

# Improving water use efficiency of irrigated sugarcane

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# Water equivalents

l water		product
300	→	1 l beer
1000	→	1 l milk
140	→	1 l tea
1120	→	1 l coffee
900	→	1 kg wheat
15500	→	1 kg beef
??	→	1 l wine
??	→	1 kg grapes
??	→	1 kg apples, pears
??	→	1kg sugar

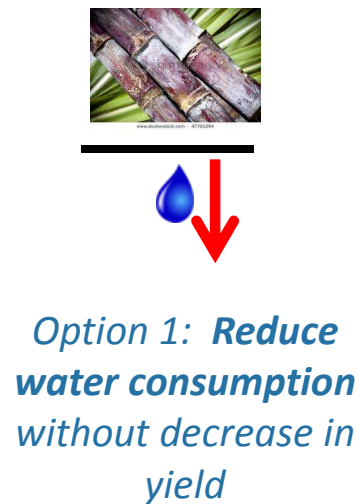
$$WUE = \frac{\text{Crop yield (kg)}}{\text{Water consumption (m}^3\text{)}}$$

# Need

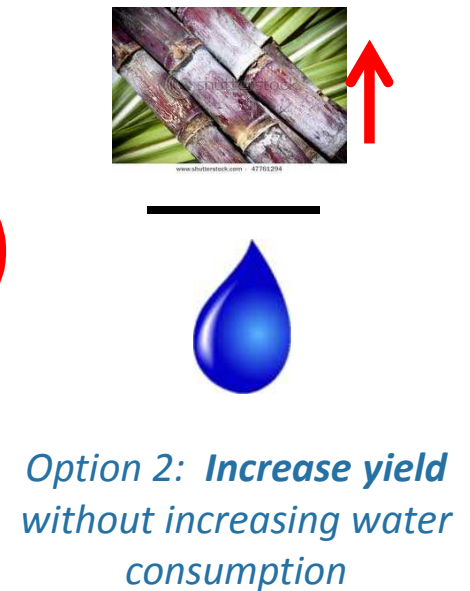
## Improve efficiency of resource use

- National Water Act (1998): “*water should be used more efficiently*”

$$\text{WUE} = \frac{\text{Crop yield (kg)}}{\text{Water consumption (m}^3\text{)}}$$

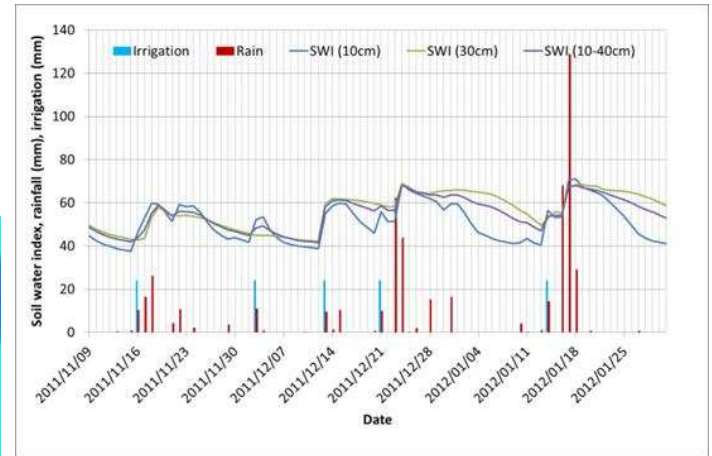
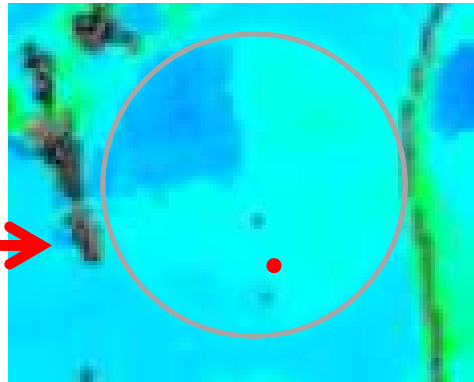
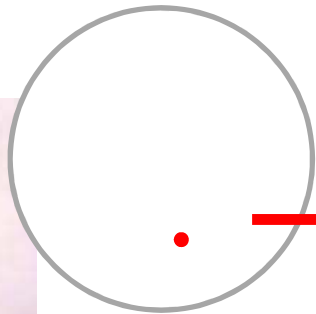


or



## Tools to inform

# Current solutions



(Soil moisture) measurements:

- Frequent updates (e.g. every hour, daily)
- One point only (not necessarily representative of block)

Modeling:

- Field based
- Model and input parameter dependent

## Satellite derived ?

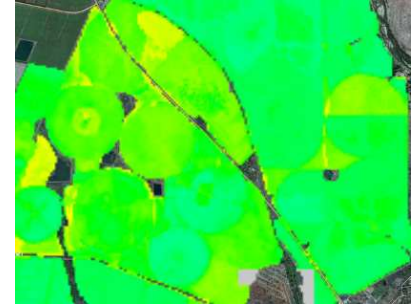


Aerial photography, other RS

- Often NDVI
- High spatial detail
- Once or twice during season



# Existing and new



New technology...

- Uses ?
- Benefits ?
- Accurate ?
- Gaps ?

... integrate with existing, accepted methods

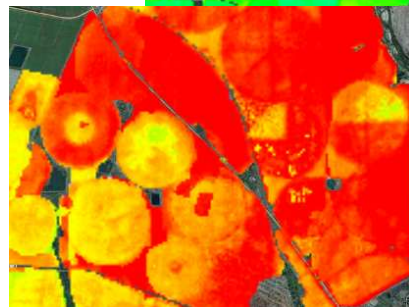
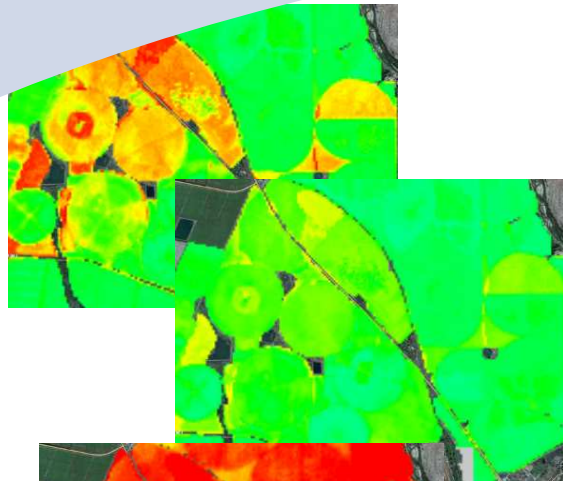
*... to assess and improve WUE in irrigated agriculture*

# Question

Instructive tools

Intelligent pixels

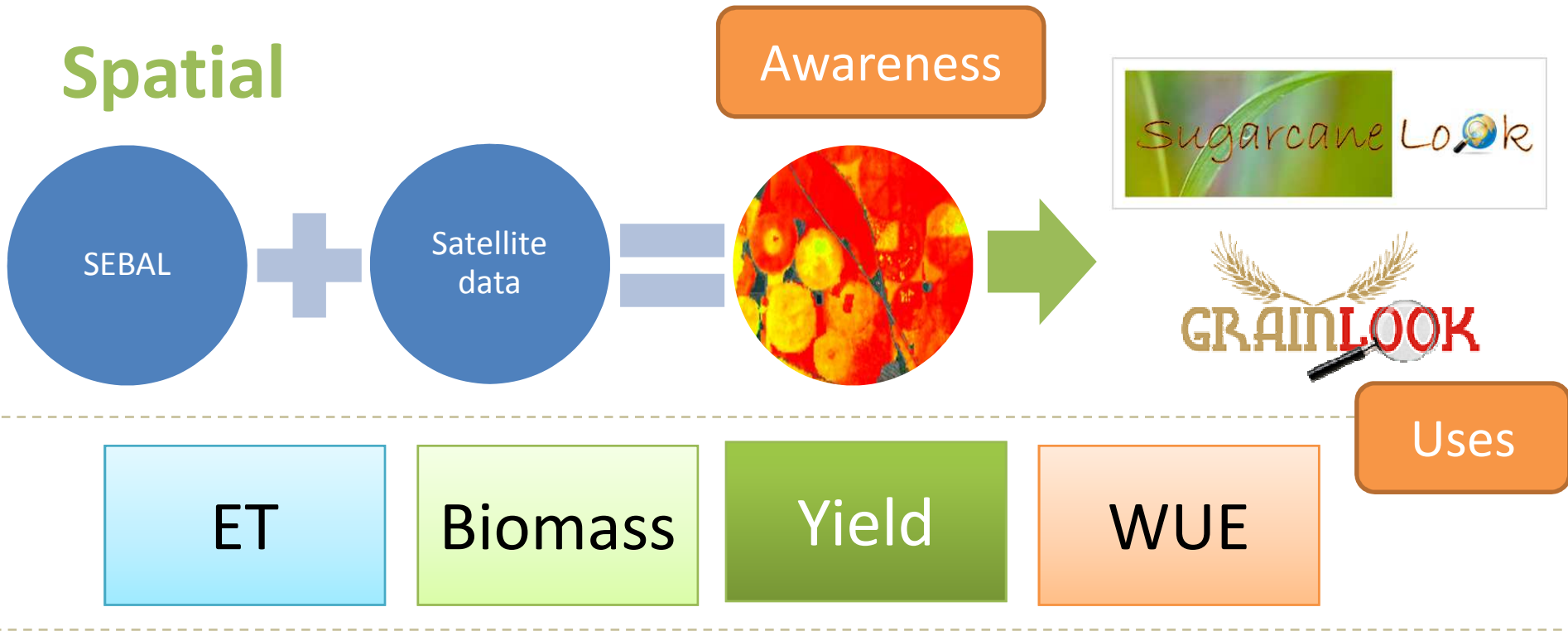
Remote sensing data



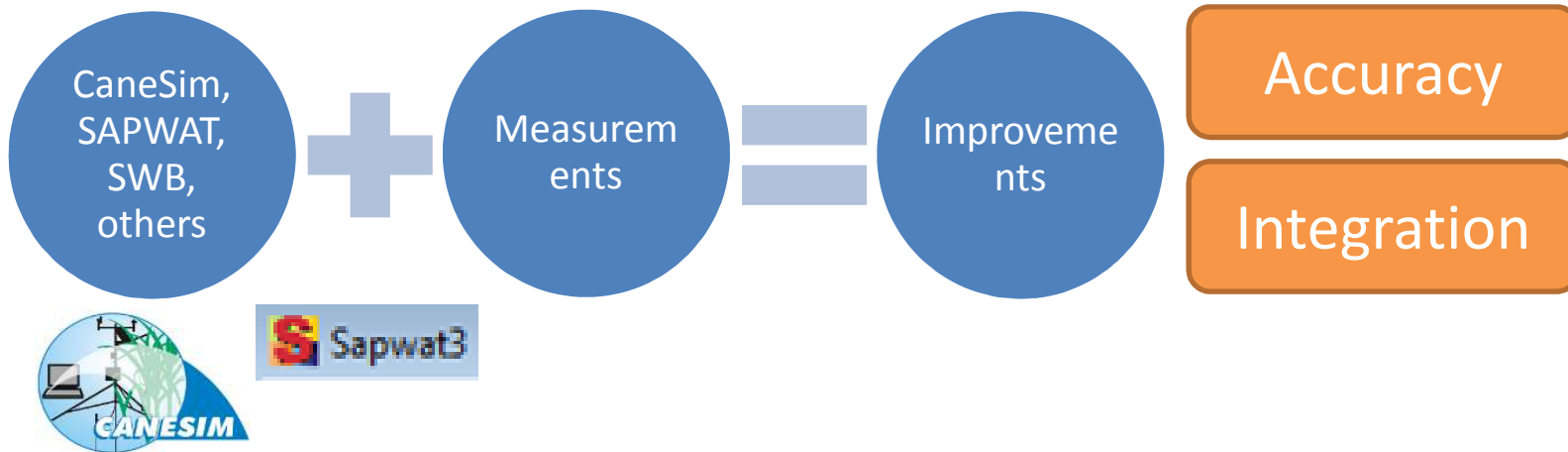
- Selecteer akker
- Akker achter ✓
- Akker links ...
- Akker groot ✓
- Akker rechts ✓

- Incorrect data entry
- Do not irrigate
- Irrigate in couple of days
- Start irrigation

# Spatial



# Field level



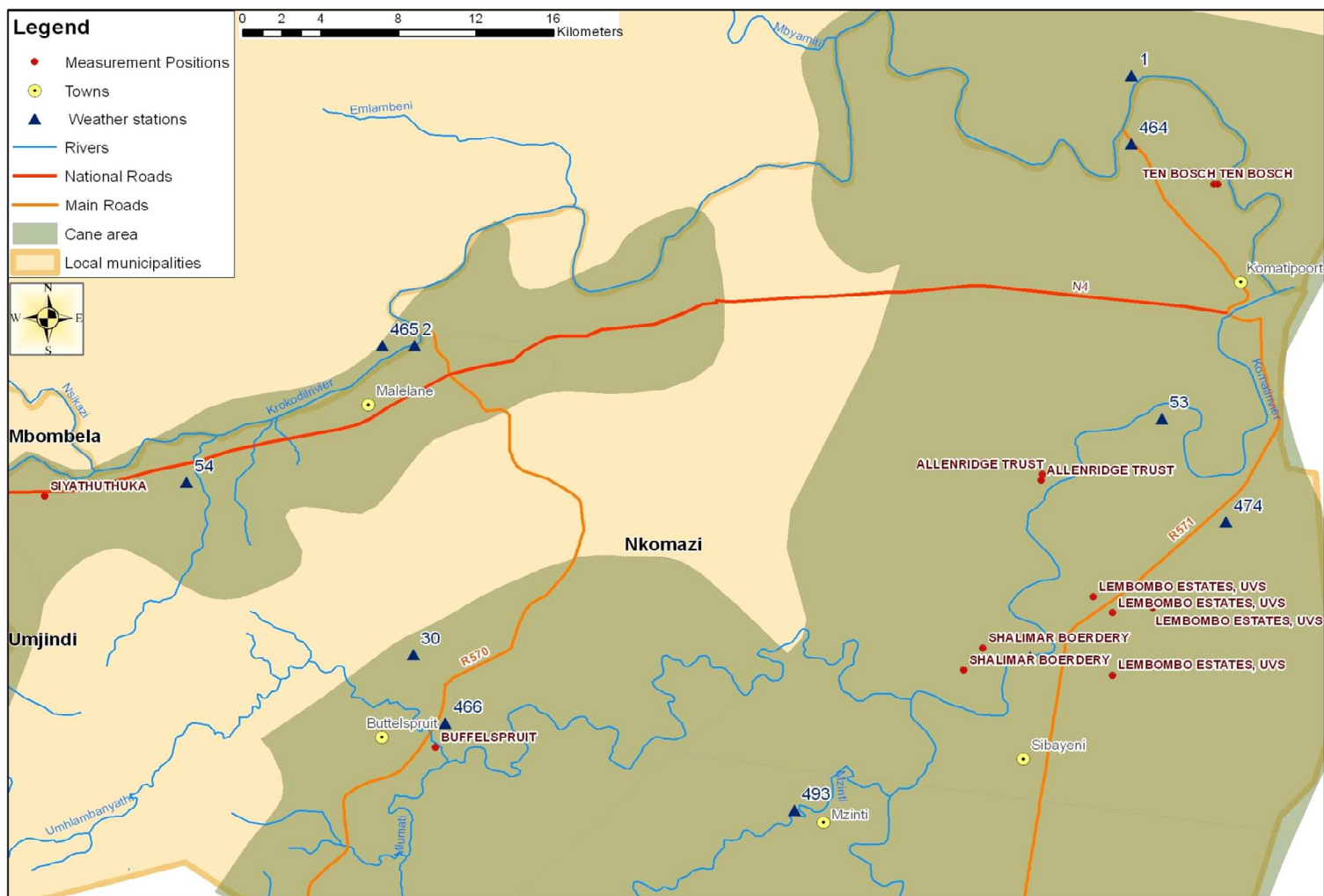
Irrigation system

Irrigation capacity

Cultivar

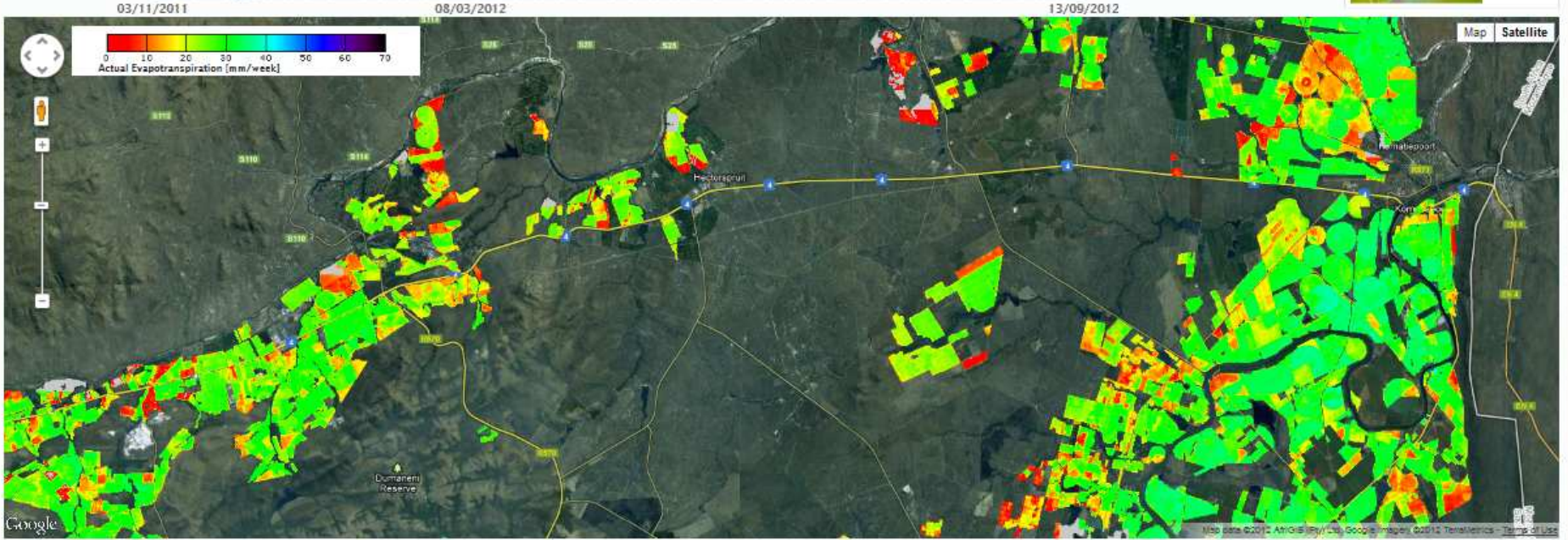
Soils

Management

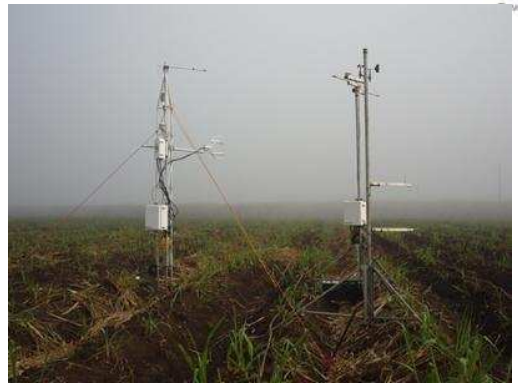


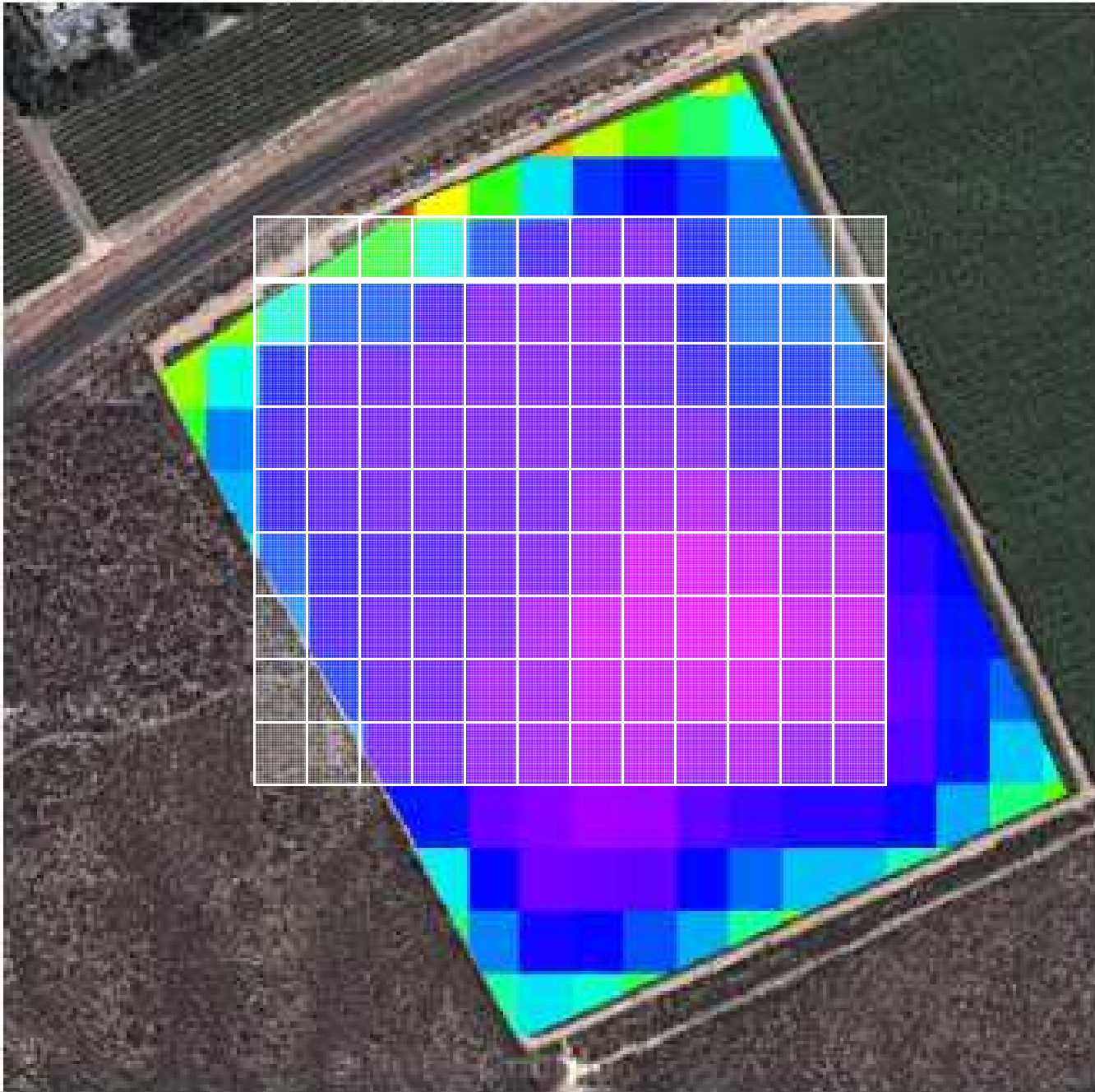
1 Nov 2011 to 31 Oct 2012

Actual Evapotranspiration data for week of 29 December 2011 to 04 January 2012  
Drag slider to view historic data



