Sand and Dust Monitoring in RA II

Xiang Fang
National Satellite Meteorological Center, CMA
Outline

- Major progresses in 2015
- Plan for Next Two Years on Dust monitoring
Major progress in 2015

- AOD retrieval from Himawari-8 (H8)
- Publish and share dust products based on website
- Establish the long-term satellite dust dataset
- Application in regional dust forecast model
AOD retrieval from Himawari-8
Development of products from Himawari-8/9 AHI

Increased Observation Spectral Bands
VIS: 1 --> 3
NIR/IR: 4 --> 13

with Higher Resolution
Spatial:
1 km --> 0.5 km for a VIS channel
4 km --> 2 km for IR channels
Temporal:
1 hr --> 10 min for a full disk scan
2.5 min for limited areas

...... will Enhance Baseline DAY-1 Products, especially
- Atmospheric Motion Vectors (AMVs)
- Cloud Properties
- Aerosol (Dust) / Volcanic Ash

Severe Weather Monitoring/ Nowcasting
Numerical Prediction
Climate Monitoring/Diagnostics
Volcano Eruption Volcanic Ash detection
Yellow Sand/ Dust Storm
Solar Irradiance Monitoring
Aerosol optical depth (AOD) products based on satellite data are used by the Japan Meteorological Agency (JMA) to monitor dust events in East Asia.

A new AOD algorithm for Himawari-8 developed by JMA’s Meteorological Research Institute (MRI) has been introduced into JMA/MSC (Uesawa, 2016).

Himawari-8 AOD retrieved by JMA/MSC for 04 UTC 17 October 2015.
Table 1 Wavelength of Sensors including Himawari, FY-4A, GOES-R, MODIS

<table>
<thead>
<tr>
<th>Channel</th>
<th>Himawari</th>
<th>Spatial resolution</th>
<th>Channel</th>
<th>FY-4A</th>
<th>Channel</th>
<th>GOES-R</th>
<th>Channel</th>
<th>MODIS</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.46</td>
<td>1 km</td>
<td>1</td>
<td>0.45~0.49</td>
<td>1</td>
<td>0.47</td>
<td>3</td>
<td>0.459~0.479</td>
</tr>
<tr>
<td>2</td>
<td>0.64</td>
<td>1 km</td>
<td>2</td>
<td>0.75~0.90</td>
<td>2</td>
<td>0.64</td>
<td>1</td>
<td>0.62~0.67</td>
</tr>
<tr>
<td>3</td>
<td>0.86</td>
<td>0.5 km</td>
<td>3</td>
<td>1.36~1.39</td>
<td>4</td>
<td>1.32</td>
<td>5</td>
<td>1.23~1.25</td>
</tr>
<tr>
<td>4</td>
<td>1.6</td>
<td>2 km</td>
<td>5</td>
<td>1.58~1.64</td>
<td>5</td>
<td>1.61</td>
<td>6</td>
<td>1.628~1.652</td>
</tr>
<tr>
<td>5</td>
<td>2.3</td>
<td>2 km</td>
<td>6</td>
<td>2.1~2.35</td>
<td>6</td>
<td>2.25</td>
<td>7</td>
<td>2.105~2.155</td>
</tr>
<tr>
<td>6</td>
<td>3.9</td>
<td>2 km</td>
<td>7</td>
<td>3.5~4.0(High);</td>
<td>7</td>
<td>3.9</td>
<td>21</td>
<td>3.929~3.989(High);</td>
</tr>
<tr>
<td>7</td>
<td>6.2</td>
<td>2 km</td>
<td>8</td>
<td>3.5~4.0(Low)*</td>
<td>22</td>
<td>3.929~3.989(Low)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>7.0</td>
<td>2 km</td>
<td>9</td>
<td>6.185</td>
<td>27</td>
<td>6.536~6.895</td>
<td></td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>7.3</td>
<td>2 km</td>
<td>10</td>
<td>7.34</td>
<td>28</td>
<td>7.175~7.475</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

![Response Function of Sensor](image_url)
CMA AOD products using Himawari-8 as proxy data

Key Points:
- Surface albedo
- Aerosol Types

Fig. Flowchart of aerosol retrieval over land

Fig. Uncertainties in the retrieved surface albedo and AOD
CMA AOD product (FY-4 algorithm) using Himawari-8 as proxy data

RGB image at 04:30 UTC in 2015.08.16

AOD (550nm) distribution of China at 04:30 UTC in 2015.08.16 (spatial resolution: 10 km)

Spatial resolution: 10 km

AOD (550nm) distribution of JingJinJi region at 04:30 UTC in 2015.08.16 (spatial resolution: 10 km)

AOD (550nm) distribution of JingJinJi region at 04:30 UTC in 2015.08.16 (spatial resolution: 2 km)
A heavy pollution case in Northern China

Fig. AOD distribution map of H8 from 00:00 UTC to 07:30 UTC in Dec 20, 2015

Himawari-8 can catch the distribution of the haze very well.
Compared CMA AOD with JMA/JAXA

- Himawari-8 can catch the distribution of the haze very well.
- JMA AOD product missed the heavy pollution of Northern China.

