Planning for the next generation geostationary satellites (GK-2A) of Korea Meteorological Administration (KMA)

Yunbok Lee & Geun-Hyeok Ryu
8th IPWG and 5th IWSSM JOINT WORKSHOP
PLANNING FOR THE NEXT GENERATION OF GEOSTATIONARY SATELLITES OF KMA

NMSC Goal

- To **operate timely** COMS, to gather reliable satellite data on weather and climate and to **deliver** them to other Agencies and countries.
GEO-KOMPSAT-2 program

<table>
<thead>
<tr>
<th>Sector</th>
<th>Satellite in Orbit</th>
<th>Operator</th>
<th>Location</th>
<th>Launch date</th>
<th>Payloads</th>
</tr>
</thead>
<tbody>
<tr>
<td>West Pacific</td>
<td>GEO-KOMPSAT-2A (GK-2A)</td>
<td>KMA</td>
<td>128.2°E</td>
<td>05/2018</td>
<td>Advanced Meteorological Imager (AMI)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Korea Space wEather Monitoring payload (KSEM)</td>
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<tr>
<td></td>
<td>GEO-KOMPSAT-2B (GK-2B)</td>
<td>MOF (Ministry of Ocean and Fisheries) ME (Ministry of Environment)</td>
<td>128.2°E</td>
<td>03/2019</td>
<td>Advanced Geostationary Ocean Colour Imager(GOCI-II)</td>
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<tr>
<td></td>
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<td></td>
<td></td>
<td></td>
<td>Geostationary Environmental Monitoring Spectrometer(GEMS)</td>
</tr>
</tbody>
</table>

The Schedule for GEO-KOMPSAT-2A and 2B program
GEO-KOMPSAT-2A AMI (Advanced Meteorological Imager)

- Multi-channel capacity: 16 channels
- Temporal resolution: within 10 minutes for Full Disk observation
- Flexibility for the regional area selection and scheduling
- Lifetime of meteorological mission: 10 years

<table>
<thead>
<tr>
<th>Bands</th>
<th>Center Wavelength (um)</th>
<th>Band Width (Max, um)</th>
<th>Resolution (km)</th>
<th>GOES-R (ABI)</th>
<th>Himawari-8 (AHI)</th>
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<tbody>
<tr>
<td>VNIR</td>
<td>VIS0.4 0.431</td>
<td>0.479 0.075</td>
<td>1</td>
<td>0.47</td>
<td>0.46</td>
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<tr>
<td></td>
<td>VIS0.5 0.5025</td>
<td>0.5175 0.0625</td>
<td>1</td>
<td>0.51</td>
<td></td>
</tr>
<tr>
<td></td>
<td>VIS0.6 0.625</td>
<td>0.66 0.125</td>
<td>0.5</td>
<td>0.64</td>
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<td>VIS0.8 0.8495</td>
<td>0.8705 0.0875</td>
<td>1</td>
<td>0.865</td>
<td>0.86</td>
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<td></td>
<td>NIR1.3 1.373</td>
<td>1.383 0.03</td>
<td>2</td>
<td>1.378</td>
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<tr>
<td></td>
<td>NIR1.6 1.601</td>
<td>1.619 0.075</td>
<td>2</td>
<td>1.61</td>
<td>1.6</td>
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<tr>
<td></td>
<td>NIR2.2 2</td>
<td>3.35 2</td>
<td>2</td>
<td>3.35</td>
<td>2.3</td>
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<tr>
<td>MWIR</td>
<td>IR3.8 3.74</td>
<td>3.96 0.5</td>
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<td>3.90</td>
<td>3.9</td>
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<td>IR6.3 6.061</td>
<td>6.425 1.038</td>
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<td>6.185</td>
<td>6.2</td>
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<tr>
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<td>IR6.9 6.89</td>
<td>7.01 0.5</td>
<td>2</td>
<td>6.95</td>
<td>7.0</td>
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<td>IR7.3 7.258</td>
<td>7.433 0.688</td>
<td>2</td>
<td>7.34</td>
<td>7.3</td>
</tr>
<tr>
<td></td>
<td>IR8.7 8.44</td>
<td>8.76 0.5</td>
<td>2</td>
<td>8.50</td>
<td>8.6</td>
</tr>
<tr>
<td>LWIR</td>
<td>IR9.6 9.543</td>
<td>9.717 0.475</td>
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<td>9.61</td>
<td>9.6</td>
</tr>
<tr>
<td></td>
<td>IR10.5 10.25</td>
<td>10.61 0.875</td>
<td>2</td>
<td>10.35</td>
<td>10.4</td>
</tr>
<tr>
<td></td>
<td>IR11.2 11.08</td>
<td>11.32 1.0</td>
<td>2</td>
<td>11.2</td>
<td>11.2</td>
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<tr>
<td></td>
<td>IR12.3 12.15</td>
<td>12.45 1.25</td>
<td>2</td>
<td>12.3</td>
<td>12.3</td>
</tr>
<tr>
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<td>IR13.3 13.21</td>
<td>13.39 0.75</td>
<td>2</td>
<td>13.3</td>
<td>13.3</td>
</tr>
</tbody>
</table>
Observation Area and Schedule

