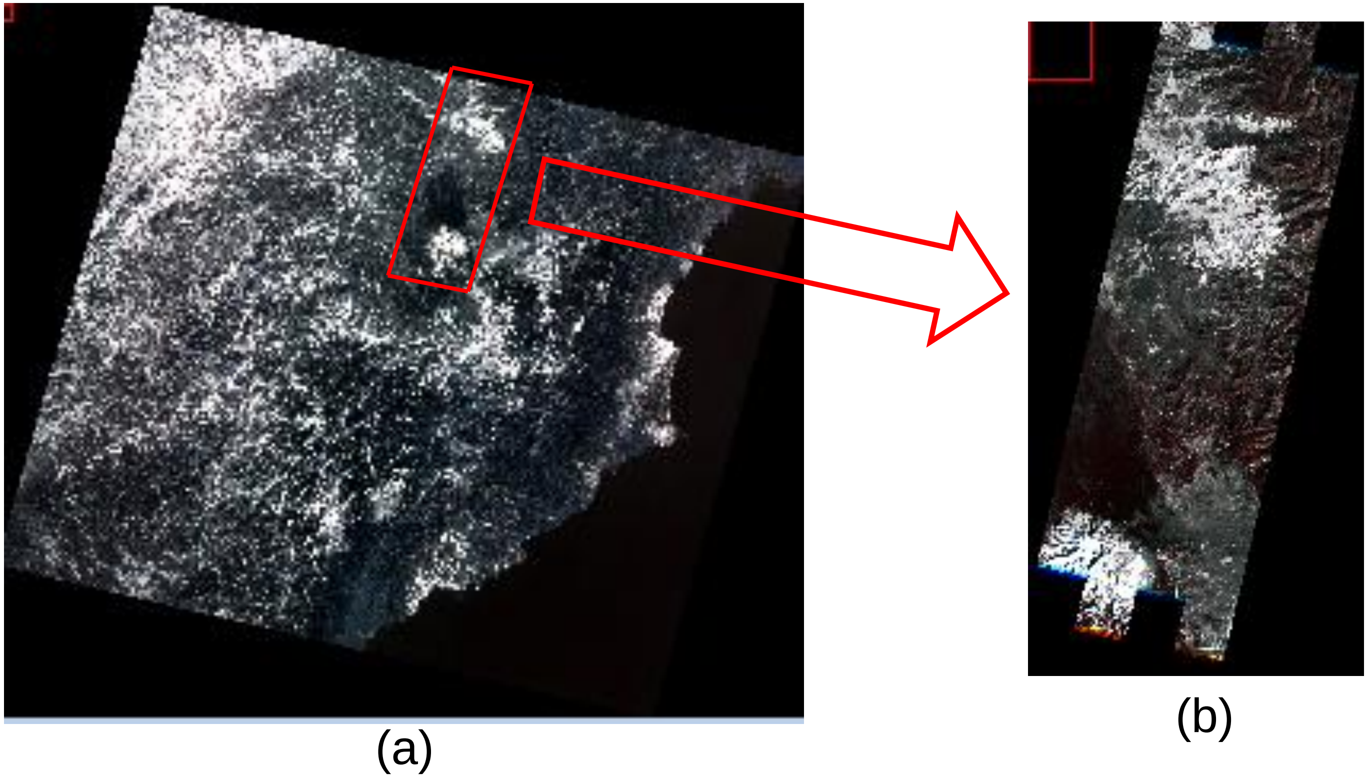
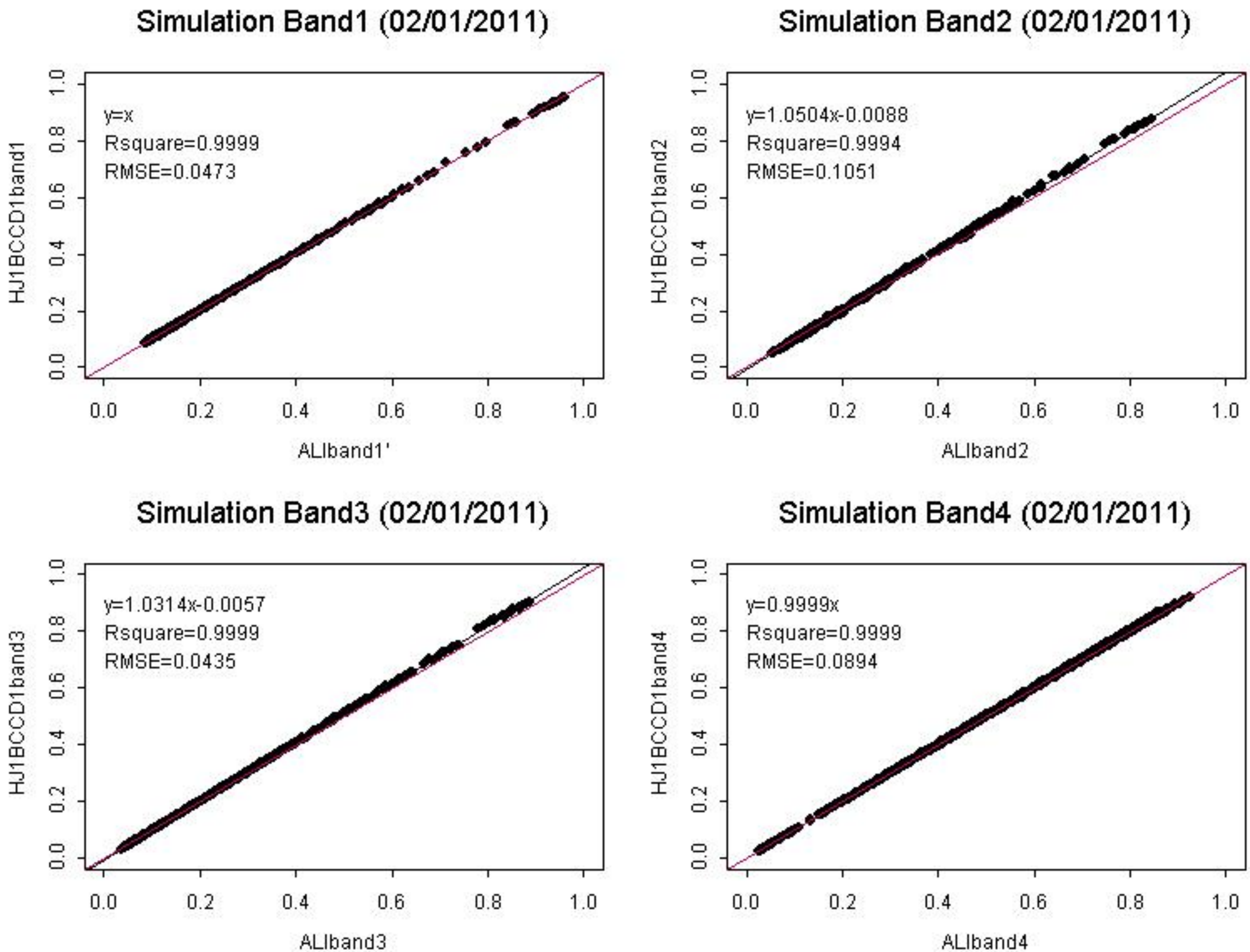


