Ergonomics and sustainability in agriculture

*The **social** component of **sustainability** in agriculture deals with:*

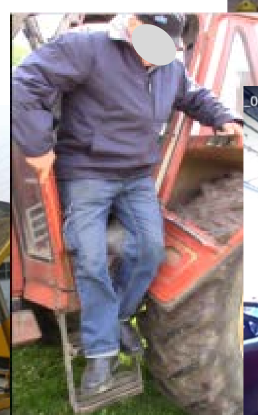
- *preventive occupational health and safety*
- *human-centered design of work*
- *empowerment*
- *individual and collective learning*
- *employee participation*

➡ To promote system efficiency

➡ To reduce social and health costs

*The **anthropocentric perspective** leads to **joint objectives** between **ergonomics/human factors** and **sustainable** development in **agriculture***

USER | TASK | MACHINERY | TECHNOLOGY | ENVIRONMENT



"Ergonomic approach for designing foldable ROPS", OECD, 2017

"PROMOSIC" (Protezione degli Operatori di Macchine Operatrici da Schiacciamento, Impigliamento, Cesoiamento), INAIL, 2015-2016

- Ergonomic user-centered approach
- Quantitative and qualitative methods
- Objective and subjective measurements

- Interviews
- Focus groups
- Observations
- Surveys

Usability of the Human-Machine Interface (ISO 9241-11:1998)

Efficacy of safety communication

Risk perception
Safety culture
Innovation adoption

Unsafe gestures/postures
Strenght capability analysis

*Study of the **physical** and **cognitive** aspects of the human-task/machine/environment **interaction,** with particular attention to physical and demographic **variability** (aging, migrations) and **technological development**, aimed at **improving** systems' **usability***

The research activity aims at identifying critical issues that may benefit from **user-oriented interventions**, in terms of:

- user-centered **(re)design** of tasks, machinery and technology, and
- targeted **information** campaigns and **training actions**

to lead to a **better fit** between the user and the work environment

"INTRAC" (Integrazione tra gli aspetti ergonomici e di sicurezza nei trattori agricoli), (MiPAAF), 2016

"IMT " Interactive Maintenance Training", Regione Piemonte POR-F.E.S.R. 2007-2013

Environmental impact of livestock sector

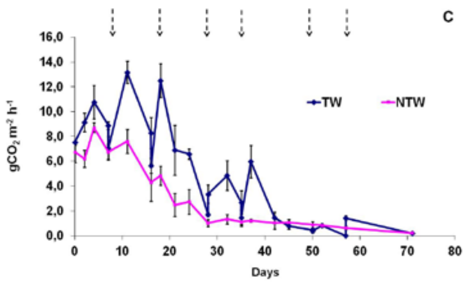
IMAMOTER

Institute for Agricultural and Earthmoving Machines

National Research Council of Italy

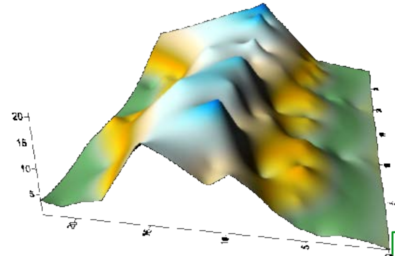
OBJECTIVES:

- Monitoring ammonia and GHG emissions derived from livestock sector;
- Improving livestock waste treatment technologies focused on ammonia and GHG reduction;
- Agronomical valorization of livestock waste



SCIENTIFIC RESULTS:

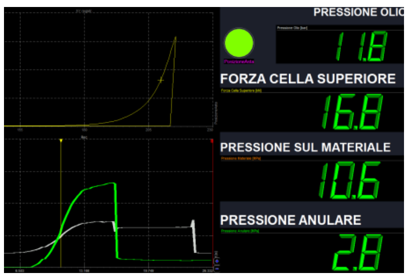
- N. Pampuro, E. Dinuccio, P. Balsari, E. Cavallo. 2016. Evaluation of two composting strategies for making pig slurry solid fraction suitable for pelletizing. Atmospheric Pollution Research. 7(2): 288-293.
- N. Pampuro, V. Tebaldo, D. Fabbri, P. Calza, M. G. Faga, E. Cavallo. 2017. Organic fertilization on Trinidad Scorpion peppers (Capsicum chinense) to increase capsaicin content: preliminary results. Chemical Engineering Transactions. 58: 253-258.
- N. Pampuro, C. Bisaglia, E. Romano, M. Brambilla, E. Foppa Pedretti, E. Cavallo. 2017. Phytotoxicity and chemical characterization of compost derived from pig slurry solid fraction for organic pellet production. Agriculture. 7(11), 94.
- N. Pampuro, C. Bertora, D. Sacco, E. Dinuccio, C. Grignani, P. Balsari, E. Cavallo, M.P. Bernal. Fertilizer value and GHG emissions of pellets from the solid fraction of pig slurry compost. 2017. The Journal of Agricultural Science. 155(10), 1646-1658.
- N. Pampuro, F. Caffaro, E. Cavallo. 2018. Reuse of animal manure: a case study on stakeholders’ perceptions about pelletized compost in Northwestern Italy. Sustainability. 10, 2028.

