A Community Approach to The Standardised Validation of Ground Surface Reflectance

Cindy Ong, Tim Malthus, Peter Fearns, Ian Lau, Medhavy Thankappan, Guy Byrne, Andrew Walsh, Kenneth Clarke, Alicia Caruso, Lola Suarez Barranco, Laurie Chisholm, Peter Scarth, Kylie Smith, Mark Broomhall

Cindy Ong | 21 November 2019

Digital Earth AUSTRALIA

CSIRO

Australia's National Science Agency

Rationale

To establish a repeatable, practical and traceable field validation procedure to achieve a lasting “infrastructure” for DEA Surface Reflectance validation and uncertainty. Key steps in the process include:

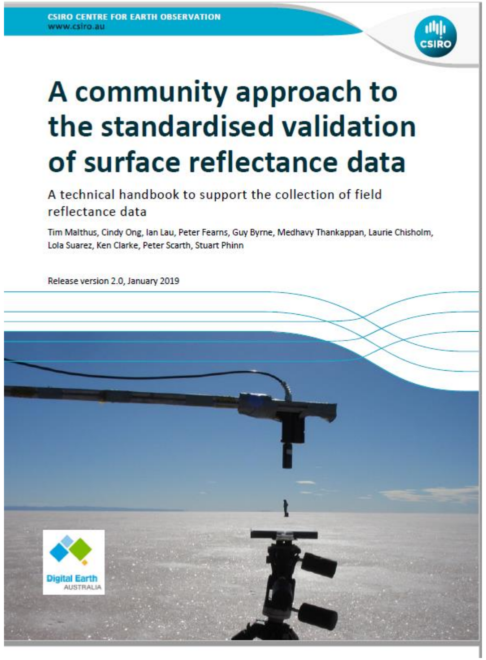
- the establishment of the calibration sites and associated infrastructure;
- the methodology behind the field calibration itself;
- the data processing and associated quality assurance and quality control;
- the establishment of an ongoing and repeatable validation program.

Digital Earth AUSTRALIA

CSIRO

The Guidebook

- Built on large bodies of work internationally and nationally;
- Living document – refined as work progressed;
- 3 components;



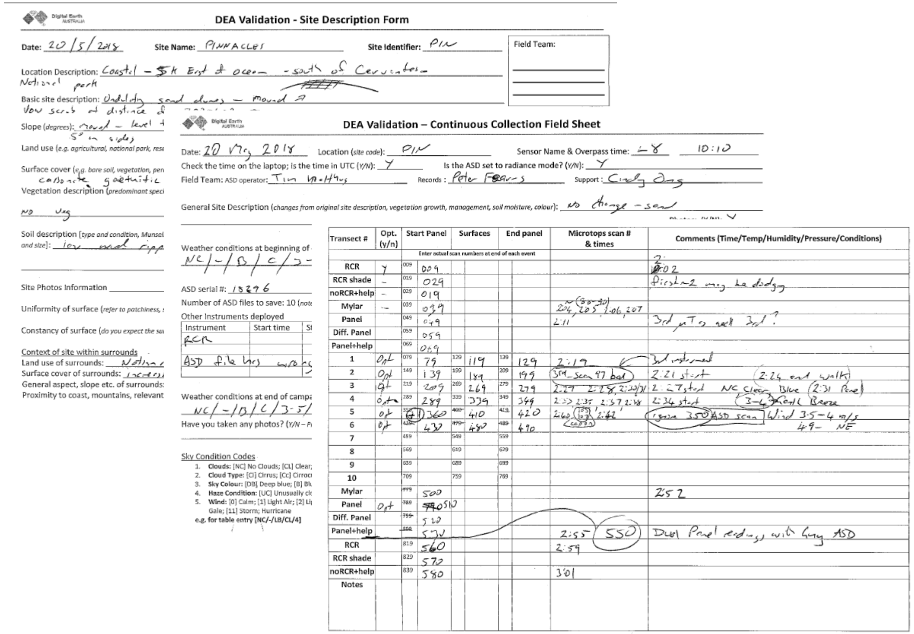
A.1 Field Quick Guide

Pre-visit:

- ☐ Check weather conditions. The following link will give you recent cloud prediction plots (https://drive.google.com/open?id=1RWgxUjSWFnwxmCz7LeS5ralmUYEsiYmm). Also refer to windy.com, darksky.net and the other resources referred to in Section 2.4.
- ☐ Organise staff availability, travel arrangements, vehicles, equipment, accommodation and health and safety plans.
- ☐ Inform landholders of intention to access.
- ☐ Pre-print field data recording sheets.
- ☐ Make sure all batteries are charged and spares for instruments (e.g. GPS and MicroTops) are packed.
- ☐ Make sure that all relevant cables, adaptors, etc. are packed.
- ☐ Check the equipment list.

On arrival:

- ☐ Ensure times on all devices have been set to UTC.
- ☐ Select most suitable site (flat and uniform over at least 100 x 100 m). Evaluate height of vegetation and ease to walk through.
- ☐ If applicable to the surface and location, use marker pegs to mark off bounds (100 x 100 m) of site to be measured. Suggested orientation ~ 8° E of N. Use the GPS to measure the locations of the marker pegs.
- ☐ Place marker pegs at 20 m intervals along the 6 transects of the 100 x 100 m plot (see the set up in Figure 17).
- ☐ Take photographs of the surface and the surroundings sufficient to characterise the validation site, its scale and the context of its surrounding environment (slope, distance to horizons, sky, vegetation type and height, soil colour)
- ☐ Evaluate overhead atmospheric conditions. Take photos (preferably geotagged) of the overhead sky conditions.
- ☐ Warm up spectroradiometer and prepare for measurements. Check the time on the computer has been set to UTC.
- ☐ Prepare the MicroTops and GPS. Sync the MicroTops with the GPS. If no GPS is available to sync with the MicroTops ensure the correct coordinates are entered manually. Ensure the time on the MicroTops is set to UTC.
- ☐ Set up the photometer and weather meters in continuous logging mode at a suitable distance away from any extraneous influences. Ensure the time on these devices is set to UTC.



