Baotou instrumented desert site

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November 18, 2015 Toulouse , France

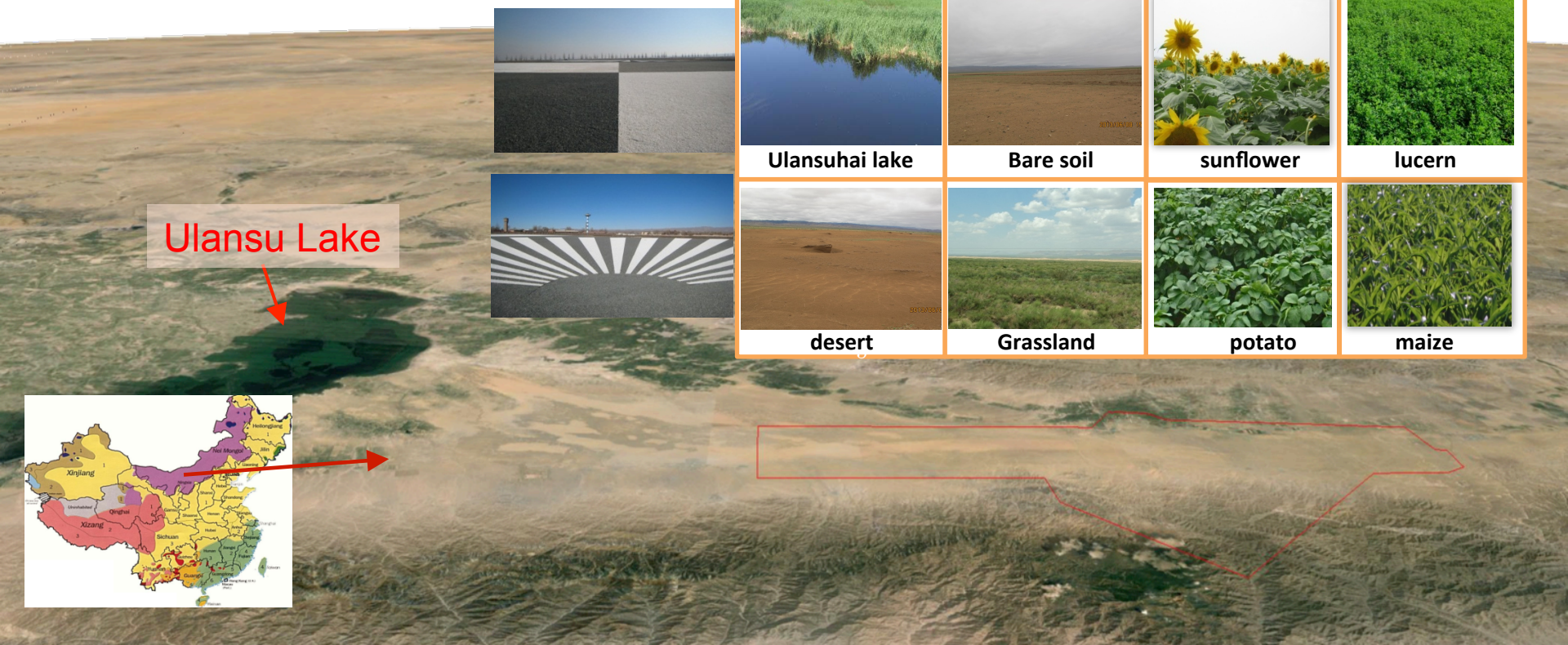
Outline

- **Goals of the instrumented desert site**
- **Surface construction and characteristics analysis**
- **Development of automated hyperspectral radiance measurement system**
- **Case of satellite calibration**
- **Future works**

Background

- Located in Inner Mongolia, China, 50km away from Baotou city.
- A flat area of approximately 300km^2, about 1270m above sea level.
- Except for the permanent artificial targets which focused on the high-resolution satellite, there are different land covers (desert, bare soil, grass, lake, various cropland).

Site overview:



Background

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

Cimel CE318 (One of AERONET sites)

Control & data collecting center

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

Due to the limited size, the permanent artificial targets are not suitable for the satellite with resolution lower than 10m.

