National Remote Sensing Center of China
Agency Report

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March 2016

CEOS/WGCV-40 Plenary

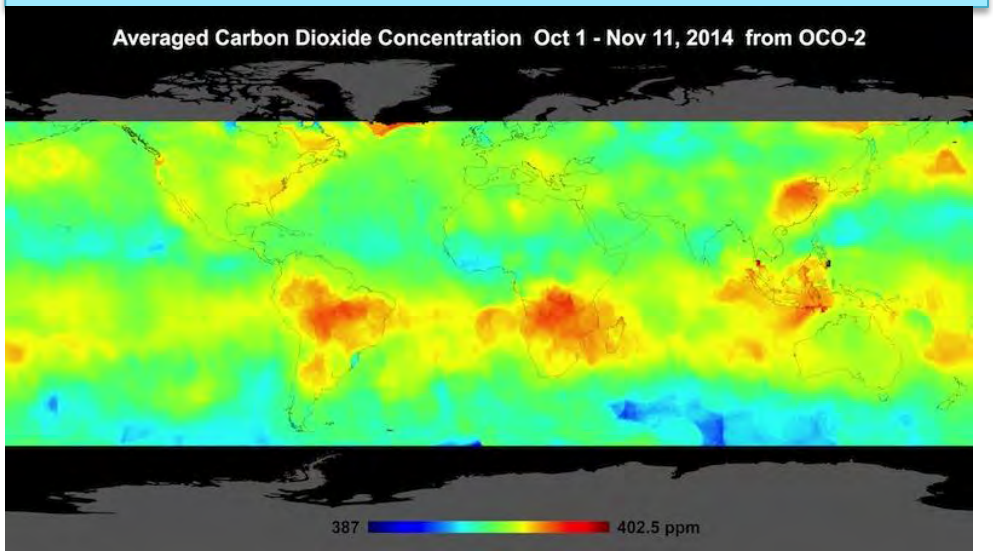
Outline

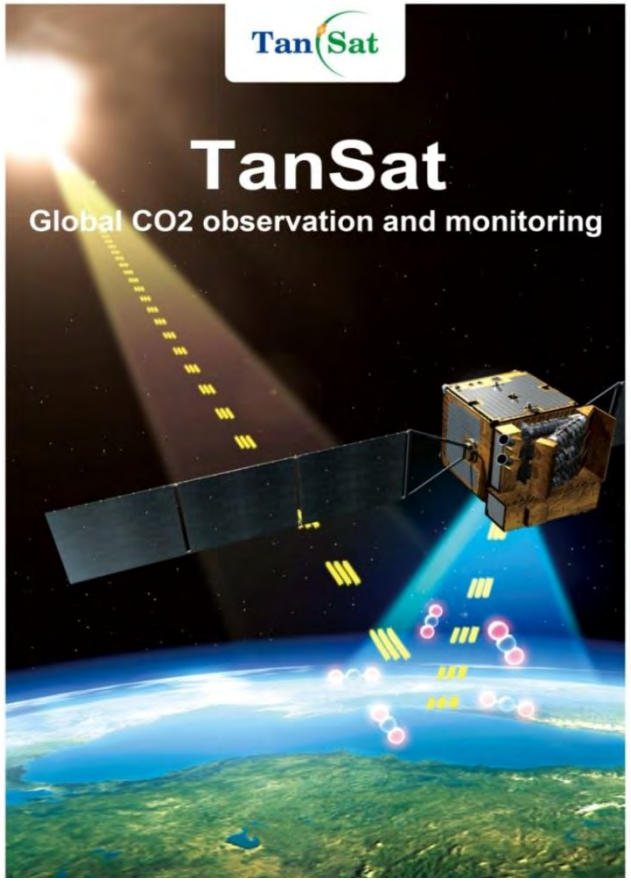
- Carbon Satellite Project
- Intensity Correlation Imaging
- Progress on Lunar Calibration
- Activities on Baotou Site
- Cal/Val in Dragon Programme 4
- Future works

Carbon Satellite Plan

- The project named “Scientific Experimental Satellite for Global Carbon Dioxide Monitoring and its application" was funded by Ministry of Science and Technology, since Nov 2011.

Aim: Develop/launch a scientific experimental micro-satellite for monitoring carbon dioxide, and establish a system for ground data processing and validation for monitoring the global atmospheric CO_2 content.





Carbon Satellite Plan

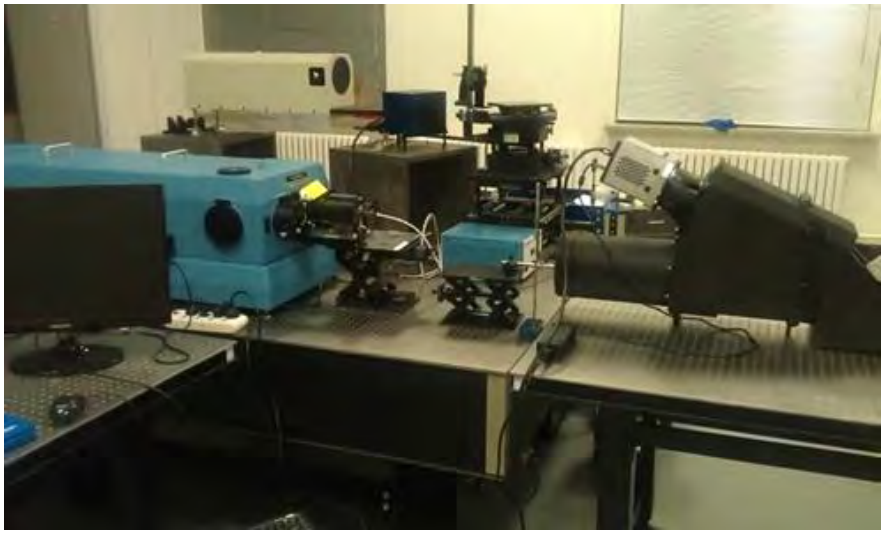
- **In 2015, the prototype of the hyperspectral sensor for detecting atmospheric absorption characteristics was developed and the flight campaigns was carried out.**

Aims：

- **Assess the performance of the hyperspectral sensor in characterizing atmospheric absorption, and validate sensor's stability.**
- **Acquire simultaneous in-situ measurements, providing datasets for retrieving atmospheric CO2 concentration(4ppm).**

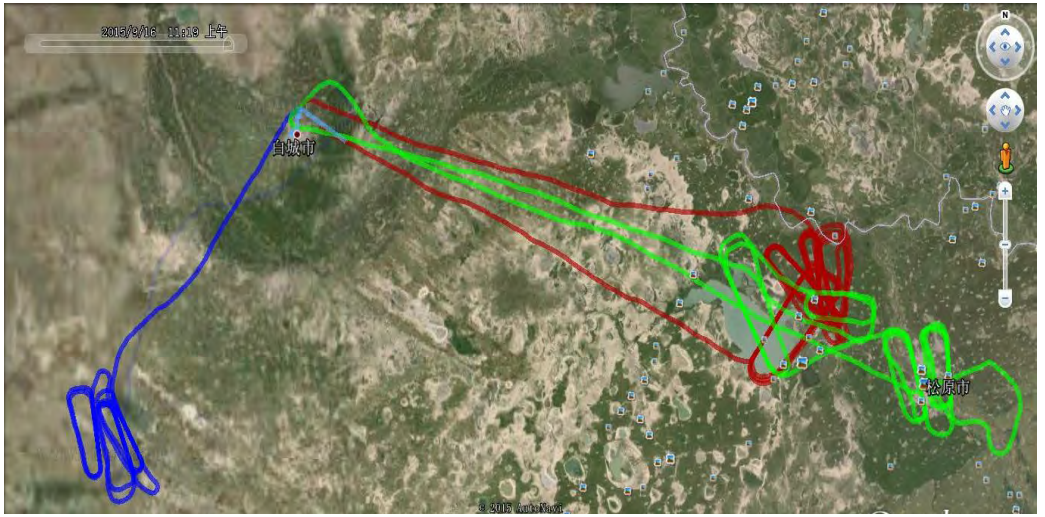
Flight simulator parameters:

- **Bands covering 1.6μm, 0.76μm**
- **Spectral resolution: better than 0.13nm, 0.044nm**
- **Absolute radiometric calibration accuracy: better than 5%**
- **Relative radiometric calibration accuracy: better than 3%**



Carbon Satellite Plan

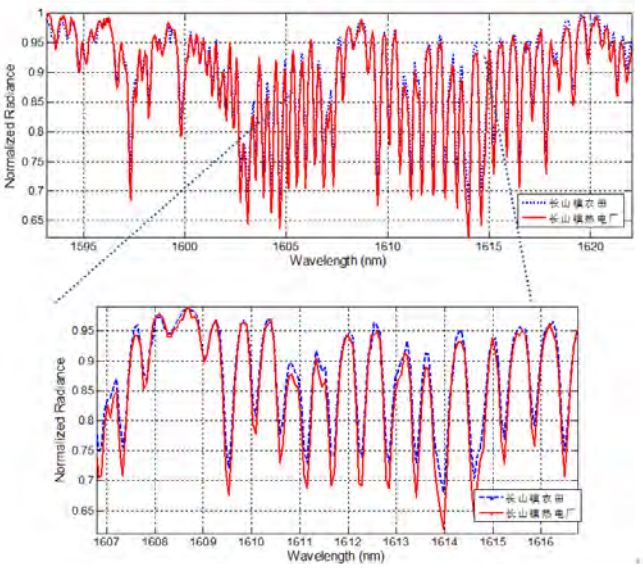
Test site: Xianghai National Nature Reserve and Chagan lake in Jilin Province, China
Flight altitude: 5km
Flight time: Sep. 2015
Land surface types: grassland, wetland, farmland, city, water, forest land, etc.
Synchronous measurements: temperature and humidity pressure profile, CO_2 profile, CO_2 surface concentration, CO_2 total column, aerosol extinction coefficient, surface reflectance.



