

Real time comparison of measured and predicted crop transpiration in greenhouse process control

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- Application of models in commercial greenhouse control

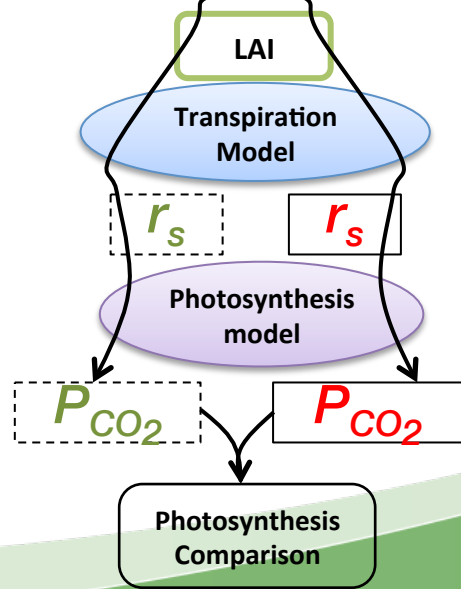
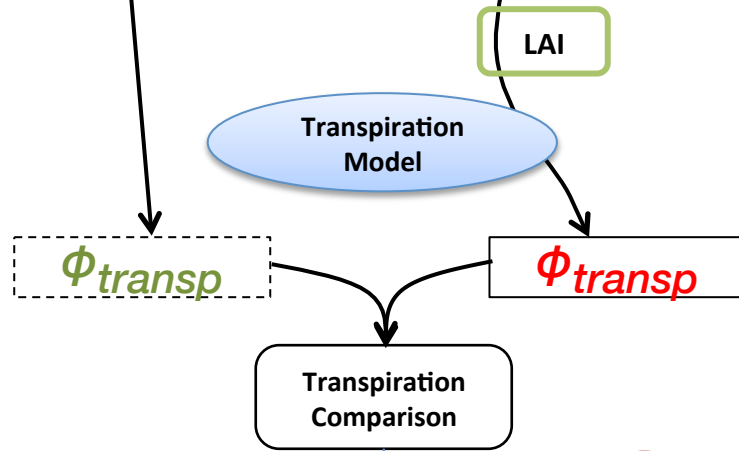
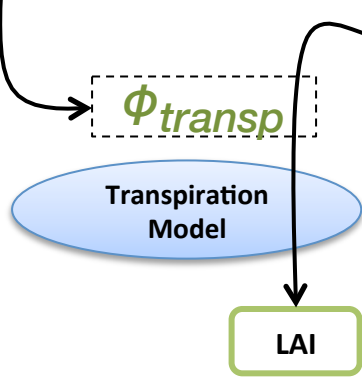
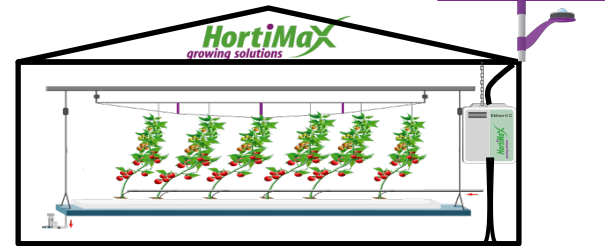
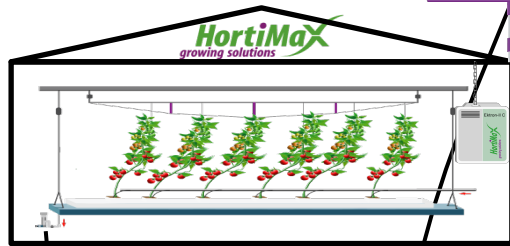
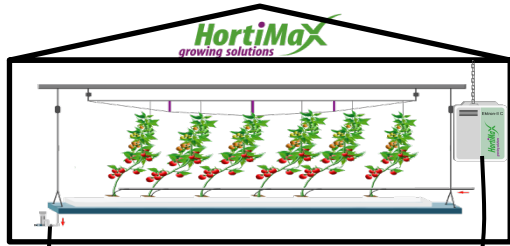
Combine transpiration model and measured data

- Provide extra information and insight to crop functioning
- Evaluate measured values
- Warning for unexpected crop functioning
- Indicate level of plant health or stress

