אוניברסיטת חיפה
University of Haifa

Department of Geography and Environmental Studies

MULTI-SOURCE SPECTRAL APPROACH FOR EARLY WATER-STRESS DETECTION IN ACTUAL FIELD IRRIGATED CROPS

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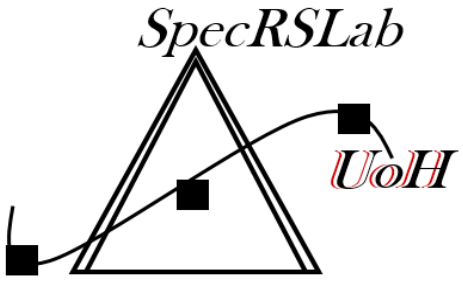
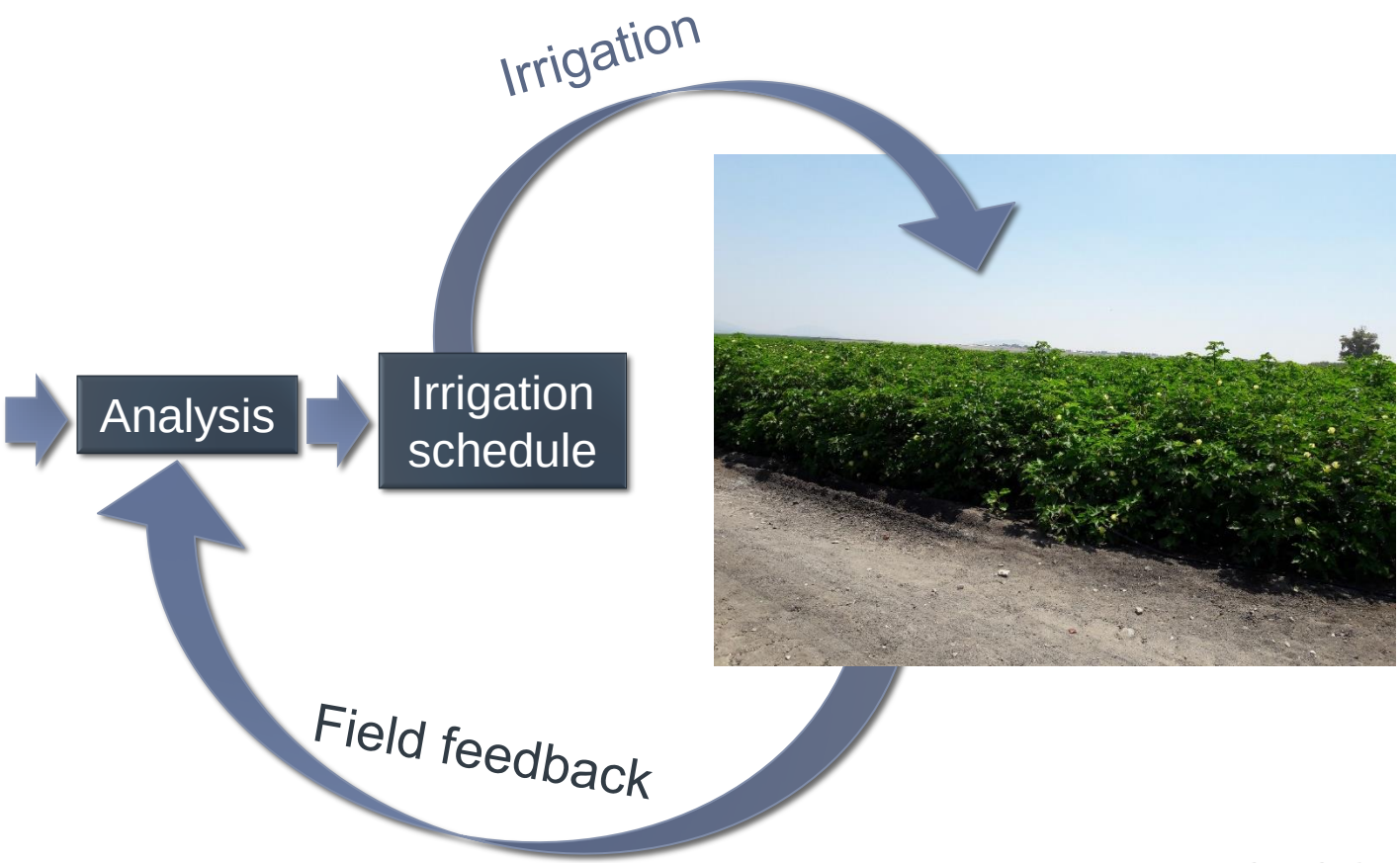


Optimal irrigation planning

Inputs
Crop
Soil properties
Weather
Type of irrigation
etc.



Grant #41683 - Funded by Israeli Water Authority

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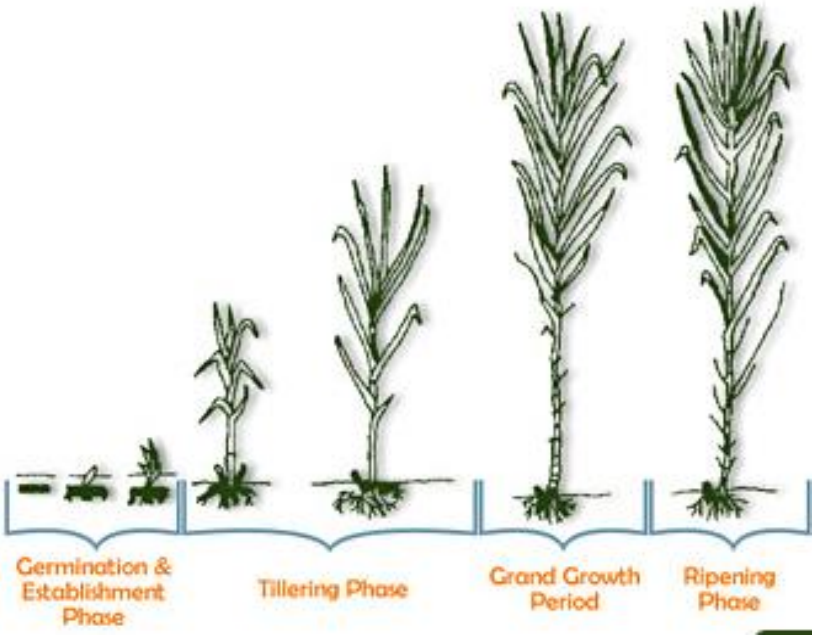
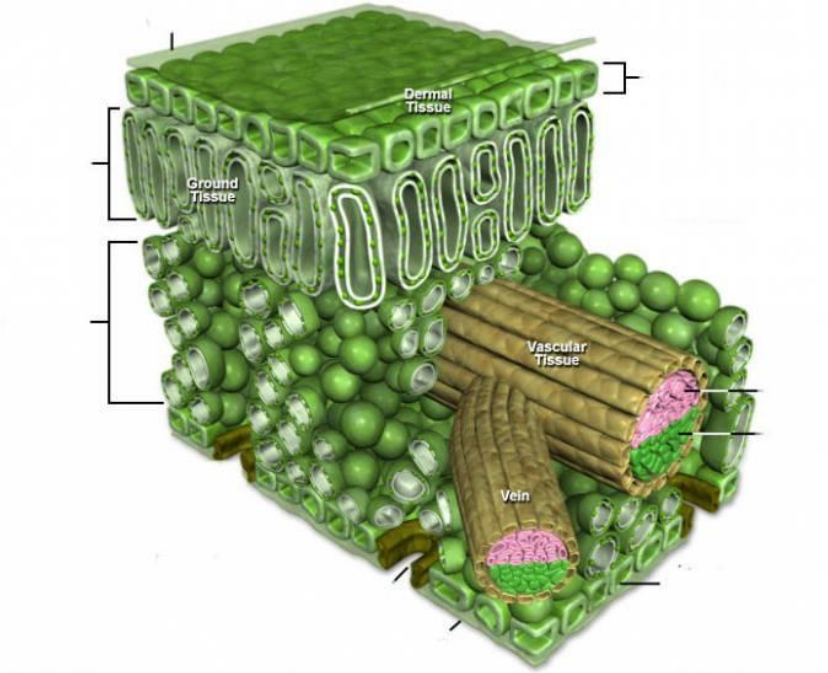
Field feedback

