Exploring Agricultural Drought Indices for Cereal Yield Prediction Assessment in Semi-Arid Regions

Manel Khlif [1], Maria José Escorihuela [2], Aicha Chahbi Bellakanji [1], Giovanni Paolini [2] and Zohra Lili Chabaane [1]

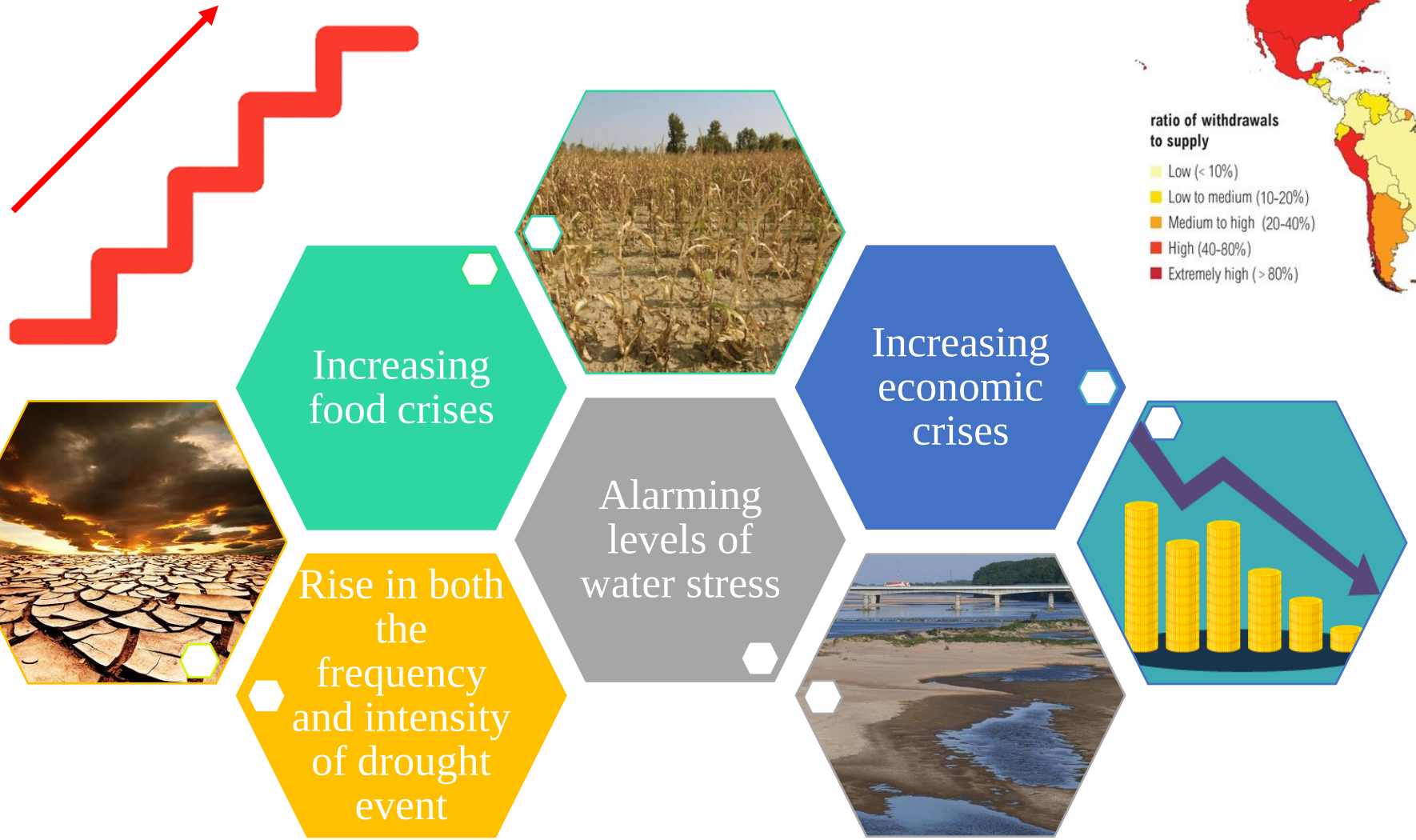
1 University of Carthage, National Agronomic Institute of Tunisia, LR GREEN-TEAM, 43 Avenue Charles Nicolle, Tunis 1082, Tunisia

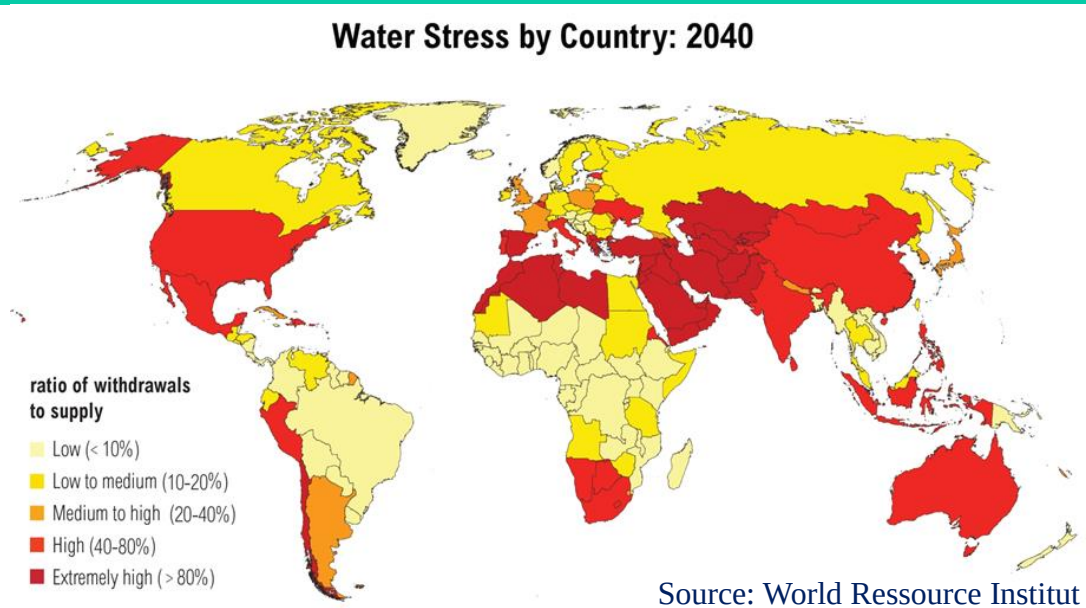
2 isardSAT, Technological Park, Marie Curie, 8-14, 08042, Barcelona, Catalonia;

