

WIDE-SCALE MODELLING OF WATER AND WATER AVAILABILITY WITH EARTH OBSERVATION/SATELLITE IMAGERY

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agriculture,
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Department:
Agriculture, Forestry and Fisheries
REPUBLIC OF SOUTH AFRICA

GWK

innovate agriculture



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GEOTERRA
IMAGE



eleaf
FEED THE WORLD



Introduction

- Growing need for up-to-date agricultural information to inform decisions and manage risks
- Earth observation data allows for the collection of such information at unprecedented scales, accuracy and speed
- Presentation focus on current work being carried out at Stellenbosch University (and collaborators)

Agenda

- Part A: Water use and availability modelling
 - Can we expand irrigated agriculture?
 - Scale: National
 - Mapping unit: Field
- Part B: Yield optimization and prediction
 - How can we be more productive? How can we predict production?
 - Scale: Regional
 - Mapping unit: Sub-Field (pixel)

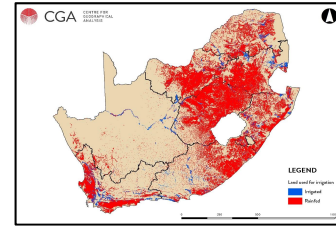
Part A: How much water is available for agricultural expansion and additional allocations? (if any)



Wide-scale modelling of water and water availability with earth observation/satellite imagery

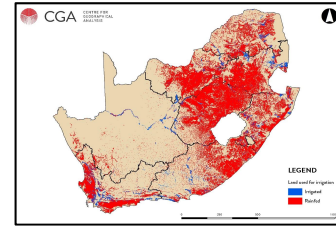
- Duration: 2014-2018
- Funded: WRC and DAFF
 - WRC Contract No. K5/2401//4
- Partners: SU, eLeaf, Caren Jarman, GeoTerra Image





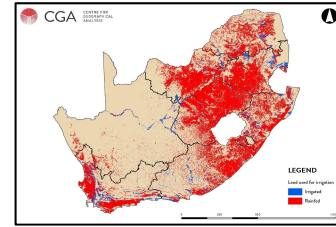
Aims

1. Map the **total area used for irrigated agriculture** in South Africa;
2. Estimate **total amount of water used by irrigated agriculture** in South Africa;
3. Quantify the **water used by selected irrigated crops** in selected areas;
4. Demonstrate how water accounting can be employed to determine water use and **water availability** over large catchments



Questions...

- **How much land** is being used for (irrigated) agriculture?
- **How much water** is used by (irrigated) agriculture?
- How much water is **available** for (irrigated) agriculture?
- Follow-up questions
 - What will happen under **different land use scenarios**?
 - What will happen if the **climate changes**?



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- How much water is **available** for (irrigated) agriculture?
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“Irrigated agriculture” definition

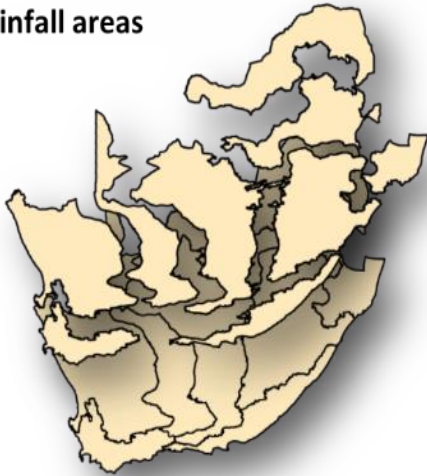
- Areas that were **actively** irrigated between August 2014 and July 2015
- **Excludes** areas that were fallow or that were **not actively irrigated** *

* However, areas that show signs of having been irrigated (e.g. pivots that are fallow) are also mapped, but as a **separate class (Previously Irrigated)** so that the total area with irrigation infrastructure can also be estimated

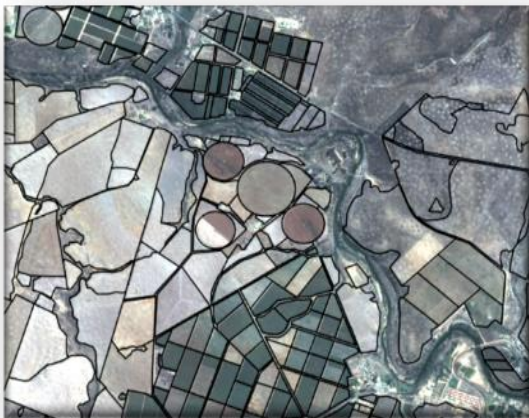


Country wide mapping of irrigated agriculture

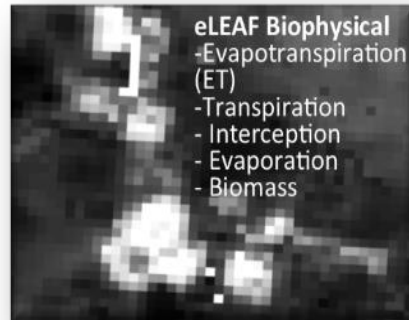
(1)... according to homogenous rainfall areas



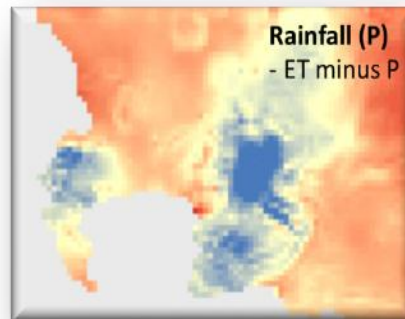
(2)... at a field level using field boundary information



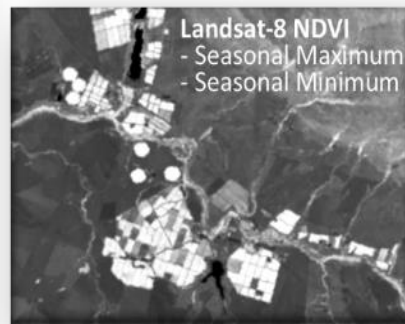
(3)...using information on crop water use,



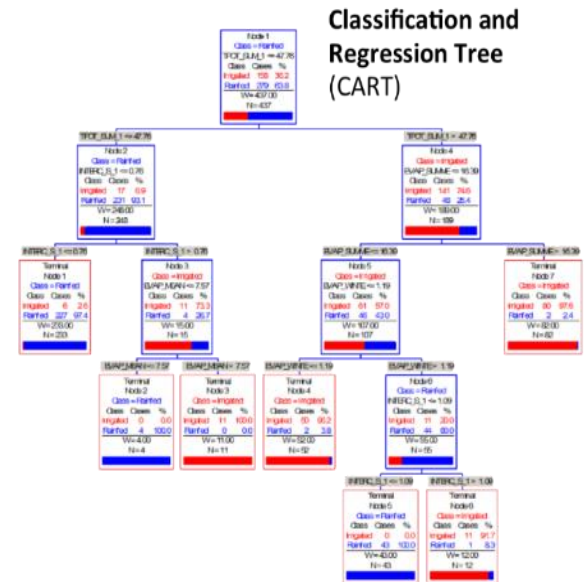
(4)...difference between ET and rainfall,



(5)...and multi-temporal vegetation indices



(6)... together with machine learning methods



(7)... to map irrigated and rainfed fields



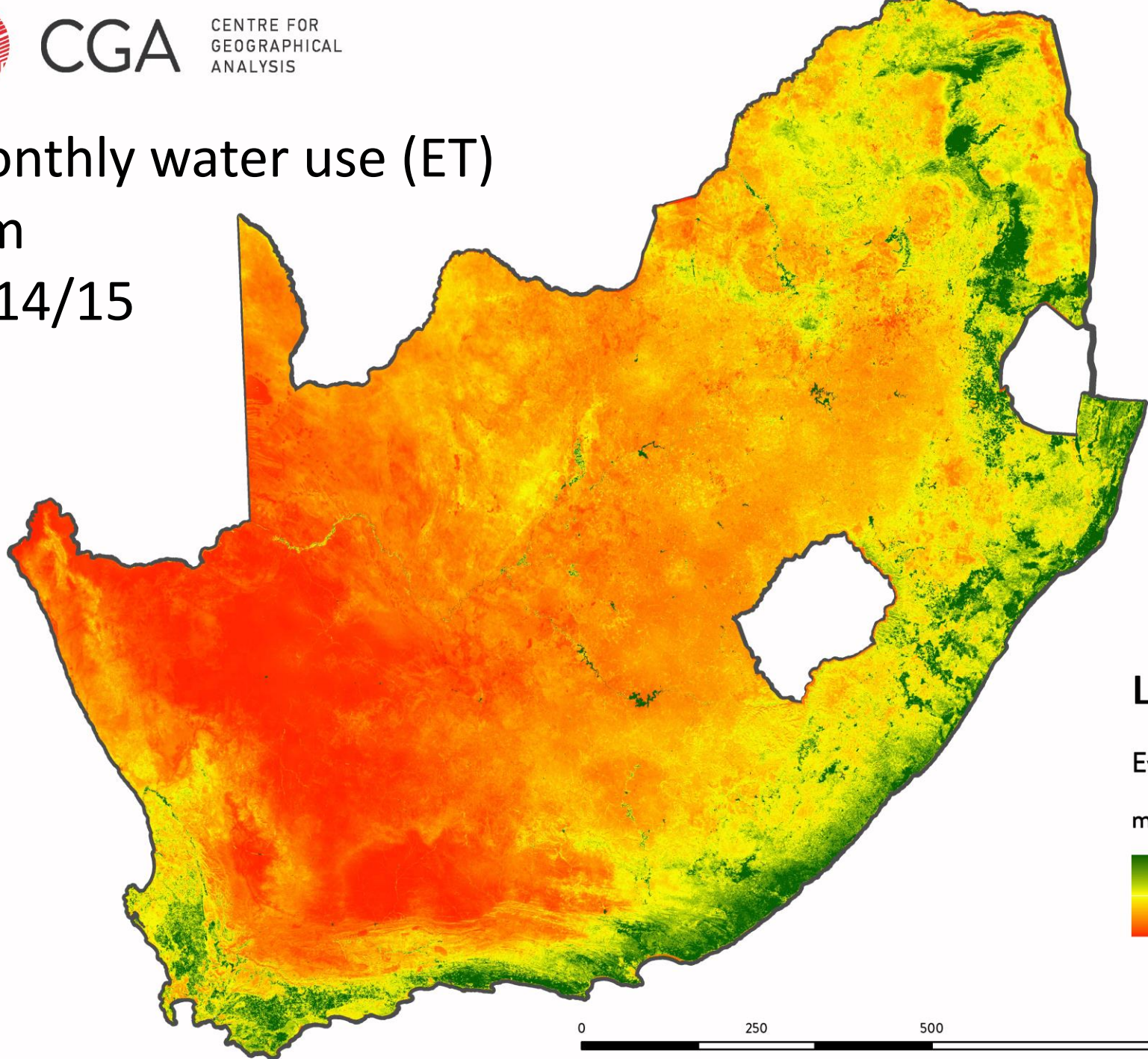


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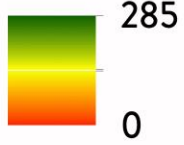
Monthly water use (ET) mm 2014/15



LEGEND

Evapotranspiration

mm



Actual water use (ET) mm/year



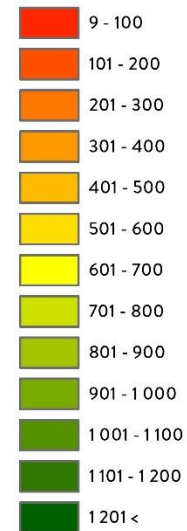
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LEGEND

● Town

Actual water use (mm/year)



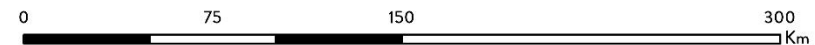
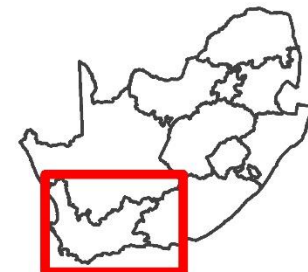
SALDANHA

