# The concept of Smart landscapes
## –
## the pilot farm Amalie
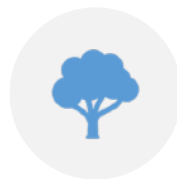
Research groups CWSL CZU Prague

Prague 2022

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CWSL
The Centre for Water, Soil and Landscape

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# Outline

Smart Landscapes

Amalia site - past

Monitoring

Analytical tools

Selected Measures

# Smart Lanscapes

# Main Issues of Current Practices

The climate change is moving faster than the course of adaptation measures in the Czech Republic

The absolute delay of adaptation measures is currently about 20-30 years and continues to grow.

Insufficient capacity of water management facilities

We size structures and systems for today's conditions, and we do not consider climate change. It is necessary to consider a time horizon of at least 2030+, preferably 2050+.

We only implement sporadic elements that are not interconnected into a complex system that would use the synergy and multifunctionality of the elements in the interest of a better price : performance ratio.

The proportion of woody plants and non-forest greenery in the agricultural landscape is reduced, and its resilience, adaptation and preventive action against the effects of climate change are thereby deteriorating.

The size of parts of land blocks and the monocultural method of industrial management on arable land reduces the ability of the landscape to mitigate or eliminate the impacts of risky situations (flash floods, drought, etc.) and worsens biodiversity.

# Smart Lanscape concept

# Basic principles

Overall optimization of water management. Minimization of the impacts of drought and floods.

Is an environmentally sound and sustainable part of the intensification of agriculture and forestry.

Minimizes soil erosion.

Makes the landscape more comfortable for living, including microclimate modification.

Promotes overall biodiversity. Increases the aesthetic value of the landscape.

Represents a sophisticated landscape system of interconnected water management, soil protection and eco-stabilizing elements supplemented by rational landscape management.
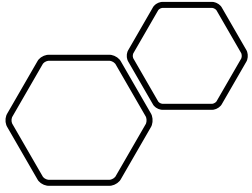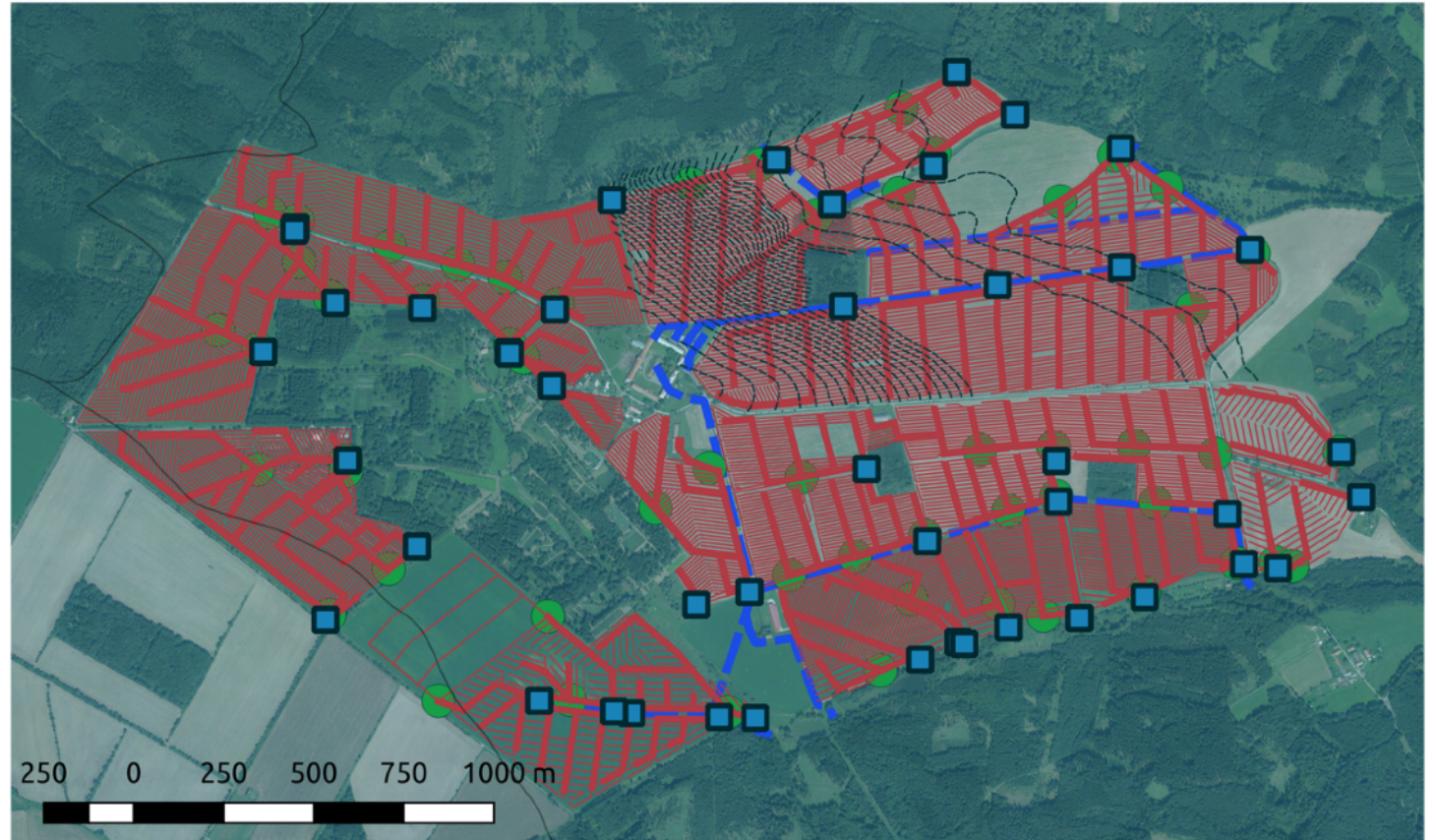
# Amalia Site

- Two paired watersheds
  - 4.4 km²
  - 3.28 km²
- Arable land
  - 60%
  - 40%
  - In total 3.672 km²
- Arable land owned by CZU



Norway grants
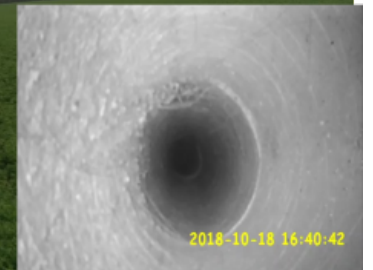
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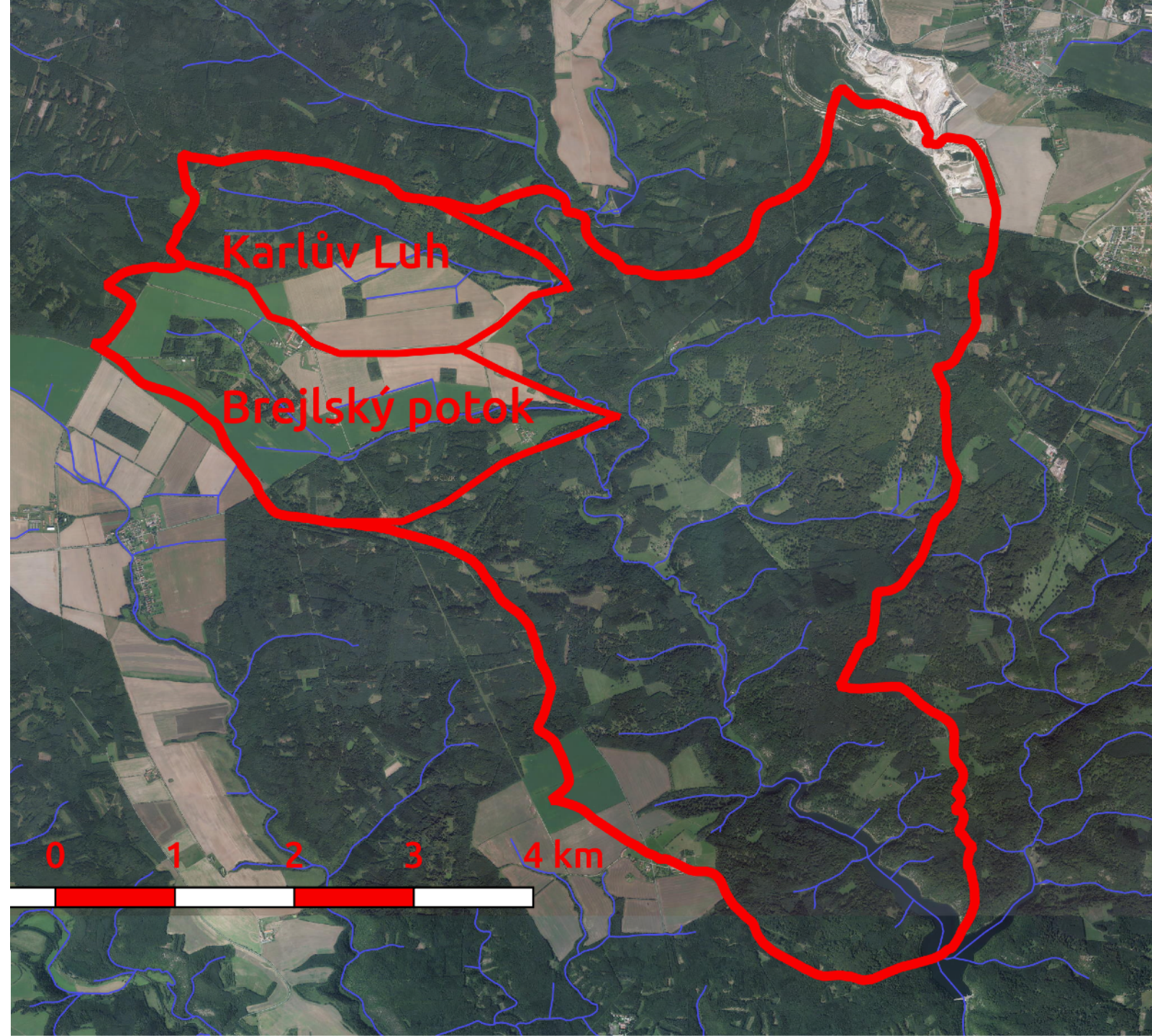
# Amalia Site