PLAN

Introduction

Impact of climate change





Source: World Ressource Institut

- Food security
- Water security

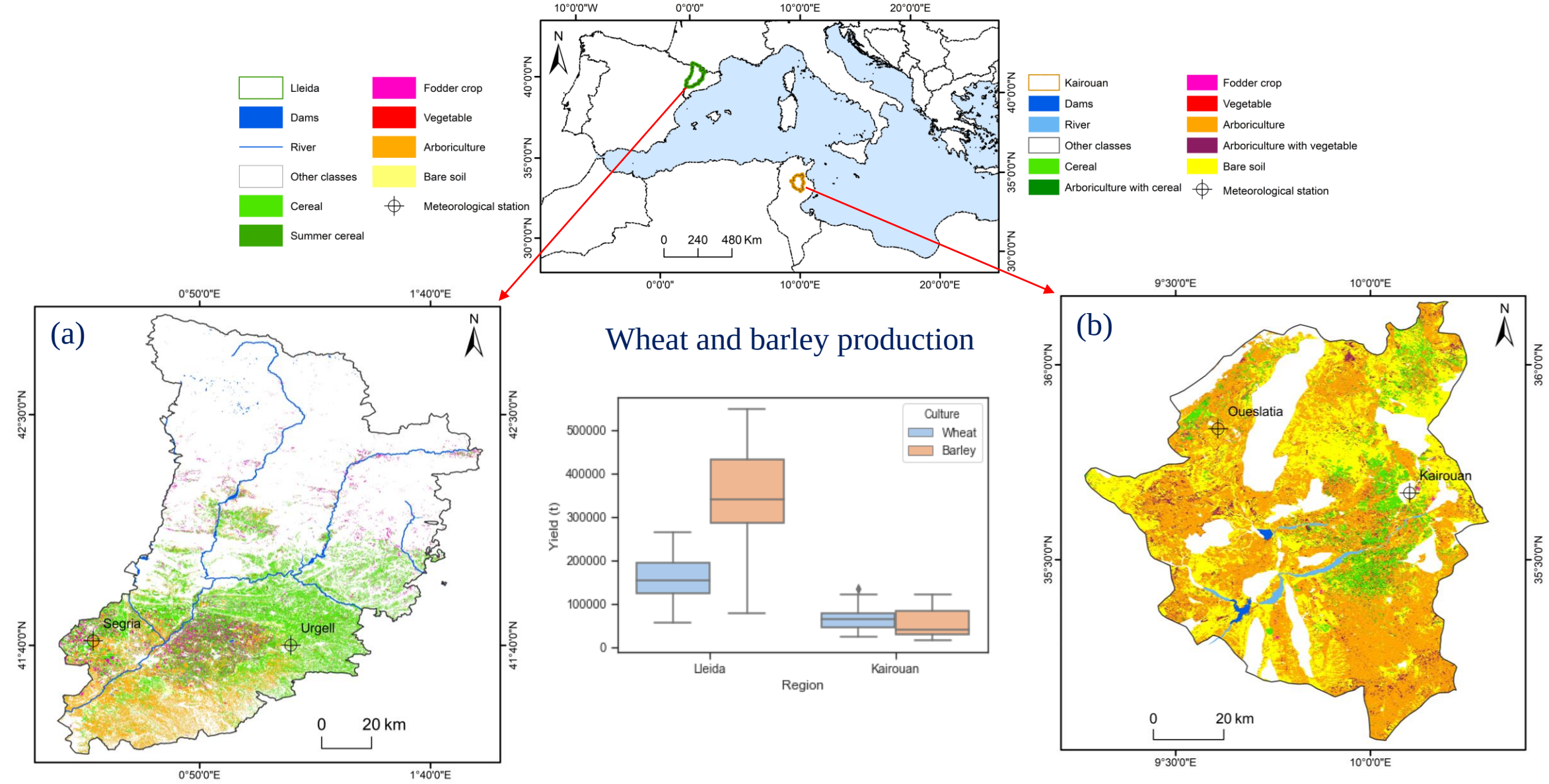
Introduction

Objectives

1) Analyze the relationship between drought indices and the cereal vegetative status for both dryland and irrigated cereals
2) Investigate the correlation between the different indices and the cereal yields

Which drought index exhibits the strongest correlation with cereal yields, and at which period?

Study area



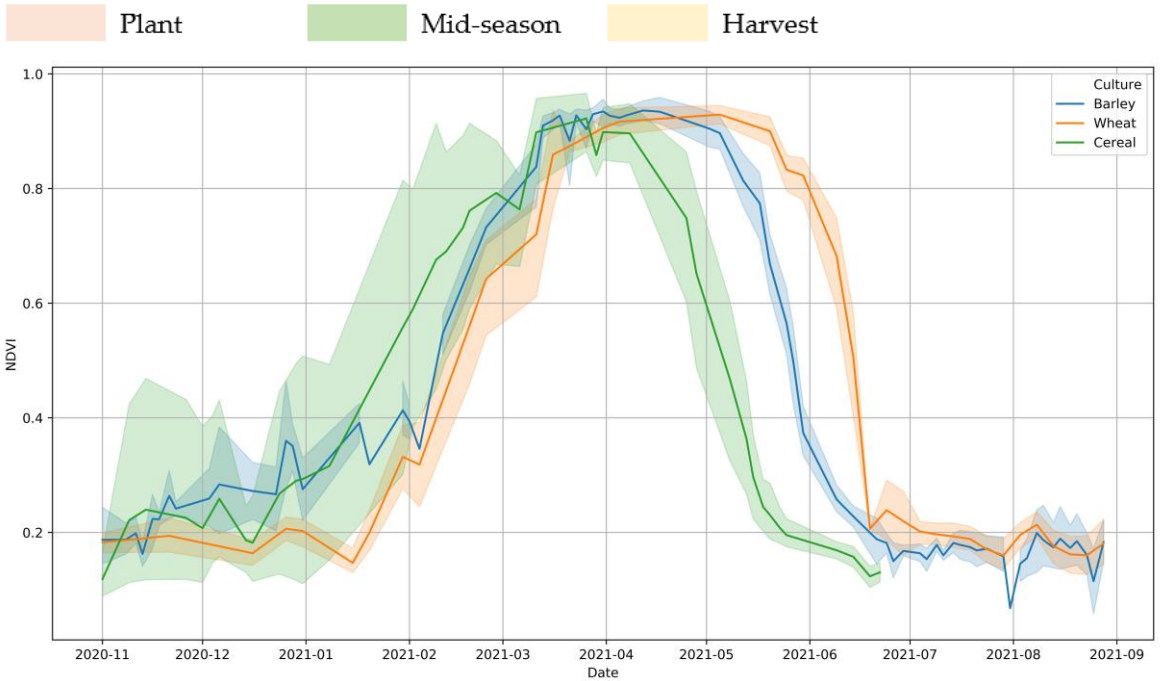
Land cover maps for the 2021/2022 agricultural year for (a) Lleida in Catalonia and (b) Kairouan in Tunisia

Study area

Lleida

Kairouan

Area	Culture	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug
Lleida	Barley												
	Wheat												
Kairouan	Barley												
	Wheat												



Different climatic conditions and agricultural practices

Barley and **wheat** crop calendars for Lleida (Catalonia) and **cereal** crop calendars (wheat and barley) for Kairouan (Tunisia)

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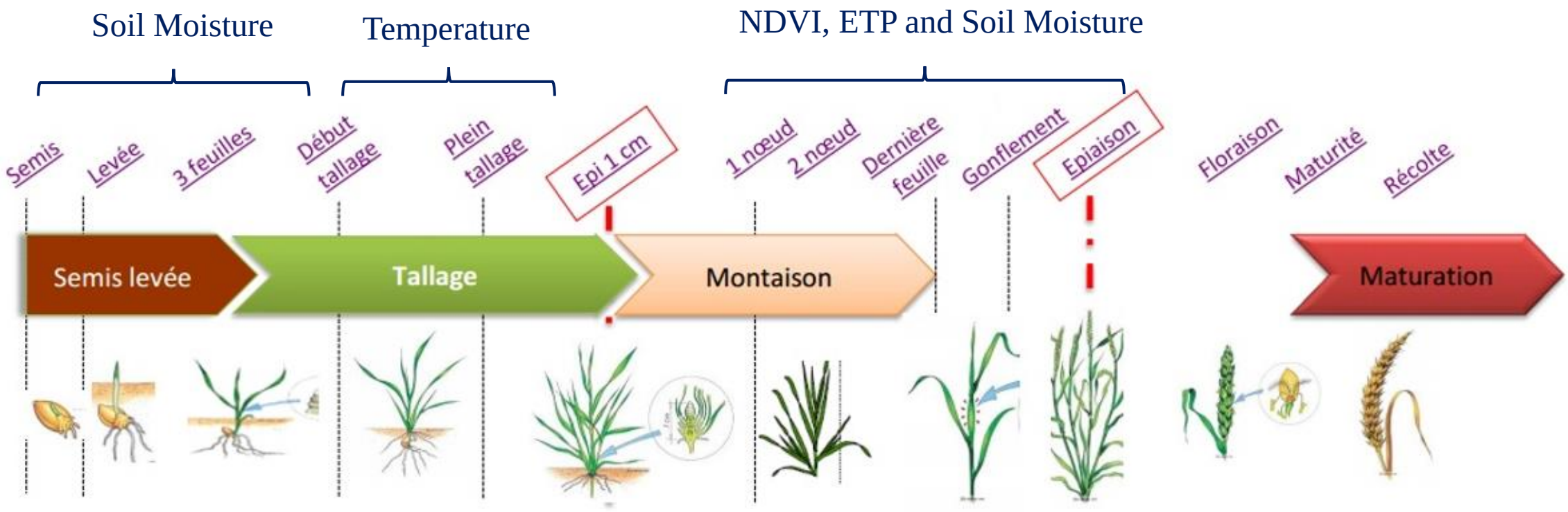
Methodology

