Contamination of Ground Spectral Measurements Due to Operator Proximity

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Ground Spectral or Field Spectrometry Measurements

• Plays an important role in many remote sensing campaigns
  • Vicarious or Scene-based calibration
  • Ground validation studies
  • Used in support of airborne and spaceborne acquired imagery
Ground Spectral or Field Spectrometry Measurements

• Accuracy requirements
  • varies depending on application
  • can be significantly influenced by the methodology used to make the ground measurements.
  • operator proximity to either the reflectance reference panel or the target of interest is one such issue that can have an impact the quality of the results.

• Question - How significant and what is the nature of the errors induced by operator proximity?
Although the issue of scattering of incident light off nearby objects is commonly referred to, only one published article was found attempting to quantify the effect.


- The reported results were simulated and for two channels, a broad red and a broad near IR band, for a black and white object.

- Wanted to get a handle on what the impact is on the quality of ground spectrometer measurements.

From Kimes et al. 1982
Panel Substitution Methodology (PSM)

\[ R_T(\lambda) = \frac{S_T(\lambda)}{S_R(\lambda)} \times R_R(\lambda) \]

where
- \( R_T(\lambda) \) = Target Reflectance
- \( R_R(\lambda) \) = Reference Panel Reflectance
- \( S_T(\lambda) \) = Target Signal
- \( S_R(\lambda) \) = Reference Panel Signal

- Radiometric System Linearity
- Instrument Stability
- Stability of Illumination conditions between reference and target measurements.
- Spectral reflectance of the reference
- Field-of-View (Target homogeneity)
Field Spectrometer Deployment Photos From Google Images
Data Acquisition

- Tripod mounted ASD Field Spec3 with 1° FOV at 1.4 m AGL
- Spectralon reference panel at 0.9 m AGL
- 1.89 m Operator
- Cloudless sky
- Open field (low horizons)
- 31° Solar Zenith Angle
- Quick data acquisition sequence (2 minutes) to minimize fluctuations in the downwelling irradiance
- Measurements of Spectralon Panel acquired with operator separation of +10m (reference), 0.15, 0.30, 0.45, 0.90, 1.40, 2.00, and +10 m (alternate reference)
Operator Induced Error - Definition

Operator induce error is define as the ratio of signal acquired with obscuration of the diffuse light by the operator (the reference measurement) to the signal acquired without operator obscuration (the target measurement).
Operator Proximity: Antisolar Position

Operator separation: 10+ m (alternate reference)
Operator Proximity: Perpendicular Position

Operator separation: 10+ m (alternate reference)

![Graph showing Operator Induced Error - Perpendicular Position](image)

- Approximate Separation (m):
  - 0.15
  - 0.30
  - 0.45
  - 0.90
  - 1.40
  - 2.00

Ratio (Target Panel / NRC01 Panel)

Wavelength (nm)
Operator Induced Error as a Function of Separation Distance

Operator Induced Error - Antisolar

Operator Induced Error - Perpendicular to Solar Plane

Operator Induced Error as a Function of Separation Distance

Operator in antisolar position - 400 nm
Operator in perpendicular position - 400 nm
Operator in antisolar position - 800 nm
Operator in perpendicular position - 800 nm

Seperation Distance (m)
Shirt Reflectance

Shirt Material Reflectance

- Antisolar
- Perpendicular
- on Panel
- Diffuse Skylight

Effective Reflectance vs Wavelength (nm)
Modeling impact of operator as function of % obstructed skylight

Operator Induced Error - Antisolar

Operator Induced Error - Perpendicular to Solar Plane

25% sky obstruction
Relative Error

Operator Induced Error - Relative

- relative error 1.40 m / 0.45 - antisolar
- relative error 1.40 m / 0.45 - perpendicular

Ratio (Target Panel / NRC01 Panel)

Wavelength (nm)
Same separation distance, different reference/panel heights
Field Spectrometer Deployment Photos From Google Images
Measurement error due to panel tilt

Influence of Panel Angle Error in Perpendicular Plane (Global Irradiance)

Ratio (Target Panel / NRC01 Panel) vs. Wavelength

- 0° Global
- (+) 2.7° Global
- (+) 5.2° Global
- (+) 7.5° Global
- (+) 9.8° Global
- (+) 15.3° Global
- (-) 0° Global
Discussion

• the error introduce by a nearby operator or other object can be minimized by attempting to ensure that the obscured background irradiance field remains consistent for both the reference and target measurement.

• using black/dark clothing does not necessarily reduce the error.

• elevated objects, clouds, or haze on the horizon would complicate the situation.

• hemispherical photos from the position of the reference/target would have allowed for a more detailed analysis.

• what, if any, is the impact of the nearby object on the spectral reference reflectance applied to the to the PSM equation?
Conclusions

• The impact of operator proximity on field spectroscopy measurements can be understood, at least in broad terms.

• The estimated “errors” identified in this work represent a worst case scenario
  • the operator non-existent in one measurement then introduced into the downwelling irradiance path in the other.
• The information can, however, be extended to estimate the error in less significant scenarios.

• Errors approached 0% at 2 m separation for the test scenario.

• Knowledge gained here also applies to nearby structures and objects that impact the downwelling irradiance on either the reference or target measurement or both.

• To minimize signal contamination when operator proximity cannot be avoided, it may be possible to determine:
  • an optimal operator material in terms of spectral composition
  • the least obstructive position of for an operator
  • a first order correction???
Thank you - Questions?

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