- Systematic drainage
- 100% Arable Land
- 1957- 1958

•Challenges:
- 1/3 of the area of Czech republic

# Amalia Site

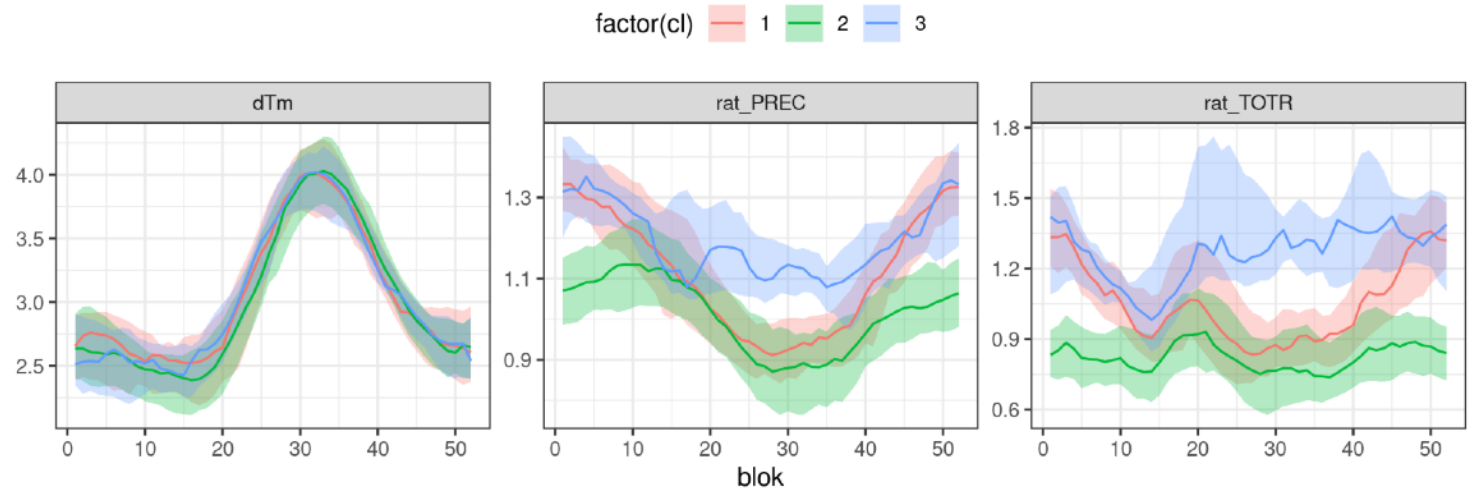- Regulated systematic drainage system

- System of ditches

- System of pipes

# Amalia site Climate change impact

- The climate change impact on the distribution of rainfall events

- 5 rainfall events with highest rainfall depth 10% of annual rainfall depth

- 20 largest rainfall events 50% of annual rainfall depth

- 10 days – ¾ annual runoff

- 20 days – 80% of annual runoff
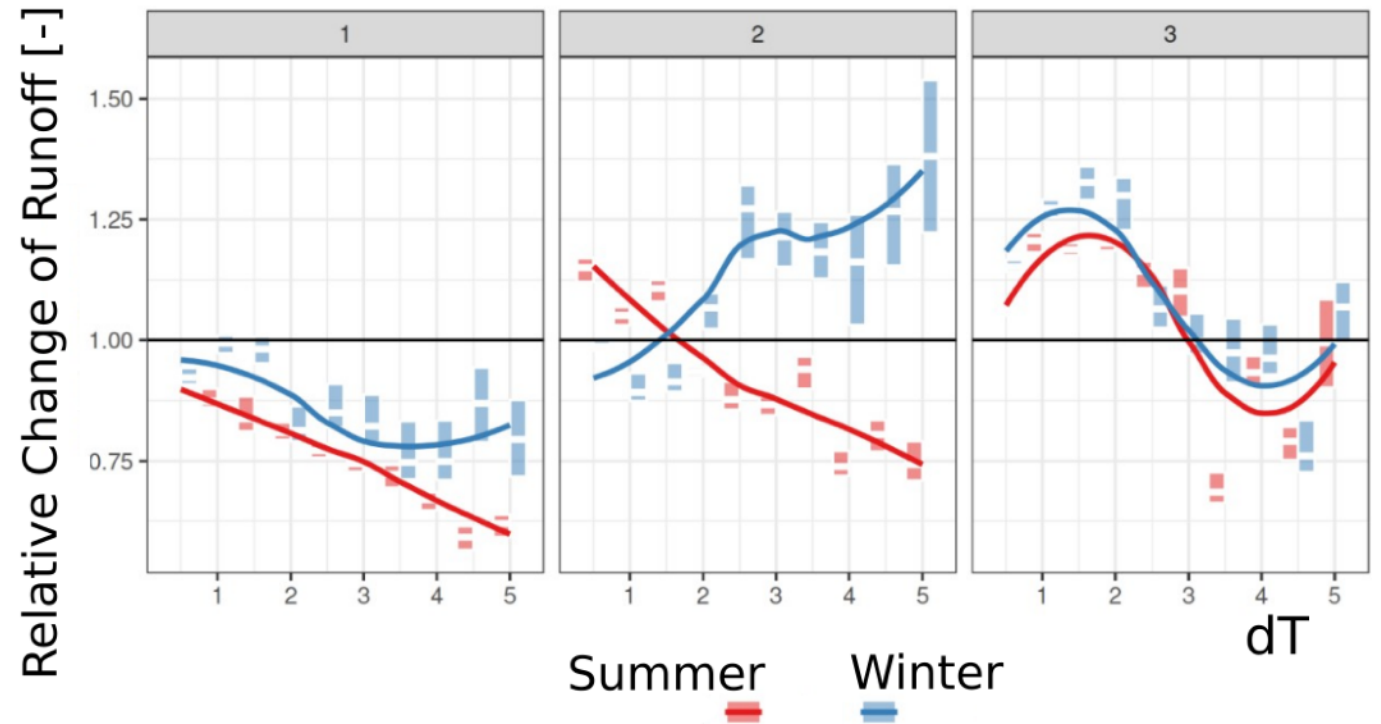
# Amalia Site Monitoring

-

# Short Summary

- 40 groundwater well depth 6- 60m + 11 shallow ground water wells 2.5 - 3m
- 110 TDT soil moisture sensors + 110 new installation 2022-2023
- 93 dendrometers + more
- 2 main meteo-stations + 6 microclimatic stations
- More than 423 observational points for monitoring temperatures
- 7 water levels on river network
- 6 points on water quality sampling: 14 days or 1 month
- 1 evaporation from small water reservoir
- The development of new sensors, 5G, IoT, new calibration strategies
- The development of digital solutions on Smart Landscape concept
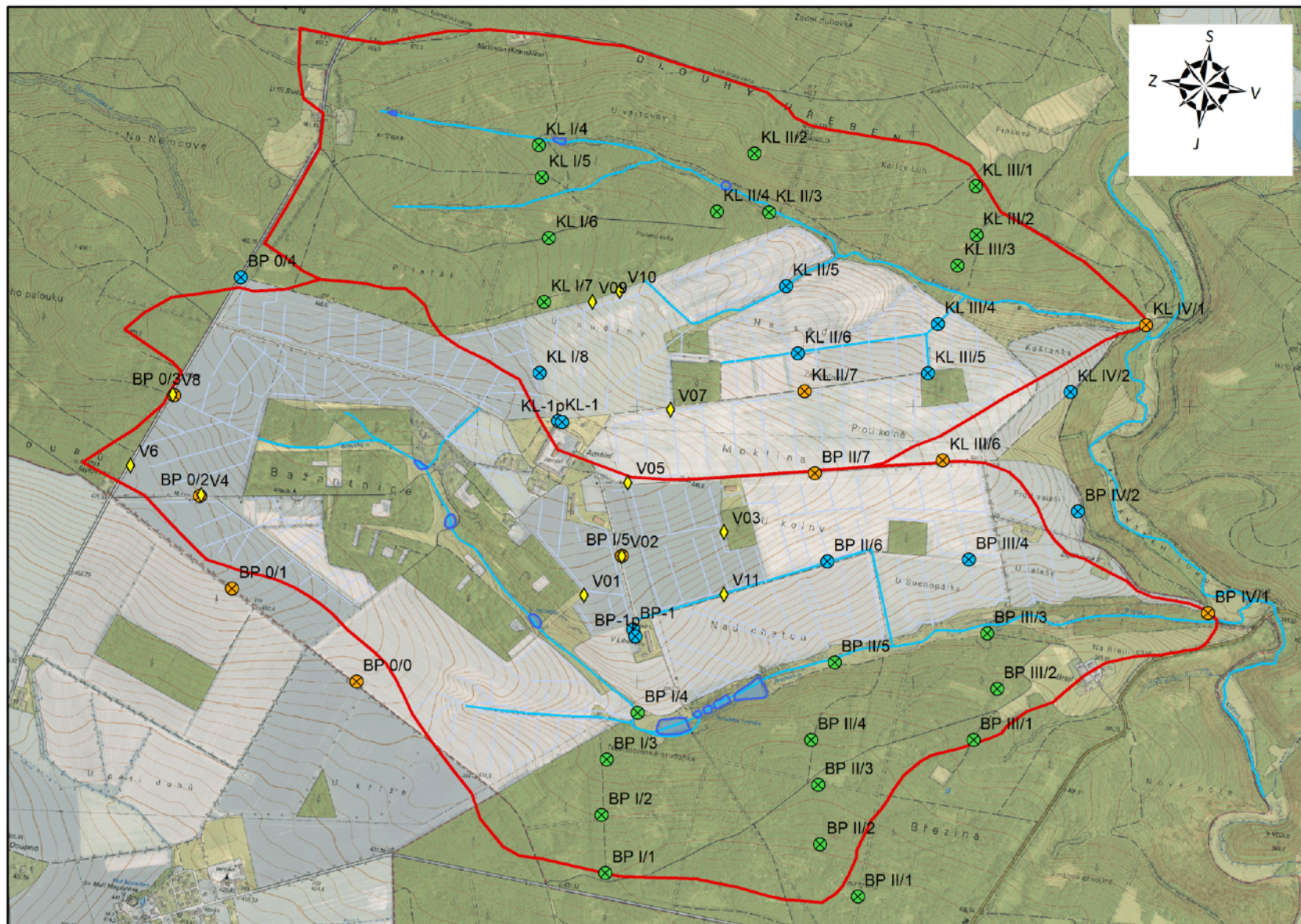- Monitoring actual evapotranspiration
- UAV
- Moving toward BigData
- Evaluation of Efficiencies on Smart Landscape measures