Outline

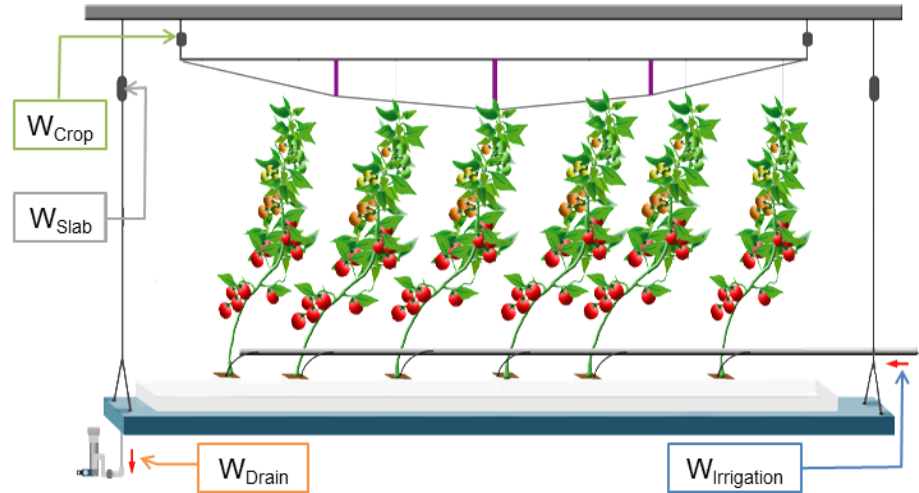
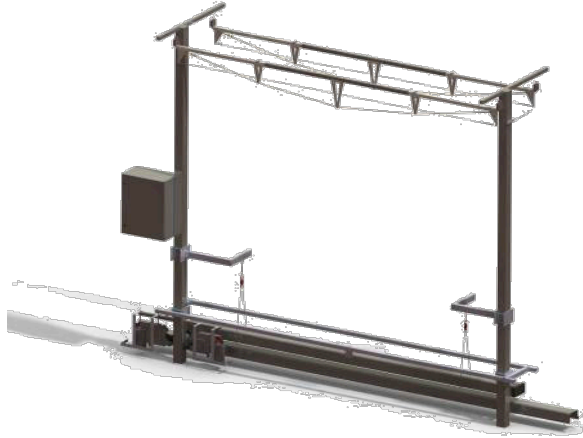
- Calibration and validation of transpiration model
- Implementation in commercial process control
- Real time comparison of measured and predicted transpiration
- Warnings when differences are detected
- Predict effect of differences on crop photosynthesis

