IoT-field: project overview and initial results

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IoT-field

IoT- field: An Ecosystem of Networked Devices and Services for IoT Solutions Applied in Agriculture

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Coordinator: UNIVERSITY OF ZAGREB Faculty of Electrical Engineering and Computing (FER)	FER
Partners: **1. JOSIP JURAJ STROSSMAYER UNIVERSITY OF OSIJEK Faculty of Electrical Engineering, Computer Science and Information Technology Osijek**	FERIT
2. Agricultural Institute Osijek	POLJOPRIVREDNI INSTITUT OSIJEK

Precision agriculture

- Smart agriculture is about "… taking the right cultivation measure at the right place at the right time "– Jacob van den Borne
- Data-driven usage of IoT solutions and Earth observation data to increase the quantity and/or quality of crops

Motivation

- Assess the impact of climate change on corn crop production
- Offer novel IoT solutions (software and hardware) for dense monitoring of microclimate conditions and physiological status of plants
- Integrate all available data sources into an interoperable IoT ecosystem for precision agriculture
- Offer low cost solutions for small farms

Project goals

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- Implement an ecosystem that **integrates relevant microclimate and agronomic data** to evaluate **physiological condition of crops** based on chlorophyll fluorescence
- **Support farmers** in making daily decisions and assessing the condition of the crop
- **Predict corn yield** based on measured indicators
- **Optimize fertilization**
- Document performed agro-technical and phytomedical measures to control compliance with legal directives using **blockchain technology**

Interoperable ecosystem for precision agriculture

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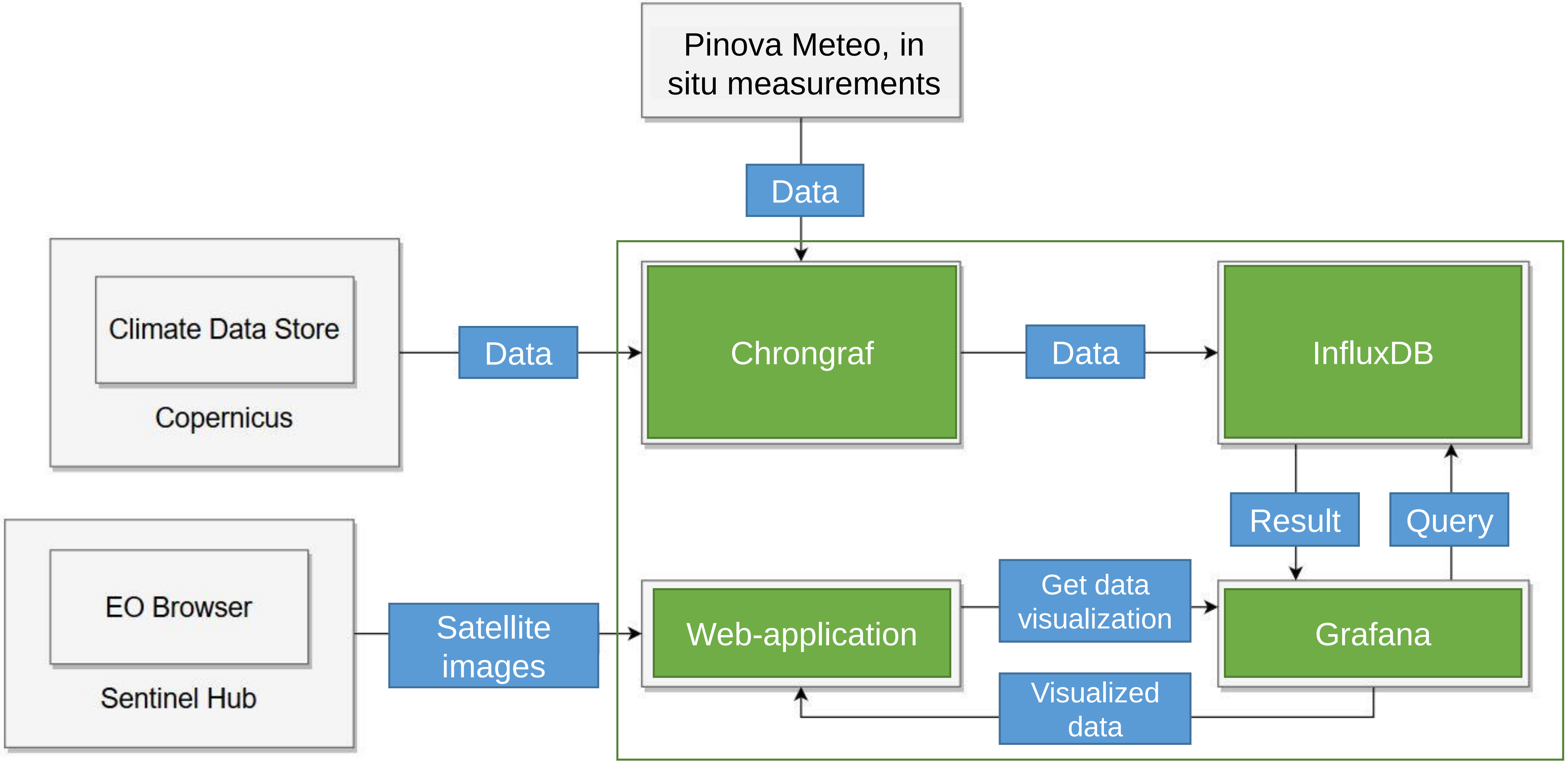
- Integration of relevant microclimate and agronomic data for agricultural applications
  - earth observation data from the Copernicus programme
  - deployment of an innovative WSN solution for dense monitoring of microclimate conditions and physiological status of plants in real time

