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The Faculty of Exact Sciences

“Soil Surface Reflectance as a Tool to Estimate Water Infiltration Rate from UAV Platforms "

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THE REMOTE SENSING LABORATORY
TEL AVIV UNIVERSITY

The iAqueduct Project

iAqueduct aim to close the gaps between global satellite observation of water cycle and local needs of information for sustainable management of water resources.

- **Tel Aviv University**
- University of Twente
- University of Basilicata
- University of Naples Federico II
- Swedish University of Agricultural Sciences
- Centre for Agricultural Research of the Hungarian Academy of Sciences
- Universitat Politecnica de Valencia

The Problem

- Soil parameters are required for several environmental and socio-economic indicators.

- However, soil information is missing at appropriate scale, and the quality of the data is questionable (Aksoy et al., 2016).

- Traditional soil survey methodologies are complicated, expensive, and time-consuming.

- Often, these methods need significant amounts of sample preparation, can use harmful reagents and usually requires complex apparatus that are inadequate when many measurements are needed (Viscarra Rossel et al., 2016).

Remote Sensing

- Soil reflectance measurements can be acquired in the laboratory or in the field, as well as from both the air and orbit.

However, in the lab, the conditions are better because:

- Controlled conditions of geometry and illumination
- No atmospheric interference
- Standard protocols

In field we have to deal with:

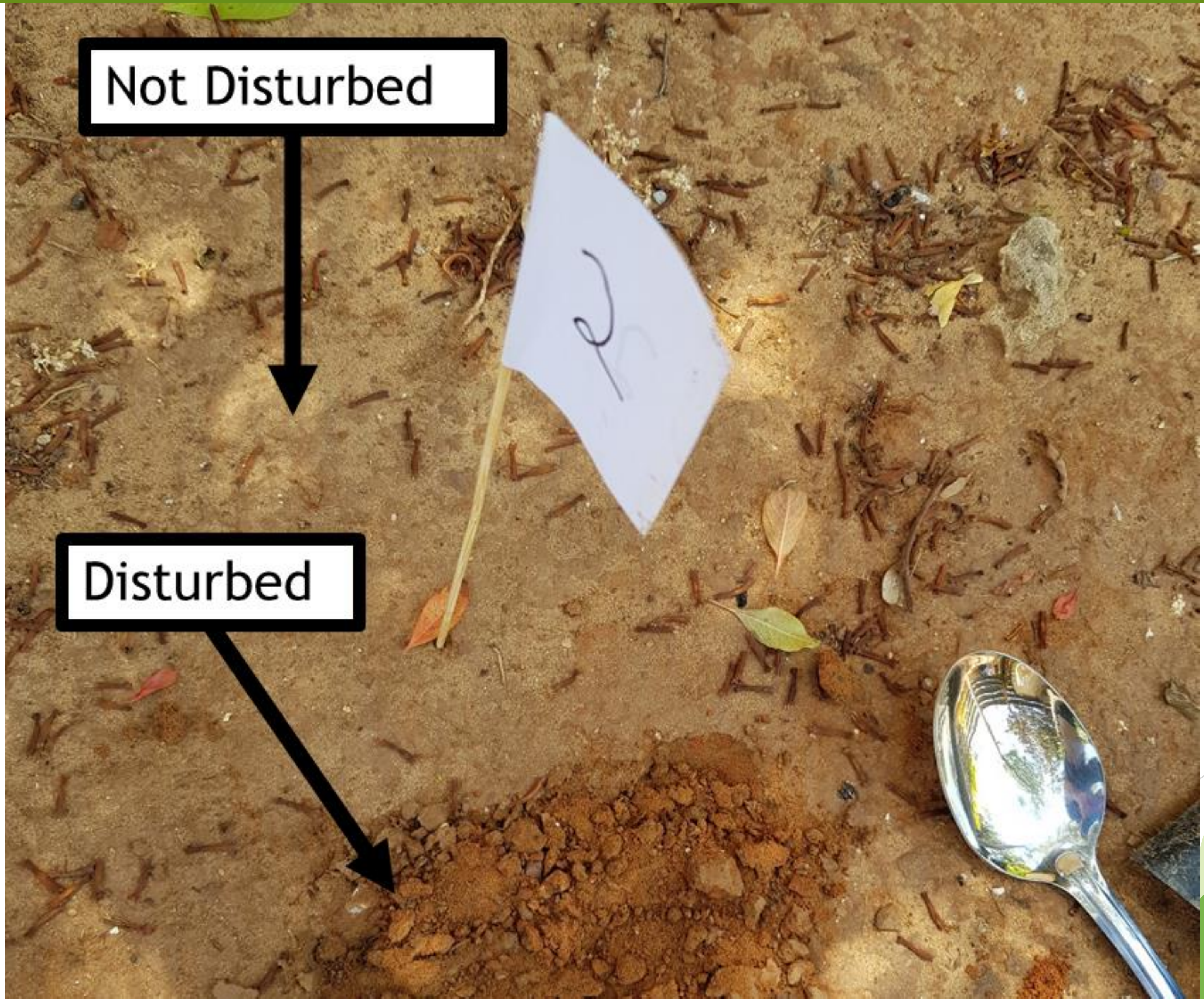
- Variations in viewing angle
- Changes in illumination
- Soil roughness
- Soil sealing-crusting

Lab-RS Problems

- Soil Spectral Libraries (SSLs) are created under laboratory conditions, so is unclear if they can be used to infer field conditions.

- This study postulates that lab-based SSLs that are composed of disturbed soil samples don't represent the real spectral signatures in field.

- Thus, there is a gap for satellite and airborne RS application when the spectral-based models are generated using laboratory measurements.


Not Disturbed
Disturbed

Why Water Infiltration Rate (WIR)?

- This study evaluates this gap assessing one soil property that is strongly affected by the soil surface. The water infiltration rate (WIR).

- According to Agassi et al., 1985 “Physical crust is generated when soil is exposed to rain drops with high energy”. Then, Agassi et al., 1994, found that this effect is also cumulative.

- WIR depends on its texture/porosity, CaCO3 and OM content, and these properties has spectral features in the VIS-NIR-SWIR spectral range

Hypothesis

"Lab-based-SSLs must be optimized to fit field conditions for a better quantitative assessment of soil properties from RS means"

For this end, we focused on the effect of soil surface-dependent properties (e.g., WIR) using lab-based SSLs for RS utilization.

Data Acquisition

- The infiltration rate of 114 samples from different areas of the Mediterranean Basin were measured using a Mini Disk infiltrometer.
- Next, we measured the spectral signature in field and in the lab.
- The field spectra was measured using a ASD (Analytical Spectral Device) connected to SoilPro (Ben Dor and Granot et al., 2017) in order to get an optima spectral signatures in field.

The Minidisk Infiltrometer.

Field Spectral Measurements using ASD connected to SoilPRO.