WORCESTER

OUTDSHOORN

CAPE TOWN

GEORGE



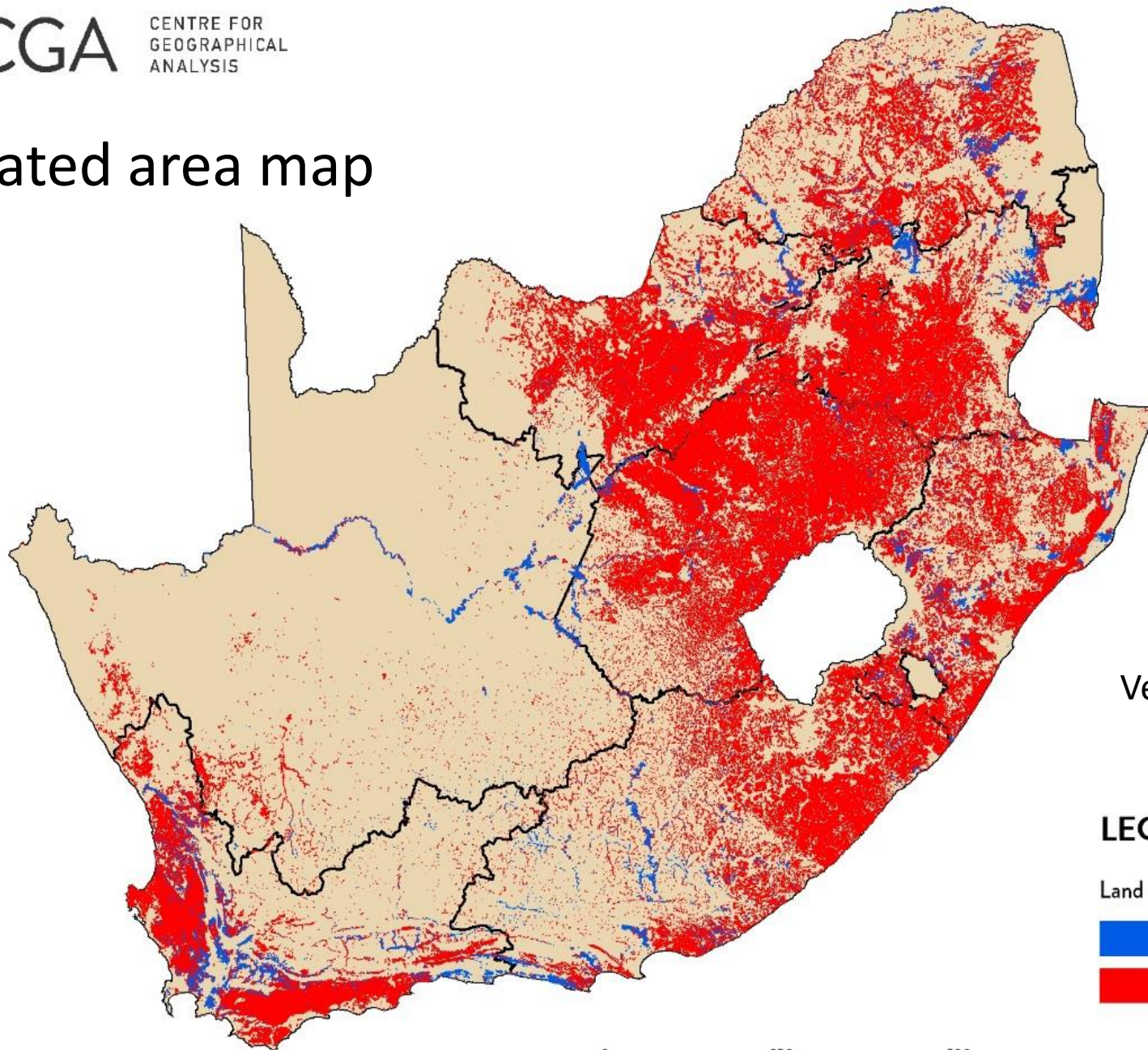


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Irrigated area map



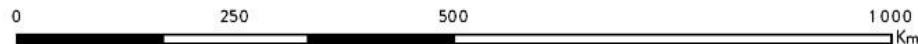
Version 2

LEGEND

Land used for irrigation

 Irrigated

 Rainfed



Classification Results

Region	Irrigated		Rainfed		Overall
	Number of samples	% correct	Number of samples	% correct	% correct
1	1086	96.96%	1311	97.56%	97.29%
2	761	95.40%	1832	97.00%	96.53%
3	377	83.55%	1 604	95.07%	92.88%
4	158	94.94%	279	97.13%	96.34%
5	576	97.22%	673	98.66%	98.00%
6	354	92.94%	804	96.64%	95.51%
7	290	98.97%	122	99.18%	99.03%
8	389	98.46%	783	98.98%	98.81%
9	696	98.13%	1137	98.68%	98.47%
ALL	3601	95.17%	867.63	97.66%	96.98%

Province	Total area	Actively irrigated area		Potentially irrigated area		Registered water use	
		Version 2 2014/15 * v2.1		DAFF 2016 (Crop Types excl sugarcane)		WARMS (2015) Cameron Tylcoat	
	ha	ha	%	ha	%	ha	%
Western Cape*	12 946 200	269 229	2.08	329 517	2.55	362 253	2.80
Northern Cape*	37 288 900	149 532	0.38	153 849	0.41	105 609	0.28
Eastern Cape	16 896 600	177 608	1.05	216 946	1.28	147 695	0.87
Free State	12 982 500	119 590	0.92	193 442	1.49	107 199	0.83
KZN	9 436 130	173 325	1.84	120 836	1.28	207 976	2.20
North West	10 488 200	84 005	0.80	108 273	1.03	82 427	0.79
Gauteng	1 817 830	14 919	0.82	28 755	1.58	49 234	2.71
Mpumalanga	7 649 470	117 170	1.53	96 678	1.26	158 246	2.07
Limpopo	12 575 400	192 104	1.53	241 319	1.92	225 360	1.79







Validations and feedback

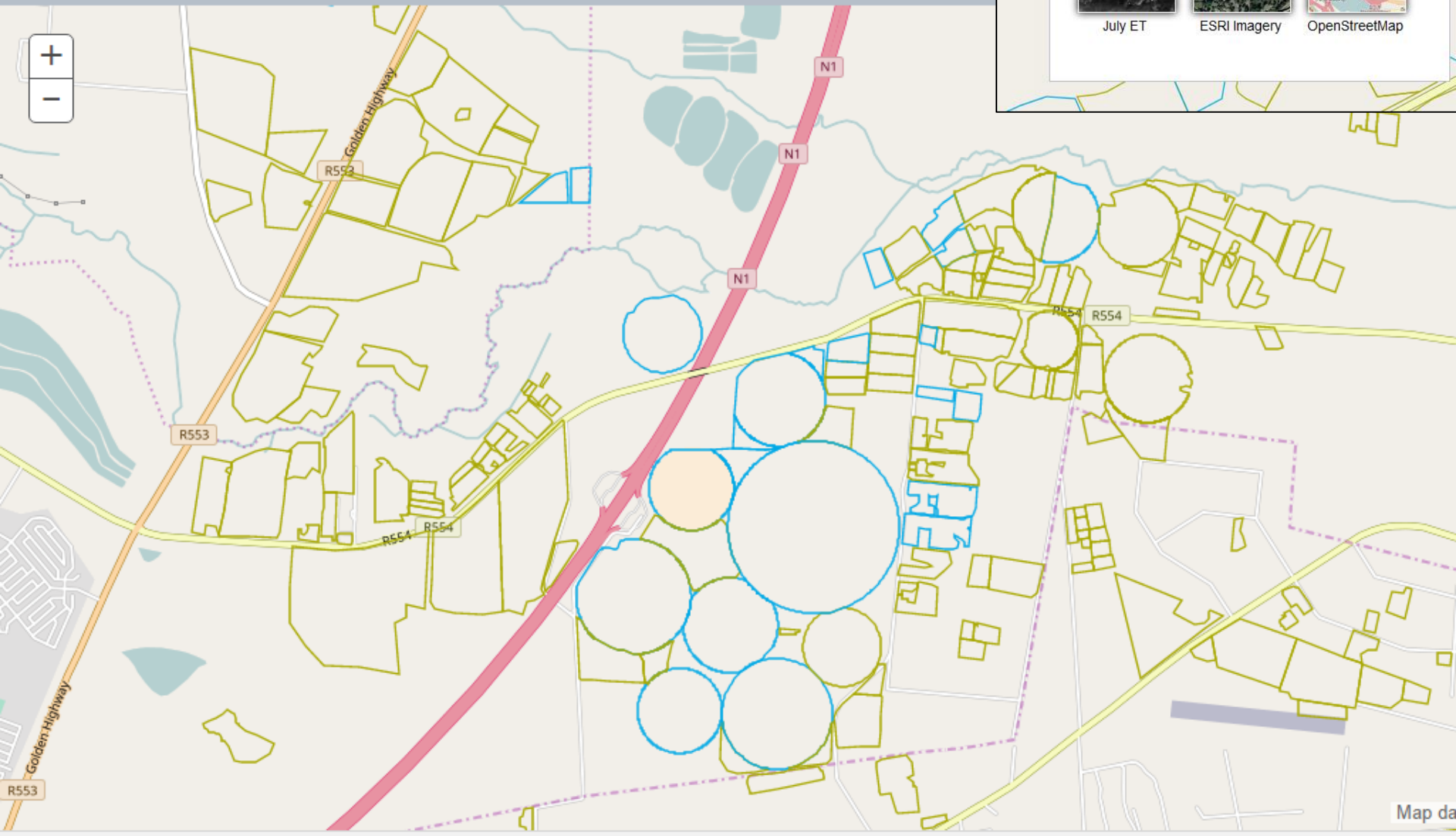
- Web-based interface created for validations
- Validation challenging, because
 - the map is of 2014/15
 - confusion between actively irrigated and previously irrigated
- Very positive feedback received
- Still opportunity to give inputs

http://sungis10.sun.ac.za/fields_wrc/

Vaal Irrigation: Zoom in and click on field to change irrigation status. Green=Rainfed, Blue=

