

**Proceeding Report of DSS WG I
on the Mid-Term Action Plan
(2015-2019)**

Working Group I for Joint Research
on Dust and Sand Storms

September 2019

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Chapter1

1.1 The research activities and achievements until 2014

The research activities and achievements from 2008 to 2014 were summarized into the following two reports:

1. Proceedings of Working Group I for Joint Research on Dust and Sandstorms in North-east Asia (2011)
2. Proceedings of Working Group I for Joint research on Dust and Sand Storms among China, Korea and Japan (2014)

Proceedings of
Working Group I for
Joint Research on Dust
and Sandstorms in
North-east Asia

2011

Proceedings of
Working Group I for
Joint Research on Dust
and Sand Storms
among China, Korea
and Japan

2014

The former report compiled the research papers of participating countries on the typical DSS event in 2017, and the related documents including the summary of the WG I meetings from 2008 to 2010, which enables us to understand the early stage of the WG I activity. The latter report presents the progress and result of the joint research from 2008 to 2013 in order to enhance the cooperation on DSS monitoring and forecast among China, Japan and Korea. The observation system and forecast model of DSS by each country and data sharing among the three countries are well articulated.

1.2 The DSS WG I Mid-Term Action Plan (2015-2019)

The contents of the Mid-Term Action Plan (MTAP) of Working Group I for Joint Research on Dust and Sand Storms (2015-2019) was discussed and agreed at the 7th WG meeting in 2014. The draft version of the MTAP was reported to SCM 9, approved by DGM and finally adopted at TEMM17. The final version of the MTAP (2015-2019) was 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).

First, four countries, including Mongolia, 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 output of WG I was compiled into international journals.

In the 7th WG I meeting held on 13-14 November, 2014, in Xi'an, China, 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 (2015-2019) of WG I for Joint Research on DSS.

II. Goals

Upon the discussion in the 7th WG I meeting, the followings are determined as the goals of the next Mid-Term Action Plan:

1. Continuation of previous WG I activities
2. Expansion of data sharing
3. Comparison of monitoring methods for particulate matters
4. Linking of WMO SDS-WAS web portal to share DSS model outputs

5. Enhancement of the cooperation between two Working Groups
6. Encouragement of the participation of outreach research groups

To achieve these goals, 6 main activities are decided as described in Section III. The detailed timeline, milestones and resource mobilization for the Mid-Term Action Plan (2015-2019) will be determined in the coming 8th WG I meeting which will be held in 2015 in Japan.

III. Main Activities

1. 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 a scientific journal.

2. Expansion of data sharing

WG I endeavors to share the maximum possible data from the existing or new monitoring stations, which were agreed upon among researchers as desirable data that need to be shared. Especially, data sharing of the visibility and hourly PM_{2.5} is encouraged. It is reported that the low visibility is observed during a DSS event. It is also reported that the air quality standard for PM_{2.5} and PM₁₀ / SPM exceeded during a DSS event. It is necessary to measure those parameters simultaneously at a certain location to identify and classify a DSS event. During this period (2015-2019), the expansion of data sharing of the visibility, PM_{2.5}, Satellite, lidar, optical data (skyradiometer or sunphotometer) as well as PM₁₀ / SPM is encouraged.

3. Comparison of monitoring methods for particulate matters

Accurate monitoring data is essential for data sharing of PM₁₀ / SPM and PM_{2.5} as well as for the improvement of an early warning system of DSS. The first step to achieve this is summarizing each country's monitoring method, such as monitoring equipment, dynamic range, target size range, QA/QC, and maintenance protocol. Then, we compare the monitoring method among three countries for the purpose of improvement of the accuracy of the monitoring data.

4. Linking of WMO SDS-WAS portal website to share DSS model outputs

A critical and practical step to establish and improve an early warning system is that the group keeps exchanging the information on the links to the websites that contain the prediction of DSS distribution on a geographical map, such as those of CUACE (CMA model), MASINGAR and ADAM, and shares the information of the predicted results of these models by linking of WMO SDS-WAS web portal.

5. Enhancement of the cooperation between two Working Groups

The importance of collaboration between 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.

It is important to hold a joint workshop between Working Groups of three countries utilizing SCM to discuss issues and collaborative part through sharing study results. WG I will continue the discussion on collaboration with WG II, on the possibility of 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.

6. Encouragement of the participation of outreach research groups

Since February of the year 2014, CMA (Chinese Meteorological Administration) has provided its DSS model outputs through the TEMM website. Therefore, CMA members are suggested to continue participating in the WG I meetings as one of the experts in accordance with the ToR and Chairman's summary of the 4th Steering Committee Meeting in 2010.

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. As the first step, potential synergy could be made by linking the websites of TEMM and SDS-WAS.

Collaboration with Acid Deposition Monitoring Network in East Asia (EANET) is a matter of concern. EANET started in 1998 as an intergovernmental initiative to create a common understanding on the state of acid deposition problems in East Asia. It maintains Acid Deposition Monitoring Network over East Asia and has experiences of data sharing, QA/QC, etc. Those experiences should be useful for WG I future activity.

IV. Expected Outcomes

1. Establishment and operation of environmental data sharing system in order to prevent DSS damages in East Asia.
2. Publication of research papers on an international journal and the proceedings.

1.3 The fact-based outcomes of the DSS WG I Mid-Term Action Plan (2015-2019)

The WG I meetings have been continuously held since its 1st meeting in 2008 as shown in Table 1.

Table 1 The 1st to 12th WG I meetings (Overview)

Meeting	Venue and Dates	Year	Participants
8 th	Fukuoka, Japan, December 9-10, 2015	2015	CJKM
9 th	Jeju, Korea, November 30-December 1, 2016	2016	CJKM
10 th	Lanzhou, China, November 9-10, 2017	2017	CJK
11 th	Tokyo, Japan, November 15-16, 2018	2018	CJK
12 th	Busan, Korea, September 26-27, 2019	2019	CJKM

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

Following the Mid-Term Action Plan (2015-2019), the project has been producing notable progress in results as Table 2 shows.

Table 2 Present status (as of September 2019) of the Mid-Term Action Plan (2015-2019)

The Mid-Term Action Plan (2015-2019) & Main activities	Present status (as of September 2019)
1) Continuation of previous WG I activities, mainly;	
i) Observation data sharing on the selected DSS events every year:	i) Observation data during 10 DSS events from 2013 to 2016 have been shared since 2015 to date.
ii) Validation and sharing of the results of the model calculation: and	ii) Model results were shared between Japan and Korea in the WG I meetings every year.
iii) Research results publication in scientific journals.	iii) 10 research papers have been published since 2015 to date.
2) Expansion of data sharing	
It is encouraged to share visibility, hourly PM2.5, satellite data, lidar, and optical data (skyradiometer or sunphotometer).	<ul style="list-style-type: none"> - From Japan, Satellite (Himawari) and polarization optical particle counter (POPC) data have been added. - From Korea, optical particle counter (OPC) data have been added. - From China, PM10 data has been added.
3) Comparison of monitoring methods for particulate matters	
The first step to achieve this is summarizing each country's monitoring method, such as monitoring equipment, dynamic range, target size range, QA/QC, and maintenance protocol.	<ul style="list-style-type: none"> - In the 8th WG I meeting (2015), CJKM introduced each country's monitoring methods for particulate matters. - In the 9th WG I meeting (2016), Japan made a "Report on the current monitoring methods for particulate matters" and presented it to the 10th SCM, 2016.

4) Linking with WMO the Sand and Dust Storm Warning Advisory and Assessment System (SDS-WAS) web portal to share DSS model outputs	<ul style="list-style-type: none"> - In the 8th WG I meeting (2015), the works of WMO SDS-WAS was introduced. - In the 9th WG I meeting (2016), the new web-portal site & observation data sharing of WHO SDS-WAS was introduced. *How to link continues to be discussed.
5) Enhancement of the cooperation between two Working Groups	<ul style="list-style-type: none"> - In February 2016, the Joint Workshop between WG I and WG II was organized in Japan. - In February 2017, the 2nd Joint Workshop between WG I and WG II was organized in Korea. - In June 2018, a DSS Sub-Forum for TEMM20 was organized in China.
6) Encouragement of the participation of outreach research groups (EANET, CMA, WMO)	<ul style="list-style-type: none"> - A CMA representative was invited to the 1st Joint Workshop between WG I and WG II in February 2016.

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 ADAM.

Table 3 Data sharing by China, Korea and Japan since 2007

Items	Since	Items	Since
China		Japan	
Daily average PM10 (10 sites)	2007	Hourly average SPM (21 sites)	2007
Hourly average PM10 (10 sites)	2011	PM10 (11 sites)	2007
Korea		PM2.5 (3 sites)	2008
Hourly average PM10 (36 sites)	2007	Lidar (17 sites)	2007
PM2.5 (1 site)	2008	Visibility & RH (60 sites)	2008
Lidar	2008	Humidity	2012
RH & Visibility (6 sites)	2008	SKYNET	2012
Humidity	2013	AOT & Angstrom exponent (1 site)	2012
AOT & Angstrom exponent (1 site)	2012	POPC (2 sites)	2015
OPC (2 sites)	2016	Satellite	2016

Chapter 2

2.1 The presentations and discussion results at respective DSS WG I meetings between 2015-2019

In a series of the WG I meetings from 2005 to 2019, the researchers shared their research activities and exchanged their opinions. The summary of the meetings is shown below.

2.1.1 The 8th WG I meeting, 2015

1. Following the overviews of the last WG I meeting, the 9th SCM, the 10th DGM and the 17th TEMM, the Mid-Term Action Plan (2015-2019) of WG I was reviewed and summarized.
2. Korea made a presentation on the current status of DSS data sharing, which shows China (1 data), Korea (5 data), Japan (6 data) and Mongolia (3 data) provided data in 2013.
3. China introduced the progress of joint research journal. Five papers have been submitted, and two of them have been accepted and the others are being reviewed.
4. In the session of “Report from the countries on DSS events”, China revealed the number of days which air quality exceeded the standard was 270 in 161 key cities in 2014. The technical requirements for dust weather classification were established and promulgated by CNEMC on a trial basis.
5. Korea, which had five DSS events in 2013, highlighted the weather conditions and signals of dusts in each of two events (DSS-2013-1; 5th to 22nd March, 2013 and DSS-2013-2; 26th December, 2013 to 6th January, 2014). They found DSS-2013-1 event duration was relatively short and chemically similar to haze in Korea, while DSS-2013-2 event affected all over Korea mainly caused by no snow in source regions. Following the presentation on event occurrence, Korea explained the development of the ADAM-Haze Model originated from Asian Dust Aerosol Model (ADAM). The model showed the difference between simulation and observation in the above these two events, and indicated the necessity of applying optimal interpolation.
6. Japan introduced the simulations by the upgraded dust prediction model MASINGER mk-2, showing the importance of confirming the surface condition of dust source regions. They unfolded plans of introducing higher resolution (40km) version of the model from 2016, and satellite data assimilation system for prediction from 2018.
7. Japan presented the analysis of the DSS events in 2013 using the lidar network and surface PM data by introducing his research paper submitted to Particuology. The work explained that dust PM_{2.5} could be estimated by using the PM_{2.5}-PM₁₀ ratio method, and that the consistency

with the result gained from lidar data method was validated. Also, it is stressed the importance of sharing both hourly PM2.5 and PM10 data.

8. In Session Three, Mongolia was invited to make a presentation. They pointed out the necessity of considering livestock disturbance effects on dust emission particularly in Mongolia, and proposed a livestock trampling function for dust flux.
9. Mongolia demonstrated the relation between seasonal precipitation and concentrations of PM2.5 and PM10.
10. Japan investigated the high time resolution of dust-nitrate and PM10 in a long-lasting dust event from 25th May to 2nd June, 2014. The yellow sand episode in Fukuoka was consisted of more than 70% of dust-nitrate originated NOx emission from Beijing-Shanghai wide area.
11. Japan, Korea and Mongolia compared the current monitoring methods of each country. It showed the progress of compiling the report on the current monitoring methods for PM2.5 and other particulate matters using automatic sampler.
12. Japan demonstrated the data sharing activities of the WMO Sand and Dust Storm Warning Advisory and Assessment System (SDS-WAS) Asia Node. It was reported that the website was under construction and the outcome of the operational forecast models and real-time observations were also prepared. (http://eng.nmc.cn/sds_was.asian_rc/)
13. Session Five was for discussing on the detailed milestones for the Mid-Term Action Plan (2015-2019). The topics and results are as followed;
 - 1) Continuation of previous WG I activities
It was consented by the member countries.
 - 2) Expansion of data sharing
The participating countries promised to upload in total seven DSS related data on the data sharing website by 31st August 2016. It was strongly encouraged to share PM2.5 and PM10 hourly data, and suggested to share Optical Particle Counter (OPC) or POPC data set. Any additional data will be welcome.
 - 3) Comparison of monitoring methods for particulate matters
It was consented that WG I will report the final version of the “Report on the current monitoring methods for PM2.5 and other particulate matters” to the SCM in February 2016.
 - 4) Linking of WMO SDS-WAS web portal to share DSS model outputs
This was consented to discuss the future collaboration at the joint WG I and II workshop in February 2016.
 - 5) Enhancement of the cooperation between two Working Groups
Japan introduced the possible collaboration menu from WG II side. It was suggested this workshop be in an academic and open manner, with participation of external experts. WG I

welcomed his additional proposal to share the data with WGs from his continuous observation from 2012 in Tsogt-Ovoo in Mongolia.

6) Encouragement of the participation of outreach research groups

This was consented to discuss the future collaboration at the joint WG I and II workshop in February 2016.

2.1.2 The 9th WG I meeting, 2016

1. Following the overviews of the last WG I meeting, the 10th SCM, the 11th DGM and the 18th TEMM, the Mid-Term Action Plan (2015-2019) of WG I was reviewed and summarized.
2. Korea reported the current status of DSS2014 data sharing. The wind and AOT & Angstrom exponent of SKYNET data were newly added and available on web-hard (<http://www.webhard.net>).
3. Session Three was opened by Japanese presentation on the heavy dust storms during 13-23 Mar. 2014; 22 May - 4 Jun. 2014 by using the lidar network data. It was highlighted that Polarization Sensitive lidar and Polarization Optical Particle Counters (POPC) are useful instruments to measure and distinguish dust from other types of aerosols in (near) real time.
4. On the second presentation, Japan found the dust emissions were improved by combining chemical transport model (GEOS-Chem) and Green's function method. The outcome will be submitted to SOLA.
5. Japan's third presentation was on the data assimilation by Himawari-8 AOT and MASINGAR mk-2. It was indicated that the high accurate results would be obtained in the future.
6. Korea found the difference in DSS source region of two DSS events.
7. Korea introduced the new version of emission inventory and also showed its impact on aerosol modeling from the case experiments during Jan. 16-30, 2015. It was mentioned that anthropogenic emissions over Asian dust pathway are also important.
8. In Session Four, Korea introduced KORUS-AQ campaign, which was made for better understanding of satellite performance, fundamental understanding of atmospheric composition and improvement of air quality modelling. The result of this campaign will be opened late next year.
9. Mongolia made a presentation about ongoing research on "white dust".
10. Session Five was open for discussion on the detailed milestones for the Mid-Term Action Plan (2015-2019). The discussion items are listed below.
 - 1) Continuation of previous WG I activities
 - i. Next target event for the next year's study
The countries will upload the data about the above suggested period to the data

sharing website by 31st July, 2017.

ii. Next publication plan of the research results in SOLA

All members will try to submit by the end of May 2017, and Korea plans to submit three papers potentially.

2) Expansion of data sharing

Japan and Korea agreed to share POPC data (2 sites) and OPC data (2 sites) of 2015.

3) Comparison of monitoring methods for particulate matters

It was emphasized that comparative verification of the monitoring methods among four countries in WG I is important for the DSS research and model development, and suggested sharing the information of PM_{2.5} monitor type.

4) Linking of WMO SDS-WAS web portal to share DSS model outputs

The information on the new web-portal site as well as the current status of observational data sharing between CMA, JMA and KMA was introduced.

5) Enhancement of the cooperation between two Working Groups

Japan reviewed the 1st Joint workshop between WG I and 2. Korea will share more detailed information after having a discussion with the Ministry of Environment of Korea and WG I

6) Encouragement of the participation of outreach research group

It was not discussed this time due to the lack of time.

11. China announced that three accepted papers were published in volume 28 of PARTICULOLOGY.
12. China presented the climate factor was conducive to dust and sand storms in April, 2014 in the country.
13. Mongolia presented “Sand fluxes and its vertical distribution in the southern Mongolia”, and insisted it was crucial to quantify the amount of soil loss by DSS, and defining the sand fluxes and measuring its vertical transportation are worth understanding DSS phenomena and atmospheric environment.

2.1.3 The 10th WG I meeting, 2017

1. Japan reviewed the last WG I meeting, the 11th SCM, the 12th DGM and the 19th TEMM.
2. Japan presented the publication status to SOLA. It was announced that five papers had been accepted and published in SOLA Vol. 13 (2017).
3. Korea introduced the current data sharing status. It was reported one data from Korea and four data from Japan were newly available on web-hard (<http://www.webhard.net>).
4. China explained the DSS monitoring result in China. It showed that the accumulative number of days that air quality exceeded the standard was 303 days in 2015 with an increase of 12.2% over the same period in 2014.

5. Japan showed the monitoring results by MASINGAR mk-2. The higher resolution (40km) version of the model demonstrated that the prediction scores were dramatically improved.
6. Korea's monitoring results were drawn by ADAM2-Haze. They gave a future plan on the data assimilation with satellite-based AOD and ensemble-based assimilation system in Korea.
7. China made a presentation on the modelling forecast of pollutant in dust weather in China. They stated NAQPMS generally well simulated the observed heavy dust and pollution episodes.
8. Four provinces in China made a presentation. First, Gansu Province reported their capacity building and the maintenance of DSS monitoring network. Second, Shaanxi Province introduced their DSS monitoring network. Third, Liaoning Province described their current DSS monitoring status and application of monitoring data. Fourth, Inner Mongolia explained their current status of DSS monitoring.
9. In Session Four, Japan introduced AD-Net (Asian dust and aerosol lidar observation network) in East Asia. Argon-oxygen decarburisation (AOD) of dust particles averaged in Japan indicated negative trend (-2.5%/year) in recent 10 years.
10. Qinghai Environmental Monitoring Centre made a presentation on their monitoring work. They concluded that sandstorm of Qinghai is not only affected by local dust source, but also by long-distance transport.
11. Korea presented their analysis and simulation result of DSS2015, and stated the importance to upgrade the dust emission algorithm based on the near real-time three-dimensional observation data.
12. Japan showed the results of analyzing characteristics of DSS over Japan and their change since 2002.
13. Lanzhou Province in China reported their monitoring result, which was the enlargement of the vegetation coverage in the local and upstream areas could effectively reduce the concentration and frequency of dust.
14. In Session Five were for discussing on the detailed milestones for the Mid-Term Action Plan (2015-2019). Data sharing period was decided and enhancing data sharing was highly encouraged to enrich the joint research.

2.1.4 The 11th WG I meeting, 2018

1. Japan reviewed the last WG I meeting, the 12th SCM, the 13th DGM and the 20th TEMM.
2. Korea introduced the current status of data sharing. Eight satellite data by HIMAWARI-8 were newly added from Japan. All data were available on web-hard (<http://www.webhard.net>).
3. Session Three were consisted of five presentations. First, Japan reported the monitoring result

by MASINGAR mk-2. They stated the necessity of various data for improving the dust aerosol model. Second, Japan introduced the new Himawari-8 satellite performance. The case study showed that the Advanced Himawari-8 Imager (AHI) captured the dust vortex changes clearly every 10 min. interval and verified the performance of AHI, which would develop the joint research. Third, Korea introduced the improvement of ADAM3, and its continuous development. Fourth, China showed the monitoring result in 2016. They found the accumulative number of days that exceeds the level of an air quality standard was 325 days in 338 key cities in 2016. It was explained that the climate factors in the dust source area were conducive to the occurrence and transportation of dust in 2016 in China. Fifth presentation was from China. They focused on and analysed a strong DSS event in March 2016. Their comparison of model and measurement showed that NAQPMS simulated occurrence and path of this DSS well, except underestimating intensity and missing the north-east China.

4. In Session Four, Korea analysed three cases of DSS2016 by ADAM3. It was mentioned that total PM10 amounts were affected by not only Asian dust but also anthropogenic emissions.
5. Japan proposed the observation results and a method to distinguish long range transported dust and locally generated dust.
6. Session Five was open by China. They presented the influence of DSS on ambient air quality. They showed the new method to identify the DSS influence worked well.
7. Korea made a presentation on the chemical composition change. They succeeded to broaden analyzing methods by coupling the Korean and Japanese chemical analysis data.
8. Session Six was for discussing on future cooperation and next steps. Japan proposed the idea of incorporating new, cross-cutting themes such as DSS and climate change, health effect of DSS and bio-aerosol DSS, and literature review surrounding DSS.
9. Then, the WG I participants agreed on; 1) allocating roles of drafting a proceeding report based on the current Mid-Term Action Plan (2015-2019), and a new Mid-Term Action Plan (2020-), 2) submitting them to pre-TEM 22 SCM and DGM (2020), and 3) the target period of two DSS events to upload this year.

2.1.5 The 12th WG I meeting, 2019

1. Japan reviewed the last WG I meeting and also introduced the schedule of the 14th DGM and 13th SCM (17th-18th October in Kitakyushu, Japan), and the 21st TEMM (24th November in Kitakyushu, Japan).

2. The current status of DSS2017 data sharing was reported by Korea. According to his report, skyradiometer data from Ishigakijima was newly added from Japan. He requested for all participating countries to reload data on web-hard (<http://www.webhard.net>) for those the quality checks are needed.
3. In Session Three, seven researchers from China, Japan and Korea reported their research on DSS monitoring and modelling: 1) “Physicochemical Characteristics of Atmospheric Aerosols during a Consecutive High Concentration Episode in Seoul, Korea”, 2) “The comparison results between dust extinction coefficient by lidar and data from air-pollution monitoring systems in Japan”, 3) “The variations of PM_{2.5} concentration in China since 2013”, 4) “ADAM3 and its Predictability of Asian Dust over Northern China”, 5) “Recent DSS related activities at the Japan Meteorological Agency and Meteorological Research Institute”, 6) "Status of Environmental Air Quality Forecast in China & Analysis on Sandstorm Forecast", and 7) "Overview of China Ambient Air Quality Monitoring".
4. In Session Four, three researchers delivered the presentations focusing on the results of their analysis of the DSS events. Further, Japan introduced the research result on recent DSS event in Japan and the dust project that is implemented in Mongolia by Tottori University. Moreover, the invited observer guest from National Agency for Meteorology and Environmental Monitoring (NAMEM) reported “Dust and sand storms monitoring in Mongolia”.
5. In Session Five and Six on “Discussion on the detailed milestones for the Mid-Term Action Plan (2020-2024)”, Japan introduced an outline of draft version of the Proceeding Report (2015-2019). Further some ideas for the next Mid-Term Action Plan (2020-2024) was introduced: 1) Continuation of previous WG I activities, 2) Expansion of data sharing for Joint Research, 3) Encouragement of sharing real-time data for developing early warning system, 4) Enhancement of the cooperation between two Working Groups, 5) Encouragement of the participation of outreach research groups, and 6) Enhancement of research on sub-seasonal to seasonal (S2S) forecasts and long-term variations of DSS.
6. For joint research, the four countries decided to share the observation data during the period from March 20 to April 20 (DSS2018-01) and from November 25 to December 5 (DSS2018-02), 2018.

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

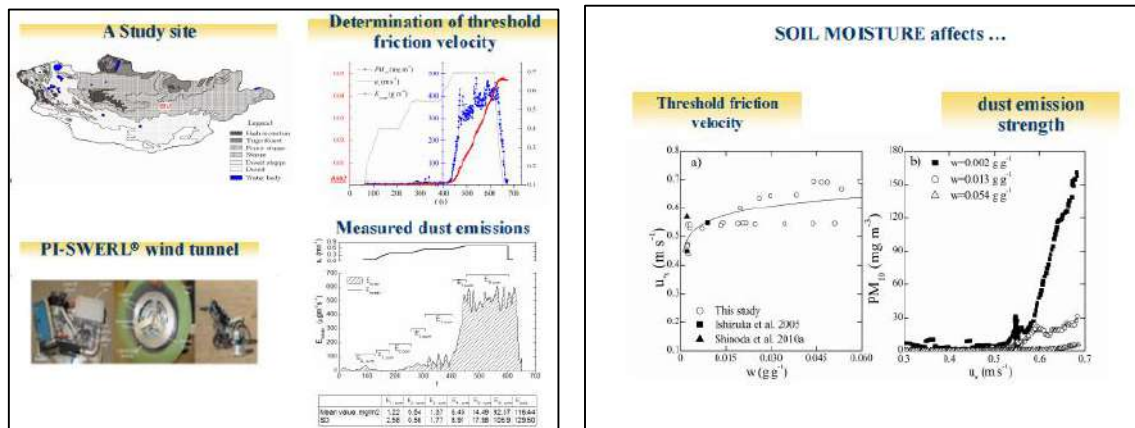
The Joint Workshop between WG I and WG II for Joint Research on Dust and Sand Storms was held in 2015, 2016 and 2018 as shown in Table 4 below.

