DLR

Planning a Field Campaign
– Field Methods –

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Contents of Lecture

- Brief introduction to field spectroscopy
  - Theoretical basics
  - How to measure
  - Processing & archiving
- Calibration / validation of hyperspectral data
  - Measurement of reference targets
- Sampling other ground reference data
  - Sampling design for R.S. studies

Field Spectroscopy

Milton 2007

Field Spectroscopy

- **Field spectroscopy as support for remote sensing**
  - Calibration / validation of RS images
    - in-flight calibration
    - validate the link of ground properties to sensor measurements
    - validation of data processing (esp. atm. correction)
  - Data tuning after atmospheric correction ("empirical line")
  - Characterization of surface materials for image analysis
  - Material identification in the field ("Spectral Geologist")
  - In-situ measurements of anomalies
  - Compilation of Spectral Libraries
  - …

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Field Spectroscopy - Equipment Pools

Access to field spectrometers:

- **NERC** / U. Edinburgh
  - ASD FieldSpec Pro, GERs, Microtops, ...
  - http://fsf.nerc.ac.uk

- **DLR** – OpAIRS (DFD & IMF)
  - ASD FieldSpec Pro, GER 3700, D&P FTIR, Microtops, ...
  - http://www.caf.dlr.de (http://www.opairs.aero)

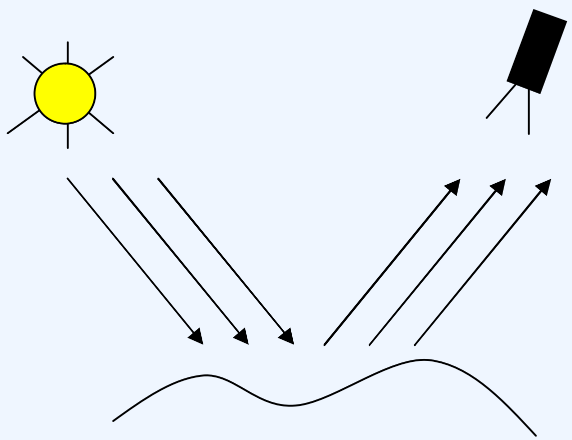
- Equipment pools of Universities
  (e.g., RSL @ U. Zürich, U. Wageningen, U. Warsaw, ...)

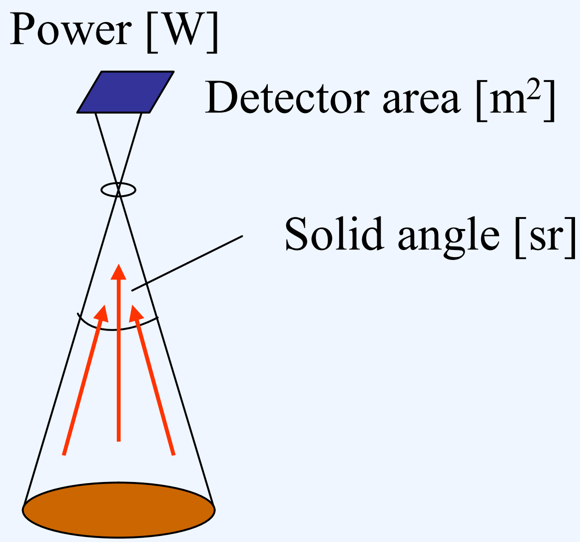
Measurement Principle

- The spectrometer measures:

  Radiance (at-sensor radiance) L [W m^{-2} sr^{-1}]

=> Power per detector area and aperture angle
=> SI Unit (***S**ystème **I**nternational d'Unités*)
=> Data value after system correction, often denoted „L1 product“





Measurement Principle

Measurements should be:

I. Independent of incoming radiation (illumination power and geometry)

II. Independent from atmospheric conditions

III. Independent of sensor properties (instrument & detector characteristics)

=> material property only !