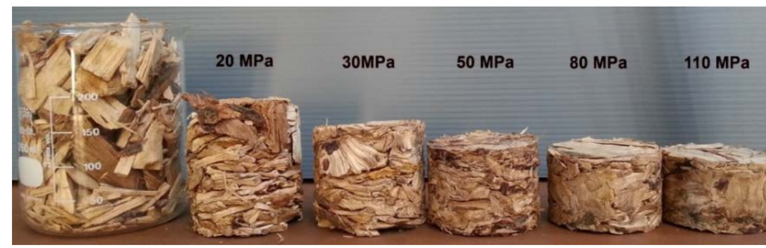


Institute for Agricultural and Earthmoving Machines
National Research Council of Italy

OBJECTIVES:

- Optimization of biomass densification processes and characterization of densified products;
- Pelletized organic fertilizers production





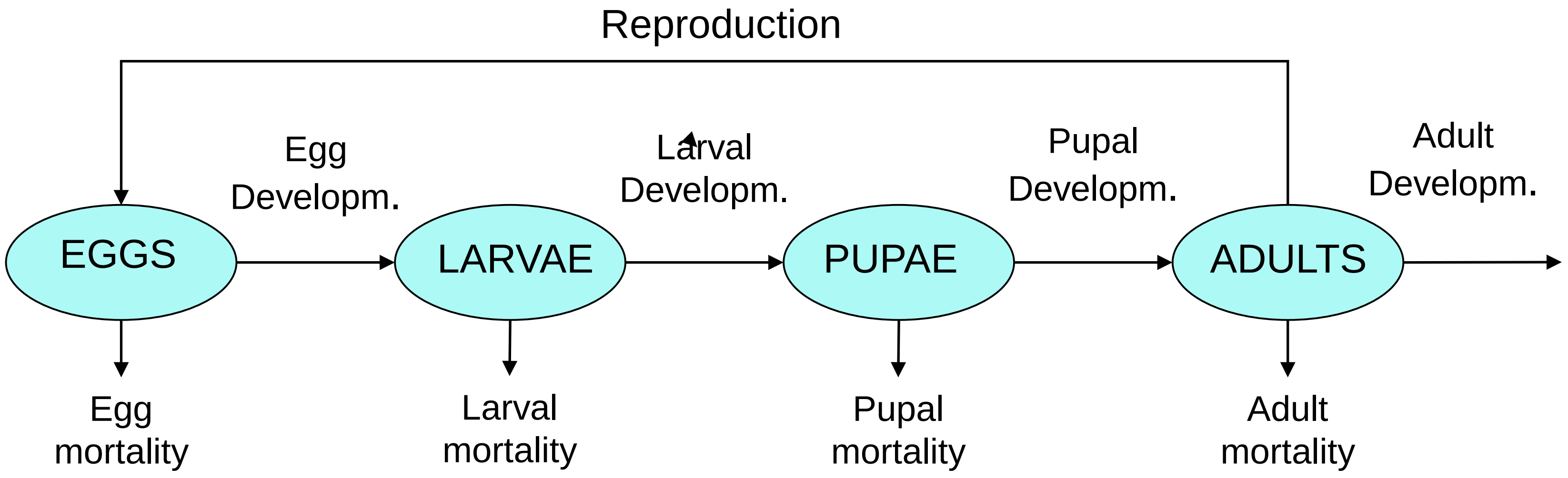
SCIENTIFIC RESULTS:

- N. Pampuro, A. Facello, E. Cavallo. 2013. Pressure and specific energy requirements for densification of compost derived from swine solid fraction. Spanish Journal of Agricultural Research. 11 (3): 678-684.
- E. Romano, M. Brambilla, C. Bisaglia, E. Foppa Pedretti, N. Pampuro, E. Cavallo. 2014. Pelletization of composted swine manure solid fraction with different organic co-formulates: effect of pellet physical properties on rotating spreader distribution patterns. International Journal of Recycling of Organic Waste in Agriculture. 3: 101-111.
- N. Pampuro, G. Bagagiolo, P.C. Priarone, E. Cavallo. 2017. Effects of pelletizing pressure and the addition of woody bulking agents on the physical and mechanical properties of pellets made from composted pig solid fraction. Powder Technology. 311: 112-119.
- E. Cavallo, N. Pampuro. 2017. Effects of compressing pressure on briquettes made from woody biomass. Chemical Engineering Transactions. 58: 517-522.
- N. Pampuro, C. Preti, E. Cavallo. 2018. Recycling pig slurry solid fraction compost as a sound absorber. Sustainability. 10(1), 277.

