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ScienceTalk

No fires, so why the haze? Calm winds are bad for urban cities

Hazy conditions in Singapore in late March were due to unusual atmospheric conditions

Steve Yim

From March 25 to 27, residents across Singapore experienced noticeably hazy conditions.

Levels of PM2.5, a type of pollutant, were elevated, and the Pollutant Standards Index – a measure of air quality here – reached 77, in the moderate range. The poor air quality was primarily due to unusual atmospheric conditions rather than transboundary pollution, which Singapore has faced in the past from peatland or forest fires in nearby regions.

Using the latest technology developed by my team at Nanyang Technological University (NTU), we detected calm winds in Singapore's lower atmosphere during those days – weather conditions that are unfavourable for dispersing air pollutants.

The technology is known as the 3-Dimensional Real-time Atmospheric Monitoring System (3DREAMS@SG), which comprises three advanced monitoring stations equipped with sophisticated light detection and ranging (Lidar) systems.

The Lidar system is able to measure wind patterns and aerosol concentrations up to 12km vertically.

Focusing on the data from 3km above ground, we can analyse detailed, second-by-second data on air particle movements and their potential sources, including urban emissions, haze or volcanic particulates.

These stations are strategically located around Singapore, including one at the NTU Smart Campus on the rooftop of Earth Observatory of Singapore, and another at Raffles Girls' School (Secondary). The team is planning to install the third one in the north region of Singapore by the end of this year.

Our data showed that after 5pm on March 25, there was a highly stable atmospheric layer.

High atmospheric stability means weak vertical mixing of air, while calm wind conditions reduce the transport of air pollutants horizontally.

Due to the combination of the two factors, fine particles are "trapped" near ground level, exacerbating the hazy conditions islandwide.

Typically, March and April mark Singapore's transition from the north-east monsoon season, when winds blow mainly from the north, to the inter-monsoon period. Historically, this period is characterised by lighter, variable winds and frequent sea breezes.

Such weather often results in stagnant air conditions, contributing to increased pollutant accumulation. Local pollution sources can include vehicle and maritime exhaust; emissions from processing plants and factories, as well as waste management facilities.

However, the severity of the haziness during the late-March episode underscores the importance of understanding local atmospheric stability and its impact on air quality.

With our 3DREAMS@SG network, we are now able to gain insights into how pollutants move horizontally and vertically throughout Singapore's atmosphere throughout the year.

The technology allows us to get a 3D picture of air and pollutant movement across the country, which helps us to improve air quality forecasting using our weather models.

As the global climate warms, we expect extreme atmospheric conditions to become increasingly common or to worsen.

For instance, climate change could alter traditional wind patterns, intensify atmospheric stability, and potentially lengthen periods of stagnant air, escalating air quality challenges for urban centres like Singapore. Likewise, a stable atmosphere and altered wind regimes could reduce the dispersion of pollutants.

Besides 3DREAMS@SG, Singapore hosts other significant climate and air quality research projects, such as the Meteorological Service Singapore's climate modelling and forecasting initiatives.

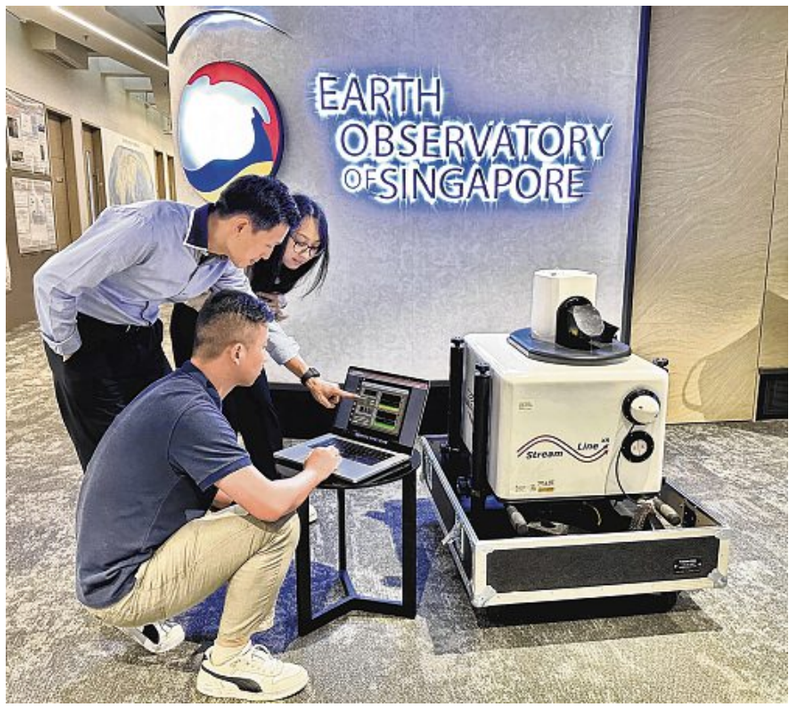
The Centre for Climate Research Singapore also collaborates extensively with other scientists, including those at NTU, on regional climate simulations and urban heat island studies.

These collective research efforts provide valuable insights, enabling effective policy responses and informed public awareness.

Ultimately, comprehensive monitoring systems together with our research in artificial intelligence and satellite retrieval technology, as well as close collaboration between agencies and institutions will help Singapore adapt to the changing climate.

By enhancing the accuracy and timeliness of air quality information, we can better safeguard public health through timely public advisories and mitigation measures for vulnerable populations. These may include tips on staying indoors, avoiding strenuous outdoor activities and staying well-hydrated.

Accurate forecasting can also give us time to prepare our healthcare institutions when we expect a rise in respiratory conditions due to unfavourable weather conditions.



NTU's Associate Professor Steve Yim (middle), Dr Huang Tao (front) and Dr Fang Tingting looking at data collected by the upcoming light detection and ranging station. PHOTO: LAURIANE CHARDOT/EARTH OBSERVATORY OF SINGAPORE

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