Crop-Vu
Optimize Your Crop's Yield
A Division of IntriCorp – No Boundaries

Visual and Thermal Imaging

An Imaging Component of the Precision Ag Toolkit

Jim Etro

jim@crop-vu.com

703-489-8507

http://www.crop-vu.com

Crop-Vu
Optimize Your Crop's Yield
A Division of IntriCorp - No Boundaries

Precision Agriculture

is spatial and temporal

Precision Agriculture enables a detailed view and understanding of the crop as it is growing so that it can be managed affordably.

Tools of the Trade

High Fidelity Sensing and Analyses
Precise Positioning - GIS
Precise Machines

An Agronomist in the Field

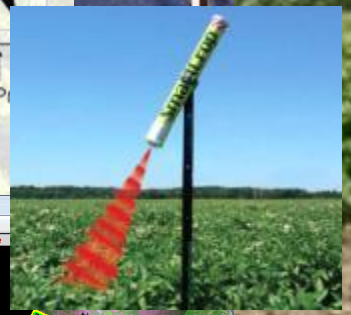
Precision Leads to Increased Margins

Crop-Vu
Optimize Your Crop's Yield
A Division of IntriCorp - No Boundaries

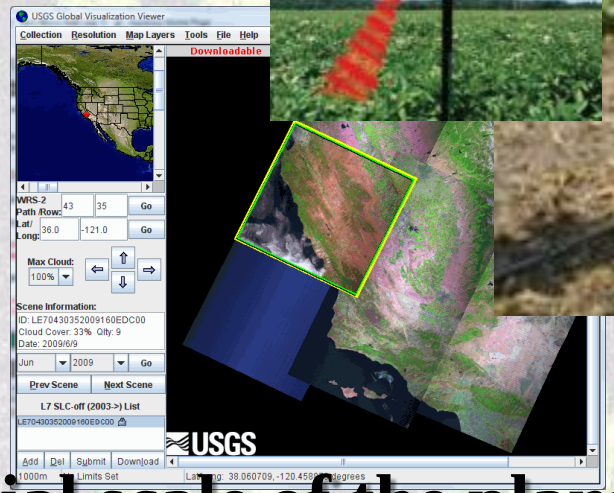
High Fidelity Sensing

In Soil

In Plant & Near Plant



Aircraft & Satellite



at the temporal and spatial scale of the plant

http://www.crop-vu.com

Applying Imaging

at the temporal and spatial scale of the plant

Provides the information needed for making agricultural decisions.

- **Disease and Pest and Irrigation Scouting/Assessment**
- **Help Guide Management of Water & Amendments & Herbicides & Pesticides**
- **Canopy Management**
- **Life Cycle Mapping**
  - **Follow Growth**
  - **Mapping for Variable/Precision Harvest Operations**
- **Direct Resources** **(Labor/Water/Amendments/Herbicides/Pesticides)**

To be at the temporal and spatial scale of the plant the imagery must be:

