Verification of operational dust prediction in Japan Meteorological Agency

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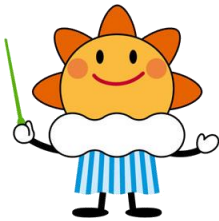

21 October 2014
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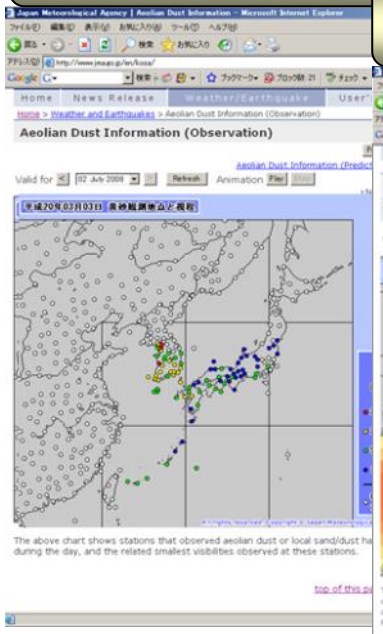
Outline

- Aeolian dust (*Kosa*) information to the public from JMA
- New operational global aerosol forecast model for dust prediction by JMA
- Verification of operational aerosol prediction, mainly focused on Aeolian dust (*Kosa*) prediction
- Summary and short-term plan

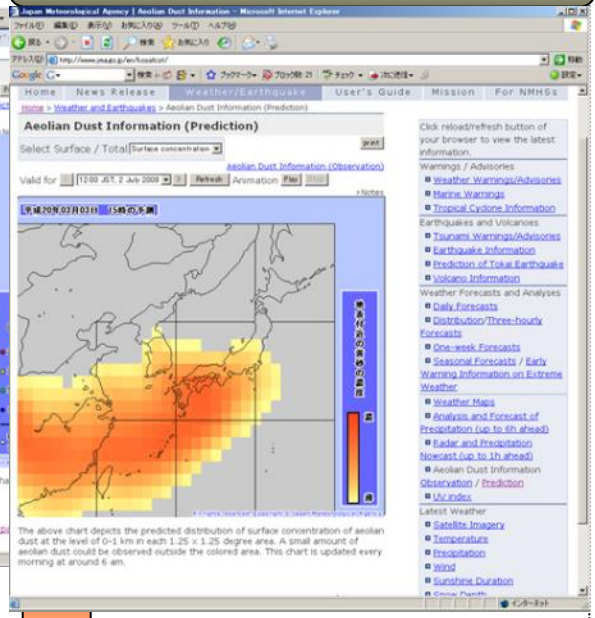
Information on aeolian dust to the public

JMA has been providing aeolian dust information based on numerical forecasts and observations since January 2004.

Aeolian dust observation

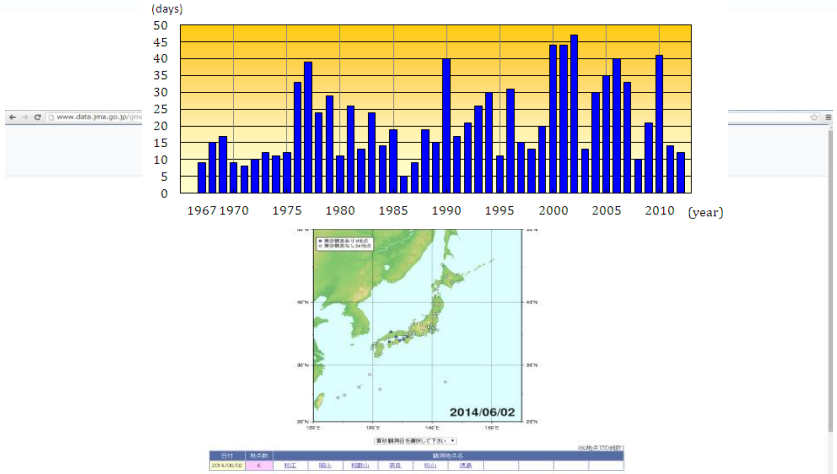


Aeolian dust prediction

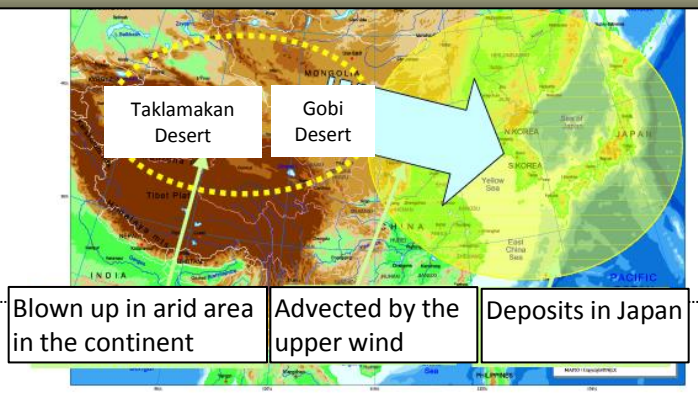


Aeolian dust advisory information
(when required, Japanese only)