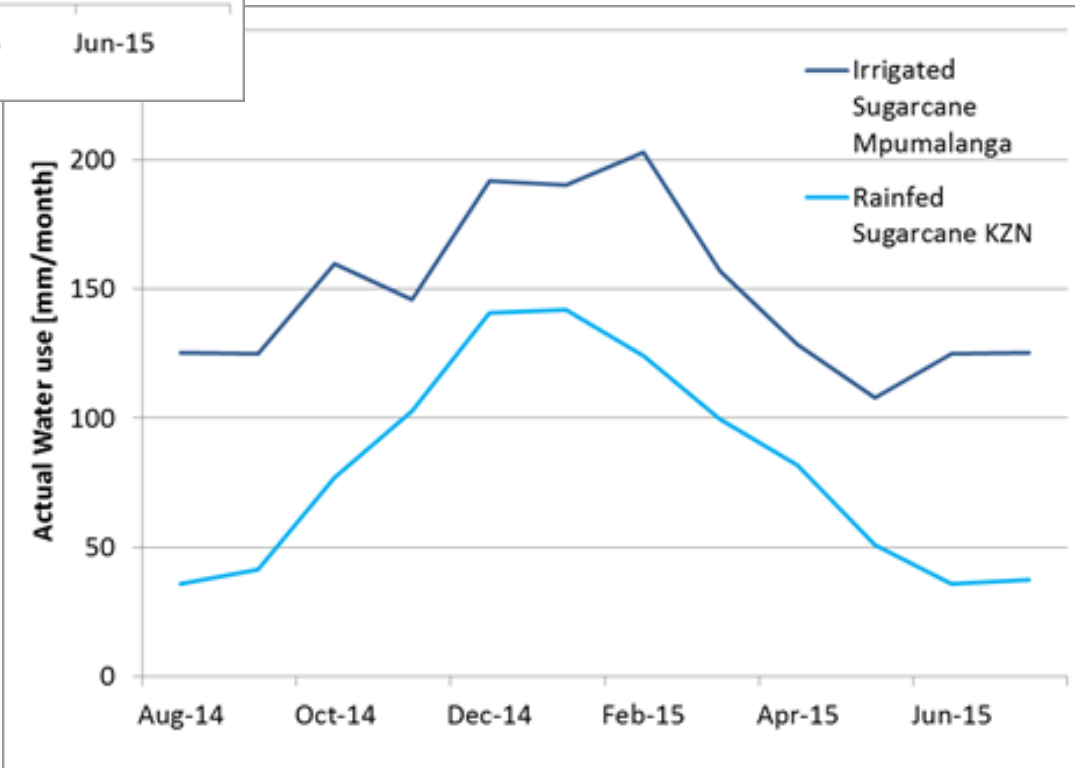
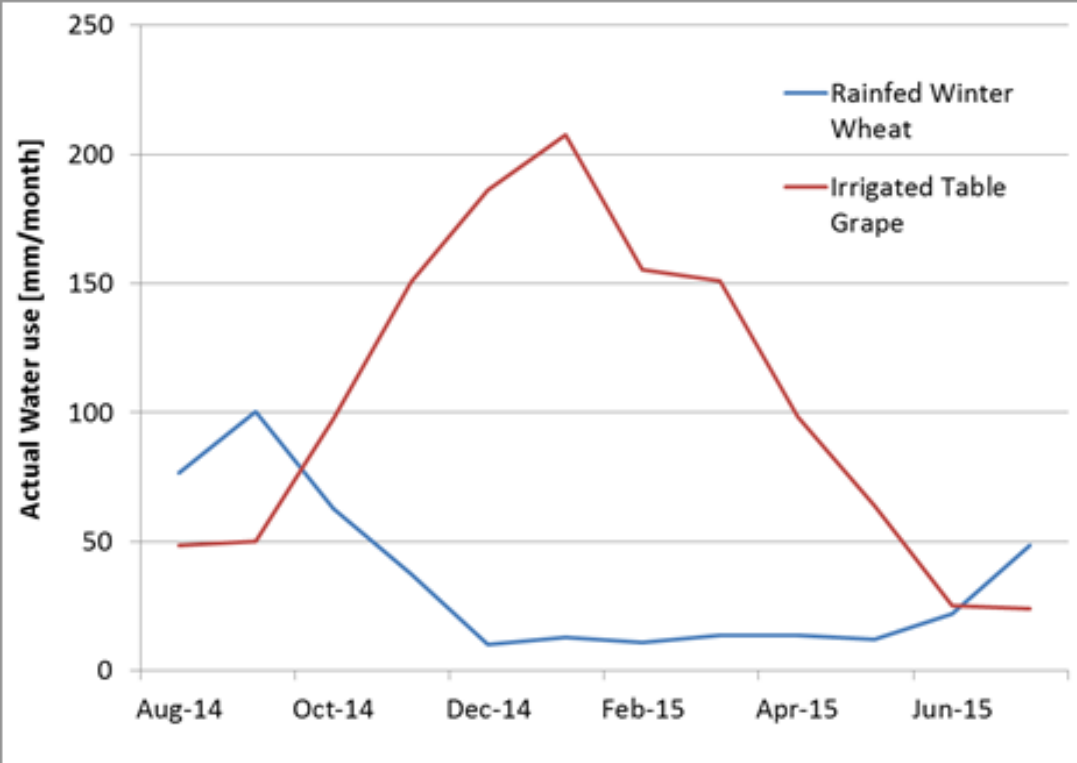
▼ Change Background

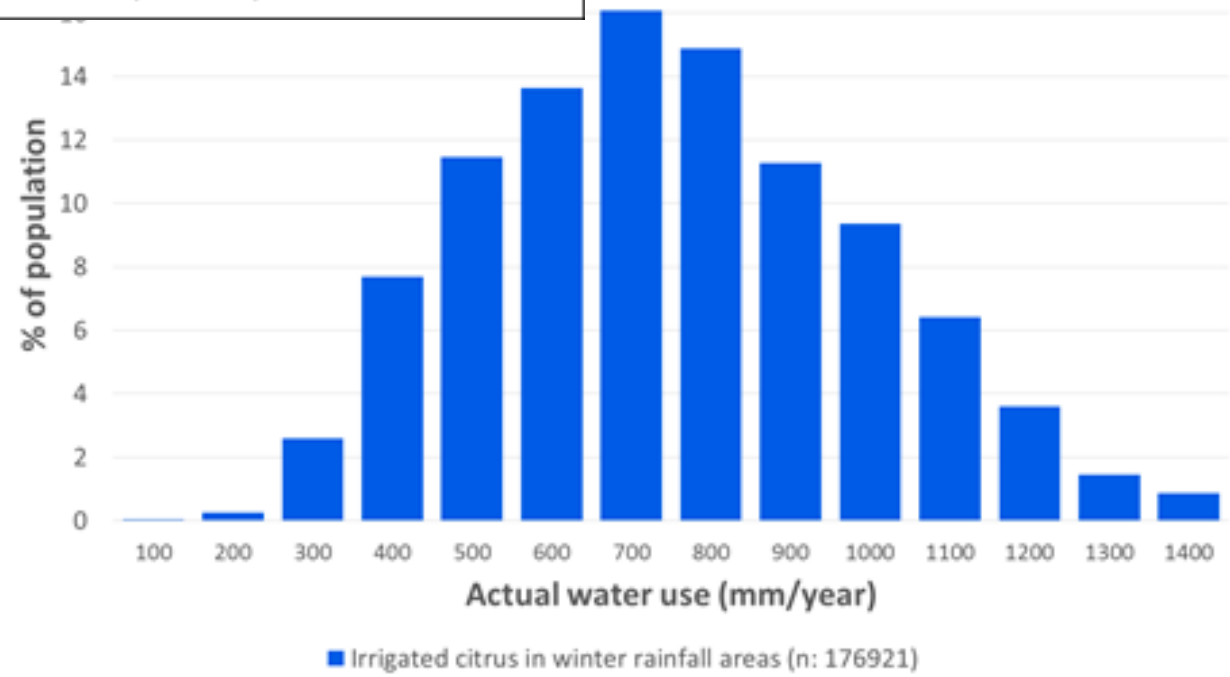
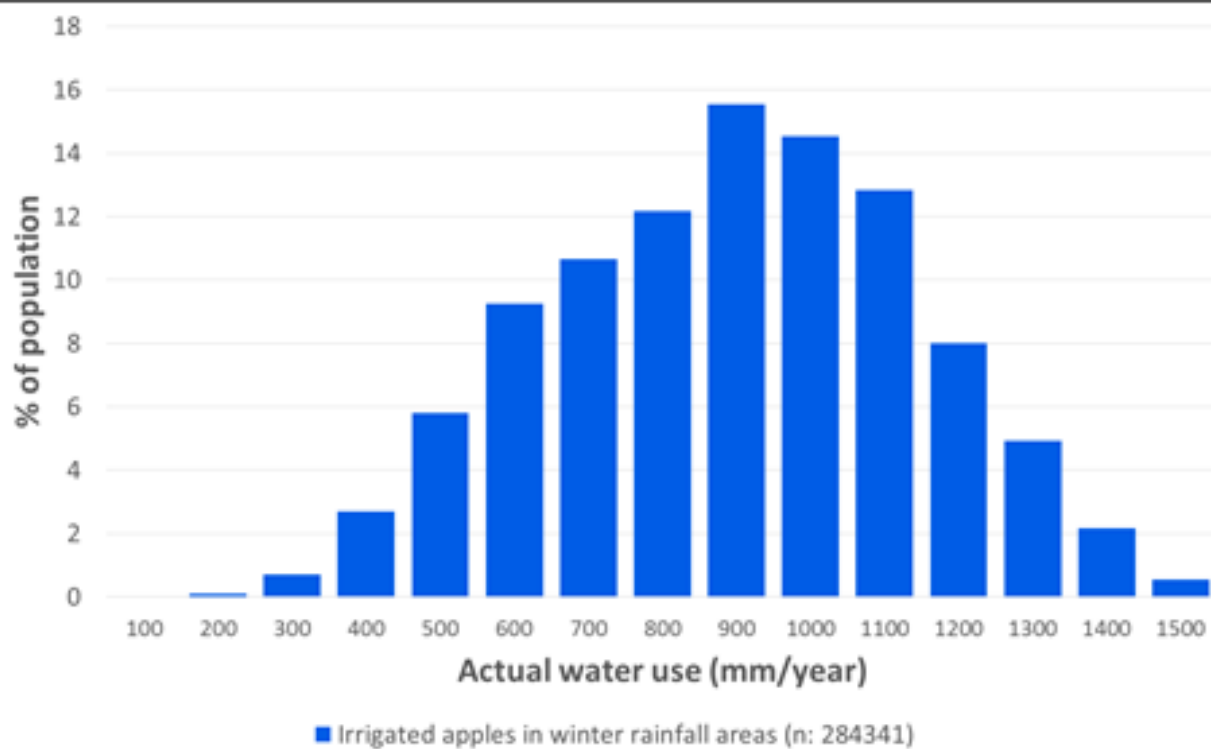
		
Summer NDVI	Winter NDVI	January ET
		
July ET	ESRI Imagery	OpenStreetMap



Outlook

- Final version (3.0), due 15 December 2017, will be used to:
 - Quantify water used for irrigated agriculture during the period 2014/15
 - Determine available water for additional allocations (selected areas)
 - Analyses of crop-specific water use profiles in different regions (extremely rich dataset that can be effectively used to improve water use efficiency)
- Version 3.0 is snapshot in time (2014/15)
- Mapping procedure is currently being automated
 - Produce actively irrigated area map on **monthly basis** going forward (much easier to validate)
 - Allow for analyses of inter-annual changes and variations





