Proceedings of
International Workshop on
Asian Dust, Bioaerosols and
Environmental Regime Shift

3–5 November 2017
Lecture Hall and Lecture Room,
Graduate School of Environmental Studies,
Nagoya University, Nagoya, Japan
Editors
Prof. Kenji Kai, Mr. Kei Kawai, and Dr. Minrui Wang
(Graduate School of Environmental Studies, Nagoya University, Japan)

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Organizer
Kakenhi research group on “International Cooperative Research on Asian Dust and Environmental Regime Shift over the Source Regions”
(Grants-in-Aid for Scientific Research (A) Overseas Academic Research 16H02703)

Sponsors
Nagoya University, Japan;
Graduate School of Environmental Studies, Nagoya University, Japan;
Information and Research Institute of Meteorology, Hydrology and Environment (IRIMHE), Mongolia; and Lanzhou University, China
Proceedings of
International Workshop on
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Lecture Hall and Lecture Room,
Graduate School of Environmental Studies,
Nagoya University, Nagoya, Japan
Welcome Message

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Welcome Message

On behalf of the Local Organizing Committee, I would like to welcome all participants to Nagoya University for the International Workshop on Asian Dust, Bioaerosols and Environmental Regime Shift (A-B-E).

The Asian dust, called “Kosa (yellow sand)” in Japan or “Huangsha” in China, is a well-known phenomenon in East Asia. The dust influences the global climate, directly by scattering and absorbing incoming solar radiation, or indirectly by changing the optical properties of clouds. In addition, the Asian dust mixed with PM2.5 and bioaerosols is one of the significant environmental matters in East Asia. A new approach to investigate the Asian dust as bioaerosols is necessary to assess health risk and some other environmental problems.

The technology of active and passive remote sensing has been developed over the last several decades. Especially, the Satellite CALIPSO installed with the space-borne lidar CALIOP and CloudSat was launched in April 2006. The CALIPSO provides a global 3D view of aerosols and clouds. In 2014, the Japan Meteorological Agency launched a next generation geostationary meteorological satellite, Himawari-8, and has provided data of aerosol properties with high spatial and temporal resolutions. Hence, combining the ground / space-borne observations with numerical models (LES, WRF, GCM etc.) offers a new possibility for an advanced research of the Asian dust.

This workshop is designed to build up a platform to exchange scientific knowledge of the latest researches on A-B-E from the world, consisting of three sessions as follows:

- Session A: Asian Dust
- Session B: Bioaerosols
- Session E: Environmental Regime Shift

We will discuss the future publication of a book on the main theme A-B-E at the business meeting on 5 November.

The workshop is organized by the Kakenhi research group on “International Cooperative Research on Asian Dust and Environmental Regime Shift over the Source Regions” (Grants-in-Aid for Scientific Research (A) Overseas Academic Research 16H02703), and supported by Nagoya University, Japan; Graduate School of Environmental Studies, Nagoya University, Japan; Information and Research Institute of Meteorology, Hydrology and Environment (IRIMHE), Mongolia; and Lanzhou University, China.

Finally, we hope that you will enjoy the workshop and collaborate on the Asian dust research.

Kenji Kai
Professor of Nagoya University
Chair of the Local Organizing Committee
Overview of the Workshop A-B-E

Kenji Kai
Chair of the Local Organizing Committee

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   Email: kai@info.human.nagoya-u.ac.jp

In recent years, international environmental problems occur due to the Asian dust, which is potentially affected by different air pollutions and microorganisms, to be transported over long distances. In order to investigate the mechanism of Asian dust and environmental regime shift, Intensive Observation Periods (IOPs) were conducted in the Gobi Desert and Mongolian grassland by using the research network of JSPS Core-to-Core Program during 2014 and 2016 (Fig. 1). The core institutions for the JSPS Program were: "<Mongolia> Information and Research Institute of Meteorology, Hydrology and Environment (IRIMHE), National Agency for Meteorology and Environmental Monitoring (NAMEM), and Hustai National Park; <China> Lanzhou University, Xinjiang Institute of Ecology and Geography (XIEG); <Japan> Nagoya University, National Institute for Environmental Studies (NIES), Rakuno Gakuen University, Kanazawa University, and Kyoto University. Three keywords of the JSPS Program were 1) Sustainability of the Mongolian grassland, 2) Environmental regime shift, and 3) Bioaerosols with genetic information.

The first JSPS Seminar was held in Nagoya, Japan in 2014, the second one in Lanzhou, China in 2015, and the third one in Ulaanbaatar, Mongolia in 2016 (Fig. 2). Results of IOPs were discussed at the JSPS Seminars, which provided a platform to exchange scientific knowledge on Asian Dust, Bioaerosols and Environmental Regime Shift (A-B-E). A lidar / ceilometer network covering the Gobi Desert and Mongolian grassland has been completed by JSPS Program and NIES. Bioaerosols can be used as a maker of the environmental regime shift, which has been investigated by remote sensing and ground truth. An effect of the Asian dust on the climate was shown by Lanzhou University’s group. At the third JSPS Seminar, we decided, “A new international workshop on A-B-E will be held in Nagoya, 2017 and Lanzhou, 2018”. The LOC has prepared the new workshop at Nagoya University in November 2017.

Fig. 1. JSPS Core-to-Core Program.
Fig. 2. JSPS Seminar at Hustai National Park, Mongolia in August 2016.
Organizing Committee

Scientific Committee

Members:
Dr. J. Batbayar (NAME M, Mongolia)
Dr. S. Chen (Lanzhou University, China)
Mr. E. Davaanyam (IRIMHE, Mongolia; University of Tsukuba, Japan)
Prof. B. Hoshino (Rakuno Gakuen University, Japan)
Prof. J. Huang (Lanzhou University, China)
Dr. Z. Huang (Lanzhou University, China)
Dr. D. Jugder (IRIMHE, Mongolia)
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Dr. N. Sugimoto (NIES, Japan)
Dr. T. Takemi (Kyoto University, Japan)
Prof. H. Zhou (Xinjiang Institute of Ecology and Geography, CAS, China)

Local Organizing Committee

Chair:
Prof. K. Kai (Nagoya University, Japan)

Members:
Prof. M. Shinoda (Nagoya University, Japan)
Dr. B. Nandintsetseg (Nagoya University, Japan; IRIMHE, Mongolia)
Mr. K. Kawai (Nagoya University)
Dr. M. Wang (Nagoya University)
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Dr. D. Jugder (IRIMHE, Mongolia)
Prof. J. Huang (Lanzhou University, China)
Prof. K. Kai (Nagoya University, Japan; Chair of the Local Organizing Committee)
Group photo at Lecture Hall

Keynote lectures [11:10-12:30]  
Chair: Prof. K. Kai
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Mr. K. Kawai (Nagoya University, Japan)
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Chair: Dr. N. Sugimoto

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Estimations of Anthropogenic Dust Emissions at Global Scale from 2007 to 2010 
Prof. J. Huang (Lanzhou University, China) 

A-5 [20 min]
Physical and Chemical Characterization of Road Dust Collected at Urban Sites in Ulaanbaatar, Mongolia 
Dr. B. Tsatsral (NAMEM, Mongolia) 

A-6 [20 min]
Anthropogenic Dust Emissions due to Livestock Trampling in a Mongolian Temperate Grassland 
Dr. E. Munkhtsetseg (National University of Mongolia, Mongolia) 

A-7 [20 min]
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[Day 2] 4 November 2017 (Saturday)

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Chair: Dr. T. Takemi

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Dr. T. Y. Tanaka (Meteorological Research Institute, JMA, Japan) 

A-9 [20 min]
Simulation of East Asian Dust Aerosol and Its Climatic Effect Using WRF-Chem Model 
Dr. S. Chen (Lanzhou University, China) 

A-10 [20 min]
Dust Simulation Result Using WRF-Chem Model over Mongolia and Analysis of Observation Data 
Mr. B. Buyantogtokh (IRIMHE, Mongolia; Tottori University, Japan) 

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Large-Eddy Simulation Studies on Turbulent Flows over Rough Surfaces: Urban versus Vegetated Areas 
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Abbreviations

BM: Business Meeting
CAS: Chinese Academy of Sciences
GSES: Graduate School of Environmental Studies
IRIMHE: Information and Research Institute of Meteorology, Hydrology and Environment
JMA: Japan Meteorological Agency
NAMEM: National Agency for Meteorology and Environmental Monitoring
NASA: National Aeronautics and Space Administration
NIES: National Institute for Environmental Studies
OC: Opening Ceremony
Abstracts

Keynote lectures

11:10-12:30 on 3 November
13:40-14:20 on 3 November
WMO Sand and Dust Storm
– Warning Advisory and Assessment System (SDS-WAS)

Enric Terradellas¹, ²

¹) State Meteorological Agency of Spain (AEMET), Barcelona, Spain
²) Chair of the WMO SDS-WAS Steering Committee
   Email: eterradellasj@aemet.es

