Introduction to Himawari-8

Training on meteorological satellite data usage

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Meteorological Satellite Center (MSC)
Japan Meteorological Agency (JMA)

The Sixth Asia/Oceania Meteorological Satellite Users' Conference
Tokyo, Japan
9 – 13 November 2015
Successful Launch of Himawari-8

Himawari-8 was successfully launched using H-IIA Launch Vehicle # 25 on 7 October 2014 from the Tanegashima Space Center in Kagoshima, Japan
Himawari-8 began operation at 02:00 UTC on 7th July 2015.
Outline of Himawari-8

Geostationary position
Around 140.7° E

Attitude control
3-axis attitude-controlled geostationary satellite

Communication
1) Raw observation data transmission
   Ka-band, 18.1 - 18.4 GHz (downlink)

2) DCS
   International channel
   402.0 - 402.1 MHz (uplink)
   Domestic channel
   402.1 - 402.4 MHz (uplink)
   Transmission to ground segments
   Ka-band, 18.1 - 18.4 GHz (downlink)

3) Telemetry and command
   Ku-band, 12.2 - 12.75 GHz (downlink)
   13.75 - 14.5 GHz (uplink)

Himawari-8 began operation on 7 July 2015, replacing the previous MTSAT-2 operational satellite
Improved Resolutions

**Spectral**
- VIS: 1 band
- NIR: 3 bands
- IR: 5 bands

**Spatial**
- At sub-satellite point
  - VIS: 1 km
  - IR: 4 km
  - VIS: 0.5/1 km
  - IR: 2 km

**Temporal**
- Observation Frequency
  - MTSAT-1R/2: 60 min.
  - Himawari-8/9: 10 min.
### Spectral Bands

**Himawari-8/9 Imager (AHI)**

<table>
<thead>
<tr>
<th>Band</th>
<th>Spatial Resolution</th>
<th>Central Wavelength</th>
<th>Physical Properties</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Visible</td>
<td>1 km</td>
<td>0.47 μm, vegetation, aerosol</td>
</tr>
<tr>
<td>2</td>
<td>Visible</td>
<td>0.5 km</td>
<td>0.51 μm, vegetation, aerosol</td>
</tr>
<tr>
<td>3</td>
<td></td>
<td>0.64 μm</td>
<td>Vegetation, low cloud, fog</td>
</tr>
<tr>
<td>4</td>
<td>Near Infrared</td>
<td>1 km</td>
<td>0.86 μm, vegetation, aerosol</td>
</tr>
<tr>
<td>5</td>
<td>Near Infrared</td>
<td>2 km</td>
<td>1.6 μm, cloud phase</td>
</tr>
<tr>
<td>6</td>
<td></td>
<td></td>
<td>2.3 μm, particle size</td>
</tr>
<tr>
<td>7</td>
<td>Infrared</td>
<td>2 km</td>
<td>3.9 μm, low cloud, fog, forest fire</td>
</tr>
<tr>
<td>8</td>
<td></td>
<td></td>
<td>6.2 μm, mid- and upper-level moisture</td>
</tr>
<tr>
<td>9</td>
<td></td>
<td></td>
<td>6.9 μm, mid-level moisture</td>
</tr>
<tr>
<td>10</td>
<td></td>
<td></td>
<td>7.3 μm, mid- and lower-level moisture</td>
</tr>
<tr>
<td>11</td>
<td></td>
<td></td>
<td>8.6 μm, cloud phase, SO₂</td>
</tr>
<tr>
<td>12</td>
<td></td>
<td></td>
<td>9.6 μm, Ozone content</td>
</tr>
<tr>
<td>13</td>
<td></td>
<td></td>
<td>10.4 μm, cloud imagery, information of cloud top</td>
</tr>
<tr>
<td>14</td>
<td></td>
<td></td>
<td>11.2 μm, cloud imagery, sea surface temperature</td>
</tr>
<tr>
<td>15</td>
<td></td>
<td></td>
<td>12.4 μm, cloud imagery, sea surface temperature</td>
</tr>
<tr>
<td>16</td>
<td></td>
<td></td>
<td>13.3 μm, cloud top height</td>
</tr>
</tbody>
</table>
Spatial Resolution

