South Korea’s geostationary satellite cloud retrievals: current status and plans for GK-2A in 2017

2014. 3. 4.

1Yong-Sang Choi, 1Hye-Sil Kim, 1Min-Jae Kwon, 1Jungmin Park and 2Sung-Rae Chung

1Ewha Womans University
2National Meteorological Satellite Center/ Korea Meteorological Administration
Current status of COMS cloud products (2010-)
Sample Images
## Algorithms and theoretical bases

<table>
<thead>
<tr>
<th>Products</th>
<th>Retrieval Methods</th>
<th>References</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cloud mask</td>
<td>Single- or bi-spectral threshold tests</td>
<td>Ackerman et al. 1998</td>
</tr>
<tr>
<td>Cloud type</td>
<td>1. Single- or bi-spectral threshold tests, texture tests</td>
<td>Derrien and Le Gleau 2005</td>
</tr>
<tr>
<td></td>
<td>2. CTTH-COT combination (ISCCP)</td>
<td>Rossow and Schiffer 1999</td>
</tr>
<tr>
<td>Cloud fraction</td>
<td>Area average of pixel group</td>
<td>MODIS ATBD, Oh et al. 2006</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Acarreta et al. 2004, Kokhanovsky 2006, Choi et al. 2007 IJRS, Choi and Ho 2009 IJRS</td>
</tr>
<tr>
<td>Cloud optical thickness</td>
<td>Sun reflectance method (cloud-reflected intensity depends on phase) (0.6,3.7)</td>
<td>Ou et al. 1993, Platnick and Valero 1995, Nakajima and Nakajima 1995, King et al. 1997</td>
</tr>
<tr>
<td>effective particle radius</td>
<td>Sun reflectance method (cloud-reflected intensity depends on phase) (0.6, 3.7)</td>
<td>Choi et al. 2007 IJRS, Choi and Ho 2009 IJRS</td>
</tr>
<tr>
<td></td>
<td>2. Radiance ratioing method (6.7, 11)</td>
<td></td>
</tr>
</tbody>
</table>
## Products validation results
(for more details, see the poster “Inter-comparison of cloud parameters between COMS and MODIS” by Haklim Choi et al.)

<table>
<thead>
<tr>
<th></th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
<th>11</th>
<th>12</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>CTP (2011)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number</td>
<td>506,857</td>
<td>502,008</td>
<td>1,209,370</td>
<td>921,060</td>
<td>783,201</td>
<td>710,904</td>
<td>784,909</td>
<td>1,128,555</td>
<td>361,295</td>
</tr>
<tr>
<td>R</td>
<td>0.79</td>
<td>0.79</td>
<td>0.84</td>
<td>0.91</td>
<td>0.96</td>
<td>0.94</td>
<td>0.90</td>
<td>0.83</td>
<td></td>
</tr>
<tr>
<td><strong>CTP (2012)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number</td>
<td>262,406</td>
<td>2,463,000</td>
<td>2,070,112</td>
<td>698,029</td>
<td>1,648,162</td>
<td>1,928,098</td>
<td>777,082</td>
<td></td>
<td></td>
</tr>
<tr>
<td>R</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.81</td>
<td>0.86</td>
<td>0.94</td>
<td>0.94</td>
<td></td>
</tr>
<tr>
<td><strong>COT (2011)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number</td>
<td>7,186,928</td>
<td>5,120,114</td>
<td>5,655,369</td>
<td>5,680,796</td>
<td>4,755,212</td>
<td>4,896,736</td>
<td>967,176</td>
<td></td>
<td></td>
</tr>
<tr>
<td>R</td>
<td>0.07</td>
<td>0.09</td>
<td>0.09</td>
<td>0.09</td>
<td>0.10</td>
<td>0.09</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>COT (2012)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number</td>
<td>661,720</td>
<td>7,418,602</td>
<td>9,939,544</td>
<td>3,089,647</td>
<td>8,553,424</td>
<td>8,513,975</td>
<td>4,843,645</td>
<td></td>
<td></td>
</tr>
<tr>
<td>R</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.76</td>
<td>0.85</td>
<td>0.83</td>
<td>0.82</td>
<td></td>
</tr>
<tr>
<td><strong>CF (2011)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number</td>
<td>32,106,895</td>
<td>-</td>
<td>101,514,547</td>
<td>68,406,931</td>
<td>67,821,246</td>
<td>68,693,589</td>
<td>57,481,217</td>
<td>74,201,714</td>
<td>16,866,578</td>
</tr>
<tr>
<td>R</td>
<td>0.90</td>
<td>0.94</td>
<td>1.00</td>
<td>1.00</td>
<td>1.00</td>
<td>1.00</td>
<td>1.00</td>
<td>1.00</td>
<td></td>
</tr>
<tr>
<td><strong>CF (2012)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number</td>
<td>9,185,198</td>
<td>89,659,779</td>
<td>104,963,490</td>
<td>35,187,443</td>
<td>106,633,644</td>
<td>105,626,985</td>
<td>65,452,771</td>
<td></td>
<td></td>
</tr>
<tr>
<td>R</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1.00</td>
<td>1.00</td>
<td>1.00</td>
<td>1.00</td>
<td>1.00</td>
</tr>
</tbody>
</table>
GEO-KOMPSAT-2A (2018- )
Object
- Obtaining a geostationary meteorological satellite for continuous monitoring of meteorological phenomena
- Development of follow-on satellite for succession of COMS mission

