MONITORING WATER USE EFFICIENCY OF IRRIGATED SUGARCANE PRODUCTION IN MPUMALANGA USING SEBAL

A Singels, C Jarmain, E Bastidas-Obando, FC Olivier and AL Paraskevopoulos

SANCID Nov 2014

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Introduction

Background

- Irrigation water supply in SA is limited
- Pressure to demonstrate efficient use
- Measure to manage crop water use
- Remote sensing (RS) could help

Objectives

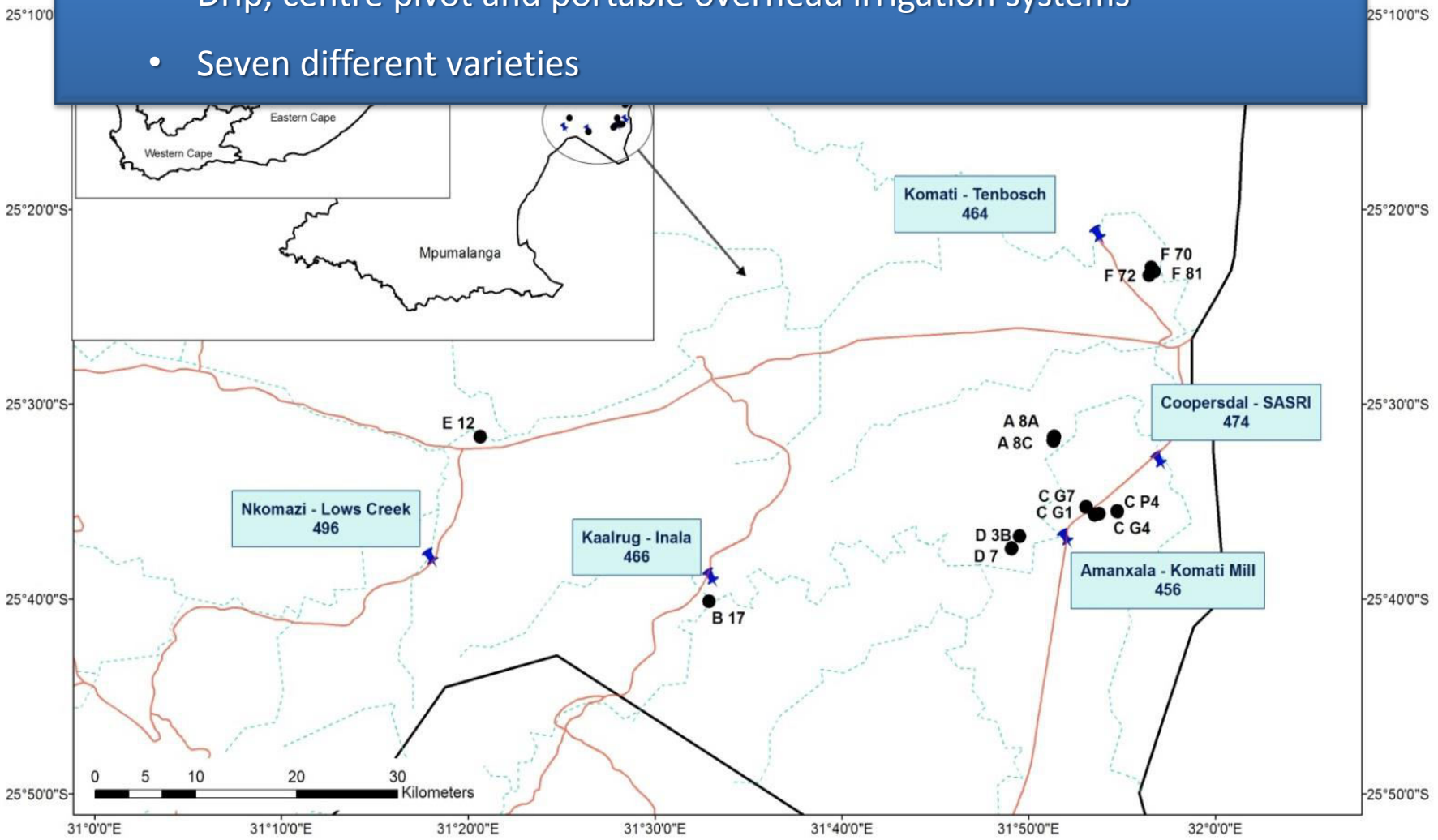
For Mpumalanga sugarcane

- Evaluate the accuracy of SEBAL estimates of
  - crop water use (ET),
  - crop water status (ETdef)
  - biomass production (ΔTDM)
- Quantify spatial variation in ET, ΔTDM, water use efficiency (BWUE)
- Explore ways of using RS information to promote efficient use of irrigation water

In this presentation

- Method
  - Study area
  - SEBAL
  - Field measurements
- Results
  - SEBAL validation
  - Spatial variation in ET, Etdef, ΔTDM, BWUE
  - Supporting management of irrigated sugarcane production
- Conclusions

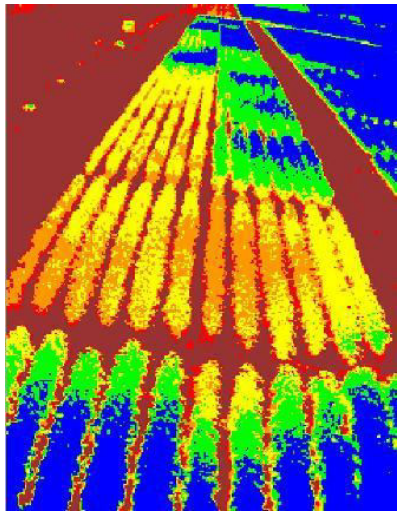
- Thirteen fields on four commercial and two small-scale farms
  - Different soils, crop cycles, row spacings
  - Drip, centre pivot and portable overhead irrigation systems
  - Seven different varieties

