

Role of UAVs for Farm Management: From Crop Water Use to Fertilization to Canopy Volume and Yield

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In collaboration with ARS USDA and E&J Gallo Research Groups

The AggieAir UAV platform:

AggieAir 2.5: Second Generation ("Minion")

Status:	Deployed
Wingspan:	9 ft
Takeoff Weight:	17 lbs
Payload Weight:	5 lbs
Flight Range:	37 miles
Flight Time:	1.25 hours
Area:	4 sq miles



Optical Cameras



- Lumenera Lt965R (CCD w/ USB 3.0)
- 9.1 mega pixel (12 mega pixel by fall)
- RGB/NIR/and other monochrome
- up to 19 images/second
- ~20 cm resolution @ 1,000 m AGL

- ICI 760; microbolometer thermal
- 640x480 pixels
- 1.4 m resolution @ 1,000 m AGL
- 0.1 °C accuracy
- NUC between consecutive images



Two scenarios

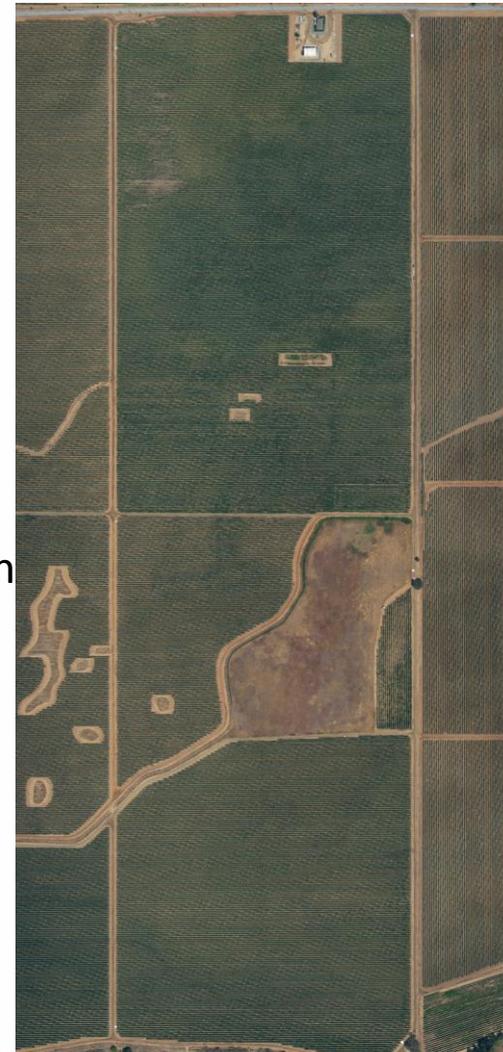
Full cover: alfalfa / grains



Location: Central Utah
Date: 2012 / 2013
Area: ~245 acres

Resolution:
RGBNIR: 0.15m
Thermal: 0.60m

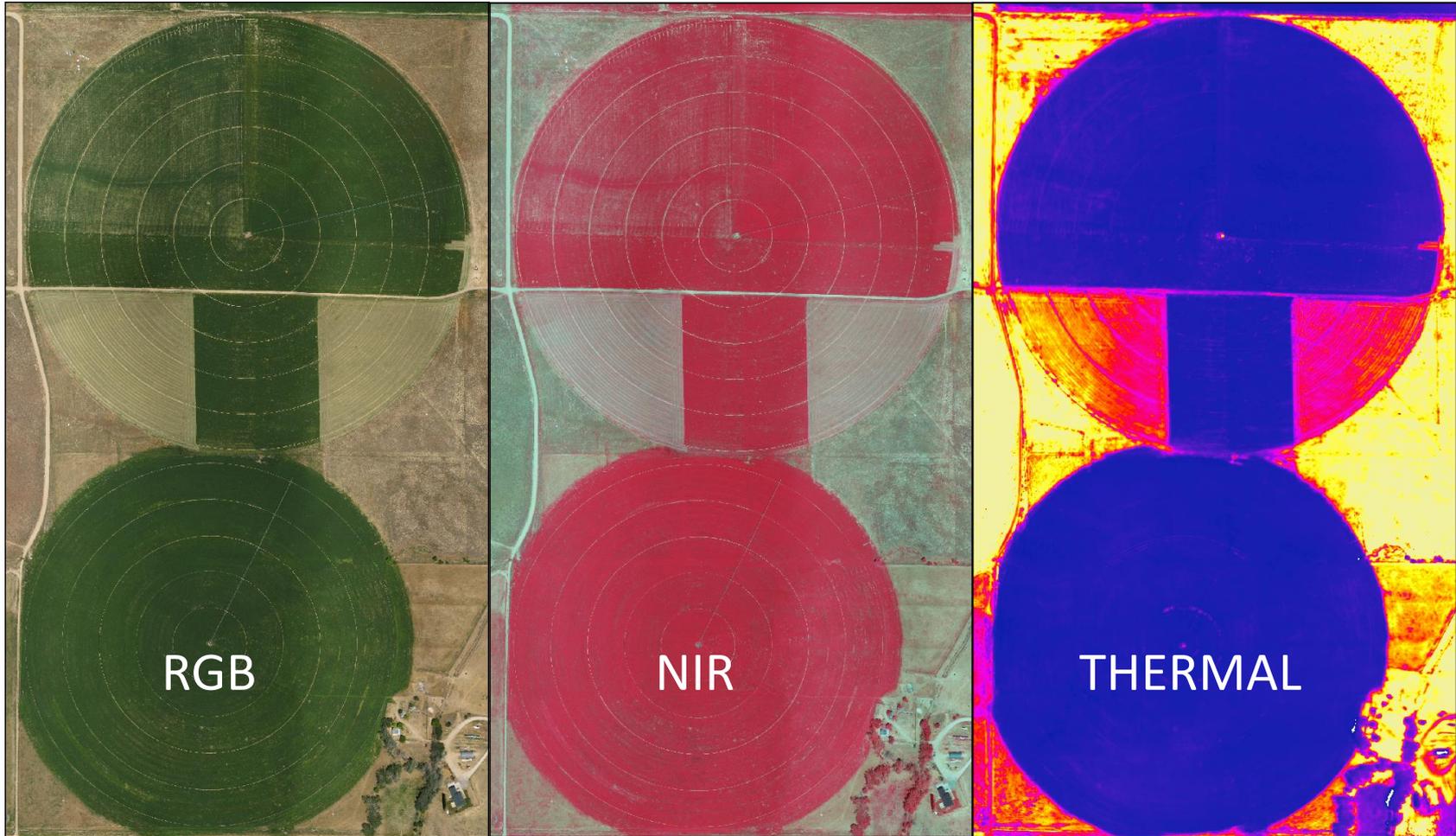
Row crop: vineyards



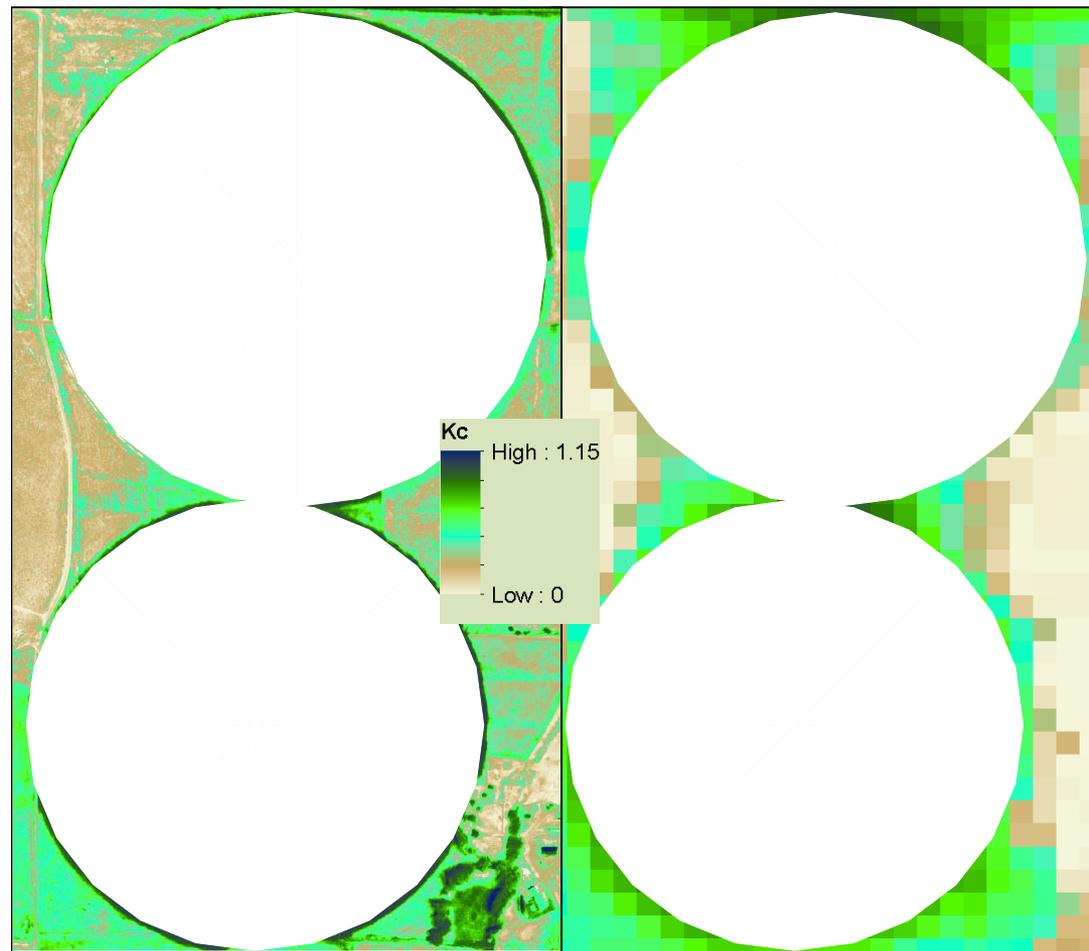
Location: Lodi, CA
Date: 2014 / 2015
Area: ~210 acres

