Project MONALISA

# Application fields of key environmental parameters

*Responsible WP3*: **F.Mazzetto**

*Team composition*:

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- WP 3.3: **F. Mazzetto**, M. Bietresato, R. Gallo, GL. Ristorto, R.Vidoni
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# Background and general objectives (WP3)

- Need of improving ***farm management activities*** integrating **technical**, **environmental** and **profitable** approaches
- Developing an ***integrated framework*** for monitoring key environmental parameters at a **plot** (and **sub-plot**) scale
- This framework must be relevant to the *needs* and *standpoints* of ***private enterprises*** involved in **land processes** interacting with the Alpine Environment
  - Focus on farming and forest systems (*intensive and extensive)*
  - Profitability, sustainability and quality of products (→ *certification*)
  - Application of *Precision Farming* approaches
  - Monitoring activities concerning not only the environmental components but also the *means of production* (land processes and machines)

# Lines of research (WP3)

- **WP3.1 - Monitoring carbon and water fluxes between soil/vegetation and the atmosphere in intensive orchards**
- **WP3.2 - Monitoring of growth rates and productivity of forests**
- **WP.3.3 - Monitoring the vigour and the state of the canopy in intensive orchards through mobile ground sensing solutions**
- **WP3.4 - Monitoring field mechanized processes in intensive and extensive farms with automatic reporting of activity logs**

- ***Monitoring details at parcel scale (from fields to single plant)***
- ***Domain of managed crops***
- ***Focus on eco-physiological, growth, vigour and productivity aspects***
- ***Focus on management of field activities***