Data Acquisition

- This repertory contain samples of 6 different fields:

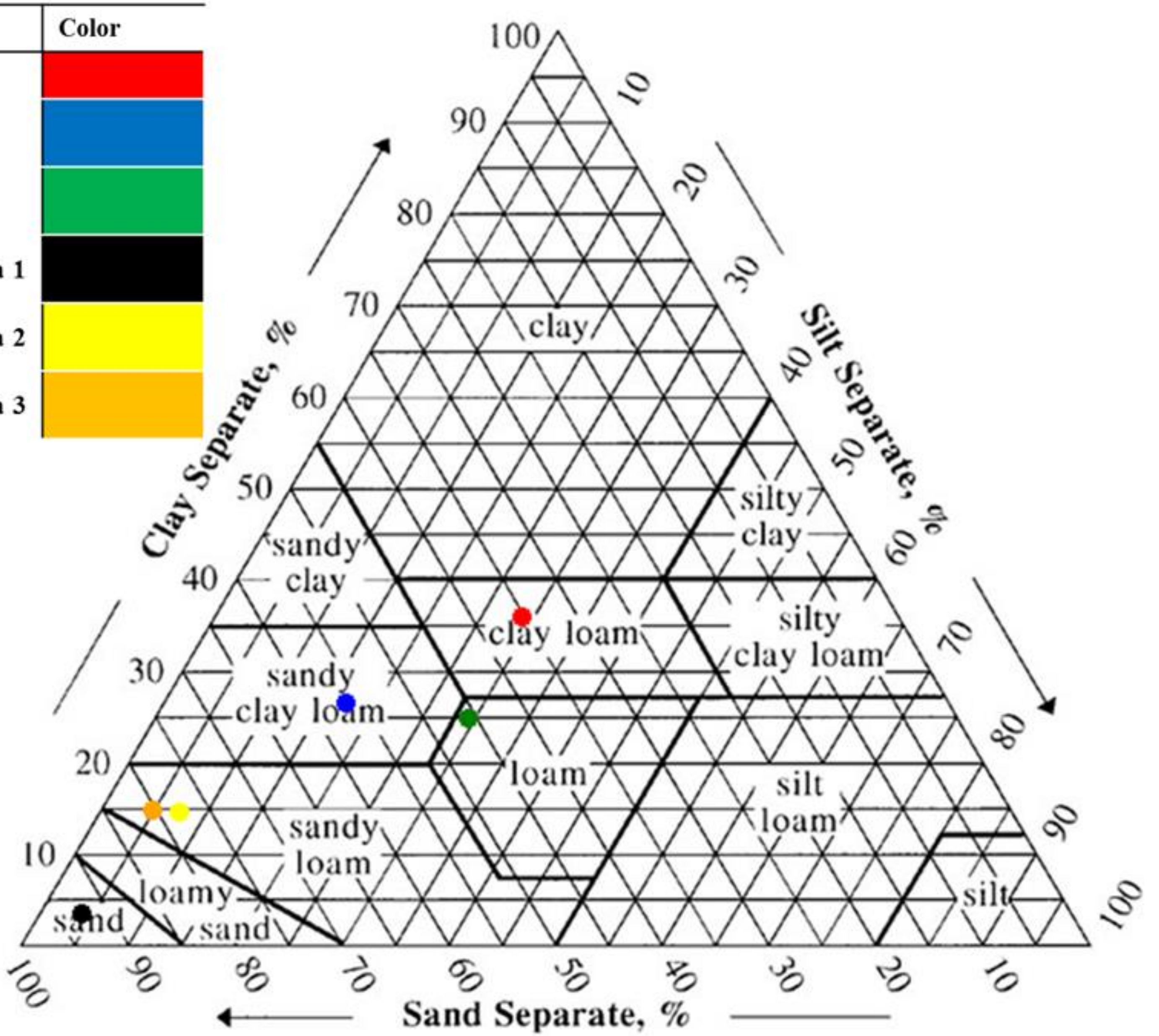
i) Kibbutz Sde Yoav, Israel (30 Samples)
ii) Afeka, Tel Aviv, Israel (18 Samples)
iii) Alento, Italy (21 Samples)
iv) Aminteo, Greece (45 Samples of 3 different fields)

- The dataset contains samples that can be divided into two groups: 1) clayey soils and 2) sandy soils.

Field	Color
Sde Yoav	
Afeka	
Alento	
C. Macedonia 1	
C. Macedonia 2	
C. Macedonia 3	

The texture prediction is necessary to estimate WIR, and was performed using spectral-based-models using the:

- Israeli SSL (Ogen et al., 2019) for the samples of Sde Yoav and Afeka
- GEOCRADLE (Mediterranean) SSL (Tsakiridis et al., 2018) for the samples of Italy and Greece.



The study site of Afeka, Tel Aviv

Campaign of Greece, September, 2019

The study sites in Central Macedonia, Greece: a) the 1st study site, b) the 2nd study site, and c) the 3rd study site.

The study site of Sde Yoav

The study site of Alento, Italy

Experiment Design

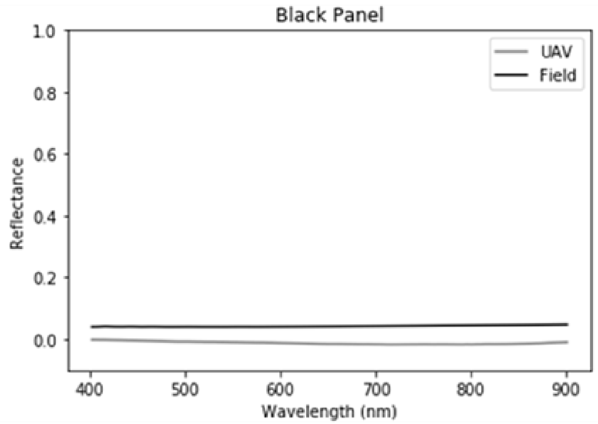
- The lab and the field based datasets, were resampled according to the spectral configuration of Cubert UHD 185.
- PLSR models were generated to predict WIR using different groups.
- For this end, we used the scikit-learn package of Python.
- We applied the best model to an UAV hyperspectral cube.
- The predicted values of the pixels that were mapped as bare soil, were randomly subset to 100 points and were interpolated using IDW.
- The measured values were also interpolated to compare.

The UAV Platform

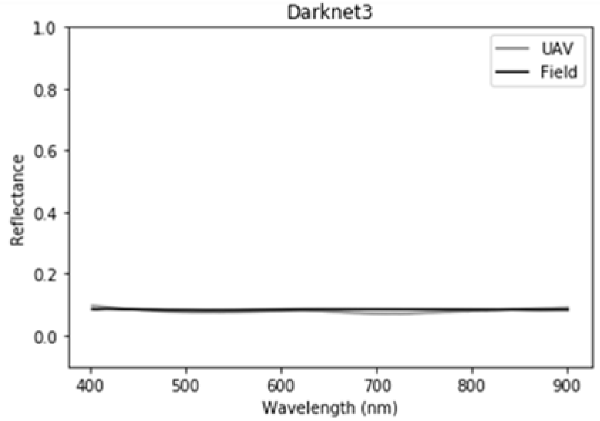
- For the UAV campaign we used a Cubert UHD-185® which is a HRS snapshot sensor onboard a CarbonCore Cortex X8 UAV.
- Cubert UHD-185 measures along the 450-950 nm spectral range with 125 channels.
- The images were acquired in a sunny day (13/06/2019) between 9:57 and 10:30 in an agricultural field of Alento, Italy.
- The images were acquired from 138 meters, with a pixel size of 5 cm/pix approx.
- For the mosaic, we used 468 images in which we applied an 80% of forward overlap and a 65% of side-lap.
- For the geometric correction, we used an HiPer V (Topcon) GNSS receiver where the GCPs showed a RMSE of 2.005 cm which is very low.

