Characterization of GK2A AMI IR Channels through inter-comparison with geostationary satellite

Yeonjin Lee; Myoung-Hwan Ahn; Taemyoung Kim
Ewha Womans University, Seoul, Korea
Contents

• Introduction
  - Backgrounds
  - Objectives

• Data and methodology

• Results and discussion
  - Performance of AMI infrared channels
  - Differences characteristics as a function of the AMI satellite zenith angle
  - Diurnal variation of the differences

• Summary
Backgrounds

Backgrounds

- Geostationary Korea Multi-Purpose Satellite – 2A (GK2A) was successfully launched in December 4, 2018.

- The Advanced Meteorological Imager (AMI), an imaging instrument onboard the GK2A, considerably improved in temporal, spatial, and spectral resolutions over its predecessors (MI).

- The AMI has a total of 16 channels ranging from 0.47 to 13.3 $\mu$m.

- The instrument is capable of generating full disk (FD) imagery every 10 minutes with the spatial resolution of 0.5 km or 1 km for visible and 2 km for the infrared channels.

- The AMI operationally has been used since July 25th, 2019 after the verification through both ground and in-orbit test.

<table>
<thead>
<tr>
<th>CH</th>
<th>Band name</th>
<th>COMS MI Center $\lambda$ (µm)</th>
<th>Resolution (km)</th>
<th>Geo-KOMPSAT-2A AMI Center $\lambda$ (µm)</th>
<th>Resolution (km)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>VIS0.4</td>
<td>0.47</td>
<td>1</td>
<td>0.64</td>
<td>0.5</td>
</tr>
<tr>
<td>2</td>
<td>VIS0.5</td>
<td>0.51</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>VIS0.6</td>
<td>0.675</td>
<td>1</td>
<td>0.64</td>
<td>0.5</td>
</tr>
<tr>
<td>4</td>
<td>VIS0.8</td>
<td>0.86</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>NIR1.3</td>
<td>1.37</td>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>NIR1.6</td>
<td>1.61</td>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>IR3.8</td>
<td>3.75</td>
<td>4</td>
<td>3.83</td>
<td>2</td>
</tr>
<tr>
<td>8</td>
<td>IR6.3</td>
<td>6.18</td>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>IR6.9</td>
<td>6.75</td>
<td>4</td>
<td>6.94</td>
<td>2</td>
</tr>
<tr>
<td>10</td>
<td>IR7.3</td>
<td>7.32</td>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>IR8.7</td>
<td>8.58</td>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>IR9.6</td>
<td>9.62</td>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>IR10.5</td>
<td>10.8</td>
<td>4</td>
<td>10.4</td>
<td>2</td>
</tr>
<tr>
<td>14</td>
<td>IR11.2</td>
<td>11.2</td>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>IR12.3</td>
<td>12.0</td>
<td>4</td>
<td>12.3</td>
<td>2</td>
</tr>
<tr>
<td>16</td>
<td>IR13.3</td>
<td>13.3</td>
<td>2</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Comparison of the spectral characteristics between MI and AMI.
Objectives

◆ GEO-GEO inter-comparison

❖ Inter-comparison of the GK2A AMI IR channels and an instrument of the neighboring geostationary satellite—Advanced Himawari Imager (AHI) onboard the Himawari-8

