EGU25-15382, updated on 20 Apr 2026
https://doi.org/10.5194/egusphere-egu25-15382
EGU General Assembly 2025

Event-Based Physics-Informed Neural Networks for Dust Storm Prediction

kimia giahchin and mohammad danesh-yazdi
Sharif University of Technology, Institute of Environmental Studies, Civil Engineering, Iran, Islamic Republic of
(kimia.giahchin77@sharif.edu)

Dust storms pose significant environmental challenges in arid and semi-arid regions, causing serious health, environmental, and socio-economic impacts. Traditional dust modeling approaches, like numerical methods, often struggle to balance accuracy, computational efficiency, and data availability. This study employed a Physics-Informed Neural Network (PINN) model for event-based dust storm modeling, integrating the physical principles of dust dynamics with data-driven methods. We demonstrated the applicability of the above framework in the Lake Urmia Basin, where the lake desiccation and external dust sources have triggered local dust storms. To this end, we first analyzed ground-recorded PM_{10} and weather data to identify dusty days between 2004 and 2019. Next, we trained an initial neural network (NN) model with remote sensing data that describe meteorological and boundary layer characteristics at the locations of pollution monitoring stations. This approach allowed us to generate gridded PM_{10} data, overcoming the limitations posed by insufficient and non-continuous data for directly training PINN. Finally, the PINN model was trained and validated on 21 selected dust events from three stations chosen for their spatial distribution and sufficient availability of PM_{10} data throughout the events. Analysis revealed that the initial NN model achieved R^2 of 62% and mean absolute error (MAE) of 65 on the test data. The PINN model demonstrated substantial improvement with mean R^2 of 93% and mean MAE of 9 on the gridded PM_{10}, and MAE of 39 when validated against ground observations. Furthermore, the model yielded lower prediction accuracy in urban compared to rural stations, which is attributed to the bias imposed by the influence of terrestrial and industrial pollutions. This study demonstrates the effectiveness of PINNs in tackling dust transport modeling challenges in data-sparse regions, providing a novel way to combine physical principles with data-driven techniques for large-scale environmental applications.