# Monitoring points

- GW locations
- Around GW locations
  - Clusters of sensors
- Approx. more than 600 time series
- Surface runoff at the catchment outlets
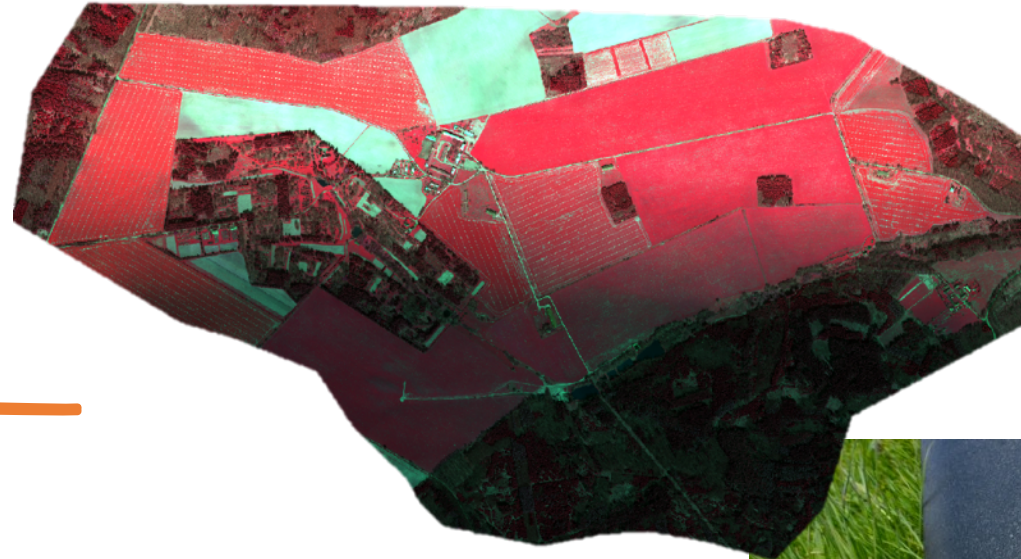- Meteorological stations
  - 1 main in each watershed

# Actual Evapotranspiration



- EC tower 7200 RS
  - Smart flux
  - TOVI
  - Full Biomet
  - Fluxsuit
  - On site camera

- Scintillometer Kipp and Zonne LAS – MKII
  - Optical Scintillometer
  - Evation Software

# UAV



- Monthly and 14 days sampling
- MicaSense RedEdge-MX - Multispectral Camera: 5-band
  - Single-band resolution: 1.2 MP, 1,280 x 960 px (4:3)
  - Multspectral bands – 5 bands
- SenseFly Duet T - Thermal Mapping Camera
  - Thermal radiometric infrared (FLIR)
  - RGB (senseFly S.O.D.A.)

# Forests hydrological regime

- Dendrometers
    - Online
    - Offline
- Groundwater wells
    - ERT profile
- Soil moisture
    - TDT
    - Laboratory calibration

# Forests hydrological regime



- Soil Water Content of 3 different forest stands
  - Beech
  - Larch
  - Spruce
  - IoT solution
- Temperature profiles
  - 3 different points
- Water retention measures
  - TDT
  - Laboratory calibration
- Measures designed with respect to data obtained at site
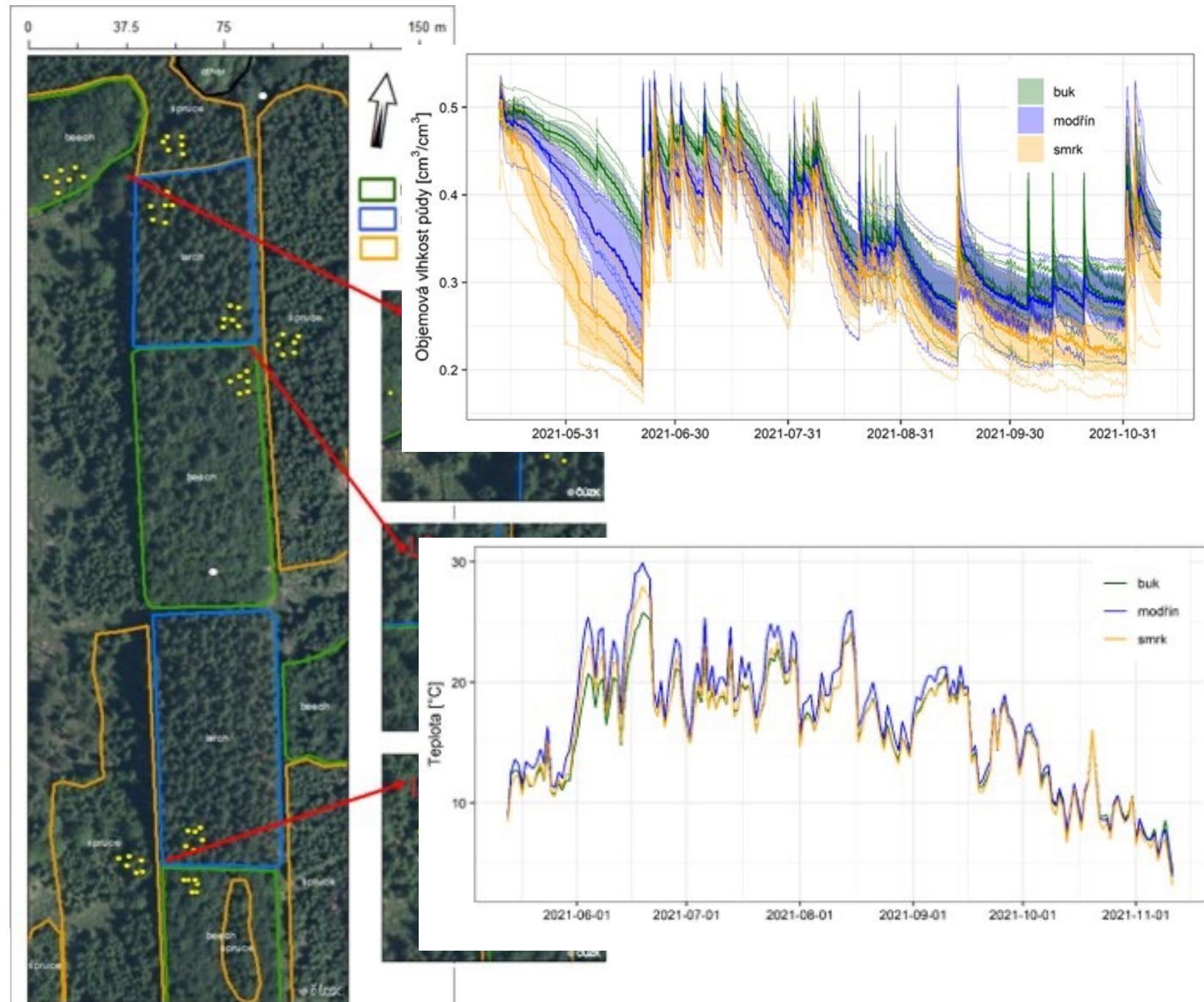
# Groundwater levels

- 22 real time monitored wells
- 18 currently drilled
- 5G Narrow Band solution
- Real time monitoring
- Grafana open-source digital solution
  - Available for phones and other IT platforms