Application of models



Transpiration Measurements

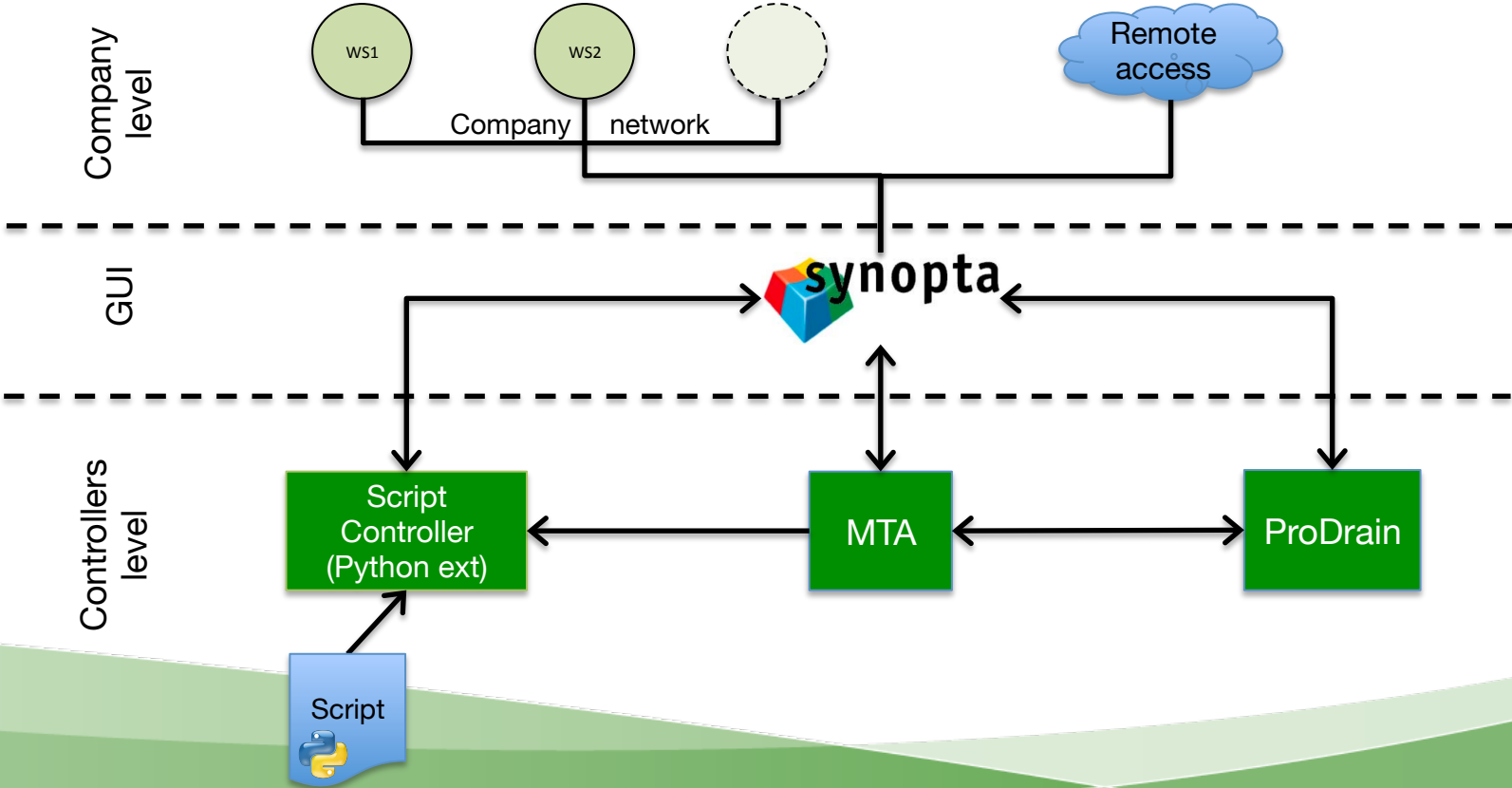
- ProDrain system



$$\frac{d(\varphi_{transp})}{dt} = \frac{d(W_{Irrigation})}{dt} - \frac{d(W_{Slab})}{dt} - \frac{d(W_{Drain})}{dt} - \frac{d(W_{Crop})}{dt}$$



Implementation in process control

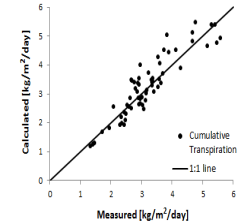
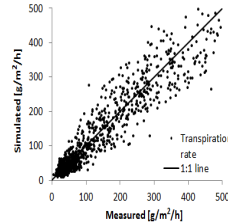
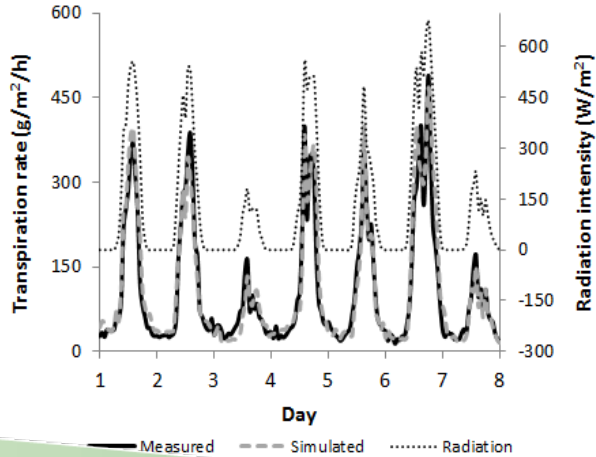


Results

- **Model Validation**

- In wide range of climate parameter values

- ✓ **Accurate transpiration prediction within and among days.**

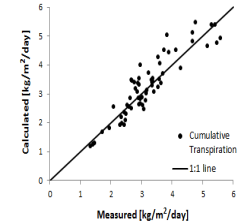
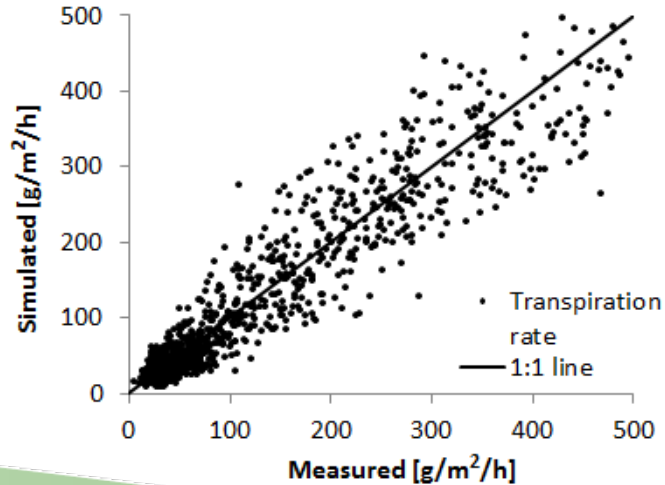
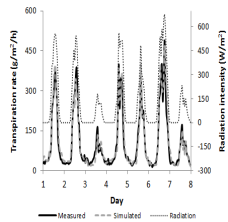


