HARMONIOUS

Infrared thermography - hydrological and hydraulic

João de Lima, Pruhonice, 27.2.2019

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Laboratory and field applications of infrared thermography: estimation of hydrological and hydraulic variables

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(2) *Marine and Environmental Sciences Centre (MARE), Portugal;*
(3) *Polytechnic of Coimbra, College of Agriculture, Coimbra, Portugal.*

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UAS for environmental monitoring

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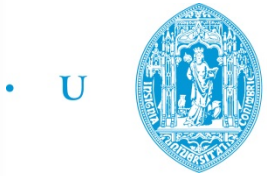
Validating thermal techniques for monitoring surface processes



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UNIVERSIDADE DE COIMBRA

MARE

University of Coimbra
Laboratory of Hydraulics, Water Resources and Environment

Lab. Hidráulica, Recursos Hídricos e Ambiente

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ECHO
Dielectric Aquameter
Decagon Devices, Inc. Pullman WA USA
509-332-2756 www.decagon.com/ech2o/
2012/02/07 14:57

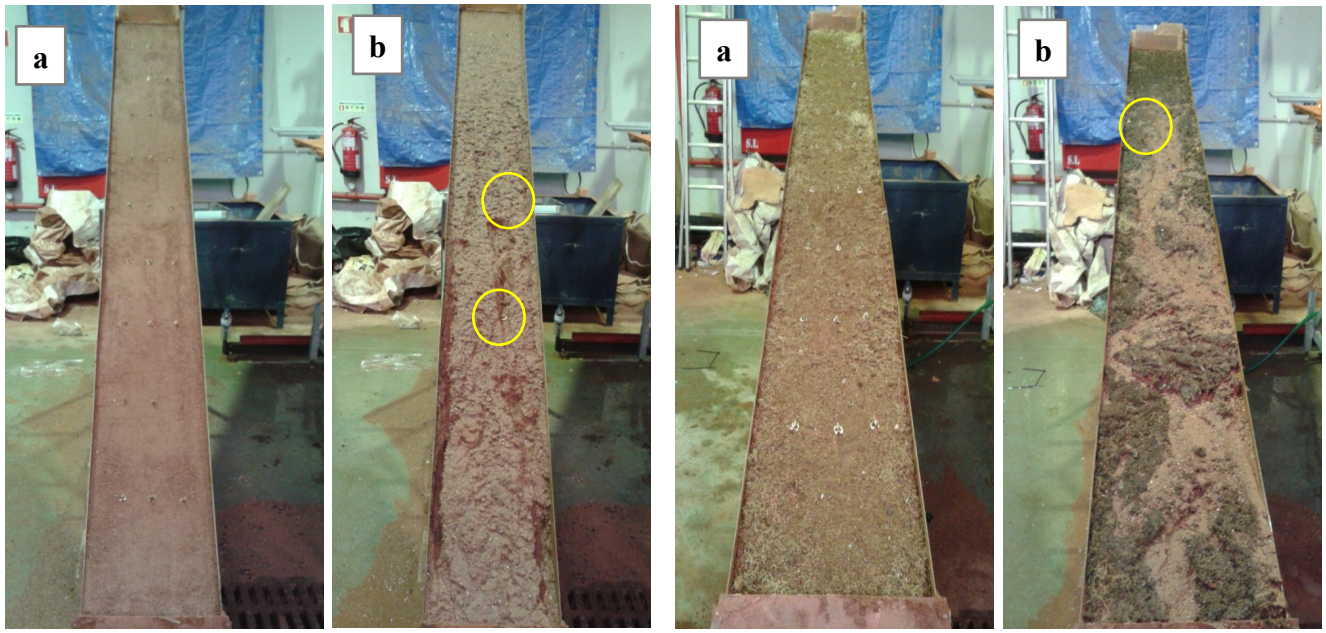

2012/02/07 17:35


2012/02/01 14:17


GH
2012/01/30 14:54

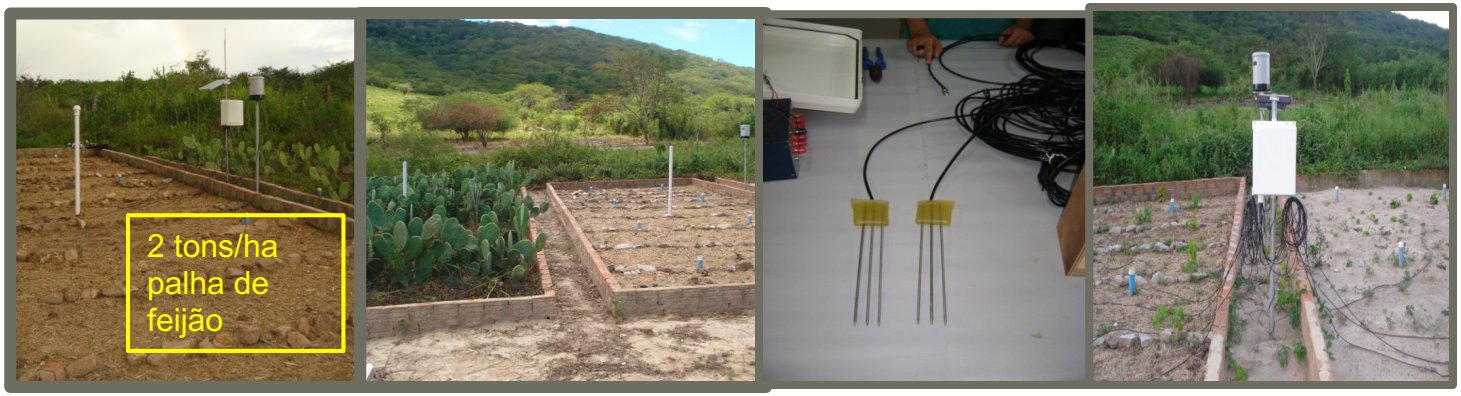
Solo descoberto

8 t ha^{-1} (Pó de coco)



Brasil - Alto Ipanema Basin – Field work
Infrared thermography

Variabilidade espaço-temporal da umidade do solo



Thermal infrared imagery

quantitative estimation of several hydrologic processes;

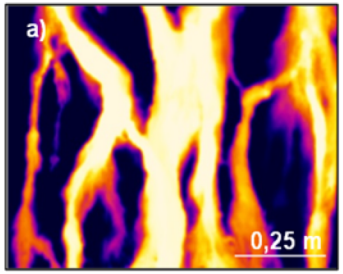
e.g.
map infiltration, macropores,
estimate flow velocities,
identify water sources, accumulation of waters, connectivity
monitor vegetation evapotranspiration
….