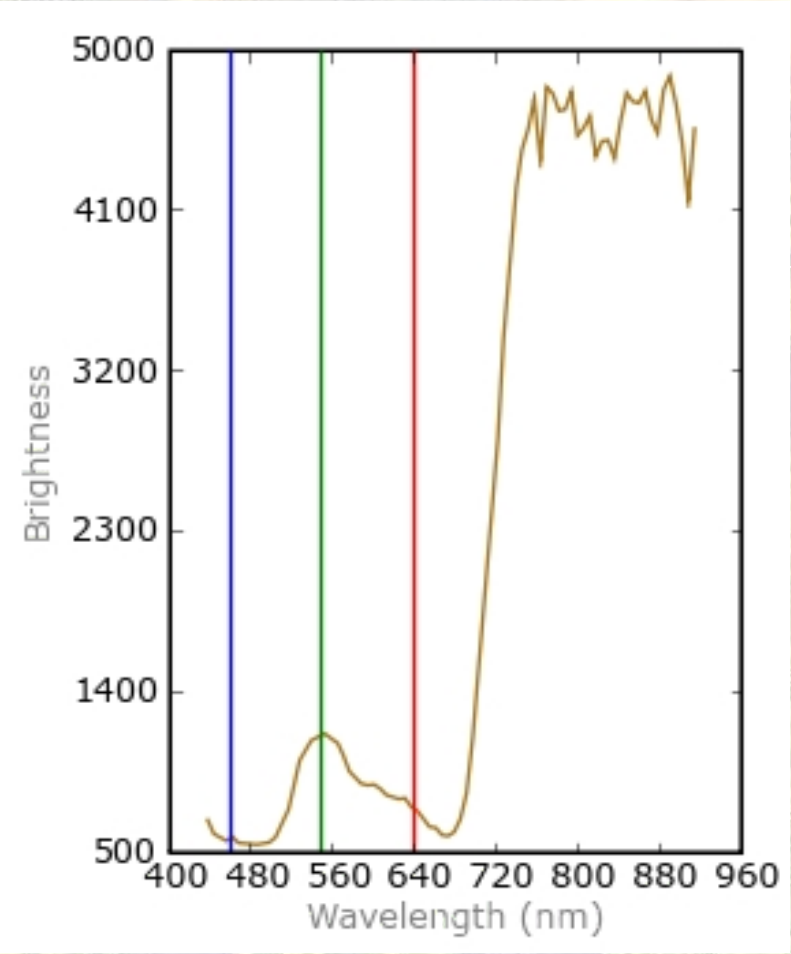
High Resolution

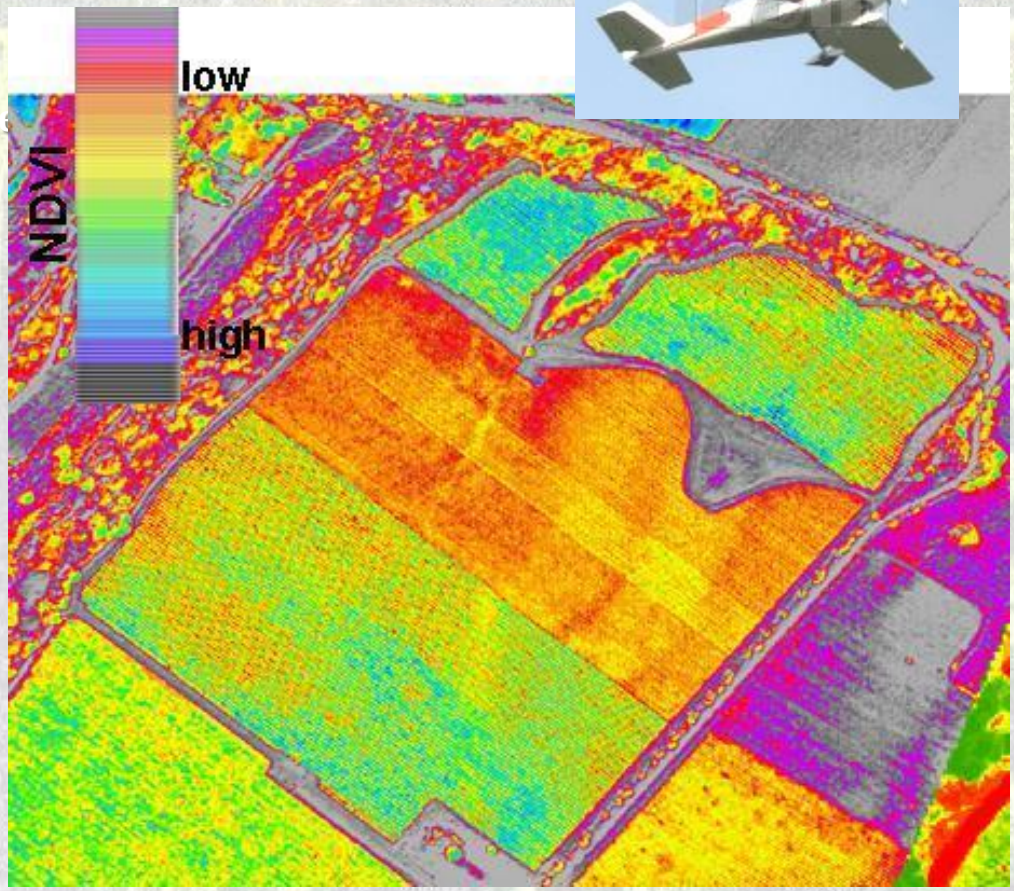
On-Demand

Affordability!!!

http://www.crop-vu.com

Remote Sensing & Analysis by Visual Imaging using NDVI





http://www.crop-vu.com

Hawk-Eye™ Remote Sensing System

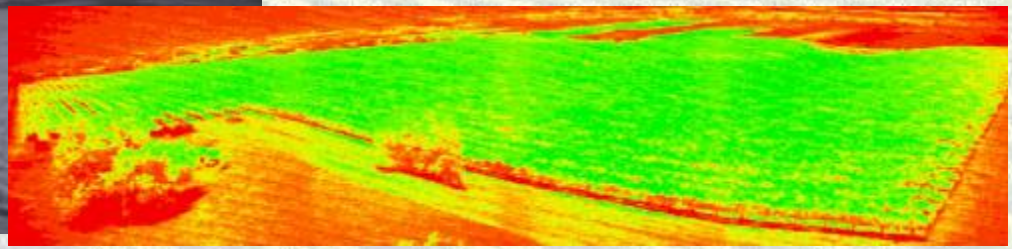
Thermal and Visual Views of the Field
Oblique
Steerable Views
On-Demand

