Modeling nitrogen dry deposition inputs to the CAP LTER urban ecosystem.

D. Hope[1], S. Grossman-Clarke[2], W. Stefanov[1,3] and P. Hyde[4]

[1]Arizona State University Center for Environmental Studies, [2]ASU Department of Mechanical and Aerospace Engineering, [3]ASU Department of Geological Sciences, [4]Arizona Department of Environmental Quality

Photo: M. Katti

Introduction

1. Dry deposition is typically a significant component of ecosystem N inputs in arid ecosystems. This is especially so in urban areas (Lovett, 1994; Schlesinger et al 1982).
2. In urban areas the majority of dry deposited N is from gaseous N oxides and particulate nitrates produced by fossil fuel combustion, particularly from motor vehicle exhausts (Baker et al, in review; Russell et al 1993)
3. Studies in and around Los Angeles have estimated such inputs at between 25 and 88 kg N ha^{-1} yr^{-1} (Burian et al, in review; Bytnerowicz and Fenn 1996; Takemoto et al. 1995).
4. Total NOx emissions for the CAP ecosystem are estimated at 320 t d^{-1}. If modeled estimates for LA are applied to CAP, then up to 22% of this NOx (i.e. 22 kg N ha^{-1} yr^{-1}) may be deposited as dry fall (Russell et al, 1993).
5. To date, measured inputs of N via atmospheric deposition have been an order of magnitude lower than these predictions (see Hope et al poster on atmospheric deposition across CAP LTER in this session). However CAP monitoring currently only samples the coarse particulate component of dryfall. Monitoring of fine particulate and gaseous deposition by NOAA is only carried out at one undeveloped desert site to the east of the urban area.