Site Selection Criteria






Characteristics

- Use existing sites where possible;
- Scale and homogeneity;
- Site proximity;
- Site accessibility and local knowledge;
- Cloud cover and aerosols;
- Distance to the site for the site owners and associated instrumentation required;
- Geographic location of the site so that it forms a component of the overall aim of wide geographic coverage across the continent
- Cover type of the site so that it forms a component of the overall aim of a range of cover types across the continent;

Priority for planning field measurements (besides good weather conditions) are as follows:

- Concurrent L8 and S2a or S2b overpasses;
- Consecutive L8 and S2a or S2b overpasses;
- A single L8, S2a or S2b overpass;



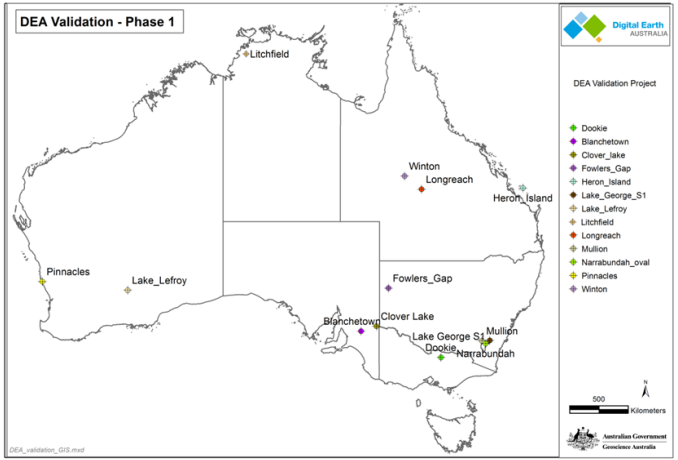
Digital Earth AUSTRALIA

Site Selection Criteria

- Primary sites
  - Visited almost as frequently as there is a L8 satellite overpass, weather permiting, and can be done as a day trip;
  - Where there are concurrent overpasses and the next day's conditions are conducive for measurements, all attempts will be made to acquire data from the concurrent day as well;
  - For each primary site we envisage a total of 4-5 measurements in 3 months.

Secondary sites

  - At least 1 visit at best twice;
  - Important in the long term to provide more comprehensive range of cover types, landscapes, geographic location and atmospheric conditions, etc;
  - Frequency of acquisitions/measurements.



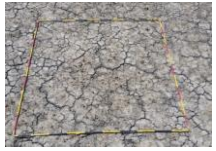
Digital Earth AUSTRALIA

CSIRO

Instrumentation

Spectroradiometer (recently wavelength checked and radiometrically calibrated) with Visible, Near Infrared (VNIR)-Shortwave Infrared (SWIR) wavelength range, such as an Analytical Spectral Devices (ASD) FieldSpec Pro.	
8 degree and Remote Cosine Receptor (RCR) foreoptics	
Boom pole (or monopod) for spectrometer head with spirit level.	
Spectralon† reflectance panel (recently calibrated), at **250 x 250 mm** prefferred and tripod	
Method for levelling panel (spirit level, that does not touch the Spectralon part of panel).	

Portable sun photometer, such as a MicroTops (https://solarlight.com/product/microtops-ii-sunphotometer/).	
Flags or pegs for marking corner points and transects. Coloured markers such as sand bags can be used where the surface is hard.	 
Note taking equipment and logging sheets (see appendices).	
Camera for sky and site photos.	
Global positioning system (GPS) (+/- compass).	

Mylar sheet for collecting wavelength calibration data	
Bluetooth or hard wired GPS to spectrometer/controller.	
Temperature, humidity, barometer (calibrated) with logging capability (The MicroTops has these sensors, but will not log the data unless continuous measurements are collected)	
Fisheye sky camera or 360 degree camera.	
Dust blower (handheld bulb type, like ones used for cameras).	
Square metre quadrat for taking standard photos of surface cover	
Small bottle of demineralised water for rinsing off the reflectance panel should it get dusty or dirty	
Sun disk for taking diffuse and direct irradiance measurements (See Appendix **Error! Reference source not found.**).	

