

*National Atmospheric Deposition Program's
Ammonia Monitoring Network (AMON)*

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National Atmospheric
Deposition Program



Talk Outline

- Introduction to NADP Monitoring
 - National Trends Network (NTN)
 - Ammonia Monitoring Network (AMoN)
- Results
- Trends in Time

What Is the National Atmospheric Deposition Program?



National Atmospheric
Deposition Program

- A Cooperative Research Support Project @UI (USDA)
 - measure wet deposition of pollutants (“precipitation”)
 - pollution flux out of the atmosphere/into the biosphere
 - over North America
 - now South America, Asia
 - ~ 450,000 precipitation samples
 - Started in 1978, 37th year
 - “acid rain network”

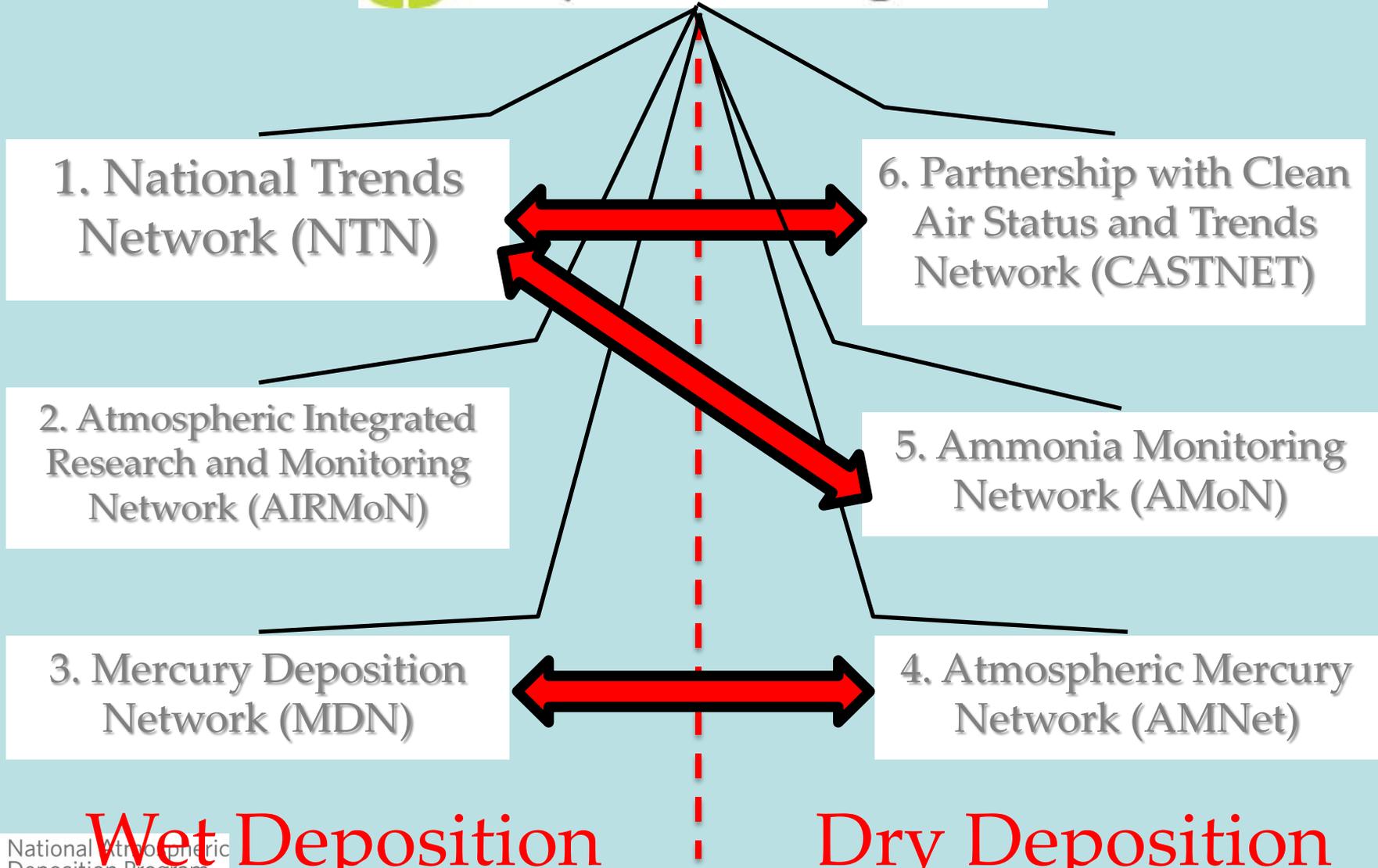


NADP's Goal

To *monitor* the chemistry of precipitation (rain and snow) and in the atmosphere, as *consistently* and *accurately* as we can, for long periods to determine changes over time (trends).



National Atmospheric Deposition Program



The NADP Cooperators

(100+ total agencies)



Tribal Organizations



Federal Agency Members



Universities



US States



Other Organizations



NADP Organization

- 250 Cooperators within NADP
- all are welcome to join any network
- All data is available to use and is online:

nadp.isws.illinois.edu/

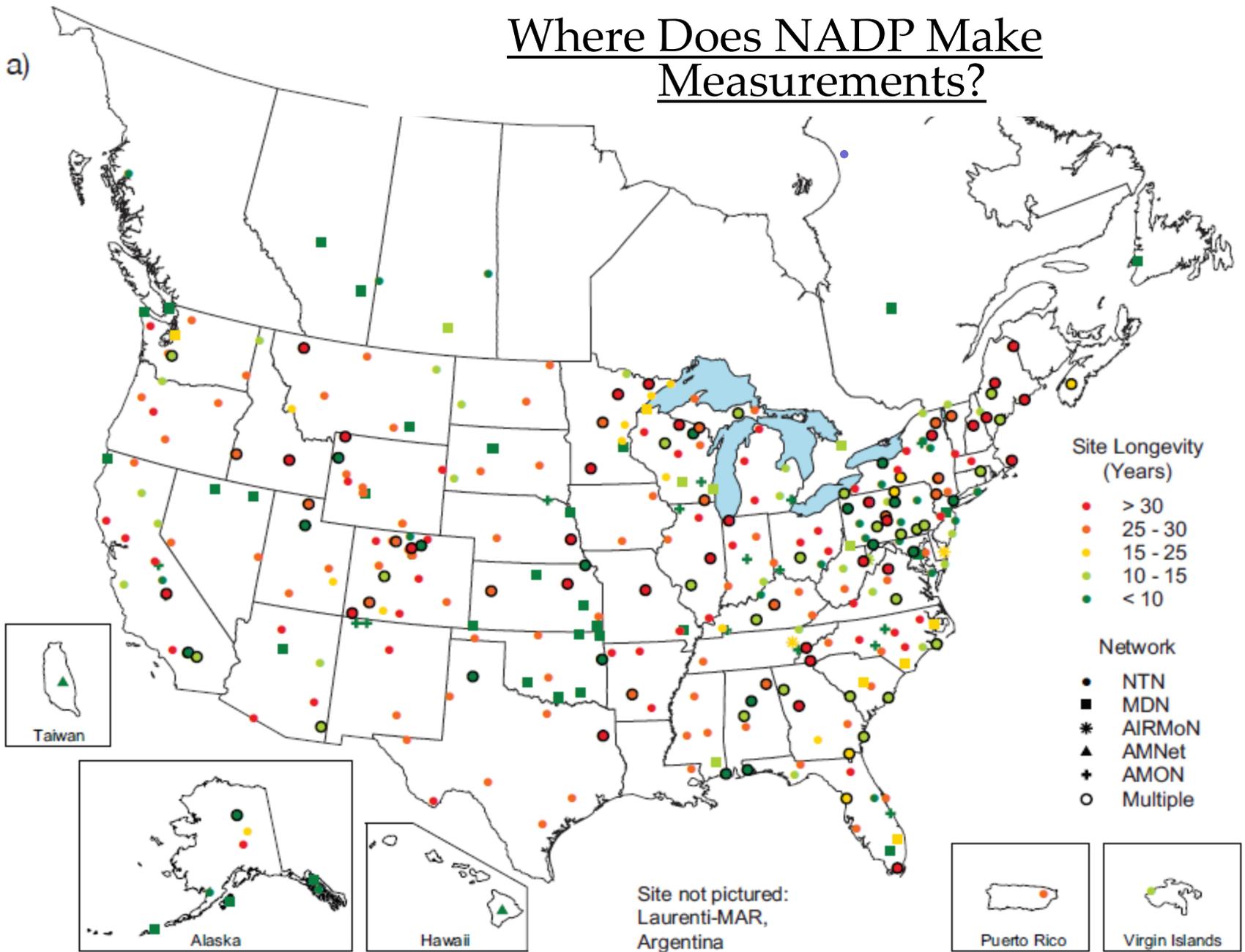


Where

Do We Measure Wet
Deposition?

