REMOTE SENSING LAB

Use of hyperspectral measurements for Sentinel-2 image classification for the regions of Berlin and Heraklion

Giannis Lantzanakis, Natalia Pynirtzi, Emmanouil Panagiotakis, Konstantinos Politakos, Dimitris Poursanidis, Nektarios Chrysoulakis

Remote Sensing Lab | IACM | http://rslab.gr

2nd Workshop on International Cooperation in Spaceborne Imaging Spectroscopy

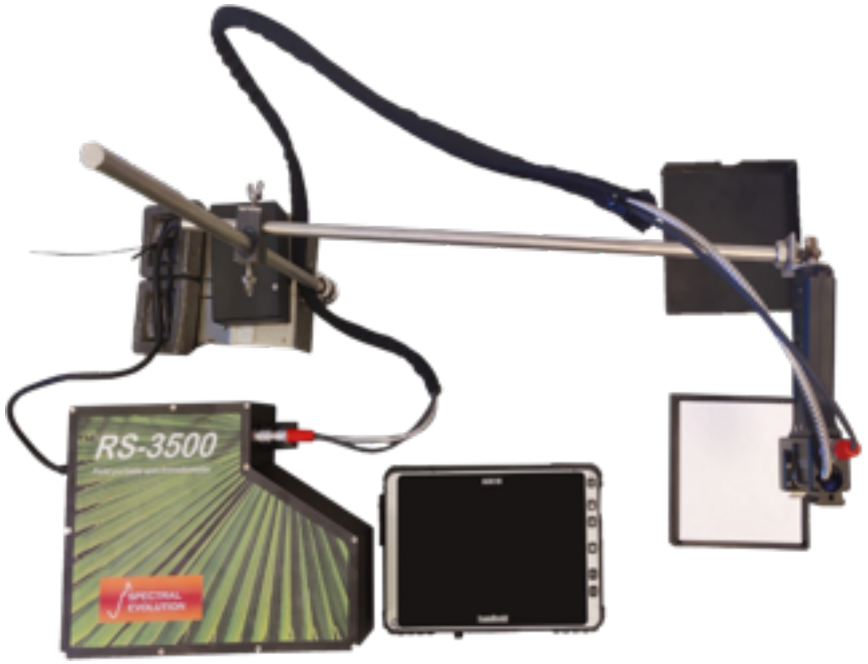
20/10/2022

FOUNDATION FOR RESEARCH AND TECHNOLOGY - HELLAS

urbisphere coupling dynamic cities and climate

European Research Council

Equipment & Experimental Set-Up



RS- 3500 Spectral evolution

- Spectral Range: 350-2500nm
  - @2.8nm (350-1000nm) (512 elements Si PDA)
  - @8nm (1000-1900nm) (256 elements InGaAs)
  - @6nm (1900-2500nm) (256 elements InGaAs)
- Optical Fiber with field of view: 22°
- Vertical distance: 20cm
- Rugged Handheld Table
  - Real-time, wireless instrument control
  - Built-in GPS, camera
- DARWin software for data acquisition
  - 5x10 measurements of Lambertian
  - 5x10 measurements of Material
  - 2151 interpolated spectral bands (1nm)

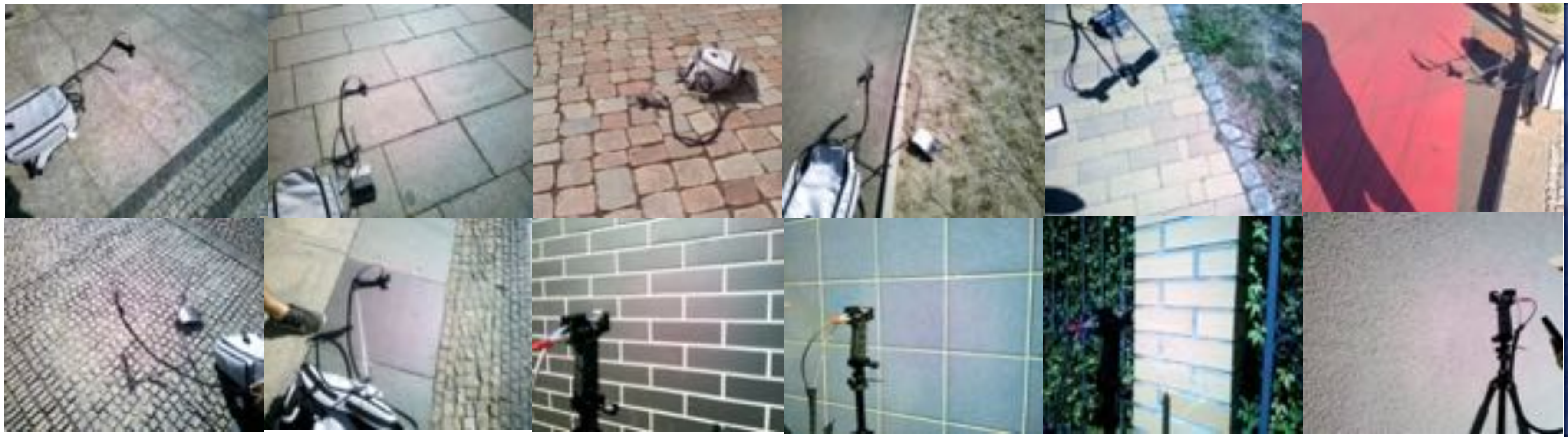
Lambertian Measurement

Material Measurement

Measurements in Heraklion & Berlin

Heraklion (to date, 334 Different Spectral Signatures have been collected)

