A Renaissance Study of Dispersion Processes around a Major Roadway

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Structure of Presentation

- Introduction
  - Renaissance…?
  - Las Vegas roadway study
- Study objectives
- Explanation of conditional approach
- Application of conditional approach
  - Observed vs modelled distance decay
  - Observed vs modelled vehicle-wake
- Discussion & conclusion

A Renaissance of Roadway Studies?

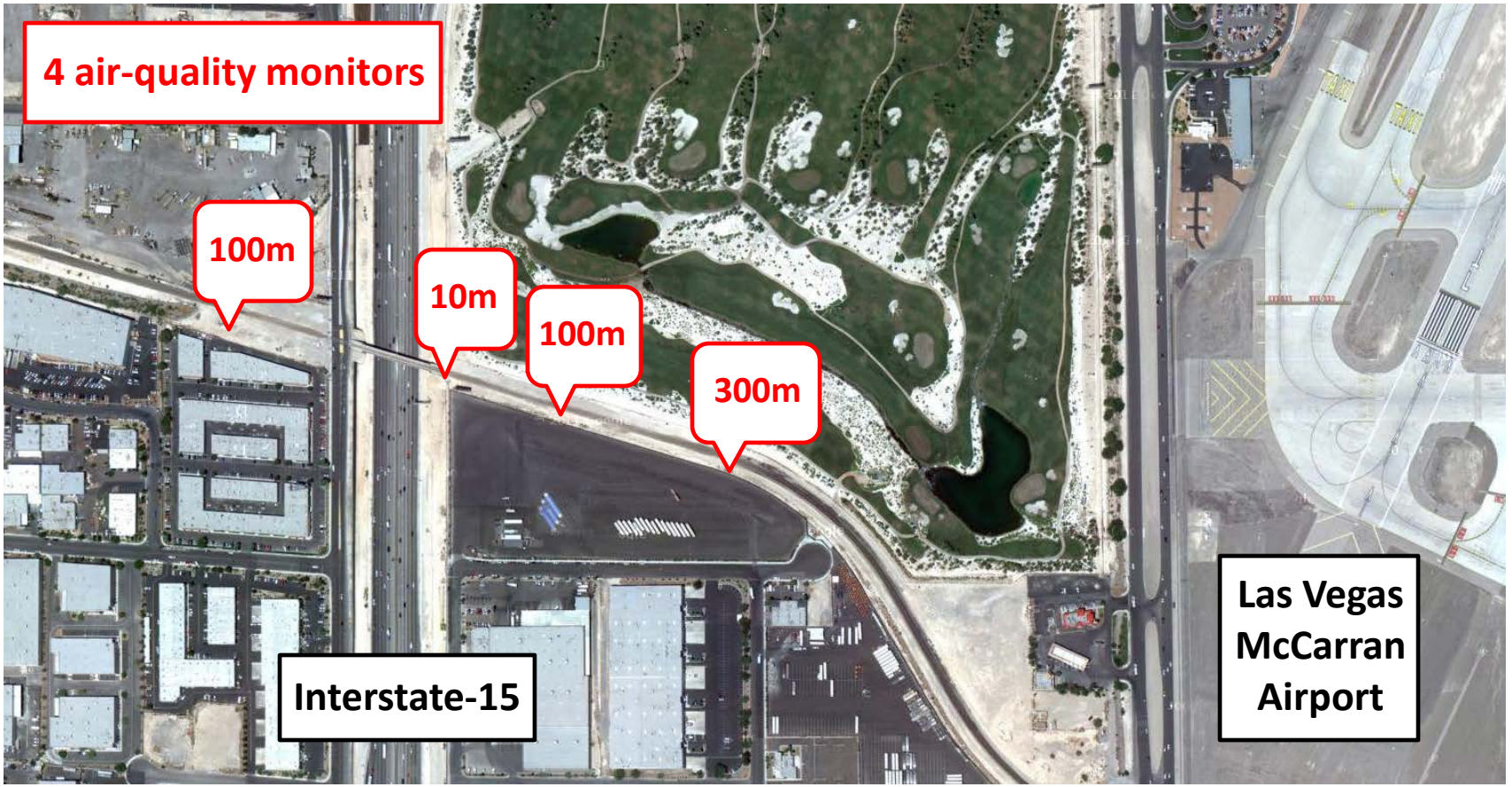
- Long history of roadway dispersion studies (e.g. from 1970s using ESL and Caltrans models)

- Recent revival following new evidence, methods & tools. For example:
  - Growing health concerns (exposure to 'no-effect' threshold pollutants)
  - New data-collection methods (e.g. sonic anemometers, vehicle-number-plate recognition)
  - 'New-generation' dispersion models
  - Directional data-analysis techniques

- This study focuses on **new techniques** for analysing ambient roadway-pollutant concentrations

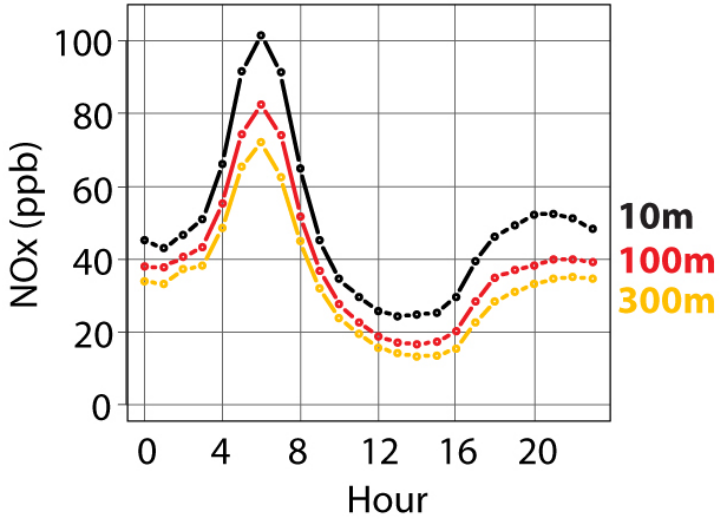
Las Vegas Roadway Study (1)

