Wireless Sensor Networks for Deficit Irrigation Management

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WAGENINGEN UR
For quality of life

FLOW AID

Outline

- Deficit Irrigation
- Setup of the Flow-Aid system
- Wireless Sensor Networks demands
- Experimental setup
- Results
- Conclusions
- Current on-going work

Full (over) irrigation …

… in cases of high (fresh) water availability

- Used water amounts depend on availability
- Leaching or run-off of water and nutrients

We need precise control of soil water

Deficit Irrigation …

…if water availability and irrigation water quality is low

- Use of marginal water resources
- Yield losses and crop damages (EC rises)

We need precise control of soil water and EC

Objectives of FLOW-AID project

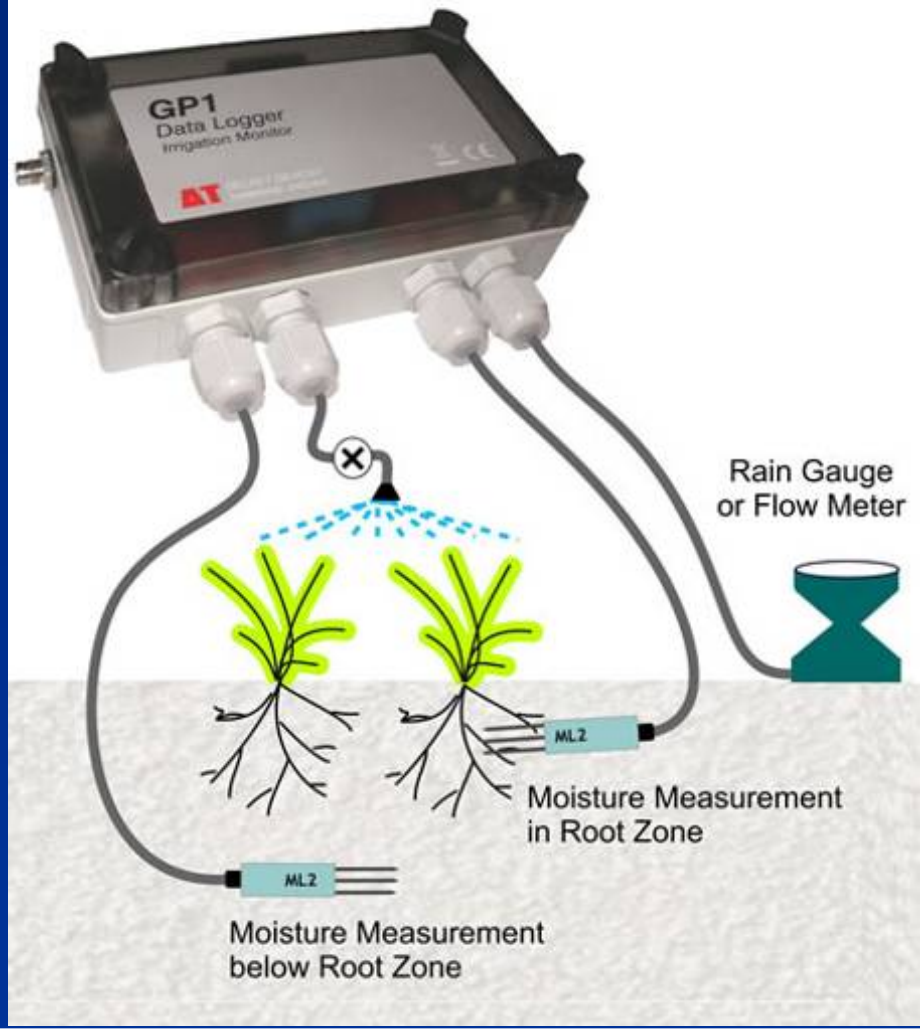
- Efficient use of fresh water resources
- Rational use of nutrients and marginal water resources
- Affordable and Simple Farm-level Irrigation Tools
  - Decision Support System (software)
  - Tools to determine amount and source of water (hardware)

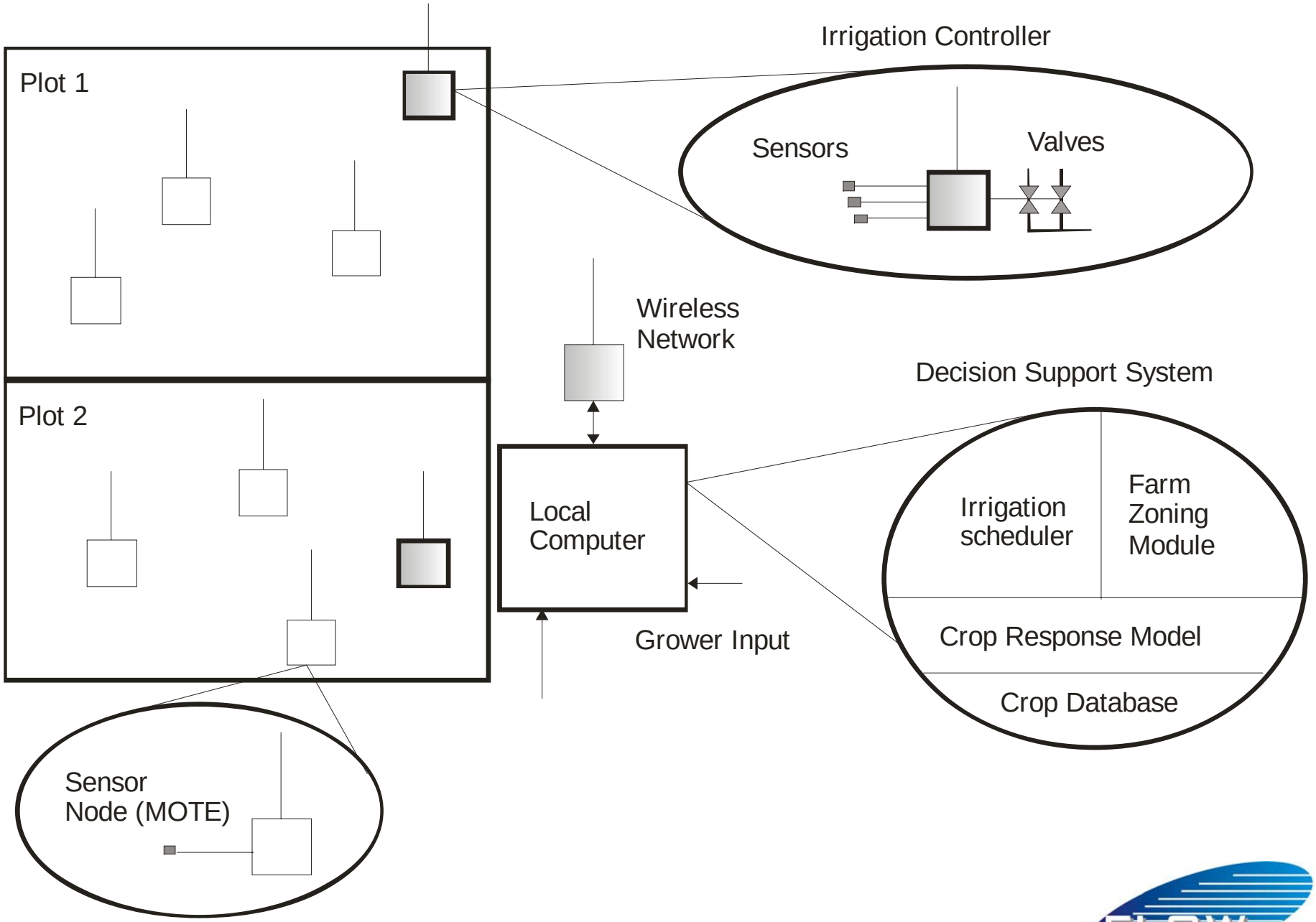
Decision Support System (Local)

