



INTERCOMPARISON OF FIELD METHODS FOR ACQUIRING GROUND REFLECTANCE AT RAILROAD VALLEY PLAYA FOR SPECTRAL CALIBRATION OF SATELLITE DATA

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Collaborators

- Commonwealth Scientific Industrial Research Organisation (CSIRO), Australia
- National Aeronautics and Space Administration (NASA) Goddard Space Flight Centre, U.S.A.
- Aerial Photogrammetric Service (SAF), Chilean Air Force, Chile
- German Aerospace Center (DLR), Germany
- Remote Sensing Group, College of Optical Sciences, University of Arizona, U.S.A.
- Spaceflight Industries, U.S.A.
- University of Massachusetts Amherst, USA



GSIS

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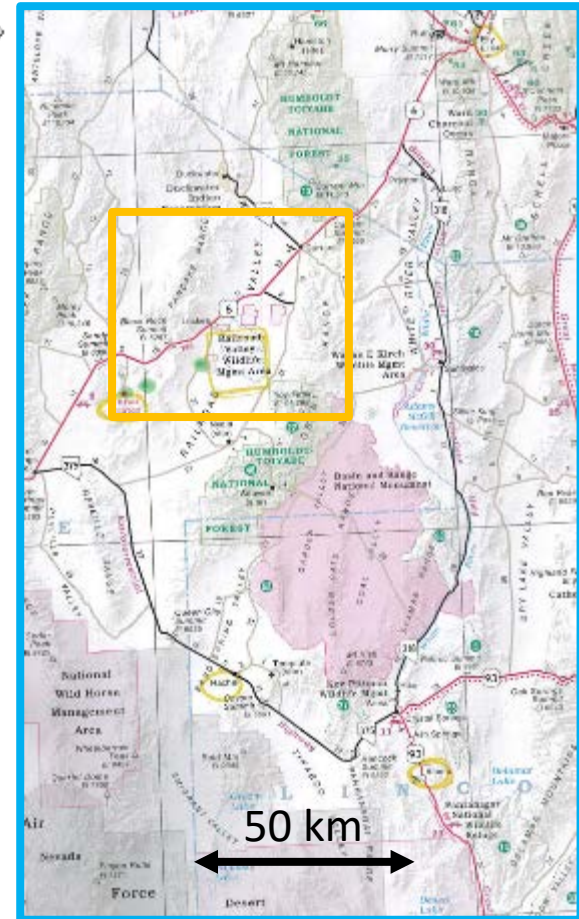
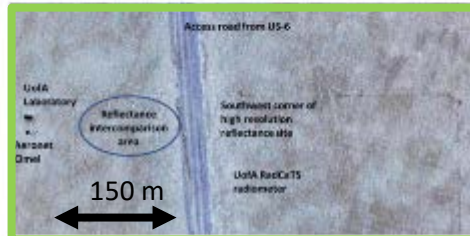
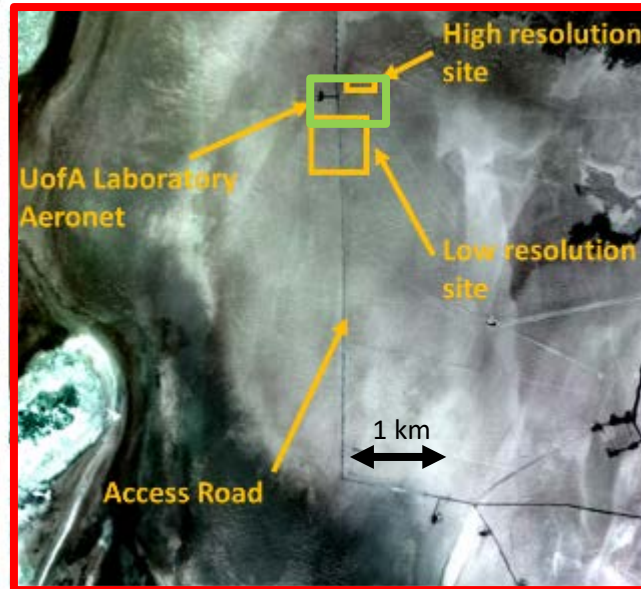
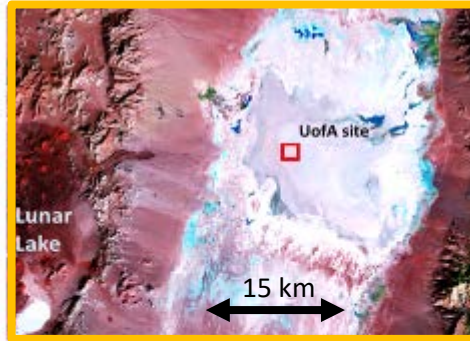
Rational

- The purpose of this research was a learning exercise for scientists and engineers undertaking work in the field of remote sensing instrumentation calibration and validation.
- The exercise included a tour of an optical calibration lab operated by the Remote Sensing Group (RSG) at the University of Arizona (UofA).
- The field component was to perform a surface reflectance inter-comparison of different methods of collection at a RadCalNet site (Railroad Valley Play, Nevada USA).
- The target was to perform a reflectance-based calibration of an on-orbit satellite sensor (Sentinel 2) with the data collected if the conditions were good.