Mission
- Continuing the COMS Meteorological Mission
- Improving the Severe Weather Monitoring
  - Higher frequency of observation
  - Retrieving the atmospheric structure (pseudo-sounding)
- Improving the support of the NWP model
  - Efficient data assimilation system
- Intensifying the environment & climate monitoring
  - Various surface information retrieval
  - Air pollution monitoring
  - Establishing long-term observation data
GEO-KOMPSAT-2 Program

-One for the next generation Meteorological Imager
-The other for the Ocean and Atmospheric Trace Gas monitoring

Launch: 2018
# GEO-KOMPSAT-2A Payload

## Meteorological payload

<table>
<thead>
<tr>
<th></th>
<th>GEO-KOMPSAT-2A</th>
<th>COMS</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Channels</strong></td>
<td>16</td>
<td>5</td>
</tr>
<tr>
<td><strong>Spatial Resolution (km)</strong></td>
<td>0.5, 1 (VIS), 2 (IR)</td>
<td>1 (VIS), 4 (IR)</td>
</tr>
<tr>
<td><strong>Temporal Resolution (min)</strong></td>
<td>10 (Full Disk)</td>
<td>25 (Full Disk)</td>
</tr>
<tr>
<td><strong>Data Rate (Mbps)</strong></td>
<td>~70</td>
<td>2.6</td>
</tr>
<tr>
<td><strong>Life time (years)</strong></td>
<td>10</td>
<td>7</td>
</tr>
<tr>
<td><strong>Main Purpose of use</strong></td>
<td>Weather Forecasting + NWP + CM</td>
<td>Weather Forecasting</td>
</tr>
</tbody>
</table>
## The Channels of GEO-KOMPSAT-2A

<table>
<thead>
<tr>
<th>Band No.</th>
<th>Band Name</th>
<th>Resolution (km)</th>
<th>Dynamic Range</th>
<th>Radiometric Accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>VIS0.4</td>
<td>1</td>
<td>0-720 W/m²/sr/um</td>
<td>5%</td>
</tr>
<tr>
<td>2</td>
<td>VIS0.5</td>
<td>1</td>
<td>0-710 W/m²/sr/um</td>
<td>5%</td>
</tr>
<tr>
<td>3</td>
<td>VIS0.6</td>
<td>0.5</td>
<td>0-620 W/m²/sr/um</td>
<td>5%</td>
</tr>
<tr>
<td>4</td>
<td>VIS0.8</td>
<td>1</td>
<td>0-320 W/m²/sr/um</td>
<td>5%</td>
</tr>
<tr>
<td>5</td>
<td>NIR1.3</td>
<td>2</td>
<td>0-114 W/m²/sr/um</td>
<td>5%</td>
</tr>
<tr>
<td>6</td>
<td>NIR1.6</td>
<td>2</td>
<td>0-77 W/m²/sr/um</td>
<td>5%</td>
</tr>
<tr>
<td>7</td>
<td>IR3.8</td>
<td>2</td>
<td>0-400 K</td>
<td>1 K</td>
</tr>
<tr>
<td>8</td>
<td>IR6.3</td>
<td>2</td>
<td>0-300 K</td>
<td>1 K(☝)</td>
</tr>
<tr>
<td>9</td>
<td>IR6.9</td>
<td>2</td>
<td>0-300 K</td>
<td>1 K</td>
</tr>
<tr>
<td>10</td>
<td>IR7.3</td>
<td>2</td>
<td>0-320 K</td>
<td>1 K(☝)</td>
</tr>
<tr>
<td>11</td>
<td>IR8.7</td>
<td>2</td>
<td>0-330 K</td>
<td>1 K</td>
</tr>
<tr>
<td>12</td>
<td>IR9.6</td>
<td>2</td>
<td>0-300 K</td>
<td>1 K</td>
</tr>
<tr>
<td>13</td>
<td>IR10.5</td>
<td>2</td>
<td>0-330 K</td>
<td>1 K</td>
</tr>
<tr>
<td>14</td>
<td>IR11.2</td>
<td>2</td>
<td>0-330 K</td>
<td>1 K</td>
</tr>
<tr>
<td>15</td>
<td>IR12.3</td>
<td>2</td>
<td>0-330 K</td>
<td>1 K</td>
</tr>
<tr>
<td>16</td>
<td>IR13.3</td>
<td>2</td>
<td>0-305 K</td>
<td>1 K</td>
</tr>
</tbody>
</table>

