Calibration Targets of the Southwest: Albedo and Homogeneity Comparisons Using AVIRIS Data

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Abstract: Various locations in the southwestern U.S. are used to calibrate remote sensing instruments. This study shows how some of these targets compare in terms of albedo and homogeneity, and records the variation of these factors for a single location (Ivanpah Playa) over a period of one year. Results indicate that there is a great deal of variation among these targets in albedo, spectral flatness, and surface uniformity, and that these factors can change throughout the year.

Introduction: The targets chosen for this study are listed in Table 1.

Table 1: Targets included in study

playa name	date of image	latitude	longitude
Ivanpah Playa	960408	35°32'30"	115°23'40"
	960615		
	961101		
	970304		
Lunar Lake	940405	38°23'41"	115°59'37"
Rogers Dry Lake (Edwards AFB)	930518	34°55'19"	117°50'30"
	970228		

These playas have been chosen for AVIRIS radiometric calibration experiments because of their size, high albedo, spectral flatness, and homogeneity. These factors are critical for a variety of reasons. First, large target is easily located in the final image, and a gives the field team a good selection of possible sites to set up. Second, a bright target provides good signal/noise for a radiometric calibration, while spectral flatness guarantees that detectors in all bands receive sufficient signal/noise for calibration. Finally, spatial homogeneity in the calibration area ensures that the field data and remotely sensed data can be compared with minimal concern about sampling issues. If the region were not homogeneous, it would be difficult to be sure if the spectra collected by the field team were representative of the calibration region as a whole.

Figure 1 illustrates spectral data for the 3 playas, and emphasizes their spectral flatness in comparison to White Sands National Monument.

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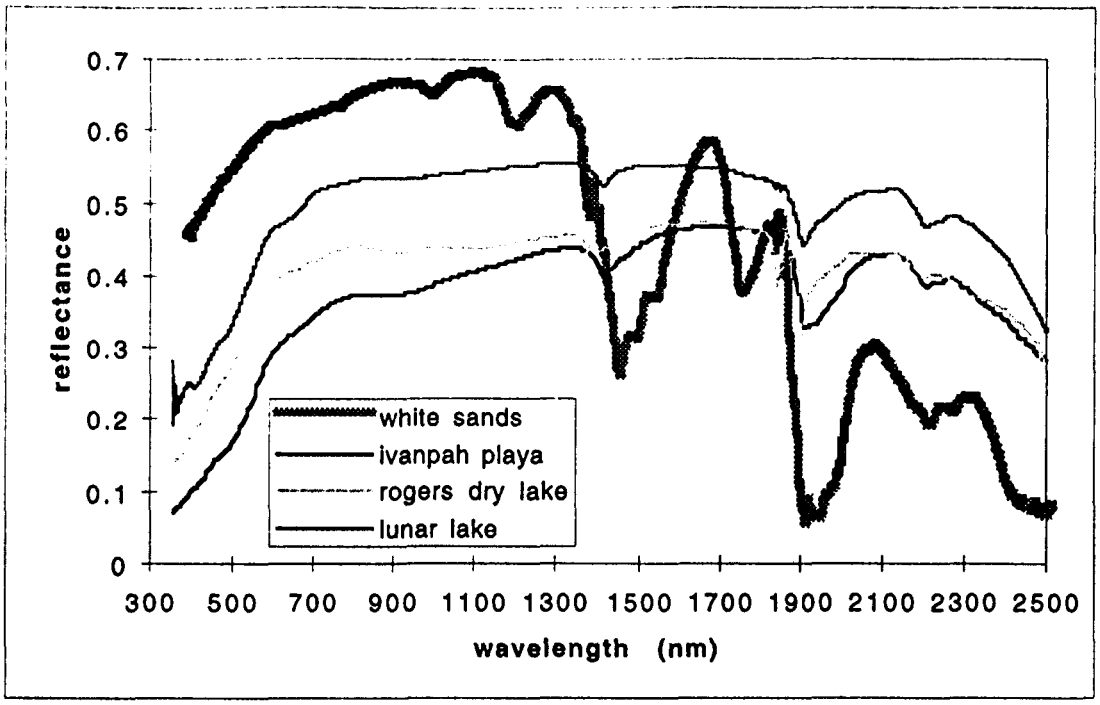

Figure 1: Reflectance of various calibration targets as measured by a field spectrometer. Note how albedo and spectral "flatness" compare to another popular remote sensing target, White Sands National Monument.

