



Update on the JMA/MRI Aerosol Prediction Model Research

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JMA update: Research and development

Updates on Model Development in JMA/MRI

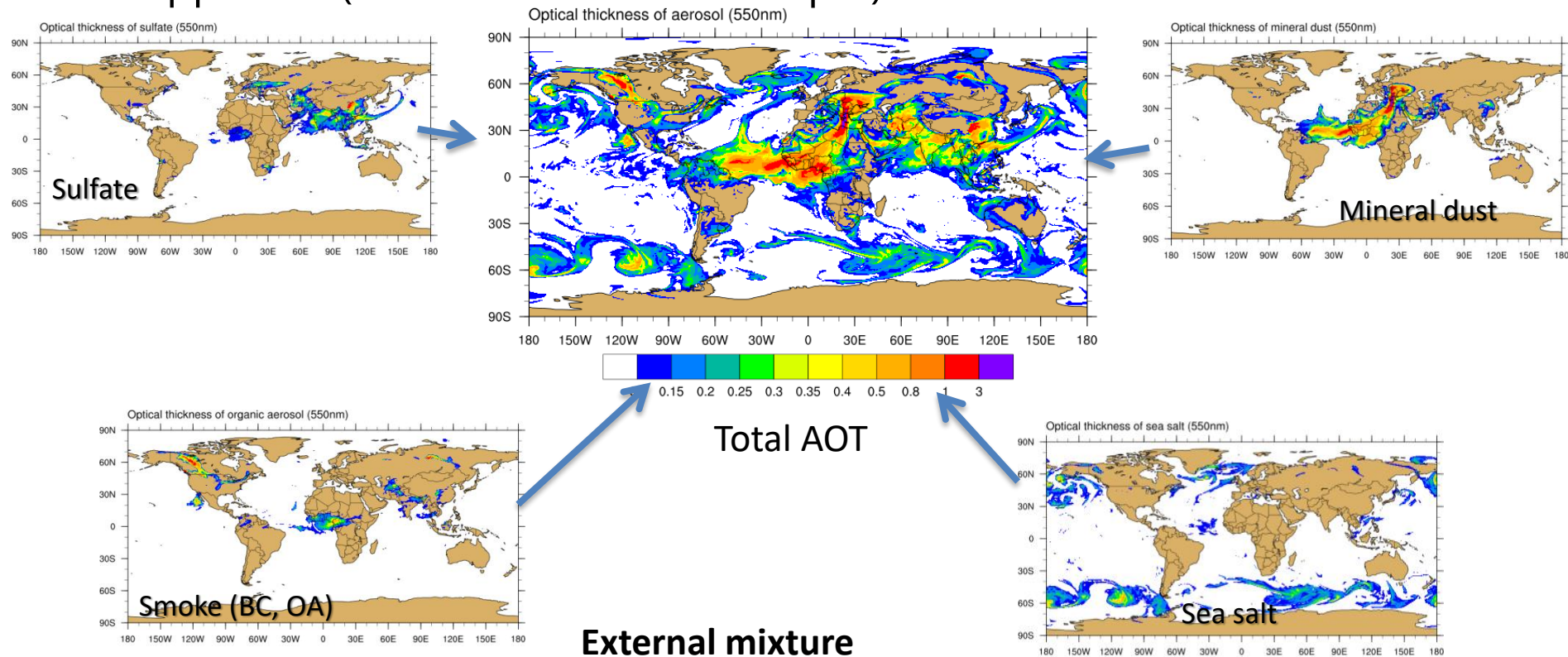
- **Model-Data Assimilation fusion**
 - In-line 2D-VAR data assimilation
 - Enables high frequency (e.g., less than 1-hour) DA test
- **Dust source correction** based on data assimilation
- The project for **GCOM-C SGLI** for data assimilation

Misc.

- Meteorological Research Institute reorganized in April 2019.

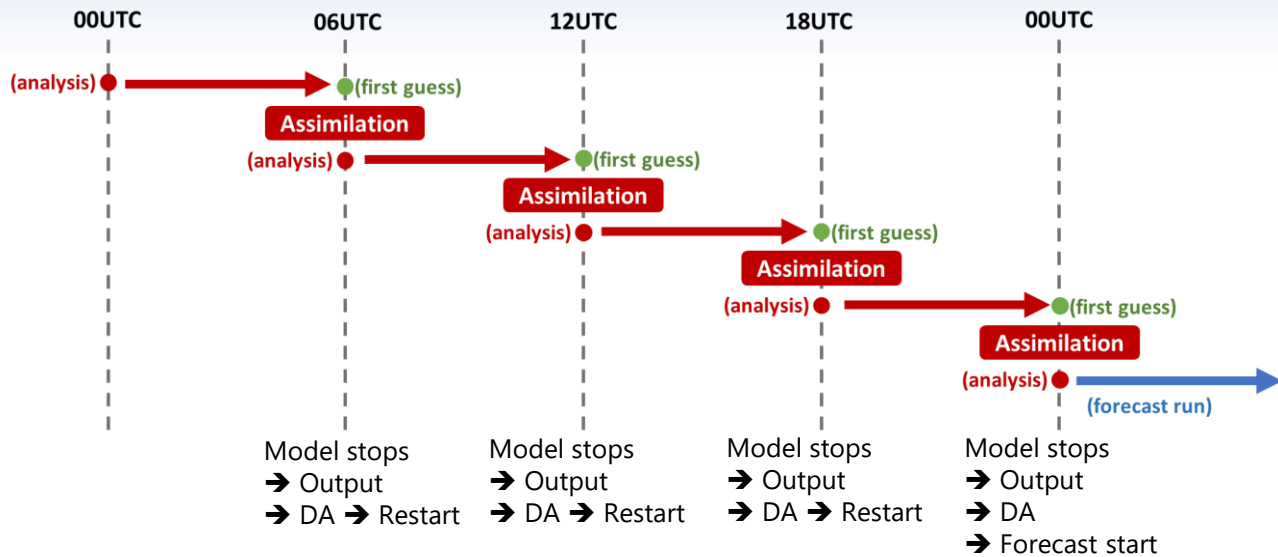
JMA/MRI Aeolian dust prediction model (Model of Aerosol Species in the Global Atmosphere: MASINGAR)

