POTENTIAL OF SENTINEL-1 AND SENTINEL-2 DATA FOR MAPPING IRRIGATED AREAS AT PLOT SCALE

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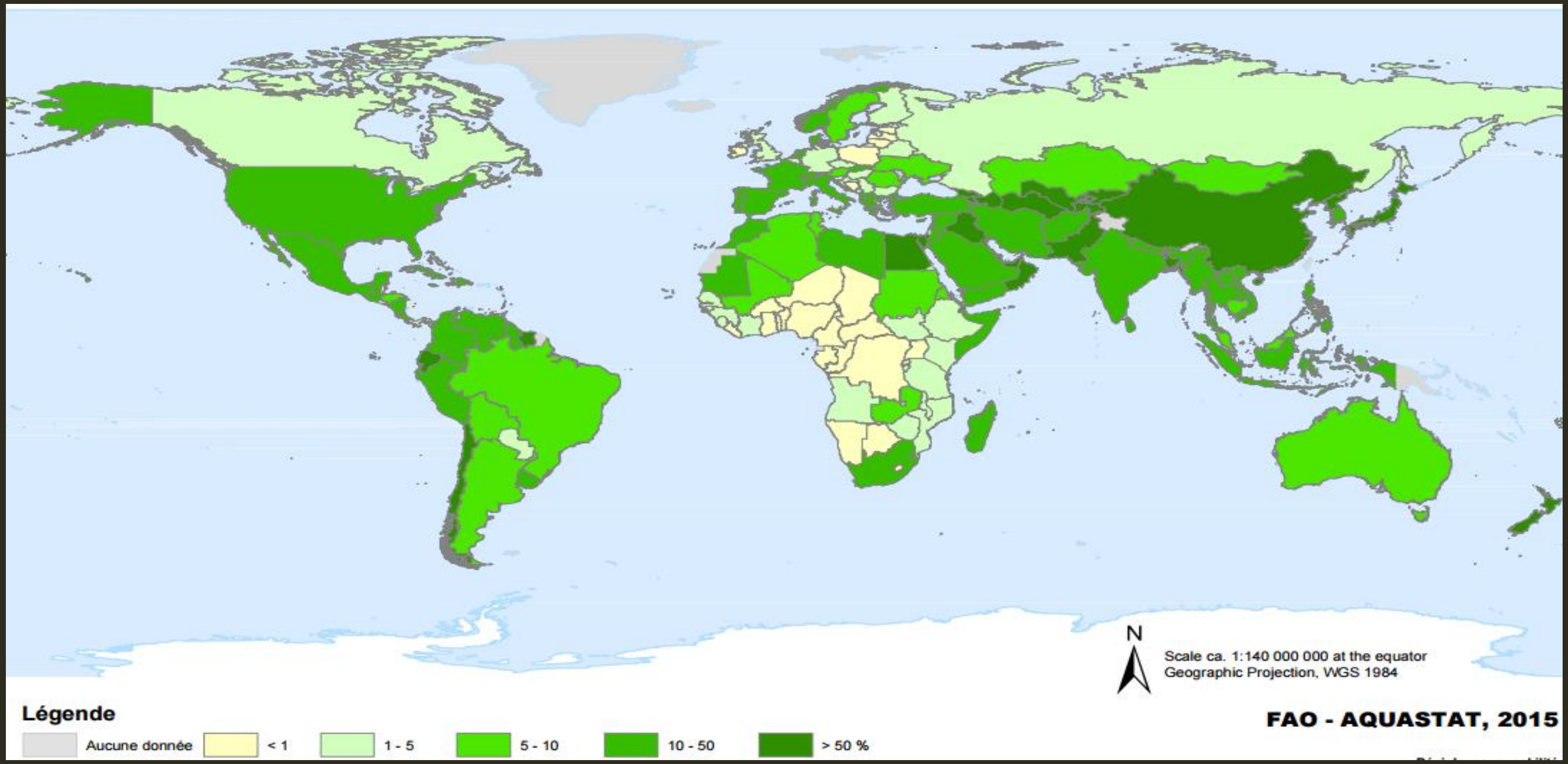
May 7, 2020

BACKGROUND

- Irrigation plays a significant role in agricultural production in order to meet the global food requirement under changing climatic conditions
- Irrigated Agriculture is 20% of agricultural zone and contributes to 40% of the total food produced (FAO-AQUASTAT, 2014)



BACKGROUND

- Irrigation efficiency which is the ratio between the water requirement and the amount of water withdrawn is 56%
- Accurate information on the irrigated area extent helps in managing water resources that affect global food security
- Several irrigation products are available at different spatial resolutions (FAO, GMIA 5.0, MIRCA2000
- The low spatial resolution of these products is an obstacle for using them in irrigation management especially in small to medium agricultural areas

BACKGROUND

- Remote sensing allows optimized water management information on large areas and very high spatial-temporal resolution on soil moisture status and vegetation

- The Sentinel-1 satellite provides an exceptional combination of high spatial and high temporal resolutions for dual polarization SAR data (six days of temporal resolution and a 10 m × 10 m pixel spacing)

- The Sentinel-2 satellite offers optical data at 10m spatial resolution for visible and Near Infrared bands.

