Proceeding Report of DSS WG I on the Mid-Term Action Plan (2020-2025)

Working Group I for Joint Research
on Dust and Sand Storms

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Contents

Chapter1

1.1 The research activities and achievements until 2019

The Working Group I (WG I) was established under the Tripartite Joint Research on Dust and Sand Storms (DSS), initiated in 2008 following the agreement at the 8th Tripartite Environment Ministers Meeting (TEMM8) among China, Japan, and Korea. The group focuses on monitoring and developing early warning systems for DSS, with a particular emphasis on countermeasures in source areas. During the first phase of the mid-term action plan (2010–2014), WG I aimed to establish and improve early warning systems, enhance model accuracy, promote information sharing, strengthen cooperation with the Working Group II (WG II), and publish research findings. These efforts laid the foundation for a more coordinated and data-driven approach to DSS monitoring in East Asia.

In the second phase (2015–2019), WG I continued its previous activities while expanding data sharing for joint research. It also focused on comparing observational methods for particulate matter and linking national DSS prediction models with the WMO's SDS-WAS website to facilitate broader information exchange. Cooperation with WG II was further strengthened, and participation from external research groups was encouraged. These initiatives contributed to improved model validation, greater transparency in data sharing, and enhanced collaboration across the three countries. The research activities and achievements from 2015 to 2019 were summarized by Proceeding Report of DSS WG I on the Mid-Term Action Plan (2015-2019).

Throughout 2015-2019, the WG I focused on several key objectives. These included continuing its core activities such as data sharing and model validation, expanding the scope and quality of shared data, comparing monitoring methods for particulate matter, and linking national DSS prediction models with the WMO's Sand and Dust Storm Warning Advisory and Assessment System (SDS-WAS). The WG I also sought to deepen cooperation with Working Group II (WG II), which focuses on source area countermeasures, and to involve external research organizations in its work. The key achievements from 2015 to 2019 are shown as follows.

Data Sharing: Observation data from 10 DSS events (2013–2017) were shared. Japan, Korea, and China contributed new datasets, including satellite and optical particle counter data.

Model Validation: Countries shared and compared simulation results using models like MASINGAR and ADAM, improving forecast accuracy.

Monitoring Method Comparison: A comprehensive report was compiled comparing PM

monitoring methods, including equipment, QA/QC protocols, and calibration standards.

Scientific Publications: Eleven research papers were published in international journals such as SOLA, Particuology, and Aerosol and Air Quality Research.

Joint Workshops: The WG I and WG II held three joint workshops to discuss integrated approaches to DSS monitoring and source mitigation.

Outreach and Collaboration: The WG I engaged with organizations like WMO SDS-WAS and EANET, and included Mongolia in joint research efforts.

Despite these achievements, challenges remained. Real-time data sharing was limited, and integrating satellite data into early warning systems proved complex. Furthermore, while collaboration with WG II improved, more structured joint research initiatives were needed.

1.2 The DSS WG I Mid-Term Action Plan (2020-2025)

The contents of the Mid-Term Action Plan (MTAP) of Working Group I for Joint Research on Dust and Sand Storms (2020-2024) was discussed and agreed at the 12th WG meeting in 2019. The draft version of the MTAP was approved by DGM and finally adopted at TEMM22. The one year extension of the MTAP (2020-2024) was agreed at the 16th WG meeting in 2023. The contents of the MTAP (2020-2025) are presented below.

I. Background

Since the Tripartite Environment Ministers Meeting (TEMM) has invited three countries, China, Japan and Korea, to jointly establish a monitoring network and early warning system in order to detect the formation and transportation of Dust and Sand Storms (hereafter DSS) in East Asia, Working Group I (hereafter WG I) has produced several outcomes in research fields during the first term (2008-2014) and second term (2015-2019). The WG I invited Mongolia experts as observer.

First, four countries shared their observational data and dust model results for the selected dust events, as well as their information of monitoring and forecasting system. The sharing and accumulation of data of DSS events served as the foundation for various studies. Secondly shared data contributed to the validation of DSS transport models and the improvement of their accuracy. It was also exploited that the data can be used to identify the transport paths from source to downstream areas and to contribute to the evaluation of impacts on health and vegetation through clarification of chemical and physical characteristics. Finally, research outputs of WG I were compiled into international journals.

In the 12th WG I meeting held on 26-27 September, 2019 in Busan, Korea, the future plan of WG I was discussed in order to enhance the cooperation on sharing observation data and establishing a joint early-warning system of DSS. This document hereby presents the work plan for the next term (2020-2024) of WG I for Joint Research on DSS.

II. Goals

Upon the discussion in the 12th WG I meeting, the followings are determined as the goals of next mid-term plan:

a. Continuation of previous WG I activities

b. Expansion of data sharing for Joint Research
c. Encouragement of sharing real-time data for developing early warning system
d. Enhancement of the cooperation between the two working groups
e. Encouragement of the participation of outreach research groups
f. Enhancement of research on sub-seasonal to seasonal (S2S) forecasts and long-term variations of DSS

To achieve these goals, 6 main activities are decided as described in Section III. The detailed timeline, milestones and resource mobilization for mid-term action plan (2020-2024) will be determined in the coming 13th WG I meeting which will be held in 2020 in China.

III. Main Activities

a. Continuation of previous WG I activities

In order to improve a DSS early warning system, WG I continues data sharing, validation and sharing of the results of the model calculation, and publication of the research results in the scientific journals.

b. Expansion of data sharing for Joint Research

The WG I has endeavored to share the maximum possible data from the existing or new monitoring stations to study and analyze selected Asian dust cases. WG I encourages to expanding the scope and duration of observation sharing over the next five years. In particular, observational data that can be useful for streamlining the DSS monitoring system, such as gas and aerosol concentration from the air quality monitoring station data and visibility from the measuring instrument. WG I also shares forecast data and research results along with observational data. The agreed-upon data will be listed on the DSS online portal, and the data will be managed through a data-sharing platform, such as a shared disk.

c. Encouragement of sharing real-time data for developing early warning system

The efforts of the three countries for the prediction of DSS and improvement of the early warning system have been steadily continued. It is expected that by sharing the real-time observation data (visibility, PM2.5, PM10, SPM, chemical component etc.) on the origins and route of the DSS, not only the case of the dust case in the past, but also satellite data (e.g. HIMAWARI-8 and GK-2A data), with a view to further advance the completion of the DSS early warning system.

d. Enhancement of the cooperation between the two working groups

The importance of collaboration between the WG I and II in sharing the data and findings has been recognized at the Tripartite Director General Meeting and the Steering Committee and

discussed at the working group level. Although the indication of information on source areas through model calculations, the observation of DSS production and reduction at source areas have been suggested as possible areas of collaboration, no agreement has been made in terms of a concrete modality of collaboration.

The WG I will continue the discussion on collaboration with the WG II, on the possibility of holding joint workshop, launching a new joint research and research site, and hopefully establish periodical proceedings on the research which consolidates these papers as well as joint report with WG II.

e. Encouragement of the participation of outreach research groups

World Meteorological Organization Sand and Dust Storm Warning Advisory and Assessment System (WMO SDS-WAS) was established in 2007. The WMO SDS-WAS integrates research and user communities (e.g. medical, aeronautical, agricultural users). Since many experts from this Joint study are participating in SDS-WAS, collaboration between two schemes is feasible. Potential synergy could be made by linking the websites of TEMM and SDS-WAS. And we would like to encourage the participation of university research institutes as well as national research institute based participation (such as the respective country's agencies which manage the satellite observation data).

f. Enhancement of research on sub-seasonal to seasonal (S2S) forecasts and long-term variations of DSS

In order to forecast sub-seasonal to seasonal scales of DSS variation, it is necessary to carry out based on numerical and statistical models. And, to study on long-term variations on DSS, considering the impact of climate change, WG I encourages to carry out the followings: 1) inter-comparisons of forecast and hindcast modeling results reported by participating countries in order to assess the DSS variation by 2050 and perturbations, 2) information sharing of the DSS observation results in past decades, and methods used by participating countries in order to assess the sustainability of the methods, and 3) discussion on variation in vegetation at source area possibly working with the WG II.

IV. Expected Outcomes

a. Enhanced platform, including web-hard and online portal, for DSS data sharing to prevent DSS damages in East Asia

b. Improved DSS forecast and early warning systems

c. Integrated information on DSS between WG I and II

d. Published research articles on DSS

1.3 The fact-based outcomes of the DSS WG I Mid-Term Action Plan (2020-2025)

The WG I meetings have been held from 2020 to 2025 as shown in Table 1.

Table 1 The 13th to 18th WG I meetings (Overview)

Meeting	Venue and Dates	Year	Participants
13th	Online, Beijing, China, October 13, 2020	2020	CJKM
14th	Online, Tokyo, Japan, September 28-29, 2021	2021	CJKM
15th	Virtual and Jeju, Korea, November 1-2, 2022	2022	CJKM
16th	Online, China, December 5, 2023	2023	CJKM
17th	Niigata, Japan, October 10-11, 2024	2024	CJKM
18th	Seoul, Korea, June 30-July 1, 2025	2025	CJKM

C: China, J: Japan, K: Korea, M: Mongolia

Table 2 shows comparisons of goals, activities and expected outcomes of the Mid-Term Action Plan (2020-2025). The WG I focuses on continuing previous efforts while enhancing data sharing, real-time monitoring, and early warning systems. It also aims to strengthen collaboration with WG II and external research groups, and to advance research on long-term and seasonal DSS forecasting.

Table 2 Comparisons of goals, activities and expected outcomes of the Mid-Term Action Plan (2020-2025) [Numbers in the parentheses are corresponded to the Mid-Term Action Plan (2020-2025)]

Goals	Activities	Expected outcomes
(1) Continuation of the previous WG I activities	(1) Sharing data and publication of the research results	(a) Enhanced platform, including web-hard and online portal, for DSS data sharing to prevent DSS damages in East Asia (b) Improved DSS forecast and early warning systems
(2) Expansion of data sharing for Joint Research	(2-1) Share the maximum possible DSS and PM chemical composition data (2-2) Establishing an online portal for sharing research results	(a) Enhanced platform, including web-hard and online portal, for DSS data sharing to prevent DSS damages in East Asia
(3) Encouragement of sharing real-time data for developing early warning system	(3-1) DSS prediction and early warning system improvements (3-2) Sharing real-time observation and satellite data to enhance the	(b) Improved DSS forecast and early warning systems

	system	
(4) Enhancement of cooperation between the two WGs	(4) Discussions about joint workshops, new research initiatives, and periodic research proceedings	(c) Integrated information on DSS between WG I and II
(5) Encouragement of the participation of outreach research groups	(5) Collaboration with WMO SDS-WAS, Participation from university and research institutes	(d) Published research articles on DSS
(6) Enhancement of research on sub-seasonal to seasonal (S2S) forecasts and long-term variations of DSS	(6) Model intercomparisons, sharing past observation data, and discussing vegetation changes with WG II	(b) Improved DSS forecast and early warning systems

Following the Mid-Term Action Plan (2020-2025), significant progress was made in data sharing and research publication, with nine papers published and observation data exchanged among countries as shown in Table 3. An online portal for data sharing was established, though storage limitations remain a challenge. Efforts to improve early warning systems and share real-time satellite data are ongoing, but full agreement on data sharing has not yet been reached. Collaboration between WG I and WG II has advanced through joint workshops and draft reports. Engagement with external partners like WMO SDS-WAS and research institutions has increased, while research on sub-seasonal forecasts still faces technical difficulties.

Table 3 Status of the activities in the Mid-Term Action Plan (2020-2025)

Activities	Status (as of June 2025)
(1) Sharing data and publication of the research results	➢ Observation data from multiple DSS events have been shared among China, Japan, Korea and Mongolia, with detailed datasets uploaded to Webhard and discussed at annual meetings. ➢ 9 research papers have been published by WG I members, and a data catalogue was proposed and partially implemented on the TEMM DSS Online Portal.
(2-1) Share the maximum possible DSS and PM chemical composition data	➢ Each country has submitted the data during DSS events identified by annual DSS WG I meeting until year 2022. ➢ Countries have shared PM10, PM2.5, and chemical composition data during selected DSS events, including crustal and anthropogenic components.
(2-2) Establishing an online portal for sharing research results	➢ Online storage portal was prepared by Korea Meteorological Administration (KMA). ➢ The TEMM DSS Online Portal was launched and updated with research articles and meeting summaries; a "Data Catalogue" page was introduced as an alternative to direct data sharing.
(3-1) DSS prediction and early	➢ Model improvements and integration of soil moisture effects have

warning system improvements	enhanced prediction accuracy by China, Japan and Korea. ➢ New forecasting models and data assimilation techniques are being developed, and it was discussed by annual DSS WG I meeting.
(3-2) Sharing real-time observation and satellite data to enhance the system	➢ Satellite data from Himawari-8 and 9 and GK-2A are being used for DSS detection and forecasting, though real-time sharing remains limited. ➢ Discussions continue on using external satellite resources and improving access through cloud-based systems.
(4) Discussions about joint workshops, new research initiatives, and periodic research proceedings	➢ Extended Workshops were held in 2021 and 2023 to promote collaboration between WG I and WG II. ➢ Developing Environmental Cooperation Platform in Northeast Asia for Joint Prevention and Control of Sandstorm under the '3+X' Cooperation Mode was held by CREAS in 2023. ➢ A proceeding report is being prepared to document cooperative activities and outcomes under the current MTAP.
(5) Collaboration with WMO SDS-WAS, Participation from university and research institutes	➢ WG I has maintained links with WMO SDS-WAS and involved academic institutions from all participating countries in joint research and data sharing. ➢ Field surveys in Mongolia and collaborative studies with universities have strengthened regional research capacity and outreach.
(6) Model intercomparisons, sharing past observation data, and discussing vegetation changes with WG II	➢ The collaborative research between two WGs was implemented by the project in Japan. Vegetation data were provided from WG II to WG I researchers. ➢ Field surveys and discussions with WG II have explored vegetation impacts on DSS, supporting integrated research for the next MTAP.

In particular, observation data related to DSS events have been continuously shared since 2007. New data items have been added progressively by Japan and Korea. China has continued to provide PM10 monitoring data. The data types and the start year of data sharing activity are shown in Table 3. In addition to these, Japan and Korea have been validating and cross-sharing the results of each country's simulation models such as Model of Aerosol Species IN the Global AtmospheRe (MASINGAR) and Asian Dust Aerosol Model (ADAM).

Table 4 List of shared data by China, Japan, Korea and Mongolia as of October 2024

Data	Year	Monitoring sites
China		
Hourly average PM10	2011-2022	10 sites (Baotou,Hohhot,etc..)
Daily average PM10	2007-2022	10 sites (Baotou,Hohhot,etc..)

Japan		
Dust extinction coefficient, spherical particle extinction coefficient (Lidar)	2011-2022	Sapporo, Niigata, Toyama, Matsue, Fukuoka, Fukue, Nagasaki, Osaka, Hedo, Tokyo, Chiba, Tsukuba, Sendai, Seoul, Jeju, Ulsan, Sainshand, Zamynuud, Ulaanbaatar
Aerosol Number Concentration (POPC)	2015-2022	Fukuoka, Seoul
Hourly average SPM	2007-2022	16 sites
Hourly average PM10	2007-2022	11 sites
Hourly average PM2.5	2007-2022	11 sites
Visibility & Relative Humidity	2008-2022	59 sites
Hourly Aerosol Optical Thickness	2012-2021	Abashiri, Ishigaki, Minamitorishima
Satellite observation data	2016-2022	HIMAWARI-8, HIMAWARI-9
Korea		
Dust extinction coefficient, spherical particle extinction coefficient (Lidar)	2008-2020	Anmyeon(KGAWO)
Hourly average PM10	2007-2022	Sokcho, Kwanaksan, Gunsan, Jinju, Gwangdeoksan, Yeongwol, Daegu, Ganghwa, Daegwallyeong, Uljin, Gwangju, Cheonan, Baengnyeongdo, Anmyeon(KGAWO), Gudeoksan, Seoul, Chupungnyeong, Heuksando, Gosan, Andong, Ulleungdo
Visibility & Relative Humidity	2008-2022	Daegwallyeong, Seoul, Cheongju, Andong, Gunsan, Jinju
Hourly Aerosol Optical Thickness	2012-2022	Anmyeon(KGAWO)
Aerodynamic Particle Sizer (APS)	2016-2020	Anmyeon(KGAWO), Gosan, Ulleungdo
Mongolia		
Hourly average PM10	-2021	Altai, Ulaan-Uul(Erdene), Nomgon
Hourly average PM2.5	-2021	Altai

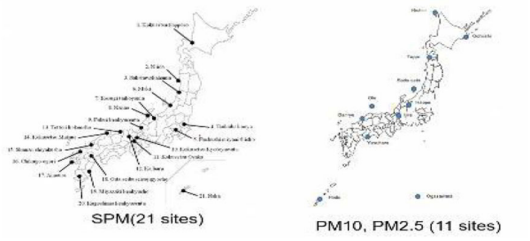

Fig. 1 Location of SPM, PM10 and PM2.5 monitoring sites in Japan

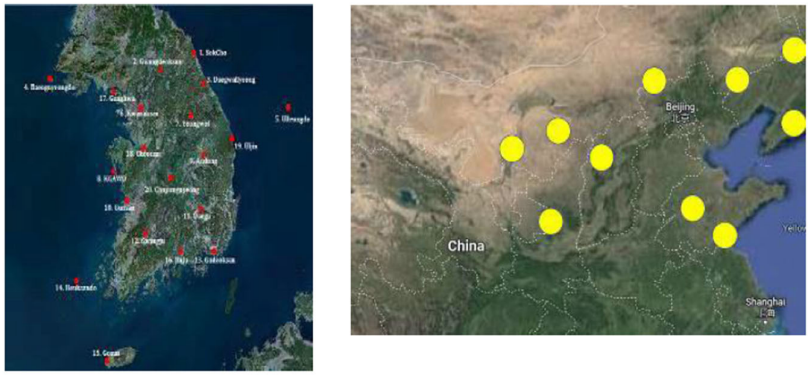

Fig. 2 Location of PM10 and PM2.5 monitoring sites in Korea(Left) and China(Right)

Chapter 2

2.1 The presentations and discussion results at respective DSS WG I meetings between 2020-2025

In a series of the WG I meetings from 2020 to 2025, the researchers shared their research activities and exchanged their opinions. The summaries of the 13th to 18th meetings are shown below. The documents of the 13th to 18th meeting are attached in Annex.

2.1.1 The 13th WG I meeting, 2020

The 13th Meeting of Working Group I (WG I) under the Tripartite Environment Ministers Meeting (TEMM) framework was held online on October 13, 2020, hosted by China. Representatives from China, Japan, Korea, and Mongolia participated in the meeting to review progress and coordinate future efforts in joint research on Dust and Sand Storms (DSS).

The meeting opened with welcoming remarks from Dr. Jianjun Li of the China National Environmental Monitoring Centre (CNEMC), followed by the adoption of the agenda. The first session focused on reviewing past discussions and activities. Dr. Sang Boom Ryoo (Korea) summarized the outcomes of the 12th WG I meeting, while Dr. Jeong Eun Kim (Korea) reported on the current status of DSS data sharing. She highlighted the addition of new air quality data from Mongolia and proposed improvements to data management, including policies for handling large files and annual data rotation.

In the Session 2, each country presented updates on their DSS monitoring and modeling efforts. Japan reported on the development of the MASINGAR-mk2 model, which suggested a potential decrease in DSS occurrences by the 2050s, though with significant variability. Korea introduced the GeoKOMPSAT-2 satellite system, emphasizing its capabilities in dust and aerosol monitoring. China showcased the use of lidar networks for tracking sand transport, while Mongolia presented its progress in developing DSS forecasting models with international support.

The Session 3 addressed specific DSS events and their scientific analysis. Japan proposed a method for long-term monitoring using its air quality network, while Korea analyzed a 2018 DSS event using both observational and model data. China presented chemical composition analyses of

particulate matter during recent DSS events in Beijing, revealing detailed insights into pollutant characteristics.

A major focus of the fourth session was the Mid-Term Action Plan (MTAP) 2020–2024. Japan proposed leading the development of an online portal for data sharing, aiming for a preliminary launch in 2021. The proposal was welcomed, though further discussions were needed regarding its design and implementation. Korea and Japan also presented ideas for enhancing research on sub-seasonal to seasonal (S2S) forecasting and long-term DSS trends. Korea suggested structuring Activity 6 of the MTAP into three distinct research areas: S2S forecasting, long-term variation analysis, and future climate projections. Japan proposed establishing a dedicated session on these topics and holding a special session during the next WG I meeting.

The meeting also discussed the potential for collaboration with Working Group II (WG II), with Japan presenting a case study of integrated research funded under a national program. This highlighted the benefits of cross-group collaboration in monitoring, modeling, and field experiments.

Finally, the countries agreed to share observation data from two DSS events in 2019 and expressed appreciation for the collaborative efforts. The meeting concluded with a proposal for Japan to host the 14th WG I meeting in autumn 2021 near Tokyo, with preparations to begin at least three months in advance.

2.1.2 The 14th WG I meeting, 2021

The 14th Meeting of the Working Group I (WG I) for Joint Research on Dust and Sand Storms (DSS), held online on 28–29 September 2021 and hosted by Japan, brought together representatives from Japan, Korea, China, and Mongolia. The meeting was convened under the framework of the Tripartite Environment Ministers Meeting (TEMM) and aimed to review progress, share data and research findings, and coordinate future actions related to DSS monitoring and modeling.

The meeting opened with welcoming remarks from Mr. Toshiyuki Yamasaki of Japan's Ministry of the Environment, followed by the adoption of the agenda. In the first session, participants reviewed the outcomes of the previous (13th) meeting and shared updates on data sharing practices. Each country reported on the types of DSS-related data they had contributed, including PM concentrations, aerosol profiles, and satellite observations. A consensus was reached to manage the limited storage space on the shared Webhard platform by deleting large files annually, with China

proposing that data be backed up on physical media before deletion.

Japan presented the progress of the TEMM DSS Online Portal, which was developed in line with the Mid-term Action Plan (2020–2024). The participants agreed to launch the portal with selected content pages and to continue discussions on the design and content of the DSS Data Set page. They also agreed on a data policy to govern the use of shared datasets and research articles.

In the session on DSS monitoring and modeling, each country presented recent advancements. China evaluated forecast products using the NAQPMS model, while Korea introduced improvements to its ADAM3 model, including enhanced data assimilation and the incorporation of soil moisture effects. Japan demonstrated the utility of Himawari-8 satellite data for early DSS detection and modeling, and Mongolia shared findings from simulations using the ADAM-Haze model, highlighting the need for equipment upgrades and expanded monitoring networks.

The meeting also featured case studies of past DSS events. Korea analyzed the November 2019 event, noting its widespread impact and elevated PM10 levels. China reported on the unusual chemical composition of PM2.5 during a DSS event in Beijing, while Japan presented detailed aerosol analyses from the May 2019 event. Based on these discussions, the participants agreed on four specific periods in 2020 for joint data analysis.

Further discussions focused on implementing the Mid-Term Action Plan. Korea and Japan presented updates on satellite data and lidar networks, and the group agreed to enhance data sharing, including contributions from Mongolia. The participants also discussed the potential for the DSS Portal to host a private data-sharing space for WG members.

Finally, the meeting concluded with a summary session. Korea proposed to host the next (15th) WG I Meeting in Autumn 2022 in Jeju Island, pending the COVID-19 situation. Participants expressed appreciation for the collaborative efforts and acknowledged Dr. Sang Boom Ryoo's long-standing contributions as he retired from his role.

2.1.3 The 15th WG I meeting, 2022

The 15th Meeting of the Working Group I (WG I) for Joint Research on Dust and Sand Storms (DSS), under the framework of the Tripartite Environment Ministers Meeting (TEMM), was held in a hybrid format in Jeju, Korea, on November 1–2, 2022. Representatives from Korea, Japan, China,

and Mongolia participated in the meeting, which aimed to review progress, share research findings, and coordinate future actions on DSS monitoring and modeling.

The meeting began with opening remarks and an overview of the agenda. In the first session, participants reviewed the outcomes of the 14th WG I meeting and the launch of the TEMM DSS Online Portal. Korea reported on the status of DSS data sharing in 2020, highlighting issues with online storage capacity. Japan offered to voluntarily share a comprehensive DSS dataset, and Korea agreed to use a separate storage device for backup purposes.

In the Session 2, each country presented updates on DSS monitoring and modeling. Japan emphasized the increasing friction velocity in dust source regions under warming scenarios, which may lead to more frequent long-range dust transport. China reported on the frequency and characteristics of DSS events in 2020, while Korea introduced improvements to its Asian Dust Aerosol Model (ADAM3). Mongolia presented research on estimating sand saltation thresholds using Sentinel-1 SAR data, identifying key surface factors such as stones and dry vegetation.

The Session 3 focused on country-specific DSS events. Korea analyzed a severe DSS case from October 2020, showing how dust traveled from the Gobi Desert to the Korean Peninsula. China presented chemical composition data of PM2.5 during DSS events, and Japan reported that no significant DSS events were detected in 2020. Based on these discussions, three DSS events from 2021 were selected for data sharing and joint analysis: March 15–20, March 25–April 2, and May 5–10.

In the Session 4, updates were provided on the Mid-Term Action Plan (2020–2024). Korea introduced satellite-based DSS monitoring using the GK-2A satellite, while Mongolia reported on desertification trends and mitigation efforts, including the national "Billion Trees" campaign. Japan proposed publishing a "Data Catalogue" on the TEMM DSS Online Portal instead of raw datasets, which was agreed upon by all participants.

The Session 5 addressed forecasting and evaluation tools. Korea presented seasonal forecasting using the GloSea6 model, Japan shared progress on the ERTDF-2001 research program, and China evaluated DSS forecast products using the NAQPMS model.

Finally, Japan proposed organizing an Extended Workshop in 2023 to enhance collaboration between WG I and WG II. The proposal was welcomed by all countries, and Japan offered to host the event and support participation from each country, including Mongolia.

The meeting concluded with a summary session, where participants confirmed the selected DSS cases for data sharing, endorsed the Data Catalogue proposal, and supported the plan for the Extended Workshop. China, as the next host, will announce the details of the 16th WG I meeting at least three months in advance. Participants expressed appreciation for the collaborative efforts and the hospitality of the host country.

2.1.4 The 16th WG I meeting, 2023

The 16th Meeting of the Working Group I (WG I) for Joint Research on Dust and Sand Storms (DSS) under the Tripartite Environment Ministers Meeting (TEMM) was held on December 5, 2023, in a hybrid format hosted by China. Representatives from China, Japan, Korea, and Mongolia participated in the meeting, which aimed to review progress, share research findings, and discuss future collaboration on DSS-related issues.