Statistics of aeolian dust



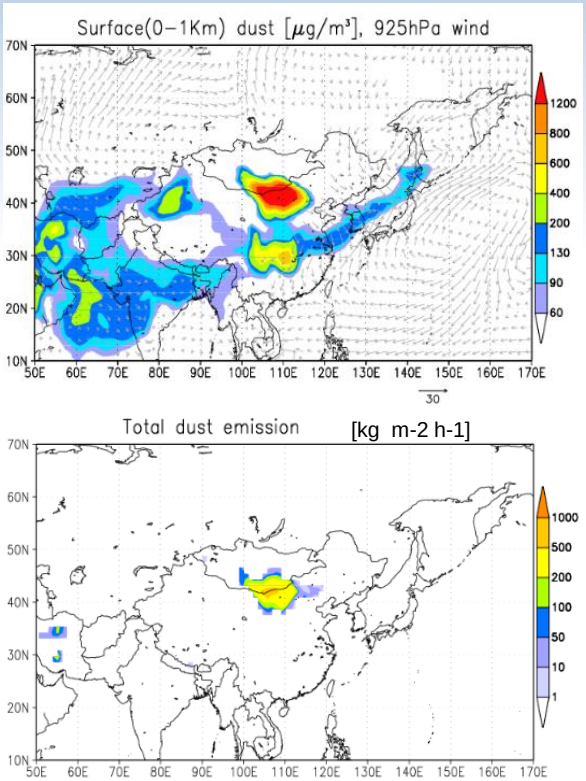
Basic knowledge about aeolian dust



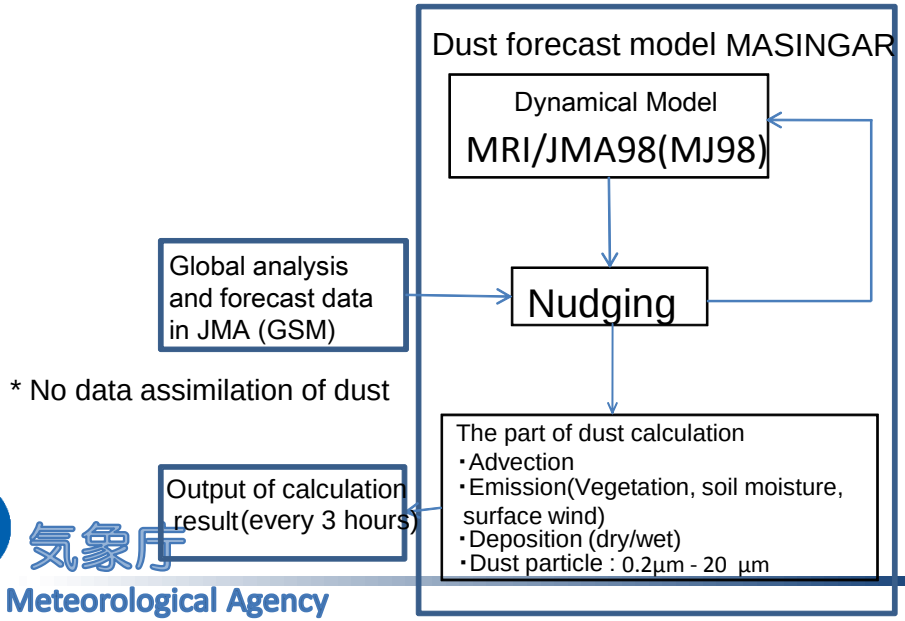
JMA also provides aeolian dust prediction results (GPV : GRIB2 format) for private weather services via the Japan Meteorological Business Support Center (JMBSC).

Outline of the current operational global aerosol forecast model（MASINGAR）

Resolution	T106L20　Horizontal -110km,　Vertical 20 layers (Surface - 34hPa)
Type of aerosol	10 bins of dust (0.2 - 20μm)
Dust emission process	Depend on particle size, vegetation, surface condition (soil moisture, snow depth etc..) and surface wind speed
Dust deposition process	Gravity (dry deposition), removal due to clouds and rain (wet deposition)
Dynamical model	MRI/JMA98　(MJ98)
Calculation interval	Once a day (12UTC initial)
Forecast period	5 days (120 hours)



30 March, 2012
12UTC ini



Dust emission flux $\propto (U_{10} - U_t) \cdot U_{10}^2$

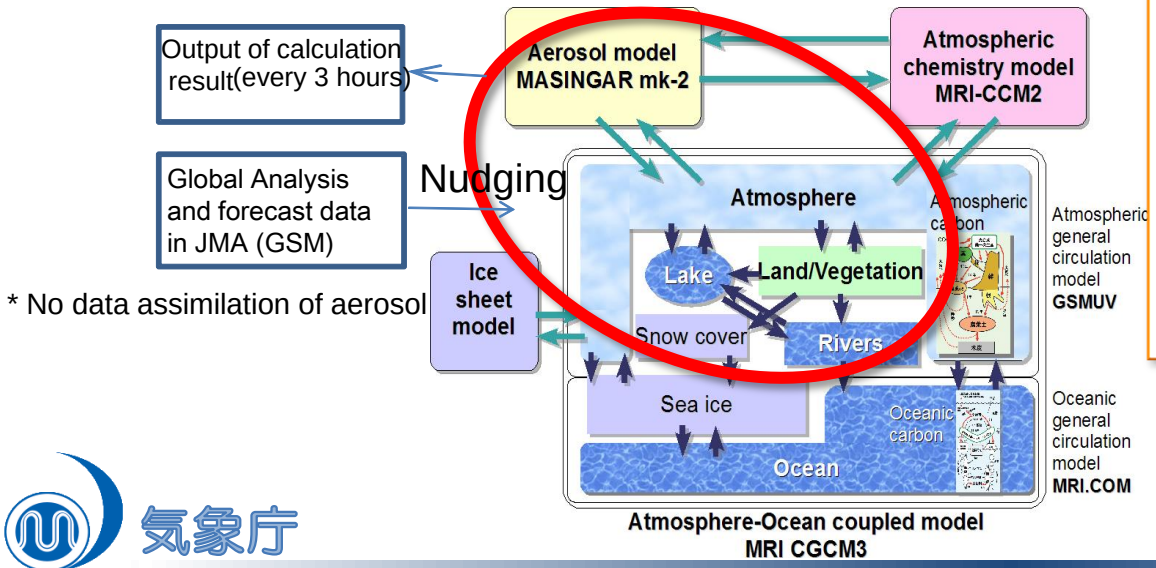
U_{10} Surface wind　U_t Threshold of wind speed (> 6.5m/s)

