

Current Status of Hyperspectral Imager Suite (HISUI)



Jadeite

翡翠

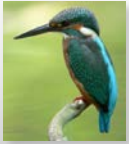


Kingfisher

Tsuneo Matsunaga¹, Akira Iwasaki², Satoshi Tsuchida³, Jun Tanii⁴,
Osamu Kashimura⁴, Ryosuke Nakamura³, Hirokazu Yamamoto³,
Tetsushi Tachikawa⁴, and Shuichi Rokugawa²

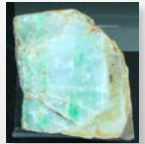
¹ National Institute for Environmental Studies, ² University of Tokyo,

³ National Institute of Advanced Industrial Science and Technology, ⁴ Japan Space Systems



What is **HISUI**?

A Successor of Terra **ASTER**

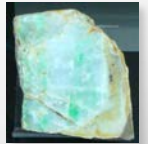


- **HISUI** is a future spaceborne hyperspectral and multispectral imager suite being developed by Japanese Ministry of Economy, Trade, and Industry (METI) as its 4th spaceborne optical imager mission.
 - 1) OPS onboard JERS-1 satellite (1992 – 1998)
 - 2) ASTER onboard NASA's Terra satellite (1999 -)
 - 3) ASNARO (2014-)
 - 4) HISUI (2018 -)
- The objectives of HISUI are :
 - 1) Global energy and resource related applications
 - 2) Environmental monitoring, agriculture, and forestry
 - 3) Promotion of domestic space and space utilization industries
- HISUI project was started in 2007 and HISUI will be launched in 2018 or later.
- Discussions with satellites/ground data system providers are still ongoing.
 - Implementation of the hyperspectral imager and the multispectral imager on separate platforms including medium or small satellites is being investigated.





HISUI Presentations at IGARSS 2014

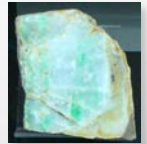


3

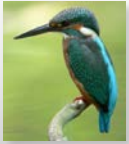
1. TUP.U.1 : Ogawa et al., EFFECTIVE OBSERVATION PLANNING AND ITS SIMULATION OF A JAPANESE SPACEBORNE SENSOR:HYPER SPECTRAL IMAGER SUITE (HISUI)
2. TUP.D.22, Tashiro et al., GENERATION OF DEM AND ORTHOIMAGE OF BORNEO(KALIMANTAN) ISLAND USING ASTER
3. TUP.U.140 : Nakazawa et al., SUPER-RESOLUTION IMAGING USING REMOTE SENSING PLATFORM
1. WE1.09.4 : Matsunaga et al., CURRENT STATUS OF HYPER SPECTRAL IMAGER SUITE (HISUI)
2. WE1.11.5, Yokoya et al., AIRBORNE UNMIXING-BASED HYPER SPECTRAL SUPER-RESOLUTION USING RGB IMAGERY
3. WE3.09.1 : Tanii et al., Instrument Development Status and Performances of Hyperspectral Imager Suite (HISUI) –Onboard Data Correction
4. WE3.09.3 : Yamamoto et al., HISUI VICARIOUS CALIBRATION AND CAL/VAL ACTIVITIES
5. TH2.03.2, Takayama et al., OPTIMAL SEGMENTATION OF CLASSIFICATION AND PREDICTION MAPS FOR MONITORING FOREST CONDITION WITH SPECTRAL AND SPATIAL INFORMATION FROM HYPER SPECTRAL DATA



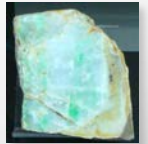
HISUI Specifications and Requirements



Parameter		Hyperspectral Imager	Multispectral Imager
Imaging Type		Pushbroom	Pushbroom
Spatial Resolution / Swath		30 m / 30 km	5 m / 90 km
Spectral	Bands	185	4
	Range	0.4 - 2.5 μm	0.485 -0.835 μm
	Resolution	10 – 12.5 nm	60 – 110 nm
SNR (30% albedo)		≥ 450 @620 nm ≥ 300 @2100 nm	≥ 200
MTF		≥ 0.2	≥ 0.3
Dynamic Range		Saturated at 70% albedo	
Spectral Calibration		VNIR : 0.2 nm SWIR :0.625 nm	
Radiometric Calibration		Absolute : $\pm 5\%$, among bands : $\pm 2\%$	
Quantization		12 bits	
Data Compression		Lossless (70%)	
Pointing		Cross track : $\pm 3^\circ$	N/A



