Wind sector analysis of volatile organic compounds (VOCs) at a suburban site downwind of New York City (NYC)

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Introduction

Volatile organic compounds (VOCs) play a significant role in air quality, particularly through ozone (O_3) and secondary organic aerosol (SOA) formation, leading to increased air pollution and thus negative health impacts for local populations. Air pollutants can be advected from urban to suburban areas, (e.g., New York City [NYC] to Long Island) and change suburban air quality. Long Island is home to the Flax Pond Marine Laboratory operated by Stony Brook University and the New York State Department of Environmental Conservation (NYSDEC). Here we present summertime VOC concentrations based on wind direction and observed trends between key anthropogenic VOCs (AVOCs) and biogenic VOCs (BVOCs).

Methodology

In summer 2023, we deployed the IONICON proton-transfer-reaction time-of-flight mass spectrometer (PTR-ToF-MS) for continuous VOC measurements at Flax Pond Marine Laboratory in Stony Brook, NY. Flax Pond is on Long Island, NY (~60 miles east of NYC), and is a 0.6 km² preserve that encompasses an entire tidal wetland area that leads into the Long Island Sound (LIS)[1]. We separated VOC data based on wind sectors at Flax Pond, defining the north, south, and west sectors using corresponding wind direction measurements from the NYSDEC Met One AIO 2D Sonic Anemometer[2].

