



WMO REGIONAL SPECIALIZED METEOROLOGICAL CENTER  
FOR ATMOSPHERIC SAND AND DUST STORM FORECASTING

BEIJING

(RSMC-ASDF BEIJING [HTTP://WWW.ASDF-BJ.NET/](http://www.asdf-bj.net/))

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**2021-2022**

2023

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# 1. SDS Models Operational

## 1.1 Status of Models Operational

From 2020 to 2022, there were a total of 26 operational failures in the dust model operation, including 12 caused by upstream model failures, 8 caused by machine failures, 4 caused by data issues, 1 point overflow failure, and 1 full disk space failure. The overall model itself operates stably (with only one integral overflow).

Main operational faults: caused by upstream model faults and machine faults (together accounting for 77%). The top three types of faults are: upstream model faults account for the highest proportion of 46%, followed by machine faults, accounting for 31%, and data issues account for 15%.

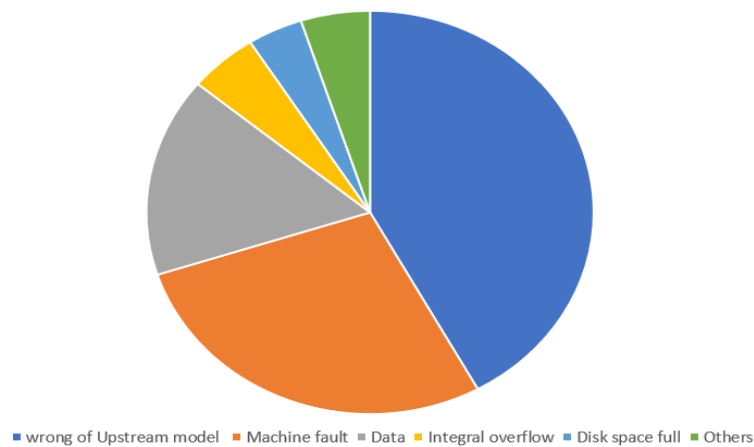


Figure 1. SDS model operation fault diagram

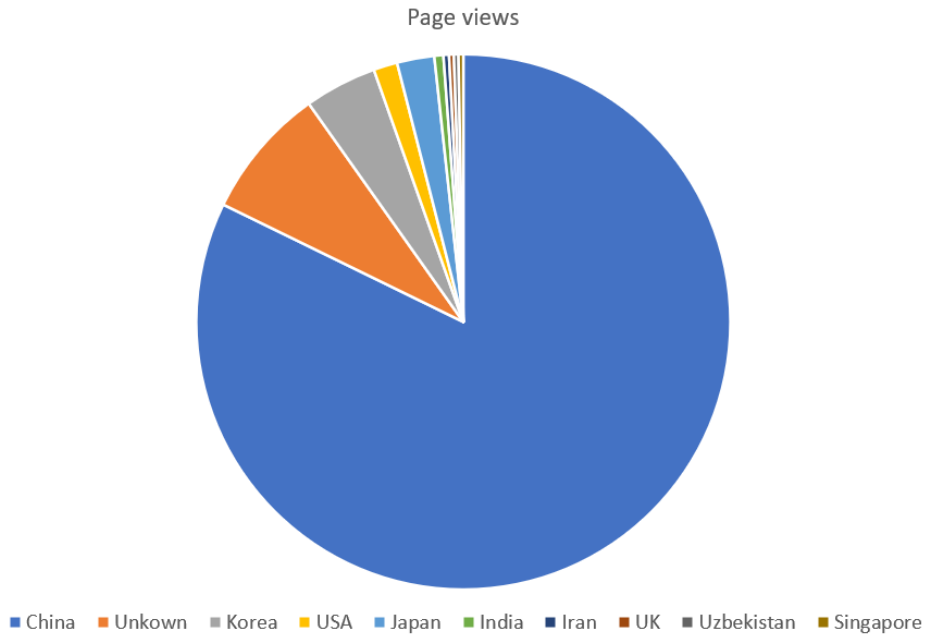
## 1.2 Website Access

The RSMC-ASDF BEIJING conducts regular monitoring of website access. The results (Table 1-2) show the number of page views and unique visitor.

Pie chart data analysis shows that in 2021, the main visitors were China, followed by South Korea, Japan, and the United States, which almost accounted for over 80% of the traffic. In 2022, the largest traffic still came from China, South Korea, Japan, and the United States, with the most obvious change being that Saudi Arabia's traffic began to increase.