# Groundwater level – Rainfall event
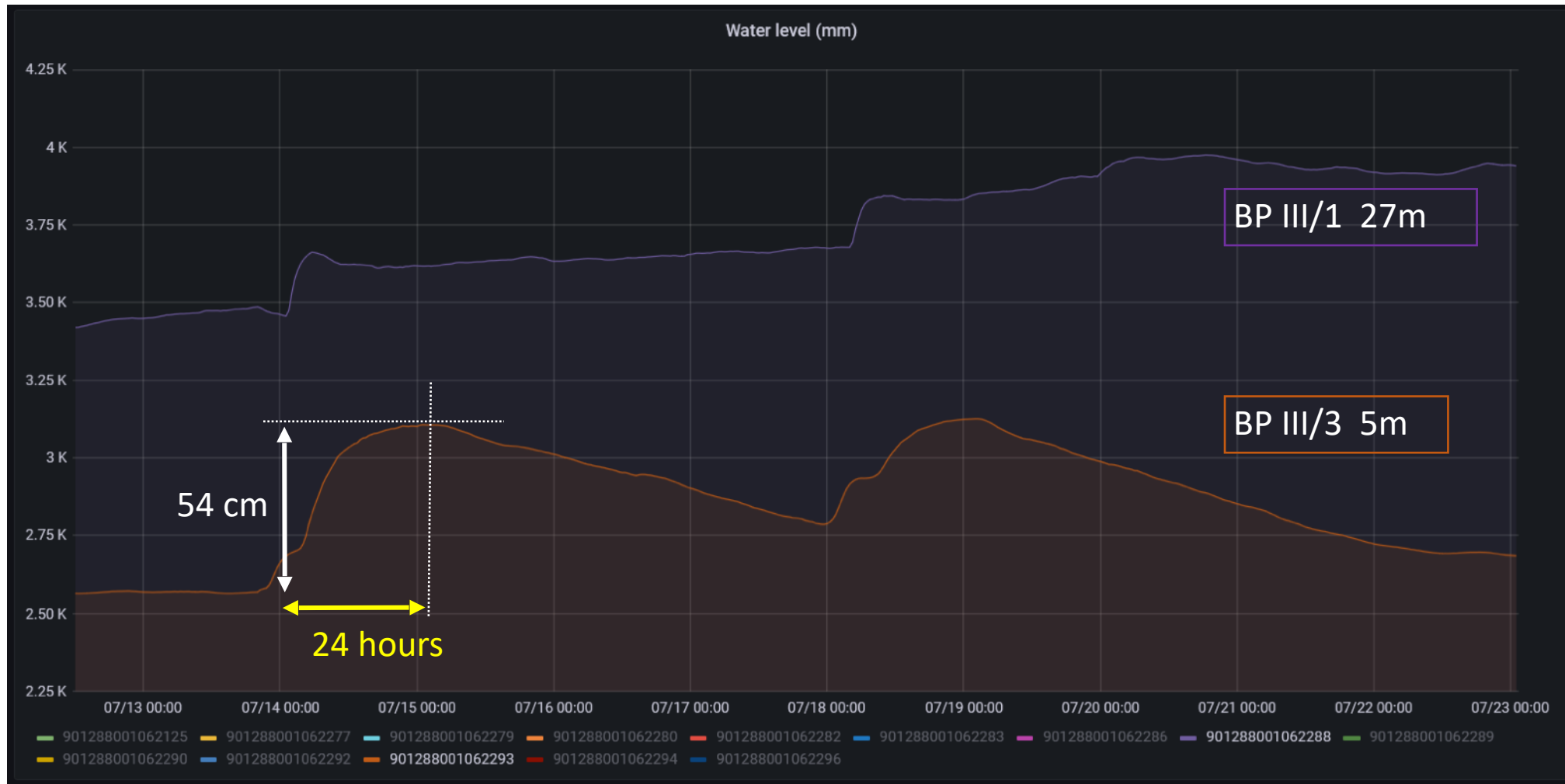
# Short-term trends
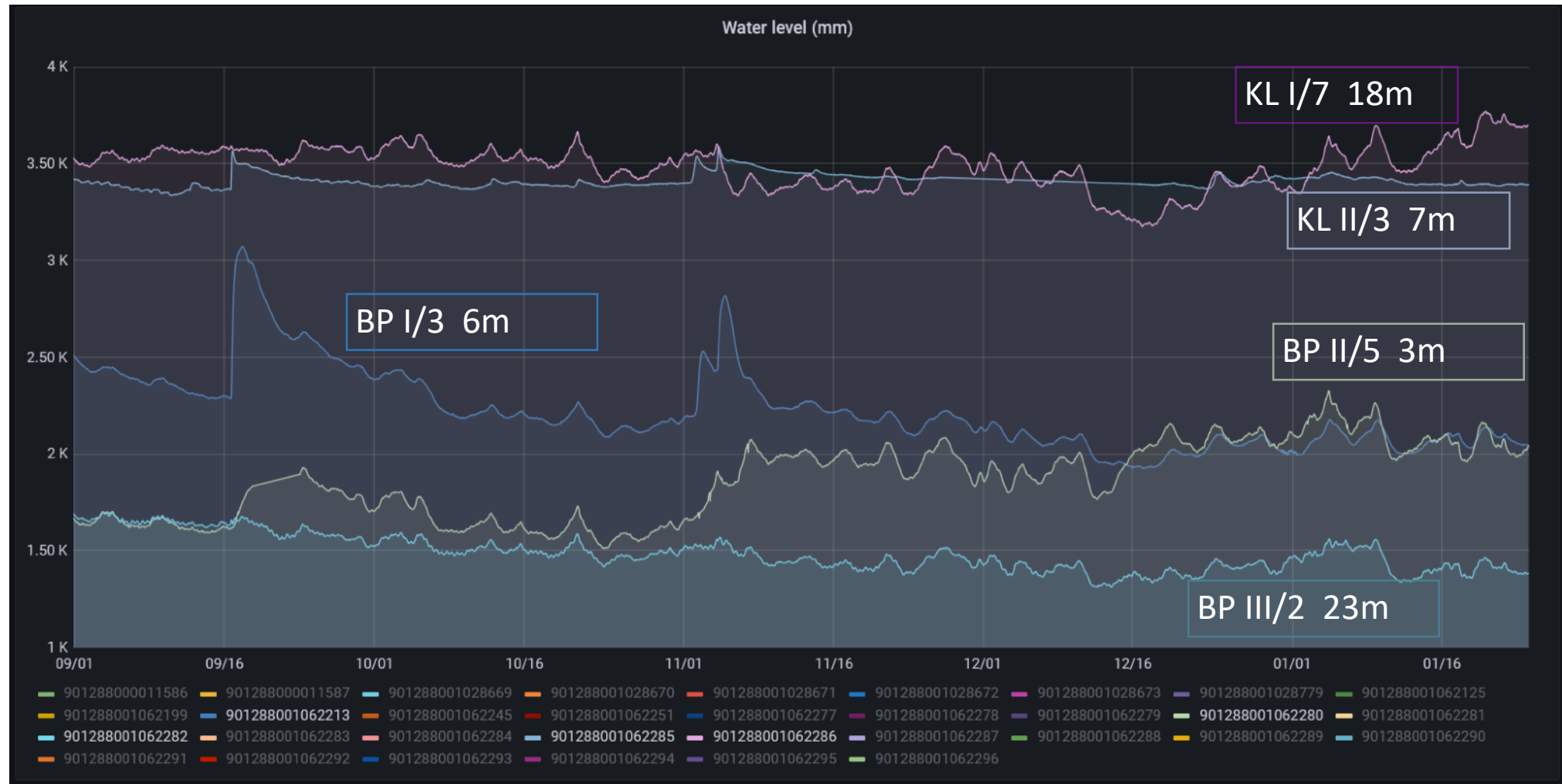
# Surface Waters

- Weekly based monitoring with Flow3D current meter 8 profiles

- 7 profiles real time monitoring

- 5G Narrow band solution

- Grafana open-source digital solution
  - Available for mobile phones and other IT platforms
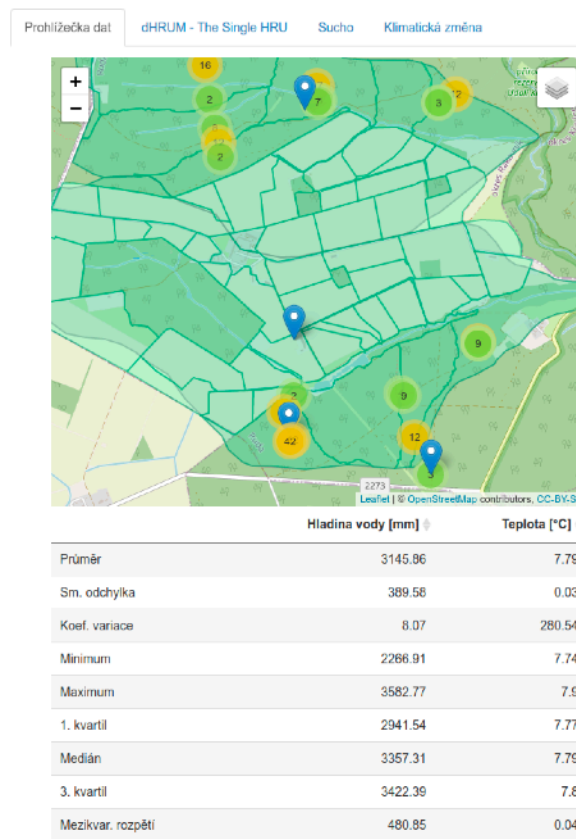  - Near Real time monitoring

