Characterizing the Impact of Poultry and Cattle Farms on Chesapeake Bay Aerosols in Baltimore, MD During the OWLETS-2 Campaign

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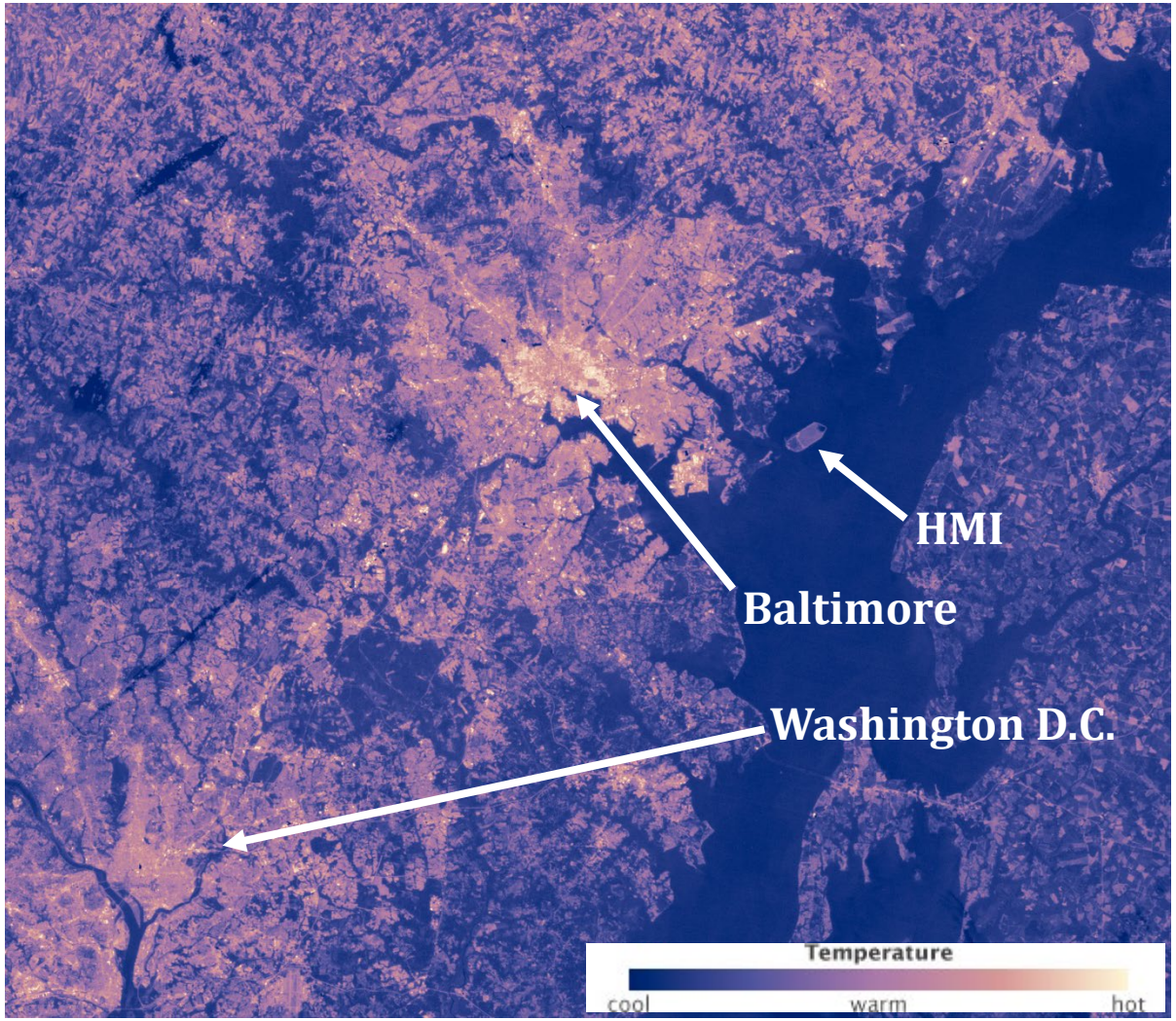
Chemical
Biochemical and
Environmental
Engineering

Study Purpose

- The Ozone Water-Land Environmental Transition Study (**OWLETS-2**) studied pollution formation and transport across the water-land transition zone in the upper portion of the Chesapeake Bay.

OWLETS-2

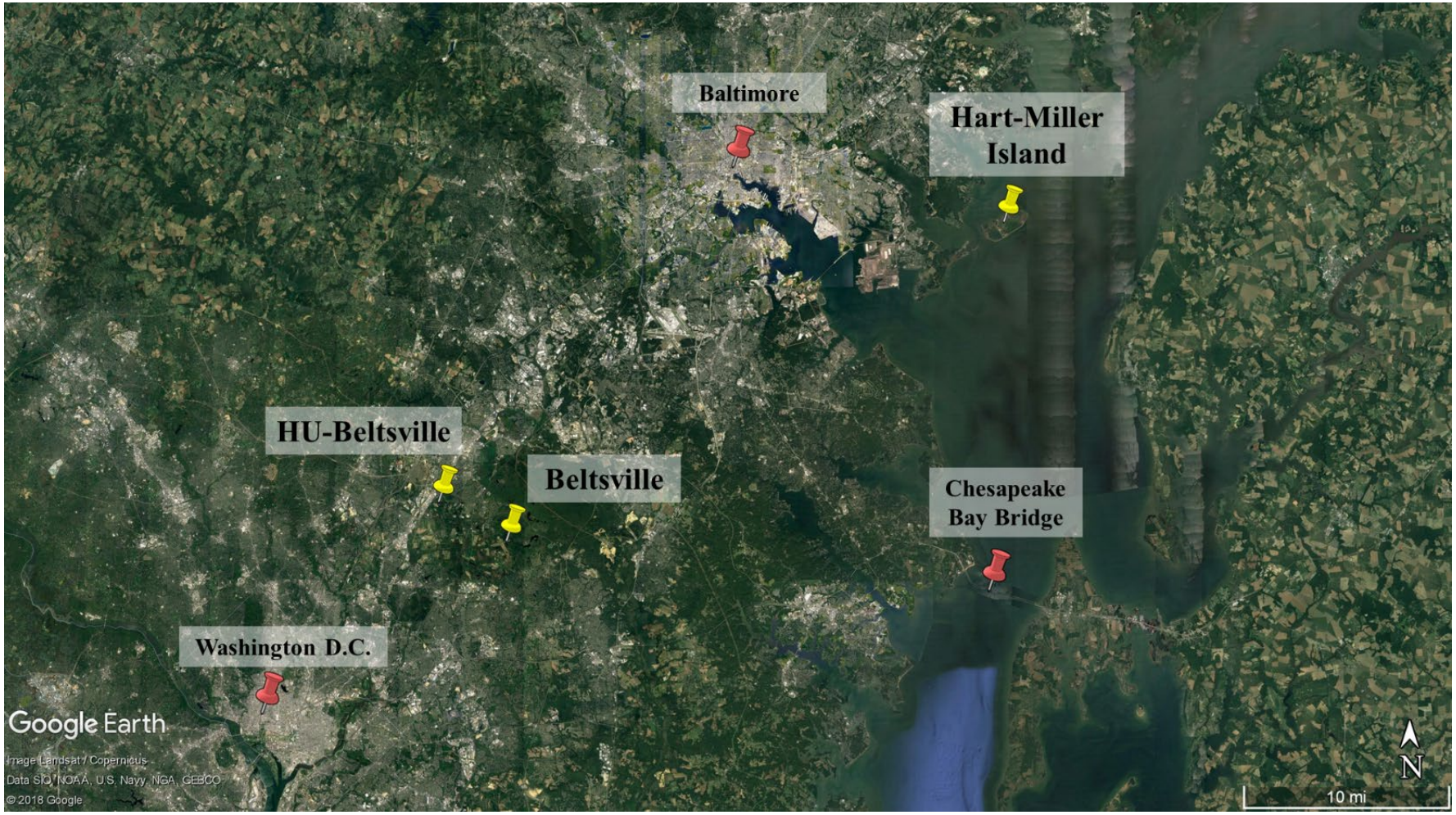
Ozone Water-Land Environmental Transition Study



https://earthobservatory.nasa.gov/images/36227/urban-heat-island-baltimore-md

Location

- Measurements made in Summer 2018 on **Hart-Miller Island (HMI)**
- HMI is on the Chesapeake Bay, an estuary located in MD and VA



