

## References

- Adams, C., McLinden, C. A., Shephard, M. W., Dickson, N., Damers, E., Chen, J., Makar, P., Cady-Pereira, K. E., Tam, N., Kharol, S. K., Lamsal, L. N., and Krotkov, N. A., Satellite-derived emissions of carbon monoxide, ammonia, and nitrogen dioxide from the 2016 Horse River wildfire in the Fort McMurray area: *Atmos. Chem. Phys.*, 19, 2577-2599, doi:10.5194/acp-19-2577-2019, 2019.
- Akagi, S. K., Yokelson, R. J., Wiedinmyer, C., Alvarado, M. J., Reid, J. S., Karl, T., Crounse, J. D., and Wennberg, P. O., Emission factors for open and domestic biomass burning for use in atmospheric models: *Atmos. Chem. Phys.*, 11, 4039-4072, doi:10.5194/acpd-10-27523-2010, 2011.
- Akagi, S. K., Yokelson, R. J., Burling, I. R., Meinardi, S., Simpson, I. J., Blake, D. R., McMeeking, G. R., Sullivan, A., Lee, T., Kreidenweis, S., Urbanski, S., Reardon, J., Griffith, D. W. T., Johnson, T. J., and Weise, D. R., Measurements of reactive trace gases and variable O<sub>3</sub> formation rates in some South Carolina biomass burning plumes: *Atmos. Chem. Phys.*, 13, 1141-1165, doi:10.5194/acpd-12-25255-2012, 2013.
- Akagi, S. K., Burling, I. R., Mendoza, A., Johnson, T. J., Cameron, M., Griffith, D. W. T., Paton-Walsh, C., Weise, D. R., Reardon, J., and Yokelson, R. J., Field measurements of trace gases emitted by prescribed fires in southeastern US pine forests using an open-path FTIR system: *Atmos. Chem. Phys.*, 14, 199-215, doi:10.5194/acp-14-199-2014, 2014.
- Alvarado, M. J., Logan, J. A., Mao, J., Apel, E., Riemer, D., Blake, D., Cohen, R. C., Min, K. E., Perring, A. E., Browne, E. C., Wooldridge, P. J., Diskin, G. S., Sachse, G. W., Fuelberg, H., Sessions, W. R., Harrigan, D. L., Huey, G., Liao, J., Case-Hanks, A., Jimenez, J. L., Cubison, M. J., Vay, S. A., Weinheimer, A. J., Knapp, D. J., Montzka, D. D., Flocke, F. M., Pollack, I. B., Wennberg, P. O., Kurten, A., Crounse, J., St Clair, J. M., Wisthaler, A., Mikoviny, T., Yantosca, R. M., Carouge, C. C., and Le Sager, P., Nitrogen oxides and PAN in plumes from boreal fires during ARCTAS-B and their impact on ozone: an integrated analysis of aircraft and satellite observations: *Atmos. Chem. Phys.*, 10, 9739-9760, doi:10.5194/acp-10-9739-2010, 2010.
- Alves, C., Gonçalves, C., Fernandes, A. P., Tarelho, L., and Pio, C., Fireplace and woodstove fine particle emissions from combustion of western Mediterranean wood types: *Atmos. Res.*, 101, 692-700, doi:10.1016/j.atmosres.2011.04.015, 2011a.
- Alves, C., Vicente, A., Nunes, T., Gonçalves, C., Fernandes, A. P., Mirante, F., Tarelho, L., Sánchez de la Campa, A. M., Querol, X., Caseiro, A., Monteiro, C., Evtyugina, M., and Pio, C., Summer 2009 wildfires in Portugal: Emission of trace gases and aerosol composition: *Atmospheric Environment*, 45, 641-649, doi:10.1016/j.atmosenv.2010.10.031, 2011b.
- Alves, C. A., Goncalves, C., Pio, C. A., Mirante, F., Caseiro, A., Tarelho, L., Freitas, M. C., and Viegas, D. X., Smoke emissions from biomass burning in a Mediterranean shrubland: *Atmospheric Environment*, 44, 3024-3033, doi:10.1016/j.atmosenv.2010.05.010, 2010.
- Alves, C. A., Vicente, A., Monteiro, C., Goncalves, C., Evtyugina, M., and Pio, C., Emission of trace gases and organic components in smoke particles from a wildfire in a mixed-evergreen forest in Portugal: *Science of the Total Environment*, 409, 1466-1475, doi:10.1016/j.scitotenv.2010.12.025, 2011c.
- Anderson, B. E., Grant, W. B., Gregory, G. L., Browell, E. V., Collins, J. E., Jr., Sachse, G. W., Bagwell, D. R., Hudgins, C. H., Blake, D. R., and Blake, N. J., Aerosols from biomass

- burning over the tropical South Atlantic region: Distributions and impacts: J. Geophys. Res., 101, 24,117-24,138, 1996.
- Andreae, M. O., Browell, E. V., Garstang, M., Gregory, G. L., Harriss, R. C., Hill, G. F., Jacob, D. J., Pereira, M. C., Sachse, G. W., Setzer, A. W., Dias, P. L. S., Talbot, R. W., Torres, A. L., and Wofsy, S. C., Biomass-burning emissions and associated haze layers over Amazonia: J. Geophys. Res., 93, 1509-1527, 1988.
- Andreae, M. O., Atlas, E., Cachier, H., Cofer, W. R., III, Harris, G. W., Helas, G., Koppmann, R., Lacaux, J.-P., and Ward, D. E., Trace gas and aerosol emissions from savanna fires, in *Biomass Burning and Global Change*, edited by J. S. Levine, pp. 278-295, MIT Press, Cambridge, Mass., 1996a.
- Andreae, M. O., Atlas, E., Harris, G. W., Helas, G., de Kock, A., Koppmann, R., Maenhaut, W., Manö, S., Pollock, W. H., Rudolph, J., Scharffe, D., Schebeske, G., and Welling, M., Methyl halide emissions from savanna fires in southern Africa: J. Geophys. Res., 101, 23,603-23,613, 1996b.
- Andreae, M. O., Andreae, T. W., Annegarn, H., Beer, F., Cachier, H., Elbert, W., Harris, G. W., Maenhaut, W., Salma, I., Swap, R., Wienhold, F. G., and Zenker, T., Airborne studies of aerosol emissions from savanna fires in southern Africa: 2. Aerosol chemical composition: J. Geophys. Res., 103, 32,119-32,128, 1998.
- Andreae, M. O., Artaxo, P., Beck, V., M. Bela, Gerbig, C., Longo, K., Munger, J. W., Wiedemann, K. T., and Wofsy, S. C., Carbon monoxide and related trace gases and aerosols over the Amazon Basin during the wet and dry seasons: Atmos. Chem. Phys., 12, 6041–6065, 2012.
- Arai, H., Hosen, Y., Hong, V. N. P., Thi, N. T., Huu, C. N., and Inubushi, K., Greenhouse gas emissions from rice straw burning and straw-mushroom cultivation in a triple rice cropping system in the Mekong Delta: Soil Sci. Plant Nutr., 61, 719-735, doi:10.1080/00380768.2015.1041862, 2015.
- Aurell, J., and Gullett, B. K., Emission factors from aerial and ground measurements of field and laboratory forest burns in the Southeastern US: PM<sub>2.5</sub>, black and brown carbon, VOC, and PCDD/PCDF: Environ. Sci. Technol., 47, 8443-8452, doi:10.1021/es402101k, 2013.
- Aurell, J., Gullett, B. K., and Tabor, D., Emissions from southeastern US Grasslands and pine savannas: Comparison of aerial and ground field measurements with laboratory burns: Atmospheric Environment, 111, 170-178, doi:10.1016/j.atmosenv.2015.03.001, 2015.
- Aurell, J., Gullett, B. K., Tabor, D., and Yonker, N., Emissions from prescribed burning of timber slash piles in Oregon: Atmospheric Environment, 150, 395-406, doi:10.1016/j.atmosenv.2016.11.034, 2017.
- Babbitt, R. E., Ward, D. E., Susott, R. A., Artaxo, P., and Kauffman, J. B., A comparison of concurrent airborne and ground-based emissions generated from biomass burning in the Amazon basin, in *SCAR-B Proceedings*, edited by V. W. J. H. Kirchhoff, pp. 23-26, Transtec Editorial, Sao Jose dos Campos, Brazil, 1996.
- Balachandran, S., Pachon, J. E., Lee, S., Oakes, M. M., Rastogi, N., Shi, W. Y., Tagaris, E., Yan, B., Davis, A., Zhang, X. L., Weber, R. J., Mulholland, J. A., Bergin, M. H., Zheng, M., and Russell, A. G., Particulate and gas sampling of prescribed fires in South Georgia, USA: Atmospheric Environment, 81, 125-135, doi:10.1016/j.atmosenv.2013.08.014, 2013.
- Ballard-Tremere, G., and Jawurek, H. H., Comparison of five rural, wood-burning cooking devices: Efficiencies and emissions: Biomass & Bioenergy, 11, 419-430, 1996.

- Bertrand, A., Stefenelli, G., Bruns, E. A., Pieber, S. M., Temime-Roussel, B., Slowik, J. G., Prevot, A. S. H., Wortham, H., El Haddad, I., and Marchand, N., Primary emissions and secondary aerosol production potential from woodstoves for residential heating: Influence of the stove technology and combustion efficiency: *Atmospheric Environment*, 169, 65-79, doi:10.1016/j.atmosenv.2017.09.005, 2017.
- Bertschi, I., Yokelson, R. J., Ward, D. E., Babbitt, R. E., Susott, R. A., Goode, J. G., and Hao, W. M., Trace gas and particle emissions from fires in large diameter and belowground biomass fuels: *J. Geophys. Res.*, 108, 8472, doi:10.1029/2002JD002100, 2003a.
- Bertschi, I. T., Yokelson, R. J., Ward, D. E., Christian, T. J., and Hao, W. M., Trace gas emissions from the production and use of domestic biofuels in Zambia measured by open-path Fourier transform infrared spectroscopy: *J. Geophys. Res.*, 108, 8469, doi:10.1029/2002JD002158, 2003b.
- Bhattacharya, S. C., Albina, D. O., and Abdul Salam, P., Emission factors of wood and charcoal-fired cookstoves: *Biomass and Bioenergy*, 23, 453-469, doi:10.1016/S0961-9534(02)00072-7, 2002.
- Biswas, A., Blum, J. D., Klaue, B., and Keeler, G. J., Release of mercury from Rocky Mountain forest fires: *Global Biogeochemical Cycles*, 21, Gb1002, doi:10.1029/2006gb002696, 2007.
- Biswas, A., Blum, J. D., and Keeler, G. J., Mercury storage in surface soils in a central Washington forest and estimated release during the 2001 Rex Creek Fire: *Science of the Total Environment*, 404, 129-138, doi:10.1016/j.scitotenv.2008.05.043, 2008.
- Blake, D. R., Smith, T. W., Chen, T.-Y., Whipple, W. J., and Rowland, F. S., Effects of biomass burning on summertime nonmethane hydrocarbon concentrations in the Canadian wetlands: *J. Geophys. Res.*, 99, 1699-1719, 1994.
- Blake, N. J., Blake, D. R., Collins, J. E., Sachse, G. W., Anderson, B. E., Brass, J. A., Riggan, P. J., and Rowland, F. S., Biomass burning emissions of atmospheric methyl halide and hydrocarbon gases in the South Atlantic region, in *Biomass Burning and Global Change*, edited by J. S. Levine, pp. 575-594, MIT Press, Cambridge, Mass., 1996.
- Bonsang, B., Lambert, G., and Boissard, C. C., Light hydrocarbons emissions from African savanna burnings, in *Global Biomass Burning: Atmospheric, Climatic and Biospheric Implications*, edited by J. S. Levine, pp. 155-161, MIT Press, Cambridge, Mass., 1991.
- Bonsang, B., Boissard, C., Le Cloarec, M. F., Rudolph, J., and Lacaux, J. P., Methane, carbon monoxide and light non methane hydrocarbon emissions from African savanna burnings during the FOS/DECAFE experiment: *J. Atmos. Chem.*, 22, 149-162, 1995.
- Brocard, D., Lacaux, C., Lacaux, J. P., Kouadio, K., and Yoboué, V., Emissions from the combustion of biofuels in Western Africa, in *Biomass Burning and Global Change*, edited by J. S. Levine, pp. 350-360, MIT Press, Cambridge, Mass., 1996.
- Brunke, E.-G., Labuschagne, C., and Slemr, F., Gaseous mercury emissions from a fire in the Cape Peninsula, South Africa, during January 2000: *Geophys. Res. Lett.*, 28, 1483-1486, 2001.
- Burling, I. R., Yokelson, R. J., Griffith, D. W. T., Johnson, T. J., Veres, P., Roberts, J. M., Warneke, C., Urbanski, S. P., Reardon, J., Weise, D. R., Hao, W. M., and de Gouw, J., Laboratory measurements of trace gas emissions from biomass burning of fuel types from the southeastern and southwestern United States: *Atmos. Chem. Phys.*, 10, 11115-11130, doi:10.5194/acp-10-11115-2010, 2010.

- Burling, I. R., Yokelson, R. J., Akagi, S. K., Urbanski, S. P., Wold, C. E., Griffith, D. W. T., Johnson, T. J., Reardon, J., and Weise, D. R., Airborne and ground-based measurements of the trace gases and particles emitted by prescribed fires in the United States: *Atmos. Chem. Phys.*, 11, 12,197–12,216, doi:10.5194/acp-11-12197-2011, 2011.
- Cachier, H., Lioussé, C., Buat-Menard, P., and Gaudichet, A., Particulate content of savanna fire emissions: *J. Atmos. Chem.*, 22, 123-148, 1995.
- Cachier, H., Lioussé, C., Pertuisot, M.-H., Gaudichet, A., Echalar, F., and Lacaux, J.-P., African fire particulate emission and atmospheric influence, in *Biomass Burning and Global Change*, edited by J. S. Levine, pp. 428-440, MIT Press, Cambridge, Mass., 1996.
- Cao, G. L., Zhang, X. Y., and Zheng, F. C., Inventory of black carbon and organic carbon emissions from China: *Atmospheric Environment*, 40, 6516-6527, doi:10.1016/j.atmosenv.2006.05.070, 2006.
- Cao, G. L., Zhang, X. Y., Gong, S. L., and Zheng, F. C., Investigation on emission factors of particulate matter and gaseous pollutants from crop residue burning: *Journal of Environmental Sciences*, 20, 50-55, doi:10.1016/s1001-0742(08)60007-8, 2008.
- Cerqueira, M., Gomes, L., Tarelho, L., and Pio, C., Formaldehyde and acetaldehyde emissions from residential wood combustion in Portugal: *Atmospheric Environment*, 72, 171-176, doi:10.1016/j.atmosenv.2013.02.045, 2013.
- Chen, L. W. A., Moosmüller, H., Arnott, W. P., Chow, J. C., Watson, J. G., Susott, R. A., Babbitt, R. E., Wold, C. E., Lincoln, E. N., and Hao, W. M., Emissions from laboratory combustion of wildland fuels: Emission factors and source profiles: *Environ. Sci. Technol.*, 41, 4317-4325, doi:10.1021/es062364i, 2007.
- Chen, Y. C., Shen, G. F., Liu, W. J., Du, W., Su, S., Duan, Y. H., Lin, N., Zhuo, S. J., Wang, X. L., Xing, B. S., and Tao, S., Field measurement and estimate of gaseous and particle pollutant emissions from cooking and space heating processes in rural households, northern China: *Atmospheric Environment*, 125, 265-271, doi:10.1016/j.atmosenv.2015.11.032, 2016.
- Christian, T. J., Kleiss, B., Yokelson, R. J., Holzinger, R., Crutzen, P. J., Hao, W. M., Saharjo, B. H., and Ward, D. E., Comprehensive laboratory measurements of biomass-burning emissions: 1. Emissions from Indonesian, African, and other fuels: *J. Geophys. Res.*, 108, 4719, doi:10.1029/2003JD003704, 2003.
- Christian, T. J., Yokelson, R. J., Carvalho, J. A., Griffith, D. W. T., Alvarado, E. C., Santos, J. C., Neto, T. G. S., Veras, C. A. G., and Hao, W. M., The tropical forest and fire emissions experiment: Trace gases emitted by smoldering logs and dung from deforestation and pasture fires in Brazil: *J. Geophys. Res.*, 112, D18308, doi:10.1029/2006JD008147, 2007.
- Christian, T. J., Yokelson, R. J., Cárdenas, B., Molina, L. T., Engling, G., and Hsu, S.-C., Trace gas and particle emissions from domestic and industrial biofuel use and garbage burning in central Mexico: *Atmos. Chem. Phys.*, 10, 565-584, 2010.
- Ciccioli, P., Brancaleoni, E., Frattoni, M., Cecinato, A., and Pinciarelli, L., Determination of volatile organic compounds (VOC) emitted from biomass burning of Mediterranean vegetation species by GC-MS: *Analytical Letters*, 34, 937-955, 2001.
- Cinnirella, S., and Pirrone, N., Spatial and temporal distributions of mercury emissions from forest fires in Mediterranean region and Russian federation: *Atmospheric Environment*, 40, 7346-7361, doi:10.1016/j.atmosenv.2006.06.051, 2006.