Results

- **Model Validation**

- In wide range of climate parameter values

- ✓ **Accurate transpiration prediction within and among days.**

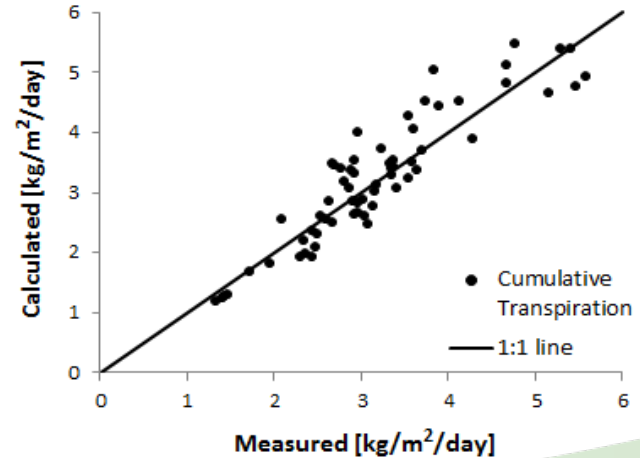
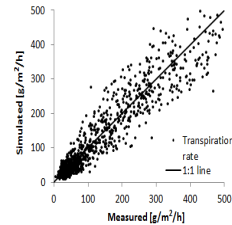
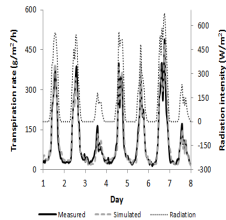


Results

- **Model Validation**

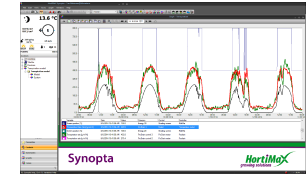
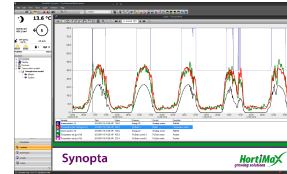
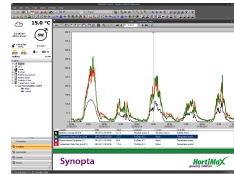
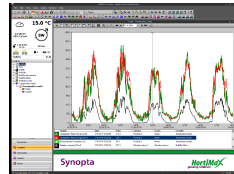
- In wide range of climate parameter values

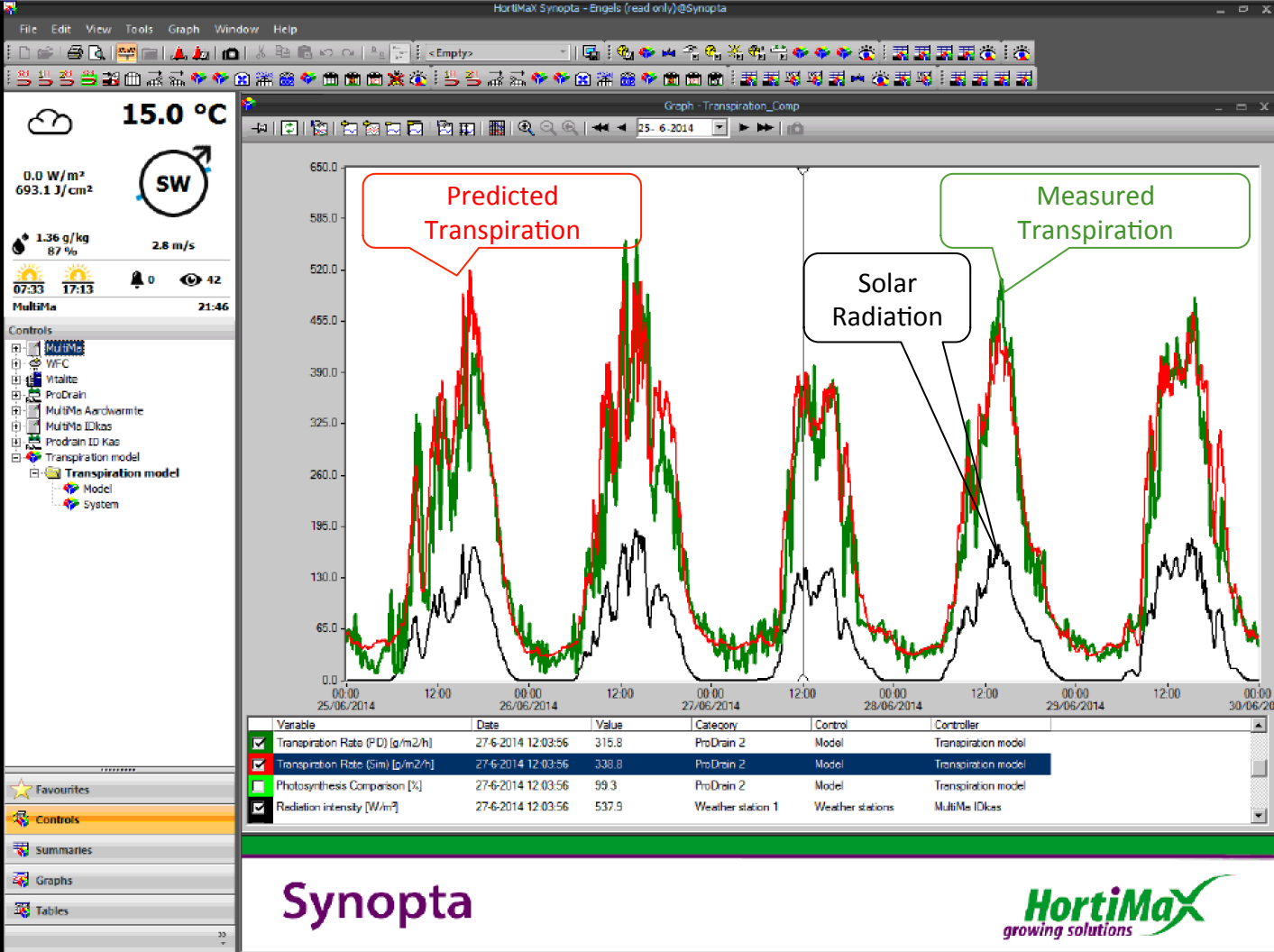
- ✓ **Accurate transpiration prediction within and among days.**