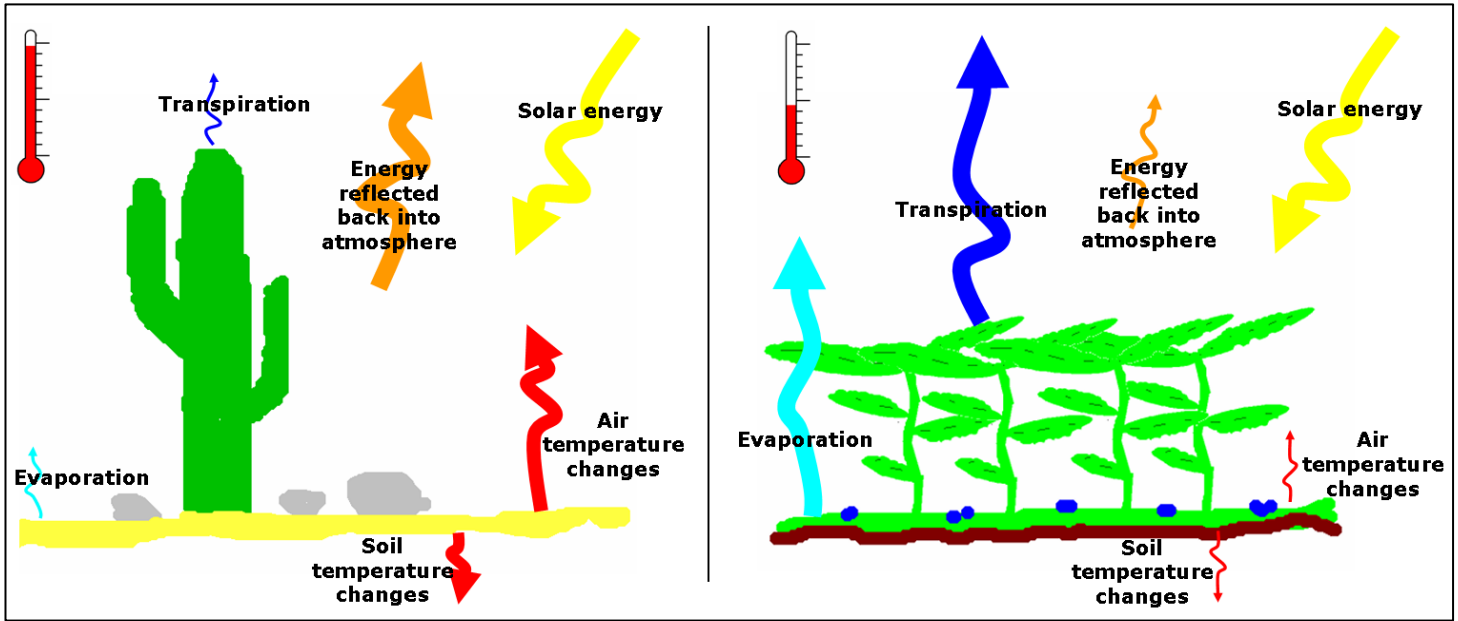


SEBAL

Surface Energy Balance Algorithm for Land

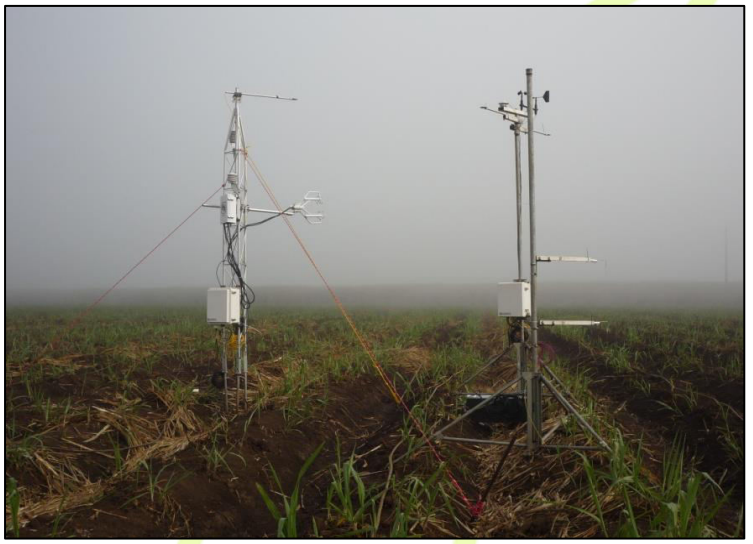
- Inputs:
  - Remotely sensed radiance in visible, near-infrared and thermal red part of spectrum
  - Weather data
- Calculates the radiation and energy balance
- Calculates actual and potential crop water use (ET, ETpot), canopy cover, crop growth (ΔTDM), and water use efficiency (BWUE)
- Weekly ET, Etdef = (ETpot-ET), ΔTDM, BWUE = ΔTDM/ET at 30 m resolution





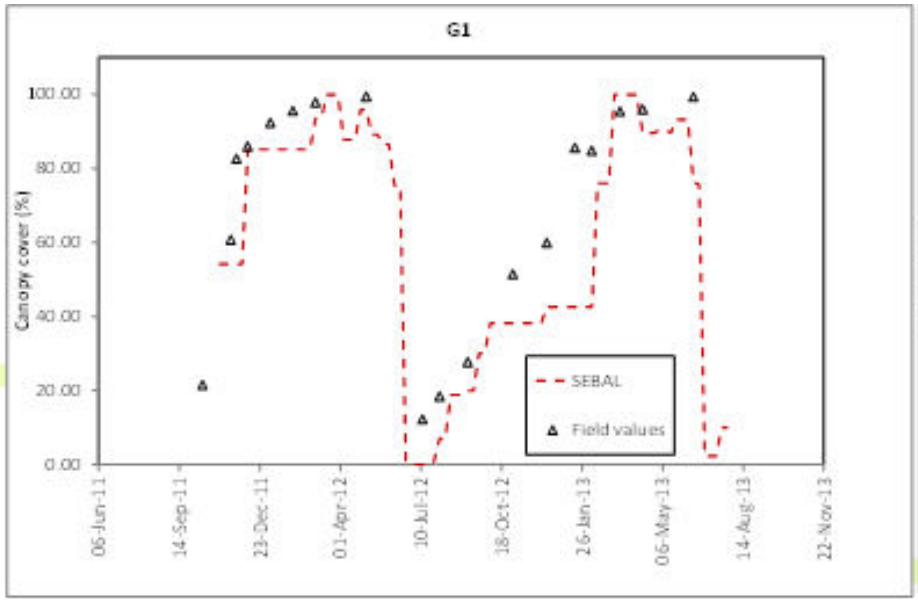
Ground measurements

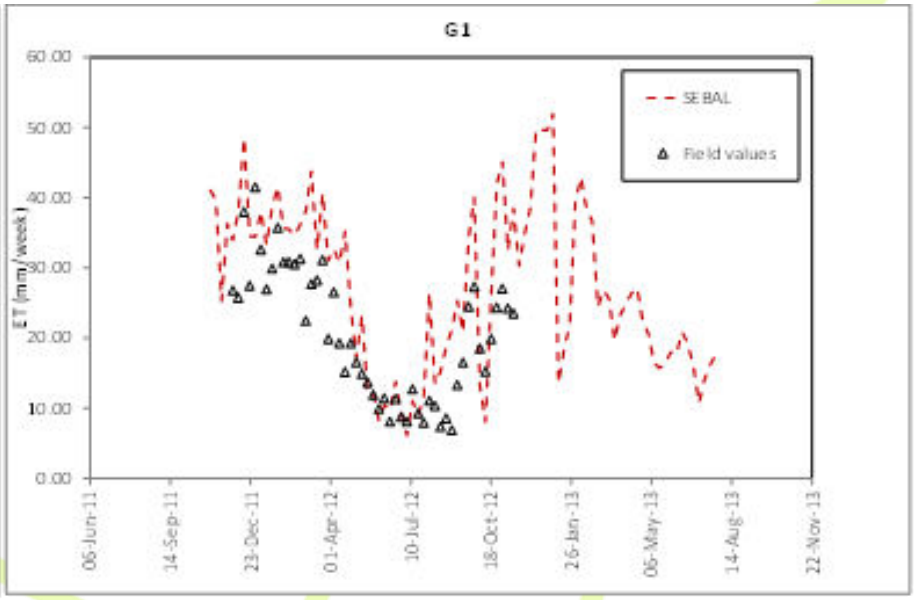
- Soil water status
  - Capacitance probes
- Evapotranspiration
  - Surface renewal system (energy balance method with sensible heat flux, soil heat flux, net radiation)
- Crop growth and yield
  - Canopy cover
  - Biomass components

