PERFORMANCE COMPARISON OF HAZE PREDICTION USING CHAOS THEORY AND MULTIPLE LINEAR REGRESSION
(Perbandingan Prestasi Peramalan Jerebu Menggunakan Teori Kalut dan Regresi Linear Berganda)

HAZLINA DARMAN* & NOR ZILA ABD HAMID

ABSTRACT

Forecasting haze is essential for protecting the environment, the economy, and public health. It assists authorities in taking preventative action to lessen the adverse effects of haze episodes and boost community resistance to air pollution. The goal of this study was to create a model for haze prediction by using two methods, multiple linear regression and chaos theory. In this study, chaos theory forecasts haze using univariate time series which is PM_{10}, whereas multiple linear regression (MLR) utilizes multivariate time series for its predictions, namely ambient temperature, wind speed, ozone, nitrogen dioxide, carbon monoxide, and sulphur dioxide. Data for this study will be collected during the southwest monsoon from an industrial area in Klang, Selangor. The results of these two models will be compared to determine which model gave better performance. With these predictive models, policymakers and relevant authorities can receive timely alerts, allowing them to implement preventive measures that can reduce the impact of haze on public health and the environment.

Keywords: haze forecasting; chaos theory; multiple linear regression; sustainability development goals

ABSTRAK

Peramalan jerebu adalah penting untuk alam sekitar, ekonomi, dan kesihatan manusia,. Ia dapat membantu pihak berkuasa untuk mengambil langkah proaktif dalam mengurangkan kesan negatif kejadian jerebu dan meningkatkan daya tahan masyarakat terhadap kesan pencemaran udara. Kajian ini bertujuan membangunkan model peramalan jerebu menggunakan dua kaedah, iaitu regresi linear berganda dan teori kalut. Dalam kajian ini, teori kalut menggunakan univariat siri masa PM_{10} manakala regresi linear berganda menggunakan beberapa pemboleh ubah bebas untuk peramalan jerebu seperti: suhu atmosfera, kelajuan angin, ozon, nitrogen doksida, karbon monoksida, dan sulfur dioksida. Dalam kajian ini, data akan diambil dari kawasan perindustrian Klang, Selangor semasa musim Monsun Barat Daya. Prestasi kedua-dua model ini akan dibandingkan untuk menentukan model yang memberikan peramalan yang lebih baik. Dengan menggunakan model peramalan ini, pihak berkuasa penggubal dasar dan pihak berkuasa yang berkaitan boleh menerima makluman tepat pada masanya, membolehkan mereka melaksanakan langkah pencegahan yang boleh mengurangkan kesan jerebu terhadap kesihatan awam dan alam sekitar.

Kata kunci: teori kalut; peramalan jerebu; regresi linear berganda; matlamat pembangunan mampan

References

Abd Hamid N.Z. 2020. Prediction of PM_{10} time series at industrial area through an improved local linear approximation method. *ASM Science Journal* **13**: 1-7.
Abd Hamid N.Z. & Md Noorani M.S. 2014. Suatu kajian perintis menggunakan pendekatan kalut bagi pengesanan sifat dan peramalan siri masa kepekatan PM10. *Sains Malaysiana* **43**(3): 475-481.
Abdullah S., Ismail M. & Fong S.Y. 2017. Multiple linear regression (MLR) models for long term PM10 concentration forecasting during different monsoon seasons. *Journal of Sustainability Science and Management* **12**(1): 60–69.

Abdullah S., Napi N.N.L.M., Ahmed A.N., Mansor W.N.W., Mansor A.A., Ismail M., Abdullah A.M. & Ramly Z.T.A. 2020. Development of multiple linear regression for particulate matter (PM_{10}) forecasting during episodic transboundary haze event in Malaysia. *Atmosphere* **11**(3): 289.

Cao L. 1997. Practical method for determining the minimum embedding dimension of a scalar time series. *Physica D: Nonlinear Phenomena* **110**(1–2): 43–50.

Chen J. & Wang J. 2019. Prediction of PM2.5 concentration based on multiple linear regression. *2019 International Conference on Smart Grid and Electrical Automation (ICSGEA)*, pp. 457–460.

Cheong K.H., Ngiam N.J., Morgan G.G., Pek P.P., Tan B.Y.-Q., Lai J.W., Koh J.M., Ong M.E.H. & Ho A.F.W. 2019. Acute health impacts of the Southeast Asian transboundary haze problem—A review. *International Journal of Environmental Research and Public Health* **16**(18): 3286.

Darman H. & Abd Hamid N.Z. 2024. Predicting haze phenomenon using chaos theory in industrial area in Malaysia. *Journal of Quality Measurement and Analysis* **20**(1): 159-169.

Department of Environment. 2019. *Annual Environmental Quality Report 2019*.

