PAX

PHOTOACOUSTICEXTINCTIOMETER

DROPLET MEASUREMENT TECHNOLOGIES

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OVERVIEW

The Photoacoustic Extinctiometer (PAX) is a sensitive, high-resolution, fast-response instrument for measuring aerosol optical properties relevant for climate change and carbon particle sensing. The instrument directly measures in-situ light absorption and scattering of aerosol particles, from which it derives extinction, single scattering albedo and black carbon (soot) mass concentration. With no filter collection required, and consequently no filter-media artifacts, the PAX provides a highly accurate measure of absorption from black carbon.

APPLICATIONS

» Air quality and visibility
» Atmosphere and climate
» Health effects
» Combustion source emissions
» Biomass burning

Suitable for fixed site, mobile or airborne sampling.

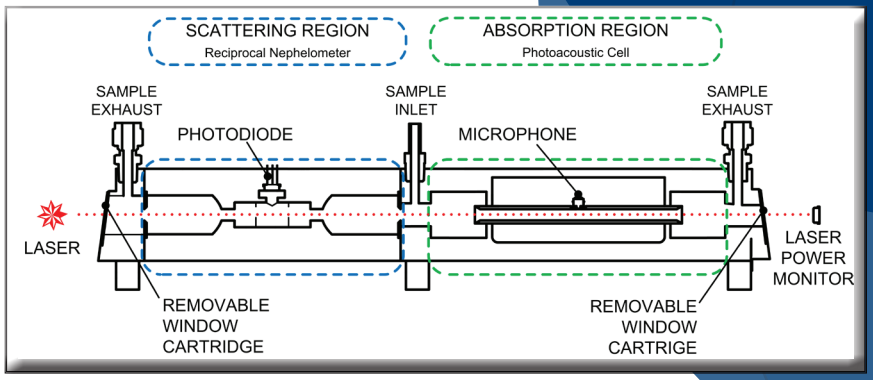
ADVANTAGES

» Direct in-situ measurement of light absorption and scattering in a single instrument
» Absorption measurement correlates to black carbon mass concentration
» Reciprocal nephelometry provides excellent scattering coefficient sensitivity
» Choice of wavelengths: 870 nm (standard); optional 405 nm or 532 nm
» Fast response, one-second resolution, real-time data display
» Wide dynamic range suitable for pristine regions to source sampling
» Continuous and autonomous operation
» High-resolution touch screen display for real-time data and instrument status
» No filter collection - no filter data artifacts

SOFTWARE

The PAX is controlled by fully integrated software that presents an intuitive user interface via either the front-panel touch-screen or a web browser on any networked computer. This interface provides real-time display of measured and calculated data and instrument status, and allows the configuration of the instrument's operating parameters. Access to this interface by web-browser is password-protected and allows full instrument operation and configuration from remote locations.

Data is written to an easy-to-read ASCII file. An external program which can be run on a network-connected computer can be used to download, archive, and display these data files. This program can also upload calibration information to the PAX and perform other maintenance functions.



HOW IT WORKS

The PAX uses a modulated diode laser to simultaneously measure light scattering and absorption. The standard 870-nm wavelength is especially sensitive to black carbon particles, since there is relatively little absorption from gases and non-BC aerosol species at this wavelength.

PAX laser wavelength options:

» Red (870 nm) – absorption is highly specific for black carbon (soot) particles; scattering best for large particles
» Green (532 nm) – measures in the visual range, typically what the human eye observes
» Blue (405 nm) – absorption correlates to the organic, or brown carbon content; efficient scattering for fine and ultrafine particles

A 1 L/min aerosol sample flow is drawn into the PAX using an internal vacuum pump controlled by two critical orifices. The flow is split between the nephelometer and photoacoustic resonator for simultaneous measurement of light scattering and absorption.

The absorption measurement uses in-situ photoacoustic technology. A laser beam directed through the aerosol stream is modulated at the resonant frequency of the acoustic chamber. Absorbing particles heat up and quickly transfer heat to the surrounding air. The periodic heating produces pressure waves that can be detected with a sensitive microphone. The system then determines the resonator quality factor and resonance frequency, which are needed to quantitatively determine aerosol light absorption. Phase-sensitive detection is used for all sensors.

The PAX uses a wide-angle integrating reciprocal nephelometer to measure the light scattering coefficient. The scattering measurement responds to all particle types regardless of chemical makeup, mixing state, or morphology.