INFRARED THERMOGRAPHY TO ACCESS SOIL SURFACE CHARACTERISTICS

Microrelief and rill morphology

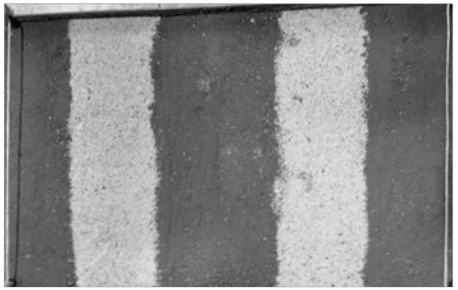
Real image

Thermal image

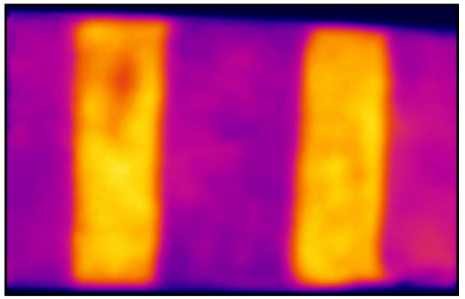


Permeability

Real image



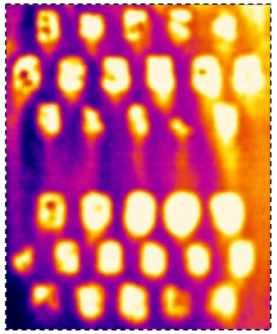
Thermal image



Water repellency

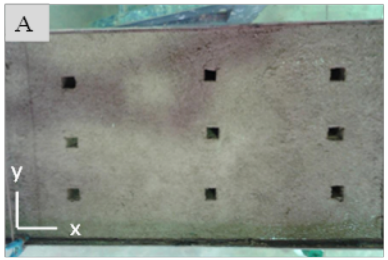
Real image

Thermal image

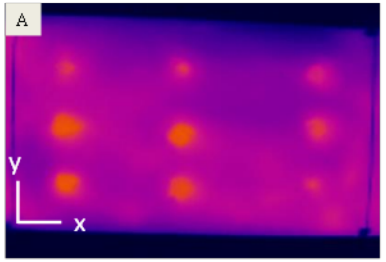


Macroporosity

Real image



Thermal image



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universidade de aveiro

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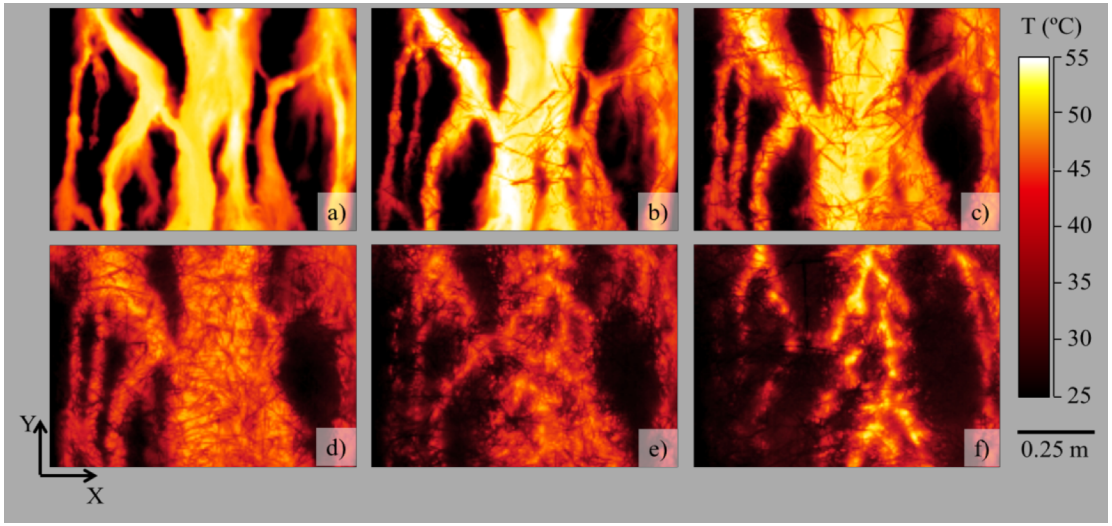
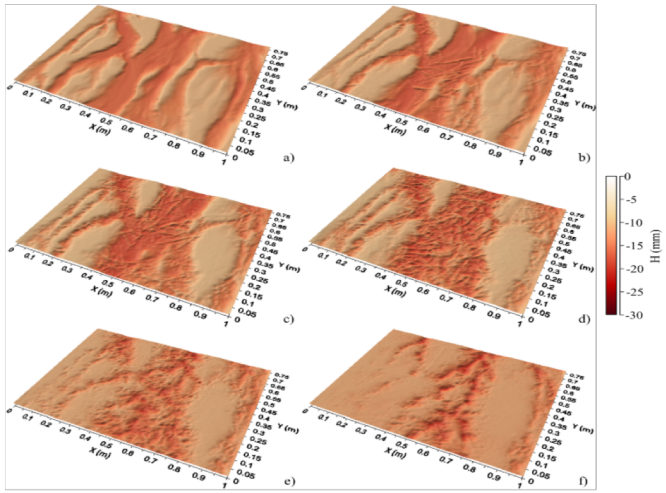
Research at UC:
Estimation of soil surface microrelief and rills

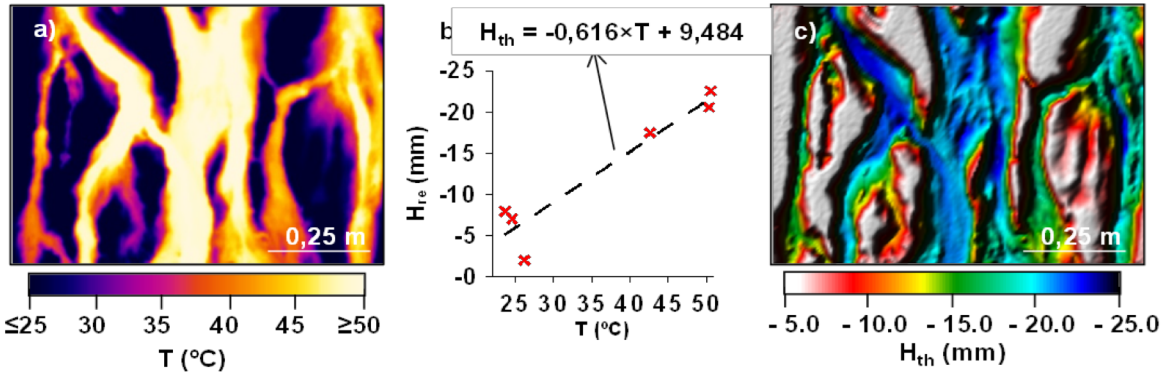
Thermal images with increasing vegetation/mulch