Table 4 1st to 3rd Joint Workshops: Overview

Meeting	Venue and Dates	Year	Participants
1 st	Tokyo, Japan, 27 February 2016	2016	CJKM
2 nd	Seoul, Korea, 16 February 2017	2017	CJK
3 rd	Suzhou, China, 23-24 June, 2018	2018	CJK

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

At the 1st joint workshop, Dr. Munkhtsetseg Erdenebayar of National University of Mongolia was invited to deliver the presentation entitled “Relationships between soil moisture and dust emissions in a bare sandy soil of Mongolia”. Throughout a series of the joint workshops, the researchers of WG I and II including the Mongolian expert proactively exchanged the information and discussed how to monitor, prevent and control DSS in China, Korea, Japan and Mongolia.



2.2.1 The 1st Joint Workshop between WG I and WG II for Joint Research on Dust and Sand Storms

1. Japan presented an overview of KOSA (Asian Dust Particles) and Material on KOSA Transported in the Free Troposphere, stressing that bio-aerosols transporting with KOSA become large concern.
2. China introduced the Development on WMO SDS-WAS Asian Node. With regard to the linking between the web of World Meteorological Organization (WMO) SDS-WAS and the web of Tripartite Environmental Ministers Meeting (TEMM). It was mentioned that he would confirm with the SDS-WAS web manager (China Meteorological Administration) on the feasibility of the web linkage.
3. The WG II experts presented on one's own study results and, research experiences on land restoration and current activities of WG II. First, Japan introduced the necessity of long-term monitoring by showing the case that the threshold of vegetation coverage was 30% which could prevent sand drift on shifting sand dune. Second presentation was made by Mongolia. They demonstrated the grassland degradation status by using indicator plants in pant community.
4. The WG II experts explained the outcomes of their field surveys. First, Chinese expert proposed screening 2-3 patterns of vegetation restoration based on the research outcomes and applying the above patterns to the similar type of regions by joint efforts of experts from three countries. Second, Japan showed the research result, which is that vegetation cover could recover after the seedling treatment (Control<2014 sites<2013 sites) and different trends of growth between *Elymus* and *Caragana* in early stage of restoration were found. Third, Korea introduced his plans of comparing satellite photographs between past and present (2016), analyzing ecological/socio-economic factors (2016, 2017) and investigating causes of desertification (2017).
5. In Session Three, the results of observation and model studies were introduced. Japan had a presentation on the PM10/PM2.5 ratio. The study showed the soil originated from the AMD source area can be accounted for about 70% to PM2.5 concentration in a typical AMD event, and it must be a common case in Japan. Secondly, Korea explained their observation study results. They concluded that southern Mongolia and northern China are one of DSS source areas, and when these areas are under warm and dry condition in winter such infrequent event could be observed in Korea. Thirdly, Japan presented lidar network observation data. It was shown that it could be used for evaluating the effect of afforestation and other dust mitigation methods through the data assimilation of dust transport models. Lidar techniques may be useful for measuring dust emission. Fourthly, Mongolia explained that dust emission flux threshold of friction velocity increased from 0.44 m/s for dry soil to 0.67 m/s for wet soil, and proved a simple dust diagram may be useful as a dust warning system to identify initial as well as

significant dust emissions.

6. The model studies were also introduced. Korea mentioned that KMA implements surface PM10 monitoring of dust source region through international cooperation with China Meteorological Administration (CMA) and National Agency of Meteorology and Environmental Monitoring (NAMEM). The work produced phenomena forecast charts with forecasted PM10 concentration and concentration ratio between the Asian dust aerosol and non-dust aerosol.
7. China presented the development of NAQPMS. They demonstrated that NAQPMS generally well simulates the observed heavy dust and pollution episodes by comparing with lidar observation.
8. Japan had a presentation on polarisation optical particle counter. It is showed that dust model could play an important role for dust emission area identification.
9. Also, Japan introduced MASINGAR mk-2. It was illustrated its calculation of dust emission flux from several land surface parameters, and information of land surface helped to modify dust emission process of the models.
10. China introduced research papers by the members in 2015. According to the presentation, six research papers were submitted.
11. In Session Four, cooperation between two Working Groups was discussed.
 - 1) WG I needs ground truth data (in situ observation data) to validate and correct the model reproducibility. In particular, WG I needs local data of vegetation, sand particulate size, soil moisture, friction velocity (observed by supersonic anemometer) in source area. WG II also comments on the possibility of setting weather station jointly with WG I but it will be a future agenda.
 - 2) WG II needs location information of DSS source areas because this information is essential for prioritization of applying restoration measures.
 - 3) The members insisted to find new long term local monitoring site in addition to Gobi Desert in order to reveal vegetation in the dust source regions and to understand the seasonal and inter-annual variations of DSS phenomena. This is consistent with the Mid-Term Action Plan of WG I and WG II for Joint Research on DSS (2015-2019), which describe “In order to promote collaboration between WG I and II, the three countries continue the discussion on the possibility of launching a new joint research and research site”.
 - 4) It was agreed that the second Joint Workshop between WG I and II for Joint Research on DSS will be held next year to deepen more collaboration between WGs.

2.2.2 The 2nd Joint Workshop between WG I and WG II for Joint Research on

Dust and Sand Storms

1. Session Two opened by two speakers invited from Kangwon National University (KNU) and Ulsan National Institute of Science and Technology (UNIST) in Korea. First, KNU made a presentation on the setting of conceptual modelling of landscape formation in pastures in Mongolia. Second, UNIST introduced the joint research and development on the X-ray polarised observation satellite (GEMS). It was stated GEMS data would be used for monitoring and prediction of air environment and chemical accident, measuring air pollutant, assimilating model data and collaborating with other fields.
2. In Session Three, China, Japan and Korea reported on the progress of the joint research activities in Hulunbeir in China conducted since 2014. Japan introduced the findings that the strong correlation between vegetation cover and sand movement. It was mentioned that the relationship between wind erosion and vegetation cover has been deeply understood. Then, China introduced remarkable findings on their study, namely the dominant species at the vegetation recovery site, the pioneer plants which disappear due to new plants suitable for the long-term vegetation recovery, the dominant species has high net photosynthesis, water use efficiency and low saturation water deficiency, vegetation recovery, and changes in root distribution and soil composition (water content and air permeability) caused by artificial vegetation. In the last, Korea indicated that vegetation recovery in the region has been declining between 2014 and 2016. However, further data analysis and continuous research on vegetation and natural environmental factors were required to assess the impact of vegetation recovery.
3. In Session Four, China, Japan and Korea reported on the progress of the WG I joint research activities. Firstly, Korea introduced 1) the relationship among the chemical composition of airborne suspended matter, haze and DSS, 2) the development of ADAM for predicting the occurrence of DSS and haze, and 3) air pollution observation report in spring 2016 in Seoul. It was shown that the air pollution in Seoul in spring was more influenced by local pollutant emissions and advection of pollutants from China than DSS. Secondly, Japan reported their research results extracted by using Asian Dust and aerosol lidar observation Network (AD-Net). The report showed lidar observation and data analysis are effective in distinguishing DSS and haze and predicting the DSS source area. In addition, data assimilation of DSS transport model by lidar network and other data provided by WG I would contribute to evaluate the effects of various measures including planting. Lastly, China explained the DSS observation system, the classification of DSS and the DSS monitoring results of 2014 events. According to monitoring in 2014, the amount of rainfall in April in the DSS source area was considered to have affected the deterioration of the atmospheric environment in the major cities observed.
4. In Session Five, Japan and Korea reported on cooperation between WG I and WG II. First, Japan made a presentation on the cooperative activities by WG I and WG II members in 2016,

which are 1) visiting the DSS source area in Mongolia, and 2) holding a joint workshop. In the report, it was indicated that 1) mutual understanding between two WGs was promoted by those activities, 2) it was important to capture the monitoring data of the ground surface including vegetation cover and sand for refining the model, and 3) Japan would share the outcomes of cooperative activities to China and Korea.

5. Then, Korea reviewed the agreed items between both WGs in the Mid-Term Action Plan (2015-2019) and the progress of the cooperative activities. Korea proposed to create a three-year work plan for searching a site by organizing a task force team consisting of both WGs members. It was stated to select a site in 2019 and create a five-year joint research plan (2020-2024). Whereas, Japan insisted that it was important to create a plan for what to cooperate with before searching a site, understanding the importance of adding a new joint research site to Hulunbeier in order to evaluate countermeasures at DSS source area. China stated that it was necessary to clarify the purposes, the contents of joint research plan and the site selection method. It was agreed that the Korean proposal was to be discussed at the next day's steering committee.
6. Korea closed the meeting by asking the members to review the outcomes of the joint research and consider the aims in the future, and what experts can recommend to policymakers since it was the 10th year since the joint research started.

2.2.3 The 3rd Joint Workshop between WG I and WG II for Joint Research on Dust and Sand Storms

1. The purpose of the Joint Workshop was explained first since it was held as a sub forum of TEMM20.
2. In Session One, China explained the research progress on monitoring and evaluation of DSS. The presentation showed six research topics namely impact prediction of DSS on air quality, monitoring and assessment of DSS in China, causes and development of duststorm – the geo-ecological process in North-Eastern Asia's Grassland Region, spatial identification of DSS source in China and Mongolia Adjacent Grassland, technology of vegetation restoration in Hulunbeier sandy land, and the joint field survey and results in Hulunbeier sandy land.
3. In Session Two, Japan showed causes and mechanism of DSS. They explained DSS observations in Japan and its application for health impact studies, verification and evaluation of DSS by numerical model and observations, and characteristics of land degradation and implementation to restoration in drylands of the Northeast Asia.
4. In Session Three, Korea introduced the control technology and national policy of DSS. The topics were on the predictability of Asian dust days over the Northern China using ADAM2 Model and the present situation and restoration effort of sandy lands in Hulunbeier, Inner

Mongolia

5. Mongolia also had a presentation on the monitoring and assessment of DSS in Mongolia. They introduced the early warning system for dust events based on their monitoring work.
6. In Session Four, the future work plan was explained. It was agreed to cooperation between WG I and WG II on the following items;
 - i) Promoting joint evaluation of DSS
 - ii) Sharing information of DSS monitoring and evaluation
 - iii) Encouraging joint technical exchanges and training activities

Also, the member countries decided to discuss and prepare a Proceeding Report on the Mid-Term Action Plan (2015-2019) and next Mid-Term Action Plan (2020-2024) in the next WG I and WG II meeting respectively. The members agreed to discuss and put the following three topics in the next Mid-Term Action Plan WG I and WG II.

- 1) Promoting the cooperation among China, Japan and Korea with Mongolia (3+1).
- 2) Conducting community technical training in the DSS source of adjacent area between China and Mongolia.
- 3) Innovating techniques of Sandstorm mitigation and land desertification control.

2.3 Published papers from 2015 to 2019

The journal publication as outcome of the WG I activity from 2008 to 2015 was decided to be submitted to Particuology. Considering the convenience in the submission process of research paper, Scientific Online Letters on the Atmosphere (SOLA), Metrological Society of Japan was recommended for the journal publication since 2016. To date, thanks to the WG I experts' great efforts, 11 research papers have successfully published at the above mentioned scientific journals: three papers to Particuology, six to SOLA & Aerosol and Air Quality Research, and one paper to Theoretical and Applied Climatology. The details of the journal publication and their abstracts of the papers are shown in Table 5 below.

Table 5 List of published papers since 2016

<p>[2016]</p> <p>1) A method for estimating the fraction of mineral dust in particulate matter using PM2.5-to-PM10 ratios</p> <p><i>Nobuo Sugimoto, Atsushi Shimizu, Ichiro Matsui, Masataka Nishikawa</i></p> <p>PARTICUOLOGY, Volume 28, Oct. 2016</p> <p>https://doi.org/10.1016/j.partic.2015.09.005</p>

A simple method for estimating the contributions of mineral dust to PM_{2.5}, PM₁₀, or TSP is presented. The method is based on the assumption of external mixing of two types of particles with different PM_{2.5}/PM₁₀ ratios. The method was applied to local and transported dust events observed in Tsukuba, Japan, and was compared with collocated polarization lidar measurements. The method was then applied to three dust events that occurred in Oki, Rishiri, and Ochiishi, Japan, in 2012. The results showed that the method was useful for detecting mineral dust and for qualitatively describing the mixing of dust with anthropogenic aerosols.

2) Forecasting of Asian Dust Storm during 10-13 May in 2011 with an Ensemble-based Data Assimilation System

Keiya Yumimoto, Hiroshi Murakami, Taichu Y.Tanaka , TsuyoshiT. Sekiyama , Akinori Ogi , Takashi Maki

PARTICUOLOGY, Volume 28, Oct. 2016

<https://doi.org/10.1016/j.partic.2015.09.001>

An ensemble-based assimilation system that used the MASINGAR mk-2 (Model of Aerosol Species IN the Global Atmosphere Mark 2) dust forecasting model and satellite-derived aerosol optical thickness (AOT) data, processed in the JAXA (Japan Aerospace Exploration Agency) Satellite Monitoring for Environmental Studies (JASMES) system with MODIS (Moderate Resolution Imaging Spectroradiometer) observations, was used to quantify the impact of assimilation on forecasts of a severe Asian dust storm during May 10–13, 2011. The modeled bidirectional reflectance function and observed vegetation index employed in JASMES enable AOT retrievals in areas of high surface reflectance, making JASMES effective for dust forecasting and early warning by enabling assimilations in dust storm source regions. Forecasts both with and without assimilation were validated using PM₁₀ observations from China, Korea, and Japan in the TEMM WG I dataset. Only the forecast with assimilation successfully captured the contrast between the core and tail of the dust storm by increasing the AOT around the core by 70-150% and decreasing it around the tail by 20-30% in the 18-h forecast. The forecast with assimilation improved the agreement with observed PM₁₀ concentrations, but the effect was limited at downwind sites in Korea and Japan because of the lack of observational constraints for a mis-forecasted dust storm due to cloud.

3) Relationships between soil moisture and dust emissions in a bare sandy soil of Mongolia

Erdenebayar Munkhtsetseg, Masato Shinoda, John A.Gillies, Reiji Kimura, James Kinge George Nikolich

PARTICUOLOGY, Volume 28, Oct. 2016

<https://doi.org/10.1016/j.partic.2016.03.001>

This study presents experimental results of the change in threshold friction velocity and dust emission strength as a function of soil moisture content. The dust and soil moisture data were obtained from irrigated plots of a bare, sandy soil (no vegetation) situated in the Mongolian steppe. Dust flux was measured using the PI-SWERL® device, while soil moisture was measured using gravimetric methods. Our results demonstrate the strong controlling effects of soil moisture on both the threshold friction velocity and dust emission strengths. Threshold friction velocity increased from 0.44 m/s for dry soil (0.002 g/g) to 0.67 m/s for wet soil (0.06 g/g), confirming the importance of soil moisture for controlling dust events. Dust emission strength was significantly depressed for wet soils, starting at a soil moisture value of 0.02 g/g. From these results, we developed a simple dust diagram that may be useful as part of a warning system to identify initial sensitivity to threshold conditions as well as conditions that could lead to potentially significant dust emissions. Overall, the research findings in this study could be used to provide foreknowledge of conditions that would be conducive to high dust emissions for this area of Mongolia.

[2017]

4) Dust Acid Uptake Analysis during Long-Lasting Dust and Pollution Episodes over East Asia Based on Synergetic Observation and Chemical Transport Model

Itsushi Uno, Keiya Yumimoto, Kazuo Osada, Zhe Wang, Xiaole Pan, Syuichi Itahashi, Shigekazu Yamamoto

Scientific Online Letters on the Atmosphere (SOLA), Volume 13, Jan. 2017

<https://doi.org/10.2151/sola.2017-020>

Two heavy dust storms that occurred between 24-26 May 2014 in Mongolia and Inner Mongolia, China were responsible for long-lasting dust episodes observed from 26 May to 2 June 2014 in Fukuoka, Japan. During this period, dust and anthropogenic pollutants were transported simultaneously to Fukuoka and Korea and remained there for almost 8 days. We successfully observed fine and coarse aerosol time variations (1-hour intervals) in Fukuoka. The GEOS-Chem chemical transport model, which includes dust-acid uptake processes, successfully reproduced the aerosol variations and explained the Asian-scale dust-pollutant transport and transformation processes. Model sensitivity analyses with and without dust-acid uptake processes showed that the formation of dust-nitrate occurred over the Yellow Sea and East China Sea before arriving in Japan. The model sensitivity analysis showed that less than 5% of the coarse dust-nitrate originated from NO_x emissions from Japan, and large amounts of dust-nitrate originated outside of Japan.

5) Improved Dust Forecast by Assimilating MODIS IR-Based Nighttime AOT in the ADAM2 Model

Sang-Sam Lee, Eun-Hee Lee, Byung-Ju Sohn, Hee Choon Lee, Jeong Hoon Cho, Sang-Boom Ryoo

Scientific Online Letters on the Atmosphere (SOLA), Volume 13, Jan. 2017

<https://doi.org/10.2151/sola.2017-020>

A data assimilation (DA) system employing day- and nighttime aerosol optical thickness (AOT) was developed for the Asian Dust Aerosol Model 2 (ADAM2), using the optimal interpolation (OI) method. The DA system assimilated nighttime AOT for dust retrieved from MODIS infrared (IR) measurements with an artificial neural network (ANN) approach. An Asian dust case that occurred during 14-18 March 2009 was simulated using ADAM2. To examine the impact of the inclusion of nighttime AOT on forecasts of the data assimilation system, experiments were performed with different assimilation cycles (i.e., DA1: 24-hour cycle with daytime MODIS AOT only, DA2: 12-hour cycle with additional nighttime AOT). A control simulation was also performed without data assimilation (CTL). Forecasts were assessed using MODIS-derived AOT distributions as well as ground-based skyradiometer, PM10, and lidar observations. The model-estimated vertical distribution of the dust extinction coefficient was also compared with lidar measurements. Both experiments (DA1, DA2) were found to have improved forecasting, but DA2 outperformed DA1. Results suggest that the ANN-based nighttime AOT contributes more positively to the forecasting through better temporal coverage for data assimilation.

6) Inverse Modeling of Asian Dust Emissions with POPC Observations: A TEMM Dust Sand Storm 2014 Case Study

Keiya Yumimoto, Itsushi Uno, Xiaole Pan, Tomoaki Nishizawa, Sang-Woo Kim, Nobuo Sugimoto

Scientific Online Letters on the Atmosphere (SOLA), Volume 13, Jan. 2017

<https://doi.org/10.2151/sola.2017-020>

An inverse modeling system for estimating Asian dust emissions was developed by combining the GEOS-Chem chemical transport model with the Green's function method. We applied the system to two heavy dust storms that occurred in 2014 (10-25 March and 24 May to 5 June), using surface-based polarization optical particle counter (POPC) observations at Fukuoka. Validation by independent observation datasets, including POPC measurements and PM10 observations at Seoul, showed that the use of a posteriori dust emissions improved overestimations in the a priori simulation and achieved much better agreement with observations. Satellite observations, surface synoptic observations, and modeled wind fields indicated that the major dust source region differed between the two dust storms; the major dust outbreak of one storm occurred in the northeastern Gobi Desert, whereas that of the other occurred in the southern Gobi Desert. The a posteriori dust emissions successfully

reproduced this difference. Thus, the inverse modeling system developed in this study was able to improve the estimation of not only the intensity but also the geographical distribution of dust emissions.

7) Simultaneous Dust and Pollutant Transport over East Asia: The Tripartite Environment Ministers Meeting March 2014 Case Study

Itsushi Uno, Keiya Yumimoto, Xiaole Pan, Zhe Wang, Kazuo Osada, Syuichi Itahashi, Shigekazu Yamamoto

Scientific Online Letters on the Atmosphere (SOLA), Volume 13, Jan. 2017

<https://doi.org/10.2151/sola.2017-020>

Heavy dust storms that occurred between 13 and 23 March 2014 were selected for analysis as a case study of dust and sand storm events by the Abstract: Tripartite Environment Ministers Meeting. During this period, two dust and anthropogenic aerosol events were observed and analyzed. The GEOS-Chem chemical transport model, which includes dust-acid uptake processes, successfully reproduced the aerosol variations and explained the Asian-scale dust-pollutant transport processes. Our results confirmed the importance of coarse-mode dust-nitrate as evidence of ‘polluted dust’ pollution. The model analysis showed that the formation of dust-nitrate occurred over the Yellow Sea and East China Sea before arriving in Japan. We showed that more than 40% of nitrate exists in dust-nitrate when air mass arrived in Japan.

8) Variations of Dust Extinction Coefficient Estimated by lidar Observations over Japan, 2007-2016

Atsushi Shimizu, Nobuo Sugimoto, Tomoaki Nishizawa, Yoshitaka Jin, Dashdondog Batdorj

Scientific Online Letters on the Atmosphere (SOLA), Volume 13, Jan. 2017

<https://doi.org/10.2151/sola.2017-020>

Dust extinction coefficients, a fundamental product of the Asian Dust and Aerosol lidar Observation Network, were analyzed to evaluate climatological variations of Asian dust in Japan. Dust optical depth (vertically integrated dust extinction coefficients) from the network displayed peaks similar to those in the official Japan Meteorological Agency reports in spring, and in other seasons they were more responsive signals of moderate dust events. Between 2007 and 2016, dust optical depth decreased by 2.5% per year in Japan, and by 0.7% per year in Mongolia, a major source region of Asian dust. Relative to Mongolia, then, Japan has displayed a stronger negative trend in dust extinction coefficients, which is attributed to the meteorological field between continental Asia and Japan, including wind and rainfall during transportation. This negative trend of Asian dust in Japan was stronger in the middle troposphere (5-6 km altitude) than in the planetary boundary layer.

9) Importance of long-range nitrate transport based on long-term observation and

modeling of dust and pollutants over East Asia

Uno, I., K. Yumimoto, K. Osada, Z. Wang, S. Itahashi, X.L. Pan, Y. Hara, S. Yamamoto and T. Nishizawa

Aerosol and Air Quality Research, Volume 17, 2017

<https://doi.org/10.4209/aaqr.2016.11.0494>

Long-term synergetic fine and coarse mode aerosol observations were analyzed at 1-h intervals at Fukuoka, Japan, from January to June 2015. The GEOS-Chem chemical transport model, including dust and sea-salt acid uptake processes, was used for detailed analysis of observation data. Several Asian dust events and long-range anthropogenic aerosol transport events were observed during our analysis period, and the numerical model generally explained the observed time variation for both fine and coarse mode aerosols. We found that (i) the majority of fine mode NO_3^- can be considered as long-range transport (LRT) outside of Japan during the cold season, and (ii) the peak timing of fine mode NO_3^- coincided with that of SO_4^{2-} , indicating that both aerosols are controlled by LRT. Also, an observed mass concentration ratio of $\text{NO}_3^-/\text{SO}_4^{2-} > 0.9$ occurred during the cold season, indicating the importance of NO_3^- as a major contributor to the $\text{PM}_{2.5}$ mass fraction. Finally, we clearly showed that large-scale dust-nitrate outflow from China to Fukuoka was confirmed in all cases of dust events, indicating that the anthropogenic NO_x is converted to dust-nitrate and transported to Japan with dust. These results demonstrate the importance of anthropogenic NO_3^- LRT during the cold season and dust-nitrate LRT for all dust events (even in June).

[2018]

10) Characteristics of Long-lasting Haze Episodes Observed in Seoul during 2009-2014

Hae-Jung Lee, Jeong Eun Kim, Joo-Wan Cha, Seungjoo Song, Sang Boom Ryoo

Theoretical and Applied Climatology, Volume 136, Mar. 2018

<https://doi.org/10.1007/s00704-018-2415-7>

The meteorological, physical, chemical, and optical characteristics of long-lasting haze in Seoul were studied. Four episodes were observed between 2009 and 2014, all in winter. PM_{10} mass concentration (PM_{10}), chemical species, and aerosol optical depth (AOD) were analyzed along with the synoptic meteorological conditions. During the episodes, the temporal variations of the PM_{10} generally proceeded from the west along the Yellow Sea. The ground-based AOD was also high in Seoul and other sites. High AOD (MODIS) distributions were observed to move from China to Korea. The high sulfate concentration, along with the high sulfur oxidation ratio value of the third and fourth episodes (Eps. 3 and 4), respectively, corroborated the possible long-range transport of air pollutants. Stagnant meteorological conditions were a reason for the occurrence of long-lasting hazes. An

anticyclone system had a dominant influence on the Korean peninsula during all episodes. The air mass over China was able to rise, and that over Korea was more stagnant in terms of climatology except Ep. 2. In addition to transport from outside, locally emitted air pollutants contributed to the PM₁₀ partly due to the stagnant conditions, during which diurnal variations in NO₂ and nitrates showed similar peak times during Eps. 3 and 4. Analysis of the episodes consistently showed that the long-lasting haze episodes were influenced by both the long-range transport of air pollutants from outside Seoul, mostly from China, and the accumulation of air pollutants that were locally emitted and transformed.