ACCESSORIES

» Deluxe hard-shell shipping case suitable for frequent travel
» PM 1.0 and PM 2.5 cyclone inlets, 1 liter/min, for particle-size selection maintenance functions

HOW TO ORDER

Contact DMT for pricing or more information:
+1.303.440.5576,
customer-contact@dropletmeasurement.com.

PAX SPECIFICATIONS

Measured Parameters	» Absorption coefficient, Babs » Scattering coefficient, Bscat
Auxiliary Parameters	» Temperature, pressure, and relative humidity
Derived Parameters	» Black carbon (BC) mass » Extinction coefficient, Bext » Single scattering albedo, SSA » Dew Point
Measurement Range--Absorp. and Scattering	» < 1 Mm^{-1} - 10,000 Mm^{-1} (870 nm, 60 sec. averaging)
Aerosol Medium	Air, 0 - 40 °C (32 - 104°F)
Laser	» 870 nm, 1.4 W (standard); optional 405 nm and 532 nm available » Modulation frequency: 1500 Hz nominal, square wave
Angular Integration for Scattering	6 to 174°
Sample Flow	Rate: 1 L/min Flow control: Critical orifice Pump: Diaphragm
Response Time	< 10 sec; one-second resolution
Data Averaging Time	1, 10 or 60 seconds; user selectable
Calibration Interval	Recommended every 6 months, or before and after critical projects
Calibration Particles	» Absorption: Strongly absorbing particles such as black smoke from a fuel-rich gas lamp, or glassy black carbon » Scattering: Strongly scattering particles such as ammonium sulfate, or polystyrene latex (PSL) spheres, 200-260 nm diameter
Zero Check	» On demand, or automated at user selectable interval at 5, 15, 20, 30, or 60 minutes » Zero check with high-efficiency filtered air sample
Maintenance Schedule	» Flow checks as necessary » Window cartridge cleaning and replacement as necessary » Yearly replacement of consumable parts

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Boulder, Colorado, USA 80301
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PAX SPECIFICATIONS, CONT.

Front Panel Features	» Graphical color touch-panel display screen » 2 USB-A ports » Power switch » Touch screen user interface (keyboard interface can also be used)
Rear Panel Connections	» Sample inlet (compression fitting for ¼" tube) » Pump exhaust (compression fitting for ¼" tube) » AC and DC power connections » Serial RS-232 jack » Ethernet port » Two analog BNC inputs, four analog BNC outputs
Data Storage Capacity	>200 days
Communications Output	Ethernet 100/10 Mbps, RS-232 Serial
Power Requirements	90 - 264 V, 47 - 63 Hz (AC Power) or 12 VDC; 25W power consumption
Dimensions	» 18 cm H x 48 cm W x 61 cm D (7" H x 19" W x 24" D) » Rack mountable
Weight	18 kg (40 lb.)
Environmental Operating Conditions	» Temperature: 0 – 40°C (32 – 104 °F) » Relative Humidity: 0 – 90% RH non-condensing
PAX Maintenance Console (PMC) Software (included)	» Executable program written in LabVIEW » External PMC software package for instrument maintenance, data playback and archiving » Computer and PMC software are not required to operate the instrument
Computer Requirements for PMC Software	» Windows XP, Vista, or Windows 7 » Minimum 1GB RAM (Computer not included)

Specifications are subject to change without notice. The PAX is a Class I Laser Product.

The PAX System includes analytical spectrometer with internal data storage, data playback and archiving software, operator manual and one-year warranty. The standard version features an 870 nm wavelength laser; 405 and 532 nm wavelengths are also available.