- Sulfate, black carbon, organics, sea salt, and mineral dust are included
 - The emission flux of sea-salt, mineral dust, and dimethylsulfide are predicted based on the surface properties calculated by the atmospheric model.
 - Particle size distributions of sea salt and dust are expressed by sectional approach (10-bins from 0.2 to 20 μm)



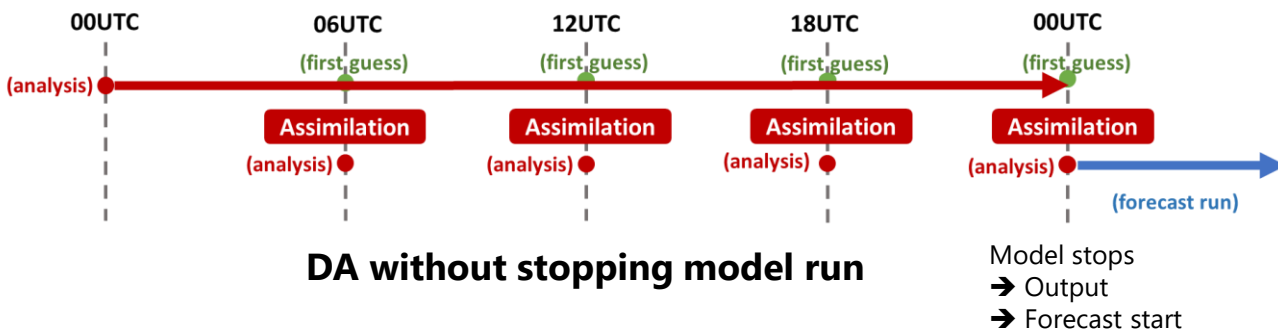
Model-Data Assimilation fusion

In-lined 2D-VAR data assimilation within the global aerosol model



Current:

- The model must be stopped at each analysis time.
→ Consume much time of I/O.

