Introduction to Himawari-8 and its Application to Volcanic Ash Cloud Monitoring

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- Summary
Himawari-8 began operation at 02:00 UTC on 7th July 2015.
### Outline of Himawari-8

<table>
<thead>
<tr>
<th>Geostationary position</th>
<th>Around 140.7° E</th>
</tr>
</thead>
<tbody>
<tr>
<td>Attitude control</td>
<td>3-axis attitude-controlled geostationary satellite</td>
</tr>
<tr>
<td>Communication</td>
<td></td>
</tr>
<tr>
<td>1) Raw observation data transmission</td>
<td></td>
</tr>
<tr>
<td>Ka-band, 18.1 - 18.4 GHz (downlink)</td>
<td></td>
</tr>
<tr>
<td>2) DCS</td>
<td></td>
</tr>
<tr>
<td>International channel</td>
<td></td>
</tr>
<tr>
<td>402.0 - 402.1 MHz (uplink)</td>
<td></td>
</tr>
<tr>
<td>Domestic channel</td>
<td></td>
</tr>
<tr>
<td>402.1 - 402.4 MHz (uplink)</td>
<td></td>
</tr>
<tr>
<td>Transmission to ground segments</td>
<td></td>
</tr>
<tr>
<td>Ka-band, 18.1 - 18.4 GHz (downlink)</td>
<td></td>
</tr>
<tr>
<td>3) Telemetry and command</td>
<td></td>
</tr>
<tr>
<td>Ku-band, 12.2 - 12.75 GHz (downlink)</td>
<td></td>
</tr>
<tr>
<td>13.75 - 14.5 GHz (uplink)</td>
<td></td>
</tr>
</tbody>
</table>

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

**Spatial**

At sub-satellite point

- VIS: 1 km
- IR: 4 km

MTSAT-1R/2  Himawari-8/9

**Spectral**

- VIS: 1 band
- IR: 4 bands
- NIR: 3 bands

**Temporal**

Observation Frequency

- MTSAT-1R/2: 60min. (full-disk obs.)
- Himawari-8/9: 10min.

- MTSAT-1R/2
- Himawari-8/9

- 5 bands
- 16 bands

**Note:**

- MTSA1-1R/2  Himawari-8/9
Spatial Resolution

MTSAT-2 (VIS)
1km

Himawari-8 (B03)
0.5 km

03:00 UTC on 29 January 2015
Eruption of Kuchinoerabujima, located south of Kyushu island in Japan, on 29 May 2015.

MTSAT-2 (VIS)
Every 30 min. (Japan area)

Himawari-8 (True Color)
Every 2.5 min. (Japan area)

Improved spatial and temporal resolution enhance capability of detecting and tracking volcanic ash clouds!
# 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 1 km</td>
<td>0.47 μm</td>
<td>vegetation, aerosol</td>
</tr>
<tr>
<td>2</td>
<td>Visible 1 km</td>
<td>0.51 μm</td>
<td>vegetation, aerosol</td>
</tr>
<tr>
<td>3</td>
<td>0.5 km</td>
<td>0.64 μm</td>
<td>low cloud, fog</td>
</tr>
<tr>
<td>4</td>
<td>Near Infrared 1 km</td>
<td>0.86 μm</td>
<td>vegetation, aerosol</td>
</tr>
<tr>
<td>5</td>
<td>Near Infrared 2 km</td>
<td>1.6 μm</td>
<td>cloud phase</td>
</tr>
<tr>
<td>6</td>
<td>Near Infrared 2 km</td>
<td>2.3 μm</td>
<td>particle size</td>
</tr>
<tr>
<td>7</td>
<td>Infrared 2 km</td>
<td>3.9 μm</td>
<td>low cloud, fog, forest fire</td>
</tr>
<tr>
<td>8</td>
<td>Infrared 2 km</td>
<td>6.2 μm</td>
<td>mid- and upper-level moisture</td>
</tr>
<tr>
<td>9</td>
<td>Infrared 2 km</td>
<td>6.9 μm</td>
<td>mid-level moisture</td>
</tr>
<tr>
<td>10</td>
<td>Infrared 2 km</td>
<td>7.3 μm</td>
<td>mid- and lower-level moisture</td>
</tr>
<tr>
<td>11</td>
<td>Infrared 2 km</td>
<td>8.6 μm</td>
<td>cloud phase, SO2</td>
</tr>
<tr>
<td>12</td>
<td>Infrared 2 km</td>
<td>9.6 μm</td>
<td>ozone content</td>
</tr>
<tr>
<td>13</td>
<td>Infrared 2 km</td>
<td>10.4 μm</td>
<td>cloud imagery, information of cloud top</td>
</tr>
<tr>
<td>14</td>
<td>Infrared 2 km</td>
<td>11.2 μm</td>
<td>cloud imagery, sea surface temperature</td>
</tr>
<tr>
<td>15</td>
<td>Infrared 2 km</td>
<td>12.4 μm</td>
<td>cloud imagery, sea surface temperature</td>
</tr>
<tr>
<td>16</td>
<td>Infrared 2 km</td>
<td>13.3 μm</td>
<td>cloud top height</td>
</tr>
</tbody>
</table>

