Atmospheric nitrogen deposition in arid Phoenix, Arizona is lower than expected: Findings from a methods comparison

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Cities occupy a small land area globally, yet atmospheric compounds generated from human-dominated ecosystems have significant impacts on protected lands. Atmospheric nitrogen (N) deposition alters ecosystems, including biogeochemical cycling, primary production, and community composition. In arid ecosystems, considerable uncertainty surrounds estimates of atmospheric N inputs due to variable precipitation and difficulties in quantifying dry deposition. We compared multiple approaches to quantify spatial and temporal patterns of N deposition at locations within Phoenix, Arizona and the surrounding native desert. Using with the Community Multi-scale Air Quality (CMAQ) model for Phoenix (for year 1996; Fenn et al. 2003) as a base for our predictions, we compared N deposition using wet-dry buckets (2000–2005; Lohse et al 2008), ion-exchange resin (IER) collectors (bulk and throughfall, 2006–2012), and inferential methods using passive samplers (atmospheric N concentrations x deposition velocity; 2010-2012). We found that rates of N deposition estimated with resin collectors, passive samplers, and wet-dry buckets (median 0.9 mgN m^{-2} d^{-1}, 0.1–4.1 mgN m^{-2} d^{-1}) are significantly lower than expected based on CMAQ model estimates (1.1-3.2 mgN m^{-2} d^{-1}). Contrary to CMAQ model predictions with high deposition within and east of Phoenix, inferential methods show elevated N deposition—in the form of ammonia, nitrogen oxides, and nitric acid deposition—is restricted to the urban core. In addition, we found that patterns of N deposition vary temporally. For example, N throughfall estimates are better predicted by summer monsoon precipitation than winter precipitation. Over two summer and winter seasons, we co-located samplers and directly compared methods for quantifying N deposition at two sites. We found estimates from inferential methods are consistently higher than throughfall estimates in an urban site, whereas inferential methods are lower than throughfall estimates in a non-urban site. Inconsistencies between approaches reveal how uncertainties related to quantifying site characteristics and deposition velocities can easily confound N deposition estimates. Our findings highlight the need for and benefit of mixed methods to quantify wet and dry N deposition in arid systems. Overall, we found that, despite the size and population of arid Phoenix, N deposition is lower than expected compared to other cities and is restricted mainly to the urban core.

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