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KAJIAN RINTIS PERAMALAN SIRI MASA SO_2 MELALUI PENDEKATAN KALUT DI KAWASAN BANDAR

(Pilot Study for Forescasting SO_2 Time Series Through Chaotic Approach in Urban Area)

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ABSTRAK

Pencemaran udara adalah suatu krisis yang boleh membahayakan jika terdedah kepadanya dalam kepekatan yang tinggi. Terdedah kepada bahan pencemar boleh memberikan kesan kepada manusia dan juga alam sekitar. Kajian rintis ini dijalankan untuk mengesan dinamik kalut pada siri masa SO_2, dan menggunakan kaedah yang ditambah baik untuk memilih parameter *k*. Data siri masa SO_2 dalam kajian ini telah dicerap di Shah Alam pada bulan Oktober 2017. Pengesanan dinamik kalut dalam siri masa SO_2 berjaya dikesan melalui kaedah plot ruang fasa dan kaedah Cao. Penentuan tiga parameter τ, m dan k dilakukan sebelum proses peramalan. Nilai τ dan m melalui penetapan $\tau = 1$ dan kaedah Cao. Nilai k ditentukan dengan kaedah plot graf k melawan pekali korelasi (pk). Nilai k yang menghasilkan nilai pk yang maksimum akan direkodkan. Proses peramalan dilakukan dengan menggunakan tiga kaedah, iaitu Kaedah Penghampiran Purata Setempat (KPPS), Kaedah Penghampiran Linear Setempat (KPLS) dan Kaedah Penghampiran Linear Setempat Ditambah Baik (KPLSD). Peramalan menggunakan KPLSD menunjukkan prestasi peramalan yang terbaik dengan gabungan parameter $\tau = 1,\ m = 6$ dan $k = 18$ yang menghasilkan $pk = 0.7831$. Ini menunjukkan peramalan ke atas siri masa SO_2 boleh dilakukan menggunakan pendekatan kalut. Penambahbaikan ke atas penentuan nilai k juga boleh meningkatkan prestasi model peramalan ke atas siri masa SO_2 di Malaysia.

Kata kunci: SO_2; dinamik kalut; plot ruang fasa

ABSTRACT

Air pollution is a crisis that can become harmful if exposure is at high concentrations. Exposure to pollutants can affect humans as well as the environment. This pilot study was conducted to detect chaotic dynamics in the SO_2 time series, and to apply the improved method in selecting parameter *k*. The SO_2 time series data was observed in Shah Alam in October 2017. The chaotic dynamics of the SO_2 time series was successfully detected by the phase space plot method and the Cao method. Determination of three parameters τ, m dan k is done before proceeding with the forecasting process. For parameters τ and m, both are determined by setting $\tau = 1$ and Cao method. The value of k is determined by the method of plotting k against correlation coefficient (cc) graphs. The value of k that produce the maximum value of cc is recorded. The forecasting process is done using three methods, namely Local Mean Approximation Method (LMAM), Local Linear Approximation Method (LLAM) and improved Local Linear Approximation Method (ILLAM). ILLAM produces the best forecasting value with a combination of the resulting parameters $\tau = 1,\ m = 6$ and $k = 18$ with the performance of the model is $cc = 0.7831$. This shows that forecasting of the SO_2 time series can be done using a chaotic approach. Improvements in determining the value of k can also improve the forecasting model's performance of the SO_2 time series in Malaysia.

Keywords: SO_2; chaotic dynamics; phase space plot

Rujukan

Abarbanel H. D. I. 1996. *Analysis of Observed Chaotic Data*. New York: Springer-Verlag.

Adenan N.H. & Noorani M.S.M. 2013. River flow prediction using nonlinear prediction method. *International Journal of Mathematical and Computational Sciences* **7**(11): 1589-1592.

Adenan N.H. & Noorani M.S.M. 2015. Peramalan data siri masa aliran sungai di dataran banjir dengan menggunakan pendekatan kalut. *Sains Malaysiana* **44**(3): 463-471.

Adenan N.H. & Noorani M.S.M. 2016. Multiple time-scales nonlinear prediction of river flow using chaos approach. *Jurnal Teknologi* **78**(7): 1-7.

Ali N.M. & Hamid N.Z.A. 2019. Chaotic Analysis for Malaysia west coast sea level: A case study of Kukup, Johor. In *IOP Conferences Series: Earth and Environmental Science* **286**.

Bahari M. & Hamid N.Z.A. 2019. Analysis and prediction of temperature time series using chaotic approach. In *IOP Conferences Series: Earth and Environmental Science* **286.**

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.

Casdagli M. 1991. Chaos and deterministics versus stochastic non-linear modelling. *Santa Fe Institute* **54(**2), 303-328.

Chen T.-M., Kuschner W. G., Gokhale J., & Shofer S. 2007. Outdoor air pollution: Nitrogen Dioxide, Sulfur Dioxide and Carbon Monoxide health effects. *The American Journal of the Medical Sciences* **333**(4): 249–256.

Fraser A.M. & Swiney H.L. 1986. Independent coordinates for strange attractors from mutual information. *Phys Rev A* **33**(2): 1134-1140.

Grant W.M. & Thomas C. C. 1987. Toxicology of the eye. *Journal of Toxicology: Cutaneous and Ocular Toxicology* **6**(2): 155-156.