# Monitoring C & $H_2O$ footprints (WP 3.1)

## Continuous monitoring of phenology and environmental drivers

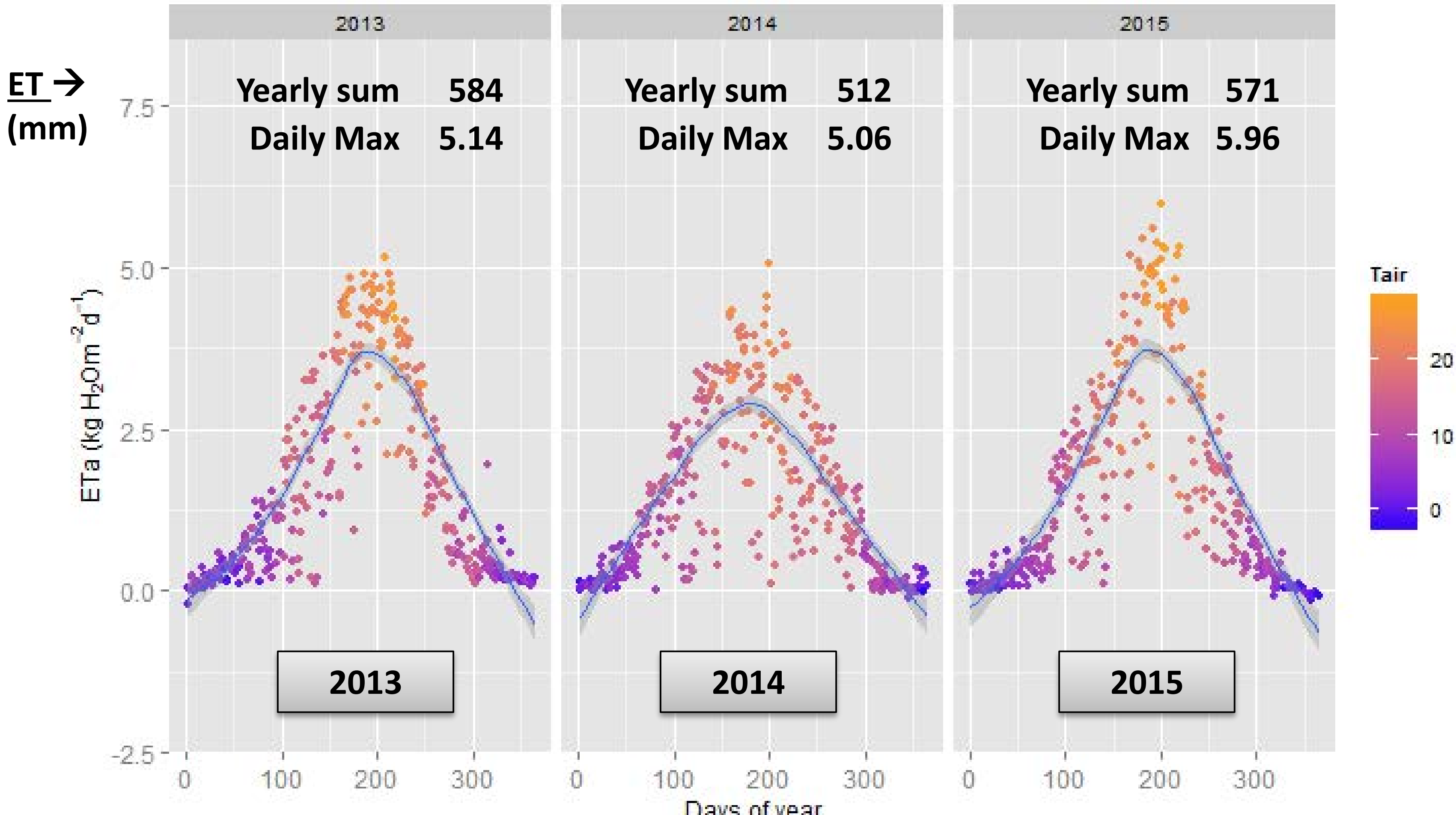



# Monitoring C & $H_2O$ footprints: Methodology

- **Eddy covariance $CO_2$ and $H_2O$ flux data**
  - 8m tower (4 m above canopy)
  - IRGA (LI-7200)
  - 3D sonic anemometer (Gill R3-50)
- **Meteorological data**
  - Net radiation (CNR1 K&Z)
  - Soil Water content (CS 616-L)
  - Air temperature and RH (CS-215)
  - Precipitation (Rain-o-matic)
  - PAR (SKP215)
- **Other instruments**
  - NDVI and PRI sensors
  - Phenocamera

# Monitoring C & $H_2O$ footprints: Results

## Assessment of the daily water consumption of the orchard



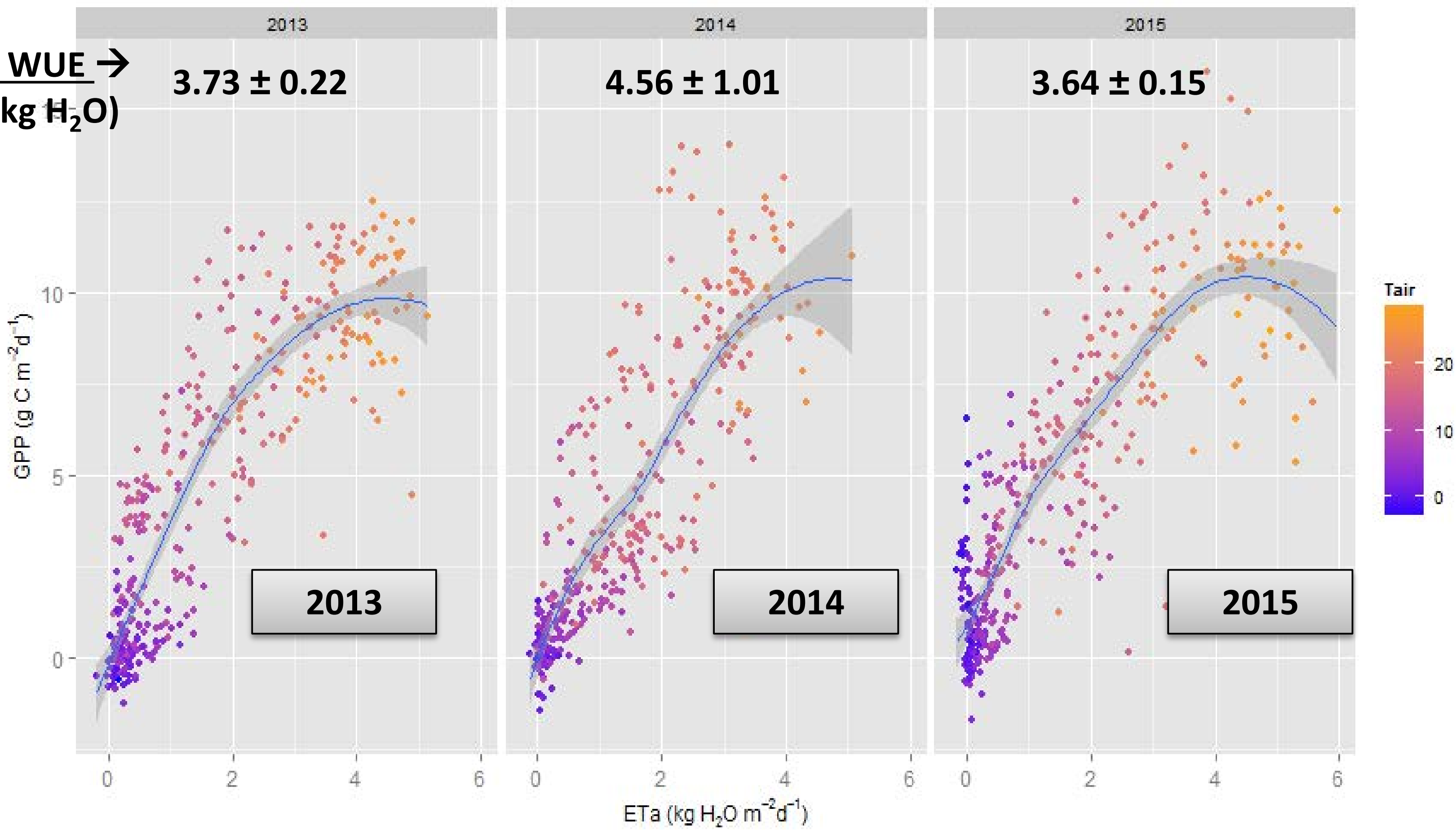

 

