Retrieval and Application of Temperature and Humidity Profiles for GK2A/AMI

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- Summary
Geo-KOMPSAT Series

- Geo-KOMPSAT launched on December 5, 2018 and **operated from July 25, 2019.**
- 16 channels / Full Disk every 10 minutes and the Korean Peninsula area every 2 minutes
Introduction

52 Meteorological Products from GK2A/AMI

Primary Products

- Cloud Detection
- Instability Index
- Vertical Moisture Profile
- Vertical Temperature Profile
- Atmospheric Motion Vector
- Total Ozone
- Convective Initiation
- Rainfall Rate
- Cloud Phase
- Cloud Top Pressure
- Cloud Top Temperature

Secondary Products

- Fire Detection
- Vegetation Index
- Vegetation Green Fraction
- Snow Cover
- Ocean Current
- Cloud Type
- Cloud Amount
- Cloud Optical Depth
- Snow Depth
- Asian Dust Detection
- Aerosol Detection
- Volcanic Ash Detection, Height & Mass
- Aerosol Optical Depth
- Asian Dust Optical Depth
- Radiance
- Cloud Type
- Cloud Amount
- Cloud Optical Depth
- Rainfall Potential
- Aerosol Particle Size
- Visibility
- Absorbed SW Radiation (SFC)
- Downward SW Radiation (TOA)
- Upward SW Radiation (SFC)
- Cloud Top Temperature
- Reflected SW Radiation (TOA)
- Downward LW Radiation (SFC)
- Upward LW Radiation (SFC)
- Aircraft Icing
- Overshooting Top Detection
- SO2 Detection
- Total Precipitable Water
- Clear Sky Turbulence
Flowchart of AAP algorithm

- Name: AMI Atmospheric Profile (AAP)
  - Iterative Optimal Estimation (Rodgers, 2000)

- RTM Forward Model
  - RTTOV v12.1

- Input
  - GK2A AMI L1B, CLD
  - Error covariance (Observation/Background)
  - Surface Emissivity (Monthly)

- Temporal and Spatial Resolution
  - Full Disk (6km) / 10min

- Products
  - 54-levels T & q profiles
  - TOZ (Total Ozone)
  - TPW (Total Precipitable Water)
  - AII (CAPE, KI, LI, SI, TTI)

[GTK2A AAP ATBD, 2018 / Lee et al., 2017]
Input for AAP algorithm

- Primary Sensor Data
  - **Calibrated TB for IR bands 8-16**
    - WV6.2, WV6.9, WV7.3, IR8.6 (sea only), IR9.6, IR10.4, IR11.2, IR12.4, and IR13.3
  - GK2A/AMI Cloud mask
  - Satellite geographical data (LZA, Lat/Ion, Ismask)

- Ancillary Data
  - Dynamic data: NWP model forecast fields, Total column ozone,
  - Static data: Ozone profile, Observation/Background error covariance matrix, Land surface emissivity,

< NEDT >

<table>
<thead>
<tr>
<th>NEdT [K]</th>
<th>Brightness Temperature and corresponding NEdT</th>
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<tbody>
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<td>0.2</td>
<td>NEdT [K]</td>
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<tr>
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<td>NEdT [K]</td>
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<tr>
<td>0.6</td>
<td>NEdT [K]</td>
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<td>NEdT [K]</td>
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<td>NEdT [K]</td>
</tr>
<tr>
<td>1.4</td>
<td>NEdT [K]</td>
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</table>

< Background error covariance matrix >

![Heatmap of T Bmatrix (30S-30N)](image)

![Heatmap of Q Bmatrix (30S-30N)](image)
Result and Validation

Output: T & q profiles (with NWP)

- At reference levels: 100, 200, 300, 400, 500, 700, 850, 925, 1000hPa
Result and Validation

Output: TPW, All

- Fusion with NWP data

[Diagrams showing various climate metrics including TPW, LPW, MPW, UPW, CAPE, LI, SSI, TTI, KI with a focus on TPW (with NWP).]
Result and Validation

Validation

- 65 stations Radiosonde (Vaisala RS92) used for the validation
- Average 20% reduction in rmse compare to the first-guess
  - Improve moisture information in middle- and upper-layer

### Accuracy of AAP algorithm

<table>
<thead>
<tr>
<th></th>
<th>Bias</th>
<th>RMSE</th>
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<tbody>
<tr>
<td>T profile [K]</td>
<td>-0.14</td>
<td>0.91</td>
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<tr>
<td>(sfc.-400hPa)</td>
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<td></td>
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<tr>
<td>Q profile (sfc.-300hPa)</td>
<td>1.32</td>
<td>12.01</td>
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<tr>
<td>(RH) [%]</td>
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<td>Q profile (300-100hPa)</td>
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<td>TPW [mm]</td>
<td>0.43</td>
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<tr>
<td>LI [°C]</td>
<td>1.17</td>
<td>3.07</td>
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<tr>
<td>CAPE [J/kg]</td>
<td>52.97</td>
<td>532.35</td>
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<tr>
<td>SSI [°C]</td>
<td>0.52</td>
<td>2.0</td>
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<tr>
<td>All</td>
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<tr>
<td>TTI [°C]</td>
<td>(All)</td>
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<tr>
<td>(Unstable)</td>
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<td>1.0</td>
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<tr>
<td>KI [°C]</td>
<td>0.88</td>
<td>4.72</td>
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</table>
Result and Validation

Validation

- Validation of AAP products with radiosonde meet user requirement
Application

- Application of AMI/GK2A Atmospheric Profile (AAP) algorithm
  - Monitoring unstable area and convective cloud: Convective clouds can be occurred in high value of TPW and CAPE
Application

- SkewT-LogP diagram
Wetter than NWP in the west sea

Wind Field (850hPa)

Conversion + Radiation + Terrain ➔ Shower

Observation (Radar+AWS)

MPW Difference (SAT Ret.-NWP)

(Radar, AWS) more than 50mm/hr

Precipitation Rate (NWP: 15~18h)

3hr Accumulated Precipitation Maximum ~30mm

Maximum ~30mm (Radar, AWS)
Expand the AAP Algorithm for MW

- AMI/GK2A+ AMSU-A/Metop + ATMS/NOAA
Expand the AAP Algorithm for Hyperspectral

- Channel selection for hyperspectral sensor
  - Step1: Sensitivity for observation error and gas absorption (T: 128, q: 149)
  - Step2: Selection of local maximum (T: 43, q: 50)
  - Step3: Consider weight function, remove channels clustered in a layer (T: 21, q: 11)
  - For surface: 2 dirty window: 861.25, 875 cm\(^{-1}\), 2 clean Window: 901.25, 943.125 cm\(^{-1}\)
KMA has developed an algorithm to retrieve atmospheric temperature and humidity profiles using GK2A/AMI.
  – 1D-var based AMI Atmospheric Profile (AAP) algorithm
  – Every 10 minutes with 6km horizontal resolution in clear sky

The validation with radiosonde shows temperature RMSE of about 0.9K (between surface and 400hPa) and relative humidity of about 12% (between surface and 300hPa).

Monitoring unstable area and convective cloud using AAP products

To improve current limitations of AAP such as first-guess dependency and clear sky only retrieval (because AMI has only 8 infrared channels)
  – Trying to expand AAP algorithm to utilize the microwave sounder and hyperspectral sounder.
Thank you!