① To assess radiometric calibration accuracy of GK2A AMI

② To characterize the brightness temperature (Tb) of GK2A AMI

③ To monitor continuously the performance of GK2A AMI
Data and methodology

◆ Inter-comparison of the AMI and AHI

<table>
<thead>
<tr>
<th>CH</th>
<th>Band name</th>
<th>GK-2A/AMI Center λ (μm)</th>
<th>Resolution (km)</th>
<th>Himawari-8/AHI Center λ (μm)</th>
<th>Resolution (km)</th>
</tr>
</thead>
<tbody>
<tr>
<td>7</td>
<td>IR3.8</td>
<td>3.83</td>
<td>2</td>
<td>3.85</td>
<td>2</td>
</tr>
<tr>
<td>8</td>
<td>IR6.3</td>
<td>6.18</td>
<td>2</td>
<td>6.24</td>
<td>2</td>
</tr>
<tr>
<td>9</td>
<td>IR6.9</td>
<td>6.94</td>
<td>2</td>
<td>6.94</td>
<td>2</td>
</tr>
<tr>
<td>10</td>
<td>IR7.3</td>
<td>7.32</td>
<td>2</td>
<td>7.35</td>
<td>2</td>
</tr>
<tr>
<td>11</td>
<td>IR8.7</td>
<td>8.58</td>
<td>2</td>
<td>8.59</td>
<td>2</td>
</tr>
<tr>
<td>12</td>
<td>IR9.6</td>
<td>9.62</td>
<td>2</td>
<td>9.64</td>
<td>2</td>
</tr>
<tr>
<td>13</td>
<td>IR10.5</td>
<td>10.4</td>
<td>2</td>
<td>10.40</td>
<td>2</td>
</tr>
<tr>
<td>14</td>
<td>IR11.2</td>
<td>11.2</td>
<td>2</td>
<td>11.2</td>
<td>2</td>
</tr>
<tr>
<td>15</td>
<td>IR12.3</td>
<td>12.3</td>
<td>2</td>
<td>12.4</td>
<td>2</td>
</tr>
<tr>
<td>16</td>
<td>IR13.3</td>
<td>13.3</td>
<td>2</td>
<td>13.3</td>
<td>2</td>
</tr>
</tbody>
</table>

Comparison of the spectral characteristics between AMI and AHI IR bands

The observation region for AMI and AHI and the longitude line of 134.45°E

❖ Collocated dataset

<table>
<thead>
<tr>
<th>Location</th>
<th>the point pixels along the 134.45°E</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time difference</td>
<td>&lt; 1 min.</td>
</tr>
<tr>
<td>Satellite zenith angle difference</td>
<td>$\left</td>
</tr>
<tr>
<td>Uniformity test</td>
<td>STDV (Tbs within 5*5 pixels of CH14) &lt; 0.9 K</td>
</tr>
<tr>
<td>Constraint conditions</td>
<td>limits of ≤ 60° in sat zenith and only ocean</td>
</tr>
</tbody>
</table>

* Calibration performance of Himawari-8/AHI IR Bands (vs. Metop-A/IASI): very small (~0.2 K at standard scene) and stable (Okuyama, Arata, et al., 2015)
Performance of AMI infrared channels

◆ AMI SRF vs. AHI SRF

Inter-comparison results (bias: AHI Tb – AMI Tb)

<table>
<thead>
<tr>
<th>Period</th>
<th>#col</th>
<th>diff</th>
<th>CH08</th>
<th>CH09</th>
<th>CH10</th>
<th>CH11</th>
<th>CH12</th>
<th>CH13</th>
<th>CH14</th>
<th>CH15</th>
<th>CH16</th>
</tr>
</thead>
<tbody>
<tr>
<td>20190613-0723 (before operation)</td>
<td>142638</td>
<td></td>
<td>-0.43</td>
<td>-0.01</td>
<td>0.16</td>
<td>-0.01</td>
<td>0.08</td>
<td>-0.05</td>
<td>-0.02</td>
<td>-0.18</td>
<td>0.50</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>RMSD</td>
<td></td>
<td></td>
<td></td>
<td>RMSD</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Bias</td>
<td>-0.42</td>
<td>-0.01</td>
<td>0.19</td>
<td>-0.02</td>
<td>0.07</td>
<td>-0.05</td>
<td>-0.02</td>
<td>-0.18</td>
<td>0.49</td>
</tr>
<tr>
<td></td>
<td></td>
<td>RMSD</td>
<td>0.51</td>
<td>0.28</td>
<td>0.36</td>
<td>0.32</td>
<td>0.20</td>
<td>0.35</td>
<td>0.32</td>
<td>0.37</td>
<td>0.56</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(-3.77%)</td>
<td>(-15.15%)</td>
<td>(-7.69%)</td>
<td>(-13.51%)</td>
<td>(-16.67%)</td>
<td>(-14.63%)</td>
<td>(-15.79%)</td>
<td>(-9.76%)</td>
<td>(-3.45%)</td>
</tr>
<tr>
<td>20190725-1127 (after operation)</td>
<td>416311</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Performance of AMI infrared channels

◆ Tb simulation by a radiative transfer model

- The AHI and AMI Tb are simulated by using RTTOV v12.3 from the GDAPS analysis

- Inter-comparison results (bias: AHI Tb – AMI Tb)
  - Period: 20190801-20190831 (00/06/12/18 UTC)
  - Collocation condition:
    - Longitude and latitude distance between 134.45°E and AMI pixel: < 0.01 degree
    - 3×3 FOV (for all sea and clear sky condition)
    - STDV of AMI Tb(11.2) < 0.7 K, STDV of AHI Tb(11.2) < 0.7 K