Where Does NADP Make Measurements?

a)



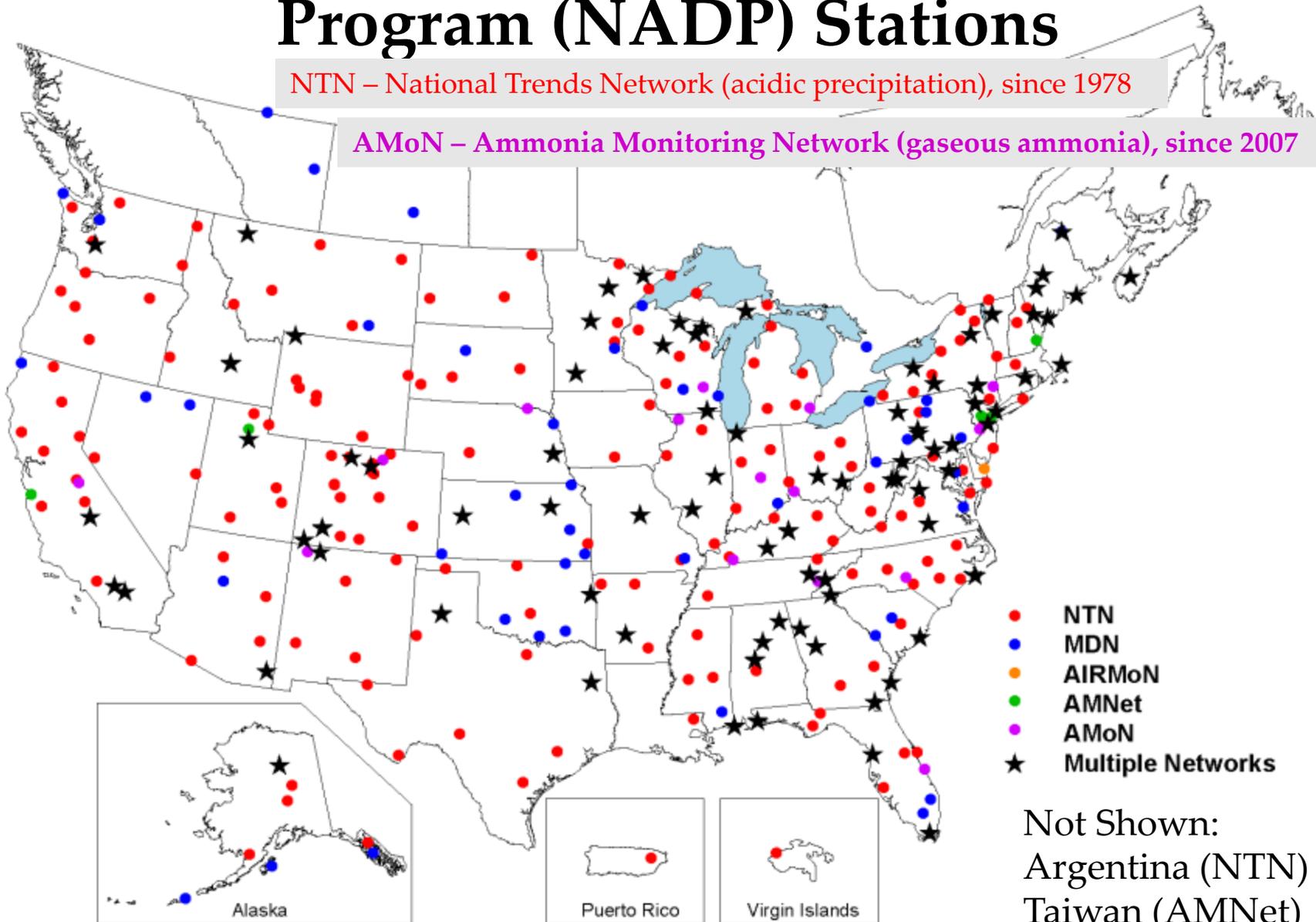


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National Atmospheric Deposition Program (NADP) Stations

NTN – National Trends Network (acidic precipitation), since 1978

AMoN – Ammonia Monitoring Network (gaseous ammonia), since 2007



Network #1: National Trends Network (NTN)



Collects one-week precipitation-only samples
concentration and deposition



Analyses

Acids (H^+ , conductivity)

SO_4^- , NO_3^- , NH_4^+

Na^+ , Cl^- , Ca^{2+} , K^+ , Mg^+

Ortho-phosphate



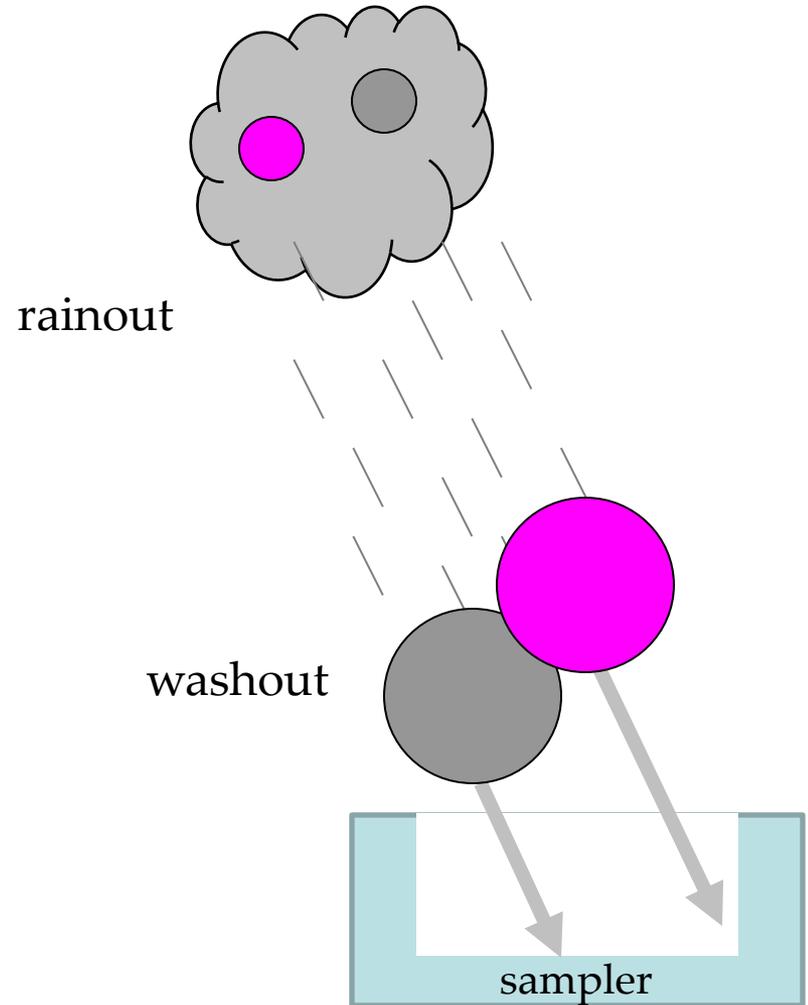
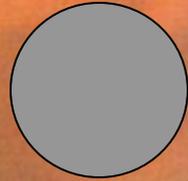
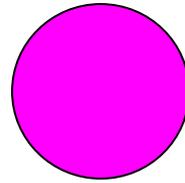
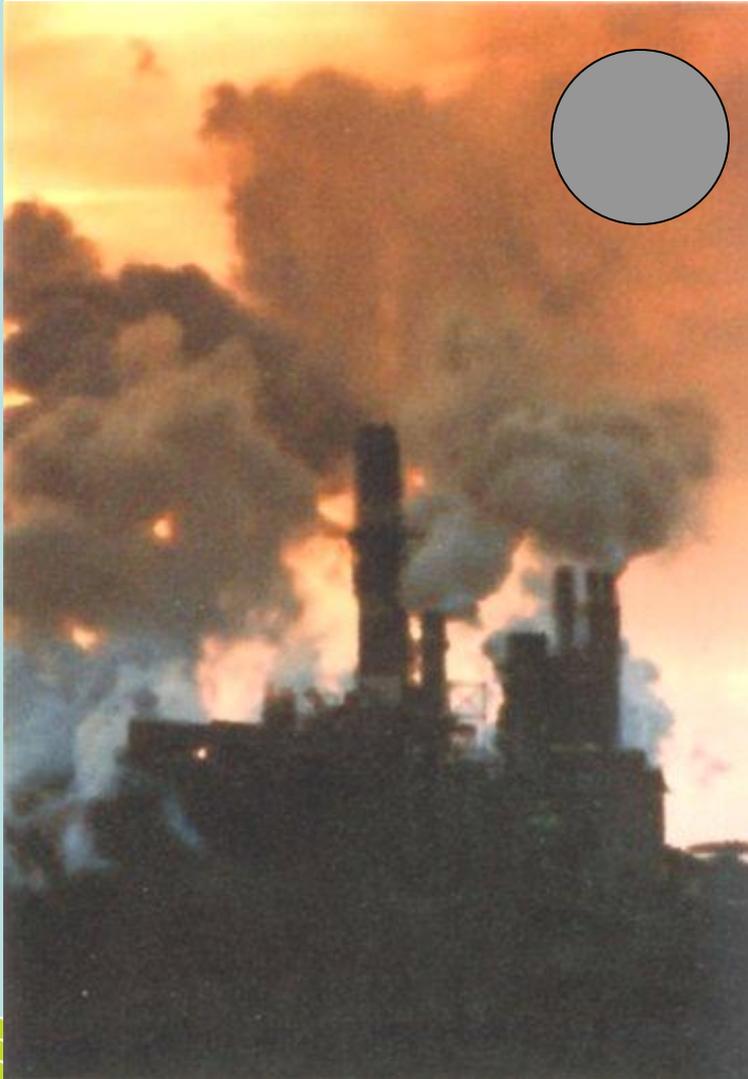
Weekly mg/L and mg/ha-week