Location



- Railroad Valley Playa, Nevada U.S.A.
- 31st July, 1st and 2nd of August 2017



Ely

Las Vegas



Method

- Two sites at RRVP
 - 80 m E-W transect for experiments
 - High resolution cal-val site used by RSG UofA and NASA
- Three teams of two people
 - Spectroradiometer operator
 - Note taker/spotter/reference panel operator
 - Teams consisted of a mixture of levels of field spectroradiometer experience
- Spectral collection methods
 - Stop and collect
 - Moving transects

Instrumentation

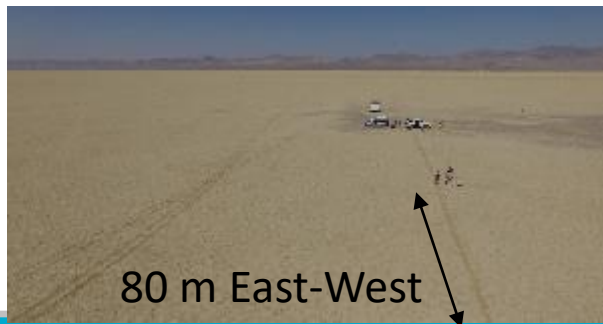
- Spectroradiometers
 - ASD FieldSpec 4, Serial number: 18497_1
 - ASD FieldSpec, Serial number: 687_7
- Reference Panels
 - Two 99% reflectance Spectralon 20 inch (500 mm) panels on custom 3 legged mounts, ~500 mm from the surface (Serial: S6 and S7).
- RadCaTS and Ancillary instruments
 - CIMEL sun photometer
 - Weather station
 - Ground viewing radiometers (GVR)
 - CaTSSITR transfer radiometer

Measurement notes

- Spectroradiometer was optimised at the start of the experiment before saving spectra over the reference panel. There is a potential for saturation of the spectroradiometer due to changing light conditions during the experiments if the collection takes a significant time.
- The reference panel was aligned to be orientated so a specific edge was always normal to the sun. The panel was also calibrated for reflectance factor at different angles based on the specific edge by the RSG at UofA.
- The reference panel was carefully levelled each time it was moved.
- A pole with the 8 degree foreoptic was held perpendicular to operator out to the south at around hip height and swapped over on the return path.

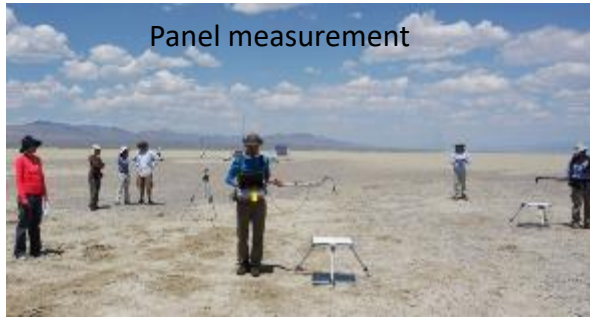
Experiment 1: Repeatability measurements

- Determine the repeatability and accuracy of multiple users measuring the same 80 m linear transect over multiple collections.
- Collection of 32 spectra (average of 20 scans per spectra) walking east for 80 m, then returning the same transect walking west collecting 20 measurements.
- Panel measurements (8 spectra) before and after the transect.



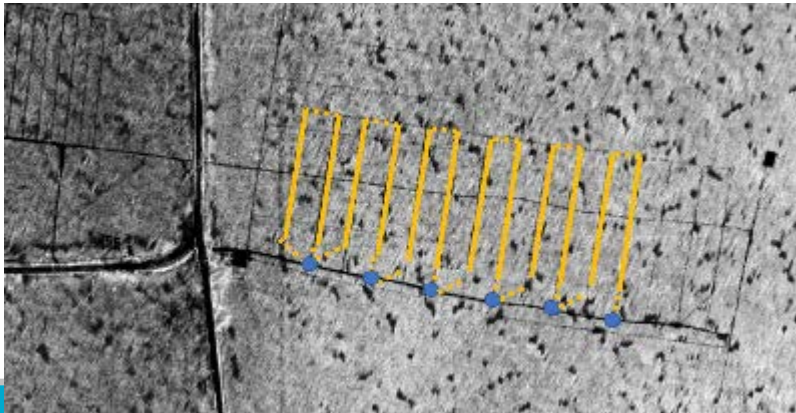
Experiment 2: Measurement method comparison

- Comparison of the moving collection (continuous) method versus a stop and measure method.
- Collect data on the same transect as the repeatability test. 8 spectra (average of 20 scans) performed every 10 m in one direction only and a panel reference measurement collected at the start and after each surface measurement.



