center for aerosol science and engineering

Washington University in St. Louis
School of Engineering & Applied Science

The Center for Aerosol Science & Engineering (CASE) at Washington University in St. Louis is focused on the **advancement of science and technology of aerosol systems**. CASE works to characterize fundamental aerosol formation and transformation processes to determine impacts on the environment, climate, and human health; and to utilize these processes to develop new materials to enable energy, environmental & medical technologies. The center is composed of a collaborative group of faculty, students, and affiliates within the department of EECE and across the university, as well as partners in universities and corporations across the globe. CASE activities include extensive collaborative research with shared instrumentation facilities, education through coordinated coursework and workshops, seminars and discussion groups, and social networking events.

Core faculty

Richard Axelbaum

The Stifel & Quinette Jens Professor of Environmental Engineering Science

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PhD, 1988, University of California

Nanoparticle Synthesis, Combustion Aerosols; Clean Energy; LACER Lab

Pratim Biswas

The Lucy & Stanley Lopata Professor

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PhD, 1985, California Institute of Technology

Chair, Combustion Aerosols, Air Quality and Pollution Control, Nanotechnology, Environmentally Benign Energy Production; AAQRL Lab

Rajan Chakrabarty

Assistant Professor

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PhD, 2008, University of Nevada-Reno

Energy, Atmospheric aerosols and radiative forcing; aerosol formation and engineering; AIR Lab

Rudolf Husar

Professor (retired)

rhusar@wustl.edu

PhD, 1970, University of Minnesota

Center for Air Pollution and Trends Analysis Information Systems for Air Quality Management; CAPITA Lab

Elijah Thimsen

Assistant Professor

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PhD, 2009, Washington University in St. Louis

Energy, Advanced gas-phase synthesis of nanomaterials for energy applications; Interface Research Group Lab

Jay R. Turner

Associate Professor

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DSc, 1993, Washington University in St. Louis

Air Quality Management, Air Pollution Characterization & Control; The Jay Turner Lab

Brent Williams

Raymond Tucker Career Development Associate Professor

brentw@wustl.edu

PhD, 2008, University of California, Berkeley

Composition and Chemistry of the Atmosphere, Biogenic and Anthropogenic Gases and Particles; ACT Lab

AFFILIATED FACULTY

Su Huang (EECE)

Benjamin Kumfer (EECE)

Tianxiang Li (EECE)

Grigoriy Yablonsky (EECE)

RESEARCH FACULTY

Samuel Achilefu (School of Medicine)

Raymond Arvidson (Earth & Planetary Sciences)

Hilary Babcock (School of Medicine)

John Fortner (EECE)

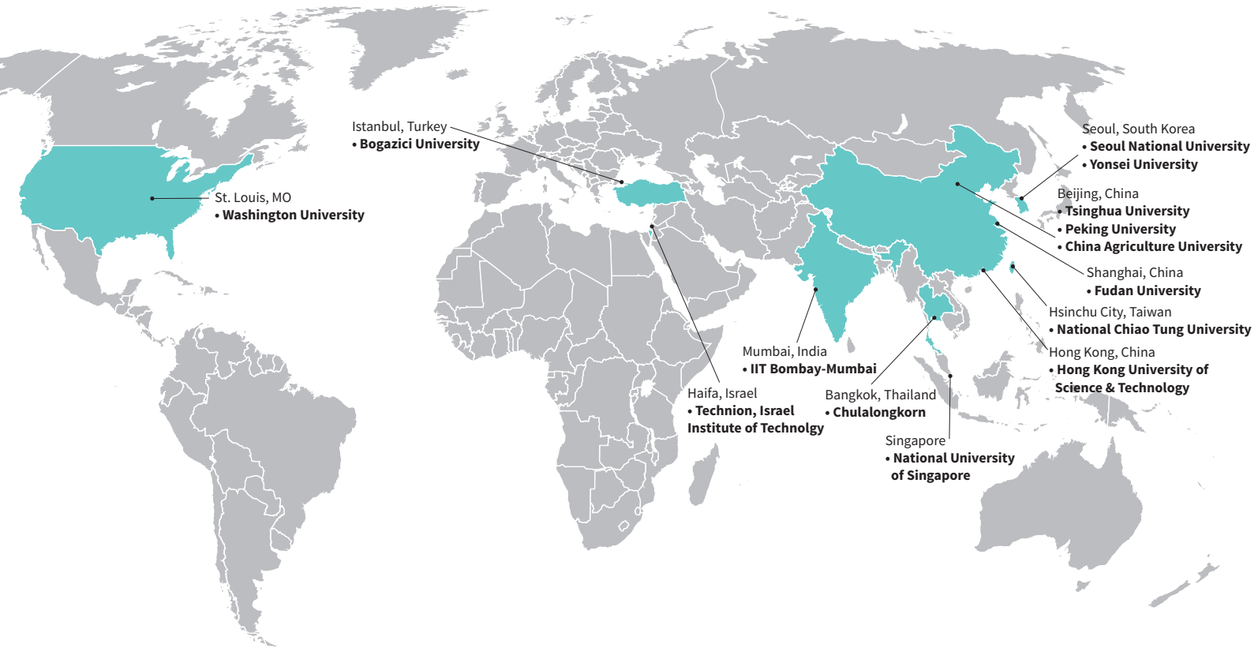
Young-Shin Jun (EECE)