Resolution:
RGBNIR: 0.10m
Thermal: 0.60m

AggieAir™ Spectral Bands

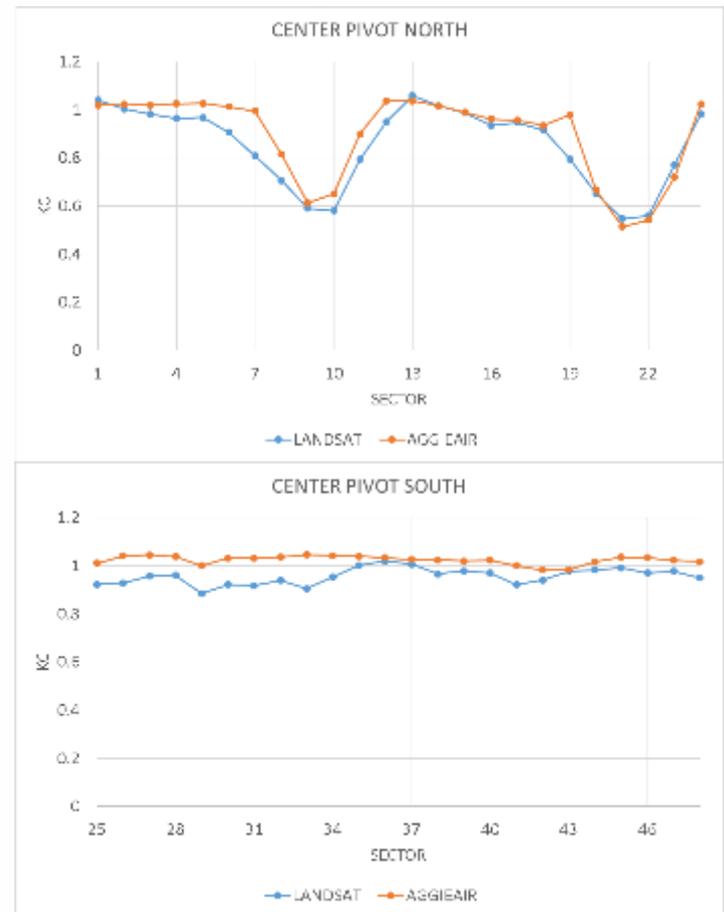


RGB-NI-THR: Evapotranspiration: METRIC™



At this resolution, AggieAir imagery contains about 40,000 times as much information per unit of land area as Landsat.

Average Kc values



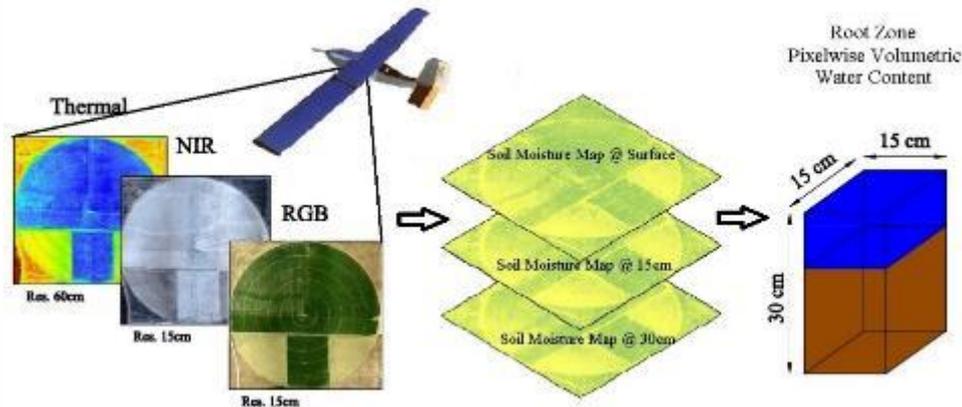
- Homogeneous areas: similar Kc pattern.
- Significant Kc differences in others.

RGB-NI-THR: Soil Moisture

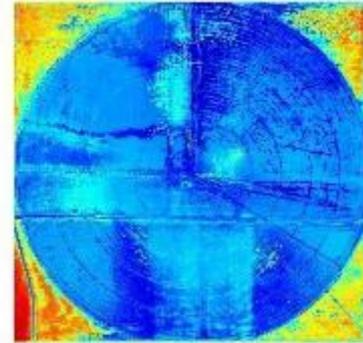
Soil Moisture is a complex variable to spatially estimate.

By use of data-mining algorithms (e.g. Artificial Neural Networks) it is possible to estimate SM at pixel level at different depths.