Sand and dust storms are common hazards in arid and semi-arid regions of the planet. They occur when strong or very turbulent winds blow over dry, sparsely vegetated soils and lift loose particles from the Earth's surface to the atmosphere. Between 1,000 and 3,000 megatons of particles are emitted annually to the atmosphere, where the finer fraction may be transported downwind over long distances, even across continents. Airborne sand and dust is detrimental to human health, ecosystems and diverse socio-economic sectors. However, it is necessary to mention that dust, especially once deposited back to the Earth's surface, has also positive environmental impacts, since it provides nutrients to terrestrial and oceanic ecosystems, boosting primary productivity. Airborne dust affects weather and climate through a wide range of interactions. These include scattering and absorbing radiation, lowering snowpack albedo, altering atmospheric CO₂ concentrations by modulating ecosystem productivity, and serving as cloud nuclei and thereby likely increasing cloud lifetime and reflectivity. Recognizing the importance for multiple societal sectors around the world to better understand and monitor atmospheric sand and dust, in 2007, the WMO endorsed the launching of the Sand and Dust Storm - Warning Advisory and Assessment System (SDS-WAS) with the mission to enhance the ability of countries to deliver timely and high-quality sand and dust storm forecasts, observations, information and knowledge to users through an international partnership of research and operational communities (Terradellas et al., 2015). The SDS-WAS works as an international network organized through regional nodes and coordinated by the SDS-WAS Steering Committee (Nickovic et al., 2015). Three regional nodes are currently in operation:

• Northern Africa, Middle East and Europe, coordinated by a Regional Center in Barcelona, Spain, hosted by the State Meteorological Agency (AEMET) and the Barcelona Supercomputing Center (BSC): https://sds-was.aemet.es.
• Asia, coordinated by a Regional Center in Beijing, China, hosted by the China Meteorological Administration (CMA): http://eng.nmc.cn/sds_was.asian_rc/.
• Pan-America, coordinated by a Regional Center in Bridgetown, Barbados, hosted by the Caribbean Institute for Meteorology and Hydrology (CIMH): http://sds-was.cimh.edu.bb/.

In 2012, in view of the demand of many National meteorological and Hydrological Services and the good results obtained by the SDS-WAS, which prove the feasibility and the need to begin developing operational services beyond the scope of R&D, WMO designated the consortium formed by AEMET and the BSC to host the first Regional Specialized Meteorological Center with activity specialization on Atmospheric Sand and Dust Forecasts. Since February 2014, the Center, called Barcelona Dust Forecast Center (BDFC, https://dust.aemet.es) operationally generates and distributes dust predictions for Northern Africa (north of equator), Middle East and Europe.

References:
Operation of an Aerosol 7-days Forecasting System with a Global Climate Model

Toshihiko Takemura1

1) Research Institute for Applied Mechanics, Kyushu University, Fukuoka, Japan
Email: toshi@riam.kyushu-u.ac.jp

A global aerosol climate model, SPRINTARS is coupled with a general circulation model, MIROC, and a global cloud resolving model, NICAM. It has been primarily developed for evaluating radiative forcing and analyzing climate change due to the aerosol-radiation and aerosol-cloud interactions. To simulate them in high accuracy, spatial and temporal distributions for major species of tropospheric aerosols has to be calculated. It can be applied to the forecast for aerosol concentrations as air pollutants. An aerosol 7-days forecasting system based on the MIROC-SPRINTARS has been operated everyday since 2007 (http://sprintars.net/forecastj.html). The model predicts mass mixing ratios of black carbon, organic matter, sulfate, soil dust, and sea salt, and the precursor gases of sulfate, that is, sulfur dioxide and dimethylsulfide. The aerosol transport processes include emission, advection, diffusion, sulfur chemistry, wet deposition, and gravitational settling. The horizontal resolution is T319 (0.375˚ in longitude and approx. 0.375˚ in latitude). The PM2.5 forecast by the MIROC-SPRINTARS is redistributed by a lot of TVs, radios, newspapers, other websites, apps, and local governments especially in Japan.

Acknowledgements:
Simulations in this study were executed with the supercomputer system of the National Institute for Environmental Studies, Japan. This study is partly supported by the Environment Research and Technology Development Fund (S-12-3) of the Ministry of the Environment, Japan and JSPS KAKENHI Grant Number JP15H01728.
Central Asia is often affected by dust due to its location within the dust belt that ranges from the Sahara desert to the Gobi desert. However, almost no vertically-resolved measurements were performed to characterize the atmospheric mineral dust above western Central Asia so far.

The Central Asian Dust Experiment (CADEX) is a joint Tajik-German project aiming to fill this lack of knowledge. Within this project aerosol lidar, sun photometer, ground-based chemical measurements, and modeling efforts were performed in Tajikistan.

The talk will introduce the used multiwavelength Raman polarization lidar methods for the vertically-resolved measurements of the intensive particle properties. Based on examples, results of CADEX will be presented. In springtime, often lofted particle layers from long-range transport were observed between 3 and 11 km heights a.s.l. as it is illustrated in Fig. 1. Backtrajectory analysis revealed even sources at the African continent. During summer the particle layers were optically thicker and ranged from ground to about 5 km height and are attributed to regional sources. The so far analyzed dust results show lower lidar ratios in comparison to Saharan dust. Often the measurements observed aerosols with lidar and depolarization ratios of intermediate values that indicate mixtures of particles and do not fit into used classification schemes.

Fig. 1. Dust layer from sources in Iran on 13 April 2015. At the end of the day a downmixing/deposition of particles has been observed.
Abstracts

Session A: Asian dust

14:20-15:30 on 3 November
16:20-17:50 on 3 November
09:00-10:30 on 4 November
Temporal and Spatial Characteristics of Dust Storms Observed in Mongolia during 1986-2016

Dulam Jugder¹, Enkhbaatar Davaanyam¹, and Tsedendamba Purevsuren²

1) Information and Research Institute of Meteorology, Hydrology and Environment, Mongolia
2) Laboratory of Environmental Remote Sensing, Rakuno Gakuen University, Japan

Climatology of dust storms in Mongolia during 1960-1999 was examined in our previous study (Natsagdorj et al., 2003). The present study is an extension of the previous study using similar surface observation data over Mongolia during 1986-2016. Surface observations of dust storms in Mongolia from 1960 to 2016 were classified into drifting dust and dust storms and we analyzed data of these two kind of dust storms and data of dusty days, which is derived from the sum of the number of days with dust storms and drifting dust.

In this study, we used dust storm data of 85 meteorological stations in the country from 1986 to 2016 and analyzed for frequency of each type of dust event. The present work examined temporal and spatial characteristics of dust storms over Mongolia during 1986-2016 and compared them with results between 1960 and 1999. Distribution maps of dust storms, drifting dust and the number of dusty days are created using the data from 1986 to 2016.

This study proved that, seasonally, spring is the dust season and dust storm frequency is the highest in April and May and higher in March and June. It was found that, the Gobi Desert areas in the southern part and sandy areas in the north-west part experienced the most number of dust events. Hot spots were appeared around some cities.

The present study results show that the number of days with dust storms is less than 5 days over the Altai, the Khangai and the Khentei mountainous regions and 20–43 days in the Gobi Desert and semi-desert area. The greatest occurrence of drifting dust arises around the Mongol Els area of west Mongolia and the Southern Altai Gobi. The number of dusty days is less than 10 days in the mountainous area and 60–101 days in the Gobi Desert and the Great Lakes Depression of west Mongolia and 90-146 in the Southern Altai Gobi. A northward increasing shift in the number of drifting dust appeared in the southeastern area of the country.


References:
Measurement of Distribution and Characteristics of Dust Particles Using Lidar Methods

Nobuo Sugimoto¹, Yoshitaka Jin¹, and Tomoaki Nishizawa¹

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In the lidar network AD-Net, 20 lidars are continuously operated for monitoring Asian dust and air pollution aerosols in East Asia. The standard AD-Net lidar has two-wavelength (1064 and 532 nm) and polarization-sensitive (532 nm) receiver channels. Nitrogen Raman scattering is also measured at several stations for deriving aerosol extinction coefficient independently from backscattering. There are three multi-wavelength Raman lidars and one multi-wavelength high-spectral-resolution lidar in the network.¹) Distributions of dust and other spherical particles (mostly air pollution particles) are derived separately using the backscattering and depolarization ratio data. Mixing states (external and internal mixing) of dust and air pollution particles can be analyzed from multi-wavelength data.²) For the measurement of dust distribution in the source regions, ceilometers are also used. Currently, a ceilometer sensitive only to the cross-polarization signals is being tested as a dust monitor. Fluorescence lidars are potentially useful for detecting microbes on dust particles. Experiments on range-resolved fluorescence lidar were performed at NIES,³ ⁴) and it was found that dust was fluorescent. However, the method for distinguishing fluorescence from microbe and mineral particle itself has not been established yet. It is also known that biomass burning smoke is highly fluorescent.⁵) A disadvantage of fluorescence lidars is the measurement is limited in the nighttime.