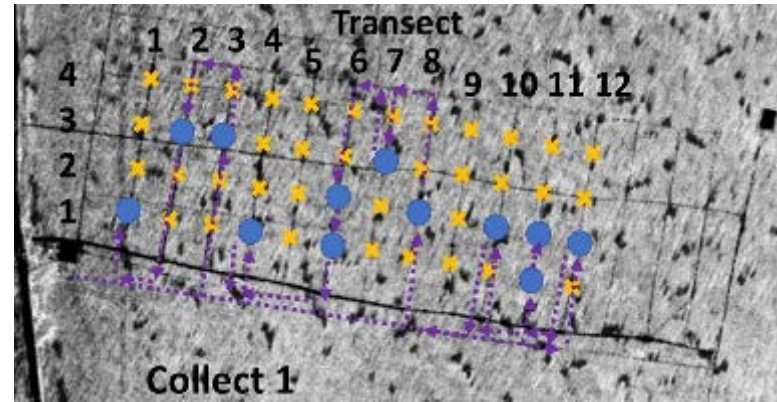
Experiment 3: Reflectance-based calibration method -1

- North-south transects. Walking north along first transect and south along second transect, returning to reference panel.
- Transects are 20 m apart.
- Reference panel measurement, relocated at the southern end, at the start and every second transect.



Experiment 3: Reflectance-based calibration method -2

- Stop and measure (S&M) along the north-south transects. 12 stop collects taken throughout the area. Panel is moved and set up before each measurement
- Reference panel measurement before each measurement.



Results

- Reflectances for each spectra were calculated by applying the specific reflectance factor for the panels (measured at RSG UofA's lab) for the illumination angle of the sun.
- Wavelengths in the 1346-1447 nm, 1800-1965 nm and 2432-2500 nm regions were removed from calculation of the averages, standard deviations and coefficient of variations.

Experiment 1 : Continuous measurement

- 12 runs over 3 hours by 7 operators using 2 spectroradiometers and 2 panels.
- ~3% variability between the average reflectance of all the runs, reduced after the data was mean-normalised.
- Instrument dependant variations seen between the spectroradiometers

Experiment 1: Continuous measurement

Run	Code	Indiv. Coll. CV %
1	E1_ASD1_P7_OP1_R1	3.23
2	E1_ASD2_P6_OP2_R1	3.88
3	E1_ASD1_P7_OP3_R1	3.41
4	E1_ASD1_P7_OP4_R1	3.37
5	E1_ASD1_P7_OP5_R1	3.99
6	E1_ASD1_P7_OP1_R2	3.01
7	E1_ASD2_P6_OP2_R2	2.78
8	E1_ASD1_P7_OP3_R2	3.49
9	E1_ASD2_P6_OP6_R1	3.48
10	E1_ASD1_P7_OP4_R2	2.59
11	E1_ASD1_P7_OP5_R2	4.64
12	E1_ASD1_P7_OP7_R1	3.17
Average CV for Individual Collections		3.42
SD		0.56

- 12 Collects by 7 operators along E-W 80m transect.
- Good solar conditions, low amount of wind, >37°C temperatures.
- Some operators first time using this type of field spectroradiometer

Key:

E – Experiment

ASD – Spectroradiometer number

P – Panel number

OP – Operator

R – Run number

CV – Coefficient of variation

SD – Standard deviation

Experiment 1: Comparison of operators

- Operators ranged in experience with operation of field spectroradiometers.
- The coefficients of variance (CV) for each operator for 2 runs were compared. Experiment (Exp) 2 continuous measurements were also included.
- **Not enough data was obtained (3 runs in total if Experiment 2 data was included) to produce meaningful results.**
- However, inexperienced operators were able to produce low CV data.
- Inexperienced operators CV lowered when both Exp 1 and Exp 2 (day 2) data was combined, while the more experienced operators CV increased, which could be partly due to changing weather conditions.