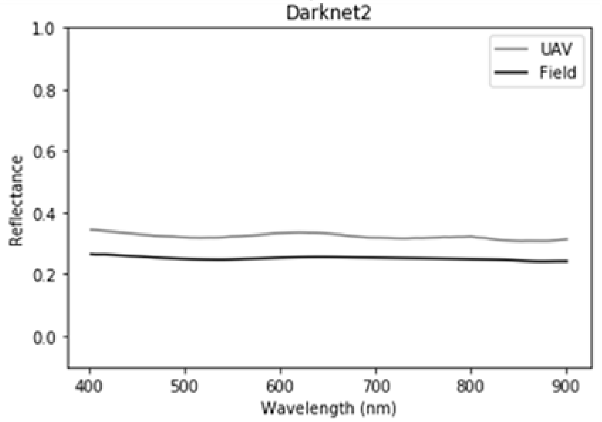
Radiometric Calibration and Validation

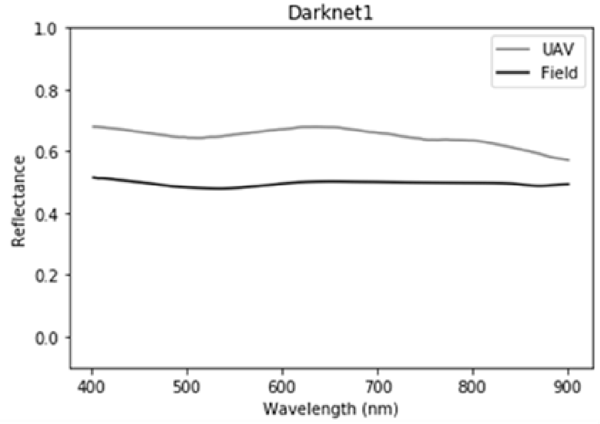
- The DN values were calibrated to a halon WR before the flight.
- In order to validate the performance of this correction, the average sum of deviation squared (ASDS) index was calculated for 5 different targets with increasing albedo.

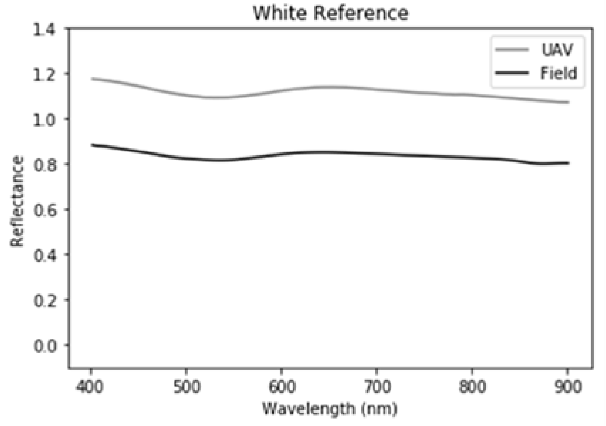


Sample	ASDS
BlackPanel	0.003
DarkNet3	0.000
DarkNet2	0.003
DarkNet1	0.011
WhitePanel	0.024