Kairouan, 17 mai 2022

Methodology

Choice of drought indices

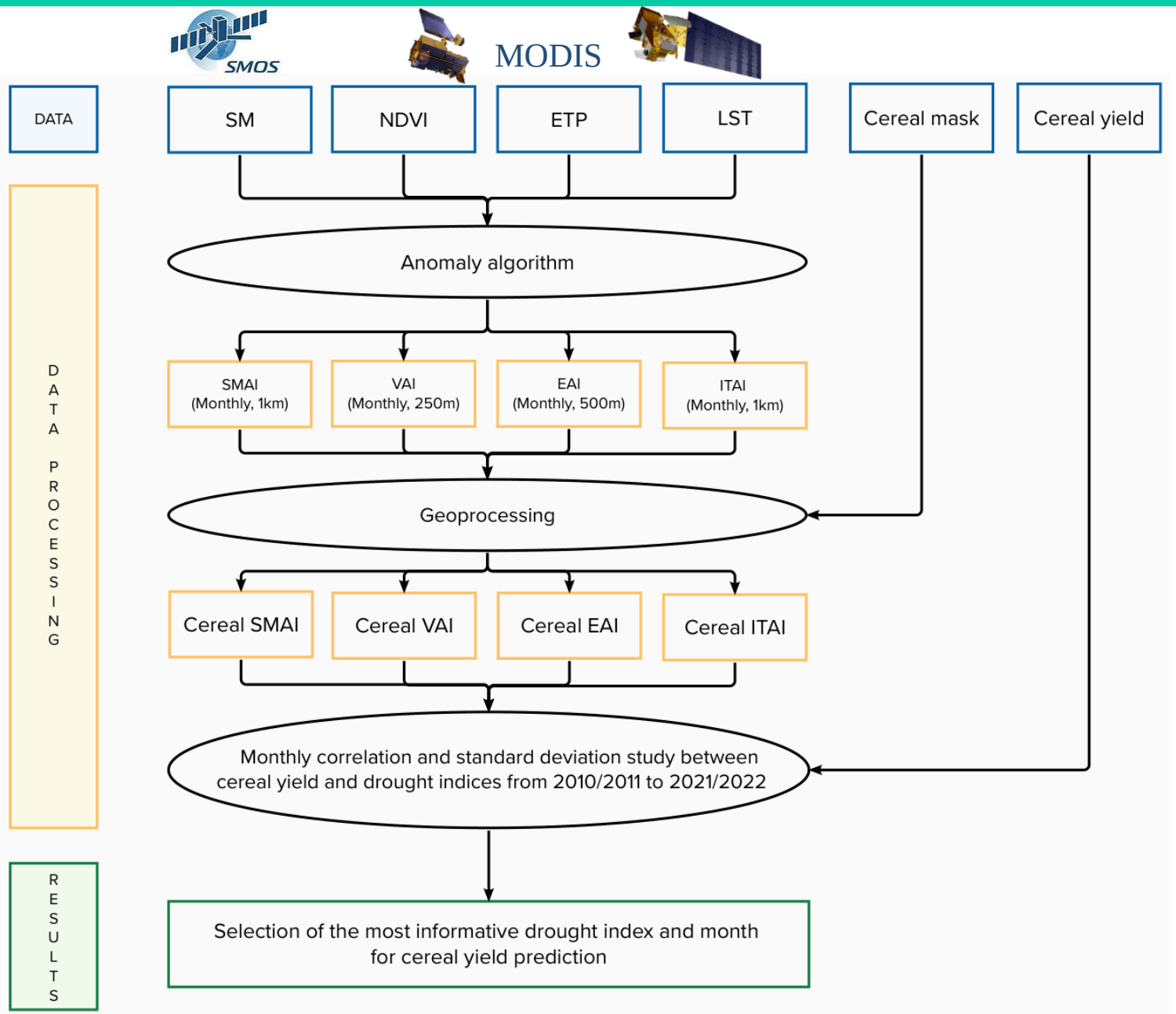


Emergence, beginning of development

Thermal stress

Vegetative activity

Methodology



Four drought indices:

- SMAI: Soil Moisture Anomaly Index
- VAI : Vegetation Anomaly Index
- EAI: Evapotranspiration Anomaly Index
- ITAI: Inverse Temperature Anomaly Index

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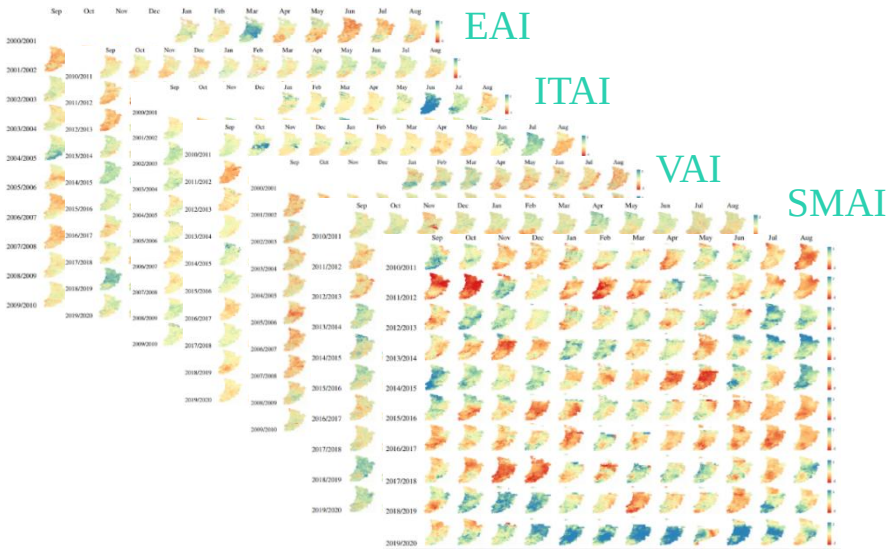
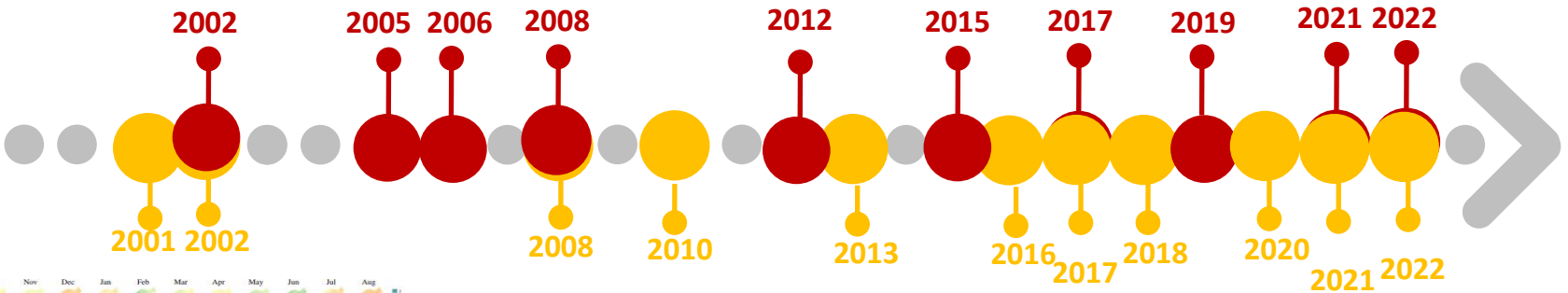
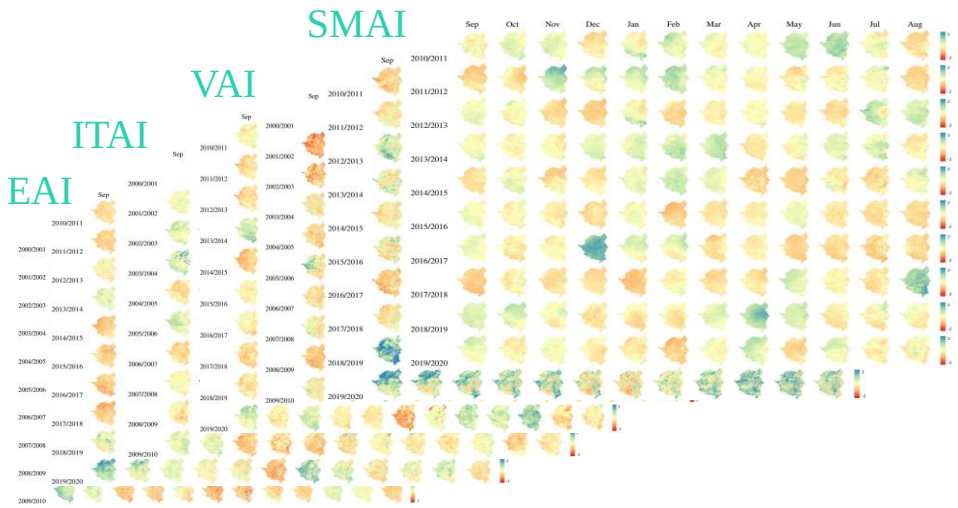
Results & Discussions