Results

- Model Implemented in commercial process control
 - ✓ Accurate real time transpiration prediction in 2 locations





Synopta

HortiMax
growing solutions

HortiMax Synopta - Engels (read only)@Synopta

File Edit View Tools Graph Window Help

Graph - Transpiration_Comp

27-8-2014

15.0 °C

0.0 W/m²
693.1 J/cm²

SW

1.36 g/kg
87 %

2.4 m/s

07:33 17:13

0 42

MultiMa 21:49

Controls

- MultiMa
- WFC
- Witalite
- ProDrain
- MultiMa Aardwarmte
- MultiMa IDkas
- Prodrain ID Kas
- Transpiration model
- Transpiration model
 - Model
 - System

Variable	Date	Value	Category	Control	Controller
<input checked="" type="checkbox"/> Radiation intensity [W/m ²]	29-8-2014 12:03:56	411.4	Weather station 1	Weather stations	MultiMa IDkas
<input checked="" type="checkbox"/> Transpiration Rate (PD) [g/m ² /h]	29-8-2014 12:03:56	173.7	ProDrain ID 2	Model	Transpiration model
<input type="checkbox"/> Photosynthesis Comparison [%]	29-8-2014 12:03:56	99.6	ProDrain ID 2	Model	Transpiration model
<input checked="" type="checkbox"/> Transpiration Rate (Sim) [g/m ² /h]	29-8-2014 12:03:56	176.2	ProDrain ID 2	Model	Transpiration model

Favourites

Controls

Summaries

Graphs


Tables

Synopta

HortiMax
growing solutions

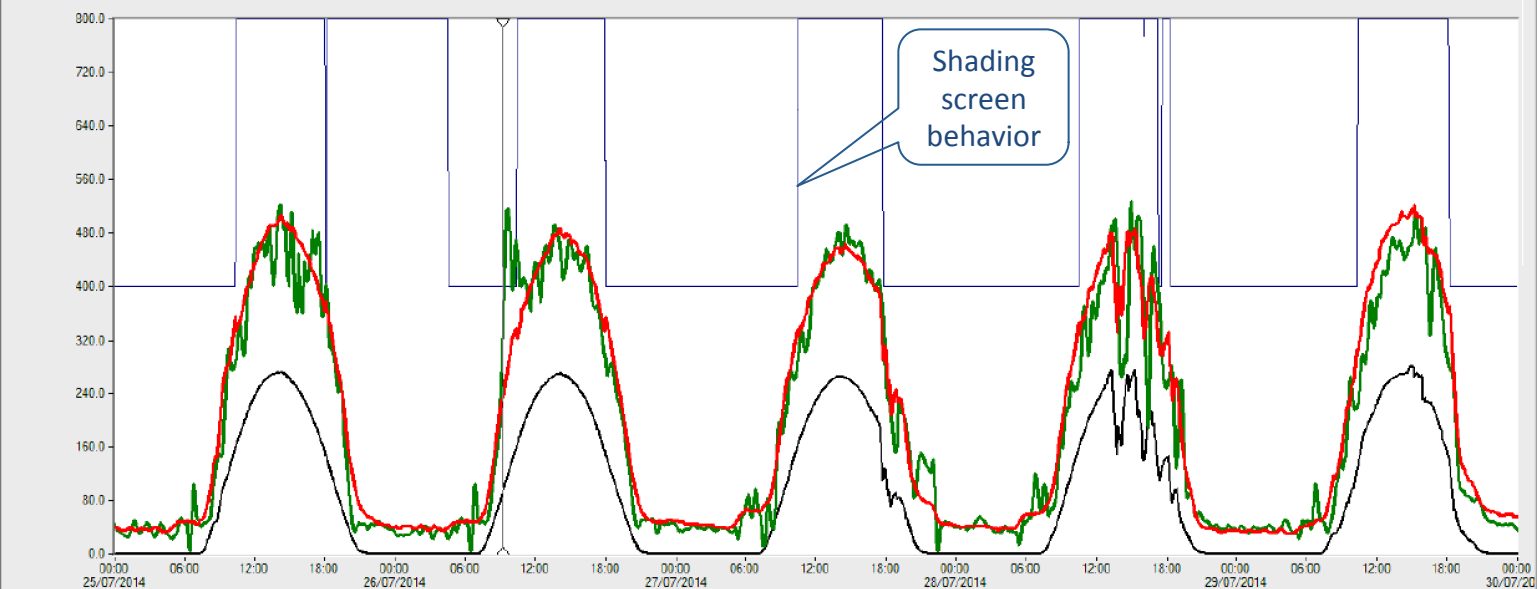
F1: Synopta help, Ctrl+F1: Variables help