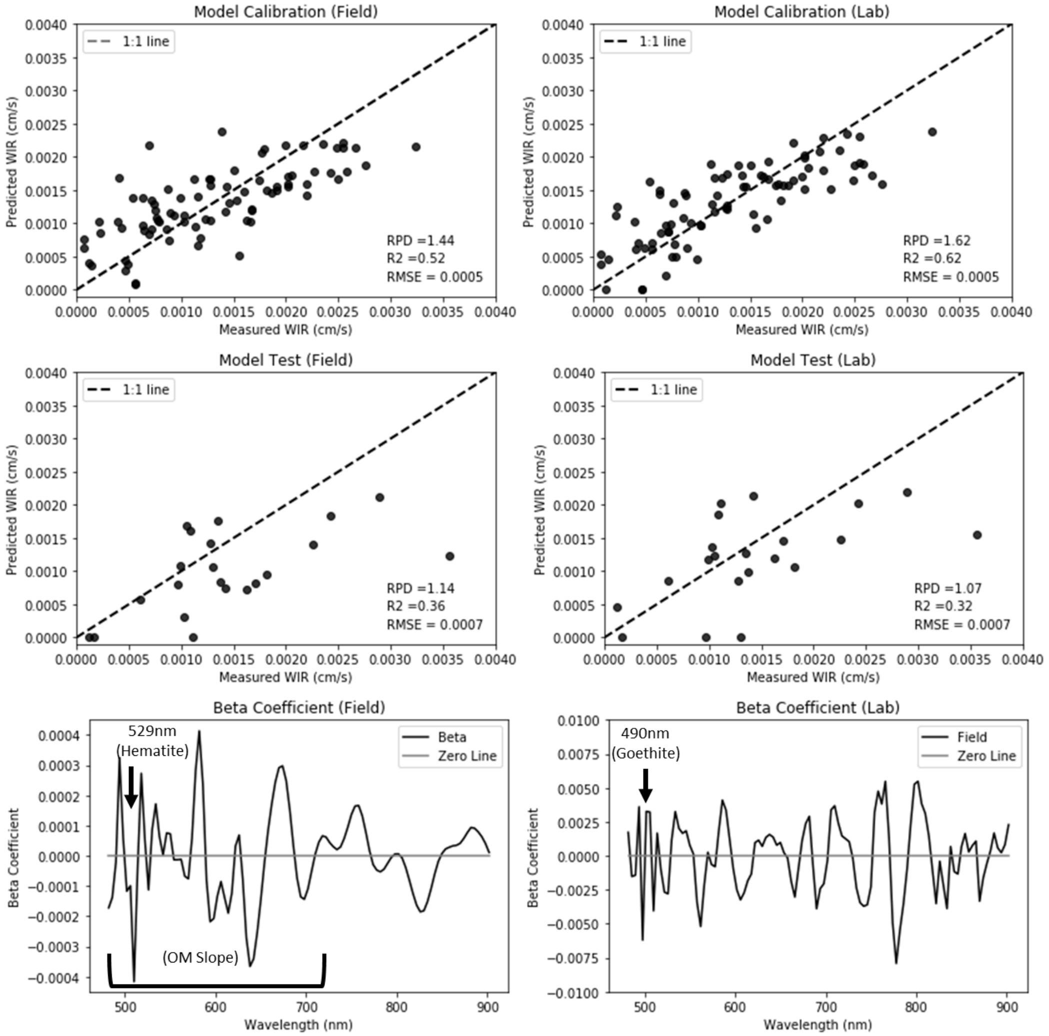




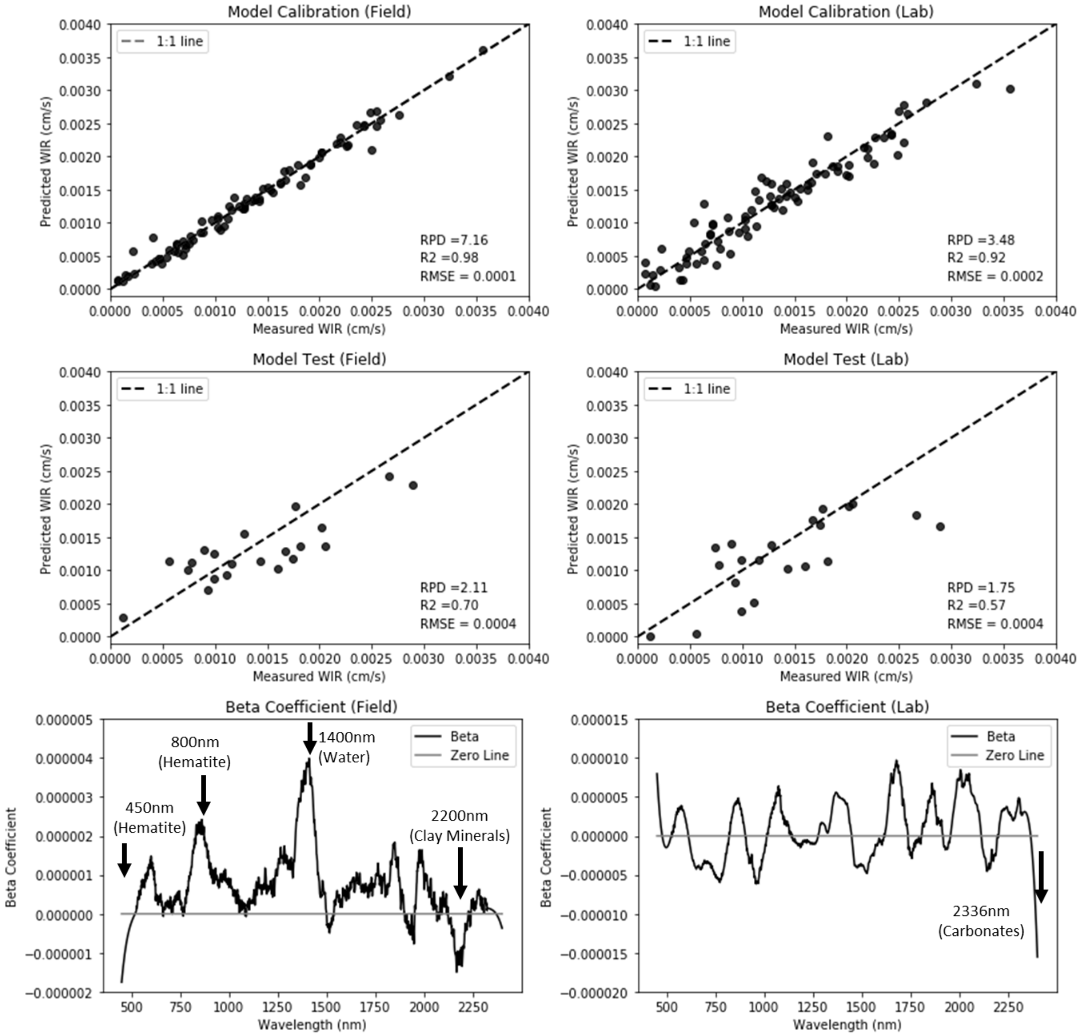


The Generic Approach

CUBERT UHD-185 SPECTRAL RESOLUTION (VIS-NIR)

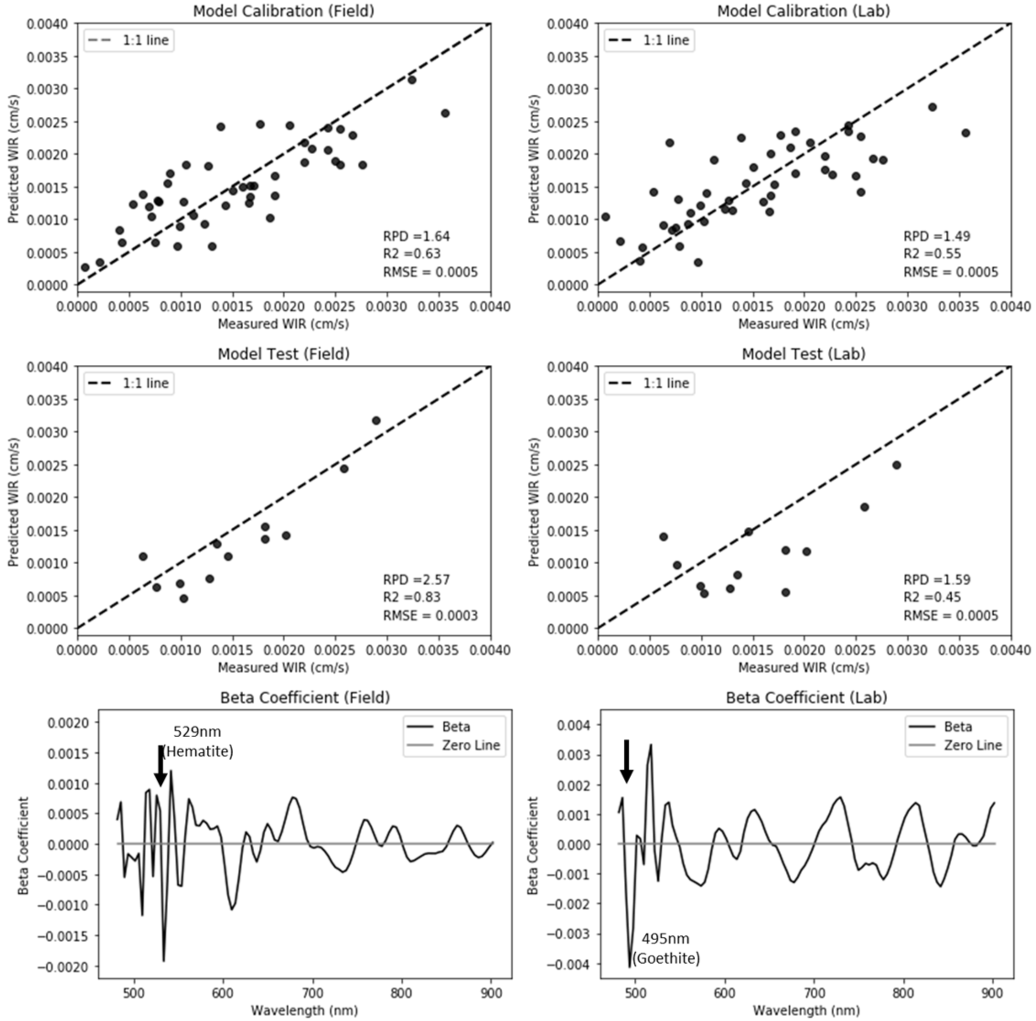


ASD SPECTRAL RESOLUTION (VIS-NIR-SWIR)

