API AND AWBI CALCULATION BASED ON PRECIPITATION DATA BETWEEN 2017 – 2022 IN THE HIDEGVÍZ VALLEY EXPERIMENTAL CATCHMENT, HUNGARY

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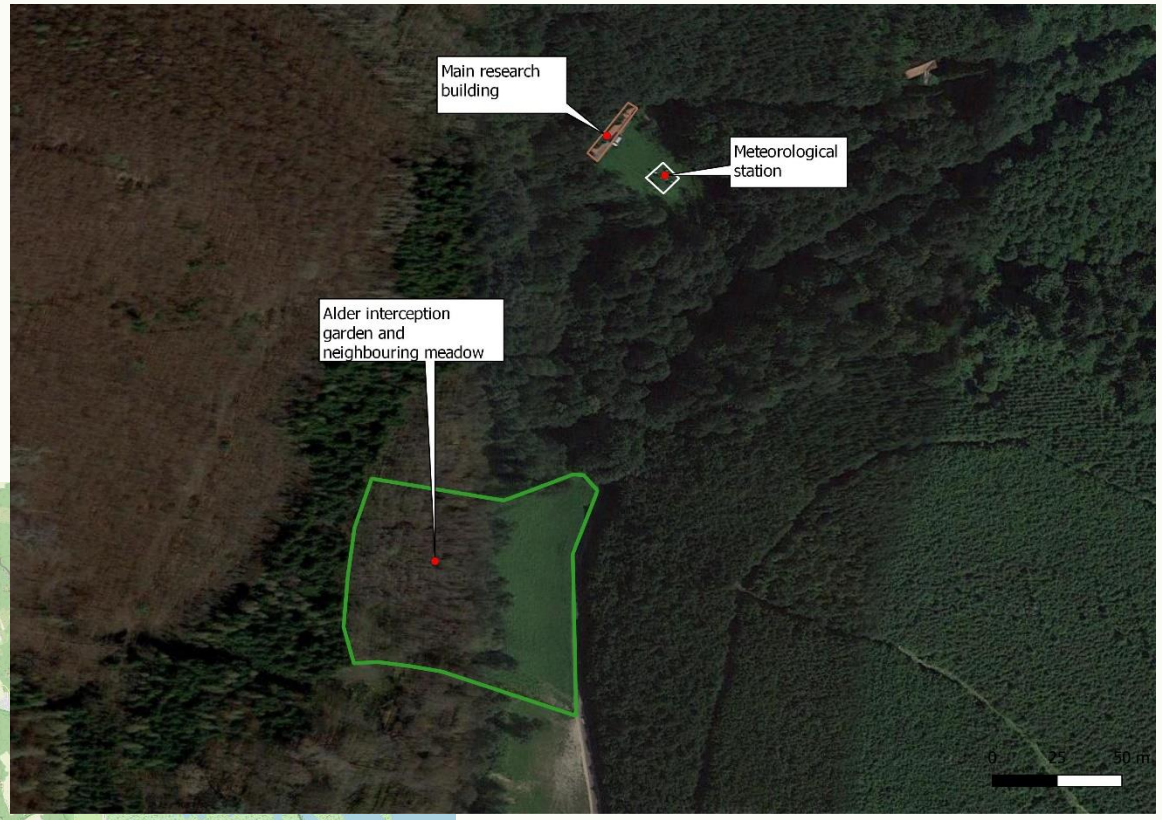
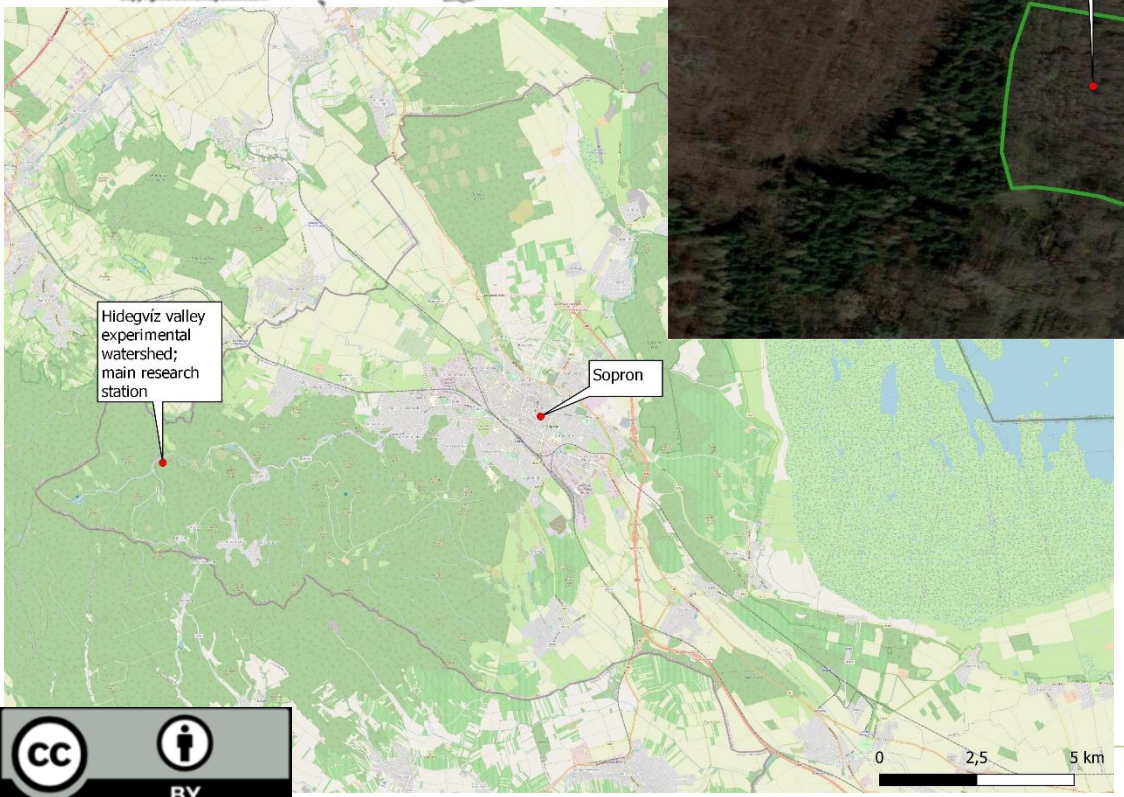
Location of the Hidegvíz Valley experimental catchment