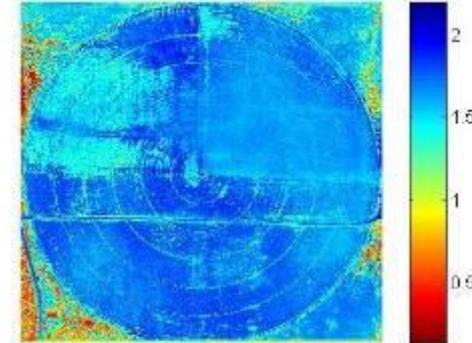
Root-Zone Soil Moisture



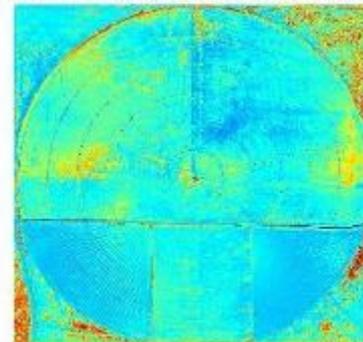
Root Zone VWC Map (cubic decimeters)(2013/05/16)



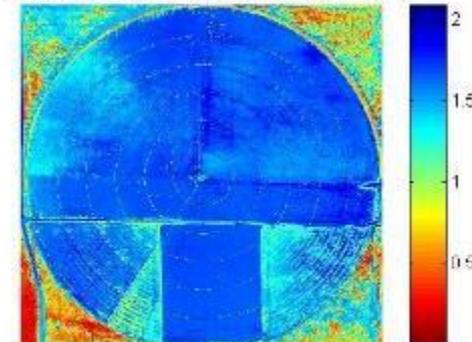
Root Zone VWC Map (cubic decimeters)(2013/06/01)



Root Zone VWC Map (cubic decimeters)(2013/06/09)



Root Zone VWC Map (cubic decimeters)(2013/06/17)



