THE 2B BUZZ

Winter 2025 Newsletter

2B Tech Spotlight
Wishing You Well in 2025

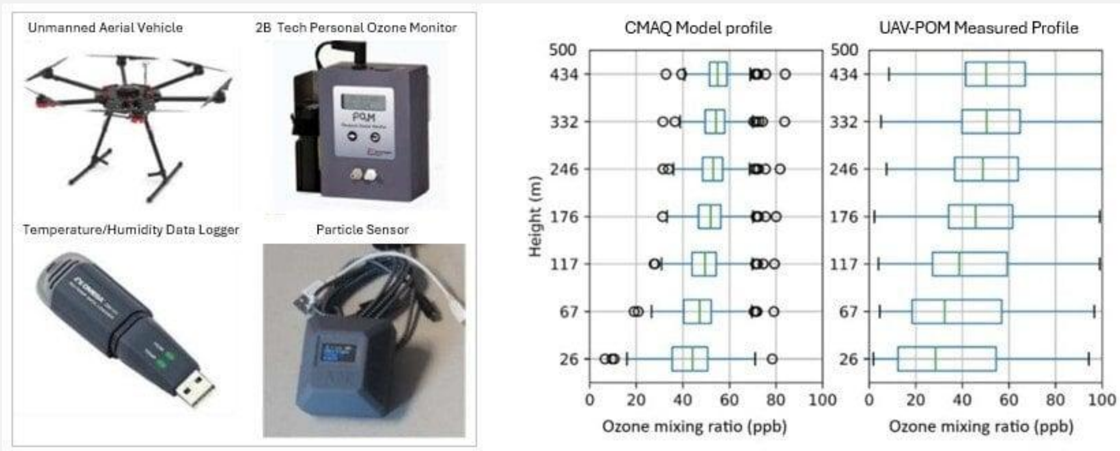
From all of us at 2B Tech - we hope your 2025 is off to a good start!

Case Study, 2B's Personal Ozone Monitor (POM)
Lightweight POM Yields Heavyweight Data Aboard UAV
Measurements Aloft Yield Improvements to AQ Emissions Estimates, Model

In the world of regulatory ozone measurements, 2B Tech's Personal Ozone Monitor is definitely punching above its weight!

Coming in at about a pound (~450 g), the versatile POM can be carried in a backpack, on a bicycle, aloft on balloons and drones, or even in the palm of a hand... all while providing Federal Equivalent Method measurements (EQOA–0815–227) over the range 0-500 ppb at a precision of 1.5 ppb.

Researchers at the University of California Riverside (UCR) put the POM to work aboard an unmanned aerial vehicle (UAV), to see how the real-world measurements of ozone levels during the UAV's ascent and descent would compare with an air quality model's estimates.



Left: Experimental system used in the study by Zhu et al. Right: Comparison of the median values of modeled and measured ozone abundances at various heights above ground level. Compared to the data, the model shows a more gradual gradient and higher values at the lower altitudes. Source: From Figures 1 and 7 of Zhu et al.

In total, the researchers gathered 321 vertical profiles from the surface to 500 meters above ground level in the early mornings and late afternoons from August to November of 2020. In addition to the 2-second ozone measurements of the POM, the data included measurements of particulate matter, temperature, and humidity.

Measurements of the vertical profiles of ozone showed discrepancies with the Community Multiscale Air Quality model (CMAQ), a model that's widely used for compliance purposes. Ozone increased more steeply for the real-world data, largely because the measured values closer to the ground started off lower than in the model.   Above about 150 meters in height, the model/measured values agreed more closely.

The authors explored various factors to bring the model into better alignment with the measured parameters. A key finding was that the NO_x emissions that go into the model are probably too low, ultimately leading to inflated ozone predictions closer to the ground. Also by refining the model's depiction of the atmospheric boundary layer, they achieved a closer match with actual measurements.

Air quality models are relied upon for decisions that affect the public's health and have implications for the economy and businesses. This makes it all the more important to check that the models align well with real-world data, especially in complex pollution hotspots like Riverside. The POM is just the ticket for this crucial research!

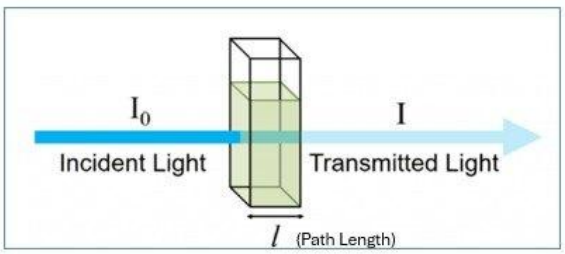
Assessing CMAQ Model Discrepancies in a Heavily Polluted Air Basin Using UAV Vertical Profiles and Sensitivity Analyses , Z. Zhu, K. Do, C.E. Ivey, and D.R. Collins, *Environmental Science: Atmospheres* (2024) **4**, 1051.