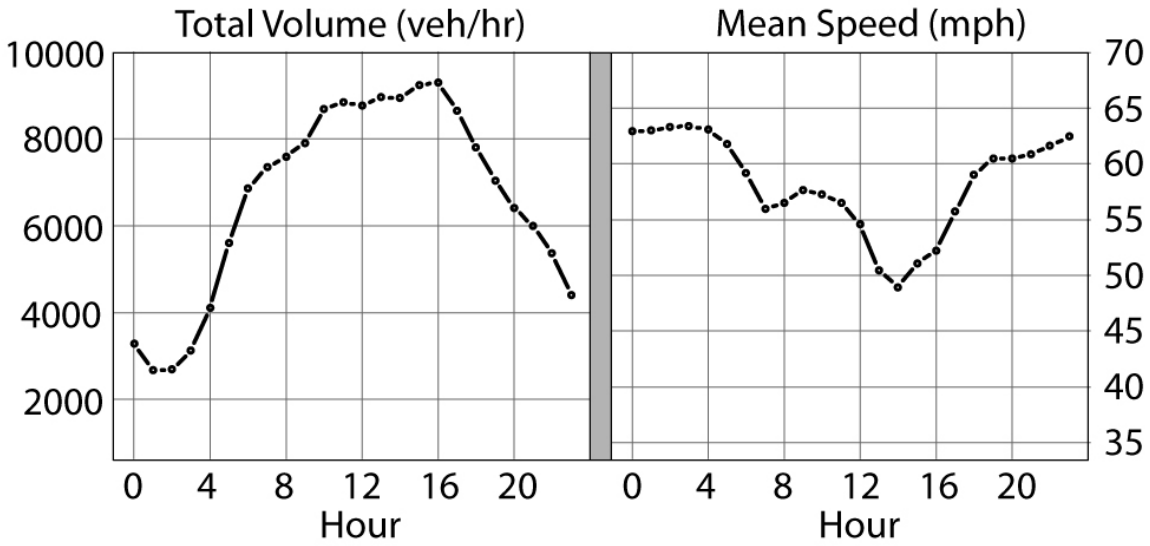
- Analysis of roadway concentrations in the ‘near-road’ environment



Las Vegas Roadway Study (2)

- 15-month campaign (Dec 2008 – Feb 2010)
- 4 x 5-minute NO, NO_2, NOx
- 4 x sonic anemometers (u, v, w)
- Hourly airport meteorology: wind speed/direction, RH, temp, cloud cover
- Hourly N- and S-bound traffic speed and volume





Objectives

- Examine observed records of NOx for evidence of:
  - Distance decay
  - Vehicle wake
- Assess ability of a model to re-produce
- ***'Conditional-analysis' approach taken → bulk tests of performance***