Part B: Yield optimization and predictions



Yield-modelling projects

1. Apples and pears
(Elsenburg Western Cape)
2. Wine grapes (Winetech)
3. Citrus (San Miguel & Humkoop)
4. Grains (GWK)

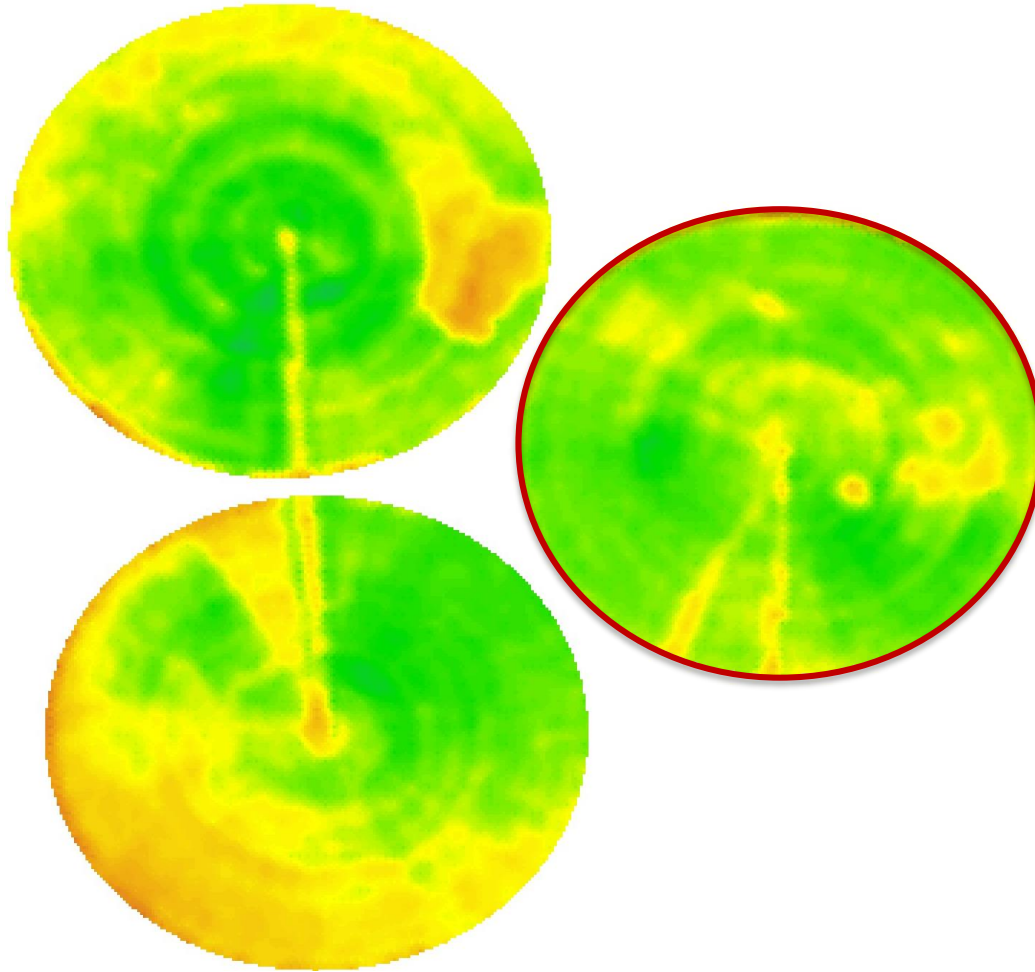


Yield-modelling projects

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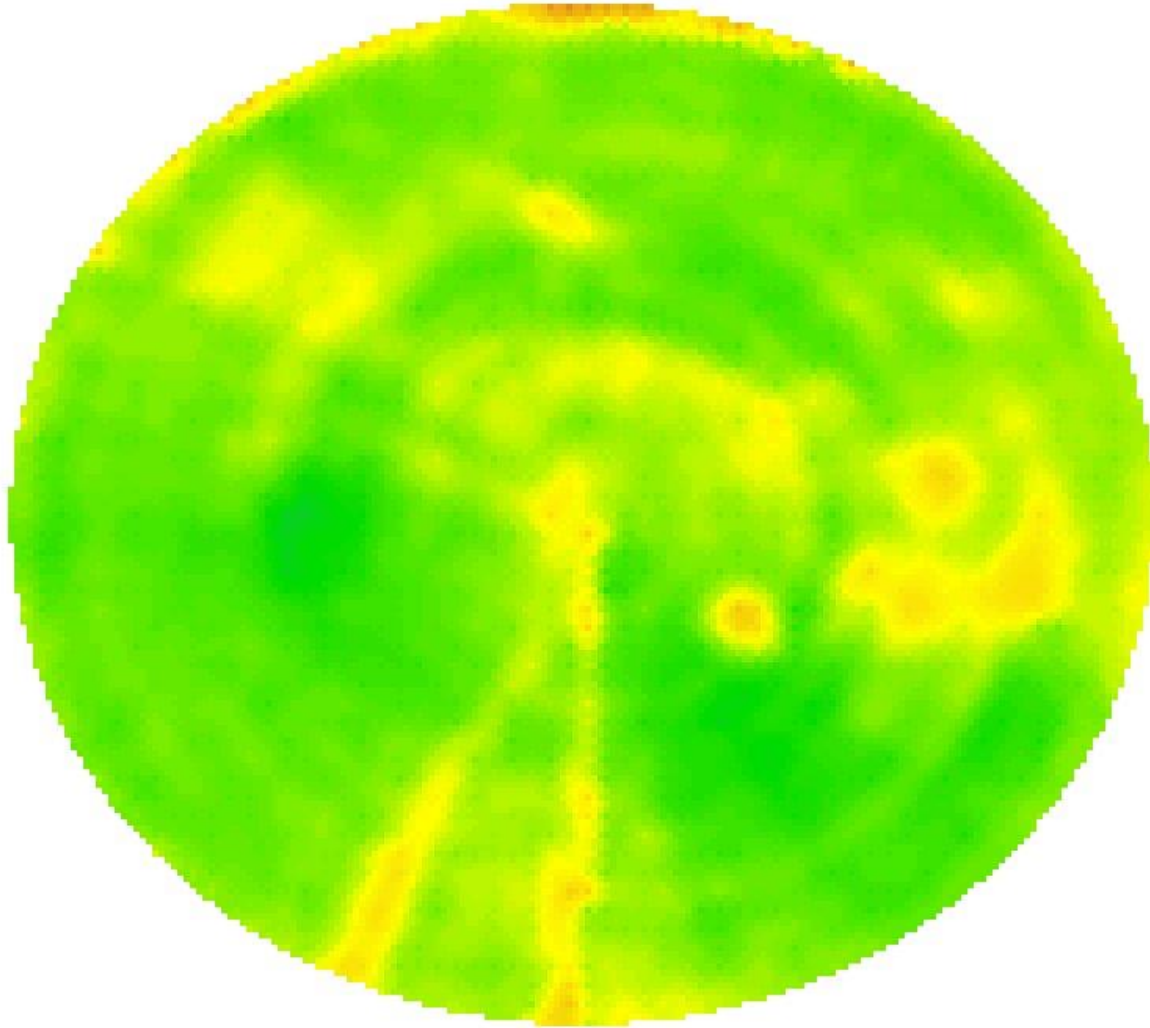
Winter grain fields



Freely available
Sentinel-2 imagery
(worldwide)

Soil-adjusted vegetation index (SAVI) of 3 Aug 2017

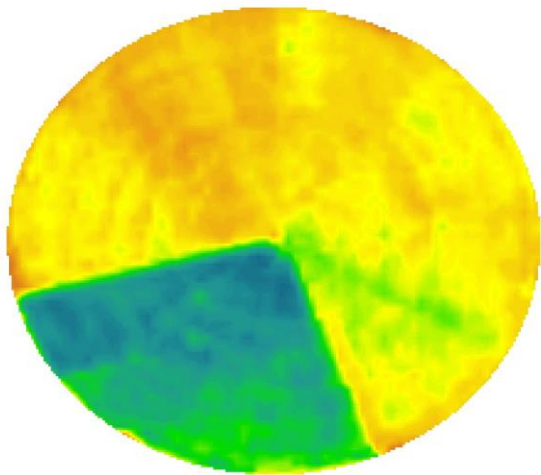
Winter grain field



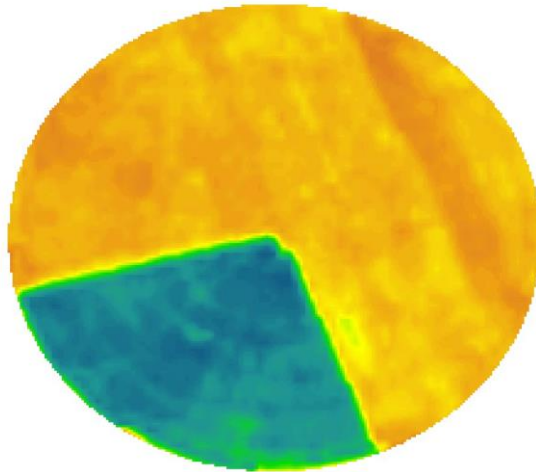
Size: 31 ha
Cultivar: SST 835
Planted: 12-Jun-2017

