

**Water consumption, yield and water use  
efficiency  
of  
table and wine grapes  
in  
Western Cape, South Africa**

*Annemarie Klaasse*

# WaterWatch



- Scientific advisory firm (12 employees)
- founded in 2000 by Prof. Bastiaanssen

Remote sensing services for quantifying water management



Diagnose historic and current water management practices  
across large irrigated river basins by means of satellite  
measurements

# Background

- ✓ Western Cape, South Africa is approaching physical water scarcity
- ✓ Agricultural sector is responsible for 43% of total water use

Optimal use of limited water resources is essential.

## Project objective

The **challenge** is to maintain an economically sustainable grape industry whilst making optimum use of the limited water resources



Understanding the spatial and temporal variation of water use efficiency in table and wine grape vineyards

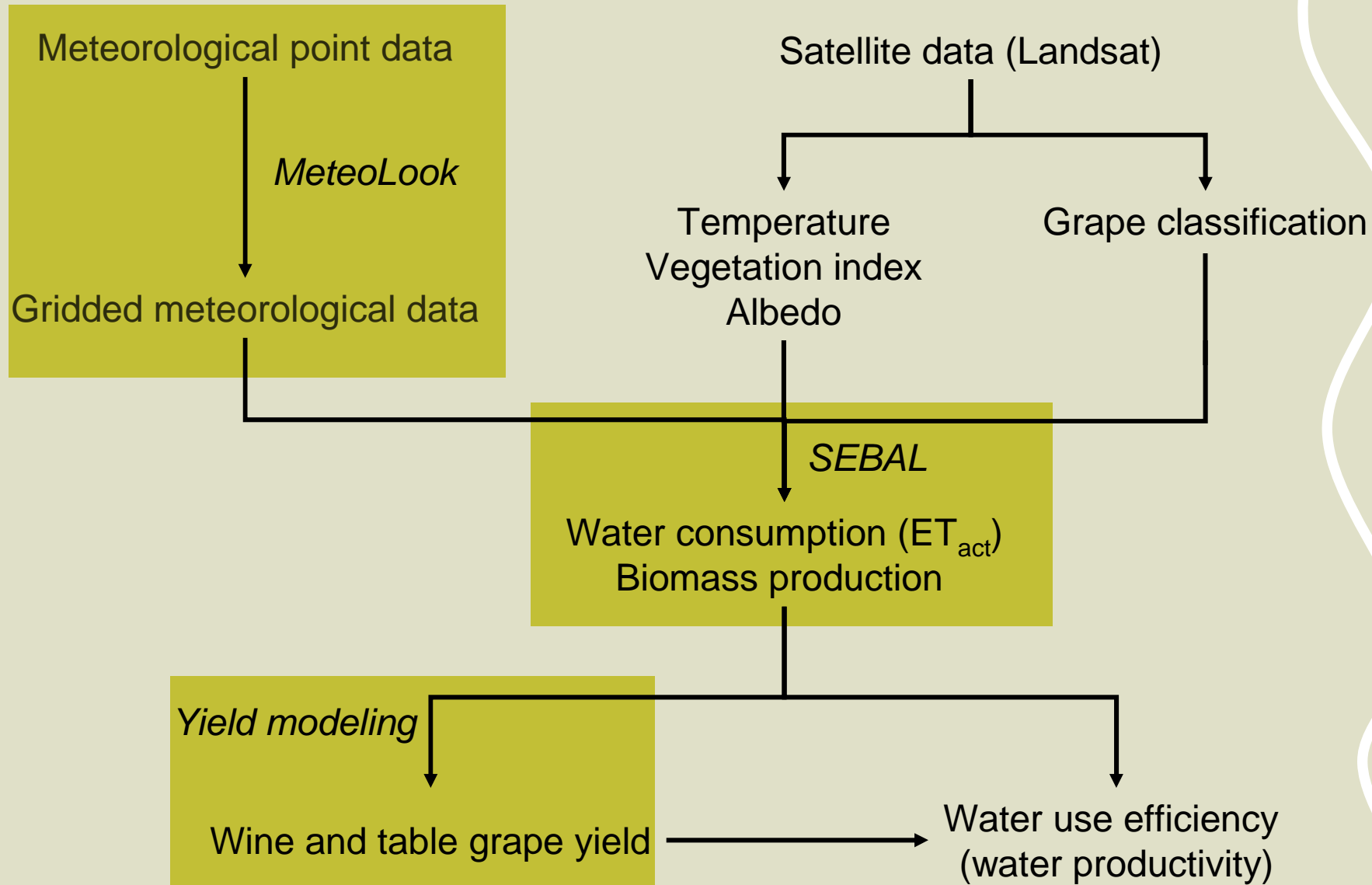
- 3 grape seasons:

September – April 2004-5, 2005-6 and 2006-7

- 6 areas (Western Cape winelands):

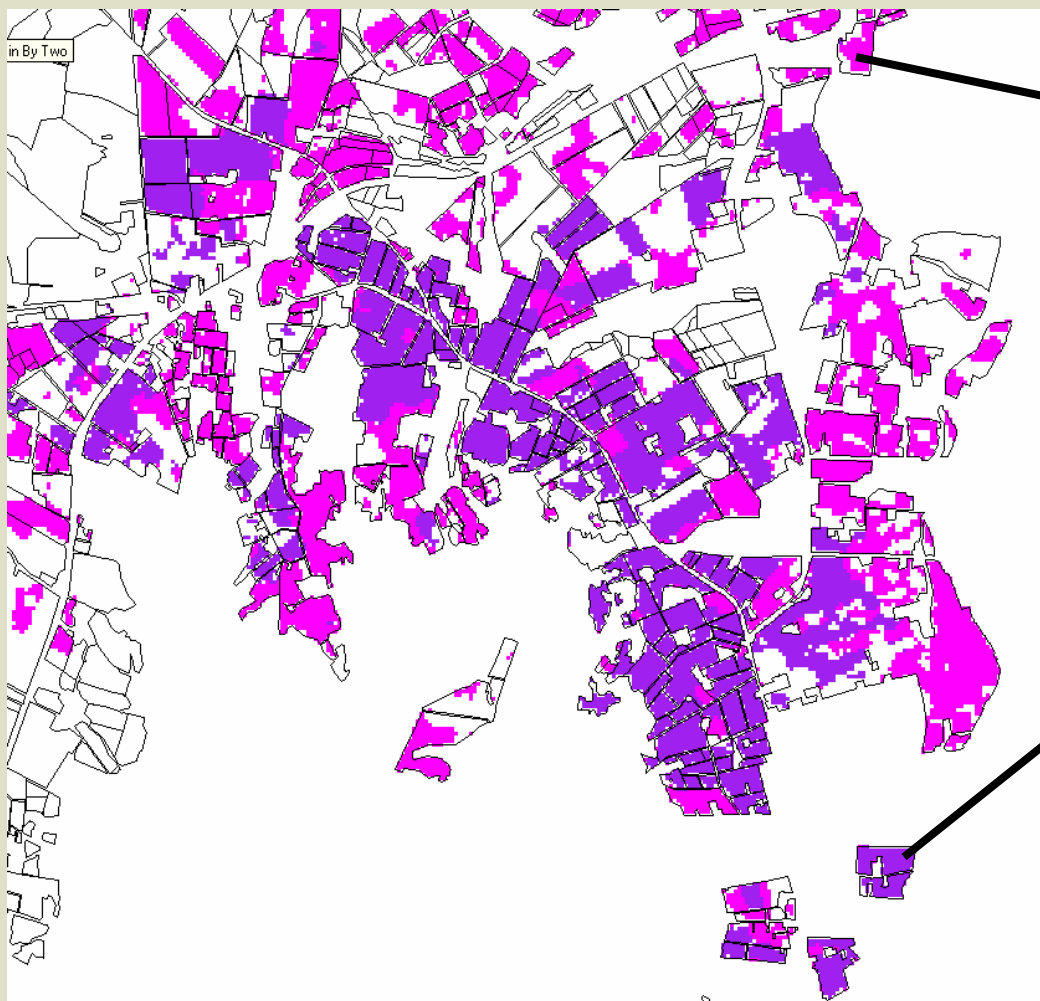
Hex Valley, Worcester, Paarl, Franschhoek, Somerset West, Stellenbosch

# Project methodology



# Location of vineyards

## Grape classification



Wine grapes

Table grapes

# SEBAL

## Surface Energy Balance Algorithm for Land

SEBAL calculates on a pixel by pixel basis:

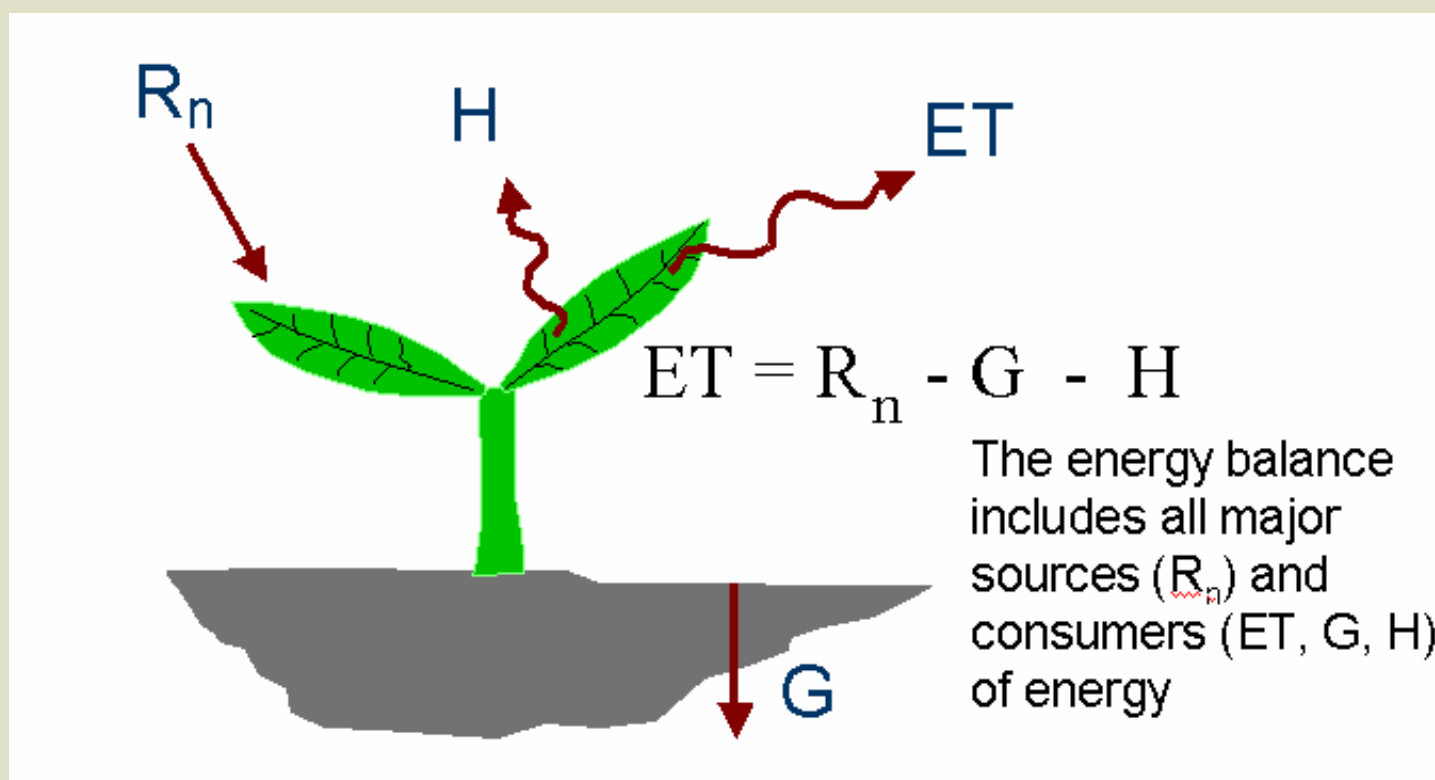
Actual evapotranspiration ( $ET_{act}$ ) = water consumption