Fig: AOD product of Himawari-8 from different aerosol retrieval algorithm at 05:30 UTC in Dec 20, 2015
Compared CMA H8 AOD with JMA/JAXA

![Image showing the comparison between CMA and JMA/JAXA AOD products.]

Compared H8 AOD product (CMA) with AERONET

![Image showing the comparison between CMA, JMA/JAXA, and AERONET AOD products.]

- The AOD product from JMA/JAXA is smaller than the product from CMA.
- When the solar zenith is large, the AOD product of is obviously smaller than AERONET AOD.

**Aerosol retrieval algorithm still need to be improved!**
Fig AOD product from Terra/MODIS, Aqua/MODIS and H8 in Dec 20, 2015

Compare H8 AOD product with MODIS
The agreement between these two AOD products is very good, when compared H8 AOD product with MODIS.

The correlation coefficients is 0.71 for JAXA and 0.85 for CMA in 2015.12.20, which means AOD product of H8 over land with reasonable accuracy.
Using satellite AOD to estimate ground-level PM2.5

Satellite-based PM2.5

AOD
(The column integration of the light extinction)

PM2.5
(measured close to the surface which is closely related to human health)

The spatial distribution in (c) and (d) are well accordance!

Fig satellite-based AOD, PM2.5, air quality classification and ground observation at 05:00 UTC in Dec 20, 2015
Publish and share dust products based on website

- Since the spring of 2015, the operational satellite dust products of CMA have been published in real time, based on the portal website constructed by the Asia Regional Centre of the WMO SDS-WAS (http://eng.nmc.cn/sds_was.asian_rc/)

- FY-2——IDDI
- FY-3——AOD
- FY-3——DST
Establish Historical database

- Historical database (2006-2015) based on CMA satellite dust products has been established, including coverage, area, frequency.
- Additional parameters will be added in the database, including aerosol parameters and underlying surface parameters, such as vegetation Index, snow cover and surface temperature.

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>cumulated area</td>
<td>609</td>
<td>502</td>
<td>307</td>
<td>278</td>
<td>649</td>
<td>372</td>
<td>501</td>
<td>480</td>
<td>488</td>
<td>677</td>
</tr>
</tbody>
</table>
Dust Occurrence frequency during 2006—2015
Application in regional dust forecast model

- FY-2 IDDI can be assimilated into GRAPES-CUACE/Dust Model——positive effect.
- It could provide 72 hours forecast results in Asian region as real-time services.
Model products verification  The ground-based observation data were assigned to their located grids and FY-2 IDDI were used in the grid without ground stations. A verification system has been developed for comparing the forecasting and observation data on each $1\times1^\circ$ grid.

Products Verification (near-real time)
DUST TS Scoring System
• Carry out the spring experiment of dust monitoring using Himawari-8 data, and compare the CMA algorithm with JMA algorithm.

• Generate FY-4 AOD product, and compare it with Himawari-8 AOD product after the launch of FY-4.

• Continue haze monitoring by using satellite products.
Plan for the Next Two Years on Dust Monitoring

• **Standardization in dust concentration description**
Without a standardized practice in describing observed dust concentration among member countries, it will be difficult to monitor and forecast the transport of dust on a regional basis. It is necessary to establish unified standards to deal with observation methods and products for dust of various concentrations.

• **Cross-verification of products from different satellites**
Now that several satellite systems are providing AOD products, for instance, FY-3/MERSI, MTSAT-1/2, COMS/MI, Himawari-8, and FY-4/AGRI to be launched in near future, the cross-verification between different satellite products should be one of the issues to achieve consistency.

• **Coupling the satellite and the surface observations**
Establish the relationship between the satellite-derived products and the surface-measured visibility, AOD, PM10, PM2.5, is important for validating the remote sensing products and for coupling the satellite and the surface observations.
• **Assimilating the satellite products into dust forecast models**

The initial value of dust forecast model is optimized using the satellite dust concentration and other data. This will improve the scientific basis for Asian dust storm forecasting in short term, medium, and long terms.

• **Extending the application scope of satellite aerosol products**

Air pollution is becoming a serious hazard in East and South Asia. There is intention to extend the use of some dust and sand products, like AOD, AAI, for monitoring the haze pollution.

• **Publishing and sharing information**

Each country would publish and share its own satellite dust products on unified website. Also, the methods of satellite products, product metadata are provided along with the user guidance, and necessary information for the support and training of the users. The website could be based on the portal website constructed by the Asia Regional Centre of the WMO Sand and Dust Storm Warning Advisory and Assessment System (SDS-WAS) (http://eng.nmc.cn/sds_was.asian_rc/).
Thanks for your attention!