MTSAT-2 (VIS) 1km

Himawari-8 (B03) 0.5 km

03:00 UTC on 29 January 2015

Tokyo
Observation Frequency

MTSAT-2 (VIS)
Hourly in Monochrome

Himawari-8 (Band01-03)
Every 10 minutes in Full-Color

16 UTC on 2\textsuperscript{nd} to 13 UTC on 3\textsuperscript{rd}, April 2015
AHI Observation Modes

Region 1 JAPAN (North-East)
- Interval: 2.5 minutes (4 times in 10 min)
- Dimension: EW x NS: 2000 x 1000 km

Region 2 JAPAN (South-West)
- Interval: 2.5 minutes (4 times in 10 min)
- Dimension: EW x NS: 2000 x 1000 km

Region 3 Target Area
- Interval: 2.5 minutes (4 times in 10 min)
- Dimension: EW x NS: 1000 x 1000 km

Region 4 Landmark Area
- Interval: 0.5 minutes (20 times in 10 min)
- Dimension: EW x NS: 1000 x 500 km

Region 5 Landmark Area
- Interval: 0.5 minutes (20 times in 10 min)
- Dimension: EW x NS: 1000 x 500 km

Full disk
- Interval: 10 minutes (6 times per hour)
AHI Scan Scenario
Upgrade of MTSAT -> Himawari-8/9

- Number of bands: 5 -> 16
- Spatial resolutions:
  - VIS: 1 km -> 0.5 or 1.0 km
  - IR: 4.0 km -> 2.0 km
- Temporal resolutions: 30/60 min -> 10 min

(Total data size: 50 times!!)

Revolution of Advanced Himawari Imager
Himawari-8: Observation Area and Interval

Visible band

RGB Composited True Color

Japan & Vicinity Obs.

Full Disk Obs.

Targeted Area obs.

in 10 minutes time frame

July 9-10, 2015
Himawari-8/9
Ground Segments
Himawari-8/9 Ground Segment and Operations

- **Primary station**
  - Antenna site (Kanto/Saitama)
  - Data center (Kanto/Tokyo)
  - AHI data, DCP data (Landline)

- **Secondary station**
  - Antenna site / Data center (Hokkaido/Ebetsu)
  - AHI data, DCP data (Landline)

- **Site diversity**
  - Himawari-8
  - Himawari-9

- **Remote control**
  - Back-up

- **Users**
  - Residents, disaster prevention agencies, media, etc.
  - National Meteorological and Hydrological Services

- **Operation by**
  - HOPE
  - JMA

- **Telemetry, tracking, command**
  - AHI data, DCP data (Ku band)
Two Ways of Data Dissemination/Distribution
HimawariCast/HimawariCloud

Himawari-8/9

Communication Satellite (CS)

HimawariCast service
HRIT files, SATAID files

CS Operator

All imagery (full data)

C-band antenna
LNB
DVB-S2 receiver
PC & software

JMA

HimawariCloud service

NMHSs

Users
Two Ways of Himawari-8/9 Imagery Dissemination/Distribution

**HimawariCast** via Communication Satellite
- Service for **Everyone**
- **No Pass Code** for Receiving
- **JMA’s Baseline** for Imagery Dissemination
- **14 bands** (1 VIS and 13 IR) every **10 minutes** for Full Disk
- Spatial Resolution is same as that of MTSAT **HRIT compatible**