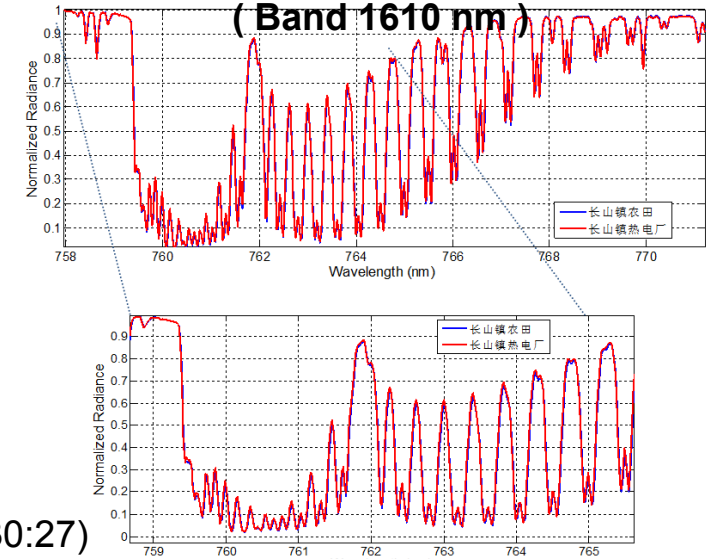
Carbon Satellite Plan

Comparison of the absorption spectra of the carbon discharge source in the power station and that in the farmland area.

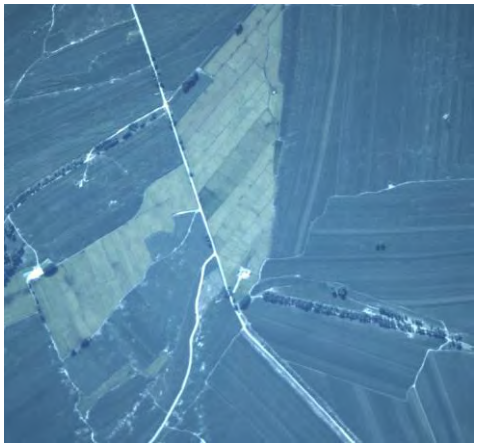
- **It is obvious that absorption spectra for band 1610 nm in power station is different from that in farmland area.**



(Band 1610 nm)



(Band 760 nm)



Farmland (20150911 10:26:23)

Power station(20150911 11:30:27)

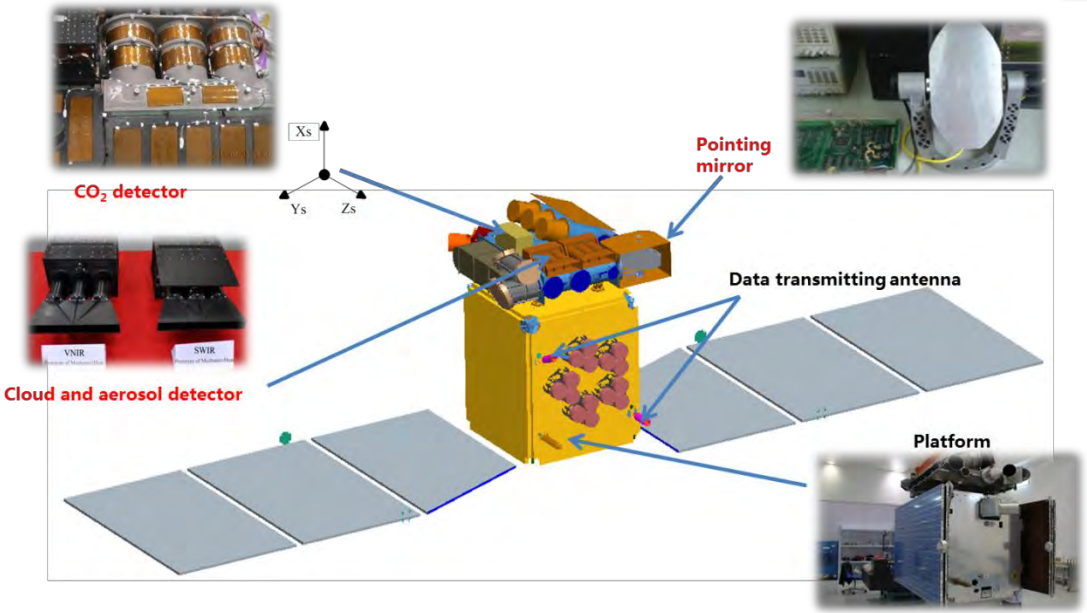
Carbon Satellite Plan

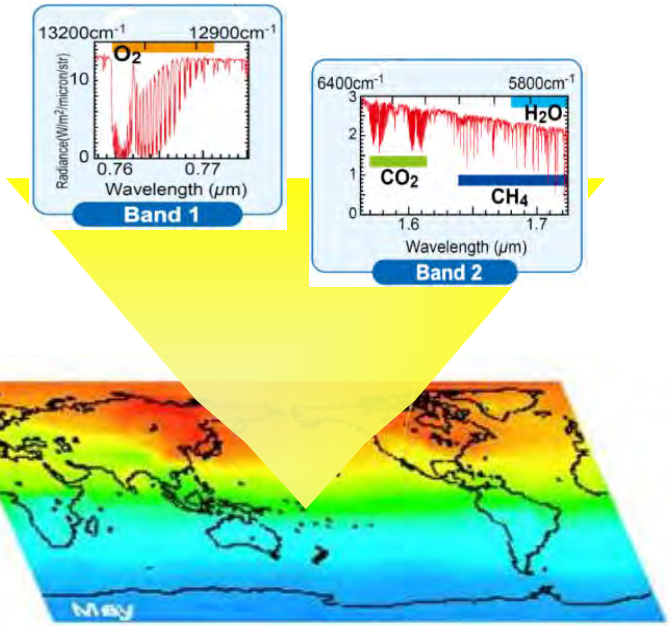
- **Planning (2016): The satellite will be launched in 2016.**