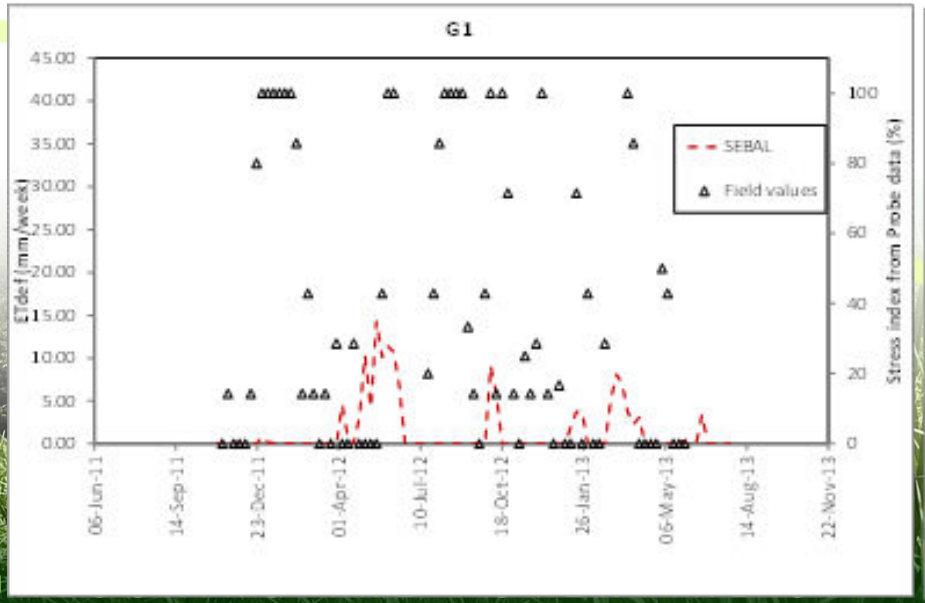


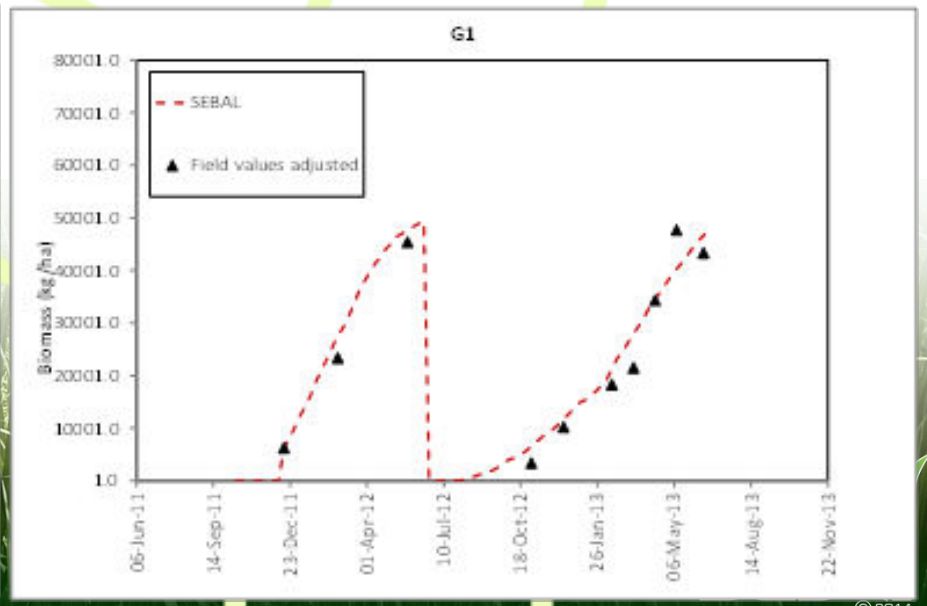
Results

Validation results for field G1

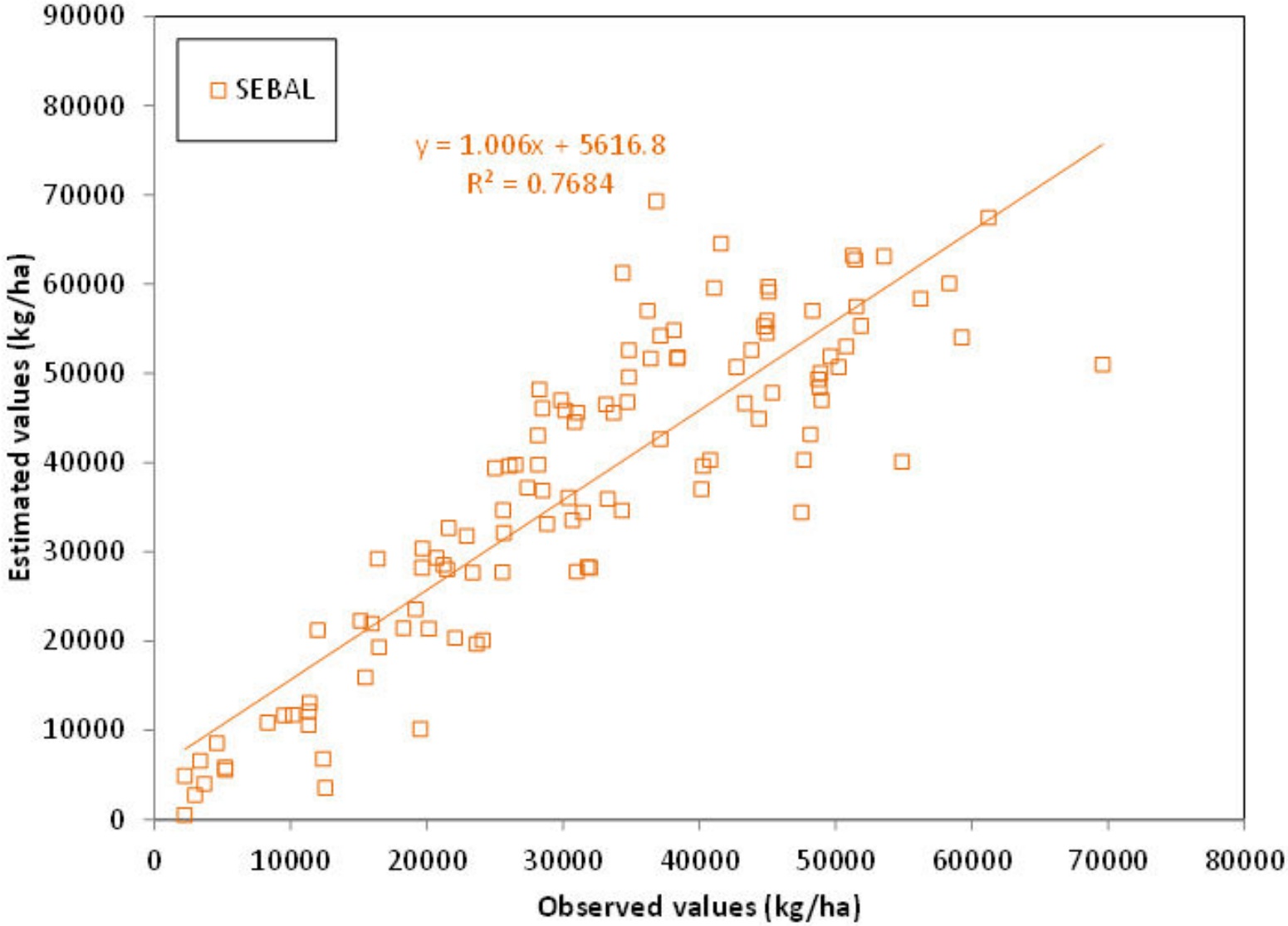








Biomass validation



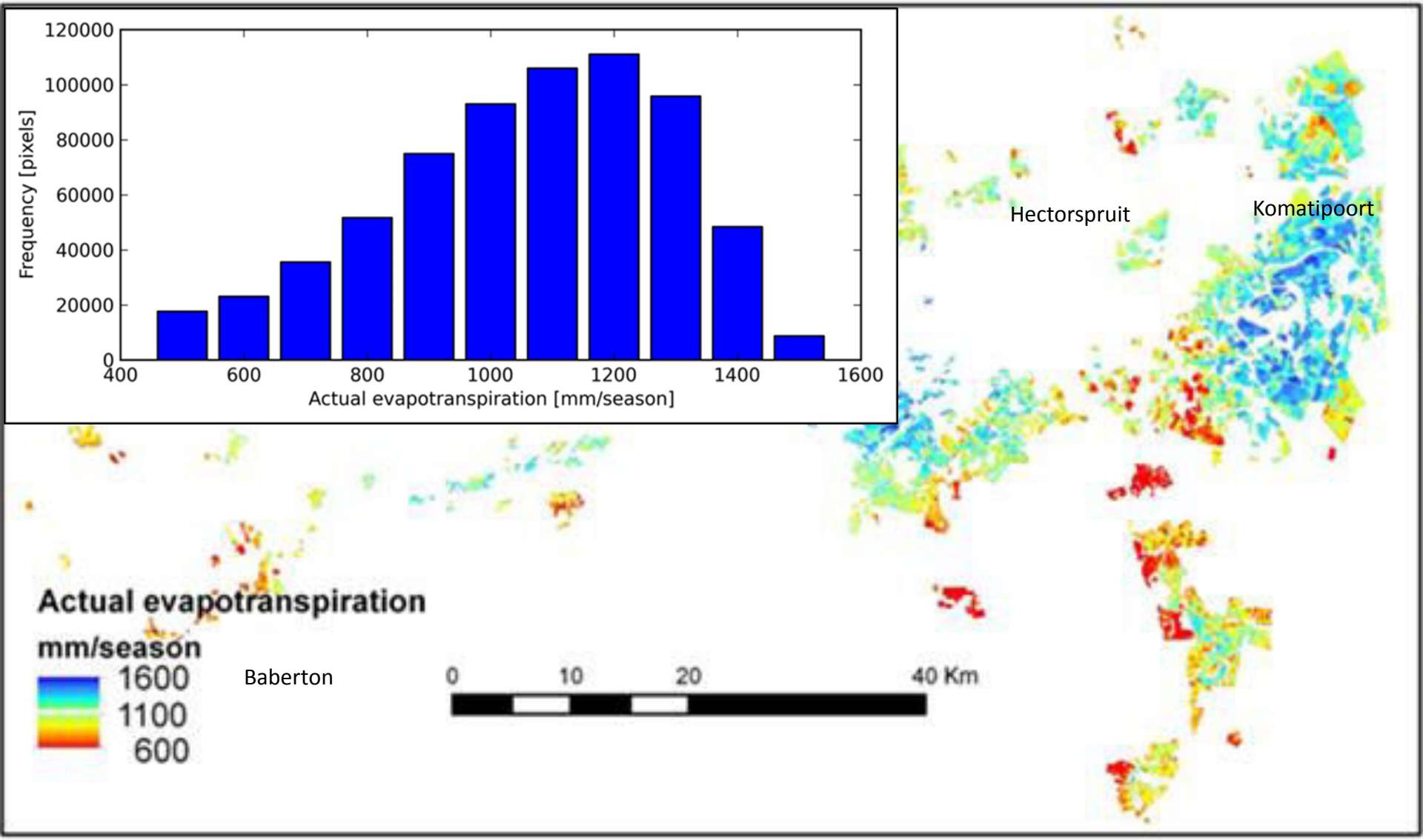
Validation summary

Variable	Slope	Intercept	R^2	n
2011/12				
Canopy cover (%)	1.02	-9.75	0.543	93
ET (mm/week)	1.05	4.9	0.721	29