Drought events in Lleida (Catalonia, Spain)

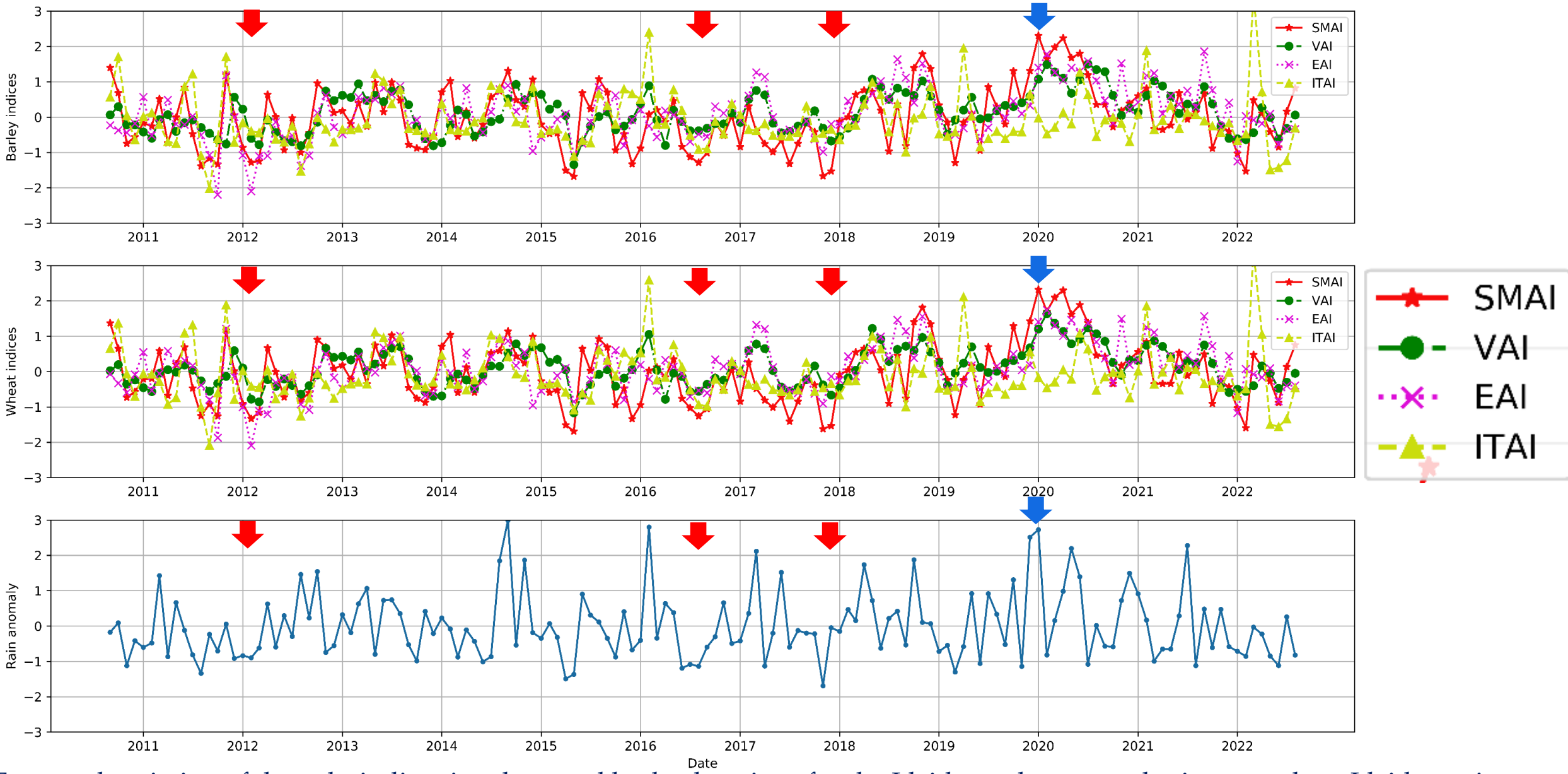




Drought events in Kairouan (Tunisia)

Results

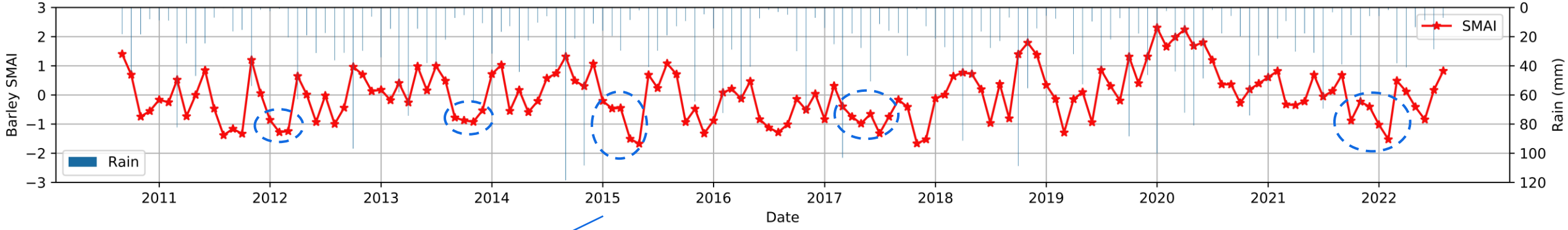
Lleida (Catalonia)

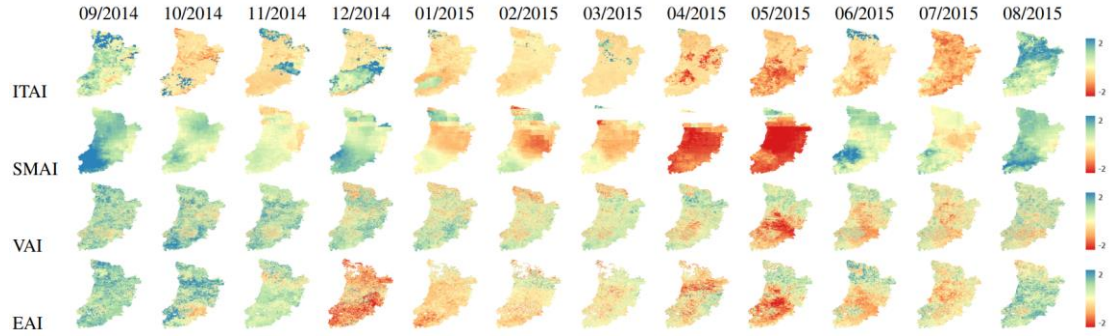


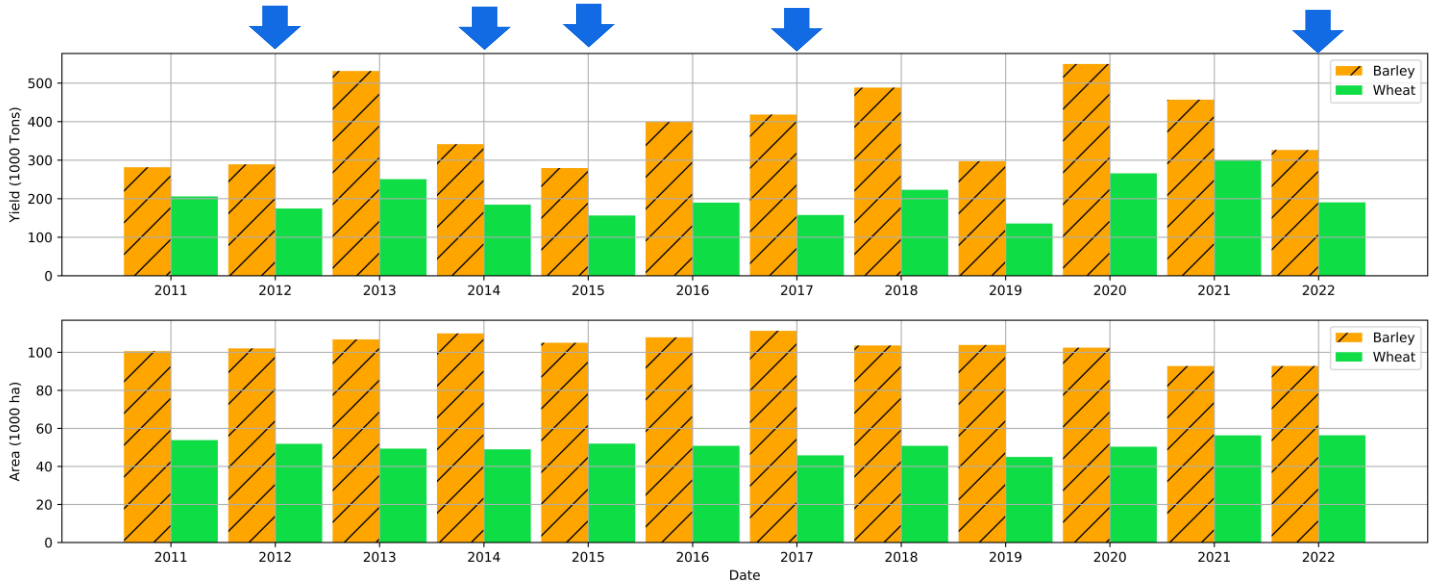
Temporal variation of drought indices in wheat and barley locations for the Lleida study area and rain anomaly at Lleida station from September 2010 to August 2022