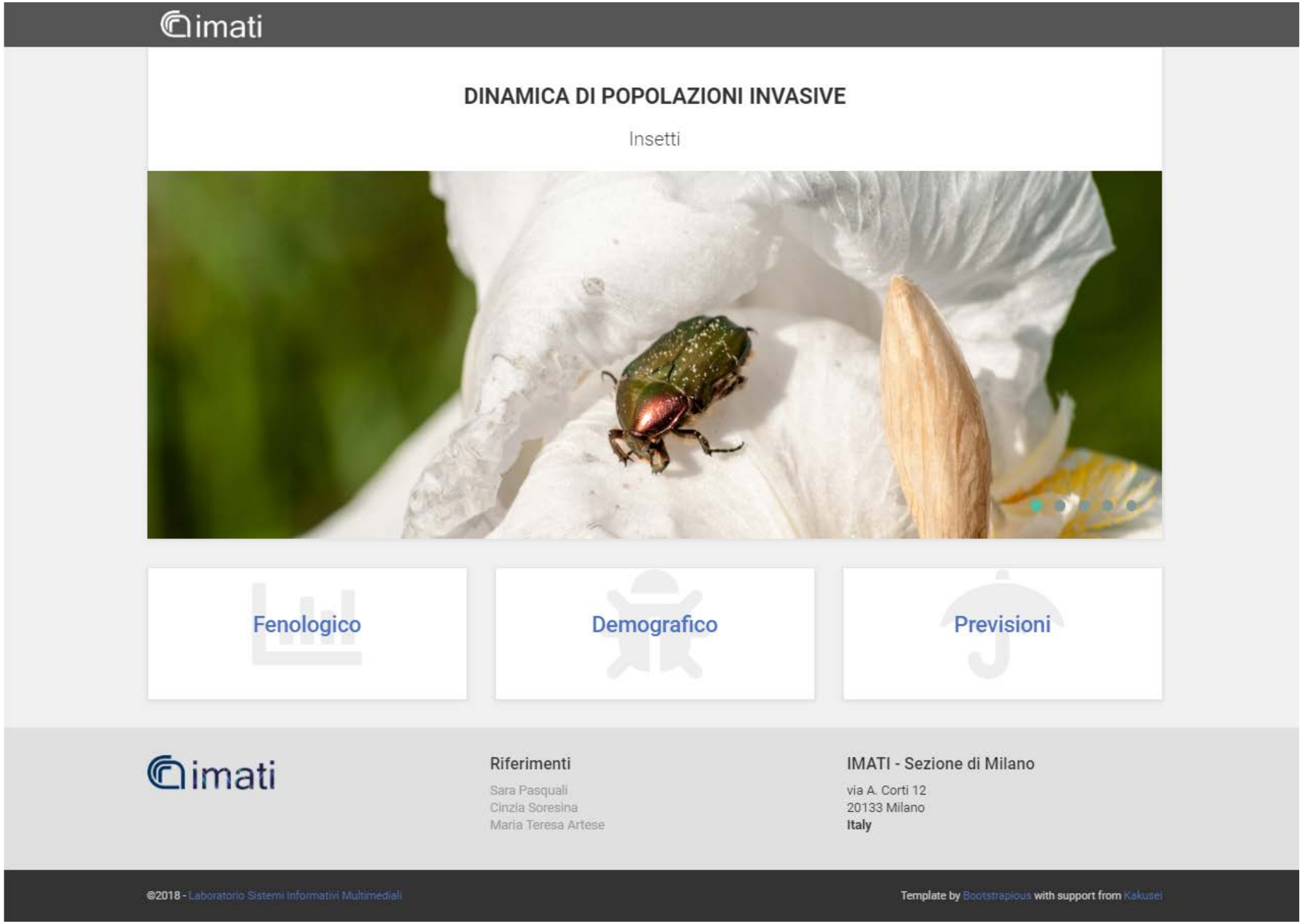
Biomass processing technologies

Software for pest control

- Software to assist the farmer in phytosanitary treatment of crop
- The software is based on stage-structured population dynamics models
