

International symposium on aerosol studies explored by electron microscopy: How can electron microscopy improve atmospheric models?

Foreword

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The Meteorological Research Institute (MRI) of the Japan Meteorological Agency held an international symposium regarding the use of electron microscopy in aerosol studies and atmospheric simulation models on 16 and 17 February 2012. To our knowledge, this was the first symposium of its kind anywhere in the world. The purpose of the symposium was to discuss (1) current atmospheric aerosol research making use of electron microscopy and (2) the use of the results of such studies in aerosol model simulations. Two keynote speakers and 18 invited speakers addressed the symposium, and there were 16 poster presentations. In total, we had close to 80 participants, who engaged in two days of intense discussion. The papers in this MRI technical report present the contents of the keynote lectures, the invited presentations, posters, and discussions.

Keywords: Electron microscopy, Aerosol, Observation, Atmospheric model

Background and scope

The primary motivation of this international symposium was the first replace of a transmission electron microscope (TEM) at the Meteorological Research Institute (MRI) in the 30 years since the MRI relocated from Tokyo to its present location in Tsukuba. This new TEM makes available state-of-the-art TEM technologies, such as automated analysis of the aerosols with energy dispersive X-rays and 3-D tomography.

Recent research trends in atmospheric aerosol sciences include the rapid development of computer models for projecting air quality, weather forecasting, and climate research. It is essential to incorporate into these models aerosol physics and chemistry. With these trends in mind, we, the aerosol researchers at the MRI, recognized that electron microscopy should play a crucial role in atmospheric aerosol research. For electron microscopy to fulfill this role, however, improved communication between electron microscopists and aerosol modelers is key.

Another motivation was to recognize the 30-year history of research on aerosols conducted at the MRI making use of TEM and scanning electron microscopy (SEM). This re-

search was led by the former section head of our laboratory, Dr. Kikuo Okada, who has carried out pioneering aerosol research since the 1980s, when atmospheric aerosol morphology and mixing states were largely unknown. Electron microscopy is a set of versatile technologies that can be used to investigate the morphology and mixing state (elemental composition) of individual aerosol particles. To clarify the climatic and meteorological impacts of aerosols and related processes, Dr. Okada used electron microscopy to examine sea salt, mineral dust (Asian dust), soot, sulfate, nitrate, and mixtures of these. His research targets included samples retrieved from the poles to the tropics, and from the boundary layer to the stratosphere, and his work has contributed greatly to our understanding of the basic roles of atmospheric aerosols in climate and meteorology (see Dr. Okada's paper in this volume).

Therefore, we decided to organize an international symposium to review the research traditions at the MRI and the cutting-edge research that has been carried out there, to set forth current knowledge and state-of-the-art technologies, and finally to promote the integration of observational, experimental, and model studies by encouraging mutual un-

derstanding among researchers.

Keynote speakers

Two distinguished keynote speakers addressed the symposium: Prof. Peter R. Buseck, Arizona State University (ASU), U.S.A., and Dr. Weijun Li, Shandong University, China. Prof. Buseck is a well-known electron microscopist whose scientific endeavors cover vast areas of geology, mineralogy, crystallography, electron microscopy, and atmospheric aerosols. Dr. Li is a promising young Chinese scientist who has used electron microscopy to conduct aerosol research at ASU under the supervision of Prof. Buseck.

The audience listened with rapt attention to Prof. Buseck's outstanding and technically sophisticated lecture on the use of electron microscopy in aerosol research. Dr. Li focused on recent TEM investigations of haze, an important air quality problem in China. His electron micrographs of aggregates of fly ash spherules were particularly impressive.

Invited speakers

The invited speakers included Dr. Kikuo Okada, formerly of the MRI (and currently a guest researcher there) and Prof. Yasunobu Iwasaka, Kanazawa University. These two leading Japanese scientists presented thought-provoking reviews in which they shared their great expertise and long research experience in the field of atmospheric and aerosol sciences.

Dr. Kouji Adachi (MRI), Dr. Yuji Fujitani (National Institute for Environmental Studies), Prof. Masahiko Hayashi (Fukuoka University), Dr. Tomoko Kojima (Kumamoto University), and Dr. Masahi Nojima (Tokyo University of Science) spoke on state-of-the-art electron microscopy techniques: 3-D tomography (Dr. Adachi), focused ion beam secondary ion mass spectrometry (FIB-SIMS) (Dr. Fujitani), environmental scanning electron microscope (ESEM) (Prof. Hayashi), 2-D elemental mapping by scanning transmission electron microscopy (STEM) (Dr. Kojima), and secondary ion mass spectrometry (SIMS) (Dr. Nojima).

Prof. Daizhuo Zhang (Prefectural University of Kumamoto), Dr. Keiichiro Hara (Fukuoka University), Prof. Kazuhiko Miura (Tokyo University of Science), and Dr. Atsushi Matsuki (Kanazawa University) described aerosol observations conducted in western Japan (Prof. Zhang), the Antarctic (Dr. Hara), the Pacific and Mt. Fuji (Prof. Miura), and the Arctic (Dr. Matsuki).

Dr. Hikari Shimadera (Central Research Institute of the Electric Power Industry), Dr. Daisuke Goto (University of Tokyo), and Drs. Naga Oshima and Hiroshi Ishimoto (MRI) described recent simulation experiments with different kinds of models: a regional chemical transport model (Dr. Shimadera), a global chemical transport model (Dr. Goto), a microphysics model (Dr. Oshima), and a shape model (Dr.

Ishimoto).

In addition, the novel features of the new TEM system installed at the MRI were briefly presented by representatives of the manufacturers (Ms. Chizu Mitsui, Oxford Instruments, and Mr. Hiromitsu Furukawa, System in Frontier Inc.).

