

OPTIMISE



Innovative Optical Tools For Proximal Sensing
Of Ecophysiological Processes

COST Action ES1309 OPTIMISE - Final Conference, 21-23 February 2018

Instruments, spectral data management, and protocols

Laurie Chisholm
University of Wollongong



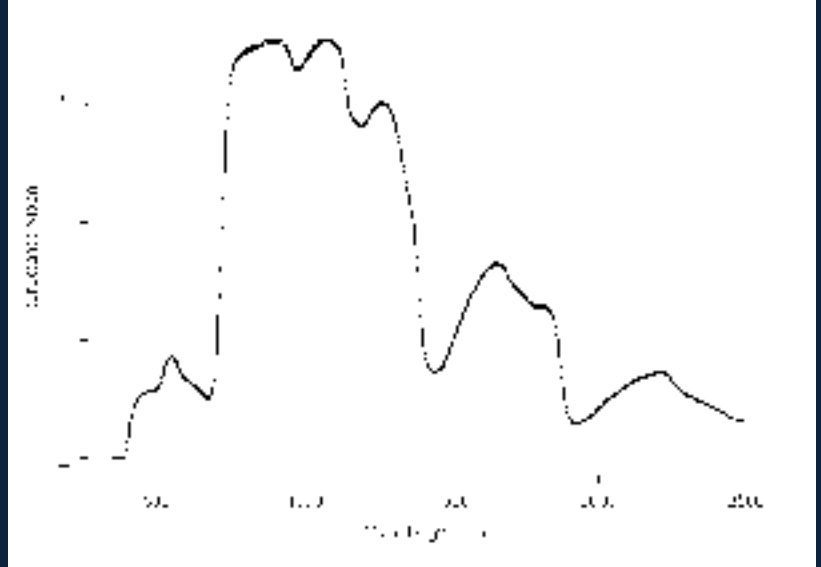
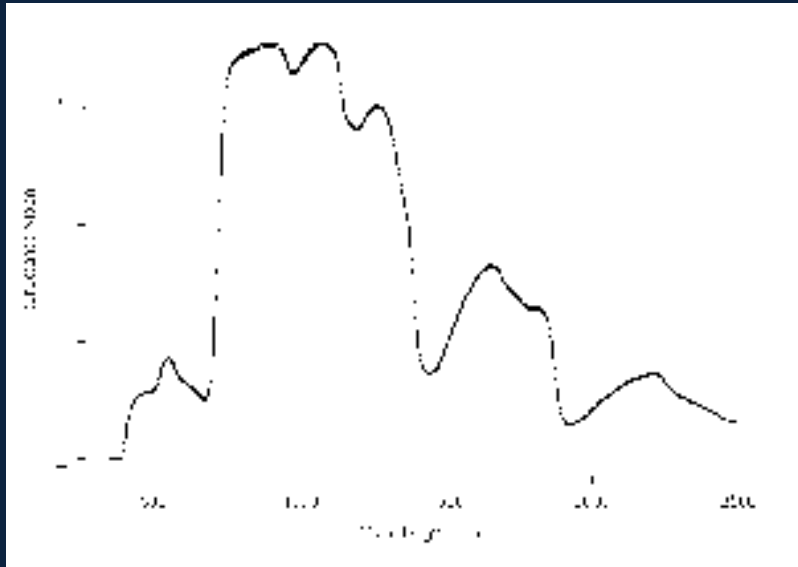
UNIVERSITY
OF WOLLONGONG
AUSTRALIA



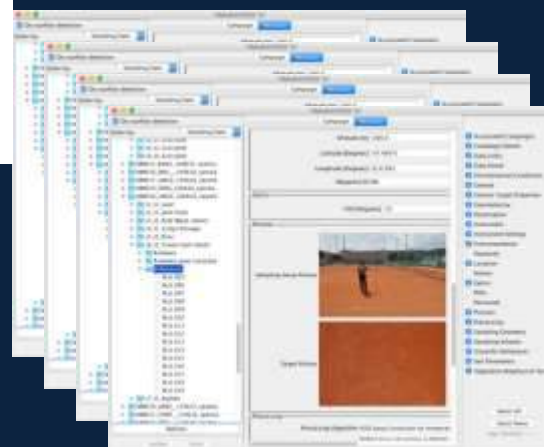
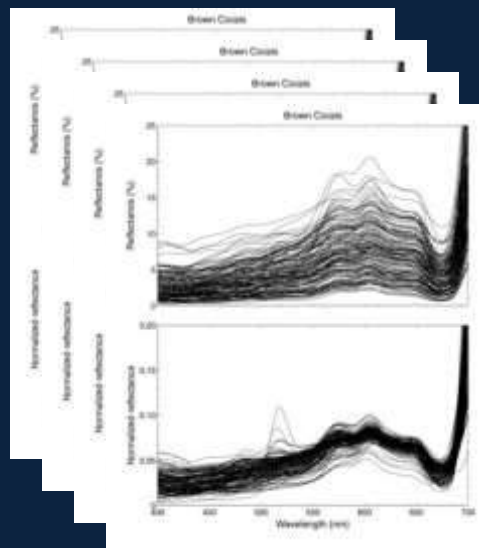
Common types of field spectroscopy Clockwise from left: vegetation, estuarine, snow, underwater coral, and geological. Source (Source: Rasaiah et al 2012)



Does this change things for your project?



21 st Sept 2013	Acquisition Date	Unknown
8	Fore optic degree	Unknown
25	Number of samples	Unknown
25	Dark current integrations	Unknown
10	White reference integrations	Unknown



Coral Reefs (2004) 25: 86–99
DOI 10.1007/s00338-003-0150-1

8.1 Coastal Goals (2004) 10, 64-65
DOI: 10.1007/978-1-4020-2852-3_8-1

81 *United States (2004) 10, 640*
DOI: 10.1017/S0022278X04000181

Eric **8.1** *Control Rooms (2004) 110, 84-101*
DOI: 10.1007/s10551-005-0190-1

REPORT

Sp...

Sp Eric J. Hockberg · Martin J. Atkinson
Amy Annell · Serge Audiffren

Spectral reflectance of coral

Abstract

exp

15. $\frac{1}{2}$

100%

4000

1994

by a
billion
more

1998, 1999, 2000, 2001, 2002, 2003, 2004, 2005, 2006, 2007, 2008, 2009, 2010, 2011, 2012, 2013, 2014, 2015, 2016, 2017, 2018, 2019, 2020, 2021, 2022, 2023, 2024, 2025, 2026, 2027, 2028, 2029, 2030, 2031, 2032, 2033, 2034, 2035, 2036, 2037, 2038, 2039, 2040, 2041, 2042, 2043, 2044, 2045, 2046, 2047, 2048, 2049, 2050, 2051, 2052, 2053, 2054, 2055, 2056, 2057, 2058, 2059, 2060, 2061, 2062, 2063, 2064, 2065, 2066, 2067, 2068, 2069, 2070, 2071, 2072, 2073, 2074, 2075, 2076, 2077, 2078, 2079, 2080, 2081, 2082, 2083, 2084, 2085, 2086, 2087, 2088, 2089, 2090, 2091, 2092, 2093, 2094, 2095, 2096, 2097, 2098, 2099, 2100, 2101, 2102, 2103, 2104, 2105, 2106, 2107, 2108, 2109, 2110, 2111, 2112, 2113, 2114, 2115, 2116, 2117, 2118, 2119, 2120, 2121, 2122, 2123, 2124, 2125, 2126, 2127, 2128, 2129, 2130, 2131, 2132, 2133, 2134, 2135, 2136, 2137, 2138, 2139, 2140, 2141, 2142, 2143, 2144, 2145, 2146, 2147, 2148, 2149, 2150, 2151, 2152, 2153, 2154, 2155, 2156, 2157, 2158, 2159, 2160, 2161, 2162, 2163, 2164, 2165, 2166, 2167, 2168, 2169, 2170, 2171, 2172, 2173, 2174, 2175, 2176, 2177, 2178, 2179, 2180, 2181, 2182, 2183, 2184, 2185, 2186, 2187, 2188, 2189, 2190, 2191, 2192, 2193, 2194, 2195, 2196, 2197, 2198, 2199, 2200, 2201, 2202, 2203, 2204, 2205, 2206, 2207, 2208, 2209, 2210, 2211, 2212, 2213, 2214, 2215, 2216, 2217, 2218, 2219, 2220, 2221, 2222, 2223, 2224, 2225, 2226, 2227, 2228, 2229, 2230, 2231, 2232, 2233, 2234, 2235, 2236, 2237, 2238, 2239, 2240, 2241, 2242, 2243, 2244, 2245, 2246, 2247, 2248, 2249, 2250, 2251, 2252, 2253, 2254, 2255, 2256, 2257, 2258, 2259, 2260, 2261, 2262, 2263, 2264, 2265, 2266, 2267, 2268, 2269, 2270, 2271, 2272, 2273, 2274, 2275, 2276, 2277, 2278, 2279, 2280, 2281, 2282, 2283, 2284, 2285, 2286, 2287, 2288, 2289, 2290, 2291, 2292, 2293, 2294, 2295, 2296, 2297, 2298, 2299, 2300, 2301, 2302, 2303, 2304, 2305, 2306, 2307, 2308, 2309, 2310, 2311, 2312, 2313, 2314, 2315, 2316, 2317, 2318, 2319, 2320, 2321, 2322, 2323, 2324, 2325, 2326, 2327, 2328, 2329, 2330, 2331, 2332, 2333, 2334, 2335, 2336, 2337, 2338, 2339, 2340, 2341, 2342, 2343, 2344, 2345, 2346, 2347, 2348, 2349, 2350, 2351, 2352, 2353, 2354, 2355, 2356, 2357, 2358, 2359, 2360, 2361, 2362, 2363, 2364, 2365, 2366, 2367, 2368, 2369, 2370, 2371, 2372, 2373, 2374, 2375, 2376, 2377, 2378, 2379, 2380, 2381, 2382, 2383, 2384, 2385, 2386, 2387, 2388, 2389, 2390, 2391, 2392, 2393, 2394, 2395, 2396, 2397, 2398, 2399, 2400, 2401, 2402, 2403, 2404, 2405, 2406, 2407, 2408, 2409, 2410, 2411, 2412, 2413, 2414, 2415, 2416, 2417, 2418, 2419, 2420, 2421, 2422, 2423, 2424, 2425, 2426, 2427, 2428, 2429, 2430, 2431, 2432, 2433, 2434, 2435, 2436, 2437, 2438, 2439, 2440, 2441, 2442, 2443, 2444, 2445, 2446, 2447, 2448, 2449, 2450, 2451, 2452, 2453, 2454, 2455, 2456, 2457, 2458, 2459, 2460, 2461, 2462, 2463, 2464, 2465, 2466, 2467, 2468, 2469, 2470, 2471, 2472, 2473, 2474, 2475, 2476, 2477, 2478, 2479, 2480, 2481, 2482, 2483, 2484, 2485, 2486, 2487, 2488, 2489, 2490, 2491, 2492, 2493, 2494, 2495, 2496, 2497, 2498, 2499, 2500, 2501, 2502, 2503, 2504, 2505, 2506, 2507, 2508, 2509, 2510, 2511, 2512, 2513, 2514, 2515, 2516, 2517, 2518, 2519, 2520, 2521, 2522, 2523, 2524, 2525, 2526, 2527, 2528, 2529, 2530, 2531, 2532, 2533, 2534, 2535, 2536, 2537, 2538, 2539, 2540, 2541, 2542, 2543, 2544, 2545, 2546, 2547, 2548, 2549, 2550, 2551, 2552, 2553, 2554, 2555, 2556, 2557, 2558, 2559, 2560, 2561, 2562, 2563, 2564, 2565, 2566, 2567, 2568, 2569, 2570, 2571, 2572, 2573, 2574, 2575, 2576, 2577, 2578, 2579, 2580, 2581, 2582, 2583, 2584, 2585, 2586, 2587, 2588, 2589, 2590, 2591, 2592, 2593, 2594, 2595, 2596, 2597, 2598, 2599, 2600, 2601, 2602, 2603, 2604, 2605, 2606, 2607, 2608, 2609, 2610, 2611, 2612, 2613, 2614, 2615, 2616, 2617, 2618, 2619, 2620, 2621, 2622, 2623, 2624, 2625, 2626, 2627, 2628, 2629, 2630, 2631, 2632, 2633, 2634, 2635, 2636, 2637, 2638, 2639, 2640, 2641, 2642, 2643, 2644, 2645, 2646, 2647, 2648, 2649, 2650, 2651, 2652, 2653, 2654, 2655, 2656, 2657, 2658, 2659, 2660, 2661, 2662, 2663, 2664, 2665, 2666, 2667, 2668, 2669, 2670, 2671, 2672, 2673, 2674, 2675, 2676, 2677, 2678, 2679, 26