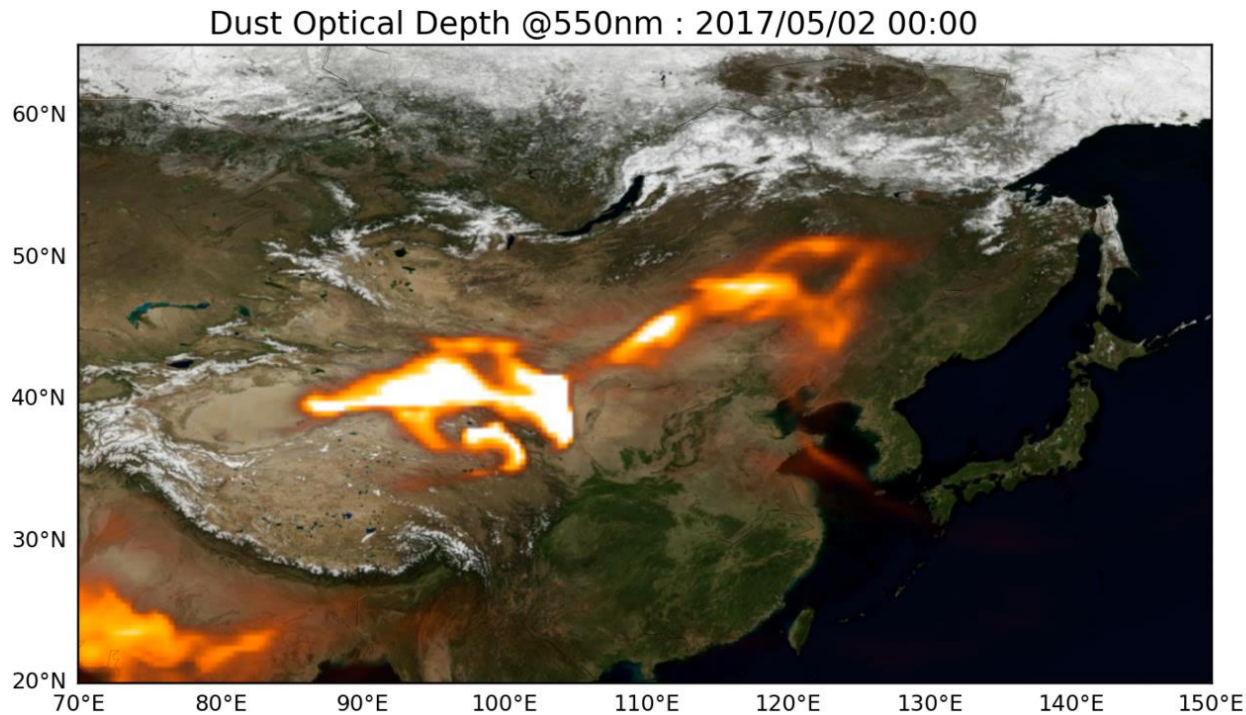


Development version:

- The analyses are conducted without stopping the model.
→ Saving I/O time.
→ More frequent D/A

Dust source correction based on data assimilation

Motivation: The assimilation of **airborne dust only** is not enough for forecasting dust storms.

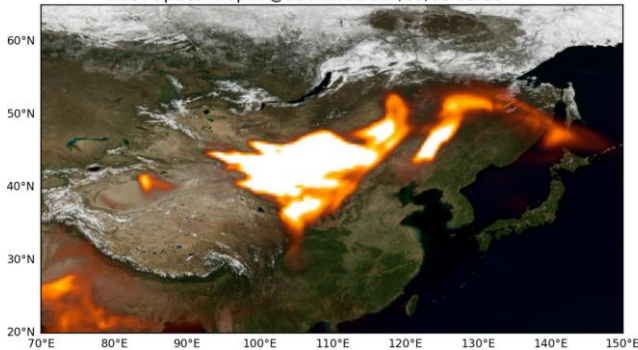


Correction of dust emission is desired!

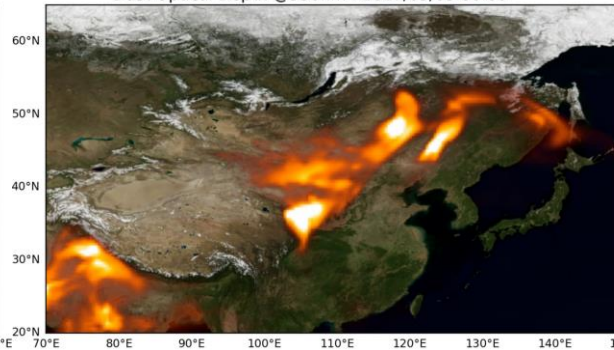
Dust source correction based on data assimilation

Airborne aerosol DA of dust storm only effective in several hours around dust source area.

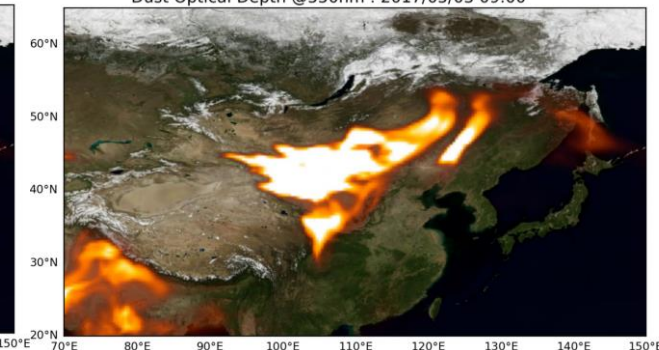
Dust Optical Depth @550nm : 2017/05/03 05:00



Dust Optical Depth @550nm : 2017/05/03 06:00



Dust Optical Depth @550nm : 2017/05/03 09:00



Before DA:
Very thick dust over
the Gobi desert

DA at 6z:
Dust is **reduced** by
MODIS data Assimilation

3 hours after DA:
dust is very thick over
the Gobi desert **again**.

Correction of dust emission is desired!

Dust source correction based on data assimilation

Generally, Dust emission flux can be expressed as

$$F = C f(u_*, w_s, A_v, A_s, \dots)$$

where $f()$ is the function of friction velocity and surface conditions (soil moisture, vegetation, snow cover, etc.), and C is the global constant to adjust the flux.

Question 1: How can we determine “ C ”?

→ Optimization using observation.

- Aerosol Optical Depth (satellites or ground based)
- Lidar extinction
- Surface (dust) concentration

Question 2: Is “ C ” constant (spatially/temporally)?