Results

Lleida (Catalonia)

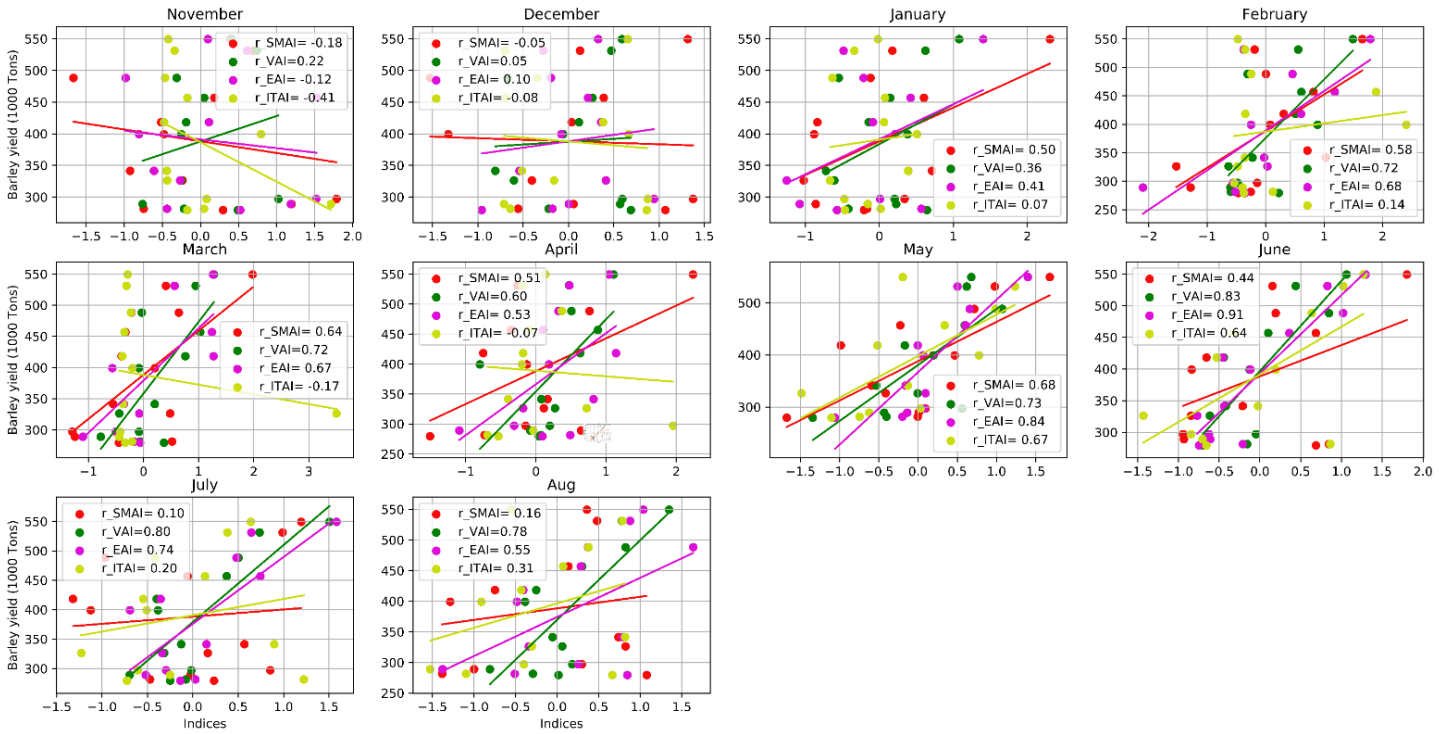


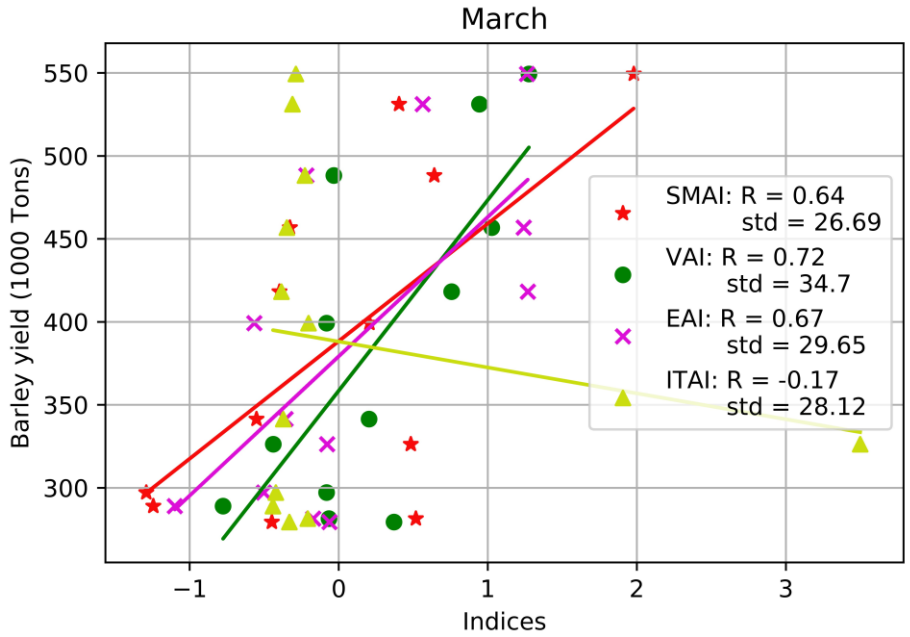


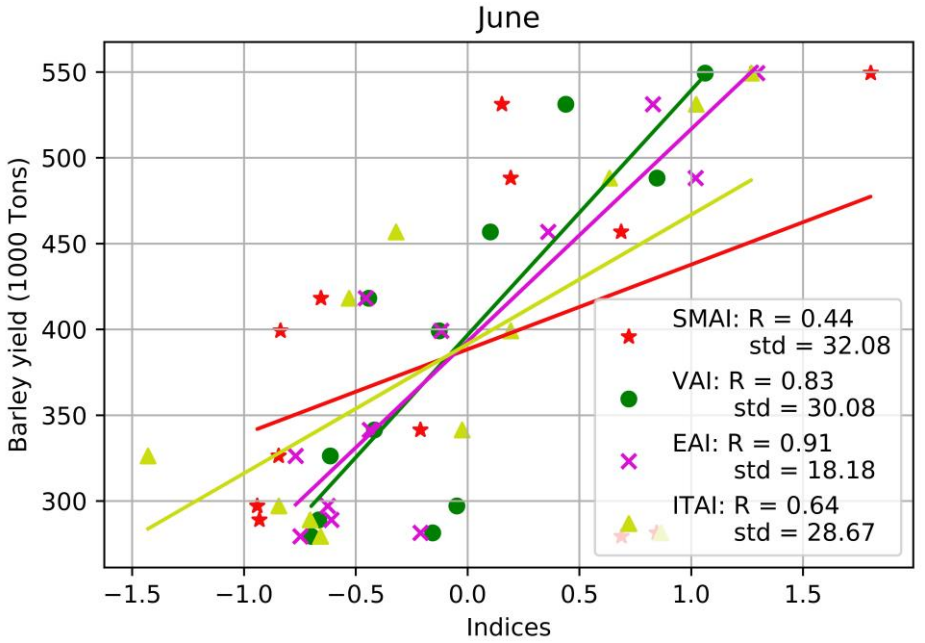


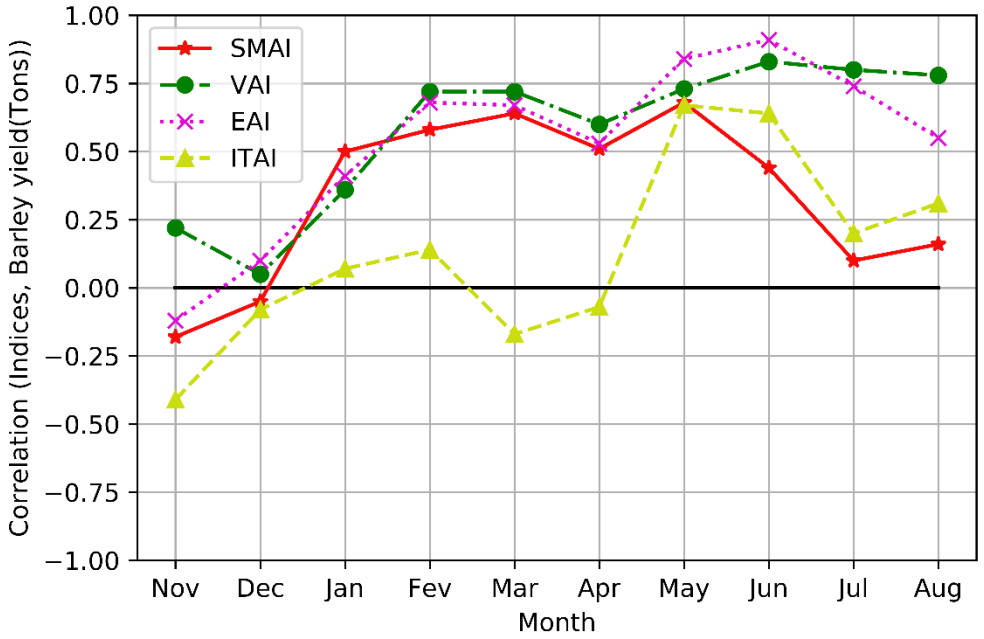
- The detection of drought periods