- **Full Disk**
- **Regional Area (RA)**: 6200 X 5900 km (EW X NS) (TBD)
- **Extended Local Area (ELA)**: 4300 X 2900 km (EW X NS) (TBD)
  - Plan 1: Full Disk (1) + ELA (4) / 10 minutes
  - Plan 2: Full disk (1) + RA (2) / 10 minutes
The algorithm prototype of 23 (primary) products have developed by 4 algorithm groups and 29 (secondary) products will be developed by the end of 2016. MODIS, SEVIERI, COMS, and AHI data are used as proxies to evaluate each algorithm.
### Detailed 52 meteorological products

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Cloud detection</td>
<td>Cloud Top Temperature</td>
<td>Aerosol Detection</td>
<td>Atmospheric Motion Vector</td>
</tr>
<tr>
<td>Snow Cover</td>
<td>Cloud Top Pressure</td>
<td>Aerosol Optical Depth</td>
<td>Vertical Temperature Profile</td>
</tr>
<tr>
<td>Sea Ice Cover</td>
<td>Cloud Top Height</td>
<td>Asian Dust Detection</td>
<td>Vertical Moisture Profile</td>
</tr>
<tr>
<td>Fog</td>
<td>Cloud Type</td>
<td>Asian Dust Optical Depth</td>
<td>Stability Index</td>
</tr>
<tr>
<td>Sea Surface Temperature</td>
<td>Cloud Phase</td>
<td>Aerosol Particle Size</td>
<td>Total Precipitable Water</td>
</tr>
<tr>
<td>Land Surface Temperature</td>
<td>Cloud Amount</td>
<td>Volcanic Ash Detection and Height</td>
<td>Tropopause Folding Turbulence</td>
</tr>
<tr>
<td>Surface Emissivity</td>
<td>Cloud Optical Depth</td>
<td>Visibility</td>
<td>Total Ozone</td>
</tr>
<tr>
<td>Surface Albedo</td>
<td>Cloud Effective Radius</td>
<td>Radiances</td>
<td>SO₂ Detection</td>
</tr>
<tr>
<td>Fire Detection</td>
<td>Cloud Liquid Water Path</td>
<td>Downward SW Radiation (SFC)</td>
<td>Convective Initiation</td>
</tr>
<tr>
<td>Vegetation Index</td>
<td>Cloud Ice Water Path</td>
<td>Reflected SW Radiation (TOA)</td>
<td>Overshooting Top Detection</td>
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<tr>
<td>Vegetation Green Fraction</td>
<td>Cloud Layer/Height</td>
<td>Absorbed SW Radiation (SFC)</td>
<td>Aircraft Icing</td>
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<tr>
<td>Snow Depth</td>
<td>Rainfall Rate</td>
<td>Upward LW Radiation (TOA)</td>
<td></td>
</tr>
<tr>
<td>Current</td>
<td>Rainfall Potential</td>
<td>Downward LW Radiation (SFC)</td>
<td></td>
</tr>
<tr>
<td>Probability of Rainfall</td>
<td></td>
<td>Upward LW Radiation (SFC)</td>
<td></td>
</tr>
</tbody>
</table>
52 Meteorological Products

● Development Schedule(2014~2018)
  • 2014-2016 : Algorithm Development
  • 2017-2018 : Validation and Integration of Algorithm for Operation

● 4 Algorithm Groups
  • Cloud and Precipitation
  • Scene analysis and Surface information
  • Radiation and Aerosol
  • Atmosphere and Aviation

● Goal & Strategy
  • “more accurate, consistent, reliable” meteorological products
  • “optimal estimation” for consistency within products
  • “artificial intelligence” for improvement of some products accuracy
  • “algorithm test-bed” for optimizing scientific algorithm to operation system
  • “international review team” for improvement of the algorithm development
Application areas