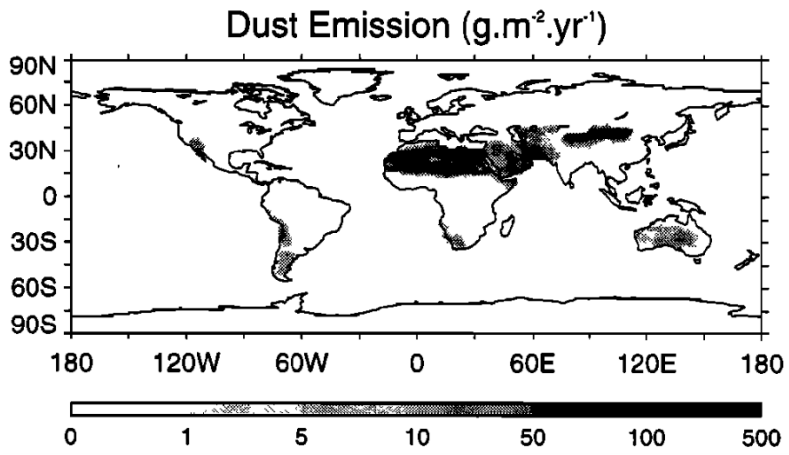
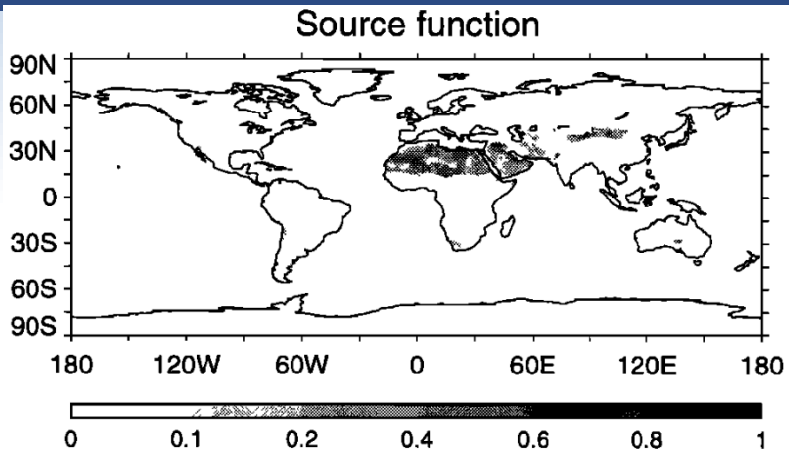
→ No!

Dust emission “constant” (or source function)

- Dust emission constant “ C ” have to apply because of
 - Factors that are **not** incorporated in dust emission scheme
 - Salt content, soil crust, soil types, to name a few.
 - Insufficient resolution of the model
 - Inaccurate meteorology (wind, rain, soil water, snow cover, etc.)
- “ C ” is inherently empirical.

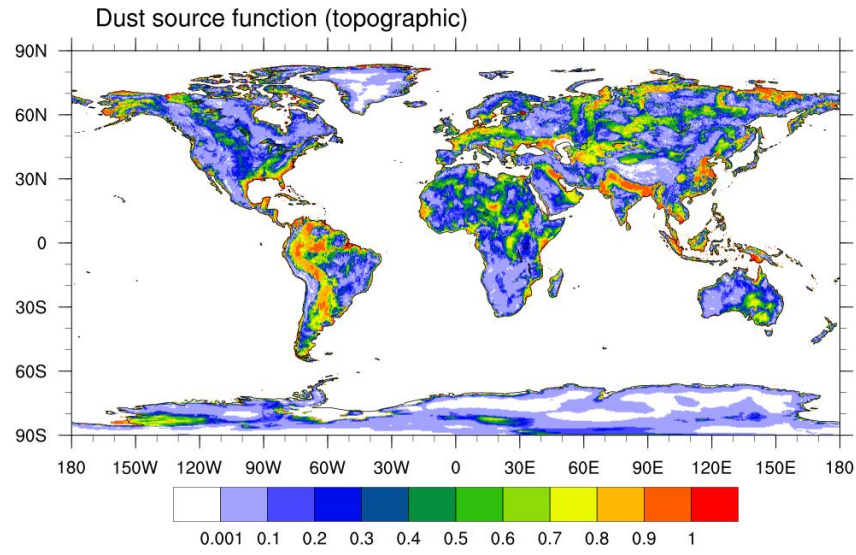
Dust source function by Ginoux et al. (2001): GOCART

"We assume that a basin with pronounced topographic variations contains large amount of sediments which are accumulated essentially in the valleys and depressions, and over a relatively flat basin the amount of alluvium is homogeneously distributed."



(Ginoux et al. 2001)

$$S = \left(\frac{Z_{max} - Z}{Z_{max} - Z_{min}} \right)^5$$



Dust source correction based on data assimilation

- With aerosol data assimilation, we can obtain corrections to dust emission flux from the DA increment.
 - It may be possible to obtain global map of the correction factor map by the average (or other statistical treatments) of sufficient simulation periods.
- We are conducting experiments to apply 2D-VAR AOT data assimilation with dust emission correction.