Vijay Ramani (EECE)

Srikanth Singamaneni (Mechanical Engineering & Materials Science)

Lan Yang (Electrical & Systems Engineering)

CASE partner universities



MAGEEP AEROSOL NETWORK

- National University of Singapore — B. Rajasekhar, J. Yu
- Chulalongkorn University — A. Suriyawong
- Seoul National University — M. Choi
- Yonsei University — T.G. Lee, J. Jeong
- Tsinghua University — J. Hao, J. Jiang, Y. Wu, S. Wang. S. Li, Q. Yao
- Peking University — M. Hu
- China Agricultural University — R. Dong, Y. Zhou
- Fudan University — Y. Zhang, J. Chen
- Hong Kong University of Science and Technology — I. Lo
- IIT Bombay — C. Venkataman, V. Sethi
- Technion — G. Grader, M. Shapiro
- Bogazici — O. Yenigun
- National Chiao Tung University — H. Bai, C.J. Tsai

HIGHLIGHTS

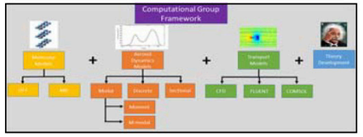
- Editor-in-Chief, *J Aerosol Science* (Pratim Biswas)
- USEPA Science Advisory Board Member (Jay R. Turner)
- Past Presidents of AAAR (Pratim Biswas, 2006-07 and Jay R. Turner 2013-14)
- International Aerosol Research Assembly Vice President, President Elect (Pratim Biswas)
- Working Group and Tutorial Chairs of AAAR (Rajan Chakrabarty, Brent Williams and Pratim Biswas)
- Host of 10th International Aerosol Conference, St. Louis, September 2-7, 2018
- Alumni as leading faculty members and corporate leaders

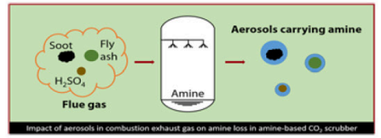
SELECTED METRICS (2016)

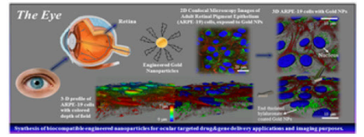
- Total Research Expenditures in 2016 = $ 4M
- Refereed Journal PublicaTIons in 2016 = 55
- Current PhD Students Advised = 35
- Average H – Index = 22
- Funding Agencies: NSF, USEPA, USDOE, NASA, NIH and industry

State-of-the-art aerosol research laboratories

Aerosol and Air Quality Research Lab (AAQRL) (aerosols.eece.wustl.edu)

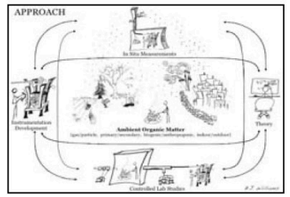


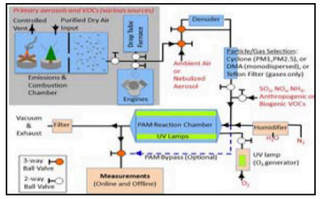




The Aerosol and Air Quality Research Laboratory (AAQRL) focus is on research and education related to particulates in gaseous suspension, known as aerosols. AAQRL's contributions to this field span the full process of technology development, from synthesis and characterization to eventual application. Through this research, we aim to mitigate the negative impacts of aerosols on the environment and leverage their potential as nanoparticles for application in energy, environment, medicine and agriculture.