- The Hidegvíz Valley experimental watershed is located in the Sopron Mountains, West Hungary
- It has three main sampling areas, one in a valley location with the main research building, a meteorological station, and an alder forest interception garden; the remainig two plots are beech and oak intercepcion gardens on higher elevations
- Data collection has started with automated data loggers and manual devices in the early 1990s
- The automated instruments are operating on daily basis, manual measurements have been done weekly
- This research is focusing on the data collected on the valley sampling plot

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Measuring precipitation data

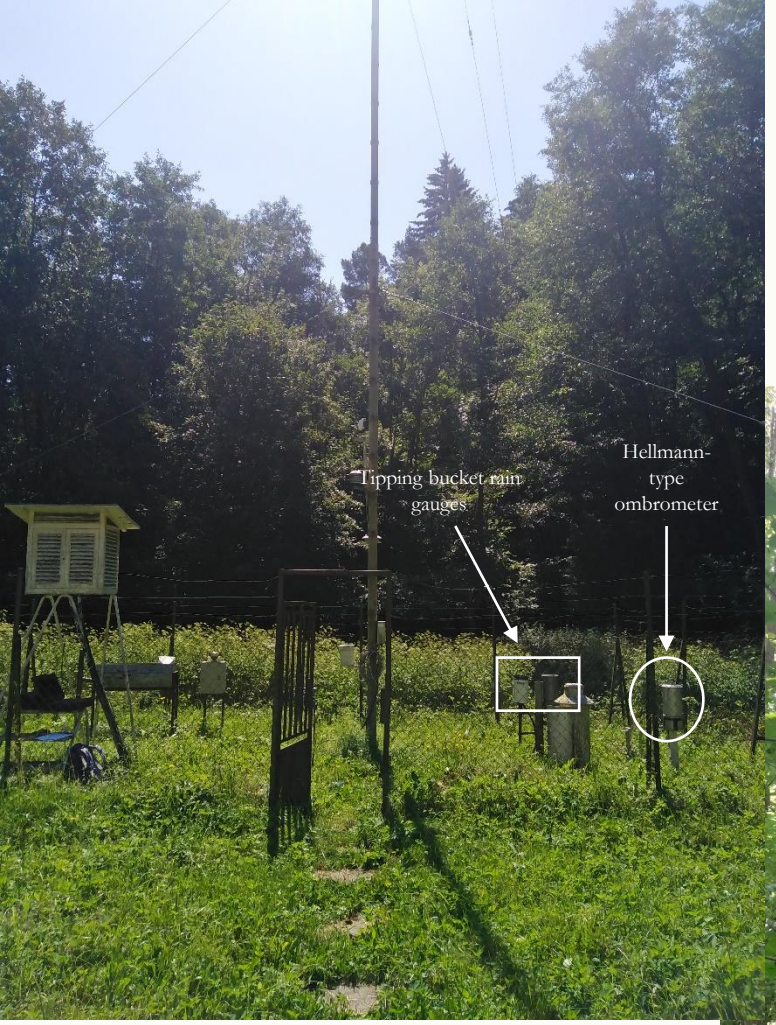

Figure 1. (above): The meteorological station in the valley sampling plot.