Location

Hart-Miller Island

UMBC Trailer

Measurements

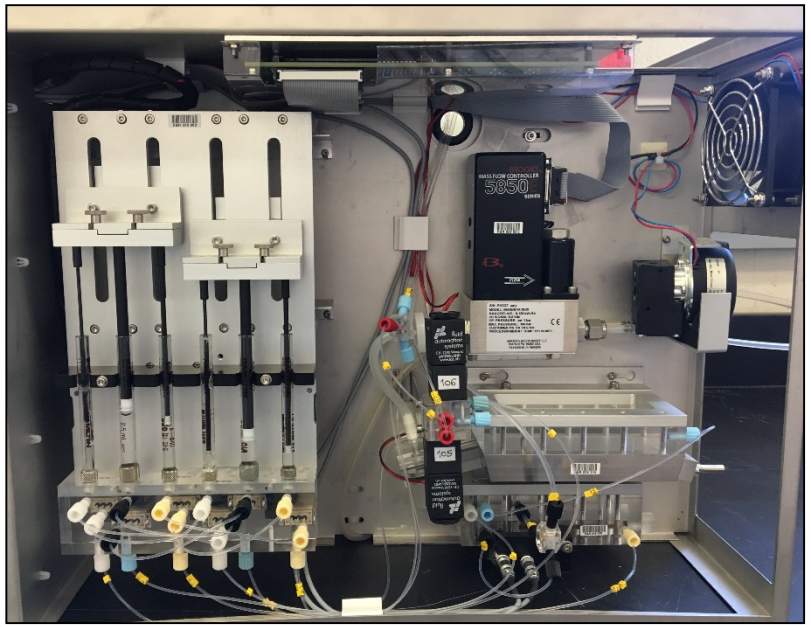
Measurements included:

1. Speciated Inorganic $PM_{2.5}$
2. Gas-phase NH_3
3. Meteorology (T, RH, WS, WD)

PILS-IC (Valerino et al., *JGR*, 2017)

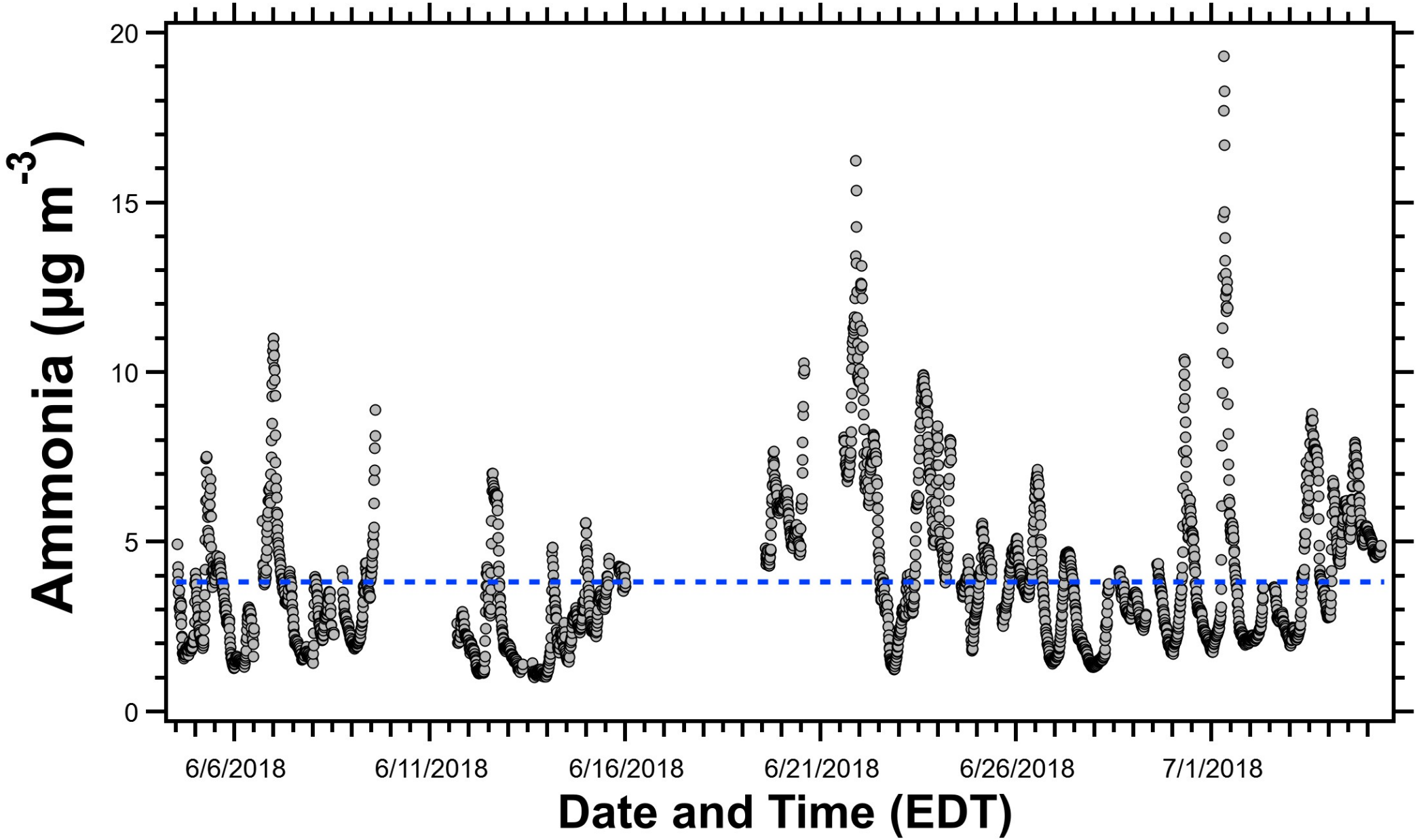
Aerosol: Cl^-, NO_3^-, SO_4^{2-}, $C_2O_4^{2-}$, Na^+, NH_4^+, K^+, Ca^{2+}, Mg^{2+} (20-min resolution)

AiRRmonia (Norman et al., ACP, 2009)



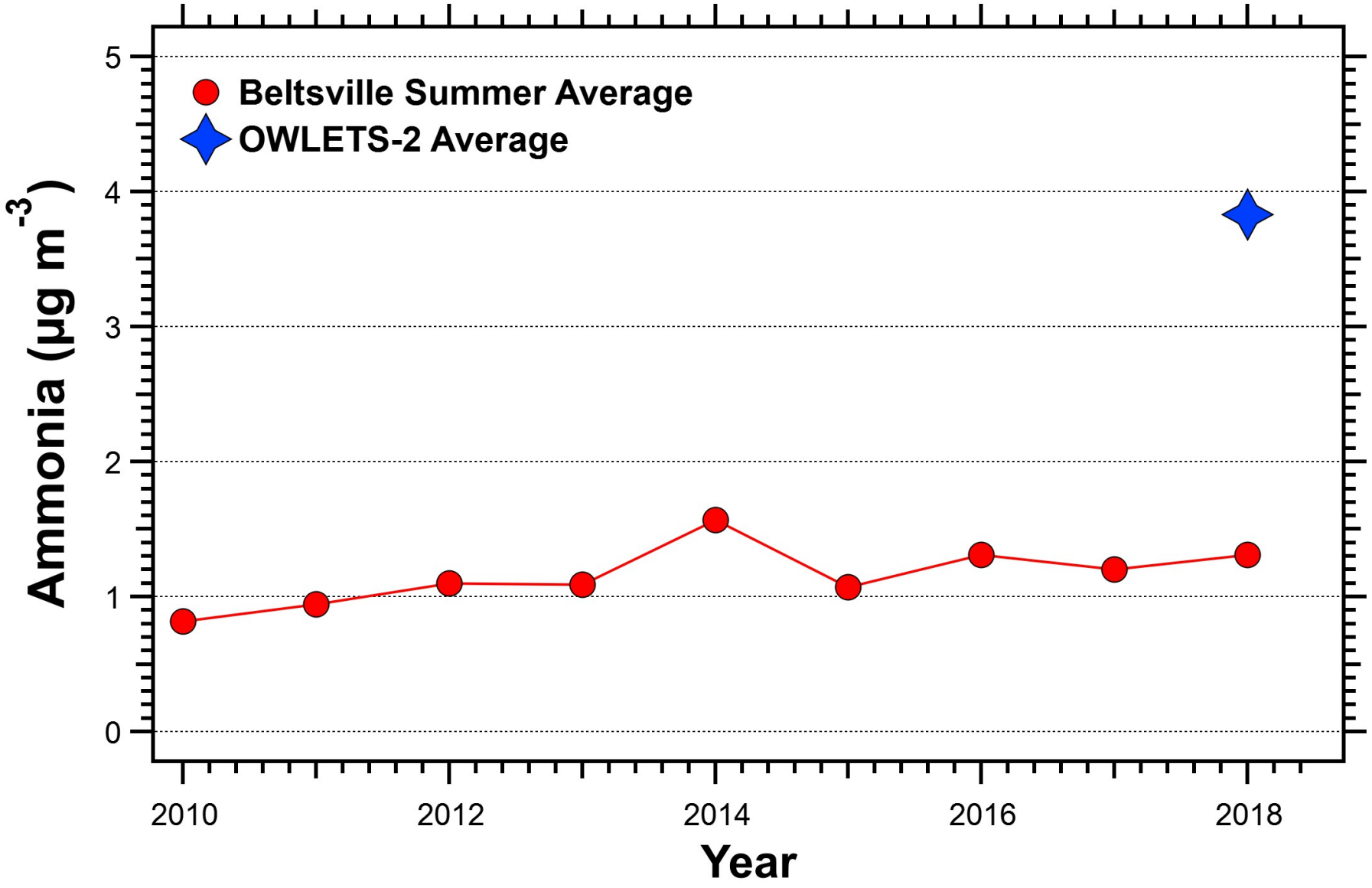
Gas-phase: NH_3 (10-min resolution)