	Image (a)	Image (b)
Sensor	HJ1BCCD1	EO-1 ALI
Date	2011-02-01 02:33:31.74	2011-02-01
Path/Row	442/64	116/30
Solar Zenith	60.134°	64.84°
Location	Jilin, China	Jilin, China
Projection	WGS84,UTM 52N	WGS84,UTM 52N


Simulation Band1 (02/01/2011)
y=x
Rsquare=0.9999
RMSE=0.0473
HJ1BCCD1band1
ALIband1'
Simulation Band2 (02/01/2011)
y=1.0504x-0.0088
Rsquare=0.9994
RMSE=0.1051
HJ1BCCD1band2
ALIband2
Simulation Band3 (02/01/2011)
y=1.0314x-0.0057
Rsquare=0.9999
RMSE=0.0435
HJ1BCCD1band3
ALIband3
Simulation Band4 (02/01/2011)
y=0.9999x
Rsquare=0.9999
RMSE=0.0894
HJ1BCCD1band4
ALIband4

FY3A MESRI and MODIS Bands

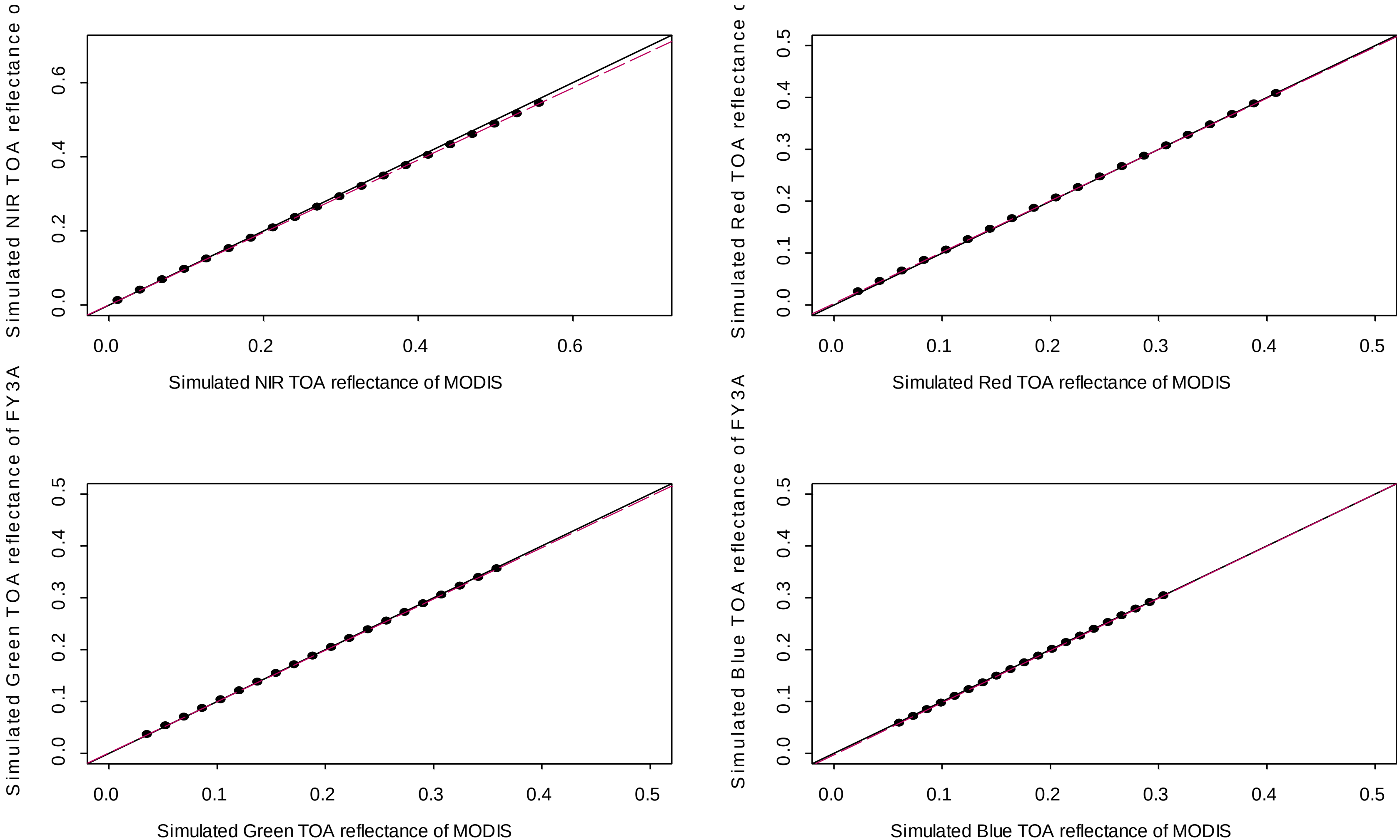
Band range (µm)	NIR	Red	Green	Blue
FY3A	0.84-0.89	0.58-0.68	0.53-0.58	0.43-0.48
MODIS	0.841-0.876	0.62-0.67	0.545-0.565	0.459-0.479