- Annual Planning
  - Farm Zoning
  - Crop Planning
- Day to day planning
  - Short-term Water Availability
  - Weather Forecasts
  - Plant Status (Crop Model)
  - Allocate water (amount) and
  - Nutrients (source and mixture)
  - Irrigation Scheduler
  - Set (remote) Irrigation Controllers

Irrigation Controllers (Remote and Wireless)

- Irrigation – Fertigation
  - Individual Farm Zones
  - Stand-alone operation
  - Parameterized
- Activation On/Off
  - Timed
  - Sensor controlled
  - Model based (f.i. ET)
  - Multiple valves (water sources)




Irrigation Controller
Plot 1
Sensors
Valves
Wireless
Network
Decision Support System
Plot 2
Local
Computer
Irrigation
scheduler
Farm
Zoning
Module
Crop Response Model
Crop Database
Grower Input
Sensor
Node (MOTE)

Wireless Networks: Why ?

- Precision Irrigation needs a high spatial and temporal density of information
  - Multiple Zones (different soils and crops)
  - Multiple Sensors (inner plot variability)

- Wireless Advantages
  - No cabling (interference with soil treatments)
  - Easy installation and handling (labor costs)

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- BUT we need: Robustness and Low Costs

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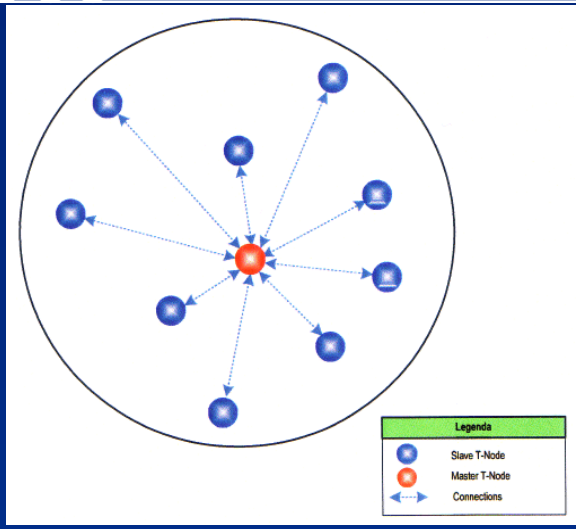
Wireless Network Configuration Types

- Star type
  - Nodes have direct communication



Wireless Network Configuration Types

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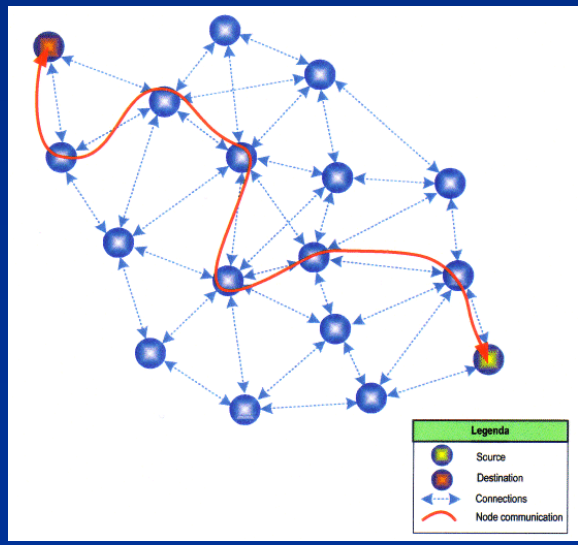
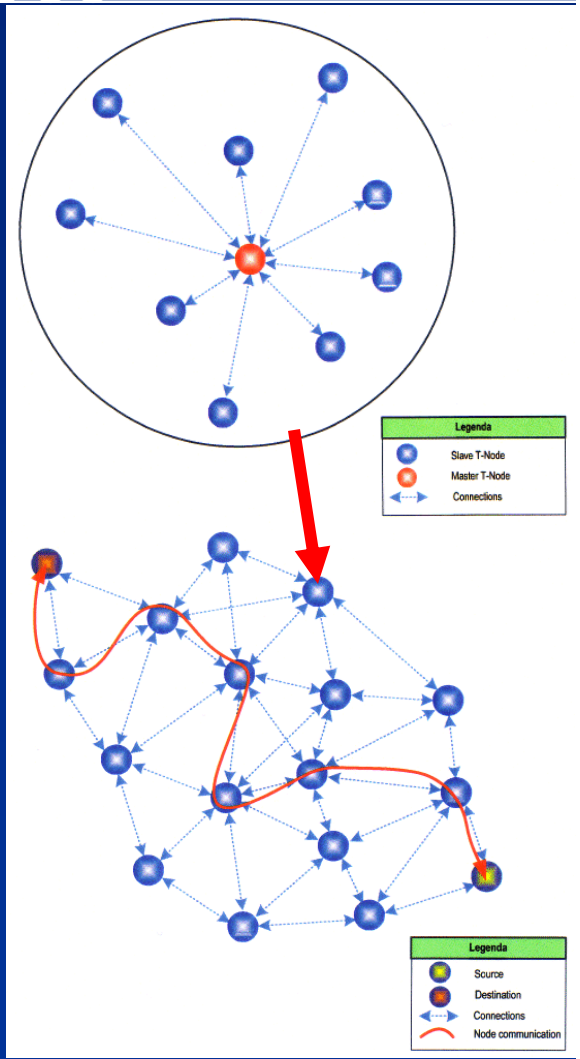
  - Nodes have direct communication
- MESH
  - Nodes have indirect communication (hopping)



Wireless Network Configuration Types

- Star type
  - Nodes have direct communication
- MESH
  - Nodes have indirect communication (hopping)
- Hybrid
  - Controllers use a Mesh (hopping)
  - Sensor Nodes communicate directly to Controller Nodes (Star)



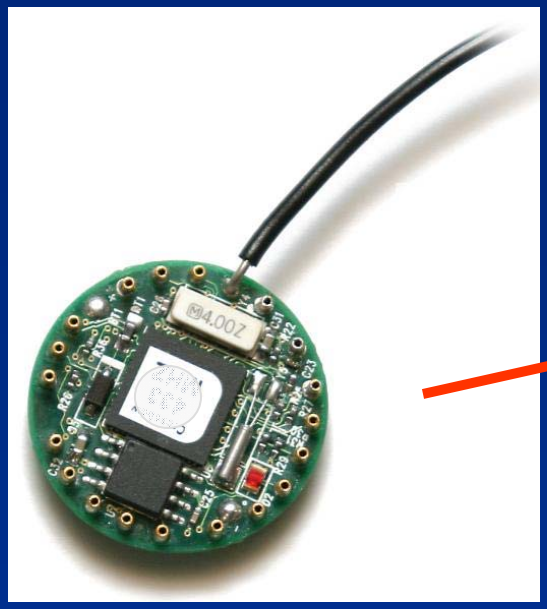
Requirements for different Farming Systems

