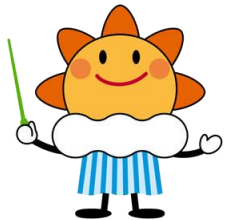




Updates of the aerosol forecast in Japan Meteorological Agency

Taichu Y. Tanaka

*Meteorological Research Institute,
Japan Meteorological Agency*



5 November 2013

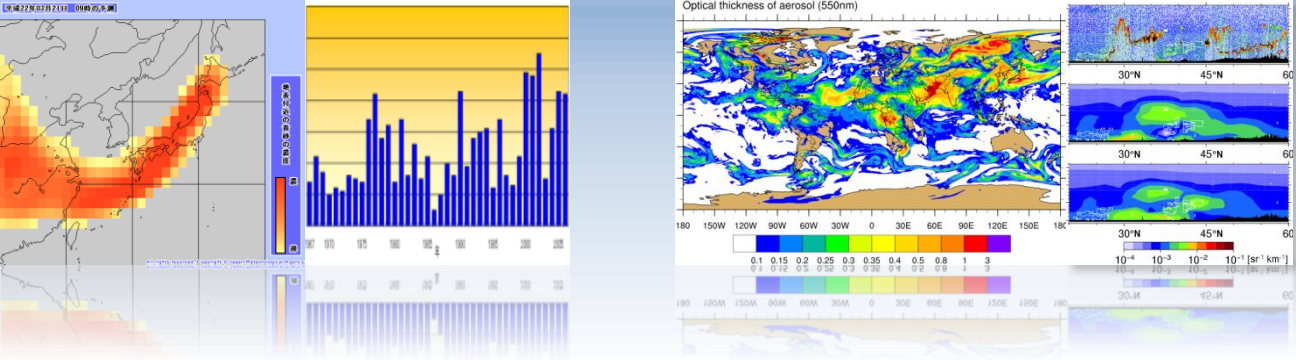
5th ICAP working group meeting, Tsukuba International Congress Center

Also, special thanks to

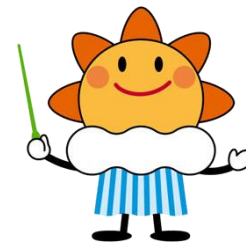
- *Meteorological Research Institute, JMA*: T. Maki, T.T. Sekiyama, K. Yumimoto, K. Okamoto, A. Uchiyama, M. Mikami
- *Atmospheric Environment Division, Global Environment and Marine Department, JMA*: H. Naoe, A. Ogi, N. Ohkawara, T. Sasaki
- *Meteorological Satellite Center, JMA*
- The Environment Research and Technology Development Fund

Outline

- Update of the global aerosol forecast and data assimilation
- Aerosol observations in JMA
 - Next generation Geostationary meteorological satellite, Himawari-8/9
- Some topics on the current aerosol and air quality situations in Japan



Current aerosol forecast status in JMA: Update of the global aerosol forecast and data assimilation

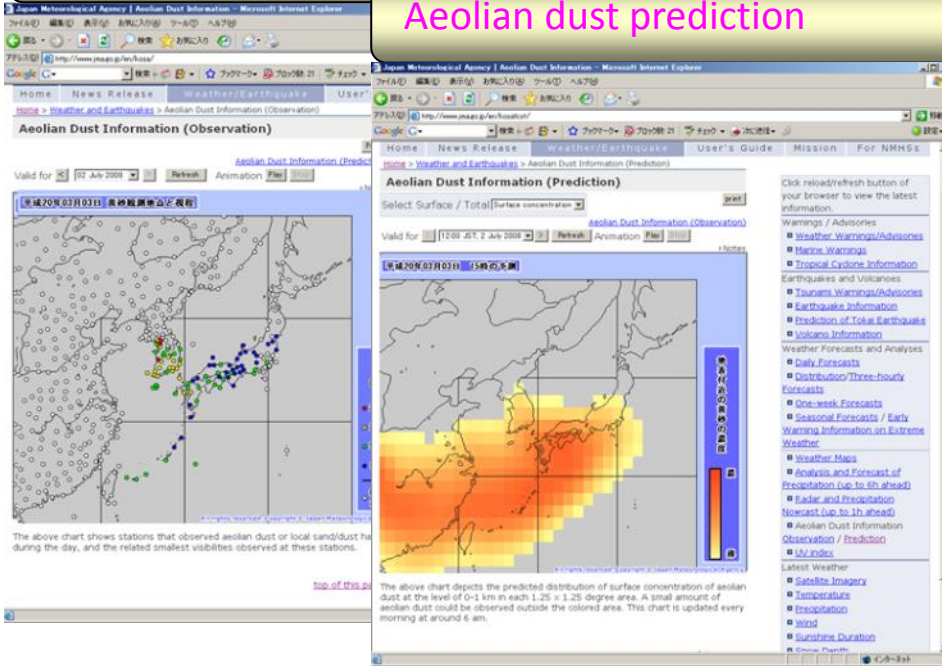


Information on aeolian dust to the public

JMA has been providing Aeolian dust information based on numerical forecast and observation since January 2004.

Aeolian dust observation

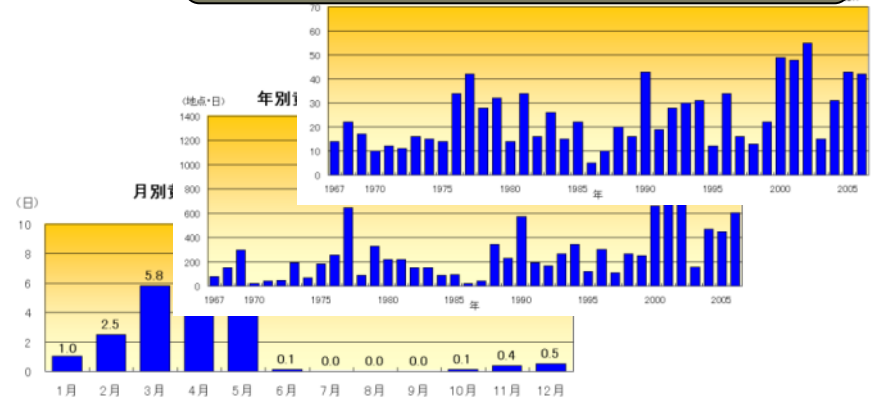
Aeolian dust prediction



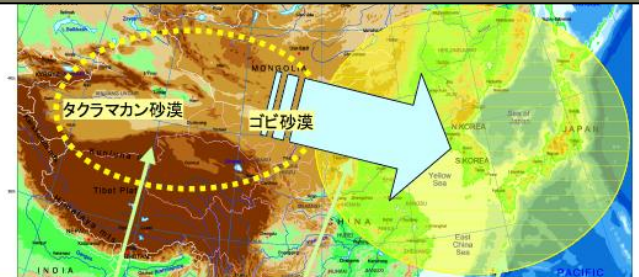
Aeolian dust warning information
(when required, Japanese only)

Japanese only

Statistics of aeolian dust



Basic knowledge about aeolian dust

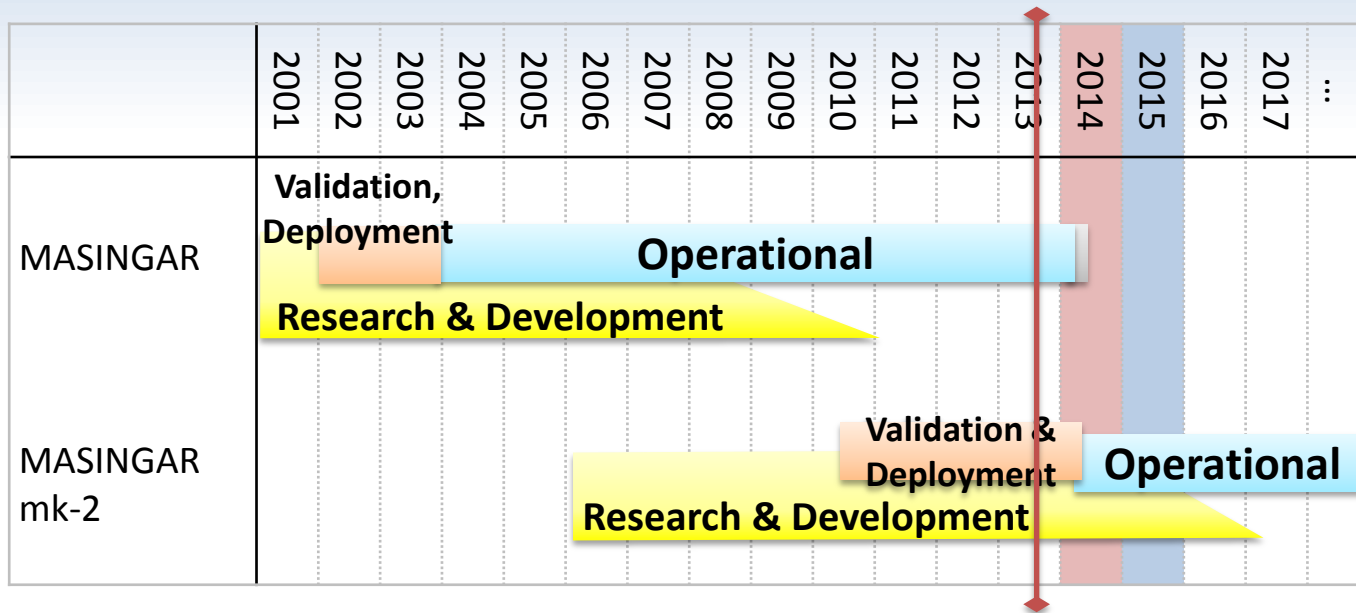


Blown up in arid area in the continent Advection by the upper wind Deposits in Japan

JMA also provides aeolian dust prediction results (GPV) for private weather services via the Japan Meteorological Business Support Centre (JMBSC).



