Atmospheric Environment 70 (2013) 280–288

Contents lists available at SciVerse ScienceDirect

Atmospheric Environment

journal homepage: www.elsevier.com/locate/atmosenv

Temporal trajectories of wet deposition across hydro-climatic regimes: Role of urbanization and regulations at U.S. and East Asia sites

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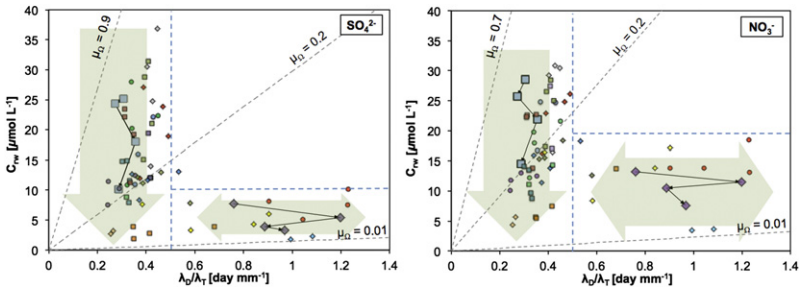
HIGHLIGHTS

- Hydro-climatology drives inter- and intra-annual variability of wet deposition flux.
- Anthropogenic controls can homogenize wet deposition trajectories of NO_3 and SO_4.
- Stochastic simulations enabled evaluation of the relative importance of drivers.
- Results are useful in identifying locations that can benefit from strong regulations.

GRAPHICAL ABSTRACT



ARTICLE INFO

Article history:
Received 17 October 2012
Received in revised form
14 January 2013
Accepted 18 January 2013

Keywords:
Urbanization
Regulation
Stochastic forcing
Anthropogenic impacts

ABSTRACT

Dominant global patterns of urbanization and industrialization contribute to large-scale modification of the drivers for hydrologic and biogeochemical processes, as evident in Asia, Africa, and South America which are experiencing rapid population and economic growth. One manifestation of urbanization and economic development is decreases in air quality, increases in dry/wet deposition fluxes, and growing adverse impacts on public health and ecosystem integrity. We examined available long-term (1980–2010) observational data, gathered at weekly intervals, for wet deposition at 19 urban sites in the U.S., and monitoring data (2000–2009) available for 17 urban sites at a monthly scale in East Asia. Our analyses are based on data for four constituents (SO_4^{2-}, NO_3^-, Ca^{2+}, and Mg^{2+}); differences in atmospheric chemistry and terrestrial sources of these constituents enabled a robust comparative analysis. We examined intra-annual variability and the long-term temporal trajectories of wet deposition fluxes to discern the relative role of anthropogenic and stochastic hydro-climatic forcing. Here, we show that: (1) temporal variability in wet deposition fluxes follows an exponential probability density function at all sites, evidence that stochasticity of rainfall is the dominant control of wet deposition variability; (2) the mean wet deposition flux, μ_Ω ($ML^{-2}T^{-1}$), has decreased in the U.S. over time since enactment of the Clean Air Act, with μ_Ω having become homogenized across varying hydro-climatic regimes; and (3) in contrast, μ_Ω values for East Asian cities are 3–10 times higher than U.S. cities, attributed to lax regulatory enforcement. Based on the observed patterns, we suggest a stochastic model that generates ellipses within which the μ_Ω temporal trajectories are inscribed. In the U.S., anthropogenic forcing (regulations) is dominant in the humid regions, while variability in hydro-climatic forcing explains

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1352-2310/$ – see front matter
http://dx.doi.org/10.1016/j.atmosenv.2013.01.033