Early Results on TEMPO Satellite Observations to Evaluate AERMOD Modeling

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Motivation

The EPA regulatory dispersion model, AERMOD, is a widely used tool to simulate near-source pollution dispersion around industrial facilities and power plants.

Fig 1. LNG Export Terminal Operation in Texas.

Satellite observations from the Tropospheric Emissions: Monitoring of Pollution (TEMPO), offer a novel opportunity to compare satellite observations with AERMOD outputs at plume level in a time-varying and spatially-resolved way.

Here, we present methods to compare AERMOD modeling results with TEMPO data, as applied to a Liquefied Natural Gas (LNG) export terminal located in Texas.

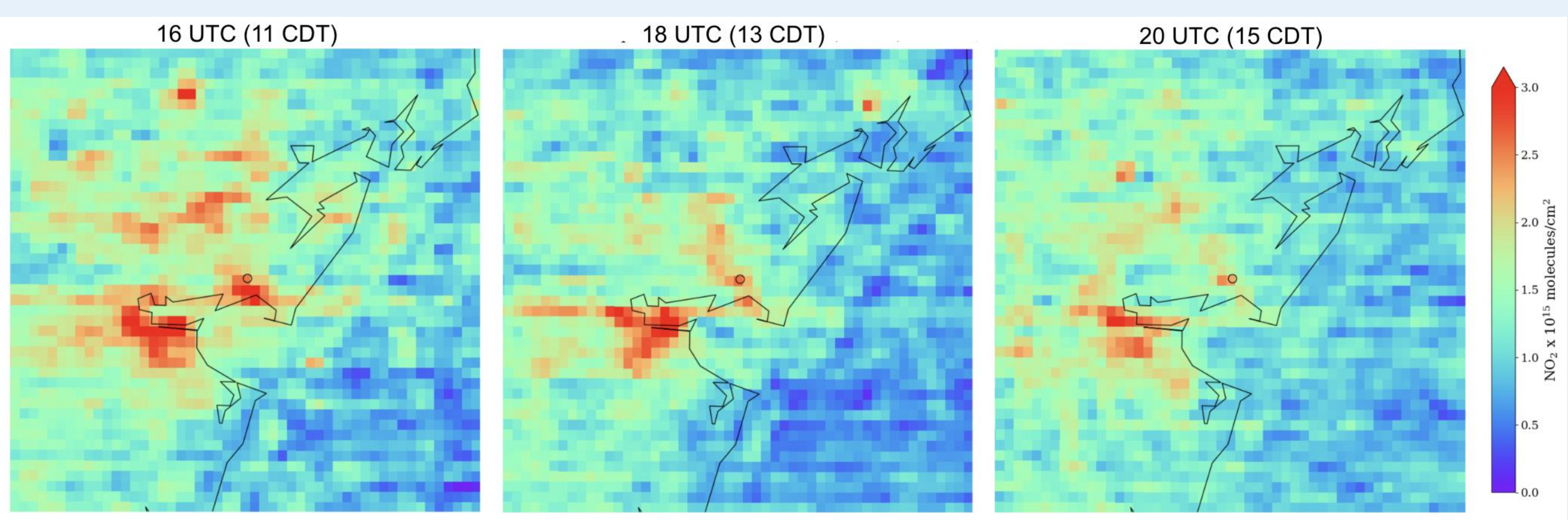


Fig 2. TEMPO observations in March 2024, from 11AM (left) to 1PM (middle) and 3PM (right) for the modeled LNG site in Texas.

Data & Methodology

Data: EPA 2022v2 Emissions Modeling Platform (EMP); EPA CAMPD 2024 hourly emissions for a similar LNG facility, TEMPO observations for 2024; WRF simulations for 2024, and USGS National Elevation Dataset (NED).

Methodology:

1. Prepare AERMOD Inputs:
   - Allocate annual EMP NO_X emissions to hourly emission rates. based on LNG operation characteristics.
   - Run AERMAP with NED data to generate terrain conditions.
   - Run WRF to generate surface and upper-air meteorology inputs.
2. Run AERMOD simulations with the above input files.
3. Convert and aggregate AERMOD outputs to each receptor location.
4. Process TEMPO observation data over the modeled area.
5. Compare AERMOD outputs with TEMPO data.

