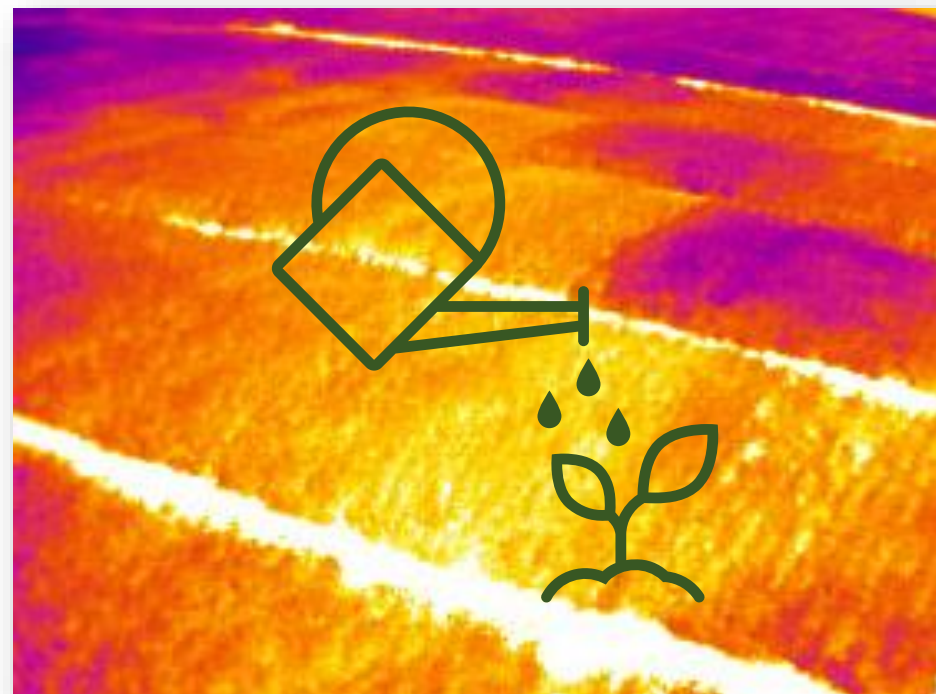


צילום תרמי למיפוי השונות במצב המים בכותנה ולהשקיה מדייקת – היכן אנו עומדים היום?



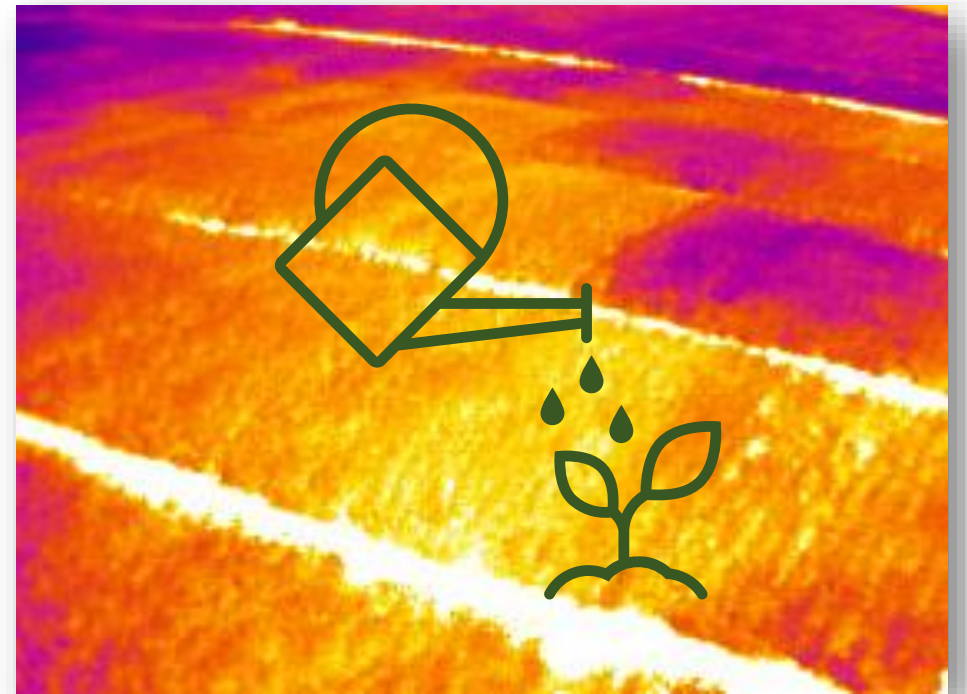
יפית כהן
המכון להנדסה חקלאית
מכון וולקני



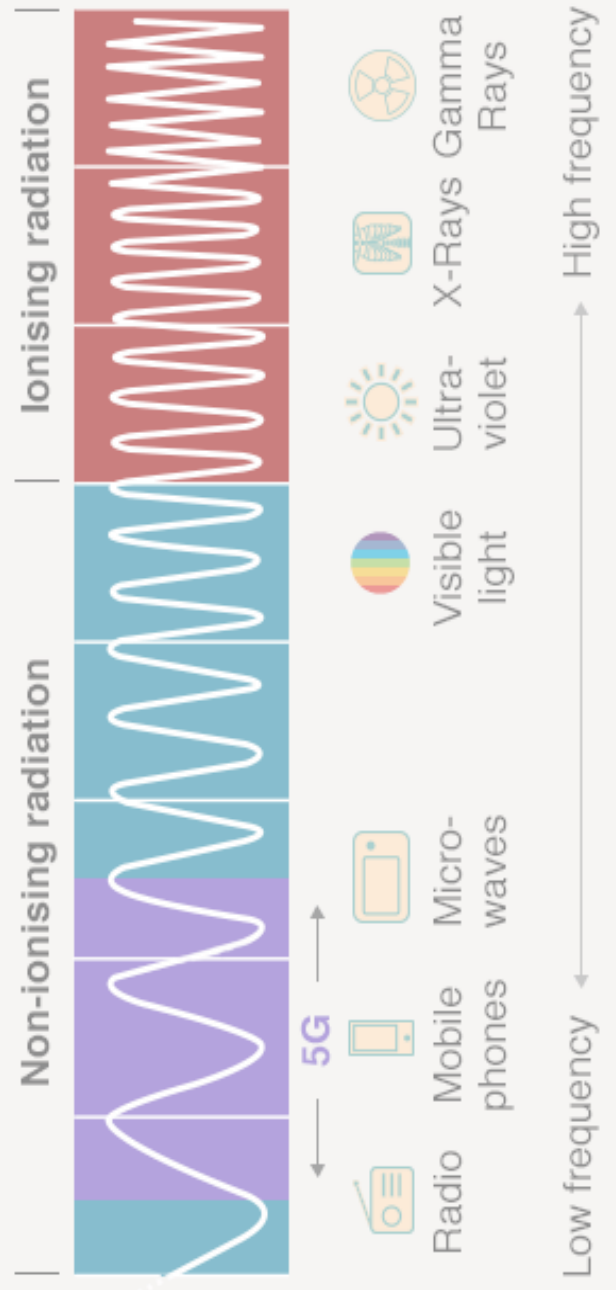
שותפים

ויקטור אלחנתי, יהושע סרנגה, אריה בוסק,
משה מרון, שבתאי כהן, יוסף ציפריס, ולרי
אורלוב, אלון בן-גל, אביבה פיטרס, חגי
יסעור

סטודנטים: איתן סלע, אורי רוזנברג, ניצן
גרף, אלכס ברסקי ואושר בוכריס



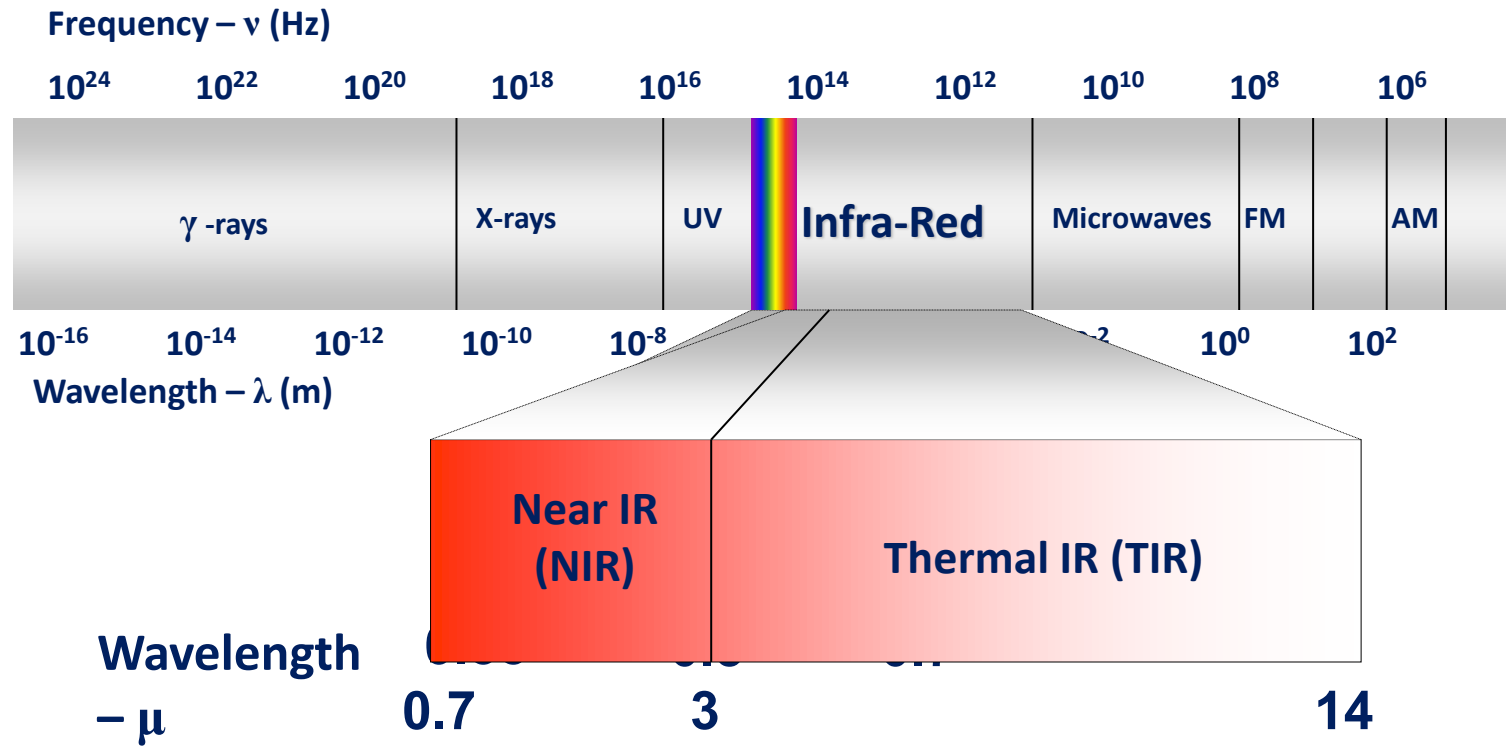
Where 5G fits in the electromagnetic spectrum