Soil-adjusted vegetation index (SAVI) of 3 Aug 2017

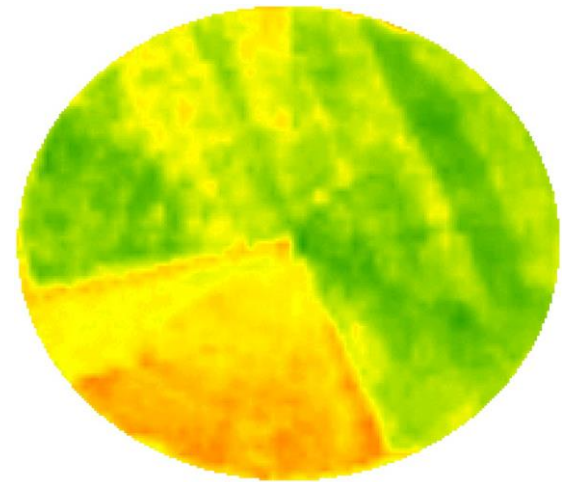
Change analyses



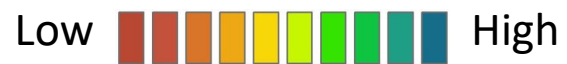
SAVI Date 1



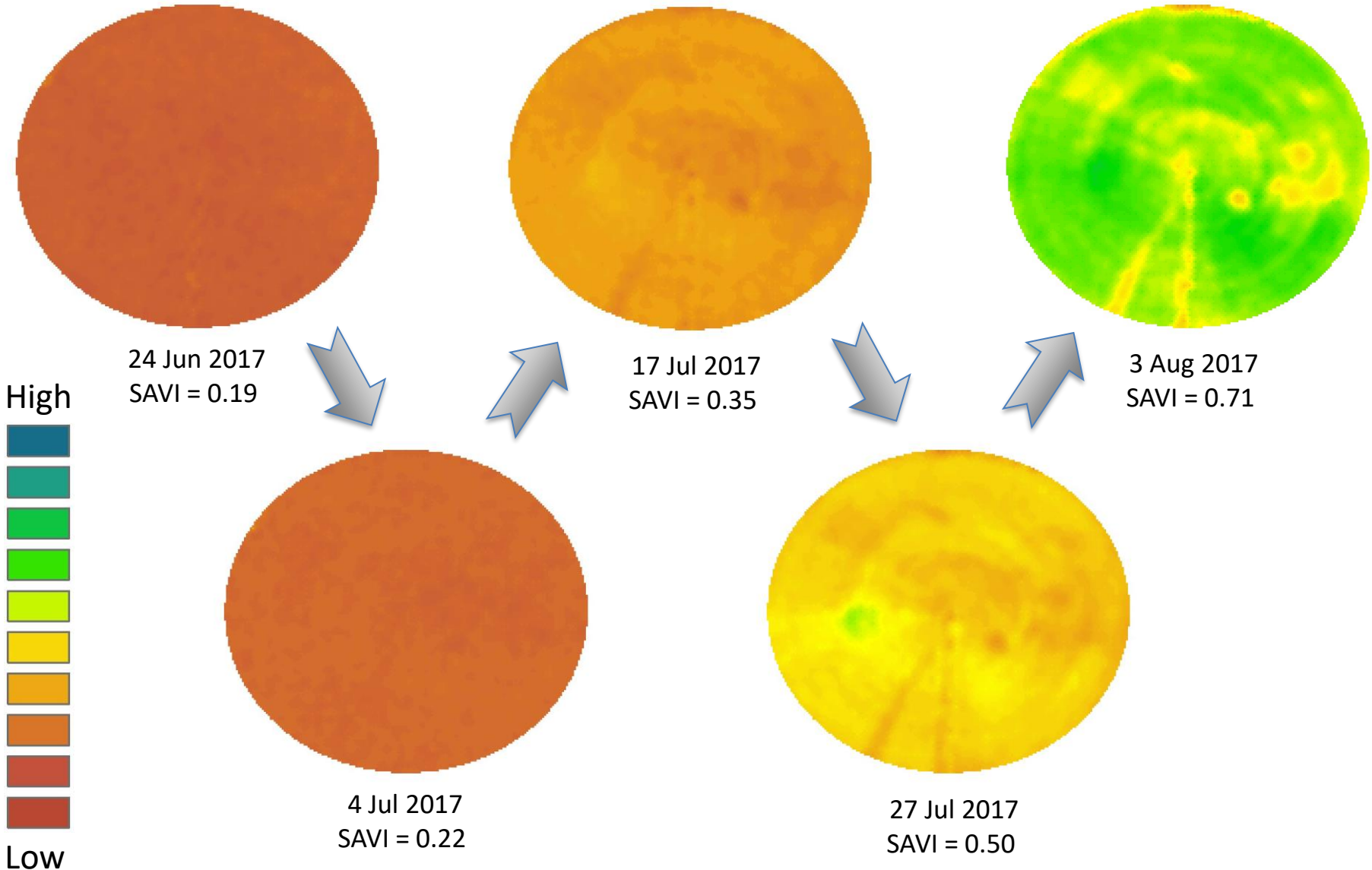
SAVI Date 2



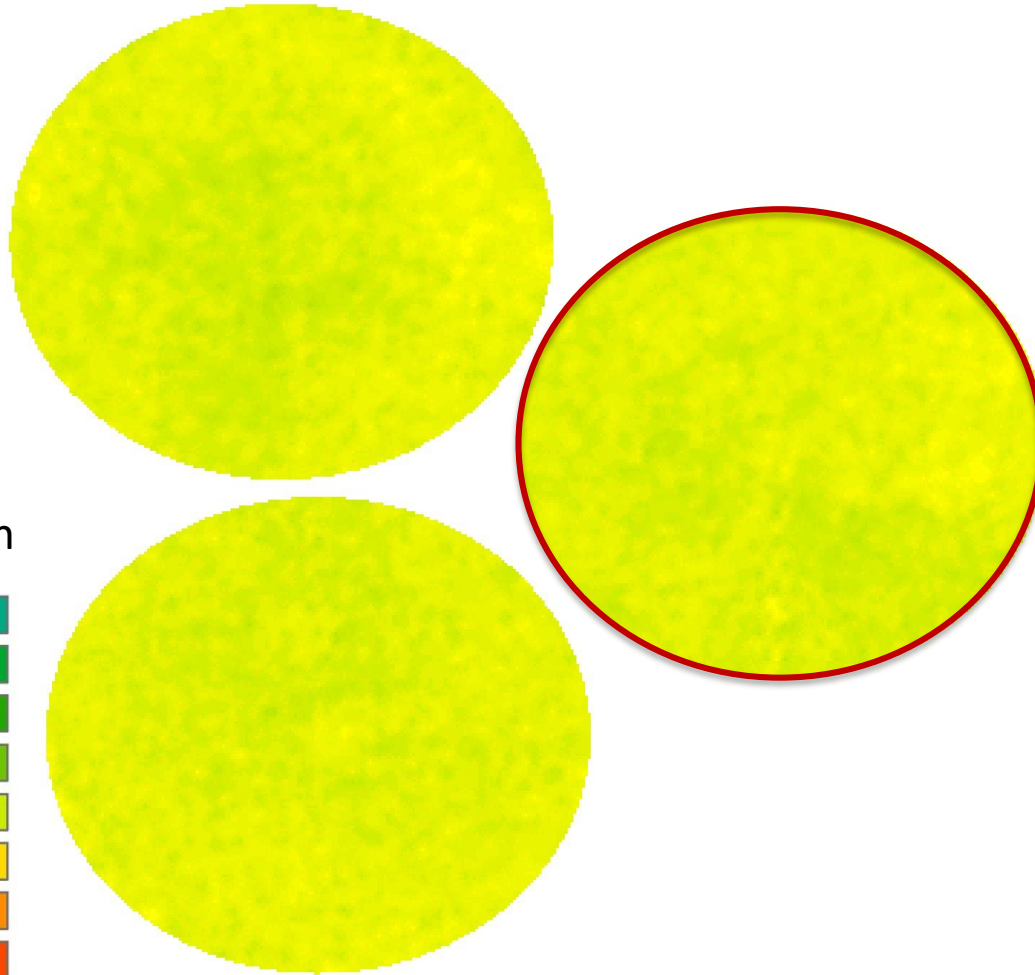
SAVI Date 2 – SAVI Date 1



Soil Adjusted Vegetation Index (SAVI)



Change in SAVI



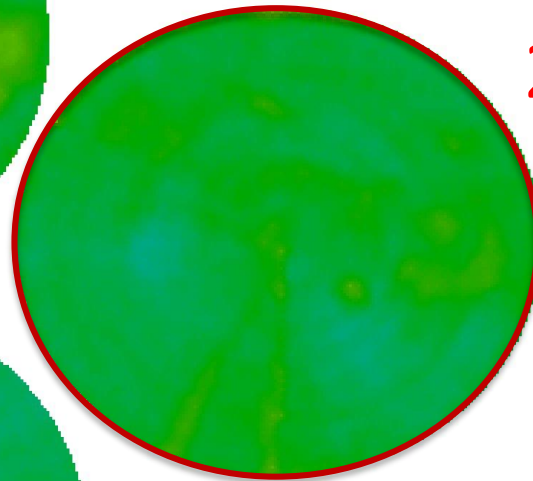
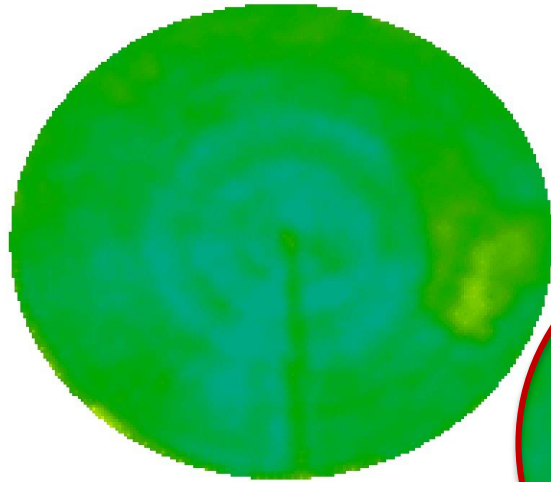
17 to 27 July 2017
+ 15 SAVI

High



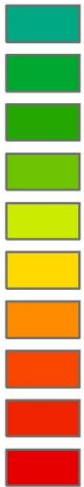
Low

Change in SAVI



27 Jul to 3 Aug 2017
+ 21 SAVI

High



Low

SAVI of field compared to other fields with the same cultivars and plant week

Vergelyking van gemiddelde NDVI waardes van
met ander soortgelyke lande (dieselfde silogebied, kultivar, en plantdatum) soos op
12 Aug 2017

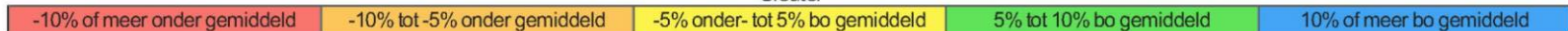
se lande



Plaasnaam	Landnaam	Ha	Kultivar	Plantdatum	PW	#	W25	W26	W27	W28	W29	W30	W31
		29.34	SST 835	13-Jun-2017	24	8	0	-	0	-	0	-4	0
		29.27	SST 835	14-Jun-2017	24	8	0	-	0	-	6	6	9
		59.62	SST 835	12-Jun-2017	24	8	-11	-	0	-	6	8	9
		20.85	SST 835	19-Jun-2017	25	5	-	-	26	-	19	14	0
		65.16	SST 835	16-Jun-2017	24	8	5	-	-5	-	-15	-	-9
		31.03	SST 835	12-Jun-2017	24	8	5	-	10	-	16	17	18
		27.94	SST 835	13-Jun-2017	24	8	18	-	10	-	9	8	10
		27.83	SST 835	12-Jun-2017	24	8	5	-	5	-	3	-4	-1

PW= Plantweek; # = Getal vergelykbare lande; W=Week

Stel



SAVI of field compared to other fields with the same cultivars and plant week

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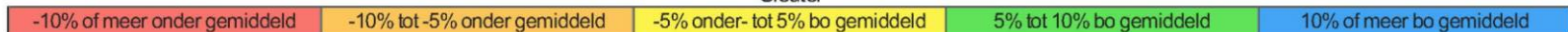
se lande



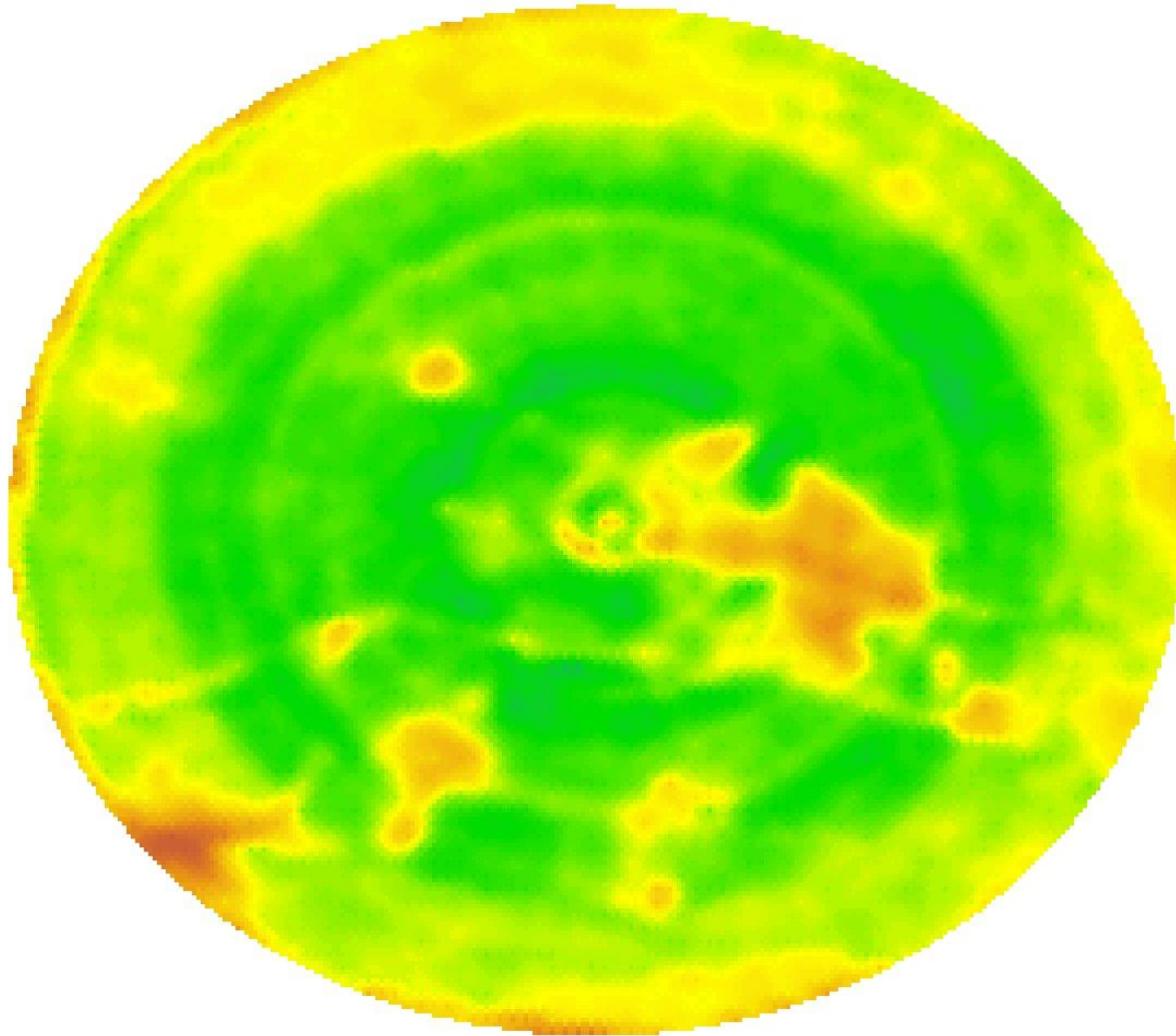
Plaasnaam	Landnaam	Ha	Kultivar	Plantdatum	PW	#	W25	W26	W27	W28	W29	W30	W31
		29.34	SST 835	13-Jun-2017	24	8	0	-	0	-	0	-4	0
		29.27	SST 835	14-Jun-2017	24	8	0	-	0	-	6	6	9
		59.62	SST 835	12-Jun-2017	24	8	-11	-	0	-	6	8	9
		20.85	SST 835	19-Jun-2017	25	5	-	-	26	-	19	14	0
		65.16	SST 835	16-Jun-2017	24	8	5	-	-5	-	-15	-	-9
		31.03	SST 835	12-Jun-2017	24	8	5	-	10	-	16	17	18
		27.94	SST 835	13-Jun-2017	24	8	18	-	10	-	9	8	10
		27.83	SST 835	12-Jun-2017	24	8	5	-	5	-	3	-4	-1

