Radiometric calibration for ASTER-VNIR and HISUI in AIST

Koki Iwao, GSJ, AIST
on behalf of
AIST members for the Radiometric Calibration

AIST

National Institute of Advanced Industrial Science and Technology

CEOS WGCV-41

Sept 05, 2016 Tokyo

QA4EO
Antalya 2009, Harwell 2011

AIST Profile

AIST is a public research institute. Its origin is the Geological Survey of Japan, the Ministry of Agriculture and Commerce, established in 1882.

In 2001, fifteen research institutions of the Agency of Industrial Science and Technology, MITI, and Weights and Measures Training Institute were integrated into AIST.

Ministry of International Trade and Industry (MITI)

Agency of Industrial Science and Technology

- Hokkaido National Industrial Research Institute
- Tohoku National Industrial Research Institute
- National Institute for Advanced Interdisciplinary Research
- National Research Laboratory of Metrology
- Mechanical Engineering Laboratory
- National Institute of Materials and Chemical Research
- National Institute of Bioscience and Human-Technology
- Electrotechnical Laboratory
- Geological Survey of Japan
- National Institute for Resources and Environment
- National Industrial Research Institute of Nagoya
- Osaka National Research Institute
- Chugoku National Industrial Research Institute
- Shikoku National Industrial Research Institute
- Kyushu National Industrial Research Institute
- Weights and Measures Training Institute (MITI)

National Institute of Advanced Industrial Science and Technology (AIST)

Employees : 2929 including 2255 researchers (July 2014)

Research subjects and the cooperation in AIST on RS/GIS

技術を社会へ
Integration for Innovation

GSJ

EMTech

Environmental Management

AIRC

Artificial Intelligence

NMIJ

Metrology

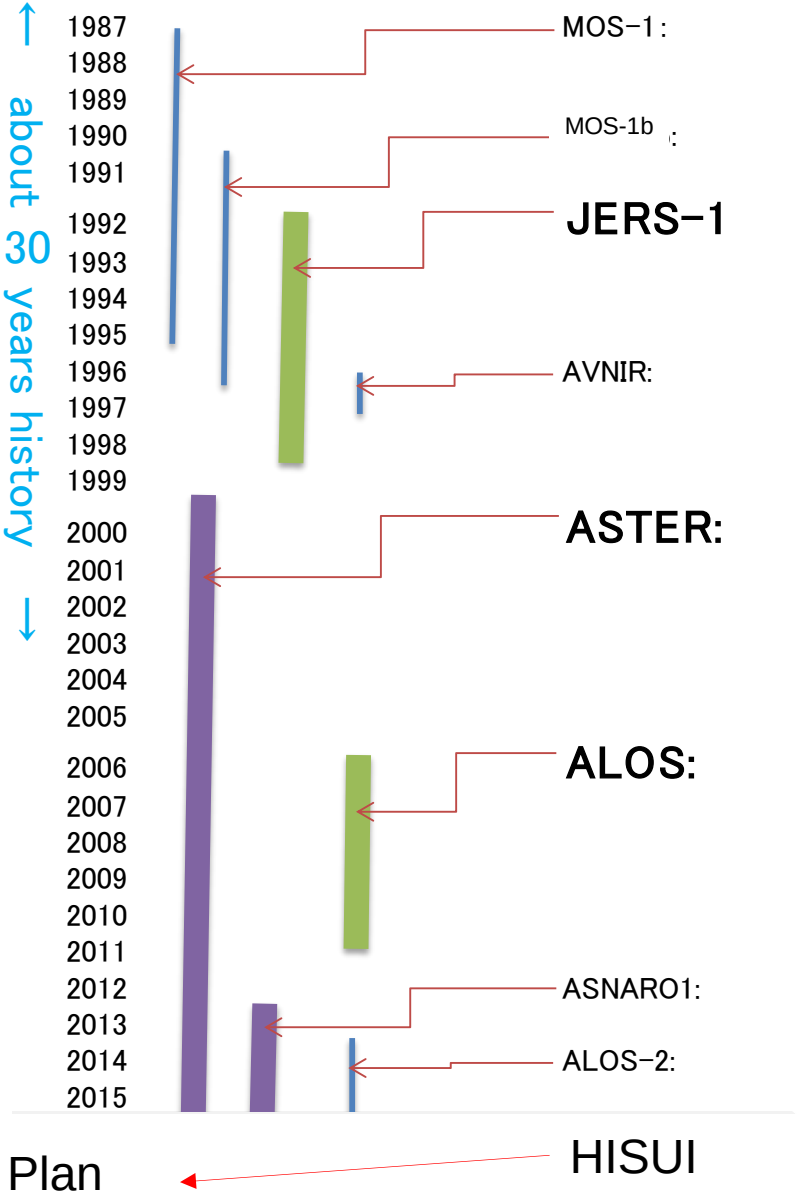
Data distribution

Cartography

Sensor accuracy

Sensor development

History of EO sensor development in JPN



High - moderate resolution

OPS/SAR by METI, onboard JERS-1

Developed by METI, onboard TERRA

PALSAR by METI, onboard ALOS

Developed by METI

Developed by METI onboard ISS

METI＝Ministry of Economy, Trade and Industry

AIST members for the Radiometric Calibration

- National Metrology Institute of Japan
  - **Pre-launch / Onboard** calibration
    - Juntaro Ishii, Yoshiro Yamada, Yu Yamaguchi
      (Former researchers :A. Ono and F. Sakuma)