CAP NUM: SCR1

 **13.6 °C**
 0.0 W/m²
 0.0 J/cm² ← **E** →
 3.69 g/kg
 66 %
 2.3 m/s
 07:07 18:02
 MultiMa 04:08

Controls
 MultiMa
 VitaLite
 Prodrain
 Transpiration model
 Model
 System

Favourites
 Controls
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 Tables



Variable	Date	Value	Category	Control	Controller
<input checked="" type="checkbox"/> Transpiration rate [g/m ² /h]	7/26/2014 9 14 31 AM	355.2	ProDrain control 1	ProDrain meter	Prodrain
<input checked="" type="checkbox"/> Transpiration Rate (Sim) [g/m ² /h]	7/26/2014 9 14 31 AM	238.1	ProDrain 1	Model	Transpiration model
<input checked="" type="checkbox"/> Radiation intensity [W/m ²]	7/26/2014 9 14 31 AM	348.5	Meteo Tech Building	Weather stations	MultiMa
<input checked="" type="checkbox"/> Screen position [%]	7/26/2014 9 14 31 AM	0.0	Energy 30	Shading screen	MultiMa

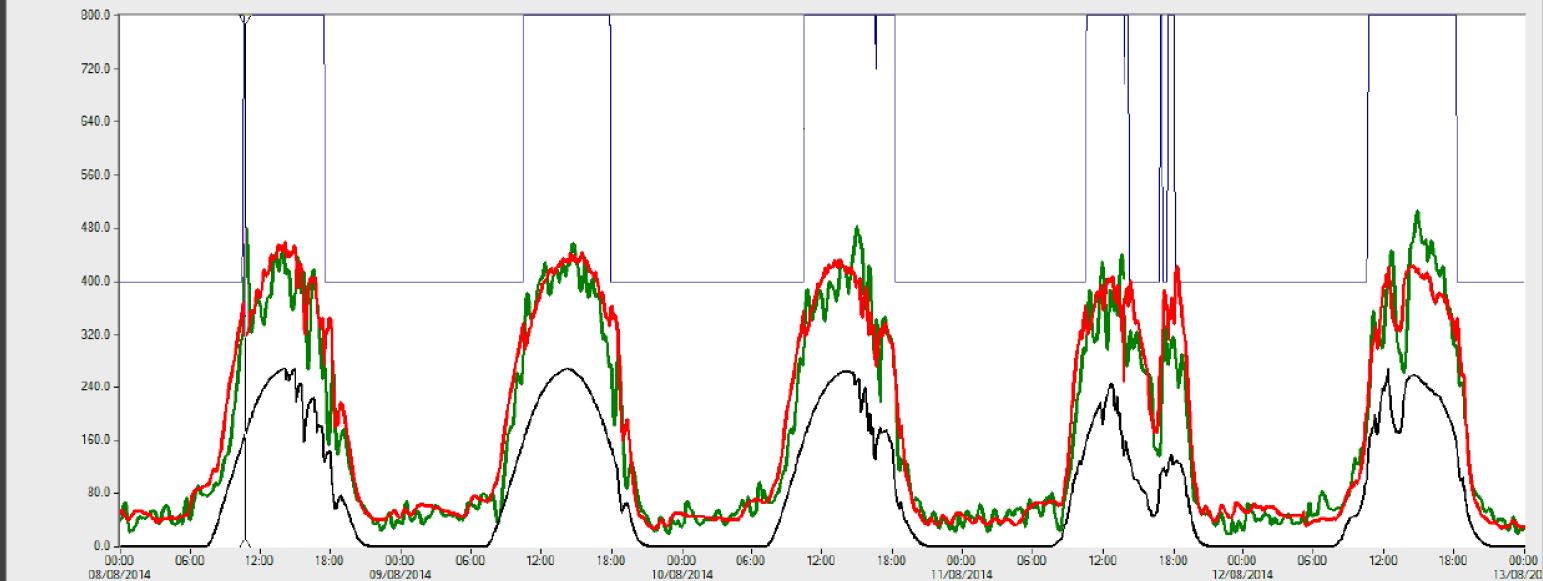
Synopta

HortiMax
growing solutions

13.6 °C
0.0 W/m²
0.0 J/cm²

3.69 g/kg
66 %
4.5 m/s
07:07 **18:02**
MultiMa **04:16**

- Controls
- MultiMa
 - VitaLite
 - Prodrain
 - Transpiration model
 - Model
 - System