GF-2 (11 Jul., 2015)

ZY-3 (12 Sep., 2015)

Worldview-3 (27 Oct., 2015)

ZY-02C (28 Mar., 2015)

SPOT-5 (13 Sep., 2015)

GF-1 (8 Jun., 2015)

Goals of the instrumented desert field

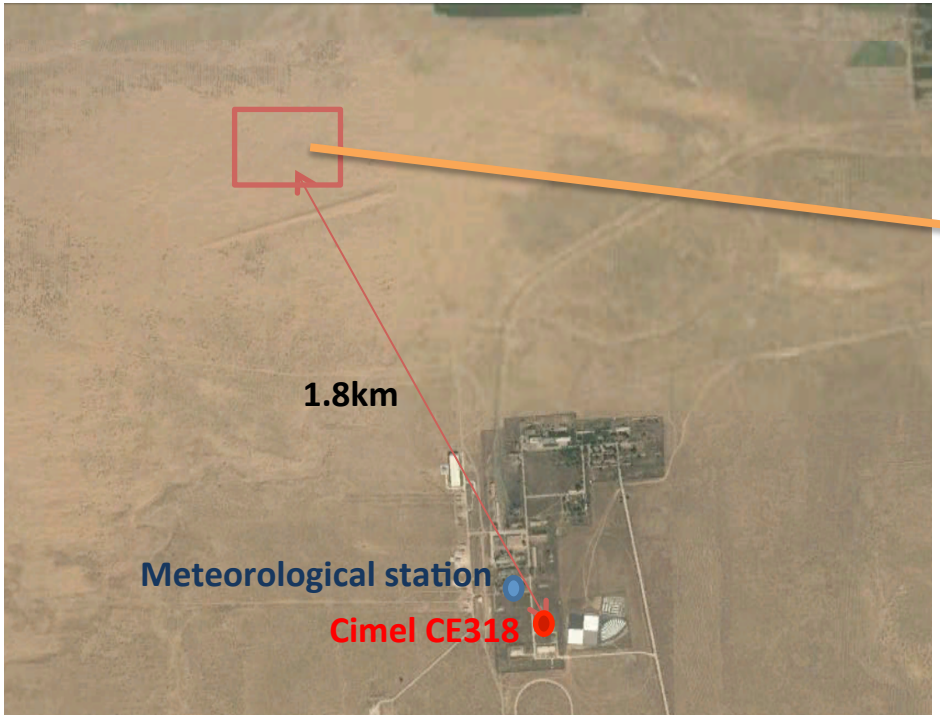
An instrumented desert field was established aiming at:

- The automated vicarious calibration of moderate/high resolution satellite sensors;
- Cross calibration between Chinese satellites and other international well-calibrated satellites;
- Calibration stability Monitoring for onboard optical sensors.

Surface construction and characteristics analysis

A desert area (1.89km^2) nearby the permanent artificial targets is selected using satellite image.

The atmospheric parameters from sunphotometer (AERONET site name: AOE_Baotou) deployed nearby permanent artificial targets can still be used in this desert field.



The site is relatively flat but still with slightly terrain fluctuation.

Surface construction and characteristics analysis

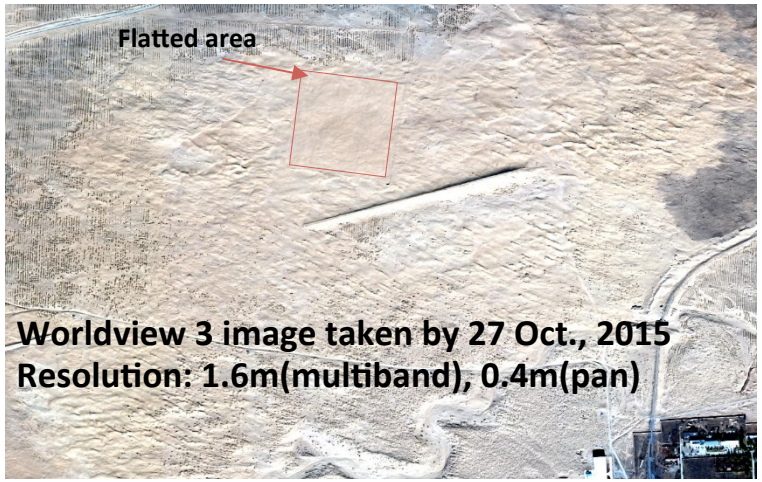
A 300m×300m sub-area has been flattened by machine in this October.