- Geological Survey of Japan
  - **Vicarious / Cross / Inter-band calibration** for VNIR
    （/ Calibration Data Archive System）
    - Kenta Obata, Izumi Nagatani, Hirokazu Yamamoto, Satoshi Tsuchida

- Artificial Intelligence Research Center
  - **Lunar Calibration** (/ Vicarious calibration for TIR)
    - Toru Koyama, Soushi Kato

ASTER radiometric calibration

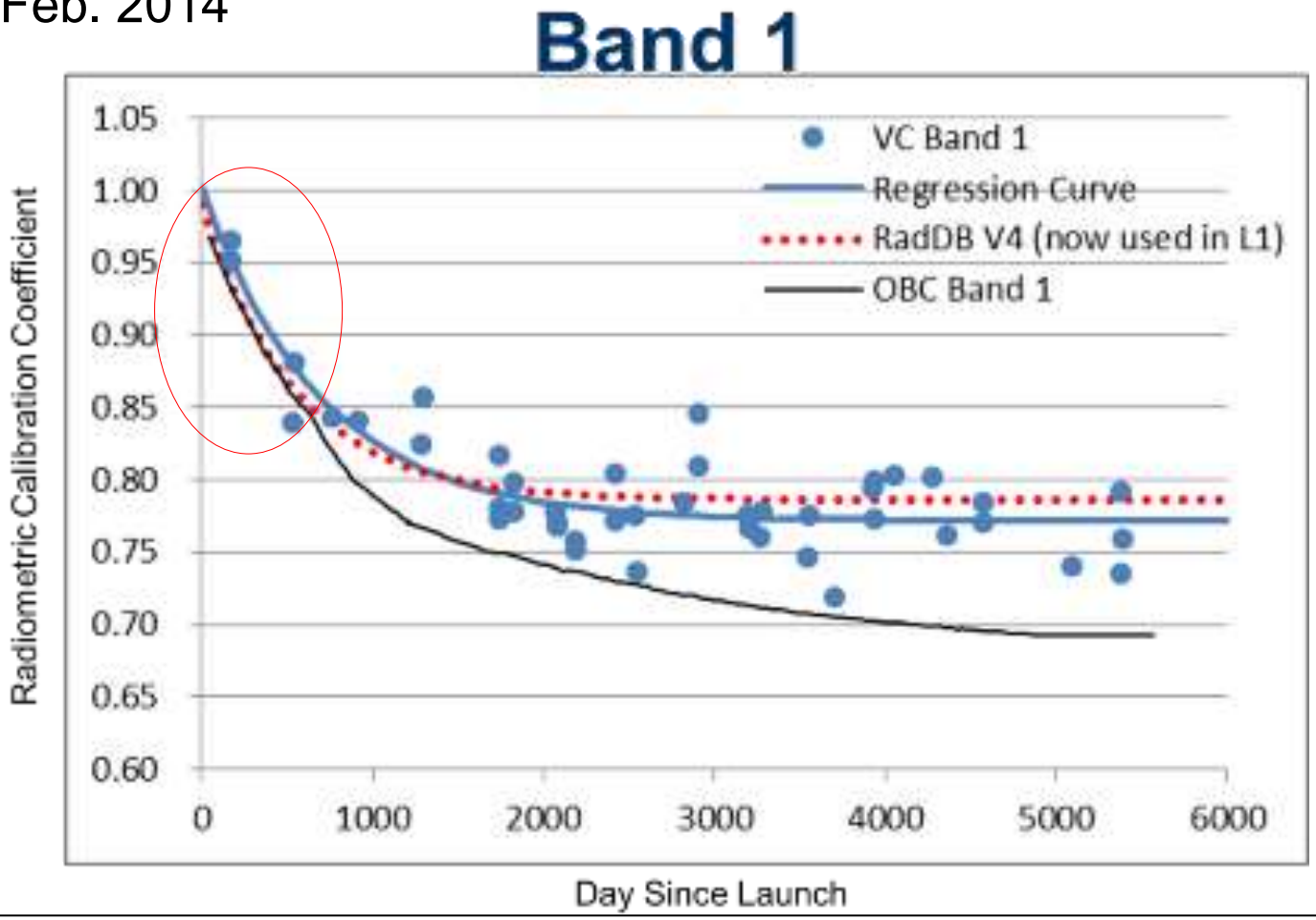
- ASTER is developed by Ministry of Economy, Trade and Industry (METI), Japan and is on TERRA satellite managed by NASA. About 3 million images have been archived covers globally. AIST has been involved in ASTER project from the development stage.
- The calibration WG in the US-Japan ASTER science team steer the radiometric calibration, and AIST plays a role in many parts in this WG.