~2016.4: Complete the payload manufacture

~2016. 8: Complete the whole satellite manufacture

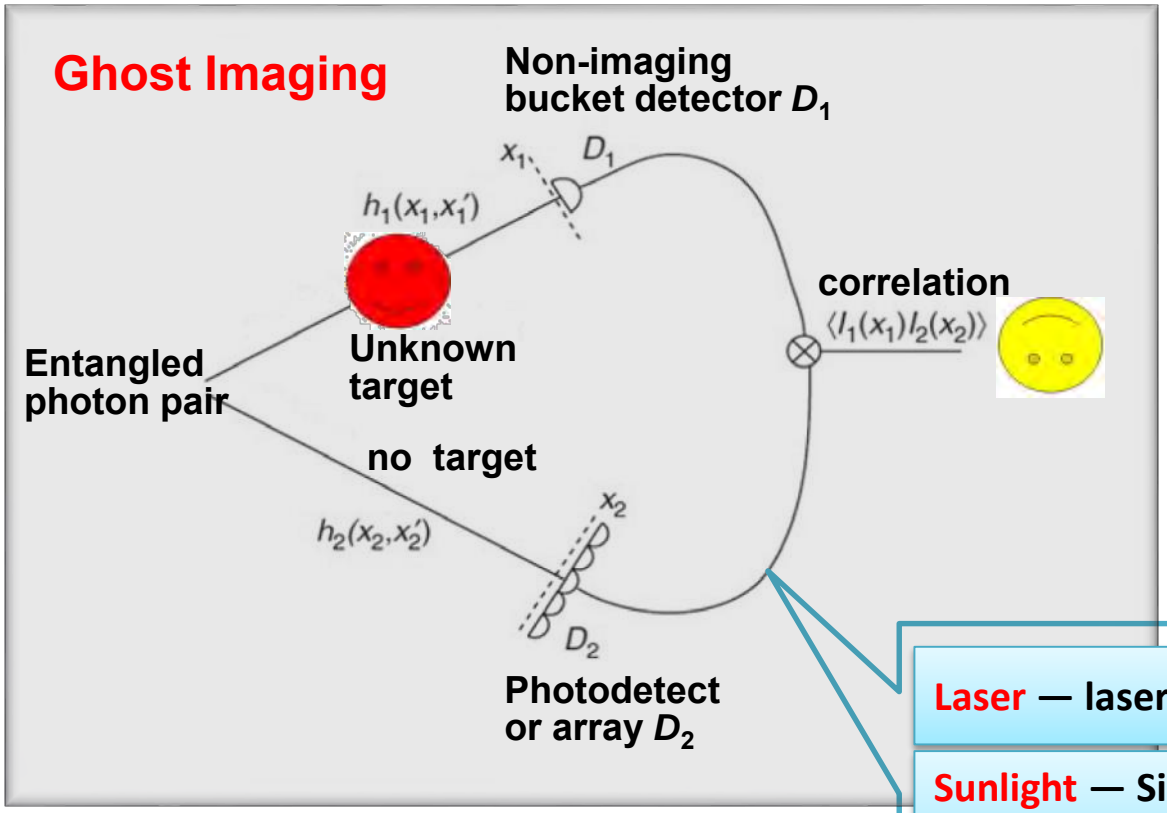
~2016.12: Launch and in-orbit test





Intensity Correlation Imaging

➢ Intensity Correlation Imaging — an extension of Ghost Imaging



- Ghost images are obtained by correlating the output of a single-pixel photodetector—which consists the object information—with the output from a photodetector array whose illumination has not interacted with that object.
- This new imaging technique has the potential of super-resolution with low-cost and resistance to noise and turbulence.

- The correlation image is reconstructed by multi-repeated observations and then solving an optimization function

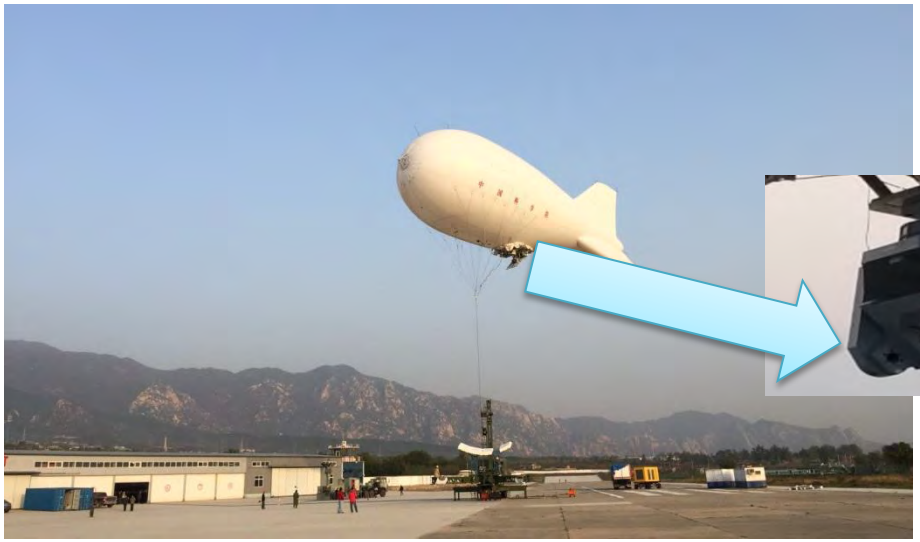
Laser — laser 3D intensity correlation imaging

Sunlight — Single frame exposure multi spectral intensity correlation imaging

Microwave — Microwave staring correlation imaging

Intensity Correlation Imaging

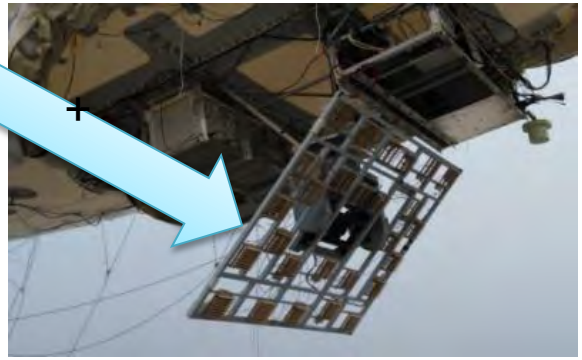
- **For the strategy of "Obtaining high spatial resolution at the cost of staring time", the stability of the platform are important.**
- **In the first phase, a tethered balloon were reformed as a stabilized platform. A hyperspectral intensity correlation imaging system and a microwave staring correlation imaging system have been developed.**



Tethered balloon

Stabilized platform +

+ Passive optical imager



+ Active microwave imager

Intensity Correlation Imaging

- **First balloon-borne experiment has been carried out in Oct. 2015, and system performance was assessed based on the ground reference targets.**

Fan-shaped(Radial), grey and colored targets

Fan-shaped target was deployed with its face perpendicular to the line of sensor sight

Corner reflectors

Parameter Measurement

Intensity Correlation Imaging

- **For hyperspectral intensity correlation imaging, compressive sensing algorithm is applied to reconstruct the data cube from the detectors' data.**

The mathematic model of the imaging system:

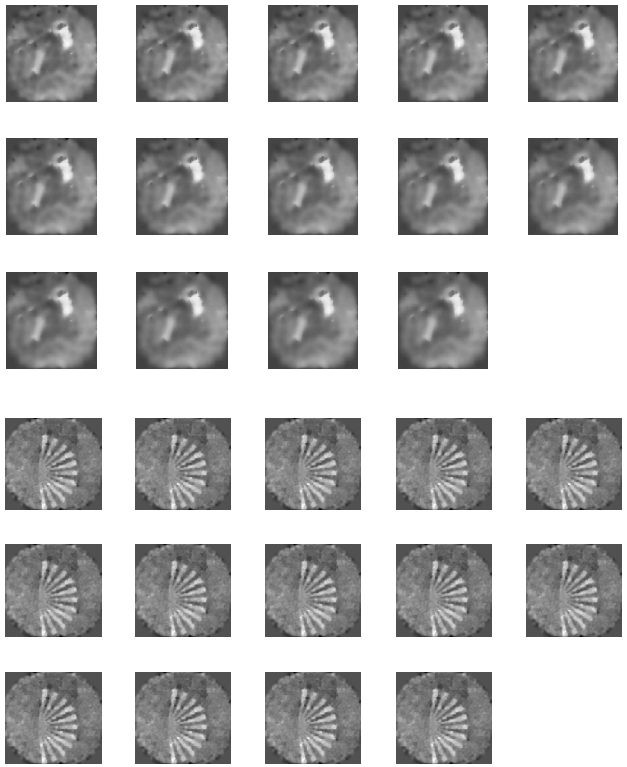
$$\begin{pmatrix} y_1 \\ y_2 \\ \\ y_M \end{pmatrix}_M = \begin{pmatrix} A_{11} & A_{12} & \cdots & A_{1L} \\ \cdots & \cdots & \cdots & \cdots \\ \cdots & \cdots & \cdots & \cdots \\ A_{M1} & A_{M1} & \cdots & A_{ML} \end{pmatrix}_{M\times(L\times N)} \begin{pmatrix} x_1 \\ x_2 \\ \\ x_L \end{pmatrix}_{L\times N}$$

y denotes for the CCD measurements, ***x*** denotes for the hyperspectral object and ***A*** denotes for the correlation matrix.

The object is reconstructed by solving the optimization problem:

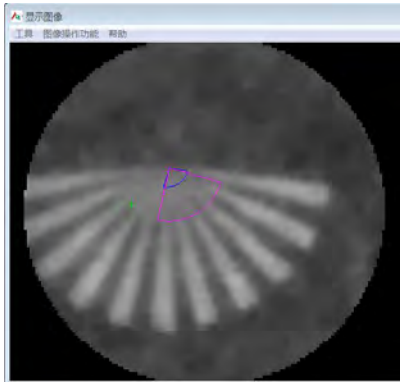
$$\hat{x} = \arg\min_x \|y - Ax\|_2^2 + \lambda \sum_{i=1}^{L} \|x_i\|_{TV}$$

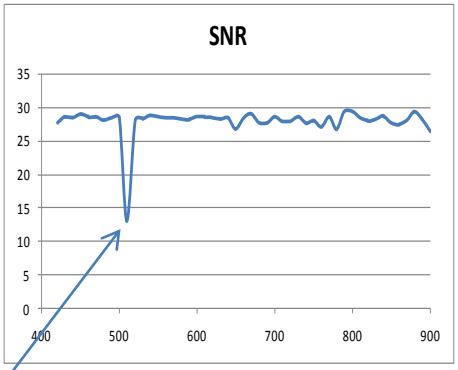
Reconstructed images of a truck and fan-shaped target in 510-640nm band.