Conditional Approach

All data:
10272 hours

↓

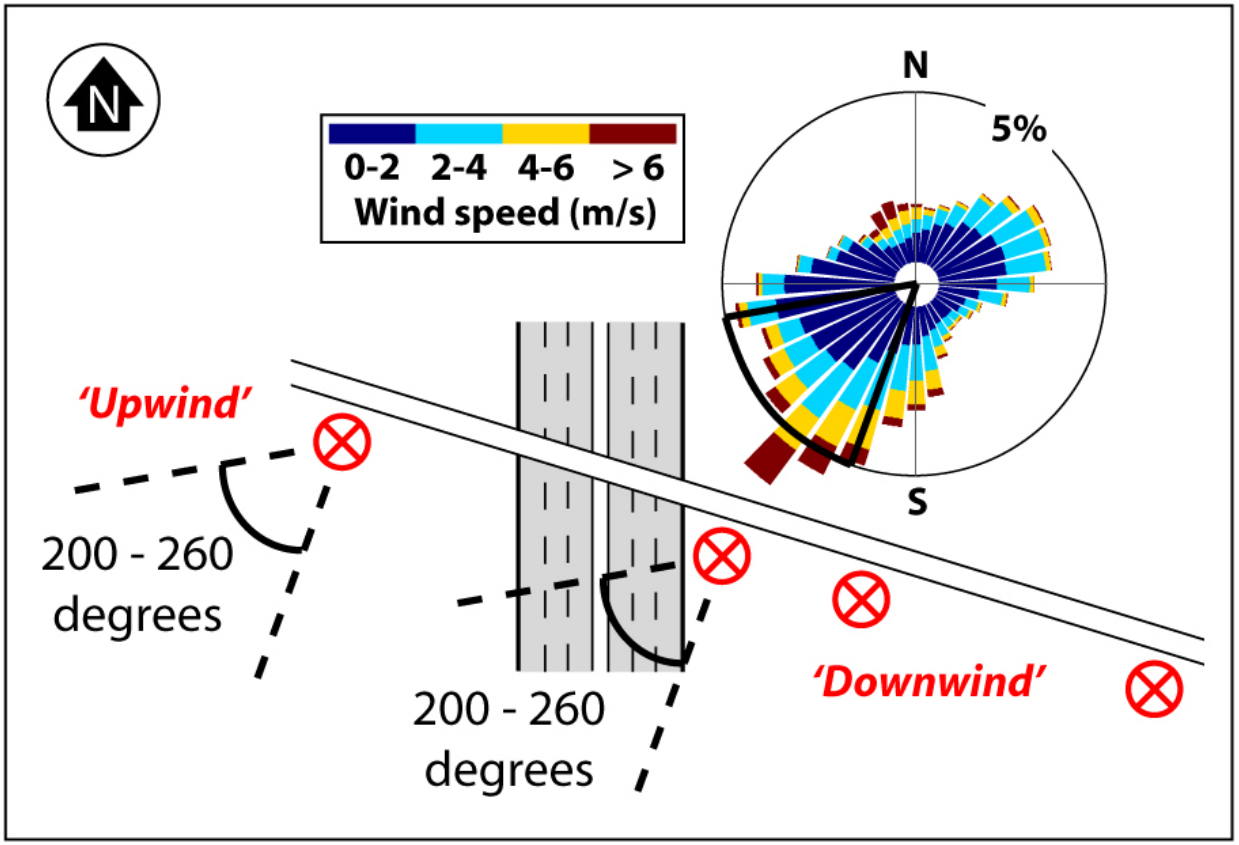
Select sector 200-260 °:
3245 hours

↓

Calculate 'incremental' NOx:
Downwind – Upwind

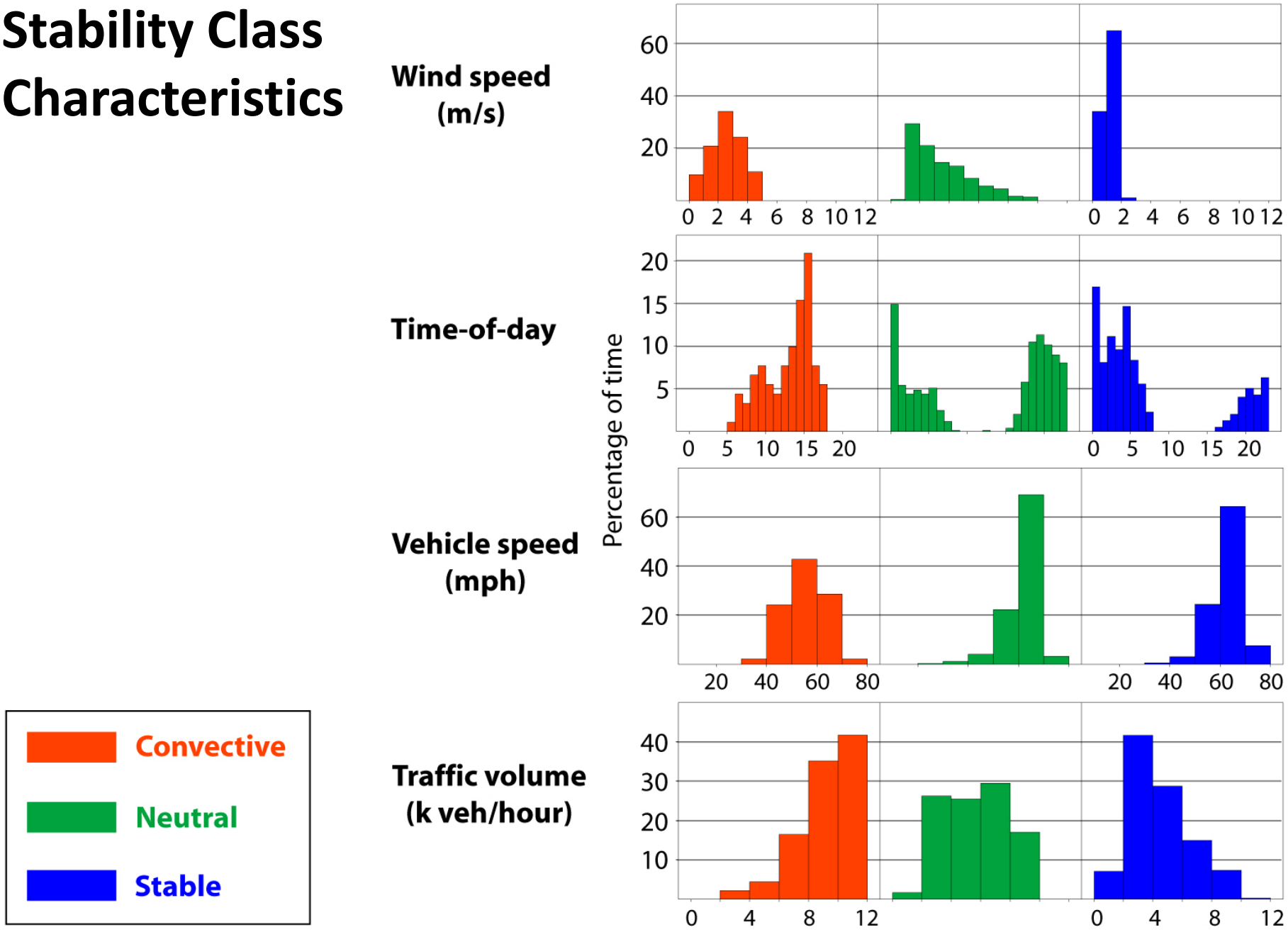
↓

Classify hours into 5 stabilities:
H/L_{MO} basis

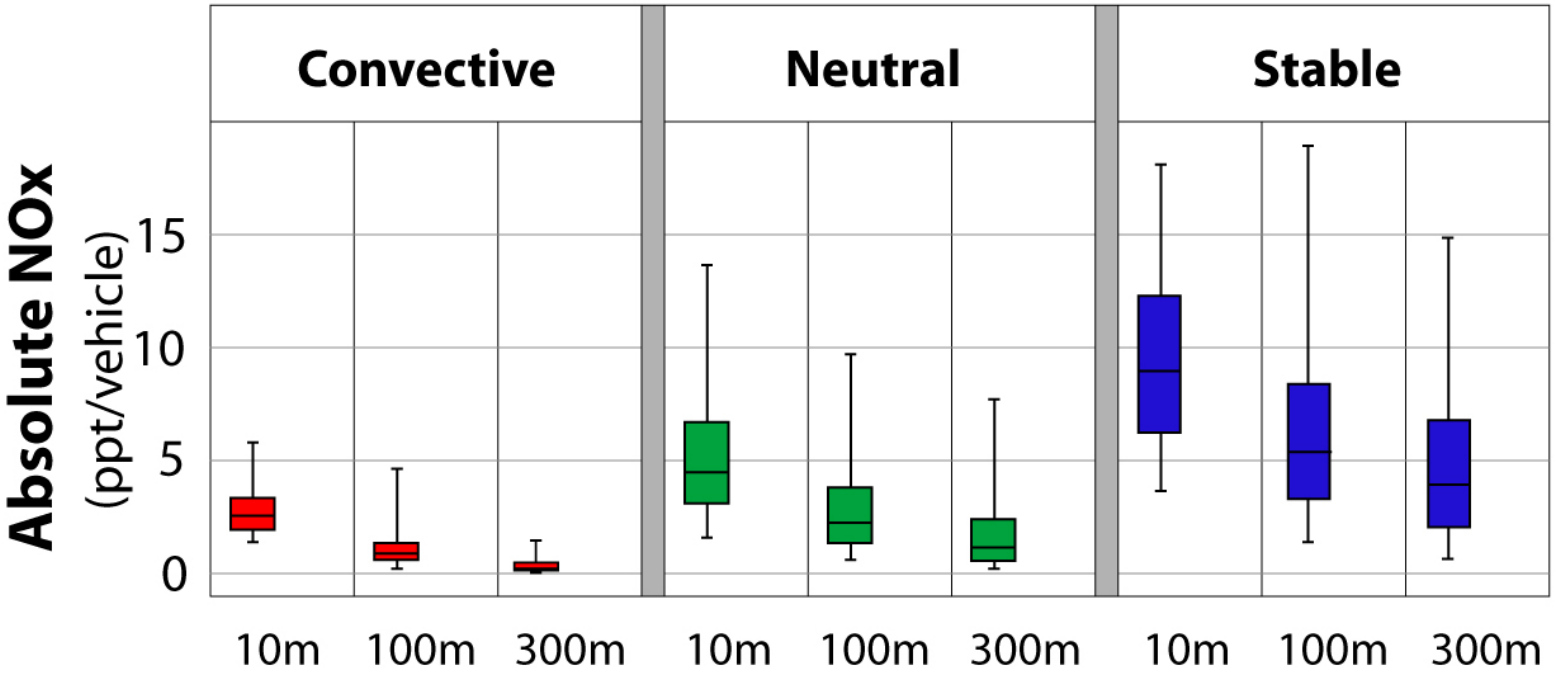