Berlin (to date, 225 Different Spectral Signatures have been collected)



Material Categorization

- ID
  - ASPcxxx
  - BRCcxxx
  - BUScxxx
  - CAOcxxx
  - CEMcxxx
  - CERcxxx
  - CONcxxx
  - ELAcxxx
  - GEOcxxx
  - GLScxxx
  - GRNcxxx
  - GRScxxx
  - GRVcxxx
  - LIMcxxx
  - MRBcxxx
  - MTLcxxx
  - MORcxxx
  - MUDcxxx
  - PLScxxx
  - ROKcxxx
  - SNDcxxx
  - SODcxxx
  - SOLcxxx
  - STNcxxx
  - TARcxxx
  - TILcxxx
  - WOOcxxx
- Material
  - Asphalt
  - Brick
  - Bush
  - Caoutchouc
  - Cement
  - Ceramic
  - Concrete
  - Elastic Acrylic
  - Geotextile
  - Glass
  - Granit
  - Grass
  - Gravel
  - Lime
  - Marble
  - Metal
  - Mortar
  - Mud
  - Plaster
  - Rock
  - Sand
  - Sod
  - Soil
  - Stone
  - Tartan
  - Tile
  - Wood
- Color
  - Beige (I)
  - Black (K)
  - Blue (B)
  - Brown (F)
  - Cyan (C)
  - Green (G)
  - Grey (E)
  - Orange (O)
  - Pink (P)
  - Purple (U)
  - Red (R)
  - White (W)
  - Yellow (Y)
  - …
- Surface Structure
  - Bare
  - Blocks
  - Burnt
  - Corrugated
  - Cracked
  - Dry
  - Fine Roughness
  - Glazed
  - Matte
  - Mosey
  - Natural
  - Painted
  - Photosynthetic
  - Porous
  - Reflective
  - Smooth
  - Uneven
  - Varnished
  - …
- Usage
  - Bench
  - Façade
  - Ground
  - Roof
- Status
  - Dusty
  - New
  - Weathered
  - -

New Painted Blue Gravel (Ground)

[1] Ilehag, R.; Schenk, A.; Huang, Y.; Hinz, S. KLUM: An Urban VNIR and SWIR Spectral Library Consisting of Building Materials. *Remote Sens.* **2019**, *11*, 2149. https://doi.org/10.3390/rs11182149

Hyperspectral Pre-Processing

Variables

- L is the Mean of 5x Lambertian Measurements (each measurement is the mean of 10 measurements in 5s timestamp)
- x is the Mean of 5x Material Measurements (each measurement is the mean of 10 measurements in 5s timestamp)
- S_L is the Spectral Response Function of the Lambertian
- S_A & S_B is the Spectral Response Function for Sentinel-2A and Sentinel-2B respectively
- R_A & R_B is the corresponding reflectance of the Hyperspectral Signatures in Sentinel-2A/2B respectively bands (b)

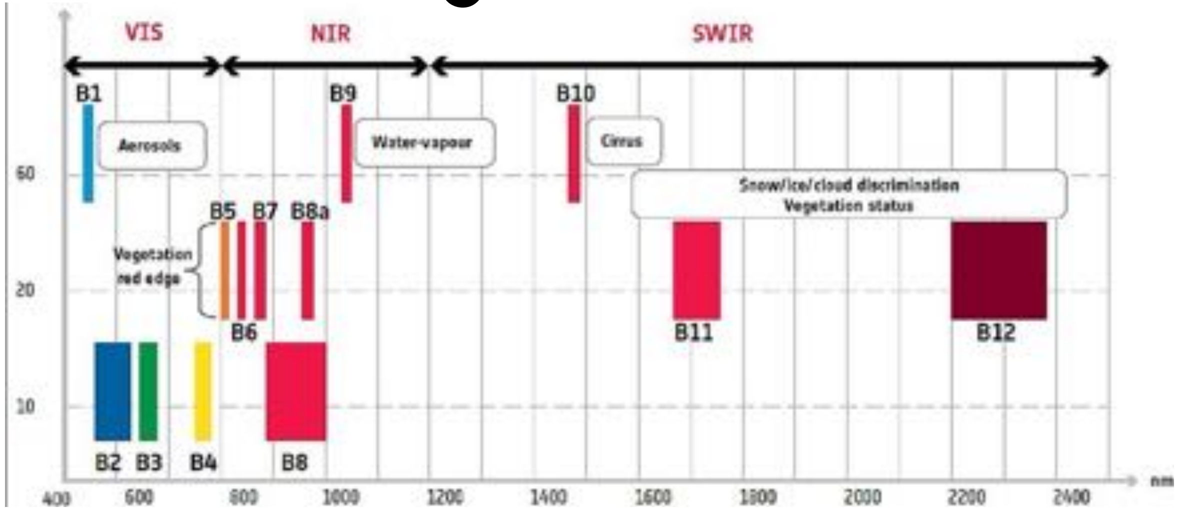
Pre-Processing Steps

- Removing wavelengths in which the solar radiation does not penetrate the atmosphere: 1340nm-1450nm, 1780nm-1970nm and 2300nm-2500nm [1]
- Measurements with STD > 2% in the reflectance of the remaining wavelengths are excluded from the Library.