Variable	Date	Value	Category	Control	Controller
<input type="checkbox"/> Screen position [%]	8/8/2014 10:41:06 AM	100.0	Energy 30	Shading screen	MultiMa
<input checked="" type="checkbox"/> Transpiration Rate (Sim) [g/m ² /h]	8/8/2014 10:41:06 AM	320.5	ProDrain 3	Model	Transpiration model
<input type="checkbox"/> Screen position [%]	8/8/2014 10:41:06 AM	100.0	Energy 23	Shading screen	MultiMa
<input checked="" type="checkbox"/> Transpiration rate [g/m ² /h]	8/8/2014 10:41:06 AM	432.8	ProDrain control 3	ProDrain meter	Prodrain
<input type="checkbox"/> Transpiration rate [g/m ² /h]	8/8/2014 10:41:06 AM	273.4	ProDrain control 2	ProDrain meter	Prodrain

- Favourites
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Synopta

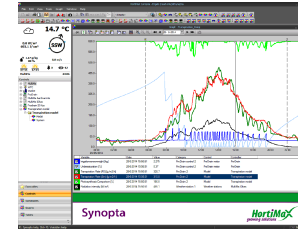
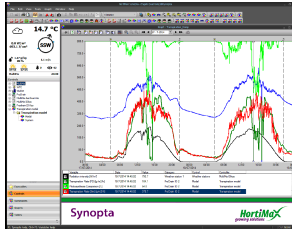


Results

- Model Implemented in commercial process control
 - ✓ Warnings for unexpected transpiration

- Unexpected stomata closure

- Inadequate water supply



15.0 °C

0.0 W/m²
680.9 J/cm²

3.11 g/kg
71 %

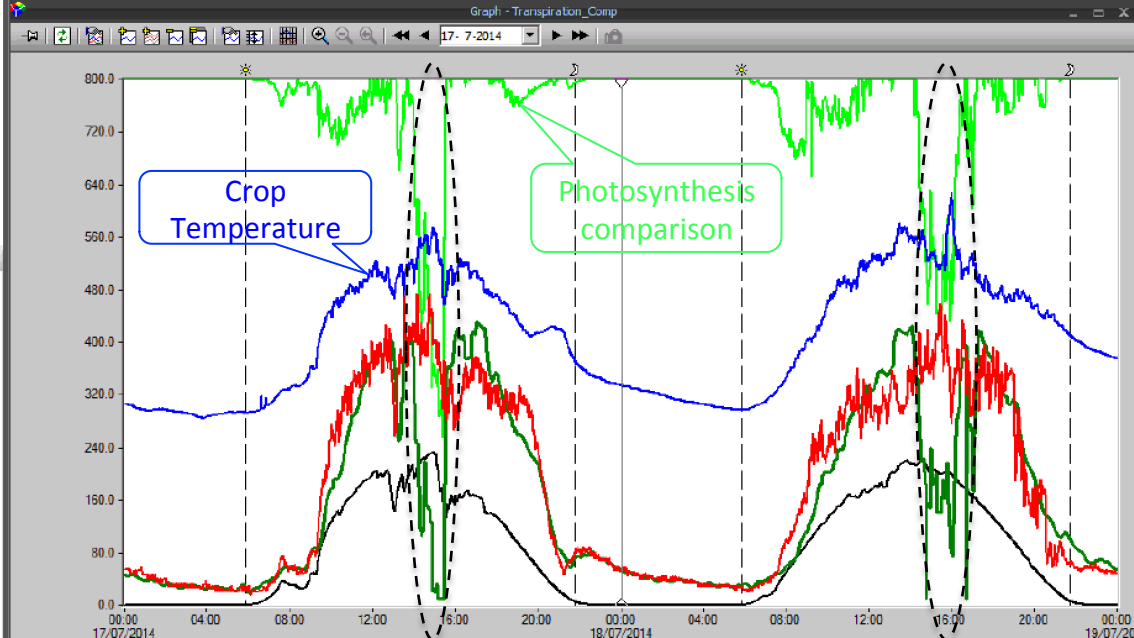
5.9 m/s

07:35 17:12

MultiMa 20:17

- Controls
- MultiMa
 - WFC
 - Vitalite
 - ProDrain
 - MultiMa Aardwarmte
 - MultiMa IDkas
 - Prodrain ID Kas
 - Transpiration model
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Variable	Date	Value	Category	Control	Controller
Air temperature [°C]	18-7-2014 0:01:34	20.9	IR 42	Sensor unit	MultiMa IDkas
Radiation intensity [W/m ²]	18-7-2014 0:01:34	0.0	Weather station 1	Weather stations	MultiMa IDkas
Transpiration Rate (PD) [g/m ² /h]	18-7-2014 0:01:34	42.3	ProDrain ID 2	Model	Transpiration model
Transpiration Rate (Sim) [g/m ² /h]	18-7-2014 0:01:34	53.5	ProDrain ID 2	Model	Transpiration model
Photosynthesis Comparison [%]	18-7-2014 0:01:34	100.0	ProDrain ID 2	Model	Transpiration model