# Monitoring C & $H_2O$ footprints: Results

## Assessment of the daily water use efficiency

**WUE** = Gross Primary Production / Evapotranspiration

**Mean WUE →**
**(g C / kg $H_2O$)**



# Monitoring C & $H_2O$ footprints: Results

- **Eddy covariance** proved to be a very efficient methodology to assess both carbon and water fluxes at *ecosystem scale*
- The obtained dataset will allow modeling the **physiological response** of trees under different growing condition
- Implications on ***crop management***: better indications on how improving the **resource use efficiency** under ***changing climatic scenarios***
- The approach meets the requirements of the ***Smart-Climate Agriculture***

# Forest Productivity (WP 3.2)

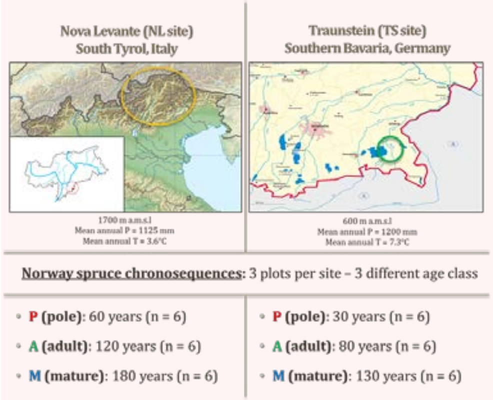
- Are today the ***Alpine Forests growing faster*** than before, and if yes which are the ***environmental drivers*** (*CO2 increase, water availability increase, N deposition,* etc.)?

- Can **LiDAR data** be used to extracted accurate information about the ***structure and biomass*** of complex Alpine forests using a **single-tree detection** approach, and if yes can we provide PA with a ***user-friendly web-GIS tool*** to analyze these data?

# Forest Productivity: Methodology

**1.**

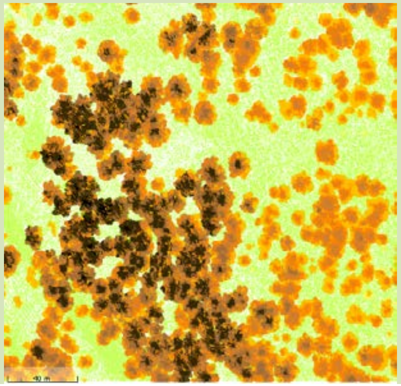
Analysis of Alpine (Norway spruce) forest productivity temporal changes by a combined **stem analysis-chronosequence** approach and assessment of the environmental drivers by a **multi-stable isotope** approach to infer the past intrinsic **water use efficiency** (**iWUE**)

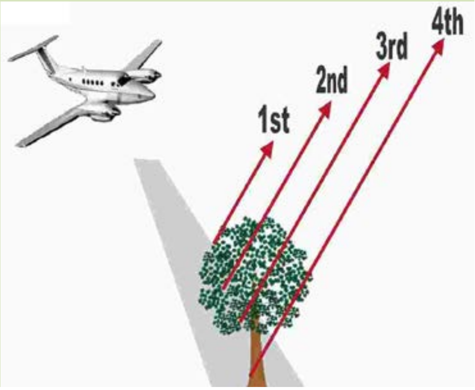



**2.**

Development and validation against field-mapped test plots of **single-tree extraction algorithms** to estimate forest structure and biomass from LiDAR data

- based on both raster (DSM – CHM) and raw *point cloud data*
- automatic calibration using Particles Swarming optimizer technique



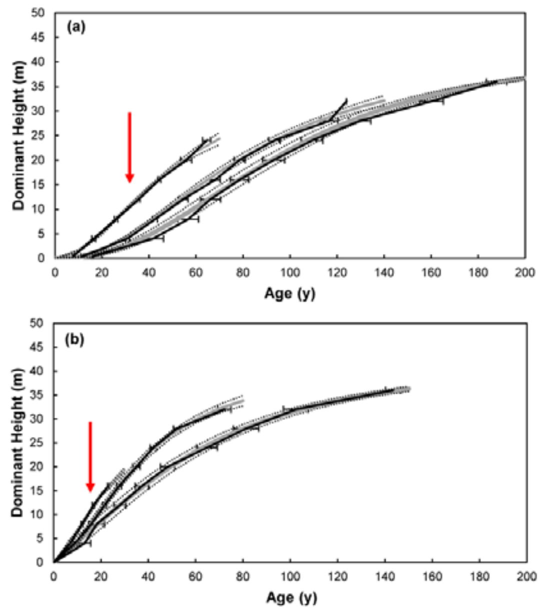


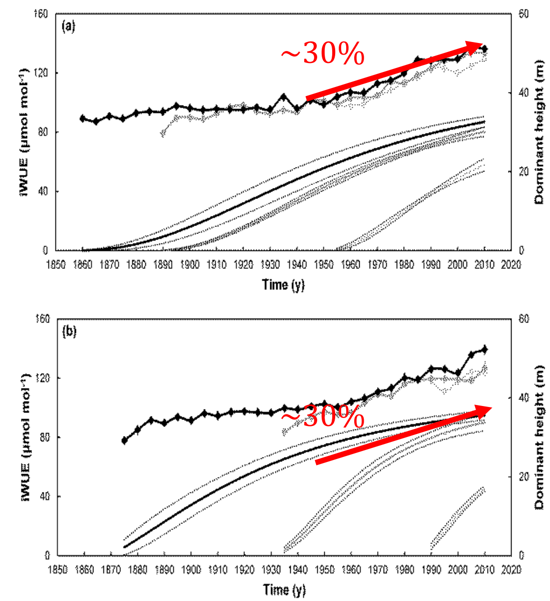
# Forest Productivity: Results

**1.**

- Remarkable increase in forest productivity of both Norway spruce chronosequences