Figure 2. (below): The alder forest interception garden in the valley sampling plot.

- Our research focused two different land covers; an open field near the valley located meteorological station, and a neighbouring alder forest
- We collected precipitation data from the meteorological station and measured surface soil moisture on both locations
- Precipitation data has been collected on a daily basis, in every 10 minutes by three automated data loggers and tipping bucket rain gauges
- Each automated device has a unique resolution: for the 'Boreas' type, 0.1 mm, for the 'Dataqua' type, 0.1, and for the 'HHM' type, 0.5 mm per tip
- Precipitation has been measured manually on a weekly basis, by a traditional Hellmann-type ombrometer
- ‚Boreas' and ‚Dataqua' devices has been measuring the air temperature, which has been used for data pre-processing

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Figure 3.: The Fieldscout TDR 300 soil moisture meter.

Measuring surface soil moisture data

- Surface soil moisture data has been collected on a weekly basis, with a Fieldscout TDR 300 soil moisture meter
- The instrument is using the TDR (Time Domain Reflectometry) method to measure surface soil moisture
- Time Domain Reflectometry described by Radcliffe et. al. 2010: „*To measure water content with time domain reflectometry (TDR), a two- or three-rod waveguide is inserted in the soil and connected via coaxial cable to a TDR instrument. The instrument transmits a voltage step to the waveguide. Changes in impedance cause reflections of the input signal at times corresponding to the beginning and end of the waveguide. These reflections can be used to determine the travel time of the EM signal in soil to the end of the waveguide and back.*"[1]
- Soil moisture has been measured five times on each sampling plot (open field and alder forest), to minimize measuring errors
- Although TDR is a simple and easy method to determine surface soil moisture, the instrument can not be used when the soil is frozen or during droughts

- [1]*RADCLIFFE, D.E.- SIMUNEK, J. (2010): Soil Physics with HYDRUS: Modeling and Applications. CRC Press, Boca Ration, FL. pp. 43 – 44.*

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Data pre-processing

- *Equation 1:* $P_d = \frac{\sum P_M}{\sum P_A} *$;where P_d [mm] is the corrected daily rainfall amount measured by the automated devices; ΣP_M [mm] is the manually measured rainfall amount in a given period; ΣP_A [mm] is the rainfall amount measured by an automated device in a given period; P_{Ad} [mm] is the rainfall amount measured by the given automated device on a given day.
- *Equation 2*: $VWC = (0{,}049 * PERIOD) - 98{,}23$; where *VWC* is the volumetric water content; and *PERIOD* is the value given by the TDR instrument.
- *Equation 3*: $PET = 29{,}8 * D * \frac{e}{T+273{,}2}$; where *D* [h] is the possible duration of sunshine in units of 12 hours; *e* [kPa] is the saturated water vapor density; *T* [°C] is the daily mean temperature (*Hamon et. al. 1963*)[2].
- Equation 4: $WBI_d = P_d - PET_d$; where WBI_d [mm] is the daily water balance index; P_d [mm] is the daily rainfall amount; PET_d [mm] is the daily potential evapotranspiration.
- Our goal was in this research to determine, if antecedent precipitation index (API), or antecedent water balance index (AWBI), is more accurate for soil moisture estimation in case of different surface covers
- For these calculations, we needed multiple data pre-processing, using Rstudio and Microsoft Excel
- At first, we corrected the daily precipitation data measured by the automated instuments, using the weekly manual observations (*Equation 1.*)
- Raw data from the surface soil moisture measurements has been converted by using *Equation 2.*
- Potential evapotranspiration (PET) has been calculated by using the Hamon method (*Hamon et. al.1963*)[2]; *Equation 3.*
- Using the PET, we calculated the daily water balance index, and labeled this value as WBI_d for better understanding (*Equation 4.*)

