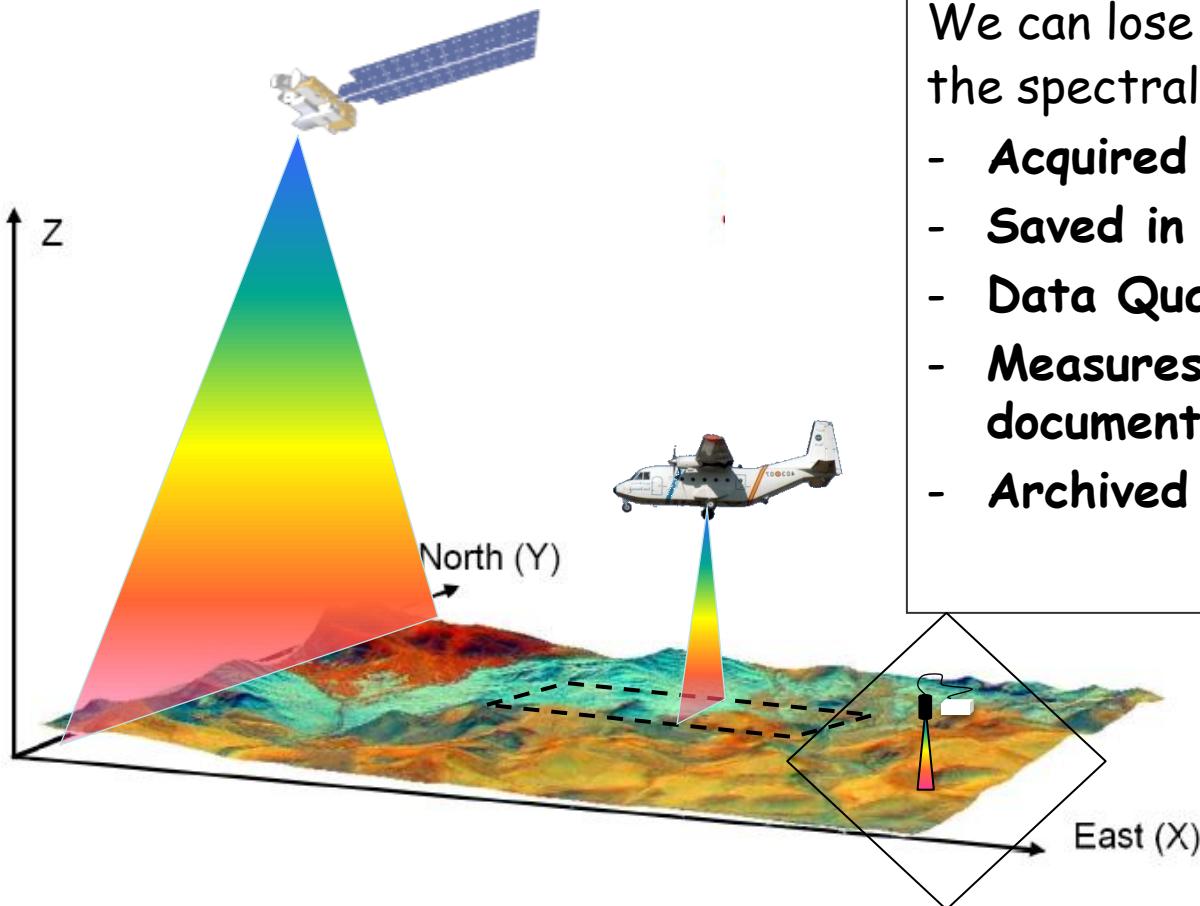


Good Practice Guidelines to Improve the Reliability of Spectral Libraries



Marcos Jiménez Michavila
Remote Sensing Systems
INTA

Field spectroscopy are considered to provide the most **reliable** information about the spectral behavior (in the solar and thermal part of the spectrum) of Earth surfaces and materials



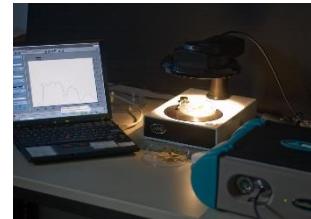
We can lose this **reliability** if the spectral libraries was not:

- Acquired by robust protocols
- Saved in common Formats
- Data Quality is reported
- Measures and conditions are documented
- Archived in searchable Databases

This proximal sensing is continuously increasing in applications and technologies



Goniometer FIGOSU. Zurich



Lab U.Jena



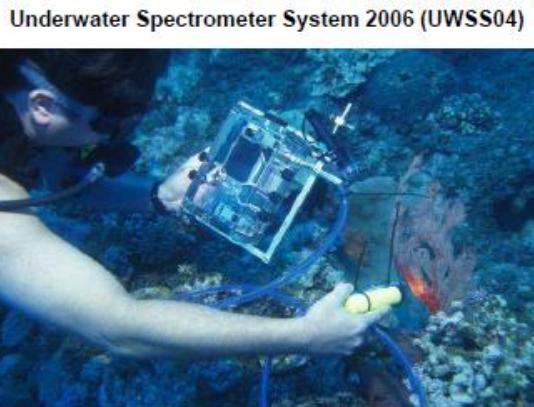
Lab SpecLab-CSIC

694

IEEE JOURNAL OF SELECTED TOPICS IN APPLIED EARTH OBSERVATIONS AND REMOTE SENSING, VOL. 5, NO. 2, APRIL 2012

Spectral Discrimination of Mediterranean Maquis and Phrygana Vegetation: Results From a Case Study in Greece

Kiril Manevski, Ioannis Minakos, George P. Petropoulos, and Chariton Kalaitzidis

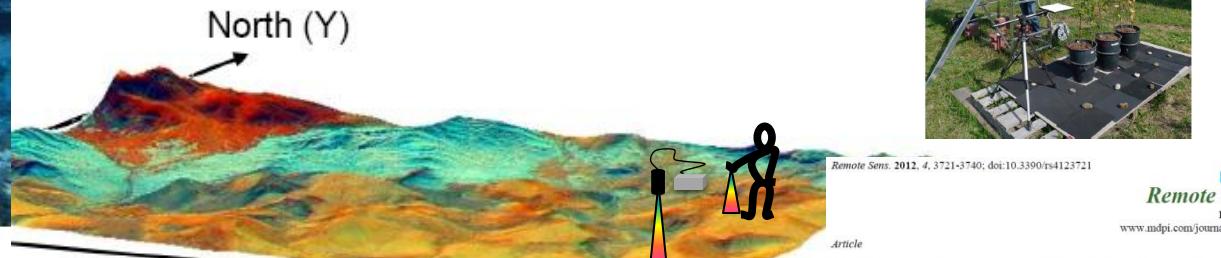


Underwater Spectrometer System 2006 (UWSS04)

29 August 2006

System developed by:

C.Roelfsema, J.Marshall, E.Hochberg, S.Phinn, A.Goldizen and K.Joyce.