HISUI Hyperspectral Imager and Multispectral Imager



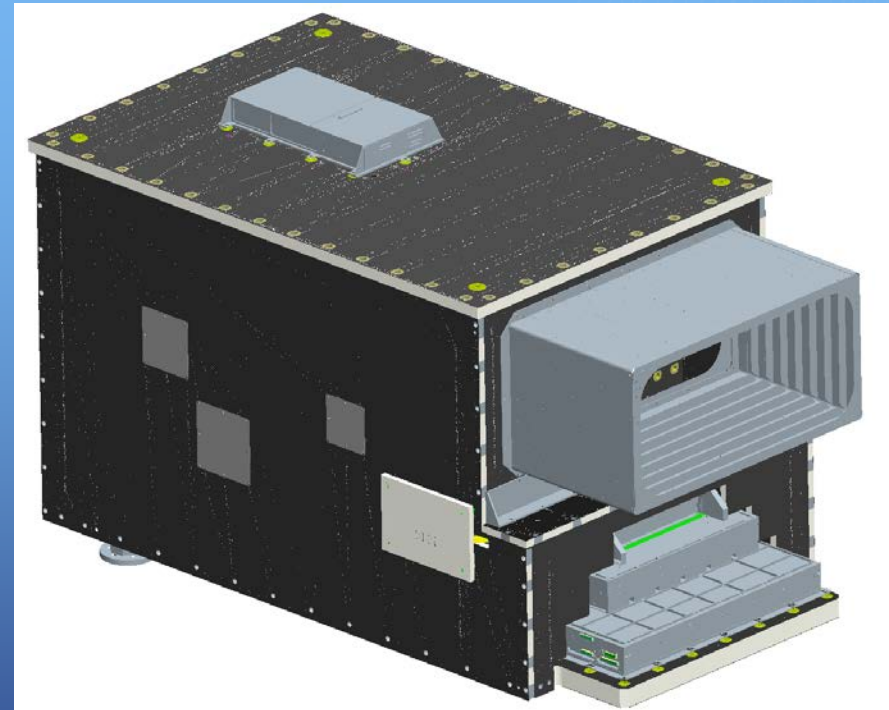
5

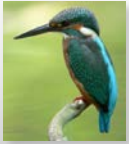
HISUI Hyperspectral Imager



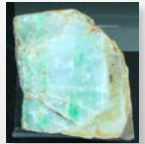
Telescope diameter ≈ 30 cm
Two grating spectrometers for VNIR and SWIR