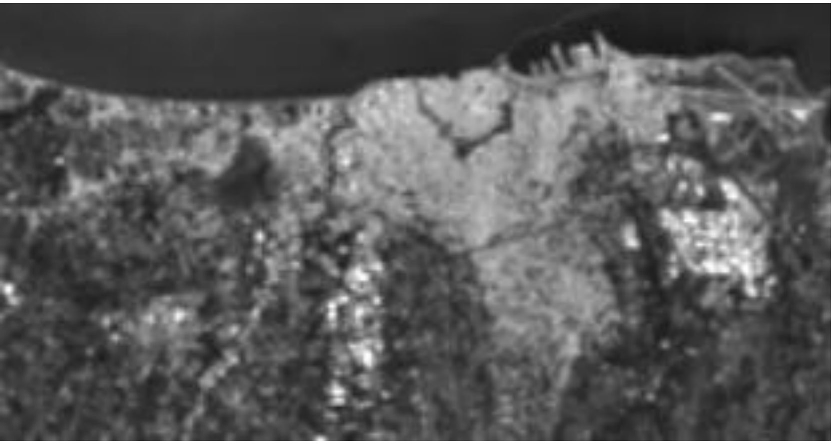
$$R_A(b) = \frac{\sum\left(\frac{s_A(b,\lambda)\cdot x(\lambda)}{s_L(\lambda)\cdot \mathrm{L}(\lambda)}\right)}{\sum s_A(b,\lambda)} \qquad R_B(b) = \frac{\sum\left(\frac{s_B(b,\lambda)\cdot x(\lambda)}{s_L(\lambda)\cdot \mathrm{L}(\lambda)}\right)}{\sum s_B(b,\lambda)}$$ [2]

[1] Ilehag, R.; Schenk, A.; Huang, Y.; Hinz, S. KLUM: An Urban VNIR and SWIR Spectral Library Consisting of Building Materials. *Remote Sens.* **2019**, *11*, 2149. https://doi.org/10.3390/rs11182149
[2] Wu, W., Liu, X., Xiong, X., Li, Y., Yang, Q., Wu, A., et al. (2018). An accurate method for correcting spectral convolution errors in intercalibration of broadband and hyperspectral sensors. *Journal of Geophysical Research: Atmospheres*, 123, 9238– 9255. https://doi.org/10.1029/2018JD028585

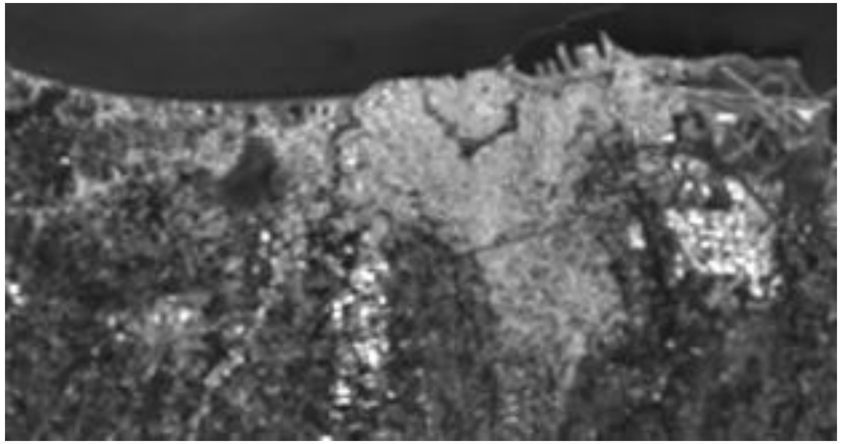
Sentinel-2 Pre-Processing



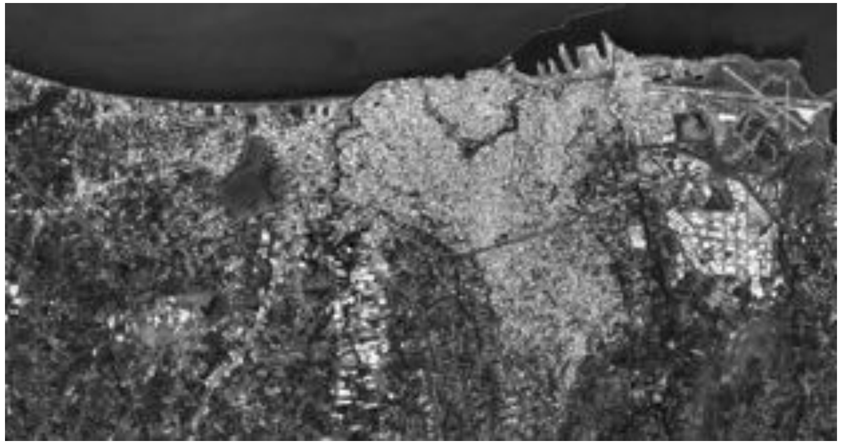
B01 Sentinel-2B L2A (Original 60m)



B01 Super-Resolving (ESA SNAP) 10m [3]