<table>
<thead>
<tr>
<th>dataset</th>
<th>#col</th>
<th>diff</th>
<th>CH08</th>
<th>CH09</th>
<th>CH10</th>
<th>CH11</th>
<th>CH12</th>
<th>CH13</th>
<th>CH14</th>
<th>CH15</th>
<th>CH16</th>
</tr>
</thead>
<tbody>
<tr>
<td>Observed Tb difference</td>
<td>96000</td>
<td>Bias</td>
<td>-0.42</td>
<td>-0.03</td>
<td>0.28</td>
<td>-0.01</td>
<td>0.05</td>
<td>-0.12</td>
<td>-0.04</td>
<td>-0.24</td>
<td>0.58</td>
</tr>
<tr>
<td>Simulated Tb difference</td>
<td>96000</td>
<td>RMSD</td>
<td>0.49</td>
<td>0.22</td>
<td>0.37</td>
<td>0.30</td>
<td>0.23</td>
<td>0.33</td>
<td>0.30</td>
<td>0.36</td>
<td>0.62</td>
</tr>
<tr>
<td>Observed Tb difference</td>
<td>96000</td>
<td>Bias</td>
<td>-0.30</td>
<td>-0.06</td>
<td>0.22</td>
<td>0.06</td>
<td>0.31</td>
<td>0.00</td>
<td>-0.02</td>
<td>-0.08</td>
<td>0.41</td>
</tr>
<tr>
<td>Simulated Tb difference</td>
<td>96000</td>
<td>RMSD</td>
<td>0.05</td>
<td>0.01</td>
<td>0.14</td>
<td>0.04</td>
<td>0.03</td>
<td>0.08</td>
<td>0.05</td>
<td>0.02</td>
<td>0.03</td>
</tr>
</tbody>
</table>

- The difference between the simulated AMI and AHI Tb is coming from only the SRF difference.
- The result from comparing AHI with AMI applied by the SRF correction factor will be improved, especially for CH08 and CH16.

Credit: Su Jeong Lee
Differences characteristics as a function of the AMI satellite zenith angle

- Differences as a function of the AMI satellite zenith angle
  - Period: 20190725-1127 (00/06/12/18 UTC)

- The AMI TB and AHI TB decrease as the satellite zenith angle increases.
- The overall biases (AHI Tb – AMI Tb) tend to increase as the satellite zenith angle increases (except for CH 07 and CH10).
- The differences of all channels show the seesaw pattern.

Distribution of TBs and differences as a function of the AMI satellite zenith angle (averaging within 0.5 deg)
The diurnal variation of the differences is very stable (varying within 0.05 K) except for CH7.

There is slight deviation of about 0.1 K during the satellite midnight time period (about 0.2 K in the SW channel).
Diurnal variation of the differences

Midnight time period (1200 to 1750 UTC)

The relative positions among the sun, satellites, and the earth can affect these patterns due to the direct incident solar radiation during the satellite midnight period.
The overall Tb differences between AHI and AMI are within 0.5 K, in between −0.42 and 0.49 K. The largest negative (positive) difference is at the channel 8 (channel 16) with about −0.42 (0.49) K which corresponds to the shortest water vapour (carbon dioxide) channel.

The difference between the simulated AMI and AHI TB is coming from only the SRF difference. The result from comparing AHI with AMI applied by the SRF correction factor will be improved, especially for CH08 and CH16.

The differences tend to increase as the satellite zenith angle increases (except for CH7 and 10) The differences of all channels show the seesaw pattern (especially, in CH16 due to the striping problem).

The diurnal variation of the differences is also very stable (varying within 0.05 K), although there is slight deviation of about 0.1 K (about 0.2 K in the SW channel) during the satellite midnight time period.