Biomass (t/ha)	0.84	14.6	0.783	24
2011/12 and 2012/13 pooled				
Canopy cover (%)	1.01	-10.5	0.774	196
ET (mm/week)	1.31	2.63	0.781	51
Biomass (t/ha)	1.01	5.6	0.768	116

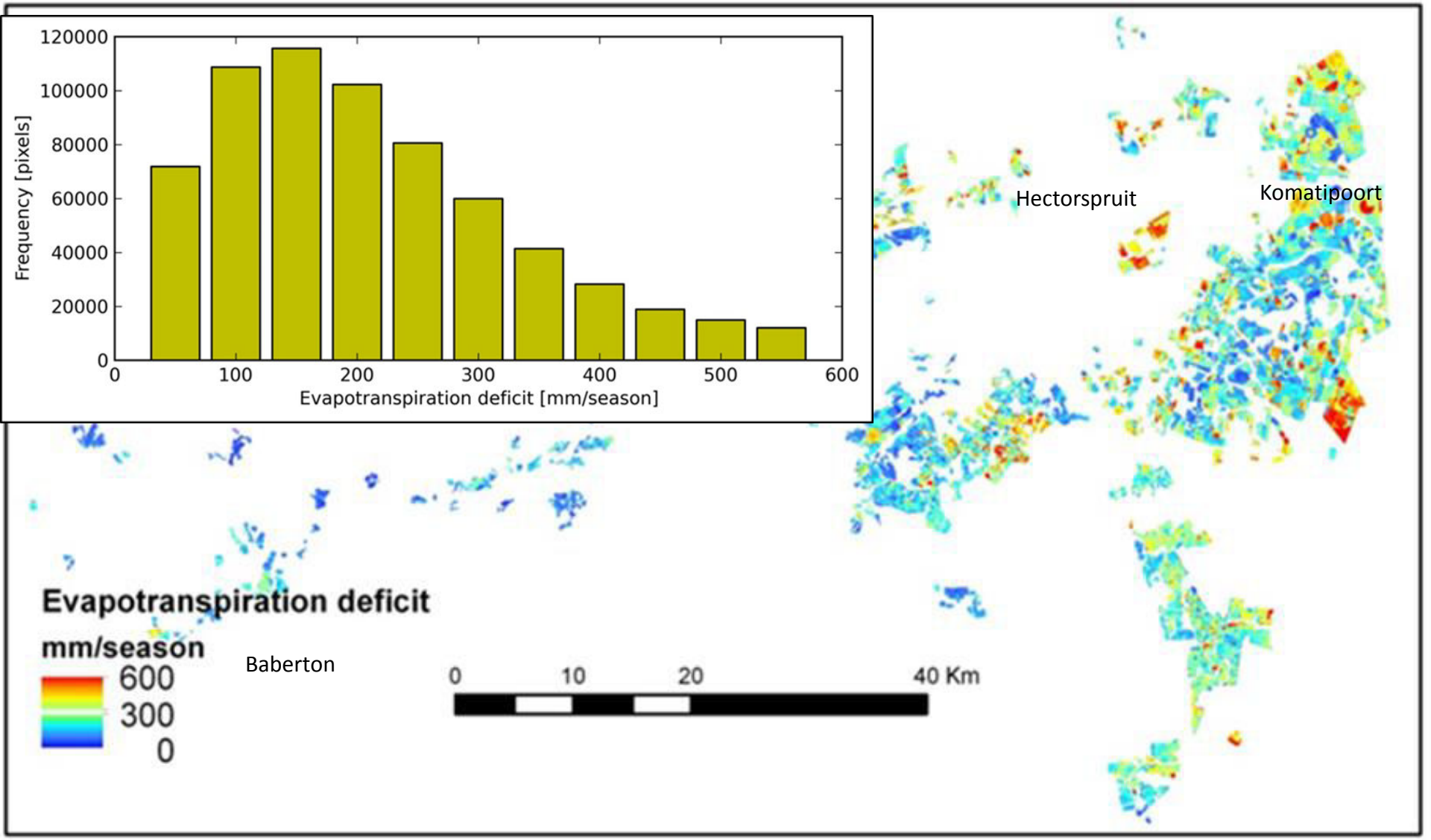
Spatial estimates of seasonal values

- Evapotranspiration (ET)
- ET deficit (ETdef)
- Dry biomass yield (TDM)
- Water use efficiency (BWUE)