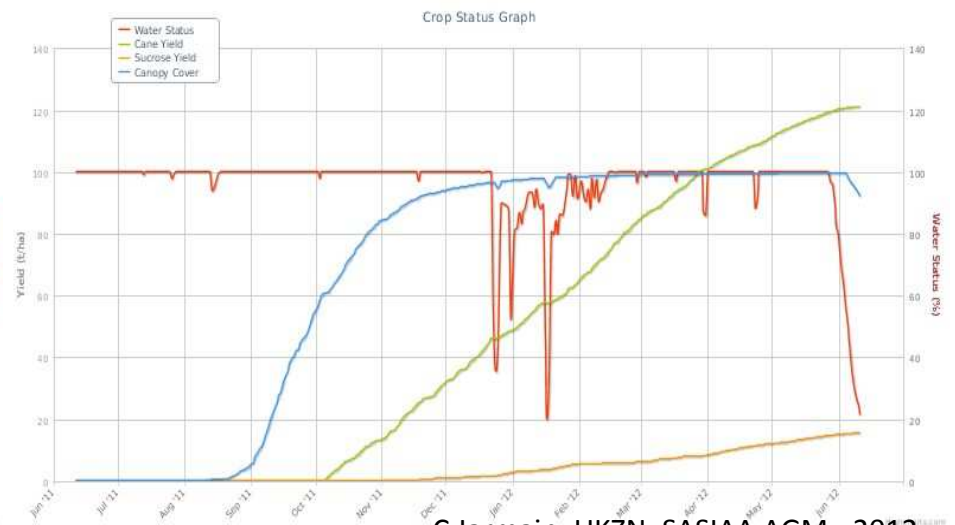
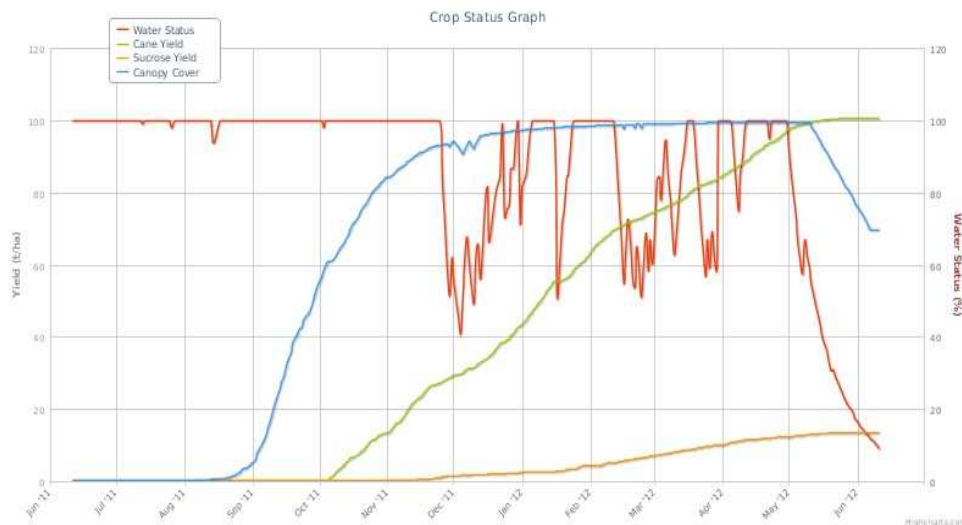
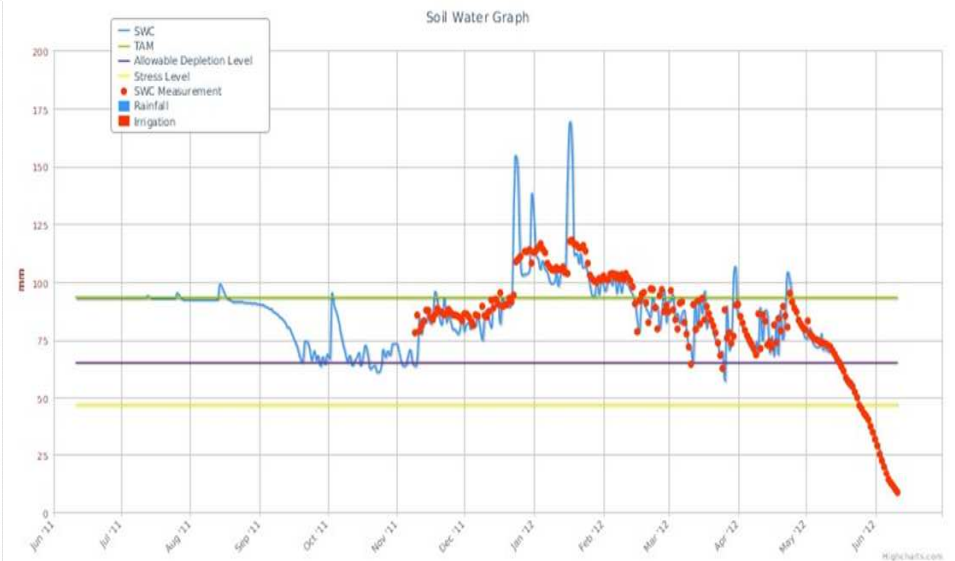
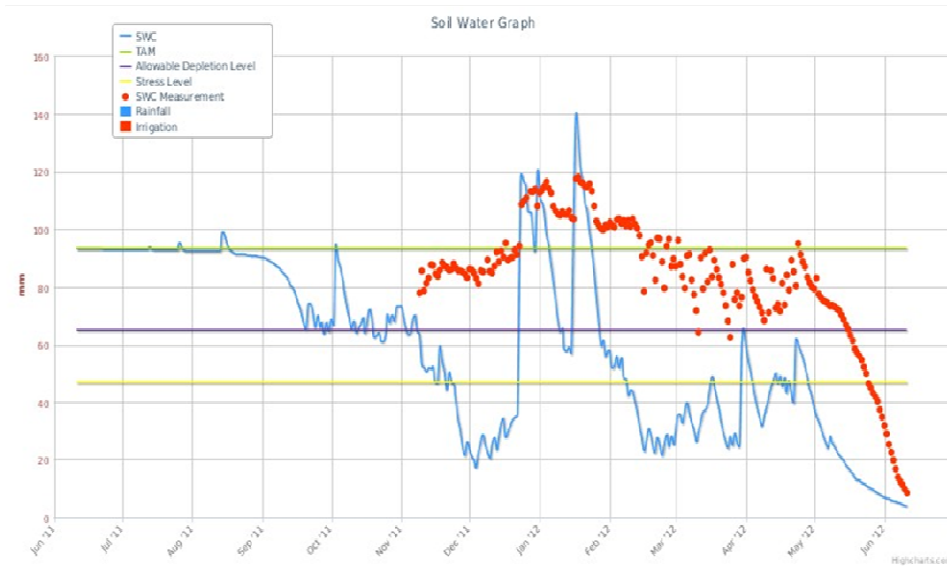
- Actual Evapotranspiration
- Evapotranspiration deficit
- Biomass Production
- Biomass Water Use Efficiency
- Reset





MODIS (1km)  
thermal data +  
DMC (22m) VNIR  
data

# MyCanesim - Integration of water balance data into simulations



# SAPWAT

Sapwat3

## Irrigation requirement: Farm/Quarternary river and Field data

### Farm / Quarternary river

Farm name: Melake\_Kaalrug\_WS

Weather station: Amanxala

Climate: Mild, humid, hot summers

Scheduled (ha):

Irrigated size (ha): 6.0

Quota (m<sup>3</sup>/ha/a):

Allocation (m<sup>3</sup>/a):

Required (m<sup>3</sup>/a): 44 800

Balance (m<sup>3</sup>/a):

Water distribution: Not defined

Efficiency (%): 75

Flow, Bal. (l/s/ha): 0

Ops. time (hrs):

Farms/Farmers:

Contact:

### Field

Field name: Shelimar\_003B

Field size (ha): 1.0000

Irrigated size (ha): 1.0000

Leaching requirement (%): 5

Irrigation requirement (m<sup>3</sup>/a): 5 600

Irrigation system: Drip

System efficiency (%), DU (%): 95 | 100

Soil: Loam

Effective depth (m): 0.4

FC (mm/m), WP (mm/m), TAW (mm): 250 | 120 | 130

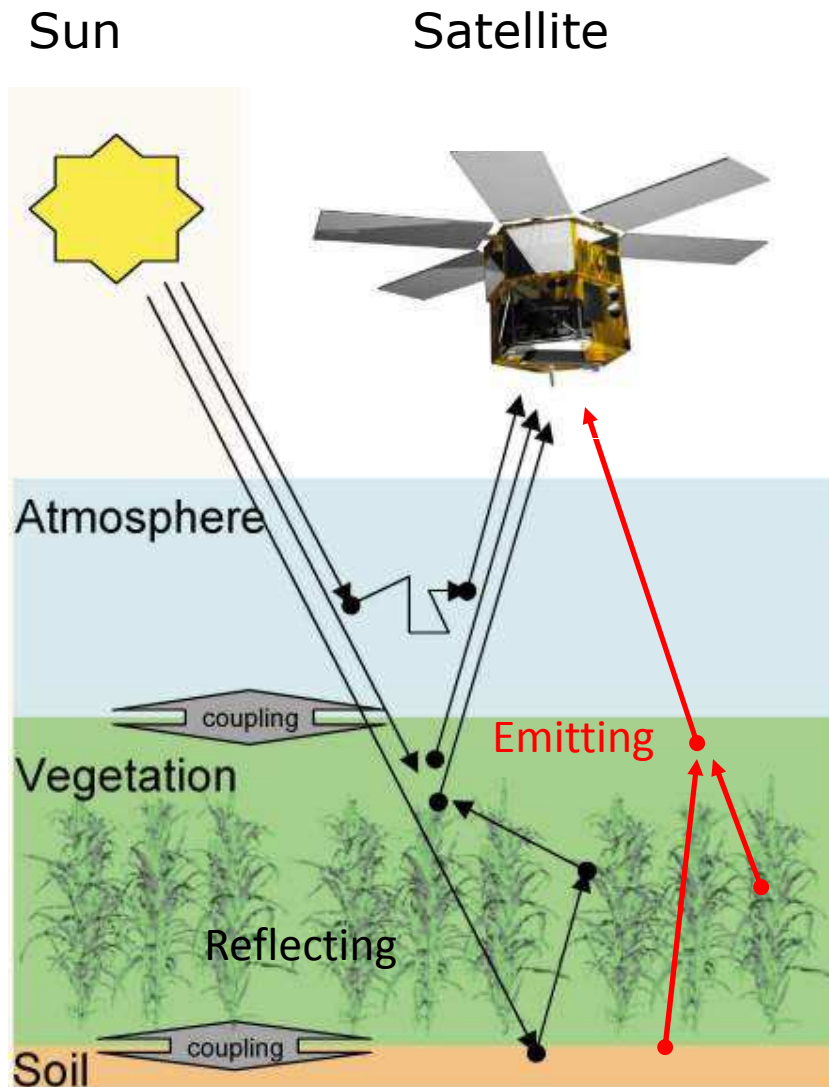
Evapo depth (m), REW (mm), TEW (mm): 0.1 | 9 | 19

Infiltration (mm/day): 40

Salinity: Soil (mS/m) , Water (mS/m): 200 | 50

WMA/WUA
Farm/Field
Crop set-up
mm (y/y)
mm (daily balance)
m<sup>3</sup>/a (avg)
m<sup>3</sup>/a (y/y)

# Electromagnetic spectrum



2 main sources of EM radiation

## 1. Sun

Visible (VIS)

Near-infrared (NIR)

Shortwave-infrared (MIR)

"Shortwave radiation" (0.1 – 3  $\mu\text{m}$ )

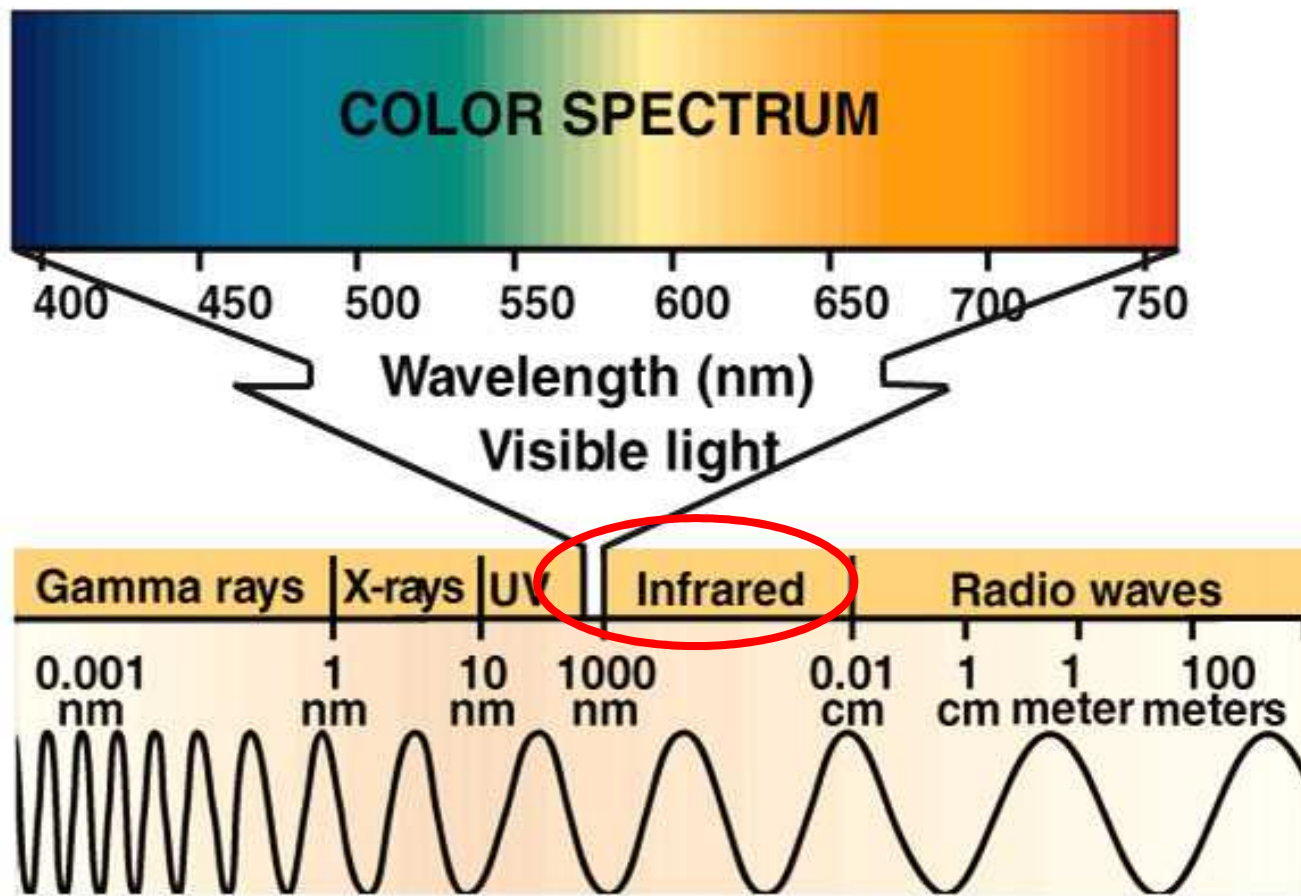
Surface albedo (0.1 – 3  $\mu\text{m}$ )

## 2. Earth

Thermal-infrared: 8 – 14  $\mu\text{m}$

"Long wave radiation" (5 – 50  $\mu\text{m}$ )

# The electromagnetic (EM) spectrum - More than the eye can see...



An image of a surface and its surface temperature – spot the differences...

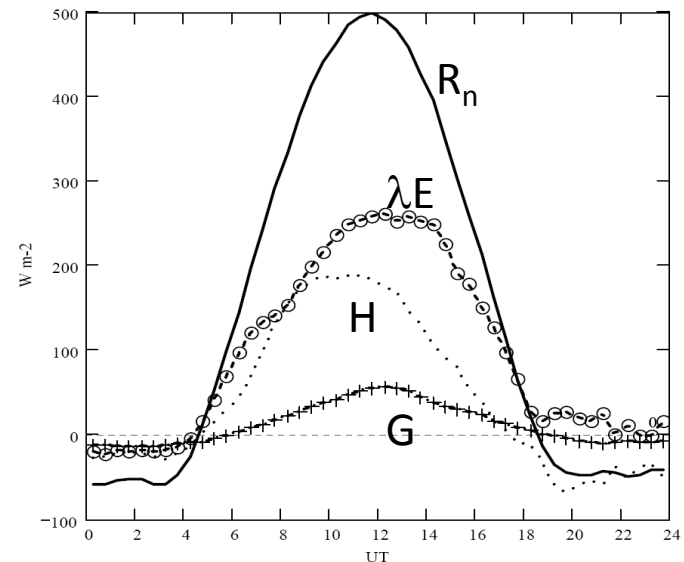
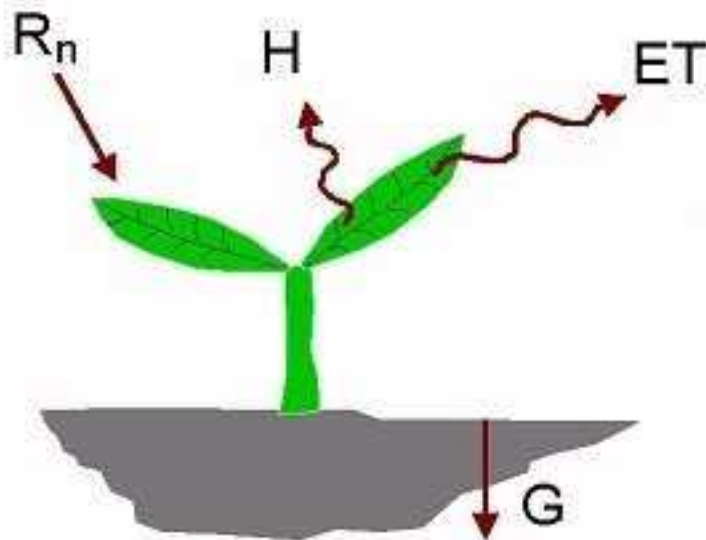


# Surface Energy Balance Algorithm for Land (SEBAL) model

SEBAL calculates evapotranspiration from the **energy balance**, not the **water balance**!

