

**Shunsuke Nakao**

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**Research Interests**

Atmospheric chemistry, Air quality, Aerosol-cloud-climate interaction

**Education**

Ph.D. in Chemical and Environmental Engineering June 2012  
University of California, Riverside (UCR)  
Dissertation: Chemical and Physical Investigation of Secondary Organic Aerosol Formation  
Advisor: Prof. David R. Cocker III  
B.E. in Applied Chemistry April 2007  
Keio University, Japan

**Professional Experiences**

Clarkson University: Assistant Professor of Chemical and Biomolecular Engineering  
Aug 2014 - Present  
Colorado State University: NSF Atmospheric and Geospace Sciences (AGS) Postdoctoral Fellow  
Aug 2012 – July 2014  
University of California, Riverside: Graduate Research Assistant  
July 2007 – June 2012

**Honors and Awards**

- NSF Atmospheric and Geospace Sciences Postdoctoral Fellowship, 2012 - 2014
- Invited participant in the Atmospheric Chemistry Colloquium for Emerging Senior Scientists (ACCESS) XII, and the Atmospheric Chemistry Gordon Research Conference, 2013
- Global Sustainability Leadership Fellowship, School of Global Environmental Sustainability, Colorado State University, 2013
- Esther F. Hays Graduate Fellowship, 2011
- University of California Transportation Center (UCTC) Graduate Fellowship at UCR, 2008

**Research Grants**

Title: Quantitative investigation of molecular tracers of primary and secondary wood smoke aerosol relevant in wintertime New York  
Agency: NYSERDA Award #:59809  
Time Period: 07/01/2015-06/30/2017 Amount: \$252,190  
Role: PI

Title: Hygroscopicity of Secondary Organic Aerosols Formed via Aqueous Reactions.  
Agency: NSF Award #: AGS-PRF-1230395  
Time Period: 08/01/2012 – 07/31/2014 Amount: \$172,000  
Role: PI

## **Research Advisees**

### Current:

Ph.D.: Vikram Pratap (2014 - present)

M.S.: Aditya Kiran Srikakulapu (2014 - 2016)

Undergraduates: Nathanael Zakreski (Spring 2016 – present), Vincent Li (Fall 2015 – present), Ying Chen (Fall 2015 – present), Rachel Hunsinger (Fall 2016 – present), Trevor Thomas (Fall 2016 – present)

### Alumni:

M.S.: Gautham Anusuya Sekar (2014 - 2016)

Undergraduates: Fabio Mitsuo Fujita (Summer 2015), Mércia Valéria de Araujo Souza Peixoto (Summer 2015)

## **Manuscript Reviewer**

- Atmospheric Chemistry and Physics
- Environmental Science & Technology
- Environmental Chemistry
- Journal of Aerosol Science
- Atmospheric Pollution Research
- Sustainable Environment Research

## **Proposal Reviewer**

- DOE Atmospheric System Research Program (Panelist)
- NSF Division of Atmospheric and Geospace Sciences (Panelist)

## **Professional Societies**

- American Association for Aerosol Research (AAAR), member, 2008 - present
- American Chemical Society (ACS), member, 2011 - present
- American Geophysical Union (AGU), member, 2011 – present
- American Society for Engineering Education (ASEE), member, 2015 - present

## **Peer Reviewed Publications**

25. Li, L., Tang, P., **Nakao, S.**, Cocker, D. R. (2016) Impact of molecular structure on secondary organic aerosol formation from aromatic hydrocarbons photooxidation under low NO<sub>x</sub> conditions, *Atmospheric Chemistry and Physics*, 16, 10793-10808.
24. Clark, C. H. C., Kacarab, M., **Nakao, S.**, Asa-Awuku, A., Sato, K., Cocker III, D. R. (2016) Temperature effects on secondary organic aerosol (SOA) from the dark ozonolysis and photo-oxidation of isoprene, *Environmental Science and Technology*, 50, 5564-5571.
23. Carrico, C. M., Prenni, A. J., Kreidenweis, S. M., Levin, E. J. T., McCluskey, C. S., DeMott, P. J., McMeeking, G. R., **Nakao, S.**, Stockwell, C., Yokelson, R. J. (2016) Rapidly evolving ultra fine and fine mode biomass more physical properties: Comparing laboratory and field results, *Journal of Geophysical Research*, DOI: 10.1002/2015JD024389.
22. Li, L., Tang, P., **Nakao, S.**, Kacarab, M., Cocker III, D. R. (2016) Novel approach for evaluating secondary organic aerosol from aromatic hydrocarbons: Unified method for predicting aerosol composition and formation, *Environmental Science and Technology*, 50, 6249-6256.

