

Potential Capability of Adjoint Inverse Modeling of Dust Emission and Transport over East Asia for Real-Time Dust Forecasting

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A four-dimensional variational (4DVAR) data assimilation system was developed for a regional dust model. This report presents results of the first adjoint inversion of Asian dust emissions over East Asia using NIES LIDAR observations, targeting the extreme dust phenomenon on 30 April 2005. Optimized dust emissions mitigated underestimation of dust concentrations and brought the structure of the elevated dust layer (both vertical structure and extinction coefficient intensity) into better agreement with LIDAR observations. We obtained a 31% (12.6 Tg) increase of calculated dust emissions through data assimilation, especially over the Mongolian region. The assimilated results agree with the TOMS AI distribution and indicate that the 4DVAR method is very powerful for unification of observation and numerical modeling.

In this study, we restricted our observation data to those from the LIDAR network. However, 4DVAR is very capable of including surface level observations (such as PM₁₀ and SPM) and satellite retrievals (e.g., aerosol optical thickness (AOT) and the Aerosol Index). The inclusion of these data will improve the dust model capability markedly and will be the next step of 4DVAR application.

Numerical dust forecasts are now used operationally by the Japan Meteorological Agency (JMA) and the Korean Meteorological Agency (KMA). However, their forecast accuracies depend on dust emission processes, which are sometimes not properly forecast (or identified). Reliable surface land-use conditions and soil/surface information are more important than the complexity of the dust emission scheme or model horizontal resolution (Uno et al., 2006). Although accurate information for the space over desert areas in China and Mongolia is very important, the use of updated Chinese/Mongolia surface conditions is usually difficult. Our feasibility results, coupled with LIDAR dust observations and chemical transport models with 4DVAR, demonstrate the importance for dust modeling under these conditions. This modeling method might serve as a powerful means for real-time dust prediction in East Asia.

Key words: Adjoint inverse method, Data assimilation, Dust model, LIDAR

Changes of Chemical Composition of Aerosols Measured at Cape Hedo, Okinawa after Long-range Transport from the East Asia with Asian Dust

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A new Japanese super site for aerosol measurements has been settled at Cape Hedo; the northern tip of the Okinawa main island, Japan (Fig.1). Comprehensive measurements of chemical, physical, and radiative properties of aerosols have started there. The changes of concentrations of EC/OC and sulfate were remarkable during Kosa period of November, 2005. Characteristics of the aerosol chemical compositions depending upon the air mass origins will be shown. The results of nitrate (NO_3^-) measurements will be shown in the latter part of the presentation. NO_3^- in Okinawa exists mostly in coarse mode. This is a big difference from that measured in China, where NO_3^- exists mainly in fine mode. Chemical transformation takes place during the long range transport.

Key words: Aerosol chemical composition, Cape Hedo Atmosphere and Aerosol Monitoring Station (CHAAMS), Coars particles, EC/OC, Nitrate

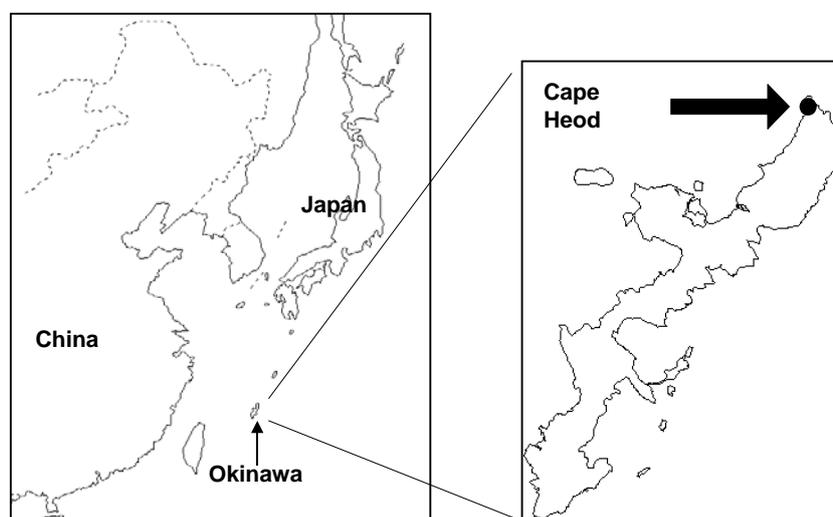


Fig.1 Location of Cape Hedo Atmosphere and Aerosol Monitoring Station (CHAAMS)