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# Surface water – small flood event
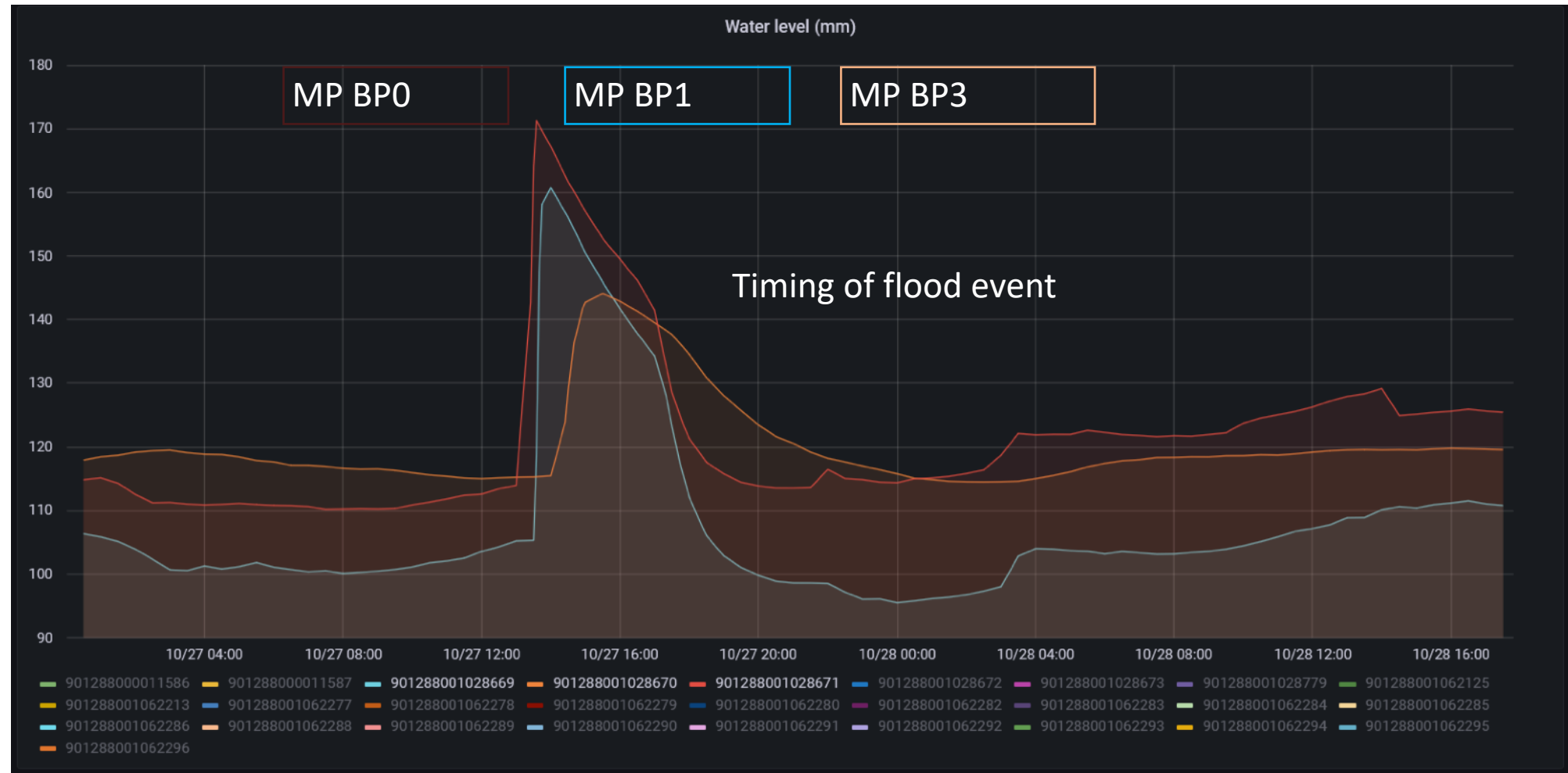
# Data, visualization, …

- Core for the assessment and design of Smart Landscape Measures

- Manual and AI/ML data driven control

- Amalia browser
  - Open - source Digital solution
  - Currently more than 600 series
  - Shiny apps
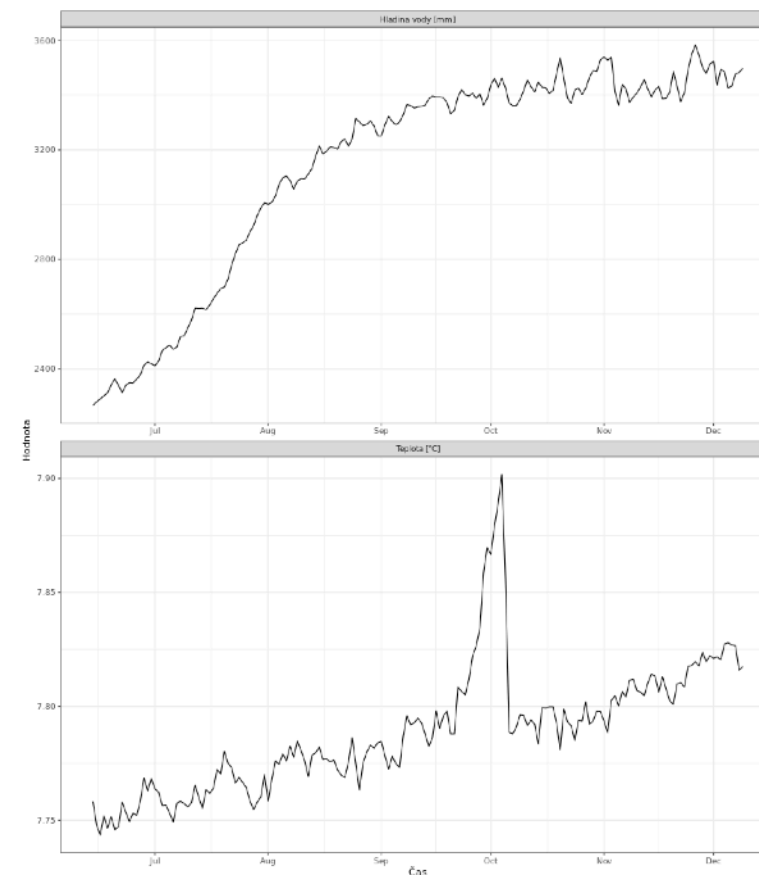
# Database solution

- Operational Database
- Currently more than 600 series
- open API
- Realtime data
- Security
- Part of future DSS
- A part of the Core of Information System on Smart Landscapes
- PostgreSQL, NodeRed, Python,...
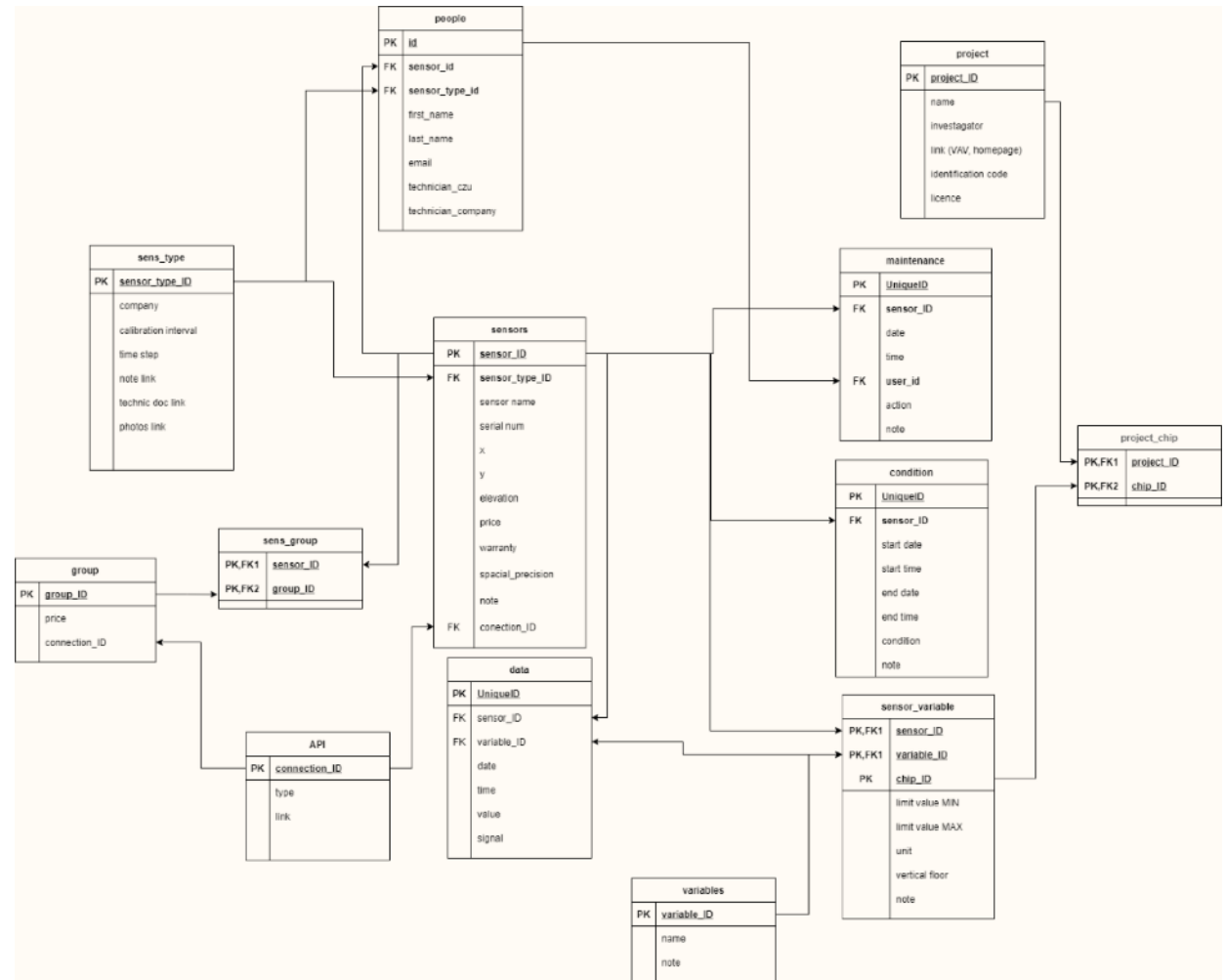
# DRUtES