CONTEXT

- Radar remote sensing is sensitive to the water content of soil due to the increase in the dielectric constant with the increase of the soil water content
- Several studies have reported that the SAR signal is highly affected by soil moisture content

Irrigation → Artificial Application of water →Increase in surface soil moisture

→Increase in SAR backscattering signal

- BUT! Rainfall and Irrigation may have the same effect on SSM and SAR signal

→ We need to remove the ambiguity between rainfall and irrigation for better detection of irrigation

CONTEXT

- Through literature, several studies demonstrated the potential of optical data to map irrigated areas

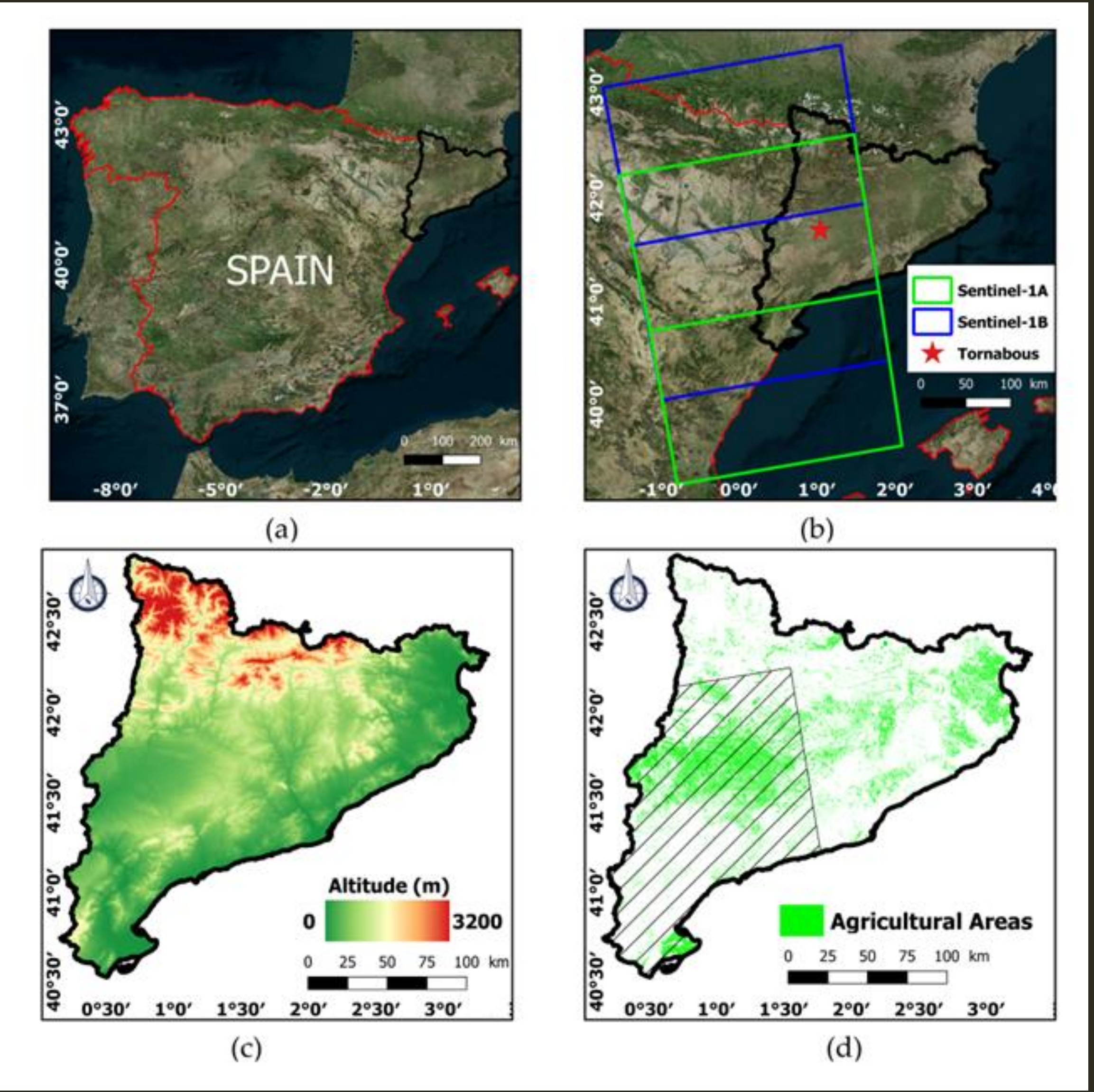
- Irrigation supplements water deficit for crops and is usually combined with fertilizer thus making crop growth healthier and faster.

- This implies that vegetation spectral information from remotely sensed imagery can be used to identify irrigation

- Studies tend to use optical indices such as NDVI and LSWI to map irrigated areas

CONTEXT – STUDY SITE

- Catalonia, North East Spain
- Plot Limits: SIGPAC Data
- Irrigation Information: SIGPAC Data
- SAR Satellite: Sentinel-1
- Optical Satellite: Sentinel-2
- Scale of mapping: Plot Scale
- Classification Approaches Tested:
  - Random Forest
  - Convolutional Neural Network



METHODOLOGY

- The detection of irrigation activities using SAR data at plot scale requires a good separation of irrigation events from rainfall events

- Additional information about the rainfall is required to remove the ambiguity between rainfall events and irrigation events in SAR temporal series

- An indicator of an existing rainfall event could be the increase of the surface soil moisture obtained within a grid scale (5 km, 10 km, 20 km)

➔ Remove the ambiguity between rainfall and irrigation events by comparing between the SAR signal obtained at plot scale and the SAR signal obtained at 10 km grid scale.

