Estimation AOD_{550} with MODIS AODs Using an Artificial Neural Network Limited Meteorological Data in Iraq/Al-Ramadi City: Case Study

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Abstract: Aerosols affect the amount of sunlight that reaches the Earth causing many damages, so it can be measured by the optical depth of the aerosols. We developed an artificial neural network and trained it on the daily climatic data of Ramadi city (temperature, solar radiation and atmospheric pressure) for four consecutive years. climatic used. Activation functions (Gaussian, sigmoid, Hyperbolic Tangent and Hyperbolic Secant), number of hidden layers used (1,2, 3 and 4), adjustments ranging from 10,000 to 50,000 on a scale of 10,000 were used each time for both the output and hidden layers. In order to obtain the best results for the developed ANN models, the statistical criteria were determined based on the correlation coefficient (R), root mean square error (RMSE). According to the statistical criteria it was calculated to evaluate the results of the developed ANN models. It was found that the best ANN models among all the ANN models that were trained and tested was the ANN model (60) where (R = 0.9169) and (RMSE = 0.0866). After obtaining these results, the obtained ANN model can be generalized.

Keywords: AOD_{550}, Artificial Neural Network, AL-Ramadi, Iraq.

Number: 10.14704/nq.2022.20.7.NQ33091 **Neuro Quantology 2022; 20(7):709-714**

1. Introduction

Aerosols mainly affect the atmosphere, including the thermal structure of the atmosphere through the absorption and scattering of incoming and outgoing radiation, which leads to accelerated climate change. This is most evident in the Arctic, where it is currently warming two to three times faster than the rest of the Earth [1]. The suspended particles include solid and liquid particles and each represents an aerosol. Aerosols can be produced directly from anthropogenic sources such as; (Natural sources such as dust, marine aerosols, volcanic ash and fossil fuel emissions). Aerosols are considered the most important influence on environmental problems, such as global warming, photochemical haze, depletion of the stratospheric ozone layer and poor air quality [2]. Thus, accurate measurements of aerosol properties are necessary to accurately estimate their influence and interaction with other components of the climate system. Uncertainties associated with aerosol measurements and their effects on climate make this a promising area of research. [4]. Researchers have applied various approaches to examine the properties and role of aerosols in the climate system to reduce uncertainties.[7] Ground-based observations, satellite measurements, and numerical/chemical transport model simulations are frequently used to study aerosol properties[12] Applications of ANN are also seen in various specialized fields of atmospheric science, including studied aerosols and air pollution. [13] predicted aerosol optical depth (AOD) values with the help of neural networks. They used global data from the MODIS (Medium Resolution Imaging Spectroradiometer) satellite to train their network. Their findings showed that neural networks work more efficiently compared to an operational retrieval algorithm.[11]. They

proposed a neural network-based methodology to calculate missing AOD data from satellites. Lewis et al (2015) used neural networks to estimate missing AOD values at one station with the help of AOD information at other stations. In this paper we consider three years of continuous measurements of A data set includes (daily mean of Air Temperature, Maximum, Minimum, Solar radiation, Solar Radiation daily Sum, atmospheric pressure as meteorological parameters employed as an input and AOD_{550}) concentration as an output. An artificial intelligence approach represented by neural network has been employed to estimate AOD_{550} concentrations. Using meteorological as input parameters and different activation functions, hidden layers and alterations.

2. Methodology, MODIS AOD_{550}, Meteorological parameters

The neural network is a massively parallel computation system consisting of specific processing units that accumulate and provide experiential information. An artificial intelligence technology branch which simulates human brain behavior is an artificial neural network [9, 10]. ANNs are a computer system which simulates biological neurons' structure and function multiple computing elements usually consist of neural networks. Interneuron alliances are arranged and the arrangement of the network is dictated by the existence of the relation. The strictures for neural networks can be used to characterize it. The Artificial neural network inclusive performance can be evaluated by the equations 1 and 2 [23].$x_i^m = \partial(v_i^m)$ (1)

$$u_i^m = \sum w_{ji}^{m-1} x_j^{m-1} + a_i^m \quad (2)$$

Where x_i^m and u_i^m are the input and output of i-th neuron in m-th of the hidden layer, ∂ is activation function. Many various types of ANN activation functions (Gaussian, Hyperbolic Tangent, sigmoid, Hyperbolic Secant), hidden layers and alterations which available where employ neural networks models have been developed by Qnet 2000 software in present work.