The dust emission flux is proportional to the cube of the wind speed.

Outline of the new operational global aerosol forecast model（MASINGAR mk-2）

Resolution	TL159L40　Horizontal -110km,　Vertical 40 layers (Surface – 0.4hPa)
Types of aerosols	10 bins of dust (0.2 - 20μm), 10 bins of sea salt (0.2 – 20μm), Sulfate, Organic aerosol, Black Carbon
Dust emission process	Depend on particle size, vegetation, surface condition (soil moisture, snow depth etc..) and surface wind speed
Dust deposition Process	Gravity (dry deposition), removal due to clouds and rain (wet deposition)
Dynamical model	MRI-AGCM3　(GSMUV)
Calculation interval	Once a day (12UTC initial)
Forecast period	5 days (120 hours)

The **MRI-ESM** aims to improve the prediction of global warming. We apply this system to the daily aerosol prediction in JMA.



In our daily operational prediction system, we're combining the atmospheric general circulation model (GSMUV) with the global aerosol forecast model (MASINGAR mk-2).

Dust emission flux
Function of the surface friction velocity

Updates of the operational global aerosol forecast model

	Current operational global dust forecast model	New operational global aerosol forecast model
Global aerosol model	MASINGAR (Tanaka et al., 2003)	MASINGAR mk-2 (Tanaka et al., manuscript in preparation)
Dust emission	Function of the wind speed (u_{10}) $F = C\,u_{10}^2(u_{10} - u_t)$	Function of the 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	Horiz. **TL159 (in 2014) → TL319 (0.56°) (in 2015)** **Vertical 40 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 (Yoshimura et al., 2014 accepted)
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)

Statistical verification for dust prediction

We calculate the statistics for dust prediction using SYNOP reports from meteorological observatories in Japan.

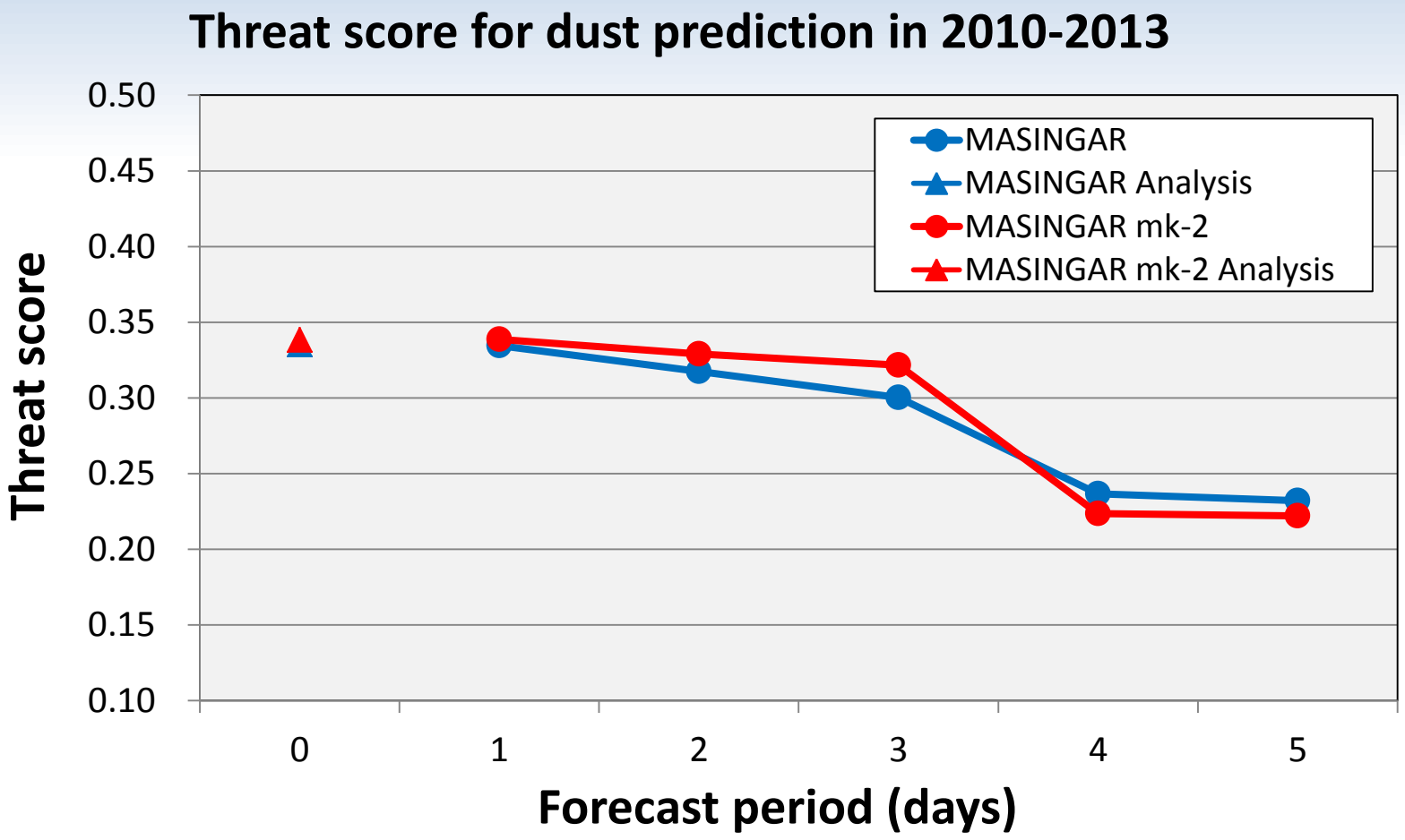
(Verification period：March–May 2010–2013, 00UTC–09UTC)