HISUI Multispectral Imager

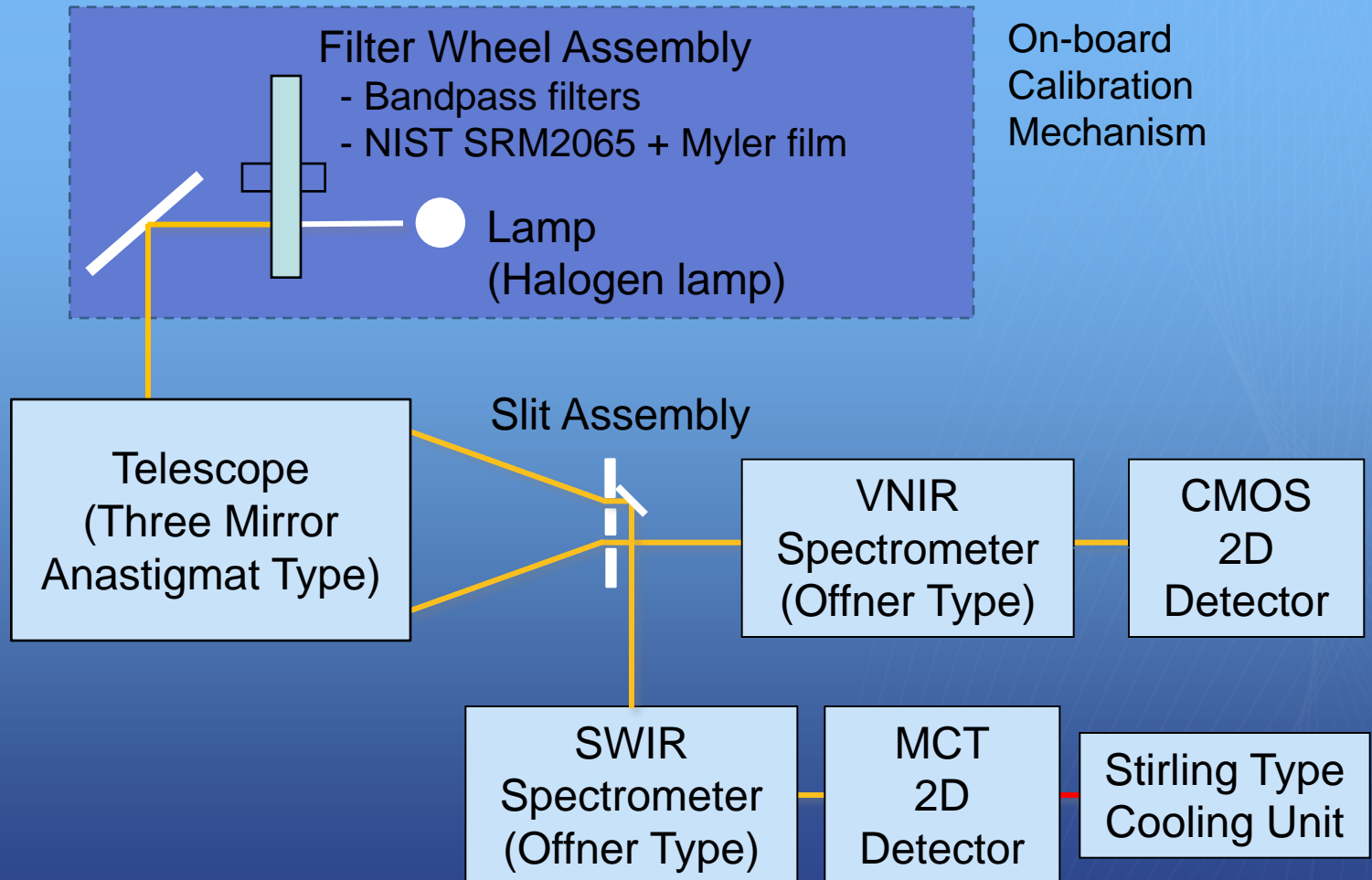


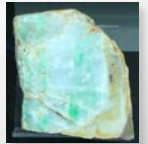


Optical Schematics of HISUI Hyperspectral Imager



6

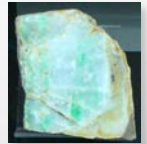


[illegible]



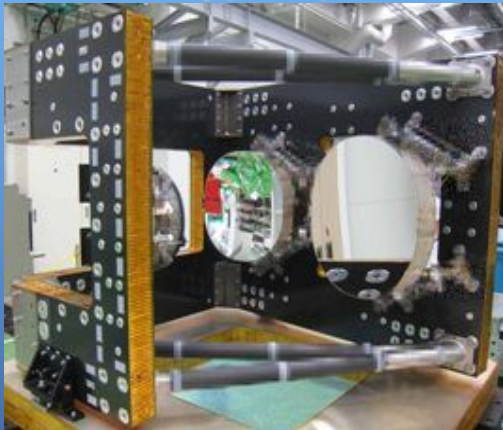
HISUI Instrument Status

(See Tani's presentation this afternoon)



8

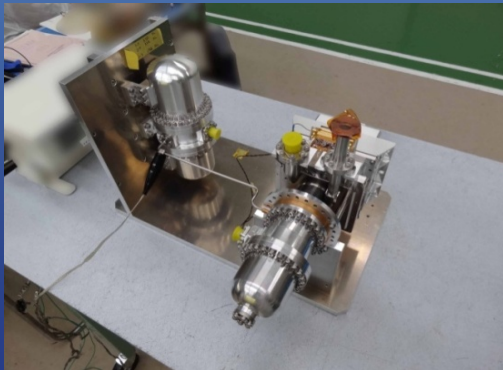
- The critical parts of FM, such as the telescope, the spectrographs and the detectors, have been manufactured and the integration & tests of the instruments are ongoing.
- CDR of Multispectral Imager : 7 July 2014 (done)
- CDR of Hyperspectral Imager : October 2014