References:
Lidar Network Observation of a Dust Event in the Gobi Desert on 22–23 May 2013

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There is a ground-based lidar network in the Gobi Desert, which is one of the major sources of Asian dust. The lidar network consists of three (currently four) lidars, which are a ceilometer (Kawai et al., 2015) and two AD-Net lidars (Sugimoto et al., 2008) in Mongolia (Fig. 1). The present study analyzed a dust event in the desert on 22–23 May 2013 by using the lidar network and various meteorological data. A cold front moved southeastward across the desert and passed the lidar observation sites in order. The cold front induced strong wind (6–16 m/s) and raised dust from the desert surface. At Dalanzadgad in the central part of the desert, a dust storm occurred on the ground below a height of 1.6 km (A in Fig. 2). Another dust layer floated at a height range of 0.9–1.6 km along the cold frontal surface (B in Fig. 2). At Sainshand and Zamyn-Uud in the eastern part of the desert, dust layers ascended from the atmospheric boundary layer (ABL) to the free troposphere along the cold frontal surface (C and D in Fig. 2). They were distributed in updraft regions of warm air in the cold frontal system. In conclusion, the overall dust layer developed while moving on the desert with the cold frontal system. It is suggested that this development was caused by the following two processes in the cold frontal system: (1) the continuous emission of dust from the desert surface to the ABL by the strong wind and (2) the continuous transport of the dust from the ABL to the free troposphere by the updraft. This mechanism contributed to the long-range transport of the dust by the middle-latitude westerlies in the free troposphere.

Fig. 1. Topographic map around Mongolia.
Fig. 2. Results of lidar observations.

References:
Estimations of Anthropogenic Dust Emissions at Global Scale from 2007 to 2010

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Dust emissions refer to the spatial displacement of dust particles from wind forcing, which is a key component of dust circulation. It plays an important role in the energy, hydrological, and carbon cycles of the Earth’s systems. However, most dust emission schemes only consider natural dust, neglecting anthropogenic dust induced by human activities, which led to large uncertainties in quantitative estimations of dust emissions in numerical modeling. To fully consider the mechanisms of anthropogenic dust emissions, both “indirect” and “direct” anthropogenic dust emission schemes were constructed and developed in the study. Cloud-Aerosol Lidar and Infrared Pathfinder Satellite Observations (CALIPSO) retrievals were used to constrain the simulations at global scale. The results showed that the schemes reasonably reproduced the spatio-temporal distributions of anthropogenic dust from 2007 to 2010. The high centers of anthropogenic dust emission flux appeared in India, eastern China, North America, and Africa range from 0.9 to 11 μg m\(^{-2}\) s\(^{-1}\). Compared with natural dust emissions, indirect anthropogenic dust emissions have indistinctive seasonal variation, with differences less than 3.2 μg m\(^{-2}\) s\(^{-1}\). Pasturelands (including pastures and artificially sparse grasslands) contribute higher anthropogenic dust emissions than croplands, with emissions of approximately 6.81 μg m\(^{-2}\) s\(^{-1}\), accounting for 60% of indirect anthropogenic dust emissions. Moreover, average anthropogenic dust emissions in urban areas have a value of 13.54 μg m\(^{-2}\) s\(^{-1}\), which is higher than those in rural areas (7.89 μg m\(^{-2}\) s\(^{-1}\)). This study demonstrates that the environmental problems caused by anthropogenic dust in urban areas cannot be ignored.
Physical and Chemical Characterization of Road Dust Collected at Urban Sites in Ulaanbaatar, Mongolia

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Road dust has significant impacts on urban air quality. To better understand the physical and chemical characteristics of road dust, main and sub-main roads in Ulaanbaatar, Mongolia were selected for dust collection. The dust samples were aerosolized by solid aerosol generator. High PM mass concentration was measured at the road site of Mongolia. Three-modal distributions at about 30 nm, 120 nm and 570 nm for main road dust as well 30 nm and 150 nm for sub-main road dust were observed. Total particle number concentrations at second mode were much higher for both main and sub-main road dust. SO$_4^{2-}$ and Cl$^-$ were major ionic components, followed by Ca$^{2+}$ and Na$^+$ for road dust in Ulaanbaatar, Mongolia. Because dust was collected in winter season in Ulaanbaatar, the SO$_4^{2-}$ was major component might be due to coal burning activities. Relatively high Cl$^-$ and Na$^+$ were measured in Ulaanbaatar Mongolia due to application of show-melting agent. The sums of element abundances were measured to be 5.3% and 16.5% for the main and sub-main road dust, respectively. Three major elements were detected; the highest was Al- key tracer for re-suspended dust, followed by Fe- key tracer for brake wear, and Zn- key tracer for tyre wear. Concentration of OC was very high contributing about 83%-88% of total carbon in Ulaanbaatar, Mongolia.
Anthropogenic Dust Emissions due to Livestock Trampling in a Mongolian Temperate Grassland

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Mongolian grasslands are a natural dust source region and they contribute to anthropogenic dust due to the long tradition of raising livestock there. Past decades of abrupt changes in a nomadic society necessitate a study on the effects of livestock trampling on dust emissions, so that research studies may help maintain a sustainable ecosystem and well-conditioned atmospheric environment. In this study, we conducted a mini wind tunnel experiment (using a PI-SWERL® device) to measure dust emissions fluxes from trampling (at three disturbance levels of livestock density, N) and zero trampling (natural as the background level) at test areas in a Mongolian temperate grassland. Moreover, we scaled anthropogenic dust emissions to natural dust emissions as a relative consequence of livestock trampling. We found a substantial increase in dust emissions due to livestock trampling. This effect of trampling on dust emissions was persistent throughout all wind friction velocities, $u^*$ (varying from 0.44 to 0.82 m s⁻¹). Significantly higher dust loading occurs after a certain disturbance level has been reached by the livestock trampling. Our results suggest that both friction velocity ($u^*$) and disturbance level of livestock density (N) have an enormous combinational effect on dust emissions from the trampling test surface. This means that the effect of livestock trampling on dust emissions can be seen or revealed when wind is strong. Our results also emphasize that better management for livestock allocation coupled with strategies to prevent anthropogenic dust loads are needed. However, there are many uncertainties and assumptions to be improved on in this study.

References:
Study on Urban Air Particle Pollution in Ulaanbaatar by Lidar, Aerosol Sampler and Radiosonde Measurements

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The atmospheric pollution in winter is one of the most serious environmental problems in Ulaanbaatar, Mongolia. In this study, we indicate both the geographical and meteorological matters that influence the urban air particulate pollution in Ulaanbaatar’s winter.

In October 2010, the temperature rapidly decreased more than 15 °C throughout the month. The Siberian High started to cover Ulaanbaatar and its surrounding areas from 10 October, and the temperature first dropped below 0 °C. The house heating in living areas (with more than 80% of coal stoves) started from this day, resulting to the beginning of heavy air particulate pollution. At the same time, as shown in Fig. 1, significantly high attenuated backscatter coefficient was detected from surface to about 300 m in lidar profile. The surface temperature inversion layer kept overlapping the diurnal mixed layer in winter, as shown in Fig. 2. These characteristics are largely related to the endemic geographical and meteorological factors of Ulaanbaatar, which contribute to the intense of urban air particulate pollution much more exceedingly than other air polluted cities like Beijing and Shanghai (Zhang et al., 2010).

Fig. 1. Total attenuated backscattering coefficient (10^5/km/sr) at 1064 nm in October 2010.

Fig. 2. Mixed layer (blue), temperature (dotted red) and potential temperature (red) at 0800 LST in January 30, 2011.

References:
Recent Developments of the Aeolian Dust Information by the Japan Meteorological Agency

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Japan Meteorological Agency (JMA) has been providing operational Aeolian dust information with numerical prediction since January 2004. We have upgraded the horizontal resolution of the global dust prediction model from TL159 (about 110 km) to TL479 (about 40 km) (Fig. 1) on 22 February 2017. Statistical verification of the model against the synoptic surface observations around Japan exhibits the threat score (TS) is improved in the new model mainly for the first 3 days of the forecast period. To obtain a better initial condition for the dust aerosol forecast, JMA is planning to incorporate an aerosol data assimilation system developed in the Meteorological Research Institute (MRI). The data assimilation system uses a two-dimensional variational method (2D-VAR) and assimilates aerosol optical depth (AOD) observations by the Himawari-8 geostationary meteorological satellite. The data assimilation system has been used for the dust researches and also used to produce an aerosol reanalysis data set (JRAero v1; Yumimoto et al., 2017).

Fig. 1. True color reproduction image of Himawari-8 over Japan area (left) and aeolian dust prediction of surface dust on 15JST, 6 May 2017.

References:
Simulation of East Asian Dust Aerosol and Its Climatic Effect Using WRF-Chem Model

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The Weather Research and Forecasting model with Chemistry (WRF-Chem) is used to investigate the seasonal and inter-annual variations of mineral dust over East Asia during 2007-2011, with a focus on the dust mass balance and its direct radiative forcing and climatic impact. A variety of in-situ measurements and satellite observations have been used to evaluate the simulation results. Generally, WRF-Chem reasonably reproduces not only the column variability but also the vertical profile and size distribution of mineral dust over and near the dust source regions. In addition, the dust lifecycle and processes that control the seasonal and spatial variations of dust mass balance are investigated in seven sub-regions. Dust direct radiative forcing in a surface cooling of up to -14 and -10 W m$^{-2}$, atmospheric warming of up to 9 and 2 W m$^{-2}$, and TOA cooling of -5 and -8 W m$^{-2}$, respectively. The ability of WRF-Chem to capture the measured features of dust optical and radiative properties and dust mass balance over East Asia provides confidence for future investigation of East Asia dust impact on regional or global climate. Over the Tibetan Plateau, dust modifies the atmospheric heating profiles and cloud properties, leading to a decrease of snowfall and hence snow coverage on the ground. These results are from a reduction of surface albedo and increased surface temperature, further accelerating snowmelt. This impact is smallest in summer, when the snow coverage is relative low. Over the East China-Korea-Japan regions, dust modifies the atmospheric heating profiles and cloud properties. Dust induces significant changes in the magnitudes and diurnal variations of surface temperature. Cloud liquid water content is also significantly impacted, as reflected in changes of cloud forcing at the top of the atmosphere (TOA) with a maximum in summer. The dust impacts on spatial distribution of precipitation and wind circulation are also investigated, showing distinct seasonality of dust impact on the regional climate over East Asia.