Dust forecast model surface～1km conc.	
Dust forecast (F)	≧90μg/m^3
No dust forecast (X)	＜90μg/m^3

- This threshold value is based on the research results of the past relating to the dust concentration and visibility. (Iwakura and Okada, 1999)

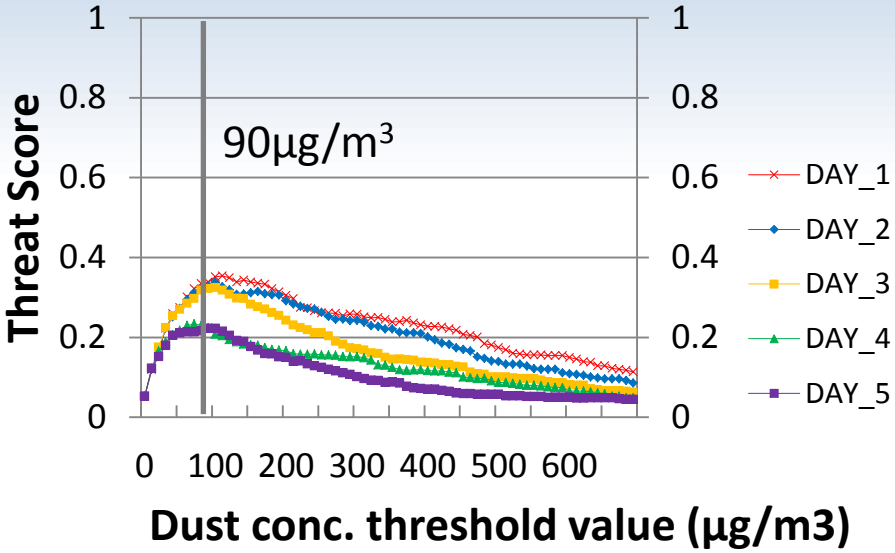
SYNOP reports at meteorological observatories in Japan	
Dust observation (O)	Visibility become less than 10km because of aeolian dust. Other phenomena (e.g. rainfall..) have not been seen within an hour.
No dust observation (X)	Aeolian dust that visibility become <10km has not been seen. Other phenomena have not also been seen within an hour.
Unknown	Other than those above. (We cannot know whether the aeolian dust has been observed because of the rainfall, etc..)