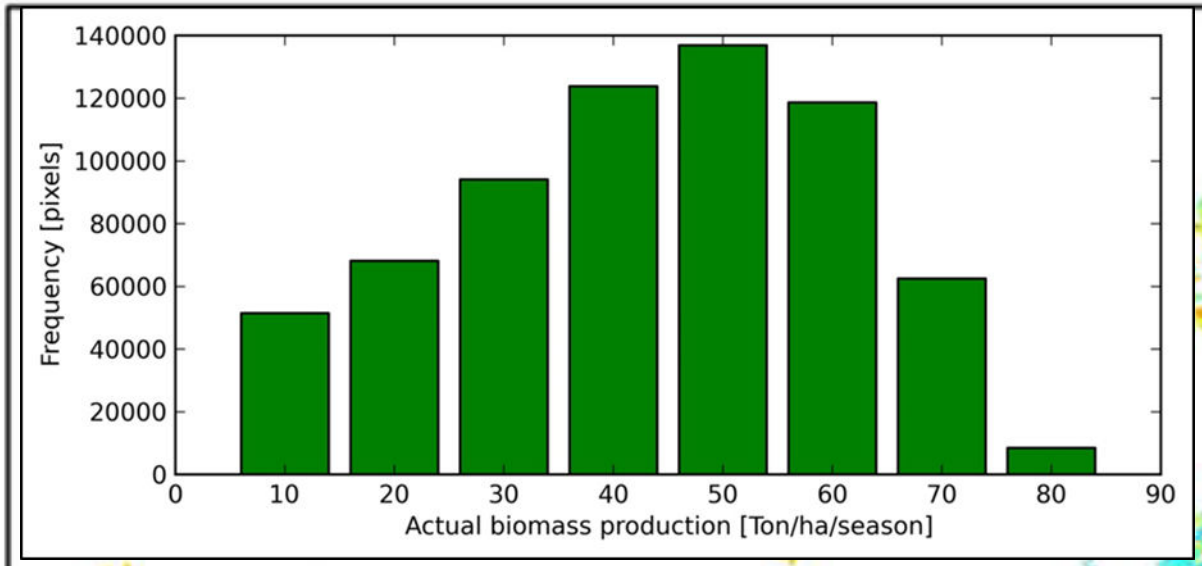
ET


Frequency [pixels]
120000
100000
80000
60000
40000
20000
0
400
600
800
1000
1200
1400
1600
Actual evapotranspiration [mm/season]
Hectorspruit
Komatipoort
Actual evapotranspiration
mm/season
1600
1100
600
Baberton
0
10
20
40 Km

ETdef


120000
100000
80000
60000
40000
20000
0
Frequency [pixels]
0
100
200
300
400
500
600
Evapotranspiration deficit [mm/season]
Hectorspruit
Komatipoort
Evapotranspiration deficit
mm/season
600
300
0
Baberton
0
10
20
40 Km

