Researchers discover cellular networks can be used to detect dangerous fog

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When warm air comes into contact with a cool surface and chills to saturation, fog materializes. It blankets open roads and runways and dramatically reduces visibility—often causing devastating accidents.

A new study published in the *Bulletin of the American Meteorological Society*, by Tel Aviv University's Prof. Pinhas Alpert and Dr. Noam David of the Department of Geosciences at TAU's Faculty of Exact Sciences, and by Prof. Hagit Messer and Omry Sendik of the Department of Electrical Engineering Systems at TAU's Faculty of Engineering, reports a practical solution to fog detection can be found in cellular communication networks already in place all over the world.

Present fog monitoring tools include satellite systems and in situ sensors, but they are costly to implement and suffer from lack of precision when measuring at ground levels—where the data is most crucial. Researchers found in previous studies that the transmission of wireless microwave links in cellular networks were able to detect only the densest fog, but new advances in higher cellular communication frequencies can facilitate the detection of even light fog.

Opening a window of opportunity

"The goal of the work presented here is to reveal the potential that exists in commercial microwave systems, where higher frequencies more sensitive to fog are starting to be used," said Prof. Alpert, who supervised the study together with Prof. Messer. "We are presenting a window of opportunity to monitor fog with high resolution using technology already in place."

Commercial wireless links that operate at frequencies of tens of gigahertz form the infrastructure for data transmission between cellular base stations. These links are widely deployed across countries by cellular communication providers and are situated at ground level altitudes. Because of this, they are affected by different atmospheric phenomena at surface level—particularly fog.

"These existing systems have the potential to be utilized as an efficient fog monitoring tool," said Dr. David, who conducted the research as part of his postdoctoral study. "However, many of these systems, in their current format, have the potential to monitor only relatively heavy fog—hence the need for emerging technology to acquire more accurate observations."

Current wireless microwave links typically operate between frequencies of about 6 to 40 gigahertz, and the signal loss induced by fog at these frequency bands is relatively low. In other words, such systems have the potential to monitor only relatively heavy fog. In order to satisfy the growing demand for higher data rates and wider bandwidth, higher frequencies of around 70/80 gigahertz are beginning to be employed. "Since these higher frequencies are highly sensitive to the effects of fog, a new opportunity to potentially acquire wide-scale, high resolution observations of fog in real time has emerged," said Dr. David.

A foggy evening in Tel Aviv

To prove their concept, the researchers used a map of existing microwave links in Israel and calculated the minimum liquid water content that could be detected using signal attenuation data at 20, 38, and

80 GHz. At 80 GHz, even light fog, with a visibility of up to 750 meters, had a measurable effect on the signal. And when the researchers analyzed actual 38-GHz signal data for an evening that was foggy in Tel Aviv but clear in Jerusalem, the visibilities and fog densities they calculated were consistent with recorded observations.

"While most studies of this kind are focused on rainfall, fog is no less hazardous to people and objects in motion," said Dr. David. "Current monitoring tools are insufficient. Our new approach exposes the potential that already exists in these communication systems to provide high-resolution spatial measurements of fog."

The researchers are continuing to explore the potential of wireless communication frequencies.

Provided by Tel Aviv University

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