PW= Plantweek; # = Getal vergelykbare lande; W=Week

Sleutel



Winter grain field



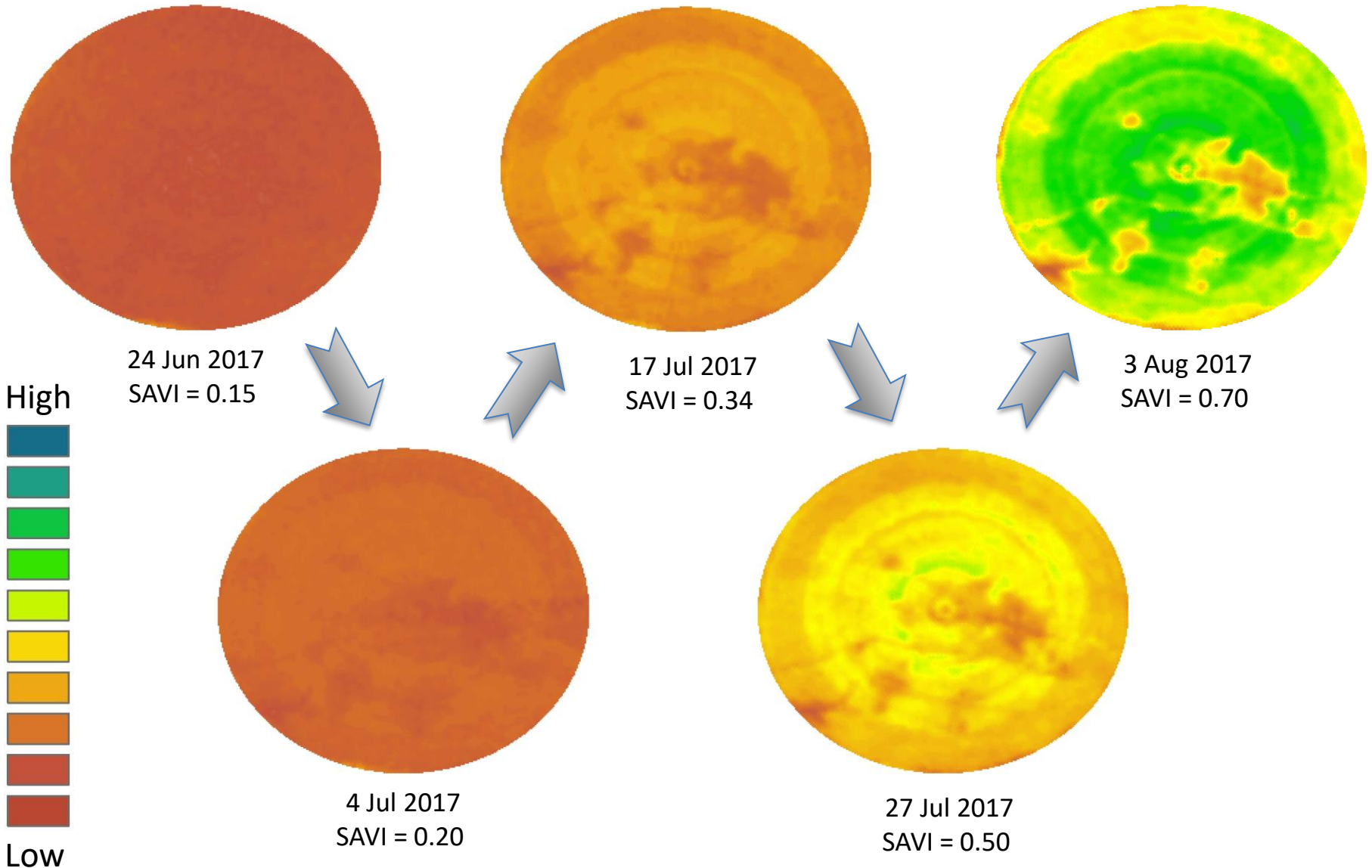
Size: 59.6 ha

Cultivar: SST 835

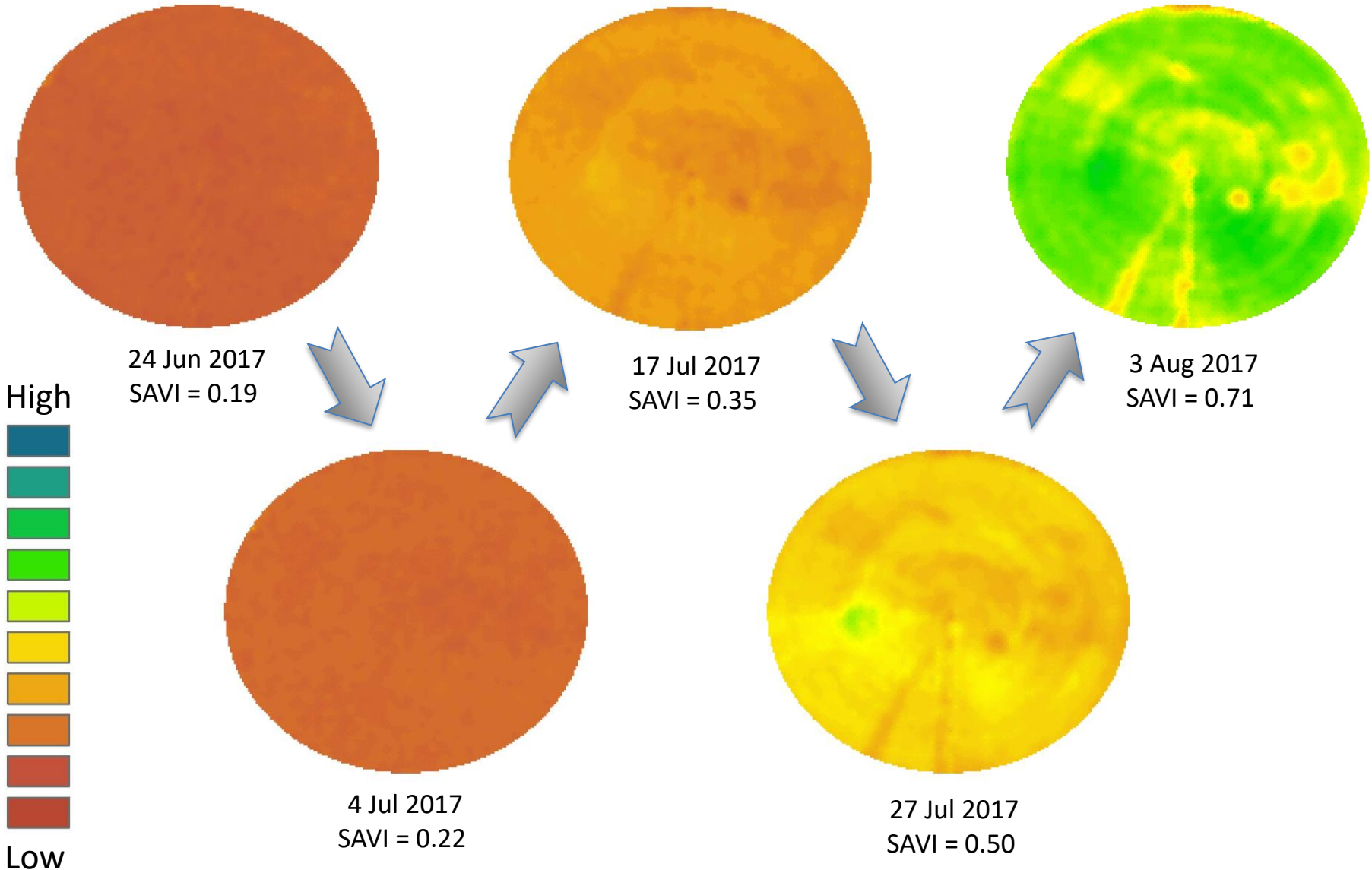
Planted: 12-Jun-2017

Soil-adjusted vegetation index (SAVI) of 3 Aug 2017

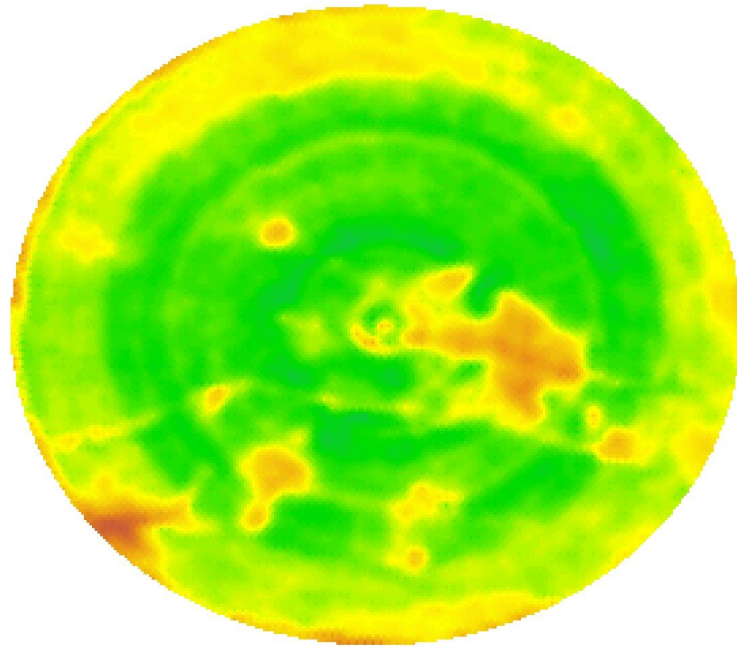
Soil Adjusted Vegetation Index (SAVI)



Soil Adjusted Vegetation Index (SAVI)

