

# Proximal and Remote Sensing of Crop Water Status for Irrigation Management

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Bread Basket International Agricultural Fair, České Budějovice, Czech Republic



Agricultural Research Organization – Volcani Center

Institute of Soil, Water and Environmental Sciences

Ministry of Agriculture & Rural Development

The State of Israel

# Overview - Outline

- ARO institutes
- Israel's Eco-Hydrology
- Irrigation objectives
- Irrigation management by soil and water status – online (proximal) sensors
- Crop water use in semi-protected cultivation
- Remote and proximal sensing - precision irrigation
- Remote sensing for irrigation quality control



# מינהל המחקר החקלאי | מרכז וולקני

AGRICULTURAL RESEARCH ORGANIZATION (ARO) | VOLCANI CENTER



About

Institutes

Public Relations

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Soil, Water and  
Environmental Sciences



Plant Protection



Animal Science



Plant Sciences



Newe Ya'ar



Gilat Center

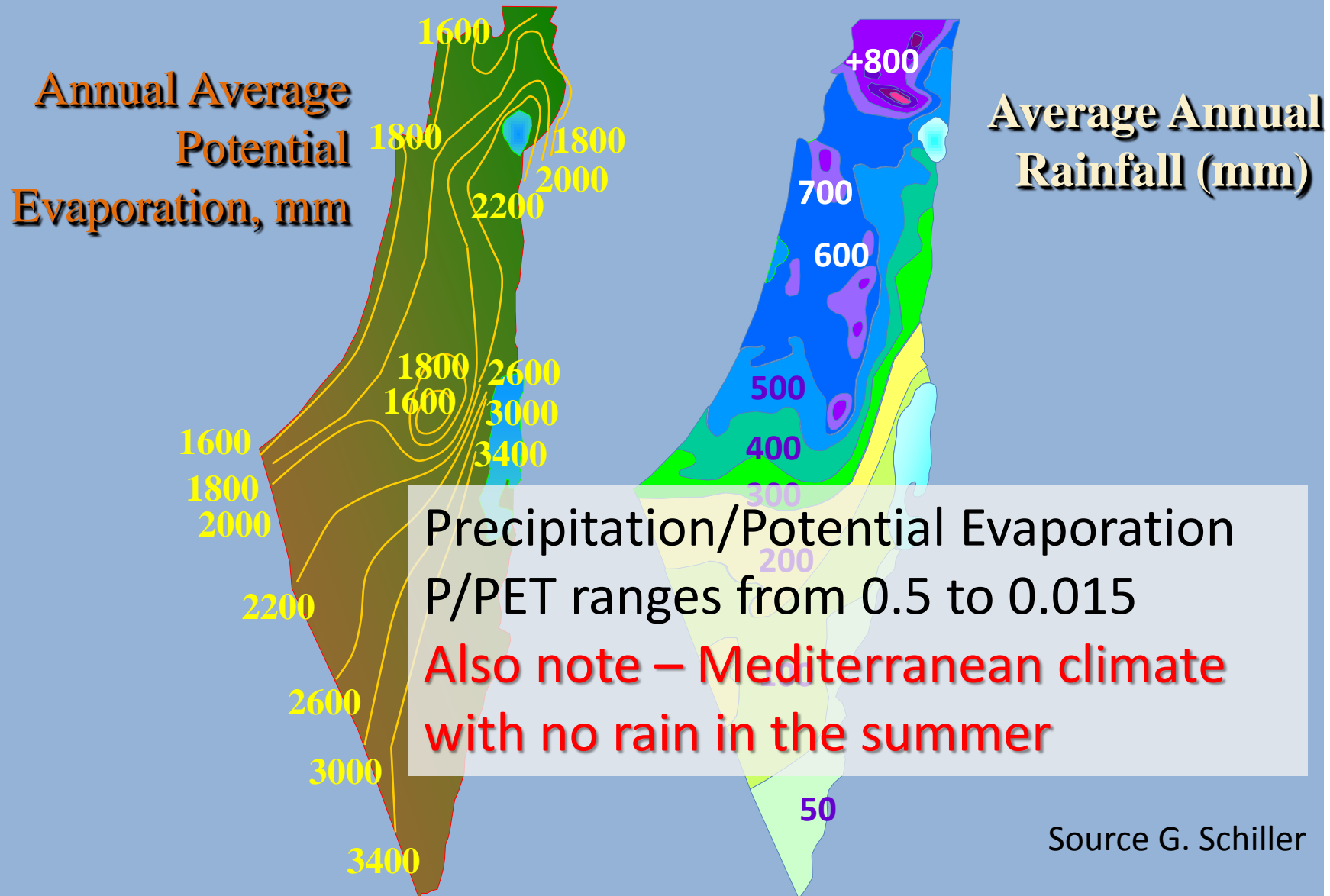


Agricultural Engineering

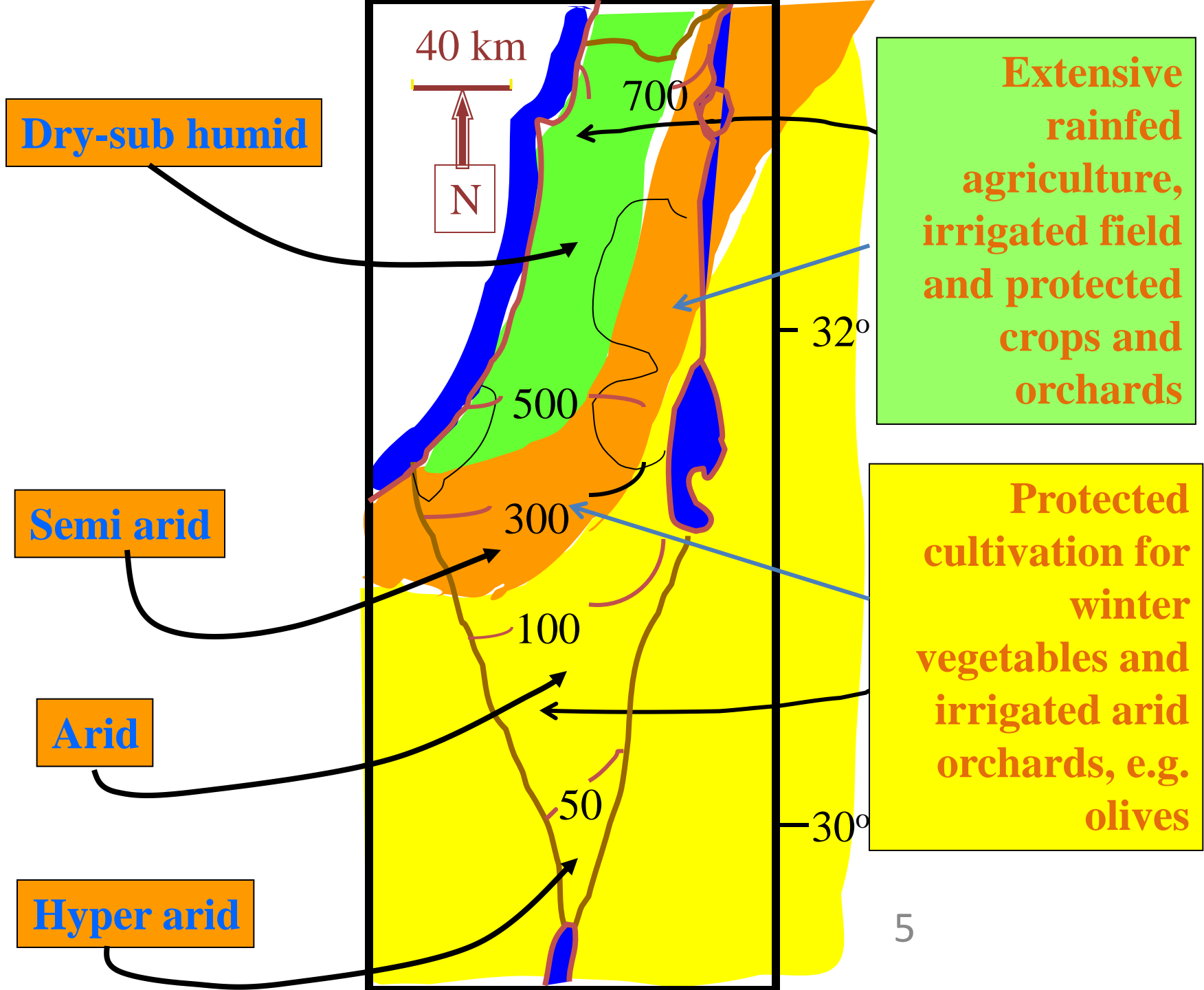


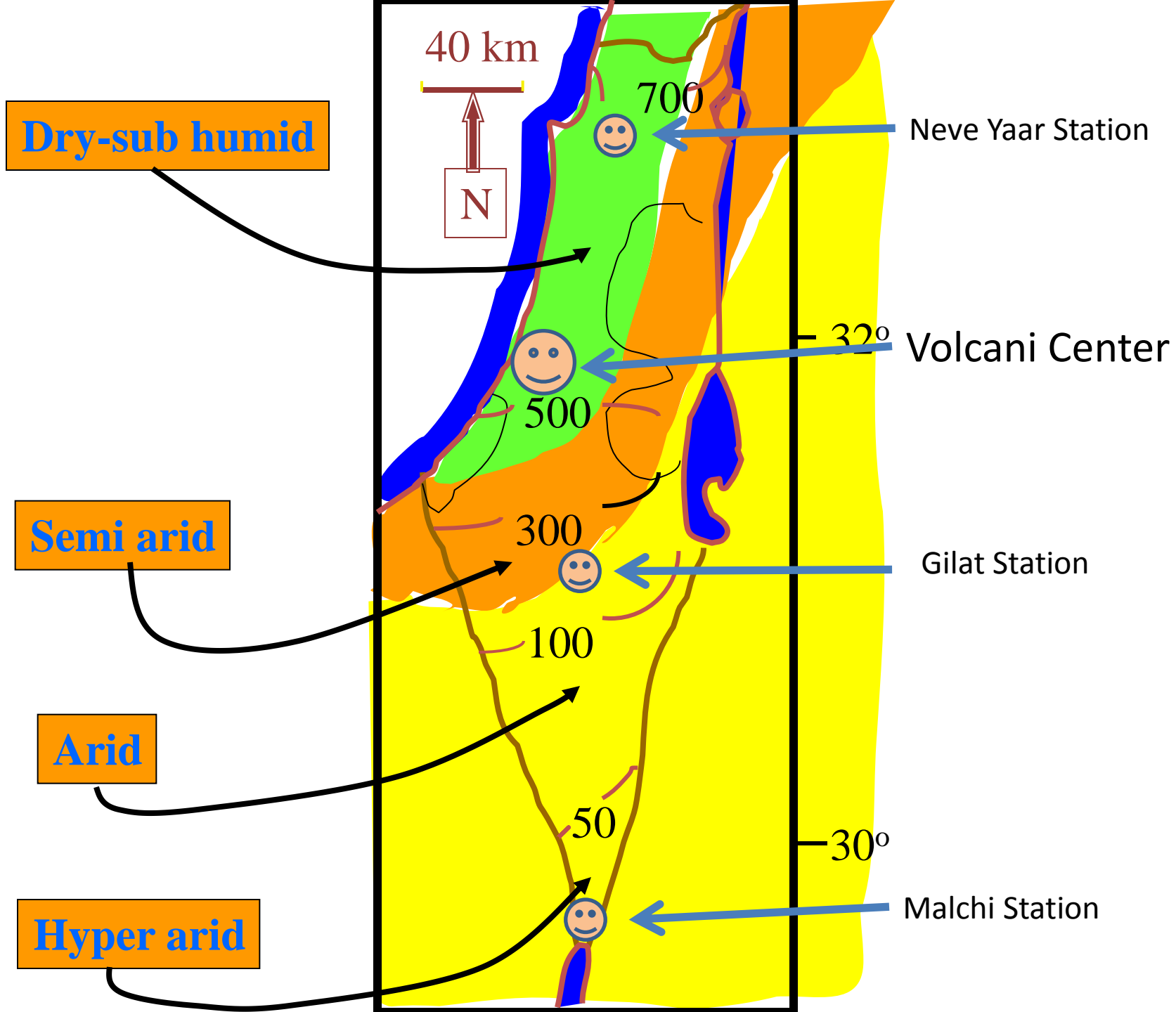
Postharvest and Food  
Sciences

# Israel's Ecosystem Hydrology



Source G. Schiller







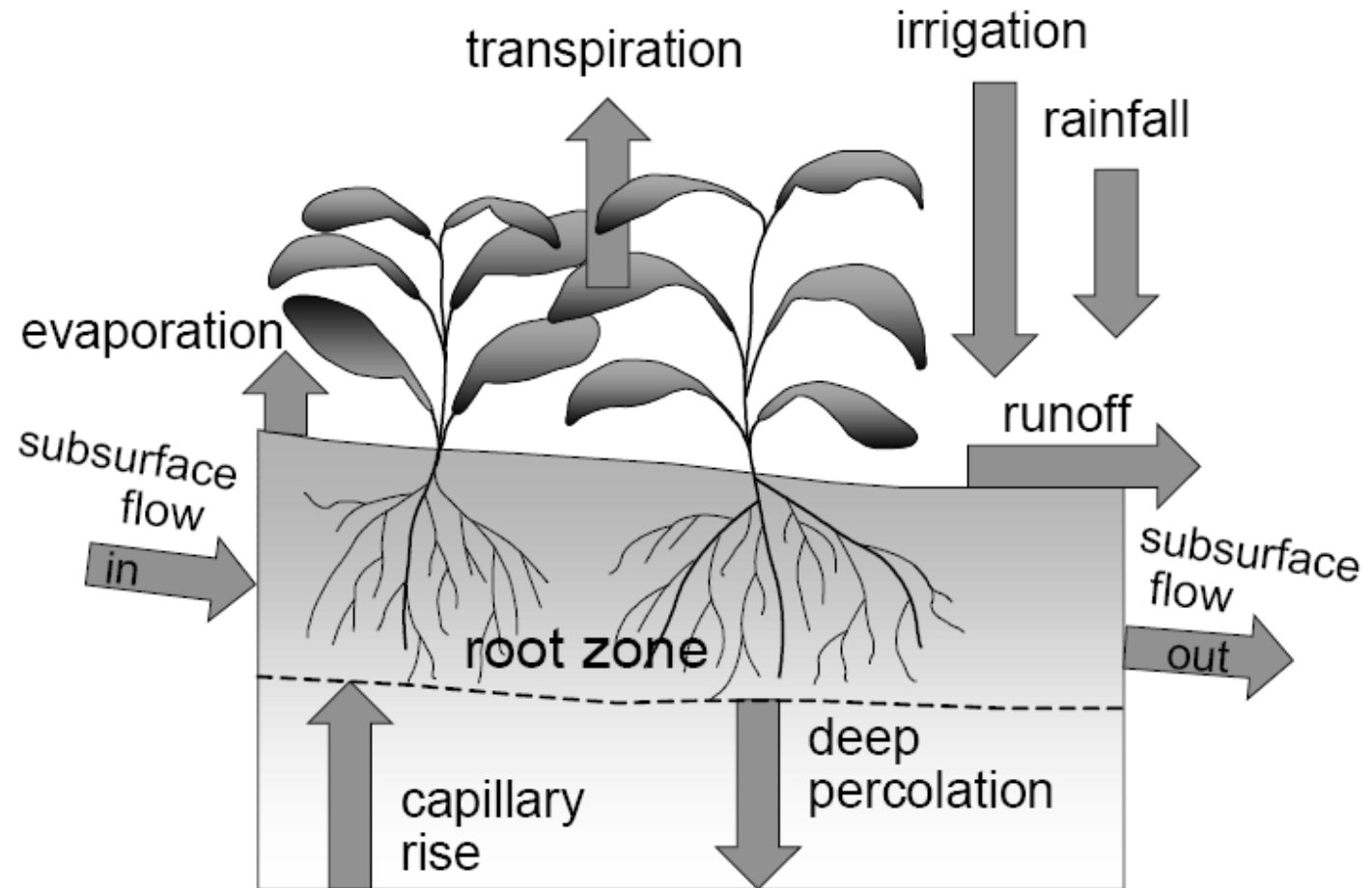
# Irrigation and its management

- Objective of Irrigation – maintaining a favorable environment in the root zone. Adequate water, aeration, drainage of detrimental elements (like salts, Boron etc), maintenance of soil structure and nutrient concentration and availability.
- **The irrigation questions:**
  - When to irrigate
  - How much to irrigate

# Irrigation is only part of the story of Plant/soil water balance

FIGURE 6

Soil water balance of the root zone





# Objective – management in irrigated agriculture

- Irrigation control based on online, proximal and remote sensing + decision support and automatic decisions if requested/needed.
- Soil and irrigation water monitoring for water quality (e.g. salinity, nutrient content, BOD etc.).

# Irrigation control based on:

Option	Advantages	Disadvantages