- Recent topics by the AIST activities
  - VNIR degradation curve
    - From the onboard calibration base to vicarious calibration base
  - Lunar calibration activity
    - Opportunity of the second observation

vicarious and cross-calibration

ASTER VNIR degradation curve

- Band 1 and 2 used the onboard calibration until Feb. 2014, and switched from onboard calibration to vicarious and cross-calibration base in Feb. 2014



Lunar Calibration

- Updating our understanding of lunar reflectance

  ROLO (GIRO) model (Kieffer & Stone, 2005)

  SELENE/SP model (Yokota et al., 2011)
  SP: Spectral Profiler

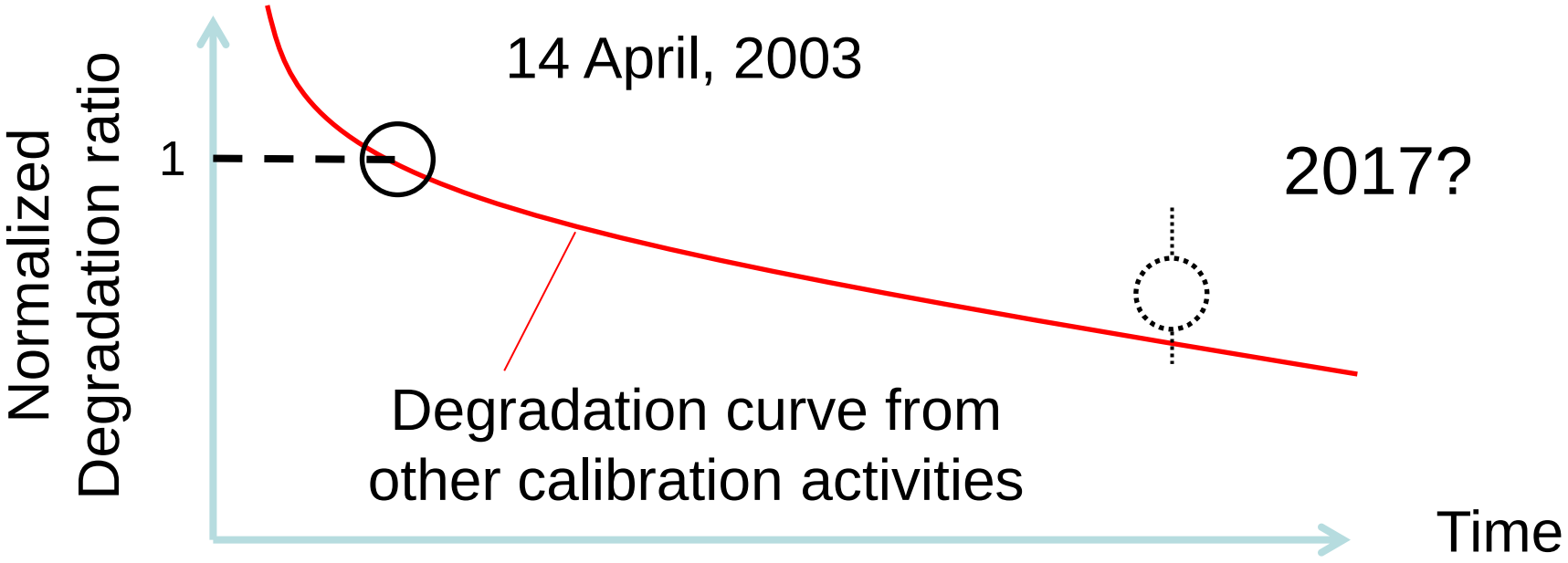
- more than 10 years since the last lunar observation

  Enough period for recognizing degradation of sensors

Now is a good timing to try the next lunar observation with ASTER (and other instruments)

We are proposing next lunar observation with ASTER in 2017.