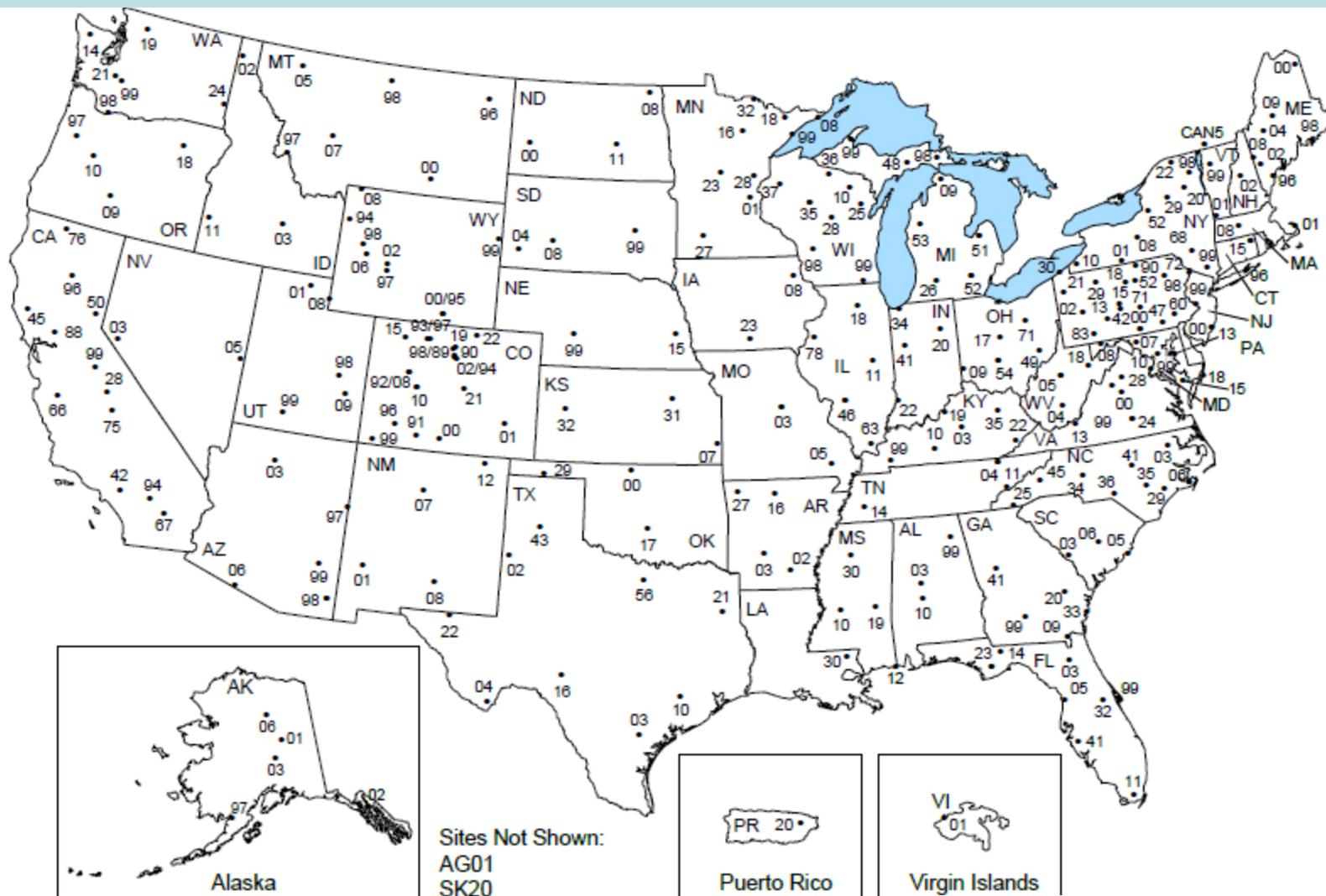
Since 1978



How does pollution get into precipitation?



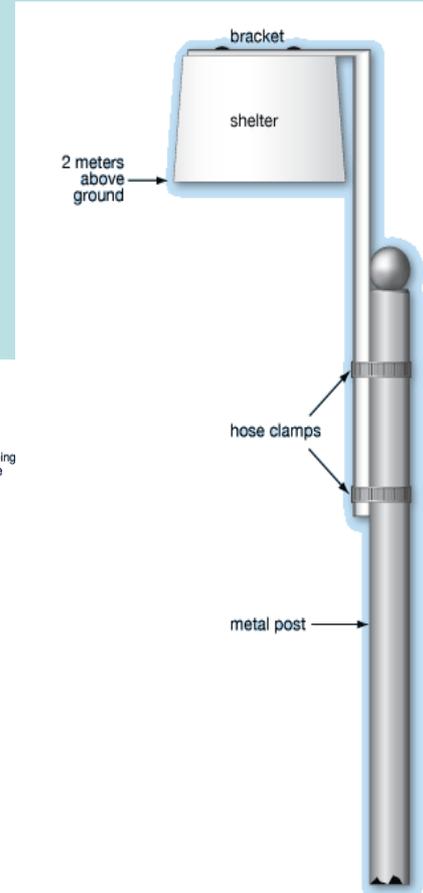
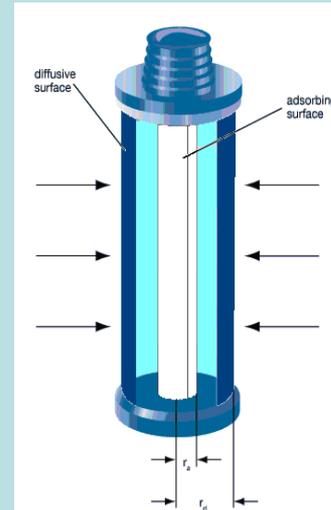
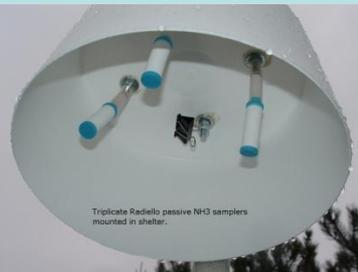
National Trends Network (NTN)



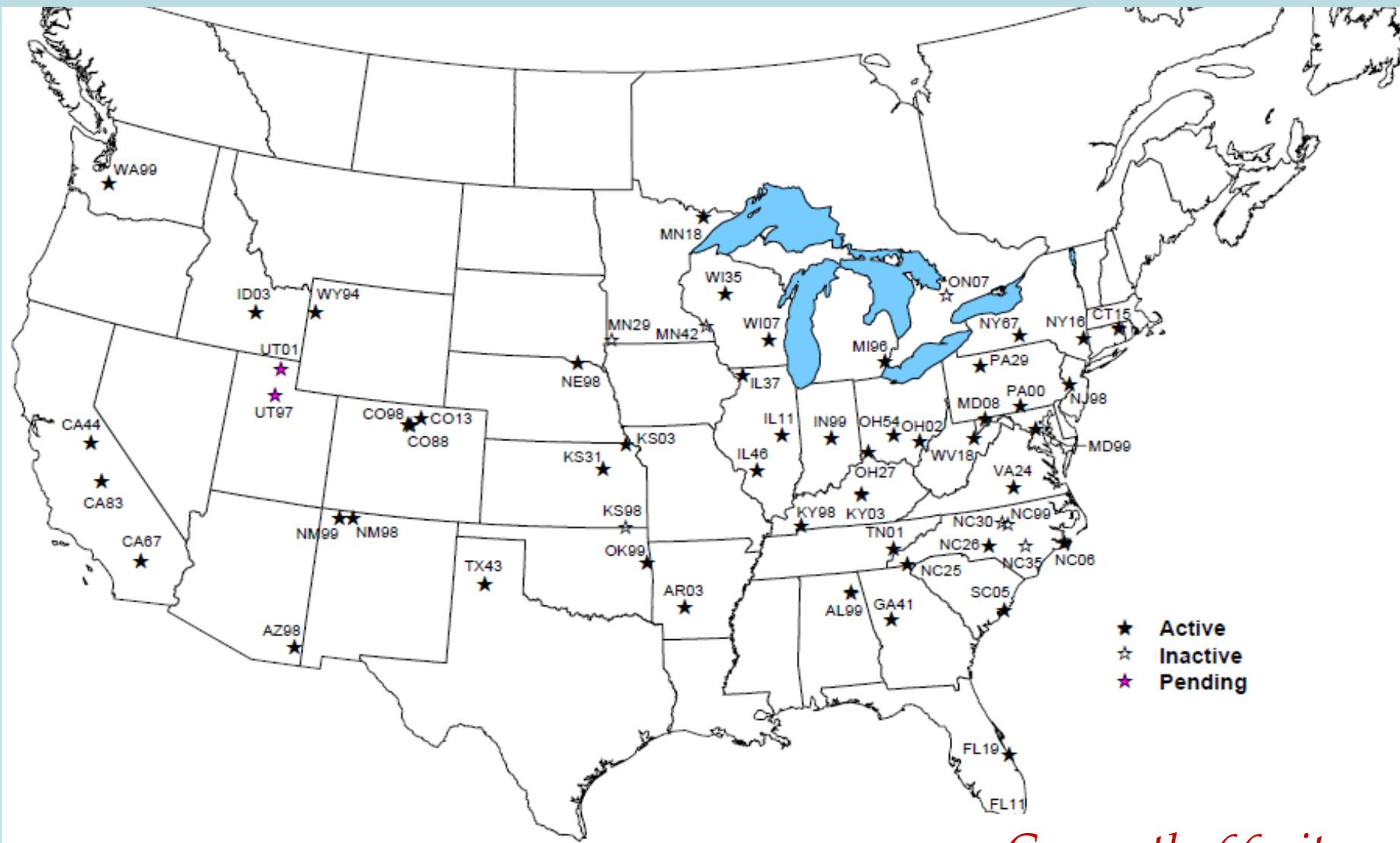
Currently 256 sites

Network #5: Ammonia Monitoring Network (AMoN)

- Measure atmospheric concentrations of ammonia, since 2010
- Passive samplers (no pumps or electricity)
- Low cost, 2 week integrated sample
 - $\mu\text{g NH}_3/\text{m}^3$
- 5,900 two-week average observations

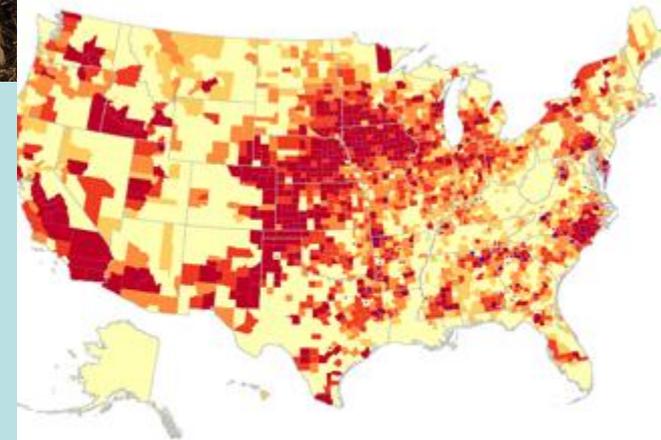


Ammonia Monitoring Network (AMoN)



Currently 66 sites

Ammonia (NH_3)



AMoN Methodology

- Sampler Type
 - Radiello-type passive diffusive sampler (PDS)
- Field Deployment
 - 2 week deployments in NADP-provided field shelter, 2 m height
- Laboratory Analysis
 - Flow injection analysis (FIA) colorimetry for ammonium ion



Why Radiello PDS?