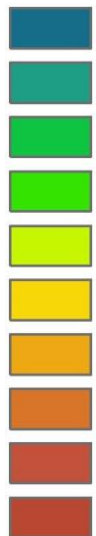


SAVI

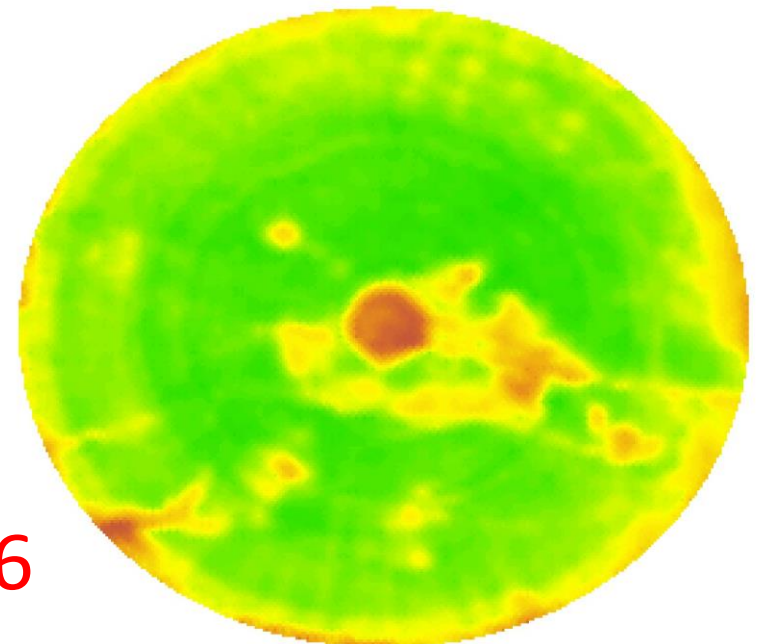


3 Aug 2017

High

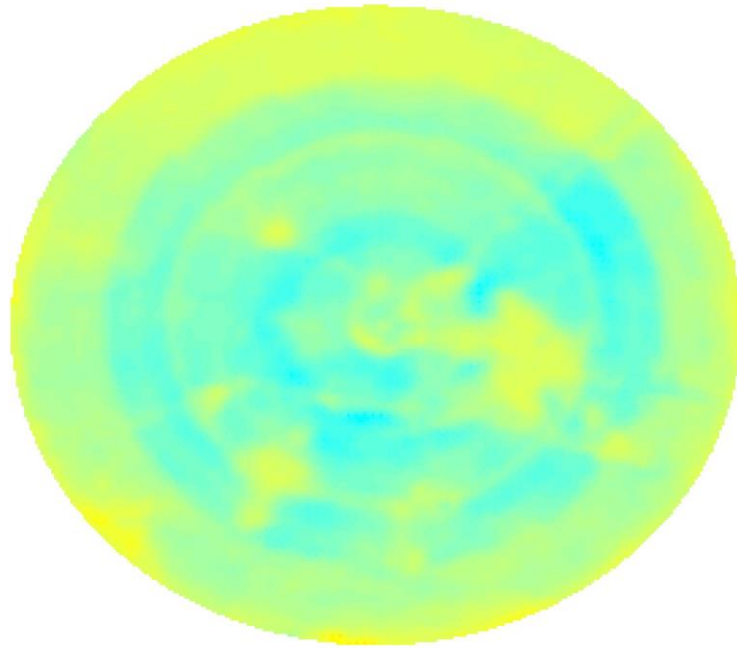


Low

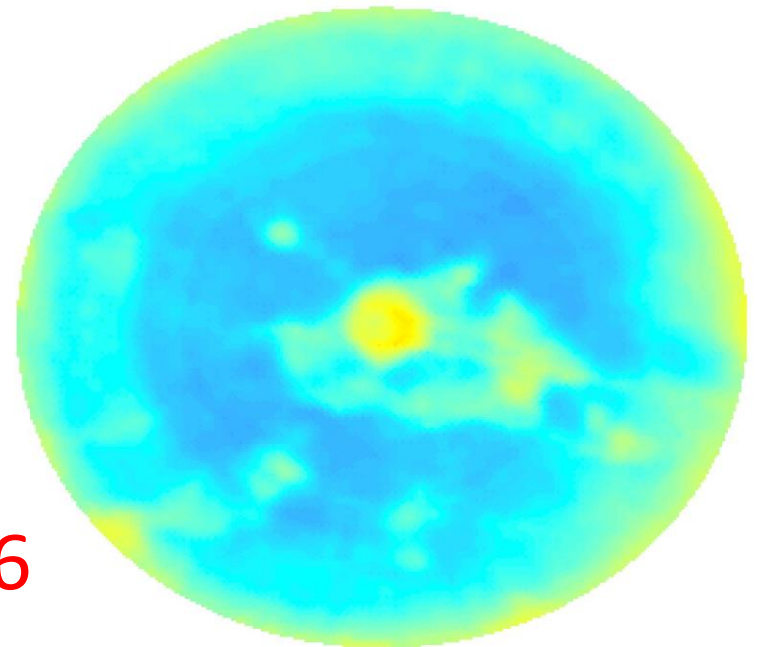


1 Aug 2016

NDMI

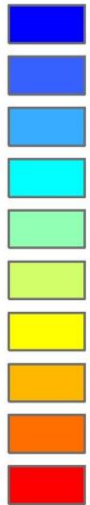


3 Aug 2017

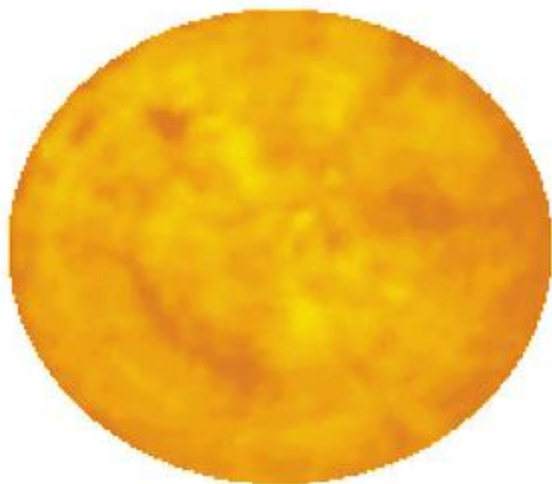


1 Aug 2016

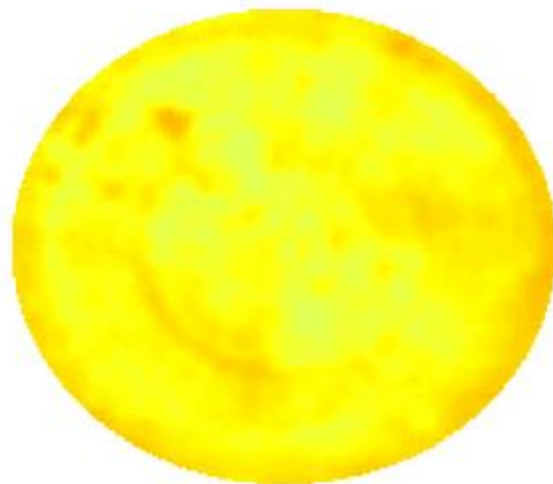
High



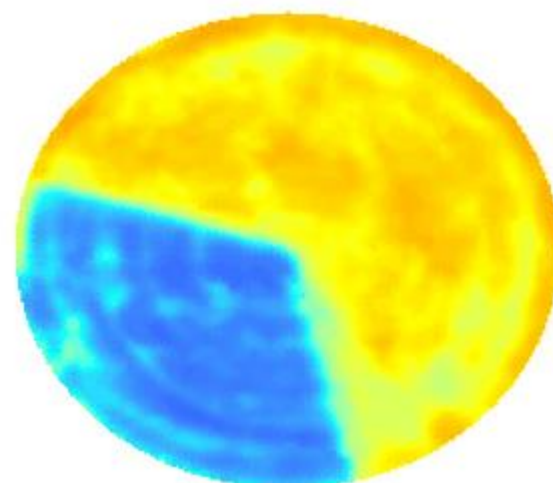
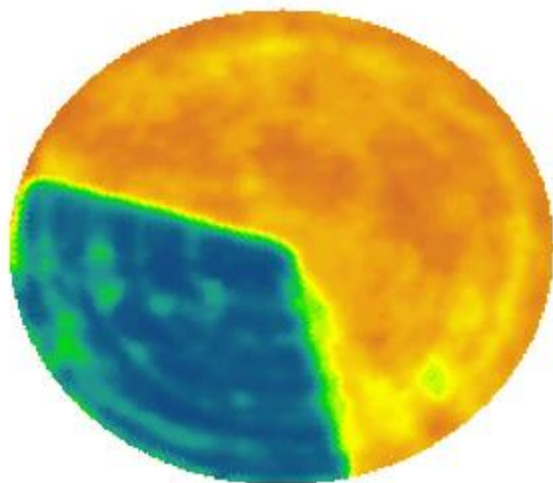
Low