Canopy scale



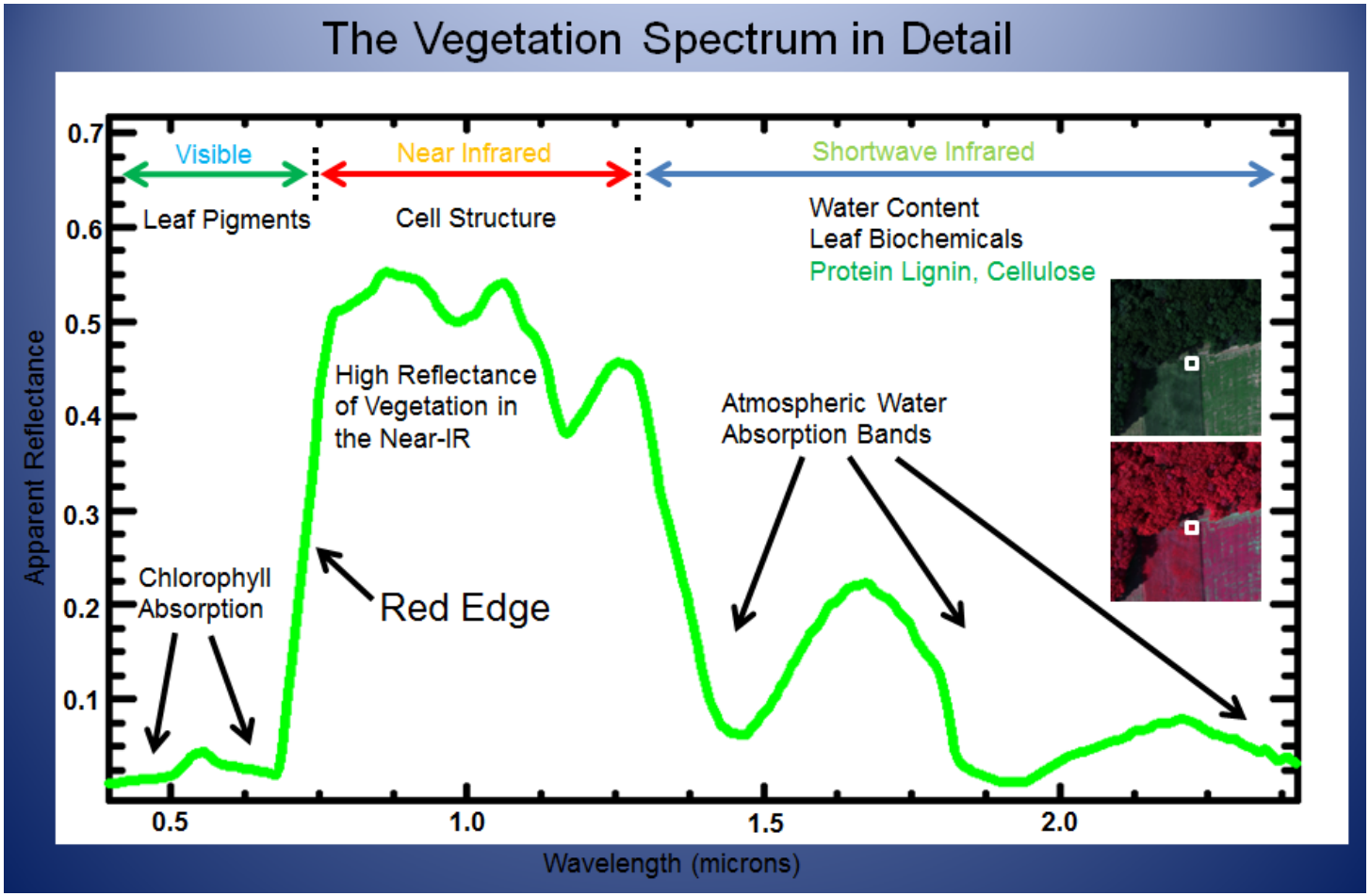
Crop growth rate: height, LAI, green biomass, etc.

Leaf scale



Photosynthesis rate, light use efficiency, chlorophyll and carotenoid level, etc.

Vegetation features by spectrum



Elowitz, M. R. (2013). What is Imaging Spectroscopy (Hyperspectral Imaging)?. *Retrieved November*, *27*, 2013.

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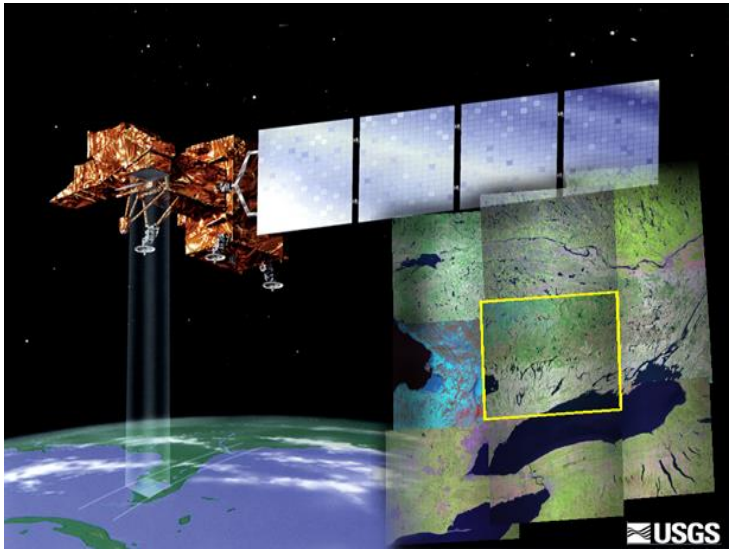
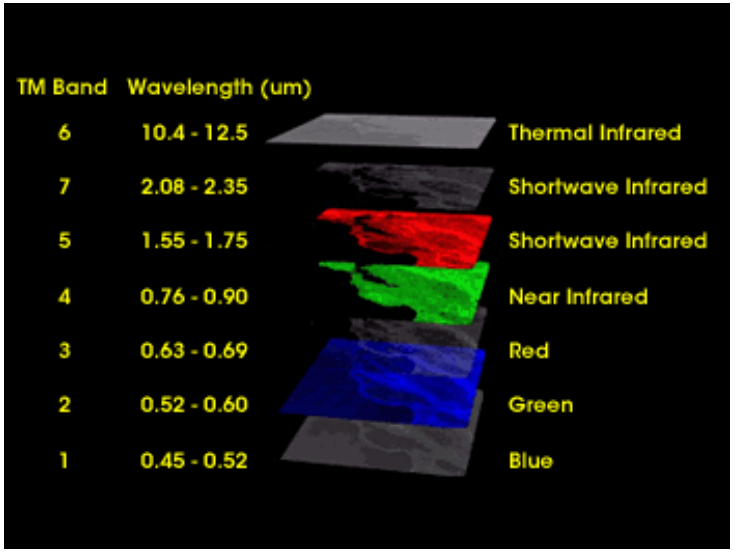
Satellite spectral imagery