OP	AVE E1	AVE Exp1 & Exp2
OP1	3.12	3.50
OP2	3.33	3.14
OP3	3.45	3.37
OP4	2.98	3.43
OP5	4.31	3.79
OP6	-	3.91
OP7	-	-

Experiment 1: Comparison of Spectroradiometers

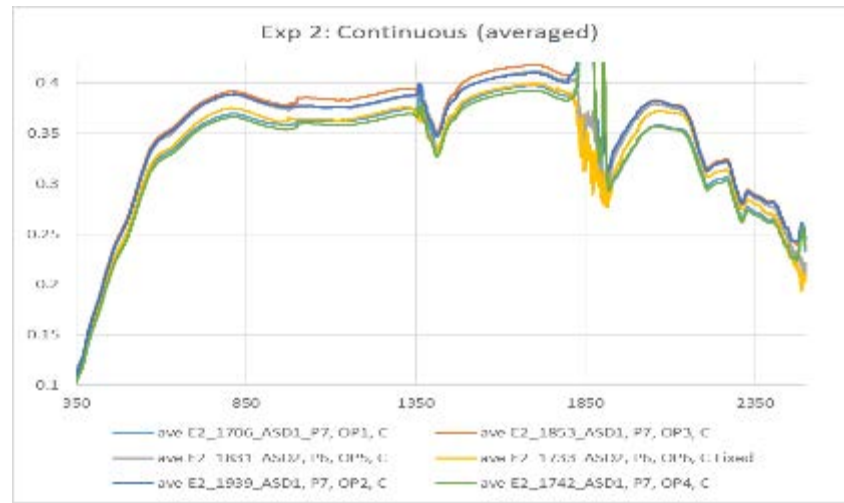
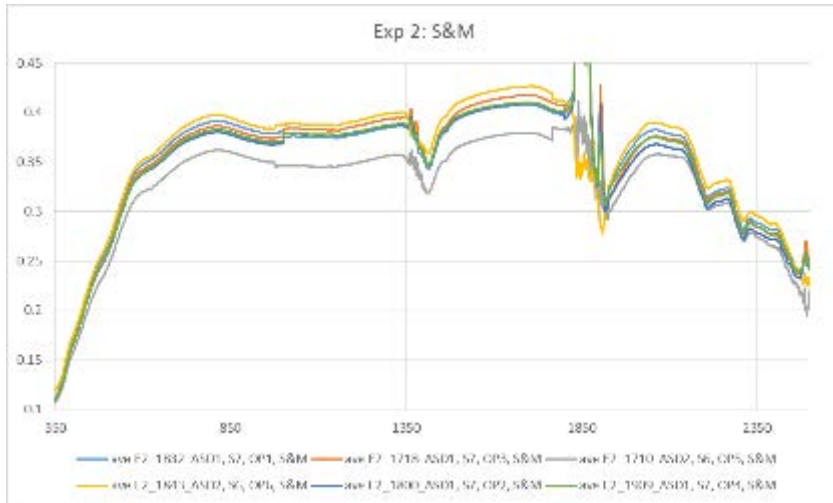
- The deviation from the mean reflectance shows that there was a difference between the two spectroradiometers/panels.
- Overall the comparison of CVs for the 2 spectroradiometers shows similar values for Exp 1 and Exp 2 continuous measurements.



Instrument	CV
Exp1 ASD1	3.43
Exp1 ASD2	3.38
Exp1 and Exp2 ASD1	3.50
Exp1 and Exp2 ASD2	3.44

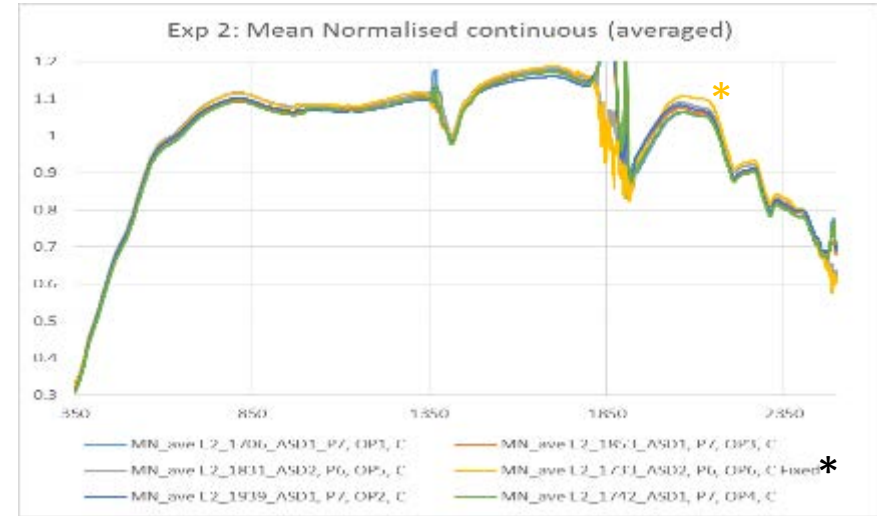
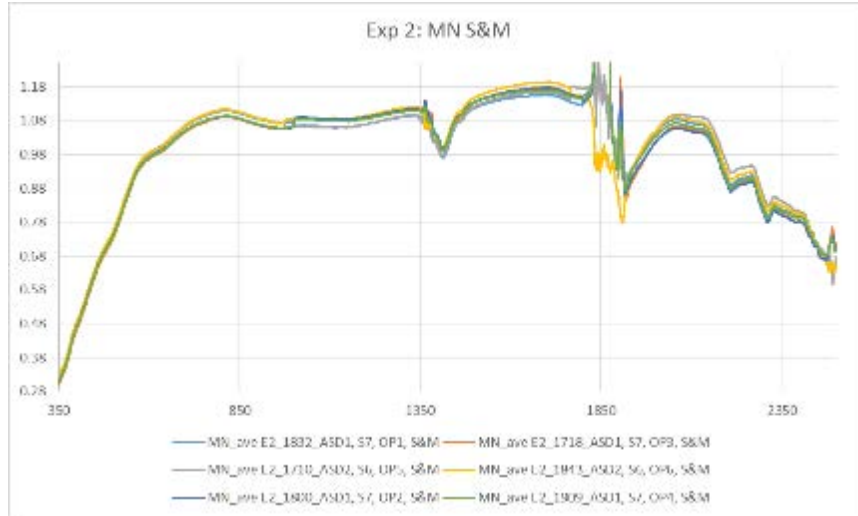
Experiment 2: Stop and measure vs continuous

- Un-normalised data shows a range of reflectance of 3-5%.
- Differences in the average reflectance spectra between the S&M vs Cont. measurements.