METHODOLOGY

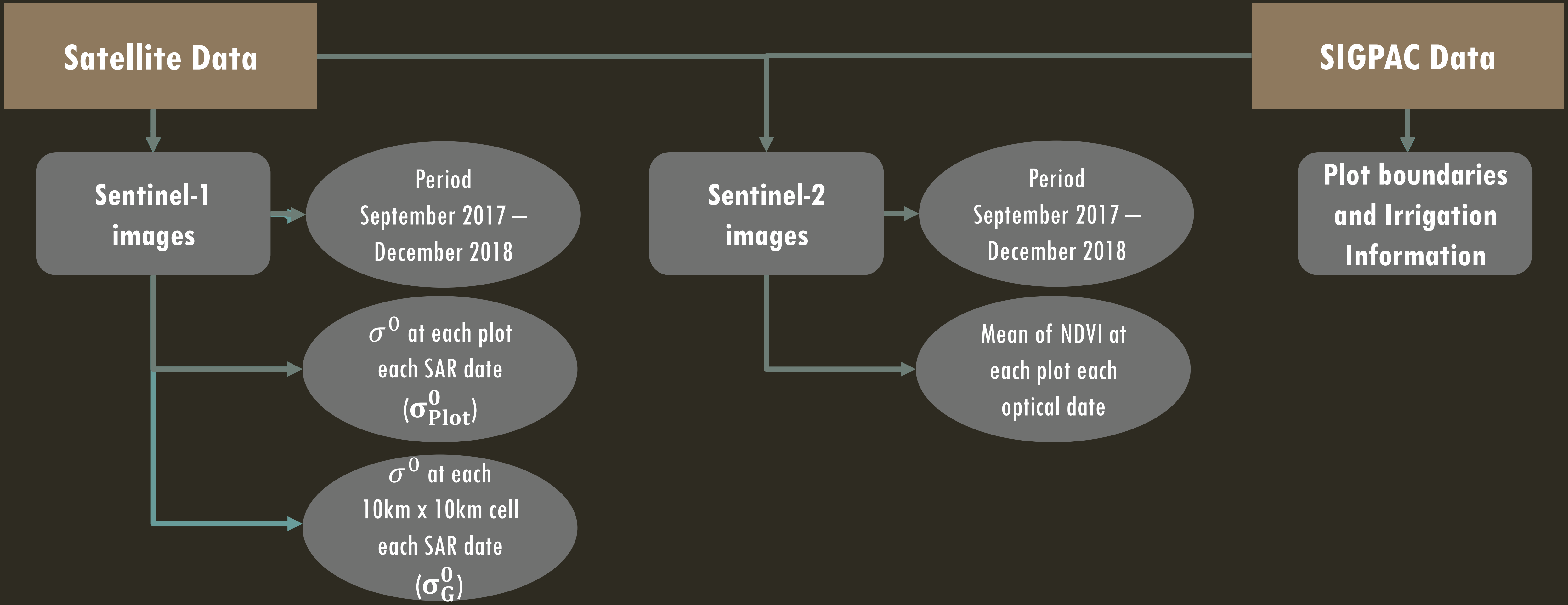
- Mapping irrigated plots with optical data relies on the difference in the temporal series in the vegetation indices

- The NDVI (Normalized Differential Vegetation Index) has been widely used to perform irrigated/non-irrigated area mapping

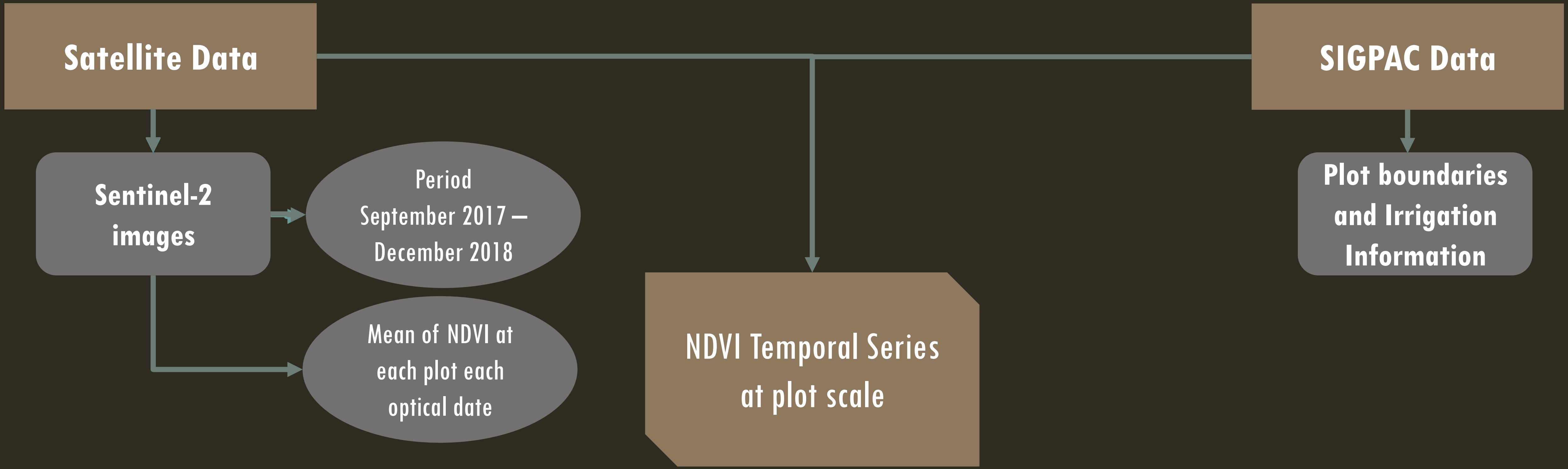
- Among optical sensors, MODIS and Landsat have been extensively used to map irrigated areas