Benefits	Disadvantages
Free or Mid-cost	Low resolution (spatial, spectral and temporal)
Wide spectral range	Weather conditions
Big area cover	No survey managing

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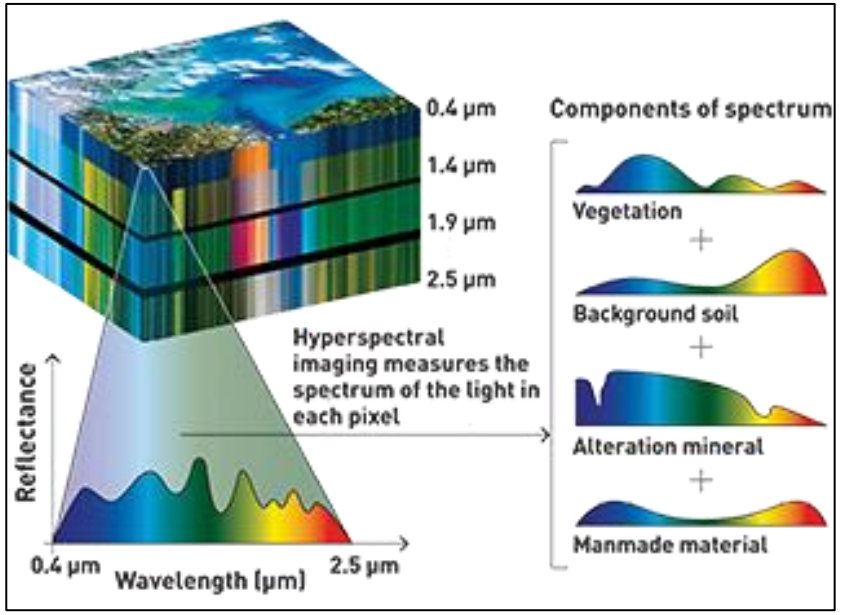
Spectral camera (airborne, field)



Benefits	Disadvantages
Big area cover	Expensive
High spatial and spectral resolution	Weather conditions
VIS-NIR-SWIR range	
Survey manage	

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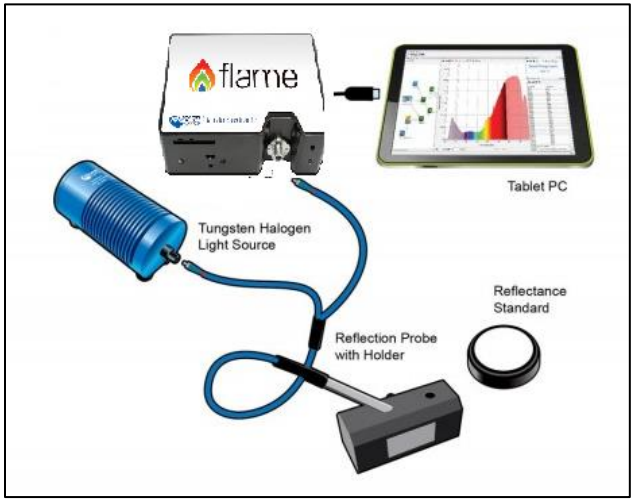
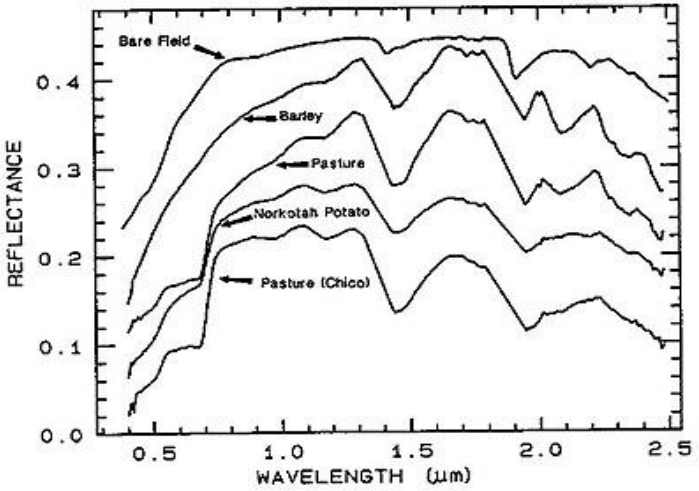
Field spectrometer





Benefits	Disadvantages
Low-cost	Point-by-point measurement
High spectral resolution	Weather conditions
VIS-NIR-SWIR range	
Direct sample measures	
Autonomous surveys	
Laboratory measures	

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Vegetation Indices (VIs)

VI	Development technologies	Type of sensitivity	Formula	Application in agriculture	Reference
Normalized Difference Vegetation Index (NDVI)	Satellite	Green biomass	$\frac{w880-w680}{w880+w680}$	Water content, physical parameters (height, LAI, biomass, dry matter), predicting yield	Rouse et al., 1973
Green Atmospherically Resistant Index (GARI)	Satellite	Chlorophyll	$w800 + (w550 - 1.7(w450 - w670))$	Crop coefficient, chlorophyll level, LAI, soil salinity, predicting yield	Gitelson, Kaufman and Merzylak, 1996
Modified Triangular Vegetation Index (MTVI)	Airborne	LAI	$2(w800 - w550) - 2.5(w670 - w$	Crop coefficient, chlorophyll level, LAI, yield predicting	Haboudane et al., 2004
Leaf area index for cotton	Field spectroscopy	LAI	$\exp(4.78\ln\left(\frac{w900-w680}{w900+w680}\right) + 1.55)$	Crop coefficient, green LAI, predicting yield	Gutierrez, 2012
Pigment-specific simple ratio algorithms	Field spectroscopy	Chlorophyll	$19.53\sqrt[1.48]{\left(\frac{w810}{w676}\right)} + 6.65\sqrt[1.61]{\left(\frac{w810}{w676}\right)}$	Nitrogen and water concentration, chlorophyll level, pests detecting	Blackburn, 1998

