4th meeting of the CEOS Working Group on Disasters

A Comprehensive Calibration and Validation Site for Information Remote Sensing

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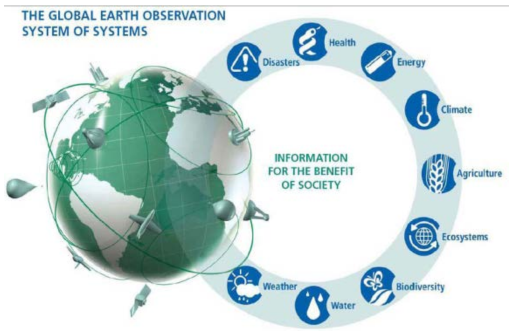
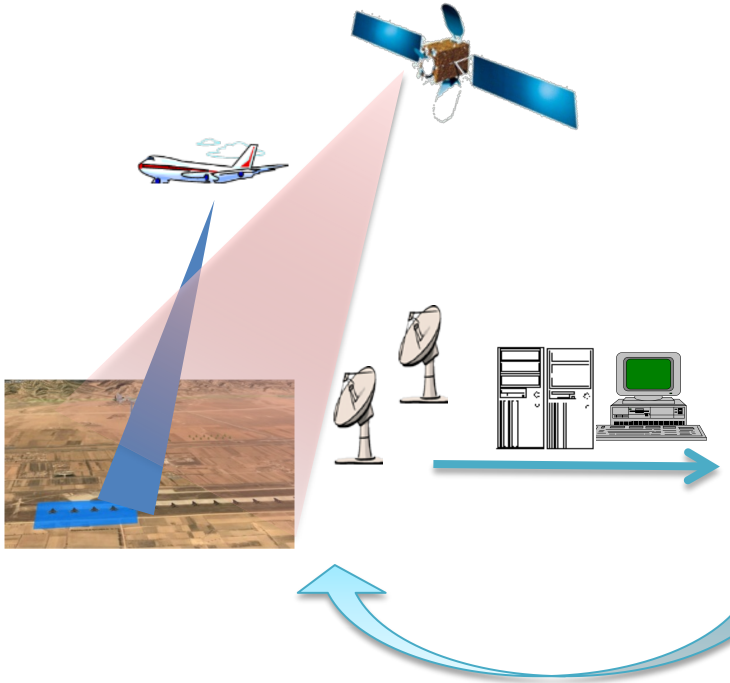
8 Sep, 2015

Technology challenges in Cal&Val for RS sensors

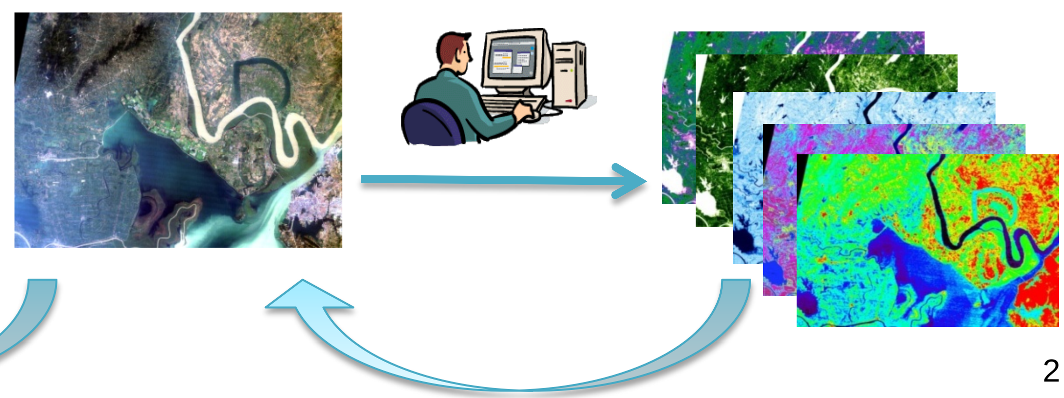
- **Remote Sensing (RS) is principally an information business. High-resolution makes it possible to provide public with more universal information.**



- **Precision and Accuracy are the basic elements for RS products to lead the market.**



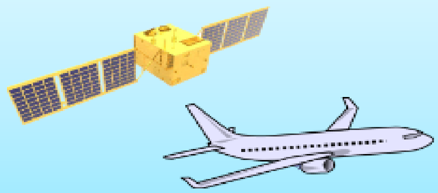
- **Quality control throughout remote sensing processing chain is a critical challenge to be solved at the moment.**



Technology challenges in Cal&Val for RS sensors

Quality Control

RS Sensors



RS data

RS products

Calibration Accuracy

- How to analyze the uncertainties in the whole calibration chain
- How to reduce those uncertainties

Benchmark Consistence

- How to ensure the long-term stability of ground reference targets
- How to ensure the comparability of the different sites
- How to ensure the comparability of different field measurements

Product Quality Traceability

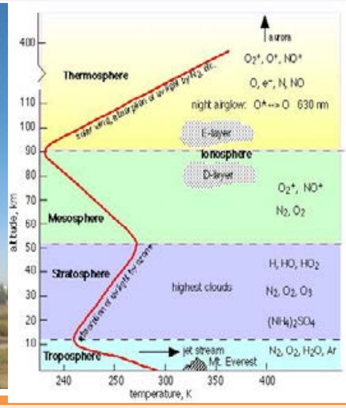
- How to understand the relationship of different performance
- How to develop a comprehensive site served for multi-performance assessment of different sensors that used to retrieve the same RS products.

Technology challenges in Cal&Val for RS sensors

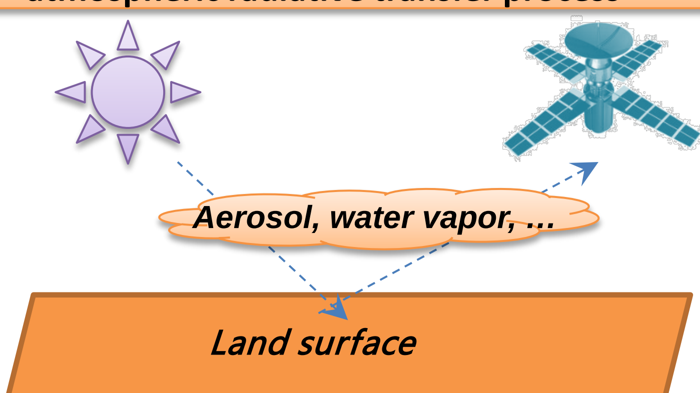
Calibration Accuracy

- The difficulties in accurately measuring temporal-spatial variation factors;
- The scaling gap between satellite and field observations;
- The scientific problems of accurate radiative transfer process description in a complicated Earth-atmosphere system

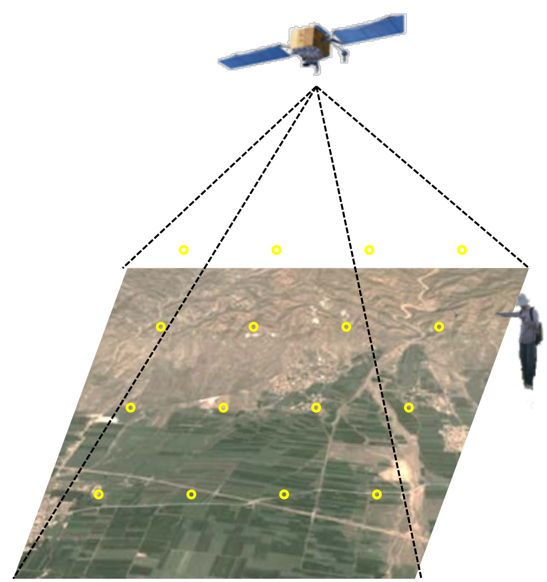
Difficult to measure the atmosphere due to the significant variation



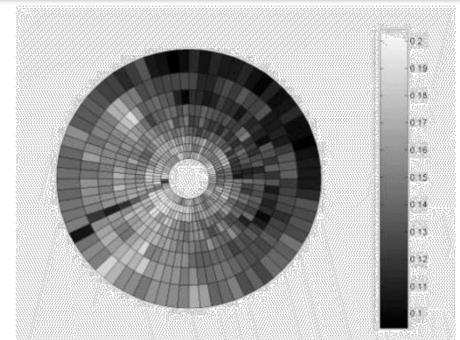
Uncertainties in the modeling of atmospheric radiative transfer process



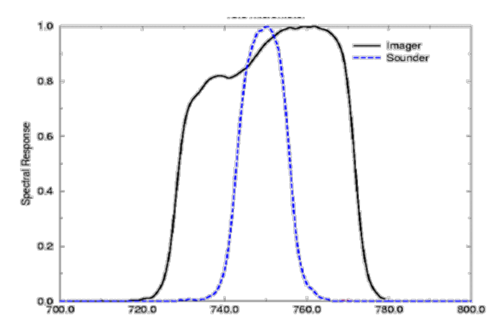
Mismatching in temporal, spatial, angular and spectral scales of the ground V.S. satellite observations



Temporal-spatial differences



The angular effect of surface radiation



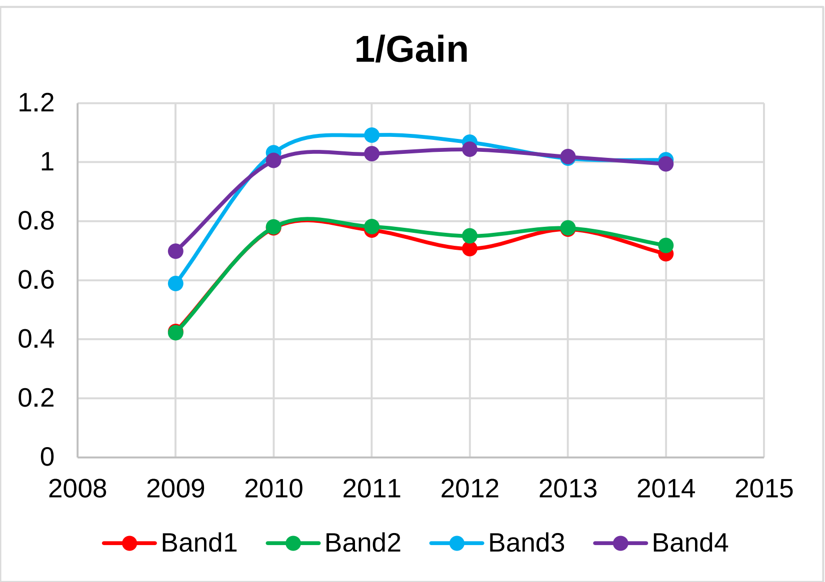
Spectral mismatching of different instrument

Technology challenges in Cal&Val for RS sensors

2 Benchmark Consistence

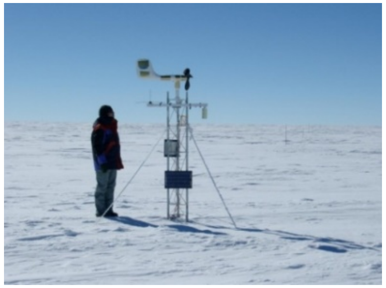
- High-frequency vicarious calibration technology;
- Ground targets with stable and significantly different characteristics;
- The standard measurement and data processing flow.

Low calibration frequency (once per year) is difficult to describe the sensor performance degradation.



HJ-1A/CCD

Natural scenes hardly provide sufficient reflected/emitted differences to cover the wide dynamic range of the sensor in a limited imaging area.



DOME C

La Crau, FR

Rice field, CA

Walker Lake, NV

Technology challenges in Cal&Val for RS sensors

3 Product Quality Traceability

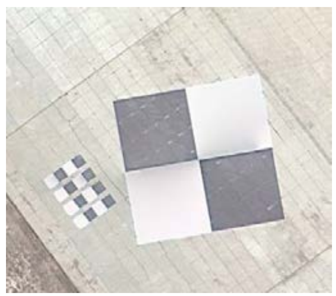
- The quality of RS information product is described by various quality metrics. Calculating different quality metrics of different sensors requires different ground reference targets.
- Quality metrics for characterizing the RS sensor performance are usually highly correlated with each other. High resolution make it possible to assess all the quality metrics in one site.