*COMS 5 channels (2010-)*

*calibration accuracy at max temperature ≤ 300K*
Plans for GK-2A cloud products
Expected algorithms and changes from COMS

Cloud Analysis

**COMS**

1. L1Sb radiance data, (5 channels) cloud detection, forecasted EBBT, satellite geometry, CLA results of previous repeat cycle
2. Scene type check
3. Clear-sky or cloudy
4. Clear-sky
   - Static dataset: static solar zenith angle thresholds
   - Static dataset: static CLA parameters for data comparison
   - Static dataset: static CLA thresholds, static CLA parameters
   - Solar zenith angle check
   - Data comparison with previous repeat cycle
   - Threshold determination
   - Determination of cloud optical thickness (COT), effective radius (ER), cloud top temperature & pressure (CTTP), cloud type (CT)
   - Quality check
   - CT, COT, ER, CTTP

   **END**

5. Cloudy
6. Cloudy
   - Static dataset: static solar zenith angle thresholds
   - Static dataset: static CLA parameters for data comparison
   - Static dataset: static CLA thresholds, static CLA parameters
   - Threshold determination
   - Determination of cloud optical thickness (COT), Effective radius (ER), cloud top temperature & pressure (CTTP), cloud type (CT), Convective cloud (CC)
   - Quality check
   - CT, COT, ER, CTTP, CC

   **END**

**GK-2A**

1. L1Sb radiance data, (16 channels) cloud detection, forecasted EBBT, satellite geometry, CLA results of previous repeat cycle
2. Scene type check
3. Clear-sky or cloudy
4. Clear-sky
   - Static dataset: static solar zenith angle thresholds
   - Static dataset: static CLA parameters for data comparison
   - Static dataset: static CLA thresholds, static CLA parameters
   - Solar zenith angle check
   - Data comparison with previous repeat cycle
   - Threshold determination
   - Determination of cloud optical thickness (COT), effective radius (ER), cloud top temperature & pressure (CTTP), cloud type (CT)
   - Quality check
   - CT, COT, ER, CTTP

   **END**

5. Cloudy
6. Cloudy
   - Static dataset: static solar zenith angle thresholds
   - Static dataset: static CLA parameters for data comparison
   - Static dataset: static CLA thresholds, static CLA parameters
   - Threshold determination
   - Determination of cloud optical thickness (COT), Effective radius (ER), cloud top temperature & pressure (CTTP), cloud type (CT), Convective cloud (CC)
   - Quality check
   - CT, COT, ER, CTTP, CC

   **END**

**Using 16 channels**
Ongoing studies for algorithm design

STREAMER Tests for cloud optical thickness (COT) & effective radius (ER) retrieval during daytime using three channels (3.7, 2.25, 1.61-µm)

$$\theta (\text{solar zenith angle}) = 60^\circ, \theta_0 (\text{satellite zenith angle}) = 60^\circ, \varphi (\text{relative azimuth angle}) = 0^\circ$$
Ongoing studies for algorithm design

STREAMER Tests for cloud optical thickness (COT) & effective radius (ER) retrieval during nighttime using three channels (10.8, 8.5, 12.0-µm)

\[ \theta (\text{solar zenith angle}) = 60^\circ, \theta_0 (\text{satellite zenith angle}) = 60^\circ, \varphi (\text{relative azimuth angle}) = 0^\circ \]
Ongoing studies for algorithm design

STREAMER Tests for cloud top property (CTP) at tropics/mid-latitude/arctic regions in summer using three channels (3.7, 9.6, 13.3-µm)