- The time delay between ITAI, SMAI, EAI and VAI
- The impact of drought timing on cereal yield

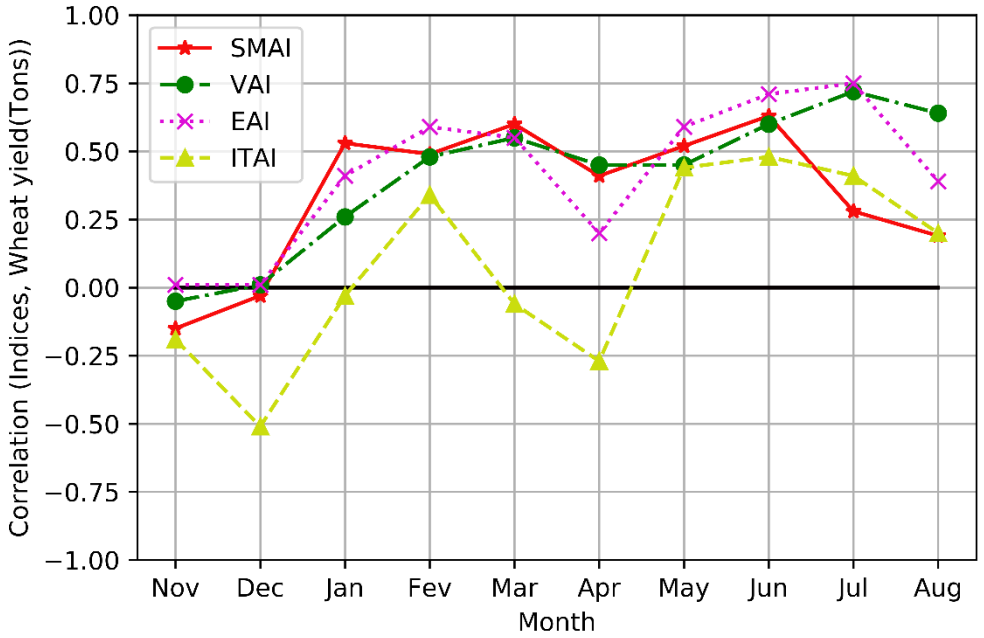
Pearson's correlation (R) and standard deviation (std) between drought indices and barley yield production







