EVALUATING THE AREA EFFECTIVELY REPRESENTED BY A METEOROLOGICAL STATION AND THE EFFECT ON AIR DISPERSION MODELLING

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INTRODUCTION

Air dispersion modelling is used to assess how an industry, roadway system or even an entire city is performing against air quality goals and regulations. One of the key inputs into a dispersion model is local meteorology for the study area. A typical model will consider five years of meteorology as well as terrain, emission parameters and surrounding buildings to predict point-of-impingement concentrations. Current practice is to use approved meteorology, often provided by a regulatory agency, from a nearby measurement site such as a local airport. While this approach maintains consistency between assessments, it sacrifices accuracy by assuming that one meteorological set is representative of a whole city or county. Given that meteorological measurement stations are typically in open areas, such as airports, this approach can ignore the urbanization and characteristics of a study area. This study aims to assess the impact of using site-specific met can have on an air dispersion model.

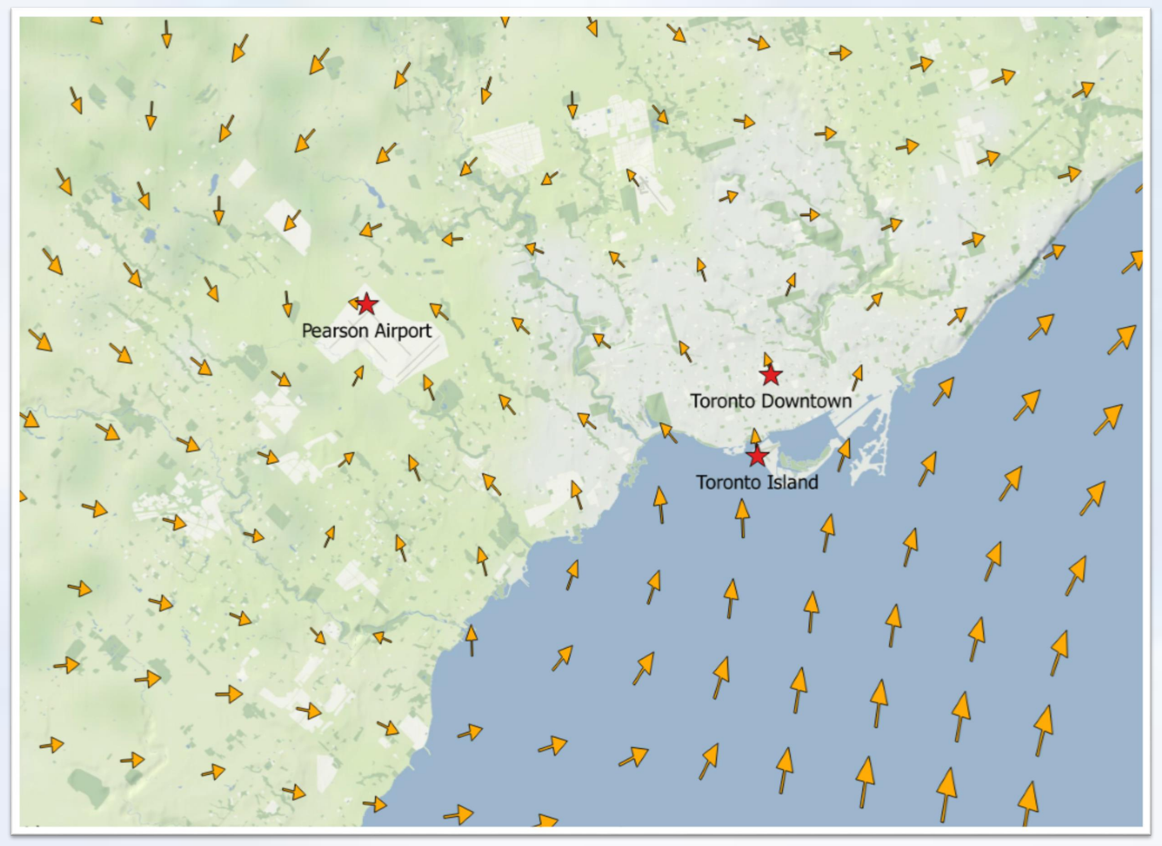


Figure 1 – Typical wind vectors for the Greater Toronto Area with modelling locations identified

MODELLING DOMAIN

Urban features such as skyscrapers can have a significant impact on local meteorology, as can natural features such as agricultural land and water. Toronto, Ontario, was chosen given the size of the city and variability in land uses. Meteorological modelling has shown that Toronto has widely varying meteorology as shown in **Figure 1**. Two locations within the city were chosen for the assessment; one downtown location in the center of the city and one location on Toronto Island which is less than a kilometer off-shore.