Key words: East Asian dust, WRF-Chem model, dust emission, dust transport, dust radiative forcing

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Dust Simulation Result Using WRF-Chem Model over Mongolia and Analysis of Observation Data

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The timing of a dust outbreak and the dust emission amount are controlled by surface wind and land surface conditions (e.g., soil wetness, land cover type, vegetation, snow cover, and soil size distribution) [e.g., Kurosaki et al., 2011]. However, current numerical models cannot simulate them very well because current dust emission theories is not perfect. For elucidation of the dust emission mechanisms, Tottori University installed a dust monitoring system at Tsogt-Ovoo, Mongolia, which is located at a northern part of the Gobi Desert. According to synoptic data, the frequency of dust outbreak is the highest at Tsogt-Ovoo in East Asia [Kurosaki and Mikami, 2005].

At the 3\(^{rd}\) workshop “Outbreaks of Asian Dust Environment Regime Shift” at Ulaanbaatar last year, we discussed threshold wind speeds for sand saltation in three dust events for the period from March to May 2015 from simulation results for at Tsogt-Ovoo. At this workshop, we will discuss them in six dust events from February to September as simulation and observation results. In the results, there are still another affects for dust emission which dose not installed in dust emission schemes such as soil crust.

According to the analysis of observation data, in order to know the reason (erosivity or erodibility) of the different amount of sand flux observed in year by year and place by place, we will discuss the spatial and temporal variation of sand flux at three sites which installed at different type of land surface conditions.

Keywords: WRF-Chem, sand flux, erosivity
Large-Eddy Simulation Studies on Turbulent Flows over Rough Surfaces: Urban versus Vegetated Areas

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Atmospheric turbulence near the surface is generated by surface roughness through buoyancy and/or shear. Man-made buildings and structures in urban areas generate highly turbulent flows within and above urban canopies. Nakayama et al. (2011) investigated the effects of the density of buildings and the variability of building heights on the statistical characteristics of turbulent flows over roughness obstacles by conducting large-eddy simulations of airflows over urban-like roughness obstacles and found that the variability of building heights significantly affects turbulent stresses not within the building canopy but also above the canopy level. Our recent study on turbulent flows over a realistic urban area from LESs of airflows over an urban area of Kyoto City and over a building distribution with a constant building height demonstrated that Reynolds stress increased with building density in Kyoto, which indicates the variability of the building height affects the turbulent features. It was also found from the quadrant analysis that the ratio of ejection to sweep was consistent with previous studies of block array experiments qualitatively and that the contributions of extreme instantaneous momentum flux to the total Reynolds stress increased with the amount of buildings.

As a comparative simulation, we have performed LESs of airflows over a vegetation-like surface. The height of the vegetation is assumed to be similar to the mean building height in Kyoto City and has a surface fully covered by a vegetation. The turbulent characteristics and the coherent structures within the simulated turbulent flows are compared between the cases over urban and vegetated surfaces. Commonalities and differences between turbulent natures over urban and vegetated surface are discussed.

References:
Long-range Transport of Kosa (Asian Dust) Particles Mixed with Bioaerosols: Environmental Effect of Kosa (Dust) Particle

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Airborne microorganisms are frequently transported long-range in the free troposphere over north-east Asia by prevailing westerly, and many investigations strongly suggested that concentration of atmospheric microorganisms increased in downwind areas during dust event (e.g., Maki et al., 2010, 2011, 2014; Hara & Zhang, 2012). In the previous investigations, however, little is known about mixing state of microorganisms with dust particles (e.g., Iwasaka et al., 2009); Size distribution of mixtures, Ratio of Mixtures to total particle content; Ratio of surface area of bioaerosols to total surface of dust particles, and so on. It is suggested that single particles of microorganism such as bacteria have been hardly possible to identify and most of bacteria are in internal mixture state with dust (Kosa) particles in the free atmosphere from the field measurements at Suzu city (37.5°N, 137.4°E) of Noto Peninsula in Japan, and in those measurements atmospheric particle sampling was performed using an aircraft and balloon at about 800m-about 3000m. Those mixture particles are suggested to be transported long range by westerly in external mixing ratio of about a few 10% in unit of particle number concentration.

Comparing the mixing ratio of bioaerosol measured in unit of mass concentration and the ratio in number concentration, the mass mixing ratio is noticeably low, suggesting that microorganism distributes mainly on the surface of dust particles. The mixture particles of bioaerosols and Kosa, therefore, possibly give significant effect on physical and chemical processes on the particle surface even if mass mixing ratio of biological material is very small.

References:
Iwasaka, Y. et al. (2009) Mixture of Kosa (Asian dust) and bioaerosols detected in the atmosphere over the Kosa particles source regions with balloon-borne measurements: possibility of long-range transport. Air Qual Atmos Health 2: 29–38.
Asian dust events caused in desert areas carry airborne microorganisms, which would influence climate changes, ecosystem dynamics and human health in downwind area of East Asia (Maki et al. 2017). However, the vertical transport of airborne microorganisms over desert areas has not understood in detail. We collected aerosols at high altitudes of 800 m and 500 m over Asian dust area such as Taklamakan and Gobi deserts, respectively and compared the airborne microbial characteristics between high and low altitudes. The particle determination using optical particle counter and microscopic observation counts demonstrated that the aerosol particles maintained 5- or 10-folds higher concentrations at more than 300 m than at ground surface levels. High-throughput sequencing targeting 16S rRNA genes (bacterial marker) showed the vertical mixtures of airborne bacteria over the both sampling sites, which were predominantly composed of Actinobacteria, Firmicutes, Bacteroidetes, and Proteobacteria. In contrast, at the sequencing analysis of internal transcribed spacer regions (fungal marker), the fungal community structures at high altitudes over the both sites differ from those of low altitudes, increasing the relative abundances of Ascomycota sequences, which commonly included Cradosporidium species at the both sites. The fungal communities would be more hardly mixed vertically than those of bacterial communities and Ascomycota populations would be selected at high altitudes in dust source atmosphere.

Fig. 1. Air sampling images at Dalanzadgad in the Gobi Desert.

References:
Investigation of Atmospheric Bioaerosols Based on Lidar Measurements and Sampling Analysis

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Atmospheric bioaerosols may play an important role in the ecological and climate systems. However, the challenge in quantifying bioaerosol climate effects (e.g., radiative forcing and aerosol-cloud interactions) arises from large spatial and temporal heterogeneity of their concentrations, compositions, sizes and optical properties. In order to investigate the characterization of atmospheric bioaerosols along transported pathways of dust aerosols, we carried out DUBI (DUst BIoaerosol) Campaign over Northern China since 2014. A multi-channel lidar spectrometer system and bioaerosols sampler were main two methods for investigating characterization of bioaerosol. The lidar spectrometer system was developed to observe Mie, Raman scattering and laser-induced fluorescence excitation at 355 nm from the atmosphere. The lidar system operated polarization measurements at 355nm, aiming to identify dust particles from other aerosols. The bioaerosol samples were collected using four sterilized polycarbonate filters simultaneously, for fluorescence microscopy and MiSeq sequencing analysis. Combing lidar observation and sampling analysis, characterization of atmospheric bioaerosols was studied along transported pathways of Asian dust.

Fig. 1. Overview of Dust-Bioaerosol (DUBI) campaign over North China conducted by Lanzhou University, aiming to study the climate effect of dust and bioaerosol.
Bioaerosol Measurements during the Dust Storm Event in IOP2015

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Desert regions continue to discharge a significant amount of dust, and they circulate the globe (Uno et al., 2009). These desert dust by itself bring the important minerals to a distant area and supply essential elements as nutrients for various trophic levels. In another case, the dust from Saharan desert was suspected to act as a carrier of biological components such as fungus across Atlantic Sea to the Caribbean Sea to cause coral leaf damage (Garrison et al., 2003). Furthermore, Iwasaka et al. (2009) reported that the presence of nucleic acid on the surface of the dust in China, which indicated biological components in the desert aerosols. The aerosols with biological components known as bioaerosols can be transported a long distance which may reach downwind and/or surrounding regions to cause possible health effects to human and livestock. Here we present some of the results from the intensive observation period (IOP) 2015 measurement campaign conducted in Gobi region of Mongolia, south part of China, and several locations in Japan during April 25 to May 10. The aerosols were sampled with Teflon filters with two-stage impactor units. Only the PM\textsubscript{2.5} fraction was analyzed with the next-generation sequencer, Ion Personal Genome Machine (IonPGM). For the dust deposition data, global aerosol reanalysis product, Japan Reanalysis for Aerosol (JRAero) was employed (Yumimoto et al., 2017). Also, particle size distributions were measured with optical particle counter in Gobi sites. From the comparisons of genetic diversity variations determined by the IonPGM and different dust deposition rates appear to have positive correlations in Gobi area, Mongolia, and Sapporo, Japan. The greater amount of dust suspension might have contributed to enhancing the biodiversity of bacterial flora in the atmosphere. Also, a large size fraction of particles might have attributed more chance for the various biological components to be airborne to enhance the biodiversity. Further understanding of the dust characteristics and co-existing bioaerosols in the atmosphere may contribute to assessing health risk with bioaerosols.

