Concentration-dependent deposition velocities for ammonia: moving from lab to field.

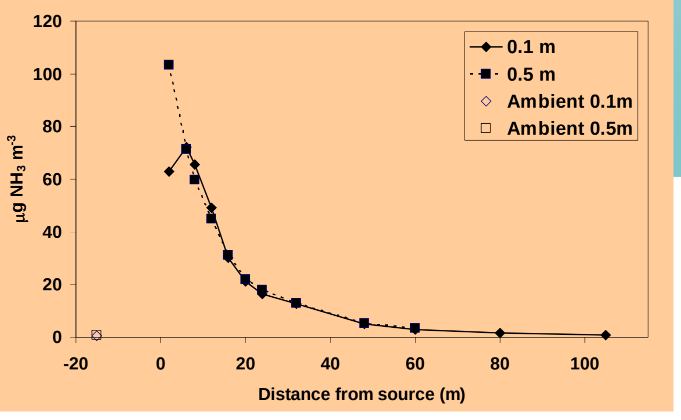
J. Neil Cape, Mathew R. Jones, Ian D. Leith, Lucy J. Sheppard, Netty van Dijk, Mark A. Sutton and David Fowler

Centre for Ecology & Hydrology, Bush Estate, Penicuik EH26 0QB, UK

E-mail: jnc@ceh.ac.uk

BACKGROUND

Measurements in a well-mixed chamber of ammonia deposition to moorland vegetation showed that the surface resistance increased as NH_3 concentrations increased (Jones et al., 2007). This means that where NH_3 concentrations are high, for example downwind of intensive animal houses, the rate of dry deposition is less than would be predicted using a constant deposition velocity. This study translated the laboratory results to a field experiment, in which moorland vegetation is exposed to NH_3 under open field conditions to simulate the effects of agricultural NH_3 pollution (Leith et al., 2004). Concentration-dependent surface resistances were combined with measured wind speed every 30 minutes to determine overall resistances and effective deposition velocities at two heights above the canopy, 0.1 and 0.5 m.

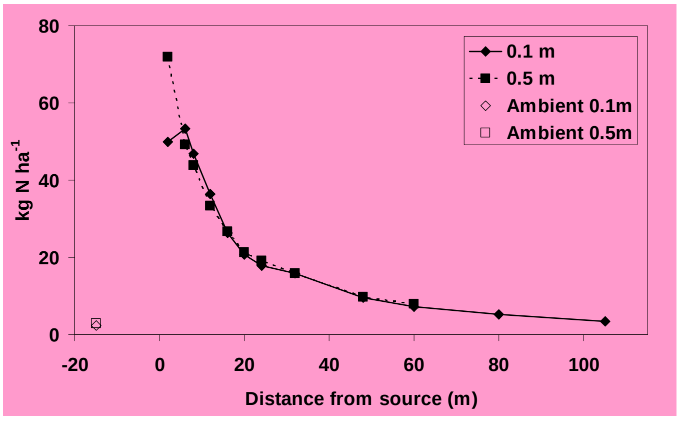


Annual average NH_3 concentrations above the canopy (at 0.1 and 0.5 m) are measured using passive diffusion samplers every month, and show a decrease downwind from 100 µg m^{-3} to ambient.

However, during NH_3 release, concentrations close to the source are over 10 times as large – these high concentrations control the surface resistance and hence the deposition rate

Annual dry deposition along the transect, calculated using the concentration-dependent surface resistances, decreases from around 50 kg N ha^{-1} y^{-1} to the ambient value of 3 kg N ha^{-1} y^{-1}.

The calculations are performed independently for the two measurement heights; the good agreement (except close to the source) gives an indication of the measurement uncertainties.