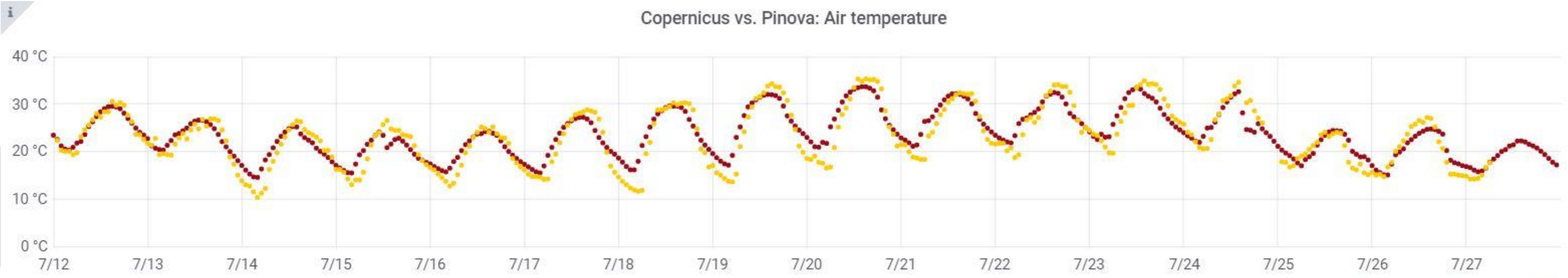
Climate Change Service

- ERA5-Land hourly data from 1981 to present
  - large set of parameters (air & soil temp, soil moisture, wind speed direction, surface solar radiation, precipitation, etc.)
  - updated monthly with a delay of about three months
  - horizontal resolution is 9 km

