Surface reflectance validation

Carroll E ; Goulden T ; Chadwick K D ; Ade C ; Eckert R ; Brodrick P ; Breckheimer I (2026): Custom surface reflectance, shade mask, and equivalent water thickness maps for the Colorado Headwaters Ecological Spectroscopy Study (2025). Watershed Function SFA, ESS-DIVE repository. Dataset. doi:10.15485/3013535

Methods

We collected *in situ* reflectance spectra with an ASD FieldSpec 4 Hi-Res NG Spectroradiometer (Analytical Spectral Devices Inc., Boulder, CO, USA; Malvern Panalytical) using the palm grip foreoptic and 8° FOV. from a diverse set of surfaces with varied cover type and topography in coordination with the CHESS airborne campaign (Carroll et al., in prep). To validate the surface reflectance retrievals, we filtered these collections to (1) those measured within one week of overflight, (2) where we had sufficient spatial information to extract corresponding NEON image spectra with high confidence, and (3) where the corresponding NEON image spectra did not contain shadows from surrounding vegetation or topography. This left three sites: a flat asphalt surface at the Crested Butte Airpark (airpark, **Figure 1**), a talus field with a slope of 30° (talus_slope, **Figure 2**), and a flat grassy surface in Rainbow Park (rainbow_park_grass, **Figure 3**). See **Table 1** for site details.

For each site, we collected approximately 25 spectral measurements and calculated the mean reflectance spectrum. We smoothed the mean spectra with a Savitzky-Golay filter with a window length of 71 and a polynomial order of 2. For each NEON overflight of a site made within one week of the *in situ* measurement, we manually delineated a polygon corresponding to the *in situ* measurements and extracted the surface reflectance estimates and uncertainties for each pixel centered within the polygon. We calculated the mean surface reflectance and uncertainty estimate across pixels (**Figures 4-6**). We then calculated the mean absolute error as the difference between the smoothed mean *in situ* reflectance and the mean extracted surface reflectance estimate for each site/overflight event averaged across wavelengths. Finally, we calculated the average mean absolute error (mae) across all overflights of each site.

Results

The surface reflectance retrievals achieved a mean absolute error of 1.5% across diverse validation surfaces (**Table 2**). Accuracy was highest at the Crested Butte Airpark (mae=0.008) and Rainbow Park grass (mae=0.011) sites and lowest at the sloped talus field site (mae=0.026).

Table 1.
Site details. Easting and northing in EPSG 32613.

site	date collected	easting	northing
airpark	20250626	332259.929	4302439.228
talus_slope	20250622	330209.361	4305434.709
rainbow_park_grass	20250622	328580.388	4304300.140

Figure 1.
Photo of the Crested Butte Airpark validation site (airpark).

Figure 2.
Photo of the talus field validation site (talus_slope).

Figure 3.
Photo of the grassy Rainbow Park site (rainbow_park_grass).

Figure 4.
Mean extracted surface reflectance plus or minus the estimated uncertainty per flightline and the smoothed mean *in situ* reflectance (black).

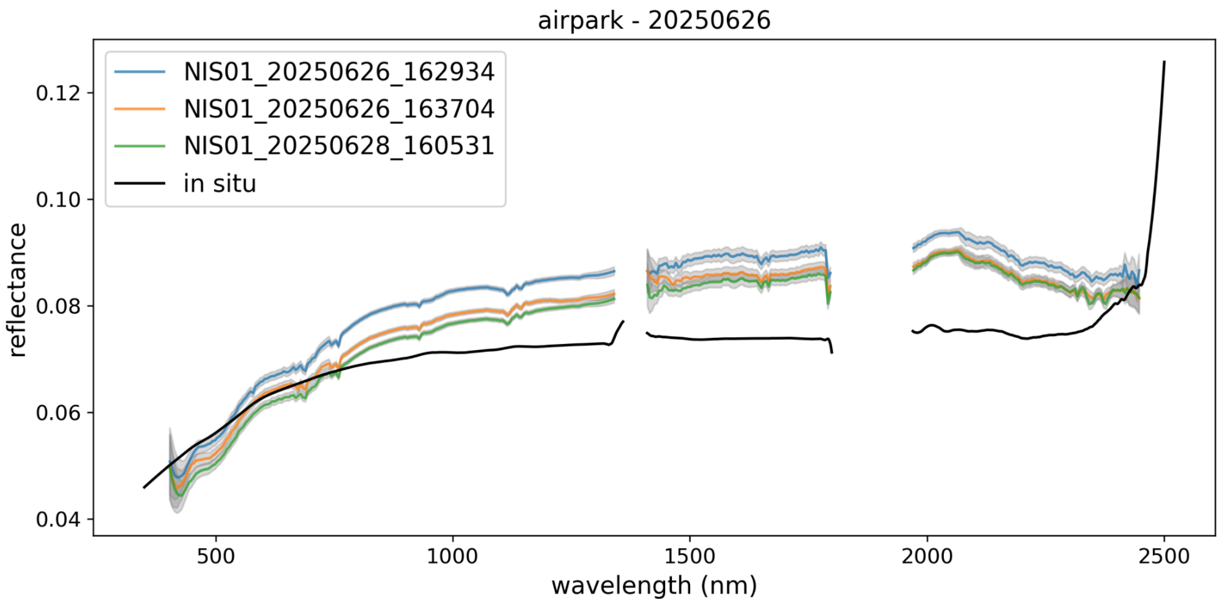

Figure 5.

Mean extracted surface reflectance plus or minus the estimated uncertainty per flightline and the smoothed mean *in situ* reflectance (black).

