Published in final edited form as:

Aeolian Res. 2014 September 1; 14: 1–2. doi:10.1016/j.aeolia.2014.05.001.

Introduction to a Special Issue of *Aeolian Research* Airborne mineral dust contaminants: Impacts on human health and the environment

David D. Breshears*,

School of Natural Resources and the Environment, The University of Arizona, Tucson, AZ, USA

Department of Ecology and Evolutionary Biology, The University of Arizona, Tucson, AZ, USA

Jeffrey J. Whicker,

Environmental Stewardship Group, Los Alamos National Laboratory, Los Alamos, NM, USA

Avelino Eduardo Sáez, and

Department of Chemical and Environmental Engineering, The University of Arizona, Tucson, AZ, USA

Jason P. Field

School of Natural Resources and the Environment, The University of Arizona, Tucson, AZ, USA

Aeolian research focuses primarily on the fundamental processes of dust emissions and transport (Ravi et al., 2011) but this scientific focus is also particularly relevant for the related consequences of the emissions of airborne mineral dust contaminants (Csavina et al., 2012), which have important implications for human health and the environment. Linking from “dust to dose” is particularly important in the context of human health (Whicker et al., 2006). However, expertise in the relevant research areas tends to be fragmented, with researchers looking at different spatial and temporal scales related to the processes, often with insufficient integration (Field et al., 2010; Ravi et al., 2011; Csavina et al., 2012). To help foster interdisciplinary interactions, a conference sponsored with support from the US National Environmental Institute of Health Sciences was held in Tucson, AZ in the USA in May 2013 with the goal “to stimulate interaction among different research communities interested in dust and to promote better integration of research on airborne mineral dust from emissions to environmental exposure” (<http://www.superfund.pharmacy.arizona.edu/content/airborne-mineral-dust-contaminants-conference-report>). Linking from dust emissions to contaminant transport through atmospheric processes and to toxicological and epidemiological relevance is complex and requires multidisciplinary perspectives and initiatives. Here we summarize the main points of the papers in this special issue in the context of a previous framework linking potential for dust emissions, potential contaminant concentration in dust, and potential risk to human health and the environment (Fig. 1, modified from Csavina et al., 2012). We also listed future needs identified in a survey from the meeting.

A first section of papers emphasize basic processes and modeling of dust emissions and transport that are relevant for airborne mineral dust contaminants. Belnap et al. (2014) present a large data set evaluating threshold friction velocities as a function of soil type and surface type for two southwestern US deserts. Their results highlight the importance of soil surface conditions and their sensitivity to disturbances. Judger et al. (2014) quantify increases in dust concentrations during dust events in Mongolia as function of health-relevant particle sizes (PM₁₀ and PM_{2.5}), documenting increases of more than an order of magnitude in some cases. Merino-Martín et al. (2014) focus on “background” conditions that do not include very windy periods but do include brief gusts; these periods, while less windy, are the most common, and the results highlight an interplay between spatial and temporal scale of measurement from different sampler types and particle size. Many field measurement methods capture horizontal dust flux using samplers such as the Big Spring Number Eight (BSNE) collector, but these horizontal fluxes are not equivalent to vertical fluxes relevant for dust emission suspension and transport; Whicker et al. (2014) consider previous formulations for horizontal and vertical fluxes based on theoretical, empirical and risk-based perspectives, yielding several potential relationships between horizontal and vertical fluxes that can serve as hypotheses for future testing. Sprigg et al. (2014) highlight improved dust emission forecasting approaches for dust avoidance, which is particularly relevant for Valley Fever. Stovern et al. (2014) highlight advances in modeling of dust and contaminant transport; importantly they also highlight how management of surface conditions can aid in controlling dust emissions.

A second section of the special issue focuses more directly on contaminant emissions, transport and risks related to toxicology and/or epidemiology. Kim et al. (2014) quantify surface enrichment of arsenic in mine tailings environments due to windborne transport and the bioaccessibility of arsenic in fine-grained tailings through the inhalation pathway. Xiao et al. (2014) evaluates characteristics of toxicity of emissions, which is directly relevant to human health risks. And Taylor et al. (2014) highlight issues related to the public health impacts in mining and smelting communities affected by the transport of metal-rich dust and aerosol contaminants, and to associated regulatory relationships.

A survey of participants at the conference highlighted the following gaps in the field (<http://www.superfund.pharmacy.arizona.edu/content/airborne-mineral-dust-contaminants-conference-report>):

- Stronger links needed between the dust community and epidemiologists.
- More specific information needed on the health impacts of dust (moving beyond generic PM_{2.5} and PM₁₀; immune system suppression; biological responses of various human organs).
- Needed improvements in dust modeling (forecast severity of dust storms; quantitative dust fluxes; verification of model predictions).
- Improved information on effects of dust storms on public safety (highways, airports).

We also note other challenges highlighted in pulling together this special section. These include issues of scaling (e.g. from small source patches of dust up through large urban area impacts) (Ravi et al., 2011); issues related to climate change (Field et al., 2011) as well as land use change (Ravi et al., 2011); the relative roles of background conditions with gusts vs. windy periods vs. dust storms; consideration of longer term processes and environmental disturbances (Breshears et al., 2012); and the need to link studies of dust and contaminant emission and transport processes more directly to epidemiology studies, including more integration with the medical community to evaluate causality of emissions. The papers in this issue reveal the value of interdisciplinary collaboration and integration spanning from source terms to human health and ecological consequences. Collectively, these papers serve as an important baseline for further advancing aeolian research in the context of airborne mineral dust contaminants, which is likely to become an increasingly important issue under pressures of future population growth, urbanization, land use change and climate change.