http://www.crop-vu.com

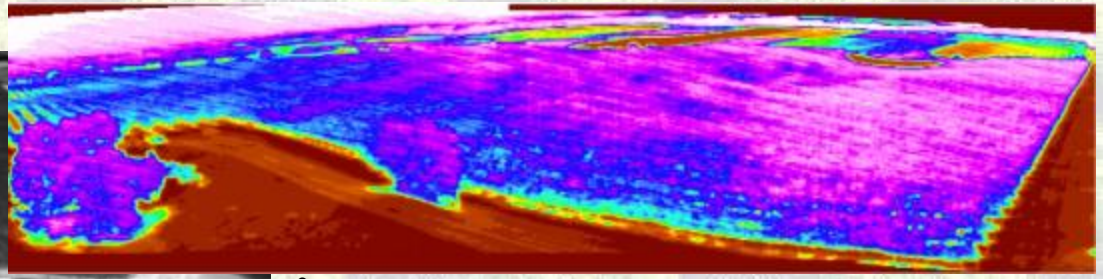
Remote Sensing & Analysis

by Imaging

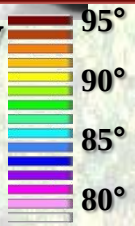
Visual – sensing reflected energy



Near-Infrared – sensing reflected energy

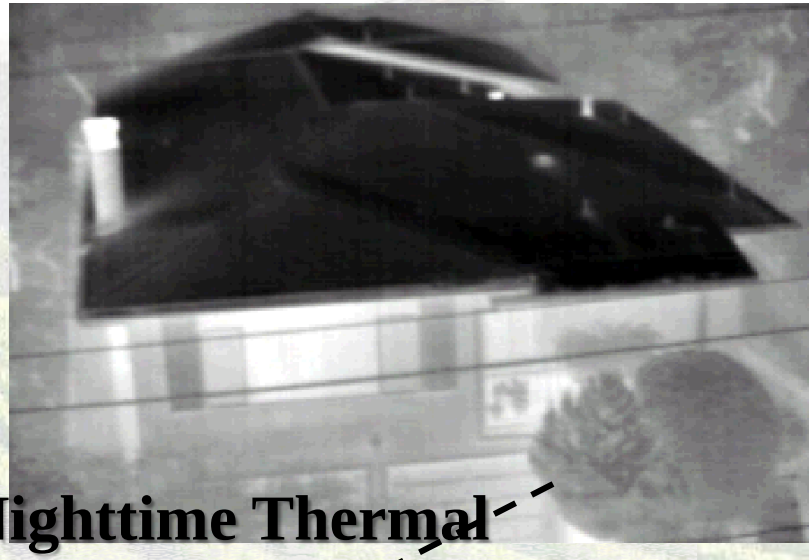


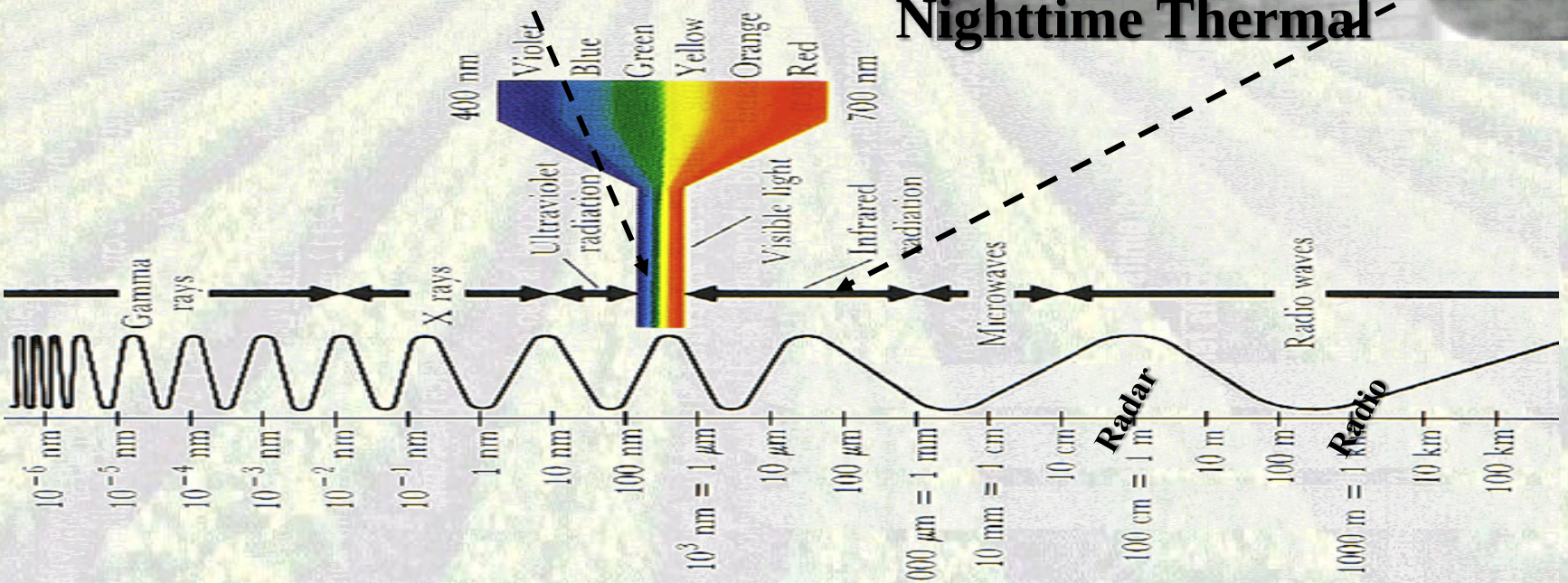
Far-Infrared – sensing emitted energy



http://www.crop-vu.com

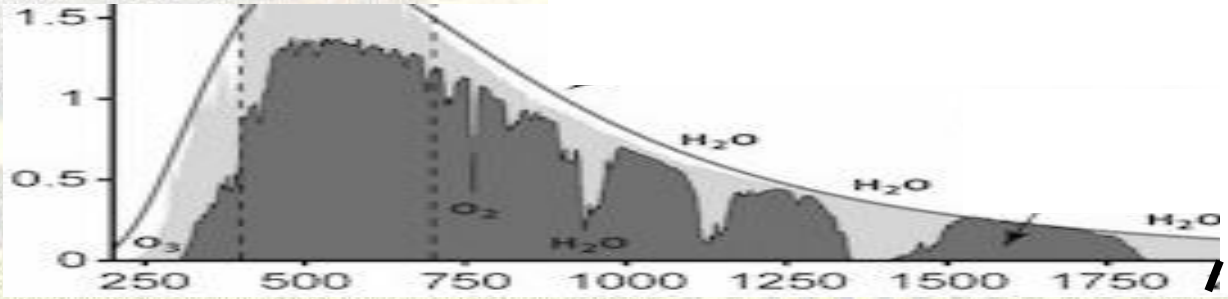
The Imaging Spectrum





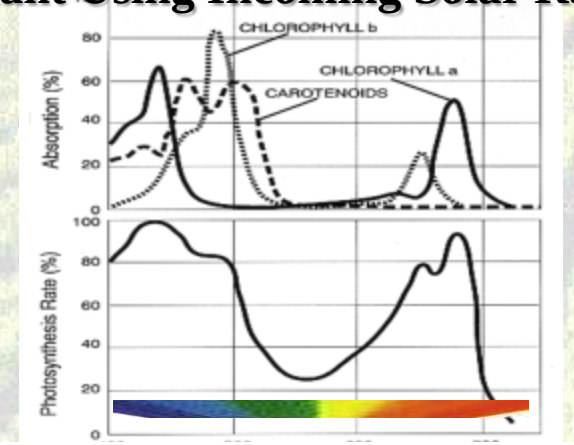
Thermal *Regulation* in Isohydric Plants