- The model is described by a system of forward Kolmogorov equations where the biodemographic functions (development, mortality and reproduction) are temperature-dependent



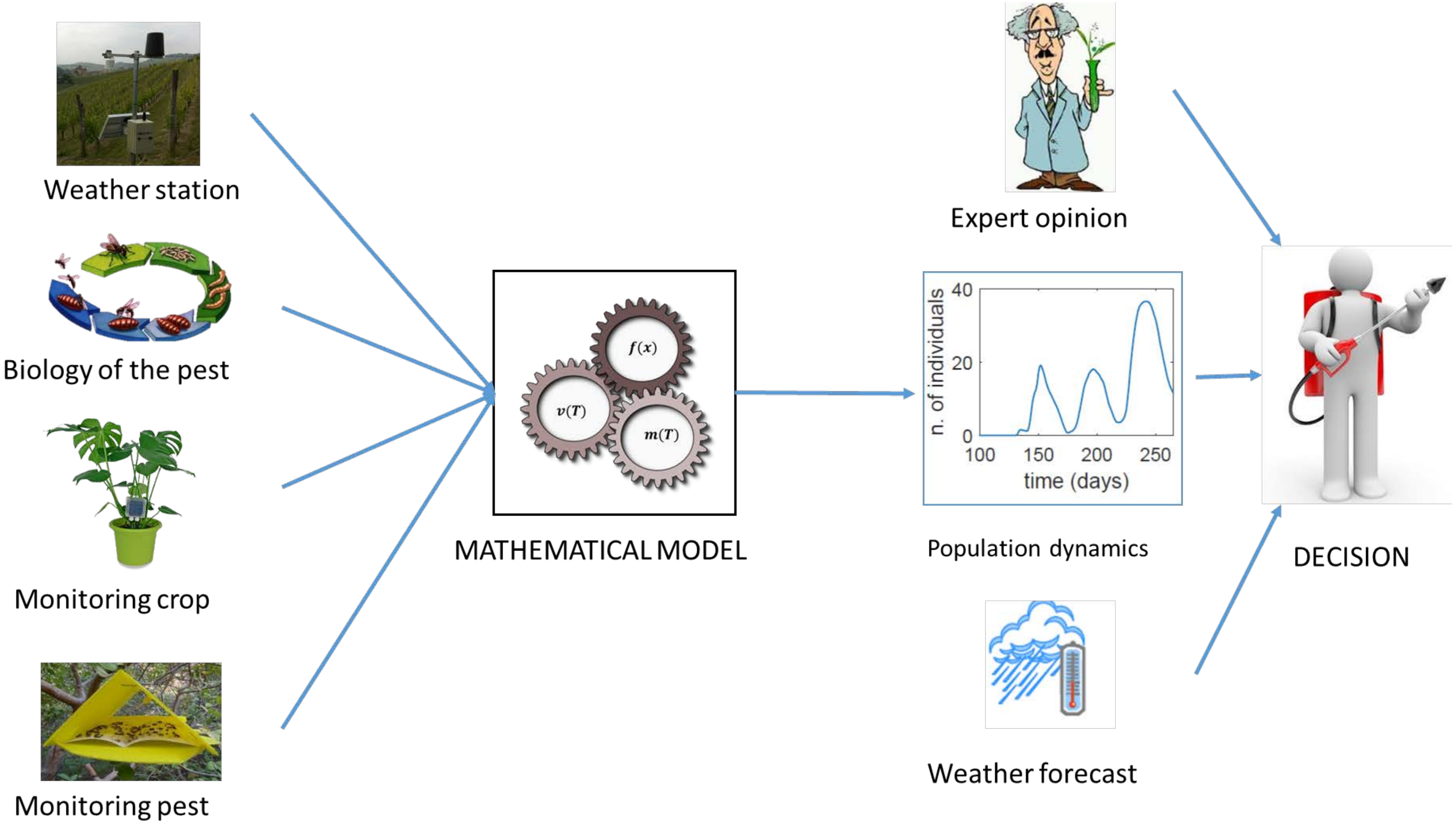
Software for pest control



Two different models:

- phenological (percentage of insect in each stage)
- demographic (abundance of insect in each stage)

Software for pest control

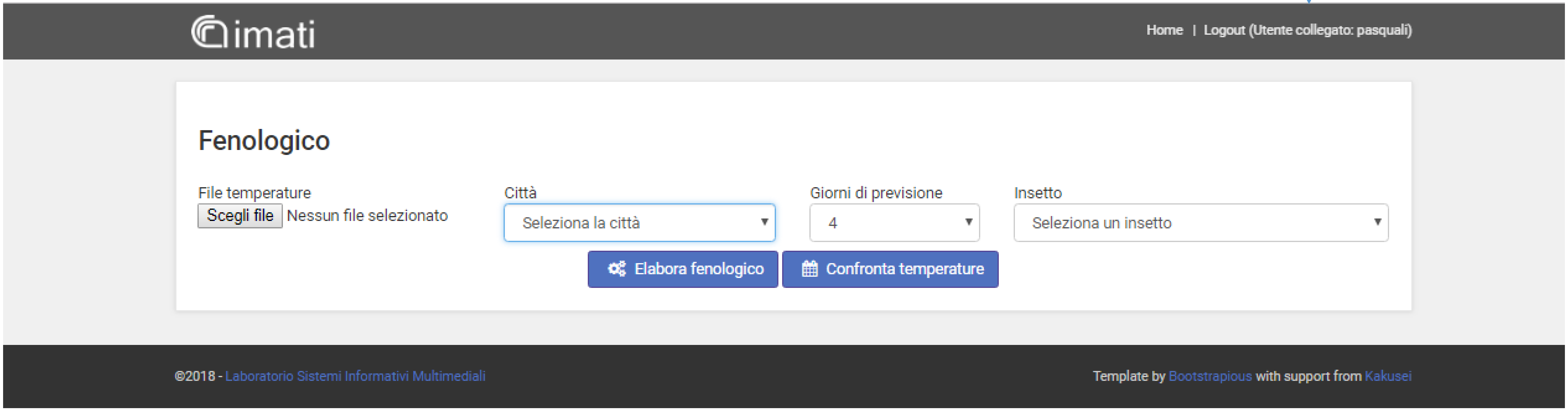


Software for pest control

You have to select

- a location in which you want to know the dynamics
- the insect of interest
- the n. of days of weather forecast
- a set of temperature of the location chosen

Example of phenological model



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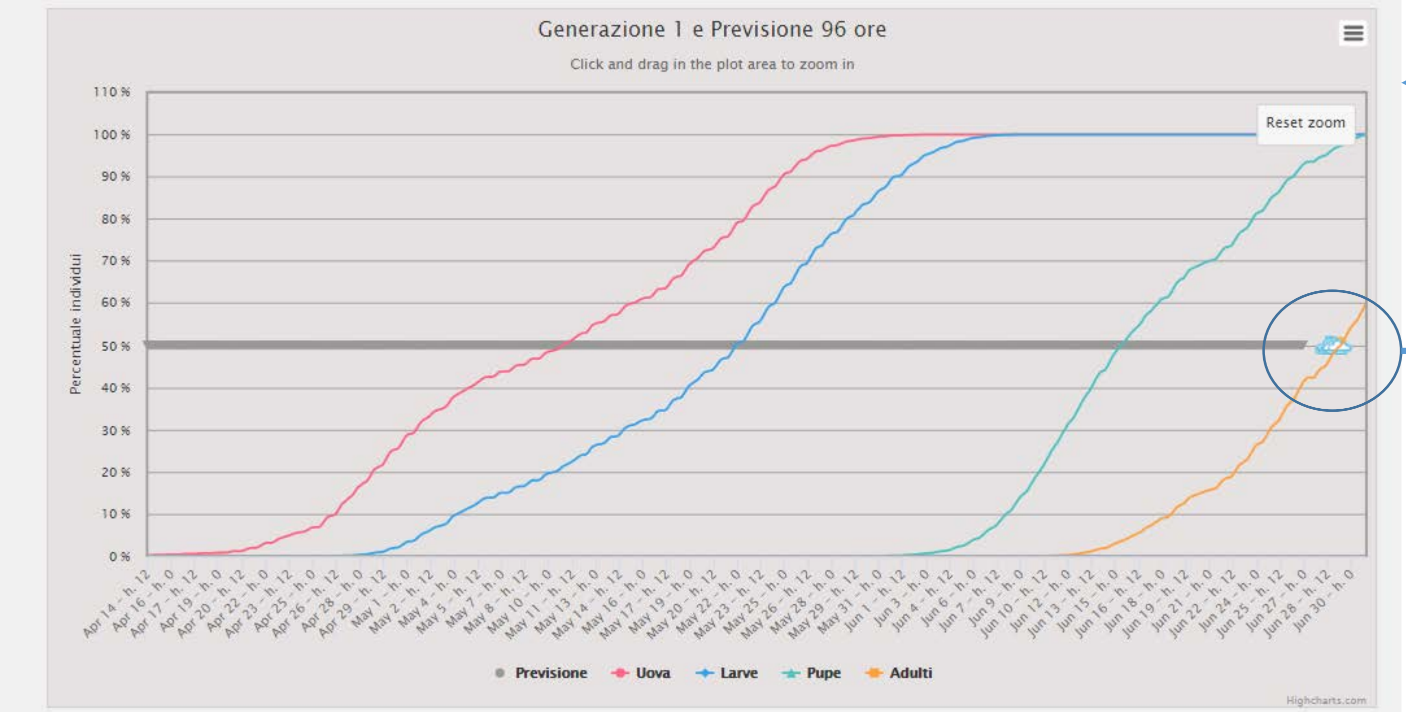
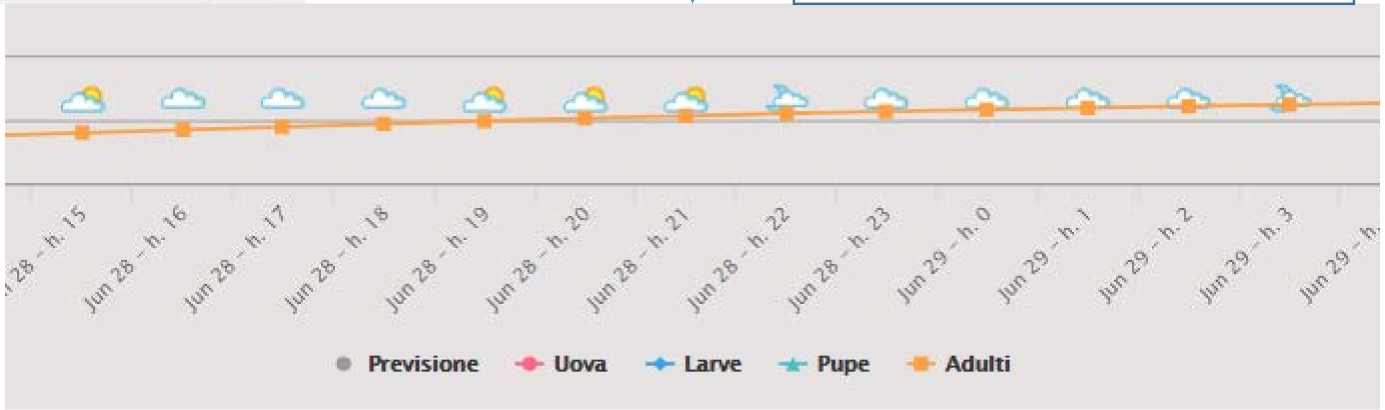
Software for pest control