**HimawariCloud** via Internet Cloud
- Service for **NMHSs** with high-speed Internet access
- All **16 bands** (3 VIS and 13 IR)
- **Full Specification** (temporal and spatial) of Imagery
<table>
<thead>
<tr>
<th>Service</th>
<th>Users</th>
<th>Format</th>
<th>Interval</th>
<th>Band</th>
<th>Resolution</th>
<th>Delivery</th>
</tr>
</thead>
<tbody>
<tr>
<td>HimawariCloud</td>
<td>NMHS</td>
<td>HSD (Himawari</td>
<td>10 min</td>
<td>16</td>
<td>VIS: 0.5-1 km, IR: 2 km</td>
<td>High-speed Internet (NTT</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Standard Data)</td>
<td></td>
<td></td>
<td></td>
<td>Communication)</td>
</tr>
<tr>
<td>HimawariCast</td>
<td>All</td>
<td>HRIT files</td>
<td>10 min</td>
<td>14</td>
<td>VIS: 1 km, IR: 4 km</td>
<td>Communication Satellite (JCSAT-</td>
</tr>
<tr>
<td>(for baseline</td>
<td></td>
<td>(MTSAT Compatible)</td>
<td></td>
<td></td>
<td></td>
<td>2A/2B)</td>
</tr>
<tr>
<td>usage)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Web-based</td>
<td>All</td>
<td>JPEG</td>
<td>10 min</td>
<td>4+</td>
<td>several km</td>
<td></td>
</tr>
<tr>
<td>Quick-Look</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

http://www.data.jma.go.jp/mscweb/data/himawari/sat_img.php?area=se1
Integrated Usage of HimawariCloud and HimawariCast

Divided Imagery Data Distribution from HimawariCloud

- Full Disk Imagery from HimawariCast
- The Specific Imagery in detail from HimawariCloud

Table. Segment number and approximate coverage in latitude

<table>
<thead>
<tr>
<th>Segment #</th>
<th>North Edge (lat.)</th>
<th>South Edge (lat.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>--</td>
<td>47 deg.N</td>
</tr>
<tr>
<td>2</td>
<td>47 deg.N</td>
<td>32 deg.N</td>
</tr>
<tr>
<td>3</td>
<td>32 deg.N</td>
<td>21 deg.N</td>
</tr>
<tr>
<td>4</td>
<td>21 deg.N</td>
<td>10 deg.N</td>
</tr>
<tr>
<td>5</td>
<td>10 deg.N</td>
<td>Equator</td>
</tr>
<tr>
<td>6</td>
<td>Equator</td>
<td>10 deg.S</td>
</tr>
<tr>
<td>7</td>
<td>10 deg.S</td>
<td>21 deg.S</td>
</tr>
<tr>
<td>8</td>
<td>21 deg.S</td>
<td>32 deg.S</td>
</tr>
<tr>
<td>9</td>
<td>32 deg.S</td>
<td>47 deg.S</td>
</tr>
<tr>
<td>10</td>
<td>47 deg.S</td>
<td>--</td>
</tr>
</tbody>
</table>
The first Segment Imagery Data will be ready to pull within 7 min. after observation start time (the last Segment within 4-5 min. after observation end time)
The first segment data is to be disseminated within 8 min. after observation start time (the last segment data within 7 min. after observation end time)
HimawariCast with SATAID

HimawariCast provides ...........
an Integrated Environment for Satellite Cloud Imagery Analysis with overlaying weather radar, GPV, SYNOP on SATAID system

Features
- Overlaying GPV, SYNOP on satellite image will be disseminated via HimawariCast.
- Satellite image in SATAID format can be downloaded from WIS Portal server, or you can convert from HRIT image data.
- SATAID System will be available from MSC Website with “Source Code”
- Image data format converter between HRIT and SATAID/NetCDF will be provided from MSC Website
- Handling Tools for reading Image Data in NetCDF format will also be provided from MSC Website for the further use in GIS applications.
The following Himawari Historical Data Servers are operated by Japanese Science Group on a voluntary basis for Non-Profit R&D Users

- **Chiba University Data Server**
  CEReS (Center for Environmental Remote Sensing)

- **NICT Himawari-8 Real-time Web**

- **JAXA Himawari Monitor**

- **University of Tokyo**
  **DIAS (Data Integration and Analysis System)**
  (in preparation for operation)
HIMAWARI-8 Image Navigation & Calibration Status
Himawari-8 Image Navigation
Estimated from “Coast Line” Analysis

Image Navigation for band 13 (10.4μm)

Image navigation accuracy is mostly less than 0.3 pixels

Scale: one pixel

MEAN OF VECTOR MAGNITUDES(px1s): 0.16 (=0.3 km)
MEAN VECTOR(px1s): PIX -0.00, LIN +0.10, MAG 0.10 (=0.2 km), # OF SAMPLES: 618
Validation of IR Bands Calibration based on GSICS inter-calibration