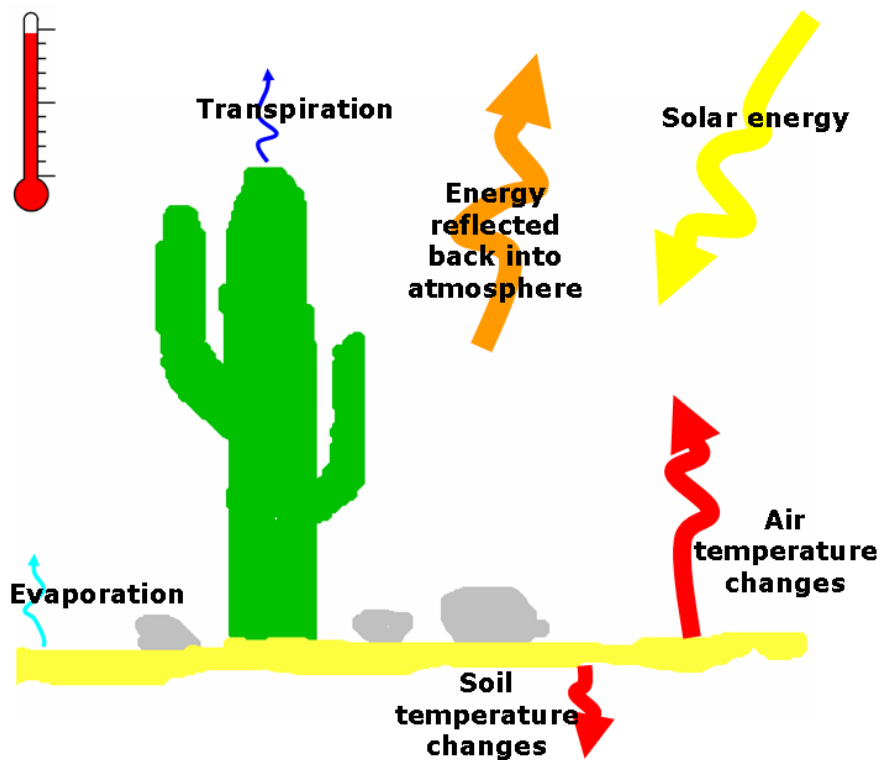
$$\lambda E = R_n - G - H$$

$$\lambda E \leftrightarrow ET$$

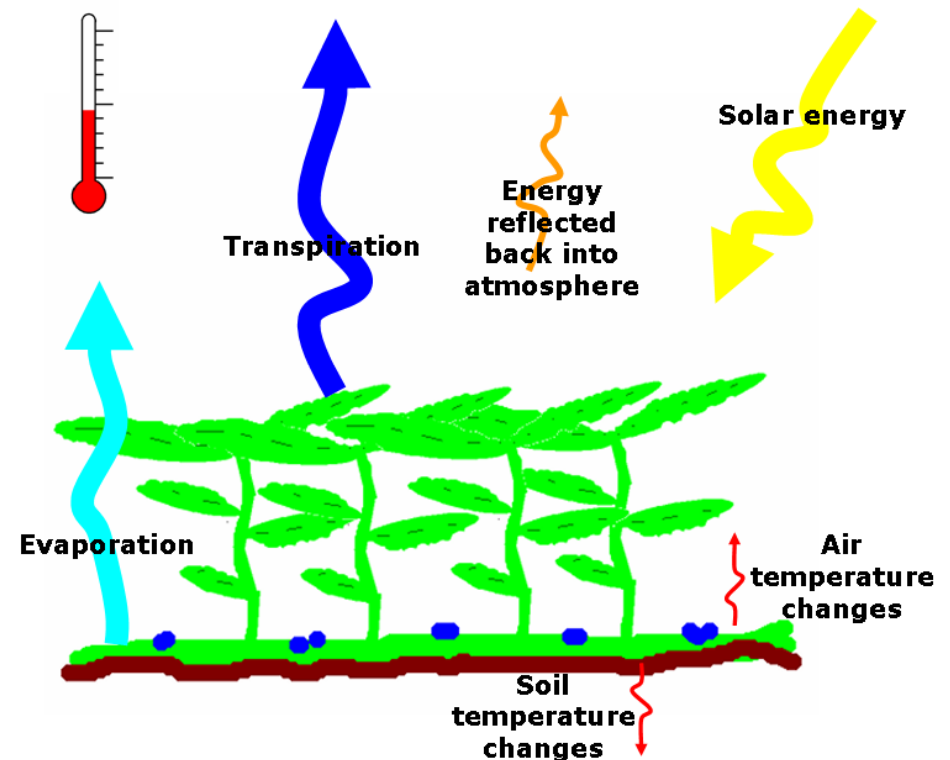


# Temperature is function of ET

## Surface energy balance



**Dry surface**



**Wet surface**

The thermal sensor is a tool of geo-scientist to measure the health of vegetation in full analogy with the thermometer of a doctor measuring the health of his patient (Anderson, 2008 EOS AGU Newsletter)

# Possible data uses



Advice	Information	Benefits
Irrigation planning	Spatial information on actual ET, ETdeficit related to soil moisture content	Improved water management, quality Improved WUE, block uniformity
Harvest planning	Biomass production	Increased yield
Pesticides and fertilizer planning	Biomass linked to spraying / application volumes	Improved input management
Evaluation and benchmarking	Actual ET and Biomass WUE	Improved WUE and quality
Longterm planning	Adjusting irrigation lines	

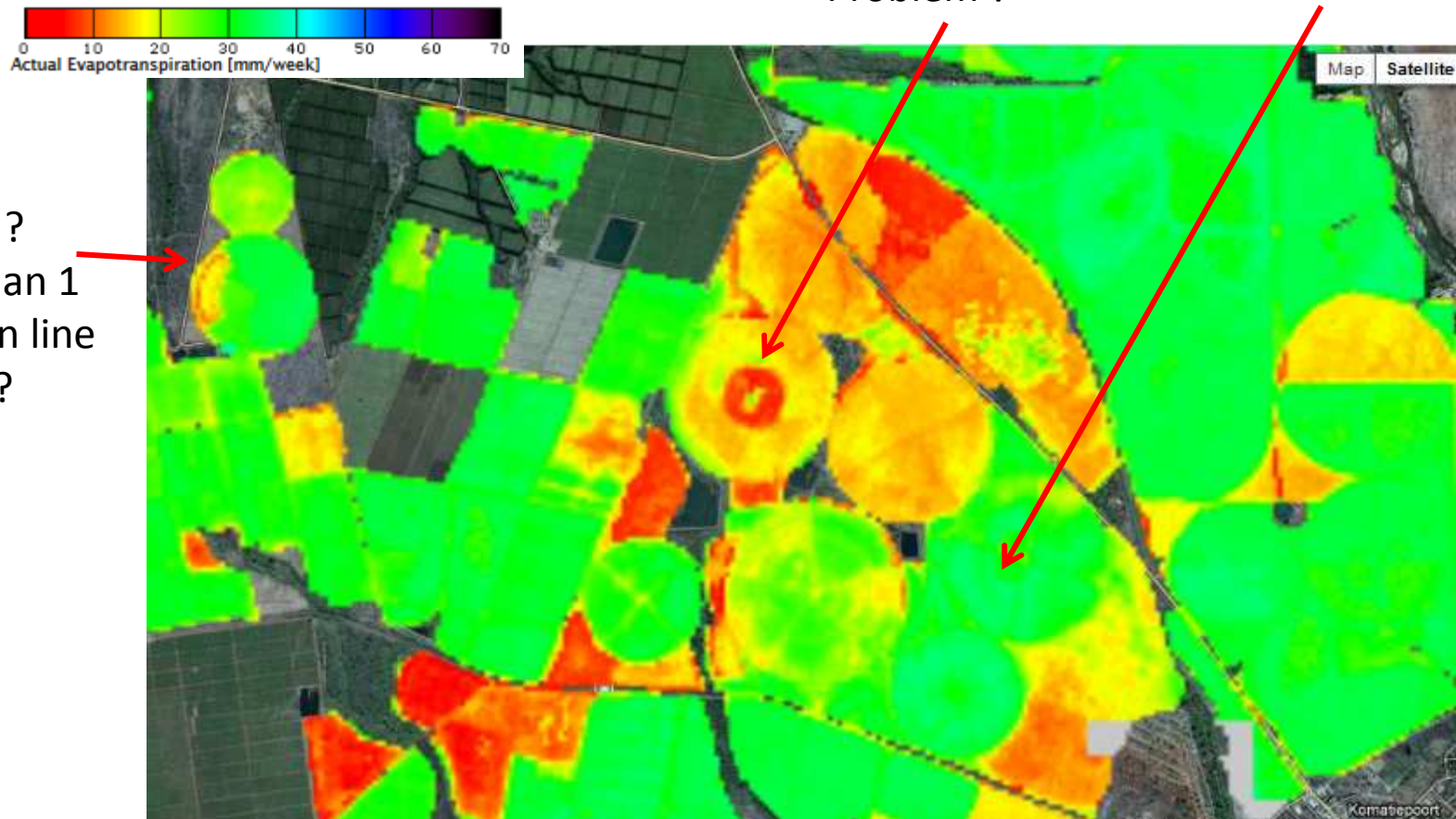
# Example 1: Water management

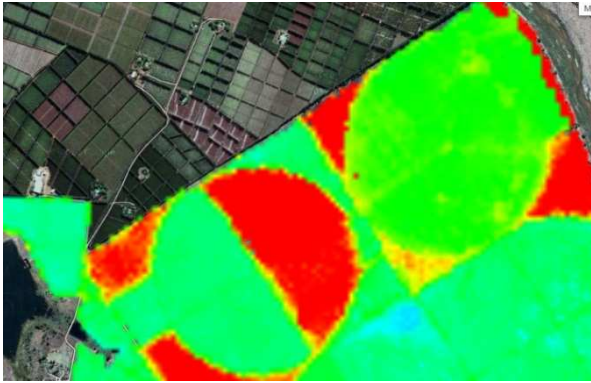
Farmer Bennie and consultant John evaluates irrigation applications

Actual ET=36 mm/week  
Irrigation=?mm/week  
Irrigation efficiency = ?

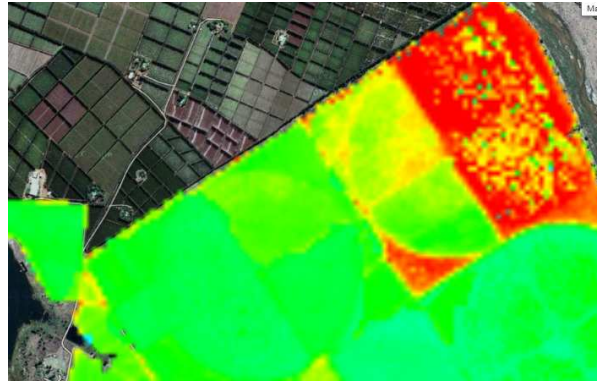
Problem ?

Harvest ?  
More than 1  
irrigation line  
needed?

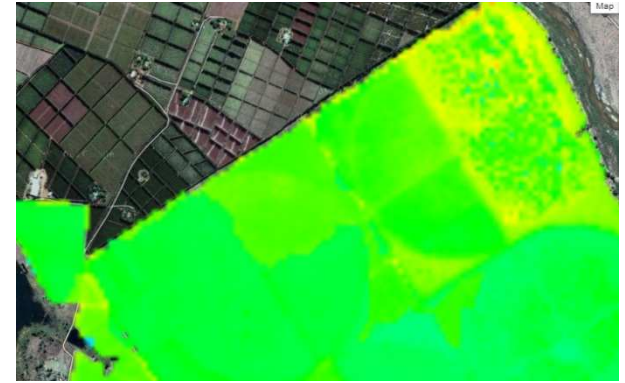




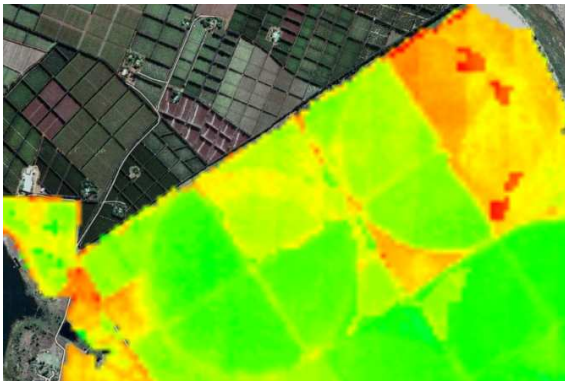
11 Nov 2011



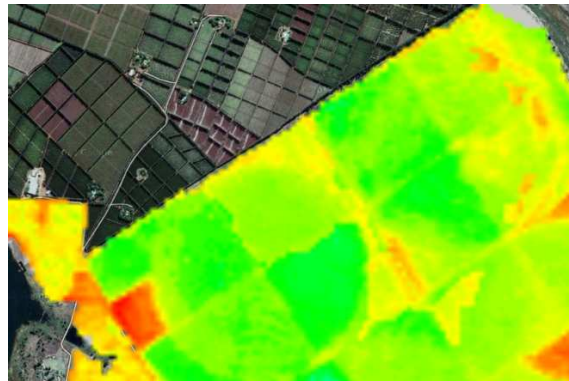
11 Jan 2012



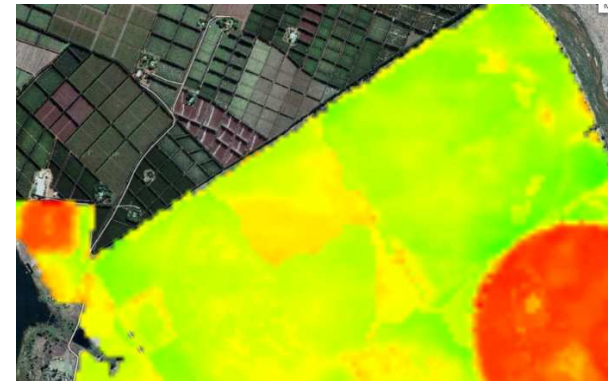
8 Feb 2012



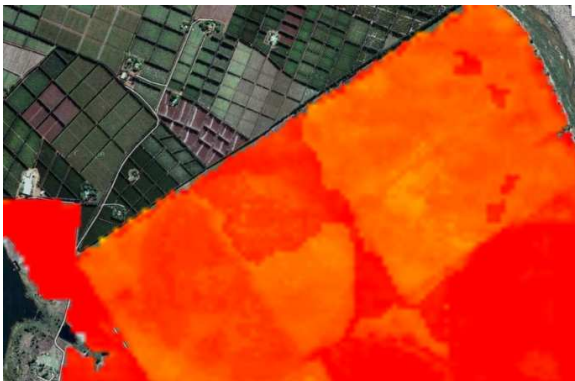
5 March 2012



4 Apr 2012



2 May 2012

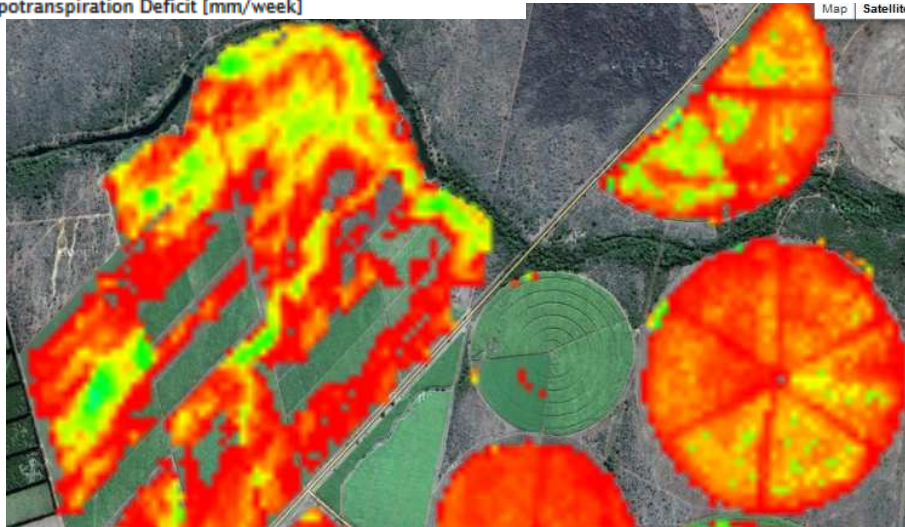
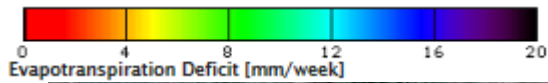


6 June 2012

## Example 2: Lawful water use

# Example 3: Water shortages ?

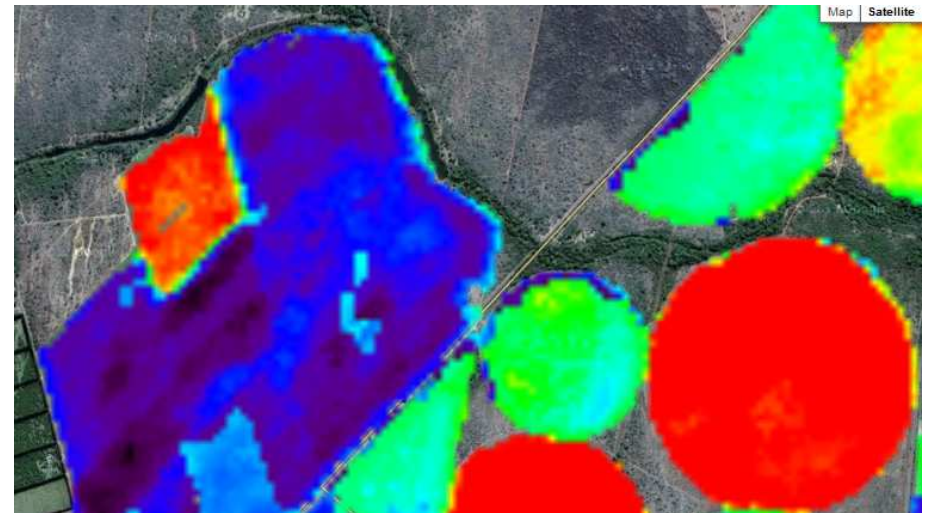
Farmer Teunis evaluates crop water status



25 Jan 2012

↑  
Small to no ET deficit after heavy rain

Drying off ?

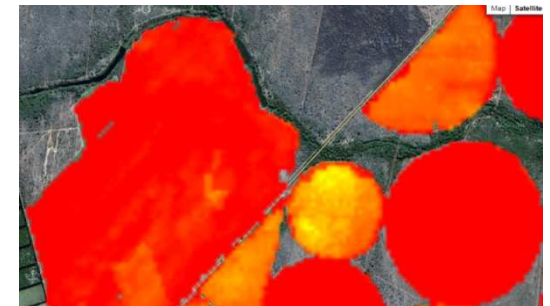


June 2012



Biomass production

↑  
Crop harvested ?



C Jarmain, UKZN, SANCID - 2012

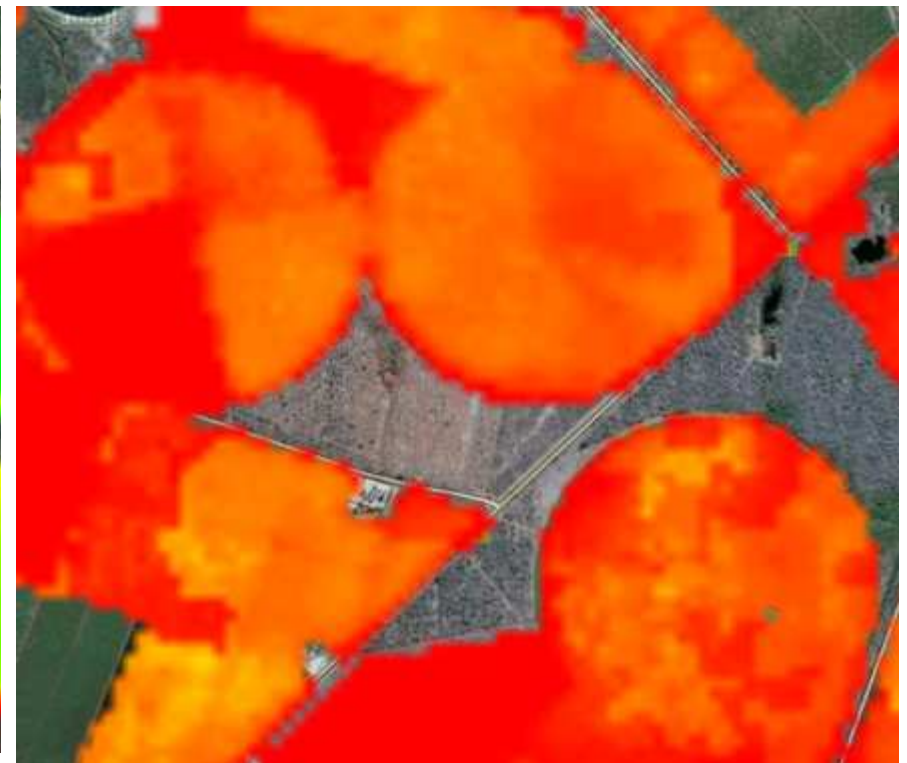
# Example 4: Crop development

Farmer Peter evaluates crop development



Nov 2011

↑  
Harvesting

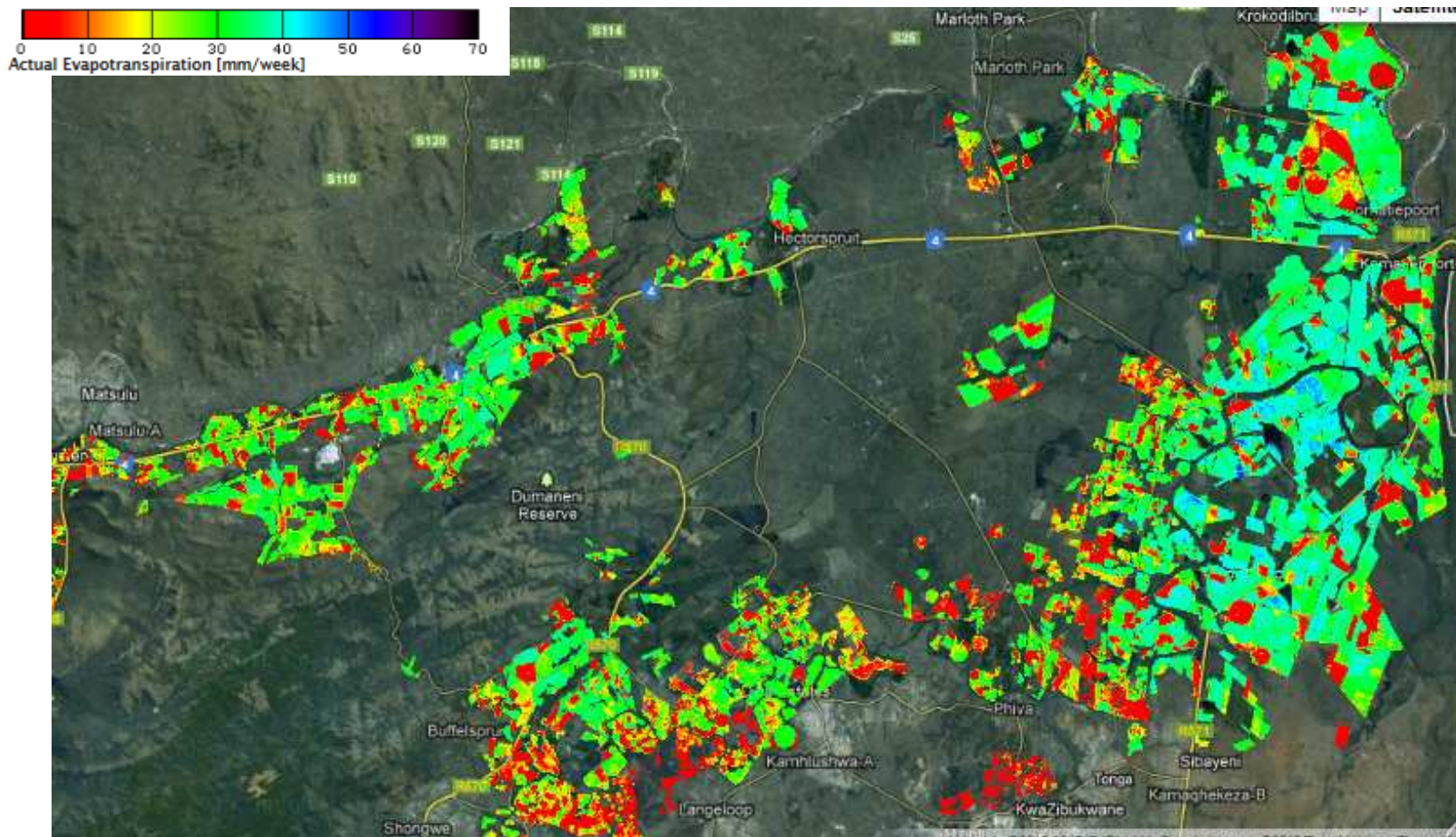


June 2012

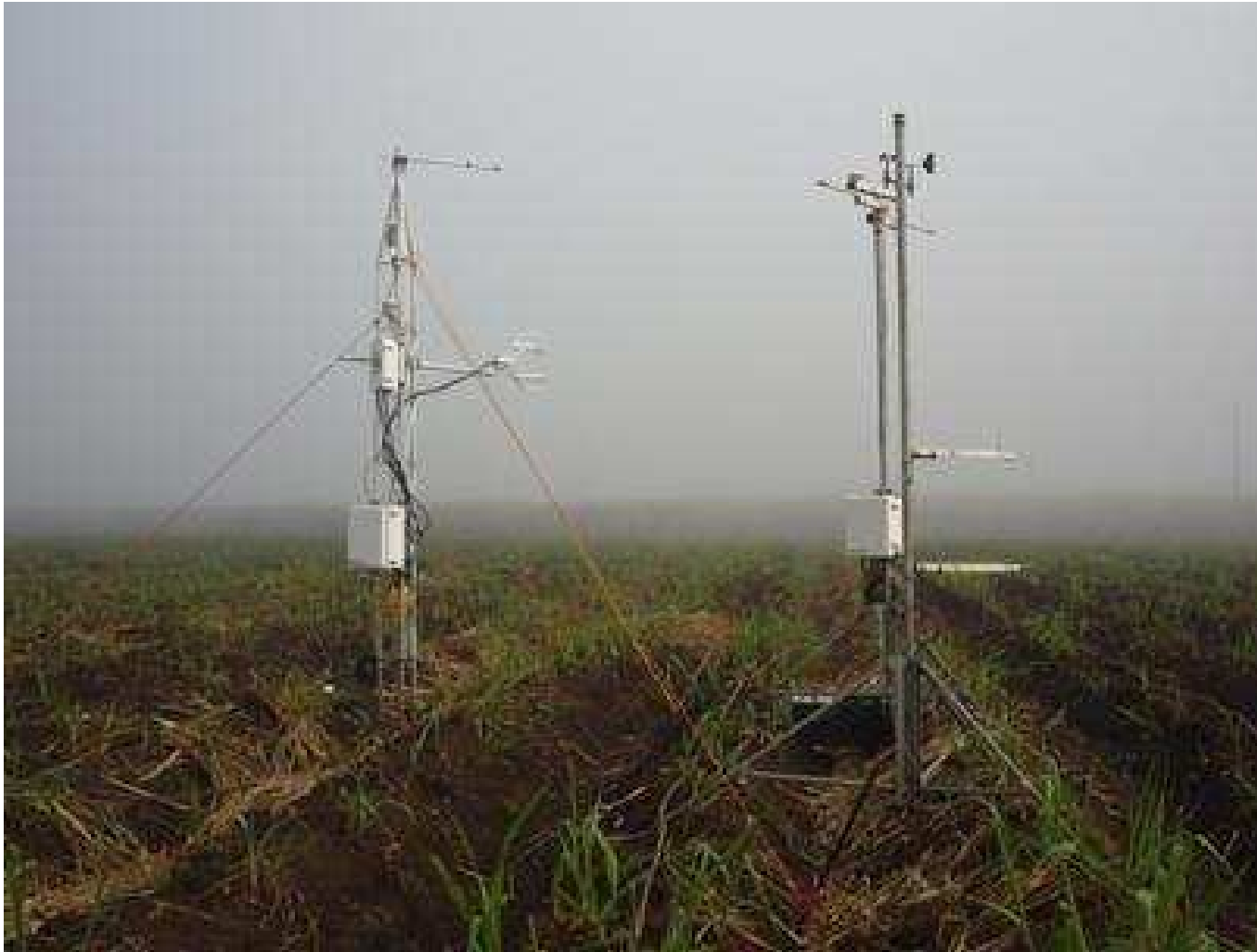
↑  
Maturing crop ?