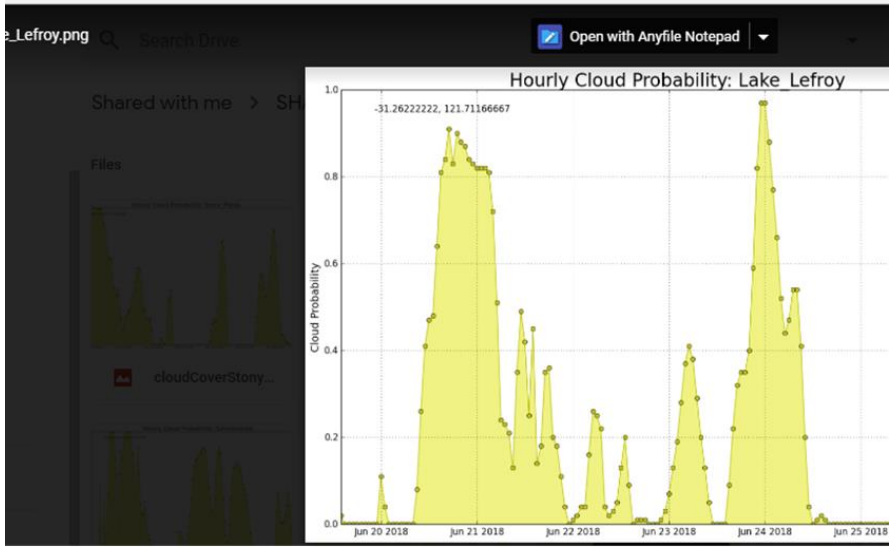
Digital Earth AUSTRALIA

CSIRO

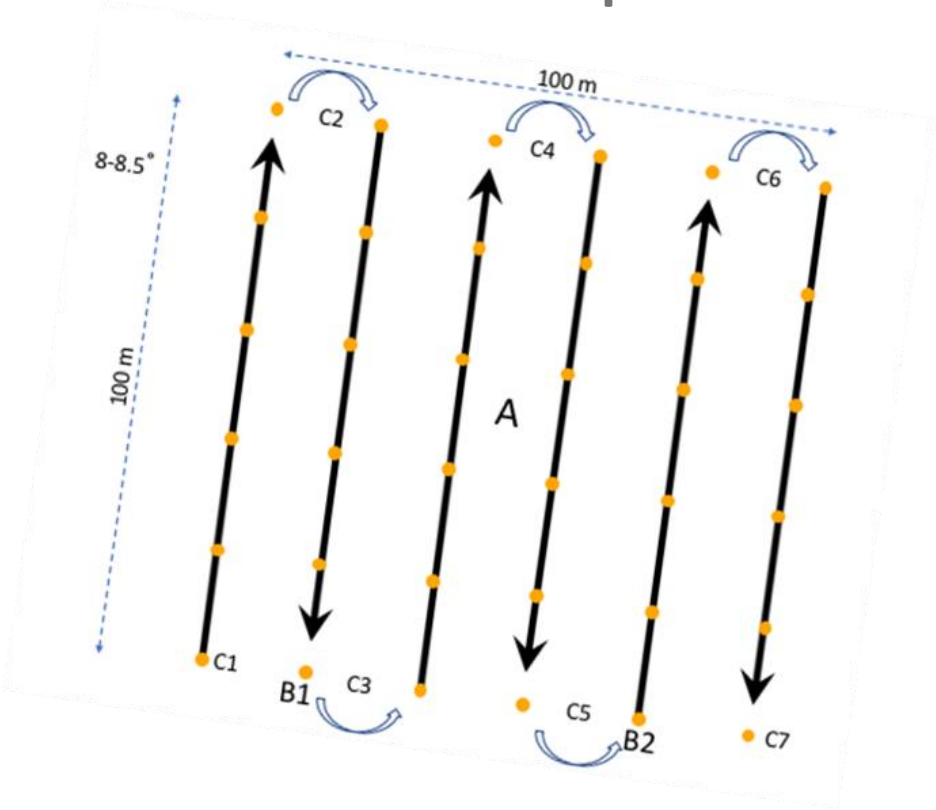
Overpass Schedule & Cloud Forecast

	D	E	F	EH	EI	EJ	EK	EL	EM	EN
				19/06	20/06	21/06	22/06	23/06	24/06	25/06
				Tue	Wed	Thu	Fri	Sat	Sun	Mon
	Cindy Ong	Pinnacles	L8			L8				
	Ian Lau		S2a			S2a				
	Peter Fearns		S2b							
		Lake Lefroy	L8							L8
			S2a							S2a
			S2b		S2b					