Aerosol Optical Depth (AOD) is a measuring satellite parameter to which amount suspended particles influence light transmission scattering or absorption [24]. It is therefore a measure of the indirect particles that occur at a given time in the air column. Moderate Resolution Imaging Spectroradiometer (MODIS) has 20 reflective solar bands (RSB) and 16 thermal emissive bands (TEB) with wavelengths of 3,75 to 14,24 μm, respectively, with wavelength between 0,41 and 2,2 μm. The observations of MODIS include three nadir spatial resolutions: 2500 meters for 1-2.500 meters for 3.7, and 1 km for 8.36 observations for 8.36. A key improvement is the advanced ability of the MODIS instrument to robust on-orbit calibration and feature over heritage sensors [13].

1.3 Region study

The city of Ramadi is the capital of Anbar Governorate / Iraq and is its largest city. It is located about 110 kilometers (68 miles) west of Baghdad, N= 43 and E=33. In 2018 its population was about 223,500 people. It represents the predominantly desert part of its terrain. The Euphrates River is adjacent to it from the east

1.4 Results and Discussion

Availability of accurate and sufficient data is very important for training an ANN. The power of artificial neural networks in responding to new problems depends to some extent on raw data. In the current study, the air quality parameters include the AOD_{550} and the meteorological parameters (day of the year, mean daily temperature, maximum, minimum temperature, daily mean solar radiation, daily sum of solar radiation, atmospheric pressure), about 1421 data (1440 days) to train several ANN algorithms. In the present work 240 experiments were performed in the training phase using 7 inputs with different activation functions (Gaussian, Hyperbolic Tangent, sigmoid, hyperbolic secant), hidden layers (1, 2, 3 and 4), and the adjustments ranged from 10,000 to 50,000 with an interval of 10,000.

Table 1 . Statistical Overview of AOD_{550} and Atmospheric parameters during 2014-2017..

Parameters	AOD_{550}	T_{mean} C^o	T_{max} C^o	T_{min} C^o	S_{mean} Watt/m²	S_{sum} Watt/m²	P Mb
Mean	0.358	32.61	18.78	25.48	156.46	16.5756	1011.03
SDEV	0.2146	10.9041	8.8715	9.7378	100.2024	6.0833	65.5386
Min	0.062	7.41	0.15	5.285	3.5589	3.0589	990.2
Max	1.089	49.5	35.76	39.91	365.1	30.403	1174.01

The efficiency of the proposed ANN models was evaluated during the preparation and estimation process based on the statistical evaluation criteria: root mean square error (RMSE) and correlation coefficient (R) as shown in Tables 2, respectively. The ANN 60 model is preferred over other ANN models because it has the fewest errors. RMSE=0.0866. The correlation coefficient (R=0.9169) for the training and estimation phases respectively which suggests that the 60 ANN model provides an accurate daily AOD_{550} estimation in Ramadi city. Figure 1, shows the scattering plot of the measured vs. AOD_{550} and the comparison between the estimated AOD_{550} by ANN models and the measured value. The results show that most of the points lie along the diagonal line and that the diagonal line difference is small. That is, the ANN 60 model is superior to other ANN models, as the diagonal line is mostly located along points as shown in **Figure 1.** The estimated AOD_{550} values are in good agreement with the measured values. The best ANN was four Hidden layers, eight neuron in each Hidden layer's , 50000 alterative and activation function was Gaussian.

Table 2. Statistical Criteria Validation for top Ten Daily AOD_{550} Mean of ANN Models for Estimated Stage

Model No.	ANN Structure	Activation Function	Alterations	RMSE	R
38	77771	Gaussian	30000	0.1085592	0.86407285
57	788881		20000	0.1048111	0.87400597
53	777771		30000	0.1043879	0.87503241
44	78881		40000	0.1034133	0.87753835
52	777771		20000	0.1032141	0.87805134
55	777771		50000	0.1015396	0.88225956
42	78881		20000	0.1011272	0.88322053
39	77771		40000	0.100626	0.88446155
54	777771		40000	0.0997556	0.88659532
60	788881		50000	0.0860744	0.91694791