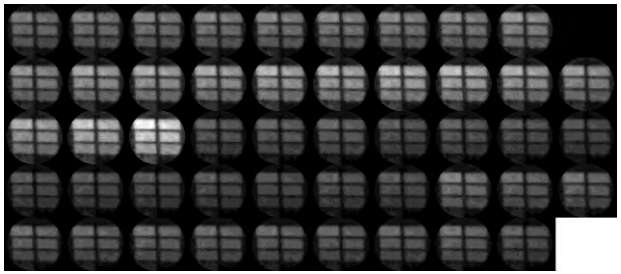


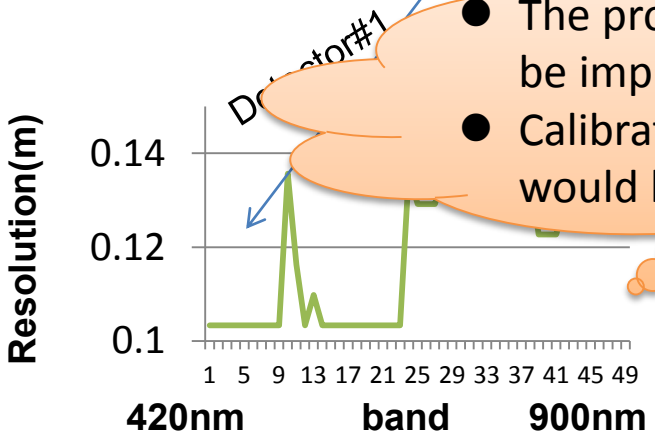
Intensity Correlation Imaging

- **Preliminary image assessment results based on the targets.**

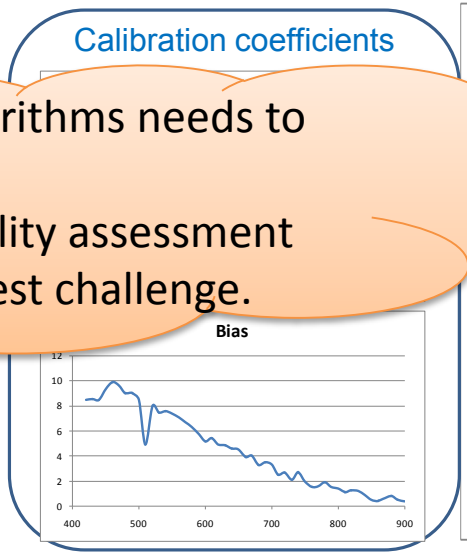


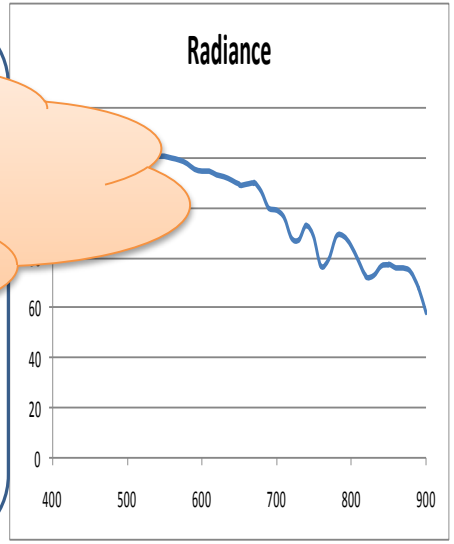






- The processing algorithms needs to be improved;
- Calibration and quality assessment would be the greatest challenge.



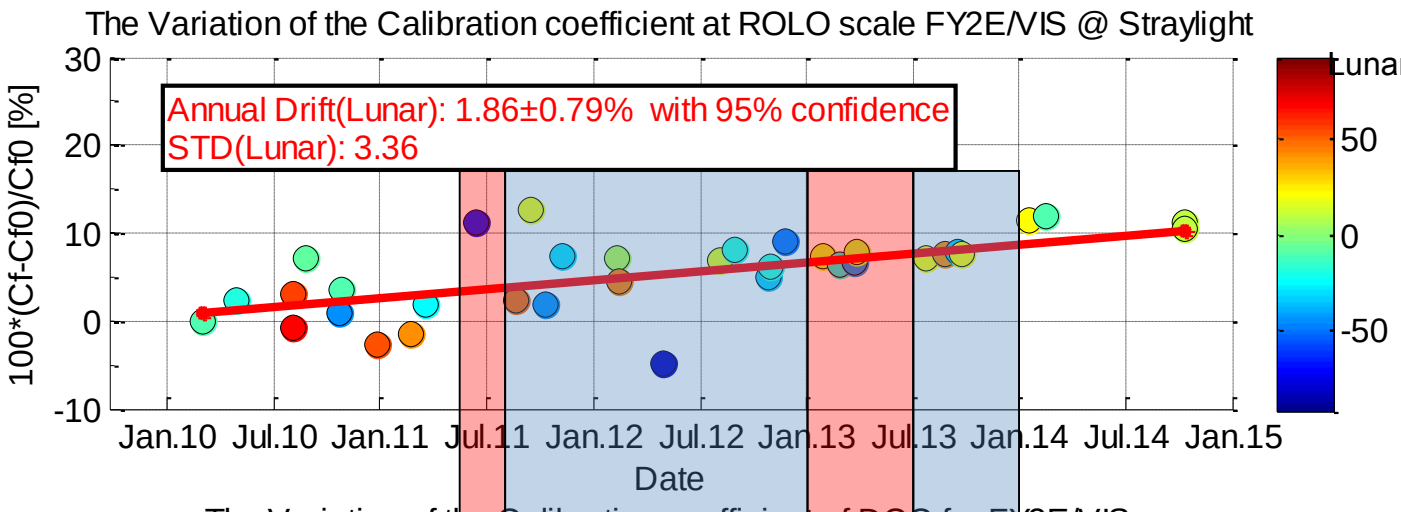


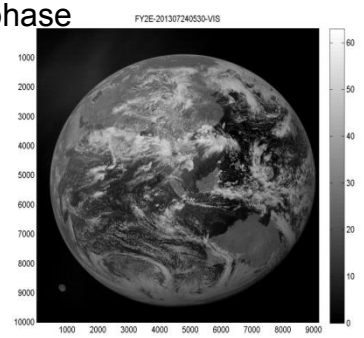
The resolutions of the images acquired from the Detector#1 and 2 are good, however in their borders, the resolution decreases. It might due to the lower SNR in the Detector edge.

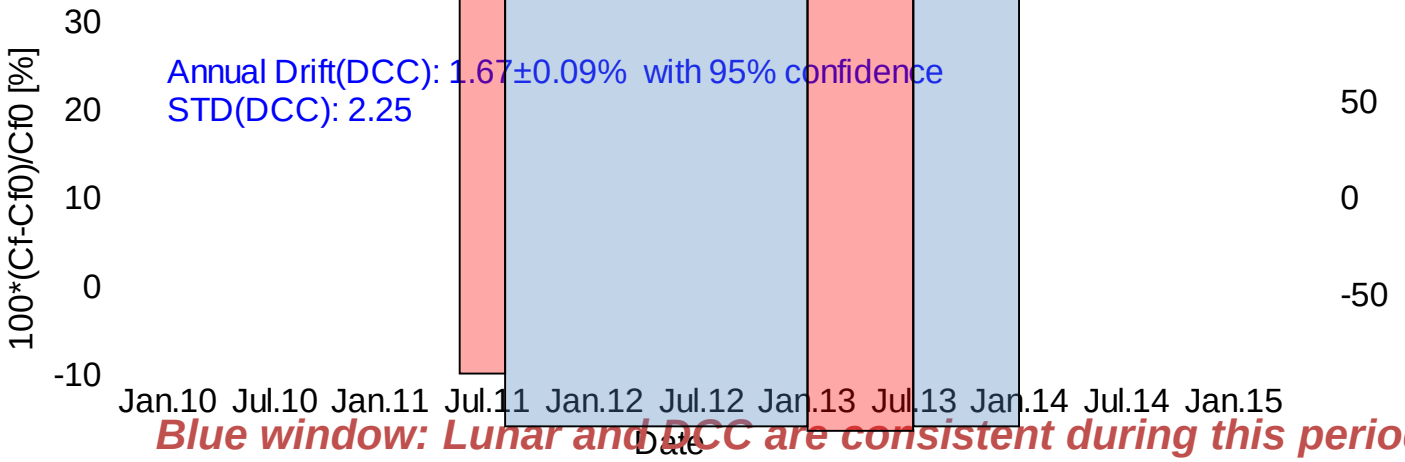
The spectral lineshape turns to be reasonable through applying the calibration coefficients (which are determined by 8 pieces of greyscale targets).