- In this study, the potential of Sentinel-2 images by means of NDVI temporal series to map irrigated areas is envistigated

METHODOLOGY – DATA PREPARATION

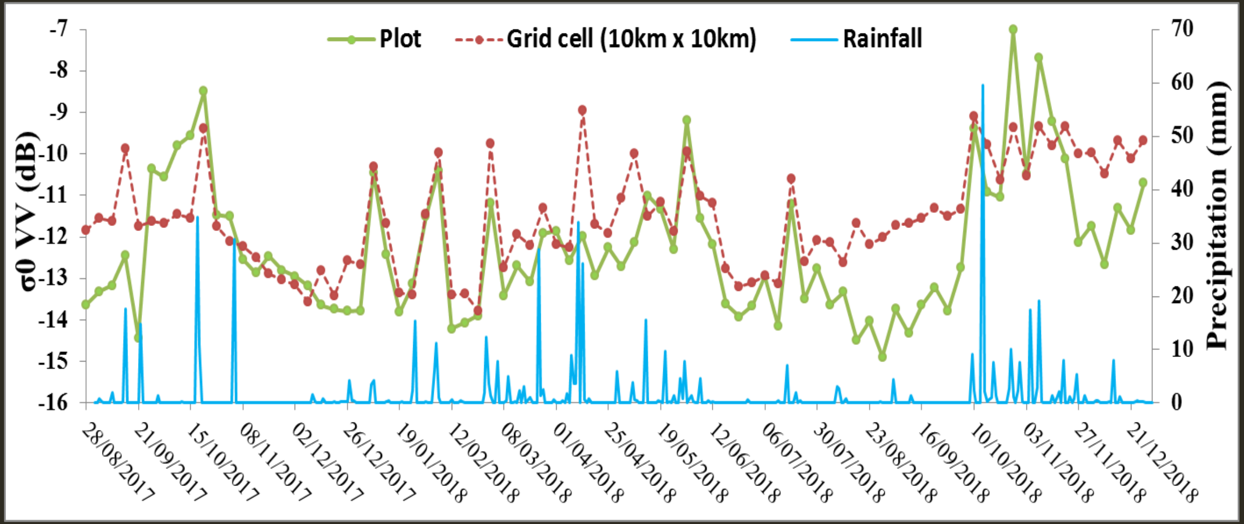


METHODOLOGY – DATA PREPARATION

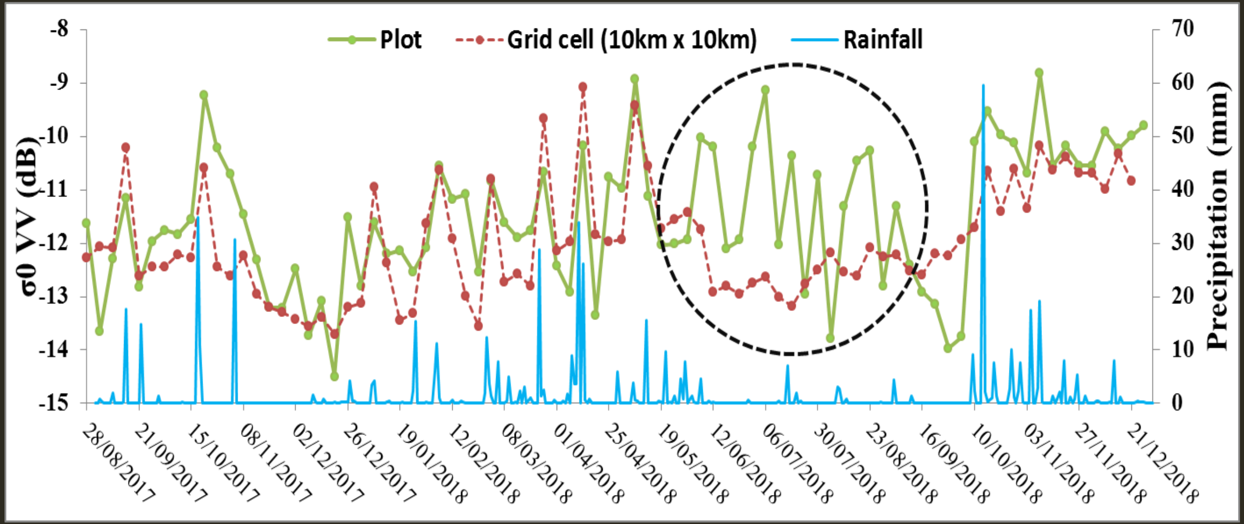