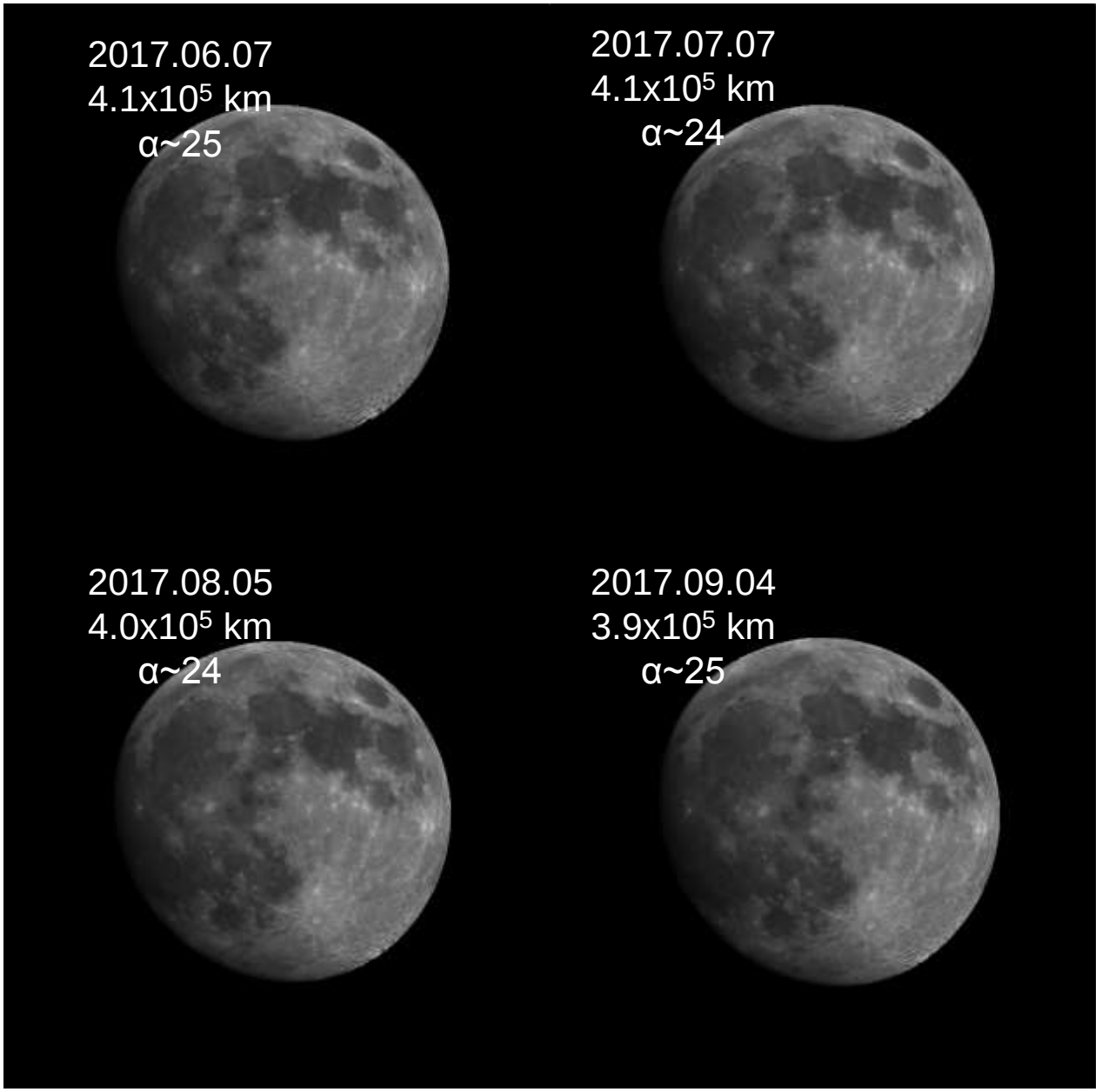
Benefit from second Lunar observation



Once we have two points of degradation, then we can compare lunar calibration results with other calibration results, such as the relative degradation curve from other calibration activities.

➡ Useful for other calibration activities


2003.04.14
3.7x10^5 km
α~27


2017.06.07
4.1x10^5 km
α~25
2017.07.07
4.1x10^5 km
α~24
2017.08.05
4.0x10^5 km
α~24
2017.09.04
3.9x10^5 km
α~25


Date: 2005 Sep 1 02:23:28 UT

HISUI hyperspectral imager

- HISUI hyperspectral imager is successor of ASTER and will be installed onto JEM-EF (Japanese Experimental Module Exposed Facility) in FY2018.