Source: SCAMP/Imperial College London/EBU



The electromagnetic spectrum



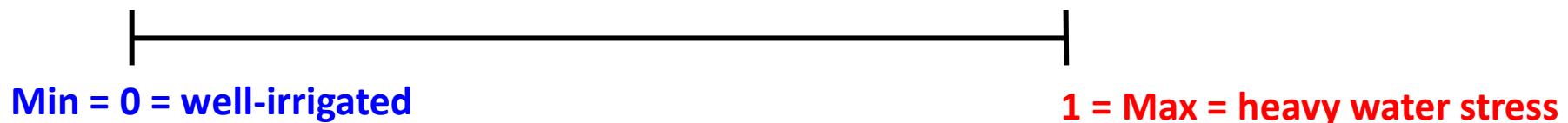
CWSI – Crop Water Stress Index

The index is based on canopy temperature (T_{canopy}) and two extreme reference temperatures:

$$CWSI = \frac{(T_{canopy} - T_{min})}{(T_{max} - T_{min})} \quad (\text{Idso } et \text{ al.}, 1981)$$

The T_{min} and T_{max} are crops with identical properties as the measured crop but

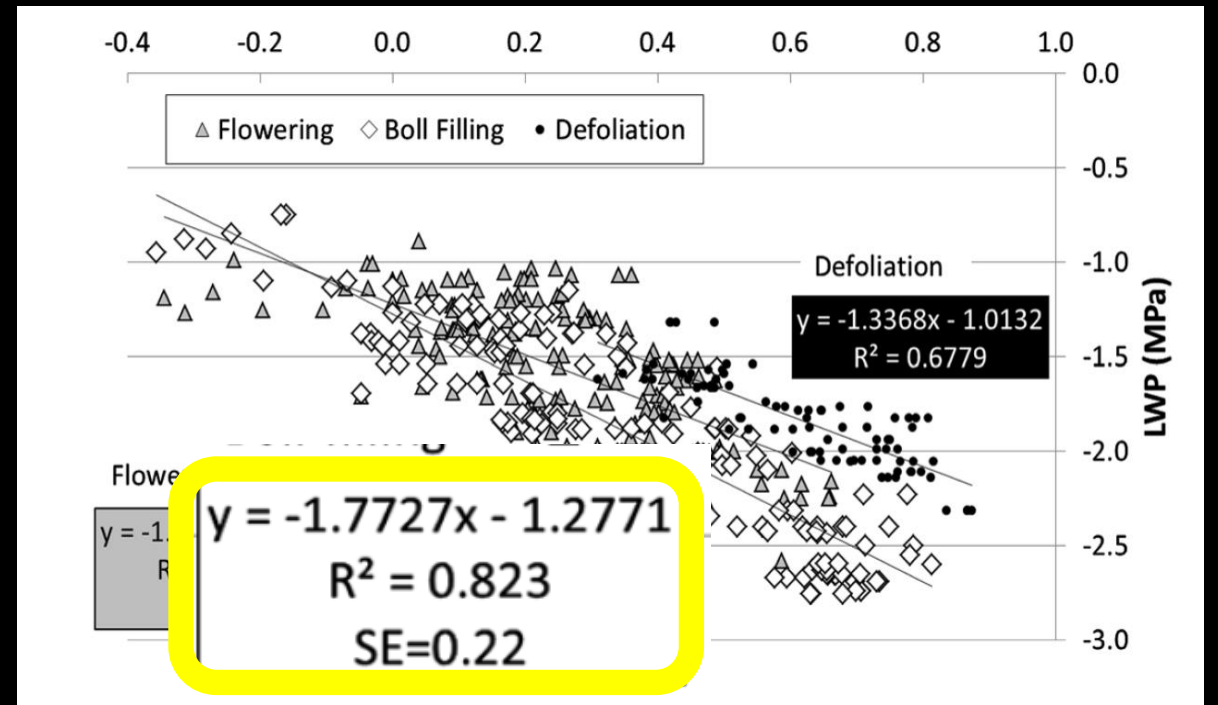
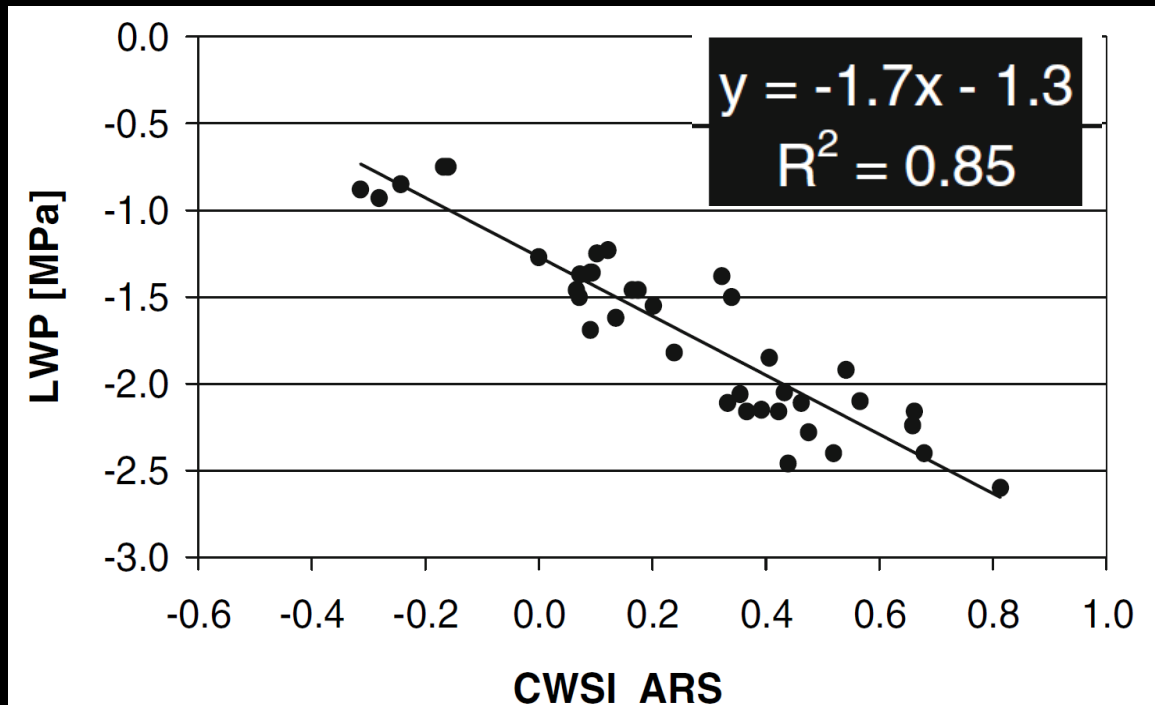
- $T_{min/wet}$ is transpiring at maximal rate
- $T_{max/dry}$ is not transpiring at all.



Thermal imaging for estimating canopy water status in cotton

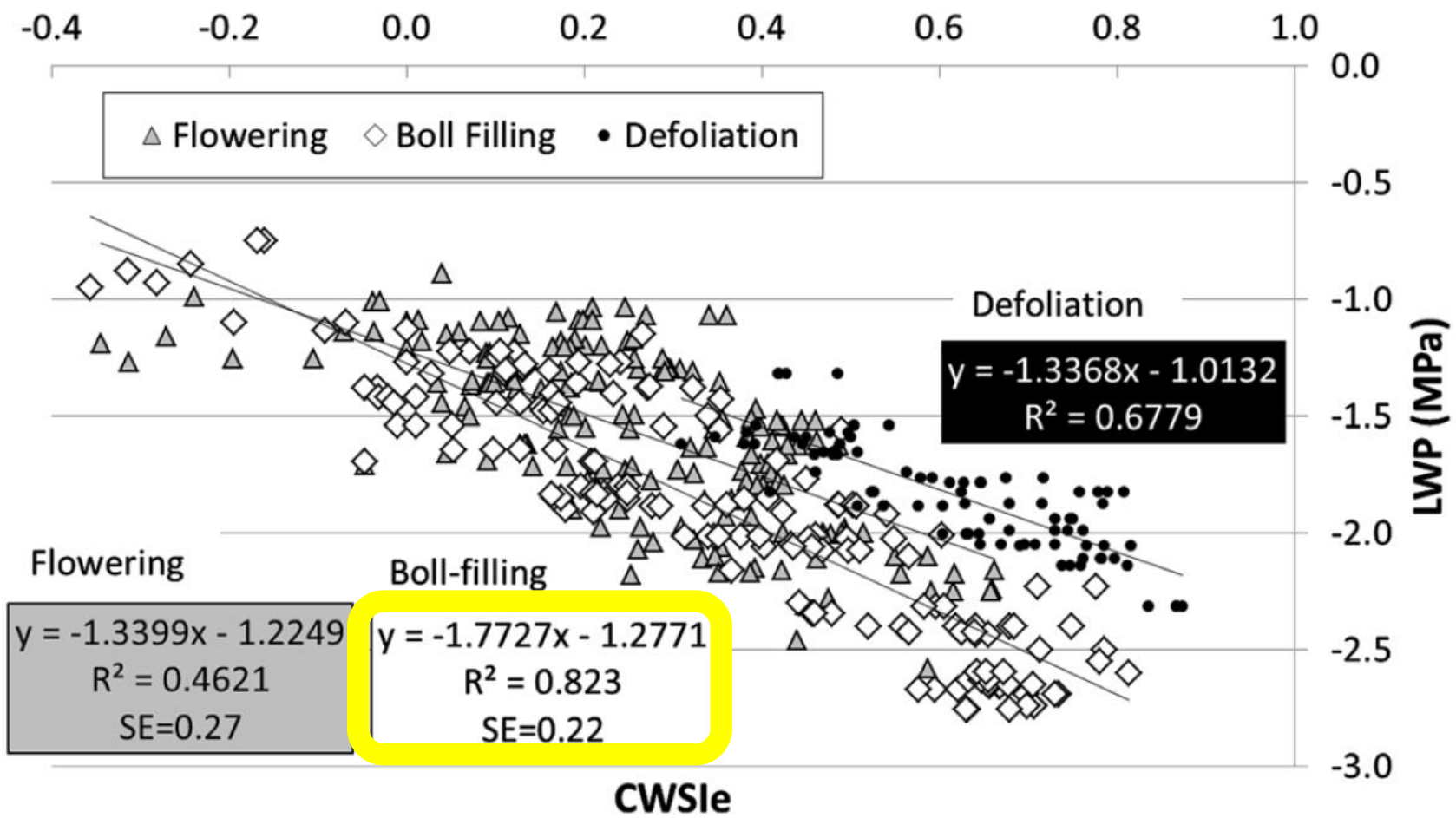
Leaf	Cohen et al., 2005: at the leaf scale (ground platform)
Canopy	Alchanatis et al., 2010: at the leaf and canopy scale (ground platform);
Canopy, multi seasons	Cohen et al., 2015: at the canopy scale (ground platform; multi-seasons)
Field	Cohen et al., 2017: at the field scale (aerial platforms)

Accuracy vs “big-data”



- Small-data with high accuracy
- Large-data with low accuracy, high statistical certainty?