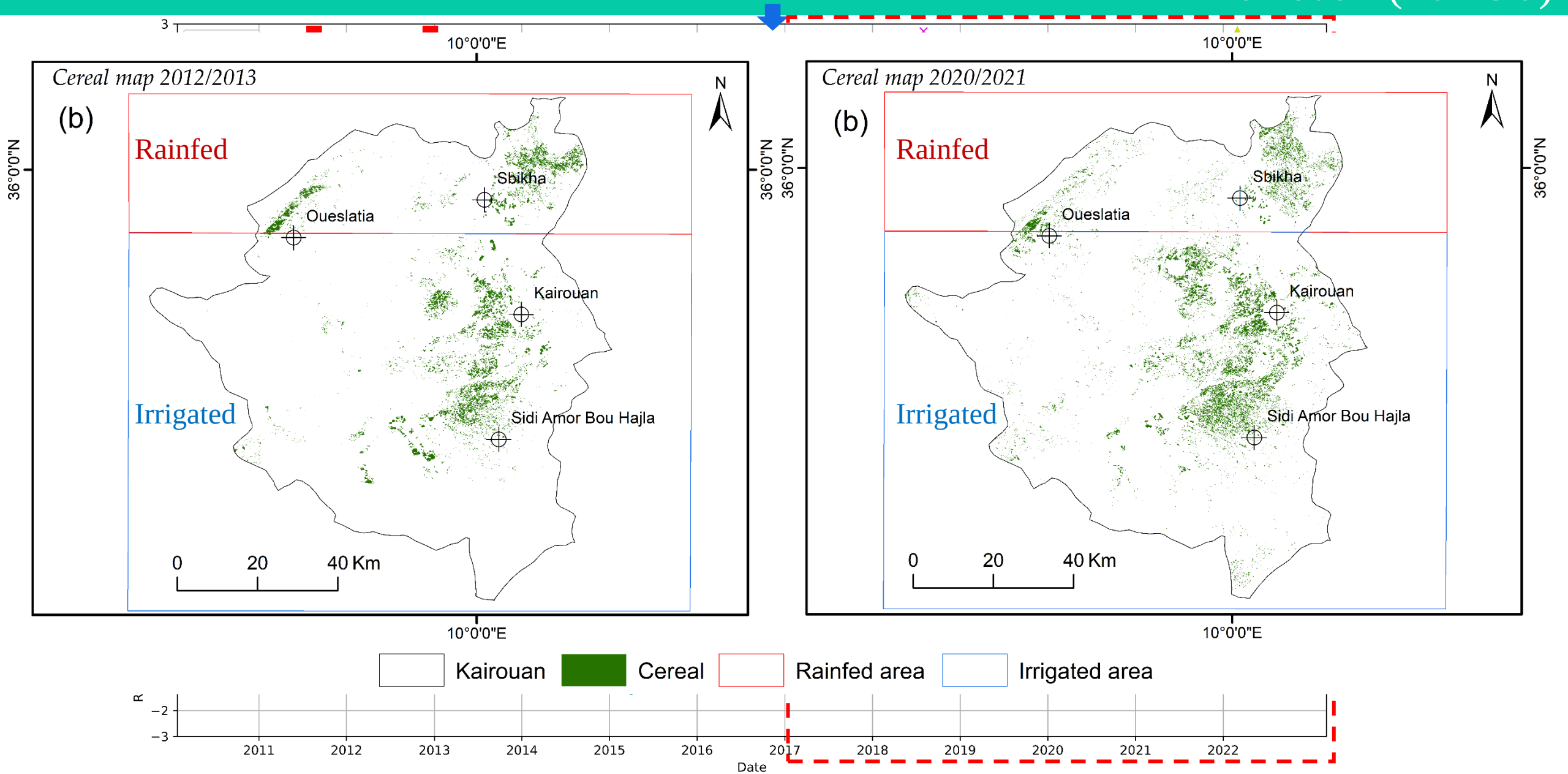




Pearson's correlation (R) and standard deviation (std) results

Cereal	Month	SMAI		VAI		EAI		ITAI	
		R	std	R	std	R	std	R	std
Barley	November	−0.18	32.37	0.22	56.57	−0.12	35.76	−0.41	43.76
	December	−0.05	33.43	0.05	58.00	0.10	63.35	−0.08	47.58
	January	0.50	29.12	0.36	51.88	0.41	39.11	0.07	82.40
	February	0.58	28.65	0.72	31.59	0.68	23.69	0.14	31.59
	March	0.64	26.69	0.72	34.70	0.67	29.65	−0.17	28.12
	April	0.51	28.88	0.60	51.12	0.53	43.23	−0.07	44.63
	May	**0.68**	**25.83**	0.73	31.43	0.84	28.87	**0.67**	**27.94**
	June	0.44	32.08	**0.83**	**30.08**	**0.91**	**18.18**	0.64	28.67
	July	0.10	37.52	0.80	30.78	0.74	32.39	0.20	41.92
	August	0.16	36.26	0.78	33.11	0.55	30.68	0.31	39.24
Wheat	November	−0.15	16.04	−0.05	31.46	0.01	17.36	−0.19	22.31
	December	−0.03	16.25	0.01	28.92	0.01	32.53	−0.51	20.36
	January	0.53	13.67	0.26	26.07	0.41	19.98	−0.03	38.49
	February	0.49	14.35	0.48	**18.18**	0.59	**12.75**	0.34	**14.12**
	March	0.60	**13.36**	0.55	21.22	0.55	16.45	−0.06	14.18
	April	0.41	14.78	0.45	27.00	0.20	23.86	−0.27	18.08
	May	0.52	15.25	0.45	21.57	0.59	21.38	0.44	16.50
	June	**0.63**	13.92	0.60	24.13	0.71	17.10	**0.48**	15.69
	July	0.28	17.48	**0.72**	19.83	**0.75**	16.78	0.41	17.65
	August	0.19	18.55	0.64	22.38	0.39	18.41	0.20	19.82

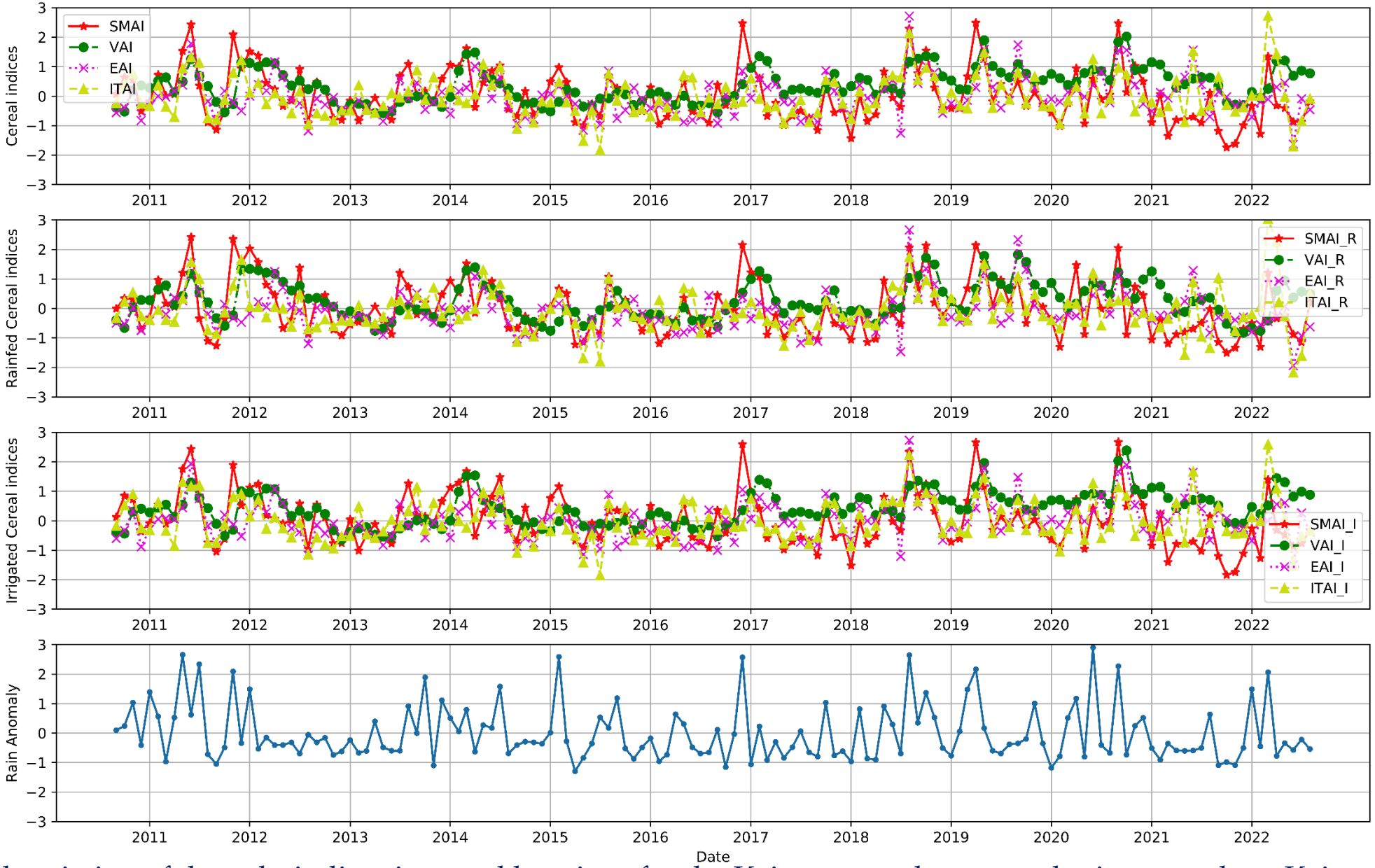
Kairouan (Tunisia)



Temporal variation of drought indices in cereal locations for the Kairouan study area and rain anomaly at Kairouan station from September 2010 to August 2022

Results

Kairouan (Tunisia)



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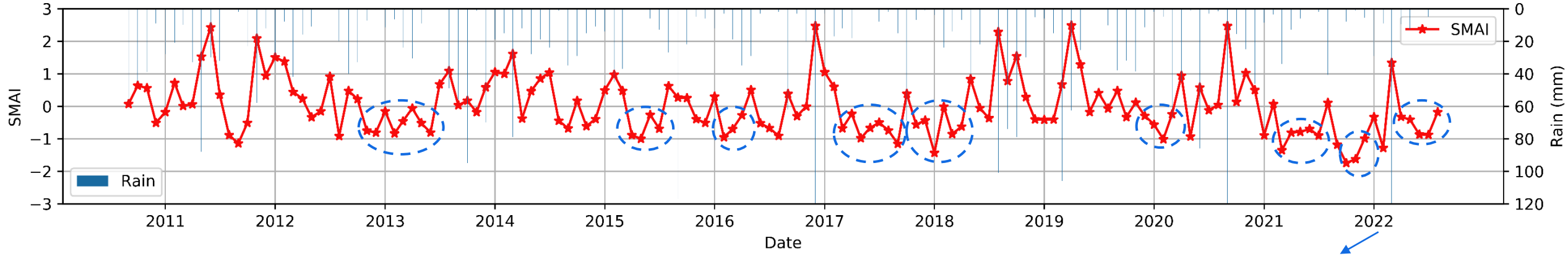