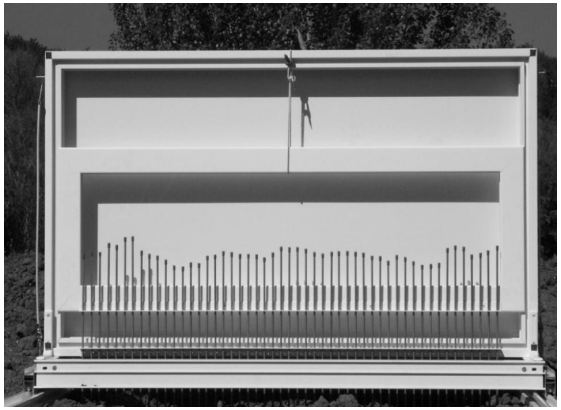
3D Model from thermograms



2 Points calibration (temperature - measure)

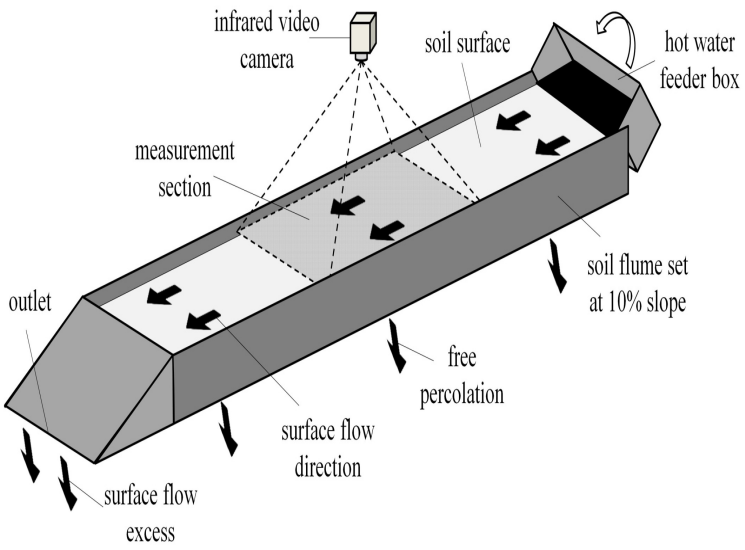


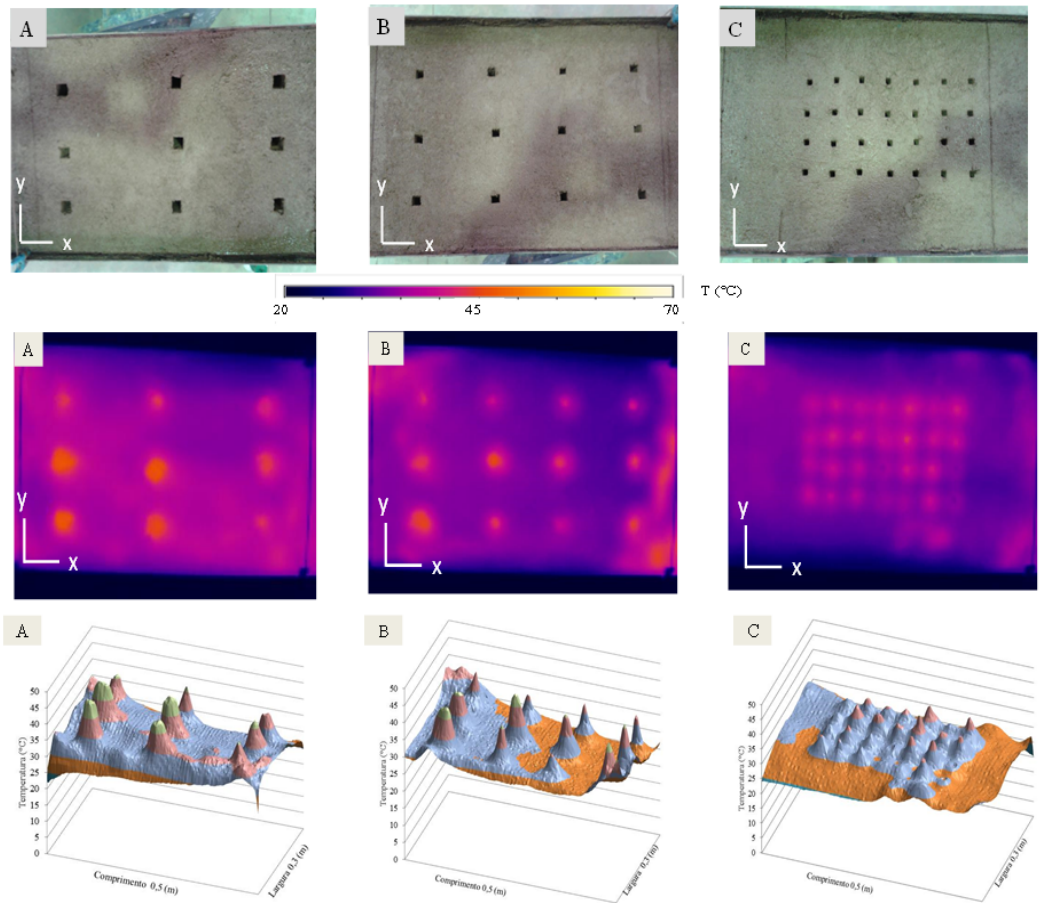
Profile meter (single line)