<b>Crop water use</b>	Plant based measure – answers how much to irrigate	No feedback about soil water accumulation or status
<b>Soil water content</b>	Refill the soil when depleted – answers when to irrigate	Soil and soil water are very variable especially with drip irrigation – where to measure?
<b>Crop water status</b>	Prevents crop water stress – answers when to irrigate	Difficult to determine when plant needs water.

- In all cases we can substitute measurements with models.
- Integrated approach – use elements of all of the above

# Sensor systems for irrigation control

Method	Basics	Advantages	Disadvantages
Crop factor tables	Relative to reference ET	Quantitative Simple to use	Based on average crop data



# Sensor systems for irrigation control

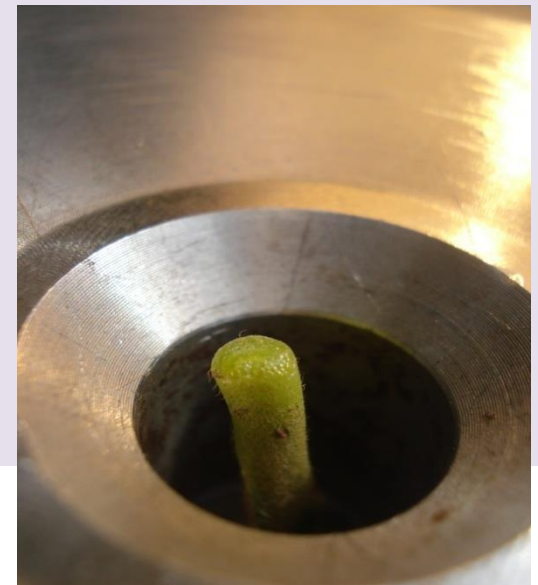
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Soil water sensors	Volumetric water content or Soil water potential	Popular and commercial Relatively easy and accurate	Large spatial variability When but not how much

[www.tensiograph.com](http://www.tensiograph.com)



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<b>Stem and Leaf Water potential</b>	Measure exposed or covered leaves in pressure chamber	Supported by the literature Precise and reliable	Slow Requires skilled manpower No automation currently possible





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Stem and Leaf Water potential	Measure covered chamber		Slow Requires skilled manpower No automation currently possible
Dendrometer – MDS, MXTD, MNTD, DG	Daily course of stem contraction and growth	Allows automatization Non destructive	Not understood, empirical. Requires calibration of control treatment

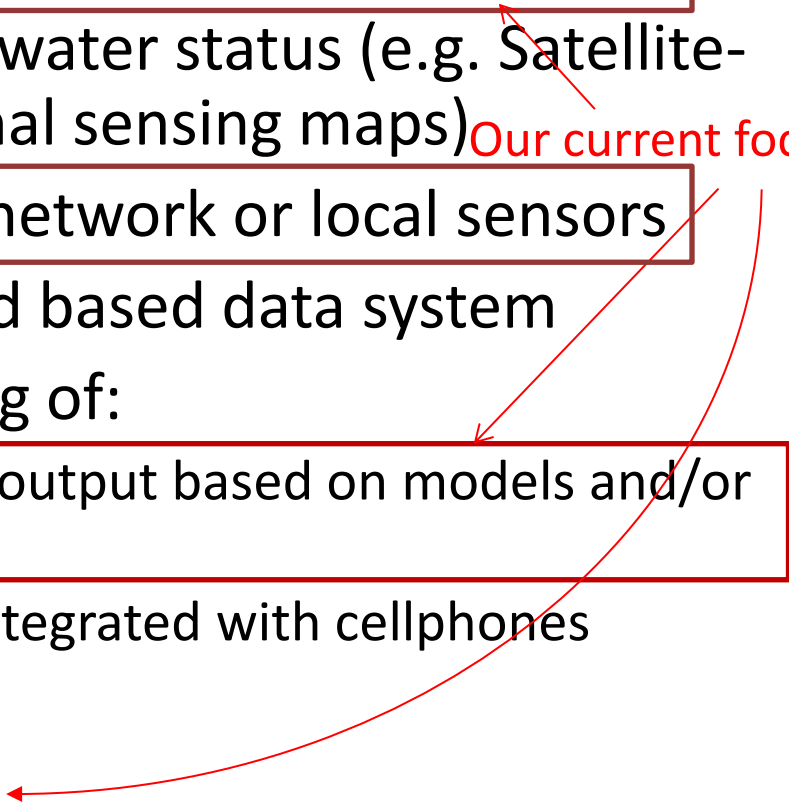
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Dendrometer – MDS, MXTD, MNTD, DG	Daily course contraction		Not understood, empirical. Requires calibration of control treatment
Stem sap flow	Use of heat to follow xylem sap flux	Quantitative Allows automation	Requires skilled manpower for installation, operation and analysis