Biomass production

Soil moisture in the root zone

# SEBAL

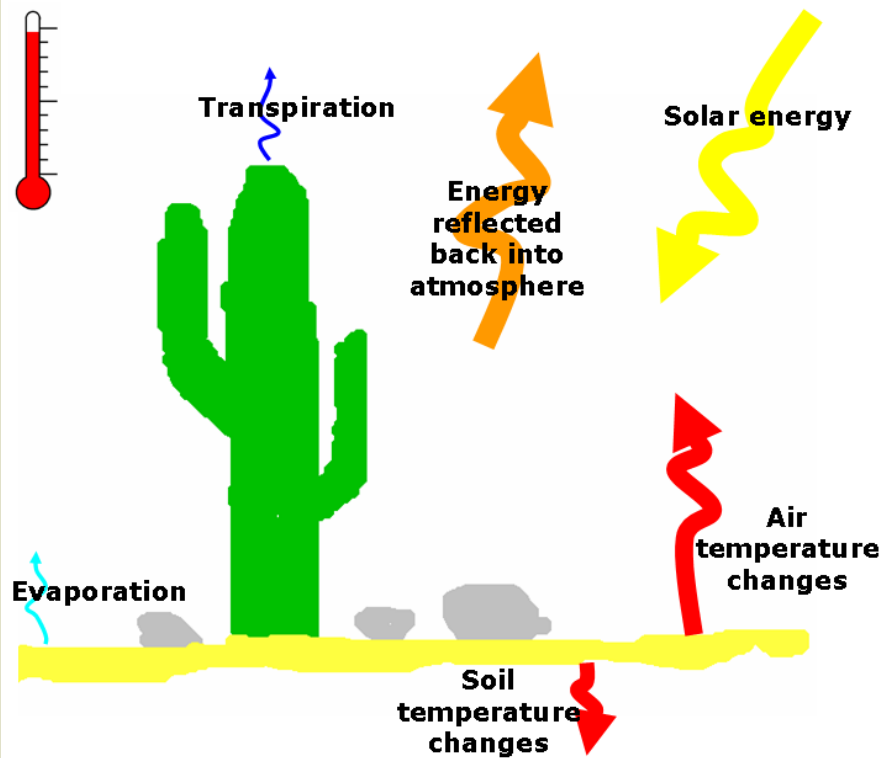
SEBAL calculates the **energy balance**,  
not the **water balance**!