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Study Area

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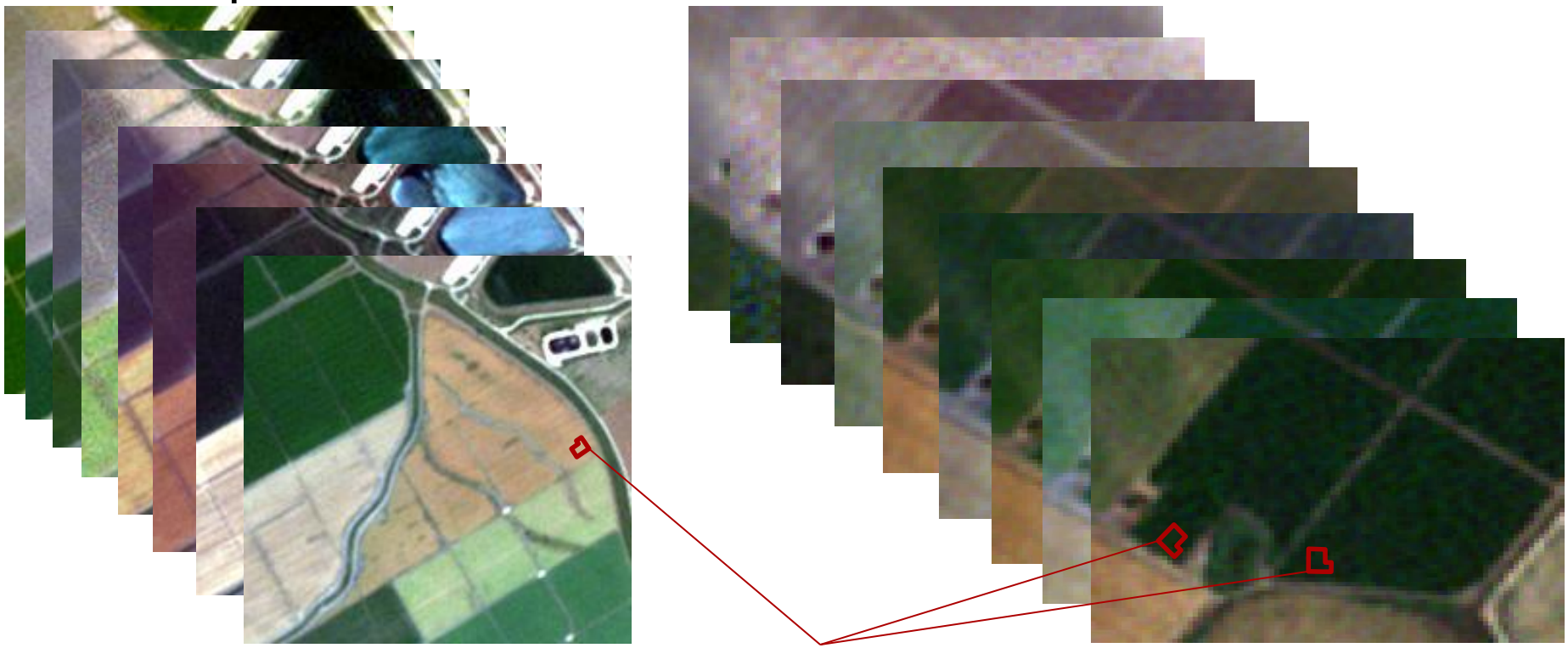
RapidEye Satellite Sensor (5m)

Chickpea

Tomato & Cotton



5 pixels

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Landsat 8 OLI8 (30m)

Chickpea

Tomato & Cotton

1 pixels

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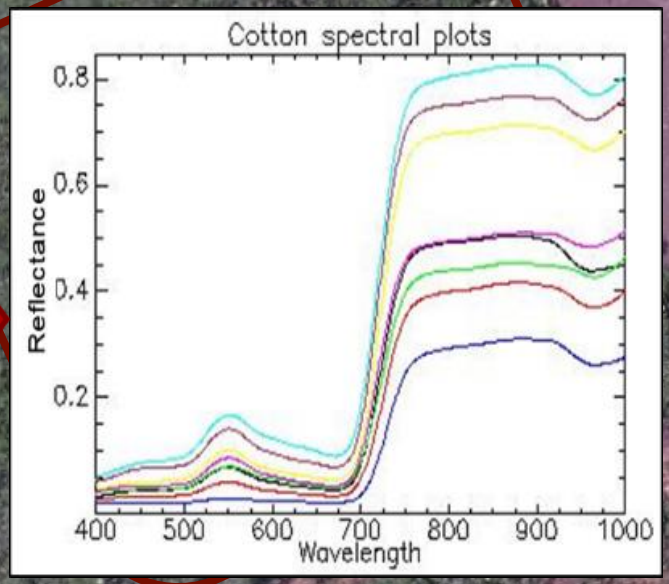
OceanOptics USB4000-VIS-NIR (1cm)



10 measures

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Dynamics of VIs temporal behavior

1. Calculate average means
2. Estimate variability of VIs by coefficient of variability

$$Cv = s / | \bar{x} |$$

where Cv is a coefficient of variation, s is the standard deviation, and $\bar{x}$ is the average mean

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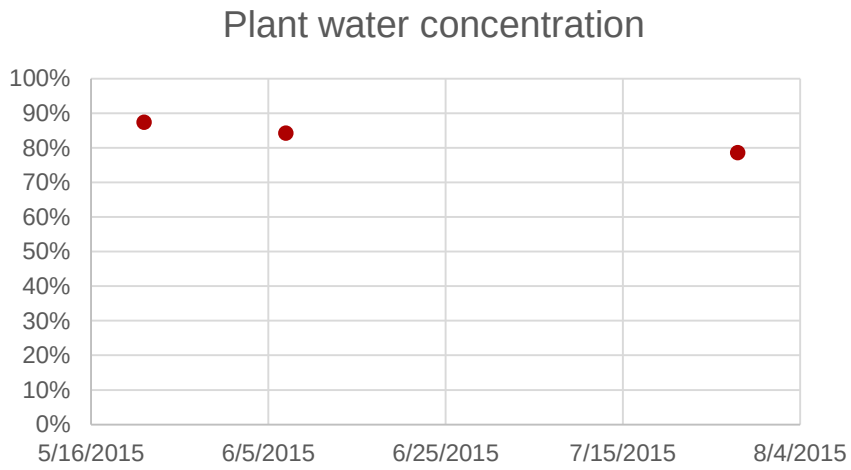
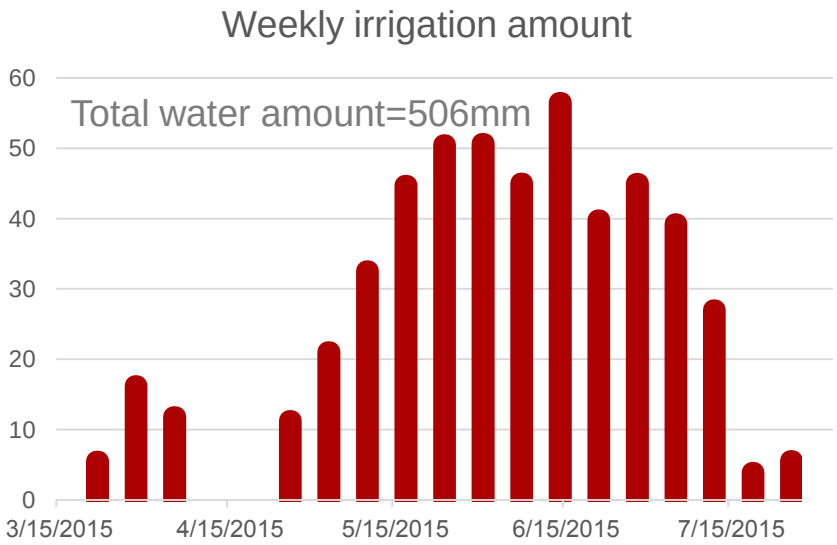
Tomato