- Cofer, W. R., III, Levine, J. S., Sebachner, D. I., Winstead, E. L., Riggan, P. J., Brass, J. A., and Ambrosia, V. G., Particulate emissions from a mid-latitude prescribed chaparral fire: *J. Geophys. Res.*, 93, 5207-5212, 1988.
- Cofer, W. R., III, Levine, J. S., Sebachner, D. I., Winstead, E. L., Riggan, P. J., Stocks, B. J., Brass, J. A., Ambrosia, V. G., and Boston, P. J., Trace gas emissions from chaparral and boreal forest fires: *J. Geophys. Res.*, 94, 2255-2259, 1989.
- Cofer, W. R., III, Levine, J. S., Winstead, E. L., LeBel, P. J., Koller, A. M., and Hinkle, C. R., Trace gas emissions from burning Florida wetlands: *J. Geophys. Res.*, 95, 1865-1870, 1990a.
- Cofer, W. R., III, Levine, J. S., Winstead, E. L., and Stocks, B. J., Gaseous emissions from Canadian boreal forest fires: *Atmospheric Environment*, 24A, 1653-1659, 1990b.
- Cofer, W. R., III, Levine, J. S., Winstead, E. L., and Stocks, B. J., New estimates of nitrous oxide emissions from biomass burning: *Nature*, 349, 689-691, 1991.
- Cofer, W. R., III, Levine, J. S., Winstead, E. L., Cahoon, D. R., Sebachner, D. I., Pinto, J. P., and Stocks, B. J., Source composition of trace gases released during African savanna fires: *J. Geophys. Res.*, 101, 23,597-23,602, 1996a.
- Cofer, W. R., III, Winstead, E. L., Stocks, B. J., Overbay, L. W., Goldammer, J. G., Cahoon, D. R., and Levine, J. S., Emissions from boreal forest fires: Are the atmospheric impacts underestimated?, in *Biomass Burning and Global Change*, edited by J. S. Levine, pp. 834-839, MIT Press, Cambridge, Mass., 1996b.
- Cofer, W. R., III, Winstead, E. L., Stocks, B. J., Goldammer, J. G., and Cahoon, D. R., Crown fire emissions of CO<sub>2</sub>, CO, H<sub>2</sub>, CH<sub>4</sub>, and TNMHC from a dense jack pine boreal forest fire: *Geophys. Res. Lett.*, 25, 3919-3922, 1998.
- Coffey, E. R., Muvandimwe, D., Hagar, Y., Wiedinmyer, C., Kanyomse, E., Piedrahita, R., Dickinson, K. L., Oduro, A., and Hannigan, M. P., New emission factors and efficiencies from in-field measurements of traditional and improved cookstoves and their potential implications: *Environ. Sci. Technol.*, 51, 12,508-12,517, doi:10.1021/acs.est.7b02436, 2017.
- Collier, S., Zhou, S., Onasch, T. B., Jaffe, D. A., Kleinman, L., Sedlacek, A. J., Briggs, N. L., Hee, J., Fortner, E., Shilling, J. E., Worsnop, D., Yokelson, R. J., Parworth, C., Ge, X. L., Xu, J. Z., Butterfield, Z., Chand, D., Dubey, M. K., Pekour, M. S., Springston, S., and Zhang, Q., Regional influence of aerosol emissions from wildfires driven by combustion efficiency: Insights from the BBOP campaign: *Environ. Sci. Technol.*, 50, 8613-8622, doi:10.1021/acs.est.6b01617, 2016.
- Crutzen, P. J., Heidt, L. E., Krasnec, J. P., Pollock, W. H., and Seiler, W., Biomass burning as a source of atmospheric gases CO, H<sub>2</sub>, N<sub>2</sub>O, NO, CH<sub>3</sub>Cl, and COS: *Nature*, 282, 253-256, 1979.
- Cui, M., Chen, Y. J., Zheng, M., Li, J., Tang, J., Han, Y., Song, D. B., Yan, C. Q., Zhang, F., Tian, C. G., and Zhang, G., Emissions and characteristics of particulate matter from rainforest burning in the Southeast Asia: *Atmospheric Environment*, 191, 194-204, doi:10.1016/j.atmosenv.2018.07.062, 2018.
- Dasch, J. M., Particulate and gaseous emissions from wood-burning fireplaces: *Environ. Sci. Tech.*, 16, 639-645, 1982.
- De Angelis, D. G., Ruffin, D. S., and Rezink, R. B., Preliminary Characterization of Emissions from Wood-Fired Residential Combustion Equipment. Washington, D.C.: US Environ. Protection Agency, 1980.

- de Gouw, J. A., Warneke, C., Parrish, D. D., Holloway, J. S., Trainer, M., and Fehsenfeld, F. C., Emission sources and ocean uptake of acetonitrile ( $\text{CH}_3\text{CN}$ ) in the atmosphere: *J. Geophys. Res.*, 108, 4329, doi:10.1029/2002JD002897, 2003.
- de Gouw, J. A., Warneke, C., Stohl, A., Wollny, A. G., Brock, C. A., Cooper, O. R., Holloway, J. S., Trainer, M., and Fehsenfeld, F. C., The VOC composition of aged forest fire plumes from Alaska and western Canada, 52 p., 2005.
- de la Sota, C., Viana, M., Kane, M., Youm, I., Masera, O., and Lumbreras, J., Quantification of carbonaceous aerosol emissions from cookstoves in Senegal: *Aerosol and Air Quality Research*, 19, 80-91, doi:10.4209/aaqr.2017.11.0540, 2019.
- de Zarate, I. O., Ezcurra, A., Lacaux, J. P., and Van Dinh, P., Emission factor estimates of cereal waste burning in Spain: *Atmospheric Environment*, 34, 3183-3193, 2000.
- Delmas, R., and Servant, J., The origins of sulfur compounds in the atmosphere of a zone of high productivity (Gulf of Guinea): *J. Geophys. Res.*, 87, 11,019-11,026, 1982.
- Delmas, R., Lacaux, J.-P., Menaut, J.-C., Abbadie, L., Le Roux, X., Helas, G., and Lobert, J., Nitrogen compound emission from biomass burning in tropical African savanna FOS/DECAFE 1991 Experiment (Lamto, Ivory Coast): *J. Atmos. Chem.*, 22, 175-193, 1995a.
- Delmas, R., Lacaux, J. P., and Brocard, D., Determination of biomass burning emission factors: Methods and results: *Environmental Monitoring and Assessment*, 38, 181-204, 1995b.
- Delmas, R. A., Marengo, A., Tathy, J. P., Cros, B., and Baudet, J. G. R., Sources and sinks of methane in the African savanna.  $\text{CH}_4$  emissions from biomass burning: *J. Geophys. Res.*, 96, 7287-7299, 1991.
- Desservettaz, M., Paton-Walsh, C., Griffith, D. W. T., Kettlewell, G., Keywood, M. D., Vanderschoot, M. V., Ward, J., Mallet, M. D., Milic, A., Miljevic, B., Ristovski, Z. D., Howard, D., Edwards, G. C., and Atkinson, B., Emission factors of trace gases and particles from tropical savanna fires in Australia: *J. Geophys. Res.*, 122, 6059-6074, doi:10.1002/2016JD025925, 2017.
- Dhammapala, R., Claiborn, C., Simpson, C., and Jimenez, J., Emission factors from wheat and Kentucky bluegrass stubble burning: Comparison of field and simulated burn experiments: *Atmospheric Environment*, 41, 1512-1520, 2007.
- Du, W., Shen, G. F., Chen, Y. C., Zhu, X., Zhuo, S. J., Zhong, Q. R., Qi, M., Xue, C. Y., Liu, G. Q., Zeng, E., Xing, B. S., and Tao, S., Comparison of air pollutant emissions and household air quality in rural homes using improved wood and coal stoves: *Atmospheric Environment*, 166, 215-223, doi:10.1016/j.atmosenv.2017.07.029, 2017.
- Du, W., Zhu, X., Chen, Y. C., Liu, W. J., Wang, W., Shen, G. F., Tao, S., and Jetter, J. J., Field-based emission measurements of biomass burning in typical Chinese built-in-place stoves: *Environmental Pollution*, 242, 1587-1597, doi:10.1016/j.envpol.2018.07.121, 2018.
- Eagan, R. C., Hobbs, P. V., and Radke, L. F., Measurements of cloud condensation nuclei and cloud droplet size distributions in the vicinity of forest fires: *J. Appl. Meteor.*, 13, 553-557, 1974.
- Ebinghaus, R., Slemr, F., Brenninkmeijer, C. A. M., van Velthoven, P., Zahn, A., Hermann, M., O'Sullivan, D. A., and Oram, D. E., Emissions of gaseous mercury from biomass burning in South America in 2005 observed during CARIBIC flights: *Geophys. Res. Lett.*, 34, L08813, doi:10.1029/2006gl028866, 2007.

- Echalar, F., Gaudichet, A., Cachier, H., and Artaxo, P., Aerosol emissions by tropical forest and savanna biomass burning: Characteristic trace elements and fluxes: *Geophys. Res. Lett.*, 22, 3039-3042, 1995.
- Edgerton, S. A., Khalil, M. A. K., and Rasmussen, R. A., Source emission characterization of residential wood-burning stoves and fireplaces: Fine particle/methyl chloride ratios for use in chemical mass balance modeling: *Environ. Sci. Tech.*, 20, 803-807, 1986.
- Eilenberg, S. R., Bilsback, K. R., Johnson, M., Kodros, J. K., Lipsky, E. M., Naluwagga, A., Fedak, K. M., Benka-Coker, M., Reynolds, B., Peel, J., Clark, M., Shan, M., Sambandam, S., L'Orange, C., Pierce, J. R., Subramanian, R., Volckens, J., and Robinson, A. L., Field measurements of solid-fuel cookstove emissions from uncontrolled cooking in China, Honduras, Uganda, and India: *Atmospheric Environment*, 190, 116-125, doi:10.1016/j.atmosenv.2018.06.041, 2018.
- Einfeld, W., Ward, D. E., and Hardy, C. C., Effects of fire behavior on prescribed fire smoke characteristics: A case study, in *Global Biomass Burning: Atmospheric, Climatic, and Biospheric Implications*, edited by J. S. Levine, pp. 412-419, MIT Press, Cambridge, Mass., 1991.
- Engle, M. A., Gustin, M. S., Johnson, D. W., Murphy, J. F., Miller, W. W., Walker, R. F., Wright, J., and Markee, M., Mercury distribution in two Sierran forest and one desert sagebrush steppe ecosystems and the effects of fire: *Science of the Total Environment*, 367, 222-233, doi:10.1016/h.scitotenv.2005.11.025, 2006.
- Evtugina, M., Calvo, A. I., Nunes, T., Alves, C., Fernandes, A. P., Tarelho, L., Vicente, A., and Pio, C., VOC emissions of smouldering combustion from Mediterranean wildfires in central Portugal: *Atmospheric Environment*, 64, 339-348, doi:10.1016/j.atmosenv.2012.10.001, 2013.
- Evtugina, M., Alves, C., Calvo, A., Nunes, T., Tarelho, L., Duarte, M., Prozil, S. O., Evtugin, D. V., and Pio, C., VOC emissions from residential combustion of Southern and mid-European woods: *Atmospheric Environment*, 83, 90-98, doi:<http://dx.doi.org/10.1016/j.atmosenv.2013.10.050>, 2014.
- Ezcurra, A. T., de Zarate, I. O., Lacaux, J.-P., and Dinh, P.-V., Atmospheric impact of cereal—waste burning in Spain, in *Biomass Burning and Global Change, vol. 2, Biomass Burning in South America, Southeast Asia, and Temperate and Boreal Ecosystems, and the Oil Fires of Kuwait*, edited by J. S. Levine, pp. 780–786, MIT Press, Cambridge, Mass., 1996.
- Fang, Z., Deng, W., Zhang, Y., Ding, X., Tang, M., Liu, T., Hu, Q., Zhu, M., Wang, Z., Yang, W., Huang, Z., Song, W., Bi, X., Chen, J., Sun, Y., George, C., and Wang, X., Open burning of rice, corn and wheat straws: primary emissions, photochemical aging, and secondary organic aerosol formation: *Atmos. Chem. Phys.*, 17, 14821-14839, doi:10.5194/acp-17-14821-2017, 2017.
- Ferek, R. J., Reid, J. S., Hobbs, P. V., Blake, D. R., and Lioussé, C., Emission factors of hydrocarbons, halocarbons, trace gases and particles from biomass burning in Brazil: *J. Geophys. Res.*, 103, 32,107-32,118, 1998.
- Fine, P. M., Cass, G. R., and Simoneit, B. R. T., Chemical characterization of fine particle emissions from fireplace combustion of woods grown in the northeastern United States: *Environ. Sci. Technol.*, 35, 2665-2675, 2001.