Telescope



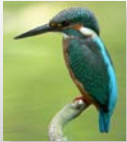
SWIR
Grating
Spectrometer



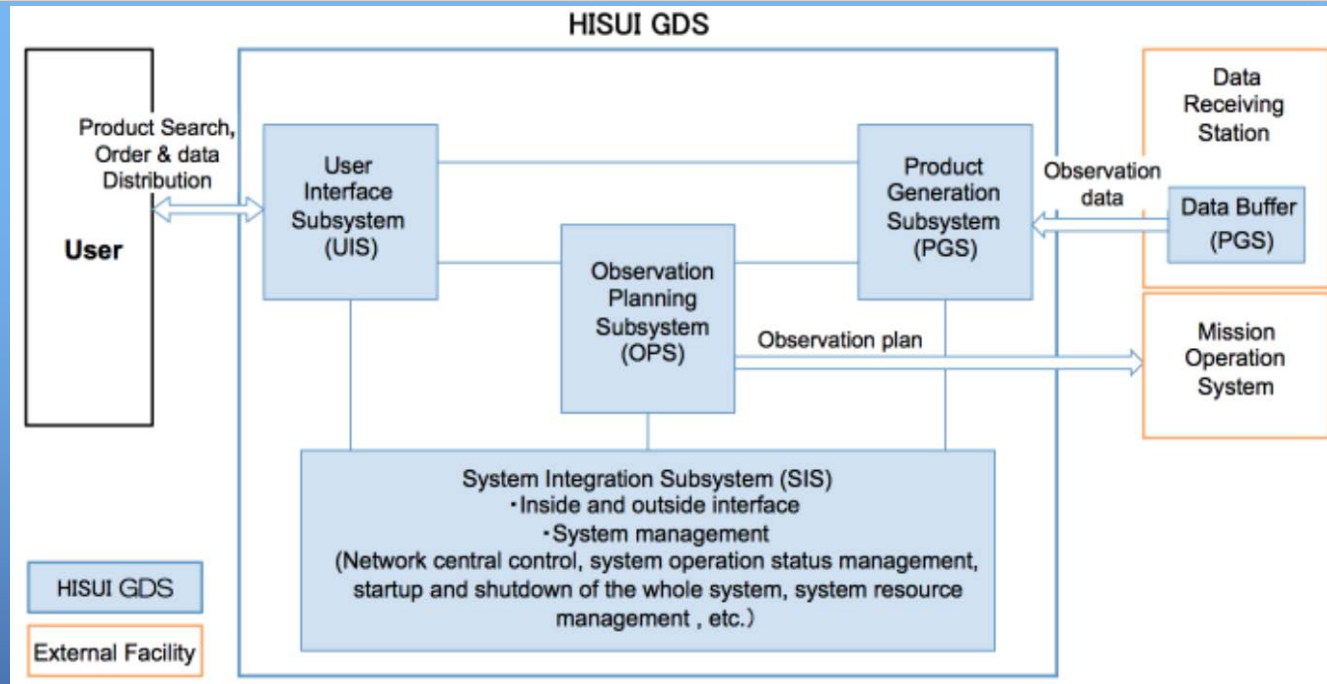
Stirling
Cooler



2D MCT
Detector



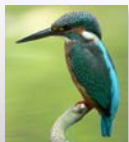
HISUI Ground Data System (GDS) Status



HISUI GDS consists of the four subsystems:

- Observation and Planning Subsystem (OPS)
- Product Generation Subsystem (PGS)
- User Interface Subsystem (UIS)
- System Integration Subsystem (SIS)

GDS's preliminary design was finished in FY2012, and its detailed design was finished FY2013. Currently GDS development is ongoing.



HISUI Product List as of July, 2014



10

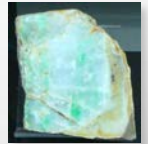
Name	Description	
Level 0	Raw data	
Level 1A	Raw DN product with all radiometric calibration coefficients. Spatial resampling is not applied.	
Level 1R	Top-of-atmosphere spectral radiance product. Spatial resampling is not applied.	
Level 1G	Geometrically corrected / orthorectified top-of-atmosphere spectral radiance product. Inter-telescope registration, parallax correction, and keystone property are considered. Spectral continuity between VNIR and SWIR are considered.	
Level 2	Atmospherically corrected surface spectral reflectance product generated from L1R/G with QA information. This is Science Product for research purpose and not validated.	

*The same product definitions will be applied to both Hyperspectral and Multispectral Imagers

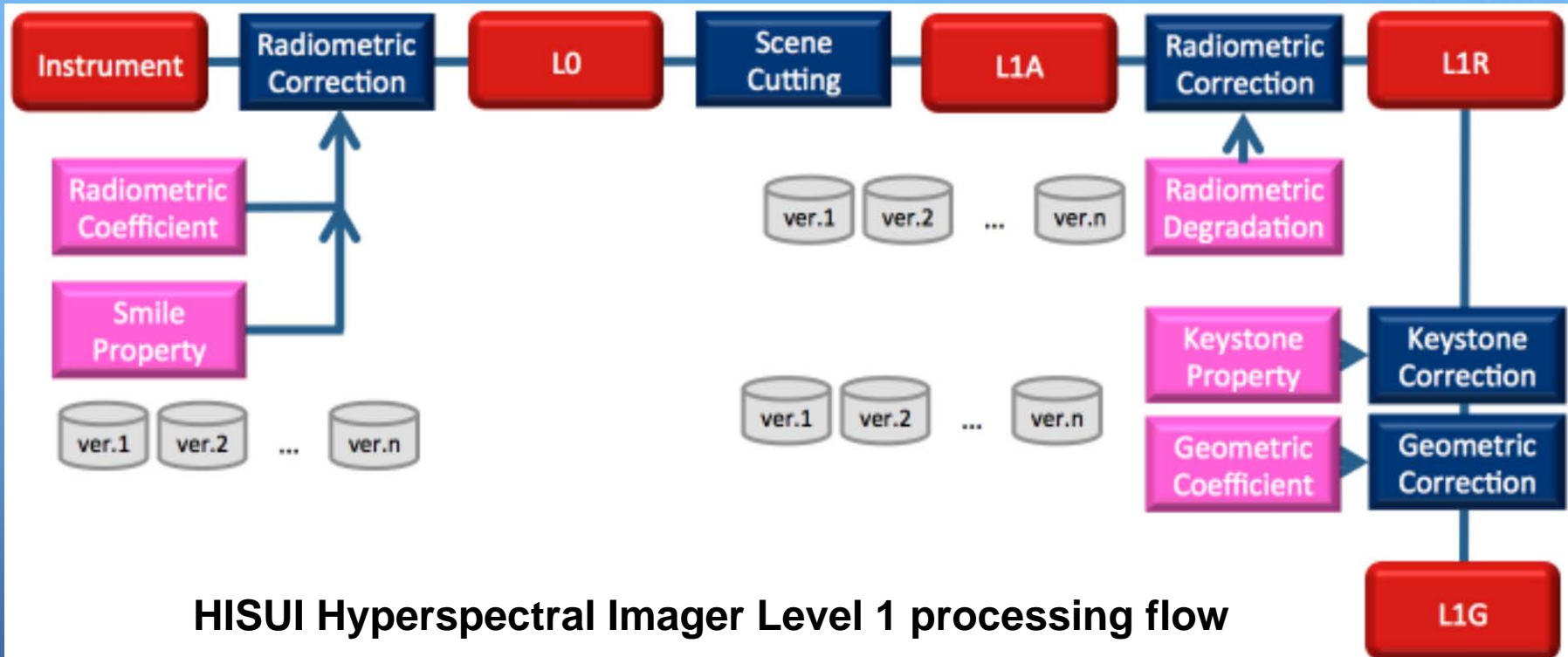
** Cloud statistical data are attached to L1 and L2 products.



