Current status of the aerosol modeling and satellite observation in KMA

LEE, Sang-Sam, Jeong Hoon Cho, Mi Eun Park, Hee Choon Lee, Sun-Young Kim, Sang Boom Ryoo

Asian Dust Research laboratory
National Institute of Meteorological Research, KMA, KOREA

sangsam.lee@korea.kr

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Outline

• Introduction of ADAM-Haze model
• Simulation result of a severe haze case
• Satellite observation of aerosol in KMA
• Future Plan
History of Asian Dust Aerosol Model (ADAM)

2001: Launching ADAM development
2002: Test run at KMA Intranet
2005: Posting at KMA Hompage
2006: Test run at KMA’s supercom
2007: ADAM operation
2008: Improvement of vegetation effect
2009: Launching UM-ADAM development
2010: UM-ADAM operation (2 days → 3 days)
       UM-ADAM2 operation (Four-seasons)
2011: UM-ADAM2(N512) operation

2014: ADAM-Haze
       (will be operational in 2015)
Development of ADAM-Haze Model

Asian Dust : Sectional approach w/ 11 size bins
Haze : Modal approach
No interactions between the AD and Haze aerosols
ADAM-Haze Configuration

**ADAM-Haze**
- Meteorological Model (UM Global)
- Met. Interface, UM-MCIP
  - Regional model
  - Vertically 47 layers
  - 25 km spatial resolution
  - 340X220 horizontal grids
- 7days(168hr) forecasting (00, 12UTC)
- Will be running in operational mode from this year (2015)

**UM-Global**
- Horizontal ~ 25km (1024*768)
- Vertical : 70 layers (top = 80km)
- FCST Period (4 times/day)
  +252hrs (00/12UTC)
  +72hrs (06/18UTC)
- Initialized by 4dVAR

**Domain of ADAM-Haze**

- Dust source region
  defined by dust occurrence statistics using 3hr SYNOP report for 1998~2006 period
  4 type soil classification ~ gobi, sand, loess, mixed
Emissions of Asian Dust

• **Emission parameterization**
  
  (Park and In, 2004; Park and Lee, 2005; Lee, 2009; Park et al., 2010)

  **Emission flux**  
  \[ F \sim u_*^4 \]  
  : with log-normal size distribution

  **Meteorological condition for dust emission**  
  : wind speed, relative humidity, ground temperature, precipitation

  **Reduction by Vegetation**  
  : NDVI change \(\rightarrow\) Reduction function
Emissions of Anthropogenic aerosols

East Asia

- Emissions (t day$^{-1}$grid$^{-1}$) (May, 2006)
  - (a) NOx, (b) SO$_2$, and (c) PM$_{10}$
- ACE-ASIA - (d) NH$_3$

- INTEX-B (Intercontinental Chemical Transport Experiment-Phase B)
  - Area: From 13.0°S to 53.5°N, From 60.0°E to 157.5°E with 0.5° resolution
  - 4 emission types: transportation, residential, power, industry
  - 8 species: BC, Co, NOx, OC, PM10, PM25, SO2, VOC

- ACE-ASIA (Aerosol Characterization Experiments – ASIA)
  - Area: 12.75°S to 53.75°N, From 60.25°E to 157.75°E with 0.5° resolution
  - Monthly Data for March, July and December
  - 12 species: BC, CH4, CO2, Co, NH3, NOx, OC, PM10, PM25, SO2, REG(?)

S. Korea

- Emissions (t day$^{-1}$grid$^{-1}$) (May, 2009)
  - (a) NOx, (b) SO$_2$, (c) PM$_{10}$, (d) NH$_3$

※ CAPSS (Clean Air Policy Supporting System) by KMOE (*gridded data)
- Area: South Korea with 1 km resolution in TM (Transverse Mercator) coordinate
- 7 species: CO, NOx, SOx, TSP, PM10, VOC, NH3

Inclusion of Biogenic emission?
- In addition, the biogenic emissions will be included using the MEGAN developed by the WSU (now being tested !!)