- Fine, P. M., Cass, G. R., and Simoneit, B. R. T., Organic compounds in biomass smoke from residential wood combustion: Emissions characterization at a continental scale: *J. Geophys. Res.*, 107, 8349, doi:10.1029/2001JD000661, 2002a.
- Fine, P. M., Cass, G. R., and Simoneit, B. R. T., Chemical characterization of fine particle emissions from the fireplace combustion of woods grown in the southern United States: *Environ. Sci. Technol.*, 36, 1442-1451, 2002b.
- Fine, P. M., Cass, G. R., and Simoneit, B. R. T., Chemical characterization of fine particle emissions from the wood stove combustion of prevalent United States tree species: *Environmental Engineering Science*, 21, 705-721, 2004.
- FIRESCAN Science Team, Fire in Ecosystems of Boreal Eurasia: The Bor Forest Island Fire Experiment Fire Research Campaign Asia-North (FIRESCAN), in *Biomass Burning and Global Change*, edited by J. S. Levine, pp. 848-873, MIT Press, Cambridge, Mass., 1996.
- Franca, D. D., Longo, K. M., Neto, T. G. S., Santos, J. C., Freitas, S. R., Rudorff, B. F. T., Cortez, E. V., Anselmo, E., and Carvalho, J. A., Pre-Harvest sugarcane burning: Determination of emission factors through laboratory measurements: *Atmosphere*, 3, 164-180, doi:10.3390/atmos3010164, 2012.
- Friedli, H. R., Atlas, E., Stroud, V. R., Giovanni, L., Campos, T., and Radke, L. F., Volatile organic trace gases emitted from North American wildfires: *Global Biogeochemical Cycles*, 15, 435-452, 2001a.
- Friedli, H. R., Radke, L. F., and Lu, J. Y., Mercury in smoke from biomass fires: *Geophys. Res. Lett.*, 28, 3223-3226, 2001b.
- Friedli, H. R., Radke, L. F., Lu, J. Y., Banic, C. M., Leaitch, W. R., and MacPherson, J. I., Mercury emissions from burning of biomass from temperate North American forests: laboratory and airborne measurements: *Atmospheric Environment*, 37, 253-267, 2003a.
- Friedli, H. R., Radke, L. F., Prescott, R., Hobbs, P. V., and Sinha, P., Mercury emissions from the August 2001 wildfires in Washington State and an agricultural waste fire in Oregon and atmospheric mercury budget estimates: *Global Biogeochemical Cycles*, 17, 1039, doi:10.1029/2002GB001972, 2003b.
- Friedli, H. R., Arellano, A. F., Cinnirella, S., and Pirrone, N., Mercury Emissions from Global Biomass Burning: Spatial and Temporal Distribution, in *Mercury Fate and Transport in the Global Atmosphere: Emissions, Measurements and Models*, edited by N. Pirrone & R. Mason, pp. 193-220, 2009.
- Gadi, R., Kulshrestha, U. C., Sarkar, A. K., Garg, S. C., and Parashar, D. C., Emissions of SO<sub>2</sub> and NO<sub>x</sub> from biofuels in India: *Tellus Series B-Chemical and Physical Meteorology*, 55, 787-795, doi:10.1034/j.1600-0889.2003.00065.x, 2003.
- Gaudichet, A., Echalar, F., Chatenet, B., Quisefit, J. P., Malingre, G., Cachier, H., Buat-Ménard, P., Artaxo, P., and Maenhaut, W., Trace elements in tropical African savanna biomass burning aerosols: *J. Atmos. Chem.*, 22, 19-39, 1995.
- Geron, C., and Hays, M., Air emissions from organic soil burning on the coastal plain of North Carolina: *Atmospheric Environment*, 64, 192-199, doi:10.1016/j.atmosenv.2012.09.065, 2013.
- Gonçalves, C., Alves, C., Evtyugina, M., Mirante, F., Pio, C., Caseiro, A., Schmidl, C., Bauer, H., and Carvalho, F., Characterisation of PM<sub>10</sub> emissions from woodstove combustion of common woods grown in Portugal: *Atmospheric Environment*, 44, 4474-4480, doi:10.1016/j.atmosenv.2010.07.026, 2010.



- Gonçalves, C., Alves, C., and Pio, C., Inventory of fine particulate organic compound emissions from residential wood combustion in Portugal: *Atmospheric Environment*, 50, 297-306, doi:10.1016/j.atmosenv.2011.12.013, 2012.
- Goode, J. G., Yokelson, R. J., Susott, R. A., and Ward, D. E., Trace gas emissions from laboratory biomass fires measured by open-path Fourier transform infrared spectroscopy: Fires in grass and surface fuels: *J. Geophys. Res.*, 104, 21,237-21,245, 1999.
- Goode, J. G., Yokelson, R. J., Ward, D. E., Susott, R. A., Babbitt, R. E., Davies, M. A., and Hao, W.-M., Measurements of excess O<sub>3</sub>, CO<sub>2</sub>, CO, CH<sub>4</sub>, C<sub>2</sub>H<sub>4</sub>, C<sub>2</sub>H<sub>2</sub>, HCN, NO, NH<sub>3</sub>, HCOOH, CH<sub>3</sub>COOH, HCHO, and CH<sub>3</sub>OH in 1997 Alaskan biomass burning plumes by airborne Fourier transform infrared spectroscopy (AFTIR): *J. Geophys. Res.*, 105, 22,147-22,166, 2000.
- Graham, B., Mayol-Bracero, O. L., Guyon, P., Roberts, G. C., Decesari, S., Facchini, M. C., Artaxo, P., Maenhaut, W., Köll, P., and Andreae, M. O., Water-soluble organic compounds in biomass burning aerosols over Amazonia: 1. Characterization by NMR and GC-MS: *J. Geophys. Res.*, 107, 8047, doi:10.1029/2001JD000336, 2002.
- Greenberg, J. P., Zimmerman, P. R., Heidt, L., and Pollock, W., Hydrocarbon and carbon monoxide emissions from biomass burning in Brazil: *J. Geophys. Res.*, 89, 1350-1354, 1984.
- Griffith, D. W. T., Mankin, W. G., Coffey, M. T., Ward, D. E., and Riebau, A., FTIR remote sensing of biomass burning emissions of CO<sub>2</sub>, CO, CH<sub>4</sub>, CH<sub>2</sub>O, NO, NO<sub>2</sub>, NH<sub>3</sub>, and N<sub>2</sub>O, in *Global Biomass Burning: Atmospheric, Climatic and Biospheric Implications*, edited by J. S. Levine, pp. 230-239, MIT Press, Cambridge, Mass., 1991.
- Guérette, E. A., Paton-Walsh, C., Desservettaz, M., Smith, T. E. L., Volkova, L., Weston, C. J., and Meyer, C. P., Emissions of trace gases from Australian temperate forest fires: emission factors and dependence on modified combustion efficiency: *Atmos. Chem. Phys.*, 18, 3717-3735, doi:10.5194/acp-18-3717-2018, 2018.
- Guyon, P., Frank, G. P., Welling, M., Chand, D., Artaxo, P., Rizzo, L., Nishioka, G., Kolle, O., Fritsch, H., Silva Dias, M. A. F., Gatti, L. V., Cordova, A. M., and Andreae, M. O., Airborne measurements of trace gases and aerosol particle emissions from biomass burning in Amazonia: *Atmos. Chem. Phys.*, 5, 2989–3002, 2005.
- Habib, G., Venkataraman, C., Shrivastava, M., Banerjee, R., Stehr, J. W., and Dickerson, R. R., A new methodology for estimating biofuel consumption for cooking: Atmospheric emissions of black carbon and sulfur dioxide from India: *Global Biogeochemical Cycles*, 18, GB3007, doi:10.1029/2003GB002157, 2004.
- Habib, G., Venkataraman, C., Bond, T. C., and Schauer, J. J., Chemical, microphysical and optical properties of primary particles from the combustion of biomass fuels: *Environ. Sci. Technol.*, 42, 8829-8834, 2008.
- Hall, D., Wu, C. Y., Hsu, Y. M., Stormer, J., Engling, G., Capeto, K., Wang, J., Brown, S., Li, H. W., and Yu, K. M., PAHs, carbonyls, VOCs and PM<sub>2.5</sub> emission factors for pre-harvest burning of Florida sugarcane: *Atmospheric Environment*, 55, 164-172, doi:10.1016/j.atmosenv.2012.03.034, 2012.
- Hamada, Y., Darung, U., Limin, S. H., and Hatano, R., Characteristics of fire-generated gas emission observed during a large peatland fire in 2009 at Kalimantan, Indonesia: *Atmospheric Environment*, 74, 177-181, doi:10.1016/j.atmosenv.2013.03.058, 2013.
- Hao, W.-M., and Ward, D. E., Methane production from global biomass burning: *J. Geophys. Res.*, 98, 20,657-20,661, 1993.

- Hao, W.-M., Ward, D. E., Olbu, G., and Baker, S. P., Emissions of CO<sub>2</sub>, CO and hydrocarbons from fires in diverse African savanna ecosystems: *J. Geophys. Res.*, 101, 23,577-23,584, 1996a.
- Hao, W. M., Ward, D. E., Olbu, G., Baker, S. P., and Plummer, J. R., Emissions of trace gases from fallow forests and woodland savannas in Zambia, in *Biomass Burning and Global Change*, edited by J. S. Levine, pp. 361-369, MIT Press, Cambridge, Mass., 1996b.
- Hao, W. M., and Babbitt, R. E., Smoke production from residual combustion. Final Report 98-1-9-01, Joint Fire Science Program, 25 p. (2007).
- Harden, J. W., Neff, J. C., Sandberg, D. V., Turetsky, M. R., Ottmar, R., Gleixner, G., Fries, T. L., and Manies, K. L., Chemistry of burning the forest floor during the FROSTFIRE experimental burn, interior Alaska, 1999: *Global Biogeochemical Cycles*, 18, GB3014, doi:10.1029/2003gb002194, 2004.
- Hartmann, W. (1990). *Carbonsäuren in der Atmosphäre*, Ph. D. Thesis, Universität Mainz.
- Hatch, L. E., Luo, W., Pankow, J. F., Yokelson, R. J., Stockwell, C. E., and Barsanti, K. C., Identification and quantification of gaseous organic compounds emitted from biomass burning using two-dimensional gas chromatography–time-of-flight mass spectrometry: *Atmos. Chem. Phys.*, 15, 1865-1899, doi:10.5194/acp-15-1865-2015, 2015.
- Haumann, F. A., Batenburg, A. M., Pieterse, G., Gerbig, C., Krol, M. C., and Röckmann, T., Emission ratio and isotopic signatures of molecular hydrogen emissions from tropical biomass burning: *Atmos. Chem. Phys.*, 13, 9401-9413, doi:10.5194/acp-13-9401-2013, 2013.
- Hayashi, K., Ono, K., Kajiura, M., Sudo, S., Yonemura, S., Fushimi, A., Saitoh, K., Fujitani, Y., and Tanabe, K., Trace gas and particle emissions from open burning of three cereal crop residues: Increase in residue moistness enhances emissions of carbon monoxide, methane, and particulate organic carbon: *Atmospheric Environment*, 95, 36-44, doi:10.1016/j.atmosenv.2014.06.023, 2014.
- Hays, M. D., Geron, C. D., Linna, K. J., Smith, N. D., and Schauer, J. J., Speciation of gas-phase and fine particle emissions from burning of foliar fuels: *Environ. Sci. Technol.*, 36, 2281-2295, 2002.
- Hays, M. D., Fine, P. M., Geron, C. D., Kleeman, M. J., and Gullett, B. K., Open burning of agricultural biomass: Physical and chemical properties of particle-phase emissions: *Atmospheric Environment*, 39, 6747-6764, 2005.
- Hedberg, E., Kristensson, A., Ohlsson, M., Johansson, C., Johansson, P.-A., Swietlicki, E., Vesely, V., Widequist, U., and Westerholm, R., Chemical and physical characterization of emissions from birch wood combustion in a wood stove: *Atmospheric Environment*, 36, 4823-4837, 2002.
- Hegg, D. A., Radke, L. F., Hobbs, P. V., Rasmussen, R. A., and Riggan, P. J., Emissions of some trace gases from biomass fires: *J. Geophys. Res.*, 95, 5669-5675, 1990.
- Helas, G., Lobert, J., Scharffe, D., Schäfer, L., Goldammer, J., Baudet, J., Ajavon, A.-L., Ahoua, B., Lacaux, J.-P., Delmas, R., and Andreae, M. O., Airborne measurements of savanna fire emissions and the regional distribution of pyrogenic pollutants over western Africa: *J. Atmos. Chem.*, 22, 217-239, 1995.
- Hildemann, L. M., Markowski, G. R., and Cass, G. R., Chemical composition of emissions from urban sources of fine organic aerosol: *Environ. Sci. Technol.*, 25, 744-759, 1991.
- Hobbs, P. V., Reid, J. S., Herring, J. A., Nance, J. D., Weiss, R. E., Ross, J. L., Hegg, D. A., Ottmar, R. D., and Lioussé, C., Particle and trace-gas measurements in the smoke from

- prescribed burns of forest products in the Pacific Northwest, in *Biomass Burning and Global Change*, edited by J. S. Levine, pp. 697-715, MIT Press, Cambridge, Mass., 1996.
- Hodgson, A. K., Morgan, W. T., O'Shea, S., Bauguitte, S., Allan, J. D., Darbyshire, E., Flynn, M. J., Liu, D., Lee, J., Johnson, B., Haywood, J. M., Longo, K. M., Artaxo, P. E., and Coe, H., Near-field emission profiling of tropical forest and Cerrado fires in Brazil during SAMBBA 2012: *Atmos. Chem. Phys.*, 18, 5619-5638, doi:10.5194/acp-18-5619-2018, 2018.
- Holder, A. L., Hagler, G. S. W., Aurell, J., Hays, M. D., and Gullett, B. K., Particulate matter and black carbon optical properties and emission factors from prescribed fires in the southeastern United States: *J. Geophys. Res.*, 121, 3465-3483, doi:10.1002/2015JD024321, 2016.
- Holder, A. L., Gullett, B. K., Urbanski, S. P., Elleman, R., O'Neill, S., Tabor, D., Mitchell, W. V., and Baker, K. R., Emissions from prescribed burning of agricultural fields in the Pacific Northwest: *Atmospheric Environment*, 166, 22-33, doi:<http://dx.doi.org/10.1016/j.atmosenv.2017.06.043>, 2017.
- Holzinger, R. (1998). *Zeitlich hoch aufgelöste Konzentrationen von volatilen organischen Komponenten in der unteren Troposphäre sowie Quantifizierung der Emissionen aus Biomasseverbrennung in den Tropen*. Ph. D. Thesis, Innsbruck, Austria, 196 p.
- Holzinger, R., Warneke, C., Hansel, A., Jordan, A., Lindinger, W., Scharffe, D. H., Schade, G., and Crutzen, P. J., Biomass burning as a source of formaldehyde, acetaldehyde, methanol, acetone, acetonitrile, and hydrogen cyanide: *Geophys. Res. Lett.*, 26, 1161-1164, 1999.
- Hornbrook, R. S., Blake, D. R., Diskin, G. S., Fried, A., Fuelberg, H. E., Meinardi, S., Mikoviny, T., Richter, D., Sachse, G. W., Vay, S. A., Walega, J., Weibring, P., Weinheimer, A. J., Wiedinmyer, C., Wisthaler, A., Hills, A., Riemer, D. D., and Apel, E. C., Observations of nonmethane organic compounds during ARCTAS - Part 1: Biomass burning emissions and plume enhancements: *Atmos. Chem. Phys.*, 11, 11103-11130, doi:10.5194/acp-11-11103-2011, 2011.
- Hosseini, S., Urbanski, S. P., Dixit, P., Qi, L., Burling, I. R., Yokelson, R. J., Johnson, T. J., Shrivastava, M., Jung, H. S., Weise, D. R., Miller, J. W., and Cocker, D. R., Laboratory characterization of PM emissions from combustion of wildland biomass fuels: *J. Geophys. Res.*, 118, 9914-9929, doi:10.1002/jgrd.50481, 2013.
- Howard, D., Macsween, K., Edwards, G. C., Desservettaz, M., Guérette, E.-A., Paton-Walsh, C., Surawski, N. C., Sullivan, A. L., Weston, C., Volkova, L., Powell, J., Keywood, M. D., Reisen, F., and Meyer, C. P., Investigation of mercury emissions from burning of Australian eucalypt forest surface fuels using a combustion wind tunnel and field observations: *Atmospheric Environment*, 202, 17-27, doi:10.1016/j.atmosenv.2018.12.015, 2019.
- Huang, H.-L., Lee, W.-M. G., and Wu, F.-S., Emissions of air pollutants from indoor charcoal barbecue: *Journal of Hazardous Materials*, 302, 198-207, doi:10.1016/j.jhazmat.2015.09.048, 2016.
- Huang, X., Li, M. M., Friedli, H. R., Song, Y., Chang, D., and Zhu, L., Mercury emissions from biomass burning in China: *Environ. Sci. Technol.*, 45, 9442-9448, doi:10.1021/es202224e, 2011.
- Huijnen, V., Wooster, M. J., Kaiser, J. W., Gaveau, D. L. A., Flemming, J., Parrington, M., Inness, A., Murdiyarso, D., Main, B., and van Weele, M., Fire carbon emissions over