May/2015

Jun/2015

Jul/2015





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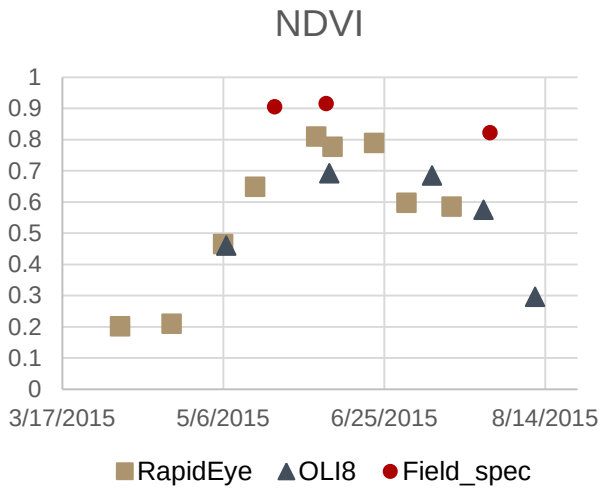
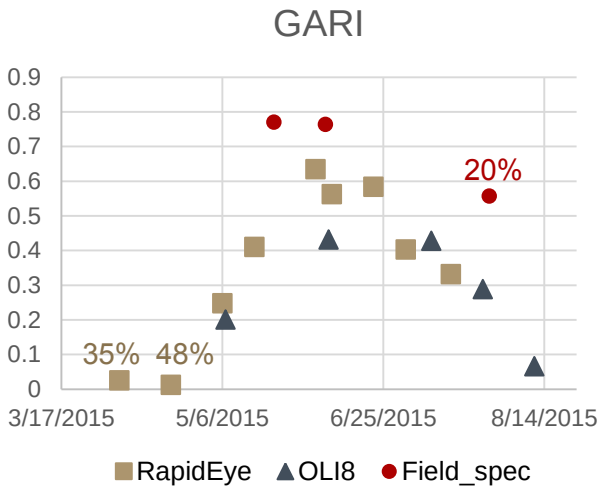
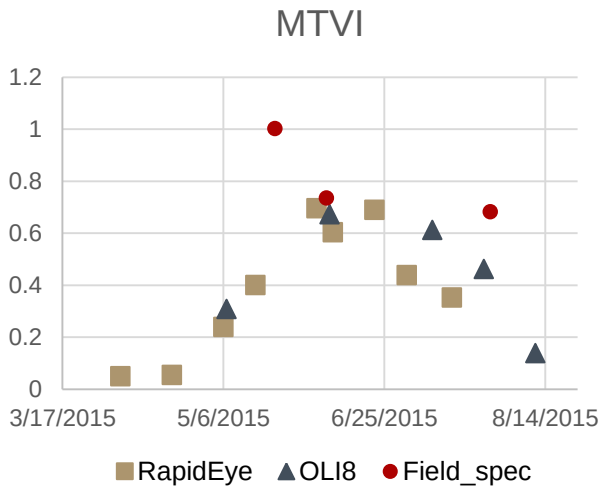
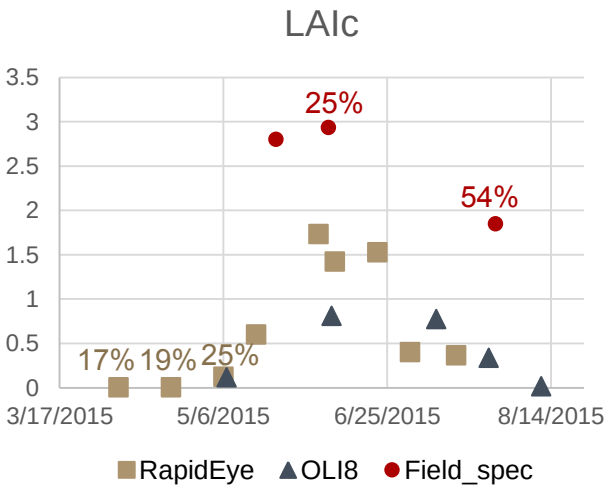
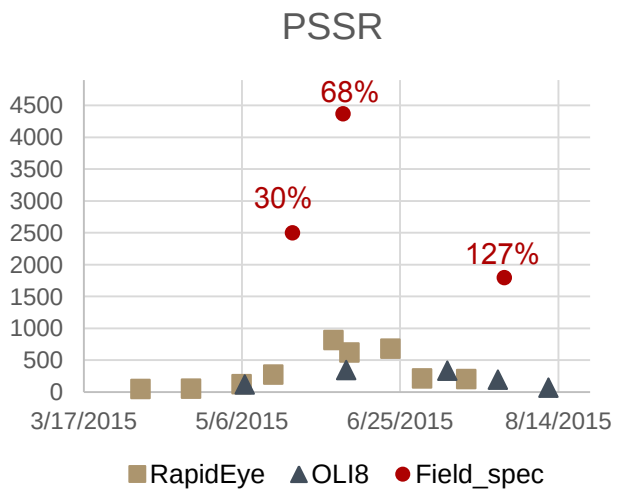
Tomato