Update of the global aerosol forecast



- Schedule

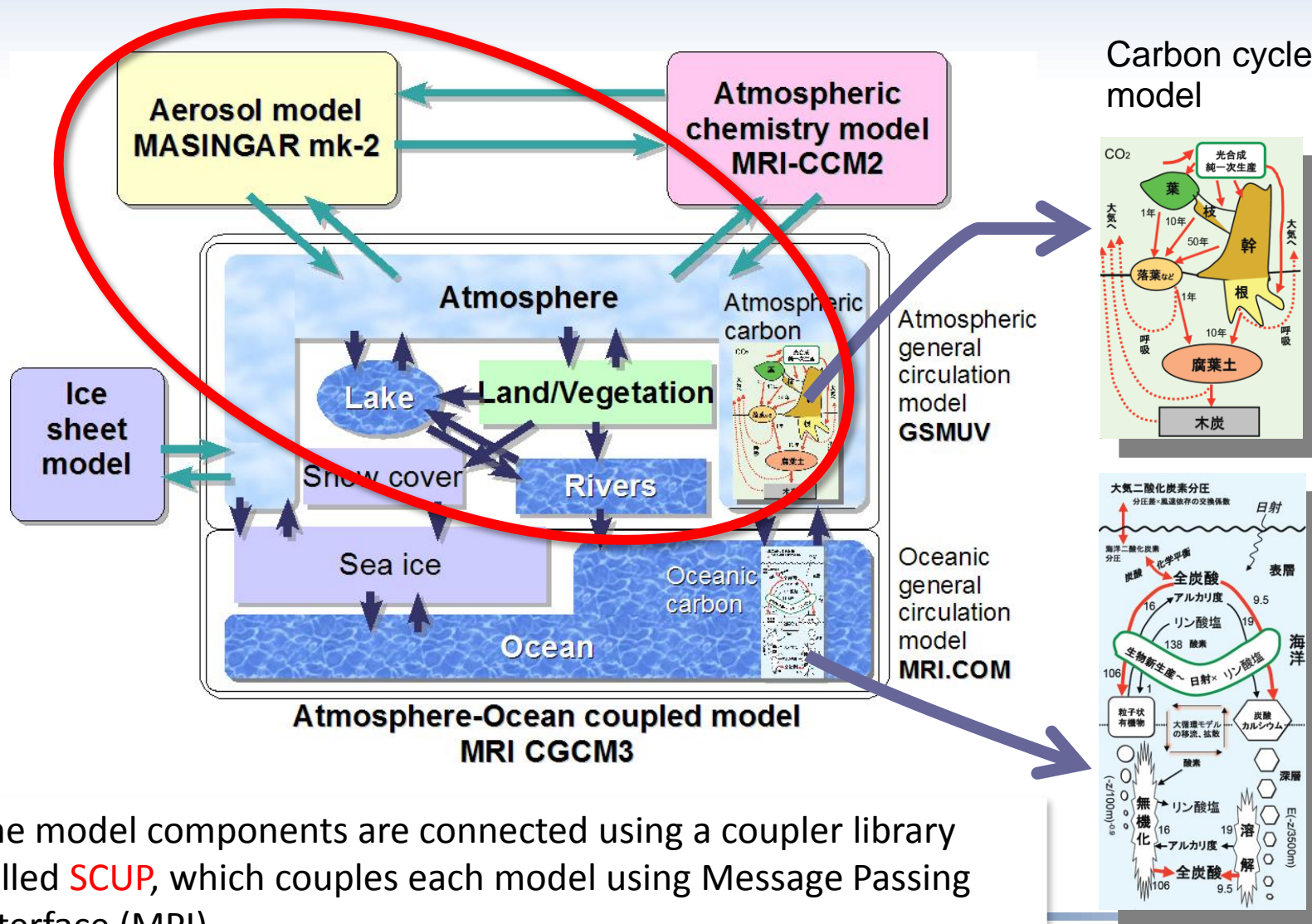
- 2014 Update to new version of aerosol model: (Horizontal TL159 (about 1.125°))
- 2015 Horizontal resolution will be increased to TL319 (about 0.56°).

Update of aerosol forecasting model

	Current operational global dust forecast model	Next global aerosol model
Global aerosol model	MASINGAR (Tanaka et al. 2003)	MASINGAR mk-2 (Tanaka et al., manuscript in preparation)
Dust emission	Function of 10m wind speed $F = C u_{10}^2(u_{10} - u_t)$	Function of surface friction velocity (Shao et al., 1996; Tanaka and Chiba, 2005)
Included aerosol species	Mineral dust	Mineral dust, sulfate, BC, OA, sea salt
Model grid resolution	Horiz. T106 (Approx. 1.125°) Vertical 20 layers	Horoz. TL159 → TL319 (0.56°) Vertical 40 or 48 layers
Atmospheric model	MRI/JMA 98 AGCM (Shibata et al., 1998)	MRI-AGCM3 (Yukimoto et al., 2012)
Advection	3-dimensional semi-Lagrangian	←
Convective transport	Arakawa-Schubert	Tiedtke-like scheme
Land surface model	3-layer Simple Biosphere	HAL
Coupling of aerosol model with AGCM	Subroutine call in each time step	Connected using SCUP library (Yoshimura and Yukimoto, 2008)

The MRI Earth System Model

The **MRI-ESM1** aims to improve the prediction of global warming.

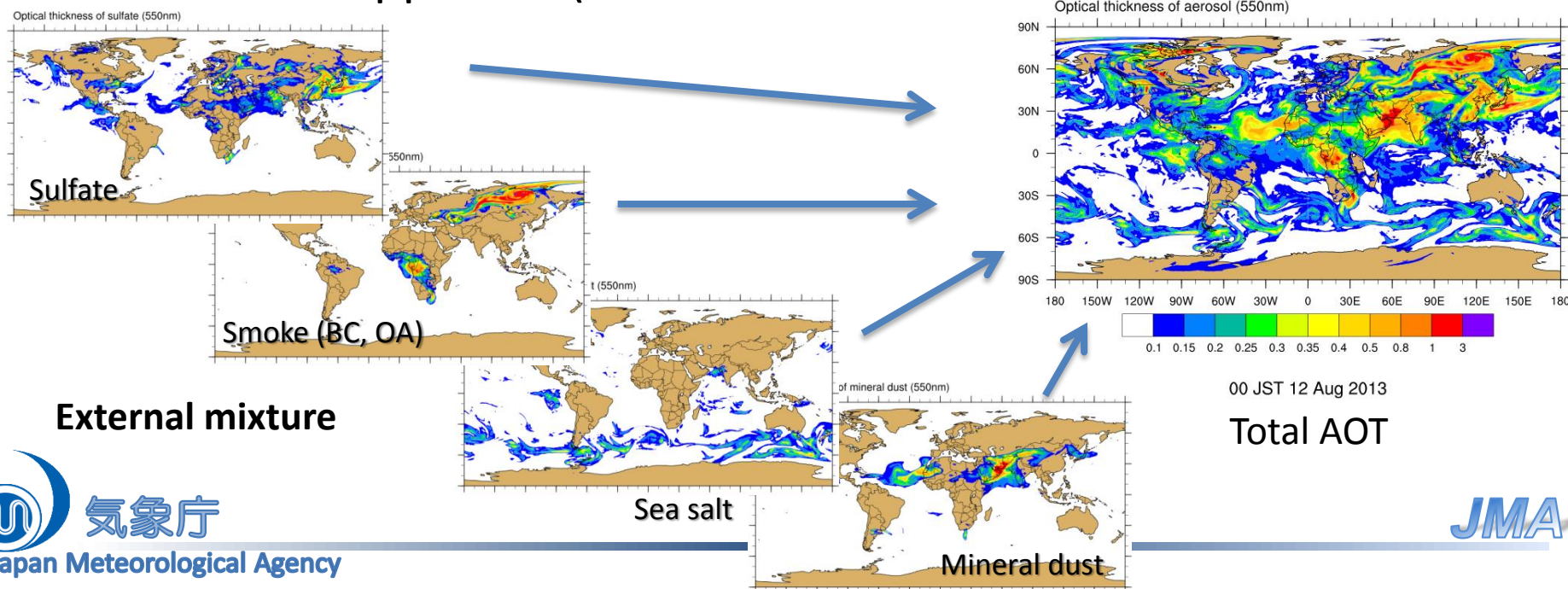


The model components are connected using a coupler library called **SCUP**, which couples each model using Message Passing Interface (MPI).

Global aerosol model MASINGAR mk-2

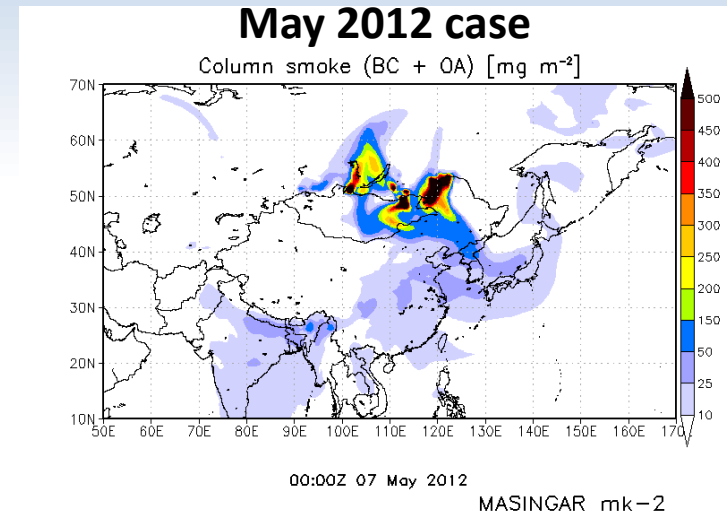
(Model of Aerosol Species in the Global Atmosphere)

- 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)

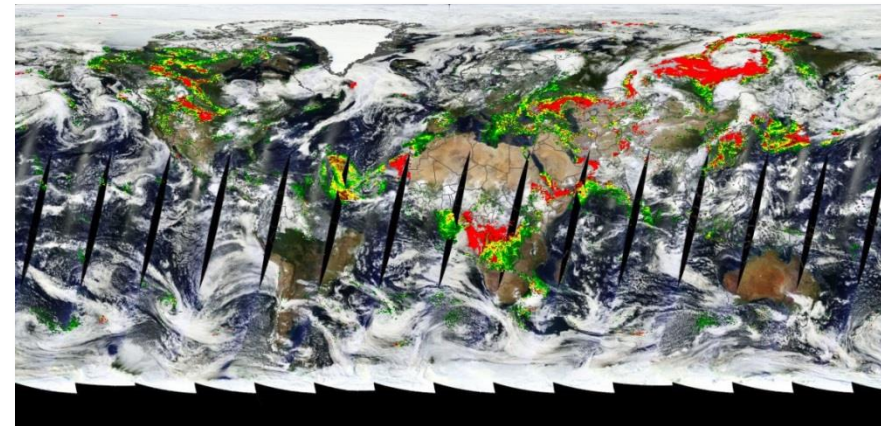
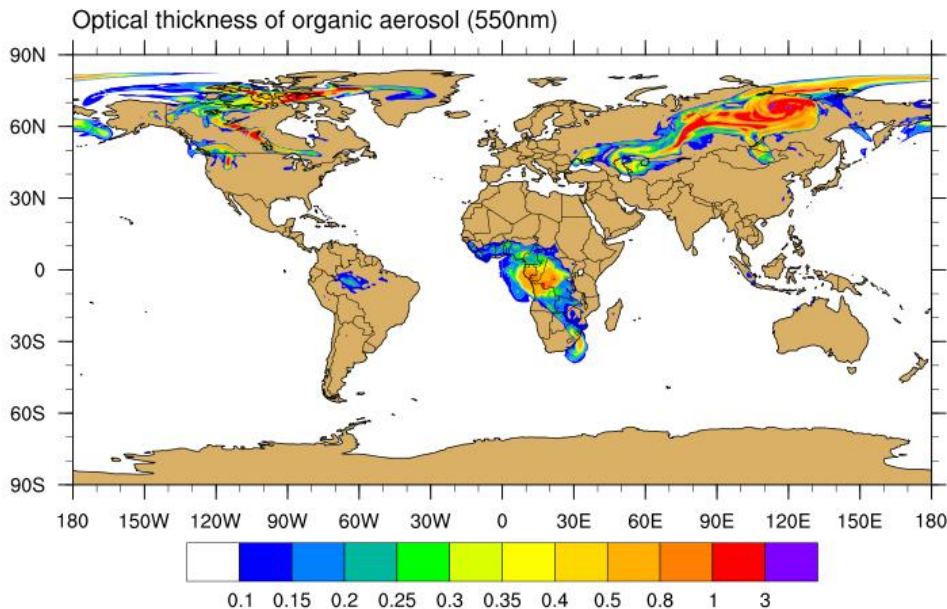


Improvement of smoke aerosol

GFAS v1.0 inventory by ECMWF
have been incorporated.
(Thanks to J. W. Kaiser, ECMWF)