ttps://drive.google.com/drive/folders/1RWgxUjSWFnwxmCz7LeS5raImUYEsiYmm



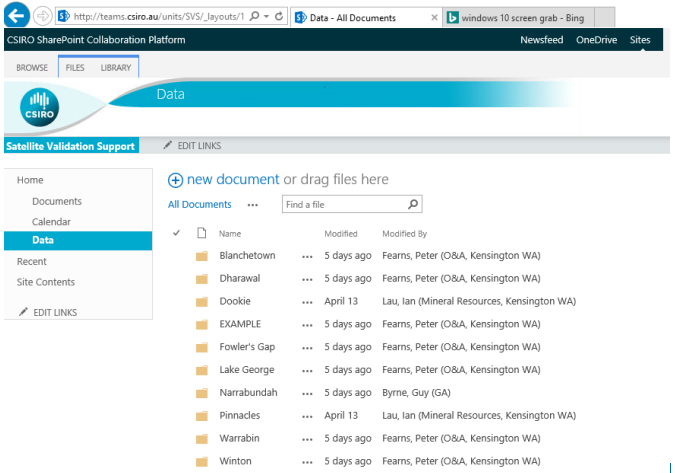
Experimental Set-up

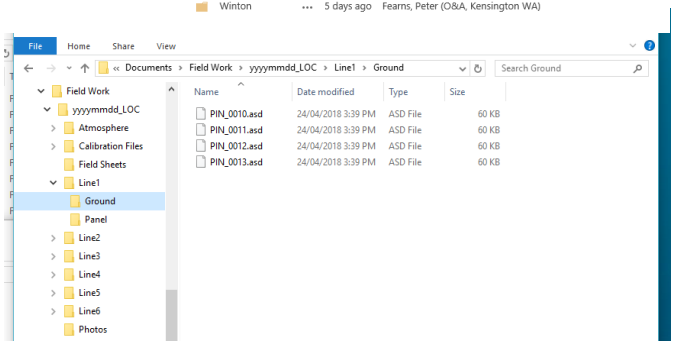


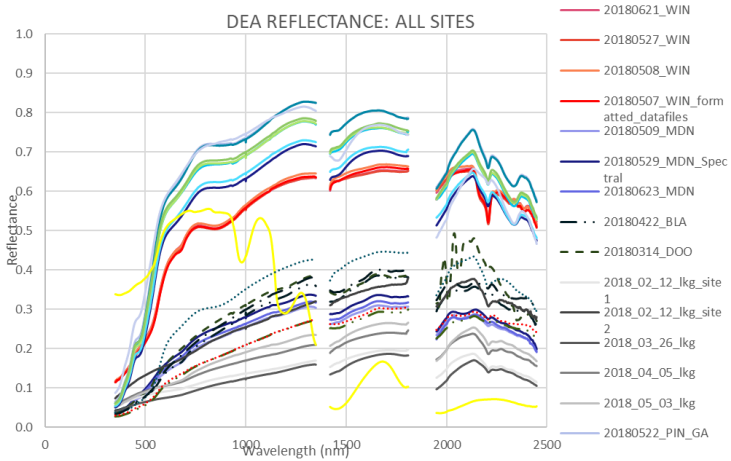
Digital Earth AUSTRALIA

CSIRO

Working Data Storage, Naming Convention, File Structure, Final Archive

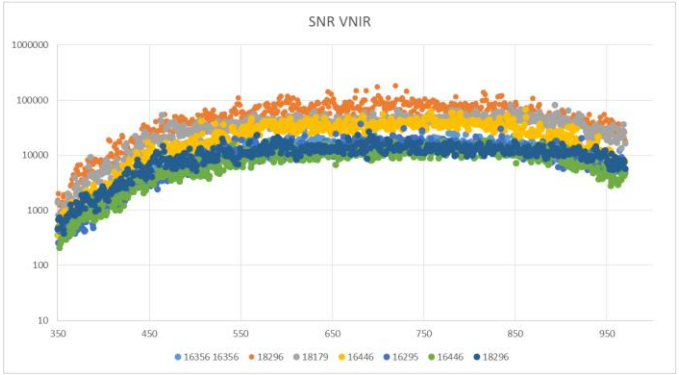


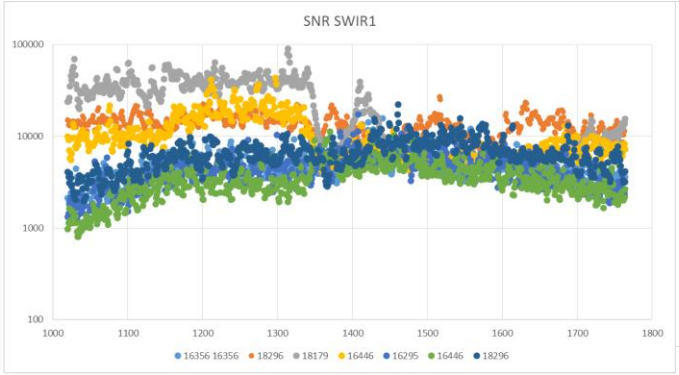


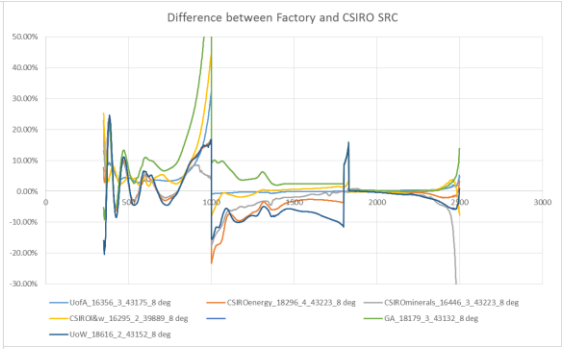


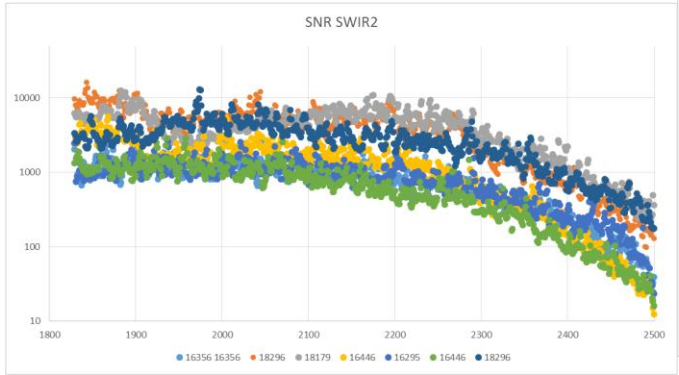
Digital Earth AUSTRALIA

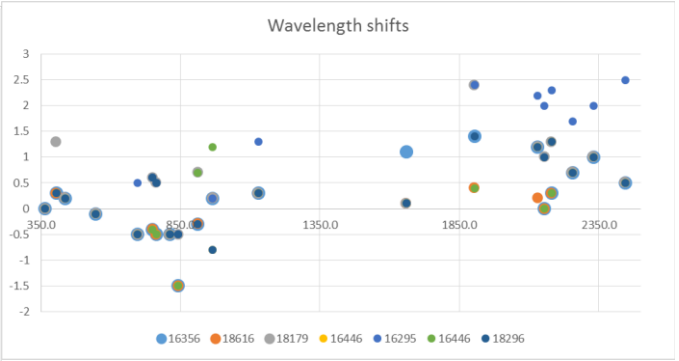
Instrument Calibration Check











Digital Earth AUSTRALIA

CSIRO

Uncertainties

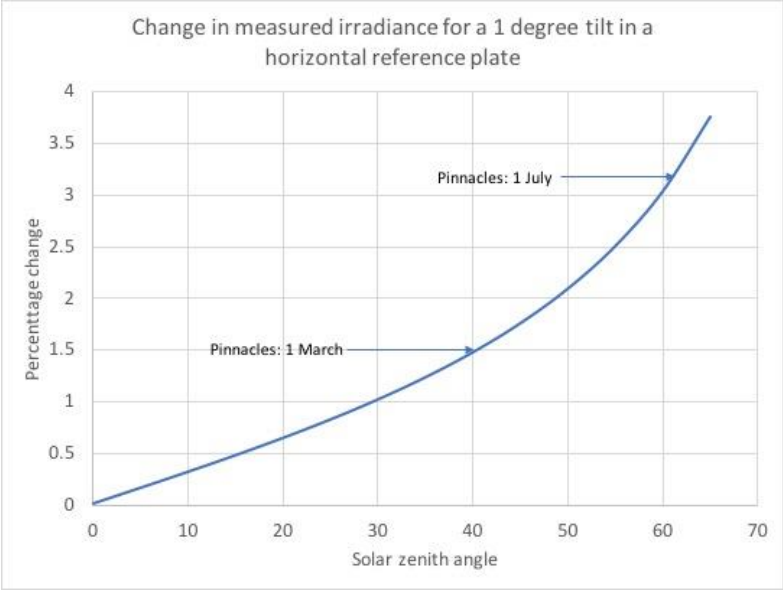
- Selected uncertainties are ultimately combined and reported as campaign wide values, both as **spectral quantities** and as a spectrally averaged **Mean Total Uncertainty**

$$u_c = \sqrt{u_{tilt}^2 + u_{BRFtilt}^2 + u_{BRFcal}^2 + u_{MPV}^2}$$

- where
  - u_{tilt} is effect of **panel tilt** on total illumination flux
  - $u_{BRFtilt}$ is panel **BRF uncertainty due to panel tilt**
  - u_{BRFcal} is panel **BRF calibration uncertainties**
  - u_{MPV} is "**Mean panel variability**" - includes effects of spread in panel measurement data, misalignment of the panel throughout the campaign, changing atmospheric conditions