Convective: ***91 hours***	Moderately Convective: ***450 hours***	**Neutral:** ***847 hours***	Moderately Stable: ***507 hours***	**Stable:** ***396 hours***

Stability Class Characteristics



Observed Distance Decay (NOx)



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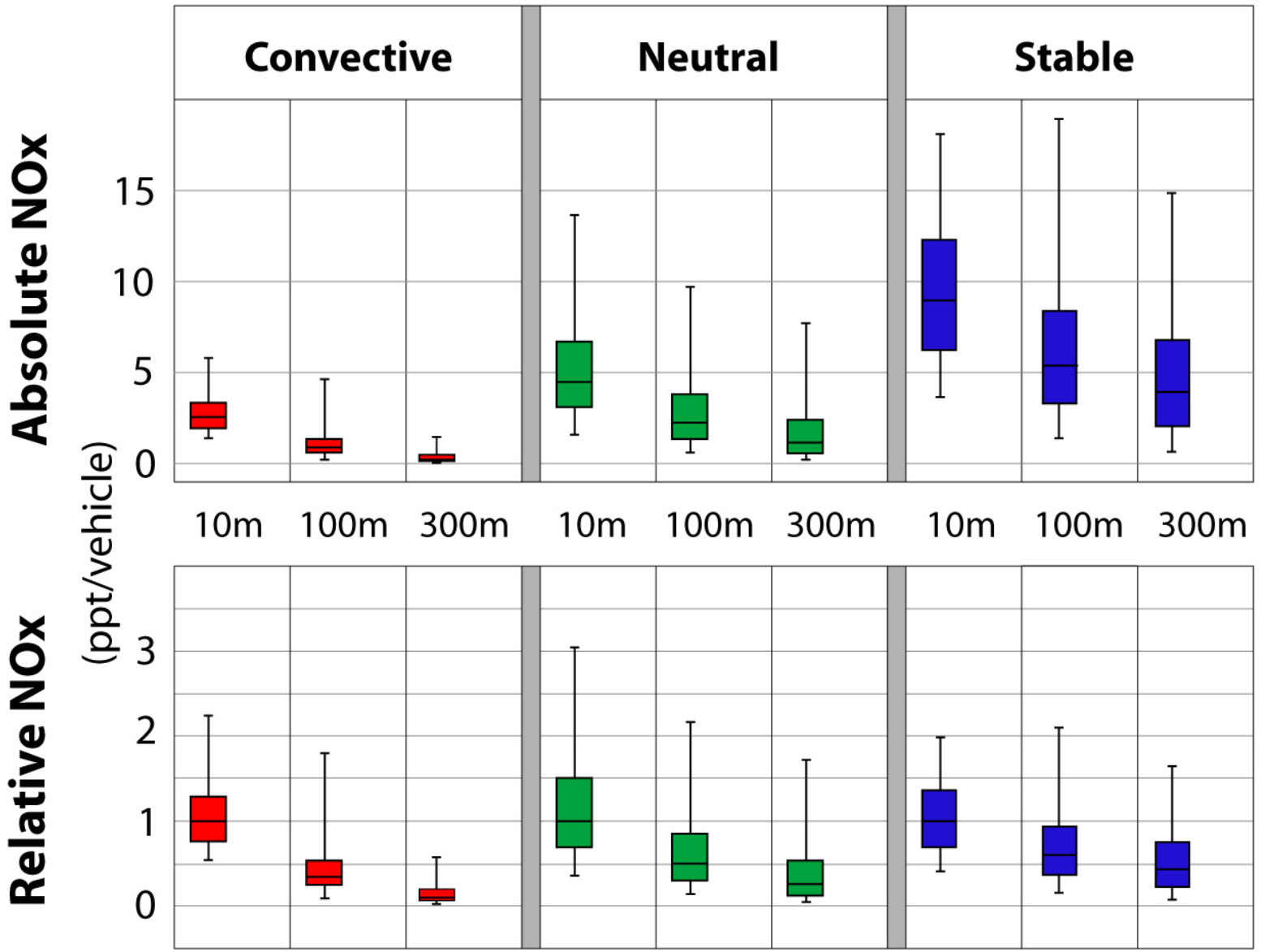

