

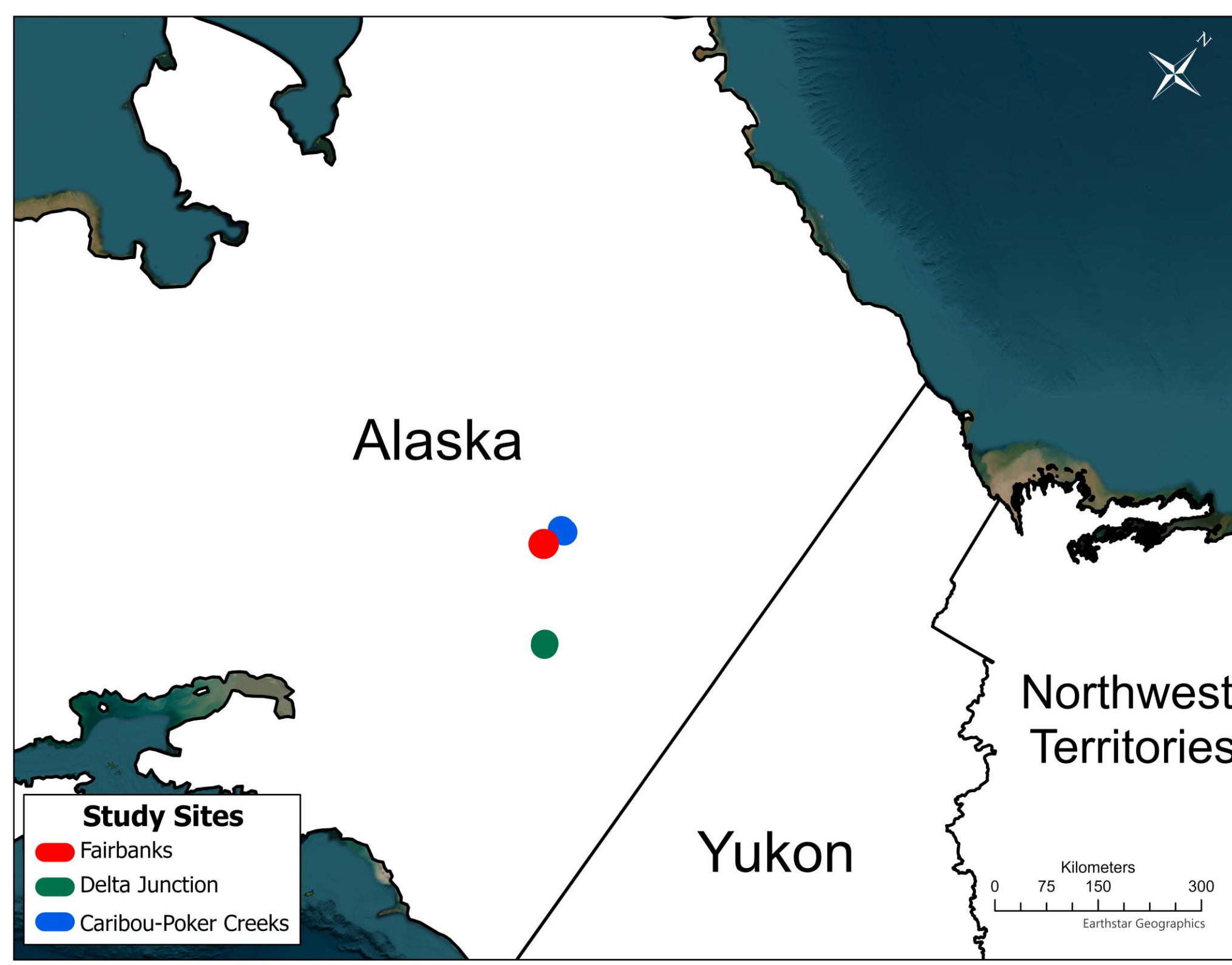
# Analyzing variation in snow albedo across scales of observation in the Alaskan boreal forest

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## Boreal Forest Snow Albedo

Snow albedo plays a critical role in Earth's energy. Two factors control snow albedo: **grain size** and **light absorbing particles (LAPs)**. After a wildfire, LAPs, such as black carbon and woody debris, are deposited on the snow surface, decreasing the snow surface albedo. At high latitudes, snow albedo changes dramatically as insolation increases during the spring. This project aims to reduce snow albedo uncertainty across the heterogeneous boreal forest landscape, before and during spring snowmelt. This work will significantly improve climate model parameterizations of snow albedo in a climatically-sensitive region.