Table 1 Overview of web access in 2021

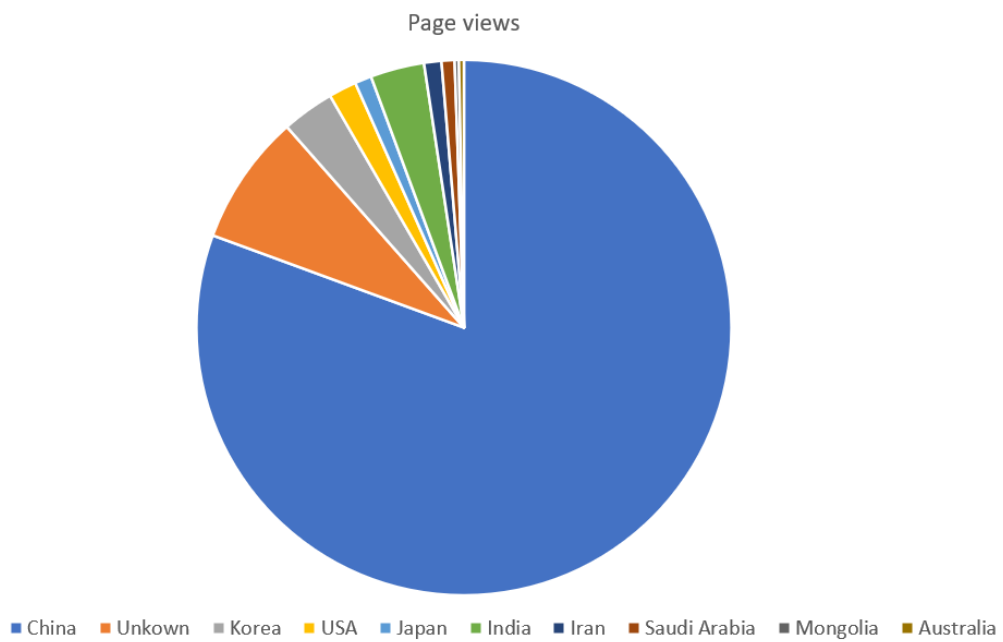
Season	Page views	Unique visitor
Jan. – Mar.	41374	26038
Apr. – Jun.	33949	23250
Jul. – Sep.	17501	14651
Oct. – Dec.	21526	18311
Total	114350	82250



**Figure 2. Statistics on the number of visits to RSMC-ASDF BEIJING from different countries in 2021**

**Table 2 Overview of web access in 2022**

Season	Page views	Unique visitor
Jan. – Mar.	44902	36314
Apr. – Jun.	36615	26047
Jul. – Sep.	19000	16096
Oct. – Dec.	22270	19673
<b>Total</b>	<b>122787</b>	<b>98130</b>



**Figure 3. Statistics on the number of visits to RSMC-ASDF BEIJING from different countries in 2022**

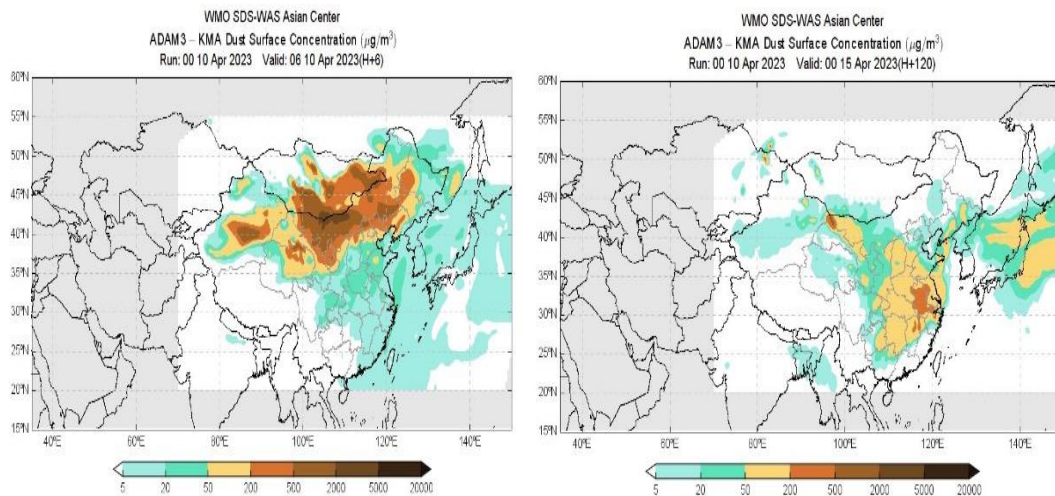
### 1.3 Data Sharing

We have established an international data sharing ftp (<ftp.nmc.cn>) since early 2019. Asian regional forecast results of CMA, KMA, JMA, ECMWF, NCEP, and FMI dust forecast models and some site observations of PM<sub>10</sub> concentration in Mongolia are shared among member countries every day. Member countries have all permissions for their own folders but only download permission folders from other countries. The current capacity is 3TB. In the future, Based on the actual situation, we will carry out corresponding expansion. we welcome more operational numerical dust forecast models and observation data to join this data sharing ftp.

## 2. Forecast products progress

### 2.1 Medium and Long Term Forecast Products

Starting from January 15, 2023, the Korean ADM3 model forecast product has been extended from the previous 72 hour forecast to 120 hour forecast (Figure 4 upper), providing an important guarantee for SDS forecasting and warning in Central North Asia. In addition, forecast products with a maximum forecast time of 15 days was provided by CMA (Figure 4 below).