Central Wavelength (µm)	NIR	Red	Green	Blue
FY3A	0.8578	0.621	0.54997	0.46255
MODIS	0.8565	0.6455	0.5536	0.4656

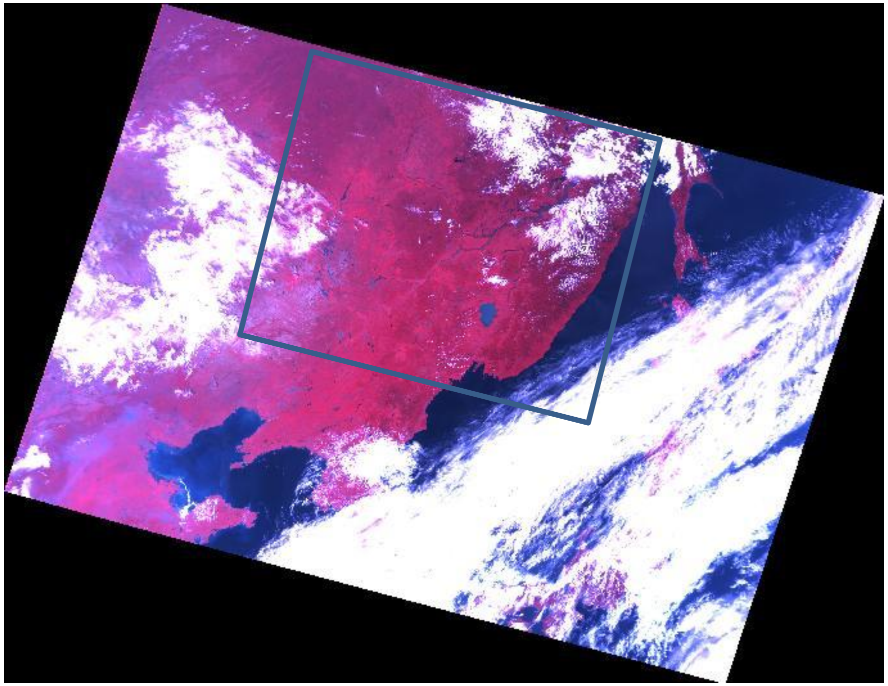
Spatial resolution (m)	NIR	Red	Green	Blue
FY3A	1000	1000	1000	1000
MODIS	250	250	500	500

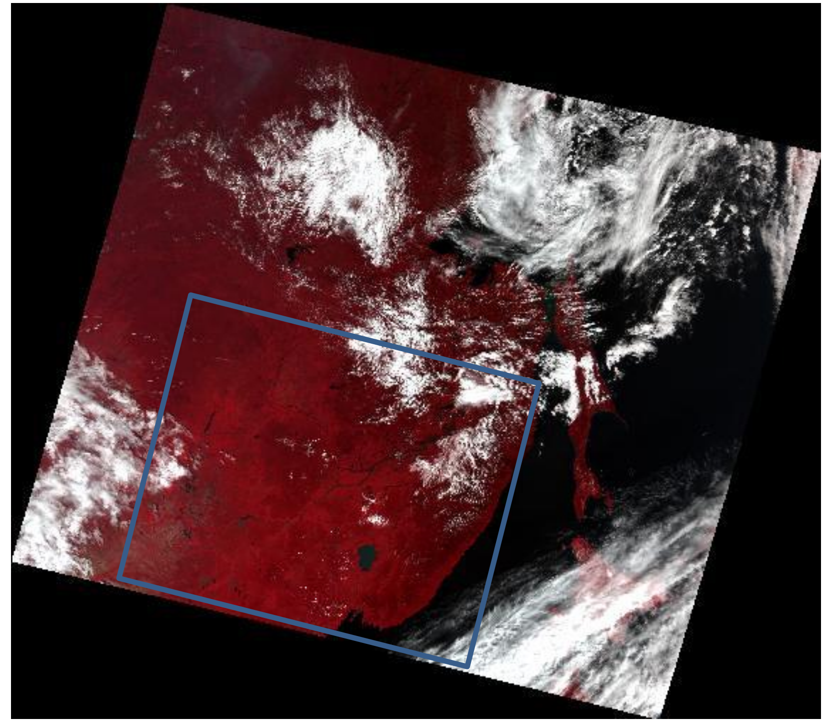
MOD02 1KM products are used to compare with FY3A_VIRRX_GBAL_L1 1km products