- maritime southeast Asia in 2015 largest since 1997: *Scientific Reports*, 6, 26886, doi:10.1038/srep26886, 2016.
- Hurst, D. F., Griffith, D. W. T., Carras, J. N., Williams, D. J., and Fraser, P. J., Measurements of trace gases emitted by Australian savanna fires during the 1990 dry season: *J. Atmos. Chem.*, 18, 33-56, 1994a.
- Hurst, D. F., Griffith, D. W. T., and Cook, G. D., Trace gas emissions from biomass burning in tropical Australian savannas: *J. Geophys. Res.*, 99, 16,441-16,456, 1994b.
- Hurst, D. F., Griffith, D. W. T., and Cook, G. D., Trace-gas emissions from biomass burning in Australia, in *Biomass Burning and Global Change*, edited by J. S. Levine, pp. 787-792, MIT Press, Cambridge, Mass., 1996.
- Inomata, S., Tanimoto, H., Pan, X., Taketani, F., Komazaki, Y., Miyakawa, T., Kanaya, Y., and Wang, Z., Laboratory measurements of emission factors of nonmethane volatile organic compounds from burning of Chinese crop residues: *J. Geophys. Res.*, 120, 5237-5252, doi:10.1002/2014JD022761, 2015.
- Irfan, M., Riaz, M., Arif, M. S., Shahzad, S. M., Saleem, F., Naveed ur, R., van den Berg, L., and Abbas, F., Estimation and characterization of gaseous pollutant emissions from agricultural crop residue combustion in industrial and household sectors of Pakistan: *Atmospheric Environment*, 84, 189-197, doi:10.1016/j.atmosenv.2013.11.046, 2014.
- Jayarathne, T., Stockwell, C. E., Bhawe, P. V., Praveen, P. S., Rathnayake, C. M., Islam, M. R., Panday, A. K., Adhikari, S., Maharjan, R., Goetz, J. D., DeCarlo, P. F., Saikawa, E., Yokelson, R. J., and Stone, E. A., Nepal Ambient Monitoring and Source Testing Experiment (NAMaSTE): emissions of particulate matter from wood- and dung-fueled cooking fires, garbage and crop residue burning, brick kilns, and other sources: *Atmos. Chem. Phys.*, 18, 2259-2286, doi:10.5194/acp-18-2259-2018, 2018a.
- Jayarathne, T., Stockwell, C. E., Gilbert, A. A., Daugherty, K., Cochrane, M. A., Ryan, K. C., Putra, E. I., Saharjo, B. H., Nurhayati, A. D., Albar, I., Yokelson, R. J., and Stone, E. A., Chemical characterization of fine particulate matter emitted by peat fires in Central Kalimantan, Indonesia, during the 2015 El Niño: *Atmos. Chem. Phys.*, 18, 2585-2600, doi:10.5194/acp-18-2585-2018, 2018b.
- Jenkins, B. M., Jones, A. D., Turn, S. Q., and Williams, R. B., Emission factors for polycyclic aromatic hydrocarbons from biomass burning: *Environ. Sci. Technol.*, 30, 2462-2469, 1996.
- Johnson, B. T., Osborne, S. R., Haywood, J. M., and Harrison, M. A. J., Aircraft measurements of biomass burning aerosol over West Africa during DABEX: *J. Geophys. Res.*, 113, D00c06, doi:10.1029/2007jd009451, 2008a.
- Johnson, M., Edwards, R., Frenk, C. A., and Masera, O., In-field greenhouse gas emissions from cookstoves in rural Mexican households: *Atmospheric Environment*, 42, 1206-1222, doi:10.1016/j.atmosenv.2007.10.034, 2008b.
- Joshi, V., Biomass burning in India, in *Global Biomass Burning: Atmospheric, Climatic, and Biospheric Implications*, edited by J. S. Levine, pp. 185-193, MIT Press, Cambridge, Mass., 1991.
- Jost, C. (2002). *Applications of atmospheric pressure chemical ionization mass spectrometry: Emissions from biomass burning and distribution of sulfur dioxide over northern Europe*, Ph.D. Thesis, Universität Heidelberg.
- Keene, W. C., Lobert, R. M., Crutzen, P. J., Maben, J. R., Scharffe, D. H., Landmann, T., Hely, C., and Brain, C., Emissions of major gaseous and particulate species during

- experimental burns of southern African biomass: J. Geophys. Res., 111, D04301, doi:10.1029/2005JD006319, 2006.
- Keshtkar, H., and Ashbaugh, L. L., Size distribution of polycyclic aromatic hydrocarbon particulate emission factors from agricultural burning: Atmospheric Environment, 41, 2729-2739, doi:10.1016/j.atmosenv.2006.11.043, 2007.
- Kim Oanh, N. T., Ly, B. T., Tipayarom, D., Manandhar, B. R., Prapat, P., Simpson, C. D., and Liu, L. J. S., Characterization of particulate matter emission from open burning of rice straw: Atmospheric Environment, 45, 493-502, doi:10.1016/j.atmosenv.2010.09.023, 2011.
- Kim Oanh, N. T., Tipayarom, A., Bich, T. L., Tipayarom, D., Simpson, C. D., Hardie, D., and Sally Liu, L. J., Characterization of gaseous and semi-volatile organic compounds emitted from field burning of rice straw: Atmospheric Environment, 119, 182-191, doi:<http://dx.doi.org/10.1016/j.atmosenv.2015.08.005>, 2015.
- Kituyi, E., Marufu, L., Wandiga, S. O., Jumba, I. O., Andreae, M. O., and Helas, G., Carbon monoxide and nitric oxide from biofuel fires in Kenya: Energy Conversion and Management, 42, 1517-1542, 2001.
- Koppmann, R., Khedim, A., Rudolph, J., Helas, G., Welling, M., and Zenker, T., Airborne measurements of organic trace gases from savanna fires in southern Africa during SAFARI-92, in *Biomass Burning and Global Change*, edited by J. S. Levine, pp. 309-319, MIT Press, Cambridge, Mass., 1996.
- Korontzi, S., Ward, D. E., Susott, R. A., Yokelson, R. J., Justice, C. O., Hobbs, P. V., Smithwick, E. A. H., and Hao, W. M., Seasonal variation and ecosystem dependence of emission factors for selected trace gases and PM<sub>2.5</sub> for southern African savanna fires: J. Geophys. Res., 108, 4758, doi:10.1029/2003JD003730, 2003.
- Koss, A. R., Sekimoto, K., Gilman, J. B., Selimovic, V., Coggon, M. M., Zarzana, K. J., Yuan, B., Lerner, B. M., Brown, S. S., Jimenez, J. L., Krechmer, J., Roberts, J. M., Warneke, C., Yokelson, R. J., and de Gouw, J., Non-methane organic gas emissions from biomass burning: identification, quantification, and emission factors from PTR-ToF during the FIREX 2016 laboratory experiment: Atmos. Chem. Phys., 18, 3299-3319, doi:10.5194/acp-18-3299-2018, 2018.
- Kudo, S., Tanimoto, H., Inomata, S., Saito, S., Pan, X. L., Kanaya, Y., Taketani, F., Wang, Z. F., Chen, H. Y., Dong, H. B., Zhang, M. G., and Yamaji, K., Emissions of nonmethane volatile organic compounds from open crop residue burning in the Yangtze River Delta region, China: J. Geophys. Res., 119, 7684-7698, doi:10.1002/2013jd021044, 2014.
- Kuhlbusch, T. A., Lobert, J. M., Crutzen, P. J., and Warneck, P., Molecular nitrogen emissions from denitrification during biomass burning: Nature, 351, 135-137, 1991.
- Lacaux, J.-P., Cachier, H., and Delmas, R., Biomass burning in Africa: An overview of its impact on atmospheric chemistry, in *Fire in the Environment: The Ecological, Atmospheric, and Climatic Importance of Vegetation Fires*, edited by P. J. Crutzen & J. G. Goldammer, pp. 159-191, J. Wiley & Sons, Chichester, England, 1993.
- Lacaux, J.-P., Delmas, R., Jambert, C., and Kuhlbusch, T. A. J., NO<sub>x</sub> emissions from African savanna fires: J. Geophys. Res., 101, 23,585-23,596, 1996.
- Lacaux, J. P., Brustet, J. M., Delmas, R., Menaut, J. C., Abbadie, L., Bonsang, B., Cachier, H., Baudet, J., Andreae, M. O., and Helas, G., Biomass burning in the tropical savannas of Ivory Coast: An overview of the field experiment Fire Of Savannas (FOS/DECAFE '91): J. Atmos. Chem., 22, 195-216, 1995.

- Landis, M. S., Edgerton, E. S., White, E. M., Wentworth, G. R., Sullivan, A. P., and Dillner, A. M., The impact of the 2016 Fort McMurray Horse River Wildfire on ambient air pollution levels in the Athabasca Oil Sands Region, Alberta, Canada: *Science of The Total Environment*, 618, 1665-1676, doi:10.1016/j.scitotenv.2017.10.008, 2018.
- Laursen, K. K., Hobbs, P. V., Radke, L. F., and Rasmussen, R. A., Some trace gas emissions from north American biomass fires with an assessment of regional and global fluxes from biomass burning: *J. Geophys. Res.*, 97, 20,687-20,701, 1992.
- Lawson, S. J., Keywood, M. D., Galbally, I. E., Gras, J. L., Cainey, J. M., Cope, M. E., Krummel, P. B., Fraser, P. J., Steele, L. P., Bentley, S. T., Meyer, C. P., Ristovski, Z., and Goldstein, A. H., Biomass burning emissions of trace gases and particles in marine air at Cape Grim, Tasmania: *Atmos. Chem. Phys.*, 15, 13,393-13,411, doi:10.5194/acp-15-13393-2015, 2015.
- Le Breton, M., Bacak, A., Muller, J. B. A., O'Shea, S. J., Xiao, P., Ashfold, M. N. R., Cooke, M. C., Batt, R., Shallcross, D. E., Oram, D. E., Forster, G., Bauguitte, S. J. B., and Percival, C. J., Airborne hydrogen cyanide measurements using a chemical ionisation mass spectrometer for the plume identification of biomass burning forest fires: *Atmos. Chem. Phys.*, 13, 9217-9232, doi:10.5194/acp-13-9217-2013, 2013.
- Le Canut, P., Andreae, M. O., Harris, G. W., Wienhold, F. G., and Zenker, T., Airborne studies of emissions from savanna fires in southern Africa, 1, Aerosol emissions measured with a laser optical particle counter: *J. Geophys. Res.*, 101, 23,615-23,630, 1996.
- Lee, M., Heikes, B. G., Jacob, D. J., Sachse, G., and Anderson, B., Hydrogen peroxide, organic hydroperoxides, and formaldehyde as primary pollutants from biomass burning: *J. Geophys. Res.*, 102, 1301-1309, 1997.
- Lee, S., Baumann, K., Schauer, J. J., Sheesley, R. J., Naeher, L. P., Meinardi, S., Blake, D. R., Edgerton, E. S., Russell, A. G., and Clements, M., Gaseous and particulate emissions from prescribed burning in Georgia: *Environ. Sci. Technol.*, 39, 9049-9056, doi:10.1021/es0515831, 2005.
- Lefer, B. L., Talbot, R. W., Harriss, R. C., Bradshaw, J. D., Sandholm, S. T., Olson, J. O., Sachse, G. W., Collins, J., Shipham, M. A., Blake, D. R., Klemm, K. I., Klemm, O., Gorzelska, K., and Barrick, J., Enhancement of acidic gases in biomass burning impacted air masses over Canada: *J. Geophys. Res.*, 99, 1721-1737, 1994.
- Lewis, A. C., Evans, M. J., Hopkins, J. R., Punjabi, S., Read, K. A., Purvis, R. M., Andrews, S. J., Moller, S. J., Carpenter, L. J., Lee, J. D., Rickard, A. R., Palmer, P. I., and Parrington, M., The influence of biomass burning on the global distribution of selected non-methane organic compounds: *Atmos. Chem. Phys.*, 13, 851-867, doi:10.5194/acp-13-851-2013, 2013.
- Li, C. L., Hu, Y. J., Zhang, F., Chen, J. M., Ma, Z., Ye, X. N., Yang, X., Wang, L., Tang, X. F., Zhang, R. H., Mu, M., Wang, G. H., Kan, H. D., Wang, X. M., and Mellouki, A., Multi-pollutant emissions from the burning of major agricultural residues in China and the related health-economic effects: *Atmos. Chem. Phys.*, 17, 4957-4988, doi:10.5194/acp-17-4957-2017, 2017.
- Li, X. G., Wang, S. X., Duan, L., Hao, J., Li, C., Chen, Y. S., and Yang, L., Particulate and trace gas emissions from open burning of wheat straw and corn stover in China: *Environ. Sci. Technol.*, 41, 6052-6058, doi:10.1021/es0705137, 2007.

- Li, X. H., Wang, S. X., Duan, L., and Hao, J. M., Characterization of non-methane hydrocarbons emitted from open burning of wheat straw and corn stover in China: *Environmental Research Letters*, 4, 044015, doi:10.1088/1748-9326/4/4/044015, 2009a.
- Li, X. H., Wang, S. X., Duan, L., Hao, J. M., and Nie, Y. F., Carbonaceous aerosol emissions from household biofuel combustion in China: *Environ. Sci. Technol.*, 43, 6076-6081, doi:10.1021/es803330j, 2009b.
- Liley, J. B., Baumgardner, D., Kondo, Y., Kita, K., Blake, B. R., Koike, M., Machida, T., Takegawa, N., Kawakami, S., Shirai, T., and Ogawa, T., Black carbon in aerosol during BIBLE B: *J. Geophys. Res.*, 108, 8399, doi:10.1029/2001JD000845, 2003.
- Liousse, C., Penner, J. E., Walton, J. J., Eddleman, H., Chuang, C., and Cachier, H., Modeling biomass burning aerosols, in *Biomass Burning and Global Change*, edited by J. S. Levine, pp. 492-508, MIT Press, Cambridge, Mass., 1996.
- Liu, X., Zhang, Y., Huey, L. G., Yokelson, R. J., Wang, Y., Jimenez, J. L., Campuzano-Jost, P., Beyersdorf, A. J., Blake, D. R., Choi, Y., St. Clair, J. M., Crounse, J. D., Day, D. A., Diskin, G. S., Fried, A., Hall, S. R., Hanisco, T. F., King, L. E., Meinardi, S., Mikoviny, T., Palm, B. B., Peischl, J., Perring, A. E., Pollack, I. B., Ryerson, T. B., Sachse, G., Schwarz, J. P., Simpson, I. J., Tanner, D. J., Thornhill, K. L., Ullmann, K., Weber, R. J., Wennberg, P. O., Wisthaler, A., Wolfe, G. M., and Ziemba, L. D., Agricultural fires in the southeastern U.S. during SEAC4RS: Emissions of trace gases and particles and evolution of ozone, reactive nitrogen, and organic aerosol: *J. Geophys. Res.*, 121, 7383-7414, doi:10.1002/2016JD025040, 2016.
- Liu, X., Huey, L. G., Yokelson, R. J., Selimovic, V., Simpson, I. J., Müller, M., Jimenez, J. L., Campuzano-Jost, P., Beyersdorf, A. J., Blake, D. R., Butterfield, Z., Choi, Y., Crounse, J. D., Day, D. A., Diskin, G. S., Dubey, M. K., Fortner, E., Hanisco, T. F., Hu, W., King, L. E., Kleinman, L., Meinardi, S., Mikoviny, T., Onasch, T. B., Palm, B. B., Peischl, J., Pollack, I. B., Ryerson, T. B., Sachse, G. W., Sedlacek, A. J., Shilling, J. E., Springston, S., St. Clair, J. M., Tanner, D. J., Teng, A. P., Wennberg, P. O., Wisthaler, A., and Wolfe, G. M., Airborne measurements of western U.S. wildfire emissions: Comparison with prescribed burning and air quality implications: *J. Geophys. Res.*, 122, 6108-6129, doi:10.1002/2016JD026315, 2017.
- Lobert, J. M., Scharffe, D. H., Hao, W.-M., and Crutzen, P. J., Importance of biomass burning in the atmospheric budgets of nitrogen- containing gases: *Nature*, 346, 552-554, 1990.
- Lobert, J. M., Scharffe, D. H., Hao, W.-M., Kuhlbusch, T. A., Seuwen, R., Warneck, P., and Crutzen, P. J., Experimental evaluation of biomass burning emissions: Nitrogen and carbon containing compounds, in *Global Biomass Burning: Atmospheric, Climatic and Biospheric Implications*, edited by J. S. Levine, pp. 289-304, MIT Press, Cambridge, Mass., 1991.
- Ludwig, J., Marufu, L. T., Huber, B., Andreae, M. O., and Helas, G., Domestic combustion of biomass fuels in developing countries: A major source of atmospheric pollutants: *J. Atmos. Chem.*, 44, 23-37, 2003.
- Lutsch, E., Dammers, E., Conway, S., and Strong, K., Long-range transport of NH<sub>3</sub>, CO, HCN, and C<sub>2</sub>H<sub>6</sub> from the 2014 Canadian Wildfires: *Geophys. Res. Lett.*, 43, 8286-8297, doi:10.1002/2016gl070114, 2016.
- Manö, S., and Andreae, M. O., Emission of methyl bromide from biomass burning: *Science*, 263, 1255-1257, 1994.