Incoming Solar Radiation

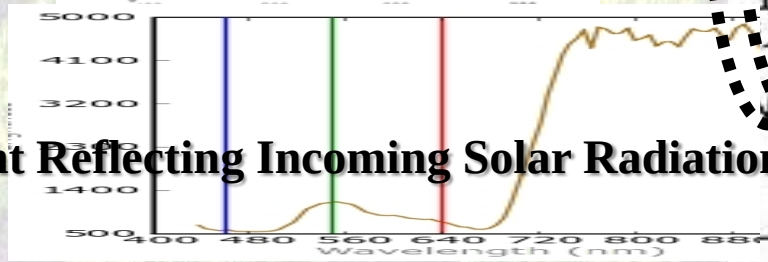


- Scatter Visible and n-IR energy that isn't used
- Transpiration
- Shade/Shape of the Canopy

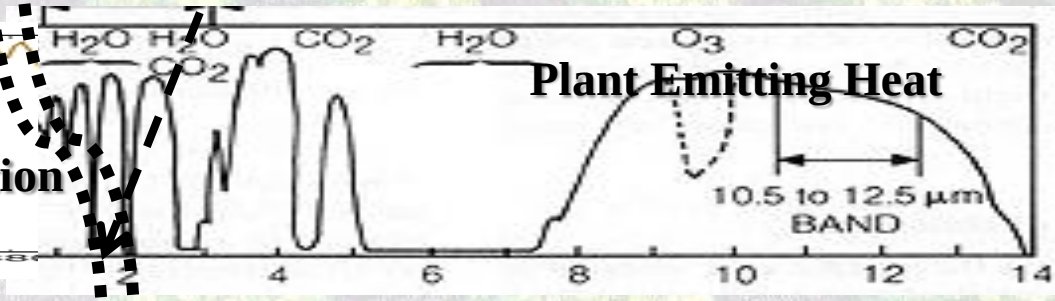
Plant Using Incoming Solar Radiation



Plant Reflecting Incoming Solar Radiation



Plant Emitting Heat



Vineyard Thermal Observations

As the day progresses **the canopy warms to a 'comfortable' range**.

- Near sunrise, healthy grapevine canopy **temperatures tend to be within a few degrees of the ambient air temperature**.
- As the day progresses canopy temperatures warm so that during the middle of the day the healthy canopies reach a **range of temperatures between 83°F and 91°F**.
- **Day-time temperature range is maintained** even when the ambient air temperatures are as much as 10°F lower than the canopy temperature and when the ambient air temperatures are as much as 15°F higher than the canopy temperature.

As the canopy fills out **canopy temperatures are inverse to the vigor** (greenness).

- relatively cool temperatures inversely proportional to high vigor patterns.
- Relatively warmer temperatures are normally reflected in relatively lower vigor patterns.
- When high vigor – **warmer temperatures is usually the signature of stress**.
- the pattern over the extant of the field leads one to understand if it is water stress or a disease/insect stress.

As grapes approach **ripeness this phase relationship may invert** (become directly proportional)

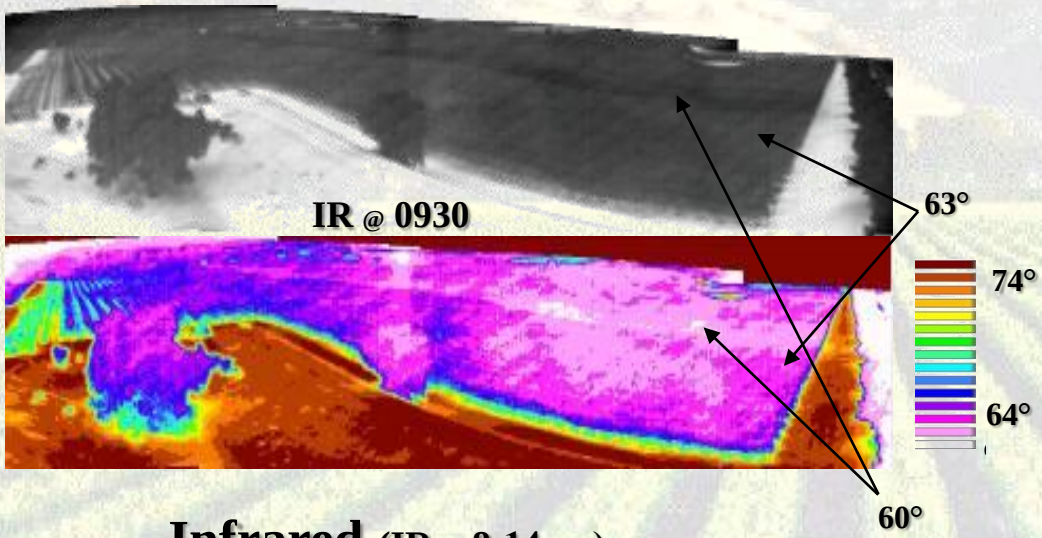
- the canopy temperatures decrease and the vigor (leaf greenness) also decreases.