MODTRAN TOA simulation results



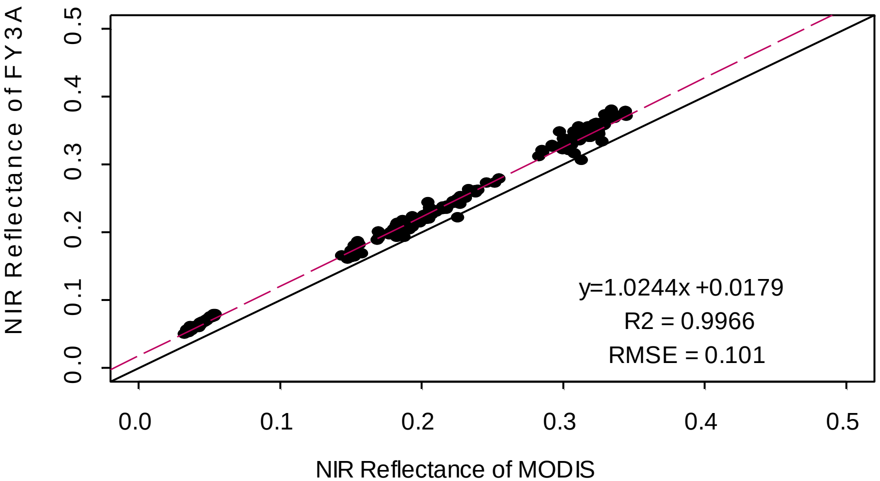
Visibility = 23km, Mid latitude summer. Geolocation: (45 N, 235 W), GWT: 2.12, SZA = 41