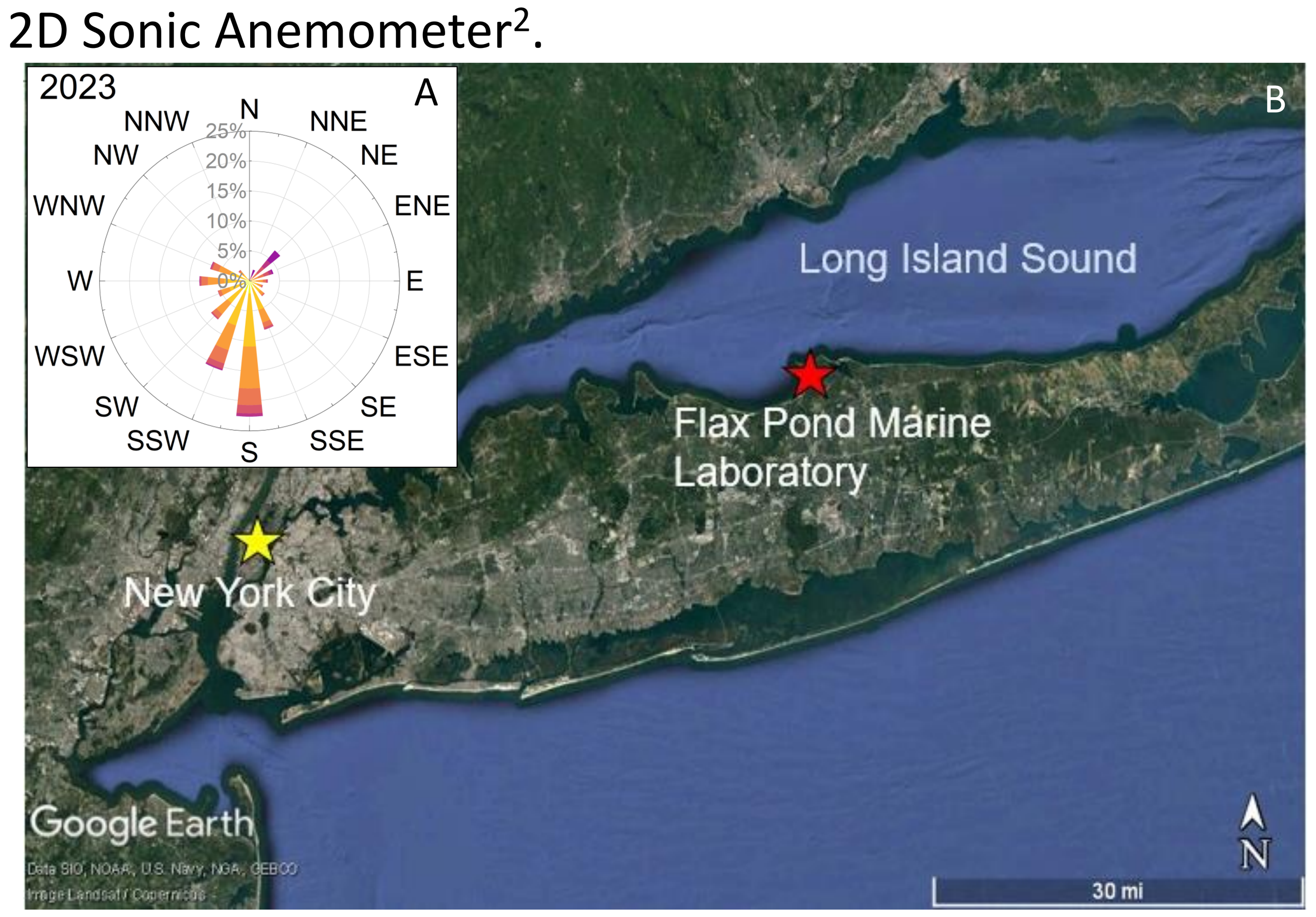

Figure 1. (a) Wind rose for summer 2023 (1 June to 19 August 2023) at Flax Pond using NYSDEC Met One observations (b) Satellite image displaying the Flax Pond Marine Laboratory in Stony Brook, NY, on Long Island and its proximity to New York City[3].

Results: VOC variations by class and wind sector

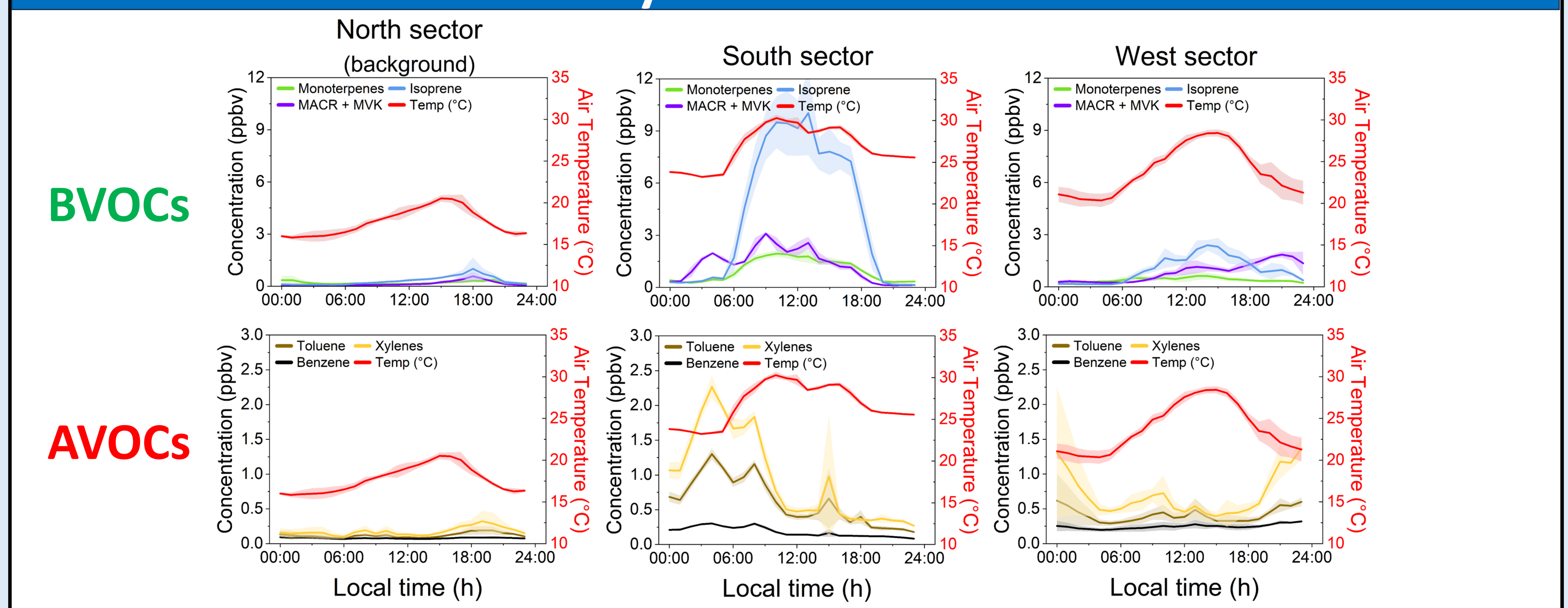

Figure 2. Top panel: selected BVOC (monoterpenes, isoprene, MACR + MVK) mean concentrations (ppbv) and air temperature diurnal profiles for each wind sector, averaged hourly from 5-min observations. Shaded region is standard deviation. Bottom panel: same as top panel, but for selected AVOCs (toluene, benzene, xylenes).