Progress on lunar calibration

- **Funded by NRSCC since 2015, explore the visible spectral calibration methods based on lunar reflection. With the aid of ROLO model, the performances of FY-2E/VISSR and FY-3/MERSI were monitored through observing lunar, and the result was compared with that of DCC.**





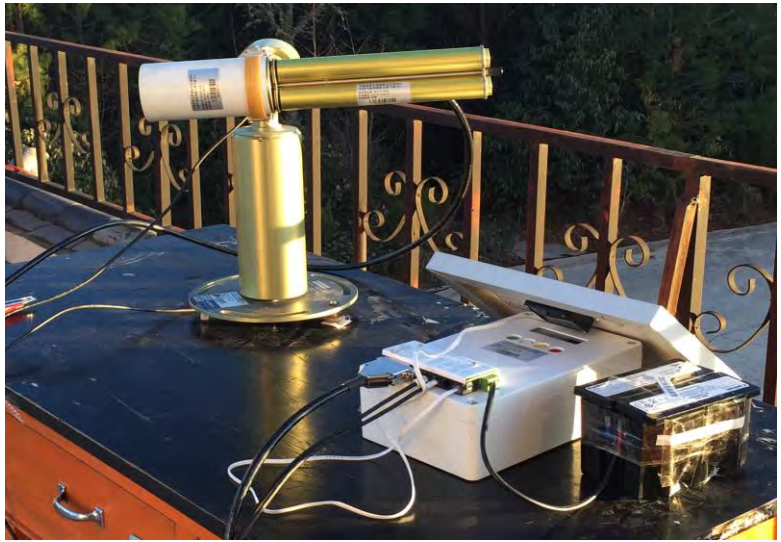


Blue window: Lunar and DCC are consistent during this period

Red window: Lunar and DCC are not consistent

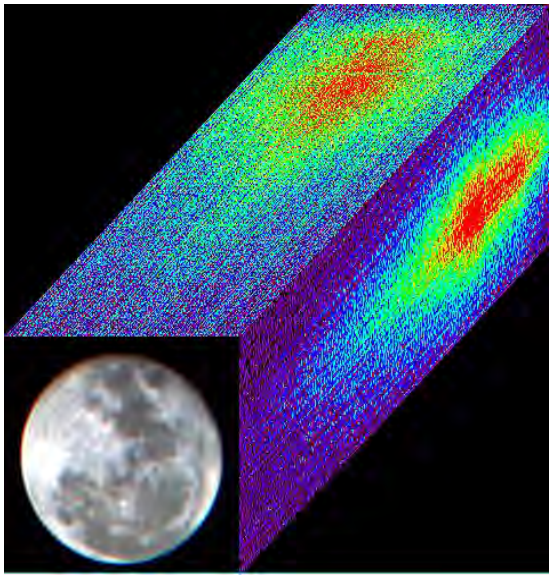
Progress on lunar calibration

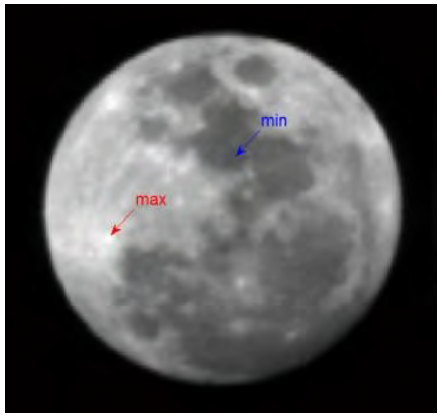
- During Dec. 17 2015~ Feb. 31 2016, field experiment was carried out in Lijiang, Yunnan Province, China.
- The site has an altitude of 3175m, with low aerosol content.
- Aims: Acquire hyperspectral lunar images to perform the validation of lunar radiation model.
- Instruments
  - ✓ Lunar hyper-spectrometer imaging system
  - ✓ lunar irradiance measurement system based on ASD spectrometer and Cimel CE318
  - ✓ Laser radar sounding;

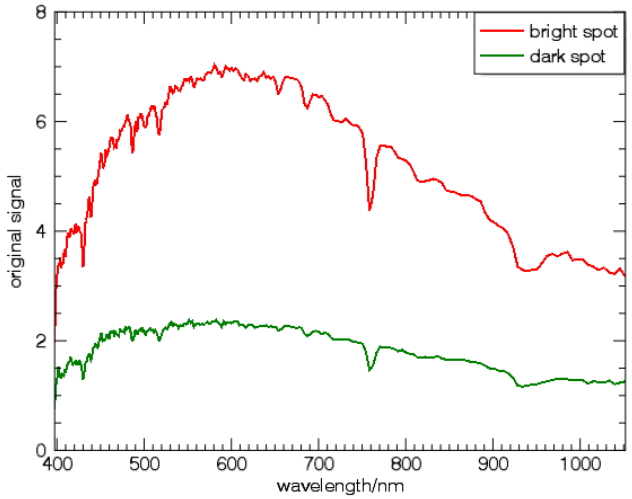


Progress on lunar calibration

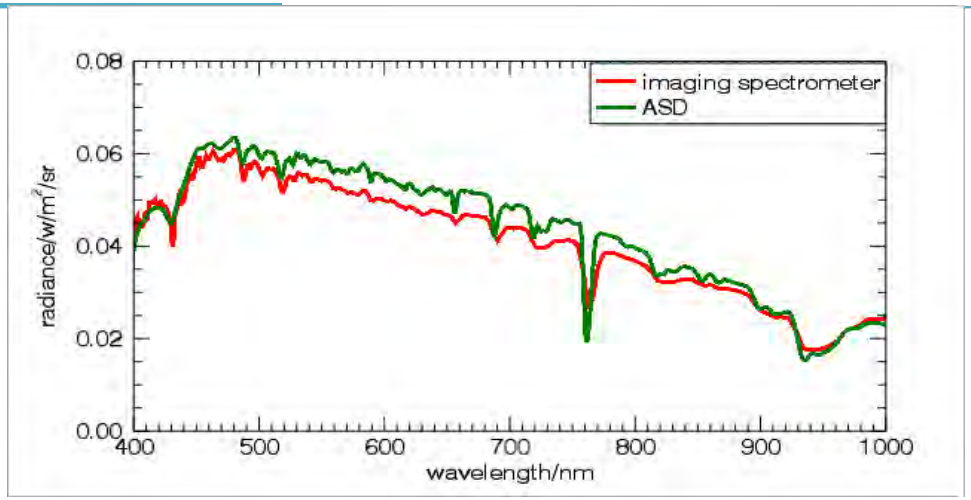
- **Hyperspectral lunar images in the spectral range of 400nm-1000nm.**





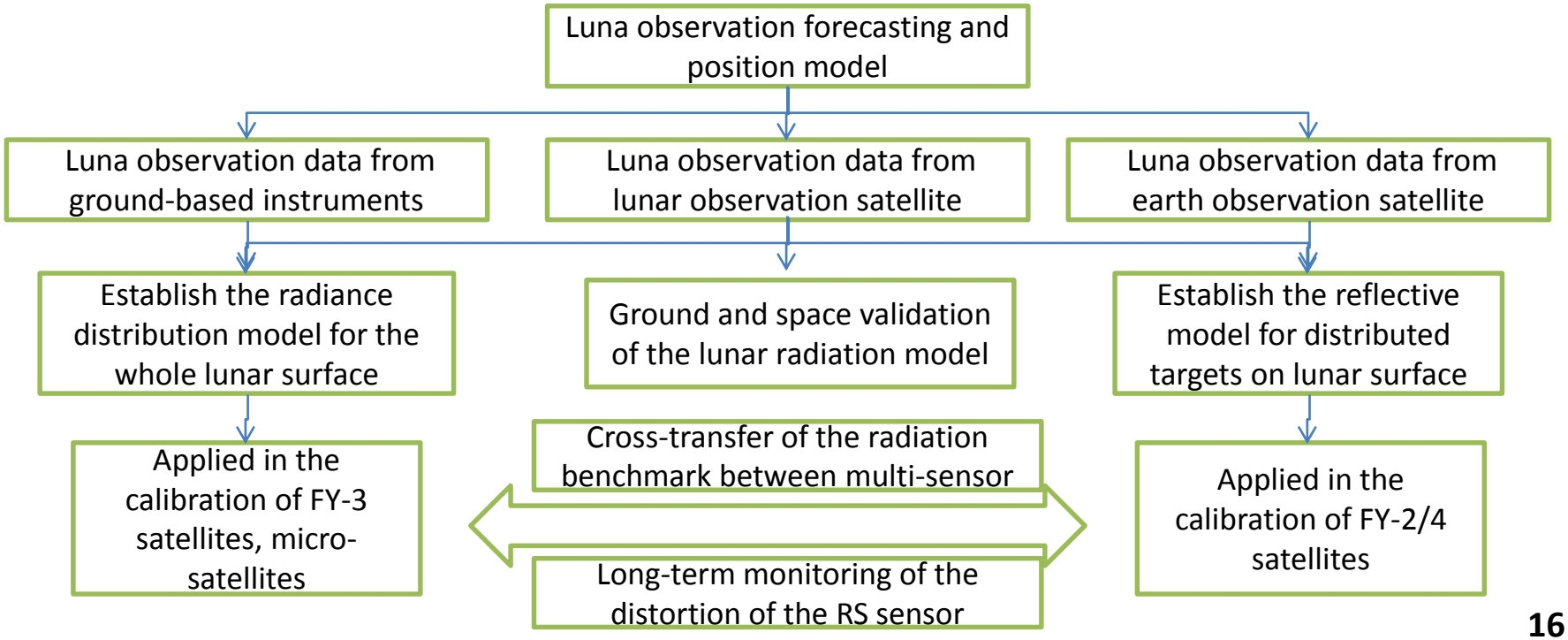


✓ **The lunar measurement of hyper-spectrometer is consistent with the measurement acquired by the lunar irradiance measurement system based on ASD spectrometer.**



Progress on lunar calibration

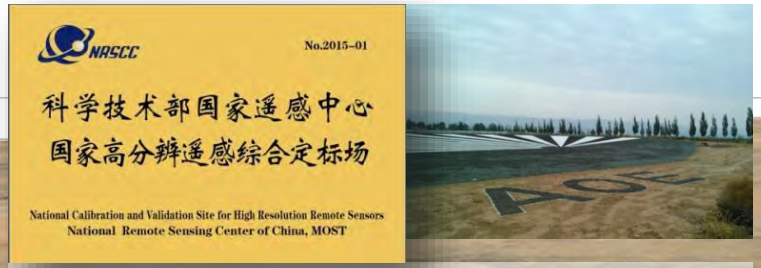
- **Next step plans:**
  - Analyze spatial and temporal variation of the lunar surface characteristics
  - Develop cross-calibration method based on lunar measurement
  - Improve lunar radiative model using in-situ hyperspectral lunar measurements and multi-source lunar measurements from spaceborne sensors



Activities on Baotou site

- On December 2015, Baotou site was officially subordinated as NRSCC's "National Calibration and Validation Site for High Resolution Remote Sensors", so as to provide performance assessment supports for the new-type remote sensors funded by NRSCC.