Experiment 2: Stop and measure vs continuous

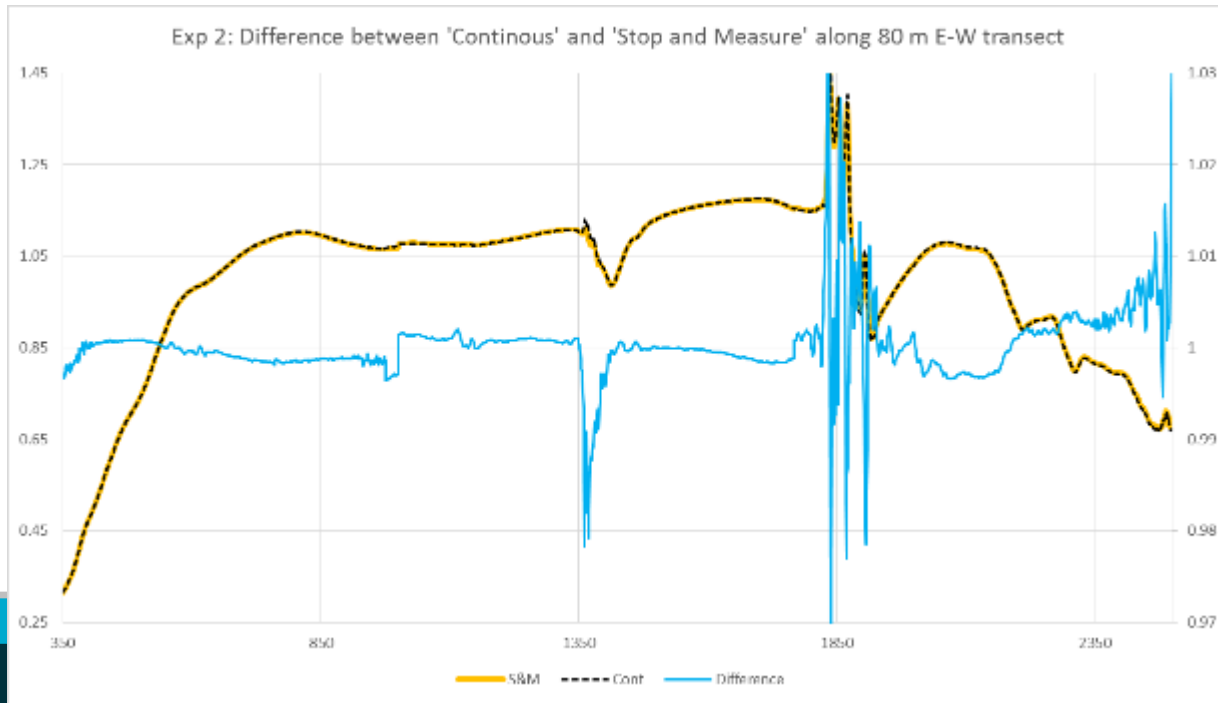
- Mean-normalised data shows similar results for each run regardless of the sampling method used for the 80 m transect.



* Saturation occurred during sections of this run. Data was omitted.

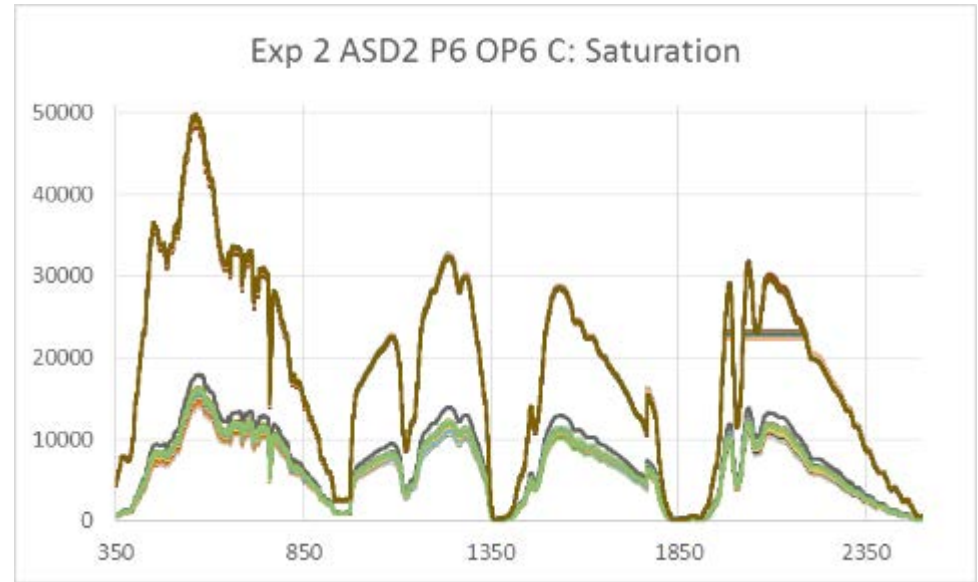
Experiment 2: Stop and measure vs continuous

- Plotting the average mean-normalised Stop and Measure with the mean-normalised Continuous measurements shows they are very similar, as shown by the difference plot between the two methods for Experiment 2.