Movement of Asian Dust Revealed by Network Observations Using Two-wavelength Polarization Lidars

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Network observations of Asian dust using ground-based two-wavelength (532 nm, 1064 nm) polarization (532 nm) lidars have been conducted since March 2001. At present, lidars are operated continuously at 13 locations in Japan, China, and Korea in cooperation with various universities and research institutes. The data are used for analysis of dust events and validation/assimilation of chemical transport models. In this paper, we report the results of the observations of Asian dust in recent years. We also discuss the data processing methods for the lidar network data.

We developed a method for deriving the "dust extinction coefficient", which is the extinction coefficient only for dust, estimated separately from air pollution aerosols in a mixture of aerosols. We also distinguish clouds in the data, and indicate the range where the data are reliable. We use the 1064-nm signal for cloud detection, and the 532-nm signal and the depolarization ratio for deriving the dust extinction coefficient.

It is seen from the results of the observations in 2001-2006 that the number of intense events (in Beijing) is high in 2001, 2002, and low in 2003, 2004, 2005, and high again in 2006. In 2001 and 2002, heavy dust events accompanying a strong low pressure in Siberia were observed. However, such typical heavy dust events were not observed in 2003, 2004. In 2005, the seasonal progress was slow in contract to that in 2004. The frequency of dust events was low in March and high in April. Several major dust events were observed with the network in April and May. A notable event observed in Japan was the elevated dust layer over Sendai on April 30. The optically dense but spatially thin layer was observed at 3-km height. The extinction coefficient at the layer exceeded 1 km^{-1} and was unusually high as an elevated dust layer over Japan. The analysis with CFORS showed the origin of the dust was in Gobi desert in Mongolia.

This case was analyzed also with the four-dimensional variational data assimilation system (Uno et al. this issue). The results show the lidar network data are useful for accurate evaluation of dust emission in the source regions.

Key words: Data assimilation, Depolarization ratio, Dust model, LIDAR

Germination Responses of Some Key Plant Species Grown at Horqin Sandy Land of China to the Simulated Desertificated Conditions

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Horqin sandy land is a severely degraded and desertificated area influencing the local sustainable development and environmental quality. The direct plant rehabilitation of this area is the effective way for desertification combating and ecological restoration. The germination response of key plant species to environmental factors such as light, temperature conditions in desertificated area of Horqin sandy land is the essential basic information for the evaluation of desertification and for the rehabilitation of degraded soil with plants.

The effects of temperature and light on seed germination have been intensively studied. However, there is little knowledge on the germination response of key plant species in Horqin sandy land to simulated environmental stress condition related to the temperatures and light intensity.

In the present study, we aim to investigate the effects of different temperatures (20/10, 25/15, 30/20, and 35/25°C) and light intensities (dark, 15, 62.5, 250, and 1000 $\mu\text{mol m}^{-2} \text{s}^{-1}$) on the germination characteristics of 4 key plant species (*Agropyron cristatum*, *Artemisia halodendron*, *Caragana microphylla*, *Caragana korshinskii*) grown in desertificated area in Horqin sandy land, in order to get essential information of some key plant species. Germination experiments were carried out in automatic temperature-, humidity-, and light-controlling growth chambers (KG- 306SHL -D/KG -50HLAS-W, Koito Co., Ltd. Japan).