- [2]*HAMON, R.W. (1963): Computation of direct runoff amounts from storm rainfall. Wallingford, Oxon., U.K.: International Association of Scientific Hydrology .63.*

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Calculating API and AWBI

- *Equation 5:* $API_{i_{20}} = \sum_{i=1}^{20} p_i * h_i = 1{,}00 * h_1 + 0{,}95 * h_2 + \cdots + 0{,}10 * h_{19} + 0{,}05 * h_{20}$; where h_1, h_2,..., h_{20} [mm] is the rainfall amount on the first, second,... twentieth day before the day when the rainfall amount causes a runoff; multiplied by lineary descending weighted values *(Koris et. al. 1993)*[3].
- *Equation 6*: $AWBI_{i_{20}} = \sum_{i=1}^{20} p_i * WBI_i = 1{,}00 * WBI_1 + 0{,}95 * WBI_2 + \cdots + + 0{,}10 * WBI_{19} + 0{,}05 * WBI_{20}$; where WBI_1, WBI_2,..., WBI_{20} [mm] is the water balance index calculated on the first, second,... twentieth day.
- Antecendent precipitation index (*API*) has been calculated by using *Equation 5. (Koris et. al. 1993)*[3]
- Antecendent water balance index (*AWBI*; as we labeled for better understanding) has been calculated using *PET* and WBI_d values, similar to API (*Equation 6.*)
- The results has been presented on scatterplots, using the surface soil moisture data from both different land covers as a comparison

[3] *SZERK. KORIS K. (1993): Hidrológiai számítások. Linograf Kft., Gödöllő. pp.354*

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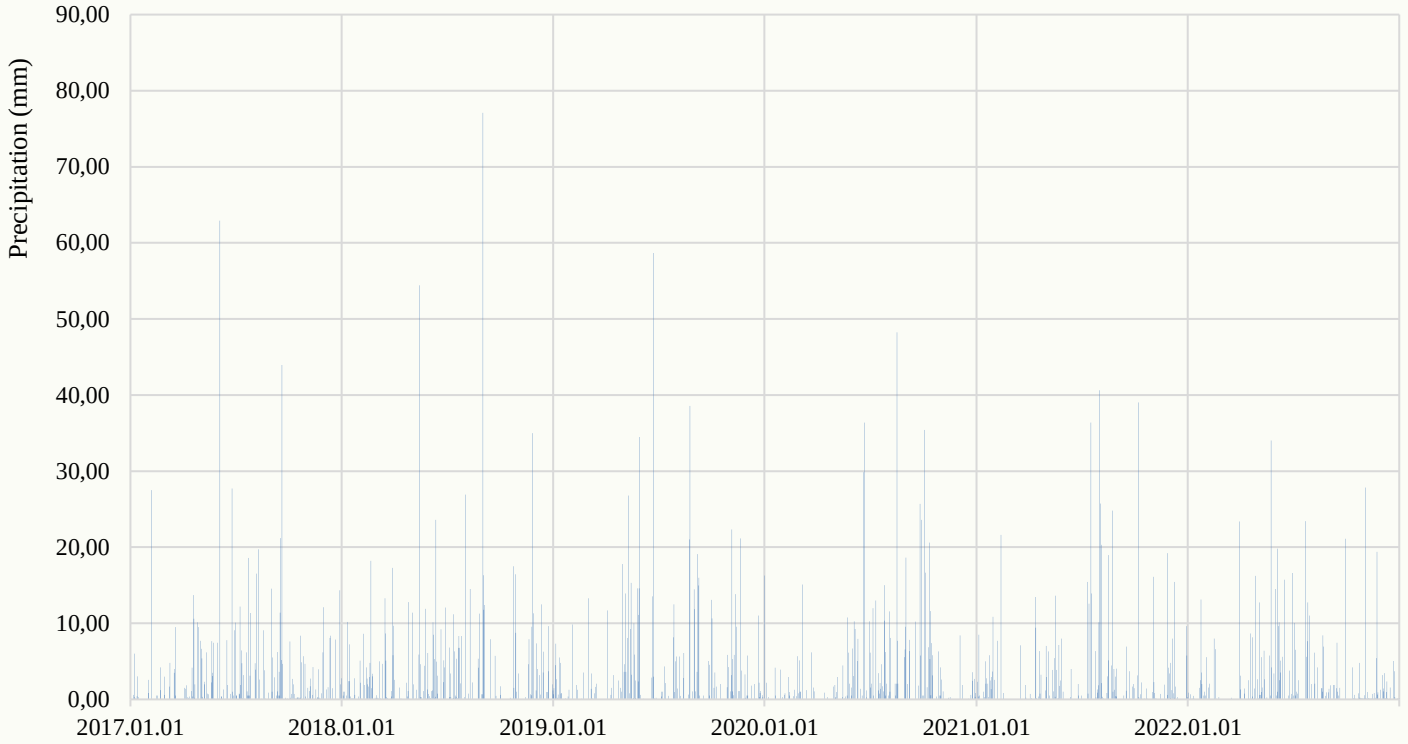
Corrected daily precipitation data between 2017-2022