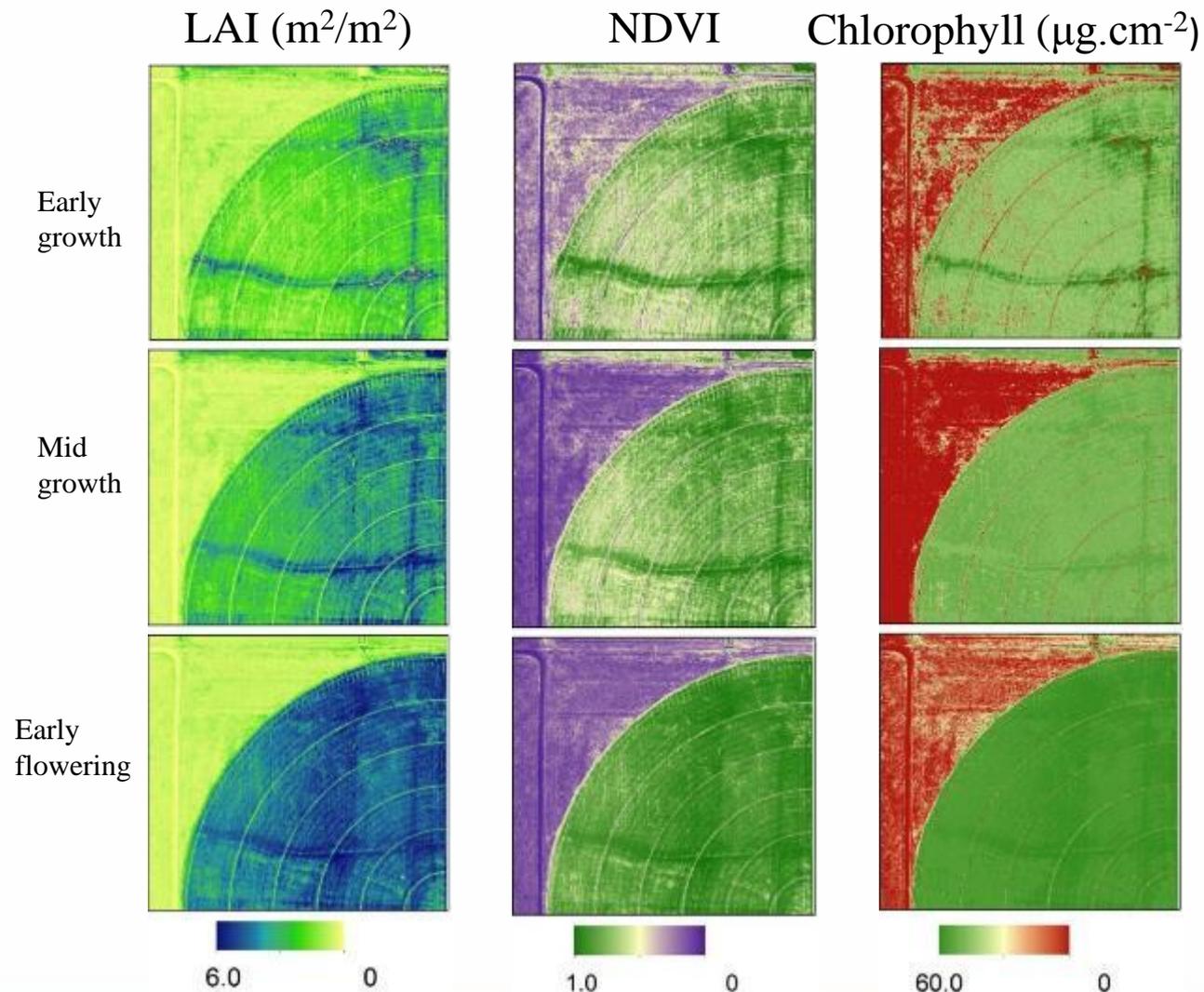
RGB-NI-THR: Plant Chlorophyll

Plant Chlorophyll without Red Edge band is complex to estimate.

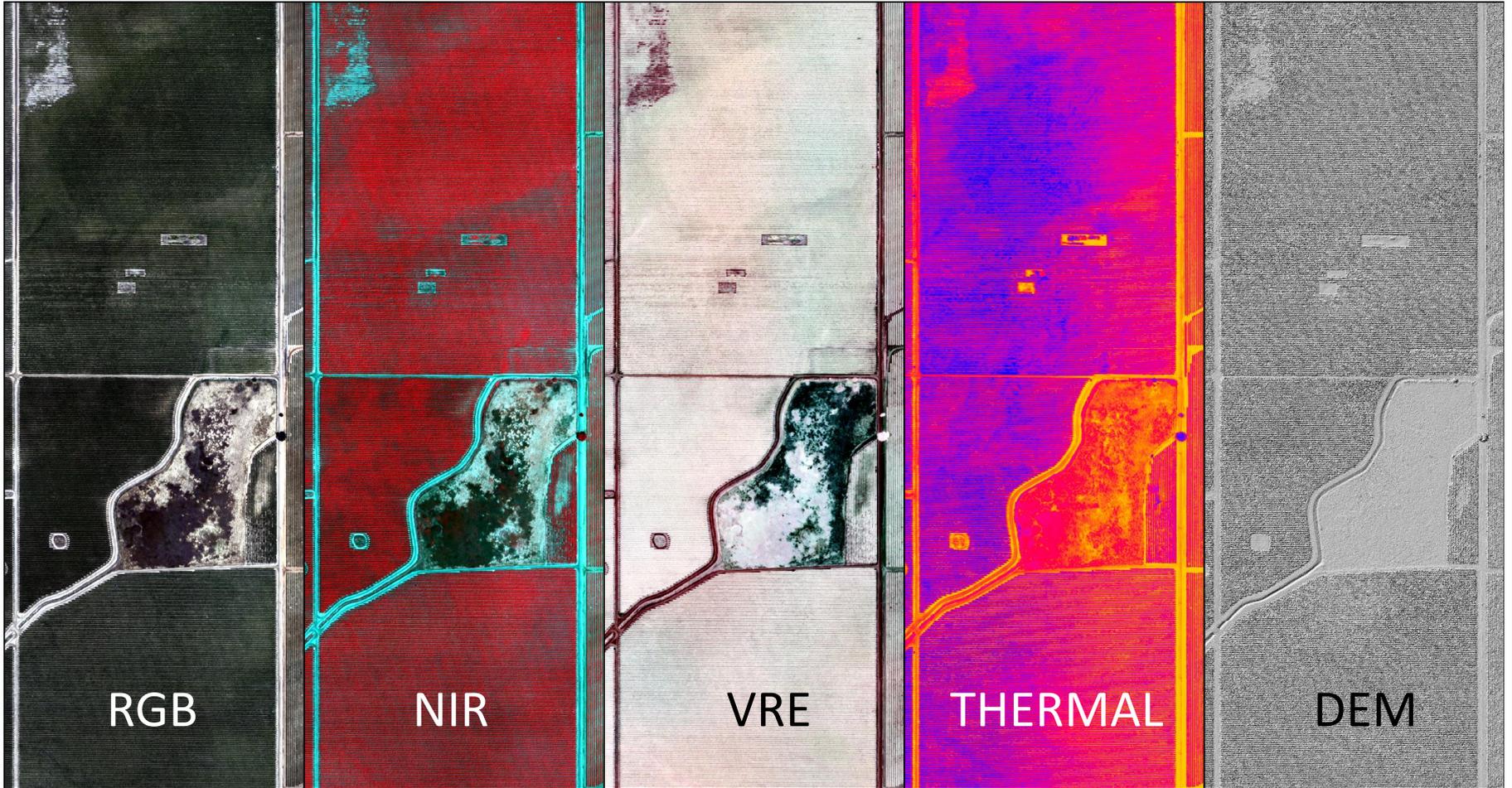
Similarly to Soil Moisture, Chlorophyll was estimated by data-mining algorithms (Relevance Vector machines).