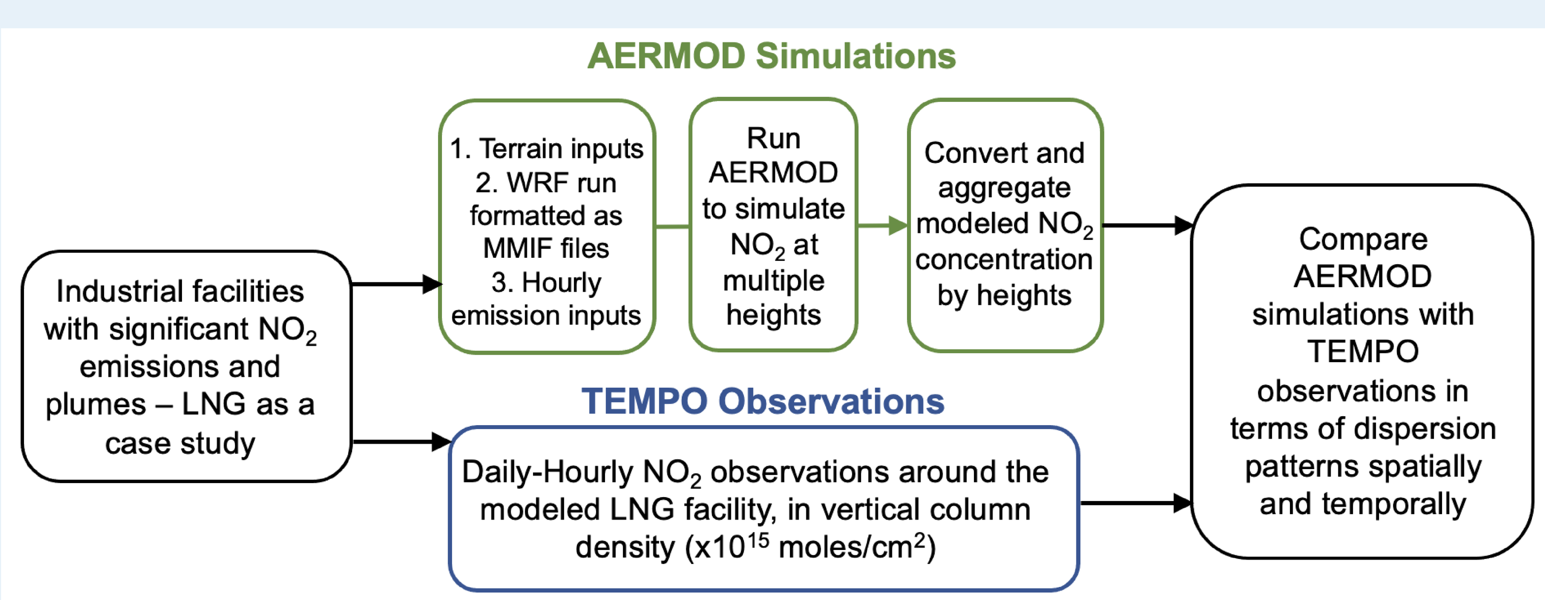


Fig 3. Schematic workflow of AERMOD-TEMPO comparison.