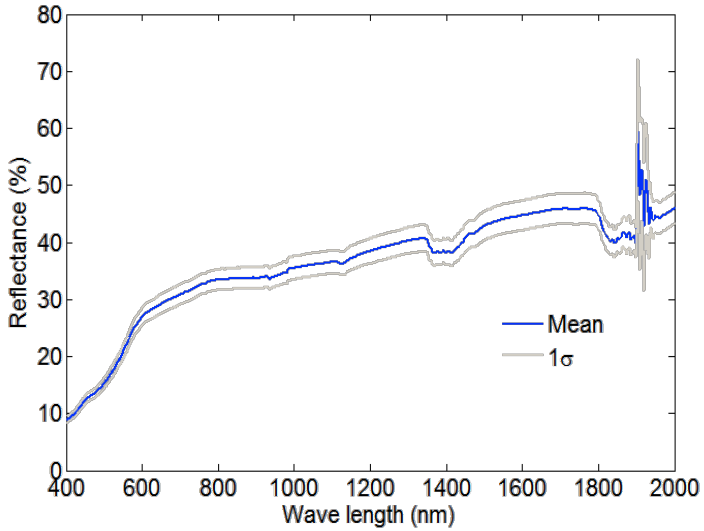
Taken on 23 Oct., 2015

Surface construction and characteristics analysis

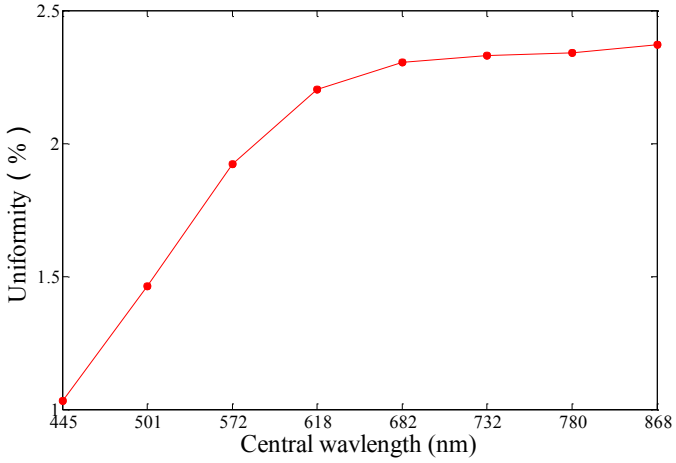
The surface uniformity:

- The in-situ measurements (127 samples) show that the uniformity of the surface is 2%~3% in reflective solar wavelength;
- From the high-resolution satellite image (Worldview-3 panchromatic band), the spatial heterogeneity is between 1% and 2% in blue and green bands, and is less than 2.5% from 618nm to 868nm.





Surface reflectance spectrum measurement

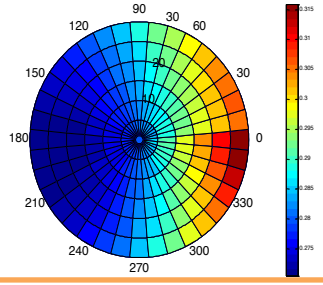


Surface construction and characteristics analysis

The surface anisotropy:

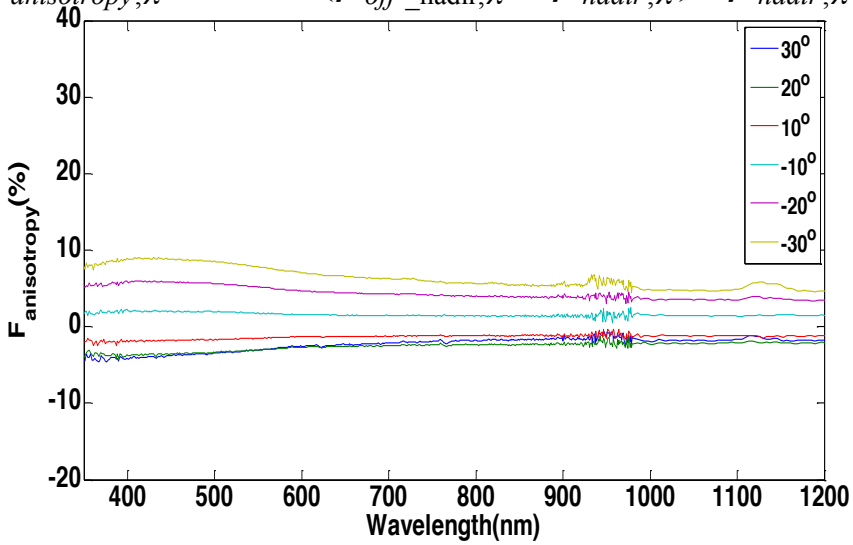
- The anisotropy between the nadir and off-nadir observation is less than 1.5% within a viewing zenith angle of 10°;
- In cloud-free days, the BRF was measured from 9:30 to 13:00. The solar zenith angle changes from 19° to 35°during this period generally. The viewing zenith angle is from 0°to 30°with a step of 5°. The viewing azimuth angle is from -180°to 180 °with a step of 45°.