Experiment 2: Saturation on panel at end of scan

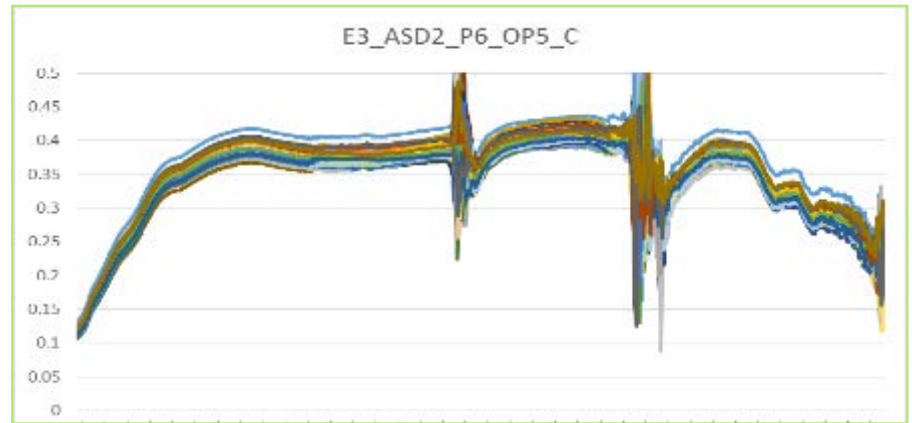
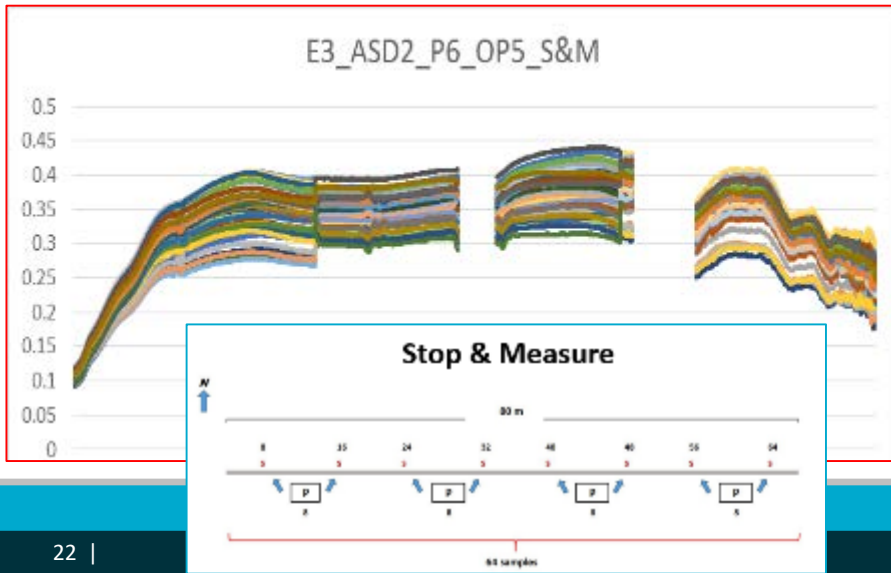
- Found to occur with older ASD (also instrument had heat related operating issues)



Experiment 2: Coefficients of variance

- The CV and SD for each of the individual Stop and Measure collects were low, but the variance between all of the measurements of the whole run of the 8 points was higher than the CV of the continuous method.

Method	CV %
Step and Measure	5.63
Continuous	2.73



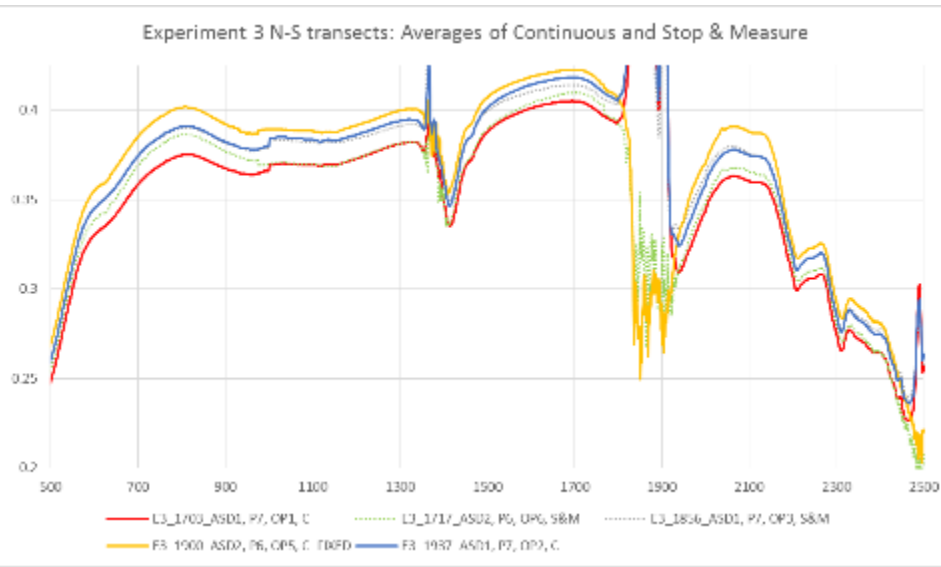
Experiment 2: Coefficients of variance

- CVs decreased for continuous measurements throughout the experiment, whereas CVs increased for the S&M measurements
- Field note sheets indicate the presence of wind and haze in the later measurements.