Ammonia Gas Concentrations During OWLETS-2



Avg. NH_3
3.8 µg m^{-3}

Elevated NH_3 During OWLETS-2



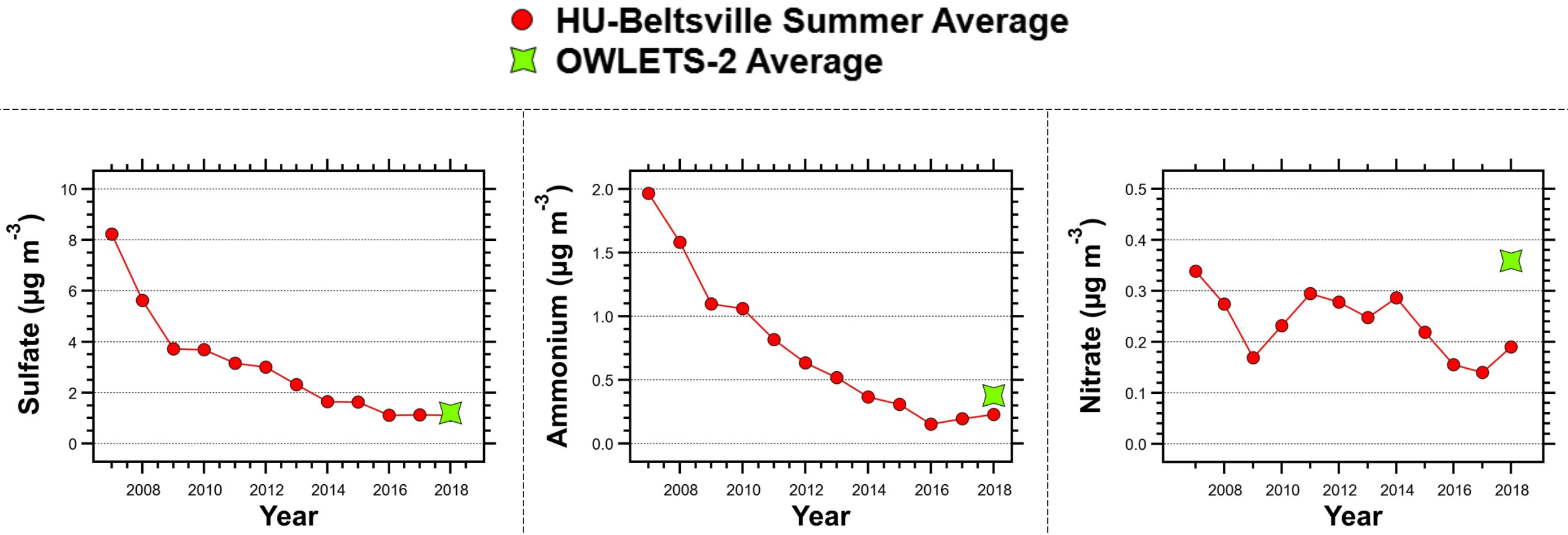
Questions for the Study

So there are high concentrations of ammonia…

(1) How does this impact aerosol chemistry?

(2) What sources caused these high concentrations?