The meeting began with opening remarks and an overview of the agenda, followed by a session reviewing past discussions and activities. Korea presented a summary of the 15th WG I Meeting, highlighting key outcomes such as the identification of major DSS events in 2021 and the agreement to publish a data catalogue on the TEMM DSS portal. The issue of limited data storage was raised, and participants discussed the need for improved data sharing mechanisms, including the use of URLs and a centralized data catalog.

In the session on monitoring and modeling, each country shared recent advancements. Japan reported on modeling studies that linked increased DSS emissions to reduced snow cover in the Gobi Desert and introduced improvements in model accuracy through the inclusion of stone coverage effects. Korea presented updates to its Asian Dust Aerosol Model (ADAM3), which now better reflects observed PM_{10} concentrations. China discussed the variability in simulation results across different models and emphasized the need for harmonization. Mongolia contributed findings from field measurements during DSS2019, showing that coarse particles dominated at lower altitudes, reflecting the soil texture of the source areas.

The country reports session featured detailed analyses of DSS events in 2021 and 2022. Japan introduced a novel method using aerosol magnetism as a proxy for dust loading and iron solubility, while China emphasized the importance of high-resolution regional models to improve forecasting accuracy. The participants agreed on three specific DSS cases from 2022 for joint study: March 2–7,

April 24–30, and December 10–16.

In the discussion on the Mid-Term Action Plan (2020–2024), Japan proposed a one-year extension to align with the next TEMM Joint Action Plan (2026–2030). This proposal was accepted by all participants, ensuring sufficient time for planning and coordination. The meeting also reflected on the success of the DSS WG II Extended Workshop held in November 2023, which fostered collaboration between WG I and WG II.

The meeting concluded with a summary session and closing remarks. Participants expressed appreciation for the collaborative efforts and acknowledged the contributions of all involved. Japan, as the host of the next WG I meeting, proposed potential collaboration with EANET and suggested holding the 17th meeting at ACAP in Niigata, Japan, with further details to be discussed.

2.1.5 The 17th WG I meeting, 2024

The 17th Meeting of the Working Group I (WG I) for Joint Research on Dust and Sand Storms (DSS) under the Tripartite Environment Ministers Meeting (TEMM) was held in Niigata, Japan, with participation from Japan, Korea, China, and Mongolia. The meeting aimed to review recent progress, share research findings, and discuss future directions for regional cooperation on DSS.

The meeting opened with welcoming remarks from Mr. Yu Kamei of Japan's Ministry of the Environment, followed by the adoption of the agenda. In the first session, Dr. Liang Li of China reviewed the outcomes of the 16th meeting, including the identification of three major DSS events in 2022 and the agreement to extend the current Mid-Term Action Plan (MTAP) by one year to align with the next TEMM Joint Action Plan (2026–2030). Mr. Jeong Hoon Cho of Korea then reported on the status of DSS data sharing, highlighting the need for improved data submission deadlines and a transition from web-hard storage to a more accessible cloud-based system.

In the session on monitoring and modeling, Japan, Korea, China, and Mongolia presented updates. Japan introduced the latest version of its Earth System Model (MRI-ESM3), which shows improved dust emission estimates. Korea outlined plans for a new integrated DSS model to be operational by 2030, incorporating AI and satellite data. China emphasized the growing demand for accurate forecasting due to severe sandstorms in 2023, while Mongolia highlighted the need for international support to modernize its monitoring infrastructure and enhance forecasting capabilities.

The country reports session featured detailed analyses of recent DSS events. Korea presented case studies from March and December 2022, showing significant impacts on air quality. Japan introduced the use of low-cost pollen sensors as a promising alternative for DSS detection, especially as traditional observation stations decline. Additional presentations examined the chemical characteristics of dust events, field surveys in Mongolia, and proposed data sharing periods for 2023. Participants agreed to focus on two periods for data sharing: April 8–24 and May 19–24, 2023.

The meeting also reviewed progress on the current MTAP (2020–2025). Participants discussed reorganizing the summary table of activities and outcomes, the potential use of cloud storage for real-time data sharing, and the importance of including past workshops and cooperative activities in the final report. It was agreed that the preparation of the MTAP proceeding report would continue via email.

The discussion on the next MTAP (2026–2030) emphasized the need for improved forecasting systems, integration of satellite and ground-based data, and stronger collaboration between WG I and WG II. Key goals include developing short-, medium-, and long-term DSS forecasts, understanding the impacts of climate change on DSS patterns, and evaluating the effectiveness of mitigation measures. Participants stressed the importance of early warning systems, adaptation strategies for semi-arid regions, and shared understanding of DSS trends.

In the final sessions, the Secretariat introduced a proposal from the UNCCD to link the SDS Toolbox with the TEMM DSS portal and recommended expanding storage capacity for shared data. The meeting concluded with a draft summary report, which will be finalized following feedback from participating countries. Representatives from all countries expressed appreciation for the collaborative efforts.

2.1.6 The 18th WG I meeting, 2025

The 18th Meeting of the Working Group I for Joint Research on Dust and Sand Storms (DSS), held under the Tripartite Environment Ministers Meeting (TEMM), took place in a hybrid format in Seoul, Korea, on June 30 and July 1, 2025. Representatives from Japan, China, Korea, and Mongolia gathered to review progress, share research findings, and discuss future collaboration on DSS-related issues.

The meeting commenced with opening remarks by Dr. Sangbaek Kim of Korea's National

Institute of Meteorological Sciences (NIMS/KMA), followed by the adoption of the agenda. In the initial sessions, participants reviewed the outcomes of the previous (17th) meeting and discussed improvements in data sharing, including a planned transition to a Google Drive platform with expanded storage.

Subsequent sessions featured presentations from each country on their ongoing DSS monitoring and modeling efforts. Japan introduced a new research initiative aimed at building databases, analyzing dust mechanisms, and developing forecasting systems. Innovative approaches, such as using low-cost pollen sensors for DSS detection, were also explored. China reported on dust events in 2023 and their impact on air quality, while Korea showcased advancements in satellite-based DSS monitoring and updates to its ADAM3 forecasting model. Mongolia presented long-term trends in dust storm occurrences and outlined future modeling plans under climate change scenarios.

The meeting also included detailed reports on the major DSS events of 2023, with each country analyzing the events' origins, transport patterns, and chemical compositions. A consensus was reached on selecting three key DSS events from 2024 for joint analysis and data sharing.

A significant portion of the meeting was dedicated to shaping the 4th Mid-Term Action Plan (MTAP) for 2026–2030. Discussions emphasized the continuation of current activities, enhancement of data sharing systems, improvement of forecasting capabilities, and deeper collaboration with Mongolia and other outreach groups. Participants agreed on the importance of setting realistic goals, valuing incremental progress, and refining the MTAP to ensure clarity and effectiveness.

The second day continued with strategic planning for the MTAP, reinforcing the need for integrated responses to DSS challenges, especially in the context of climate change. The meeting concluded with a review of the draft summary, closing remarks from all participating countries, and a reaffirmation of their commitment to ongoing cooperation. The venue and schedule for the 19th meeting, potentially to be held in conjunction with the UNCCD COP17 in Mongolia, will be confirmed by November 2025.

2.2 The Extended Workshop between WG I and WG II for Joint Research on Dust and Sand Storms

The Extended Workshop between WG I and WG II for Joint Research on Dust and Sand Storms was held in 2021 and 2023 as shown in Table 4 below.

Table 5 The Extended Workshop between WG I and WG II: Overview

Year	Venue and Dates	Participants
2021	Tokyo, Japan, 30 September 2021	CJKM
2023	Tokyo, Japan, 7, November 2023	CJKM

C: China, J: Japan, K: Korea, M: Mongolia

2.2.1 Extended Workshop on Dust and Sand Storms: Sub-seasonal to Seasonal forecast and Long-term Variations in 2021

On September 30, 2021, the Online Workshop on Dust and Sand Storms (DSS), held as an outreach session of the Tripartite Environmental Ministers Meeting (TEMM) DSS Working Group I (WG I) Extended Workshop, brought together experts from China, Korea, Japan, Mongolia, along with around 60 experts from 12 countries. The workshop aimed to foster scientific exchange on the sub-seasonal to seasonal (S2S) forecasting and long-term variation of DSS, and to strengthen the role of WG I as a platform for broader research collaboration.

The outreach session began with opening remarks from Mr. Yutaka Matsuzawa of Japan's Ministry of the Environment, who introduced the TEMM DSS Joint Research activities and announced the launch of the TEMM DSS Online Portal for sharing research data. Then, the keynote presentations by Mr. Takashi Maki and Dr. Masao Mikami emphasized the importance of using CMIP6 model results for downscaling and predicting DSS intensity and hydrological changes in arid regions. They highlighted the value of international collaboration in addressing the challenges posed by DSS and climate change.

Following the keynote, seven presentations were delivered by experts from China, Korea, Mongolia, and Japan. The topics included:

- Long-term trends in dust storm frequency in Northern China, showing a decline due to increased precipitation, vegetation cover, and reduced wind speeds
- Statistical analysis of dust events in China from 2015 to 2019

- Seasonal forecasting of Asian dust using the GloSea5-ADAM model developed by Korea's NIMS
- Dust monitoring and modeling in Mongolia, including particle size distribution during storm events and the need for improved monitoring infrastructure
- Desertification dynamics in the steppe regions of China and Mongolia, with evidence of reversal trends linked to increased precipitation and ecological restoration efforts
- A Japanese research initiative on predicting DSS variability under climate change, emphasizing sustainable monitoring and improved modeling
- Korea's plans to expand DSS research into Mongolia, focusing on ecological impacts and policy support.

The session concluded with a relay comment and Q&A segment, where presenters discussed the benefits of studying DSS from long-term and seasonal perspectives and the value of international cooperation through TEMM DSS. Mr. Yuichi Nagasaka closed the session by reaffirming the importance of collaborative efforts in addressing climate challenges and promoting shared solutions.

2.2.2 Extended Workshop for Joint Research on Dust and Sand Storms (DSS) to strengthen collaboration between WG II and WG I in 2023

The Extended Workshop for the Dust and Sand Storms (DSS), held on November 7, 2023, in Tokyo and online, was convened to deepen collaboration between WG II and WG I under the Tripartite Environmental Ministers Meeting (TEMM). Hosted by the Ministry of the Environment, Japan, the workshop brought together experts from China, Korea, Japan, Mongolia, and international organizations to exchange scientific insights and policy perspectives on DSS mitigation.

The workshop opened with remarks from Mr. Yu Kamei of MOEJ, who emphasized the importance of regional cooperation and celebrated the contributions of Dr. Atsushi Shimizu and Dr. Saeromi Mun, recipients of the TEMM Environment Award. The keynote address by Dr. Ken Yoshikawa of Okayama University introduced ecological findings on Juniperus sabina, a resilient shrub species in northern China, highlighting its potential role in combating desertification and informing DSS-related research.

The morning session featured a series of presentations from WG II and WG I members, as well as invited speakers. These included an overview of ecological restoration efforts in Mongolia using

nature-based solutions, a Japanese collaborative research project on Asian dust variability under climate change, and updates on WG I's 2023 activities and data-sharing initiatives. Additional presentations explored regional cooperation frameworks, vulnerability assessments, vegetation restoration in Inner Mongolia, and global strategies led by the UN Coalition on SDS. Mongolia's ambitious "Billion Tree National Movement" was also introduced as a national response to desertification and climate change.

In the afternoon, participants engaged in breakout sessions to explore two central questions: what lessons can be drawn from existing collaborations, and what gaps must be addressed to enhance future cooperation? Discussions revealed that while data and knowledge sharing have significantly improved modeling and restoration planning, challenges remain. These include differences in research scale and disciplinary focus between WG I and WG II, limited integration of research into policy, and the need for standardized data and methodologies.

Participants emphasized the importance of identifying common goals, enhancing communication, and leveraging remote sensing technologies to bridge the gap between large-scale modeling and localized restoration. The discussions also highlighted the value of transboundary cooperation, capacity building, and inclusive frameworks such as the "3+X" model to engage a broader range of stakeholders.

The workshop concluded with a wrap-up session summarizing the key insights and outlining next steps. Dr. Yoshikawa closed the event by expressing appreciation for the active participation and reaffirming the importance of continued collaboration between WG II and WG I. The outcomes of the workshop are expected to inform the upcoming 16th DSS WG II meeting and contribute to the development of the next Mid-Term Action Plan.

2.3 Published papers from 2020 to 2025

The journal publications as outcome of the WG I activity from 2020 to 2025 were submitted to Atmosphere, Remote Sensing, Scientific Online Letters on the Atmosphere (SOLA), Atmospheric Environment, and Journal of Geophysical Research: Atmospheres. During 2020 and 2025, thanks to the WG I experts' great efforts, 9 research papers have successfully published at the above mentioned scientific journals: three papers to Atmosphere, three to SOLA, one paper to Remote Sensing, Atmospheric Environment and Journal of Geophysical Research: Atmospheres. The bibliographic information and abstracts of these research articles are summarized in Table 6.

Table 6 List of published papers from 2020 to 2025

[2020]

1) **Compositional Characteristics of Atmospheric Aerosols during a Consecutive High Concentration Episode in Seoul, Korea**

Hee-Jung Ko, Seung Joo Song, Jeong Eun Kim, Jung-Min Song and Joo Wan Cha

Atmosphere 2020, 11(3), 310

https://doi.org/10.3390/atmos11030310

This study focuses on the temporal variation in the compositional characteristics of atmospheric aerosols in Seoul, South Korea, during the consecutive high aerosol concentration episode from 30 December 2013 to 2 January 2014. The temporal variations in the observed physical, optical, and chemical properties show that there were three distinct episodes during the period: haze, mixed haze/Asian dust, and Asian dust episodes. For the haze period, the concentration of secondary inorganic aerosols increased and both secondary inorganic aerosols and calcium species exhibited simultaneously high concentrations during the mixed haze/Asian dust period. The neutralization factors by ammonia in the haze periods were higher as 1.03 than the other periods, meanwhile the neutralization contribution by calcium carbonate was relatively higher as 1.39 during the Asian dust episode. The backward trajectory analysis showed that concentrations of SO_4^{2-}, NO_3^-, and NH_4^+ were relatively high when air masses moved over East China. Principal component analysis showed that water-soluble components originated from soil dust/incineration, secondary aerosols/biomass burning, and road dust from the haze aerosol. For the mixed haze/Asian dust episode, the major source of aerosols was estimated to have originated from soil dust,

pollutants from fossil fuel combustion, biomass burning, and sea-salt emissions. Furthermore, the main sources of ionic species in the Asian dust aerosols were estimated to be sea-salt/soil dust, secondary aerosols/coal combustion, and road dust.

2) Seasonal Asian Dust Forecasting Using GloSea5-ADAM

Sang-Boom Ryoo, Yun-Kyu Lim and Young-San Park

Atmosphere 2020, 11(5), 526

https://doi.org/10.3390/atmos11050526

The springtime dust events in Northeast Asia pose many economic, social, and health-related risks. Statistical models in the forecasting of seasonal dust events do not fully account for environmental variations in dust sources due to climate change. The Korea Meteorological Administration (KMA) recently developed the GloSea5-ADAM, a numerically based seasonal dust forecasting model, by incorporating the Asian Dust and Aerosol Model (ADAM) 's emission algorithm into Global Seasonal Forecasting Model version 5 (GloSea5). The performance of GloSea5 and GloSea5-ADAM in forecasting seasonal Asian dust events in source (China) and leeward (South Korea) regions was compared. The GloSea5-ADAM solved the limitations of GloSea5, which were mainly attributable to GloSea5′s low bare-soil fraction, and successfully simulated 2017 springtime dust emissions over Northeast Asia. The results show that GloSea5-ADAM's 2017 and 2018 forecasts were consistent with surface PM10 mass concentrations observed in China and South Korea, while there was a large gap in 2019. This study shows that the geographical distribution and physical properties of soil in dust source regions are important. The GloSea5-ADAM model is only a temporary solution and is limited in its applicability to Northeast Asia; therefore, a globally applicable dust emission algorithm that considers a wide variety of soil properties must be developed.

3) Performance of KMA-ADAM3 in Identifying Asian Dust Days over Northern China

Sang-Boom Ryoo, Jinwon Kim and Jeong Hoon Cho

Atmosphere 2020, 11(5), 526

https://doi.org/10.3390/atmos11060593

Recently, the Korea Meteorological Administration developed Asian Dust

Aerosol Model version 3 (ADAM3) by incorporating additional parameters into ADAM2, including anthropogenic particulate matter (PM) emissions, modification of dust generation by considering real-time surface vegetation, and assimilations of surface PM observations and satellite-measured aerosol optical depth. This study evaluates the performance of ADAM3 in identifying Asian dust days over the dust source regions in Northern China and their variations according to regions and soil types by comparing its performance with ADAM2 (from January to June of 2017). In all regions the performance of ADAM3 was markedly improved, especially for Northwestern China, where the threat score (TS) and the probability of detection (POD) improved from 5.4% and 5.5% to 30.4% and 34.4%, respectively. ADAM3 outperforms ADAM2 for all soil types, especially for the sand-type soil for which TS and POD are improved from 39.2.0% and 50.7% to 48.9% and 68.2%, respectively. Despite these improvements in regions and surface soil types, Asian dust emission formulas in ADAM3 need improvement for the loess-type soils to modulate the overestimation of Asian dust events related to anthropogenic emissions in the Huabei Plain and Manchuria.

[2021]

1) **Improvements of ADAM3 by Incorporating New Dust Emission Reduction Formulations Based on Real-Time MODIS NDVI**

Jeong Hoon Cho, Sang-Boom Ryoo and Jinwon Kim

Remote Sensing. 2021, 13(16), 3139

https://doi.org/10.3390/rs13163139

Dust events in Northeast Asia have several adverse effects on human health, agricultural land, infrastructure, and transport. Wind speed is the most important factor in determining the total dust emission at the land surface; however, various land-surface conditions must be considered as well. Recently, the Korea Meteorological Administration updated the dust emission reduction factor (RF) in the Asian Dust Aerosol Model 3 (ADAM3) using data from the normalized difference vegetation index (NDVI) of the Moderate Resolution Imaging Spectroradiometer (MODIS). We evaluated the improvements of ADAM3 according to soil types. We incorporated new RF formulations in the evaluation based on real-time MODIS NDVI data obtained over the Asian dust source regions in northern China during spring 2017. This incorporation improved the

simulation performance of ADAM3 for the PM10 mass concentration in Inner Mongolia and Manchuria for all soil types, except Gobi. The ADAM3 skill scores for sand, loess, and mixed types in a 24 h forecast increased by 6.6%, 20.4%, and 13.3%, respectively, compared with those in forecasts employing the monthly RF based on the NDVI data. As surface conditions in the dust source regions continually change, incorporating real-time vegetation data is critical to improving performance of dust forecast models such as ADAM3.

[2022]

1) **Spatiotemporal Dispersion of Local-Scale Dust from the Erdenet Mine in Mongolia Detected by Himawari-8 Geostationary Satellite**

Chultem Batbold, Keiya Yumimoto, Sonomdagva Chonokhuu, Batdelger Byambaa, Batdavaa Avirmed, Shuukhaaz Ganbat, Naoki Kaneyasu, Yutaka Matsumi, Teppei J. Yasunari, Kenji Taniguchi, Noriko Hasebe, Keisuke Fukushi, Atsushi Matsuki

SOLA. 2022, 18, p.225-230

https://doi.org/10.2151/sola.2022-036

In Mongolia, combined with the dry and windy climate during spring and autumn, the exposed sediment of mine tailings pond becomes an additional source of anthropogenic windblown dust and poses potential threats to the surrounding environment and human health. In this study, we reported on our first attempt to derive the spatiotemporal distribution of dust originating from the tailings pond of the Erdenet mine using a combination of ground-based in-situ measurements and Himawari-8 geostationary satellite remote sensing. Temporal evolution of the dust plume visualized by the RGB imagery corresponded well with the in-situ particle concentration measured on the ground. Under relatively cloud-free conditions, the dust RGB imagery from Himawari-8 clearly showed the spatial extent of the white dust plume originating from the tailings pond, in the range of 2,040-2,748 km2. Therefore, the dust RGB imagery by Himawari-8 is demonstrated to be sensitive enough to resolve the highly localized anthropogenic dust, even from a point source as small as the tailings pond, and is effective in studying susceptible areas subject to associated heavy metal deposition and contamination.

2) **Changes in Dust Emissions in the Gobi Desert due to Global Warming**

Using MRI-ESM2.0

Takashi Maki, Taichu Y. Tanaka, Tsuyoshi Koshiro, Atsushi Shimizu, Tsuyoshi T. Sekiyama, Mizuo Kajino, Yasunori Kurosaki, Toshiya Okuro, Naga Oshima

SOLA. 2022, 18, p218-224

ttps://doi.org/10.2151/sola.2022-035

Ensemble future climate projections were performed using the Meteorological Research Institute Earth System Model version 2.0 (MRI-ESM2.0) for sand and dust storms (SDS), which have a significant social and climatic impact on East Asia. A replication experiment using MRI-ESM2.0 reproduced the decreasing trend of SDS emissions in the Gobi Desert in the early 21st century. Prediction experiments using MRI-ESM2.0 in Coupled Model Intercomparison Project phase 6 future scenarios indicated no considerable differences in the total amount of SDS emissions in the Gobi Desert for 2015-2100; however, SDS emissions increased with warmer scenarios in spring and autumn. In particular, March in the highest warming scenario (SSP5-8.5) exhibited an annual increase rate of 3.0% in SDS emissions for the years 2015-2100. Friction velocity was highly correlated with SDS emissions, with a correlation of ~ 0.6 for all climate scenarios throughout the year. In spring and autumn, snow cover exhibited a low negative correlation with SDS emissions, while ground temperature exhibited a positive correlation. The increase in SDS emissions and subsequent dust transport by midlatitude westerlies in spring and autumn during accelerated warming scenarios could be attributed to the changes in friction velocity and erodibility due to the decrease in snow accumulation.

[2023]

1) Development and Assessment of ADAM3 Ensemble Prediction System

Migyeong Kim, Jeong Hoon Cho, Sang-Boom Ryoo

SOLA. 2023, 19, p.26-32

https://doi.org/10.2151/sola.2023-004

Forecasts of discrete events, such as precipitation, dust storms, and typhoons, can be deterministic, categorical, or probabilistic. Ensemble-based probabilistic predictions generate more consistent forecasts than individual deterministic models. We introduce and evaluate the Ensemble Prediction System of Asian Dust Aerosol Model 3, which generates probability forecasts of Asian dust.

Probability forecasts were produced for 300 μgm−3 PM10 mass concentrations, according to the air-quality standards of the Ministry of Environment of South Korea and Korea Meteorological Administration. Crisis-level information was produced to categorize the dust risk level for Asia, using a risk matrix. The model's performance was evaluated using a 2 × 2 contingency table, the Brier skill score, and a reliability diagram. For skill score evaluation via the contingency table, the average hit rate and threat score were 0.46 and 0.34 for the best three sites, Jurihe, Erenhot, and Wulatezhongqi. The Brier skill score was positive for approximately 60% of stations, with the highest (0.410) and lowest (−2.038) values in Erenhot and Yanan, respectively. The reliability diagram revealed overestimated Asian dust frequencies for all stations. Although the stations were located within the same regions, their skill scores differed. Regional characteristics of skill scores should be further investigated in the future.

2) **Sources of aeolian magnetite at a remote site in Japan: Dominantly Asian desert dust or anthropogenic emissions?**

Nozomu Tsuchiya, Shota Kato, Kazuo Kawasaki, Takanori Nakano, Naoki Kaneyasu, Atsushi Matsuki

Atmospheric Environment 2023, 314

https://doi.org/10.1016/j.atmosenv.2023.120093

Asian dust (AD) profoundly impacts human health and the environment, and the soluble Fe in AD is essential for nutrient supply to the ocean and atmospheric chemistry. To accurately assess the impacts of AD, it must be separated from other natural and anthropogenic sources in the total aerosol loading. In this study, coarse aerosol samples (Dp > 2.5 μm) collected in Noto, a remote coastal area in Japan, were analyzed through an environmental magnetic analysis. A comparison of the metal content and Pb isotopic ratios revealed that the magnetization of aerosols, which reflects magnetite content, highly correlated with AD inflow. That is, aerosol magnetite is preferentially concentrated in atmospheric particles during AD events; therefore, AD-affected samples can easily be identified and distinguished from those primarily affected by transboundary air pollution by using magnetic measurements. Based on the magnetization intensity of an AD reference material (CJ-2), the AD loading for ambient samples was estimated to be 5.2–32 $\mu g/m^3$, similar to that calculated

based on the Al mass concentration. Moreover, magnetism is strongly linked with Fe solubility in the ambient samples. This is notable because such information has been obtained previously only through labor-intensive chemical speciation involving sequential extraction. Therefore, magnetism can be used as a new measure of both AD loading and Fe solubility via non-destructive measurements.

3) Improvement in Dust Storm Simulation by Considering Stone Coverage Effects for Stony Deserts in East Asia

T. T. Sekiyama, Y. Kurosaki, M. Kajino, M. Ishizuka, B. Buyantogtokh, J. Wu, T. Maki

Journal of Geophysical Research: Atmospheres, 2023, 128 (2)

https://doi.org/10.1029/2022JD037295

Approximately 50% of the Earth's deserts are covered with stony surfaces, not dunes. The stony surfaces often block or diminish mineral dust aerosol emissions through area fraction and roughness element effects. Incorporating these stone coverage effects is crucial for climate and environmental modeling research. Based on our field observations, this study combined the stone coverage effects into a dust simulation model for East Asia using two regression formulas and some constants. The double regression scheme assumed that the stone roughness density could be derived from the coarse fragment fraction of the SoilGrids 2.0 data set. According to the data set, the stone coverage is higher in Western Mongolia and Dzungaria and lower in the Chinese Gobi Desert and the Loess Plateau. Consequently, the model reproduced fewer dust aerosols in the higher coverage areas and more in the lower coverage areas. This simulation result was consistent with the World Meteorological Organization's current weather reports and satellite aerosol observations. The improved model reproduced the diversity of soil erodibility and was well balanced in performance statistics. This study is the first successful investigation of stone coverage effects on dust storm simulation using a realistic stone coverage map to the authors' best knowledge.

Chapter 3 (Summary)

3.1 The achievements and problems to be solved of the research activities (2020-2025)

From 2020 to 2025, Working Group I (WG I) under the Tripartite Environment Ministers Meeting (TEMM) made significant strides in advancing Dust and Sand Storm (DSS) research and cooperation across East Asia. The group focused on enhancing data sharing, improving forecasting systems, strengthening collaboration, and expanding scientific outreach. Key achievements include:

(Data Sharing and Infrastructure Development)

- Extensive observational data including PM10, PM2.5, chemical composition, and satellite images were shared among China, Japan, Korea, and Mongolia.
- The TEMM DSS Online Portal was launched to centralize information on DSS WG and research outputs.