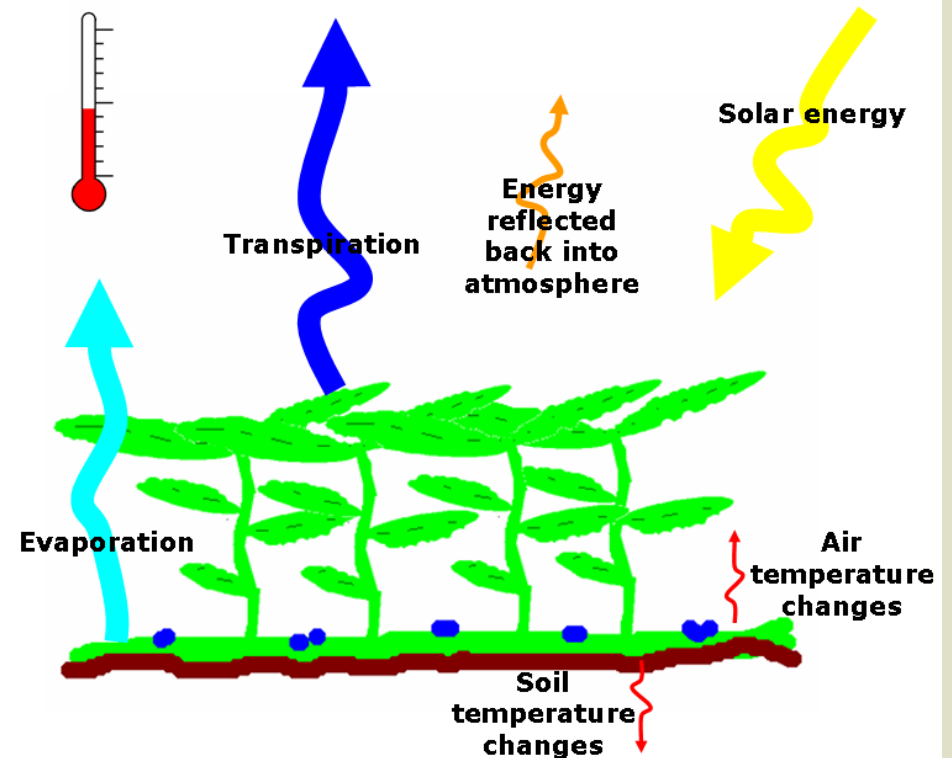


# SEBAL

## Surface energy balance



Dry surface



Wet surface





Alchanatis and Cohen, ARO, Israel





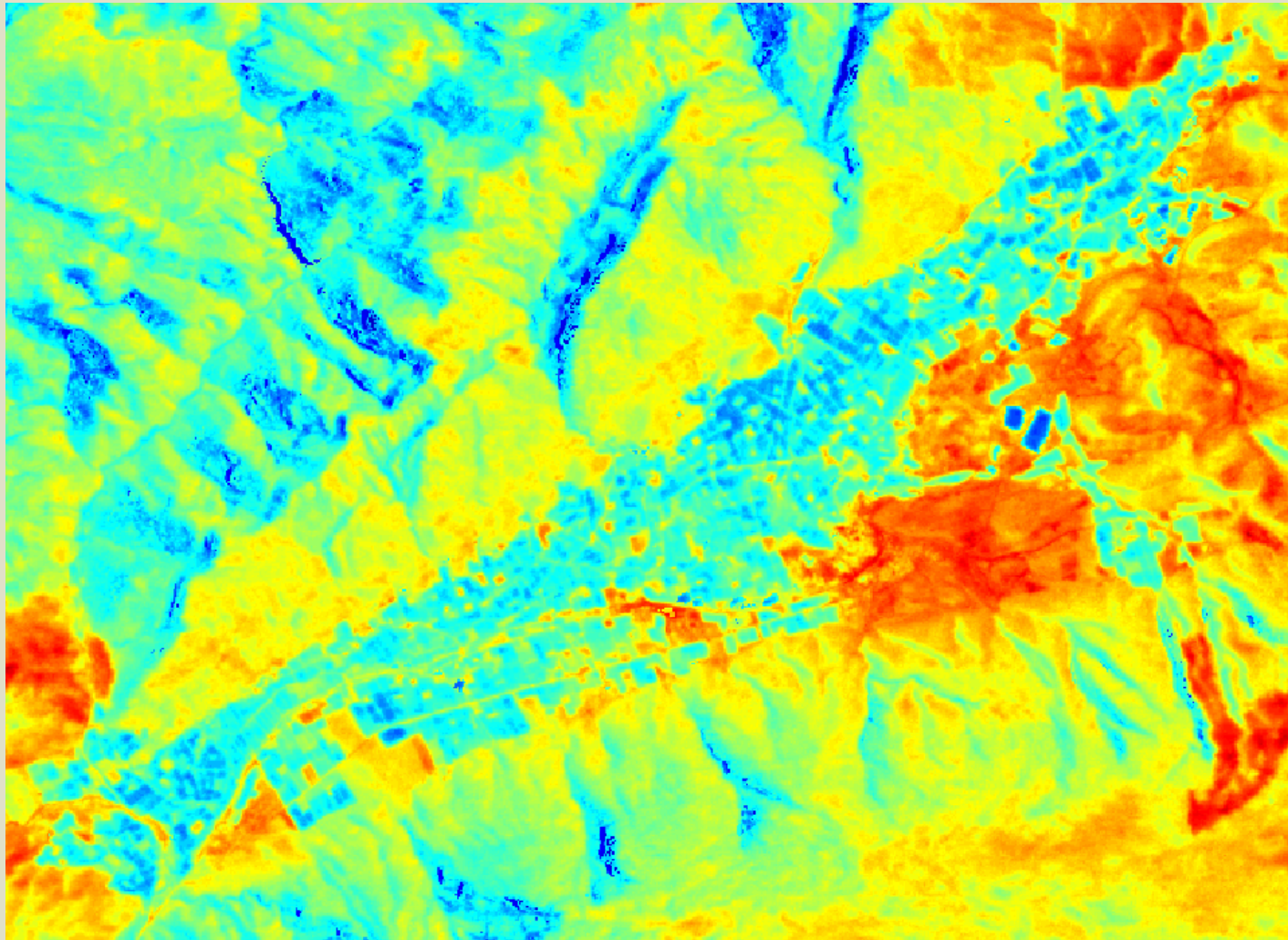
Alchanatis and Cohen, ARO, Israel

Alchanatis and Cohen, ARO, Israel

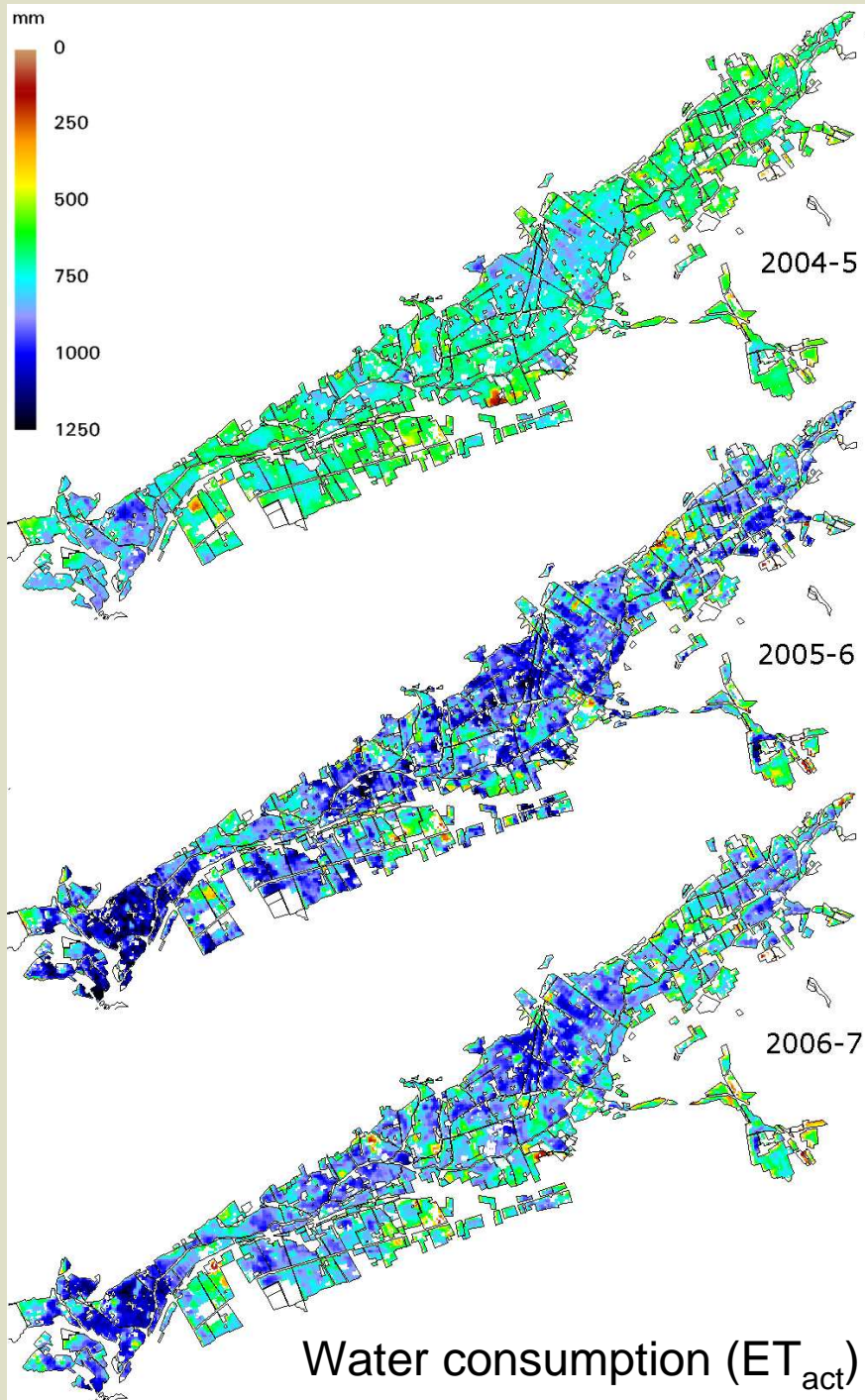


# SEBAL

Surface temperature in Hex Valley



# Water consumption



Water consumption ( $ET_{act}$ ) of table grapes in Hex Valley

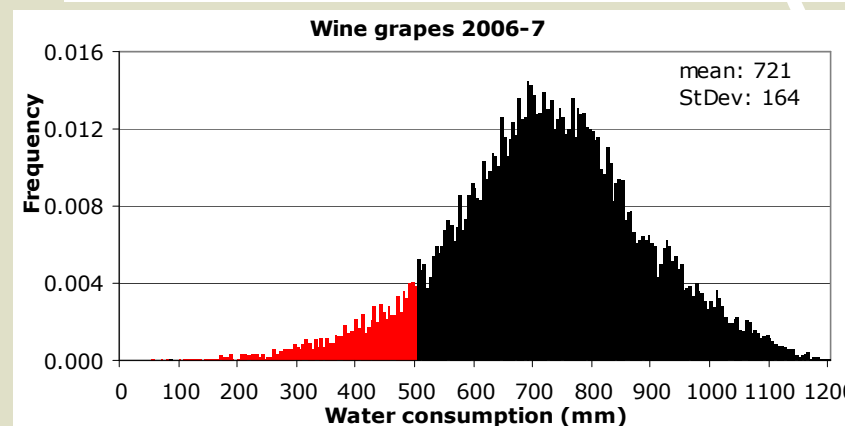
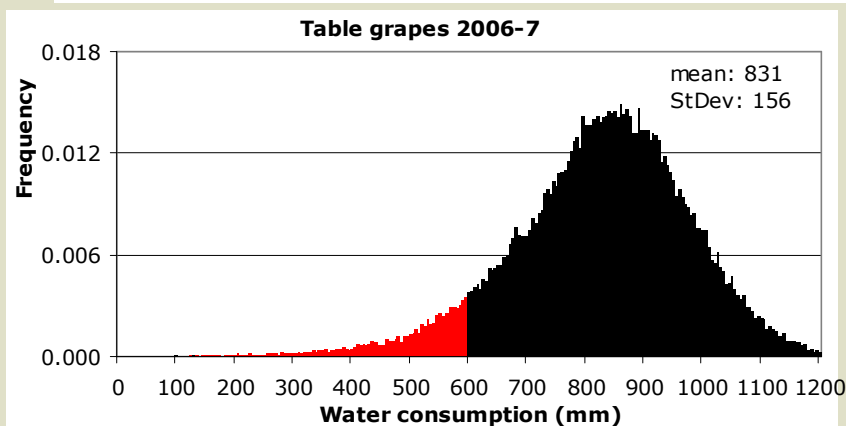
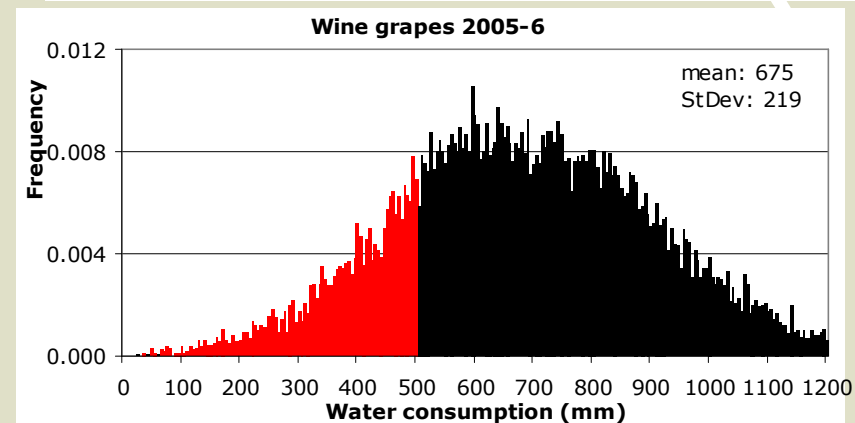
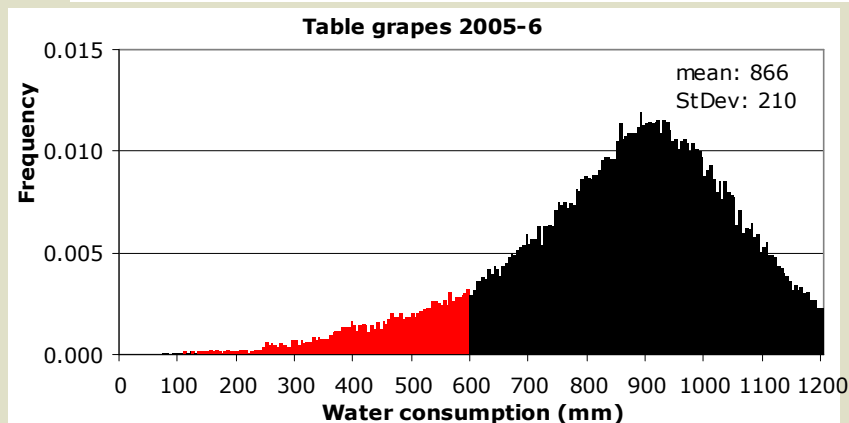
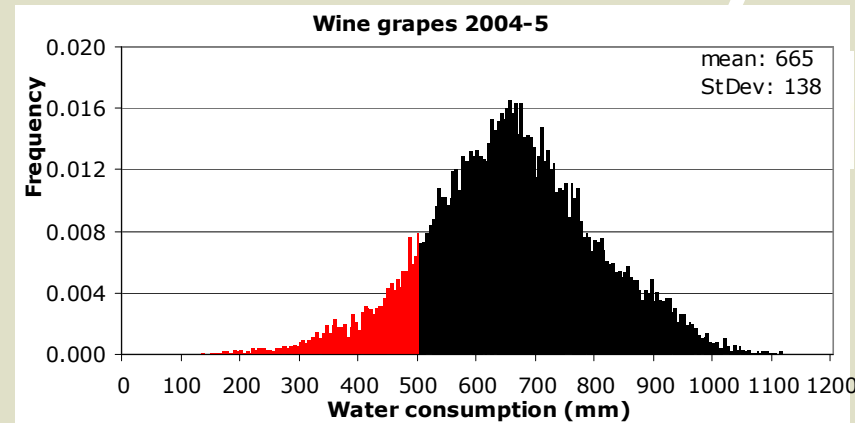
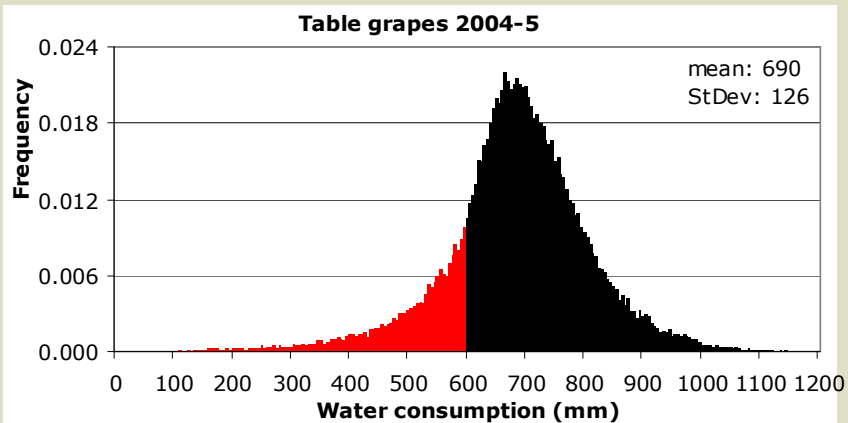


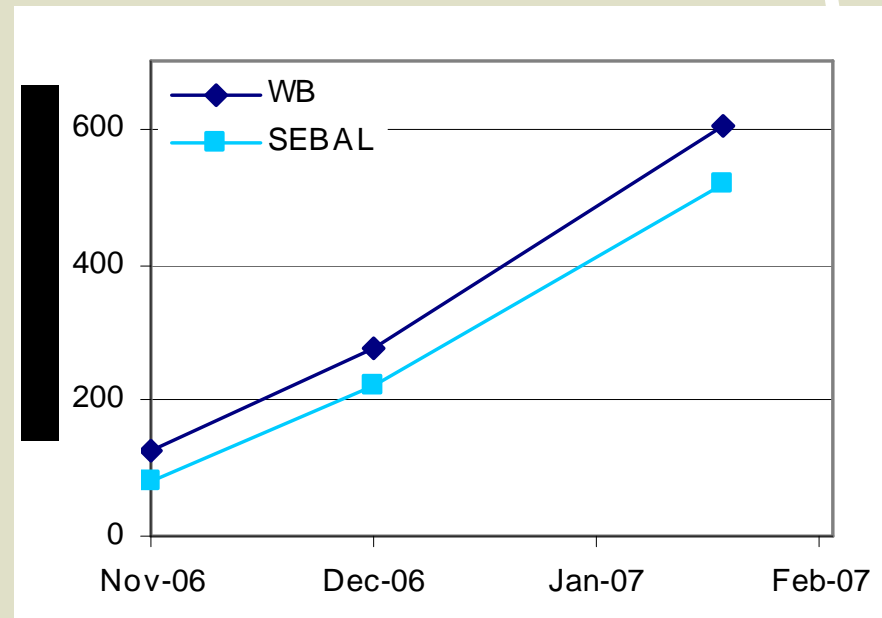
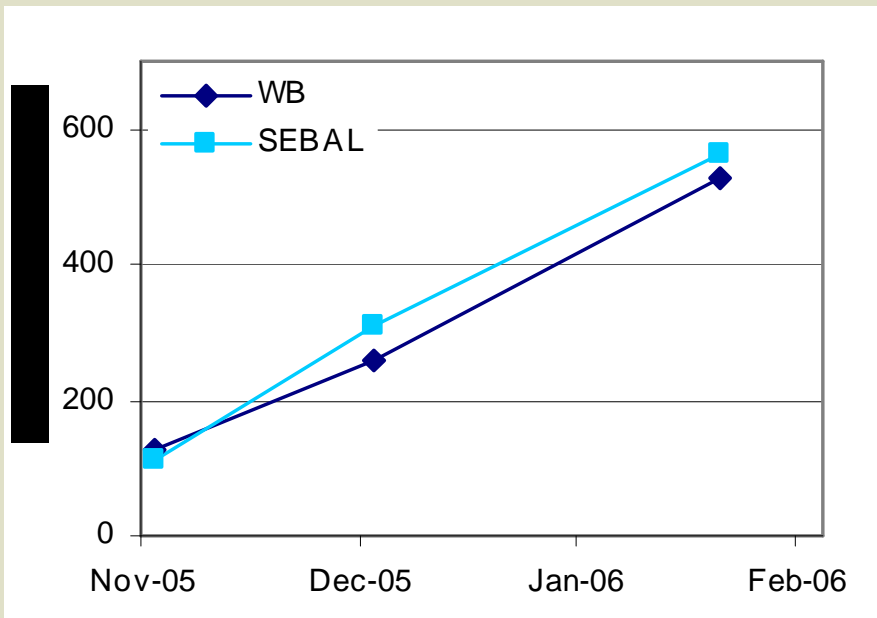
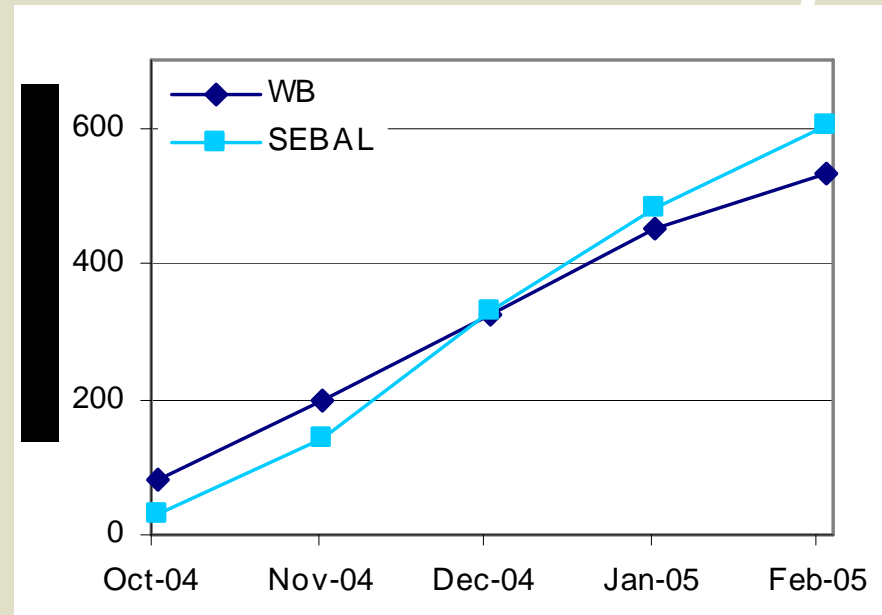
Table grape vineyards in Hex  
Valley, Worcester and Paarl