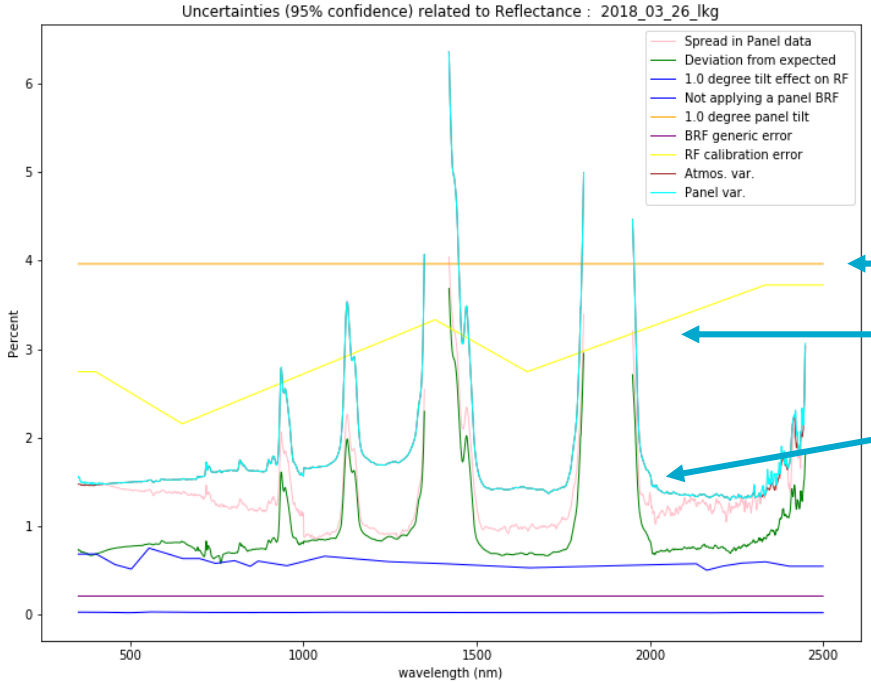
Tilt – Pinnacles (30.5° S)

- Dependent on sun position
- Tilt error in mid-winter - **~3%**
- Solution: automated levelling



