ESTIMATING NITROGEN DEPOSITION INTO THE CONNECTICUT RIVER BASIN USING CMAQ

Patricia A. Bresnahan, * David R. Miller, Jesse O. Bash
Natural Resource Management and Engineering, University of Connecticut, Storrs, CT
e-mail: **pbresnah@canr.cag.uconn.edu**
Voice (860) 429-5769 Fax (860) 429-5769

1. INTRODUCTION

Nitrogen from the Connecticut River Basin is a significant component of nitrogen loading into Long Island Sound and contributes to the problems of hypoxia in this water body (Mullaney et al. 2002). Deposition also impacts terrestrial and freshwater ecosystems through the acidification of soil and surface waters, reducing the diversity of aquatic organisms and stressing native vegetation (Driscoll et al., 2003).

Annual estimates of total nitrogen deposition have been reported in a number of measurement studies in the northeast region. Goodale et al. (2002) reported nitrogen deposition rates between 5 and 12 kg N per hectare per year for 16 basins in the northeast region. Kelly et al. (2002) reported rates of between 6 and 15 kg N per hectare per year for a site in southeastern New York State. Annual nitrogen deposition rates of 11 kg N per hectare were reported by Bowen and Valiela (2001) in their study of historical trends in the Cape Cod area.

The atmospheric modeling group associated with the Connecticut River Airshed/Watershed project (http://www.crawc.org/) is focusing on the factors affecting air quality and atmospheric deposition in the Connecticut River Basin. The study reported here is describes some preliminary estimates of nitrogen deposition into the Connecticut River Basin using CMAQ.

* *Corresponding author address:* Patricia A. Bresnahan, Natural Resource Management and Engineering, University of Connecticut, UNIT 4087, 1376 Storrs Rd., Storrs, CT 06269-4087

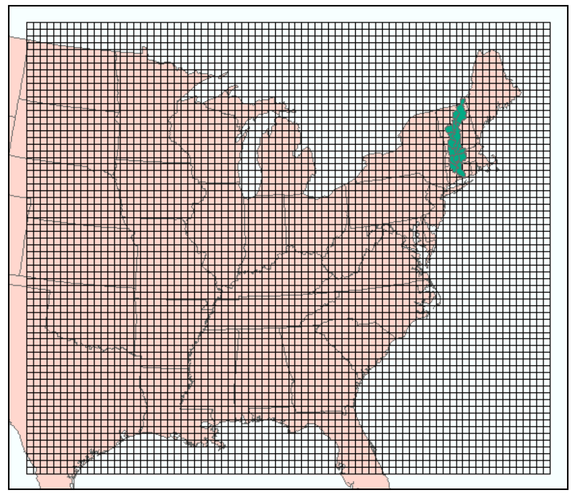

Fig. 1. 36 km modeling domain, with the Connecticut River Basin highlighted.

2.0 METHODS

The spatial domain (Figure 1) was based on a July 1997 MM5 run provided to us through NYDEC, that was generated at the University of Maryland. This dataset is based on the 36km Unified Grid and covers the eastern portion of the United States (67x78x21, 84Hrs). Emissions were generated using SMOKE with the Net96 inventory.

The hardware and software configuration used in this work was described in a benchmark study reported on in Bresnahan (Bresnahan et al., 2003). The May 2003 release of CMAQ (version 4.2.2) and other Models3 tools were compiled and used for this test.

In order to extract deposition within the basin boundary only, in ArcInfo, the modeling domain was overlayed onto a data layer containing the shape of the Connecticut River Basin. The percent of each grid cell's area that fell within the basin boundary was determined and used to calculate the weighted contribution of that cell's deposition to basin deposition totals.

The contribution of each model nitrogen species to total nitrogen mass deposition was made by weighting the species deposition mass by the relative amount of nitrogen mass in that species.

The annual deposition estimate was made by multiplying daily average deposition for the modeling period (excluding the 12 hour "spin up") by 365. The hourly deposition rates were converted to kilograms per hectare for comparison with published deposition estimates for the region.

3.0 RESULTS AND DISCUSSION

As shown in Figure 2, HNO3 contributed by far the most dry deposition nitrogen mass during the 3-day simulation period, with peak deposition occurring during the afternoons of the second and third simulation days.

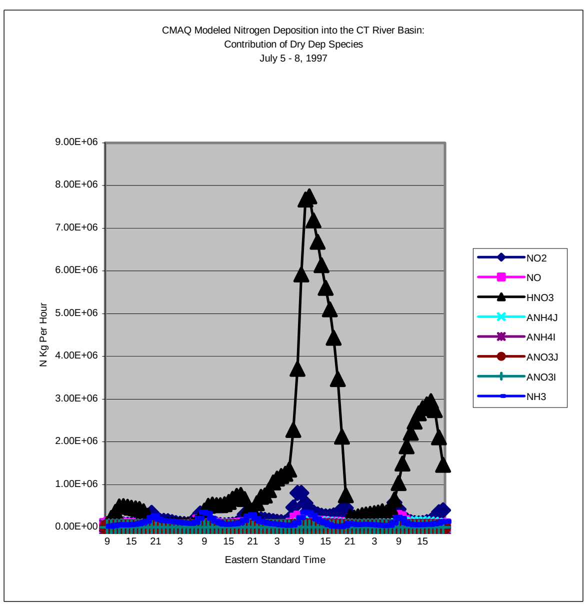

Fig. 2. CMAQ modeled dry deposition of nitrogen species, Connecticut River Basin, July 5-7 1997.