HISUI Onboard and Level 1 Processing

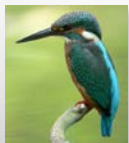


11



HISUI Hyperspectral Imager Level 1 processing flow

- Spectral binning, radiometric calibration, and smile corrections are carried out on orbit.
- Level 1 processing at GDS include scene cutting, radiometric degradation correction, keystone correction, geometric correction, and VNIR-SWIR parallax correction using DEM.
- The development of Level 1 data processing software for GDS started in 2013.



HISUI Calibration and Level 2 Processing



Calibration :

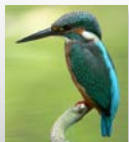
HISUI project has calibration plans which include not only pre-launch calibration but also other calibration methods.

- Onboard Calibration : Calibrated using the calibration device on satellite
- Vicarious Calibration : Calibrated by simultaneous ground measurement
- Cross Calibration : Calibrated using other satellite instruments
- Lunar Calibration (TBD): Calibrated by viewing the moon (stable radiance)*

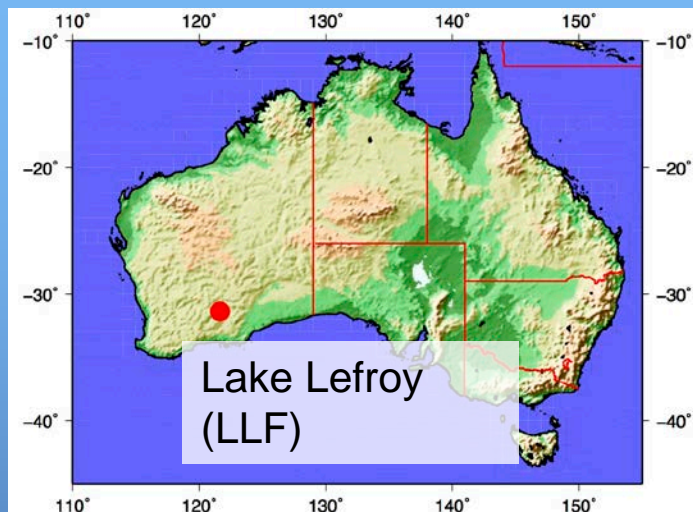
*T. Kouyama et al., "Comparison of A New Lunar Radiometric Model based on SELENE/SP with Satellite Observing Lunar Images, 45th Lunar Planet. Sci. Conf., #1302, 2014.

Level 2 Processing :

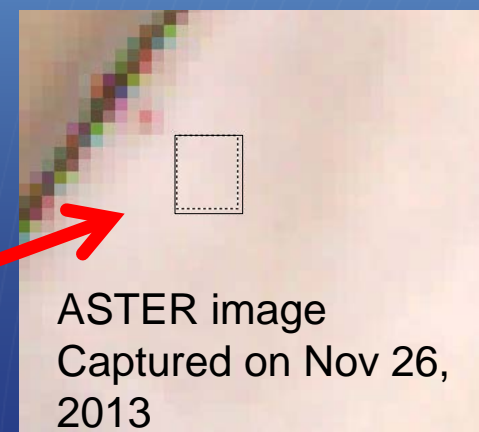
HISUI atmospherically corrected surface reflectance products will be generated for both of multispectral and hyperspectral imagers as science products. HISUI atmospheric correction algorithm will use Dark Pixel method with MODTRAN5 code. CEOS recommended solar irradiance spectrum (Thuillier 2002) and NewKurucz (SUN01kurucz2005) will be adopted as HISUI Irradiance model. Validation plans for HISUI atmospheric correction algorithm is to be discussed.