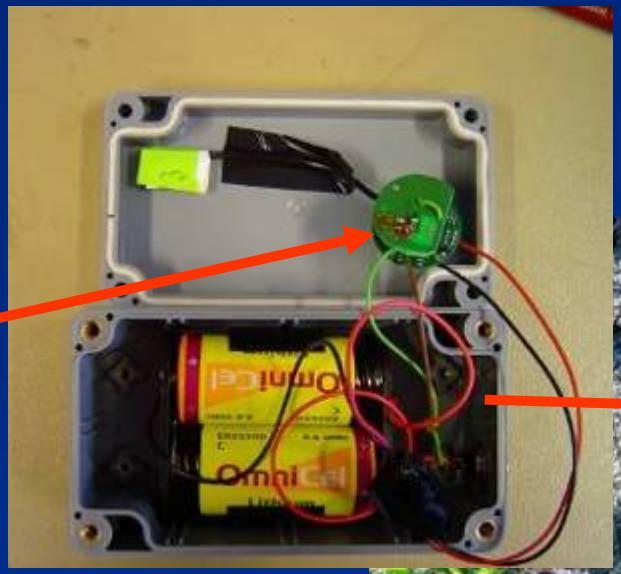
	Open field	Greenhouses	Container crops
Farm size	10 - 100 ha	1 - 10	ha
Irrigation unit size	3000 m^2	300	m^2
Spatial sensor resolution	10 / ha	100 / ha	1/100 m^2 = 100 / ha
Range	100 - 500 m	10 m	- 50 m
Sample frequency	6 hours (down to 15 m.)	1 hour	(down to 1 minute)

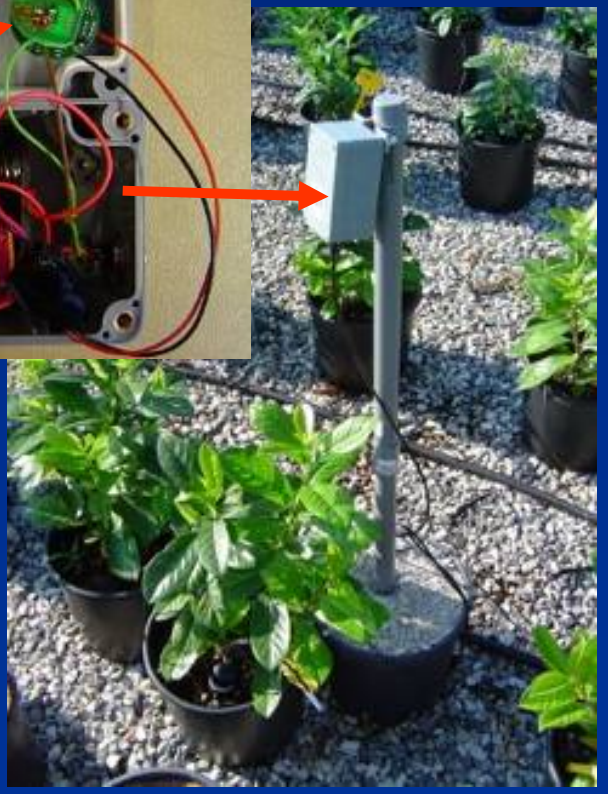
Wireless System Demands

- Communication Robustness: < 5% data loss
- Range: 10-500m (using hopping)
- Maintenance free operation: 4-8 months
- Oudoor Usefullnes: All weather conditions
- Connectivity: easy connection to PC/internet
- Low Cost: a user price preferably around € 100

Sensor Node Design







- Mini TX/RX + analog interface
  TNODE: Texas Instruments CC1000, 866MHz, 1.5 mW at 17.8 mA (lowest!)
  SOWNET Technologies BV, NL

SOWNet technologies

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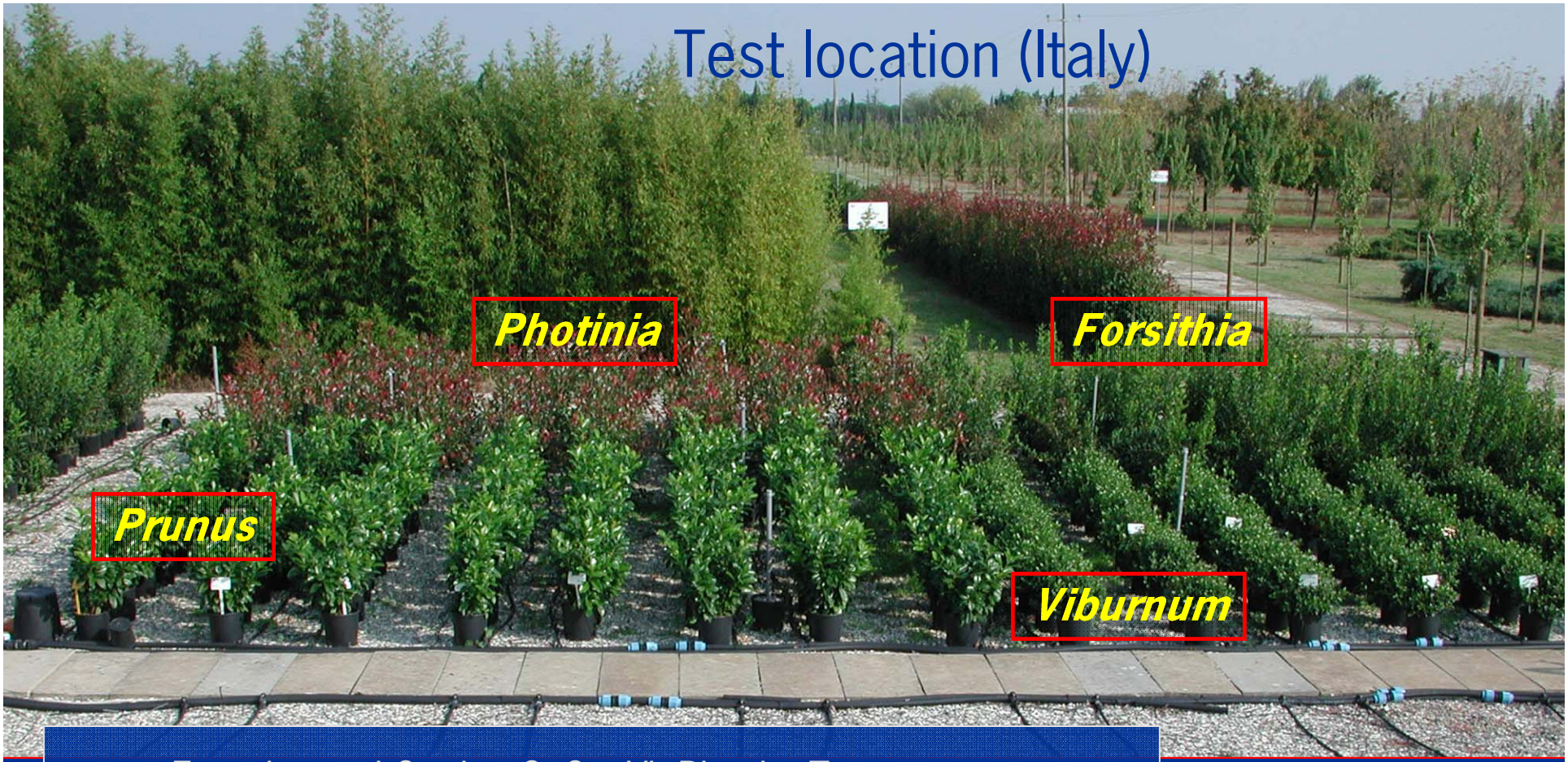
Sensor Node Design