TDM



Hectorspruit

Komatipoort

Actual Biomass Production

Ton/ha/season

80

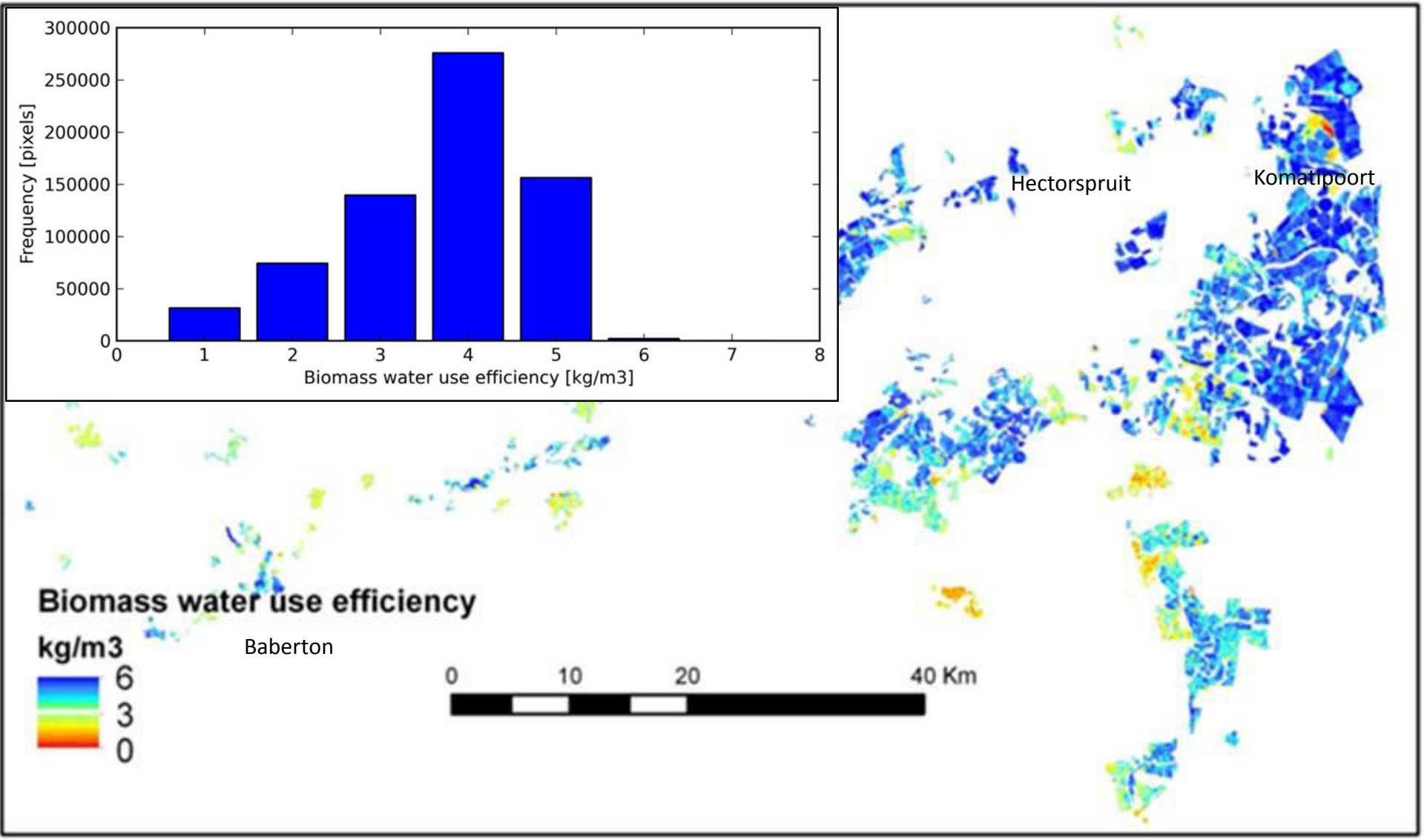
50

20

Baberton

0 10 20 40 Km

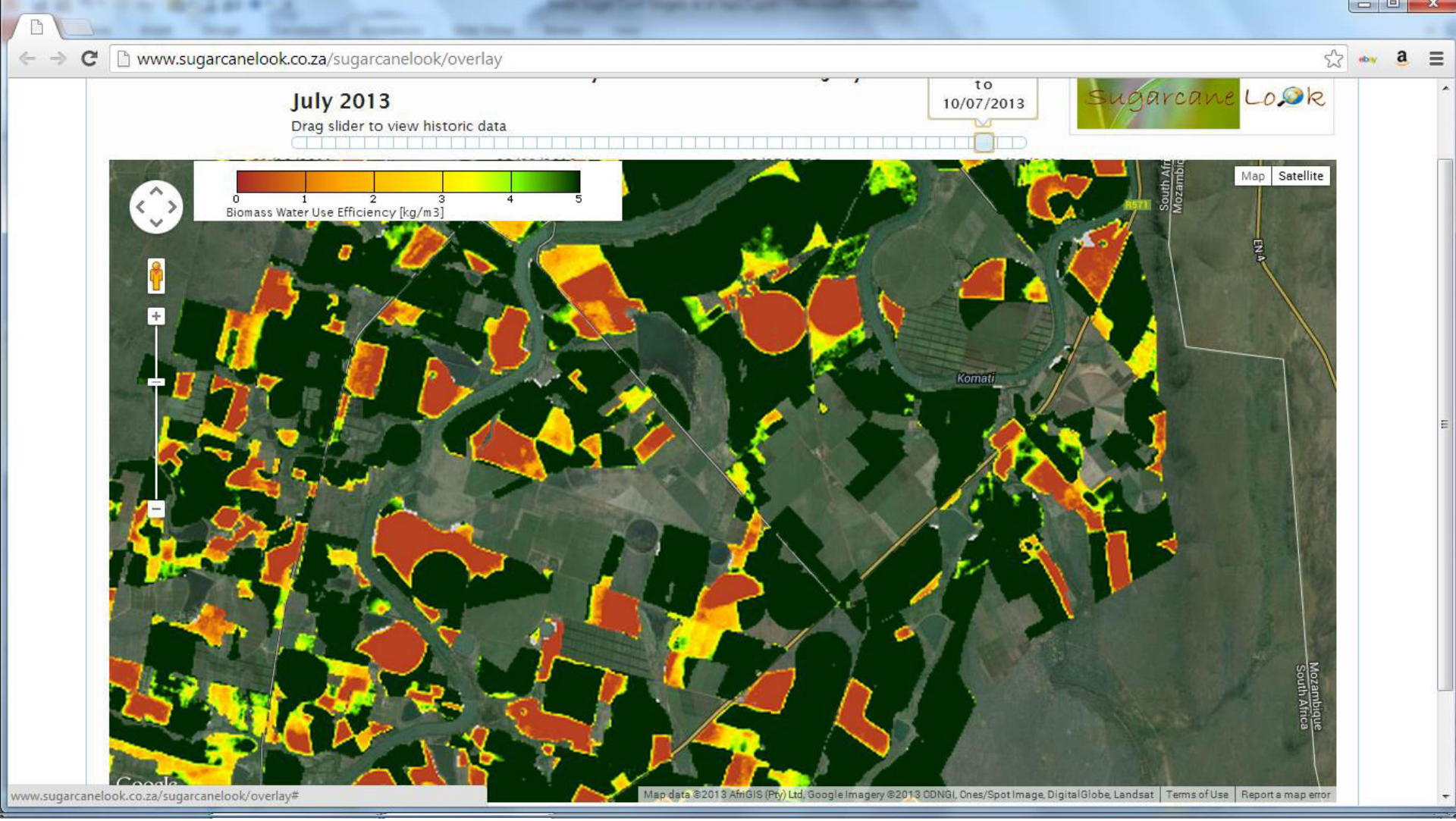
BWUE


300000
250000
200000
150000
100000
50000
0
Frequency [pixels]
0
1
2
3
4
5
6
7
8
Biomass water use efficiency [kg/m3]
Hectorspruit
Komatipoort
Biomass water use efficiency
kg/m3
6
3
0
Baberton
0
10
20
40 Km

Summary

	Min	25th %	50th %	75th %	Max
MALELANE MSA					
ET (mm/385 days)	89	892	1070	1200	1760
Biomass (t/ha/385 days)	0	32	47	58	94
BWUE (kg/m^3)	0.0	3.6	4.5	4.9	6.3
KOMATI MSA					
ET (mm/385 days)	63	780	982	1150	1686
Biomass (t/ha/385 days)	0	29	43	56	93
BWUE (kg/m^3)	0.0	3.7	4.4	4.9	6.2

Parameter	ML	KO
ET<1000mm	40	53
Biomass < 35 t/ha (≈90 t cane/ha)	30	34
BWUE< 4 kg/m^3 (≈9.5 t cane/100 mm)	36	33



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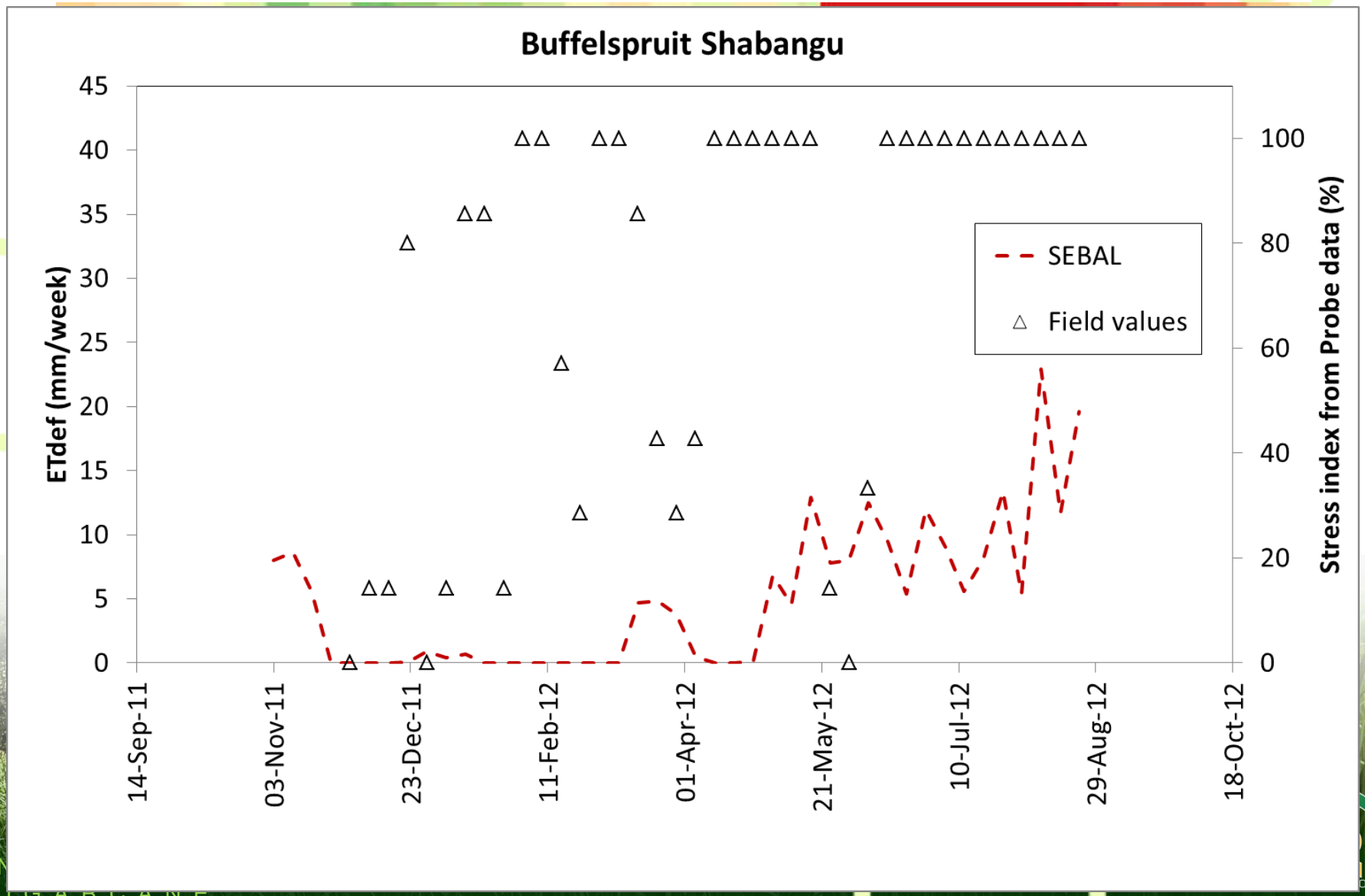
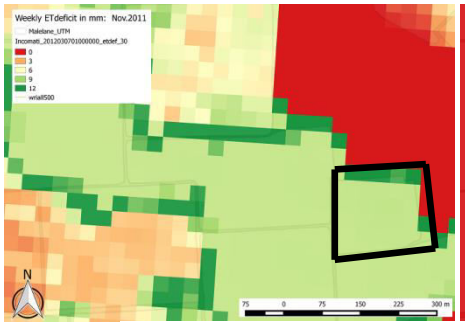
Potential value of SEBAL data