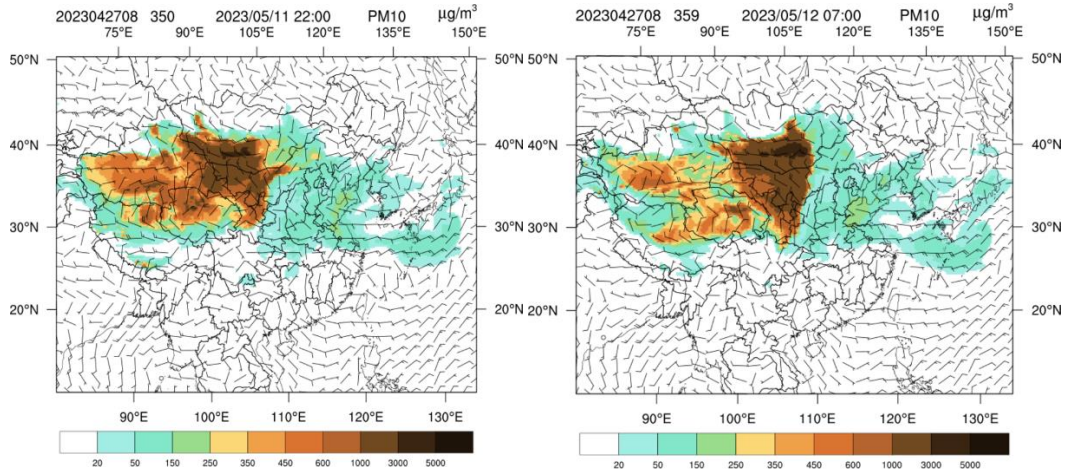


Figure 4. SDS forecast products from 3 days to 5 days by KMA(upper), from 3 days to 15 days by CMA(below)

## 2.2 Diversified product development

In order to better reduce and mitigate the harm of SDS, and to provide early warning of SDS, a GIS based 3D visualization product of SDS has been developed. Dust forecasting of SDS model can be viewed as 3D isosurface, particles and volume programmatically and interactively. The dust emission, transport and vertical distribution were clearly identified in 3D visualization figures.

In addition, dust concentration time evolution product based on the site has been developed .