The relative positions among the sun, satellites, and the earth can affect these patterns due to the direct incident solar radiation during the satellite midnight period.
Thank you 😊

If you have any questions and comments, Send me e-mail please
►duswIsl7609@daum.net◄
Backup slides
Pseudo-AHI considered the SRF differences based on the radiative transfer computation

- Spectral Band Adjustment Factor (SBAF), a calculator from the IR hyperspectral data (IASI), is developed by NASA

- Conditions of the SBAF
  - Region: Tropical Western Pacific (TWP)
  - Period: July, October
  - Land use: 0% (sea: 100%)
  - Fitting function: linear fitting

### SBAF AHI/AMI coefficients (slope and offset) for AHI/AMI bands

<table>
<thead>
<tr>
<th>#Ch</th>
<th>slope</th>
<th>intercept</th>
<th>#Ch</th>
<th>slope</th>
<th>intercept</th>
</tr>
</thead>
<tbody>
<tr>
<td>7</td>
<td>1.04</td>
<td>-12.40</td>
<td>12</td>
<td>1.01</td>
<td>-1.70</td>
</tr>
<tr>
<td>8</td>
<td>0.99</td>
<td>1.29</td>
<td>13</td>
<td>1.00</td>
<td>-0.75</td>
</tr>
<tr>
<td>9</td>
<td>1.00</td>
<td>0.23</td>
<td>14</td>
<td>1.00</td>
<td>-0.01</td>
</tr>
<tr>
<td>10</td>
<td>1.00</td>
<td>-0.36</td>
<td>15</td>
<td>1.00</td>
<td>0.00</td>
</tr>
<tr>
<td>11</td>
<td>1.00</td>
<td>-0.18</td>
<td>16</td>
<td>1.00</td>
<td>1.00</td>
</tr>
</tbody>
</table>
Performance of AMI infrared channels

**Pseudo-AHI considered the SRF differences based on the radiative transfer computation**

- Spectral Band Adjustment Factor (SBAF), a calculator from the IR hyperspectral data (IASI), is developed by NASA
- Before vs. after SBAF

![Graph](image)

**AHI Tb vs. Pseudo-AHI Tb**

- Ch16A: SBAF before the SRF shift (20190725-0926)
- Ch16B: SBAF after the SRF shift (20190928-1127)

*Limitation of the pseudo-AHI dataset: the factor using the limited region and period data*
CH 16 striping

Credit: Su Jeong Lee
Time series of the differences

Time series of the average differences over 1 hour intervals (20190613-1127)

SW (CH07)

WV (CH08)

window (CH13)

CO₂ (CH16)
약 96,000개
- 134.45E와 AMI 화소 경도 거리 < 0.01(deg)
- 134.45E와 AH1 화소 경도 거리 < 0.01(deg)
- 위에서 선택된 화소를 중심으로 두고 3x3FOV에 대해 아래 조건 체크

1. 9개 화소 모두 sea
2. STD of AMI TB(11.2) < 0.7 K, STD of AH1 TB(11.2) < 0.7 K
3. UMTB_AMI(14)-AMITB(14) < 3 K, UMTB_AHI(14)-AHITB(14) < 3 K
4. AMITB(14)-AMITB(8) > 40 K, AHITB(14)-AHITB(8) > 40 K

Credit: 이수정 박사님
AMI IR13.3μm SRF 변이에 따른 편차 비교결과

◆ L1A 16번 채널 SRF 업데이트

❖ L1A에서 16번 채널의 SRF관련 정보(0.8 μm 변이)
❖ AHI와 AMI TB의 상호비교

➢ 자료 기간: 20190725-0926/20190928-1127 (6시간 간격)

<table>
<thead>
<tr>
<th>기간</th>
<th>#col</th>
<th>오차</th>
<th>IR 13.3</th>
</tr>
</thead>
<tbody>
<tr>
<td>SRF 변이 전</td>
<td>212318</td>
<td>Bias</td>
<td>0.49</td>
</tr>
<tr>
<td></td>
<td></td>
<td>RMSD</td>
<td>0.56</td>
</tr>
<tr>
<td>(20190725-0926)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SRF 변이 후</td>
<td>203993</td>
<td>Bias</td>
<td>0.50</td>
</tr>
<tr>
<td></td>
<td></td>
<td>RMSD</td>
<td>0.56</td>
</tr>
<tr>
<td>(20190928-1127)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Performance of AMI infrared channels

◆ AMI SRF vs. AHI SRF

Spectral Response Function of AMI and AHI

Spectral response functions (SRFs) of AMI and AHI IR channels

❖ Inter-comparison results (bias: AHI Tb – AMI Tb)