**Figure 1:** Map of study sites from the SnowEx Snow Albedo 2023 Project.

### Our objectives include:

1. Characterizing snow albedo across spatial scales in burned and unburned forests;
2. Evaluating uncertainties of snow albedo in existing remote sensing products;
3. Developing snow albedo calibration/validation site data for future space-borne missions.

## Snow Measurements and Model Output

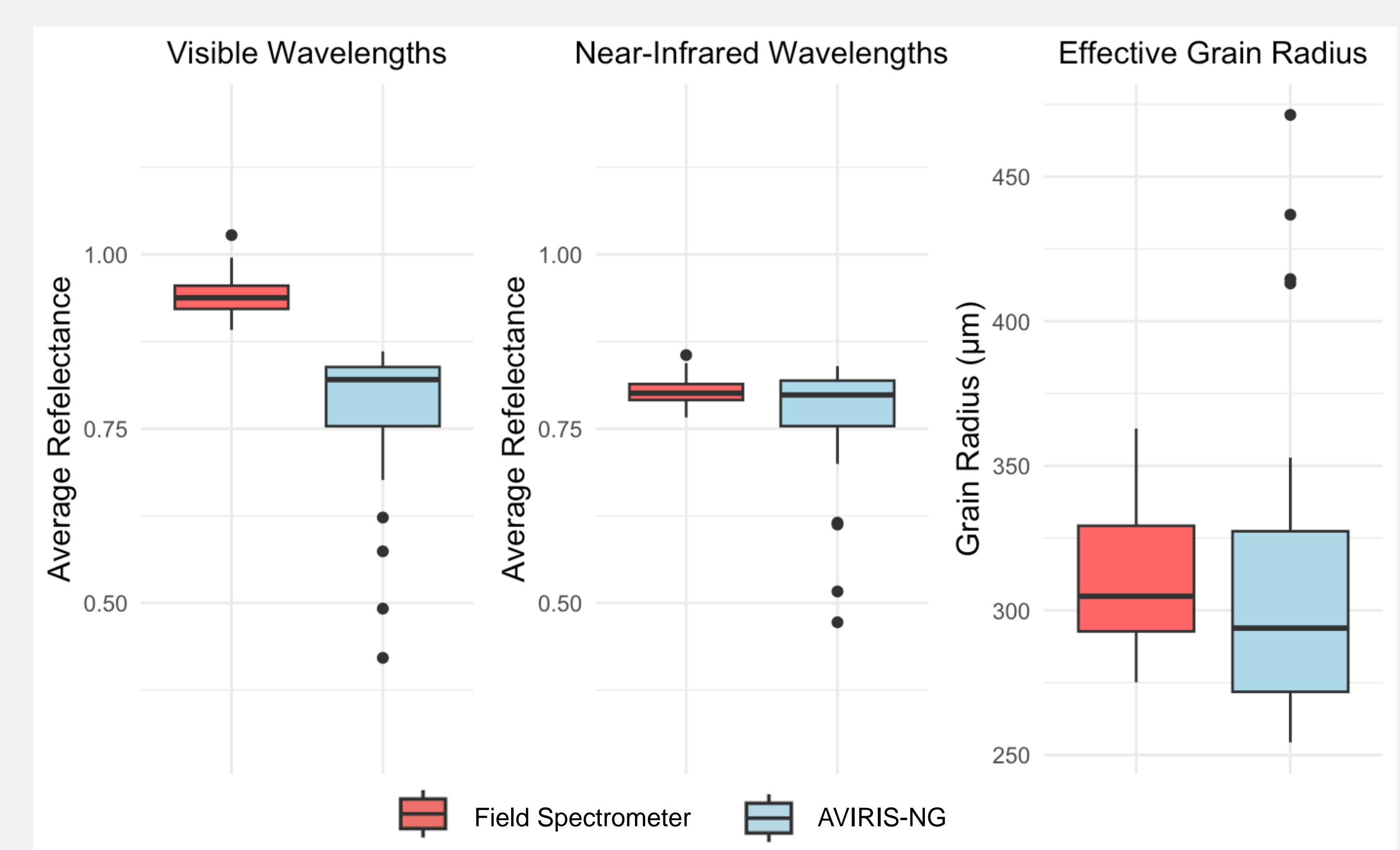
We compare snow surface reflectance values at two spatial scales: an *in situ* field spectrometer and the Airborne Visible-Infrared Imaging Spectrometer-Next Generation (AVIRIS-NG). Measurements were made along transects in forested, open and burned areas, with coincident AVIRIS-NG flights during April 2023. Measurements were compared with output from the Snow, Ice and Aerosol Radiative (SNICAR) model. Values for effective grain radius ( $r_{eff}$ ) were estimated using data from both instruments and the model.