SM200 Volumetric Water Content

DeltaT-Devices, UK

Test location (Italy)



- Experimental Station CeSpeVi, Pistoia, Tuscany
- Nursery stock production
- Container plants (drip/sprinkler, peat-pumice)
- Irrigation unit size: approx. 1200 m2
- Irrigation target: zero-drain
- Dual water irrigation: Cleaned Waste Water and Fresh Water

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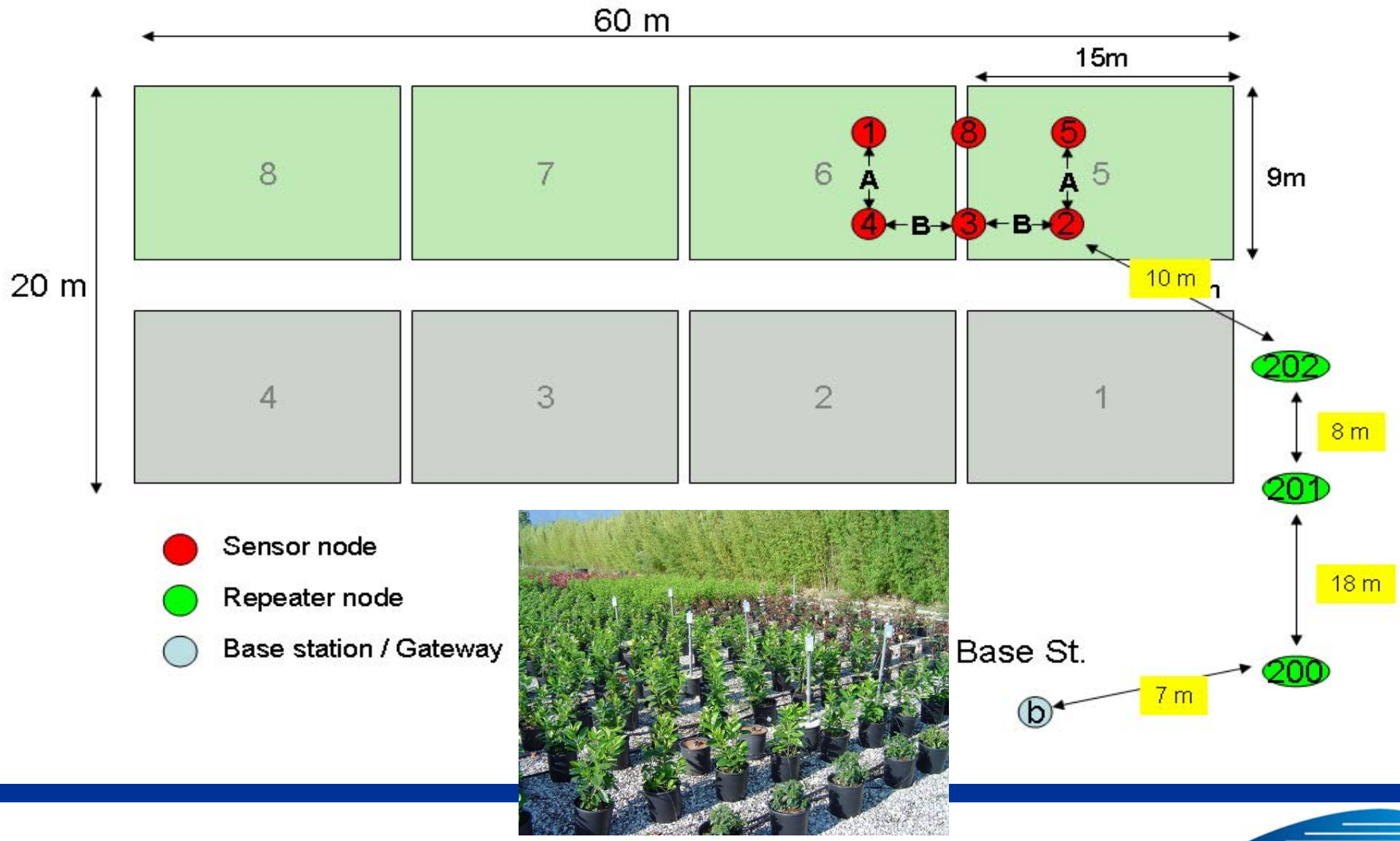
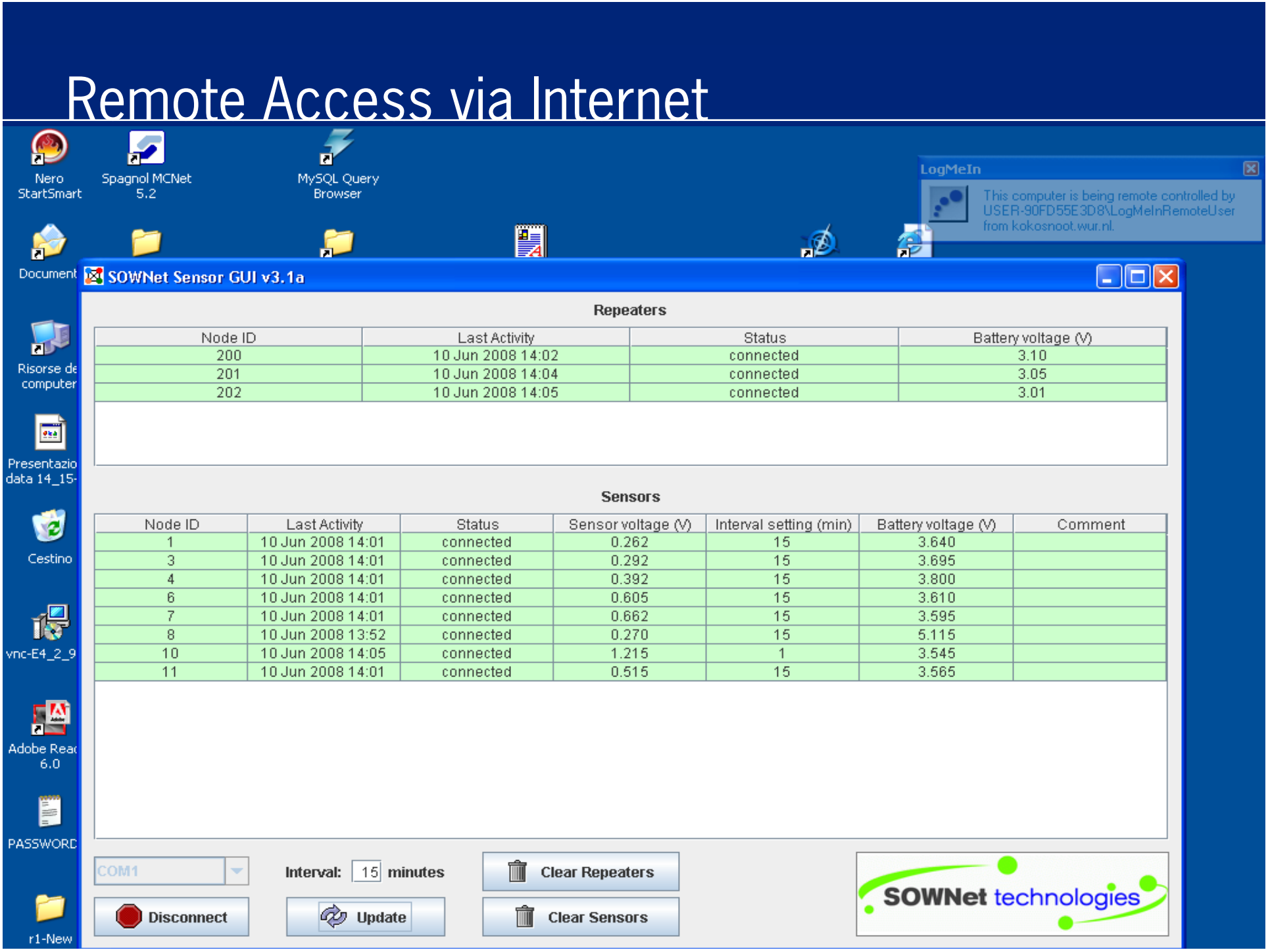
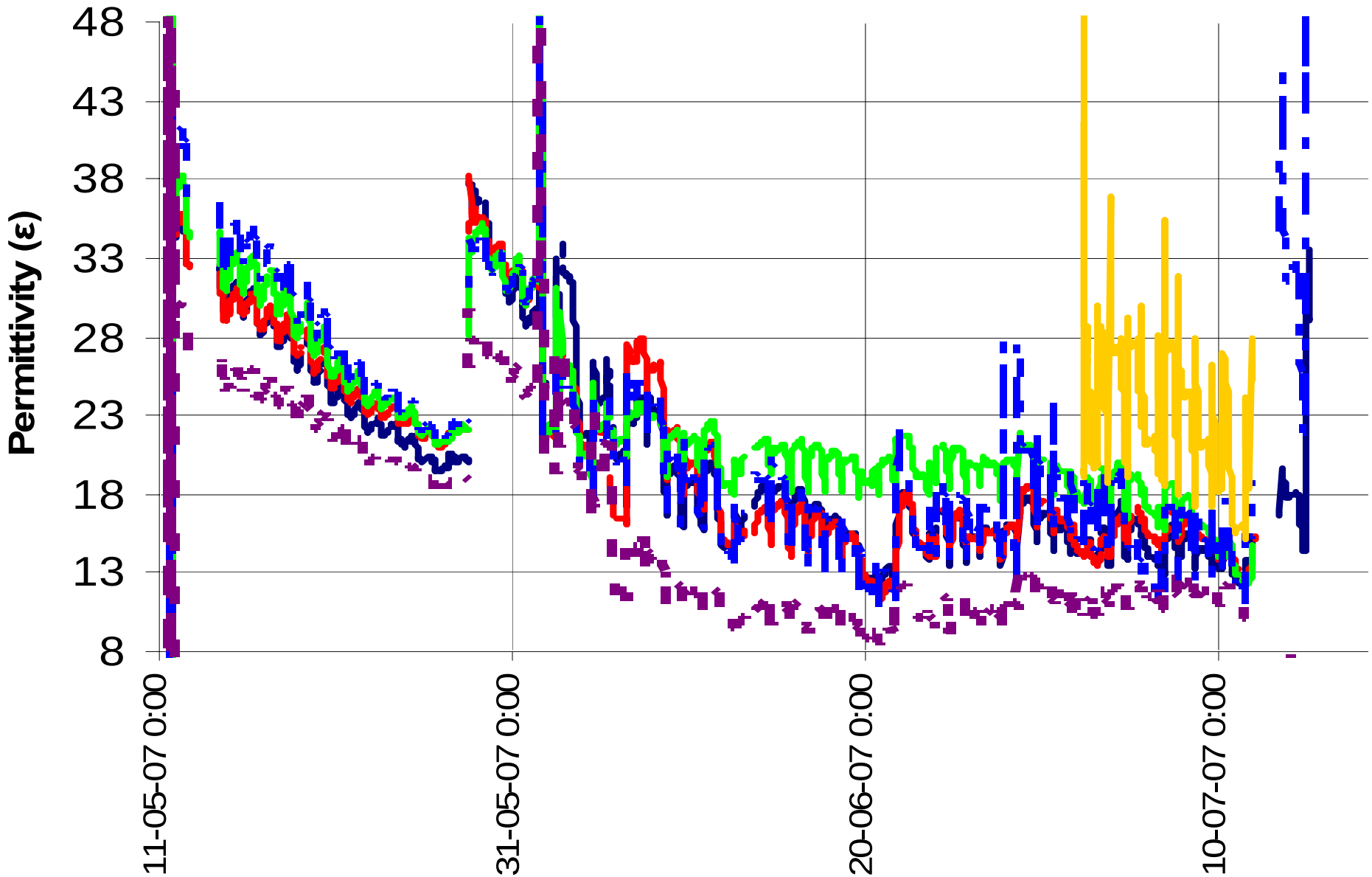
Experimental layout (Hybrid)