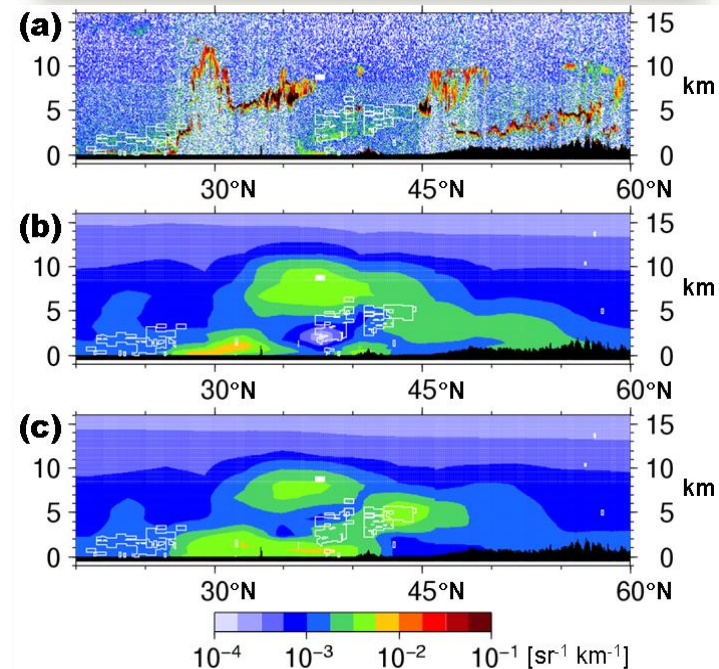
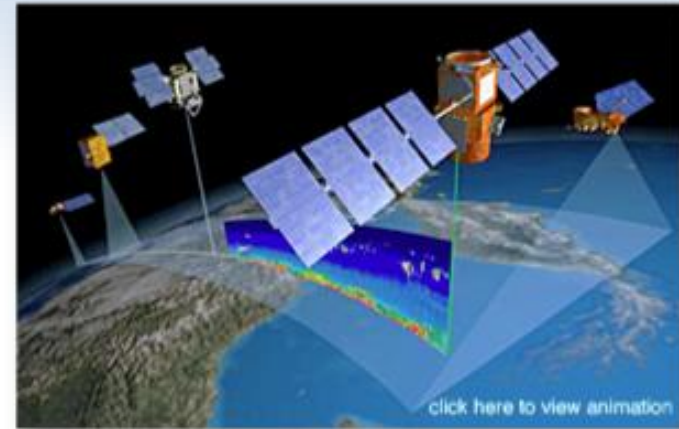
August 2013 case: Intense Russian forest fires



MODIS AOD (NASA)

Data assimilation: Lidar observation

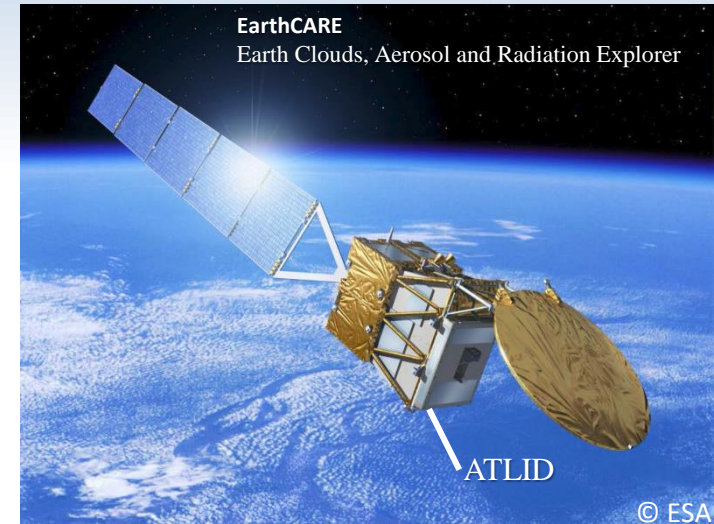
- We are studying the aerosol lidar data assimilation with **Local Ensemble Transform Kalman Filter (LETKF)** with **CALIPSO/CALIOP**.
- Currently, operational testing of NRT aerosol data assimilation with **CALIPSO level 1.5** is under way.



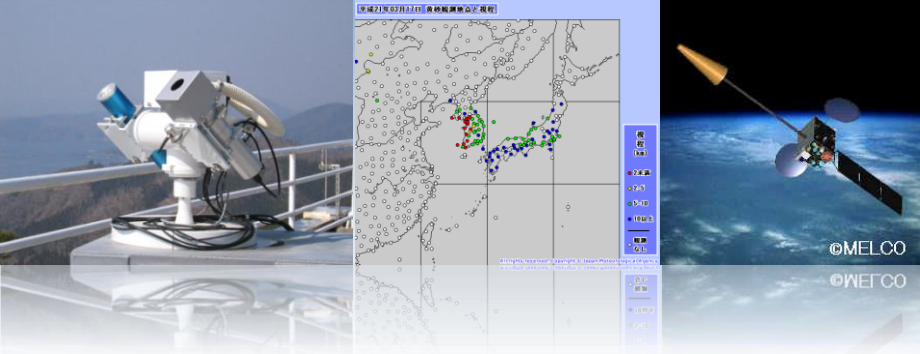
Sekiyama et al., ACP (2010)

Data assimilation: Future Plans

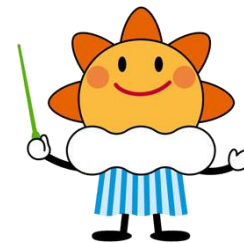
- Plans:
 - We are planning to apply operational aerosol lidar data assimilation with LETKF after the launch of **EarthCARE/ATLID**.
 - An **OSSE experiment** of EarthCARE/ATLID is planned (Cooperation with JAXA).
 - **Data assimilation experiment of AOD** with satellite image sensors is also now under way.



Talk on DA using
AOD by
Keiya Yumimoto will
be on Friday.



Aerosol observations in JMA



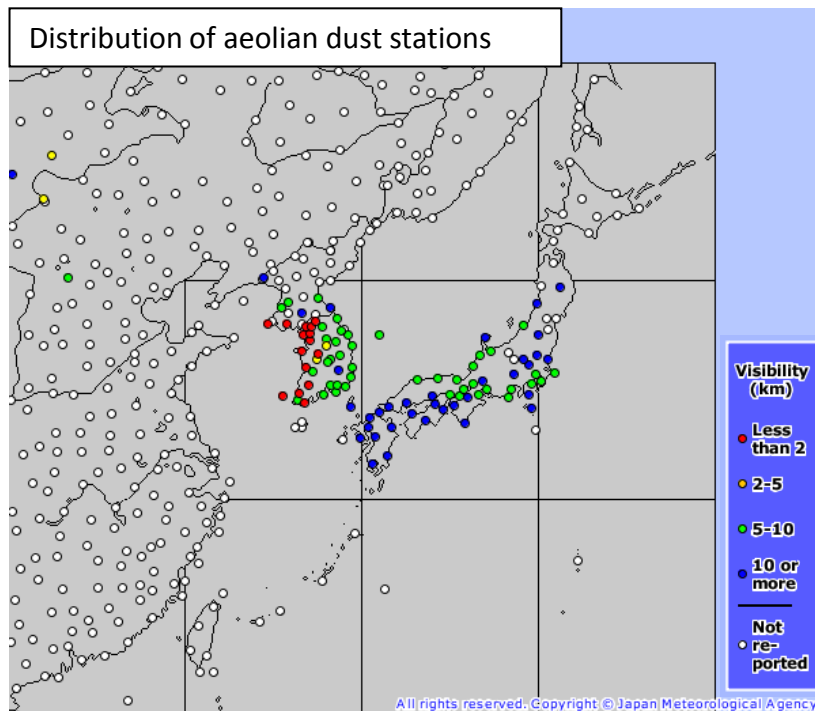
Aerosol observations in JMA

JMA has been operating the following aerosol observations.

- **Visibility** and meteorological conditions
- Surface AOD measurements by **Sunphotometers**
- (Ground-based **Raman lidar** observation)
- **Satellite** observations of dust index and AOD

Visibility and meteorological conditions

- JMA operates 61 manned observational stations, which observe Aeolian dust in terms of the visibility and meteorological conditions.
- The minimum visibility at each station is categorized in different colors on the JMA website.
- When the visibility becomes below 10 km, the station reports Aeolian dust in SYNOP messages.



Map of stations observing Aeolian dust Kosa or local sand/dust haze during the day

- **This observation is used for the validation of the dust forecast with Equitable Threat Score (ETS).**

Surface observation of AOD

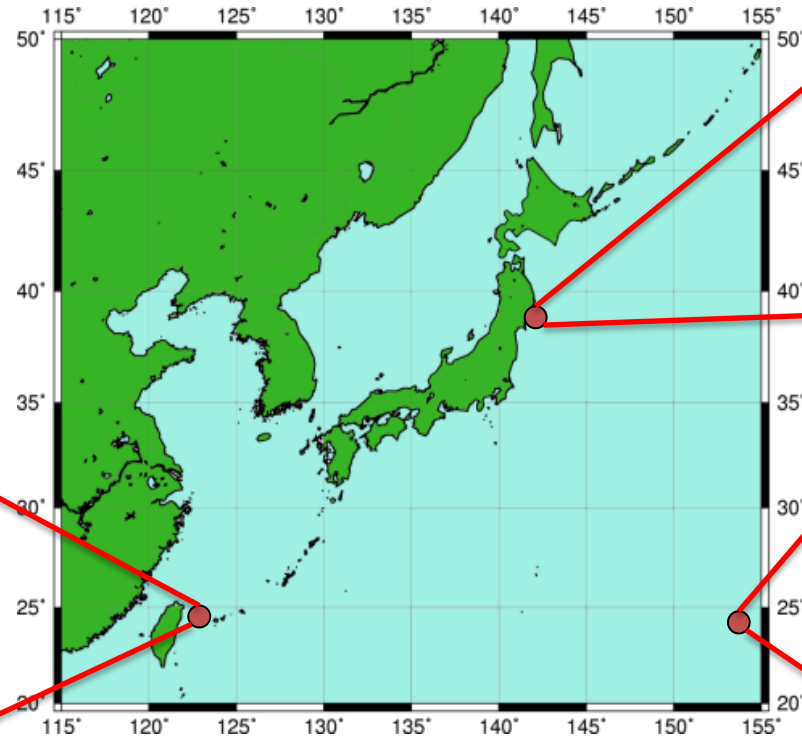
JMA has been conducting AOD measurements using sun-photometers at 3 WMO/GAW stations as part of its environmental monitoring network.