- Manö, S., Messung von partiell oxidierten Kohlenwasserstoffen in Emissionen von Biomasseverbrennung. Ph.D. Thesis. Frankfurt: Goethe-Universität, 120 p, 1995.
- Martins, J. V., Artaxo, P., Hobbs, P. V., Liousse, C., Cachier, H., Kaufman, Y., and Planafattori, A., Particle size distributions, elemental compositions, carbon measurements, and optical properties of smoke from biomass burning in the Pacific Northwest of the United States, in *Biomass Burning and Global Change*, edited by J. S. Levine, pp. 716-732, MIT Press, Cambridge, Mass., 1996.
- Marufu, L., Ludwig, J., Andreae, M. O., Lelieveld, J., and Helas, G., Spatial and temporal variation in biofuel consumption rates and patterns in Zimbabwe: Implications for atmospheric trace gas emission: *Biomass and Bioenergy*, 16, 311-332, 1999.
- Masclat, P., Cachier, H., Liousse, C., and Wortham, H., Emissions of polycyclic aromatic hydrocarbons by savanna fires: *J. Atmos. Chem.*, 22, 41-54, 1995.
- May, A. A., McMeeking, G. R., Lee, T., Taylor, J. W., Craven, J. S., Burling, I., Sullivan, A. P., Akagi, S., Collett, J. L., Flynn, M., Coe, H., Urbanski, S. P., Seinfeld, J. H., Yokelson, R. J., and Kreidenweis, S. M., Aerosol emissions from prescribed fires in the United States: A synthesis of laboratory and aircraft measurements: *J. Geophys. Res.*, 119, 11,826–11,849, doi:10.1002/2014JD021848, 2014.
- McDonald, R. D., Zielinska, B., Fujita, E. M., Sagebiel, J. C., Chow, J. C., and Watson, J. G., Fine particle and gaseous emission rates from residential wood combustion: *Environ. Sci. Technol.*, 34, 2080-2091, 2000.
- McKenzie, L. M., Hao, W. M., Richards, G. N., and Ward, D. E., Measurement and modeling of air toxins from smoldering combustion of biomass: *Environ. Sci. Technol.*, 29, 2047-2054, 1995.
- McMeeking, G. R., Kreidenweis, S. M., Baker, S., Carrico, C. M., Chow, J. C., Collett, J. L., Hao, W. M., Holden, A. S., Kirchstetter, T. W., Malm, W. C., Moosmuller, H., Sullivan, A. P., and Wold, C. E., Emissions of trace gases and aerosols during the open combustion of biomass in the laboratory: *J. Geophys. Res.*, 114, D19210, doi:10.1029/2009jd011836, 2009.
- Mebust, A. K., Russell, A. R., Hudman, R. C., Valin, L. C., and Cohen, R. C., Characterization of wildfire NO<sub>x</sub> emissions using MODIS fire radiative power and OMI tropospheric NO<sub>2</sub> columns: *Atmos. Chem. Phys.*, 11, 5839-5851, doi:10.5194/acp-11-5839-2011, 2011.
- Medeiros, P. M., and Simoneit, B. R. T., Source profiles of organic compounds emitted upon combustion of green vegetation from temperate climate forests: *Environ. Sci. Technol.*, 42, 8310-8316, doi:10.1021/es801533b, 2008.
- Melendez-Perez, J. J., Fostier, A. H., Carvalho, J. A., Jr., Windmoeller, C. C., Santos, J. C., and Carpi, A., Soil and biomass mercury emissions during a prescribed fire in the Amazonian rain forest: *Atmospheric Environment*, 96, 415-422, doi:10.1016/j.atmosenv.2014.06.032, 2014.
- Miner, S., Preliminary air pollution survey of ammonia, Report APTD-69-25. Raleigh, N.C.: Nat. Air Pollut. Control Admin., 39 p, 1969.
- Miura, Y., and Kanno, T., Emissions of trace gases (CO<sub>2</sub>, CO, CH<sub>4</sub>, N<sub>2</sub>O) resulting from rice straw burning: *Soil Sci. Plant Nutr.*, 43, 849-854, 1997.
- Mugica-Álvarez, V., Hernández-Rosas, F., Magaña-Reyes, M., Herrera-Murillo, J., Santiago-De La Rosa, N., Gutiérrez-Arzaluz, M., de Jesús Figueroa-Lara, J., and González-Cardoso, G., Sugarcane burning emissions: Characterization and emission factors: *Atmospheric Environment*, 193, 262-272, doi:10.1016/j.atmosenv.2018.09.013, 2018.



- Müller, M., Anderson, B. E., Beyersdorf, A. J., Crawford, J. H., Diskin, G. S., Eichler, P., Fried, A., Keutsch, F. N., Mikoviny, T., Thornhill, K. L., Walega, J. G., Weinheimer, A. J., Yang, M., Yokelson, R. J., and Wisthaler, A., In situ measurements and modeling of reactive trace gases in a small biomass burning plume: *Atmos. Chem. Phys.*, 16, 3813-3824, doi:10.5194/acp-16-3813-2016, 2016.
- Munchak, L. A., Schichtel, B. A., Sullivan, A. P., Holden, A. S., Kreidenweis, S. M., Malm, W. C., and Collett, J. L., Development of wildland fire particulate smoke marker to organic carbon emission ratios for the conterminous United States: *Atmospheric Environment*, 45, 395-403, doi:10.1016/j.atmosenv.2010.10.006, 2011.
- Nance, J. D., Hobbs, P. V., Radke, L. F., and Ward, D. E., Airborne measurements of gases and particles from an Alaskan wildfire: *J. Geophys. Res.*, 98, 14,873-14,882, 1993.
- Nara, H., Tanimoto, H., Tohjima, Y., Mukai, H., Nojiri, Y., and Machida, T., Emission factors of CO<sub>2</sub>, CO and CH<sub>4</sub> from Sumatran peatland fires in 2013 based on shipboard measurements: *Tellus Series B-Chemical and Physical Meteorology*, 69, doi:10.1080/16000889.2017.1399047, 2017.
- Nguyen, B. C., Rice straw burning in southeast Asia as a source of CO and COS to the atmosphere: *J. Geophys. Res.*, 99, 16,435-16,439, 1994.
- Nguyen, B. C., Mihalopoulos, N., Putaud, J. P., and Bonsang, B., Carbonyl sulfide emissions from biomass burning in the tropics: *J. Atmos. Chem.*, 22, 55-65, 1995.
- Ni, H. Y., Han, Y. M., Cao, J. J., Chen, L. W. A., Tian, J., Wang, X. L., Chow, J. C., Watson, J. G., Wang, Q. Y., Wang, P., Li, H., and Huang, R. J., Emission characteristics of carbonaceous particles and trace gases from open burning of crop residues in China: *Atmospheric Environment*, 123, 399-406, doi:10.1016/j.atmosenv.2015.05.007, 2015.
- Ni, H. Y., Tian, J., Wang, X. L., Wang, Q. Y., Han, Y. M., Cao, J. J., Long, X., Chen, L. W. A., Chow, J. C., Watson, J. G., Huang, R. J., and Dusek, U., PM<sub>2.5</sub> emissions and source profiles from open burning of crop residues: *Atmospheric Environment*, 169, 229-237, doi:10.1016/j.atmosenv.2017.08.063, 2017.
- Njenga, M., Karanja, N., Karlsson, H., Jamnadass, R., Iiyama, M., Kithinji, J., and Sundberg, C., Additional cooking fuel supply and reduced global warming potential from recycling charcoal dust into charcoal briquette in Kenya: *Journal of Cleaner Production*, 81, 81-88, doi:10.1016/j.jclepro.2014.06.002, 2014.
- O'Shea, S. J., Allen, G., Gallagher, M. W., Bauguitte, S. J. B., Illingworth, S. M., Le Breton, M., Muller, J. B. A., Percival, C. J., Archibald, A. T., Oram, D. E., Parrington, M., Palmer, P. I., and Lewis, A. C., Airborne observations of trace gases over boreal Canada during BORTAS: campaign climatology, air mass analysis and enhancement ratios: *Atmos. Chem. Phys.*, 13, 12,451-12,467, doi:10.5194/acp-13-12451-2013, 2013.
- Obrist, D., Moosmüller, H., Schürmann, R., Chen, L. W. A., and Kreidenweis, S. M., Particulate-phase and gaseous elemental mercury emissions during biomass combustion: Controlling factors and correlation with particulate matter emissions: *Environ. Sci. Technol.*, 42, 721-727, doi:10.1021/es071279n, 2008.
- Oros, D. R., and Simoneit, B. R. T., Identification and emission factors of molecular tracers in organic aerosols from biomass burning Part 1. Temperate climate conifers: *Applied Geochemistry*, 16, 1513-1544, doi:10.1016/s0883-2927(01)00021-x, 2001a.
- Oros, D. R., and Simoneit, B. R. T., Identification and emission factors of molecular tracers in organic aerosols from biomass burning Part 2. Deciduous trees: *Applied Geochemistry*, 16, 1545-1565, doi:10.1016/s0883-2927(01)00022-1, 2001b.

- Oros, D. R., bin Abas, M. R., Omar, N., Rahman, N. A., and Simoneit, B. R. T., Identification and emission factors of molecular tracers in organic aerosols from biomass burning: Part 3. Grasses: *Applied Geochemistry*, 21, 919-940, doi:10.1016/j.apgeochem.2006.01.008, 2006.
- Pallozzi, E., Lusini, I., Cherubini, L., Hajiaghayeva, R. A., Ciccioli, P., and Calafapietra, C., Differences between a deciduous and a conifer tree species in gaseous and particulate emissions from biomass burning: *Environmental Pollution*, 234, 457-467, doi:doi.org/10.1016/j.envpol.2017.11.080, 2018.
- Pandey, A., Patel, S., Pervez, S., Tiwari, S., Yadama, G., Chow, J. C., Watson, J. G., Biswas, P., and Chakrabarty, R. K., Aerosol emissions factors from traditional biomass cookstoves in India: insights from field measurements: *Atmos. Chem. Phys.*, 17, 13721-13729, doi:10.5194/acp-17-13721-2017, 2017.
- Parashar, D. C., Gadi, R., Mandal, T. K., and Mitra, A. P., Carbonaceous aerosol emissions from India: *Atmospheric Environment*, 39, 7861-7871, doi:10.1016/j.atmosenv.2005.08.034, 2005.
- Park, S.-K., Choi, S.-J., Kim, J.-Y., Park, G.-J., Hwang, U.-H., Lee, J.-J., and Kim, T.-S., A field survey on the characteristics of air pollutants emission from commercial charcoal kiln: *Journal of Korean Society for Atmospheric Environment*, 29, 601-614, doi:10.5572/kosae.2013.29.5.601, 2013.
- Paton-Walsh, C., Jones, N. B., Wilson, S. R., Haverd, V., Meier, A., Griffith, D. W. T., and Rinsland, C. P., Measurements of trace gas emissions from Australian forest fires and correlations with coincident measurements of aerosol optical depth: *J. Geophys. Res.*, 110, D24305, doi:10.1029/2005JD006202, 2005.
- Paton-Walsh, C., Wilson, S. R., Jones, N. B., and Griffith, D. W. T., Measurement of methanol emissions from Australian wildfires by ground-based solar Fourier transform spectroscopy: *Geophys. Res. Lett.*, 35, L08810, doi:10.1029/2007GL032951, 2008.
- Paton-Walsh, C., Deutscher, N. M., Griffin, D. W. T., Forgan, B. W., Wilson, S. R., Jones, N. B., and Edwards, D. P., Trace gas emissions from savanna fires in northern Australia: *J. Geophys. Res.*, 115, D16314, doi:10.1029/2009JD013309, 2010.
- Pennise, D. M., Smith, K. R., Kithinji, J. P., Rezende, M. E., Raad, T. J., Zhang, J. F., and Fan, C. W., Emissions of greenhouse gases and other airborne pollutants from charcoal making in Kenya and Brazil: *J. Geophys. Res.*, 106, 24,143-24,155, 2001.
- Pham-Van-Dinh, Serpolay, R., and Lacaux, J.-P., Laboratory investigation on aerosols from the combustion of savanna grass and cereal straw, in *Biomass Burning and Global Change*, edited by J. S. Levine, pp. 472-484, MIT Press, Cambridge, Mass., 1996.
- Piccot, S. D., Beck, L., Srinivasan, S., and Kersteter, S. L., Global methane emissions from minor anthropogenic sources and biofuel combustion in residential stoves: *J. Geophys. Res.*, 101, 22,757-22,766, 1996.
- Pöhlker, M. L., Ditas, F., Saturno, J., Klimach, T., Hrabě de Angelis, I., Araùjo, A. C., Brito, J., Carbone, S., Cheng, Y., Chi, X., Ditz, R., Gunthe, S. S., Holanda, B. A., Kandler, K., Kesselmeier, J., Könemann, T., Krüger, O. O., Lavrič, J. V., Martin, S. T., Mikhailov, E., Moran-Zuloaga, D., Rizzo, L. V., Rose, D., Su, H., Thalman, R., Walter, D., Wang, J., Wolff, S., Barbosa, H. M. J., Artaxo, P., Andreae, M. O., Pöschl, U., and Pöhlker, C., Long-term observations of cloud condensation nuclei over the Amazon rain forest – Part 2: Variability and characteristics of biomass burning, long-range transport, and pristine