Wine grape vineyards in  
Worcester

# Validation of results



Validation of water consumption (ET) with water balance measurements in the Hex Valley (charts) and Worcester

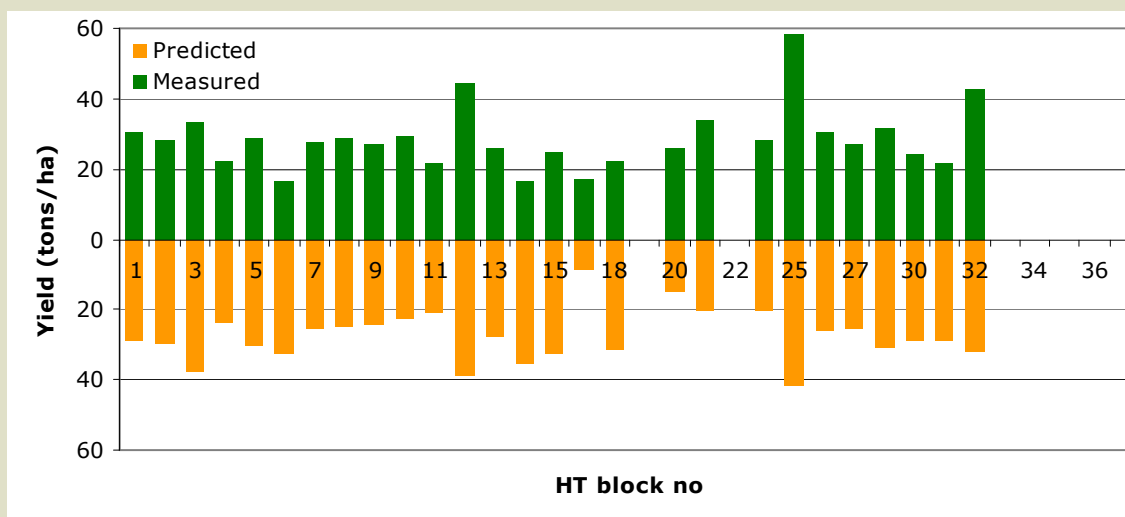


# Yield modeling

A complex empirical function of

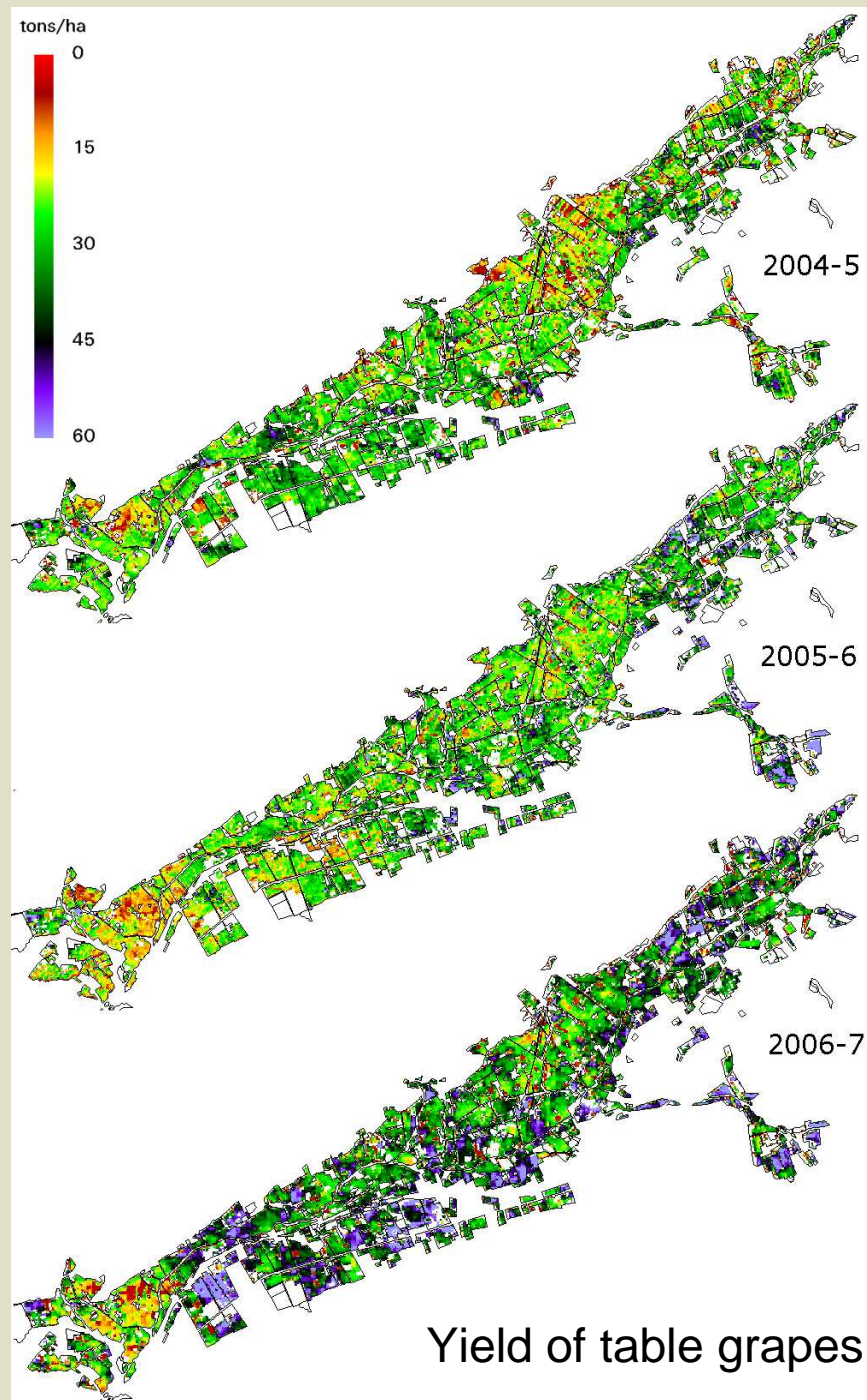
- soil moisture in November/December, and
- water deficit in February
- biomass production between September and April

Calibrated with yield data of Hex Valley (Sunred, Dauphine, Crimson) and Worcester (Colombard)

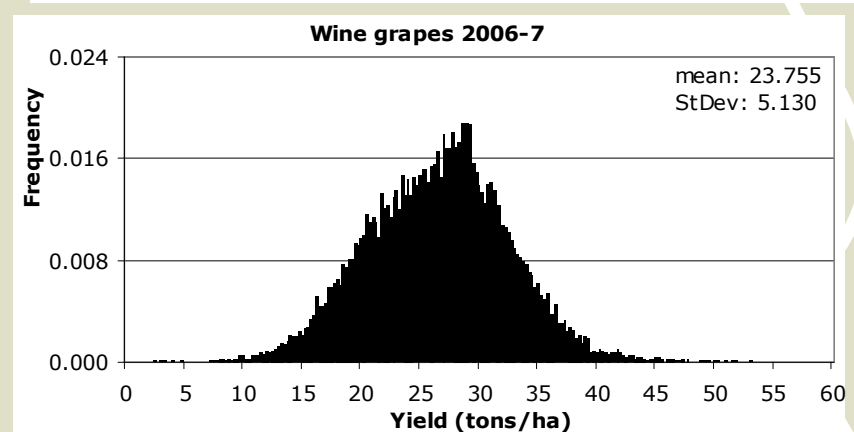
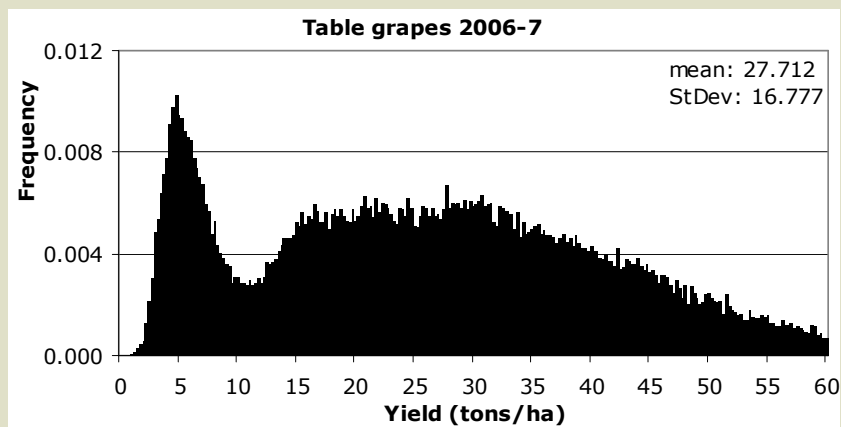
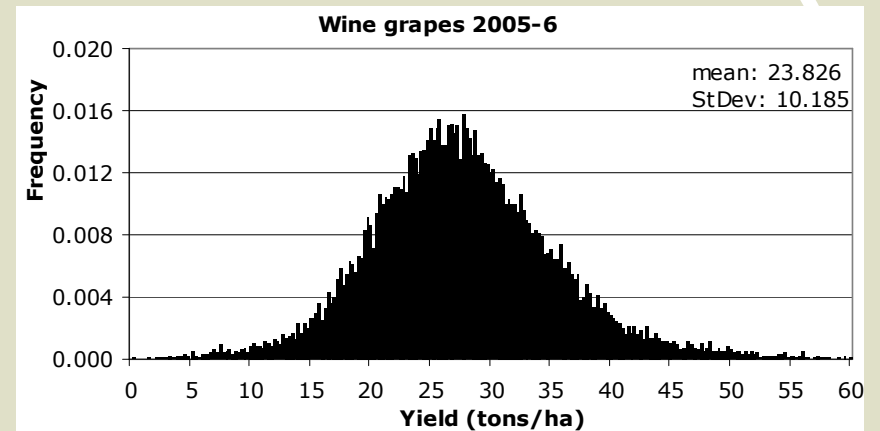
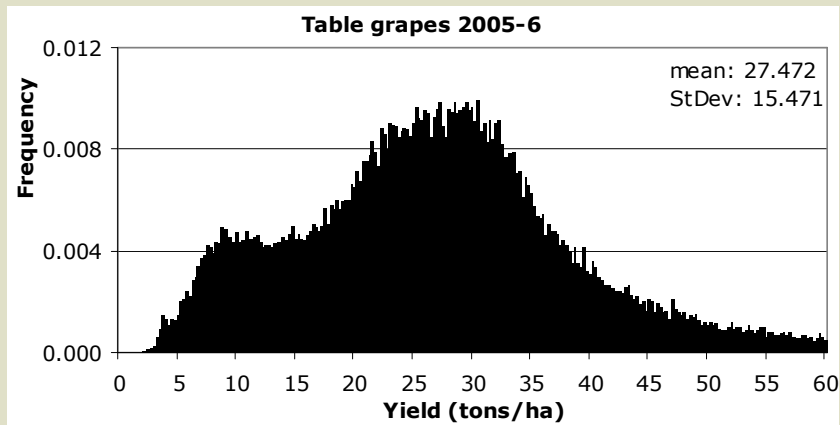
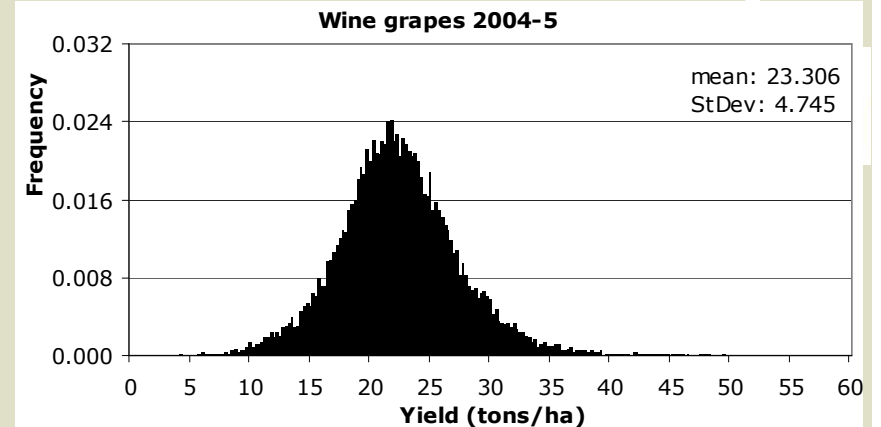
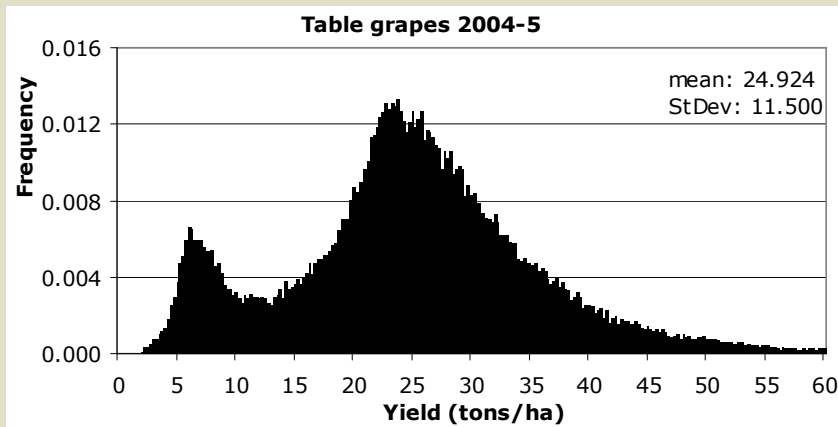