REFERENCES:

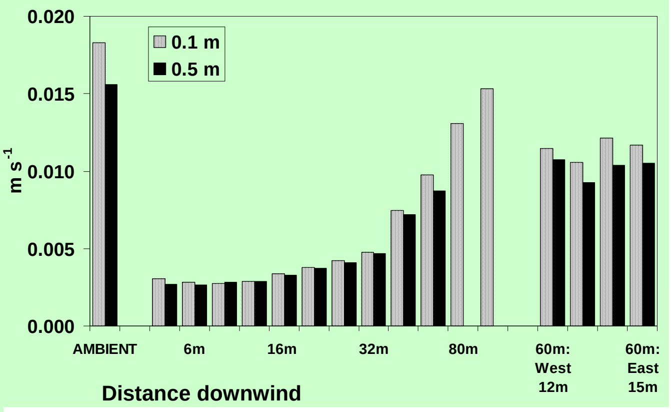
Jones, M.R., Leith, I.D., Fowler, D., Raven, J.A., Sutton, M.A., Nemitz, E., Cape, J.N., Sheppard, L.J., Smith, R.I., Theobald, M.R., 2007. Concentration-dependent NH_3 deposition processes for mixed moorland semi-natural vegetation. Atmospheric Environment 41, 2049-2060

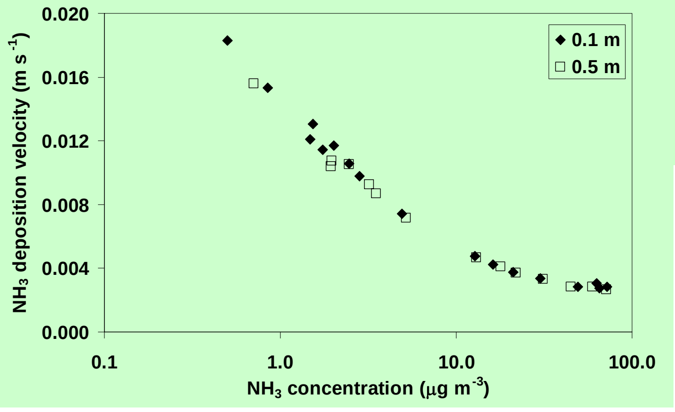
Leith I.D., Sheppard L.J., Fowler D., Cape J.N., Jones M., Crossley A., Hargreaves K.J., Tang Y.S., Theobald M., Sutton M.A., 2004. Quantifying dry NH_3 deposition to an ombrotrophic bog from an automated NH_3 field release system. Water, Air, & Soil Pollution: Focus 4, 207-218

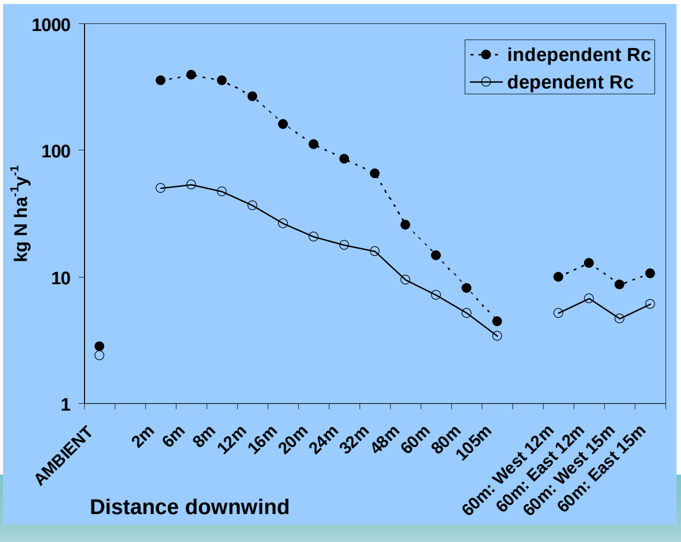
Centre for Ecology & Hydrology
NATURAL ENVIRONMENT RESEARCH COUNCIL

The field experiment, in south-east Scotland, emits NH_3 under the prevailing SW wind conditions to provide a controlled exposure along a 100m transect, with concentrations decreasing to the ambient values of < 1 µg m^{-3}. Effects on the vegetation are studied as a function of exposure, and in comparison with an adjacent experiment that applies nitrogen as ammonium or nitrate ions in simulated rainfall.

The variation in the surface resistance with NH_3 concentration is shown in the variation in annual average deposition velocity (height dependent) along the transect, as a function of distance (right) or average NH_3 concentration (below).







CONCLUSIONS

- **The slower uptake of NH_3 at high concentrations means that dry deposition is much smaller than it would be if calculated using a concentration-independent deposition velocity (upper line)**
- **In this field experiment the difference is a factor of 10 close to the source, and a factor of 2 at 60 m downwind**
- **Accurate estimates of dry deposition are required in order to predict the ecological effects of N deposition close to sources – simple inferential techniques are not appropriate.**