Sources of Formaldehyde in Bountiful, Utah

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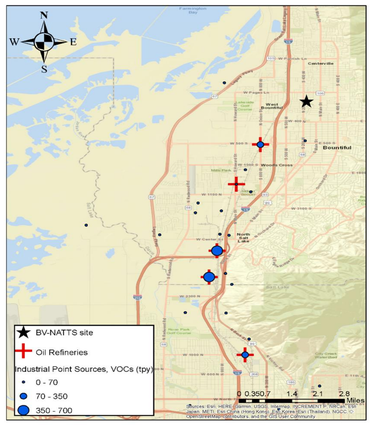
Introduction

- Hazardous Air pollutants (HAPs) – pollutants known or suspected to cause cancer or cause other serious health effects.
- Most of these pollutants are detected in low concentrations in Utah.
- Elevated levels of formaldehyde concentrations were observed in Bountiful, beginning 2013 winter.
- Formaldehyde levels exceeded the 1 in 1 million cancer risk threshold.
- The purpose of this study was to identify the sources of formaldehyde in Bountiful, Utah.

Bountiful sampling station



Location of various oil refineries and industries to the south-west of Bountiful site

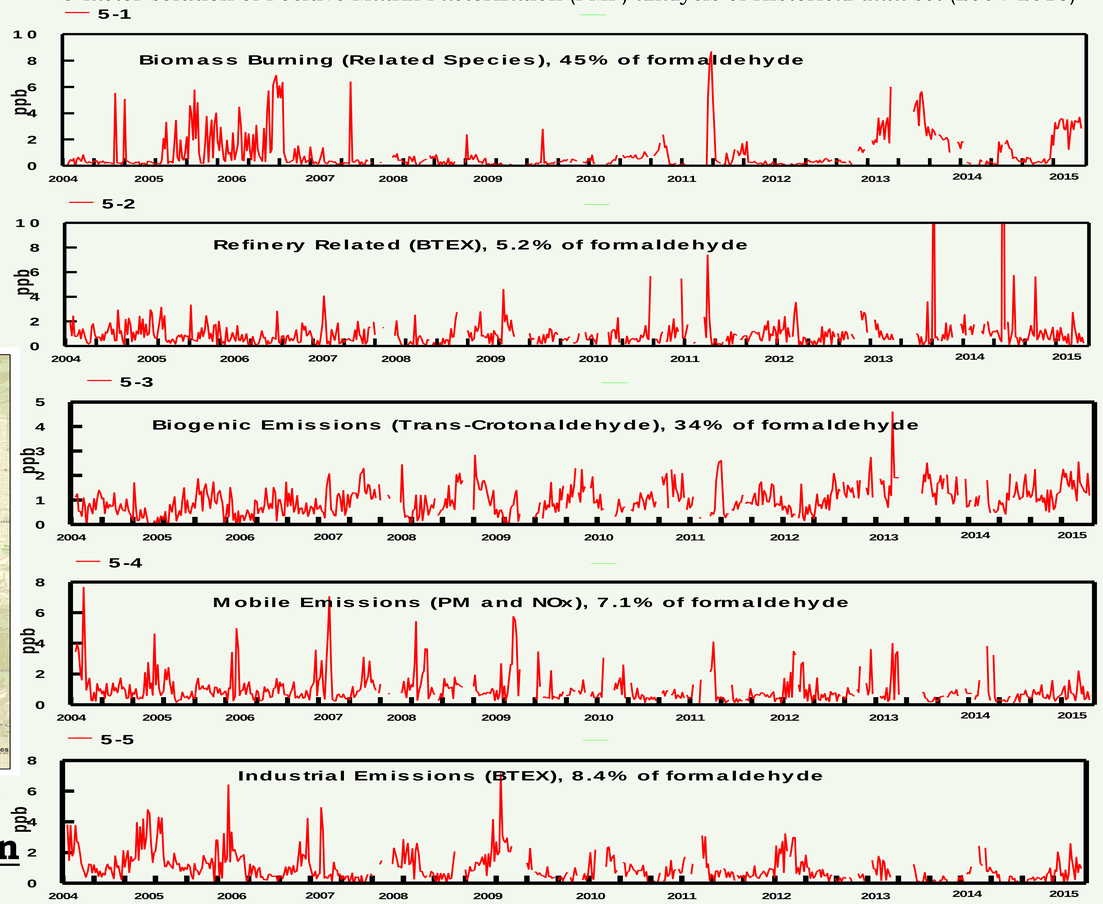
Data Collection & Instrumentation

- Two complimentary air quality studies done in Bountiful, Utah were utilized.