# Example 5: Evaluate areas

Pure Sugar Inc. evaluates regional (or farm specific) data for sustainable production



# Data agreement



**Preliminary results**

C Jarman, UKZN, SANCID - 2012

# Example

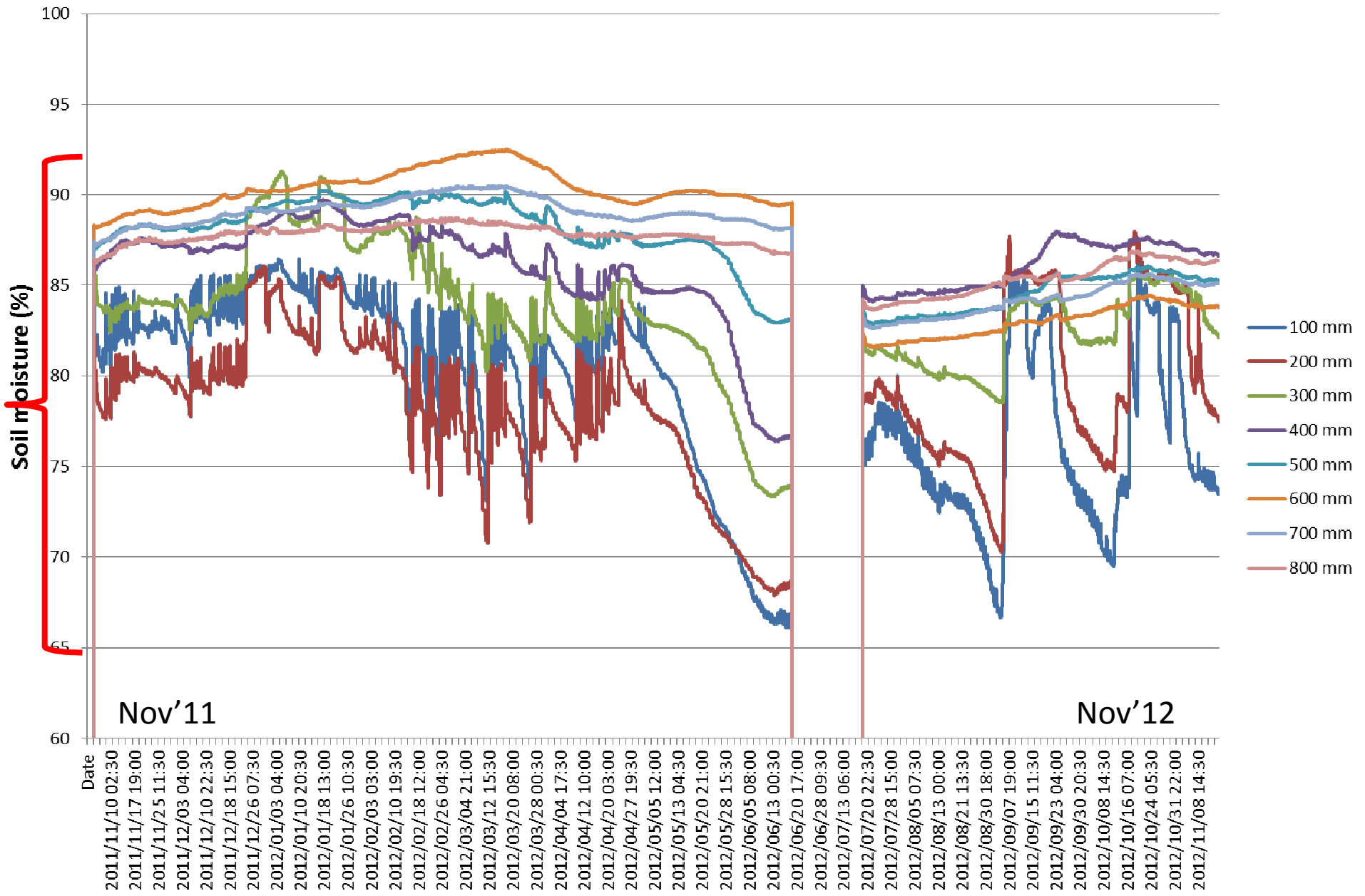
Scenario			
Yield	High	Low	Very high
Farm	Lebombo G1	Buffelspruit	TenBosch
Yield t/ha	108 (est. 100)	69.4 (est. 56)	(est. 146)
Sucrose t/ha	15.3	N/a	
Irrigation type	Drip	Dragline	Centre pivot
Harvest date	11/06/2012	25/08/2012	Oct 2012
Irrigation capacity mm/d	7	3.43	7.5