Spatial and temporal analysis of irrigated crop performance

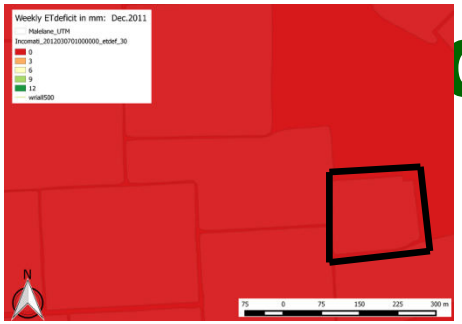
- Poorly performing fields identified by high ETdef and /or low BWUE
- Detect problems early, focus management and extension effort on priority areas at field, farm and regional level

Field 17


Buffelspruit Shabangu
ETdef (mm/week)
Stress index from Probe data (%)
SEBAL
Field values
0
5
10
15
20
25
30
35
40
45
0
20
40
60
80
100
14-Sep-11
03-Nov-11
23-Dec-11
11-Feb-12
01-Apr-12
21-May-12
10-Jul-12
29-Aug-12
18-Oct-12



Nov 11



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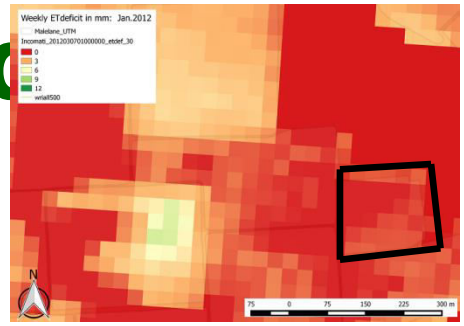

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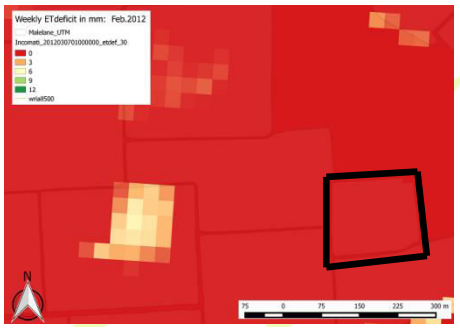

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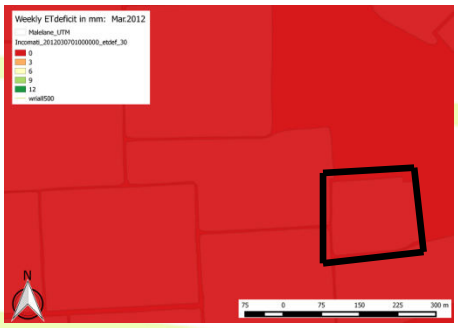
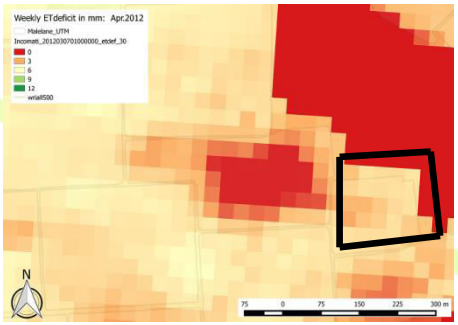
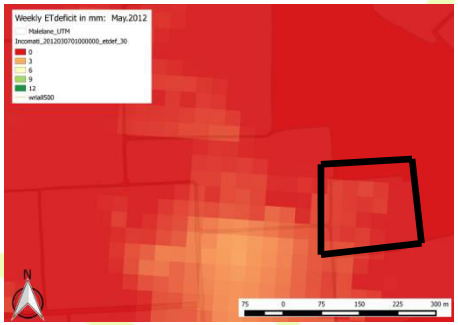


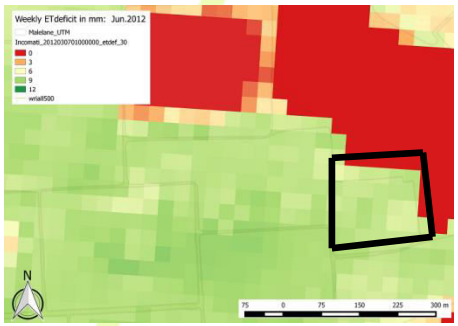
Mar 12



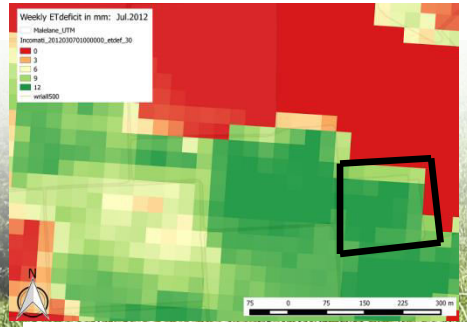
Apr12

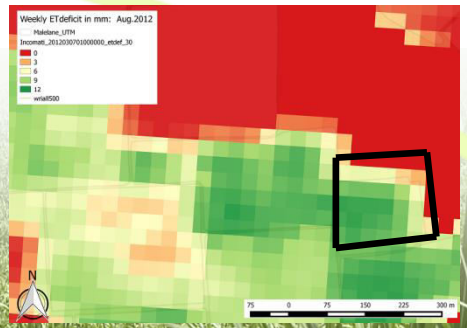


May12

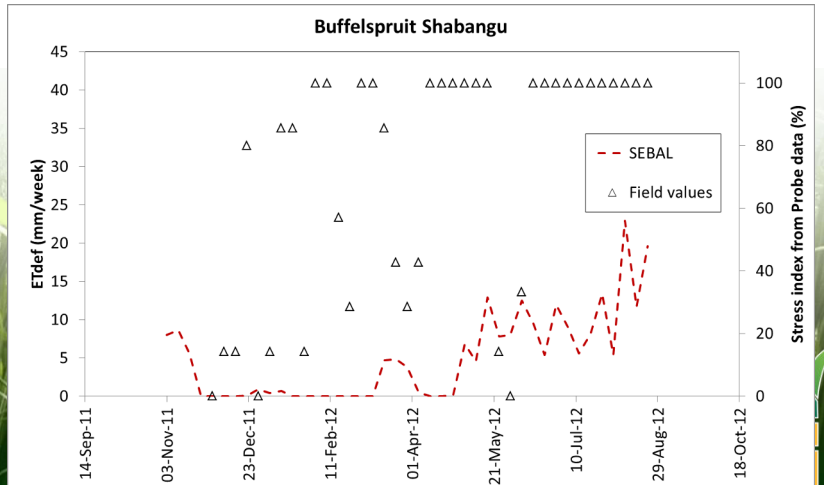


Jun12





Jul12 Aug12



Conclusions

- SEBAL estimates of ET and TDM reasonably accurate
- Substantial spatial variation in ET, TDM and BWUE in Mpumalanga sugarcane production
- Room for improving productivity and efficiency of sugarcane production
- RS is a useful tool for monitoring WUE – retrospective benchmarking, near real-time identification of problem areas
- Technology proven – requires user friendly packaging and commercialization for wide implementation

Acknowledgments

- Funding:
  - WRC and DAFF, SASRI, UKZN
  - (WRC project K5/2079//4, WRC Report No. TT 602/14)
- SASRI technical team
- Pieter Cronje of TSB
- SA Canegrowers' Association
- Sugarcane farmers