(Scientific Publications)

- A total of nine peer-reviewed papers were published in international journals such as Atmosphere, SOLA, Remote Sensing, Atmospheric Environment and Journal of Geophysical Research: Atmospheres, covering topics like dust composition, climate impacts, and model development.

(Forecasting and Early Warning System Enhancements)

- Models such as ADAM3 and NHM-Chem-DUST were improved by incorporating soil moisture and stone coverage effects.
- Satellite data (e.g., Himawari-8 and 9, GK-2A) were integrated into DSS detection and forecasting systems.

(Research on Seasonal and Long-Term DSS Variability)

- Studies on sub-seasonal to seasonal (S2S) forecasting and long-term DSS trends were initiated, including model intercomparisons and climate scenario analyses.

(Collaboration with WG II and International Collaboration)

- Extended Workshops with WG II were held in 2021 and 2023, promoting integrated research on DSS mitigation and ecological restoration.
- Collaboration with external organizations like WMO SDS-WAS and academic institutions expanded the research network and outreach.

Despite these accomplishments, several challenges remain that need to be addressed in the next phase of the Mid-Term Action Plan (2026–2030):

(Data Storage and Accessibility)

- The current Webhard platform lacks sufficient capacity and accessibility, prompting discussions about transitioning to cloud-based systems.

(Limited Real-Time Data Sharing)

- Real-time exchange of satellite and ground-based data is still restricted, hindering the full implementation of early warning systems.

(Technical Barriers in S2S Forecasting)

- Developing reliable models that incorporate climate change impacts and land surface dynamics remains a complex challenge.

(Need for Structured Collaboration between WG I and WG II)

- While there has been progress on collaboration with WG II, more structured and periodic joint research initiatives are needed, including shared site and dust emission information and integrated reporting.

(Strengthening collaborative efforts with Mongolia)

- Strengthening collaboration with Mongolia on reducing dust and sandstorms in East Asia through the 'Trilateral+X Cooperation' framework, as agreed in the 9th Joint Declaration of the Ninth Trilateral Summit among the Republic of Korea, Japan, and China (May 2024).

In summary, the 2020-2025 period marked a phase of meaningful progress for DSS WG I, laying the groundwork for more integrated and effective DSS monitoring and mitigation strategies. At the same time, it revealed key areas for improvement that will guide the development of the Mid-Term Action Plan (2026–2030) and future collaborative efforts.

Annex

1. Meeting agenda and summary from the 13th to 18th WG I meetings
2. Meeting agenda and summary of the Extended Workshop between WG I and WG II for Joint Research on Dust and Sand Storms

Annex 1.
Meeting agenda and summary from the 13th to 18th WG I meetings

Summary of the Thirteenth Meeting of Working Group I for Joint Research on Dust and Sand Storms

Online Meeting, Beijing, China 13th October 2020

1. The thirteenth meeting of the Working Group I (WG I) for Joint Research on Dust and Sand Storms (DSS) under the Tripartite Environment Ministers Meeting (TEMM) was hosted by China through an online Webex meeting on 13th October 2020. The representatives from China, Japan, Korea, and Mongolia participated in this meeting (Annex1: List of participants).

2. In Session One, Dr. Jianjun LI, Deputy Chief Engineer of China National Environmental Monitoring Centre of Ministry of Ecology and Environment of China (CNEMC/MEE), delivered the opening remarks and warmly welcomed the participants. Mr. Haohao ZHENG from CNEMC/MEE introduced the agenda of the meeting, which was adopted by all participants, and then introduced the experts and officials from the participating countries.

3. In Session Two on "Taking stock of discussions and activities" chaired by Dr. SUGIMOTO Nobuo from National Institute for Environmental Studies (NIES), two participants made their presentations. Dr. Sang Boom RYOO, the National Institute of Meteorological Sciences of the Korea Meteorological Administration (NIMS/KMA) gave a presentation entitled "Review on the 12th Meeting of Working Group (I)". In his presentation, he summarized the 12th Meeting of the WG I (26-27 September 2019 in Busan, Korea).

4. Dr. Jeong Eun KIM from NIMS/KMA made a presentation on the current status of DSS data sharing. According to her report, air quality data at Ulaanbaataar were newly added from Mongolia. She requested that all participating countries upload data plots to the Webhard as well as data files for their quality check. She also proposed to make a policy for big size files (e.g. satellite data) to secure the enough Webhard storage. She suggested data in the Webhard should be deleted at end of year to store new data of next year, which needs to be further discussed within the four countries. Finally she expressed her thanks to all participating countries for sharing their data.

5. In Session Three on "Progress of the study on DSS monitoring and modeling from each country" chaired by Dr. Chu-Young CHUNG from NIMS/KMA, five participants made their presentations. Mr. MAKI Takashi from Meteorological Research Institute of Japan Meteorological Agency (MRI/JMA) gave a presentation entitled "Recent DSS related activities at the Japan Meteorological Agency and Meteorological Research Institute". He reported MASINGAR-mk2 development and climate model research activities. The preliminary results showed that DSS occurrence in the 2050s tended to decrease with respect to January through March compared to the recent 30-year average. However, there were also significant differences between ensemble members. He concluded the presentation by emphasizing the importance to enrich data including dust concentrations, meteorological data and land surface related data to improve the dust aerosol model.

6. Dr. Chu-Yong Chung from NIMS/KMA gave a presentation entitled "Introduction on dust sand monitoring capability of GeoKOMPSAT-2 satellite systems (KOREA)". GeoKOMPSAT is the South Korean second geostationary multi-purpose satellite program consisting of two satellite systems, GeoKOMPSAT-2A (GK-2A) and GeoKOMPSAT-2B (GK-2B). In his presentation, the information on the status of GK-2A/2B mission and their geophysical products were provided. In particular, GK-2A dust sand and aerosol

monitoring products and the validation results on 2020 Asian dust cases were discussed.

7. Ms. Wenxuan CHAI from CNEMC/MEE gave a presentation entitled "Application of lidar network in sand transportation". She introduced the application of Lidar network in sand transportation processes, including the establishment of lidar network in Beijing-Tianjin-Hebei and its surrounding areas and intensive monitoring of mobile vehicle-based lidars.

8. Mr. DAVAANYAM Enkhbaatar from Information and Research Institute of Meteorology, Hydrology and Environment (IRIMHE), Mongolia made a presentation entitled "Dust monitoring and dust modelling in Mongolia." He introduced that Mongolia developed the monitoring systems and modelling with supports from China, Korea and Japan. Then, he presented the Asian dust forecast model in Mongolia which output surface PM10 (μm/m3), accumulated TSP (mg/m2) and aerosol optical depth. He explained that the model needed to be updated, and concluded the presentation by stressing the importance of further cooperation.

9. Dr. Liang LI from CNEMC/MEE made a presentation entitled "Introduction to the occurrence of DSS in China in 2018". According to his report, there were 18 large-scale dust weather processes across the country in 2018 and the number of days that DSS occurred in China is 50 days. The accumulative number of days that air quality exceeded the standard is 549 days in 2018, an increase of 30.2% over the same period of year 2017. The climate factor is conducive to dust and sand storms in 2018 in China.

10. In Session Four on "Progress of the study on DSS events" chaired by Dr. Chu-Young CHUNG from NIMS/KMA, three participants made their presentations. Dr. SHIMIZU Atsushi from NIES gave a presentation entitled "Detection of Asian dust using the air quality monitoring network in Japan. He proposed a sustainable dust monitoring

11. d using data from air quality monitoring network in Japan (AEROS) to detect a long-term variation of Asian dust in Japan. Utilizing a combination of SPM and PM2.5 from AEROS enables detection of Asian dust events in winter, spring and autumn. Some results of application on the data during April 2018 were presented.

12. Dr. Yun-Kyu LIM from NIMS/KMA gave a presentation entitled "Analysis of Model (ADAM3) and Observation Data in DSS 2018 Case." In his presentation, DSS 2018-1 case event was analyzed with observation data and numerical model results (ADAM3). In particular, in the western coast of the Korean peninsula (Anmyeondo), the effects of anthropogenic pollutants were more pronounced along with Asian dust, while the east coast (Ulsan) had a remarkable characteristic of Asian dust.

13. Dr. Siyuan LIANG from CNEMC/MEE made a presentation entitled "Characteristics of the Chemical Compositions in Particulate Matters during Three Sand-Dust Events in Beijing in 2020". She introduced the characteristics and variations of PM2.5/PM10, ion, OC, EC and heavy metals in PM2.5 during some DSS events in Beijing.

14. In Session Five on "Discussion on the detailed milestones for mid-term action plan (MTAP 2020-2024)" chaired by Mr. OHMURA Takashi from the Overseas Environmental Cooperation Center, Japan (OECC), four participants made their presentations. On behalf of Japan, Ms. WATARAI Hiroka from OECC presented the cooperation proposal for constructing an online portal which is stated in the Activity 2 of the MTAP 2020-2024. According to her presentation, Japan proposed to lead constructing the online portal and to have it pre-launched in 2021 with minimum information and among the WG I experts. After her

presentation, the participating countries proposed that Japan could start the preparation for the online portal, but the detailed designs of the online portal including data sharing need to be further discussed.

15. In Session Five on "Discussion on the milestones for research on sub-seasonal to seasonal (S2S) forecasts and long-term variations of DSS", Dr. Yun-Kyu LIM from NIMS/KMA gave a presentation entitled "Seasonal Asian Dust Forecasting Using GloSea5-ADAM". He introduced dust prediction for S2S in KMA and suggested that each country's dust forecast result for S2S be shared in order to improve the accuracy of spring prediction. In addition to Dr. Lim's presentation, Dr. Sang-Boom Ryoo of NIMS pointed out the item 1) in the Activity 6 of the MTAP 2020-2024 is a mixture of climate variation and climate change and there are some misunderstandings among the three countries. Thus, Dr. Ryoo proposed to establish three research fields under the Activity 6, 1) "inter comparisons of forecast and hindcast modeling results reported by participating countries in order to assess the DSS variation by 2050 and perturbations" in order to conduct the Activity 6 successfully. The proposed research fields were (1) sub-seasonal to seasonal scales of DSS forecast, (2) long-term variations of DSS occurrence and intensity, and (3) scenario or future climatic projection on DSS activities. These need to be further discussed by the meeting participants.

16. Ms. WATARAI Hiroka from OECC gave a presentation to discuss the proposal of Japan for the research on DSS and Sub-seasonal to Seasonal forecast and long-term variations of DSS. Ms. WATARAI, on behalf of Japan, proposed two ideas regarding the Activity 6 of the MTAP 2020-2024. One is to establish a new session entitled "DSS and S2S forecast and long-term variations of DSS" from 2021 onward. Another is to hold a special session on "DSS and S2S forecast and long-term variations of DSS" in the 14th WG I meeting in Japan in 2021. The special session would accommodate researchers from other research institutions. Also, Japan proposed to seek the possibility of holding a joint workshop with the WG II in the 14th WG I meeting and seeks the collaboration with them. The two ideas proposed by Japan need to be further discussed within the four countries.

17. Dr. SHIMIZU Atsushi from NIES gave a presentation to discuss the proposal for collaboration with the WGII. He introduced his and his colleagues' study funded by ERTDF5-2001 which consists of three sub-themes including monitoring, modeling and surface experiment. He stressed that interactions among these sub-themes were good practices of collaboration between the DSS WGI and WGII in Japan, and the outcome from this study is expected to be utilized by policy-makers, TEMM DSS WGs, and related international collaborative activities.

18. The period of DSS observation data for joint research was discussed in this section. Two DSS events were detected in 2019. The four countries agreed on sharing he observation data during the period from 20 April 2019 to 10 May 2019 [DSS2019-01], from 13 November to 24 November 2019 [DSS2019-02].

19. In Session Six on "Closing" chaired by Dr. Liang LI from CNEMC/MEE, a brief summary was made by the four countries. Dr. LI made an acknowledgement for the efforts and contributions of all the participant countries and a special thanks to Japan side for their help for using the online meeting software Webex.

20. Before closing, it was suggested that the 14th meeting of the WG I will be held in Autumn 2021 in near Tokyo, Japan. As the host country of the next WG I meeting, Japan will propose the detailed date, venue, and timeline for preparing agenda and meeting materials more than three months ahead of the meeting.

Summary of the Fourteenth Meeting of the Working Group I for Joint Research on Dust and Sand Storms

Online Meeting, Tokyo, Japan, 28-29 September 2021

1. The 14th meeting of the Working Group I (WG I) for Joint Research on Dust and Sand Storms (DSS) under the Tripartite Environment Ministers Meeting (TEMM) was hosted by Japan virtually on 28 and 29 September 2021. The representatives of the WG members from Japan, Korea and China as well as invited representatives from Mongolia participated in this meeting (Annex1: Agenda of the Meeting and List of participants).

2. In Session One, Mr. YAMASAKI Toshiyuki, Director of Office of International Cooperation in Air and Water Quality Management, Environmental Management Bureau of Ministry of the Environment of Japan (MOEJ), delivered the opening remarks and warmly welcomed the participants. Ms. SUMIKOSHI Masae from the Overseas Environmental Cooperation Center, Japan (OECC) introduced the agenda of the Meeting which was adopted by all participants.

3. In Session Two on "Taking stock of discussions and activities" chaired by Dr. Sang Boom RYOO from National Institute of Meteorological Sciences of the Korea Meteorological Administration (NIMS/KMA), the three participants made their presentations. Dr. Liang LI from China National Environmental Monitoring Centre of Ministry of Ecology and Environment of China (CNEMC/MEE) gave a presentation entitled "Review on the 13th Meeting of Working Group (I)". In his presentation, he summarized the 13th Meeting of the WG I (13 October 2020) hosted by China.

4. Dr. Jeong Eun KIM from NIMS/KMA made a presentation on the current status of DSS data sharing. According to her report, observation data for the selected research cases have been shared among the participating countries through the Webhard. The shared data are meteorological parameters such as relative humidity and visibility, PM mass concentration, aerosol size distribution, spectral AODs, aerosol vertical profile, and satellite aerosol products. For DSS2019 cases, China shared hourly average of PM_{10} mass concentration from 10 sites, which are located on the pathway of dust storm, including Northeast or East part of China. A sharp increase of PM_{10} mass concentration was observed when DSS was detected in those sites. Korea uploaded hourly average of PM_{10} from 20 sites, RH and visibility from 6 sites, spectral AOD from 1 site, aerosol number and volume size distribution from 3 sites, and aerosol Lidar data. PM_{10} mass concentration increased up to 6 times when DSS arrived in Korea. Coarse particles were dominant when DSS was observed. Japan shared hourly average of PM_{10} mass concentration from 11 sites, SPM from 21 sites, $PM_{2.5}$ from 11 sites, Lidar from 17 sites (Mongolia and Japan), visibility and RH from 59 sites, hourly AOT from 4 sites, POPC from 1 site, and aerosol products from HIMAWARI-8 satellite. POPC showed that particles with a diameter larger than 1 micrometer increased during dust event on 2-3 May 2019. After his presentation, the four countries recalled the discussion made last year by Korea regarding the shortage of the space of the Webhard. The suggestion to delete large data on the Webhard at the end of year to save up the repository was agreed by the four countries. China suggested that taking into account the preciousness of the data, the WG I should burn a DVD-ROM or mobile hard drive for backup to each member state before deleting it.

5. Ms. WATARAI Hiroka from OECC shared the updates of developing the TEMM DSS Online Portal (www.temm-dss.com) according to the requirements of the Mid-term Action Plan 2020- 2024 (MTAP2020-2024). After expressing the gratitude to all WG I members for their cooperation, she shared that the draft contents which had been circulated among the four countries and asked the participants for their confirmation on opening the Portal to public during the outreach session on 30 September 2021 as well as their continued cooperation for updating the Portal. The four countries welcomed the progress of the work, confirmed that the contents are appropriate and agreed to publish Top page, What is TEMM DSS page, Research Articles page and Links page in the Portal with the contents as well as DSS Data Set page as "Coming soon" without contents because its content and layout style need further discussion, on 30 September 2021.

6. In Session Three on "The study on DSS monitoring modelling" chaired by Dr. Liang LI from CNEMC, the four participants made their presentations. Ms. Yilin ZHAO from CNEMC gave a presentation entitled "Evaluation of Sand and Dust Forecast Products based on NAQPMS Mode". She explained followings: Using the multi-mode prediction products of the new platform, the results of the numerical forecast model are evaluated according to a sand and dust process in November 2019, the model output products in different periods and the next three days in the same day are analyzed, and the automatic correction of the model is interpreted.

7. Mr. Jeong Hoon CHO from NIMS/KMA gave a presentation entitled "Recent improvements of Asian Dust Aerosol Model version 3 (ADAM3) in KMA". In his presentation, KMA operates ADAM3 to support prediction of Asian dust and haze over East Asia. Recently two major improvements have been achieved. Firstly, data assimilation system was upgraded. The data assimilation method was changed from the optimal interpolation to the three-dimensional data assimilation where background error covariance is updated by ensemble method every 6 hour. And also, observed $PM_{2.5}$ concentration data from air quality monitoring network in China and South Korea were additionally utilized in the data assimilation system. Upgrade of data assimilation system improved performance of ADAM3 during the initial 12 hours, especially over the Asian dust emission region (Gobi). The second one is applying soil moisture effect on the dust emission model of ADAM3. Followed Fécan et al. (1999), threshold wind speed increases with soil moisture. With this method, dust generation time was reduced and the emitted PM_{10} ratio was also decreased. With case experiment, it was clearly shown the new dust emission model could improve the performance of ADAM3 in South Korea as well as in Asian dust emission region.

8. Dr. YUMIMOTO Keiya from Kyushu University, Japan gave a presentation entitled "DSS monitoring and modeling with Himawari-8". He explained followings: (i) Himawari-8 (H08) can provide full-disk (from East Asia to Oceania) with high frequency; (ii) Dust RGB by H08 can detect DSS outbreaks and transport paths and provide early warnings. The location and timing of DSS outbreaks detected by H08 will lead to the understanding of the mechanism of DSS outbreak and the improvement of the dust emission process in numerical model. JMA started the dust prediction which assimilates H08 observations. The high-frequency observation provides a more DA opportunity and a better AOD coverage compared with LEO satellite. Unification of satellite retrieval process, data assimilation and model forecasting will lead to synergistic improvement.

9. Mr. DAVAANYAM Enkhbaatar from Information and Research Institute of Meteorology, Hydrology and Environment (IRIMHE), Mongolia made a presentation entitled "Dust monitoring and dust modelling in Mongolia." In 2017, ADAM-Haze model was installed at NAMEM in Mongolia. The particle size in ADAM model is divided into three different classes for the research convenience: Size 1 (the particle

diameter, D 2.23 μm), Size 2 (2.23 μm D 10 μm) and Size 3 (10 μm D 74 μm). In this research, the simulation of ADAM model 72 hours forecast on 14th march 2021 was made. According to the simulation results during the dust storm, it was found that the ratio of particles size was 6.6% of size 1, 57.8% of size 2, and 35.5% of size 3. The maximum concentration of larger particle Size 3 was of about 800 μg/m³ in 1 kilometer. Medium particle Size 2 was maximum concentration about 1000 μg/m³ in 2.4 kilometer. These results were one of the examples of Asian dusts (yellow sand) of the Gobi Desert, its size and the vertical distribution of the cases. Mr. Davaanyam also mentioned that DSS monitoring network in Mongolia was in necessity to repair equipment (most of the stations are not working) and needs to expand monitoring sites for further research.

10. In Session Four on "Report from the countries on DSS Events" chaired by Dr. Chu-Yong CHUNG from NIMS/KMA, the four presentations were delivered. First, Dr. Chu-Yong CHUNG from NIMS/KMA gave a presentation entitled "Observation and Analysis of DSS2019-2 (November 2019) Case". This study presents the observation and analysis results on DSS2019-2 (November 2019) case in NIMS/KMA. In this case, strong Asian dust outbreak was observed over inner Mongolia on 17 November 2019 in the morning and this moved and diffused along the low- pressure system and affected all over the Korean Peninsula on 18 November 2019. Based on ground PM_{10} observation, dust began to be observed at Baengnyengdo site at 5:50 KST and finished to be observed at 21:30 KST at Seogwipo site in Jeju Island on 18 November 2019 in South Korea. Total dust influence duration time in South Korea was 15 hours and 50 minutes. The highest PM_{10} concentration was 318 $\mu g/m^3$ at Ganghwa site in Incheon area around 15:00 KST on 18 November 2019. In this case, dust distributed vertically from surface to 1.5 km altitude height with uniform range corrected backscattering signal values around 0.15 A.U. when it passed over Seoul, based on the Lidar observation. Chemical component analysis showed that the contribution of soil components (Calcium ion) of PM_{10} and $PM_{2.5}$ were 7.6% and 6.6%, respectively, which were higher than those in non-dust cases (normally 3-5%). These results also denote the Asian dust influence in South Korea in this case period.

11. Ms. Xian ZHANG from CNEMC/MEE made a presentation entitled "Case Study of Higher Sulfate than Nitrate in $PM_{2.5}$ During Dust and Sand Storm Events in Beijing". She introduced the variations of SO_2, NO_2, $PM_{2.5}/PM_{10}$, water-soluble ions, heavy metals in $PM_{2.5}$ during a dust and sand storm event in Beijing. This research found that although water-soluble ions in $PM_{2.5}$ in China were driven by NO_3^- rather than SO_4^{2-} under the control measures of SO_2 emission reduction, the SO_4^{2-} concentration was still higher than that of NO_3^- in $PM_{2.5}$ during DSS in Beijing.
12. Dr. NISHIKAWA Masataka from National Institute for Environmental Studies (NIES), Japan made a presentation entitled "Chemical characteristics of aerosol samples during the Asian dust phenomenon (1-2 May 2019) in Japan". He showed the annual number of DSS events (Asian dust event) observed in 2019. During DSS2019-1 period, the Asian dust observed only on 2 May 2019 in limited Kyushu area including Fukue Island located in the East China Sea, while any Asian dust events during DSS2019-2 period were not observed in Japan. Automated time series monitoring for PM_{10}, $PM_{2.5}$ and chemical components of aerosols in the coarse range and fine range were performed at Fukue station. The time series changes elemental component concentration of the group of Al, Fe, Ca, K, Ti and Mn are similar, whereas that of the other group of Zn, Pb, S, SO_4 and NO_3 showed different behavior. From analyses for X/Al concentration ratios, the former group can be concluded as the crustal elements originated from Gobi

Desert, and be considered that the latter group existed as contamination substances mixed with naked Asian dust particles in the air-parcel.

13. The period of DSS observation data to be studied by the joint research was discussed in this section led by Dr. Chu-Yong CHUNG from NIMS/KMA. In his presentation, Korea suggested two mixed dust cases among 7 dust cases occurred in South Korea for DSS2020 case study. The first one is 18-24 February case, which occurred in winter season and was the dust case mixed with haze phenomenon. On 20 February, a strong low-pressure system occurred in the east of Mongolia, and moved to the northeastern part of China on 22 February and to Hokkaido of Japan on 23 February. At this time, Asian dust occurred at the rear of this low-pressure system and moved together. Another interesting thing is that haze occurred widely in East Asian region due to the influence of wide high-pressure system, before the low-pressure system arrived. The second one is the autumn case from 20 October to 4 November. During this period, the strong low- pressure system occurred in the east Mongolia on 20 and 30 October, and passed through a similar route to the first case. Around 20 and 31 October, very high PM_{10} concentration greater than 2,000 $\mu g/m^3$ was observed in CMA. After that, on 22 October and 1 and 2 November, dust PM_{10} were captured in South Korea. Haze phenomenon has already lasted for about 2-3 days in this case. Thus, these two cases are considered to be good cases where unusually occurred in winter or in autumn, and dust and haze can be studied at the same time. After the presentation, the participants shared the view that the DSS's transport was slow in some cases in 2020 and agreed on four periods for data sharing of this WG I: 18-24 February 2020 [DSS2020-01], 20-25 October 2020 [DSS2020-02], 29 October to 3 November 2020 [DSS200-03] and 5-9 November 2020 [DSS2020-04].

14. In Session Five on "Discussions about concrete actions and milestones for the Mid-Term Action Plan (MTAP), as continued from the 13th DSS WG I Meeting: Activities 1 to 3" chaired by Dr. Liang LI from CNEMC/MEE, the four presentations were made. Dr. Chu-Yong CHUNG from NIMS/KMA introduced "GeoKOMPSAT-2A data status for the DSS research". In his presentation, updated information on the current status of GeoKOMPSAT-2A/B were provided. GeoKOMPSAT-2A images and products were operationally serviced on NMSC webpage. NMSC tried to refine the aerosol detection algorithm to compensate for some weakness, such as spatial and temporal discontinuity on the aerosol detection results. The observation data of GEMS and GOCI-II on GeoKOMPSAT-2B is available recently on each satellite center website. However, these are under commissioning phase and DSS WG1 needs more time to utilize these data .

15. Dr. SUGIMOTO Nobuo from NIES made a presentation entitled "Evolving DSS Observation and Data Continuity". In his presentation, he described the evolution of the lidars in the Asian dust and aerosol lidar observation network (AD-Net) and consistency of data from different types of lidar. To better characterize aerosols, advanced lidars that can measure multiple parameters and the analysis method that can separate aerosol types have been developed. This method is also useful to ensure consistency of data from different types of lidar by establishing reasonable aerosol optical models. He also presented about the possible use of commercial ceilometers. Based on the presentations by Dr. CHUNG and Dr. SUGIMOTO, the participants agreed to enrich data sharing. The participants welcomed Mongolia to share its available data.

16. Ms. WATARAI Hiroka from OECC asked the participants to confirm the list of data set to be uploaded to the DSS Data Set, and proposed a data policy to be applied to the Portal, using the discussion material. She explained that the list for confirmation had been prepared based on the responses form the four countries to the questionnaire survey conducted in February 2021, and this Session was expected to

officially agreed on the data set to upload. In the questionnaire, countries have selected the content and data types that can be uploaded in their own countries according to their own circumstances. However, a concern was expressed from China regarding the number of the countries which contribute to the DSS Data Set page, and they requested to have an internal discussion with their respective management departments if they could add data to the Data Set page to solve the concern. The participants understood such concern and request, and agreed to wait their internal discussion results about additional inputs to the data list, and continue the discussion via e-mail communication for confirmation. Suggestions were made to enrich the contents of the Portal like more storytelling type by adding some factual explanations, pictures and graphics to the current contents, after its launch. Japan welcomed the suggestions and asked the participants' cooperation to materialize them.