21. Levin, E. J. T., McMeeking, G. R., DeMott, P. J., McCluskey, C. S., Carrico, C. M., **Nakao, S.**, Jayarathne, T., Stone, E. A., Stockwell, C. E., Yokelson, R. J., Kreidenweis, S. M. (2016) Ice nucleating particle emissions from biomass combustion and the potential importance of soot aerosol, *Journal of Geophysical Research*, DOI: 10.1002/2016JD024879.
20. Li, L., Tang, P., **Nakao, S.**, Chen, C.-L., Cocker III, D. R. (2016) Role of methyl group number on SOA formation from aromatic hydrocarbons photooxidation under low NO<sub>x</sub> conditions, *Atmospheric Chemistry and Physics*, 16, 2255-2272.
19. Xu, J., Griffin, R. J., Liu, Y., **Nakao, S.**, and Cocker III, D. R. (2015) Simulated impact of NO<sub>x</sub> on SOA formation from oxidation of toluene and m-xylene, *Atmospheric Environment*, 101, 217-225.
18. Jayarathne, T., Stockwell, C., Yokelson, B., **Nakao, S.**, and Stone, E. A. (2014) Emissions of fine particle fluoride from biomass burning, *Environmental Science & Technology*, 48, 12636-12644.
17. McCluskey, C. S., DeMott, P. J., Prenni, A. J., Levin, E. J. T., McMeeking, G. R., Sullivan, A. P., Hill, T. C. J., **Nakao, S.**, Carrico, C. M., and Kreidenweis, S. M. (2014) Characterization of atmospheric ice nucleating particles associated with biomass burning in the US: prescribed burns and wildfires, *Journal of Geophysical Research: Atmosphere* 119, doi: 10.1002/jgd021980.
16. **Nakao, S.**, Suda, S. R., Camp, M., Petters, M. D., and Kreidenweis, S. M. (2014) Droplet Activation of Wet Particles: Development of the Wet CCN Approach, *Atmospheric Measurement and Techniques* 7, 2227-2241.
15. Clark, C. H., **Nakao, S.**, Asa-Awuku, A., Sato, K., and Cocker III, D. R. (2013) Real-time study of particle-phase products from  $\alpha$ -pinene ozonolysis and isoprene photo-oxidation using particle into liquid sampling directly coupled to a time of flight mass spectrometer (PILS-ToF), *Aerosol Science and Technology* 47, 1374-1382.
14. **Nakao, S.**, Tang, P., Tang, X., Clark, C., Qi, L., Heo, E., Asa-Awuku, A., Cocker III, D. R. (2013) Density and elemental ratio of secondary organic aerosol: application of a density prediction method, *Atmospheric Environment* 68, 273-277.
13. Qi, L., **Nakao, S.**, Cocker III, D. R. (2012) Aging of secondary organic aerosol from alpha-pinene ozonolysis: Roles of hydroxyl and nitrate radicals, *Journal of the Air & Waste Management Association* 62, 1359-1369.
12. **Nakao, S.**, Liu, Y., Tang, P., Chen, C.-L., Zhang, J., Cocker III, D. R. (2012) Chamber studies of SOA formation from aromatic hydrocarbons: observation of limited glyoxal uptake, *Atmospheric Chemistry and Physics* 12, 3927-3937.
11. **Nakao, S.**, Clark, C., Tang, P., Sato, K., Cocker III, D. R. (2011) Secondary Organic Aerosol formation from phenolic compounds in the absence of NO<sub>x</sub>, *Atmospheric Chemistry and Physics* 11, 10649-10660.
10. Sato, K., **Nakao, S.**, Clark, C., Qi, L., Cocker III, D. R. (2011) Secondary Organic Aerosol formation from the photooxidation of isoprene, 1,3-butadiene, and 2,3-dimethyl-1,3-butadiene under high NO<sub>x</sub> conditions, *Atmospheric Chemistry and Physics* 11, 7301-7317.
9. **Nakao, S.**, Shrivastava, M., Nguyen, A., Jung, H., Cocker III, D. R. (2011) Interpretation of secondary organic aerosol formation from diesel exhaust photooxidation in an environmental chamber, *Aerosol Science and Technology* 45, 954-962.
8. Qi, L., **Nakao, S.**, Malloy, Q., Warren, B., Cocker III, D. R. (2010) Can secondary organic aerosol formed in an atmospheric simulation chamber continuously age?, *Atmospheric Environment* 44, 2990-2996.
7. Qi, L., **Nakao, S.**, Tang, P., Cocker III, D. R. (2010) Temperature effect on physical and chemical properties of aerosols from m-xylene photooxidation, *Atmospheric Chemistry and Physics* 10, 3847-3854.