We:

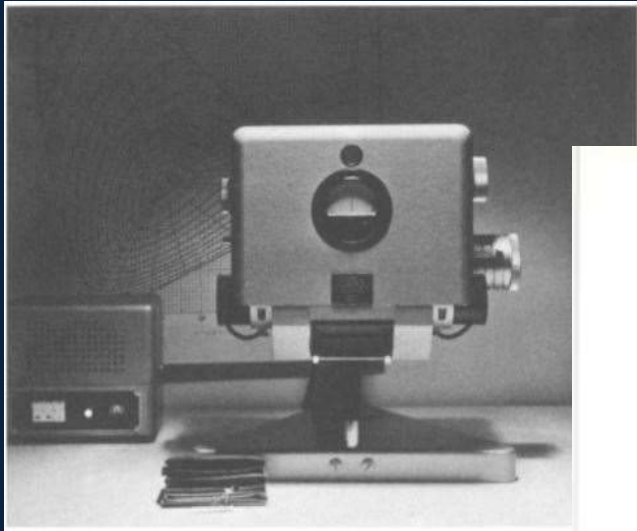
FBI

1

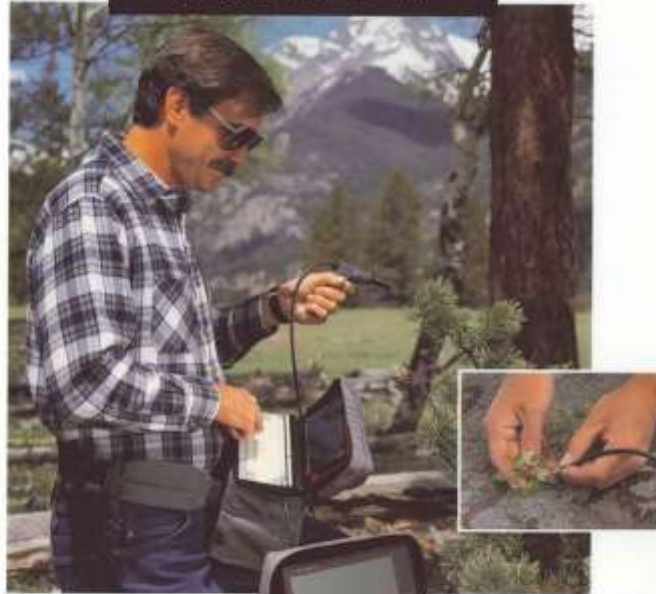
Received: 1 March 2003 / Accepted: 27 August 2003 / Published online: 10 October 2003
© Springer-Verlag 2003

Abstract Sessile, reflective (R) corals are a functional component to coral reef remote sensing. We explore general trends as well as geographic and taxonomic variabilities of coral R using a data set consisting of 3,199 R measurements at sites at depths of up to 15 m from 195 coral colonies at 11 sites worldwide. Corals with R values of 0.40 or less at 400 nm (R₄₀₀ ≤ 0.40) at 700 nm, mean coral R₄₀₀ than less ~2.5% at 400–500 nm to ~8% between 580 and 650 nm. All corals measured in this study exhibit one of two basic shapes of R, which we label the "brown" and "blue" modes. We postulate that brown-mode R is determined by the presence of brown pigments in the coral tissue, while blue-mode R arises through expression of a non-fluorescing coral-tissue pigment. Taxonomic and geographic variabilities are approximately equal to global variability, both in magnitude and shape, indicating that coral R is independent of taxonomic or geographic differences. We conclude that coral R is a useful remote sensing tool, as revealed by pigments that are conservative across geographic and taxonomic boundaries.

Instruments



**PERSONAL
SPECTROMETER II**
Real Time Display in a
Truly Portable Unit.



ASD FR 4 Hi Res



PolyPen RP 400



Spectral Data Management

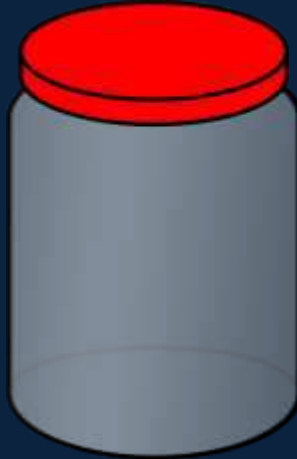
Giving thought to the story of your research data



Setting up your research design



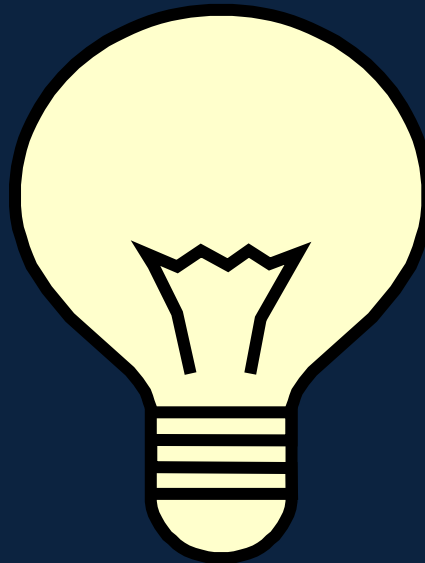
collect



store



describe



share

What's your data management plan?

- The Usual Stuff
 - My name, project title, project timing, project context, etc.
- The Field Stuff
 - Sites, permissions, documentation, etc...
- The Spectral Data Stuff
 - Instrument
 - Protocol
 - Generate data
 - How much data to generate
 - What do you expect to be able to do with it?

= RESEARCH OUTPUT



Why?

