HISUI Status Toward FY2019 Launch and Collaboration with Other Missions

“HISUI” has two meanings in Japanese, names of a mineral and a bird.

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What is **HISUI**?

A Successor of Terra **ASTER**

- **HISUI** (Hyperspectral Imager SUIt) is a spaceborne hyperspectral imager 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 (2020 -)

- HISUI covers 0.4 – 2.5 µm region with 185 bands, 20 x 30 m spatial resolution, and 20 km swath. It consists of a reflective telescope and two grating spectrometers.

- HISUI launch is currently scheduled in **January 2020 by SpaceX’s Falcon-9 (SpX-20)**.

- **HISUI will be deployed on Japan Experiment Module (JEM) of International Space Station (ISS) for three year operation.**
### HISUI Specifications

<table>
<thead>
<tr>
<th>Parameter</th>
<th>HISUI Specifications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Imaging Type / Spectral Dispersion</td>
<td>Pushbroom / Grating</td>
</tr>
<tr>
<td>Spatial Resolution / Swath</td>
<td>20 m (CT) x 30 m (AT) / 20 km</td>
</tr>
<tr>
<td>Spectral Range / Bands</td>
<td>0.4 - 2.5 μm / 185 bands</td>
</tr>
<tr>
<td>Spectral Resolution</td>
<td>10 – 12.5 nm</td>
</tr>
<tr>
<td>SNR (30% albedo)</td>
<td>≥ 450 @620 nm</td>
</tr>
<tr>
<td></td>
<td>≥ 300 @2100 nm</td>
</tr>
<tr>
<td>MTF</td>
<td>≥ 0.2</td>
</tr>
<tr>
<td>Dynamic Range</td>
<td>Saturated at 70% alebdo</td>
</tr>
<tr>
<td>Spectral Calibration</td>
<td>VNIR : 0.2 nm</td>
</tr>
<tr>
<td></td>
<td>SWIR : 0.625 nm</td>
</tr>
<tr>
<td>Radiometric Calibration</td>
<td>Absolute : ±5%, among bands : ±2%</td>
</tr>
<tr>
<td>Onboard Calibration Sources</td>
<td>Halogen lamp and filter wheel</td>
</tr>
<tr>
<td>Quantization / Data Compression</td>
<td>12 bits / Lossless (70%)</td>
</tr>
<tr>
<td>Telescope Diameter</td>
<td>≈ 30 cm</td>
</tr>
<tr>
<td>HISUI Exposed Payload (ExP)</td>
<td>≈ 2.3 x 1.5 x 1.6 m</td>
</tr>
<tr>
<td>Dimensions / Mass</td>
<td>≈ Nominal / Max 550 / 570 kg</td>
</tr>
<tr>
<td></td>
<td>including Hyperspectral Imager (≈ 240 kg)</td>
</tr>
</tbody>
</table>

HISUI was originally designed for a dedicated satellite with 600 km altitude. ISS orbit ≈ 400 km altitude.
HISUI Chronology

- **2018**
  “HISUI will be launched in January 2020 by SpX-20 flight.”

- **2017**
  “HISUI, without a cross track pointing system, will be launched in 2019 by Space-X’s Falcon 9 rocket.”

- **2015**
  “HISUI hyperspectral imager will be launched in 2018 and attached to ISS JEM EF.”

- **2014**
  “HISUI will be launched in 2018 or later.”

- **2013**
  “HISUI development will be completed in 2016. ” “Discussions with satellites/ground data system providers are ongoing.”

- **2012**
  “HISUI will be launched in 2015 or later.”

- **2010**
  “HISUI will be launched in FY 2014.”

- **2009**
  “METI’s hyperspectral and multispecyral sensor systemn JAXA’s ALOS-3 satellite will be launched by H-IIA rocket in 2013 – 2014.”

- **2007**
  “METI’s hyperspectral and multispecyral sensor system onboard JAXA’s disaster monitoring satellite will be launched by H-IIA rocket in FY2012.”
HISUI Deployment on ISS JEM

- HISUI consists of two components:
  - Exposed Payload (HISUI-ExP)
  - HISUI-Mission Data Recorder - Pressurized Module (MDR-PM)
They will be delivered to ISS by Dragon / Falcon 9 cargo rocket (SpX-20) in January, 2020.

- HISUI-ExP will be attached to Port #8 of JEM Exposed Facility (EF) as a nadir-viewing instrument. It also has support sensors such as a gyro, two star trackers, GPS receivers, and a mission data processor.