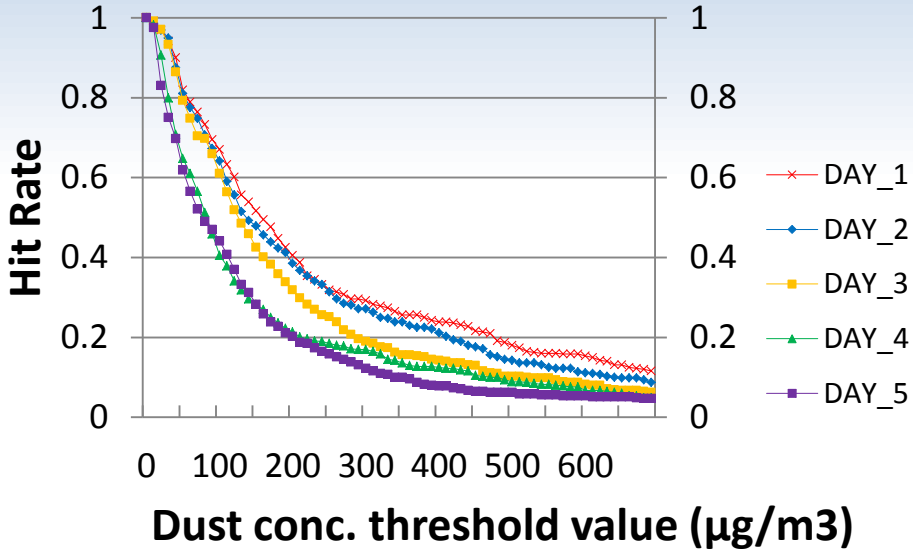
Threat score for dust prediction

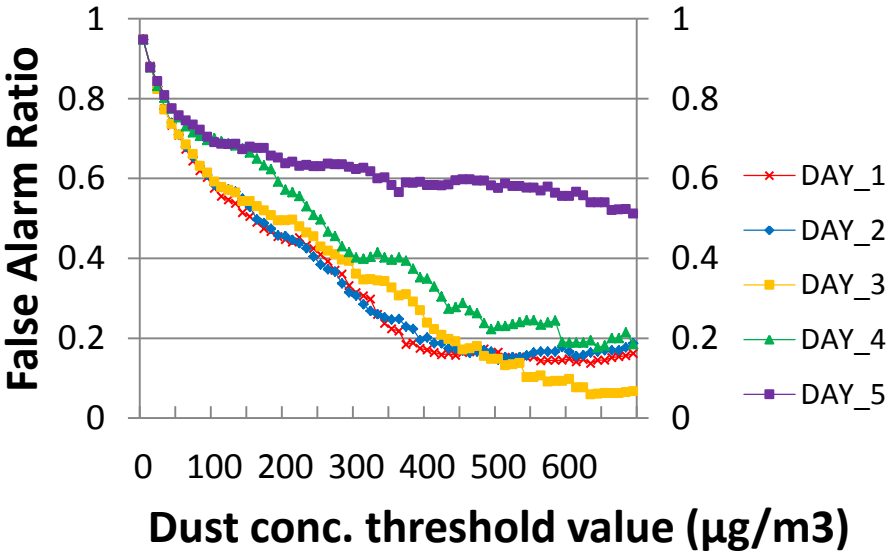


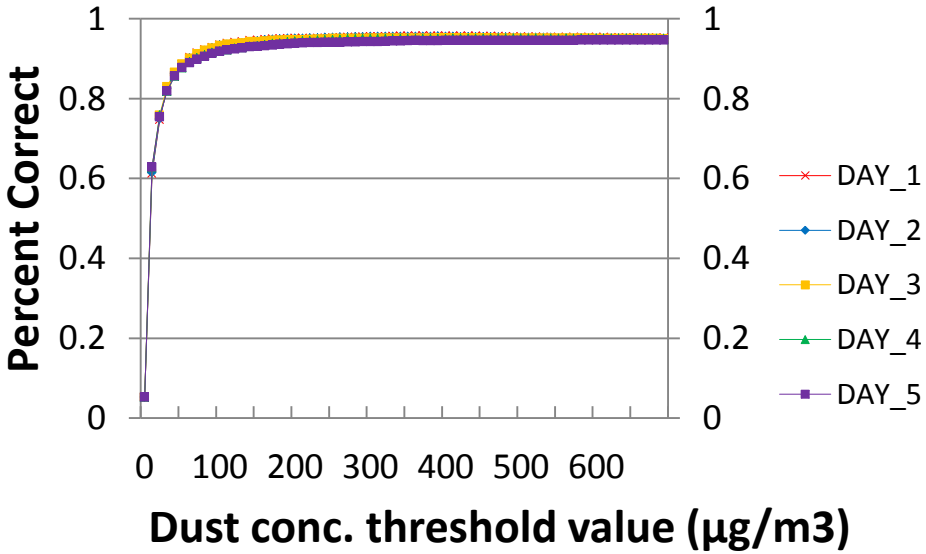
- The threat score for dust prediction is improved mainly for the first half of the forecast period.

Other statistics for dust prediction (MASINGAR mk-2)