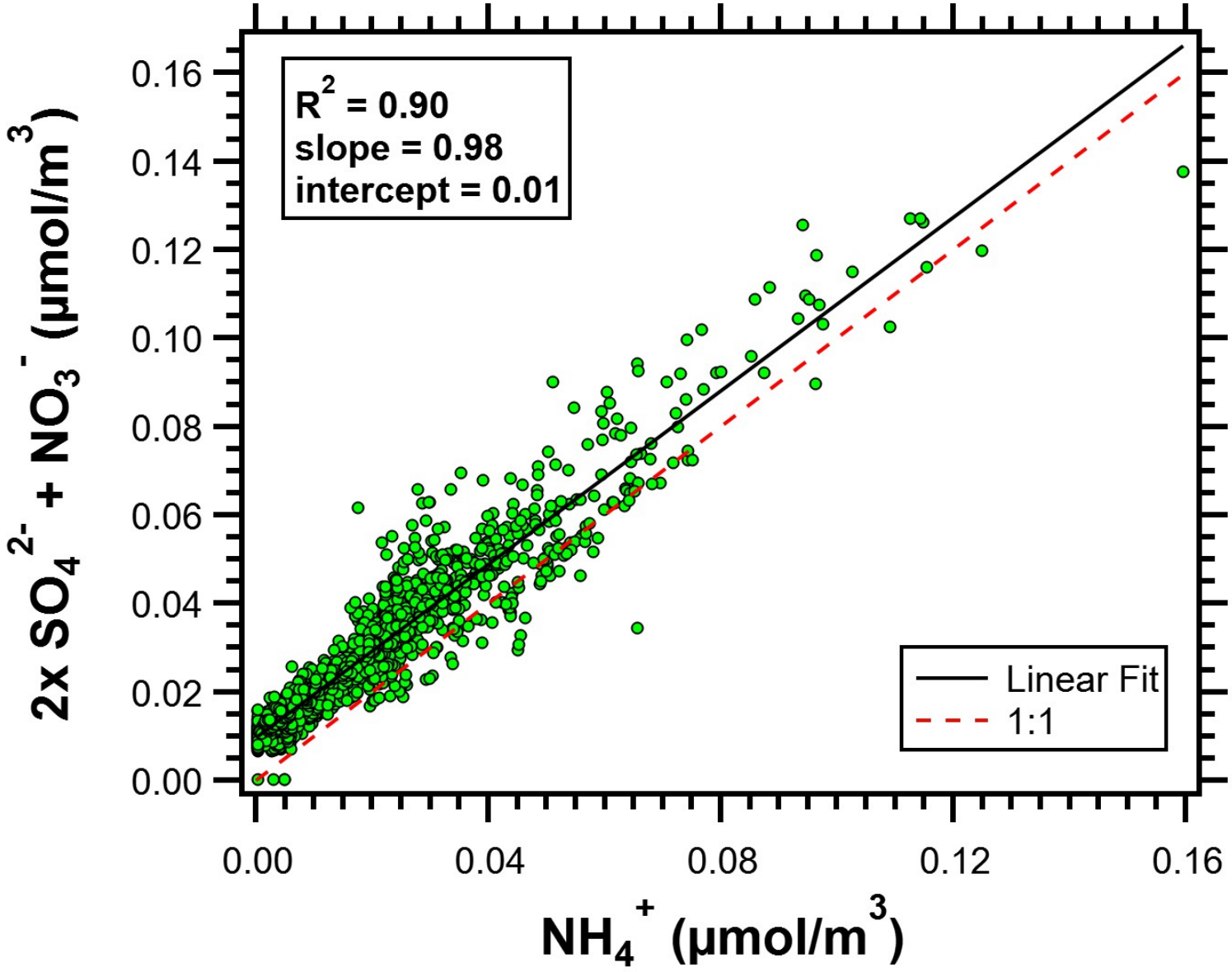
NH_3 Effects on Aerosol Chemistry



OWLETS-2/HU-Beltsville Ratios

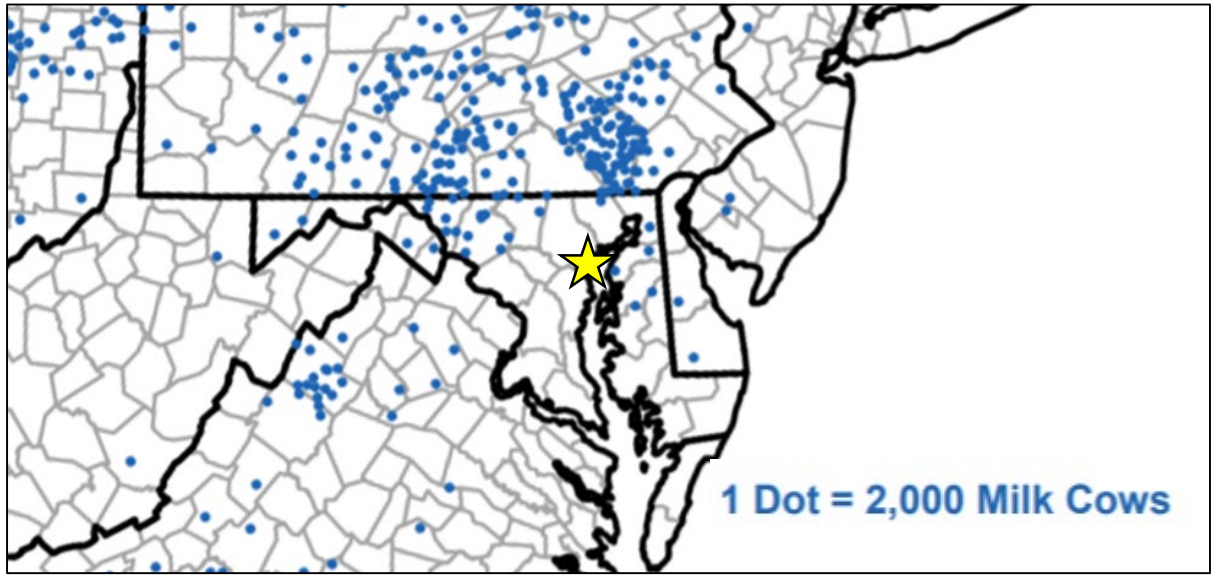
1.08	1.65	1.89

NH_4NO_3 and $(NH_4)_2SO_4$ Significant Components of $PM_{2.5}$

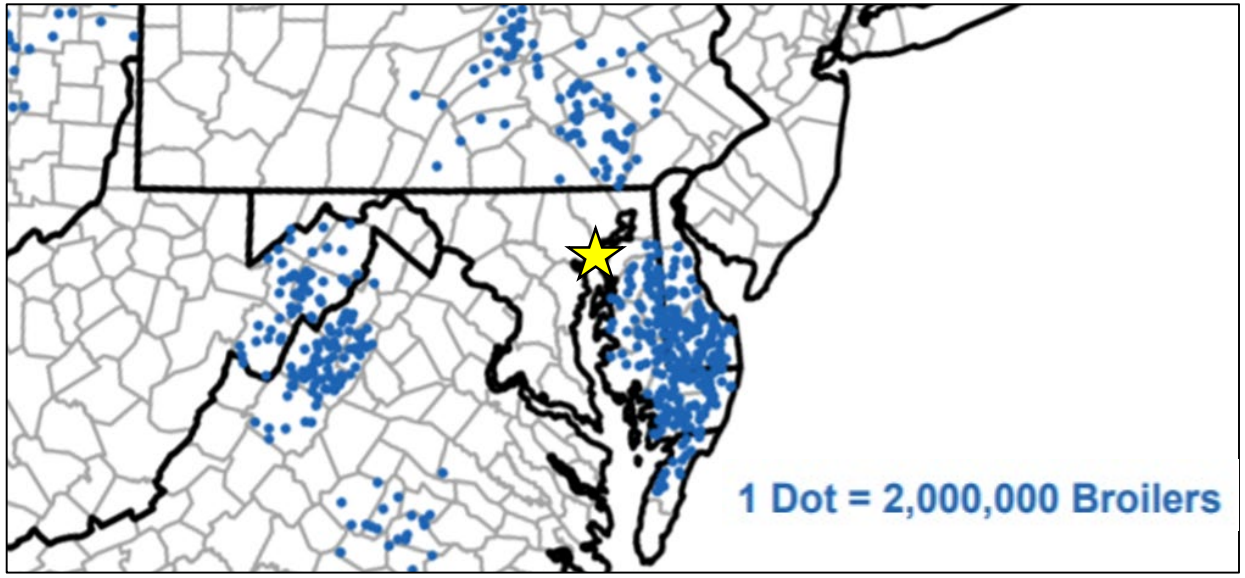


Agricultural Sources of Ammonia

Milk Cows - Inventory: 2012

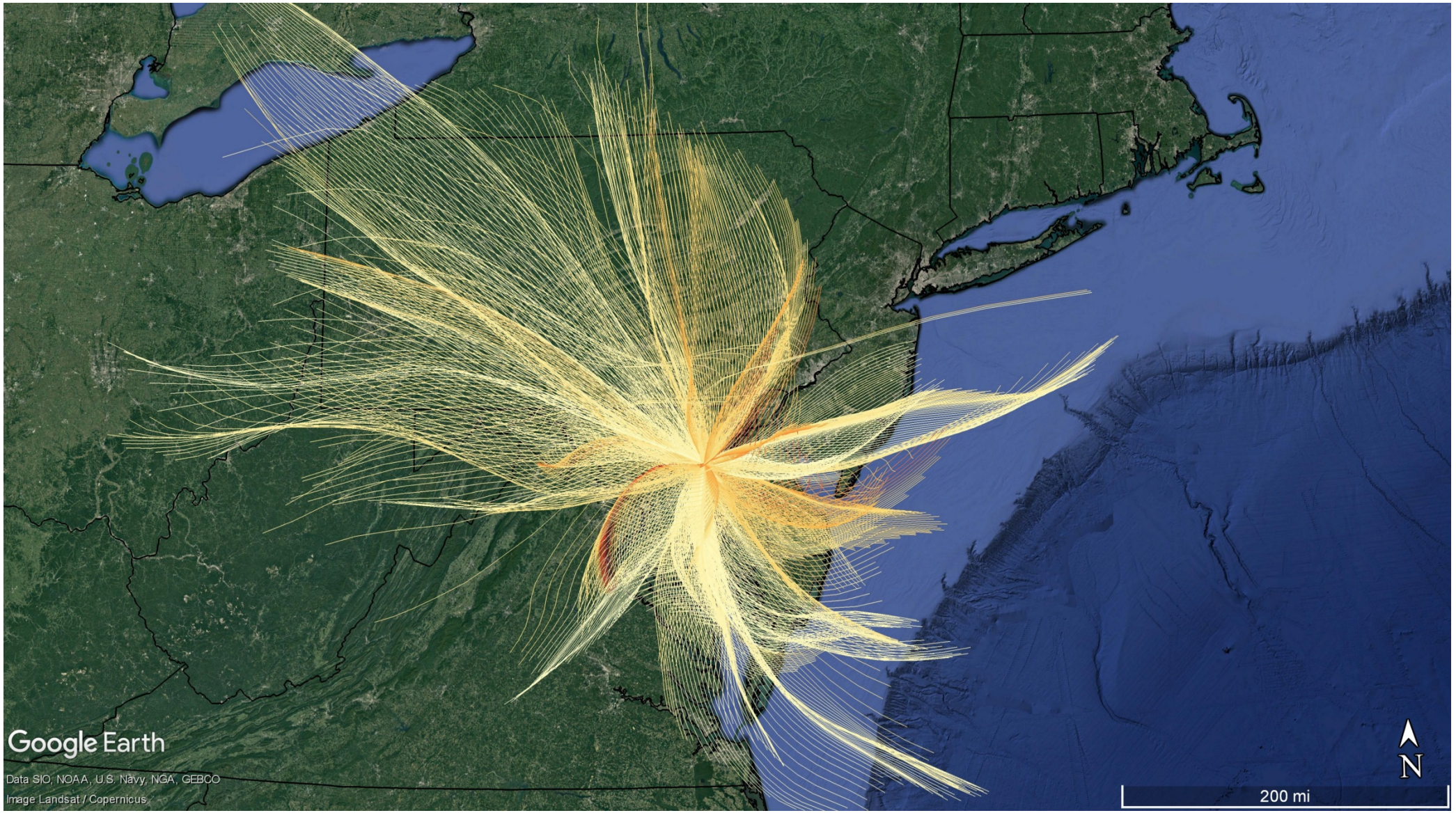


Number of Broilers and
Other Meat-Type Chickens Sold: 2012



Source: USDA 2012 Census of Agriculture
https://www.nass.usda.gov/Publications/AgCensus/2012/