**Precision Filter Radiometer
(PFR)**



Yonagunijima

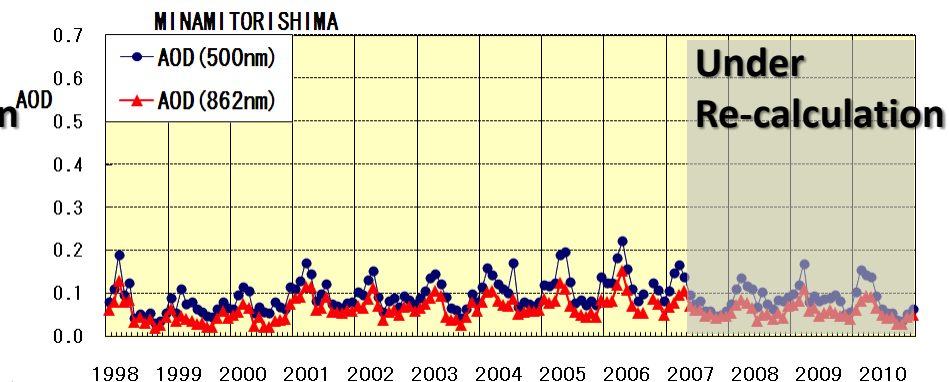
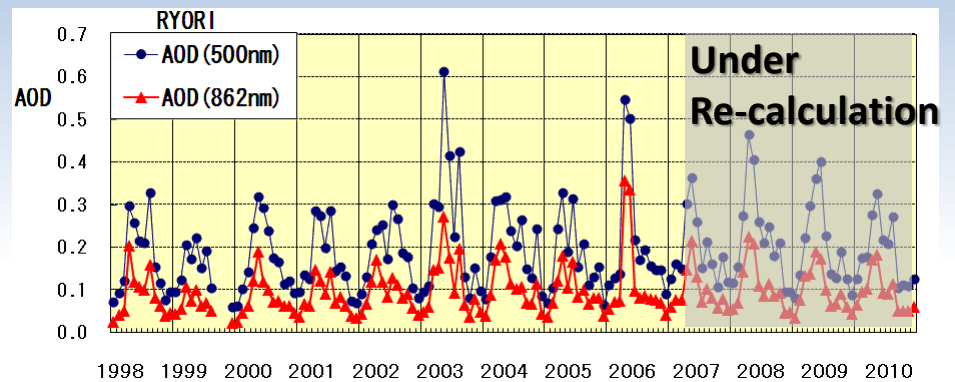
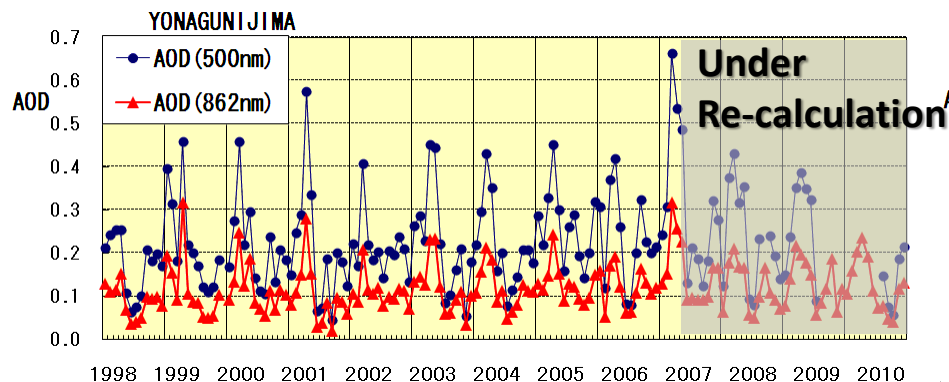


Ryori



Minamitorishima

Long term surface AOD trends



Long-term trends of AOD (500 and 862nm) at 3 Japanese stations

- JMA has submitted the AOD data to GAW/World Data Centre for Aerosols(WDCA).
- JMA also contributes to the pilot project “Improvement of Dissemination of Ozone and Aerosol Observations through the WMO Information System (WIS)” on the transfer of AOD data in near-real-time.

Plan: Upgrade of surface radiation observation

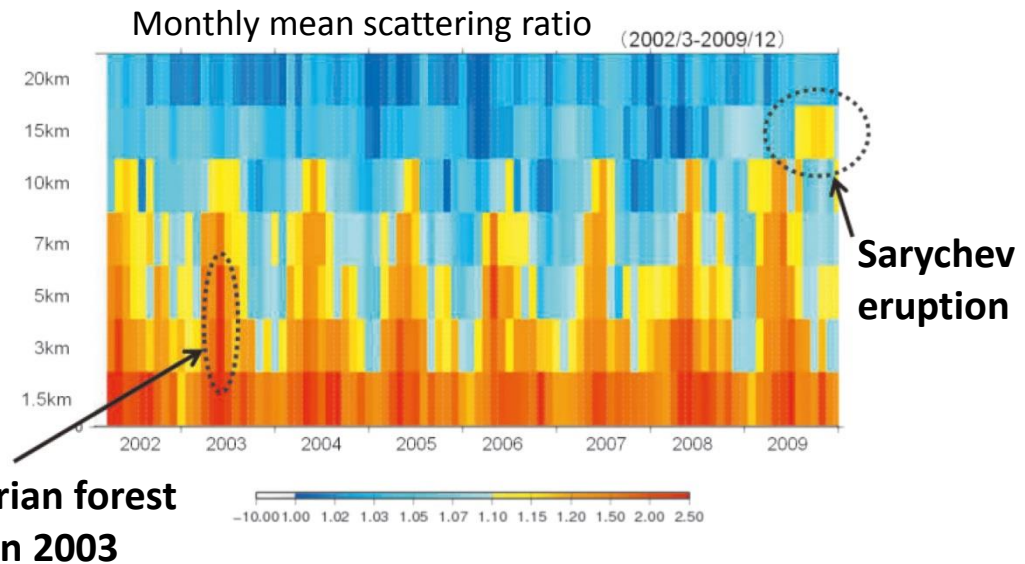
- JMA is planning its radiation measurement of sunphotometer to **sky-radiometer** at 5 stations in Japan.
- Radiation measurement comparable to SKYNET or AERONET
- More detailed retrieval products are expected.

Ground lidar observation (until 2011)

- JMA operated ground based **Raman lidar** at Ryori GAW station from March 2002 to the end of 2011, and observed vertical profiles of aerosols.
- MRI/JMA operates Raman lidar at Tsukuba for Research purpose.

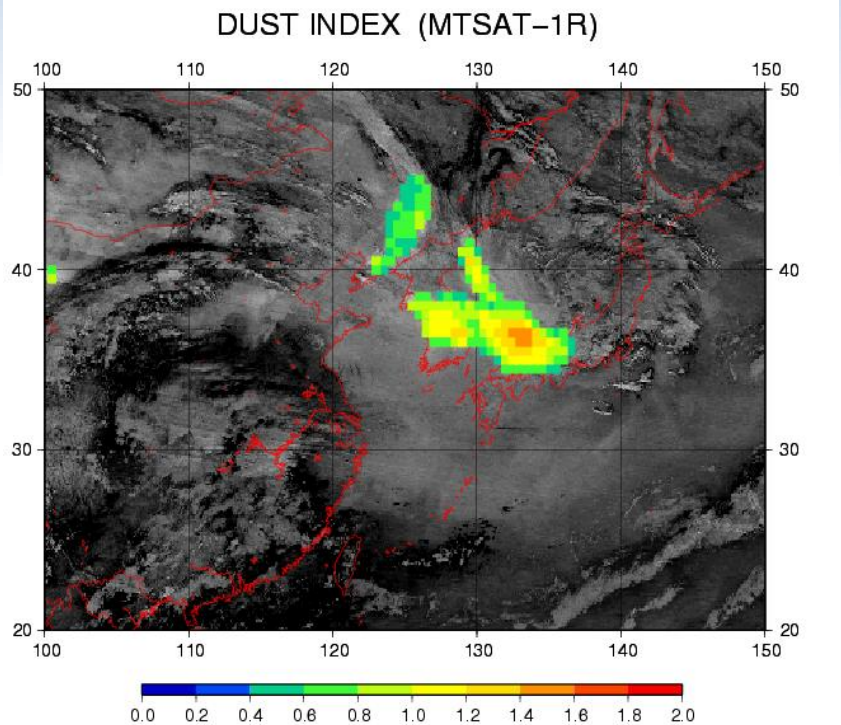


Lidar at Ryori observatory



(Climate Change Monitoring Report, JMA, 2011(in Japanese))

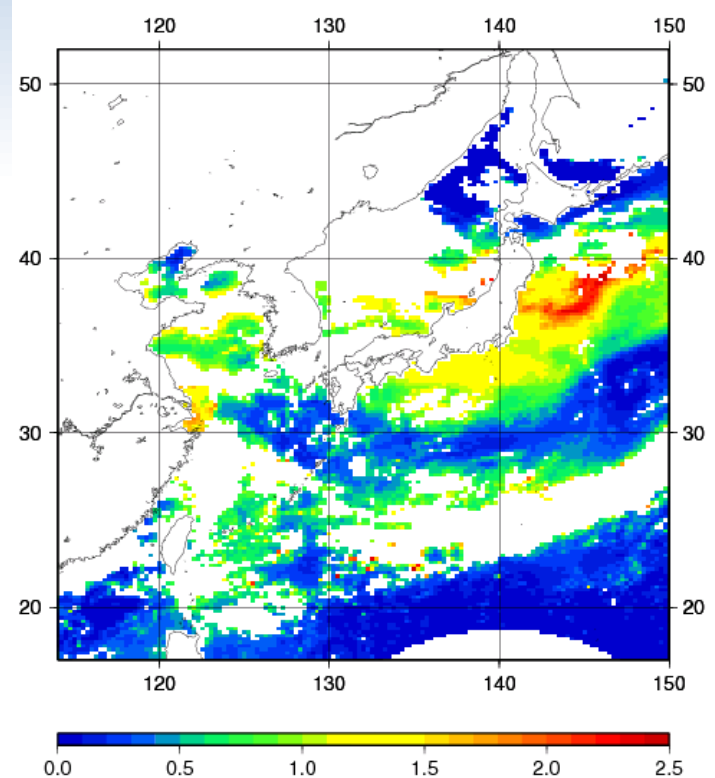
Current satellite products: dust aerosol



DATE: 2006/04/08/ 03Z

JMA/AED

Aeolian dust index derived from infrared differential imagery of MTSAT (03UTC on 8 April 2006)



AOD derived from visible imagery of MTSAT (03 UTC on 18 April 2006)

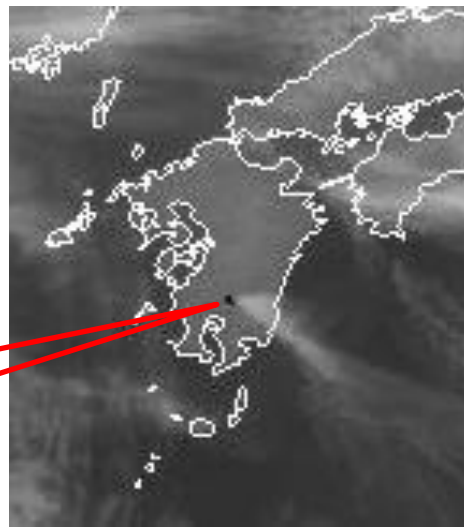
JMA has been monitoring dust aerosol using satellite products (AOD and aeolian dust index) derived from satellite imagery of MTSAT at Meteorological Satellite Center (MSC) of JMA.

Volcanic ash cloud monitoring

The infrared brightness difference temperature image of the MTSAT split window channels (10.8-12.0 μm) can distinguish volcanic ash clouds from conventional ice/water clouds.

