DEPARTMENT OF LANDSCAPE
WATER CONSERVATION

Low cost Evaporometers

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Motivation

- Research of evaporation water surface are curtailing for measuring of the water balance in small catchments
- Ongoing project to develop the simple and reliable, easy to reproduce evaporation measuring device

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Description

- Aims of the project is measuring of the water level in field in affordable manner
- 3D printed design in combination with open source affordable electronics is used
- Increase the number of opportunities for the measuring of evaporation

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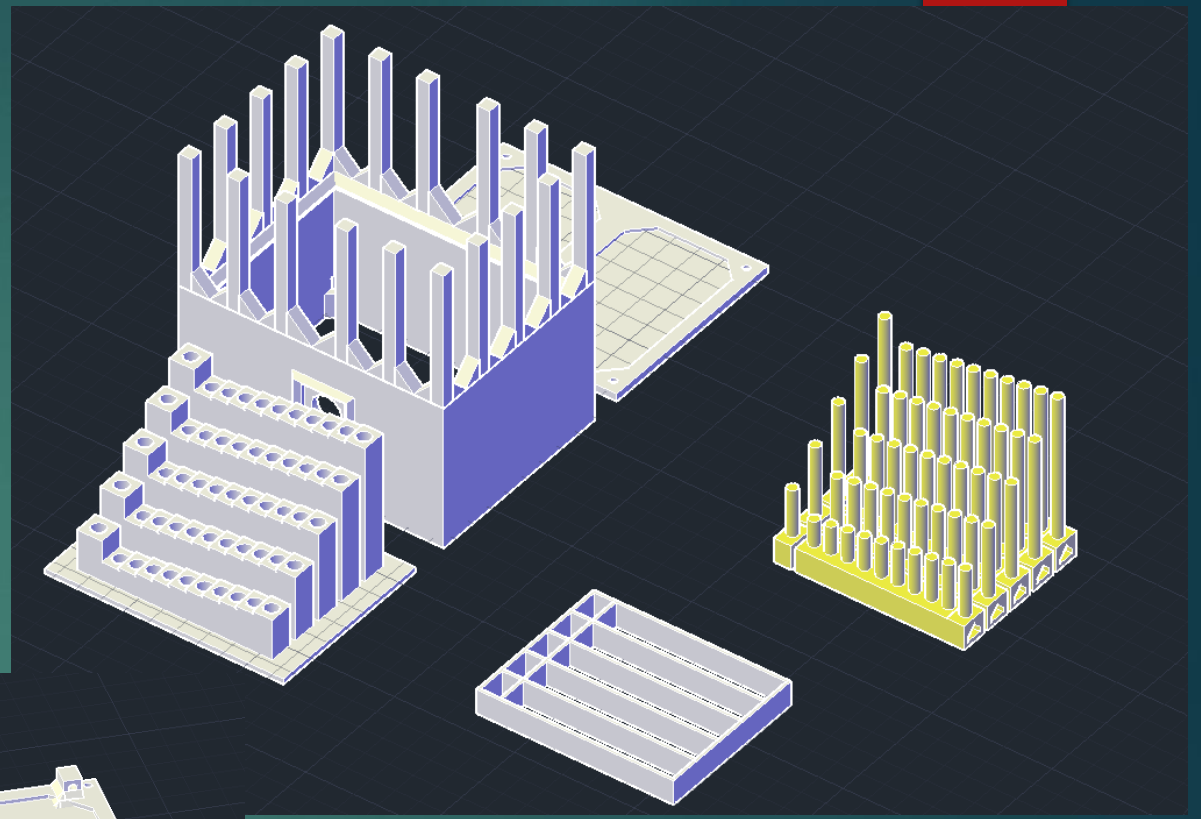
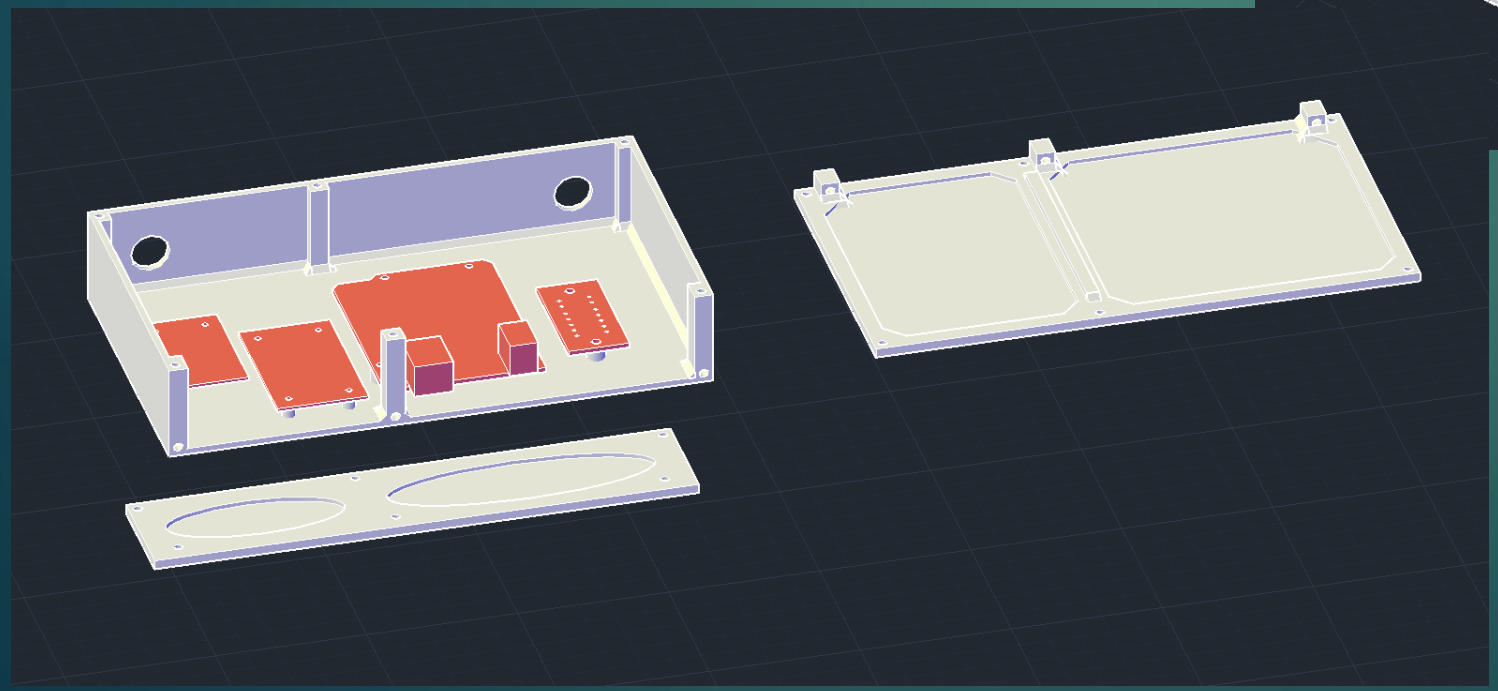
3D model