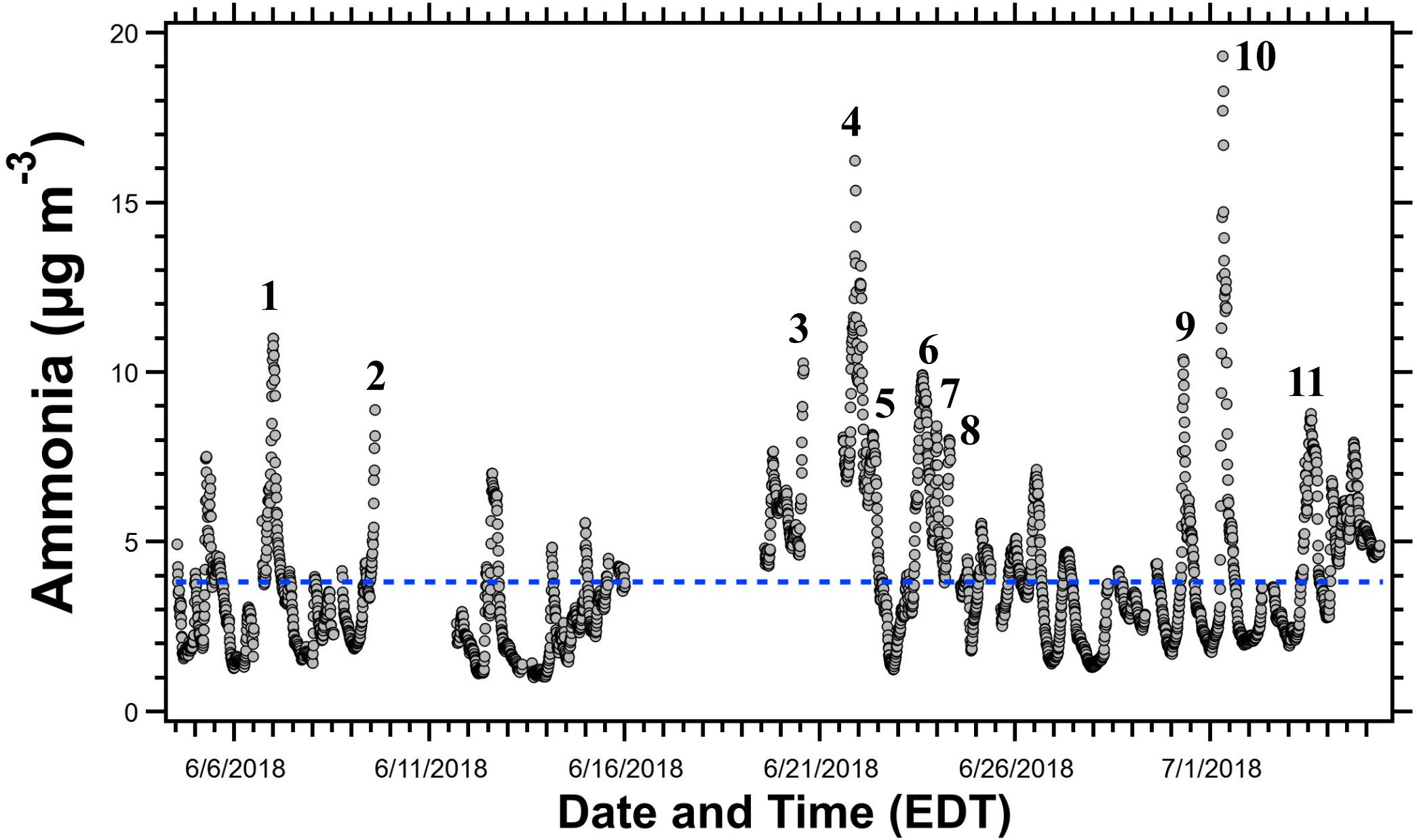
Back Trajectories from HMI



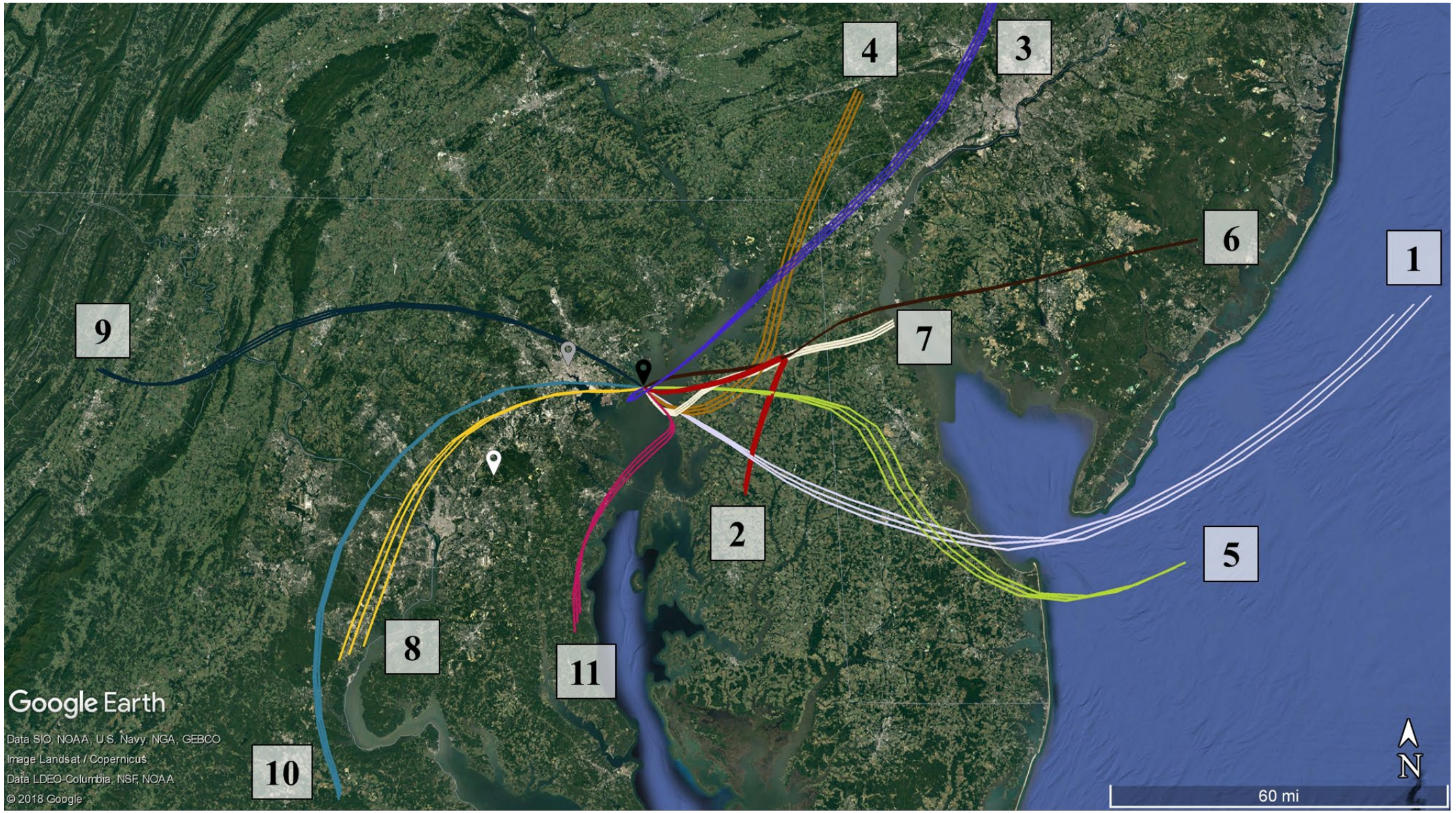
Atmospheric NH_3 lifetime is ~15 hrs (Hauglustaine et al., 2014)

NOAA HYSPLIT 15-hour back trajectories from HMI using NAM (12 km) meteorology (alt. of 50 m).