In situ measurement of desert BRF with AOE multi-angle measurement system and SVC field spectrometer



BRDF model SZA=30°@ 650nm

$$F_{anisotropy,\lambda} = 100 * (\rho_{off\_nadir,\lambda} - \rho_{nadir,\lambda}) / \rho_{nadir,\lambda}$$

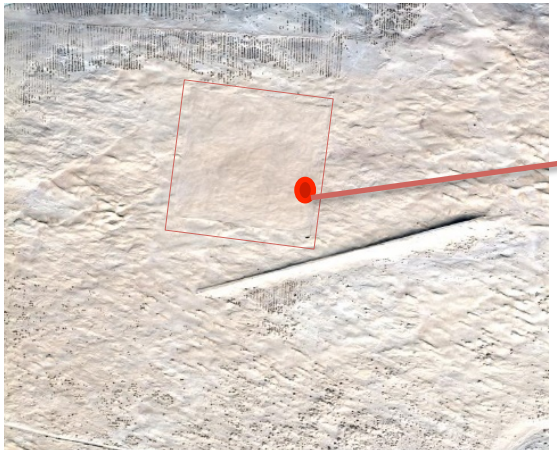


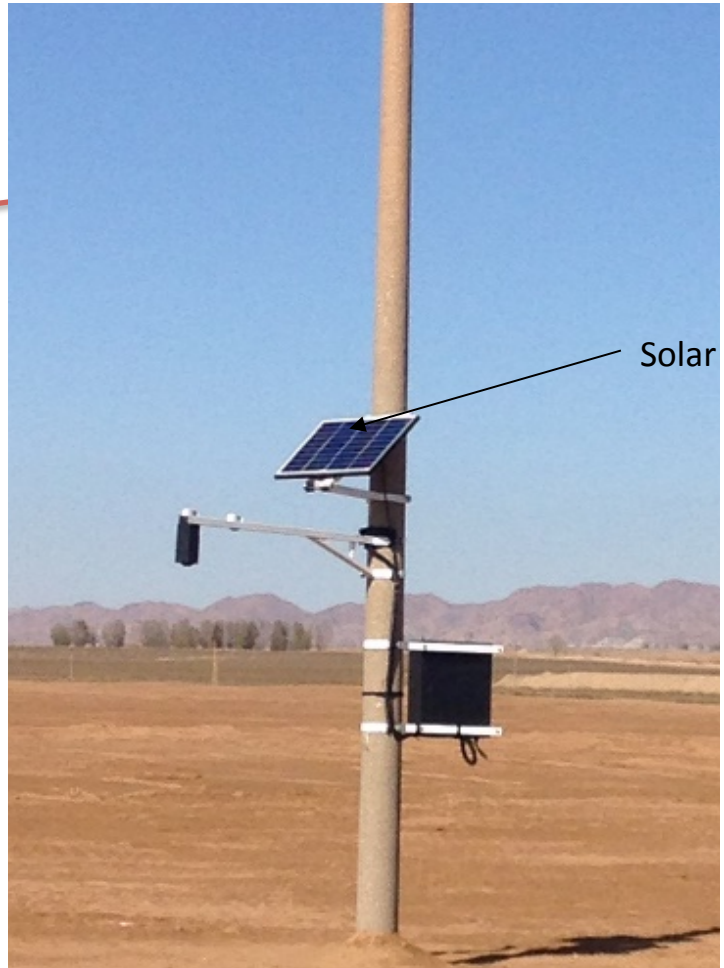
Anisotropy factors in principle plane @ 550nm

Backward	10°	20°	30°
Sand	1.7%	5.2%	7.8%
Forward	10°	20°	30°
Sand	-1.5%	-3.1%	-3.2%

Development of automated hyperspectral radiance measurement system

An prototype of automated surface hyperspectral reflectance measurement system was deployed in the field on 21 October, 2015. And the first prototype is located on the east of the 300m×300m flat area.
This system measure the surface every 2min, from local time 8:00 to 18:00.