Crop-Vu
Optimize Your Crop's Yield
A Division of IntriCorp - No Boundaries

Thermal (far-IR) Imaging

Daytime Warm-Up

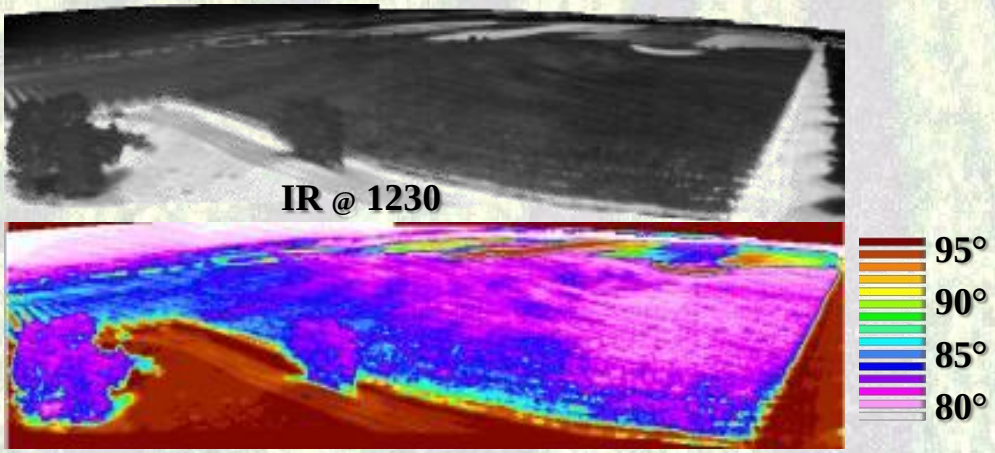
11 July 2008
Salinas Valley, WestSide



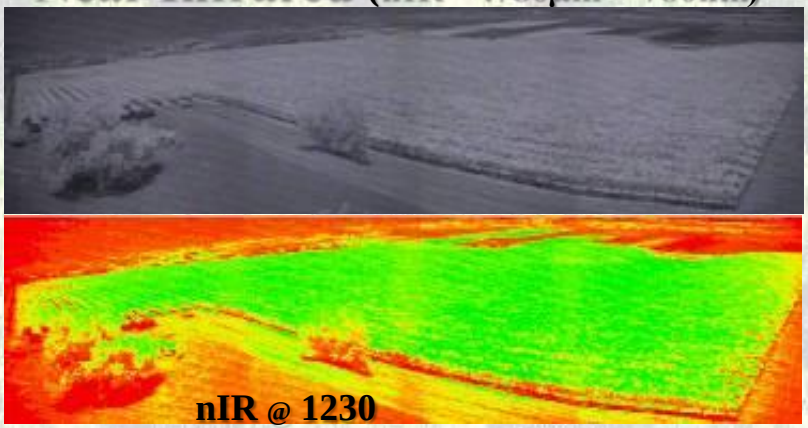
0930 Environment
- airtemp - 64°
- grndtemp - 73°
- leaftemp - 64°
- wind – calm
- sky – 10/10
- low stratus
- vsby - 5mi]

1230 Environment
- airtemp - 74°
- grndtemp - 96° sun / 79°shade
- leaftemp – 83° - 90°sunside
- wind – ~04/020
- sky – 0/10
- vsby - 9mi

Infrared (IR = 8-14µm)



Near Infrared (nIR = .780µm = 780nm)

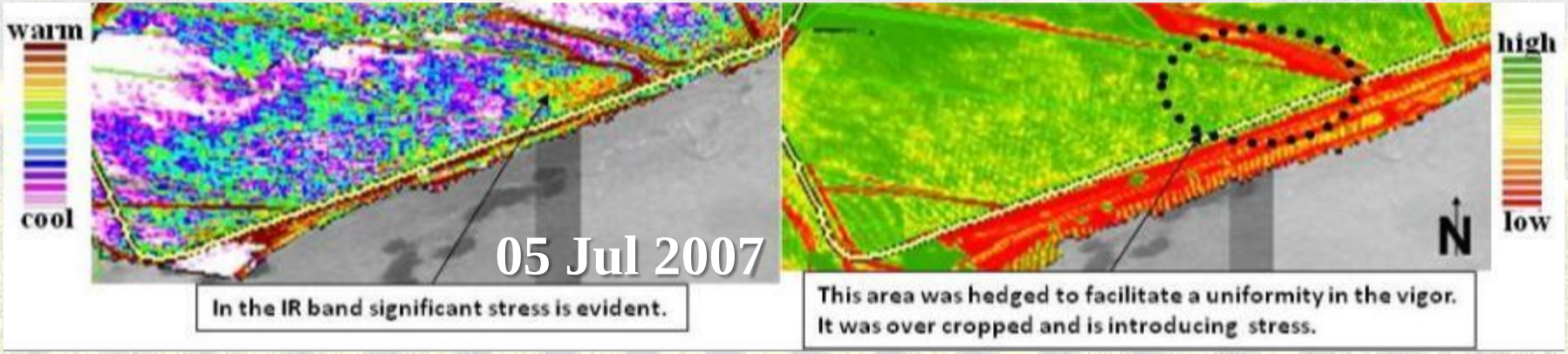


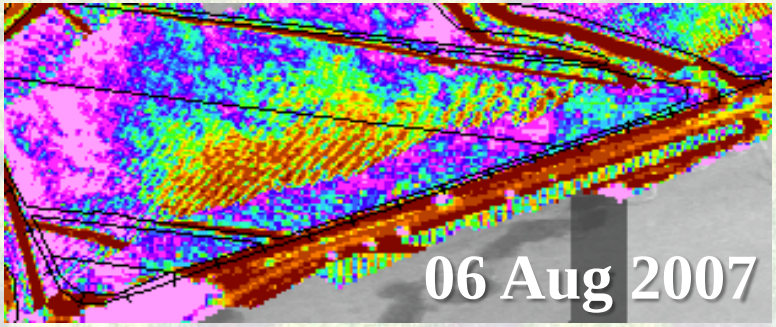
http://www.crop-vu.com

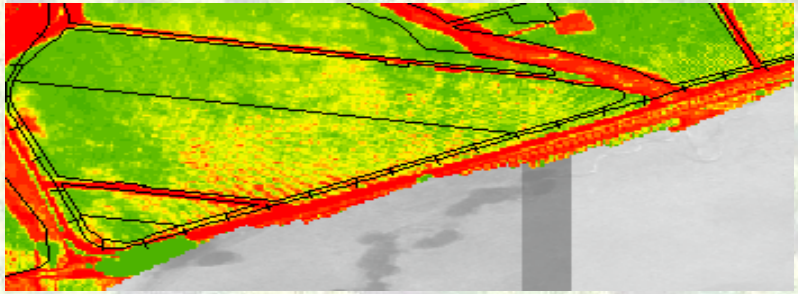
Crop-Vu
Optimize Your Crop's Yield
A Division of IntriCorp - No Boundaries