Example of first generation

Weather forecast combined with dynamics



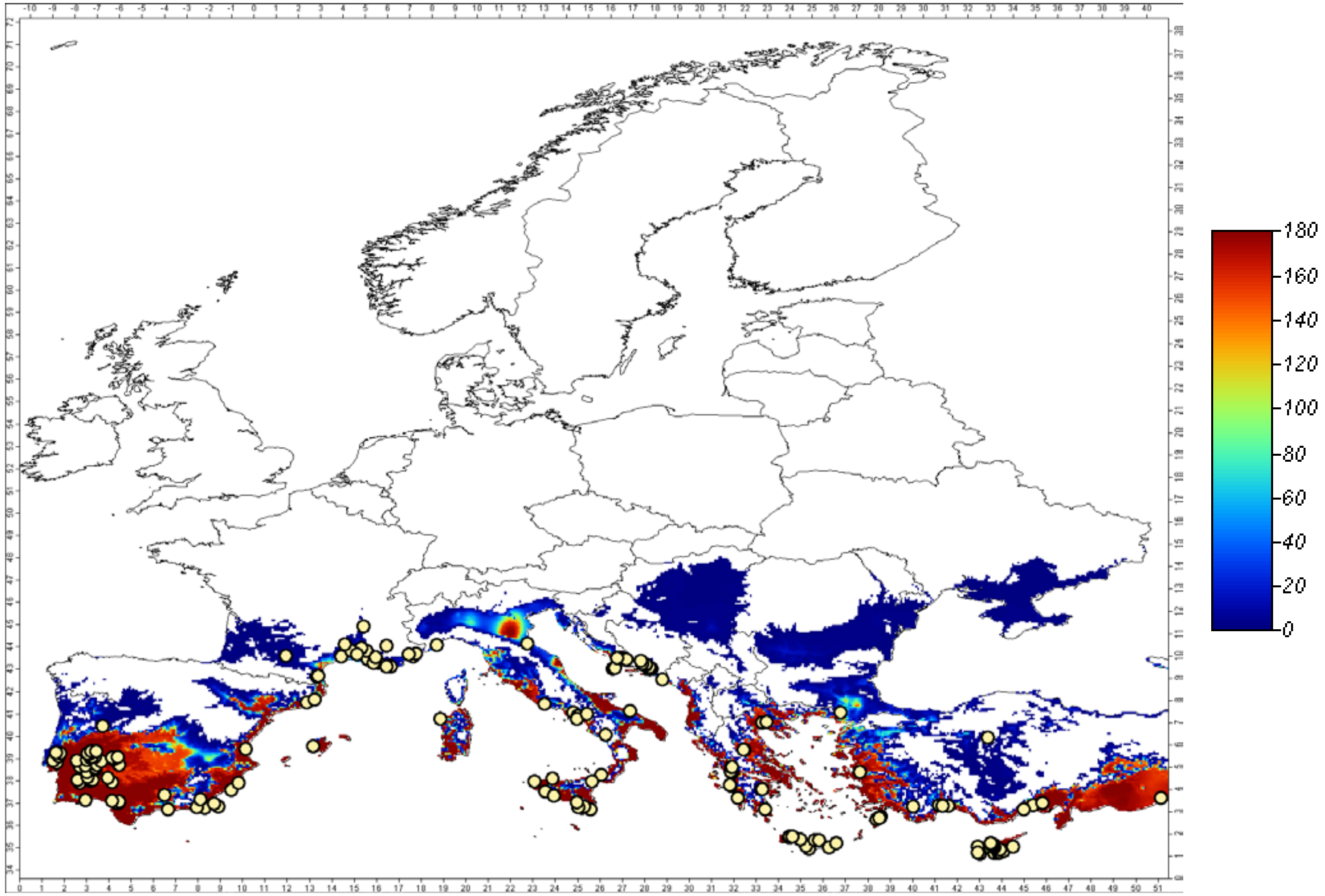
The software produces

- the dynamics of each stage and each generation of the population
- a weather forecast useful to decide if or not make a treatment on the basis of a risk threshold on the level of the population

Software for pest control

Next step: integrate in the software the production of invasion maps

Example of an invasion map produced for a Scientific Opinion of the European Food Safety Authority



Average number of adults per plant. Yellow dots: place of detection

An *in vivo* integrated biosensor for plant physiology monitoring and water management

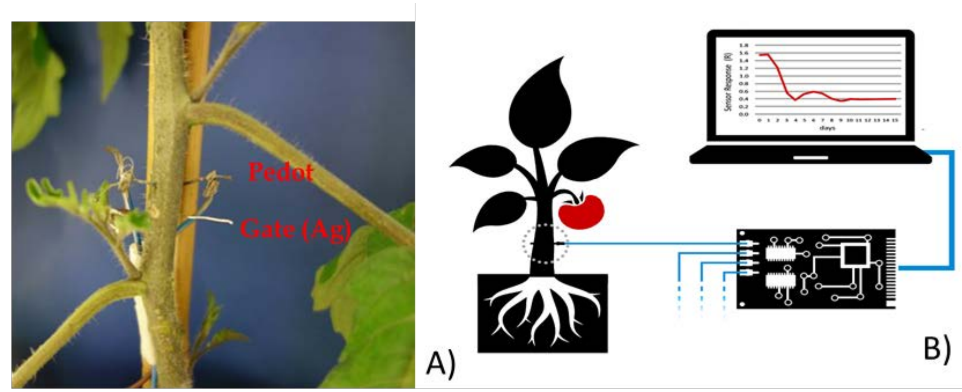
Agriculture withdraw 70% of the fresh water available in the world.

The possibility to have an early warning for drought stress in plant cultivation, thus reducing the water consumption, is mandatory in the next decades.

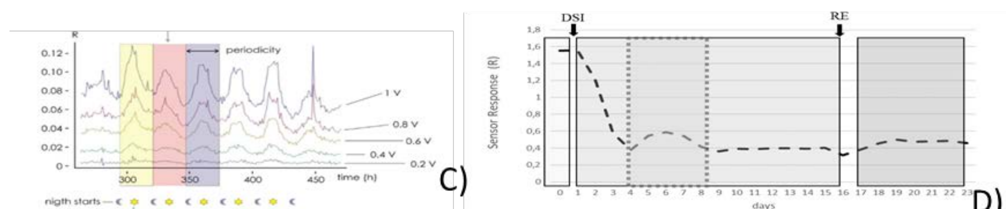
The developed sensor being directly integrated in the plant stem, monitors , in vivo , in realtime the dynamic changes occurring in the plant sap, during the plant growth, development and during abiotic stresses events.

The in vivo OECT based sensor, enable

- an early warning (within the first 30hourse post stress)
- The possibility to fine tuning the crop water supply
- Have a closer look on the mechanisms that take place in the plant during the stress



A) The in- vivo sensor in vivo integrated in the plant, B) and the read out system



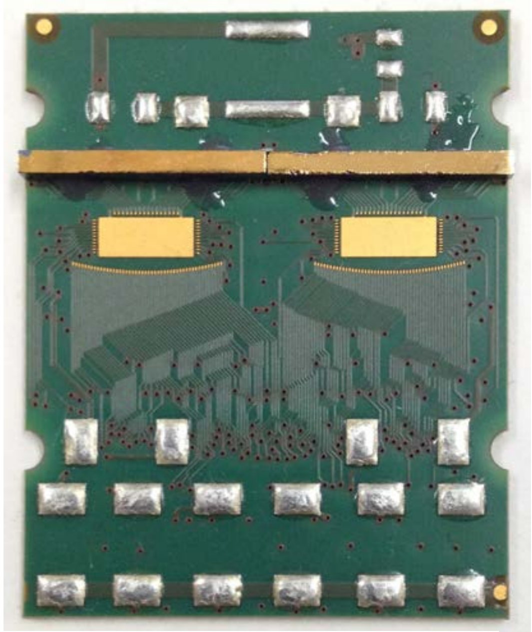
C) Detection of the circadian rhythm in tomato, D) early detection of drought stress