- Parallel Water Use Efficiency increase mainly due to **higher photosynthetic capacity** explained by rising **atmospheric $CO_2$ levels** rather than by Vapour Potential Deficit changes. This can have important implication for forest management.



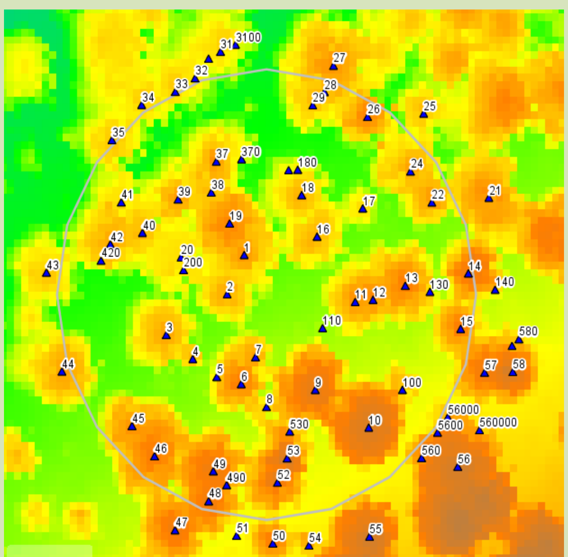

$$iWUE = (\boldsymbol{a} * Age) * (\boldsymbol{b} * Size) + \boldsymbol{c} * CO_2$$

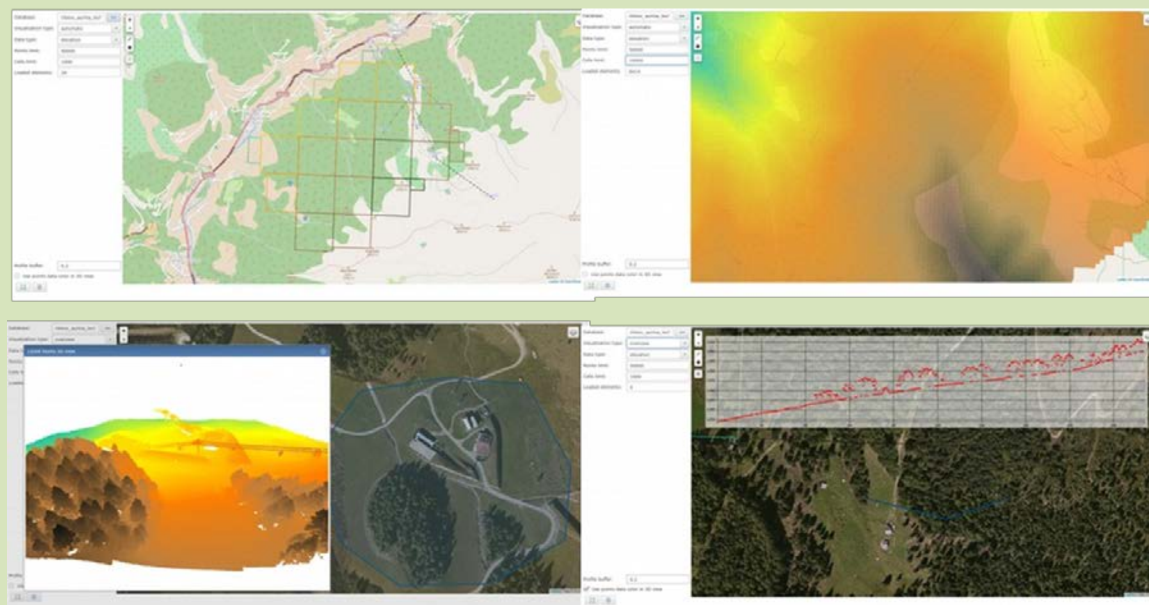
| | NOVA LEVANTE | TRAUNSTEIN |
|---|---|---|
| **a** | 0.103 (±0.006) | 0.087 (±0.016) |
| **b** | 0.034 (±0.002) | 0.030 (±0.005) |
| **c** | 0.312 (±0.021) | 0.321 (±0.011) |

# Forest Productivity: Results

**2.**

- Assessment with high accuracy **(estimation error < 5%)** of the forest aboveground biomass from LiDAR data using **single-tree** extraction algorithms;
- Development of a Web-Gis tool (called **LESTO -** *LiDAR Empowered Sciences Toolbox Opensource*) to properly analyse LIDAR data