Multi-year model development using ground-based thermal images



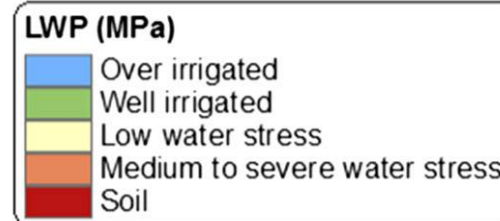
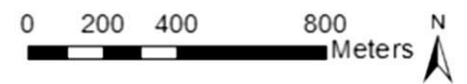
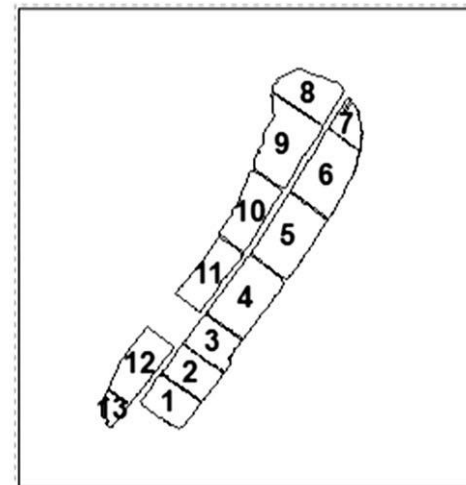
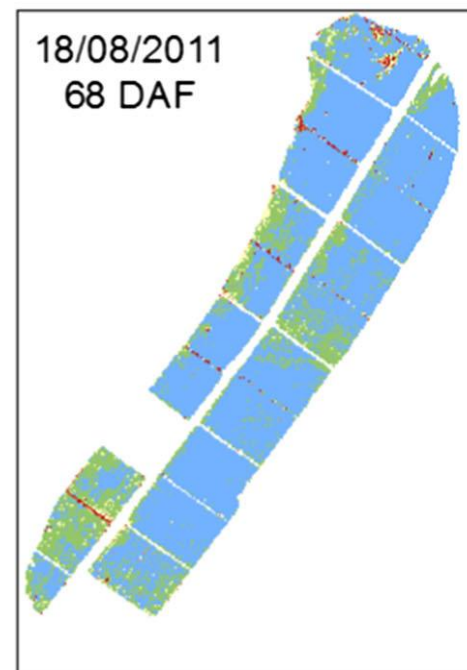
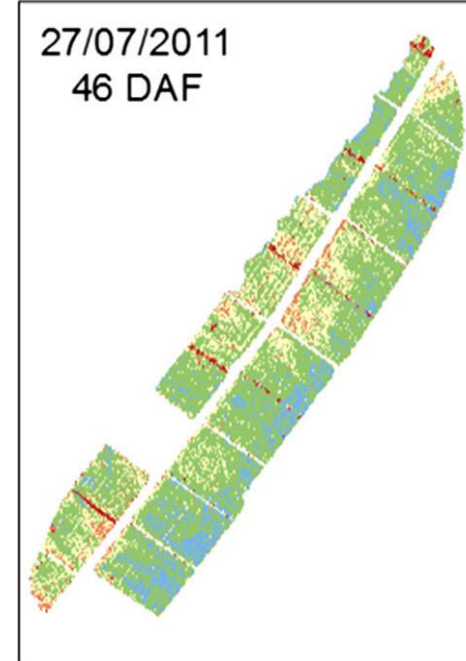
Cohen et al.,
2015, *Precision
Ag*

Mapping water status based on aerial thermal imagery: comparison of methodologies for upscaling from a single leaf to commercial fields



CWSI-LWP model for LWP mapping in a field-scale

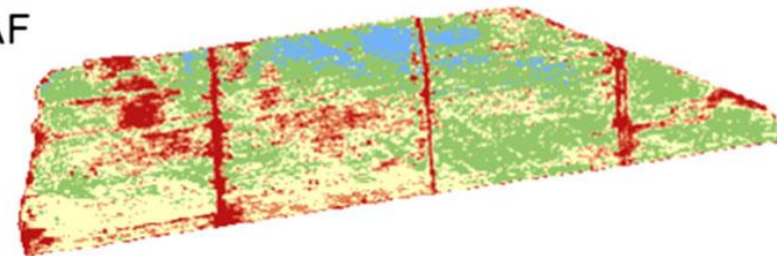
- הדגם המרחבי של מצב המים משתנה לאורך העונה



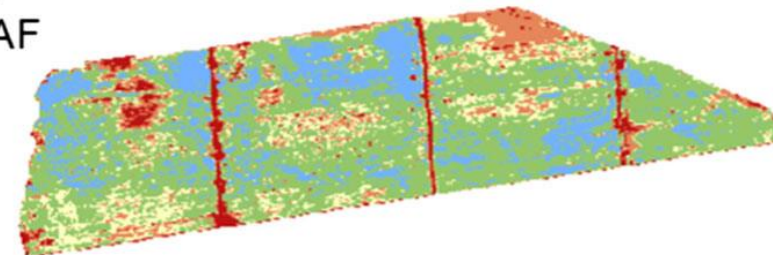
CWSI-LWP model for LWP mapping in a field-scale

- הדגם המרחבי של מצב המים משתנה לאורך העונה

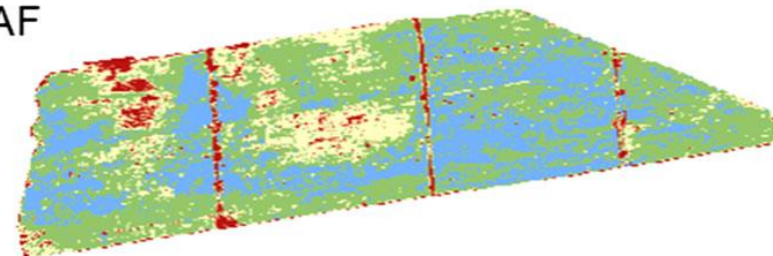
10/07/2011
Akalpi, 22 DAF



27/07/2011
Akalpi, 39 DAF



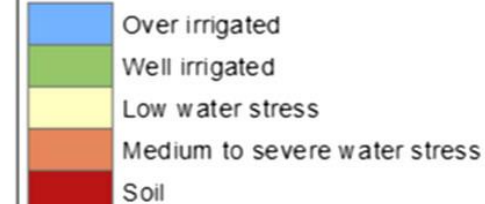
18/08/2011
Akalpi, 61 DAF



0 50 100 200 300 400
Meters



LWP (MPa)



Thermal imaging for irrigation management in cotton

Giv'at Brener

Cohen et al., 2022: Oblique imaging, **Experimental plots**

Bney-Darom

Cohen et al., 2022: UAV thermal imaging, Drip irrigation, in a **commercial field** 2018, 2019

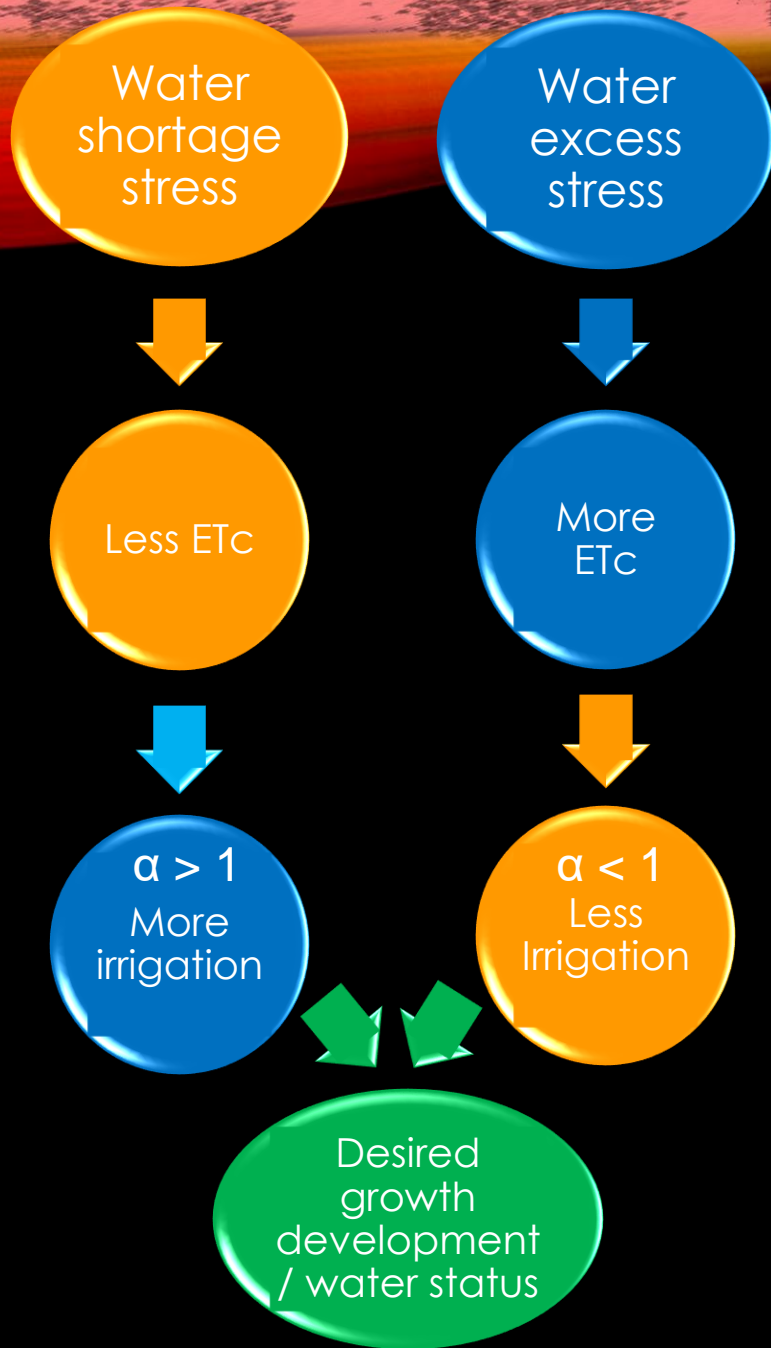
Gilat

UAV thermal imaging, VR pivot, **a commercial scale** 2020, 2021

?