Journal of
Environmental
Monitoring

Cite this: *J. Environ. Monit.*, 2011, **13**, 3156

www.rsc.org/jem

Dynamic Article Links 

PAPER

Passive ammonia monitoring in the United States: Comparing three different sampling devices†

Melissa A. Puchalski,^{*a} Mark E. Sather,^b John T. Walker,^c Christopher M. B. Lehmann,^d David A. Gay,^d Johnson Mathew^e and Wayne P. Robarge^f



AMoN Quality Assurance

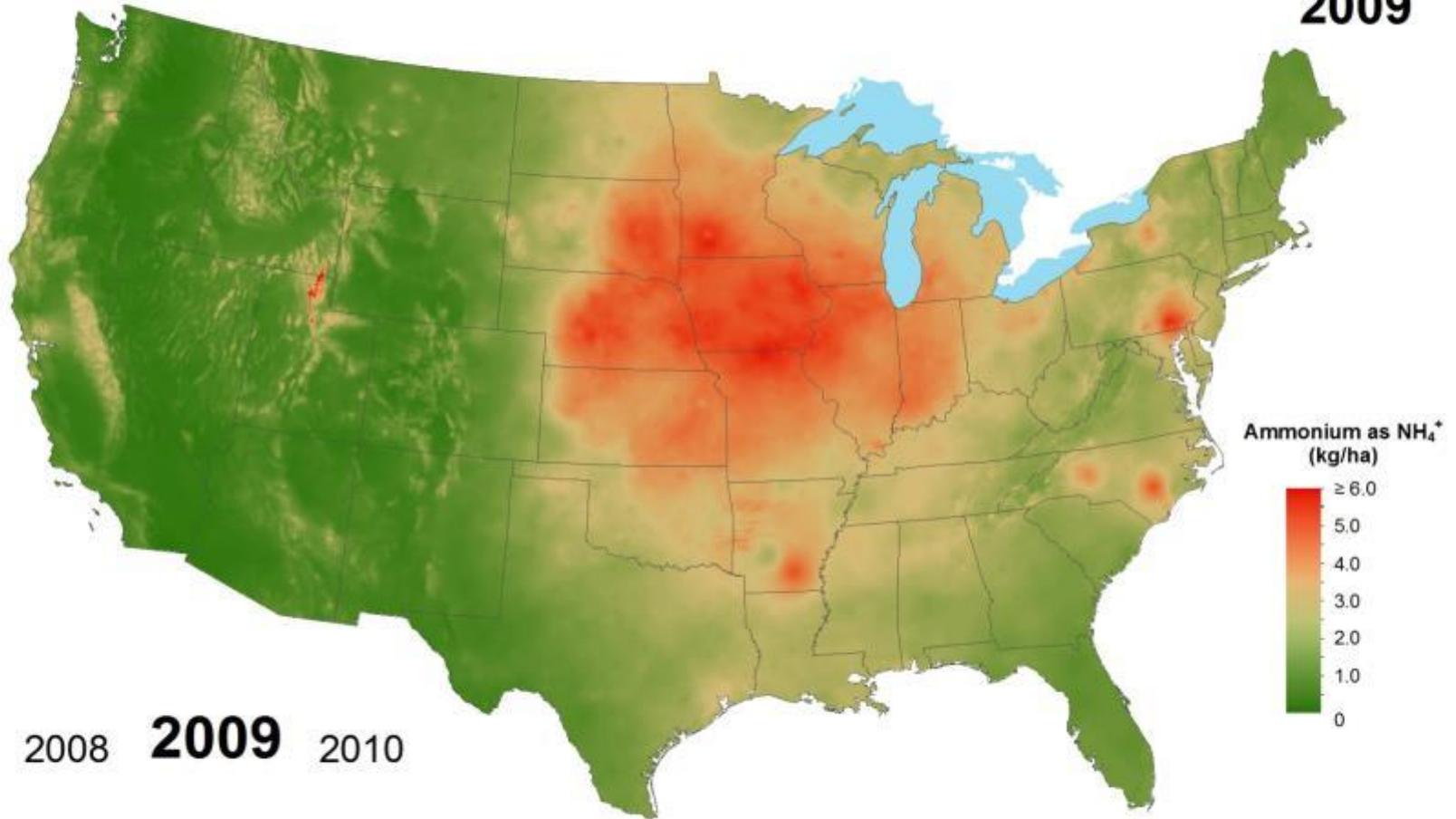
- **Travel Blanks** – Deployed randomly at 25% of sites every 2 weeks
- **Triplicates** – Deployed randomly at 5% of sites and always at Bondville, IL; select sites pay supplement to have triplicates for all deployments
- **Reference Comparison** – Denuders at Bondville, IL
- **External Audit** – Visit to each AMoN site



Results of all of this?

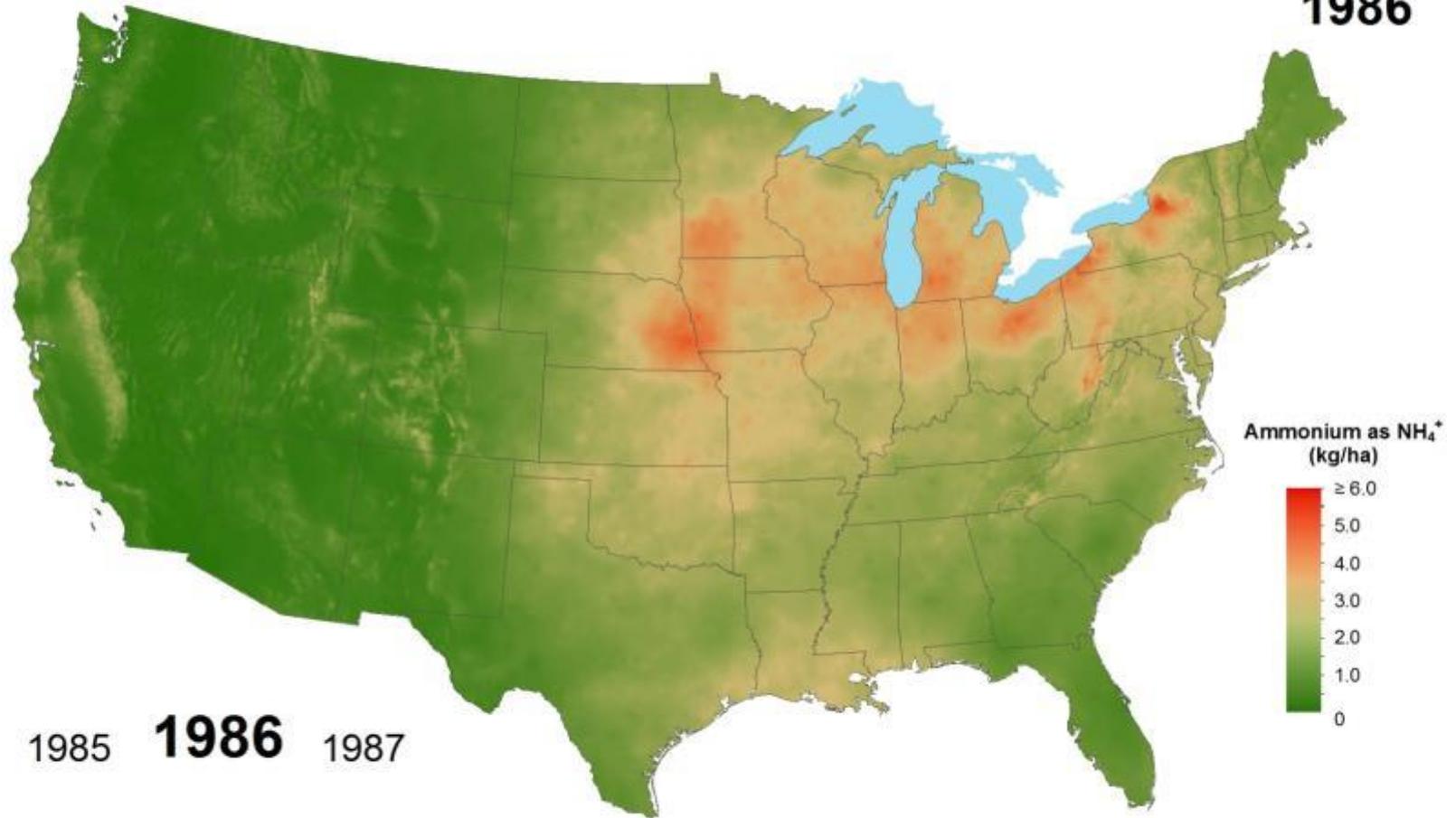
Wet Deposition Results

Ammonium ion wet deposition 2009



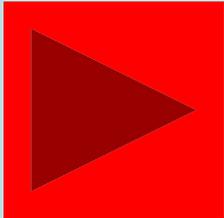
National Atmospheric Deposition Program/National Trends Network
<http://nadp.isws.illinois.edu>

