Advancments in Remote Sensing Applciations in Precision Agriculture

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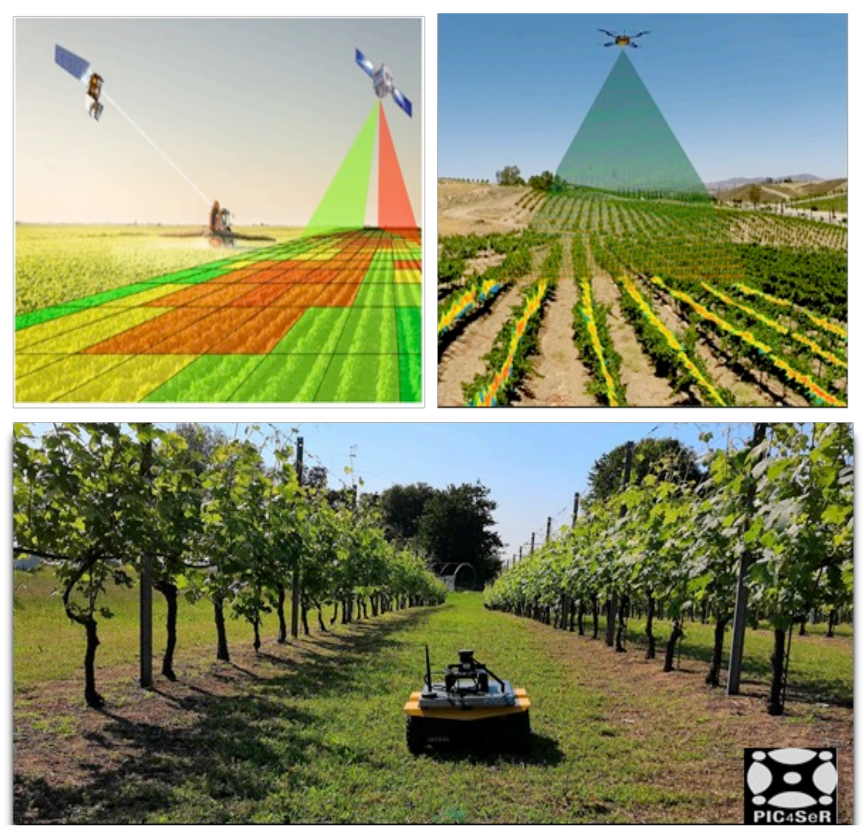
XXXII Cycle