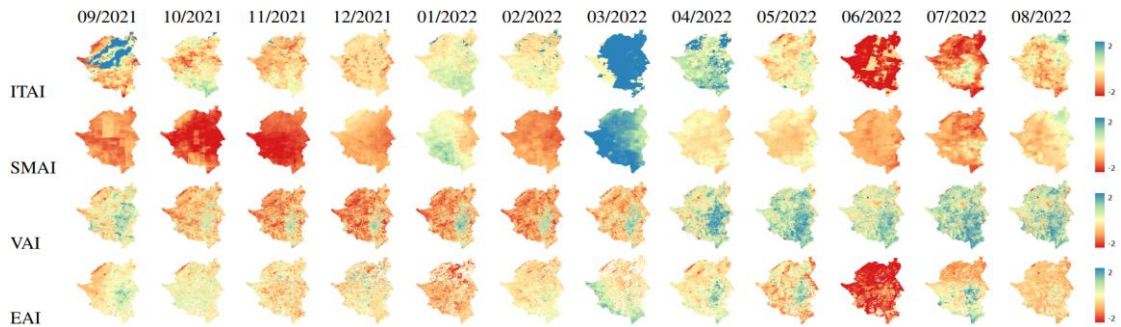

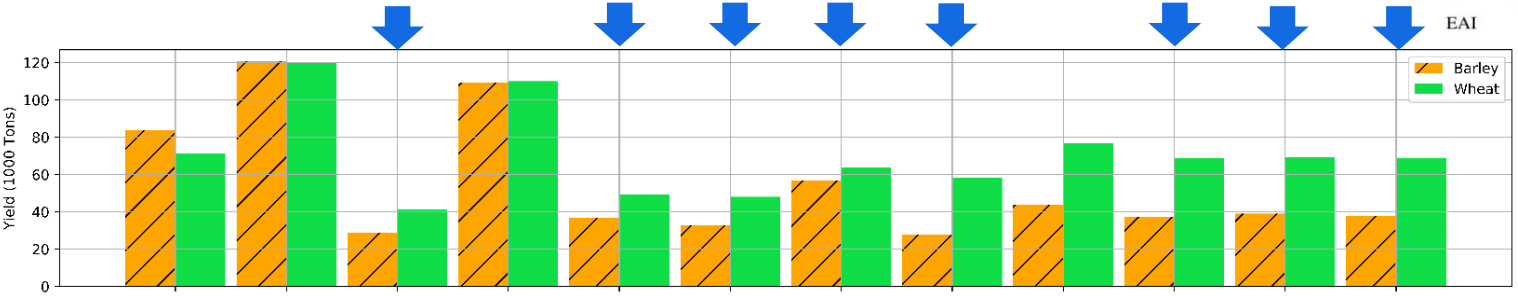

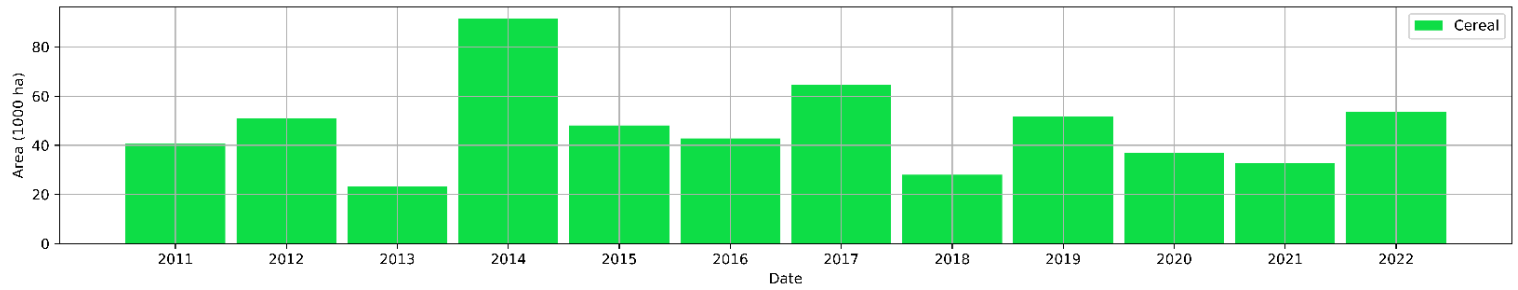

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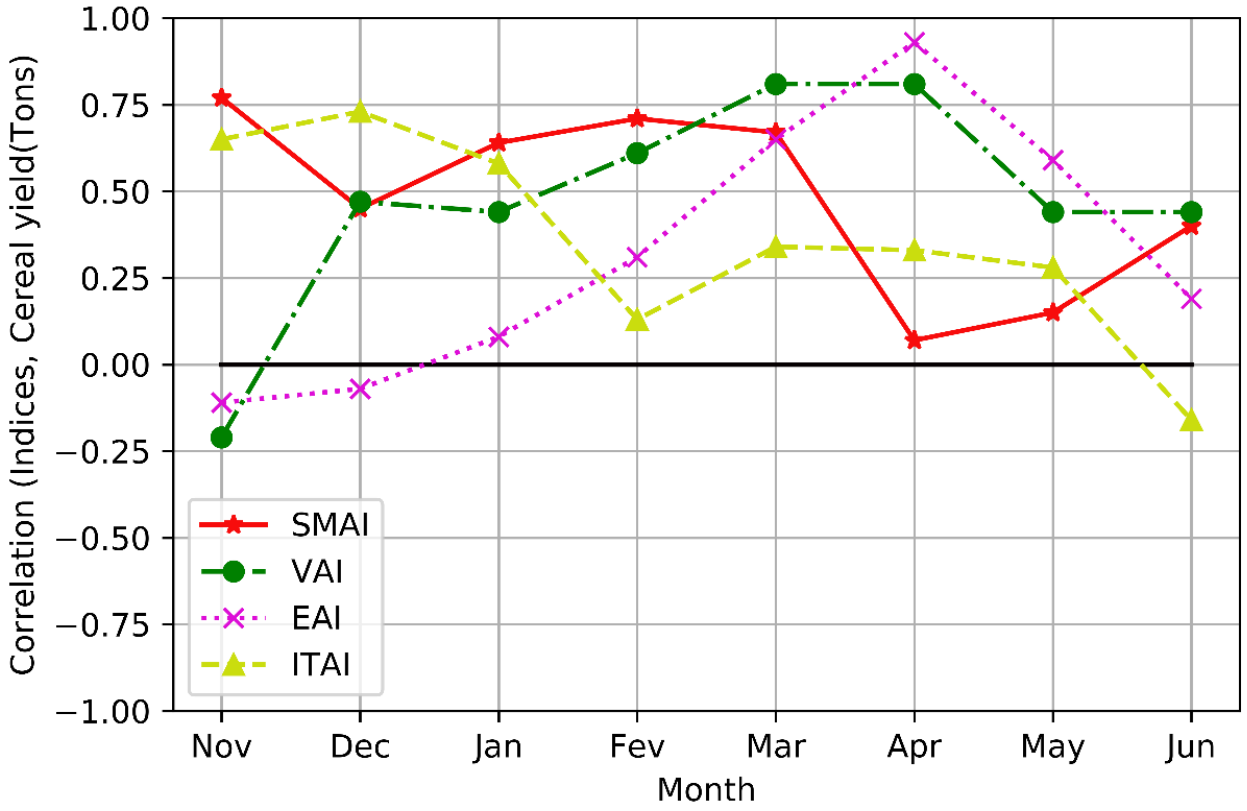
Pearson's correlation (R) and standard deviation (std) results

Month	SMAI		VAI		EAI		ITAI	
	R	std	R	std	R	std	R	std
November	0.63	14.03	−0.19	30.41	−0.11	37.01	0.65	18.99
December	0.44	15.88	0.39	28.24	−0.06	39.69	**0.72**	26.47
January	0.64	15.24	0.35	29.64	0.15	64.13	0.55	35.14
February	**0.67**	**13.88**	0.54	27.57	0.32	50.14	0.15	39.18
March	0.51	16.23	**0.79**	20.32	0.66	64.19	−0.07	19.29
April	0.11	18.50	0.71	**19.10**	**0.90**	**13.43**	0.11	26.18
May	0.18	18.54	0.37	23.54	0.53	18.26	0.30	**17.65**
June	0.42	16.54	0.40	28.05	0.14	18.03	−0.08	17.69



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Conclusion

Kairouan, 17 mai 2022

Conclusion

Lleida (Catalonia)

- In the dry cereal area of **Lleida**, the strongest correlation was found between EAI (0.91) and VAI (0.83) at the time of cereal maturity in June.
- However, SMAI showed the best performance as an earlier indicator in **March** (roughly three months before harvest) with the highest correlation with barley (0.68) and wheat (0.63) yield and the lowest standard deviation.

Conclusion

Kairouan (Tunisia)

- For the irrigated cereal zone of **Kairouan**, the strongest correlation is found between EAI and cereal yield at the time of dough development in April, which corresponds also to the minimum standard deviation.
- In terms of advanced prediction, VAI shows a high correlation in **March** (0.79) while SMAI shows a slightly lower correlation in **February** (0.67) but with a lower standard deviation.

Conclusion

Comparison between two study areas (Rainfed, irrigated)

1 km SR is insufficient to capture irrigation of small fields in Kairouan

SMAI is an early indicator of yield prediction

Data availability over an extended period (cereal mask, soil moisture data, plot-scale yield, etc.).

Khlif, M.; Escorihuela, M.J.; Chahbi Bellakanji, A.; Paolini, G.; Lili Chabaane, Z. Remotely Sensed Agriculture Drought Indices for Assessing the Impact on Cereal Yield. Remote Sens. 2023, 15, 4298. https://doi.org/10.3390/rs15174298

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