**Radiance**

HIMALAWARI-8 BAND13 vs. METOP-A/IASI

<table>
<thead>
<tr>
<th>Number</th>
<th>13503</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coefficient</td>
<td>0.588246e-06</td>
</tr>
<tr>
<td>Slope</td>
<td>0.018660 (0.000327)</td>
</tr>
<tr>
<td>Intercept</td>
<td>0.653566 (0.029888)</td>
</tr>
</tbody>
</table>

**Brightness Temp. (Tb)**

HIMALAWARI-8 BAND13 vs. METOP-A/IASI

* Standard Radiance was calculated under clear sky condition over the ocean in nighttime by RTTOV 11.2 with US standard atmosphere (1976)
Validation of VIS/NIR Bands Calibration for Himawari-8 Imagery

- Two ways of validation results are well agreed
- Ratio to observed AHI reflectivity are around 1.0 for all VIS/IR bands
- However, it differs in property between B01-04 and B05-06

4/1 - 5/15

before update of calibration table based on pre-launch ground test

Radiative Transfer Simulation with RSTAR

29 May 2015 to 21 Jun 2015

Band 01

Updating calibration coefficients on 8 June, 2015

6/10 - 6/20

after update of calibration table based on solar diffuser observation

Ray-matching with VIIRS

Band 01
Contents:

- Overview of satellite observation
- Overview of data dissemination
- Imager (AHI) specifications
- Operational status
- Sample data
- Sample source code to read Himawari-8 data and convert into other formats

Feel free to contact:

Satellite Program Division, Japan Meteorological Agency
metsat@met.kishou.go.jp
Enhancement in HIMAWARI-8 Level-2 Products
Development of L2 Products from Himawari-8/9 AHI

**Increased Observation Spectral Bands**
- VIS: 1 --> 3
- NIR/IR: 4 --> 13

**with Higher Resolution**
- **Spatial:**
  - 1km --> 0.5km for a VIS channel
  - 4km --> 2 km for IR channels
- **Temporal:**
  - 1 hr --> 10 min for a full disk scan
  - 2.5min for limited areas

**Development of Baseline Products, focusing on**
- Atmospheric Motion Vectors (AMVs)
- Cloud Properties (incl. Rapidly Developed Convective Clouds)
- Aerosol (incl. Asian Dust) / Volcanic Ash

**Applications:**
- Numerical Prediction
- Severe Weather Monitoring
- Environmental Monitoring
Cloud Products from Himawari-8/9 AHI

- Extracted Parameters: Cloud Mask, Type, Phase, and Top Height
- Algorithm is based on NWC-SAF*1 and NOAA/NESDIS*2

(*1) Meteo-France 2012: Algorithm Theoretical Basis Document for “Cloud Products” (CMa-PGE01v3.2, CT-PGE02 v2.2 & CTTH-PGE03 v2.2)
http://www.nwcsaf.org/HD/MainNS.jsp

(*2) Andrew Heidinger, 2011: ABI Cloud Mask, NOAA NESDIS CENTER for SATELLITE APPLICATIONS and RESEARCH ATBD
http://www.goes-r.gov/products/baseline.html

Cloud Mask

Type

Phase

Cloud Top Height

Cloud
Clear Ocean
Clear Land

Fractional
Semi-transparent
Opaque

Mixed Phase
Liquid
Ice

[m]
18,000
9,000
0
Objective Cloud Analysis Information (OCAI)

- Basic cloud product with latitude-longitude grid in 0.05 degree.
  - cloud mask, cloud type and cloud top height
- Be produced hourly
- Started to provide to NMHSs, e.g. Indonesia and Myanmar, in response to requests.