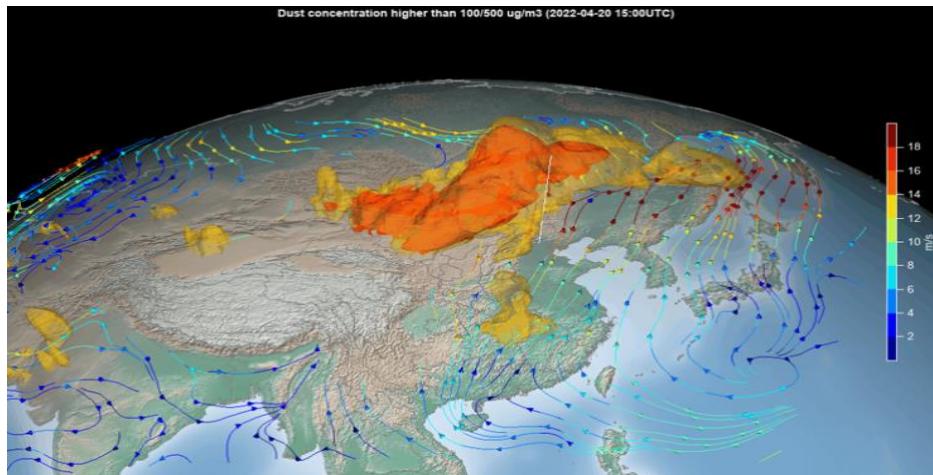


Figure 5. 3D visualization of sand and dust forecast by CMA

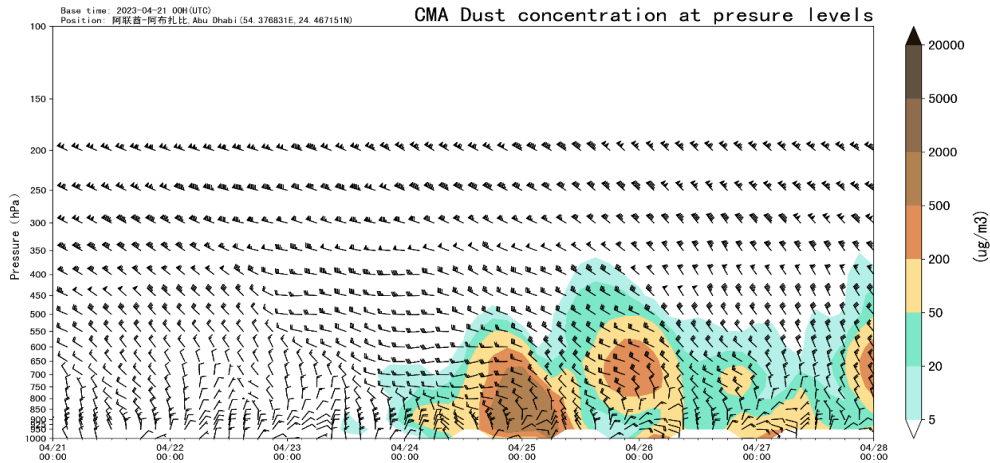


Figure 6. Cross-section of SDS concentration by CUACE/DUST

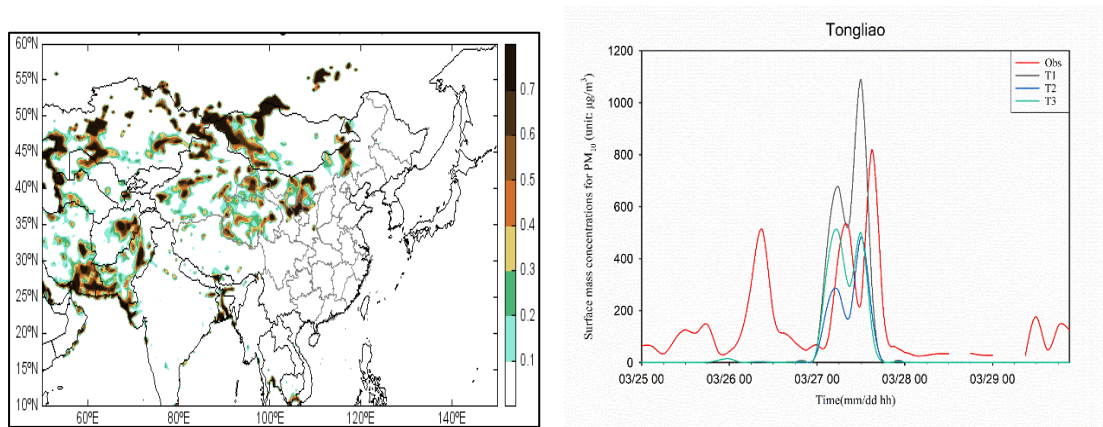
### 3. Technical progress

#### 3.1 Regional biocrust retrieval and its impacts on dust emissions

In order to learn grant stability of biological crusts to dust source areas by inhibiting dust emission (Figure 7), the distribution of biological soil crust in SDS source areas of Central and East Asia is obtained by using MODIS satellite surface reflectance data collected in 2000 – 2019 (Figure 8). The biological crusts are widely distributed in SDS source areas of Central and East Asia (Zhang et al., 2021). And the inhibiting effect of CUACE/Dust model was numerically studied, combined the retrieved biocrusts with two biocrust inhibit schemes (the roughness length scheme and biocrust strength scheme) (Zhang et al., 2023). The inhibiting effect on dust emission is increasing with the coverage of biocrusts. The roughness length scheme and biocrust strength scheme can reduce the total dust emission by about a half in average during a strong dust storm in March 25~30, 2018. When biocrusts are considered, the forecast of stations near the dust source area is much more improved (Figure 8).



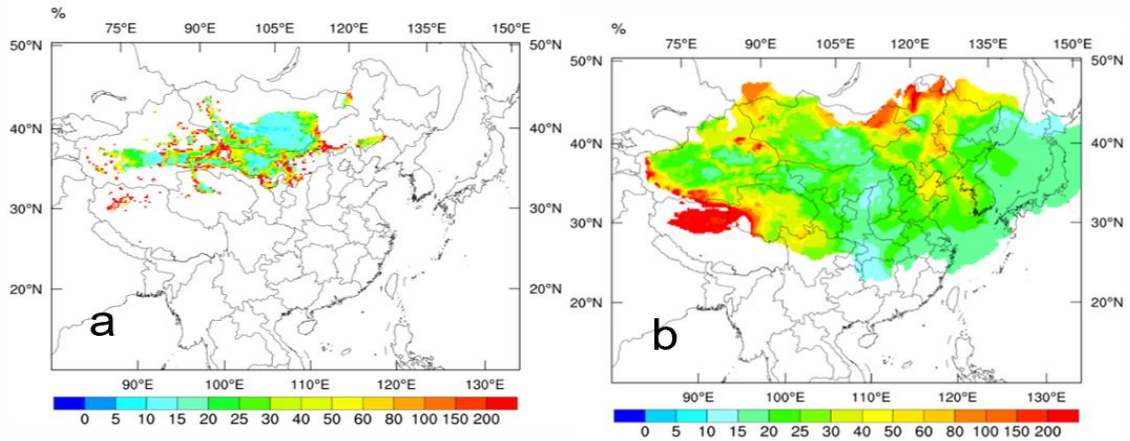
**Figure 7. Biological crust in sand source areas**



**Figure 8. Spatial distribution of Cyanobacteria crust coverage in dust and SDS source areas of Central and East Asia(left), Surface mass concentrations for PM<sub>10</sub> with impact of biocrusts (unit:  $\mu\text{g}/\text{m}^3$ ) for observation data; T1 (the control test); T2 (the roughness length scheme); T3 (the biocrust strength scheme) for the site of Tongliao(right)**