Onboard calibration unit

Telescope diameter ≈ 30 cm
Dimension = 1485(L) x 950(W) x 1380(H) mm
Mass = 168 kg
Two grating spectrometers for VNIR and SWIR

Specification of instrument

	VNIR	SWIR
Spectral coverage	400~970nm	900nm~2500nm
Number of band	57	128
Spectral resolution	10nm	12.5nm
Spatial resolution / Swath	20(CT)x30m(AT) / 20km	
Radiometric resolution	12bit	
SNR	>450@620nm	>300@2100nm
Radiometric calibration accuracy	Absolute: 5%, Interband: 2%	
Smile and Keystone	< 1 image pixel	
MTF	>0.2	
Dynamic range	Saturated at 70% albedo	
Pointing	Cross track: ±5°(TBD)	

HISUI Radiometric calibration and its Calibration Data Archive System

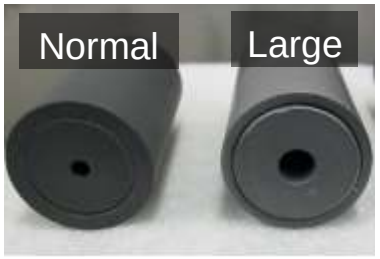
(from Obata et al, 2016)

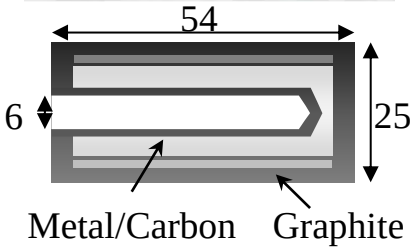
- Pre-launch calibration
  - Source-based calibration with blackbody radiation
  - Metal freezing point / Metal-Carbon eutectic point
  - Large-aperture blackbody cell
    - Pt-C:400-600nm, Cu:600-1500nm, Zn:1500-2500nm
- In-orbit calibration
  - Onboard calibration (using lamp and filters)
  - Vicarious calibration (using reflectance-based method)
  - Cross-calibration
  - *No lunar calibration*
- Calibration data archive system (CDAS)

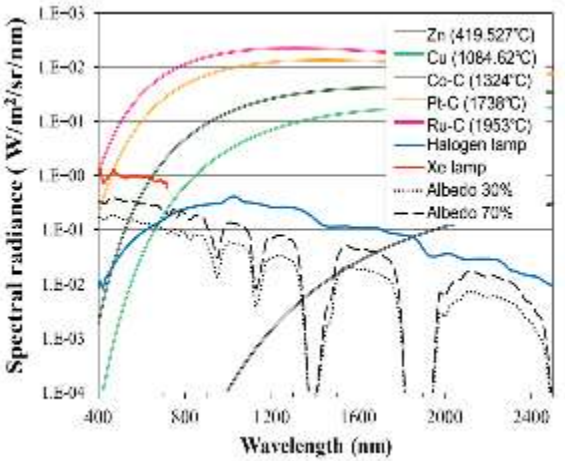
Pre-launch / Onboard calibration

◆ Pre-launch calibration

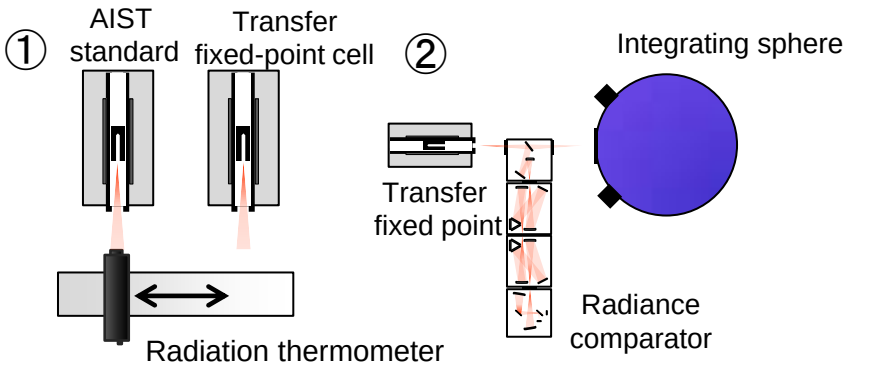
① Transfer standard calibration
② Integrating sphere calibration
③ Sensor calibration
④ Validation

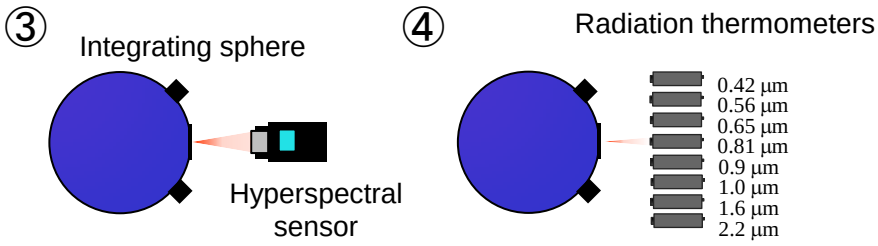






Spectral radiance of fixed-point blackbody





Prelaunch calibration

◆ Onboard calibration

- Lamp-based calibration unit
- 4 bandpass filters
  - Radiance temperature calculation of the lamp
- 1 wavelength filter
  - Absorption bands fitting

ISS HISUI vicarious calibration

- Observation frequency of the ISS HISUI will be limited to a few times over each calibration site in one year because of its orbital characteristics.