NO_2 Dispersion Simulated by AERMOD

1. 2D & 3D Dispersion Patterns

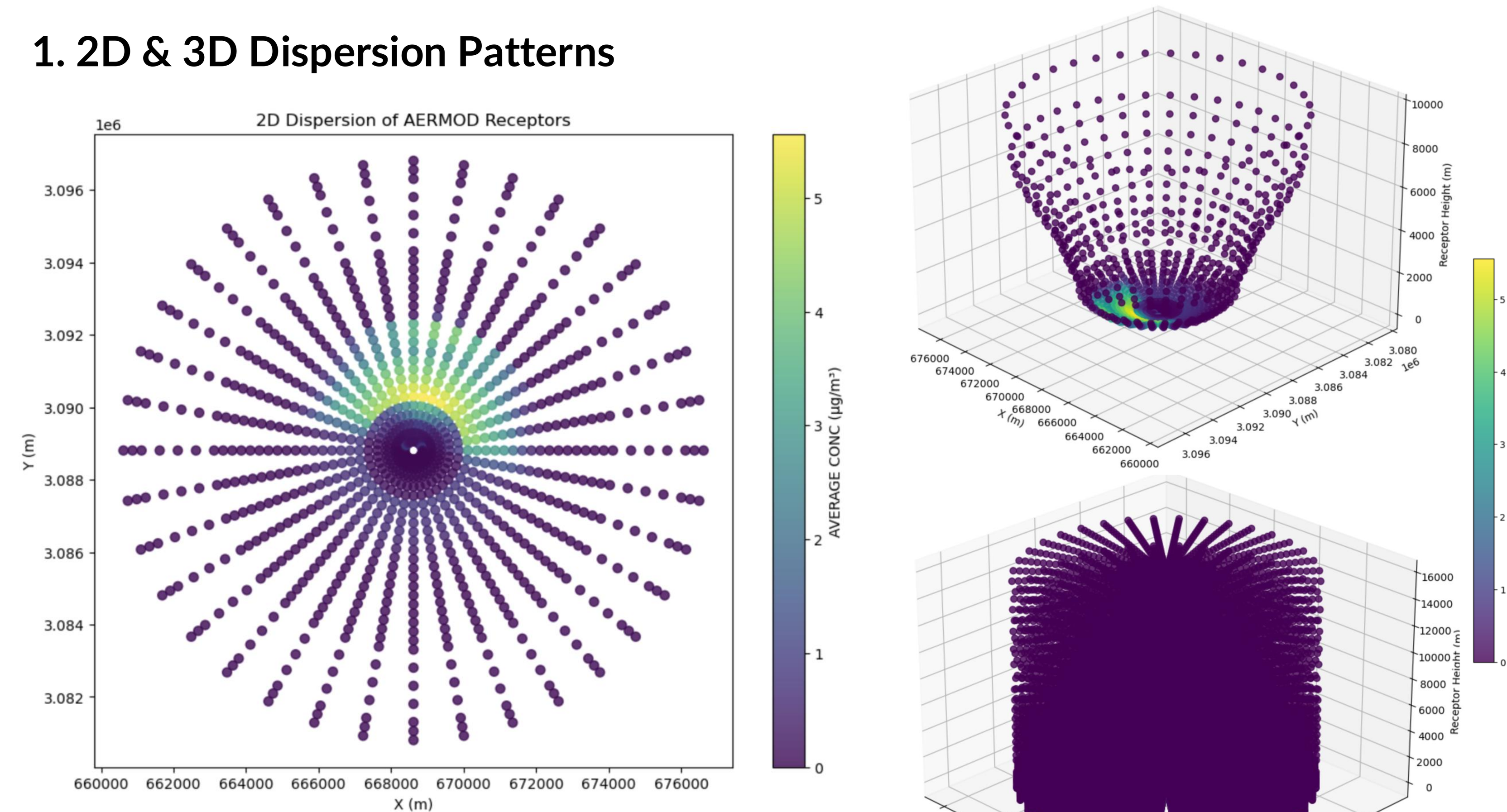


Fig 4. NO_2 Dispersion Pattern – 2D view of surface NO_2 concentrations (left), (b) example 3D view of horizontal and vertical NO_2 concentrations (upper right), (c) full receptors set up in AERMOD (lower right).