Ammonium ion wet deposition 1986

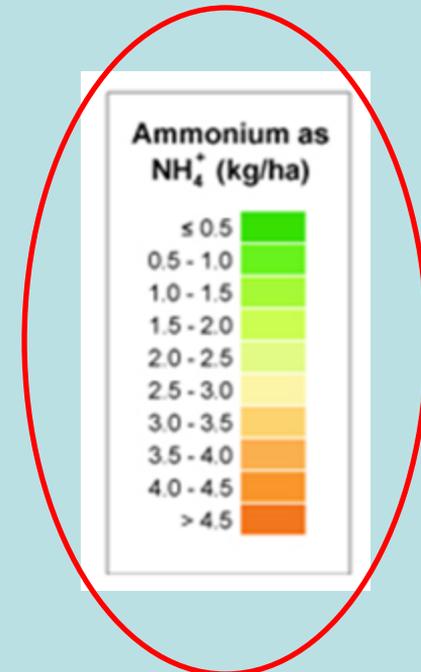
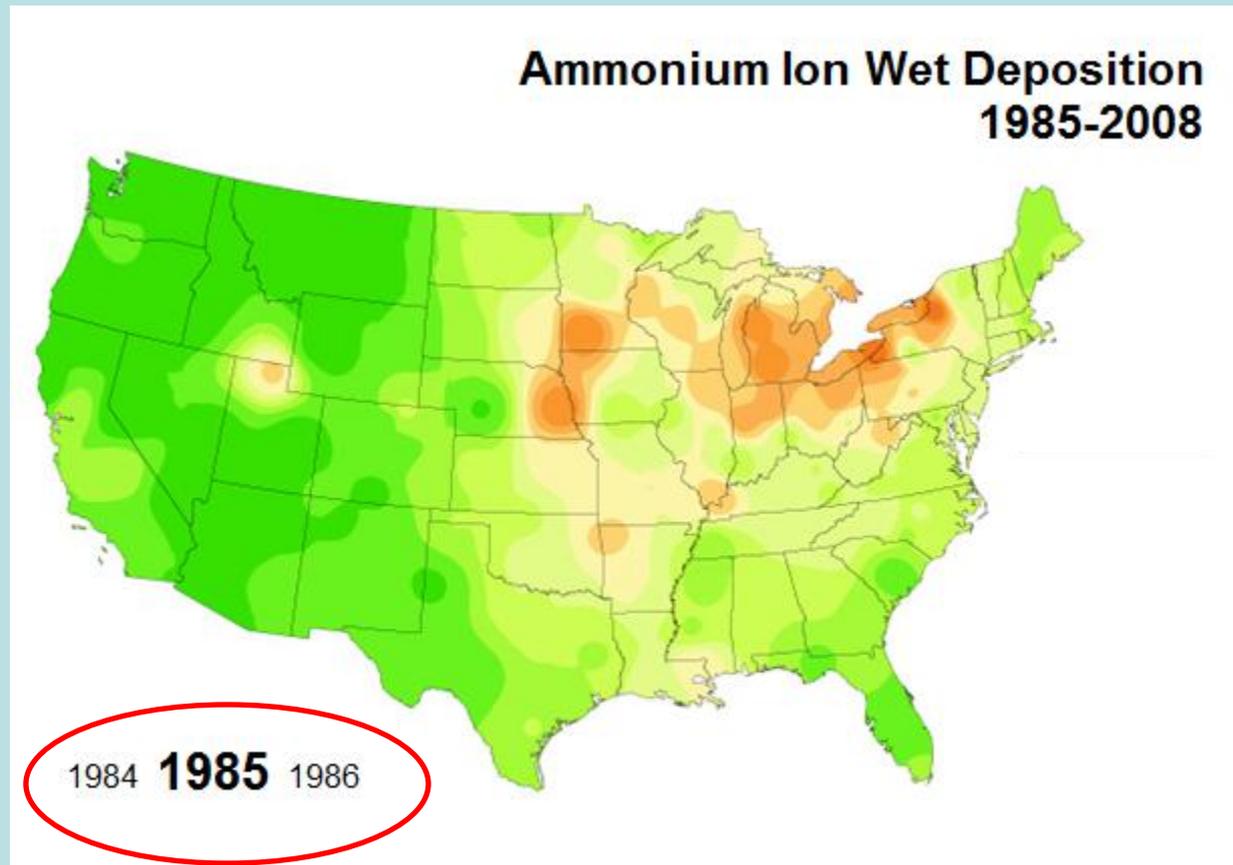


National Atmospheric Deposition Program/National Trends Network
<http://nadp.isws.illinois.edu>

Ammonium Deposition Animations (Trends)



3-year running average
1985 – 2009



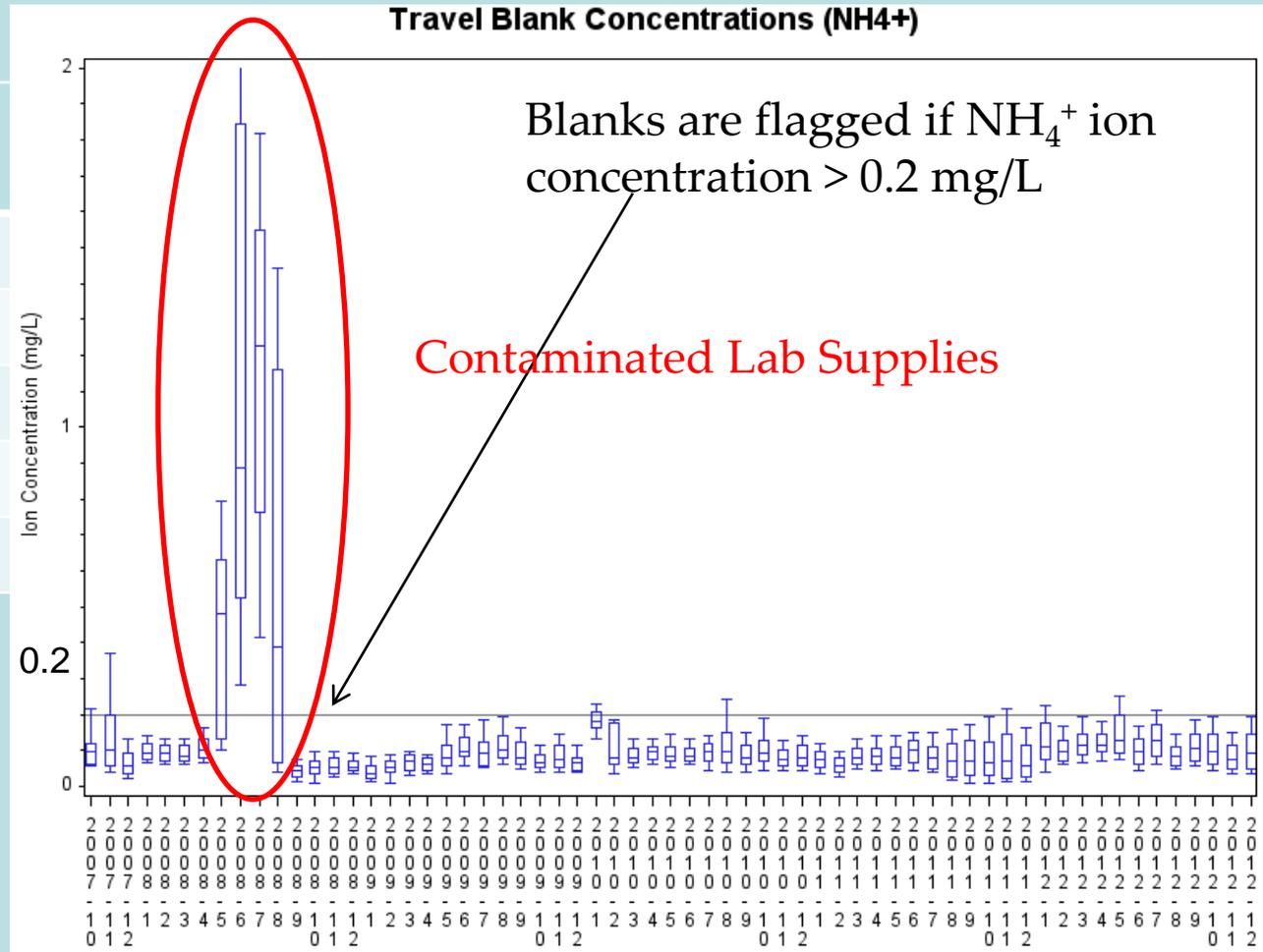
Gaseous Ammonia Results

Travel Blanks

Year	Median TB Concentration (mg/L)	Number of TB
2008*	0.069	340
2009	0.072	522
2010	0.092	523
2011	0.076	1107
2012	0.10	1441

**does not include May –August*

235 ml/min or 4.7 m3 per two weeks = ~ 2 to 4% of typical values



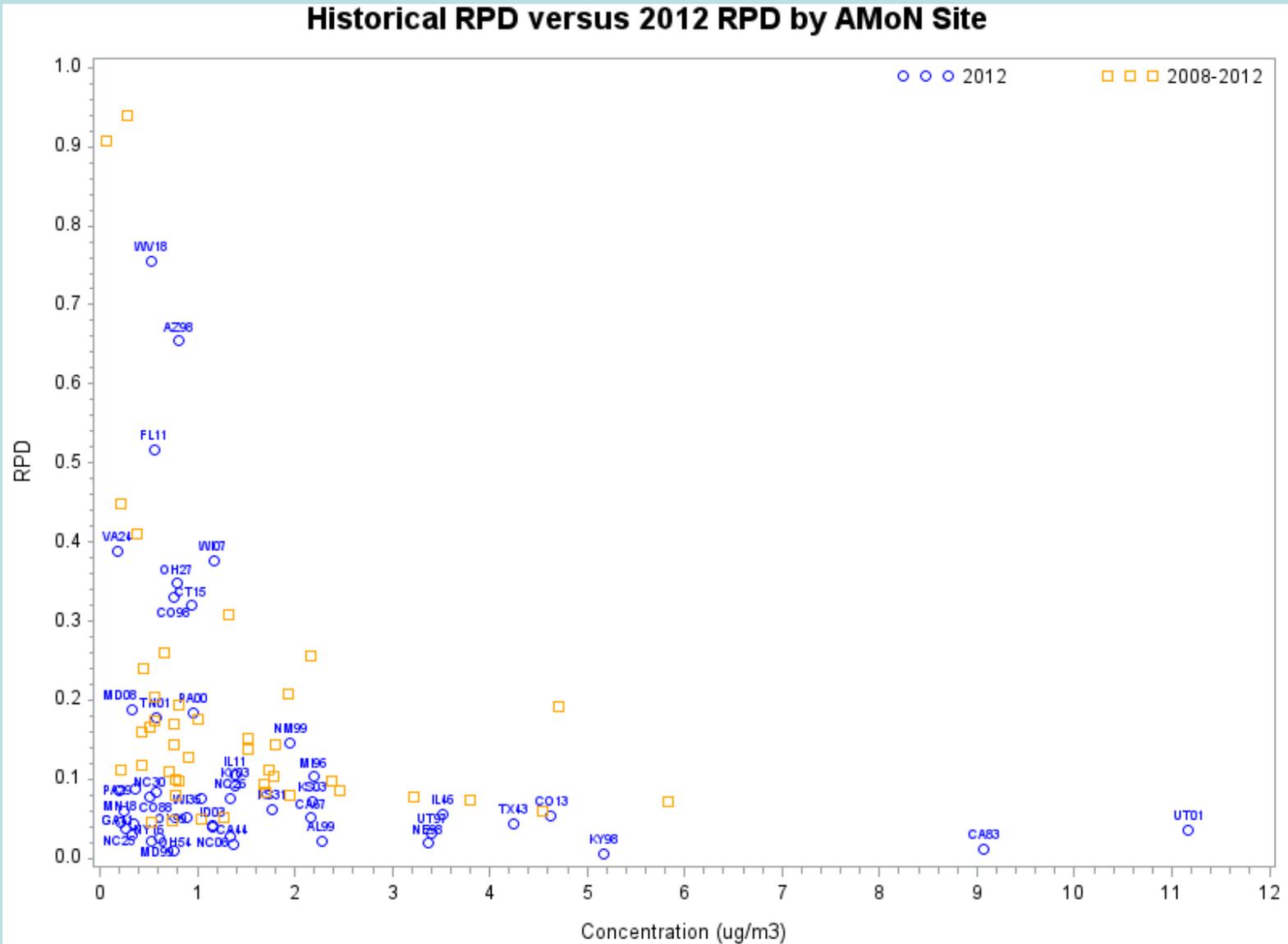
Fall 2012 meeting: motion passed to ship 1 travel blank every fourth sampling period beginning 1/1/13