Synopta

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14.7 °C

0.0 W/m²
693.1 J/cm²

SSW

1.17 g/kg
89 %

0.8 m/s

07:33 17:13

0 42

MultMa 23:06

- Controls
- MultMa
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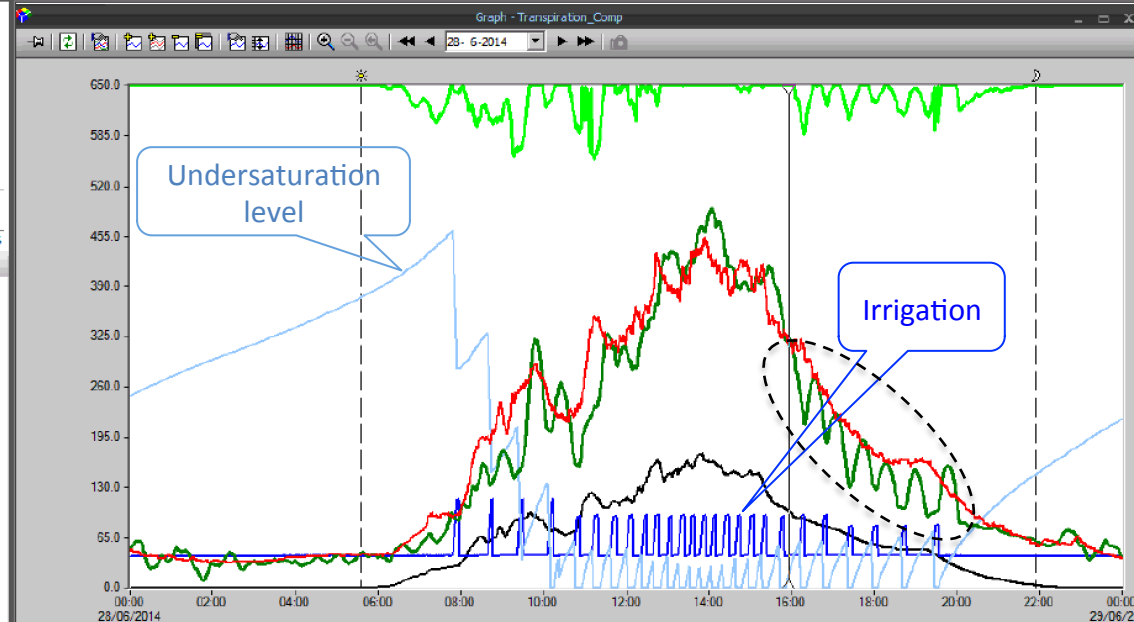
Favourites

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Variable	Date	Value	Category	Control	Controller
<input checked="" type="checkbox"/> Irrigation sensor weight [kg]	28-6-2014 15:56:51	2.275	Pro Drain control 2	Pro Drain motor	Pro Drain
<input checked="" type="checkbox"/> Undersaturation [%]	28-6-2014 15:56:51	0.37	Pro Drain control 2	Pro Drain meter	Pro Drain
<input checked="" type="checkbox"/> Transpiration Rate (PD) [g/m ² /h]	28-6-2014 15:56:51	328.7	Pro Drain 2	Model	Transpiration model
<input checked="" type="checkbox"/> Transpiration Rate (Sim) [g/m ² /h]	28-6-2014 15:56:51	310.8	Pro Drain 2	Model	Transpiration model
<input checked="" type="checkbox"/> Photosynthesis Comparison [%]	28-6-2014 15:56:51	100.0	Pro Drain 2	Model	Transpiration model
<input checked="" type="checkbox"/> Radiation intensity [W/m ²]	28-6-2014 15:56:51	455.1	Weather station 1	Weather stations	MultMa IDkas

Synopta

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Conclusions

- ✓ Tomato transpiration was predicted accurately
- ✓ Applied in commercial greenhouses
- ✓ Real time predictions in different locations, greenhouses and varieties
- ✓ Warnings inform the grower for unexpected crop behavior
- ✓ Feedback on possible effects on photosynthesis

The end!

Thank you for
your attention!

Questions...?