- Hydrodynamic model

- Dual Richards Unsaturated Equation Solver

- Open-source solution

- Real scheduling of irrigation scheduling using the opensource products, meteorological forecast, data assimilation from onsite monitoring

- Currently operational on selected vineyards in Argentina

## Solving the nonlinear Richards equation model with adaptive domain decomposition

Michal Kuraz [a,*], Petr Mayer [b], Pavel Pech [a]

[a] Czech University of Life Sciences Prague, Faculty of Environmental Sciences, Department of Water Resources and Environmental Modeling, Czech Republic
[b] Czech Technical University in Prague, Faculty of Civil Engi
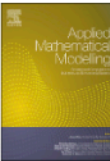
## Adaptive higher-order space-time discontinuous Galerkin method for the computer simulation of variably-saturated porous media flows

Vít Dolejší [a], Michal Kuraz [b,*], Pavel Solin [c]

[a] Charles University, Prague, Faculty of Mathematics and Physics, Sokolovská 83, Praha 186 75, Czech Republic
[b] Department of Water Resources and Environmental Modeling, Faculty of Environmental Sciences, Czech University of Life Sciences Prague, Czech Republic
[c] Department of Mathematics and Statistics, University of Nevada, Reno, USA

## Domain decomposition adaptivity for the Richards equation model

Michal Kuraz · Petr Mayer · Vojtech Havlicek · Pavel Pech

# dHRUM
# distributed Hydrological
# Response Unit Model

- Rainfall-runoff modelling framework
  - 37 different structures of HRU
  - Different calibration strategies in ungauged catchments
- Climate change impact assessment studies
- Drought forecasting
- Tool for supporting the design of smart landscape measures
- Open-source solution
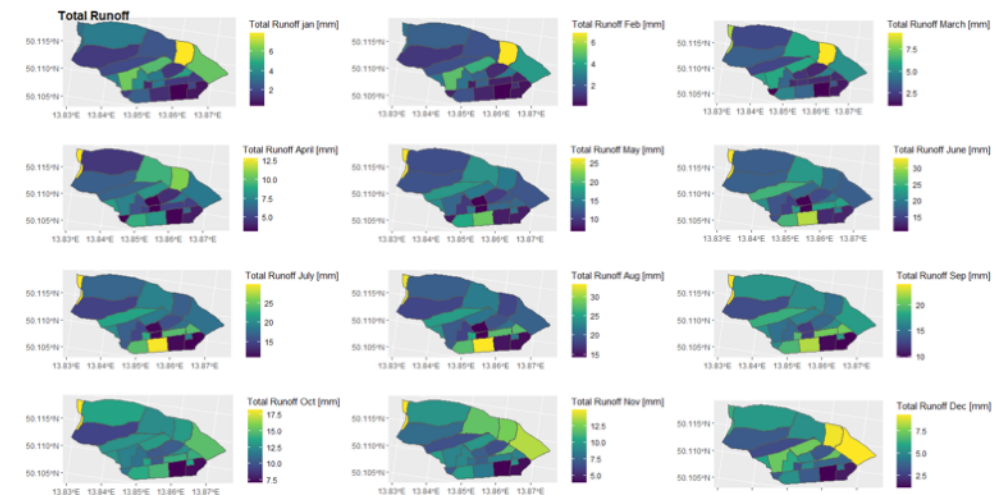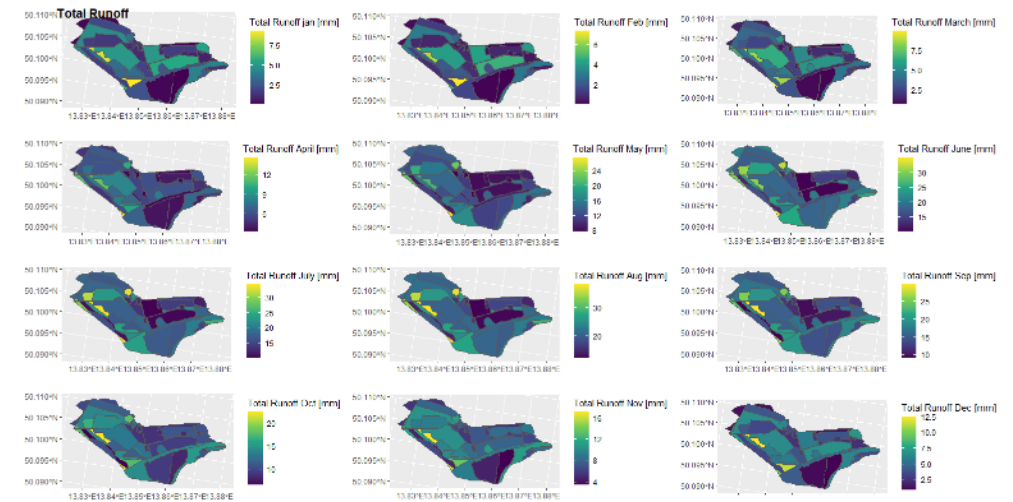
# Drought forecasting system