### 3.2 Influence of boundary layer gust on dust emission

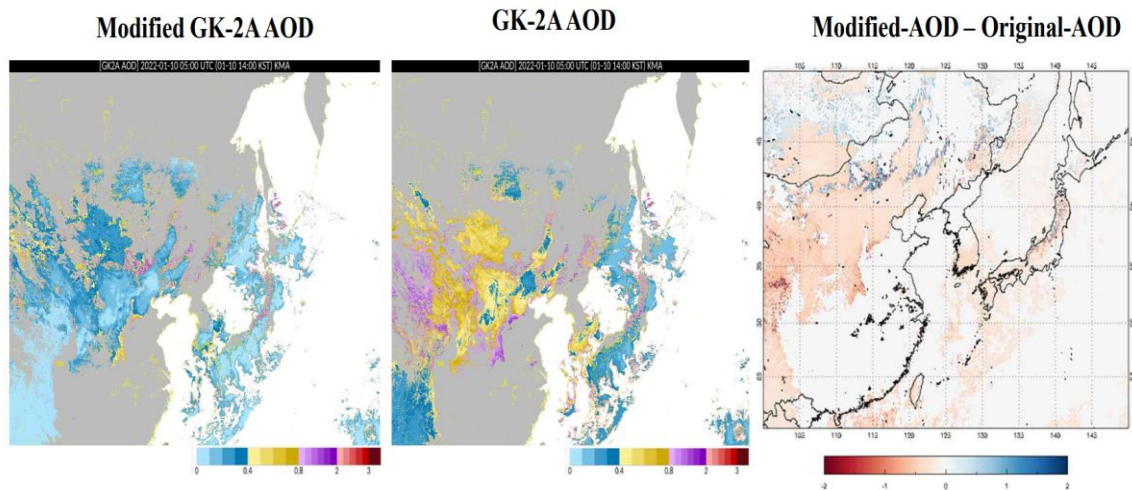
A statistical gusty wind model was implemented in the dust emission scheme, and it was used to quantify the gusty wind contribution to dust emissions and peak PM<sub>10</sub> concentration. As a result, the LS scheme (Lu and Shao 1999) produced the minimum errors for peak PM<sub>10</sub> concentrations, the MB scheme (Marticorena and Bergametti 1995) underestimated the PM<sub>10</sub> concentrations by 70–90%, and the KOK scheme (Kok et al. 2014) overestimated PM<sub>10</sub> concentrations by 10–50% in most areas. The gusty wind model could reasonably reproduce the probability density function of 2-min wind speeds. There were 5–40% more dust emission flux and 5–40% more peak PM<sub>10</sub> concentrations generated by the gusty wind than the hourly wind in the dust source regions. The increase of peak PM<sub>10</sub> concentration caused by gusty wind in the non-dust source regions was higher than in the dust source regions, with 10–50%. Implementing the gusty wind model could help improve the LS scheme's performance in simulating PM<sub>10</sub> concentrations of this severe SDS event. More work is still needed to investigate the reliability of the gusty wind model and LS scheme on various SDS events.



**Figure 9. Improved the dust scheme's performance on PM<sub>10</sub> concentration simulation for the severe SDS event on 15 March 15, 2021**

### 3.3 Development status of Asian Dust Aerosol Model 3 (ADAM3)

1) Korea's assimilation technology has been upgraded from the previous optimal interpolation to 3D variational assimilation, it is expected to achieve GK-2A AOD data assimilation into the ADAM3 in 2023.



**Figure 10. Modified GK-2A AOD data**

2) KMA developed the Asian Dust Aerosol Model 3 Ensemble Prediction System to produce probabilistic forecasts of Asian dust and haze and plans to launch it as an operational system in 2024. and its forecast time will reach 168-hour including 50 members.