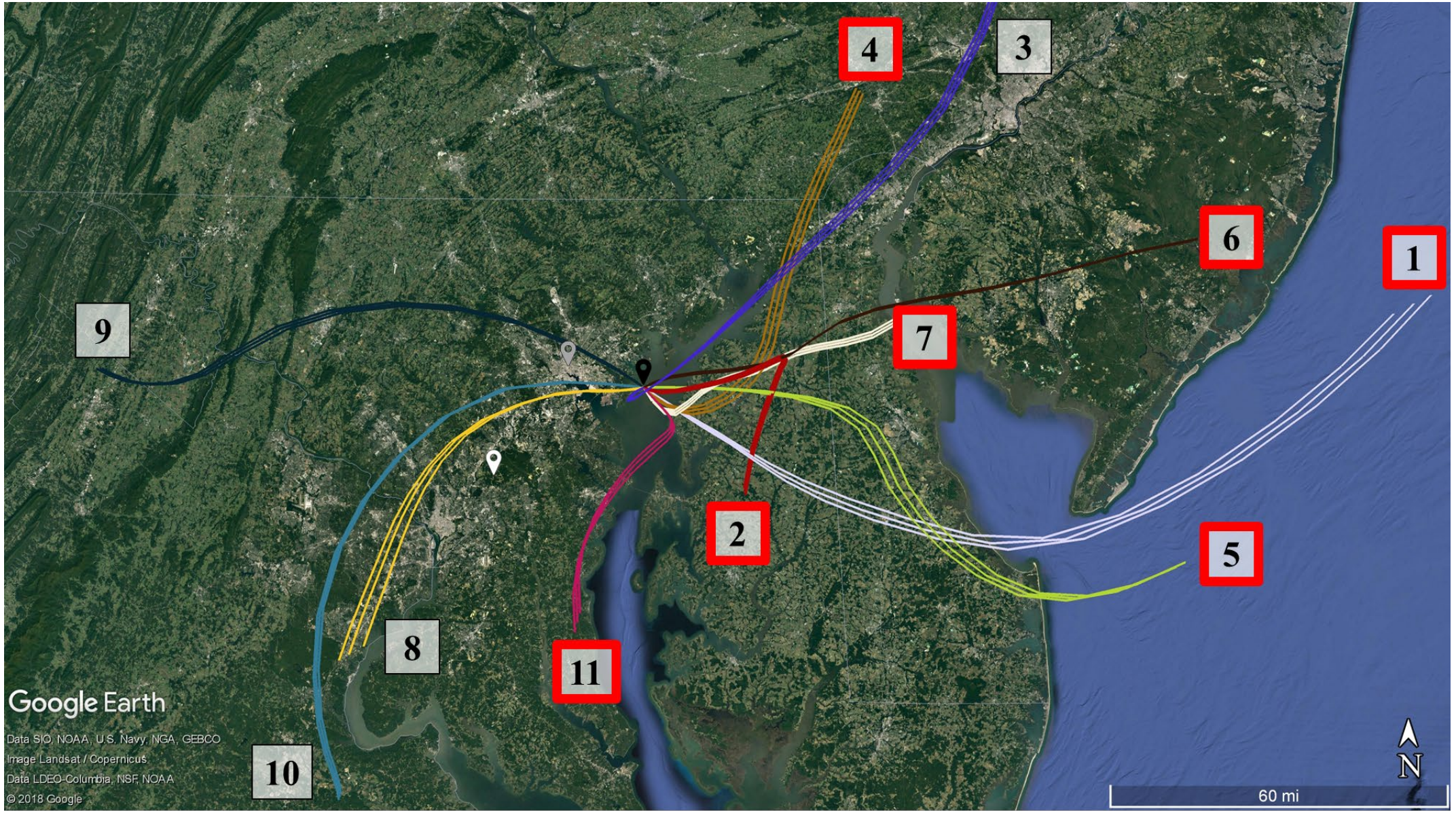
Investigating Peak NH_3 Events



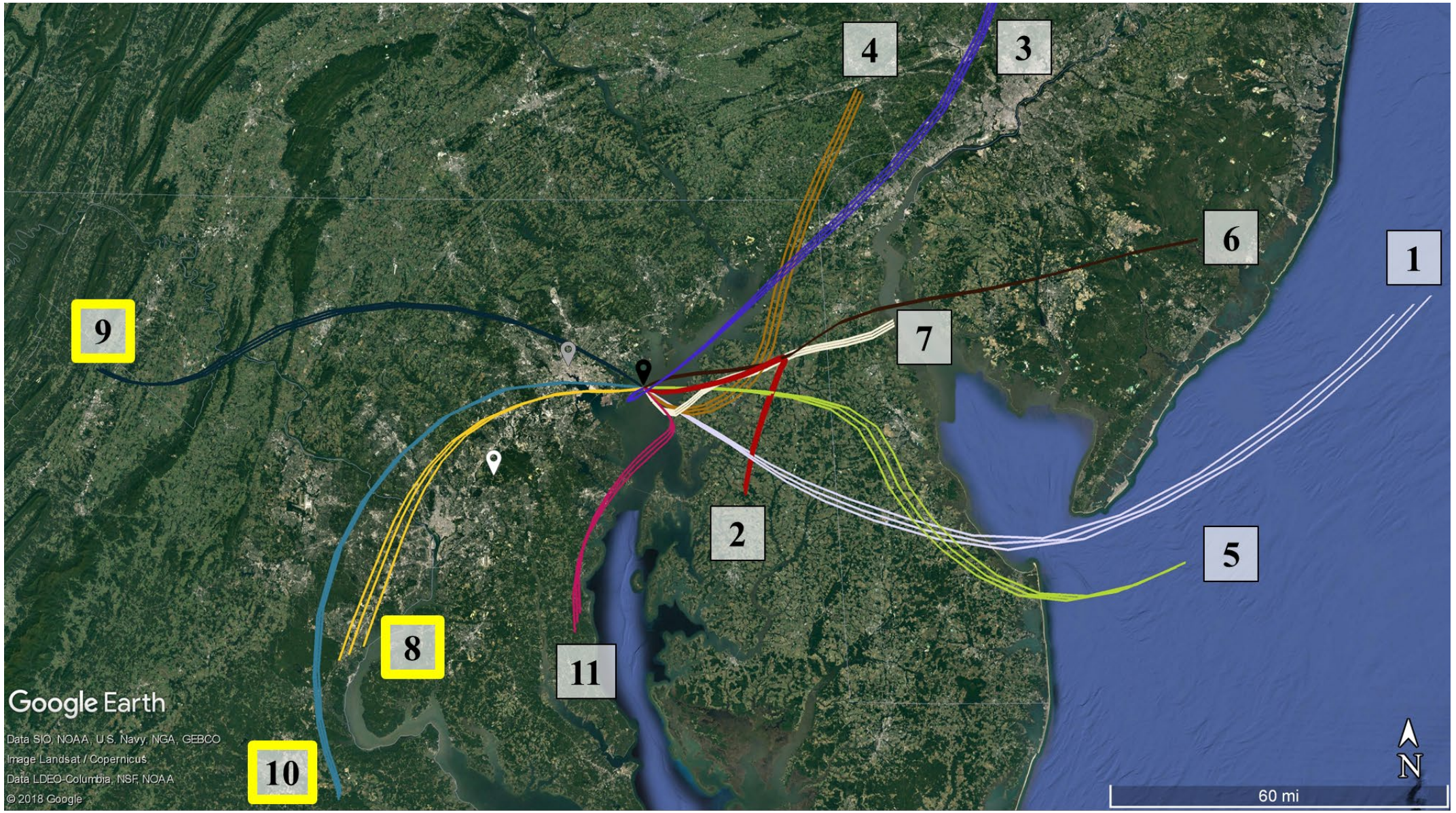
Investigating Peak NH_3 Events



Agricultural Sources of Ammonia



Industrial Sources of Ammonia



Industrial Sources of Ammonia

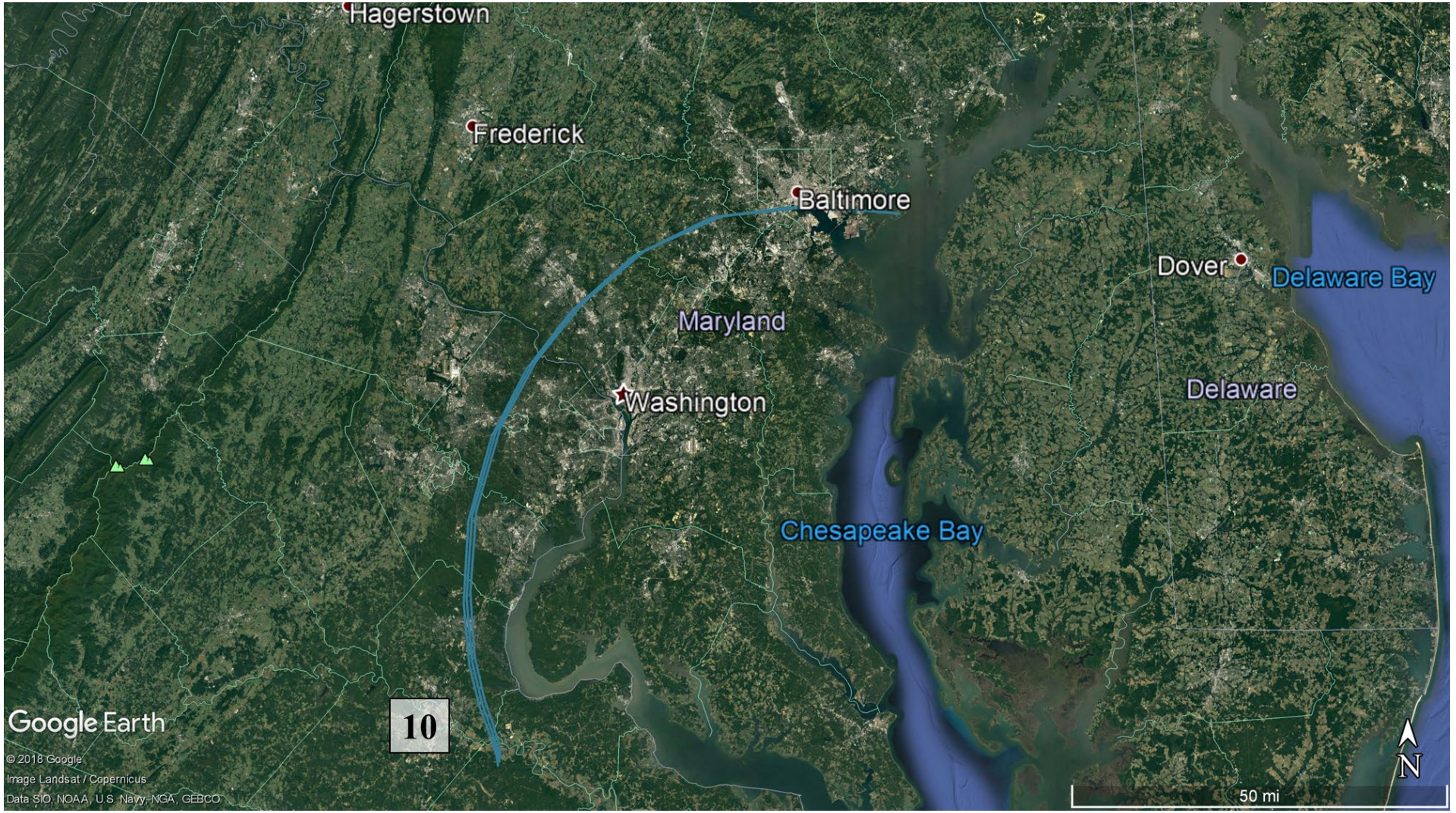
Globally, **agriculture** is the dominant source of ammonia (*over 70%*).