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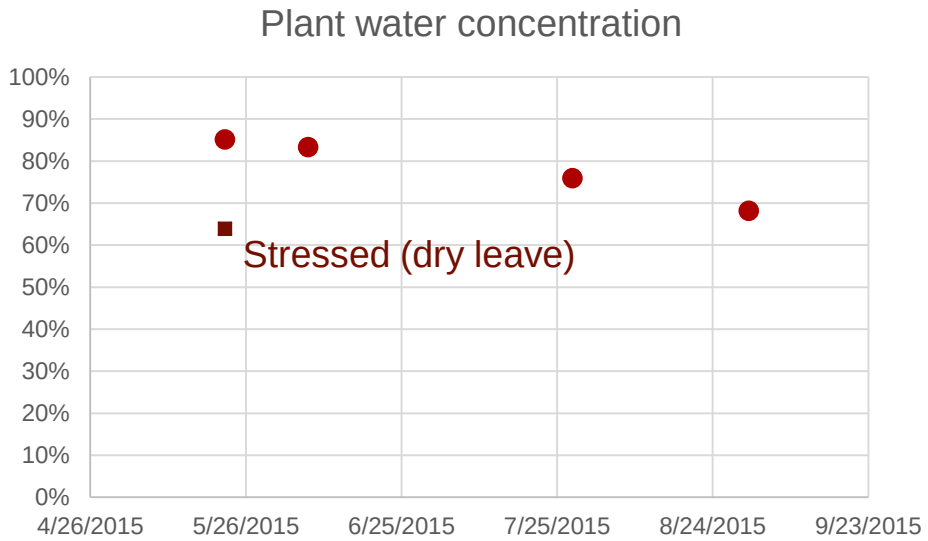
Cotton

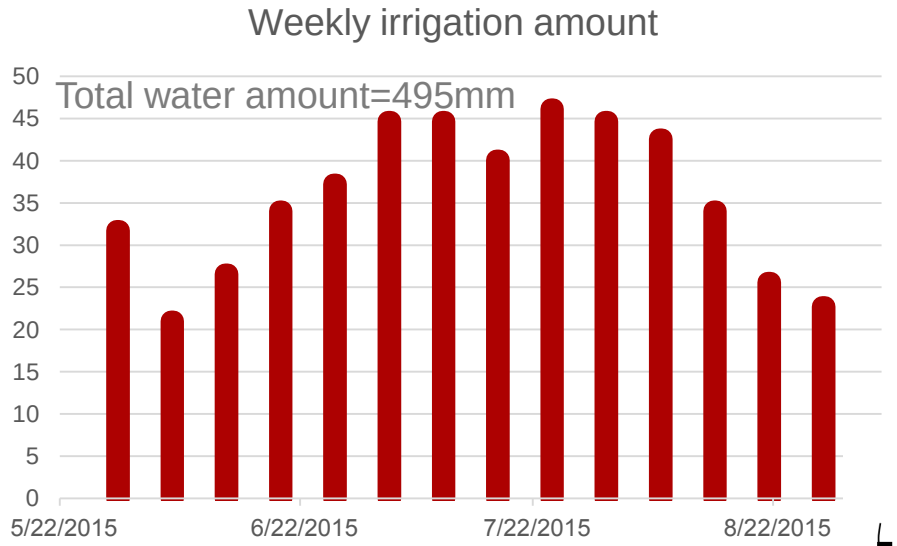
May/2015

Jun/2015

Jul/2015

Aug/2015





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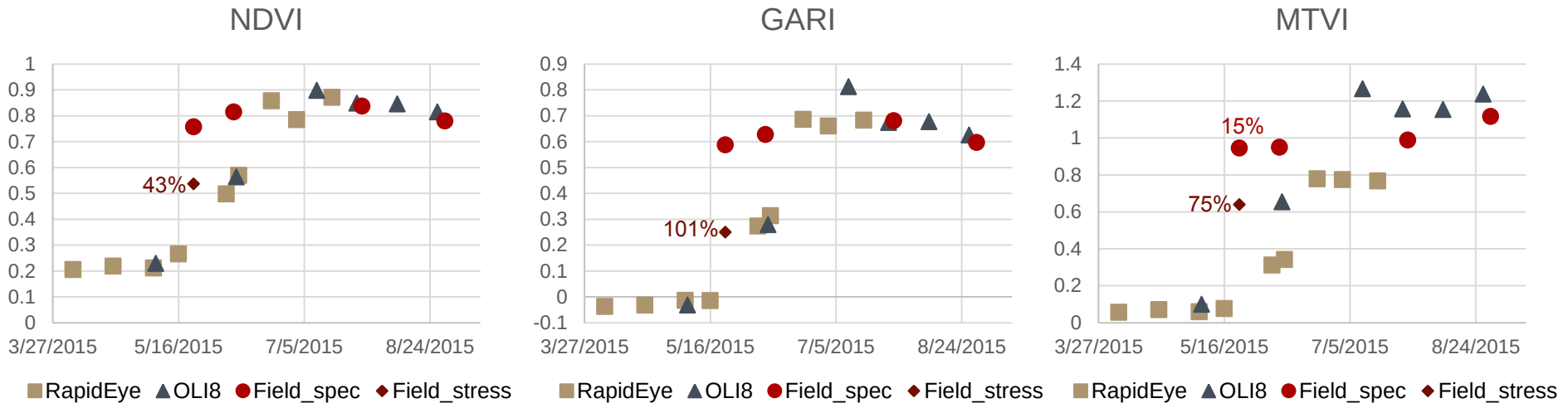
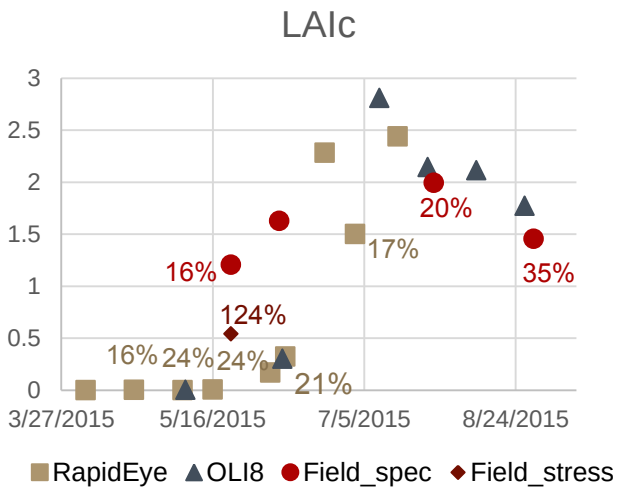
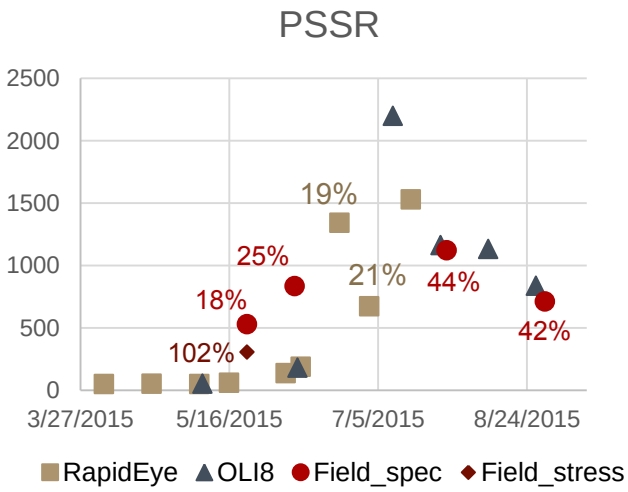
Cotton