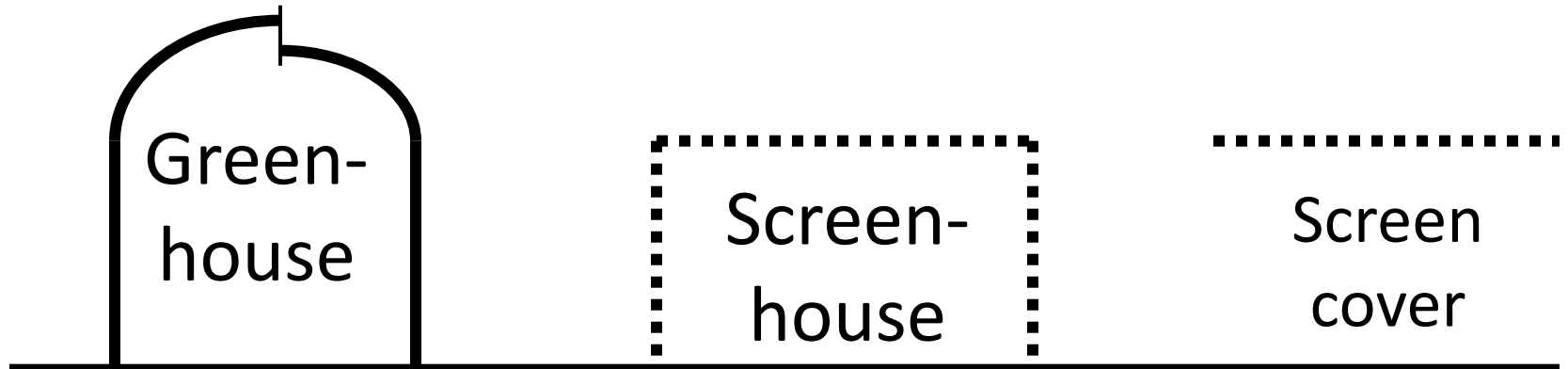


# Irrigation control of the future?

## Future requirements – Hi Tech system

- Online sensors measure soil and plant water status
  - Other information on crop water status (e.g. Satellite-remote, airborne or proximal sensing maps) Our current foci
  - Climate data from climate network or local sensors
  - Communications with cloud based data system
  - Control algorithm consisting of:
    - Algorithm to analyze sensor output based on models and/or empirical results
    - Decision support system – integrated with cellphones
  - Economic requirements
    - Relatively cheap sensors
- 

# Climate modification and water use



- Common to these are reduced radiation and wind speed
- Analysis shows that crop water requirements relative to outside should be reduced in all cases
  - Evaporation is usually **more sensitive to solar radiation** than to **wind speed**.





