2B Tech

THE 2B BUZZ

Spring 2024 Newsletter

2B Tech Spotlight

Senate Subcommittee Hearing: Are AQ Sensors Ready for Prime Time?

2B Tech Figures into Discussion of the Future of Air Quality Monitoring

Air quality monitoring has a bit of a split personality.

On the one hand are the rigorously tested, most accurate instruments that gain regulatory status, such as the Federal Reference Methods (FRM) and Federal Equivalent Methods (FEM) of the U.S. Environmental Protection Agency.

On the other hand are sensors, which do not meet the same testing standards and are generally acknowledged to be less accurate... but are much more affordable. While they've been used in efforts to expand air quality monitoring, it's been difficult for scientists to interpret the data they produce.

Do sensor newcomers have a role to play in the regulatory and policy space? Now decision-makers have come to question how--and even whether--sensors should be used. On April 10 the Senate Subcommittee on Environment & Public Works held a **hearing** on this topic, "Examining the State of Air Quality Monitoring Technology."

2B Tech's ears were ringing during this hearing. One of the three experts testifying was William Obermann, who is the Air Program Supervisor at Denver's Department of Public Health and Environment. His department has pioneered the "Love My Air" program for augmenting air quality monitoring at schools and in communities in the Denver area, using monitoring technologies including sensors that are more affordable and hence accessible. Denver is now bringing 2B Tech's **AQSync Air Quality Monitoring Station** into the program, to provide a more rigorous multi-pollutant FEM and reference-quality dataset.

Multiple AQSync stations, which each weigh a little over 50 pounds, will be used in various Love My Air locations to provide O_3, NOx, CO, particulate matter, and weather data that will help anchor the measurements from the program's sensor network and aid in their interpretation. It's the type of marriage we envisioned when we designed the AQSync to be either a stand-alone air quality station, or a readily mobile FEM-quality reference station for "making sense of sensors."

In the discussion at the hearing, Mr. Obermann alludes to the six AQSyncs that will be used in Denver to provide high-quality data. To see a short excerpt of the part of the hearing that focused on the discussion

relevant to the AQSync, click the picture above. The full hearing can be viewed by clicking the link below (watch from 1:10-1:18 to see the discussion referring to our instruments).

Video of Full Senate Subcommittee Hearing

AQSync Air Quality Monitoring Station

Denver's "Love My Air" Program (video)

Employee Spotlight: Meet our Manufacturing Assistant

Chenda Savath Brings a Knack for Building Things to 2B Tech

Chenda Savath joined 2B Tech as a Manufacturing Assistant in March 2023, and just a few weeks later found herself pitching in to help the company in its move from Boulder to Broomfield, Colorado. True to her positive outlook, Chenda viewed the packing and unpacking as an opportunity to learn about different parts of the company and quickly build a comradery with her new teammates. She's one of the company's 5 Manufacturing Assistants who build the ~800 instruments the company typically ships each year.

In some ways it seems it was destiny that brought Chenda to 2B Tech. She loves hands-on work and troubleshooting. As a kid, she took apart a computer to find out more about it. She started her work at 2B Tech with building some of the component assemblies of the instruments, and quickly graduated to building entire instruments. (The Model 205 Dual-Beam Ozone Monitor is her personal favorite to build.) There are only a couple of our ~20-instrument lineup that she has not yet built, but it is her goal to build those soon.

To mark her one-year anniversary with 2B Tech, Chenda took on new responsibilities: final inspections of some of our instruments. The final inspection is the last step of our instrument quality control, following the steps of manufacture, initial inspection, and calibration. In "doing finals," it falls to Chenda to find anything that might

have been missed in the process. She views it as an adventure and a challenge, a "treasure hunt" of sorts. She says doing the final inspections has helped her learn more about how the instruments work, and what to watch for when she is building the instruments.

Aside from the perfect fit to the job here, Chenda likes the "one big family" vibe of 2B Tech and the diversity of the team members. The occasional company barbecue lunches are also part of the fun of working here, she notes.

Chenda grew up in Fresno, California. In her spare time she enjoys reading, listening to true-crime podcasts, fishing, and volleyball. Add to that: wedding planning! She'll get married next summer. Turns out she and her fiancee were both born in Fresno only two days apart, but never met until they were in Colorado. Some things are just meant to be.