- Index based approach
  - Quantile mapping
  - Deficit volumes
- Semi-distributed model of drought occurrence and propagation
- Modelling various drought types
  - Meteorological
  - Hydrological
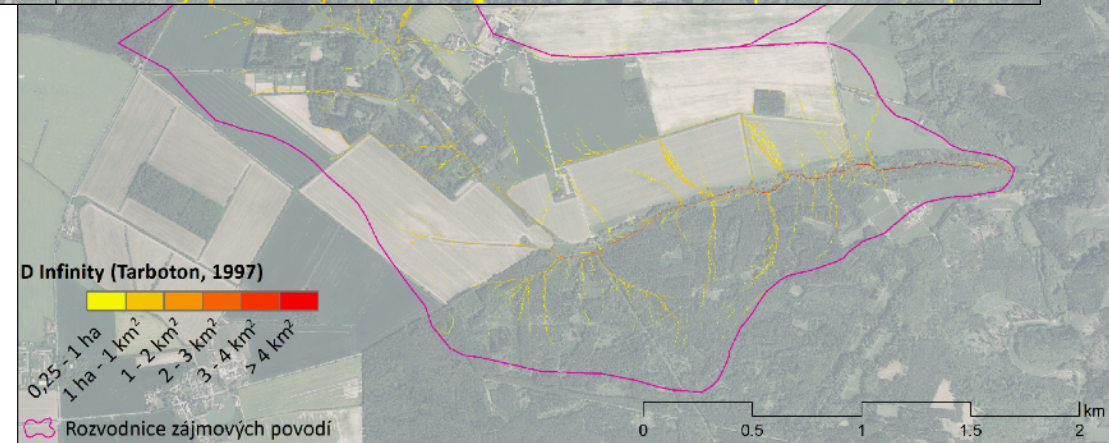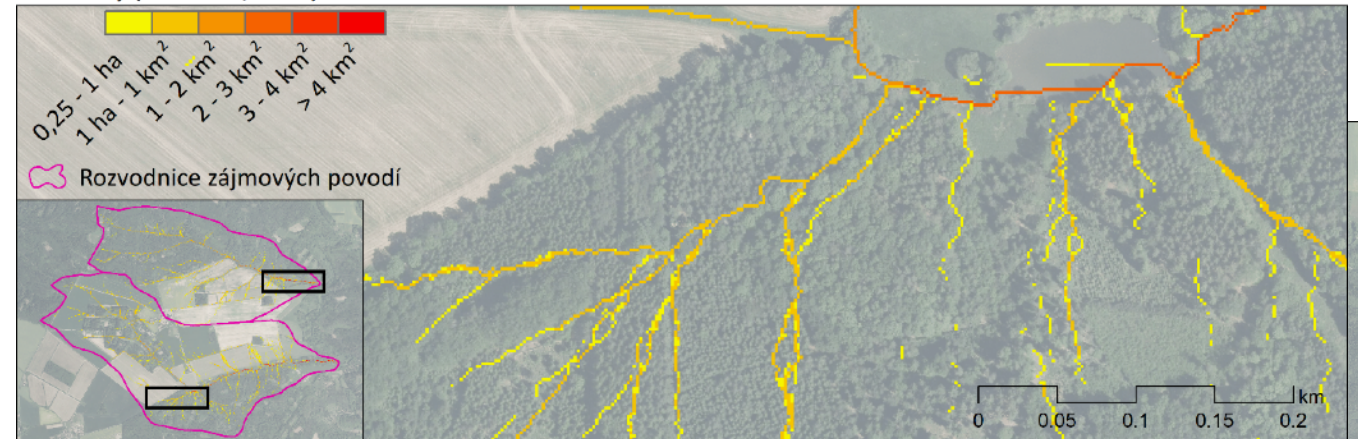  - Agricultural
  - Groundwater
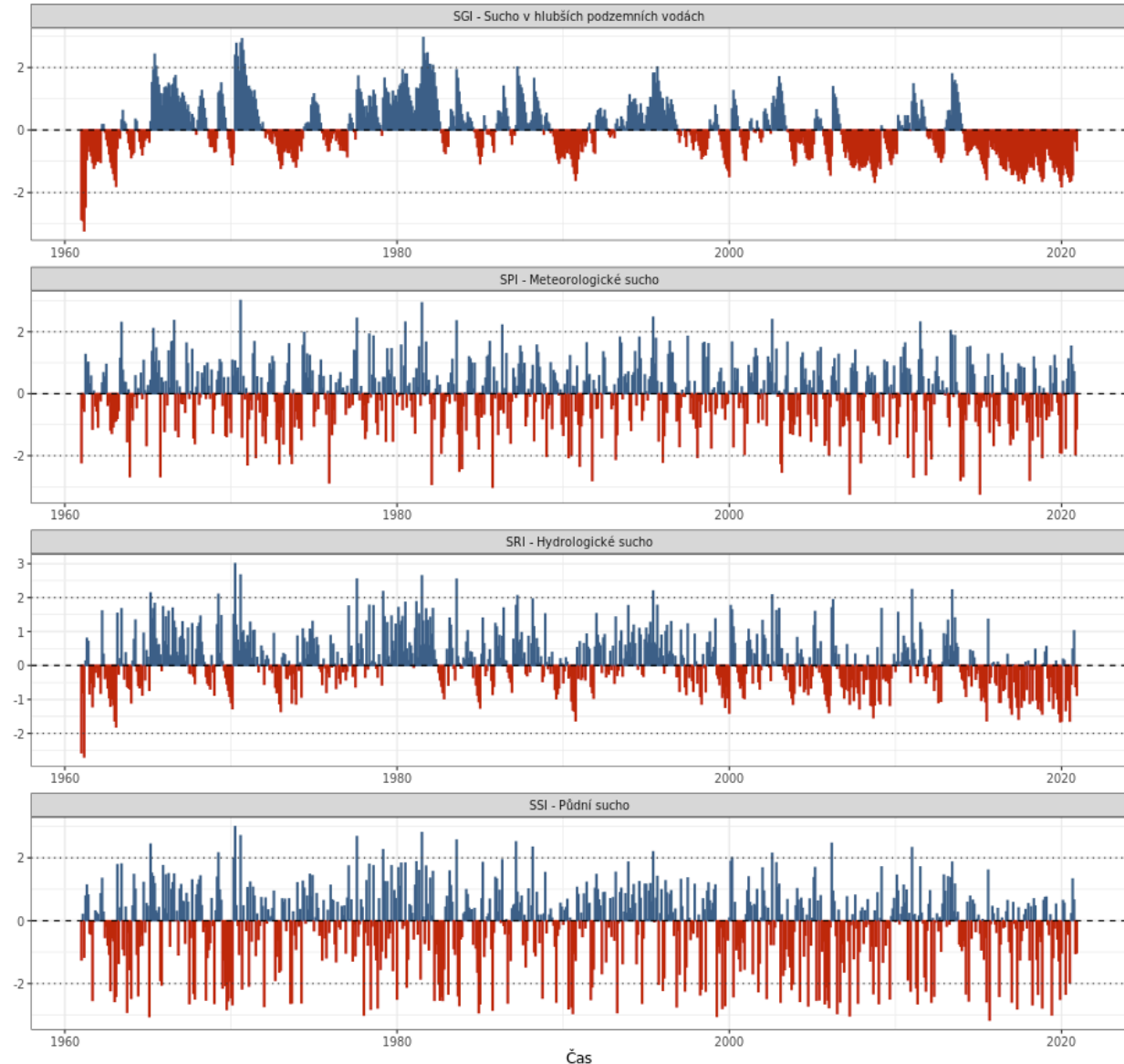
# Flow Algorithms

- High resolution DEM analyses
- DEM – lidar
- Ensemble of surface flow algorithms
- Identification of surface runoff lines
  - Soil erosion on arable land and in forests
- Identification of future locations for surface water retention
- NBS solutions in forests
  - input to the design of surface retention measures

# Amalia site Smart landscape measures



- The core of surface retention measures
  - Nature based solution

- Connection to the real time monitoring
  - Small water reservoir of the new generation
  - Constructed wetland with biofilters
  - Smart drainage systems, and cascade swales
  - Water pumping using the Solar Energy
  - Smart irrigation



Smart Roofs with solar panels
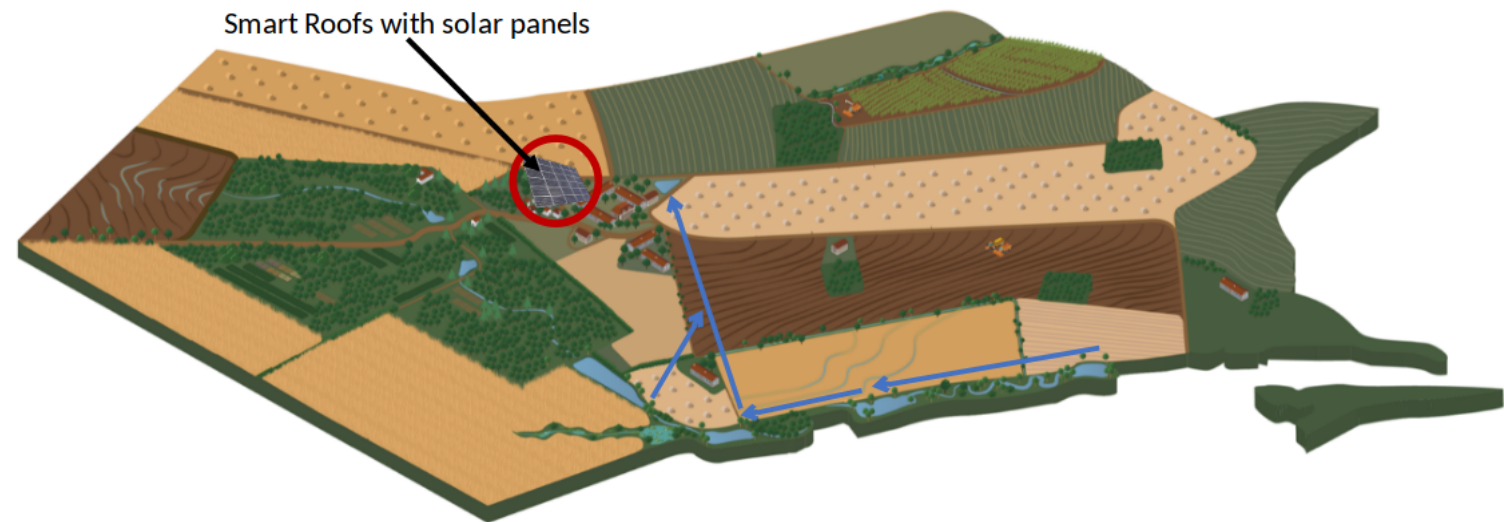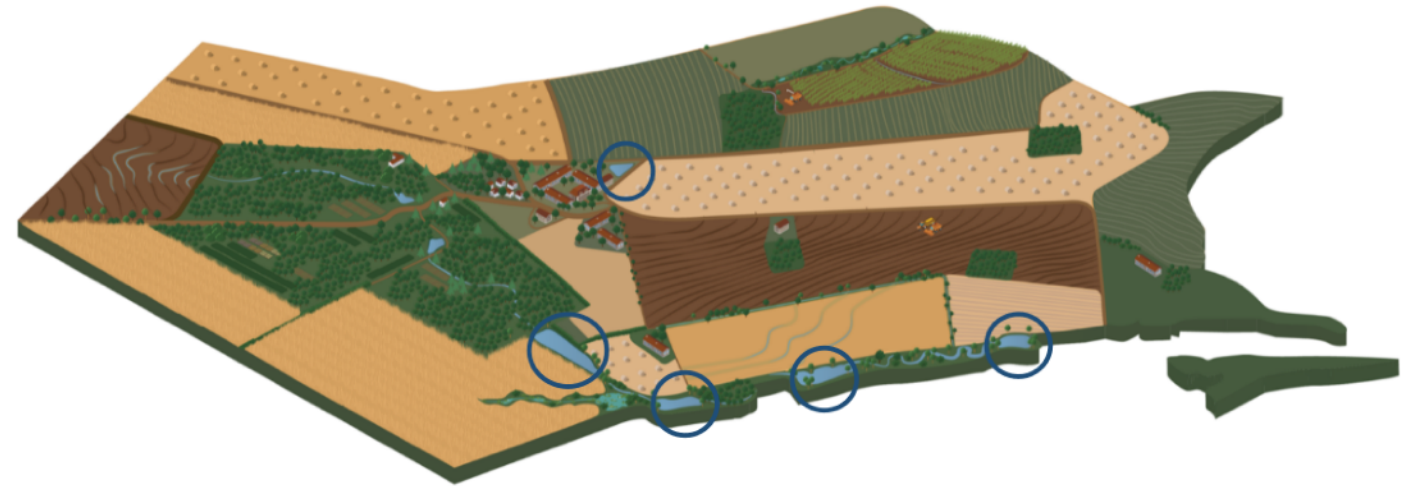
# Amalia site Smart Water Reservoir