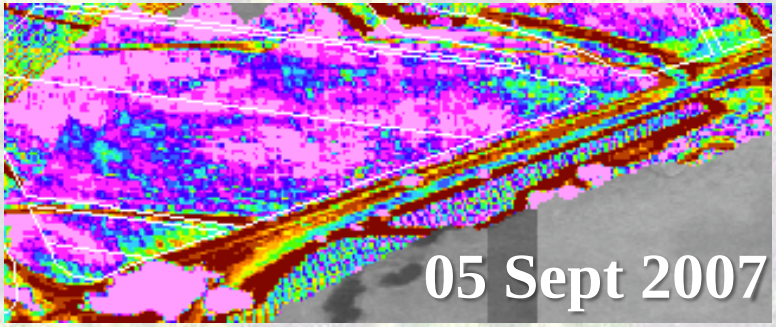
Thermal (far-IR) Imaging

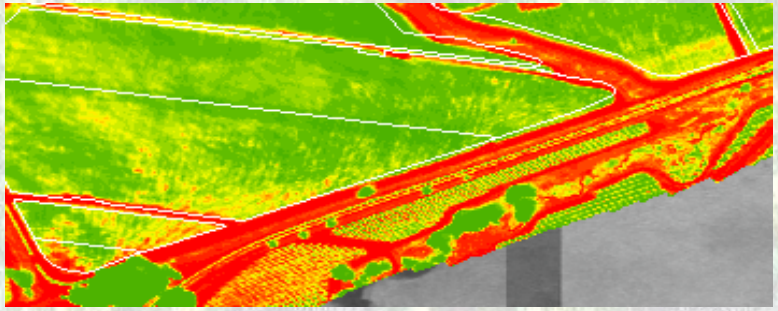
Temperature - Vigor Relationship











http://www.crop-vu.com

Grape Vine
Canopy Temperature - Related Notes

Quality

- 70°F to 80°F favor the accumulation of malic acid
- above 100°F accumulation of malic acid is degraded
- accumulation of anthocyanin is repressed when temperatures above 86°F

Disease

- The primary factor that controls the spread of Powdery Mildew is temperature.
- fungus can multiply rapidly when temperatures are in the mid-60s to mid-80s
- inactive while temperatures remain above 90°F and some spores and colonies are killed after relatively short exposures above 95°F

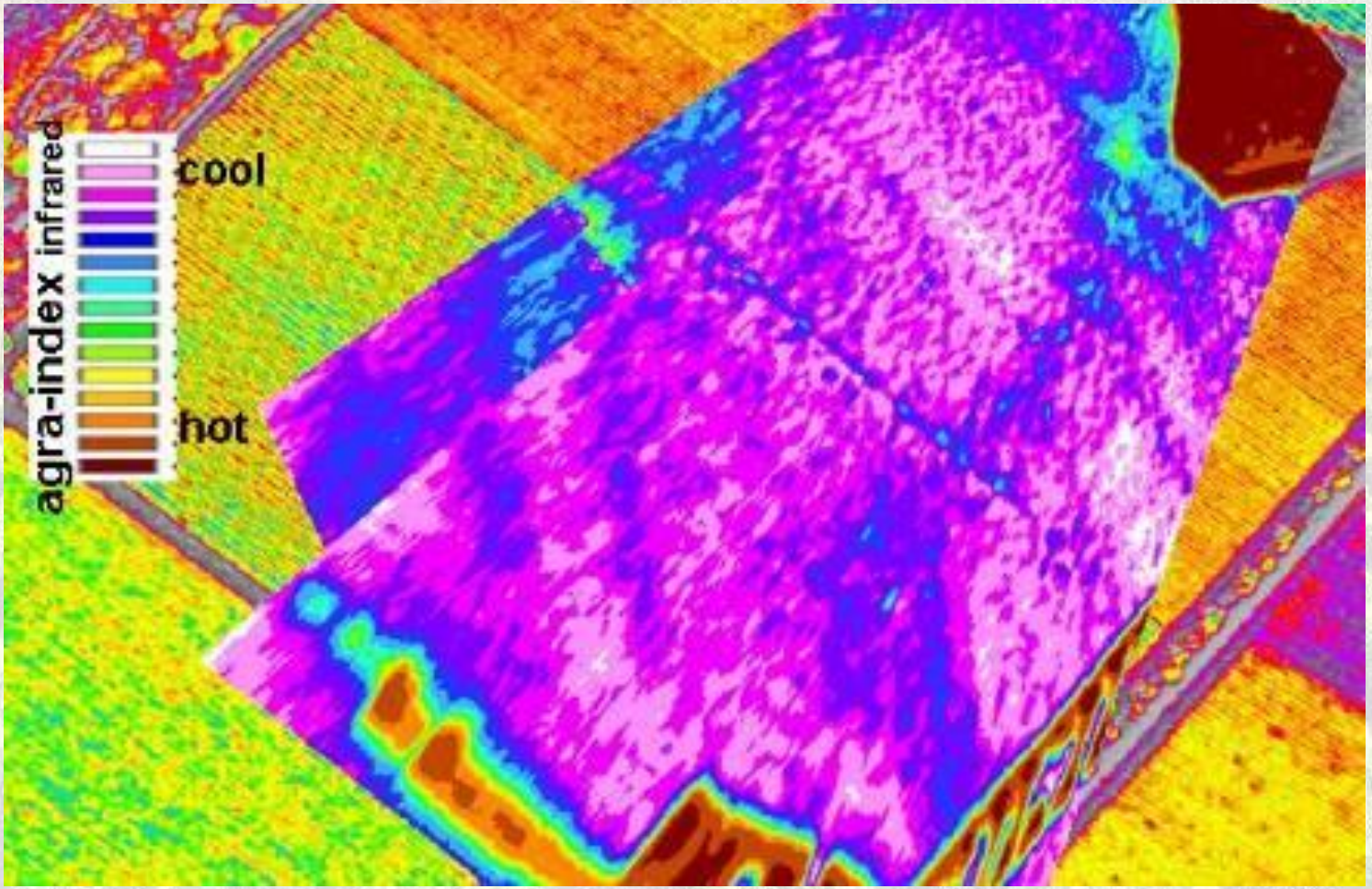
Pests

- As the canopy temperatures increase above 86°F Pacific Spider Mites tend to bloom and at 95°F the rate of development is at a maximum