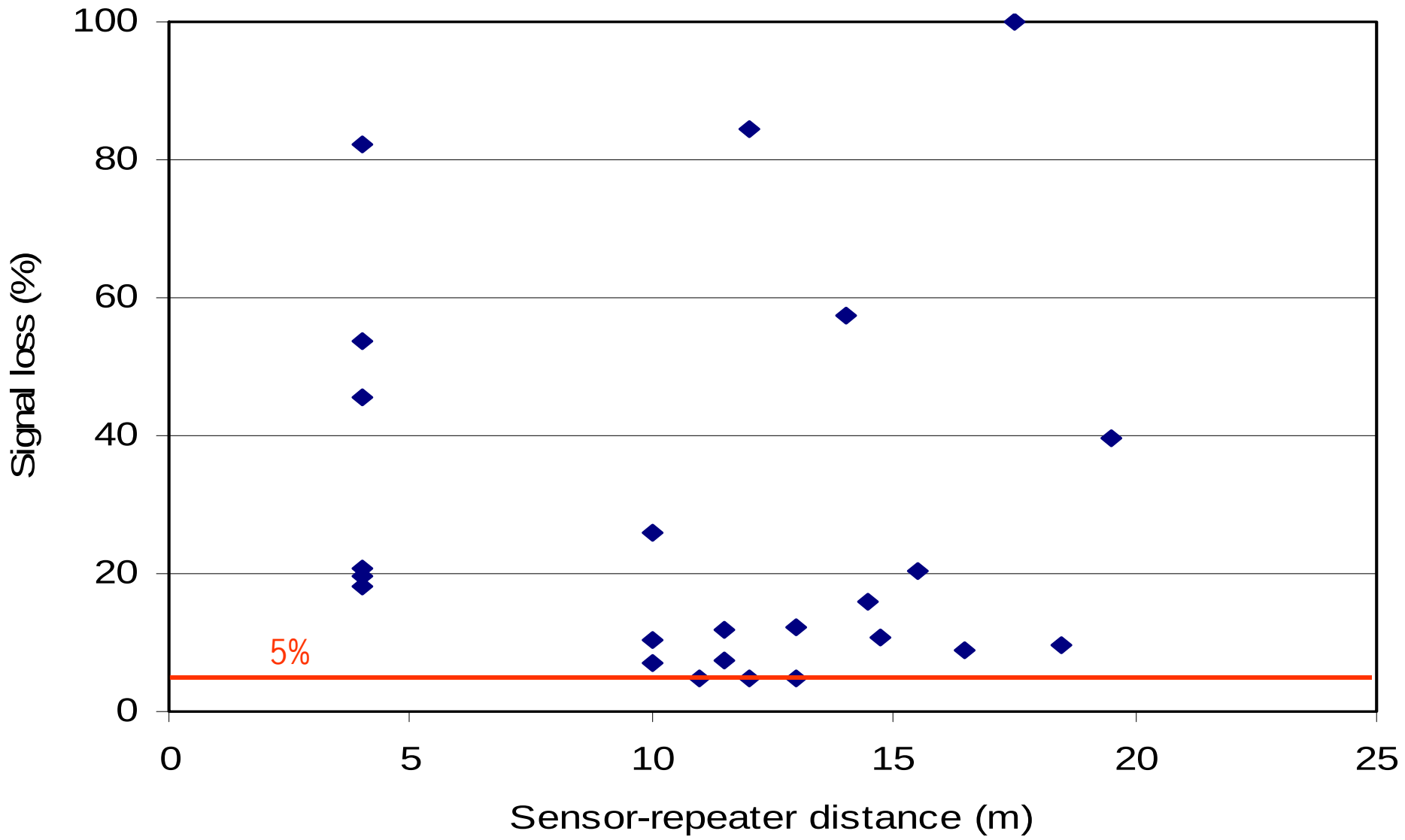
Remote Access via Internet



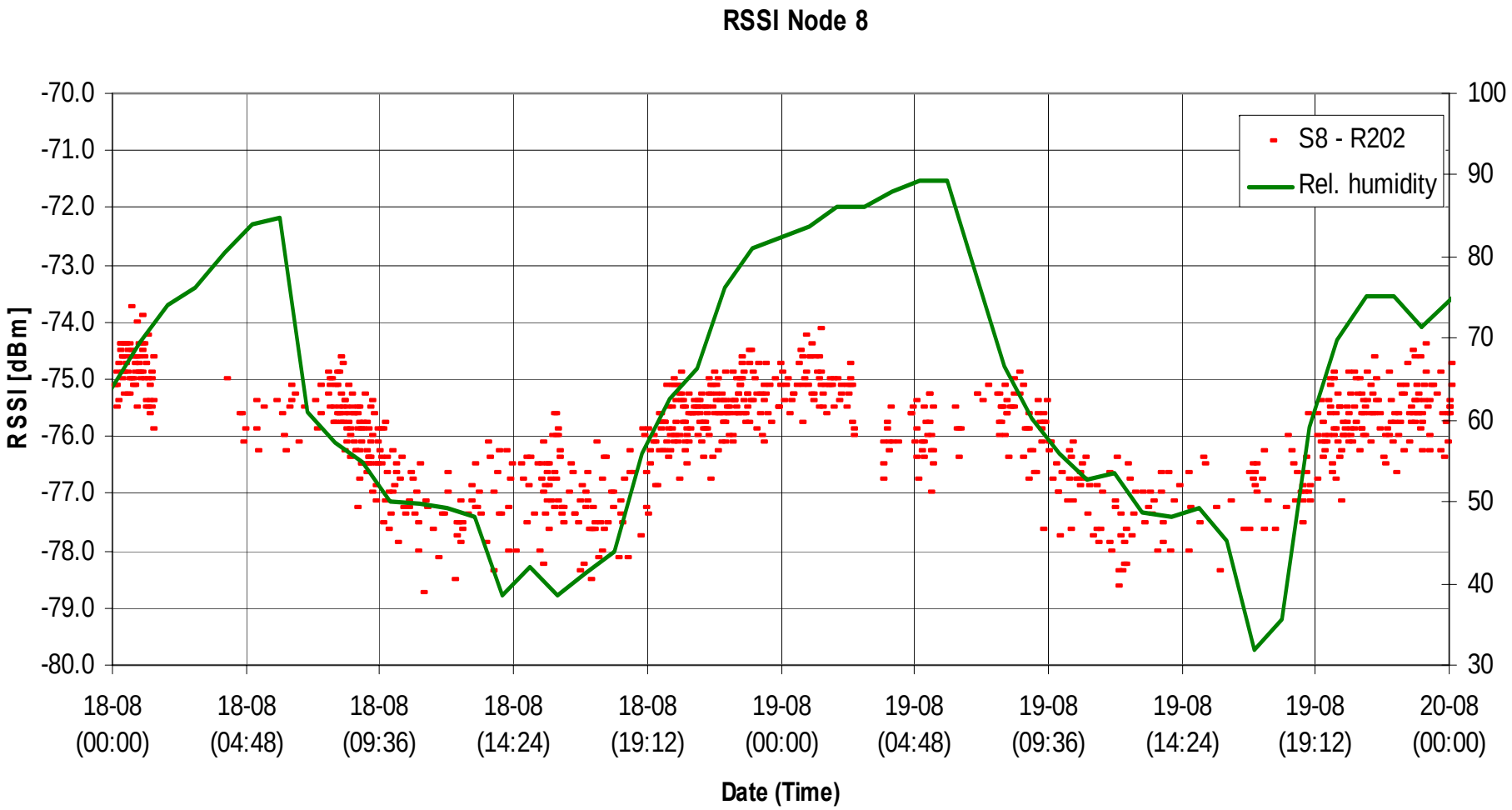
Results of SM200 readings



Number of Lost Data Packets



Signal Strength versus Relative Humidity



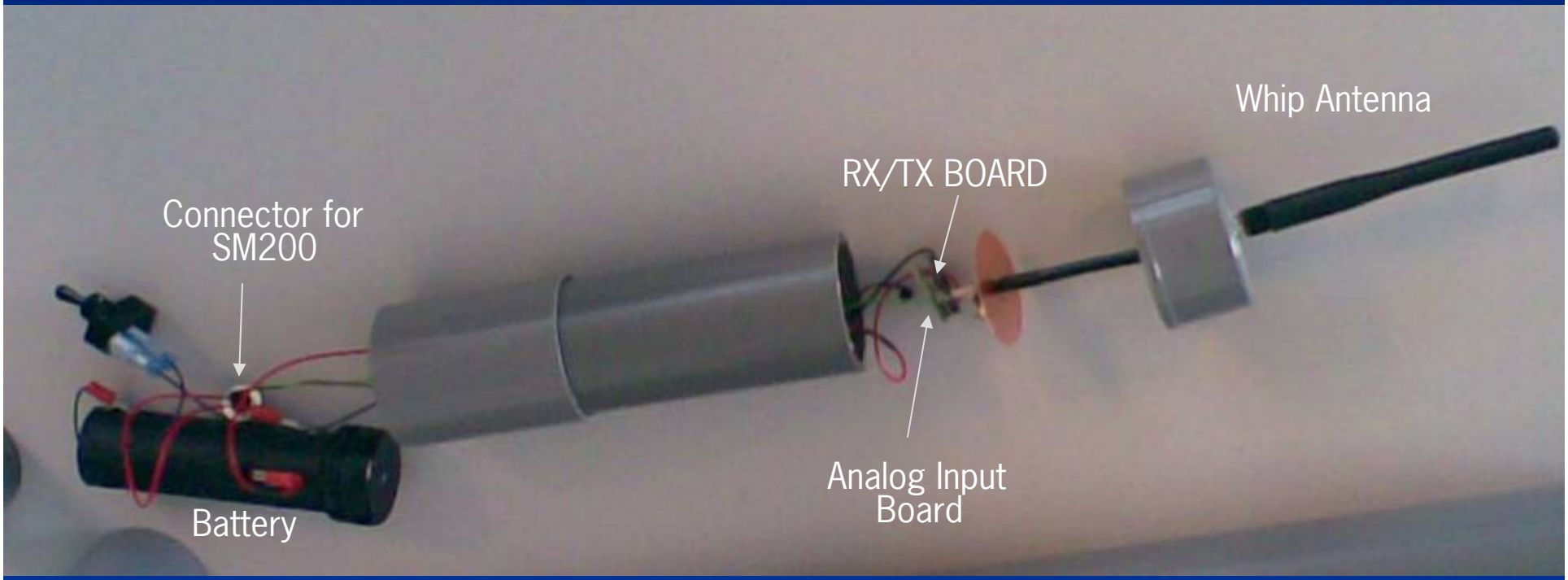
Conclusion

- Communication Robustness
  - Bad (5 -100% data loss)
- Range
  - ~ 10m
- Battery Lifetime
  - ~ 4.5 months, 15 min. frequency
- Oudoor use
  - Battery failure due to direct radiation (heating)