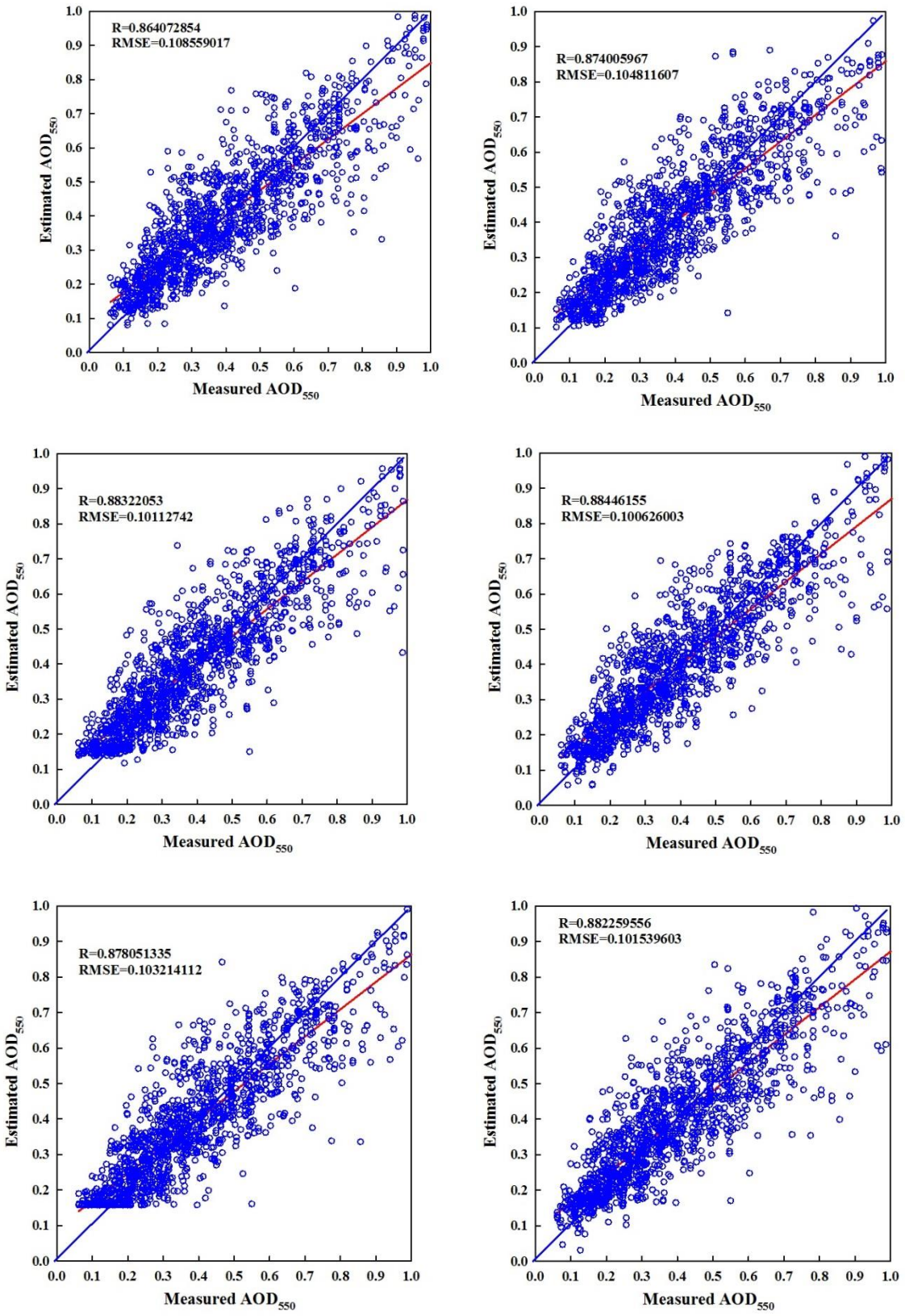

Figure 1. Scatter Plot of the Measured AOD_{550} vs. Estimated AOD_{550}

1.5 Conclusion

Several ANN models employing meteorological measurements were proposed to enhance their capabilities in estimation AOD_{550} values. The ANN models were constructed to incorporate meteorological parameters in addition to MODIS and AOD_{550} data. The developed models were examined for AL-Anbar, Iraq. Despite the significance of airborne particulate problems and the need for examining new measurement techniques, in spite of the importance of airborne particulate impacts and problems, the need for examining new measurement techniques, no such researches had been carry out in AL-Anbar city. The capability of developing models for AOD_{550} estimations were examined and their result were compared to the other suggested models. In conclusion, this approach reflects the ANN's ability to consider AOD_{550} values; therefore, the developed ANN model (60) may be suitable for estimating AOD_{550} in other locations in Iraq, utilizing limited meteorological measurement.