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Uno et al. (2009). Asian dust transported one full circuit around the globe, Nature Geoscience, (2), 8, 55.
Health Impacts of Asian Dust on Emission and Downwind Regions

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Asian dust events are massive meteorological phenomena during which fine particles from Chinese and Mongolian deserts are blown into the atmosphere and carried by westerly winds into northeast Asia. Concerns have been expressed over health hazards in affected areas. The principal damage by Asian dust differs in emission region from that of downwind region. In emission region, an intense dust storm does severe damage to human and livestock. The health effects of dust may be associated with a high prevalence of respiratory diseases and severe subjective symptoms. In downwind regions such as Japan, recent epidemiological studies have shown that Asian dust events coincided with increases in daily admissions and clinical visits for allergic diseases such as asthma. Moreover, it is pointed out that Asian dust influence the symptoms such as itchy eye and skin, nasal congestion, and sore throat in healthy subjects. Analysis of Asian dust particles has shown the presence of ammonium ions, sulfate ions, nitrate ions, and heavy metal compounds that are not considered to originate from the soil. Asian dust particles have been thought to adsorb anthropogenic atmospheric pollutants during transport. These dust events should be considered as a major environmental issue caused by human impact via deforestation, desertification, and atmospheric pollution.

References:
Abstracts

Session E: Environmental regime shift

13:50-15:30 on 4 November
15:50-17:00 on 4 November
Inner and Central Asia are identified as the source of 25% of global dust emissions with much originating in the region’s deserts and steppe grasslands. In addition to naturally-caused bio-aerosols, a long history of human intervention in the region has significantly increased airborne particulates. The Soviet-era Virgin Land programme converted >400,000 km² of Central Asian grassland into farmland; ensuing water diversion led to the desiccation of the Aral Sea and a new dust hotspot. China’s recent intensified development in northern and western regions resulted in desertification of 375,000 km² of land whilst generating potential new dust emissions. As awareness of Asian dust sources has increased, the implication for recipient regions and nations and understanding of the potential damage to human health has amplified. Disentangling the causal factors of dust and desertification and their impact on human systems is a major challenge and asks the question: are new environmental conditions a result of a regime shift and changing climate or do they reflect anthropogenic forces?

Literature on dust and desertification on the Inner Asian steppe is quite contradictory with findings and interpretations dependent on methods and perspective. Our recent research in the Gobi Desert incorporates two approaches to evaluate dust and desertification. The first examines climate data to assess the expansion and contraction of the Gobi Desert in Mongolia and northern China. The second addresses the role of intensive mega-mining in the region as a primary human-induced cause of dust through investigation of the Oyu Tolgoi copper and gold mine in Southern Mongolia. In the national context the mine dust is identified as damaging human and livestock health and pasture quality. Research findings demonstrate that 1) precipitation is the main driver of the Gobi Desert expansion and contraction, and 2) dust distribution in 2016 is not concentrated in the vicinity of the mine, reflecting the need to examine larger-scale emission patterns.

The inadequate field-based quantification and assessment of aerosol particulates across the Eurasian steppe limits analysis of dust implications for human and animal health in the region. Similarly, there is a lack of consensus on climate regimes, large-scale causal factors, dust impact and definition and determination of degradation and desertification on the steppe. Research, such as featured at this conference, can initiate collaboration and emphasise the importance of environmental knowledge for the >1 billion people living in East Asia. Further improved in-depth environmental and epidemiological research can lead to identification of exposure to dust and vulnerability to desertification processes in Central and Inner Asia.

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Environmental Regime Shifts in Mongolia: Climatic, Ecological and Human Systems

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Regime shifts are large, persistent changes in the structure and function of climate-ecological-social systems. Better understanding of regime shifts is important as they may have substantial impacts on human economies, societies and well-being, and are often difficult to anticipate and costly to reverse. A review of environmental regime shifts during the Mongol empire (12/13th Centuries) and modern Mongolia (20th/21st Centuries) will be presented focusing on interactions between climatic, ecological and human systems. Tree-ring based fascinating study (Pederson et al., 2012) indicated that beneficial changes in climate (wet) regimes in 13th and 20th centuries that made the Mongolian grasslands green (high productivity) and helped recover of Mongolia during the Mongol Empire (under Chinggis Khan) and agricultural development of Modern Mongolia. The expansion of the Mongol empire coincided with the period of persistent wet/warm environment in the 12nd/13th centuries. This likely led to a period of high grassland productivity (increased carrying capacity) that fed vital herds of horses and livestock and contributing fuel to their expansion. Moreover, another period in 20th century, rapid agricultural and economic development of modern Mongolia is coincided with wetter climate than any of the previous 11 centuries. However, this followed by unusual environmental changes of the steppe under significant impacts of dry and warm climate. These recent droughts in 2000s compares in their severities only to those dry periods in the late 1100s (Pederson et al., 2014). As a result, widespread decline of vegetation across the steppe (about 70% of this ecosystem degraded), thereby led to decrease overall carrying capacity and also frequent dust emissions in 2000s (Nandintsetseg and Shinoda, 2015). In addition, the steppe negatively affected by human activities. Since 1990s, political and economic shifts from socialist to market economy in modern Mongolia stimulated rapid increase of livestock population. Increased livestock numbers and reduced mobility (lack of rotational grazing) have resulted in overgrazing and the degradation of steppe (desertification). That’s in 2000s, severe droughts and consecutive dzuds (massive mortality of livestock) killed 21.5 ml. livestock and had dramatic impacts on herders’ livelihoods, society and economy (Nandintsetseg et al., 2017). This climate-human induced environmental shifts in modern Mongolia adversely affected nomadic herders, forcing them to shift livelihoods from traditional nomadic to urbanized in 21st century. Moreover, future warming likely leads to similar heat droughts with shifting to a more arid climate regime and land degradation with potentially severe consequences for modern Mongolia.

References:
Seasonal Dynamics for Vegetation Response to Precipitation and Detection of Environmental Regime Shifting in Semi-Arid Region

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Sparsely vegetated drylands (including mainly has annual herbs and perennial shrubs) are an important source for dust emission, annual plants strongly depend on rainfall, and perennial plants can survive even in years of extreme drought. But the mechanism of dust emission in response to seasonal dynamics of precipitation and the consequent effects on vegetation dynamics in these settings is little known. This study used remotely sensed methods, to extract the area where regime shift had occurred in semi-arid region. As a result of analyzing the Hovmoller diagrams generated using vegetation index and precipitation data, NDVI values tended to increase with increasing precipitation during the vegetation growth period (VGP) between May and September. Vegetation showed high response to precipitation during the VGP.

We compared the longitudinal and latitudinal distribution of vegetation with respect to precipitation. Vegetation in the eastern monsoon region where precipitation was found to be higher than in other regions responded well to precipitation. When the pasture land undergoes desertification, the seed bank in the soil disappears and the soil layer is destroyed. We found that vegetation does not respond to precipitation at all after a certain time in some regions (Fig. 1). We found that from 2003 that vegetation no longer responded to precipitation in F2 region.

Fig. 1. (Left) Relationship between dust storm days and NDVI at Sainshand Station. (Right) Environmental regime shifting in North China during 2003-2013.

References:
A Model Analysis for the Regime Shift in Alpine Vegetation under Climate Change

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Global warming may accelerate the time of snowmelt in spring, which extends the annual growth period of plants but shortens the duration of snowmelt-water supply in alpine regions, resulting in drier soil conditions in mid-summer. This may influence the growth and species composition of alpine vegetation especially inhabiting moist habitat. Using a dynamic mean field model, the regime shift of vegetation change in alpine ecosystem under warming is theoretically analyzed. Our model is based on the observed vegetation change, rapid expansion of dwarf bamboo (Sasa kurilensis) into snow-meadow vegetation, in the Daisetsuzan National Park, Northern Japan. A positive feedback mechanism is considered in the model, that is, dwarf bamboo favorably expands the distribution area under early-snowmelt conditions and soil water contents are more suppressed due to high transpiration ability of dwarf bamboo once it develops dense clonal patches. The feedback mechanism between the abundance of dwarf bamboo (B) and soil water content (W) is formulated as two equations. The effect of B on W is introduced through a differential equation in which a decreasing period of snowmelt-water supply caused by an increase in air temperature (T) is contained. Invasion of dwarf bamboo to early-melting places accelerate the soil aridification due to high transpiration action of dwarf bamboo. The effect of W on B is represented by a function B = B(W, T), which is based on the empirical photosynthesis responses of dwarf bamboo to W and T. The former gives an indirect effect of T on B via a change in snowmelt period due to a change in T, while the latter gives a direct effect of T on B. We analyzed numerically the occurrence of regime shift in various parameter regions such as transpiration and evaporation rate. It is found by our analysis that a regime shift, i.e., quasi irreversible drastic change from snow-meadow to bamboo shrubland, can occur substantially not through the direct effect of temperature but through indirect effect of T on B via early snowmelt followed by soil aridification. This work was supported by Grant-in-Aid for Scientific Research (C) 15K00524 by the Japan Society for the Promotion of Science.