However, in urban areas, significant industrial sources exist, including:

- *Vehicle emissions*
- *Waste composting and processing*
- *Fertilizer production*
- *Landfill sites*

References: Sutton et al. 2000, Sutton et al. 2013, Reche et al. 2014, Sun et al. 2017

Event #10 Back Trajectory

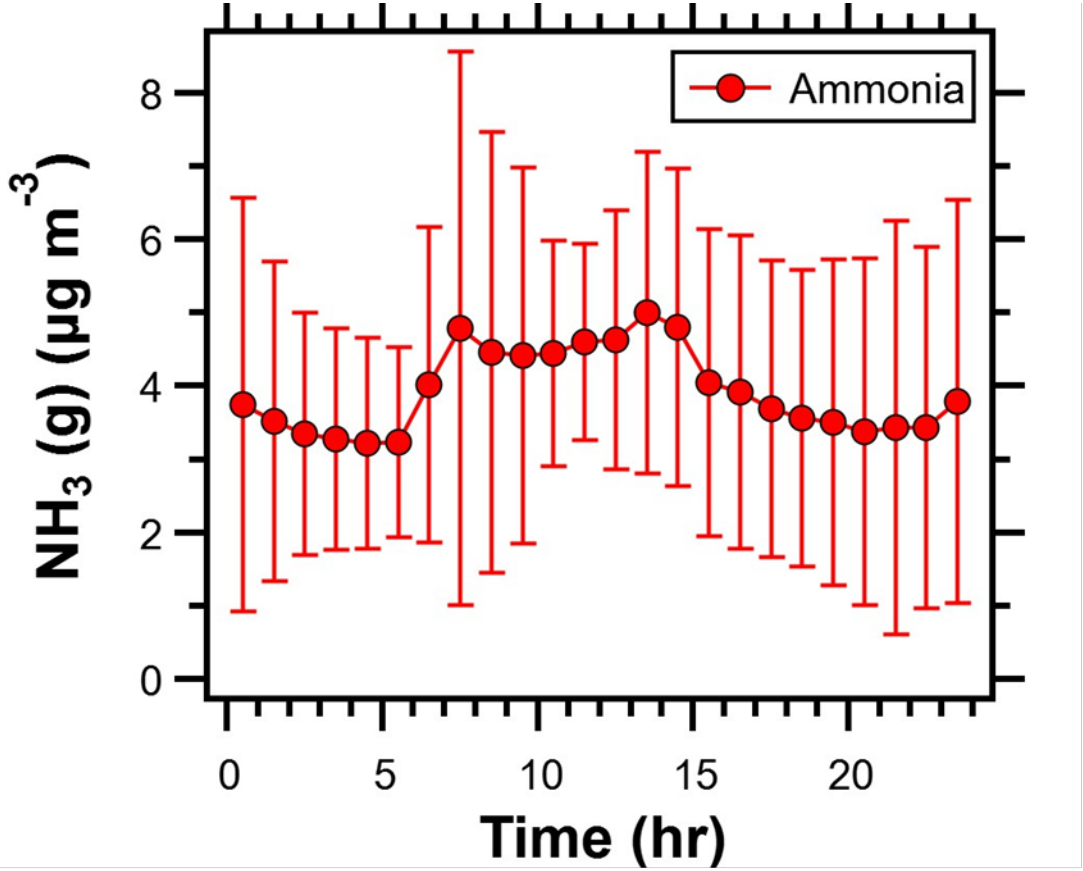


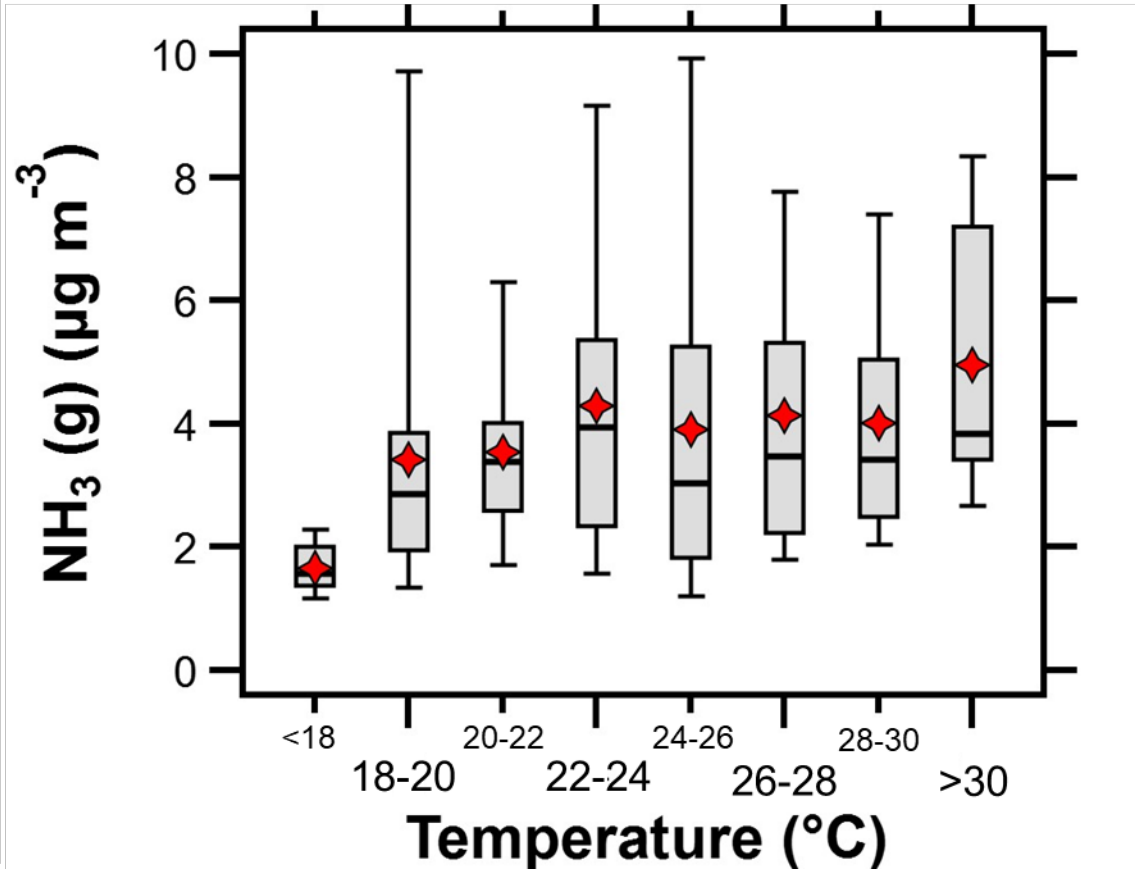
July 1st, 2018
Max NH_3: **19.3 µg m^{-3}**