[2019]

11) Aerosol Physical Characteristics over the Yellow Sea During the KORUS-AQ Field Campaign: Observations and Air Quality Model Simulations

Yun-Kyu Lim, Jinwon Kim, Hee Choon Lee, Sang-Sam Lee, Joo-Wan Cha, Sang Boom Ryoo

Asia-Pacific Journal of Atmospheric Sciences, Online first article, Mar. 2019

<https://doi.org/10.1007/s13143-018-00100-x>

For understanding the aerosol characteristics over the Yellow Sea according to the air flow patterns in East Asia, the aerosol volume concentration distribution by particle size (size distribution) of the shipborne samples collected in the KORUS-AQ campaign is examined in conjunction with air quality (AQ) model simulations and air parcel trajectory analyses. Cluster analyses of the air parcel trajectories show that 42% of the collected air samples originated in Korea and Japan, 30% in inland/east-coast China, 16% in the highlands of Inner Mongolia, and 11% in the East China Sea. The aerosol size distribution varies characteristically according to the upstream path of individual trajectory clusters; particles of diameters <1 μm dominate when the upstream pathways include China, Korea, and/or Japan, that are significant sources of anthropogenic aerosols. Air flows from the East China Sea, a region virtually free of anthropogenic aerosol sources, show aerosol concentrations peaks at larger sizes of 1–5 μm . The flows from the Inner Mongolia are characterized by a bimodal distribution with a peak at 0.7 μm and another peak of a similar magnitude at diameters >2 μm , indicating a mixed industrial-dust aerosol type in which the dust particles from the Inner Mongolia is mixed with fine particles in the industrialized northeast China. Model studies for cases of typical air flow trajectory groups show that the model simulates the spatial distribution of the satellite-observed particulate matter reasonably, but underestimates the observed volume concentration of fine particles <1 μm .

Chapter 3 (Summary)

3.1 The achievements and problems to be solved of the research activities (2015-2019)

Sharing of various data parameters has been enhanced through the WG I activities and the mutual understandings among the WG I experts from China, Japan, Korea and Mongolia have been fostered. As a result, 11 research papers were accepted by Particuology, SOLA, etc. between 2015 and 2019.

Also in 2016, WG I jointly issued the “Report on the current monitoring methods for particulate matters”, which summarized and assessed the monitoring methods including the instruments, QA/QC (quality assurance and quality control) protocols, equivalency test for particulate matters in China, Korea, Mongolia and Japan in order to verify the quality of the monitoring data.

Report on the current
monitoring methods
for particulate matters

Working Group I for Joint Research
on Dust and Sand Storms among
China, Japan, and Korea

2016

◆ Outline of “Report on the current monitoring methods for particulate matters”

Chapter 1: Introduction

Chapter 2: China / Chapter 3: Korea / Chapter 4: Mongolia

- ✓ Monitoring target and air quality standard for PM
- ✓ Monitoring method for PM_{2.5}
- ✓ Monitoring method for PM₁₀
- ✓ Monitoring method for TSP

Chapter 5: Japan

- ✓ Monitoring target, quality standard and manual
- ✓ Monitoring method for PM_{2.5}
- ✓ Monitoring method for SPM

Appendix

Throughout the solid WG I activities since 2015, a role of WG I as platform for DSS monitoring and early warning system has been surely enhanced.

3.2 The proposed research plans for the Mid-Term Action Plan (2020-)

With a view to further improvement and enhancement of DSS monitoring and early warning system under the Mid-Term Action Plan from 2020, WG I continues its works following its mandate to achieve the goal(s) of WG I. In addition, WG I will introduce a new concept of Climate Change into the existing research work in order to further enhance the role of WG I as a scientific knowledge sharing platform. The activities and expected outcomes under the Mid-Term Action Plan from 2020 are proposed as follows.

(Activities)

1. Continuation of previous WG I activities
2. Expansion of data sharing for Joint Research
3. Encouragement of sharing real-time data for developing early warning system
4. Enhancement of the cooperation between two Working Groups
5. Encouragement of the participation of outreach research groups
6. Enhancement of research on sub-seasonal to seasonal (S2S) forecasts and long-term variations of DSS

(Expected Outcomes)

1. Enhanced platform, including web-hard and online portal, for DSS data sharing to prevent DSS damages in East Asia
2. Improved DSS forecast and early warning systems
3. Published research papers on DSS
4. Integrated information on DSS between WG I and II

Annex

1. Meeting agenda and summary from the 8th to 12th WG I meetings
2. Meeting agenda and summary of the WG I and WG II joint meetings
3. List of shared data on the Webhard
4. List of published papers from 2015 to 2019

Annex 1.

Meeting agenda and summary from the 8th to 12th WG I meetings

Meeting agenda

The 8th meeting of Working Group I for Joint Research on DSS

9-10 December, 2015

ACROS Fukuoka, Fukuoka, Japan

Day 1 (9, December)

8:30-9:00 Registration of participants

Opening

Chair: Mr. Tatsuya YANASE (Ministry of the Environment, Government of Japan)

9:00-9:05 Opening remarks
Mr. Tatsuya YANASE (Ministry of the Environment, Government of Japan)

9:05-9:15 Introduction of participants

9:15-9:20 Adoption of the agenda

Session I Looking back at discussion and activities

Chair: Mr. Masayoshi Futami (Overseas Environmental Cooperation Center, Japan)

【Japan's presentation】

9:20-9:30 Overviews of the last DSS-WG I meeting, SCM, TDGM and TEMM
Mr. Tatsuya YANASE (Ministry of the Environment, Government of Japan)

【Korea's presentation】

9:30-9:40 Review on contents of the Mid-Term Action Plan (2015-2019)
Dr. Sang Boom RYOO (National Institute of Meteorological Sciences, Korea)

9:40-9:45 Questions and answers

【Korea's presentation】

9:45-9:55 Current status of DSS data sharing
Dr. Sang Sam LEE (National Institute of Meteorological Sciences, Korea)

9:55-10:00 Questions and answers

【China's presentation】

10:00-10:10 Progress of joint research journal
Mr. PAN Benfeng (China National Environmental Monitoring Center)

10:10-10:15 Questions and answers

10:15-10:25 Coffee break

Session II Report from the countries on DSS events (2013 3.5-3.22 and 2013 12.26-2014 01.06)

Chair: Dr. Masataka NISHIKAWA (Tokyo University of Science)

【China's presentation】

10:25-10:40 DSS monitoring in China 2014

Mr. Li Liang (China National Environmental Monitoring Center)

10:40-10:45 Questions and answers

【Korea's presentation】

10:45-11:00 Dust Monitoring results of DSS2013 cases in KMA

Dr. Sang Sam LEE (National Institute of Meteorological Sciences, Korea)

11:00-11:05 Questions and answers

11:05-11:20 Simulation Results of DSS2013 cases with ADAM

Mr. Hee Choon LEE (National Institute of Meteorological Sciences, Korea)

11:20-11:25 Questions and answers

【Japan's presentation】

11:25-11:40 Modeling Study in JMA/MRI

Dr. Takashi MAKI (Meteorological Research Institute, Japan)

11:40-11:45 Questions and answers

11:45-12:00 Analysis of the DSS events in 2013 using the lidar network and surface PM data

Dr. Nobuo SUGIMOTO (National Institute for Environmental Studies, Japan)

12:00-12:05 Questions and answers

Session III Reports of studies from Mongolian and Japanese experts

Chair: Mr. Masayoshi Futami (Overseas Environmental Cooperation Center, Japan)

【Mongolia's presentation】

12:05-12:15 A Livestock Trampling Function for Emission Rate of Wind-blown Dust in Mongolia

Dr. Munkhtsetseg ERDENEBAIYAR (National University of Mongolia)

12:15-12:25 Analysis of the PM_{2.5} and PM₁₀ in Ulaanbaatar, Mongolia

Dr. Sonomdagva CHONOKHUU (National University of Mongolia)

12:25-12:30 Questions and answers

12:30-14:00 Lunch

【Japan's presentation】

14:00-14:15 Analysis of long-range transport of Yellow Sand and Dust-Nitrate over East Asia
Dr. Itsushi UNO (Kyushu University)

14:15-14:20 Questions and answers

Session IV Conducted activities in 2014-2015 for each goal of the Mid-Term Action Plan (2015-2019)

Dr. Takashi MAKI (Meteorological Research Institute)

1. Comparison of monitoring methods for particulate matters

【Japan's presentation】

14:20-14:30 Current monitoring methods for PM_{2.5} and other particulate matters
Dr. Masataka NISHIKAWA (Tokyo University of Science, Japan)

14:30-14:35 Questions and answers

【Korea's presentation】

14:35-14:45 Current monitoring methods and QC algorithm for particulate matters
Dr. Sunyoung KIM (National Institute of Meteorological Sciences, Korea)

14:45-14:50 Questions and answers

【China's presentation】

14:50-15:00 Current monitoring methods for PM_{2.5} and other particulate matters
Mr. PAN Benfeng (China National Environmental Monitoring Center)

15:00-15:05 Questions and answers

【Mongolia's presentation】

15:05-15:15 Current monitoring methods for PM_{2.5} and other particulate matters
Dr. Munkhtsetseg ERDENEBAIYAR (National University of Mongolia)

15:15-15:20 Questions and answers

2. Linking of WMO SDS-WAS web portal to share DSS model outputs

15:20-15:30 Current state of WMO SDS-WAS Asia node
Dr. Takashi MAKI (Meteorological Research Institute, Japan)

15:30-15:35 Questions and answers

15:35-15:45 Coffee break

Session V Discussion on the detailed milestones for the Mid-Term Action Plan (2015-2019)

Chair: Dr. Masao MIKAMI (Japan Meteorological Business Support Center)

15:45-17:05 **【Discussion 1~4】**

1. Continuation of previous WG I activities

- Next target event for the next year's study
- Milestone of booklet making process (submitted papers to Particuology)
- Next publication of the research results in a scientific journal

2. Expansion of data sharing

- Additional data to share among the countries (e.g., PM2.5)

3. Comparison of monitoring methods for particulate matters

- Finalizing plan to edit the monitoring method report to submit to the next Steering Committee Meeting

4. Linking of WMO SDS-WAS web portal to share DSS model outputs

5. Enhancement of the cooperation between two Working Groups

- Collaboration menu with WG II

17:05-17:15 **【presentation】**

Possible collaboration menu between WG I and II

Mr. Masayoshi Futami (Overseas Environmental Cooperation Center, Japan)

17:15-17:20 Questions and answers

17:20-18:00 **【Discussion 5~6】**

6. Encouragement of the participation of outreach research groups

- EANET
- CMA
- WMO

18:45- Reception

Day 2 (10, December)

Session VI Summary

Chair: Mr. Tatsuya YANASE (Ministry of the Environment, Government of Japan)

【Discussion】

9:30-11:55 Discussion and adoption of meeting summary

【Closing】

11:55-12:00 Closing remarks

Mr. Tatsuya YANASE (Ministry of the Environment, Government of Japan)

Summary of the Eighth Meeting of Working Group I

for Joint Research on Dust and Sand Storms

Fukuoka, 9-10 December 2015

1. The eighth meeting of Working Group I (WG I) for Joint Research on Dust and Sand Storms (DSS) under Tripartite Environment Ministers Meeting (TEMM) was held in ACROS Fukuoka, Fukuoka City, Japan on 9th and 10th of December, 2015. Representatives from China, Korea, Mongolia and Japan participated in this meeting (Annex1 : List of participants).
2. Mr. Tatsuya YANASE, Deputy Director of Air Environment Division, Ministry of the Environment Japan (MOEJ) delivered opening remarks and warmly welcomed the experts from China, Korea and Mongolia. Upon his request, all participants took a moment to officially introduce with each other. He introduced the provisional agenda of the meeting and the agenda was adopted by all participants (Annex 2 : Meeting agenda).
3. In Session One chaired by Mr. Masayoshi FUTAMI, Overseas Environmental Cooperation Center (OECC), the overviews of the last WG I meeting, the 9th SCM, the 10th TDGM and the 17th TEMM were reported by Mr. Tatsuya YANASE. Dr. Sang Boom RYOO, National Institute of Meteorological Sciences (NIMS), Korea reviewed and summarized the Mid-Term Action Plan (2015-2019) of WG I.
4. Dr. Sang Sam LEE, NIMS, made a presentation on current status of DSS 2013 data sharing. According to his report, China provided with hourly average PM10 (10 sites), Korea with hourly average PM10 (36 sites), PM2.5 (1 site), lidar (2 sites), RH and visibility (6 sites) and AOT and angstrom exponent (1 site), and Japan with hourly average SPM (21 sites), PM10 (11 sites), PM2.5 (3 sites), lidar (17 sites), RH and visibility (60 sites) and AOT and angstrom exponent (1 site). Mongolia submitted hourly average PM10, PM2.5, RH and visibility (5sites) of DSS 2012 and 2013.
5. Mr. PAN Benfeng, China National Environmental Monitoring Center (CNEMC) made a presentation on the progress of joint research journal. He reported that five research papers have been submitted to the Particuology from the WG I experts up to now, two of them have been accepted and others are being reviewed. He mentioned that, when the papers are accepted, he will collect all the papers and bind them in one volume for WG I.
6. In Session Two chaired by Dr. Masataka NISHIKAWA, Tokyo University of Science, several results of studies on DSS events (2013-2014) were reported from China, Korea and Japan.
7. Mr. Li Liang, CNEMC, made a presentation on DSS monitoring in China 2014. He showed the number of days that DSS occurred and pointed out that the accumulative number of days that air quality exceeded the standard was 270 days in 161 key cities in 2014. He explained the technical requirements for dust weather classification that were established and promulgated by CNEMC on a trial basis.
8. Dr. Sang Sam LEE, NIMS, made a presentation on dust monitoring results of DSS 2013 events in Korea. He highlighted the weather conditions and signals of dusts in each of two events (DSS-2013-1; 5th to 22nd March, 2013 and DSS-2013-2; 26th December, 2013 to 6th January, 2014). He summarized that in

2013 there occurred only five DSS events in Korea and all of them were not severe mainly due to heavy rain and snow. He mentioned that regarding DSS-2013-1 event the duration was relatively short and chemically similar with haze in Korea, while DSS-2013-2 event affected all over Korea mainly caused by no snow in source regions.

9. Mr. Hee Choon LEE, NIMS, made a presentation on simulation results of DSS 2013 events with the Asian Dust Aerosol Model (ADAM). He explained the development of ADAM-Haze Model, and showed the difference between simulation and observation in the above two DSS-2013 events. In so doing, he suggested the necessity of applying optimal interpolation.
10. Dr. Takashi MAKI, Meteorological Research Institute (MRI), Japan, made a presentation on modeling study in Japan Meteorology Agency (JMA) / MRI. He pointed out that MASINGER mk-2 could simulate a dust event at 9-10th and 19-20th March 2013, meanwhile it overestimated DSS-2013-2 event. He mentioned that surface condition (vegetation, soil wetness, snow cover and soil temperature) of dust source regions should be confirmed. He also stated that JMA upgraded the dust prediction model from MASINGER to MASINGAR mk-2 in November 2014. Also, JMA has a plan to introduce higher resolution (40km) version of the model from 2016, and to introduce satellite data assimilation system for prediction from 2018.
11. Dr. Nobuo SUGIMOTO, National Institute for Environmental Studies, Japan, made a presentation titled “Analysis of the DSS events in 2013 using the lidar network and surface PM data”. After briefly introducing his report submitted to Particuology titled “A Method for Estimating the Fraction of Mineral Dust in Particulate Matter Using PM2.5-to-PM10 Ratios”, he explained that dust PM2.5 could be estimated using the PM2.5-to-PM10 ratio method, and that the consistency with the result of using lidar data method was validated. He demonstrated the similar consistency in the two events of DSS 2013. He stressed the importance of sharing both hourly PM2.5/10 data.
12. Every presentation in Session Two was followed by question and answer session. The questions raised were mainly clarification and about the features and operability of the simulation models, as well as interpretation of data shown in the presentations.
13. In Session Three chaired by Mr. Masayoshi FUTAMI, results of studies on DSS were reported from Mongolia and Japan. Dr. Munkhtsetseg ERDENEBAJAR presented “A Livestock Trampling Function for Emission Rate of Wind-blown Dust in Mongolia”. She pointed out the necessity of considering livestock disturbance effects on dust emission; particularly in Mongolia, and proposed a livestock trampling function for dust flux.
14. Dr. Sonomdagva CHONOKHUU, National University of Mongolia, demonstrated the analysis of the PM2.5 and PM10 in Ulaanbaatar, Mongolia. He stated that the PM10 and PM2.5 particle pollution had a same source and mass concentrations of PM2.5 and PM10 were higher in winter than in summer. He explained the reason being the abundant precipitation in summer and the pollution from coal burning in winter, being typical microclimate in Ulaanbaatar.
15. Dr. Itsushi UNO, Kyushu University, made a presentation titled “Analysis of long-range transport of Yellow Sand and Dust-Nitrate over East Asia”. He observed a long-lasting dust event from 25th May to 2nd June, 2014, using a polarization optical particle counter (POPC), aerosol chemical speciation analyzer (ACSA), and compared these data with the outputs from the updated version of GEOS-Chem

transport model with dust acid uptake. He concluded that high time resolution measurement of nitrate and PM10 (mostly dust) showed a high correlation during the yellow sand episode in Fukuoka (May-June 2014). He estimated that more than 70% of dust-nitrate originated NO_x emission from Beijing-Shanghai wide area.

16. Session Four began with the announcement made by Dr. Takashi MAKI, a chairperson. For the comparison of monitoring methods for particulate matters among four countries, Dr. Masataka NISHIKAWA, Dr. Sunyoung KIM, NIMS, Mr. PAN Benfeng, and Dr. Munkhtsetseg ERDENEBAIYAR made presentations on current monitoring methods of each country. They reported the progress of compiling the Report on the current monitoring methods for PM_{2.5} and other particulate matters using automatic sampler.

17. The current status of activities of the WMO Sand and Dust Storm Warning Advisory and Assessment System (SDS-WAS) Asia Node was introduced by Dr. Takashi MAKI. He reported current activities of WMO SDS-WAS Regional Steering Group for Asia and introduced SDS observation data sharing list approved among Korea Meteorological Administration (KMA), JMA and China Meteorological Administration (CMA). Regarding SDS forecasting system, SDS-WAS is assembling forecasts from North-East Asian countries, and preparing a website to share the information of activities in three countries, as well as the outcome of the operational forecast models and real-time observations. (http://eng.nmc.cn/sds_was.asian_rc/)

18. In Session Five chaired by Dr. Masao MIKAMI, Japan Meteorological Business Support Center, all participants were invited to discuss on “the detailed milestones for the Mid-Term Action Plan (2015-2019)”. Participants discussed on each item below.

- 1) Continuation of previous WG I activities
- 2) Expansion of data sharing
- 3) Comparison of monitoring methods for particulate matters
- 4) Linking of WMO SDS-WAS web portal to share DSS model outputs
- 5) Enhancement of the cooperation between two Working Groups
- 6) Encouragement of the participation of outreach research groups

The main outcome of the discussion was following;

19. Regarding 1), it was decided that DSS event data (2014.3.13 ~ 3.23 and 2014.5.22 ~ 6.4) will be shared by the participating countries to study these DSS events by each researcher. Korea will provide hourly average PM₁₀ (36 sites), PM_{2.5} (hourly data, number of sites to be determined later), lidar (3 sites), visibility and RH (6 sites), AOT (COMS, KMA skyradiometer). Japan was willing to share hourly average SPM (21 sites), PM₁₀ (11 sites), PM_{2.5} (3 sites), lidar (17 sites), visibility and RH (60 sites), AOT (3 sites (JMA), SKYNET) and MTSAT. China will offer hourly average PM₁₀ (10 sites). Any additional data will be welcomed.

The countries will upload these data to the data sharing website by 31st August 2016.

Regarding journal publication, it was decided that all articles which have been submitted to Particuology to date, accepted as well as under review, should be forwarded to Chinese focal person by 1st February 2016. The papers will be combined in one volume and presented to SCM in February.

Next international journal to be submitted for publication will be Scientific Online Letters on the

Atmosphere (SOLA), Meteorological Society of Japan. The authors will submit their papers to SOLA by the end of March 2017, and the submission will be managed by a Japanese focal point (to be confirmed).

20. Regarding 2), it was recognized that, in order to achieve an increased accuracy for the models, PM_{2.5}/PM₁₀ hourly data sharing be strongly encouraged. Korea suggested to share its Optical Particle Counter (OPC) or POPC data set, and discussed the possibility to share the OPC data set for the joint research 1).

China stated that it does not have any OPC data yet. WG I stressed the importance of sharing both PM₁₀ and PM_{2.5} hourly data at same sites, because the PM_{2.5} to PM₁₀ ratio is an effective dust indicator.

21. Regarding 3), focal points were designated for revising the “Report on the current monitoring methods for PM_{2.5} and other particulate matters” as below;

China: Mr. PAN Benfeng, CNEMC

Japan: Ms Ayako INOUE, OECC

Korea: Dr. Sang Sam LEE, NIMS

Mongolia: Dr. Sonomdagva CHONOKHUU, NUM

In December 2015, OECC will share the combined draft report among China and Korea. After each country will finalize it and cross review by country’s experts, the country’s focal point will send the final version to OECC by the end of January. Mongolia will send its draft to OECC by the end of January. WG I will report the final version to the SCM in February 2016.

22. Regarding 4) and 6), WG I agreed with linking with WMO SDS-WAS. WG I recommended to invite Dr. ZHANG Xiaoye, the Chair of Regional Steering Group (RSG) of SDS-WAS Asian node, for the joint WG I and II workshop in February 2016, to discuss future collaboration between two bodies.

23. Regarding 5), Mr. Masayoshi FUTAMI presented the activities of WG II and possible collaboration menu between WG I and II. Dr. Masao MIKAMI stated that the collaboration would start by organizing a joint workshop to share experience and knowledge. He also suggested this workshop be in an academic and open manner, with participation of external experts. WG I welcomed his additional proposal to share the data with WGs from his continuous observation from 2012 in Tsogt-Ovoo in Mongolia.

24. In Session Six chaired by Mr. Tatsuya YANASE, all participants checked and confirmed summary of the meeting and Mr. Tatsuya YANASE announced that next DSS SCM will be held in Tokyo, Japan on 26 February 2016, and the results of the discussion at this meeting will be reported to SCM. He also announced the joint workshop between WG I and WG II will be held in Tokyo, Japan on 27 February 2016.

25. Before closing, it was announced that the ninth meeting of WG I will be held in Jeju, Korea in November or December, 2016 based on the decision of the TOR of WG I. The detail of the ninth meeting will be confirmed at a later date.