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Chickpea

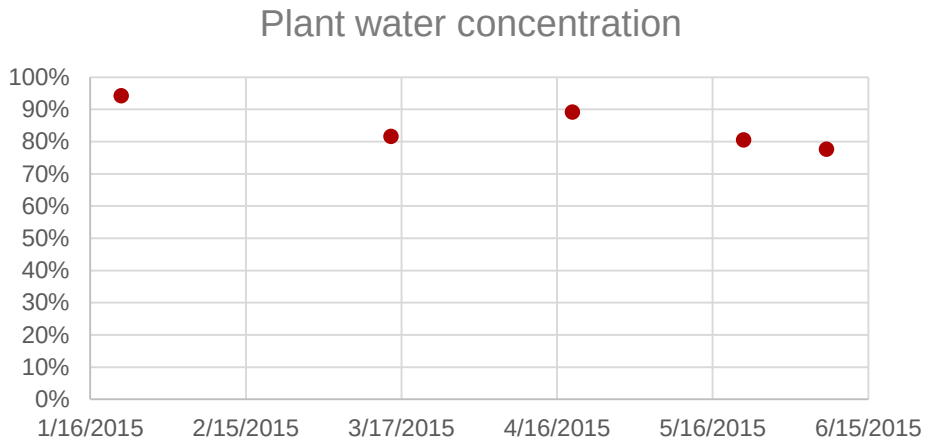

Jan/2015

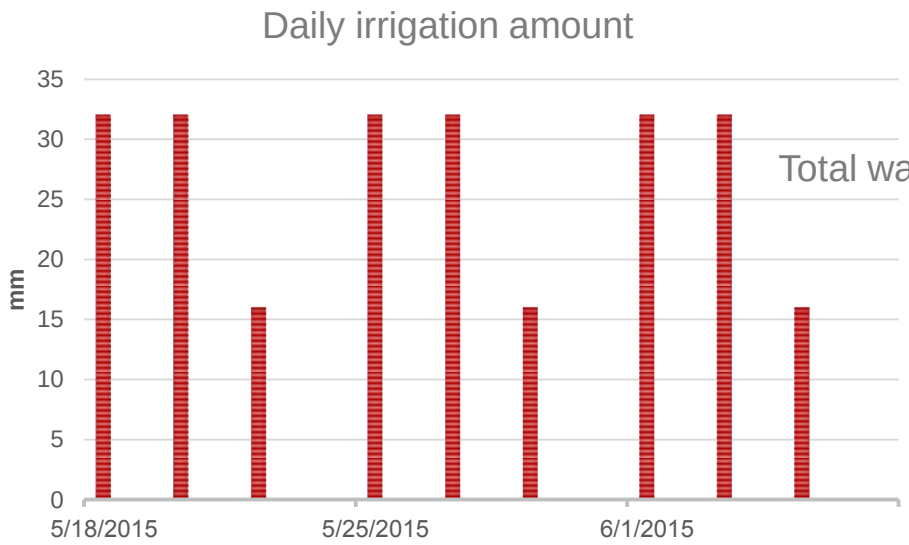

Mar/2015


Apr/2015


May/2015


Jun/2015





Total water amount=240mm

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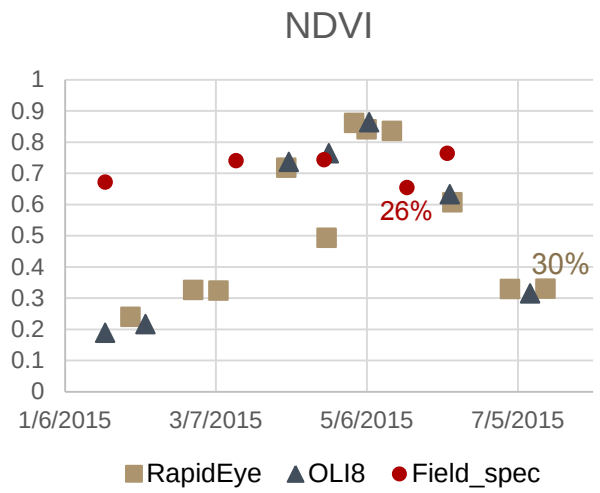
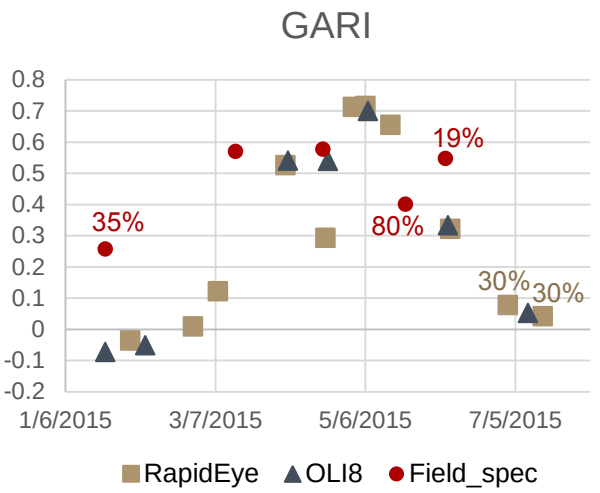
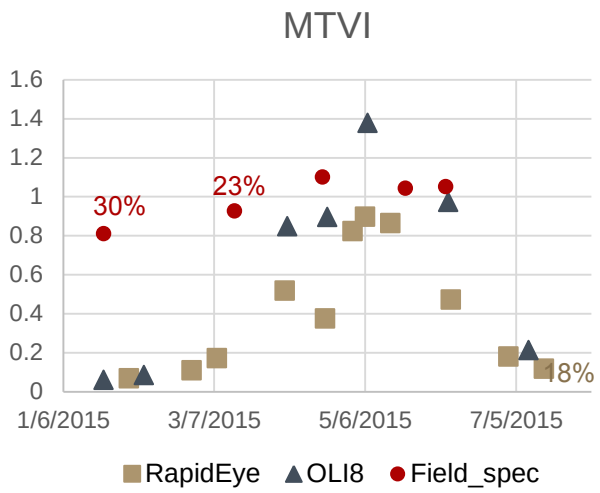
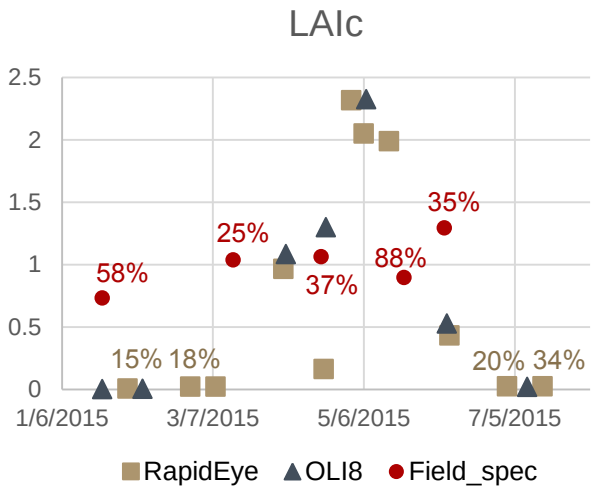
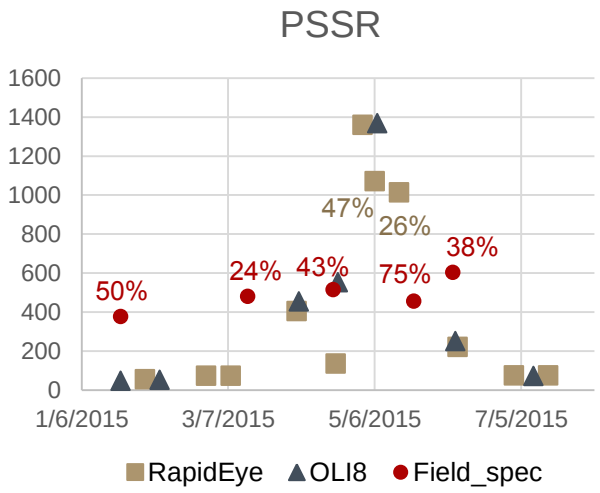
Chickpea