METEOROLOGICAL DATA

This research evaluates the effect of using regional-scale meteorological data for small-scale air dispersion assessments. As this assessment is not aimed at evaluating the WRF model, both data sets were extracted from the WRF model as opposed to using measured data for the regional set. It is worth noting that only wind speed, wind direction, and temperature were taken from the WRF model; the remaining surface parameters (i.e. cloud cover, ceiling height) were taken from measured data.

The WRF model was run using 4-km grid cells over the City of Toronto and surrounding area. The model used local measurement stations and land uses, as well as complex physics models, to develop a time-series of met conditions over the domain. The WRF model output for a one-year period (2008) at Lester B. Pearson International Airport was used to represent 'regulatory' data. WRF data was extracted for both study locations. Using the US EPA's AERMET pre-processor, the WRF-generated data was processed to reflect the two study sites and combined with upper air data from the Buffalo International Airport using AERMET. Wind roses from the WRF output from Pearson Airport and the two study areas are shown in **Figure 2**.

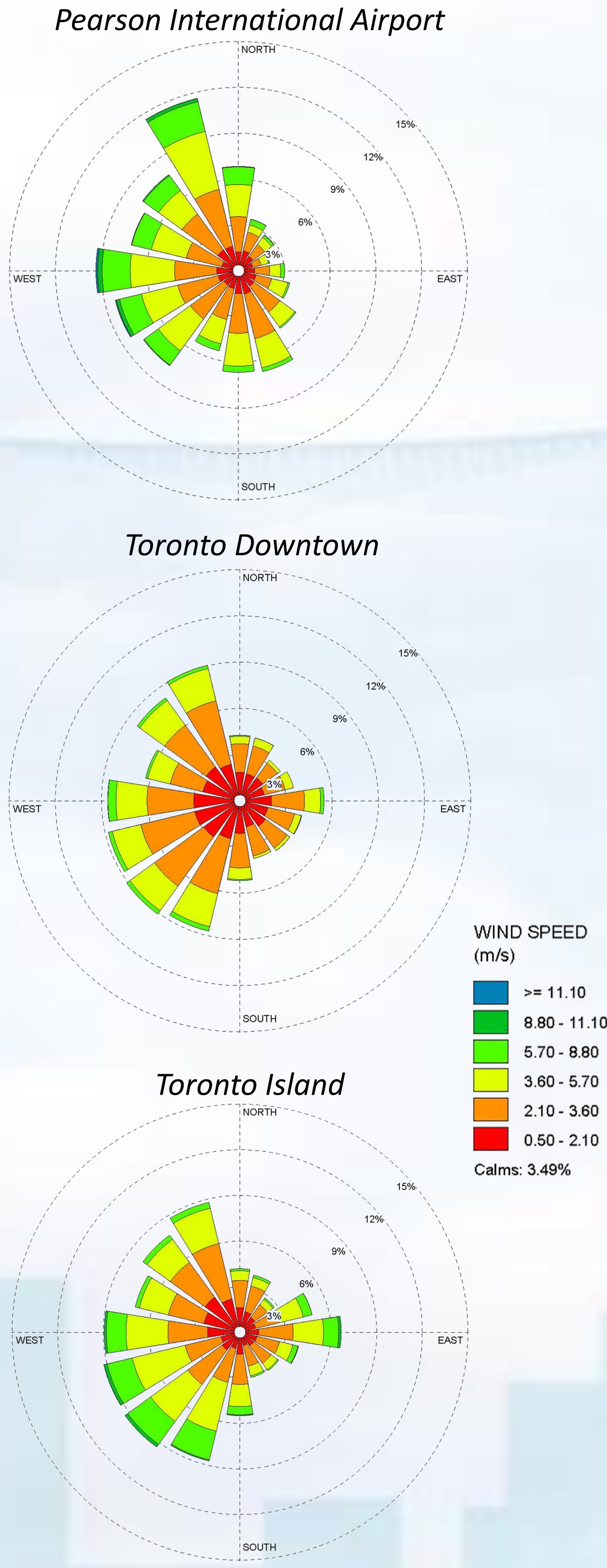
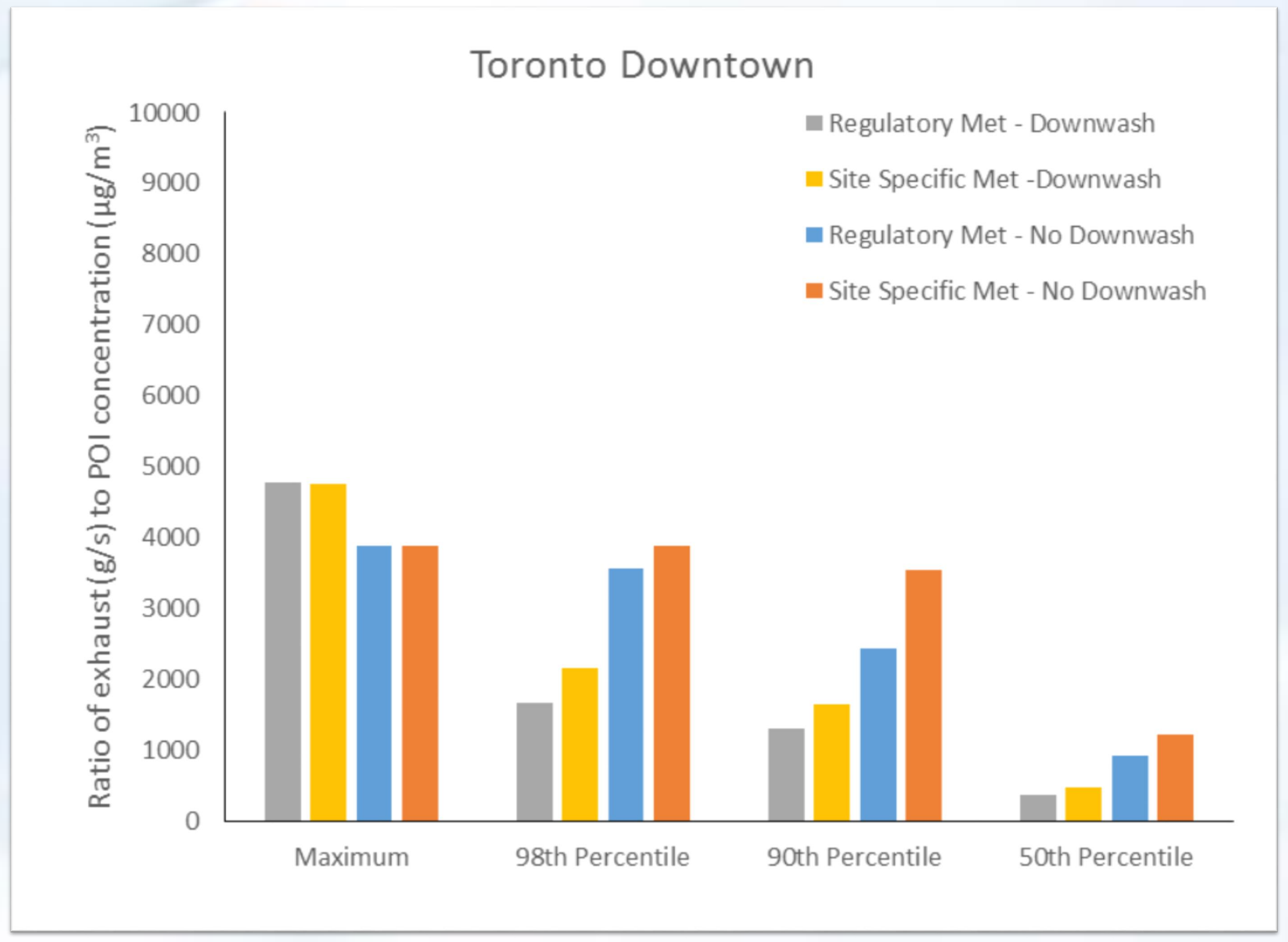


Figure 2 – Wind Roses at the Three Modelling Locations

AIR DISPERSION MODELLING

Modelling was performed using the US EPA's AERMOD model. Two scenarios were run at each location: a single stack with no downwash and a single stack on top of a building, subject to same-structure downwash. These simple scenarios were chosen to isolate the effect of meteorology. Stack parameters were chosen to represent a typical scenario: 5 m exhaust height, 10 cm diameter, 25 ft/s velocity and a 1 g/s emission rate. The model was run for a one-year period (2008) to coincide with the met data being used.



RESULTS

Toronto Downtown

Evaluating the results of the modelling at the Toronto Downtown location without building downwash, it can be seen that both sources have similar maximum values but that the percentile values have as much as a 45% difference (95th percentile).