# Yield modeling



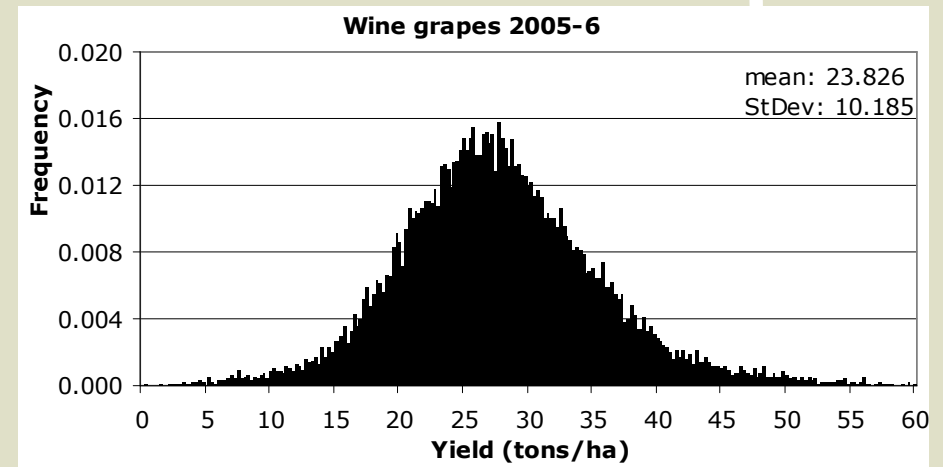
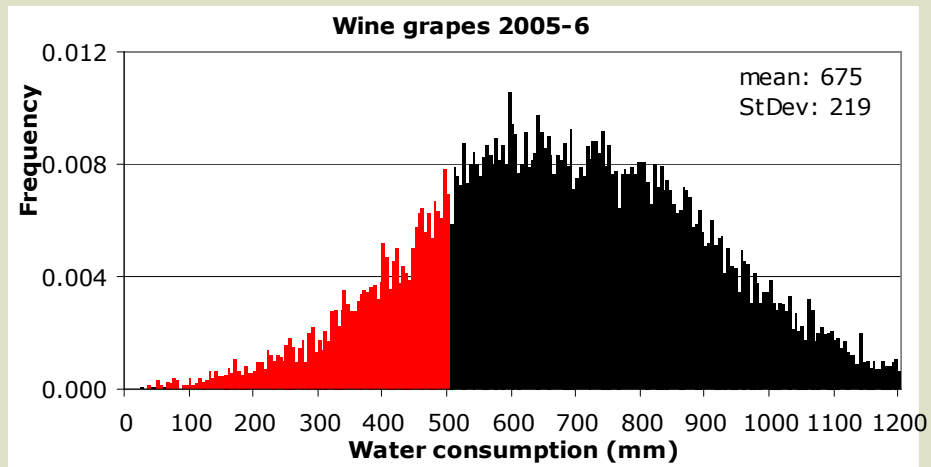
Yield of table grapes in Hex Valley



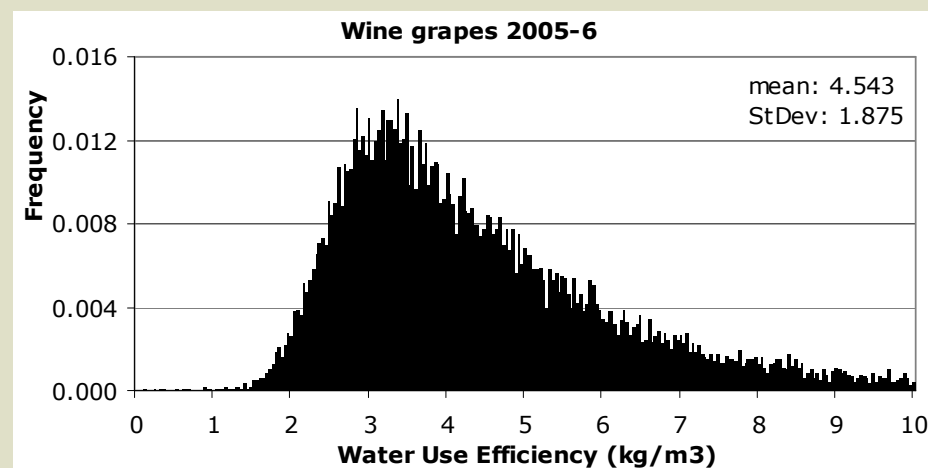
Yield of table grapes in Hex Valley,  
Worcester and Paarl