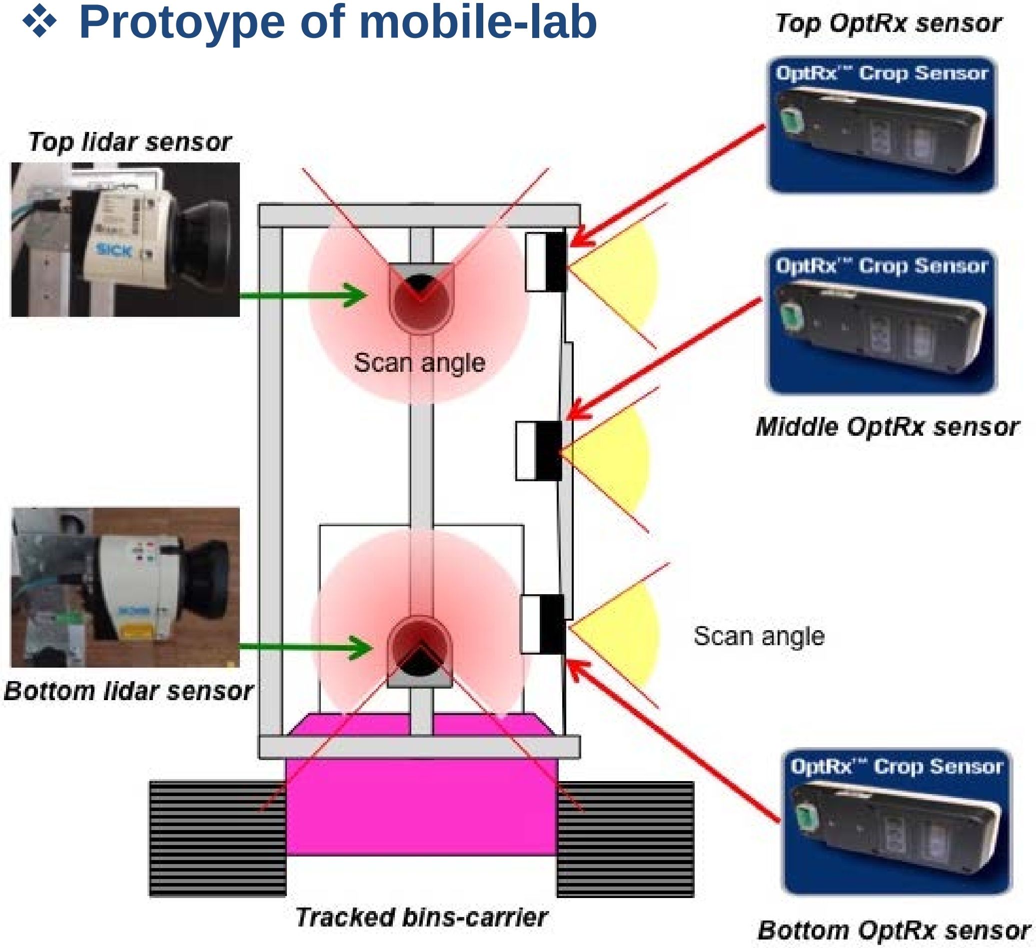


# Crop Monitoring (WP 3.3)

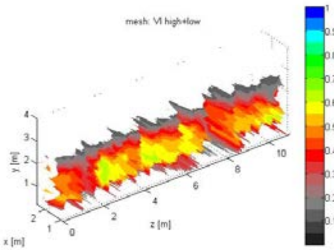
- Application of **ground sensing optical sensors (GSOS)** to carry out crop monitoring activities (*phenological state, health conditions and vigor*) through *periodical* ***non–destructive***, ***in-motion*** measures in proximity of the canopy (high representativity and details of the entire cultivated plot)
- GSOS ***overcome*** the general problems of conventional remote sensing (RS) techniques, generally due to **organizational aspects** and **resolution details**
- GSOS provide a ***near side-view*** of the canopy to be investigated, with more accurate details on the vegetation status, thus integrating a classic **far top-view** typically provided by conventional RS surveys

# Crop Monitoring: Methodology

❖ **Protoype of mobile-lab**




❖ **Laboratory tests** *(calibration and effects of vibrations)*

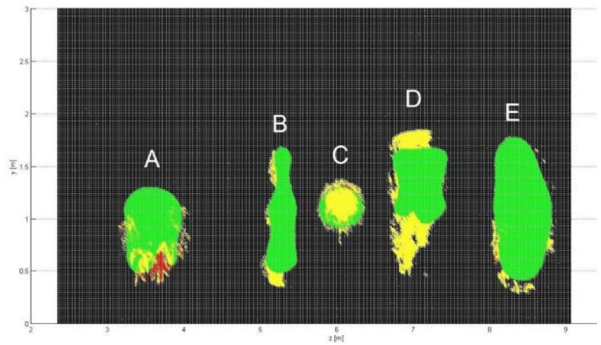


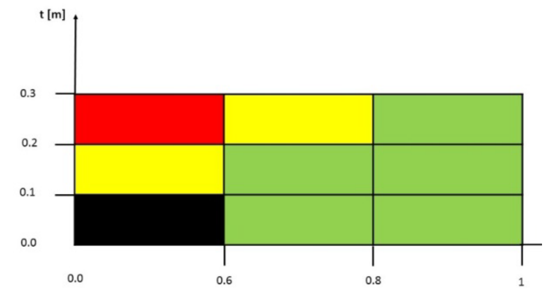
❖ **Field tests** *(combining LIDAR and NDVI measures at plot scale)*