- The Smart Water Reservoir
  - Innovative solution of spillway and outlet
- Real time operation
  - Irrigation
  - Constructed Wetland and set of Biofilters
  - Water redistribution using solar energy driven pumping
  - Preserving minimal ecological flows
- Connection to the real time

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# Amalia site Constructed Wetlands

- The Smart Constructed Wetlands
  - Horizontal biofilter
  - Vertical biofilter
- Water quality issues
  - Biochar
  - Pesticides treatment
  - Preserving biodiversity of aquatic ecosystems
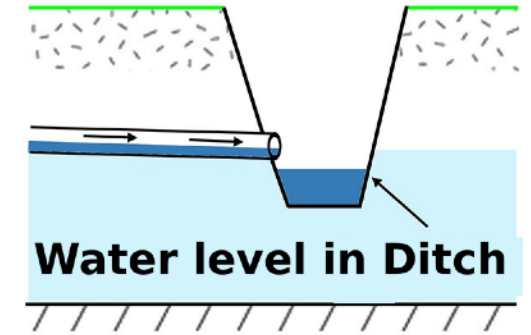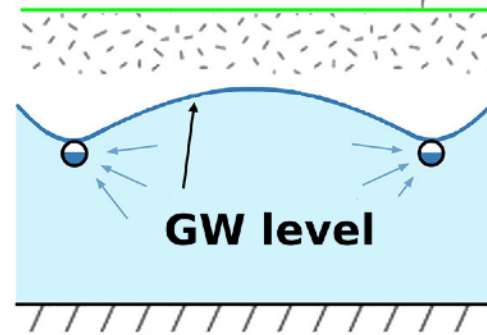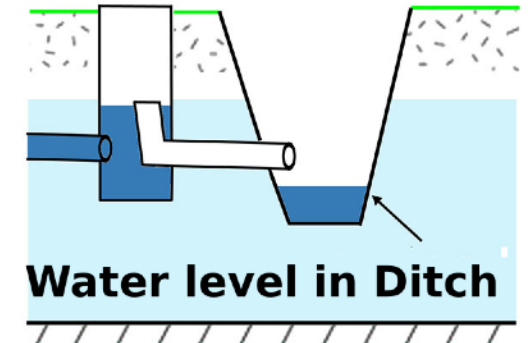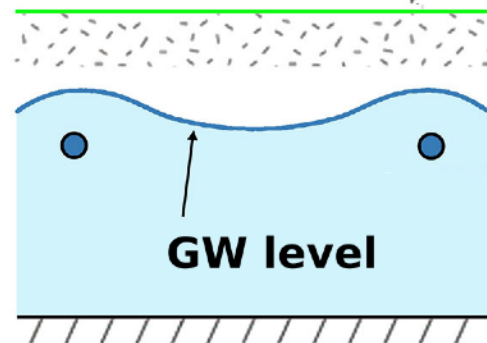- Connection to the Small Water Reservoir

# Amalia site Regulated drainage system

- The different types of drainage systems
  - Manual regulation
  - Automatic regulation
- Drainage system with regulated outflow
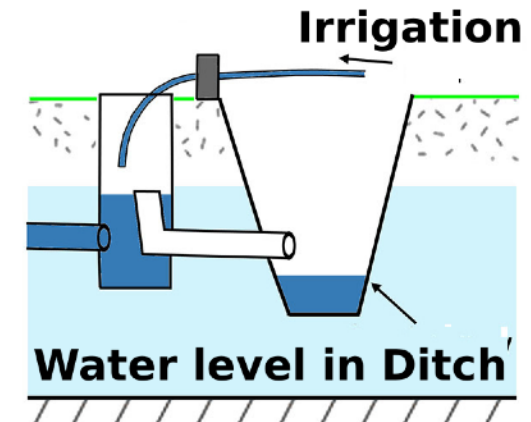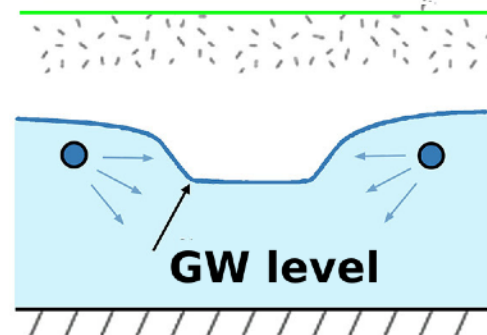- Regulated drainage system

# Amalia site Regulated drainage system

- Cleaning of drainage systems

- Manual and Automatic regulation

- Monitoring of drainage discharge using tipping bucket

- Remote control

- Connection to precise fertilization

# Amalia site ditches, swales

- NBS retention system
- Different types of small dams
- Revitalization of man-made ditches
- Slowing the runoff
- Cascading swale

# Amalia site
# Agrotechnical measures



- Soil erosion plots
  - 3 times 1 ha plots

- Testing different soil treatment and technologies
  - conventional ploughing
  - strip-till
  - sowing in narrow rows
  - deep and shallow pre-sowing cultivation.
  - Agroforestry

- Measuring soil erosion

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# Amalia site
# Agrotechnical measures

- Case study heavy rainfall event
  - Sediment transport

- Sorghum
  - conventional ploughing
  - strip-till
  - sowing in narrow rows

- Measuring soil erosion
  - Heavy rainfall event
  50 years return period

# Amalia site Biodiversity





- Experimental biozones
  - Stripes approx. 30(40)m  x 400 m
- Trees in the landscape
  - Linear greenery
- Agroforestry
  - High-growing seedlings of wild fruit tree varieties - apple, pear, cherry and walnut trees, and from less traditional trees - white mulberry, wild service tree and rowan
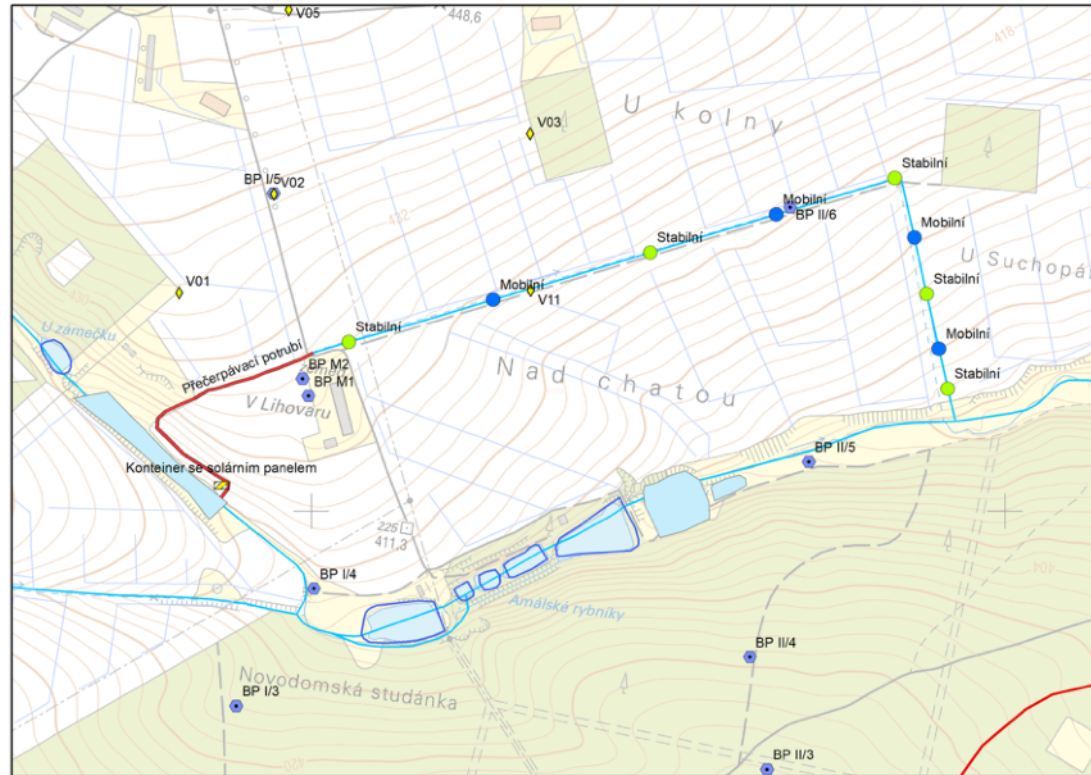
# Amalia site Solar energy

- Solar energy driven water recirculation
  - Stable
  - Manual
- Real time operation
  - System of small dams
  - Water redistribution using solar energy driven pumping
- Slowing down the runoff and water re-circulation
- Connection to Irrigation



Amálie Rago - solární přečerpávání

# Challenges …

- Capacity building
- Decision support system
- Information System on Smart landscapes
- Adding High tech observation
- Data assimilation, real time control
- Irrigation, fertigation
- Adding other "smart" agriculture technologies
- Efficient How-Tos
- …

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# Thank you
# for your attention