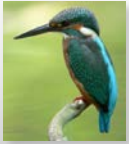


Vicarious Calibration in Australia

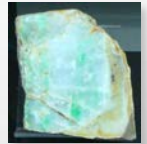


Field Campaign on Nov 26, 2013

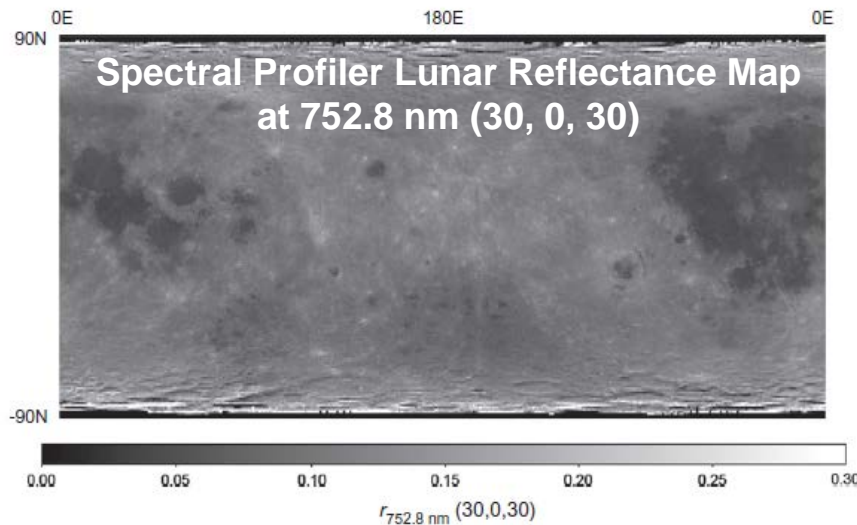




Lunar Reflectance Model based on SELENE Spectral Profiler data



14



Spectral Profiler Lunar Reflectance Model

530 – 1600 nm, $\Delta\lambda = 6 - 8$ nm
0.5° x 0.5° grid interval
→ 1~2 pixel size of ASTER/VNIR

Radiometric cal. with M3 and ROLO :
See Pieters et al., Icarus, 2013

Photometry : See Yokota et al., Icarus, 2011

Lunar radiance under any Sun-Moon-Earth geometry can be calculated by this model.



April 13, 2003



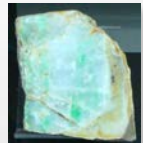
April 15



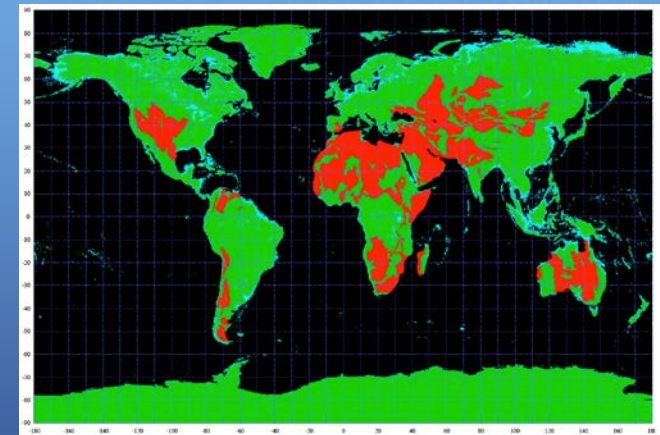
April 18



HISUI Operation and Mission Planning : Overview



- **HISUI OPS** (Observation Planning Subsystem) will automatically create command tables based on data acquisition requests(DARs), their priorities, and available resources such as instrument operation time and data downlink capability.
- DAR is valid until cloud free images of the target area are obtained.
- HISUI DAR categories (draft)
 - **Priority area mapping**
 - Including oil/gas/metal resource exploration areas
 - **Periodical observation**
 - Monthly, seasonal, and annual observations including protected areas and land glaciers
 - Nighttime SWIR fire/volcano observation
 - **Emergency / disaster observation**
 - **Calibration / validation observation**
 - Including vicarious and lunar calibration
 - **Global mapping** (using remaining resources)
 - All land surface and shallow coastal regions
 - **Engineering observation**

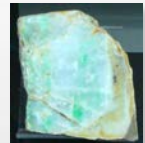


Example of HISUI Priority Map

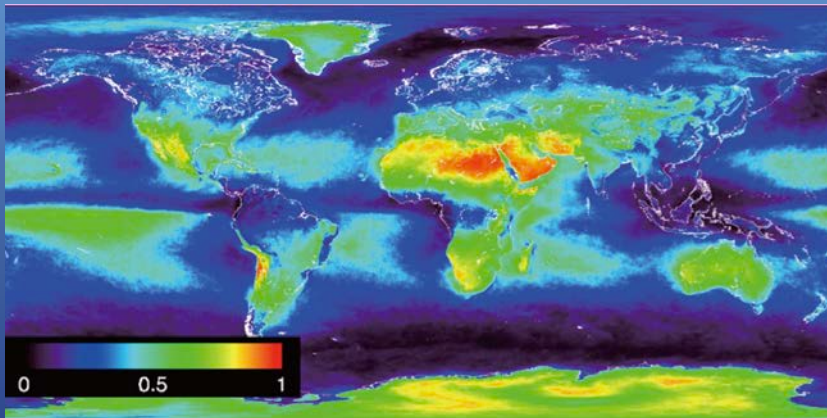
Red = Priority areas for oil/gas/metal resources, **Green** = Other land, **Light blue** = Shallow coastal zones shallower than 30 m.