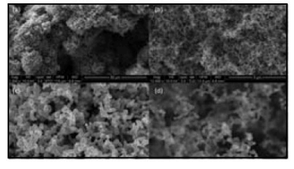
Atmospheric Chemistry and Technology Lab (ACT) (actlab.seas.wustl.edu)

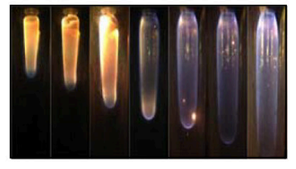




Through novel laboratory and field measurements, ACT works to determine the sources, composition, transformation, and fate of atmospheric biogenic and anthropogenic organic gases and particles, which are detrimental to human health, affect the hydrological cycle, and affect the Earth's energy balance.

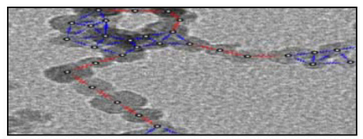
Aerosol Impacts & Research Lab (AIR) (air.eece.wustl.edu)

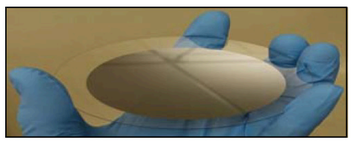




Investigating the role of atmospheric aerosols in earth's energy balance using novel instrumentation and diagnostic techniques, and numerical models; and understanding aerosol formation in combustion systems toward synthesis of high porosity and surface-area materials for energy applications.

Interface Research Group (sites.wustl.edu/irg1)

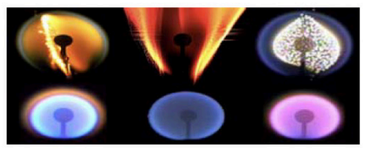
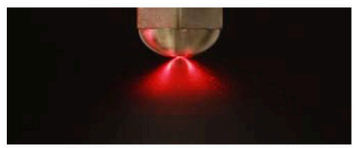




Interface Research Group studies systems in which interfaces play a central role. Specifically, focus is on thin films and nanostructured materials.

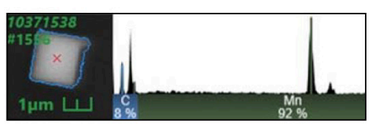
State-of-the-art aerosol research laboratories

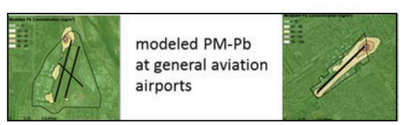
Laboratory for Advanced Combustion & Energy Research (LACER) (wulacer.com)

LACER develops approaches to synthesize advanced materials for electrical vehicles, conducts fundamental studies of combustion, studies combustion of renewable fuels, and develops novel approaches to reduce emissions from power plants. LACER has advanced large scale facilities for combustion research.

The Jay Turner Lab (users.seas.wustl.edu/jrturner)





The Jay Turner Lab focuses on air quality characterization with emphasis on field measurements and data analysis to support a variety of applications in the atmospheric science, regulation and policy, and health studies arenas. One thrust, with projects in both the United States and abroad, is research to inform air quality planning and management.

Affiliated centers

McDonnell Academy Global Energy and Environment Partnership (MAGEEP)
mageep.wustl.edu

Consortium for Clean Coal Utilization (CCCU)
cccu.wustl.edu

Solar Energy and Energy Storage (SEES)
solarstorage.wustl.edu

International Center for Energy and Sustainability (InCEES)
incees.wustl.edu

National & International Organizations

American Association for Aerosol Research

International Aerosol Research Assembly

European Aerosol Assembly (EAA)

CASE Student Chapter

The CASE Student Chapter works to support our parent center and coordinate its student focused activities. Our membership includes over 35 graduate students in energy, environment, materials, health and other areas of applied research. Our foremost goal is to help advance the research, educational and professional goals for aerosol science students at WashU. To that end, we organize technical workshops and lectures to help students develop skills in practical or advanced topics not necessarily taught in a classroom. We also hold monthly happy hours where faculty members discuss topics ranging from their professional journeys to the history of aerosol science to recent events related to aerosols and related fields. Occasionally, WashU hosts seminars or workshops by leading aerosol scientists from across the world; the CASE student chapter facilitates informal meetings between the visitors and students interested in their research. Another goal of our organization is to increase the capabilities and presence of aerosol research at WashU, in affiliation with other graduate student bodies on WashU as well as with nationally recognized organizations in the field of aerosol science. We serve as the WashU chapter for the American Association of Aerosol Research (AAAR), and are working to use AAAR conferences as a platform for encouraging more connectivity with our alumni.