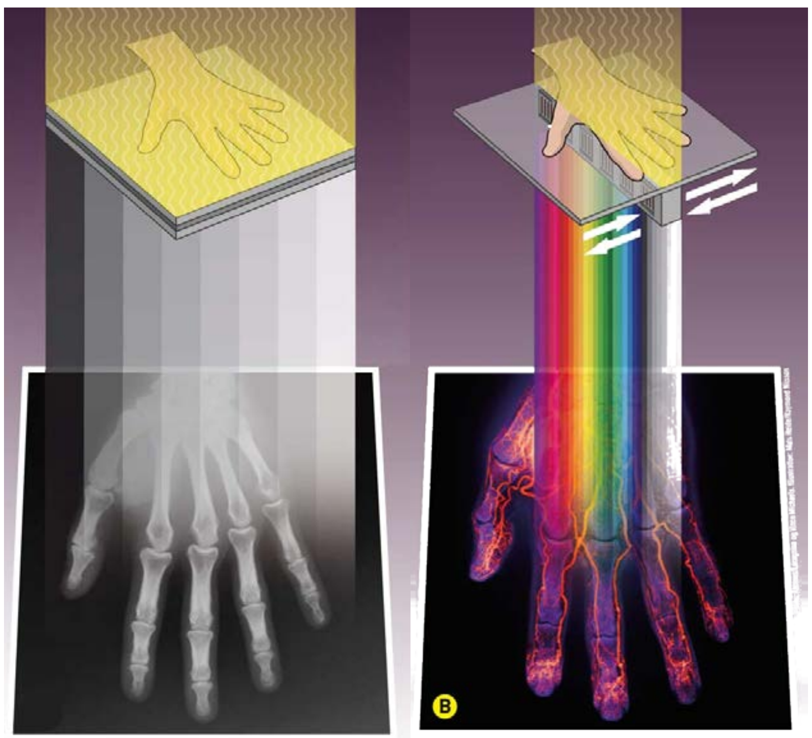
E) Application of in vivo sensor in controlled environment and F) in field

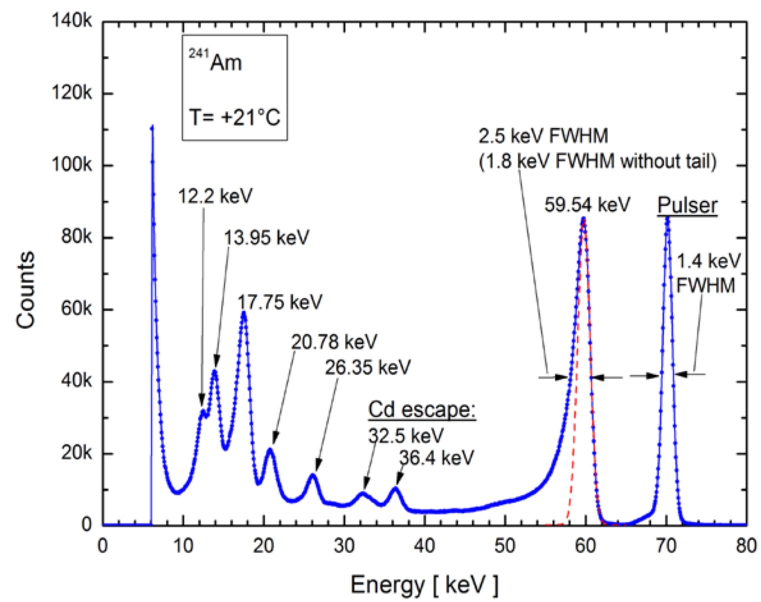
(Coppedè et al , Sci Rep 2017

Multy energy x-ray scanner for food control

Nowadays, in-line food control has become an important issue to ensure food safety.
Existing X-ray scanners have no energy discrimination.
IMEM-CNR is developing spectroscopic CdZnTe detectors, and, is collaborating with national industries to realize multi-energy x-ray scanners that ensure a high capability to reveal physical and chemical alterations in the inspected food.







Ambient Awareness for Autonomous Agricultural Vehicles

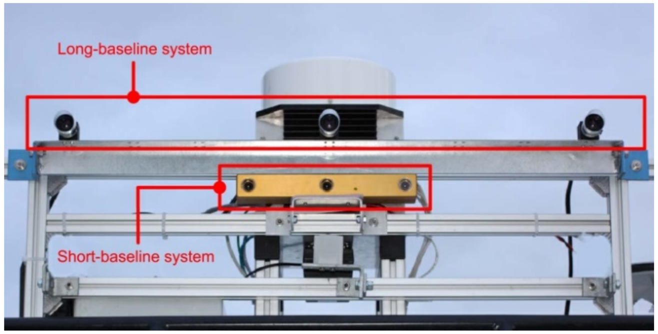
STIIMA–CNR

<u>Objective</u>:
development of sensors and sensor processing methods to provide an autonomous agricultural vehicle with ambient awareness. The *obstacle detection* problem is specifically addressed, considering different obstacle types such as positive obstacles, negative obstacles, moving obstacles (people/animal) and difficult terrain. The potential of four sensor technologies i.e., (stereo) vision, radar, LiDAR and thermography is investigated.

<u>Impact</u>:
- to increase safety
- to allow for more optimal farming
- to reduce the demands for labor and increase competitiveness
- to reduce negative impacts on the environment (e.g. more fuel-friendly operation and reduction of fertilizers, herbicides, pesticides)

STIIMA–CNR

Multi-baseline stereo for scene segmentation in natural environments



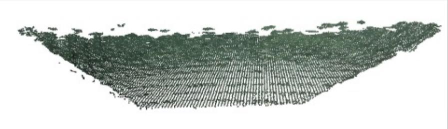
Self-supervised scene segmentation:

- Stereo 3D information are used to segment the scene into *ground* and *non-ground* regions
- Self-learning framework: the ground model is automatically built during an initial bootstrapping stage, and is continuously updated to incorporate changes in the ground appearance

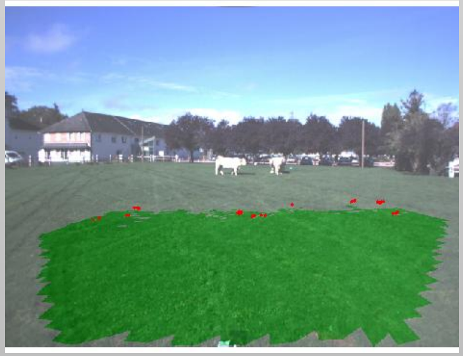
G. Reina, A. Milella, R. Rouveure, M. Nielsen, R. Worst and M. R. Blas (2016) *Ambient awareness for agricultural robotic vehicles*, Biosystems Engineering, Volume 146, June 2016, Pages 114–132