1.6 ACKNOWLEDGMENTS

The author Enas Mohamed Abbas thank Assit. Prof. Anmar Dherar Kusag and Prof. Dr. Ali Mohammed Al-Salihi for fruitful discussions. This work was part of the requirements for student Enas to obtain a master's degree in Physics in Iraq / University of Anbar / College of Education for Pure Sciences

References

[1]A. M. Al-Salihi, "Characterization of aerosol type based on aerosol optical properties over Baghdad, Iraq", Arabian Journal of Geosciences, Vol. 11,no. 20, pp. 1-15, 2018.

[2]A. M. AL-Salihi, "Impact of aerosols optical depth on angstrom exponent and microphy-sical properties of clouds over Iraq", ARPN Journal of Engineering and Applied Sciences, Vol. 13, no. 5,pp. 1889-1899, 2018.

[3]N. A. B. Mabahwi, O. L. H. Leh, and D. Omar, "Human health and wellbeing: Human health effect of air pollution", Procedia-Social and Behavioral Sciences, Vol. 153, pp. 221-229, 2014.

[4]M. Catalano and F. Galatioto, "Enhanced transport-related air pollution prediction through a novel metamodel approach", Transportation Research Part D: Transport and Environment, Vol. 55, pp. 262-270, 2017.

[5]W.-J. Guan, X.-Y. Zheng, K. F. Chung, and N.-S. Zhong, "Impact of air pollution on the burden of chronic respiratory diseases in China: time for urgent action", The Lancet, Vol. 388, no. 10054, pp. 1939-1951, 2016.

[6]P. Mahapatra, P. Sinha, R. Boopathy, T. Das, S. Mohanty, S. Sahu, "Seasonal progression of atmospheric particulate matter over an urban coastal region in peninsular India: role of local meteorology and long-range transport", Atmospheric Research, Vol. 199, pp. 145-158, 2018.

[7]W. Qin, L. Wang, A. Lin, M. Zhang, and M. Bilal, "Improving the estimation of daily aerosol optical depth and aerosol radiative effect using an optimized artificial neural network", Remote Sensing, Vol. 10,no. 7, 2018.

[8]X. Chen, G. de Leeuw, A. Arola, S. Liu, Y. Liu, Z. Li,"Joint retrieval of the aerosol fine mode fraction and optical depth using MODIS spectral reflectance over northern and eastern China: Artificial neural network method", Remote Sensing of Environment, Vol. 249, 2020.

[9] H. B. Demuth, M. H. Beale, O. De Jess, and M. T. Hagan, Neural network design, Available Online: https://hagan.okstate.edu/NNDesign.pdf

[10] K. Shao, J. Chen, Z. Zhao, and D. H. Zhang, "Communication: Fitting potential energy surfaces with fundamental invariant neural network", AIP The Journal of Chemical Physics, Vol. 145, no. 7, 2016.

[11] R. Hambli, "Multiscale prediction of crack density and crack length accumulation in trabecular bone based on neural networks and finite element simulation", International Journal for Numerical Methods in Biomedical Engineering, Vol. 27, no. 4, pp. 461-475, 2011.

[12] A. D. Salman, K. J. Al-Jumaily, and A. M. AL-Salihi, "Aerosol-cloud-precipitation interactions over Iraq using MODIS satellite data and HYSPLIT model during (2008-2017)", AIP Conference Proceedings, Vol. 2290, no. 1, 2020.

[13] X. Xiong, A. Angal, T. Chang, K. Chiang, N. Lei, Y. Li, "MODIS and VIIRS calibration and characterization in support of producing long-term high-quality data products", Remote Sensing, Vol. 12, no. 19, 2020.