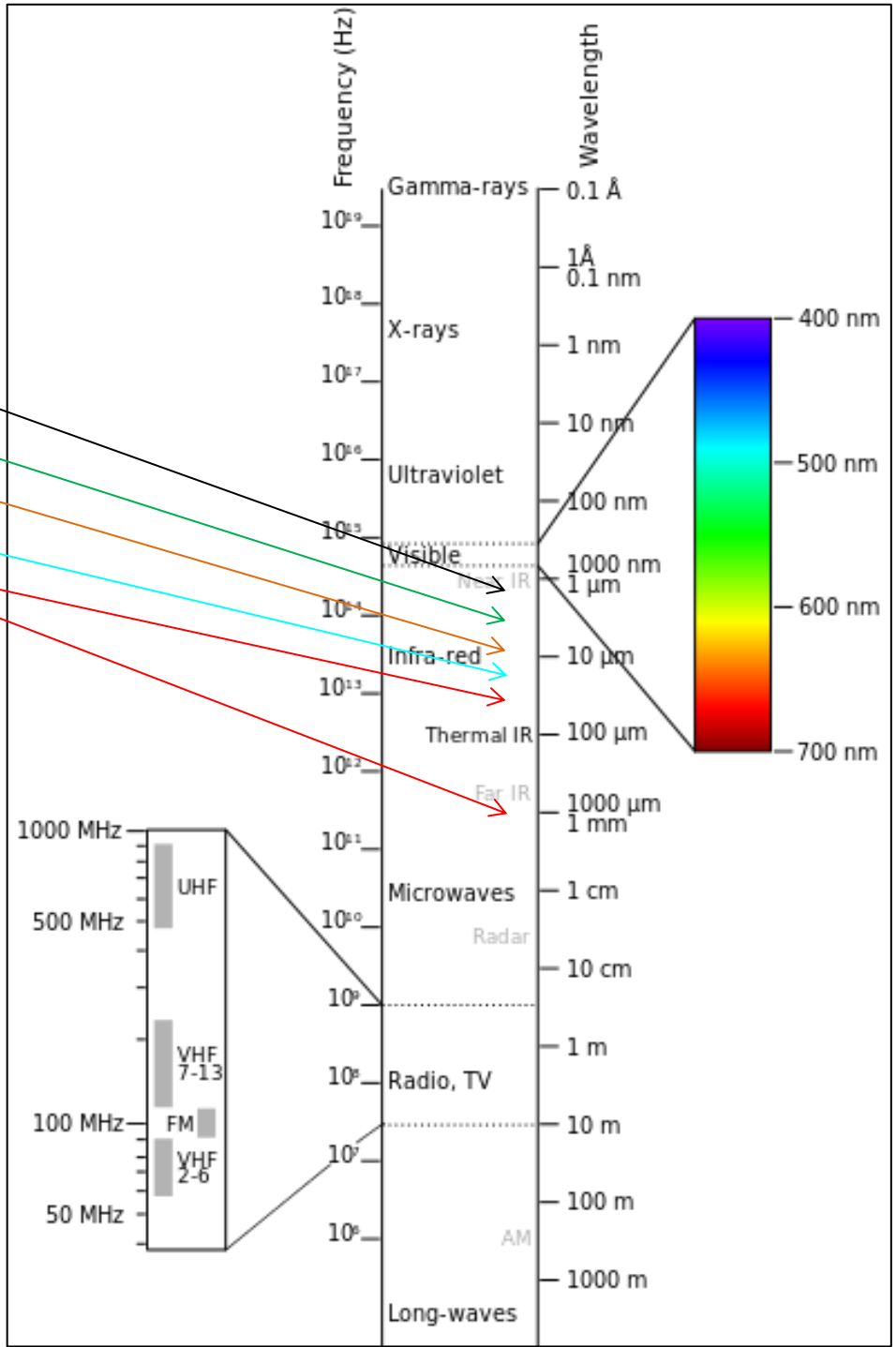
Remote sensing platforms

- Satellite
  - Landsat (30 m, ≈14 days)
  - Modis (200 m, daily)
  - Many others

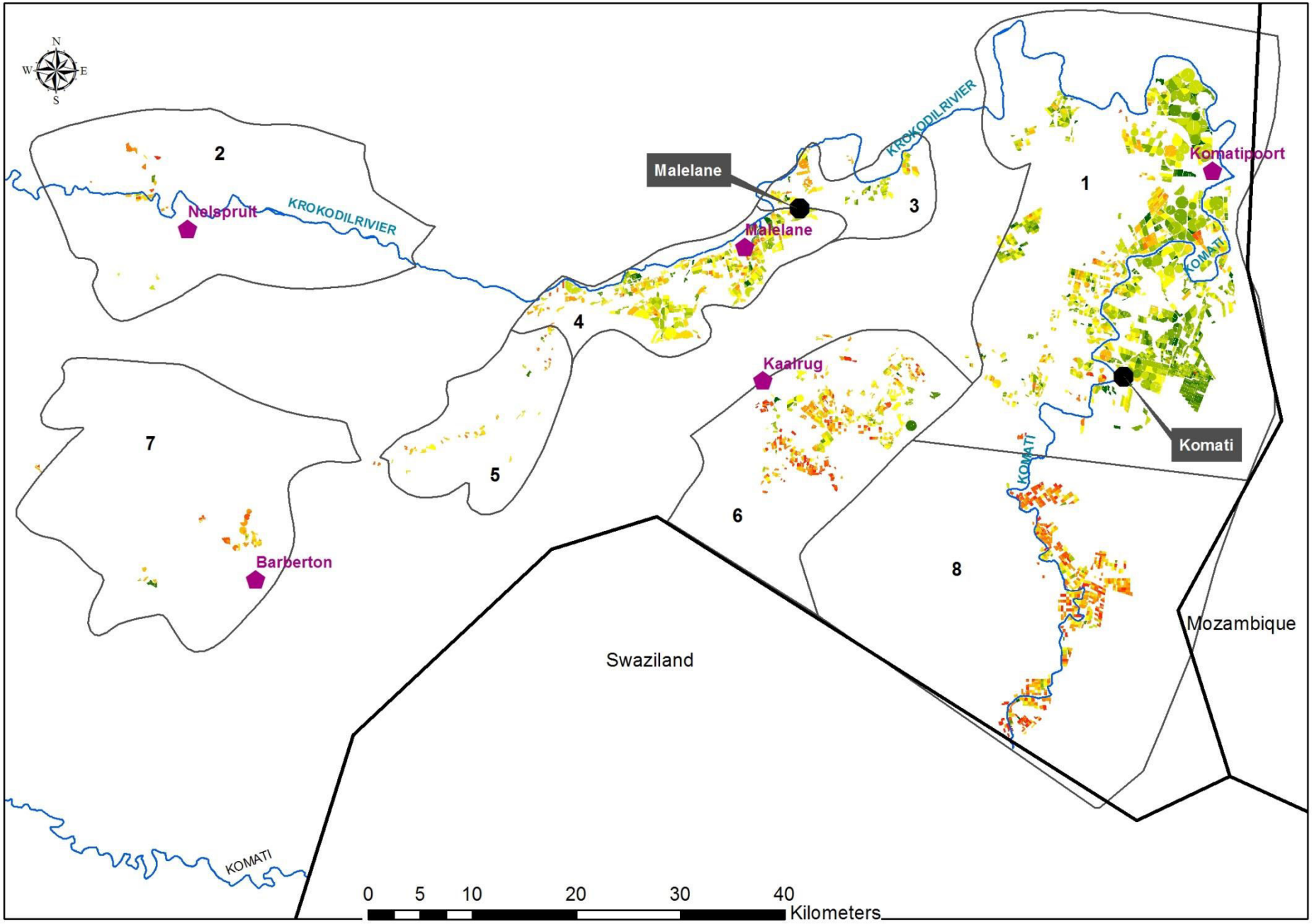
- Airborne
  - Drones

Electromagnetic radiation

NIR
SWIR
MWIR
LWIR
FIR



- All bodies emit and reflect radiation
- Body temperature determines long wave radiation
- Transpiration determines canopy temperature
- Stomatal conductance (and hence transpiration and carbon fixation) can be deduced from thermal radiation
- Combined with the energy balance, ET and biomass growth can be estimated: SEBAL, METRIC


N
W
E
S
2
Nelspruit
KROKODILRIVIER
Malelane
KROKODILRIVIER
Malelane
3
4
1
Komatipoort
KOMATI
Komati
Kaalrug
7
5
6
8
KOMATI
Barberton
Swaziland
Mozambique
KOMATI
0
5
10
20
30
40
Kilometers