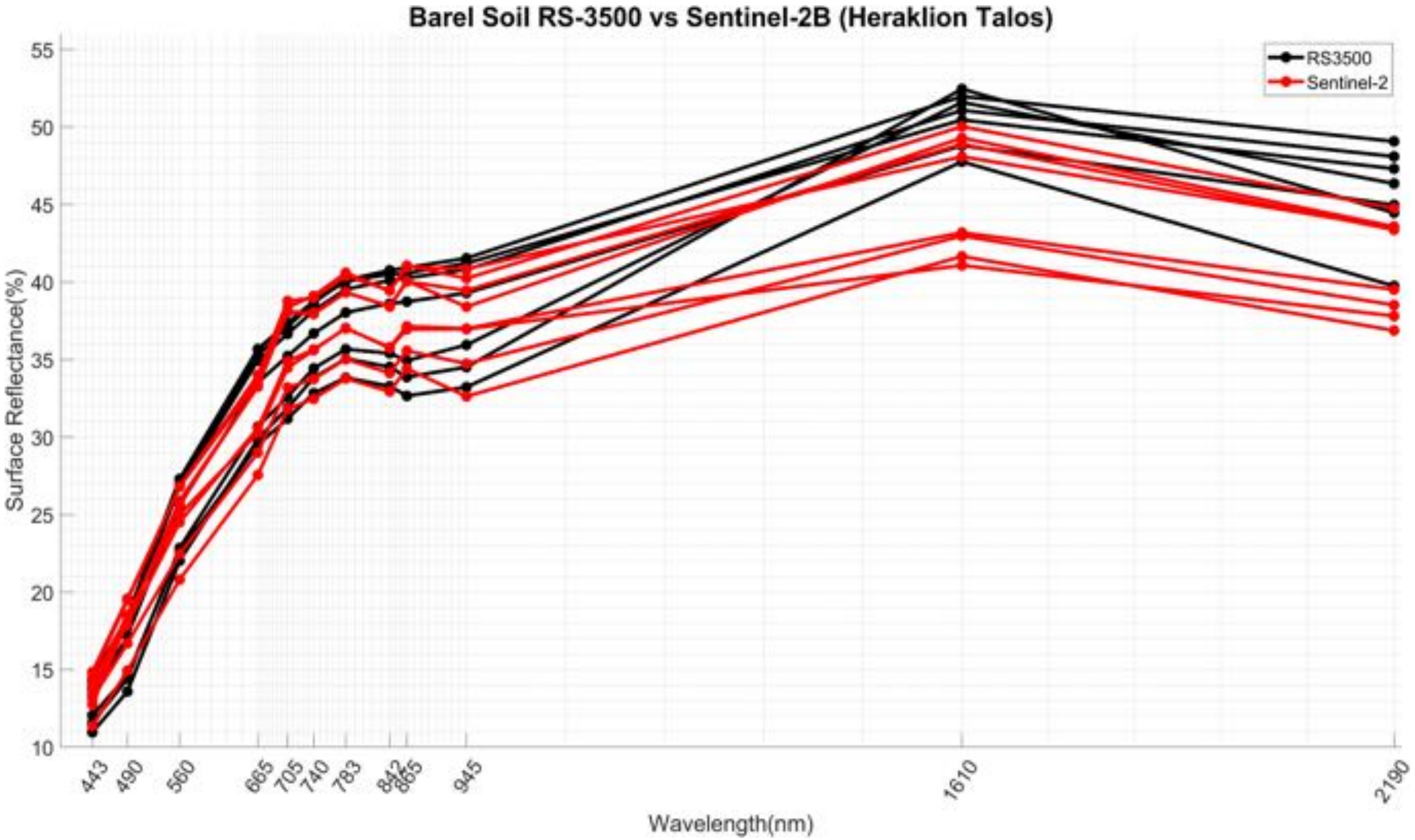
B01 Super-Resolution(Matlab) 10m [4]



[3] N. Brodu, "Super-Resolving Multiresolution Images With Band-Independent Geometry of Multispectral Pixels," in *IEEE Transactions on Geoscience and Remote Sensing*, vol. 55, no. 8, pp. 4610-4617, Aug. 2017, doi: 10.1109/TGRS.2017.2694881.

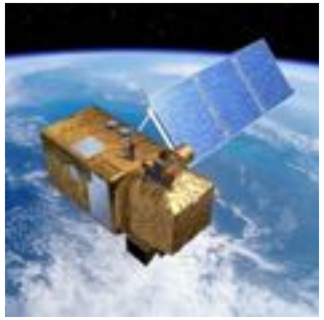
[4] C. Lanaras, J. Bioucas-Dias, E. Baltsavias and K. Schindler, "Super-Resolution of Multispectral Multiresolution Images from a Single Sensor," *2017 IEEE Conference on Computer Vision and Pattern Recognition Workshops (CVPRW)*, 2017, pp. 1505-1513, doi: 10.1109/CVPRW.2017.194.