- MDR-PM will be installed in JEM-PM.

- HISUI data will be partially transmitted to ground stations (≈ 10 GB/day ≈ 30,000 km²/day). The rest (≈ max. 300 GB/day ≈ 900,000 km²/day) will be recorded in removal media and shipped back to Earth by cargo ships three or four times a year.

Priority downlink
HISUI Flight Model
HISUI Exposed Payload (HISUI-ExP)

- **FRGF**: Flight Releasable Grapple Fixture
- **PIU**: Payload Interface Unit
- **STT**: Star Tracker

**HISUI Spectrometer**
HISUI ExP Attached to Port 8 of JEM EF

OCO-3? (SpX-17, Feb. 2019)

ECOSTRESS (SpX-15, June 2018)

GEDI (SpX-18, Dec. 2018)

HISUI (SpX-20, Jan. 2020)
## HISUI Product List as of July, 2018

<table>
<thead>
<tr>
<th>Name (Format)</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Level 0</td>
<td>Raw data</td>
</tr>
<tr>
<td>Level 1A (TIFF)</td>
<td>Raw DN product with all radiometric calibration coefficients. Spatial resampling is not applied.</td>
</tr>
<tr>
<td>Level 1R (TIFF)</td>
<td>Top-of-atmosphere spectral radiance product. Spatial resampling is not applied.</td>
</tr>
<tr>
<td>Level 1G (GeoTIFF)</td>
<td>Geometrically corrected / orthorectified top-of-atmosphere spectral radiance product. Parallax correction, keystone property, and spectral continuity between VNIR and SWIR spectrometers are considered.</td>
</tr>
<tr>
<td>Level 2 (TBD)</td>
<td>Atmospherically corrected surface spectral reflectance product generated from L1G with QA information. This is Science Product for research purpose and not validated.</td>
</tr>
</tbody>
</table>

* Cloud statistical data are attached to L1 and L2 products.
Example of One-day Observation of HISUI

15 orbit/day, 8 minute/orbit (≈ 3600 km/orbit), and 3 segment/orbit (1st segment, 2nd segment, and 3rd segment)
with 200 targets, Priority region, and Global mapping,
Using MODIS Cloud Statistics

Cloud-free coverage in three years:
Priority Regions ≈ 65 => 85 => 92 %
Global Mapping ≈ 48 => 67 => 76 %

(Source: 180724)
HISUI Observation Opportunities of Large Cities in Three Years (Solar Elevation ≥ 30°)

Concentrate Mid-latitude Regions?

- Frankfurt (N50) = 14 times
- Vancouver (N49) = 8 times
- Ulaanbaatar (N48) = 5 times
- Montreal (N46) = 5 times
- Sapporo (N43) = 10 times
- Madrid (N41) = 5 times
- Tokyo (N36) = 15 times
- Los Angeles (N34) = 10 times

Other cities:
- Cairo (N30)
- New Delhi (N29)
- Naha (N26)
- Mecca (N22)
- Mexico City (N20)
- Manila (N15)
- Colombo (N17)
- Singapore (N1)
- Nairobi (S1)
- Jakarta (S6)
- Luanda (S9)
- Lima (S12)
- Rio de Janeiro (S23)
- Brisbane (S28)
- Capetown (S34)
- Sydney (S34)
- Christchurch (S44)
- Puerto Santa Cruz (S50)
HISUI Observation Opportunities of Important Sites in Three Years (Solar Elevation ≥ 30°)

Railroad Valley (US, N39)
La Crau (France, N44)
Lake Lefroy (Australia, S31)
Puna Forest Reserve (US, N19)
North Fuji Flux Site (Japan, N35)
Kiryu Flux / SIF Site (Japan, N35)
Sekisei lagoon (Japan, N24)
Four Corners (US, N37)
Hekinan Coal Powerplant (Japan, N35)
Sasan Coal Powerplant (India, N24)

Observation Date

Observations:
- Railroad Valley: 7 times
- La Crau: 5 times
- Lake Lefroy: 6 times
- Puna Forest Reserve: 6 times
- North Fuji Flux Site: 5 times
- Kiryu Flux / SIF Site: 7 times
- Sekisei lagoon: 4 times
- Four Corners: 8 times
- Hekinan Coal Powerplant: 6 times
- Sasan Coal Powerplant: 7 times
Other Earth Observing Instruments onboard ISS around 2020

**ECOSTRESS:**
Measure the temperature of plants and use that information to better understand how much water plants need and how they respond to stress. Launched in June 2018

**DEISI:**
Provide VNIR hyperspectral data with high spectral resolution (2.3 nm). One of instruments attached to MUSES. Launched in June 2018

**GEDI:**
Provide the first global, high-resolution observations of forest vertical structure using a lidar. To be launched in Dec. 2018

**OCO-3:**
Investigate the distribution of atmospheric carbon dioxide and Fluororescence from terrestrial vegetation. To be launched in February 2019.