Remote Sens. 2012, 4, 3721–3740; doi:10.3390/rs4123721

Article

Field Imaging Spectroscopy of Beech Seedlings under Dryness Stress

Hennig Buddenbaum^{1,*}, Oksana Stern¹, Marion Stellmes¹, Johannes Stoffels¹, Pyare Pueschel¹, Joachim Hill¹ and Willy Werner²

OPEN ACCESS

Remote Sensing

ISSN 2072-4292

www.mdpi.com/journal/remotesensing

REALIABILITY. APPLICATIONS AND MEASUREMENTS



INSTITUTO NACIONAL DE TÉCNICA AEREOESPACIAL

Applications

<http://www.asdi.com/solutions>

The screenshot shows the ASD Inc. website under the 'Application Solutions' section. It features six thumbnail images representing different fields: Geology/Mining (stacks of mineral samples), Materials Analysis (various colored powders), Image Classification/Analysis (a globe with geographical data), Agriculture (rows of crops), Defense and Intelligence (military personnel with equipment), and Environmental (a snowy mountain peak). The top navigation bar includes links for PRODUCTS AND SERVICES, SOLUTIONS, LEARN, SUPPORT, EVENTS, ABOUT US, and a CONTACT US button.

Magnitudes HCRF or BRDF...now Fluorescence

© EARSeL and Warsaw University, Warsaw 2005. Proceedings of 4th EARSeL Workshop on Imaging Spectroscopy. New quality in environmental studies.
Zajączkowski B., Sołoczek M., Wrzesień M., (eds)

THE IMPORTANCE OF REFLECTANCE TERMINOLOGY IN IMAGING SPECTROSCOPY

Gabriela Schaepman-Strub¹, Michael Schaepman², Stefan Dangel³,
Thomas Painter⁴, and John Martonchik⁵

Measurements Surfaces (Pure Pixels) or Elements (Endmembers)

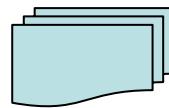
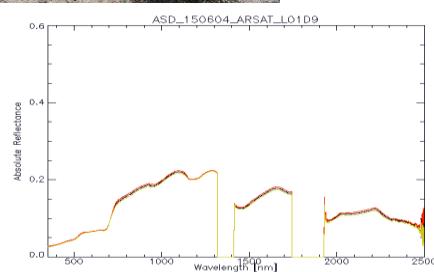


Yeso

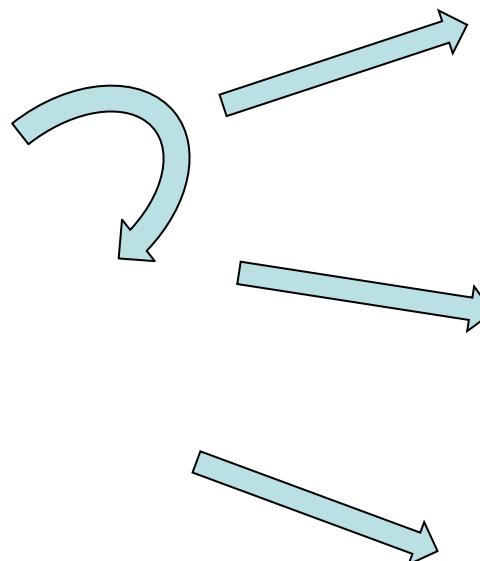
Incoming/Reflected	Directional	Conical	Hemispherical
Directional	Bidirectional Case 1	Directional-conical Case 2	Directional-hemispherical Case 3
Conical	Conical-directional Case 4	Biconical Case 5	Conical-hemispherical Case 6
Hemispherical	Hemispherical-directional Case 7	Hemispherical-conical Case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

REALIABILITY. IMPLEMENTATION

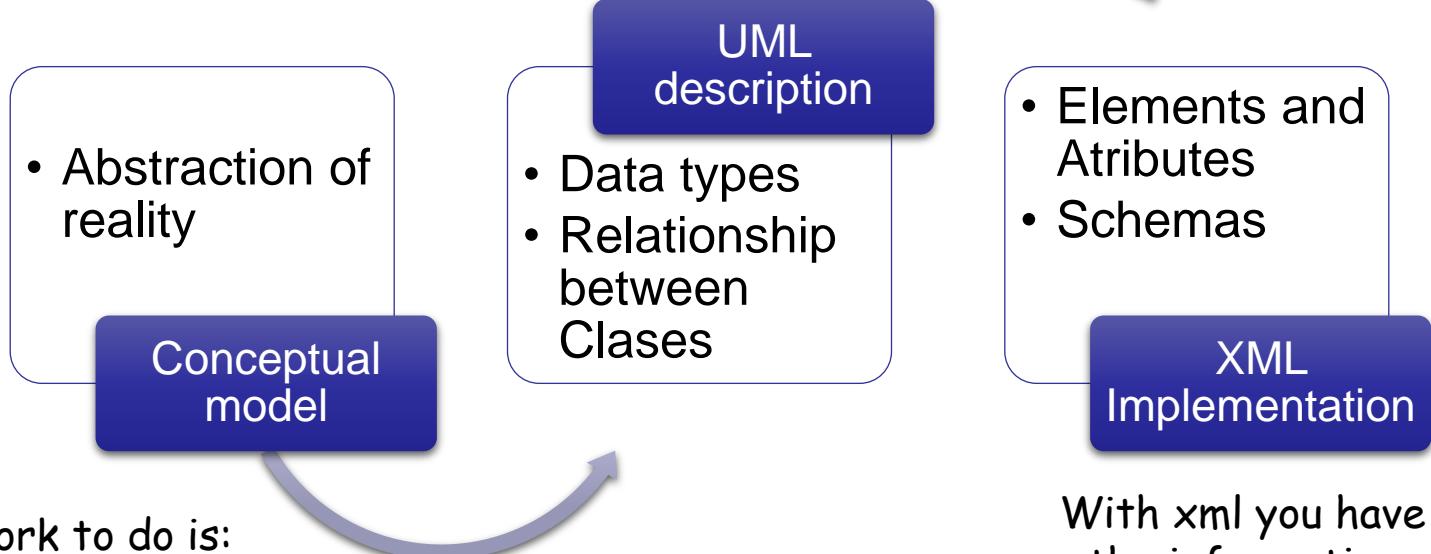
- ✓ Acquire our spectra as we are data providers
- ✓ Archive the data to always have it available and easily shared
- ✓ Standardization is very difficult but we have to try



IDL
Python
Matlab
..



- A standard is a document that provides requirements, specifications, guidelines or characteristics that can be used consistently to ensure that materials, products, processes and services are fit for their purpose
- International organizations are ISO and OGC
- For Geographic Information ISO TC 211
- DIFFICULTY: Very huge, abstract and general documents
- ADVANTAGE: UML and XML Implementation



- The work to do is:
- -understanding normatives
- -selection of element for our data

With xml you have
the information
located

Good Practice

FIELD SPECTROMETRY: TECHNIQUES AND INSTRUMENTATION
 (Presented at the International Symposium on Spectral Sensing Research, July, 1994)

Brian Curtiss
 Analytical Spectral Devices, Inc.
 4760 Walnut Street Suite 105
 Boulder, CO 80301-2561, USA
 303-444-6522 FAX: 303-444-6825

Alexander F. H. Goetz
 University of Colorado
 Center for the Study of Earth from Space/
 Cooperative Institute for Research in the Environmental Sciences
 Boulder, Colorado 80309-0449, USA

Available online at www.sciencedirect.com



Remote Sensing of Environment 113 (2009) S92 - S109

Remote Sensing
 Environment

www.elsevier.com/locate/rse

Progress in field spectroscopy

Edward J. Milton^{a,*}, Michael E. Schaepman^b, Karen Anderson^c, Mathias Kneubühler^d, Nigel Fox^e

dx.doi.org/10.1016/j.rse.2008.09.010

Making Accurate Field Spectral Reflectance Measurements

By Dr. Alexander F. H. Goetz, Co-founder
 ASD Inc., Boulder, Colorado, 80301, USA
 October 2012