**The 8th Meeting of Working Group I Joint Research on Dust and Sand Storms among
Mongolia, China, Korea and Japan**

Fukuoka, Japan
(9-10 December, 2015)

List of Participants

China

Mr. PAN Benfeng
Senior engineer
Ambient Air Quality Monitoring Dept
China National Environmental Monitoring Center

Mr. LI Liang
Senior engineer
Ambient Air Quality Monitoring Dept
China National Environmental Monitoring Center

Korea

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Director
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National Institute of Meteorological Sciences,
Korea Meteorological Administration

Mr. LEE Hee Choon
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Environmental Meteorology Research Division
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Ms. PARK Minah
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Observation Policy Division
Korea Meteorological Administration

Dr. KIM Sunyoung
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Environmental Meteorology Research Division

National Institute of Meteorological Sciences,
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Environmental Management Bureau
Ministry of the Environment, Government of Japan

Dr. NISHIKAWA Masataka
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Environmental Safety Center
Tokyo University of Science,

Dr. SUGIMOTO Nobuo
Fellow
Center for Environmental Measurement and Analysis,
National Institute for Environmental Studies (NIES)

Dr. MIKAMI Masao
Japan Meteorological Business Support Center (JMBSC)

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Meteorological Research Institute (MRI)

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Mr. IWAMOTO Shinji
Senior Technical Adviser
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Dr. Sonomdagva CHONOKHUU
Associate Professor
Department of Environmental Sciences and Chemical Engineering
School of Engineering and Applied Sciences
National University of Mongolia

OBSERBER

Mr. NISHI Takayuki
Japan Environmental Sanitation Center (JESC)

Mr. YAMAMOTO Shigekazu
Fukuoka Institute of Health and Environmental Sciences

SECRETARIAT

**Overseas Environmental
Cooperation Center,
Japan (OECC)**

Mr. FUTAMI Masayoshi
Senior Researcher

Mr. HIEDA Yasushi
Senior Researcher

Ms. HAYASHI Yayoi
Researcher

Ms. INOUE Ayako
Researcher

The 9th Meeting of Working Group I for Joint Research on Dust and Sand Storms

◆ **Date : November 30 (Wed.) ~ December 2 (Fri.), 2016**

Venue : Seogwipo KAL Hotel, Jeju, KOREA

Host: National Institute of Meteorological Sciences/KMA, KOREA

◆ **DAY 1 (November 30)**

9:00 - 9:30	REGISTRATION
Session I	Opening
	Chair: Mr. Hee Choon LEE (National Institute of Meteorological Sciences/KMA, KOREA)
9:30 - 9:40	Opening Remarks
	Dr. Sang Boom RYOO (National Institute of Meteorological Sciences/KMA, KOREA)
9:40 - 9:50	Introduction of participants
9:50 - 10:00	Adoption of the agenda
10:00 - 10:20	Break & Group Photo
Session II	Looking back at discussion and activities
	Chair: Mr. Liang LI (China National Environmental Monitoring Center, CHINA)
10:20 - 10:40	Overview of the last DSS-WG I activities, 10th SCM, the 11th TDGM and the 18th TEMM
	Mr. Kinichi SUDO (Ministry of the Environment of Japan/MOEJ, JAPAN)
10:40 - 11:00	Current status of DSS Data Sharing
	Dr. Sang-Sam LEE (National Institute of Meteorological Sciences/KMA, KOREA)
11:00 - 11:20	Current status of published research papers to the Particuology
	Mr. Liang LI, Pan BENFENG (China National Environmental Monitoring Center, CHINA)
Session III	Report from the countries on DSS events (2014.3.13-23, 2014.5.22-6.4)
	Chair: Dr. Nobuo SUGIMOTO (National Institute for Environmental Studies, JAPAN)
11:20 - 11:40	Analysis of dust and haze events in 2014-2016 using the lidar network
	Dr. Nobuo SUGIMOTO (National Institute for Environmental Studies, JAPAN)
11:40 - 12:00	Inverse Modeling of Asian Dust Emission with POPC Observations for TEMM DSS 2014 Case Study
	Dr. Nobuo SUGIMOTO (National Institute for Environmental Studies, JAPAN)
12:00 - 13:40	LUNCH

13:40 - 14:00	DSS Modeling and Monitoring Study by MRI/JMA Dr. Takashi MAKI (Meteorological Research Institute/MRI, JAPAN)
14:00 - 14:20	A Cases of DSS 2014 Monitoring Result in China Mr. Liang LI (China National Environmental Monitoring Center, CHINA)
14:20 - 14:40	Dust monitoring results of DSS2014 cases in KMA Dr. Jeong Eun KIM (National Institute of Meteorological Sciences/KMA, KOREA)
14:40 - 15:00	Simulation results of DSS2014 cases with ADAM Dr. Yun-Kyu LIM (National Institute of Meteorological Sciences/KMA, KOREA)
Session IV Other Related Activities Chair: Dr. Munkhtsetseg ERDENEYAYAR (National University of Mongolia, MONGOLIA)	
15:00 - 15:20	Introduction of KORUS-AQ campaign Dr. Joo Wan CHA (National Institute of Meteorological Sciences/KMA, KOREA)
15:20 - 15:40	Ambient air quality and white dust dispersion and transport in Erdenet city, Mongolia Dr. Sonomdagva CHONOKHUU (National University of Mongolia, MONGOLIA)
15:40 - 16:00	Sand trap (BSNE) observational results for the case 2011 spring Dr. Munkhtsetseg ERDENEYAYAR (National University of Mongolia, MONGOLIA)
16:00 - 16:20	Break
Session V Discussion on the detailed milestones for the Mid-Term Action Plan (2015-2019) Chair: Dr. Sang-Sam LEE (National Institute of Meteorological Sciences/KMA, KOREA)	
16:20 - 18:00	Continuation of previous WG I activities <ul style="list-style-type: none"> - Next target event for the next year's study - Next publication plan of the research results in SOLA (Mr. Yu KUDO, JAPAN) Expansion of data sharing <ul style="list-style-type: none"> - Additional data to share among the countries (Dr. Sang-Sam LEE, KOREA) Comparison of monitoring methods for particulate matters <ul style="list-style-type: none"> - Report on the current monitoring methods for particulate matters (Dr. Atsushi SHIMIZU, JAPAN) Linking of WMO SDS-WAS web portal to share DSS model outputs <ul style="list-style-type: none"> - Current status of SDS-WAS RSG for Asia (Dr. Sang-Sam LEE, KOREA) Enhancement of the cooperation between two Working Groups <ul style="list-style-type: none"> - Review of the 1st Joint Workshop between WG I and II (Mr. Yasushi HIEDA, JAPAN) Encouragement of the participation of outreach research group <ul style="list-style-type: none"> - EANET, CMA, WMO
18:00 - 20:00	BANQUET

◆ **DAY 2 (December 1)**

Session VI Summary	
Chair: Dr.Sang Boom RYOO (National Institute of Meteorological Sciences/KMA, KOREA)	
9:00 - 12:00	Discussion and adoption of meeting summary
12:00 - 12:10	Closing Remarks
12:10 - LUNCH	

◆ **DAY 3 (December 2)**

Scientific Site Visiting	
9:00 - 12:00	Gosan GAW site
12:00 - 13:30	Lunch
13:30 - 18:00	Jeju World Natural Heritage Site Visiting

Summary of the Ninth Meeting of Working Group I

for Joint Research on Dust and Sand Storms

Jeju, 30th November-2nd December 2016

1. The ninth meeting of Working Group I (WG I) for Joint Research on Dust and Sand Storms (DSS) under the Tripartite Environment Ministers Meeting (TEMM) was held at Seogwipo KAL Hotel, Jeju, Korea, from 30th November to 2nd December, 2016. Representatives from Japan, China, Mongolia and Korea participated in this meeting (Annex1: List of participants).
2. In Session One chaired by Mr. Hee Choon LEE, Senior Researcher of National Institute of Meteorological Sciences (NIMS)/KMA, Dr. Sang Boom RYOO, Director of Environmental Meteorology Research Division of NIMS/KMA, Korea, delivered opening remarks and warmly welcomed the participants. All participants took a moment to officially introduce to each other. Mr. LEE introduced the provisional agenda of the meeting, but it was adjusted to some extent because two participants (Mr. Liang LI & Dr. Munkhtsetseg ERDENEBAIYAR) could not attend the sessions of 30th Nov. Besides the adjustment of some presentation order and the time of Session VI, the agenda was adopted by all participants (Annex 2: Meeting agenda). Group photo time was postponed to 1st Dec.
3. In Session Two chaired by Dr. Jeong Eun KIM, NIMS/KMA, the last discussion and activities were reported and previewed including the Mid-Term Action Plan of WG I.
4. Mr. Kinichi SUDO, Ministry of the Environment of Japan, made a presentation on “Review on the 8th WG I meeting (Dec. 9-10, 2015 in Fukuoka, Japan), the 10th SCM (Feb. 26, 2016 in Tokyo, Japan), the 1st Joint Workshop (Feb. 27, 2016 in Tokyo, Japan), the 11th TDGM (Mar. 24, 2016 in Shizuoka, Japan) and the 18th TEMM (Apr. 26-27, 2016 in Shizuoka, Japan)”.
5. Dr. Sang-Sam LEE, NIMS/KMA, made a presentation on the current status of DSS2014 data sharing. According to his report, several data were newly added, for example, wind (5 sites) from Mongolia, and AOT & Angstrom exponent of SKYNET (6 sites) from Japan. He emphasized the availability of web-hard (<http://www.webhard.net>) to obtain the useful data and expressed his thanks to all participating countries for sharing their data.
6. In Session Three chaired by Dr. Nobuo SUGIMOTO, National Institute for Environmental Studies (NIES), Japan, several cases from the countries on DSS events (heavy dust storms during Mar. 13-23, 2014; May. 22 - Jun.4, 2014) were reported.
7. Dr. Nobuo SUGIMOTO, NIES, made a first presentation on “Analysis of dust events in 2014-2016 using the lidar network data”. On his presentation, he highlighted that Polarization Sensitive Lidars and Polarization Optical Particle Counters (POPC) are useful instruments to measure and distinguish dust from other types of aerosols in (near) real time.
8. Dr. Nobuo SUGIMOTO, NIES, made a second presentation on “Inverse Modeling of Asian Dust Emission with POPC Observation for DSS 2014 Case Study”, which was done by Prof. UNO (Kyushu Univ., Japan). By combining chemical transport model (GEOS-Chem) and Green’s function method, two heavy dust storm events in 2014 were applied. From this result, it is found that dust emissions were

improved and the related two papers will be submitted to SOLA .

9. Dr. Takashi MAKI, Meteorological Research Institute (MRI), Japan, made a presentation on “DSS Modeling and Monitoring Study by MRI/JMA”. He explained about Geostationary Satellite Himawari-8, reported the new version of MASINGAR mk-2, which will be updated from 2017, and showed the expectation of its better presentation for dust event in the future. One example of forest-fire event in May, 2016 by combining Himawari-8 AOT and MASINGAR mk-2 through data assimilation was presented.
10. Dr. Jeong Eun KIM, NIMS/KMA, made a presentation on “Dust monitoring results of DSS2014 cases in KMA”. DSS2014-01 affected for a relatively short period, but all over the Korean Peninsula. While DSS2014-02 was two separated outbreaks from different source regions for five consecutive days, aerosol characteristics showed anthropogenic pollutants during this period.
11. Dr. Yun-Kyu LIM, NIMS/KMA, made a presentation titled “Simulation results of DSS2014 cases with ADAM”. He introduced the new version of emission inventory and also showed its impact on aerosol modeling from the case experiments during Jan. 16~30, 2015. Additionally, he explained the features of ADAM-Haze through DSS2014-01, 02 cases. To improve the predictability of the ADAM-Haze, he mentioned that anthropogenic emissions over Asian dust pathway are also important.
12. In Session Four chaired by Dr. Sonomdagva CHONOKHUU, National University of Mongolia (NUM), Mongolia, results of other related activities were introduced from Korea and Mongolia.
13. Dr. Joo Wan CHA, NIMS/KMA, introduced KORUS-AQ campaign, which was carried out over the Korean Peninsula under the Korea-USA cooperation during May-June, 2016. This campaign was made for better understanding of satellite performance, fundamental understanding of atmospheric composition and improvement of air quality modelling. After the presentation, Dr. Maki showed the interest in joining this campaign in the future, but this time no plan was developed for the next campaign. In the future, however, it needs to consider making a joint campaign which includes Japanese institutes. The result from this campaign will be opened late next year.
14. Dr. Sonomdagva CHONOKHUU, NUM, explained “Ambient air quality and white dust dispersion and transport in Erdenet city, Mongolia”. The purpose of the study was to identify the air quality, dispersion and trajectories of the “white dust”, which was resulted from the process of Erdenet copper mining. To date, SO₂ and NO₂ were identified, whereas Silicium is still in process.
15. In Session Five chaired by Dr. Sang-Sam LEE, discussion was made on the detailed milestones for the Mid-Term Action Plan (2015-2019). According to the agenda, participants discussed each item listed below.
 - 1) Continuation of previous WG I activities
 - a) Next target event for the next year’s study
 - b) Next publication plan of the research results in SOLA
 - 2) Expansion of data sharing
 - a) Additional data to share among the countries
 - 3) Comparison of monitoring methods for particulate matters
 - a) Report on the current monitoring methods for particulate matters
 - 4) Linking of WMO SDS-WAS web portal to share DSS model outputs
 - a) Current status of SDS-WAS RSG for Asia
 - 5) Enhancement of the cooperation between two Working Groups
 - a) Review of the 1st Joint Workshop between WG I and II

6) Encouragement of the participation of outreach research group

16. Regarding 1)-a) it was decided that the data for the DSS event (Feb. 18-28, 2015; Mar. 15-26, 2015; and Jun. 6-16, 2015) will be shared by the participating countries.

The countries will upload the data about the above suggested period to the data sharing website by 31th July, 2017.

17. Regarding 1)-b) Mr. Yu KUDO, Overseas Environmental Cooperation Center (OECC), Japan, made a presentation on “Next Publication Plan of the research results in SOLA” along with submission regulations. Two papers are already planned to be submitted from Japan. When papers are submitted to SOLA, all submitters will inform OECC (to Mr. Yasushi HIEDA). All accepted papers will be uploaded to the web-site one by one, and in the end they will be bound as one volume for distribution. All members will try to submit by the end of May 2017, and Korea plans to submit three papers potentially.

18. Regarding 2)-a) Expansion of data sharing, Japan and Korea agreed to share POPC data (2 sites) and OPC data (2 sites) of 2015.

19. Regarding 3)-a) Dr. Atsushi SHIMIZU, NIES, reported current monitoring methods for particulate matters. He emphasized that comparative verification of the monitoring methods among four countries in WG I is important for the DSS research and model development, and suggested sharing the information of PM_{2.5} monitor type.

20. Regarding 4)-a) Dr. Sang-Sam LEE, NIMS/KMA, reported the meeting of the 5th WMO SDS-WAS Regional Steering Group for Asia, which was held on Sep. 22-23 in Jeju, Korea. He introduced information on the new web-portal site as well as the current status of observational data sharing between CMA, JMA and KMA.

21. Regarding 5)-a) Mr. Yasushi HIEDA, OECC, made a presentation on “Review of the 1st Joint Workshop between WG I and II”. For the 2nd Joint Workshop, Korea will share more detailed information after having a discussion with the Ministry of Environment of Korea and WG II.

22. Regarding 6) Encouragement of the participation of outreach research group was not discussed this time and decided to postpone to the next meeting.

23. All participants including Mr. Liang LI and Dr. Munkhtsetseg ERDENEBAIYAR participated in Session Six which was held on 1st December and chaired by Dr. Sang Boom RYOO, NIMS/KMA.

24. Mr. Liang Li, China National Environmental Monitoring Center (CNEMC), made a presentation on “Progress on joint journal of WG I (2014-2016)”. To date, PARTICUOLOGY has accepted three papers out of six submitted papers from the WG I experts. And two papers were rejected, and one paper is under revision. Three accepted papers were published in volume 28.

25. Mr. Liang LI, CNEMC, made a presentation on “Cases of DSS 2014 Monitoring Result in China”. According to Mr. LI, the climate factor is conducive to dust and sand storms in April, 2014 in China.

26. Dr. Munkhtsetseg ERDENEBAIYAR, NUM, presented “Sand fluxes and its vertical distribution in the southern Mongolia”. According to Dr. Munkhtsetseg ERDENEBAIYAR, it is crucial to quantify the amount of soil loss by DSS, and defining the sand fluxes and measuring its vertical transportation are

worth understanding DSS phenomena and atmospheric environment.

27. Dr. Sang Boom RYOO, NIMS/KMA, confirmed a summary of the meeting and announced that the next DSS SCM venue will be held in Korea 2017, and the results of the discussion at this meeting will be reported to SCM.
28. Before closing, it was announced that the tenth meeting of WG I will be held in China based on the decision of the TOR of WG I. The details of the tenth meeting will be confirmed at a later date. Lastly, all participants took a group photo.

The 9th Meeting of Working Group I Joint Research on Dust and Sand Storms

Jeju, KOREA

(30 November - 2 December, 2016)

List of Participants

Japan

Mr. Kinichi SUDO

Senior Analyst

General Affairs Division, Environmental Management Bureau

Ministry of the Environment, Government of Japan

Mr. Takashi MAKI

Head, 1st laboratory

Atmospheric Environment and Applied Meteorology Research

Department

Meteorological Research Institute

Dr. Nobuo SUGIMOTO

Fellow

Center for Environmental Measurement and Analysis

National Institute for Environmental Studies

Dr. Atsushi SHIMIZU

Senior Researcher

Center for Regional Environmental Research

National Institute for Environmental Studies

Mr. Yasushi HIEDA

Principal Researcher

First Operation Department

Overseas Environmental Cooperation Center

Mr. Yu KUDO

Researcher

First Operation Department

Overseas Environmental Cooperation Center

China

Mr. Liang LI

Senior Engineer

Ambient Air Quality Monitoring Dept

China National Environmental Monitoring Center

Korea

Dr. Sang Boom RYOO

Director

Environmental Meteorology Research Division

National Institute of Meteorological Sciences,

Korea Meteorological Administration

Dr. Joo Wan CHA
Senior Researcher
Environmental Meteorology Research Division
National Institute of Meteorological Sciences,
Korea Meteorological Administration

Mr. Hee Choon LEE
Senior Researcher
Environmental Meteorology Research Division
National Institute of Meteorological Sciences,
Korea Meteorological Administration

Dr. Sang-Sam LEE
Researcher
Environmental Meteorology Research Division
National Institute of Meteorological Sciences,
Korea Meteorological Administration

Dr. Jeong Eun KIM
Researcher
Environmental Meteorology Research Division
National Institute of Meteorological Sciences,
Korea Meteorological Administration

Dr. Yun-Kyu LIM
Researcher
Environmental Meteorology Research Division
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Mongolia

Dr. Munkhtsetseg ERDENEBAIYAR
Associate Professor
Department of Applied Mathematics
National University of Mongolia

Dr. Sonomdagva CHONOKHUU
Associate Professor
Department of Environment and Forest Engineering
National University of Mongolia

Staff

Mrs. Hyo Jeong JEONG
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Climate Research Division
National Institute of Meteorological Sciences,
Korea Meteorological Administration

Dr. Hee-Jung KO
Researcher
Environmental Meteorology Research Division
National Institute of Meteorological Sciences,
Korea Meteorological Administration

Mr. Won Ick SEO
Researcher
Environmental Meteorology Research Division
National Institute of Meteorological Sciences,
Korea Meteorological Administration

**The Agenda of The 10th Meeting of Joint Research
on Dust and Sand Storms
among
China, Japan and Korea**

Date: November 8th(Wed.) -11th(Sat.), 2017

Venue: Ningwozhuang Hotel Natatorium, Lanzhou, Gansu Province, China

Host: China National Environmental Monitoring Center, MEP of China

Day 1 (November 8)

Meeting Registration and Accommodation.

Ningwozhuang Hotel Lanzhou, Gansu Province, China

Day 2 (November 9)

Session I Opening Remarks

Room: Small Hall NO.1 building, Ningwozhuang Hotel

Chair: Mr. Li Liang (China National Environmental Monitoring Center/MEP, China)

Time	Activities
9:00-9:30	Participants Receive Conference Materials (Prepare)
9:30-9:40	Opening Remarks(<i>China</i>) Chair: Mr. Wang Yalin (Ministry of Environmental Protection of China)
9:40-9:45	Introduction of Participants
9:45-9:50	Adoption of the agenda

Session II Looking Back at Discussion and Activities

Room: Small Hall NO.1 building, Ningwozhuang Hotel

Chair: Mr.Sang Boom Ryoo (National Institute of Meteorological Sciences/KMA, KOREA)

Time	Activities
9:50-10:10	<i>Korea:Overviews of the 9th Meeting of WG I for Joint Research on DSS (Dr. Sang Boom RYOO)</i>
10:10-10:30	<i>Japan:Current Posting Status about the Research Results to SOLA (Yu Kudo)</i>
10:30-10:50	Break
10:50-11:10	<i>Korea:Current Status of DSS Data Sharing (Dr. Sang-Sam LEE)</i>
11:10-11:30	<i>China:China: DSS monitoring in China 2015 (Mr.Li Liang)</i>
11:30-13:30	Lunch (Room: To Be Decided)
Session III The Study On DSS Monitoring and Modeling From Each Country	
Room: Small Hall NO.1 building, Ningwozhuang Hotel	
Chair: Yasushi HIEDA (Overseas Environmental Cooperation Center, JAPAN)	
14:00-14:20	<i>Japan: The Study on DSS Monitoring and Modeling from Japan (Mr.Takashi Maki)</i>
14:20-14:50	<i>Korea: Current Status of Operational Dust and Haze</i>

	<i>Model (ADAM2-Haze) In KMA (Mr. Hee Choon LEE)</i>
14:50-15:10	<i>China: Modeling forecast of pollutants in dust weather (Ms. Zhu Lili)</i>
15:10-15:30	<i>China: The Report on dust weather monitoring in GanSu Province (Mr.Li Xiaohong)</i>
15:30-15:50	Break
15:50-16:10	<i>China: DSS Monitoring in Shaanxi Province (Mr. Zheng Hao)</i>
16:10-16:30	<i>China: Study on Sandstorm Monitoring in Liaoning Province (Mr.Wang Duo)</i>
16:30-16:50	<i>China: DSS Monitoring in Inner Mongolia (Ms. Gu Yu)</i>
16:50-17:00	Discussion and Photo

Day3 (November 10)

Session IV Report From the Countries on DSS Events Room: Small Hall NO.1 building, Ningwozhuang Hotel Chair: Dr. Sangsam Lee (National Institute of Meteorological Sciences/KMA, KOREA)	
Time	Activities
	Reports From Each Country
9:00-9:20	<i>Japan: Asian Dust Observations Based on AD-Net Lidar Network in East Asia (Atsushi Shimizu)</i>
9:20-9:40	<i>China: Introduction of Sandstorm Monitoring work in Qinghai(Mr.Zhao Xudong)</i>

9:40-10:00	<i>Korea: Analysis and Simulation Results of DSS2015 By NIMS/KMA (Dr. Yun-Kyu LIM)</i>
10:00-10:20	Break
10:20-10:40	<i>Japan: Case Study of DSS event in Japan (Satoshi WATANABE)</i>
10:40-11:00	<i>China: Monitoring and forecasting of dust weather in Lanzhou (Ms. Ma Qiong)</i>
11:00-11:20	<i>Conference Optimization of WG I Meeting of DSS (Dr. Li Liang)</i>
11:20-11:30	Other Related Activities and Discussion
11:30-13:30	Lunch (Room: To Be Decided)
Session V Summary Room: Small Hall NO.1 building, Ningwozhuang Hotel Chair: Mr. Takashi MAKI (Meteorological Research Institute)	
Time	Activities
13:30-15:00	Meeting Summary and Discussion
15:00-16:00	Closing Remarks

Day4 (November 11)

Checkout And Departure

Summary of the Tenth Meeting of Working Group I

for Joint Research on Dust and Sand Storms

Lanzhou, 8th -11th November 2017

1. The tenth meeting of Working Group I (WG I) for Joint Research on Dust and Sand Storms (DSS) under Tripartite Environment Ministers Meeting (TEMM) was held at Lanzhou Ningwozhuang Hotel, Lanzhou, Gansu, China from 8th -11th November, 2017. Representatives from China, Japan and Korea participated in this meeting (Annex1: List of participants).
2. In Session One chaired by Mr. Yalin Wang Deputy Director General of Ministry of Environmental Protection of China, he delivered opening remarks and warmly welcomed to the participants. Then Dr. Liang Li, Senior Researcher of China National Environmental Monitoring Center (CNEMC), introduced the agenda of the meeting, which was adopted by all participants. All participants took a moment to officially introduce themselves to each other.
3. In Session Two chaired by Dr. Sang Boom Ryoo, Director of Environmental Meteorology Research Division of National Institute of Meteorological Sciences/Korea Meteorological Administration (NIMS/KMA), he made a presentation on “Overviews of the 9th Meeting of WG I for Joint Research on DSS”. In his presentation, he summarized the 9th Meeting of WG I and also introduced other related meetings such as the 2nd Joint Workshop (Feb. 16, 2017 in Seoul, Korea), the 11th SCM (Feb. 17, 2017 in Seoul, Korea), the 12th TDGM (Apr. 24, 2017 in Suwon, Korea) and the 19th TEMM (Aug. 24-25, 2017 in Suwon, Korea).
4. Mr. Yu Kudo, Researcher of Overseas Environmental Cooperation Center of Japan (OECC), made a presentation on “Current Posting Status about the Research Results to SOLA”. SOLA was chosen as the joint publication of research results in the 7th Meeting of WG I, and until now SOLA received 6 research papers from the WG I experts. 5 papers had been accepted and been published in SOLA Vol. 13 (2017). The submission of the paper was closed on Nov. 9, 2017. Accepted papers will be compiled and be distributed at 12th Steering Committee Meeting for Joint Research on DSS.
5. Dr. Sang-Sam Lee, Researcher of NIMS/KMA, made a presentation on the current status of DSS2015 data sharing. According to his report, several data were newly added, for example, OPC (2 sites) from Korea, and single scattering albedo (SSA), refractive indices, and size distribution of SKYNET (6 sites) and POPC (2 sites) from Japan. He emphasized the availability of web-hard (<http://www.webhard.net>) to obtain the useful data and expressed his thanks to all participating countries for sharing their data.
6. Dr. Liang Li, CNEMC, made a presentation on DSS monitoring in China 2015. According to his report, the number of days that DSS occurred in China in 2015 is 46 days. The accumulative number of days that air quality exceeded the standard is 303 days in 2015, an increase of 12.2% over the same period of year 2014. The climate factor is conducive to dust and sand storms in 2015 in China.
7. In Session Three chaired by Mr. Yasushi Hieda, Principal Researcher of OECC, the Study on DSS Monitoring and Modeling from Japan was reported by Mr. Takashi Maki, Head of 1st Laboratory of

Meteorological Research Institute/Japan Meteorological Agency (MRI/JMA). According to his report, MASINGAR mk-2 could capture 2015 DSS events qualitatively. More data near dust source region, not only dust concentrations and meteorological data but also land surface related data, are required to improve dust emission processes of the model. JMA has introduced higher resolution (40km) version of the model mk-2 since Feb. 2017. The prediction scores are dramatically improved. JMA operates Himawari-8 since July 2015. Himawari-8 could continuously monitor dust storm at wide area. And also, MRI/JMA has developed data assimilation system for the satellite data.