6. Malloy, Q., **Nakao, S.**, Qi, L., Austin, R., Stother, C., Hagino, H., Cocker III, D. R. (2009) Real-time aerosol density determination utilizing a modified scanning mobility particle sizer - aerosol particle mass analyzer system, *Aerosol Science and Technology* 43, 673-678.
5. Shen, Z., Cao, J., Arimoto, R., Han, Z., Zhang, R., Han, Y., Liu, S., Okuda, T., **Nakao, S.**, Tanaka, S. (2009) Ionic composition of TSP and PM<sub>2.5</sub> during dust storms and air pollution episodes at Xi'an, China, *Atmospheric Environment* 43, 2911-2918.
4. Shen, Z., Arimoto, R., Cao, J., Zhang, R., Li, X., Du, N., Okuda, T., **Nakao, S.**, Tanaka, S. (2008) Seasonal variations and evidence for the effectiveness of pollution controls on water-soluble inorganic species in total suspended particulates and fine particulate matter from Xi'an, China, *J. Air & Waste Manage. Assoc.* 58, 1560-1570.
3. Okuda, T., Katsuno, M., Naoi, D., **Nakao, S.**, Tanaka, S., He, K., Ma, Y., Lei, Y., Jia, Y. (2008) Trends in hazardous trace metal concentrations in aerosols collected in Beijing, China from 2001 to 2006, *Chemosphere* 72(6), 917-924.
2. Okuda, T., **Nakao, S.**, Katsuno, M., Tanaka, S. (2007) Source identification of nickel in TSP and PM<sub>2.5</sub> in Tokyo, Japan, *Atmos. Environ.* 41(35), 7642-7648.
1. Okuda, T., **Nakao, S.**, Tanaka, S., Shen, Z.X., He, K., Ma, Y., Lei, Y., Jia, Y. (2007) Characterization of water-soluble ionic composition of aerosols in Xi'an and Beijing, China, *Chikyukagaku(Geochemistry)* 41(4), 113-123 (in Japanese with English abstract).

### **Publications in Review**

**Nakao, S.** (2017) The role of volatility and solubility distribution in cloud condensation nucleus activity of organic aerosol.

### **Invited Seminars**

4. University of Toronto, Southern Ontario Centre for Atmospheric Aerosol Research, 6 April 2016, Bridging cloud condensation nuclei activity and volatility of oxidized organic aerosol.
3. University of Wyoming, Department of Atmospheric Science, 18 April 2014, Droplet activation of wet particles: Development of the Wet CCN approach.
2. Nagoya University, Japan, Department of Earth and Environmental Sciences, 24 July 2012.
1. National Institute for Environmental Studies, Japan, Secondary Organic Aerosol Seminar, 21 December 2011.

### **Oral Presentations**

15. Jayarathne, T., Stockwell, C., Yokelson, R. J., **Nakao, S.**, Stone, E. (2014) Fluoride Emissions from Biomass Burning, American Association for Aerosol Research, Orlando, FL, USA.
14. **Nakao, S.**, Lim, Y., Turpin, B., Boris, A., Collett, J., Kreidenweis, S. (2014) The Role of Aqueous Chemistry in Cloud Formation: Impact of Oligomerization, American Association for Aerosol Research, Orlando, FL, USA.
13. Levin, E., McMeeking, G., DeMott, P., McCluskey, C. S., Carrico, C., **Nakao, S.**, Stockwell, C., Yokelson, R. J., Kreidenweis, S. (2014) Ice Nucleating Particle Emissions from Biomass Combustion and the Potential Importance of Soot Aerosol, American Association for Aerosol Research, Orlando, FL, USA.
12. **Nakao, S.**, Heo, G., Warren, B., Qi, L., Hagino, H., Carter W. P. L., Cocker III, D. R. (2013) Chemical and Physical Investigation of Fractal-Like Iodine Oxide Particle Formation, 2013 AIChE Annual Meeting, San Francisco, CA, USA.