- rain forest aerosols: *Atmos. Chem. Phys.*, 18, 10289-10331, doi:10.5194/acp-18-10289-2018, 2018.
- Prasad, V. K., Gupta, P. K., Sharma, C., Sarkar, A. K., Kant, Y., Badarinath, K. V. S., Rajagopal, T., and Mitra, A. P., NO<sub>x</sub> emissions from biomass burning of shifting cultivation areas from tropical deciduous forests of India - estimates from ground-based measurements: *Atmospheric Environment*, 34, 3271-3280, 2000.
- Radke, L. F., Hegg, D. A., Lyons, J. H., Brock, C. A., Hobbs, P. V., Weiss, R., and Rasmussen, R., Airborne measurements on smokes from biomass burning, in *Aerosols and Climate*, edited by P. V. Hobbs & M. P. McCormick, pp. 411-422, A. Deepak Publishing, Hampton, VA, 1988.
- Radke, L. F., Lyons, J. H., Hobbs, P. V., Hegg, D. A., Sandberg, D. V., and Ward, D. E., Airborne Monitoring and Smoke Characterization of Prescribed Fires on Forest Lands in Western Washington and Oregon: Final Report USDA Forest Service General Technical Report PNW-GTR-251. Portland, Ore., USA: USDA Forest Service, 81 p, 1990.
- Radke, L. F., Hegg, D. A., Hobbs, P. V., Nance, J. D., Lyons, J. H., Laursen, K. K., Weiss, R. E., Riggan, P. J., and Ward, D. E., Particulate and trace gas emissions from large biomass fires in North America, in *Global Biomass Burning: Atmospheric, Climatic and Biospheric Implications*, edited by J. S. Levine, pp. 209-224, MIT Press, Cambridge, Mass., 1991.
- Rasmussen, R. A., Rasmussen, L. E., Khalil, M. A. K., and Dalluge, R. W., Concentration distribution of methyl chloride in the atmosphere: *J. Geophys. Res.*, 85, 7350-7356, 1980.
- Reinhardt, T. E., and Ward, D. E., Factors affecting methyl chloride emissions from forest biomass combustion: *Environ. Sci. Tech.*, 29, 825-832, 1995.
- Reisen, F., Meyer, C. P., Weston, C. J., and Volkova, L., Ground-based field measurements of PM<sub>2.5</sub> emission factors from flaming and smoldering combustion in eucalypt forests: *J. Geophys. Res.*, 123, 8301-8314, doi:10.1029/2018JD028488, 2018.
- Rinsland, C. P., Dufour, G., Boone, C. D., Bernath, P. F., Chiou, L., Coheur, P. F., Turquety, S., and Clerbaux, C., Satellite boreal measurements over Alaska and Canada during June-July 2004: Simultaneous measurements of upper tropospheric CO, C<sub>2</sub>H<sub>6</sub>, HCN, CH<sub>3</sub>Cl, CH<sub>4</sub>, C<sub>2</sub>H<sub>2</sub>, CH<sub>3</sub>OH, HCOOH, OCS, and SF<sub>6</sub> mixing ratios: *Global Biogeochemical Cycles*, 21, GB3008, doi:10.1029/2006gb002795, 2007.
- Robertson, K. M., Hsieh, Y. P., and Bugna, G. C., Fire environment effects on particulate matter emission factors in southeastern U.S. pine-grasslands: *Atmospheric Environment*, 99, 104-111, doi:10.1016/j.atmosenv.2014.09.058, 2014.
- Roden, C. A., Bond, T. C., Conway, S., and Pinel, A. B. O., Emission factors and real-time optical properties of particles emitted from traditional wood burning cookstoves: *Environ. Sci. Technol.*, 40, 6750-6757, 2006.
- Roden, C. A., Bond, T. C., Conway, S., Pinel, A. B. S., MacCarty, N., and Still, D., Laboratory and field investigations of particulate and carbon monoxide emissions from traditional and improved cookstoves: *Atmospheric Environment*, 43, 1170-1181, doi:10.1016/j.atmosenv.2008.05.041, 2009.
- Romasanta, R. R., Sander, B. O., Gaihe, Y. K., Alberto, M. C., Gummert, M., Quilty, J., Nguyen, V. H., Castalone, A. G., Balingbing, C., Sandro, J., Correa, T., and Wassmann, R., How does burning of rice straw affect CH<sub>4</sub> and N<sub>2</sub>O emissions? A comparative experiment of different on-field straw management practices: *Agriculture Ecosystems & Environment*, 239, 143-153, doi:10.1016/j.agee.2016.12.042, 2017.

- Rudolph, J., Khedim, A., Koppmann, R., and Bonsang, B., Field study of the emissions of methyl chloride and other halocarbons from biomass burning in western Africa: *J. Atmos. Chem.*, 22, 67-80, 1995.
- Saarnak, C. F., Nielsen, T. T., and Mbow, C., A local-scale study of the trace gas emissions from vegetation burning around the village of Dalun, Ghana, with respect to seasonal vegetation changes and burning practices: *Clim. Change*, 56, 321-338, 2003.
- Sahai, S., Sharma, C., Singh, D. P., Dixit, C. K., Singh, N., Sharma, P., Singh, K., Bhatt, S., Ghude, S., Gupta, V., Gupta, R. K., Tiwari, M. K., Garg, S. C., Mitra, A. P., and Gupta, P. K., A study for development of emission factors for trace gases and carbonaceous particulate species from in situ burning of wheat straw in agricultural fields in India: *Atmospheric Environment*, 41, 9173-9186, doi:10.1016/j.atmosenv.2007.07.054, 2007.
- Sahu, L. K., Kondo, Y., Moteki, N., Takegawa, N., Zhao, Y., Cubison, M. J., Jimenez, J. L., Vay, S., Diskin, G. S., Wisthaler, A., Mikoviny, T., Huey, L. G., Weinheimer, A. J., and Knapp, D. J., Emission characteristics of black carbon in anthropogenic and biomass burning plumes over California during ARCTAS-CARB 2008: *J. Geophys. Res.*, 117, D16302, doi:10.1029/2011jd017401, 2012.
- Samburova, V., Connolly, J., Gyawali, M., Yatavelli, R. L. N., Watts, A. C., Chakrabarty, R. K., Zielinska, B., Moosmuller, H., and Khlystov, A., Polycyclic aromatic hydrocarbons in biomass-burning emissions and their contribution to light absorption and aerosol toxicity: *Science of the Total Environment*, 568, 391-401, doi:10.1016/j.scitotenv.2016.06.026, 2016.
- Sanchis, E., Ferrer, M., Calvet, S., Coscolla, C., Yusa, V., and Cambra-Lopez, M., Gaseous and particulate emission profiles during controlled rice straw burning: *Atmospheric Environment*, 98, 25-31, doi:10.1016/j.atmosenv.2014.07.062, 2014.
- Santiago-De la Rosa, N., Mugica-Alvarez, V., Cereceda-Balic, F., Guerrero, F., Yanez, K., and Lapuerta, M., Emission factors from different burning stages of agriculture wastes in Mexico: *Environ. Sci. & Pollut. Res.*, 24, 24297-24310, doi:10.1007/s11356-017-0049-4, 2017.
- Santiago-De La Rosa, N., Gonzalez-Cardoso, G., Figueroa-Lara, J. D., Gutierrez-Arzaluz, M., Octaviano-Villasana, C., Ramirez-Hernandez, I. F., and Mugica-Alvarez, V., Emission factors of atmospheric and climatic pollutants from crop residues burning: *J. Air & Waste Manage. Assoc.*, 68, 849-865, doi:10.1080/10962247.2018.1459326, 2018.
- Saud, T., Mandal, T. K., Gadi, R., Singh, D. P., Sharma, S. K., Saxena, M., and Mukherjee, A., Emission estimates of particulate matter (PM) and trace gases (SO<sub>2</sub>, NO and NO<sub>2</sub>) from biomass fuels used in rural sector of Indo-Gangetic Plain, India: *Atmospheric Environment*, 45, 5913-5923, doi:10.1016/j.atmosenv.2011.06.031, 2011.
- Schauer, J. J. (1998). *Source contributions to atmospheric organic compound concentrations: Emission measurements and model predictions*. Ph. D., California Institute of Technology.
- Schauer, J. J., Kleeman, M. J., Cass, G. R., and Simoneit, B. R. T., Measurement of emissions from air pollution sources. 3. C<sub>1</sub>-C<sub>29</sub> Organic compounds from fireplace combustion of wood: *Environ. Sci. Technol.*, 35, 1716-1728, 2001.
- Schreier, S. F., Richter, A., Schepaschenko, D., Shvidenko, A., Hilboll, A., and Burrows, J. P., Differences in satellite-derived NO<sub>x</sub> emission factors between Eurasian and North American boreal forest fires: *Atmospheric Environment*, 121, 55-65, doi:10.1016/j.atmosenv.2014.08.071, 2015.

- Selimovic, V., Yokelson, R. J., Warneke, C., Roberts, J. M., de Gouw, J., Reardon, J., and Griffith, D. W. T., Aerosol optical properties and trace gas emissions by PAX and OP-FTIR for laboratory-simulated western US wildfires during FIREX: *Atmos. Chem. Phys.*, 18, 2929-2948, doi:10.5194/acp-18-2929-2018, 2018.
- Selimovic, V., Yokelson, R. J., McMeeking, G. R., and Coefield, S., In situ measurements of trace gases, PM, and aerosol optical properties during the 2017 NW US wildfire smoke event: *Atmos. Chem. Phys.*, 19, 3905-3926, doi:10.5194/acp-19-3905-2019, 2019.
- Sheesley, R. J., Schauer, J. J., Chowdhury, Z., Cass, G. R., and Simoneit, B. R. T., Characterization of organic aerosols emitted from the combustion of biomass indigenous to South Asia: *J. Geophys. Res.*, 108, 4285, doi:10.1029/2002JD002981, 2003.
- Shen, G., Wei, S., Wei, W., Zhang, Y., Min, Y., Wang, B., Ron, W., Li, W., Shen, H., Huang, Y., Yang, Y., Wang, W., Wang, X., Wang, X., and Tao, S., Emission factors, size distributions, and emission inventories of carbonaceous particulate matter from residential wood combustion in rural China: *Environ. Sci. Technol.*, 46, 4207-4214, doi:10.1021/es203957u, 2012a.
- Shen, G. F., Yang, Y. F., Wang, W., Tao, S., Zhu, C., Min, Y. J., Xue, M. A., Ding, J. N., Wang, B., Wang, R., Shen, H. Z., Li, W., Wang, X. L., and Russell, A. G., Emission factors of particulate matter and elemental carbon for crop residues and coals burned in typical household stoves in China: *Environ. Sci. Technol.*, 44, 7157-7162, doi:10.1021/es101313y, 2010.
- Shen, G. F., Wang, W., Yang, Y. F., Ding, J. N., Xue, M. A., Min, Y. J., Zhu, C., Shen, H. Z., Li, W., Wang, B., Wang, R., Wang, L., Tao, S., and Russell, A. G., Emissions of PAHs from indoor crop residue burning in a typical rural stove: Emission factors, size distributions, and gas-particle partitioning: *Environ. Sci. Technol.*, 45, 1206-1212, doi:10.1021/es102151w, 2011.
- Shen, G. F., Tao, S., Wei, S. Y., Zhang, Y. Y., Wang, R., Wang, B., Li, W., Shen, H. Z., Huang, Y., Chen, Y. C., Chen, H., Yang, Y. F., Wang, W., Wang, X. L., Liu, W. X., and Simonich, S. L. M., Emissions of parent, nitro, and oxygenated polycyclic aromatic hydrocarbons from residential wood combustion in rural China: *Environ. Sci. Technol.*, 46, 8123-8130, doi:10.1021/es301146v, 2012b.
- Shen, G. F., Tao, S., Chen, Y. C., Zhang, Y. Y., Wei, S. Y., Xue, M., Wang, B., Wang, R., Lu, Y., Li, W., Shen, H. Z., Huang, Y., and Chen, H., Emission characteristics for polycyclic aromatic hydrocarbons from solid fuels burned in domestic stoves in rural China: *Environ. Sci. Technol.*, 47, 14485-14494, doi:10.1021/es403110b, 2013.
- Shen, G. F., Xue, M., Chen, Y. C., Yang, C. L., Li, W., Shen, H. Z., Huang, Y., Zhang, Y. Y., Chen, H., Zhu, Y., Wu, H. S., Ding, A. J., and Tao, S., Comparison of carbonaceous particulate matter emission factors among different solid fuels burned in residential stoves: *Atmospheric Environment*, 89, 337-345, doi:10.1016/j.atmosenv.2014.01.033, 2014.
- Shen, G. F., Chen, Y. C., Xue, C. Y., Lin, N., Huang, Y., Shen, H. Z., Wang, Y. L., Li, T. C., Zhang, Y. Y., Su, S., Huangfu, Y. B., Zhang, W. H., Chen, X. F., Liu, G. Q., Liu, W. X., Wang, X. L., Wong, M. H., and Tao, S., Pollutant emissions from improved coal- and wood-fuelled cookstoves in rural households: *Environ. Sci. Technol.*, 49, 6590-6598, doi:10.1021/es506343z, 2015.
- Shirai, T., Blake, D. R., Meinardi, S., Rowland, F. S., Russell-Smith, J., Edwards, A., Kondo, Y., Koike, M., Kita, K., Machida, T., Takegawa, N., Nishi, N., Kawakami, S., and Ogawa,

- T., Emission estimates of selected volatile organic compounds from tropical savanna burning in northern Australia: *J. Geophys. Res.*, 108, 8406, doi:10.1029/2001JD000841, 2003.
- Sigler, J. M., Lee, X., and Munger, W., Emission and long-range transport of gaseous mercury from a large-scale Canadian boreal forest fire: *Environ. Sci. Technol.*, 37, 4343-4347, doi:10.1021/es026401r, 2003.
- Sillapapiromsuk, S., Chantara, S., Tengjaroenkul, U., Prasitwattanaseree, S., and Prapamontol, T., Determination of PM<sub>10</sub> and its ion composition emitted from biomass burning in the chamber for estimation of open burning emissions: *Chemosphere*, 93, 1912-1919, doi:10.1016/j.chemosphere.2013.06.071, 2013.
- Simpson, I. J., Akagi, S. K., Barletta, B., Blake, N. J., Choi, Y., Diskin, G. S., Fried, A., Fuelberg, H. E., Meinardi, S., Rowland, F. S., Vay, S. A., Weinheimer, A. J., Wennberg, P. O., Wiebring, P., Wisthaler, A., Yang, M., Yokelson, R. J., and Blake, D. R., Boreal forest fire emissions in fresh Canadian smoke plumes: C<sub>1</sub>-C<sub>10</sub> volatile organic compounds (VOCs), CO<sub>2</sub>, CO, NO<sub>2</sub>, NO, HCN and CH<sub>3</sub>CN: *Atmos. Chem. Phys.*, 11, 6,445-6,463, doi:10.5194/acp-11-6445-2011, 2011.
- Singh, H. B., O'Hara, D., Herlth, D., Sachse, G. W., Blake, D. R., Bradshaw, J. D., Kanakidou, M., and Crutzen, P. J., Acetone in the atmosphere: Distribution, sources and sinks: *J. Geophys. Res.*, 99, 1805-1819, 1994.
- Singh, H. B., Anderson, B. E., Brune, W. H., Cai, C., Cohen, R. C., Crawford, J. H., Cubison, M. J., Czech, E. P., Emmons, L., Fuelberg, H. E., Huey, G., Jacob, D. J., Jimenez, J. L., Kaduwela, A., Kondo, Y., Mao, J., Olson, J. R., Sachse, G. W., Vay, S. A., Weinheimer, A., Wennberg, P. O., Wisthaler, A., and the ARCTAS Sci Team, Pollution influences on atmospheric composition and chemistry at high northern latitudes: Boreal and California forest fire emissions: *Atmospheric Environment*, 44, 4553-4564, doi:10.1016/j.atmosenv.2010.08.026, 2010.
- Sinha, P., Hobbs, P. V., Yokelson, R. J., Bertschi, I. T., Blake, D. R., Simpson, I. J., Gao, S., Kirchstetter, T. W., and Novakov, T., Emissions of trace gases and particles from savanna fires in southern Africa: *J. Geophys. Res.*, 108, 8487, doi:10.1029/2002JD002325, 2003.
- Sinha, P., Hobbs, P. V., Yokelson, R. J., Blake, D. R., Gao, S., and Kirchstetter, T. W., Emissions from miombo woodland and dambo grassland savanna fires: *J. Geophys. Res.*, 109, D11305, doi:10.1029/2004jd004521, 2004.
- Sirithian, D., Thepanondh, S., Sattler, M. L., and Laowagul, W., Emissions of volatile organic compounds from maize residue open burning in the northern region of Thailand: *Atmospheric Environment*, 176, 179-187, doi:10.1016/j.atmosenv.2017.12.032, 2018.
- Smith, K. R., Air pollution: Assessing total exposure in developing countries: *Environment*, 30, 16-35, 1988.
- Smith, K. R., Khalil, M. A. K., Rasmussen, R. A., Thorneloe, S. A., Manegdeg, F., and Apte, M., Greenhouse gases from biomass and fossil fuel stoves in developing countries: A Manila pilot study: *Chemosphere*, 26, 479-505, 1993.
- Smith, K. R., Pennise, D. M., Khummongkol, P., Chaiwong, V., Ritgeen, K., Zhang, J., Panyathanya, W., Rasmussen, R. A., and Khalil, M. A. K., Greenhouse Gases From Small-Scale Combustion Devices in Developing Countries. Charcoal-Making Kilns in Thailand (No. EPA-600/R-99-109). U.S. Environmental Protection Agency, Research Triangle Park, NC, USA, 62 p. (1999).
- Smith, K. R., Uma, R., Kishore, V. V. N., Lata, K., Joshi, V., Zhang, J., Rasmussen, R. A., and Khalil, M. A. K., Greenhouse Gases From Small-Scale Combustion Devices in Developing Countries: Phase IIa

