Spectroscopy Applications: Radiometry

In the most basic sense, Radiometry is the measurement of radiation. Scientifically, radiometry is the detection and measurement of radiation in the optical range of the electromagnetic spectrum which includes visible light as well as extending into the ultraviolet and near-infrared ranges.

The AvaSpec line of instruments provide exceptional resolution, thermal stability, and stray-light rejection to ensure the accuracy of radiometric measurements. In addition to the spectrometer, Avantes offers a variety of sampling accessories ranging from integration sphere to cosine correctors along with NIST traceable calibration services to provide a complete Spectroradiometry system. Avantes systems can be configured over the range from 200-2500 nm and provide for exceptional portability for use in the lab or the field. Pulsed source radiometry is also an area of expertise for Avantes with many of our instruments capable of supporting high-speed measurements with 21 nanosecond jitter.

NASA's Pandora Spectrometer System

We see the application of radiometry in numerous fields of study, but possibly the most familiar uses of radiometric measurements are in climatology and astronomy.

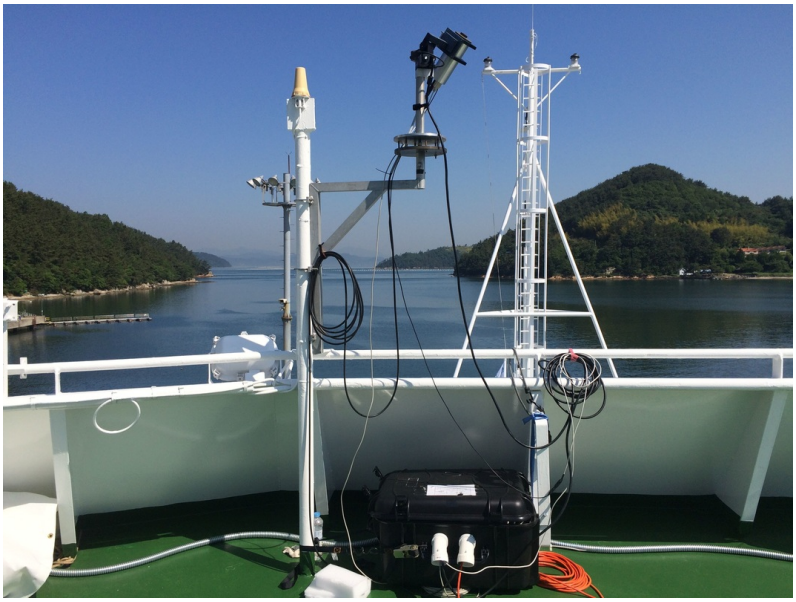
The Pandora spectrometer system, developed at NASA's Goddard Space Flight Center, has been deployed around the world to measure atmospheric constituents such as O_3, NO_2, and SO_2.

The Pandora system is a relatively small system that uses Avantes AvaSpec-ULS2048x64 back-thinned CCD spectrometers with 50-micron slit and 1200 line/mm grating. The spectrometers are optimized for the wavelength range 280-525 nm and deliver 0.6 nm resolution with 4.5x over-sampling.

Since 2006, the Pandora system has been deployed at installations around the world, from Finland and Thessaloniki to the University of Alaska and atop the NOAA station in Boulder, CO. A specialized version of the Pandora system even allows it to operate on a ship at sea under moderate wave action while still tracking the sun continuously using software to correct for motion and keep the sun centered in Pandora's field of view.

Climate and atmospheric scientists derive important information from data about the total ozone column, other trace gas constituents, and airborne particulates.

Pandora Deployment in the Chesapeake Bay



NASA led the DISCOVER-AQ project, a four-year Earth Venture mission to improve the monitoring of air quality for public and environmental health, to study trace gas pollutants in urban estuarine ecosystems. A network of ground-based Pandora spectrometers was deployed in the Washington, D.C. / Baltimore area and throughout the Chesapeake Bay waterway in July of 2011 to provide high-resolution data on air-quality variability. Researchers used information about local pollution conditions and meteorological conditions to compare with model simulations and space-based observations.

This campaign demonstrated the limitations in space-based pollution monitoring and temporal and spatial variability of near-surface Ozone (O_3) and its precursor Nitrogen Dioxide (NO_2). Near-surface, NOx is responsible for up to 70% of nitrogen loading in urban waterways and can have significant effects on terrestrial and aquatic ecosystem health.

The portability of the Pandora system allowed continuous measurements of total column O3 and NO2 and captured data on short-term and small-scale dynamics in near-surface trace gas pollution that satellite data did not detect.

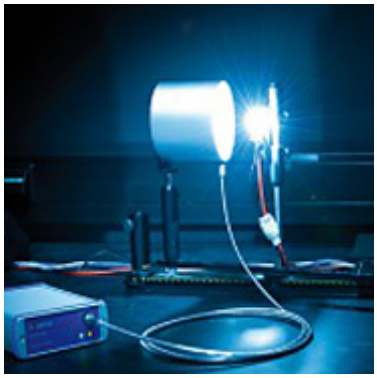
Radiometry for Particulate Intrusions

Italian researchers, Pavese et al., combined visible light radiometry, Raman LiDAR and ground meteorological sensors to track the extent of dust intrusion over southeast Italy carried by air masses across the Mediterranean

from the northwest Sahara Desert and anthropogenic particulate from northern Europe. These aerosols and particulates pose a health and environmental hazard, particularly when near ground surface where they can be inhaled.

Aerosol Optical Depth is the measurement of sunlight prevented from reaching the ground by dust and particulate suspended in the atmosphere. The value is dependent on the amount of particulate in a vertical column over the observation point with spectra measured at 451, 670, and 870 nm. These measurements were obtained with an Avantes spectroradiometer instrument calibrated for the 400-900 nm wavelength range such as the AvaSpec-ULS2048L, a versatile optical system with back-thinned CCD detector and resolution as high as 0.06 nm.

Radiometry for Calibration



Another common application for radiometric measurements is the calibration and certification of other systems. The National Renewable Energy Laboratory in Golden Colorado uses a three-channel AvaSpec instrument to profile some of their solar simulators. The system consists of an AvaSpec-ULS2048XL back-thinned CCD spectrometer for the range from 300-1100 nm, an AvaSpec-NIR512-1.7-TEC spectrometer for the range from 1000-1700 nm and an AvaSpec-NIR256-2.5-TEC for the range from 1700-2500 nm. The system supports 1 millisecond integration times after being externally triggered by the solar simulator devices. Light is collected via an AvaSphere-50-IRRAD 50 mm integrating sphere. Avantes systems facilitate calibrations of solar simulators to the IEC60904-9 and IEC60904-16 via an external software solution.

Radiometry in Process Control

Spectroradiometers are frequently used in process control for the manufacturing of emitting devices such as LEDs, VCSELs, and others. The ability to measure sources of various power levels, wavelength ranges with continuous or pulsed output make a spectroradiometer an ideal tool for process control. While absolute calibration is typically desirable for this application, relative calibration compared to a reference or gold standard is also possible. Avantes works closely with a variety of VCSEL manufacturers to provide high-resolution spectral profiling as well as power measurements on their devices during the manufacturing process.

Avantes Radiometry

Typical radiometry systems from Avantes consist of one or more spectrometers which span the range from 200-2500 nm. In the case of multi-channel spectrometers, where more than one optical bench and detector is required, Avantes offers housings to integrate all the devices into a single instrument and software that provides for merging of these channels into a single data file. Most instrument configurations involve fiber optic connections which are fitted with standard, keyed FCPC connectors to ensure maximum repeatability and portability. Affixed to the fiber optics are any one of Avantes' sampling accessories for radiometry or a customer provided device. Most systems are radiometrically calibrated using our direct NIST standard calibration lamp following our ISO documented procedures. For more information about any of Avantes solutions for radiometry, please contact a Sales Engineer.

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