SAVI



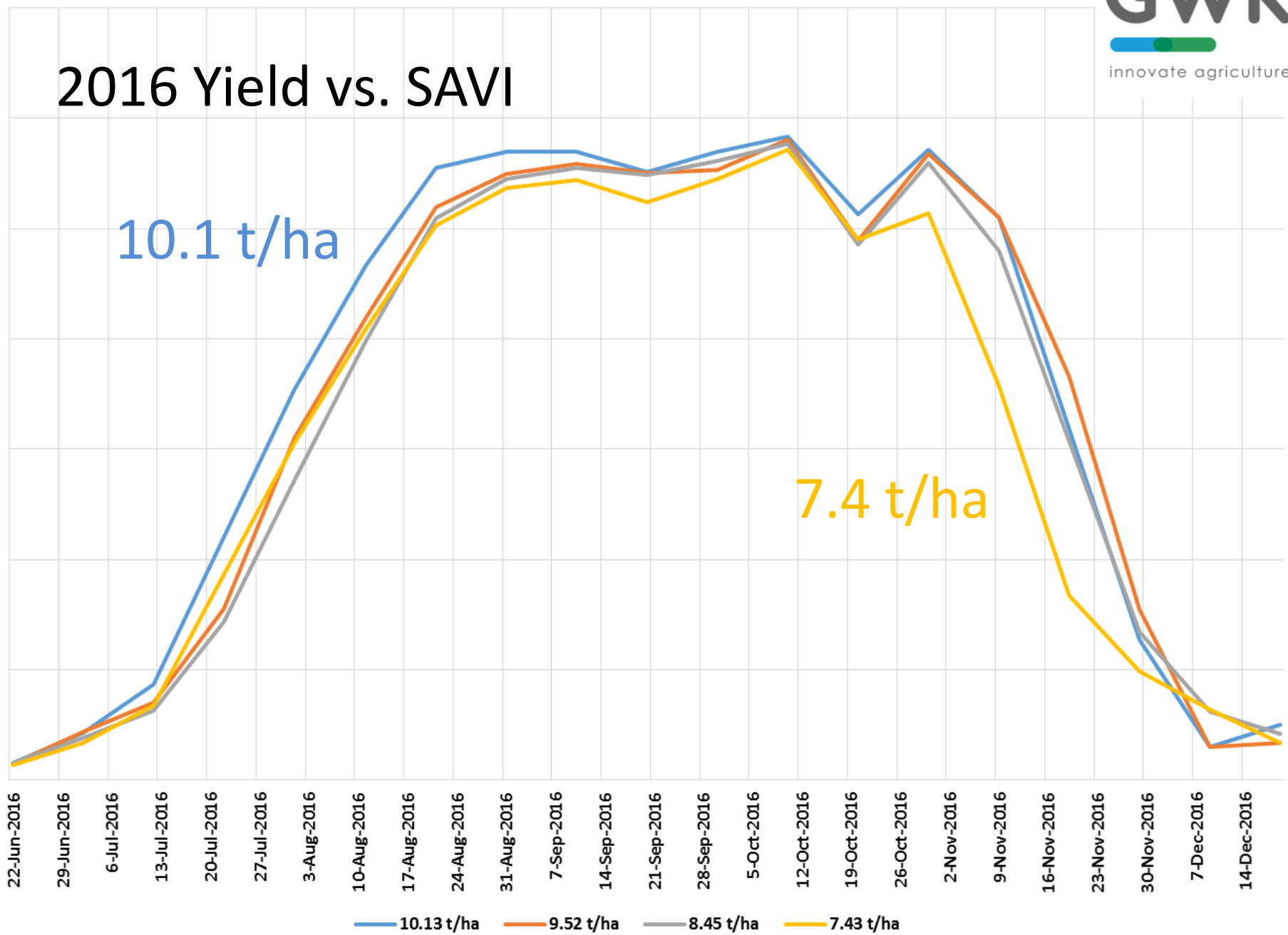
NDMI



2016 Yield vs. SAVI

10.1 t/ha

7.4 t/ha



DOUGLAS - PAN 3497 - >10t/ha

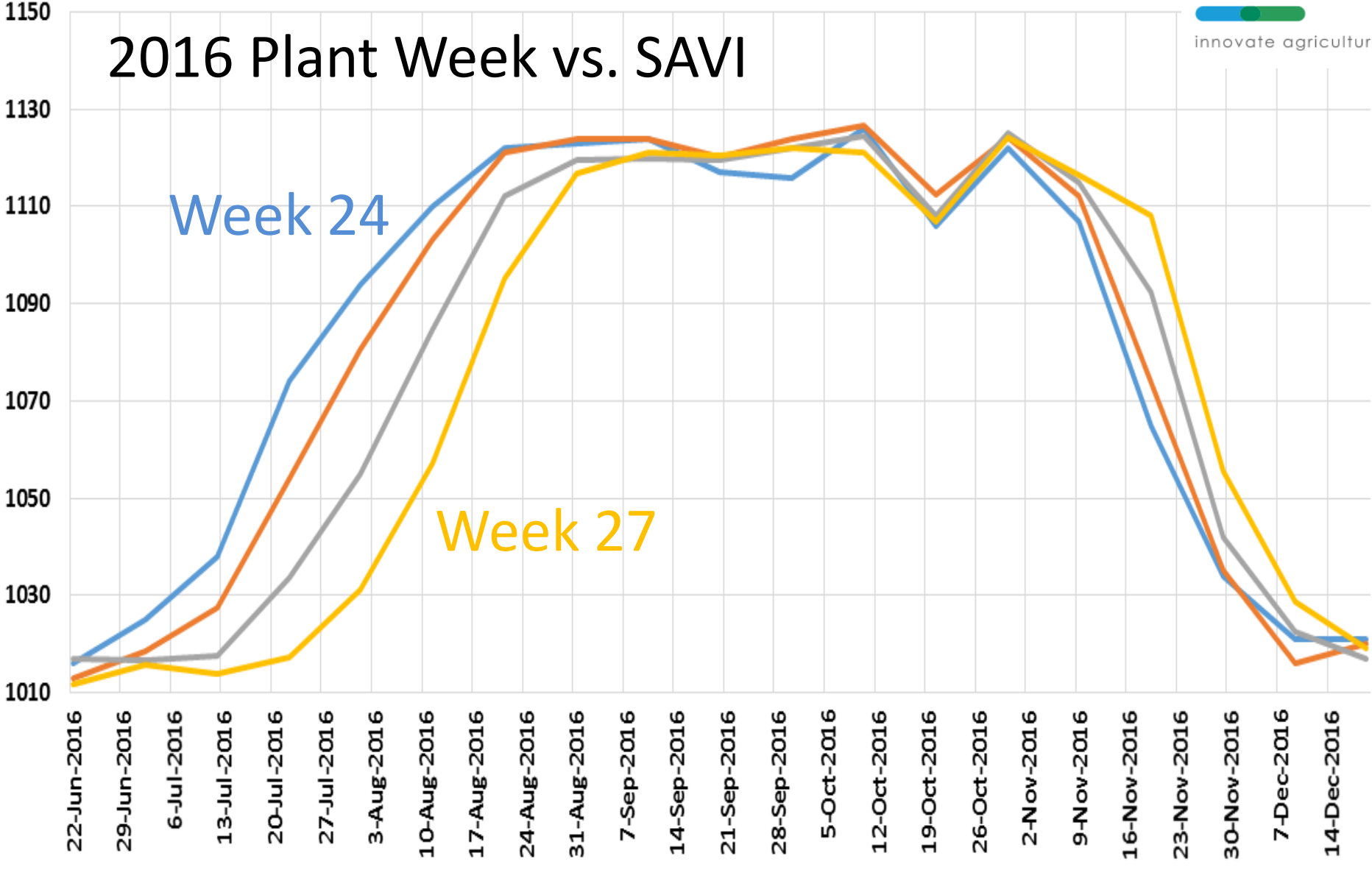
2016 Plant Week vs. SAVI

Week 24

Week 27

22-Jun-2016 29-Jun-2016 6-Jul-2016 13-Jul-2016 20-Jul-2016 27-Jul-2016 3-Aug-2016 10-Aug-2016 17-Aug-2016 24-Aug-2016 31-Aug-2016 7-Sep-2016 14-Sep-2016 21-Sep-2016 28-Sep-2016 5-Oct-2016 12-Oct-2016 19-Oct-2016 26-Oct-2016 2-Nov-2016 9-Nov-2016 16-Nov-2016 23-Nov-2016 30-Nov-2016 7-Dec-2016 14-Dec-2016

Douglas - Wk 24 - 10.03t/ha Douglas - WK 25 - 10.13 t/ha Douglas - Wk 26 - 10.65 t/ha Douglas - Wk 27 - 9.32 t/ha

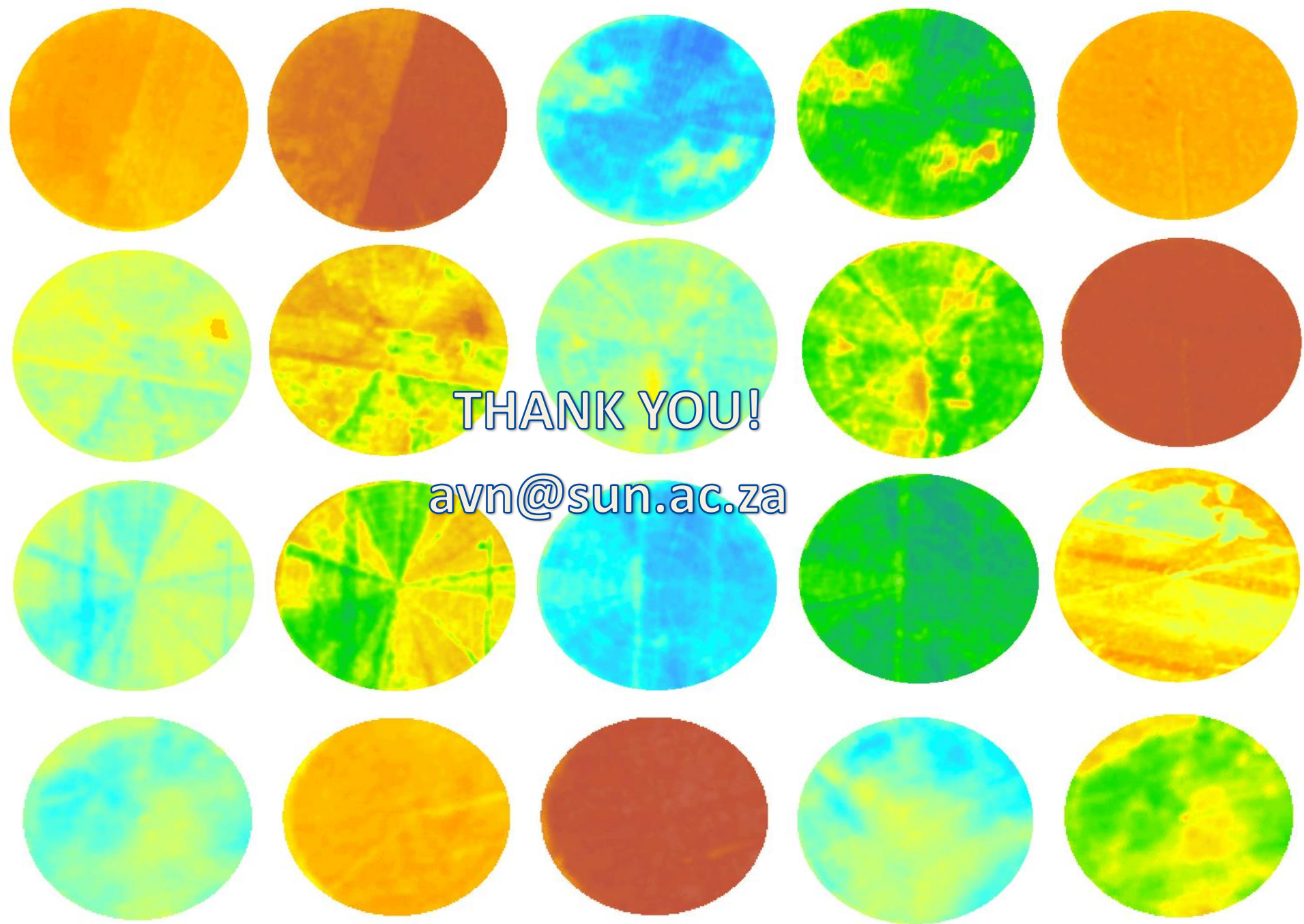


2016 Yield vs. SAVI for PAN 3487

Ha	Kultivar	T/ha	Week	Gem	Ha gem	Wk26	Wk27	Wk29	Wk30	Wk32	Wk33	Wk35	Wk36	Wk37	Wk39	Wk40	Wk42	Wk43	Wk45	Wk46	Wk47	Wk49	Ave
14.2	PAN 3497	10.4	26	8.4	843.1	█			█	█	█	█								█	█	█	
46.6	PAN 3497	10.05	25	8.8	771.4			█	█	█	█	█								█	█		█
49.1	PAN 3497	10.03	24	7.2	508.1	█	█		█	█	█	█				█			█	█	█		█
47.8	PAN 3497	10	25	8.8	771.4				█	█	█	█				█				█	█		█
59.9	PAN 3497	9.85	25	8.8	771.4		█		█	█	█	█								█	█	█	█
46.5	PAN 3497	9.82	26	8.4	843.1	█	█		█	█	█	█								█	█	█	█
46.6	PAN 3497	9.8	26	8.4	843.1	█	█		█	█	█	█								█	█	█	█
47.4	PAN 3497	9.7	26	8.4	843.1	█	█		█	█	█	█								█	█	█	█
45.8	PAN 3497	9.64	26	8.4	843.1	█			█	█	█	█				█				█	█	█	█
46.9	PAN 3497	9.35	25	8.8	771.4	█			█	█	█	█								█	█	█	█
50.6	PAN 3497	9.2	27	8.4	136.9	█	█		█	█	█	█						█		█	█	█	█
47.9	PAN 3497	9.2	25	8.8	771.4		█		█	█	█	█				█				█	█	█	█
50.4	PAN 3497	8.9	25	8.8	771.4	█	█		█	█	█	█								█	█	█	█
48.1	PAN 3497	8.9	26	8.1	98.5	█	█		█	█	█	█								█	█	█	█
47.0	PAN 3497	8.85	24	7.2	508.1	█			█	█	█	█				█				█	█	█	█
6.8	PAN 3497	8.8	26	8.4	843.1	█			█	█	█	█								█	█	█	█
59.9	PAN 3497	8.7	25	8.8	771.4	█	█		█	█	█	█								█	█	█	█
49.5	PAN 3497	8.7	24	7.2	508.1	█			█	█	█	█				█				█	█	█	█
46.9	PAN 3497	8.52	25	8.8	771.4		█		█	█	█	█								█	█	█	█
47.6	PAN 3497	8.45	26	8.4	843.1	█	█		█	█	█	█								█	█	█	█
47.2	PAN 3497	7.7	24	7.2	508.1	█			█	█	█	█				█				█	█	█	█
46.9	PAN 3497	7.7	27	8.4	136.9		█		█	█	█	█								█	█	█	█
48.1	PAN 3497	7.7	26	8.4	843.1				█	█	█	█								█	█	█	█
46.5	PAN 3497	7.6	24	7.2	508.1	█	█		█	█	█	█				█				█	█	█	█
47.9	PAN 3497	7.43	26	8.4	843.1	█	█		█	█	█	█								█	█	█	█
47.4	PAN 3497	7.4	25	8.8	771.4	█	█		█	█	█	█				█				█	█	█	█
50.4	PAN 3497	7.32	26	8.1	98.5	█	█		█	█	█	█								█	█	█	█
46.5	PAN 3497	7	25	8.8	771.4				█	█	█	█							█	█	█	█	█

Conclusions

- LACK of data is no longer an impediment
- UNPRECEDENTED (free) EO data
 - High spatial resolution (10m)
 - Short intervals (5 days)
- CHANGES tells the story (consistency vs. absolute precision)
- Complex! Making SENSE of the story is current challenge (BIG data & machine learning)



THANK YOU!

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