Grzesiak P., Schroeder G. & Hopke W. 1997. Degradation of the natural environment resulting from the presence of sulphur compounds in the atmosphere. *Polish Journal of Environmental Studies* **6**(4): 45-48.

Hamid N.Z.A. & Noorani M.S.M. 2013. An improved prediction model of ozone concentration time series based on chaotic approach. *International Journal of Mathematical and Computational Sciences* **7**(11): 1593-1598.

Hamid N.Z.A. & Noorani M.S.M. 2014. Suatu Kajian Perintis Menggunakan Pendekatan Kalut Bagi Pengesanan Sifat dan Peramalan Siri Masa Kepekatan PM_{10}. *Sains Malaysiana* **43**(3): 475-481.

Hamid N.Z.A. & Noorani M.S.M. 2017 Aplikasi model baharu penambahbaikan pendekatan kalut ke atas peramalan siri masa kepekatan ozon. *Sains Malaysiana* **46**(8): 1333-1339.

Hamid N.Z.A., Noorani M.S.M, Juneng L. & Latif M.T. 2013. Prediction of ozone concentration using nonlinear prediction method. In *Proceedings of the 20th National Symposium on Mathematical Sciences* **1522**: 125-131.

Hamid N.Z.A., Noorani M.S.M. & Adenan N.H. 2017. Chaotic analysis and short-term prediction of ozone pollution in Malaysian urban area. *Journal of Physics: Conference Series* **890**.

Hamid N.Z.A. 2018. Application of Chaotic Approach in Forecasting Highland's Temperature Time Series. *IOP Conference Series Earth and Environmental Science* **169**(1): 1-9.

Idris N.A. & Mahmud M. 2017. Kajian jejak karbon di Kuala Lumpur. *Journal of Social Sciences and Humanities* **12**(2): 165-182.

Jabatan Statistik Malaysia. 2010. Largest cities and municipalities in Malaysia. https://web.archive.org/web/20150205090002/http://www.statistics.gov.my/portal/download_Population/files/population/03ringkasan_kawasan_PBT_Jadual1.pdf (20 Disember 2019).

Jabatan Alam Sekitar Malaysia. 2013. Standard Baru Kualiti Udara Ambien Malaysia. https://www.dosm.gov.my/v1/index.php?r=column/cthemeByCat&cat=162&bul_id=QXp4UnZmekFnVGNINy9GemxBWWZTZz09&menu_id=NWVEZGhEVlNMeitaMHNzK2htRU05dz09 (20 Disember 2019).

Jabatan Statistik Malaysia. 2018. Prestasi ekonomi negeri Tahun 2017. https://www.dosm.gov.my/v1/index.php?r=column/pdfPrev&id=TzY5SmhiS2p2KzZxNm9vR3hQdWFqdz09 (20 Disember 2019).

Jayawardena A.W. 1997. Runoff forecasting using a local approximation method. *IAHS* **239**: 167-171.

Mashuri A., Adenan N.H. & Hamid N.Z.A. 2019. Determining the chaotic dynamics of hydrological data in flood-prone area. *Civil Engineering and Architecture* **7***(*6A): 71-76.

Regonda S., Rajagopalan B., Lall U., Clark M., & Moon Y.-I. 2005. Local polynomial method for ensemble forecast of time series. *Nonlinear Processes in Geophysics* **12**(3): 397–406.

Ruslan A.B. & Hamid N.Z.A. 2019. Application of improved chaotic method in determining number of k-nearest neighbor for CO data series. *International Journal of Engineering and Advanced Technology* **8**(6S3): 10-14.

Saari M.Y. 2019. Kerugian ekonomi akibat jerebu. http://www.astroawani.com/berita-malaysia/kerugian-ekonomi-akibat-jerebu-217890 (20 Disember 2019).

Sahril N.A. 2019. Kesan jerebu pada produktiviti negara. https://www.sinarharian.com.my/article/49060/Analisis-Sinar/Kesan-jerebu-pada-produktiviti-negara (3 Mac 2020).

Schuster H.G. 1988. *Deterministic Chaos: An Introduction.* Weinheim, VCH Publishers..

Sivakumar B. 2002. A Phase-Space reconstruction reconstruction approach to prediction of suspended sediment concentration in rivers. *Journal of Hydrology* **258**: 149-162.
Sivakumar B. 2003. Forecasting monthly streamflow dynamics in the Western United States: A nonlinear dynamical approach. *Environmental Modelling & Software* **18**(8-9) 721-728.
Sprott C. 2003. *Chaos and Time Series Analysis*. Oxford : Oxford University Press.
Lakshmi S. & Tiwari, R. K. 2009. Model Dissection from Earthquake Time Series: A Comparative Analysis Using Modern Non-Linear Forecasting and Artificial Neural Network Approaches. *Computers & Geosciences* **35**(2): 191–204.
Velickov S. 2004. *Nonlinear Dynamics and Chaos with Application to Hydrodynamics and Hydrological Modelling*. London: Taylor & Francis.
Zaim W.N.A.W.M. & Hamid N.Z.A. 2017. Peramalan bahan pencemar ozon (O_3) di Universiti Pendidikan Sultan Idris, Tanjung Malim, Perak, Malaysia mengikut monsun dengan menggunakan pendekatan kalut. *Sains Malaysiana* **46**(12): 2523-2528.

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