טפטפת חכמה





ESTIMATION OF LEAF WATER POTENTIAL BY THERMAL IMAGERY AND SPATIAL ANALYSIS

- LWP as a water status estimation

$$Irrig = \alpha * K_c * ET_0$$

α = irrigation correction coefficient

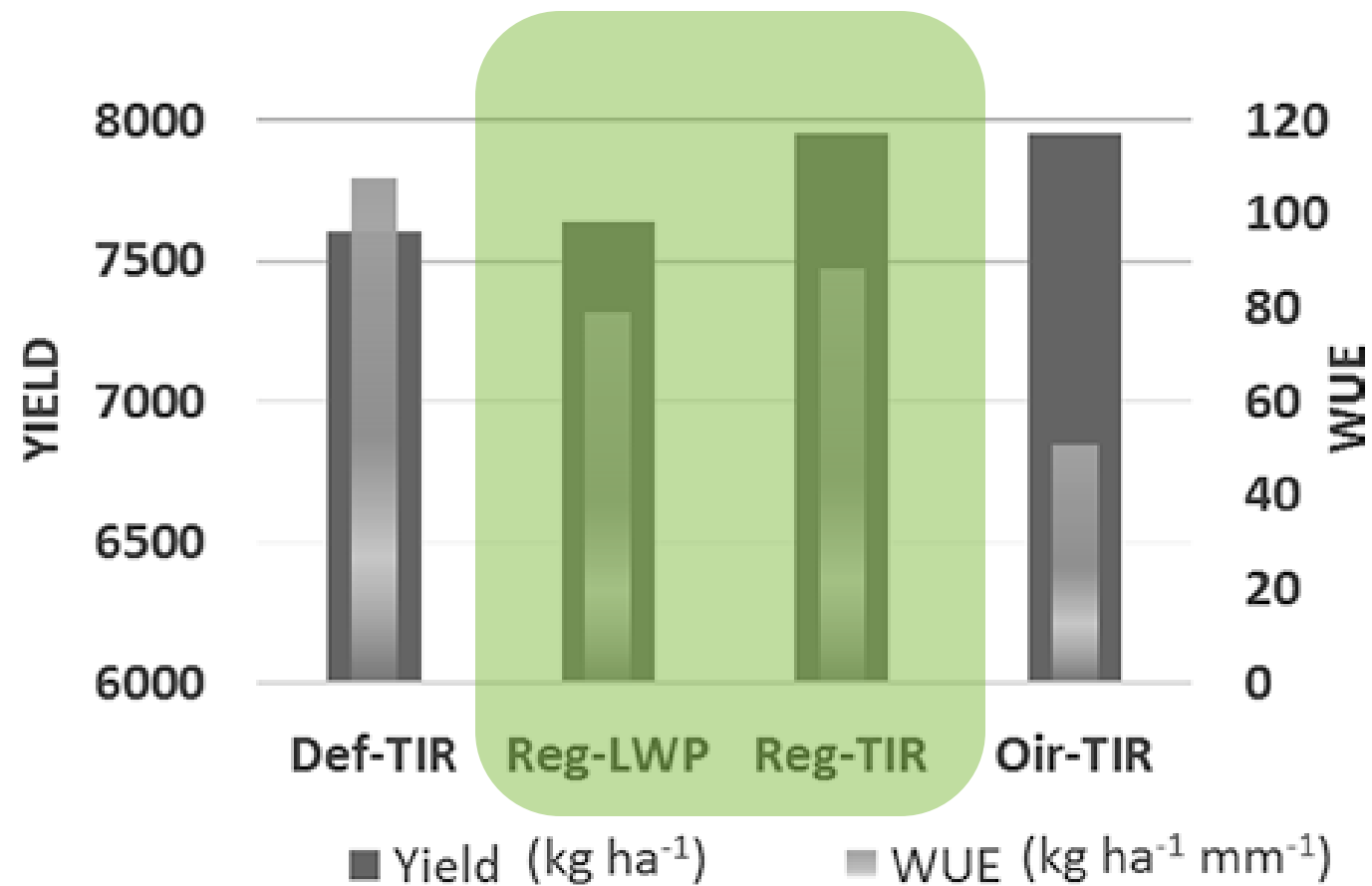
ET_0 –reference evapotranspiration

K_c – crop coefficient generally based on the phenology, LAI

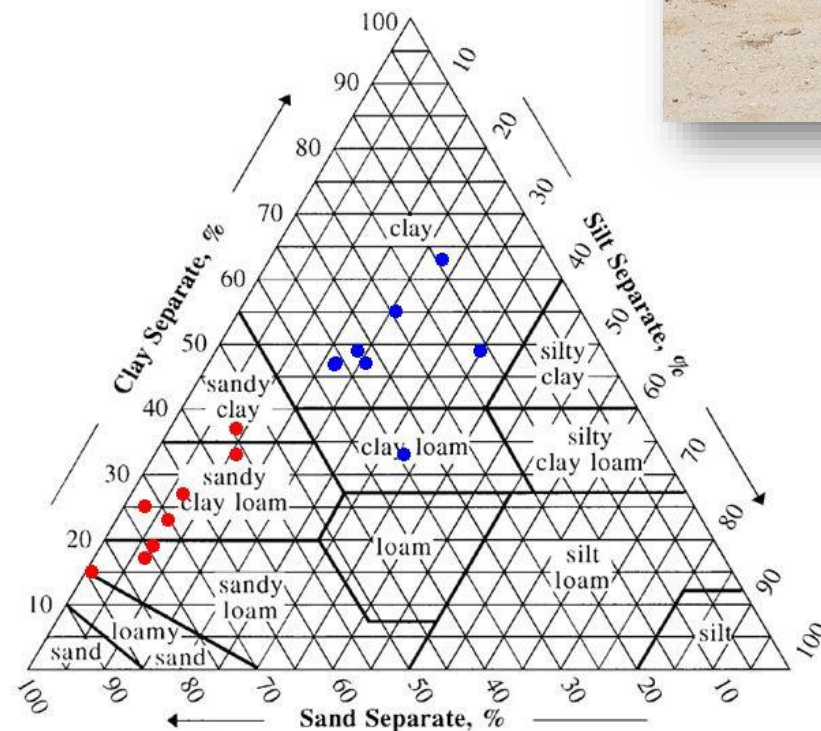
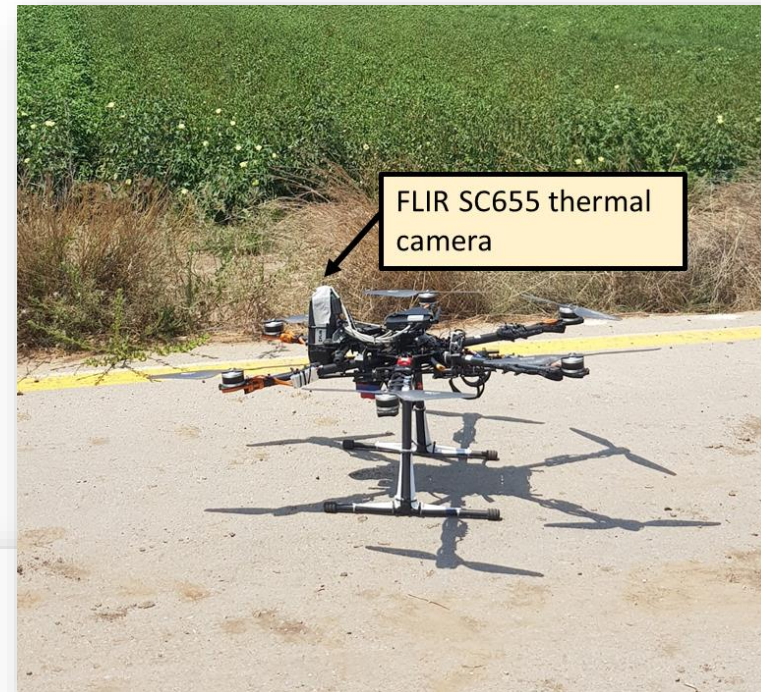
Giv'at Brener



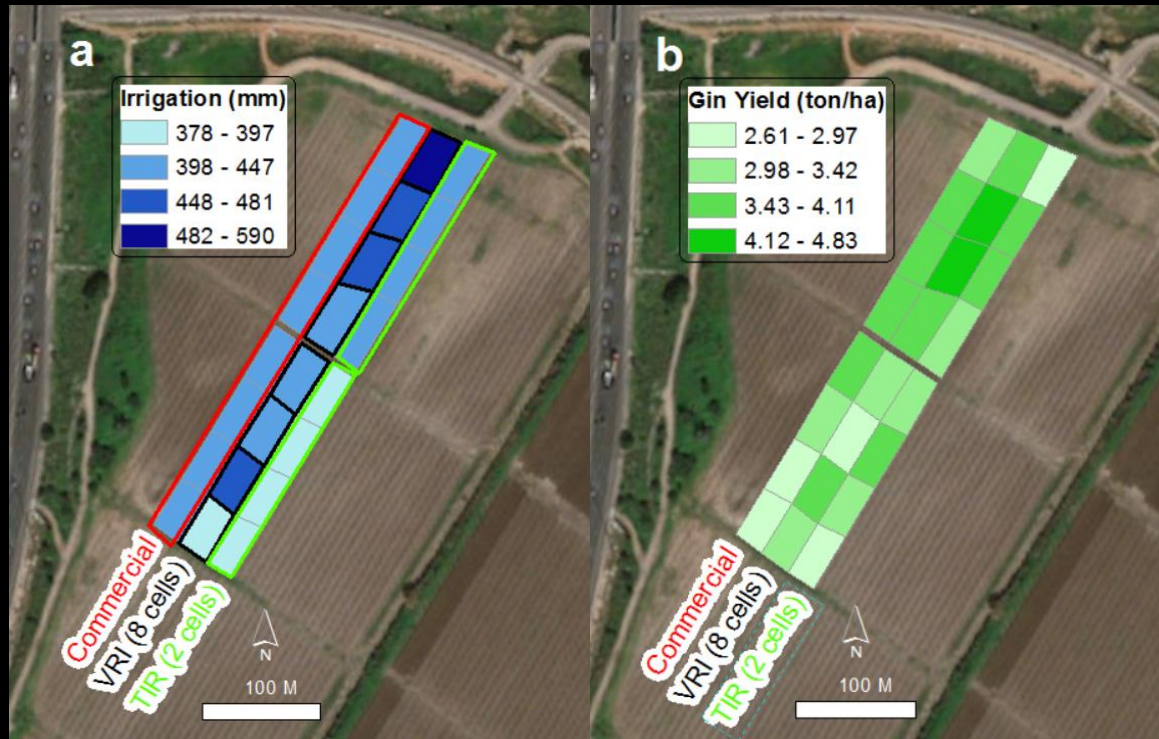
Giv' at Brener



Bney-Darom



Thermal imaging for irrigation management -2018



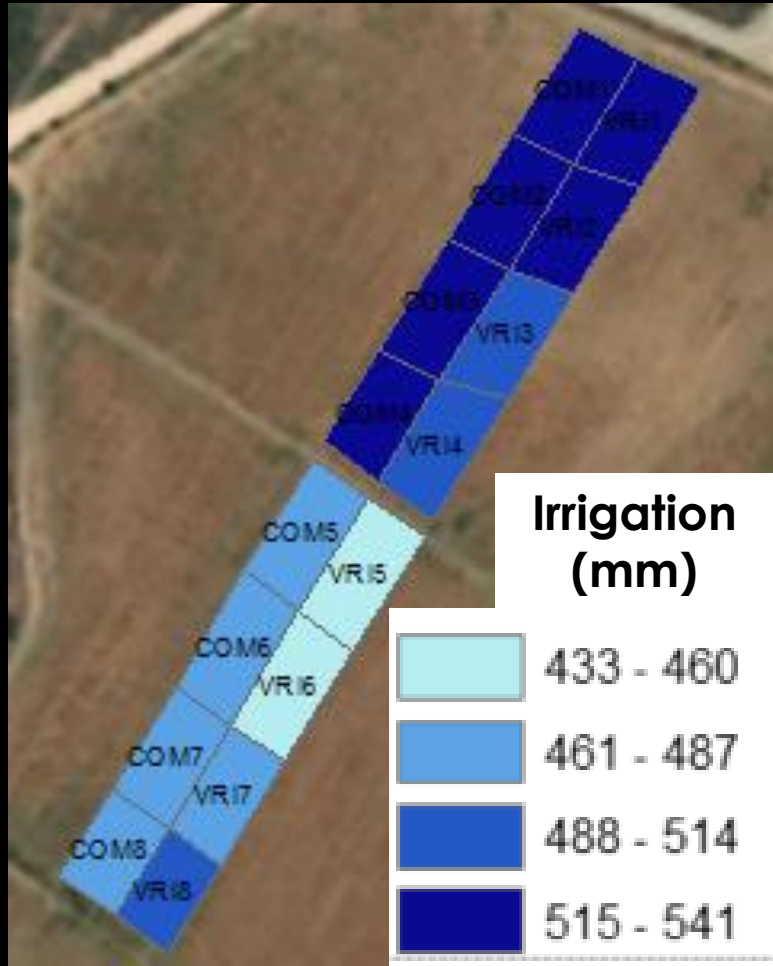
	Block	Com	VRI	Diff VRI
Yield (kg ha ⁻¹) + 7.2%	1	7997	9282	16%
	2	9263	12388	34%
	3	10398	12108	16%
	4	9103	9199	1%
	5	9531	8718	-9%
	6	7794	7276	-7%
	7	7013	9444	35%
	8	10593	7519	-29%
	Avg.	8961	9492	7.2%
WUE (kg ha ⁻¹ mm ⁻¹) - 0.2%	1	16.80	15.26	-9%
	2	19.46	25.64	32%
	3	21.84	24.27	11%
	4	19.12	19.77	3%
	5	24.69	20.52	-17%
	6	20.19	17.85	-12%
	7	18.17	20.54	13%
	8	27.44	20.95	-24%
	Avg.	20.96	20.60	-0.2%