Image resolution

Tri-bar target

Fan-shaped target

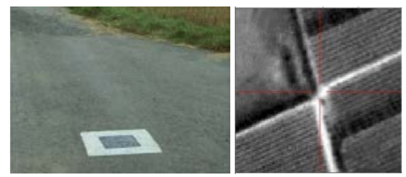
MTF assessment



Edge target

Point target

Geometric assessment

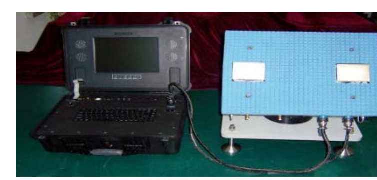


Artificial/natural control points

Geometric calibration test field

SAR quality assessment

Passive targets



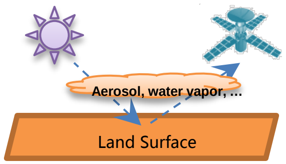
Active targets

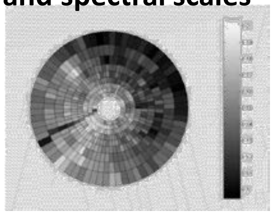
Summary

Calibration Accuracy

atmosphere

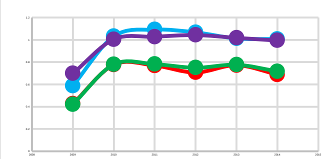
Mismatching in temporal, spatial, angular and spectral scales





Benchmark Consistence

Sensor degradation



Reliable ground targets

Product Quality Traceability

Comprehensive targets for various product quality assessment

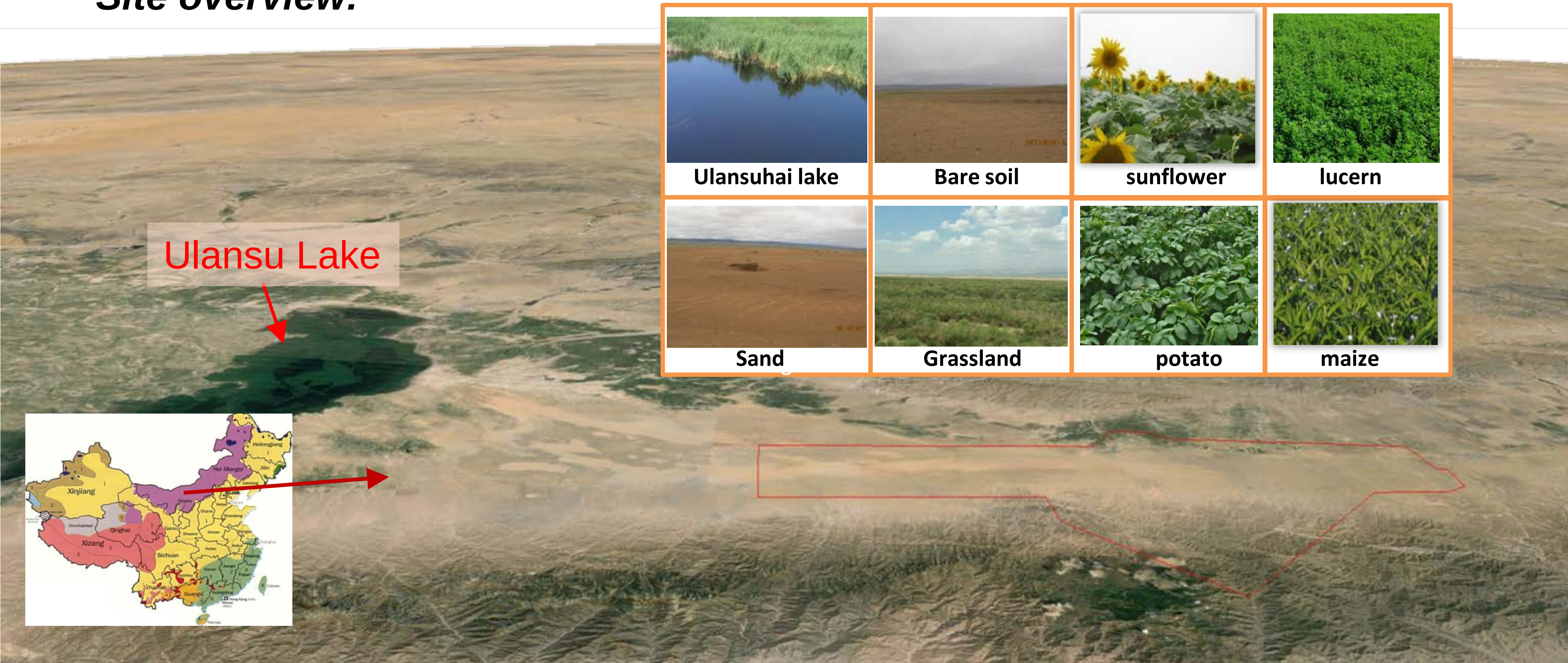
Comprehensive Cal&Val site

- High-stable ground standard targets
- High-accuracy stepwise Cal&Val system
- High-frequency automated radiometric calibration

Baotou comprehensive Cal&Val site

- Located in Inner Mongolia, China, 50km away from Baotou city.
- A flat area of approximately 300km^2, about 1270m above sea level.
- Land cover: Sand, bare soil, grass, lake, various agriculture(maize, sunflower, lucern, potato, etc.).
- Features a cold semi-arid climate with approximately 300 clear-sky days per year.

Site overview:



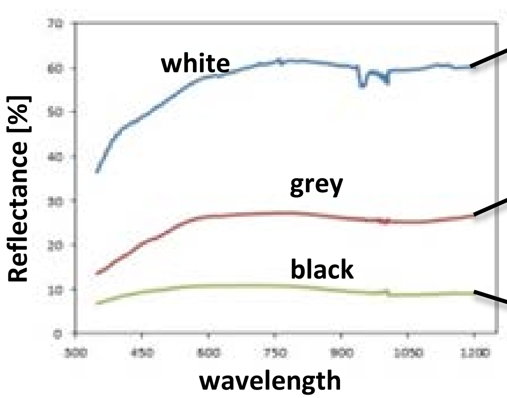
1. High-stable ground standard targets

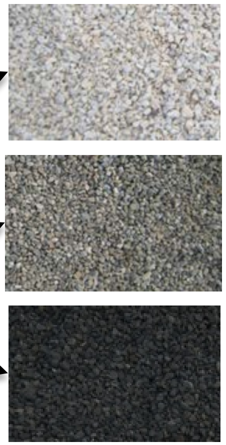
1.1 Artificial Permanent Targets

Optical edge and fan-shape target

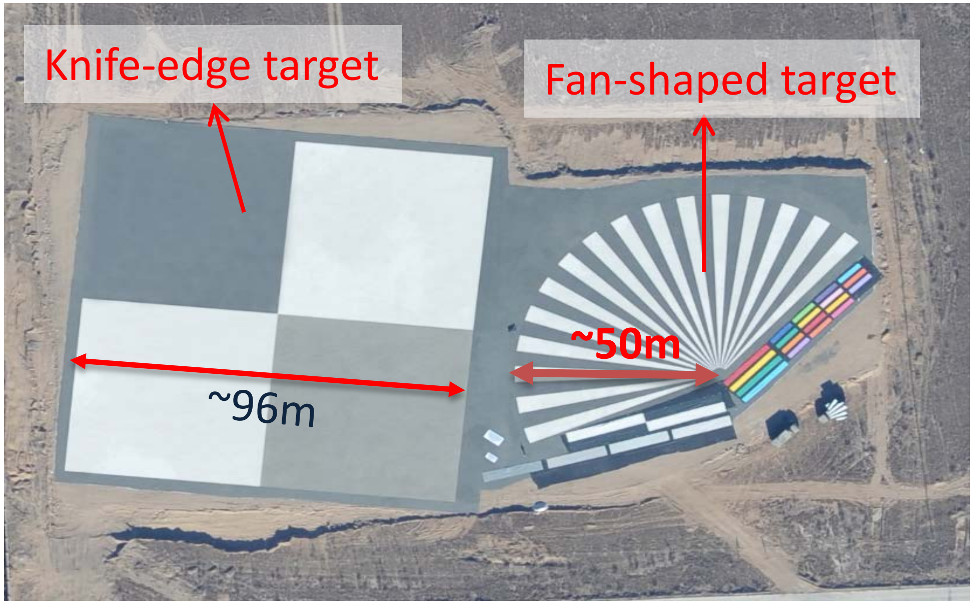
Dedicated to high-accuracy and high-stable radiometric calibration:

- **High-stable**: made of natural gravels
- **Wide-range**: three grey-scale
- **Well-uniform**: each block filled with the same gravels

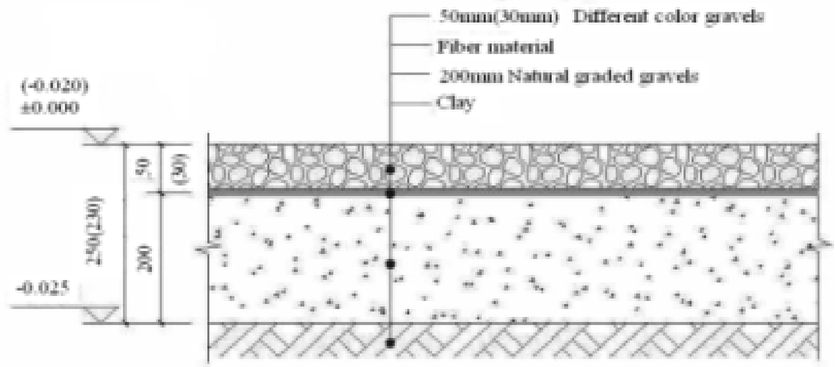




Gravel (size<1.5cm)



Aerial image of the optical artificial permanent targets

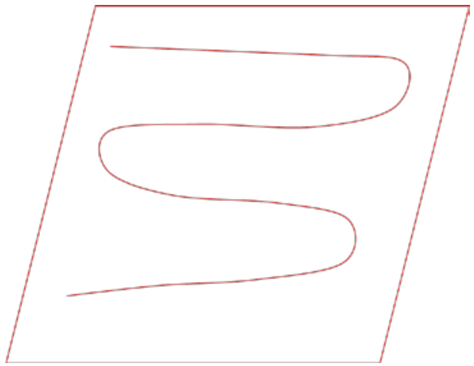


Baotou comprehensive Cal&Val site

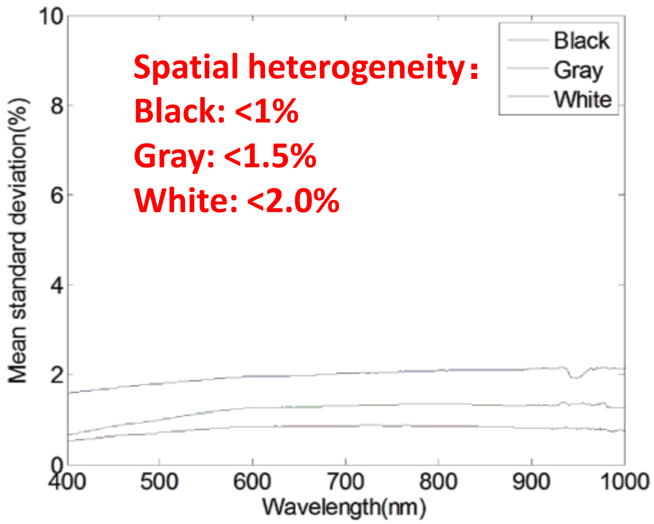
➢ 1. High-stable ground standard targets

1.1 Artificial Permanent Targets

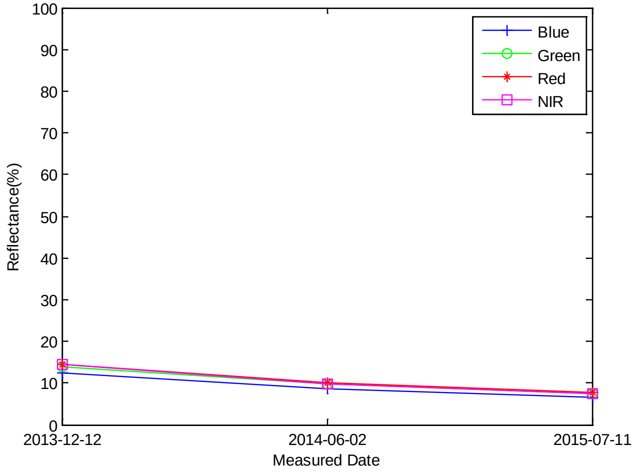
Uniformity of the edge target

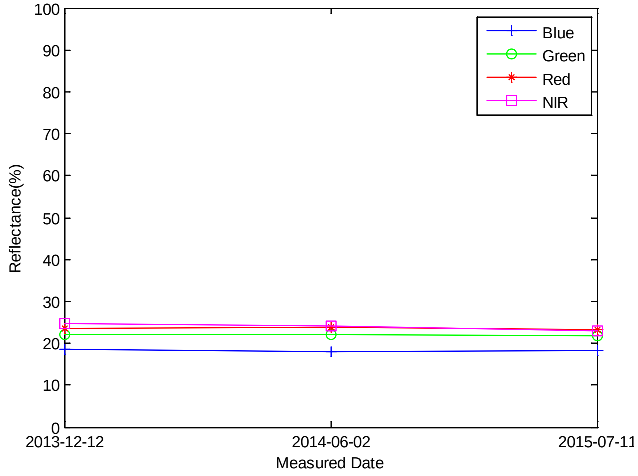


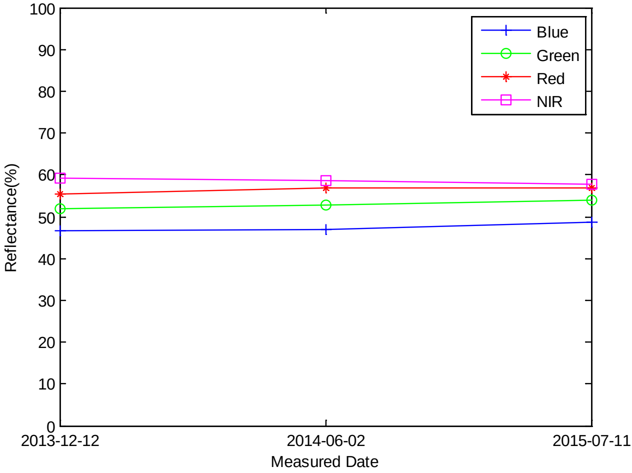
Sampling strategy of the measurement



Annual degradation of the reflectance of three kinds of gravels







Baotou comprehensive Cal&Val site

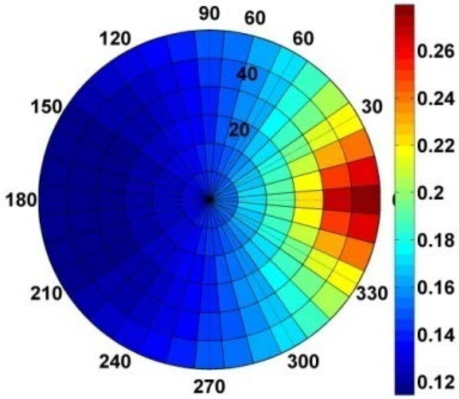
➢ 1. High-stable ground standard targets