Research at UC:
Mapping soil permeability and macro-porosity

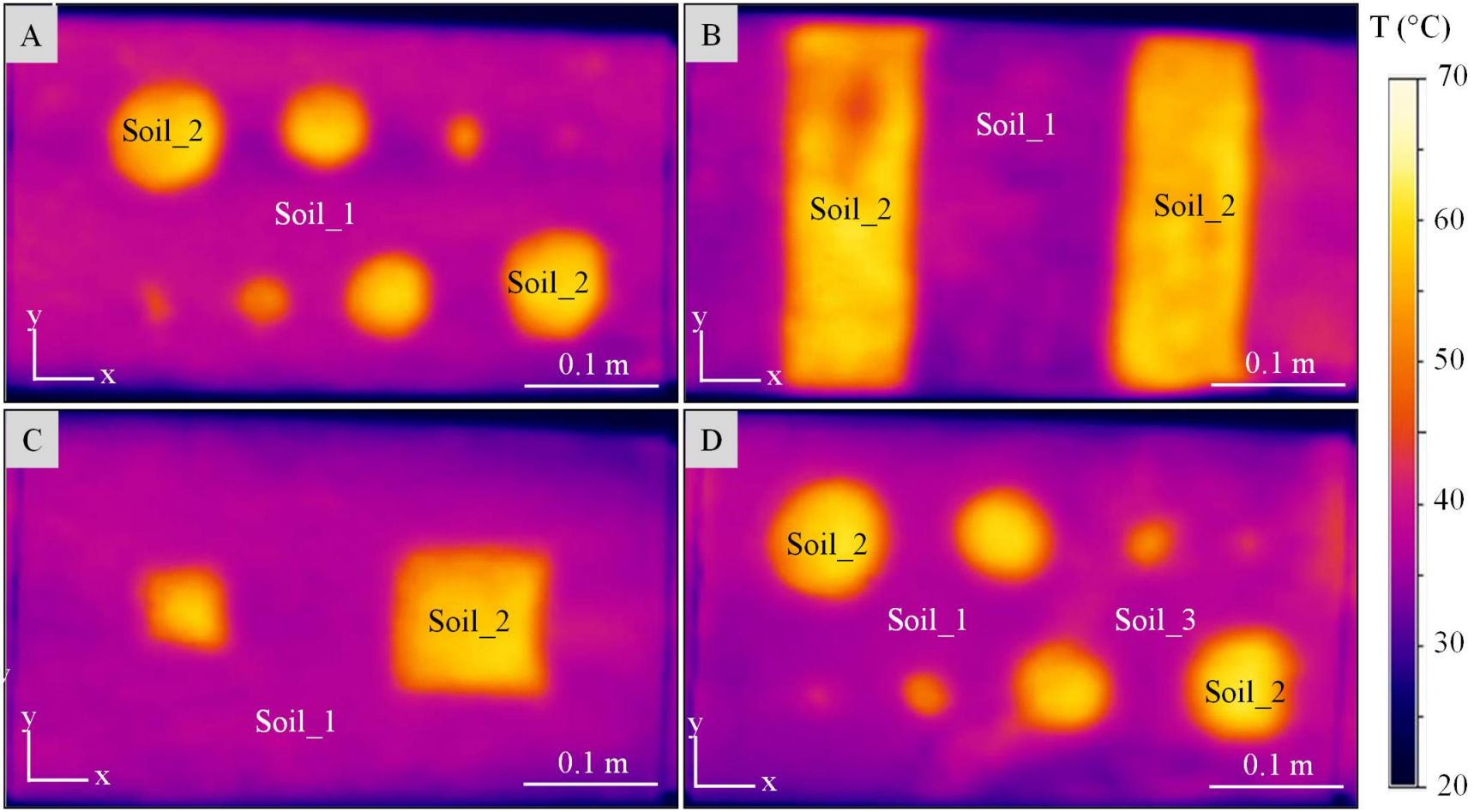
Detection of macro-porosity





Research at UC:
Mapping soil permeability and macro-porosity

Mapping of soil porosity

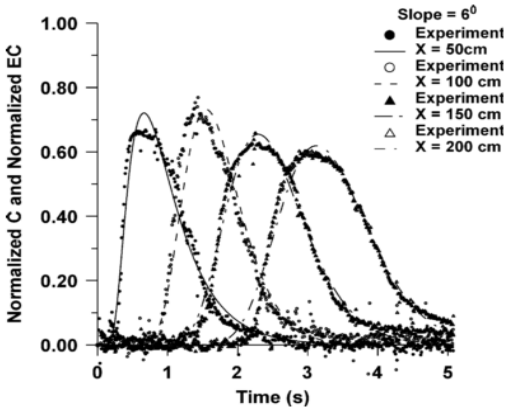


SHALLOW FLOWS

TRACER TECHNIQUES

DYES

SALTS



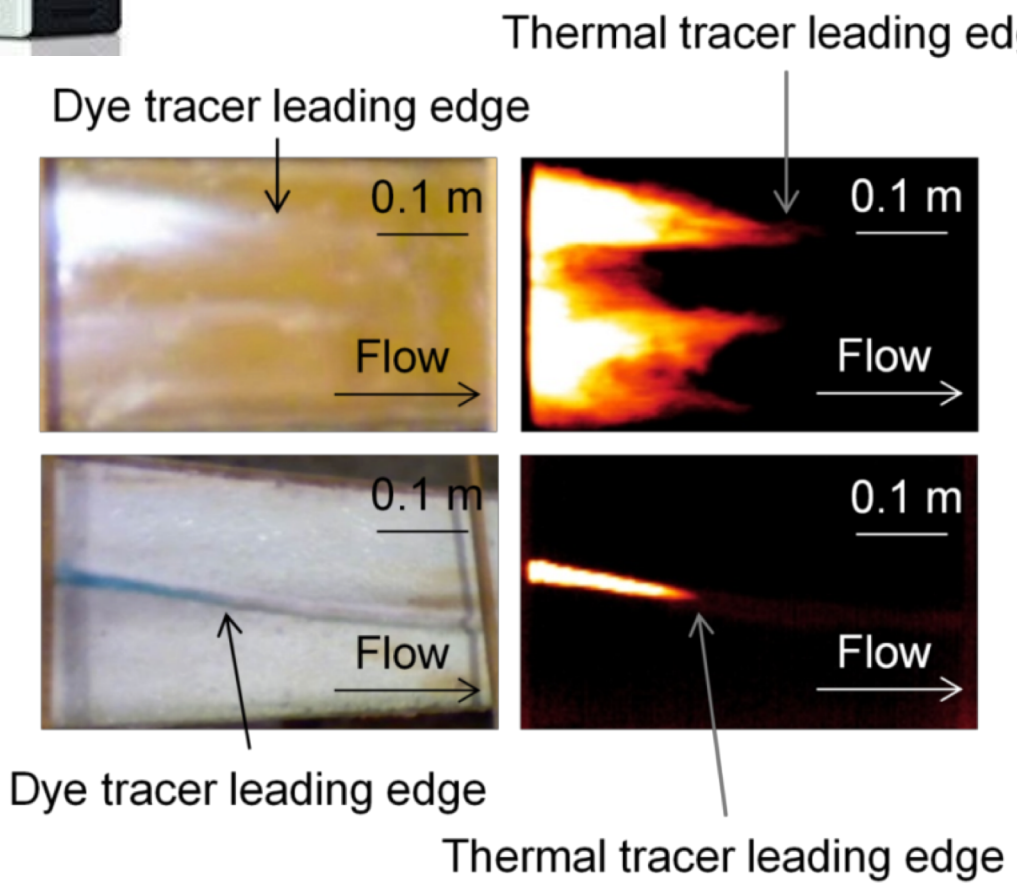
THERMAL TRACER
& INFRARED THERMOGRAPHY

TECHNIQUE TO ESTIMATE SHALLOW FLOW VELOCITIES

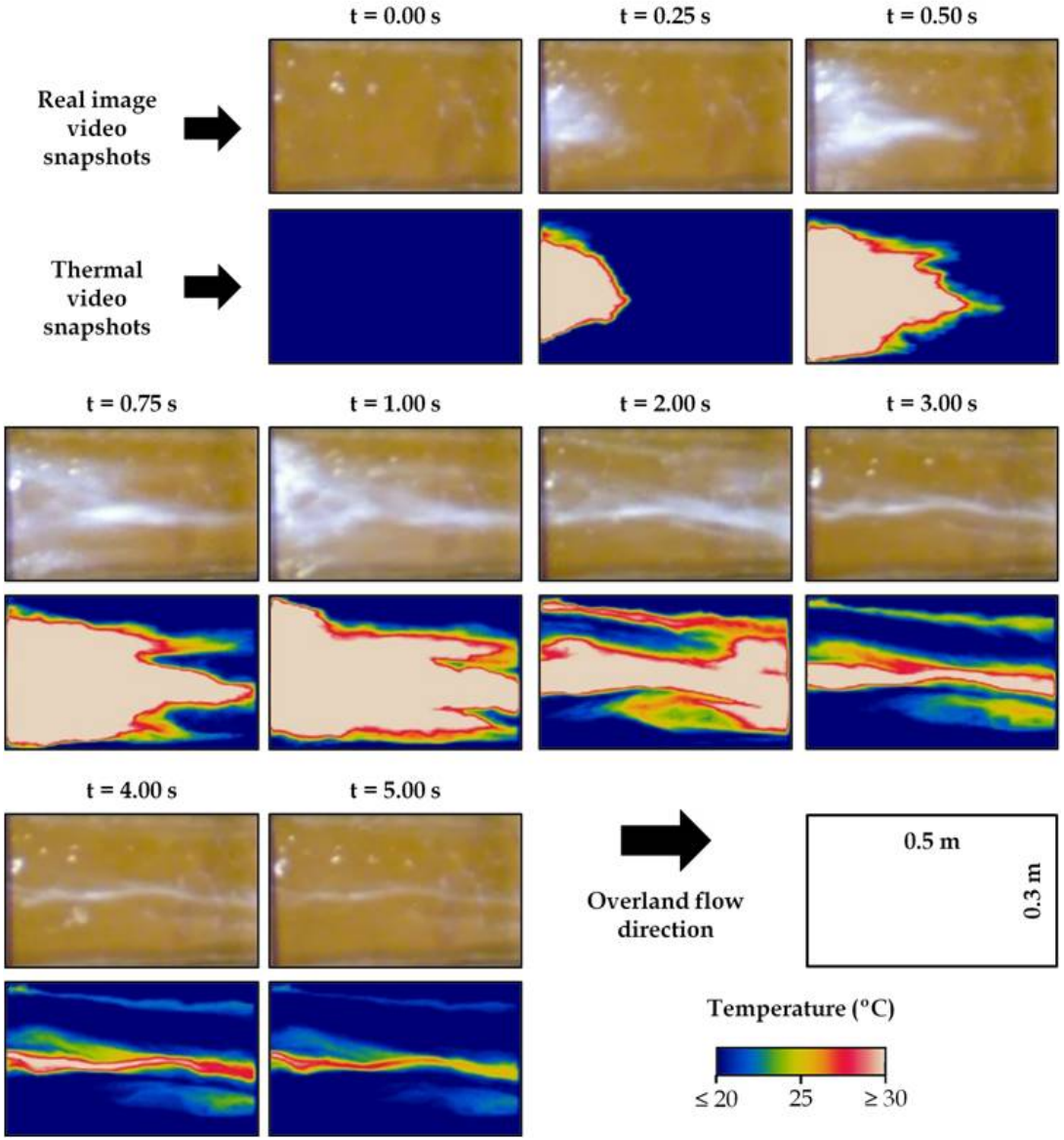
THERMAL TRACER VS DYE TRACER

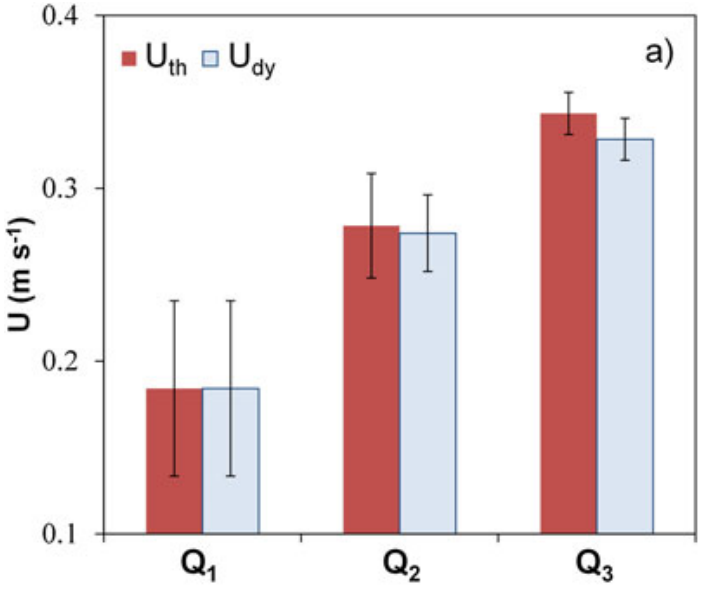