Method: AVIRIS data at 20m resolution was used to evaluate the homogeneity of each target. Bands from 710 - 870nm were averaged for the analysis. To simulate the resolution of some proposed spaceborne instruments, the pixels in each image were binned into 13x13 and 51x51 groups, so that homogeneity was measured on two scales: 260m and 1020m (Figure 2). Homogeneity was quantified by the following equation:

$$\text{homogeneity factor} = \frac{\text{average radiance (AVIRIS pixels)}}{\text{standard deviation of radiance (AVIRIS pixels)}}$$

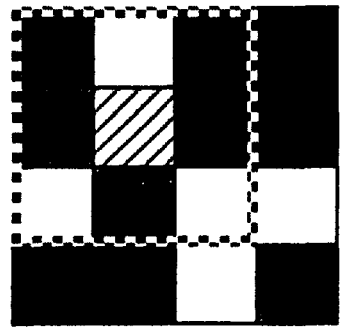

Figure 2: Mean and standard deviation are calculated for a group of 20m AVIRIS pixels. Group is defined by scale on which homogeneity is to be calculated; the statistics for the group are used to calculate the homogeneity factor for the central pixel.

In the resulting images, regions homogeneous on the scale of interest appear brighter than non-homogeneous ones. The ratio is independent of albedo.

Statistics were extracted for a sample region in each homogeneity image. Evaluation areas did not include the entire playa surface, but were contiguous regions specifically chosen to exclude anthropogenic structures such as roads, runways, and buildings. This was done on the assumption that only the most homogeneous regions of each target would be used for calibration purposes. The same area of each playa was used for the evaluation at both the 260m and 1020m scales. For Ivanpah Playa, a single region was evaluated for different times throughout one year.

Results: The results of the homogeneity transformation are shown in Figure 3. Note that the locations of the most homogeneous (brightest) regions vary with scale, and that features at the scale of interest are emphasized (runways in the 260m scale image and large-scale drainage patterns in the 1020m scale image).

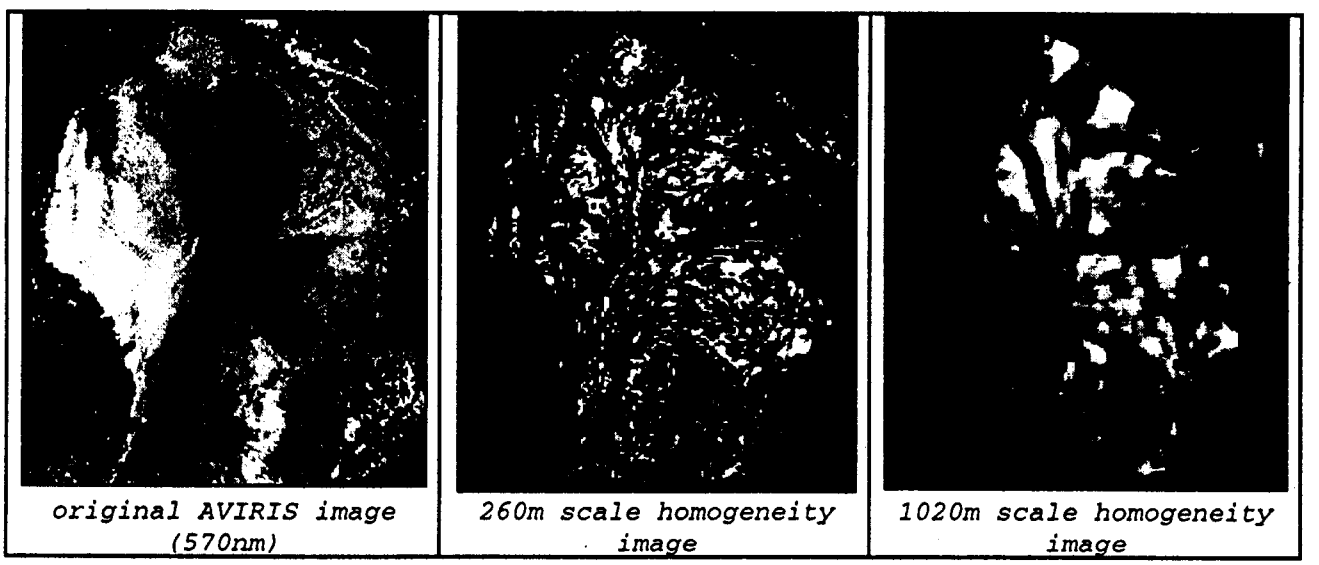

Figure 3: Homogeneity algorithm applied to AVIRIS image of Rogers Dry Lake. Note how runways, roads, and drainage patterns are emphasized.