2. Vertical Profile of AERMOD Simulations

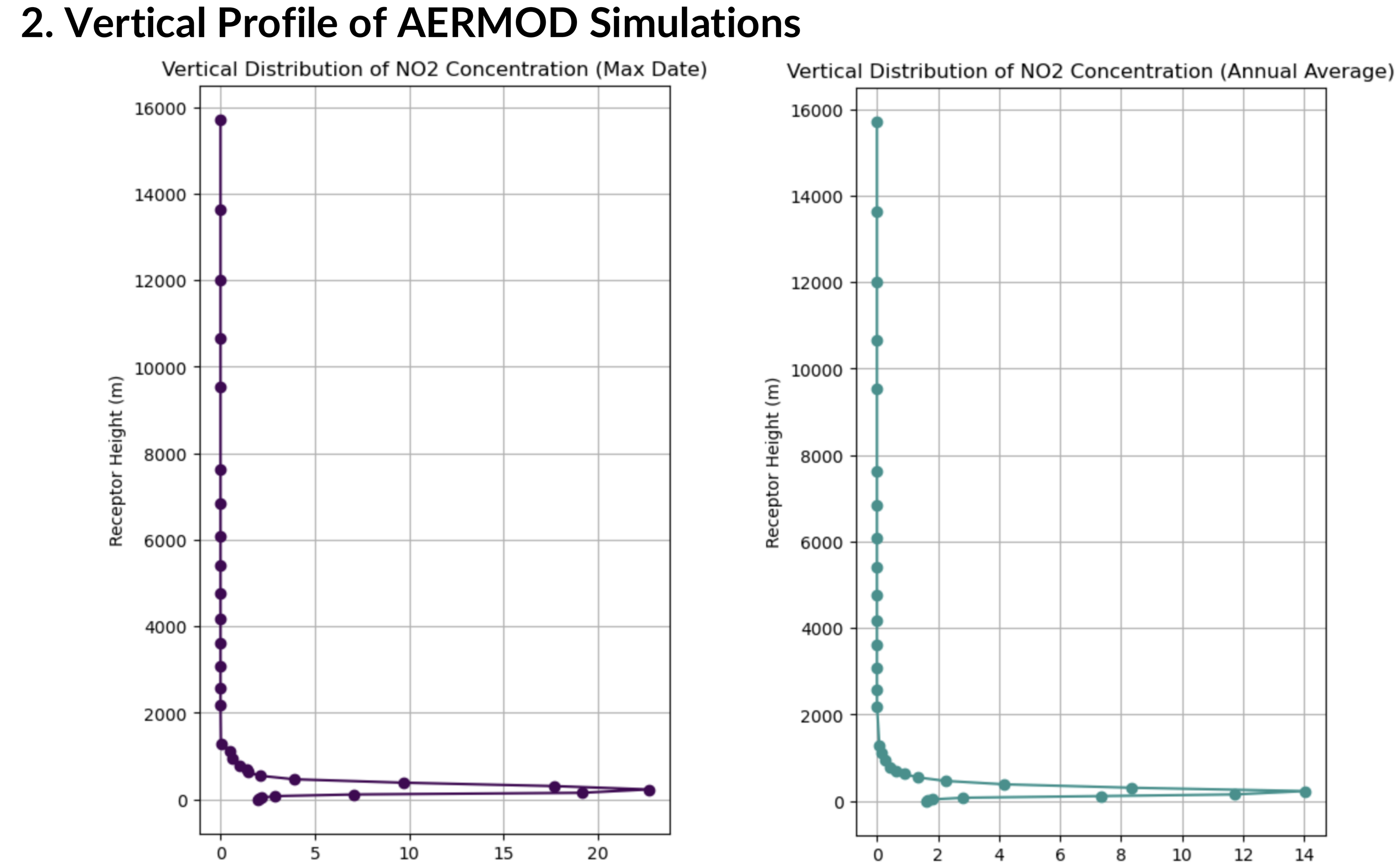


Fig 5. Vertical NO_2 Profile – maximum date (left) and annual average (right).