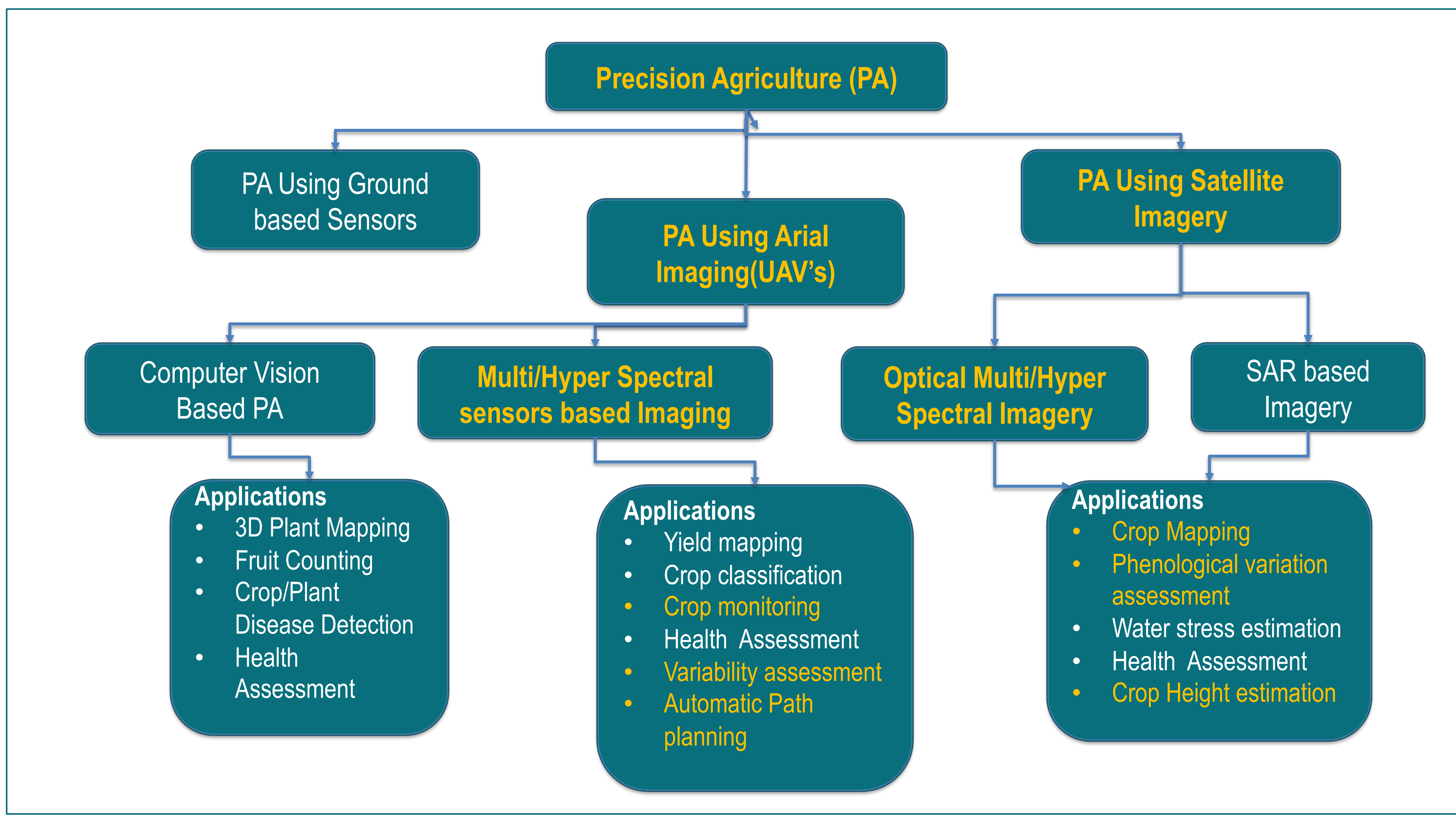
Research context and motivation

Precision Agriculture and Remote Sensing Platforms



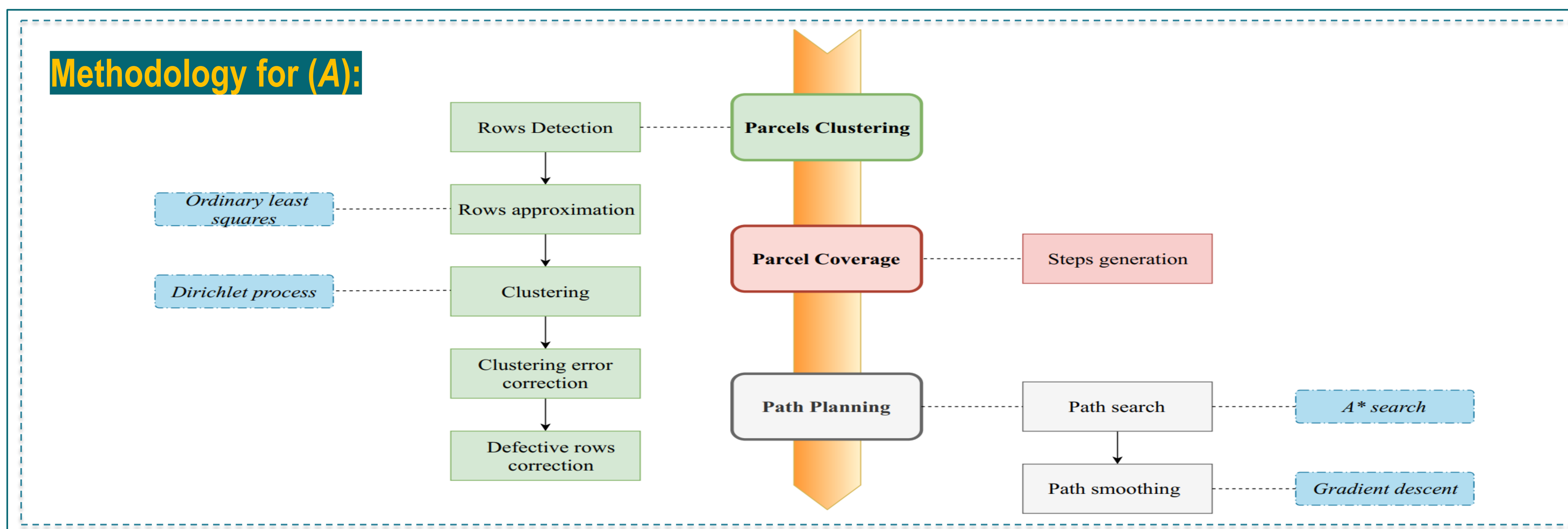
Precision agriculture (PA)–defined as a set of technologies that combines acquisition, analysis, management, and delivery of information to help in making site-specific decisions, with the ultimate goal of optimizing production while reducing the environmental noise caused by over usage of fertilizers and chemicals. At the heart of the evolving tools, technologies, and information management strategies found in precision agriculture is remote sensing. In this work, various remote sensing platforms (UAV, UGV, Satellite Images) have been used to address several of applications such as " Automatic Path Planning for Unmanned Ground Vehicle Using UAV Imagery", "Refining satellite imagery using UAV images", "Relationship between maize height and spectral indices derived from multispectral imagery", "Comparison of Satellite and UAV-Based driven Multispectral Imagery for site Vineyard Variability Assessment", and "Understanding effects of major atmospheric variables on spectral vegetation indices derived from satellite based time series of multispectral images".

Addressed research questions/problems



Adopted methodologies

Methodology for (*A*):



Methodology for (*D*):

$$NDVI_{\mathrm{sat}}(i,j) = \frac{n_N(i,j) - n_R(i,j)}{n_N(i,j) + n_R(i,j)}$$

$$NDVI_{\mathrm{uav}}(i,j) = \frac{\sum_u \sum_v \frac{m_N(u,v) - m_R(u,v)}{m_N(u,v) + m_R(u,v)}}{\mathrm{card}\,\mathcal{G}(i,j)} \forall d(u,v) \in \mathcal{G}(i,j)$$

$$NDVI_{\mathrm{vin}}(i,j) = \frac{\sum_u \sum_v \frac{m_N(u,v) - m_R(u,v)}{m_N(u,v) + m_R(u,v)}}{\mathrm{card}\,\mathcal{G}(i,j)} \forall d(u,v) \in \mathcal{G}_{\mathrm{vin}}(i,j)$$