Passive Sampler Precision

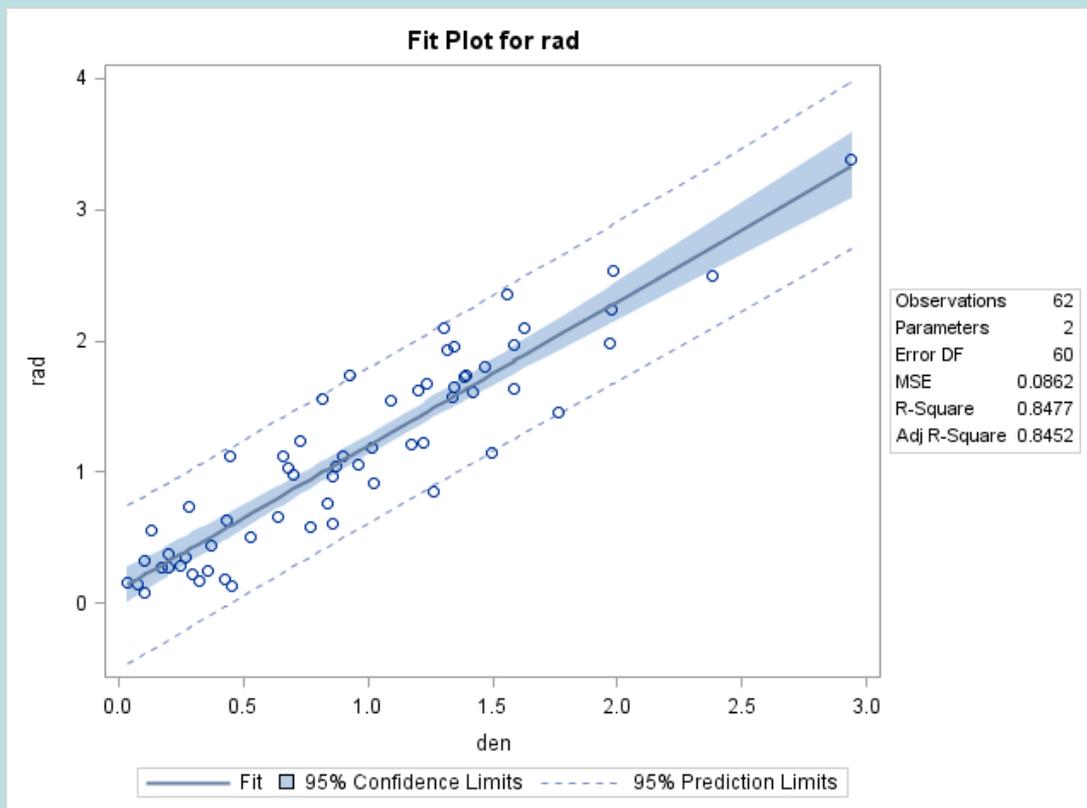
- 2007 – 2010: Triplicates for all deployments
- 2011 – present: Triplicates shipped for 5% of samples
- Precision Data Quality Objective = 20%

Year	Precision	No. of triplicates
2008	11%	333
2009	10%	525
2010	10%	522
2011	21%	81
2012	12%	90
Overall	11%	

Precision of Triplicates by Site



Denuder Reduced Major Axis Regression (Bondville, IL)



Proposed DQO for AMoN Accuracy:
Slope $\pm 20\%$

2009 - 2012

$$Radiello = 1.19 \times denuder + 0.011$$

$$R^2 = 0.85$$

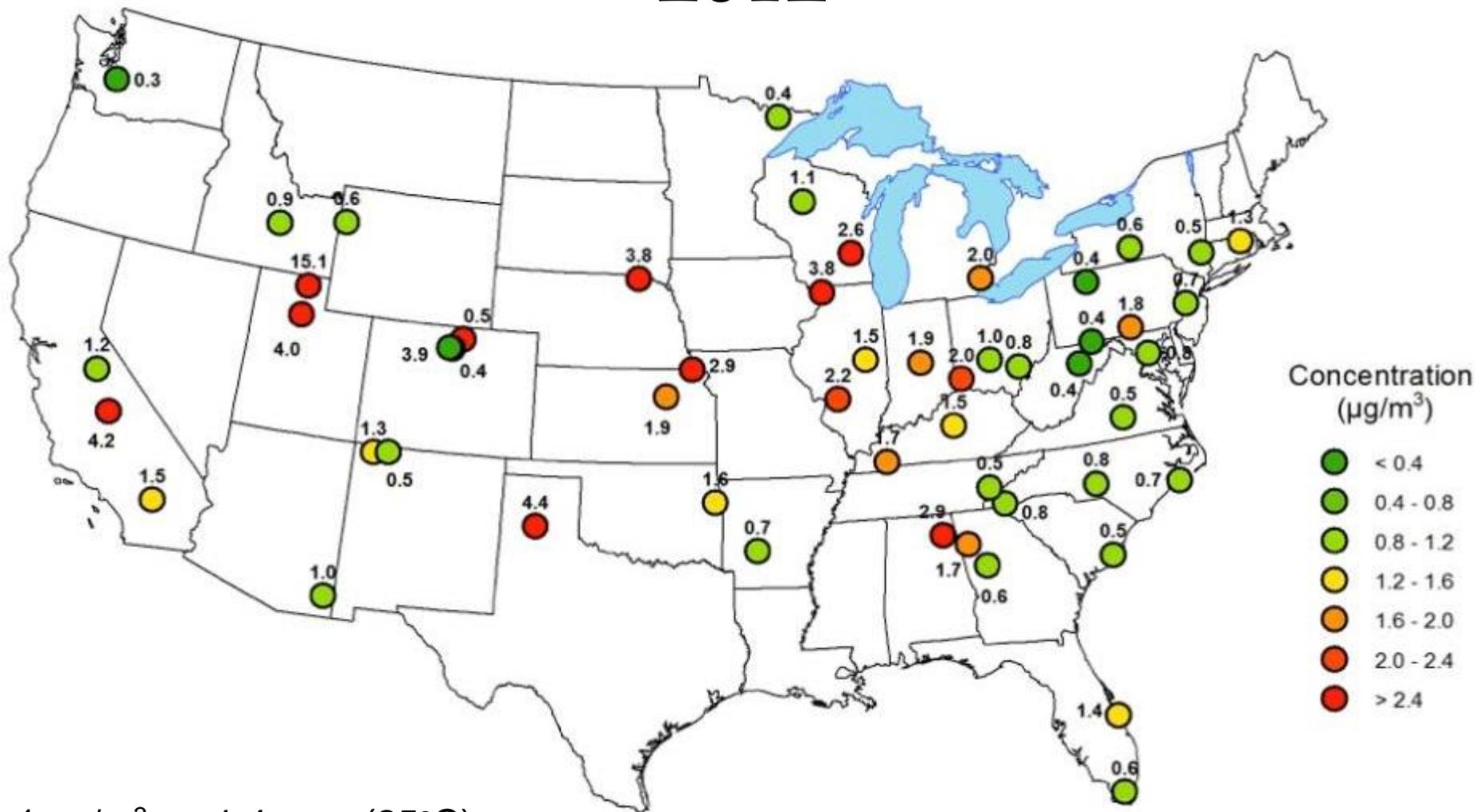
2012*

$$Radiello = 1.35 \times denuder - 0.12$$

$$R^2 = 0.91$$

* January - August 2012
(QA'ed denuder data not available after August)