Simplified dust source correction

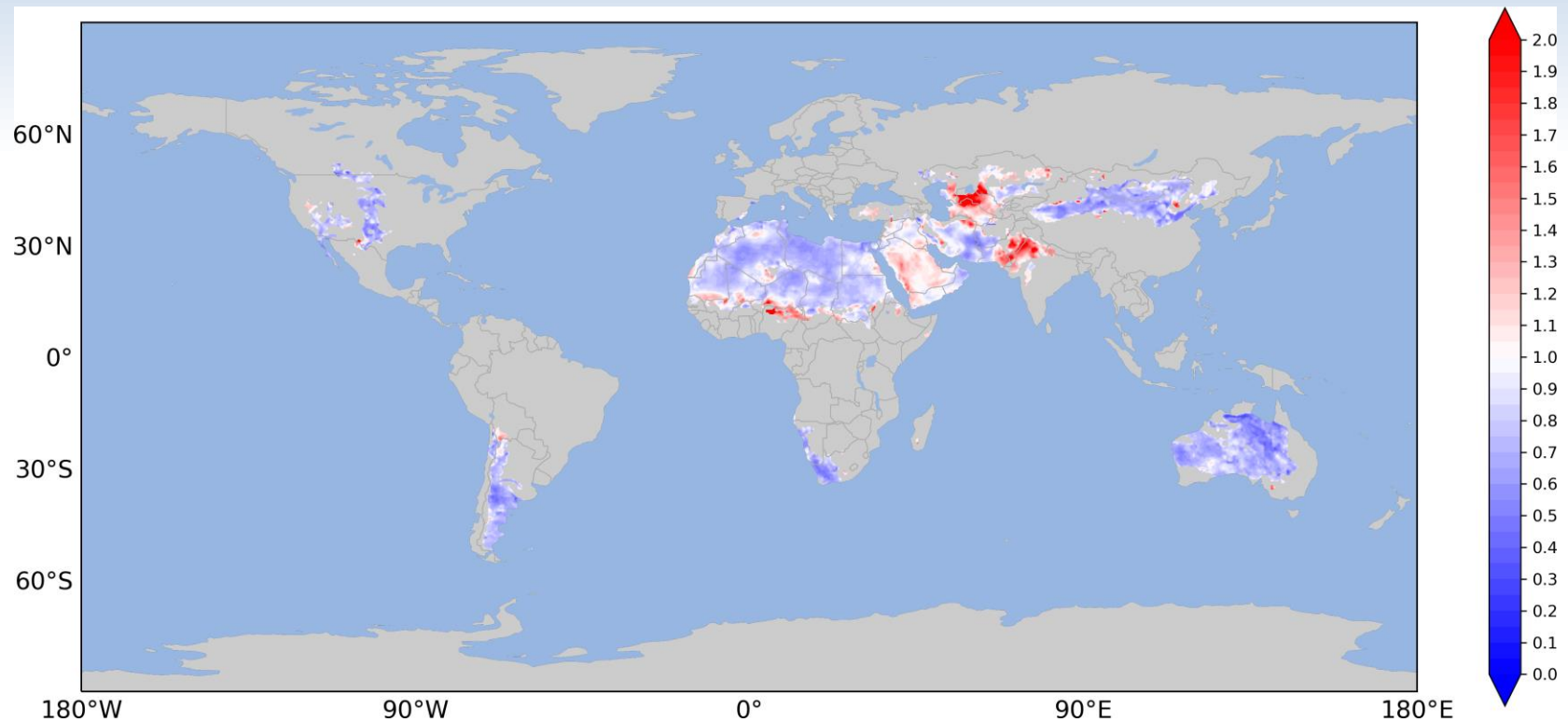
- We can assume that the concentration of the coarse dust particles (μ_{dust}) at the lowest model layer is **approximately proportional to** their emission flux (F_{dust}) when there is a large dust emission:

$$\mu_{\text{dust},k=0} \propto F_{\text{dust}} \text{ (where } F_{\text{dust}} > 0 \text{)}$$

- If we obtain data-assimilated concentration (μ'_{dust}),

$$\frac{\mu'_{\text{dust},k=0}}{\mu_{\text{dust},k=0}} \propto \frac{F'_{\text{dust}}}{F_{\text{dust}}}$$

An example of DA dust source correction map



The Figure shows the dust source function derived from the annually averaged data assimilation increments during the experimental period of Aug. 2017 to Aug. 2018.