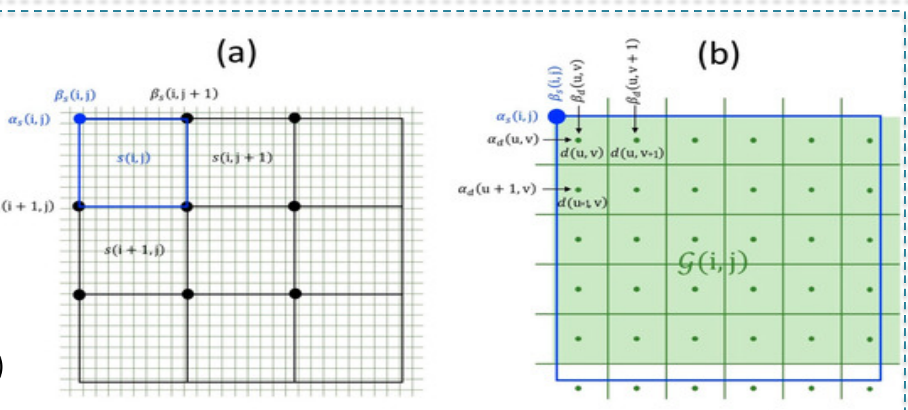
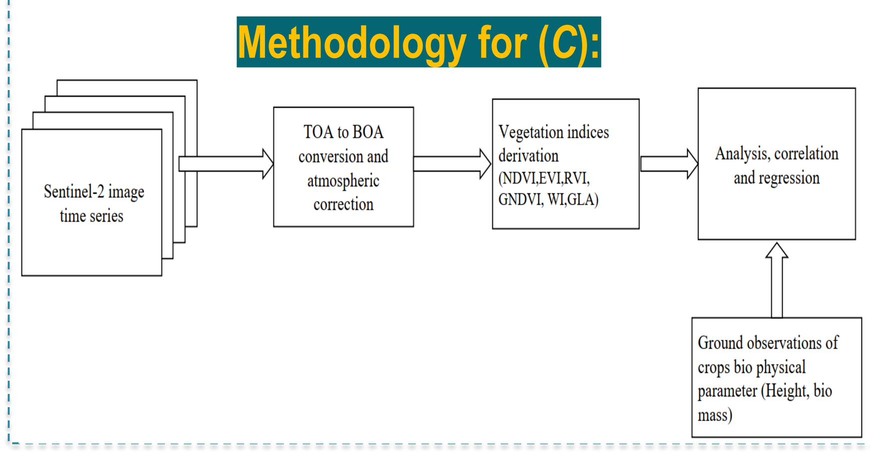
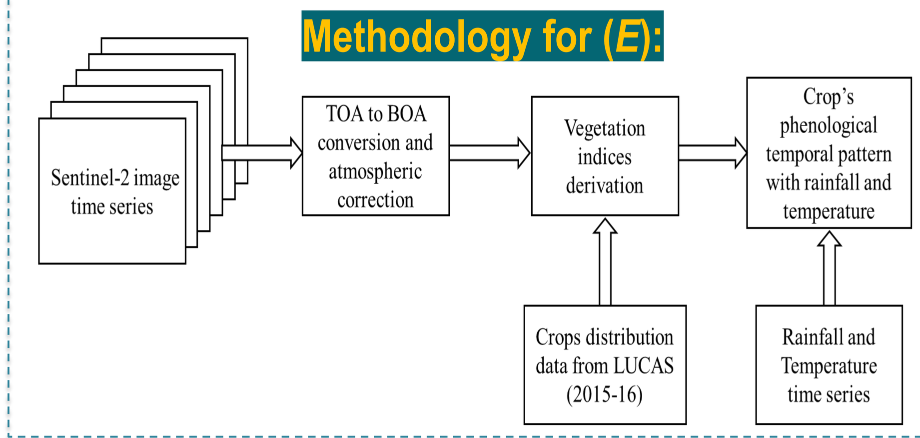


Figure . (a) Ordered grid of pixels *s*(i, j) belonging to satellite tile *S*, located at latitude and longitude coordinates α_s(i, j) and β_s(i, j); and (b) ordered grid of pixels *d*(u, v) belonging to satellite imagery *D*, located at α_d(i, j) and β_d(i, j). Selected UAV pixels belonging to *G*(i, j), used for comparison to satellitepixel *s*(i, j), are highlighted in light green.