17. Regarding the data policy, the participants agreed that the following statements shall be described in the Portal.
    - For "DSS Data Set" page: "This page provides various set of DSS related data shared by the contributors to the Portal. Those who use this data set need to be compliant with the data policy given by the relevant data contributors. If such data policy is not available, the users need to be compliant with the general data policy of the relevant government to which the contributor belongs."
    - For documents in "Research Articles" page (articles and summaries produced by the WG I): "The articles produced by the WG I and the meeting summaries are public domain, unless explicitly indicated otherwise. Those who use/cite these documents need to indicate explicitly their source - "the Working Group I for Joint Research on Dust and Sand Storms of the TEMM DSS Meeting (www.temm-dss.com)."

    Related to the Portal, an idea was suggested that the Portal Data Set could provide a space for sharing the research data dedicated only for WG members, which are currently stored at the Webhard. The participants agreed to continue exchanging views on this idea through e-mail communication.

18. Ms. WATARAI Hiroka from OECC proposed to develop the detailed milestones as a the Thirteenth WG I Meeting discussion, in order to implementing the MTAP for the WG I, under common understanding/timelines. She presented a table filled with the possible milestones until 2024 (Annex2), and proposed that this table could be amended every year according to each country's situation and progress. She encouraged the participants to add any potential activities to the proposed milestones. The four countries discussed the milestones and welcomed the proposal in general. The four countries share the views that each activity and their milestones shall be further considered.

19. In Session Six on "Summary" chaired by Ms. HAYASHI Yayoi from OECC, the four countries made initial discussions at the Session. This Summary was finalized through post-meeting communications. Korea, the host country of the next 15th WG I Meeting, suggested that the Meeting would be held in Autumn 2022 in Jeju Island, Korea, if COVID-19 situation allows. Detailed date, venue, timeline for preparing agenda and meeting materials would be informed by Korea more than three months ahead of the Meeting. In Closing, each country representative gave their brief summary. Among others, Mr. YAMASAKI Toshiyuki, from MOEJ, as the host country of the 14th Meeting, made an acknowledgement for the efforts and contributions made by all participants, and sought their cooperation to the TEMM DSS WG I Extended Workshop to be held online on 30 September 2021. Appreciations was expressed to Dr. Sang Boom RYOO for his longtime and outstanding contributions to the WG I, noting that this Meeting became his last participation due to his retirement from NIMS/KMA.

Summary of the Fifteenth Meeting of the Working Group I for Joint Research on Dust and Sand Storms

Offline/Online Meeting, Jeju, Korea, 1-2 November 2022

1. The 15th meeting of the Working Group I (WG I) for Joint Research on Dust and Sand Storms (DSS) under the Tripartite Environment Ministers Meeting (TEMM) was hosted by Korea virtually and on-site on 1 and 2 November 2022. The representatives of the WG members from Korea, Japan, and China as well as invited representatives from Mongolia participated in this meeting (Annex1: Agenda of the Meeting and List of participants).

2. In Session One, chaired by Ms. Seungsook Shin from National Institute of Meteorological Sciences of the Korea Meteorological Administration (NIMS/KMA), Korea, Dr. Hyun-Seok Kang, Director of Forecast Research Department, from NIMS/KMA delivered the opening remarks and warmly welcomed the participants. Ms. Seungsook Shin introduced in-person participants as well as online participants from four countries including Korea, Japan, China, and Mongolia. Then, she went over the agenda of the two-day meeting which was adopted by all participants. There was a commemorative photo time.

3. In Session Two on "Taking stock of discussions and activities" chaired by Dr. Liang LI from China National Environmental Monitoring Centre of the Ministry of Ecology and Environment of China (CNEMC/MEE), two participants made presentations. Ms. Hiroka Watarai from the Overseas Environmental Cooperation Center, Japan (OECC) of Japan gave a presentation entitled "Review on the 14th Meeting of Working Group (I)". In her presentation, she summarized the 14th Meeting of the WG I (28-29 September 2021) and DSS WG I Extended Workshop (30 September 2021) hosted by Japan, and other related events including the launch of TEMM DSS Online Portal.

4. Dr. Jeong Eun KIM from NIMS/KMA made a presentation on the current status of DSS 2020 data sharing. According to her report, there were four cases, one in February and other three were between October and November. She explained data shared by each country. Then, she pointed out the Webhard storage issue of last year and mentioned that all satellite data is now deleted to secure enough space in the storage. After her presentation, Japan offered to share a set of DSS data for the period which covers whole DSS transport as a voluntarily basis from the viewpoint of research. Then, four countries recalled the discussion made last year by China regarding backup of data in online storage called the Webhard. Korea agreed to use a separate storage device for the data backup.

5. In Session Three on "The study on DSS monitoring modeling" chaired by Mr. Takashi Maki from Meteorological Research Institute (MRI), Japan, the four participants made their presentations. Mr. Maki gave the first presentation entitled "Recent DSS-related activities at the Meteorological

Research Institute". According to his presentation, although the total annual amount of SDS emissions around the Gobi Desert has not changed significantly, we still see an increase in early spring and autumn. He focused on friction velocity that is closely related to dust emissions noting that the friction velocity tends to increase significantly compared to the base period in the accelerated warming scenario. This increase would result in transporting dust to distant locations which could be a societal concern. He also introduced a dust simulation model that was conducted which incorporated the stone coverage effects with an actual soil/stone map. He stressed the significance of the UN coalition on combating SDS by going through the "five-point plan", 5 working groups as well as resources.

6. Dr. Liang LI from CNEMC/MEE made a presentation entitled "A introduction to DSS Monitoring in China in 2020". According to his report, there were 11 large-scale dust weather processes across the country in 2020 and the number of days that DSS occurred in China is 31 days. From 2018 to 2020, China experienced 41 large-scale sand and dust processes, an average of 13.7 times per year, and an average of 36.3 days of cumulative impact per year. In the spring of 2020, although climate factors such as temperature and precipitation are favorable for sand dust, the frequency of sand dust weather is still reduced due to relatively weak cold air.

7. Mr. Jeong Hoon CHO from NIMS/KMA gave a presentation on the topic of recent improvements in the Asian dust aerosol model version3 (ADAM3) in KMA. He started off his presentation by sharing a brief introduction to ADAM3. Then he went on to explain more about Asian dust emission and operational procedure which covers five Asian dust emission regions. He also touched upon the implementation of the 3DVAR system on KIM-ADAM3 and looked at the comparison experiment with OI and 3DVAR with an example on the Asian Dust case on March 29th, 2021. The future plans were also shared including the development of the GK2A AOD application for the 3DVAR system and advanced dust emission scheme with the soil moisture effect adding that his team is testing a new version and he believes that the updated algorithm will be available next year.

8. Dr. Buyantogtokh Batjargal from Department of Meteorlogical and Environmental Analysis, Mongolia made a presentation entitled "Estimating the sand saltation thresholds from Sentinel-1 SAR data in the Gobi Desert, Mongolia". In his presentation, He introduced his research with its background which is sand transport in wind erosion. He mentioned that sand saltation transport is the most important process of dust emission. There were two research objectives. One was to evaluate the effect of stone on the threshold friction velocity during natural sand and dust storm and the other one was to investigate the relationship between the threshold and the Sentinel-1 data. To conclude, he stressed that the stone, dry vegetation, and crust are important factors affecting the sand saltation threshold in the Gobi Desert. Also, The Sentinel-1 SAR intensity has the potential to estimate the spatial distribution of the threshold at dry natural heterogeneous surfaces.

9. In Session Four on "Report from the countries on DSS Events" chaired by Dr. Jeong Eun Kim from NIMS/KMA, the four presentations were delivered. First, Dr. Jeong Eun Kim from NIMS/KMA gave a presentation entitled "Observation and Analysis of DSS2020 Case". This study presents the observation and analysis results of the DSS2020 case in NIMS/KMA. She selected case number two, which is the severe one in 2020. She explained how dust impacted Korea by showing three surface weather charts. Also, she showed that GK-2A satellite dust RGB images and ADAM3 simulation well matches each other. And PM10 mass concentration was compared between China and Korea. In China, PM10 mass concentration maximized on 20th October, and it peaked on two days later in Korea. She went on to the LIDAR observation where the dust signal depolarization ratio shows uniform distribution of dust. When analyzing chemical composition, the most dominant chemicals were soil components such as Mg, Ca, Al and Fe. To conclude, for the DSS2020-02 case, a strong dust outbreak was observed over the Gobi Desert and inner Mongolia on 20 October 2020. DSS moved and dispersed along the low-pressure system and affected the Korean Peninsula on 22 October. DSS duration time in South Korea was 20h 20m. PM10 peak concentration was 195 ug/m^3.

10. Dr. Mingyuan LIU from CNEMC/MEE made a presentation entitled "Chemical composition characteristic of PM2.5 in North China Plain during dust and sandstorms events". Continuous online monitoring for chemical composition of PM2.5 is performed at CNEMC monitoring site in Beijing, He showed the variation trend of concentration of SO2, NO2, PM2.5/PM10, organic matter, ions, trace elements in PM2.5 from 20th October to 14th November, 2020, including three dust and sandstorms events (DSS2020-02/03/04) and three moderate haze events. The crustal elements in three DSS2020 cases share similar chemical composition, indicating the similar source. The haze events in Beijing are dominated by nitrate under the control measures of SO2 emission reduction.

11. Dr. Atsushi Shimizu from National Institute for Environmental Studies (NIES), Japan made a presentation entitled "Asian Dust Events Detected by AD-Net in 2020". The presentation covered the introduction of AD-Net, which is a lidar observation network for Asian dust and anthropogenic aerosols, 2020 Asian dust events reported by JMA, Annual variations of Asian dust over Japan, and time-height sections of Asian dust revealed by AD-Net. In summary, in Japan, there was no significant Asian dust event detected in 2020. Also, the dust extinction coefficient obtained in AD-net was not so high on Asian dust days reported by JMA. Regarding data sharing periods, Asian dust during four data sharing periods showed a variety of transport patterns. Finally, dust detection using an air pollution monitoring system was examined, and the lowest dust occurrence in the last 10 years was confirmed.

12. The selection of DSS 2021cases was discussed in this section led by Dr. Jeong Eun Kim from NIMS/KMA. In Korea, there were 10 dust events in 2021. Two in winter and others are observed in spring. In spring, there were two very strong events, one from the end of March to April 1st and the other one is in May. She proposed the following two cases, which were also observed in China and Japan: 1) 2020.03.25-04.25 2) 2021.05.05-05.10. After the presentation, Dr. Shimizu

expressed that his agreement, then suggested that the case in March is also to be considered as it seems to have a distinctive feature. The participants agreed on the three periods for data sharing of this WG I: 15-20 March 2021 [DSS2021-01], 25 March to 2 April 2021 [DSS2021-02], and 5-10 May 2021 [DSS2021-03].

13. In Session Five on "Updates on the actions of mid-term action plan (2020-2024): Act1- 3" chaired by Dr. Liang LI from CNEMC/MEE, three presentations were made. Dr. JaeYoung Byon from National Meteorological Satellite Center of Korea introduced "GeoKOMPSAT-2A data status for the DSS research". In the presentation, he shared GK-2A satellite products and observations, improvements in aerosol detection and AOD in 2022 as well as validation and plans ahead. According to him, GK-2A was launched in 2018 and introduced 75 types of satellite information. Most of the information is publicly available. His focus is aerosol particles and improvements made this year. GK- 2A aerosol products are produced in three regions including the full disk region, East Asia, and Korea. He also introduced an algorithm for GK-2A dust and sandstorm. Information including GK-2A Dust and sandstorm monitoring and dust sand monitoring were followed. Then he went on to touch on improvements made in 2022. NMSC modified background surface reflectance in order to improve overestimated AOD over China. There was also an improvement made on the validation side. Future plans would cover providing surface aerosol concentration and dust height as well as data fusion with satellite, surface observation, and numerical model.

14. The next presentation was delivered by Ms. Purevsuren Nyamsuren from the Ministry of Environment and Tourism, Mongolia on behalf of Mr. Altangerel Enkhbat from the Department of Environment and Natural Resources Management of the Ministry, Mongolia. The presentation was titled "Desertification, Land Degradation, and Impacts of Dust Storms in Mongolia". The first part of the presentation was the policy and legal framework on desertification that includes joining the UN convention to combat desertification, vision 2050, and the government action plan for 2020-2024. Then she briefly touched on the climate change-related situation in Mongolia including rising temperatures, changes in precipitation in winter and summer, and some other severe weather-related events. The current status of desertification and land degradation as well as measures to reduce desertification and land degradation were shared as well. Also, she mentioned that a total of 11 monitoring research stations are measuring dust concentration in Mongolia. Trends in the number of days with sand storms were also covered. Then in the last part, a national campaign called "Billion Trees" was introduced.

15. Ms. Hiroka Watarai from OECC gave a brief presentation "Updates of the TEMM DSS Online Portal". She presented information to be posted on the TEMM DSS Online Portal (www.temm-dss.com) this year, according to what was agreed upon last year. Four countries agreed to post the updated list of published research articles and the 14th DSS WG I meeting summary to the Portal. Then, Japan recalled the discussion on Data Set page which remains "Coming soon". Japan proposed to disclose "the Data Set" page and to publish "Data Catalogue" as an alternative idea, which is a list of parameters (available time periods, monitoring sites, data owners with contact address) of the data

set shared among four countries, instead of publishing actual data sets. Japan offered to develop and publish "Data Catalogue" with others cooperation and confirmation in mid-2023. The meeting agreed these proposals Japan raised for publishing "Data Catalogue" as an alternative option and agreed to have a further discussion on content of "Data Catalogue". After the further discussion concluded, the Data Catalogue Page will be shown in the TEMM DSS Online Portal in 2023.

16. In Session Six on "Discussion on the detailed milestones for the Mid-Term Action Plan: Activities 4 to 6" chaired by Ms. Hiroka Watarai from OECC, four presentations were delivered. Ms. Woojeong Lee from NIMS/KMA shared "Seasonal Asian Dust Forecasting using GloSea6". In her presentation, she explained what GloSea6 is with its dust emission process and showed the evaluation results for springtime seasonal Asian dust event hindcasting and forecasting. She started off by covering the history of seasonal Asian dust forecasting using GloSea and compared GloSea5 with GloSea6. Next, she touched on the dust emission process in GloSea6 and for verification, the results for spring time Asian dust seasonal forecasting indicates that Glosea6 is underestimated for the hindcast period and the anomaly is well consistent with observation. For next year, GloSea6 will be used for springtime seasonal Asian dust forecasting.

17. Dr. Atsushi Shimizu from National Institute for Environmental Studies (NIES), Japan gave a presentation on "Prediction and Detection of Variability in Asia Dust Emission and Transport". According to Dr. Shimizu, a research program ERTDF-2001 was organized by Japan team to promote studies along with MTAP2020-2024. In the study which is consist of 3 sub themes, dust monitoring, numerical model, surface experiments are coupled interactively to understand the mechanism of generation and transportation of Asian dust and to forecast chances of Asian dust that may come with global warming. He wrapped up the presentation by mentioning that ERTDF-2001 would be completed in next four months and there will be discussions among the experts for next steps.

18. Ms. Yilin Zhao's presentation was on "Evaluation of Sand and Dust Forecast Products based on NAQPMS Model." The presentation included four parts, the current situation of the mode operation, case selection, model prediction path and concentration comparison as well as aging and product evaluation. According to her, MULTI forecast model working platform has been revised and upgraded in 2019. And the new platform has powerful functions such as big data docking and more convenient business operation mode. After going through the case selection, she showed the hourly value curve of PM2.5 and PM10 concentration in cities covered by sand and dust. Then she went on to explain how evaluation is done and wrapped up the presentation by providing a short summary.

19. Dr. Sumikoshi Masae from OECC proposed that Japan will organize and host an WG II Extended Workshop by hybrid format back to back with the 16th WG II meeting in 2023 using the document of the Proposal (Annex2: WGII Extended Workshop (Proposal)). The main idea of the Workshop is to facilitate the collaborations between the DSS WGII and WGI with participation of both DSS WGII and WGI members including Mongolia, in line with the Mid Term Action Plan of WGII. Japan

expressed its willingness to invite one or two WGI members each from China, Korea and Mongolia to the Extended Workshop, with in the budget availability. Four countries welcomed the proposal. Japan explained that elaborated plan will be announced to each focal point of the WGII and WGI by Japan focal point through e-mail communications, taking into other countries comments/inputs account.

20. The last session was on "Summary". Ms. Seungsook Shin from NIMS/KMA chaired the session. The four countries made initial discussions for the three items at the Session The three items were as follows: 1) Identify DSS events in 2021 2) Updates of the TEMM DSS Online Portal 3) DSS WGII Extended Workshop. China, the host country of the next 16th WG I Meeting. Detailed date, venue, timeline for preparing agenda and meeting materials would be informed by China more than three months ahead of the Meeting. For closing remarks, the representatives acknowledged the efforts and contributions, collaborations made by participants and expressed sincere appreciation to the host country.

Agenda of the Meeting and List of participants

The 15th Meeting of Working Group (I) for Joint Research on Dust and Sand Storms

(Online & On-site Meeting)

- **Date: November 1st and 2nd (Tue. and Wed.), 2022**
- **Venue: Lotte City Jeju (5F Ruby)**
- **Host: National Institute of Meteorological Sciences/KMA**
- **Tool: Zoom meeting**
- **Language: English**

◈ DAY 1 (November 1)

09:50 (UTC+9) Connection Test	
Session I	**Opening** Chair: Ms. Seungsook Shin (KOREA)
10:00 - 10:05	**Opening Remarks** Dr. Hyun-Suk Kang, KOREA
10:05 - 10:15	**Introduction of participants**
10:15 - 10:20	**Adoption of the agenda**
10:20 - 10:30	**Group Photo**
Session II	**Taking stock of discussions and activities** Chair: Dr. Liang Li (CHINA)
10:30 - 10:40	**Review on the 14th Meeting of Working Group (I)** Ms. Hiroka Watarai, JAPAN
10:40 - 10:50	**Current status of DSS Data Sharing** Dr. Jeong Eun Kim, KOREA
10:50 - 11:10	**BREAK**
Session III	**The study on DSS monitoring and modeling from each country** Chair: Mr. Takashi Maki (JAPAN)
11:10 - 11:30	**Recent DSS related activities at the Meteorological Research Institute** Mr. Takashi Maki, JAPAN
11:30 - 11:50	**An introduction to DSS Monitoring in China in 2020** Dr. Liang Li, CHINA
11:50 - 12:10	**Recent improvements of Asian Dust Aerosol Model version3 (ADAM3) in KMA** Mr. Jeong Hoon Cho, KOREA
12:10 - 12:30	**Estimating the sand saltation thresholds from Sentinel-1 SAR data in the Gobi Desert, Mongolia** Dr. Buyantogtokh Batjargal, MONGOLIA

12:30 - 14:00	**LUNCH**
Session IV	**Report from the countries on DSS Events**
	Chair: Dr. Jeong Eun Kim (KOREA)
14:00 - 14:20	**Observation and Analysis of DSS2020 Case** Dr. Jeong Eun Kim, KOREA
14:20 - 14:40	**Chemical composition characteristic of PM2.5 in North China Plain during dust and sandstorms events** Dr. Mingyuan Liu, CHINA
14:40 - 15:00	**Asian Dust Events Detected by AD-Net in 2020** Dr. Atsushi Shimizu, JAPAN
15:00 - 15:20	**Selection of DSS2021 cases** Dr. Jeong Eun Kim, KOREA
15:20 - 15:40	**BREAK**
Session V	**Updates on the actions of mid-term action plan (2020-2024): Act 1 - 3** Chair: Dr. Liang Li (CHINA)
15:40 - 16:00	**GeoKOMPSAT-2A data status for the DSS research** Dr. JaeYoung Byon, KOREA
16:00 - 16:20	**Desertification, Land Degradation, and Impacts of Dust Storms in Mongolia** Mr.Altangerel Enkhbat, MONGOLIA
16:20 - 16:40	**Updates of the TEMM DSS Online Portal** Ms. Hiroka Watarai, JAPAN +**Discussion**
17:00 ~	**Bangquet**

◈ DAY 2 (November 2)

10:00 (UTC+9) Opening	
Session VI	**Discussion on the detailed milestones for mid-term action plan: Act. 4 - 6** Chair: Ms. Hiroka Watarai (JAPAN)
10:00 - 10:15	**Seasonal Asian Dust Forecasting using GloSea6** Ms. Woojeong Lee, KOREA
10:15 - 10:30	**Prediction and Detection of Variability in Asian Dust Emission and Transport** Dr. Atsushi Shimizu, JAPAN
10:30 - 10:45	**Evaluation of Sand and Dust Forecast Products based on NAQPMS Model** Ms. Yilin Zhao, CHINA
10:45 - 11:00	**Proposal: DSS WG II Extended Workshop** Dr. Masae Sumikoshi, JAPAN
11:00 - 11:20	**BREAK**
Session VII	**Summary** Chair: Ms. Seungsook Shin (KOREA)
11:20 - 12:20	**Making a Meeting summary**
12:20 - 12:30	**Closing Remarks** Representative from China Representative from Japan Representative from Mongolia Representative from Korea
12:30 - 14:00	**LUNCH**
14:00 - 16:00	**Technical Tour**

List of the participants:

	Name	Nationality	Organization	Position
1	Mr. Koki AZUMA	Japan	Ministry of the Environment, Japan (MOEJ)	Counsellor for Transboundary Pollution Analysis
2	Mr. Takashi MAKI	Japan	Meteorological Research Institute (MRI)	Head of 3rd laboratory
3	Dr. Atsushi SHIMIZU	Japan	National Institute for Environmental Studies (NIES)	Chief Senior Researcher
4	Dr. Masao MIKAMI	Japan	Japan Meteorological Business Support Center (JMBSC)	Senior Engineer
5	Dr. Nobuo SUGIMOTO	Japan	National Institute for Environmental Studies (NIES)	Visiting Researcher
6	Dr. Keiya YUMIMOTO	Japan	Kyushu University	Professor
7	Mr. Takashi OHMURA	Japan	Overseas Environmental Cooperation Center, Japan (OECC)	Senior Advisor
8	Dr. Masae SUMIKOSHI	Japan	Overseas Environmental Cooperation Center, Japan (OECC)	Senior Researcher
9	Ms. Hiroka WATARAI	Japan	Overseas Environmental Cooperation Center, Japan (OECC)	Researcher
10	Mr. Yizheng QIU	China	Overseas Environmental Cooperation Center, Japan (OECC)	Researcher
11	Chuan SHI	China	Department of International Cooperation, Ministry of Ecology and Environment of the People's Republic of China (MEE)	Officer
12	Liang LI	China	Air Quality Monitoring Division, CNEMC	Senior Engineer
13	Yilin ZHAO	China	Environmental quality forecast center, CNEMC	Senior Engineer
14	Congying JIAO	China	Technology Division, CNEMC	Senior Engineer
15	Mingyuan LIU	China	Air Quality Monitoring Division, CNEMC	Engineer

16	KANG In-sook	Korea	Air Quality Bureau Ministry of Environment, Korea	Deputy Director
17	YOU Sojung	Korea	Air Quality Bureau Ministry of Environment, Korea	International Cooperation Advisor
18	Dr. Hyun-Suk KANG	Korea	National Institute of Meteorological Sciences/KMA	Head of Forecast research department
19	Dr. Seungsook SHIN	Korea	National Institute of Meteorological Sciences/KMA	Senior Researcher
20	Dr. Jeongeun KIM	Kore	National Institute of Meteorological Sciences/KMA	Senior Researcher
21	Ms. Myounghee LEE	Korea	National Institute of Meteorological Sciences/KMA	Officer
22	Ms. Woojeong LEE	Korea	National Institute of Meteorological Sciences/KMA	Researcher
23	Mr. Jeonghoon CHO	Korea	National Institute of Meteorological Sciences/KMA	Researcher
24	Ms. Misun KANG	Korea	National Institute of Meteorological Sciences/KMA	Researcher
25	Ms. Migyeong KIM	Korea	National Institute of Meteorological Sciences/KMA	Researcher
26	Dr. Jae-Young BYON	Korea	National Meteorological Satellite Center/KMA	Senior Researcher
27	Ms. Purevsuren NYAMSUREN	Mongolia	Ministry of Environment and Tourism	Officer
28	Mr. Altangerel ENKHBAT	Mongolia	Department of Environment and Natural Resources Management of the Ministry	Director General
29	Dr. Buyantogrokh BATJARGAL	Mongolia	Department of Meteorological and Environmental Analysis	Specialist
30	Ms. Avimed TSEEPIL	Mongolia	Laboratory of Forest Genetics and Ecophysiology, School of Applied Sciences and Engineering, NUS	Researcher

[Note] No. 2, 3, 9, 18-26, and 29 attended the meeting on-site. Others participated in the meeting online.

Summary of the Sixteenth Meeting of the Working Group I for Joint Research on Dust and Sand Storms

Online Meeting, Beijing, China, 5 December 2023

1. The 16th meeting of the Working Group I (WG I) for Joint Research on Dust and Sand Storms (DSS) under the Tripartite Environment Ministers Meeting (TEMM) was hosted by China virtually and on-site on 5 December 2023. The representatives of the WG I members from Korea, Japan, and China as well as invited representatives from Mongolia participated in this meeting (Annex1: Agenda of the Meeting and List of participants).

2. In Session One, chaired by Dr. Liang LI from China National Environmental Monitoring Centre of the Ministry of Ecology and Environment of China (CNEMC/MEE). Mr.Xiaoyan MENG from China National Environmental Monitoring Centre (CNEMC) delivered the opening remarks and warmly welcomed the participants. Dr. Liang LI introduced in-person participants as well as online participants from four countries including Korea, Japan, China, and Mongolia. Then, he went over the agenda of the one- day meeting which was adopted by all participants. There was a commemorative photo time.

3. In Session Two on "Taking stock of discussions and activities" chaired by Dr Shimizu Atsushi from National Institute for Environmental Studies, Japan (NIES), two participants made presentations. Ms. Seungsook Shin from NIMS/KMA gave a presentation entitled "Review on the 15th Meeting of Working Group (I)". In her presentation, she summarized the 15th Meeting of the WG I which was held from 1st to 2nd November 2022 at Jeju Lotte City Hotel hosted by Korea. The main outcomes are the identification of the three DSS events in 2021 and the agreement for publishing the data catalogue at the TEMM DSS online portal. Shared data for research on four DSS events in 2020 were listed. Three scientific articles on DSS have been published by TEMM-DSS members since 2022. As a DSS-related meeting, the 17th Tripartite Director General Meeting on DSS was also introduced. It was held from 25th to 26th September 2023 at Nagoya Convention Hall hosted by Japan.