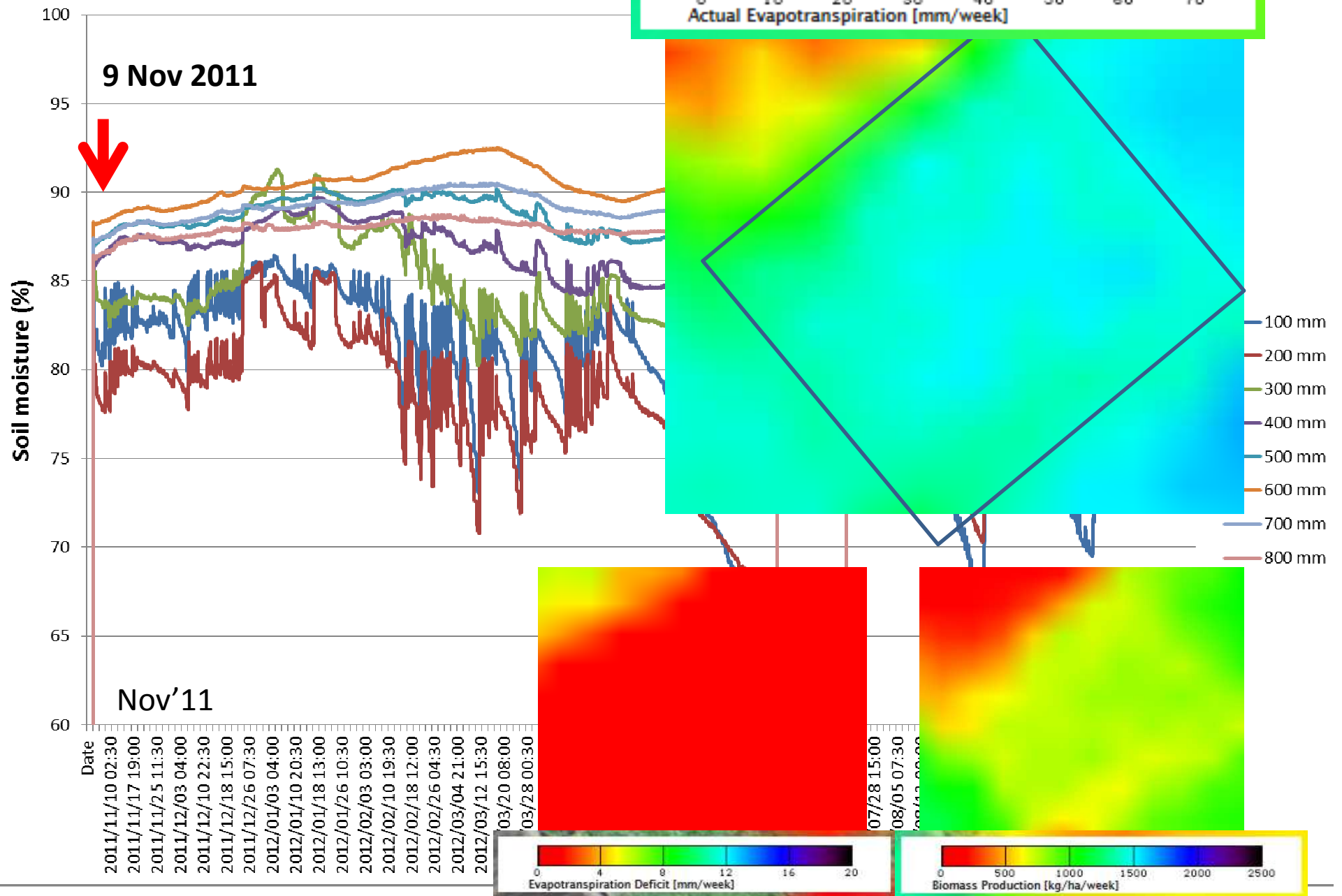
# Lebombo



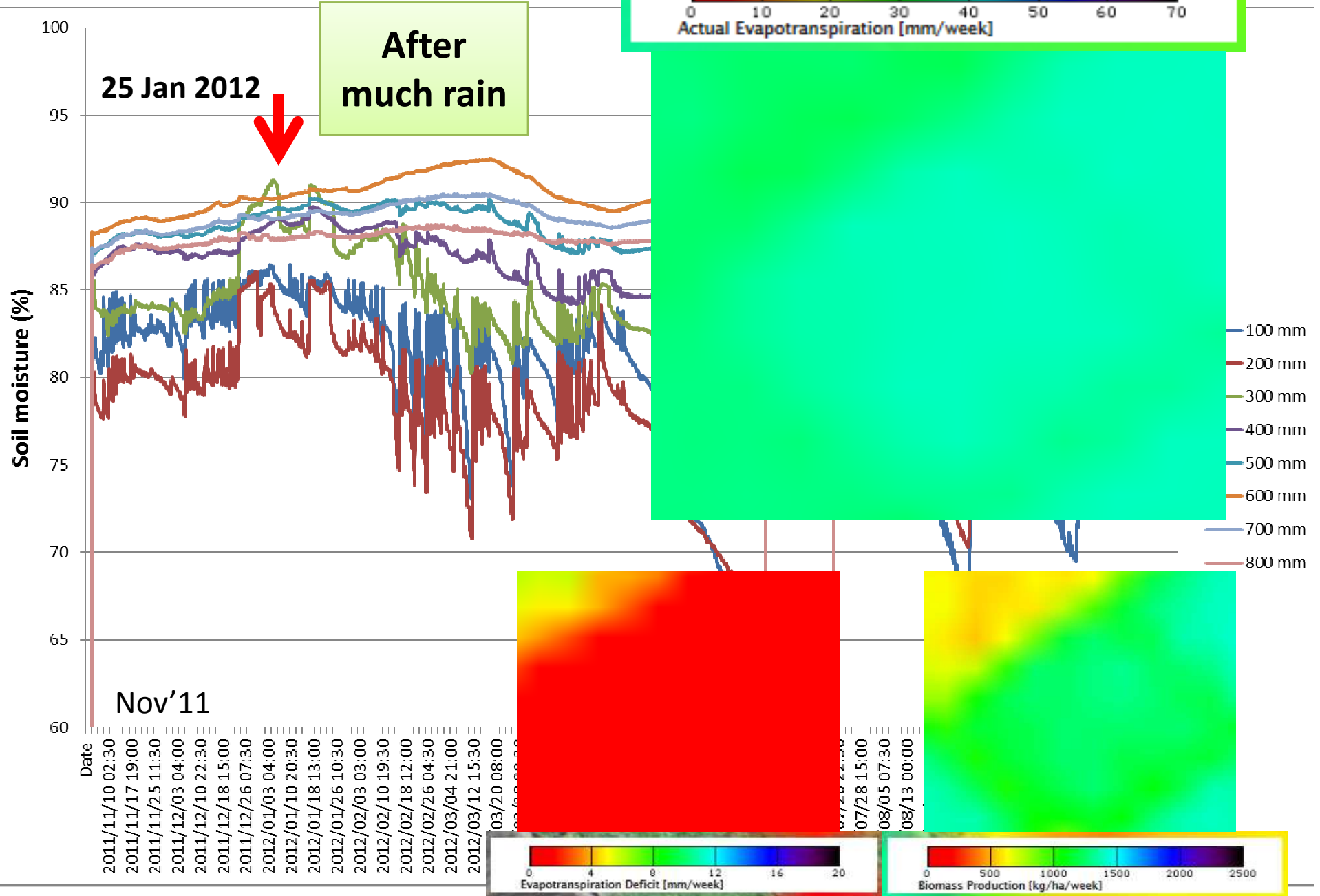
# Lebombo G1



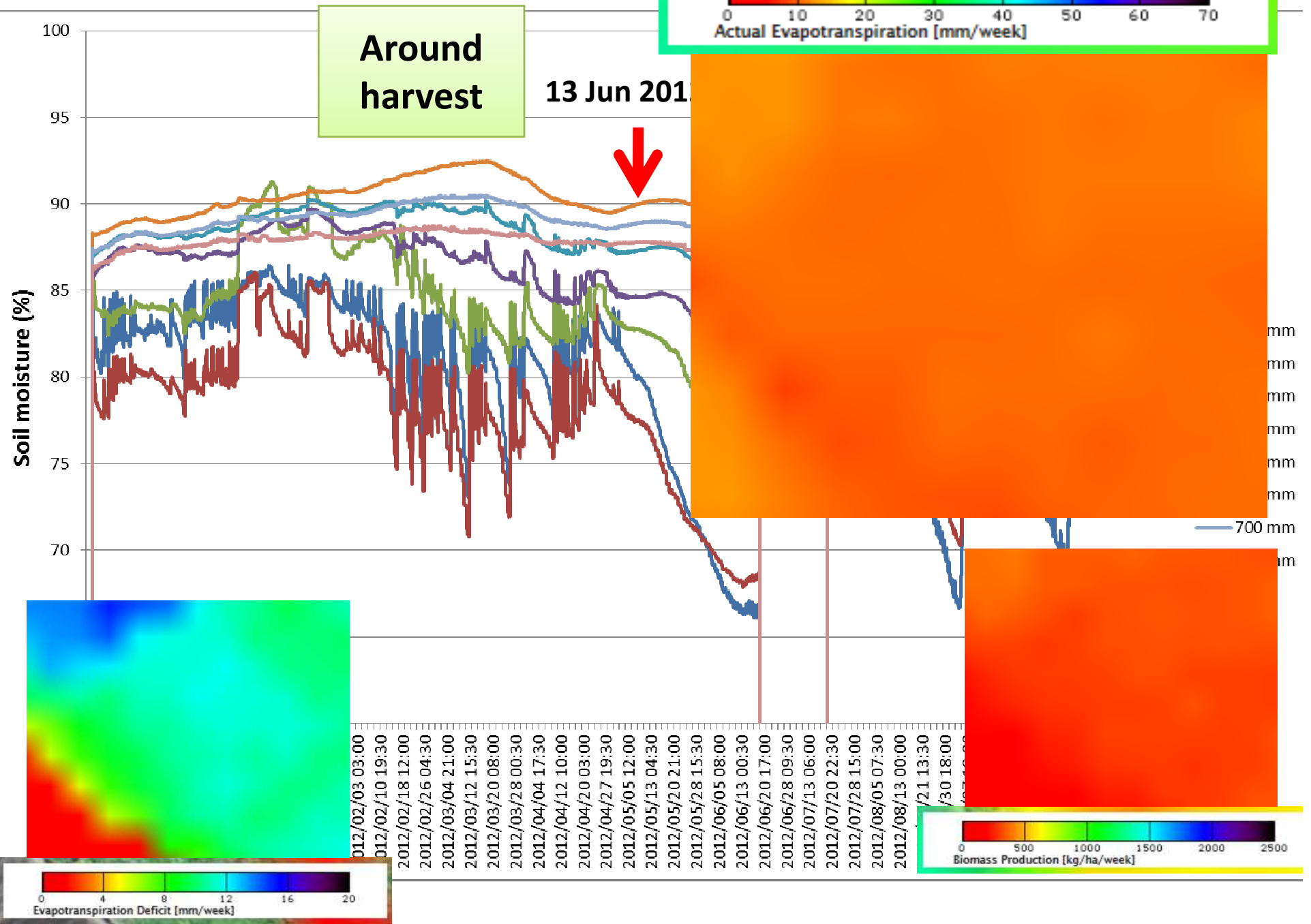
# Lebombo G1

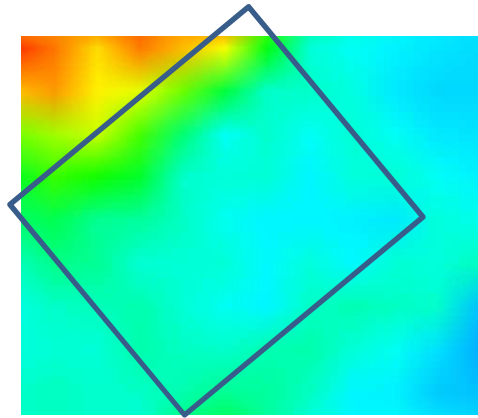


# Lebombo G1



# Lebombo G1

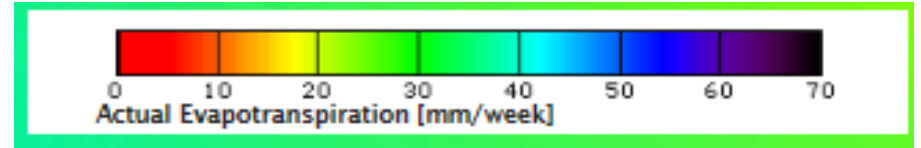




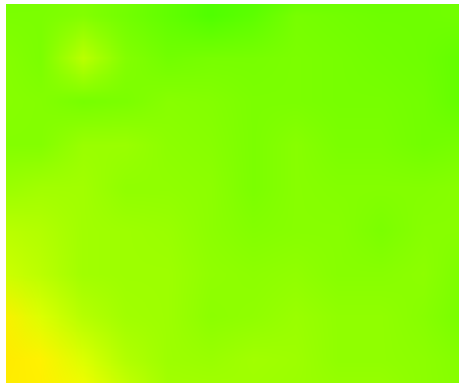
9 Nov 2011



25 Jan 2012



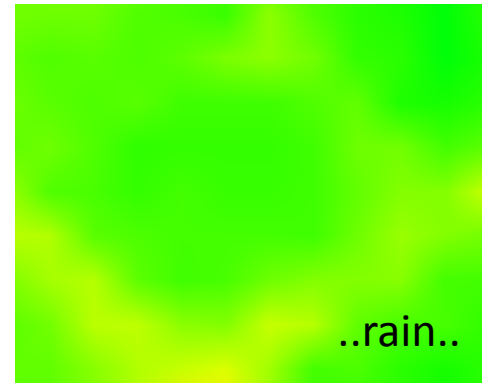
14 Mar 2012



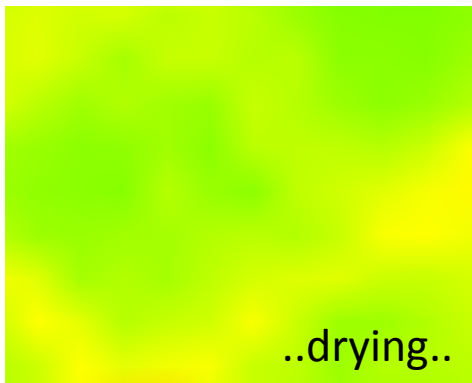
16 May 2012



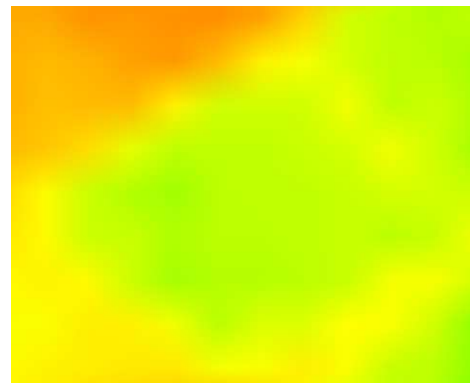
13 Jun 2012



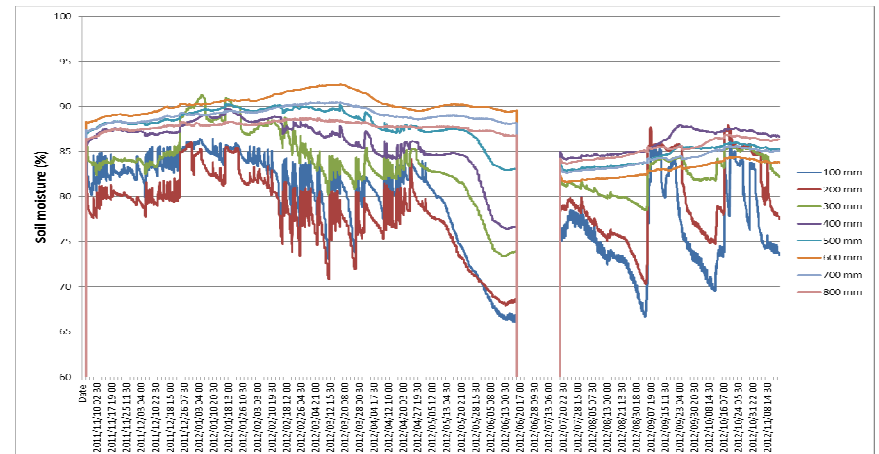
8 Aug 2012

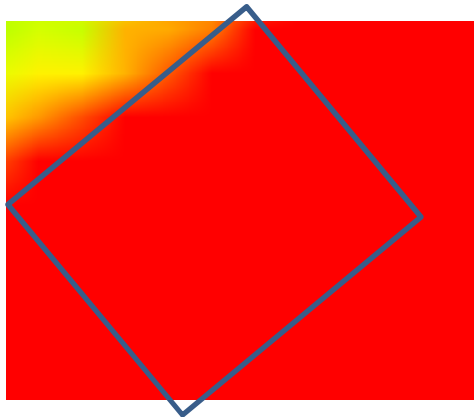


5 Sep 2012

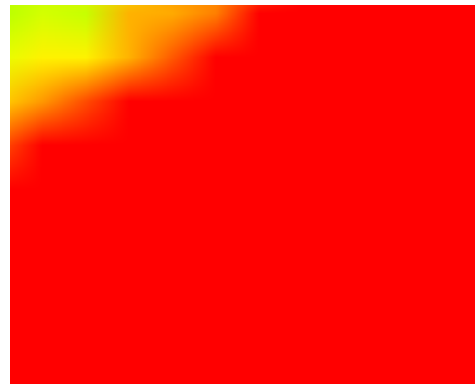


19 Sep 2012

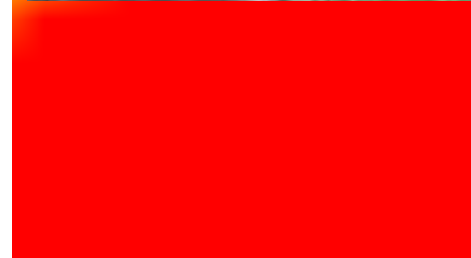
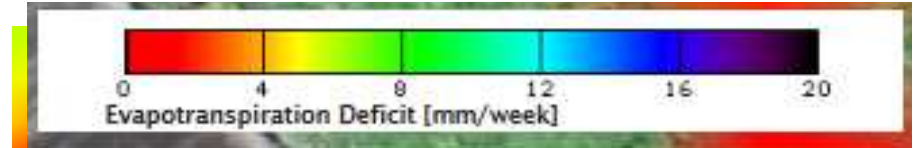




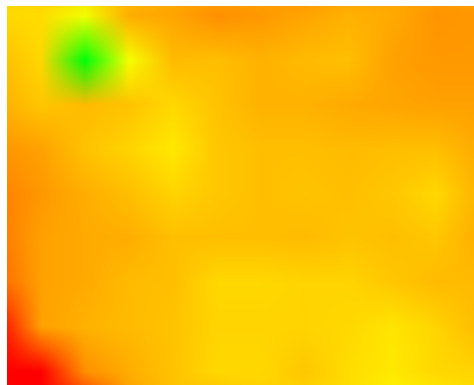
9 Nov 2011



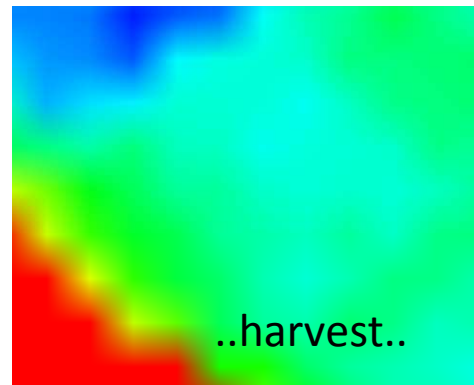
25 Jan 2012



14 Mar 2012



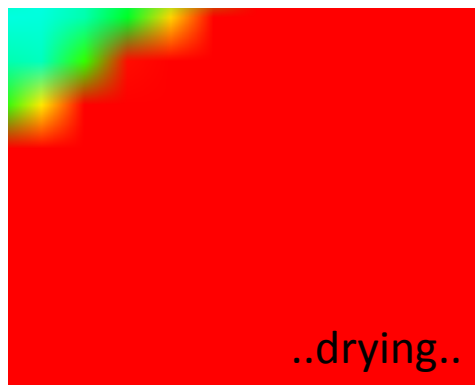
16 May 2012



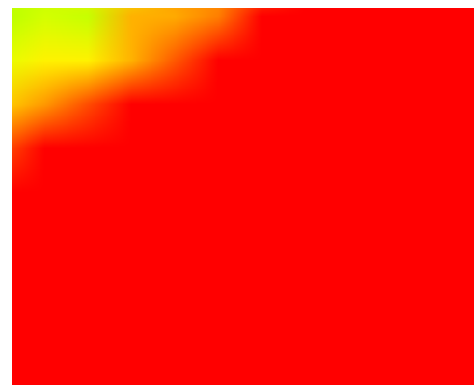
13 Jun 2012



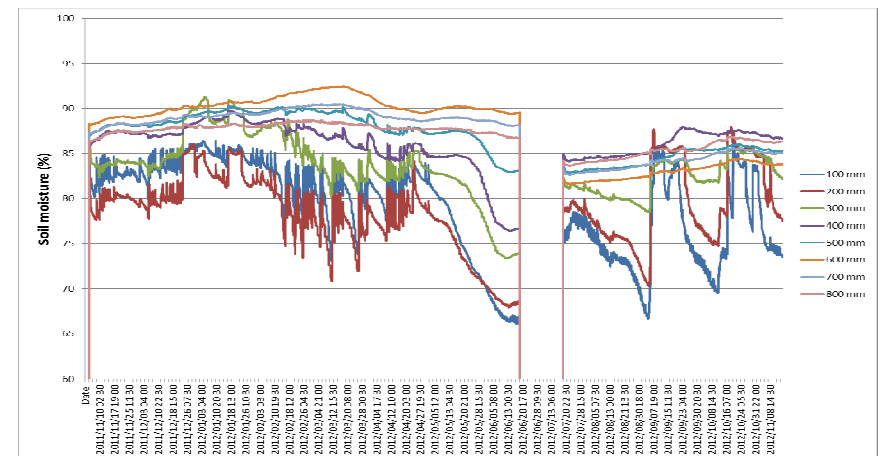
8 Aug 2012

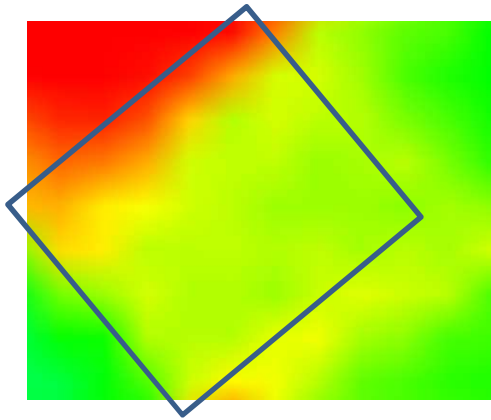
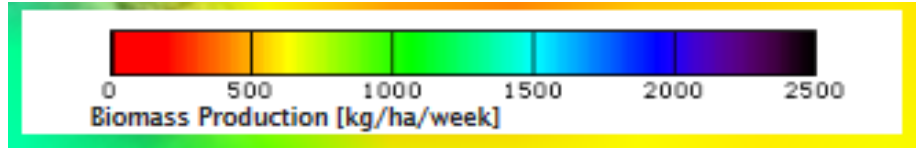


5 Sep 2012

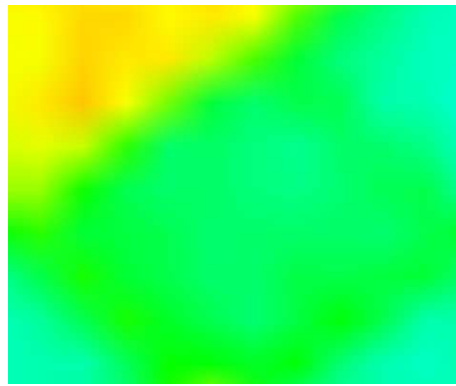


19 Sep 2012





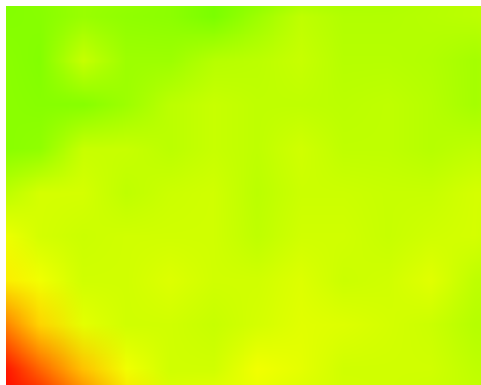
9 Nov 2011



25 Jan 2012



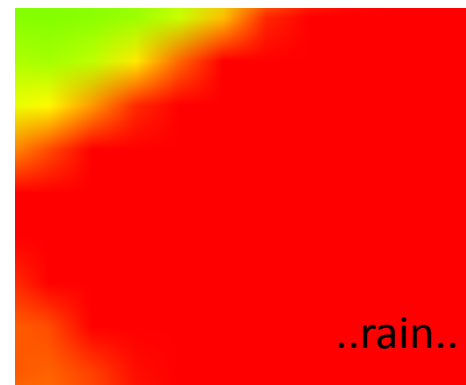
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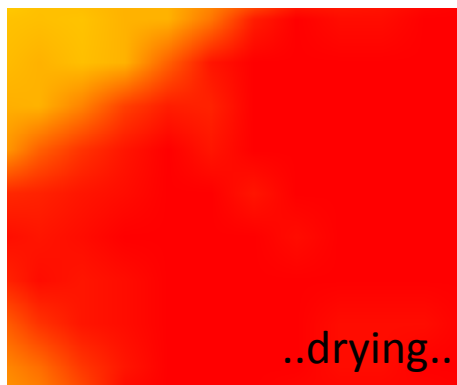
16 May 2012



13 Jun 2012



8 Aug 2012

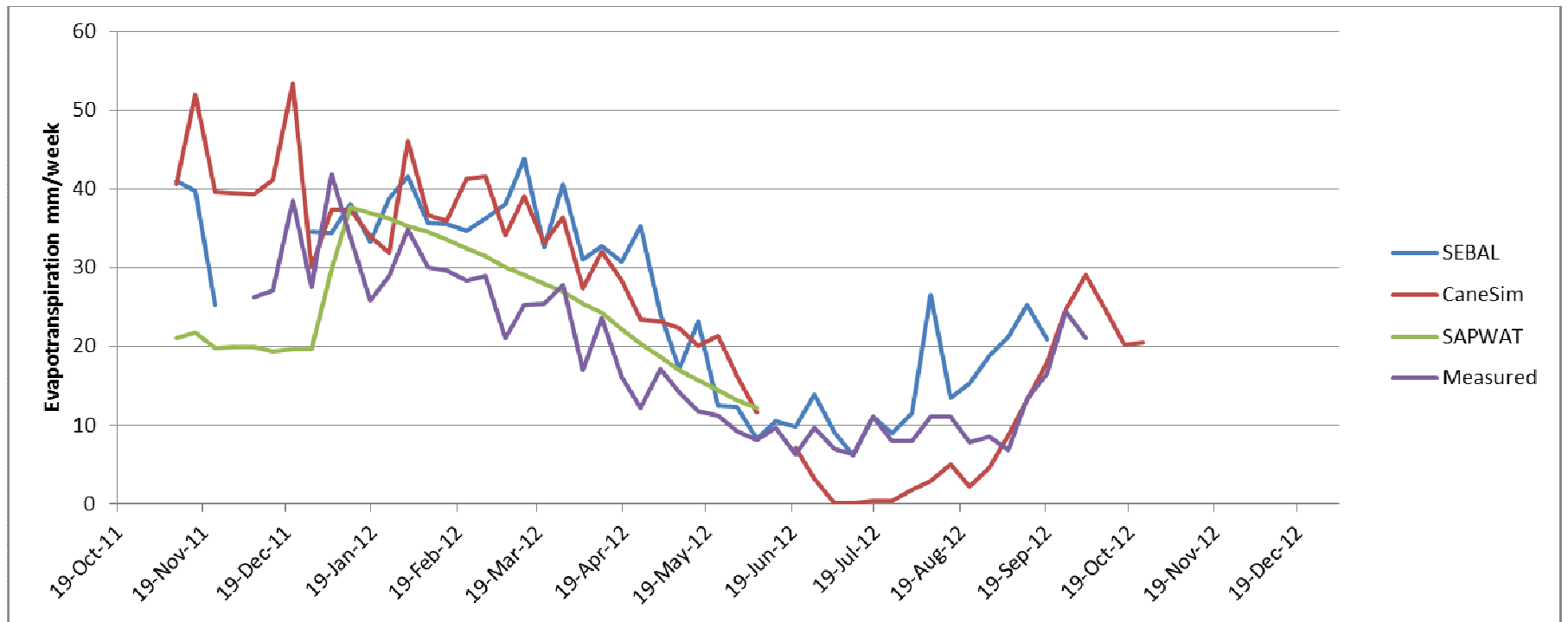


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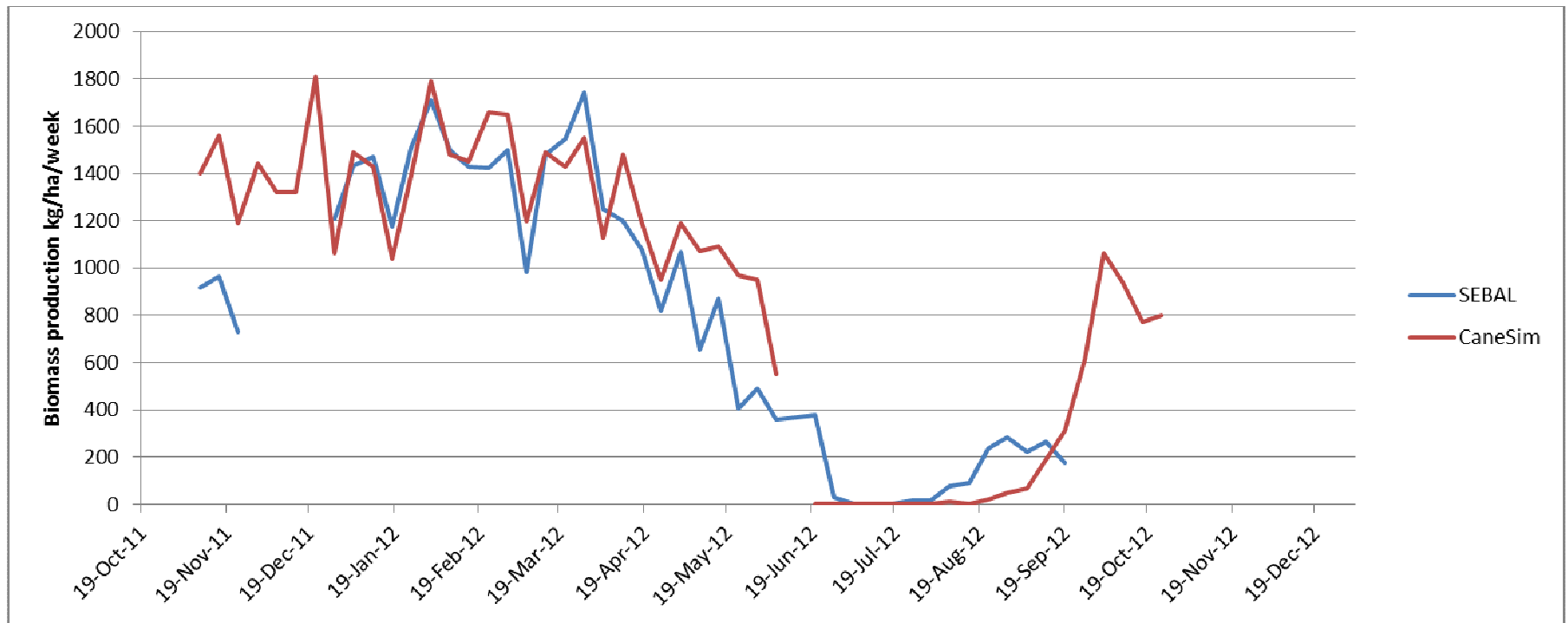