SPECTROSCOPY FIELD STRATEGIES AND THEIR EFFECT ON MEASUREMENTS OF HETEROGENEOUS AND HOMOGENEOUS EARTH SURFACES

Alasdair Mac Arthur⁽¹⁾, Luis Alonso⁽²⁾, Tim Malthus⁽³⁾, Jose Moreno⁽⁴⁾

⁽¹⁾NERC FS, Geosciences, Grant Inst., University of Edinburgh EH9 3JW, UK. alasdair.macarthur@ed.ac.uk:

⁽²⁾Faculty of Physics, University of Valencia, 46100 Burjassot, Valencia, Spain. luis.alonso@uv.es:

⁽³⁾CSIRO Land and Water, Christian Rd, Acton ACT 2601, Australia. tim.malthus@csiro.au:

⁽⁴⁾Faculty of Physics, University of Valencia, 46100 Burjassot, Valencia, Spain. jose.moreno@uv.es:

STANDARDISED SPECTRA (400-2500 nm) AND ASSOCIATED METADATA: AN EXAMPLE FROM NORTHERN TROPICAL AUSTRALIA.

Pfizner, K., Bollhöfer, A., Esparon, A., Bartolo, R and Staben, G.



Contents lists available at ScienceDirect

Computers & Geosciences

journal homepage: www.elsevier.com/locate/cageo

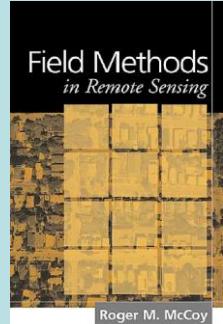
The spectral database SPECCHIO for improved long-term usability and data sharing²⁵

A. Hueni^{a,*}, J. Nieke^b, J. Schopfer^a, M. Kneubühler^a, K.I. Itten^a

^a Remote Sensing Laboratories, University of Zurich, Winterthurerstrasse 190, 8057 Zurich, Switzerland

^b European Space Research and Technology Centre (ESTEC), 2200AG Noordwijk, The Netherlands

Guides



SPECTRAL MEASUREMENTS FIELD GUIDE

by

John W. Salisbury

Earth Satellite Corporation

April 23, 1998

**FIELD SPECTROMETER & RADIOMETER GUIDE
 REMOTE SENSING PROGRAM**

School of Geography, Planning and Architecture
 The University of Queensland

Version 6

(Any comments /corrections welcomed !)
 S. Phinn, P. Scarth, C. Roelfsema, T. Gill and M. Stanford
 October 27 2006

Spectroradiometric Field Surveys in Remote Sensing Practice: A Workflow Proposal, from Planning to Analysis

L. POMPILIO, Department of Psychological, Humanistic and Earth Sciences,
 University "G. d'Annunzio," V. Dei Vestini, 31, Chieti, Italy. I-66013

P. VILLA, Institute of Information Science and Technologies "A. Faedo,"

National Research Council (ISTI-CNR), Via G. Moruzzi 1, Pisa, Italy. 56124

M. BOSCHETTI, AND M. PEPE, Institute for Electromagnetic Sensing of the Environment,

National Research Council (IREA-CNR), Via Bassini 15, Milan, Italy. 20133



AusCover Good Practice Guidelines

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

Standards



ISO 19156:2011 Geographic Information - Observations and Measurements

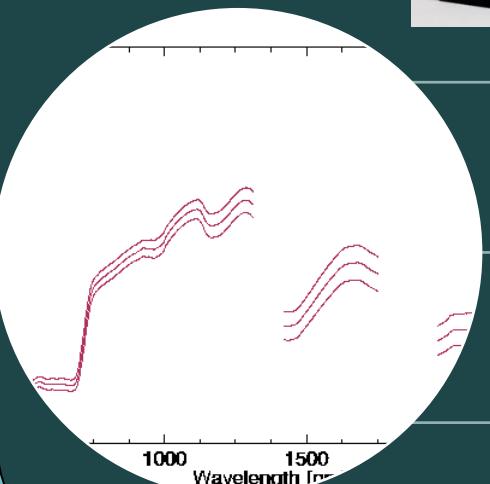
ISO 19115-1:2014 Geographic Information - Metadata- Part 1 Fundamentals



SensorML

Spectral databases are systems for the organised storage of spectral signatures accompanied by associated metadata (Hueny, 2009)

Spectra + auxdata measurements



GPS



Pictures



Environm



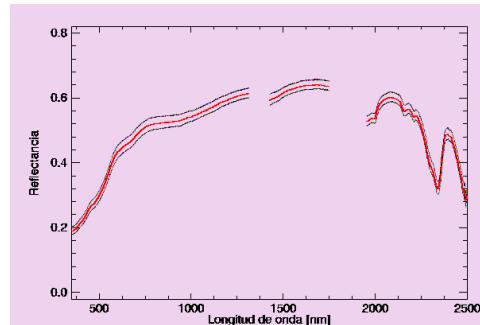
Data Quality

Metadata files

Database software

SPECTRAL LIBRARIES.TYPES AND FORMATS

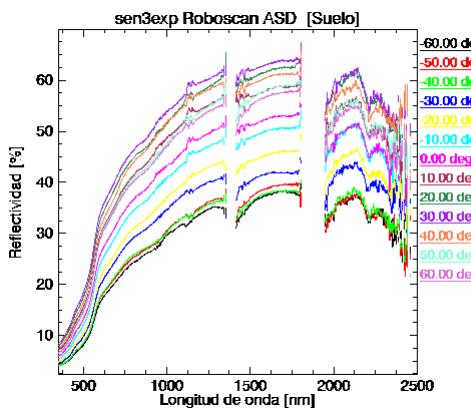
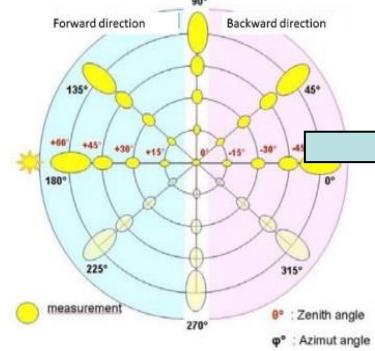
I) Simple case: characterize spectral response



File formats

Envi (.sli)
Excel (.xls)
Ascii (.txt)
JCAMP
Geomatica (.spl)
XML

II) Complex case: characterize spectral spatial, temporal, angular response



Procedures are application and objectives dependent.... standardization is possible????
Write your protocol....even publish
Actualize if it is necessary



Estimation of the remote-sensing reflectance from above-surface measurements

Curtis D. Mobley

Ocean Optics Protocols For Satellite Ocean Color Sensor Validation, Revision 5, Volume V:

Biogeochemical and Bio-Optical Measurements and Data Analysis Protocols

James L. Mueller, Giulietta S. Fargion and Charles R. McClain, Editors
J. L. Mueller, R. R. Bidigare, C. Trees, W. M. Balch, J. Dore, D.T. Drapeau, D. Karl, L. Van Heukelem, and J. Perl Authors.