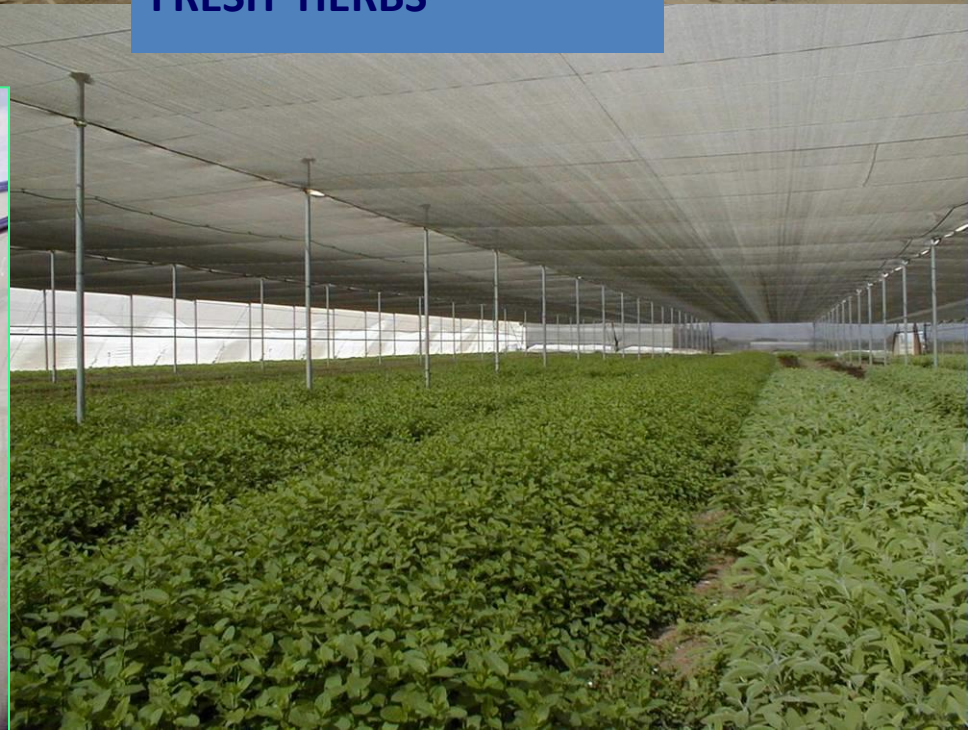
**FOR PEPPERS**



**FRESH HERBS**



**FOR TOMATOES**







Pomegranate



Grapes

## Fruits under cover



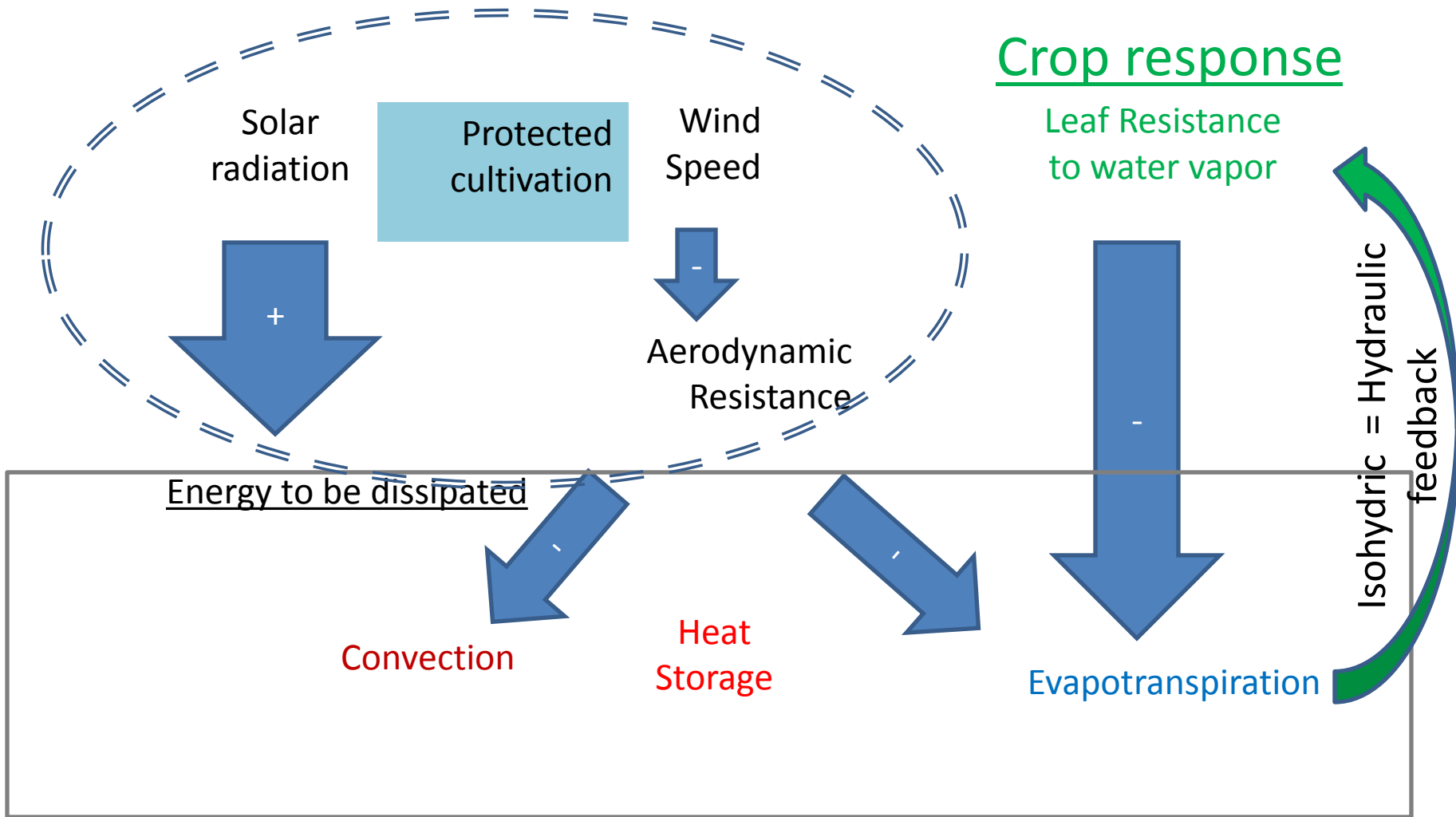
Nectarines



Bananas

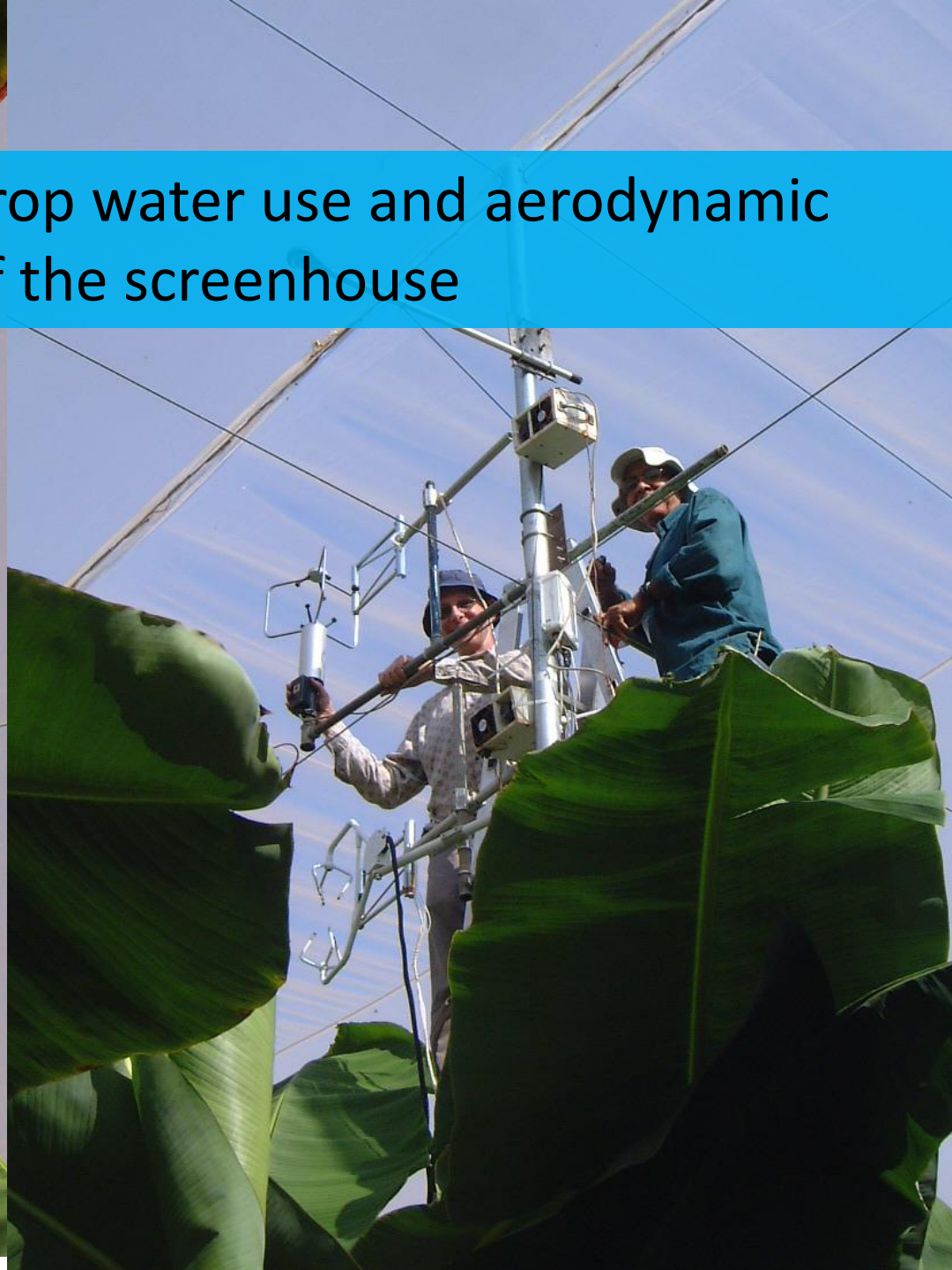
# Estimating crop water use – physical models

## Energy balance of the evaporating surface

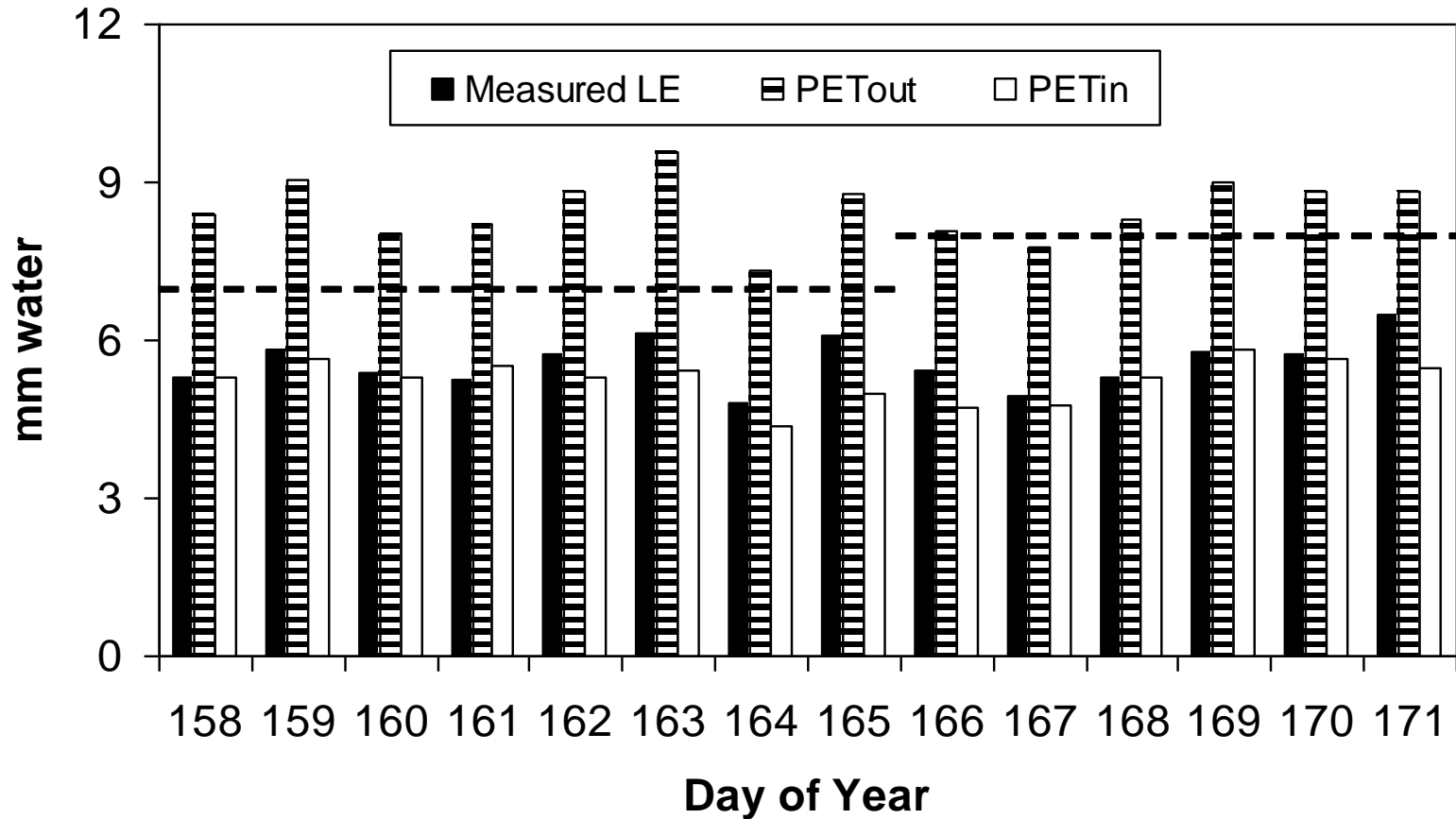




# Measuring crop water use and aerodynamic properties of the screenhouse



# Banana screenhouse (20% clear screen) water use as measured by the eddy covariance system and P-M model



Ratio PETin/PETout = 0.62



# Field variability

Precision Agriculture  
Water and nutrient management – interdisciplinary  
research led by Volcani's Institute of Agricultural  
Engineering

**Improper soil disinfection**



# Field variability

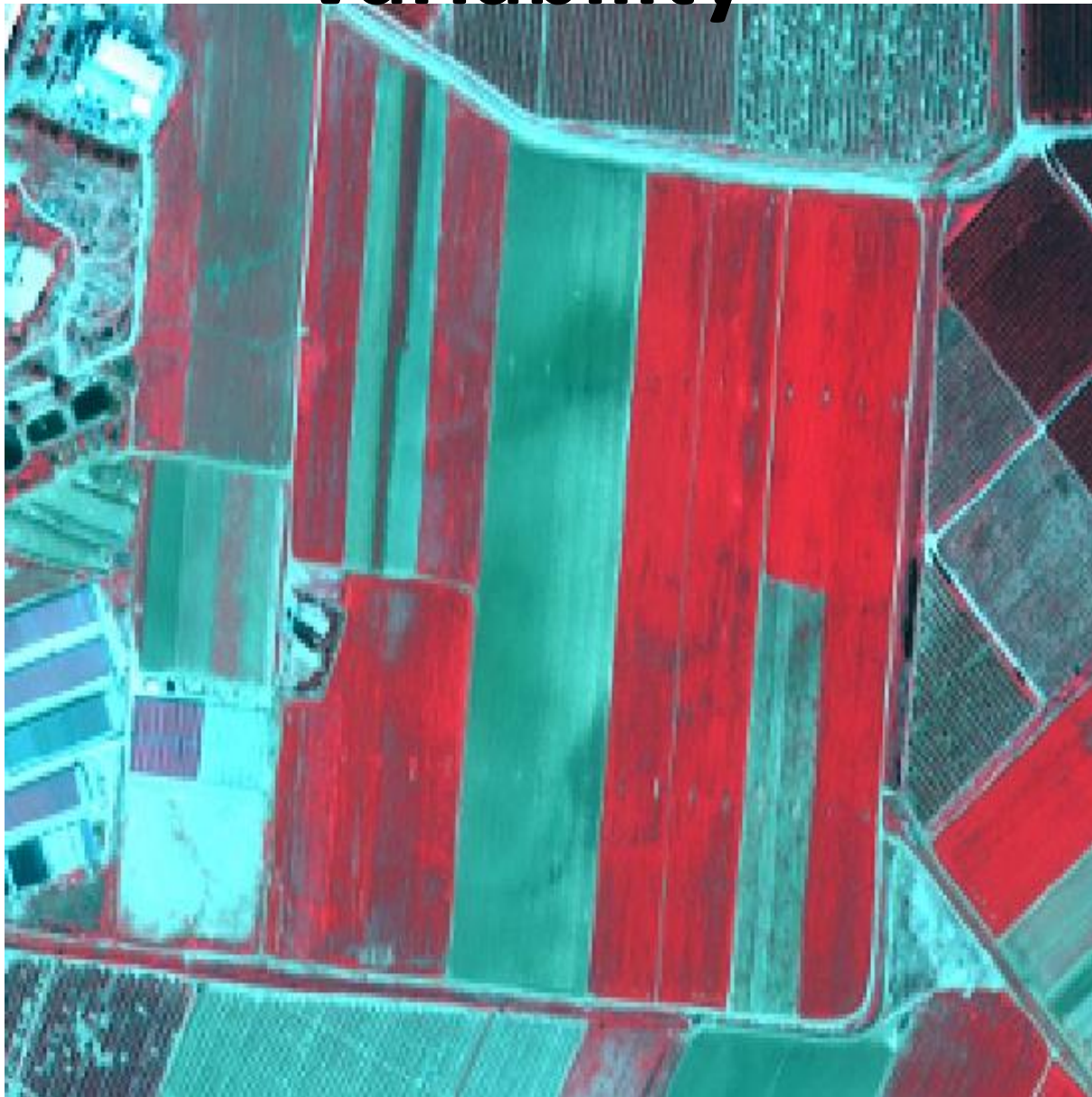
An aerial photograph of a vast agricultural field, likely an onion field, showing distinct longitudinal rows of green crops. The field is bordered by a line of trees on the left and right, and a range of dry, hilly mountains is visible in the background under a clear blue sky.