Run	Code	CV %
1	E2_1706_ASD1_P7_OP1_C	4.26
2	E2_1710_ASD2_P6_OP5_S&M	5.63
3	E2_1718_ASD1_P7_OP3_S&M	5.45
4	E2_1733_ASD2_P6_OP6_C	4.34
5	E2_1742_ASD1_P7_OP4_C	4.32
6	E2_1800_ASD1_P7_OP2_S&M	4.98
7	E2_1831_ASD2_P6_OP5_C	2.73
8	E2_1832_ASD1_P7_OP1_S&M	6.42
9	E2_1843_ASD2_P6_OP6_S&M	6.15
10	E2_1853_ASD1_P7_OP3_C	3.21
11	E2_1909_ASD1_P7_OP4_S&M	6.33
12	E2_1939_ASD1_P7_OP2_C	2.75
	Average	4.71
	Average S&M	5.88
	Average Continuous	3.60

Experiment 3: Comparison at the Cal val site

- Larger area of measurement (80 x 220 m), therefore less runs were collected.
- Cloudy conditions in the afternoon hindered the collection. Only 5 runs were made.
- Older spectroradiometer started to overheat, limiting the number of concurrent runs.
- Good agreement between step and measure and continuous data for ASD1.



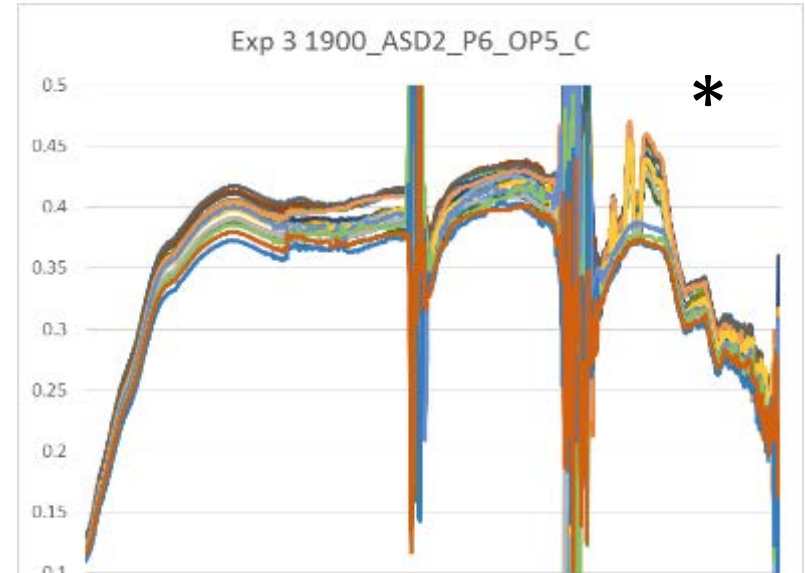
Experiment 3: Saturation during two transects

- Older ASD exhibited problems.
- Example of spectra from Transects 2 and 3.
- No optimisation was done on the panel after transect 2.
- Cirrus clouds may have changed light conditions causing the spectroradiometer to saturate on the panel
- Removed the two transects with saturated data.

Taken from the field note sheets:

OVER for COLLECTION NOTES

Panel & Transect	Target Spectrum #	Actual Spectrum #	SWIR Status Optimize or Ok	Sky, Weather Conditions (Clouds, Wind)	Notes
Start Spectrum	000	000	ok	clear #1	Start Time: 19:00
End Panel 1-Start Panel 2	010	008		clear	Problem: 00/00 (00/00)
End Transect 2-Start Panel 3	072	072			
End Panel 2-Start Transect 3	080	080			
End Transect 4-Start Panel 3	144	144			
End Panel 3-Start Transect 5	192	182/180	opt	clear #2	opt on 12/02/15/2