**Other missions:**
NASA’s EMIT (2024) and JAXA’s lidar, MOLI (FY2021-)
### Operation Periods of ECOSTRESS, DESIS, GEDI, OCO-3, and HISUI

<table>
<thead>
<tr>
<th>Year</th>
<th>2018</th>
<th>2019</th>
<th>2020</th>
<th>2021</th>
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<tbody>
<tr>
<td></td>
<td>Q1</td>
<td>Q2</td>
<td>Q3</td>
<td>Q4</td>
</tr>
<tr>
<td>ECOSTRESS</td>
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<td></td>
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<td></td>
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<tr>
<td>DESIS</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>GEDI</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>OCO-3</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>HISUI</td>
<td></td>
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</tr>
</tbody>
</table>

- **Launch**
- **Design Lifetime**
- **Nominal Operation**
- **Extended Operation**

Design lifetime of DESIS and OCO-3 are 5 and 3 years, respectively.
Ideas for Collaborations with Other Missions

- **HISUI and DESIS**
  - Radiometric and spectral calibration in VNIR (DLR - JSS discussion started)
  - Joint observation for high temporal resolution of VNIR hyperspectral data.

- **HISUI and ECOSTRESS**
  - ECOSTRESS ET and HISUI vegetation parameters (e.g. PRI)
    - May give answers to some of CQs?
  - High temperature targets at night
    (Spectral region: HISUI = SWIR, ECOSTRESS = TIR)

- **HISUI and GEDI**
  - GEDI biomass and HISUI vegetation parameters (e.g. LAI)
    - Simultaneous observation required?

- **HISUI and OCO-3**
  - Radiometric calibration at 0.765 µm, 1.61 µm, and 2.06 µm.
  - OCO-3 SIF and HISUI vegetation parameters (e.g. PRI)
  - CO2 point sources
    (Pixel size: HISUI = 20 x 30 m, OCO-3 = 1.8 x 2.2 km)
HISUI Research Announcement and Data Policy

- HISUI Research Announcement (Ver 2.0) was issued in November 2017. Proposals from overseas users will be accepted from April 2019 (TBR). Contact: hisui_application@jspacesystems.or.jp

- For collaborating organizations / missions and research announcement investigators, priority observation*, priority downlink, and data distribution for their requested areas will be given for free.

  *One AOI is about 10 x 10 km. Requests for multiple AOIs and for multiple observation of AOIs are acceptable.

- The archived HISUI data will be provided for free to other science users with some conditions (e.g. submission of reports to HISUI Project).

- The data policy for commercial users is not finalized yet.
Thank you

Contact : matsunag@nies.go.jp

Contact for Research Announcement : hisui_application@jspacesystems.or.jp
Optical Diagram of HISUI Hyperspectral Imager

Filter Wheel Assembly
- Bandpass filters
- NIST SRM2065 + Myler film

Lamp (Halogen lamp)

Telescope (Three Mirror Anastigmat Type)

VNIR Spectrometer (Offner Type)

CMOS 2D Detector

SWIR Spectrometer (Offner Type)

MCT 2D Detector

Stirling Type Cooling Unit

On-board Calibration Mechanism

Telescope

Slit Assembly
HISUI Long-term (3 years) Operation Simulation Setup

Cloud assessment and HISUI observation rescheduling

- 8 minute / orbit excluding warming up / shut-down time, 3 segments
- 410 km altitude
- 1 deg attitude fluctuation
- Terra MODIS global daily 1km cloud mask for three years
- 20 km swath

A) Emergency / Calibration Obs.
B) Verification Observation
C) Priority Region Mapping
D) Global Mapping

- JEM EF MDP
- JEM PM MDR-PM
- 0.4 Gbps 26 Gbyte/orbit
- 40 Mbps
- 300 GByte/day media transport several times per year
- 10 GByte/day daily transmission
- 20 km swath

- 4 Gbps
- 0.4 Gbps
- 40 Mbps