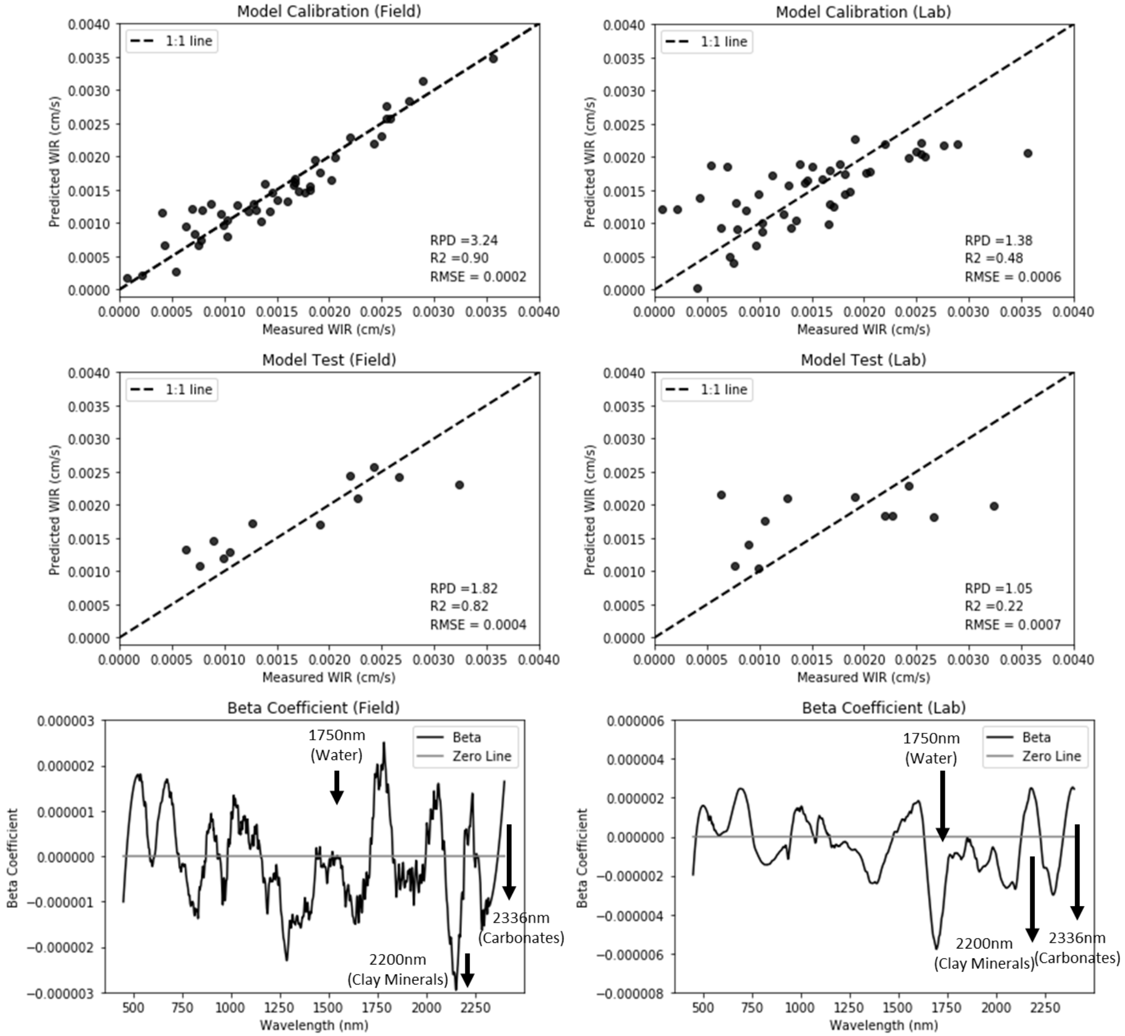


The Sandy Group

CUBERT UHD-185 SPECTRAL RESOLUTION (VIS-NIR)

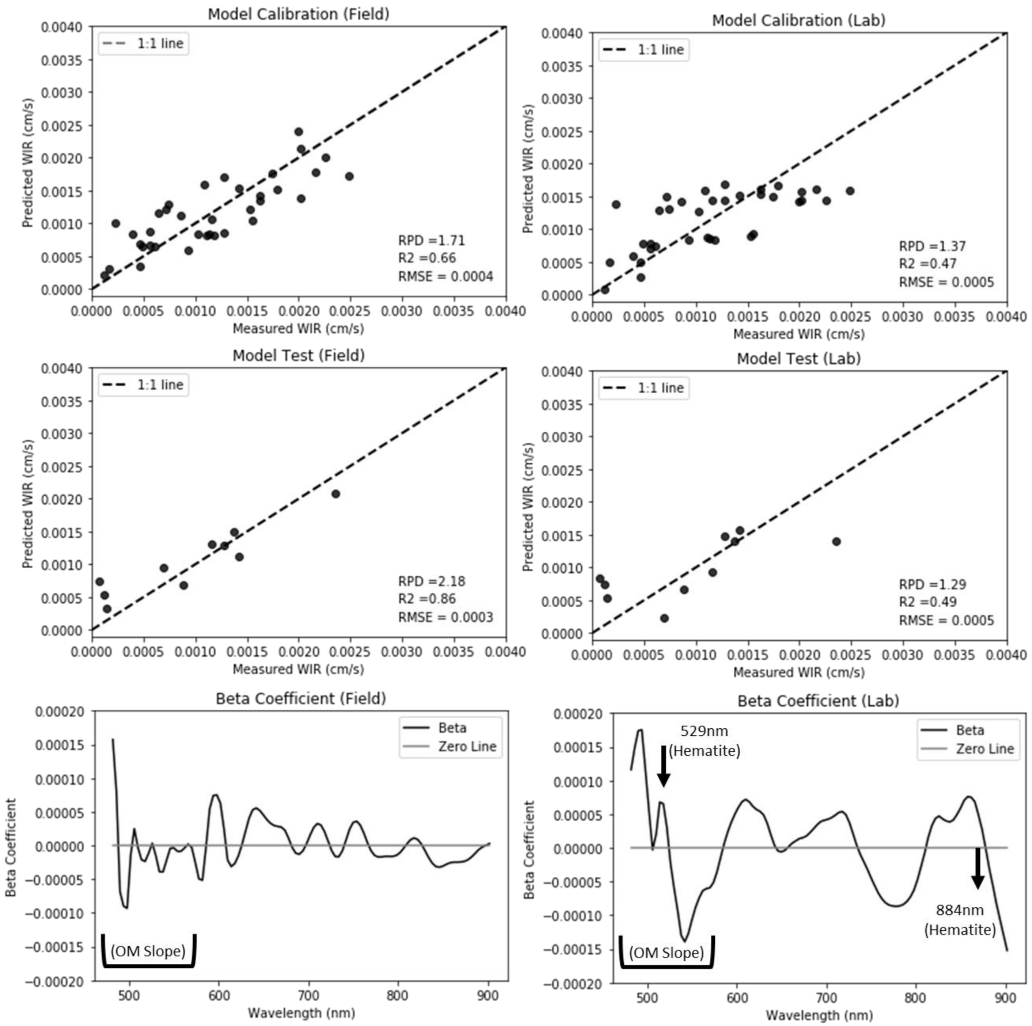


ASD SPECTRAL RESOLUTION (VIS-NIR-SWIR)