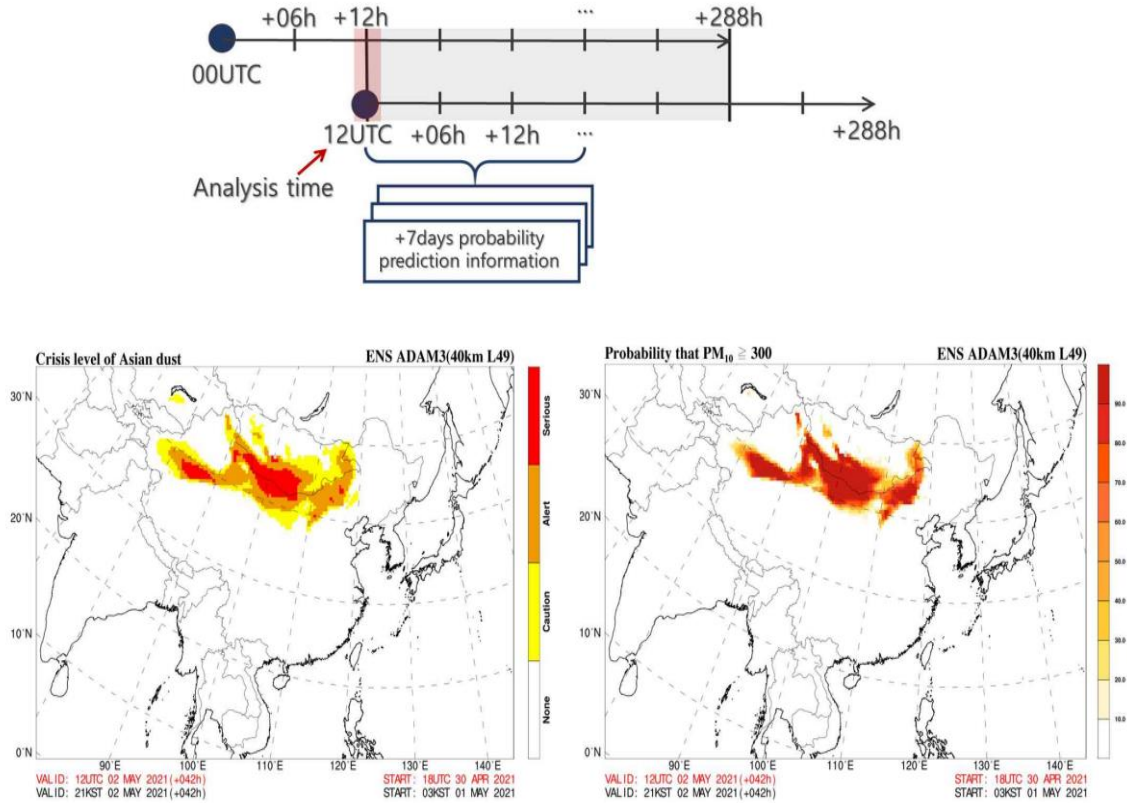


Figure 11. Crisis level of Asian dust

### 3.4 Lidar Applications

JMA uses the polarization characteristics of cloud altimeters to Separating dust and spherical particles .Recent ceilometer (Vaisala CL61) has ability to measure depolarization ratio.

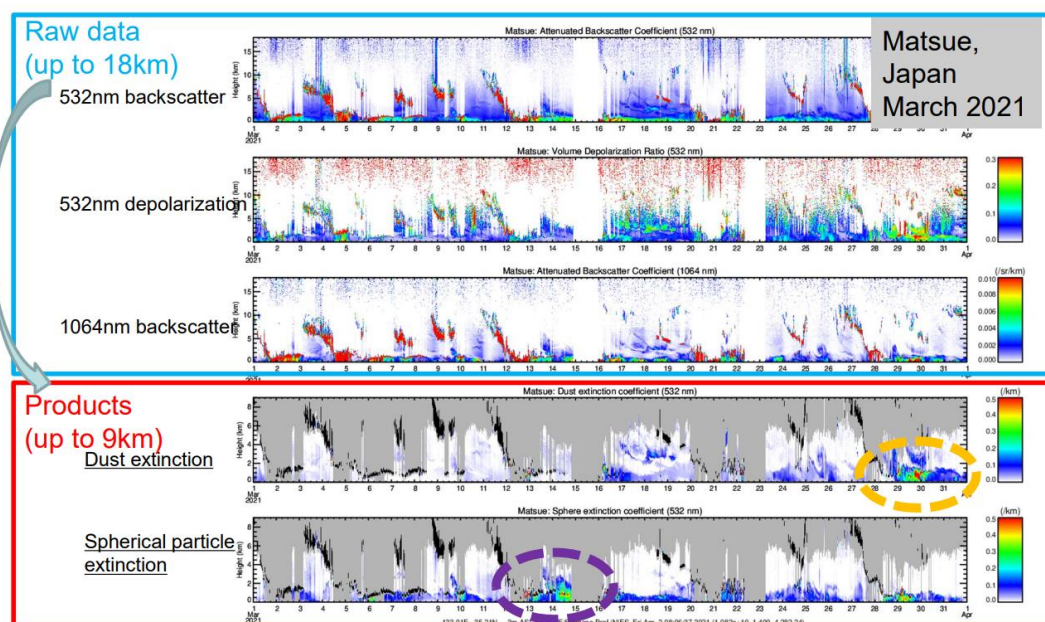


Figure 12. Separation of dust and spherical particle using depolarization ratio

MRI/JMA introduced a data assimilation system (2D-Var) since 2020 (assimilating Himawari 8 (GEO) AOD) once a day.