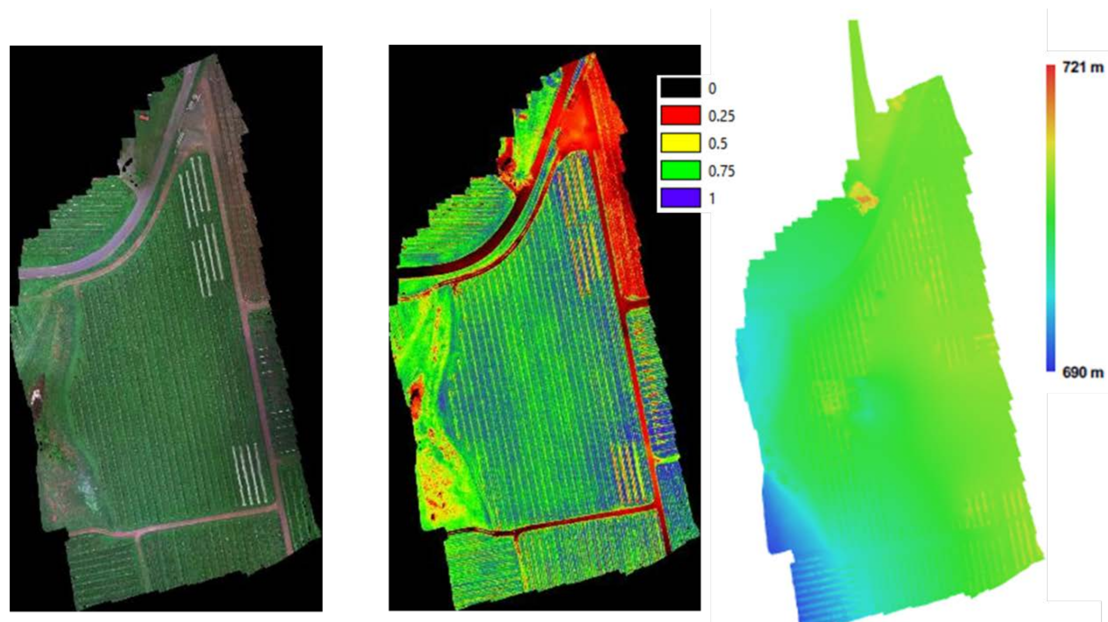
**F.Mazzetto - unibz**

# Crop Monitoring: Results

- Capability of **disease early detection** (combining LIDAR & NDVI measures)
- Detection with **high details** that could be even useful for site-speficic automation approaches
- Good correlations with top-view surveys carried out by UAVs, carried out with *fewer work times*
- Good correlations with bloom charge and final yields (useful **for planning thinning and harvesting operations**)




RGB NDVI DEM

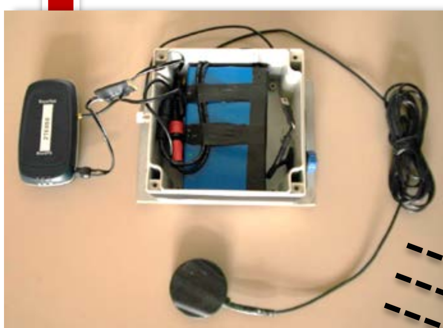
# Operational Monitoring (WP 3.4)