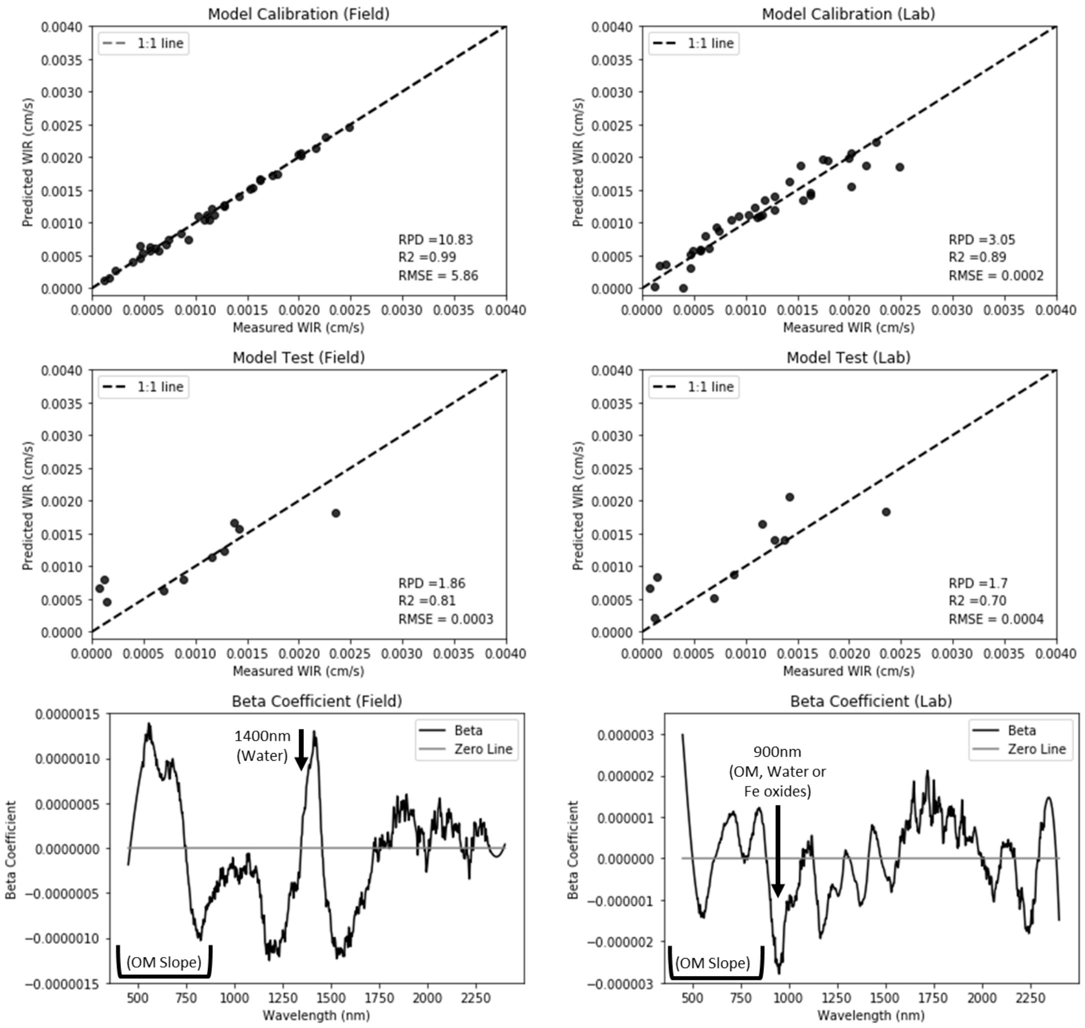


The Clayey Group

CUBERT UHD-185 SPECTRAL RESOLUTION (VIS-NIR)



ASD SPECTRAL RESOLUTION (VIS-NIR-SWIR)