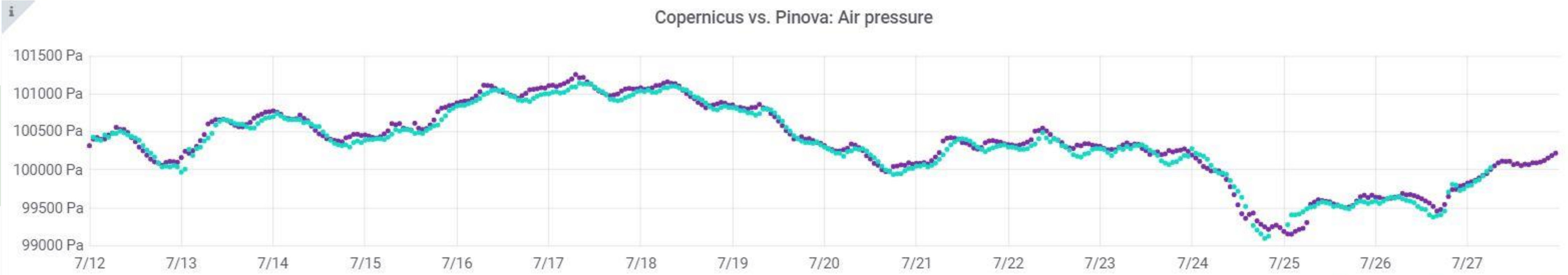
Integrating time-series data



Copernicus vs. in situ measurements



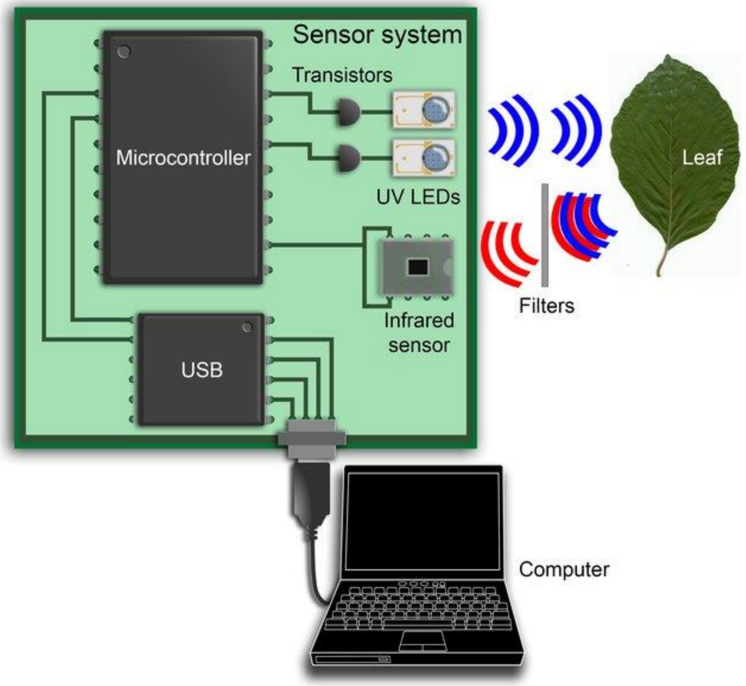
	min	max	avg
copernicusdata.air temperature	14.63 °C	33.67 °C	23.55 °C
pinovadata.air temperature	10.40 °C	35.30 °C	23.07 °C



	min	max	avg
copernicusdata.air pressure	99156 Pa	101255 Pa	100353 Pa
pinovadata.air pressure	99100 Pa	101140 Pa	100345 Pa

WSN for crop monitoring

- Design and deployment of a secure and energy-efficient WSN to monitor environmental parameters and plant status
  - dense monitoring of microclimate conditions and physiological status of plants
- Design of a networked sensor for assessing the physiological state of crops based on chlorophyll fluorescence



Izvor: https://www.researchgate.net/publication/312633525_A_Low-Cost_Chlorophyll_Fluorescence_Sensor_System

The problem of data sparsity

- Variability in field conditions:
  - **Plant based** factors (genotypes, morphology, adaptness)
  - **Environmental** factors (soil status, high/low temperatures, precipitation, etc...)

- **The data collected by farmers underrepresents true field conditions**

- Usually a **single datapoint** on plant side is collected once the plant is already a **dead tissue -> harvest**

Stress states

- Empirical optima of plant states -> often **violated** by **deviations** of environmental conditions
- **Deviations** from **optimum** affecting the plant status -> PLANT **STRESS STATES**

Stress intensity:

1. No stress -> no measures need to be applied (no detectable stress)
2. Mild stress -> good time for application of measures (if detectable)
3. Moderate stress -> last call for measures (easily detectable, moderately detrimental)
4. Severe stress -> critical measures and remedies can be applied (detrimental effects, sometimes lethal)
5. Plant death

Monitoring the plant status in field conditions

- Plant status changes in the course of the **day -> week -> month** with **past conditions** affecting the **present state of an organism**
- Many **adverse environmental effects** can be **mitigated** by timely **application** of certain **measures**
- The key steps are:
  - Defining informative parameters (with low cost) on the plant side
  - Good choice of environmental variables
  - Account of all the measures that have been undertaken (fertilization, spraying, soil analysis data, etc.)
  - **SPATIO-TEMPORAL MONITORING OF THE PLANT STATUS**

Model development

- Once the data is collected -> model development stage
- Objectives of models:
  1. To model the plant growth (approximate Bayesian computation (ABC) or similar)
  2. To model plant states as affected by environmental deviations in real time (machine learning, LASSO or similar)
  3. To model the leverage of stress states on final outcome of crop production - yield (PLS, machine learning, LASSO)

DATA-DRIVEN DECISIONS IN AGRICULTURE

Envisioned services and applications

- Service for data-driven processing of integrated microclimate and agronomic data
- IoT-application for daily assessment of crop condition and yield estimation
- Blockchain service for taking note of the applied agrotechnical and phytomedical measures in the field

Expected impact

- Identification of critical moments in crop vegetation to mitigate effects of climate change
- Timely application of agrotechnical measures for stable development of plants
- Prediction of crop yield to plan storage and drying capacity and costs

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Further information

https://iot-polje.fer.hr/iot-polje/en

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