IEEE Access • Volume 13, Pages 12554 - 12565 • 2025

Document type
Article

Source type
Journal

ISSN
21693536

DOI
10.1109/ACCESS.2025.3530261

View more

Dust Storm Attenuation Prediction Using a Hybrid Machine Learning Model Based on Measurements in Sudan

Elsheikh, Elfatih A. A.[a]; Eltahir E.I.[b, c]; Tasdelen, Abdulkadir[b, d]; Hamdan, Mosab[e, f]; Rafiqul Islam, Md[b]; Hadi Habaebi, Mohamed[b]; Abdullah Hashim, Aisha H.[b]

Save all to author list

[a] King Khalid University, College of Engineering, Department of Electrical Engineering, Abha, 62529, Saudi Arabia

[b] International Islamic University Malaysia, Faculty of Engineering, Department of Electrical and Computer Engineering, Kuala Lumpur, 53100, Malaysia

[c] Omdurman Ahia University, Department of Applied Physics and Mathematics, Omdurman, 768, Sudan

[d] Ankara Yildirim Beyazit University, Faculty of Engineering and Natural Sciences, Department of Software Engineering, Ankara, 06010, Türkiye

View additional affiliations

View PDF Full text options Export

Abstract
Author keywords
Indexed keywords
SciVal Topics
Funding details

Abstract

Sand and dust storms significantly challenge microwave and millimeter-wave communications, particularly in arid and semi-arid regions. Various models have been developed to predict attenuation caused by these storms theoretically and empirically based on two meteorological parameters, namely visibility and humidity. However, these models are found unable to predict most of the attenuation measurements. This study presents a hybrid Machine Learning (ML) model that predicts dust storm attenuation for 22 GHz terrestrial links using meteorological data. The received signal levels were measured for a 22 GHz link over a month in Khartoum, Sudan. The visibility, humidity, atmospheric pressure, temperature and wind speed were also monitored simultaneously by Automatic Weather Station (AWS). The proposed model incorporates XGBoost for feature selection and combines Long Short-Term Memory (LSTM) and Gated Recurrent Unit (GRU) layers to capture both short-term and long-term

dependencies in meteorological data. The results demonstrate a strong correlation between meteorological parameters and dust storm attenuation. The model's performance is validated against the measured data at 22 GHz, outperforming existing empirical and theoretical models. The RMSE for the proposed model is 0.07, while all existing theoretical and empirical models are higher than 0.25. Furthermore, the proposed model demonstrates significant enhancements over the available ML model for dust attenuation prediction. This hybrid ML approach offers a more accurate and robust solution for predicting microwave and millimetre wave attenuation during dust storms, enhancing the reliability of communication systems in affected regions. © 2025 The Authors.

Author keywords

Dust storm attenuation; GRU; LSTM; machine learning; meteorological parameters; microwave propagation; terrestrial communication; XGBoost

Indexed keywords

SciVal Topics

Funding details

References (36)

View in search results format >

All

Export Print E-mail Save to PDF Create bibliography

1 Gu, Z., He, Y., Zhang, Y., Su, J., Zhang, R., Yu, C.W., Zhang, D.

An overview of triggering mechanisms and characteristics of local strong sandstorms in china and haboobs

(2021) *Atmosphere*, 12 (6), art. no. 752. Cited 12 times.
https://www.mdpi.com/2073-4433/12/6/752/pdf
doi: 10.3390/atmos12060752

View at Publisher

2 Arishi, A.A.
Classification of sandstorms in Saudi Arabia
(2021) *Atmos. Climate Sci.*, 11 (1), pp. 177-193. Cited 8 times.
Dec.

3 Elsheikh, E.A.A., Islam, M.R., Habaebi, M.H., Ismail, A.F., Zyoud, A.

Dust Storm Attenuation Modeling Based on Measurements in Sudan

(2017) *IEEE Transactions on Antennas and Propagation*, 65 (8), art. no. 7948717, pp. 4200-4208. Cited 37 times.
doi: 10.1109/TAP.2017.2715369

View at Publisher

4 Elsheikh, E.A.A., Rafiqul, I.M., Habaebi, M.H., Zyoud, A., Suliman, F.E.M., Eltahir, E.I., Amin, N.W.

Effect of Dust Storm Intensity Variations on Total Path Attenuation Prediction

(2022) *IEEE Transactions on Antennas and Propagation*, 70 (4), pp. 2884-2890. Cited 5 times.
https://ieeexplore.ieee.org/servlet/opac?punumber=8
doi: 10.1109/TAP.2021.3138259

View at Publisher

5 Eltahir, E.I., Elfatih Elsheikh, A.A., Awad Babiker, A., Bilal, K.H.

10 GHz investigation of sudanese dust event particles characteristics

(2019) *Proceedings of the International Conference on Computer, Control, Electrical, and Electronics Engineering 2019, ICCCEEE 2019*, art. no. 9071029. Cited 6 times.
http://ieeexplore.ieee.org/xpl/mostRecentIssue.jsp?punumber=9052497
ISBN: 978-172811006-6
doi: 10.1109/ICCCEEE46830.2019.9071029

View at Publisher

6 Musa, A., Camara, M.F., Abdulla, A.H., Bashir, S.O., Hamed, S.M.A.

Modeling of dust particles canting as input to microwave cross polarization (Open Access)

(2015) *Proceedings - 2015 International Conference on Computing, Control, Networking, Electronics and Embedded Systems Engineering, ICCNEEE 2015*, art. no. 7381435, pp. 87-90. Cited 8 times.
ISBN: 978-146737869-7
doi: 10.1109/ICCNEEE.2015.7381435

View at Publisher

7 Eltahir, E.I., Elsheikh, E.A.A., Islam, M.R., Habaebi, M.H., Hashim, A.H.A., Hamdan, M.

Effects of Meteorological Parameters on Microwave Propagation Modeling During Dust Storm

(2024) *Proceedings of the 9th International Conference on Mechatronics Engineering, ICOM 2024*, pp. 101-106.
http://ieeexplore.ieee.org/xpl/mostRecentIssue.jsp?punumber=10651580
ISBN: 979-835034978-8
doi: 10.1109/ICOM61675.2024.10652381

View at Publisher

8 Shamim, M.Z.M., Elsheikh, E.A.A., Salih, F.E.M.S., Islam, M.R.

Signal Attenuation Prediction Model for a 22 GHz Terrestrial Communication Link in Sudan Due to Dust and Sand Storms Using Machine Learning

(2021) *IEEE Access*, 9, pp. 164632-164642. Cited 7 times.
http://ieeexplore.ieee.org/xpl/RecentIssue.jsp?punumber=6287639
doi: 10.1109/ACCESS.2021.3132700

View at Publisher