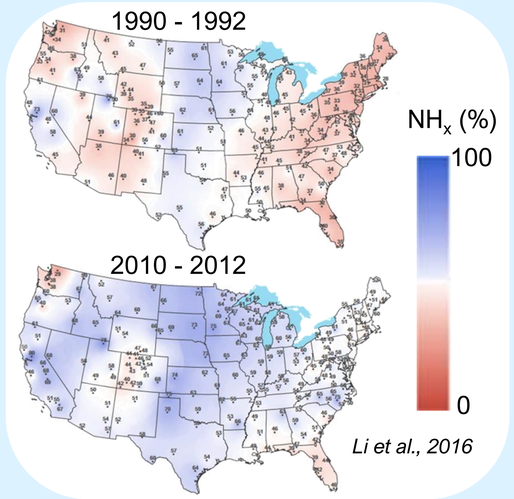
STAGE-simulated dry deposition across the Ammonia (NH_3) Monitoring Network (AMoN)

Colleen Baublitz[1] (baublitz.colleen@epa.gov), Zhiyong Wu[1*], John Walker[1], Jesse Bash[1]
1. Office of Research and Development (ORD), U.S. Environmental Protection Agency (EPA), Durham, NC
*Now with: Research Triangle Institute International, Durham, NC

Dry deposition: an influential but uncertain sink for NH_3

Nitrogen deposition affects air pollutant lifetimes.
Ammonia (NH_3) is a growing contributor to total nitrogen deposition (Figure), primarily via dry deposition.

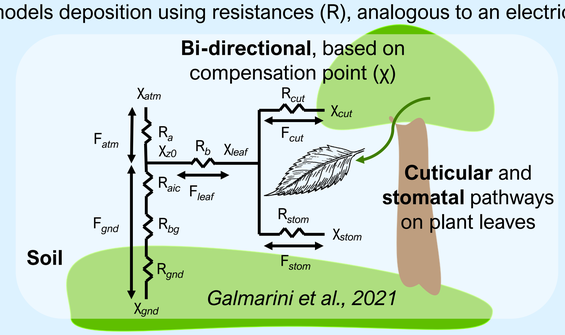


There are few long-term measurements of NH_3 dry deposition, so we study this process over AMoN using an inferential model.

Surface Tiled Aerosol and Gaseous Exchange (STAGE)

STAGE is a new option available in CMAQ v5.3 that is used in the EPA Air Quality Time Series (EQUATES) project; https://www.epa.gov/cmaq/equates.

STAGE models deposition using resistances (R), analogous to an electrical circuit.

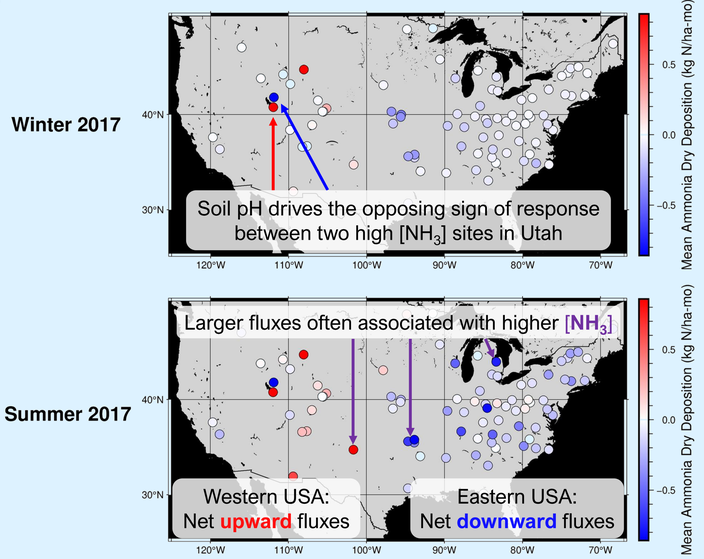


We use STAGE as a field scale model and observation-based data as input—to the extent possible--to test the sensitivity of NH_3 dry deposition to individual drivers.

