Revised (*)

The Hong Kong University of Science and Technology

Department of Mathematics

MPhil THESIS EXAMINATION

Improving Regional Air Quality Forecast based on a Hybrid Deep Learning Model

By

Mr. Mingyun HU

ABSTRACT

Accurate air quality forecasting plays a vital role in providing reliable early warning information to the public. However, the predictions generated by three-dimensional (3D) chemical transportation models (CTMs), such as the widely used Community Multiscale Air Quality (CMAQ) model, often demonstrate considerable biases compared to observations. In this thesis, we propose a hybrid deep learning model, namely AirQFormer, to improve the accuracy and reliability of regional air quality forecasts over a 72-hour period. The performance of AirQ-Former was evaluated based on fine suspended particulates ($PM_{2.5}$) and ozone (O_3) observations for the year 2022 in the Greater Bay Area (GBA) of Southern China. At the temporal scale, AirQFormer demonstrated superior accuracy compared to the CMAQ model over the 72-hour forecasting period. It achieved a 60% reduction in root mean square error (RMSE) and a 54% reduction in mean absolute error (MAE) in terms of $PM_{2.5}$. Similarly, for O_3 forecasting, AirQFormer exhibited a 36% reduction in RMSE and a 38% reduction in MAE. Moreover, AirQFormer outperformed both the CMAQ model and traditional spatial bias correction methods at the spatial scale. Specifically, the RMSE of AirQFormer for $PM_{2.5}$ was 34% and 10% lower than that of the CMAQ model and traditional spatial bias correction methods, respectively. For O_3, the RMSE of AirQFormer was 25% and 5% lower than that of the CMAQ model and traditional spatial bias correction methods. Regarding extreme events forecasting, AirQFormer exhibited notable improvements compared to the CMAQ model. Specifically, the false alarm rate (FAR) of AirQFormer for $PM_{2.5}$ was 37% lower than that of the CMAQ model, indicating a more accurate identification of extreme events. Moreover, the Proportion of Correct (POC) for extreme events increased to 0.90, reflecting a higher rate of correct detection. For O_3, AirQFormer demonstrated increased hit rates (HIT) and decreased FAR, further enhancing the forecasting of extreme events. These results demonstrate the effectiveness of our proposed model in improving air quality prediction.

Date : 4 August 2023, Friday

Time : 9:00 a.m. *

Venue : Room 4472 (Lifts 25/26)

Thesis Examination Committee

Chairman	:	**Prof. Jianfeng CAI, MATH /HKUST**
Thesis Supervisor	:	**Prof. Jimmy Chi Hung FUNG, MATH/HKUST**
Member	:	**Prof. Xinzhou GUO, MATH/HKUST**

(Open to all faculty and students)

The student's thesis is now being displayed on the reception counter in the General Administration Office (Room 3461).