But: at-sensor radiance L [w m^{-2} sr^{-1}] still depends on (I, II, III)

Thus more suitable measure: **reflection ρ = % of reflected radiation**

- No unit, but [%]
- Independent from illumination & sensor
- (Almost) independent from geometry & atmosphere

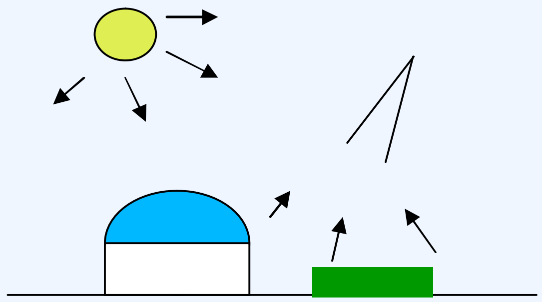
Measurement Principle

But: spectrometer do measure radiance L = f (sensor, illumination, ...)
We want: % reflected (ρ)

(1) Measuring incoming and reflected radiance, then ratio:

$$\rho_{target} = L_{target} / L_{reference}$$

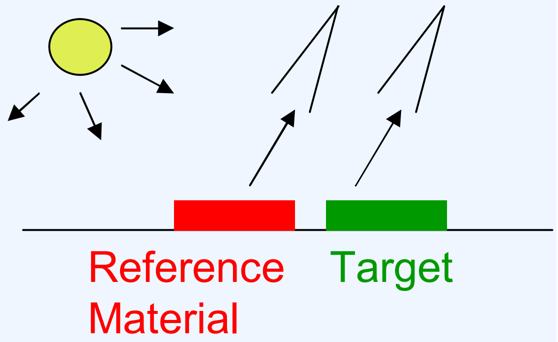
(2) Commonly for higher precision the hemispherical radiation E is measured:



$$\rho_{target} = L_{target} * \pi / E$$

(3) If you use only one instrument:
measure **relative** to known reference material

$$\frac{L_{Reference}}{L_{Target}} = \frac{\rho_{Reference}}{\rho_{Target}}$$



$$\rho_{target} = (L_{target} / L_{reference}) * \rho_{reference}$$

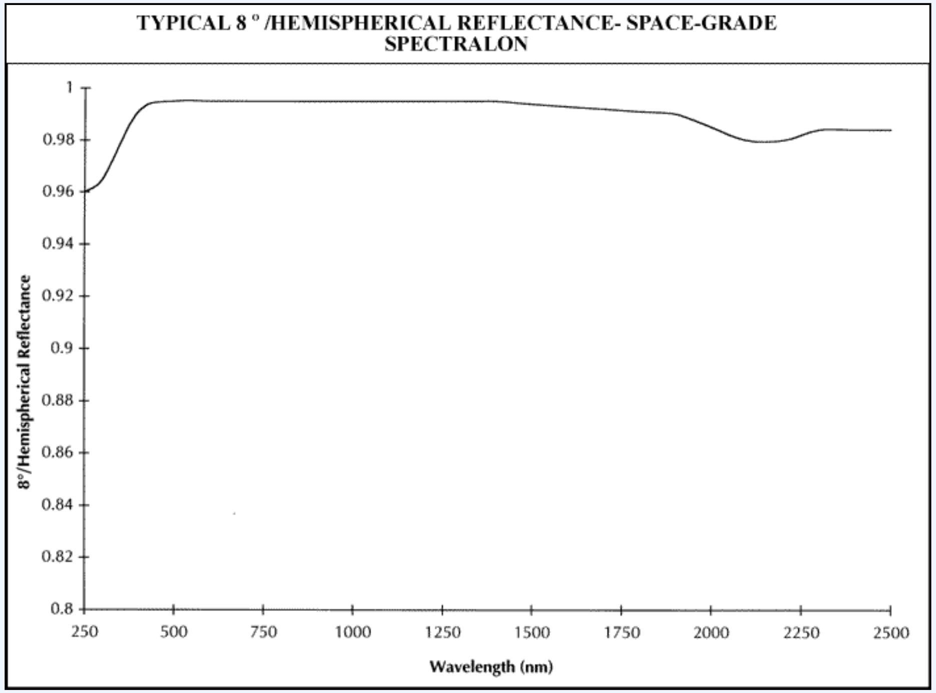
White Referencing

$$\rho_{\text{target, Band 1}} = (L_{\text{target, Band 1}} / L_{\text{reference, Band 1}}) * \rho_{\text{reference, Band 1}}$$