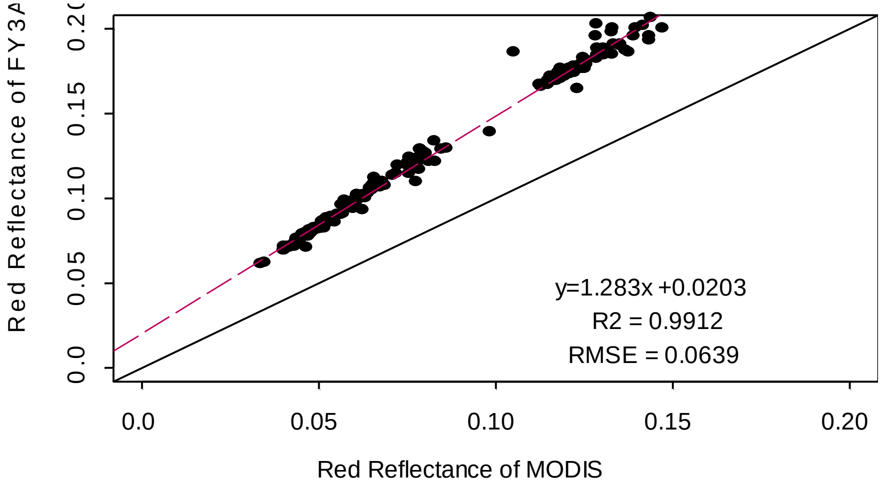


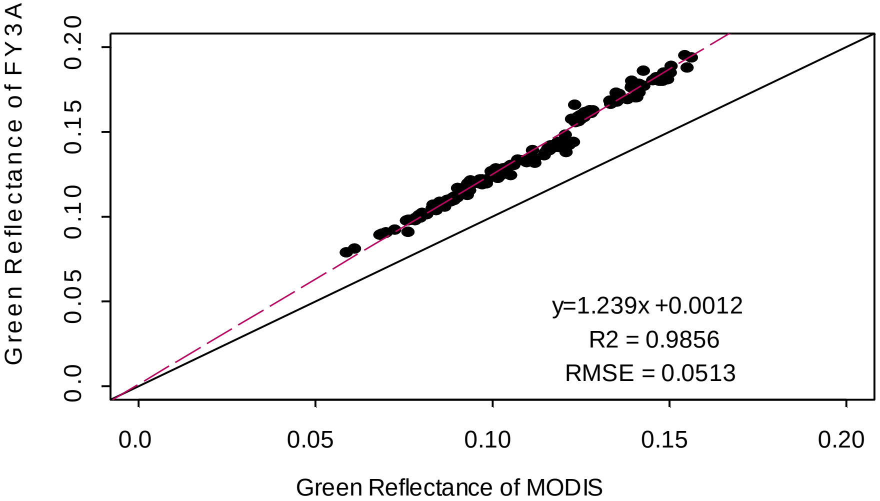


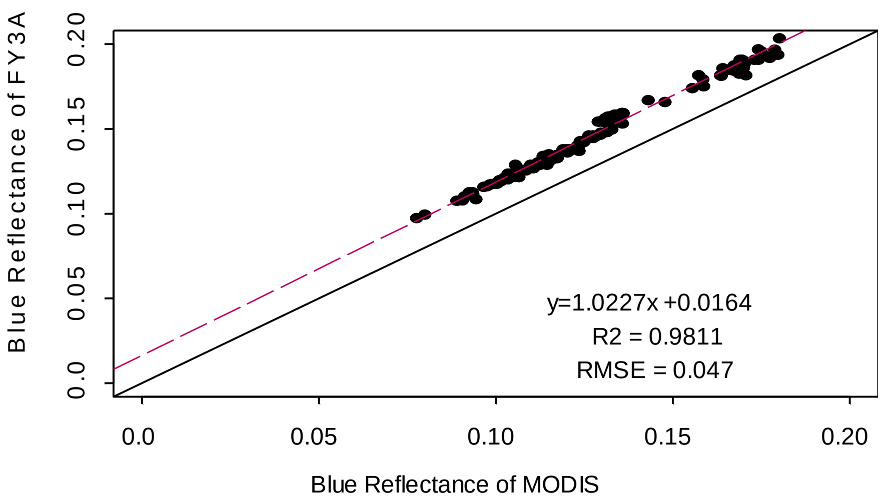
	FY3A	MODIS
Time	2009-8-30, 2:05 GMT	2009-8-30, 2:10 GMT
Location	32 -53 N, 112 -142 E	39 -61 N, 117 -144 E
Product	VIRR L1 1km	MOD02 1km
Solar zenith angle	23 - 53	30 - 57
Sensor zenith angle	0 - 69	0 - 66