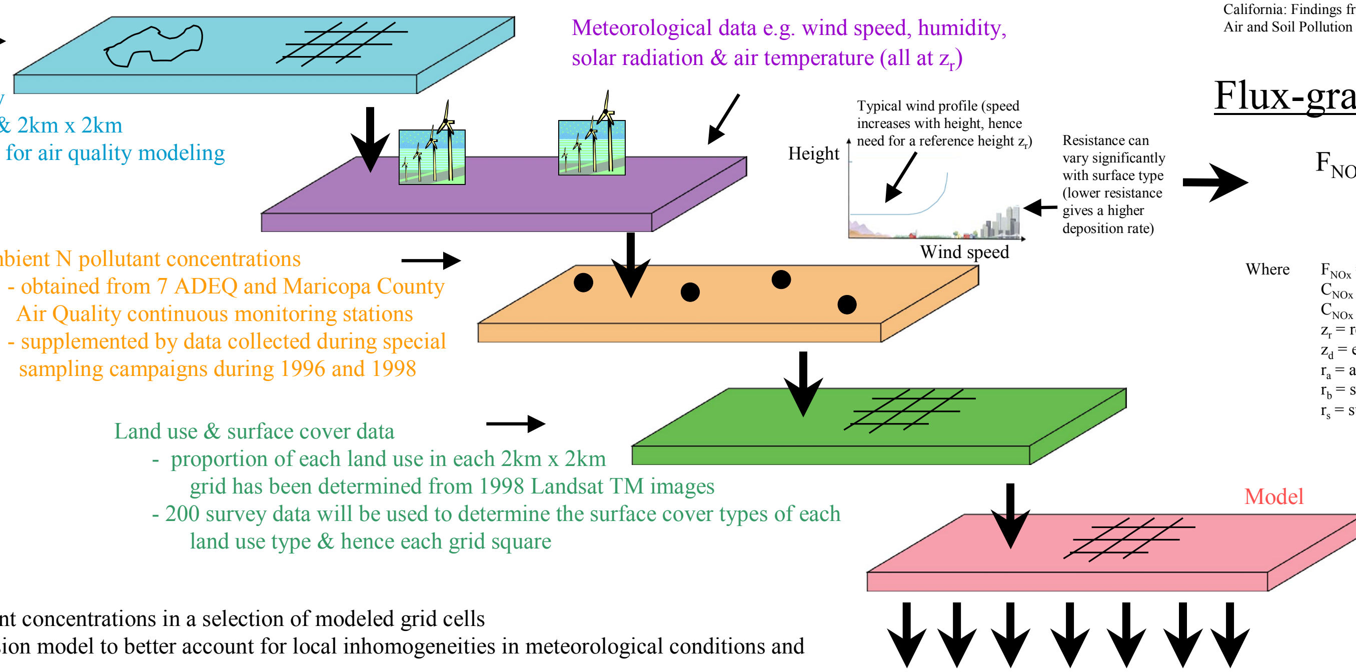
Aims

1. Accurately estimate dry N deposition rates across the CAP ecosystem.
2. Use available air quality data from monitoring networks operated by state and county agencies(ADEQ and Maricopa County).
3. Develop a flux-gradient resistance model to estimate deposition of all the main N species (NO_2, HNO_3, NH_3, NH_4NO_3).

Input Data

Study area defined by CAP ecosystem boundary (*sensu* Baker et al) & 2km x 2km grid used by ADEQ for air quality modeling

Meteorological data e.g. wind speed, humidity, solar radiation & air temperature (all at z_r)



Ambient N pollutant concentrations
- obtained from 7 ADEQ and Maricopa County Air Quality continuous monitoring stations
- supplemented by data collected during special sampling campaigns during 1996 and 1998

ADEQ's Phoenix Supersite – one of the air pollutant monitoring stations from which data will be used for the deposition model

Land use & surface cover data
- proportion of each land use in each 2km x 2km grid has been determined from 1998 Landsat TM images
- 200 survey data will be used to determine the surface cover types of each land use type & hence each grid square

Model

RESULT = N deposition flux for each N pollutant in each grid cell

Σ = Total dry N deposition

Future Work

- field test modeled air pollutant concentrations in a selection of modeled grid cells
- apply an atmospheric dispersion model to better account for local inhomogeneities in meteorological conditions and pollutant concentrations
- include emission inventory data in the model
- incorporate remotely sensed data (surface albedo and temperature) to improve surface characteristics in the model

References

Baker, L., Xu, Y., Lauver, L., Hope, D. and Edmonds, J. (in review) Nitrogen balance for the Central Arizona-Phoenix Ecosystem. Ecosystems.

Burian, S. J., Streit, G. E., McPherson, T. N., Brown, M. J. and Turin, H. J. (in review). Modeling the atmospheric deposition and stormwater washoff of nitrogen compounds. Environmental Modelling and Software.

Bytnerowicz, A. & Fenn, M. E. 1996. Nitrogen deposition in California forests: a review. Environmental Pollution 92: 127-146.

Lovett, G. M. 1994. Atmospheric deposition of nutrients and pollutants in North America: an ecological perspective. Ecol. Applications 4: 629-650.

Russell, A. G., Winner, D. A., Harley, R. A., McCue, K. F., Cass, G.R. 1993. Mathematical modeling and control of the dry deposition flux of nitrogen-containing air pollutants. Environmental Science & Technology 27: 2772-2782.

Schlesinger, W. H., Gray, J. T. and Gilliam, F. S. 1982. Atmospheric deposition processes and their importance as sources of nutrients in a chaparral ecosystem of southern California. Water Resources Research, 18: 623-629.

Takemoto, B. K., Croes, B.E., Brown, S. M., Motallebi, N. Westerdahl, F. D., Margolis, H. G., Cahill, B. T. Mueller, M. D. and Holmes, J. R. 1995. Acidic deposition in California: Findings from a program of monitoring and effects research. Water Air and Soil Pollution 85: 261-272.

Flux-gradient resistance model

$$F_{NOx} = \frac{C_{NOx}(z_r) - C_{NOx}(z_d)}{r_a + r_b + r_s}$$

Where
F_{NOx} = Nitrogen deposition flux[mol m^{-2} s^{-1}]
$C_{NOx}(z_r)$ = NO_x concentration at z_r
$C_{NOx}(z_0)$ = NO_x concentration at z_d
z_r = reference height in the atmosphere [m]
z_d = effective source/sink height at the surface [m]
r_a = aerodynamic resistance at z_r [s m^{-1}]
r_b = sub-layer resistance [s m^{-1}]
r_s = surface resistance [s m^{-1}]