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**HyspIRI preparatory campaign reference target collection protocol**

Adapted from the Ivanpah protocol by Sven Geier and Scott Nolte, with much help from Mark Helmlinger

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**Equipment**:

Spectrometer

Yellow Pelican case containing 1 clean large white standard (Spectralon or another Sintered PTSE target), bull’s eye bubble level, and a bracket to hold the target on a tripod.

GPS

Tripod to hold the white standard, or some other way to hold the target level.

10mx10m Blue tarps (optional, see below)

All the usual stuff: sunblock, gloves, hats, water...

Make sure the ASD battery packs are charged, and that your laptop’s clock is correctly set to UTC.

**Target selection**

Targets should be spatially homogeneous, geographically flat regions. They should be big enough to subtend multiple AVIRIS pixels - ideally at least 40x40m, and the bigger, the better. It is common to demarcate a region in the middle of a large feature. If possible, try to leave at least an additional 20m of margin between your sampling area and any significant change in surface albedo. This will help to avoid contamination by scattered light from adjacent pixels.

Examples of good targets:

* Parking lots, provided they don’t contain cars or islands with plants.
* Dam spillways
* Quarry bottoms
* Plowed fields, provided they are dry
* Clay-based playas
* Airfields
* Dry beaches

Examples of bad targets:

* Anything adjacent to significant tall vegetation
* Wet soil or sand
* Dunes (uneven surfaces change too much with lighting angle)
* Salt playas (spectra depend on atmospheric moisture)

Record the GPS coordinates of the corners of your target region. It would also be helpful to have *ground control points* – additional GPS coordinates from obvious nearby landmarks. The best ground control points are sharp features large enough to be resolved by AVIRIS, such as the corners of large buildings and the centers of major road crossings. Try to collect *at least* two or three.

Even with ground control points, it can be challenging to find the pixels of your reference area using GPS coordinates alone. So it is also useful to know the target area’s position relative to obvious visual features in the AVIRIS image. This is particularly important if your reference area is part of a larger feature, such as a beach or a playa – try place it within 200m of the nearest landmark. If this is not possible, you can *introduce your own landmarks* with a couple of large blue plastic tarps that will be visible in the AVIRIS image. These tarps are available at most sporting goods and hardware stores. A 10m x 10m tarp is large enough. It’s best to place them to bracket your sampled region, making sure to leave several pixels’ worth of terrain between the tarps.

Your acquisition would ideally take place coincident with the overflight. If this is not possible you can do the collection at some other time – just be sensitive to the following potential problems. First, it is important that the target is really spectrally invariant. So your collection should be close enough to the time of the overflight to avoid weather-related modifications such as changes in moisture content (soils) or dirt accumulation (concrete). The other important consideration is to mimic the sun angle of the overflight: try to perform your collection at a similar time of day.

*Special notes on parking lots:* If your target is a parking lot with painted lines, avoid pointing at them during the terrain data collection. Instead, collect a few additional spectra of JUST the lines and send them to us along with your standard dataset. It is unlikely that the lines will be visible in the AVIRIS spectra, but if they are, we can use your “line only” spectra to remove this signal.

**White references and transect planning**

Before you go, make sure your white reference is clean. If you’d like to discuss cleaning procedures, give us a call and we’ll guide you through the process. But it’s best to simply make sure the surface is never touched, except at the edge to place a bubble level (see below).

Whether mounted on a tripod or placed on the ground, the spectralon target should be leveled to within a degree. The best way to do this is to place a bulls-eye bubble level on the edge of the target - not the middle!

The idea is to walk transects that cover the reference region as evenly as possible, with regular revisits to the white reference. Plan to spend about 30-40 minutes collecting spectra, and space your transects accordingly. You’ll take regular spectra from the white reference target throughout the process and the white target should be placed to minimize the distance between acquisitions. It’s common to put the target in the center of the reference region, with transects radiating out like spokes on a wheel. Alternatively, a field assistant can move the target move along the edge while you walk a “farming pattern” of parallel rows. 5m-10m spacing between rows is typical. Use whatever is sufficient to fairly sample the entire region of interest.

We recommend attaching the spectrometer foreoptic to a meter-long rod. This helps avoid shadows, shoes, and reflected light from your clothing.

**Data Collection**

Typical field teams have one person taking notes, photos, and GPS coordinates, another walking the transect, and (optionally) a third moving and re-leveling the calibration target if your sampling pattern calls for this.

The following procedure assumes ASD spectrometers, but the same basic principles apply to other devices. Start the ASDs (Not the laptops) 30 minutes in advance to warm them up. For ASDs, you’ll want to operate the spectrometer in “raw DN” mode to record the raw data. These numbers are a linear factor away from the true radiance, and we can use values from the white reference and the surface to directly calculate true reflectance. Therefore, no software-guided “white reference” procedures are necessary in the field. However, there is still an initial optimization process that sets the dynamic range of the spectrometer for the current illumination level. To perform this step, point the ASDs at the Spectralon and hit Optimize. This takes ~10 sec. If the measurement is performed over a short enough interval over the appropriate time of day, re-optimization should not be necessary. But if your instrument beeps to demand a re-optimization, go ahead and we’ll account for this afterword.

Choose for output (Control|Save) new filenames like 061129xx. The first six characters are the year, month and day, which gives you two free characters to fill the 8.3 filename convention. You’ll have an option to save the data using the new or old ASD binary format. Please use the old format, which is more compatible with our analysis code.

Set the spectrometer up to save a spectrum whenever you press the spacebar. This will let you verify that the spectrum has “settled” and has not changed for a couple of refresh intervals before saving the data. Walk along the transects while saving data every meter or half meter. Be aware of what the foreoptic is pointing at when you push the button.

Visit the white standard often, and capture 5 spectra each time. Multiple spectra can be averaged to improve signal to noise, and provide an additional check against shadows, clouds and other data collection errors. After each white reference set, collect an additional set of 5-10 “dark” spectra by holding the foreoptic against your body. We’ve used this method in the past to overcome errors in the past where the shutter doesn’t close entirely. Regardless, you should still use the dark correction command (a button on the screen labeled “DC,” or alternatively the F3 key).

In summary, the collection sequence should be something like:

<5 white> <5 dark> <transect> <5 white> <5 dark> <transect> … <5 white> <5 dark>

It’s best to collect a dark and white spectrum about every 5 minutes. The ASD software has a built-in timer that displays the time since the last dark spectrum, and you can use this as a guide to adjust your transect length.

**Submission process**

Make directories for the spectra, including the date (ex: 120514\_[last name]\_ASD), and a short note with any details of experience (ex: 120514\_[last name].txt). Record the GPS coordinates of the site. Include the factory-provided reflectance spectrum of your Spectralon reference target if you have it, and any spectra you collected of potential contaminants like parking lot lines.

Ideally we’d like to receive these spectra files as column-delineated ASCII files with two columns: wavelength, radiance, with time of collection in the column header. ViewSpec Pro’s “Convert to ASCII” option will do this. But please send the raw ASD binary formats too. The time is useful to us because we can fit time-varying illumination models and better estimate the white reference level.

Log on to <ftp://watkins.sonoma.edu> . Create a new subfolder invariant\_targets/lastname/ and upload your directories, spectralon spectrum, and text file. Contact Mateo Clark ([mateolclark@gmail.com](mailto:mateolclark@gmail.com)) if you need access.

Email David R. Thompson ([david.r.thompson@jpl.nasa.gov](mailto:david.r.thompson@jpl.nasa.gov)) to let him know the spectra have been submitted.