- Total annual rainfall amounts:
- **2017: 704,04 mm**
- **2018: 828,19 mm**
- **2019: 767,21 mm**
- **2020: 662,3 mm**
- **2021: 627,87 mm**
- **2022: 565,73 mm**
- The average annual rainfall amount in the Hidegvíz Valley is 700-750 mm; it means that in 2018 we measured above average rainfall amount; and 2022 has been affected by severe drought.

Figure 4: Corrected daily precipitation between 2017-2022 in the Hidegvíz valley meteorlogical station

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Monthly surface soil moisture data between 2017-2022

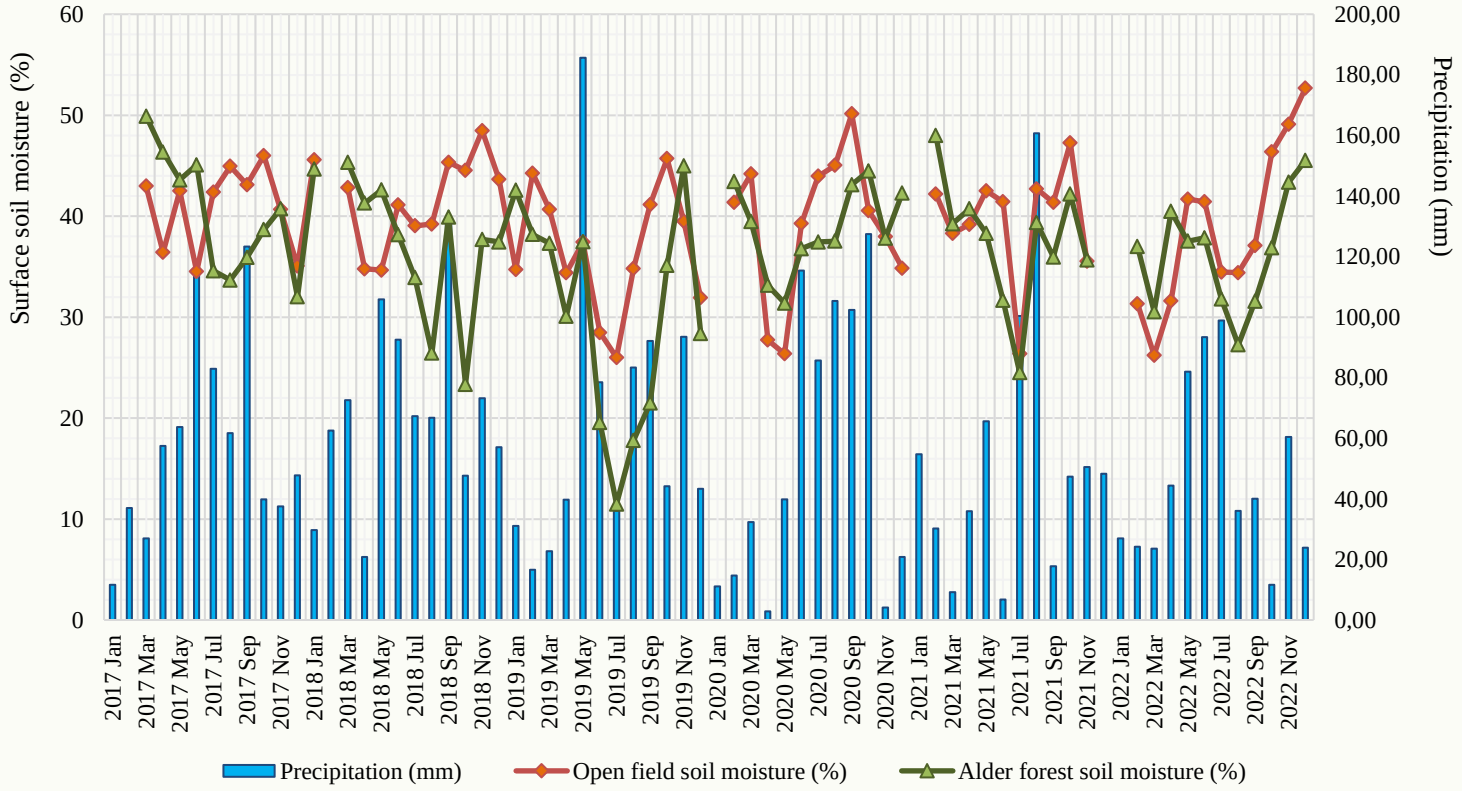

Figure 5: Monthly surface soil moisture between 2017-2022 in the Hidegvíz valley

- Monthly surface soil moisture data has been summarised monthly for better visualisation
- Gaps are representing the months when the soil was frozen
- The forest has generally lower soil moisture values tha the open field, especially in the vegetation period; the cause of this difference is the interception and the trees' higher water consumption

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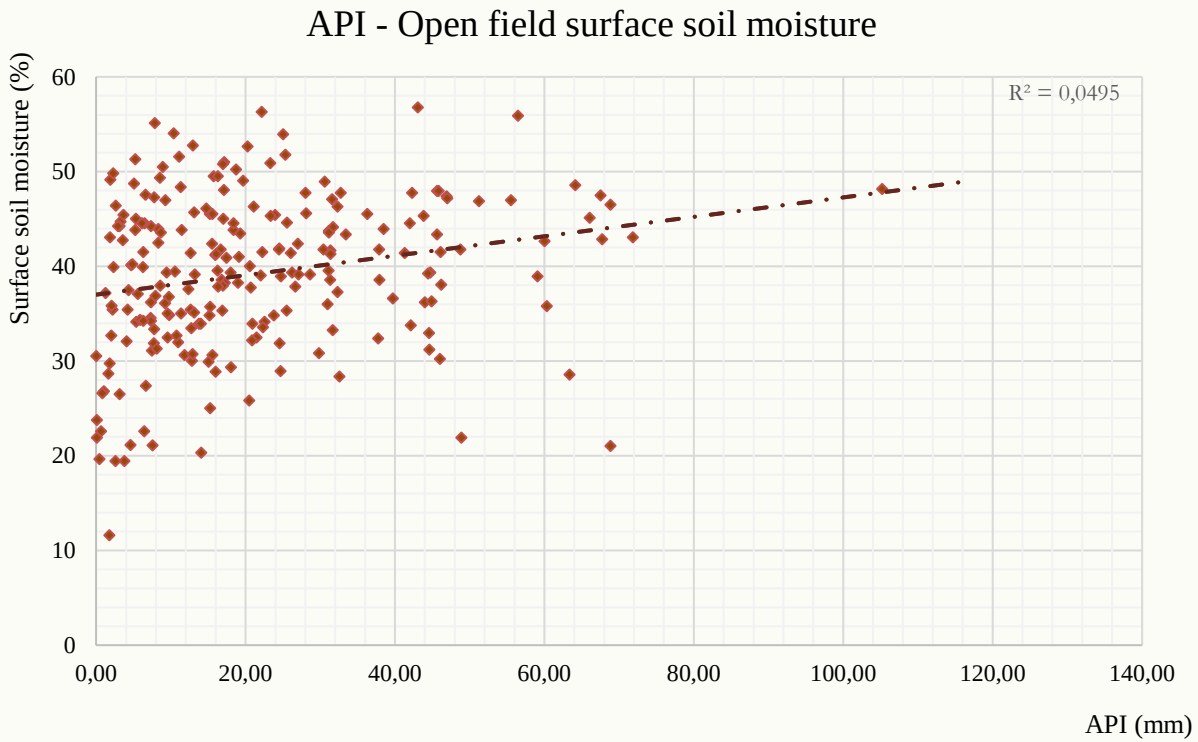
API on different land covers