Methodology for (*C*):

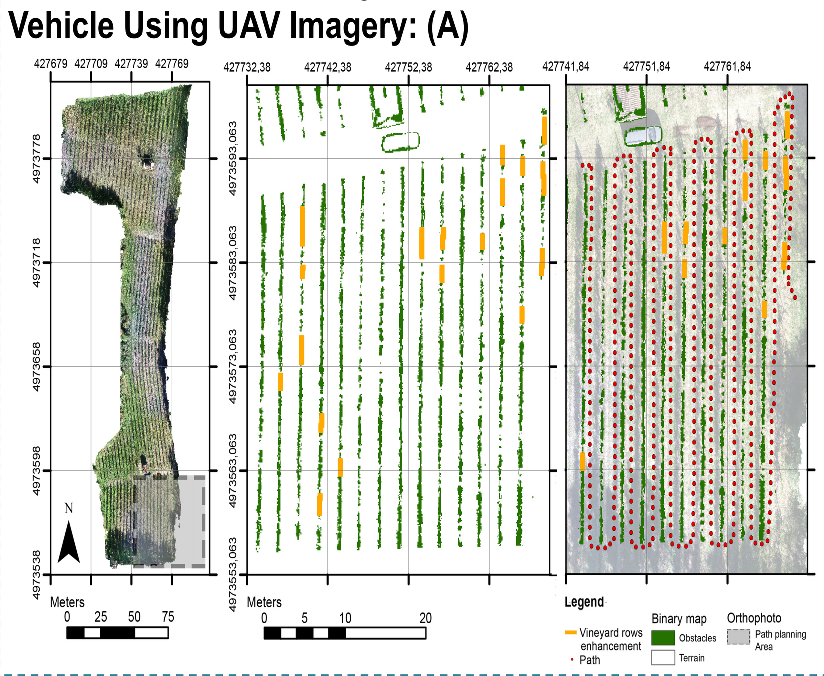


Methodology for (*E*):

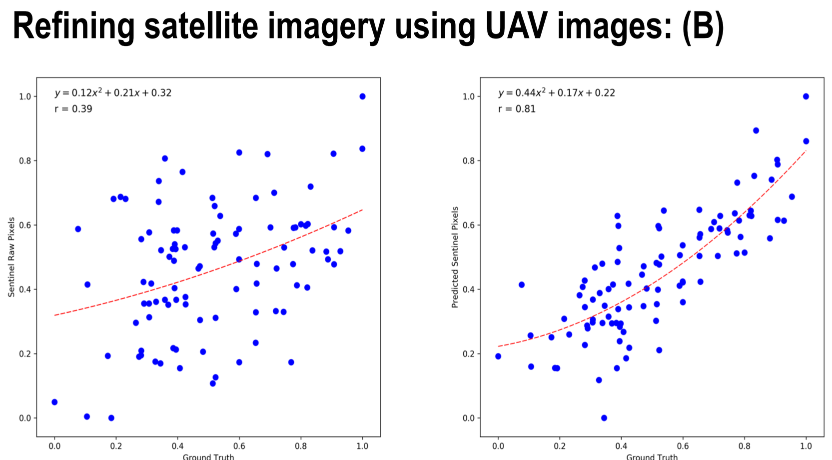


Novel Contributions

Automatic Path Planning for Unmanned Ground Vehicle Using UAV Imagery: (A)



Refining satellite imagery using UAV images: (B)



Analyzing relationship between maize height and spectral indices derived from sentinel-2 multispectral imagery: (C)