- To be designed to maximize the utilization of the satellite products for forecasters and NWP

<table>
<thead>
<tr>
<th>Areas</th>
<th>Contents</th>
</tr>
</thead>
</table>
| Nowcasting                | • Cloud analysis  
• Heavy rainfall and snowfall analysis  
• QPF                                                                                                                                 |
| Typhoon & Ocean           | Typhoon analysis system based on Satellite SST, red tide, freezing over the ocean  
3D Winds analysis          |
| Hydrology & SFC           | Soil moisture, Drought and Floods, Fire detection  
Fine Dust analysis  
Verification, grid and image composite technique |
| Climate & Environmental Monitoring | Aerosol concentration, height, vertical distribution  
Greenhouse gases, atmospheric composition  
Energy budget, Air Quality model applications, Volcanic Ash |
Drought

- **Goal**: Drought determination using VHI (Vegetation Health Index)
- **Procedure**
  - Improvement of sensitive variable in order to explain vegetation stress by VHI
  - Considering seasonal and individual vegetation difference with respect to change weight of VHI and TCI (Temperature Condition Index)

\[ \text{The algorithm will be developed by using both GK2A and GK2B data} \]

Support Comprehensive Drought information systems of KMA
Goal: Flooding real-time monitoring

Procedure
- Using analysis technique development of GK-2A RGB and Reflection

(Left) RGB composite, (right) detection of flooding region on Feb. 19, 2010 from Ireland et al., 2015
**Forest Fire**

- **Goal**: Forest fire detection, vulnerability, damage area

- **Procedure**
  - FRP (fire radiative power): fire power and forest map $\rightarrow$ guess biomass loss $\rightarrow$ estimate fire emission
  - Vulnerability: Nesterov Index (NI) \( NI = \sum_{i=1}^{w} (T_i - T_{idew})T_i \)
  - Damage area: \( dNBR = \text{Prefire (NBR)} - \text{PostFire (NBR)} \)
Aerosol

- **Goal**: Aerosol density and height
- **Procedure**
  - Aerosol height estimated by statistical regression equation model using aerosol optical depth, surface observation, other metrological element
  - Aerosol height algorithm based O4 AMF (air mass factor)
Volcanic Ash

- Goal: Detect volcanic eruption and ash movement
- Procedure
  - Day: $BT_{11} < 290$, $BTD_{11-12} < -0.5$, $TVAP > 70$, $\rho_{3.9}/\rho_{0.66} > 0.6$
  - Night: $BT_{11} < 290$, $BTD_{11-12} < -0.5$, $TVAP > 70$  
    (Lee et al., 2014, 2015)

Mt. Shinmoedake eruption, Japan  
(26 Jan 2011)

MODIS
Evapotranspiration

\[ \text{evapotranspiration} = \text{transpiration} + \text{evaporation} \]

\[ \text{transpiration} \]

\[ \text{trees} \quad \text{grass} \]

\[ \text{evaporation} \]

\[ \text{runoff} \]

\[ \text{groundwater recharge} \]

\[ R_n = LE + H + G \]

\[ \Rightarrow LE = R_n - H \]

\[ H = \rho \cdot c_p \frac{(T_s - T_a)}{r_a} \]

- **Comparison of evapotranspiration**
  - a) Daily
  - b) 7days(±3) average
  - c) Synthetic daily

- **Scatter plot (2013.3.4)**
  - a) 7days(±3) average
  - b) Synthetic daily

- **Annual output rate**
  - a) daily
  - b) Synthetic daily

<table>
<thead>
<tr>
<th>7days(±3) average</th>
<th>Synthetic daily</th>
</tr>
</thead>
<tbody>
<tr>
<td>RMSD</td>
<td>0.928</td>
</tr>
<tr>
<td>Bias</td>
<td>0.574</td>
</tr>
</tbody>
</table>

**Improve the Algorithm with coefficients and input data (2016)**
Summary

Resolution **4 times**
- COMS VIS 1km
- IR 4km
- Geo-KOMPSAT-2A VIS 0.5~1km
- IR 2km

Freq. of obs. **5 times**
- 1 HR
- Global 1 time
- Region 2 times
- Korea 4 times
- 4 FM
- More than 10 times
- Every 2 minutes

# of channels **3 times**
- VIS
  - COMS 1 channel (B/W)
  - Geo-KOMPSAT-2A 4 channels (colors)
- NIR
  - COMS 2 channels
  - Geo-KOMPSAT-2A 10 channels
- IR
  - COMS 5 Ch.
  - Geo-KOMPSAT-2A 16 Ch.