Short range ***Long range***

3D Reconstruction



Classification

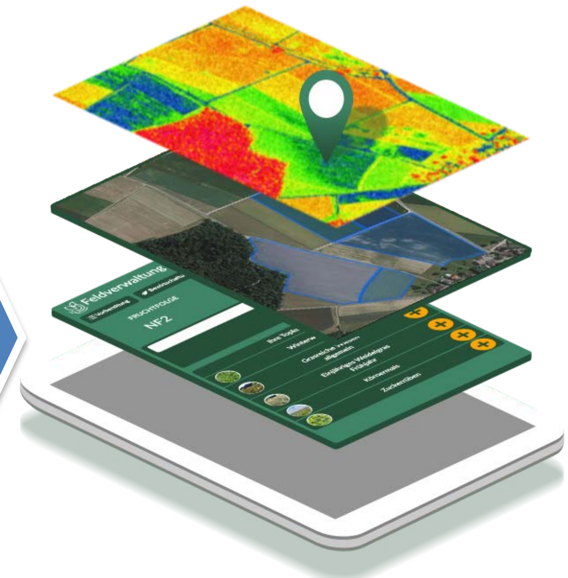


Green: ground - Red: obstacle

QUAD-AV FP7 ERA-NET ICT-AGRI-1

STIIMA–CNR

Simultaneous Safety and Surveying for Collaborative Agricultural Vehicles



- ***Multi-sensor obstacle detection***
- ***Multi-modal 3D maps***
- ***Situation awareness***
- ***Crop assessment and recognition of condition***
- ***Trafficability***
- ***Traversability***

Partners

- Danish Technological Institute (Denmark)
- University of Salento (Italy)
- Fraunhofer Institute for Intelligent Analysis and Information Systems IAIS (Germany)
- CNR - Institute of Intelligent Systems for Automation (Italy)
- AgriCircle AG (Switzerland)

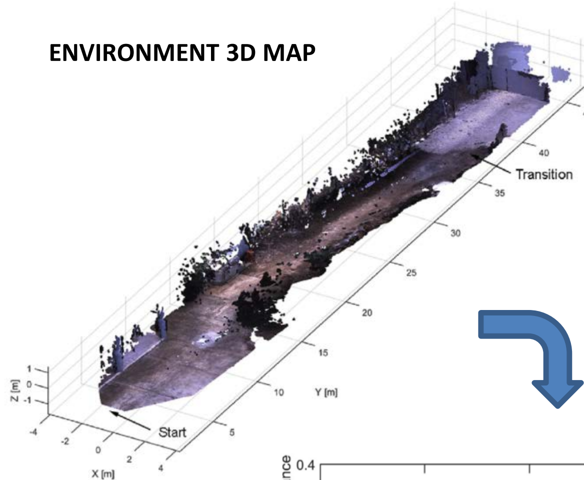
S3-CAV FP7 ERA-NET ICT-AGRI-2

STIIMA–CNR

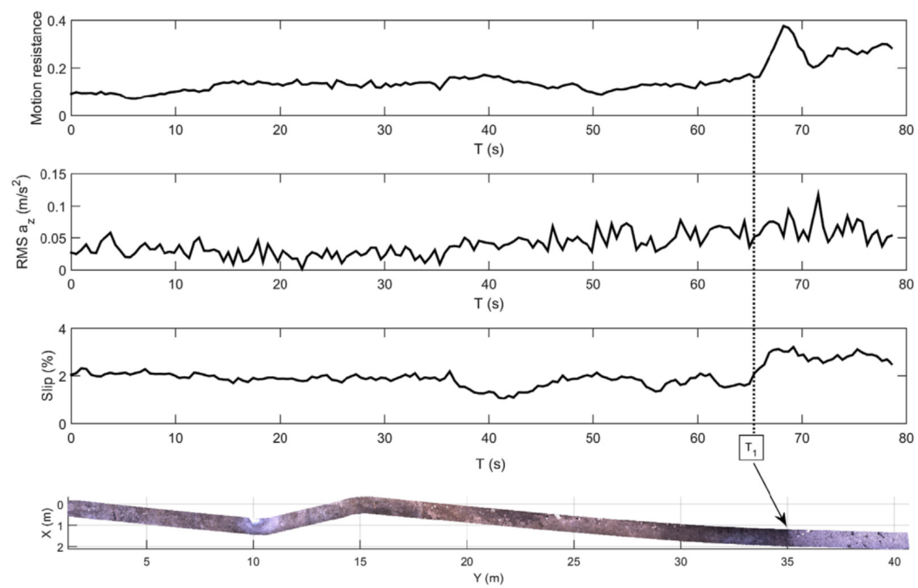
Multi-modal terrain mapping and identification

EXPERIMENTAL ROBOTIC PLATFORM

ENVIRONMENT 3D MAP



MULTI-MODAL TERRAIN MAP



- ***Objective***: multi-sensor terrain mapping and classification to support autonomous operations by an agricultural vehicle.
- ***Contribution***: terrain identification based not only on classical appearance features, such as color and geometric properties, but also on contact features, which measure the dynamic effects related to vehicle-terrain interaction that affect vehicle's mobility.

Reina G., Milella A., Galati R. (2017) *Terrain assessment for precision agriculture using vehicle dynamic modelling*, Biosystems Engineering, Volume 162, October 2017, Pages 124-139.

S3-CAV FP7 ERA-NET ICT-AGRI-2