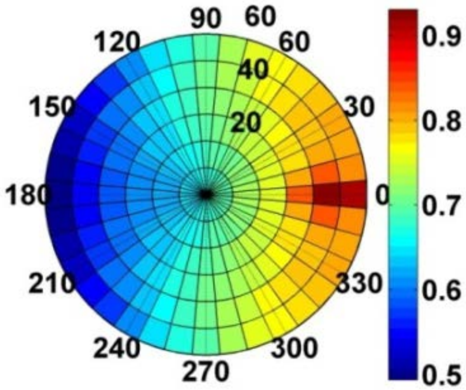
1.1 Artificial Permanent Targets

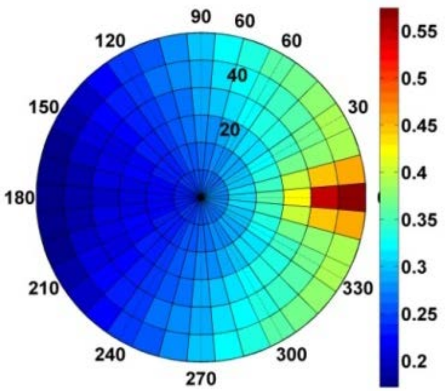
In situ BRF measurement and modeling

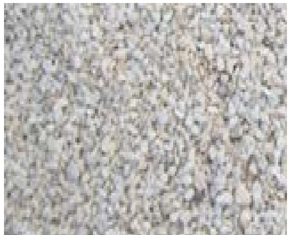
- **The relative difference of measured angular reflectance in three targets: <10% (VZA within ±10°).**
- **The RMSE of BRDF model: <3% for three targets.**

$$R(\theta_i,\theta_v,\phi,\lambda) = f_{iso}(\lambda) + f_{vol}(\lambda)K_{vol}(\theta_i,\theta_v,\phi,\lambda) + f_{geo}(\lambda)K_{geo}(\theta_i,\theta_v,\phi,\lambda)$$









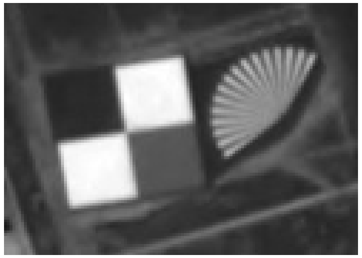
Baotou comprehensive Cal&Val site

➢ 1. High-stable ground standard targets

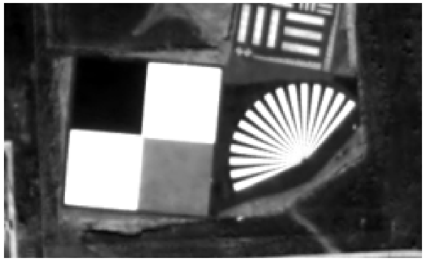
1.1 Artificial Permanent Targets

Optical edge and fan-shape target

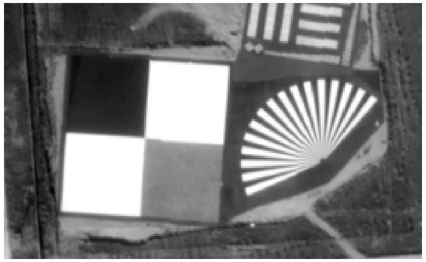
The construction of these targets was finished at the end of October, 2013. During the operation phase, the performance of several optical sensors were assessed.



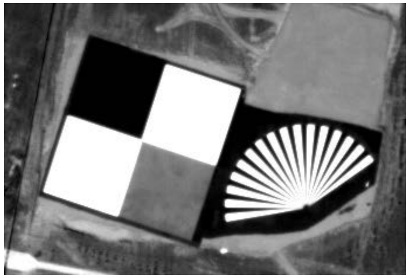
2013/11/4 GF-1 PAN image



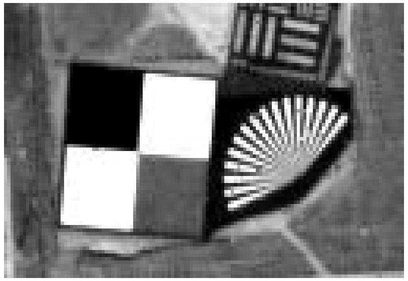
2014/10/13 GF-2 PAN image



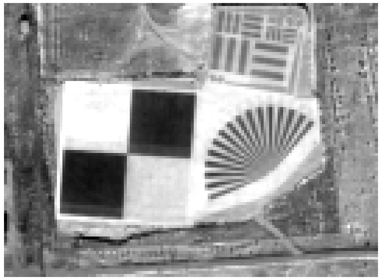
2014/11/29 KZ PAN image



2014/08/14 KOMPSAT-3 PAN image



2014/10 /17airborne SWIR sensor image



2014/10 /17 airborne MIR sensor image

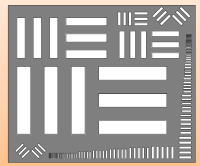
Baotou comprehensive Cal&Val site

1. High-stable ground standard targets

1.1 Artificial Permanent Targets

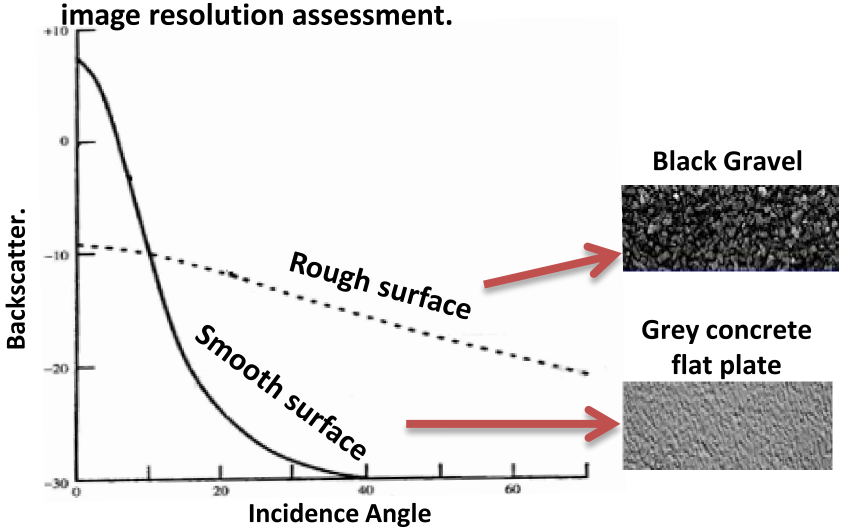
Microwave/optical bar-pattern target

1. “bar-pattern” design, rather than “point”, benefiting for microwave image resolution assessment



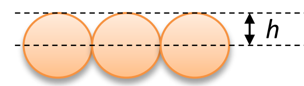
2. Intensity contrast between bars and the background is realized by their roughness difference

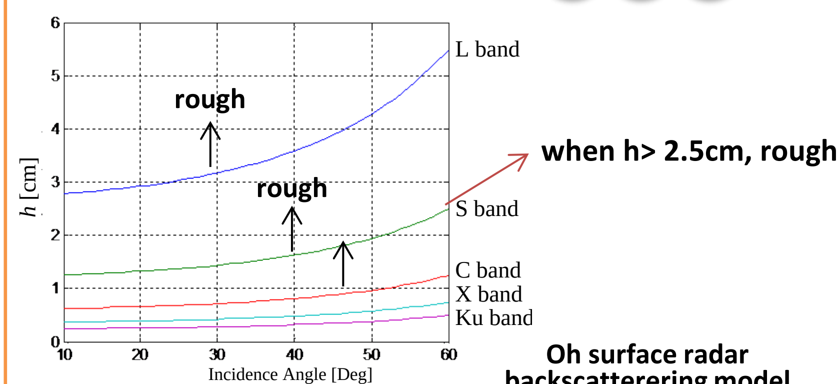
Black gravel and grey concrete flat plate were exploited to construct the target for both microwave and optical image resolution assessment.



3. The size of the gravel was calculated based on both Rayleigh roughness criterion and Oh surface radar backscatterering model, in order to exhibit sufficient contrast in Ku to S band radar image.

Rayleigh criterion: $h > \dfrac{\lambda}{8 \cdot \cos\theta}$



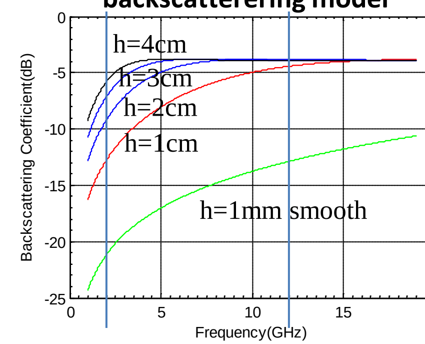


when h=3 cm, contrast=12dB at 5GHz

Gravel size S=2h:

<0.4m width bars: S=2cm±0.5;
>0.4m width bars: S=5cm±1.

Oh surface radar backscatterering model



@20° incidence angle

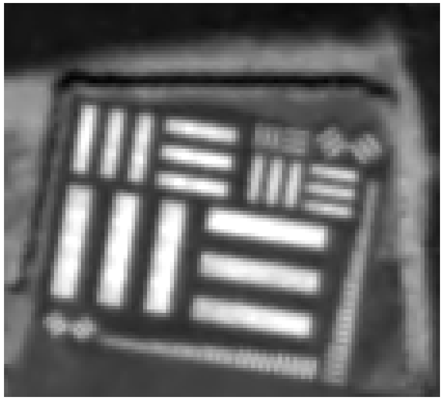
Baotou comprehensive Cal&Val site

➢ 1. High-stable ground standard targets

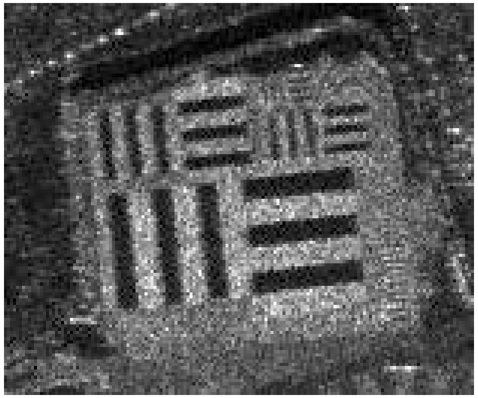
1.1 Artificial Permanent Targets

Microwave/optical bar-pattern target

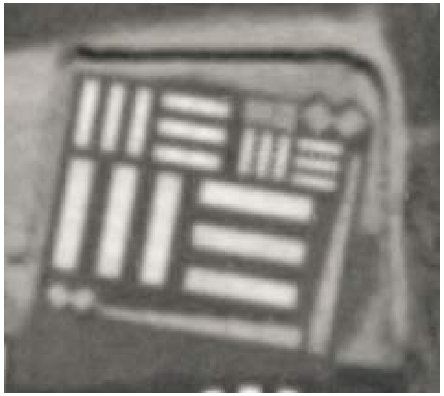
Finished construction by the end of September, 2014



