

Measurements of sulfur dioxide, ozone and ammonia concentrations in Asia, Africa, and South America using passive samplers

Carmichael G.R., Ferm M., Thongboonchoo N., Woo J.-H., Chan L.Y., Murano K., Viet P.H., Mossberg C., Bala R., Boonjawat J., Upatum P., Mohan M., Adhikary S.P., Shrestha A.B., Pienaar J.J., Brunke E.B., Chen T., Jie T., Guoan D., Peng L.C., Dhiharto S., Harjanto H., Jose A.M., Kimani W., Kirouane A., Lacaux J.-P., Richard S., Barturen O., Cerda J.C., Athayde A., Tavares T., Cotrina J.S., Bilici E.

Dept. of Chem./Biochem. Engineering, Ctr. for Global/Regl. Environ. Res., University of Iowa, Iowa City, IA 52240, United States; Dept. of Civ./Structural Engineering, Hong Kong Polytechnic University, Hung Hom, Kowloon, Hong Kong; Natl. Inst. for Environ. Studies, 16-2 Onogawa, Tsukuba-Shi, Ibaraki 305-0053, Japan; Dept. of Chem./Environ. Eng. (CEED), Ctr. of Environ. Chemistry (CECT), Vietnam National University, 90 Nguyen Trai, Hanoi, Viet Nam; C/o ISO/Swedforest, P.O. Box 4298, Vientiane, Lao PDR, Viet Nam; Dept. of Chem./Environ. Engineering, National University of Singapore, 10 Kent Ridge Crescent, Singapore 119260, Singapore; SEA START RC, Institute of Environmental Research, Chulalongkorn University, Phayathai Road, Bangkok 10330, Thailand; 16/7 Moo 8, Amphor Sankamphang, Chiang Mai 50130, Thailand; Center for Atmospheric Sciences, India Institute of Technology, Hauz Khas, New Delhi 110 016, India; Himalayan Climate Center, P.O. Box 10872, Kathmandu, Nepal; Dept. of Hydrology and Meteorology, P.O. Box 406, Babar Mahal, Kathmandu, Nepal; School of Chemistry and Biochemistry, Potchefstroom University, Potchefstroom 2520, South Africa; South African Weather Bureau, CSIR, P.O. Box 320, Stellenbosch 7599, South Africa; Institute of Earth Sciences, Academia Sinica, P.O. Box 1-55, Nankang, Taipei 11529, Taiwan; China Meteorol. and Administration, #46 Baishiqiao Rd., Haidian, Beijing 100081, China; Chinese Acad. of Meteorol. Science, Institute of Atmospheric Chemistry, No. 46 Baishiqiao Rd., Beijing 100081, China; Malaysian Metrological Service, Jabatan Perkhidmatan Kajicuaca M., Jalan Sultan, 46667 Petaling Jaya, Selangor, Malaysia; BANDAN, Dept. of Meteorology and Geophysics, Jakarta, Indonesia; Meteorol. and Geophysical Agency, JL Angkasa I No. 2, 10720 Jarkata, Indonesia; PAGADA, Department of Science and Technology, 1424 Quezon Avenue, Quezon City 1104, Philippines; Kenya Meteorological Department, Dagoretti Corner, Ngong Rd., Nairobi, Kenya; Departement de la Recherche, Office National de la Meteorologie, ONM B. P. 153, Dar el Beida, Algiers, Algeria; J.P. Lacaux, OMP/Laboratories de Aerologie, 14 Avenue Edouard Belin, Toulouse 31400, France; HYDRECO, Lab. Environnement de Petit Saut, BP823, Kourou Cedex 97388, French Guiana; Ushuaia GAW Station, P.O. Box 187, Ushuaia 9410, Argentina; Department of Climatology, Casilla 717, Santiago, Chile; Eixo Monumental, Via S-1, Cruseir, CEP. 70610-400 Brasilia, DF, Brazil; Chem. Istitute Depto. Quim. A., Univ. Federal da Bahia Salvador, Bahia 40210-340, Brazil; De Investigacion y Desarrollo, Jr. Cahuida No. 785, Jesus Maria-Lima 11-peru, Peru; Turkish State Meteorological Service, Kalaba-Ankara 06120, Turkey

Abstract: Measurements of gaseous SO₂, NH₃, and O₃ using IVL passive sampler technology were obtained during a pilot measurement program initiated as a key component of the newly established WMO/GAW Urban Research Meteorology and Environment (GURME) project. Monthly measurements were obtained at 50 stations in Asia, Africa, South America, and Europe. The median SO₂ concentrations vary from a high of 13ppb at Linan, China, to <0.03ppb at four stations. At 30 of 50 regional stations, the

observed median concentrations are <1ppb. Median ammonia concentrations range from 20ppb at Dhangadi, India, to <1ppb at nine stations. At 27 of regional stations, the ambient ammonia levels exceed 1ppb. The median ozone concentrations vary from a maximum of 45ppb at Waliguan Mountain, China, to 8ppb in Petit Saut, French Guiana. In general, the highest ozone values are found in the mid-latitudes, with the Northern hemisphere mid-latitude values exceeding the Southern hemisphere mid-latitude levels, and the lowest values are typically found in the tropical regions. © 2003 Elsevier Science Ltd. All rights reserved.