$$\rho_{\text{target, Band 2}} = (L_{\text{target, band 2}} / L_{\text{reference, Band 2}}) * \rho_{\text{reference, Band 2}}$$

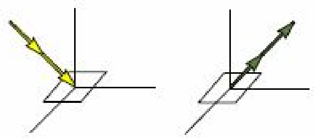
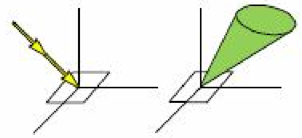
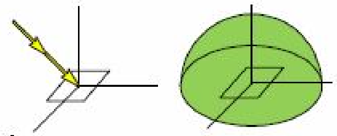
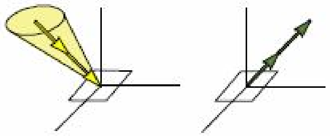
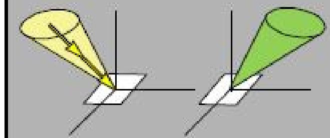
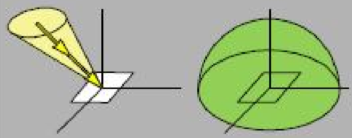
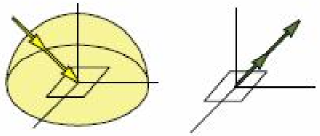
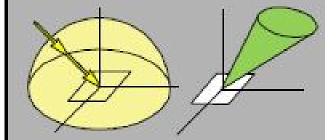
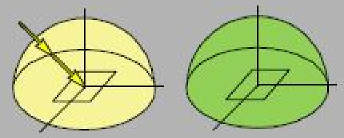
…

$$\rho_{\text{target, Band n}} = (L_{\text{target, Band n}} / L_{\text{reference, Band n}}) * \rho_{\text{reference, Band n}}$$



http://www.labsphere.com/

Measurement Principles

Incoming/**Reflected**	**Directional**	**Conical**	**Hemispherical**
Directional	Bidirectional Case 1 	Directional-conical Case 2 	Directional-hemispherical Case 3 
Conical	Conical-directional Case 4 	Biconical Case 5 	Conical-hemispherical Case 6 
Hemispherical	Hemispherical-directional Case 7 	Hemispherical-conical Case 8 	Bihemispherical Case 9 

Schaepman-Strub 2006

Instrumentation

ASD FieldSpec Pro
http://www.asdi.com

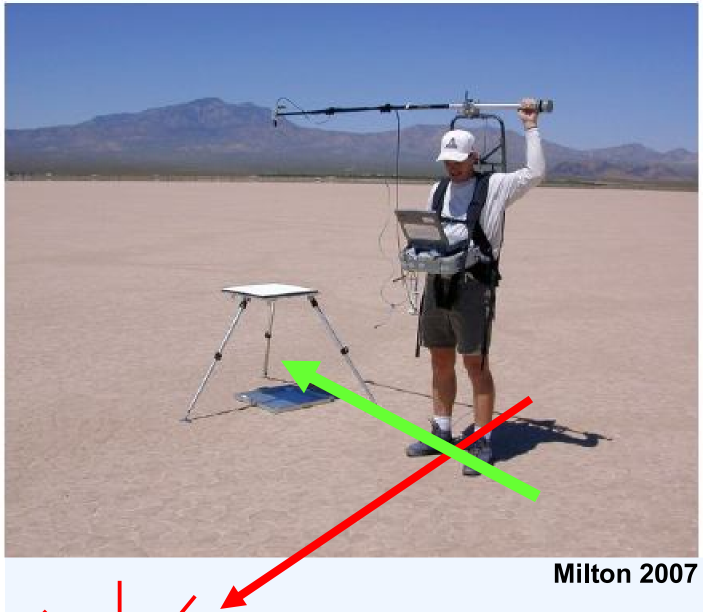
GER 3700
http://www.spectravista.com

http://www.spectravista.com

Common characteristics:

- Spectral range: 350 – 2500 nm
- Bandwidth < 10nm
- FOV from 3°   to 25°   (lenses, fiber optic)

Measurement Configuration



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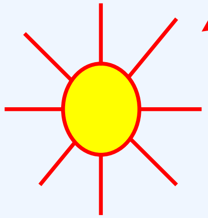
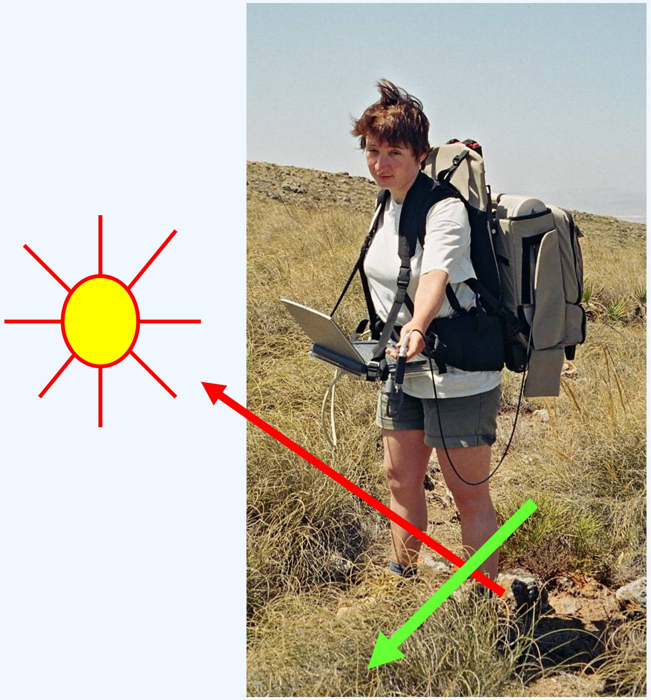




Time:

- Solar noon ± 2 h (depends on season & latitude)

Geometry:

- Orthogonal to the sun (no shade)
- Best: facing sun, measure in 90° sideward
- Distance sensor to target ~ distance sensor to Spectralon

Weather Conditions:

- Cloud free
- Extremely careful when hazy (rapidly changing illumination) !