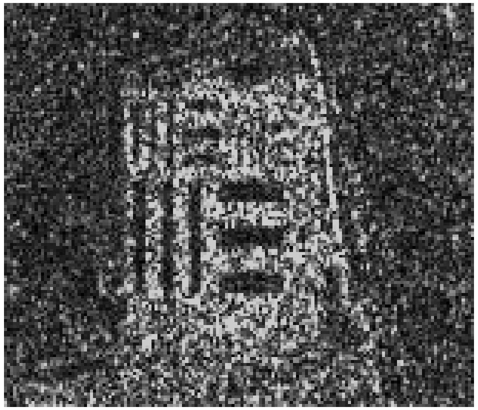
2014/10/13 GF-2 PAN image



2014/10/19 C-band airborne SAR image



2014/10/17 airborne SWIR image



2014/10/22 KOMPSAT-5 SAR image

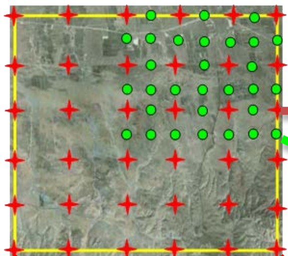
Baotou comprehensive Cal&Val site

➢ 1. High-stable ground standard targets

1.1 Artificial Permanent Targets

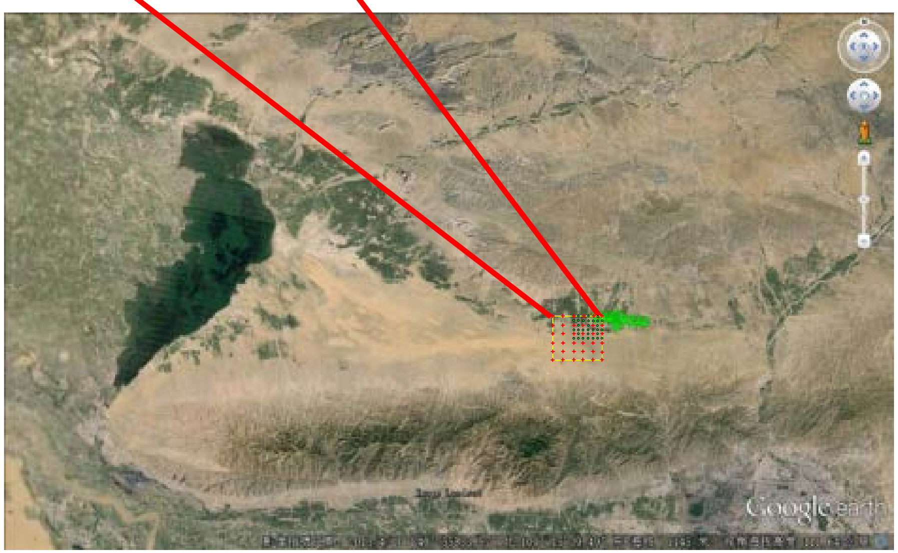
Geometric control points

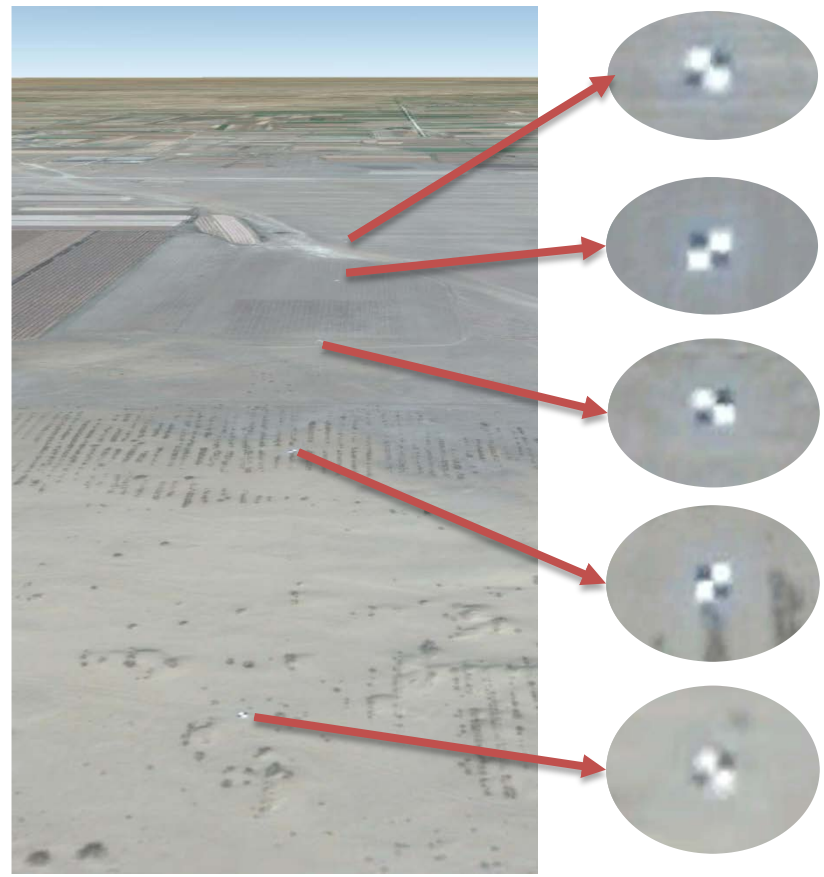
75 geometric control points with positional accuracy of 2cm(horizontal), 4cm (vertical).



Size: 2mx2m

For mounting portable geometric targets (size: 3x3m)





GCP Google Earth image(from Digital Global, 0.5m)

➢ 1. High-stable ground standard targets

1.1 Artificial Permanent Targets

SAR corner reflector base

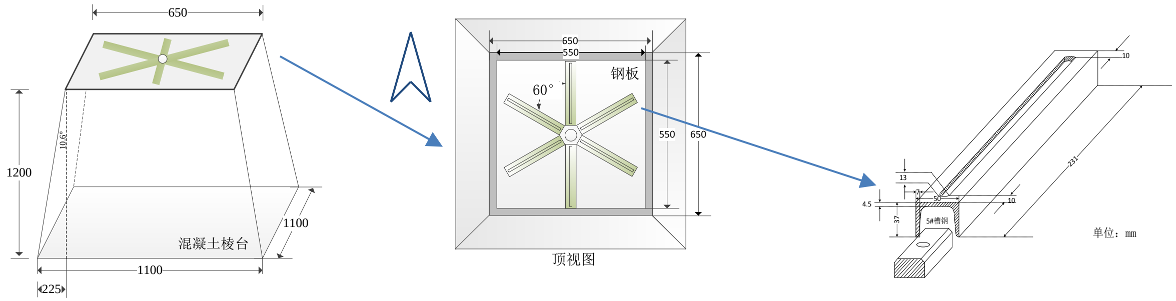
Distribution direction (east-west) is 95° to North, with compromise of transportation convenience and SAR flight direction:

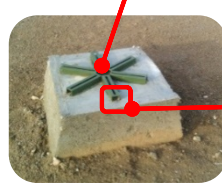
$$\beta = \arcsin\frac{\pm\cos\alpha}{\cos\xi} \approx 10^\circ$$

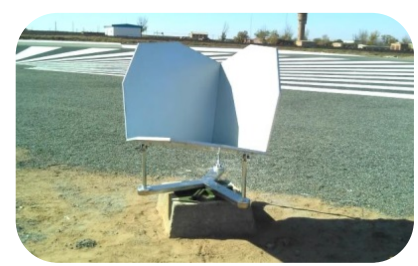
β : Azimuth
α : Latitude
ξ : Inclination

Satellite	Inclination
TerraSAR	97.44°
Radarsat-2	98.6°
Sentinel-1	98.18°
SkyMed	97.86°
HJ-1-C	97.37°

For quickly deploying corner reflectors and avoiding repeated measurement of position information







Baotou comprehensive Cal&Val site

➢ 1. High-stable ground standard targets

1.2 Artificial Portable Targets

Optical

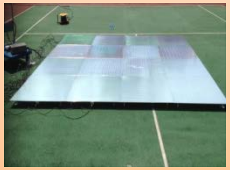
Knife-edge

Color targets

Fan-shaped

Array of point source targets

Grayscale



Low-emissivity Target(4mx4m)

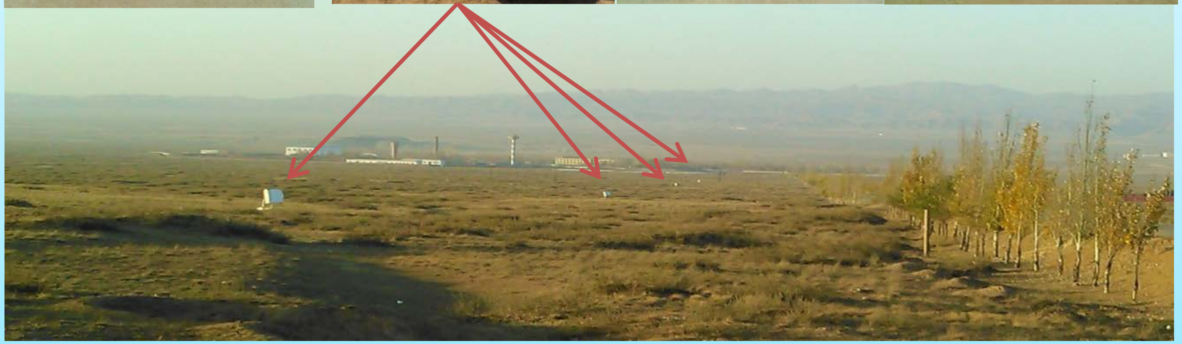
Microwave

Triangular Trihedral CRs

Hexagonal Trihedral CRs

Dihedral Trihedral CRs

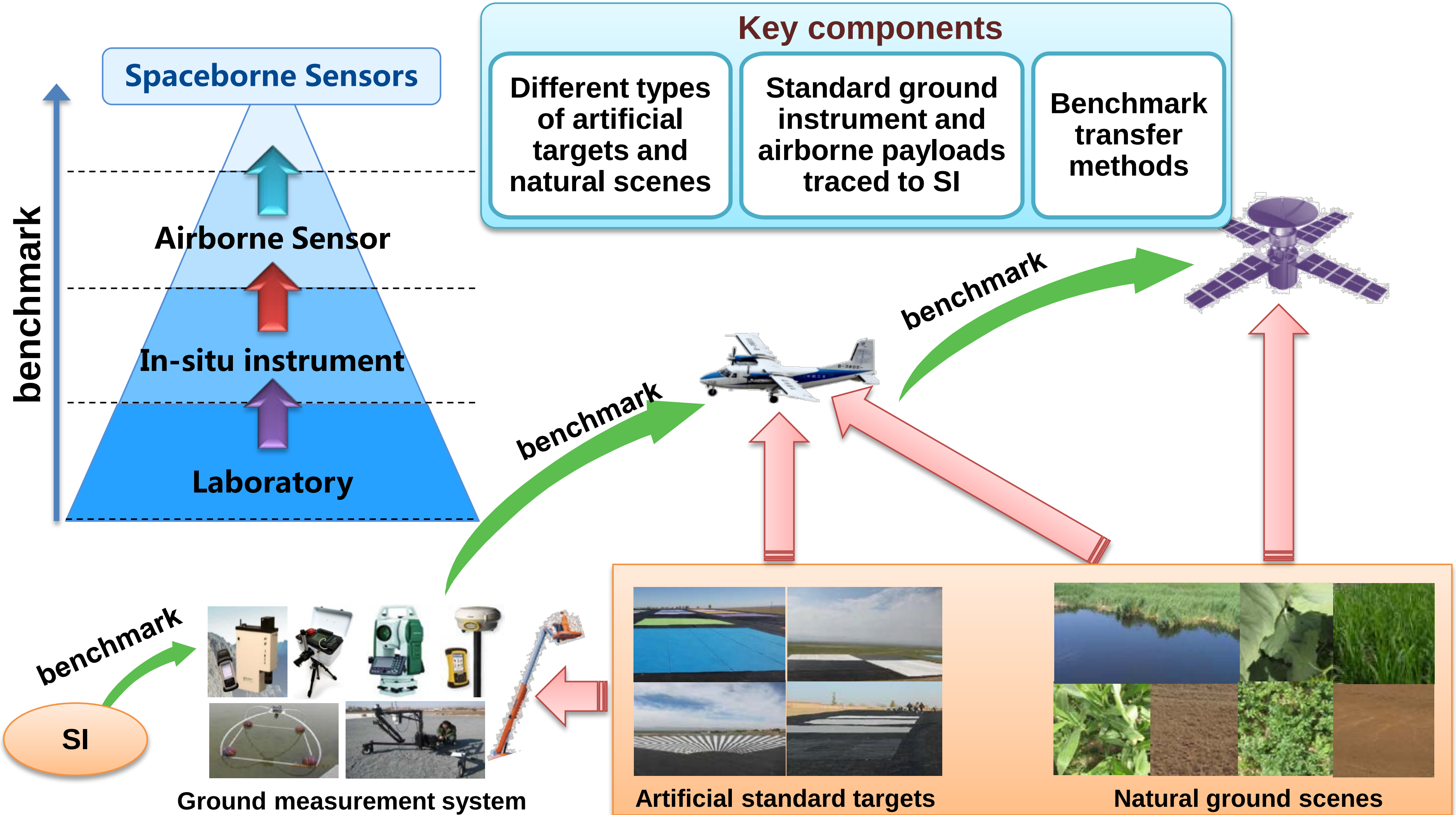
Bottom-extended Trihedral CRs



Square Trihedral CRs

➢ 2. High-accuracy Stepwise Cal&Val system

The system aims to develop a chain that transfers the benchmark from laboratory to spaceborne sensors.