Shinmoedake volcano erupted on 26th January 2011

The black dot in 3.8 μm image shows a heat source



3.8 μm image

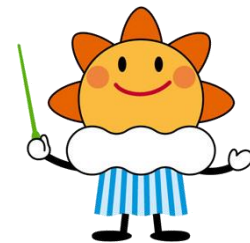


Infrared differential image (10.8 – 12.0 μm)



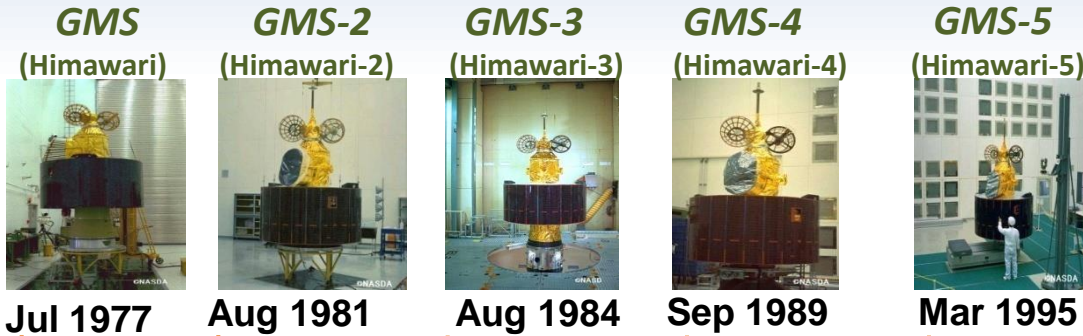
“Himawari” = Sunflower

Next generation geostationary meteorological satellites (Himawari-8/9)



History of Japanese Geostationary Meteorological Satellites "Himawari"

GMS (Geostationary Meteorological Satellite)



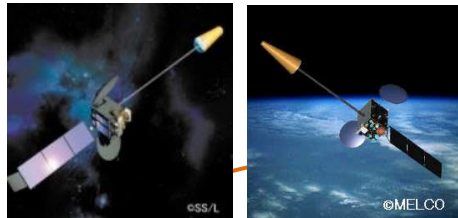
A Ranging Station for GMS was operated by Australian Bureau of Meteorology

(GOES-9)

Back-up operation of GMS-5 with GOES-9 by NOAA/NESDIS from May 22, 2003 to June 28, 2005

MTSAT (Multi-functional Transport SATellite)

MTSAT-1R (Himawari-6) **MTSAT-2 (Himawari-7)**

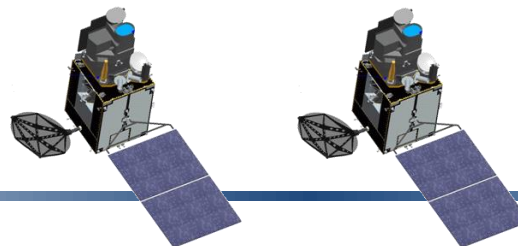


Feb 2005 Feb 2006

Himawari
Himawari-8 Himawari-9

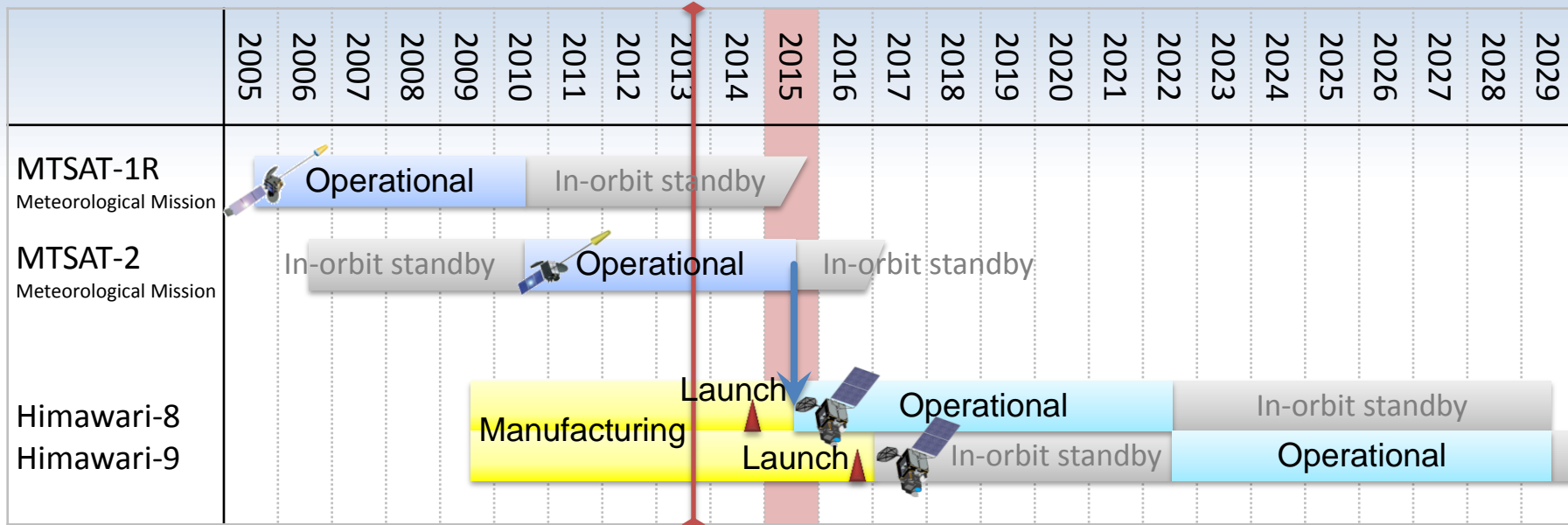
2014

2016



Satellite	Observation period
GMS	1977 – 1981
GMS-2	1981 – 1984
GMS-3	1984 – 1989
GMS-4	1989 – 1995
GMS-5	1995 – 2003
GOES-9	2003 – 2005
MTSAT-1R	2005 – 2010
MTSAT-2	2010 –
Himawari-8	Launch in 2014
Himawari-9	Launch in 2016

Transition of Operational Satellites



- JMA plans to launch **Himawari-8** in **2014** and begin its operation in **2015**.
- The launch of **Himawari-9** for in-orbit standby is scheduled in **2016**.
- **Himawari-8/9** will be in operation around **140 degrees East** covering the East Asia and Western Pacific regions for 15 years.

Specification of Himawari-8/9 Imager (AHI)

MTSAT-1R/2 →

VIS: 1km, IR: 4km

AHI = Advanced Himawari Imager

Band	Wavelength [μm]	Spatial Resolution
1	0.46	1Km
2	0.51	1Km
3	0.64	0.5Km
4	0.86	1Km
5	1.6	2Km
6	2.3	2Km
7	3.9	2Km
8	6.2	2Km
9	7.0	2Km
10	7.3	2Km
11	8.6	2Km
12	9.6	2Km
13	10.4	2Km
14	11.2	2Km
15	12.3	2Km
16	13.3	2Km

RGB band
Composited

NIR Similar to ABI for GOES-R, but
0.51 μm(Band 2) instead of ABI's 1.38 μm

Water vapor

SO₂

O₃

Atmospheric
Windows

CO₂



Products

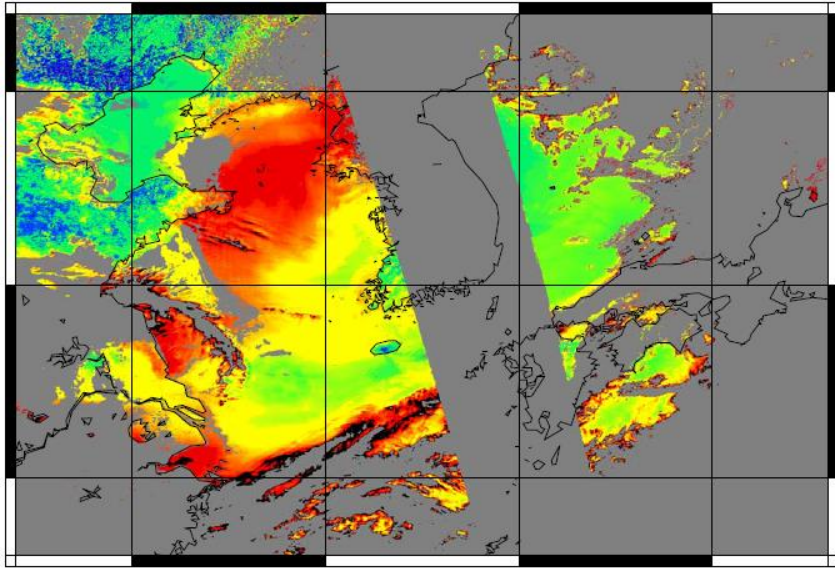
- Volcanic Ash
- Global Instability Index
- Nowcasting
- Typhoon Analysis
- Atmospheric Motion Vector
- Clear Sky Radiance
- Sea Surface Temperature
- Yellow Sands
- Snow and Ice Coverage

Planned satellite product: Dust

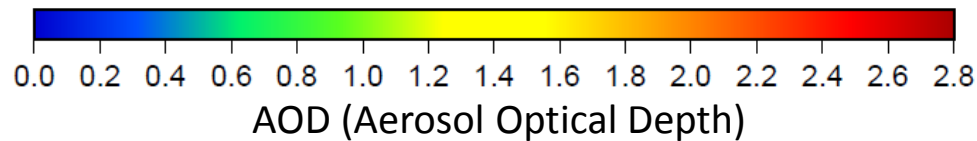
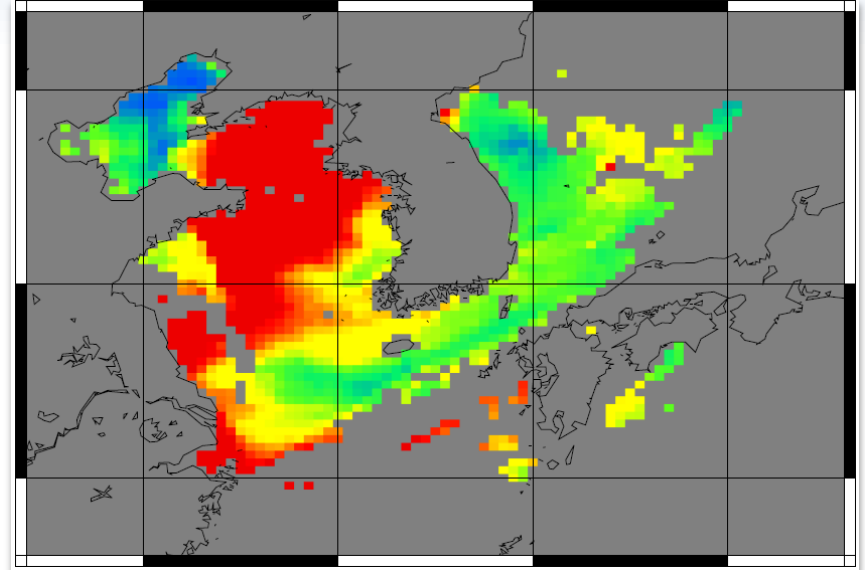
- Development of **Dust Product** (Plan)
 - Product will be developed for the purpose of monitoring of Asian dust
 - Two different approaches,
 - one from **visible and near-infrared data** and
 - another one from **infrared data**, will be taken for the product
 - Algorithm for visible data product has been developed based on **NOAA/NESDIS Aerosol algorithm**

Aerosol Product (Prototype)

Prototype (MODIS/Terra)



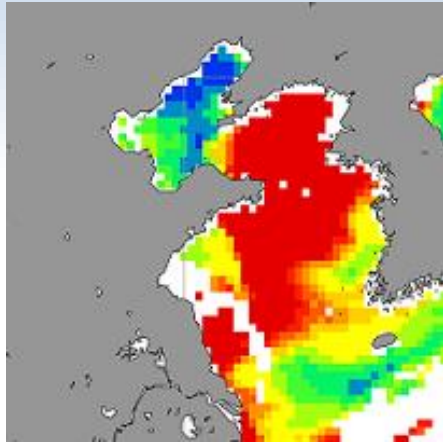
Current (MTSAT-2)



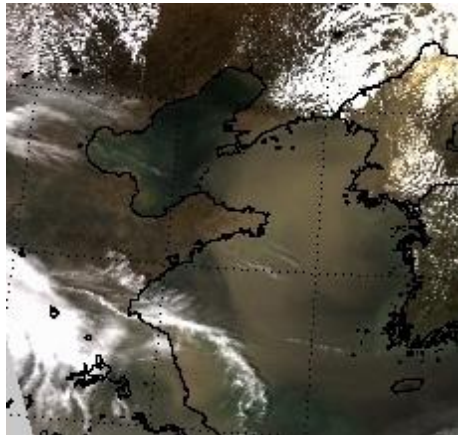
Trial processing with MODIS/Terra
(0430 UTC), without cloud mask