Case Study: 2B Tech Models 205, 405 nm, and 714

2B Tech Instruments Team Up to Measure Emissions from Inland Shipping on the Rhine River

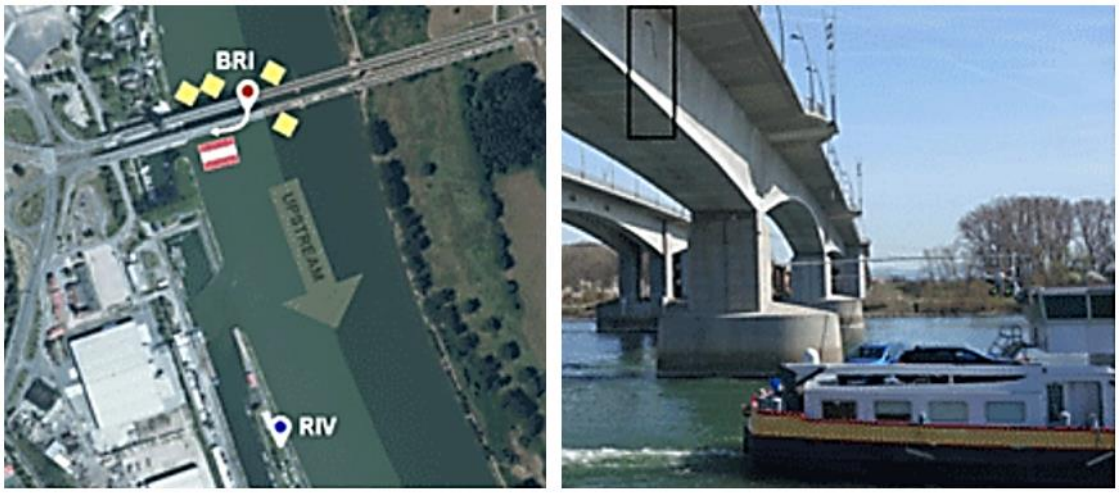
Study Takes First Extensive Look at a Mode of Commerce That's Expected to Grow

It's not just our staff who work as a team at 2B Tech. Sometimes our 2B Tech instruments do, too.

Three of our instruments spent over a year on the Rhine River, as part of an array of instruments aimed at looking at the emissions from ships traveling inland on the Rhine. The Model 205 and 405 nm measured ozone (O_3), nitrogen dioxide (NO_2), and nitric oxide (NO), and the Model 714 provided a calibration source for all three.

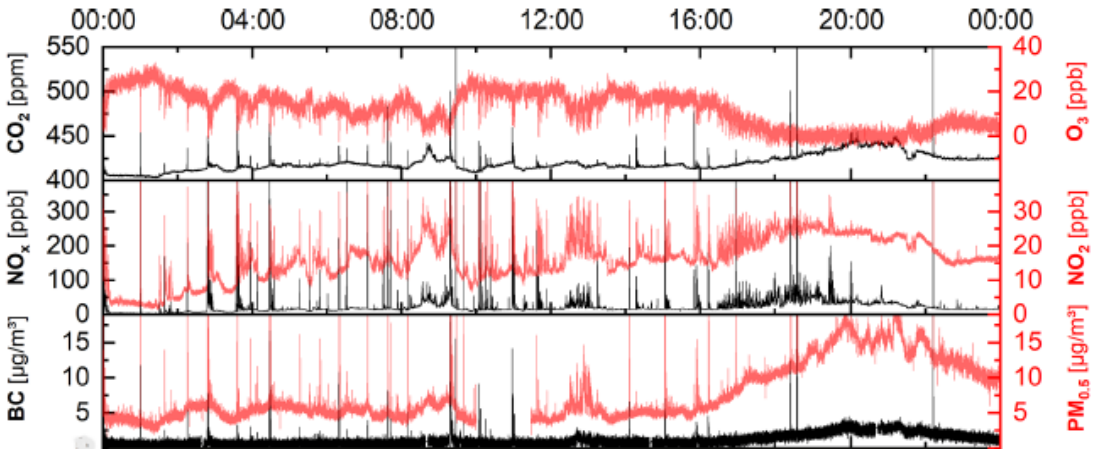
The Rhine is Europe's busiest inland waterway for the shipping of goods. And it's expected to get busier, by 50%, as Europe favors shipping as the most environmentally friendly way to move goods within the continent. That makes it especially timely that the most detailed study to date of ship emissions under real-world conditions has recently been published -- in August 2023 by Eger et al. in *Atmospheric Chemistry and Physics*.

In the study, instruments housed in a station on a bridge above the Rhine sniffed the plumes of the passing ships, and other instruments on a riverbank made measurements that were more representative of the pollution exposure of people onshore. About 4700 ship passages were analyzed for CO_2, NO, NO_2, particle number count, PM_1, $PM_{2.5}$, and black carbon during 14 months spanning March 2021 to June 2022.