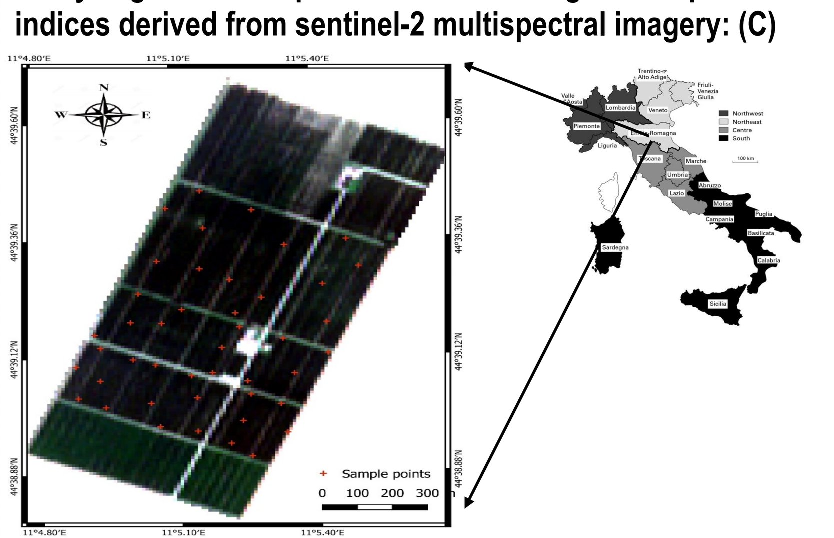
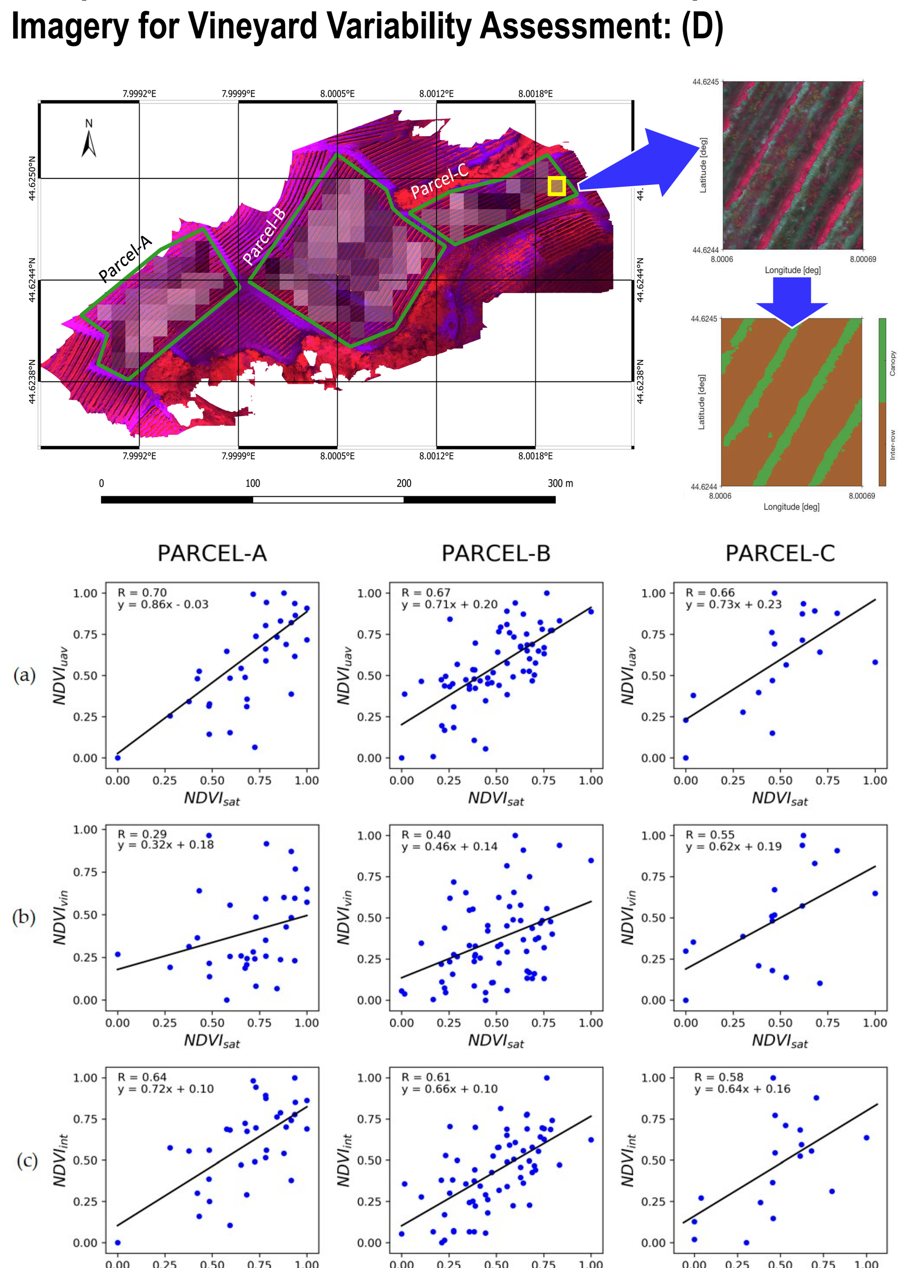