4. Ms. Sumin Kim from NIMS/KMA made a presentation on the current status of DSS2021 data sharing. According to her report, each country uploaded three DSS cases in 2021. Two are in March and one is in May. The second case is the most severe dust event among DSS 2021. She mentioned that the web hard storage is almost full and suggested to download all data by each country before emptying the storage. A discussion followed on whether there was a need to accumulate and share data and the use of a "Data catalog" on the TEMM website. The use of URLs (about the satellite images, eg. JAXA website) also mentioned as a way to share data.

5. In Session Three on "Progress of the study on DSS monitoring and modeling from each country" chaired by Dr. Liang Li from CNEMC/MEE, the four participants made their presentations. Dr. Maki gave the first presentation entitled "Recent DSS modeling research activities from Japan". Mr. Takashi MAKI presented an overview of modelling studies on DSS being conducted by MRI. In the Gobi Desert, a significant increase in DSS emissions was found in association with a decrease in snow cover in early spring and late autumn in scenarios with more accelerated global warming. This was also observed in Central Asia and North America in the Northern Hemisphere, but these regions did not show the significant increase in friction velocity seen in the Gobi Desert. There was also an improvement in DSS reproducibility by introducing stone coverage effects into the regional aerosol model. He also presented an overview and future directions with regard to the SDS-WAS being implemented by the World Meteorological Organization.

6. Mr. Jeong Hoon Cho from NIMS made a presentation entitled "Recent improvements of Asian Dust Aerosol Model version3 (ADAM3) in KMA". According to his report, KMA has improved the Asian dust emission scheme to increase the threshold wind speed based on soil moisture. The results showed that predicted PM10 concentrations matched observations better than the experiment using the previous version of the Asian dust emission scheme. And also, KMA updated observation error for three-dimensional variational data assimilation system based on characteristics of observation sites.

7. Ms. Yinlin ZHAO from CNEMC/MEE gave a presentation on the topic of Performance of domestic and foreign sand source areas in simulation of transport contribution of different sand and dust models. Said in her presentation, different numerical models of sand and dust, combined with different atmospheric chemical schemes and different parameterization schemes for sediment generation, have resulted in inconsistent peak times, significant differences in peak concentrations, and low accuracy in concentration simulation for the same research target city. In terms of contribution to external transmission, different model simulation results have a relatively large contribution in absolute concentration, and some calculation results even exceed the actual total PM10 concentration monitored locally in Beijing. There are also certain differences in contribution percentages.

8. Dr. Munkhtsetseg Erdenebayar from The National University of Mongolia, Mongolia made a presentation entitled "Percentage of coarse particles captured by BSNE during DSS2019 in Mongolia". Said in her presentation, we collected transported dust and sand samplings using BSNE sand traps during dust events that occurred between the period of April 23 and June 11, 2019. All samplings captured at the 4 bins (those mounted at different heights) were classified into 6 distinct sizes of particles. Our preliminary results showed that medium to coarse particles are mainly composed DSS2019, and those reflect the soil texture of the source area. Moreover, percentages of medium to coarse particles were larger at the low heights. In contrast, percentages of fine to very fine particles gradually increase as a collecting height (BSNE traps bin height) increase. This preliminary result demonstrates a pattern of percentages of coarse particles during DSS2019 at

some point. However, we need more investigation and research in depth.

9. In Session Four on "Report from the countries on DSS Events" chaired by Dr. Hyun- Suk Kang from NIMS/KMA, the seven presentations were delivered. First, Dr. Hee- Jung Yoo from NIMS/KMA gave a presentation entitled "Observation and Analysis of DSS2021 Case". This study presents the observation and analysis results of the DSS2021 case in NIMS/KMA. Dr. Hee-Jung Yoo selected analysis of a DSS case observed in 2021. DSS2021-02 case is a case that affected the Korean Peninsula for 80 hours and 10 minutes from March 28th to April 1st, 2021, and the maximum PM10 mass concentration was 1,491 $\mu g/m^3$.

10. Dr. Shimizu Atsushi from National Institute for Environmental Studies, Japan (NIES) made a presentation entitled "Characteristics of Asian Dust Observed over Japan in 2021". Daily variations of dust extinction coefficient below 1 km observed by AD-Net lidars in 2021 were shown to confirm the dust situations during 2021 data sharing periods. Dust extinction in 2022/2023 were also displayed for interannual comparison. Several major dust events in 2021 were analyzed using AEROS (surface atmospheric environment monitoring system in Japan) and JMA records to identify the time evolution of Asian dust at independent prefectures. He stressed an importance of the non-spring dust with an analysis of fall dust event in November 2021.

11. Ms. Ming HU from Shanghai Environmental Monitoring Center (SEMC), China made a presentation entitled "Size distribution and chemical composition of particulate matter in Shanghai during a dust transport event". The presentation firstly introduced the dust storms affecting Shanghai during the past 8 years, and then detailed described a dust storm case in March 2021, which resulted one moderate pollution day and one lightly pollution day in Shanghai. Compared with the non-dust period, the proportion of crustal elements in PM during the dust event increased by 27 percentage points and the particles smaller than 1μm decreased, but the number concentration and mass concentration of particles larger than 1μm increased significantly.

12. The period of DSS observation data to be studied by the joint research was discussed in this section led by Dr. Hee-Jung Yoo from NIMS/KMA. In his presentation, Korea suggested two dust cases among four cases occurred in South Korea: two in the springtime and two in the wintertime. After the presentation, the participants shared the view and agreed on three periods for data sharing of this WG I: 2-7 March 2022 [DSS2022-01], 24-30 April 2022 [DSS2022-02], and 10-16 December 2022 [DSS2022-03].

13. Dr. MATSUKI Atsushi from Kanazawa University made a presentation entitled "Aerosol magnetite concentrates in PM during Asian dust events: a new proxy for natural dust loading and Fe-solubility". His recent effort to evaluate the sensitivity of environmental magnetism to dust storm event was presented. The aim of the study was to establish the basis for a new dust storm detection method. The magnetic intensity of coarse aerosols collected in the remote background site (Noto) in Japan was investigated and compared with metal and isotopic compositions. It was reported that aerosol magnetization is primarily controlled by the magnetite content and

remarkably enhanced during DSS events. It was suggested that the influence of DSS and anthropogenic emission can be identified simply by comparing aerosol mass and magnetization. There is a potential for the aerosol magnetism to be used as a new measure of dust loading as well as Fe solubility in the atmospheric aerosols.

14. Senior engineer Yuanzhe REN and engineer Yawen TANG from the Department of Ecology and Environment of Inner Mongolia Autonomous Region gave a speech entitled "The impact of dust weather processes on air quality in northern China and its prediction and forecasting techniques". The content of the speech includes the definition of sand and dust weather in China, the source and basic meteorological characteristics of sand and dust weather in China, the transmission path, the spatial and temporal distribution characteristics, and the impact on air quality in northern China, and summarizes the relevant influencing factors and classification of sand and dust weather forecasts.

15. Dr. SUGIMOTO Nobuo from the National Institute for Environmental Studies gave a speech entitled "Dust Hot Spots Seen in Himawari-8 Dust RGB Data and Needs for a High-Resolution Regional Model with High-Resolution Surface Condition Data". In his presentation, a dust event where dust hot spots were clearly seen in the Dust RGB data from the geostationary satellite HIMAWARI-8 was presented. Dust hot spots were observed around Lake Hulun located about 200 km west of Hulunbeier. However, CFORS (a regional chemical transport model) did not reproduce any emission in this area. CFORS instead showed relatively large dust emission in Horqin Desert in the same period, but no dust emission was observed in Dust RGB. The results suggest the needs for a high-resolution regional model with high-resolution surface data. Such a model would also be useful for linking the activities of WGI and WGII.

16. In Session Five on "Discussion on the mid-term action plan (2020-2024)" chaired by Dr. Maki Takashi from Meteorological Research Institute, Japan. Dr. Ken YOSHIKAWA, Emeritus Professor, Okayama University, reported the results of the DSS WGII Extended Workshop that was hosted to facilitate the collaborations between the DSS WGII and WGI by Japan on 7th November 2023 in hybrid format. DSS WGII experts from China, Korea and Japan and DSS WGI experts from China and Japan as well as the invited speakers from Mongolia, China and FAO of the United Nations participated in the workshop. The participants exchanged views and discussed on technical and scientific aspects on DSS related matters with a view to enhance and identify scientific collaboration on DSS countermeasures to tackle the DSS issues. He appreciated the great inputs and cooperation from the DSS WGI members to the WGII Extended Workshop.

17. Dr. SHIMIZU Atsushi from National Institute for Environmental Studies, Japan (NIES) made a presentation entitled "Proposed Activities for the Next Mid-Term Action Plan (MTAP)". He suggested one year extension of the current TEMM-DSS WG1 MTAP(2020-2024) to synchronize it to next TEMM joint action plan (2026-2030). This extension also keeps enough time to discuss and exchange the ideas related to next MTAP (2026-2030) in 2024. He also recommended that the WG1 meeting in 2025 should finalize MTAP before TEMM-DGM. As a result of discussion, all

participants finally accepted the suggestion..

18. Session six was on "Summary". Dr. Liang Li from CNEMC/MEE chaired the session. The four countries made discussions and finalized the meeting summary at the Session.

19. In the last session was closing remarks, the representatives acknowledged the efforts and contributions, collaborations made by participants and expressed sincere appreciation to the host country. Dr. LI made an acknowledgement for the efforts and contributions of all the participant countries and a special thanks to Japan side for their help for using the online meeting software Webex. Each country representative gave their brief summary. Among others, Mr. KAMEI Yu, from MOEJ, as the host country of the next 17th WG I Meeting, made an acknowledgement for the efforts and contributions made by all participants. He also mentioned the potential collaboration with EANET and the possibility of holding next year's WG1 meeting at ACAP in Niigata, Japan. Detailed date, venue, timeline would be further consulted among Japanese FPs.

Agenda of the Meeting and List of participants

The 16th Meeting of Working Group (I) for Joint Research on Dust and Sand Storms

(Beijing, Online Meeting)

◈ **Date : December 5th (Tuesday), 2023**

Host: China National Environmental Monitoring Center/MEE, P.R.CHINA

◈ **Meeting tool: WebEx**

◈ **Meeting language: English**

◈ **DAY (December 5th Tuesday)**

09:00 CST (10:00 KST & JST) Opening
Session I Chair: Dr./Mr./Ms. Li liang. (CNEMC/MEE, CHINA)
09:00 - 09:05 Opening Remarks Mr./Ms. Officers/Leader, P.R. China (CNEMC/MEE, CHINA) **09:05- 09:10 Introduction of participants** Introduce experts and officials from participating countries **09:10 - 09:15 Adoption of the agenda** **09:15 - 09:20 Group Photo**
Session II Taking stock of discussions and activities Chair: Dr Shimizu Atsushi (JAPAN)
09:20 - 09:35 Ms. Seungsook Shin, **Review on the 15th Meeting of Working Group (I)** (KOREA) **09:35 - 09:50** Ms. Sumin Kim, **Current status of DSS 2021 Data Sharing** (KOREA)
09:50 - 10:05 Break
Session III Progress of the study on DSS monitoring and modeling from each country Chair: Mr./Ms. Li liang. (CNEMC/MEE, CHINA)
10:05 - 10:25 Dr. Maki Takashi, **Recent DSS modeling research activities from Japan** (JAPAN) **10:25- 10:45** Mr. Jeong Hoon Cho, **Recent improvements of Asian Dust Aerosol Model version3 (ADAM3) in KMA (KOREA)** **10:45 - 11:05** Ms. Yinlin Zhao, **Performance of domestic and foreign sand source areas in simulation of transport contribution of different Sand and Dust Models** (CHINA) **11:05 - 11:30** Dr. Munkhtsetseg Erdenebayar, **Percentage of coarse particles captured by BSNE during DSS2019 in Mongolia** (MONGOLIA)

11:30 - 13:30 LUNCH

Session IV Report from the countries on DSS Events

Dr. Hyun-Suk Kang (KOREA)

13:30 - 13:50 Dr. Hee-Jung Yoo, **Observation and Analysis of DSS2021 Case** (KOREA)

13:50 - 14:10 Dr. Shimizu Atsushi, **Characteristics of Asian Dust Observed over Japan in 2021** (JAPAN)

14:10 - 14:30 Ms. Ming Hu, **Size distribution and chemical composition of particulate matter in Shanghai during a dust transport event** (CHINA)

14:30 - 14:50 Dr. Hee-Jung Yoo, **Selection of DSS2022 cases** (KOREA)

14:50 - 15:10 Dr. Matsuki Atsushi, **Aerosol magnetite concentrates in PM during Asian dust events: a new proxy for natural dust loading and Fe-solubility** (JAPAN)

15:10 - 15:40 Mr./Ms. Ren Yuanzhe & Tang Yawen., **The impact of sand and dust weather on air quality in northern China and its prediction and forecasting techniques** (CHINA)

15:40 - 15:45 Dr. Nobuo SUGIMOTO, **Dust Hot Spots Seen in Himawari-8 Dust RGB Data and Needs for a High-Resolution Regional Model with High-Resolution Surface Condition Data** (JAPAN)

15:45 - 16:00 Break

Session V Discussion on the mid-term action plan (2020-2024)

Chair: Mr. Maki Takashi. (JAPAN) 16:00-16:15

Discussion on the cooperation with two working groups (DSS WGII Extended Workshop)

Dr. Yoshikawa Ken, **Report on the DSS WGII Extended Workshop in Nov. 2023 16:00-16:10**

Discussion on the mid-term action plan (2020-2024) and next mid-term action plan

Dr Shimizu Atsushi, **Proposed Activities for the Next Mid-Term Action Plan (MTAP)**

China/Korea/Japan 16:10-16:30

Session VI Summary 16:30-17:20

Chair: Dr. Li Liang (CNEMC, CHINA)

Dr. Li Liang **(**CHINA**)** 16:30-17:20

Making a Meeting summary

Session VII Closing Remarks (CHINA etc.) **17:20-17:30**

List of the participants:

Name	Nationality	Organization	Position
Wenjing JIN	China	Department of International Cooperation, Ministry of Ecology and Environment of the People's Republic of China (MEE)	Officer
Buying WANG	China	Department of Ecological and Environmental Monitoring. Ministry of Ecology and Environment of the People's Republic of China (MEE)	Officer
Liang LI	China	Air Quality Monitoring Division, CNEMC	Senior Engineer
Xiaoyan MENG	China	Air Quality Monitoring Division, CNEMC	Deputy Director
Yilin ZHAO	China	Environmental quality forecast center, CNEMC	Senior Engineer
Hanyang LIU	China	FECOMEE	Project Assistant
Ren Yuanzhe	China	Department of Ecology and Environment of Inner Mongolia Autonomous Region	Senior Engineer
Tang Yawen	China	Department of Ecology and Environment of Inner Mongolia Autonomous Region	Engineer
Ming Hu	China	Shanghai Environmental Monitoring Center	Senior Engineer
Insook Kang	Korea	Ministry of Environment, Korea	Deputy Director
So-Jung You	Korea	Ministry of Environment, Korea	International Cooperation Advisor
Hyun-Suk Kang	Korea	National Institute of Meteorological Sciences (NIMS)	Director

Seungsook Shin	Korea	National Institute of Meteorological Sciences (NIMS)	Senior Researcher
Jeong Hoon Cho	Korea	National Institute of Meteorological Sciences (NIMS)	Researcher
Sumin Kim	Korea	National Institute of Meteorological Sciences (NIMS)	Senior Researcher
Hee-Jung Yoo	Korea	National Institute of Meteorological Sciences (NIMS)	Researcher
Woojeong Lee	Korea	National Institute of Meteorological Sciences (NIMS)	Researcher
Migyeong Kim	Korea	National Institute of Meteorological Sciences(NIMS)	Researcher
Misun Kang	Korea	National Institute of Meteorological Sciences(NIMS)	Researcher
SHIMIZU Atsushi	Japan	National Institute for Environmental Studies (NIES)	Chief Senior Researcher
SUGIMOTO Nobuo	Japan	National Institute for Environmental Studies (NIES)	Visiting Researcher
MAKI Takashi	Japan	Meteorological Research Institute	Head
MATSUKI Atsushi	Japan	Kanazawa University	Associate Professor
MIKAMI Masao	Japan	Meteorological Business Support Center	Senior Chief Engineer

YUMIMOTO Keiya	Japan	Kyushu University	Professor
YOSHIKAWA Ken	Japan	Okayama University	Professor Emeritus
KAMEI Yu	Japan	International Cooperation Office, Environmental Management Bureau, Ministry of the Environment	Director for International Cooperation
GOMI Kayoko	Japan	International Cooperation Office, Environmental Management Bureau, Ministry of the Environment	Deputy Director
YASUDA Yumi	Japan	International Cooperation Office, Environmental Management Bureau, Ministry of the Environment	Section Chief
YAMADA Katsuyuki	Japan	Environmental Pollution Control Office, Environmental Management Bureau, Ministry of the Environment	Deputy Director
YOSHIMOTO Takatoshi	Japan	Environmental Pollution Control Office, Environmental Management Bureau, Ministry of the Environment	Researcher
HASHIDATE Kaori	Japan	Environmental Management Division, Environmental Management Bureau, Ministry of the Environment	Staff
Munkhtsetseg Erdenebayar	Mongolia	The National University of Mongolia	Senior Researcher

Summary of the Seventeenth Meeting of the Working Group I for Joint Research on Dust and Sand Storms

Hybrid Meeting, Niigata, Japan, 10, October 2024

1. The 17th meeting of the Working Group I (WGI) for Joint Research on Dust and Sand Storms (DSS) under the Tripartite Environment Ministers Meeting (TEMM) was hosted by Japan on 10 October 2024. The representatives of the WGI members from Japan, Korea and China as well as invited representatives from Mongolia participated in this meeting (Annex1: Agenda of the Meeting and List of participants).

2. In Session One, Mr. Yu KAMEI, Director of Office of International Cooperation, Environmental Management Bureau of Ministry of the Environment of Japan (MOEJ), delivered the opening remarks and warmly welcomed the participants. Dr. Atushi Shimizu, from National Institute for Environmental Studies, Japan (NIES) introduced the agenda of the Meeting which was adopted by all participants. There was a commemorative photo session.

3. In Session Two on "Taking stock of discussions and activities" chaired by Dr. Liang LI from China National Environmental Monitoring Centre of Ministry of Ecology and Environment of China (CNEMC/MEE), the two participants made their presentations. Dr. Liang LI gave a presentation entitled "Review on the 16th Meeting of Working Group (I)". In his presentation, he summarized the 16th Meeting of the WGI which was held on 5 December, 2023 through online meeting hosted by China. The main outcomes were the identification of the three DSS events in 2022 and reaching a consensus on a one-year extension period of the current TEMM-DSS WGI MTAP (2020-2024) to synchronize it to next TEMM joint action plan (2026-2030).

4. Following it, Mr. Jeong Hoon CHO, from National Institute of Meteorological Sciences, Korea (NIMS) made a presentation on "The current status of DSS data sharing". According to his report, China, Japan Korea and Mongolia uploaded three DSS cases in 2022. He also introduced issues and suggestion as follows. A deadline for uploading materials should be determined so that the shared observation data can be used in the next meeting's analyses. WGI members proposed every August or 3 months before the WGI meeting. Web-hard storage was almost full and it is inconvenient for non-Korean users to use. It is recommended to move from web-hard to a cloud service or to use the TEMM-DSS online portal so that WGI members can share the observation data through the web-portal.

5. In Session Three on "Progress of the study on DSS monitoring and modeling from each country" chaired by Mr. Takashi MAKI from Japan Meteorological Research Institute, Japan Meteorological Agency (JMA), the four participants made their presentations.

6. First, Mr. Takashi MAKI from JMA gave a presentation entitled "Current DSS monitoring and modeling activity from JMA". He explained that JMA monitors of aerosol optical thickness and provides information on DSS-related activities, satellite images, model predictions, and ground observations. The Meteorological Research Institute (MRI) develops the Earth System Model (MRI-ESM) for global warming and DSS predictions. The new version (MRI-ESM3) shows reduced dust over-emission. The United Nations (UN) formed a coalition to combat sandstorms in 2019 and designated July 12th as the International Day of Combating Sand and Dust Storms starting in 2023. The World Meteorological

Organization (WMO) promotes the SDS-WAS program for DSS. In Asia, CMA acts as the regional center, coordinating district activities and serving as the forecasting center.

7. Second, Mr. Jeong Hoon CHO from NIMS/KMA gave a presentation entitled "Progress of the study on DSS monitoring and modeling in Korea". He explained the development of a new numerical model for Sand and Dust Storms (SDS) in Korea. It highlights the limitations of the current model (ADAM3) and the need for a new model integrated into the Korea Integrated Model (KIM). The plan includes developing a new Asian dust emission model and a regional-scale forecast model by 2025, launching the new model operationally by 2030. The presentation also introduces a novel method for detecting natural dust source regions using satellite and ground- based measurements, improvements in saltation and vertical dust flux modeling, the application of AI techniques for PM10 concentration correction, and updates on the data assimilation system.

8. Dr. Yilin ZHAO, as the third presenter, from Forecast Center, China National Environmental Monitoring Centre (CNEMC) gave a presentation entitled "Simulation and Verification of Medium and Long term Sand and Dust Forecasting". She described that the severe sandstorm process in 2023 had a significant impact on the central and northern regions of China, making it the year with the greatest impact on the North China region in recent years. Considering such situation, the requirements of the government and the public for the technical ability of sand and dust forecasting have also increased. She also explained the forecasting results which indicated that there was a significant sandstorm process that affected Xi'an and Zhengzhou from April 21 to April 24, and the high PM10 concentration in Zhengzhou will be occurred in October. In addition, there were three predicted sandstorm weather processes, occurring from April 1-7, April 15-17 and April 24-27, respectively. The first process predicts the highest PM10 concentration might be occurred in December in 2024.

9. Fourth presenter was Dr. Purevjav GOMBOLUUDEV from Research Institute of Meteorology, Hydrology and Environment, Mongolia (RIMHE) gave a presentation entitled "Present status of dust monitoring and modeling in Mongolia". His presentation highlights the locations and parameters of various DSS monitoring sites, the challenges with outdated equipment, and the need for international collaboration to enhance the monitoring system, especially in regions prone to yellow dust storms. The presentation also covers the integration of AI techniques for air pollution forecasting, the use of satellite and ground-based measurements, and the development of new models to improve dust and sand storm predictions. The emphasis was on the importance of international training and exchange programs to build human resource capabilities.

10. In Session Four on "Report from the countries on DSS Events" chaired by Mr. Duk Jin WON from National Institute of Meteorological Sciences, Korea (NIMS), the five presentations were delivered.

11. First, "Analysis on Asian dust cases in 2022" by Mr. Jeong Hoon CHO. He analyzed two significant dust storm events: one in early March and another in mid-December. Both events originated from the Gobi Desert and Inner Mongolia, affecting the Korean Peninsula with high PM10 concentrations and prolonged dust durations. The analysis includes surface weather charts, PM10 distributions, LIDAR observations, and chemical compositions of dust particles. The study highlights the impact of these dust storms on air quality in Korea and emphasizes the importance of continuous monitoring and analysis for better prediction and management of such DSS events.

12. Following it, "Applicability of low-cost pollen sensor for the detection of DSS events" by Prof. Atsushi MATSUKI (Kanazawa University) introduced the efforts to use low-cost pollen sensors for detecting DSS events in both Mongolia and Japan. The number of stations in Japan conducting visual dust observations has drastically decreased, from 60 to 11, and now only two remain (Tokyo and Osaka). The current situation requires to establish a new ground-based DSS monitoring network to compensate for the discontinued observations. There are high expectations for emerging low-cost sensors to replace the current operational observations. A preliminary intercomparison with conventional high-end optical particle counters (OPCs) revealed that the pollen sensor performed well, showing a strong correlation, particularly with the coarse particle counts measured by the OPCs.

13. As the third presentation, "A Study on the Characteristics of Asian Dust Cases Affecting the Korean Peninsula" by Ms. Migyeong KIM, National Institute of Meteorological Sciences Korea (NIMS). They analyzed the characteristics of an Asian dust event that affected the Korean Peninsula from April 16 to 20, 2024. Originating from the Gobi Desert and Inner Mongolia Plateau, the dust increased soil component concentrations, particularly calcium ions, which led to higher neutralization rates of calcium carbonate in the atmosphere. The study utilized various observation sites and instruments to measure PM_{10} and $PM_{2.5}$ concentrations, chemical compositions, and aerosol mass concentrations. The observational results highlighted the significant impact of Asian dust on air quality and the importance of continuous monitoring and analysis to better understand and predict such events. Future research will focus on estimating the sources of Asian dust using aerosol elemental composition analysis. It was pointed out that the horizontal pattern of DSS event is similar between Korea and Japan.

14. "Report on the field survey in Mongolia in 2024 - Towards stronger cooperation between WG1 and WG2" by Prof. Keiya YUMIMOTO from Kyushu University, Japan was the fourth presenter. He reported details of the field survey conducted in Mongolia in 2024 to enhance cooperation between two DSS Working Groups (WGI and WGII). The survey aimed to understand the local conditions affecting DSS and to strengthen joint research efforts. The findings revealed that the DSS source regions are highly heterogeneous, with significant variations in vegetation, soil types, and surface conditions. The report emphasizes the need for close collaboration between WGI, which focuses on monitoring and modeling, and WGII, which conducts field observations. The survey's insights will inform the development of a Medium-term Action Plan (2026-2030) and highlight the importance of integrating local observations with model results and satellite data for a comprehensive understanding of DSS dynamics. It was pointed out that DSS event in Mongolia is sensitive to precipitation changes and seasonal changes.

15. Last presenter of Session Four was Dr. Atsushi SHIMIZU from NIES who talked about "A proposal of data sharing period for Asian dust events in 2023". He explained the number of Asian Dust (AD) days in 2023 was relatively high among last 10 years. He also proposed several AD events happened in 2023 in order to select the target of data sharing activities in 2025. They are based on the published monitoring data in China, Korea and Japan. Candidates for data sharing periods proposed by him were (A) April 8-16, (B) April 18-24, (C) May 19-24 and (D) December 6-11, 2023. And he also mentioned the shrinking of JMA dust monitoring.

16. The selection of DSS 2023 cases was discussed in this section led by Mr. Duk Jin WON from , NIMS/KMA. In Korea, there was no observation of Asian Dust in December. It was also mentioned that December is not paid attention by WGI members in China. However, it was pointed out that direct effect of climate change should be considered for analysis of AD event. The participants agreed on the two periods for data sharing of this WGI: April 8-24 [DSS2023-01], May 19-24 [DSS2023-02].