Digital Earth AUSTRALIA

We end up with uncertainties expressed spectrally



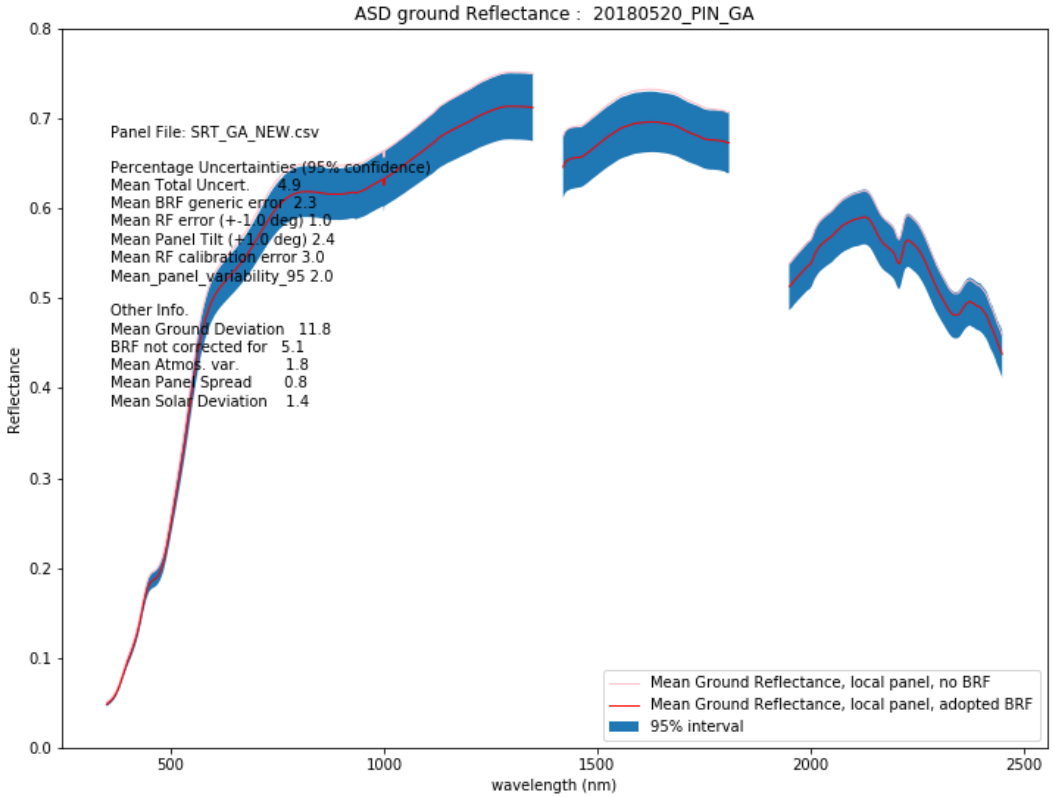
Panel tilt

Panel RF calibration

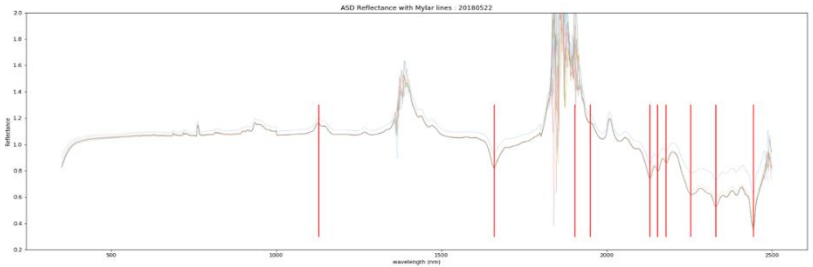
Panel variability

Digital Earth AUSTRALIA

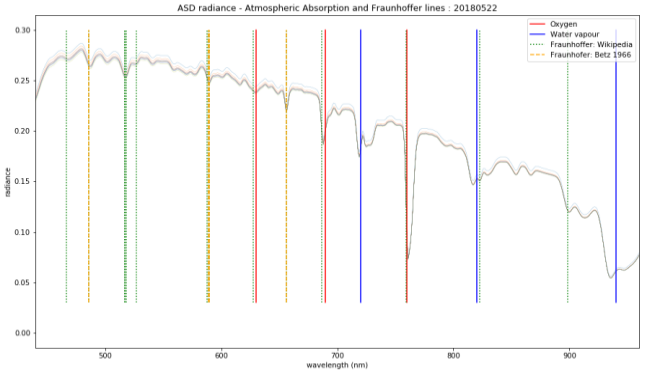
Campaign Overview



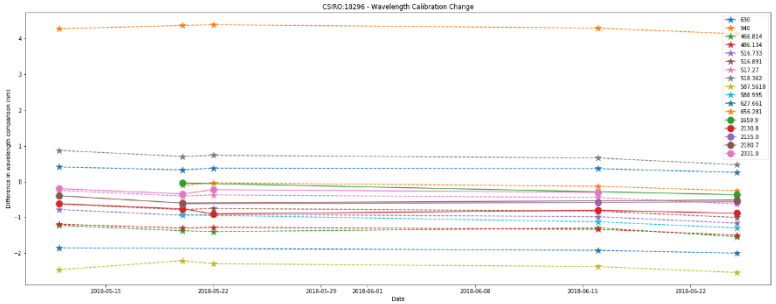
Wavelength Stability

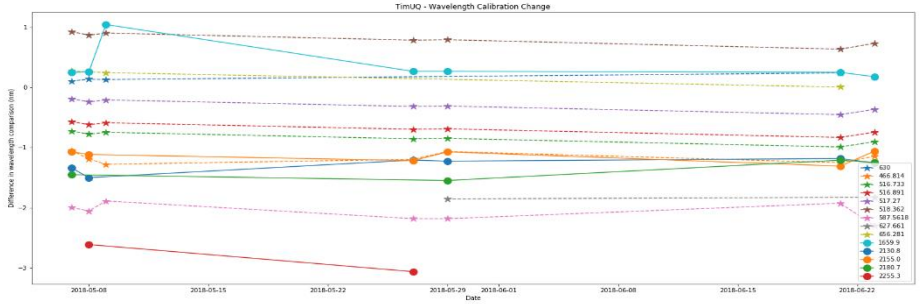


Field-measured reflectance through Mylar



Augmented with Fraunhofer line subset





Wavelength stability over time in two field spectroradiometers

Digital Earth AUSTRALIA

Monitoring wavelength stability through time

Conclusions

- Method repeatable despite time pressures
  - Would have been better with workshop to initiate;
- Field guide was refined and evolved as we learned new things;
- Panels - the largest sources of error in field measurements
  - Absolute calibration, BRF;
  - Tilt;
- Points to the improved method
  - Laboratory calibration;
  - Leveling and orientation in the field.
- Field handbook publicly available: https://doi.org/10.25919/5c9d0ba9e9c12
  - Contributed to CEOS WGCV WP CV-17 (continental scale SR validation), currently in review and will soon be available on cal/val portal;
  - Extension to new SR validation WP for global scale protocol;

Digital Earth AUSTRALIA

Thank You

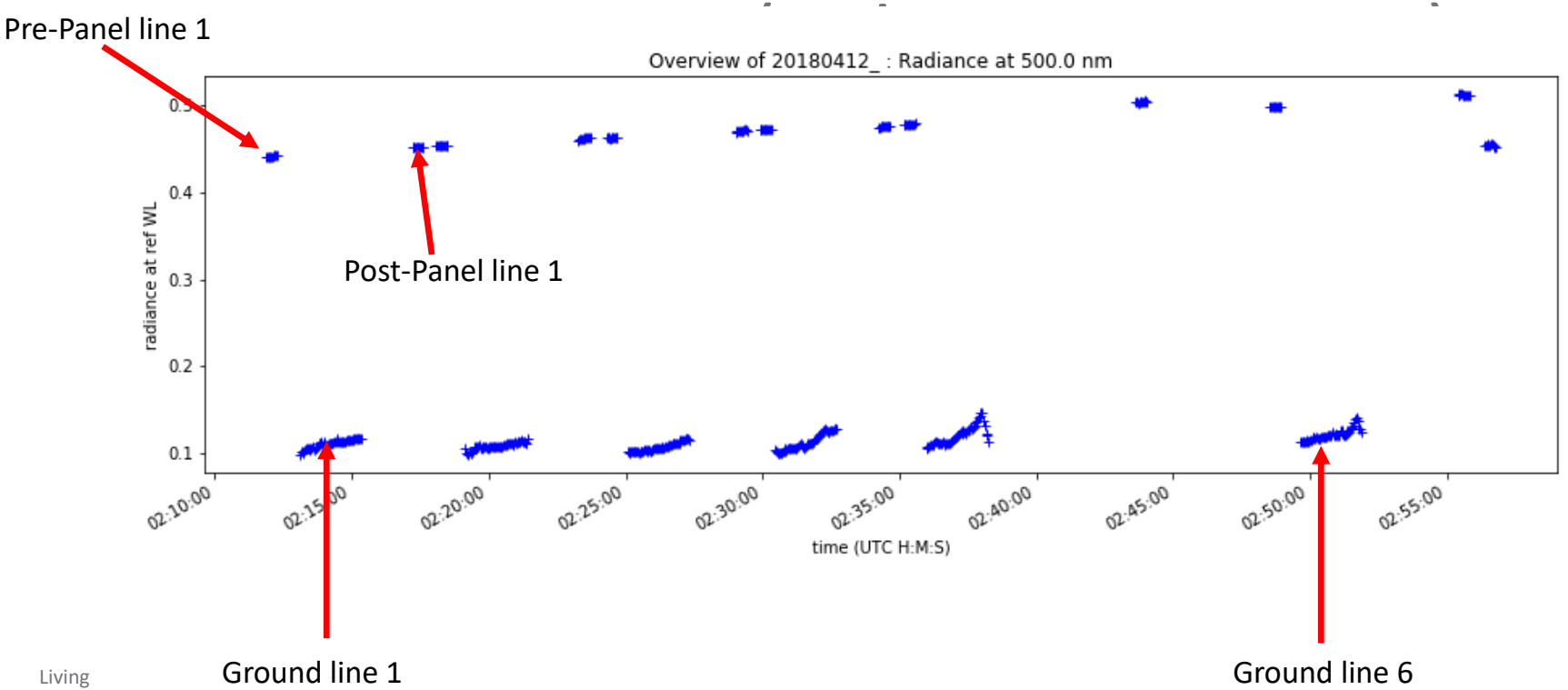
CSIRO Energy
Cindy Ong
Principal Research Scientist