It saves time



Encourages re-use



Supports research
integrity



Adds value

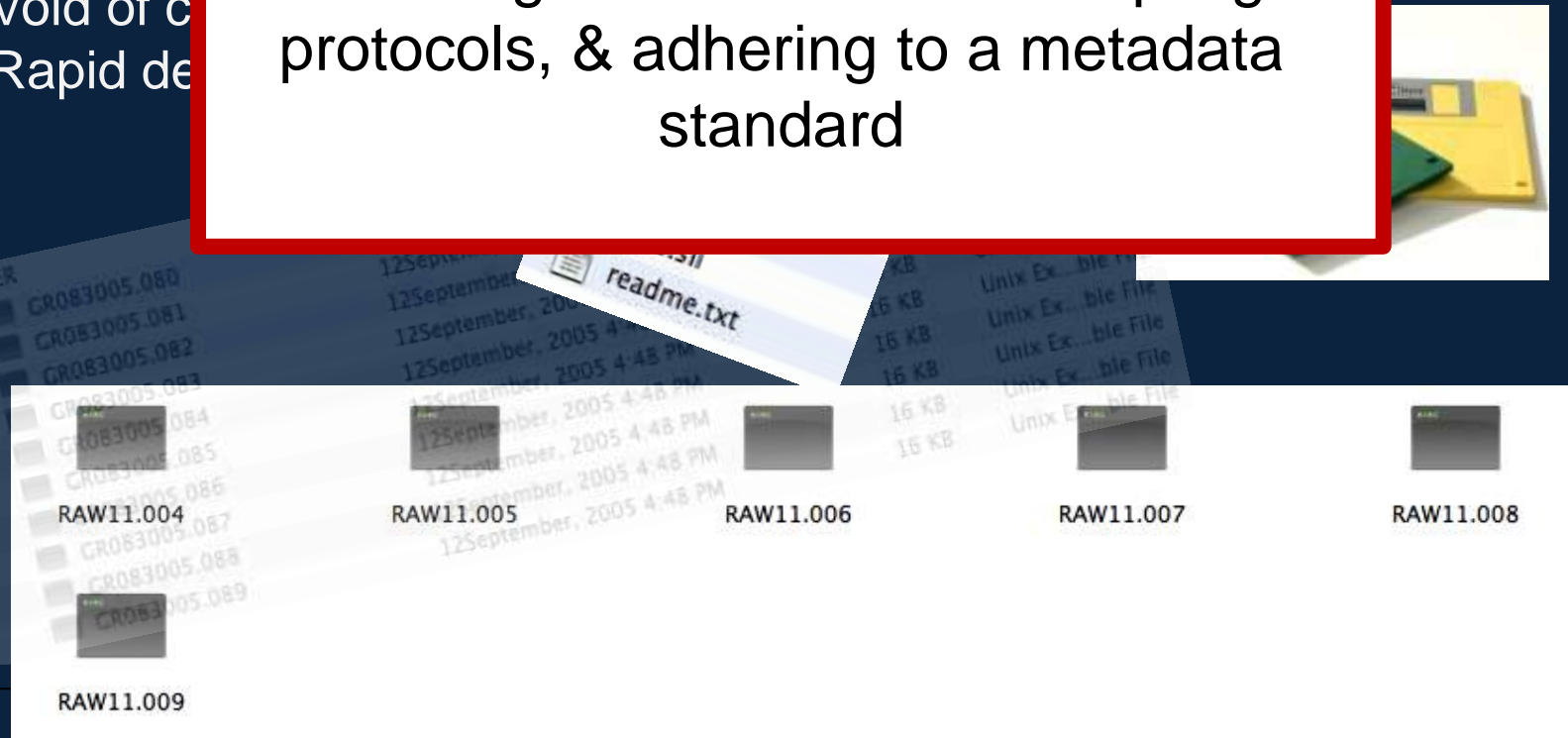


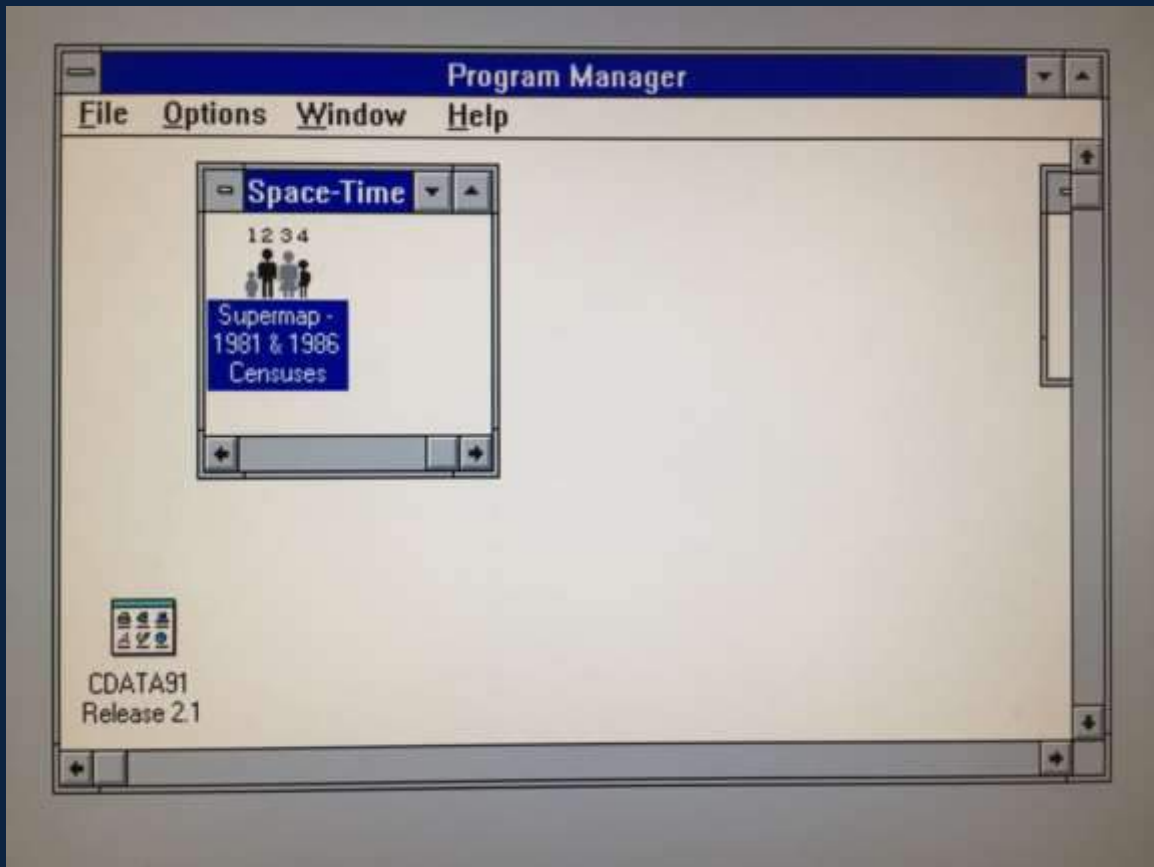
Nemesis of spectral data collections

Collections of spectral data held in any random, semi-structured or static way, such as files and folders stored on personal computers or servers:

- Undiscovered
- Non shared
- Void of context
- Rapid decay

..... planning of sampling experiments, including the definition of sampling protocols, & adhering to a metadata standard







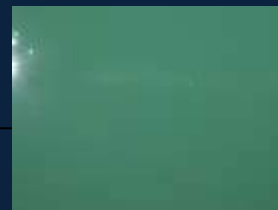
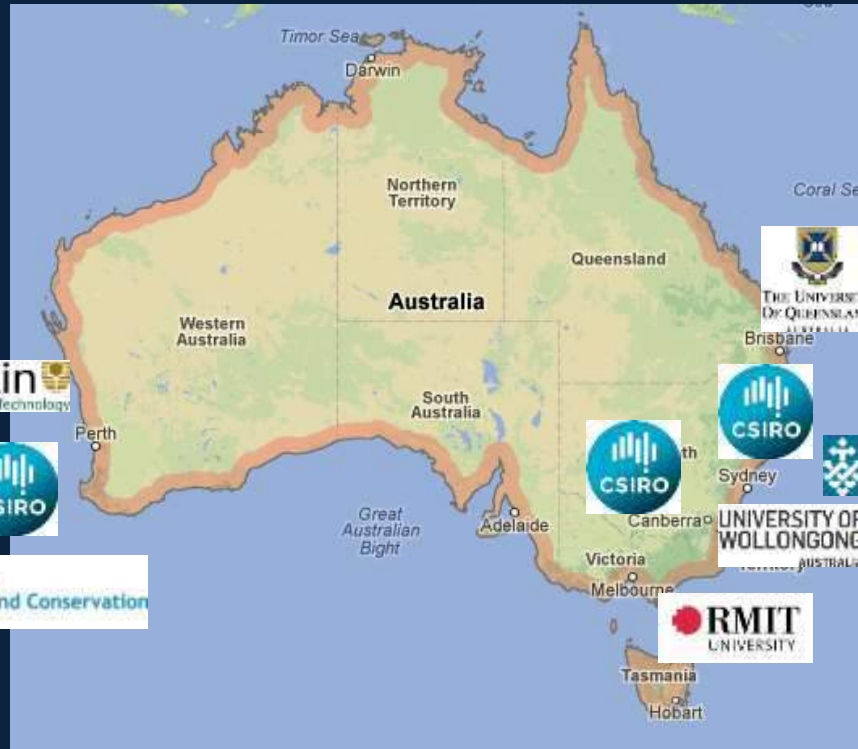
Bio-optical data: Best practice and legacy datasets workshop

18 – 22 June 2012

University of Queensland, Brisbane

Report: <http://www.aceas.org.au>

Spectroscopy User Info Sessions



5/14/2018

- Identified **core metadata requirements** for a number of different applications.
- Considered a variety of methods to both **exchange** and store spectral data and tools to assist in summarising the **completeness and quality** of such datasets.
- Agreed that with modifications, the SPECCHIO (Hueni et al 2009) software could meet international objectives for **spectral data exchange** and to promote **best practice protocols**.