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

K. Pfitzner
A. Bollhöfer
G. Carr

ISPRS Int. J. Geo-Inf. 2015, 4, 2472-2495; doi:10.3390/ijgi4042472

OPEN ACCESS
ISPRS International Journal of
Geo-Information
ISSN 2220-9964
www.mdpi.com/journal/ijgi/

Article

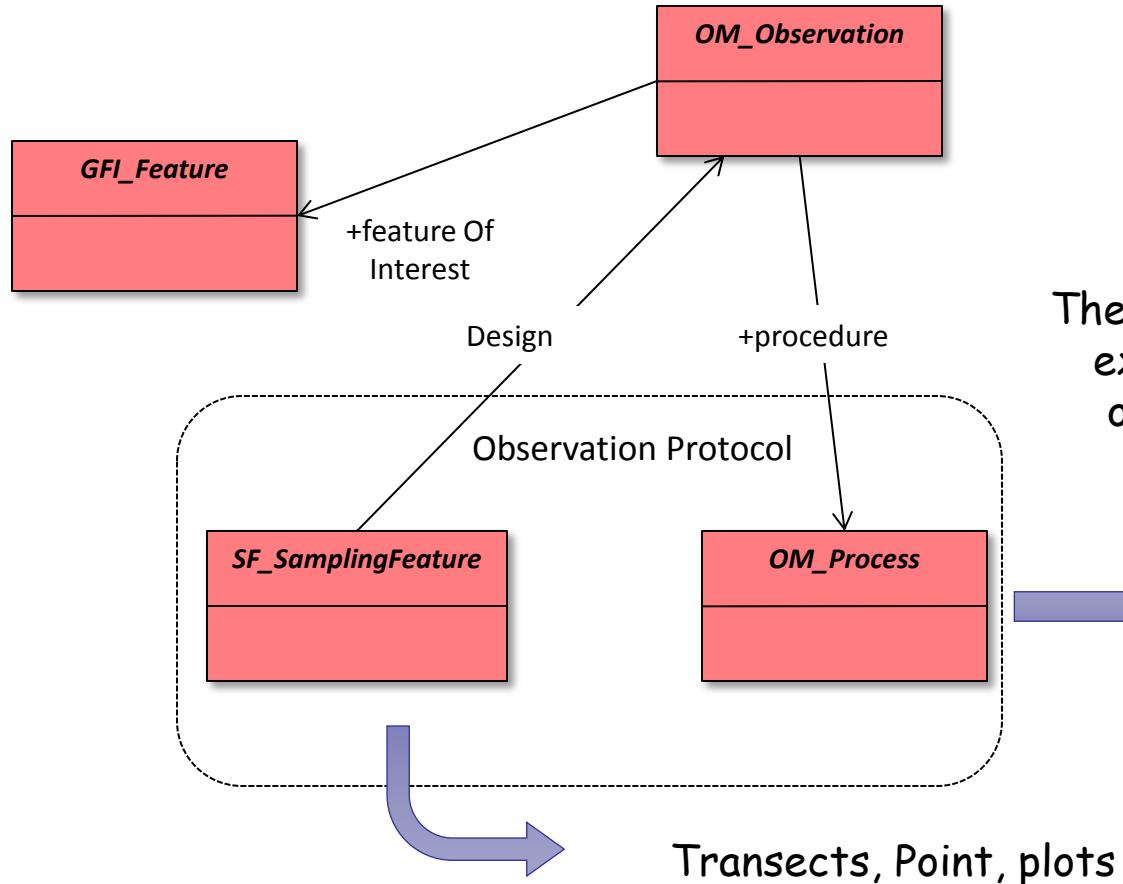
Towards a Standard Plant Species Spectral Library Protocol for Vegetation Mapping: A Case Study in the Shrubland of Doñana National Park

Marcos Jiménez ^{1,*} and Ricardo Diaz-Delgado ²



Reflectance measurements of soils in the laboratory: Standards and protocols

Eyal Ben Dor ^{a,b}, Cindy Ong ^b, Ian C. Lau ^b
^a Tel Aviv University (TAU), Israel
^b CSIRO, Perth, Western Australia, Australia



ISO 19156:2011

Geographic Information -
Observations and
Measurements

These provide document models for the exchange of information describing observation acts and their results

In-situ, ex-situ

Sampling protocol [ISO 19156 and guides]

Sampling Strategy

- Date → Phenomenon detection
- Site number and distribution → Stratified, random, site ID
- Individuals, target selection → Representative, Target ID

Spectra acquisition

- Spectroradiometer configuration → Single or Dual FOV, distance
- Observation geometry → Number files, Integration time
- Target sampling → Point, transect, plot
- Panel sampling

Auxiliar acquisition

- Geolocation → Coordinates
- Sun → Sun zenith and azimuth
- Target information → Texture, picture

Data Processing [references + SensorML]

Spectra Processing

- Pre-process**
 - reflectance → Reference panel
 - preparation → Numer of spectra, pre-process
- Post-process**
 - statistics → Spectral polishing
 - format save → Number of files