Left: Rhine River air measurement stations on the bridge (BRI) and at the riverbank (RIV). The yellow diamonds indicate ship passage lanes. Right: The bridge measuring station, with the suspended sampling line shown in the black box. Modified from Figure 1 of Eger et al., Atmospheric Chemistry and Physics, 23, 8769-8788 (2023).

At the bridge location where the plumes were directly sampled closest to the source, shipping had the biggest influence on NO_x levels (an increase of 50% within the plumes above background levels). Black carbon was higher by 15%, and particle number counts and PM_1 had modest increments of 10% and 4% in the plume. Along the riverbank, NO_x contributions were lower (8%), as would be expected from dilution at greater distances from the passing ships. Ultra-fine particles (<100 nm diameter) dominated the particulates observed, making up 75% of the distribution. The authors point out that studies that don't measure this component of the particle distribution would be missing a key part of the emissions inventory.



One day's measurements in December 2021 of ship plumes from the bridge station over the Rhine River. Ship plumes are detected as spikes in most species and a drop in ozone. Modified from Figure 3 of Eger et al., Atmospheric Chemistry and Physics, 23, 8769-8788 (2023).

One overall point confirmed by the study: The plumes from inland ships can't be compared with seagoing ship plumes. Differences in motor dimensions, fuel sulfur content, driving conditions, and particle filtering technology lead to different emission profiles.

The ships in the study had a wide range of engine types and engine ages, and the authors took a detailed look at engine characteristics to see their relationship to the emissions. One bright spot: the more modern the engine, the cleaner the plume. Only a few ships they studied had the latest engine technology, but the finding bodes well for the future. The authors estimate that fully transitioning the commercial shipping fleet, which is

bound to happen eventually, would reduce emissions by ~90% and greatly improve air quality for residents along inland rivers with heavy ship traffic.

Measurement Report: Inland ship emissions and their contribution to NOx and ultrafine particle concentrations at the Rhine, P. Eger, T. Mathes, A. Zavarsky, and L. Duester, *Atmospheric Chemistry and Physics*, **23**, 8769-8788, 2023.

Link to Published Paper

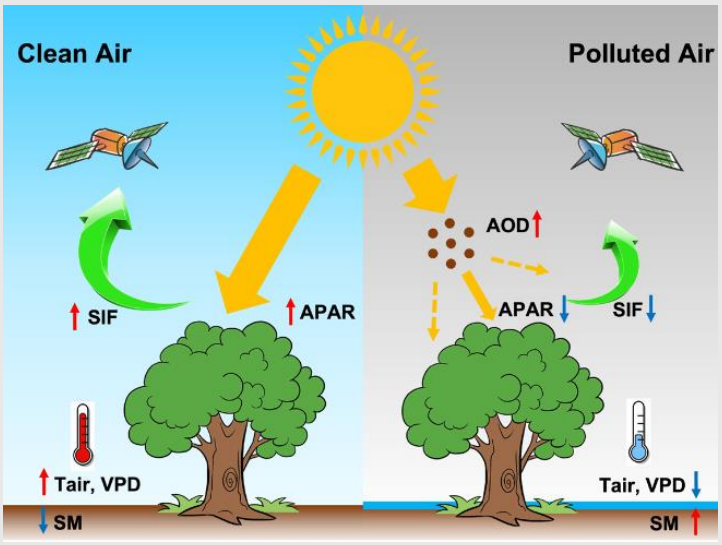
Atmosphere News

Satellite Data Show that Particle Pollution Suppresses Photosynthesis on a Continental Scale

Vegetation "Breathes" Better on Weekends

We all breathe a little easier (literally!) on the weekend, when commuter-related traffic and pollution levels are lower than during the Monday-through-Friday workweek. It turns out that crops, forests, and other vegetation are also relieved.

Several studies at the plot or site scale have shown that the productivity of ecosystems declines when fine-particle (aerosol) pollution is high, largely because less sunlight reaches the plants. It's also been shown that anthropogenic pollution follows the weekly work cycle: higher during the work week, and lower on weekends. A **new study** used data from satellites to show how these two phenomena are interrelated on a much bigger, continental scale over all of Europe.