Illumination Sources – Influences in the Field

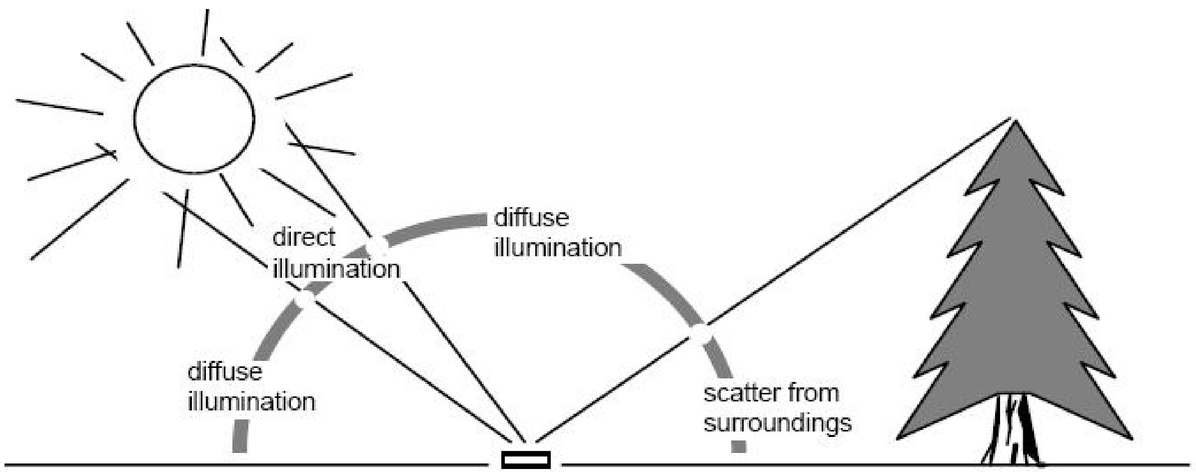
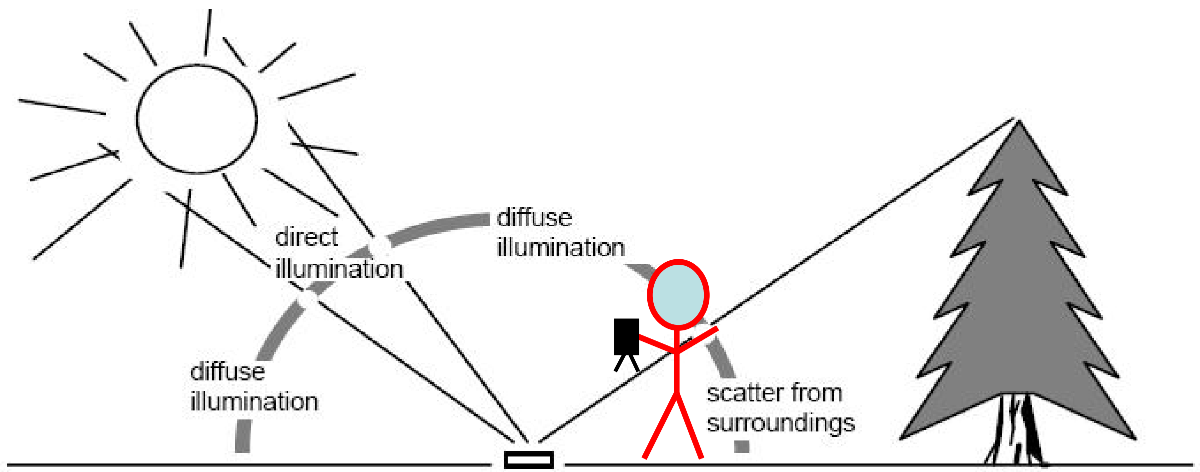


Figure 1. The major sources of illumination. Note that it is possible to have several sources of light scattered off of surrounding objects, each with its own unique spectral distribution.

ASD 1999

Illumination Sources – Influences in the Field



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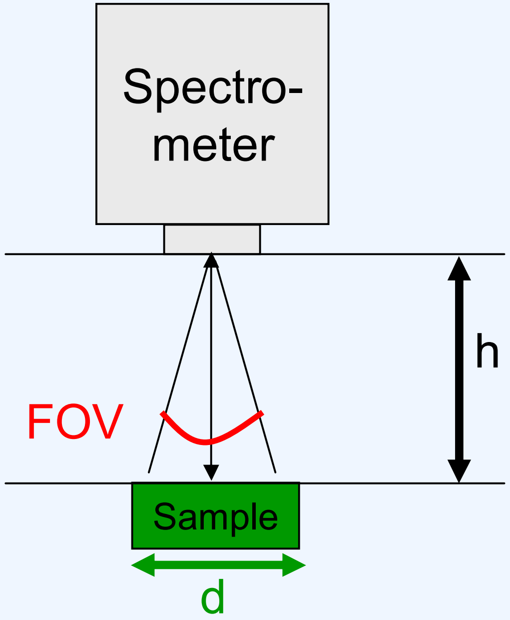
ASD 1999