Yield of Colombard wine grapes in  
Worcester

# Water use efficiency

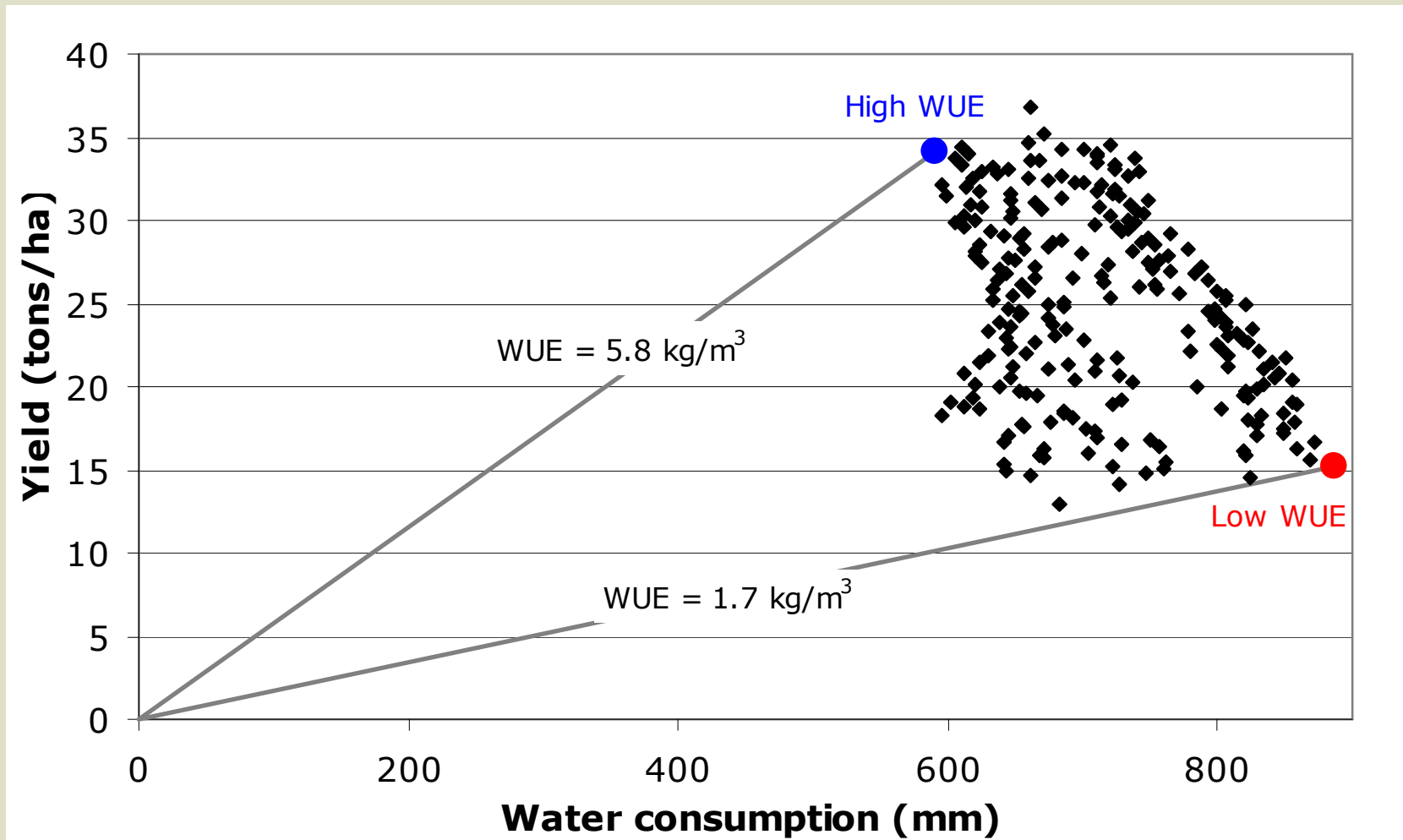


$$WUE = \frac{Y}{10 * ET}$$



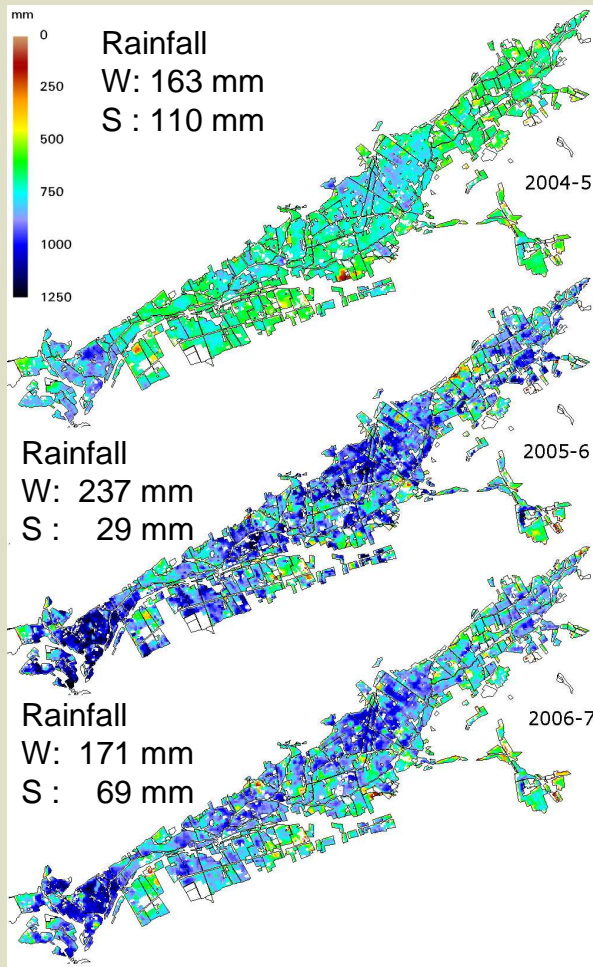
# Water use efficiency

Table grapes in Hex Valley, 2004-5

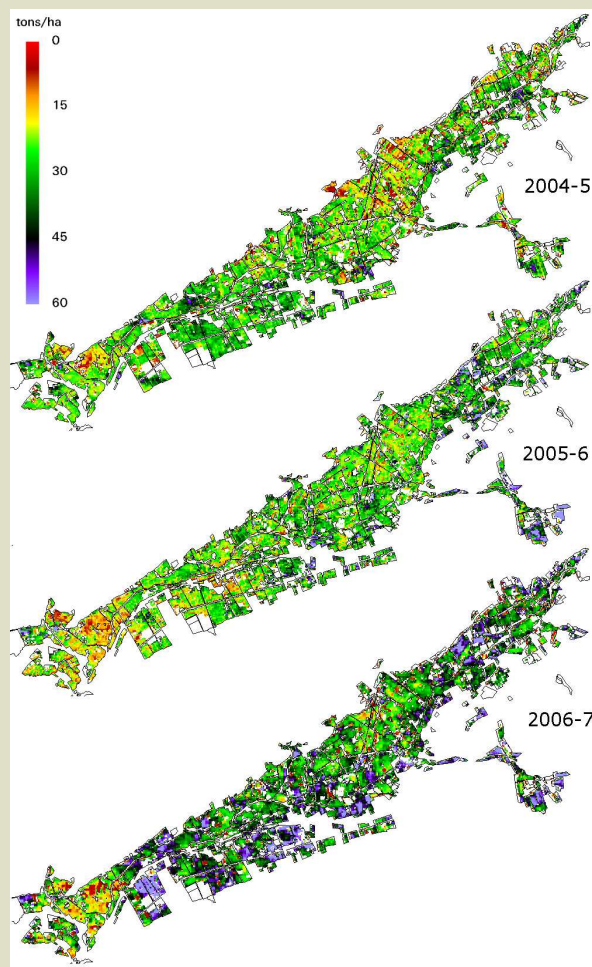


# Hex River Valley: water availability

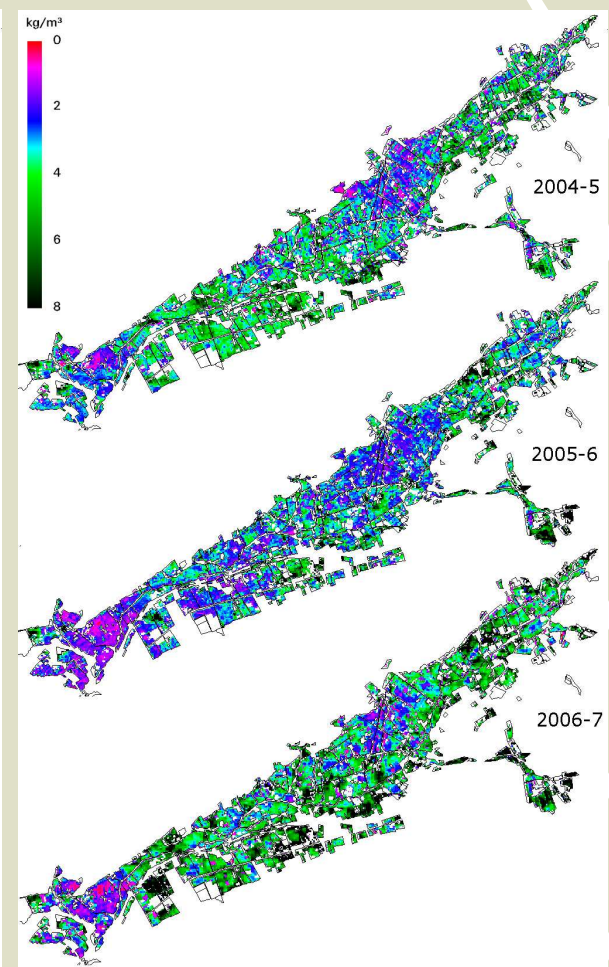
Water shortage in 2004-5 had a strong effect on water consumption, but the effect on table grape yield was only small



Water consumption ( $Et_{act}$ )



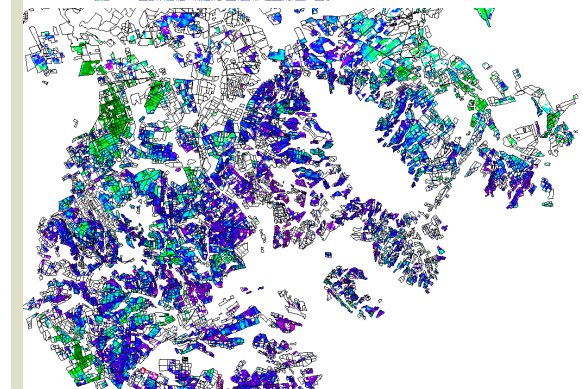
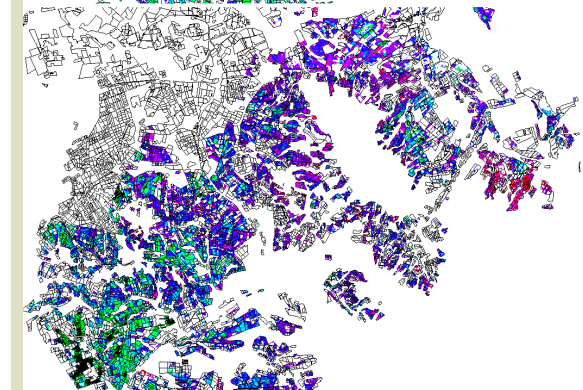
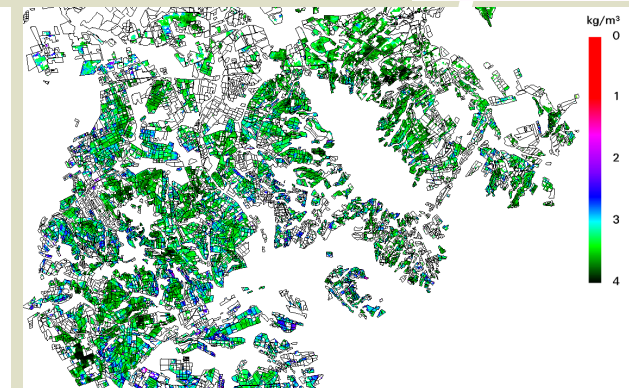
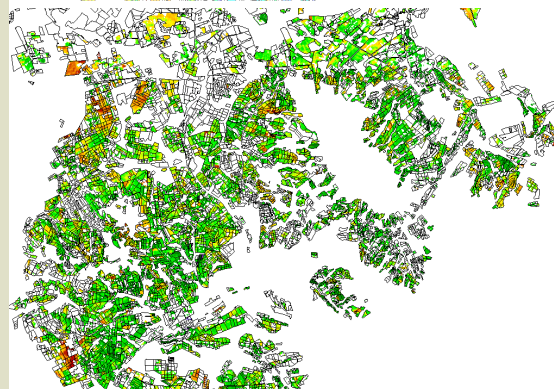
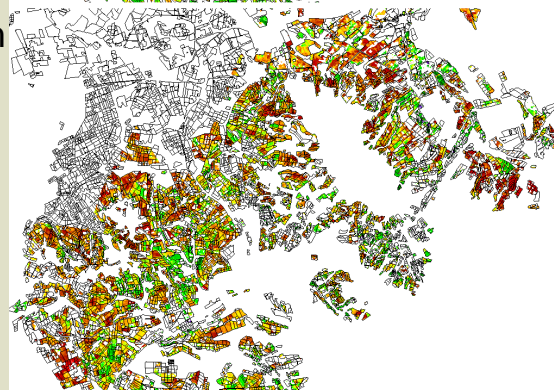
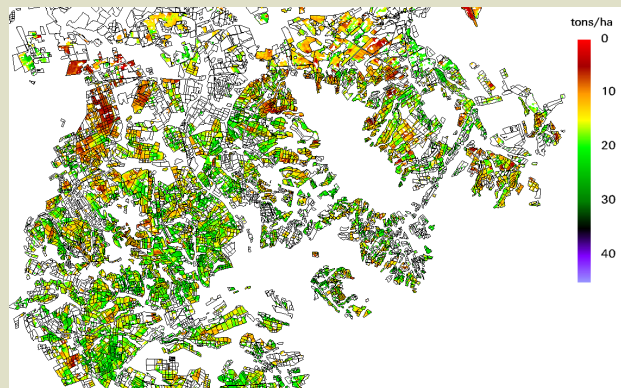
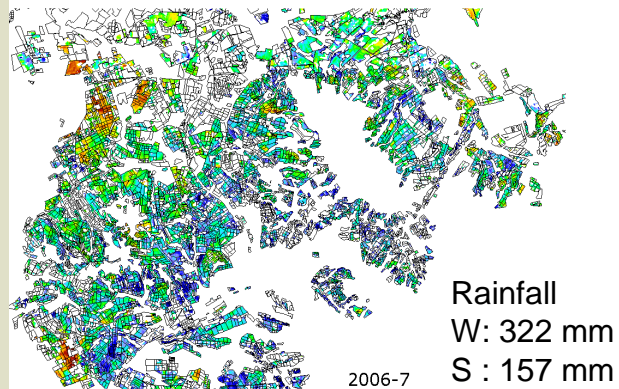
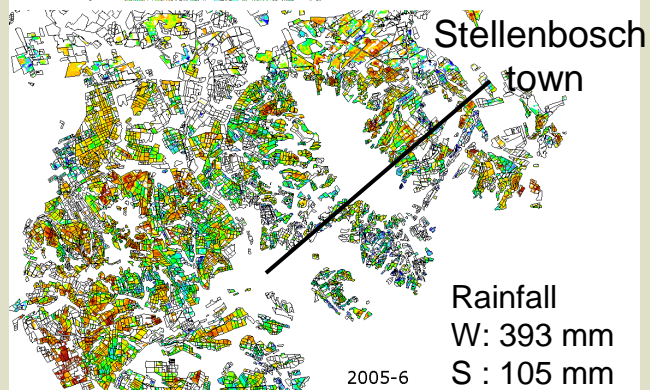
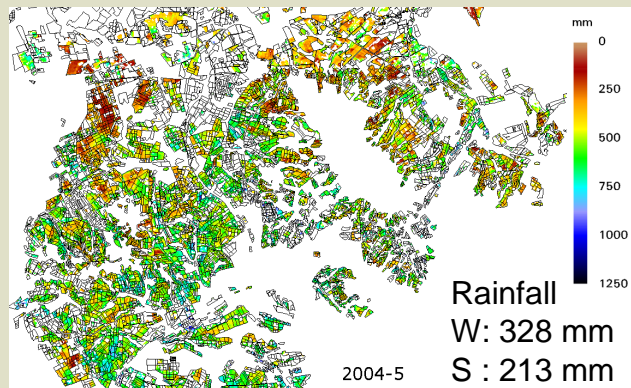
Yield



Water use efficiency



# Stellenbosch: rainfall



Water consumption

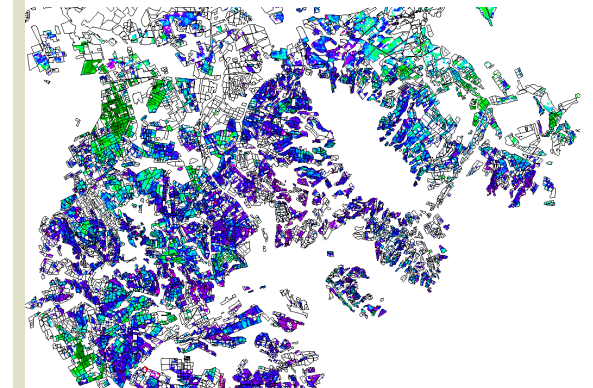
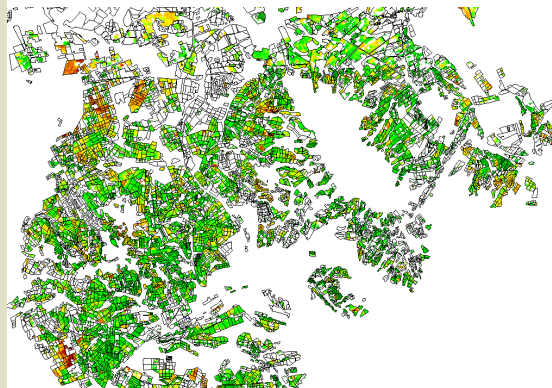
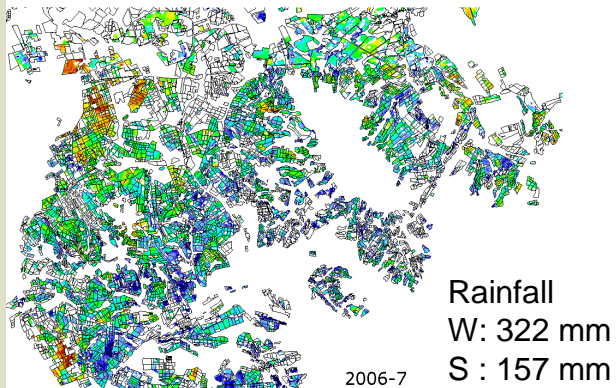
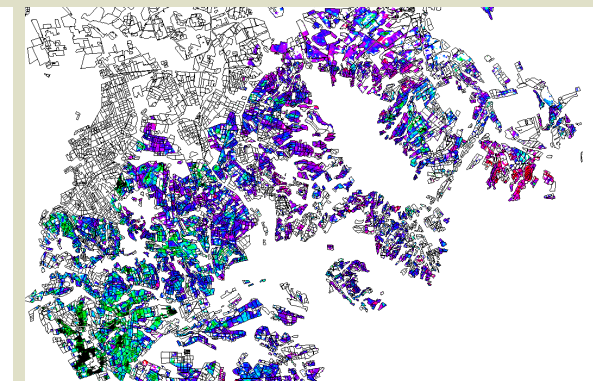
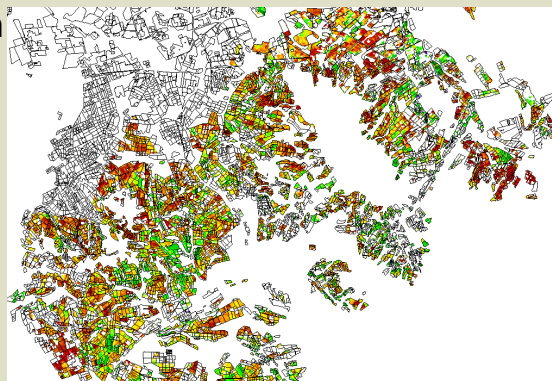
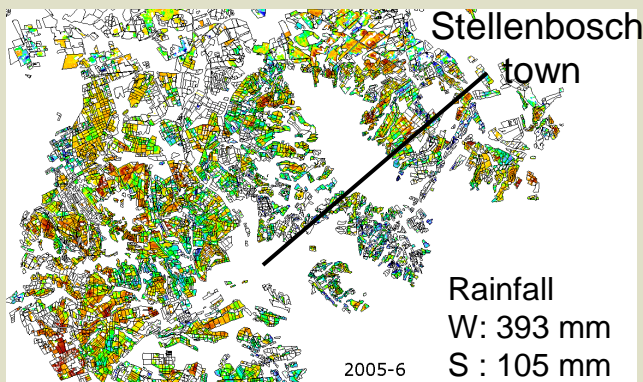
Biomass production