Inputs were Red, LAI, NDVI, Thermal images.

RSME = $8.52 \mu\text{g}\cdot\text{cm}^{-2}$
Eff Coeff = 0.71.

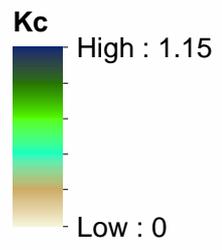
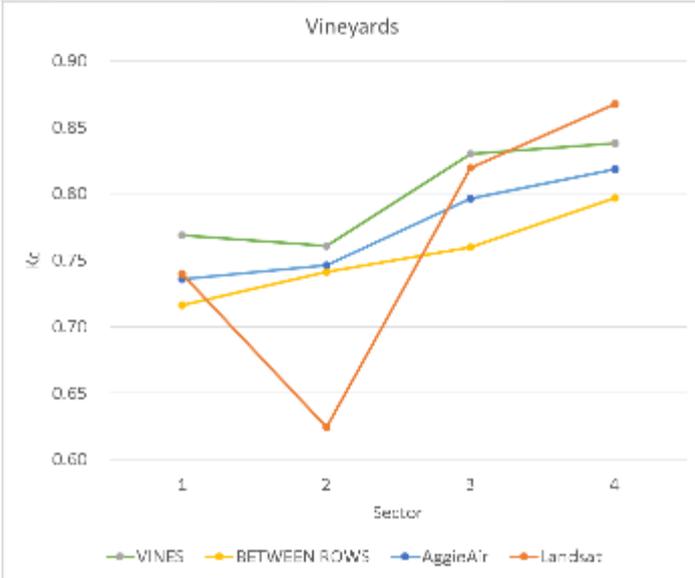
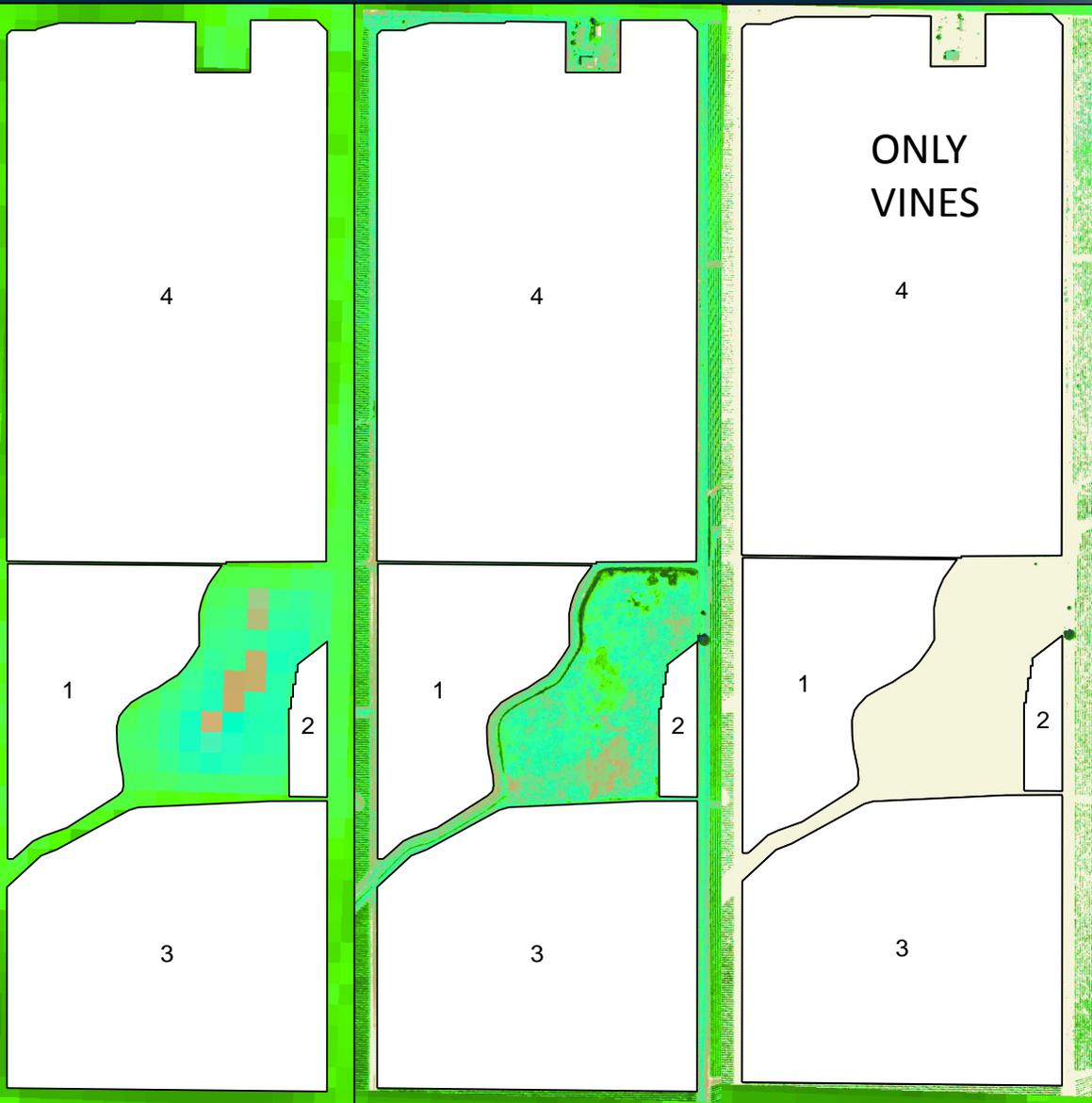