Products **3.5 times**
- VIS
  - COMS 16 types
  - Geo-KOMPSAT-2A 52 types
- IR
  - COMS 4 channels
  - Geo-KOMPSAT-2A 16 Ch.
- Atmos. motion
  - COMS 3->6 types
  - Geo-KOMPSAT-2A 5->19 types
- Surface Info.
  - COMS 3->11 types
  - Geo-KOMPSAT-2A 5->16 types
- Rad./Aero.
  - COMS 5->16 types
  - Geo-KOMPSAT-2A 5->19 types
Thank you

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Acronym

- KIOST : Korea Institute of Ocean Science and Technology (한국해양과학기술원)
- DCPC : Data Collection or Production Centre (slide 3)
- CHL : Chlorophyll (slide 4)
- CDOM : Colored Dissolved Organic Matter (slide 4)
- OBPG : Ocean Biology Processing Group (slide 4)
- UCAR : UCAR - University Corporation for Atmospheric Research (slide 4)
- GNSS-RO : Global Navigation Satellite System-radio occultation (slide 5)
- MODIS : Moderate Resolution Imaging Spectroradiometer (slide 9)
  NOAA Terra, Aqua 위성에 탑재
- SEVERI : Spinning Enhanced Visible and Infrared Imager (slide 9)
  EUMETSAT의 MSG 위성시리즈에 탑재
- AHI : Advanced Himawari Imager (slide 9)
  일본 정지궤도기상위성 Himawari-8/-9에 탑재
- TEMPO : Tropospheric Emissions: Monitoring of Pollution (slide 9)
**GEO-KOMPSAT-2A Data Service Plan**

**[Via GK-2A broadcast]**
- Broadcast all 16 channels data (UHRIT) of meteorological observations
- Maintain L/HRIT broadcast corresponding to COMS five channels

<table>
<thead>
<tr>
<th>Categories</th>
<th>UHRIT</th>
<th>COMS-like H/LRIT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Service</td>
<td></td>
<td>HRIT</td>
</tr>
<tr>
<td>Data Rate</td>
<td>≤ 31 Mbps</td>
<td>3 Mbps</td>
</tr>
<tr>
<td></td>
<td></td>
<td>* Same Frequencies band with COMS</td>
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<tr>
<td>Data Type</td>
<td>AMI Image (16 Ch.)</td>
<td>AMI Image (5 Ch.)</td>
</tr>
<tr>
<td></td>
<td>Alphanumeric text</td>
<td>Alphanumeric text</td>
</tr>
<tr>
<td></td>
<td>Encryption Key Message</td>
<td>Encryption Key Message</td>
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<td>GOCI-II products (TBD)</td>
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<td></td>
<td>* Additional info could be added in the future</td>
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</tr>
<tr>
<td>Mode</td>
<td>FD</td>
<td>FD, ENH</td>
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<tr>
<td>Station</td>
<td>LDUS</td>
<td>MDUS</td>
</tr>
<tr>
<td></td>
<td></td>
<td>SDUS</td>
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</tbody>
</table>

**[Via Landline]**
- Cloud service is under development (completed in 2018)
- Renovated web-based service system is under development (completed in 2018)
- GK-2A data also will be available in DCPC-NMSC (http://dcpc.nmsc.kma.go.kr)
Volcanic Ash
Comparisons with other satellite products

Lee et al (RSE, 2016)
1. COMS-based ECVs long-term development plan (2011 yr)
   - Content: International trend analysis, COMS-based ECVs definition, selection variables in the second step

2. COMS meteorological variables (L2) production
   - Polar orbiting satellites (MetOp/IASI, Aqua/AIRS) verification system (GSICS), quality control
   - COMs Level2 Production and regular service (Since April, 2011)

3. Domestic and international satellite-based ECVs data sharing and utilization system
   - Objective: long-term securing of consistent data
   - (2015 yr) Primary ECVs (SST, INS, OLR) L3 unified system development
   - (2016 yr) Second ECVs (Albedo, Precipitation, cloud fraction) Algorithm Improvement

ECDs Integrated System

- Level 3: reprocessed through the rough footage, the details check in the calibration process, including spatial information grid-type satellite (composite) output