Sentinel-2 L2A Spectrums vs Adjusted Hyperspectral



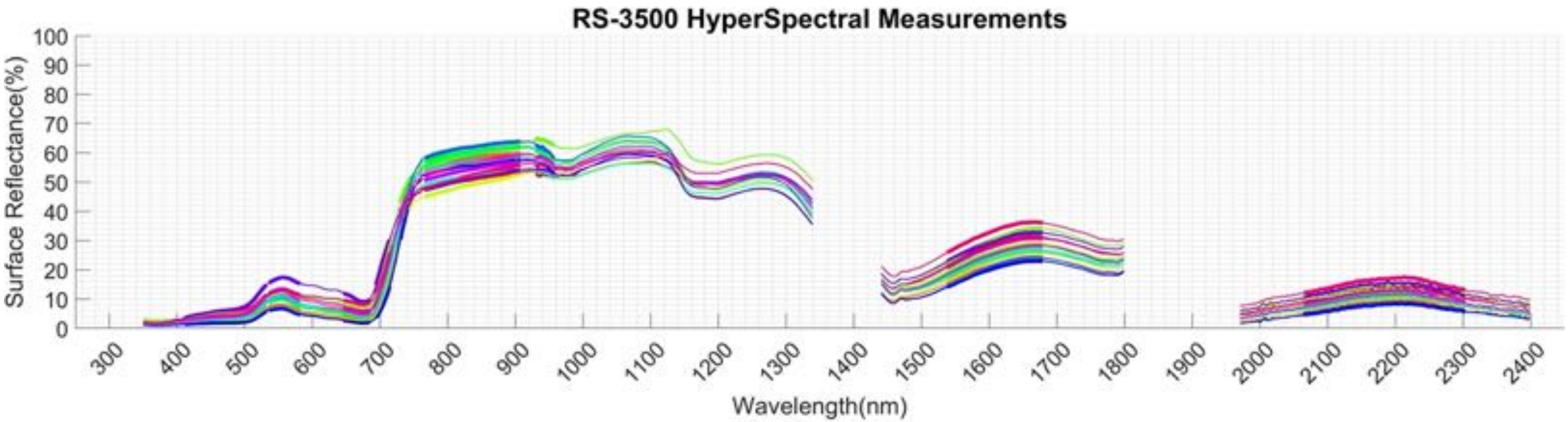
RS 3500 SpectoRadiometer

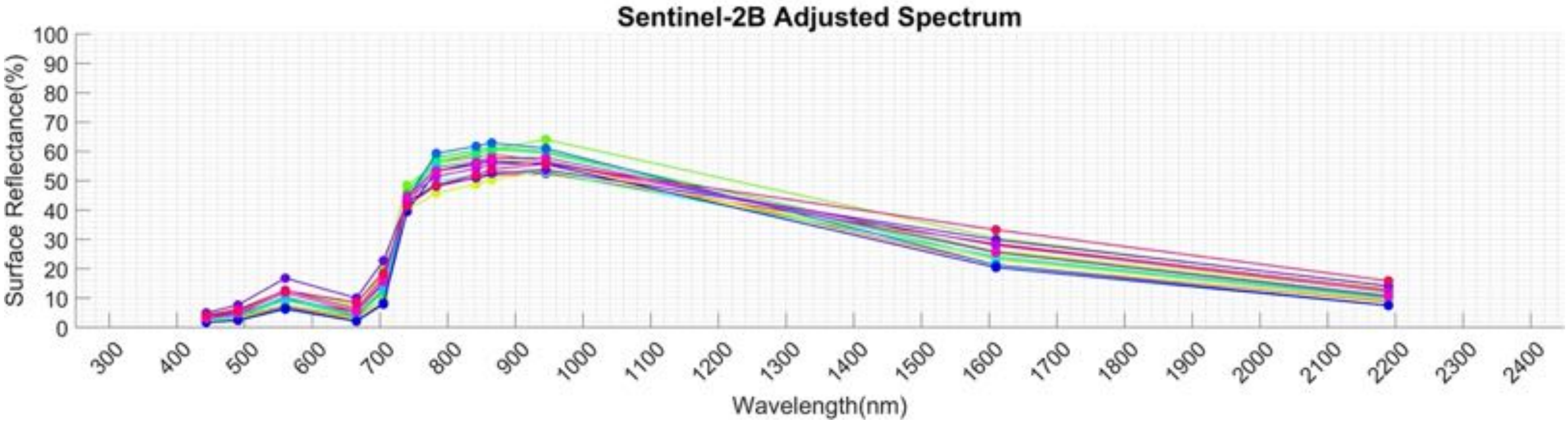
Sentinel − 2 (10m)



