## Background

- **Ultrafine particles (UFPs)** are particles under 100 nanometers.
- UFPs harm human health and influence the climate.
- Various factors affect the concentration of UFPs.
- Vehicle load, acceleration, distance from source, frequency of vehicles, etc.
- Meteorology (wind, temperature, humidity) impacts the concentration, formation, and transport of pollutants.

- Primary pollutants.
- Sources: fireworks, vehicles, volcanoes, sea salt, etc.
- Secondary pollutants are formed in the atmosphere through chemical reactions from primary pollutants.
- New particle formation (NPF) occurs with homogeneous nucleation of two or more vapor species (Seinfeld 2006).
- Air quality models have been developed to better understand atmospheric processes.
- E.g., WRF-Chem (Weather Research and Forecasting coupled with Chemistry).
- WRF-Chem’s predictions should be compared against recorded observations.

## Methods

### Objective 1 – Evaluating WRF-Chem’s performance
- Obtained predicted and observed wind data from four sites in Central US.
- Used two weeks of September 2013 data.
- Evaluated WRF-Chem’s performance by comparing the model’s predictions against recorded observations using Matlab and Excel.

### Objective 2 – Concentration vs Distance
- Used past research to find data on emission factors and average Iowa City concentrations of NOx, SO2, PM2.5, and BC.
- Assumed the locomotive was parked in front of the site for 10 seconds, moving at 10 mph with the wind blowing at 2 m/s directly towards the site.
- Used a Gaussian diffusion model to analyze concentrations of NOx, SO2, PM2.5, and BC 50m away from the railway.

## Results and Conclusions

### Objective 1 – Evaluating WRF-Chem’s performance
- The model reasonably simulates wind direction, but tends to overpredict wind speed.
- WRF-Chem can reproduce wind data satisfactorily.

### Objective 2 – Concentration vs. Distance
- Locomotives emit harmful air pollutants such as NOx, SO2, PM2.5, and BC.
- Regional background in Iowa City: 2.57 ppb for NOx, 0.33 ppb for SO2, 8.3 µg/m³ for PM2.5, and 0.22 µg/m³ for BC.
- NOx emitted at multiple distances from the railway.

## Data

### Wind Diagrams

#### Recorded hourly observations for wind speed and direction

#### WRF-Chem’s hourly predictions for wind speed and direction at 4km resolution

#### WRF-Chem’s hourly predictions for wind speed and direction at 8km resolution

### Concentration vs. Distance

#### WRF-Chem’s predictions for wind speed at 4km resolution

#### Wind Diagrams

### Observed vs Predicted

<table>
<thead>
<tr>
<th>Distance from track (m)</th>
<th>1 train episode (ppb)</th>
<th>Additional NOx in 24 hrs (ppb)</th>
</tr>
</thead>
<tbody>
<tr>
<td>30</td>
<td>1.29</td>
<td>1.49 × 10⁴</td>
</tr>
<tr>
<td>60</td>
<td>8.24</td>
<td>9.34 × 10⁴</td>
</tr>
<tr>
<td>90</td>
<td>6.89</td>
<td>7.97 × 10⁴</td>
</tr>
</tbody>
</table>

- If a train passes a site 60m away from a railroad, the site would receive:

### Chemical and Biochemical Engineering, University of Iowa

- Used two weeks of September 2013 data.
- Evaluated WRF-Chem for wind speed and direction at 4km resolution.
- Measured and recorded observations using Matlab and Excel.

### Reference


## Future Research

- Use WRF-Chem to simulate NPF under different emission scenarios and better understand the features of NPF in Central US.
- Set up an experiment to collect data at multiple distances from a railway and compare the results to these predictions for NOx, SO2, PM2.5, and BC.

## Acknowledgements

- Special thanks to:
  - Dr. Ilirig and Dr. Mahatmya
  - The Belin-Blank Center and SSTP
  - Dr. Stanier, Can Dong, and Megan Christiansen
  - CGRER

## Additional Information

- Special thanks to: Dr. Ilirig and Dr. Mahatmya
- The Belin-Blank Center and SSTP
- Dr. Stanier, Can Dong, and Megan Christiansen
- CGRER

## References

- The John Cooper School, The Woodlands, Texas. Chemical and Biochemical Engineering, University of Iowa. IIHR Hydrosience and Engineering, University of Iowa.