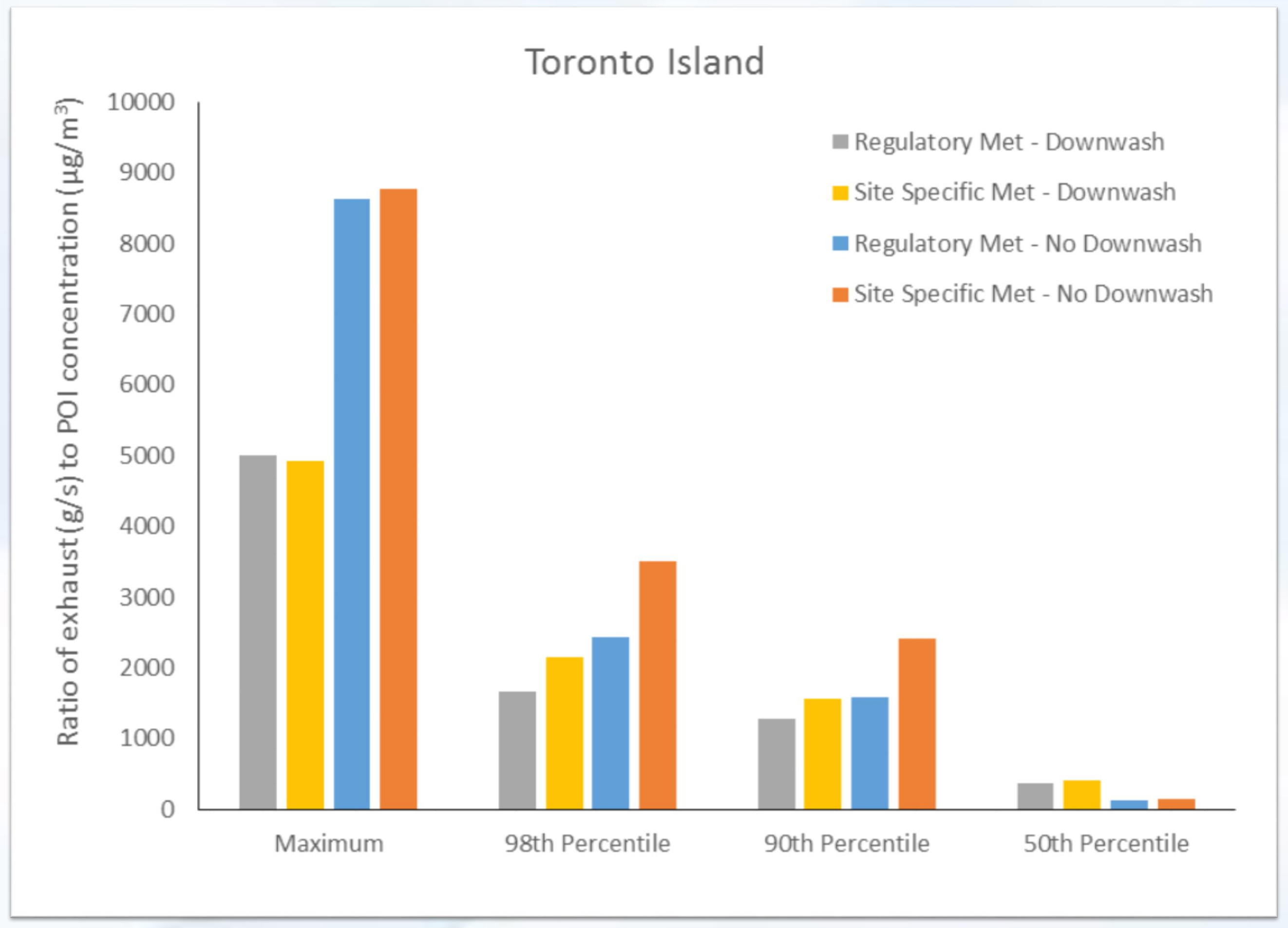
Considering downwash, it can be seen that both sources have similar maximum values but that the percentile values have as much as a 28% difference (98th percentile).

Toronto Island

Evaluating the results of the modelling at Toronto Island without building downwash, it can be seen that both sources have similar maximum values that the percentile values have as much as a 52% difference (90th percentile).

Considering downwash, it can be seen that both sources have similar maximum values that the percentile values have as much as a 29% difference (98th percentile).

Figure 3 shows the spatial variations between the two data sets with respect to maximum concentration with downwash. It can be seen that as much as a 25% change in the maximum concentrations at any particular location is expected.