AUS-
SPECCHIO

☒ Do conflict detection

Order by:

Sampling Date

- ▶ sG_t1_Grassland
- ▶ sG_t2_Grassland
- ▶ sG_t3_Grassland
- ▶ MM015_BASEL_100625_spectra
- ▶ MM016_ZRH__100626_spectra
- ▶ MM017_LAEGE_100626_spectra
- ▶ MM020_OENS_100626_spectra
- ▼ MM026_LAEGE_100629_spectra
 - ▶ s1_t1_Lawn
 - ▶ s2_t1_Sand (Fine)
 - ▶ s3_t1_Roof (Black rubber)
 - ▶ s4_t1_Tartan (Orange)
 - ▶ s5_t1_River
 - ▼ s6_t1_Tennis Court (Sand)
 - ▶ Radiance
 - ▶ Radiance Jump Corrected
 - ▼ Reflectance
 - W_6.005
 - W_6.006
 - W_6.007
 - W_6.008
 - W_6.009
 - W_6.010
 - W_6.011
 - W_6.012
 - W_6.013
 - W_6.014
 - W_6.015
 - W_6.016
 - W_6.017
 - W_6.018
 - W_6.019
 - ▶ s7_t1_Asphalt
- ▶ MM029_OENS_110615_spectra
- ▶ MM031_CHNP__110626_spectra
- ▶ MM034_ZRH__110626_spectra

Refresh

Update

Reset

Campaign

Metadata

Altitude [m] 390.0

Latitude [Degrees] 47.46471

Longitude [Degrees] 8.31583

Waypoint ID W6

Optics

FOV [Degrees] 25

Pictures

Sampling Setup Picture



Target Picture



Processing

Processing Algorithm ASD Jump Correction by temperat

Reflectance calculation in Matlab

- ☒ Associated Campaigns
- ☒ Campaign Details
- ☒ Data Links
- ☒ Data Portal
- ☒ Environmental Conditions
- ☒ General
- ☒ Generic Target Properties
- ☒ Geochemistry
- ☒ Illumination
- ☒ Instrument
- ☒ Instrument Settings
- ☒ Instrumentation
- ☐ Keywords
- ☒ Location
- ☐ Names
- ☒ Optics
- ☐ PDFs
- ☐ Personnel
- ☒ Pictures
- ☒ Processing
- ☒ Sampling Geometry
- ☒ Sampling Scheme
- ☒ Scientific References
- ☒ Soil Parameters
- ☒ Vegetation Biophysical Variables

Select All


Select None

App. Domain: ---

Protocols

- Various methods developed by many in the past
 - Variability between different methods
 - International organisations such as CEOS WGCV LPV do not currently have a standard protocol for the validation of surface reflectance data.
-

Validating foundation products within Digital Earth Australia

 Guy Byrne ·  Medhavy Thankappan

Goal: Working to develop and identify protocols and data sets to support the validation of both the historic and future epochs of Geoscience Australia' analysis ready Landsat archive.

Geoscience Australia has agreed to host a National Spectral Database (Aus-SPECCHIO) that will support data analysis and validation for Australia' Earth Observation community.

The database is currently managed by the University of Wollongong who have been active developing, documenting and promoting SPECCHIO within the Australian research community.

It is expected the national node for Aus-SPECCHIO will be launched in the first quarter of 2018.

Digital Earth Australia reflectance validation - A community approach to the standardised validation of surface reflectance data

Tim Malthus, Cindy Ong, Jan

Nov 2017



- nationally agreed strategy
- establishment of guidelines for
 - site selection
 - sampling methodology including metadata and spectral reference standards collected in the field
 - training
 - traceable (to NIST) inter-calibration of optical equipment and reference panels
- review

Reflectance Measurement of Soils in the Laboratory: Standards and Protocols



- Detailed instructions/routines on how to measure laboratory soil reflectance systematically and accurately
- Reproducible data of high quality.

A Standard Design for Collecting Vegetation Reference Spectra: Implementation and Implications for Data Sharing

K. Pfitzner
A. Bollhöfer
G. Carr

Spectral signatures represent the relationship between radiation and biophysical relationships. This report provides a standard documentation of these signatures and their meaning. It describes the procedures for the transition from field measurements to another format for implementation and collection of metadata. A standard for the assessment and documentation of the concept of collecting accurate spectral data while minimizing the influence of potential extraneous factors is relevant to field spectrometry in all environments and is particularly important for ecological applications.

Standards for reflectance spectral measurement of temporal vegetation plots
Department of Sustainability, Environment, Water, Population and Communities, 2011
Supervising Scientist Report 195
Pfitzner K, Bartolo R, Carr G, Esparon A & Bollhöfer A
ISSN 1325-1554
ISBN: 978-1-921069-16-1

The relationship between spectral properties of vegetation and the biological, chemical, physical and atomic structure of gases, water, vegetation and soils has been explored using remote sensing techniques in areas of atmospheric chemistry, plant physiology, geological sciences, soil sciences, and limnology and oceanography since the 1960s. Coupled with recent advances in remote sensing technology and expectations of future developments in satellite technology, has been the increasing need to measure field-

INTERRELATIONSHIP OF METADATA – SINGLE SPECTRA

ILLUMINATION AND VIEWING GEOMETRY

Date	Cloud cover and type	Dark current integrations
Time	Aerosols/smoke/haze	White reference integrations
Position	Air pressure	White reference source
Sun altitude	Wind speed and direction	Fore optic height above target
Sun azimuth	Fore optic degree	Fore optic height above ground
Temperature	Number of samples	IFOV
Humidity	Number of averages/sample	

CALIBRATION

Spectralon panel
Spectrometer

PHOTOGRAPHS

Site setup
Eastern sky
Western sky
Nadir
Azimuth

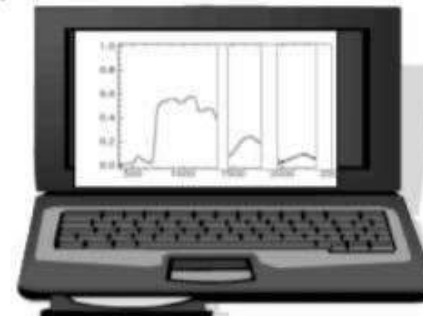
TARGET, e.g. vegetation

Species	Layering	Health
Homogeneity	Cover	Localised conditions
Form	Phenology	Texture (specular/diffuse)

ANALYSIS
Identification of outliers
using metadata

REFERENCE SPECTRUM
For a point in time

SPECTRA



Best Practice Guides (through 2013)

Name of document	Topics addressed					
	Application specific	Em theory	Instrument optimization	Recommended viewing geometry	Sampling strategy	Field data documentation protocol
NERC FSF instrument guides (ASD Field Spec Pro, GER1500, GER3700) (Mac Arthur, 2006, 2007a, 2007b)			X			
Australian Government Department of Sustainability, Environment, Water, Population and Communities: Standards for reflectance spectral measurement of temporal vegetation plots (Pfitzner <i>et al.</i> , 2011)	X	X	X	X	X	X
University of Queensland Field Spectrometer and Radiometer Guide (Phinn <i>et al.</i> , 2007)	X	X	X	X	X	X
Spectranomics Protocol: Leaf Spectroscopy (350-2500nm) (Carnegie Spectranomics, 2010)	X				X	
ASD instrument guides and FAQ (ASD 2012, 2013b)		X	X	X		

AusCover Good Practice Guidelines

A technical handbook supporting calibration and validation activities of remotely sensed data products



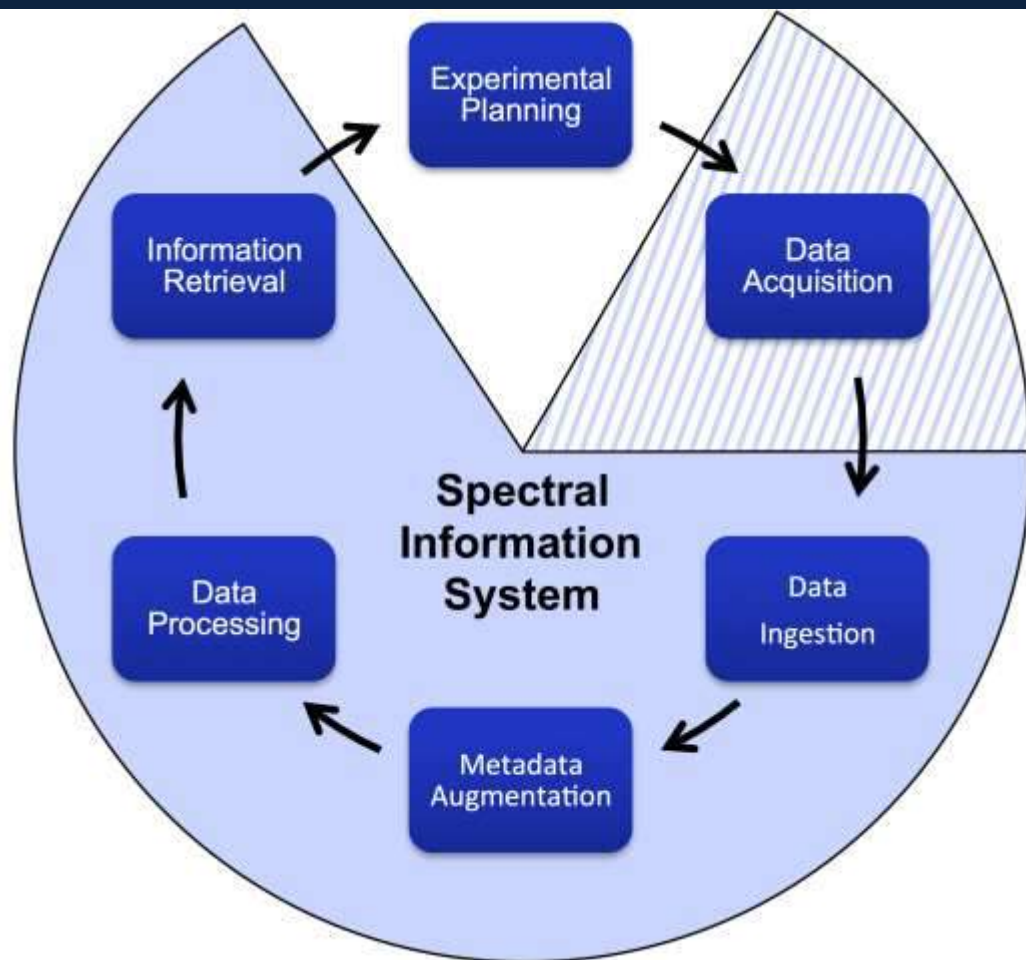
Version 1.1
August 2015

www.auscover.org.au

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Spectroscopy data life cycle