Crop-Vu
Optimize Your Crop's Yield
A Division of IntriCorp - No Boundaries

Thermal (far-IR) Imaging

Heat/Water Stress



http://www.crop-vu.com

Stress Scouting

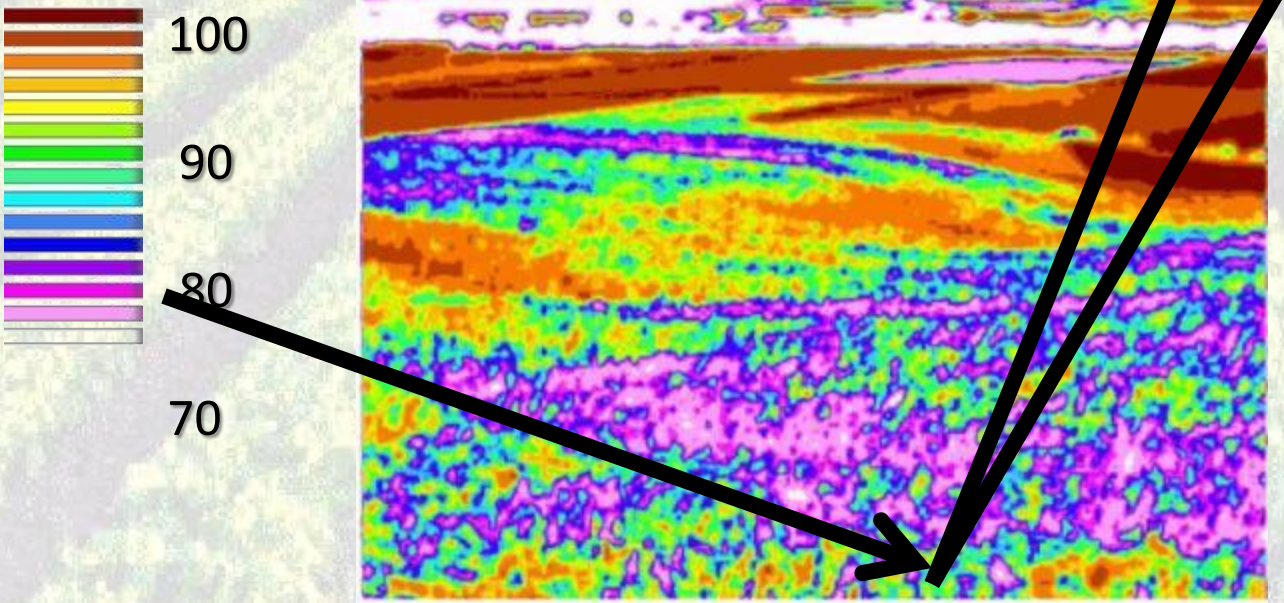
Salinas Valley

1130 PDT, 23 July 09

Air Temp - 71°

Sky – 0/8 cover

Vsby - unrestricted



http://www.crop-vu.com

Irrigation Scouting

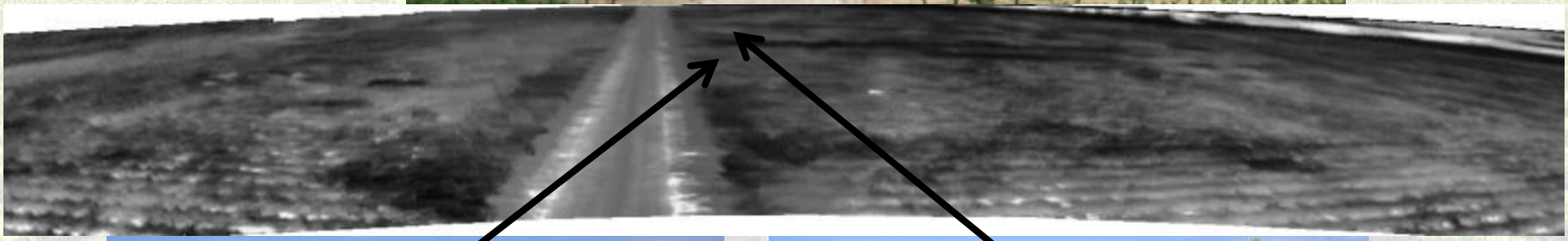
Salinas Valley

1500 PDT, 23 July 09

Air Temp - 74°

Sky – 0/8 cover

Vsby - unrestricted

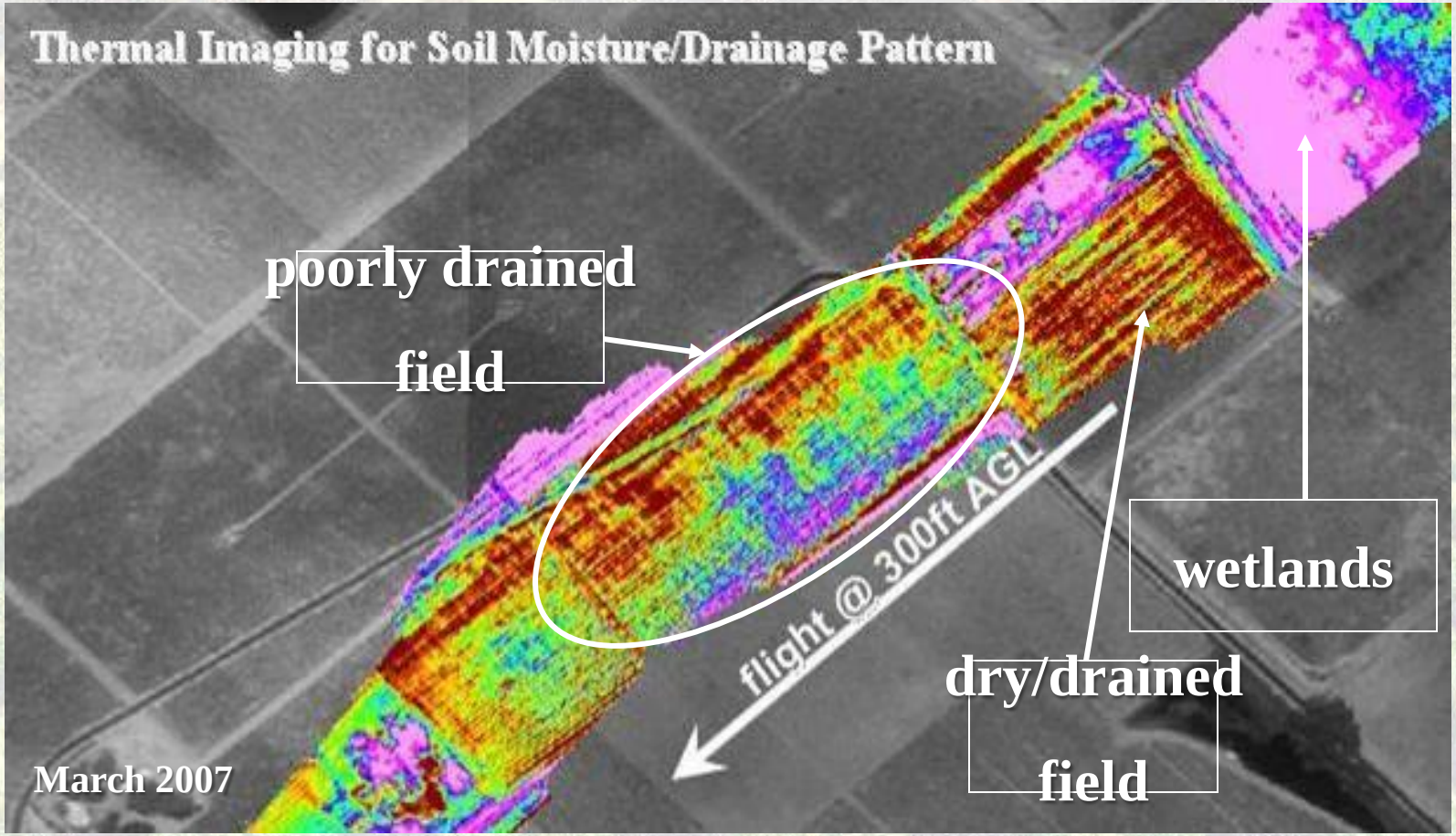


http://www.crop-vu.com