GoPro Hero 3

Optris PI160



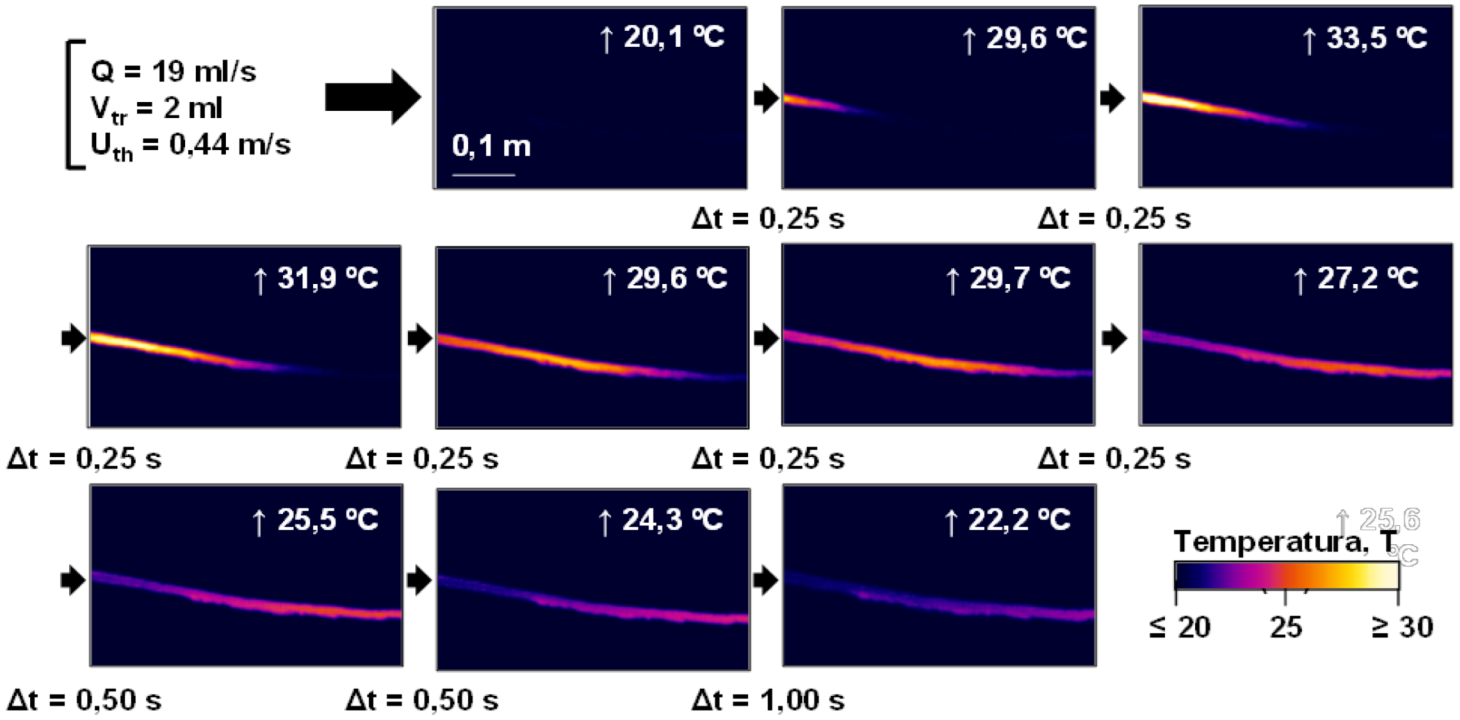
SHEET FLOW

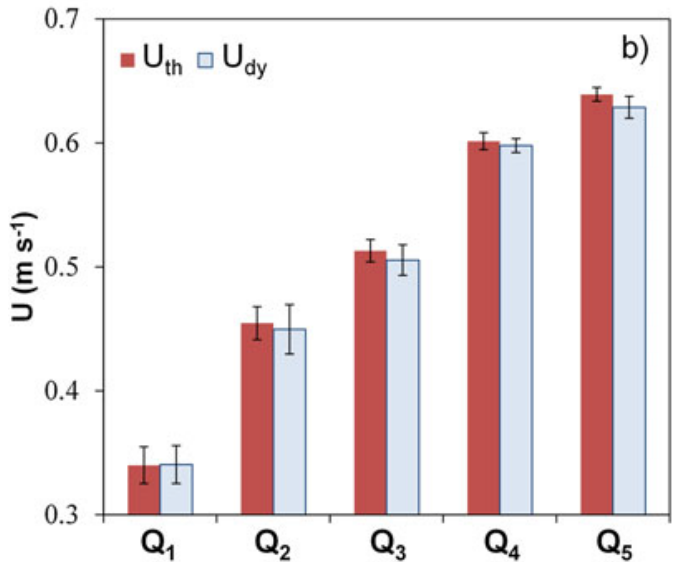




Q_1 = 19 ml/s
Q_2 = 70 ml/s
Q_3 = 157 ml/s

RILL FLOW





Q_1 = 6 ml/s
Q_2 = 19 ml/s
Q_3 = 37 ml/s
Q_4 = 77 ml/s
Q_5 = 151 ml/s

COMPARISON OF 3 TRACERS

TRIPLE TRACER TECHNIQUE

DYED - SALTED - HEATED

Food coloring

Table salt
5 g/L water

Electric kettle
70 °C

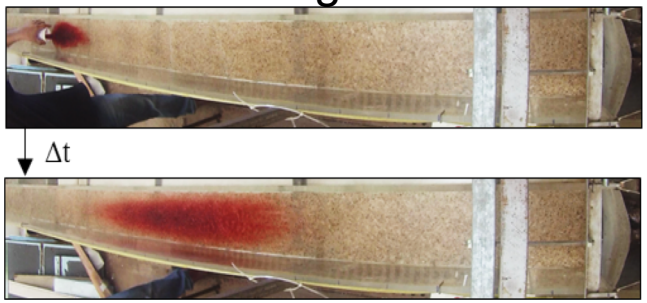
COMBINED IN ONE TRACER

DATA ACQUISITION AND VISUALIZATION

DYE

GoPro Hero 3

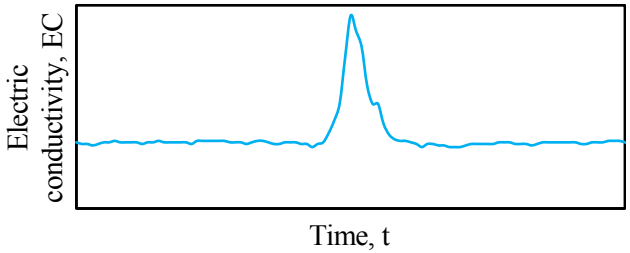