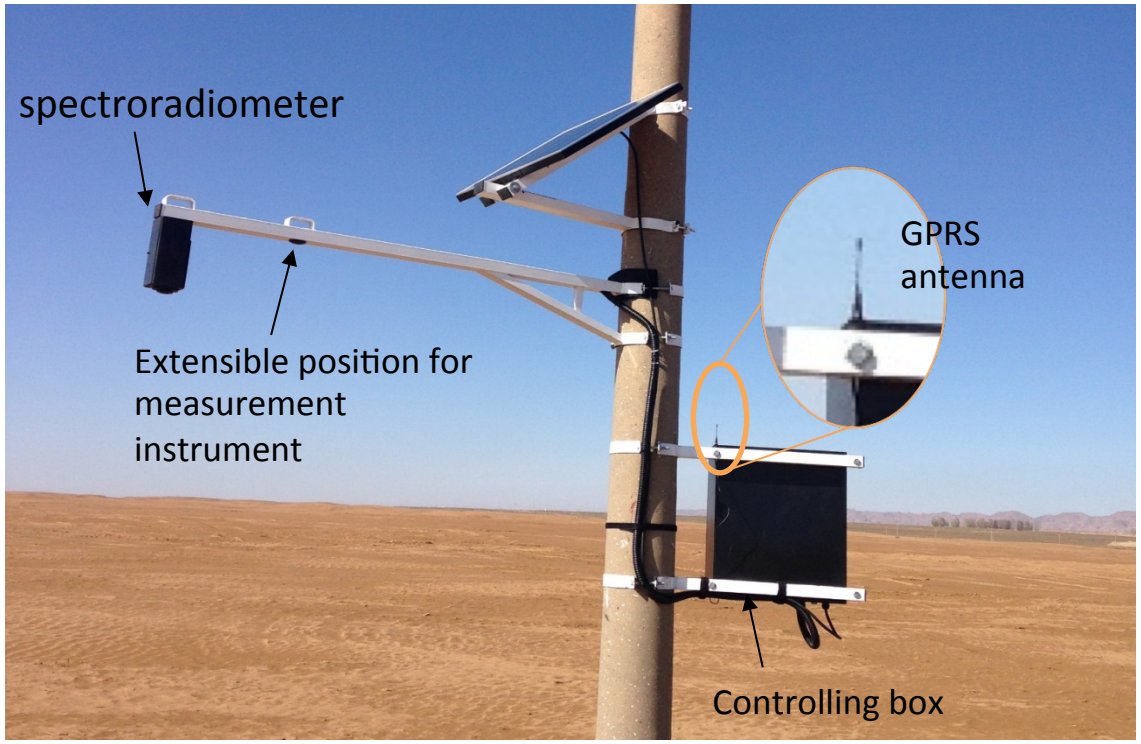


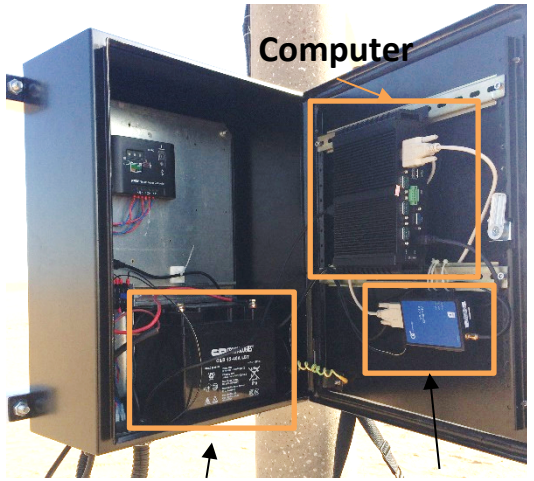
- Height of the spectrometer installation: 2m
- Length of the arm: 1.5m
- A solar panel and a battery to provide the power (continuously working more than 36h with the battery fully charged)

Development of automated hyperspectral radiance measurement system

- ✓ Main instrument: CR 280 spectroradiometer (Colorimetry Research, Inc.)
  - Spectral range: 380nm – 1080nm
  - Band No.: 351
  - FOV：3°
  - Footprint: 0.1m (diameter)
  - Calibration accuracy (traced to NIST): 2%(k=1)