19 Sep 2012

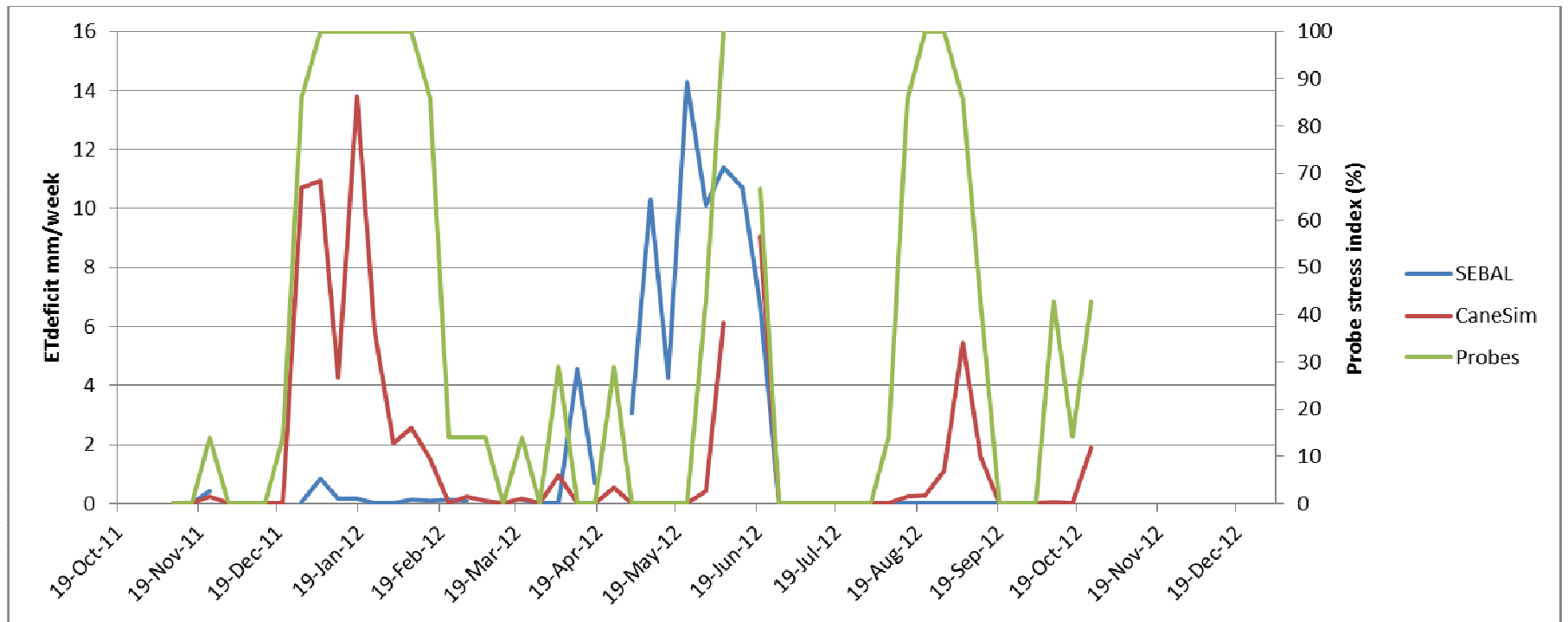
# Evapotranspiration



## Biomass production



# Stress index

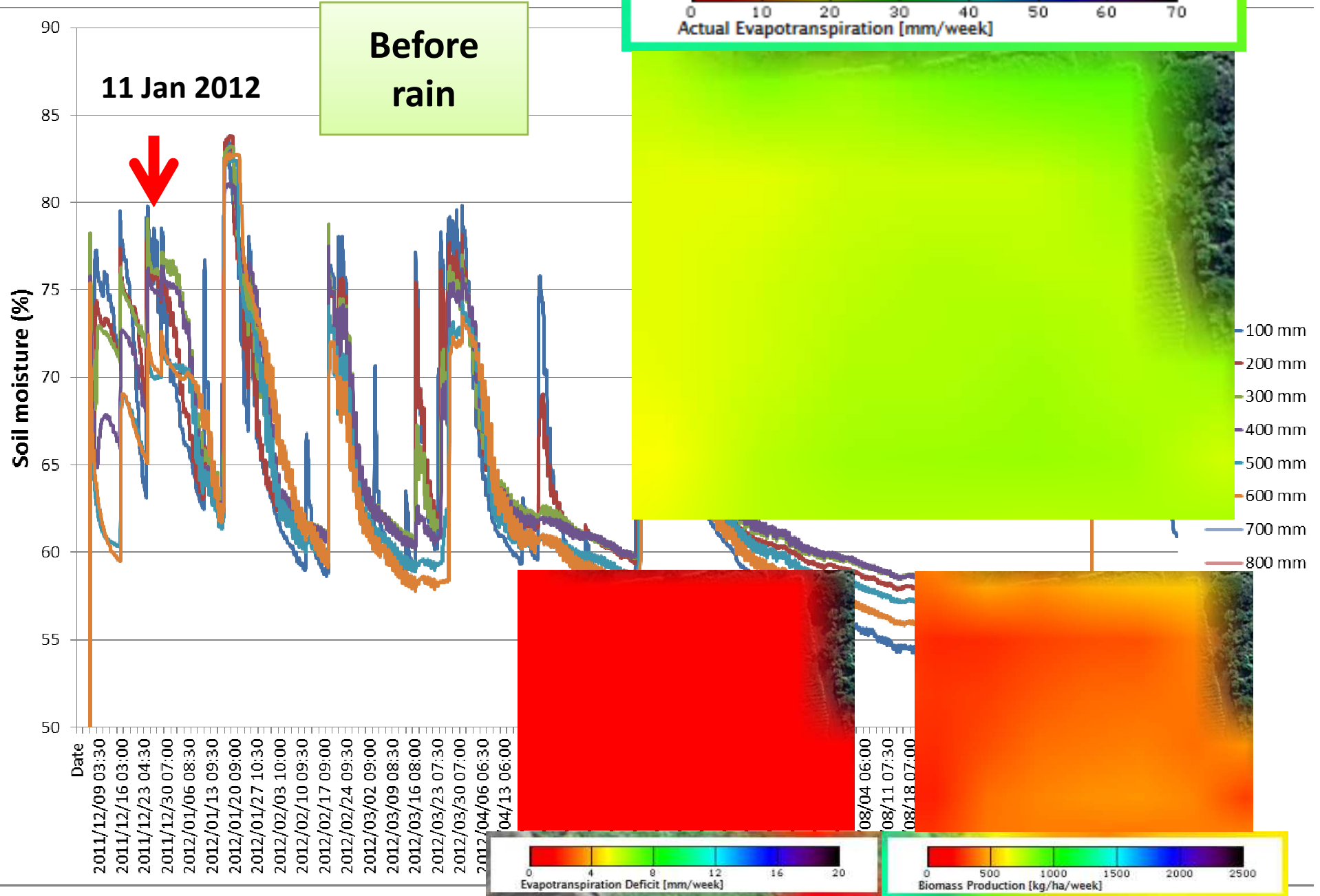


# Buffelspruit

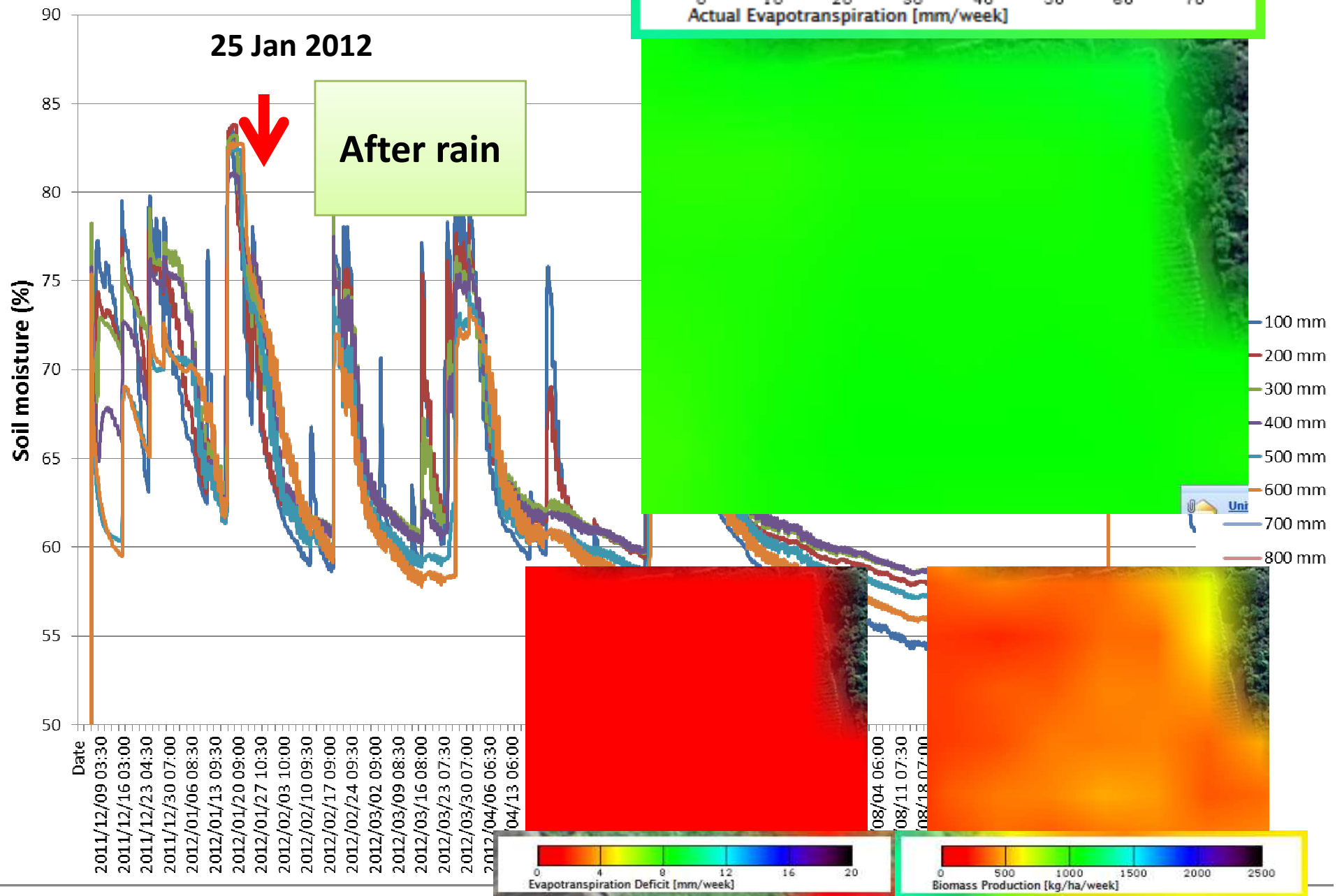




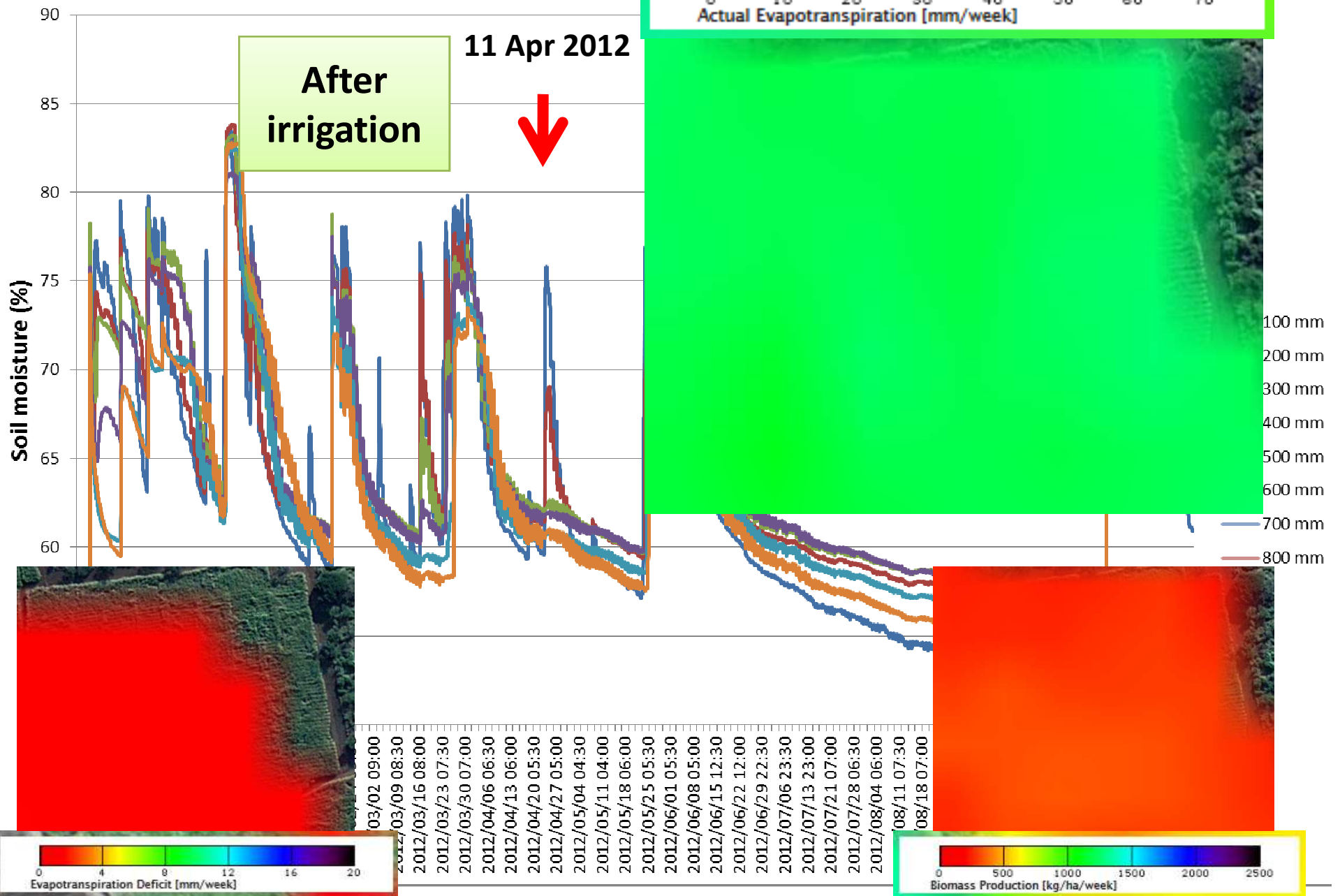
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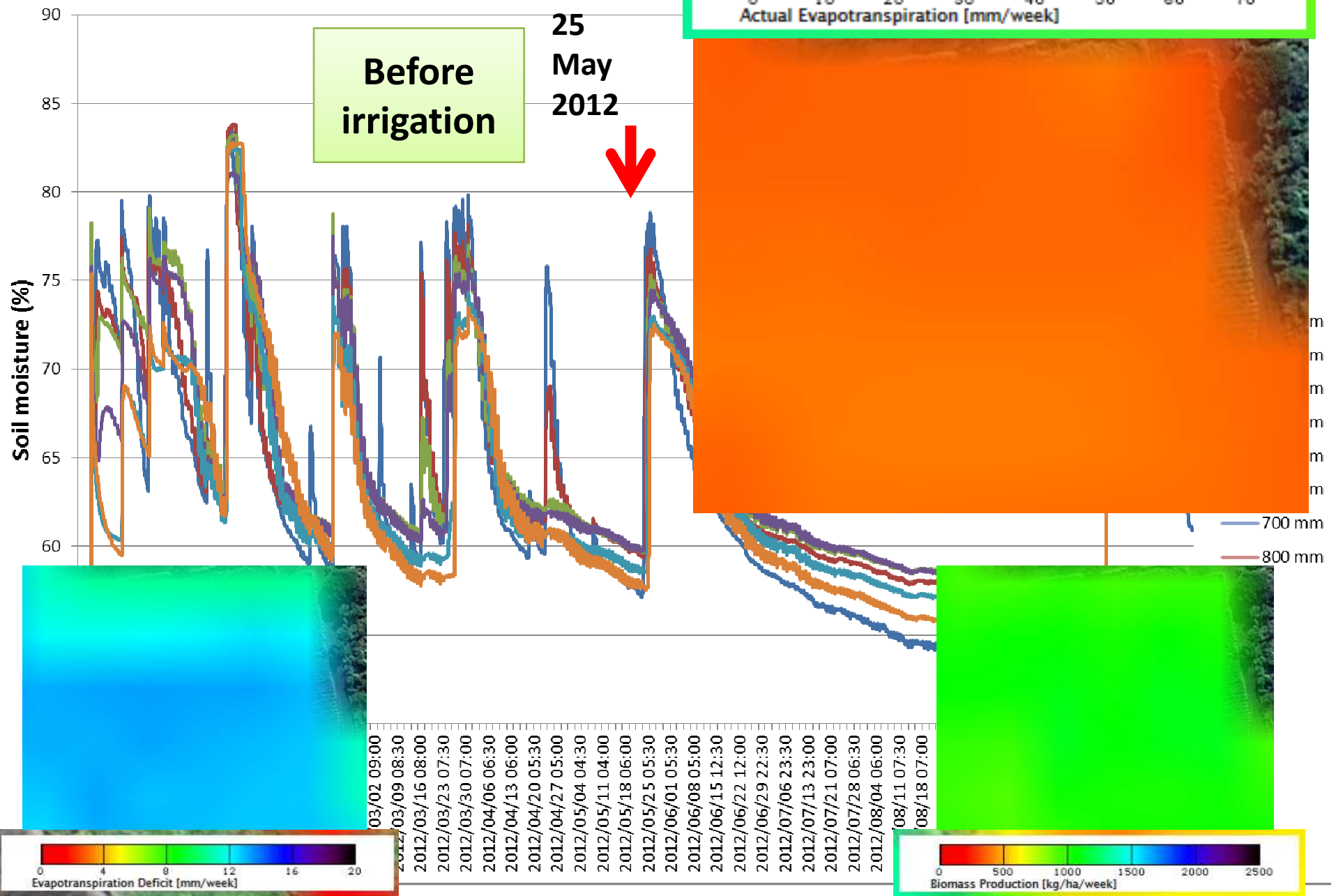
# Buffelspruit



# Buffelspruit



# Buffelspruit



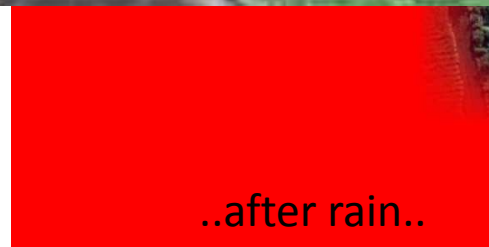
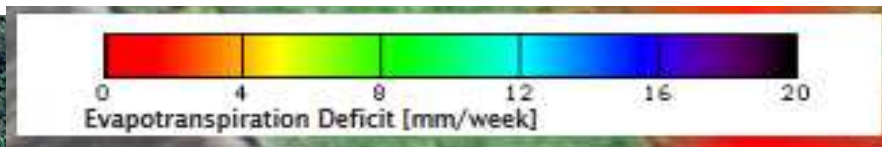




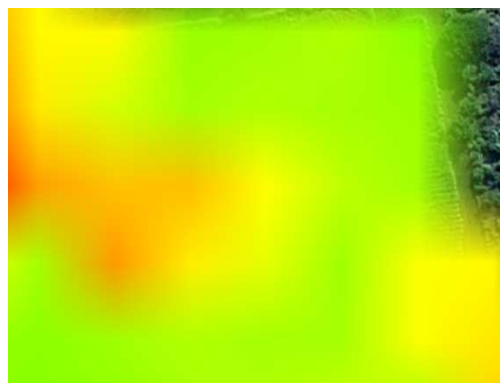
28 Dec 2011



11 Jan 2012



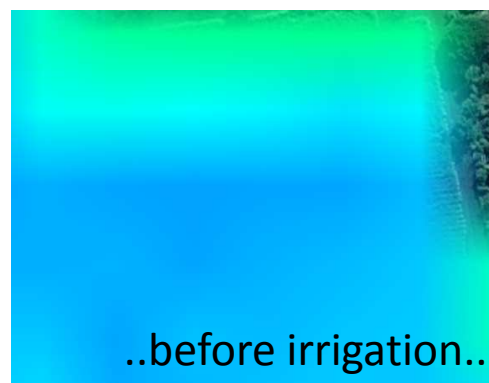
25 Jan 2012



28 Mar 2012



11 April 2012



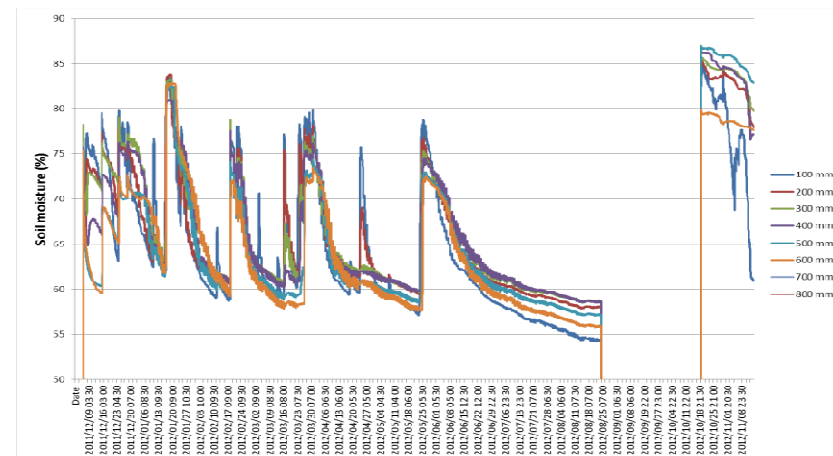
23 May 2012



11 July, 15 Aug 2012



19 Sept 2012

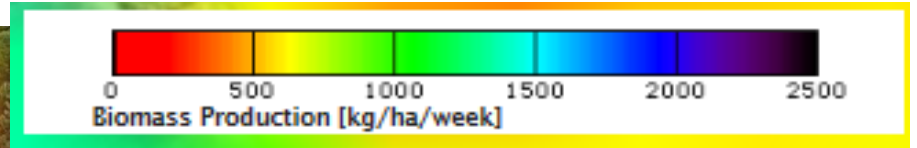




28 Dec 2011



11 Jan 2012



25 Jan 2012



28 Mar 2012



11 April 2012



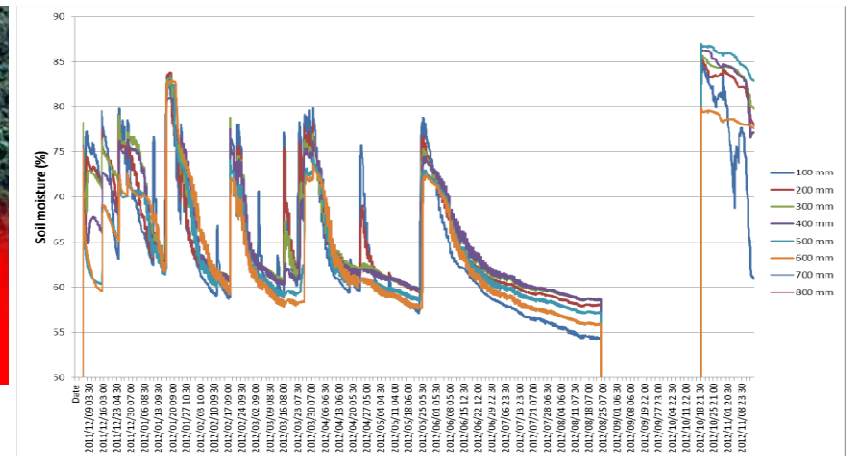
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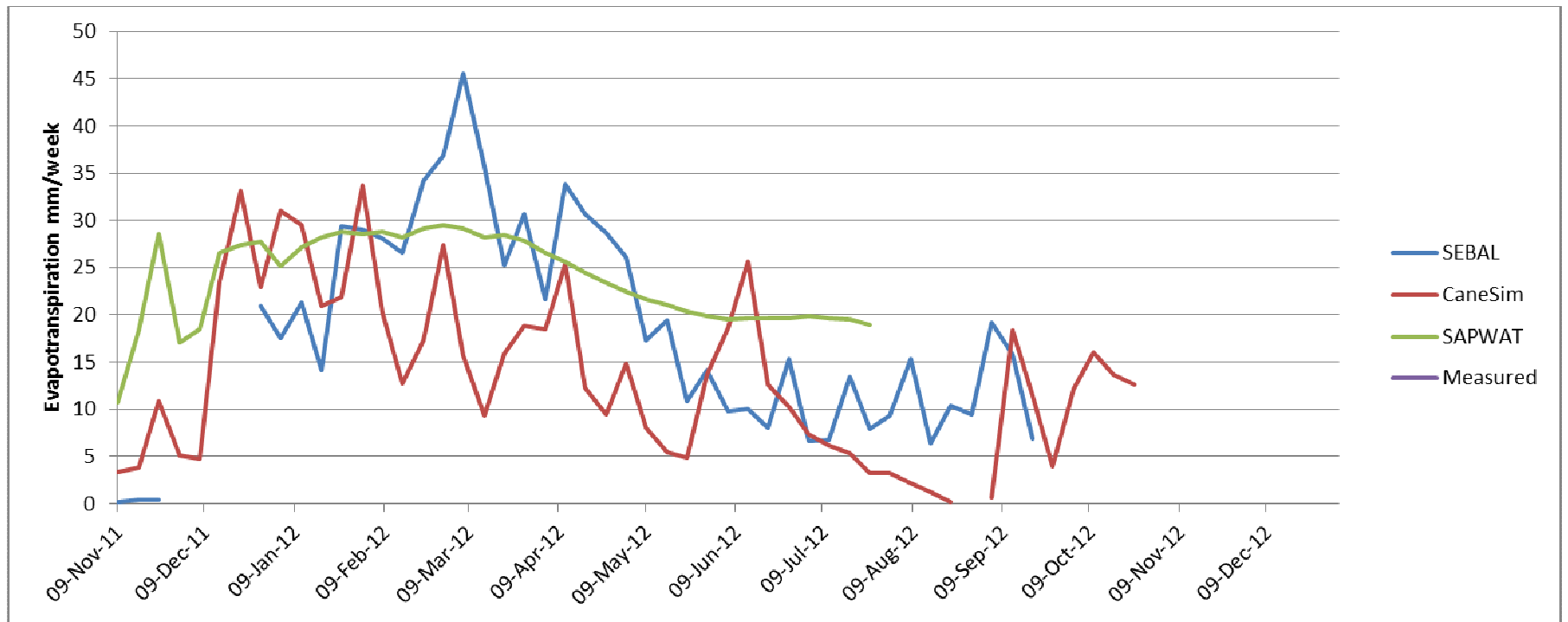
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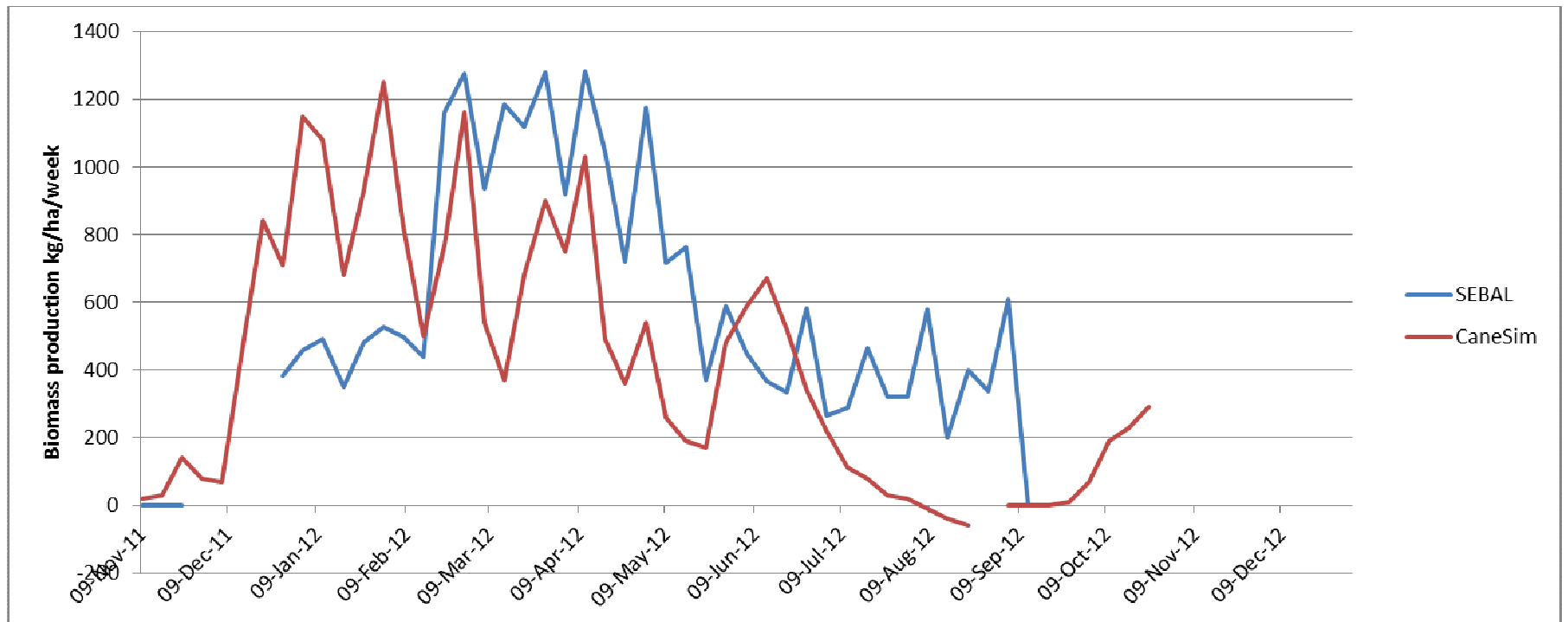
19 Sept 2012