Current Algorithm with MTSAT-2
(0500 UTC)

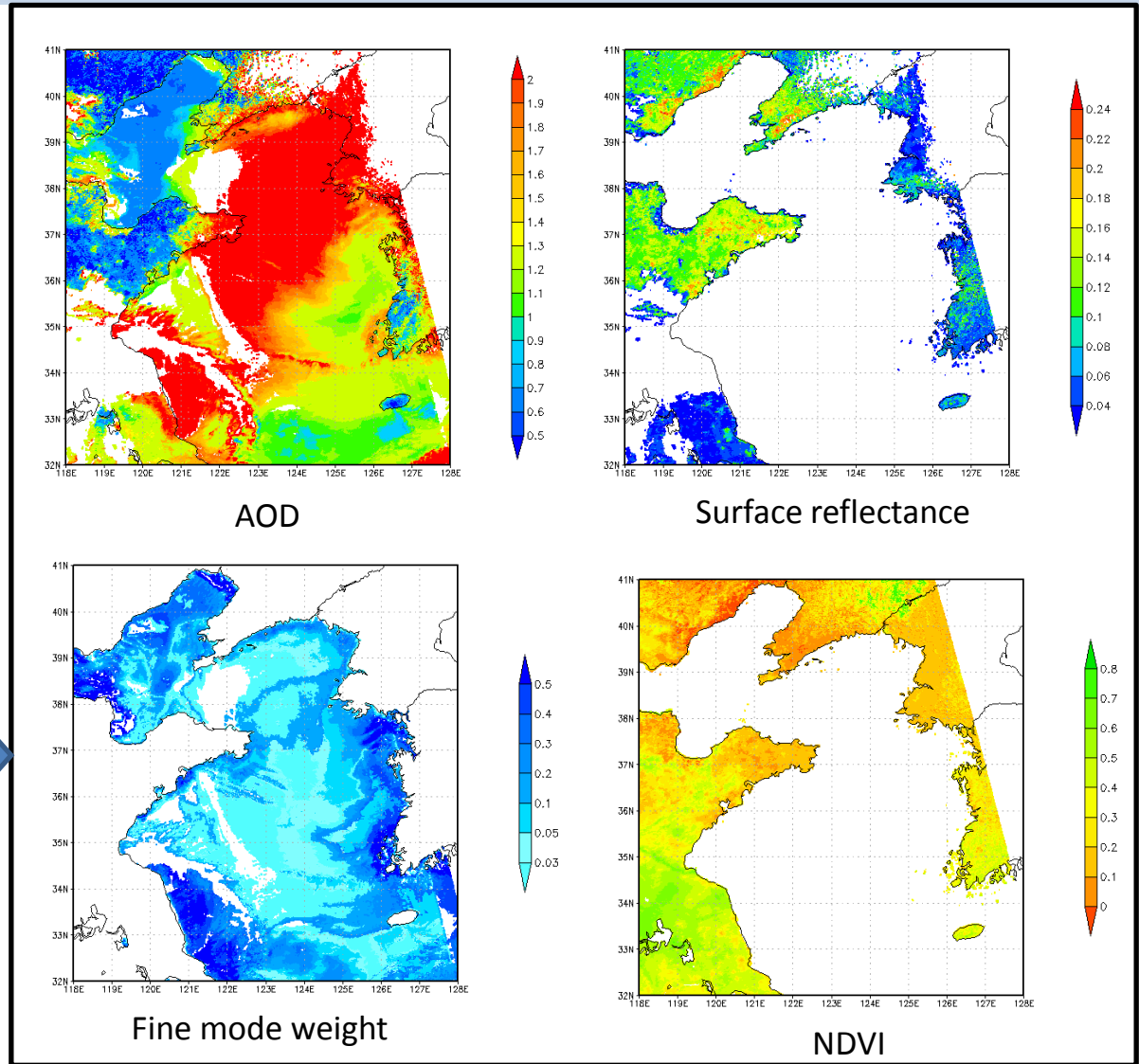
Algorithm test using MODIS/Aqua (0430 UTC, 01 May 2011)



(Ref.) MTSAT-2 AOD (0500)



MODIS/Aqua (IIS-U-Tokyo, Japan)



AOD

Surface reflectance

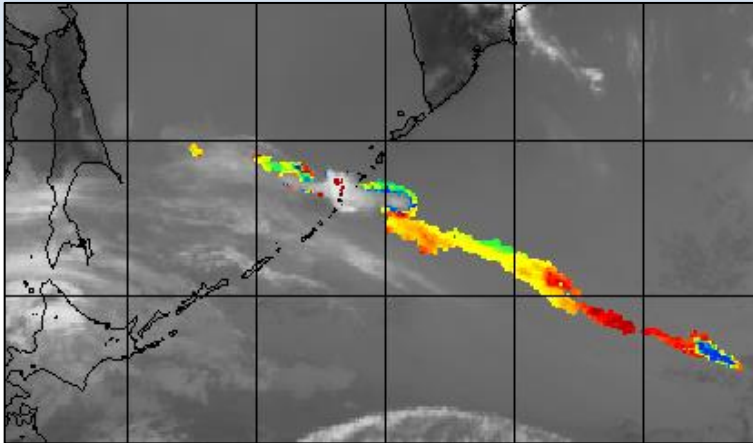
Fine mode weight

NDVI

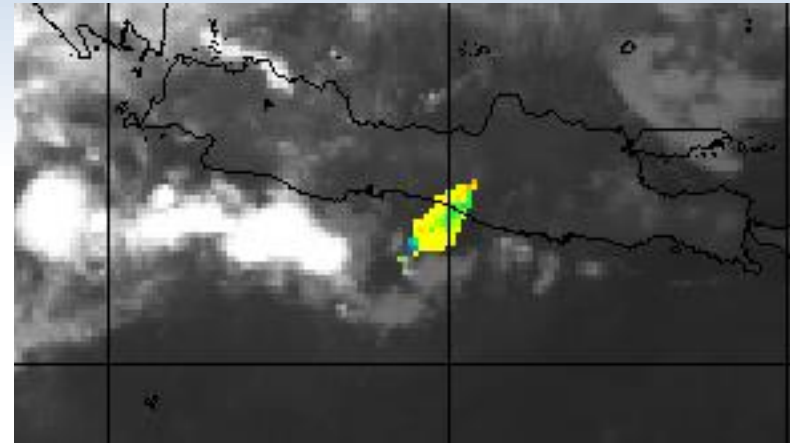
Planned satellite product: Volcanic Ash

- JMA is developing a satellite-based volcanic ash product for MTSAT-2 and Himawari-8/9 in collaboration with [EUMETSAT](#).
- [NOAA/NESDIS volcanic ash algorithm](#) is also planned to be introduced.
 - Two volcanic ash products will be generated from Himawari-8 using two algorithms from EUMETSAT and NOAA/NESDIS.
- By the start of Himawari-8's operation, further algorithm improvements will be made and operational products will be provided to Tokyo VAAC/JMA.

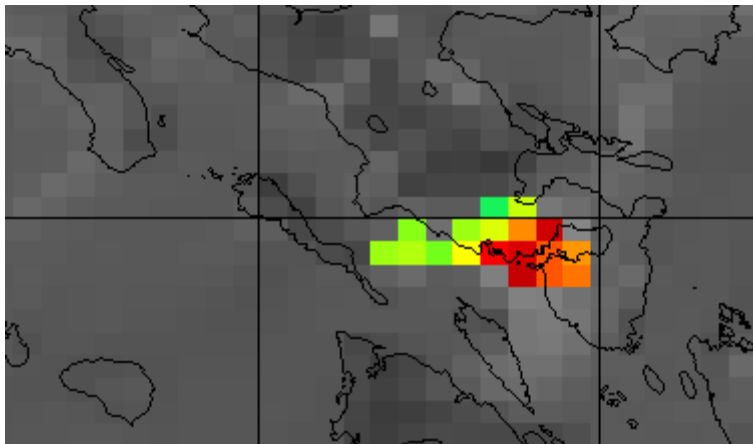
Experimental volcanic ash product



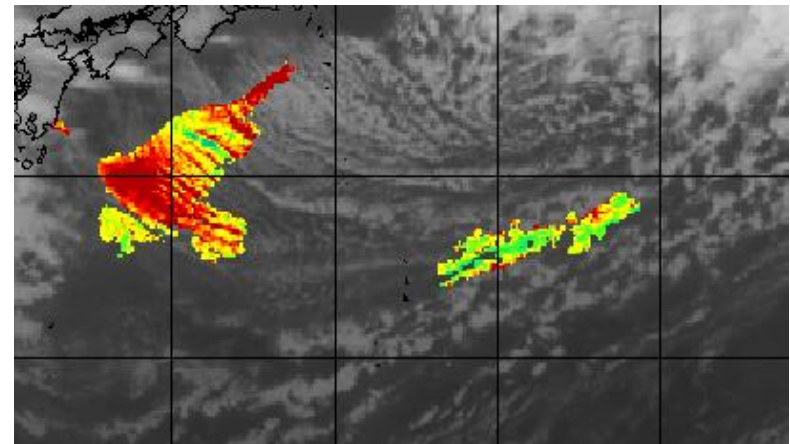
Mt. Sarychev 2009.6.14 0300UTC, MTSAT-1R