CR spectroradiometer

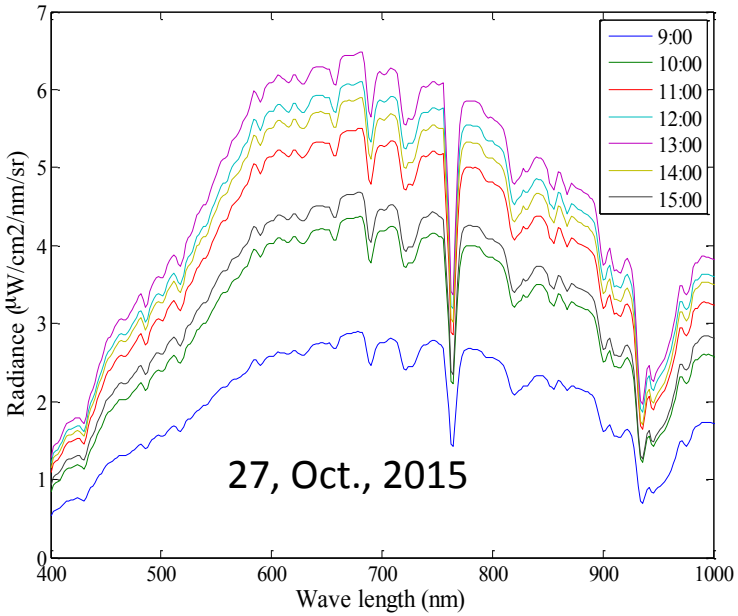




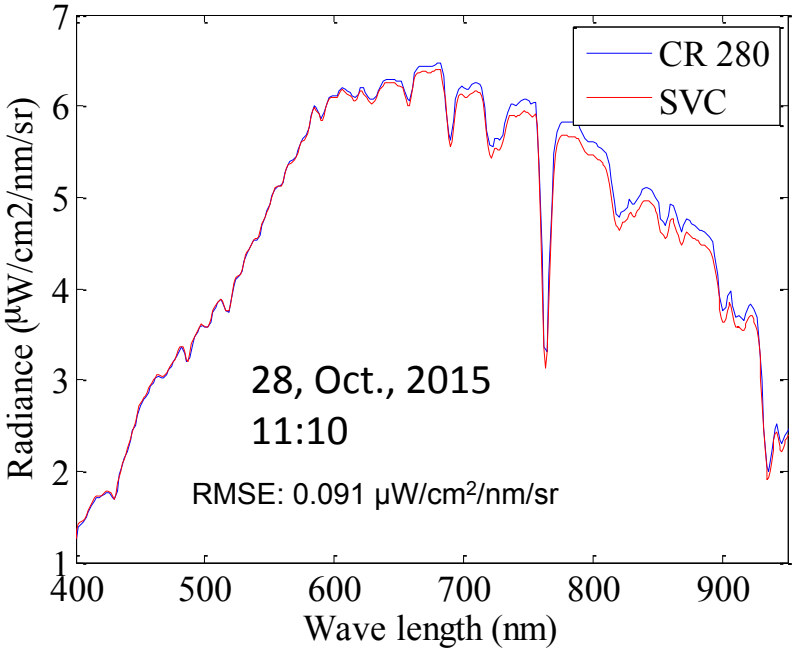
Controlling box

Development of automated hyperspectral radiance measurement system

From 25 Oct., 2015, this system is operationally tested. It suffered from a continues 4 rainy and cloudy days from 7 NOV., 2015. The system was shut down during that time because of no power, but it was automatically restarted on 12 NOV., 2015.