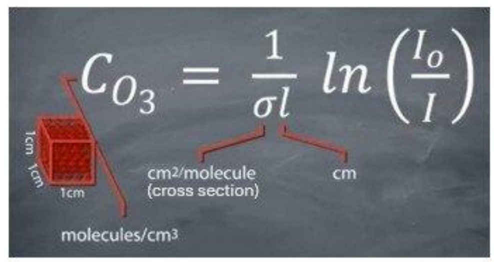
Regulatory News: EPA Updates Ozone Cross Section Value

2B Tech Instrument Calibrations Implement the New Value

The value of a basic parameter that underlies ozone measurements of many ozone monitors, including those made by 2B Tech, has recently been updated by the U.S. Environmental Protection Agency and regulatory agencies worldwide: the ozone cross section.

Absorption of UV light (wavelength 254 nanometers) has long been used to make measurements of atmospheric ozone with high precision and accuracy. A beam of 254nm light passed through a gas sample will be absorbed by ozone molecules that are present. Comparing the resulting intensity of light after the sample (I) with the intensity of the incident light (light measured with no ozone present, I_0), Beer's Law gives the ozone concentration in the sample: C_{O3} = [1/(path length x cross section)] x [ln (I_0/I)]

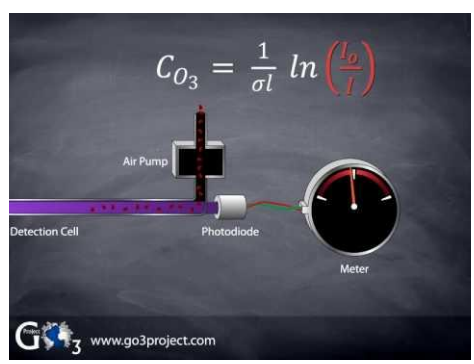




As shown in the equation, the value of the cross section is inversely related to the concentration of ozone calculated through Beer's Law.

Until this update, the cross section value used in ozone measurements has been 1.1476 x 10^{-17} $cm^2molecule^{-1}$ (308.32 $atm^{-1}cm^{-1}$ at standard temperature and pressure) based on a 1961 study, with an estimated uncertainty in this value of 1.4%. Since then, research advances have improved the accuracy of the ozone absorption cross section and rigorously assessed the bias and uncertainty in the value. In 2020, an international group of stakeholders agreed to implement a globally coordinated change to the new value of 1.1329 x 10^{-17} $cm^2molecule^{-1}$ (304.39 $atm^{-1}cm^{-1}$ at STP) for surface ozone monitoring. This value has a greatly reduced uncertainty of 0.31%. The reduction of 1.29% in the cross section value leads to a 1.29% increase in the ozone values calculated via Beer's Law.

In the U.S., the new value is finalized in the ruling (88FR 70595) and required to be fully implemented by 1 January 2026. 2B Technologies has already updated its calibrations to reflect the new cross section value, through re-calibrations of our working standards carried out in early January 2025. Our working standards are referenced to a primary working standard, which is in turn calibrated against a standard reference photometer at the National Institute of Standards and Technology (NIST).