Fraser A.M. & Swinney H.L. 1986. Independent coordinates for strange attractors from mutual information. *Physical Review A* **33**(2): 1134–1140.

Hasmarullzakim A.M. & Abdullah A. 2018. Haze pattern prediction using deep learning. *UTM Computing Proceedings* **3**.

Idris A.C. & Yassin H. 2021. Deep learning method for haze prediction in Singapore. *2021 IEEE Asia-Pacific Conference on Computer Science and Data Engineering (CSDE)*, pp. 1–6.

Dewan Negeri Selangor. 2016. Kawasan perindustrian di Selangor. https://dewan.selangor.gov.my/question/kawasan-perindustrian-di-selangor/ (1 July 2023).

Ministry of Health Malaysia. 2020. *Pelan Tindakan Pengurusan Kesihatan Akibat Jerebu*.

Latif M.T., Othman M. & Kamin K.H. 2017. *Fenomena Jerebu di Asia Tenggara: Punca dan penyelesaian*. UKM Bangi, Selangor: Insitute for Environment and Development (LESTARI).

Latif M.T., Othman M., Idris N., Juneng L., Abdullah A.M., Hamzah W.P., Khan M.F., Nik Sulaiman N.M., Jewaratnam J., Aghamohammadi N., Sahani M., Xiang C.J., Ahamad F., Amil N., Darus M., Varkkey H., Tangang F. & Jaafar A.B. 2018. Impact of regional haze towards air quality in Malaysia: A review. *Atmospheric Environment* **177**: 28–44.

Li W., Liu X., Zhang Y., Tan Q., Feng M., Song M., Hui L., Qu Y., An J. & Gao H. 2019. Insights into the phenomenon of an explosive growth and sharp decline in haze: A case study in Beijing. *Journal of Environmental Sciences* **84**: 122–132.

Liu X., Liu Q., Zou Y. & Liu Q. 2019. A LSTM-based approach to haze prediction using a self-organizing single hidden layer scheme. In Yang C.N., Peng S.L. & Jain L. (eds.). *Security with Intelligent Computing and Big-data Services. SICBS 2018. Advances in Intelligent Systems and Computing, vol 895.* Cham: Springer.

Pinghua Z. 2018. Empirical study on haze forecasting model based on neural network. *IOP Conference Series: Materials Science and Engineering* **439**: 032073.

Pino-Vallejo M., Tierra A., Haro A. & Perugachi N. 2018. Prediction of concentrations of PM2.5 in Downtown Quito using the chaos theory. *AIP Conference Proceedings* **2003**: 020013.

Quah E., Chia W.-M. & Tan T.-S. 2021. Economic impact of 2015 transboundary haze on Singapore. *Journal of Asian Economics* **75**: 101329.

Shang K., Chen Z., Liu Z., Song L., Zheng W., Yang B., Liu S. & Yin L. 2021. Haze prediction model using deep recurrent neural network. *Atmosphere* **12**(12): 1625.

Sivakumar B. 2002. A phase-space reconstruction approach to prediction of suspended sediment concentration in rivers. *Journal of Hydrology* **258**(1–4): 149–162.

Soleiman A., Othman M., Samah A.A., Sulaiman N.M. & Radojevic M. 2003. The Occurrence of Haze in Malaysia: A Case Study in an Urban Industrial Area. In Rao G.V., Raman S. & Singh, M.P. (eds.). *Air Quality*, pp. 221-238. Birkhäuser, Basel: Pageoph Topical Volumes.

Talhelm T. 2024. *Particle Air Pollution: PM10 vs PM2.5.* https://smartairfilters.com/en/blog/pm10-pm2-5-difference-particle-air-pollution/ (15 April 2024).

Ul-Saufie A.Z., Yahaya A.S., Ramli N. & Hamid H.A. 2012. Performance of multiple linear regression model for long-term PM10 concentration prediction based on gaseous and meteorological parameters. *Journal of Applied Sciences* **12**(14): 1488–1494.

Varkkey H. & Copeland A. 2020. Exchanging health for economic growth? Haze in the context of public health and political economy in Malaysia. *Journal of Social Health* **3**(1): 1-13.

Wu X., Liu Z., Yin L., Zheng W., Song L., Tian J., Yang B. & Liu S. 2021. A haze prediction model in Chengdu based on LSTM. *Atmosphere* **12**(11): 1479.

Zhang Z., Tian J., Huang W., Yin L., Zheng W. & Liu S. 2021. A Haze prediction method based on one-dimensional convolutional neural network. *Atmosphere* **12**(10): 1327.

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Department of Mathematics,
Faculty of Science and Mathematics,
Universiti Pendidikan Sultan Idris
35900, Tanjung Malim, Perak DR, MALAYSIA
E-mail: hazlinadarman@gmail.com[*], nor.zila@fsmt.upsi.edu.my

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[*]Corresponding author