※ SMOKE (Sparse Matrix Operator Kernel Emissions)
※ MEGAN (Model of Emissions of Gases and Aerosols from Nature)
Case Study

• Strong and long-lasting haze case in S. Korea
• Huge societal impacts in both China and Korea

Cheonan city
Hrly Avg. PM10 = 261ug/m3
Predicted SFC PM10 & Haze Obs.

GTS

Anthropogenic PM$_{10}$

[Images of atmospheric maps and concentration levels]

UM-CMAQ+CAPPS2008
Run by KMA
Vertical Distributions - LIDAR

Mie–Lidar extinction coefficient in Seoul
Horizontal Distributions-AOD

MODIS AOD @ 2014-02-27 13:26KST

COMS AOD @ 2014-02-27 13:30KST

AOD @ 2014-02-27 14:00KST
COMS Aerosol Products

• **COMS** (Communication, Ocean and Meteorological Satellite)
  • Launching: 2010. 6. 27
  • Location: 128°E (Geostationary)

• **MI** (Meteorological Imager)
  - Wavelengths: visible (0.55-0.90 µm), IR1(10.3-11.3 µm), IR2(11.5-12.5 µm), WV (6.5-7.0 µm), NIR (3.5-4.0 µm)
  - Horizontal res.: 1 km (VIS), 4 km (IR)
  - Time interval: 15 min.
  - Area: Global, Northern hemisphere

  Kim, J. et al. (2008, IJRS)

• **GOCI** (Geostationary Ocean Color Imager)
  - Wavelengths: 412, 443, 490, 555, 660, 680, 745, 865 nm
  - Horizontal res.: 500 m x 500 m
  - Time interval: 1 hr
  - Area: Eastern Asia

  Lee, J. et al. (2010, RSE)
COMS dust products

COMS AI
2011. 5.11. 20:15 ~ 5.12. 16:45

COMS/GOCI
2011. 5.12. 09-16시
Hyperspectral TBs (Dust FOVs) | MODIS AOT or CALIPSO $z_{dust}$
---|---
Training dataset

Training

ANN model

Dust?

Yes

AOT $z_{dust}$

Validation

Inputs

De Souza-Machado et al. (2010)

AIRS Inputs:
1. TBs
2. Surface elevation
3. $1/\mu$ ($\mu = \cos\theta_{sat}$)

Domain: East Asia region
15°N~55°N, 70°E~150°E

Han, H. et al. (2013, JGR)
AIRS Dust Aerosol Products

Channel selection
- 2007~2009
- 2007~2013

Calibration problem

Validation

Dust AOT
- Statistics:
  - Corr. coeff.: 0.83 → 0.84
  - RMSE: 0.41 → 0.39

Dust Height
- Validation: Period: Jan 2009 – Dec 2013
- Statistics:
  - Corr. coeff.: 0.77 → 0.81
  - RMSE: 0.56 → 0.51

WIN : 130 → 52
CO2 : 31 → 21
WV : 44 → 35
O3 : 29 → 3
TOT : 234 → 111

Han, H. et al. (2013, JGR)
AIRS Dust Aerosol Products (1 May 2011)

MODIS true color image

AIRS VIS AOT

R: 0.88

MODIS VIS deep blue AOT

AIRS dust height [km]

CALIOP total attenuated backscatter 532 nm
Summary

- **ADAM-Haze** model will be used operationally in 2015.

- **ADAM-Haze** has a capability to forecast not only dust aerosol but also anthropogenic aerosols.

- More elaborate modification is needed to upgrade. For example, new emission inventory, Inclusion of Biogenic emission (MEGAN), coagulation and chemical reaction process, etc.

- COMS aerosol products (AI, AOT) is used for dust monitoring, and AIRS products (AOT, Height) algorithm is developed.