Dispersion Modelling Approach

BASIC

Model:	ADMS-Urban 3.0
Meteorology:	Sonic anemometer and airport
Traffic:	Binned distribution per stability
Emissions:	ADMS rates based on traffic

Flat terrain

OTHER

Surface roughness:	1.0m
Minimum L_{MO}:	30m
Wake height:	3.5m

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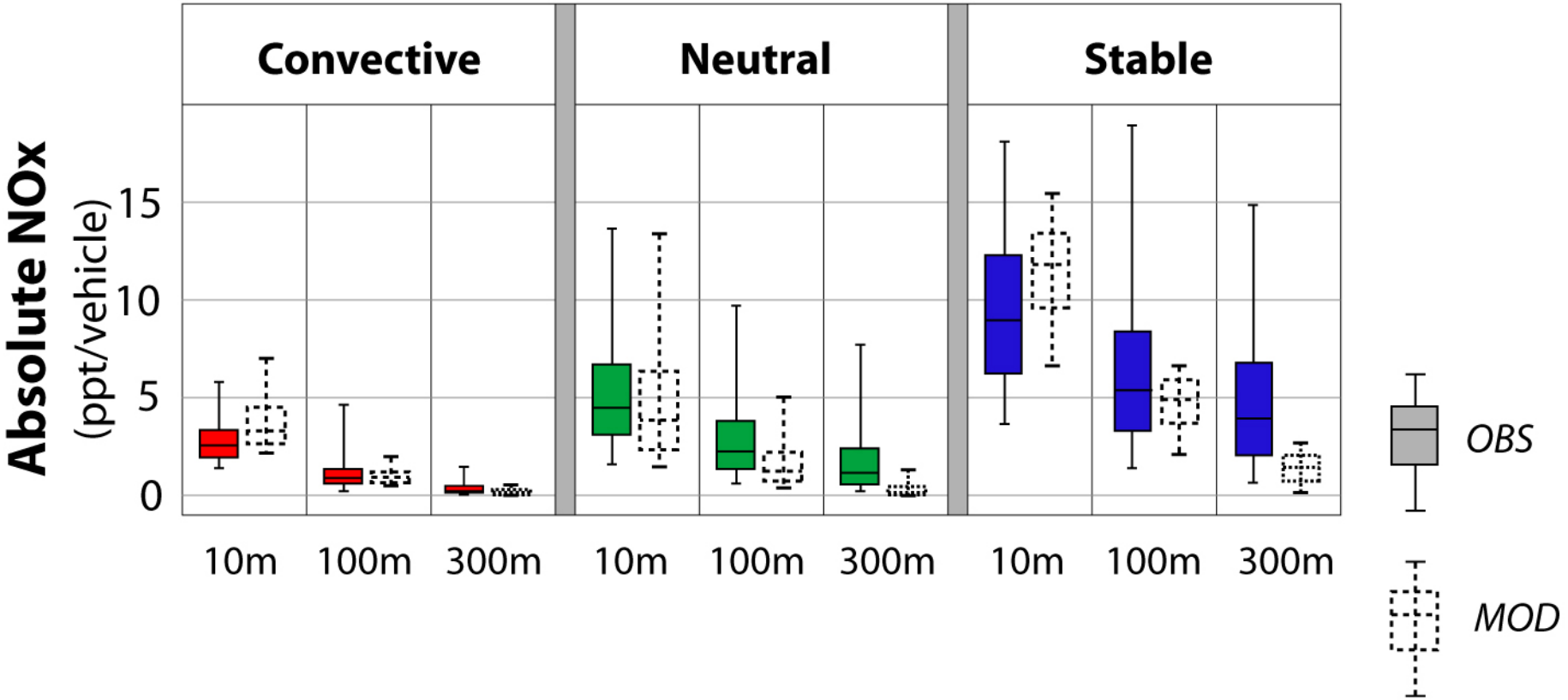
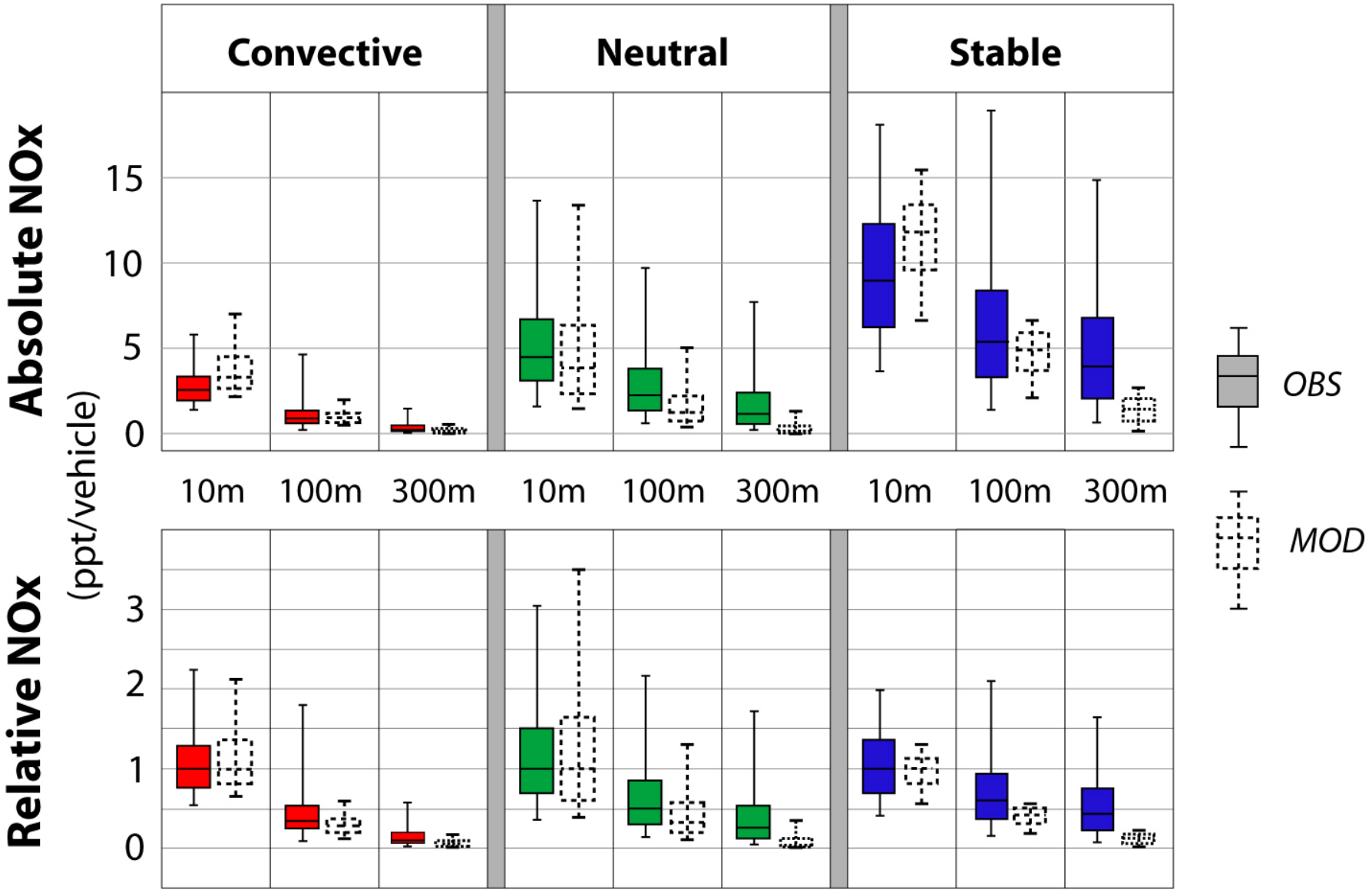
Modelled Distance Decay (NOx)