- Household Stoves in India (No. EPA-600/R-00-052). U.S. Environmental Protection Agency, Research Triangle Park, NC, USA, 98 p. (2000a).
- Smith, K. R., Uma, R., Kishore, V. V. N., Zhang, J. F., Joshi, V., and Khalil, M. A. K., Greenhouse implications of household stoves: An analysis for India: *Annu. Rev. Energy Environ.*, 25, 741-763, 2000b.
- Smith, T. E. L., Paton-Walsh, C., Meyer, C. P., Cook, G. D., Maier, S. W., Russell-Smith, J., Wooster, M. J., and Yates, C. P., New emission factors for Australian vegetation fires measured using open-path Fourier transform infrared spectroscopy – Part 2: Australian tropical savanna fires: *Atmos. Chem. Phys.*, 14, 11335-11352, doi:10.5194/acp-14-11335-2014, 2014.
- Smith, T. E. L., Evers, S., Yule, C. M., and Gan, J. Y., In situ tropical peatland fire emission factors and their variability, as determined by field measurements in peninsula Malaysia: *Global Biogeochemical Cycles*, 32, 18-31, doi:10.1002/2017GB005709, 2018.
- Soares Neto, T. G., Carvalho, J. A., Jr., Veras, C. A. G., Alvarado, E. C., Gielow, R., Lincoln, E. N., Christian, T. J., Yokelson, R. J., and Santos, J. C., Biomass consumption and CO<sub>2</sub>, CO and main hydrocarbon gas emissions in an Amazonian forest clearing fire: *Atmospheric Environment*, 43, 438-446, doi:10.1016/j.atmosenv.2008.07.063, 2009.
- Soares Neto, T. G., Carvalho, J. A., Cortez, E. V., Azevedo, R. G., Oliveira, R. A., Fidalgo, W. R. R., and Santos, J. C., Laboratory evaluation of Amazon forest biomass burning emissions: *Atmospheric Environment*, 45, 7455-7461, doi:10.1016/j.atmosenv.2011.05.003, 2011.
- Stith, J. L., Radke, L. F., and Hobbs, P. V., Particle emissions and the production of ozone and nitrogen oxides from the burning of forest slash: *Atmos. Environ.*, 15, 73-82, 1981.
- Stockwell, C. E., Veres, P. R., Williams, J., and Yokelson, R. J., Characterization of biomass burning emissions from cooking fires, peat, crop residue, and other fuels with high-resolution proton-transfer-reaction time-of-flight mass spectrometry: *Atmos. Chem. Phys.*, 15, 845-865, doi:10.5194/acp-15-845-2015, 2015.
- Stockwell, C. E., Christian, T. J., Goetz, J. D., Jayarathne, T., Bhave, P. V., Praveen, P. S., Adhikari, S., Maharjan, R., DeCarlo, P. F., Stone, E. A., Saikawa, E., Blake, D. R., Simpson, I. J., Yokelson, R. J., and Panday, A. K., Nepal Ambient Monitoring and Source Testing Experiment (NAMaSTE): emissions of trace gases and light-absorbing carbon from wood and dung cooking fires, garbage and crop residue burning, brick kilns, and other sources: *Atmos. Chem. Phys.*, 16, 11043-11081, doi:10.5194/acp-16-11043-2016, 2016a.
- Stockwell, C. E., Jayarathne, T., Cochrane, M. A., Ryan, K. C., Putra, E. I., Saharjo, B. H., Nurhayati, A. D., Albar, I., Blake, D. R., Simpson, I. J., Stone, E. A., and Yokelson, R. J., Field measurements of trace gases and aerosols emitted by peat fires in Central Kalimantan, Indonesia, during the 2015 El Niño: *Atmos. Chem. Phys.*, 16, 11711-11732, doi:10.5194/acp-16-11711-2016, 2016b.
- Strand, T., Gullett, B., Urbanski, S., O'Neill, S., Potter, B., Aurell, J., Holder, A., Larkin, N., Moore, M., and Rorig, M., Grassland and forest understorey biomass emissions from prescribed fires in the southeastern United States - RxCADRE 2012: *International Journal of Wildland Fire*, 25, 102-113, doi:10.1071/wf14166, 2016.
- Sun, J., Shen, Z., Cao, J., Zhang, L., Wu, T., Zhang, Q., Yin, X., Lei, Y., Huang, Y., Huang, R. J., Liu, S., Han, Y., Xu, H., Zheng, C., and Liu, P., Particulate matters emitted from maize straw burning for winter heating in rural areas in Guanzhong Plain, China: *Current*

- emission and future reduction: *Atmos. Res.*, 184, 66-76, doi:10.1016/j.atmosres.2016.10.006, 2017.
- Sun, J., Zhi, G., Jin, W., Chen, Y., Shen, G., Tian, C., Zhang, Y., Zong, Z., Cheng, M., Zhang, X., Zhang, Y., Liu, C., Lu, J., Wang, H., Xiang, J., Tong, L., and Zhang, X., Emission factors of organic carbon and elemental carbon for residential coal and biomass fuels in China- A new database for 39 fuel-stove combinations: *Atmospheric Environment*, 190, 241-248, doi:10.1016/j.atmosenv.2018.07.032, 2018.
- Susott, R. A., Ward, D. E., Babbitt, R. E., Latham, D. J., Weger, L. G., and Boyd, P. M., *Fire Dynamics and Chemistry of Large Fires (Final Report)*. Missoula, Montana: USDA Forest Service, 39 p, 1990.
- Tang, X.-b., Huang, C., Lou, S.-r., Qiao, L.-p., Wang, H.-l., Zhou, M., Chen, M.-h., Chen, C.-h., Wang, Q., Li, G.-l., Li, L., Huang, H.-y., and Zhang, G.-f., Emission factors and PM chemical composition study of biomass burning in the Yangtze River Delta Region: *Huanjing Kexue*, 35, 1623-1632, 2014.
- Tawfiq, M. F., Aroua, M. K., and Sulaiman, N. M. N., On-line CO, CO<sub>2</sub> emissions evaluation and (benzene, toluene, xylene) determination from experimental burn of tropical biomass: *Journal of Environmental Sciences*, 33, 239-244, doi:10.1016/j.jes.2015.01.015, 2015.
- Tereszchuk, K. A., Abad, G. G., Clerbaux, C., Hurtmans, D., Coheur, P. F., and Bernath, P. F., ACE-FTS measurements of trace species in the characterization of biomass burning plumes: *Atmos. Chem. Phys.*, 11, 12169-12179, doi:10.5194/acp-11-12169-2011, 2011.
- Tereszchuk, K. A., Abad, G. G., Clerbaux, C., Hadji-Lazaro, J., Hurtmans, D., Coheur, P. F., and Bernath, P. F., ACE-FTS observations of pyrogenic trace species in boreal biomass burning plumes during BORTAS: *Atmos. Chem. Phys.*, 13, 4529-4541, doi:10.5194/acp-13-4529-2013, 2013.
- Thompson, R. J., Li, J., Weyant, C. L., Edwards, R., Lan, Q., Rothman, N., Hu, W., Dang, J., Dang, A., Smith, K. R., and Bond, T. C., Field emission measurements of solid fuel stoves in Yunnan, China demonstrate dominant causes of uncertainty in household emission inventories: *Environ. Sci. Technol.*, 53, 3323-3330, doi:10.1021/acs.est.8b07040, 2019.
- Tian, J., Ni, H. Y., Cao, J. J., Han, Y. M., Wang, Q. Y., Wang, X. L., Chen, L. W. A., Chow, J. C., Watson, J. G., Wei, C., Sun, J., Zhang, T., and Huang, R. J., Characteristics of carbonaceous particles from residential coal combustion and agricultural biomass burning in China: *Atmospheric Pollution Research*, 8, 521-527, doi:10.1016/j.apr.2016.12.006, 2017.
- Tsai, S. M., Zhang, J. F., Smith, K. R., Ma, Y. Q., Rasmussen, R. A., and Khalil, M. A. K., Characterization of non-methane hydrocarbons emitted from various cookstoves used in China: *Environ. Sci. Technol.*, 37, 2869-2877, 2003.
- Turetsky, M. R., Harden, J. W., Friedli, H. R., Flannigan, M., Payne, N., Crock, J., and Radke, L., Wildfires threaten mercury stocks in northern soils: *Geophys. Res. Lett.*, 33, L16403, doi:10.1029/2005gl025595, 2006.
- Turn, S. Q., Jenkins, B. M., Chow, J. C., Pritchett, L. C., Campbell, D., Cahill, T., and Whalen, S. A., Elemental characterization of particulate matter emitted from biomass burning. Wind tunnel derived source profiles for herbaceous and wood fuels: *J. Geophys. Res.*, 102, 3683-3699, 1997.



- Urbanski, S. P., Hao, W. M., and Baker, S., Chemical composition of wildland fire emissions, in *Wildland Fires and Air Pollution*, edited by A. Bytnerowicz, M. J. Arbaugh, A. R. Riebau, & C. Andersen, pp. 79-107, 2009.
- Urbanski, S. P., Combustion efficiency and emission factors for wildfire-season fires in mixed conifer forests of the northern Rocky Mountains, US: *Atmos. Chem. Phys.*, 13, 7241-7262, doi:10.5194/acp-13-7241-2013, 2013.
- Vasileva, A., Moiseenko, K., Skorokhod, A., Belikov, I., Kopeikin, V., and Lavrova, O., Emission ratios of trace gases and particles for Siberian forest fires on the basis of mobile ground observations: *Atmos. Chem. Phys.*, 17, 12303-12325, doi:10.5194/acp-17-12303-2017, 2017.
- Veldt, C., GEIA note on residential biomass burning. A short communication about emission factors for the residential combustion of biomass fuels, unpublished, 1992.
- Venkataraman, C., and Rao, G. U. M., Emission factors of carbon monoxide and size-resolved aerosols from biofuel combustion: *Environ. Sci. Technol.*, 35, 2100-2107, 2001.
- Venkataraman, C., Habib, G., Eiguren-Fernandez, A., Miguel, A. H., and Friedlander, S. K., Residential biofuels in South Asia: Carbonaceous aerosol emissions and climate impacts: *Science*, 307, 1454-1456, 2005.
- Viatte, C., Strong, K., Hannigan, J., Nussbaumer, E., Emmons, L. K., Conway, S., Paton-Walsh, C., Hartley, J., Benmergui, J., and Lin, J., Identifying fire plumes in the Arctic with tropospheric FTIR measurements and transport models: *Atmos. Chem. Phys.*, 15, 2227-2246, doi:10.5194/acp-15-2227-2015, 2015.
- Vicente, A., Alves, C., Monteiro, C., Nunes, T., Mirante, F., Evtyugina, M., Cerqueira, M., and Pio, C., Measurement of trace gases and organic compounds in the smoke plume from a wildfire in Penedono (central Portugal): *Atmospheric Environment*, 45, 5172-5182, doi:10.1016/j.atmosenv.2011.06.021, 2011.
- Vicente, A., Alves, C., Monteiro, C., Nunes, T., Mirante, F., Cerqueira, M., Calvo, A., and Pio, C., Organic speciation of aerosols from wildfires in central Portugal during summer 2009: *Atmospheric Environment*, 57, 186-196, doi:10.1016/j.atmosenv.2012.04.030, 2012.
- Vicente, E. D., and Alves, C. A., An overview of particulate emissions from residential biomass combustion: *Atmos. Res.*, 199, 159-185, doi:10.1016/j.atmosres.2017.08.027, 2018.
- Vicente, E. D., Vicente, A., Evtyugina, M., Carvalho, R., Tarelho, L. A. C., Oduber, F. I., and Alves, C., Particulate and gaseous emissions from charcoal combustion in barbecue grills: *Fuel Processing Technology*, 176, 296-306, doi:10.1016/j.fuproc.2018.03.004, 2018.
- Virkkula, A., Pohja, T., Aalto, P. P., Keronen, P., Schobesberger, S., Clements, C. B., Petaja, T., Nikmo, J., and Kulrinala, M., Airborne measurements of aerosols and carbon dioxide during a prescribed fire experiment at a boreal forest site: *Boreal Environment Research*, 19, 153-181, 2014.
- Vose, J. M., Swank, W. T., Geron, C. D., and Major, A. E., Emissions from forest burning in the Southeastern United States: Application of a model determining spatial and temporal fire variation, in *Biomass Burning and Global Change*, edited by J. S. Levine, pp. 733-749, MIT Press, Cambridge, Mass., 1996.
- Wang, H. L., Zhuang, Y. H., Hao, Z. P., Cao, M. Q., Zhong, J. X., Wang, X. K., and Oanh, N. T. K., Polycyclic aromatic hydrocarbons from rural household biomass burning in a typical