11. Tang, P., ***Nakao, S.***, Chen, C.-L., Cocker III, D. R. (2013) Secondary Organic Aerosol Formation from Aromatic Compounds: Describe SOA Yield Using [OH]/[HO<sub>2</sub>] Ratio, American Association for Aerosol Research, Portland, OR, USA.
10. ***Nakao, S.***, Kreidenweis, S., Suda, S., Petters, M. (2013) A New Experimental Approach toward Determining Cloud Nucleating Activities of Haze Particles, American Association for Aerosol Research, Portland, OR, USA.
9. McCluskey, C., DeMott, P.J., Prenni, A. J., McMeeking, G. R., Sullivan, A. P., Levin, E., ***Nakao, S.***, Carrico, C. M., Franc, G. D., Hill, T. C., Kreidenweis, S. M. (2013) The production and characteristics of ice nuclei from biomass burning in the US, European Science Foundation Atmospheric Ice Nucleation Workshop, Vienna, Austria.
8. ***Nakao, S.***, Tang, P., Clark, C., Qi, L., Seo, E., Chen, C.L., Asa-Awuku, A., Cocker III, D. R. (2012) Density and Elemental Ratios of Secondary Organic Aerosol: Application of a Density Prediction Method, American Association for Aerosol Research, Minneapolis, MN, USA.
7. ***Nakao, S.***, Liu, Y., Tang, P., Cocker III, D. R. (2011) Role of glyoxal in SOA formation from aromatic hydrocarbons, American Association for Aerosol Research, Orlando, FL, USA.
6. ***Nakao, S.***, Shrivastava, M., Nguyen, A., Qi, L., Jung, J., Cocker III, D. R. (2010) Influence of dilution and particle fractal dimension of diesel exhaust on measured SOA formation in a smog chamber, American Association for Aerosol Research, Portland, OR, USA.
5. Clark, C., ***Nakao, S.***, Sato, K., Qi, L., Asa-Awuku, A., Cocker III, D. R. (2010) Chemical characterization by particle into liquid sampling directly coupled to an accurate mass time-of-flight mass spectrometer (PILS-ToF) of secondary organic aerosol (SOA), American Association for Aerosol Research, Portland, OR, USA.
4. ***Nakao, S.***, Cocker III, D. R. (2010) Secondary Organic Aerosol (SOA) formation, 5th Annual CE-CERT- Shanghai Jiao Tong Student Symposium, Shanghai, China.
3. Qi, L., ***Nakao, S.***, Warren, B., Malloy, Q., Cocker III, D. R. (2009) Temperature effect on SOA chemical composition from select chamber reaction systems: From the perspective of a High-Resolution Aerosol Mass Spectrometer, American Association for Aerosol Research, Minneapolis, MN, USA.
2. Qi, L., ***Nakao, S.***, Malloy, Q., Warren, B., Cocker III, D. R. (2008) Can secondary organic aerosol formed in atmospheric simulation chamber be continuously aging?, American Association for Aerosol Research, Orlando, FL, USA.
1. ***Nakao, S.***, Okuda, T., Tanaka, S., Shen, Z. X., He, K., Ma, Y., Lei, Y., Jia, Y. (2006) Observation of water-soluble ionic composition of aerosols in Xi'an China, Japan Young Geochemist Symposium, Japan.

#### **Poster Presentations** (*Nakao group students shown with underlines and italics*)

21. ***Nakao, S.***, *Pratap, V.*, Philip Hopke (2016) Quantitative investigation of molecular tracers of wood smoke aerosol relevant in wintertime in New York State, Understanding and Reducing Residential Wood Combustion Emissions Symposium, Albany, NY, USA.
- 20\* . *Pratap, V.*, ***Nakao, S.*** (2016) Lifetime evaluation of biomass burning markers in low temperature conditions – Effect of vapor loss in a Teflon chamber, American Association for Aerosol Research, Portland, OR, USA. [\*Won a student poster award]
19. *Pratap, V.*, ***Nakao, S.*** (2015) Multiphase chemistry of biomass burning markers and its relevance in cold regions, American Association for Aerosol Research, Minneapolis, MN, USA.