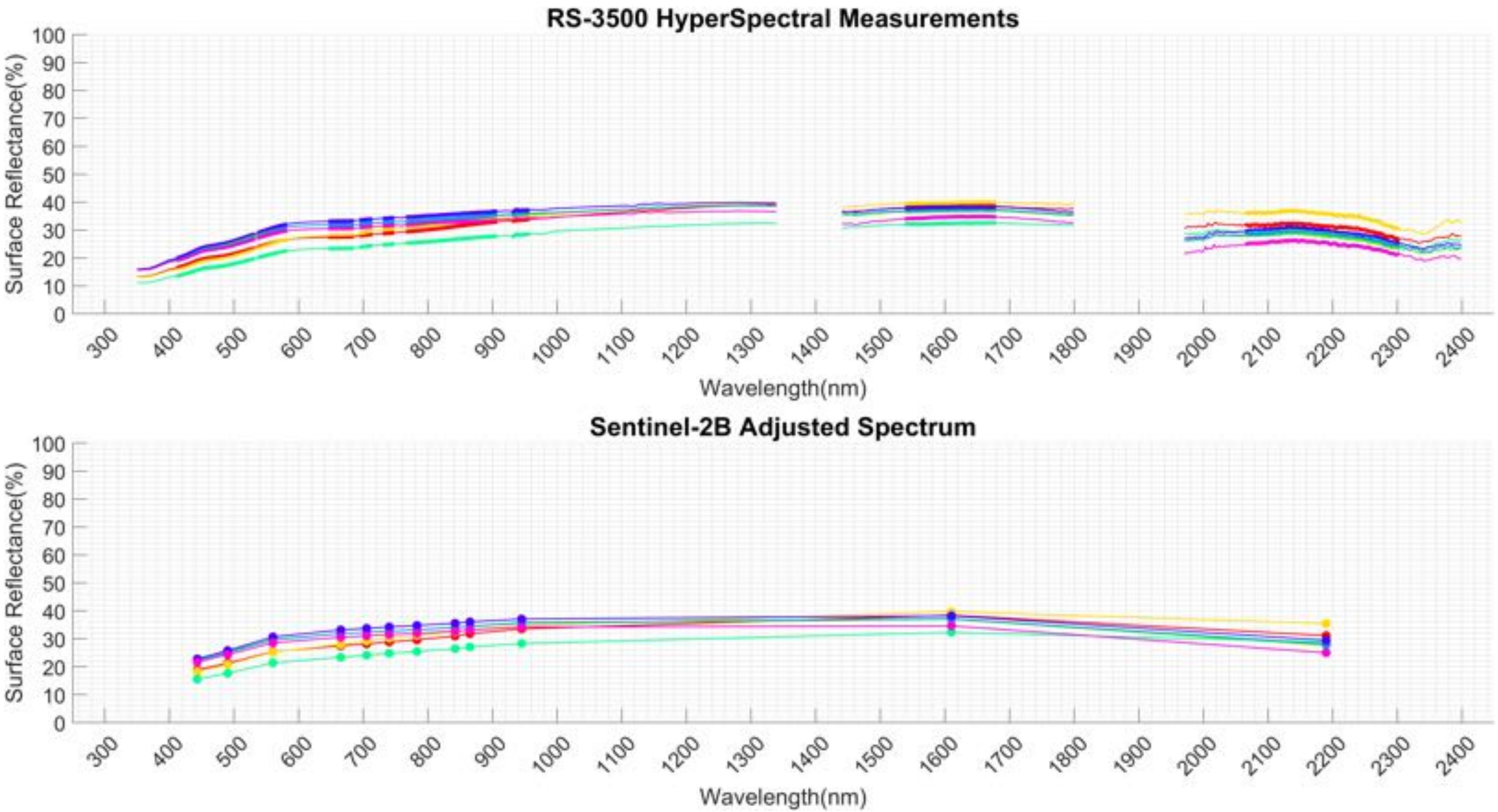
RSLab

Grass

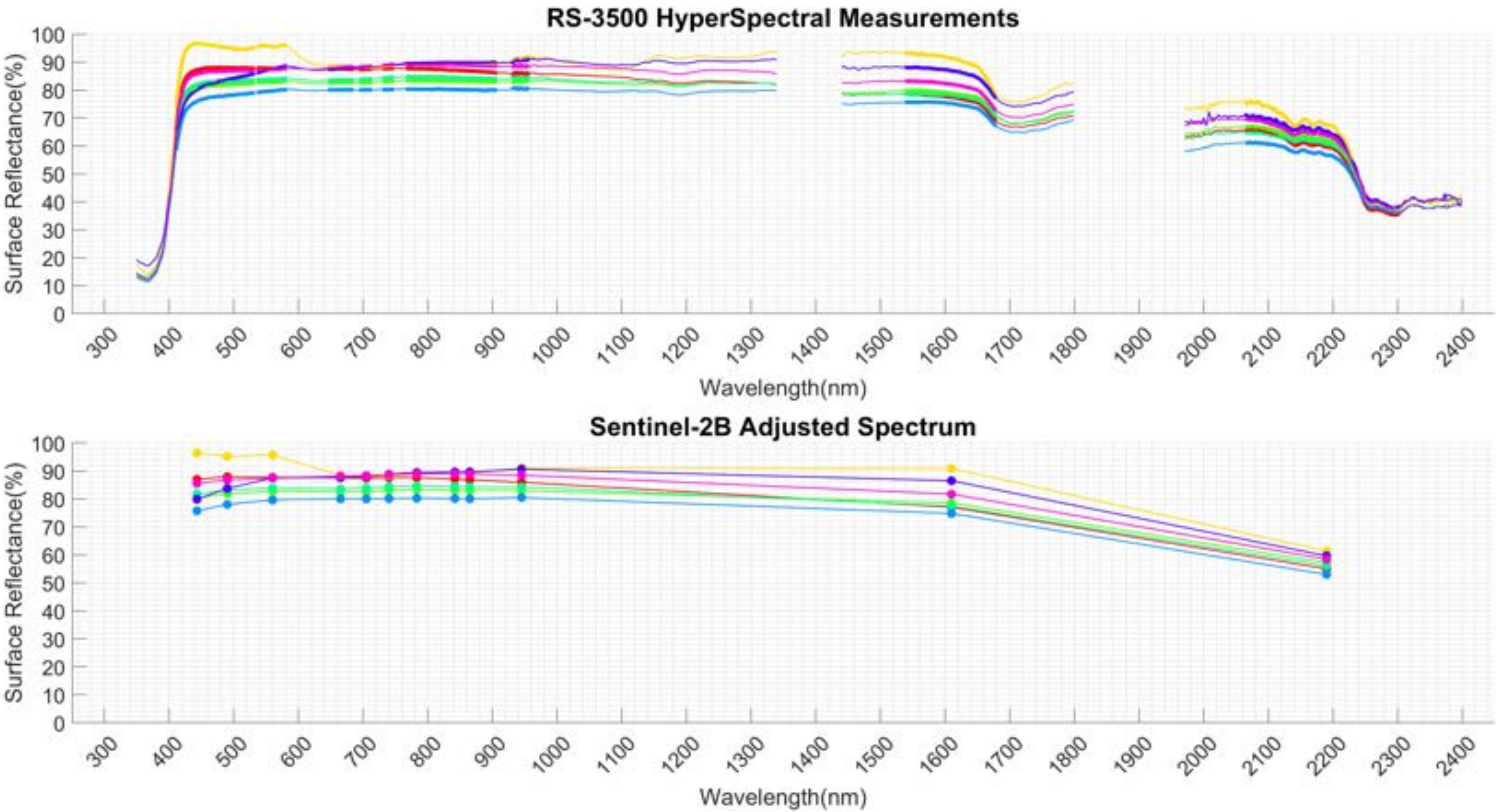

RS-3500 HyperSpectral Measurements
Surface Reflectance(%)
100
90
80
70
60
50
40
30
20
10
0
300
400
500
600
700
800
900
1000
1100
1200
1300
1400
1500
1600
1700
1800
1900
2000
2100
2200
2300
2400
Wavelength(nm)


Sentinel-2B Adjusted Spectrum
Surface Reflectance(%)