2004-2015	2019
Historical data set ▪ Measured HAPs on every 6th day for a 24-hr period. ▪ Species measured were carbonyls, volatile organic compounds (VOCs), $PM_{2.5}$ and NO_x (NO, NO_2). ▪ Samples were collected/analyzed through evacuated canisters, NO_x analyzer and MetOne SASS sampler. ▪ Meteorological data was also collected using MetOne 020b Wind Direction Sensor and 010b Wind Speed Sensor.	**High Temporally Resolved measurements** ▪ Formaldehyde and other gas-phase species were measured on 2-hour averaged basis. ▪ Gas phase species: BTEX (benzene, toluene, ethylbenzene and xylenes), O_3, NO_x, (NO, NO_2) ▪ Formaldehyde was measured using Broadband Cavity Enhanced Absorption Spectrometer (BBCEAS). ▪ GC-FID was used to measure BTEX compounds. ▪ O_3 and NO_x were measured using ozone analyzer and NO_x analyzer, respectively. ▪ Meteorological data was collected using MetOne 020b Wind Direction Sensor and 010b Wind Speed Sensor.

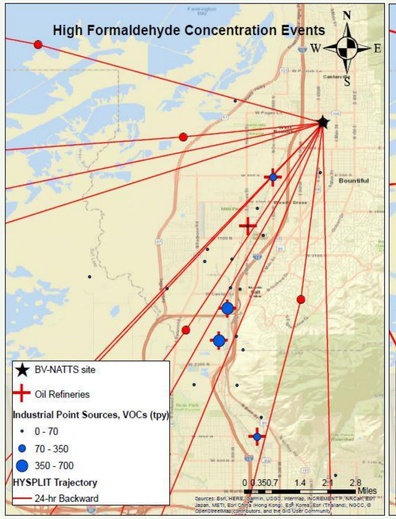
Results and Discussion

5-factor solution of Positive Matrix Factorization (PMF) analysis of Historical data set (2004-2015)

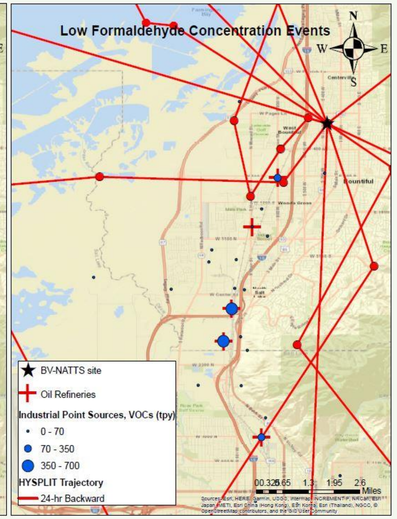


- **Factor 1** had formaldehyde, acetaldehyde, butyraldehyde, propionaldehyde and valeraldehyde as dominant species, which were related to biomass burning. This factor contained 45% of total formaldehyde.
- **Factor 2** was dominated by high concentrations (40-60%) of BTEX (benzene, toluene, ethylbenzene and xylenes). This factor contained 5.2% of total formaldehyde.
- **Factor 3** was attributed to photochemically produced formaldehyde from biogenic emissions (34% of total formaldehyde). This factor was dominated by mainly aldehydes ,especially trans-crotonaldehyde, which is a product of biogenic emissions.
- **Factor 4** contained 100% of $PM_{2.5}$ and 34% of NO_x. This factor was attributed to mobile emissions, which contained 7.1% of total formaldehyde.
- **Factor 5** contained high concentrations of BTEX (22-65%), but it also had 62% of NO_x. This factor was attributed to industrial emissions, possibly related to refinery emissions.

Backwind Trajectory Results of 2019 Data



24 h backwind trajectories during high formaldehyde concentration (23.8-32.5 ppbv) events



24 h backwind trajectories during low formaldehyde concentration (≤3 ppbv) events

- Backward wind trajectories were calculated for a 24-hr period to identify formaldehyde emission source locations at Bountiful sampling site.
- Hybrid Single Particle Langrangian Integrated Trajectory (HYSPLIT) model (version4) was used.
- Meteorological input data (wind speed, wind direction) was acquired from the High-Resolution Rapid Refresh (HRRR) model.
- A total of 22 trajectories, equally split between the high and low formaldehyde concentration events were computed.
- Trajectories associated with low formaldehyde concentrations (≤3 ppbv) had a mixed origin, with **no predominant source direction**.
- Under high formaldehyde events (23.8 -32.5 ppbv), trajectories had **southwesterly component**.
- It is likely that precursors emissions from oil refineries and industrial sources contribute to formaldehyde formation at Bountiful.

Conclusion

- The PMF results of historical data set (2004-2015) indicate that the principal sources of formaldehyde are associated with biomass burning (45%) and conversion of biogenic emissions (34%).
- Backwind trajectory analysis of low and high formaldehyde cases in 2019 shows a clear dominance of high formaldehyde originating in trajectories that come from the southwest and pass over the area of the oil refineries in the North Salt Lake City area.

Acknowledgement

This project is funded by Utah Division of Air Quality