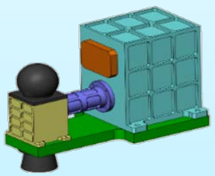


Baotou comprehensive Cal&Val site

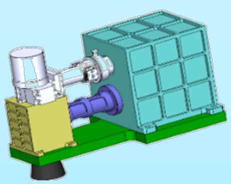
➢ 2. High-accuracy Stepwise Cal&Val system

In order to obtain the “truth” of ground scenes and targets, the Stepwise Cal&Val system are integrated and some standard payloads are still under-development.

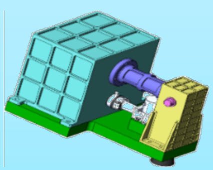
Ground hyperspectral imager



VNIR
400-1050nm
650 channels



SWIR
1000-2500nm
300 channels



LWIR
8-12.5μm
150 channels

Cover the same spectral range

Have more channels and higher resolution for ground imagers

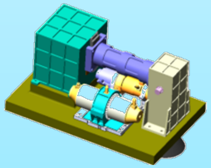
All have the self-calibration units

Carry out the lab calibration traced to SI

Airborne hyperspectral imager

VNIR
400-1050nm
300 channels

SWIR
1000-2500nm
170 channels



LWIR
8-12.5μm
75 channels

Total station and GPS

VIS-IR Field Spectrometers

LAI-2200C plant canopy analyzer

Overhead working platform

Photoelectric stabilized platform

Baotou comprehensive Cal&Val site

➢ 2. High-accuracy Stepwise Cal&Val system

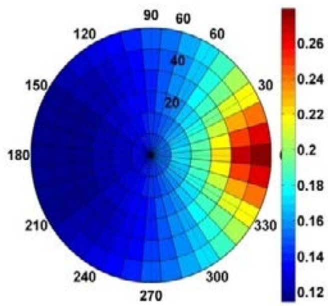
Benchmark transfer methods:

Angular Matching

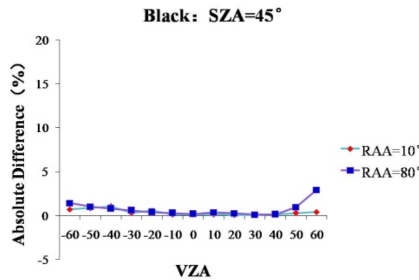
Develop BRDF model for typical targets:

$$R(\theta_i,\theta_v,\phi,\lambda)= f_{iso}(\lambda)+ f_{vol}(\lambda)K_{vol}(\theta_i,\theta_v,\phi,\lambda)+ f_{geo}(\lambda)K_{geo}(\theta_i,\theta_v,\phi,\lambda)$$

Target (black gravels)



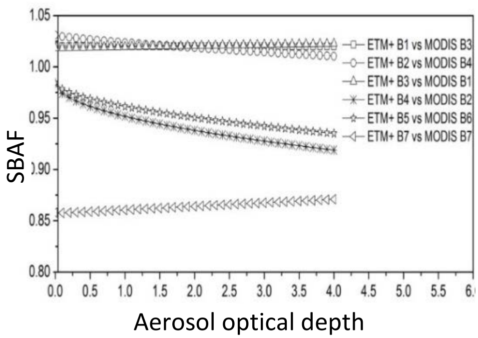
Modeled BRFs

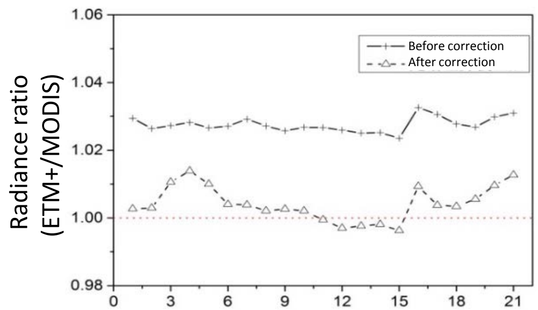


Modeling absolute differences

Spectral Matching

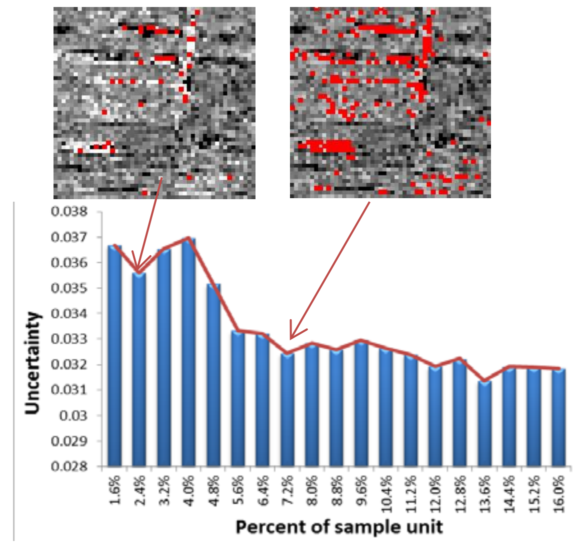
Improve the spectral band adjustment factor (SBAF) by taking into account for the atmospheric effects

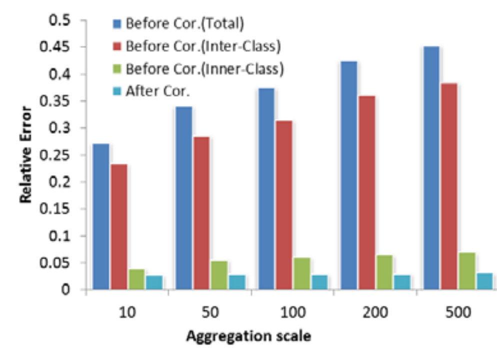




Spatial Transformation

The optimal sampling strategy considering the cost-effectiveness

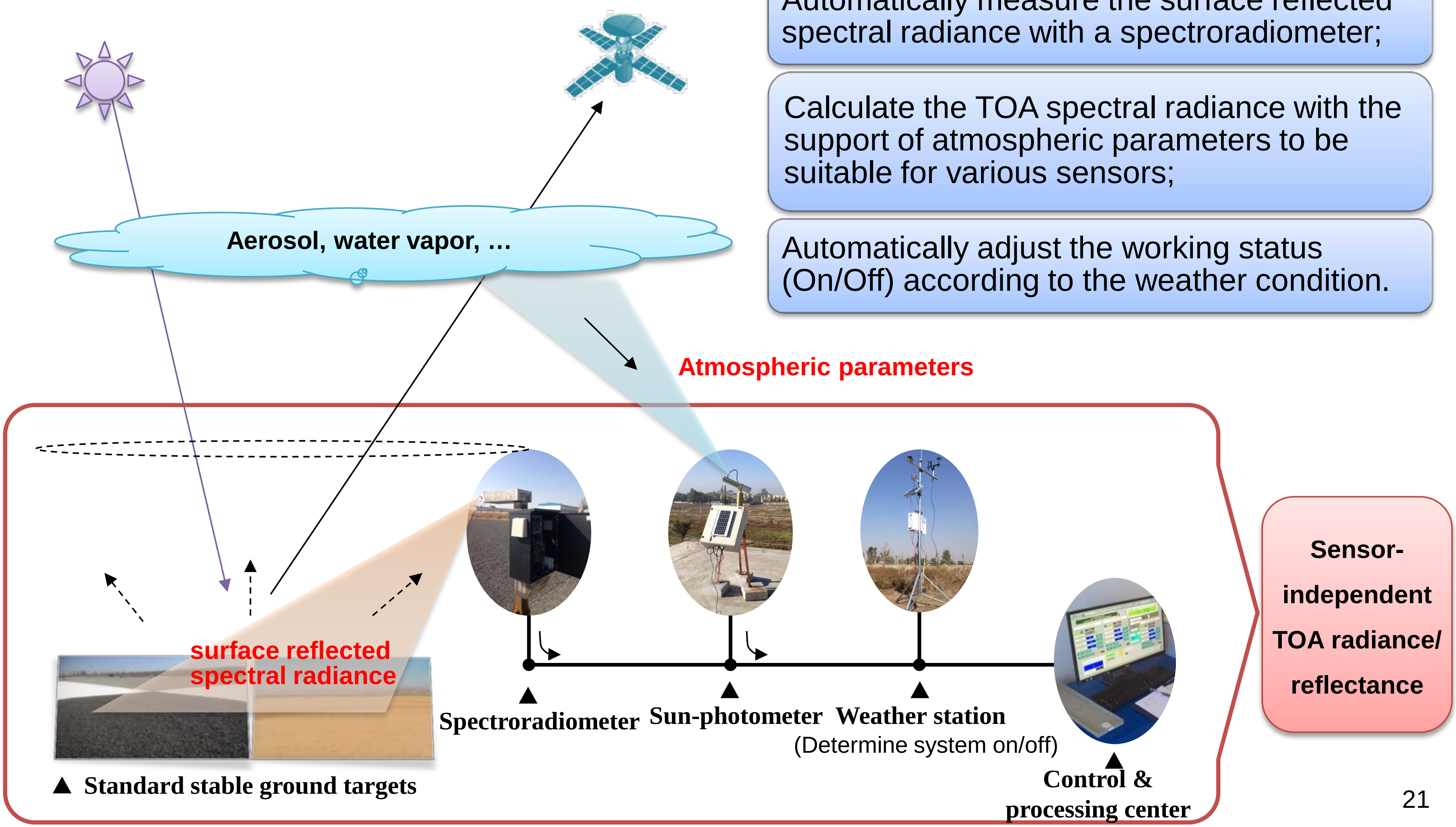




The scaling effect of crops LAI

➢ 3. High-frequency automated radiometric calibration

Automated reflectance spectrum measurement system



Automatically measure the surface reflected spectral radiance with a spectroradiometer;

Calculate the TOA spectral radiance with the support of atmospheric parameters to be suitable for various sensors;

Automatically adjust the working status (On/Off) according to the weather condition.

3. High-frequency automated radiometric calibration

Automated measurement processing procedure

Atmospheric parameters including:
- ✓ Aerosol optical thickness;
- ✓ Columnar water vapor;
- ✓ Absorption and asymmetry coefficients;
- ✓ Phase function…

Compared to the on-site personnel mode, the automated approach produces the TOA radiance with the high-frequency atmospheric and surface monitoring data.

- Difference in the use of ground reflected spectral radiance instead of spectral reflectance in on-site personnel mode;
- The atmospheric multi-scattering effect and adjacent effect are taken into account for higher accuracy.

Atmospheric radiative transfer model (MODTRAN)

Automated measured parameters

- ✓ Ground-to-Sensor total transmittance;
- ✓ Path radiance.

Ground reflected spectral radiance

TOA radiance   Ground reflected radiance

$$L_{TOA} = L_{path} + L^{\uparrow} \cdot T(\theta_v)$$

Path radiance   Total transmittance from ground to sensor

Radiative transfer equation calculation

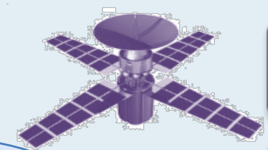
TOA spectral radiance → **SRF** → **Calibration**

Cal&Val Capability of the Baotou site

Automated radiometric calibration

- Monitor the surface and atmosphere to infer the TOA spectral radiance
- As the key function contributed to RadCalNet

Performance assessment of spaceborne RS payloads



- High resolution optical sensor
- Moderate resolution optical sensor
- High-resolution SAR

Baotou site

Capability

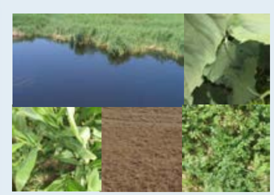
RS sensor testing based on aerial platform

- Panchromatic sensor
- Multi-/hyperspectral sensor
- Mid-infrared sensor
- Thermal-infrared sensor
- Synthetic aperture radar

Calibration

Performance assessment

Remote sensing product validation



- Surface basic characteristic product
- Surface ecology product
- Atmospheric and environmental characteristic product

Results of Cal&Val Campaigns

During 2009 to 2015, multiple scientific flight campaigns were carried out in Baotou site, including more than 11 airborne sensors and 12 spaceborne sensors.

Baotou comprehensive Cal&Val site

Airborne sensors

Optical:

- Hyperspectral camera, Large field multispectral imager, Area array camera, Lidar, infrared camera…

SAR:

- X-band full-polarimetric SAR, Ku-band InSAR, C-band SAR.