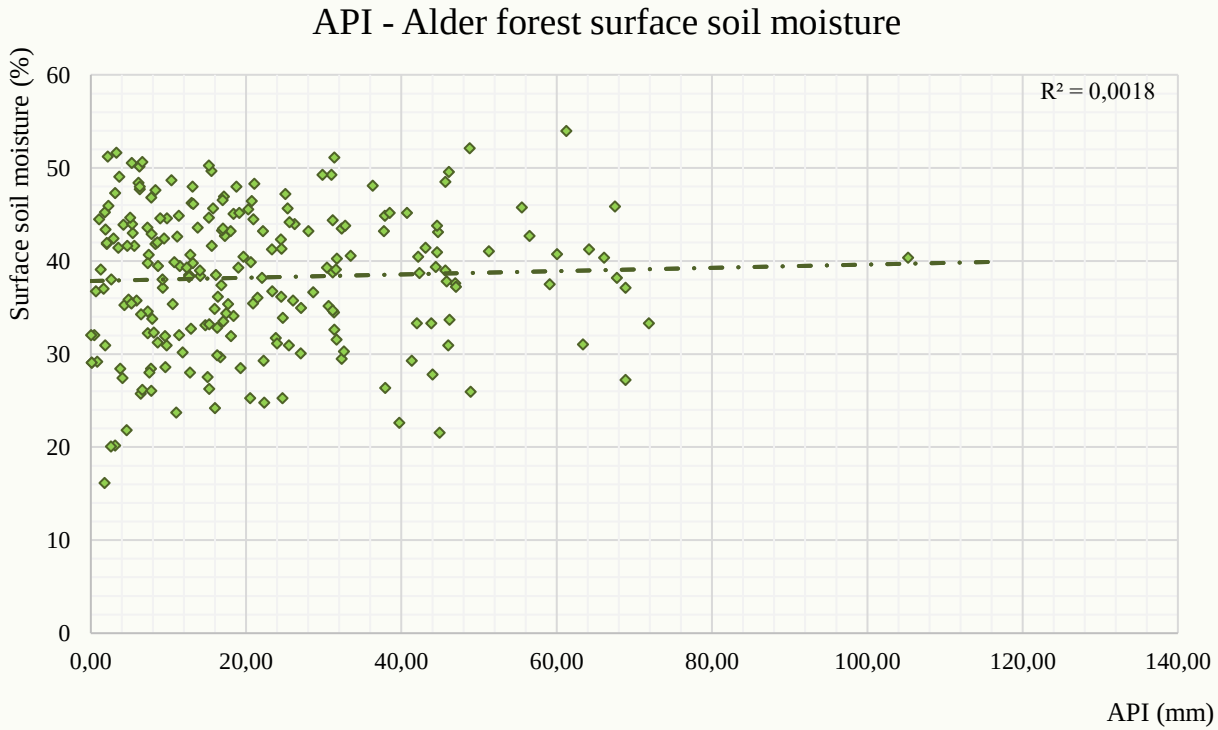


Figure 6. (left) and Figure 7. (right): API compared to open field surface soil moisture (*left*) and alder forest surface soil moisture (*right*)

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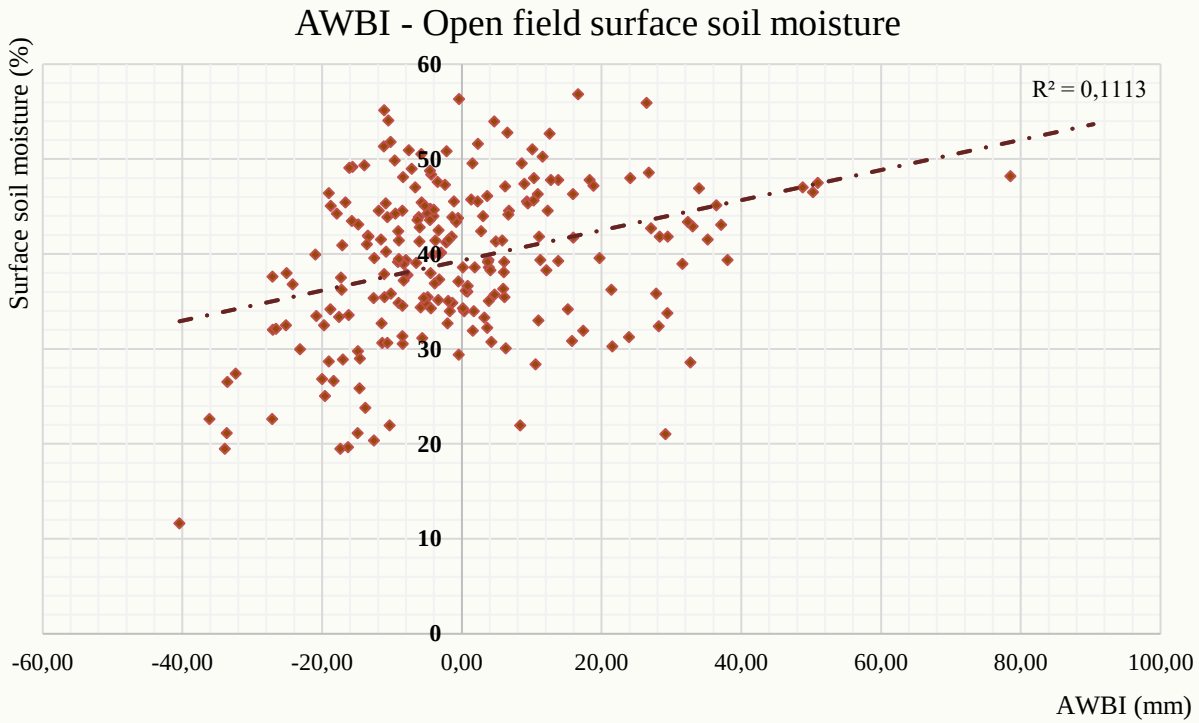
AWBI on different land covers