8. Mr. Hee Choon Lee, Senior Researcher of NIMS/KMA, made a presentation on “Current status of operational dust and haze model in KMA”. He introduced the operational dust and haze model called ADAM2-Haze. He also presented about the data assimilation with PM₁₀ data observed in China and Korea. In addition he gave a future plan on the data assimilation with satellite-based AOD and ensemble-based assimilation system in Korea.
9. Ms. Lili Zhu, Engineer of CNEMC, made a presentation on “Modelling forecast of pollutant in dust weather in China”. In her presentation, the numerical forecast system NAQPMS was introduced, and a DSS case (Mar. 27- Apr. 2, 2015) was studied. The results showed that NAQPMS generally well simulated the observed heavy dust and pollution episodes, and observed coarse mode NO₃ and SO₄ are mainly coming from heterogeneous reactions of dust with HNO₃ and SO₂, resulting in significant internal mixing of dust and pollutants.
10. Mr. Xiaohong Li, Vice Chief of Gansu Province Environmental Monitoring Center, made a presentation on “Dust Weather Monitoring in Gansu Province”. The capacity building and maintenance of DSS monitoring network in Gansu province, as well as application of DSS monitoring data, was introduced. Some suggestions regarding DSS monitoring were put forward.
11. Mr. Hao Zheng, Assistant Engineer of Shaanxi Environmental Monitoring Center, made a presentation on “Dust and Sandstorm Monitoring in Shaanxi Province”. He introduced the DSS Monitoring Network of Shaanxi Province, and overall condition of DSS including major sources, transport route, frequency of occurrence in different seasons, as well as its impact on air quality.
12. Mr. Duo Wang, Engineer of Liaoning Environmental Monitoring and Experiment Center, made a presentation titled “Dust storm monitoring of Liaoning Province”. In his presentation, he introduced the current DSS monitoring status and application of monitoring data. One case of DSS heavy pollution in Liaoning Province was studied in terms of air quality, transport route and meteorological conditions. He also made some suggestions regarding DSS monitoring and research.
13. Ms. Yu Gu, Senior Engineer of Environmental Monitoring Station of Inner Mongolia, made a presentation titled “Monitoring and Analysis of Dust Storm in Inner Mongolia”, in which she introduced the background, history and current status of DSS monitoring in Inner Mongolia. A severe DSS pollution case was also showed in her presentation.
14. In Session Four chaired by Dr. Sang-Sam Lee, NIMS/KMA, Dr. Atsushi Shimizu, Senior Researcher of National Institute for Environmental Studies of Japan (NIES), introduced Asian dust observations based on AD-Net (Asian dust and aerosol lidar observation network) in East Asia. AD-Net observed three dimensional distribution of Asian dust continuously in 2016 and 2017. AOD of dust particles averaged in Japan indicated negative trend (-2.5%/year) in recent 10 years. Daily dust density was estimated and

provided for epidemiological studies. Introduction of ceilometer into AD-Net is considered, and Ministry of the Environment of Japan (MOEJ) has a plan to deploy a ceilometer in Iran to monitor dust storms.

15. Ms. Yaqian Liu, Assistant Engineer of Qinghai Environmental Monitoring Center, made a presentation titled “Introduction of Sandstorm Monitoring work in Qinghai”. She made a brief introduction of sandstorm monitoring stations and analysis of DSS monitoring data. She concluded that sandstorm of Qinghai is not only affected by local dust source, but also affected by long-distance transport.
16. Dr. Yun-Kyu Lim, Researcher of NIMS/KMA, made a presentation titled “Analysis and simulation result of DSS2015”. He explained the feature of DSS2015 cases at Korea using not only the observation data but also the numerical model (ADAM). And to improve the predictability of the model, he mentioned that it is necessary to upgrade the dust emission algorithm based on the near real-time three-dimensional observation data.
17. Mr. Satoshi Watanabe, Assistant Manager of MOEJ, made a presentation titled “Case Study of DSS event in Japan”. MOEJ has analyzed characteristics of DSS over Japan and their change since 2002. Case study of an observed DSS event showed a relation with DSS/Haze observation points, weather map, generation status of sand storm in the continent, back trajectory from observation points and sulfate ion concentration at observation points.
18. Ms. Qiong Ma, Assistant Engineer of Lanzhou Environmental Monitoring Station, made a presentation on “Monitoring and Forecasting of dust weather in Lanzhou”. The dust weather in Lanzhou is the result of the interaction of regional environment, geographical location and meteorological conditions. Enlargement of the vegetation coverage in the local and upstream areas can effectively reduce the concentration and frequency of dust.
19. Dr. Liang Li, CNEMC, made a presentation titled “Conference Optimization of WG I Meeting of DSS”. He suggested and discussion was made on the possibility to fix the date of WG I meeting of each year, to determine the date of WG I meeting early (at least 3 months a prior) for visa application, to reduce the related meetings, to prepare the draft of summary of WG I meeting in advance, to designate SOLA as the journal to submit WG I research results, and to hire interpreter for WG I meeting. He also confirmed that the submission to the journal is not compulsory.
20. In Session Five chaired by Dr. Sang-Sam Lee, NIMS/KMA, discussion was made on the detailed milestones for the Mid-Term Action Plan (2015-2019). It was decided that the data for the DSS event (Mar. 2-12, 2016; Apr. 20-30, 2016; and May. 4-14, 2016) will be shared by the participating countries. The countries will upload the data about the above suggested period to the data sharing website by the end of June, 2018. Dr. Sang Boom Ryoo, NIMS/KMA, introduced information on the web-portal site (http://eng.nmc.cn/sds_was.asian_rc/), operated by China Meteorological Agency (CMA), to share real time DSS model outputs. Enhancement of data sharing was discussed and encouraged among related countries in order to enrich the joint research.
21. Before closing, it was announced that the 11th meeting of WG I will be held in Japan. As the host country of next WG I meeting, Japan will propose the date and venue of the meeting and timeline for preparing agenda and meeting materials more than 6 months before the meeting. Current candidate of the date of the meeting is the first or second week of Nov, 2018. Japan as the next host country suggested that English is common language in the meeting but, if necessary, Japan will prepare interpreters at own

expense according to requests from the other countries to make the efficient communications in the meeting.

The 10th Meeting of Working Group I Joint Research on Dust and Sand Storms

Lanzhou, China

(8 November - 11 November , 2017)

List of Participants

Name	Nationality	Organization	Position
Yalin Wang	Chinese	Ministry of Environmental Protection of China	Deputy director general
Liang Li	Chinese	Air quality monitoring division. China national environmental monitoring center	Senior engineer
Li Du	Chinese	Air quality monitoring division. China national environmental monitoring center	Senior engineer
Lili Zhu	Chinese	Environmental quality forecast center, China national environmental monitoring center	Engineer
Wei Wang	Chinese	Environmental quality forecast center, China national environmental monitoring center	engineer
Fuli Peng	Chinese	Environmental quality forecast center, China national environmental monitoring center	Senior engineer
Xiaohong Li	Chinese	Gansu Province Environmental Monitoring Center	Vice chief
Yi Chang	Chinese	Gansu Province Environmental Monitoring Center	Engineer
Hai Yang	Chinese	Inner Mongolia Autonomous Region Environmental Monitoring Center Station	Director of division
Yu Gu	Chinese	Inner Mongolia Autonomous Region Environmental Monitoring Center Station	Senior engineer
Qiang Fang	Chinese	Inner Mongolia Autonomous Region Environmental Monitoring Center Station	engineer
Duo Wang	Chinese	Liaoning Environmental Monitoring and Experiment Center	Engineer
Bei Zhao	Chinese	Shaanxi Environmental Monitoring Center	Engineer
Hao Zheng	Chinese	Shaanxi Environmental Monitoring Center	Assistant Engineer
Luhe Yan	Chinese	Lanzhou environmental monitoring station	Vice director
Qiong Ma	Chinese	Lanzhou environmental monitoring station	Clerk
Wenwei Duan	Chinese	Lanzhou environmental monitoring station	Clerk
Yaqian Liu	Chinese	Qinghai environmental monitoring center	Assistant Engineer
Wanyue Deng	Chinese	Xinjiang Environmental Monitoring Centre	Assistant Engineer
Heechoon Lee	Korean	National Institute of Meteorological Sciences/ Korea Meteorological Administration	Senior Researcher
Sangsam Lee	Korean	National Institute of Meteorological Sciences/ Korea Meteorological Administration	Researcher
Yunkyu Lim	Korean	National Institute of Meteorological Sciences/ Korea Meteorological Administration	Researcher
Sang Boom Ryoo	Korean	National Institute of Meteorological Sciences/ Korea Meteorological Administration	Director

Name	Nationality	Organization	Position
		Administration	
Yasushi Hieda	Japan	Overseas Environmental Cooperation Center, JAPAN	Deputy Manager/Principal Researcher
Yu Kudo	Japan	Overseas Environmental Cooperation Center, JAPAN	Researcher
Yizheng Qiu	Japan	Overseas Environmental Cooperation Center, JAPAN	Researcher
Takashi Maki	Japan	Meteorological Research Institute	Head, 1st Laboratory
Masao Mikami	Japan	Japan Meteorological Business Support Center	International Division Manager
Atsushi Shimizu	Japan	National Institute for Environmental Studies	Senior Researcher
Satoshi Watanabe	Japan	Ministry of the Environment	Assistant Manager

The 11th meeting of Working Group I for Joint Research on DSS

15 -16 November, 2018
Keio Presso Inn Ikebukuro, Tokyo, Japan

■ Day 1 (November 15th)

9:00-9:30	Registration
Session I Opening Session Chair: Dr. Nobuo SUGIMOTO (Japan)	
9:30-9:35	Opening Remarks Mr. Tetsuya TAKAZAWA, Ministry of the Environment, Japan
9:35-9:40	Introduction of Participants
9:40-9:45	Adoption of the agenda
9:45-9:50	Group photo
Session II Looking Back at Discussion and Activities Chair: Dr. Sang-sam LEE (Korea)	
9:50-10:10	Japan : <u>Overviews of the 10th Meeting of WG I for Joint Research on DSS (Mr. Yasushi HIEDA)</u>
10:10-10:25	Korea: <u>Current Status of DSS2016 Data Sharing (Dr. Sang-sam LEE)</u>
10:25-10:40	discussions
Session III The Study On DSS Monitoring and Modeling From Each Country Chair: Mr. Liang LI (China)	
10:40-11:10	Japan: <u>The Study on DSS Monitoring and Modeling from Japan (Mr. Takashi MAKI)</u>
11:10-11:30	Japan: <u>Atmospheric Environment Modeling at Kyushu University (Dr. Itsushi UNO, Dr. Zhe WANG)</u>
11:30-11:50	Korea: <u>Current status of dust/haze monitoring and forecasting in KMA (Mr. Hee-choon LEE)</u>
11:50-12:10	China: <u>2016 Annual Report on Monitoring of Dust and Sandstrom in China (Mr. Liang LI)</u>
12:10-12:30	China: <u>Analysis of a typical severe DSS event in 2016 (Mr. Wei WANG)</u>
12:30-12:45	discussions
13:00-14:00	Lunch Aka Oni (赤鬼 池袋店) https://tabelog.com/tokyo/A1305/A130501/13055315/dtlmenu/lunch/
Session IV Report From the Countries on DSS Events Chair: Mr. Hee-choon LEE (Korea)	
14:00-14:20	Korea: <u>Analysis of model (ADAM3) and observation data in DSS2016 cases (Dr. Yun-kyu LIM)</u>
14:20-14:40	Japan: <u>Asian dust observations by AD-Net, a lidar network in East Asia (Dr. Atsushi SHIMIZU)</u> (*) including 2017 DSS events for WG I joint studies
14:40-14:50	discussions

14:50-15:00	-- Coffee break --
Session V Report From the Countries : Free themes Chair: Mr. Liang LI (China)	
15:00-15:20	<i>China: <u>The influence of dust and sandstorms on ambient air quality in urban China -A new way to identify DSS influence</u> (Ms. Jingyan LI)</i>
15:20-15:40	<i>Korea: <u>On the Chemical Composition Change according to Pathway of week Asian dust during June 2015</u> (Dr. Sang-sam LEE)</i>
15:40-15:50	<i>discussions</i>
15:50-16:00	-- Coffee break --
Session VI Discussions on future cooperation and next steps Chair: Ms. Yayoi HAYASHI (Japan)	
16:00-16:15	<i>Japan: <u>A proposal to review the current Mid-Term Action Plan (2015-2019) and thoughts for the next Mid-Term Action Plan (2020-)</u> (by Mr. Nobuyuki KONUMA)</i>
16:15-16:30	<i>Korea: <u>A proposal to thoughts for the next Mid-Term Action Plan</u> (Dr. Sang-boom RYOO)</i>
16:30-16:45	<i>discussions</i>
18:30-20:00	Reception Dinner Yon-pachi Gyojo (四十八漁場 池袋東口店) < http://www.48gyojyou.com/shop/151/ >

■ Day 2 (November 16th)

Session VII Summary Chair: Dr. Masataka NISHIKAWA (Japan)	
9:30-11:00	Meeting Summary and Discussions
11:00-11:20	Closing Remarks <i>Korea: Dr. Sang-boom RYOO, National Institute Meteorological Sciences of KMA</i> <i>China: Mr. Liang LI, China National Environment Monitoring Center</i> <i>Japan: Mr. Nobuyuki KONUMA, Ministry of the Environment</i>
12:00-13:00	Lunch Baku no Yume (Baku の夢) http://www.wagami-takamura.com/baku/shop.html https://r.gnavi.co.jp/a321600/lunch/

■ Field trip (November 16th) : Site visit to Shinjuku lidar station

13:30	Take a metro “Shin Toshi-line” (approx. 10 min.) (Ikebukuro station – Shinjuku Sanchome station)
14:00	Visit to Shinjuku lidar station (approx. 30 min.)
15:00	Return to Ikebukuro by metro

Summary of the Eleventh Meeting of Working Group I

for Joint Research on Dust and Sand Storms

Tokyo, 15th -16th November 2018

1. The eleventh meeting of Working Group I (WG I) for Joint Research on Dust and Sand Storms (DSS) under Tripartite Environment Ministers Meeting (TEMM) was held at Keio Presso Inn Ikebukuro, Tokyo, Japan from 15th -16th November 2018. Representatives from China, Japan and Korea participated in this meeting (Annex1: List of participants).
2. In Session One, Mr. Tetsuya TAKAZAWA, Director of Air Environment Division, Ministry of the Environment, Japan (MOEJ) delivered opening remarks and warmly welcomed to the participants. Dr. Nobuo SUGIMOTO from National Institute for Environmental Studies (NIES) introduced the agenda of the meeting, which was adopted by all participants. All participants took a moment to introduce themselves to each other. The group took its official photos between the Sessions two and three.
3. In Session Two on “Looking Back at Discussion and Activities” chaired by Dr. Sang-Sam LEE from National Institute of Meteorological Sciences, Korea Meteorological Administration (NIMS/KMA), two participants made their presentations. Mr. Yasushi HIEDA from Overseas Environmental Cooperation Center, Japan (OECC) made a presentation on “Overview of the last DSS WG I meeting, SCM, DGM and TEMM”. In his presentation, he summarized the 10th Meeting of WG I (8th - 11th November 2017 in Lanzhou, China) and also introduced other related meetings such as the 12th SCM and the 13th DGM (30th May 2018 in Suzhou, China), Tripartite Joint Workshop between WG I and WG II (23rd June 2018 in Suzhou, China) and the 20th TEMM (23rd-24th June 2018 in Suzhou, China).
4. Dr. Sang-Sam LEE from NIMS/KMA made a presentation on the current status of DSS2016 data sharing. According to his report, HIMAWARI-8 satellite data (Aerosol Optical Thickness (AOT), AOT_pure, AOT_uncertainty, AOT_Pure_uncertainty, Angstrom Exponent (AE), AE_Pure, Quality Assurance (QA)_flag, QA_flag_Pure) were newly added from Japan. He requested for all participating countries to reload data on web-hard (<http://www.webhard.net>) for those the quality checks are needed. And he expressed his thanks to all participating countries for sharing their data.
5. In Session Three on “The Study on DSS Monitoring and Modeling from Each Country” chaired by Mr. Liang LI from China National Environmental Monitoring Centre of Ministry of Ecology and Environment of P. R. China (CNEMC/MEE), five participants made their presentations. Mr. Takashi MAKI from Meteorological Research Institute (MRI) reported “The Study on DSS Monitoring and Modeling from Japan.” He reported that MASINGAR mk-2 captured 2016 DSS events but almost overestimated aerosol concentrations. He considered that he should modify dust emission processes of the model. The reason may be surface conditions. He needs more data near the dust source region on not only the dust concentrations and meteorological data but also on the land surface related data to improve the dust aerosol model.
6. As a preliminary examination and to demonstrate the new Himawari-8 satellite performance, Dr. Itsushi UNO and Dr. Zhe WANG from Kyushu University made presentations entitled “Atmospheric Environment Modeling at Kyushu University: Dust and Pollution Analysis for May 2017.” During the

year of 2017, the Japan Meteorological Agency only observed the dust during May 6th and 8th. This is a good target for our next joint analysis. They clearly reported two big dust events occurred from April 29 to May 7, 2017. Dr. UNO reported the first dust event occurred over Taklimakan Desert, and showed the Advanced Himawari-8 Imager (AHI) clearly captured the dust vortex changes every 10 min. interval and verified the performance of AHI. Dr. WANG reported the second dust event mainly occurred over the Gobi Desert and then travelled over the China, Korea and then Japan. They compared the dust concentrations observed and simulated by NAQPMS, and suggested the importance of the heterogeneous reactions on the formation of polluted dusts.

7. Mr. Hee Choon LEE from NIMS/KMA made a presentation entitled “Current status of dust/haze monitoring and forecasting in KMA”. He introduced the improvement of KMA dust/haze model, called as ADAM3, in the dust emission algorithm and the data assimilation of surface PM data. He also reported that the data assimilation method of ADAM3 would be changed into an ensemble-based 3-D variational technique within a couple of years.
8. Mr. Liang LI from CNEMC/MEE made a presentation on 2016 annual report on monitoring of Dust and Sandstorm in China. He showed the number of days that DSS occurred and pointed out that the accumulative number of days that exceeds the level of an air quality standard was 325 days in 338 key cities in 2016. According to Mr. LI, the climate factors in the dust source area are conducive to the occurrence and transportation of dust in 2016 in China. He also explained the revision of China's national ambient air quality standards.
9. Mr. Wei WANG from CNEMC/MEE made a presentation titled "Analysis of a typical severe DSS event in 2016". He showed that a strong DSS event in March 2016 impacted air quality seriously in the north, north-east and middle parts of China, with PM10 concentrations of more than 1000 $\mu\text{g}/\text{m}^3$ observed near sand source regions. Mid-latitude cyclones and strong wind in front of high-pressure system caused this DSS event meteorologically. Comparison of model and measurement showed that NAQPMS simulated occurrence and path of this DSS well, except underestimating intensity and missing the north-east China.
10. In Session Four on “Report from the Countries on DSS Events” chaired by Mr. Hee Choon LEE from NIMS/KMA, two participants made their presentations. Dr. Yun Kyu LIM from NIMS/KMA made a presentation entitled “Analysis of model (ADAM3) and observation data in DSS 2016 cases”. In his presentation, three cases of DSS 2016 event were analyzed with observation data and numerical model results (ADAM3). He mentioned that total PM10 amounts were affected by not only Asian dust but also anthropogenic emissions.
11. Dr. Atsushi SHIMIZU from NIES proposed a typical Asian dust event in May 2017 in order to share the observation results among three countries. Also a method to distinguish long range transported Asian dust and locally generated dust in Kanto, Japan was presented.
12. In Session Five on “Report from the Countries: Free Themes” chaired by Mr. Liang LI from CNEMC/MEE, two participants made their presentations. Ms. Jingyan LI from CNEMC/MEE made a presentation on the influence of DSS on ambient air quality in urban China. A method was applied to identify the DSS influence on up-to-down-stream cities based on the time variation of PM10 and PM2.5/PM10. This method worked well to separate fine-particle pollution and DSS pollution. Three main routes of DSS in 2016 were summarized. Contributions of DSS on yearly particle concentration and air pollution days on different province were compared.

13. Dr. Sang-Sam LEE from NIMS/KMA made a presentation on the chemical composition change according to pathway of weak Asian dust during June 2015. He identified different chemical compositions along with different pathway of aerosol. From the chemical analysis between Gosan and Fukuoka on 12 June 2015, local pollution effect in Fukuoka was supposed. Also chemical analysis between Gosan and Seoul gives us dust transport from Gosan to Seoul during 12-13 June 2015. He emphasized this case might be a good example of coupling the Korean and Japanese chemical analysis data.
14. In Session Six on “Discussions on future cooperation and next steps” chaired by Ms. Yayoi HAYASHI from OECC, one participant made his presentation. Mr. Nobuyuki KONUMA from MOEJ, introduced a proposal to review the current Mid-Term Action Plan (2015-2019) and thoughts for the next Mid-Term Action Plan (tentatively from 2020), and highlighted the idea of incorporating new, cross-cutting themes such as DSS and climate change, health effect of DSS and bio-aerosol DSS, and literature review surrounding DSS. Mr. KONUMA and Dr. Sang Boom RYOO from NIMS/KMA proposed a general timeline from now to 2020 to start the next Action Plan and stressed the importance of exploring further involvement of both the experts from other areas and government officials toward the future.
15. The WG I participants suggested on the future milestones of WG I as follows:
- 1) A proceeding report of activities related to the current Mid-Term Action Plan (2015-2019) and draft of a new Mid-Term Action Plan (tentatively from 2020), which will be drafted by Japan and Korea, respectively, will be submitted to pre-TEM 22 SCM and DGM (2020).
 - 2) Before next WG I meeting in Korea, three countries will on a voluntary basis respectively propose the contents of the new Mid-Term Action Plan, such as linkage effects between DSS and climate change issues, etc. through emails, and Korea will summarize the proposed contents in the draft.
 - 3) Prepared proceeding report and a draft of the new Mid-Term Action Plan (tentatively from 2020) will be discussed and adopted in next WG I meeting (Korea).
16. The participants decided two DSS events i.e. April 18-23, May 1-10, 2017 as the target for joint research. The three countries decided to share the observation data during the period from April 18 to May 10, 2017. The countries will upload the data designated website by the end of May, 2019.
17. Before closing, it was announced that the 12th meeting of WG I will be held in late September in Busan, Korea. As the host country of next WG I meeting, Korea will propose the detailed date, venue, and timeline for preparing agenda and meeting materials more than 3 months before the meeting.