Spaceborne sensor

Optical:

- GF-1/2, SJ-9A, ZY-1/02C, ZY-3, KZ-1/2, KOMPSAT-3, Landsat-8

SAR:

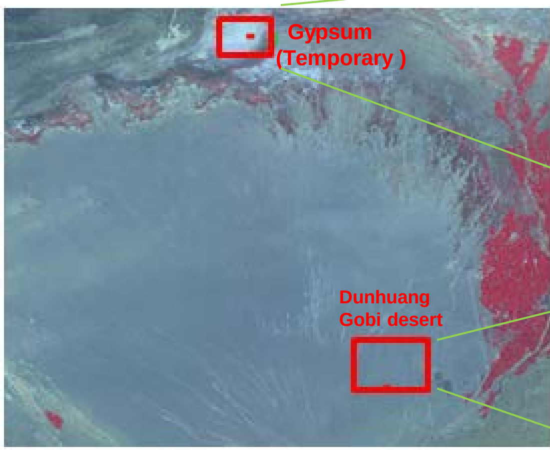
- KOMPSAT-5, RADARSAT-2

Results of Cal&Val Campaigns

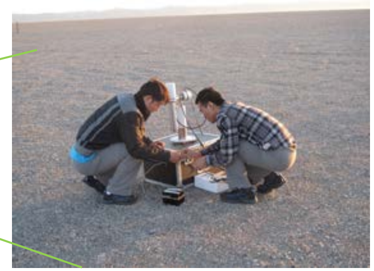
➢ Case1. Radiometric calibration in simultaneous mode

In China, the traditional vicarious calibration method for optical sensors mainly depend on Dunhuang site (Gobi). In recent years, some temporary fields with different reflectance were added to perform wide-range calibration.

But the surface uniformity and stability of these fields are not ideal, and can not be covered within a single image. This would induce more errors for calibration.

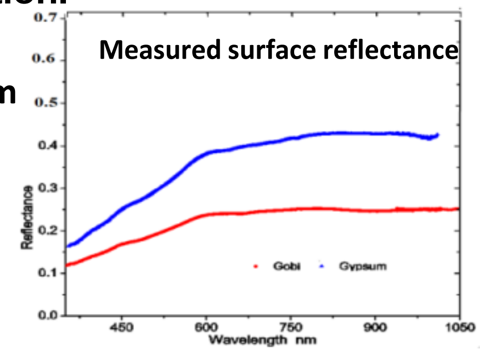


GF-1 calibration over Dunhuang site (Aug, 2014)



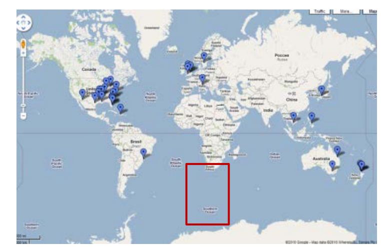
The sun photometer was installed temporarily on Dunhuang site.

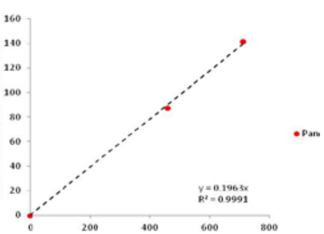
Site1:Gypsum

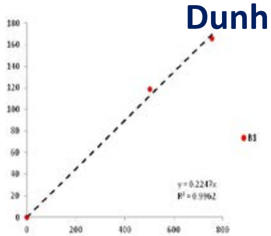


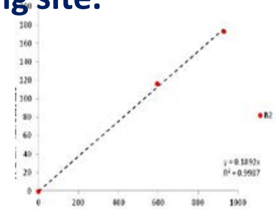
Site2:Dunhuang Gobi desert

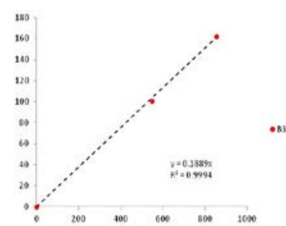
Site3: Deep sea

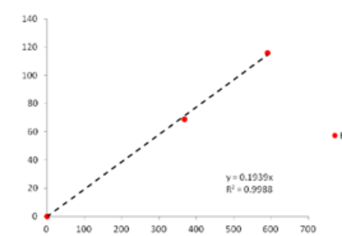










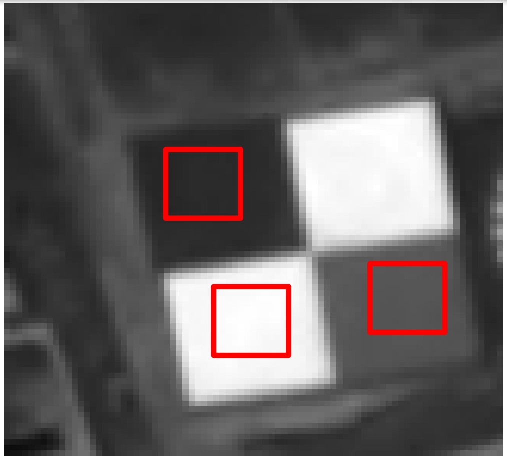


Results of Cal&Val Campaigns

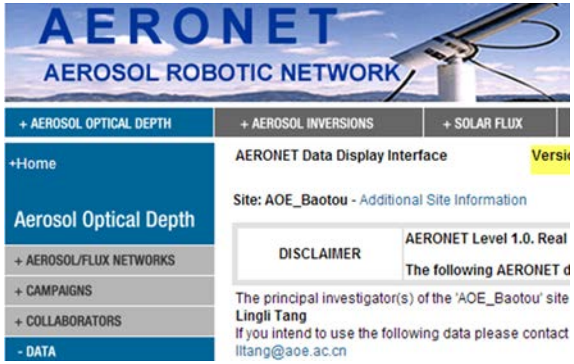
➢ Case1. Radiometric calibration in simultaneous mode

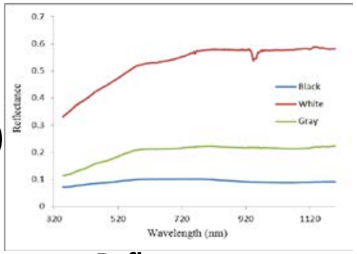
Baotou site has been greatly improved in a wide dynamic, stable, uniform ground standard targets for calibration. In addition, the sun photometer in this site joined the AERONET, providing quality-assured atmospheric data.

Case for the vicarious calibration of GF-1

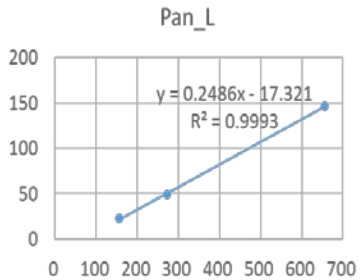


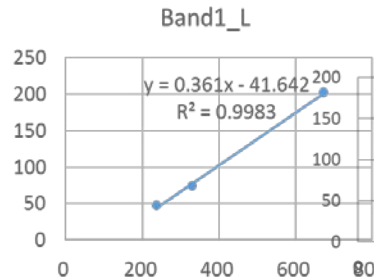
GF-1 image over Baotou site(2014-10-13)

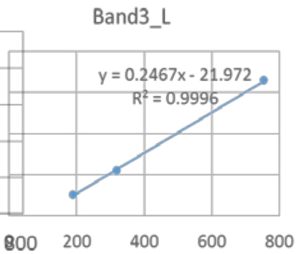


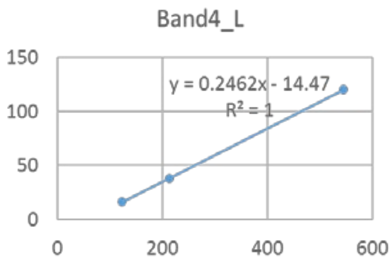


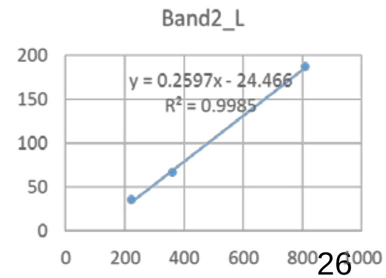
Reflectance









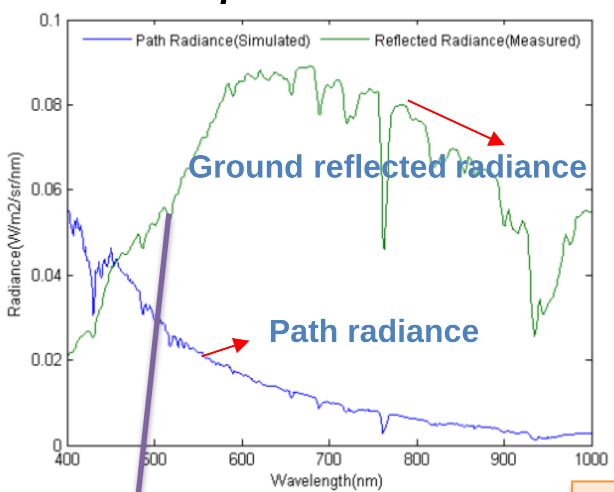


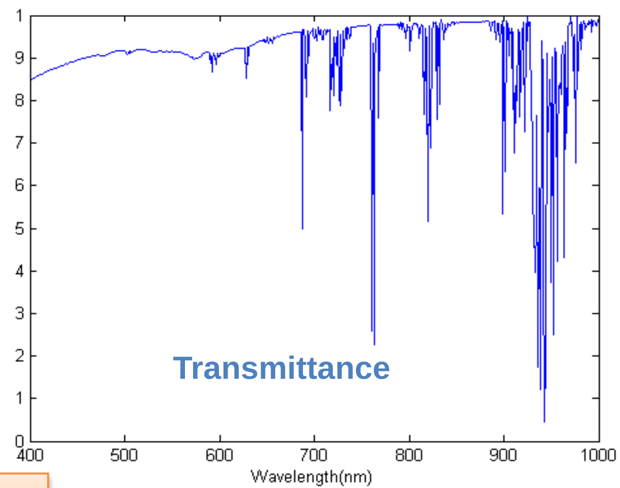
➢ Case2. Radiometric calibration in automated mode

Case study: Simulation of TOA radiance for OLI/Landsat 8

- **1. Calculation of atmospheric radiative transfer and TOA spectral radiance**

Data acquisition time :March 27, 2015

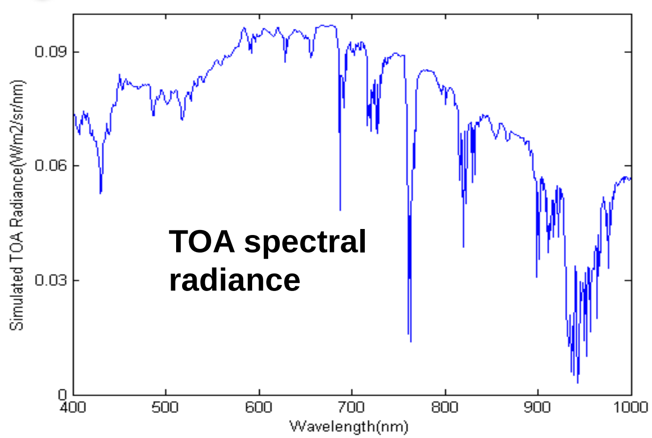




Total transmittance and path radiance were simulated with the automated atmospheric observations.

RTE

The ground reflected radiance was measured at the sand field in Baotou site.

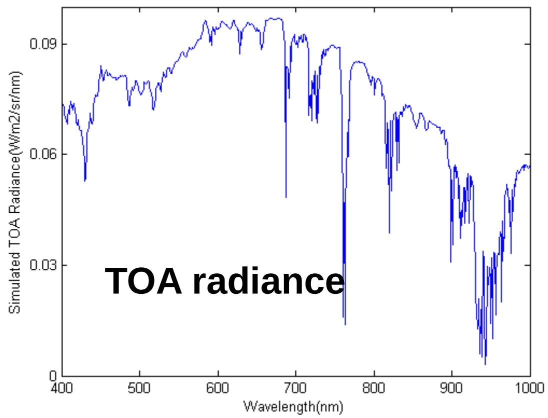


TOA spectral radiance was calculated based on the RTE.

