SIEUSOIL

SIno-EU Soil Observatory for Intelligent
Land use Management

DISASTER RISK MANAGEMENT TOWARDS HEALTHIER SOILS IN CRISIS SITUATIONS

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European Commission

Motivations

Soil compaction

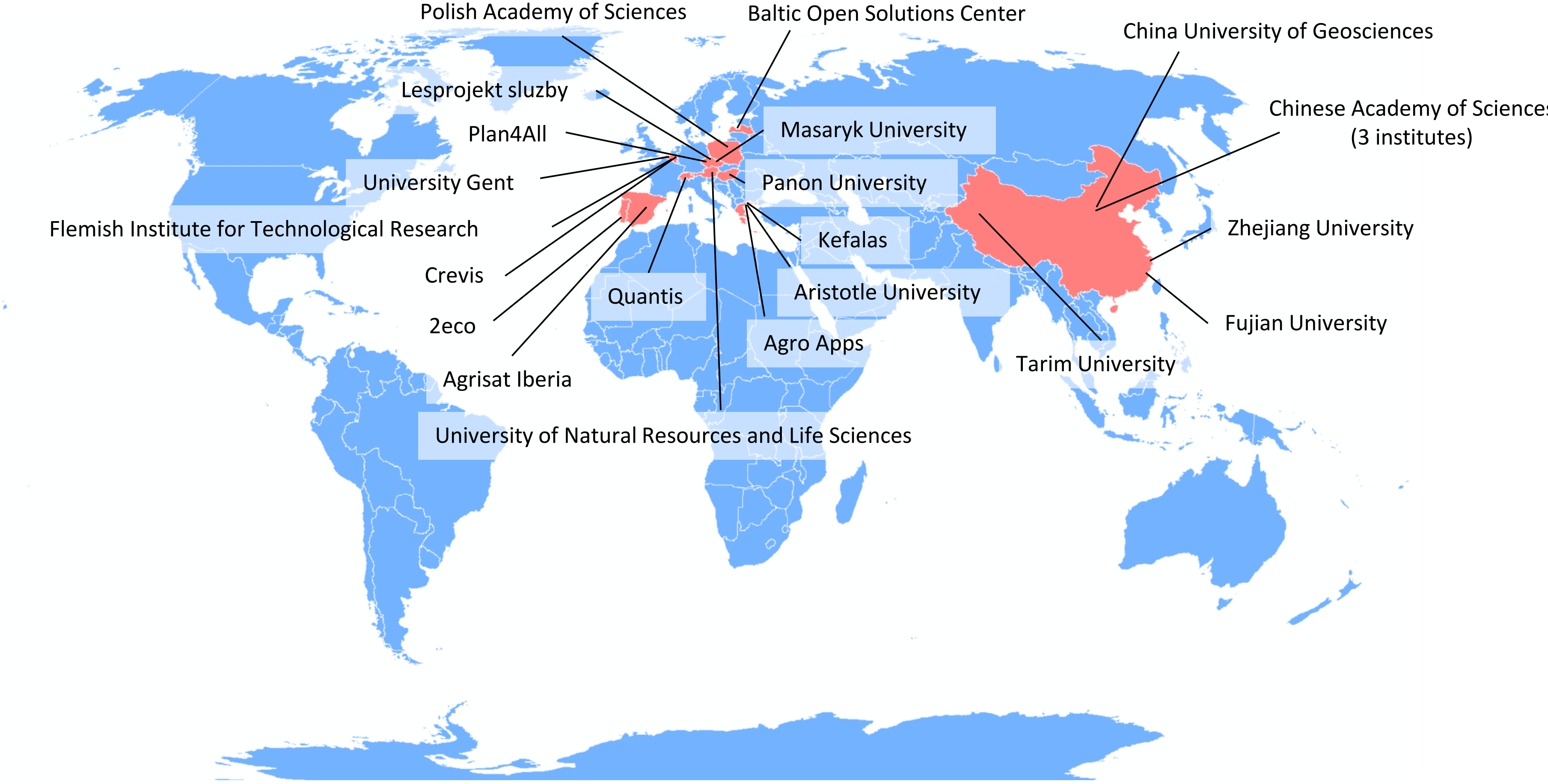
Soil erosion

Soil and water pollution

Basic project information

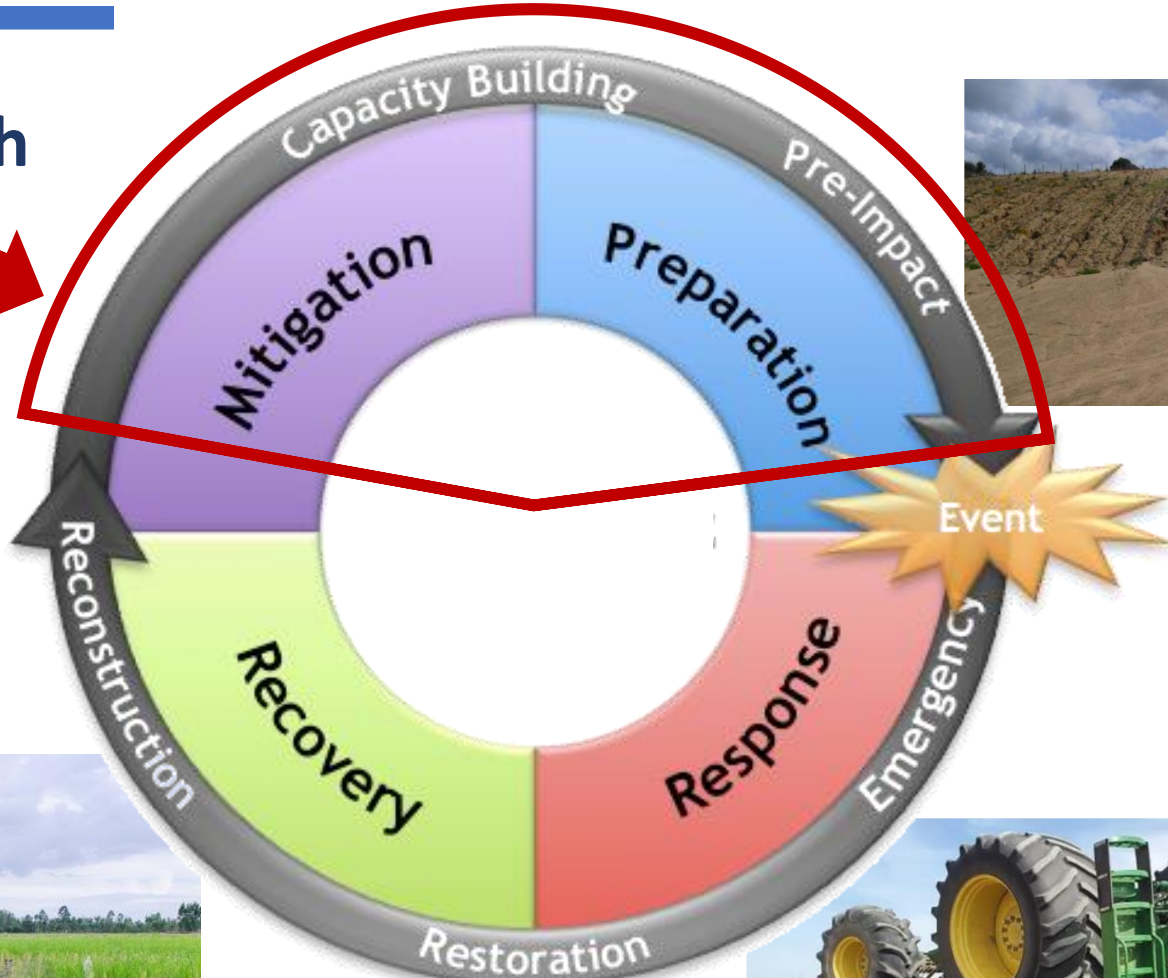
- Flagship EU Research & Development Horizon 2020 project
  - Addresses identical environmental challenges common in China and Europe
  - Design, implement and test a shared China-EU Web Observatory platform that will provide Open Linked Data to **monitor status and threats of soil** and assist in decision making for sustainable support of **agroecosystem functions**, in view of the projected climate change
  - http://sieusoil.eu
- Funded between 2019 and 2022 (36 months)
  - Project started on 1 June 2019
  - European budget 5 mil. €
  - Chinese budget 12.1 mil. CNY (about 1.5 mil. €)
- Leaders
  - Dimitrios MOSHOU, Aristotle University, Greece (SIEUSOIL coordinator)
  - Ganlin ZHANG, Chinese Academy of Sciences, China (Chinese coordinator)
  - Tomáš ŘEZNÍK, Masaryk University, Czech Republic (technical coordinator, WP leader)