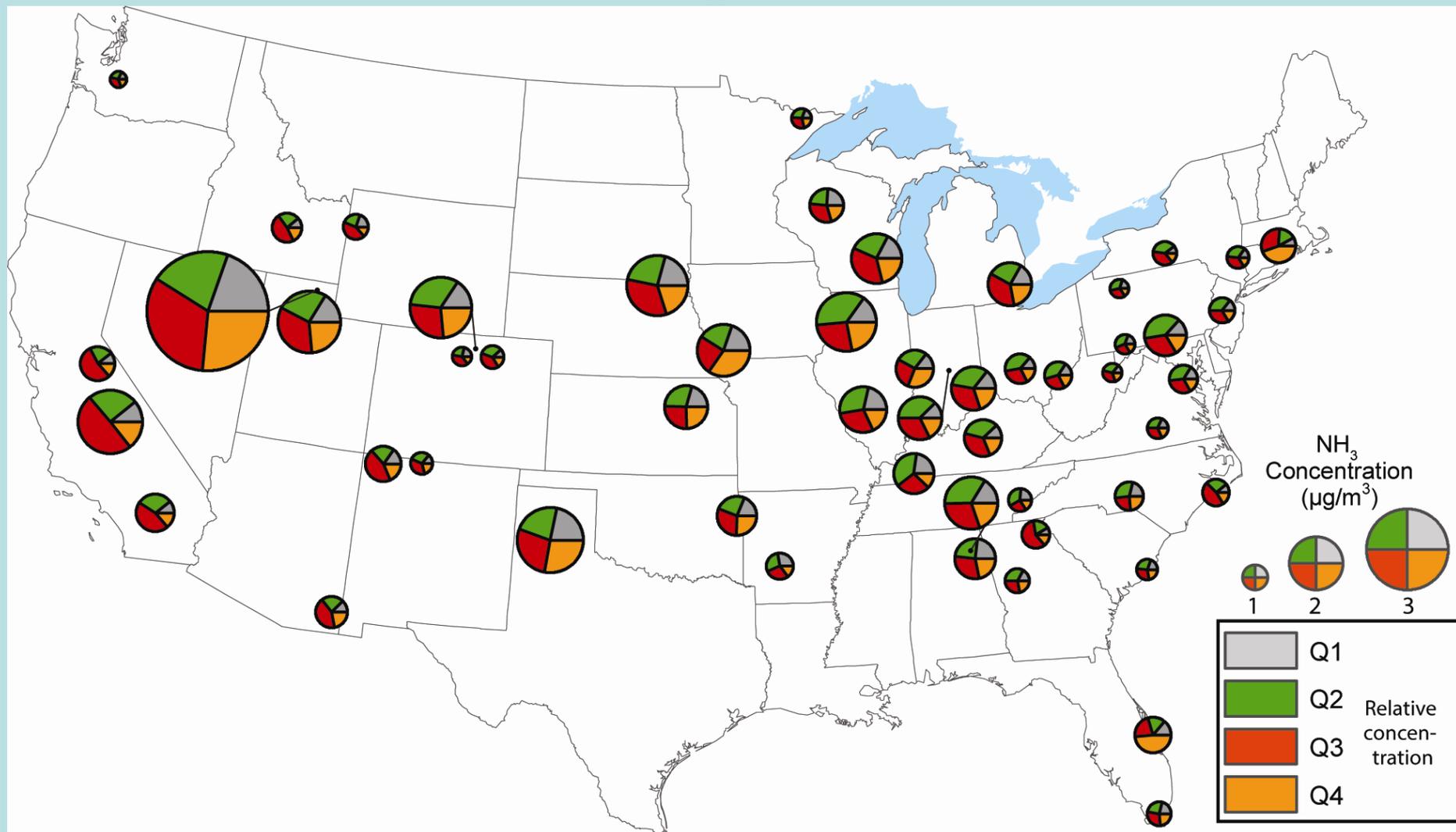
AMoN Average Concentration 2012



$1 \mu\text{g}/\text{m}^3 = \sim 1.4 \text{ ppm} (25^\circ\text{C})$

Network median (2007 – 2012) = $0.8 \mu\text{g}/\text{m}^3 = 1.2 \text{ ppm}_v$

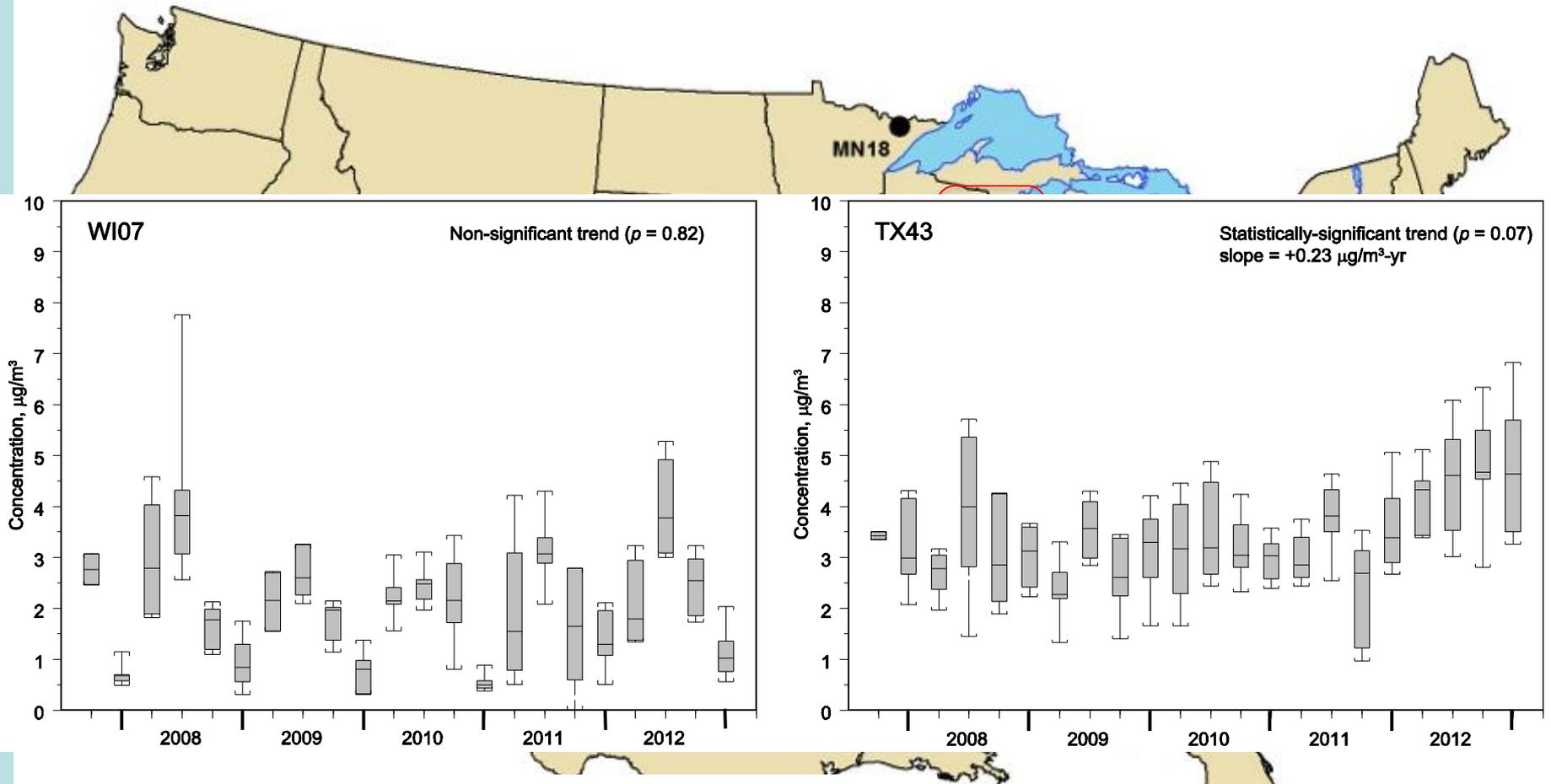
AMoN Seasonal Concentration 2012



AMoN 5-Year Trends ('07-'12)

- Seasonal Kendall Trends Test using S-Plus Environmental Statistics module
- Seasonal arithmetic mean of 2-week deployments; minimum of 75% valid data for each season
- Trend magnitude ($\mu\text{g}/\text{m}^3\text{-yr}$) by Sen's median estimator

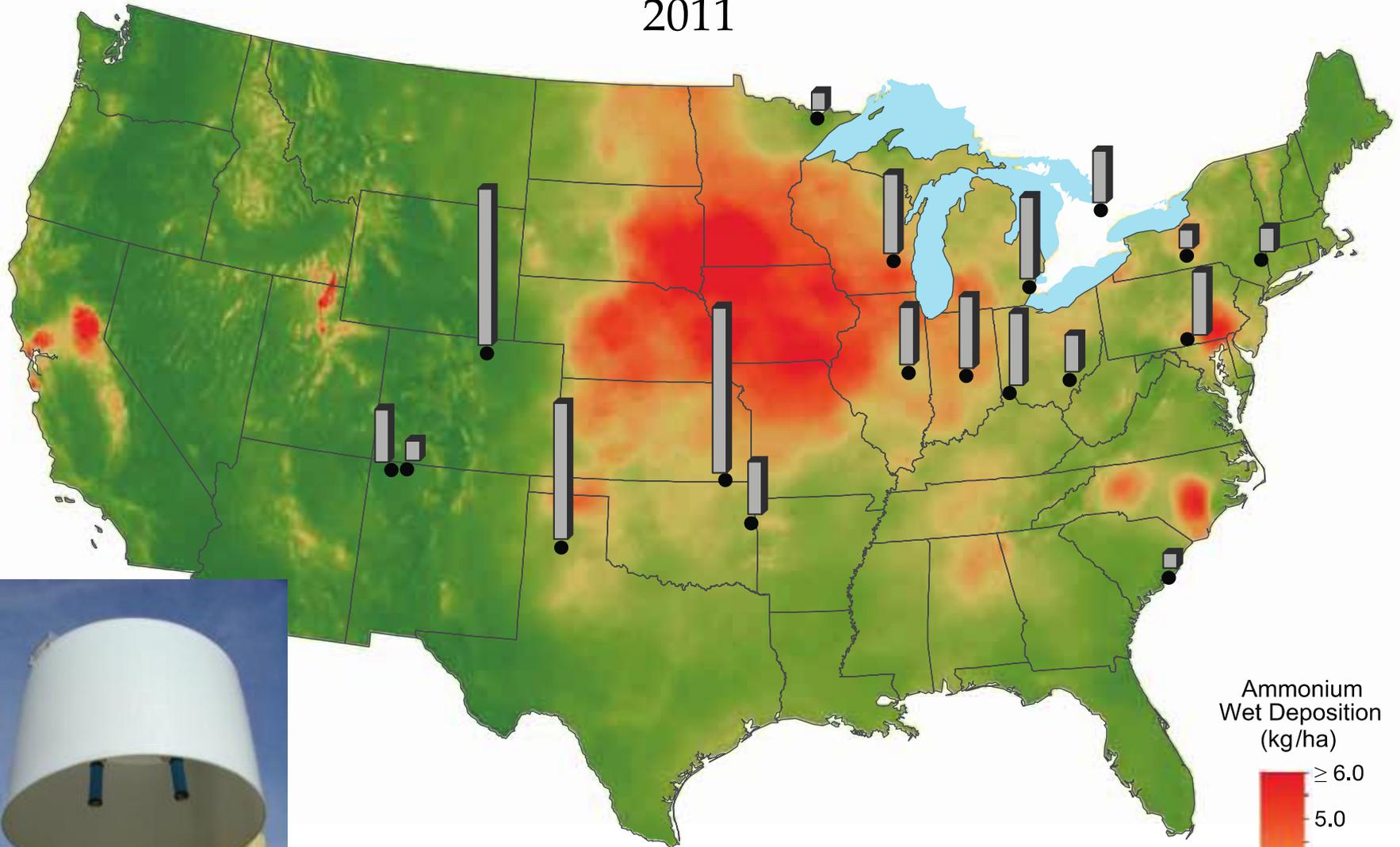
AMoN 5-Year Trends (2007 – 2012)