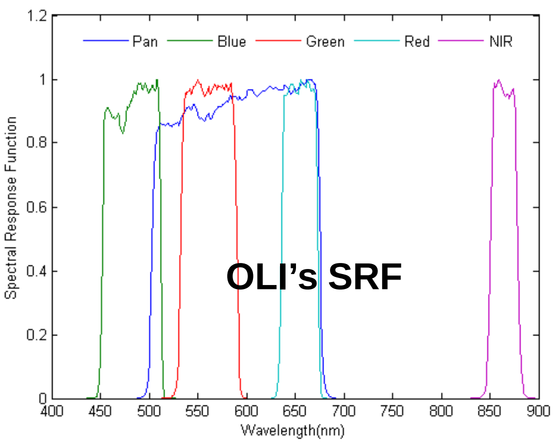
Results of Cal&Val Campaigns

➢ Case2. Radiometric calibration in automated mode

- **2. Prediction of channel TOA radiance and inter-comparison**

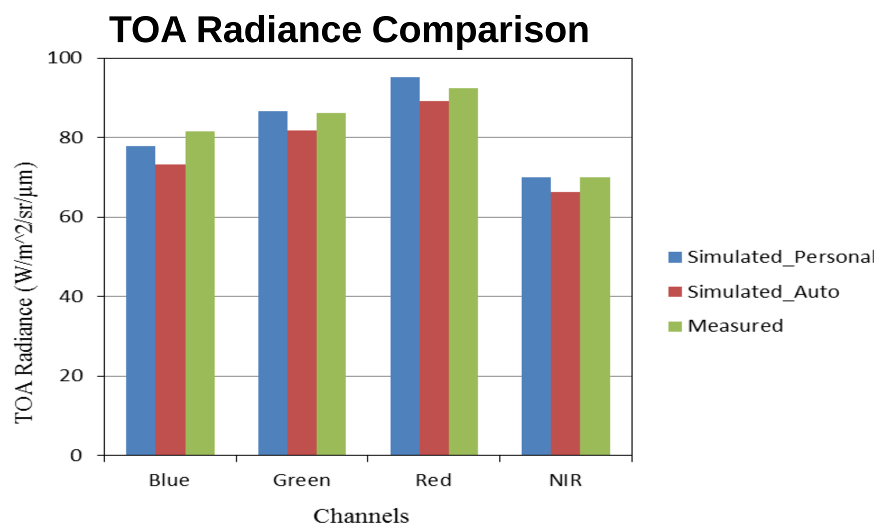


+



Convolution

	Observed Rad.	Simulated Rad.			
		Automated mode		On-site personnel mode	
	Value	Value	RE	Value	RE
Blue	81.59	73.19	10.2%	77.90	4.5%
Green	86.11	81.74	5.0%	86.71	0.7%
Red	92.38	89.13	3.5%	95.09	2.9%
NIR	70.10	66.25	5.4%	70.05	0.06%



The relative difference for automatic mode is higher than on-site personnel mode. More detailed analysis will be performed to improve the automatic calibration approach.

Results of Cal&Val Campaigns

➢ Case1. Radiometric calibration in an automated mode

- **3. Uncertainty analysis of automated radiometric calibration**

The calculation equations of automated radiometric calibration

$$L_{TOA} = L_g \cdot \tau + L_p$$

The sources of uncertainty

- The instrument: calibration errors, repeatability of radiospectrometer
- The target: uniformity, BRDF
- The atmosphere: aerosol optical depth, water vapour, aerosol type, ozone, etc…
- The model: accuracy of MODTRAN, solar irradiance, etc…
- Others: observation time, cloud, etc…

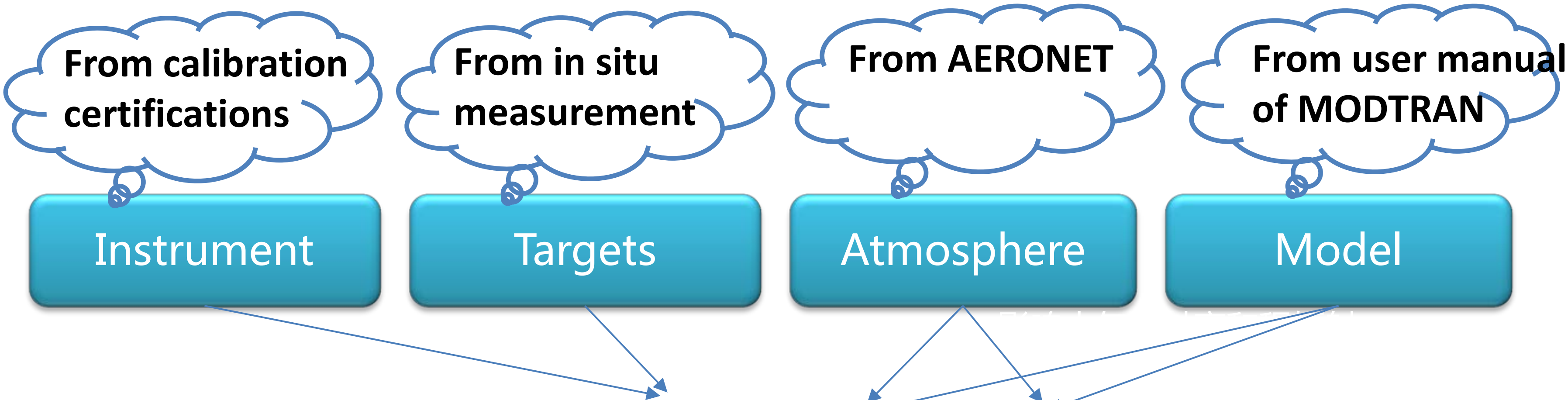
The measurement equation

$$L_{TOA} = [(L_g \cdot K_{cal} \cdot K_{rep} \cdot K_{uni} \cdot K_{BRDF}) \cdot (\tau \cdot K_{AOD} \cdot K_{ars\_m} \cdot K_{CWV} \cdot K_{atp} \cdot K_{MODTRAN}) + (L_p \cdot K'_{AOD} \cdot K'_{ars\_m} \cdot K'_{CWV} \cdot K'_{atp} \cdot K'_{MODTRAN} \cdot K_{sol\_ir})] \cdot K_{model} \cdot K_t$$

Results of Cal&Val Campaigns

➢ Case1. Radiometric calibration in an automated mode

- **3. Uncertainty analysis of automated radiometric calibration**



$$L_{TOA} = L_g \cdot \tau + L_p$$

Changing the value of one of the factors to find how the TOA radiance will be changed, and to calculate the uncertainty associated with TOA radiance due to this factor. Then, the total uncertainty is calculated according to the law of propagation of uncertainties.

$$u_c^2(y) = \sum_{i=1}^{n} \left(\frac{\partial f}{\partial x_i} \right)^2 u^2(x_i) + 2 \sum_{i=1}^{n-1} \sum_{j=i+1}^{n} \frac{\partial f}{\partial x_i} \frac{\partial f}{\partial x_j} u(x_i, x_j)$$

➢ Case1. Radiometric calibration in an automated mode

- **3. Uncertainty analysis of automated radiometric calibration**

Uncertainty budget

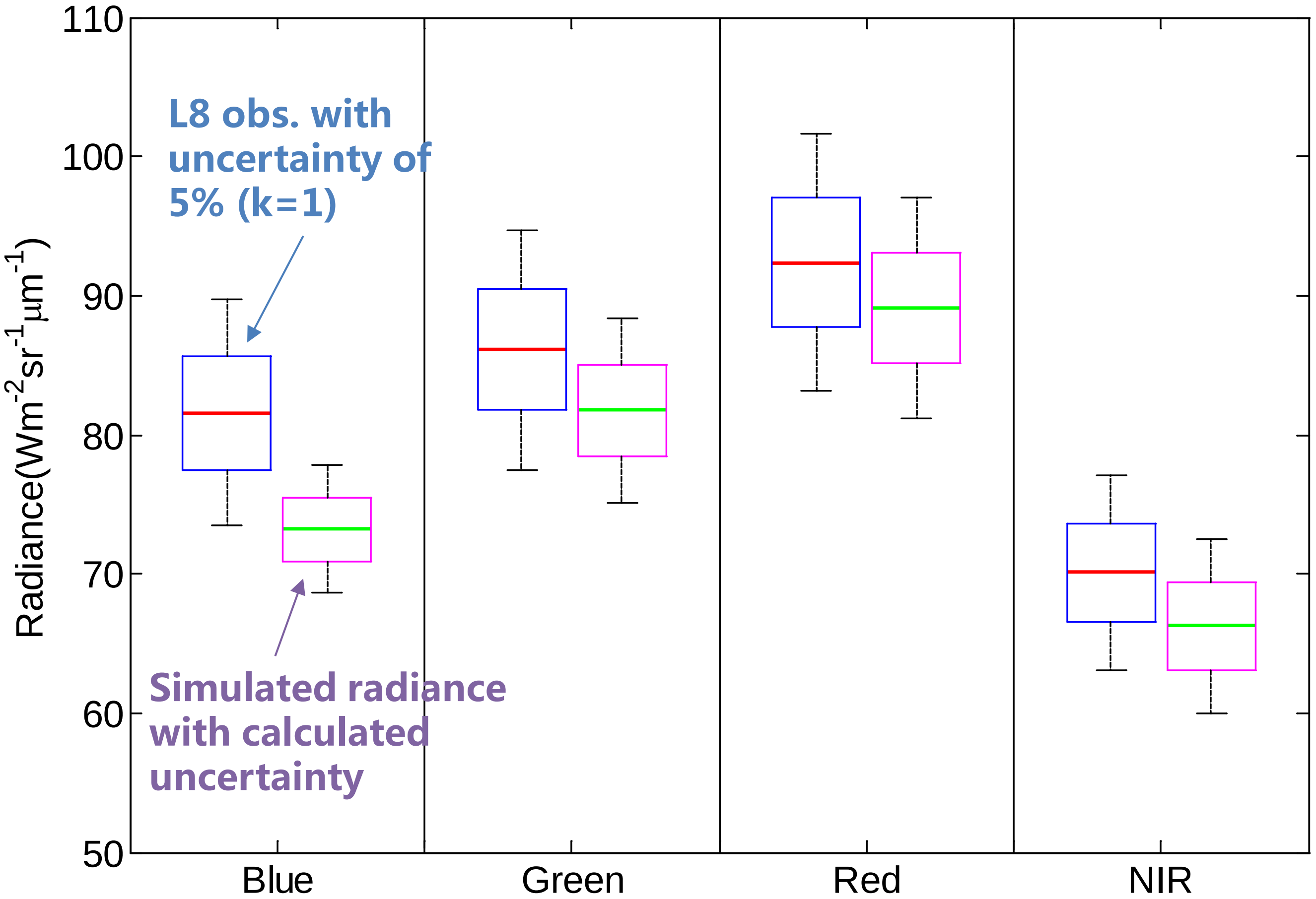
Uncertainty component		Associated uncertainty		Sensitivity coefficient	Uncertainty associated with L_{toa} due to this			
		absolute	relative		Blue	Green	Red	NIR
Instrument	Calibration	——	4%	1	2.415%	3.304%	3.683%	3.894%
	Repeatability	——		1	0.017%	0.015%	0.013%	0.033%
Target	Uniformity	——	2.17%	1	1.310%	1.793%	1.998%	2.112%
	BRDF	——	~1.5%	1	0.905%	1.239%	1.381%	1.460%
Atmospheric	AOD	——	5.5%	1	0.113%	0.055%	0.023%	0.004%
	CWV	——	10%	1	0.005%	0.011%	0.018%	0.004%
	Solar irradiance	——	1%	1	0.396%	0.174%	0.079%	0.027%
Model	MODTRAN	Transmittance ±0.005	Radiance ±2%	1	1.122%	0.804%	0.646%	0.548%
	Simplified RTE	——		1	0.022%	0.067%	0.113%	0.011%
Total uncertainty					**3.130%**	**4.044%**	**4.461%**	**4.696%**

Results of Cal&Val Campaigns

➢ Case1. Radiometric calibration in an automated mode

- **3. Uncertainty analysis of automated radiometric calibration**

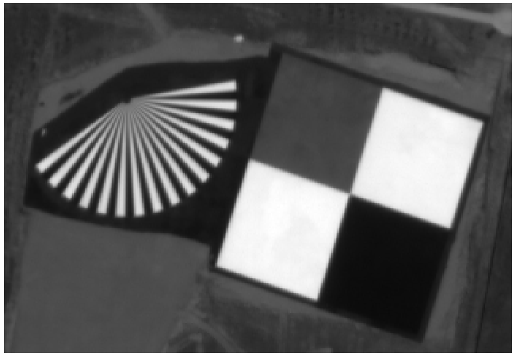
The calculated radiance is consistent with Landsat 8 observations, but more bias can be found in blue band.
More comparison results are needed to achieve reliable conclusion.