Fig. 1. (Left) A positive feedback mechanism between the abundance of dwarf bamboo (B) and soil water content (W). (Right) Hysteresis graph peculiar to regime shift. (S₁ and S₂ are the stable states of snow-meadow and bamboo shrubland respectively, and U is the unstable state).

References:

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Extending Dryland Disaster Science to Health Science

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Climate hazards comprise 87% of disaster events in Asia. In particular, mid–high latitudes drylands (such as those in Eurasia) present a harsh environment with a cold, arid climate. The livelihoods of the people inhabiting these areas have long been jeopardized by the repeated occurrence of natural hazards associated with such a climate. Events can be characterized as the ‘4Ds’: drought, dzud (severe winter conditions), dust storms, and desertification, which occur interactively. However, previous attempts to elucidate disaster mechanisms and efforts to implement appropriate land management techniques have been unsatisfactory as these efforts have typically focused only on individual disasters. To address this issue, the 'Integrating Dryland Disaster Science' project has been conducted focusing on Mongolia (Shinoda, 2017). This talk presents some achievements of this project and their applications to an early warning system of meteorological disasters. It then outlines the significance and possible approach of extending dryland disaster science to health science. This approach is expected to meet the pressing demand of inhabitants and animals whose health and life have been endangered under recent, frequent occurrences of high-impact climate hazards.

Reference:
Influence of Land Surface Conditions on Frequency of the Dusty Days in Inner Mongolian Grasslands, China

Yongmei\textsuperscript{1, 2}, Masato Shinoda\textsuperscript{1}, Banzragch Nandintsetseg\textsuperscript{1, 3}, Hailin Gao\textsuperscript{4}, Uljibayar\textsuperscript{5}, and Huirong Li\textsuperscript{5}

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Asian dust has been widely recognized as among the most serious environmental issues throughout East Asia that have an adverse effect on ecosystem, human life, and health. This study focused on Xilingol grasslands that an environmental gradient from the driest Gobi Desert eastwards to the wetter grasslands. Aeolian processes in temperate grasslands (or steppe) are unique in that the plant growth-decay cycle, soil moisture dynamics, and induced grazing and mowing grass for winter livestock stock forage interactivity affect seasonal and interannual variations of dust emission. This study used process-based terrestrial biogeochemical model DAYCENT to simulate such grassland land-surface dynamics and to identify primary land surface factors that control dust emission with soil moisture and vegetation components (live grasses, standing dead grasses and litter) in the Xilingol grasslands (one site in the desert steppe and the other in typical steppe), which is an important ecological barrier to block dust storms originated in the steppe and deserts of the Mongolian Plateau and the western China to be transported to Beijing. In order to further understand the influence of surface factors on dust frequency, the regressive analysis was analyzed. Results showed that the DAYCENT model realistically simulated seasonal and interannual variations of the vegetation components and soil moisture that were captured by field observations during 2005–2015. The standing dead grasses and wind speed had the strongest memory and simultaneous correlation with spring dust emission in Erlianhot, similar with Mongolian steppe site, where light grazing and preceding vegetation was protected well and suppressing spring dust emission. Dust event had a similar amplitude of significant correlation with wind speed and live vegetation and soil moisture in typical steppe, where vegetation turns green earlier and more precipitation and soil moisture. However, moderate grazing and large areas of grass were cut off in autumn and the following spring almost no standing dead grasses to suppressing dust emission.

Key words: Dust storm, DAYCENT model, Vegetation components, Soil moisture, Xilingol grassland
Impacts of Erodibility Factors on Dust Occurrence in Inner Mongolia, China

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Dust occurrence in Inner Mongolia, China shows a decreasing trend during the period of 1999 to 2013. Results of quantifying the relative contributions of erosivity (i.e., wind speed) and erodibility (i.e., land surface conditions) indicate that such inter-annual dust variation is more related to erodibility factors. In the Inner Mongolia steppe, we analyzed impacts of erodibility factors on dust variation, and found that the expansion of fenced grassland areas, and the control of livestock population are related to the increase in the spring NDVI, which depresses the occurrence of dust emission.

Also, we identified dust hot spots in Xilingol League, Inner Mongolia by using MODIS level 1B data and the brightness temperature difference algorithm, and by filed survey. Dust hot spots such as dry lakes and mines contribute to dust emissions. We will discuss the impact of erodibility factors in the areas of dust hot spots.

References:
Abstracts

Poster session

13:10-13:40 on 3 November
15:50-16:20 on 3 November
13:20-13:50 on 4 November
Evaluation of Ceilometer Attenuated Backscattering Coefficient for Quantitative Aerosol Measurement

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Ceilometers measure cloud base height and usually deploy in the airport to provide the information for taking off and landing of airplanes. Ceilometers are simple, low-cost, and robust backscatter lidars that utilize a near infrared laser with high repetition rates and low energy. Recently, ceilometers are used for aerosol profile measurement in the world. In Asia, a Nagoya University group is conducting continuous observation of dust with ceilometers in Mongolia (Kawai et al., 2015). Accurate calibration of ceilometers is very important to estimate aerosol extinction profiles. Calibration coefficient is determined at the factory, but the resulting attenuated backscattering coefficients are not absolutely correct as reported by Jin et al., (2015). Recalibration is needed for each ceilometer at the site with ceilometer signal itself. In this study, we recalibrate Lufft CHM15k ceilometer signals. A new calibration method using depolarization ratio is also proposed. Correction factors by the recalibration are evaluated by comparing with lidar signals. Overlap function correction is also evaluated.

Fig. 1. Attenuated backscattering coefficient at 1064 nm observed by (a) CHM15k and (b) NIES Lidar during 20–29 August 2016.

References:
Relationship between Dust Emission and Vegetation Coverage over Mongolia: Moving Observation from Dalanzadgad to Ulaanbaatar

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Mongolian arid lands distribute from southern Gobi Desert to northern Mongolian grassland. These lands are one of the main source of Asian dust. In order to investigate a relationship between dust emission and vegetation coverage, we conducted moving observations from Dalanzadgad (DZ) to Ulaanbaatar (UB) every 100 km on 7 May 2015 and 5 May 2016 by using an optical particle counter (OPC: Aerotrak 9306-V2) and a sunphotometer (Microtops II) (Fig. 1).

Figure 2 indicates the horizontal distribution of number concentration of aerosols in May 2016 from Dalanzadgad (No. 1) to Ulaanbaatar (No. 8). Number concentrations of coarse particles (1-10 μm) decreased from point 1 to 7, changing from the desert to the grassland. Point 8 is the center of UB. Number concentrations of coarse particles are lowest at No. 7 that was a grassland with melting snow because of high elevation. Number concentrations of coarse particles have significant negative correlations with NDVI from 3 to 10 μm, but the number concentration at 0.3–0.5 μm has no correlation to the vegetation because of its anthropogenic origin. It is concluded that the cover has a suppression effect on the dust emission.

The aerosol optical thickness and Angstrom exponent were obtained by the sunphotometer. In 2015, the aerosol optical thickness was high in desert area and low in grasslands. In reverse, the Angstrom exponent was low in deserts areas and high in grassland/urban area. But, synoptic-scale strong wind blew during the moving observation in May 2016, and lifted up the dust in wide areas. The relations in 2015 were not applicable to those of 2016.

In summary, the number concentrations of aerosol particles reflect the surface condition such as vegetation, and the aerosol optical thickness represent the characteristics of the wide areas.
The Relationship between Aerosol Density and Extinction Coefficients over the Gobi Desert

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The Gobi Desert is one of main resources of the Asian Dust, which affect the environmental quality and human health as well as the climate by scattering of solar radiation and cloud-forming process. In order to estimate the amount of the Asian dust over the source regions, we carried out a simultaneous observation of the Asian dust by a dust-balloon, a ceilometer and radiosonde at Dalanzadgad meteorological observatory in the Gobi Desert at 8:00 LST on 29 April 2016. An optical particle counter (OPC) was installed on the dust balloon, measuring the number-size distribution of the Asian dust. The ceilometer (Vaisala CL51) was used to observe the vertical profile of backscattering coefficient.

There was an inversion layer at height of 100–150 m. Dust particles concentrated under the inversion layer. Above the inversion layer, there was a clean layer from 150 to 500 m. The backscattering coefficient observed by the ceilometer was converted to the extinction coefficient using Fernald's scheme (lidar ration = 50). There is an exponential correlation between particle number and extinction coefficient. Especially, the number density of coarse particle strongly correlates ($R = 0.946$) with the extinction coefficient (Fig. 1). We assume that the specific gravity of dust particle is 2.6, and calculate mass/extinction ratio (MECF: mass/extinction conversion factor). Dust resource area has higher MECF value than those of downwind cities (Beijing, Seoul and Tsukuba) (Table 1).

Table 1. MECFs (mass/extinction conversion factors) at various sites.