New disease in onion?

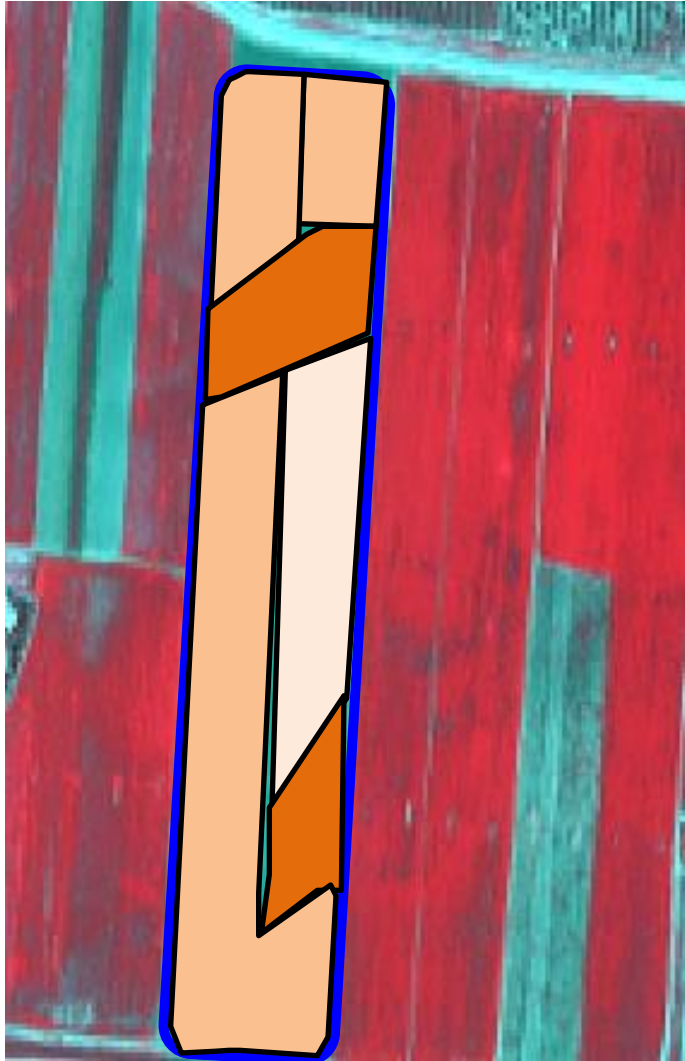




# Variability



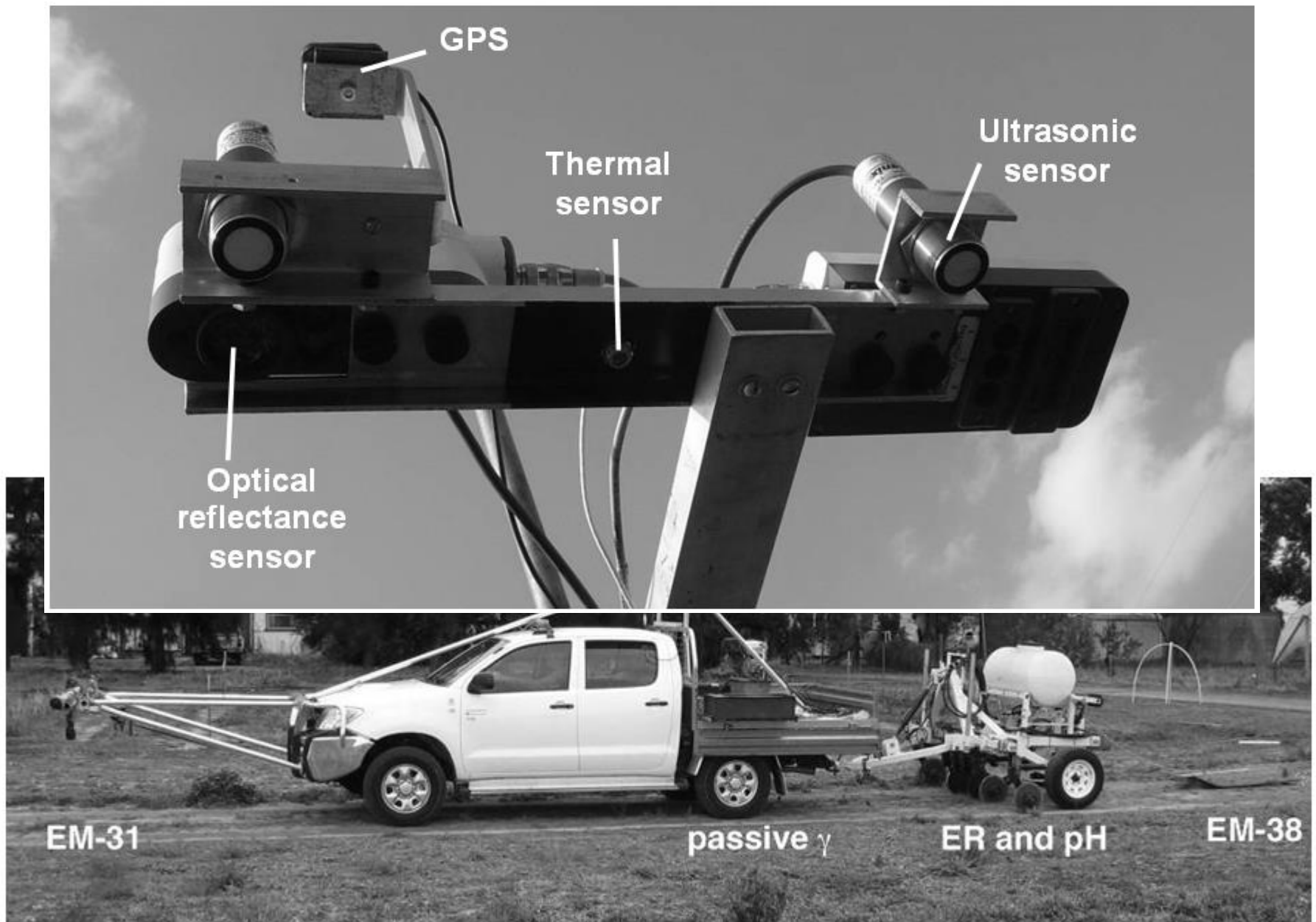
# Precision Agriculture (PA)



Site-specific management  
- the 3 *rs*:

Doing

the *right* thing  
*in* the *right* place  
*at* the *right* time.



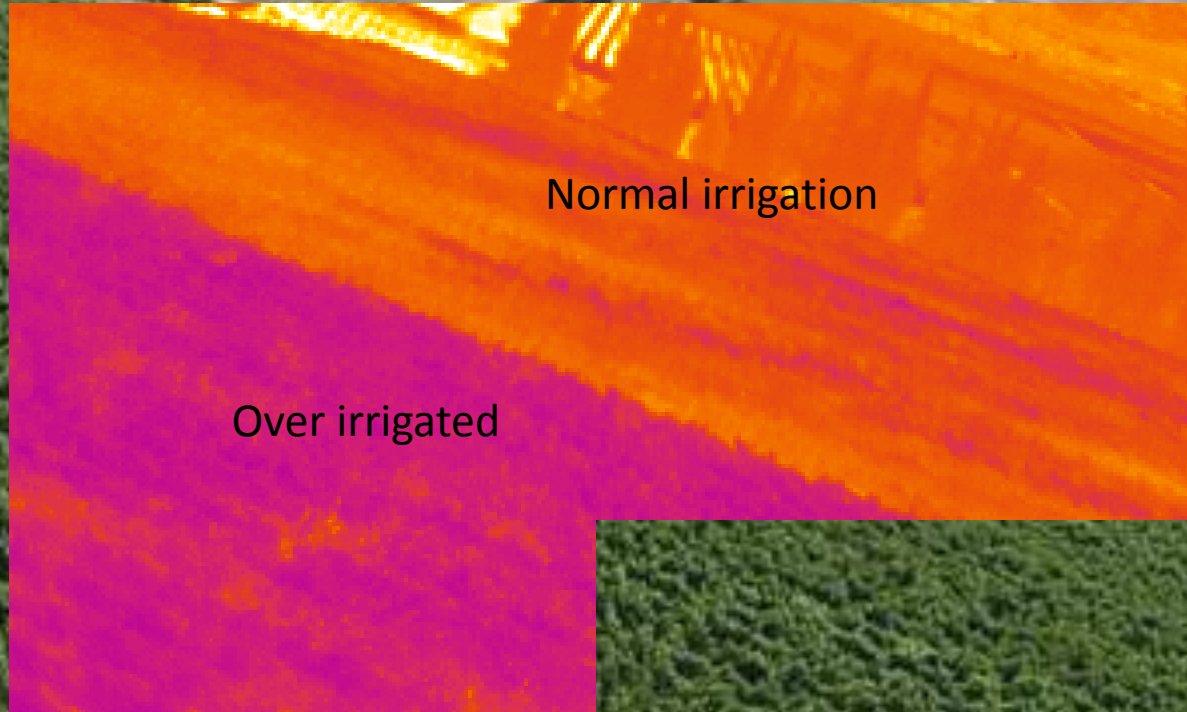


Remote sensing can help us -  
Thermal imaging for monitoring crop water status –  
Mast or airborne systems