**Table 1. Spectrometer Data and Model Output**

Data Product	Spectral Range (nm)	Spectral Resolution (nm)	Spatial Sampling (m)
Field Spectrometer	350-2500	2.8-6	<0.5
AVIRIS-NG	380-2510	5 ± 0.5	4-5
SNICAR Model	205-4995	10	model parameters

## Key Findings

The spatial scale of observation matters. In-situ field spectrometer data, which are snow-only in the field of view, are consistently higher than AVIRIS-NG values, which include sparse vegetation and shadows.



**Figure 2.** Comparison of field spectrometer and AVIRIS-NG data for the open transect at Delta Junction (pictured below). Effective snow grain radius was estimated using the SNICAR modeled relationship.

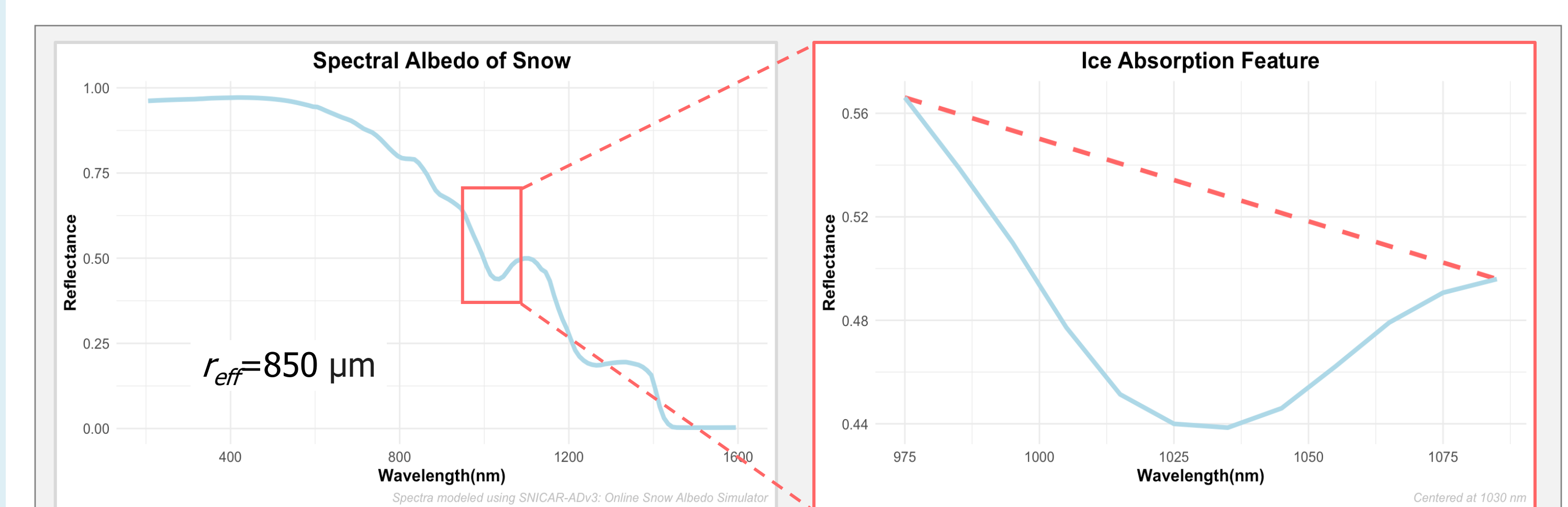


## Computing Effective Grain Size

Grain size affects snow albedo. Effective grain radius can be estimated from the area of a near-infrared ice absorption feature. Here are the steps we use to estimate  $r_{eff}$  and relate to snow albedo.

1. Estimate model input parameters given location, snowpack and atmospheric conditions
2. Run SNICAR-Adv3 for  $r_{eff}$  from 50-1500 microns
3. Calculate scaled band area (SBA) of **modeled** snow spectra (Nolin and Dozier, 2000)

$$\text{Scaled Band Area} = \int_{\lambda=975 \text{ nm}}^{\lambda=1085 \text{ nm}} \frac{R_{cont,\lambda} - R_{snow,\lambda}}{R_{cont,\lambda}} d\lambda$$



**Figure 3.** Scaled band area method applied to estimate  $r_{eff}$ , where the dashed red line is the continuum and solid blue line is snow reflectance.