CURRENT PHD STUDENTS

Ahmed Abokifa
Adewale Adeosun
Jiung-Wen Chen
Audrey Dang
Sukrant Dhawan
Claire Fortenberry
Akshay Gopan
Kelsey Haddad
Phillip Johnson
Sungyoon Jung
Clayton Kacica
Bedia Karakocak
Shalinee Kavadiya
Dishant Khatri
Jiayu Li
Zhichao Li
Pai Liu
Jose Madero Munoz
Yao Nie
Christopher Oxford
Apoorva Pandey
Pradeep Sivaprabha Prathibha
Nathan Reed
Girish Sharma
Kuan-Yu Shen
Nishit Jaideep Shetty
Benjamin Sumlin
Yuanzi Sun
Che Tan
Necip Uner
Piyush Kumar Verma
Michael Walker
Yang Wang

POST DOCTORAL STUDENTS

William Heinson
Yuli Heinson
David Stokie
Zhiwei Yang

RESEARCH AND VISITING SCIENTISTS

Ray Ehrhard
Yanjie Hu
Ramesh Raliya
Xuebin Wang
Liang-Yi Yin

2016 publications

Xia, F., Yang, Z., Adeosun, A., Gopan, A., **Kumfer**, B. M., & **Axelbaum**, R.L. "Pressurized oxy-combustion with low flue gas recycle: Computational fluid dynamic simulations of radiant boilers." *Fuel*, 181, 1170-1178, 2016.

Wu, W., **Yablonsky**, G. & **Axelbaum**, R. L., "Observation of water-gas shift equilibrium in diffusion flames." Combustion and Flame*, 173*, 57-64, 2016.

Wang, X., Jing, H., Dhungel, B., Wang, W. N., **Kumfer**, B. M., **Axelbaum**, R. L. and **Biswas**, P. "Characterization of organic and black carbon aerosol formation during coal combustion: An experimental study in a 1MW pilot scale coal combustor." *Fuel*, 180, 653-658, 2016.

Greenberg, J.B., Mindelis, Y. and **Axelbaum**, R.L., "A simple model of a water/fuel spray diffusion flame." *Fuel*, 181, 547–556, 2016

Lengyel, M., Shen, K-Y., Lanigan, D., Martin, J., Zheng, X. and **Axelbaum**, R.L., "Trace level doping of Lithium-rich cathode materials." *Journal of Materials Chemistry A*, 4, 3538-3545, 2016.

Li, S., Mathews, J., Bhattacharya, S., Kneer, R., Gupta, R., Johnsson, F. and **Axelbaum**, R.L., "The 8th International Symposium on Coal Combustion (ISCC-8)." (Eds.), *Fuel*, 184,1-1008, 2016

Xia, F., Yang, Z., Adeosun, A., **Kumfer**, B.M. and **Axelbaum**, R.L. "Control of radiative heat transfer in high-temperature environments via radiative trapping—Part I: Theoretical analysis applied to pressurized oxy-combustion." *Fuel*, 172(15), 81-88, 2016.

Axelbaum, R.L., **Kumfer**, B., and Wang, X., "Advances in pressurized oxy-combustion for carbon capture." *Cornerstone 4*(2), 52-56, 2016

Wang, Y., Kangasluoma, J., Attoui, M., Fang, J., Junninen, H., Kulmala, M., Petäjä, T., and **Biswas**, P., "Observation of incipient particle formation during flame synthesis by tandem differential mobility analysis-mass spectrometry dma-s)." *Proceedings of the Combustion Institute*, http://dx.doi.org/10.1016/j.proci.2016.07.005, 2016.

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Saharan, V., Kumaraswamy, R., Choudhary, R.C., Kumari, S., Pal, A., Raliya, R. and **Biswas**, P., "Cu-chitosan nanoparticle mediated sustainable approach to enhance seedling growth in maize by mobilizing reserved food." *Journal of Agricultural and Food Chemistry*, 64, 6148-6155, 2016.

Raliya**,** R., Tarafdar, J.C. and **Biswas**, P., "Enhancing the mobilization of native phosphorus in the mung bean rhizosphere using no nanoparticles synthesized by soil fungi." *Journal of Agricultural and Food Chemistry*, 64, 3111-3118, 2016.