<table>
<thead>
<tr>
<th>Site</th>
<th>Mass/extinction conversion factor $([\text{mg/m}^3]/\text{km}^2)$</th>
<th>Wavelength (nm)</th>
<th>Year</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dalanzadgad</td>
<td>\textbf{3.03}</td>
<td>910</td>
<td>2016</td>
<td>This study</td>
</tr>
<tr>
<td>Beijing</td>
<td>\textbf{1.78}</td>
<td>532</td>
<td>2002</td>
<td>Sugimoto \textit{et al.}, 2003</td>
</tr>
<tr>
<td>Seoul</td>
<td>\textbf{1.40}</td>
<td>532</td>
<td>2007</td>
<td>Sugimoto \textit{et al.}, 2011</td>
</tr>
<tr>
<td>Tsukuba</td>
<td>\textbf{1.18}</td>
<td>532</td>
<td>2007</td>
<td>Sugimoto \textit{et al.}, 2011</td>
</tr>
</tbody>
</table>

Fig. 1. Correlation between extinction coefficient and particle number at the size of 2.0–5.0 \textmu m.

References:
Analysis of Temporal and Spatial Distribution of Grassland Fire in Mongolian Plateau

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Wildfire plays a key role in the past, present and future of Earth system as one of the major factors in this system. Monitoring and assessing the temporal and spatial pattern of wildfire have significance in understanding the ecological processes and the human impacts on ecosystem.

The Mongolian Plateau, which is an important part of the global ecosystem and one of the most important ecological barriers in Northeast Asia, is important for the ecological security of the Mongolian Plateau and its surrounding areas. Therefore, in this study, the temporal and spatial distribution of wildfire was analyzed by using MCD64A fire slash production in the Mongolian Plateau from 2000 to 2017. It was found that the grassland fire was mainly distributed in the eastern Mongolia where is the border of China and Mongolia, with the great difference near the borderline. Therefore, taking the buffer zone with 100 km from the borderline as the main study area (core area), the frequency and spatiotemporal characteristics of grassland fire was analyzed, and the temporal and spatial pattern of grassland fire on both sides of the borderline was compared. The results showed that 248500 km² were burned with in the study area from 2000 to 2017 and 119700 km² of them were in the core area, which represented the 48.17 percent of the total burned areas. The temporal distribution of burned areas were declined firstly, then increased in the core area from 2000 to 2017, which the fire more than 10000 km² occurred in 2002, 2003, 2005, 2010, 2011 and 2015. In the daily dynamics of the number of wildfire, the frequency is high in the spring, mainly from March 29th to July 11th, from August 22th to October 26th in autumn. In the spatial distribution, the 96.45% percent of total burned areas were in the Mongolia, which is 113300 km², 6400 km² were in the Inner Mongolia. The high frequency area was mainly distributed in the borderline where the frequency had a significant difference. The borderline between China and Mongolia is not a natural geographic boundary where the natural environment on both sides of the borderline is exactly same, but a line delineated by human. However, why did the fire distribution on the side of the borderline have such a difference? The occurrence of wildfire is closely related to climate and human activities. The general trend in a region is likely to be climate-related, whereas the great difference of wildfire in the sides of borderline may be related to human activities. The border area of China and Mongolia is also an ideal research area to study the impact of human activities on wildfires. It has important characteristics of climate change and human activities. Research from climate change and human activity is also the main content of future study.
Global Distribution of Anthropogenic Dust Aerosol from CALIOP Satellite

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Anthropogenic dust aerosols are those produced by human activity, which mainly come from cropland, pasture, and urban in this paper. Because understanding of the emissions of anthropogenic dust is still very limited, a new technique for separating anthropogenic dust from natural dust using CALIPSO dust and planetary boundary layer height retrievals along with a land use dataset is introduced. Using this technique, the global distribution of dust is analyzed and the relative contribution of anthropogenic and natural dust sources to regional and global emissions are estimated. Local anthropogenic dust aerosol due to human activity, such as agriculture, industrial activity, transportation, and overgrazing, accounts for about 22.3\% of the global continental dust load. Of these anthropogenic dust aerosols, more than 52.5\% come from semi-arid and semi-wet regions.
Characteristics of Cloud Base Height from Ceilometer Data Measured at Dalanzadgad, Mongolia

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2) University of Tsukuba, Tsukuba, Japan
3) Graduate School of Environmental Studies, Nagoya University, Nagoya, Japan

Eye visible observation was used for determining cloud base heights in Mongolia. A laser ceilometer, model Cl-51 was installed at a weather station in Dalanzadgad in the southern Mongolia since May 2013. We analyzed data of high resolution (6 s measurements) ceilometer measurements at Dalanzadgad within the period 2013–2016 and data of eye visible observation in the same period.

Cloud occurrences were lower in December to February and higher in June and July by both observations of ceilometer and weather observers. Clear day frequencies were higher in winter months at this location. Low cloud frequency was higher in January, lower level middle clouds (2-4 km) occurred frequently in April and July and higher level middle clouds (4-6 km) was commonly in October and January.

The cloud vertical structure was analyzed from the dataset. The ceilometer detected single, double and three layered cloud base heights (CBH). Low clouds represent 19.7% of detected CBH, while middle clouds 58.9%, and high clouds 21.3%. For two and three layered clouds, distances between CBH of interlayer were found.

When low pressure systems arrived at the country both winter and summer, the ceilometer detected low clouds with the highest frequencies of CBH at 800-1600 m, while middle clouds at 2800-3600 m.

Keywords: cloud base height, cloud occurrences, cloud cover, cloud vertical structure, cloud layers, ceilometer
Comparison between Meteorological Fields Analysis and Surface Measurements on Asian Dust Events at the Beginning of May 2017

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Gobi Desert is distributed from southern Mongolia to northern China and is a major source region of Asian dust. Three cold fronts passed through Gobi Desert, and dust storms occurred by strong wind on 2-4 May 2017. The dust flowed to the whole of Japan on 6-8 May, and caused visibility hindrances (Fig. 1). This study compares meteorological fields with surface measurements during this period.

At 12 UTC 2 May, a cold front associated with the first depression (L1) passed through Gobi Desert, and the dust was produced. After that, two cold fronts moved across the desert, and each of them caused dust storms at 06 UTC 3 May and 06 UTC 4 May. Because the depression involving the third cold front (L3, Fig. 1) moved eastward, the dust was transported to Japan. The two pressure troughs (T1, T2) developed on the south side of L3. On 6 May, the cold front associated with L3 and T1 brought the dust to Japan, so the SPM concentration increased (Fig. 2b). When T2 went through Japan on 7 May, SPM concentration increased again because T2 transported the dust likewise.

Fig. 1. The path of L3 (surface) and the cold front (850 hPa).

Fig. 2. (a) Attenuated backscatter coefficient at 1064nm (NIES AD-Net lidar) and wind profile (NCEP/NCAR reanalysis) at Nagasaki. (b) SPM concentration (MOE) and precipitation (JMA) at Nagasaki.
Variations of Airborne Microbial Communities in Auckland City (New Zealand) during Christmas Season

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Aerosols that were transported from Australian and Asian continents disperse airborne microorganisms to the downwind area in islands, such as New Zealand and Japan, respectively, across the sea area. Airborne microbial transports have potential impacts on climate change, bio-ecosystem, and human health. However, the microbial transport process and their environmental influences have rarely been generalized all over the world. New Zealand is close to the Australian continent and this situation is similar to Japan, and dust events in New Zealand are reported to be transported from the Victoria Desert in Australia continent. Accordingly, we attempted to compare the airborne bacterial communities in New Zealand to those of Japan, of which the information has been already obtained (Maki et al., 2017), for the first steps of worldwide generalization of the microbial inter-continental transports. In this study, air samples were collected on the roof of building at Auckland city in New Zealand, from December 20, 2016 to January 23, 2017. The community structures of bacteria and fungi in the 19 air samples were analyzed using high-throughput sequencing analysis using 16S rRNA genes. Furthermore, the particle concentration was determined by fluorescence microscopic observation using DAPI staining techniques. The community structures and abundances of microorganisms changed around Christmas day (the 25th Dec), when human activities reduced. Human activities would influence on the variations in airborne microorganisms. The air-mass trajectory analyses showed that the air masses during this sampling periods were not transported from the Australian continent. During this sampling period, the airborne microorganisms would be originated from local or marine environments. This phenomenon is similar to Japanese non-dust event.

Fig. 1. Investigation strategy (a) and air-sampling images (b).

References:
Techniques for the Determining Association between Chemical and Biological Components of Aerosols Loading in Airborne Particulate Matter

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The amount of particulate matter (PM) in urban aerosols is a key indicator of air pollution and these have documented adverse health impacts on humans. Recent studies have revealed PM is not a single pollutant but a mixture of particulate, chemical and biological fraction (Morakinyo et al., 2016). However, the method to investigate the association between chemical and biological aerosols components is still far from being understood. In terms of the experimental design, it is often difficult to measure the association between biological and chemical components of PM due to different response times of instruments and differences in their flowrates, which often results in a time difference between these two types of measurements. We have collected samples of PM$_{2.5}$ and PM$_{10}$ every 24 hours with a high volume air sampler (1440 m$^3$) for 3 months (August to October 2016) in the Central Auckland, New Zealand. For chemical and biological analyses, the filters were divided onto two equal parts. One filter portion was analysed for PAHs and NPAHs using HPLC with fluorescence and Chemiluminescence detection, respectively. The total median concentration of PAHs was significantly higher (56%) than NPAHs (44.6%). For biological analyses, particles on the filter were observed using epifluorescence microscopy with DAPI staining protocol. A filter transect was scanned, and the four categorized particles, including white fluorescent particles, blue fluorescent particles (microbial particles), yellow fluorescent particles, and black particles, on the filter transect were counted. Microscopic observation of aerosol particles showed relatively high levels of black carbon ($7\times10^6$ particles/m$^3$), which were likely produced by vehicle exhaust in Auckland. Chemical components of PM in the air cannot be investigated in isolation of biological components, but the consideration has to be given to their characteristics such as concentration, size distribution and meteorological factors.