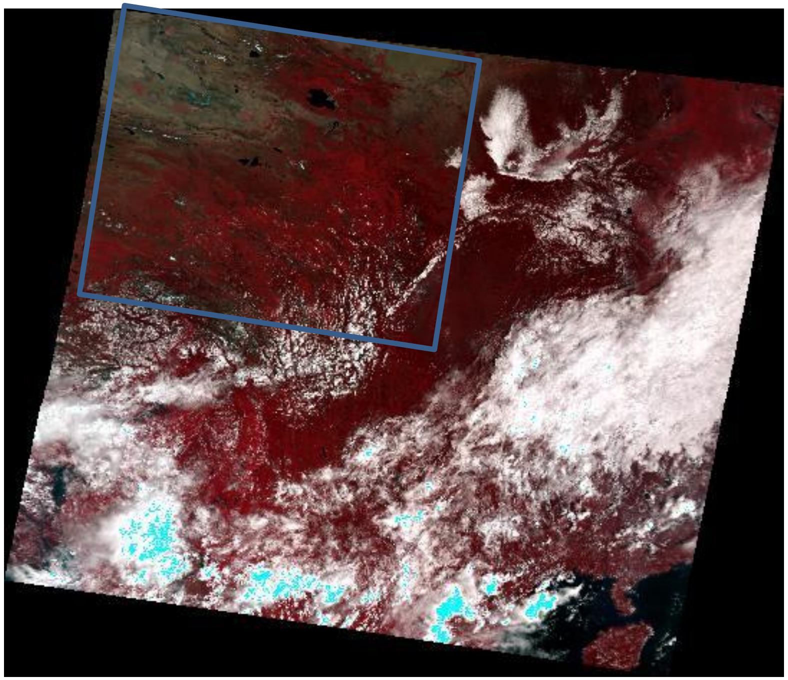
2009242_205, 2009242_210, Aug 30

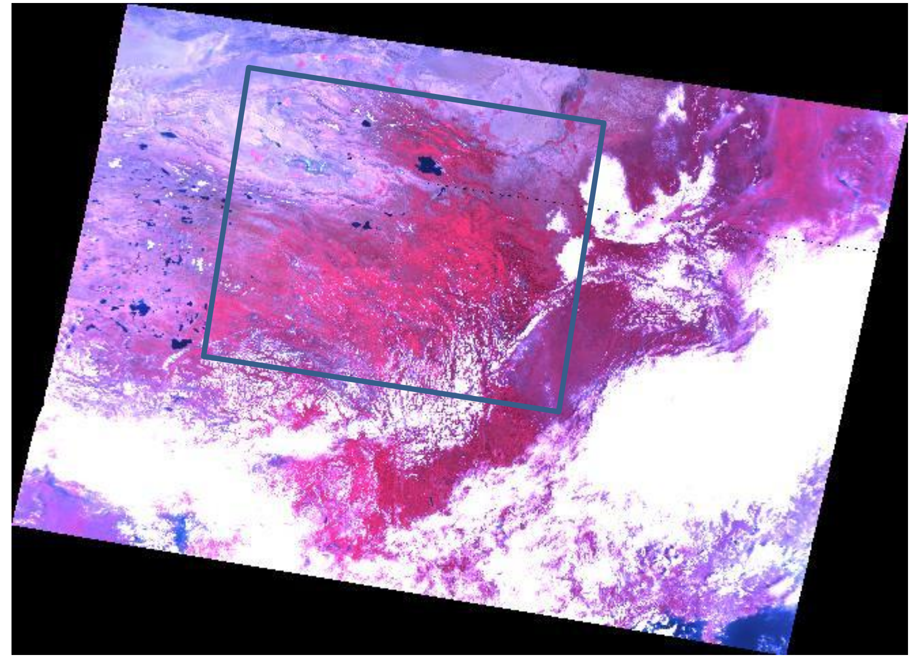






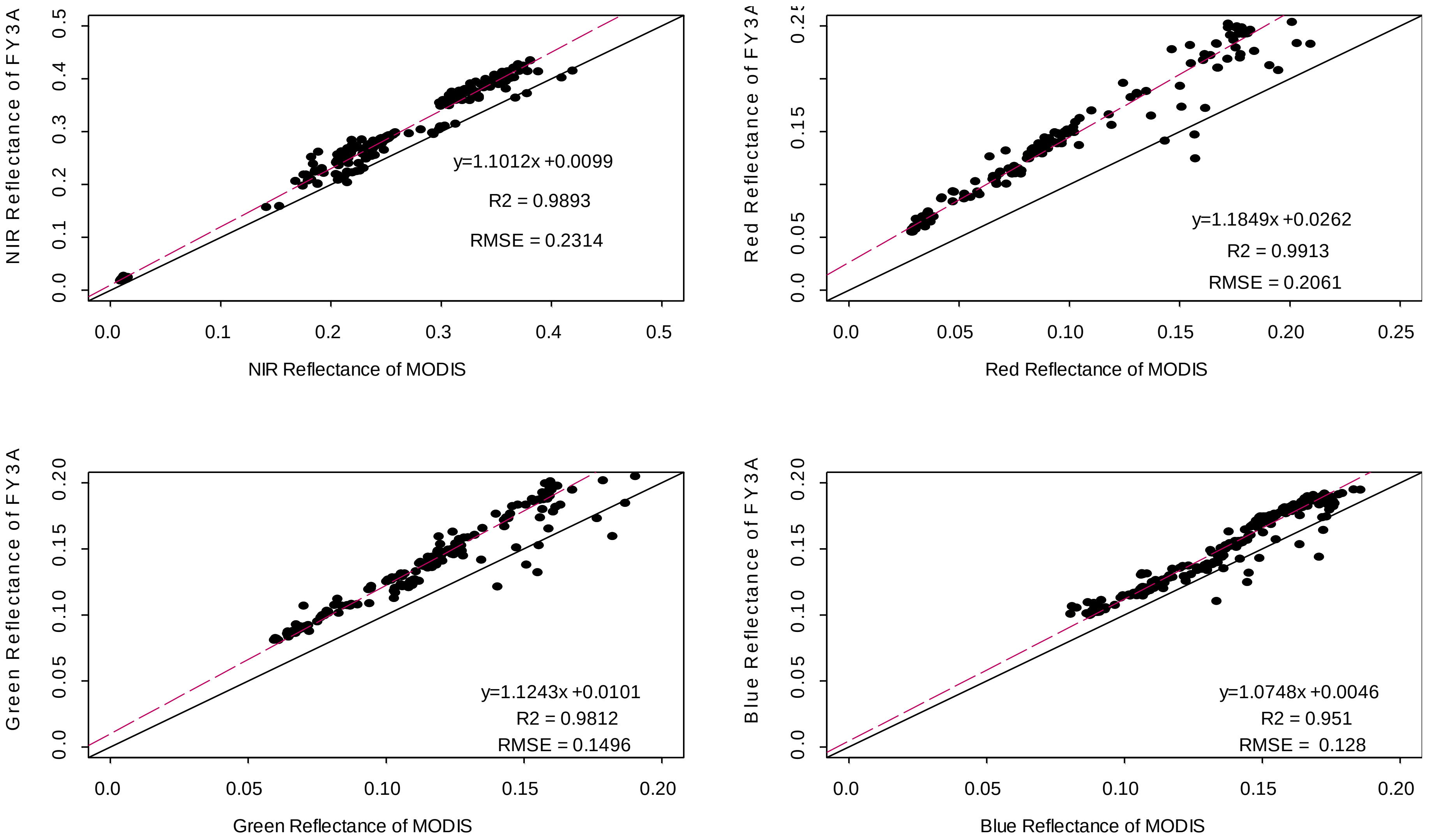


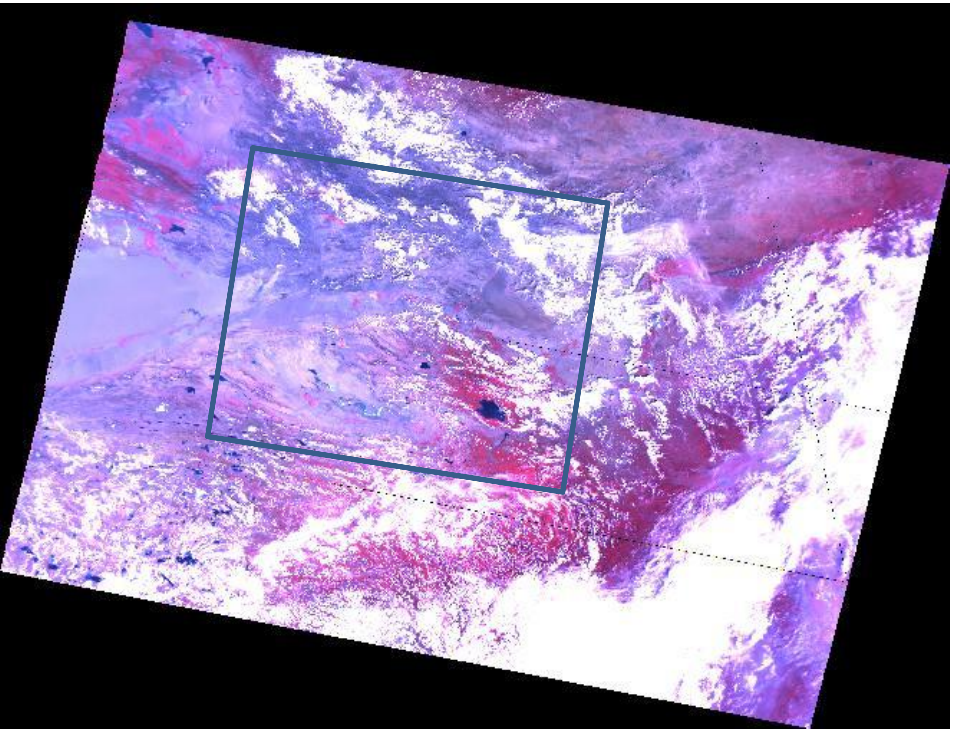


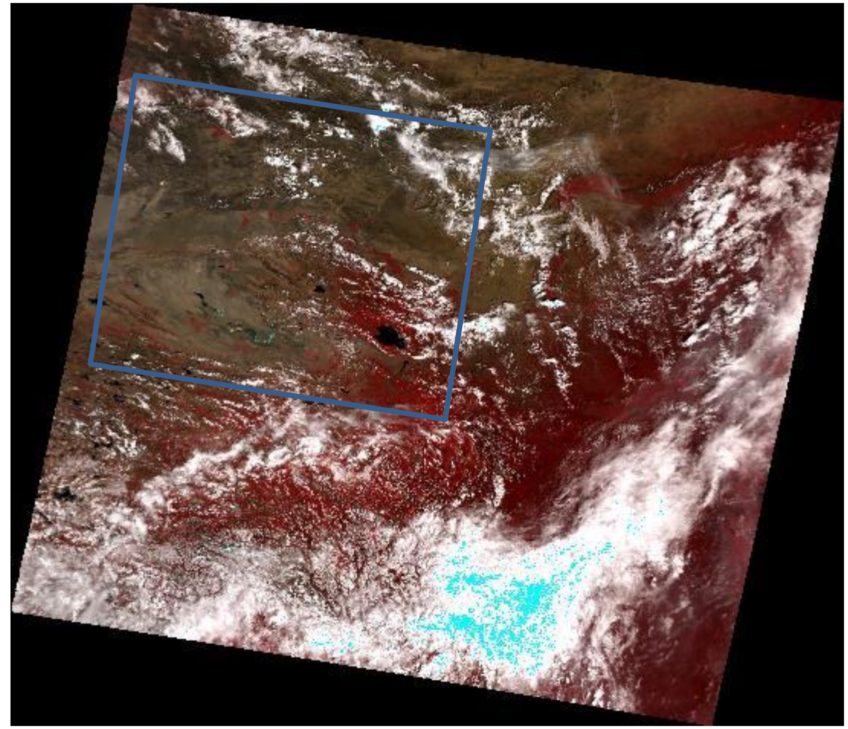


	FY3A	MODIS
Time	2009-8-30, 3:50 GMT	2009-8-30, 3:55 GMT
Spatial Coverage	20 -41 N, 87 -112 E	18 -39 N, 91 -111 E
Product	VIRR L1 1km	MOD02 1km
Solar zenith angle	14 - 46	12 - 41
Sensor zenith angle	0 - 69	0 - 66