Row Crops - Vineyards



*In collaboration with ARS USDA and E&J Gallo Research Groups

RGB-NI-THR: Evapotranspiration: METRIC™



Landsat: only large areas (min area?)

UAV can enhance Landsat ET pixel

Row crops can be discriminated.

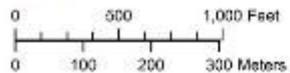
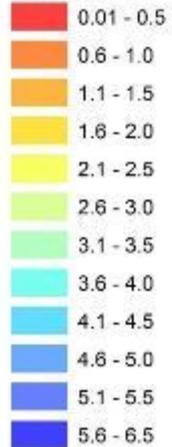


DEM: Canopy Volume and Yield

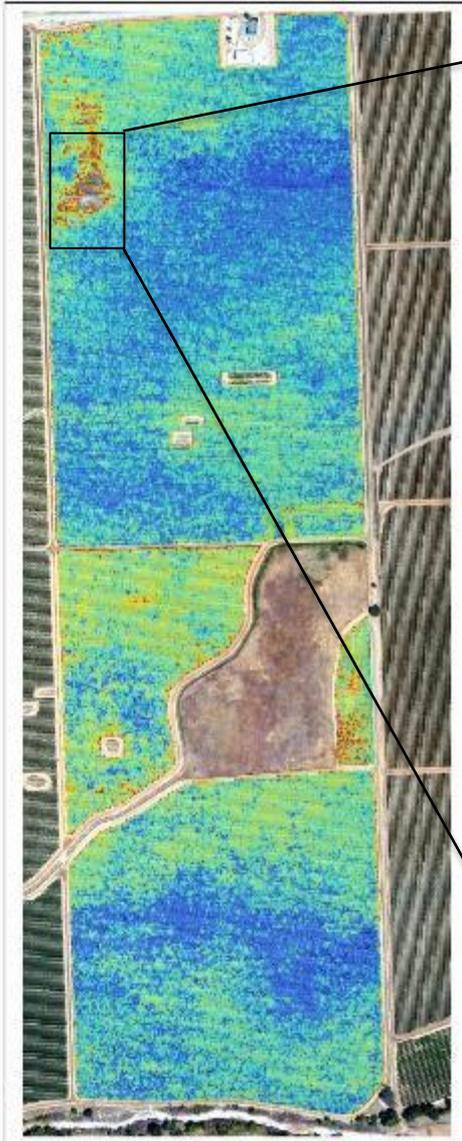
Canopy Volume (m3) per vine

Lodi
AggieAir
Flight: 08/09/2014

Legend Canopy Volume (m3)



Coordinate System: WGS 1984 UTM Zone 10N
Projection: Transverse Mercator
Datum: WGS 1984