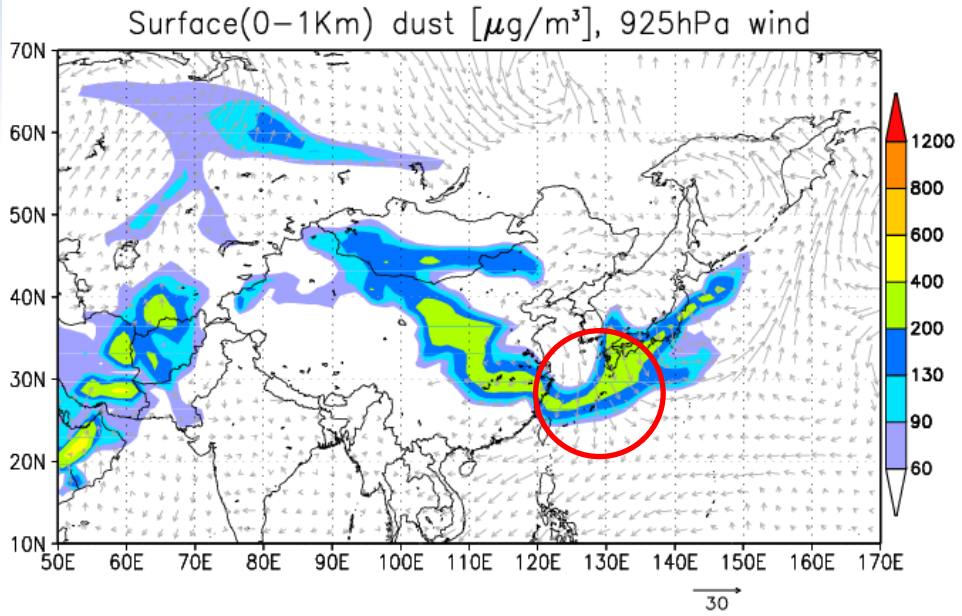




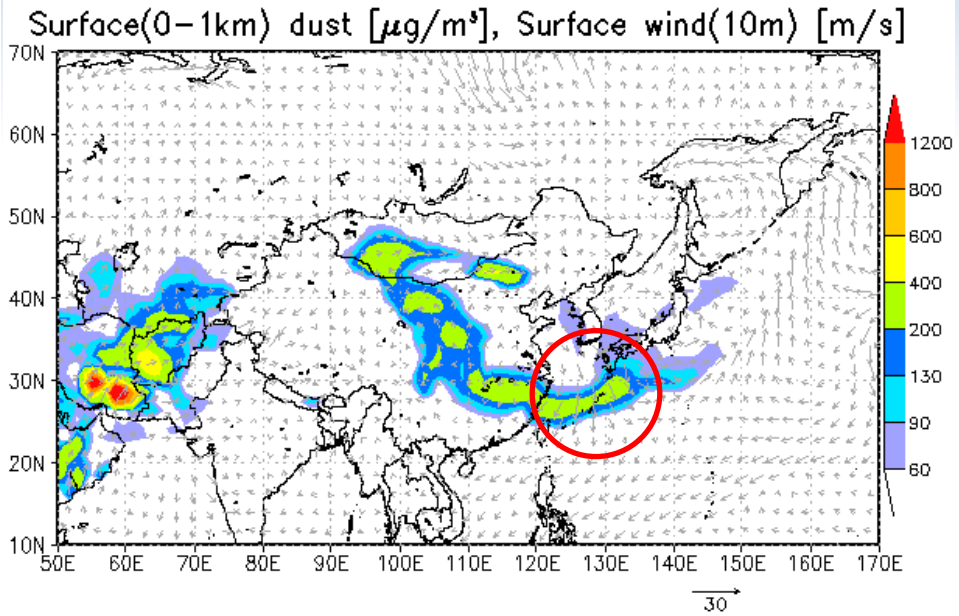


Dust distribution

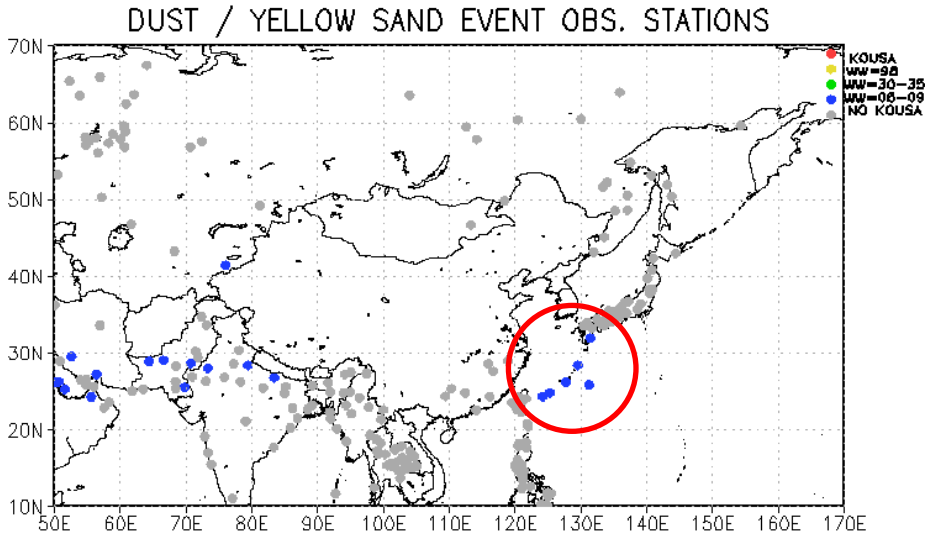
MASINGAR



MASINGAR mk-2



SYNOP

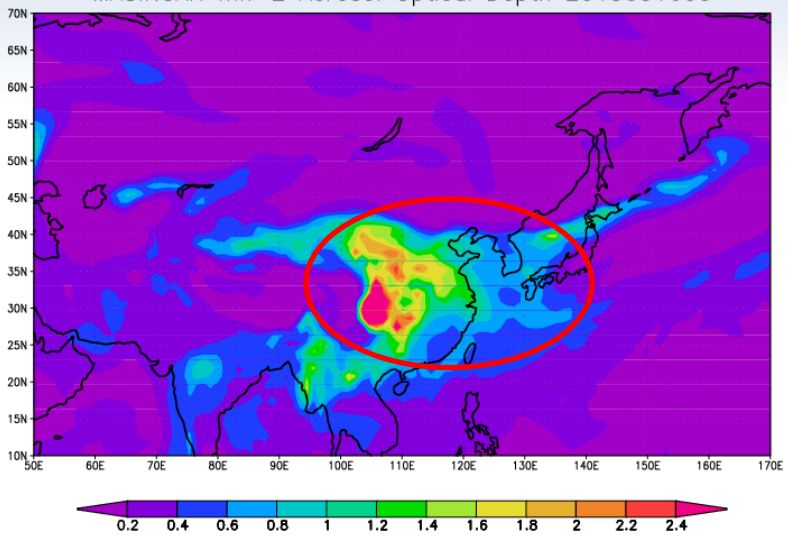


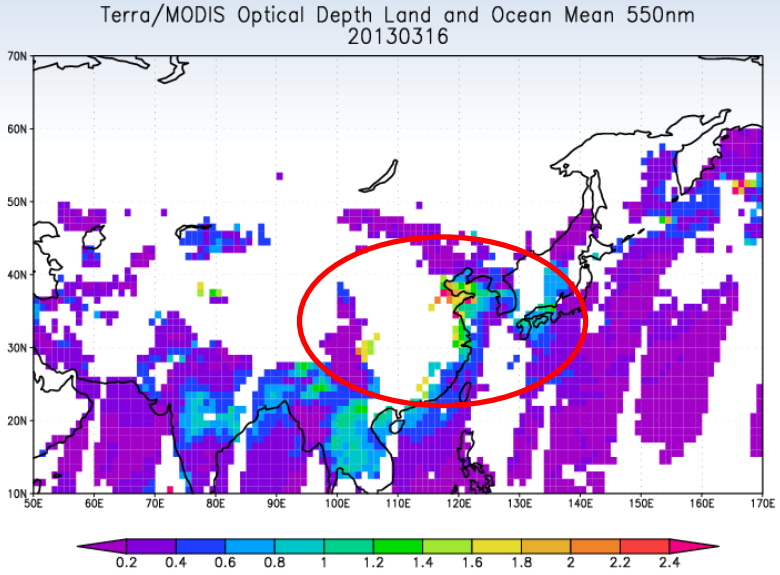
- The dust prediction of current model is overestimated in Japan area. In the new model, the dust prediction is improved well and the distributions of dust prediction are matched with the SYNOP observation results.