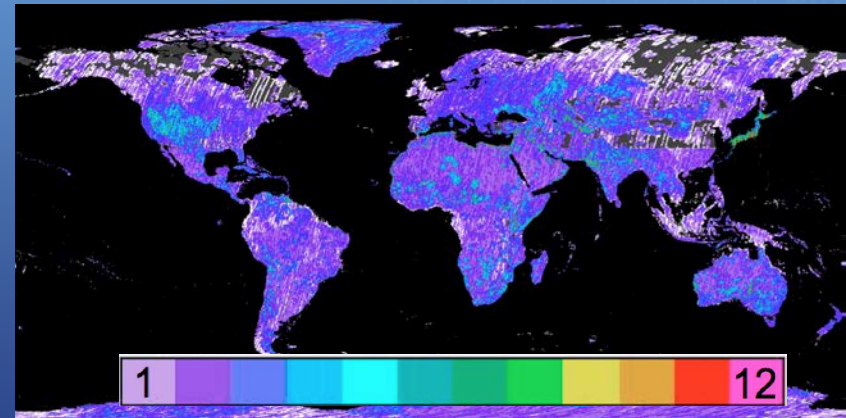
HISUI Operation and Mission Planning : Status



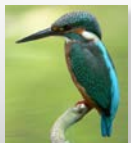
- HISUI OPS is being developed as one of subsystems of HISUI GDS.
- Long term operation simulation tool was developed. Terra MODIS global 1-km daily cloud mask dataset for three years is used in the simulation.
- Use of cloud climatology statistics in HISUI scheduling will increase long-term cloud-free coverage as much as a few percents.



Probability of cloud free days at 10:30 am local time in 2011 based on Terra MODIS data.



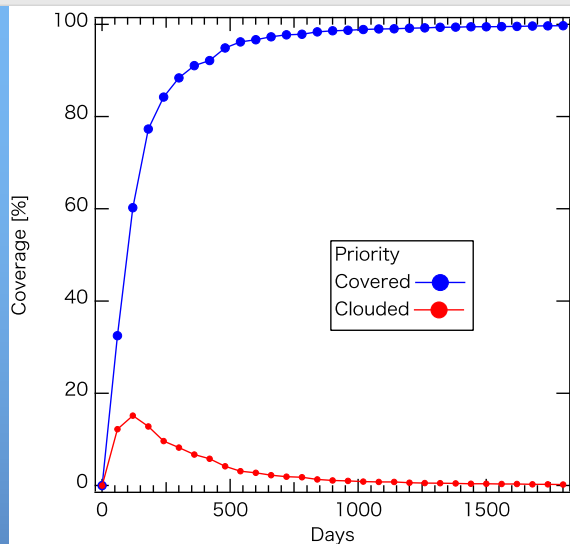
The number of cloud free images in 5 years. White areas = no cloud free images. (150FB/day)