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Methodology

- Continuously the theories are developed and tested, subsequently conclusions are implemented into the next generation of the device.
- Five generations of 3D printed parts have been done, and now the research focus on the electronical and software side of the device
- Durability and reliability of the device is tested in field, in three locations
- All plots are also frequently checked by research staff and data is saved and later compared with data measured by device
- Refilling of the evaporation of the pan is for now done by research staff.

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Electronic hardware

- Main control unit of the device is microcontroller Arduino Uno. This is a development board based on ATmega328P chip.
- Microcontroller has 14 digital pins, 6 of them can be pulse width modulated, 6 analog inputs, 16 MHz crystal oscillator, USB connection, power connection, ICSP reader a reset button
- Power source can be battery, USB cable or power cord.

First prototypes

- Prototype 1a should verify a combination of contact and resistance measurement method. It consisted of a prototyping board with pre-drilled contact holes. The holes were arranged in a grid with a spacing of 1.25 mm. The accuracy of the device was therefore assumed to be 1.25 mm. Subsequently, the connections of the reading electrodes were created in individual height steps. And the power electrode was connected to the lowest level.
- The prototype was then connected to an analog voltage logger with an accuracy of 0 - 1023. The power electrode was connected to a 5V output.
- The capacitive sensor was made of two stainless steel 1 mm thick sheets connected by plastic screws. Such a setup was placed in the cut finger of a laboratory glove, which electrically insulated the electrodes and allowed the water to surround the setup smoothly. The electrodes were connected to the digital pins of the Arduino microcontroller and a specific cycle of filling and emptying the capacitor was created within the internal program.
- This prototypes shown, that resistance measuring method is suitable for our need

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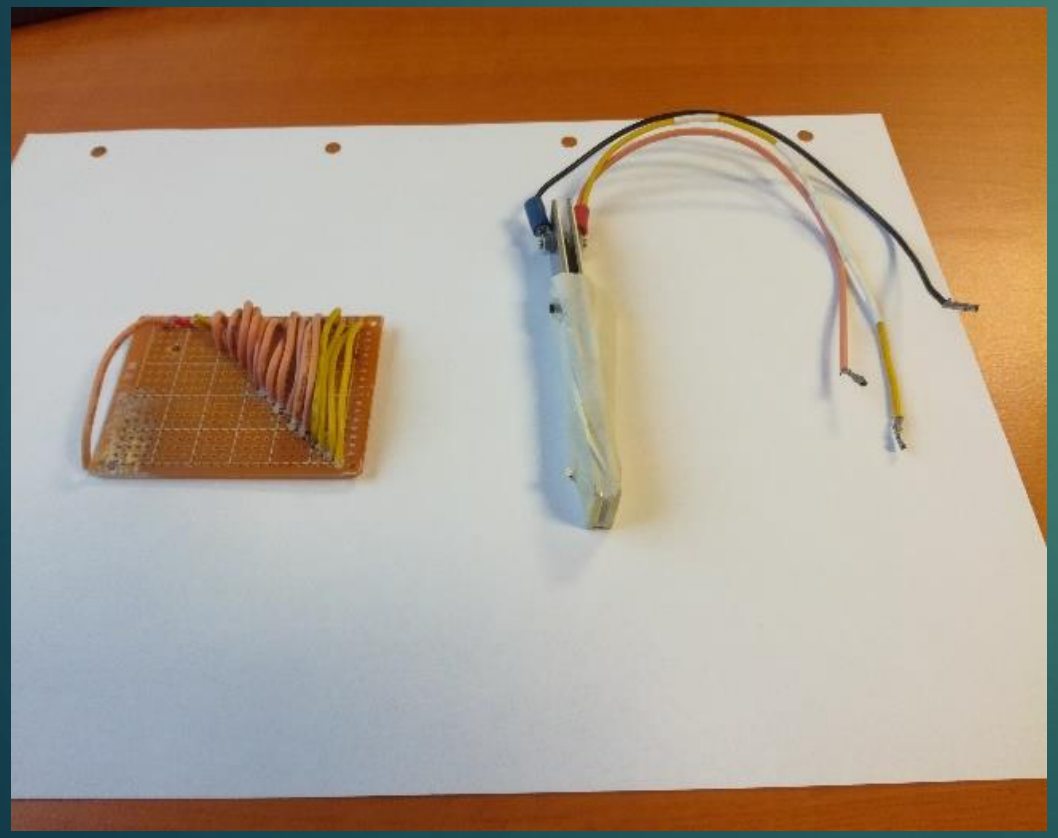
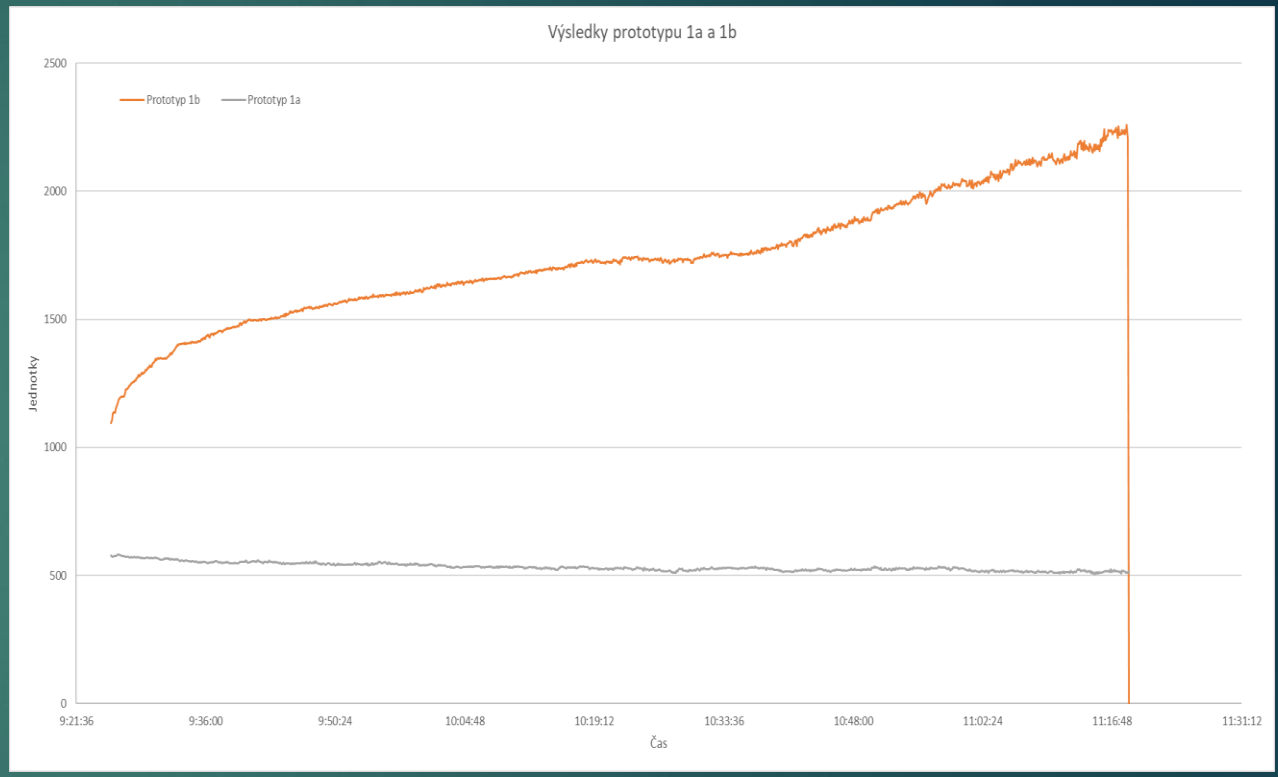
First prototypes





Results of the measurement

- Orange line – resistance measurement
- Grey line – capacitive measurement

Last prototype

- Prototype 3 used the experience of all previous prototypes
- The construction is equipped with 5 sets of electrodes, each with a measuring range of 10 mm. The total measuring range is 50 mm
- The whole structural part of prototype 3 is designed as a printout on a 3D printer, electrodes are printed from conductive material
- Above the electrodes there is a printed circuit board carrying the microelectronics control.

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Principle

- The principle of measurement consists in gradual interrogation of the set of electrodes, subsequent reversal of polarity and repeated interrogation
- This cycle is repeated several times and the result is averaged, then the next set is measured
- The polarity reversal is controlled by the relay
- Thanks to the use of printed circuit board it was possible to simplify the device, so only 7 wires, one analog output, polarity reversal control and 5 sets of electrodes are led from the whole device.

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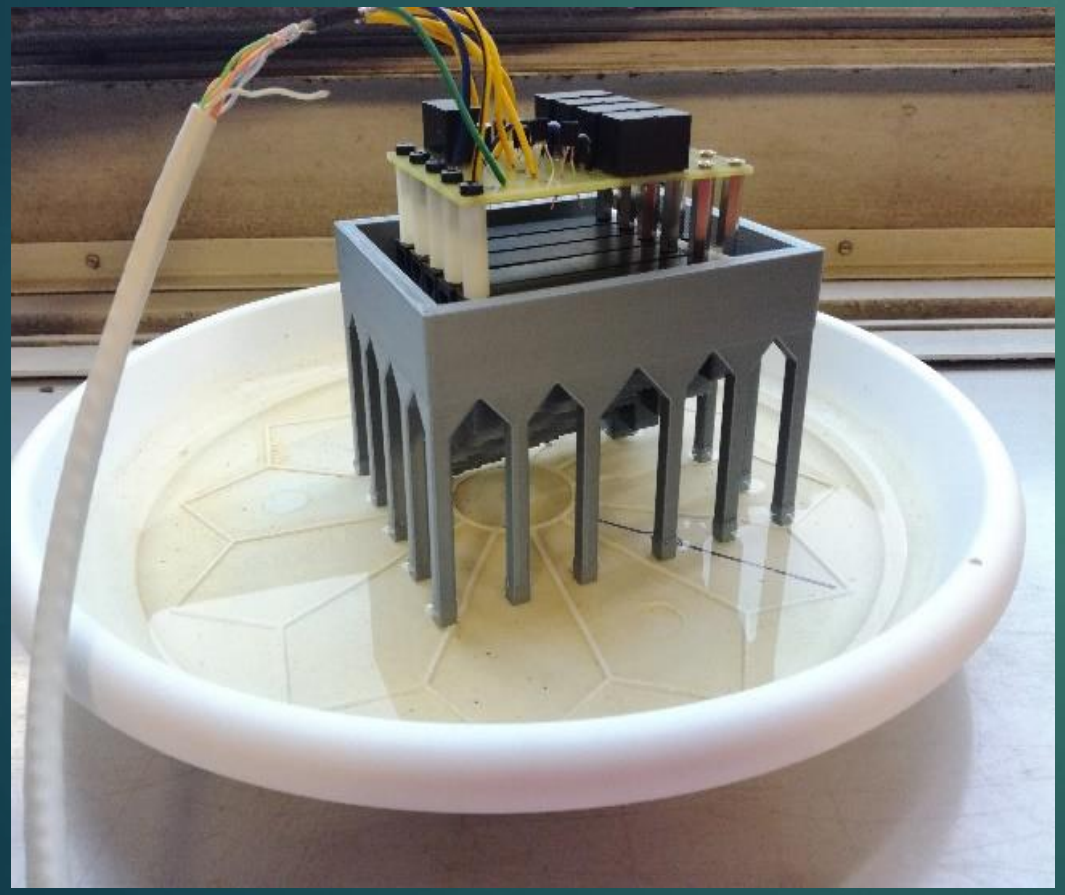
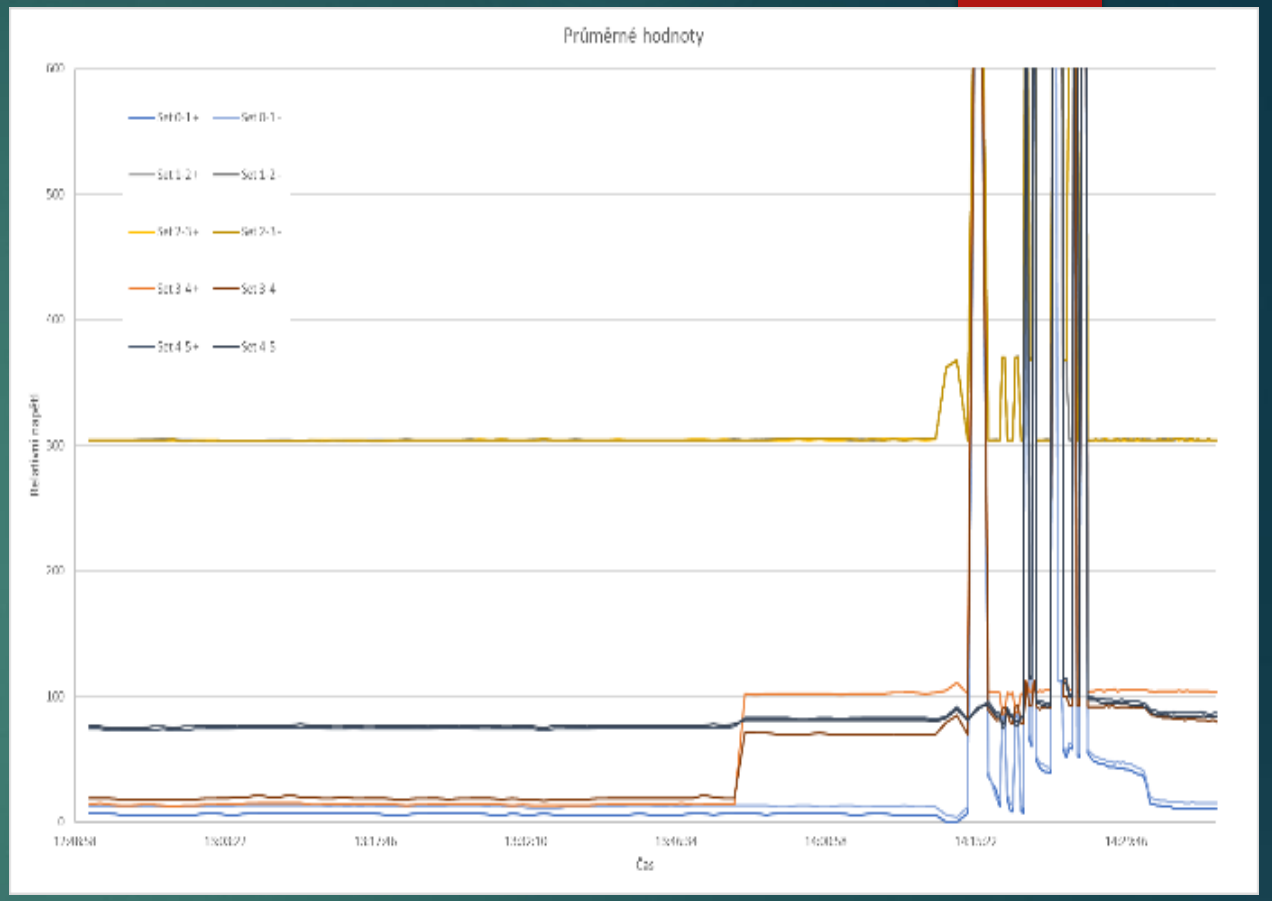
Last prototype