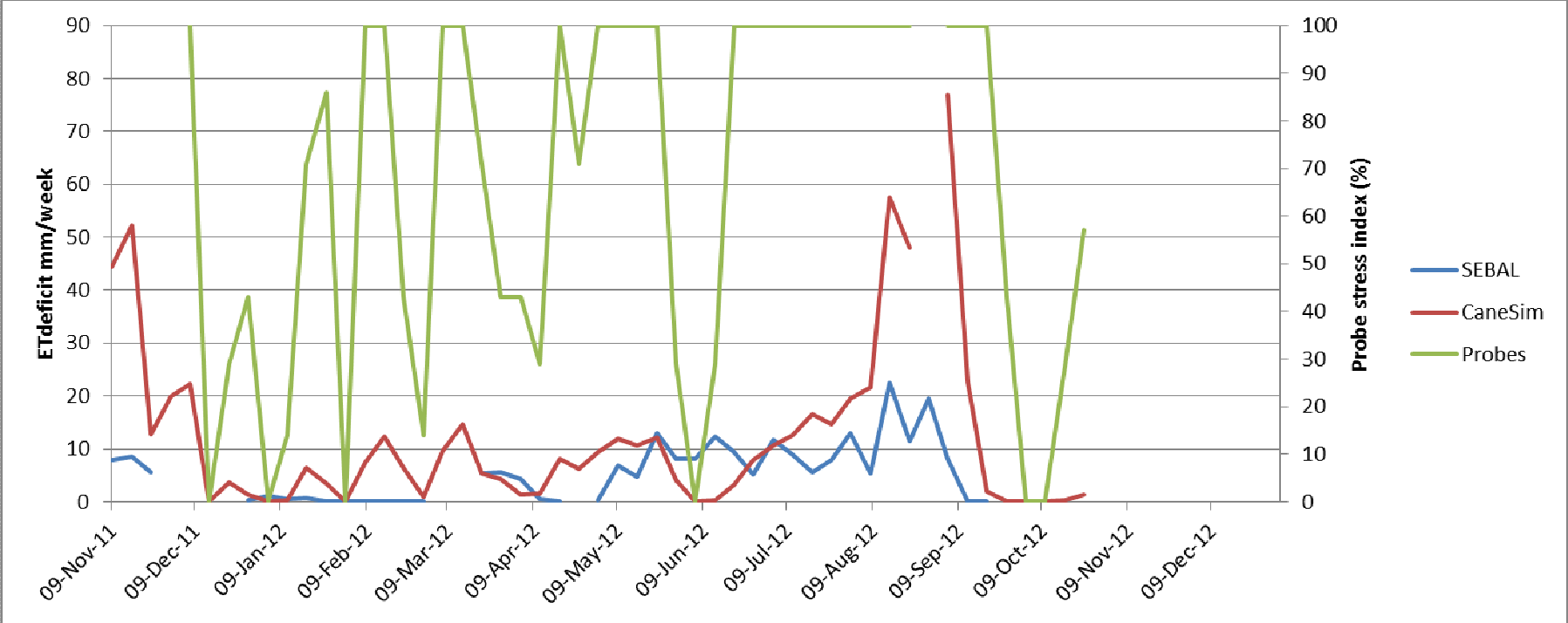
# Evapotranspiration



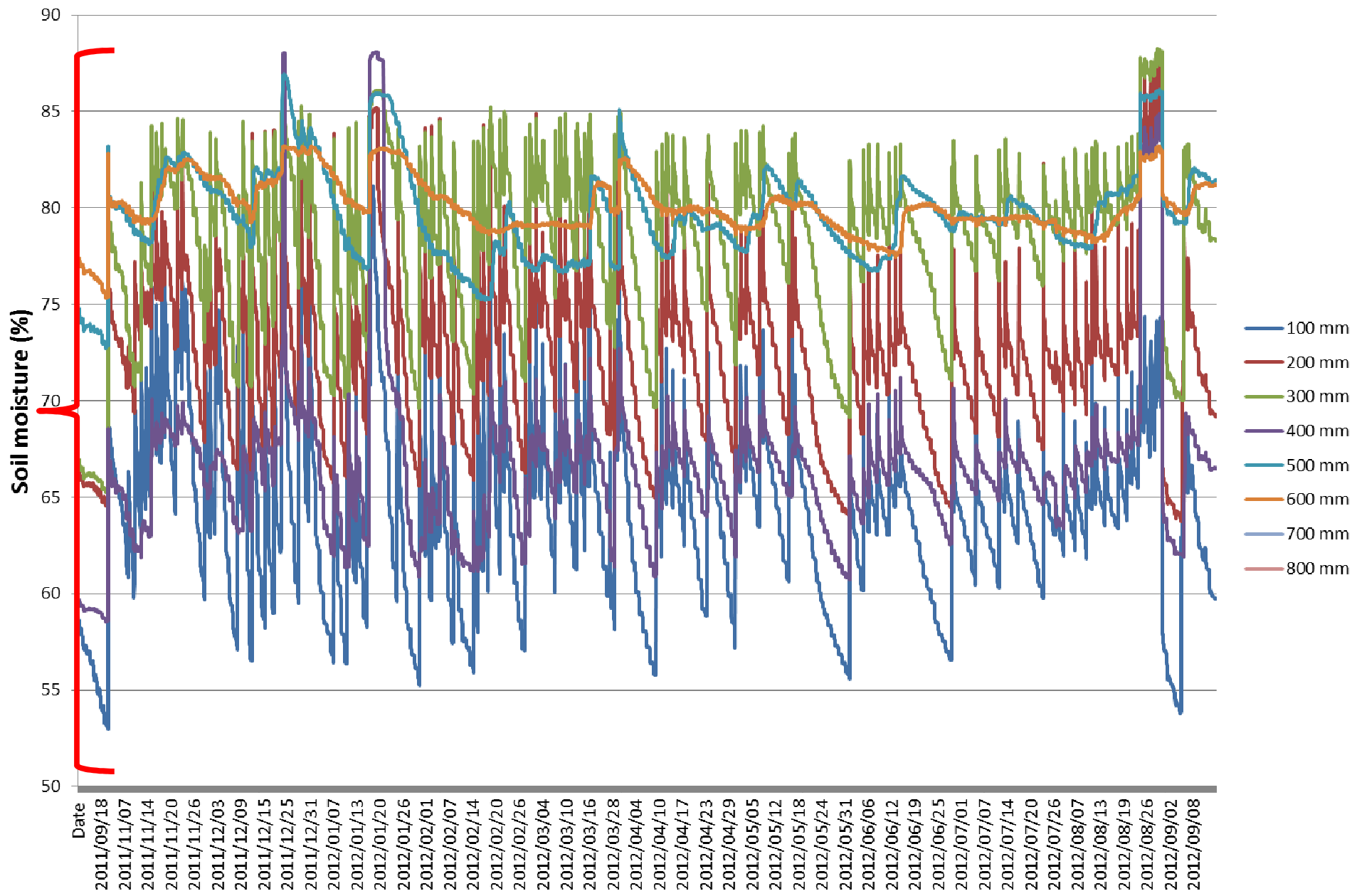
## Biomass production

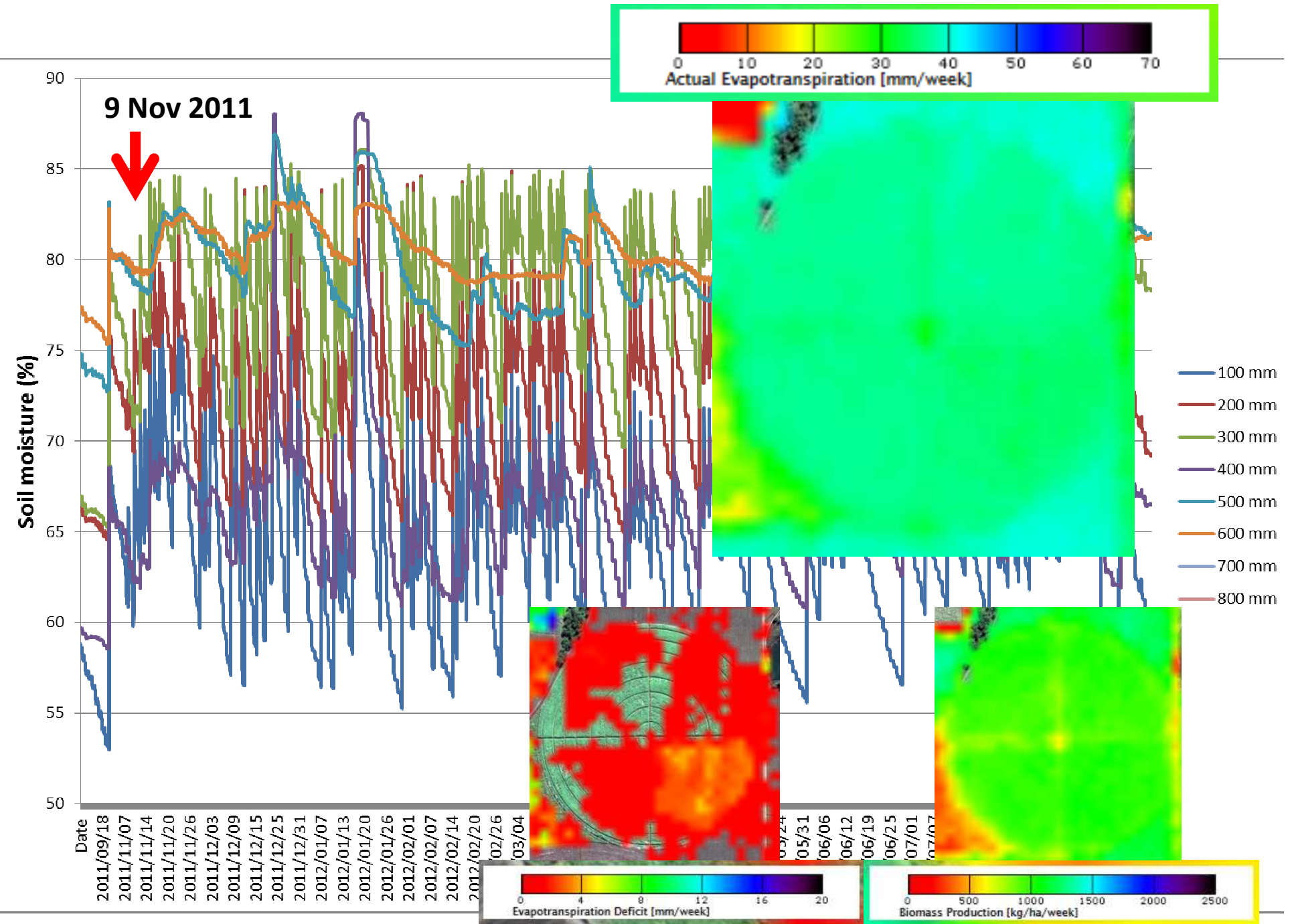


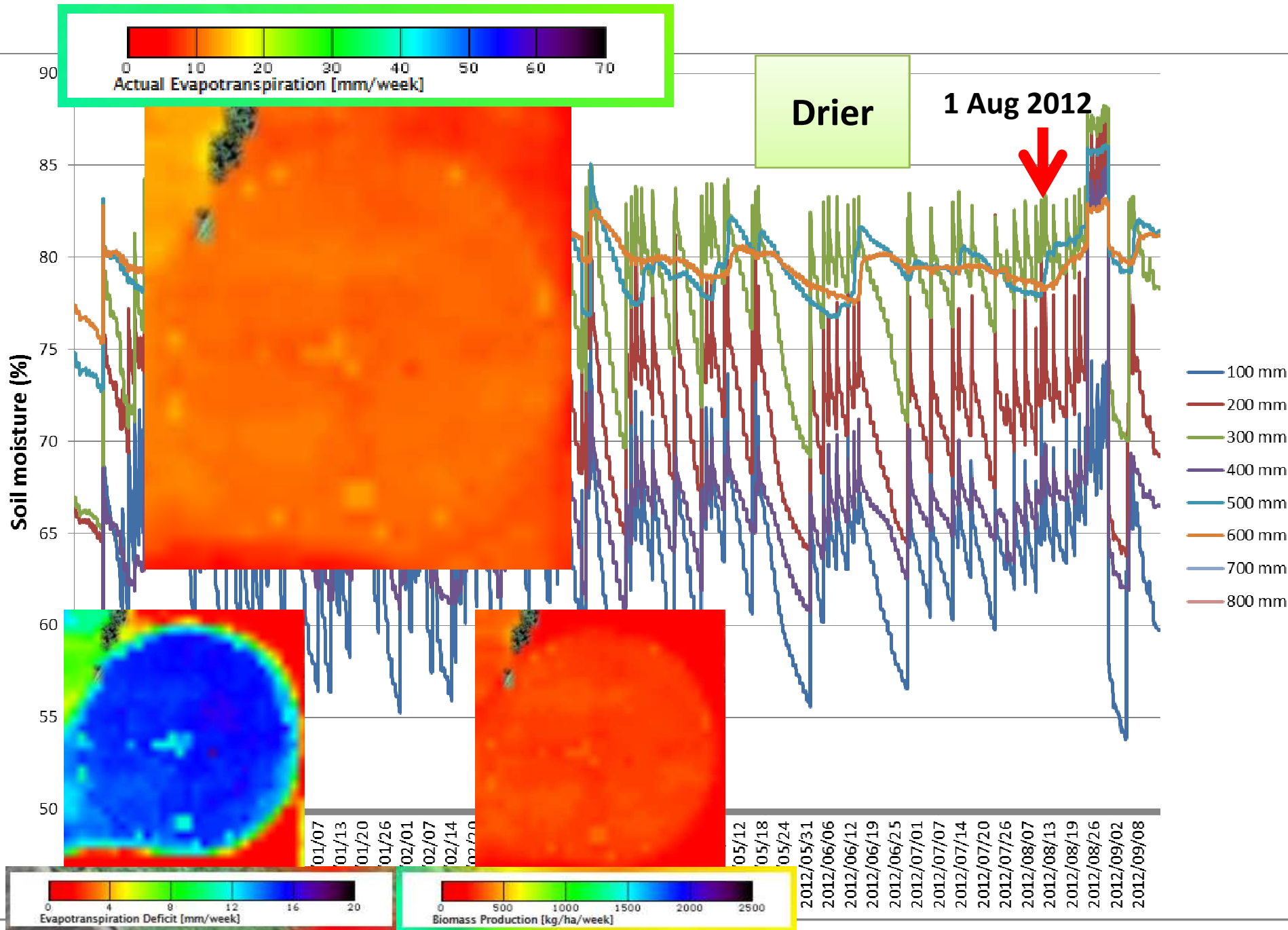
# Stress index

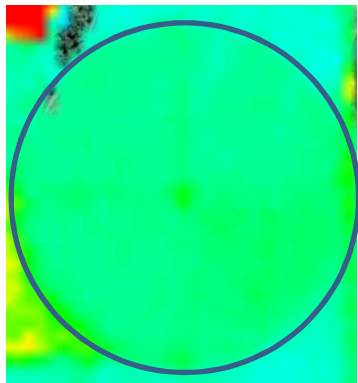




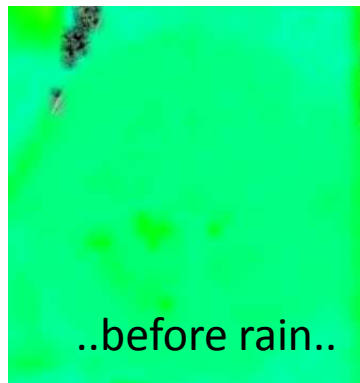




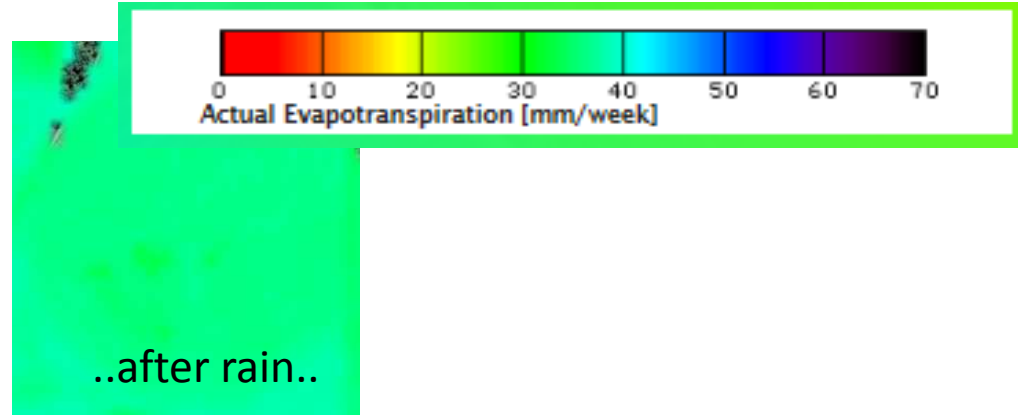




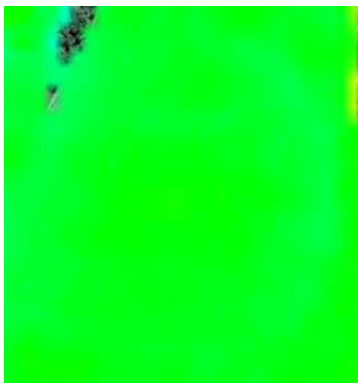
9 Nov 2011



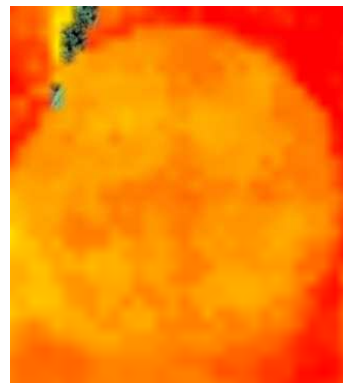
11 Jan 2012



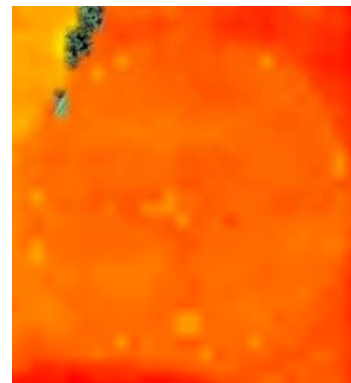
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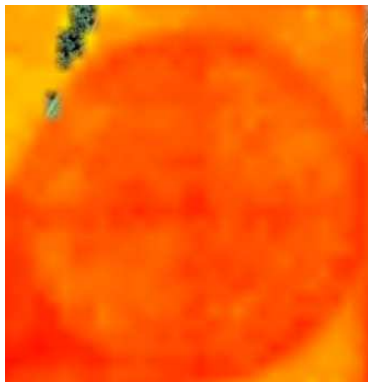
11 Apr 2012