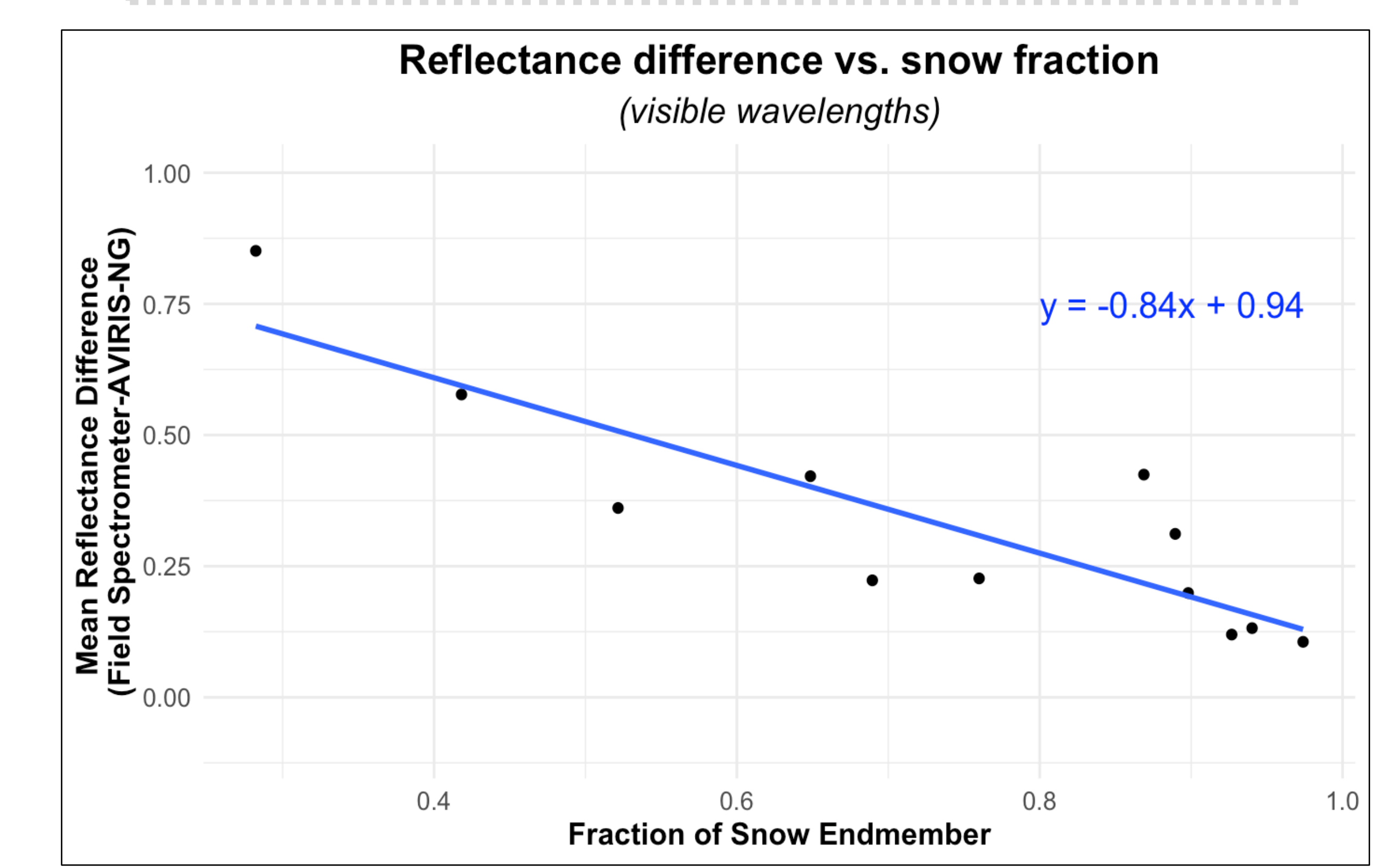
4. Calculate SBA of *in situ* measurements
5. Estimate  $r_{eff}$  of snow using modeled relationship between SBA and  $r_{eff}$

## Linear Spectral Unmixing

### Estimate fraction of snow and vegetation in mixed pixels

$$R_c = \sum_{i=1}^n F_i R_{i,c} + E_c$$

F = fraction of endmember  
 c = hyperspectral channel  
 n = endmember  
 R = reflectance  
 E = error



**Figure 4.** The mean reflectance difference between the field spectrometer and AVIRIS-NG in the visible wavelengths as it relates to the fraction of snow endmember.