Site overview:



National Calibration and Validation Site for High Resolution Remote Sensors
National Remote Sensing Center of China ,MOST

Stepwise Cal&Val system

Airborne standard sensors

Ground test equipment

Comprehensive Cal&Val site with artificial target and natural scene reasonably matching

Artificial portable targets

Artificial permanent targets

Natural scenes

- **Advanced Cal&Val system**
- **Great contribution to RS application**
- **International platform for R&D**

Architecture of national RS standards and quality evaluation processing system

Exploration of Automatic in-situ calibration mode

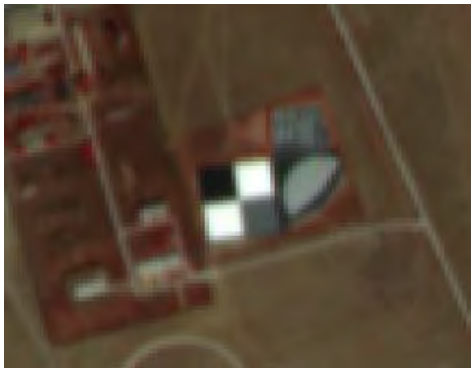
Ulansu Lake

Activities on Baotou site

- **Since WGCV-39 meeting, Baotou site has supported the in-orbit calibration of 8 Chinese high resolution satellite, and the results have been compared with that from Dunhuang site.**

GF-2 (11 Jul., 2015)

GF-1 (8 Jun., 2015)



ZY-3 (12 Sep., 2015)

ZY-02C (28 Mar., 2015)

SJ-9A （18 Oct., 2015）

GF-2 （18 Oct., 2015）

Activities on Baotou site

➢ Enhance the capability of automated radiometric calibration

- **As a member of RadCalNet, three suits of automated hyperspectral radiance measurement systems have been installed over the permanent artificial targets in Baotou site.**

Cimel CE318 (One of AERONET sites)

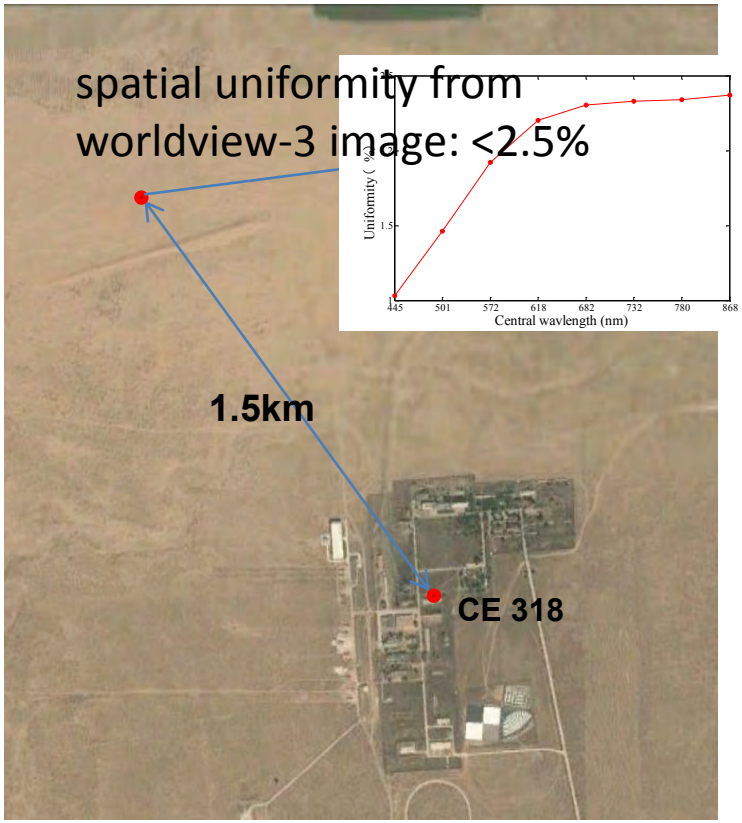
Worldview3 image over Baotou site on 27 Oct., 2015 . (Band 5, 3 ,2)

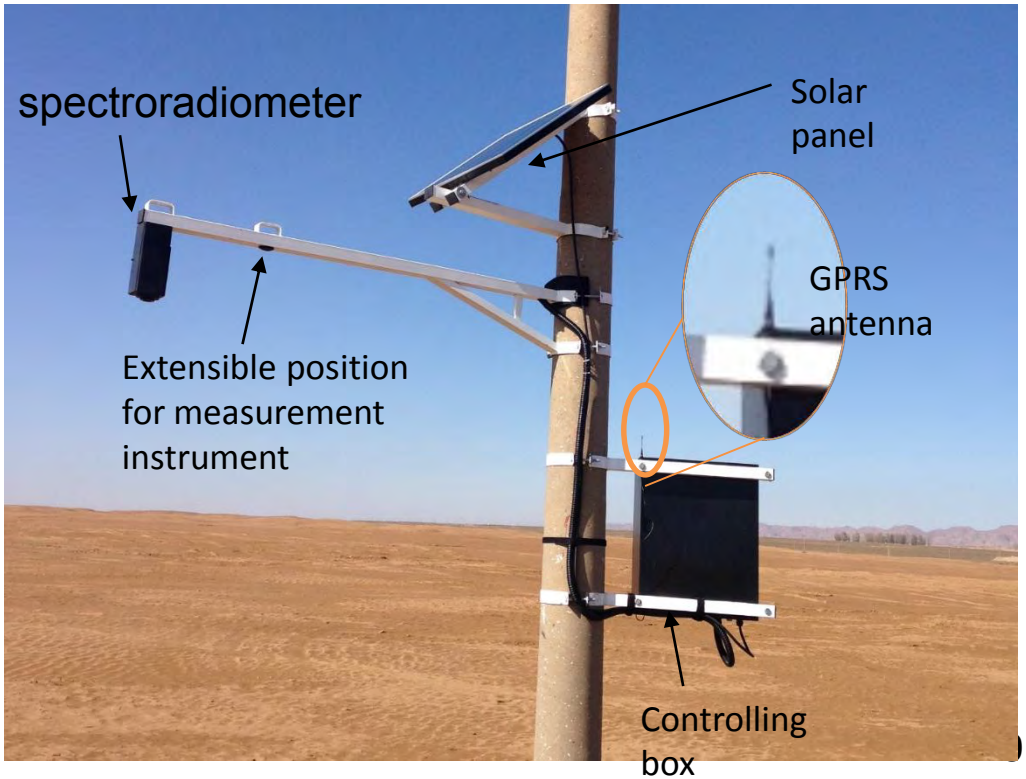
The spectrometer covers a spectral range of 380nm to 1080nm with spectral resolution of 2nm is used.