## Vineyards, Kibutz Yiftah, Upper Galilee





## Vineyards, Kibutz Yiftah, Upper Galilee

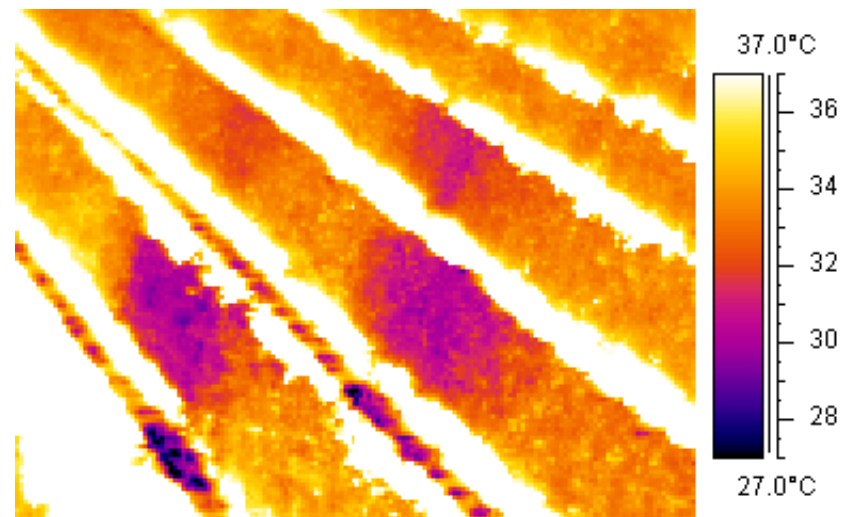
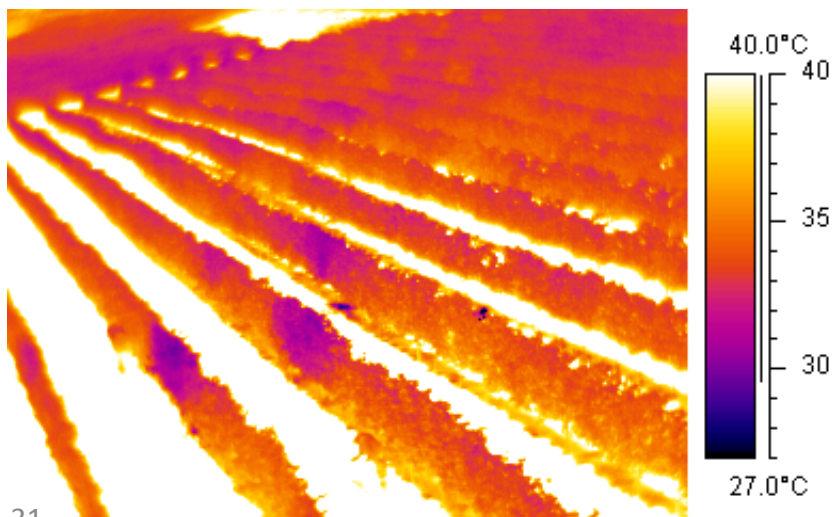
Nectarines,  
irrigated in  
excess

