

Research Highlight

Identification of New Particle Formation Events Using a You Only Look Once (YOLO) Deep Learning Algorithm

Summary

A new study published in the ACS ES&T Air special issue “*Elevating Atmospheric Chemistry Measurements and Modeling with Artificial Intelligence*” introduces, for the first time, a deep learning method — the You Only Look Once (YOLO) algorithm — to detect atmospheric new particle formation (NPF) events. NPF events involve the formation and growth of molecular clusters, a key process that influences air quality, climate, and human health. The study is led by Rajat Bhandari under the supervision of Dr. Vijay P. Kanawade (CARE-C, CyI) and Assoc. Prof. Chandan Sarangi (Indian Institute of Technology Madras, India), and is supported by a global team of collaborators, including colleagues from CyI (Dr. Michael Pikridas, Prof. Jean Sciare, and Assoc. Prof. Tuija Jokinen).

Traditionally, NPF events are identified by the manual visualisation of daily contour plots of particle number size distributions, a method that is subjective, inconsistent, and time-consuming. This work uses a real-time fast object detection algorithm (YOLO) to automate the identification of NPF events from particle number size distribution (PNSD) data. This study trained the YOLO model using annotated data from 20 diverse atmospheric monitoring sites across India, Europe, Africa, East Asia, and North America. The trained YOLO model was then evaluated on over 6,424 observation days and achieved accuracy levels as high as 97% in detecting NPF events. This work offers a solution for labour-intensive manual analysis to real-time, automated NPF event detection and interpretation, demonstrating AI’s growing role in large-scale environmental data processing and climate research.

Authors’ bios



Dr. Vijay P. Kanawade is a Research Scientist at CyI’s Climate and Atmosphere Research Center (CARE-C). Vijay joined CyI in September 2023 from the University of Hyderabad, India, where he was an Assistant Professor. Vijay holds a Ph.D. in Earth Observation Science from the University of Leicester, UK, and has held research positions in the USA, Sweden, and India. Vijay’s research focuses on new particle formation, aerosol–cloud–climate interactions, and air quality using ground-based and satellite observations.

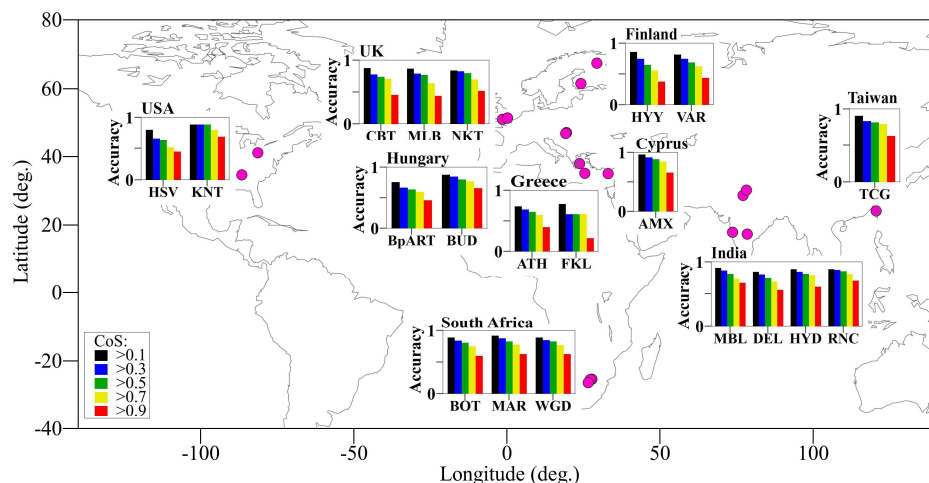


Figure 1. The YOLO algorithm's accuracy in detecting NPF events at different confidence scores (CoS>0.1, >0.3, >0.5, >0.7 and >0.9) for all evaluated 20 sites across the globe. The cyan dots indicate the location of the measurement sites. The inset bar graph shows the YOLO algorithm's accuracy at different CoS for each site.

Impact

This work demonstrates the potential of AI tools in atmospheric chemistry and climate research, specifically, new particle formation. By automating NPF event detection across varied environmental conditions, AI tools help to enhance the speed, objectivity, and reproducibility of new particle formation event identification and characterisation. The training source code and the trained YOLO model shared via GitHub enable researchers worldwide to adopt and expand this approach, facilitating climate and air quality studies. This study showcases how AI can bridge gaps in environmental research and opens new avenues for integrating machine learning into global atmospheric monitoring networks and climate modeling.

Reference

Bhandari, R., Sarangi, C., Sebastian, M., Hooda, R. K., Hyvärinen, A.-P., Asmi, E., Vakkari, V., Pandithurai, G., Singh, S., Soni, V. K., Nieminen, T., van Zyl, P. G., Jaars, K., Laakso, L. K., Beddows, D. C. S., Harrison, R. M., Beukes, J. P., Kalivitis, N., Mihalopoulos, N., Salma, I., Vörösmarty, M., Young, L.-H., Watson, Z., Lee, S.-H., Pikridas, M., Sciare, J., Jokinen, T., Kanawade, V. P. (2025). Identification of new particle formation events using a You Only Look once (YOLO) deep learning algorithm. ACS ES&T Air. <https://doi.org/10.1021/acsestair.5c00021>

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