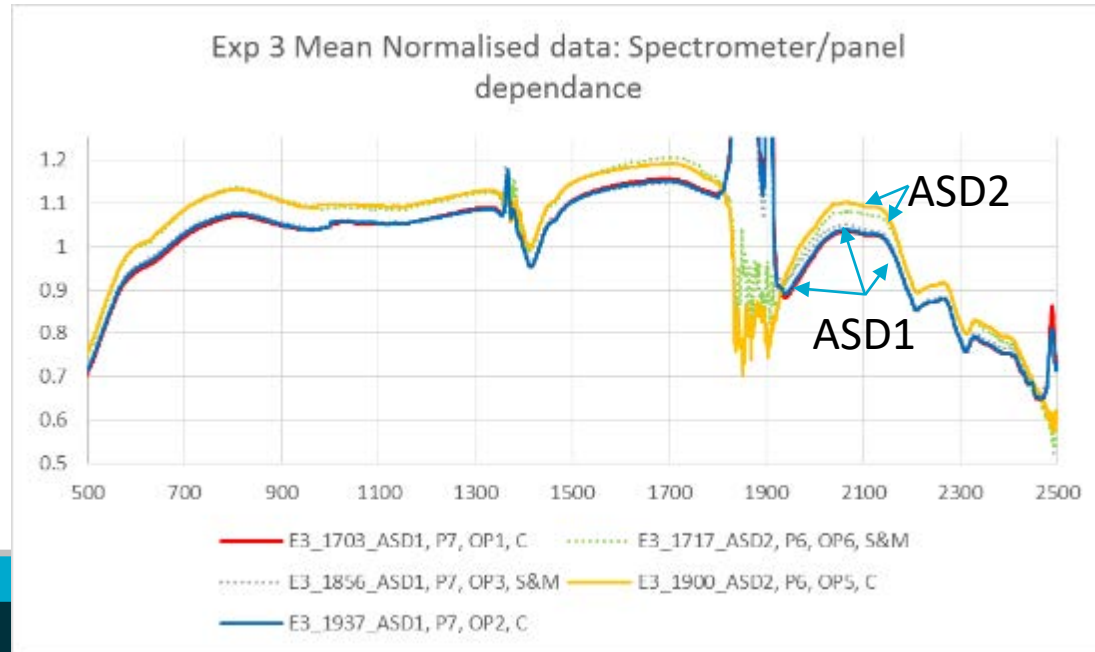


General weather conditions (wind, clouds, etc.) for collection *thin layer of cirrus clouds over sun*
stratocumulus clouds around the site

Sky conditions at overpass: Over sun *almost clear except for thin layer of cirrus clouds*

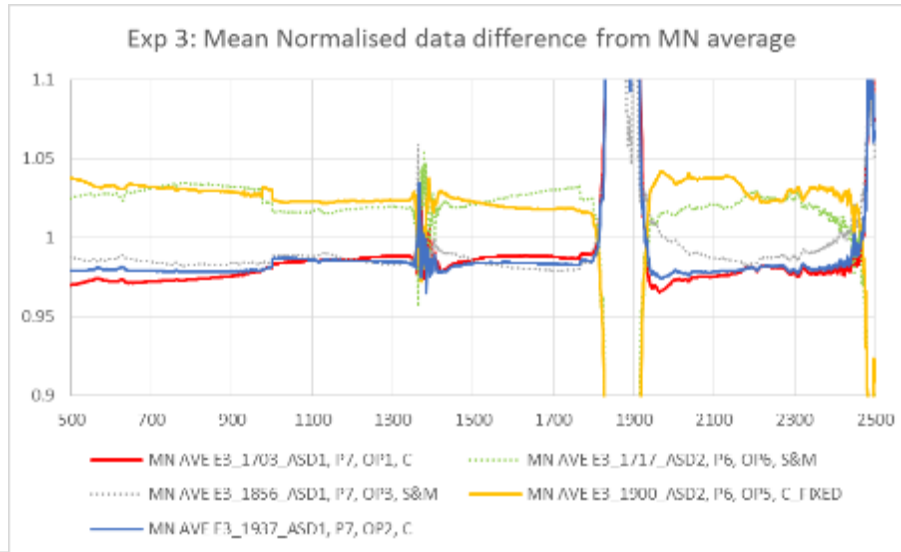
Experiment 3: Mean normalisation of data

- When the data is mean normalised, the spectra of the different spectroradiometers plot together, with Stop & Measure and Continuous data producing similar average spectra.



Experiment 3: Mean normalisation of data

The difference plots from the average of all of Exp3 measurements shows a similar grouping, with greater variation in the S&M and Continuous spectra in the SWIR2 region (1900 - 2500 nm).



Experiment 3: Coefficients of variance

- Average CV values were higher for Exp3 than Exp1 or Exp2.
- Measurements were interrupted by clouds.
- Only 5 runs were collected.
- Conditions were much more windy that previous days experiments.
- Continuous measurements took ~20 minutes. Whereas S&M took ~35 minutes.

Run	Code	CV %
1	E3_1703_ASD1, P7, OP1, C	4.79
2	E3_1717_ASD2, P6, OP6, S&M	8.07
3	E3_1856_ASD1, P7, OP3, S&M	5.77
4	E3_1900_ASD2, P6, OP5, C	3.44
5	E3_1937_ASD1, P7, OP2, C	4.03
	Ave CV	5.22
	Ave S&M CV	6.92
	Ave Cont CV	4.09

Conclusion

- Field sheets were useful for looking back at the conditions or when anomalies were found in the data.
- Meteorological, AERONET and transfer radiometer data needs to be examined in detail.
- Stop and Measure method allows control to remove bad spectra and can better characterize the surface, but less area can be measured in a restricted time, such as a satellite overpass. Thus, this technique may be useful for surface characterization of an area in good conditions.
- Solar irradiance variations can be observed in the samples, but the influence of pointing cannot be discarded as a possible source of variability.
- The exercise proved highly successful at demonstrating the procedure of field measurement for satellite cal-val measurements.

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