Vineyard,  
normal  
irrigation

Vineyard,  
normal  
irrigation

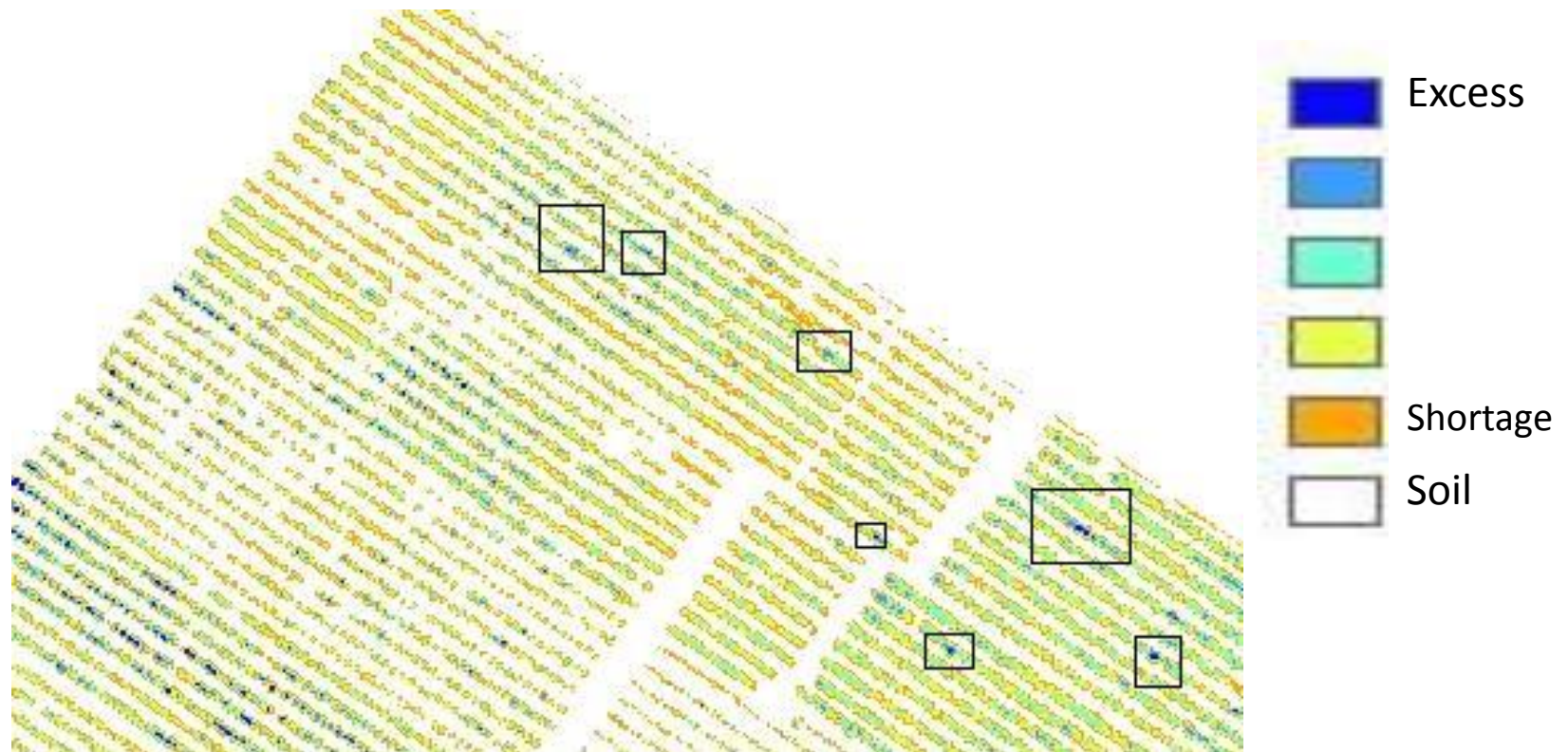
Vineyard,  
over  
irrigated





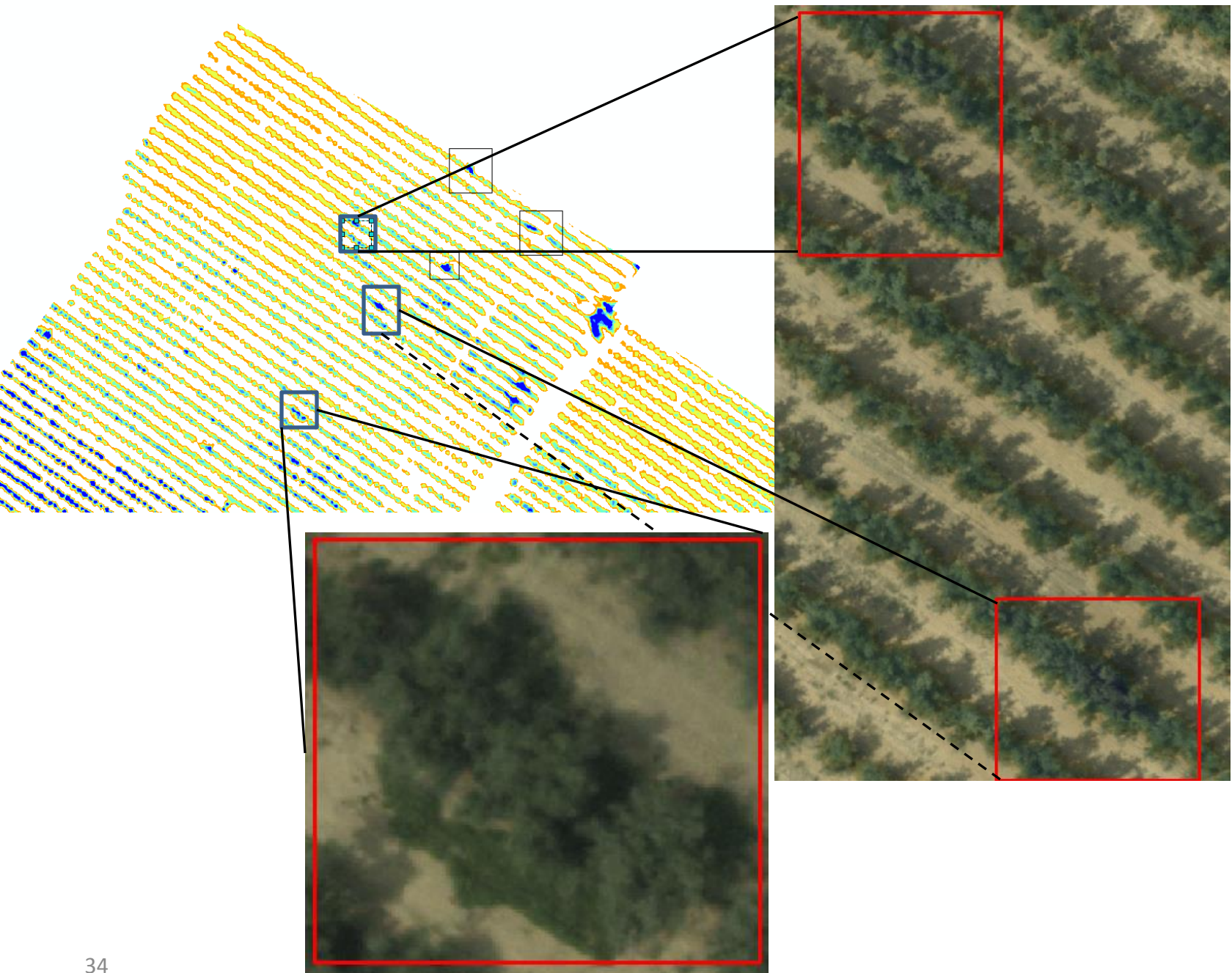






**Olives, Southern Israel, Revivim, June, 2010**





# Irrigation system quality control – detection of irrigation malfunctions – ground truthing

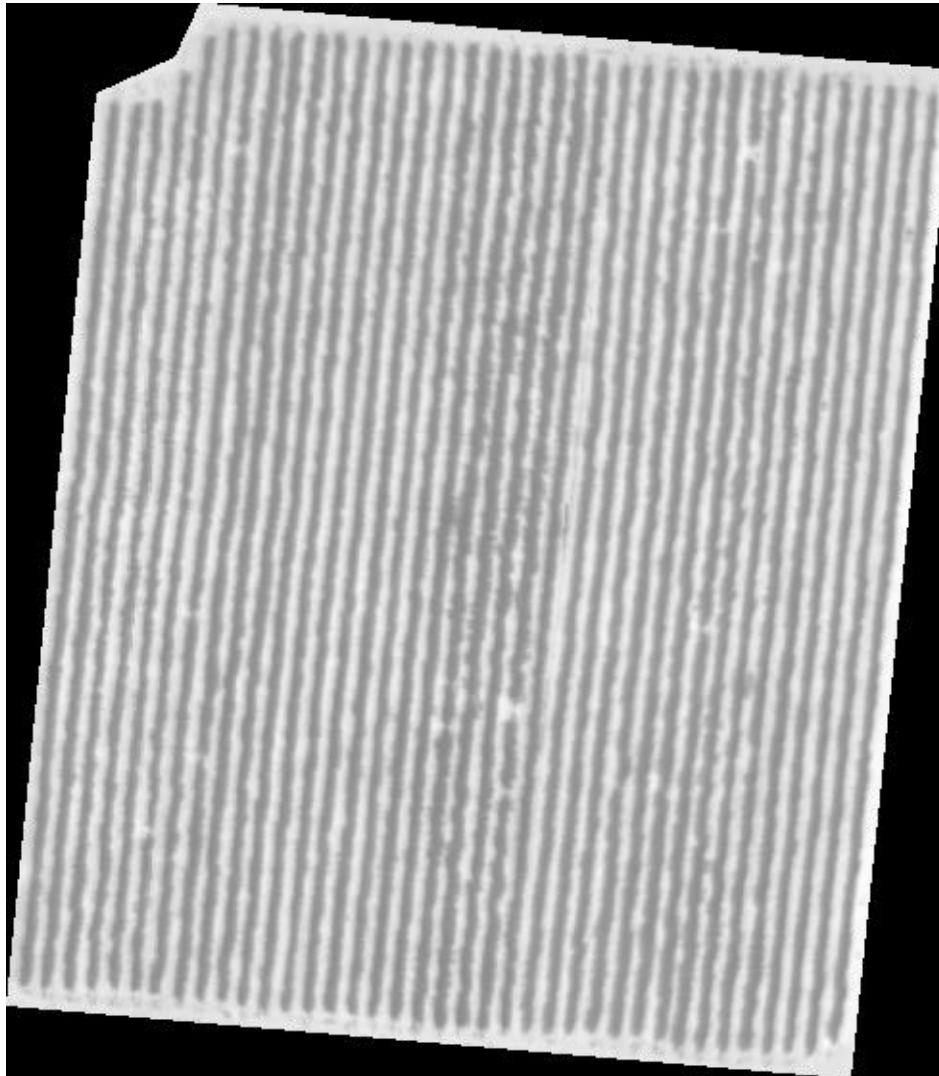




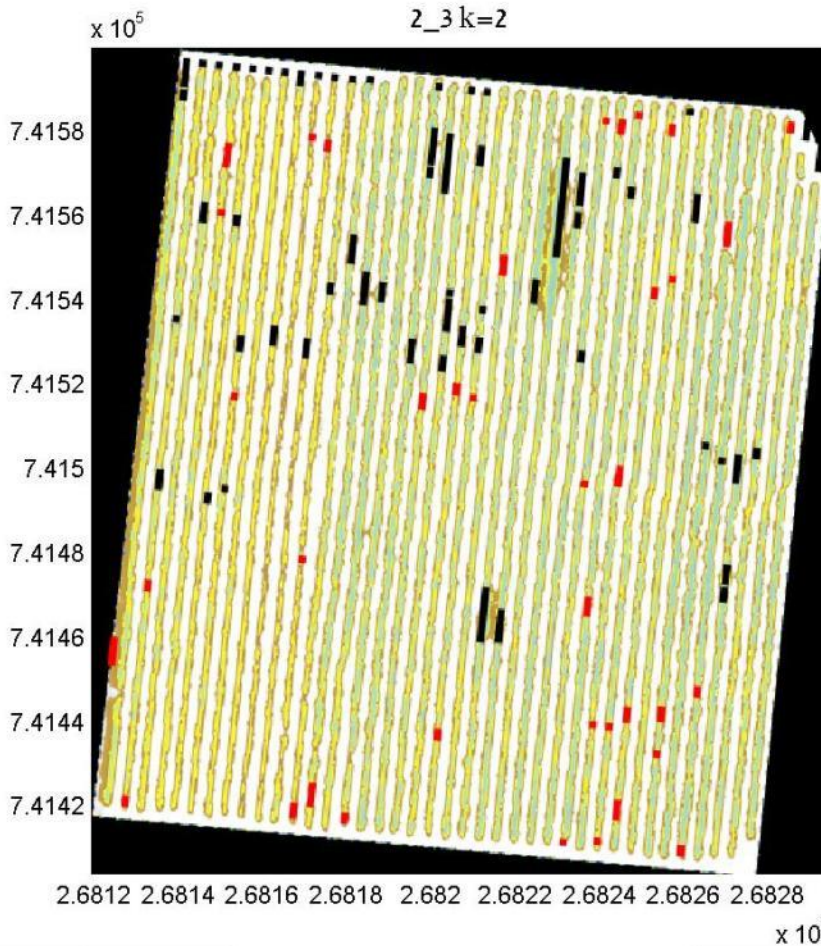
# Aerial RGB



# Thermal IR



# Automatic recognition



Index	x	y	Type
1	268135.5	741497.6	Low
2	268139.7	741535.4	Low
3	268141.5	741588.6	Low
4	268141.8	741593.8	Low
5	268146	741595.9	Low
6	268146	741560.9	Low
7	268147.1	741493	Low
8	268149.9	741595.6	Low
9	268151.3	741495.1	Low
10	268154.1	741595.2	Low
11	268154.1	741558.8	Low
12	268154.8	741529.8	Low
13	268157.9	741594.9	Low
14	268161.8	741594.5	Low
15	268162.8	741531.5	Low
16	268165.6	741594.2	Low

Pixel info: (268200.25, 741506.03) [243 240 51]

Display range: [ ]