Study Site

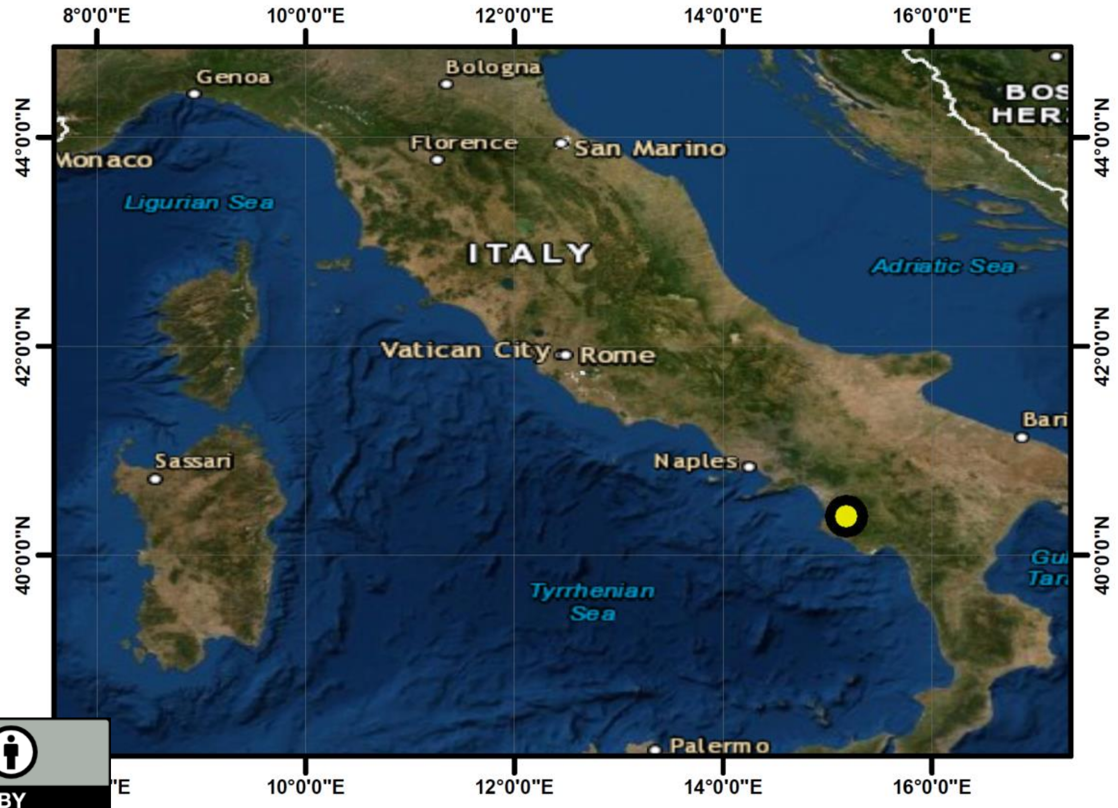
In red, the masked pixels

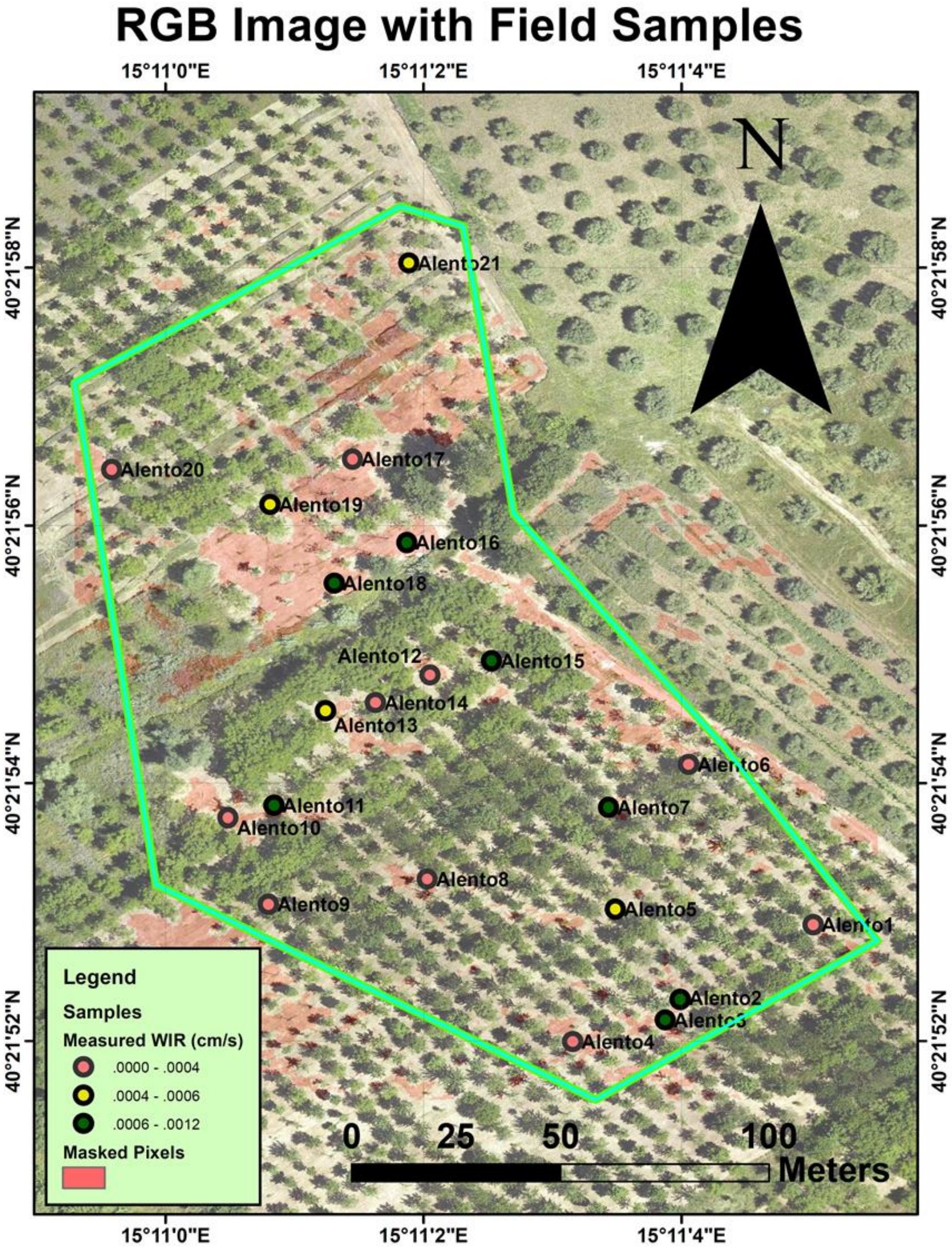
Legend

Field Samples

Infiltration Rate (cm/sec)

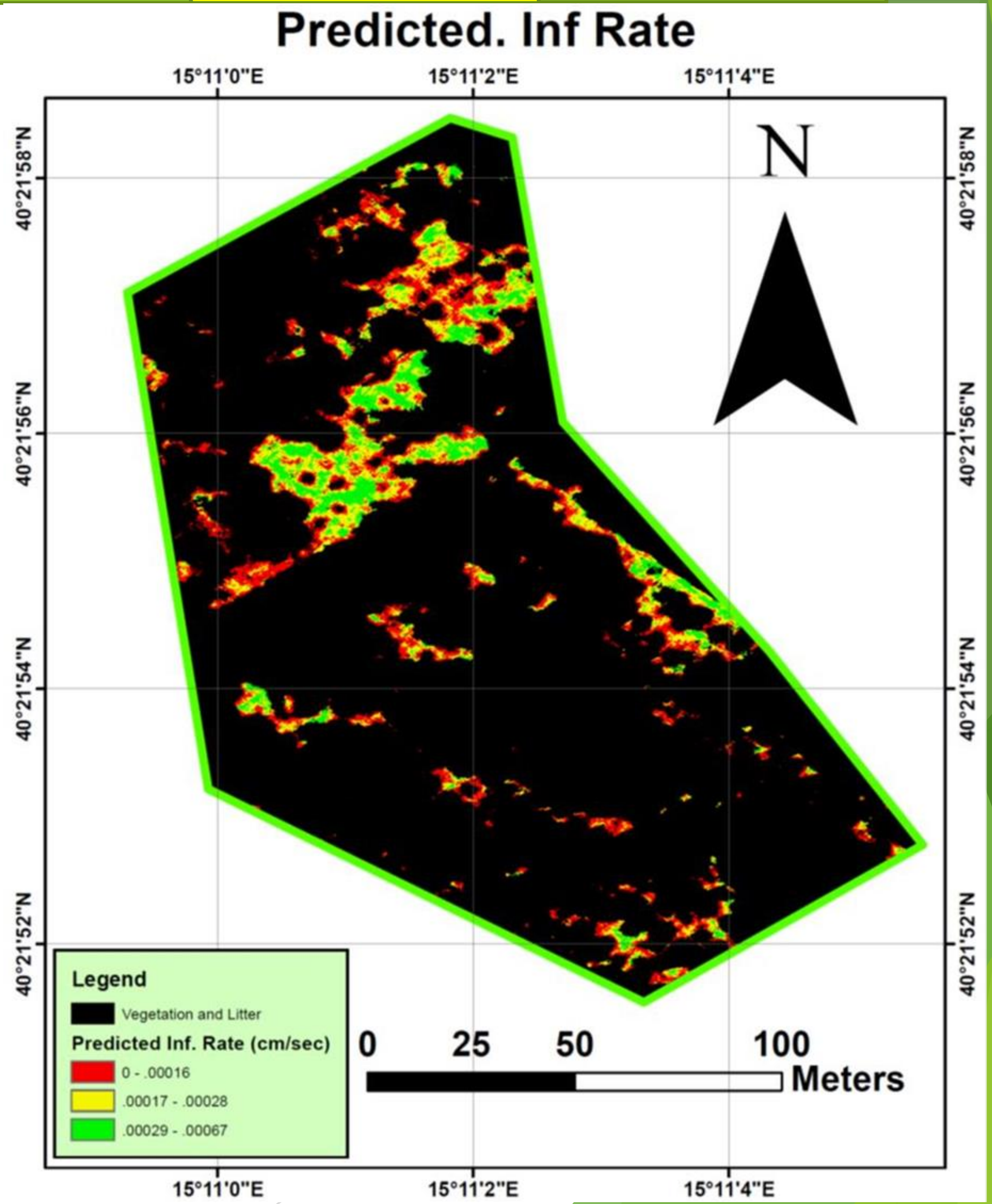
- .0000 - .0004
- .0004 - .0006
- .0006 - .0012