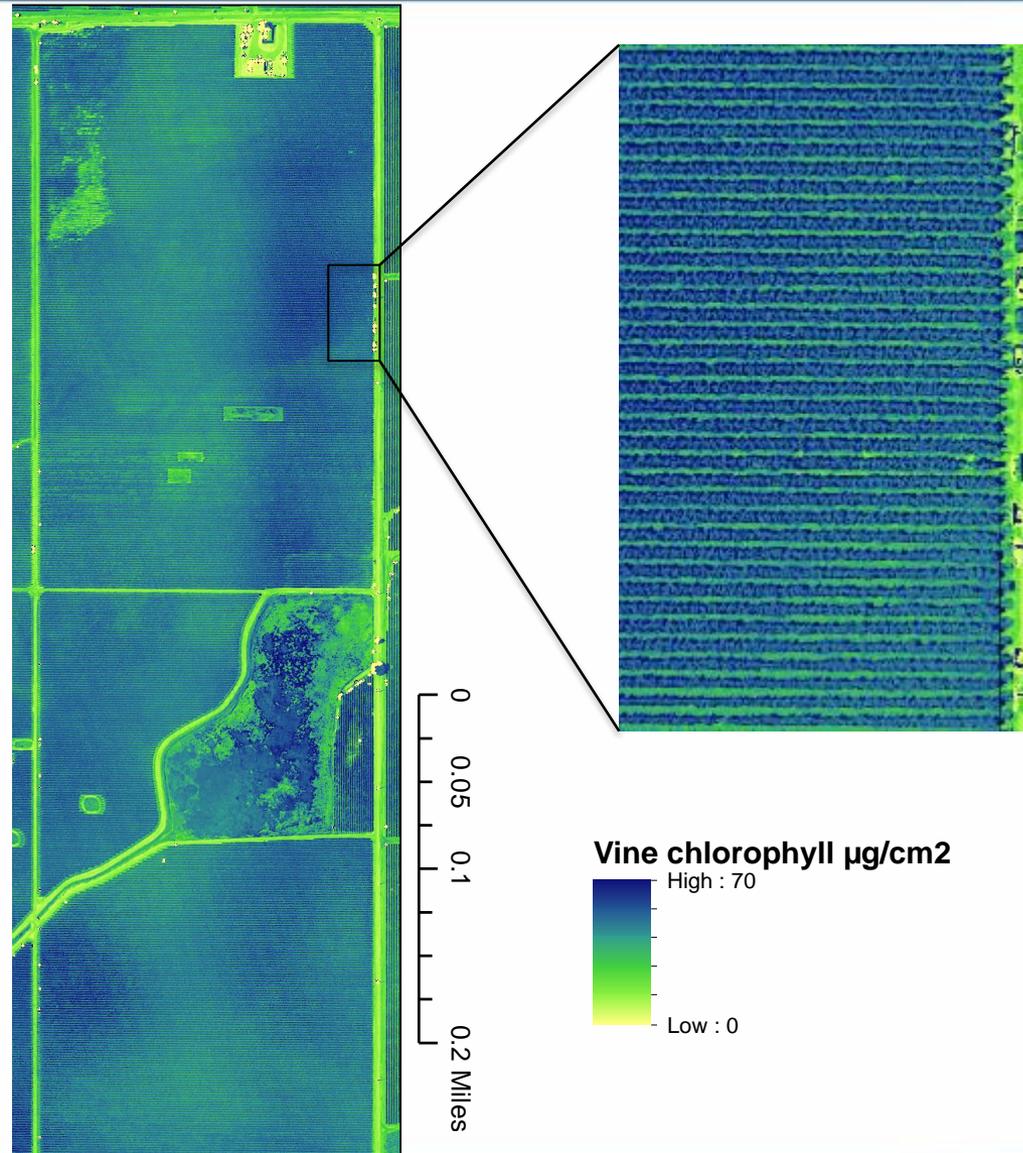
Section	N° Vines
1	15,685
2	2,345
3	40,599
4	68,743

Plant mgmt. (leaves trimming, dead vines, irrigation issues) can be detected.

On-the-plant grape yield (quantity & quality) is related to canopy mgmt.

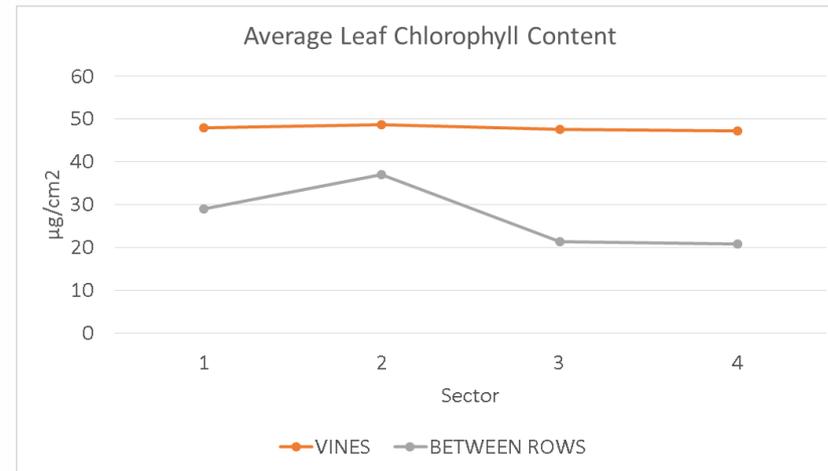
A vine-scale farm mgmt.?

Red-Edge: Vine Chlorophyll



Leaf chlorophyll content can be used to monitor Nitrogen status and estimate requirements.

Red, Green, NIR, and VRE bands are necessary*.



* Based on Zarco-Tejada et al. 2005

Conclusions

- UAVs such as AggieAir™ provide ON-DEMAND remote sensing capabilities for diverse crop groups.
- UAVs information can enhance satellite scientific models and products.
- AG requisites: right sensors and analytics, along with adequate aerial platform.
- “Precision Agriculture” does not mean smaller pixels.
- UAV’s next steps: affordability, ease of use, area coverage, smaller turnaround time.



Questions?

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Years of
Water
Excellence

AggieAir 3.0: Third Generation “Condor” - 2016



Status:	In Testing
Wingspan:	11 ft
Takeoff Weight:	25 lbs
Payload Weight:	5 lbs
Flight Range:	100+ miles
Flight Time:	2+ hours
Area:	20 sq miles



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Minion Launch (“Pinot”):