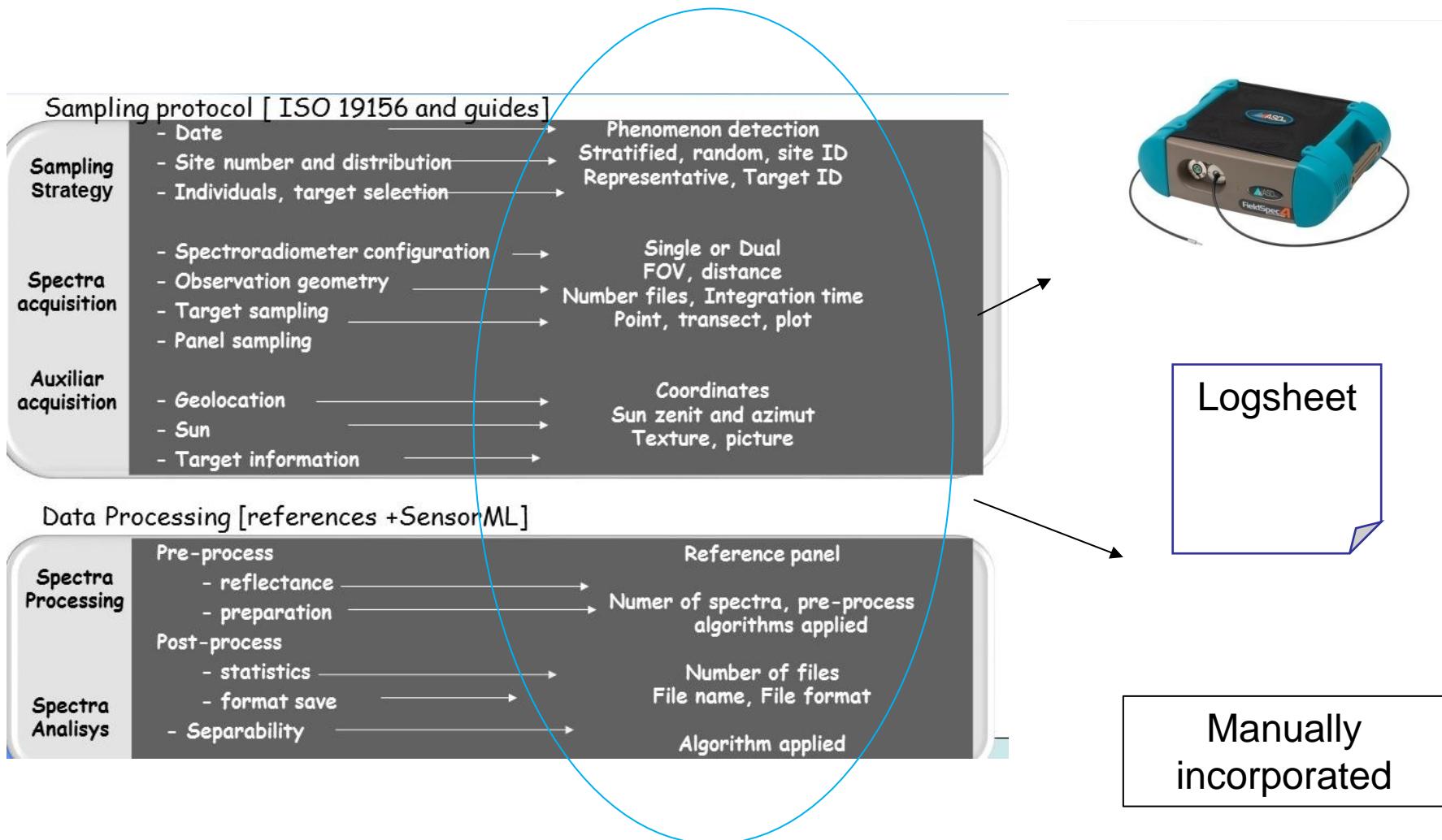
Spectra Analisys

- format save → File name, File format
- Separability → Algorithm applied

PROTOCOLS. INGESTION



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A QUALITY ASSURANCE
FRAMEWORK FOR
EARTH OBSERVATION

QA4EO Principle

Data and derived products shall have associated with them a fully traceable indicator of their quality

Quality Indicator

A Quality Indicator (QI) shall provide sufficient information to allow all users to readily evaluate the “fitness for purpose” of the data or derived product

Traceability

A QI shall be based on a documented and quantifiable assessment of evidence demonstrating the level of traceability to internationally agreed (where possible SI) reference standards

What is the meaning of a result without an uncertainty/confidence statement

JCGM 100:2008

GUM 1995 with minor corrections

Evaluation of measurement data — Guide to the expression of uncertainty in measurement

ISO 19157:2013

Geographic Information – Data quality

Thematic, Positional, temporal

Uncertainty Type A and Type B

Measurement uncertainties arise from a combination of several sources because the measurements are influenced by metrological agents, such as: measurement method, operator, environmental conditions, equipment and the sample itself (Mendes & Rosario, 2005)

- Repeatability
 - Same measurand, same conditions
 - Laboratory conditions
 - Usually only applies to single instrument measuring a single source multiple times
 - Indicator of theoretical measurement PRECISION
- Reproducibility
 - Closeness of agreement between measurements of the same physical parameter, under different conditions
 - Indicator of operational measurement precision
 - Quantification = critical to application of field spectroscopy across user groups with different instruments, and to MULTI-TEMPORAL studies
- Calibrations and trazability reports for spectroradiometer and panel



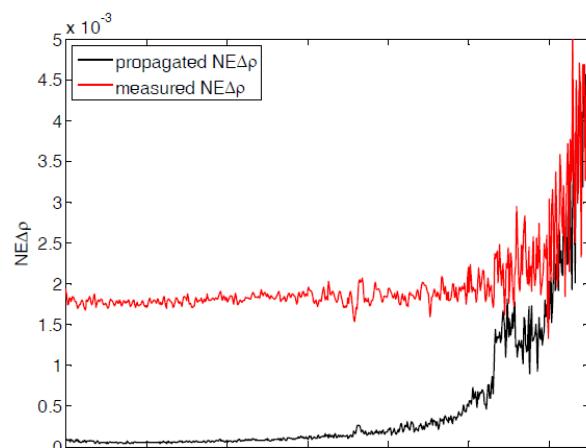
On the reproducibility of reflectance factors: implications for EO science

Karen Anderson
School of Geography,
University of Exeter, UK
karen.anderson@exeter.ac.uk

E. J. Milton, Vincent Odongo
School of Geography,
University of Southampton, UK
e.j.milton@soton.ac.uk

Jennifer L. Dungan
NASA Ames Research Center,
Moffett Field, CA, USA
Jennifer.L.Dungan@nasa.gov

$$NE\Delta\rho = \rho \sqrt{\left(\frac{NE\Delta L_{tar}}{L} \right)^2 + \left(\frac{NE\Delta L_{ref}}{E} \right)^2}$$



SPECTRAL UNIFORMITY EVALUATION OF REFERENCE SURFACES FOR AIRBORNE AND ORBITAL SENSORS ABSOLUTE CALIBRATION

Cibele Teixeira Pinto^{1,2}, Flávio Jorge Ponzoni¹, Ruy Morgado de Castro^{2,3}
and Derek John Griffith⁴

$$\sigma_{final} = \sqrt{\sum (\sigma_A)^2 + \sum (\sigma_B)^2}$$

$$\sigma_A = \sqrt{(\sigma_{repetitividade})^2 + (\sigma_{reprodutibilidade})^2}$$

A field spectroscopy metadata standard is defined as those data elements that explicitly document the spectroscopy dataset and field protocols, sampling strategies, instrument properties and environmental and logistical variables

Metadata

Text ascii
files
Standard
XML

SPECCHIO *Universidad de Zurich*

EcologicalML de la Ecological Society of America

SpectroML de *National Institute of Standards and Technology (NIST)*

Malthus et al., 2009 CSIRO

Remote Sens. 2015, 7, 15668-15701; doi:10.3390/rs71115668

Article

Towards an Interoperable Field Spectroscopy
Metadata Standard with Extended Support for Marine
Specific Applications

Barbara A. Rasaiyah ^{1,*}, Chris Bellman ¹, Simon. D. Jones ¹, Tim J. Malthus ² and Chris Roelfsema ³



Remote Sens. 2014, 6, 3662-3680; doi:10.3390/rs6053662

Article

Critical Metadata for Spectroscopy Field Campaigns

Barbara A. Rasaiyah ^{1,*}, Simon. D. Jones ¹, Chris Bellman ¹ and Tim J. Malthus ²



Table 2.1 Categories of metadata fields in the survey

Generic campaign metadata

- ◆ instrument
- ◆ reference standards
- ◆ calibration
- ◆ hyperspectral signal properties
- ◆ illumination information
- ◆ viewing geometry
- ◆ environment information
- ◆ atmospheric conditions
- ◆ general project information
- ◆ location information
- ◆ general target and sampling information

Campaign-specific metadata

- ◆ vegetation
- ◆ woodland and forest
- ◆ agriculture
- ◆ soil
- ◆ mineral exploration
- ◆ snow
- ◆ urban environments
- ◆ marine and estuarine
- ◆ underwater substratum targets

ISO 19115-1:2014
Geographic Information -
Metadata- Part 1
Fundamentals

ISPRS Int. J. Geo-Inf. **2014**, *3*, 1003-1022; doi:10.3390/ijgi3031003

OPEN ACCESS

ISPRS International Journal of
Geo-Information

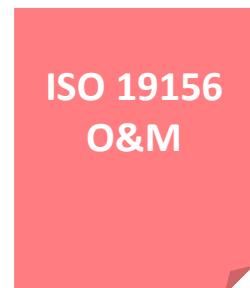
ISSN 2220-9964

www.mdpi.com/journal/ijgi/

Article

Field Spectroscopy Metadata System Based on ISO and OGC Standards

Marcos Jiménez ^{1,*}, Magdalena González ¹, Alberto Amaro ² and Alix Fernández-Renau ¹