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Correspondence Address: Carmichael, G.R.; Dept. of Chem./Biochem. Engineering, Ctr. for Global/Regl. Environ. Res., University of Iowa, Iowa City, IA 52240, United States; email: gcarmich@engineering.uiowa.edu

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Authors with affiliations:

- Carmichael, G.R., Dept. of Chem./Biochem. Engineering, Ctr. for Global/Regl. Environ. Res., University of Iowa, Iowa City, IA 52240, United States
- Ferm, M.
- Thongboonchoo, N., Dept. of Chem./Biochem. Engineering, Ctr. for Global/Regl. Environ. Res., University of Iowa, Iowa City, IA 52240, United States
- Woo, J.-H., Dept. of Chem./Biochem. Engineering, Ctr. for Global/Regl. Environ. Res., University of Iowa, Iowa City, IA 52240, United States
- Chan, L.Y., Dept. of Civ./Structural Engineering, Hong Kong Polytechnic University, Hung Hom, Kowloon, Hong Kong
- Murano, K., Natl. Inst. for Environ. Studies, 16-2 Onogawa, Tsukuba-Shi, Ibaraki 305-0053, Japan

- Viet, P.H., Dept. of Chem./Environ. Eng. (CEED), Ctr. of Environ. Chemistry (CECT), Vietnam National University, 90 Nguyen Trai, Hanoi, Viet Nam
- Mossberg, C., C/o ISO/Swedforest, P.O. Box 4298, Vientiane, Lao PDR, Viet Nam
- Bala, R., Dept. of Chem./Environ. Engineering, National University of Singapore, 10 Kent Ridge Crescent, Singapore 119260, Singapore
- Boonjawat, J., SEA START RC, Institute of Environmental Research, Chulalongkorn University, Phayathai Road, Bangkok 10330, Thailand
- Upatum, P., 16/7 Moo 8, Amphor Sankamphang, Chiang Mai 50130, Thailand
- Mohan, M., Center for Atmospheric Sciences, India Institute of Technology, Hauz Khas, New Delhi 110 016, India
- Adhikary, S.P., Himalayan Climate Center, P.O. Box 10872, Kathmandu, Nepal
- Shrestha, A.B., Dept. of Hydrology and Meteorology, P.O. Box 406, Babar Mahal, Kathmandu, Nepal
- Pienaar, J.J., School of Chemistry and Biochemistry, Potchefstroom University, Potchefstroom 2520, South Africa
- Brunke, E.B., South African Weather Bureau, CSIR, P.O. Box 320, Stellenbosch 7599, South Africa
- Chen, T., Institute of Earth Sciences, Academia Sinica, P.O. Box 1-55, Nankang, Taipei 11529, Taiwan
- Jie, T., China Meteorol. and Administration, #46 Baishiqiao Rd., Haidian, Beijing 100081, China
- Guoan, D., Chinese Acad. of Meteorol. Science, Institute of Atmospheric Chemistry, No. 46 Baishiqiao Rd., Beijing 100081, China
- Peng, L.C., Malaysian Metrological Service, Jabatan Perkhidmatan Kajicuaca M., Jalan Sultan, 46667 Petaling Jaya, Selangor, Malaysia
- Dhiharto, S., BANDAN, Dept. of Meteorology and Geophysics, Jakarta, Indonesia
- Harjanto, H., Meteorol. and Geophysical Agency, JL Angkasa I No. 2, 10720 Jarkata, Indonesia
- Jose, A.M., PAGADA, Department of Science and Technology, 1424 Quezon Avenue, Quezon City 1104, Philippines
- Kimani, W., Kenya Meteorological Department, Dagoretti Corner, Ngong Rd., Nairobi, Kenya
- Kirouane, A., Department de la Recherche, Office National de la Meteorologie, ONM B. P. 153, Dar el Beida, Algiers, Algeria
- Lacaux, J.-P., J.P. Lacaux, OMP/Laboratories de Aerologie, 14 Avenue Edouard Belin, Toulouse 31400, France
- Richard, S., HYDRECO, Lab. Environnement de Petit Saut, BP823, Kourou Cedex 97388, French Guiana
- Barturen, O., Ushuaia GAW Station, P.O. Box 187, Ushuaia 9410, Argentina
- Cerda, J.C., Department of Climatology, Casilla 717, Santiago, Chile
- Athayde, A., Eixo Monumental, Via S-1, Cruseir, CEP. 70610-400 Brasilia, DF, Brazil
- Tavares, T., Chem. Istitute Depto. Quim. A., Univ. Federal da Bahia Salvador, Bahia 40210-340, Brazil
- Cotrina, J.S., De Investigacion y Desarrollo, Jr. Cahuida No. 785, Jesus Maria-Lima 11-peru, Peru
- Bilici, E., Turkish State Meteorological Service, Kalaba-Ankara 06120, Turkey