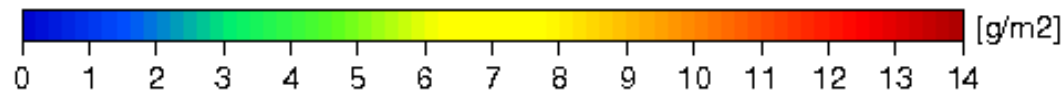
Mt. Merapi 2010.11.11 2000UTC, MTSAT-1R



Mt. Bulusan 2011.2.21 0400UTC, MTSAT-2

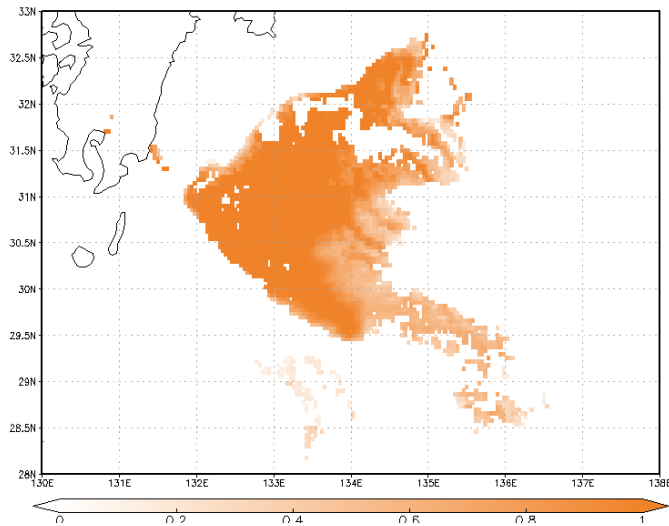


Mt. Shinmoe 2011.1.27 0000UTC, MTSAT-2

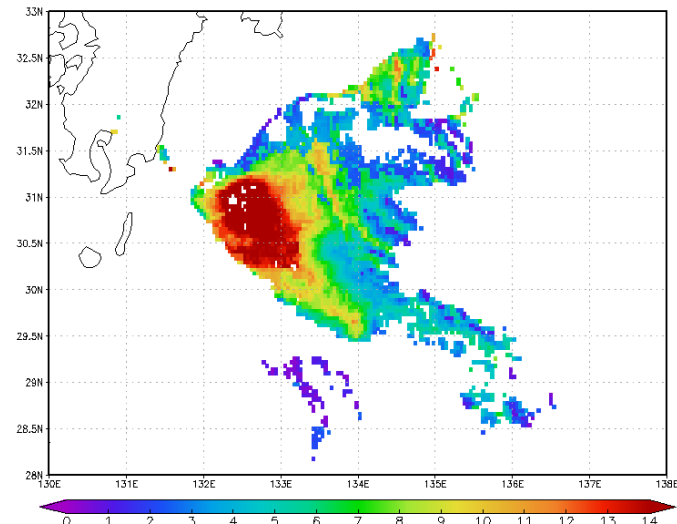
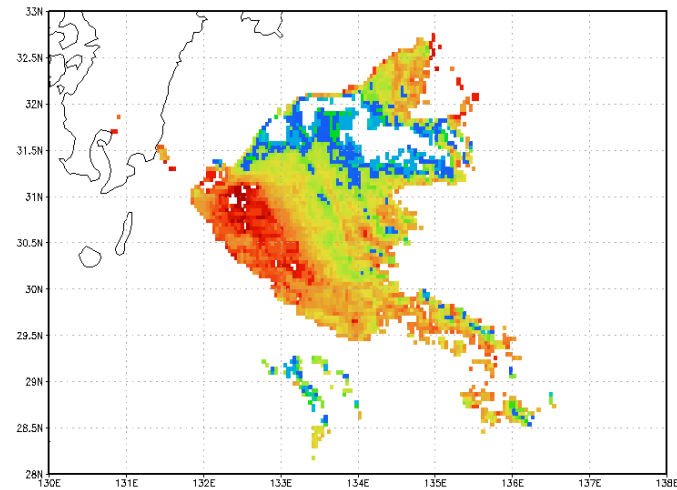


An example of volcanic ash from Mt. Shinmoe, 27 Jan. 2011

MTSAT-2 data, EUMETSAT algorithm is applied.

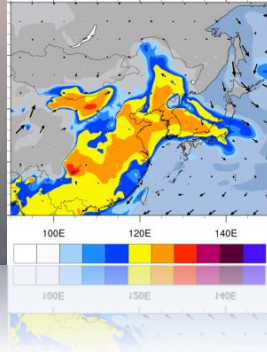


- Optical thickness (above)
- Effective radius (μm , upper right)
- Mass loading (g m^{-2} , down right)

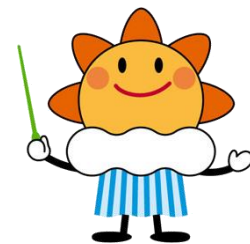


Aerosol Product / Current Status and Plan

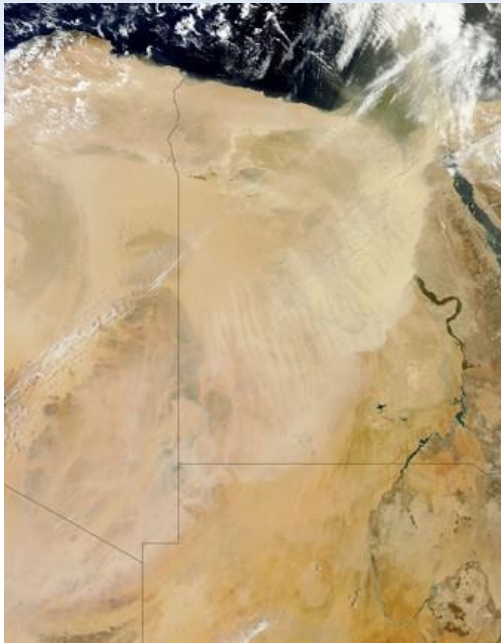
- Reviewed ATBD for NOAA/NESDIS aerosol product (2012.4-6)
- Designed LUT for aerosol retrieval and generated the 1st version of LUT (2012.8-11)
- Experimental retrieval from MODIS L1B data (2012.12)
- Software and/or LUT will be adjusted using Himawari-8 data after the data becomes available.
- JMA will also introduce NOAA/NESDIS volcanic ash algorithm.



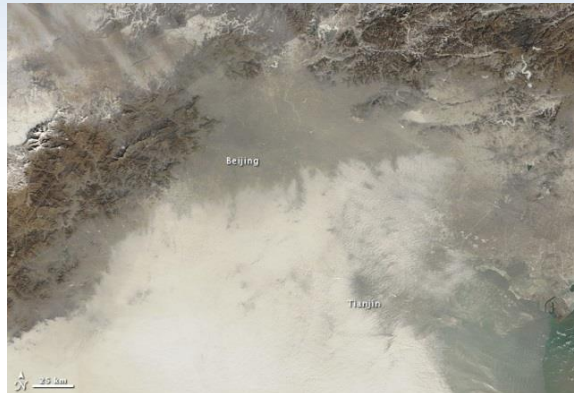
Some topics on the current aerosol and air quality situations in Japan



WGNE experience: Evaluating aerosols impacts on Numerical Weather Prediction



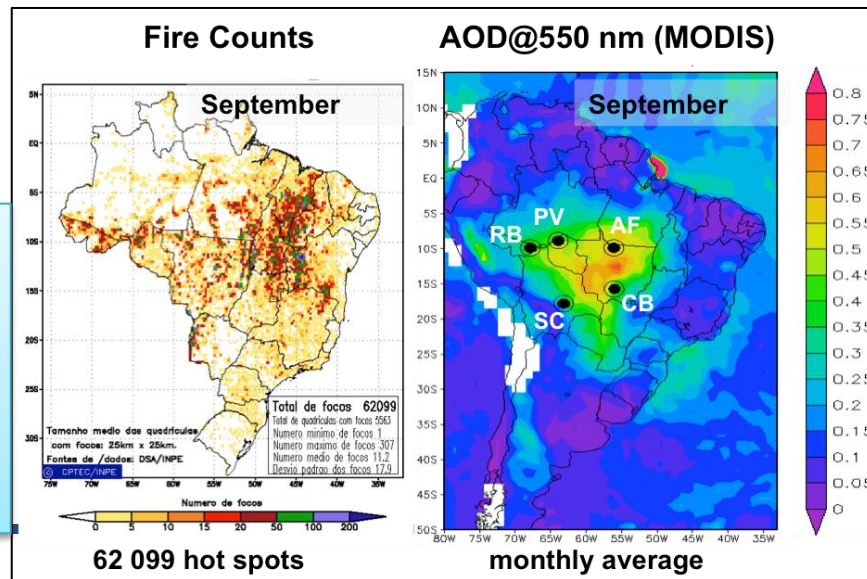
Case 1: Severe dust storm in north Africa



Case 2: Severe air pollution in China

How important are aerosols for predicting the physical system as distinct from predicting the aerosols themselves?

Case 3: biomass burning in South America

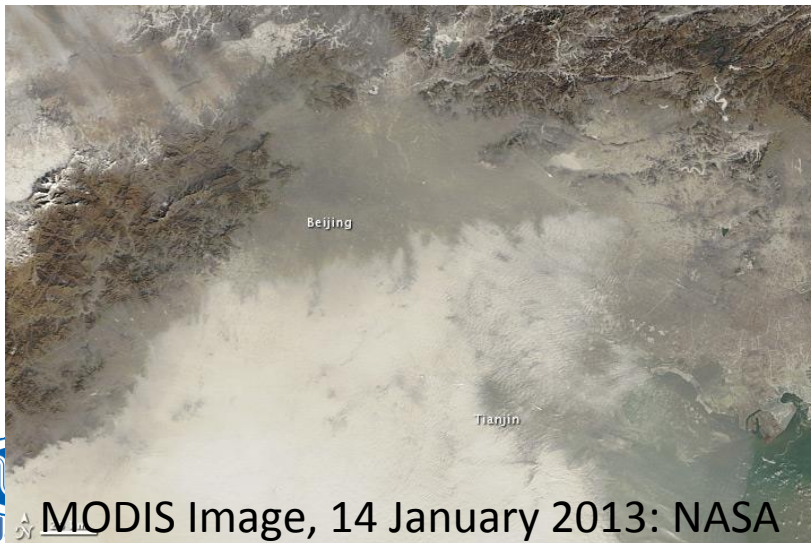


Meanwhile in East Asia, ...

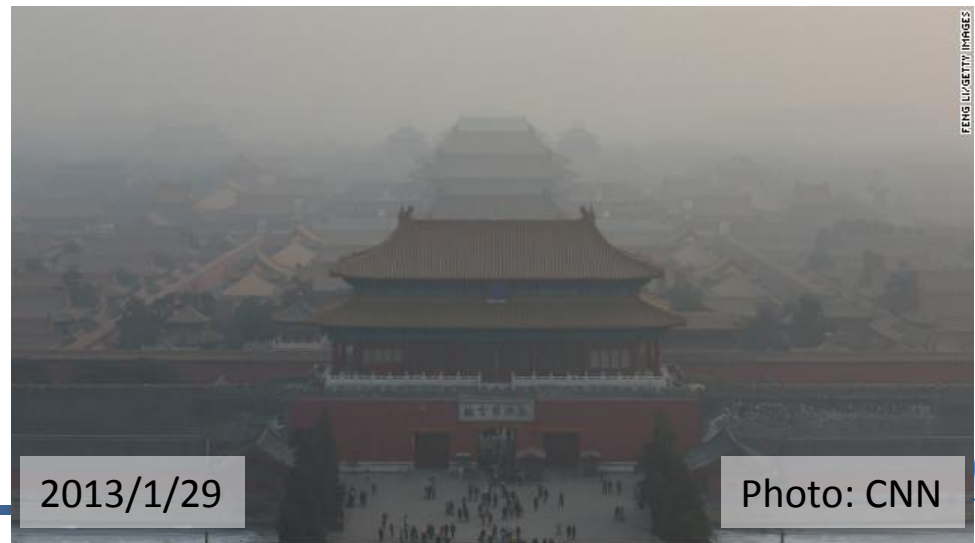
- Along with Asian dust, air pollution (PM2.5) is much concerned by general public, especially for human health.