The 11th Meeting of Working Group I Joint Research on Dust and Sand Storms

Tokyo, Japan

(15th – 16th November 2018)

List of Participants

China

- Mr. Liang LI, Senior Engineer, Ambient Air Monitoring DEPT., China National Environment Monitoring Center, Ministry of Ecology and Environment, P. R. China
- Ms. Xia ZHANG, Senior engineer, Ambient air quality monitoring department, China National Environment Monitoring Center, Ministry of Ecology and Environment, P. R. China
- Mr. Wei WANG, Engineer, Ambient air quality forecast division, China National Environment Monitoring Center, Ministry of Ecology and Environment, P. R. China
- Ms. Jingyan LI, Engineer, Ambient Air Quality Monitoring Department, China National Environmental Monitoring Centre, Ministry of Ecology and Environment, P. R. China

Japan

- Mr. Tetsuya TAKAZAWA, Director, Air Environment Division, Environmental Management Bureau, Ministry of the Environment
- Mr. Nobuyuki KONUMA, Deputy Director, Air Environment Division, Ministry of the Environment
- Mr. Kazuyuki UEO, Deputy Director, Air Environment Division, Ministry of the Environment
- Dr. Masataka NISHIKAWA, Director, Environmental Safety Center, Tokyo University of Science
- Dr. Nobuo SUGIMOTO, Fellow, Center for Environmental Measurement and Analysis, National Institute for Environmental Studies (NIES)
- Dr. Itsushi UNO, Professor, Research Institute for Applied Mechanics, Kyushu University
- Dr. Zhe WANG, Assistant Professor, Research Institute for Applied Mechanics, Kyushu University
- Mr. Takashi MAKI, Head, 1st laboratory, Atmospheric Environment and Applied Meteorology Research Department, Meteorological Research Institute (MRI)
- Dr. Atsushi SHIMIZU, Senior Researcher, Center for Environmental Measurement and Analysis, National Institute for Environmental Studies (NIES)
- Mr. Yasushi HIEDA, Secretariat (Overseas Environmental Cooperation Center (OECC))
- Ms. Yayoi HAYASHI, Secretariat (OECC)
- Ms. Masae SUMIKOSHI, Secretariat (OECC)
- Mr. Yu KUDO, Secretariat (OECC)

Korea

- Dr. Sang Boom RYOO, Director, Environmental Meteorology Research Division, National Institute of Meteorological Sciences, Korea Meteorological Administration
- Dr. Sang Sam LEE, Senior Researcher, Environmental Meteorology Research Division, National Institute of Meteorological Sciences, Korea Meteorological Administration
- Dr. Yun Kyu LIM, Scientific Researcher, Environmental Meteorology Research Division, National Institute of Meteorological Sciences, Korea Meteorological Administration
- Mr. Hee Choon LEE, Senior Researcher, Environmental Meteorology Research Division, National Institute of Meteorological Sciences, Korea Meteorological Administration

The 12th Meeting of Working Group I for Joint Research on Dust and Sand Storms

◆ **Date : September 26 (Thu.) ~ 27 (Fri.), 2019**

Venue : Ramada Encore HAEUNDAE, BUSAN, KOREA

Host: National Institute of Meteorological Sciences/KMA, KOREA

◆ **DAY 1 (September 26)**

09:00 - 09:30	REGISTRATION
Session I	Opening Chair: Dr. Sang-Sam LEE (National Institute of Meteorological Sciences/KMA, KOREA)
09:30 - 09:40	Opening Remarks Dr. Sang Boom RYOO (National Institute of Meteorological Sciences/KMA, KOREA)
09:40 - 09:50	Introduction of participants
09:50 - 10:00	Adoption of the agenda
10:00 - 10:10	Group Photo
10:10 - 10:20	BREAK
Session II	Looking back at discussion and activities Chair: Mr. Nobuyuki KONUMA (Ministry of the Environment, JAPAN)
10:20 - 10:40	Review on the 11th Meeting of Working Group I Ms. Masae SUMIKOSHI (Overseas Environmental Cooperation Center, JAPAN)
10:40 - 11:00	Current status of DSS Data Sharing Dr. Sang-Sam LEE (National Institute of Meteorological Sciences/KMA, KOREA)
Session III	The study on DSS monitoring and modeling from each country Chair: Dr. Liang LI (Ambient Air Quality Monitoring Department/CNEMC, CHINA)
11:00 - 11:20	Physicochemical Characteristics of Atmospheric Aerosols during a Consecutive High Concentration Episode in Seoul, Korea Dr. Hee-Jung KO (National Institute of Meteorological Sciences/KMA, KOREA)
11:20 - 11:40	Characteristics of Asian dust events detected by a lidar network in East Asia Dr. Atsushi SHIMIZU (National Institute for Environmental Studies, JAPAN)
11:40 - 12:00	The variations of PM_{2.5} concentration in China since 2015 Mrs. Meng XIAOYAN (Ambient Air Quality Monitoring Department/CNEMC, CHINA)
12:00 - 13:30	LUNCH
13:30- 13:50	ADAM3 and its Predictability of Asian Dust over Northern China Dr. Sang Boom RYOO (National Institute of Meteorological Sciences/KMA, KOREA)
13:50- 14:10	Recent DSS related activities at the Japan Meteorological Agency and Meteorological Research Institute Mr. Takashi MAKI (Meteorological Research Institute, JAPAN)
14:10- 14:30	Status of Environmental Air Quality Forecast in China & Analysis on Sandstorm Forecast Ms. Zhao YILIN (Environmental Quality Forecast and Early Warning Center/CNEMC, CHINA)
14:30 – 14:50	Overview of China Ambient Air Quality Monitoring Mr. Sun KANG (Ambient Air Quality Monitoring Department/CNEMC, CHINA)

Session IV	Report from the countries on DSS Events Chair: Dr. Atsushi SHIMIZU (National Institute for Environmental Studies, JAPAN)
14:50 - 15:10	Analysis of model (ADAM3) and observation data in DSS2017 cases Dr. Yun-Kyu LIM (National Institute of Meteorological Sciences/KMA, KOREA)
15:10 - 15:30	Analysis of Asian Dust Events in 2017 Using Lidar Network, Satellite, and Surface Observation Data Dr. Nobuo SUGIMOTO (National Institute for Environmental Studies, JAPAN)
15:30 - 15:50	The PM_{2.5} composition during a dust process Mrs. Dao XU (Ambient Air Quality Monitoring Department/CNEMC, CHINA)
15:50 - 16:10	Investigation of recent yellow sand event in Japan and introduction of dust project at Tottori University Dr. Masao MIKAMI (Japan Meteorological Business Support Center, JAPAN)
16:10 - 16:30	Dust and sand storms monitoring in Mongolia Mr. Dashdondog BATDORJ (National Agency for Meteorology and Environmental Monitoring, Mongolia)
16:30 - 16:40	BREAK
Session V	Discussion on the detailed milestones for the Mid-Term Action Plan (2020-2024) Chair: Dr. Sang-Sam LEE (National Institute of Meteorological Sciences/KMA, KOREA)
16:40 - 18:30	Proceeding Report (2015 – 2019) Mr. Nobuyuki KONUMA (Ministry of the Environment, JAPAN) Continuation of previous WG I activities Expansion of data sharing for joint research Sharing real-time observation data in the origins and routes of DSS Comparison of monitoring methods for particulate matters Enhancement of the cooperation between two Working Groups Encouragement of the participation of outreach research group
18:30 - 20:00	BANQUET

◆ **DAY 2 (September 27)**

Session VI	Discussion on the detailed milestones for the Mid-Term Action Plan(Continue) Chair: Dr. Sang-Sam LEE (National Institute of Meteorological Sciences/KMA, KOREA)
09:30- 1200	Continuation of previous WG I activities Expansion of data sharing for joint research Sharing real-time observation data in the origins and routes of DSS Comparison of monitoring methods for particulate matters Enhancement of the cooperation between two Working Groups Encouragement of the participation of outreach research group
12:00 - 14:00	LUNCH
Session VII	Summary Chair: Dr. Sang Boom RYOO (National Institute of Meteorological Sciences/KMA, KOREA)
14:00 - 15:30	Meeting summary and discussions
15:30 - 16:00	Closing Remarks

Summary of the Twelfth Meeting of Working Group I

for Joint Research on Dust and Sand Storms

Busan, 26th - 27th September 2019

1. The twelfth meeting of Working Group I (WG I) for Joint Research on Dust and Sand Storms (DSS) under the Tripartite Environment Ministers Meeting (TEMM) was held at RAMADA Encore, Busan, Korea from 26th - 27th September 2019. Representatives from China, Japan, Korea, and Mongolia participated in this meeting (Annex1: List of participants).
2. In Session One, Dr. Sang Boom RYOO, Director of Environmental Meteorology Research Division, National Institute of Meteorological Sciences of Korea Meteorological Administration (NIMS/KMA), delivered opening remarks and warmly welcomed to the participants. Dr. Sang-Sam LEE from NIMS/KMA introduced the agenda of the meeting, which was adopted by all participants. All participants took a moment to introduce themselves to each other. The group took its official photos between the Sessions one and two.
3. In Session Two on “Looking Back at Discussion and Activities” chaired by Mr. Nobuyuki KONUMA from Ministry of the Environment, Japan (MOEJ), two participants made their presentations. Ms. Masae SUMIKOSHI from Overseas Environmental Cooperation Center, Japan (OECC) made a presentation on “Review on Previous Work”. In her presentation, she summarized the 11th Meeting of WG I (15th - 16th November 2018 in Tokyo, Japan) and also introduced the schedule of the 14th DGM and 13th SCM (17th - 18th October in Kitakyushu, Japan), and the 21st TEMM (24th November in Kitakyushu, Japan)
4. Dr. Sang-Sam LEE from NIMS/KMA made a presentation on the current status of DSS2017 data sharing. According to his report, skyradiometer data from Ishigakijima was newly added from Japan. He requested for all participating countries to reload data on web-hard (<http://www.webhard.net>) for those the quality checks are needed. And he expressed his thanks to all participating countries for sharing their data.
5. In Session Three on “The Study on DSS Monitoring and Modeling from Each Country” chaired by Dr. Liang LI from China National Environmental Monitoring Centre of Ministry of Ecology and Environment of P. R. China (CNEMC/MEE), seven participants made their presentations. Dr. Hee-Jung KO from NIMS/KMA reported “Physicochemical Characteristics of Atmospheric Aerosols during a Consecutive High Concentration Episode in Seoul, Korea”. She reported 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.
6. Dr. Atsushi SHIMIZU from National Institute for Environmental Studies (NIES) made a presentation on the comparison results between dust extinction coefficient by lidars and data from air-pollution monitoring systems in Japan. He showed that the correlation between lidar and PMc (PM10-PM2.5) was relatively better at Matsue than at Hedo in 2017, and appropriate screening on SPM/PM2.5 was useful to identify Asian dust events from air-pollution monitoring data.
7. Mrs. Xiaoyan MENG from CNEMC/MEE reported “The variations of PM2.5 concentration in China

since 2013”. She introduced the great achievements of air quality improvement have been made from 2013 to 2018, and also she mentioned the situation with air pollution prevention remained challenging for China. There are still many severe pollution events occurring in northern China in autumn and winter.

8. Dr. Sang Boom RYOO from NIMS/KMA made a presentation entitled “ADAM3 and its Predictability of Asian Dust over Northern China”. He reported that ADAM3 model performance in identifying Asian dust days varied systematically according to soil types; good performance for sand-type soil, and relatively poor performance for mixed and loess-type soil.
9. Mr. Takashi MAKI from Meteorological Research Institute of Japan Meteorological Agency (MRI/JMA) showed that the aerosol transport model developed by the MRI/JMA could reproduced qualitatively well in 2017 DSS events. In order to improve the quantitative reproducibility of the model, detailed observation data near the source of the DSS are also required. He also reported on the progress of data assimilation system development. The MRI/JMA has released an aerosol reanalysis product (JRAero) using 2D-VAR, and this system is scheduled to be introduced to the JMA's aeolian dust forecast system in the spring of 2020.
10. Ms. Yilin ZHAO from CNEMC/MEE made a special presentation entitled "Status of Environmental Air Quality Forecast in China & Analysis on Sandstorm Forecast". This presentation mainly summarized the work of the air quality forecast in China, the effectiveness evaluation of multi-model air quality forecast operating system, and the application of sandstorm forecast model in prediction analysis of pollution process.
11. Mr. Kang SUN from CNEMC/MEE reported "Overview of China Ambient Air Quality Monitoring". This presentation mainly showed remarkable development on China ambient air quality monitoring after through efforts during last decade. The report aims to introduce the improvement of China ambient air quality monitoring network, especially most representative urban ambient air quality monitoring network. The report includes three parts: current situation of China ambient air quality monitoring network, quality management of urban ambient air quality monitoring network and Quality Management System.
12. In Session Four on “Report from the Countries on DSS Events” chaired by Dr. Atsushi SHIMIZU from NIES, four participants made their presentations. Dr. Yun-Kyu LIM from NIMS/KMA made a presentation entitled “Analysis of model (ADAM3) and observation data in DSS 2017 cases”. In his presentation, two cases of DSS 2017 event were analyzed with observation data and numerical model results (ADAM3). In particular, the ratio of soil component in elemental composition of Asian dust case was about three times higher than that of non-Asian dust case.
13. Dr. Nobuo SUGIMOTO from NIES made a presentation on analysis of DSS2017 using Himawari-8, the lidar network, surface observations, and chemical transport models. He showed Himawari-8 Dust RGB (not yet shared in WG I) was useful for identifying dust emission areas, and the lidar network was useful for studying structure of transported dust. It was clearly shown in the analysis of the dust event of May that dust emitted in the Gobi desert was transported behind the cold front near the surface, up to Japan. Using the Dust RGB data, he showed dust emission areas predicted by CFORS were

wrong in some cases. He also showed that spot-like dust emission sources were sometimes observed. The results suggest high spatial and temporal resolution Himawari-8 Dust RGB data can be useful for studying dust emission mechanism and for improving dust prediction

14. Mrs. Xu DAO from CNEMC/MEE made a special presentation entitled "The PM_{2.5} composition during DSS process". She introduced the variational characteristics of ion, OC, EC and heavy metal during DSS process. She emphasized the chemical composition observation of particulate matter in China to more accurately determine the chemical characteristics during the DSS process.
15. Dr. Masao MIKAMI from Japan Meteorological Business Support Center (JMBSC) reported "Investigation of recent yellow sand phenomenon in Japan and introduction of dust project at Tottori University". The MOEJ domestic committee, Yellow Sand Technical Committee, have been compiling every year a technical report on the status of the yellow sand activity in Japan. Dr. Mikami introduced the outline of the annual report of this year. In addition, as a report on the current status of research on yellow sand in Japan, the introduction of "Evaluation of climate change impacts and adaptation measures," which Tottori University is working on, was also made.
16. Mr. Dashdondog BATDORJ from National Agency for Meteorology and Environmental Monitoring (NAMEM) reported "Dust and sand storms monitoring in Mongolia". NAMEM has established the 9 DSS monitoring networking system since 2005 with support from Japan (NIES, JICA), Korea (KMA) and China (CMA), which enabled NAMEM to monitor dust concentrations such as PM₁₀ and PM_{2.5} in Mongolia. He underlined that all stations have been running very well but maintenance are required in order to continue the DSS monitoring in Mongolia.
17. In Session Five and Six on "Discussion on the detailed milestones for the Mid-Term Action Plan (2020-2024)" chaired by Dr. Sang-Sam LEE from NIMS/KMA, Mr. Nobuyuki KONUMA from MOEJ introduced an outline of draft version of the Proceeding Report (2015-2019). He reviewed the progress of the WG I activities in line with the Mid-Term Action Plan (2015-2019) and underlined the major achievements of the WG I activities. Further he proposed some ideas for the next Mid-Term Action Plan (2020-2024) and he also said that he will propose the Proceeding Report (2015-2019) and draft for the Mid-Term Action Plan (2020-2024) in order to obtain the approval at the 14th DGM and the endorsement at 21st TEMM in 2019.
18. The goals of draft for the Mid-Term Action Plan (2020-2024) are followings: 1) Continuation of previous WG I activities, 2) Expansion of data sharing for Joint Research, 3) Encouragement of sharing real-time data for developing early warning system, 4) Enhancement of the cooperation between two Working Groups, 5) Encouragement of the participation of outreach research groups, and 6) Enhancement of research on sub-seasonal to seasonal (S2S) forecasts and long-term variations of DSS.
19. For joint research, the four countries decided to share the observation data during the period from March 20 to April 20 (DSS2018-01) and from November 25 to December 5 (DSS2018-02), 2018. The countries will upload the data designated website by the end of June, 2020.
20. Before closing, it was suggested that the 13th meeting of WG I will be held in September/October 2020 in Qingdao, China. As the host country of next WG I meeting, China will propose the detailed date, venue, and timeline for preparing agenda and meeting materials more than 4 months before the meeting.

The 12th Meeting of Working Group (I) for Joint Research on Dust and Sand Storms

◆ **Date : September 26 (Thu.) ~ 27 (Fri.), 2019**

Venue : Ramada Encore HAEUNDAE, BUSAN, KOREA

Host: National Institute of Meteorological Sciences/KMA, KOREA

◆ **DAY 1 (September 26)**

09:00 - 09:30	REGISTRATION
Session I	Opening Chair: Dr. Sang-Sam LEE (National Institute of Meteorological Sciences/KMA, KOREA)
09:30 - 09:40	Opening Remarks Dr. Sang Boom RYOO (National Institute of Meteorological Sciences/KMA, KOREA)
09:40 - 09:50	Introduction of participants
09:50 - 10:00	Adoption of the agenda
10:00 - 10:10	Group Photo
10:10 - 10:20	BREAK
Session II	Looking back at discussion and activities Chair: Mr. Nobuyuki KONUMA (Ministry of the Environment, JAPAN)
10:20 - 10:40	Review on the 11th Meeting of Working Group I Ms. Masae SUMIKOSHI (Overseas Environmental Cooperation Center, JAPAN)
10:40 - 11:00	Current status of DSS Data Sharing Dr. Sang-Sam LEE (National Institute of Meteorological Sciences/KMA, KOREA)
Session III	The study on DSS monitoring and modeling from each country Chair: Dr. Liang LI (Ambient Air Quality Monitoring Department/CNEMC, CHINA)
11:00 - 11:20	Physicochemical Characteristics of Atmospheric Aerosols during a Consecutive High Concentration Episode in Seoul, Korea Dr. Hee-Jung KO (National Institute of Meteorological Sciences/KMA, KOREA)
11:20 - 11:40	Characteristics of Asian dust events detected by a lidar network in east Asia Dr. Atsushi SHIMIZU (National Institute for Environmental Studies, JAPAN)
11:40 - 12:00	The variations of PM_{2.5} concentration in China since 2015 Mrs. Xiaoyan MENG (Ambient Air Quality Monitoring Department/CNEMC, CHINA)
12:00 - 13:30	LUNCH
13:30 - 13:50	ADAM3 and its Predictability of Asian Dust over Northern China Dr. Sang Boom RYOO (National Institute of Meteorological Sciences/KMA, KOREA)
13:50- 14:10	Recent DSS related activities at the Japan Meteorological Agency and Meteorological Research Institute Mr. Takashi MAKI (Meteorological Research Institute, JAPAN)
14:10- 14:30	Status of Environmental Air Quality Forecast in China & Analysis on Sandstorm Forecast Ms. Yilin ZHAO (Environmental Quality Forecast and Early Warning Center/CNEMC, CHINA)
14:30 – 14:50	Overview of China Ambient Air Quality Monitoring Mr. Kang SUN (Ambient Air Quality Monitoring Department/CNEMC, CHINA)
Session IV	Report from the countries on DSS Events

	Chair: Dr. Atsushi SHIMIZU (National Institute for Environmental Studies, JAPAN)
14:50 - 15:10	Analysis of model (ADAM3) and observation data in DSS2017 cases Dr. Yun-Kyu LIM (National Institute of Meteorological Sciences/KMA, KOREA)
15:10 - 15:30	Analysis of Asian Dust Events in 2017 Using Lidar Network, Satellite, and Surface Observation Data Dr. Nobuo SUGIMOTO (National Institute for Environmental Studies, JAPAN)
15:30 - 15:50	The PM_{2.5} composition during a dust process Mrs. Xu DAO (Ambient Air Quality Monitoring Department/CNEMC, CHINA)
15:50 - 16:10	Investigation of recent yellow sand event in Japan and introduction of dust project at Tottori University Dr. Masao MIKAMI (Japan Meteorological Business Support Center, JAPAN)
16:10 - 16:30	Dust and sand storms monitoring in Mongolia Mr. Dashdondog BATDORJ (National Agency for Meteorology and Environmental Monitoring, Mongolia)
16:30 - 16:40	BREAK
Session V	Discussion on the detailed milestones for the Mid-Term Action Plan (2020-2024) Chair: Dr. Sang-Sam LEE (National Institute of Meteorological Sciences/KMA, KOREA)
16:40 - 18:30	Proceeding report 2015 - 2019 Mr. Nobuyuki KONUMA (Ministry of the Environment, JAPAN) Continuation of previous WG I activities Expansion of data sharing for joint research Sharing real-time observation data in the origins and routes of DSS Comparison of monitoring methods for particulate matters Enhancement of the cooperation between two Working Groups Encouragement of the participation of outreach research group
18:30 - 20:00	BANQUET

◆ **DAY 2 (September 27)**

Session VI	Discussion on the detailed milestones for the Mid-Term Action Plan (2020-2024) (Continue) Chair: Dr. Sang-Sam LEE (National Institute of Meteorological Sciences/KMA, KOREA)
09:30 - 1200	Continuation of previous WG I activities Expansion of data sharing for joint research Sharing real-time observation data in the origins and routes of DSS Comparison of monitoring methods for particulate matters Enhancement of the cooperation between two Working Groups Encouragement of the participation of outreach research group
12:00 - 14:00	LUNCH
Session VII	Summary Chair: Dr. Sang Boom RYOO (National Institute of Meteorological Sciences/KMA, KOREA)
14:00 - 15:30	Meeting summary and discussions
15:30 - 16:00	Closing Remarks

The 12th Meeting of Working Group I Joint Research on Dust and Sand Storms

Busan, Korea

(26th – 27th September 2019)

List of Participants

China

- Dr. Liang LI, Senior Engineer, Ambient Air Quality Monitoring department., China
National Environment Monitoring Center, Ministry of Ecology and Environment, P. R.
China
- Mrs. Xiaoyan MENG, Senior Engineer, Ambient Air Quality Monitoring department,
China National Environment Monitoring Center, Ministry of Ecology and Environment,
P. R. China
- Mrs. Xu DAO, Senior Engineer, Ambient Air Quality Monitoring department, China
National Environment Monitoring Center, Ministry of Ecology and Environment, P. R.
China
- Mr. Kang SUN, Engineer, Ambient air quality monitoring department, China National
Environment Monitoring Center, Ministry of Ecology and Environment, P. R. China
- Ms. Yilin ZHAO, Engineer, Environmental Quality Forecast and Early Warning Center,
China National Environment Monitoring Center, Ministry of Ecology and Environment,
P. R. China

Japan

- Mr. Nobuyuki KONUMA, Deputy Director, Air Environment Division, Ministry of the
Environment
- Dr. Nobuo SUGIMOTO, Fellow, Center for Environmental Measurement and Analysis,
National Institute for Environmental Studies (NIES)
- Mr. Takashi MAKI, Head, 1st laboratory, Atmospheric Environment and Applied
Meteorology Research Department, Meteorological Research Institute (MRI)
- Dr. Atsushi SHIMIZU, Senior Researcher, Center for Environmental Measurement and
Analysis, National Institute for Environmental Studies (NIES)
- Dr. Masao MIKAMI, International Division Manager, International Division, Japan
Meteorological Business Support Center (JMBSC)
- Ms. Masae SUMIKOSHI, Secretariat, Project Development Department, Overseas
Environmental Cooperation Center (OECC)
- Ms. Hiroka WATARAI, Secretariat, Project Development Department, Overseas
Environmental Cooperation Center (OECC) (OECC)

Korea

- Dr. Sang Boom RYOO, Director, Environmental Meteorology Research Division, National
Institute of Meteorological Sciences, Korea Meteorological Administration
- Dr. Sang-Sam LEE, Senior Researcher, Environmental Meteorology Research Division,
National Institute of Meteorological Sciences, Korea Meteorological Administration
- Dr. Yun-Kyu LIM, Scientific Researcher, Environmental Meteorology Research Division,
National Institute of Meteorological Sciences, Korea Meteorological Administration
- Dr. Hee-Jung KO, Scientific Researcher, Environmental Meteorology Research Division,
National Institute of Meteorological Sciences, Korea Meteorological Administration

Mr. Dae-Geun Shin, Researcher, Environmental Meteorology Research Division, National Institute of Meteorological Sciences, Korea Meteorological Administration

Mr. Sae-Ho OH, Researcher, Environmental Meteorology Research Division, National Institute of Meteorological Sciences, Korea Meteorological Administration

Mr. Hong-Pyo KO, Researcher, Environmental Meteorology Research Division, National Institute of Meteorological Sciences, Korea Meteorological Administration

Ms. Da-Jeong LEE, Researcher, Environmental Meteorology Research Division, National Institute of Meteorological Sciences, Korea Meteorological Administration

Mongolia

Mr. Dashdondog BATDORJ, Engineer/Researcher, National Agency for Meteorology and Environmental Monitoring

Annex 2.