17. In Session five on "Progress on the mid-term action plan (2020-2025)" chaired by Dr. Liang LI (CNEMC/MEE), the secretariate reported the goals and activities and outcomes of the current mid- term action plan, then discussions were made as follows;

- It was recommended that the summary table be re-organized as Goals for MTAP (2020-2025), Activities for MTAP, Expected Outcomes for MTAP and Outcomes.
- It was clarified that the summary table will provide useful information on the Proceeding Report of DSS WGI.
- The possibility of use of cloud storage services to store the observation and modeling data was discussed. For the cloud service for the real time data sharing, participants expressed some uncertainty of security issues and access right issues. A participating country expressed that they would do some necessary investigations on this matter, and ask participants' comments via email.
- It was clarified that encouragement of sharing real-time observation and satellite data to enhance the system is described in current MTAP. At the 16th meeting, consideration on the use of satellite image of external resources was discussed.
- It was pointed out that the TEMM DSS WGI Extended Workshop was held in 2021. This activity should be included in the outcomes.
- It was pointed out that participation on the Workshop on Developing Environmental Cooperation Platform in Northeast Asia organized by CREAS in 2023 and 2024 should be checked.
- The WGI members agreed to prepare the Proceeding Report of DSS WGI on the Mid-Term Action Plan (2020-2025). The preparation of development of report will be continued to discuss via email among WGI participants, as no clear role assignments of writing was decided during the meeting.

18. In Session Six on "Discussion on the NEXT mid-term action plan (2026-2030)" Chaired by Dr. Atsushi SHIMIZU (NIES/JAPAN), MOEJ presented the expected points to be stressed for the next MTAP, as follows:

- Participants are expected to have a common understanding of the future schedule. Since the current MTAP will end in 2025, the next MTAP will be from 2026 to 2030. In order to start promptly in 2026, it is necessary to obtain the agreement among the three countries at the DSS WGI meeting to be hosted by Korea in 2025 and to be approved at the TEMM Director-General Meeting to be hosted by China in the same year. The DSS WG meetings are usually held in the autumn, but in light of the above, it is strongly recommendable to hold the WG meetings in July, before the TEMM Director-General's Meeting.

- The NEXT MTAP for WGI focuses on improving Dust and Sandstorm (DSS) forecasting and monitoring systems and enhancing cooperation with WGII. Key targets include developing short-term, medium-term (S2S), and long-term DSS forecasts using LIDAR, satellite data, and land and vegetation information. Long-term goals emphasize understanding climate change impacts on DSS variations and evaluating past mitigation efforts. It also highlights streamlining monitoring systems by leveraging existing air quality data, satellite technology, and low-cost sensors. Additionally, it calls for strengthened collaboration with WGII to share data from DSS origin points, monitor vegetation changes, and analyze links between DSS reduction and air quality improvements.

19. The participants discussed the targets and activities on the NEXT mid-term action plan (2026- 2030). The main points are shown as follows:

- The participant emphasized the importance of developing reliable early warning systems and adaptation strategies for semi-arid regions, based on numerical models and long-term forecasting.
- IPCC report highlights increased climate-related phenomena in sub-tropical and dry regions. The occurrence of DSS and droughts varies greatly depending on land surface conditions, and the TEMM DSS WG is expected to promote the research on DSS generation due to land surface changes, etc.
- Effective collaboration and communication among countries and groups (WGI and WGII) is essential for reliable forecasts and adaptation measures.
- The participants stressed the importance of cooperation between WGI (providing data) and WGII (implementing countermeasures).
- Despite having knowledge and experience, collaboration is currently lacking. Greater cooperation could lead to better outcomes for people in semi-arid regions.
- It is important to share whether countries have a common understanding of the long-term trends of DSS, including the observed decrease in frequency but increase in intensity. Organizing existing knowledge on the relationship between frequency and intensification is also important. Understanding of past variations in DSS frequency and differences from predictions is important for future forecasting. Additionally, it would be beneficial to evaluate the effectiveness of source control measures implemented under WGII in relation to changes in DSS frequency.
- There are challenges in long-term forecasting and dust event prediction. It would be better to build a common understanding among three countries regarding the short, medium, and long term forecasts.
- More collaboration between WGI and WGII is needed for accurate scenario understanding.
- It was noted that the member countries are facing challenges in short-term forecasting due to limited funds and requires time to develop effective forecast models.
- Future targets include monitoring data as a priority, crucial for developing forecast models and strengthening cooperation with WGII.
- Assessment of effect on future climate change on DSS event is an important research topic.
- Each country has specific important topics, so it's not necessary to implement the common research topics.
- The participants were invited to submit additional comments for the NEXT mid-term action plan

(2026-2030) by e-mail.

20. In Session Seven on "Other topics" chaired by Dr Atsushi SHIMIZU (NIES/JAPAN), the Secretariate introduced the proposal from UNCCD expecting a form of cooperation with DSS WGI and II, and create the link of SDS Toolbox to TEMM DSS Online Portal.

21. It was recommended to increase the storage space of the TEMM-DSS portal to store shared data and strengthen cooperation with external DSS related websites could be considered for the NEXT mid-term action plan (2026-2030).

22. In Session Eight on "Summary", continuously chaired by Dr. Atsushi SHIMIZU (NIES/JAPAN), the Secretariate presented the 1st draft of meeting summary report and following confirmation by three countries. It was informed that the 1st draft will be circulated by the Secretariate after the meeting. The participants are kindly requested to amend the summary within two weeks after the meeting.

23. For closing remarks, the representatives of China, Korea, Mongolia, Japan acknowledged the efforts and contributions, collaborations made by participants and expressed sincere appreciation to the meeting arrangement by host country.

Agenda of the Meeting and List of participants

The 17th Meeting of Working Group (I) for Joint Research on Dust and Sand Storms

(Niigata, Japan)

◈ **Date: October 10th (Thursday) and 11th (Friday) 2024**

◈ **Venue: Minatopia Niigata City History Museum, Niigata, Japan**
https://www.nvcb.or.jp/multilingual/sightseeing/minatopia

◈ **Host: Ministry of the Environment, Japan**

◈ **Meeting language: English**

◈ **DAY 1 (October 10th Thursday)**

10:00 JST (10:00 KST & 9:00 CST)	**Opening**
Session I	**Opening**
Chair:	Dr. Atsushi SHIMIZU (JAPAN)
10:00 – 10:05	**Opening Remarks**
	Mr. Yu KAMEI, JAPAN
10:05 – 10:15	**Introduction of**
10:15 – 10:20	**participants**
10:20 – 10:30	**Adoption of the agenda Group Photo**
Session II	**Taking stock of discussions and activities**
Chair:	Dr. Liang LI (CHINA)
10:30 – 10:45	**Review on the 16th Meeting of Working Group (I)**
	Dr. Liang LI, CHINA
10:45 – 11:00	**Current status of DSS 2022 Data Sharing**
	Mr. Jeong Hoon CHO, KOREA
Session III	**Progress of the study on DSS monitoring and modeling from each country**
Chair: Mr. Takashi MAKI (JAPAN)	
11:00 – 11:20	**Current DSS monitoring and modeling activity from JMA**
	Mr. Takashi MAKI, JAPAN
11:20 – 11:40	**Progress of the study on DSS monitoring and modeling in Korea**
	Mr. Jeong Hoon CHO, KOREA
11:40 – 12:00	**Simulation and Verification of Medium- and Long-term Sand and Dust Forecasting**
	Dr. Yilin ZHAO, CHINA
12:00 – 12:15	**Present status of dust monitoring and modeling in Mongolia**
	Dr. Purevjav GOMBOLUUDEV, MONGOLIA
12:15 - 13:30	**LUNCH**

Session IV	**Report from the countries on DSS Events** Chair: Mr. Duk Jin WON (KOREA)
13:30 – 13:50	**Analysis on Asian dust cases in 2022** Mr. Jeong Hoon CHO, KOREA
13:50 – 14:10	**Applicability of low-cost pollen sensor for the detection of DSS events** Prof. Atsushi MATSUKI, JAPAN
14:10 – 14:30	**A Study on the Characteristics of Asian Dust Cases Affecting the Korean Peninsula** Ms. Migyeong KIM, KOREA
14:30 – 14:50	**Report on the field survey in Mongolia in 2024 - Towards stronger cooperation between WG1 and WG2** Prof. Keiya YUMIMOTO, JAPAN
14:50 – 15:10	**A proposal of data sharing period for Asian dust events in 2023** Dr. Atsushi SHIMIZU, JAPAN
15:10 - 15:30	**Break**
Session V	**Progress on the mid-term action plan (2020-2025)** Chair: Dr. Liang LI (CHINA)
15:30 – 16:10	**Review on the activities during 2020-2024**
16:10 – 16:30	**Discussions on the Potential Cooperative Activities between the WGI and WGII** (Secretariate)
Session VI	**Discussion on the NEXT mid-term action plan (2026-2030)** Chair: Dr. Atsushi SHIMIZU (JAPAN)
16:30 – 17:30	**Proposed points for the Next mid-term action plan (MTAP) (2026-2030)** **Detailed milestones to develop** (Secretariate)
Session VII	**Other topics** Chair: Dr. Atsushi SHIMIZU (JAPAN)
17:30 – 17:40	**Discussions on the other topics**
Session VIII	**Summary** Chair: Dr. Atsushi SHIMIZU (JAPAN)
17:40 - 17:50	**Making a meeting summary report** (Secretariate)
17:50 - 18:00	**Closing remarks** Representative from Korea Representative from China Representative from Mongolia Representative from Japan
19:00 –	**Reception**

◈ DAY 2 (October 11th Friday)

9:30 - 11:30	**Excursion (ACAP Facility)**
11:30 - 13:00	**LUNCH**
13:00 - 14:30	**Excursion (The Niigata Saitou Villa)**

The list of participants of 17th meeting of DSS WGI

(In-person/Online participants)

Name	Nationality	Organization	Position	In-person /Online
Mr. Jun Zhou	China	Department of International Cooperation, Ministry of Ecology and Environment	Director	Online
Dr. Liang Li	China	Ambient Air Quality Monitoring Department, China National Environmental Monitoring Centre	Senior Engineer	In-person
Dr. Yilin Zhao	China	Forecast Center, China National Environmental Monitoring Centre	Senior engineer/ Chief forecaster	In-person
Ms. Sarah Kwon	Korea	Interational Cooperation Bureau, Ministry of Environment	Senior Researcher Expert	Online
Mr. Jeong Hoon Cho	Korea	Global Atmospheric Watch and Research Division, National Institute of Meteorological Sciences	Researcher	In-person
Ms. Migyeong Kim	Korea	Global Atmospheric Watch and Research Division, National Institute of Meteorological Sciences	Researcher	In-person
Mr. Duk Jin Won	Korea	Global Atmospheric Watch and Research Division, National Institute of Meteorological Sciences	Director	In-person
Dr. Hee-Jung Yoo	Korea	Global Atmospheric Watch and Research Division, National Institute of Meteorological Sciences	Researcher	Online
Mr. Yu Kamei	Japan	Office for International Cooperation, Environmental Management Bureau, Ministry of the Environment	Director	In-person
Ms. Yumi Yasuda	Japan	Office for International Cooperation, Environmental Management Bureau, Ministry of the Environment	Deputy Director	In-person

Mr. Katsuyuki Yamada	Japan	Environmental Pollution Control Office, Environmental Management Bureau, Ministry of the Environment	Deputy Director	Online
Mr. Takatoshi Yoshimoto	Japan	Environmental Pollution Control Office, Environmental Management Bureau, Ministry of the Environment	Researcher	Online
Ms. Yurika Ito	Japan	International Forest, Dryland and Polar Ecosystem Conservation Measures Section, Natural Environment Planning Division, Natural Environment Bureau, Ministry of the Environment	Section Chief	Online
Dr. Atsushi Shimizu	Japan	Regional Environment Conservation Division, National Institute for Environmental Studies	Prime Senior Researcher	In-person
Mr. Takashi Maki	Japan	Department of Atmosphere, Ocean, and Earth System Modeling Research, Meteorological Research Institute	Section Head	In-person
Dr. Masao Mikami	Japan	Promotion of Meteorological Research Division, Japan Meteorological Business Support Center	Acting Division Director	In-person
Dr. Nobuo Sugimoto	Japan	Earth System Division, National Institute for Environmental Studies	Visiting Researcher	Online
Prof. Keiya Yumimoto	Japan	Research Institute for Applied Mechanics, Kyushu University	Professor	In-person
Prof. Atsushi Matsuki	Japan	Institute of Nature and Environmental Technology, Kanazawa University	Assocaite Professor	In-person
Ms. Sukhee Bayartsetseg	Mongolia	Integrated Policy Planning Department, Ministry of Environment and Climate Change	Senior Analyst in charge of Desertification and Land degradation	In-person
Dr. Purevjav Gomboluudev	Mongolia	Climate Research Division, Research Institute of Meteorology, Hydrology and Environment	Scientific Secretary	In-person

(Meeting Secretariate)

Name	Nationality	Organization	Position	In-person /Online
Mr. Ryuji Tomisaka	Japan	Asia Center for Air Pollution Research, Japan environmental Sanitation Center	Deputy Director General	In-person
Dr. Fan Meng	Japan	Asia Center for Air Pollution Research, Japan environmental Sanitation Center	Deputy Director General	In-person
Dr. Ken Yamashita	Japan	Asia Center for Air Pollution Research, Japan environmental Sanitation Center	Head, Planning & Training Dept.	In-person
Dr. Keiichi Sato	Japan	Asia Center for Air Pollution Research, Japan environmental Sanitation Center	Head, Atmospheric Research Dept.	In-person
Dr. Hiroyuki Sase	Japan	Asia Center for Air Pollution Research, Japan environmental Sanitation Center	Head, Ecological Impact Research Dept.	Online
Dr. Junichi Kurokawa	Japan	Asia Center for Air Pollution Research, Japan environmental Sanitation Center	Head, Data Management Dept.	In-person
Dr. Meihua Zhu	Japan	Asia Center for Air Pollution Research, Japan environmental Sanitation Center	Chief Senior Researcher, Planning & Training Dept.	In-person
Mr. Hiroki Yotsuyanagi	Japan	Asia Center for Air Pollution Research, Japan environmental Sanitation Center	Senior Researcher, Ecological Impact Research Dept.	In-person
Ms. Miho Tamura	Japan	Asia Center for Air Pollution Research, Japan environmental Sanitation Center	Chief, Planning & Training Dept.	In-person
Mr. Katsutoshi Uehara	Japan	Asia Center for Air Pollution Research, Japan environmental Sanitation Center	Administrative Staff, Planning & Training Dept.	In-person
Ms. Eriya Tsuchiya	Japan	Asia Center for Air Pollution Research, Japan environmental Sanitation Center	Administrative Staff, General Affair Dept.	In-person

Summary of the 18th Meeting of the Working Group I for Joint Research on Dust and Sand Storms

Hybrid meeting, Seoul, Korea, June 30th and July 1st (Mon. -Tue.), 2025

1. The 18th meeting of the Working Group I (WG I) for joint research on Dust and Sand Storms (DSS) under the Tripartite Environment Ministers Meeting (TEMM) was hosted by the Republic of Korea on June 30th and July 1st (Mon. and Tue.), 2025. The representatives of the WG I members from Japan, China, and Korea as well as invited representatives from Mongolia participated in this meeting (Annex1: Agenda of the meeting and list of participants).

2. In Session I, Dr. Sangbaek Kim, Director of the Global Atmospheric Watch and Research Division, National Institute of Meteorological Sciences (NIMS/KMA), Korea, delivered the opening remarks and warmly welcomed the participants. Ms. Young-Ah Kim from NIMS/KMA, introduced the agenda of the meeting, which was adopted by all participants. There was a commemorative photo session.

3. In Session II, chaired by Dr. Liang Li from Air Quality Monitoring Division, China National Environmental Monitoring Center (CNEMC/MEE), China, focused on taking stock of discussions and activities. Dr. Atsushi Shimizu from Regional Environment Conservation Division, National Institute for Environmental Studies, Japan, presented a review of the 17th meeting of WG I, summarizing the key outcomes and follow-up actions from the previous meeting. This was followed by a presentation from Dr. Hee-Jung Yoo from NIMS/KMA, who introduced the current status of DSS data sharing and proposed a new method for improving the sharing of observation data among member countries. He stated that the transition to Google Drive with expanded 200GB storage is planned to be completed by July 31st.

4. Session III, chaired by Dr. Atsushi Shimizu featured a series of presentations on ongoing studies related to DSS monitoring and modeling in each participating country.

5. Prof. Keiya Yumimoto from Research Institute for Applied Mechanics, Kyushu University, Japan, introduced a newly launched DSS research project in Japan, explaining its objectives, methodology, and anticipated results. The research aims to build databases, analyze dust mechanisms, develop forecasting systems, assess economic impacts, and propose countermeasures, contributing to policy support and international cooperation on Asian dust issues.

6. Prof. Atsushi Matsuki from Institute of Nature and Environmental Technology, Kanazawa University, Japan, presented assessing the potential of a low-cost pollen sensor for DSS event detection, including comparative analysis with conventional Optical Particle Counters (OPCs). The key point is that an intercomparison of pollen sensors (PS2, PS3) with OPCs in Tsukuba (2024–2025) showed that PS2 was not suitable for detecting DSS in Japan but may be useful in source regions. PS3 showed good potential for simultaneous pollen and DSS monitoring, despite saturation issues in fog, and could serve as a low-cost alternative for DSS observation with proper threshold settings.

7. Dr. Liang Li presented assessment of dust monitoring and ambient air quality in China (2023), highlighting recent trends in dust weather and its effects on urban air quality. In 2023, 50 large-scale regional dust events were recorded across China, significantly increasing PM2.5 and PM10 concentrations in many cities. Among

339 cities, 203 met national air quality standards, with O3, PM2.5, and PM10 identified as the main pollutants. The proportion of good air quality days ranged from 16.7% to 100%, with a national average of 85.5%. The chemical composition of PM2.5 varied by region, and dust weather was found to have a notable impact on air quality nationwide.

8. Mr. Changbeom Cho from National Meteorological Satellite Center (NMSC/KMA) reported on the current status of the GK2A service products for DSS monitoring, demonstrating their applications for improved forecasting and early warning. He introduced four key products—RGB Dust, DEBRA, D*-Parameter, and ADPs. Each product utilizes techniques such as Brightness Temperature Difference (BTD) based visualization, dynamic enhancement algorithms, quantitative intensity estimation, and aerosol type classification. He also shared results from a verification case study of a weak dust event in January 2021, emphasizing the importance of combining satellite observations with ground-based data and numerical weather prediction models to enhance the accuracy of dust detection and monitoring.

9. Dr. Mi Eun Park from NIMS/KMA presented the current status and utilization of KMA's DSS model (ADAM3), with updates on recent model developments. ADAM3, Korea's DSS prediction model developed since 2001, has been continuously enhanced to accurately simulate Asian dust occurrence, transport, and removal processes. Recent improvements include incorporating soil moisture, vegetation, and precipitation impacts, as well as applying 3DVAR data assimilation using monitoring data. Further update of critical wind speed for Asian dust source is forthcoming.

10. Dr. Gomboluudev Purevjav from the information and Research Institute of Meteorology, Hydrology and Environment, Mongolia, presented an overview of the spatial and temporal distribution of dust storms in Mongolia, based on meteorological station data from 2000 to 2023, and highlighted long-term trends and their implications for regional monitoring efforts. The study indicated that dust storm occurrence is closely linked to surface conditions and strong wind frequency, with major events recorded in 2018, 2021, and 2023. Future research will apply regional climate models (RegCM4/5) to project DSS trends and associated risks under climate change scenarios.

11. In session IV, chaired by Ms. Young-Ah Kim focused on reports from the countries on DSS2023 Events.

12. Dr. Hee-Jung Ko (NIMS/KMA) presented the observation and analysis of the DSS2023 case, which originated in the Gobi Desert and Inner Mongolia on May 19, 2023. The dust traveled to Korea and affected the country for approximately 59 hours, during which PM10 concentrations increased significantly nationwide. Chemical analysis revealed that the dust contained not only soil particles but also various air pollutants.

13. Ms. Yajing Li from CNEMC/MEE presented the impact of sand storms on the proportion of crustal elements in PM2.5, focusing on the chemical characteristics of dust events. She introduced the current status of particle composition network monitoring in China, and based on the monitoring results of Beijing, she showed the variation trend of concentration of SO2, NO2, PM2.5/PM10, water-soluble ions, crustal elements in PM2.5 from Apr. 8 to May. 23, 2023. The crustal elements in two sand storm events share similar chemical composition, indicating a similar source. Meanwhile, different from dust pollution, she introduced other two types of pollution events. Different pollution events exhibit varying trends in component increase.

14. Dr. Takashi Maki from Department of Atmosphere, Ocean, and Earth System Modeling Research,

Meteorological Research Institute (MRI), Japan, presented report on model analysis from Japan for the DSS2023 event and related international activities. He reported that the JMA model successfully captured the DSS2023 transport timing, with some intensity overestimation, and highlighted international efforts (WMO SDS-WAS, UNCCD COP16), stressing the importance of promoting TEMM DSS work toward UNCCD COP17 in Mongolia (2026).

15. The session concluded with a discussion led by Dr. Mi Eun Park (Korea) and Dr. Atsushi Shimizu (Japan) on the selection of DSS2024 cases for joint data sharing and future analysis. Korea proposed three events (March 28–31, April 16–20, June 24), and Japan suggested three key periods (March 27–April 3, April 16–21, June 24–28), based on their respective monitoring data. Korea and Japan shared similar spikes in similar periods, China agreed. Therefore, 3 cases were selected: March 27–April 3, April 16–21, and June 24–28.

16. Following a short break, Session V, chaired by Dr. Liang Li was dedicated to discussions on the detailed milestones for the 4th Mid-Term Action Plan (MTAP) (2026–2030).

17. Dr. Keiichi Sato (Japan Secretariat of WG I) presented a report summarizing the achievements of DSS WG I and the progress of the current 3rd MTAP (2020–2025), including advancements in data sharing platforms, forecasting models, and scientific contributions. The report also identified challenges such as delays in cloud migration, limited real-time data sharing, and the need for stronger collaboration with WG II, Mongolia and outreach groups. He will circulate the zero-draft among the 4 countries for review and confirmation.

18. Discussions followed on setting priorities for the next 4th MTAP, covering enhanced data sharing, improved DSS forecasting and early warning systems, streamlined monitoring networks, expanded collaboration with WG II, and the promotion of joint activities with Mongolia.
    - It was emphasized that the continuation of previous WG I activities should remain unchanged.
    - Rather than feeling burdened by the need to produce definitive results over the next five years for research on short-, medium-, and long-term DSS predictions, we agreed that even small progress or pilot projects are valuable.
    - It was agreed to make the new 4th MTAP more detailed. It was agreed to remove redundant mention to satellite data that was also included in previous activities and to clarify unclear phrases about expected results.
    - Description of collaboration with Mongolia was unclear. It was noticed that this description will be modified as appropriate.

19. The first day of the meeting concluded with a banquet hosted by the organizing committee.

20. The second day of the 18th meeting of the WG I began with Session VI, chaired by Ms. Yumi Yasuda from Ministry of the Environment, Japan (MOEJ). The session focused on further discussions for the 4th MTAP, continuing from the discussions held on the first day.

21. Participants discussed key elements and strategic directions for the 4th MTAP based on a presentation delivered by Ms. Yasuda.
    - Key priorities outlined for the next 4th MTAP included: continuation of current WG I activities; expansion of data sharing scope and enhancement of the data sharing system; improvement of DSS forecast and early warning systems – including short-term, Sub-Seasonal to Seasonal (S2S), and long-term forecasting; streamlining and automation of monitoring systems; strengthening cooperation with WG Ⅱ; deepening

collaboration with Mongolia; and encouraging broader participation from external research groups. Special emphasis was placed on the need to enhance integrated response capabilities by strengthening data sharing and collaborative research, particularly in view of the evolving impacts of climate change on dust source regions and affected areas.

22. Participants also recognized the importance of close cooperation with WG Ⅱ. Furthermore, there was a shared understanding on the need to further develop collaborative frameworks with Mongolia to build a more effective regional response system.

23. Overall, participants expressed general agreement with the proposed direction of the 4th MTAP. It was confirmed that detailed timelines and milestones would be finalized at the 19th meeting of WG I scheduled for 2026. In addition, the venue and schedule of the 19th meeting will be confirmed by the beginning of November 2025, whether to be held in China sequentially or together with the UNCCD COP17 scheduled to be held in Mongolia in August 2026.

24. Following a short break, Session VII was chaired by Ms. Young-Ah Kim and focused on summarizing the key outcomes of the meeting.

25. The participants reviewed the draft meeting summary collectively, and minor revisions were suggested to ensure accuracy and reflect the key points of the two-day discussions. The participants agreed that the draft would be further revised by the Secretariat and circulated to all members for final confirmation after the meeting.

26. The meeting concluded with closing remarks from representatives of China, Japan, Mongolia, and Korea. In their remarks, the representatives expressed appreciation for the efforts of all participants and the excellent organization of the host country. They also reaffirmed their commitment to continuing close collaboration under the WG I framework in the years ahead. The host country of next year's WG I meeting will be decided after discussions among 4 countries before the beginning of November 2025.