- Chinese village: Science in China Series D-Earth Sciences, 51, 1013-1020, doi:10.1007/s11430-008-0064-x, 2008.
- Wang, H. L., Lou, S. R., Huang, C., Qiao, L. P., Tang, X. B., Chen, C. H., Zeng, L. M., Wang, Q., Zhou, M., Lu, S. H., and Yu, X. N., Source profiles of volatile organic compounds from biomass burning in Yangtze River Delta, China: Aerosol and Air Quality Research, 14, 818-828, doi:10.4209/aaqr.2013.05.0174, 2014.
- Wang, S., Wei, W., Du, L., Li, G., and Hao, J., Characteristics of gaseous pollutants from biofuel-stoves in rural China: Atmospheric Environment, 43, 4148-4154, doi:10.1016/j.atmosenv.2009.05.040, 2009.
- Wang, X. Y., Meyer, C. P., Reisen, F., Keywood, M., Thai, P. K., Hawker, D. W., Powell, J., and Mueller, J. F., Emission factors for selected semivolatile organic chemicals from burning of tropical biomass fuels and estimation of annual Australian emissions: Environ. Sci. Technol., 51, 9644-9652, doi:10.1021/acs.est.7b01392, 2017a.
- Wang, X. Y., Thai, P. K., Mallet, M., Desservettaz, M., Hawker, D. W., Keywood, M., Miljevic, B., Paton-Walsh, C., Gallen, M., and Mueller, J. F., Emissions of selected semivolatile organic chemicals from forest and savannah fires: Environ. Sci. Technol., 51, 1293-1302, doi:10.1021/acs.est.6b03503, 2017b.
- Ward, D., and Hardy, C., Advances in the characterization and control of emissions from prescribed broadcast fires of coniferous species logging slash on clearcut units. Final Report to U.S. Environmental Protection Agency and U.S. Dept. of Energy. Missoula, Mont., USA, 1986.
- Ward, D. E., McMahon, C. K., and Adams, D. F., Laboratory measurements of carbonyl sulfide and total sulfur emissions from open burning of forest biomass. Paper presented at the 75th Annual Meeting of the Air Pollution Control Association, New Orleans, Louisiana, 20-25 June, 1982., 1-16, 1982.
- Ward, D. E., and Hardy, C. C., Emissions from prescribed chaparral burning. Paper presented at the Air & Waste Management Association Annual Meeting, Anaheim, CA, pp. 21.
- Ward, D. E., Susott, R. A., Babbitt, R. E., and Hardy, C. C., Properties and concentration of smoke near the ground from biomass field tests. Paper presented at the Symposium on Smoke/Obscurants XIV; 17-19 April 1990, Laurel, Maryland, USA., 21 p, 1990.
- Ward, D. E., and Hardy, C. C., Smoke emissions from wildland fires: Environment International, 17, 117-134, 1991.
- Ward, D. E., Setzer, A. W., Kaufman, Y. J., and Rasmussen, R. A., Characteristics of smoke emissions from biomass fires of the Amazon region - BASE-A experiment, in *Global Biomass Burning: Atmospheric, Climatic, and Biospheric Implications*, edited by J. S. Levine, pp. 394-402, MIT Press, Cambridge, Mass., 1991.
- Ward, D. E., Susott, R. A., Kauffman, J. B., Babbitt, R. E., Cummings, D. L., Dias, B., Holben, B. N., Kaufman, Y. J., Rasmussen, R. A., and Setzer, A. W., Smoke and fire characteristics for cerrado and deforestation burns in Brazil: BASE-B experiment: J. Geophys. Res., 97, 14,601-14,619, 1992.
- Ward, D. E., Hao, W.-M., Susott, R. A., Babbitt, R. A., Shea, R. W., Kauffman, J. B., and Justice, C. O., Effect of fuel composition on combustion efficiency and emission factors for African savanna ecosystems: J. Geophys. Res., 101, 23,569-23,576, 1996.
- Ward, D. E., Chidumayo, E., Baker, S. P., and Susott, R. A., Charcoal production and smoke emissions from earthen kilns in Zambia. A Final Report for EPA/IAGDW12935987-01-0. Intermountain Fire

- Sciences Laboratory, Rocky Mountain Research Station, USDA Forest Service, Missoula, MT 59807, 34 p. (1999).
- Wathore, R., Mortimer, K., and Grieshop, A. P., In-use emissions and estimated impacts of traditional, natural- and forced-draft cookstoves in rural Malawi: *Environ. Sci. Technol.*, 51, 1929-1938, doi:10.1021/acs.est.6b05557, 2017.
- Wei, S. Y., Shen, G. F., Zhang, Y. Y., Xue, M., Xie, H., Lin, P. C., Chen, Y. C., Wang, X. L., and Tao, S., Field measurement on the emissions of PM, OC, EC and PAHs from indoor crop straw burning in rural China: *Environmental Pollution*, 184, 18-24, doi:10.1016/j.envpol.2013.07.036, 2014.
- Weiss-Penzias, P., Jaffe, D., Swartzendruber, P., Hafner, W., Chand, D., and Prestbo, E., Quantifying Asian and biomass burning sources of mercury using the Hg/CO ratio in pollution plumes observed at the Mount Bachelor observatory: *Atmospheric Environment*, 41, 4366-4379, doi:<http://dx.doi.org/10.1016/j.atmosenv.2007.01.058>, 2007.
- Wentworth, G. R., Aklilu, Y.-a., Landis, M. S., and Hsu, Y.-M., Impacts of a large boreal wildfire on ground level atmospheric concentrations of PAHs, VOCs and ozone: *Atmospheric Environment*, 178, 19-30, doi:10.1016/j.atmosenv.2018.01.013, 2018.
- Whitburn, S., Van Damme, M., Clarisse, L., Hurtmans, D., Clerbaux, C., and Coheur, P. F., IASI-derived NH<sub>3</sub> enhancement ratios relative to CO for the tropical biomass burning regions: *Atmos. Chem. Phys.*, 17, 12239-12252, doi:10.5194/acp-17-12239-2017, 2017.
- Wiriya, W., Chantara, S., Sillapapiromsuk, S., and Lin, N. H., Emission profiles of PM<sub>10</sub>-bound polycyclic aromatic hydrocarbons from biomass burning determined in chamber for assessment of air pollutants from open burning: *Aerosol and Air Quality Research*, 16, 2716-2727, doi:10.4209/aaqr.2015.04.0278, 2016.
- Wofsy, S. C., Sachse, G. W., Gregory, G. L., Blake, D. R., Bradshaw, J. D., Sandholm, S. T., Singh, H. B., Barrick, J. A., Harriss, R. C., Talbot, R. W., Shipham, M. A., Browell, E. V., Jacob, D. J., and Logan, J. A., Atmospheric chemistry in the Arctic and Subarctic: Influence of natural fires, industrial emissions, and stratospheric inputs: *J. Geophys. Res.*, 97, 16,731-16,746, 1992.
- Woodruff, L. G., and Cannon, W. F., Immediate and long-term fire effects on total mercury in forests soils of northeastern Minnesota: *Environ. Sci. Technol.*, 44, 5371-5376, doi:10.1021/es100544d, 2010.
- Wooster, M. J., Freeborn, P. H., Archibald, S., Oppenheimer, C., Roberts, G. J., Smith, T. E. L., Govender, N., Burton, M., and Palumbo, I., Field determination of biomass burning emission ratios and factors via open-path FTIR spectroscopy and fire radiative power assessment: headfire, backfire and residual smouldering combustion in African savannahs: *Atmos. Chem. Phys.*, 11, 11,591-11,615, doi:10.5194/acp-11-11591-2011, 2011.
- Worden, H., Beer, R., and Rinsland, C. P., Airborne infrared spectroscopy of 1994 western wildfires: *J. Geophys. Res.*, 102, 1287-1299, 1997.
- Yamasoe, M. A., Artaxo, P., Miguel, A. H., and Allen, A. G., Chemical composition of aerosol particles from direct emissions of vegetation fires in the Amazon Basin: water-soluble species and trace elements: *Atmospheric Environment*, 34, 1641-1653, 2000.
- Yates, E. L., Iraci, L. T., Singh, H. B., Tanaka, T., Roby, M. C., Hamill, P., Clements, C. B., Lareau, N., Contezac, J., Blake, D. R., Simpson, I. J., Wisthaler, A., Mikoviny, T., Diskin, G. S., Beyersdorf, A. J., Choi, Y., Ryerson, T. B., Jimenez, J. L., Campuzano-Jost, P., Loewenstein, M., and Gore, W., Airborne measurements and emission estimates

- of greenhouse gases and other trace constituents from the 2013 California Yosemite Rim wildfire: *Atmospheric Environment*, 127, 293-302, doi:10.1016/j.atmosenv.2015.12.038, 2016.
- Yedinak, K. M. (2013). *Characterization of smoke plume emissions and dynamics from prescribed and wildland fires using high-resolution field observations and a coupled fire-atmosphere model*. Ph.D. Thesis, Washington State University, 126 p.
- Yokelson, R., Crounse, J. D., DeCarlo, P. F., Karl, T., Urbanski, S., Atlas, E., Campos, T., Shinozuka, Y., Kapustin, V., Clarke, A. D., Weinheimer, A., Knapp, D. J., Montzka, D. D., Holloway, J., Weibring, P., Flocke, F., Zheng, W., Toohey, D., Wennberg, P. O., Wiedinmyer, C., Mauldin, L., Fried, A., Richter, D., Walega, J., Jimenez, J. L., Adachi, K., Buseck, P. R., Hall, S. R., and Shetter, R., Emissions from biomass burning in the Yucatan: *Atmos. Chem. Phys.*, 9, 5785–5812, 2009.
- Yokelson, R. J., Griffith, D. W. T., and Ward, D. E., Open-path fourier-transform infrared studies of large-scale laboratory biomass fires: *J. Geophys. Res.*, 101, 21,067-21,080, 1996.
- Yokelson, R. J., Susott, R., Ward, D. E., Reardon, J., and Griffith, D. W. T., Emissions from smoldering combustion of biomass measured by open-path Fourier transform infrared spectroscopy: *J. Geophys. Res.*, 102, 18,865-18,877, 1997.
- Yokelson, R. J., Goode, J. G., Ward, D. E., Susott, R. A., Babbitt, R. E., Wade, D. D., Bertschi, I., Griffith, D. W. T., and Hao, W. M., Emissions of formaldehyde, acetic acid, methanol, and other trace gases from biomass fires in North Carolina measured by airborne Fourier transform infrared spectroscopy: *J. Geophys. Res.*, 104, 30,109-30,125, 1999a.
- Yokelson, R. J., Griffith, D. W. T., Susott, R. A., and Ward, D. E., Spectroscopic studies of biomass fire emissions, in *International Perspectives on Landscape Fires*, edited by J. Greenlee, Fairfield, Wash., 1999b, in press.
- Yokelson, R. J., Bertschi, I. T., Christian, T. J., Hobbs, P. V., Ward, D. E., and Hao, W. M., Trace gas measurements in nascent, aged, and cloud-processed smoke from African savanna fires by airborne Fourier transform infrared spectroscopy (AFTIR): *J. Geophys. Res.*, 108, 8478, doi:10.1029/2002JD002322, 2003.
- Yokelson, R. J., Urbanski, S. P., Atlas, E. L., Toohey, D. W., Alvarado, E. C., Crounse, J. D., Wennberg, P. O., Fisher, M. E., Wold, C. E., Campos, T. L., Adachi, K., Buseck, P. R., and Hao, W. M., Emissions from forest fires near Mexico City: *Atmos. Chem. Phys.*, 7, 5569-5584, 2007.
- Yokelson, R. J., Christian, T. J., Karl, T. G., and Guenther, A., The tropical forest and fire emissions experiment: laboratory fire measurements and synthesis of campaign data: *Atmos. Chem. Phys.*, 8, 3509-3527, 2008.
- Yokelson, R. J., Burling, I. R., Urbanski, S. P., Atlas, E. L., Adachi, K., Buseck, P. R., Wiedinmyer, C., Akagi, S. K., Toohey, D. W., and Wold, C. E., Trace gas and particle emissions from open biomass burning in Mexico: *Atmos. Chem. Phys.*, 11, 6,787-6,808, doi:10.5194/acp-11-6787-2011, 2011.
- Yokelson, R. J., Burling, I. R., Gilman, J. B., Warneke, C., Stockwell, C. E., De Gouw, J., Akagi, S. K., Urbanski, S. P., Veres, P., Roberts, J. M., Kuster, W. C., Reardon, J., Griffith, D. W. T., Johnson, T. J., Hosseini, S., Miller, J. W., Cocker III, D. R., Jung, H., and Weise, D. R., Coupling field and laboratory measurements to estimate the emission factors of identified and unidentified trace gases for prescribed fires: *Atmos. Chem. Phys.*, 13, 89-116, doi:10.5194/acp-13-89-2013, 2013.

- Yonemura, S., and Kawashima, S., Concentrations of carbon gases and oxygen and their emission ratios from the combustion of rice hulls in a wind tunnel: *Atmospheric Environment*, 41, 1407-1416, doi:10.1016/j.atmosenv.2006.10.015, 2007.
- Zarzana, K. J., Min, K.-E., Washenfelder, R. A., Kaiser, J., Krawiec-Thayer, M., Peischl, J., Neuman, J. A., Nowak, J. B., Wagner, N. L., Dubé, W. P., St. Clair, J. M., Wolfe, G. M., Hanisco, T. F., Keutsch, F. N., Ryerson, T. B., and Brown, S. S., Emissions of glyoxal and other carbonyl compounds from agricultural biomass burning plumes sampled by aircraft: *Environ. Sci. Technol.*, 51, 11761-11770, doi:10.1021/acs.est.7b03517, 2017.
- Zarzana, K. J., Selimovic, V., Koss, A. R., Sekimoto, K., Coggon, M. M., Yuan, B., Dubé, W. P., Yokelson, R. J., Warneke, C., de Gouw, J. A., Roberts, J. M., and Brown, S. S., Primary emissions of glyoxal and methylglyoxal from laboratory measurements of open biomass burning: *Atmos. Chem. Phys.*, 18, 15,451-15,470, doi:10.5194/acp-18-15451-2018, 2018.
- Zhang, H. F., Ye, X. N., Cheng, T. T., Chen, J. M., Yang, X., Wang, L., and Zhang, R. Y., A laboratory study of agricultural crop residue combustion in China: Emission factors and emission inventory: *Atmospheric Environment*, 42, 8432-8441, doi:10.1016/j.atmosenv.2008.08.015, 2008.
- Zhang, J., and Smith, K. R., Hydrocarbon emissions and health risks from cookstoves in developing countries: *Journal of Exposure Analysis and Environmental Epidemiology*, 6, 147-161, 1996.
- Zhang, J., and Smith, K. R., Emissions of carbonyl compounds from various cookstoves in China: *Environ. Sci. Tech.*, 33, 2311-2320, 1999.
- Zhang, J., Smith, K. R., Uma, R., Ma, Y., Kishore, V. V. N., Lata, K., Khalil, M. A. K., Rasmussen, R. A., and Thorneloe, S. T., Carbon monoxide from cookstoves in developing countries: 1. Emission factors: *Chemosphere: Global Change Science*, 1, 353-366, 1999.
- Zhang, J., Smith, K. R., Ma, Y., Ye, S., Jiang, F., Qi, W., Liu, P., Khalil, M. A. K., Rasmussen, R. A., and Thorneloe, S. A., Greenhouse gases and other airborne pollutants from household stoves in China: a database for emission factors: *Atmospheric Environment*, 34, 4537-4549, 2000.
- Zhang, T., Wooster, M. J., Green, D. C., and Main, B., New field-based agricultural biomass burning trace gas, PM<sub>2.5</sub>, and black carbon emission ratios and factors measured in situ at crop residue fires in Eastern China: *Atmospheric Environment*, 121, 22-34, doi:10.1016/j.atmosenv.2015.05.010, 2015.
- Zhang, W., Wei, W., Hu, D., Zhu, Y., and Wang, X., Emission of speciated mercury from residential biomass fuel combustion in China: *Energy & Fuels*, 27, 6792-6800, doi:10.1021/ef401564r, 2013.
- Zhuang, Y.-H., Cao, M., Wang, X., and Yao, H., Spatial distribution of trace gas emissions from burning crop residue in China, in *Biomass Burning and Global Change*, edited by J. S. Levine, pp. 764-770, MIT Press, Cambridge, Mass., 1996.