Foreoptics & FOV



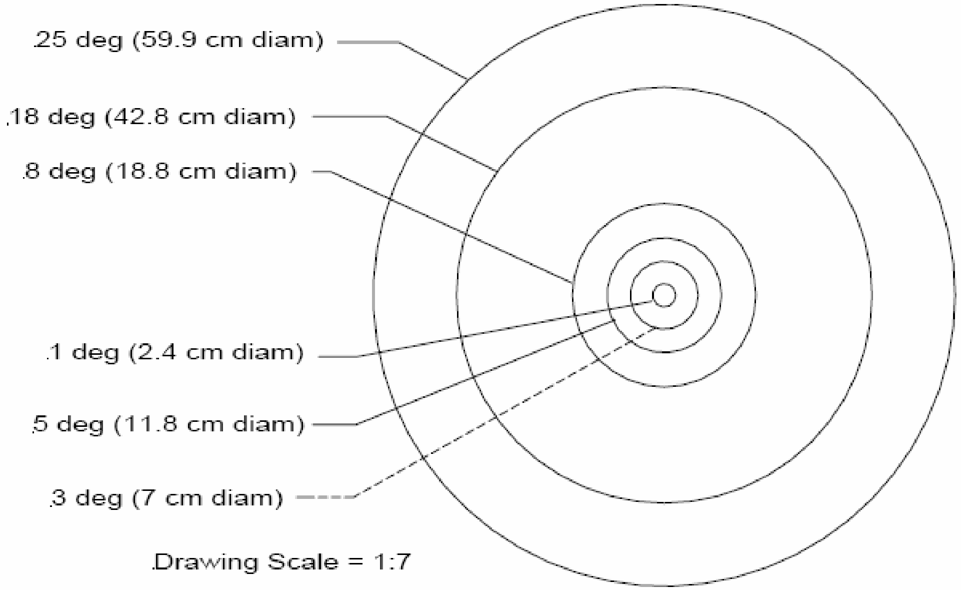
Bare Fiber, FOV = 25°

tan (FOV/2) = d/2 / h

d ~ 0.44 * h

Examples:

h = 0.5m	d = 0.22m
h = 1.0m	d = 0.44m
h = 1.5m	d = 0.67m



The figure above shows the available fields-of-view (FOV) for the FieldSpec® FR with an instrument fore optic height of 135 cm. The dashed circle represents the FOV of a non-ASD instrument with a fixed 3° FOV. The solid circles are for ASD's FieldSpec® FR. The largest circle is the FOV of the FieldSpec®'s standard built-in fiberoptic cable, with optional foreoptics providing 1°, 5°, 8°, or 18°. Fore optics covering approximately the same range of angular FOVs are available for the other FieldSpec® instruments.

ASD 1999

How to Measure

1. Get your gear ready:
   - Batteries reloaded?
   - Spectralon clean?
   - Spare batteries for laptop & spectrometer?
   - All safely packed?
2. Power on / warm up of spectrometer
   - Minimum 15 min before 1st measurement
3. **First** connect **running ASD** to laptop, **then** power on **laptop**
4. Check software settings
   - White Reference mode?
   - Correct directory & file base name?
   - Set DC, WR & spectra averaging to (25-) **50**
   - Correct foreoptic selected?

How to Measure

5. **Optimization**
   - Whenever changes in illumination / instrument temperature
6. Dark Current (DC)
   - Automatically retrieved during WR & Optimization
7. **White Reference (WR)**
   - Wait for stable signal (2x screen refresh) before WR
   - At least every 10 minutes / 25 measurements
8. **Measurement**
   - Wait for stable signal (1x screen refresh)
   - (Approx.) same geometric setup as WR measurement
   - Number in display "plant.**008**" => the **next** measurement to be saved!
9. **Quality Control**
   - When pointing at spectralon, are there steps, or deviations from 100% line ?
10. "Lifetime": ~2-4 h for one ASD-battery

Protocol your Measurements

Spectral Measurements Form – Field version

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Section A – GENERAL INFORMATION

Project name:		Country:		Region:		
Calibration use:	Yes ☐	No ☐	Observer(s):		Date:	Additional information:
Latitude: ° ´ ´´		Longitude: ° ´ ´´		Altitude	m	
Environment description:	(Middle-european, mediterranean, artic, desert, coastal,...)					
Weather description:						