Meeting agenda and summary of the WG I and WG II joint meetings

Meeting agenda

The Joint Workshop between WG I and WG II for Joint Research on Dust and Sandstorms

27 February, 2016

Meeting Room 1, ZENKOKU CHOSON KAIKAN, Japan

9:00-9:30 Registration of participants

Opening

Chair: Prof. YOSHIKAWA Ken (Okayama University, Japan)

9:30-9:40 Opening remarks
Mr. TAKIGUCHI Hiroaki (Ministry of the Environment, Government of Japan)

9:40-9:50 Introduction of participants

9:50-9:55 Adoption of the agenda

Session I Invited Presentation

Chair: Dr. MAKI Takashi (Meteorological Research Institute, Japan)

9:55-10:10 KOSA (Asian Dust Particles) and Material on KOSA Transported in the Free Troposphere
Prof. IWASAKA Yasunobu (The University of Shiga Prefecture, Japan)

10:10-10:20 Questions and answers

10:20-10:35 An Overview of the Development on WMO SDS-WAS Asian Node
Mr. ZHOU Qingliang (National Meteorological Center, China)

10:35-10:45 Questions and answers

10:45-10:55 Coffee break

Session II **Sharing study contents and plans by WG II**

Chair: Dr. KWON Jino (National Institute of Forest Science, Korea Forest Service)

【Presentation of study contents and plans】

- | | |
|-------------|---|
| 10:55-11:10 | Re-afforestation in the Northeast Asian dryland
Prof. YOSHIKAWA Ken (Okayama University, Japan) |
| 11:10-11:25 | Degradation indicator plants in Mongolian grassland
Dr. INDREE Tuvshintogtokh (Mongolian Academy of Sciences) |
| 11:25-11:35 | Questions and answers |
| 11:35-11:50 | Overview of CRAES and Research Progress of DSS research in WG II of China
Mr. XIA Rui (Chinese Research Academy of Environmental Sciences) |
| 11:50-12:05 | Research Experiences of Land Restoration and Current Activities of WG II
in Hulunbeier Grassland
Prof. OKURO Toshiya (The University of Tokyo) |
| 12:05-12:20 | Report on the results of the joint field survey in Hulunbeier, '14~'15
Dr. JOO Sungbae (National Institute of Ecology, Korea) |
| 12:20-12:35 | Research Plan – Land use change of Ganzhuier and Wangong in Hulunbeier, China
Dr. PARK Ki-Hyung (National Institute of Forest Science, Korea Forest Service) |
| 12:35-12:45 | Questions and answers |

12:45-14:00	Lunch
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Session III **Sharing study contents and plans by WG I**

Co-Chair: Prof. UNO Itsushi (Kyushu University, Japan)

Dr. SUGIMOTO Nobuo (National Institute for Environmental Studies, Japan)

【Presentation of study contents and plans】

- | | |
|-------------|---|
| 14:00-14:15 | Aerosol properties of Asian mineral dusts existed in PM _{2.5} range
Dr. NISHIKAWA Masataka (Tokyo University of Science, Japan) |
| 14:15-14:30 | Case study of the heavy Asian dust observed in late February 2015
Dr. PARK Mi Eun (Korea Meteorological Administration) |
| 14:30-14:45 | The activities of WG I in China
Mr. PAN Benfeng (China National Environmental Monitoring Center) |

- 14:45-15:00 Asian dust monitoring using a network of ground-based lidars
Dr. SUGIMOTO Nobuo (National Institute for Environmental Studies, Japan)
- 15:00-15:15 Questions and answers
- 15:15-15:30 To have a better performance of dust model
Prof. UNO Itsushi (Kyushu University, Japan)
- 15:30-15:45 Current status of dust/haze monitoring and forecasting in KMA
Dr. LEE Sang-Sam (Korea Meteorological Administration)
- 15:45-16:00 Overview of dust emission studies by MRI/JMA
Dr. MAKI Takashi (Meteorological Research Institute, Japan)
- 16:00-16:15 Polluted Dust - Modeling approach of the Interaction of Dust and Pollution
Dr. WANG Zhe (Kyushu University, Japan)
- 16:15-16:30 Questions and answers
- 16:30-16:45 Relationships between soil moisture and dust emissions in a bare sandy soil of Mongolia
Dr. ERDENEYAYAR Munkhtsetseg (National University of Mongolia)
- 16:45-16:50 Questions and answers

16:50-17:00 Coffee break

Session IV Discussion on Cooperation between two Working Groups

Co-Chair: Dr. NISHIKAWA Masataka (Tokyo University of Science, Japan)
Prof. OKURO Toshiya (The University of Tokyo, Japan)

17:00-18:00 Discussion

Session V Closing

18:00-18:10 Closing remarks
Mr. TAKIGUCHI Hiroaki (Ministry of the Environment, Government of Japan)

18:40- Reception

Summary of The Joint Workshop between WG I and WG II for Joint Research on Dust and Sand Storms

27 February, 2016

Meeting Room 1, ZENKOKU CHOSON KAIKAN, Tokyo, Japan

Opening Session

1. Mr. TAKIGUCHI Hiroaki (Ministry of the Environment, Japan) made welcome remarks and expressed the hope that, this first joint workshop between Working Groups (WGs) will be an opportunity to lead better understanding between WGs and to bring a robust viewpoint for further collaboration between WGs. He stated that enhanced co-operation will lead a stronger forward-driving force for Dust and Sand Storm (DSS) joint research.
2. Upon the moderator's request, all participants took a moment to officially introduce with each other. The moderator introduced the provisional agenda of the meeting and the agenda was adopted by all participants.

Session one: Invited presentation

3. Dr. IWASAKA Yasunobu (The University of Shiga Prefecture, Japan) presented an overview of KOSA (Asian Dust Particles) and Material on KOSA Transported in the Free Troposphere. He stressed that bioaerosols transporting with KOSA becomes large concern.
4. Mr. ZHOU Qingliang (National Meteorological Center, China) presented an overview of the Development on WMO SDS-WAS Asian Node. With regard to the linking between the web of World Meteorological Organization (WMO) SDS-WAS and the web of Tripartite Environmental Ministers Meeting (TEMM), Mr. ZHOU Qingliang mentioned that he would confirm with the SDS-WAS web manager (China Meteorological Administration) on the feasibility of the web linkage.

Session two: Sharing study contents and plans by WG II

5. The WG II experts presented on one's own study results and, research experiences on land restoration and current activities of WG II. Major points of the presentation and the discussion on the session two are summarized as follows:

i) The necessity of long-term monitoring

Dr. YOSHIKAWA Ken (Okayama University, Japan) introduced that the threshold of vegetation coverage is 30% which can prevent sand drift on shifting sand dune. Long-term monitoring is necessary to know the real function of restored vegetation, because of a slow growth rate of tree. It is necessary to find a simple and easy way of vegetation monitoring with high resolution and evaluation method of vegetation function to fix sand drift at the height of less than 5m from the ground.

ii) Degradation indicator plants

Dr. INDREE Tuvshintogtokh (Mongolian Academy of Sciences) introduced that the easy way to determine of grassland degradation status is using indicator plants in plant community. Degradation indicator plants (e.g., *Festuca lenensis*; *Stipa krylovii*) are grazing-tolerant (unpalatable or bad palatable for livestock) and environmental stress-tolerant. Therefore, they can remain after hard grazing and under damaged environment condition.

iii) Field survey

Mr. XIA Rui (Chinese Research Academy of Environmental Sciences) proposed screening 2-3 patterns of vegetation restoration based on the research outcomes and applying the above patterns to the similar type of regions by joint efforts of experts from three countries.

Dr. OKURO Toshiya (The University of Tokyo) analyzed the effects of countermeasures on land restoration by “chronosequence” approach. He explained that vegetation cover could recover after the seedling treatment (Control < 2014 sites < 2013 sites) and different trends of growth between *Elymus* and *Caragana* in early stage of restoration were found. Also slope direction could significantly affect survival and reproduction of sown species (e.g., restoration score were higher on the east slope than the other slope.).

Dr. JOO Sungbae (National Institute of Ecology, Korea) explained that main restored plants in Ganzhuer site are *Corethroedendron fruticosum*, *Caragana microphylla*, *Pinus sylvestris* L.v ar. *mongolica* Litv, *Populus canadensis*. Dr. PARK Ki-Hyung (National Institute of Forest Science, Korea Forest Service) introduced his plans of comparing satellite photographs between past and present (2016), analyzing ecological/socio-economic factors (2016, 2017) and investigating causes of desertification (2017).

iv) Potential collaboration between WG I and WG II

(1) Ground observation data of WG II (e.g. changes of vegetation cover, soil properties and landform...) might contribute to the assessment/estimation of effects of land restoration measures on prevention of dust emission at large scales.

(2) WG II needs location information of DSS source areas because this information is essential for prioritization of applying restoration measures.

Session three: Sharing study contents and plans by WG I

6. The WG I experts introduced results of observation and model studies regarding DSS. Major points of the presentation and the discussion on the session three are as follows:

i) PM10/PM2.5 ratio

Dr. NISHIKAWA Masataka (Tokyo University of Science, Japan) presented that the chemical components (derived from soil) of the fine Asian Mineral Dust (AMD) in the PM2.5 range is similar to those of the coarse AMD in the PM10-2.5 range. Soil originated from the AMD source area can be accounted for about 70% to PM2.5 concentration in a typical AMD event, and it must be a common case in Japan.

ii) Observation studies

Dr. PARK Mi Eun (Korea Meteorological Administration) presented the study on investigating the causes of unusual heavy Asian dust event observed in winter 2015 in Seoul using both ground-based and satellite observations, as well as numerical simulations by ADAM2-Haze. She concluded that southern Mongolia and northern China are one of DSS source areas, and when these areas are under warm and dry condition in winter such infrequent event could be observed in Korea.

Dr. SUGIMOTO Nobuo (National Institute for Environmental Studies, Japan) mentioned that Light Detection and Ranging (lidar) network observation data can be used for evaluating the effect of afforestation and other dust mitigation methods through the data assimilation of dust transport models. Lidar techniques may be useful for measuring dust emission.

Dr. ERDENEBAIYAR Munkhtsetseg (National University of Mongolia) explained that dust emission flux threshold of friction velocity increased from 0.44 m/s for dry soil to 0.67 m/s for wet soil. Dust emission strength was observed to be significantly depressed starting at a soil moisture value of 0.02 g/g, therefore, a simple dust diagram may be useful as a dust warning system to identify initial as well as significant dust emissions.

iii) Model studies

Dr. LEE Sang-Sam (Korea Meteorological Administration: KMA) mentioned that KMA implements surface PM₁₀ monitoring of dust source region through international cooperation with China Meteorological Administration (CMA) and National Agency of Meteorology and Environmental Monitoring (NAMEM). Aerosol Optical Depth (AOD) and Asian dust indexes from satellites are also deployed to detect and to track the Asian dust. ADAM-Haze Model provides three dimensional structures of the Asian dust aerosol and forecast guides to forecast tracks and powers of the Asian dust. It also produces phenomena forecast charts with forecasted PM₁₀ concentration and concentration ratio between the Asian dust aerosol and non-dust aerosol.

Dr. WANG Zhe (Kyushu University, Japan) introduced Nested Air Quality Prediction Modeling System (NAQPMS) and explained that NAQPMS is developed by Institute of Atmospheric Physics (IAP), Chinese Academy of Sciences (CAS) and is widely used to study the atmospheric environmental issues and for air quality forecast in China. It is demonstrated that NAQPMS generally well simulates the observed heavy dust and pollution episodes by comparing with Lidar observation.

Dr. UNO Itsushi (Kyushu University, Japan) explained that Polarization optical particle counter (POPC) can separate anthropogenic aerosols, dust, sea salt and their mixture by depolarization ratio and particle diameter information. Dust model can play an important role for dust emission area identification (control strategy).

Dr. MAKI Takashi (Meteorological Research Institute, Japan) stated that MASINGAR mk-2 calculates dust emission flux from several land surface parameters. In spite of MASINGAR mk-2 coarse horizontal resolution (40-100km), information of land surface through the field survey will help to modify dust emission processes of the models.

iv) Submission

Mr. PAN Benfeng (China National Environmental Monitoring Center) explained that during the 7th WG I meeting in Xi'an, China, 2014, China recommended PARTICUOLOGY as a scientific journal submitted the research papers, and PARTICUOLOGY received 6 research papers by the end of year 2015 from the WG I experts. Some papers combined as booklet and it was reported to the Steering Committee Meeting (SCM).

v) Potential collaboration between WG I and WG II

Dr. SUGIMOTO Nobuo proposed that vegetation map in the dust source regions and its seasonal and inter-annual variations are needed to understand the long-term variation of dust phenomena.

Session four: Discussion on Cooperation between two Working Groups

7. Major points of the discussion on the session four are as follows:

i) Ground data sharing

WG I needs ground truth data (in situ observation data) to validate and correct the model reproducibility. In particular, WG I needs local data of vegetation, sand particulate size, soil moisture, friction velocity (observed by supersonic anemometer) in source area. In order to compare in situ data and model output, it is necessary to consider the spatial representativeness of local observed data because numerical models calculate the physical parameters change through differential equations in grids of dozens km or several hundred km. WG II have possibility to share in situ data through the field survey and they welcome joint survey if WG I member has an interest. WG II also comments on the possibility of setting weather station jointly with WG I but it will be a future agenda.

ii) Source areas information

WG II needs location information of DSS source areas because this information is essential for prioritization of applying restoration measures. On the other hand, WG I can provide DSS source areas information through the back trajectory analysis of numerical model and inverse model. Additionally, Japan Meteorology Administration (JMA) has started the daytime observation of DSS by Himawari 8 (the newest geostationary satellite), and WG I can share the visual DSS source areas information. With regard to the source areas, it is difficult to ranking of DSS source area because there are many models which detect source area, however, common understanding by WG I is that Gobi Desert is a candidate of the main emitter of sand (DSS source area).

iii) New long term monitoring site

The long term local monitoring site contributes to reveal vegetation in the dust source regions and to understand the seasonal and inter-annual variations of DSS phenomena. Since Gobi Desert is one of the main source area, some experts proposed to establish the new long term monitoring site in Mongolia and showed their expect to use vegetation and land data to reflect on future forecast of DSS. Long-term monitoring in source area of DSS is necessary to know the real function of restored vegetation (e.g., effectiveness whether the vegetation coverage of 30% and more can prevent sand drift on shifting sand dune). This is consistent with the Mid-Term Action Plan of WG I and WG II for Joint Research on DSS (2015-2019), which describe “In order to promote collaboration between WG I and II, the three countries continue the discussion on the possibility of launching a new joint research and research site”.

8. It was agreed that the second Joint Workshop between WG I and WG II for Joint Research on DSS will be held next year to deepen more collaboration between WGs.

**The First Joint Workshop between Working Group I and Working Group II
for joint research on Dust and Sand Storm (DSS)**

among
China, Korea, Mongolia and Japan

Tokyo, Japan
(27 February, 2016)

List of Participants

Invited

Dr. IWASAKA Yasunobu
Trustee, The University of Shiga Prefecture
Professor Emeritus at Nagoya University, Japan

Mr. ZHOU Qingliang
Chief Coordinator for International Cooperation
National Meteorological Center
China Meteorological Administration

China

Mr. XIAO Jianjun
Director
Environmental Monitoring Dept
Ministry of Environmental Protection, China

Ms. HU Yunfang
Division of Asian Affairs
International Cooperation Dept
Ministry of Environmental Protection, China

Mr. LIU Haibo
Science, Technology and Standards Dept
Ministry of Environmental Protection, China

Mr. PAN Benfeng
Senior engineer
Ambient Air Quality Monitoring Dept
China National Environmental Monitoring Center

Mr. XIA Rui
Project Manager/Assistant Professor
International Cooperation Center
Chinese Research Academy of Environmental Sciences

Korea

Mr. ZHOU Jun
Division for China-ASEAN Cooperation
China-ASEAN Environmental Cooperation Center

Ms. KIM Bomi
Deputy Director
International Cooperation Office
Ministry of Environment, Korea

Ms. SEONG Mie
Researcher
International Cooperation Office
Ministry of Environment, Korea

Ms. WO Jung A
program officer
International Cooperation Office
Ministry of Environment, Korea

Dr. RYOO Sang Boom
Director
Environmental Meteorology Research Division
National Institute of Meteorological Sciences,
Korea Meteorological Administration

Dr. LEE Sang-Sam
Researcher
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National Institute of Meteorological Sciences,
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Dr. PARK Mi Eun
Researcher
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Dr. KWON Jino
Senior Researcher
Forest Conservation Dept
National Institute of Forest Science,
Korea Forest Service

Dr. PARK Ki-Hyung
Scientific Researcher
Forest Conservation Dept
National Institute of Forest Science,
Korea Forest Service

Dr. CHOI Seungse
Researcher
Nature Survey Dept
National Institute of Ecology

Dr. JOO Sungbae
Researcher
Ecology & Evolution Dept
National Institute of Ecology

Ph. D. CHU Jang Min
Senior Research Fellow
Biological Sciences Dept
Korea Environment Institute

Japan

Mr. TAKIGUCHI Hiroaki
Director
Air Environment Division
Environmental Management Bureau
Ministry of the Environment, Japan

Mr. YANASE Tatsuya
Deputy Director
Air Environment Division
Environmental Management Bureau
Ministry of the Environment, Japan

Dr. NISHIKAWA Masataka
Director
Environmental Safety Center
Tokyo University of Science,

Dr. MAKI Takashi
Head, 1st laboratory

Atmospheric Environment and Applied Meteorology Research Department
Meteorological Research Institute (MRI)

Dr. SUGIMOTO Nobuo
Fellow
Center for Environmental Measurement and Analysis,
National Institute for Environmental Studies (NIES)

Dr. UNO Itsushi
Professor
Research Institute for Applied Mechanics
Kyushu University

Dr. YOSHIKAWA Ken
Professor
Graduate School of Environmental and Life Science
Okayama University

Dr. OKURO Toshiya
Professor
Graduate School of Agricultural and Life Sciences
The University of Tokyo

Dr. WANG Zhe
Visiting Fellow
Division of Earth Environment Dynamics
Research Institute for Applied Mechanics
Kyushu University

Mongolia

Dr. ERDENEBAIYAR Munkhtsetseg
Associate Professor
Department of Applied Mathematics
School of Engineering and Applied Sciences
National University of Mongolia

Dr. INDREE Tuvshintogtokh
Head of laboratory
Laboratory of Vegetation Ecology and Plant Resource
Department of Botany
Institute of General and Experimental Biology
Mongolian Academy of Sciences

SECRETARIAT

**Overseas Environmental
Cooperation Center,
Japan (OECC)**

Mr. FUTAMI Masayoshi
Senior Researcher

Mr. HIEDA Yasushi
Senior Researcher

Ms. INOUE Ayako
Senior Researcher

Ms. ICHIGE Junko
Senior Coordinator

Ms. NOJI Tomoka
Coordinator

Mr. QIU Yizheng
Researcher

Agenda of the 2nd Joint Workshop between WG I and WG II for Joint Research on Dust and Sandstorms

16 February, 2017

Shilla Stay Gwanghwamun, Seoul, Korea

[Session 1] Opening

09:30-09:45 Opening Remarks
- Korea (5'), China (5') and Japan (5')

09:45-09:50 Adoption of the Agenda

[Session 2] Invited Presentation

09:50-10:05 Monitoring climate and land surface factors of yellow dust occurrence using satellite data
- Prof. KANG Sinkyu, Kangwon National University

10:05-10:15 Question and Answers

10:15-10:30 Geostationary Environmental Monitoring Satellite/Spectrometer (GEMS) and its Application
- Prof. SONG Chang-Keun, Ulsan National Institute of Science and Technology

10:30-10:40 Question & Answers

10:40-11:00 Coffee Break

[Session 3] Sharing study contents and plans by WG II

11:00-11:15 (KOREA) Comparison of ecological status after restoration in Hulunbeier
- Mr. LEE Seunghyuk, National Institute of Ecology & Kongju National University

11:15-11:25 Question & Answers

11:25-11:40 (JAPAN) Researches on the assessment of countermeasures to DSS in Hulunbeier Grassland
– Progress report by Japanese Group of WG II
- Mr. KONO Akito, the University of Tokyo

11:40-11:50 Question & Answers

11:50-12:05 (CHINA) Sharing study contents and plans by WG II
- Dr. ZHENG Zhirong, Chinese Research Academy of Environmental Sciences

12:05-12:15 Question & Answers

12:15-13:50 Lunch

[Session 4] Sharing study contents and plans by WG I

13:50-14:05 (KOREA) Chemicals composition characteristics of atmospheric aerosols in relation to haze, Asian dust and mixed haze-Asian dust episodes at Gosan site in 2013
- Dr. CHA Joo Wan, National Institute of Meteorological Science, Korea

14:05-14:15 Question & Answers

14:15-14:30 (KOREA) Development of the aerosol data assimilation in ADAM2-Haze using surface PM10

monitoring networks

- *Dr. LIM Yun-Kyu, National Institute of Meteorological Science, Korea*

14:30-14:40 Question & Answers

14:40-14:55 (KOREA) Potential source of PM10, PM2.5, and OC and EC in Seoul during spring 2016

- *Ms. HAM Jeeyoung, National Institute of Meteorological Science, Korea*

14:55-15:05 Question & Answers

15:05-15:20 Coffee Break

15:20-15:35 (JAPAN) Observational Studies of Dust Events Using the Shared Data in WG I

- *Dr. SUGIMOTO Nobuo, National Institute for Environmental Studies*

15:35-15:45 Question & Answers

15:45-16:00 (CHINA) DSS Monitoring and Report of China in 2014

- *Mr. LI Liang, China National Environmental Monitoring Center*

16:00-16:10 Question & Answers

16:10-16:30 Coffee Break

[Session 5] Discussion on Cooperation between two Working Groups

16:30-17:00 Presentation and Discussion

(JAPAN) Joint Activities of Japanese WG I and WG II in 2016

- *Ms. SUMIKOSHI Masae, Overseas Environmental Cooperation Center*

17:00-17:30 Presentation and Discussion

(KOREA) Suggestion for developing Joint Research Site of Two Working Groups

- *Dr. CHU Jang Min, Korea Environment Institute*

[Session 6] Closing

17:30-17:45 Closing Remarks

- *Korea (5'), China (5'), and Japan (5')*

17:45-18:00 Photo Session

18:00- Reception

Summary of The Joint Workshop between WG I and WG II

for Joint Research on Dust and Sand Storms

16 February, 2017

Shilla Stay Gwanghwamun, Seoul, Korea

Presentations from invited researchers

1. Speakers were invited from Kangwon National University (KNU) and Ulsan National Institute of Science and Technology (UNIST) in Korea. First, KNU made a presentation on the setting of conceptual modelling of landscape formation in pastures in Mongolia. The university has been studying on the causal relationship using satellite data on how nomadic activities, vegetation, soil and climate affect the occurrence of DSS, desertification, cold snow damage and drought. Second, UNIST introduced the joint research and development on the X-ray polarised observation satellite (GEMS). In Korea, geostationary Korea Multi-Purpose Satellite -2A equipped with AMI (Advanced Meteorological Imager), GOCI-II (Geostationary Ocean Color Imager: Follow-on Imaging radiometer) and Geostationary Korea Multi-Purpose Satellite -2B equipped with GEMS (Geostationary Environmental Monitoring Spectrometer) are scheduled to be launched. GEMS measure 16 items including nitrogen dioxide and sulfur dioxide in the 5,000km x 5,000km area including the Korean Peninsula. GEMS data will be used for monitoring and prediction of air environment and chemical accident, measuring air pollutant, assimilating model data and collaborating with other fields.

WG II joint research progress

2. China, Japan and Korea reported on the progress of the joint research activities in Hulumbuir in China conducted since 2014. Japan has been working to elucidate the effects of vegetation array conditions on sand movement by measuring vegetation rate, erosion status, soil moisture conditions and so forth. They found the strong correlation between vegetation cover and sand movement. It was mentioned that the relationship between wind erosion and vegetation cover has been deeply understood.
3. China introduced remarkable findings on their study, namely the dominant species at the vegetation recovery site, the pioneer plants which disappear due to new plants suitable for the long-term vegetation recovery, the dominant species has high net photosynthesis, water use efficiency and low saturation water deficiency, vegetation recovery, and changes in root distribution and soil composition (water content and air permeability) caused by artificial vegetation.

4. Korea indicated that vegetation recovery in the region has been declining between 2014 and 2016. However, further data analysis and continuous research on vegetation and natural environmental factors were required to assess the impact of vegetation recovery.