Participating partners

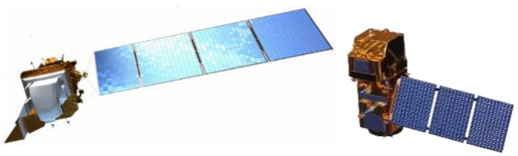


Disaster management cycle

Our approach aims at



Research objectives

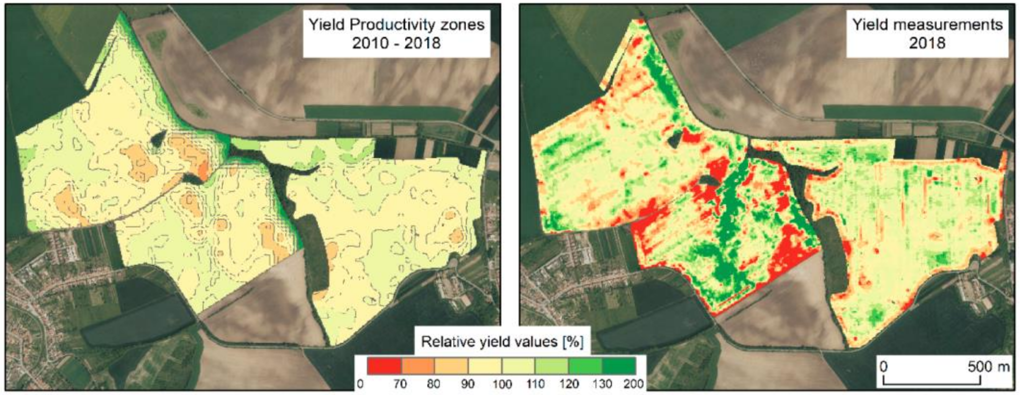


Remote sensing

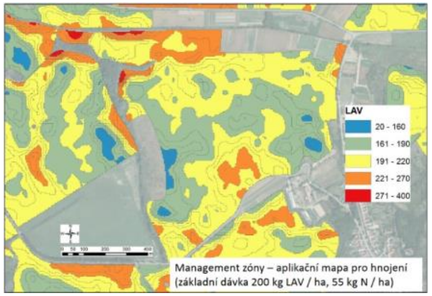
Sensor measurement

Predictions through EVI calculation

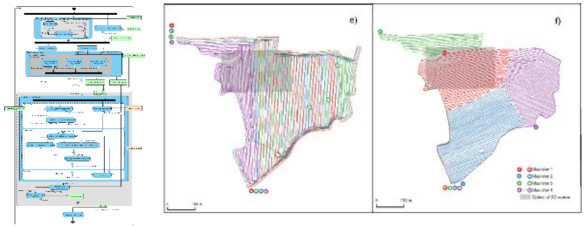
Interpolations & interpretations



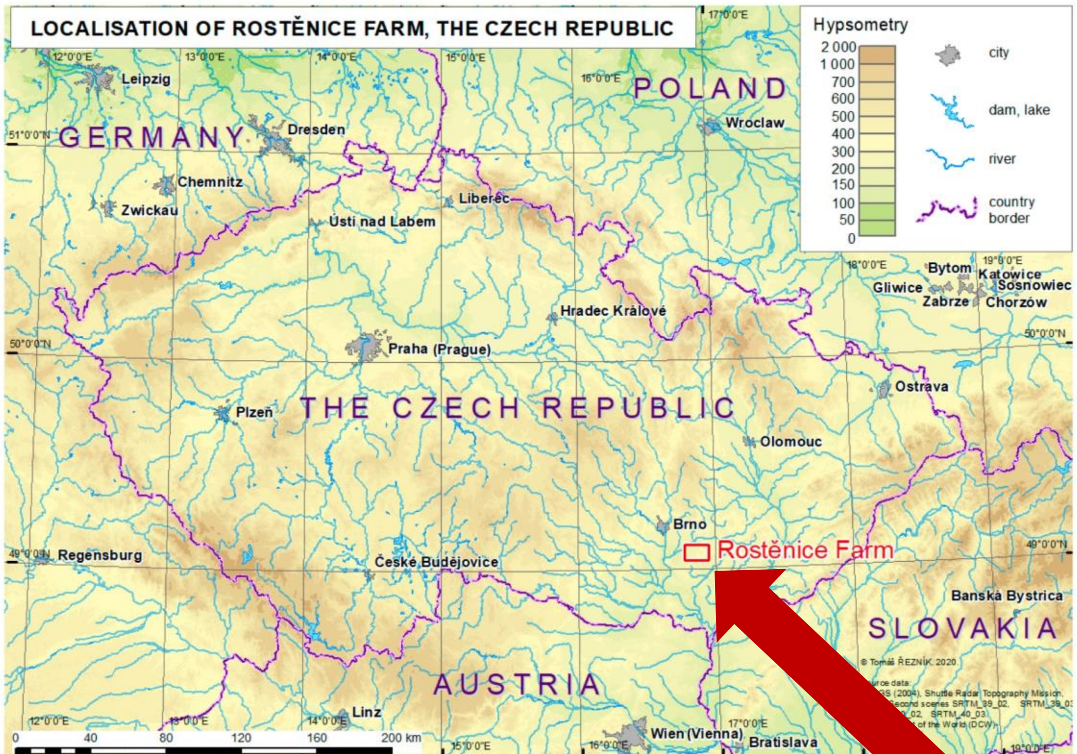
"Targeted application of fertilizers"



"3D trajectory optimization"

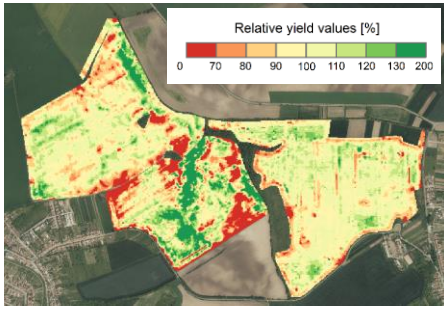


Case study area



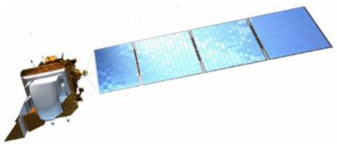
- **Rostěnice Farm**
  - manages over 10,000 ha of arable land in the South Moravia region of the Czech Republic.
  - average annual rainfall is 544 mm,
  - average annual temperature is 8.8 °C.
  - prevailing soil types are Chernozem, Cambisol, haplic Luvisol, Fluvisol near to water bodies, and occasionally also Calcic Leptosols.
  - main program is plant production (cultivation of malting barley, maize for grain and biogas production, winter wheat and oilseed rape)

Remote Sensing data



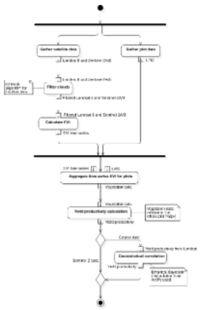
Reference data from field harvesters

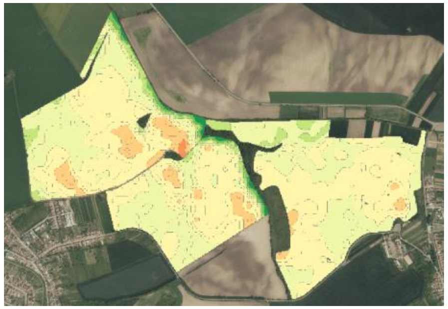
Data from Landsat and Sentinel satellites



Yield Productivity Zone Computation and Identification

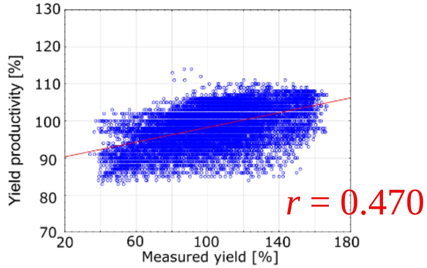
$$EVI = 2.5 \times \frac{NIR - Red}{NIR + 6 \times Red - 7.5 \times Blue + 1}$$



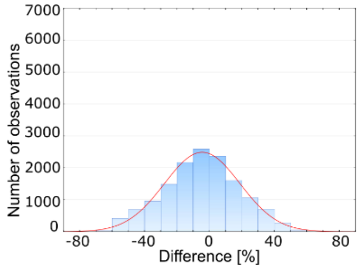


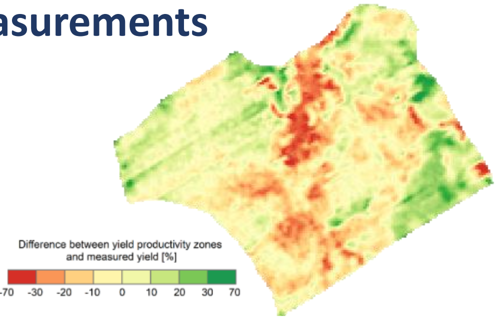
Yield Productivity Zone Verification against Yield Measurements

Correlations

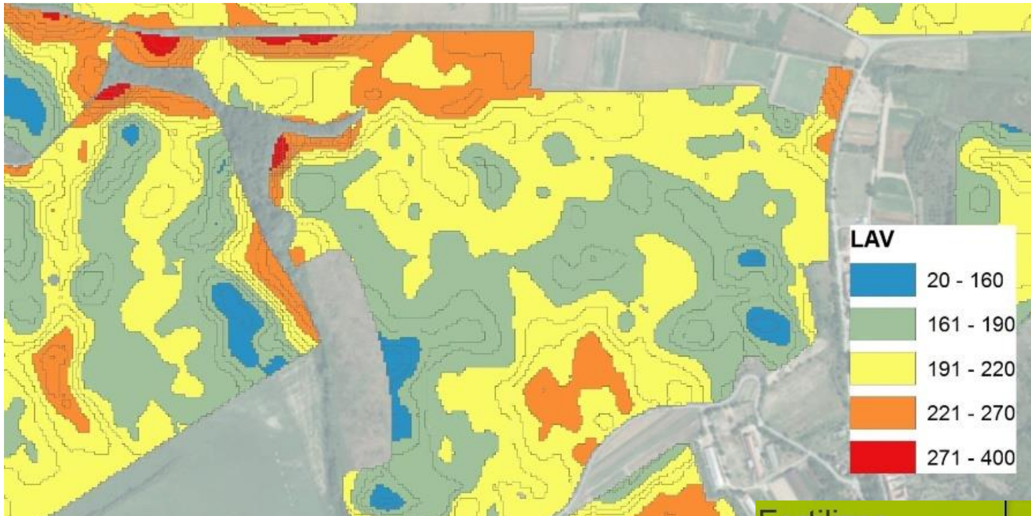


Differences





Fertilization planning based on yield potential zones

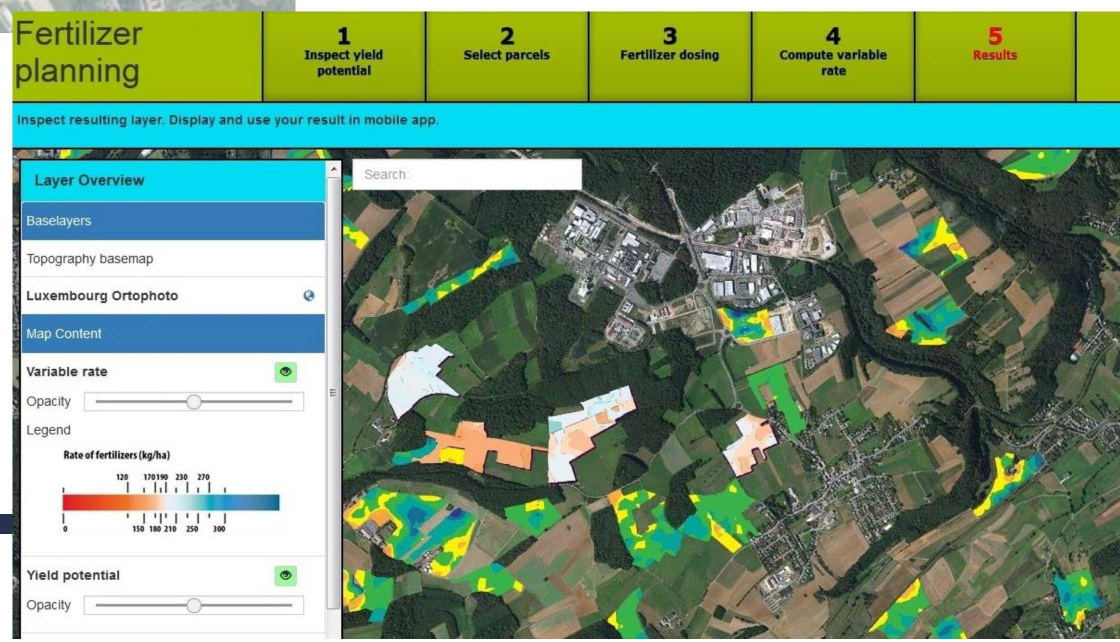


Application map for fertilization

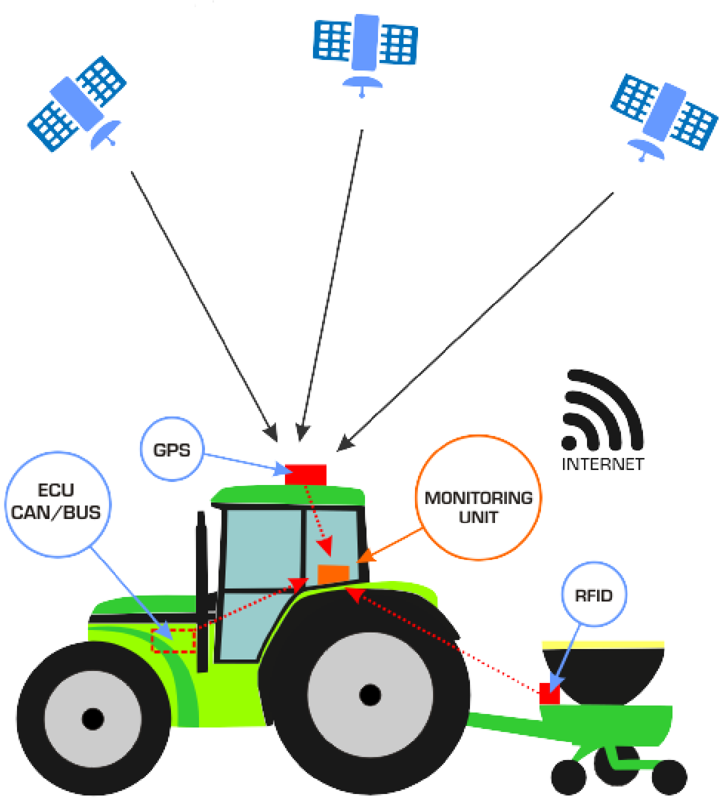
- the basic dose is 200 kg nitrogen fertilizer

Fertilization planning software

- interactive web-based tool
- based on visual analytics approach

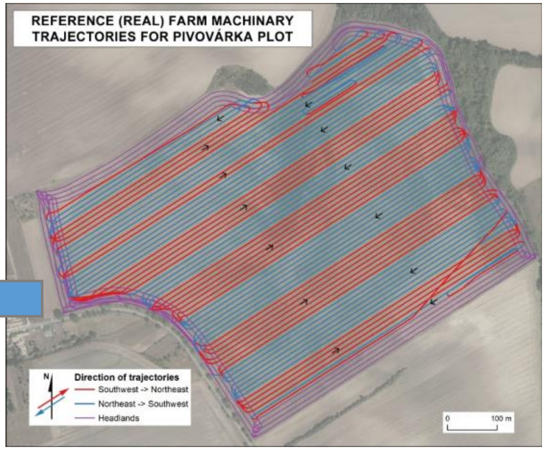


Sensor measurements



- Measurement using a series of sensors directly on the agricultural machinery during field operations
- Main advantages:
  - Data density - measurement every second, i.e., approx. 1.5 m
  - Data detail - dozens of attributes from sensors, e.g., crop weight since last measurement, machine speed and direction, air humidity, fuel consumption, machine type, position …
- **Result: up to tens of thousands of data points per field with detailed attributes**

3D-Based Farm Machinery Trajectory Algorithm

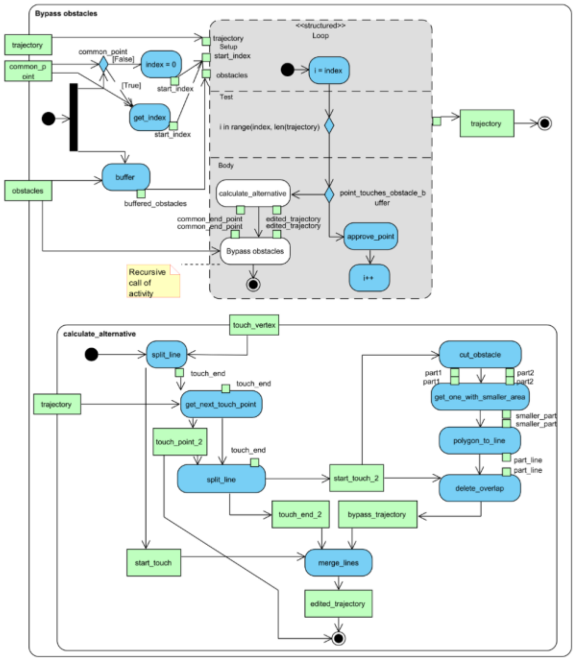


Reference data – real trajectories

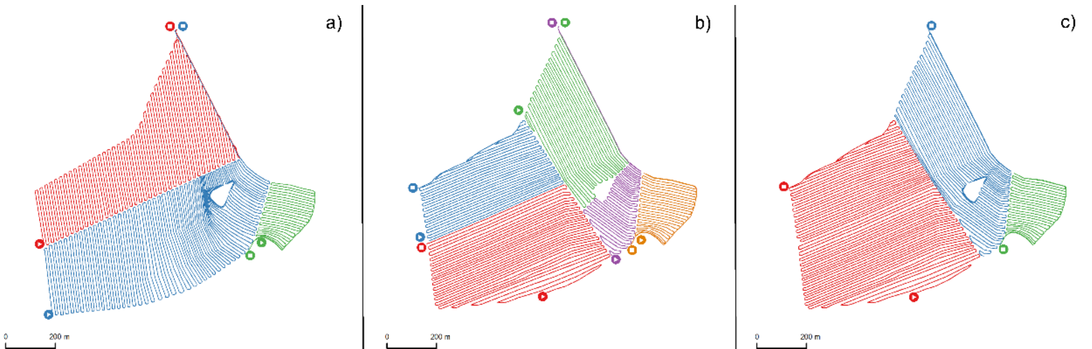
Optimized algorithm documented by UML activity diagrams and pseudocode

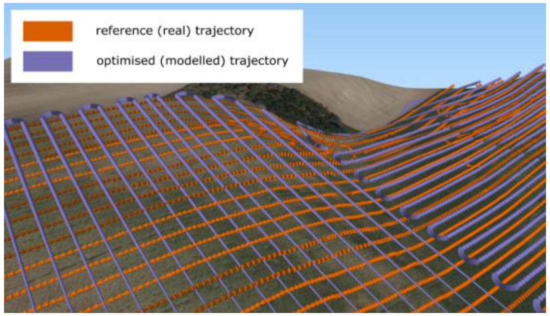
```
function exposition                // you could choose this function, identifies natural changes in the landscape
{
    aspect.ELEVATIONMODEL
    compare angle in line z with neighbours
    if  i>180
        split by boundary
}

function slopeDivide               // identification obstacles from nature
{
    add ELEVATIONMODEL
    clip.ELEVATIONMODEL by bound
    for i, i=0, i++
    {
    calculate.slope = ELEVATIONMODI
    }
    for i, i=0, i++
            {
                if slope >=10
                push to obstacles
            }
}
```



Statistical evaluation and comparison of various version of optimised trajectories





Plot	Trajectory	Length: Length [m]	Length: Difference [%]	Turns: Number	Turns: Difference [%]	Elevation: Gain	Elevation: Difference [%]
Pivovárka	Real	59762.16	N/A	93	N/A	2074.79	N/A
	Optimized-1 sequence	50623.76	-15.29	121	30.11	1818.85	-12.34
	Optimized-2 sequences	51011.80	-14.64	136	N/A	1784.11	-14.01
Liny	Real	87614.32	N/A	151	11.03	1865.13	N/A
	Optimized-4 sequences Option 1	72299.52	-17.48	98	N/A	1509.51	-19.07
	Optimized-3 sequences Option 1	70924.94	-19.05	161	18.38	1499.34	-19.61
	Optimized-3 sequences Option 2	70770.85	-19.22	177	80.61	1512.03	-18.93
	Optimized-4 sequences Option 2	69841.97	-20.28	40.58	N/A	1461.37	-21.65
Pindni Prostřední	Real	73429.95	N/A	98	N/A	2862.37	N/A
	Optimized-4 sequences	66050.45	-10.05	177	80.61	1351.52	-52.78
	Optimized-3 sequences Option 1	62588.99	-14.76	122	24.49	1342.00	-53.12
	Optimized-5 sequences	62390.99	-15.03	150	53.06	1314.00	-54.09
	Optimized-3 sequences Option 2	65761.20	-10.44	199	103.06	1534.16	-46.40

Conclusions I.