Section B – EQUIPMENT USED

Spectrometer:	ASD-DFD ☐	ASD-IMF ☐	Other ☐	Specify:	White stand.:	Spectralon A ☐	Spectralon B ☐
Fore optic:	1° ☐	3° ☐	5° ☐	8° ☐	18° ☐	Other: °	Bare fiber - FOV: °
Light source:	Sun ☐	Reflectance probe ☐	Tripod ☐	Additional information:			

Section C – TARGET INFORMATION

Rock ☐		Soil ☐		Vegetation ☐		
Igneous ☐		Soil type:		Specie:		
Sedimentary ☐		Soil colour:		Dry ☐	Growing ☐	Flowering ☐
Metamorphic ☐		Humus content:				
		Moisture:				
Mineral ☐		Water ☐		Other ☐	Specify:	

Protocol your Measurements

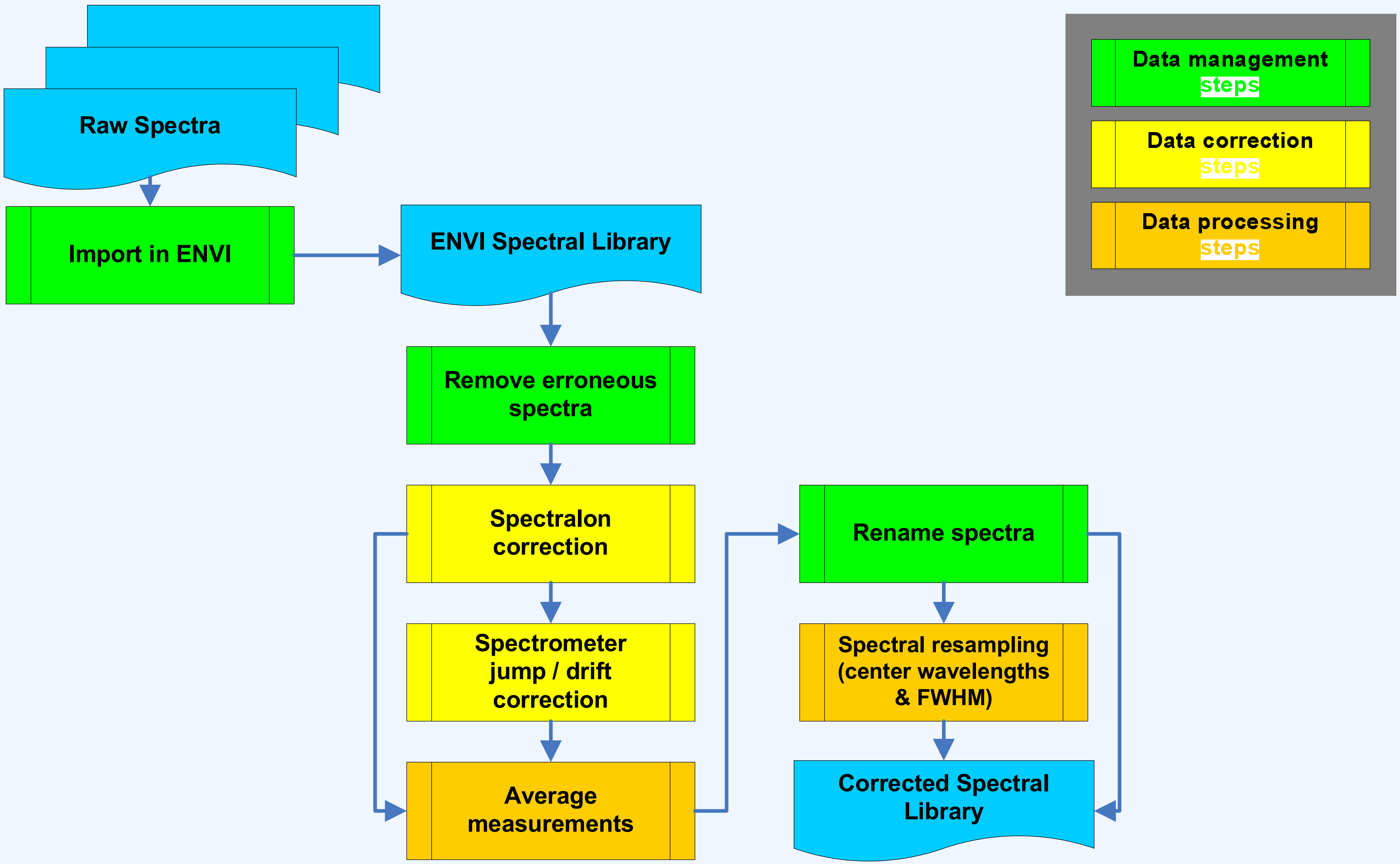
Section D – MEASUREMENTS

Type:	Radiance ☐	Reflectance ☐	DN ☐	Emissivity ☐	Additional information:
Averaging:	Optimisation	White reference	Spectra		
	Optimisation ☐	White reference ☐	Measurement height:		

ID	Name	Photo (tick or name)	Time	Additional	Check 100 %	WR
					☐	☐
					☐	☐
					☐	☐
					☐	☐
					☐	☐

…	…	…	…	…
020 - 024	Soil degraded, upper slope	126	12.25	Soil sample B-12 GPS-Waypoint 43
025	Bad measurement	-	-	-
026 – 030	Soil lower slope	127,128	12.28	Some vegetation GPS-Waypoint 45

Processing of Field Spectra – Typical Steps



Archiving of Spectra – Spectral Libraries

- Online SpecLibs incl. processing software
  - DLR http://cocoon.caf.dlr.de
  - RSL http://www.specchio.ch