METHODOLOGY - TEMPORAL PROFILES

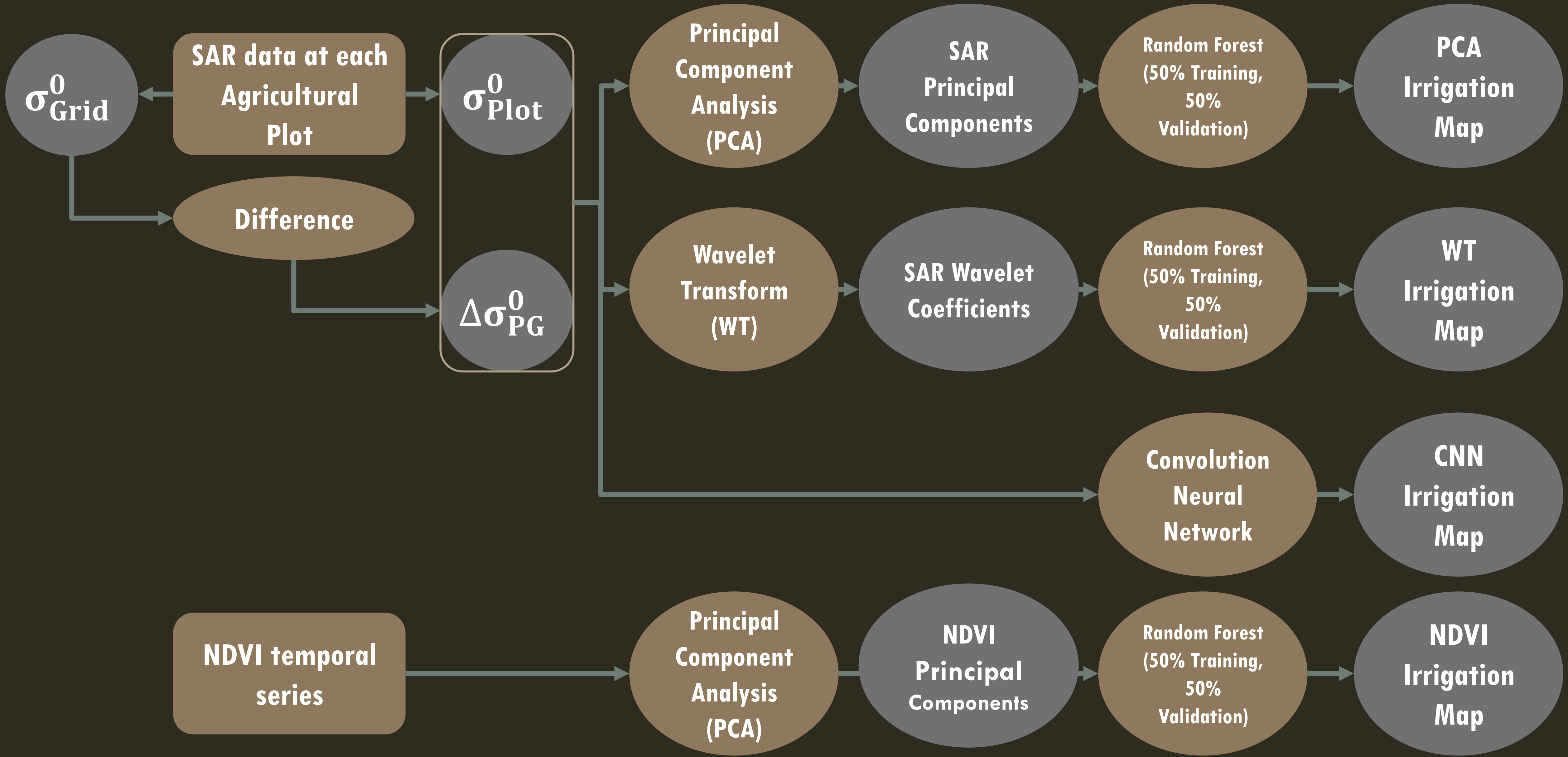
Non Irrigated Plot



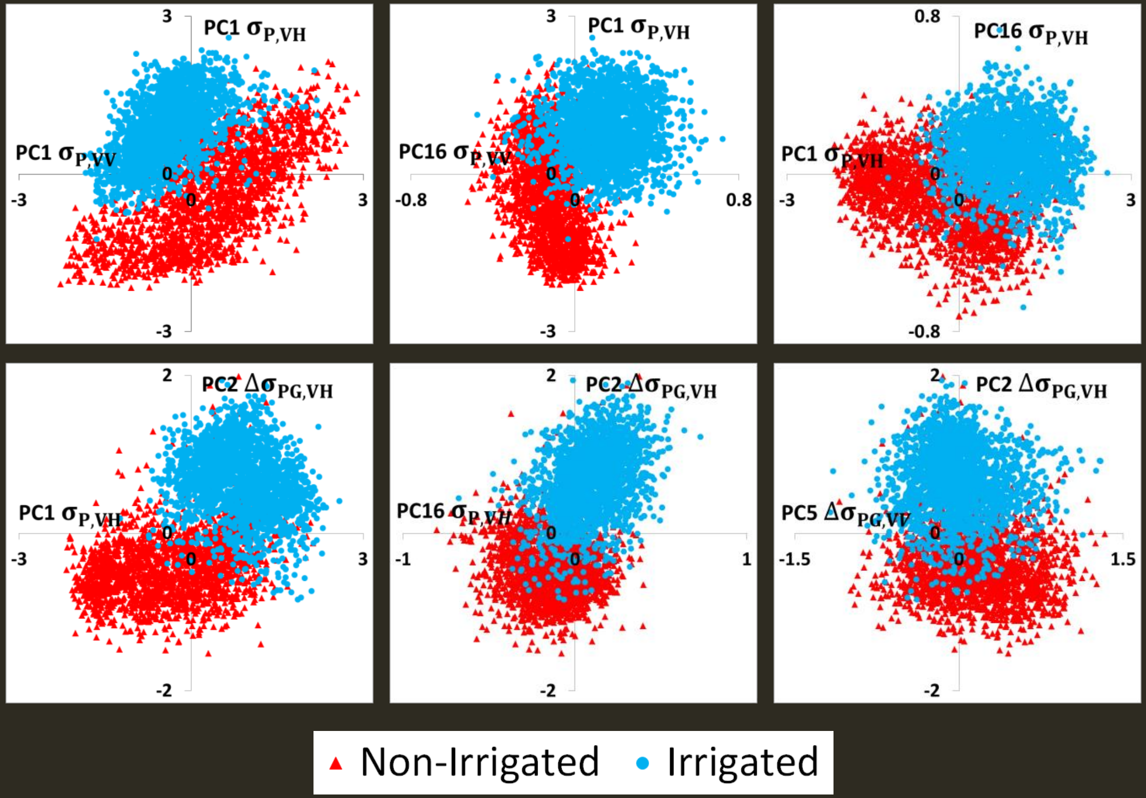
Irrigated Plot



METHODOLOGY - WORKFLOW

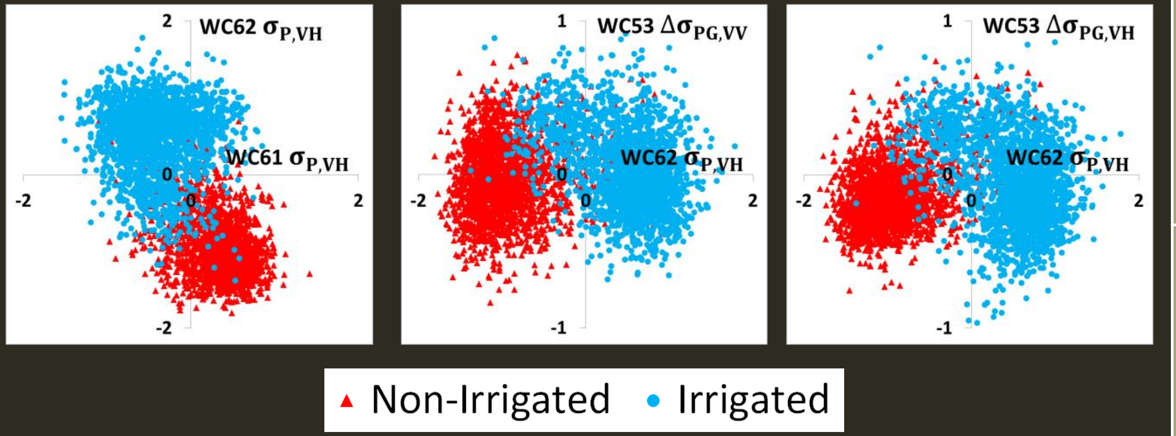


MAIN RESULTS – PCA RF



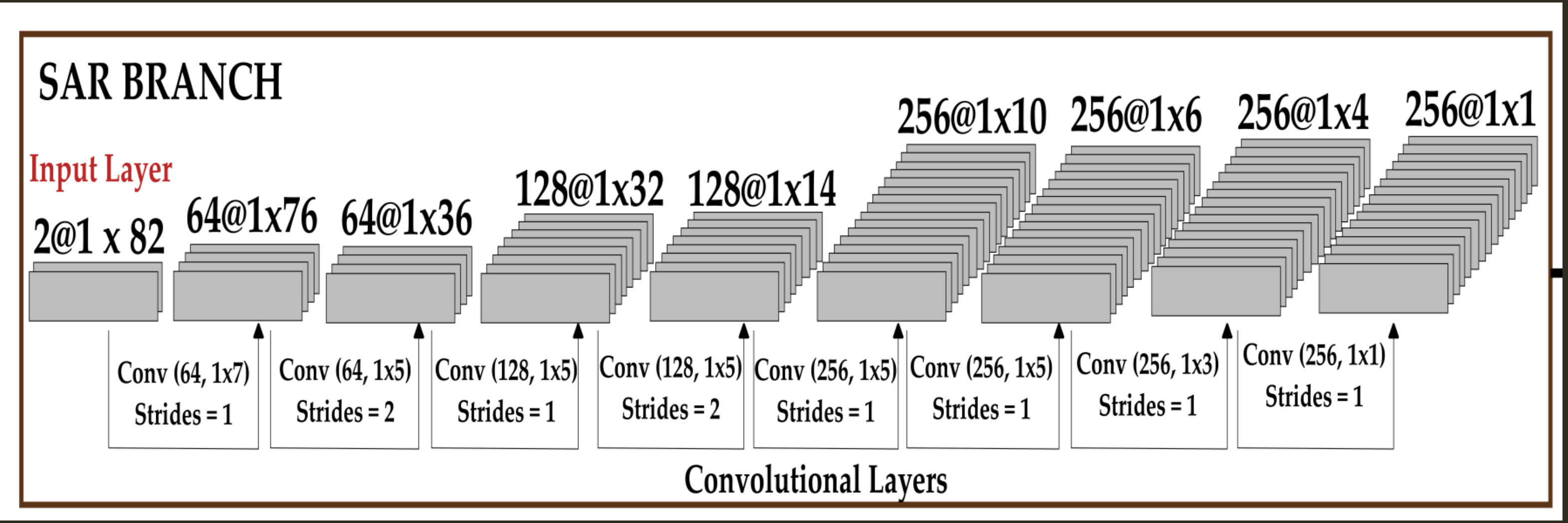
Method	Class	Precision	Recall	F-score
PC-RF 328 Variables	Irrigated	0.95	0.79	**0.86**
	Non-Irrigated	0.90	0.98	**0.94**
	OA		**91.2%**	
	Kappa		0.79	
	F-score		0.91	
PC-RF 15 Important Variables	Irrigated	0.92	0.81	**0.86**
	Non-Irrigated	0.90	0.96	**0.93**
	OA		**90.7%**	
	Kappa		0.79	
	F-score		0.91	