- 18\*. *Sekar, G. A., Nakao, S.* (2015) Organic aerosol-sulfate interaction: Evaluation of thermodynamic effects, American Association for Aerosol Research, Minneapolis, MN, USA. [\*Won a student poster award]
17. *Nakao, S.,* Levin, E., McMeeking, G., Carrico, C., Jayarathne, T., Stone, E., Kreidenweis, S. (2014) Hygroscopicity and Cloud Condensation Nuclei Activity of Fresh Biomass Burning Aerosol: Black Carbon Mixing States, American Association for Aerosol Research, Orlando, FL, USA.
16. Tang, P., *Nakao, S.,* Chen, C. L., Cocker III, D. R. (2012) Secondary Organic Aerosol Formation from Aromatic Compounds: Relationship between SOA Yield and Chemical Structure, American Association for Aerosol Research, Minneapolis, MN, USA.
15. *Nakao, S.,* Heo, G., Carter W. P. L., Warren, B., Cocker III, D. R. (2011) Investigation of particle formation and ozone impacts of methyl iodide (CH<sub>3</sub>I), American Geophysical Union, San Francisco, CA, USA.
14. Liu, Y., *Nakao, S.,* Tang, P., Cocker III, D. R., Griffin, R. J. (2011) Computational Simulation of Secondary Organic Aerosol Formation from Toluene Oxidation, American Association for Aerosol Research, Orlando, FL, USA.
13. Tang, P., *Nakao, S.,* Qi, L., Tang, P., Cocker III, D. R. (2011) Relationships Between Chemical Structure and Secondary Organic Aerosol Formation for Aromatic Compounds, American Association for Aerosol Research, Orlando, FL, USA.
12. Clark, C., *Nakao, S.,* Sato, K., Asa-Awuku, A., Cocker III, D. R. (2011) Temperature Dependence of Secondary Organic Aerosol Particle-Phase Products from Isoprene Dark Ozonolysis and NO Photooxidation, American Association for Aerosol Research, Orlando, FL, USA.
11. Heo, G., *Nakao, S.,* Tang, P., Cocker III, D. R., Carter, W. P. L. (2011) Development and Evaluation of PM-SAPRC to Model Secondary Organic Aerosol Formation from Various Aromatic Compounds, American Association for Aerosol Research, Orlando, FL, USA.
10. *Nakao, S.,* Clark, C., Tang, P., Cocker III, D. R. (2010) SOA formation from benzene, toluene, and phenolic compounds, Atmospheric Chemical Mechanisms, Davis, CA, USA.
9. *Nakao, S.,* Tang, P., Clark, C., Sato, K., Cocker III, D. R. (2010) SOA formation from phenolic compounds, American Association for Aerosol Research, Portland, OR, USA.
8. Tang, P., *Nakao, S.,* Tang, X., Cocker III, D. R. (2010) Secondary organic aerosol formation from the trimethylbenzene isomers, American Association for Aerosol Research, Portland, OR, USA.
7. *Nakao, S.,* Qi, L., Tang, P., Sato, K., Cocker III, D. R. (2009) Secondary organic aerosol formation from m-xylene photooxidation: the role of the phenolic product, American Geophysical Union Fall meeting, San Francisco, CA, USA.
6. *Nakao, S.,* Qi, L., Malloy, Q., Clark, C., Tang, P., Sato, K., Cocker III, D. R. (2009) Secondary organic aerosol formation from m-xylene photooxidation: Evaluation of the phenolic SOA formation route, American Association for Aerosol Research, Minneapolis, MN, USA.
5. Gookin, G., Salazar, K., Mac Kinnon, M., Willett, P., Keebaugh, A., Meacher, D., *Nakao, S.,* Cocker III, D. R., Kleinman, M. T. (2009) Is toxicity reduced by inhalation of biodiesel-versus petroleum-diesel-fueled engine exhaust in an asthma mouse model?, UC Toxic Substances Research and Teaching Program Annual Symposium, Berkeley, CA, USA.
4. Malloy, Q.G.J., *Nakao, S.,* Austin, R., Stothers, C., Araiza, J., Cocker III, D.R. (2009) Real-time aerosol density determination utilizing a Aerosol Particle Mass Analyzer - Scanning Mobility Particle Sizer System, 26th Informal Symposium on Kinetic and Photochemical Processes in the Atmosphere, University of California, Riverside, USA.

3. **Nakao, S.**, Malloy, Q., Shrivastava, M., Jung, H., Cocker III, D. R. (2009) Volatility evolution of aerosols in diesel exhaust, University of California Transportation Center Student Conference, USA.
2. Malloy, Q., **Nakao, S.**, Cocker III, D. R. (2009) Density evolution of fresh and aged diesel exhaust, University of California Transportation Center Student Conference, USA.
1. Warren, B., Carter, W. P. L., Song, C., Malloy, Q. G. J., Qi, L., **Nakao, S.**, Cocker III, D. R., Predicting secondary organic aerosol formation: PM-SAPRC08, American Association for Aerosol Research, Orlando, FL, USA.