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Assessment of variability level

Test datasets

Tomato	Cotton	Chickpea	Stressed cotton	Chickpea on 22.05.15
30 samples	**40 samples**	**30 samples**	**18 samples**	**10 samples**
22.05.15 (flowering)	22.05.15 (vegetative)	22.01.15 (emergence)	22.05.15 (vegetative, with stress signs)	22.05.15 (flowering/ fruit formation)
07.06.15 (flowering/fruit formation)	07.06.15 (vegetative)	15.03.15 (vegetative)		
28.07.15 (ripening)	28.07.15 (flowering)	19.04.15 (flowering)		
	31.08.15 (fruit formation)			

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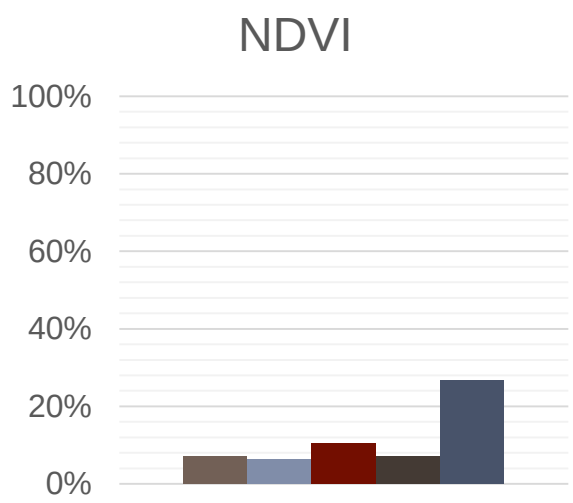
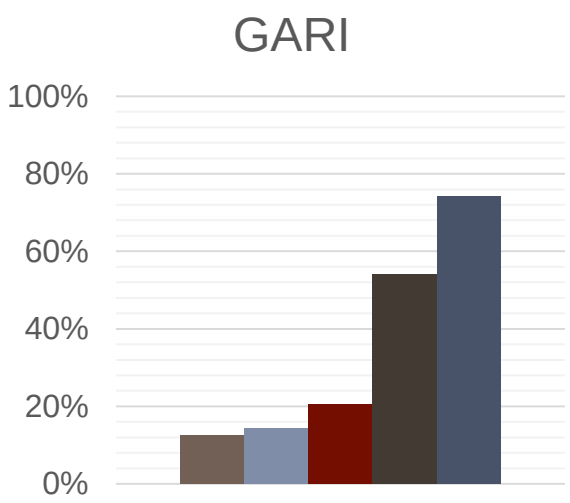
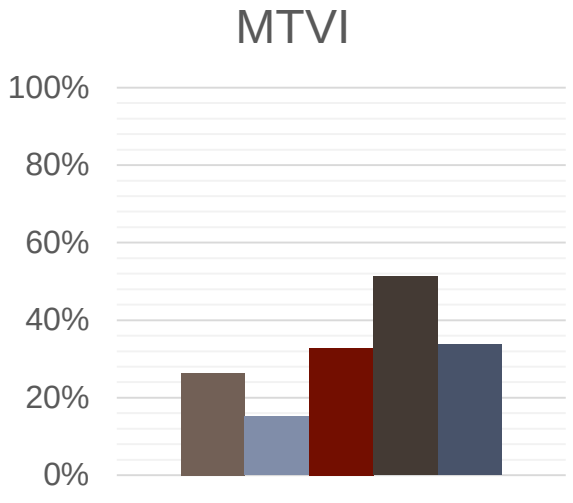
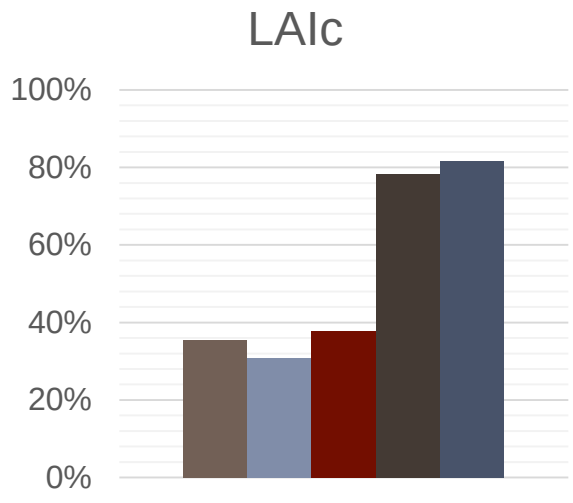
Variability in health and stressed crops









Tomato

Cotton

Chickpea

Stressed cotton

Chickpea on 22.05.15

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Water-stress detection

Satellite imagery

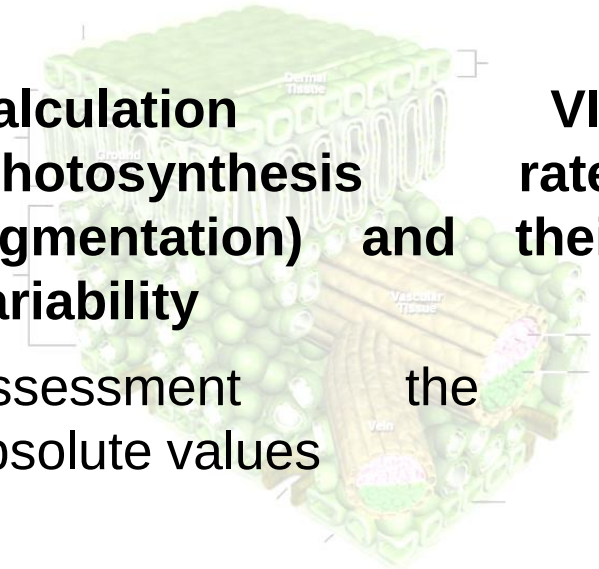
Estimation growth rate (LAI, green biomass, crop coefficient)

Compression with reference values

Field spectroscopy

Calculation VIs (photosynthesis rate, pigmentation) and their variability

Assessment the absolute values



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Irrigation optimization by spectral data

Detected stress by field spectroscopy

Inputs
Crop
Soil properties
Weather
Type of irrigation
etc.

Analysis

Irrigation schedule

Water requirement by spectral image

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Thank you for your attention!

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