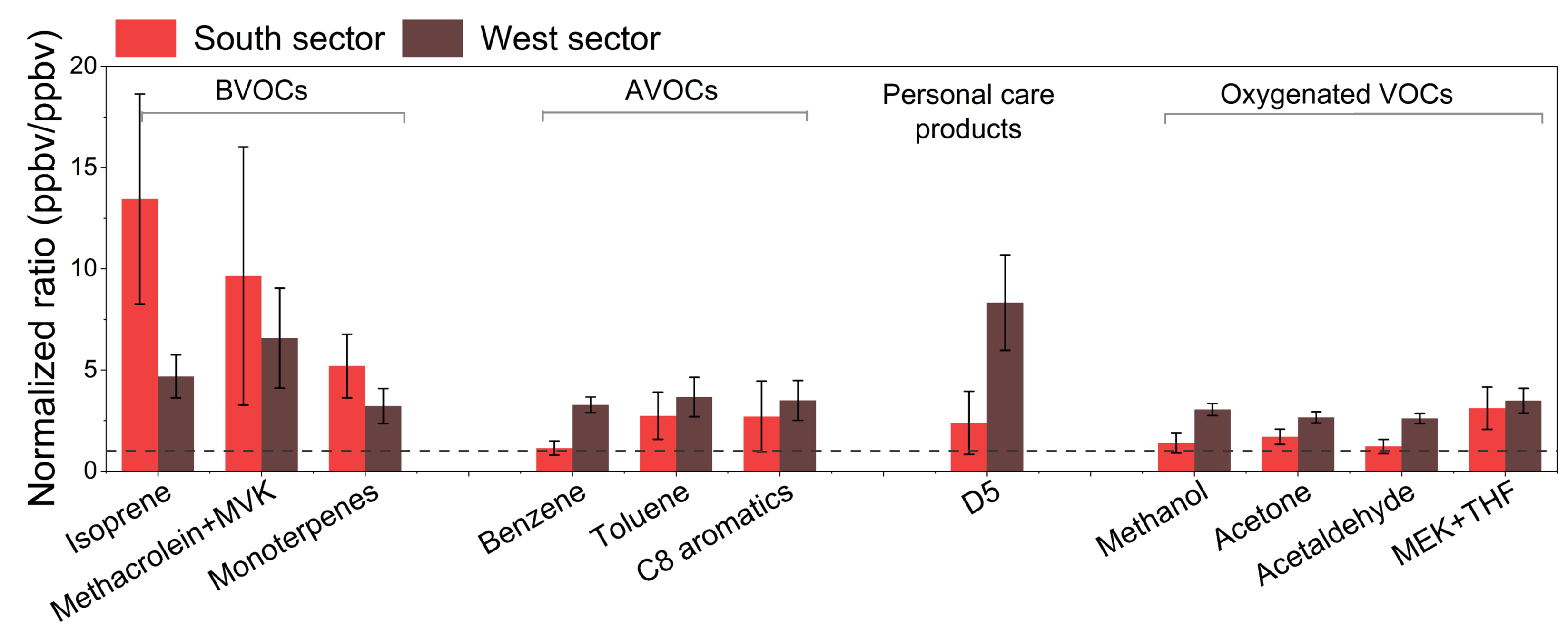

Figure 3. Normalized VOC concentration ratios (ppbv/ppbv) for the south and west sector, using daytime (08:00-17:00) hourly averaged data, from 5-min observations. Average VOC concentrations are normalized to the north sector, assumed as background. Dashed line represents a 1:1 ratio between each respective wind sector to the north (background) sector (i.e., south/north, west/north). Standard deviation represented by whiskers.