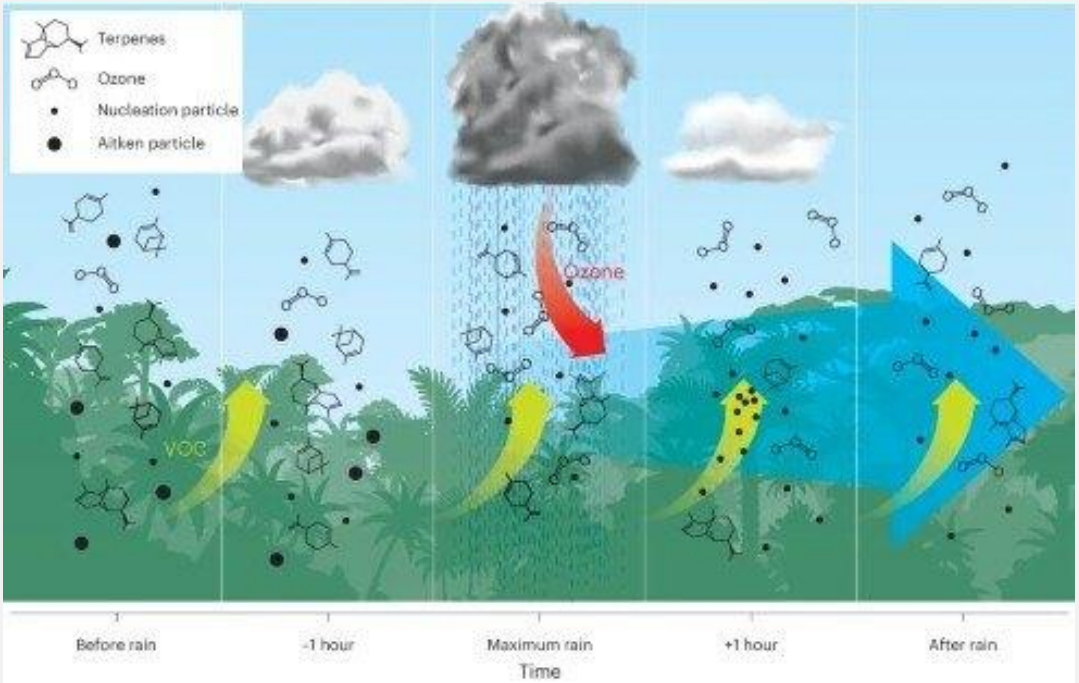


Click on the image to see the video developed by 2B Tech, showing Beer's Law and how an ozone instrument works!

Atmosphere News

Rainfall + Ozone Pollution Induce Nanoparticle Bursts in Amazon Rainforest

Newly Identified Process Upends Previous Understanding



The evolution of particles and gases before, during, and after rain events in the Amazon forest. Nanoparticle "bursts" arise when ozone washed into the canopy during rainfall interacts with terpenes and isoprene emitted by the trees. The nanoparticles feed into processes that create cloud condensation nuclei and ultimately, clouds. Figure 6 from Machado et al., Nature Geosciences.

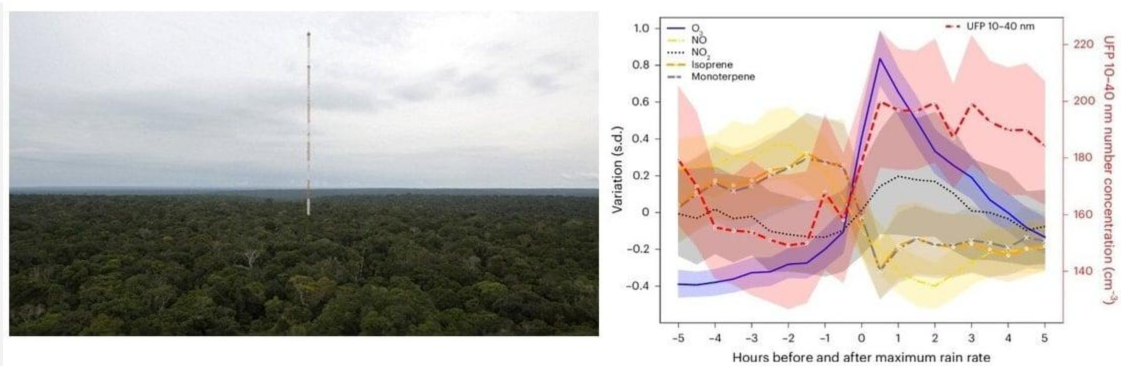
A new study shows that in the Amazon wet season, the rainforest is not merely a recipient of atmospheric pollution washing downward in rainstorms. In today's polluted atmosphere, it's a *source*, returning nanoparticles in bursts above the forest canopy.

The process was identified by an international team of researchers using comprehensive chemistry and meteorological data from the Amazon Tall Tower Observatory, a technological wonder in Brazil that at 325 meters is taller than the Eiffel Tower and 5 times taller than the tallest tree in the forest.

Although it was expected that ultrafine particle concentrations would increase with altitude above the forest, the tower data showed the opposite. The highest concentrations were above the canopy and decreased with altitude.

Researchers showed that as rain washes ozone and other pollution down into the canopy, the ozone reacts with biogenic volatile organic compounds naturally emitted by the forest. Subsequent chemistry leads to the nanoparticles' higher abundances at the canopy top.

Data before, during, and after rain events (figure below) clearly show the uptick in ozone and ultrafine particles during rain events, with simultaneous declines in the isoprene and terpene levels.



Left: The Amazon Tall Tower Observatory near Manaus, Brazil. Right: Chemistry data showing ozone and ultrafine particles (UFP) spiking during and after a rain event, and biogenic isoprene and monoterpene falling (Figure 5 from Machado et al., Nature Geosciences).

The nanoparticles eventually grow to become cloud condensation nuclei, the precursors to clouds. Cloud formation processes are crucial to weather and climate.

Frequent rainfall-induced new particle formation within the canopy in the Amazon rainforest, L.A.T. Machado, G.R. Unfer, S. Brill *et al., Nature Geosciences* **17**, 1225–1232 (2024).

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