Crop-Vu
Optimize Your Crop's Yield
A Division of IntriCorp - No Boundaries

Thermal

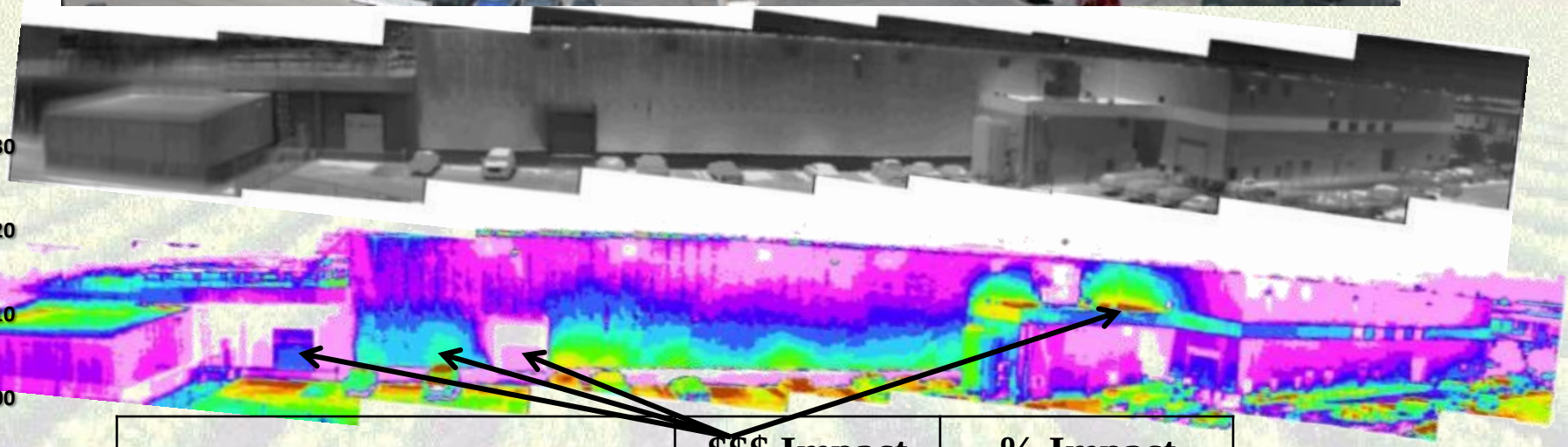
Assessing Surface Soil Moisture Using Thermal IR Imaging



Checking Drainage
Planning Irrigation Strategies

Another Application for Thermal Imaging

Controlled Climate Building Audits



Action	$$$ Impact Approximate	% Impact Approximate
…… access doors ……	$ 4,700/Yr	> 1%
……. Walls ……..	$ 24,000/Yr	2.5%
……. on roof surface	$145,000/Yr	15%
Increase ….. Insulation by factor of 3	$170,000/Yr	18%

19

http://www.crop-vu.com