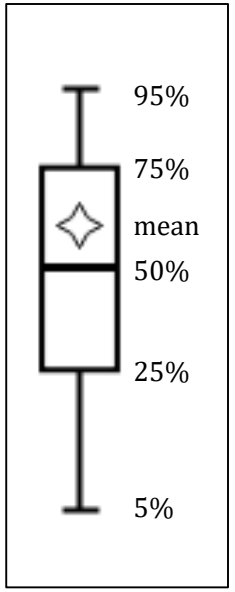
Potential Industrial Ammonia Sources in Baltimore

R^2 = 0.002 for NH_3 and CO… Likely no traffic influence.

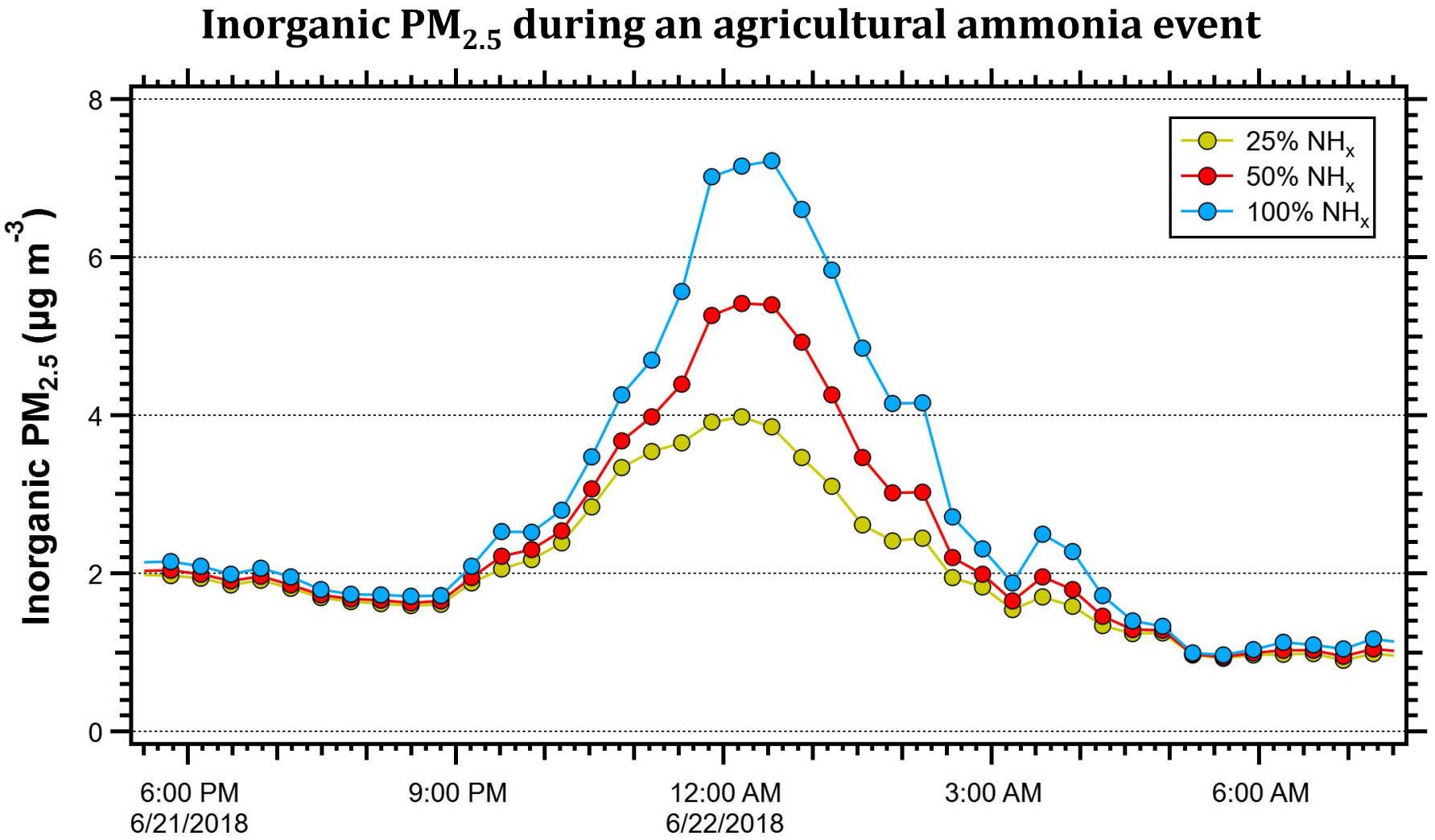
Temperature Effects on Ammonia







Effect of Ammonia on $PM_{2.5}$

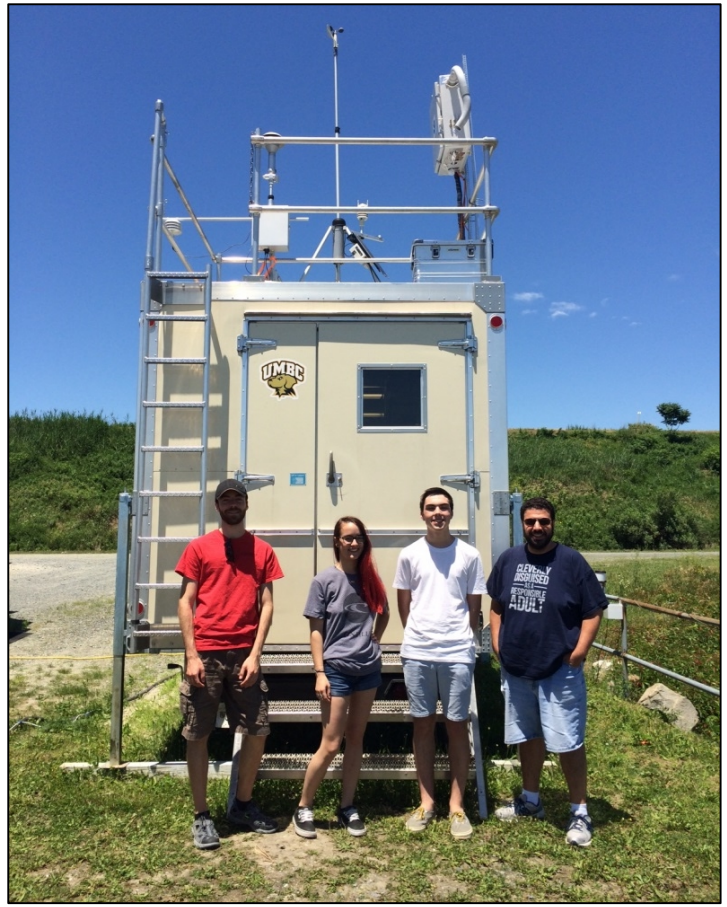


Only includes Cl^-, NO_3^-, SO_4^{2-}, $C_2O_4^{2-}$, Na^+, NH_4^+, K^+, Ca^{2+}, Mg^{2+}

Conclusions and Implications

- At HMI, ammonia and nitrate were high relative to historical trends.
- Significant agricultural ammonia emissions from poultry production in the Delmarva area.
- Periodic (but strong) influence from industrial/urban ammonia emissions from Baltimore.
- Regional ammonia emissions impacted aerosol chemistry near Baltimore.

Acknowledgments



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Ozone Water-Land Environmental Transition Study

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https://github.com/AirChem/HYSPLITcontrol

Impact on Aerosol pH, Aerosol Liquid Water Content