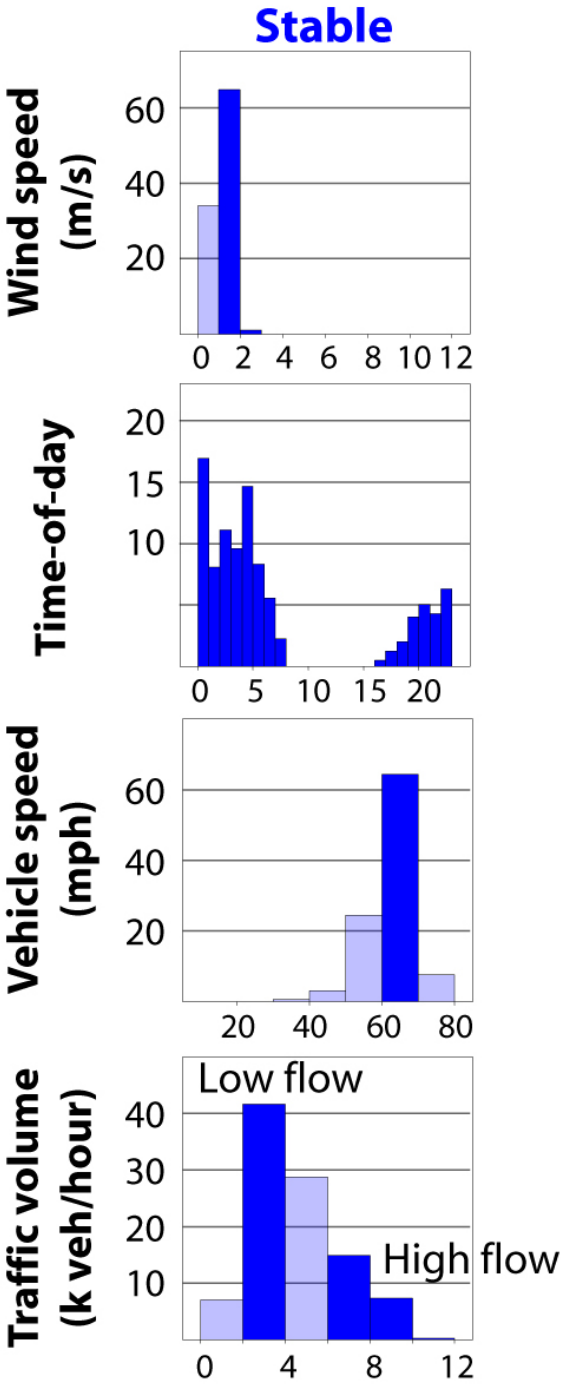


Modelled Distance Decay (NOx)