3. Temporal Profile of AERMOD Simulations Versus Emissions

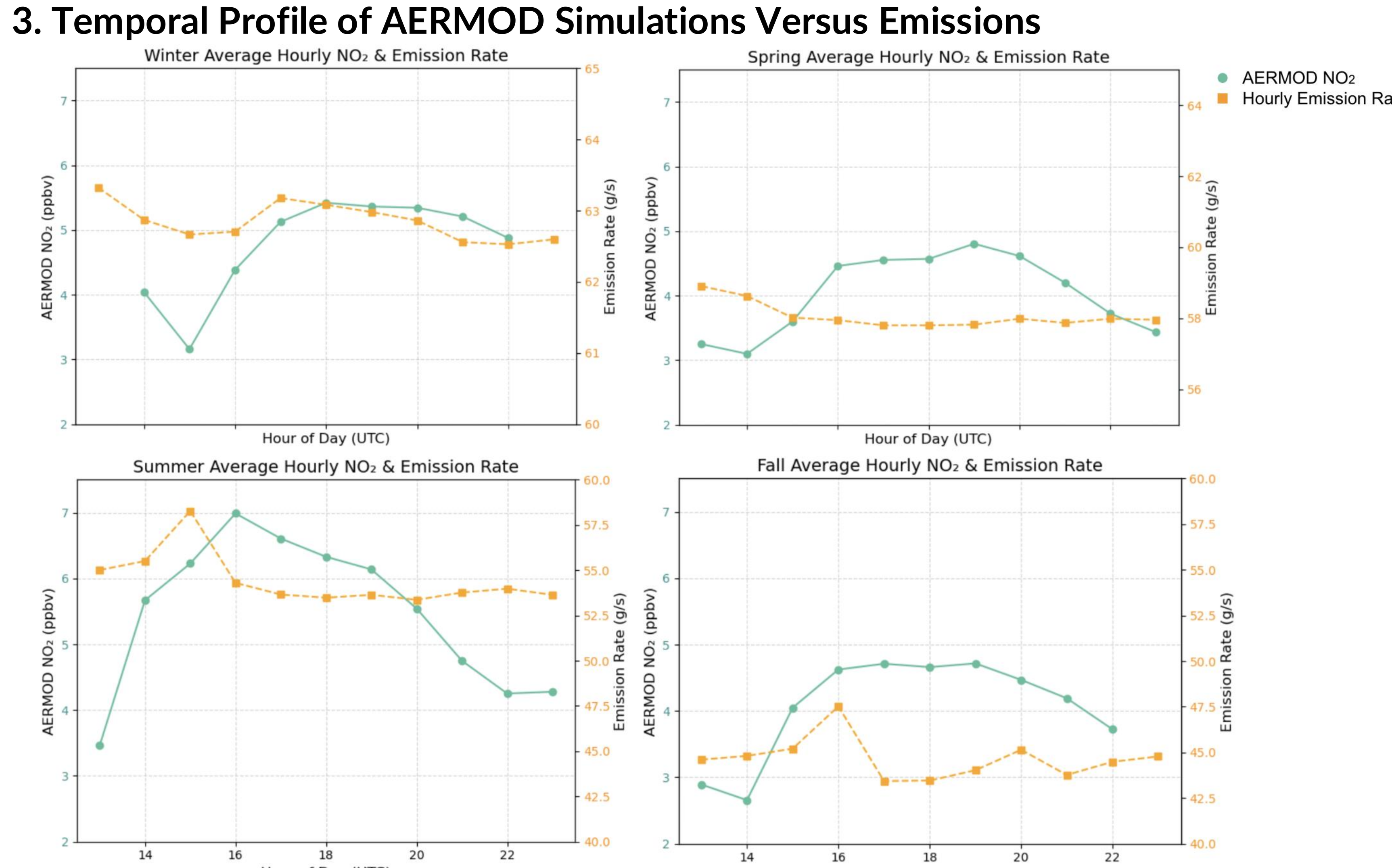
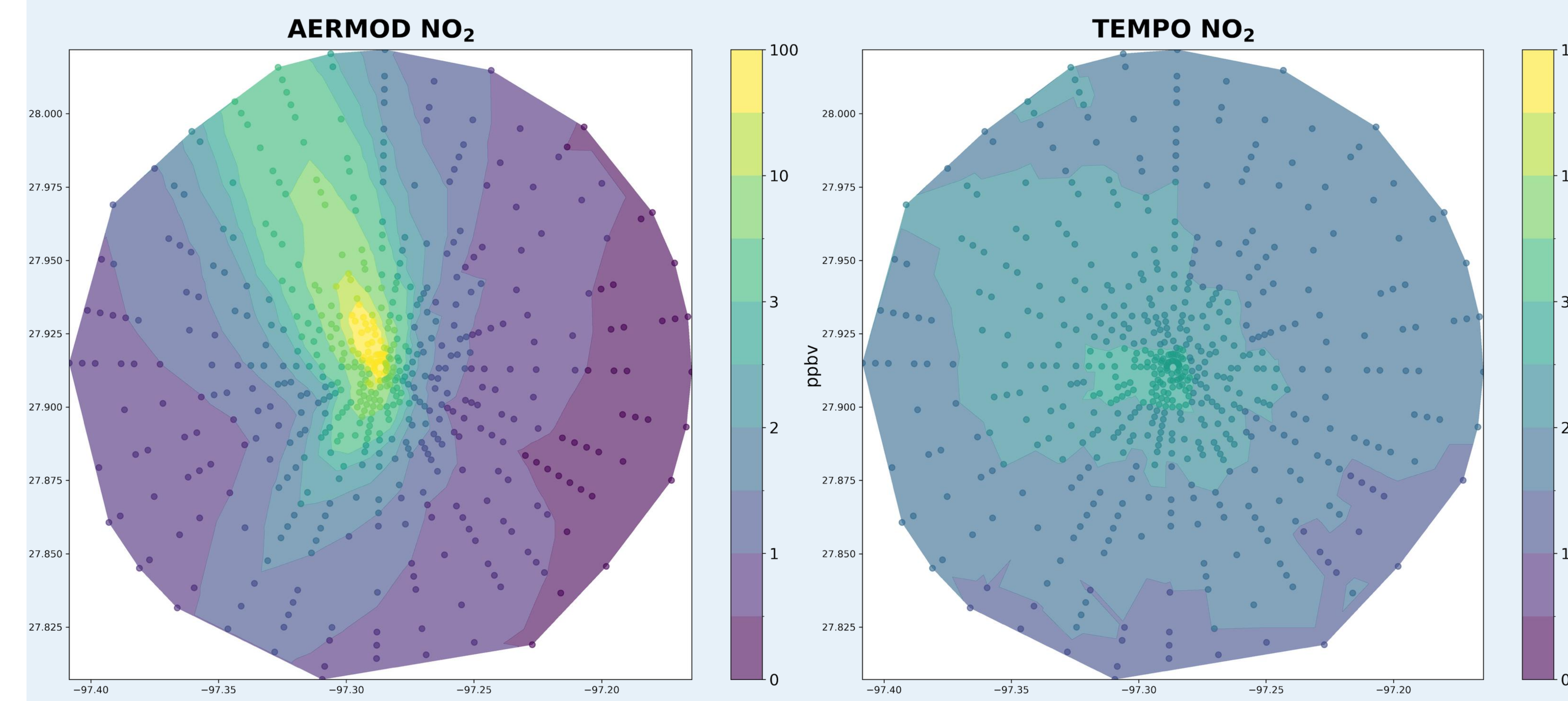
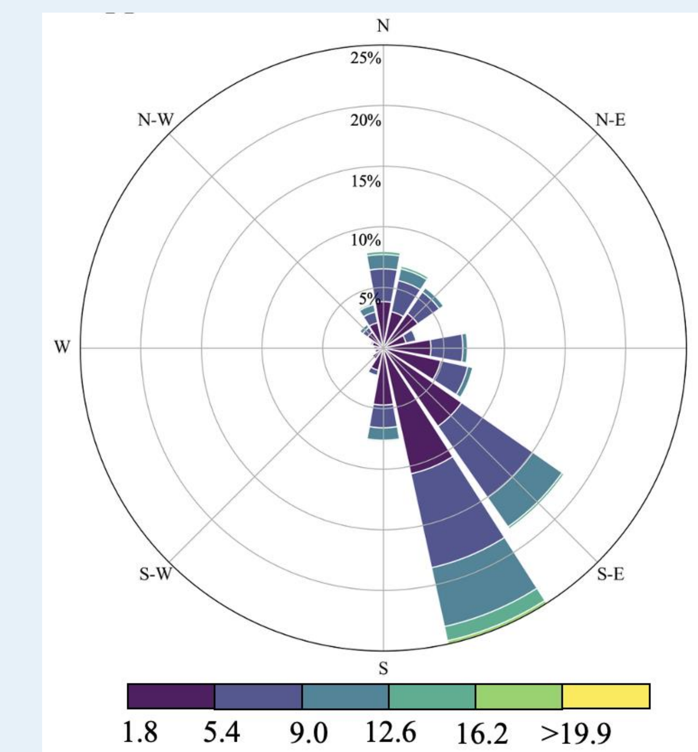