DISCUSSION AND CONCLUSIONS

The air dispersion modelling results show that using site-specific meteorology can have a substantial impact. Comparing the results of models run with recommended meteorological data and WRF-generated site-specific meteorological data showed that both data sets produce similar maximum values, but differences between 95th percentile (up to 44%), 90th percentile (up to 52%) and 50th percentile (up to 31%) predicted values were seen. In addition, an analysis of the maximum concentrations showed that at any particular receptor a change of up to 25% could be expected.

Choosing appropriate meteorological data is a key factor in air dispersion modelling. The impact of using site-specific meteorology generated with the Weather Research and Forecasting (WRF) model was assessed by performing air dispersion modelling at two sites in the Toronto area with meteorology from Toronto's Pearson International Airport as well as site-specific modelled data. The results showed that there were differences as great as 52% between the modelled results from the two sources.

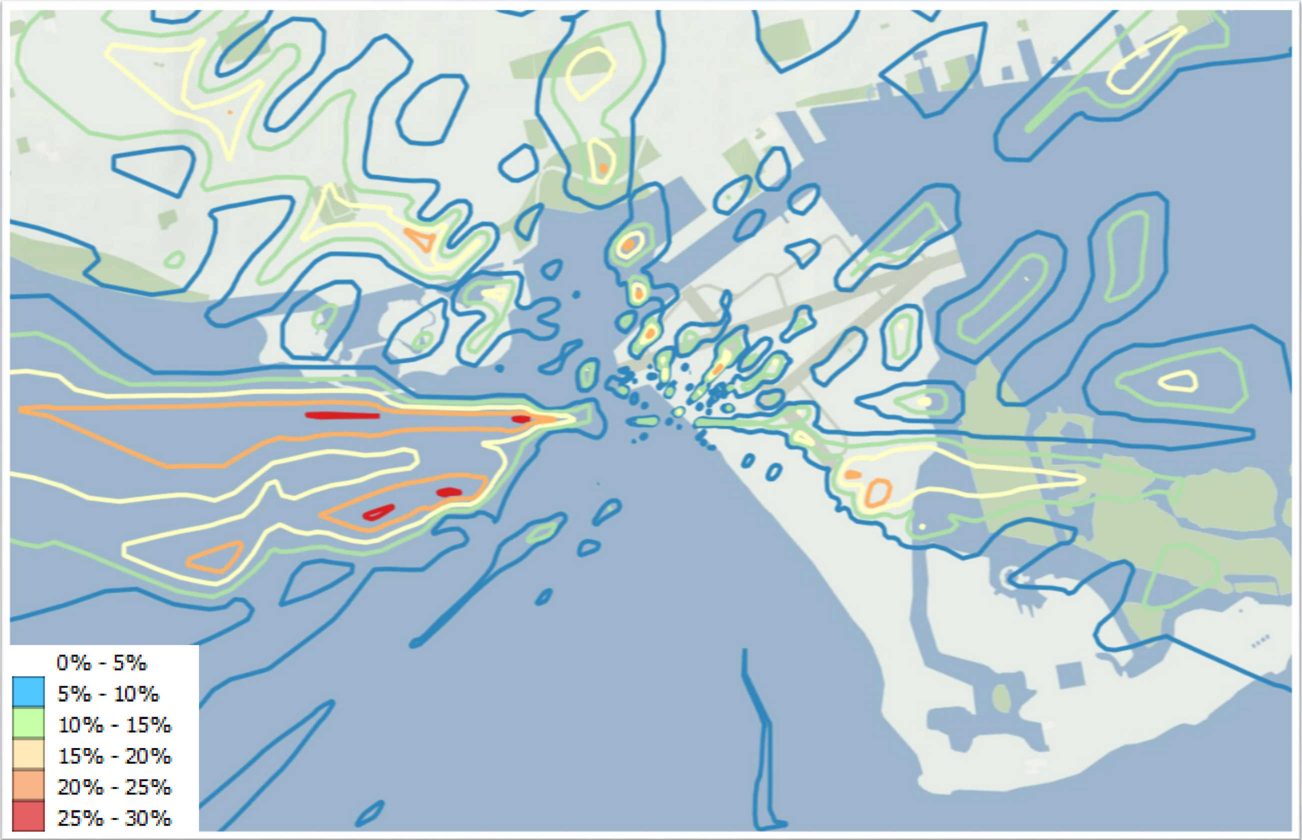


Figure 3 – Percent difference by modelling location, Island meteorology vs. Pearson meteorology

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