IT CAME FROM BEYOND THE WATERSHED: Evaluating Atmospheric Inputs of NH_3 Across Watershed Boundaries to an Upstate New York lake

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Abstract

Though long considered by the US EPA to be one of the cleanest lakes in the country, Skaneateles Lake has experienced toxic blooms of cyanobacteria since 2017. While oxidized nitrogen (N) deposition has been falling throughout the US over the last few decades, reduced N, including gaseous ammonia (NH_3) has been on the rise. N, and NH_3 in particular, may be furthering the blooms, as it is a highly available form of N to phytoplankton in lake surface waters. Agricultural sources, including manure, represent likely possible origins of much gaseous ammonia deposition. We examined the relationship between large dairy farms and atmospheric NH_3 deposition measured over 2-to-4 week periods throughout the year at multiple sites in the Skaneateles Lake watershed. Using NOAA's HYSPLIT model, we found positive, seasonally-varying correlations between the number of large dairy farms lying in the paths of air trajectories to the sample sites and the average concentration of atmospheric NH_3 at the sites.

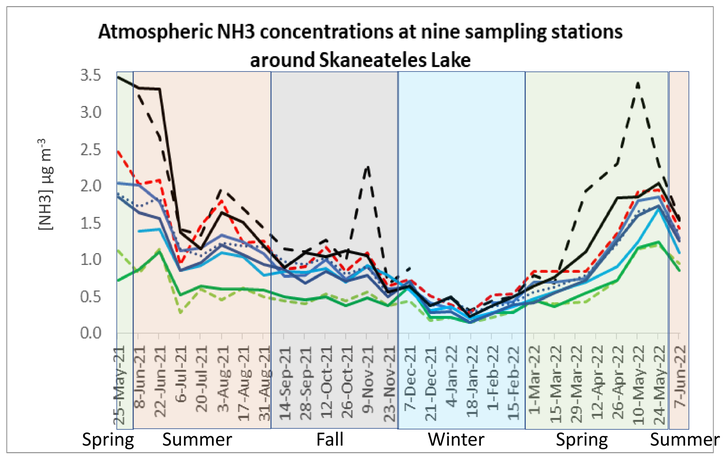
Study Site

Red dots indicate large dairy farm locations; dark blue dots are NH_3 sampling sites

Skaneateles Lake, NY

- 5th largest of the Finger Lakes
- 23 mi W of Syracuse, central NY
- 25 km long, 1 to 2.5 km wide
- Max / mean depth: 96 m/44 m
- Watershed land cover:
  22% lake surface
  36% agriculture
  37% forest and shrub/ grasses
  5% residential

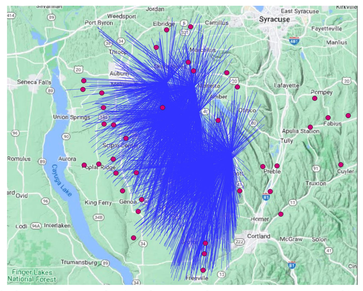
Background Data



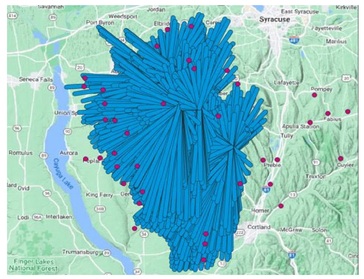
Integrated average gaseous NH_3 concentrations over 2-week periods from May 2021 to June 2022 at 9 sites, using Radiello passive samplers and the NADP AIRMoN network protocols. All sites show a consistent, seasonal pattern, suggesting a regional signal. Colors indicate 3-month seasonal periods.

Methods

- NOAA HYSPLIT model[1-7] version 5.2 was run in R using the "Splitr" program to calculate 1-hour backward trajectories from 9 sampling sites around Skaneateles Lake for several 2-week periods.
  - Meteorological data: Global Data Assimilation System, 1 degree (GDAS1)
  - SPLITR[8] was run in Rstudio using R version 4.2.2.
- Coordinate points defining each trajectory were converted into trajectory lines using QGIS[9], a GIS software package in the public domain. The trajectories were buffered by 0.5 km on either side.
  - The coordinates of large dairy farms (acquired from NYSDEC) were also input into the QGIS environment.
- A QGIS function was used to count the number of large dairy farms intersecting the buffered trajectories for each sampling period ("hits").
- Linear regression analysis on the count data and NH_3 concentrations at each site and sampling period determined the correlation between the number of large dairy farms within the buffered trajectories and NH_3 over time.