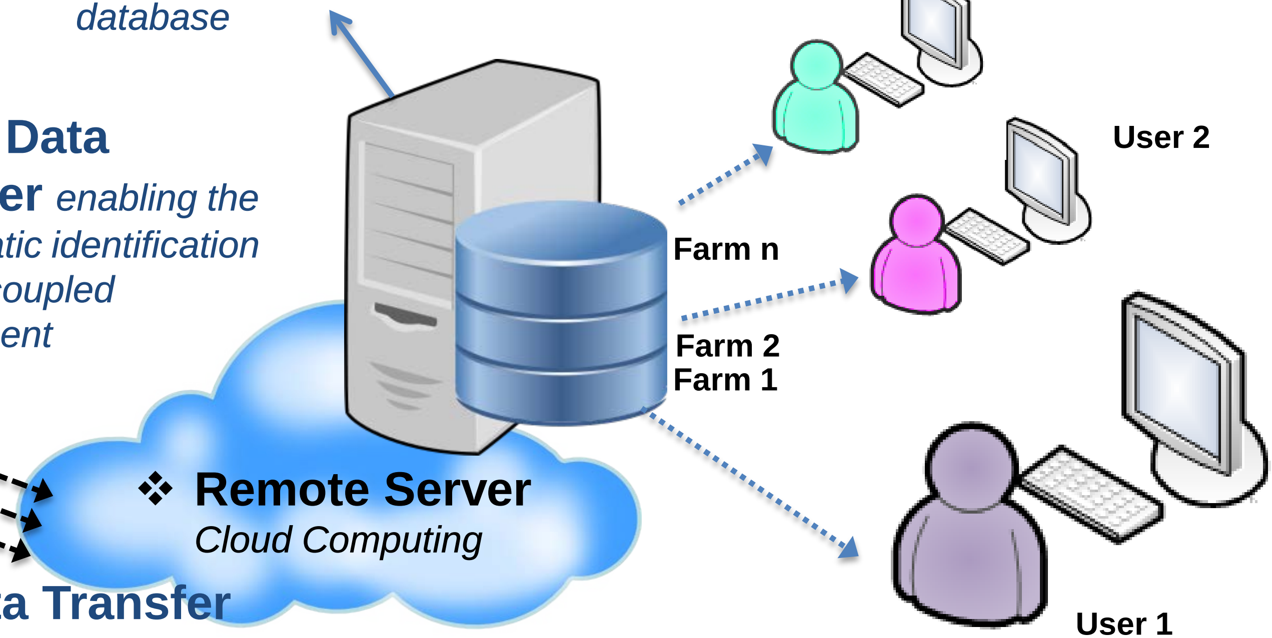
- Development of solutions to get **information automatically** on how the mechanized field processes are carried to satisfy management support, logistic and production purposes
- Achievement of technologies and methods to enable managers to keep permanently updated their **field activity registers** at the enterprise (build up of an objective and reliable ***enterprise historical memory*** as **precondition** for any management information and precision agriculture goal
- Enabling forms of **quality certification** (especially for environment and processes, even within EPD, PEFC and CoC frameworks) based on ***reliable ex-post observations***

# Operational Monitoring: Methodology

❖ **Inference Engine** *interpreting raw data and daily updating each farm database*

❖ **Field Data Logger** *enabling the automatic identification of the coupled implement*






❖ **Remote Server** *Cloud Computing*

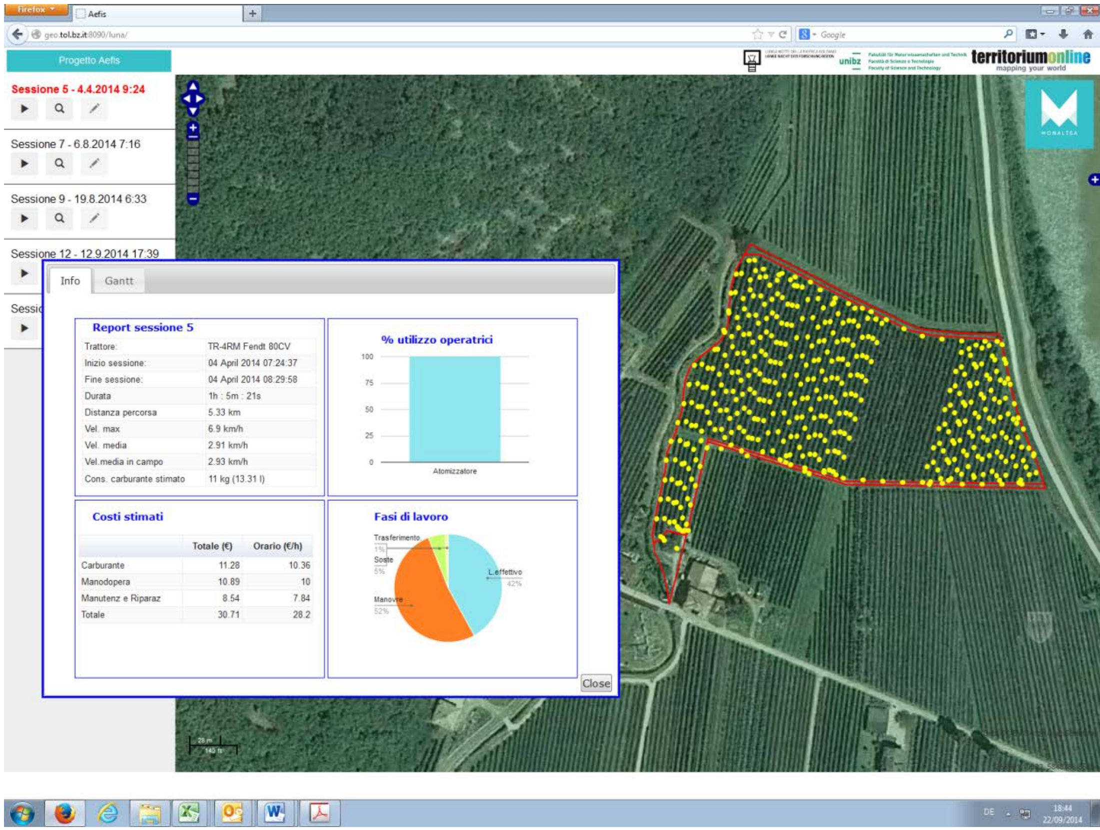
❖ **Data Transfer** *Through GPRS transmission*