<table>
<thead>
<tr>
<th>Period</th>
<th>#col</th>
<th>diff</th>
<th>CH07</th>
<th>CH08</th>
<th>CH09</th>
<th>CH10</th>
<th>CH11</th>
<th>CH12</th>
<th>CH13</th>
<th>CH14</th>
<th>CH15</th>
<th>CH16</th>
</tr>
</thead>
<tbody>
<tr>
<td>20190613-0723 (before operation)</td>
<td>142638</td>
<td>Bias</td>
<td>-0.82</td>
<td>-0.43</td>
<td>-0.01</td>
<td>0.16</td>
<td>-0.01</td>
<td>0.08</td>
<td>-0.05</td>
<td>-0.02</td>
<td>-0.18</td>
<td>0.50</td>
</tr>
<tr>
<td></td>
<td></td>
<td>RMSD</td>
<td>1.87</td>
<td>0.53</td>
<td>0.33</td>
<td>0.39</td>
<td>0.37</td>
<td>0.24</td>
<td>0.41</td>
<td>0.38</td>
<td>0.41</td>
<td>0.58</td>
</tr>
<tr>
<td>20190725-1127 (after operation)</td>
<td>416311</td>
<td>Bias</td>
<td>-0.67</td>
<td>-0.42</td>
<td>-0.01</td>
<td>0.19</td>
<td>-0.02</td>
<td>0.07</td>
<td>-0.05</td>
<td>-0.02</td>
<td>-0.18</td>
<td>0.49</td>
</tr>
<tr>
<td></td>
<td></td>
<td>RMSD</td>
<td>1.62</td>
<td>0.51</td>
<td>0.28</td>
<td>0.36</td>
<td>0.32</td>
<td>0.20</td>
<td>0.35</td>
<td>0.32</td>
<td>0.37</td>
<td>0.56</td>
</tr>
</tbody>
</table>

Center wavelength of AMI SRF and AHI SRF

<table>
<thead>
<tr>
<th>Channel</th>
<th>AMI center wavelength [μm]</th>
<th>AHI center wavelength [μm]</th>
<th>Difference [μm]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ch07</td>
<td>3.83</td>
<td>3.89</td>
<td>0.06</td>
</tr>
<tr>
<td>Ch08</td>
<td>6.18</td>
<td>6.24</td>
<td>0.06</td>
</tr>
<tr>
<td>Ch09</td>
<td>6.94</td>
<td>6.94</td>
<td>0.00</td>
</tr>
<tr>
<td>Ch10</td>
<td>7.33</td>
<td>7.35</td>
<td>0.02</td>
</tr>
<tr>
<td>Ch11</td>
<td>8.58</td>
<td>8.59</td>
<td>0.01</td>
</tr>
<tr>
<td>Ch12</td>
<td>9.62</td>
<td>9.64</td>
<td>0.02</td>
</tr>
<tr>
<td>Ch13</td>
<td>10.35</td>
<td>10.40</td>
<td>0.05</td>
</tr>
<tr>
<td>Ch14</td>
<td>11.21</td>
<td>11.24</td>
<td>0.03</td>
</tr>
<tr>
<td>Ch15</td>
<td>12.34</td>
<td>12.38</td>
<td>0.04</td>
</tr>
<tr>
<td>Ch16</td>
<td>13.28</td>
<td>13.28</td>
<td>0.00</td>
</tr>
</tbody>
</table>

TOGETHER. TOMORROW. EWHA
편차의 일주기 변동성 분석

◆ 일주기 변동성 분석을 위한 Stray light 영향분석
  ❖ B08 (wv063) AMI, AHI 10분 차이 영상 (동영상)

Difference of AHI Tb wv063 - 20190801 13:20-13:10 UTC
Difference of AMI Tb wv063 - 20190801 13:30-13:20 UTC
편차의 일주기 변동성 분석

◆ 자료 기간: 201907

 Bias between AHI TB and AMI TB (20190725-1023) - wv063

 Bias between AHI TB and AMI TB (20190725-1023) - wv069

 Bias between AHI TB and AMI TB (20190725-1023) - wv096

 Bias between AHI TB and AMI TB (20190725-1023) - ir087

 Bias between AHI TB and AMI TB (20190725-1023) - ir112

 Bias between AHI TB and AMI TB (20190725-1023) - ir105

 Bias between AHI TB and AMI TB (20190725-1023) - ir123

 Bias between AHI TB and AMI TB (20190725-1023) - ir133

 Bias between AHI TB and AMI TB (20190725-1023) - ir105