In Figure 4, note that average homogeneity values as well as the range of homogeneity values vary with the playa chosen. Lunar Lake has the highest overall homogeneity values, but few of them, as its average homogeneity value is slightly lower than that of Rogers Dry Lake. At the 1020m scale, Rogers Dry Lake has both the greatest homogeneity value of the three playas and the largest mean value as well. According to this analysis, Lunar Lake might be superior for high spatial resolution instruments, but would probably be a poor choice for instruments with coarser resolutions on the order of 1km.

Figure 5 shows that Ivanpah playa varies in both its average homogeneity value and the range of values over one year. Not only do the values change, but the locations of the most homogeneous regions change as well, depending on weather and other factors such as off-road vehicle use since the last rain.

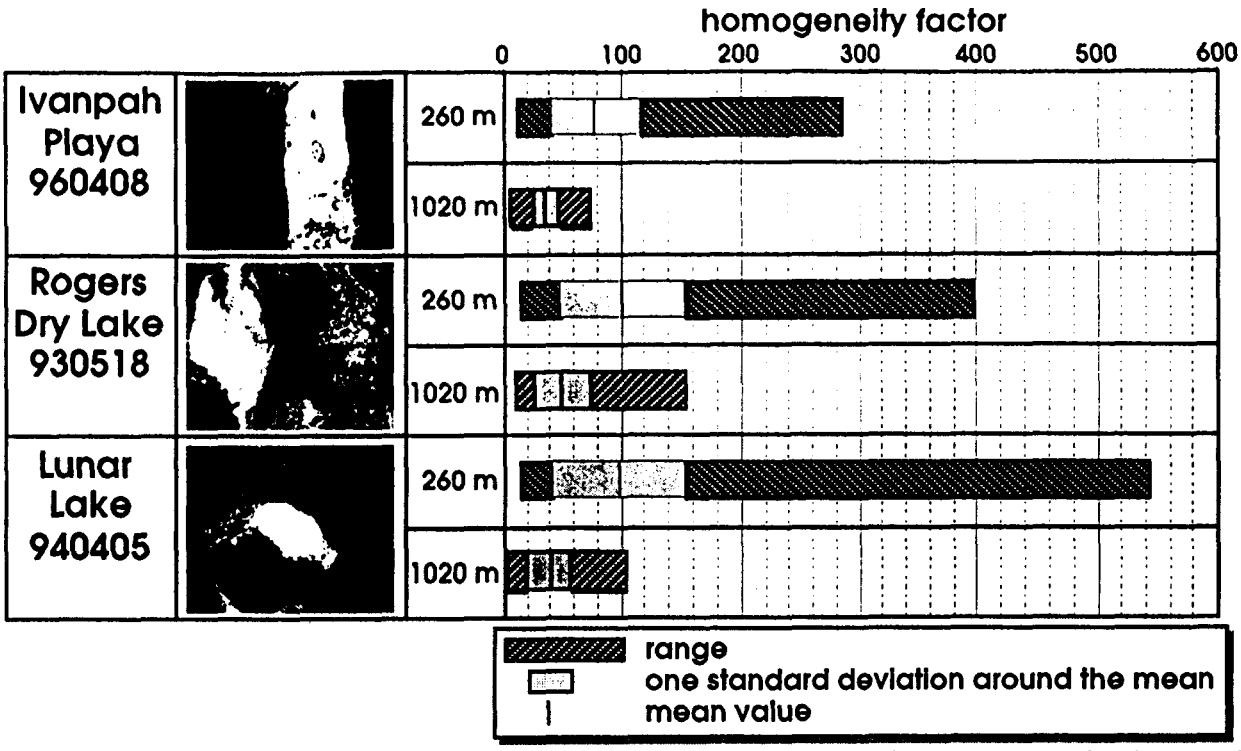

Figure 4: Playa homogeneity comparisons. All AVIRIS images are single band images, not homogeneity images, and are shown at the same scale (11 km wide).