- Statistically-significant trend ($p < 0.1$): 5 sites
- No trend: 9 sites

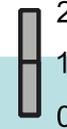
Gaseous Ammonia Observations vs Wet Deposition Observations

2011

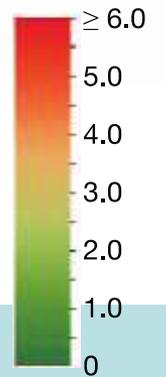


Position of Ammonium Ion (map, kg/ha) and
Atmospheric Ammonia Concentration (bars, $\mu\text{g}/\text{m}^3$)

Atmospheric Ammonia
Concentration
($\mu\text{g}/\text{m}^3$)

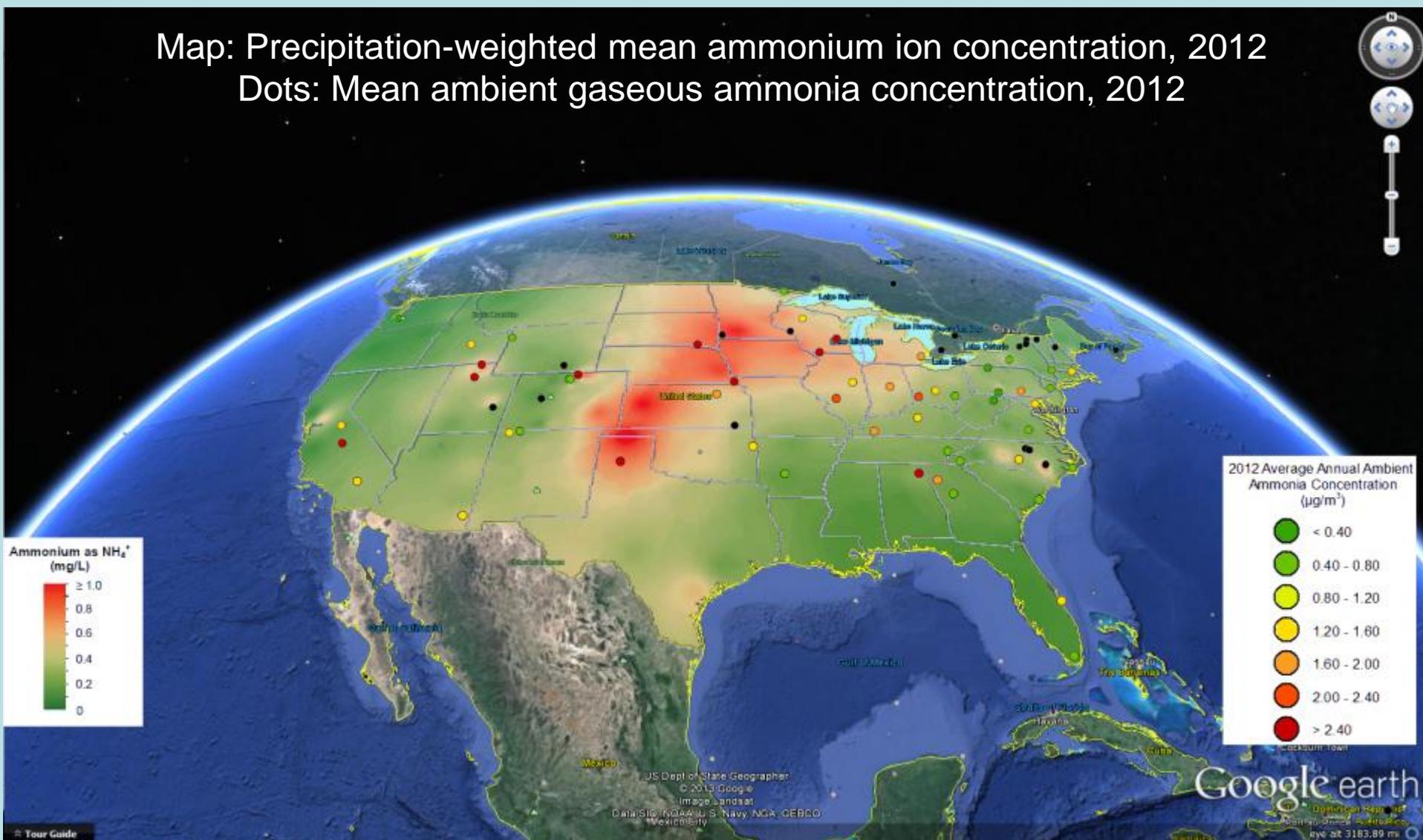


Ammonium
Wet Deposition
(kg/ha)



Map: Precipitation-weighted mean ammonium ion concentration, 2012

Dots: Mean ambient gaseous ammonia concentration, 2012

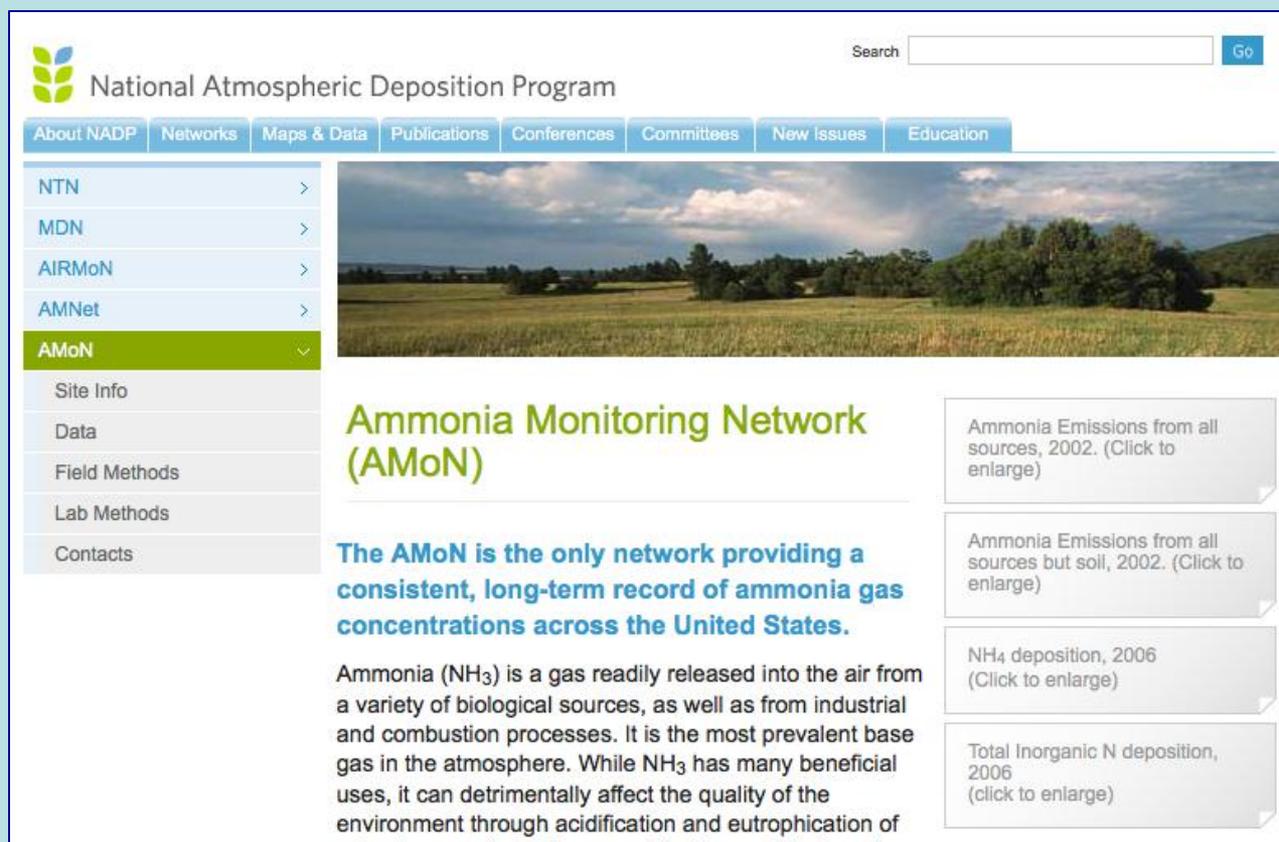


<http://go.illinois.edu/NADPAMonMap>

Summary

- Wet Deposition of NH_3
 - Highest in the Midwest and Plains
 - Increasing drastically since 1986
- Ammonia Gas
 - Highest in the same regions
 - Increasing at several sites, but we have few records
- High gaseous concentrations and wet deposition regions correlate reasonably well
 - Highest in the Plains States

For more information, see
<http://nadp.isws.illinois.edu/amon>
or email nadp@isws.illinois.edu



The screenshot shows the website for the National Atmospheric Deposition Program (NADP). At the top left is the NADP logo, a stylized green plant. To its right is the text "National Atmospheric Deposition Program". Further right is a search bar with the word "Search" and a "Go" button. Below the logo and search bar is a horizontal navigation menu with buttons for "About NADP", "Networks", "Maps & Data", "Publications", "Conferences", "Committees", "New Issues", and "Education". The "Networks" button is highlighted in blue. Below the navigation menu is a vertical sidebar menu with links for "NTN", "MDN", "AIRMoN", "AMNet", "AMoN", "Site Info", "Data", "Field Methods", "Lab Methods", and "Contacts". The "AMoN" link is highlighted in green. To the right of the sidebar menu is a large landscape photograph of a field under a cloudy sky. Below the photograph is the section header "Ammonia Monitoring Network (AMoN)" in green. Underneath the header is a blue text box containing the text: "The AMoN is the only network providing a consistent, long-term record of ammonia gas concentrations across the United States." Below this text box is a paragraph of text: "Ammonia (NH₃) is a gas readily released into the air from a variety of biological sources, as well as from industrial and combustion processes. It is the most prevalent base gas in the atmosphere. While NH₃ has many beneficial uses, it can detrimentally affect the quality of the environment through acidification and eutrophication of". To the right of the main text are four grey boxes, each containing a link to a specific data set: "Ammonia Emissions from all sources, 2002. (Click to enlarge)", "Ammonia Emissions from all sources but soil, 2002. (Click to enlarge)", "NH₄ deposition, 2006 (Click to enlarge)", and "Total Inorganic N deposition, 2006 (click to enlarge)".

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