Activities on Baotou site

➢ Enhance the capability of automated radiometric calibration

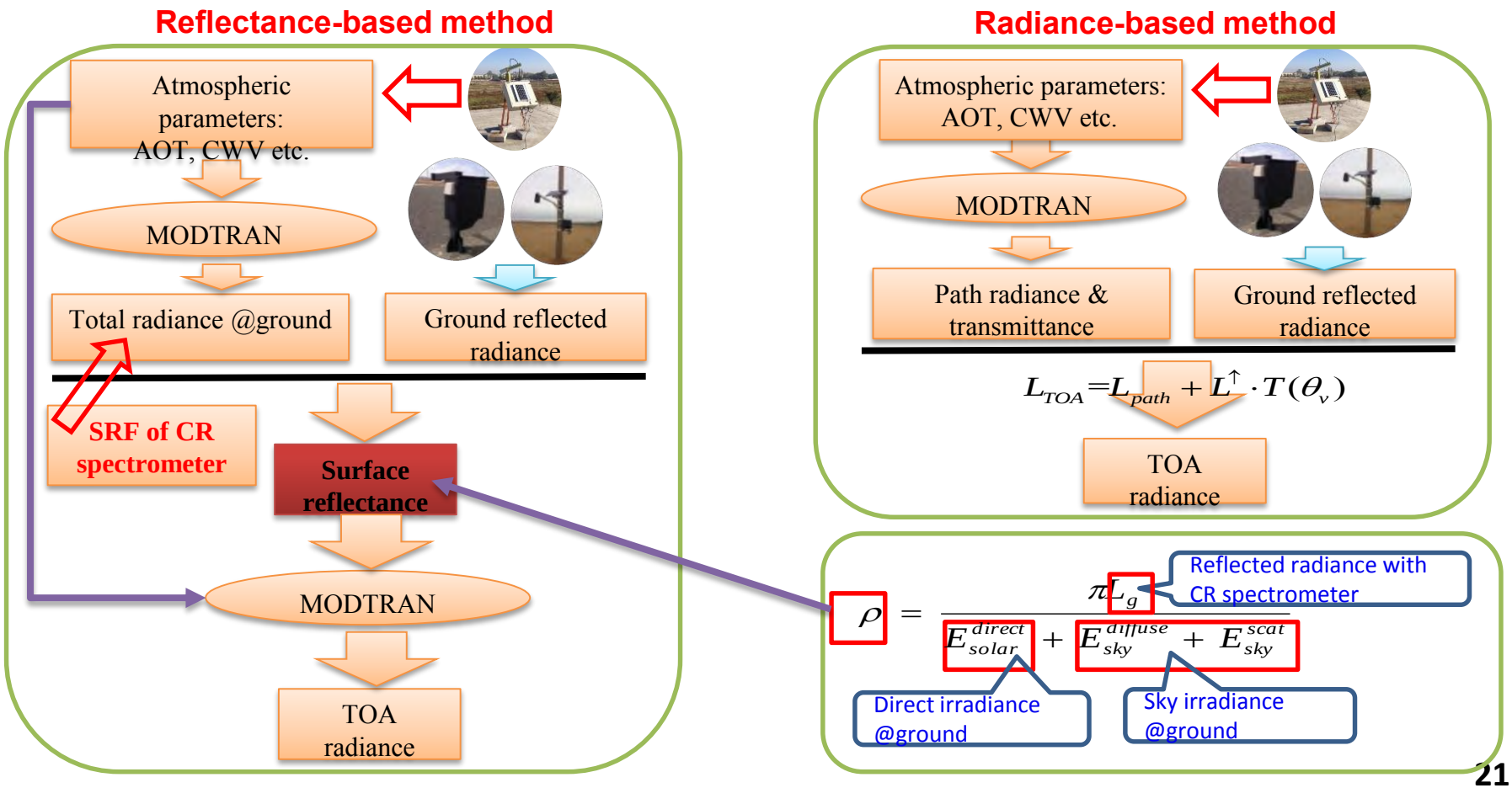
- **Towards the auto-calibration of middle resolution satellite, a 300m×300m homogeneous sand field was flattened in Oct, 2015.**
- **An automatic spectral radiance measurement system with a solar panel has been installed over the sand field.**





Activities on Baotou site

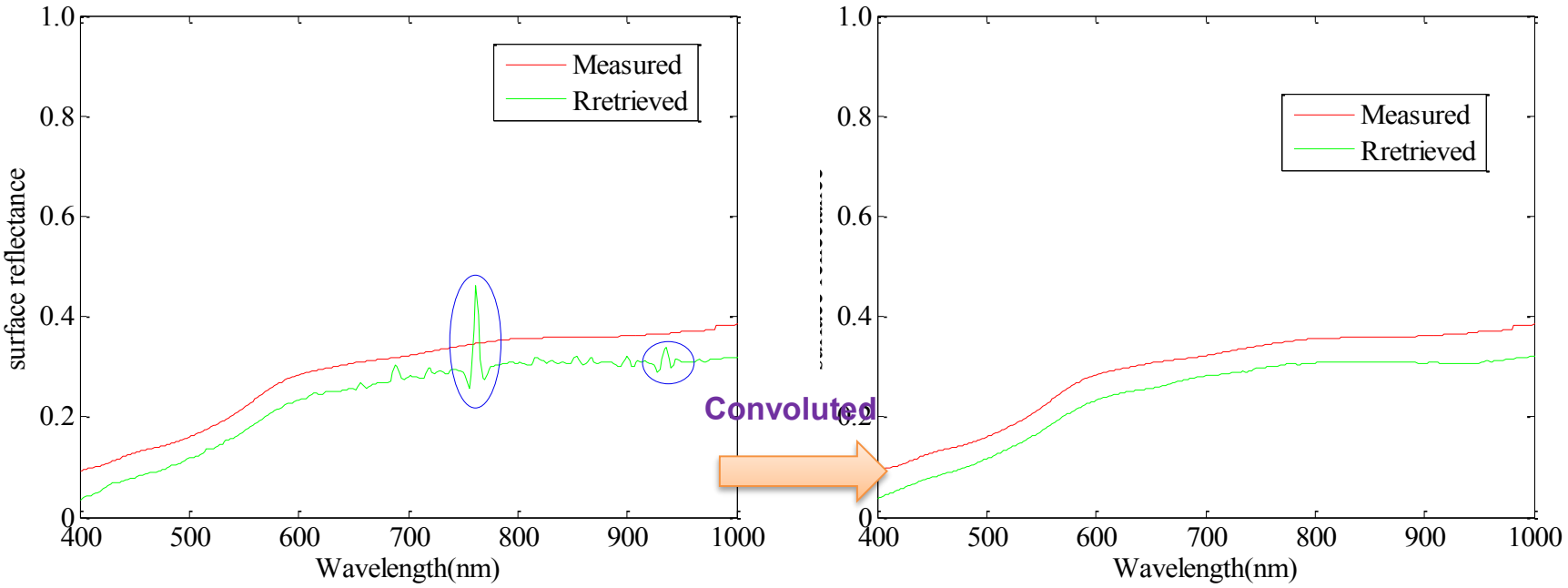
- **Reflectance-based method (left, according to RadCalNet's demand) and radiance-based method (right, based on the directly hyperspectral radiance measurement) are used to predict the TOA radiance.**



Activities on Baotou site

➢ **Enhance the capability of automated radiometric calibration**

- **The retrieved reflectance is consistent with measured result except for the atmospheric absorption channels of oxygen and water vapor(left).**
- **Considering the FWHM broadening of spectrometer, the retrieved reflectance is improved.**



A systematic bias of reflectance is found. Probably it is caused by the model errors of RTM (MODTRAN) and the difference between actual and standard atmospheric profiles. The historical in-situ measurement is expected to correct this problem.

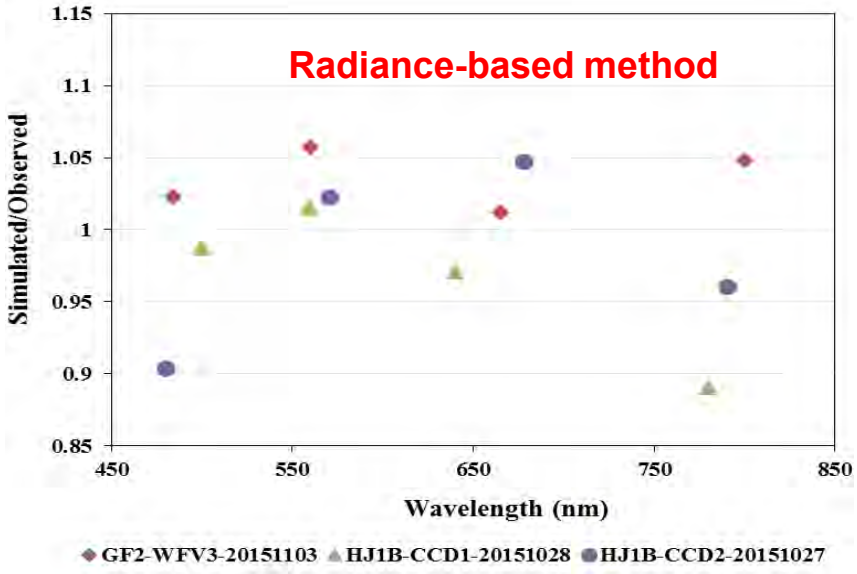
Activities on Baotou site

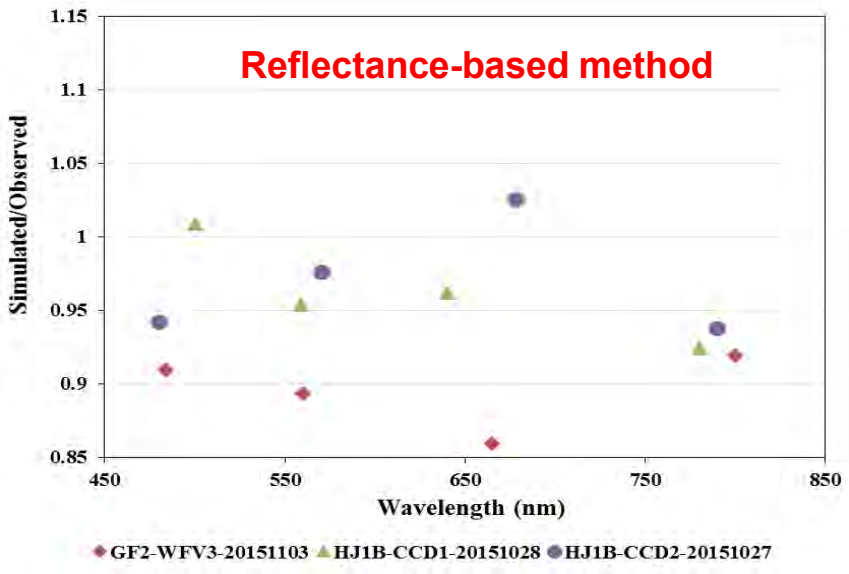
➢ Enhance the capability of automated radiometric calibration