Fig. 1. Sampling site and microscopic observation of interaction of chemical (black carbon) and microbial components of aerosols in New Zealand air.

References:
The Simulation for Wind Erosion Effects on Soil-vegetation Characteristics in Mongolian Grasslands by Ecosystem Model

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Aeolian processes can contribute to the disruption of human activities, affect human-livestock health, and lead to environmental problems such as removing material deposition which affect surface soil properties-vegetation distribution, especially in arid-semiarid regions and downwind regions. Clearly, these facts in Mongolian grasslands, which lie in a prominent transition belt, suggest the vulnerability of this region to the dust emission and also the possible increase in dust event frequency from this source area. In this study, the impacts of Aeolian processes on grassland ecosystem are concerned. In general, dust is controlled by atmospheric and land-surface factors, and the vegetation growth-decay cycle and snow pack play a role an initial condition during the spring. Therefore, we assumed that permanent loss of fine particles from soil surface by dust emission may reduce soil water-holding capacity and nutrients, thereby restrict plant growth in grasslands and lead to increase of land degradation (Fig. 1), and we used process-based DAYCENT model (Parton et al., 1988) to simulate exchanges of C, N, trace gases in the atmosphere, soil and plants, and plants production in grassland ecosystem during dust emission, based on meteorological, land-surface and vegetation input data at Bayan-Unjuul, Mongolia (Nandintsetseg and Shinoda, 2015). Results showed that decreases in soil moisture and soil organic matter (0-10 cm) after wind emission can lead to plants production decreasing obviously. In conclusion, soil moisture and nutrients are key factors that influence plants production in erosion processes and these factors can be distinguished by model.

Fig. 1. A basic sketch of simulation assumption during wind emission.

References:
Effect of Extreme Winter Hazards on the Grazing Behavior and Energy Intake of Mongolian Sheep

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Animals’ energy intake source all rely on the intake of food, which purports the forage intake for grazing animals in natural grassland grazing system. Energy intake rate depends on the quantity of forage intake (M. Lachica, et al., 2005). And animals’ grazing behavior mainly include feeding, rumination, standing, walking, resting, drinking water and so on. Different activities (behavior) have very different effect to animals’ energy flowing (R. L. Senft, et al., 1985). In general, the main factors that affect animals’ grazing behavior are climate conditions (air temperature, air pressure, solar radiation, wind speed, snow, et al.), forage conditions (plant species and production) and human-induced grazing management (John C, et al., 1976).

The aim of this study was to investigate the affect of winter climate hazards on the grazing behavior of sheep, which decide energy flowing mode of Mongolian sheep. Six sheep were selected for behavioral study as measuring daily total bites using bite counters in Bayantsogt, Mongolia. We used air temperature, precipitation, snow depth and wind speed condition during November-February as the winter hazard factors. Preliminary results of relationship between winter climate hazards and sheep’s energy intake during 2016/2017 winter will be presented.

Fig. 1. Bite counter devices on sheep for feeding behaviors’ monitoring (Photo by Yoshihara Yu, 2016.11).

References:
M. Lachica and J. F. Aguilera, 2005: Energy needs of the free-ranging goat, Small Ruminant Research, 60, 111-125.
Determining Local Dust Source Area Using Modeled Soil Moisture in Xilinhot, Inner Mongolia

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Temperate grasslands, including Inner Mongolia, are one of the source regions for Asian dust outbreaks. Land surface elements (e.g., soil moisture) are considered an important controlling factor for dust outbreaks in the grassland. So far, large-scale dust source areas, including grasslands, have been studied extensively, however, very little research on local-scale dust source areas (radius of 20 kilometers) has been carried out. Therefore, this study aims to identify local dust source areas surrounding Xilinhot, located in the middle of Inner Mongolian grassland, using modeled soil moisture and observed meteorological (dust events, wind direction and speed) data at Xilinhot during 1986–2015 springs. Soil moisture is estimated by thermal inertia from a linear surface heat budget model (Matsushima et al., 2012) by radiative surface temperatures, insolation, and meteorological observations. Local dust source areas are determined from K-M model (Kormann and Meixner, 2001), which is used to analyze footprint of turbulent scalar fluxes by atmospheric boundary layer characteristics and meteorological data. Moreover, land use patterns in surrounding areas of Xilinhot have been investigated through field survey in summer 2017. Based on our preliminary results, totally 52 local-dust outbreaks out of 225 during 1986–2015 have been identified in Xilinhot. This indicated that areas surrounding Xilinhot are likely one of the local sources of grassland dust outbreaks.

References:
The Influence of Soil Moisture and Heat Balance on Summer Precipitation Events in Mongolia

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From 1960 to 2012, daily thunderstorm frequency has increased in the northern part of Mongolia. Heavy rains lasting less than one hour damage nomadic herders’ pastures, animals and daily life (Goulden et al., 2015). Also, a large drying trend has been observed in a soil moisture index over land areas in the Northern Hemisphere since the middle 1950s, including Mongolia. Previous study highlighted that further research is required on land–atmosphere interactions to explore the mechanisms by which soil–vegetation system directly affects the drying trend over Eurasia via soil moisture/precipitation recycling (Shinoda and Nandintsetseg, 2013). Hence this study examined the feedback processes between soil moisture and summer precipitation occurrence in a Mongolian grassland. We used unique half-hourly measurements of meteorological (temperature, precipitation, sensible heat flux etc.) and land-surface (soil moisture content and soil temperature) data measured in Mongonmorit forest steppe site (2002-2006) and Bayan-Unjuul steppe site (2008-2014). First, we categorized each precipitation event into convective and non-convective precipitation based on mixing layer height, sensible heat flux, soil moisture, and atmospheric stability. Then, the quality of the categorization is assessed using NCEP final analysis data and vertical equivalent potential temperature inclines. Results showed that the yearly amount of convective precipitation were 6-15% in the forest steppe and 3-16% in the steppe site. In general, our analysis revealed that the feedback of soil moisture on convective precipitation amount was too little to produce a persistent moisture anomaly in the atmosphere-land surface system due to not significant influence of each convective precipitation on soil moisture.

Fig. 1. Station locations in Mongolia.

References:
Changes in Cold Air Outbreaks and Their Atmospheric Conditions over Mongolia

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In 2000s, Mongolia experienced frequent dzuds (winter disaster in Mongolian) that killed more than 20 million livestock. The cold air outbreak events (COEs) are one of the most severe hazards that contributed to these dzuds (Iijima and Hori, 2017; Nandintsetseg et al., 2017). Their studies examined interannual changes in characteristics of COEs (frequency and severity) and their causal factors of synoptic patterns across Mongolia during 1971–2015. We used observed daily air temperature from 70 meteorological stations and modeled air temperature and pressure, wind components by ERA-Interim reanalysis from European Centre for Medium-Range Weather Forecasts. In the present study, COEs have been defined statistically as a period of at least 5 consecutive days with average daily air temperature below one sigma of the local-normal level (average of 1981–2010) during cold season (December, January and February). For regional analysis, we divided Mongolia into six subregions: Northern (west, middle and east) and Southern (west, middle and east) regions. To examine the associated synoptic patterns, the composite analysis (temperature and wind components) at 500hPa geopotential height (GPH) are conducted using ERA-interim reanalyze data. In general, an increasing trend in COE frequency was found across the country during 1971–2015 and it was significantly (p< 0.05) increased particularly since 2000s. At the regional scale, COEs in northern regions significantly increased, but not in southern regions. This significant increases in frequency of COEs in northern regions in 2000s are coincided with changes in wind directions, namely cold air advection from westerly (1971–1999) to northerly (2000–2015). These results imply that changing atmospheric circulation pattern in relation to sea-ice decline in the Arctic Ocean, which enhance cold air advection under the negative phase of the Arctic Oscillation during winter.

References:
Spatial Analog Methodology for Temporal Disaggregation of Daily Precipitation

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The South-East France Mediterranean climate is characterized by strong precipitation variation with very dry summers succeeded by very watered falls. As a South-East France river, Gardon à Anduze is exposed to heavy rains which sometimes generate floods. Since the watershed Gardon à Anduze time response is around 3 to 5 hours, it is necessary to establish temporal disaggregation methods \cite{1, 2}.

Conducted on the watershed Gardon à Anduze, this study puts forward a temporal disaggregation method based on analogy. This method requires to characterize each day of the study period (1997-2006), to look for the nearest neighbor after standardization based on the daily characteristics, to construct a catalog of temporal profiles in order to disaggregate.

Four analog methods were obtained after combining different variants. The leave-one-out cross validation method allowed the evaluation of each of the methods. The mean absolute error was employed in this evaluation process as validation criteria.

Fig. 1. Digital elevation map (m) with extended Lambert II coordinates (km). The dashed line represents the border of the watershed.

References: