





Vicarious Radiometric Calibration

"Radiometric calibration refers to a set of techniques that are applied during remote sensing data processing and includes corrections related to the sensitivity of the remote sensor, topography and sun angle, and atmospheric scattering and absorption." ("Radiometric Calibration", 2016)

"Vicarious calibration refers to any approach that does not rely on an onboard calibrator." (Thome, 2002)

The value of VNIR and Full-Range Spectroradiometers for Vicarious Radiometric Calibration:

- "Due to the rigors of launch and the harsh environment of space, it becomes necessary to perform evaluations of the radiometric performance of a sensor once on orbit, as well as over the course of its operational life, to insure its accurate absolute radiometric calibration. While several techniques are available to calibrate a sensor on orbit, few offer the direct traceability that is obtainable by vicarious calibration." (Leigh et al., 2013)
- "The utility of a satellite imager for scientific analysis necessitates a quantitative understanding of the sensor's accuracy either in a relative or absolute sense. In particular, long-term monitoring of climate variables requires an assessment of the temporal variation of the sensor accuracy." (Minnis et al., 2002)
- "Comparison of 'predicted' radiance with the radiance measured by the sensor provides a check on the sensor calibration and sensor control of stray light." (Smith, 2002)
- "Accurate radiometric calibration of a sensor allows for atmospheric correction of data and retrieval of surface reflectance. Calibration also allows for a correction of instrument drift over time and for comparison of datasets from different sensors." (Biggar et al., 2003)
- "Calibrating imaging spectroscopy data to surface reflectance is an integral part of the data analysis process, and is vital if accurate results are to be obtained." (Clark et al., 2002)
- "The accuracy and precision of ground-based vicarious calibration depends on the instrumentation used to measure both the atmosphere and surface at the test location." (Czapla-Myers et al., 2008)
- "The field collection of reflectance spectra of intact materials (often referred to as ground truth data collection) is essential for interpreting unknown materials in multispectral and hyperspectral remote sensing data, and validating sensor performance." (ASD Inc., 2014)

- "It is common place to use field spectroscopy as part of an image analysis program. ...Field spectral data provide information for calibrating and testing imagery reflectance, determining the spectral features of target species, and evaluating their detectability in the presence of other plant species." (Ustin & Santos, 2010)
- "The radiometric calibration depends on measurements of the reflectance of the bright surface and characterization of the atmospheric path from the sun to the surface and then to the sensor." (Biggar et al., 2003)



Figure 1. Considerations for spectral imaging sensor calibration to reflectance and correcting for atmospheric effects. (ASD Inc., n.d.)



Figure 2. Compare ground endmember spectra to overflight spectra. (ASD Inc., n.d.).



The Solution:

ASD field portable spectroradiometers have optimal signal-to-noise design for faster measurements, and wide spectral coverage of 350-2500 nm that is ideal for the vicarious radiometric calibration of a wide range of aircraft and satellite remote sensing systems.

Used in conjunction with 8 to 10° field-of-view fore optics and a calibrated Spectralon panel, ASD's FieldSpec® 4 spectroradiometer enables rapid collection of the grid of surface reflectance spectra necessary to characterized calibration targets used for vicarious radiometric calibration of imaging sensors. ASD's direct irradiance receptor coupled to a solar tracking stage turns the ASD FieldSpec 4 spectroradiometer into a hyperspectral sun photometer enabling the calculation of the atmospheric scattering parameters necessary for accurate vicarious calibrations.

ASD offers different instrument configurations and additional accessory options for a variety of set-up and sampling approaches for a versatile, wide range of measurement scenarios.

ASD instruments offer a practical solution to analyze Vicarious Radiometric Calibration data measurements.



Full-range spectroradiometers designed specifically around the challenges researchers face when performing spectral measurements in the field.



FieldSpec 4 Features:

SWIR Detector Packages:

- Two stage thermo electric cooling to reduce dark current and noise.
- Shunt resistance optimized to reduce dark current and noise.
- SWIR 2 responsive out to 2.55 microns at -20Deg C for optimal S/N at our instrument performance specification limit of 2.5 microns.

SWIR Dispersion Elements:

- Concave holographic reflective diffraction gratings are master gratings, not replicates.
- Optimized aberration reduction.
- Optimized response and resolution.

Built-in Fiber Optic Cables:

- Low OH fibers for optimal signal transmission.
- Hard mounted, continuous (not jumpered), direct to dispersion elements for optimal signal transmission.
- Constructed with steel coil jacket and Kevlar fiber to protect fiber optics.

NIST Traceable Calibration Facilities:

- Wavelength calibrations from various NIST traceable sources including many emission lines from Neon, Mercury, Argon, Krypton, and Xenon.
- Wavelength verifications on various reflectance standards including NIST traceable pucks.
- NIST traceable FEL lamps.
- Radiometric calibration facilities that have been compared to NASA-Ames Research Center and Los Alamos National Laboratory and have been found to be within 1% of both facilities.
- Main calibration source cross checked against second source for every instrument.

ASD's RS^{3™} Software:

• Highly developed spectral curve generation functions to optimize spectral performance and to reduce noise to the lowest possible level.



FieldSpec HandHeld 2 a versatile and durable handheld spectroradiometer that utilizes the FieldSpec 4 VNIR spectrometer for accurate analysis in the 325 – 1075 nm spectral range.

FieldSpec* HandHeld



Ideal for Vicarious Radiometric Calibration applications

- Portable solution
- Simple, rapid and cost effective real-time measurement (data and analysis in the field)
- Use to ground truth hyperspectral and multispectral imaging data



Optional fore optics for wide and small field-of-views, for use with the FieldSpec and HandHeld 2 spectroradiometer, to meet a variety of applications:

- Lenses which limit the field-of-view from 1 to 25 degrees
- A radiometric calibration for radiance (W/m²/steradian/nm) measurements
- Diffuse transmission and reflective type cosine receptors and radiometric calibrations for measuring full sky irradiance (W/m²/nm)

ASD pioneered the science of field spectroscopy over 25 years ago and continues to lead the industry with the world's most trusted field-portable spectroradiometers.

References

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Which FieldSpec spectroradiometer is best suited for my application?

All ASD FieldSpec spectroradiometers provide 3 nm spectral resolution in the VNIR (350 nm – 1000 nm) range. Several spectral resolution options are available for the SWIR (1001 nm – 2500 nm) range to better address specific user needs and provide superior performance across the full solar irradiance spectrum (350 nm – 2500 nm).

FieldSpec 4 Hi-Res NG: The enhanced 6 nm SWIR spectral resolution provides both the sampling interval and spectral resolution necessary for accurate sensor calibration and image ground truthing for the next generation of sub-10 nm spectral resolution hyperspectral imagers such as the Next Generation Airborne Visible/Infrared Imaging Spectrometer (AVIRIS-NG) and HySpex ODIN.

FieldSpec 4 Hi-Res: The 8 nm SWIR spectral resolution is particularly useful for detecting and identifying compounds with narrow spectral features in the longer wavelengths. The FieldSpec 4 Hi-Res is an excellent choice for standard sensor validation and calibration, as well as ground truth measurements and building spectral libraries.

FieldSpec 4 Standard-Res: The 10 nm SWIR spectral resolution meets the technical requirements of most field researchers seeking to characterize typical spectral features with widths of 10 nm to 50 nm. The FieldSpec 4 Standard-Res has long been the industry's number one choice for trusted NIR field spectroscopy.

FieldSpec 4 Wide-Res: The 30 nm SWIR spectral resolution is an ideal fit for applications such as vegetation analysis and vegetation indices that are characterized by broad spectral features. The wider optical slit provides superior signal throughput and signal-to-noise performance.

Resolution			Application			
Hi-Res	Standard-Res	Wide-Res	Ideal Adequate Not recommended			
			Asbestos detection			
			Atmospheric research			
			Camouflage			
			Concrete and aggregates			
			Cosmetics			
			Crop science			
			Food and agricultural products			
			Forestry			
			General material identification			
			Geologic mapping			
			Hyperspectral image ground truthing			
			Landscape ecology			
			Multispectral image ground truthing			
			Pharmaceuticals and nutraceuticals			
			Photonics			
			Pigment/color analysis vegetation			
			Plant physiology			
			Plastics/petrochemicals			
			Quantitative analysis			
			Sensor and radiometric calibration			
			Snow and ice research			
			Soil mineralogy			
	Spectral library creation					
			Water body/column analysis			

FieldSpec 4 specifications

Product		FieldSpec 4 Hi-Res NG	FieldSpec 4 Hi-Res	FieldSpec 4 Standard-Res	FieldSpec 4 Wide-Res
Spectral range		350 – 2500 nm			
Resolution		3 nm @ 700 nm 6 nm @ 1400/2100 nm	3 nm @ 700 nm 8 nm @ 1400/2100 nm	3 nm @ 700 nm 10 nm @ 1400/2100 nm	3 nm @ 700 nm 30 nm @ 1400/2100 nm
Noise Equivalent Radiance (NEdL)	VNIR	1.0 x 10 ⁻⁹ W/cm ² /nm/sr @ 700 nm	1.0 x 10 ⁻⁹ W/cm ² /nm/sr @700 nm	1.0 x 10 ⁻⁹ W/cm²/nm/sr @ 700 nm	1.0 x 10 ⁻⁹ W/cm²/nm/sr @700 nm
	SWIR 1	8.0 x 10 ⁻⁹ W/cm ² /nm/sr @ 1400 nm	1.4 x 10 ⁻⁹ W/cm ² /nm/sr @ 1400 nm	1.2 x 10 ⁻⁹ W/cm ² /nm/sr @ 1400 nm	1.5 x 10 ⁻⁹ W/cm ² /nm/sr @ 1400 nm
	SWIR 2	8.0 x 10 ⁻⁹ W/cm ² /nm/sr @ 2100 nm	2.2 x 10 ⁻⁹ W/cm ² /nm/sr @ 2100 nm	1.9 x 10 ⁻⁹ W/cm ² /nm/sr @ 2100 nm	2.8 x 10 ⁻⁹ W/cm ² /nm/sr @ 2100 nm
Height x width x depth		12.7 x 36.8 x 29.2 cm			
Weight (w/o battery)		5.44 kg (12 lbs)			



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