100
90
80
70
60
50
40
30
20
10
0
300
400
500
600
700
800
900
1000
1100
1200
1300
1400
1500
1600
1700
1800
1900
2000
2100
2200
2300
2400
Wavelength(nm)

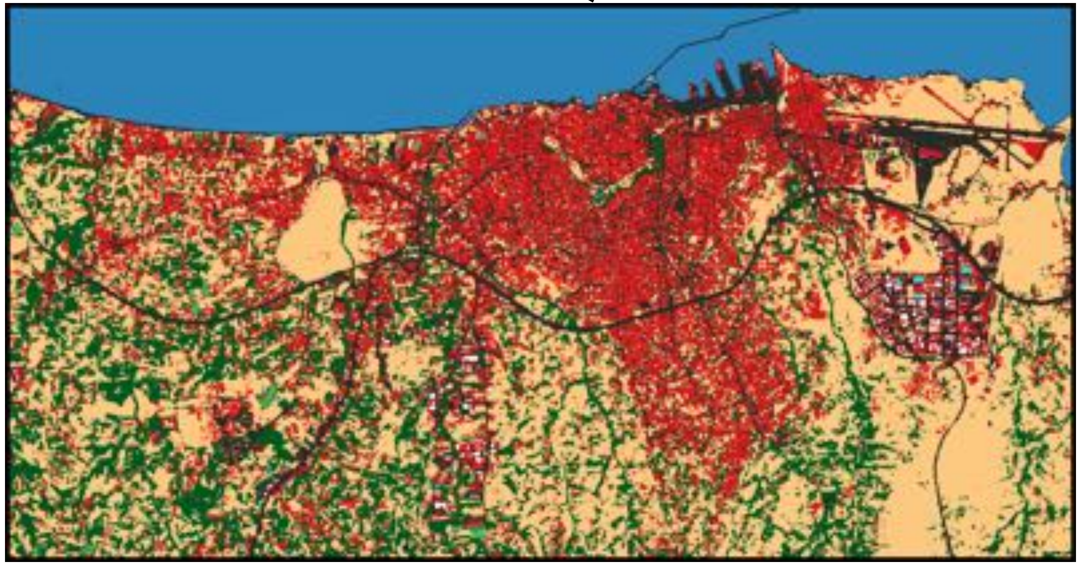
Grey Cement


RS-3500 HyperSpectral Measurements
Surface Reflectance(%)
Wavelength(nm)
Sentinel-2B Adjusted Spectrum
Surface Reflectance(%)
Wavelength(nm)