The 18th Meeting of Working Group I for Joint Research on Dust and Sand Storms

(Online & On site Meeting)

- **Date: June 30th and July 1st (Mon. and Tue.), 2025**
- **Venue: Mercure Seoul Magok Hotel (4F), Seoul, Republic of Korea**
- **Host: National Institute of Meteorological Sciences (NIMS)/KMA**
- **Language: English**
- **Online meeting Link: Webex**

◈ DAY 1 (June 30)

09:50 (UTC+9) Connection Test	
Session I	**Opening** Chair: Ms. Young-Ah Kim (KOREA)
10:00 - 10:05	**Opening Remarks** Dr. Sangbaek Kim, KOREA
10:05 - 10:10	**Introduction of participants**
10:10 - 10:15	**Adoption of the agenda**
10:15 - 10:25	**Group Photo**
Session II	**Taking stock of discussions and activities** Chair: Dr. Liang Li (CHINA)
10:25 - 10:35	**Review on the 17th Meeting of Working Group I** Dr. Atsushi Shimizu, JAPAN
10:35 - 10:50	**Introduction to current status and a new method of DSS data sharing** Dr. Hee-Jung Yoo, KOREA
Session III	**The study on DSS monitoring and modeling from each country** Chair: Dr. Atsushi Shimizu (JAPAN)
10:50 - 11:05	**Newly launched DSS research project in Japan** Dr. Keiya Yumimoto, JAPAN
11:05 - 11:20	**Assessing the potential of a low-cost pollen sensor for DSS event detection** Dr. Atsushi Matsuki, JAPAN
11:20 - 11:40	**DSS monitoring and air quality analysis in China (2023)** Dr. Liang Li, CHINA
11:40 - 12:00	**Current status of GK2A service products for DSS** Mr. Changbeom Cho, KOREA
12:00 - 12:15	**Current status and utilization of Korean DSS model (ADAM3) in KMA** Dr. Mi Eun Park, KOREA
12:15 - 12:35	**Spatial and temporal distribution of dust storm in Mongolia based on meteorological station data between 2000-2023** Dr. Purevjav Gomboluudev, MONGOLIA
12:35 - 14:00	**LUNCH**
Session IV	**Report from the countries on DSS2023 Events** Chair: Ms. Young-Ah Kim (KOREA)

14:00 - 14:20	**Observation and analysis of DSS2023 Case** Dr. Hee Jung Ko, KOREA
14:20 - 14:40	**The impact of sandstorms on the proportion of crustal material in $PM_{2.5}$ components** Ms. Yajing Li, CHINA
14:40 - 15:00	**Report on model analysis from Japan for the DSS2023 event and related international activities** Dr. Takashi Maki, JAPAN
15:00 - 15:20	**Selection of DSS2024 cases** Dr. Mi Eun Park, KOREA Dr. Atsushi Shimizu, JAPAN
15:20 - 15:40	**BREAK**
Session V	**Discussion on the detailed milestones for Mid-Term Action Plan (2026-2030)** Chair: Dr. Liang Li (CHINA)
15:40 - 17:00	**Proceeding report 2020-2025** Dr. Keiichi Sato (Japan Secretariat of WG I) **Continuation of previous WG I activities** **Encourage the expansion of data sharing scope and enhanced data sharing system** **Encourage the enhancement of the DSS forecast and early warning systems** **Enhancement of the streamline of DSS monitoring system** **Enhancement of cooperation with WG II** **Strengthening collaborative efforts with Mongolia** **Encouragement of the participation of outreach research groups**
17:00 -	**Banquet**

◈ DAY 2 (July 1)

10:00 (UTC+9) Opening	
Session VI	**Discussion on the detailed milestones for Mid-Term Action Plan (2026-2030) (Continue)** Chair: Ms. Yumi Yasuda (JAPAN)
10:00 - 11:00	**Continuation of previous WG I activities** **Encourage the expansion of data sharing scope and enhanced data sharing system** **Encourage the enhancement of the DSS forecast and early warning systems** **Enhancement of the streamline of DSS monitoring system** **Enhancement of cooperation with WG II** **Strengthening collaborative efforts with Mongolia** **Encouragement of the participation of outreach research groups**
11:00 - 11:20	**BREAK**
Session VII	**Summary** Chair: Ms. Young-Ah (KOREA)
11:20 - 12:20	**Making a Meeting summary**
12:20 - 12:30	**Closing Remarks** Representative from China Representative from Japan Representative from Mongolia Representative from Korea
12:30 - 13:30	**LUNCH**
13:30 - 17:30	**Technical Tour**

The list of participants of the 18th meeting of DSS WG I

Name	Country	Affiliation	Position	In-person Online
Sangbaek Kim	Korea	Global Atmospheric Watch and Research Division, National Institute of Meteorological Sciences/KMA	Director	In-person
Young-Ah Kim	Korea	Global Atmospheric Watch and Research Division, National Institute of Meteorological Sciences/KMA	Senior Researcher	In-person
Hee-Jung Yoo	Korea	Global Atmospheric Watch and Research Division, National Institute of Meteorological Sciences/KMA	Researcher	In-person
Mi Eun Park	Korea	Global Atmospheric Watch and Research Division, National Institute of Meteorological Sciences/KMA	Researcher	In-person
Hee Jung Ko	Korea	Global Atmospheric Watch and Research Division, National Institute of Meteorological Sciences/KMA	Researcher	In-person
Migyeong Kim	Korea	Global Atmospheric Watch and Research Division, National Institute of Meteorological Sciences/KMA	Researcher	In-person
Changbeom Cho	Korea	Satellite Analysis Division, National Meteorological Satellite Center/KMA	Senior Researcher	In-person
Yao Liu	China	Department of International Cooperation, Ministry of Ecology and Environment of the People's Republic of China (MEE)	Officer/ Director	Online
Liang Li	China	Air Quality Monitoring Division, China National Environmental Monitoring Center CNEMC/MEE	Senior Engineer	In-person
Yajing Li	China	Air Quality Monitoring Division, China National Environmental Monitoring Center CNEMC/MEE	Engineer	Online
Tomoyuki Izumi	Japan	Office for International Cooperation, Environmental Management Bureau, Ministry of the Environment	Director	Online
Yumi Yasuda	Japan	Office for International Cooperation, Environmental Management Bureau, Ministry of the Environment	Deputy Director	In-person
Ayano Kotani	Japan	Office for International Cooperation, Environmental Management Bureau, Ministry of the Environment	Technical Officer	Online
Katsuyuki Yamada	Japan	Environmental Pollution Control Office, Environmental Management Bureau, Ministry of the Environment	Deputy Director	Online
Takatoshi Yoshimoto	Japan	Environmental Pollution Control Office, Environmental Management Bureau, Ministry of the Environment	Deputy Director	Online

Taketo Mori	Japan	Biodiversity Strategy Office, Biodiversity Policy Division, Nature Conservation Bureau, Ministry of the Environment	Technical officer	Online
Atsushi Shimizu	Japan	Regional Environment Conservation Division, National Institute for Environmental Studies	Prime Senior Researcher	In-person
Takashi Maki	Japan	Department of Atmosphere, Ocean, and Earth System Modeling Research, Meteorological Research Institute	Section Head	In-person
Keiya Yumimoto	Japan	Research Institute for Applied Mechanics, Kyushu University	Professor	In-person
Atsushi Matsuki	Japan	Institute of Nature and Environmental Technology, Kanazawa University	Associate Professor	In-person
Gomboluudev Purevjav	Mongolia	Information and Research Institute of Meteorology, Hydrology and Environment	Scientific Secretary	In-person
Bayartsetseg Sukhee	Mongolia	Integrated Policy Planning Department of the Ministry of Environment and Climate Change	Senior Specialist	In-person

(Meeting Secretariats)

Keiichi Sato	Japan	Asia Center for Air Pollution Research, Japan environmental Sanitation Center	Head, Atmospheric Research Dept. (Secretariat for Japanese Delegation)	In-person
Mari Futami	Japan	Asia Center for Air Pollution Research, Japan environmental Sanitation Center	Senior Researcher, Atmospheric Research Dept. (Secretariat for Japanese Delegation)	In-person

Annex 2.
Meeting agenda and summary of the Extended Workshop between WG I and WG II for Joint Research on Dust and Sand Storms

Summary Note of Outreach Session of Tripartite Environmental Ministers Meeting the Working Group I for Joint Research On Dust and Sand Storms Extended Workshop Online Meeting, Tokyo, Japan, 30 September 2021

1. Tripartite Environmental Ministers Meeting (TEMM) Working Group I (WG I) for Joint Research on Dust and Sand Storms (DSS) held the Extended Workshop as an online event which consisted of two sessions, the Outreach Session and the Limited Session, on 30 September 2021. This note is prepared by the Secretariat of the Workshop to summarize the results of the Outreach Session. The program of Outreach Session is in Annex 1.

2. The Outreach Session accommodated the WG I and WG II members from Japan, Korea and China as well as invited representatives from Mongolia, and about 60 researchers and experts from external organizations from 12 countries as audiences, while the Limited Session was held with the participants limited to the WG I and WG II members and invitees from Mongolia.

3. The objectives of the Outreach Session were to share the latest research on DSS and to discuss sub-seasonal to seasonal (S2S) forecasts, long-term variations of DSS and future prospects with experts and scientists who would be interested in the theme over the world.

4. The Session was opened with the remarks by Mr. MATSUZAWA Yutaka, Director General of Environment Management Bureau, Ministry of the Environment, Japan (MOEJ). After expressing his gratitude to all the participants around the world, he introduced the TEMM DSS Joint Research activities and stated that the Workshop would contribute to the progress of climate science such as further development of climate models. He also announced that the TEMM DSS Online Portal had just launched to share accumulated research information and data on DSS though TEMM Joint Research.

5. The Keynote Presentation was delivered by Mr. MAKI Takashi, Meteorological Research Institute, Japan, and Dr. MIKAMI Masao, Japan Meteorological Business Support Center, Japan. The presentation showed that it would be extremely valuable information for taking countermeasures in arid regions if the Coupled Model Intercomparison Project Phase 6 (CMIP6) results could be used for downscaling and future prediction of dust storm intensity and changes in hydrological processes in mountains and basins. They concluded the presentation by saying that the TEMM DSS Joint Research Project was an international collaborative project for contributing to the region suffered from DSS, and future activities were expected.

6. The Keynote Presentation followed by 6 presentations from by Dr. Huizheng CHE, World Meteorological Organization Sand and Dust Storm Warning Advisory and Assessment System Regional Centre for Asia, Dr. Liang LI, China National Environmental Monitoring Centre, China, Ms. Woojeong LEE, National Institute of Meteorological Sciences, Korea, Mr. Davaanyam ENHKBAATAR, Information and Research Institute of Meteorology Hydrology and Environment, Mongolia, Dr. DIAO Zhaoyan, Chinese Research Academy of Environmental Sciences, China, Dr. SHIMIZU Atsushi, National Institute for Environmental Studies, Japan, and Dr. Gilsang JEONG, National Institute of Ecology, Korea. Abstracts of each presentation are in Annex 2.

7. After the presentations, Relay Comments and Q&A session were conducted by the keynote speaker and presenters with a facilitator Mr. OHMURA Takashi, Overseas Environmental Cooperation Center, Japan.

The speaker and presenters pointed out the importance of joint research for advancing the DSS research. The keynote Speaker, Mr. Maki suggested that: studying DSS from a long-term perspective helped us to deepen our understanding of the interaction between aerosols (DSS) and the Earth system, and by combining and strengthening the knowledge of TEMM DSS WGI and WGII, we might be able to improve our understanding DSS emissions and thereby advance Earth system models.

8. The Outreach Session was closed with remarks by Mr. NAGASAKA Yuichi, Director of Air Environment Division, MOEJ. He thanked all the participants for their attendance and insightful discussions. He stated that the climate change mentioned over the Session was a common challenge to all the people and cooperative activities such as TEMM DSS were a key for the solution.

■ **AGENDA**

09:30-10:30 (UTC+9) Open the webex meeting room for technical check

Session 1: OUTREACH SESSION (3 hrs)

MC. Ms. Hiroka WATARAI, Overseas Environmental Cooperation Center, Japan

To share the latest research on sub-seasonal to seasonal (S2S) forecasts and long-term variations of DSS, with participations of member of DSS WG1 and researchers and experts from external organizations.

10:30-10:35 Opening (5mins)

Mr. MATSUZAWA Yutaka, Director General of Environment Management Bureau, Ministry of the Environment, Japan

10:35-11:00 Keynote speech (25mins)

Long-term variations of climate system and adaptation measures on arid land

Mr. MAKI Takashi, Meteorological Research Institute, Japan

Dr. MIKAMI Masao, Japan Meteorological Business Support Center, Japan

To raise issues and have a common understanding on the relationship between DSS and time series analysis of climate system, which is a new research theme in DSS WGI set in 2020

Presentations (15mins x max 7 presentations)

To share the latest research on DSS and sub-seasonal to seasonal forecast and long-term variation, and the related research to this theme. (*The presentation order is subject to change after fixing all presentation contents.)

- **Longterm variation of SDS events of China over two past decades**
- Dr. Huizheng CHE, World Meteorological Organization Sand and Dust Storm Warning Advisory and Assessment System Regional Centre for Asia
- **Dust Monitoring in Northern China and Statistics of Dust And Storms since 2015**

Dr. Liang LI, China National Environmental Monitoring Centre, China

- **Seasonal Asian Dust Forecasting Using GloSea5-ADAM**

Ms. Woojeong LEE, National Institute of Meteorological Sciences, Korea

11:45-11:55 Coffee Break

- **Dust monitoring and modelling in Mongolia**

Mr. Davaanyam Enkhbaatar, Information and Research Institute of Meteorology Hydrology and Environment, Mongolia

- **The Temporal and Spatial Dynamics of Desertification in the Adjacent Steppe of China and Mongolia**

Dr. DIAO Zhaoyan, Chinese Research Academy of Environmental Sciences, China

- **Prediction and Detection of Variability in Asian Dust Emission and Transport**

Dr. SHIMIZU Atsushi, National Institute for Environmental Studies, Japan

- **New start: What we will do there in Mongolia**

Dr. Gilsang JEONG, National Institute of Ecology, Korea

12:55-13:25 Relay comments from presenters and Q&A from audience (30 mins)

Chair: Mr. OHMURA Takashi, Overseas Environmental Cooperation Center, Japan

Presenters make comments on the current trend of DSS research and future prospect of the DSS research related to sub-seasonal to seasonal (S2S) forecast and long-term variation. After the relay comments, there will be Q&A time from audience.

<Guiding Questions>

1) What benefits can be expected from studying DSS from sub-seasonal to seasonal and long-term perspective?
2) What do you expect from international cooperation activities on DSS, such as TEMM DSS?

13:25-13:30 Closing (5mins)

Mr. Yuichi NAGASAKA, Director of Air Environment Division, Ministry of the Environment, Japan

13:30-14:30 <Lunch break>

Keynote Presentation

Long-term variations of climate system and adaptation measures on arid land

Mr. MAKI Takashi, Meteorological Research Institute, Japan

Dr. MIKAMI Masao, Japan Meteorological Business Support Center, Japan

Since the industrial revolution, the earth has been consistently warming, and extreme weather events tend to become more frequent. International intercomparison experiments (CMIP) using Earth system models have been conducted by research institutes around the world, and the results of the sixth experiment (CMIP6) have now been published. It is very important to use the results of these model predictions in the formulation of adaptation and mitigation measures, which are two important policies to combat global warming. For the former, numerical models with relatively high resolution using downscaling techniques have been used, and for the latter, global-scale numerical models have been used. In arid regions, the IPCC report suggests that drought will increase in the future, and more accurate knowledge is required. On the other hand, these arid regions lack the necessary resources to carry out the various steps (future projections, impact assessment, adaptation measures, and social implementation) to implement adaptation measures. If the results of CMIP6 in the arid regions of Northeast Asia can be used for downscaling and future prediction of dust storm intensity and changes in hydrological processes in mountains and basins, it will be extremely valuable information for arid regions. The occurrence of DSS is extremely sensitive to meteorological and soil conditions in arid regions. The TEMM DSS Joint Research Project is an international collaborative project that is being carried out against this background, and its results are expected.

Presentations

Long-term Variation of SDS Events in Northern China over Two Past Decades

Huizheng Che1, Ke Gui1, Linchang An2, Wenrui Yao1, Yaqiang Wang1, Xiaoye Zhang1
1 State Key Laboratory of Severe Weather & Key Laboratory of Atmospheric Chemistry of CMA, Chinese Academy of Meteorological Sciences, Beijing, 100081, China
2 National Meteorological Center, CMA, Beijing 100081, China

Dust aerosols play a vital role in the global and regional climate through its direct, indirect, and semidirect effects. Based on ground observations, satellite remote sensing and aerosol reanalysis, it was found that the decrease in wind speed (WS) and the increase in precipitation, soil moisture and vegetation cover have directly contributed to the decrease in the dust storm frequency (DSF) since 2000. Among these drivers, the weakening of WS was found to be the dominant factor leading to the decrease in spring DSF over northern China (NC) during recent decades, contributing 79.9, 67.7, and 31.2% of the variation in Northwestern China (NWC), North-central China (NCC) and Northeastern China (NEC), respectively. Moreover, we found that the inter-annual variation of DSF in NC is not only controlled by meteorological factors, but also affected by the long-distance transport of dust aerosols emitted from the upstream dust source areas. Although a remarkable reduction in DSF in the past several decades, two unexpectedly extreme SDS events occurred on March 15–20, 2021 and March 27–29, 2021, greatly degrading air quality over large areas of northern China, have reawakened widespread concern. The MODIS-retrieved dust optical depth (DOD) data registered this two massive SDS events as the most intense episode in the same period in history over the past two decades. This two extreme SDS events are associated with local meteorological anomalies that favor enhanced dust emissions in the Gobi and southern Mongolia. The early melting of spring snow caused by surface temperature anomalies, together with the negative soil moisture anomalies induced by reduced precipitation, formed drier and barer soil surfaces, which allowed enhanced emissions of dust into the atmosphere by intense surface winds generated by the Mongolian cyclone.

Dust Monitoring in Northern China and Statistics of DSS 2015 -2019

Dr. Liang LI, China National Environmental Monitoring Centre, China

It is reported that there were 12 large-scale dust weather processes across the country in 2019 and the number of days that DSS occurred in China is 28 days. The accumulative number of days that air quality exceeded the standard is 204 days in 2018, a decrease of 60% over the same period of year 2017. The climate factors are not conducive to dust and sand storms in 2019. From 2015 to 2019, China experienced 78 large-scale sand and dust processes, an average of 15.6 times per year, and an average of 43.4 days of cumulative impact per year.

Seasonal Asian Dust Forecasting Using GloSea5-ADAM

Woojeong Lee, Sang-Boom Ryoo, Yun-Kyu Lim, Kyung-On Boo National Institute of Meteorological Sciences

Asian dust events originated in the deserts or arid areas over Northern China and Mongolia give a serious social-economic impacts on Asian countries including Korea. To manage its impacts in advance, it is important to accurately predict how many dust events will be occurred in the source regions during springtime, main season of Asian dust events. For the seasonal forecasting of Asian dust events, the National Institute of Meteorological Sciences (NIMS) has recently developed the GloSea5-ADAM, which incorporating the Asian Dust and Aerosol Model (ADAM)'s emission algorithm into Global Seasonal Forecasting Model version 5 (GloSea5), and conducted in operationally. GloSea5 is a fully coupled ocean-atmosphere-land-sea ice ensemble prediction system. The atmospheric model horizontal resolution is 0.83° longitude x 0.55° latitude (corresponding to approximately 60 km in the midlatitudes), with 85 vertical levels extending into the stratosphere. The performance of GloSea5-ADAM predicting Asian dust events is evaluated during spring (from March to May) seasons of the 26-yr hindcast period from 1991 to 2016. The hindcast consists with mean of a 9-member ensemble outputs, which is started on three days centered around 1st, 9th, and 17th February, respectively. We also examine the skill scores of real-time seasonal Asian dust forecasts conducted during the springs of 2017-2021. KMA has been making an effort to improve seasonal Asian dust forecast skill and related upgrade will be introduced.

Dust monitoring and dust modelling in Mongolia

Mr. Davaanyam Enkhbaatar, Information and Research Institute of Meteorology Hydrology and Environment, Mongolia

In 2017, ADAM-Haze model was installed at NAMEM in Mongolia. The particle size in ADAM model is divided into three different classes for the research convenience: Size 1 (the particle diameter, D 2.23 μm), Size 2 (2.23 μm D 10 μm) and Size 3 (10 μm D 74 μm). In this research, the simulation of ADAM model 72 hours forecast on 14th March 2021 was made. According to the simulation results during the dust storm, it was found that the ratio of particles size was 6.6% of size 1, 57.8% of size 2, and 35.5% of size 3. The maximum concentration of larger particle Size 3 was of about 800 μg/m³ in 1 kilometer. Medium particle Size 2 was maximum concentration about 1000 μg/m³ in 2.4 kilometer. These results were one of the examples of Asian dust (yellow sand) of the Gobi Desert, its size and the vertical distribution of the cases. It was also mentioned that DSS monitoring network in Mongolia was in necessity to repair equipment (most of the stations are not working) and needs to expand monitoring sites for further research.

The Temporal and Spatial Dynamics of Desertification in the Adjacent Steppe of China and Mongolia

Dr. DIAO Zhaoyan, Chinese Research Academy of Environmental Sciences, China

Land desertification is one of the most important driving factors leading to the frequent occurrence of dust and sandstorms (DSS) in the Adjacent Steppe of China and Mongolia (ASCM). To reveal the dynamic changes of land desertification and its mechanism in ASCM, we interpreted Landsat images and MODIS image of 2001, 2010 and 2020, and constructed desertification monitoring difference index (DDI) to analyze the temporal and spatial changes of land desertification in ASCM over the past 20 years. The results showed that: (1) the land desertification in ASCM presented the spatial characteristics of 'high in the west and low in the east, high in the south and low in the north'. Among them, the typical steppe in Sukhbaatar province of Mongolia was dominated by non- desertification (ND) and light desertification (LD), the desert steppe in Dornogovi province of Mongolia was dominated by extreme severe desertification (ESD) and severe desertification (SD), while the desert steppe in Inner Mongolia Autonomous Region of China was dominated by moderate and severe desertification (MD & SD). (2) in the past 20 years, the area of desertification in ASCM had showed the reversal trend, and the net reversal area (the difference between the reversal area and the aggravated area) was

about 147,220 km2, of which the reversal area during 2001-2010 accounted for 34.89%, while that during 2010-2020 accounted for 65.11%; (3) the desertification reversal pattern in ASCM generally presented the 'high in the east and low in the west. The regions with the most obvious reversal trend were mainly distributed in the desert steppe of Inner Mongolia Autonomous Region of China; (4) there was a significantly positive correlation between the degree of desertification reversal and annual precipitation ($P<0.01$), indicating that the increase in precipitation contributed to the desertification reversal in ASCM. The increase in precipitation fluctuations in the past 20 years had determined the overall reversal of land desertification in ASCM. Meanwhile, a number of ecological protection projects implemented in the adjacent grassland areas of China had effectively accelerated the rate of desertification reversal. This study showed that the ecological restoration projects could effectively restrict the development of desertification. It is necessary to strengthen cooperation with neighboring countries to prevent land desertification and DSS in ASCM.

Prediction and Detection of Variability in Asian Dust Emission and Transport: Introduction of research activities based on ERTDF5-2001 "Prediction and Detection of Variability in Asian Dust Emission and Transport Affected by Climate Change"

Dr. SHIMIZU Atsushi, National Institute for Environmental Studies, Japan

Research activities based on the competitive research funding ERTDF5-2001 "Prediction and Detection of Variability in Asian Dust Emission and Transport Affected by Climate Change" (FY2020-2022) is introduced with their results. This research project is conducted by members of TEMM-DSS WG1/2, and consists of three sub-themes. The 1st sub-theme is related to proposing a sustainable monitoring method of DSS to capture the long-term variation of DSS. The 2nd one is related to the improvement of the numerical prediction of DSS under the future climate. And the 3rd one is related to supplying information to the modeling group about the surface conditions including vegetation and soil conditions in the source region. This project is a good practice of collaboration between TEMM DSS WG1 and WG2 in Japan.

New start: What we will do there in Mongolia

Dr. Gilsang JEONG, National Institute of Ecology, Korea

After being in China area for studying DSS (Dust and Sand Storm), we are going to move to Mongolia for doing the same thing. However, due to the Covid-19 pandemic, we have yet to meet many prerequisites.

Here I will briefly discuss first what we have done in China, and then present what we will do in Mongolia. To fulfill our goal, we will have to find appropriate study sites with relatively intact vegetation, with desert sands and with some devastated land largely because of human activities. We also need to find local researchers who can assess the study sites and also are cooperative, motivated with expertise. We will develop what research we will do there how we do the research etc. I also have to find a PI who will take over the duty for the project. Finally, we will have to make the project stable with the cement financial status and man powers.

By doing so, we think that we all achieve the goal of the project:

- Understanding the effects of DSS on living things
- Suggesting improvement measures
- Supporting relevant policies

Extended Workshop for Joint Research on Dust and Sand Storms (DSS) to strengthen collaboration between WG II and WG I in 2023

■ OUTLINE OF THE EXTENDED WORKSHOP

Date: Tuesday, 7 November 2023
Time: 10:30-17:20 (JST/KST) / 9:30-16:20 (CST)
Host: Ministry of the Environment, Japan (MOEJ)
Format: Hybrid (Tokyo and Online)
Venue: TKP Shimbashi Conference Center
Language: English

■ AGENDA

Moderator: Mr. OHMURA Takashi, Overseas Environmental Cooperation Center, Japan (OECC) [Japan]	
10:30-10:40	**Opening Remarks** Mr. KAMEI Yu, Director for International Cooperation, International Cooperation Office, Environmental Management Bureau, Ministry of the Environment, Japan **Introduction of Participants** **Adoption of the Agenda** **Group Photo**
10:40-11:05	**Keynote by Japan** **Life History Strategy of Evergreen Shrub, Juniperus Sabina, Growing in the Sand Shifting Environment** Dr. YOSHIKAWA Ken, Okayama University
11:05-11:20	**Presentation (DSS WGII, Korea)** **An International Collaborative Study on the Yellow Dust Reduction and Ecological Restoration** Dr. MUN Saeromi, National Institute of Ecology
11:20-11:35	**Presentation (DSS WGII / WGI, Japan)** **Collaboration of WGI&2 in Japan; Research Project "Prediction and Detection of Variability in Asian Dust Emission and Transport Affected by Climate Change"** Dr. SHIMIZU Atsushi, National Institute of Environmental Studies, Japan Dr. OKURO Toshiya, The University of Tokyo Dr. KUROSAKI Yasunori, Tottori University
11:35-11:50	**Presentation (DSS WGI China)**

	Activities of Working Group I for Joint Research on Dust and Sand Storms in 2023 Dr. LI Liang, China National Environmental Monitoring
11:50-12:00	**Q&A**
12:10-12:25	**Presentation (DSS WGII, China)** **Developing Environmental Cooperation Platform in Northeast Asia for Joint Prevention and Control of Sandstorm under the '3+X' Cooperation Mode** Dr. ZHENG Zhirong, Chinese Research Academy of Environmental Sciences
12:25-12:40	**Presentation (Invited Speaker)** **Preliminary Results of SDS Vulnerability Assessment and Dust Vulnerability Index Development** Dr. MANDAKH Nyamtseren, Institute of Geography and Geoecology Mongolian Academy of Sciences
12:40-12:55	**Presentation (Invited Speaker)** **Vegetation Restoration for Mitigation of Dust and Sandstorm in China - A Case in Horqin Sandy Land in East Inner- Mongolia** Dr. ZHAO Xueyong, Northwest Institute of Eco-environment and Resources, Chinese Academy of Sciences / Visiting Professor of The University of Tokyo
12:55-13:10	**Presentation (Invited Speaker)** **The United Nation Coalition on Combating Sand and Dust Storms: Fostering Global Action and International Collaboration** Dr. Feras ZIADAT, Food and Agriculture Organization of the United Nations
13:10-13:25	**Presentation (Invited Speaker)** **Forest restoration and Combating Desertification Actions and the "Billion Tree National Movement-2030" of Mongolia** Dr. BATKHUU Nyam-Osor, Office of the President of Mongolia
13:25-13:35	**Q&A**
13:35-15:00	Lunch hosted by Japan *Parallel group members will be arranged by the secretariat.