Raliya**,** R., Som, A., Shetty, N., Reed, N., Achilefu, S., and **Biswas**, P., "Nano-antacids enhance pH neutralization beyond their bulk counterparts: Synthesis and characterization." *RSC Advances*, 6, 54331-54335, 2016.

Raliya**,** R., Chadha, T. Singh, Haddad, K., and **Biswas**, P., "Perspective on nanoparticle technology for biomedical use." *Current Pharmaceutical Design*, 22, 2481-2490, 2016.

Raliya**,** R., Franke, C., Chavalmane, S., Nair, R., Reed, N., and **Biswas**, P., "Quantitative understanding of nanoparticle uptake in watermelon plants." *Frontiers in Plant Science*, 7, 1288, doi: 10.3389/fpls.2016.01288, 2016.

Patel, S., Leavey, A., He, S., Fang, J., O'Malley, K., and **Biswas**, P., "Characterization of gaseous and particulate pollutants from gasification-based improved cookstoves." *Energy for Sustainable Development*, 32, 130-139, 2016.

Patel, S., Khandelwal, A., Leavey, A., and P. **Biswas**. "A model for cost-benefit analysis of cooking fuel alternatives from a rural Indian household perspective." *Renewable and Sustainable Energy Reviews*, 56, 291-302, 2016.

Nie, Y., Wang, W.N., Jiang, Y., **Fortner**, J. and **Biswas**, P., "Crumpled reduced graphene oxide–amine–titanium dioxide nanocomposites for simultaneous carbon dioxide adsorption and photoreduction." *Catalysis Science & Technology*, 6, 6187-6196, 2016.

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Li, Z., Jing, H., and **Biswas**, P., "Capture of submicrometer particles in a pressurized electrostatic precipitator." *Aerosol Science and Technology*, 50, 1115-1129, 2016.

Li, S., Ren, Y., **Biswas**, P. and Stephen, D.T., "Flame aerosol synthesis of nanostructured materials and functional devices: Processing, modeling, and diagnostics." *Progress in Energy and Combustion Science*, 55, 1-59, 2016.

Lee, M.H., Kim, J.H., **Biswas**, P., Kim, S.S., Suh, Y.J., Jang, H.D., Bhang, S.H., Yu, T., Kim, J.H., and Cho, K., "Enhancedcollection efficiency of nanoparticles by electrostatic precipitator with needle-cylinder configuration." *Journal of Nanoscience and Nanotechnology*, 16, 6884-6888, 2016.

Kavadiya, S., Chadha, T. S., Liu, H., Shah, V.B, Blankenship, R.E. and **Biswas**, P., "Directed assembly of the thylakoid membrane on nanostructured TiO_2 for a photo-electrochemical cell." *Nanoscale*, 8, 1868-1872, 2016.

Karakoçak, B.B., Raliya, R., Davis, J.T., Chavalmane, S., Wang, W.N., Ravi, N. and **Biswas**, P., "Biocompatibility of gold nanoparticles in retinal pigment epithelial cell line." *Toxicology in Vitro*, 37, 61-69, 2016.

Jiang, Y., Raliya, R., **Fortner**, J. and **Biswas**, P., "Graphene oxides in water: Correlating morphology and surface chemistry with aggregation behavior." *Environmental Science & Technology*, 50, 6964-6973, 2016.Jiang, Y., Liu, D., Cho, M., Lee, S.S., **Zhang**, F., **Biswas**, P., and **Fortner**, J., "In situ photocatalytic synthesis of ag nanoparticles (nAg) by crumpled graphene oxide composite membranes for filtration and disinfection applications." *Environmental Science & Technology*, 50, 2514 2521, 2016.

Jiang, Y., **Biswas**, P., and **Fortner**, J., "A review of recent developments in graphene-enabled membranes for water treatment." E*nvironmental Science: Water Research & Technology*, 2, 915-922, 2016.

Jiang, Q., Tian, L., Liu, K.K., Tadepalli, S., Raliya, R, **Biswas**, P., Naik, R.R. and Singamaneni, S., "Bilayered biofoam for highly efficient solar steam generation." *Advanced Materials*, 28, 9400-9407, 2016.

Haddad, K., Abokifa, A., Kavadiya, S., Chadha, T., Shetty, P., Wang, Y., **Fortner**, J. and **Biswas**, P., "Growth of single crystal, oriented SnO_2 nanocolumn arrays by aerosol chemical vapour deposition." *CrystEngComm*, 18, 7544-7553, 2016.