Thermal imaging for irrigation management -2019

Chapter:
Cohen et al.,
2022

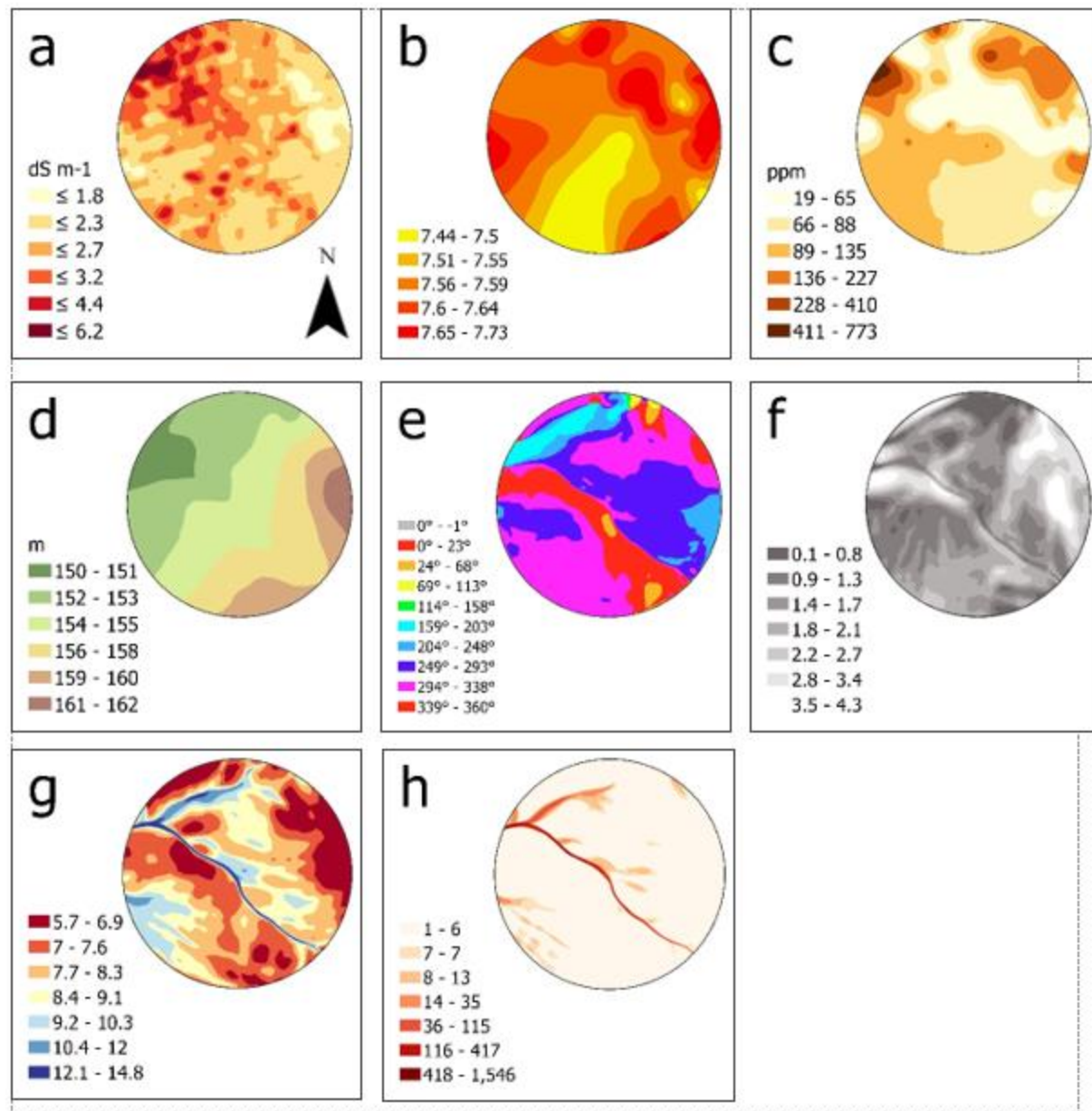
in
Kerry and
Escolà, Eds,
Sensing
Approaches for
Precision
Agriculture



	Block	Com	VRI	% Diff VRI
Yield (kg ha ⁻¹) + 17.8%	1	5702	5316	-7%
	2	4651	5136	10%
	3	3582	5671	58%
	4	6841	7310	7%
	5	5417	6681	23%
	6	5601	7072	26%
	7	5459	5660	4%
	8	4136	4961	20%
	Avg.		5174	5976
IWUE (kg ha ⁻¹ mm ⁻¹) + 19.8%	1	10.54	10.30	-2%
	2	8.59	9.95	16%
	3	6.62	11.44	73%
	4	12.64	14.52	15%
	5	12.11	14.53	20%
	6	12.53	16.33	30%
	7	12.21	12.28	1%
	8	9.25	9.85	6%
	Avg.		10.6	12.4