- Presented techniques demonstrate the **possibilities of geospatial (Big) data** collection in agriculture.
- **Remote sensing** data serves for
  - monitoring field spatial variability and crop status,
  - **fertilization planning**, which can significantly **reduce soil** and **water pollution**.
- **Farm machinery telemetry** data
  - providing information about machinery operations on fields,
  - is an important input for the development of an **3D-based farm machinery trajectory algorithm** that **reduces soil compaction** and **soil erosion**,
  - also serves for verification of remote sensing data.

Conclusions II.

- Data are available for large, typically **rural areas**, where, usually, such data sources are limited even though they are valuable for decision making. Indeed, crisis situations in sparsely populated rural areas, such as groundwater contamination, often **have consequences also in cities**. Therefore, it is important that data also be available from rural areas.
- Risks created by agricultural activities, such as risks of soil and water pollution, erosion or landslides, are minimized through the combination of the described techniques – in the **prevention and mitigation phases**.
- Described techniques are **re-usable** as building blocks in the **modular architecture** of decision making systems and/or in any other relevant crisis/emergency management systems.

Broader context

- The described combination of two techniques together with Wireless Sensor Networks has been registered under the **GEOSS** (Global Earth Observation System of Systems) Architecture Implementation Pilot (Phase 8).
- This research contribute to achieving the goals of the **Soil Health & Food EU Mission** and is in line with **United Nations 2030 Agenda for Sustainable Development**, especially with following **Sustainable Development Goals** (SDGs):
  - Nr. 2.: End hunger, achieve food security and improved nutrition and promote sustainable agriculture,
  - Nr. 6.: Ensure availability and sustainable management of water and sanitation for all

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More information

- ŘEZNÍK T., HERMAN L., KLOCOVÁ M., LEITNER F., PAVELKA T., LEITGEB Š., TROJANOVÁ K.,ŠTAMPACH R.,MOSHOU D.,MOUAZEN A.M.,ALEXANDRIDIS T.K.,HRÁDEK J.,LUKAS V., ŠIRŮČEK P. (2021): Towards the Development and Verification of a 3D-Based Advanced Optimized Farm Machinery Trajectory Algorithm. *Sensors*, 21(9): 2980. ISSN 1424-8220. doi:10.3390/s21092980.

- ŘEZNÍK T., PAVELKA T., HERMAN L., LUKAS V., ŠIRŮČEK P., LEITGEB Š., LEITNER F.(2020): Prediction of Yield Productivity Zones from Landsat 8 and Sentinel-2A/B and Their Evaluation Using Farm Machinery Measurements. *Remote Sensing*, 12(12): 1917. ISSN 2072-4292. doi:10.3390/rs12121917.

- ŘEZNÍK T., HERMAN L., TROJANOVÁ K., PAVELKA T., LEITGEB Š. (2020): Interpolation of Data Measured by Field Harvesters: Deployment, Comparison and Verification. In: Athanasiadis, I., Frysinger, S., Schimak, G., Knibbe, W. (eds.): *Environmental Software Systems. Data Science in Action. ISESS 2020. IFIP Advances in Information and Communication Technology, Vol. 554*. Cham, Germany: Springer, 2020. pp. 258-270. ISBN 978-3-030-39814-9. doi:10.1007/978-3-030-39815-6_25.

- ŘEZNÍK, T., PAVELKA, T., HERMAN, L., LEITGEB, Š., LUKAS, V., ŠIRŮČEK, P. (2019): Deployment and Verifications of the Spatial Filtering of Data Measured by Field Harvesters and Methods of Their Interpolation: Czech Cereal Fields between 2014 and 2018. *Sensors,* 19(22): 4879. ISSN 1424-8220. doi:10.3390/s19224879.

- ŘEZNÍK, T., LUKAS, V., CHARVÁT, K., CHARVÁT, K. jr., KŘIVÁNEK, Z., KEPKA, M., HERMAN, L., ŘEZNÍKOVÁ, H. (2017): Disaster Risk Reduction in Agriculture through Geospatial (Big) Data Processing. *ISPRS International Journal of Geo-Information*, 6(8): 238. doi:10.3390/ijgi6080238.

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