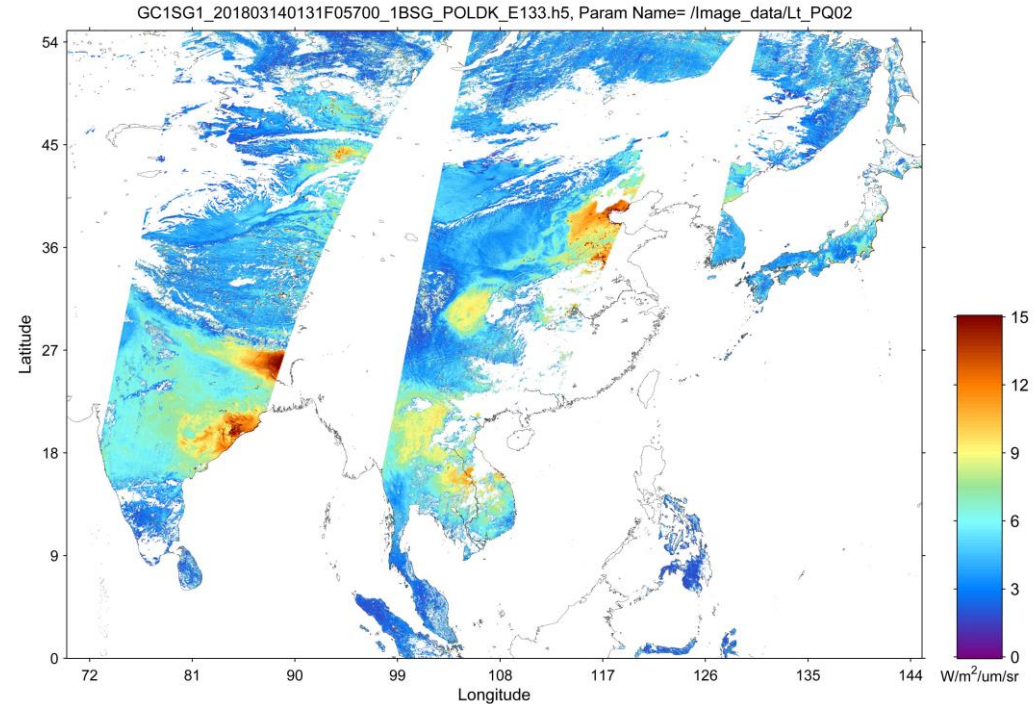
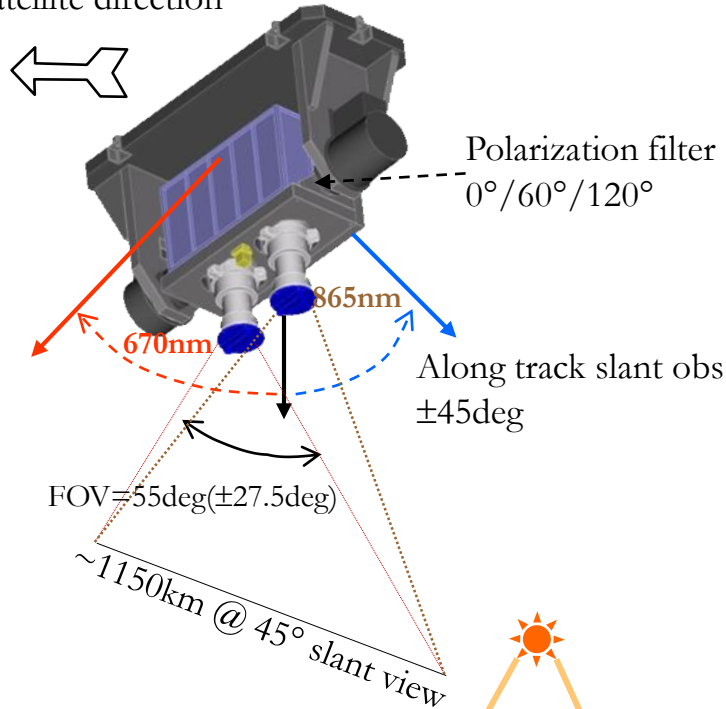
- The dust model generally overestimates the dust over the East Asia, large part of the Sahara desert, Australia, North and South America, South Africa.
- The dust model underestimates the dust in the central Asia, India and Pakistan, Arabian Peninsula, and Sahel

1. GCOM-C/SGLI:



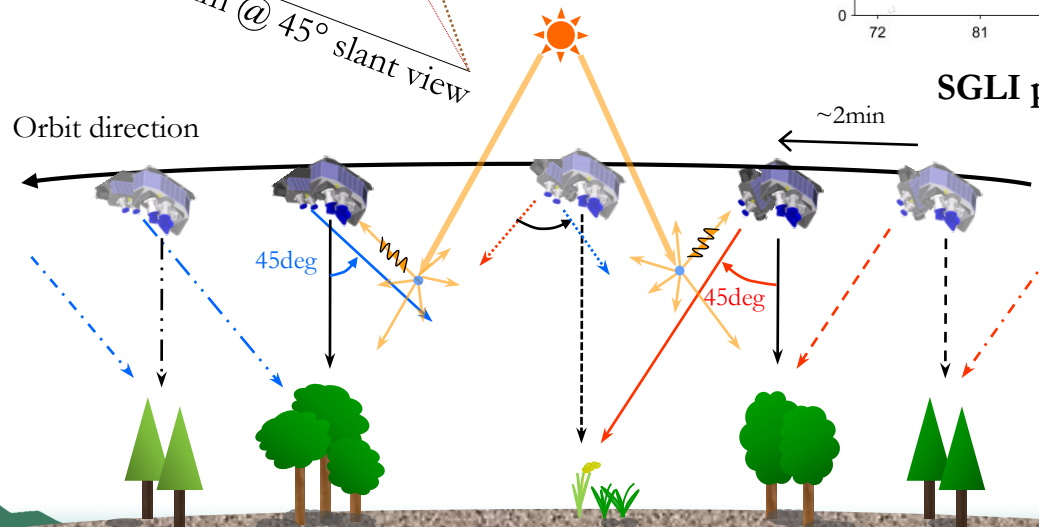
SGLI slant-view polarization observation

Satellite direction



SGLI polarization radiance at 867nm (PL02)

Orbit direction



Along-track $\pm 45\text{deg}$ tilt for polarization observation of the atmospheric scattering