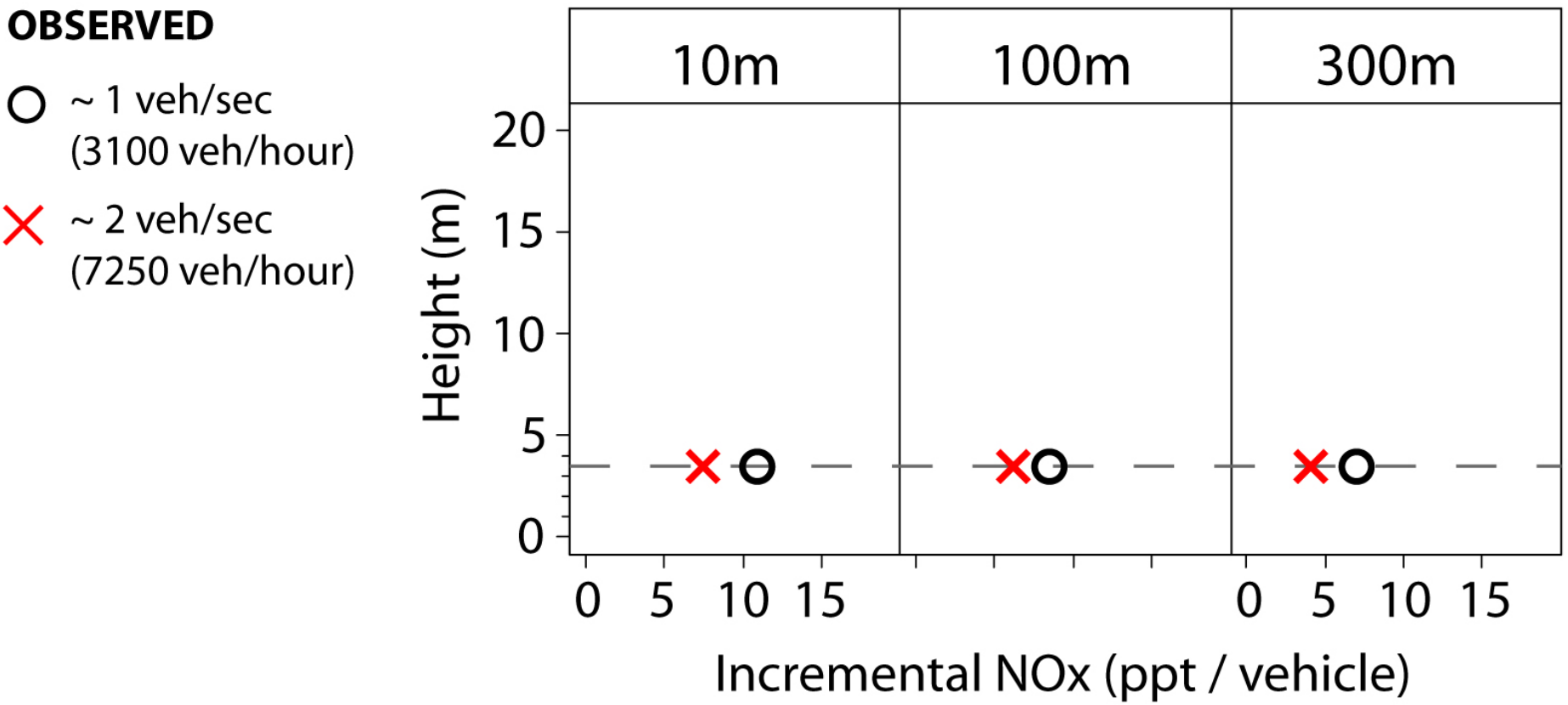
Downwind Analysis for Wake Effects

- Stable conditions
- Compare ~ 1 veh/sec vs ~ 2 veh/sec
- NOx concentrations normalised (ppt/vehicle)
- Compare observed and modelled (profile) at 10, 100 & 300m



Selected Un-selected

Observed Vehicle Wake



Modelled Vehicle Wake

OBSERVED

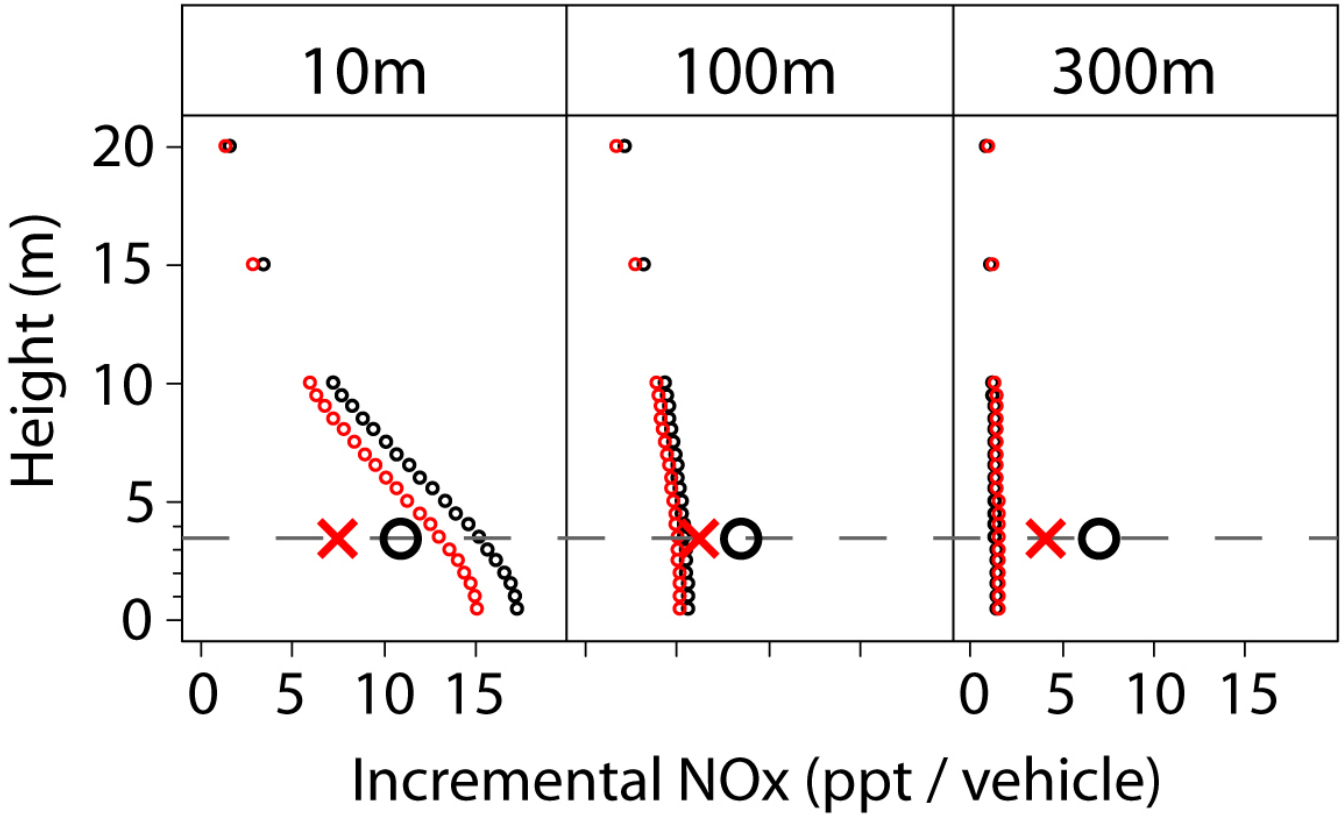
○ ~ 1 veh/sec (3100 veh/hour)