  - Humidity: small effects
- Connectivity
  - Good
- Cost Price
  - High: ~ €300 (sensor, batteries)

Recommendations

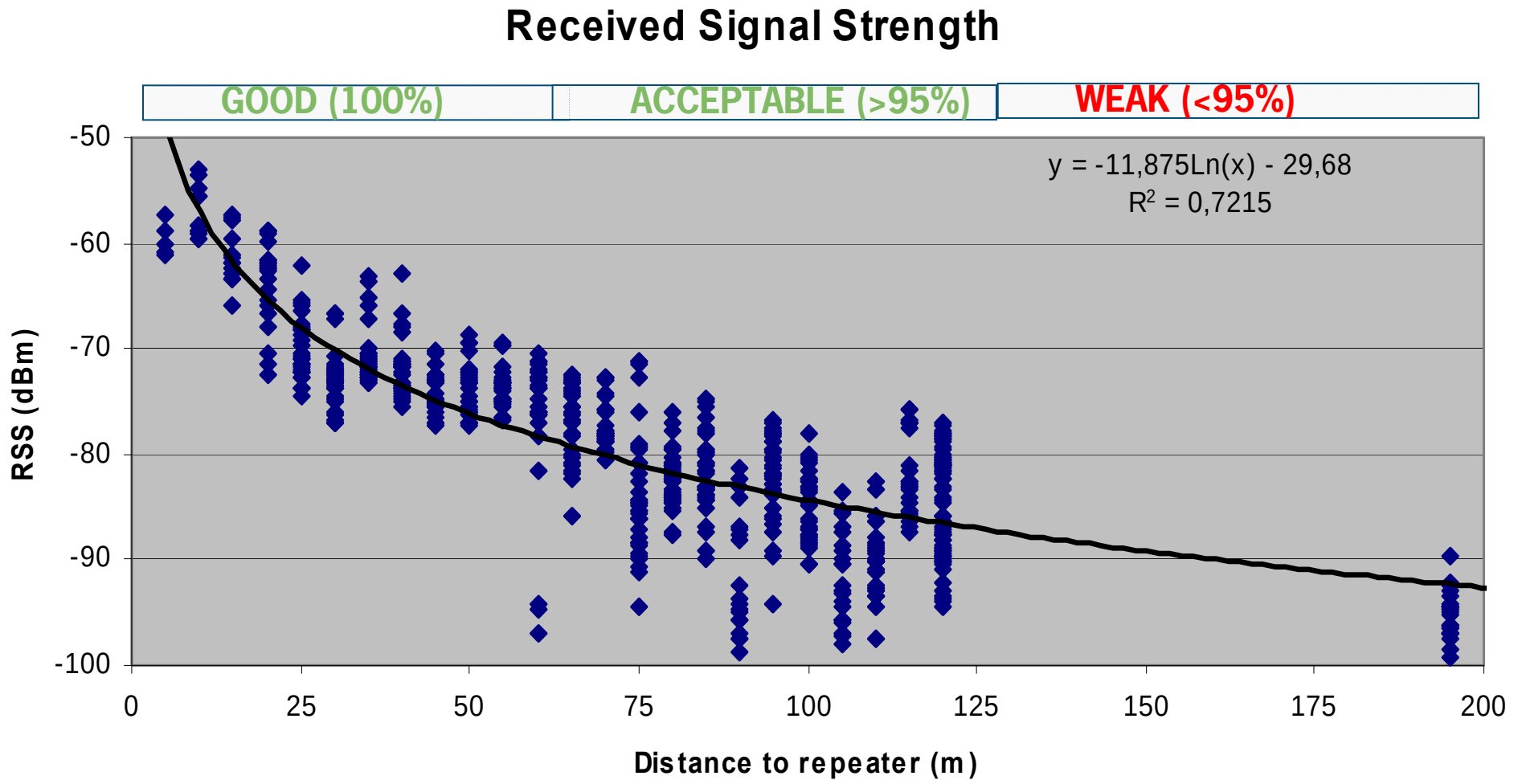
- Higher power
- External antenna
- Alignment of antennas
- Double housing (radiation shield)
- Batteries away from antenna
- Explore solar panel (Crossbow: Eko Pro series)
- Watermark (cheap, granular matric sensor)

Redesign of Wireless Sensor Node



Range Performance Test (Line of Sight)