SPECTRO-RADIOMETER

- Model → D
- Serial number → D
- Calibration date → D
- ForeOptic applied → D
 - FOV used → D
 - VNIR (FWHM) → D
 - SWIR1 (FWHM) → D
 - SWIR2 (FWHM) → D

CONTACT

- Organization responsible → D
- Person responsible of the data → D

QUALITY

- Radiometric (NEDL) → D
- Geometric (RMSE_{x,y}) → D
 - Measurement Uncertainty → C
 - Surface Heterogeneity → C

D: read Directly

M: Manually

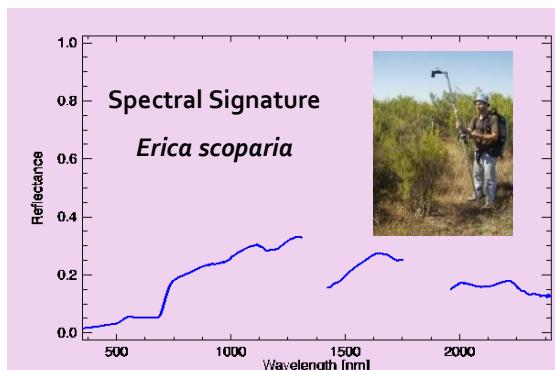
C: Calculated

LOCALIZATION

- Reference system → M
- Projection → M
- X coordinate → C
- Y coordinate → C
- Altitude → C

METHODOLOGY

- Acquisition date → D
- Acquisition time → D
- Observation angle → M
 - Sensor height → M
- Quantity measured → D
- Reference Panel → M
- Measurement method → M



Incorporation mode to XML metadata files

CAMPAIGN

- Name → D
- Date → D
- Objective → M
- Purpose → M
- Locality → M
- User (Organization) → M
- Operator → M

ENVIRONMENT

- illumination source → M
- Solar zenith angle → C
- Solar azimuth angle → C
- Cloud cover → M
- Aerosol Optical depth → M

FILE

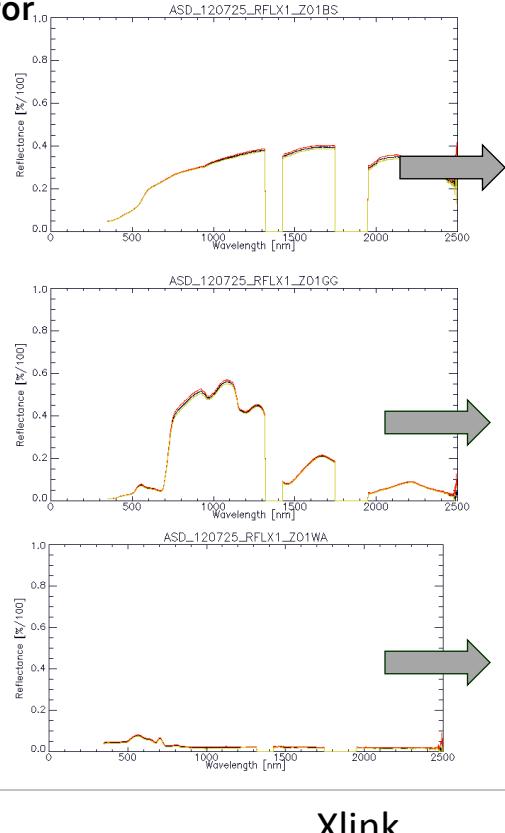
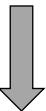
- Name → D
- Format → D
- Creation date → D
- Number of samples → M
- Number of spectra → C
- Process level → M