- **The optical sensors onboard GF-2/HJ1B have been assessed using radiance-based and reflectance-based method with the data measured by automated measurement system over sand site.**

Method	GF-2/WFV3 (16m)	HJ-1B/CCD1 (30m)	HJ-1B/CCD2 (30m)
Radiance-based	1.04	0.96604	0.983686
Reflectance-based	0.895536	0.962347	0.970338

- The ref-based method underestimate the TOA radiance for the similar reasons.
- In blue band, the results show different trends, partly because of the influence of aerosol.





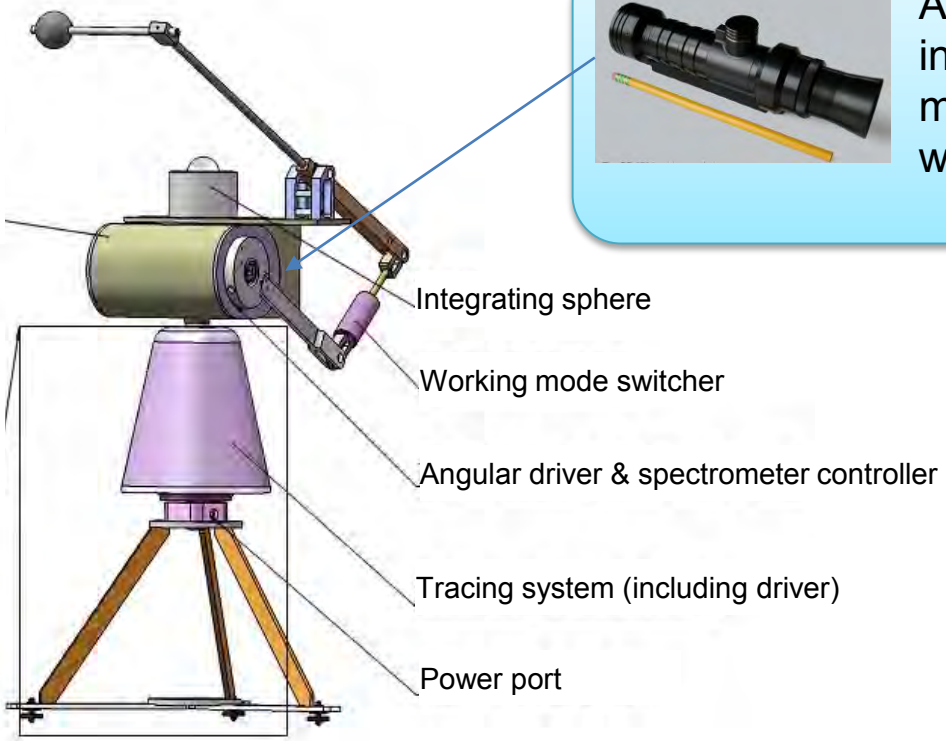
Activities on Baotou site

➢ Enhance the capability of automated radiometric calibration

- **An sky total/diffused irradiance automated measurement instrument is being developed. This system can provide the total irradiance information to support the calculation of surface reflectance combined with the measurement of surface reflected radiance.**

- A closed box containing the angular driver, spectrometer and temperature controller.
- Integrating sphere and spectrometer are connected via a fiber.

- This part is fixed when the system is working.
- The power is supplied from the port at the bottom of this part

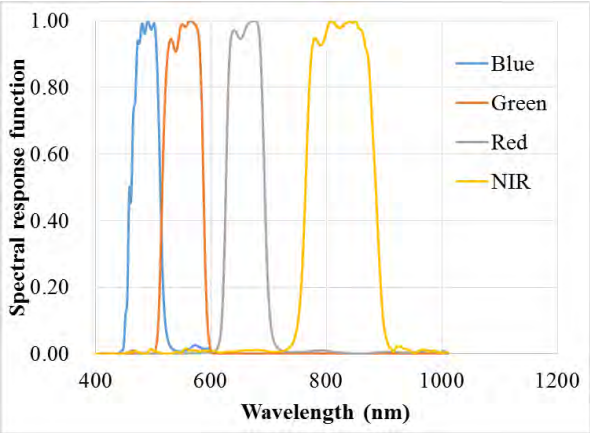


A same spectrometer in automated surface measurement system will be used.

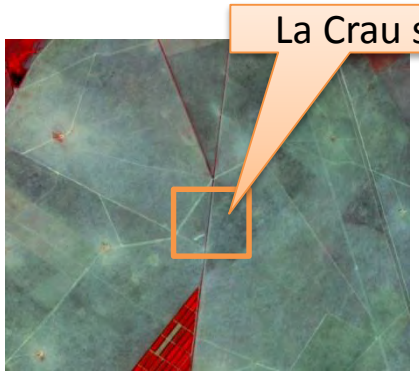
Activities on Baotou site

➢ List ZY-3 as a RadCalNet demonstration satellite

- **ZY-3: Launched on January 9, 2012, onboard three panchromatic cameras and one multispectral camera (4 bands). Charged by State Bureau of Surveying and Mapping.**



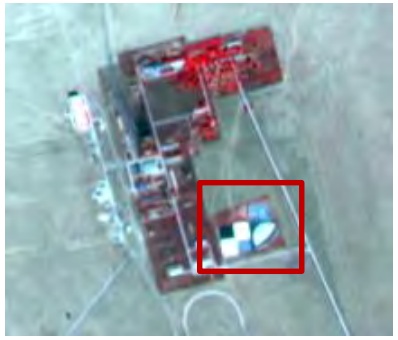
Resolution	2.1 m (nadir, Pan) 3.5 m (forward/backward, Pan) 6 m (multispectral camera)
Spectral range	0.5-0.8 um (Pan) 0.45-0.52 um (Blue) 0.52-0.59 um (Green) 0.63-0.69 um (Red) 0.77-0.89 um (NIR)
Revisit cycle	59 days (Nadir observation)



20140802 (Band 4,3,2)

20120824 (Band 4,3,2)

20140824 (Band 4,3,2)



20150912 (Band 4,3,2)

Cal/Val in Dragon Programme 4

➢ Dragon Programme 4

Background:

- ESA, together with the NRSCC, had cooperated in the field of Earth observation application development for more than 17 years.
- In 2004, The cooperation taken on a new momentum called Dragon.

Objectives:

- The Dragon cooperation is targeted towards land, ocean, cryosphere, geodesy, climate and atmospheric investigations in P.R. China.

Progress of Dragon :

- Dragon 1(2004-2008): formally kicked-off in April 2004 ,in Xiamen city in P.R. China. was initiated in 16 priority areas using ESA ERS and Envisat data in P.R. China
- Dragon 2(2008-2012): 25 geo-science projects
- Dragon 3(2012-2016): further expanded to a third phase with 51 projects exploiting ESA, TPM and Chinese EO data.
- Dragon 4(2016-2020): Proposal submission.

Cal/Val in Dragon Programme 4

➢ Dragon Programme 4

A proposal named "Calibration and Data Quality Assurance for Quantitative Remote Sensing" has been submitted to the Dragon 4 "Calibration/Validation" theme .

European LI: Bojan Bojkov(ESRIN) Chinese LI: Chuan-rong Li(AOE, CAS)

Optical

- RadCalNET-related work, Traceable cal method of ground instruments，Consistent transfer cal, Uncertainty propagation, step-wise validation technique
- Attendees: ESRIN, NPL, U. of Valencia, U. of Strasbourg, AOE-CAS, NMI, CIOMP-CAS, SITP-CAS, CRESDA, Ocean U. of China

Microwave

- Cal of Microwave Sensors and Product generation.
- Attendees: ESRIN, NRRS-CAS, CMA

SAR

- Best practices of CR, Use of bar-pattern targets for image quality assessment.
- Attendees: ESRIN, AOE-CAS, IE-CAS

Future Works

Manage the implement of EO projects

- Intensity correlation imaging
- TANSAT—Global CO2 observation and Monitoring
- Lunar calibration…

Arrange new EO projects (five years' plan)

- Stationary orbit high-spatial and high-spectral EO Sensor development
- Spaceborne radiation benchmark satellite and consistent calibration system
- Recalibration of historical satellite data
- Regional networked earth observation…

Thank you for attention!