Chapter 14. The Spectroscopy Dataset Lifecycle: Best Practice for Exchange and Dissemination

L.A. Chisholm¹, A. Hueni²

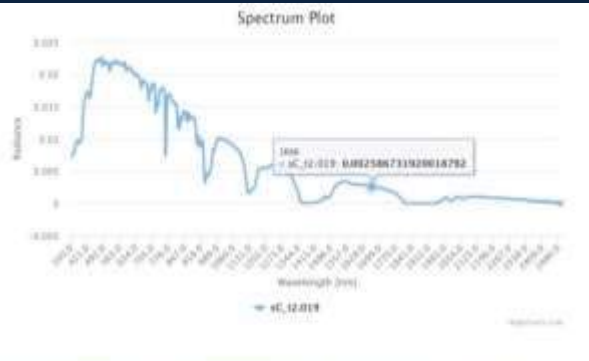
¹ School of Earth and Environmental Sciences, Centre for Sustainable Ecosystem Solutions, University of Wollongong, Wollongong, NSW, Australia

² Remote Sensing Laboratories, University of Zurich, Switzerland

*Corresponding author:
laurie_chisholm@uow.edu.au

Citation:
Chisholm, L.A., Hueni, A. (2015). The Spectroscopy Dataset Lifecycle: Best Practice for Exchange and Dissemination. In: A. Inel, S. Phien, M. Soto-Devellos, S. S. Jones (Eds.), *ArcCover Good Practice Guidelines: A technical handbook supporting calibration and validation activities of remotely sensed data products* (pp. 288-288). Version 1.2. 1180p. ArcCover, ISBN 978-0-445-94133-0.

Why enter all that metadata?
 → Quantitative and qualitative interpretation!
 → Spectral in situ data without metadata is useless. (Hueni, all the time)



Generic Target Properties

Target/Reference Designator:	Target
Basic Target Type:	Roof (Black rubber)

Optics

FOV:	25
------	----

Sampling Geometry

Sensor Distance:	1.0
Illumination Azimuth:	105.00302797758435
Illumination Zenith:	45.06345046087947
Sensor Zenith:	0.0

General

File Comments:	
Spectrum Number:	19
File Name:	sC_12.019
Acquisition Time:	2010-06-26 11:23:25
Loading Time:	2016-12-02 14:23:13
Show All	

Instrumentation

Reference Panel Levelled:	true
---------------------------	------

Sampling Scheme

Spatial Sampling Scheme:	Sweep
--------------------------	-------

Processing

UTC Time Computation:	UTC Acquisition Time computed by shifting 2 hours East using the SPECCHIO UTC function.
-----------------------	---

Location

Environmental Conditions

Cloud Cover:	0.0
--------------	-----

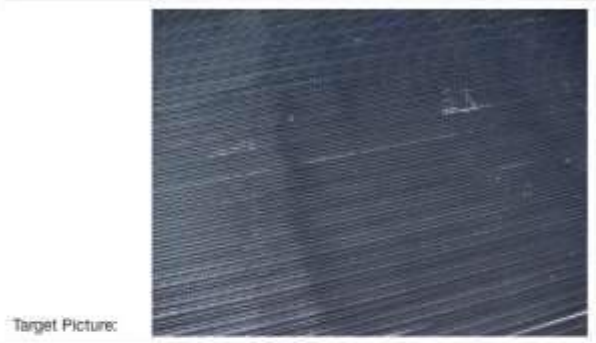
Instrument Settings

Integration Time:	34
Number of Internal Scans:	10
Gain_SWIR1:	44
Gain_SWIR2:	16
Offset_SWIR1:	2072
Show All	