気象庁 Japan Meteorological Agency

JMA

Aerosol Optical Depth (AOD) prediction





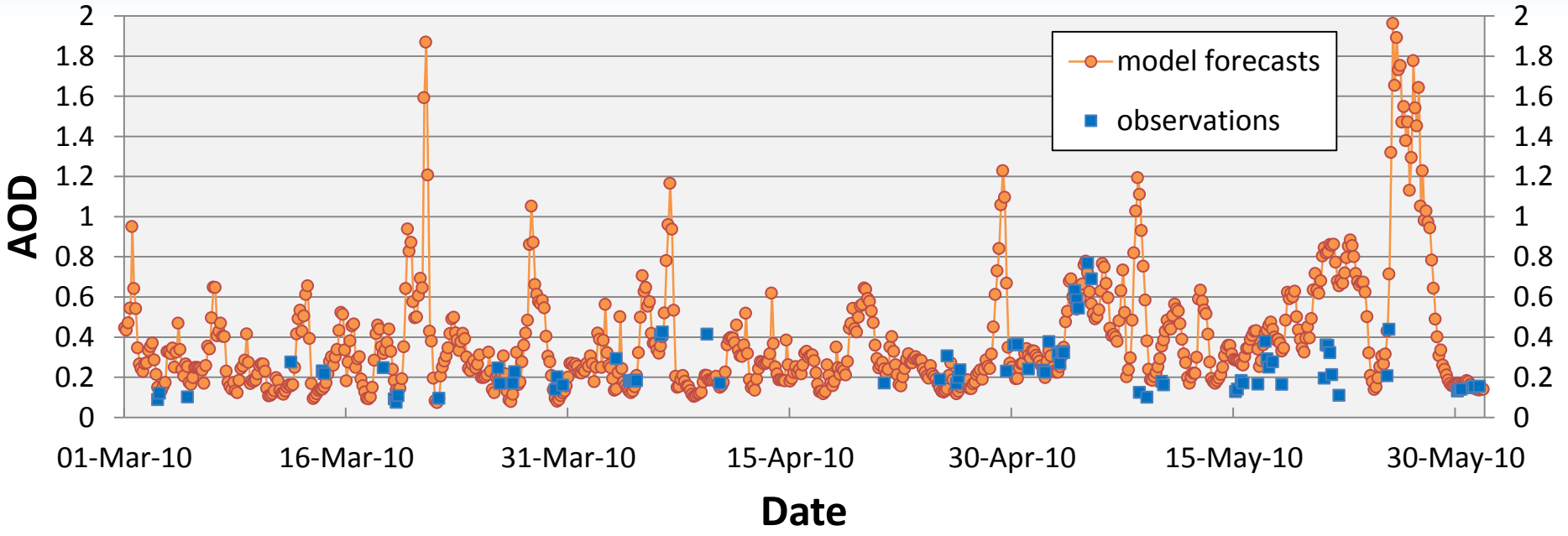
16 Mar 2013

- The new operational global aerosol forecast model includes 5 major aerosol species, and we also calculate 3-hourly AOD.

- In this case, it can be seen that high AOD regions spread from eastern China to western Japan due to air pollution and the new model can predict the distribution of AOD well.