White Painted Metal



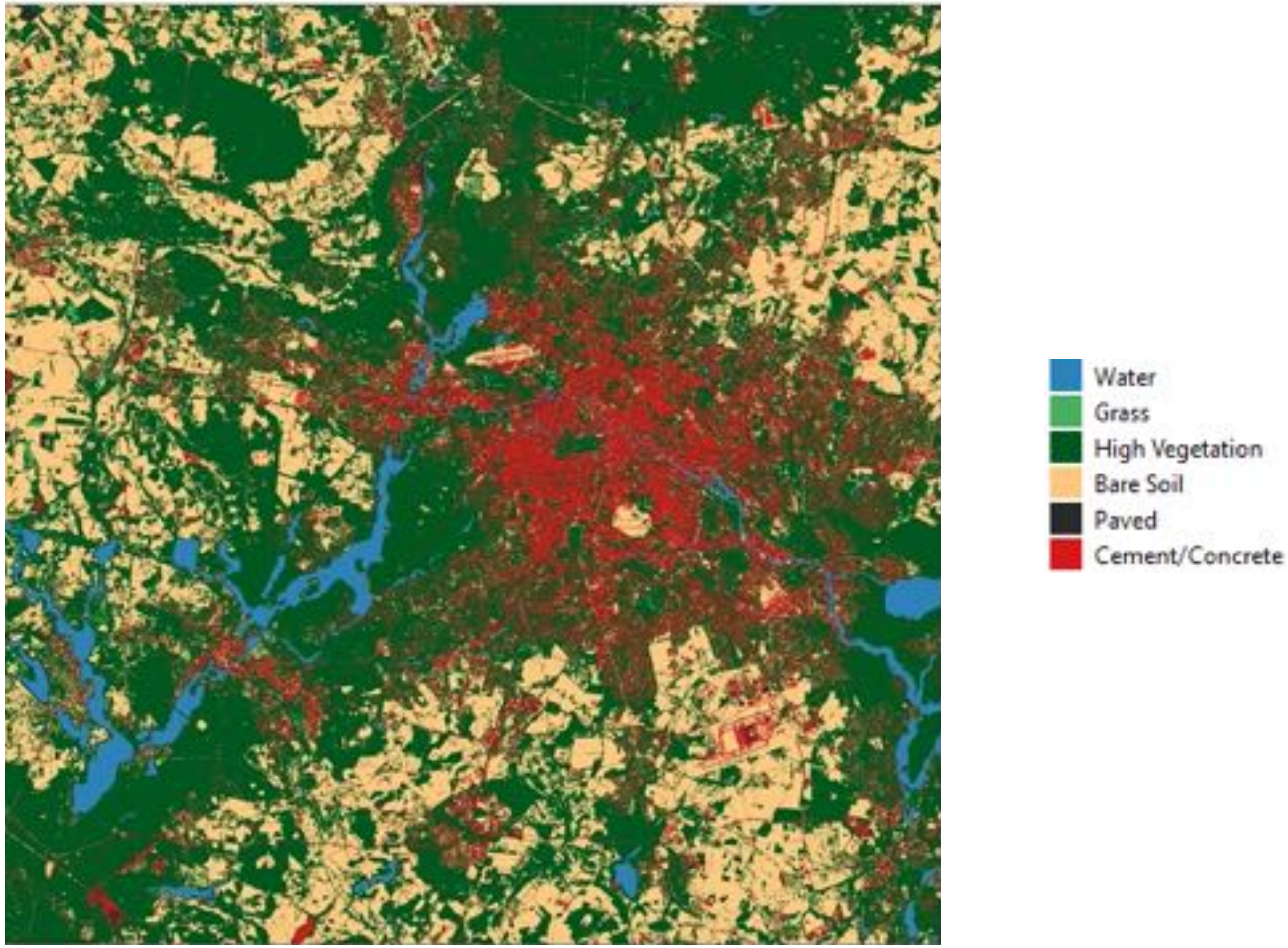
Heraklion Results (using X-SVM[5] model)



A/A	Water	Low Veget	High Veget	Soil	Asphalt	Concrete	White Metal	Grey Metal	User Acc %
Water	50	0	0	0	1	0	0	0	98.0%
Low Veget	0	43	2	0	0	0	0	0	95.6%
High Veget	0	5	48	3	0	2	0	0	82.8%
Soil	0	1	0	45	5	4	1	14	64.3%
Asphalt	0	0	0	1	38	4	1	1	84.4%
Concrete	0	0	0	1	6	39	0	2	81.3%
White Metal	0	0	0	0	0	0	48	0	100.0%
Grey Metal	0	1	0	0	0	1	0	33	94.3%
Prod Acc	100.0%	86.0%	96.0%	90.0%	76.0%	78.0%	96.0%	66.0%	86.0%

[5] G. Lantzanakis, Z. Mitraka and N. Chrysoulakis, "X-SVM: An Extension of C-SVM Algorithm for Classification of High-Resolution Satellite Imagery," in IEEE Transactions on Geoscience and Remote Sensing, vol. 59, no. 5, pp. 3805-3815, May 2021, doi: 10.1109/TGRS.2020.3017937.

Berlin Results (in progress…)



Outline

- We are developing an Urban Hyperspectral Library (currently in Berlin & Heraklion) with as much possible different material are included in Urban Environment.

- To date, the Hyperspectral Library includes 334 Different Spectral Signatures from the area of Heraklion and 225 from the area of Berlin.

- The library can be used to classify accurately Sentinel-2 images

- We plan to expand the Hyperspectral Library to other European cities focusing on roofing materials is lacking

- We plan to repeat the experiment with other Satellites, e.g. Planet and Worldview

JURSE 2023
Heraklion - Crete

17 - 19 May 2023

http://jurse2023.org/

Contact info

Giannis Lantzanakis

lantzanakis@iacm.forth.gr

tel. +30 2810 391773

FORTH/IACM

http://rslab.gr

This project has received funding from the European Research Council (ERC) under the European Union's Horizon 2020 research and innovation programme (grant agreement No 855005)