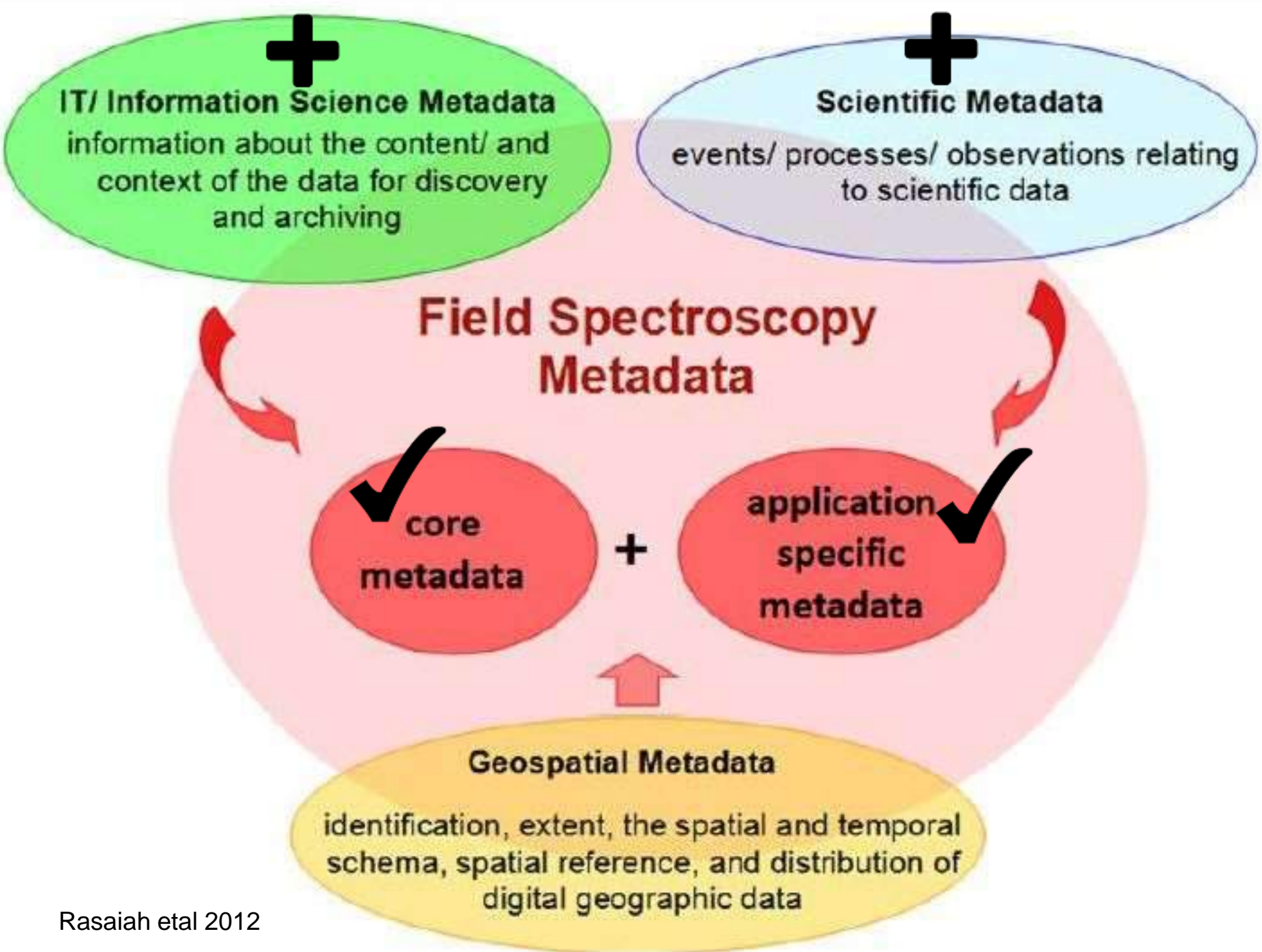
Campaign Details

Campaign Name:	APEX SGCPs
----------------	------------

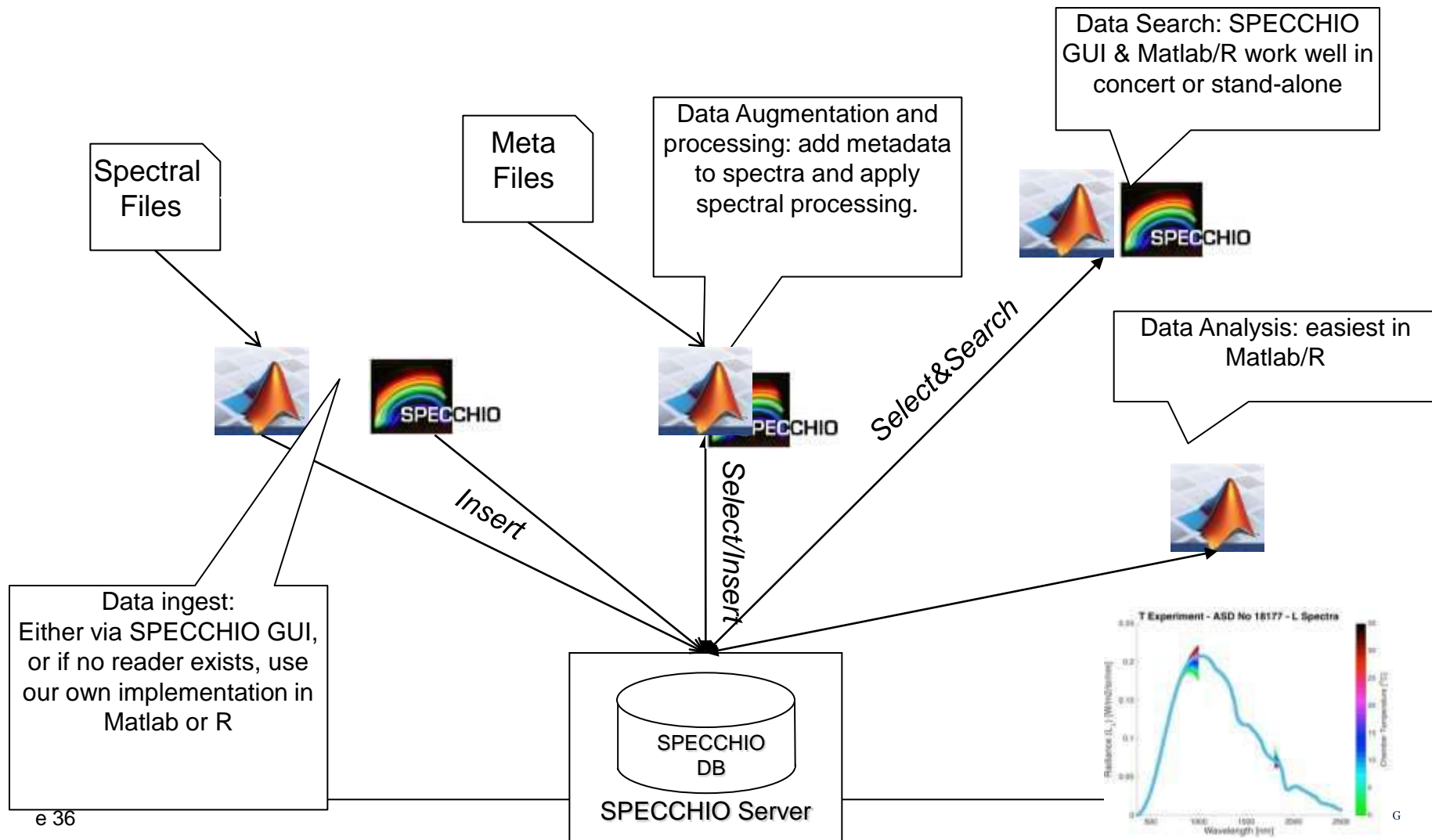
Pictures







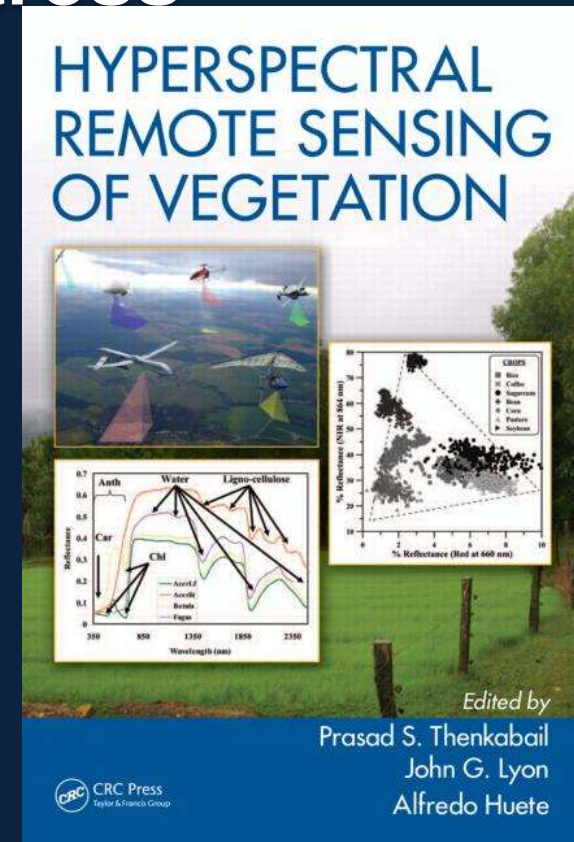
Spend your research time analysing data instead of trying to find it on your file system

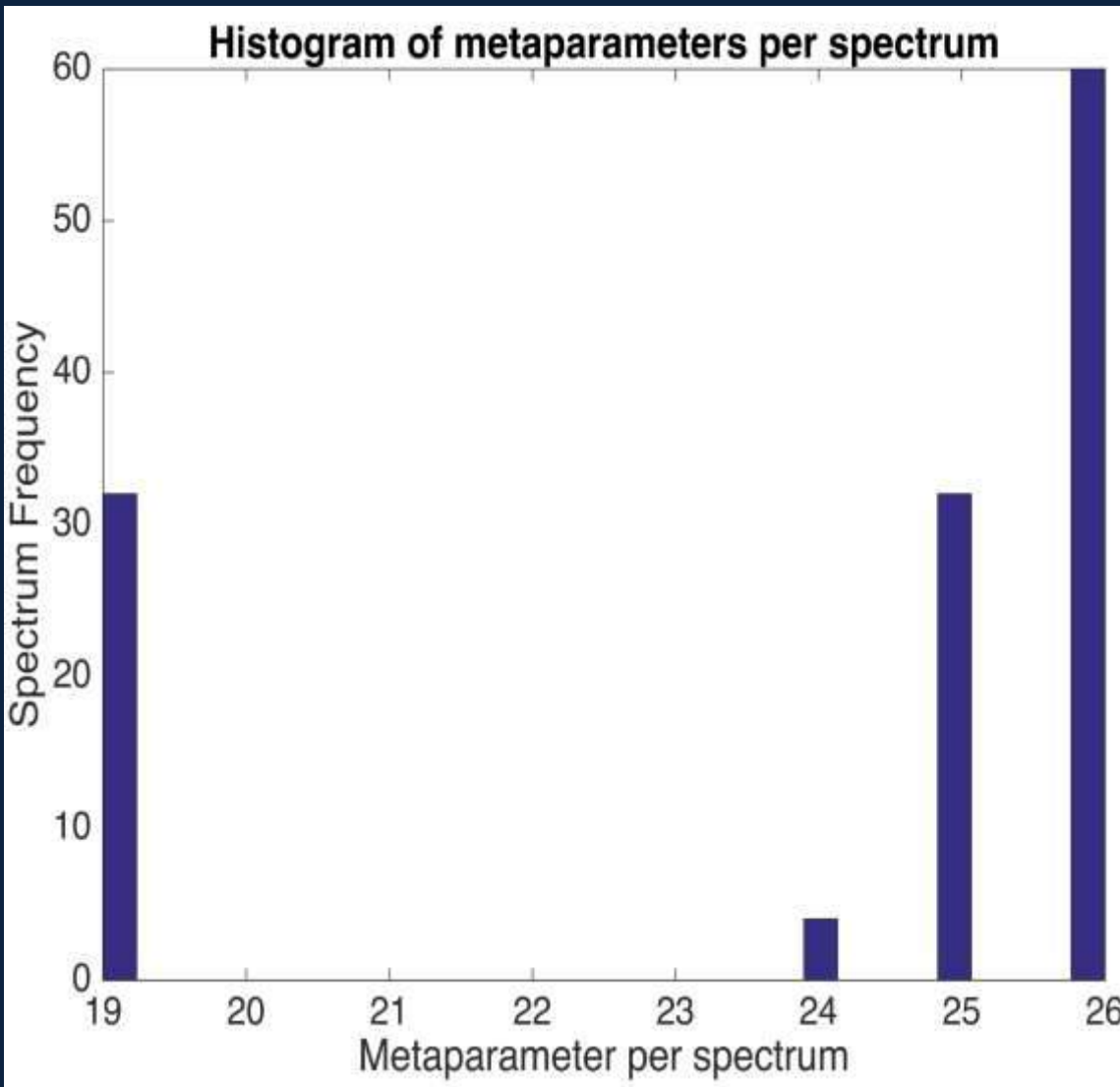


Case Study

Spectral Database Containing Pigment Content in A Water Stress Experiment

Hueni, A., Suarez, L., Chisholm, L.A., & Held, A. (2018) The use of spectral databases for remote sensing of agricultural crops, in Thenkabail, Lyon, Huete (eds), Hyperspectral Remote Sensing of Vegetation, second edition, Volume II: Advanced Approaches and Applications in Crops and Plants.



