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How AI is helping cities tackle invisible pollution

Researchers are designing AI-powered virtual cities to help authorities predict street-level pollution and act where it is needed most.

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In cities, air pollution can vary sharply from one street to the next. Fumes may linger between tall buildings, collect at busy junctions or drift towards a school gate. However, cities often lack the detailed forecasts needed to act before levels become dangerous.

For Professor Soledad Le Clainche, an applied mathematician at the Technical University of Madrid and leader of the ModelFLOWs research group, better understanding how air moves through cities could help tackle one of Europe's biggest environmental health challenges.

As part of an EU-funded research project called MODELAIR, Le Clainche is working with researchers in Belgium, the Netherlands, Sweden and the UK to make the invisible, highly local patterns of urban pollution easier for cities to understand.

"Many people develop tools for air pollution, but we are the first to calculate, in real time, the 3D pollution environment of the urban areas we are studying," she said.

AI-powered virtual cities

The MODELAIR researchers are developing AI-powered, 3D "digital twins" of cities. Combining computer simulations, sensor data and 3D models, they provide a real-time, street-level picture of urban air quality.

The goal is to help city authorities make better-informed decisions on traffic planning, local monitoring and where to apply pollution control measures. The research complements the EU Mission for Climate-Neutral and Smart Cities, which is helping European cities reduce emissions and improve urban life.

The tools are being tested in Brussels, Madrid and Bristol. Each city is exploring a different use, from understanding the effects of urban design to improving local monitoring and testing practical responses.

The vast majority of people in European cities are exposed to air pollution levels above what the World Health Organization (WHO) considers safe. Air pollution increases our risk of heart disease, stroke and various cancers, and worsens asthma and respiratory infections. Though often invisible, it is no small matter.

The European Environment Agency estimated that, in 2023, cutting air pollution to WHO guideline levels could have prevented 182 000 deaths from fine particles, 63 000 from exposure to ozone pollution and 34 000 from nitrogen dioxide gas in the 27 EU Member States.

New evidence also points to air pollution as a possible cause of dementia, WHO said, and eastern and south-eastern countries in Europe suffered the most health impacts from pollution.

Although air pollution has generally improved in Europe, surprising new findings about its harm keep emerging. A 2025 study found that exposure to common tiny particles and nitrogen oxides in the air over the first 18 years of life is linked to poorer cardiovascular health, especially higher blood pressure in young adults.

Getting down to street level

Le Clainche and her colleagues aim to go beyond the usual big-picture view of a city's overall pollution levels.

The team uses AI "agents", software assistants that continuously bring together information from sensors, weather forecasts and computer models to produce local forecasts.

Some of the project's methods are already available through the open-source ModelFLOWs-App.

The models available today can give us useful information, but they don't always give cities the detailed picture they need to take action. The challenge is to bring together all the different pieces of information we have – from air-quality monitoring stations and other limited sources of data – with highly detailed simulations of how air moves through a city.

"That's what MODELAIR does, allowing us to make much more accurate predictions about how pollutants travel through urban areas," said Alessandro Parente, an expert in air flows and AI for digital twins at Université Libre de Bruxelles in Belgium, and part of the MODELAIR team.

"Cities are struggling to take decisions on air pollution," he added.

Launched in 2023, the initiative combines computerised 3D city replicas with wind-tunnel experiments to test and refine its predictions.

Reacting in real time

Understanding how particles and gaseous pollution behave is complicated by the complex 3D environment of cities, where variables like pressure, wind and heat can change hourly and affect pollution levels.

Parente said the team wants a collaboration between scientists and AI agents to fill in the gaps and predict what is happening at a specific street corner or road junction.

“The AI agents bring together experimental data, run predictions and suggest possible responses,” Parente said. “But it’s important to be clear that AI can only make suggestions. It’s still up to scientists to assess those suggestions, and ultimately up to policymakers to decide whether and how to act on them.”

The real-time insights could help city planners weigh options such as changing traffic flows or deciding where to locate local industry.

“You could reroute traffic to avoid traffic jams or help control heat-island effects by how you build new areas of a city,” said Le Clainche.

Urban heat islands occur because asphalt, concrete and buildings retain heat, encouraging ozone formation and trapping pollutants in some streets.

City planning, traffic rerouting

The AI agents could suggest tree planting in specific locations to reduce temperatures, absorb some pollutants and introduce shade, for example. Ultimately, scientists and policymakers would use the detailed street-level insights provided by the digital twin to decide exactly where to intervene.

“A digital twin is a tool that will mimic a small area of a city, giving us information about how an air flow pattern is connected to high pollution levels,” said Le Clainche. “We’re creating tools that can be genuinely valuable for municipalities. Madrid is already very interested in using them.”

Having combined high-fidelity simulations with real-world data, the researchers are now preparing to test a real-time decision-making tool in Brussels’ Ixelles district. In Madrid, they will use the models to assess traffic routing options.

One project partner, Belgian engineering company BuildWind, develops digital city models to examine street-level wind flows, microclimates and air quality. Its existing BrusAir platform maps air pollution across Brussels, including near sensitive locations such as schools.

“This information is designed to help urban planners and the city administration understand exactly where pollutants concentrate,” said BuildWind’s CEO Alessandro Gambale.

BuildWind has worked with scientists such as Parente on real-world air pollution challenges and hopes the new research will strengthen BrusAir further. Findings from the MODELAIR research will be made more widely available towards the end of this year.

If the approach works as planned, it could give cities a more detailed view of the air people breathe on their own streets, making it easier to decide when and where action is needed before pollution builds up.

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More info

- MODELAIR (CORDIS)
- MODELAIR project website
- EU Mission: Climate-Neutral and Smart Cities
- Air quality status report 2025
- ModelFLOWs Research Group