Results: Implications of AVOC and BVOC ratios

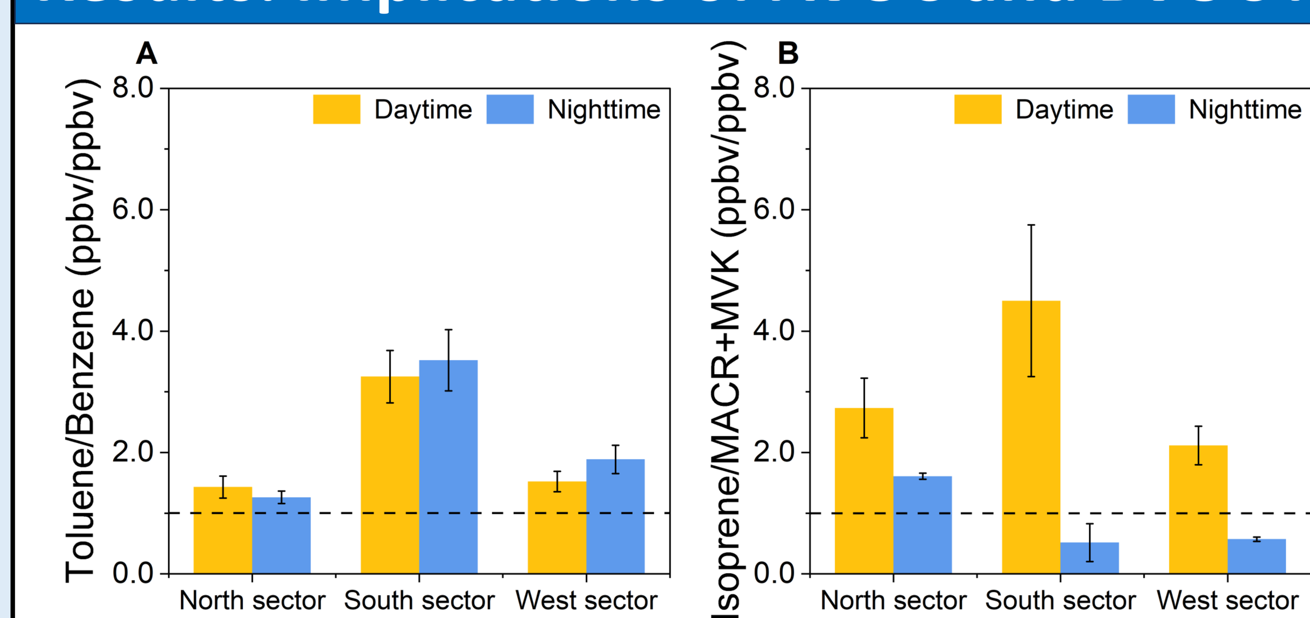

Figure 4. (a) Toluene/benzene ratio (ppbv/ppbv) for each wind sector, for both daytime (08:00-17:00) and nighttime (00:00-04:00) hourly averaged data, from 5-min observations. Dashed line represents a 1:1 ratio. Standard deviation represented by whiskers. (b) same as (a) but for isoprene/MACR+MVK ratio.