- Tropics
- Mid-latitude
- Arctic

Radiance ratio for CO₂ slicing method

\[ \frac{L_{108}^{obs} - L_{108}^{clr}}{L_{6.7}^{obs} - L_{6.7}^{clr}} = \int_{p_c}^{p_t} t_1(p,0) \frac{\partial B_1(p)}{\partial p} dp \]

Radiance ratio for COMS algorithm

\[ \frac{L_{108}^{obs} - L_{108}^{clr}}{L_{6.7}^{obs} - L_{6.7}^{clr}} = \frac{B_{108}[T(p_c)] - L_{108}^{clr}}{\int_{p_c}^{p_t} t_{6.7}(p,0) \frac{\partial B_{6.7}(p)}{\partial p} dp} \]
## Summary

<table>
<thead>
<tr>
<th>Products</th>
<th>Current retrieval methods for MI/COMS</th>
<th>Direction of Development for AMI/GK-2A</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cloud mask</td>
<td>Single- or bi-spectral threshold tests with 5 channels</td>
<td>Use all 16 channels, optimization</td>
</tr>
<tr>
<td>Cloud phase</td>
<td>IR trispectral algorithm (Absorptivity of ice and water)</td>
<td>Replace 6.7 µm with 8.7 µm channel, optimization</td>
</tr>
<tr>
<td>Cloud optical thickness &amp; effective radius</td>
<td>Sun reflectance method (cloud-reflected intensity depends on phase) with 0.6 and 3.7 µm</td>
<td>Replace 3.7 µm by 1.6, or 2.2 µm channels, optimization, Only daytime</td>
</tr>
<tr>
<td>Cloud top temperature and pressure</td>
<td>1. IR window channel estimate</td>
<td>Replace 6.7 µm with 13.3 µm channel for radiance ratioing, optimization</td>
</tr>
<tr>
<td>Cloud type</td>
<td>2. Radiance ratioing method</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1. Single- or bi-spectral threshold tests, texture tests</td>
<td>SEVIRI cloud type algorithm via the collaboration with NWC SAF, No ISCCP cloud type retrieved</td>
</tr>
<tr>
<td></td>
<td>2. CTTH-COT combination (ISCCP)</td>
<td></td>
</tr>
<tr>
<td>Cloud fraction</td>
<td>Averaging, hemispheric projection</td>
<td></td>
</tr>
<tr>
<td>Convective cloud</td>
<td></td>
<td>Threshold techniques with CTT</td>
</tr>
</tbody>
</table>
Thank You!

We welcome your cooperation, and hope to contribute.

CREW

ysc@ewha.ac.kr
Baseline cloud products

- **Cloud mask**
  - Existence and nonexistence of cloud with probability
- **Cloud type**
  - Cloud classification by optical thickness, top height, and textures
- **Cloud fraction**
  - Cloudiness in %
- **Cloud phase**
  - Thermodynamic cloud phase: Ice, liquid, and mixed phase
- **Cloud optical thickness and effective radius**
  - COT: A measure of cloud transparency, -\log(I / I_0)
  - ER: A weighted mean of the size distribution of cloud droplets.
    the ratio of the 3^{rd} to 2^{nd} moment of a droplet size distribution.
- **Cloud top temperature/pressure/height**
  - Cloud-top temperature (in K), pressure in (hPa), height (m)
References


Ongoing studies for algorithm design

STREAMER Tests for cloud top property (CTP) at mid-latitude using three channels (3.7/9.6/13.3-µm)

- **Summer (τ= 1)**
  - 13.3-µm /10.8- µm
  - 9.6-µm /10.8- µm
  - 3.7-µm /10.8- µm

- **Winter (τ= 1)**
  - 13.3-µm /10.8- µm
  - 9.6-µm /10.8- µm
  - 3.7-µm /10.8- µm

---

- water
- ice
Ongoing studies for algorithm design

STREAMER Tests for cloud top property (CTP) at mid-latitude using three channels (3.7/9.6/13.3-μm)

- **Summer (τ=50)**
  - 13.3-μm / 10.8-μm
  - 9.6-μm / 10.8-μm
  - 3.7-μm / 10.8-μm

- **Winter (τ=50)**
  - 13.3-μm / 10.8-μm
  - 9.6-μm / 10.8-μm
  - 3.7-μm / 10.8-μm
Expected algorithms and changes from COMS

Cloud Optical Thickness (COT) and Effective Radius (ER)