Fig 6. Hourly Profile of modeled NO_2 Versus Emission Rates – winter (upper left), spring (upper right), summer (lower left), fall (lower right).

TEMPO-AERMOD Comparison





- AERMOD captures higher peak NO_2 values than TEMPO, along with a directional difference.
- Potential reasons include: (1) emissions and meteorology inputs to AERMOD might not accurately represent rea-world conditions; (2) TEMPO observes a "footprint" of diluted concentrations, and (3) TEMPO senses NO_2 more above the surface, where we could not vertically weight AERMOD column to match that sensitivity.

Fig 7. Annual-average NO_2 from AERMOD simulations (upper left), TEMPO observations (upper right), and wind diagram (lower).

Discussion & Future Work

Discussion:

- AERMOD can simulate vertical pollution dispersion and has the potential to be compared with TEMPO satellite observations.
- The highest NO_2 concentrations occurred at vertical receptors around 100–200 m and declined rapidly above 2 km.
- Temporal profile is largely dependent on hourly emission allocation.

Further Work is needed:

- Compare temporal profiles pf AERMOD outputs and TEMPO data.
- Investigate potential sources of spatial and temporal discrepancies between AERMOD and TEMPO, including: 1) calibration of the AERMOD concentration profiles; 2) meteorology inputs, especially WRF versus observations; and 3) emissions that might not reflect real conditions.
- Consider background NO_2 and determine how to to include them.

Acknowledgments

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