- Online SpecLibs
  - USGS http://speclab.cr.usgs.gov
  - NASA /JPL http://speclib.jpl.nasa.gov
  - ...

Spectroscopic Reference Measurements

- **Objectives**
  – In-flight **calibration** of imagery
  – **Validate** the link of ground properties to sensor measurements

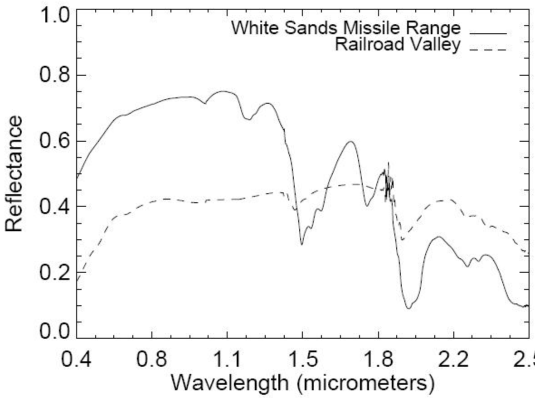
- **Measurement procedure**
  – Measure during sensor overflight (if possible)
  – Cover large area (> 5x GSD)
  e.g., measure parallel transects
  (1 measurement every n meters)
  – Take plenty of single measurements
  (>> 30) and average
  – Try to include all natural variability of target area
  but: do not overestimate atypical spots
  – Take special care
  (clean Spectralon, no haze nor clouds)


Milton 2007

Radiometric / Spectral Validation

- **Site requirements:**
  - **Spectrally homogeneous** (low stdev of spectra)
  - **Large** (at least 5x GSD)
  - Spectrally “flat” (few absorption features) and low angular (BRDF) effects
  - High overall albedo (bright target), if possible with dark target nearby
  - Temporally invariant (no vegetation, if possible impervious surface)

http://digilander.libero.it/sarodb/usaparks/foto/nm/ws1.jpg



http://modis.gsfc.nasa.gov/sci_team/meetings/199905/presentations/Thome_L1B_Validation.pdf