Manpower & Budget limitations

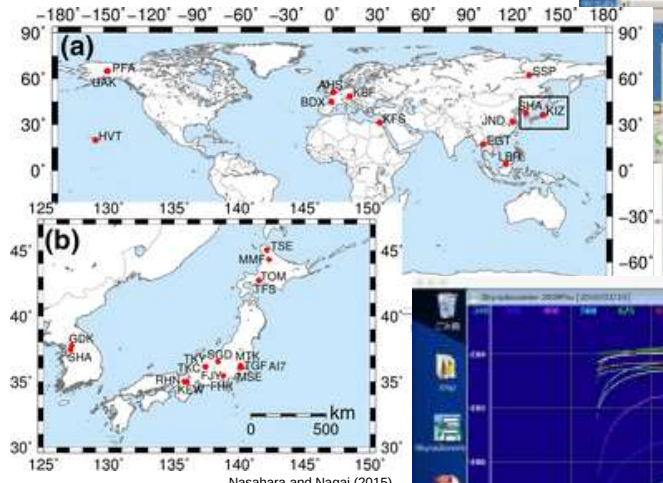
- We can travel to northern and southern hemispheres only once a year for a field campaign for the vicarious calibration, and conditions for ground and sky would **not be always suitable for the measurements.**

- To address the issue, we have started to discuss the use of the automated calibration facilities such as the radiometric calibration network of automated instruments.

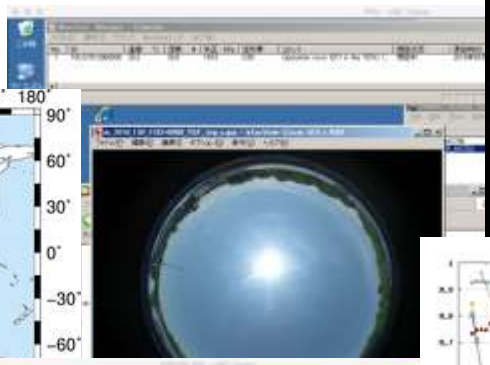
That is the RadCalNet.

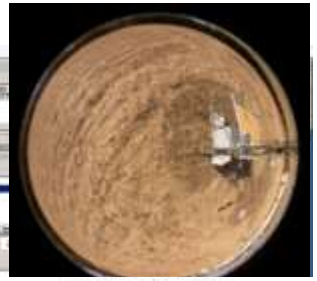
Core instruments in PEN

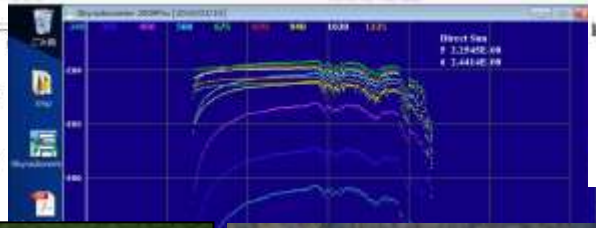
Automatic-capturing Digital Fisheye Camera (ADFC)
HemiSpherical Spectro-Radiometer (HSSR)
SunPhotometer (SP)



Nasahara and Nagai (2015)







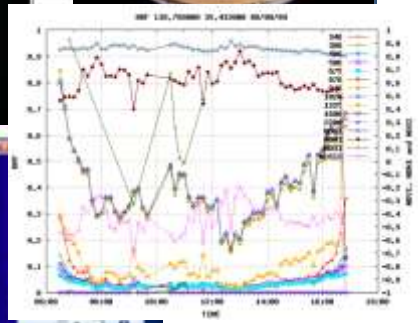
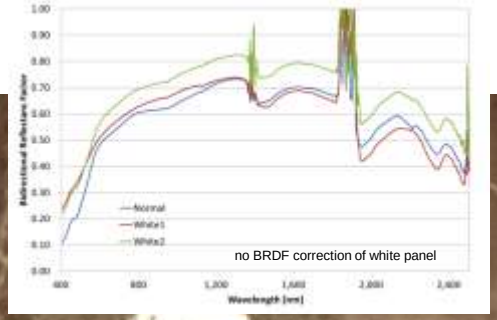
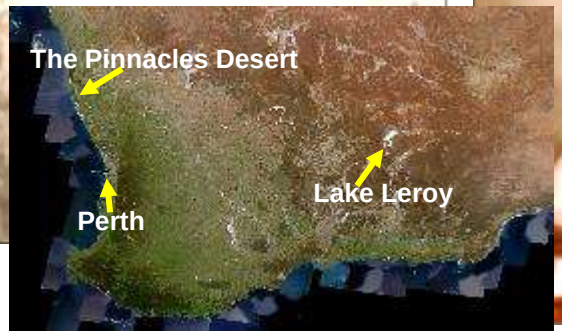