HISUI Hyperspectral Imager Long-term Operation Simulation : 150 Gbyte/Day

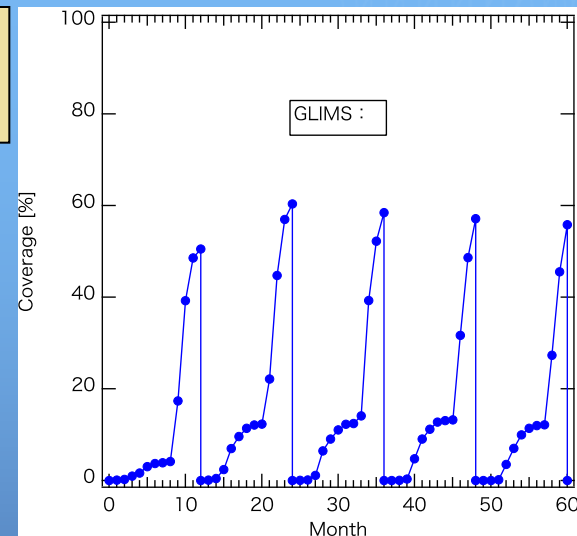


Priority Areas

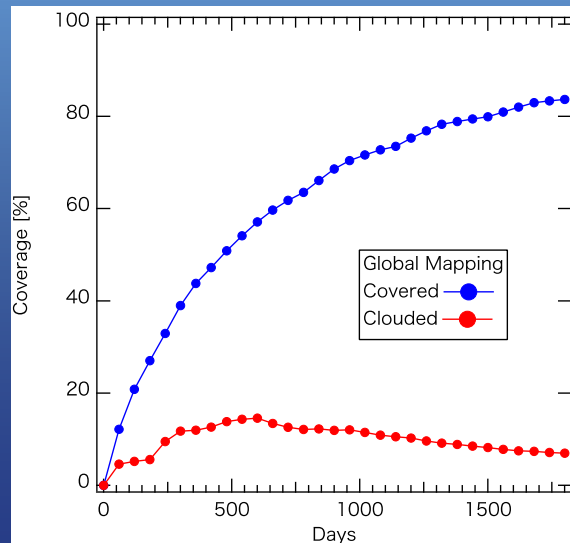


Land Ice (GLIMS*)

*Global Land Ice Measurements from Space

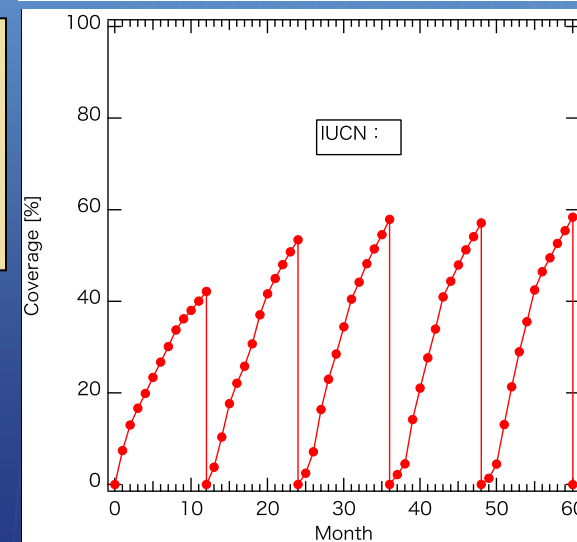


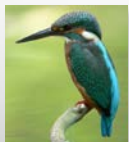
Global Mapping



IUCN**-defined Protected Areas

**International Union for Conservation of Nature

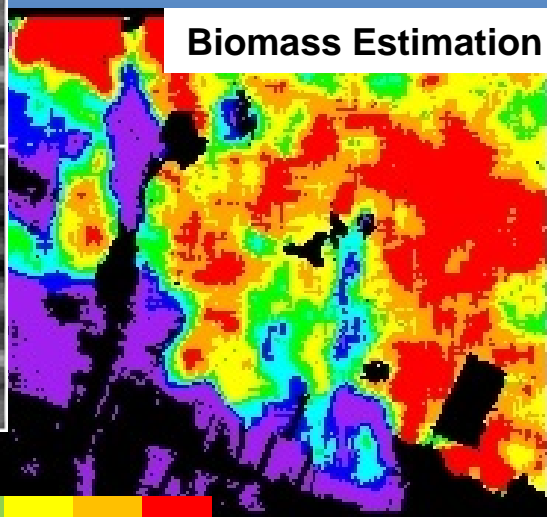
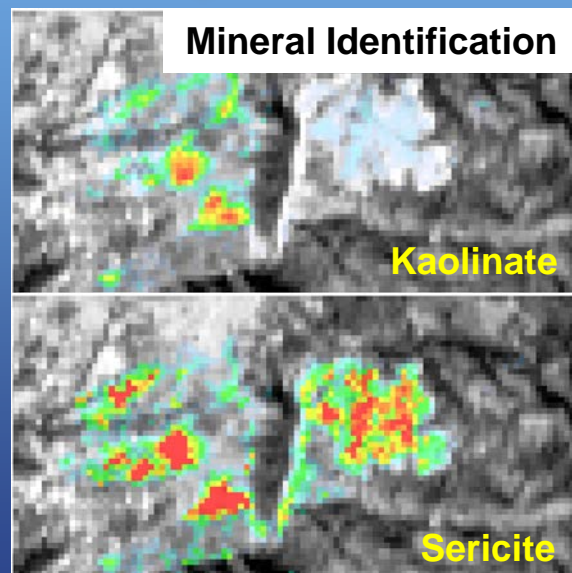




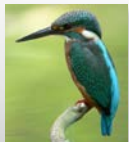
Application Studies Conducted by Japan Space Systems



- Since FY2007, to promote the use of HISUI data, Japan Space Systems has been conducting various application studies using the airborne hyperspectral data in Asia-Pacific regions.



Field	Research Themes
Oil/Gas /Mineral Resources	Oil spill classification
	Exploration of various type of mineral deposits
	Identification of minerals
Agriculture	Paddy yield, quality and growth
	Wheat yield, quality and growth
	Pasture grass yield and classification
	Extraction of illicit crop cultivation
	Estimation of soil salinity
Environment	Carbon dynamics in tropical peatland
	Detection of coral bleaching and recovery



Thank you

Contact : matsunag@nies.go.jp