**Notes:**
- **3 Visible Bands**
- **Addition of NIR Bands**
- **Increase of WV Bands**
- **Increase of TIR Bands**
**Improved resolutions achieved by Himawari-8**

- **Spatial** (AHI resolution)
- **Temporal** (Observation Frequency)
- **Spectral** (Number of AHI bands)

**Expected improvements in volcanic ash monitoring**

- Sophistication of detecting and tracking volcanic ash clouds
- Enhancement of precision in retrieving quantitative information
RGB Composite Imagery

Full-color imagery which implements the information of 3 different channels or combined channels and mark each part in red, green and blue color.

<table>
<thead>
<tr>
<th>Channel</th>
<th>Range</th>
<th>Gamma</th>
</tr>
</thead>
<tbody>
<tr>
<td>Red</td>
<td>12.0 - 10.8 K</td>
<td>1.0</td>
</tr>
<tr>
<td>Green</td>
<td>10.8 - 10.7 K</td>
<td>1.0</td>
</tr>
<tr>
<td>Blue</td>
<td>10.8</td>
<td>1.0</td>
</tr>
</tbody>
</table>

Interpretation of Colours:

- Cold, thick, high-level clouds
- Thin Cirrus clouds or Contrails
- Volcanic SO₂ clouds
- Volcanic Ash clouds

Increase of available spectral bands leads to improvements of volcanic ash cloud detection capability!

Continuous eruption of Mt. Raung, Indonesia on 13 July 2015
Volcanic Ash Products of JMA

**JMA+EUMETSAT Algorithm (for MTSAT-1R/2)**

- Yukio Kurihara developed the algorithm based on look-up tables provided by EUMETSAT
- Output: cloud top height, AOD, effective radius, mass loading, probability
- Products are experimentally provided to Tokyo VAAC for evaluation and verification

**NOAA/NESDIS Algorithm (for Himawari-8/9)**

- Developed as a software package named VOLCAT (VOLcanic Cloud Analysis Toolkit) by NOAA/NESDIS
- Utilize combination of several techniques to identify volcanic ash (and dust) clouds
- Output: cloud top height, AOD, effective radius, mass loading, probability
- Implementation into JMA/MSC system is in progress
- Outputs will be experimentally provided to Tokyo VAAC for evaluation and verification

Many thanks to Dr. Pavolonis and Dr. Sieglaff!
Features of VOLCAT

- The Spectrally Enhanced Cloud Objects algorithm※ is adopted
- Globally applicable (day and night)
- Wide range of low earth orbit and geostationary satellite sensors and combinations of them can be supported as inputs
- Identify volcanic ash clouds with a very low false alarm rate

※ References (Most recent)
Eruption of Kuchinoerabujima on 29 May 2015.

Height

AOD
Volcanic plumes (eruption column), especially those reach the stratosphere, are difficult to detect as volcanic ash clouds.

- Optically thick cloud has no signal in brightness temperature difference (BTD) as volcanic ash, and cannot distinguish from deep cumulonimbus (Cb) clouds.

While the eruption occurs around 17 UTC (analysis by Darwin VAAC), JMA+EUMETSAT product cannot detect volcanic ash cloud until BTD becomes negative at 20 UTC.
Idea:
Using cloud vertical growth information from time-series satellite data

Time scale: several to several tens of minutes
Available only from high observation-frequency satellite data like those by Himawari-8!

Fast!
Volcanic Plume Detection by Cloud Vertical Growth Information

Eruption of Mt. Manam, Papua New Guinea on 31 May 2015.

**Eruption Column**

65000FT (19800 m a.s.l.)
Future Plan

- **Replacement of ancillary data**
  - SST: Daily MGDSST by JMA
  - LST: GSM forecast by JMA
  - Atmospheric Profiles: GSM forecast by JMA

- **Experimental provision to Tokyo VAAC**
  - Evaluation and Validation
  - Feedback to NOAA/NESDIS for further improvement

- **Intercomparison environment**
  - Different algorithms
  - Different parameter settings
  - Different ancillary data
Introduction to Himawari-8

- Remarkable advantage in resolutions
  - Spatial (AHI resolution)
  - Temporal (Observation Frequency)
  - Spectral (Number of AHI bands)

Applications to Volcanic Ash Cloud Monitoring

- Himawari-8 can greatly contribute improvements on volcanic ash cloud monitoring and analysis
  - Detection and tracking
  - Retrieval of quantitative information (height, AOD, etc.)
- NOAA/NESDIS algorithm is adopted for Himawari-8 volcanic ash product of JMA/MSC
- Volcanic plumes can be detected by use of cloud vertical growth information
End

Thank you for your kind attention!