Poster presentations

In the poster sessions, a total of 16 posters were presented, covering topics such as aerosol observations, including morphology, composition, and optical properties; state-of-the-art technologies; and novel approaches to aerosol modeling, and their mixtures.

Discussion session

During the discussion session, Dr. Igarashi, Prof. Buseck, Dr. Oshima and Dr. Matsuki presented comments and suggestions. All of them emphasized the urgent need to build bridges between microscopists and modelers to further advance our understanding of atmospheric aerosols and improve atmospheric models. Endeavors such as this symposium were concluded to be necessary to promote active collaboration among scientists.

Acknowledgments

On behalf of the local organizing committee of the international symposium, I would like to express my sincere gratitude to all speakers and participants. I also hope that this MRI technical report volume will inspire and inform its readers. Thanks are also extended to the Environment Research and Technology Development Fund "Assessment of the Effects of Reductions of Black Carbon Aerosols as a Measure of Slowing down Global Warming" (Fund #A-1101; PI: Prof. Yutaka Kondo, Univ. of Tokyo), whose support made the invitation of the keynote speakers possible.

Finally, I would like to add my thanks to our laboratory staff for their support in organizing the present symposium. Ms. K. Yanagida helped the editing this volume to which my thanks are also due.

Table 1: Final agenda of the International Symposium on Aerosol Studies Explored by Electron Microscopy

Thursday, 16 February 2012			
Opening (welcoming remarks, purpose of the workshop)	Y. Igarashi (MRI)	pheric aerosols from viewpoint of environmental effects	(Kanazawa U.)
Keynote lectures		Modification of individual sea salt particles	K. Miura (Tokyo U. of Sci.)
Individual aerosol particles in hazes of North China	W. J. Li (Shandong U.)	Single particle analysis of aerosols and cloud residues in the Arctic troposphere	A. Matsuki (Kanazawa U.)
Identification and Analysis of Atmospheric Aerosol Particles (& Climate Implications)	P. R. Buseck (Arizona State U.)	The latest application software for electron tomography	H. Furukawa (JEOL)
Invited oral presentations		Posters	
Welcome speech by the Director General	Y. Kano (MRI)	Determination of the aerosol direct effect over the East China Sea using ground-based remote sensing and aircraft observation data	P. Khatri (Chiba U.)
Studies of aerosol particles performed with the MRI electron microscopes during the last three decades	K. Okada (MRI)	Particle effective density measurement using a DMA-APM- CPC system in Nagoya, Japan: Estimation of mixing state and shape	T. Nakayama (Nagoya U.)
Modification of dust particles by sea salt adherence and surface chemical reactions in the marine atmosphere	D. Zhang (Pref. U. of Kumamoto)	Measurements of light absorption enhancement of black carbon using a photoacoustic spectrometer in Nagoya, Japan	T. Nakayama (Nagoya U.)
Aerosol particle shape revealed by transmission electron microscopy and the implications for its optical properties	K. Adachi (MRI)	Some measurements of mixing state of soot-containing particles at urban and non-urban sites	S. Hasegawa (Center for Environ. Sci. in Saitama)
Internal mixtures of diesel nanoparticles investigated by FIB-SIMS microscopy	Y. Fujitani (NIES)	Changes in chemical compositions of sea-salt particles collected at Mt. Rokko, Kobe, Japan	S. Mukai (Kobe U.)
Modeling atmospheric transport of fine particulate matter with WRF/CMAQ in the Kan-to region in summer 2007	H. Shimadera (CRIEPI)	Laser post-ionization mass spectrometry of PAHs on diesel soot particles	K. Ohishi (Kogakuin U.)
Treatment of black carbon by a global climate model and the potential contribution of electron microscopy	D. Goto (U. of Tokyo)	Analysis of black carbon particles by high-resolution TOF-SIMS	N. Mayama (Tokyo Inst. Tech./Kogakuin U.)
Aerosol particle analysis with INCAFeature TEM	C. Mitsui (Oxford Instruments)	Analysis of source apportionment and chemical transformation of particles in trans-boundary air pollution using high lateral resolution imaging SIMS	T. Sakamoto (Kogakuin U.)
Friday, 17 February 2012		Mixing state of atmospheric black carbon particles and its effect on light absorption	H. Naoe (MRI)
Invited oral presentations		Fine mineral aerosols collected in Japan during two Asian dust events: Size distributions and mixing properties	Y. Zaizen (MRI)
Observation of fine ice crystals on ice nucleus at -70 °C using ESEM	M. Hayashi (Fukuoka U.)	Aerosol-related services of the Japan Meteorological Agency	H. Shiozuru (JMA)
Vertical distributions of aerosol constituents and their mixing states in Antarctic troposphere during the summer	K. Hara (Fukuoka U.)	Climatic effect of black carbon in the MRI global climate model	Y. T. Tanaka (MRI)
Aerosol isotope analysis by secondary ion mass spectrometry	M. Nojima (Tokyo U. of Sci.)	Model formulation and predictability of atmospheric aerosol properties and processes	M. Kajino (MRI)
Two-dimensional elemental mapping using a scanning transmission electron microscope	T. Kojima (Kumamoto U.)	Transmission electron microscope for atmospheric aerosol analysis	JEOL
Aging of black carbon and its impact on aerosol optical properties and cloud condensation nuclei activities using a mixing state resolved model	N. Oshima (MRI)	The latest application software for electron tomography	JEOL
Formation and variations of aerosols around Beijing using the WRF-chem model	H. Matsui (U. of Tokyo)	Particle analysis of aerosol with INCA Feature TEM	Oxford Instruments
Shape modeling of dust and soot particles for remote sensing applications by considering the geometrical features of sampled aerosols	H. Ishimoto (MRI)		
Importance of structural diversity in atmos-	Y. Iwasaka		