Average values
- Noise created by filling of bowl

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Evaluation

- An important step in the evaluation of the obtained data (the values of current passed through the water), is its analysis
- Often read values vary only slightly
- A commonly used vapor unit is mm of water column per day
- It is therefore necessary to analyze a long time series, at least longer than one day, and covering the entire day from 00:00 to 23:59.

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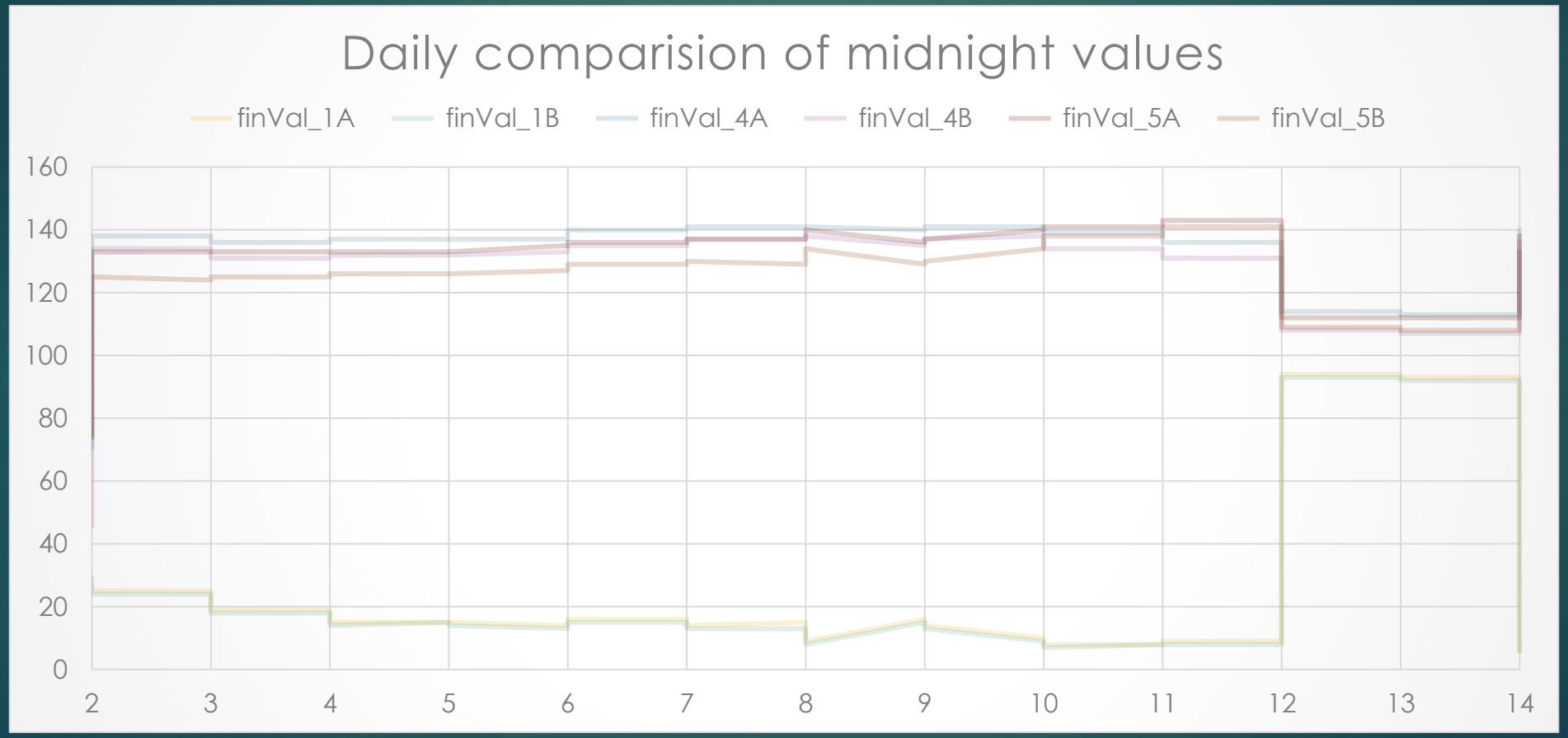
Evaluation



Next phases of research

- The use of multi-filament printing, ie printing on a 3D printer with the possibility of changing the plastic during the printing of one layer, seems to be very promising for further development.
- When printing with conductive and non-conductive plastic, almost the entire sensor can be created.
- Calibration of the sensor will be done. So far this is done by removing or adding water to bowl by pipette. This procedure makes it possible to accurately capture the moment when the electrode is disconnected. To determine the exact level between the individual electrodes, a mass measurement on a very accurate scale will be used.

Miscelaneous

- The sites of the experimental testing are the CTU Faculty of Civil Engineering in Dejvice Prague, the experimental sites of the CULS in Prague Suchdol and the Water Research Institute in Prague Podbaba.
- The research is funded by the Technological Agency of the Czech Republic (research project TJ02000351 - Development of Tools and Methods Improving Estimation of annual Evaporation Balance).

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Thanks for your attention

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