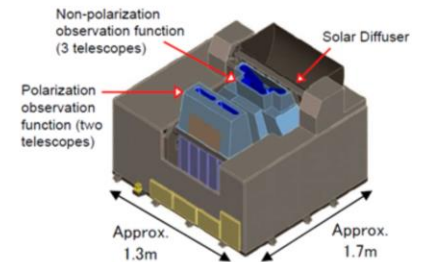
GCOM-C SGLI Aerosol product

Characteristics of SGLI

- Spectral channels: 19 spectral bands from Near UV - IR
- Resolution: 250 m / 1 km
- Polarization observation
- Multi-angle observation

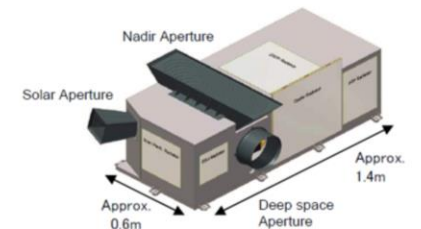
Visible and Near Infrared Radiometer (VNR)

Non-polarization nadir view (11ch)	Polarization/along-track slant view (2ch)
spatial resolution: 250m, swath: 1150km	spatial resolution: 1km, swath: 1150km



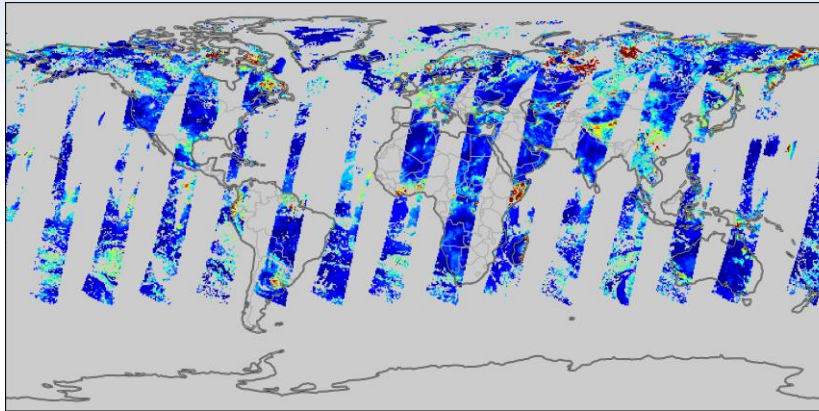
Infrared Scanner (IRS)

Shortwave infrared (SWI:4ch)	Thermal infrared (TIR:2ch)
spatial resolution: 250m/1km, swath: 1400km	spatial resolution: 250m, swath: 1400km



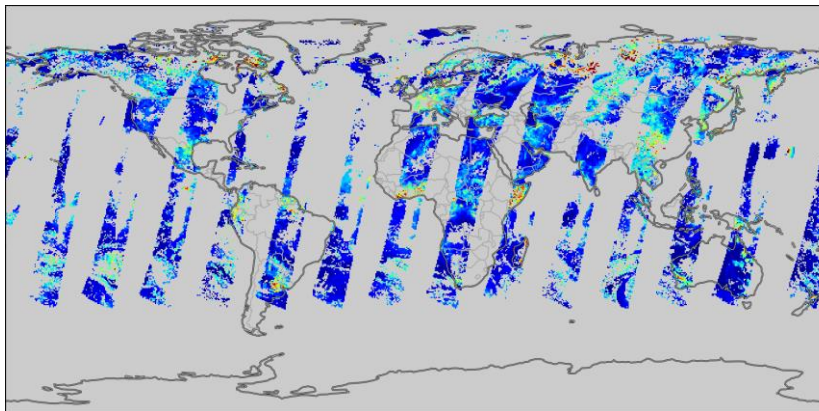
Global view of the SGLI AOT @500 nm (example: 2019/06/01)

SGLI AOT@ 500 nm

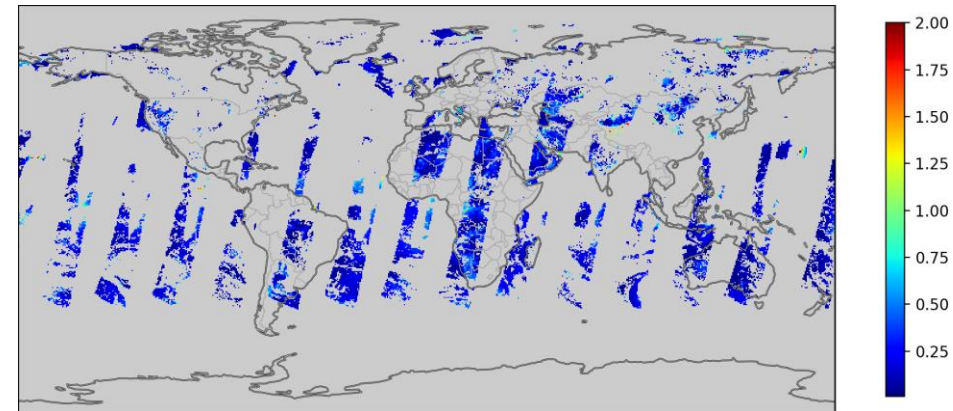


Checking the quality of the retrieved AOT.

