Atmospheric ammonia measurements at a coastal site along the east coast of the USA

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Context & Objective

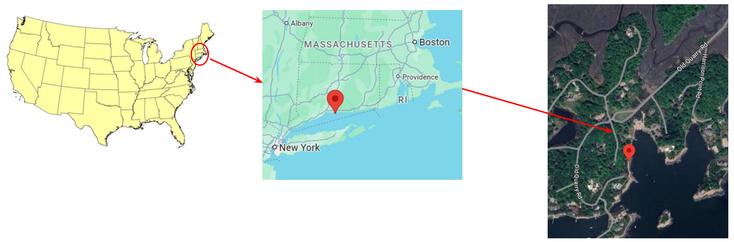
Nearly 40% of the US population lives in coastal regions. Coastal ecosystems are extremely vulnerable to climate change and human pressures. Reactive nitrogen (Nr) is one of the most widespread, costly and challenging environmental pollutants in the U.S. Over-enrichment of Nr leads to eutrophication, which is the greatest pollution problem in coastal marine waters of the U.S. The Northeastern U.S. experiences particularly large amounts of nitrogen pollution, specifically ammonia (NH_3), from agricultural and urban sources that emit nitrogen directly into these ecosystems or indirectly through atmospheric deposition processes. Despite this, atmospheric measurements of NH_3 concentrations and fluxes in coastal areas of the Eastern and Mid-Atlantic U.S are sparse.

In this study, ground-based atmospheric NH_3 concentration measurements were conducted within the Atmospheric Emissions and Reactions Observed from Megacities to Marine Area (AEROMMA) campaign over a six month period. The purpose of this study is to investigate the NH_3 concentration level in a coastal region near the Long Island Sound, which often experience poor air quality, and analyze the emission sources of NH_3 in this complex terrain.

Materials and Methods

- Continuous and high temporal resolution measurements of atmospheric NH_3 concentrations at the Yale Coastal Field Station (YCFS) (Guilford, CT) from April to October 2023.
- Micrometeorological variables were measured using an eddy covariance (EC) system.

Field site location



NH_3 concentrations & meteorological measurements

- Continuous NH_3 concentrations were measured with a Cavity Ringdown Spectroscopy (CRDS) system.
- Meteorological measurements provided using an EC tower mounted on a boardwalk located 30 m from the trailer housing the CRDS system.



Ground-based measurements at the YCFS (Guilford, CT)

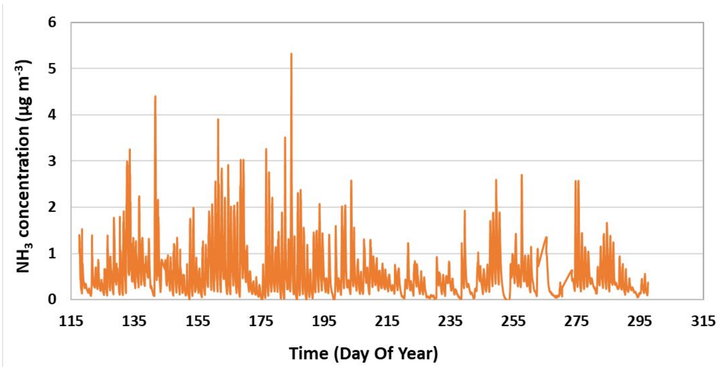


The 3 m meteorological tower

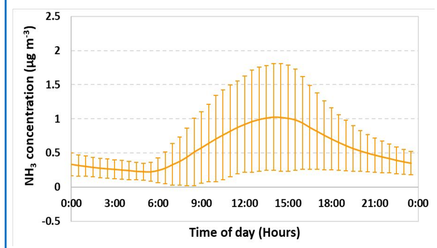


The CRDS system (Picarro G2103) inside the trailer

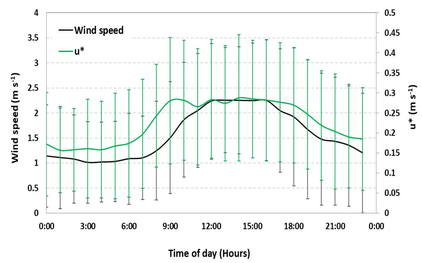
Results



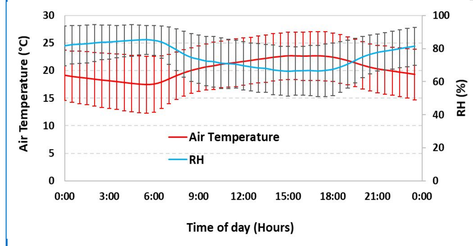
NH_3 concentrations as measured using the CRDS system at the YCFS



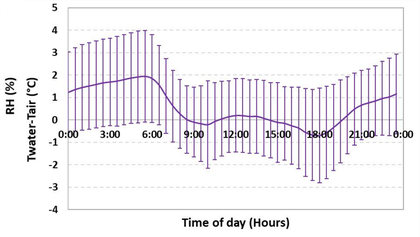
Average hourly diurnal cycle of NH_3 concentrations



Average hourly diurnal cycle of wind speed and friction velocity



Average hourly diurnal cycle of air temperature and relative humidity



Average hourly diurnal cycle of the difference between water surface temperature and air temperature

Discussion

- Continuous NH_3 concentrations from the CRDS are reported as 30 min averages.
- Mean and standard deviation values of NH_3 concentration from the CRDS was 0.57 ± 0.54 µg m^{-3} with a range of 0.001 – 5.320 µg m^{-3}.
- Measured NH_3 concentration using the CRDS showed a diurnal pattern with two prominent concentration peaks of 5.32 µg m^{-3} and 4.40 µg m^{-3} on DOY 184 and 141, respectively.
- The NH_3 concentration measurements indicate the presence of a seasonal variation with peak concentrations in the spring and summer.
- This seasonal fluctuation is likely due to increased fertilizer usage during the spring and summer, and enhanced ammonia production from increased microbial activity during warmer temperatures.
- The average diurnal cycle of NH_3 concentrations, wind speed, friction velocity, air temperature and relative humidity show that NH_3 concentrations increase after sunrise, peak when the air temperature maximizes then decrease when the air temperature decreases.
- High NH_3 concentrations coincide with the increase in wind speed and friction velocity as well as the decline in relative humidity.
- The difference in temperature between the water surface temperature and the air temperature was negative in daytime and positive at night.
- This result indicates that the situation for the YCFS is complex. The reverse situation observed over water surface at the YCFS could be explained by the fact that surface temperatures over water are less extreme than surface temperature over land. In fact the stability regime is reversed over water surface compared to the land-based expectations.

Future Work

- Back-trajectory modeling using HYSPLIT to study the sources of NH_3 at the YCFS
- Analyze the Planetary Boundary Layer Height (PBLH) measurements at the YCFS.

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