Photo from http://www.pheno-eye.org/

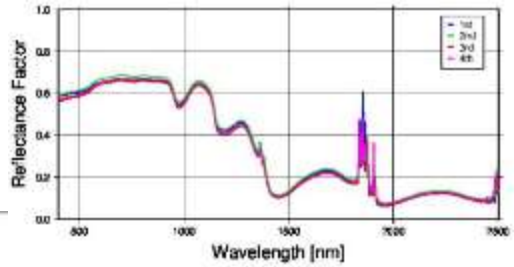
Candidate sites in Australia

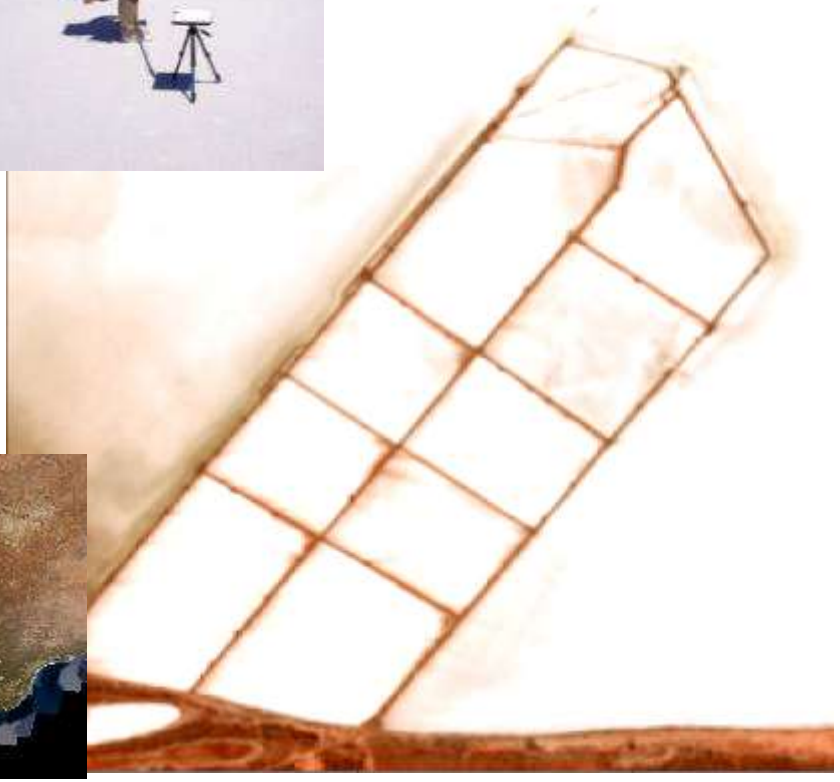
The Pinnacles Desert



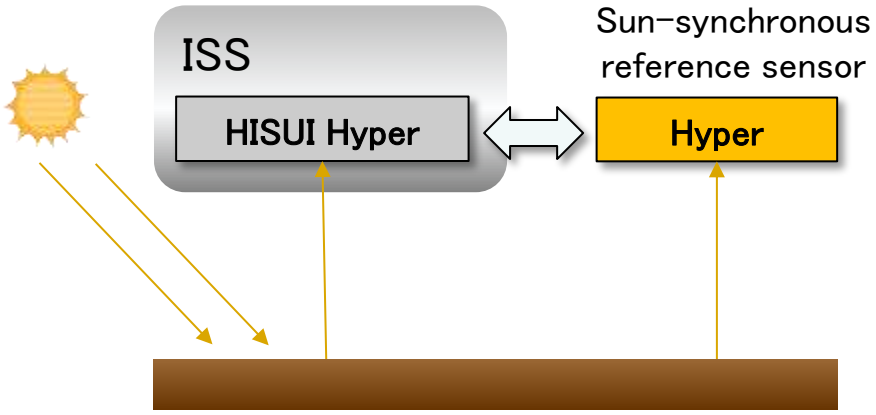


Lake Lefroy



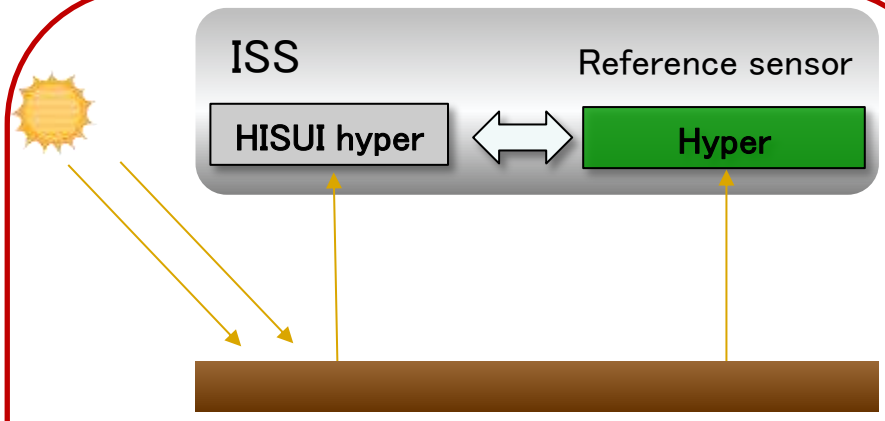


Cross-calibration for HISUI sensor



Characteristics:

- Pair of ISS and sun-synchronous orbits increases cross-calibration opportunity
- Effect of time difference
  - Atmospheric condition
  - BRDF
- Registration errors



Characteristics:

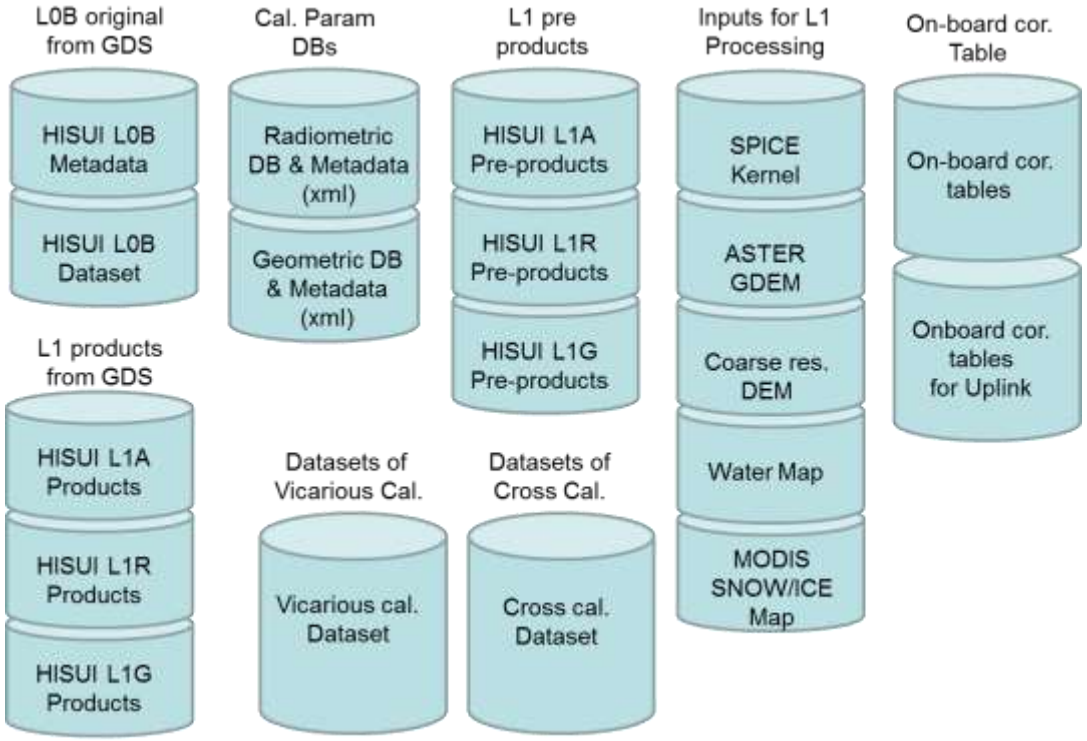
- No time difference effects
- Small registration errors
- Many datasets for cross-calibration from same platform

Candidates for test site:

- Dry lake in US such as Railroad Valley Playa, Dry lake and desert in Australia
- PICS (Pseudo Invariant Calibration Site)

Calibration Data Archive System (CDAS)

- Archiving Data
  1. HISUI image data (L0B and L1) and other source data used for radiometric (and geometric) assessment
  2. Radiometric and geometric database (DB) files



- Production of radiometric (geometric) DB file
  for producing L1 product
- L1 processing software（L2 too?）
  for testing/validating produced radiometric and geometric DB files
- Analyzing onboard, vicarious, and cross-sensor calibration data

Summary

- After the launch, the main calibration method should be selected (or combined).
  - ASTER
    - On-board calibrator (before 2014.2)
    - Vicarious, Cross calibration and On-board calibrator (after 2014.2)
    - Future: Legacy and Auto-system vicarious calibration ?
      + Lunar calibration
  - HISUI (will be launch in FY2018)
    - Unfortunately, the Lunar calibration can not be planned due to the platform (ALOS3 to ISS) change
    - On-board calibrator maybe main, if the calibrator will be no problem.
    - Cross calibration is also main, if the CLARREO Pathfinder will be aboard the ISS.
    - For the vicarious calibration, the Auto-system data will be major.