The species, temperature conditions/light intensity and their interaction significantly influenced the final germination percentage and the germination rate of 4 species in Horqin sandy land. The final germination percentages of *C. microphylla* was independent of temperature, while those of *A. cristatum*, *A. halodendron*, *C. korshinskii* were inhibited significantly by higher temperature. A temperature increase could significantly speed up the germination rate of *C. microphylla*, and the maximum value was found at 35/25°C. However, the maximum rate was observed at 30/20°C in other 3 species. The maximum values in the final germination percentage and the germination rate were found under the dark treatment in all plant species. These indices decreased with a light intensity increase, and inhibited significantly under 1000 $\mu\text{mol m}^{-2} \text{s}^{-1}$ treatment. The final germination percentage and germination rate of *C. korshinskii* were not significantly different among other light intensity treatments except for 1000 $\mu\text{mol m}^{-2} \text{s}^{-1}$, whereas those of other species showed that the higher light intensity treatments decreased both indices significantly as compared with the lower ones. The final germination percentage and the germination rate of each plant species decreased with a light intensity increase, and both indices were significantly inhibited by 1000 $\mu\text{mol m}^{-2} \text{s}^{-1}$ treatment.

Key words: Desertification, Germination, Growth, Horqin sandy land, Key plant species, Light intensity, Nitrogen, Phosphorus, Temperature

Recent Interannual Variation in Dust from Changes in Emission and Transport

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Interannual variation of soil dust in East Asia in spring was studied by using simulation in 2001-2006. Numerical simulations were carried out with tags based on emission areas to understand interannual change of dust in downwind areas, such as eastern areas in China. Simulated surface concentrations showed fair agreement with those observed by laser particle counters at surface sites in China. Interannual change of dust emission in emission areas and averaged surface dust concentrations in down-wind areas are investigated. Contribution of interannual changes of emission and transport on the interannual change of the dust concentration in down-wind areas area separately discussed, and it is understood that the change of transport plays comparable or larger role than that of emission. It is also shown that the most contributing emission area depends largely on the location of a down-wind area. For example, more than two thirds of the surface dust concentration in Beijing neighboring area is come from eastern Inner Mongolia and Mongolia, although more than two thirds of that in southeast China is come from western Inner Mongolia and Mongolia.

Key words: Down-wind areas, Emission, Interannual change of dust, Simulation, Transport

Interactive Effects of Water Stress and High Temperature on Growth and Photosynthesis of *Leymus chinensis* -- A Dominated Grass in a Semi-arid Steppe Ecosystem --

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Water deficit and high temperature are important environmental factors restricting plant growth and photosynthesis in many of regions of the world, and while the two stresses often occur simultaneously, little is known about how their combination impacts plants. Of additional concern is global climate change, which will presumably increase global temperature, change the distribution of precipitation, and intensify drought in arid and semiarid areas, leading to a reduction of grass productivity. Grassland dominated by *Leymus chinensis* (Trin.) Tzvel., which is a rhizomatous native perennial plant with good palatability and high forage value, is widespread from the southern Chinese steppe. This regional grassland has been severely degraded during recent decades due to water scarcity combined with the higher temperature that occurs at its growth peak season in middle summer, as well as overgrazing. Our objective was to compare effects of soil moisture, growth temperature, and their interactions on photosynthesis and growth of *L. chinensis*.

Plants subjected to regimes of five soil moisture (soil relative water contents of 80 to 25%) at 20, 23, 26, 29 and 32°C in controlled environments. In the present study, the plant growth, leaf area, carbon allocation, photosynthetic gas exchange, chlorophyll fluorescence, nitrogen level were determined. Seeds of *L. chinensis* and soil were obtained from natural grassland in Xilinhot, Inner Mongolia. Soil water-holding treatments were initially conducted 30 d after sowing in the greenhouse. The soil relative water content was divided into five levels: control (75-80% of FC); MID (mild drought, 60-65%); MOD (moderate drought, 50-55%); SD (severe drought, 35-40%); and ED (extreme drought, 25-30%) in parallel with -0.09 to -0.04, -0.30 to -0.15, -0.99 to -0.72, -1.97 to -1.45, and -2.34 to -2.27 MPa of soil matrix potential, respectively