Abokifa, A. A., Yang, Y.J., Lo, C.S. and **Biswas**, P., "Investigating the role of biofilms in trihalomethane formation in water distribution systems with a multicomponent model." *Water Research*, 104, 208-219, 2016.

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Huang, X., Huang, S., **Biswas**, P. and Mishra, R., "Band Gap Insensitivity to Large Chemical Pressures in Ternary Bismuth Iodides for Photovoltaic Applications" *Journal of Physical Chemistry C,* 120 (51), pp 28924–28932, 2016

2016 publications *continued*

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Bisht, D. S., Tiwari, S., Dumka, U.C., Srivastava, A.K., Safai, P.D., Ghude, S.D., Chate, D.M., Rao, P.S.P, Ali, K., Prabhakaran, T., Panickar, A.S., Soni, V.K., Attri, S.D., Tunved, P., **Chakrabarty**, R.K., Hopke , P.K., "Tethered balloon-born and ground-based measurements of black carbon and particulate profiles within the lower troposphere during the foggy period in Delhi, India." *Sci. Tot. Env.* 573, 894-905, 2016

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Dewangan, S., Pervez, S., **Chakrabarty**, R.K., Watson, J. G, Chow, J.C., Pervez, Y., Tiwari, S., and Rai, J., "Study of carbonaceous fractions associated with indoor $PM_{2.5}$/PM_{10} during Asian cultural and ritual burning practices." *Building and Environment*, 106, 229-236, 2016

Chakrabarty, R. K., Gyawali, M., Yatavelli, R.L.N., Pandey, A., Watts, A.C., Knue, J., Chen, L.W.A., Pattison, R.R., Tsibart, A., Samburova, V. and Moosmüller, H. "Brown carbon aerosols from burning of boreal peatlands: microphysical properties, emission factors, and implications for direct radiative forcing." *Atmos. Chem. Phys.*, 16 (5), 3033-3040, 2016

Heinson, W. R**.** and **Chakrabarty,** R.K., "Fractal morphology of black carbon aerosol enhances absorption in the thermal infrared Wavelengths." *Opt. Lett.*, 41 (4), 808-811, 2016

Liu, P**.** and **Chakrabarty,** R.K., "Sensitivity analysis of aggregate morphology on mass-mobility relationship and improved parameterizations." A*erosol Sci. Tech.*, 50 (1), 63-70, 2016

Pervez, S., **Chakrabarty**, R.K., Dewangan, S., Watson, J.G., Chow, J.C. and Matawale, J.L., "Chemical speciation of aerosols and air quality degration during the festival of lights (Diwali)." *Atmos. Poll. Res.* 7 (1), 92-99, 2016

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CASE alumni

Christopher Hogan, PhD

Benjamin Mayhugh Associate Professor and McKnight Land-Grant Professor, University of Minnesota College of Science & Engineering

Hogan's lab at Minnesota focuses on the fundamentals of the physics and chemistry of very small particles in the gas phase, called aerosol nanoparticles. While application is secondary to his research, potential applications include new particle formation in the atmosphere, combustion emissions or materials synthesis in high temperature reactors.

While a doctoral student at Washington University, Pratim Biswas was Hogan's adviser, but he also worked with Michael Gross, professor of chemistry. He credits both of them with influencing him to go into academic research. Hogan had 22 refereed journal publications from his PhD work at CASE in Washington University in St Louis.

Melissa Holtmeyer, PhD

AAAS Science and Technology Policy Fellow, U.S. Department of Defense

Melissa Holtmeyer has helped shape the direction of national science and technology policy through her opportunities as an American Association for the Advancement of Science (AAAS) Science and Technology policy fellow in both the U.S. Senate and the U.S. Department of Defense, where she is currently performing the duties of the deputy director for Energy Security in the Office of the Secretary of Defense.

Using her engineering background, she advised senators and congressional staffers on energy, environment and climate change legislation. At the DoD, she is helping to develop plans to reduce military fuel use, ensure secure fuel supplies for global operations and provide technical expertise on next-generation DoD technologies to military leaders.

While her background in fundamental combustion has been drawn upon many times, her communication and writing skills, approach to solving problems and ability to understand highly technical topics have been valued assets and respected by high-level leaders. Holtmeyer worked with Professor Axelbaum for her PhD.