Wet deposition of nitrogen mass for this period was dominated by nitrogen contributed by the particulate species of NO3 and NH4 (indicated as ANO3J and ANH4J in Figure 3 below), with a peak on the second day occurring slightly later than the dry deposition peak. Wet deposition was associated with a precipitation event in the lower basin.

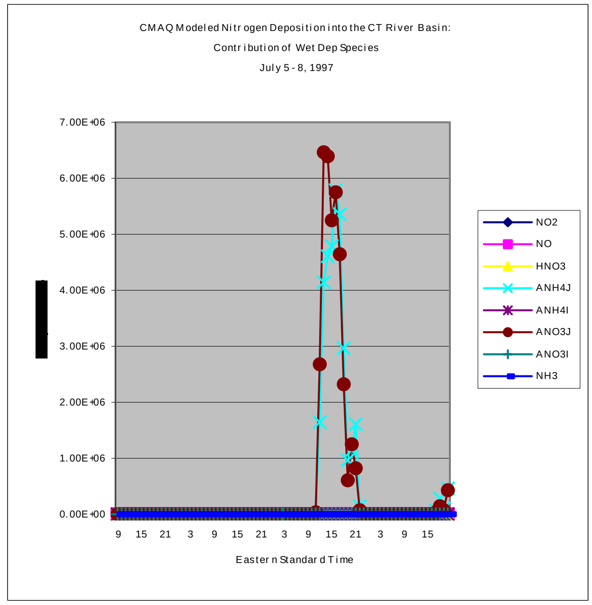

Fig. 3. CMAQ modeled wet deposition of nitrogen species, Connecticut River Basin, July 5-7 1997.

Total nitrogen mass deposition (Figure 4) was dominated by dry deposition for most hours in the simulation period, but during the precipitation event, wet deposition exceeded dry in the basin.

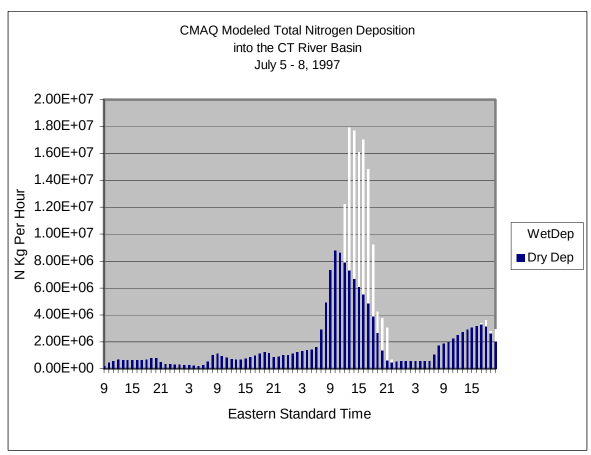

Fig. 4 CMAQ modeled total deposition of nitrogen species, relative contribution of wet and dry species, Connecticut River Basin, July 5-7 1997.

A very crude estimate of annual nitrogen mass deposition into the Connecticut River Basin can be made using the results of the July 5-7, 1997 data. When the July estimates are extrapolated to an annual time period, the estimate comes out to approximately 10.4 kilograms of nitrogen per hectare per year (Table 1 below). This is well within the range of annual estimates reported by other researchers for the region.

Time Period	Dry	Wet	Total
84 HR Total Basin N Kg	1.54E+08	7.11E+07	2.25E+08
72 HR Total Basin N Kg:	1.47E+08	7.11E+07	2.18E+08
Ave Total Basin N Kg/Day:	4.90E+07	2.37E+07	7.27E+07
N Kg/Hectare/Day	1.92E-02	9.30E-03	2.85E-02
N Kg/Hectare/Yr	7.01E+00	3.39E+00	1.04E+01

Table 1. Estimating annual nitrogen deposition in the Connecticut River basin using CMAQ output for July 5-7, 1997.

4.0 CONCLUSIONS

Nitrogen deposition rates in the Connecticut River Basin as calculated using CMAQ compare favorably with published estimates. Dry deposition is dominated by HNO_3, and wet deposition by particulates of NO_3 and NH_4. Wet deposition exceeded dry only during precipitation events. Extrapolating the July 5-7 results gives an estimate of annual total nitrogen deposition of 10.4 kg per hectare within the basin.

5.0 ACKNOWLEDGEMENTS

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