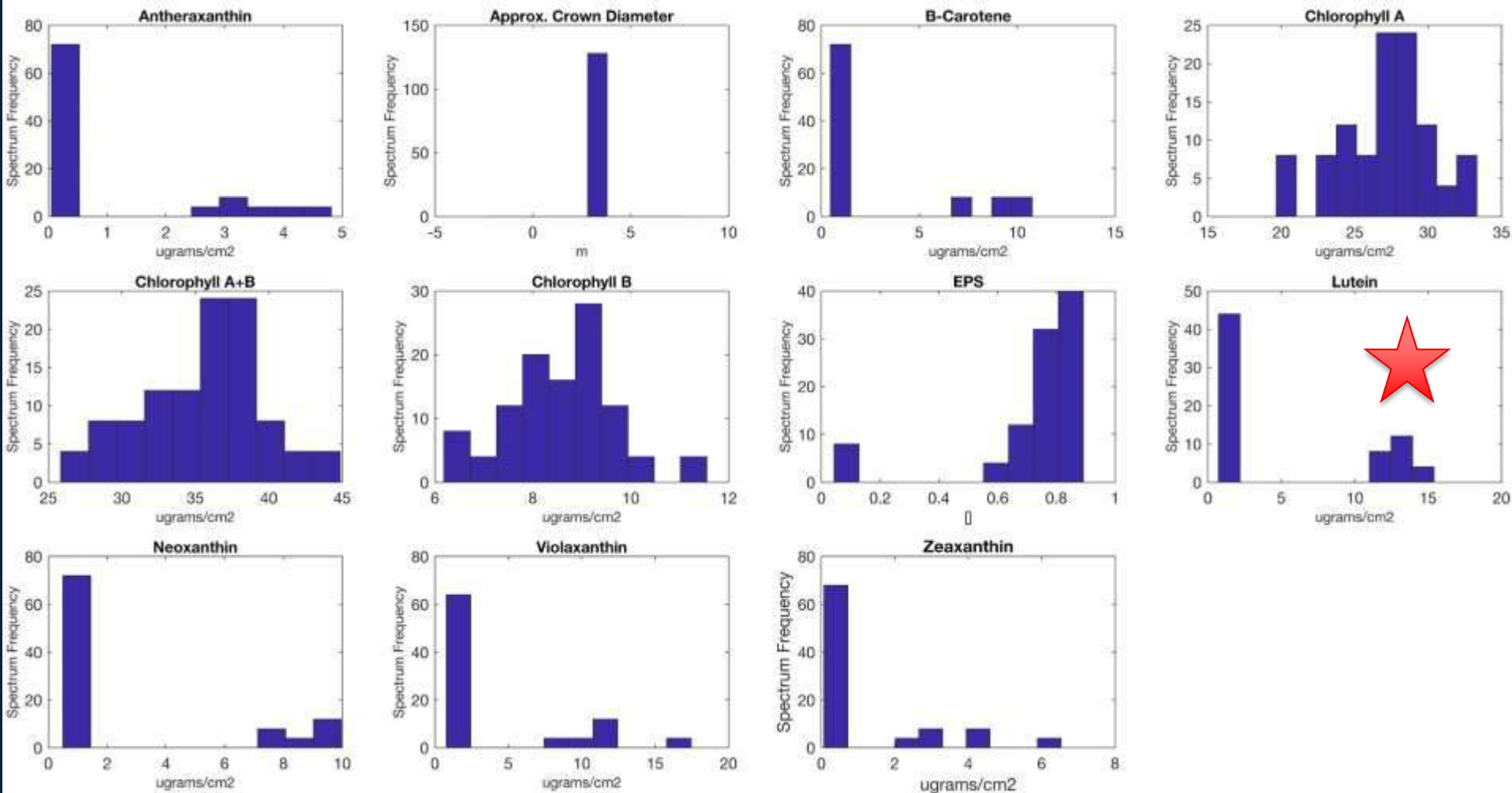


Ingestion of 12
metaparameters

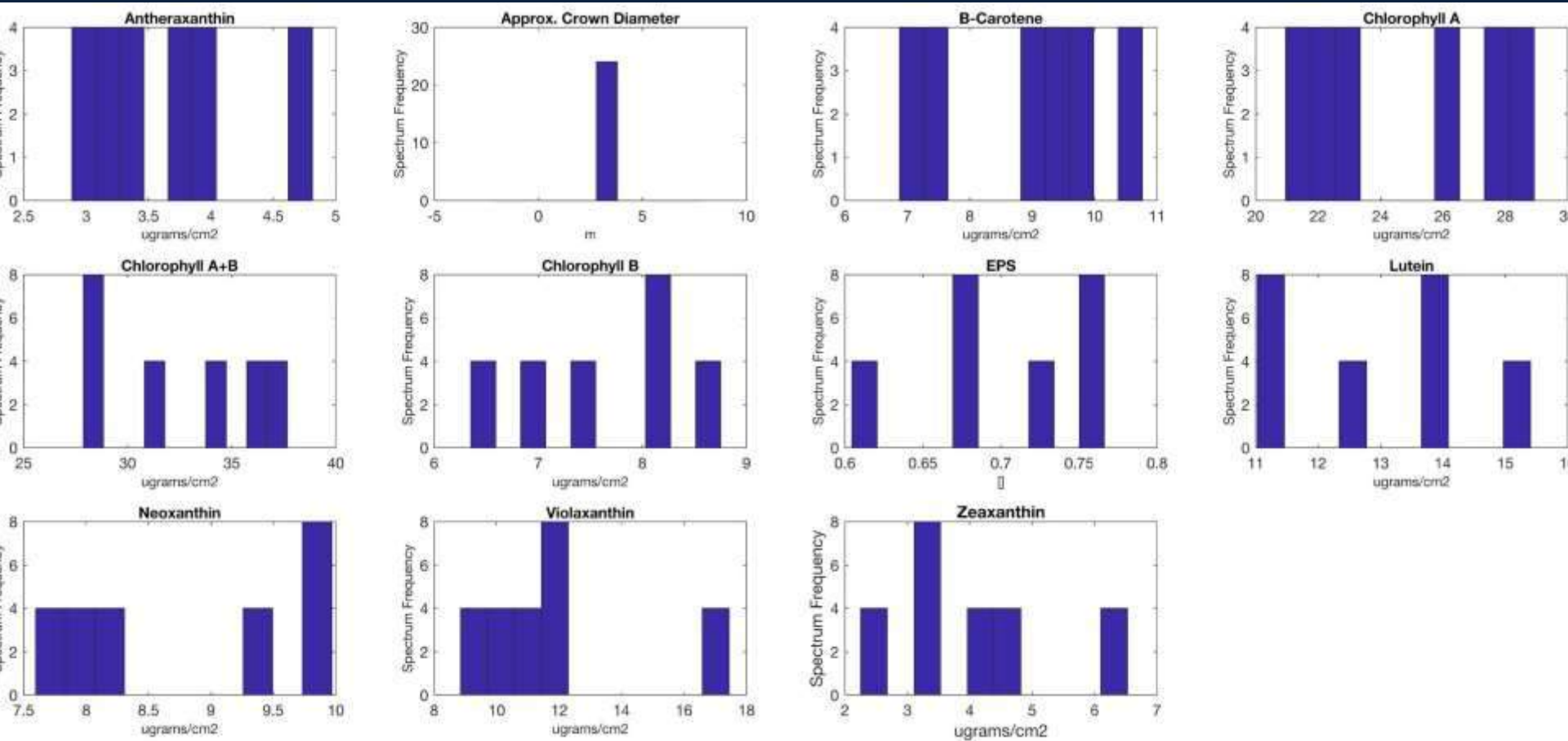
lab-based chemical
leaf data included
linked by tree
identifier

Total of 24
metaparameters per
spectrum

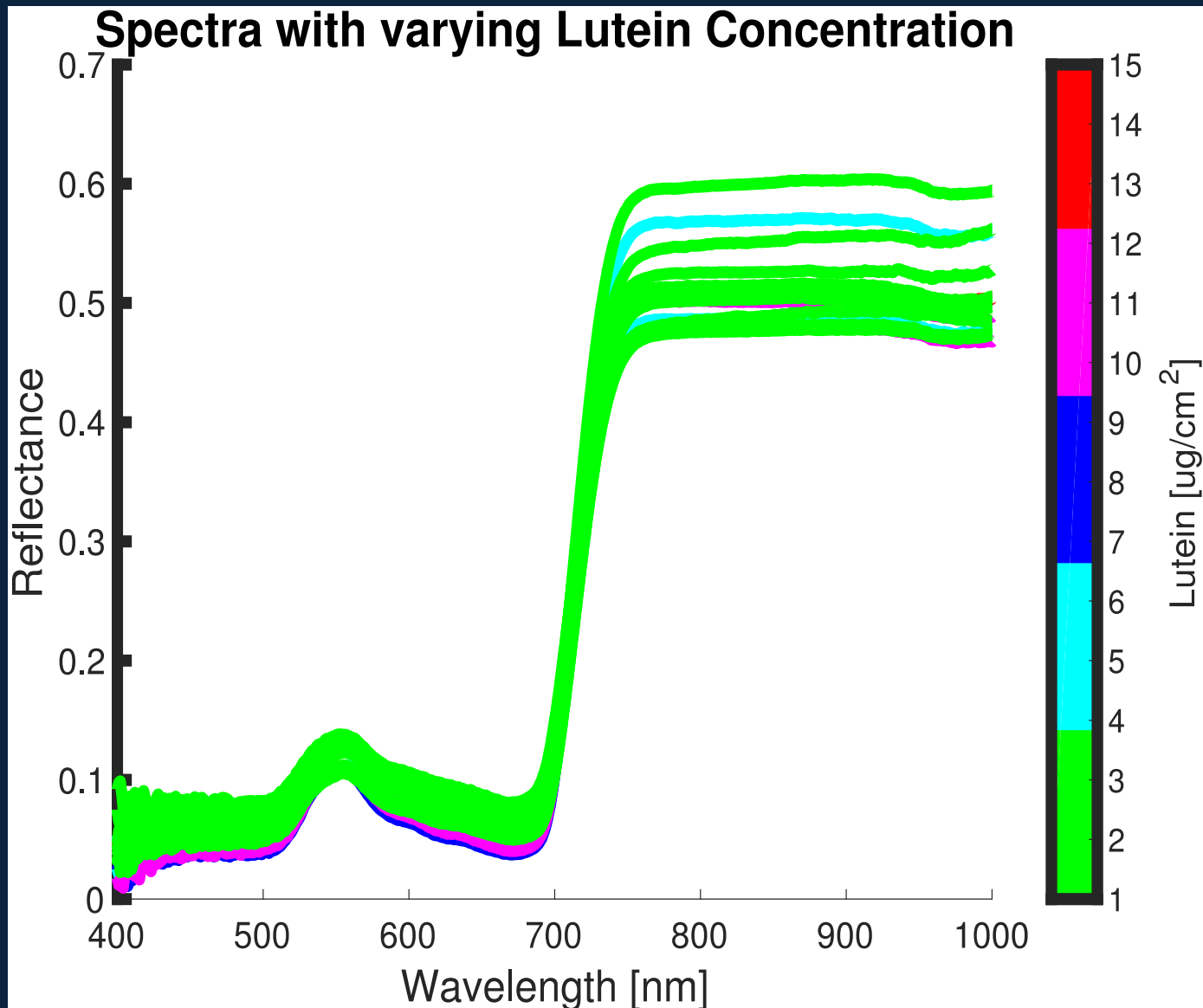
Histogram of the metadata space density after biophysical
metadata augmentation.