Real image videos



SALT

CON-BTA

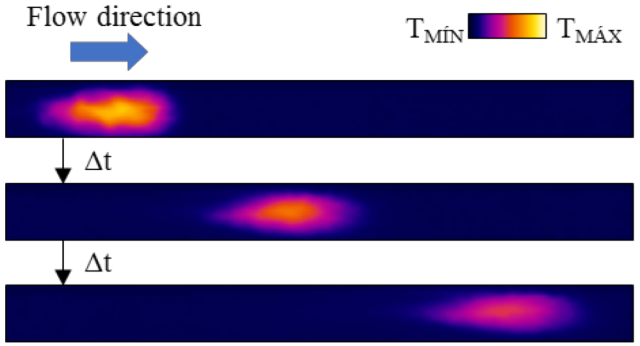
Salt transport graphs



THERMAL

Optris PI160

Thermal videos



LABORATORY SETUP

Acrylic

Stones

Sand

Synthetic grass

Discharge: 30 – 1800 ml/s

Slopes: 0.8, 4.4 and 13.2%

THERMAL TRACER RESULTS

Q ≈ 850 ml/s; S = 0.8%;
Vol. tracer = 85 ml

Acrylic

V_{LE} = 0.703 m/s; V_C = 0.684 m/s

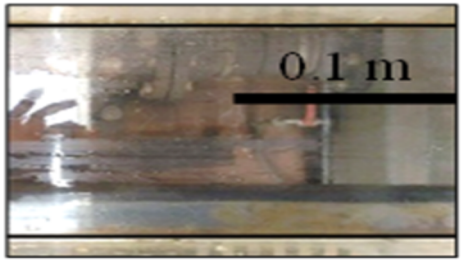
Stones

V_{LE} = 0.359 m/s; V_C = 0.240 m/s

THERMAL TRACER RESULTS

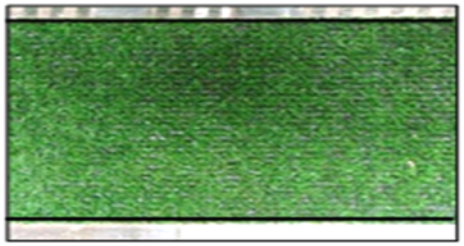
Q ≈ 1100 ml/s; S = 0.8%;
Vol. tracer = 110 ml