WG I joint research progress

5. Korea introduced 1) the relationship among the chemical composition of airborne suspended matter, haze and DSS, 2) the development of ADAM for predicting the occurrence of DSS and haze, and 3) air pollution observation report in spring 2016 in Seoul. It was shown that the chemical composition of suspended matter was different between DSS and haze. It was found that PM10, PM2.5, OC and OE in spring have come mainly from China. The air pollution in Seoul in spring was more influenced by local pollutant emissions and advection of pollutants from China than DSS.
6. Japan reported their research results extracted by using Asian Dust and aerosol lidar observation Network (AD-Net). The report showed lidar observation and data analysis are effective in distinguishing DSS and haze and predicting the DSS source area. In addition, data assimilation of DSS transport model by lidar network and other data provided by WG I would contribute to evaluate the effects of various measures including planting.
7. China explained the DSS observation system, the classification of DSS and the DSS monitoring results of 2014 events. According to monitoring in 2014, the amount of rainfall in April in the DSS source area was considered to have affected the deterioration of the atmospheric environment in the major cities observed.

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Collaboration between WG I and WG II

8. Japan and Korea reported on the collaboration activities between WG I and WG II.
9. Japan reported the collaborative activities by WG I and WG II members in 2016, which are 1) visiting the DSS source area in Mongolia, and 2) holding a joint workshop. In the report, it was indicated that 1) mutual understanding between two WGs was promoted by those activities, 2) it was important to capture the monitoring data of the ground surface including vegetation cover and sand for refining the model, and 3) Japan would share the outcomes of collaborative activities to China and Korea.
10. Korea reviewed the agreed items between both WGs in the Mid-Term Action Plan (2015-2019) and the progress of the collaboration activities. It was indicated that searching a new collaborative research site was not well discussed. Korea proposed to create a three-year work plan for searching a site by organising a task force team consisting of both WGs members. It was stated to select a site in 2019 and create a five-year joint research plan (2020-2024).

11. Whereas, Japan insisted that it was important to create a plan for what to collaborate with before searching a site, understanding the importance of adding a new joint research site to Hulumbuir in order to evaluate countermeasures at DSS source area.
12. China stated that it was necessary to clarify the purposes, the contents of joint research plan and the site selection method.
13. The Korean proposal was to be discussed at the next day's steering committee.

Conclusion

14. Mr. Yoo, Director, Ministry of Environment, Korea, closed the meeting by asking the members to review the outcomes of the joint research and consider the aims in the future, and what experts can recommend to policymakers since it was the 10th year since the joint research started.



Dust and Sandstorms Sub-Forum for the 20th Tripartite Environment Ministers Meeting Among China, Japan and Korea

-3rd Joint Workshop

between WG I and WG II for Joint Research on Dust and Sandstorms

Agenda

June 23-24, 2018 | Suzhou, China

Date: June 23, 2018 (Saturday)

Venue: Furong Meeting Room, Suzhou Castle Hotel

08:30-09:00 Registration

Session I: Opening Ceremony

Chair: Ms. WU Jieyun, Assistant Director, International Cooperation Centre,
Chinese Research Academy of Environmental Sciences (CRAES), China

- 09:00-09:05 **Opening Remark**
Dr. QUAN Zhanjun, Vice Director, Institute of Ecological Environment, CRAES,
China
- 09:05-09:10 **Welcome Remark**
Mr. YANG Jide, Director, Suzhou Environmental Science Research Institute, China

Session II: Monitoring and Evaluation of Dust and Sandstorms (DSS)

Chair: Dr. LV Shihai, Professor, CRAES, China

- 09:10-09:30 ***DSS Measurement by Lidar and its Result Application in Japan***
Dr. Atsushi SHIMIZU, National Institute for Environmental Studies, Japan
- 09:30-09:50 ***Verification and Evaluation of DSS by Numerical Model and Observations***
Dr. Takashi MAKI, Metrological Research Institute, Japan
- 09:50-10:10 ***On the Predictability of Asian Dust Days over the Northern China
Using ADAM2 Model***
Dr. YUNKYU LIM, National Institute of Meteorological Sciences, Korea
- 10:10-10:30 Coffee Break / Group Photo
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- 10:30-10:50 ***Monitoring and Assessment of DSS in Mongolia***



Ms. Baljinnyam Nyamjantsan, Information and Research Institute of Meteorology, Hydrology and Environment, Mongolia

- 10:50-11:10 ***Impact Prediction of DSS on Air Quality***
Ms. ZHU Lili, China National Environmental Monitoring Centre, China
- 11:10-11:30 ***Monitoring and Assessment of DSS in China***
Dr. LI Liang, China National Environmental Monitoring Centre, China
- 11:30-13:30 Lunch (Buffet)

Session III: Causes and Mechanism of DSS

Chair: Dr. Toshiya OKURO, Professor, the University of Tokyo, Japan

- 13:30-13:50 ***Causes and Development of Duststorm – the Geo-ecological Process in North-Eastern Asia's Grassland Region***
Prof. LI Qingfeng, Inner Mongolia Agricultural University, China
- 13:50-14:10 ***The Sand Control and Vegetation in Hulunbeier Sandy Land***
Mr. JIN Weilin Chief Engineer, Hulunbeier Forestry Bureau, China
- 14:10-14:30 ***Spatial Identification of DSS Source in China and Mongolia Adjacent Grassland***
Dr. DIAO Zhaoyan, CRAES, China
- 14:30-14:50 Coffee Break
-

Session IV: Control Technology and National Policy of DSS

Chair: Dr. Sang-Boom Ryoo, National Institute of Meteorological Sciences, Korea

- 14:50-15:10 ***The Control Policy of DSS in China***
Dr. QUAN Zhanjun, Vice Director, Institute of Ecological Environment, CRAES, China
- 15:10-15:30 ***Restoration and Sustainable Use of Grassland Ecosystem Services***
Dr. OKURO Toshiya, the University of Tokyo, Japan
- 15:30-15:50 ***The Present Situation and Restoration Effort of Sandy Lands in Hulunbeier, Inner Mongolia***
Prof. LEE Eun Ju, Seoul National University, Korea
- 15:50-16:10 ***The Joint Field Survey and Results in Hulunbeier Sandy Land***
Dr. ZHENG Zhirong, CRAES, China

Session V: Future Work Plan & Conclusion

Chair: Ms. WU Jieyun, Assistant Director, International Cooperation Centre, CRAES, China

- 16:10-16:30 **Future Work Plan**
- Japan (5');
 - Korea (5');
 - Mongolia (5')
 - China (5') ;
- 16:30-16:50 **Discussion about the Outcome Report of DSS Sub-Forum to TEMM20 & Closing Remarks**
- 17:00-19:00 Gather and Transfer to the Venue of TEMM20 by bus
- 19:00-21:00 Welcome Dinner (Venue: World Hotel Grand Dushulake Suzhou)

Date: June 24, 2018 (Sunday)

Venue: World Hotel Grand Dushulake Suzhou

Attending TEMM20

- 09:00-10:25 Part 1. Opening Ceremony & Environmental Policies Dialogue
- 10:25-10:55 Coffee Break(Transition)
- 11:40-12:15 Part3. Press Conference
- 12:15-13:15 Luncheon



The 20th Tripartite Environment Ministers Meeting among China, Japan and Korea
June 24, 2018 | Suzhou, China

Report of Dust and Sandstorms Sub-Forum

LV Shihai

Chinese Research Academy of Environmental Sciences

Contents

- * 1. Purposes of the Forum**
- * 2. Review of Joint Research Progress**
- * 3. Discussion on Future Work Plan**

Purposes of the Forum

- * To exchange and share the research outcomes from activities of two Working Groups among China, Japan, Korea and Mongolia;
- * To explore a series of effective technical methods in the fields of dust storm monitoring, evaluation, early warning and mitigation.

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Experts who Attended the Forum

1. China Side

- Chinese Research Academy of Environmental Sciences, China
- China National Environmental Monitoring Centre, China
- Inner Mongolia Agricultural University, China
- Hulunbeir Forestry Bureau, Inner Mongolia, China
- Suzhou Environmental Science Research Institute, China

2. Japan Side

- National Institute for Environmental Studies, Japan
- Metrological Research Institute, Japan
- The University of Tokyo, Japan
- Ministry of the Environment, Japan
- Overseas Environmental Cooperation Center, Japan

3. Korea Side

- National Institute of Meteorological Sciences, Korea
- Seoul National University, Korea
- National Institute of Ecology, Korea

4. Mongolia Side

- Information and Research Institute of Meteorology, Hydrology and Environment, Mongolia

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Review of Joint Research Progress

- * **Session I:**

Monitoring and Evaluation of DSS

- * **Session II:**

Causes and Mechanism of DSS

- * **Session III:**

Control Technology and National Policy of DSS

- * **Session IV:**

Future Work Plan & Conclusion

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1. China Side

- * *Impact Prediction of DSS on Air Quality*
- * *Monitoring and Assessment of DSS in China*
- * *Causes and Development of Duststorm – the Geo-ecological Process in North-Eastern Asia's Grassland Region*
- * *Spatial Identification of DSS Source in China and Mongolia Adjacent Grassland*
- * *Technology of Vegetation Restoration in Hulunbeier Sandy Land*
- * *The Joint Field Survey and Results in Hulunbeier Sandy Land*

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2. Japan Side

- * *DSS Observations in Japan and its application for health impact studies*
- * *Verification and Evaluation of DSS by Numerical Model and Observations*
- * *Characteristics of Land Degradation and Implementation to Restoration in Drylands of the Northeast Asia*

3. Korea Side

- * *On the Predictability of Asian Dust Days over the Northern China Using ADAM2 Model*
- * *The Present Situation and Restoration Effort of Sandy Lands in Hulunbeier, Inner Mongolia*

4. Mongolia Side

- * *Monitoring and Assessment of DSS in Mongolia*

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Future Work Plan

- * **Cooperation between WG I and WG II**
 - Promote Joint evaluation of DSS source between WG I and WG II.
 - Share information of DSS monitoring and evaluation.
 - Joint technical exchanges and training activities.
- * **Prepare the proceeding report on the Mid-Term Action Plan(2015-2019) and next Mid -Term Action Plan**
- * Will be discussed in next WG I and II Meeting respectively.

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Future Work Plan

* Next Mid-Term Action Plan(WG I & II)

- Promote the cooperation among China, Japan and Korea with Mongolia (3+1).
- Conduct community technical training in the DSS source of adjacent area between China and Mongolia.
- Innovate techniques of Sandstorm mitigation and land desertification control.

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Thanks for your attention!

Annex 3.

List of shared data on the Webhard

List of shared data on the Webhard

Monitoring item (Number of monitoring stations)

Period [DSS2007]		[01] 2007.3.25-4.5
Items (sites)	Mongolia	DSS Meteorological information, Vegetation data
	China	Daily average PM10(10)
	Korea	Hourly average PM10(36)
	Japan	Hourly average PM10(10), PM7(21), Lidar(9)
Period [DSS2008]		[01] 2008.5.24-6.4
Items (sites)	Mongolia	Hourly average PM10(2), PM2.5(2), Lidar(2), Daily meteorological data(120)
	China	Daily average PM10(10)
	Korea	Hourly average PM10(36), PM2.5(2), Lidar(2), Visibility(1)
	Japan	Hourly average PM10(11), PM7(21), PM2.5(2), Lidar(14), Visibility(85)
Period [DSS2009]		[01] 2009.3.12-3.25, [02] 2009.10.13-10.26, [03] 2009.12.15-12.28
Items (sites)	Mongolia	Hourly average PM10(2), PM2.5(2), Lidar(2)
	China	Daily average PM10(10)
	Korea	Hourly average PM10(36), Lidar(2), Visibility(7)
	Japan	Hourly average PM10(11), PM7(21), PM2.5(3), Lidar(15), Visibility(76)
Period [DSS2010]		[01] 2010.3.15-3.24, [02] 2010.11.4-11.16
Items (sites)	Mongolia	Hourly average PM10(2), PM2.5(2), Lidar(2)
	China	Daily average PM10(10)
	Korea	Hourly average PM10(36), Lidar(2), Visibility(6)
	Japan	Hourly average PM10(11), PM7(21), PM2.5(2), Lidar(12), Visibility(76)
Period [DSS2011]		[00] 2011.2.1-2.9, [01] 2011.4.27-5.6, [02] 2011.5.7-5.18
Items (sites)	Mongolia	Hourly average PM10(4)
	China	Hourly average PM10(10)
	Korea	Hourly average PM10(36), Lidar(1), Visibility(6)
	Japan	Hourly average PM10(11), PM7(21), PM2.5(3), Lidar(15), Visibility(61)
Period [DSS2012]		[00] 2012.3.27-4.2, [01] 2012.4.20-5.2, [02] 2012.11.25-11.30
Items (sites)	Mongolia	Hourly average PM10(5), PM2.5(3), Visibility(3), Humidity(2), Lidar(2)
	China	Hourly average PM10(10)
	Korea	Hourly average PM10(36), Lidar(3), Visibility(6), AOT (COMS: Communication, Ocean and Meteorological Satellite, KMA Skyradiometer)
	Japan	Hourly average SPM(21), PM10(11), PM2.5(3), Lidar(16), Visibility(60), Humidity(60), AOT(1), MTSAT(tentative), SKYNET

Period [DSS2013]		[00] 2013.3.5-22, [01] 2013.12.26-2014.1.6
Items (sites)	Mongolia	PM10(5), PM2.5(3), Visibility(3), Humidity(2)
	China	Hourly average PM10(10)
	Korea	Hourly average PM10(36), PM2.5(1), Lidar(3), Visibility(6), Humidity(6), AOT (COMS: Communication, Ocean and Meteorological Satellite, KMA Skyradiometer)
	Japan	Hourly average SPM(21), PM10(11), PM2.5(3), Visibility(60), Humidity(60), AOT(1), Lidar (17)
Period [DSS2014]		[00] 2014.3.13-2, [01] 2014.5.22-6.4
Items (sites)	Mongolia	PM10(4), PM2.5(3), Visibility(3), Wind speed & direction(4)
	China	Hourly average PM10(10)
	Korea	Hourly average PM10(36), PM2.5(1), Lidar(1), Visibility(6), Humidity(6), AOT(1)
	Japan	Hourly average SPM(21), PM10(11), PM2.5(3), Lidar(17), Visibility(60), Humidity(60), AOT(1), SKYNET(6)
Period [DSS2015]		[00] 2015.2.18-28, [01] 2015.3.15-26, [02] 2015.6.6-16
Items (sites)	China	Hourly average PM10(10)
	Korea	Hourly average PM10(36), PM2.5(1), Lidar(1), Visibility(6), Humidity(6), AOT(1), OPC(2)
	Japan	Hourly average SPM(21), PM10(11), PM2.5(11), Lidar(18), Visibility(60), Humidity(60), AOT(1), SKYNET(6), POPC(2)
Period [DSS2016]		[01] 2016.3.2-12, [02] 2016.4.20-30, [03] 2016.5.4-14
Items (sites)	China	Hourly average PM10(10)
	Korea	Hourly average PM10(32), PM2.5(1), Visibility(6), Humidity(6), AOT(1), OPC(2)
	Japan	Hourly average SPM(21), PM10(11), PM2.5(11), Lidar(18), Visibility(60), Humidity(60), AOT(1), POPC(2), Himawari Satellite data
Period [DSS2017]		[01] 2017.4.18-23, [02] 2017.5.1-10
Items (sites)	China	Hourly average PM10(10)
	Korea	Hourly average PM10(36), PM2.5(1), RH & Visibility (6), Lidar(1), AOT & Angstrom(1), OPC(2)
	Japan	Hourly average SPM(21), PM10(11), PM2.5(11), Lidar(18), Visibility(59), Humidity(59), AOT(2), POPC(2), Satellite HIMAWARI-8 data

*Monitoring stations with deficient data are included.

Annex 4.

List of published papers from 2015 to 2019

List of published papers from 2015 to 2019

Jan. 2011	Scientific Online Letters on the Atmosphere (SOLA)	Volume 7A Issue Special_Edition < https://www.jstage.jst.go.jp/browse/sola/7A/0/_contents/-char/en >
1	Relationship between Lidar-derived Dust Extinction Coefficients and Mass Concentrations in Japan	Atsushi Shimizu, Nobuo Sugimoto, Ichiro Matsui, Ikuko Mori, Masataka Nishikawa, Mizuka Kido
2	Solubility of Iron in the Aerosol Collected during Kosa (Asian Dust) Events in Japan	Ikuko Mori, Masataka Nishikawa, Atsushi Shimizu, Masamitsu Hayasaki, Takumi Takasuga
3	Short-Term Variations in Aerosol Components during the Same Asian Dust (Kosa) Event Observed in Nagasaki, Japan and Beijing, China	Masataka Nishikawa, Ikuko Mori, Katsuyuki Takahashi, Ichiro Matsui, Nobuo Sugimoto, Kazuaki Kawamoto, Yanpeng Wang, Shuping Dong
4	Comparison of Surface Observations and a Regional Dust Transport Model Assimilated with Lidar Network Data in Asian Dust Event of March 29 to April 2, 2007	Nobuo Sugimoto, Yukari Hara, Atsushi Shimizu, Keiya Yumimoto, Itsushi Uno, Masataka Nishikawa
5	Meteorological Features and Particulate Matter Monitoring of the Asian Dust (Hwangsä) Event Observed in Korea on 1 April 2007	Youngsin Chun, Sumin Kim
6	The Impact of Ground-Based Observations on the Inverse Technique of Aeolian Dust Aerosol	Takashi Maki, Taichu Y. Tanaka, Tsuyoshi T. Sekiyama, Masao Mikami
7	Dust Model Intercomparison Between ADAM and CFORS/Dust For Asian Dust Case in 2007 (March 28 - April 3)	Seung-Bum Kim, Keiya Yumimoto, Itsushi Uno, Youngsin Chun
8	Intensity of a Dust Storm in Mongolia during 29-31 March 2007	Jugder Dulam, Masato Shinoda
9	Asian Dust Transport to Kanto by Flow around Japan's Central Mountains	Masamitsu Hayasaki, Munehisa K. Yamamoto, Atsushi Higuchi, Atsushi Shimizu, Ikuko Mori, Masataka Nishikawa, Takumi Takasuga
10	The Effects of Snow Cover and Soil Moisture on Asian Dust: I. A Numerical Sensitivity Study	Taichu Y. Tanaka, Tsuyoshi T. Sekiyama, Takashi Maki, Masao Mikami
11	The Effects of Snow Cover and Soil Moisture on Asian Dust: II. Emission Estimation by Lidar Data Assimilation	Tsuyoshi Thomas Sekiyama, Taichu Y. Tanaka, Takashi Maki, Masao Mikami
Jan. 2013	Asia-Pacific Journal of Atmospheric Sciences (APJAS)	Volume 49, Issue 1, Dust and Sand Storms (DSS) in East Asia < https://link.springer.com/journal/13143/49/1/page/1 >
1	Dust and Sand Storms (DSS) in East Asia	Youngsin Chun, Yaping Shao, and Masataka Nishikawa
2	Comparative inverse analysis of satellite (MODIS) and ground (PM10) observations to estimate dust emissions in East Asia	Bonyang KuRokjin J. Park
3	The retrieval of the Asian dust depolarization ratio in Korea with the correction of the polarization-dependent transmission	Sungkyun ShinDetlef MüllerY. J. KimBoyan TatarovDongho ShinPatric SeifertYoung Min Noh
4	Analysis of dust events in 2008 and 2009 using the lidar network, surface observations and the CFORS model	Nobuo SugimotoEmail authorYukari HaraAtsushi ShimizuTomoaki NishizawaIchiro MatsuiMasataka Nishikawa
5	Physical explanation of the weakened brightness temperature difference signal over the yellow sea during a dust event: Case study for March 15–16, 2009	Byung-Ju SohnHyoung-Wook ChunHwan-Jin SongEmail authorYoung-Chan NohSang-Moo LeeSang-Sam LeeYoungsin Chun
6	The comparison of two severe Hwangsä (Asian dust) cases of spring and winter in Seoul, Korea	Haeyoung LeeEmail authorJeong Eun KimYoungsin Chun
7	A numerical study of the effect of frozen soil on dust emission during an East Asian dust event in December 2009	Jung-Yoon KangEmail authorTaichu Y. TanakaMasao MikamiSoon-Chang Yoon
8	Influence of DSSs on urban air quality in China during 2005–2010 and analysis of a severe DSS event	Wei WangEmail authorLiang LiBenfeng PanShuang ChenRuibin WangJianjun LiHaohao Zheng
9	PM10 data assimilation over south Korea to Asian dust forecasting model with the optimal interpolation method	Eun-Hee LeeEmail authorJong-Chul HaSang-Sam LeeYoungsin Chun

10	The influence of vegetation variation on Northeast Asian dust activity	Rui MaoEmail authorChang-Hoi HoSong FengDao-Yi GongYaping Shao
11	A simulation of Asian dust events observed from 20 to 29 December 2009 in Korea by using ADAM2	Soon-Ung ParkAnna ChoeMoon-Soo ParkEmail author
12	Numerical simulation and evaluation of Asian dust events observed in Mongolia in spring 2011	Eun-Hee LeeEmail authorErdenebayar MunkhtsetsegSeung-Bum KimJong-Chul HaSang-Sam LeeYoungsin Chun
13	Impact of a dust storm on characteristics of particle matter (PM) in Guangzhou, China	Qi FanChong ShenXuemei WangEmail authorYuan LiWei HuangGuixiong LiangShaoyi WangZhuoer Huang
Oct. 2016	PARTICUOLOGY	Volume 28 < https://doi.org/10.1016/j.partic.2015.09.001 >
1	A method for estimating the fraction of mineral dust in particulate matter using PM2.5-to-PM10 ratios	Nobuo Sugimoto, Atsushi Shimizu, Ichiro Matsui, Masataka Nishikawa
2	Forecasting of Asian Dust Storm during 10-13 May in 2011 with an Ensemble-based Data Assimilation System	Keiya Yumimoto, Hiroshi Murakami, Taichu Y. Tanaka, Tsuyoshi T. Sekiyama, Akinori Ogi, Takashi Maki
3	Relationships between soil moisture and dust emissions in a bare sandy soil of Mongolia	Erdenebayar Munkhtsetseg, Masato Shinoda, John A. Gillies, Reiji Kimura, James Kinge George Nikolich
Mar. 2018	Theoretical and Applied Climatology	< https://doi.org/10.1007/s00704-018-2415-7 >
1	Characteristics of Long-lasting Haze Episodes Observed in Seoul during 2009~2014	Hae-Jung Lee, Jeong Eun Kim, Joo-Wan Cha, Seungjoo Song, Sang Boom Ryoo
Jan. 2017	Scientific Online Letters on the Atmosphere (SOLA)	Volume 13 < https://www.jstage.jst.go.jp/browse/sola/13/0/_contents/-char/en >
1	Dust Acid Uptake Analysis during Long-Lasting Dust and Pollution Episodes over East Asia Based on Synergetic Observation and Chemical Transport Model	Itsushi Uno, Keiya Yumimoto, Kazuo Osada, Zhe Wang, Xiaole Pan, Syuichi Itahashi, Shigekazu Yamamoto
2	Improved Dust Forecast by Assimilating MODIS IR-Based Nighttime AOT in the ADAM2 Model	Sang-Sam Lee, Eun-Hee Lee, Byung-Ju Sohn, Hee Choon Lee, Jeong Hoon Cho, Sang-Boom Ryoo
3	Inverse Modeling of Asian Dust Emissions with POPC Observations: A TEMM Dust Sand Storm 2014 Case Study	Keiya Yumimoto, Itsushi Uno, Xiaole Pan, Tomoaki Nishizawa, Sang-Woo Kim, Nobuo Sugimoto
4	Simultaneous Dust and Pollutant Transport over East Asia: The Tripartite Environment Ministers Meeting March 2014 Case Study	Itsushi Uno, Keiya Yumimoto, Xiaole Pan, Zhe Wang, Kazuo Osada, Syuichi Itahashi, Shigekazu Yamamoto
5	Variations of Dust Extinction Coefficient Estimated by Lidar Observations over Japan, 2007-2016	Atsushi Shimizu, Nobuo Sugimoto, Tomoaki Nishizawa, Yoshitaka Jin, Dashdondog Batdorj
Dec. 2017	Aerosol and Air Quality Research	Volume 17 < https://doi.org/10.4209/aaqr.2016.11.0494 >
1	Importance of long-range nitrate transport based on long-term observation and modeling of dust and pollutants over East Asia	Uno, I., K. Yumimoto, K. Osada, Z. Wang, S. Itahashi, X.L. Pan, Y. Hara, S. Yamamoto and T. Nishizawa
Mar. 2019	Asia-Pacific Journal of Atmospheric Sciences	Online first article < https://doi.org/10.1007/s13143-018-00100-x >
1	Aerosol Physical Characteristics over the Yellow Sea During the KORUS-AQ Field Campaign: Observations and Air Quality Model Simulations	Yun-Kyu Lim, Jinwon Kim, Hee Choon Lee, Sang-Sam Lee, Joo-Wan Cha, Sang Boom Ryoo