Time series spectrum measurements



CR 280 observation
V.S.
SVC measurements at fixed point close to CR

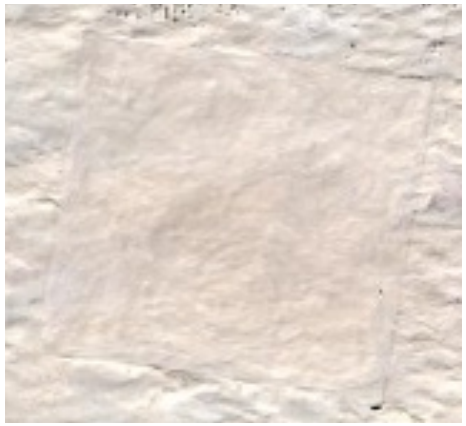
z

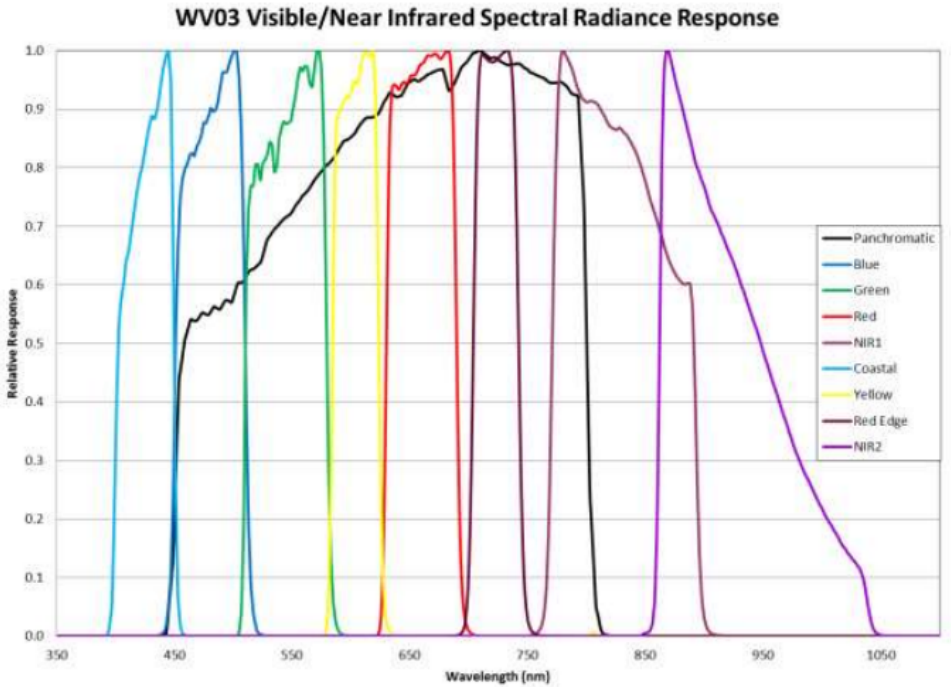
Oct 30, 2015

Case of satellite calibration

- **Calibration and analysis for Worldview 3 image**

There are totally 8 multispectral bands and 1 panchromatic band in the acquired WorldView-3 image. The spatial resolution of pan band is 0.4m, of multispectral band is 1.6m.





Acquisition date	October 27, 2015
Acquisition time	03:41:48 UTC
SAA (°)	166.7
SZA(°)	54.3
VAA (°)	103.9
VZA(°)	12.3

Atmospheric parameters when the image acquired

AOD	0.0809
Column water vapour	0.732

Case of satellite calibration

Simulation of TOA radiance based on ground reflected spectral radiance measurement

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

Atmospheric radiative transfer model (MODTRAN)

Assuming surface ref. is 0

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

A improved radiance-based method to calculate TOA radiance

Automated measured parameters

Ground reflected spectral radiance

BRDF correction

Radiative transfer equation calculation

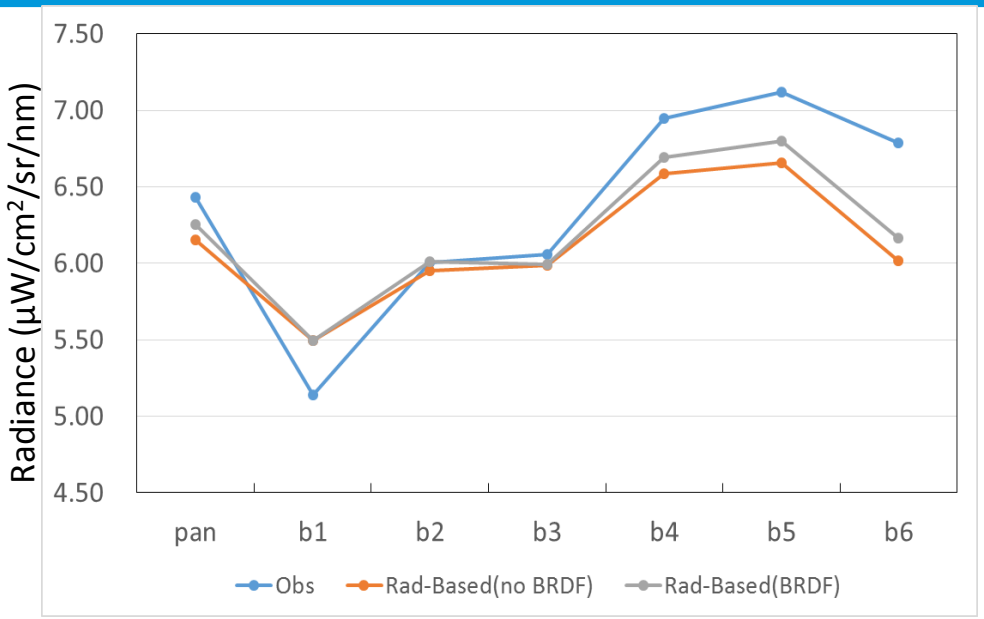
TOA radiance — Ground reflected radiance