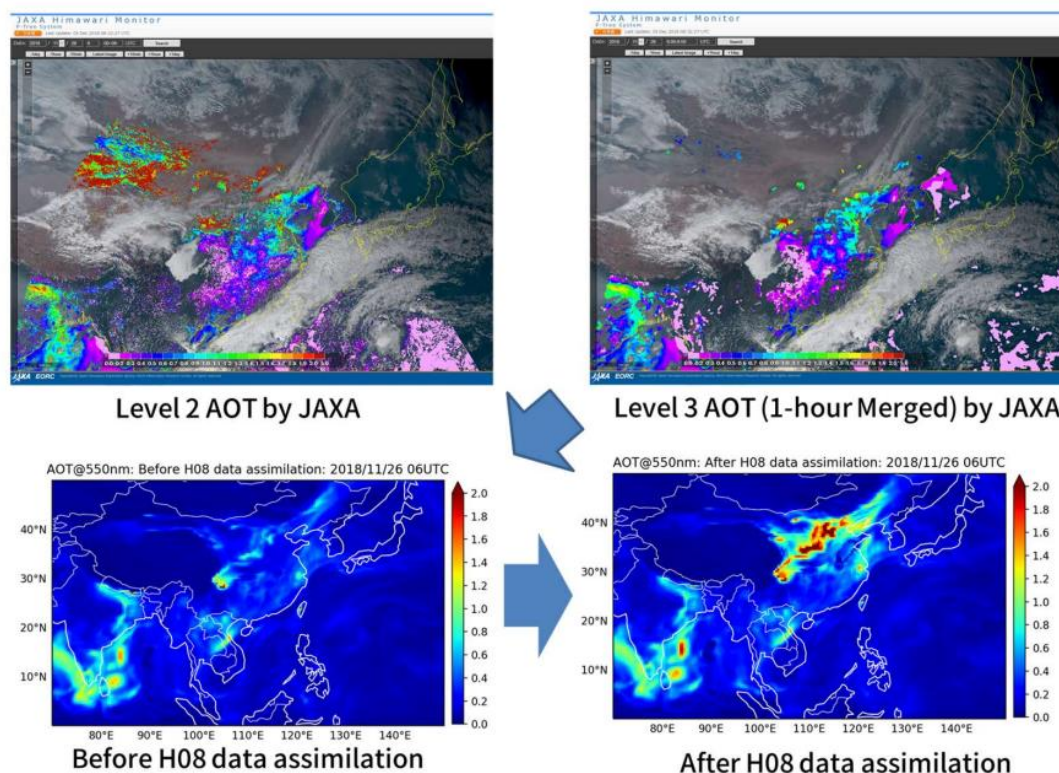


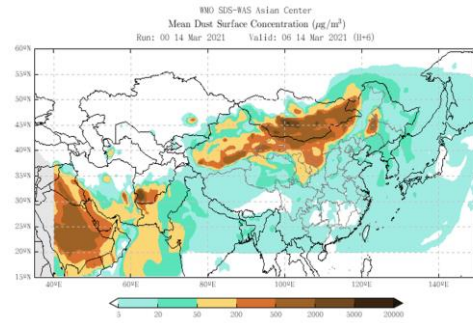
Figure 13. Assimilation using Himawari 8 AOD

## 4. Major sand and dust events during 2020 to 2022

### 4.1 Dust event in 14-17 March, 2021

On March 14, 2021, due to the influence of a strong cyclone in Mongolia (with a sea level pressure of 980hPa in the central region) and its cold air behind it, Mongolia experienced a strong SDS with an instantaneous wind force of 10-12. On the night of the 14th, the cyclone moved eastward and southward with the cyclone, causing sand and dust to enter China and affect most of northern China from north to south. Many areas in northern China have experienced sandstorms or strong sandstorms. With the transportation of the westerly belt, SDS have also gradually affected places such as the Korean Peninsula and Japan. Due to the impact of SDS, visibility has significantly decreased in many places, with the lowest visibility in some areas falling below 500 meters.

Furthermore, high PM<sub>10</sub> levels were recorded in many locations exceeding 4000  $\mu\text{g m}^{-3}$ , with a peak of over 8000  $\mu\text{g m}^{-3}$  in Beijing, China.

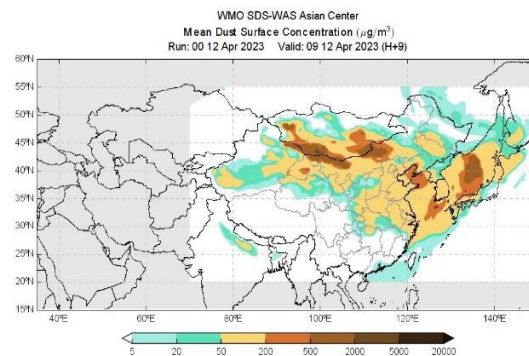
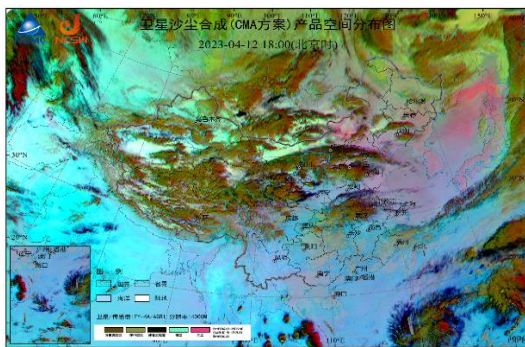


**Figure 14. March 14, 2021, Mongolia Sandstorm(left), Prediction of surface concentration of SDS model**

#### 4.2 Dust events in March,2023

Since 2023, the air temperature in the sand source areas of southern Mongolia and northwestern China has been higher than that of the same period in years, with less precipitation, poor vegetation coverage in the sand source areas, and a lack of vegetation protection on the exposed surface, Therefore, once there is a cyclone with strong winds, it is easy to experience large-scale sandstorm weather. By the mid April 2023, there have been 10 sandstorms in Central and North Asia.

From April 9th to 12th, 2023, due to the influence of a strong cyclone in Mongolia and its cold air behind, A strong SDS occurred from southern Mongolia and affected most of China's Yangtze River, the Korean Peninsula, Japan, and other areas with the airflow. Fukuoka City observed dust at 9:40 am on April 12th. It is said that the "visibility" in the horizontal direction is 5-8 kilometers. The SDS will spread to most areas in northern and eastern Japan, and the impact on traffic should be noted.