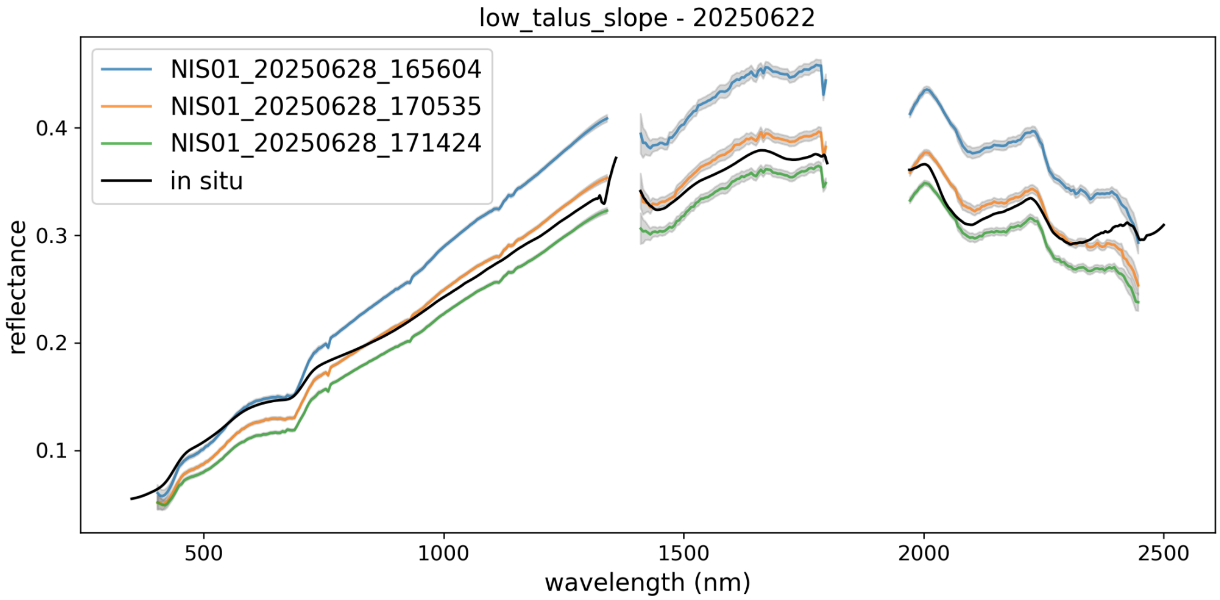

Figure 6.
Mean extracted surface reflectance plus or minus the estimated uncertainty per flightline (gray bands) and the smoothed mean *in situ* reflectance (black).

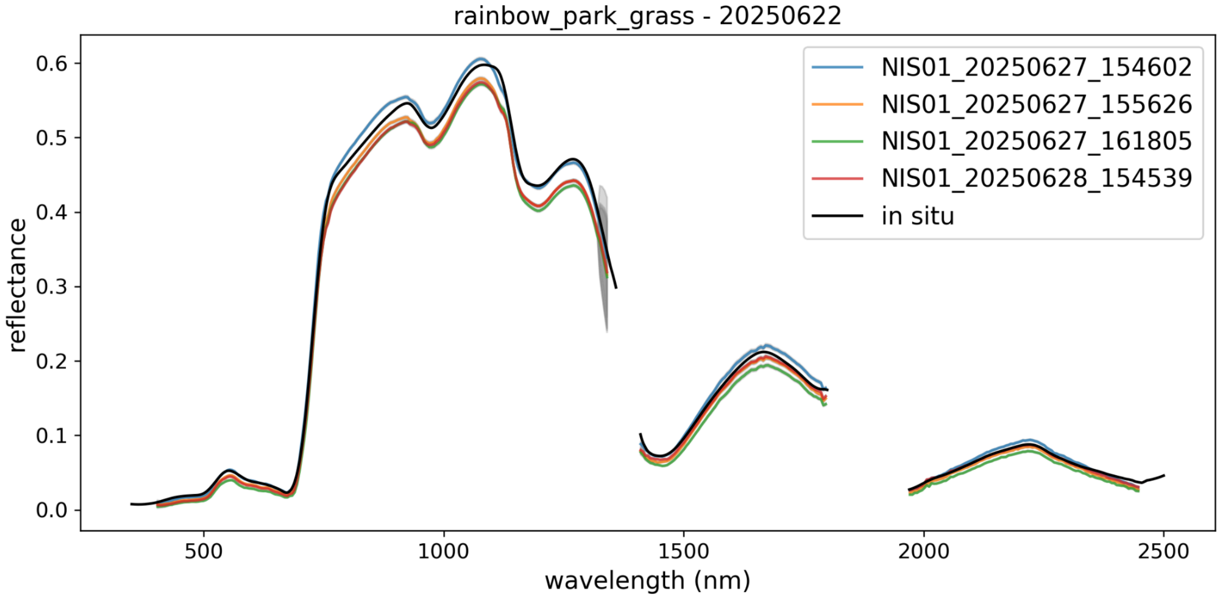

Table 2.
Mean absolute error across wavelengths.

site	date in situ	fid	mae	
airpark	20250626	NIS01_20250626_162934	0.011	0.008
		NIS01_20250626_163704	0.007	
		NIS01_20250628_160531	0.007	
rainbow_park_grass	20250622	NIS01_20250627_154602	0.006	0.011
		NIS01_20250627_155626	0.011	
		NIS01_20250627_161805	0.017	
		NIS01_20250628_154539	0.012	
talus_slope	20250622	NIS01_20250628_165604	0.046	0.026
		NIS01_20250628_170535	0.012	
		NIS01_20250628_171424	0.020	