+61 8 6436 8677
Cindy.ong@csiro.au@csiro.au
csiro.au/energy

CSIRO Ocean & Atmosphere
Tim Malthus
Research Group Leader

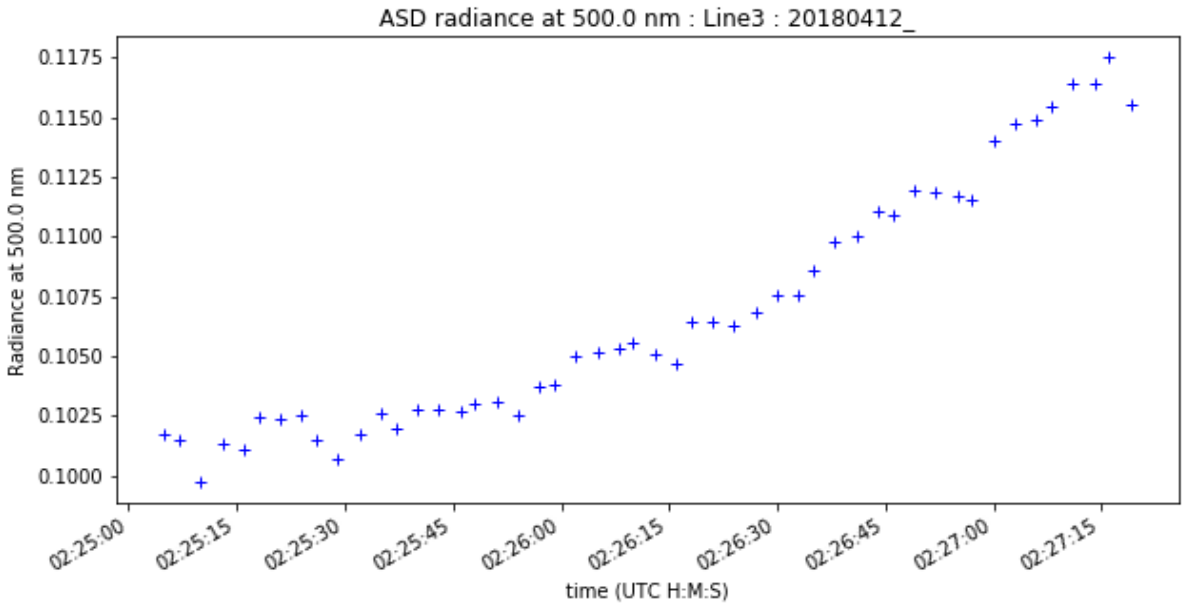
+61 7 3833 5583
tim.malthus@csiro.au
www.csiro.au/O&A

Back ups

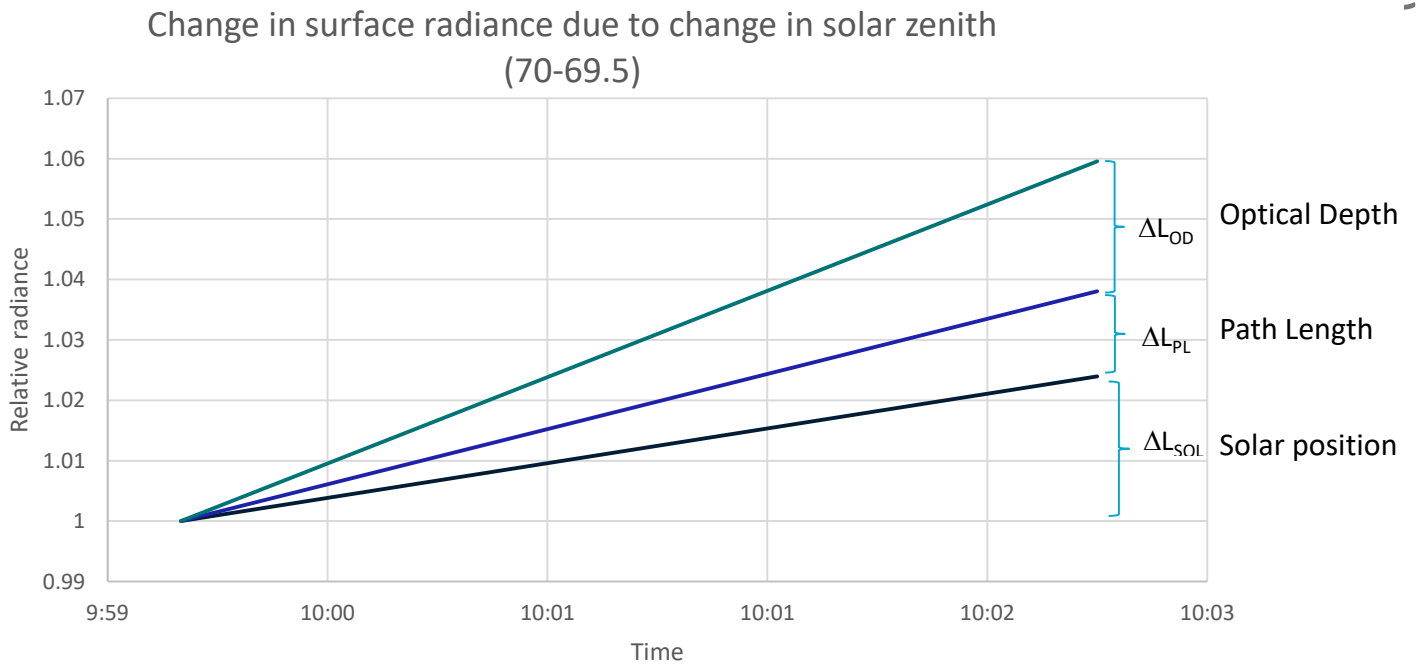

Pre-Panel line 1
Overview of 20180412_ : Radiance at 500.0 nm
radiance at ref WL
0.5
0.4
0.3
0.2
0.1
Post-Panel line 1
02:10:00
02:15:00
02:20:00
02:25:00
02:30:00
02:35:00
02:40:00
02:45:00
02:50:00
02:55:00
time (UTC H:M:S)
Ground line 1
Ground line 6

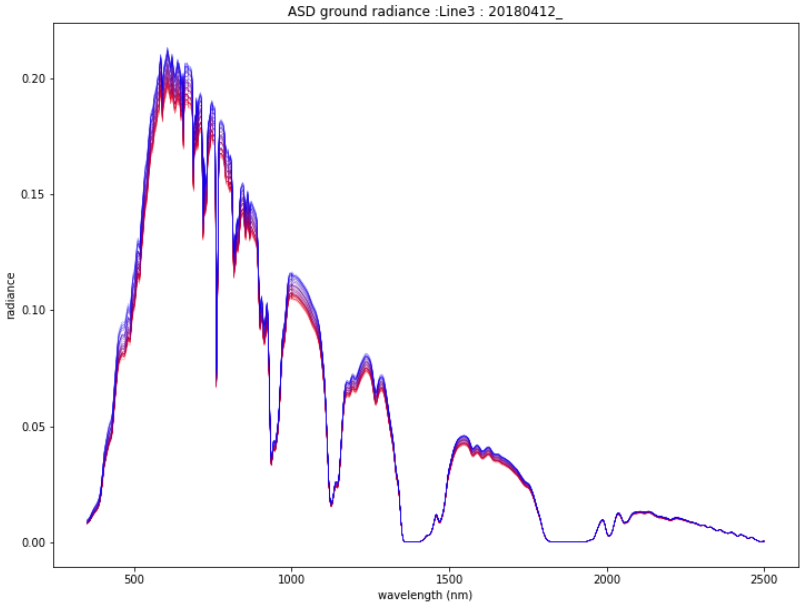
Ground line 3 (radiance @500nm)