**COMS**

1. **START**
   - Scene type check

2. Clear-sky or cloudy
   - Clear-sky
     - Solar zenith angle check
     - Day or night
     - Day
     - Get ground-reflected radiances, and cloud- and ground-thermal radiances
       - \( L_i^{\text{sr}} \approx A_u L_i^{\text{sr}} (A_u = 1) \)
       - \( L_i^{\text{th}} \approx a \cdot L_{10,8}^{\text{obs}} + b \cdot L_{10,8}^{\text{obs}} + c \)

3. Cloudy
   - Day
     - Get decoupled radiances
       - \( L_{0.6} = r_0^{\text{obs}} - L_{0.6}^{\text{sr}} \)
       - \( L_{3.7} = L_{3.7}^{\text{obs}} - L_{3.7}^{\text{sr}} - L_{3.7}^{\text{th}} \)

4. COT and ER

5. **END**

**GK-2A**

1. **START**
   - Scene type check

2. Clear-sky or cloudy
   - Clear-sky
     - Solar zenith angle check

3. Cloudy
   - Solar zenith angle check
     - Day or night
     - Day
     - Rayleigh scattering adjustment

4. Get decoupled radiances
   - \( L_{0.6} = L_{0.6}^{\text{obs}} - L_{0.6}^{\text{sr}} \)
   - \( L_{1.6} = L_{1.6}^{\text{obs}} - L_{1.6}^{\text{sr}} \)

5. COT and ER

6. **END**
Expected algorithms and changes from COMS

Cloud Top Temperature/Pressure/Height (CTT, CTP, CTH)

START

Clear-sky or cloudy

Clear-sky

Offset table with sat. viewing angle from RIM

Vertical profile from NWP

CTP correction

BT 11 fitting

CTT

CTP/CTH

Ratio table with CTP at 2 channels from RIM

Vertical profile from NWP

Rationing method

CTP/CTH

CTT

Considering regional dependence

10.8μm

6.57, 10.8μm

END
Expected algorithms and changes from COMS

Cloud Top Temperature/Pressure/Height (CTT, CTP, CTH)

START

Clear-sky or cloudy

Clear-sky

Level 1b data (Radiance)

Offset table with sat. viewing angle from RTM

Vertical profile from NWP

CTP correction

BT 11 fitting

CTT

CTP/CTH

Ratio table with CTP at 2 channels from RTM

Vertical profile from NWP

Rationing method

CTP/CTH

CTT

10.8 μm

13.3, 10.8 μm

Considering regional, seasonal, cloud phase dependence

END
Expected algorithms and changes from COMS Cloud Type (CT)

START

Clear-sky

Clear-sky or cloudy

Cloudy

Day or night

Day

Night

Reflectance test 0.6

Simple IR test 10.8

Bispectral IR test 10.8-12.3, 3.75-10.8

Texture features test 0.6 and 10.8

Simple IR test 10.8

Bispectral IR test 10.8-12.3, 3.75-10.8

Opaques cloud

Opaque cloud

10.8 IR test

Very High

High

High

High

Semi-transparent thick/med/thin/above low clouds

END

Level 1b data (Radiance)

Clear-sky

1. Satellite zenith angle
2. Temperature (NWP) at 1000, 850, 700, 500 hPa
3. Land mask

RTM lookup tables for semi-transparency test, opaque cloud classification
Expected algorithms and changes from COMS

Cloud Type (CT)

1. Satellite zenith angle
2. Temperature (NWP) at 1000, 850, 700, 500 hPa
3. Land mask

RTM look-up tables for semi-transparency test, opaque cloud classification

Level 1b data (Radiance)

Clear-sky

Clear-sky or cloudy

Cloudy

Day or night

Day

Night

Day

Reflectance test 0.6

Simple IR test 10.8

Bispectral IR test 10.8-12.3, 3.75-10.8, 8.7-10.8

Texture features test 0.6 and 10.8

Night

Simple IR test 10.8

Bispectral IR test 10.8-12.3, 3.75-10.8, 8.7-10.8

Opaque cloud

Opaque cloud

Low fractional cloud

Semi-transparent thick/med/thin/above low clouds

10.8 IR test

Very High

High

High

High

Very low

END
Expected algorithms and changes from COMS

Convective Cloud (CC)

Several thresholds of CTT
-65°C : Hall & Harr, 1999
-58°C : Fu et al, 1990
-43°C : Hendon & woodbery, 1993
-40°C : Liu et al, 1995