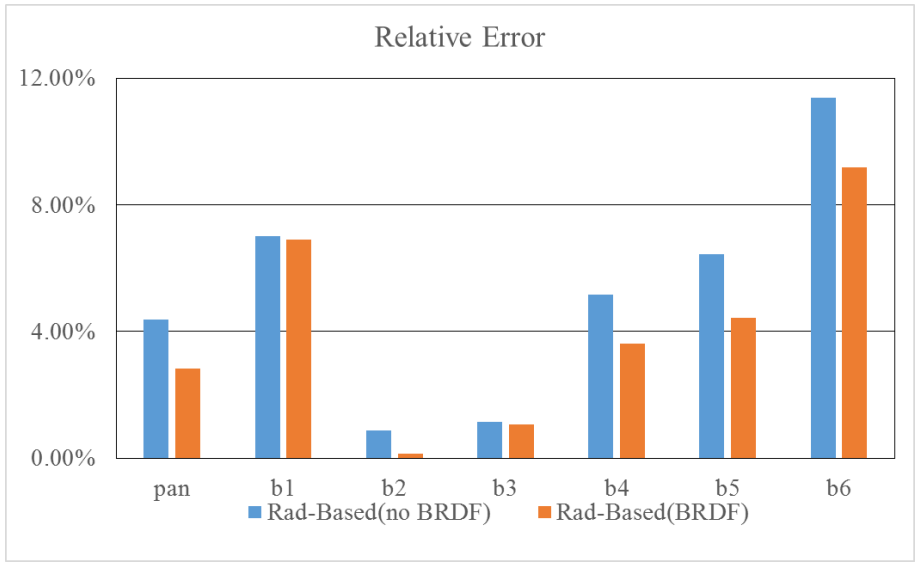
$$L_{TOA} = L_{path} + L^{\uparrow} \cdot T(\theta_v)$$

Path radiance — Total transmittance from ground to sensor

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

Case of satellite calibration





		pan	b1	b2	b3	b4	b5	b6
In-band radiance (μW/cm²/sr/nm)	Obs	6.43	5.14	6.00	6.06	6.94	7.12	6.79
	Rad-Based(no BRDF)	6.15	5.50	5.95	5.99	6.59	6.66	6.02
	Rad-Based(BRDF)	6.25	5.49	6.01	5.99	6.69	6.80	6.17
Relative error	Rad-Based(no BRDF)	4.37%	7.00%	0.88%	1.14%	5.16%	6.44%	11.37%
	Rad-Based(BRDF)	2.82%	6.89%	0.14%	1.05%	3.63%	4.43%	9.18%

The results suggest that the relative errors turn smaller between simulated and observed TOA radiance after being BRDF corrected except for band6, maybe due to low SNR of measured ground reflected radiance.

Future works

- **To monitor the characteristics of desert site**, e.g., analysis of the uniformity of the whole desert area with satellite data, and to conduct the maintenance when it is quite necessary. It will also provide us important information for the uncertainty analysis.
- **To improve and enhance the function of automated measurement system**:
  - Install more systems over the sand site (at least four suits).
  - Add the SWIR spectrometer and thermal radiometer into the system, so it can acquire the infrared information;
  - Enhance the operational reliability of the system, such as strengthening the instrument protection capability;
  - Try to add a spectroradiometer for observing the sky vertically with a cosine corrector to directly obtain the downwelling irradiance
- **To improve the data processing procedure and uncertainty analysis**, so as to be satisfied with RadCalNet requirement.