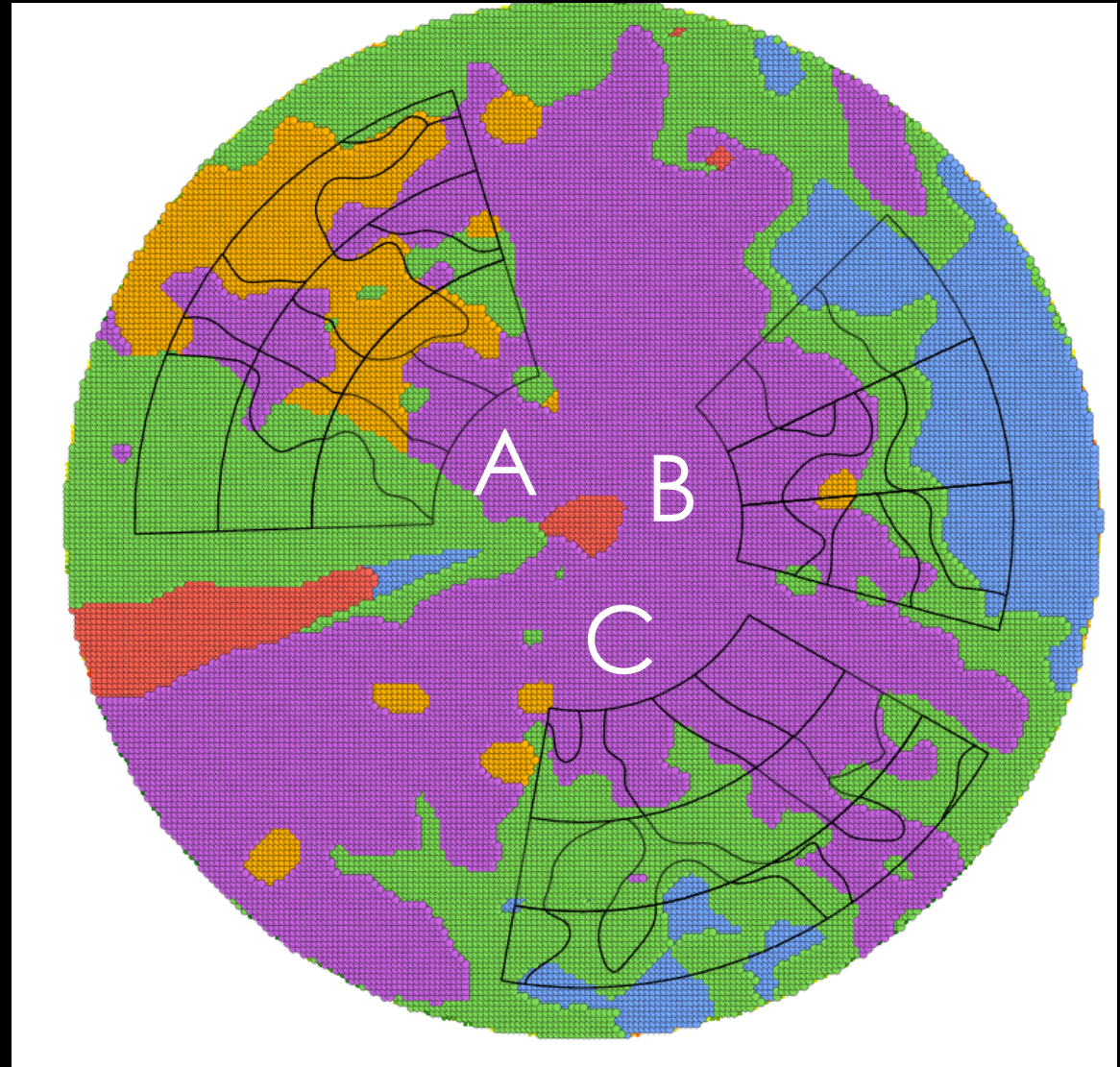


Gilat

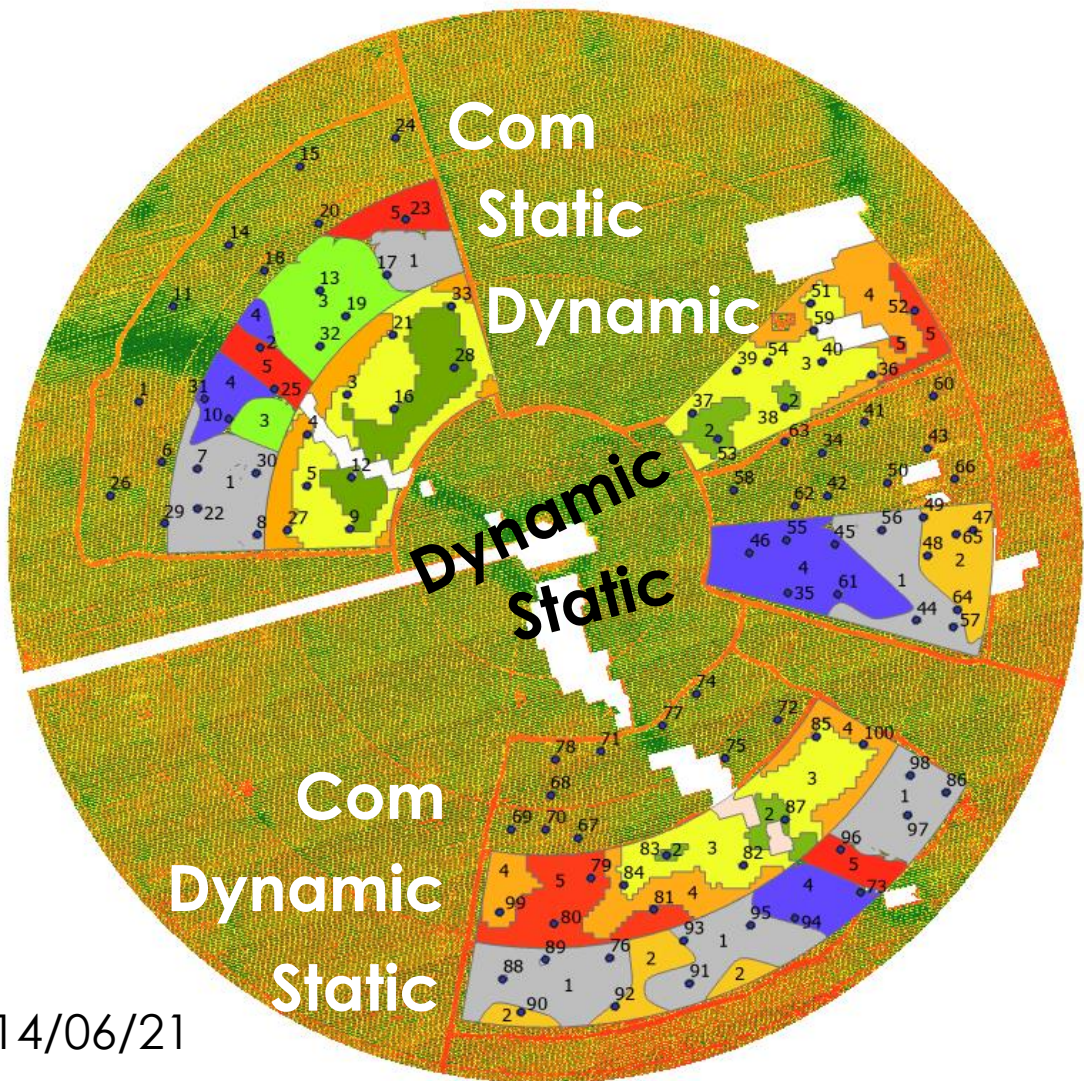


TREATMENTS

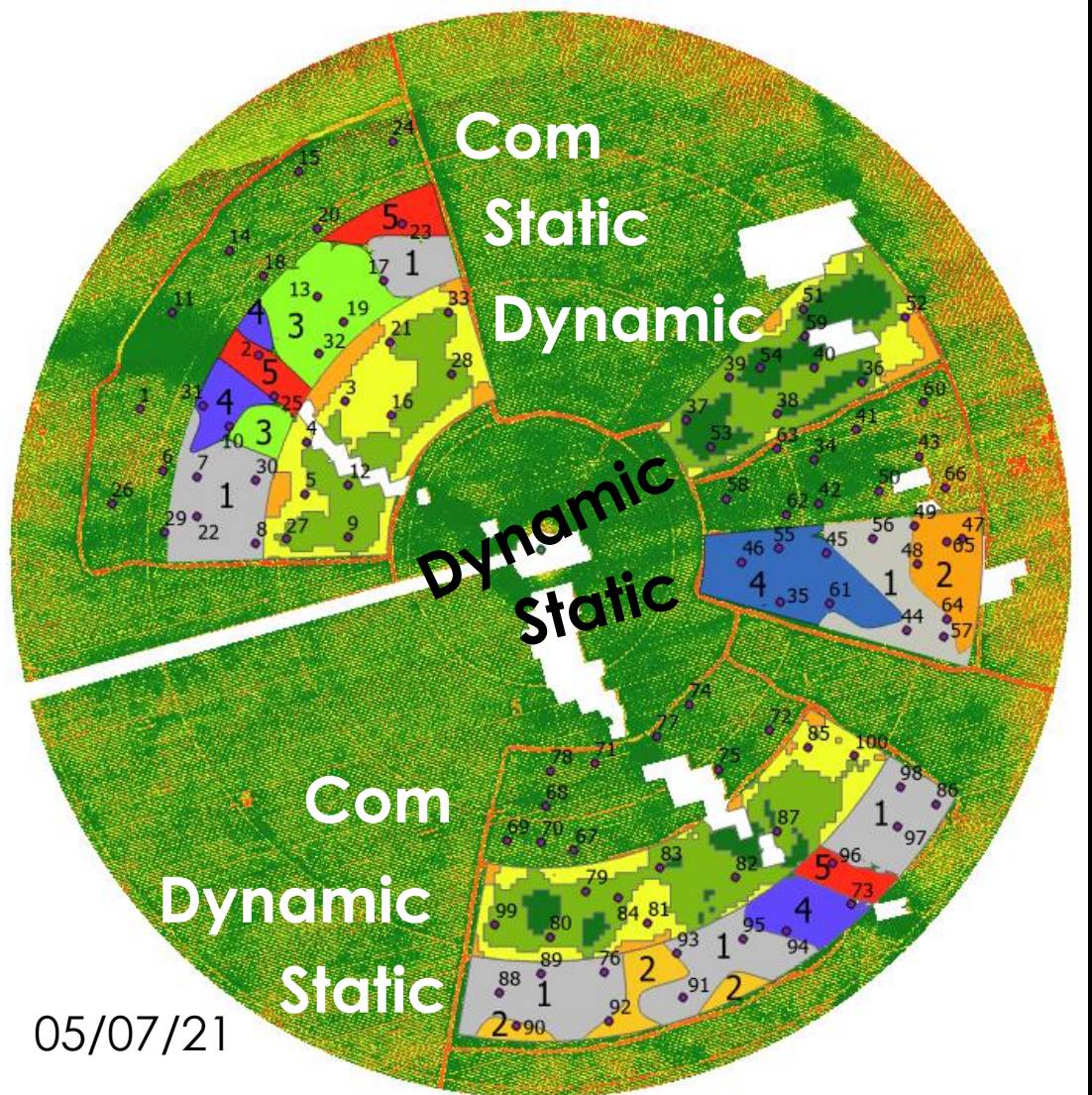
- Commercial – Direct LWP measurements
- RS-based
 - Static MZ
 - Dynamic MZ
 - 3 sectors
 - NDVI for K_c
 - CWSI for α