Cloud Mask

Cloud Top Height
Clear Sky Radiances (CSRs)

- Area averaged clear sky radiance and brightness temperature.
- Specifications:
  - All IR bands (3.9, 6.2, 6.9, 7.3, 8.6, 9.6, 10.4, 11.2, 12.4, 13.3 um)
  - Full disk, Hourly produced
  - Spatial resolution (size of area for averaging): 16 x 16 pixel (IR) (32 x 32 km @SSP)

Band #8 (6.2 um)  Band #9 (6.9 um)  Band #10 (7.3 um)

03 UTC 20 April 2015
Improvement in Atmospheric Motion Vectors (AMVs) Retrieval

Himawari-8 AMVs derived from Himawari-8 imagery with new algorithm

MTSAT-2 AMVs derived from MTSAT-2 imagery and heritage algorithm

Resolution

2km/10min.

Resolution

4km/30min.

Resolution

4km/60min.

Himawari-8 and MTSAT-2 IR AMV (QI>60, 2015 01 14 1700UTC)
Atmospheric Motion Vectors (AMVs)

- JMA/MSC has developed a new algorithm for Himawari-8 AMVs based on an optimal estimation method for full exploitation of satellite data (Shimoji 2014).
- Validation results are informed to NWP users (IWW mailing list)
MTSAT-2 AMVs on 250 hPa in vicinity of Japan, which were assimilated into the routine system.

Himawari-8 AMVs on 250 hPa in vicinity of Japan, which were assimilated into the test system.

Himawari-8 AMVs were derived from three sequential satellite images with 10-minute time interval by a new retrieval method based on maximum likelihood estimation.

MTSAT-2 AMVs were derived from three sequential satellite images with 15- or 30-minute time interval. (Himawari-8 and MTSAT-2 AMVs used for this study were produced by Meteorological Satellite Center of JMA.)
Typhoon track forecasts using Himawari-8 AMVs
Impact of Himawari-8 AMVs compared to routine

Typhoon track forecast errors averaged for NOUL (T1506)
CNTL (Routine): Result by assimilating MTSAT-2 AMVs
TEST: Result by assimilating Himawari-8 AMVs

Period:
Assimilation: From 1 to 24 May 2015
Forecast: From 2 to 12 May 2015

Typhoon track forecast of NOUL (T1506) initialized at 12 UTC on 10 May 2015.
Black is the best track. CNTL (Routine) and TEST are same to the left panel.

Mr Koji Yamashita (Numerical Prediction Division, JMA)
Detection of Rapidly Developed Convective Clouds

Himawari-8 Imagery

Information on Potential Area for Rapidly Developed Convective Cloud Area

JMA’s Weather Radar System

JMA’s Lightning Detection System (LIDEN)

Cb Clouds
Rapidly Developed
Unknown

Cloud - Cloud
Cloud - Ground
Utilization of RGB Imagery: Visible and Near Infrared Detection of Aerosol (Asian Dust)

- R: band 5 (1.6 \( \mu \) m)
- G: band 4 (0.86 \( \mu \) m)
- B: band 3 (0.64 \( \mu \) m)
Utilization of RGB Imagery: Visible True Color Detection of Volcanic Ash and Gas from Volcano Eruption

29 May 2015, Kuchinoerabu Island
Utilization of RGB Imagery: SO\textsubscript{2} Band (8.6 μm)
Detection of Volcanic Ash and Gas from Volcano Eruption

29 May 2015, Kuchinoerabu Island

R: band 15(12.4 μm) – band 13(10.4 μm)
G: band 13(10.4 μm) – band 11(8.6 μm)
B: band 13(10.4 μm)
JMA provides the Web site and the User’s Guide documentation.

- RGB composite imagery based on the WMO standard recipe are produced from Himawari-8 imagery.
  
  *e.g. Day Microphysics, Night Microphysics.*

- Products are provided for supporting SWFDP in RA II/RA V region.
  - IR(10.8um), IR(3.9um), WV(6.8um), VIS(0.68um), and Sandwich Imagery are also provided.

**Future plan**

- Development of new RGB imagery or “localization” for typical weather phenomena in Asia/Oceania regions.

**RGB Imagery are available from:**

http://www.data.jma.go.jp/mscweb/data/himawari/sat_hrp.php?area=r2s
http://www.data.jma.go.jp/mscweb/data/himawari/sat_hrp.php?area=r5s