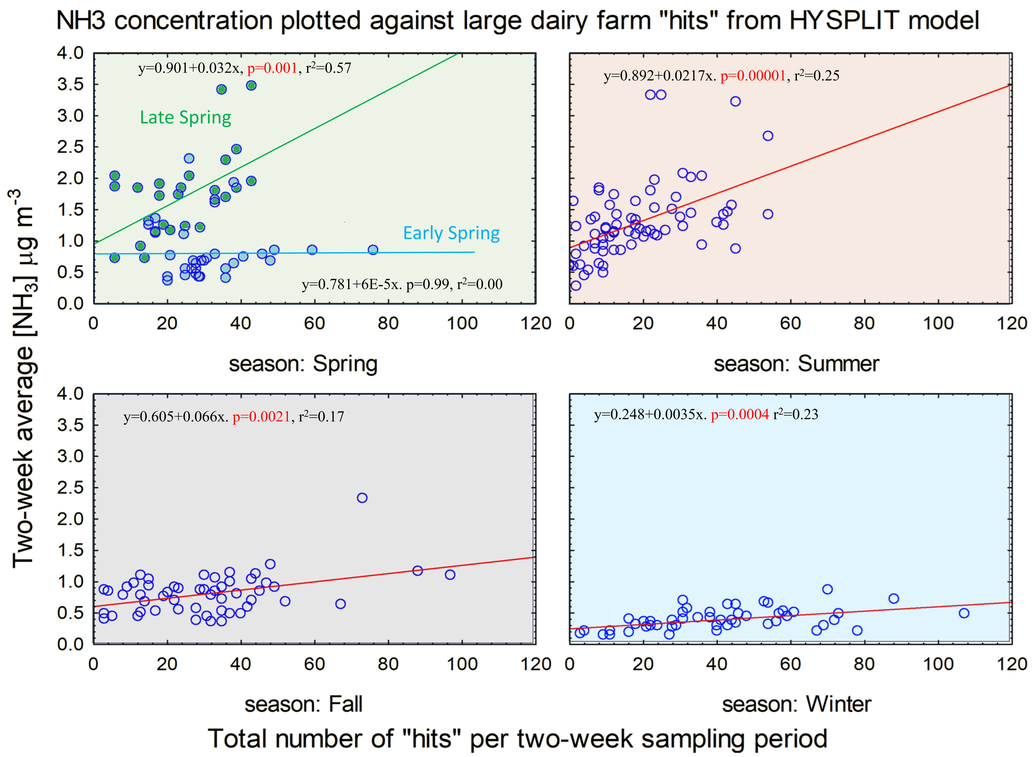


1-hour back trajectories at every site for the sampling period 6/22/21 -7/6/21



Same trajectories as above, with 0.5 km buffers. Every red dot within one trajectory is a "hit."

Results



In each season except Spring, [NH3] shows a significant linear relationship to the number of "hits" with large dairy operations. However, breaking Spring into Early and Late periods reveals a relationship similar to the earlier or later season.

Take Home Points

- There is a strong seasonal pattern of higher atmospheric ammonia deposition in warmer months, leading to stronger correlations with large dairy farm "hits."
- We found a consistently positive correlation between large dairy farm "hits" and average atmospheric ammonia concentrations at the sampling stations.
- This suggests that these atmospheric depositions can be attributed to activities of large dairy farms and further, that they are a significant contribution to the N input into the lake[10].
- These N inputs can have consequences for water quality concerns such as Harmful Algal Blooms (HABs).

Next Steps / Future Work

- Subsequent sampling in a subset of sites on Skaneateles and nearby Owasco lake show similar seasonal variation, increasing time trends in NH_3 concentration, and similar back-trajectories from sampling sites.
- We are currently evaluating additional characteristics of the HYSPLIT trajectories (wind speed, direction, and the magnitude of potential sources) seasonally throughout the year, and relationships with measured NH_3 deposition to the lake and around the watershed.

Acknowledgements

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References & Further Information

Scan the QR code for a link to this poster, references, and related information, or visit the lab webpage at:
https://www.research.howarthlab.org