Rev C-8

August 19, 2014

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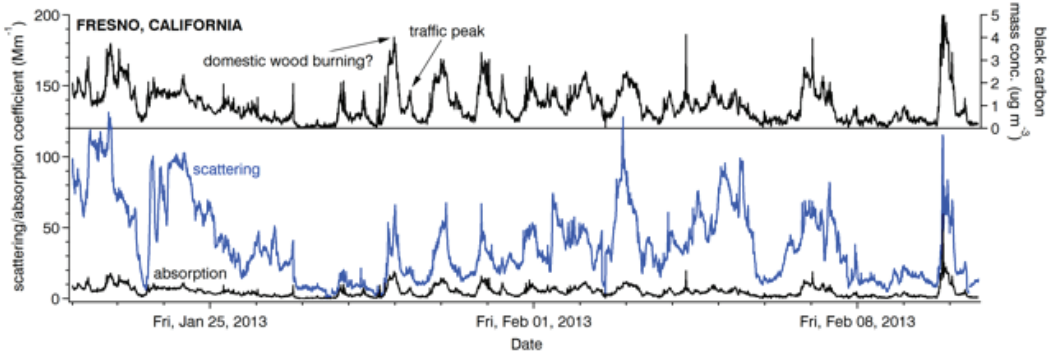
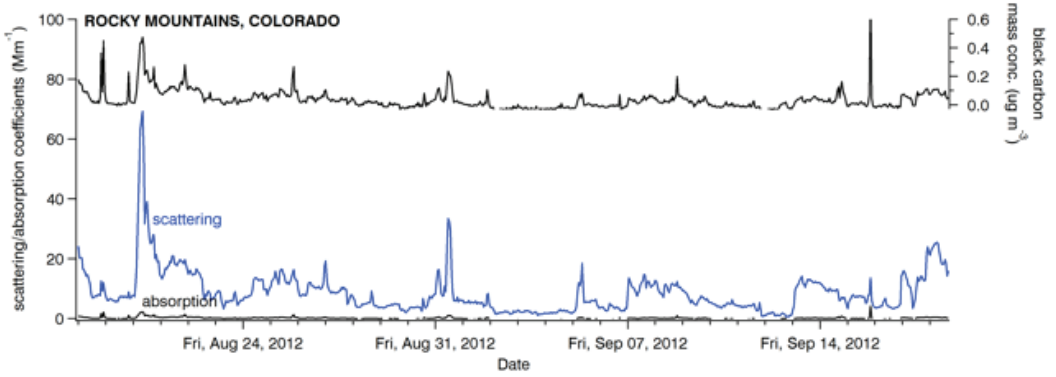
PAX Applications: Black Carbon and Aerosol Optical Property Measurements

Black carbon monitoring - urban site



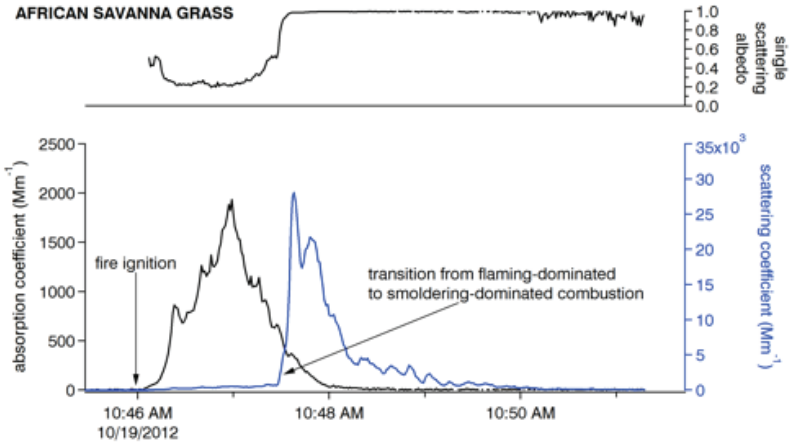
Light scattering and absorption coefficients and black carbon mass concentrations measured at the urban Fresno-Garland ground-site in California's San Joaquin Valley, January/February 2013. This data was collected with a 870 nm PAX as part of the DISCOVER-AQ project. Data are averaged to 5-minute intervals. Preliminary data suggest periods of the campaign had a large, typically nighttime biomass burning influence from domestic wood burning, with other periods having either local traffic or regional influences. The instrument was installed and operated by C. Cappa, X. Zhang and colleagues at the University of California, Davis.

Black carbon and visibility monitoring - remote site



Light scattering and absorption coefficients and black carbon mass concentrations measured at 870 nm by a PAX operating at a remote site in the Colorado Rocky Mountains during the summer of 2012. Data are averaged to 1-hour intervals. Black carbon mass concentrations were 10 to 20 times lower compared to those observed in Fresno, California (above). Scattering coefficients were approximately 10 times lower. The instrument was installed and operated in collaboration with Air Resource Specialists (Fort Collins, Colorado), Colorado State University, and the National Park Service.

Source measurements - biomass burning



Light scattering and absorption coefficients measured at 870 nm by a PAX sampling emissions from a small-scale biomass fire in a laboratory. The single scattering albedo, defined as the ratio of light scattering to light extinction, is also shown. Aerosol particles emitted during the initial, flaming-dominated period of the burn were strongly light absorbing, while those emitted during the smoldering-dominated period that followed were strongly light scattering. Data are shown at 1-second time resolution. Note scattering and absorption coefficients are shown on different scales.