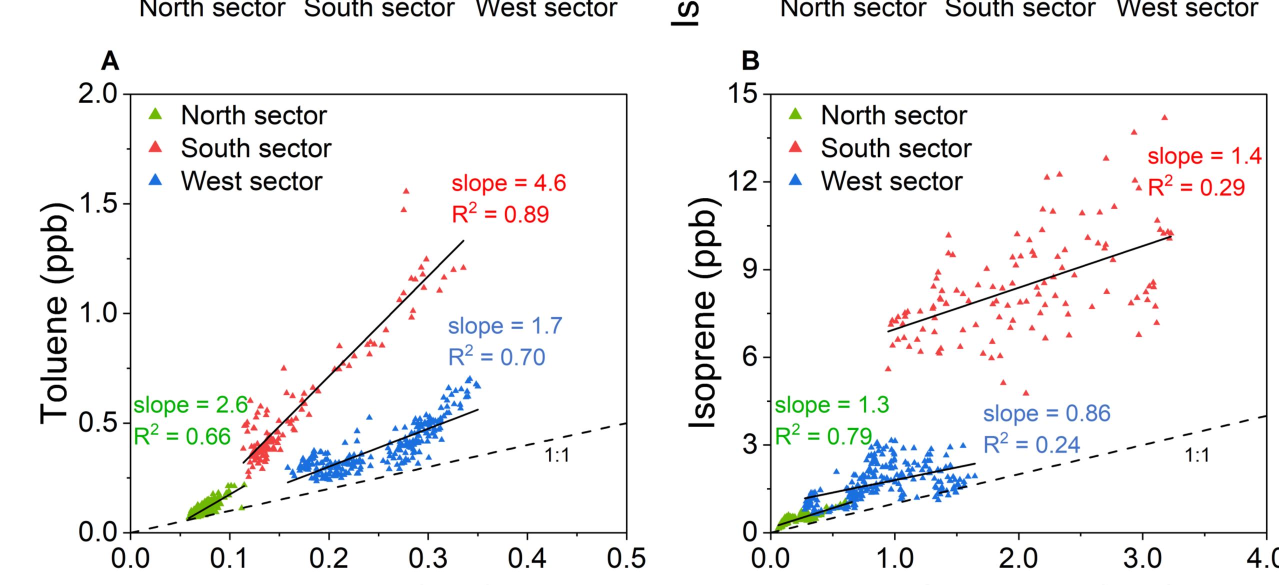

Figure 5. (a) Toluene vs. benzene concentrations for each wind sector, using daytime (08:00-17:00) 5-min averaged data. Dashed line represents 1:1 ratio. (b) same as (a) but for isoprene vs. MACR + MVK.

Results: Temperature dependency of selected BVOCs

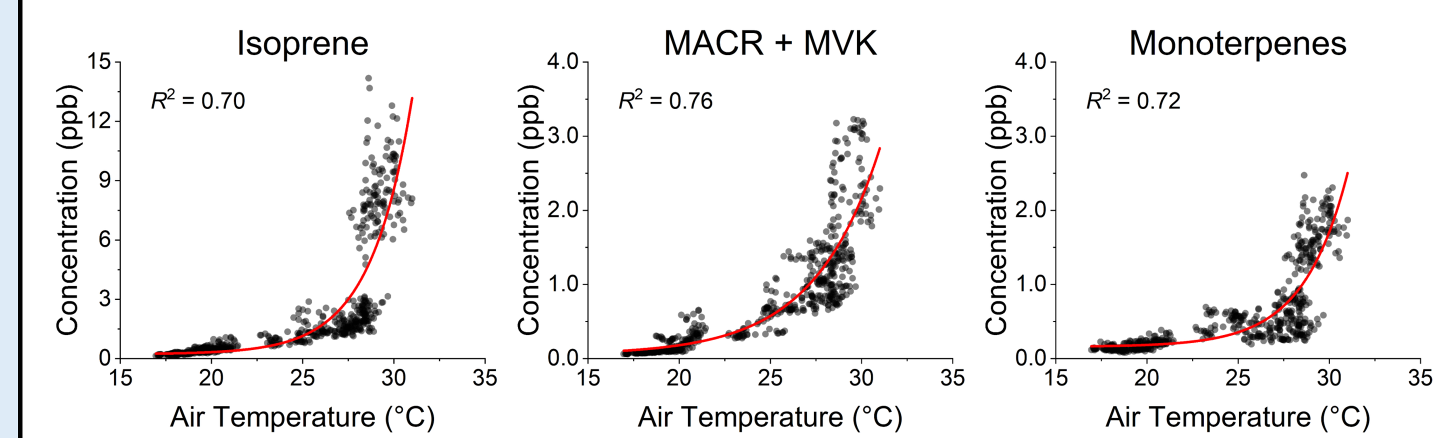

Figure 6. Temperature dependency of selected BVOCs for data from north, south, and west sectors using daytime (08:00-17:00), 5-min average observations.

Discussion & Conclusions

- BVOCs and AVOCs showed differing diurnal profiles, with BVOCs dominating in the afternoon and AVOCs highest in the morning, in both south and west sectors.
- Normalized ratios of VOCs vary based on organic class and wind sector: BVOCs have higher enhancements from the south sector, whereas AVOCs, VCPs, and OVOCs have higher enhancements from the west sector.
- T/B ratios are highest from the south sector (~ 3.4:1) compared to west sector (~ 1.6:1), indicative of anthropogenic sources, e.g., vehicle and industrial emissions. Isoprene/MACR+MVK ratio is also highest from the south, implying low yield of oxidation products in a low NOx environment.
- BVOCs, such as isoprene, MACR+MVK, monoterpenes, exhibit exponential temperature dependence at a suburban site.

References

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3. Google Maps. (n.d.). [Long Island and New York City]. Retrieved December 3, 2023, from Google Earth Pro 7.3.

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