Table. Pearson correlation between vegetation indices (NDVI, GNDVI, ENVI, WI, and GLA) derived from multitemporal satellite imagery and height (Hcanopy) and biomass (AGB) field measurement's

Pearson Correlation	T1	T2	T3	T4
$R_{NDVI-Hcanopy}$	0.55	0.58	0.63	0.57
$R_{NDVI-AGB}$	0.58	0.59	0.59	0.51
$R_{GNDVI-Hcanopy}$	0.34	0.42	0.66	0.43
$R_{GNDVI-AGB}$	0.57	0.63	0.52	0.63
$R_{RVI-Hcanopy}$	0.61	0.64	0.74	0.65
$R_{RVI-AGB}$	0.59	0.55	0.51	0.58
$R_{ENVI-Hcanopy}$	0.53	0.61	0.74	0.66
$R_{ENVI-AGB}$	0.57	0.62	0.61	0.55
$R_{WI-Hcanopy}$	0.36	0.41	0.51	0.38
R_{WI-AGB}	0.47	0.59	0.48	0.51
$R_{GLA-Hcanopy}$	0.36	0.36	0.63	0.36
$R_{GLA-AGB}$	0.47	0.47	0.47	0.47

Comparison of Satellite and UAV-Based Multispectral Imagery for Vineyard Variability Assessment: (D)



Understanding effects of atmospheric variables on spectral vegetation indices derived from satellite based time series of multispectral images: (E)