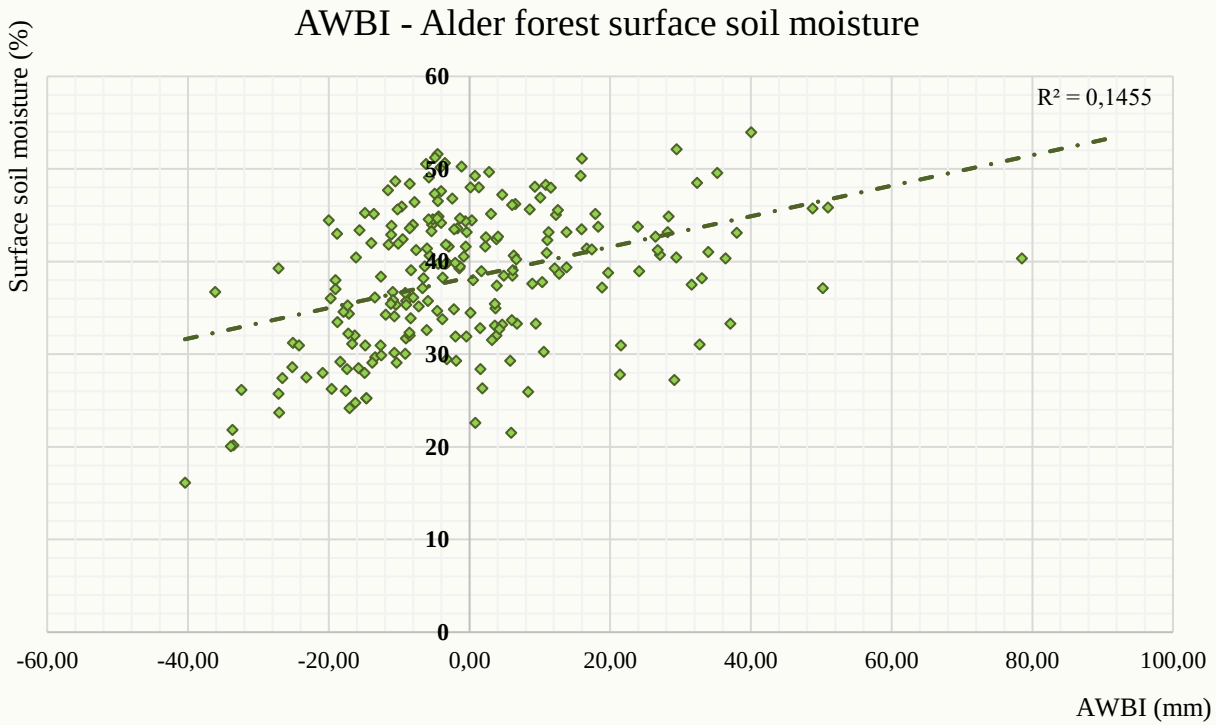


Figure 8. (left) and Figure 9. (right): AWBI compared to open field surface soil moisture (*left*) and alder forest surface soil moisture (*right*)

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Discussion

- The daily precipitation correction during the data pre-processing was mostly successful, although in the future we will need more precise methods to eliminate measuring errors
- AWBI values compared to surface soil moisture values showed siginficantly better relations than API values compared to surface soil moisture values
- Neither of the indexes showed significant relation to the surface soil moisture data, therefore we concluded that neither of them are useful for soil moisture estimation

- **Future goals:**
- Using the corrected daily precipitation data and soil moisture for modeling
- Further research on the topics water balance index and antecendent water balance index – we could not found any precisely related articles yet
- Using another statistical methods including API and AWBI, to determine their most useful appliance

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