**Figure 15. Fengyun Satellite Dust Monitoring at 10:00 on April 12<sup>th</sup>(UTC), (left), Prediction of surface concentration of SDS model**



Figure 16. Dust shrouded Fukuoka City

## 5. International Activities

### 5.1 Communication between RSMC-ASDF BEIJING and the Saudi Arabian Meteorological Agency

At the invitation of the Saudi Arabian Meteorological Agency, effective communication was conducted with the Saudi Arabian Meteorological Agency on the progress of sand and dust technology and the work on SDS-WAS nodes in the GCC countries, and a progress report on the RSMC-ASDF BEIJING was made through video in May 2023.

### 5.2 The 8th Meeting of the WMO SDS-WAS regionals steering group (RSG) for Asia

The 8<sup>th</sup> Meeting of the Asian Regional Steering Group of WMO Sandstorm Early Warning Advisory and Assessment System (WMO SDS-WAS RSG for Asia) and the 4<sup>rd</sup> International Dust and Aerosol Workshop were held in Jeju Korea, from 17 to 18 Oct.2022,with both online and offline meeting . The Secretariat of the World Meteorological Organization, China, Japan, Korea, Kazakhstan, Mongolia, India and other organizations and countries participated.

The meeting was chaired by MAKI from the Japan Meteorological Agency,. Experts from participating countries reported on various fields of sand storm research and operational center development and discussed the current status, challenges, and future work of WMO SDS-WAS. The meeting agreed that member states need to strengthen cooperation in scientific research and business, and focus on data assimilation and sharing, dust monitoring, model performance evaluation, regional centers website construction, dust training and technical exchanges with other regional

operational centers.

## 6. Authors

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## Appendix

<b>Operation of sand-dust model business (2020 ~2022)</b>				
<b>Failure date</b>	<b>Fault module</b>	<b>fault type</b>	<b>Cause of failure</b>	<b>Fault handling method</b>
2022-11-06	fcstmonitor	machine fault	The running time of the module is more than doubled.	Kill the faulty module with the kill command in the background.
2022-08-28	fcstmonitor	Integral overflow fault	Integral fault	Contact Mr. Yang Jianxin to handle it.
2022-07-01	fcstmonitor	machine fault	Fcst integration speed is slow, resulting in fcstmonitor being killed over time.	Resubmit fcstmonitor
2022-06-16	an_3dvar	machine fault	Machine failure caused slow operation timeout.	Manual redo
2022-06-15	fcst	machine fault	Module running time exceeds 25 minutes.	Feedback to HPC operation and maintenance personnel.
2022-05-04	fcst	machine fault	Running much slower than usual.	Feedback to HPC operation and maintenance personnel
2022-03-15	00	Upstream mode system problem	Double the running timeout.	Waiting for the upstream global mode system to complete.
2022-02-23	an_3dvar	Data source failure	Fy4a data is not available.	skip
2022-01-11	fcstmonitor	machine fault	The module task was repeatedly submitted twice,	Because the module has been completed

			resulting in communication failure.	when it fails, set complete directly.
2021-12-01	fcst	machine fault	Fcst integration overtime, resulting in fcst_monitor automatically reporting an error.	Record the overtime task number and feed it back to the high-performance personnel on duty for investigation.
2021-11-20	gmf_get_114	Upstream mode system problem	Gmf failure caused the data to be unavailable.	Waiting for gmf data
2021-03-18	gmf_get_114	Upstream mode system problem	The upstream mode gmf_grapes product is generated late.	Resubmit
2021-06-07	gmf_get_126、 gmf_get_120	Upstream mode system problem	There is something wrong with the grib2 file generated by upstream grapes_gmf_post120 and 126.	Resubmit the upstream job, and resubmit the error module after it is generated.
2021-04-11	gmf_get_114	Upstream mode system problem	GFS 12 time delay	Modify the script to increase the loop waiting.
2021-03-22	gmf_get	Upstream mode system problem	Upstream system failure	When the upstream system returns to normal, make up the wrong operation.
2021-02-21	gmf_get_144	Upstream mode system problem	Gmf data was not retrieved.	Resubmit
2021-01-27	gmf_get	Upstream mode system problem	Error in upstream gfs system caused by delay.	When the upstream system returns to normal, make up the wrong operation.
2021-01-15	gmf_get	Upstream mode system problem	Error caused by upstream gfs system delay.	After the grib2 module of the upstream system gfs_post is completed, redo the dust system gmf-get.
2020-08-31	an_3dvar	Data source failure	Wind 4 data missing	Resubmit still reported an error. set complete skipped the job.
2020-08-31	gmf_get	Upstream mode system problem	Error reported by upstream gfs system	Hang gmf_get module, and resubmit gmf_get module after gfs system operation returns to normal.
2020-07-24	an_3dvar	Data source failure	Wind 4 data is missing.	Skip the job, set complete.

2020-07-21	gmf_get_162 (168\174\180)	Upstream mode system problem	The ne data of GFS 00 time is not generated on time.	Wait for the data to be generated and rerun.
2020-06-28	archiving	Disk/file system space is full.	Information center adjustment limit	Resubmit
2020-05-14	an_3dvar	Data source failure	Missing FY4A data	Set complete, skip directly.
2020-04-25	gmf_get	Upstream mode system problem	T639 error not running.	Wait for T639 to be completed and resubmit.
2020-02-16	fcst	machine fault	Integral overflow	Repeated resubmission