Schematic showing how the solar-induced fluorescence (SIF) of plant chlorophyll is affected by the cleaner air on weekends (left) versus weekdays. Aerosol optical depth (AOD) is higher on weekdays, reducing the absorbed photosynthetically active radiation (APAR) of vegetation. The temperature of the air (Tair), vapor pressure deficit (VPD) and soil moisture are also influenced by aerosol pollution. [Credit: Figure 2A of He et al., Proceedings of the National Academy of Sciences, doi:10.1073/pnas.2306507120.]

The Tropospheric Monitoring Instrument (TROPOMI) onboard the Copernicus Sentinel-5 Precursor satellite measures solar-induced fluorescence (SIF). SIF is emitted by chlorophyll in vegetation, and is an indicator of the photosynthetic activity ("productivity") of vegetation. The Visible Infrared Imaging Radiometer Suite (VIIRS) instrument on the Suomi satellite measures aerosol optical depth to gauge fine particle pollution. The study, published in the *Proceedings of the National Academy of Sciences* (PNAS), uses both data sets.

A pattern of higher photosynthetic activity over the weekend was observed in about two-thirds of Europe, while aerosol pollution was reduced over most of Europe on weekends. Using other data and modeling techniques,

the authors demonstrated that the pollution was affecting the amount of sunlight reaching the vegetation, which in turn affects the photosynthetic productivity and the SIF signal seen by the satellite instrument.

By focusing on weekend versus weekday differences, the study teases out the effects of human-caused aerosols (from vehicles, factories, etc.) from natural sources of aerosols (e.g., dust, pollen, sea spray), which do not have such a weekly cycle.

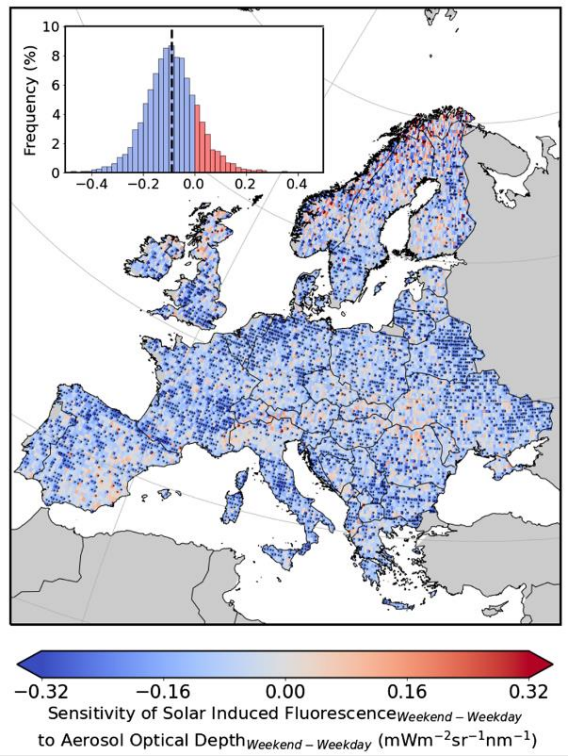


Figure showing how the solar-induced fluorescence (SIF) of vegetation chlorophyll is affected by a 1 unit increase in aerosol optical depth, derived from weekly patterns over Europe for 3 years (2018, 2019, 2021). The prevalence of blue shading shows the tendency for decreased ecosystem productivity when aerosols are increased. Black dots indicate statistically significant results. [Credit: Figure 3 of He et al., Proceedings of the National Academy of Sciences, doi:10.1073/pnas.2306507120.]

The PNAS study gives an interesting glimpse of how efforts to reduce pollution could not only boost ecosystem productivity, but also could benefit climate because the ecosystem would remove more of the greenhouse gas carbon dioxide (CO_2) from the atmosphere.

But the authors also raise a caution flag. Some proposed geoengineering schemes would inject fine particle pollution deliberately into the atmosphere, to shield sunlight and cool Earth's surface. The PNAS study shows that such schemes would also decrease crop yields and reduce how much CO_2 is removed from the atmosphere by ecosystems. As noted by the authors, "These unforeseen results underscore the intricate nature and inherent uncertainties associated with manipulating the Earth system on a large scale, highlighting the need for cautious and comprehensive evaluations when considering geoengineering as a potential solution to global climate challenges."

The weekly cycle of photosynthesis in Europe reveals the negative impact of particulate pollution on ecosystem productivity, L. He, L. Rosa, D.B. Lobell, Y. Wang, Y. Yin, R. Doughty, Y. Yao, J.A. Berry, and C. Frankenberg, *Proceedings of the National Academy of Sciences*, doi:10.1073/pnas.2306507120, 2023.

Link to PNAS Article