Performance of 8 new nodes



Field test

Crossbow Eko Pro series

Solar Panel
Watermark Sensor

SowNet Technologies

Radiation Shield

SO FAR SO GOOD

AFTER 1 MONTH OPERATION

Range: 60m

Internal Temperatures: OK

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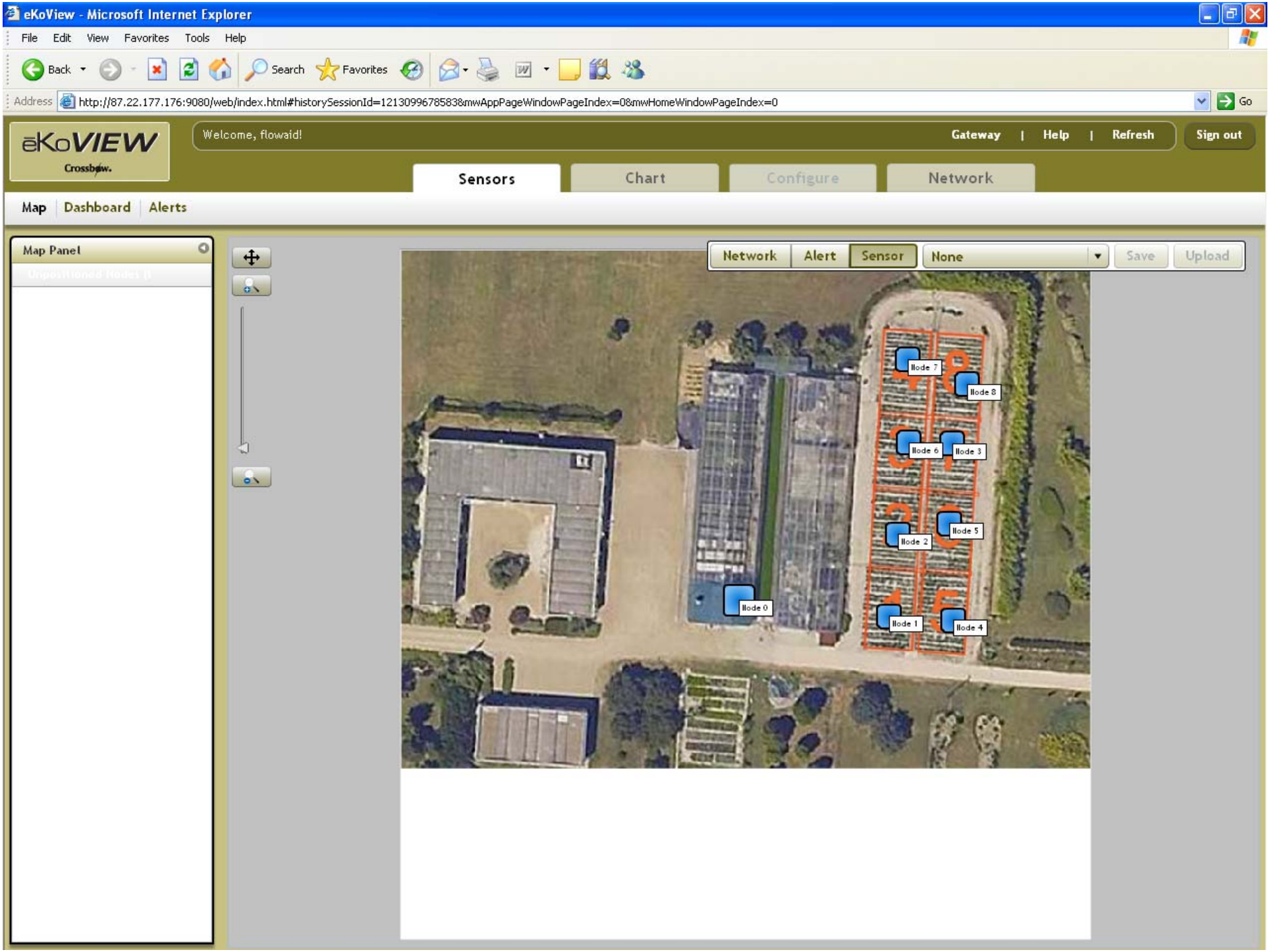
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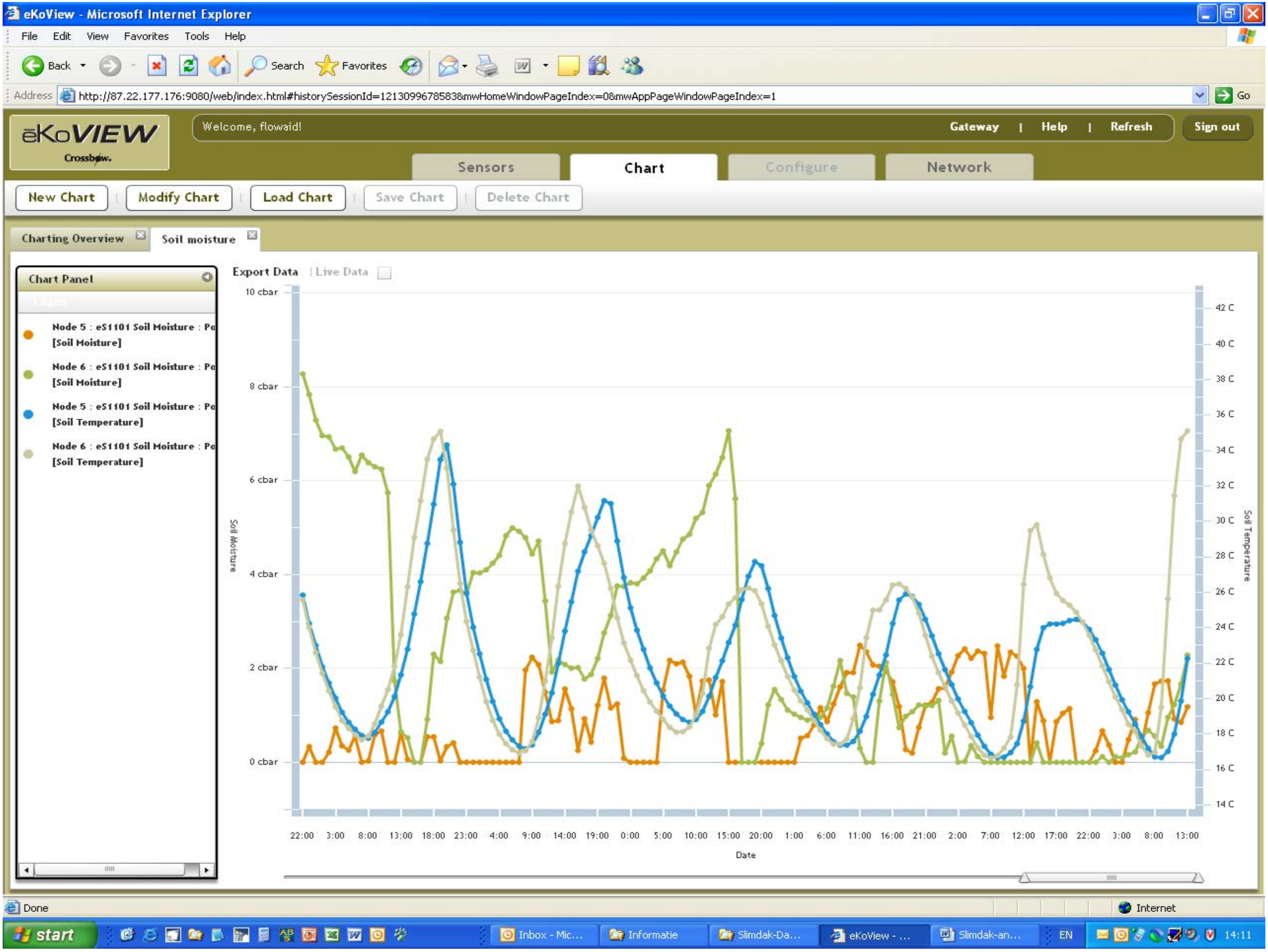
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Charting Overview
Soil moisture
Chart Panel
Node 5 : eS1101 Soil Moisture : Pa
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Node 6 : eS1101 Soil Moisture : Pa
[Soil Moisture]
Node 5 : eS1101 Soil Moisture : Pa
[Soil Temperature]
Node 6 : eS1101 Soil Moisture : Pa
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Export Data
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8 cbar
6 cbar
4 cbar
2 cbar
0 cbar
Soil Moisture
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36 C
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30 C
28 C
26 C
24 C
22 C
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Soil Temperature
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Thanks for your attention

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