15:00-15:10	**Guidance** Chair: Dr. OKURO Toshiya, The University of Tokyo 1) Purpose of the Breakout Parallel Session; and 2) How to facilitate the session for brainstorming (Topics and facilitators, summary presentations for the wrap-up session, etc.)
15:10-16:40	**Breakout Parallel Session** **<u>Guiding Questions:</u>** 1) What are the lessons to be learned from existing cases of collaboration (e.g. DSS WGI and WGII Japan joint research, UN-Coalition on SDS)? 2) What are the gaps in promoting collaboration and how can they be overcome? Participants will split into two/three small groups and conduct a 90 min in-depth discussion. They could focus on cross cutting topics or common interests, which may include policy support, policy implications, scientific themes to jointly resolve, potential areas for synergy among the DSS WGII and WGI domains, and potential collaboration between the DSS WGII and WGI including with external partners with a view to plan for the next MTAP. (e.g. Effect of vegetation on DSS mitigation and its assessment method including effective usage of DSS monitoring data collected by the DSS WGI members.)
16:40-17:00	**Break for Preparing Wrap-up Materials by Each Facilitator** Facilitators (and some friends) of each group are expected to prepare a short presentation material by summarizing the discussion in the breakout session for the wrap-up session during this break time.
17:00-17:15	**Wrap-up Session** To summarize the discussion and the Outreach Webinar. - Wrap-up comments from Breakout Session Facilitators (5' x 2 facilitators) - The Chair's summary statement (5') Note: The wrap up reporting and the Chair's summary will be compiled into a summary note as an output of the collaboration work. It will be further developed and finalized through email communications lead by Japan after the workshop. Further, the finalized output will be posted on the DSS Online Portal.
17:15-17:20	**Closing** Dr. YOSHIKAWA Ken, Okayama University

List of Participants of the Extended Workshop for Joint Research on Dust and Sand Storms (DSS) to strengthen collaboration between WG II and WG I in 2023

First Name	Last Name	Title	Organization	Department	Position
Administrative Officers: Japan					
Yu	KAMEI	Mr.	Ministry of the Environment	International Cooperation Office, Environmental Management Bureau	Director for International Cooperation
Kayoko	GOMI	Ms.	Ministry of the Environment	International Cooperation Office, Environmental Management Bureau	Assistant Director
Yumi	YASUDA	Ms.	Ministry of the Environment	International Cooperation Office, Environmental Management Bureau	Section Chief
Katsuyuki	YAMADA	Mr.	Ministry of the Environment	Environmental Pollution Control Office, Environmental Management Bureau	Assistant Director
Takatoshi	YOSHIMOTO	Mr.	Ministry of the Environment	Environmental Pollution Control Office, Environmental Management Bureau	Researcher
Kaori	HASHIDATE	Ms.	Ministry of the Environment	Environmental Management Division, Environmental Management Bureau	Staff
Ryuji	KANEDA	Mr.	Ministry of the Environment	Environmental Management Division, Environmental Management Bureau	Staff
Administrative Officers: Korea					
Younghun	CHO	Mr.	Ministry of Environment		Deputy Director
Suyeon	JI	Ms.	Ministry of Environment		Assistant Director
Experts: Japan (WGII)					
Ken	YOSHIKAWA	Dr.	Okayama University		Professor Emeritus

Toshiya	OKURO	Dr.	The University of Tokyo		Professor
Yasunori	KUROSAKI	Dr.	Tottori University	Arid Land Research Center	Professor
Experts: Japan (WGI)					
Atsushi	SHIMIZU	Dr.	National Institute for Environmental Studies, Japan	Regional Atmosphere Research Section	Chief Senior Researcher
Nobuo	SUGIMOTO	Dr.	National Institute for Environmental Studies, Japan	Earth System Division	Visiting Researcher
Atsushi	MATSUKI	Dr.	Kanazawa University	Institute of Nature and Environmental Technology	Associate Professor
Experts: Korea (WGII)					
Saeromi	MUN	Dr.	National Institute of Ecology	Ecological Restoration Team	Associate Researcher
Seungwon	LEE	Mr.	National Institute of Ecology	Ecological Restoration Team	Researcher
Experts: China (WGII)					
Zhirong	ZHENG	Dr.	Chinese Research Academy of Environmental Sciences	Institute of Ecology Research	Director/ Associate Researcher
Zhaoyan	DIAO	Dr.	Chinese Research Academy of Environmental Sciences	Institute of Ecology Research	Associate Professor
Qian	WU	Dr.	Chinese Research Academy of Environmental Sciences	International Cooperation Center	Project Officer
Experts: China (WGI)					
Liang	LI	Dr.	China National Environmental Monitoring	Ambient Air Quality Monitoring Department	Senior Engineer
YiLin	ZHAO	Dr.	China National Environmental Monitoring	Ambient Air Quality Monitoring Department	Senior Engineer

Invited Speakers					
Nyam-Osor	BATKHUU	Dr.	Office of the President of Mongolia		Advisor to the President on Environment and Green Development Policy
Nyamtseren	MANDAKH	Dr.	Institute of Geography and Geoecology Mongolian Academy of Sciences		Researcher
Purevee	SODGEREL	Dr.	Agricultural University of Darkhan	Environmental Science	Head of Department
Feras	ZIADAT	Dr.	Food and Agriculture Organization of the United Nations (FAO)		
Xueyong	ZHAO	Dr.	Northwest Institute of Eco-environment and Resources, Chinese Academy of Sciences / The University of Tokyo		Professor / Visiting Professor
Secretariat					
Takashi	OHMURA	Mr.	Overseas Environmental Cooperation Center	Project Development Department	Senior Advisor
Masae	SUMIKOSHI	Dr.	Overseas Environmental Cooperation Center	Project Development Department	Senior Researcher
Yuko	YOSHIDA	Ms.	Overseas Environmental Cooperation Center	Project Development Department	Researcher

Satoko	OHARA	Ms.	Overseas Environmental Cooperation Center	Project Development Department	Senior Coordinator
Tomomi	ITO	Ms.	JAPAN NUS CO., LTD.	Energy Consulting Department IT Solution Unit	Consultant
Kazuyuki	MAIWA	Dr.	JAPAN NUS CO., LTD.	Energy Consulting Department IT Solution Unit	Consultant

Summary Note of
Dust and Sand Storms (DSS) Working Group II (WGII)
Extended Workshop

Hybrid Meeting, Tokyo, Japan and online,
7 November 2023

1. Tripartite Environmental Ministers Meeting (TEMM) Working Group II (WGII) for Joint Research on Dust and Sand Storms (DSS) held the Extended Workshop as a hybrid event including two main sessions, the presentation session and the breakout parallel session, on 7 November 2023. This summary note is prepared by the Secretariat of the Workshop to summarize the results of each session.

2. The objective of the Workshop was to facilitate the collaborations between the DSS WGII and WGI with the participation of both DSS WGII and WGI members including Mongolia. Aiming to learn more efforts on combating DSS made by outside of TEMM DSS Working groups, speakers from international/regional organizations were also invited.

3. The Extended Workshop was opened with a remark by Mr. KAMEI Yu, Director for International Cooperation, International Cooperation Office, Environmental Management Bureau, Ministry of the Environment, Japan (MOEJ). After expressing his gratitude to all the participants, he congratulated that Dr. SHIMIZU Atsushi of DSS WGI Japan and Dr. MUN Saeromi of DSS WGII were awarded the TEMM Environment Award for their enormous contribution to the TEMM Environment Cooperation. Also, he showed his expectation to this Workshop to make fruitful discussion to make further collaboration for the better air quality in East Asia.

4. The keynote was delivered by Dr. YOSHIKAWA Ken, Okayama University, Japan. Based on a review published in Landscape and Ecological Engineering in 2021, Dr. YOSHIKAWA showed that the physiological and ecological features of the growth and regeneration processes of evergreen coniferous shrub tree species, Juniperus sabina, which grows in the Mu Us Sandy Land in northern China where desertification has progressed over time.

5. In the presentation session, 8 presentations from the following DSS WGII and I members and invited speakers were delivered to exchange views and discussed on technical and scientific aspects on DSS occurrence mechanisms, DSS countermeasures how to mitigate DSS occurrences and its impacts; as well as their implications on the policy relevant matters with a view to enhance and identify scientific collaboration on DSS countermeasures to tackle the DSS issues: Dr. MUN Saeromi, National Institute of Ecology, Korea, members of the Japan's collaborative research project (Dr. SHIMIZU Atsushi, National Institute of Environmental Studies, Japan, Dr. OKURO Toshiya, the University of Tokyo, Dr. KUROSAKI Yasunori, Tottori University), Dr. LI Liang, China National Environmental Monitoring Centre, and Dr. ZHENG Zhirong, Chinese Research Academy of Environmental Sciences, Dr. MANDAKH Nyamtseren, Institute of Geography and Geoecology Mongolian Academy of Sciences, Dr. ZHAO Xueyong, Northwest Institute of Eco-environment and Resources, Chinese Academy of Sciences / Visiting Professor of the University of Tokyo, Dr. Feras ZIADAT, Food and Agriculture Organization of the United Nations and Dr. BATKHUU Nyam-Osor, Office of the President of Mongolia. The abstract of

the presentations is attached in Annex 1.

6. In the breakout parallel session, the participants were divided into two groups (Group A and Group B) and conducted a 90-minute in-depth discussion. The group discussion was facilitated by Dr. OKURO Toshiya, the University of Tokyo and Dr. KUROSAKI Yasunori, Tottori University according to the two guiding questions: 1) What are the lessons to be learned from existing cases of collaboration (e.g. DSS WGI and WGII Japan joint research, UN-Coalition on SDS)? and 2) What are the gaps in promoting collaboration and how can they be overcome?. The session was wrapped up with the discussion summaries from each group reported by the facilitators. The discussion summary is attached in Annex 2.

7. The Workshop was closed with a remark of Dr. YOSHIKAWA Ken, Okayama University. He thanked all the participants for their attendance and active discussions by underlining that: 1) each of the presentations contained important results and suggestions which provided many ideas contributing to further DSS WGII and WGI collaboration and 2) the breakout parallel session was a good opportunity for all the participants to identify high-priority issues to strengthen the collaboration between DSS WGII and WGI. He concluded his closing remarks hoping that the fruitful discussions in this Workshop would contribute to the discussion in the 16th DSS WGII meeting which was held the following day.

Presentation Abstract

Keynote

Life History Strategy of Evergreen Shrub, *Juniperus Sabina,*

Growing in the Sand Shifting Environment

Dr. YOSHIKAWA Ken, Okayama University

Based on a review published in Landscape and Ecological Engineering in 2021, the physiological and ecological features of the growth and regeneration processes of evergreen coniferous shrub tree species "*Juniperus sabina*" which grows in the Mu Us Sandy Land in northern China where desertification has progressed over time were introduced.

Many arid land plants including *Juniperus sabina* are adopting the environment in arid climate and can play an important role in protecting the deserted area but also assessing the climate change impact on the environment. In order to deepen the understanding of the climate change impact, further research in larger scale is required, which also is expected to contribute to the DSS WGI activity.

Presentations: WGII and WGI members

An International Collaborative Study on the Yellow Dust Reduction and Ecological Restoration

Dr. MUN Saeromi, National Institute of Ecology

The impacts of dust and sandstorm (DSS), a transboundary problem, are not limited to the countries of origin. The research on dust storm in Mongolia is not only scientific but also social implications. Under the MOU to promote biodiversity conservation and research transboundary environmental issues in Northeast Asia, the National Institute of Ecology and the National University of Mongolia have been implementing the international joint research for yellow dust storm reduction through restoration in desertified area in East Asia.

In this research, nature-based solutions (NbS) is applied to restore Mongolia's degraded ecosystem and reduce dust and sand storm. The seed ball method has been examined to verify seed germination in the three research sites (Zunnkhara, Mandalgobi and Bayan Zag) collecting data on survival rates through continuous monitoring. Based on the field surveys conducted and the ongoing monitoring activities, the suitability of the target plants (Suaeda glauca and Haloxylon ammodendron) will be assed and additional plant species will be considered to apply in the research to enhance the on-site restoration.

Collaboration of WGI&2 in Japan; Research Project “Prediction and Detection of Variability in Asian Dust Emission and Transport Affected by Climate Change”

Dr. SHIMIZU Atsushi, National Institute of Environmental Studies, Japan Dr.
OKURO Toshiya, The University of Tokyo
Dr. KUROSAKI Yasunori, Tottori University

Japanese experts of DSS WGI/WGII conducted the joint research project "Prediction and Detection of Variability in Asian Dust Emission and Transport Affected by Climate Change" in FY2020-2022 which was supported by the Ministry of the Environment, Japan to promote studies along with the both working groups of the MTAP2020-2024. The project consists of 3 sub themes (dust monitoring, modeling, source region) and those sub theme are coupled interactively to understand the mechanism of generation and transportation of Asian dust and to forecast chances of Asian dust that may come with global warming.

In the sub theme of dust monitoring, effects of the climate change on the DSS emission and transport were investigated based on the monitoring and modeling in the atmosphere and the surface conditions at the source region of DSS.

In the sub theme of modeling, numerical simulations were performed from 1850 to 2100 using five common warming scenarios and the results of the future projection experiment were provided to sub theme 1.

In the sub theme of source region, application of stone effect to model (NHM-Chem-Dust) for wide area estimation was studied and the results provided to the sub theme 2 made the accuracy of the model improved. Also, effects of spatial distribution of shrubs on the relationships among saltation, roughness, and vegetation structure and development and validation of vegetation indicators for saltation occurrence were studied in this sub theme.

In the assessment of the effect of vegetation on wind erosion in shrub-dominated vegetation, it was found that it is important to take spatial distribution of shrubs into account and the threshold of vegetation cover at which wind erosion occurs might increase under heterogeneous vegetation conditions. By further validation of the effectiveness and versatility of the new indicators for other vegetation types, it is expected to detect vegetation thresholds related to wind erosion control and to propose optimal plant species and planting arrangement.

Activities of Working Group I for Joint Research on Dust and Sand Storms in 2023

Dr. LI Liang, China National Environmental Monitoring

The 15th meeting of the Working Group I (WGI) for joint research on dust and sand storms (DSS) under the Tripartite Environment Ministers Meeting (TEMM) was held at Jeju, Korea from 1-2 November in hybrid format. 30 members of the DSS WGI from China, Korea and Japan including Mongolia participated in the meeting in person and online.

In this meeting, the three countries including Mongolia agreed on the three periods of the data sharing that they contribute every year: 1) 15-20 March 2021, 2) 25 March to 2 April 2021 and 3) 5-10 May 2021. Korea as the host country of the 14th DSS WGI meeting shared the outline of the directors general meeting for TEMM 24 which was held in Nagoya, Japan on 25-26 September 2023. For the 16th DSS WGI meeting, China will host the meeting in online format on 5 December 2023.

Developing Environmental Cooperation Platform in Northeast Asia for Joint Prevention and Control of Sandstorm under the '3+X' Cooperation Mode

Dr. ZHENG Zhirong, Chinese Research Academy of Environmental Sciences

Northeast Asia is one of the most affected areas in the world by Sand and Dust Storms (SDS), where SDS seriously threatens the environment, agriculture, food security, human health and etc. The more frequent SDS makes an urgent need for regional cooperation among China, Japan, Korea and Mongolia, as well as the related countries and relevant stakeholders.

Chines Research Academy of Environment Sciences (CRAES) held the workshop entitled "Developing Environmental Cooperation Platform in Northeast Asia for Joint Prevention and Control of Sandstorm under the '3+X' Cooperation Mode" on 10 November 2023 in hybrid format. The representatives from embassy, ministry of environment, UNEP, university, research academy as well as some members of DSS WGI and WGII were invited to the workshop. Through this workshop, the various information was shared by the participants and the importance of the 3+X cooperation platform for joint prevention and control of sandstorms in Northeast Asia was recognized. CRAES is expecting a wider range of partners to be involved to mitigate DSS and enhance regional environmental protection in Northeast Asia in future.

Presentations: Invited Speakers

Preliminary Results of SDS Vulnerability Assessment and Dust Vulnerability Index Development

Dr. MANDAKH Nyamtseren, Institute of Geography and Geoecology Mongolian Academy of Sciences

Recent research reported that 151 countries worldwide are affected by DSS. 45 countries, mostly from the Arab region, Central Asia, China and Mongolia, are classified as source areas. The consequences of DSS are varied and wide-ranging. Not only for human health but it affects social and economic development such as agriculture, electricity generation, and the transport industry. Given those facts, DSS is gaining increasing attention at the global policy level. Although scientific research and studies including the mechanisms of DSS have been conducted by researchers, vulnerability assessment and risk assessment are also needed for hazardous risk reduction. Such assessments provide a whole picture of the issue to develop policies at the national level and help prioritization of actions and resource mobilization.

Vulnerability assessment is conducted by setting 3 factors and 8 indicators: Economic (agriculture and poverty), Social (rural population, life expectancy, population with disease of respiratory organ) and Infrastructural (road density, energy loss and flight delays) with analytical data based on the Mongolian national statistics. Correlation among the three factors will be continued on a literature basis. The chart shows that the total vulnerabilities decrease as economic vulnerability falls while social and infrastructural vulnerabilities still stay at a high level due to DSS. The analysis of 6 chosen regions indicates that economic development does not necessarily mean high resistance to DSS.

Risk assessment is planned to be engaged in for further work. The Principal Components Analysis (PCA) Model has been developed and it will be used for the analysis of the risk exposed by DSS as the comparison of the traditional IPCC recommended model. The PCA model is expected to find the best low dimensional space that gives a proper image to lead the proper decision making by policymakers.

Vegetation Restoration for Mitigation of Dust and Sandstorm in China - A Case in Horqin Sandy Land in East Inner-Mongolia

Dr. ZHAO Xueyong, Northwest Institute of Eco-environment and Resources, Chinese Academy of Sciences / Visiting Professor of The University of Tokyo

Socio-economic growth based upon the use of natural resources degrades lands on Earth. Vegetation is the first sacrifice to human activities. In order to restore vegetation for DSS reduce DSS, the two processes, the natural process (climate change) and the land use process (human activities) must be considered.

His and his colleagues' research projects on the management of deserts and desertificated land to deal with the conflict between economic development, social development and capacity of the earth system in Horqin Sandy Land located in the Eastern part of China was introduced in his presentation.

China has made great progress in the restoration of degraded vegetation with systematical laws, platforms and support by the government, adapting human activities to growing challenges due to climate change and land use pressures.

Sustainable restoration of degraded vegetation needs integrated support such as capacity building and poverty relief in the concerned regions as well as long-term research and monitoring.

The United Nations Coalition on Combating Sand and Dust Storms: Fostering Global Action and International Collaboration

Dr. Feras ZIADAT, Food and Agriculture Organization of the United Nations

Massive transboundary impacts of Sand and Dust Storms (SDS) on the environment, climate, health, livelihoods, agriculture and socio-economic well-being of societies in 151 countries. It is estimated that 2 billion tons of dust are emitted into the environment each year. Economic and socio-economic losses are very big, and this also leads to ecosystem degradation and deterioration, and desertification.

Dust Belt is the areas with high emissions and concentrations of SDS, starting from Africa, the Arabian Peninsula, the Middle East, Central Asia, East Asia and Northeast Asia. Measures to address SDS are needed in these areas.

The United Nations launched the UN Coalition on Combating Sand and Dust Storms in 2019. The coalition sets 5 priority themes: identify and analyze SDS source areas, help countries develop policy plans, identify and implement good practices for source and impact mitigation, facilitate knowledge sharing and capacity enhancement and identify vulnerable places and vulnerable populations, and it operates through five working groups: adaptation and mitigation (UNDP and FAO), forecasting and early warming (WMO), health and safety (WHO), policy and governance (UNCCD) and mediation and regional collaboration (ESCAP and ESCWA) to work on the five priority themes. Many countries and regions are supported to promote national, regional and global actions to enhance mitigation of sources and management of impacts of SDS. The coalition stands ready to move from planning to implementation toward further support for countries with adequate resources allocated.

International collaboration and resource mobilization are indispensable to enable the Coalition to support affected countries to mitigate the SDS sources and reduce their impacts on people, societies, and economies.

Forest restoration and Combating Desertification Actions and the "Billion Tree National Movement-2030" of Mongolia

Dr. BATKHUU Nyam-Osor, Office of the President of Mongolia Mongolia

is a vulnerable country to climate change caused by anthropogenic activities. The government recognizes desertification and land degradation are the main ecological problems related to climate change.

In order to reduce the impact of global climate change, to protect and increase the ecological balance of forests and water resources, the President of Mongolia issued a decree to implement the Billion Trees national movement which plans to plant one billion trees by 2030 nationwide with 1% of GDP spent for all the related ecological conservation issues. The movement holds six objectives including the reduction of dust storms in the source areas. The same variety of native trees, shrubs and mushrooms that naturally grow are planned to be planted and will be under the Monitoring, Reporting and Verification (MRV) process.

Mongolia is also actively engaged in the activities of forestry worldwide. They have been cooperating closely with their neighbors, China, Korea and Russia. Mongolia is currently getting prepared for the UNFCCD COP17 in 2026 as a host country.

Discussion Summary

Discussion Summary of Group A

- Members of Group A:
  Dr. OKURO Toshiya (Facilitator)
  Dr. MUN Saeromi
  Dr. SUGIMOTO Nobuo
  Dr. SODGEREL Purevee
  Dr. ZHENG Zhirong
  Dr. LI Liang
  Dr. MANDAKH Nyamtseren
  Dr. ZIADAT Feras

- Discussion summary reported by Dr. OKURO

➢ ***Guiding Question 1) What are the lessons to be learned from existing cases of* collaboration (e.g. DSS WGI and WGII Japan joint research, UN-Coalition on SDS)?**

Information and data sharing

- Data and information sharing enhance the quality and completeness of activities.
- Lidar can provide robust information. Active images from the satellite can identify the vegetation and desert areas for WGII.
- Knowledge sharing is important to get to know good practices, possible practices and what others are working on. Successful policies can be applied to other areas or countries.
- Generating maps could support activities against DSS and knowledge transfer from the perspective of sustainability.

Hot spots

- For WGII, hot spot identification and modeling are important for the effective implementation of land restoration measures.
- Hot spot identification is also important for the development of an early warning system to reduce and mitigate the impacts of DSS.
- For WGI, parameters of surface condition are important to improve modeling

accuracy.

Gaps between WGII and WGI

- Understanding the differences in the scales between the two working groups is needed.
- The establishment of common goals between the two working groups is important for collaborative work.
- Listing up items to be solved and requests by the two working groups is needed for further work.
- Resource mobilization is the keyword of the cooperation.

Focus areas of research and activities

- The research should focus on restoration. More attention will be paid to land degradation caused by human disturbance such as excessive use of land resources, construction activities and mining.
- Sustainable land management is critical to combat DSS and land degradation.
- Planting and growing trees is important in the reason, on the other hand it could change the landscape and ecosystem of the planted areas.
- Capacity enhancement is usually a good case for collaborative activities among countries.
- Impact assessment and capacity building are needed.

Cooperation

- Wider cooperation such as the 3+X cooperation framework is needed to get more stakeholders and more financial support involved in activities.
- More organizations should join activities to work together.
- Transboundary collaboration works are needed for afforestation as it requires human resources and financial recourses as well as natural resources.
- Working across borders is important for transboundary issues of DSS.

- ***Guiding Question 2) What are the gaps in promoting collaboration and how can*** **they be overcome?**

- The communication gap is seen among the two working groups and among individuals. Identifying problems and solutions based on their own research fields can hardly make the problems and solutions generalized. Educational meetings and activities held regularly can provide basic knowledge.
- Research work should be more integrated into policies.
- Entities such as governments, universities and other organizations have their own data. Such data needs to be shared and aggregated into the common applicable dataset.
- WGII and WGI work on the same issue in a different manner and with different research skills. This causes the gap between the two working groups. Identification of the common interest and cooperation items is needed for further collaboration.
- The lack of standards prevents successful collaboration between WGII and WGI.
- Innovation in technology such as satellite sensor images could solve the gap problem.
- Landscape-scale approach could fill the gap.
- Upscaling is important for effective afforestation and sustainable resource use such as water resources and biomass.

Discussion Summary of Group B

■ Members of Group B:

Dr. KUROSAKI Yasunori (Facilitator)
Dr. YOSHIKAWA Ken
Dr. LEE Seungwon
Dr. SHIMIZU Atsushi
Dr. ZHAO Xueyong
Dr. DIAO Zhaoyan
Dr. WU Qian
Dr. MATSUKI Atsushi
Dr. ZHAO Yi Lin
Dr. BATKHUU Nyam-Osor

■ Discussion summary reported by Dr. KUROSAKI

➢ ***Guiding Question 1) What are the lessons to be learned from existing cases of* collaboration (e.g. DSS WGI and WGII Japan joint research, UN-Coalition on SDS)?**

- Identification of SDS source areas (dust hot spots), vulnerable places
- Linkage of monitoring, forecasting, early warning, adaptation, mitigation

➢ ***Guiding Question 2) What are the gaps in promoting collaboration and how can* they be overcome?**

<u>What are the gaps in promoting collaboration?</u>

(Gap 1) Scale gap between researches of WGI and WGII

- Researchers of WGI proceed their researches on the scale of several thousands' kilometers or more. However, WGII proceed them on the scale from several meters to at most several ten kilometers

(Gap 2)

- Big difference of study background of researchers of WGI and WGII

<u>How can they be overcome?</u>

For (Gap 1)-1: (Remote sensing information)

- There was a discussion about a research using Himawari Satellite's Dust RGB data. The study discusses dust hot spots. If we see it as a monitoring of dust emission, it is a theme of WGI. However, if we discuss the causes why we have dust hotspots there, such discussion is a theme of WGII, like this, remote sensing information includes.

For (Gap 1)-2 (Monitoring land surface conditions. Evaluation of effectiveness of DSS mitigation activities)

- By monitoring land surface conditions, we can evaluate the effectiveness of DSS mitigation activities. This action is belonging to WGII theme, but the information about this can contribute a development of numerical dust model (WGI theme).

What are the gaps in promoting collaboration?

(Gap 1) Scale gap between researches of WGI and WGII.

- Researchers of WGI proceed their researches on the scale of several thousands' kilometers or more. However, WGII proceed them on the scale from several meters to at most several ten kilometers.

(Gap 2)

- Big difference of study background of researchers of WGI and WGII

How can they be overcome?

For (Gap 2): (Communication of researchers of WGI and WGII)

- There was an introduction of Japan's TEMM case.

(End)