Acrylic

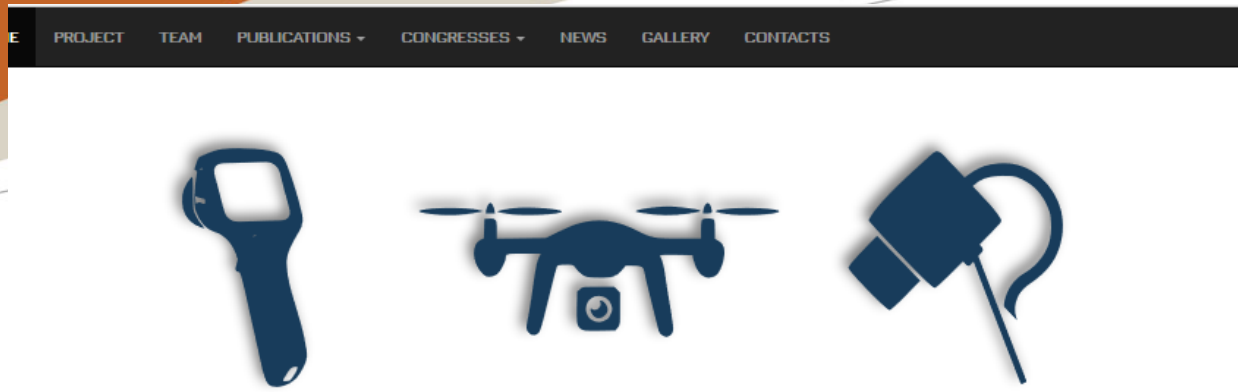


V_{LE} = 0.762 m/s; V_C = 0.750 m/s

Synthetic grass



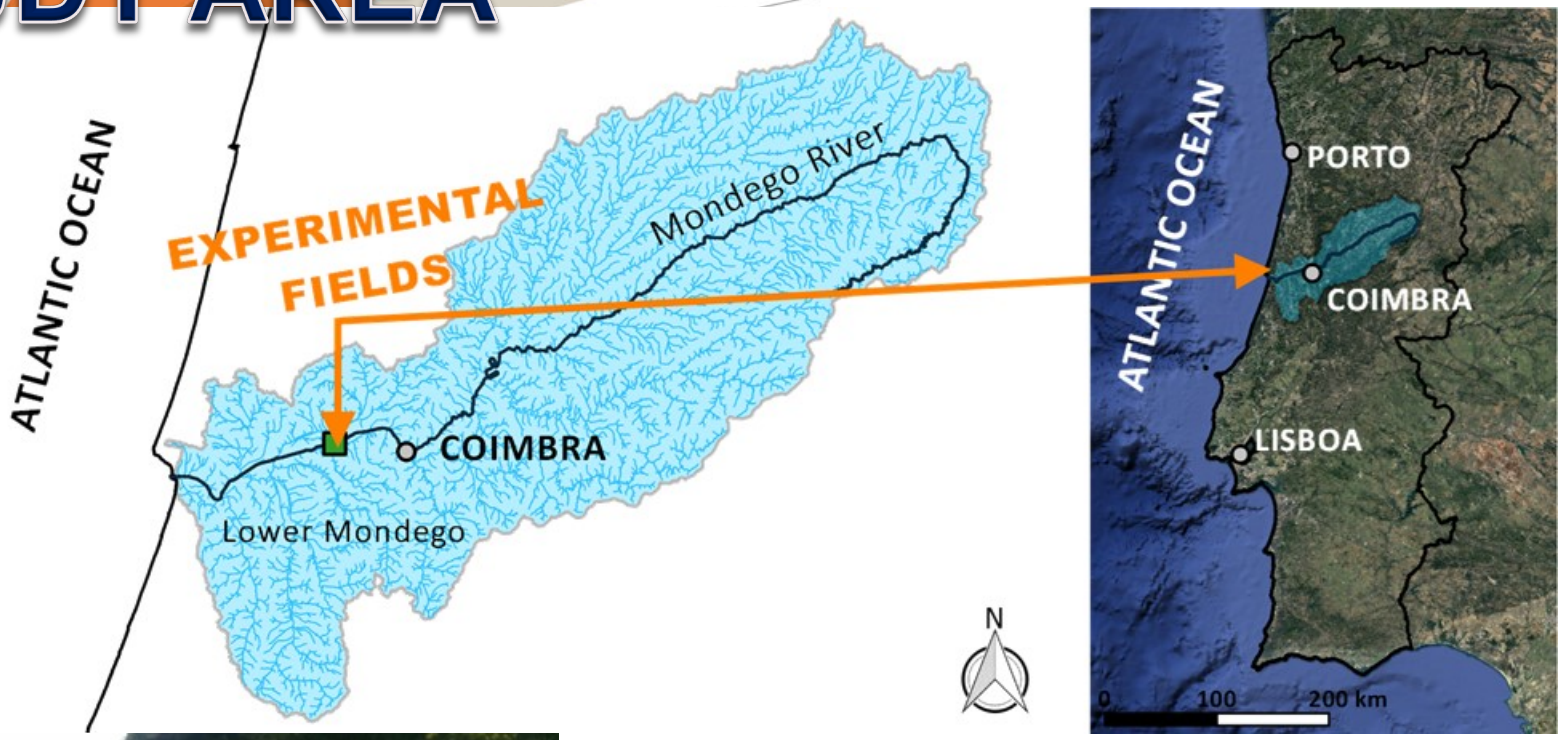
V_{LE} = 0.338 m/s; V_C = 0.299 m/s



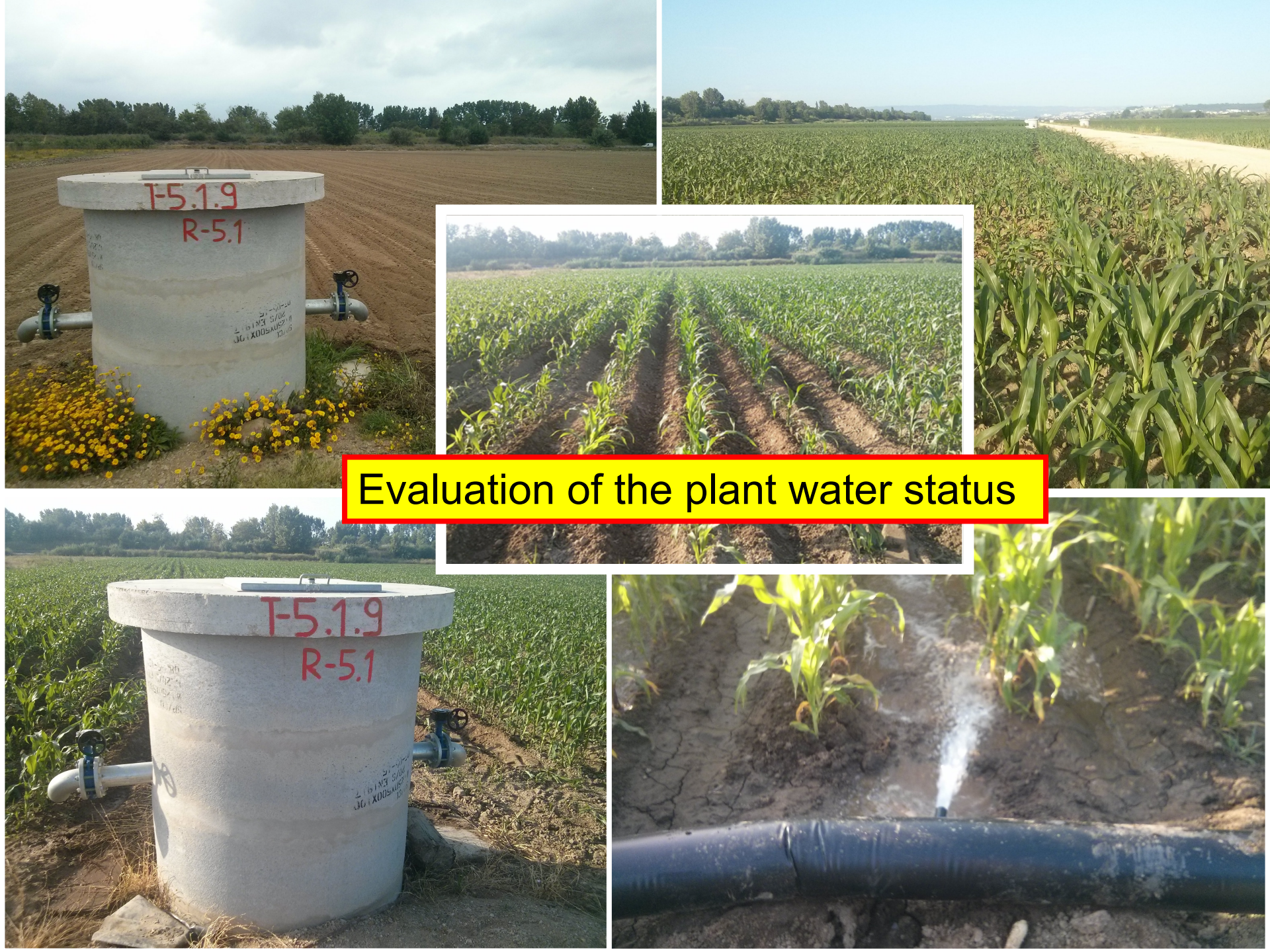
Work in progress…

Development of **infrared thermography** based tools for the analysis of water distribution efficiency in irrigated agricultural fields, aiming at optimizing the use of water in agricultural systems.