STATIC AND DYNAMIC MZS

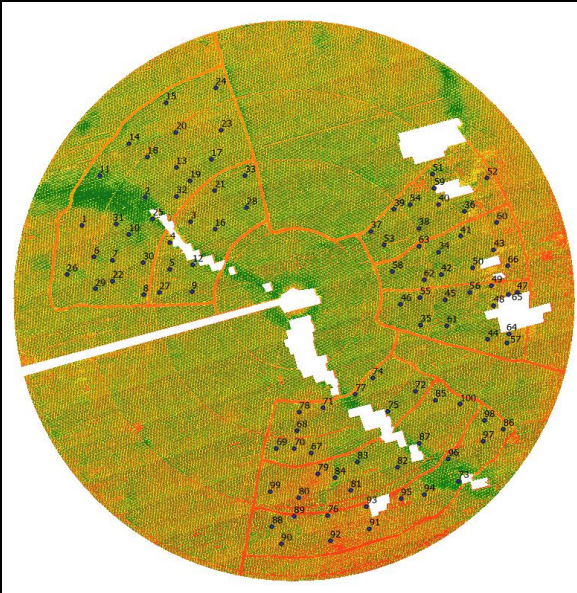


14/06/21

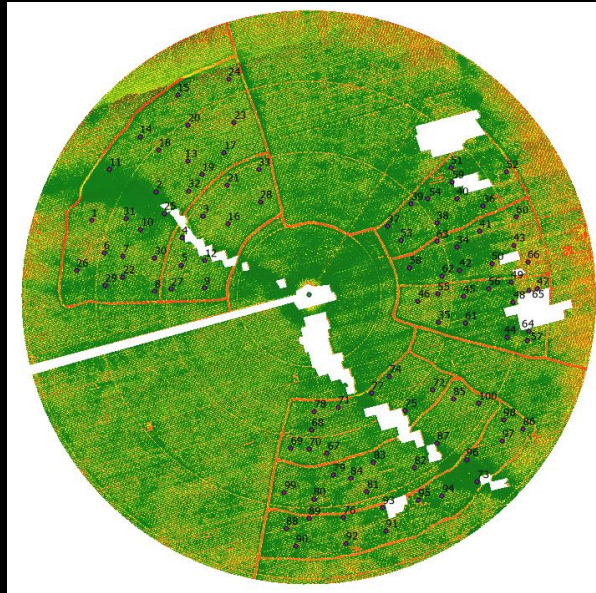


05/07/21

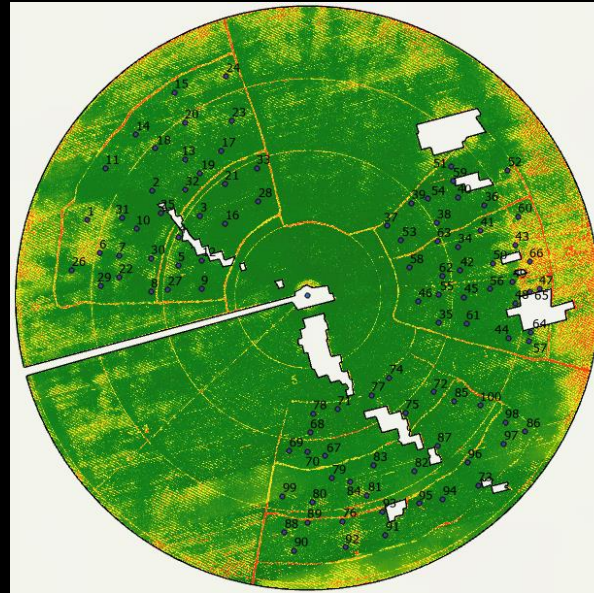
NDVI – TIME SERIES



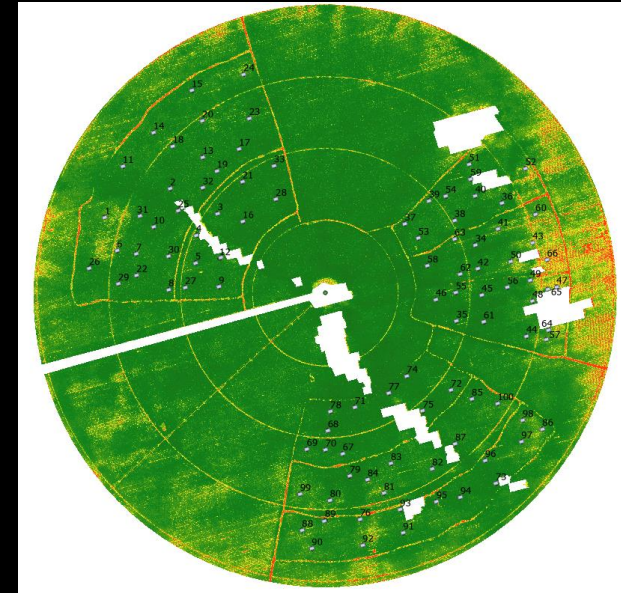
14/06/21



05/07/21

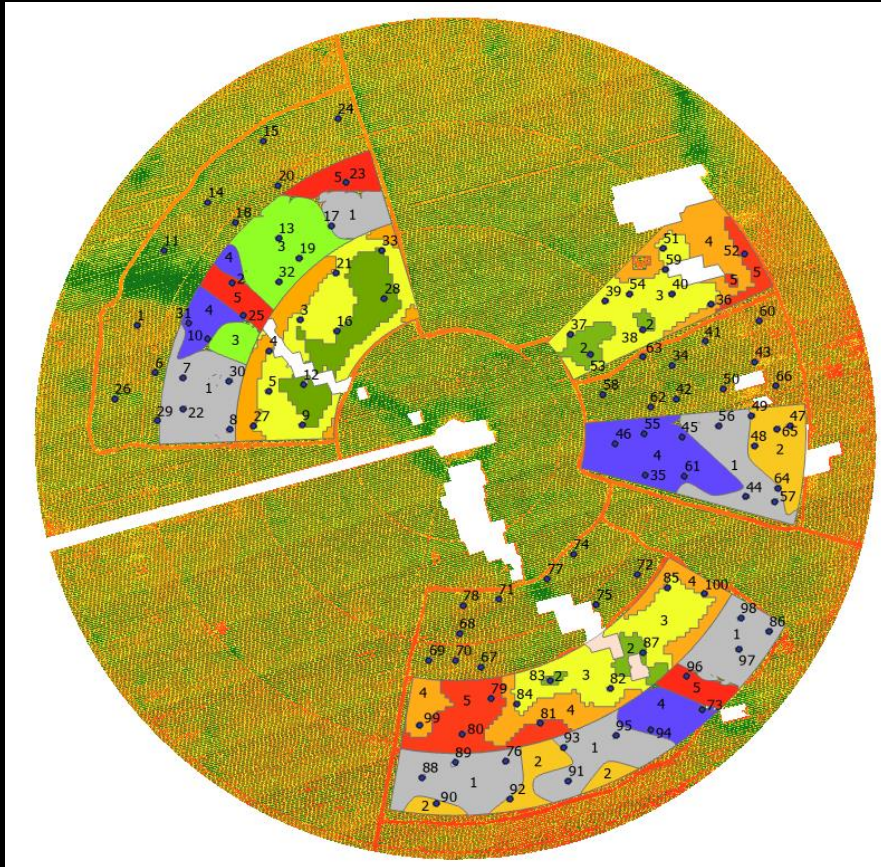


26/07/21

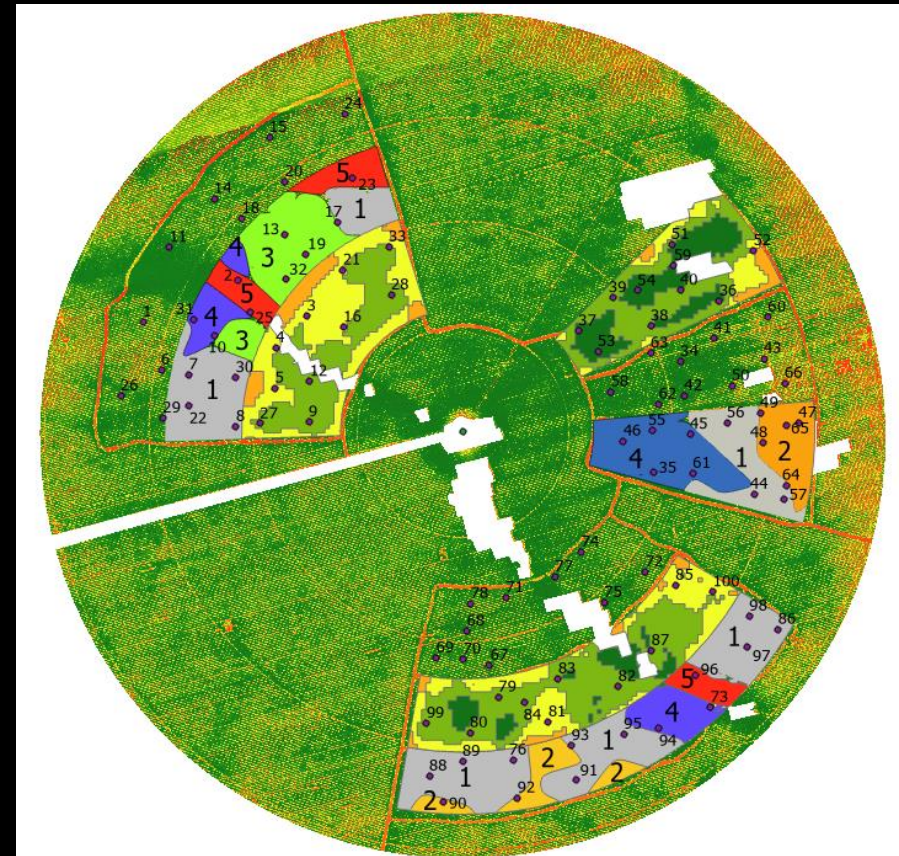


09/08/21

DYNAMICS IN MZ



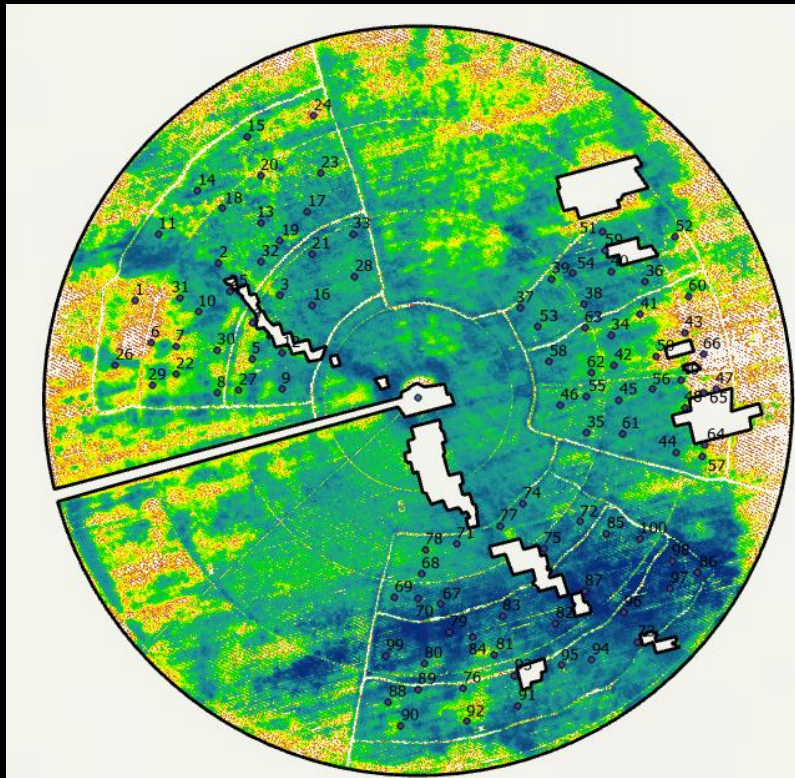
14/06/21



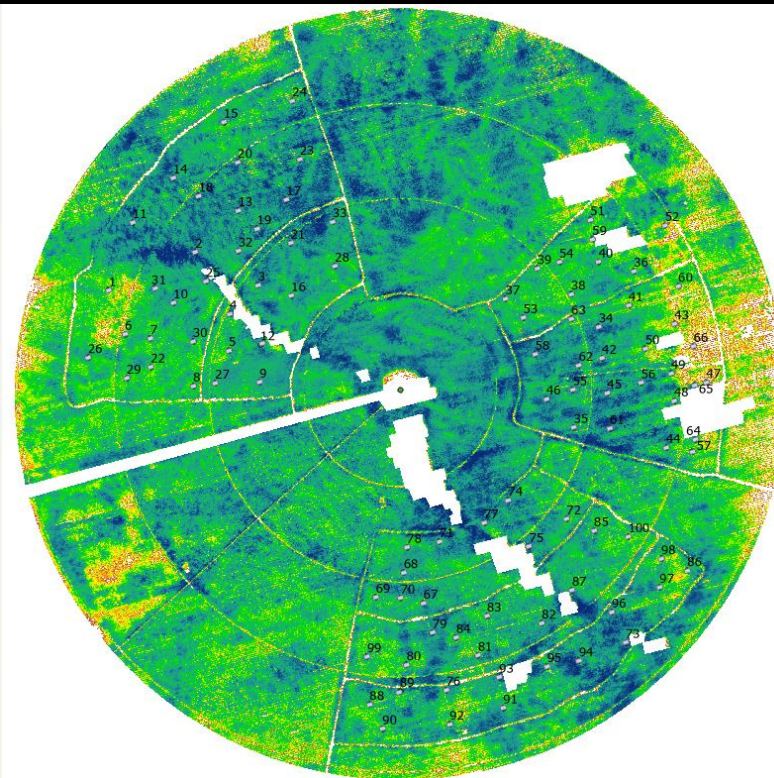
05/07/21

CWSIbasepixel
Value
1.19914
-0.147315

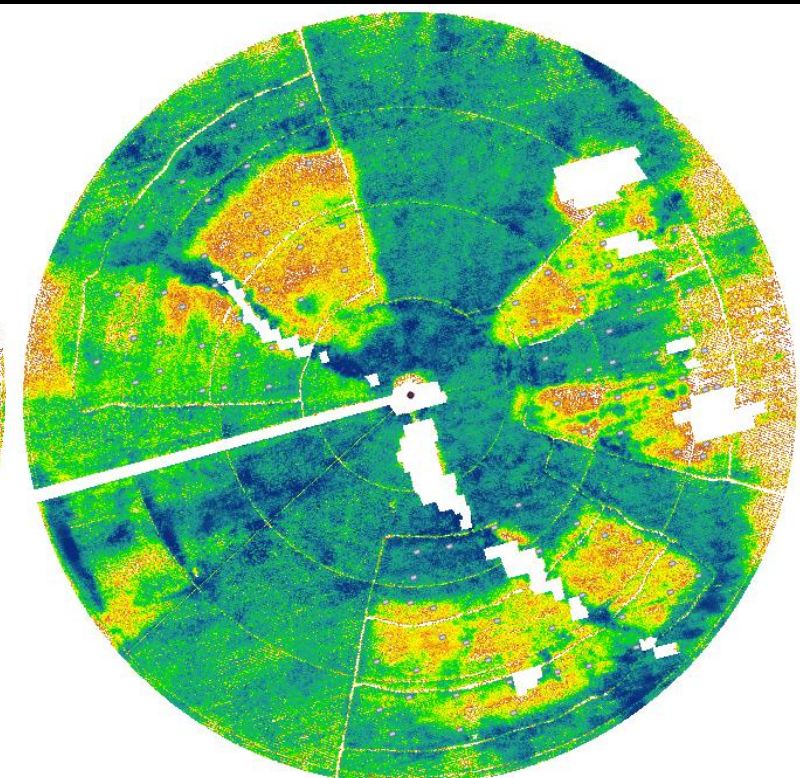
CWSI – TIME SERIES



26/07/21

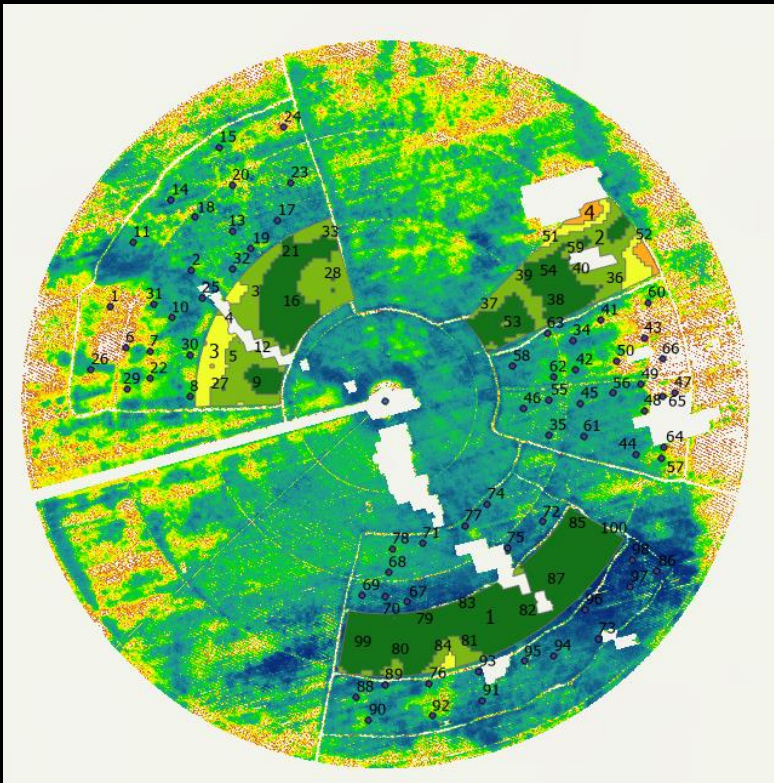


09/08/21

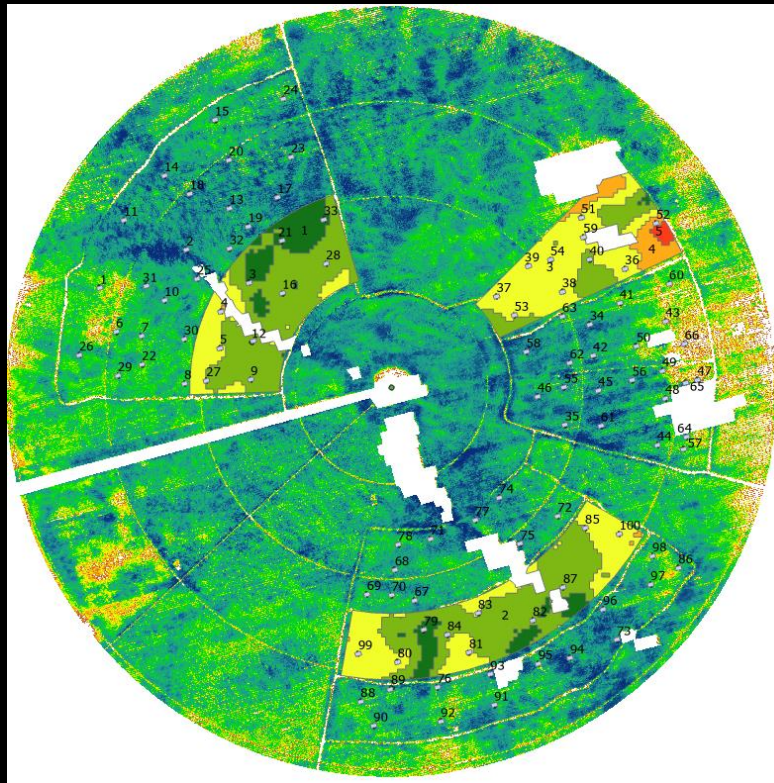