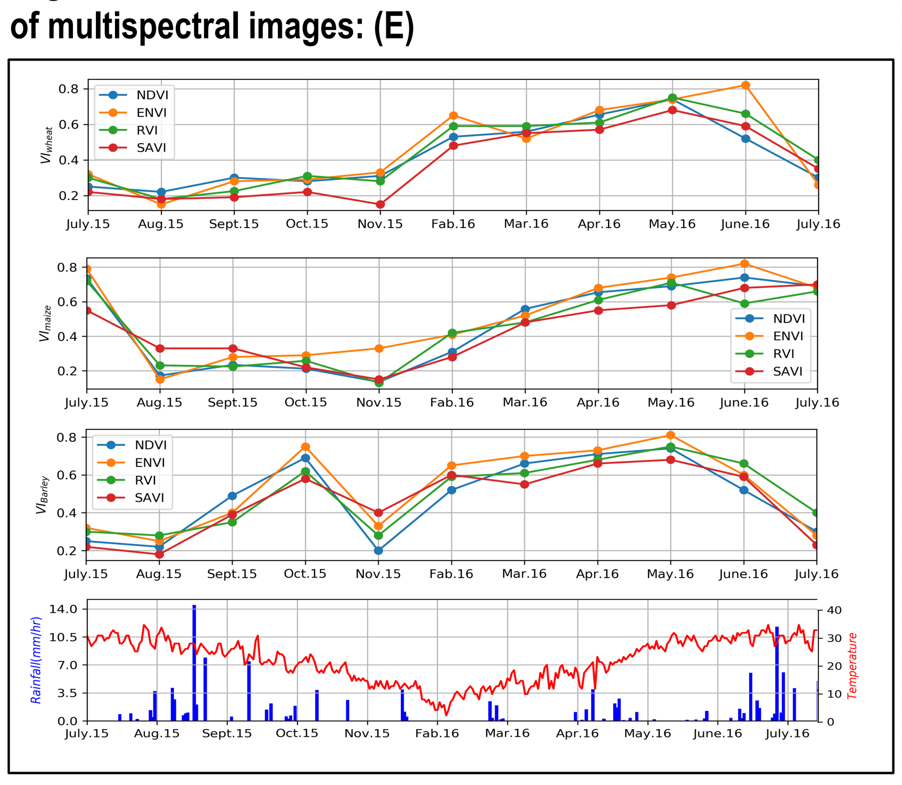


Figure. Observations over the wheat, maize and barley: temporal behavior of vegetation Indices (NDVI, ENVI, RVI and SAVI) derived from sentinel-2 multispectral imagery over the study area depicted in figure.1. Wheat crop field phenological cycles starts from February-16 and ends in July-16. Maize is cultivated in summer and barley is double crop field that cultivated in November-2015 and mid July-2016. Metrological observations are shown in bottom plot, Precipitation and temperature time series are shown in blue bars and red plot respectively.

Future work

- Integration of data acquired from various platforms such as Satellite, Airborne, UAV, UGV for real time vegetaion monitoring.
- Addressing role of remotely sensed data for irrigation monitoring and managment.

Attended course points

- Soft skill courses: 53 points
- Hardskill courses: 262 points
- External training: 1st IEEE GRSS Instrumentation and Future Technologies (IFT) Remote Sensing Summer School (IFT-R3S)

List of Publication

1- **Khaliq, A.;** Comba, L.; Biglia, A.; Ricauda Aimonino, D.; Chiaberge, M.; Gay, P. Comparison of Satellite and UAV-Based Multispectral Imagery for Vineyard Variability Assessment. Remote Sens. **2019**, 11, 436. (**Impact Factor: 4.118**) .

2- V. Mazzia, **A. Khaliq,** M. Chiaberge, "Improvement in land cover and crop classification based on temporal features learning using Recurrent-Convolutional Neural Network (R-CNN)", IEEEAccess, 2019. (**Impact factor: 4.098)** (under minor revision)

3- **A. Khaliq**, M. A. Musci and M. Chiaberge, "Analyzing relationship between maize height and spectral indices derived from remotely sensed multispectral imagery," 2018 IEEE Applied Imagery Pattern Recognition Workshop (AIPR), Washington, DC, USA, **2018**, pp. 1-5.

4- **A. Khaliq**, M. A. Musci and M. Chiaberge, "Understanding effects of atmospheric variables on spectral vegetation indices derived from satellite based time series of multispectral images," 2018 IEEE Applied Imagery Pattern Recognition Workshop (AIPR), Washington, DC, USA, **2018**, pp. 1-4.

5- **A. Khaliq**, V. MAzzia, M. Chiaberge, "Refining satellite imagery by using UAV imagery for vineyard environment: A CNN Based approach", Intl workshop on Metrology for Agriculture and Forestry 2019. Accepted

6- **A. Khaliq**, L. Peroni and M. Chiaberge, "Land cover and crop classification using multitemporal sentinel-2 images based on crops phenological cycle," 2018 IEEE Workshop on Environmental, Energy, and Structural Monitoring Systems (EESMS), Salerno, Italy, 2018, pp. 1-5.

7- Zoto J., Musci M.A., **Khaliq A**., Chiaberge M., Aicardi I. (2020) Automatic Path Planning for Unmanned Ground Vehicle Using UAV Imagery. In: Berns K., Görges D. (eds) Advances in Service and Industrial Robotics. RAAD 2019. Advances in Intelligent Systems and Computing, vol 980. Springer,.

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