STUDY AREA

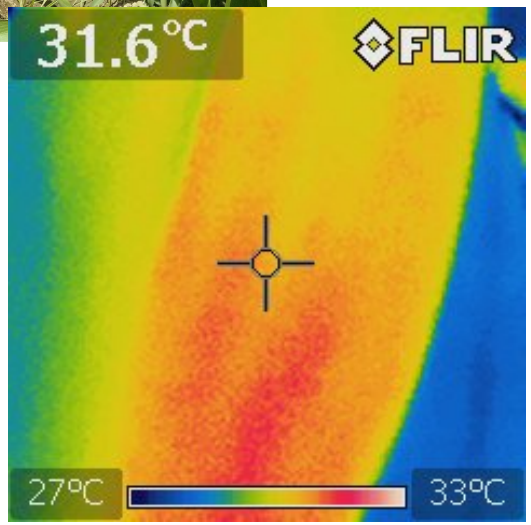


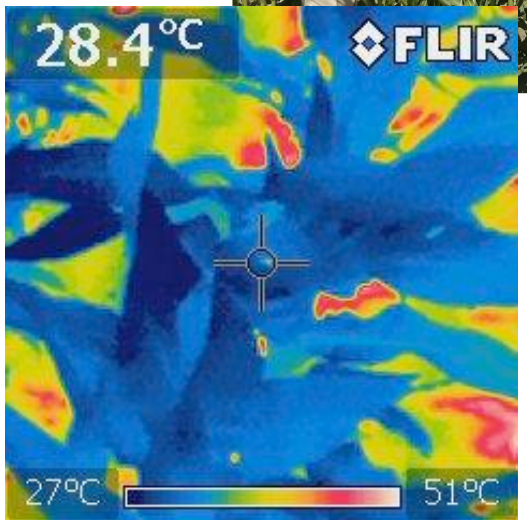
- Irrigated area of 12.500 ha, supplied by
- of 12.500 ha, supplied by Mondego


T-5.1.9
R-5.1
T-5.1.9
R-5.1
Evaluation of the plant water status

In addition to other detailed data:

- ✓ **IR thermography (ground) measurements** at the **local** and **field** scales (*for assessing the canopy, leaf and soil*), using handheld cameras and UAS,
- ✓ **satellite** based images.

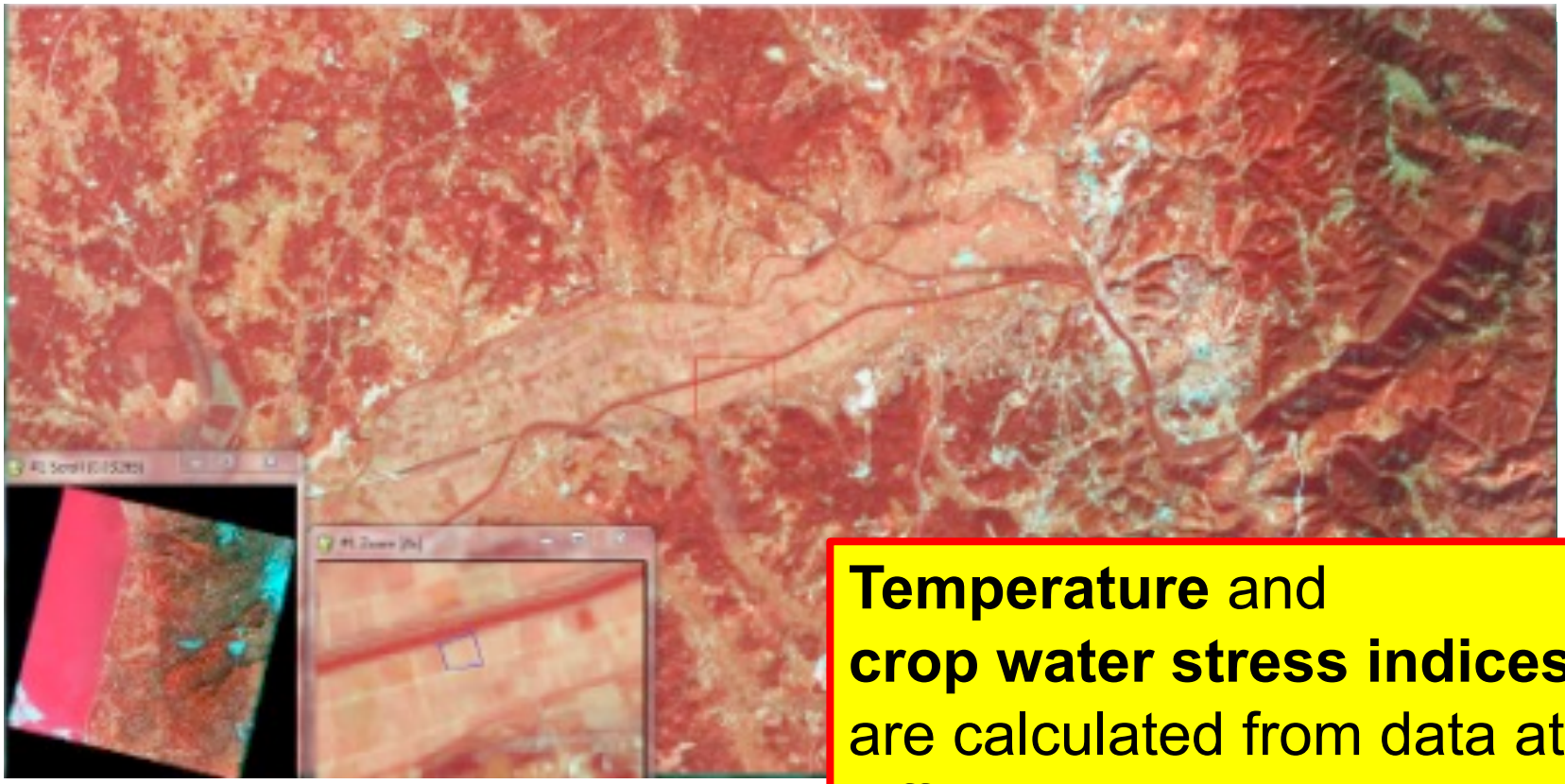




Leaf

Canopy

✓**satellite** based images.



Thermal Infrared Sensor

Temperature and
crop water stress indices
are calculated from data at different scales…

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CONCLUDING REMARK

We aim at better understanding **bridging between the different scales of observation…**.

… and contributing to using **infrared thermography based tools** (*that use non-invasive and non-destructive technology*) to achieve better water management and soil and water conservation.

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Publications on thermography (2018)

Abrantes, J.R.C.B., R.B. Moruzzi, A. Silveira, J.L.M.P. de Lima, 2018. Comparison of thermal, salt and dye tracing to estimate shallow flow velocities: Novel triple tracer approach. **Journal of Hydrology**

Prats S.A., J.R. Abrantes, J.J. Keizer, C.O.A. Coelho, J.L.M.P. de Lima, 2018. Comparing topsoil char, ash and stone cover effects on the post-fire hydrologic and erosive response under laboratory conditions. **Land Degradation & Development**

Abrantes, J.R.C.B., A. Silveira, AA.A. Montenegro, R.B. Moruzzi, J.L.M.P. de Lima, 2018. Combining a thermal tracer with a transport model to estimate shallow flow velocities. **Physics and Chemistry of the Earth**

Mujtaba B., JLMP de Lima, 2018. Laboratory testing of a new thermal tracer for infrared-based PTV technique for shallow overland flows. **CATENA**

Obrigado

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