23/08/21

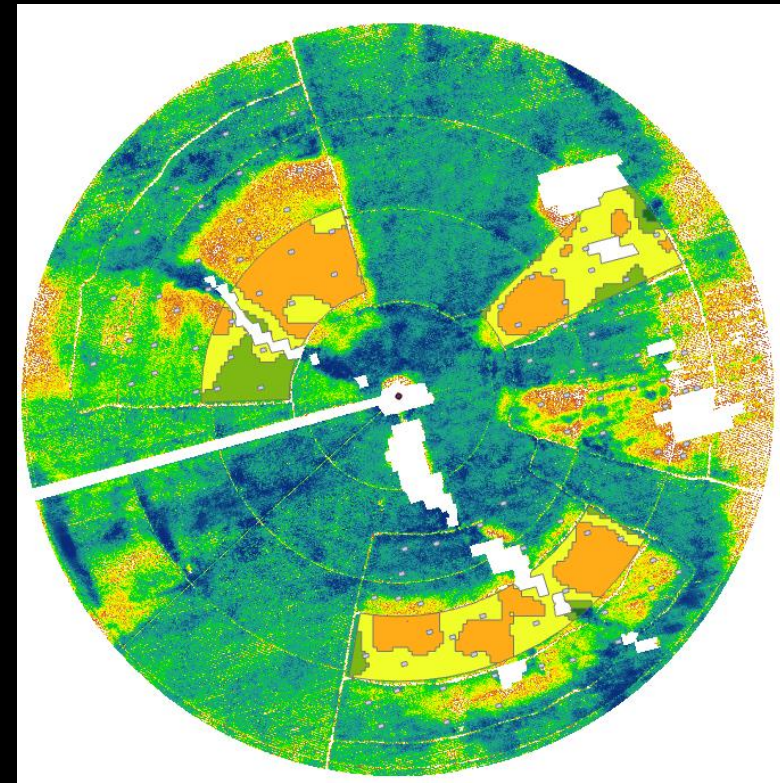
DYNAMICS IN MZ



26/07/21



09/08/21

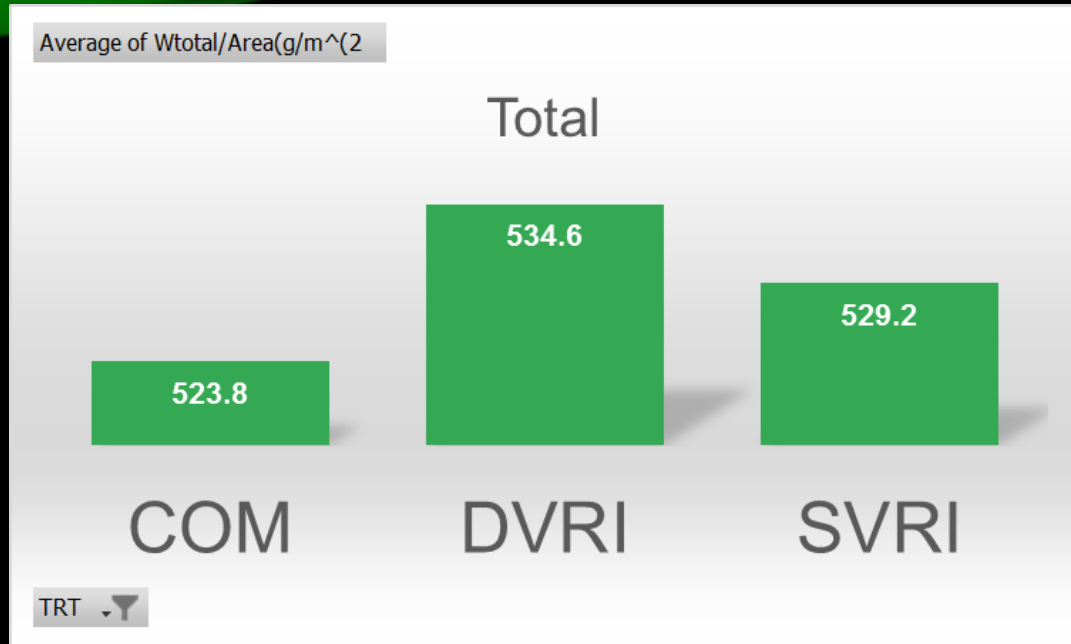


23/08/21

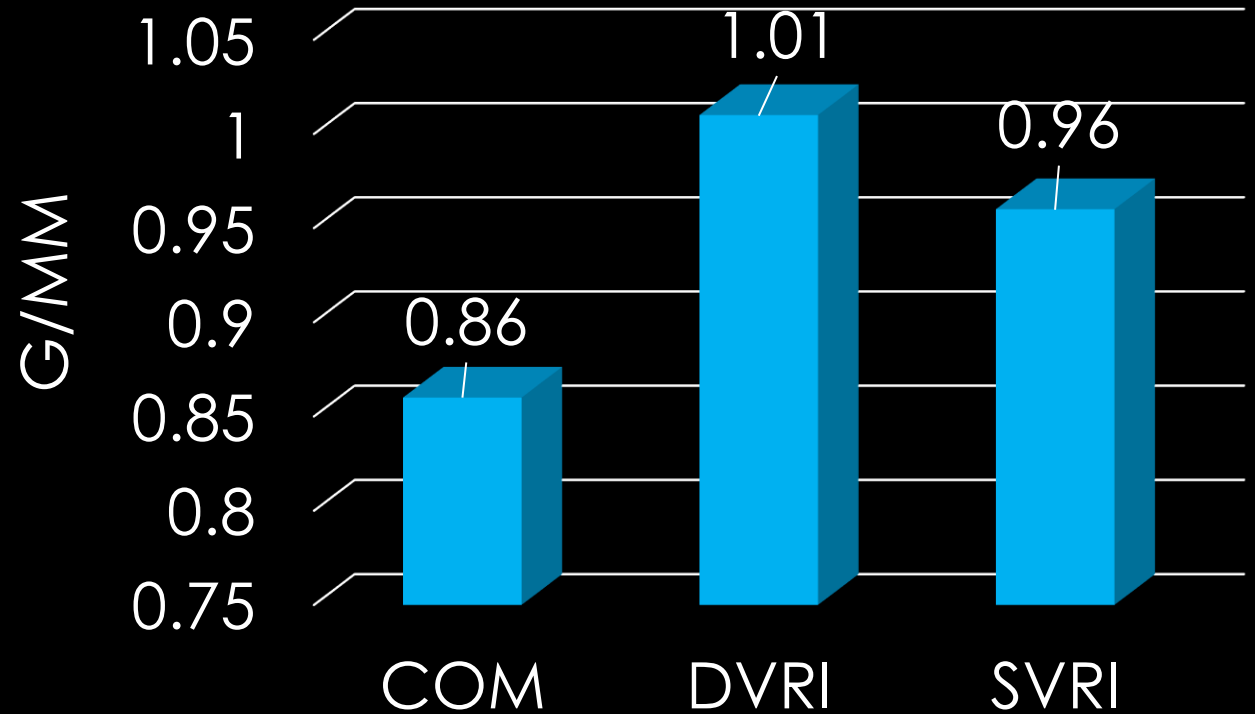




Yield



IWUE



עליה מינורית ביבול
הורדה של 15% / 10% בהשקיה (דינאמי וסטטי בהתאמה)
עליה של 17% / 11% ביעילות ההשקיה





היכן אנו עומדים היום?

- צילומים מ"ס ותרמיים באמצעות כטב"מים
- המודל שפותח למיפוי LWP עובד טוב ברמה של קבלת החלטות להשקיה
- ניתוח חצי-אוטומטי של הצילומים
- בסיס לקבלת החלטות – ההחלטות הן בסופו של דבר אנושיות ולא אוטומטיות
- קיים פוטנציאל להגדלת יעילות השימוש במים ובמקרים מסויימים אף להגדלת היבול.
- אזורי הממשק הם דינאמיים
- הצילומים התרמיים עדיין יקרים

