Monitoring Atmospheric Pollutants From Ground-based Observations

N. Danesi$^1$, M. Jain$^{23}$, Y.H. Lee$^4$ and S. Dev$^{23}$

1 School of Biology and Environmental Science, University College Dublin, Ireland
2 ADAPT SFI Research Centre, Dublin, Ireland
3 School of Computer Science, University College Dublin, Ireland
4 School of Electrical and Electronic Engineering, Nanyang Technological University (NTU), Singapore

Send correspondence to S. Dev, email soumyabrata.dev@adaptcentre.ie
| Dataset | Methodology | Results |
|---------|-------------|---------|

Table of contents

1. Dataset
2. Methodology
3. Results
Air quality monitoring and early warning systems are an important tool to help prevent populations being exposed to harmful concentrations of air pollutants [1].

Early warning systems primarily function using ‘live data’; advances in predictive modelling such as machine and deep learning offer advanced warning capabilities [2].

This position paper aimed to identify the key meteorological variables that affect air pollutant concentrations to identify their potential use in forecasting models.

In addition, this paper examines the effect of climate on meteorological relationships with air pollutants in tropical, subtropical, and arid climates.
Dataset

- The data used in the experiment was meteorological data from 17 ground monitoring stations across Queensland, Australia. [4]
- The data was time-stamped at hourly intervals throughout 2017 - 2019. [4]
- All the stations used within the experiment follow the Australian and New Zealand Standards (AS/NZS) for collecting data; however, not every station uses the same operating equipment for data measurements. [4]
# Dataset

## Parameters examined in this paper

| Meteorological variable | Air pollutant                  |
|-------------------------|--------------------------------|
| Wind speed (m/s)        | Ozone (ppm)                    |
| Air temperature (°C)    | Sulphur Dioxide (ppm)          |
| Relative Humidity (%)   | Nitrogen Dioxide (ppm)         |
| Rainfall (mm)           | PM$_{10}$ (µg/m$^3$)           |
| Barometric Pressure (hPa)| PM$_{2.5}$ (µg/m$^3$)          |
| Solar Radiation (W/m$^2$)| Visibility-reducing particles (mm$^{-1}$) |
To examine the interdependence of meteorological parameters with air pollutants, we used Pearson Correlation Coefficients in the form of a heatmap.

Data was aggregated for each of the ground monitoring stations from the period 2017 – 2019; with each site being examined independently.

Relationships between parameters were categorised by their correlation strength (strong >0.7, moderate (0.5 - 0.7) and weak (0.3 - 0.5)).
## Results

### Interdependency relationships observed at Rocklea

| Relationship       | Parameters                                                                 |
|--------------------|-----------------------------------------------------------------------------|
| **Strong relationships** | PM$_{2.5}$:PM$_{10}$  
PM$_{2.5}$:Visibility-reducing particles,  
PM$_{10}$:Visibility-reducing particles  
O$_3$: Air temperature  
O$_3$: Solar radiation |
| **Moderate relationships** | NO$_2$: Wind speed  
NO$_2$: Air temperature  
O$_3$: Wind speed  
O$_3$: Air temperature  
O$_3$: Relative Humidity |
| **Weak relationships**     | NO$_2$: Relative Humidity  
NO$_2$: Solar Radiation  
PM$_{10}$: Relative Humidity  
PM$_{10}$: Barometric Pressure |
The common findings across multiple monitoring station data were:

• Strong relationships between $O_3$ and air temperature and wind speed
• Moderate relationships between NO$_2$ and air temperature, wind speed
• Moderate relationships between relative humidity and NO$_2$, O$_3$ and PM$_{10}$

• There were limited relationships between SO$_2$ and any meteorological parameters
• Relationships between meteorological parameters and air pollutants were significantly weaker using data from tropical climate monitoring stations

Limitations:

• Data resolution was limited to hourly averages; more granular data with 5- or 15-minute recording intervals could improve the results
• While the collection methods were consistent for pollutants across sites, the recording devices differed between the ground-based weather stations.
Conclusion

- Identifying the interdependent relationships between meteorological parameters and air pollutants will allow the development of multivariate prediction models.
- Understanding the differences in interdependent relationships between different climatic zones will inform us of the differing performance between forecasting models.

Future work:

- Develop a detailed analysis of pollutant concentrations across varying climatic zones.
- Develop LSTM-based deep learning model for pollutant forecasting.
References

[1] D. Kaloni, Y. H. Lee, and S. Dev, “Impact of COVID19-induced lockdown on air quality in Ireland,” in Proc. International Geoscience and Remote Sensing Symposium (IGARSS), 2021.

[2] L. Bai, J. Wang, X. Ma, and H. Lu, “Air pollution forecasts: An overview,” International journal of environmental research and public health, vol. 15, no. 4, p. 780, 2018.

[3] A. Dean and D. Green, “Climate change, air pollution and health in Australia,” Sydney, Australia: UNSW Sydney, 2017.

[4] Queensland Government, 2020. Air Quality Monitoring data, Brisbane: Queensland Government.