Publicly available datasets used as input for STAGE

- MODIS retrievals for leaf area index, land cover
- USDA NRCS survey for soil pH, bulk density
- Meteorological reanalyses from NLDAS, RTMA, NARR
- (Future) pilot site data for STAGE evaluation
- AMoN biweekly [NH_3]
- CMAQ EQUATES hourly NH_3
- Noah land surface model simulations of soil temperature, moisture and friction velocity

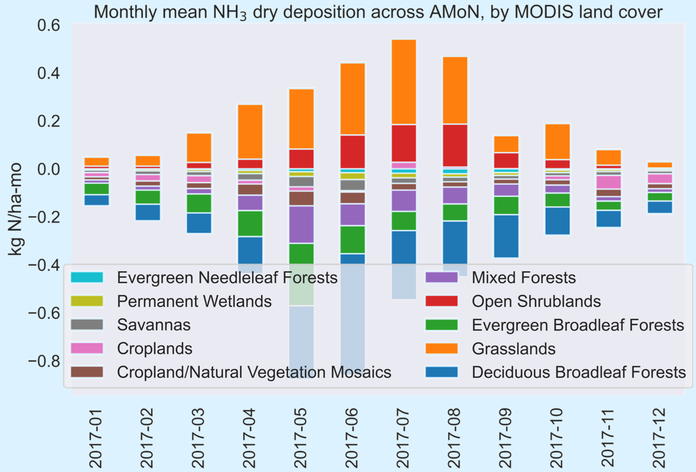
Across AMoN, spatial coherence in the direction of flux



Unidirectional (downward) NH_3 dry deposition schemes in chemical transport models may overestimate the depositional sink, underestimating the role of summertime re-emission in the western US NH_3

Few land cover types modulate AMoN NH_3 dry deposition

Grasses and **shrubs**: most of the upward, evasive flux
Broadleaf **deciduous** and **evergreen** forests: most of the downward sink

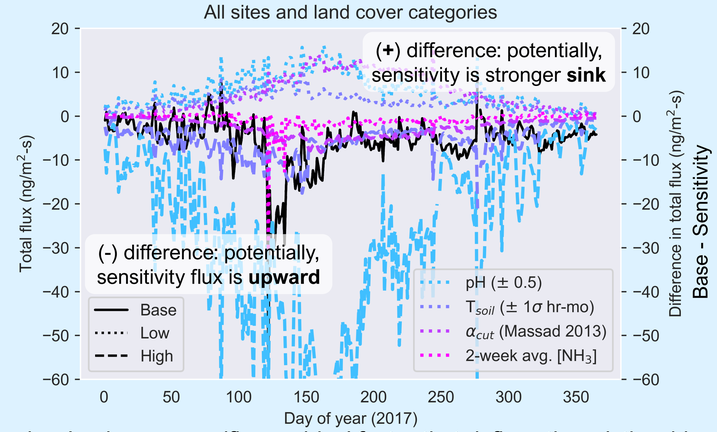


Note that AMoN sites are generally located distant from NH_3 sources (i.e., this is not necessarily spatially representative for the USA).

This suggests that future measurements should focus on reducing uncertainty in the representation of NH_3 dry deposition over these land cover types toward improved constraints on the NH_3 sink.

Which processes modulate NH_3 dry deposition?

Compare the "Base" with alternative simulations, which have individual input terms adjusted up ("High") or down ("Low") based on measured variations, to test the sensitivity of AMoN NH_3 dry deposition to each term.



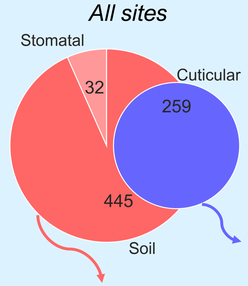
α_{cut} is a landcover-specific empirical factor that defines the relationship between relative humidity and cuticular resistance to dry leaves.

Removing the hourly normalization of [NH_3] (*i.e.*, using the bi-weekly observed value for each hourly timestep) has a smaller effect than modifying other biophysical inputs (*e.g.*, soil **pH** or **temperature**) or the empirically determined α_{cut} on modeled AMoN NH_3 dry deposition.

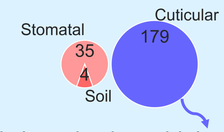
Constraints on western US NH_3 dry deposition are needed

AMoN annual component fluxes (kg N/ha-y)

All sites



Excluding high soil pH sites; note that these sites are excluded from the bar chart in the center column



*Excluded sites also have high annual [NH_3], contributing the difference in **cuticular** flux*

Western US **grassland** sites with relatively high soil pH (>7.5) show **unrealistically large** upward fluxes from soils in the summer, highlighting the need for **more observational constraints**.

Funding information and acknowledgements

The authors gratefully acknowledge support for this work in progress from the postdoctoral programs of the Oak Ridge Institute for Science and Education and the U.S. EPA, as well as under U.S. EPA ORD StRAP4 Output ACE.401.405.01.

References: Y. Li, *et al.*, Increasing importance of deposition of reduced nitrogen in the United States. *Proc. Natl. Acad. Sci. U.S.A.* **113**, 5874–5879 (2016).
S. Galmarini, *et al.*, Technical note: AQMEII4 Activity 1: evaluation of wet and dry deposition schemes as an integral part of regional-scale air quality models. *Atmos. Chem. Phys.* **21**, 15663–15697 (2021).