Biomass water use efficiency



# Stellenbosch: rainfall

Wine vineyards in Stellenbosch are rainfed or are irrigated at low frequency. Low rainfall in the summer of 2005-6 resulted in very low water consumption but also strongly affected the biomass produced.



Water consumption

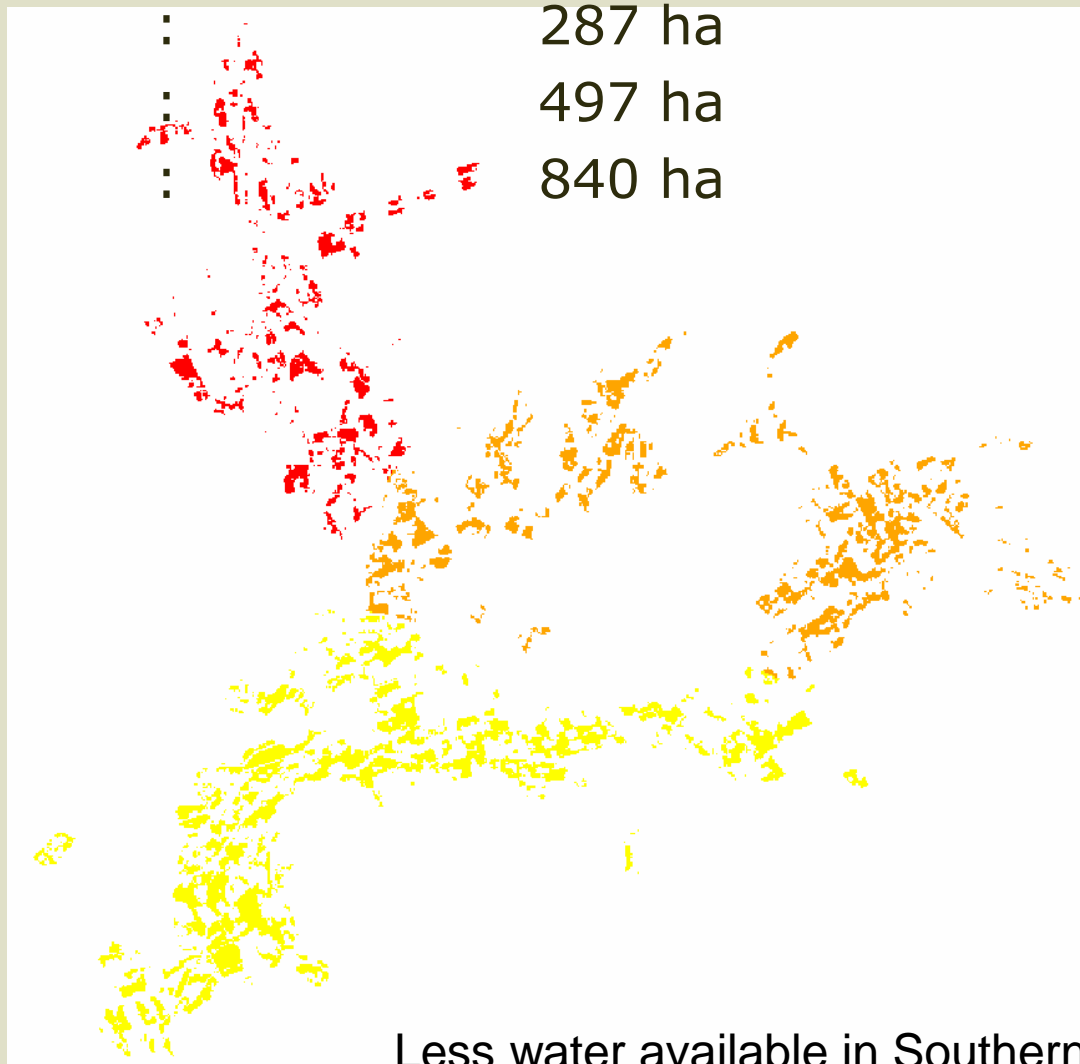
Biomass production

Biomass water use efficiency

# Worcester: irrigation water availability

Worcester wine grapes:

Hex River area	:	287 ha
Nuy area	:	497 ha
Southern part	:	840 ha



Less water available in Southern part



# Water availability

## Worcester wine grapes

<b>ET (mm)</b>	<b>2004-5</b>	<b>2005-6</b>	<b>2006-7</b>
Hex River area	: 766	833	800
Nuy area	: 718	722	746
Southern part	: 610	627	694

<b>Yield (tons/ha)</b>	<b>2004-5</b>	<b>2005-6</b>	<b>2006-7</b>
Hex River area	: 22.3	29.7	27.1
Nuy area	: 21.6	25.8	26.6
Southern part	: 24.1	29.1	27.2

<b>WUE (kg/m<sup>3</sup>)</b>	<b>2004-5</b>	<b>2005-6</b>	<b>2006-7</b>
Hex River area	: 3.0	3.9	3.6
Nuy area	: 3.1	3.9	3.7
Southern part	: 4.1	5.1	4.1

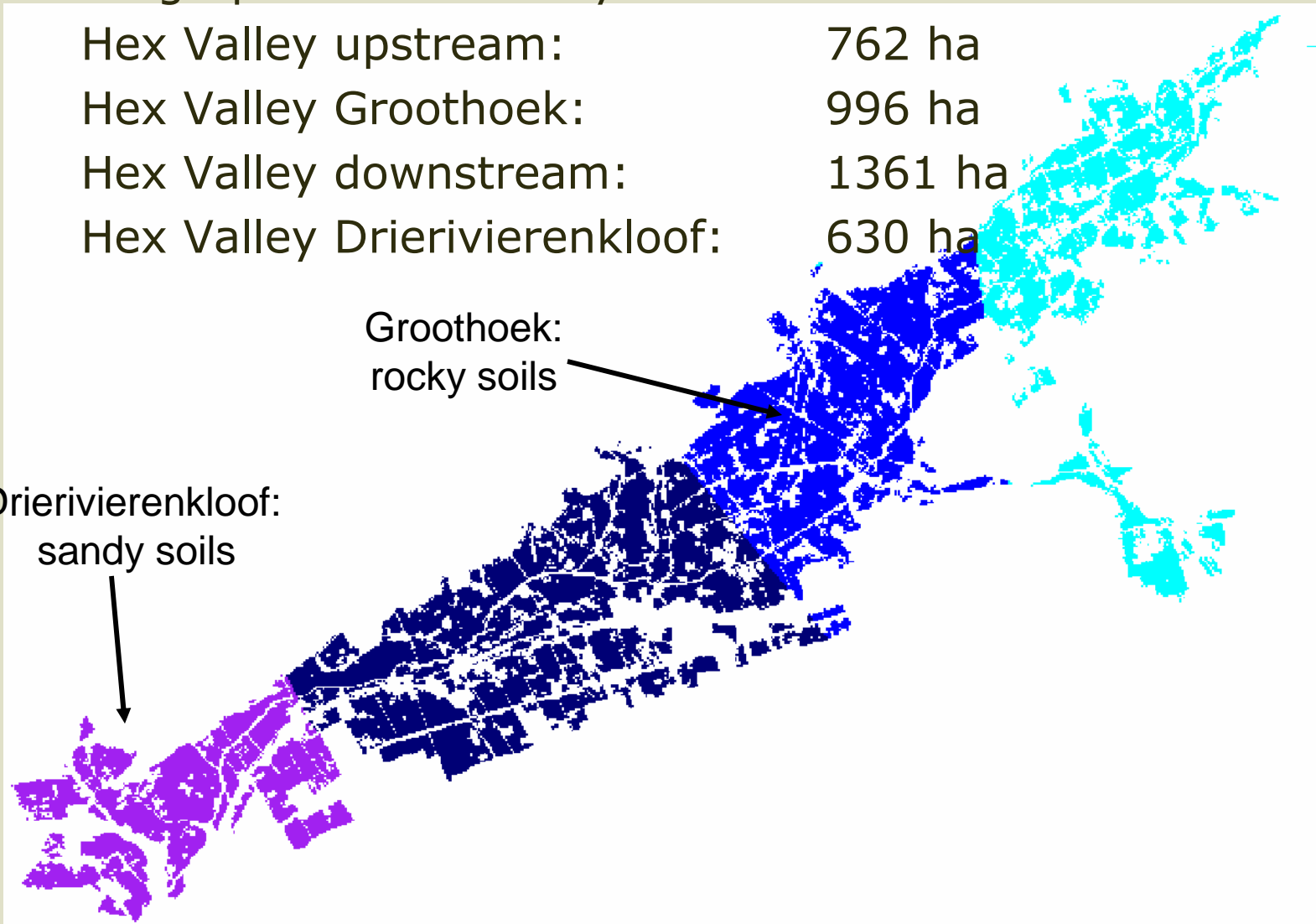
# Soil type and water table

## Table grapes in Hex Valley

Hex Valley upstream:	762 ha
Hex Valley Groothoek:	996 ha
Hex Valley downstream:	1361 ha
Hex Valley Drierivierenkloof:	630 ha