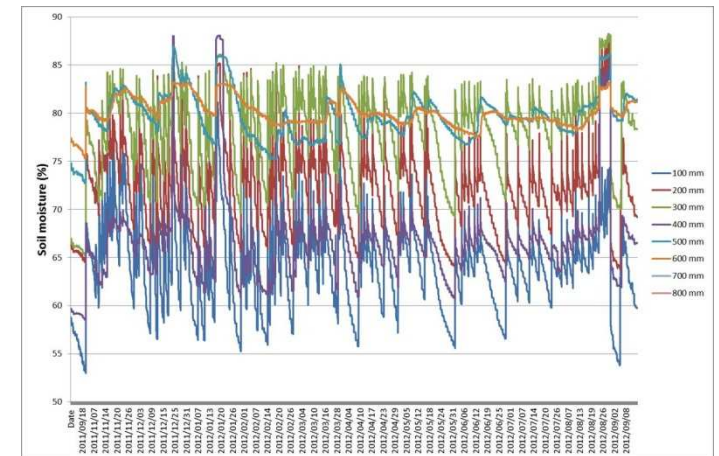
30 May 2012

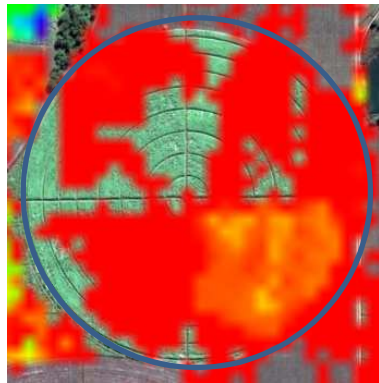


1 Aug 2012

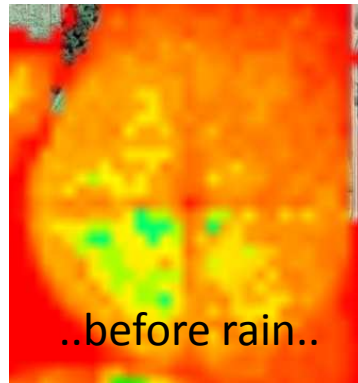


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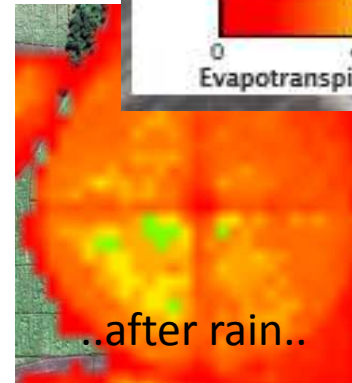




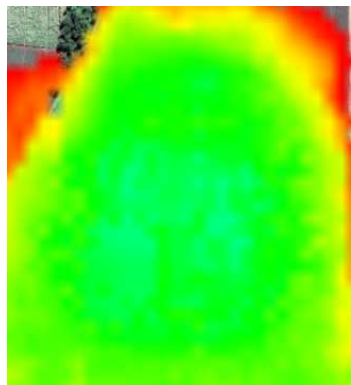
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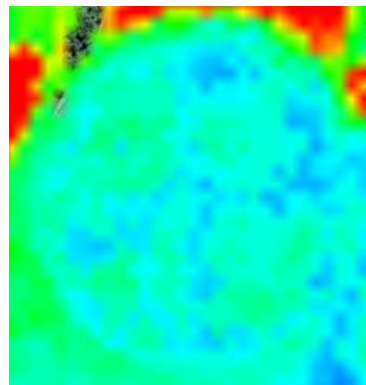
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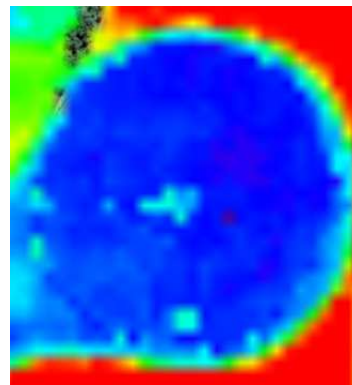
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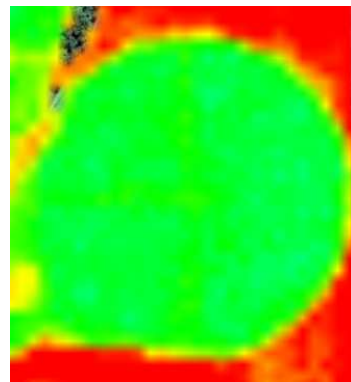
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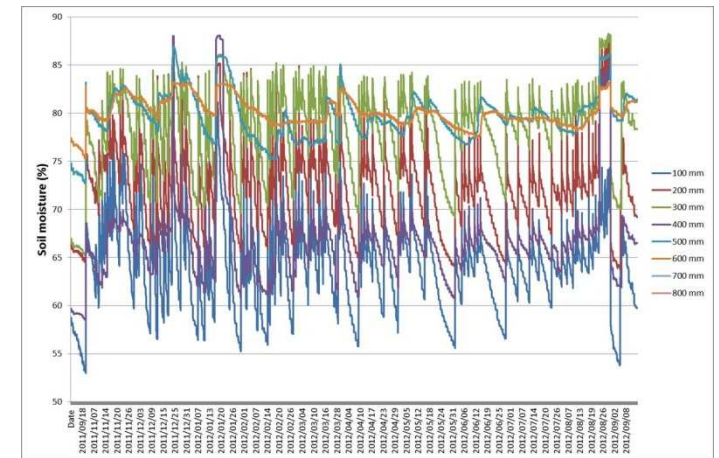
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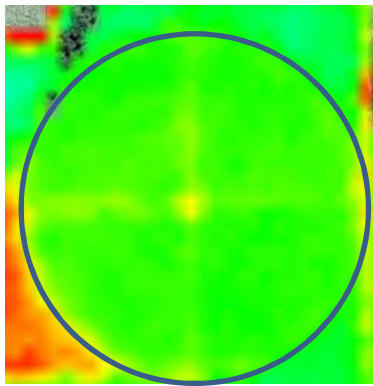


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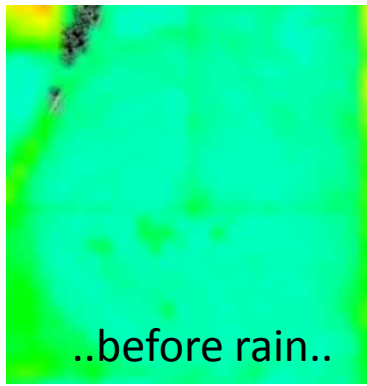


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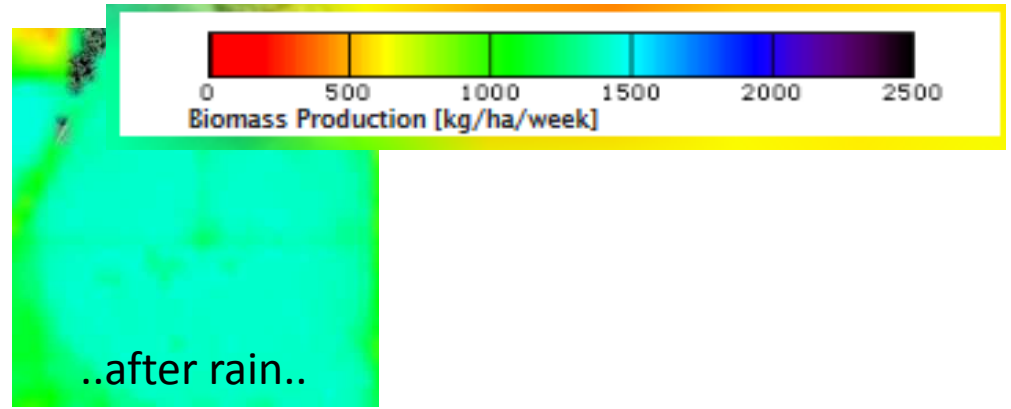




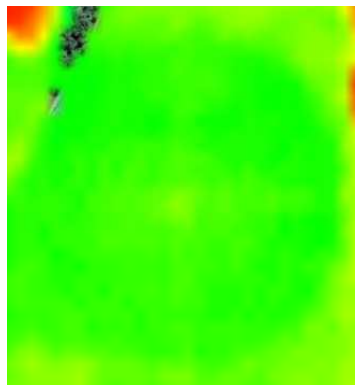
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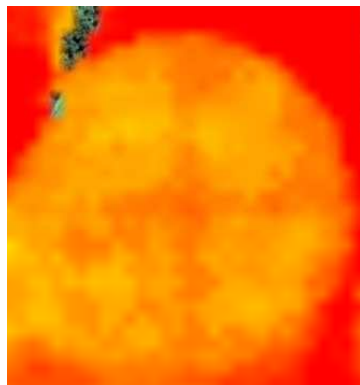
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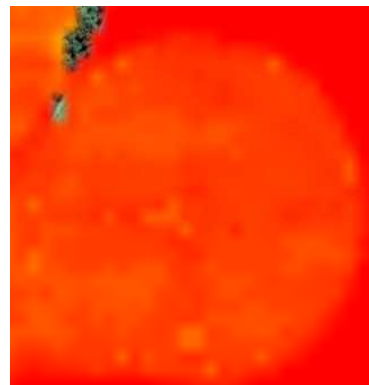
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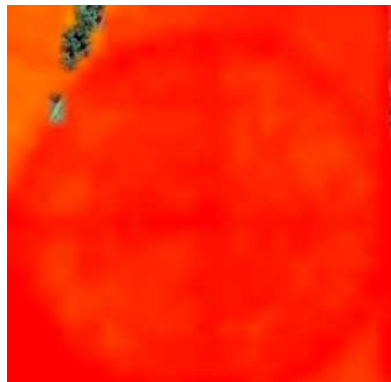
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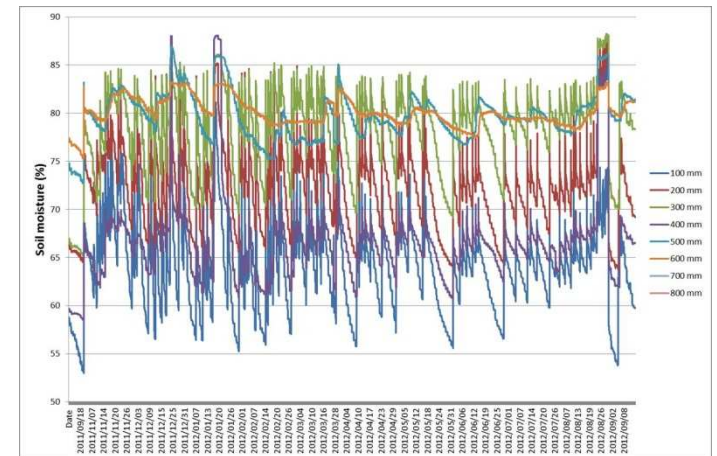
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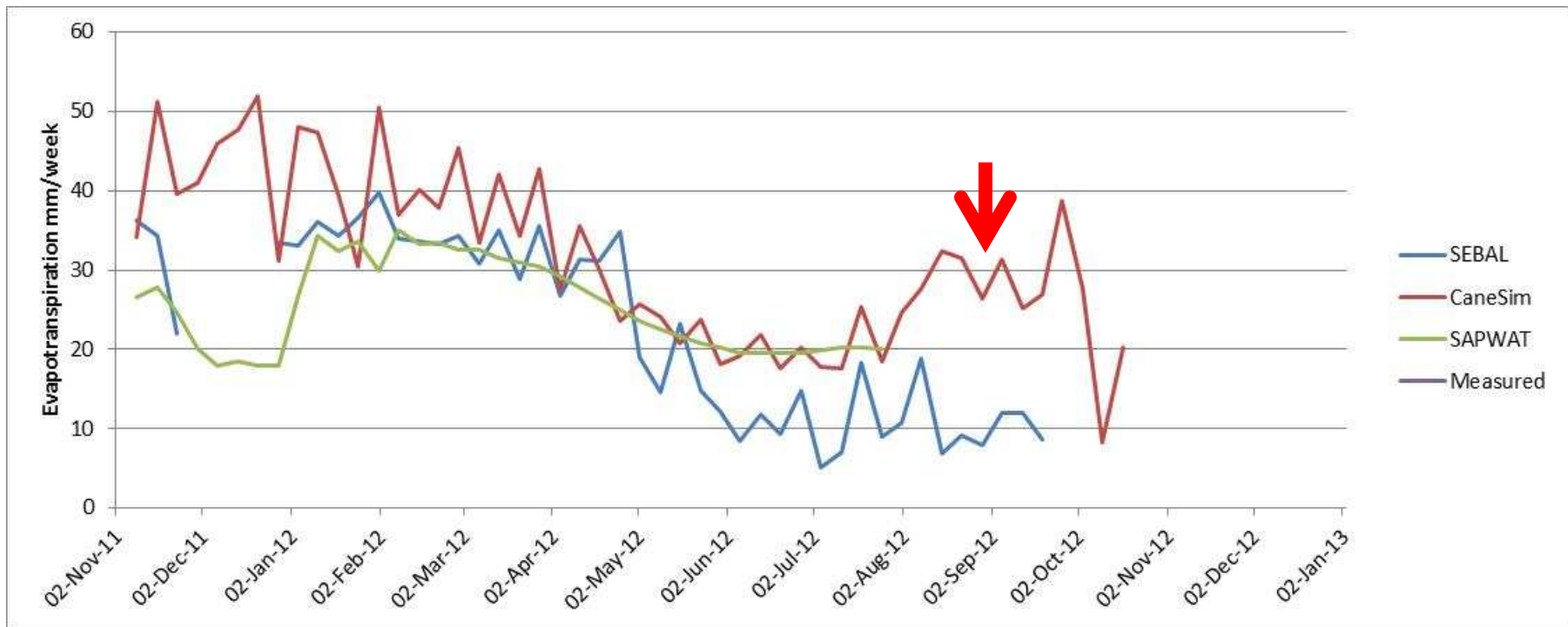
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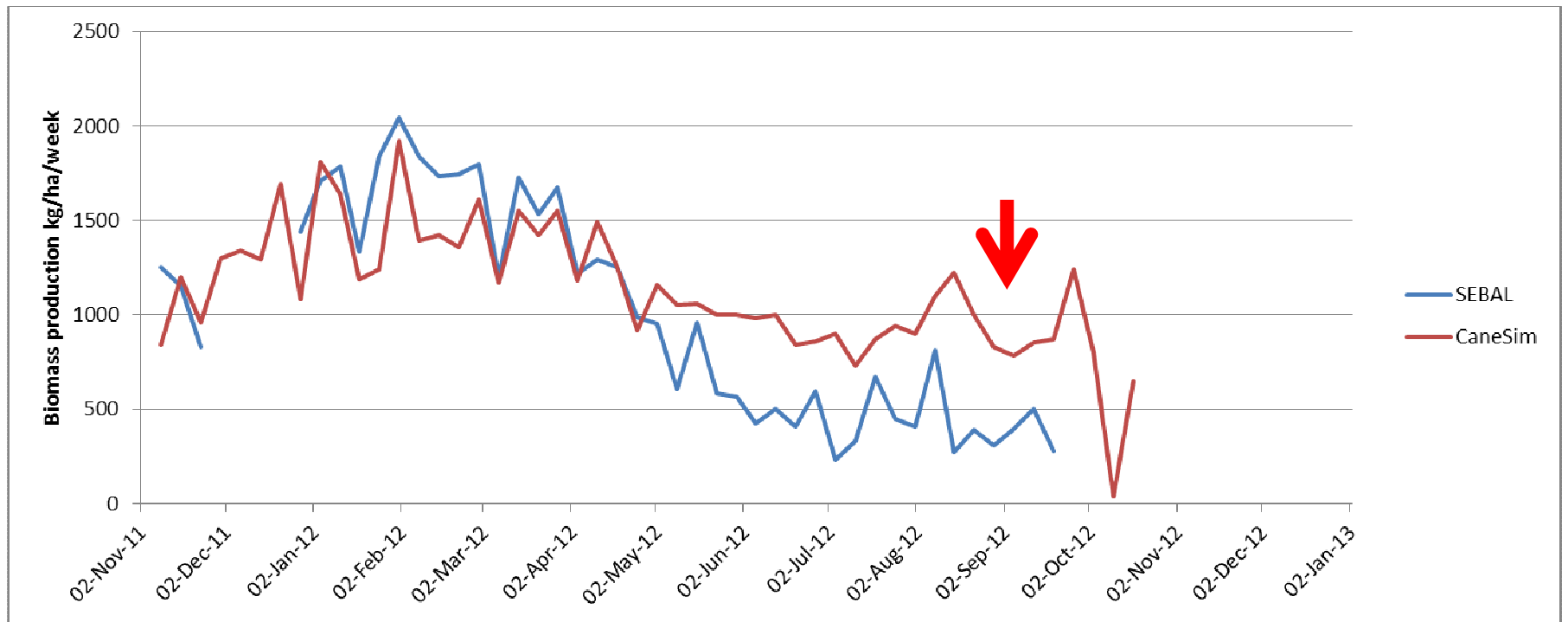
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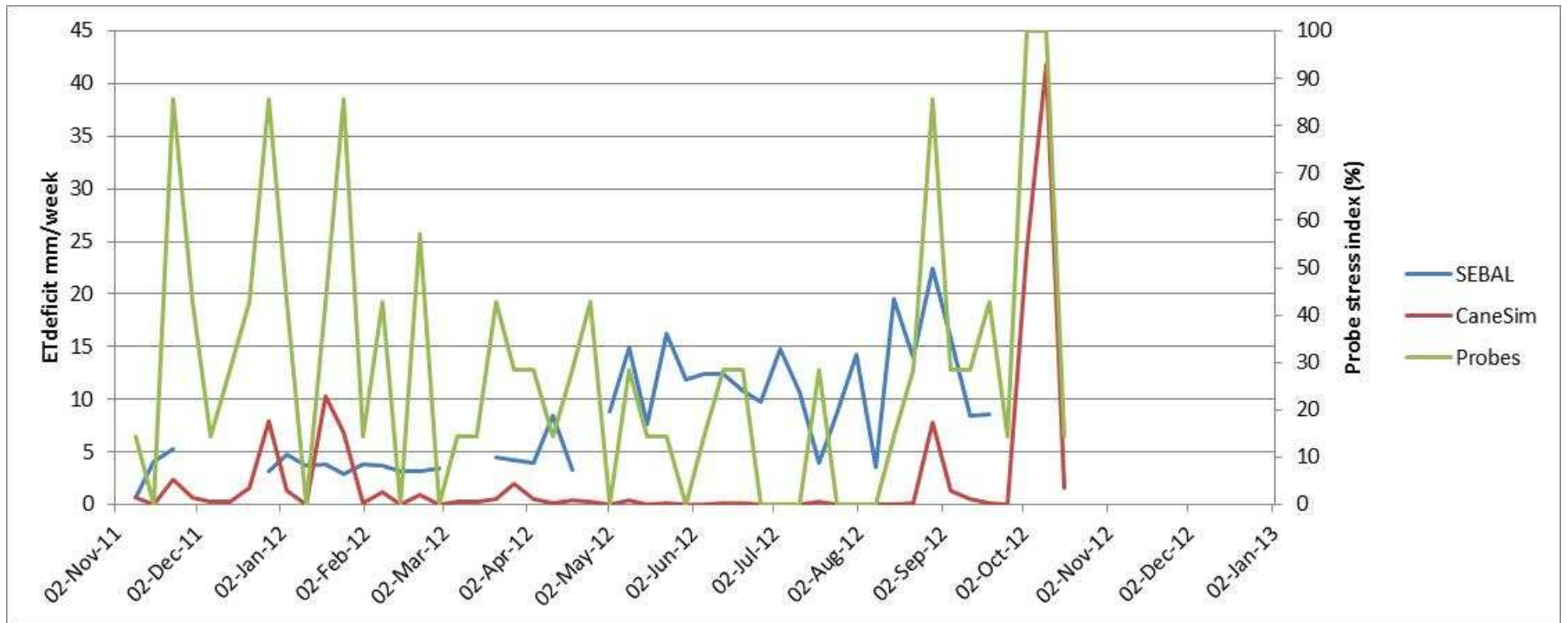
# Evapotranspiration



## Biomass production



# Stress index



# Conclusions

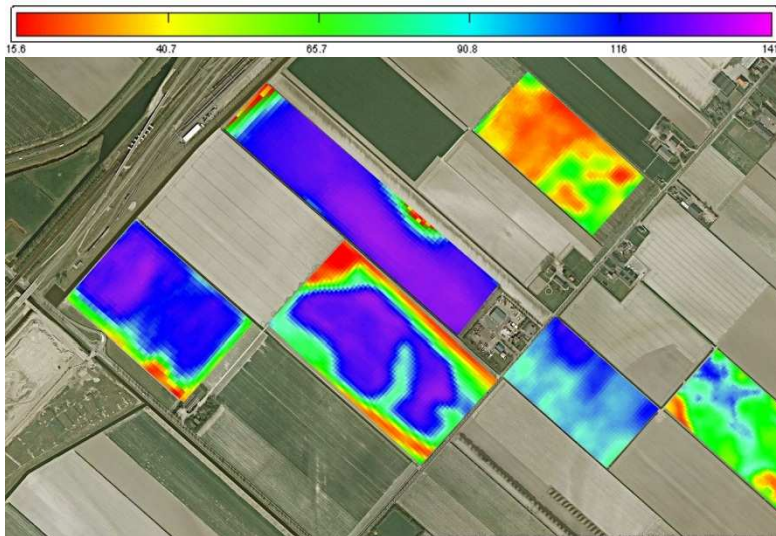
Remote sensing derived data....

- Useful, benefits derived
- Complimentary
- Accurate
- New spatial and temporal dimensions

Wayforward ....

- Operationalisation
- Changed perceptions
- Products, examples of use

# Dutch farmers co-op ZLTO use smart Irrigation Management application



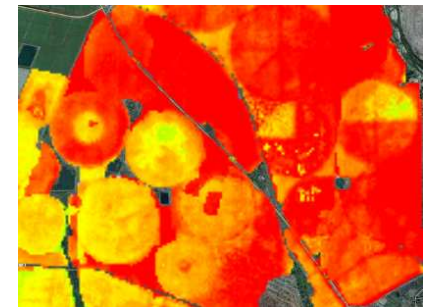
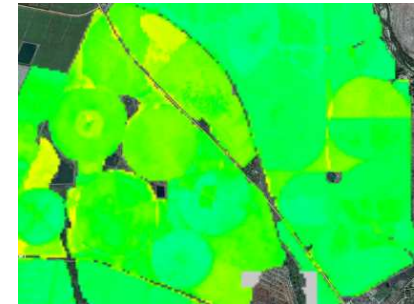
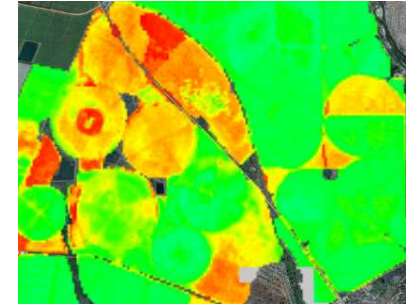
- Selecteer akker
- Akker achter ✓
  - Akker links ...
  - Akker groot ✓
  - Akker rechts ✓

- Incorrect data entry
- Do not irrigate
- Irrigate in couple of days
- Start irrigation

# Thank you!



**Caren Jarmain**  
**jarmainc@ukzn.ac.za**



# Other SA initiatives

- [www.watplan.com](http://www.watplan.com) – Incomati catchment
- [www.fruitlook.co.za](http://www.fruitlook.co.za) – Western Cape
- [www.grainlook.co.za](http://www.grainlook.co.za) – Douglas area