SGLI AOT@ 500 nm (QA AOT confident)



SGLI AOT@ 500 nm (QA: stray light possibility removed)

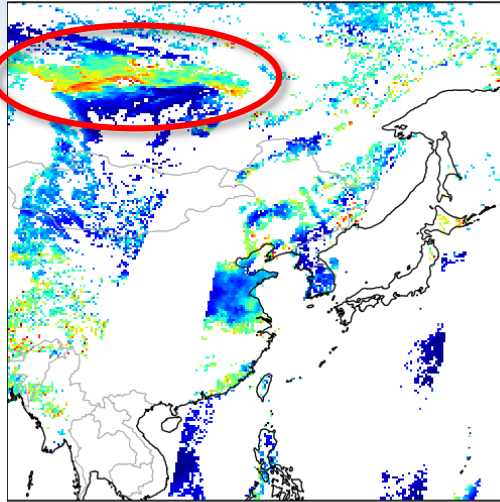


Still questionable over bright surface
(Siberia, Himalayas)?

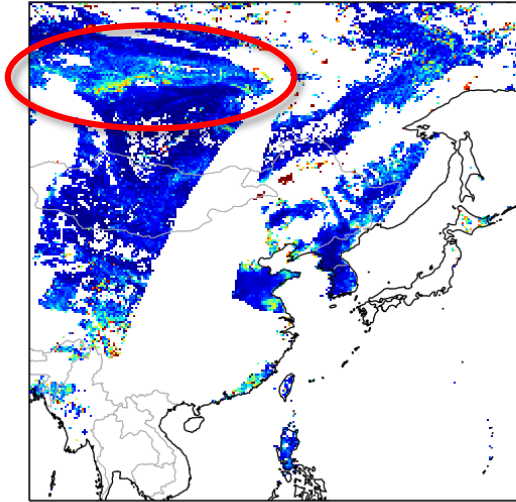
AOT comparison over East Asia

Smoke

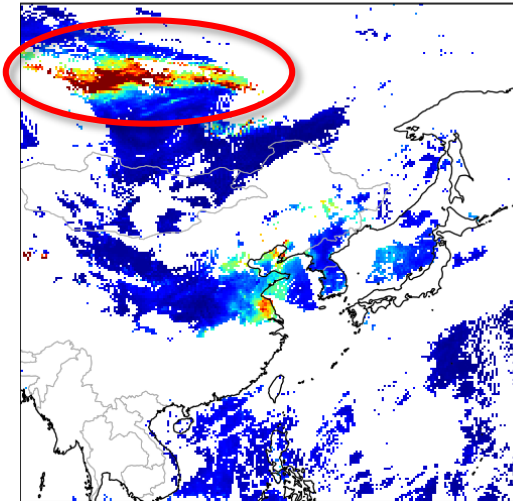
SGLI ARNP AOT500: 2019-07-05



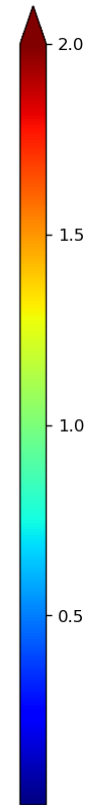
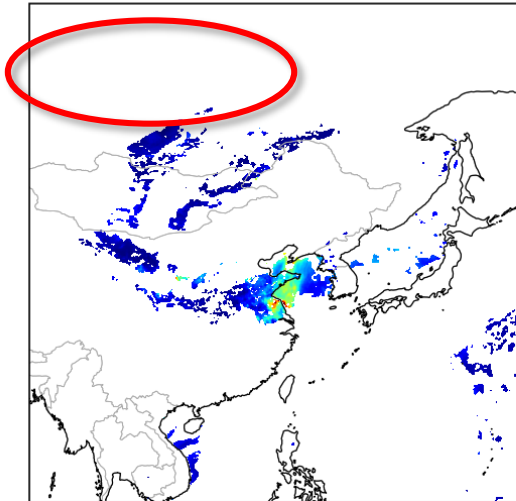
SGLI ARPL AOT500: 2019-07-05



MODIS C6.1 L2 MxD04 AOT550: 2019-07-05



Himawari-8 v3.0 L3 AOT_Merged: 2019-07-05 05UTC



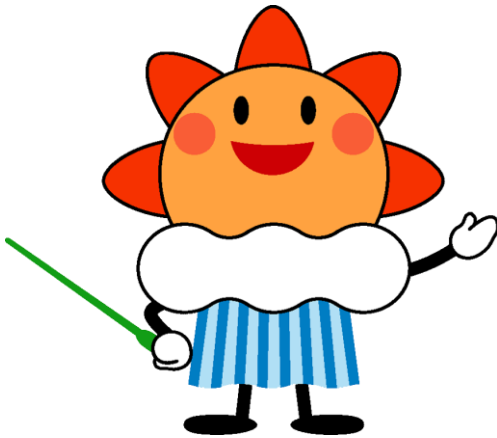
2019-07-05

Future tasks

- Investigation of the aerosol impacts to long-range (seasonal) forecast
 - Impact of large-scale volcanic eruption will be first investigated.
- Nesting of regional chemical transport model (NHM-Chem) for detailed prediction over targeted area (East Asia)
- Next version of the JMA's Aerosol Reanalysis (JRAero)
 - Preparing the boundary conditions



Thank you very much for your attention.



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