2009242_350, 2009242_355, Aug 30

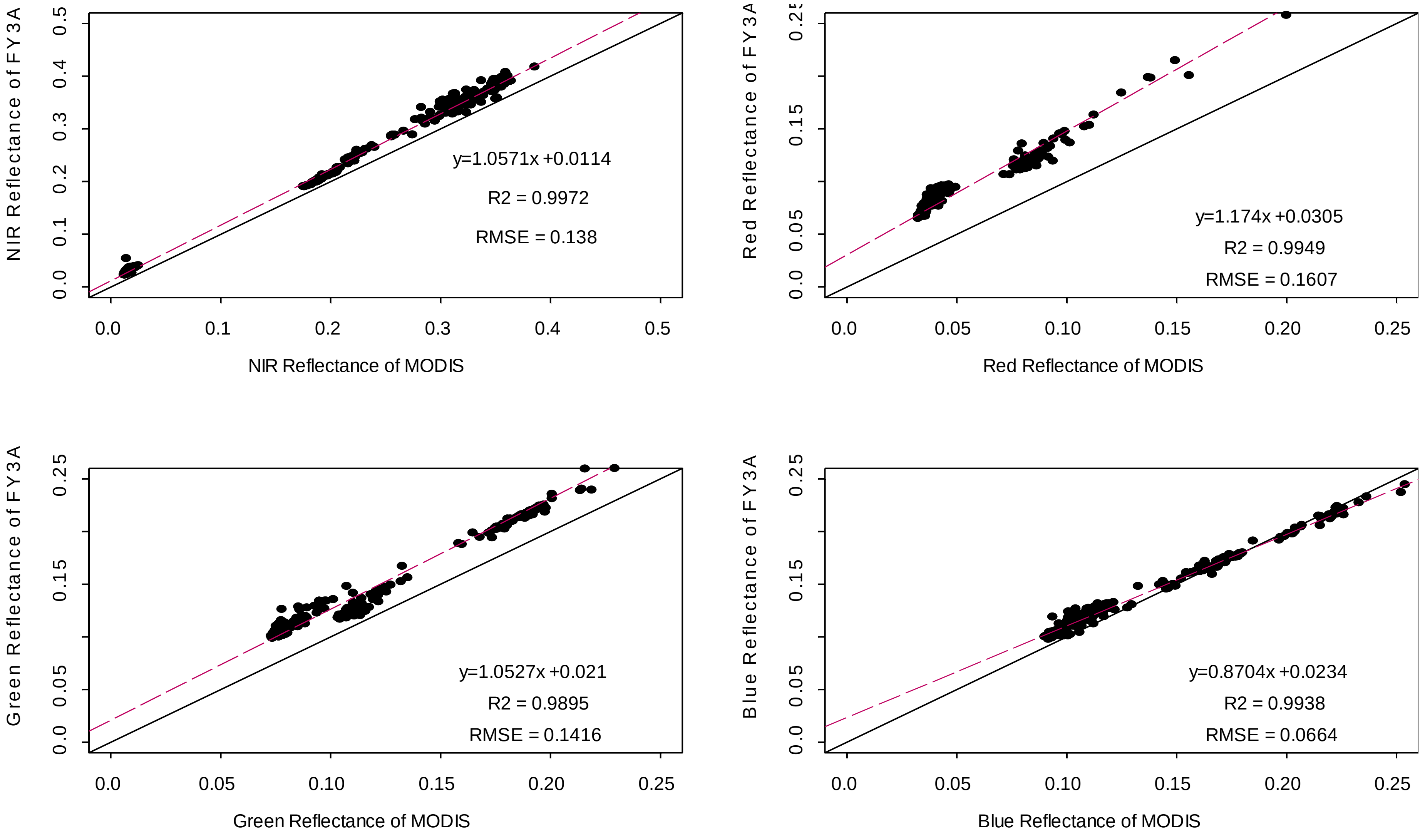






	FY3A	MODIS
Time	2010-8-31, 4:05 GMT	2010-8-31, 4:05 GMT
Spatial Coverage	27 -48 N, 83 -111 E	25 -46 N, 89 -110 E
Product	VIRR L1 1km	MOD02 1km
Solar zenith angle	18 - 50	17 - 45
Sensor zenith angle	0 - 69	0 - 66

2010243_405, Aug 31



Evaluation of the instrument algorithms

- We have extensively interacted with Chinese colleagues on their satellite inversion algorithms through the workshops and informal discussions.
- Dr. Liang is participating in a Chinese 863 project on producing five global land products: broadband albedo, leaf area index, broadband emissivity, insolation and photosynthetically active radiation (PAR). All these products will be distributed through Dr. Townshend's Global Land Cover Facility at UMD.

Exploring data sharing policies

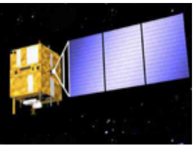
- We have acquired some CBERS data and FY-2/FY-3 data, which can be shared;
- HJ-1 optical CCD data outside China can be shared;
- Anyone who needs HJ-1 CCD data over China needs to sign a collaborative agreement with CRESDA, and we can help make it happen;
- If anyone needs to schedule HJ-1 data acquisition outside China at specific times and locations, we can help make it happen;
- All high-level land products will be freely distributed

Project Website

- We have also designed a website that allows us to communicate our goals of providing the U.S. Earth science community.
- Users can find specific information about the three Chinese satellites, their products, and applications at www.chinasatellites.org.
- We also provided the user with the appropriate links for accessing the data and our plans to distribute data.

NASA Funded Project:

Accessing Chinese Satellite Data Products for Land Applications



- Introduction
- Satellites
- Products
- Applications
- Data Distribution

Personnel

- **Principal Investigator:**
  Shunlin Liang
- **Co-Investigator:**
  John Townshend
- **Graduate Research Assistants:**
  Zan Dodson
  Bo Jiang
  Xin Tao

Introduction

Land data and products from satellite observations are critically important for various environmental modeling and applications. Becuase of the failure of Landsat 7 ETM+ and launch delay of Landsat Data Continuity Mission (LDCM), gaps exist in acquiring high-resolution (about 30m) satellite data. There also may be a gap in acquiring moderate-resolution data (1km) between Terra/Aqua and NPP missions. Moreover, in spite of multi-year efforts, moderate-resolution high-level land products still retain high uncertainties. One of the best solutions to improve various land products is to integrate multiple products from different satellites using different inversion algorithms. This is exactly the issue being addressed by the Committee on Earth Observation Satellites (CEOS) Land Surface Imaging Virtual Constellation Working Group.

China has recently launched multiple environment and resource satellites and expects to launch more in the near future. The U.S. Earth science community, however, is not yet quite familiar with the Chinese satellite data and products, and has difficulty in accessing them. We have interacted extensively with Chinese scientists and participated in their algorithm devlopment and product generation. In this study, we will **1)** continue to actively particpate in Chinese satellite programs; **2)** Inter-compare and validate Chinese satellite data products to determine the uncertainties; **3)** evaluate the instrument algorithms and jointly work with Chinese colleagues to improve them if needed; **4)** archive and distribute data products at the University of Maryland; and **5)** extensively advertise available data and products.

This project is built on our existing strong connections with the Chinese Earth science community, and is a direct response of the NASA call for Earth Science U.S. Participating Investigator (USPI). It is a cost-effective strategy for us to access the enormous amount of additional satellite data products for possibly filling in U.S. data gaps, improving NASA land products and supporting a variety of applications.

This project will enhance international collaboration on Earth observations, and significantly contribute to the CEOS Land Surface Imaging Constellation Study, which is working toward the provision of integrated interoperable data sets from multiple Landsat-like missions including CBERS (China-Brazil Earth Resources Satellite), HJ (Huan Jing), and FY (Feng Yun) satellites.

National Aeronautics and Space Administration | UNIVERSITY OF MARYLAND | University of Maryland Department of Geography

Basic Introduction page that details the need for covering gaps in Landsat data with outside satellite sources. This is done primarily via a joint effort with the Chinese science community.

Thank you!