× ~ 2 veh/sec (7250 veh/hour)

MODELLED

4,000 veh/hour

10,000 veh/hour



Limitations

- Field campaign Design
  - Background levels at ‘upwind’ monitor assumed representative
  - Oblique alignment of prevailing winds relative to monitored transect
- Modelling
  - Neglect of shallow cutting
    (USEPA wind-tunnel experiment show minimal effect)
  - Simplified approach to vehicle-fleet composition

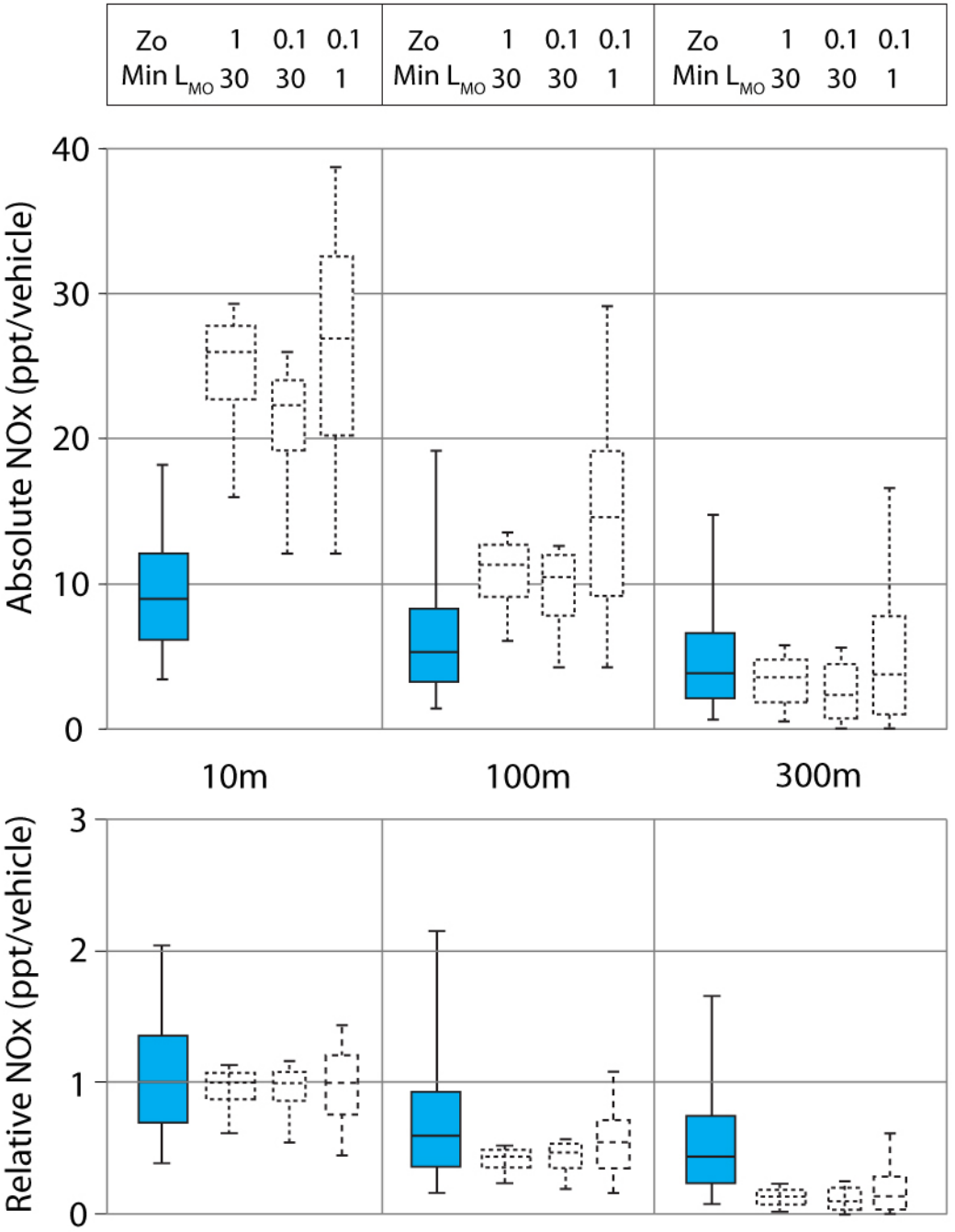
Opportunities

- Data-rich field campaign → opportunities for conditional testing of models
- Bulk tests of performance: model group vs observed group
- Only possible given large investment by USEPA

- Hourly-data analysed; 5-minute resolution data available
- Thermal-rise of vehicle plumes → non 1/u wind-speed dependence?

- Scope for wider application within modelling community...

Surface roughness & Min. L_{MO} sensitivity: Stable conditions



Upwind and Downwind NOx (200-260°)