TARGET/SURFACE

- Identification → D
- Description → M

Field spectrometer

One SensorML XML file for each instrument used



Spectral curves

One ISO 19156 XML file for each surface/material measured

ISO 19156
O&M
Surface 1

ISO 19156
O&M
Surface 2

ISO 19156
O&M
Surface 3

Xlink

Xlink

Xlink

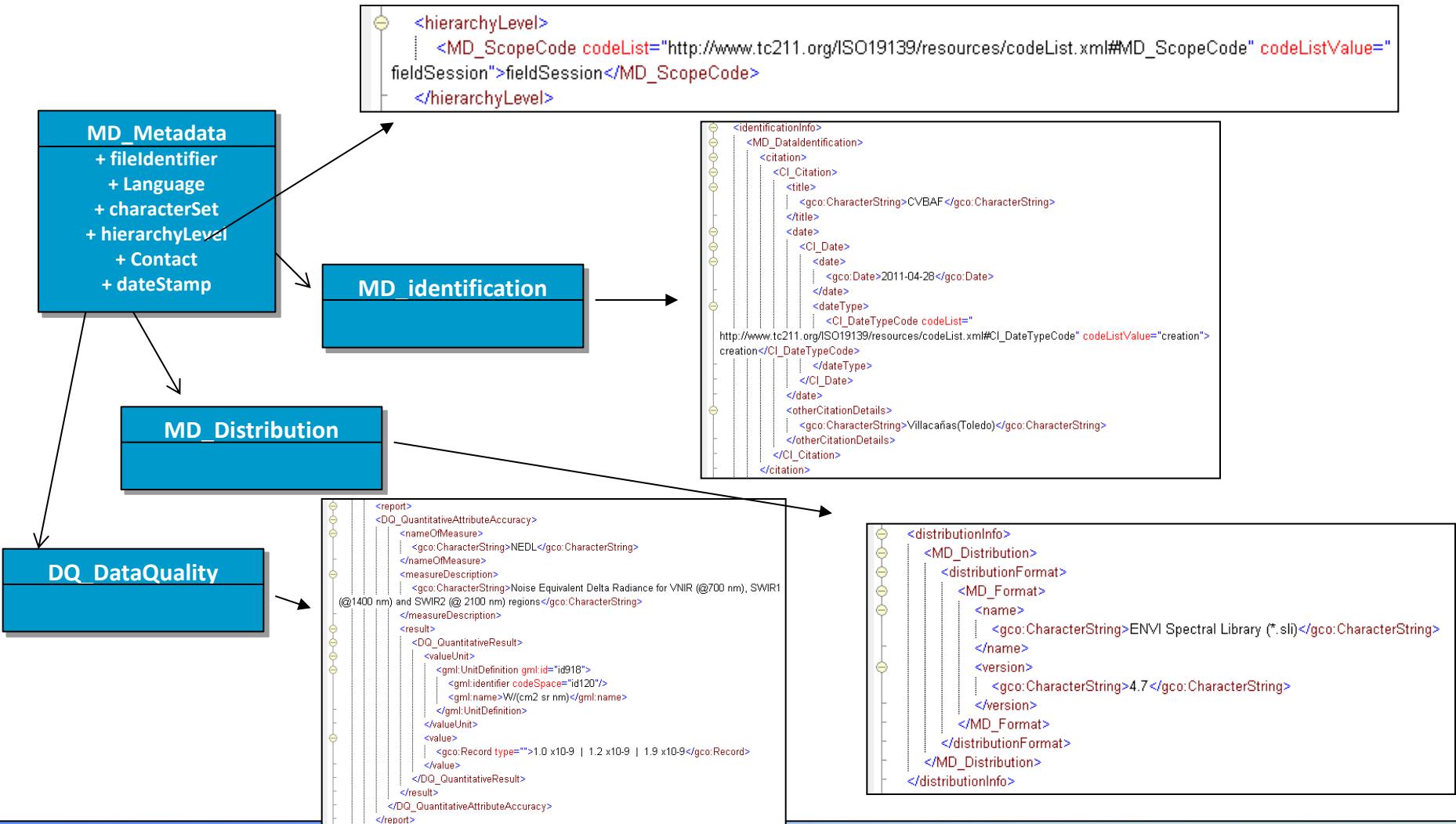
Field campaign

One ISO 19115 XML file for each date

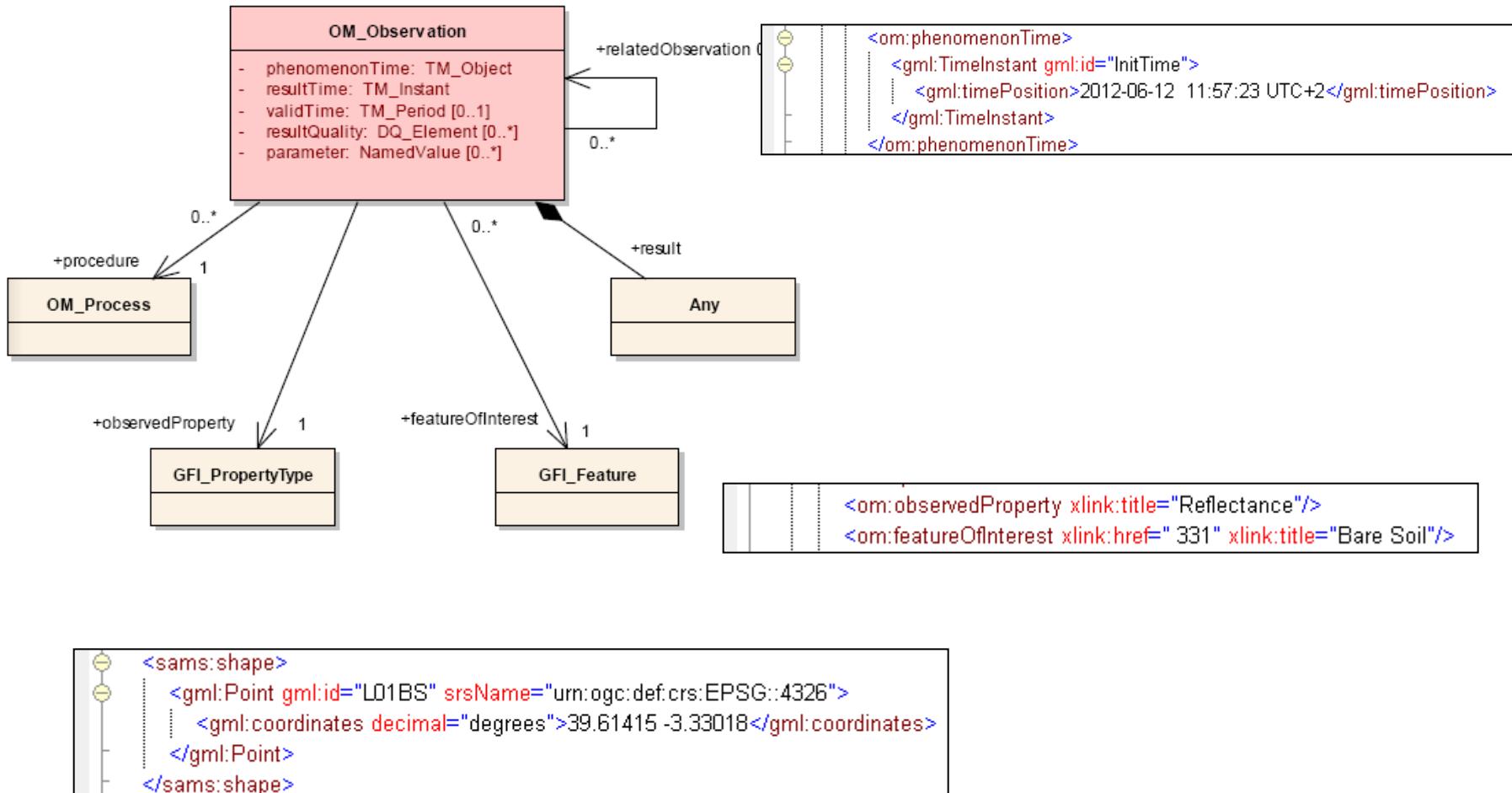


ISO 19115
MD-
Metadata

ISO 19115 Field Spectroscopy namespaces



ISO 19156 Field Spectroscopy namespaces



SensorML ASD FieldSpec3 namespaces

```
<<Process Type>>
System

+name:string
+description[0..1]
+metadata Group
+input[0..*]: anyData
+output[1..*]:anyData
+parameter[0..*]
+spatialReferenceFrame
+temporalReferenceFrame
+bundedBy[0..1]
+position[0..1]
+interface[0..1]
+component[1..*]:Process
+connection[0..*]: Link
```

SensorML ASD Fieldspec Profile

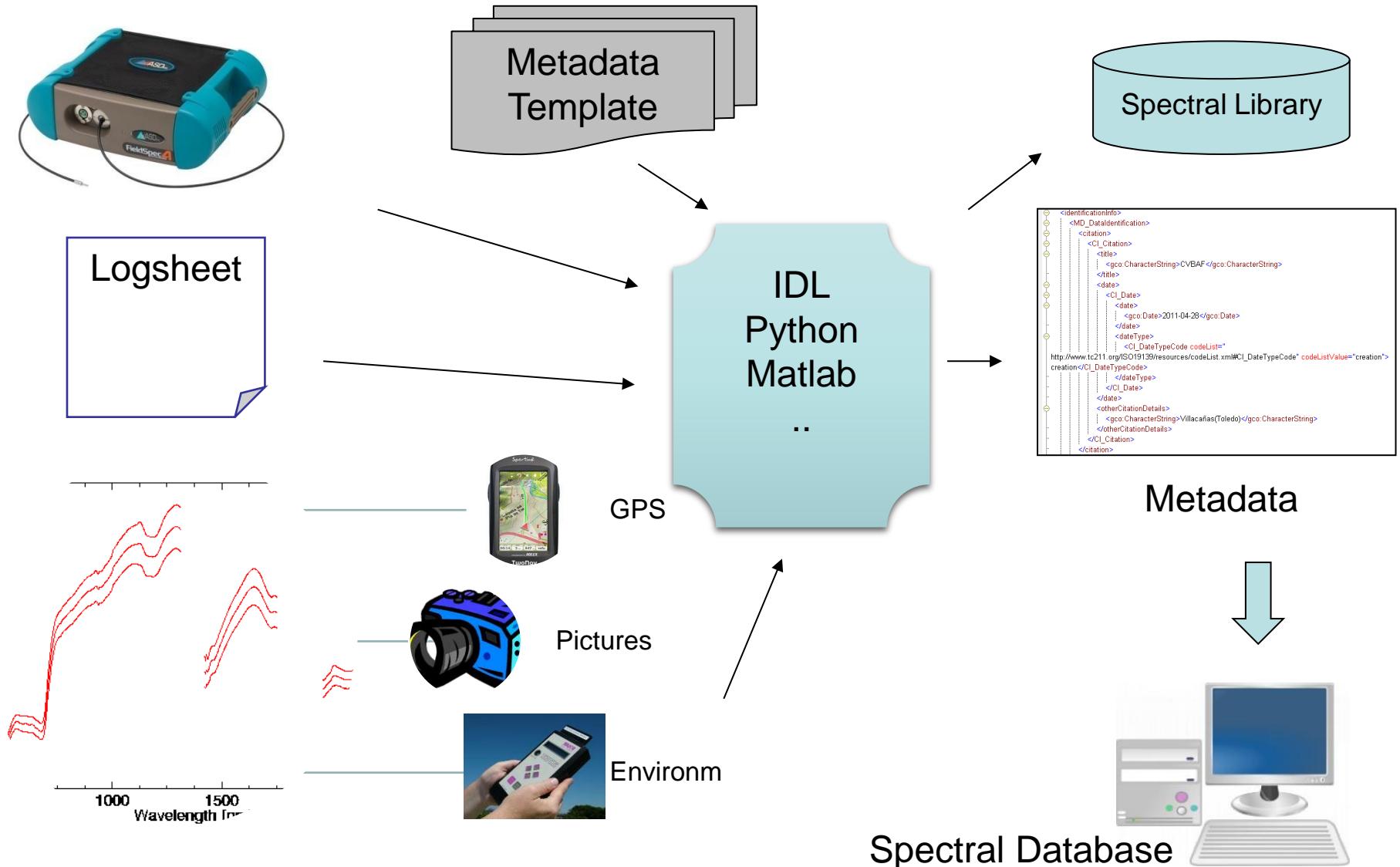
```
<<Process Type>>
System

+name:string
+description[0..1]
+metadata Group
+input[0.. *]: anyData
+output[1.. *]:anyData
+parameter[0..*]
```

```
<sml:identification>
<sml:IdentifierList>
<sml:identifier name="ShortName">
<sml:Term definition="">
| <sml:value>ASDFieldspec3-16040</sml:value>
</sml:Term>
</sml:identifier>
</sml:IdentifierList>
</sml:identification>
```

```
<sml:contact>
<sml:ResponsibleParty>
<sml:individualName>Marcos Jimenez Michavila</sml:individualName>
<sml:organizationName>INTA</sml:organizationName>
<sml:positionName>Responsible of Field Radiometry</sml:positionName>
<sml:contactInfo>
<sml:phone>
| <sml:voice>34 915201989</sml:voice>
| <sml:facsimile>34 915201633</sml:facsimile>
</sml:phone>
<sml:address>
| <sml:deliveryPoint>Remote Sensing Area</sml:deliveryPoint>
| <sml:city>C/ Carretera de Ajalvir s/n. Torrejon de Ardoz</sml:city>
| <sml:administrativeArea>Madrid</sml:administrativeArea>
| <sml:postalCode>28850</sml:postalCode>
| <sml:country>Spain</sml:country>
| <sml:electronicMailAddress>jimenezmm@inta.es</sml:electronicMailAddress>
</sml:address>
</sml:contactInfo>
</sml:ResponsibleParty>
</sml:contact>
```