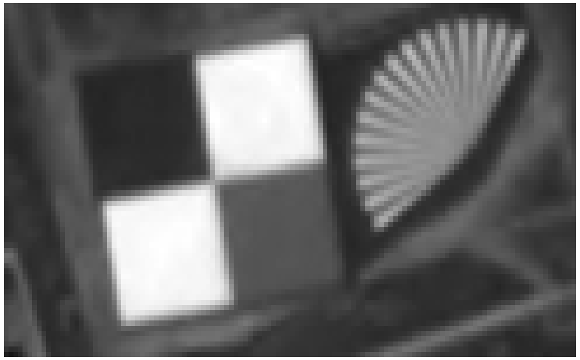
Results of Cal&Val Campaigns

➢ Case 3. Performance assessment for high-resolution optical sensors

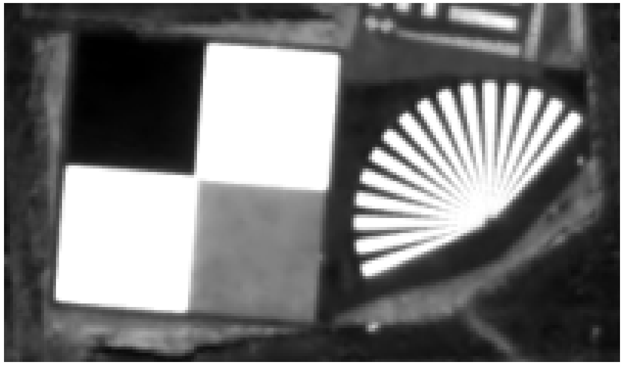
- **MTF**



KOMPSAT-3 panchromatic image



GF-1 panchromatic image
View zenith angle: 1.7º



GF-2 panchromatic image
View zenith angle: 8.86º

KOMPSAT (2014/8/14)	AOE's results	KARI's results
Along track	0.083	0.091
Cross track	0.105	0.106

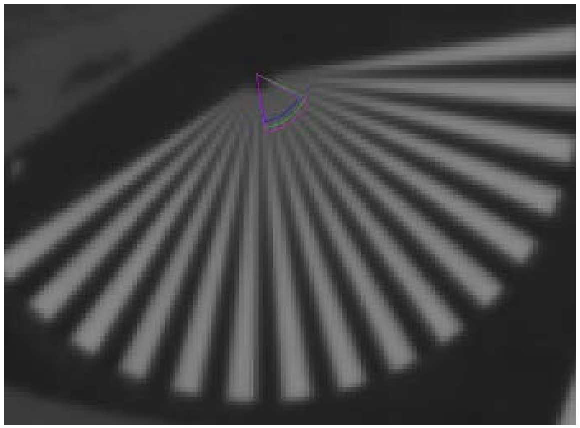
	GF-1 (2013/11/4)	GF-2 (2014/ 10/13)
Along track	0.0217	0.0722
Cross track	0.0467	0.0933

An improved "knife-edge" method was used, which has three aspects of improvements on the ISO 12233 method :

- **The use of the Fermi function for edge detection.**
- **Filter the ESF curves using S-G filter for noise suppression.**
- **Process LSF curve with Hamming window for avoiding spectral leakage and making more LSF central symmetry.**

➢ Case 3. Performance assessment for high-resolution optical sensors

- **Spatial resolution**

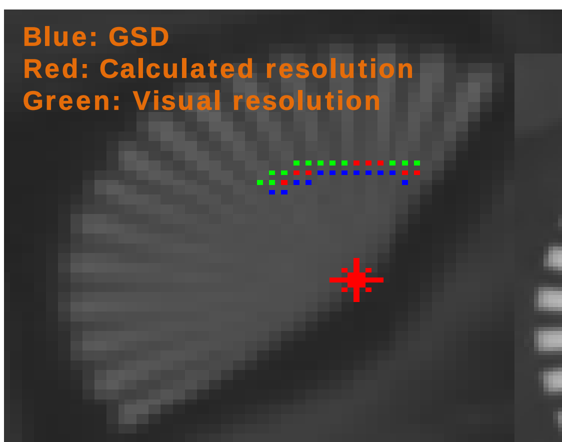


KOMPSAT-3 panchromatic image on August 14, 2014

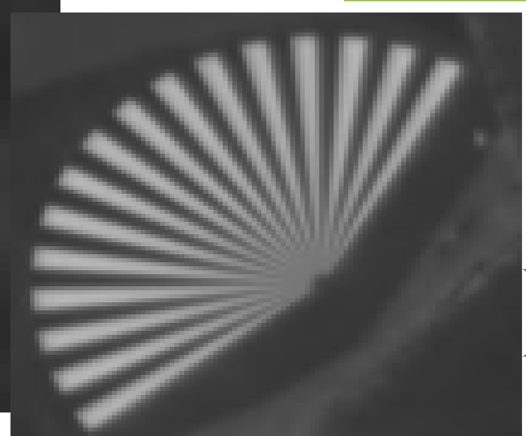
Automated detection algorithm for calculating resolution:

- Take the maximum radius of the target as a reference radius r_2.
- Select an area containing 5 white segments .
- Detect the number of white segment for a certain radius r< r_2 when DN differences between white and black segment<5, and the limited radius r_0 is acquire when number of white segment <4.
- Calculated resolution= r_0*φ (where φ is the angle of each segment).

	KOMPSAT-3(2014/8/14)
GSD	0.7m
Calculated resolution	0.79m
Visual resolution	0.73m



GF-1 panchromatic image View zenith angle: 1.7º



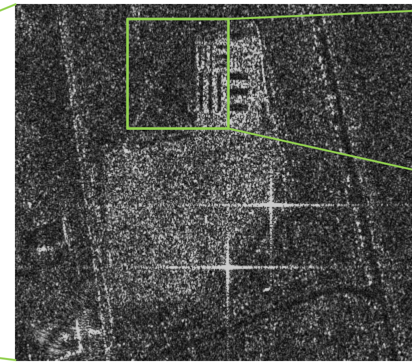
GF-2 panchromatic image View zenith angle: 8.86º

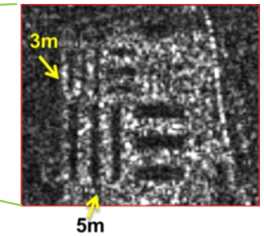
	GF-1 (2013/11/4)	GF-2 (2014/10/13)
GSD	2m	1m
Calculated resolution	2.16 m	1.13m
Visual resolution	2.22m	1.05m

➢ Case 4. Image quality assessment for KOMPSAT-5 SAR

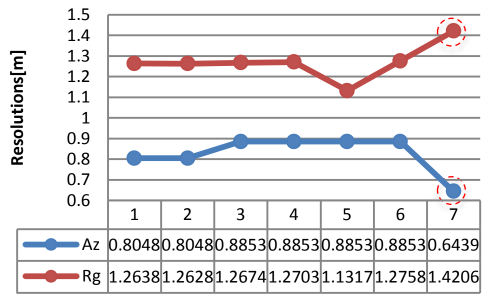
KOMPSAT-5 SAR image on October 22, 2014(HH)

Azimuth





The "image resolution" is better than 3m.



	1	2	3	4	5	6	7
Az	0.8048	0.8048	0.8853	0.8853	0.8853	0.8853	0.6439
Rg	1.2638	1.2628	1.2674	1.2703	1.1317	1.2758	1.4206

Nominal resolution:

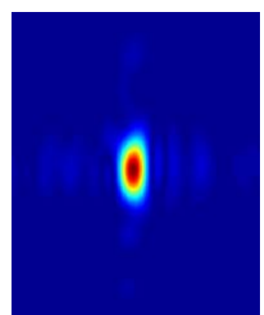
- Ground range instrument geometric resolution:1.21m
- Azimuth instrument geometric resolution: 0.90m

The resolution assessment results of the seven CRs are consist with each other except CR#7. The image of CR#7 is not a ideal point response image.

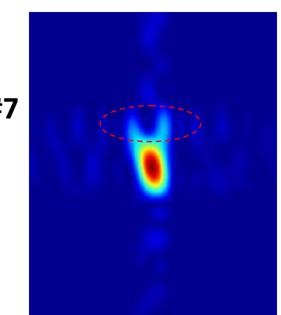
Corner reflector

SAR image

CR #1



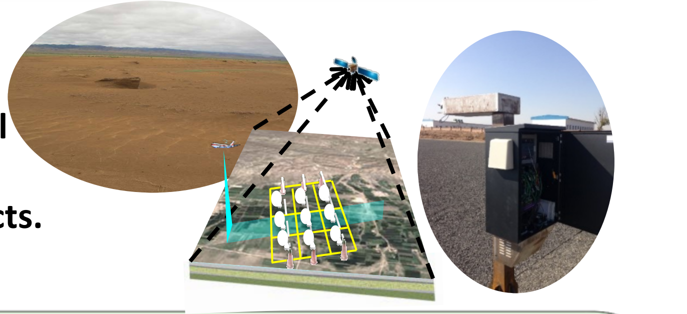
CR #7



Way Forward

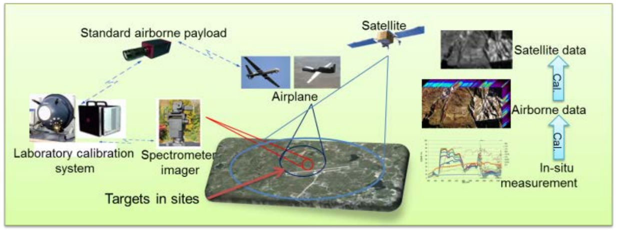
1. Strengthen the capability to support long-term calibration operation

- Improve auto-observation/calibration system to provide precise Cal&Val service in an operational way.
- Introduce more large-area natural scenes to improve the Cal&Val function for the moderate/coarse resolution sensors.
- Expand the functions on the validation of remote sensing products.



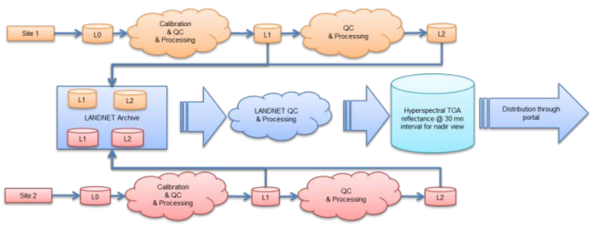
2. Upgrade consistent traceable approach for quality control

- Complete the development of VNIR, SWIR and TIR hyperspectral imagers.
- Study on the temporal, spatial, spectral and viewing angle matching technologies, decreasing significant scaling bias.
- Characterize the uncertainties and perform quality controlling in the whole benchmark transfer chain.



3. Offer contribution to the “global calibration” of EO through RADCALNET

- Participate the RADCALNET activities, including the inter-calibration of the instrument, technique support for making guidelines or standards, and collaboration with other networks, so as to demonstrate the feasibility of the concept for “global calibration” traceable to SI.
- Promote RADCALNET to be an operational network used for calibration, intercalibration and validation for the benefit of GEOSS.



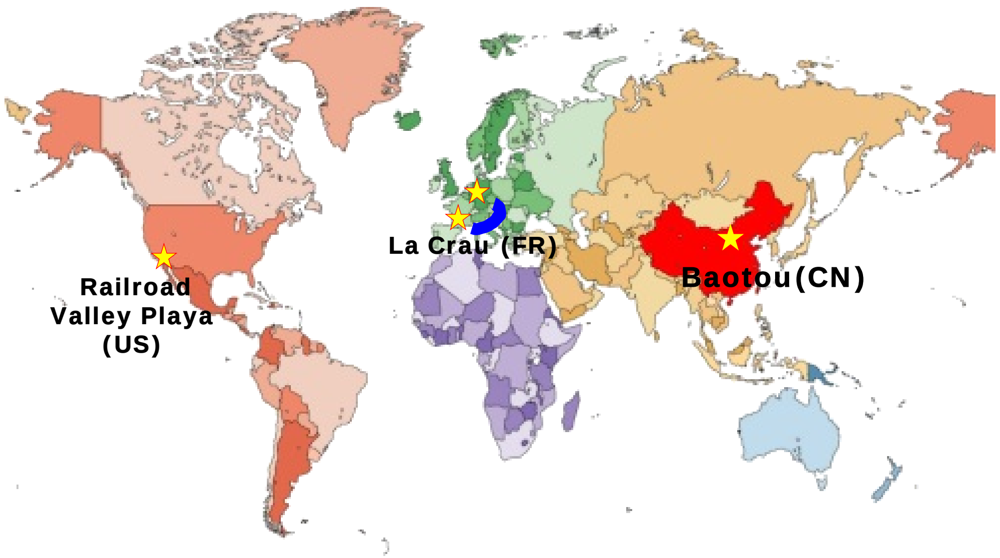

Thank you !

3. High-frequency automated radiometric calibration for RadCalNet

Aims at an prototype of "global calibration" traceable to SI, CEOS/WGCV/IVOS WG agreed to set up the RADCALNET (Radiometric Calibration Network of Automated Instruments). Three RADCALNET WG meetings have took place.

- **Four sites provide data to RADCALNET:**
  - ✓ **AOE Baotou site (China)**
  - ✓ **La Crau site(France)**
  - ✓ **Railroad Valley Playa site (US)**
  - ✓ **ESA Site TBD (ESA/CNES)**

- **NPL (UK) provides support in harmonization, traceability, instrument calibration**



4. Comprehensive Cal&Val site

Baotou site

Support stringent aviation flight testing, radiometric calibration and in-orbit performance assessments for spaceborne optical / SAR payloads, Support remote sensing product validation.

Comprehensive

Radiometric calibration

Geometric calibration

Product Validation

Image quality assessment