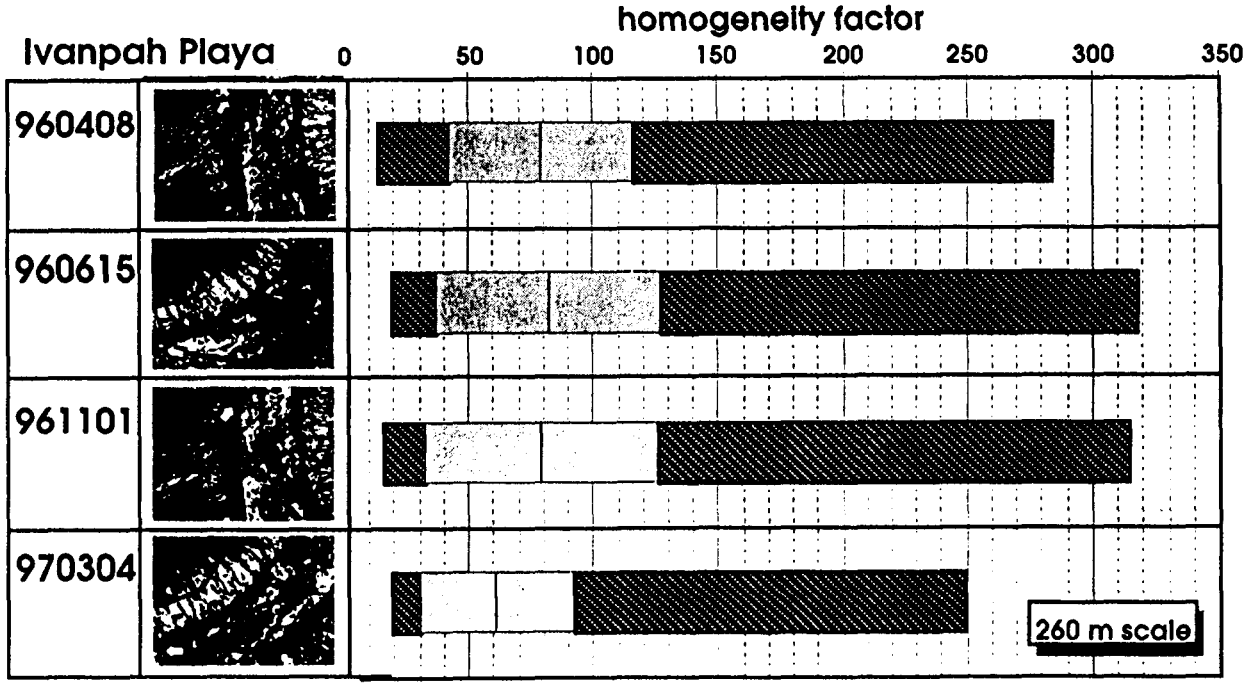

Figure 5: Seasonal variation in homogeneity of Ivanpah Playa. Homogeneity images shown on left. Note that 960615 and 970304 images are perpendicular to 960408 and 961101 data. White arrows indicate north in each image.

Conclusions: Choosing a good calibration experiment target involves balancing issues such as accessibility and facilities with the desire for a pristine, homogeneous surface on which to work. Lunar Lake may be homogeneous, but is remote and often flooded; Ivanpah Playa gets some offroad vehicle use, but is close to the highway, and has hotel facilities close by. Rogers Dry Lake is relatively pristine, but requires access to Edwards Air Force Base -- access which can be revoked on short notice. The inter-playa comparison indicates the following: first, playas vary not only in overall (average) homogeneity, but also in the range of the homogeneity factors observed. Second, the targets most homogeneous on a small scale are not necessary the most homogeneous on larger scales, so it may be necessary to choose a target based on the spatial resolution of the instrument to be calibrated. Further, the homogeneity and brightness of a playa, as well distribution of homogeneous regions within it, varies with time. As a result, analyses such as this can provide guidelines on good places to work, but a field team needs to make an evaluation of the best location to set up at the time of a radiometric calibration experiment.