Ground-based AOD observations vs. model forecasts

Ground-based AOD observations by sun photometer vs. MASINGAR mk-2 model forecasts at Ryori, Japan in 2010



Statistics	Value
Mean Error (ME)	0.072
Root Mean Square Error (RMSE)	0.222
Correlation Coefficient (CC)	0.428

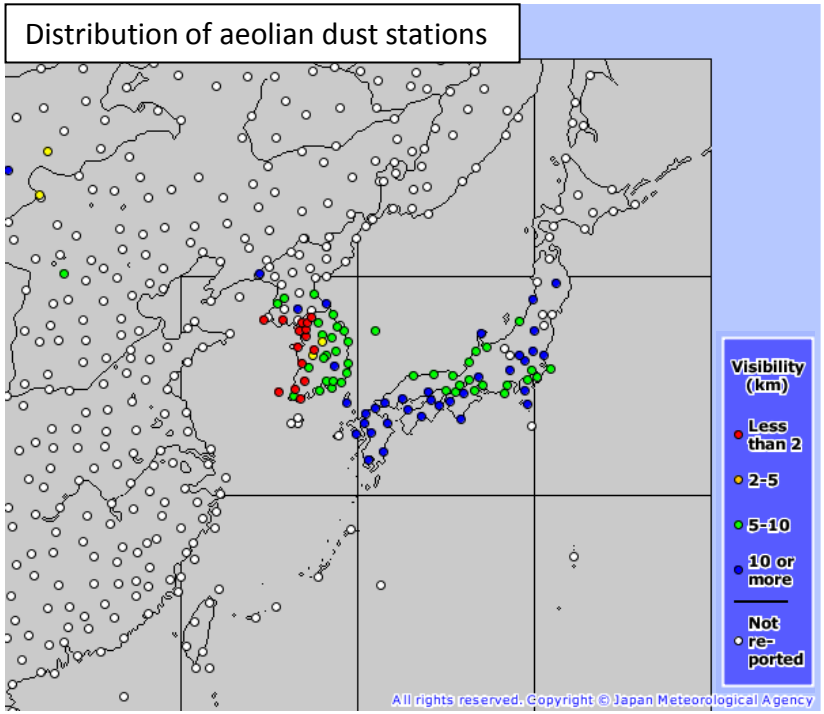
Summary

- JMA plans to upgrade the operational global aerosol forecast model (MASINGAR mk-2) for dust prediction in November 2014 and started a test operation in the supercomputer system of JMA.
- The results of statistical verification show that dust prediction is improved in the new model.
- The new model can forecast the dust distribution better than the current one.
- The comparison between the AOD observations and the new model forecasts indicates the good performance.

That is all for my presentation.
Thank you very much for your kind attention!

Visibility and meteorological conditions

- JMA operates 60 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 Threat Score (TS).**

Calculating the statistics for dust prediction

FO : Forecast・Observation
FX : Forecast・No Observation
XO : No Forecast・Observation
XX : No Forecast・No Observation

$$\text{Threat Score} = \frac{FO}{FO + FX + XO}$$

It combines 'Hit Rate' and 'False Alarm Ratio' into one score for low frequency events.

$$\text{Hit Rate} = \frac{FO}{FO + XO}$$

It's the fraction of observed events that are forecasted correctly.

$$\text{False Alarm Ratio} = \frac{FX}{FO + FX}$$

It's the fraction of forecasts that are wrong, i.e., are false alarm.

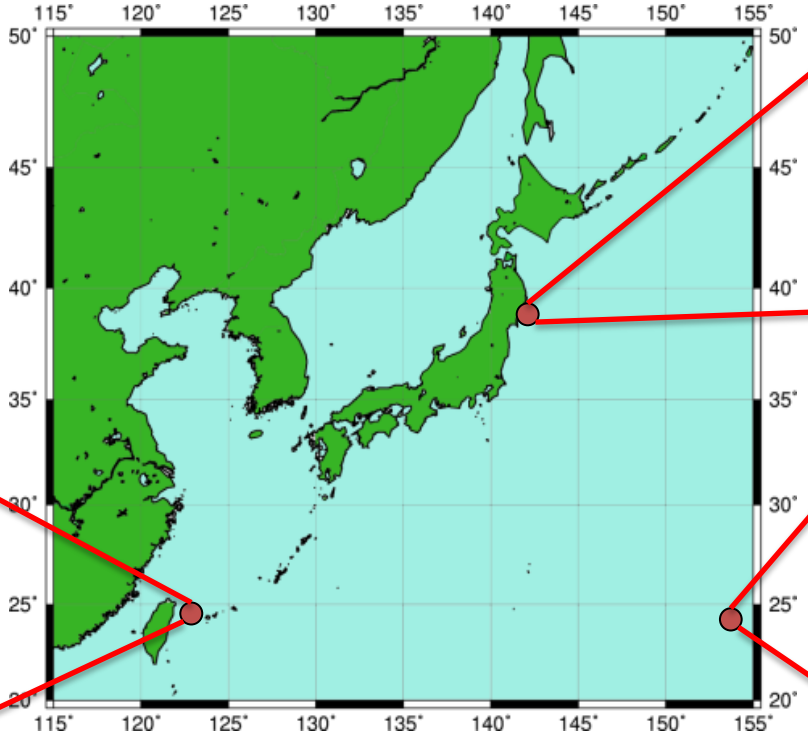
$$\text{Percent Correct} = \frac{FO + XX}{FO + XO + FX + XX}$$

It's the fraction of forecasts that are correct.

Surface observation of AOD in JMA

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)



Ryori

Yonagunijima

Minamitorishima