References:

- Ayers, G.P., Keywood, M.D., Gillet, R.W., Manins, P.C., Malfroy, H., Bardsley, T., Validation of passive diffusion samplers for SO₂ and NO₂ (1998) *Atmospheric Environment*, 32, pp. 3593-3609
- Ayers, G.P., Peng, L.C., Fook, L., Kong, C.W., Gillet, R.W., Manins, P.C., Atmospheric concentrations and deposition of oxides sulfur and nitrogen species at Petaling Jaya, Malaysia, 1993-1998 (2000) *Tellus B*, 52, pp. 60-73
- Ayers, G.P., Peng, L.C., Gillet, R.W., Fook, L., Rainwater composition and acidity at five sites in Malaysia in 1996 (2002) *Water, Air and Soil Pollution*, 133, pp. 15-30
- Carmichael, G.R., Ferm, M., Adikary, S., Ahmed, J., Mohan, M., Hong, M.-S., Chen, L., Chen, L.L., Observed regional distribution of sulfur dioxide in Asia (1995) *Water, Air and Soil Pollution*, 85, pp. 2289-2294

- Carmichael, G.R., Street, D.G., Calori, G., Amann, M., Jacobson, M.Z., Hansen, J., Ueda, H., Changing trends in sulfur emissions in Asia: Implications for acid deposition, air pollution and climate (2002) *Environmental Science and Technology*, 36 (22), pp. 4707-4713
- Ferm, M., The theories behind diffusive sampling (2001) *Proceedings from the International Conference on Measuring Air Pollutants by Diffusive Sampling*, pp. 31-40. , Montpellier, France, 26-28 September 2001
- Ferm, M., Validation of a diffusive sampler for ozone in workplace atmospheres according to EN838 (2001) *Proceedings from the International Conference on Measuring Air Pollutants by Diffusive Sampling*, pp. 298-303. , Montpellier, France, 26-28 September 2001
- Ferm, M., Rodhe, H., Measurements of air concentrations of SO₂, NO₂ and NH₃ at rural and remote sites in Asia (1997) *Journal of Atmospheric Chemistry*, 27, pp. 17-29
- Ferm, M., Svanberg, P.A., Cost-efficient techniques for urban- and background measurements of SO₂ and NO₂ (1998) *Atmospheric Environment*, 32, pp. 1377-1381
- Gillett, R.W., Ayers, G.P., Mhwe, T., Selleck, P.W., Harjanto, H., Concentrations of nitrogen and sulfur species in gas and rainwater from several sites in Indonesia (2000) *Water, Air and Soil Pollution*, 120, pp. 205-215
- Kirchner, M., Braeutigam, S., Ferm, M., Haas, M., Hangartner, M., Hofschreuder, P., Kasper-Giebl, A., Zimmerling, R., Field intercomparison of diffusive samplers for measuring ammonia (1999) *Journal of Environmental Monitoring*, 1, pp. 259-265
- Palmes, E.D., Gunnison, A.F., Personal monitoring device for gaseous contaminants (1973) *American Industrial Hygiene Association Journal*, 34, pp. 78-81
- Sjöberg, K., Lövblad, G., Ferm, M., Ulrich, E., Cecchini, S., Dalstein, L., Ozone measurements at forest plots using diffusive samplers (2001) *Proceedings from the International Conference on Measuring Air Pollutants by Diffusive Sampling*, pp. 116-123. , Montpellier, France, 26-28 September 2001
- Stevenson, K., Bush, T., Mooney, D., Five years of nitrogen dioxide measurement with diffusion tube samplers at over 1000 sites in the UK (2001) *Atmospheric Environment*, 35, pp. 281-287
- Street, D.G., Jiang, K., Hu, X., Sinton, J.E., Zhang, X.-Q., Xu, D., Jacobson, M.Z., Hansen, J.E., Recent reductions in China's greenhouse gas emissions (2001) *Science*, 294, pp. 1835-1837