Groothoek:  
rocky soils

Drierivierenkloof:  
sandy soils



# Soil type and water table

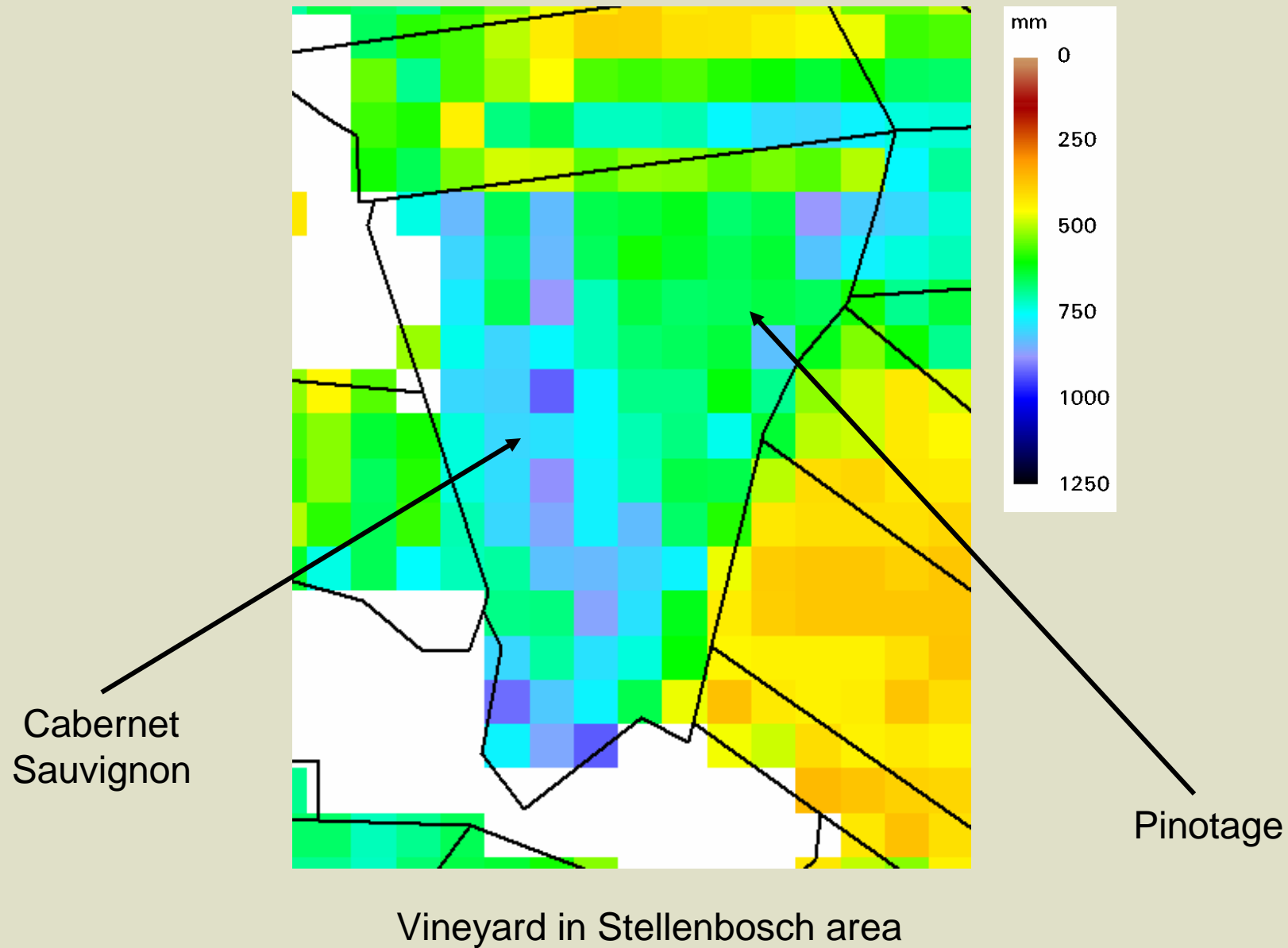
## Hex Valley table grapes

<b>ET (mm)</b>	<b>2004-5</b>	<b>2005-6</b>	<b>2006-7</b>
downstream	639	781	739
Groothoek	725	877	837
upstream	676	837	796
Drierivierenkloof	766	948	880

<b>Yield (tons/ha)</b>	<b>2004-5</b>	<b>2005-6</b>	<b>2006-7</b>
downstream	25.7	35.8	37.6
Groothoek	21.5	27.1	27.1
upstream	26.7	26.5	26.5
Drierivierenkloof	23.3	20.8	20.8

<b>WUE (kg/m<sup>3</sup>)</b>	<b>2004-5</b>	<b>2005-6</b>	<b>2006-7</b>
downstream	4.1	5.2	5.4
Groothoek	3.0	3.3	4.0
upstream	4.0	3.4	4.9
Drierivierenkloof	3.1	2.4	3.6

# Cultivar



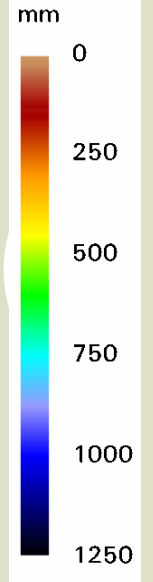
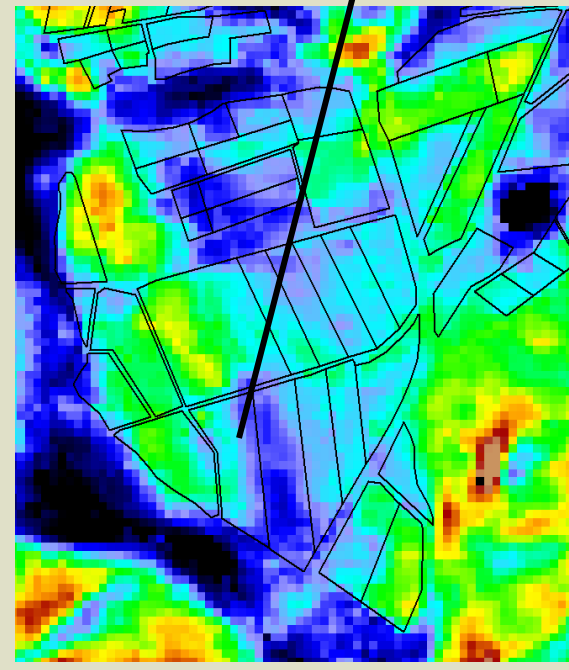
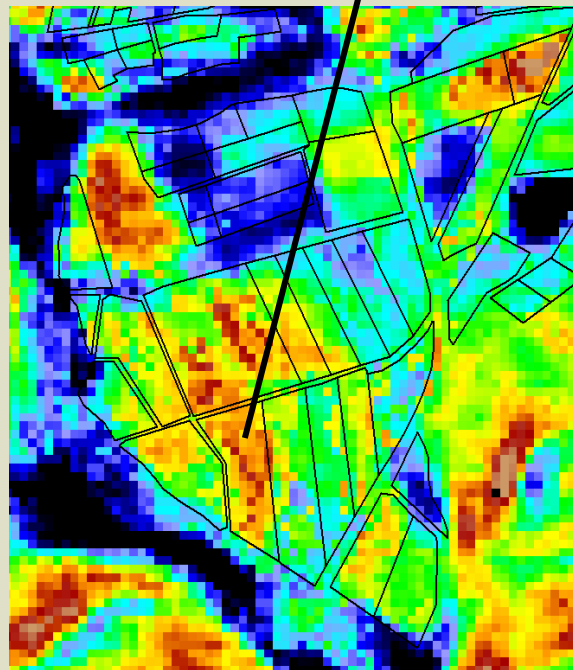
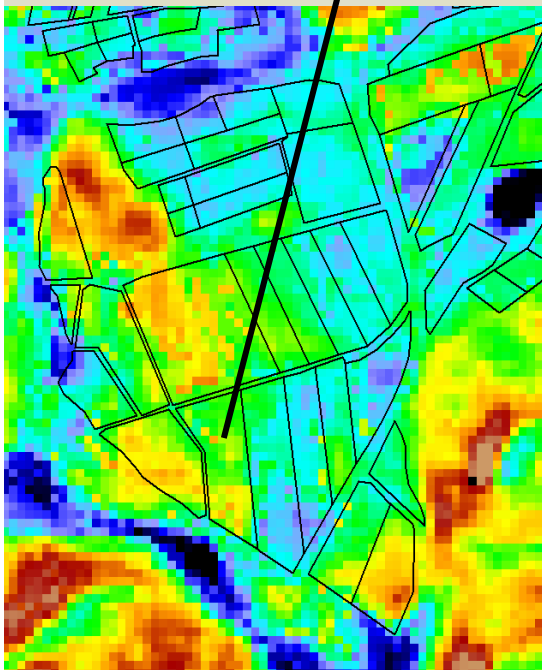
# Management



550 mm

405 mm

825 mm



2004-5

2005-6

2006-7

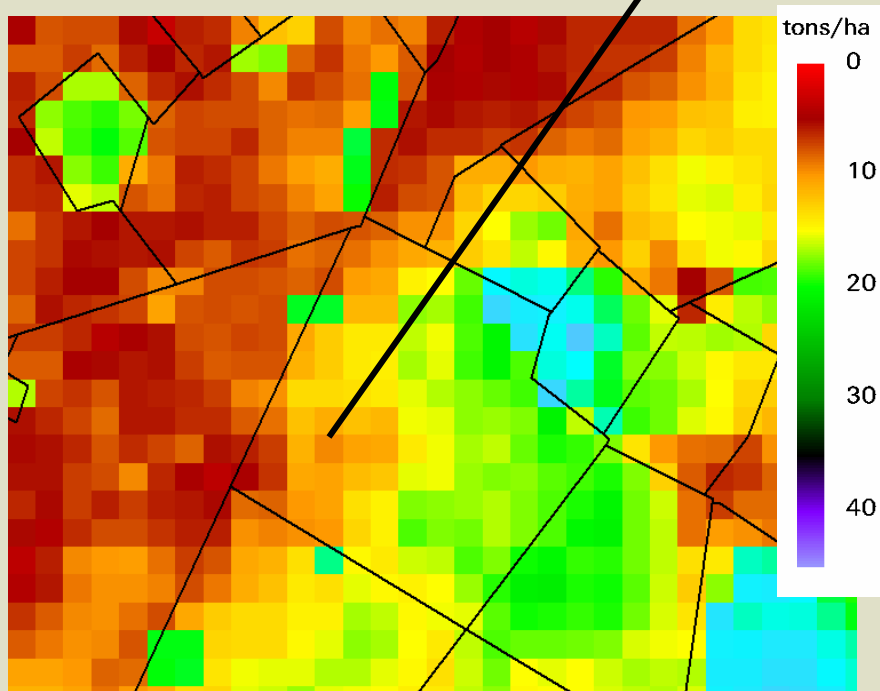
Dry year

Drastic change in  
management

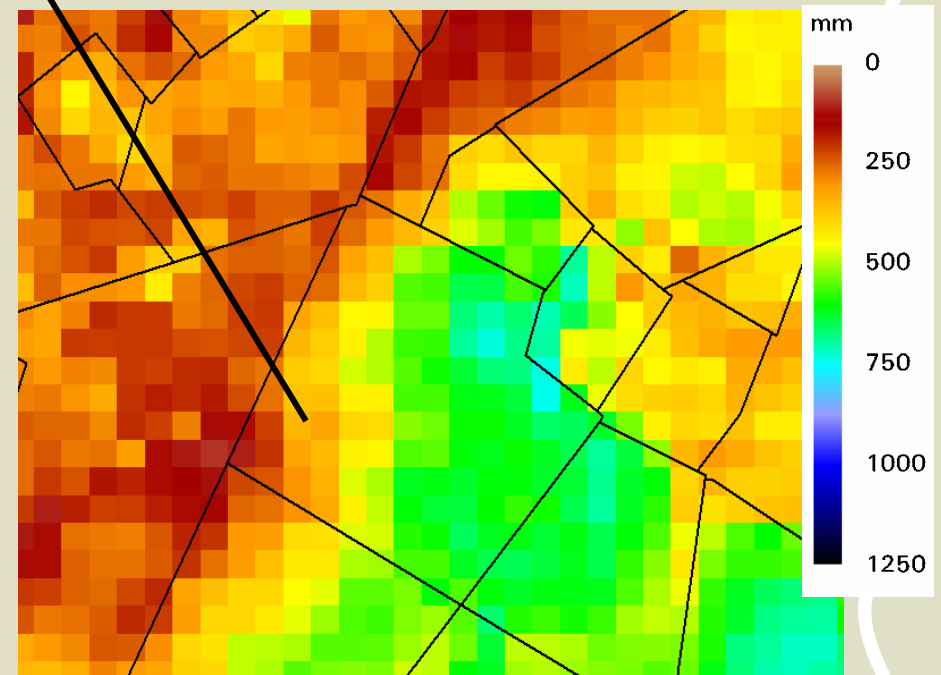
Management  
improved

# Plant stress

Water logging early in season



Biomass production in 2005-6



Water consumption in 2005-6

# Conclusions

- High variation in water consumption, yield and water use efficiency between fields, areas, and between years.
- Crop water consumptive use can be spatially mapped with 90% accuracy
- Some fields perform similarly over years, indicating e.g. low performance can be related to local conditions
- Table grapes consume on average more water than wine grapes
- Reduced irrigation in table grape areas resulted in lower water consumption but similar yields -> high WUE !
- A dry summer in wine grape areas in Stellenbosch did reduce water consumption and yield, resulting in low WUE!
- There is scope for improvement
- RS can be used to help farmers in optimizing irrigation water resources
- Google Earth applications are emerging now

For more information:

Email:

[A.Klaasse@waterwatch.nl](mailto:A.Klaasse@waterwatch.nl)

Results in Google Maps and Google Earth:

[www.WaterWatch.nl/grapes](http://www.WaterWatch.nl/grapes) (soon)

Operational product for farmers in the Netherlands:

[www.MijnAkker.nl](http://www.MijnAkker.nl)