High temperature with severe water stress significantly decreased plant biomass, leaf green area, leaf water potential, photosynthetic capacity. The leaf biomass of light or moderate soil drought treatment was the greatest under at 20~26°C, but decreased with decreasing soil moisture at 29°C and 32°C. Under sufficient soil moisture, both net photosynthetic rate and water use efficiency were always reduced with elevating temperature, but both stomatal conductance and transpiration rate were always increased with rising temperature. Soil moisture did not significantly affect leaf stomatal conductance and transpiration rate, indicating the higher adaptive ability to soil drought may be exhibited under the experimental conditions. However, under any soil moisture conditions, both net photosynthetic rate and water use efficiency were always reduced with elevating temperature, but both stomatal conductance and transpiration rate were always increased with rising temperature. The results indicated that a no higher tolerance to severe water deficit at high temperature is of great physiological significance for *L. chinensis*. In view of global change, the decrease in precipitation and the increase in temperature might happen in the future in the region dominated by *L. chinensis*, suggesting the distributing ranges of *L. chinensis* may be constrained. How to enhance drought tolerance of the plant in semiarid region at high temperature should be emphasized in the future.

Key words: Grass land, High temperature, *Leymus chinensis* (Trin.) Tzvel., Photosynthesis, Water stress, Water use efficiency (WUE)

Typical Appearance of DSS in Beijing Grasped by the Collaborative Monitoring Project with China, and Future Expectations of the New DSS Monitoring Network Based on the ADB/GEF Plan

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DSS (dust and sandstorm) aerosols are formed when the surface soils of desert and loess regions of the Asian continent are lifted into the atmosphere during dust storms. It has been observed that the aerosol mass concentration and the concentrations of crustal elements in aerosols increase in East Asia with the arrival of kosa aerosols named in Japan. It has been established DSS (including kosa aerosol) sampling network in the Northeast China and has now observed DSS along their transport route.

High-volume samplers were used to collect aerosol samples at 16 monitoring stations in Northeast China when the kosa aerosol was transported. At a few monitoring stations light-scattering digital dust monitors (LD-3K, Sibata Co.) were used to measure aerosol mass concentrations continuously. At the same time, we measured by LD-3k at 4 sites in Beijing to monitor that DSS(kosa) has come from which direction and moved at how speed.

Figure1 shows the typical case of DSS phenomenon (15 March 2002), the DSS front arrived at Shisanling site on the northwestern outskirts of Beijing at 20:30, and about 30 minutes later it was simultaneously observed at the Sino-Japan Friendship Center (SJF Center) and Pinggu sites. It means the DSS was moved from northwest to southeast. Therefore, calculating the vector implied the transport speed from Shisanling direction toward Yongledian, it was gotten average 27km/hr at near ground level. And, the kosa event was covered over the Beijing area about 11 hours.

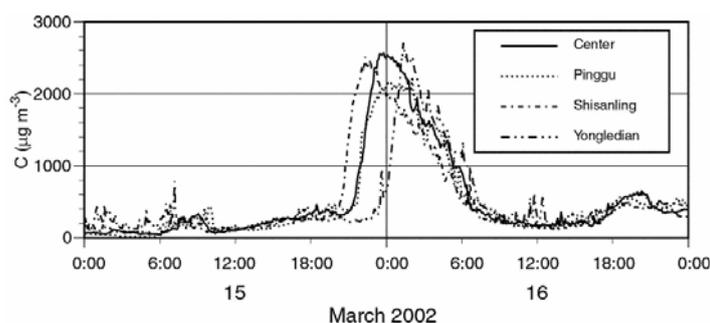


Fig.1 Minutely fluctuations of DSS aerosol at four sites, Beijing.

The regional master plan in the ADB/GEF project to establish a DSS monitoring and early warning network has been summarized in 2005. According to this plan, China and Korea has been already operated 5 sites-monitoring network for PM10 and TSP, and Japan and China agreed to establish 16 sites-network in China including LIDAR system will be installed 7 sites. When those monitoring network data among Japan, China, Korea will be handled with the real-time sharing condition, there are expected the developments of various scientific fields concerning of DSS (kosa) to improve the early warning and forecasting model as well as to reveal the atmospheric dynamic behavior and to estimate influence/damage against the ecosystem in the northern Asia region.

Key words: Chemical composition, DSS, Kosa, Monitoring network