2・ 項目簡介

(項目所屬科學技術領域、主要技術內容、授權專利情況、技術經濟指標及應用推廣情況) The recent rapid growth of the Macao SAR and the Pearl River Delta that Macao sits within has imposed stresses on the atmospheric environment as well as the wellbeing of the residents of Macao. The increase of public awareness and concern on the ambient air quality propels the research and development on air-quality modeling and forecasting in Macao. The research group started their works in 1997. The project can be divided into three phases, in which different set goals were achieved by developing and applying various scientific methods and technological skills. The three phases are (i) Development of a User Friendly Air-Quality Management and Forecasting System with Artificial Neural Network, (ii) Understanding the Fundamental Air-Quality Meteorology of Macao, (iii) Improvement of the Air-Quality Prediction Techniques by Efficiency-Robustness Tradeoff Adaptive Modeling.

(i) Development of a User Friendly Air-Quality Management and Forecasting System with Artificial Neural Network: In the beginning of the project in late 1997, it was learned that the Macao Meteorological and Geophysical Bureau (SMG) was setting up continuous ambient air concentration monitoring stations to accurately and effectively record the air quality and planned to launch an air-quality-index (AQI) release scheme for public announcement in 1999. SMG also planned to release one-day-ahead AQI forecast two years later in 2001. Therefore, it was identified that the development of a computationally economical and intelligent short-term air-quality-forecasting system would meet the immediate needs of Macao. Artificial neural networks (ANN) or sometimes called multilayer perceptron was considered as a modern approach for air quality modeling applications at that time. A pilot study in testing the applicability of ANN in air quality forecasting for Macao was then launched with great success. The success led to an international EUREKA project INTELAIR (E! 1920) - Hybrid System for Urban Air Pollution Management: Artificial Intelligent and Classical Modeling. The research group at the University of Macau was in charge of developing the "INTELAIR Neural Component" that could forecast future air quality with ANN based on historical information. The "INTELAIR Neural Component" was a Windows based user-friendly efficient system that can be run on personal computers. The software was officially released in 2001. It was adopted by the Macao Meteorological and Geophysical Bureau officially in the same year for their usage in releasing the daily forecasting AQI. The success of the developed software satisfied the immediate needs of Macao then.

(ii) Study on the Fundamental Air-Quality Meteorology of Macao: The modeling and forecasting of future air concentration of Macao at that time were based on the time history of its measurements. Two questions were raised: How would other factors such as the meteorological conditions influence the air quality of Macao? Could their influencing behaviors be explicitly expressed so that better modeling and forecasting models can be formulated? These questions led to one answer. The fundamental air quality meteorology of Macao must be understood first. After identifying that particulate matters were the main pollutants in Macao, the research group investigated the relation of PM10 with meteorological parameters through analyzing the data officially recorded by SMG. It was found that the different wind blowing directions associated with the Asian monsoon climates have strong relation with the PM10 concentration in a year as they dictate the type of

air masses (whether particle enriched or not) being brought to Macao. In addition, the rainfall volume and frequency were found important in affecting the air quality as well. The air quality of Macao was found influenced by both local and regional factors. One of the major local sources affecting the air quality, especially on street level, is the increasing busy land traffic in Macao. To understand the detailed spatial distribution of air quality within the complex urban street network of Macao, the research group of the University of Macau teamed up with the Meteorological and Geophysical Bureau, and the Environmental Protection Bureau in 2009 to carry out a pilot study to monitor the air quality in Macao for seven consecutive days using a world-class mobile in-situ platform. Analysis of the results indicates that both traffic and regional meteorological conditions would impose effects on the air quality level of the whole area. This set of benchmark data is proved to be valuable for further analysis leading to researches and applications of different aspects.

(iii) Improvement of the Air-Quality Prediction Techniques by Efficiency-Robustness Tradeoff Adaptive Modeling: Understanding that the meteorological conditions have strong effects on the local air quality, building models that explicitly include these influencing factors would improve the performance greatly. Meanwhile, the research group also realized that the previous ANN forecasting model or other contemporary statistical prediction models of China were operated in an offline manner. These models could not automatically adapt to the changing air quality environment, which is usually the case for many rapidly developing cities of our nation. Therefore, offline models are expected to underperform if not retrained regularly. To tackle with these issues, the research team developed an explicit time-varying autoregressive model (TVAREX) with exogenous inputs of the pollutant past history as well as the influencing meteorological parameters identified in the previous phase. With the Kalman filter embedded as the model learning scheme, the TVAREX can change its model coefficients automatically according to the new measurement of PM10 concentration. Apart from this new application, two fundamental contributions were made during the model development. First, a Bayesian noise parameter selection scheme was proposed for properly assigning the uncertain noise parameters of Kalman filter, which could affect the adaptive model performance with incorrect assumptions. Secondly, the adaptive Bayesian model class selection technique was proposed to select an efficient and robust dynamic statistical model from the proposed candidates. To show the adaptive capability of the proposed TVAREX, it was compared against the offline ANN model with the same input variables. It was found that the TVAREX outperformed the offline ANN model especially under the episode days that public concern. With this comparison, it was more confident that the underperformance of the original ANN model should be due to the changed environment. Therefore, the research team solved this problem by proposing the time-varying MLP with adaptive network weights and biases. Application of the TVMLP to model the daily PM10 concentrations showed statistically significant improvement over the MLP counterpart. Meanwhile, the adaptive learning scheme could address the uncertainty of the prediction so that confidence intervals could be provided. In conclusion, these finding have propelled and widen the use of adaptive air quality model in China and even worldwide.

The project has trained/under training 1 Postdoctoral Fellow, 1 Ph.D, 4 M.Sc and 10 B.Sc students, led to a total of 12 international journal publications (11 SCI or SCIE-indexed) and 26 conference paper publications

(18 international), and one professional software released (officially adopted by SMG). A total of 6 awards in conferences and competitions (1 international, 1 national, 2 regional and 2 university) were won by students trained by this project. Principal investigator of the project was awarded a Research Award and an Academic Award from the University of Macau; and a Mobility Scholarship from the JEMES CiSu Consortium, Erasmus Mundus, European Union to give 6 hours of lecture on the air quality study of this project at the University of Aveiro, Portugal in March of 2013.