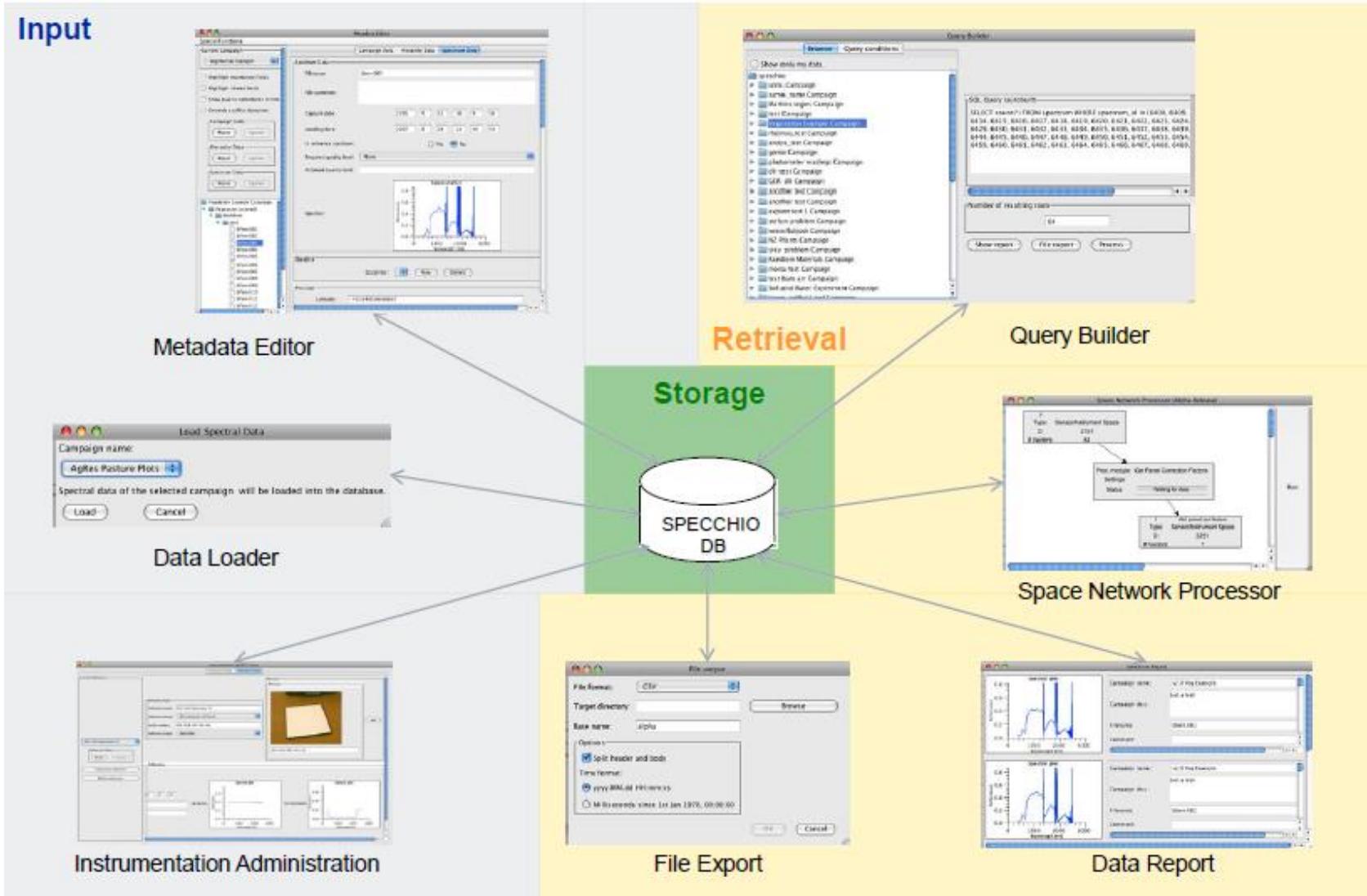
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<sml:characteristics>
<swe:DataRecord>
<swe:field name="Radiometric and spectral Calibration date">
<swe:Time>
| <gml:description>Radiometric and Spectral calibration carried out in the ASD laboratory facilities</gml:description>
| <swe:value>December 2010</swe:value>
</swe:Time>
</swe:field>
```



SPECTRA DATABASE. SPECCHIO



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CONCLUSIONS



INSTITUTO NACIONAL DE TÉCNICA AEROSPACE

- Proximal sensing is increasingly complex but mainly the HCRF is the magnitude that we want to characterize
- Spectral Databases are the key issue for spectral libraries reliability
- A complete metadata system to properly report what has been measured and the conditions in which the measurements were carried out
- Robust protocols must be only actualized if it is need it.
- Develop or use software applications to manage your data looking for high automatic implementation
- Standardization is possible by widespread tools or by International normatives