❖ **Mechanized Field Activities** *real time monitored*

❖ **Farm final Users** *access with reserved domain*

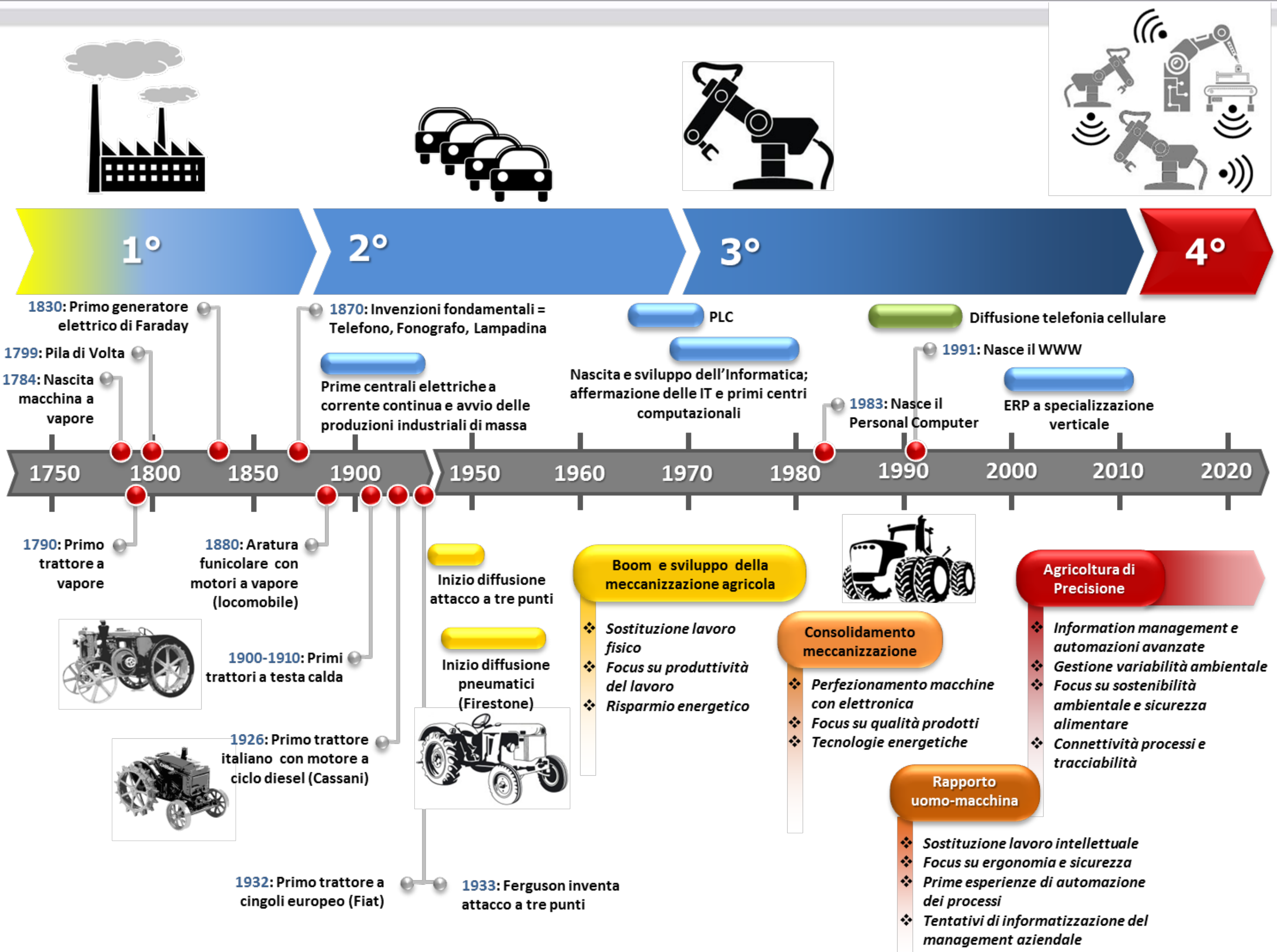
# Operational Monitoring: Results

- **Reliable capability** of self detecting and describing farm field activities
- Provision of **high details** for each operation reported (*work time analysis, execution dynamics, actual scheduling, cost analysis)*
- Development of a friendly final us**er-interface**, easily manageable directly by farmers
- Relatively high annual costs for **data transmission** (via GPRS): to be revised the data transfer approach through WiFi connections




- **Diffusion strategy:** required the presence of a service centre to be coordinated by agricultural experts

# AGRICULTURE 4.0 INDUSTRY



# General Conclusion

- Times are ready for a **highly connected management** approach in the *Agri-Environmental Enterprises*
- Platforms able to easily integrate **environmental, crop and operational monitoring activities** must be developed and promoted among farmers
- Any monitoring task must be **highly automated** and considered as an integral part of any agri-environmental production process
- *Next steps*: organizing **service centers** to enable farmers to quickly access these tools and solving problems of **big data** management