Acknowledgements

In addition to support by National Institute of Environmental Health Sciences (NIEHS) Superfund Research Program Grant 2 P42 ES04940, the conference was co-sponsored by the Water Sustainability Program, the Lowell Institute for Mineral Resources, the Institute of the Environment, and the Renewable Energy Network, all at University of Arizona. Conference planning committee members included E. Betterton, R. Maier, C. Lantz, E. Sáez, D. Breshears, J. Field, W. Sprigg, K. Nuñez, R. Estrella, and Sarah Wilkinson. DDB was also supported by UA-UNAM. We thank Jeff Lee and Ted Zobeck for handling papers for which the guest editors had a conflict of interest.

References

- Belnap J, Walker BJ, Munson SM, Gill RA. Mineral dust contaminants controls on sediment production in two U.S. deserts. *Aeolian Res.* 2014; 14:15–24.
- Breshears DD, Kirchner TB, Whicker JJ, Field JP, Allen CD. Modeling aeolian transport in response to succession, disturbance and future climate: dynamic long-term risk assessment for contaminant redistribution. *Aeolian Res.* 2012; 3:445–457.
- Csavina J, Field J, Taylor MP, Gao S, Landázuri A, Betterton EA, Sáez AE. A review on the importance of metals and metalloids in atmospheric dust and aerosol from mining operations. *Sci. Total Environ.* 2012; 433:58–73. [PubMed: 22766428]
- Field JP, Belnap Jayne, Breshears David D, Neff Jason C, Okin Gregory S, Whicker Jeffrey J, Painter Thomas H, Ravi Sujith, Reheis Marith C, Reynolds Richard L. *Front. Ecol. Environ.* 2010; 8:423–430.
- Field JP, Breshears DD, Whicker JJ, Zou CB. On the ratio of wind- to water-driven sediment transport: conserving soil under global-change-type extreme events. *J. Soil Water Conserv.* 2011; 66:51A–55A.
- Judger D, Shinoda M, Kimura R, Batbold A, Amarjargal D. Quantitative analysis on windblown dust concentrations of PM₁₀ (PM_{2.5}) during dust events in Mongolia Dulam. *Aeolian Res.* 2014; 14:3–13.
- Kim CS, Anthony TL, Goldstein D, Rytuba JJ. Windborne transport and surface enrichment of arsenic in semi-arid mining regions: examples from the Mojave Desert, California. *Aeolian Res.* 2014; 14:85–96.
- Merino-Martín L, Field JP, Villegas JC, Whicker JJ, Breshears DD, Law DJ, Urgeghe AM. Aeolian sediment and dust fluxes during predominant “background” wind conditions for unburned and burned semiarid grassland: Interplay between particle size and temporal scale. *Aeolian Res.* 2014; 14:97–103.
- Ravi S, D’Odorico P, Breshears DD, Field JP, Goudie AS, Huxman TE, Li J, Okin GS, Swap RJ, Thomas AD, Van Pelt S, Whicker JJ, Zobeck TM. Aeolian processes and the biosphere. *Rev. Geophys.* 2011; 49:RG3001.

- Sprigg WA, Nickovic S, Galgiani JN, Pejanovic G, Petkovic S, Vujadinovic M, Vukovic A, Dacic M, DiBiase S, Prasad A, El-Askary H. Regional dust storm modeling for health services: the case of valley fever. *Aeolian Res.* 2014; 14:53–73.
- Stovern M, Felix O, Csavina J, Rine KP, Russell MR, Jones RM, King M, Betterton EA, Saez AE. Simulation of windblown dust transport from a mine tailings impoundment using a computational fluid dynamics model. *Aeolian Res.* 2014; 14:75–83.
- Taylor MP, Davies PJ, Kristensen LJ, Csavina JL. Licensed to pollute but not to poison: the ineffectiveness of regulatory authorities at protecting public health from atmospheric arsenic, lead and other contaminants resulting from mining and smelting operations. *Aeolian Res.* 2014; 14:35–52.
- Whicker JJ, Pinder JE III, Breshears DD, Eberhart CF. From dust to dose: effects of forest disturbance on increased inhalation exposure. *Sci. Total Environ.* 2006; 368:519–530. [PubMed: 16618498]
- Whicker JJ, Breshears DD, Field JP. Progress on relationships between horizontal and vertical dust flux: mathematical, empirical and risk-based perspectives. *Aeolian Res.* 2014; 14:105–111.
- Xiao Z, Shao L, Zhang N, Wang J, Chuang H, Deng Z, Wang Z, BeruBe K. A toxicological study of inhalable particulates in an industrial region of Lanzhou City, northwestern China: results from plasmid scission assay. *Aeolian Res.* 2014; 14:25–34.

Fig. 1.

Natural and anthropogenic sources of dust associated with potential emission rates, contaminant concentration, and risk to human health and the environment (modified from Csavina et al., 2012). Papers in this special issue are related to airborne mineral dust contaminants and span a diverse range of systems that includes most major natural and anthropogenic sources of dust.