# Field system

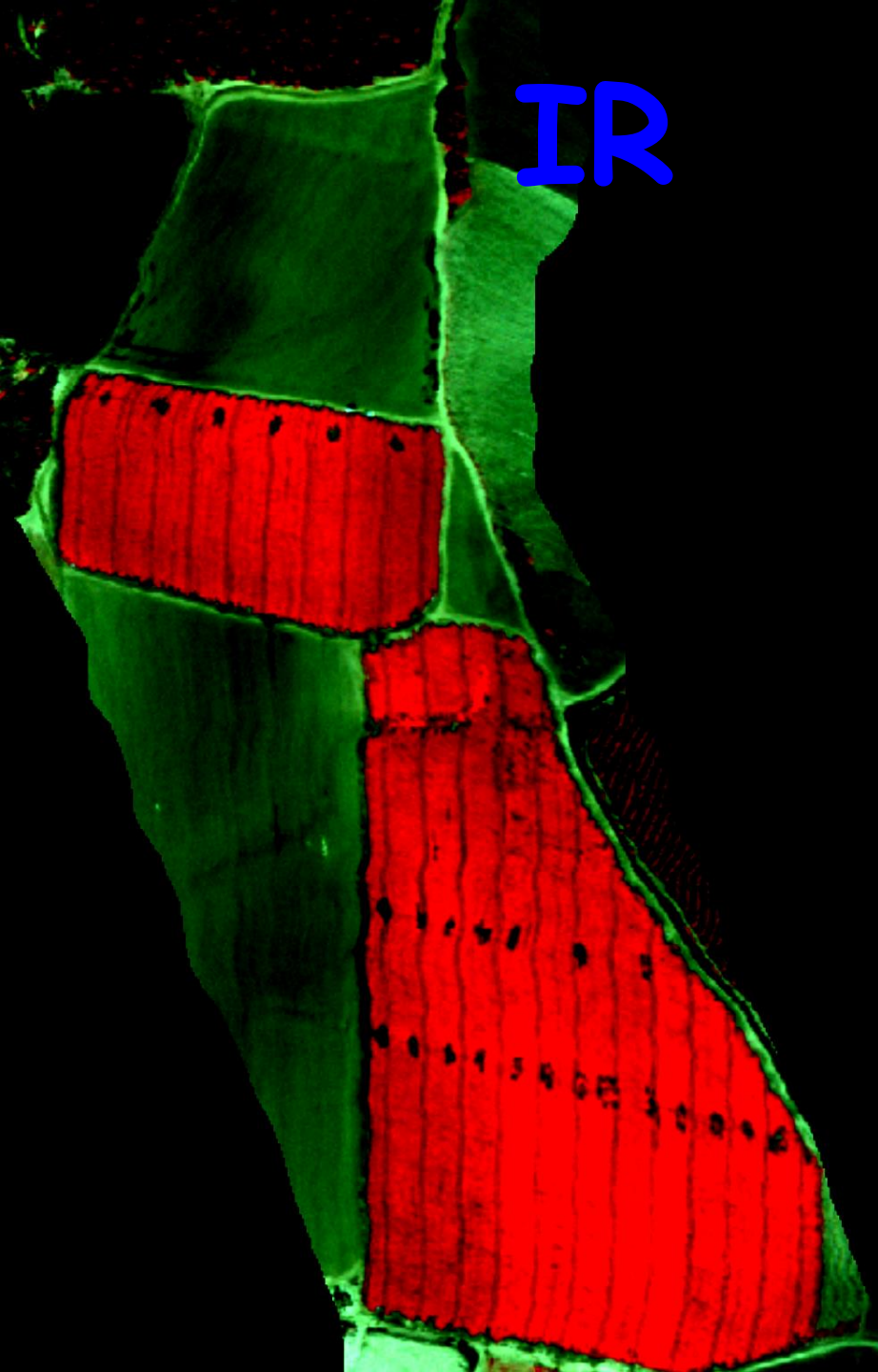


# Mapping of data

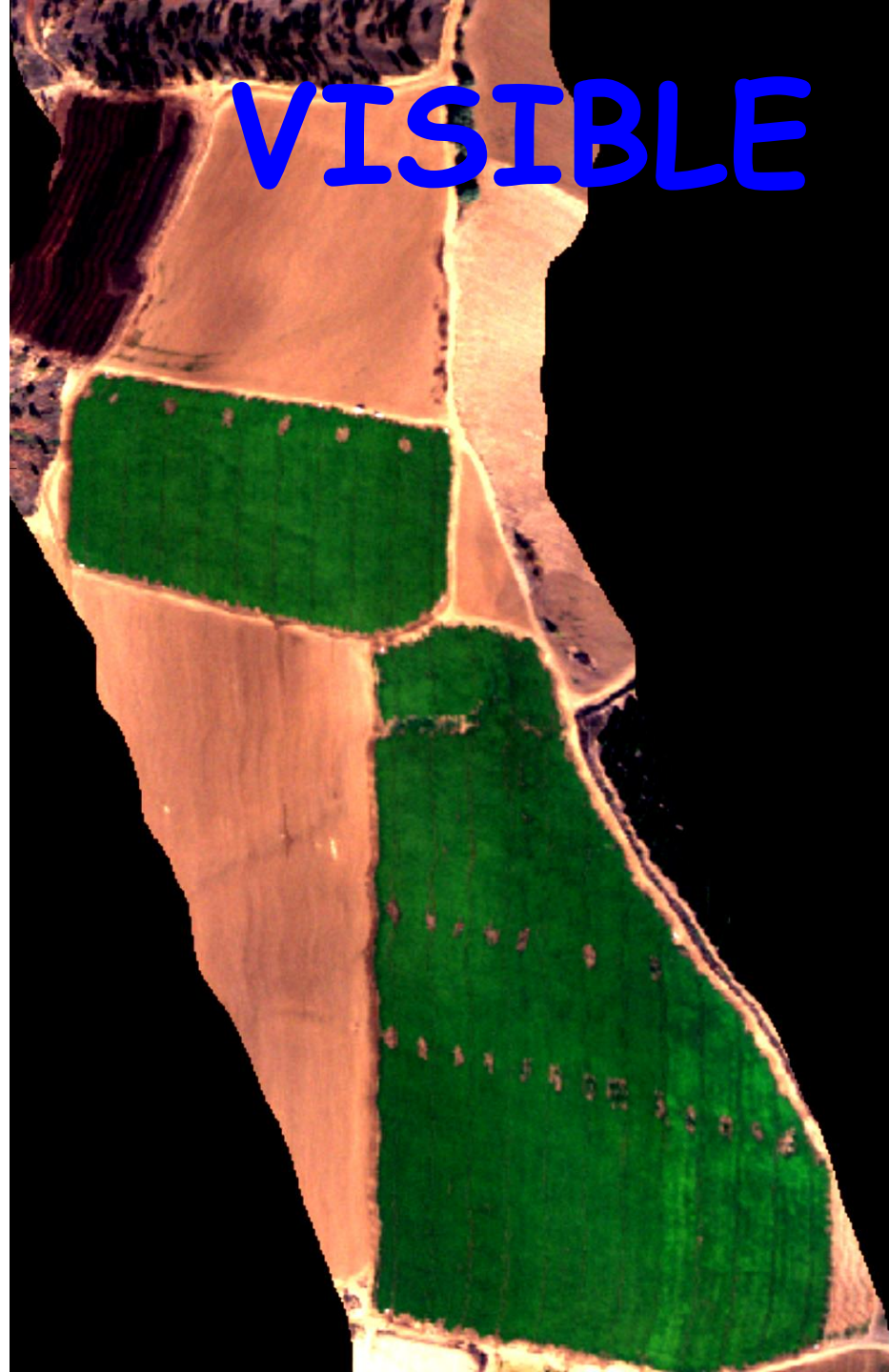


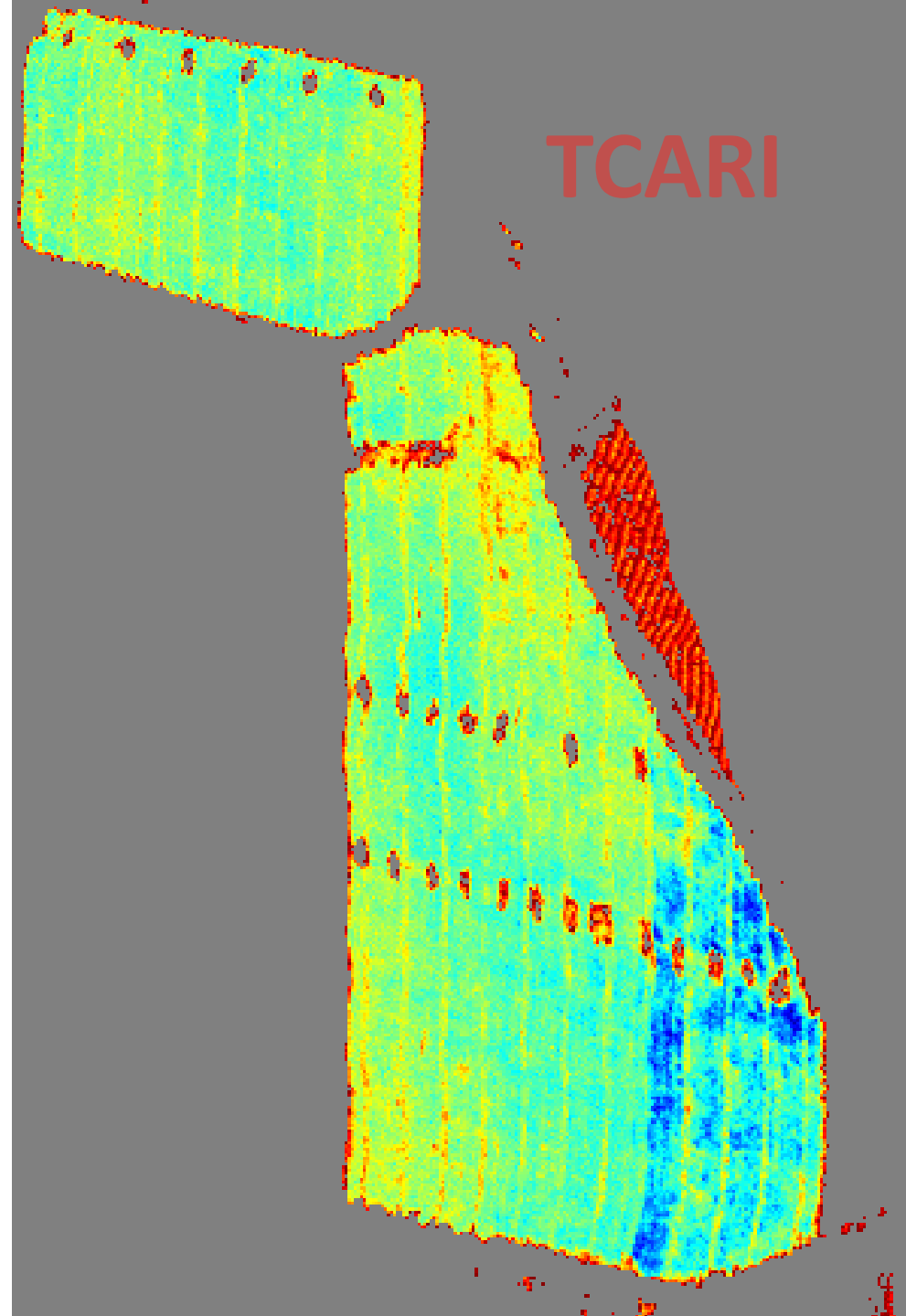
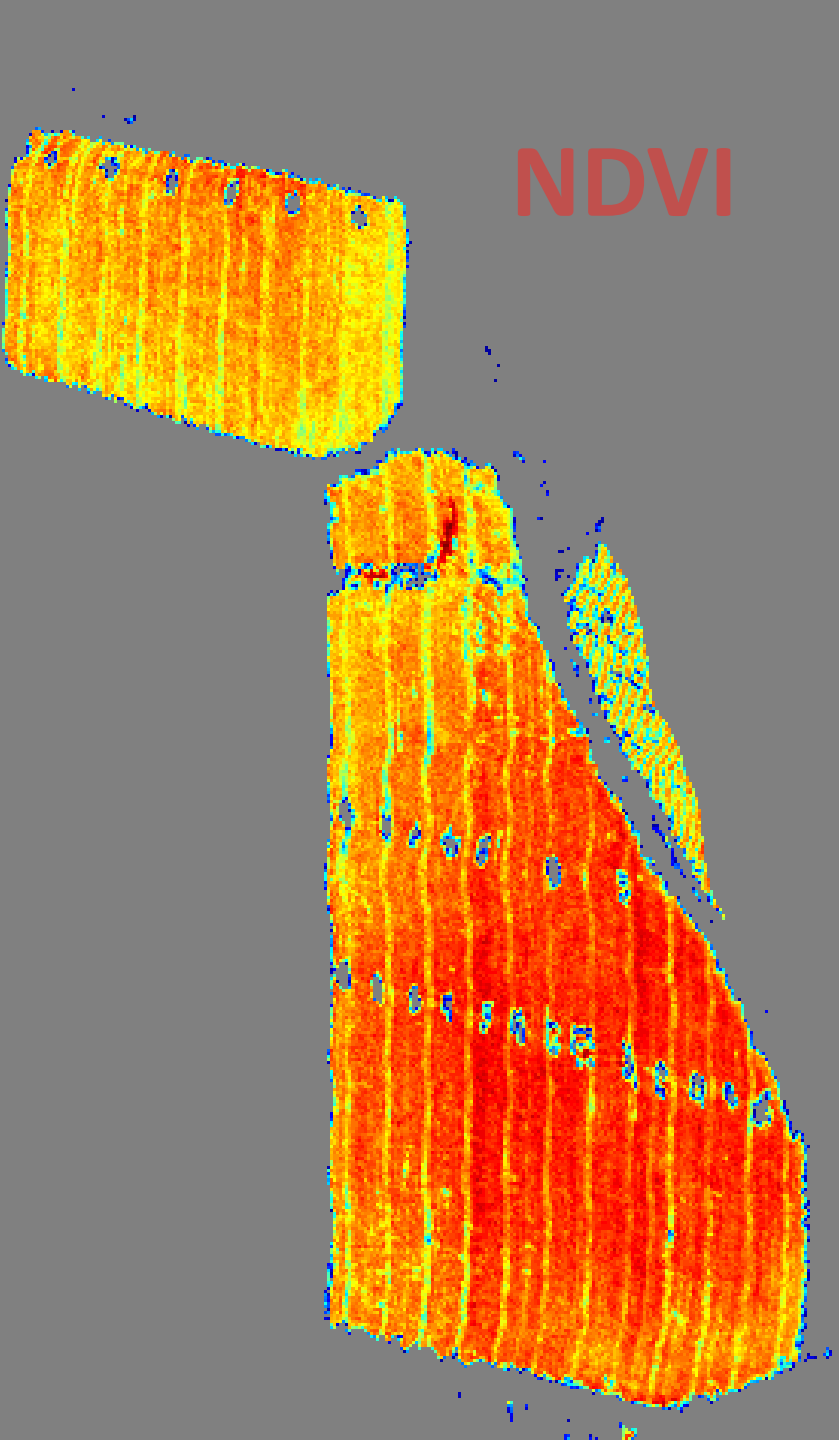


IR



VISIBLE







# Next Generation....





Prof. Jan Cermak of Mendel U. and Tamir Klein in  
Yatir forest, 2009

Thanks for  
your  
attention





# Objective – soil and water management in irrigated agriculture

- Objective of Irrigation – maintaining a favorable environment in the root zone. Adequate water, aeration, drainage of detrimental elements (like salts, Boron etc), maintenance of soil structure and nutrient concentration and availability.
- We would like to control water
- Objectives of sensing systems:
- Irrigation control based on online proximal and remote sensing + decision support and automatic decisions if requested.
- Soil and irrigation water monitoring for water quality (e.g. salinity, nutrient content, BOD etc.).
- Decision support for irrigation systems.