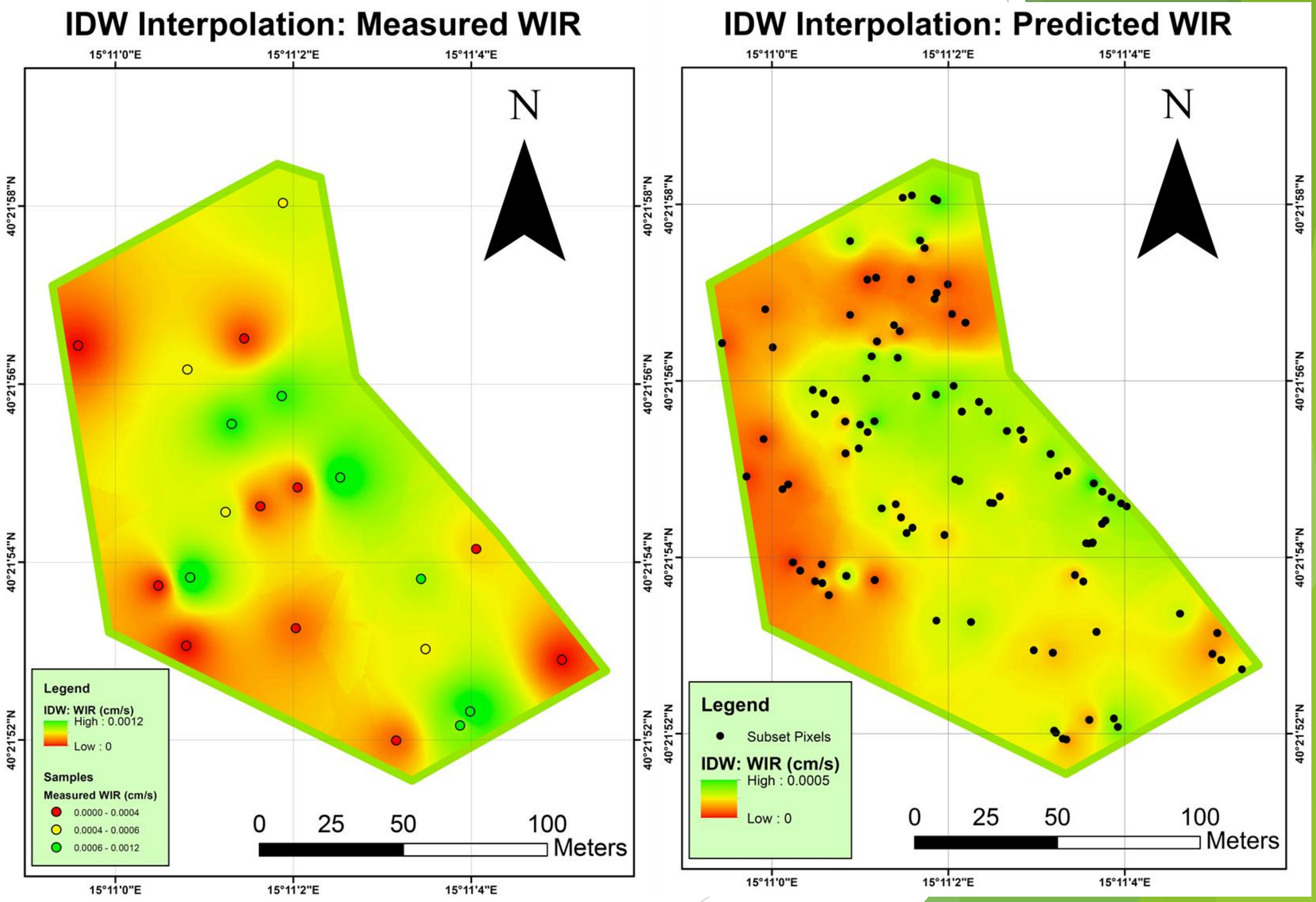


WIR Map

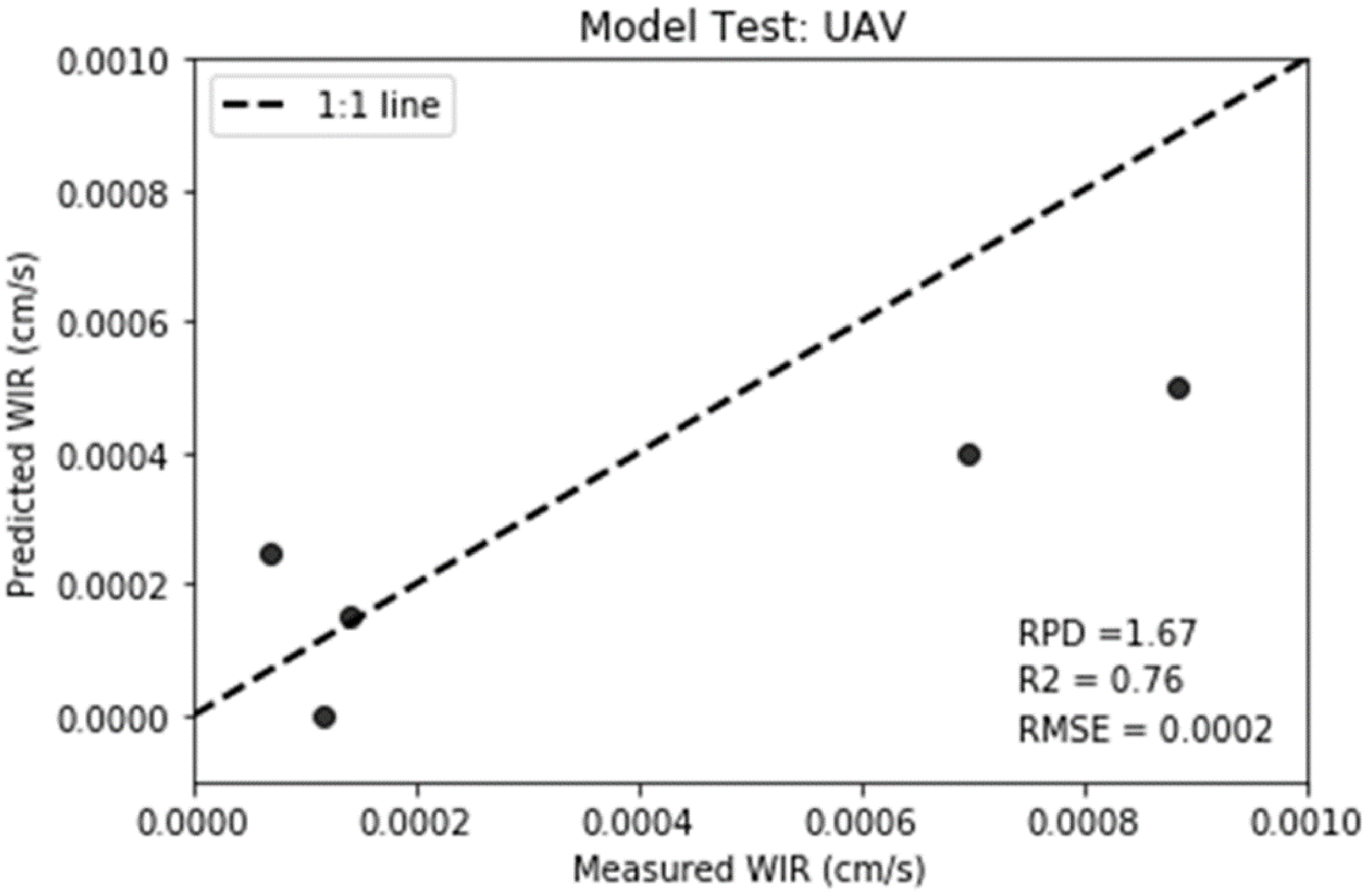
- The field based model of the clayey dataset presented the best results and was selected to be applied in the UAV image



Validation


IDW Interpolation: Measured WIR
15°11'0"E
15°11'2"E
15°11'4"E
40°21'58"N
40°21'56"N
40°21'54"N
40°21'52"N
N
Legend
IDW: WIR (cm/s)
High : 0.0012
Low : 0
Samples
Measured WIR (cm/s)
0.0000 - 0.0004
0.0004 - 0.0006
0.0006 - 0.0012
0 25 50 100
Meters
IDW Interpolation: Predicted WIR
Legend
Subset Pixels
IDW: WIR (cm/s)
High : 0.0005
Low : 0

Validation


Model Test: UAV
1:1 line
Predicted WIR (cm/s)
0.0010
0.0008
0.0006
0.0004
0.0002
0.0000
Measured WIR (cm/s)
0.0000
0.0002
0.0004
0.0006
0.0008
0.0010
RPD =1.67
R2 = 0.76
RMSE = 0.0002

Conclusions

- This study showed that soil surface reflectance is a good tool to predict soil WIR.
- The beta coefficients revealed that quantitative spectral properties of Fe oxides and OM may be lost once the soil samples are collected to the laboratory.
- The field-based models showed better results than the lab-based models in all the cases.
- Soil surface reflectance showed a very good generic model including all the samples when the SWIR range was considered.
- A field based model was adapted to a UAV sensor. Then, the results were successfully validated in field.


ANY
QUESTIONS
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