A view from a Hotel in Nanjing,
23 Oct. 2013 (Photo: Izuru Takayabu)



MODIS Image, 14 January 2013: NASA

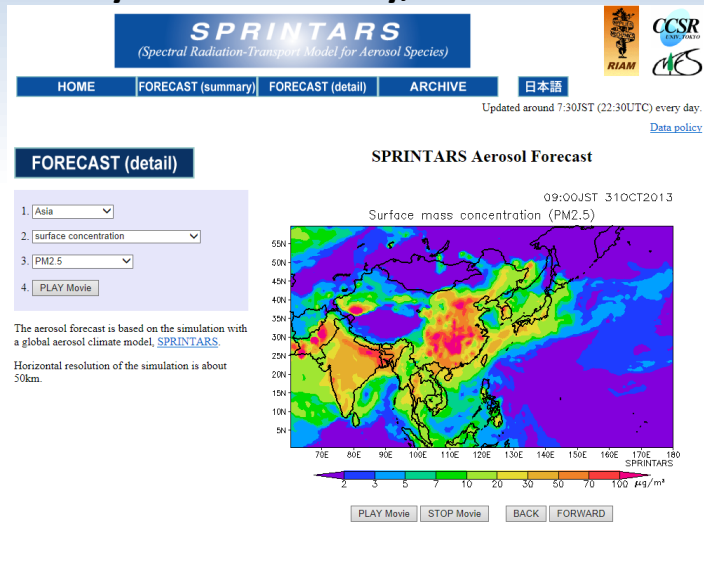


2013/1/29

Photo: CNN

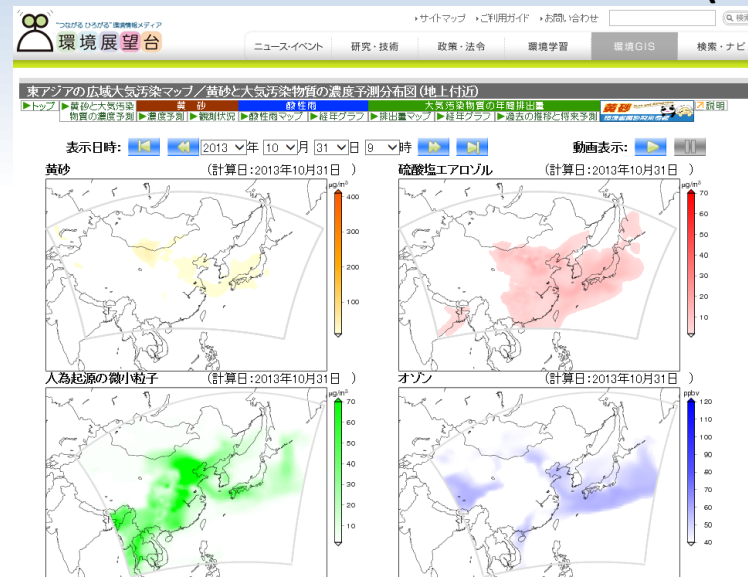
Air pollution forecasts in Japan

Kyushu University, SPRINTARS



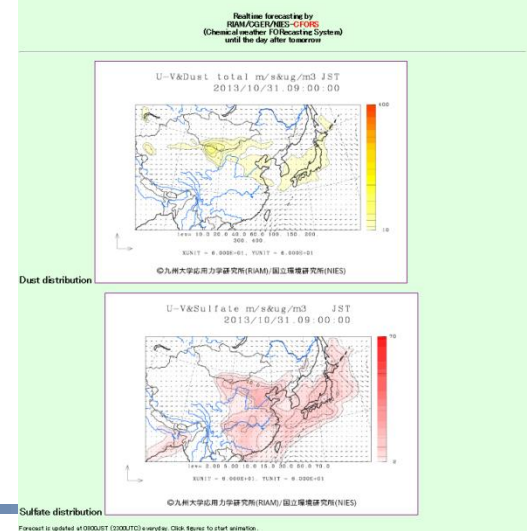
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National Institute of Environmental Studies (NIES)



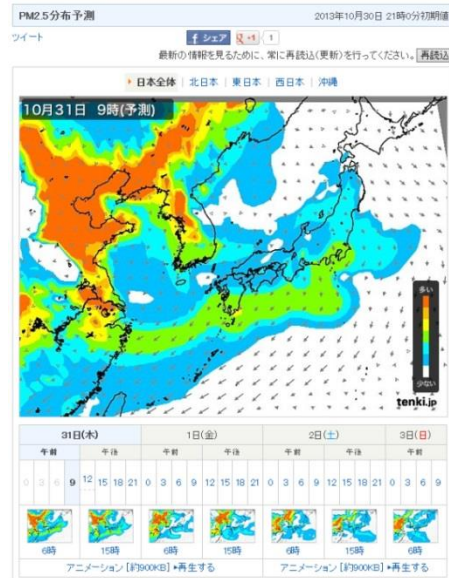
NIES/Kyushu-U (CFORS)

Forecast for distributions of Asian dust and anthropogenic aerosols in east Asian region

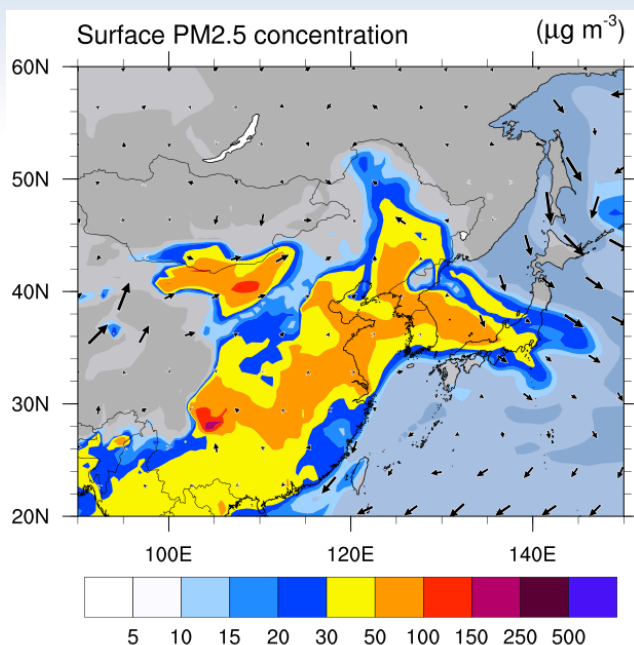


Japan Weather Association

Several institutes are releasing forecasts of atmospheric pollution (that includes PM2.5).



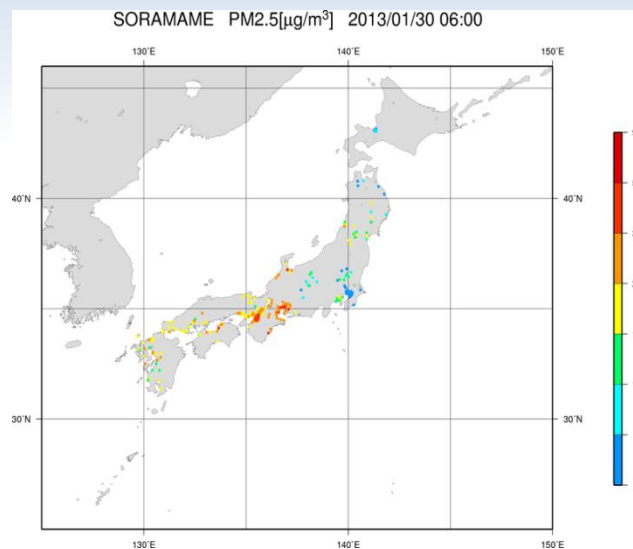
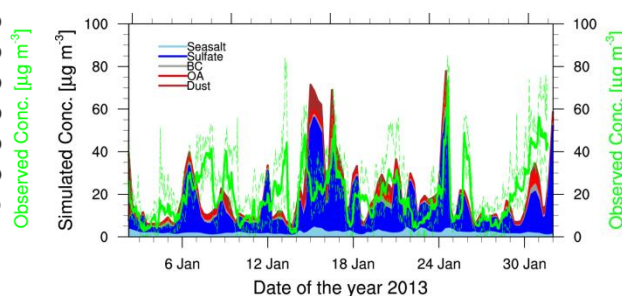
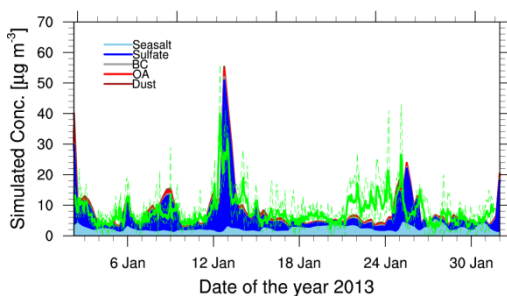
PM2.5 evaluation with the MRI global aerosol model (MASINGAR mk-2)



09 JST 30 Jan 2013

Simulated PM2.5 : Aomori

Simulated PM2.5 : Fukuoka



PM2.5 observation by Ministry of the Environment

Currently, MRI is cooperating with NIES to understand the air pollution of PM2.5 and Asian dust as a research project.

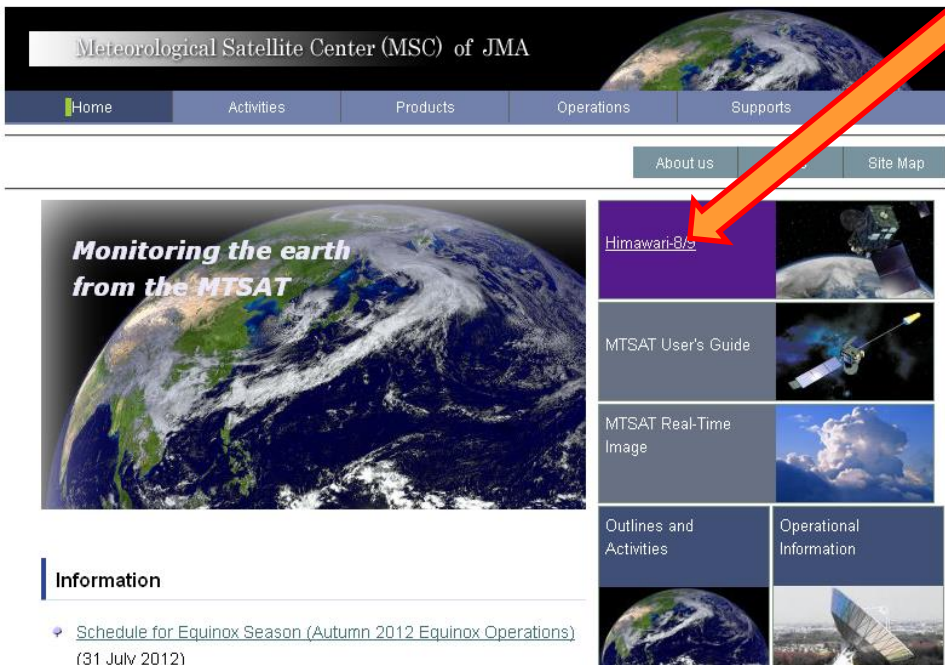
Summary

- JMA plans to upgrade the dust aerosol forecast to its new global aerosol model in 2014. Horizontal resolution will be increased to TL319 (0.56°) in 2015.
- Aerosol-related observations in JMA is presented.
 - Visibility
 - Radiation measurement by Sun-photometer, and plans to upgrade it to the sky-radiometer.
 - Ground-based lidar observation
 - AOD and dust index by geostationary meteorological satellite
- JMA plans to launch the next generation geostationary meteorological satellite, Himawari-8/9.

MSC Web Page for Himawari-8/9 Information

MSC website top page

<http://mscweb.kishou.go.jp/>



Details of AHI

The Japan Meteorological Agency (JMA) has operated the GMS and MTSAT series of satellites at around 140 degrees east to cover the East Asia and Western Pacific regions since 1977, and makes related contributions to the WMO's World Weather Watch (WWW) Programme. As a follow-on to the MTSAT series, the Agency plans to operate next-generation satellites called Himawari-8 and Himawari-9 (*himawari* means "sunflower" in Japanese).


Overview of satellite observations

The functions and specifications are notably improved from those of the on-board imager of MTSAT, and enable better nowcasting, improved numerical weather prediction accuracy and enhanced environmental monitoring.

Enhancement of the observation function of Himawari-8/9 as compared to that of MTSAT-1R/2

Higher spatial resolutions		More frequent observations		More spectral bands	
MTSAT-1R/2	Himawari-8/9	MTSAT-1R/2	Himawari-8/9	MTSAT-1R/2	Himawari-8/9
VIS 1km IR 4km	VIS 0.5 - 1km IR 2km	Full disk observation with 10-minute intervals	Full disk observation with 10-minute intervals	VIS 1 band (black/white image)	VIS 3 bands (color image)
30 min.	10 min. 10 min. 10 min.	N/A	N/A	N/A	3 bands
Small-sector observation	Small-sector observation	4 bands	4 bands	5 bands	10 bands
	Every 2.5 minute around Japan				16 bands

This is the end of the presentation.



Thank you
very much!