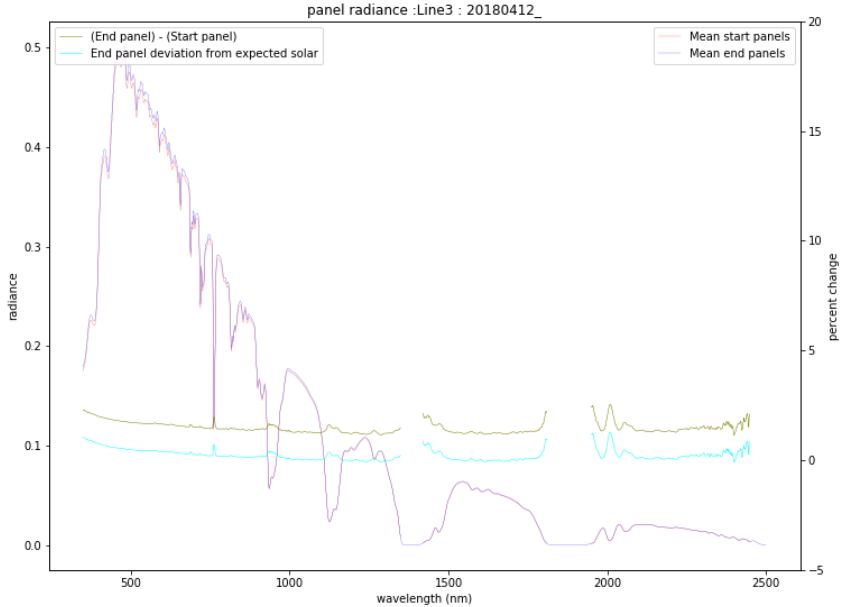
- 2 min transect
- Why is the curve not straight and flat?
- Does the ground get brighter?
- Is the sun rising slightly?
- Is the atmospheric path length decreasing?
- Is the atmosphere changing?



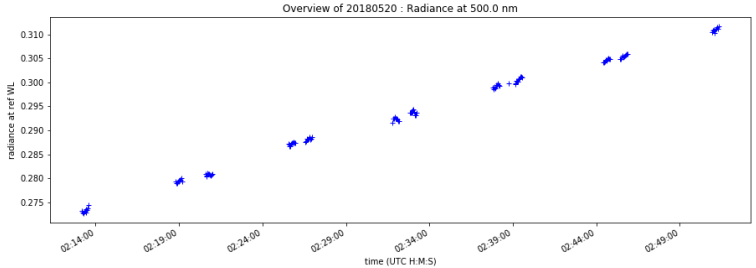
Inter


Change in surface radiance due to change in solar zenith (70-69.5)
Relative radiance
1.07
1.06
1.05
1.04
1.03
1.02
1.01
1
0.99
9:59
10:00
10:01
10:01
10:02
10:03
Time
ΔL_{OD}
Optical Depth
ΔL_{PL}
Path Length
ΔL_{SOL}
Solar position

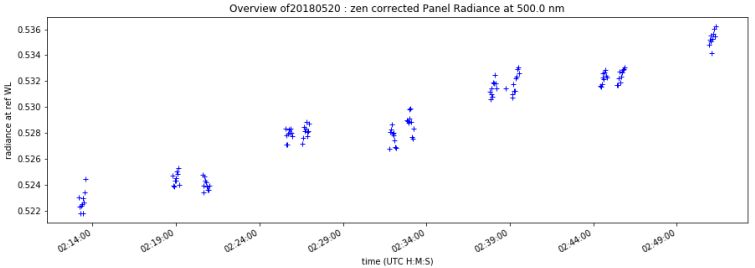

ASD ground radiance :Line3 : 20180412_
radiance
wavelength (nm)
0.00
0.05
0.10
0.15
0.20
500
1000
1500
2000
2500


panel radiance :Line3 : 20180412_
(End panel) - (Start panel)
End panel deviation from expected solar
Mean start panels
Mean end panels
radiance
percent change
wavelength (nm)
0.0
0.1
0.2
0.3
0.4
0.5
−5
0
5
10
15
20
500
1000
1500
2000
2500

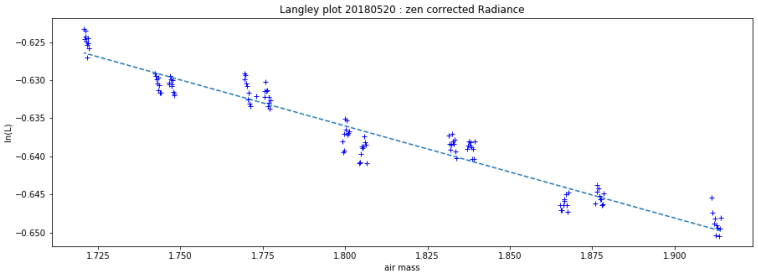
ta



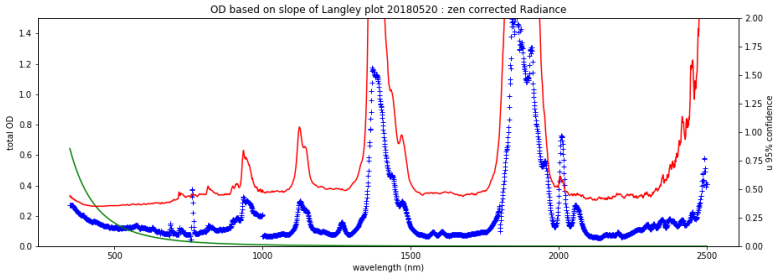
Panel data through time



Solar angle removed



Langley plot



Optical density