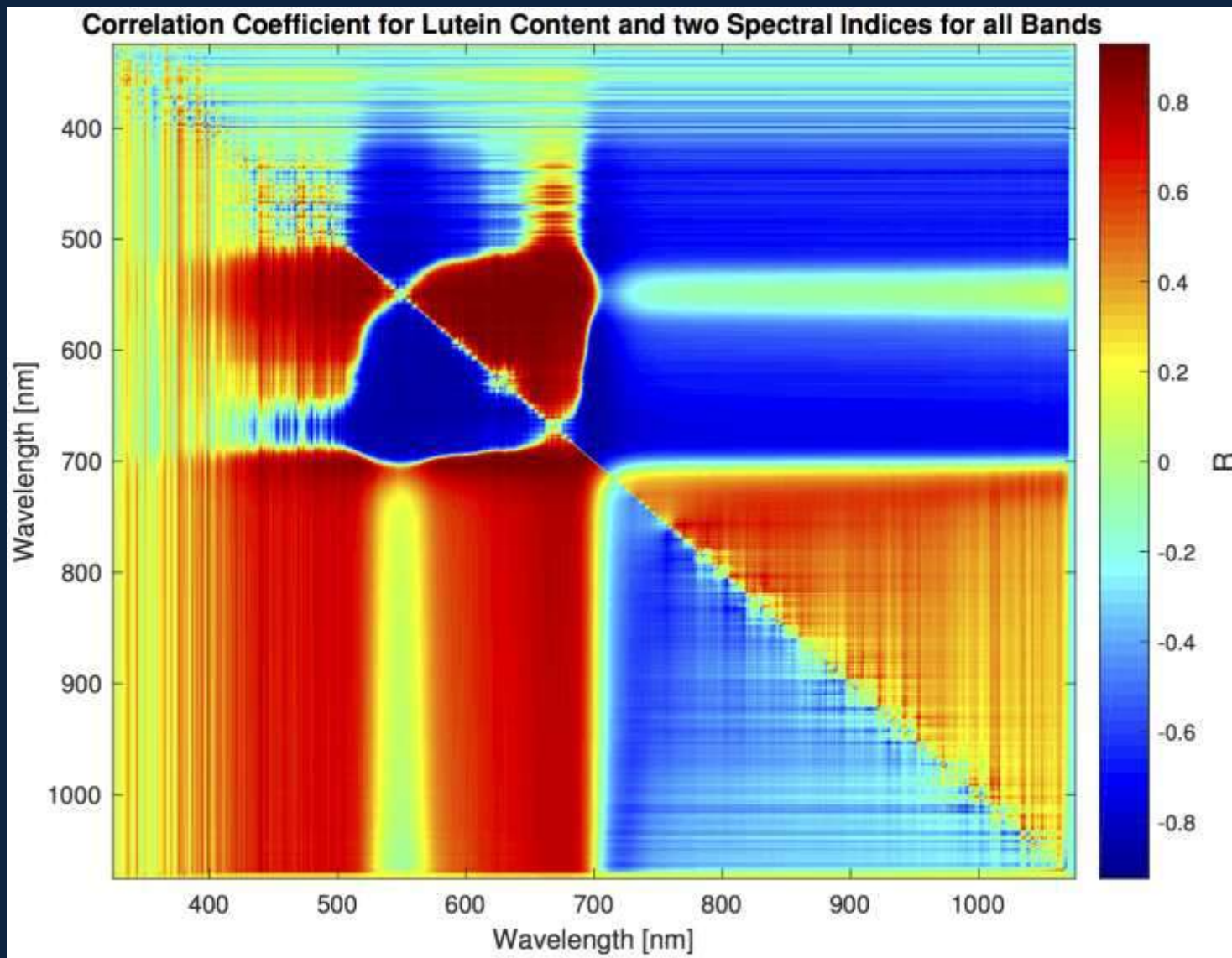
Histograms by biophysical parameter showing value ranges and number of spectra per value via Matlab / SPECCHIO Java API – including which spectra have a Lutein content above 10 $\mu\text{grams}/\text{cm}^2$



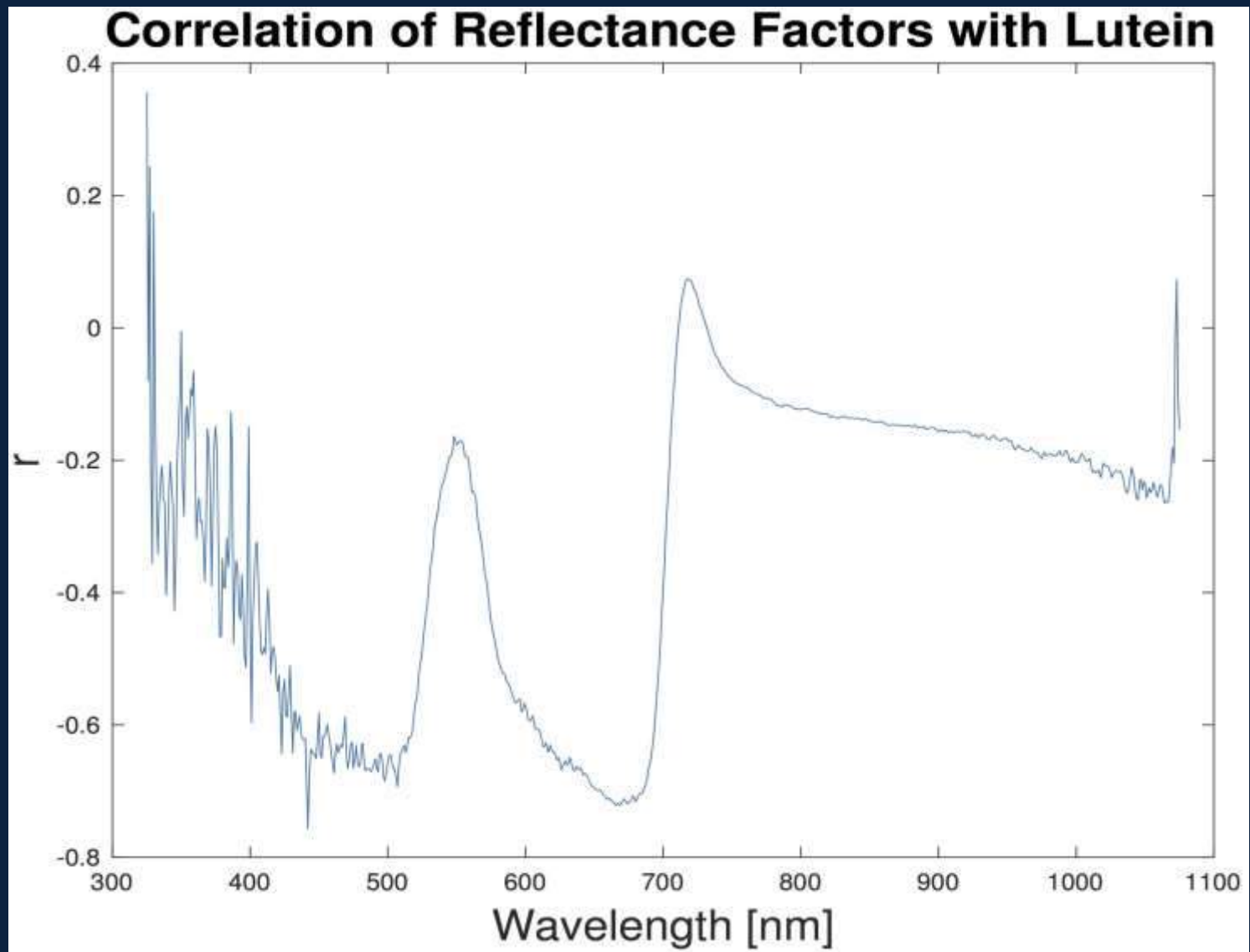
Histograms by biophysical parameter showing value ranges and number of spectra per value for spectra with high associated Lutein content - useful for comparison to entire dataset + visualising the variation of pigment content related to water stress.



Averaged spectra color coded by mean Lutein concentration, demonstrating a generally low reflectance in the 400 nm to 700 nm range for high Lutein contents, and absorption in the visible in at the lower end of the range.



Correlation analysis of Lutein concentration and two spectral indices calculated for all bands: upper triangle: simple band ratio (R_x / R_y), lower triangle: normalised difference index $(R_x - R_y) / (R_x + R_y)$ – potential to estimate Lutein content from leaf spectra



Correlation between reflectance factors and Lutein content –if Lutein is the pigment of interest, it is useful to know which wavelengths are highly related to Lutein concentration

Summary

Instruments, spectral data management, and protocols comprise a package of considerations when acquiring spectral data directed by research goals.

- New instrumentation
- Research data planning for spectral data acquisition
- Evolving protocols

Trends towards intelligent searching for data, but is only possible with metadata-rich datasets

Need for streamlining protocols & improving scalability to changing IT infrastructure

Challenge is applying science to the (large) volume of data

Case study demonstrates the potential of a spectral database system to address specific needs for an application, e.g. agricultural management.

Such systems must be based upon data collection protocols and metadata descriptions that enhance data transferability within and among working groups.

If conducted over time and compiled for a wide range of agricultural-related measurements over varying conditions could become a tool as a source of data for hypothesis testing and validation.

This approach opens the potential to apply machine learning techniques for prediction using large, quality-controlled datasets.

Thank you ...