RESULTS – WT RF



Method	Class	Precision	Recall	F-score
WT-RF 256 Variables	Irrigated	0.94	0.81	**0.87**
	Non-Irrigated	0.90	0.97	**0.94**
	OA		**91.4%**	
	Kappa		0.81	
	F-score		0.91	
WT-RF 18 Important Variables	Irrigated	0.89	0.78	**0.83**
	Non-Irrigated	0.89	0.95	**0.92**
	OA		**89.1%**	
	Kappa		0.75	
	F-score		0.89	

MAIN RESULTS – SAR CNN



Method	Class	Precision	Recall	F-score
CNN on SAR Data	Irrigated	0.93	0.89	**0.91**
	Non-Irrigated	0.95	0.96	**0.96**
	OA	**94.1%±0.06**		
	Kappa	0.87±0.0014		
	F-score	0.94±0.0006		

MAIN RESULTS – NDVI RF AND CNN

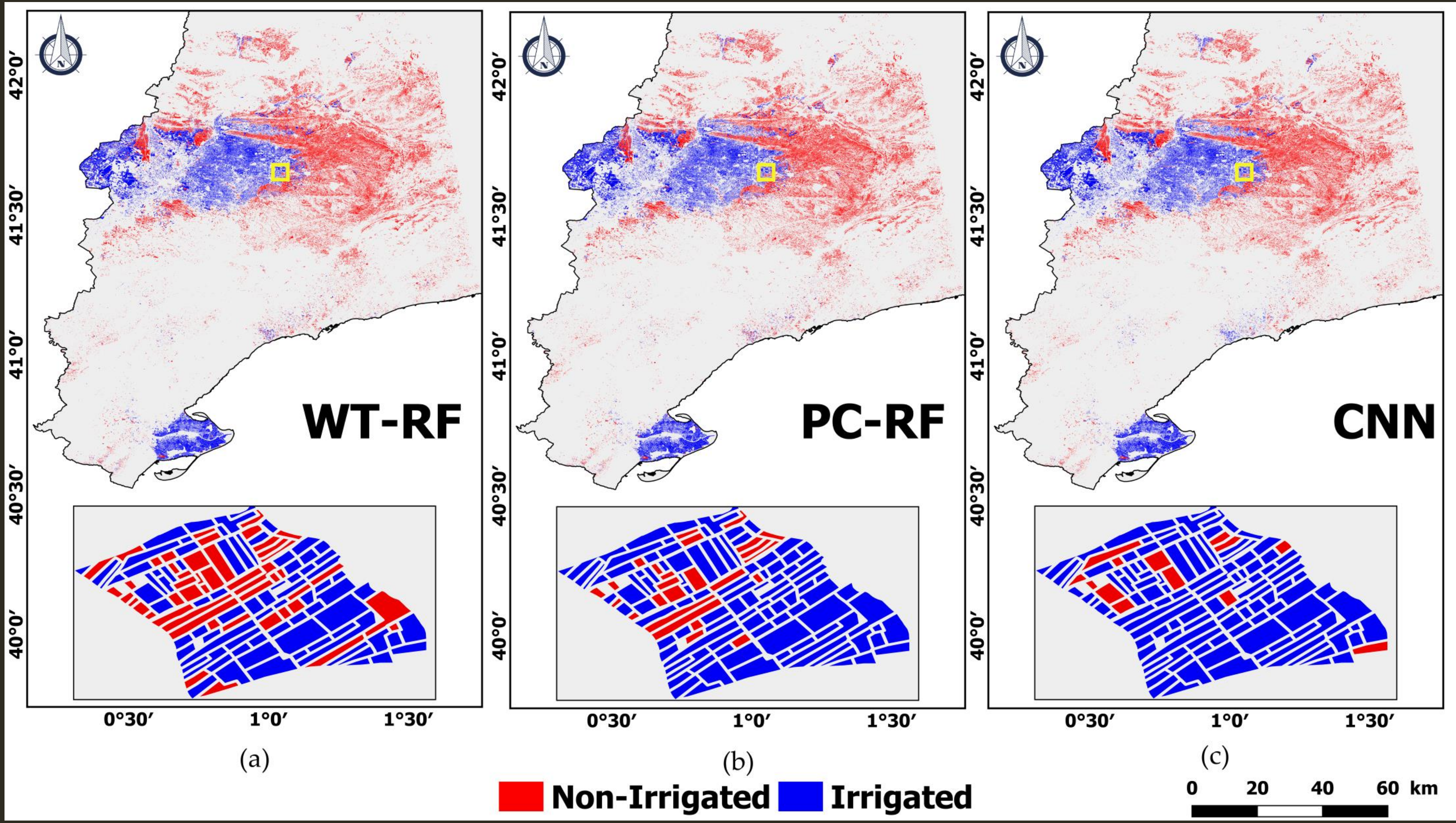
RF - NDVI

Method	Class	Precision	Recall	F-score
NDVI-RF 17 Variables	Irrigated	0.94	0.78	**0.85**
	Non-Irrigated	0.89	0.97	**0.93**
	OA	**90.5%**		
	Kappa	0.78		
	F-score	0.91		
NDVI-RF 7 Important Variables	Irrigated	0.92	0.76	0.84
	Non-Irrigated	0.88	0.96	0.92
	OA	**89.5%**		
	Kappa	0.76		
	F-score	0.88		

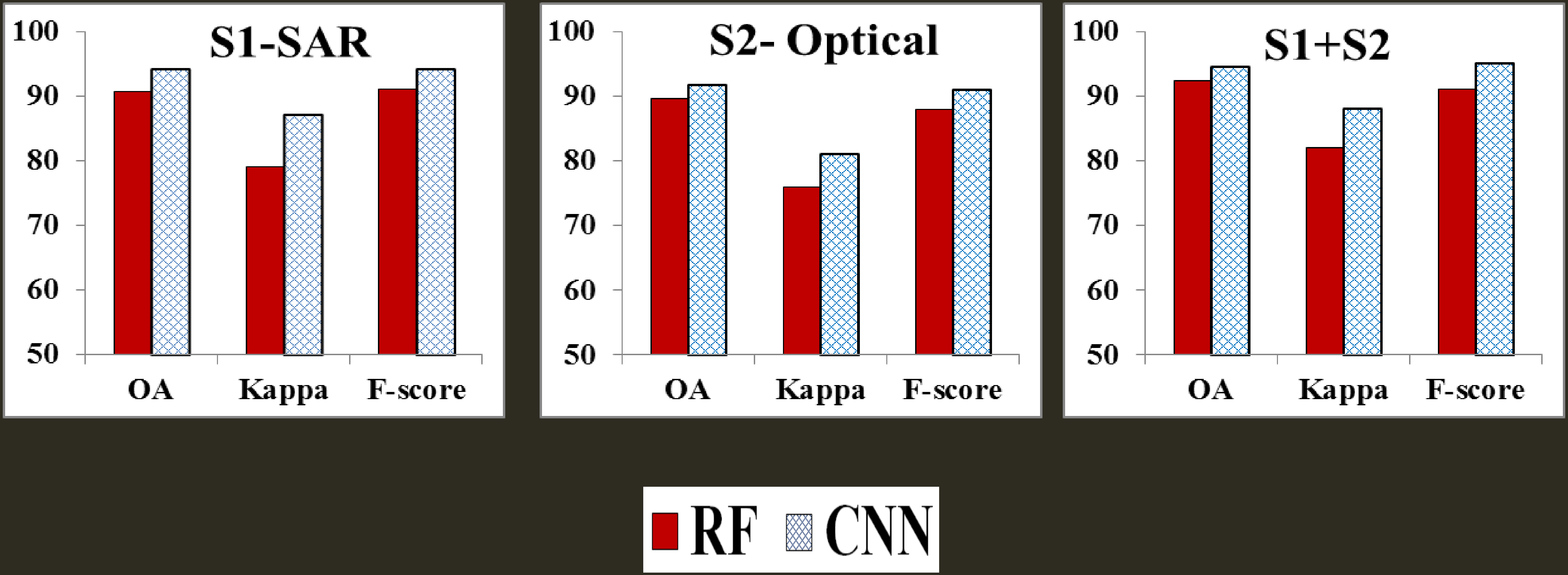
CNN - NDVI

Method	Class	Precision	Recall	F-score
CNN on Optical Data	Irrigated	0.93	0.81	**0.87**
	Non-Irrigated	0.91	0.97	**0.94**
	OA	**91.6%±0.06**		
	Kappa	0.81±0.0016		
	F-score	0.91±0.0006		

MAIN RESULTS – MAPPING



MAIN RESULTS – INTERCOMPARISON



MAIN FINDINGS

- Sentinel-1 SAR data is efficient for mapping irrigated plots

- The SAR signal at basin scale could be a good representative of rainfall events

- Adding the SAR signal at grid scale to the classification approach remarkably improved our classification accuracy where the overall accuracy increased by more than 15%

- This enhancement confirms the relevance of our assumption of using conjointly $\boldsymbol{\sigma}_{\mathbf{P}}^{\mathbf{0}}$ and $\boldsymbol{\sigma}_{\mathbf{G}}^{\mathbf{0}}$ to in order to remove the rainfall-irrigation ambiguity

MAIN FINDINGS

- The CNN deep-learning is superior to the classical RF machine-learning approach in the classification

- The gain in the performance offered by the CNN is clearly visible on the irrigated class

- The increase of the overall accuracy when using the CNN approach is mainly caused by better detection of irrigated plots

- Fusion of Optical and SAR data enhanced the accuracy of the RF classification but did not significantly change the overall accuracy of the CNN model.

THE END!

Thank you

Question!