Lesnická a dřevařská fakulta

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Forest hydric function and water balance

Mendelova univerzita v Brně

Visegrad Fund

Forest hydrology as science

- Questions:
  - The effect of forests on landscape hydrology
  - The effect of forest managment practice on the hydrological regime of catchments
  - The effect of individual tree species
- Challenges:
  - Global climate change

Global climate change (GCC) in Central Europe

- In the last 50 years the mean annual temperature has increased by 3°C
- This trend is expected to continue
- Changes in precipitation and tempereture patterns during the year
- Spring comes earlier
- Summer is drier
- Less snow cover

The negative effects of GCC on forests

- Longer growing season (more transpiration – water uptake)
- Decreased stability of forests
- Outdated Forest Typology

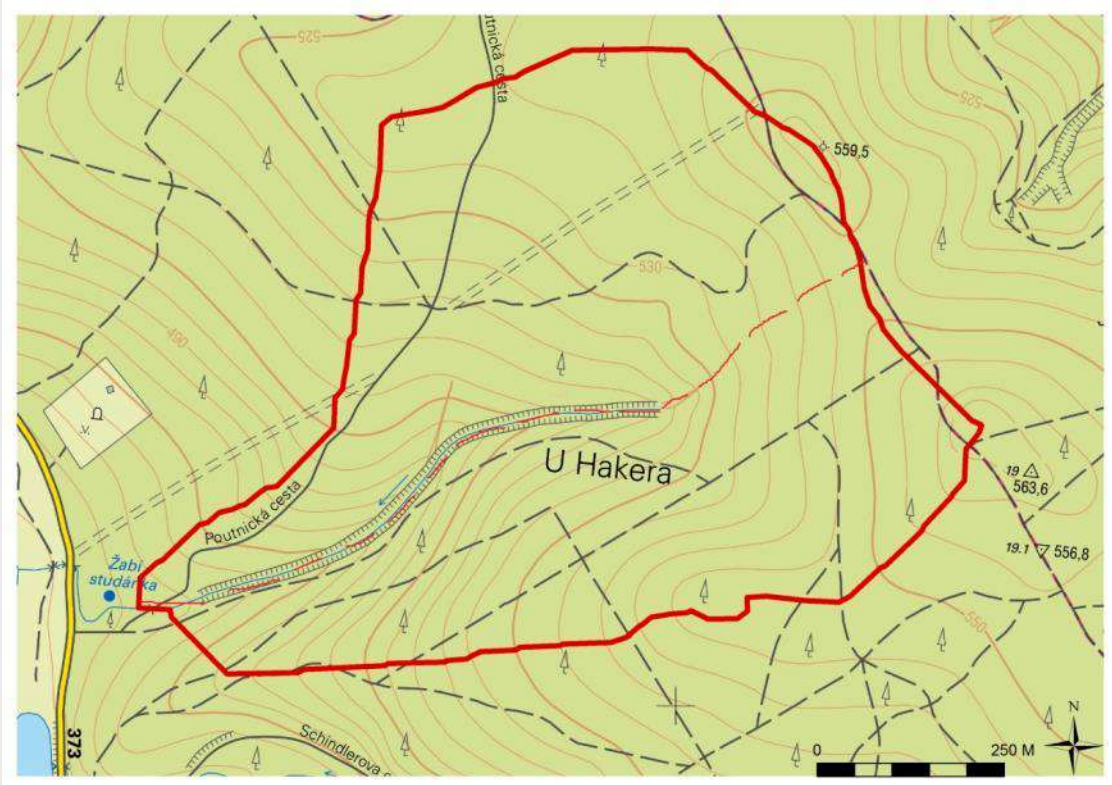
Water balance in forested catchments

Catchment/drainage basins/watershed

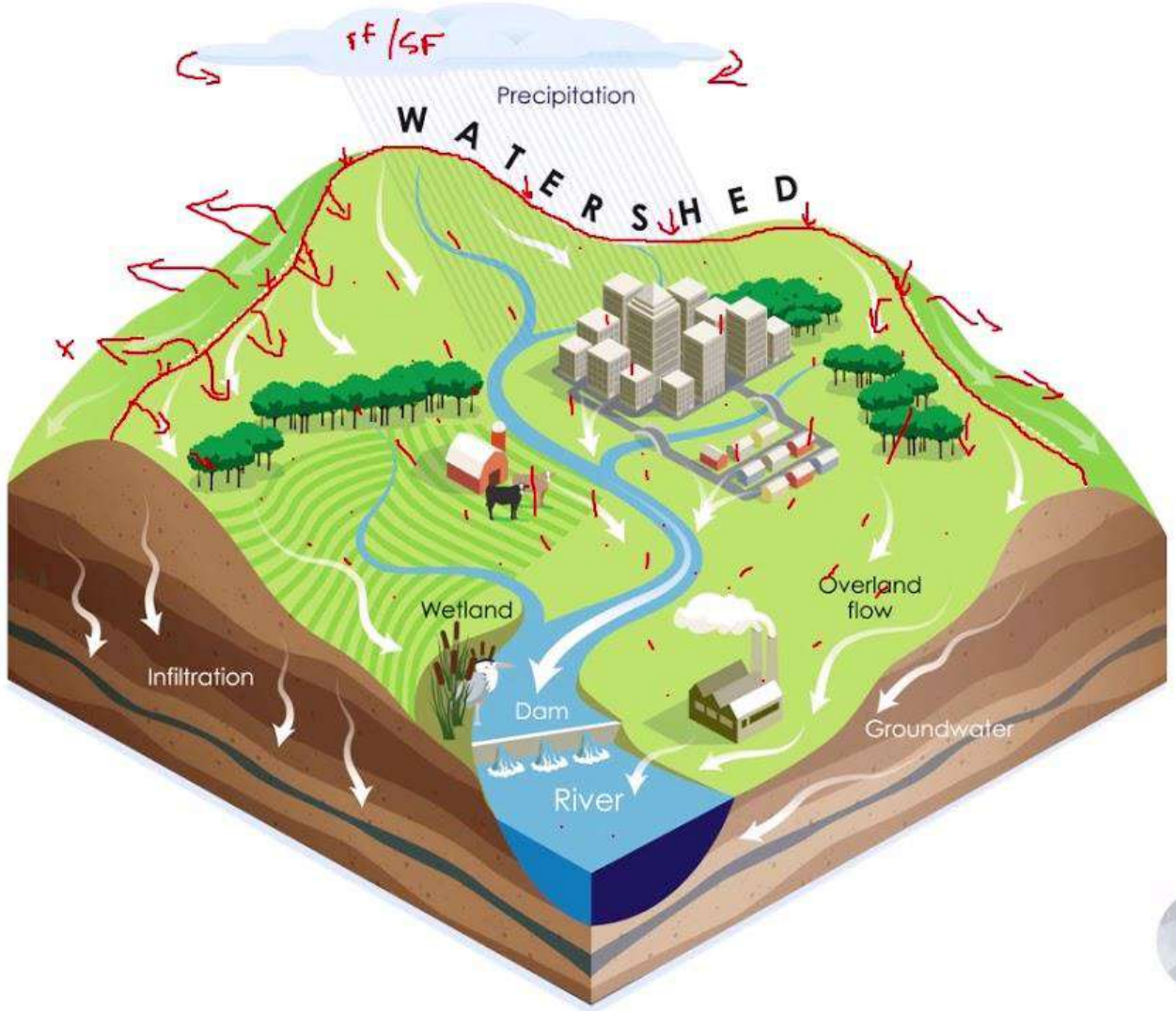
- Area from which all precipitation drains out as runoff to a „recipient“ – river, see, lake, etc.

- Cathment divide

- Discharge/run off/catchment **outlet**

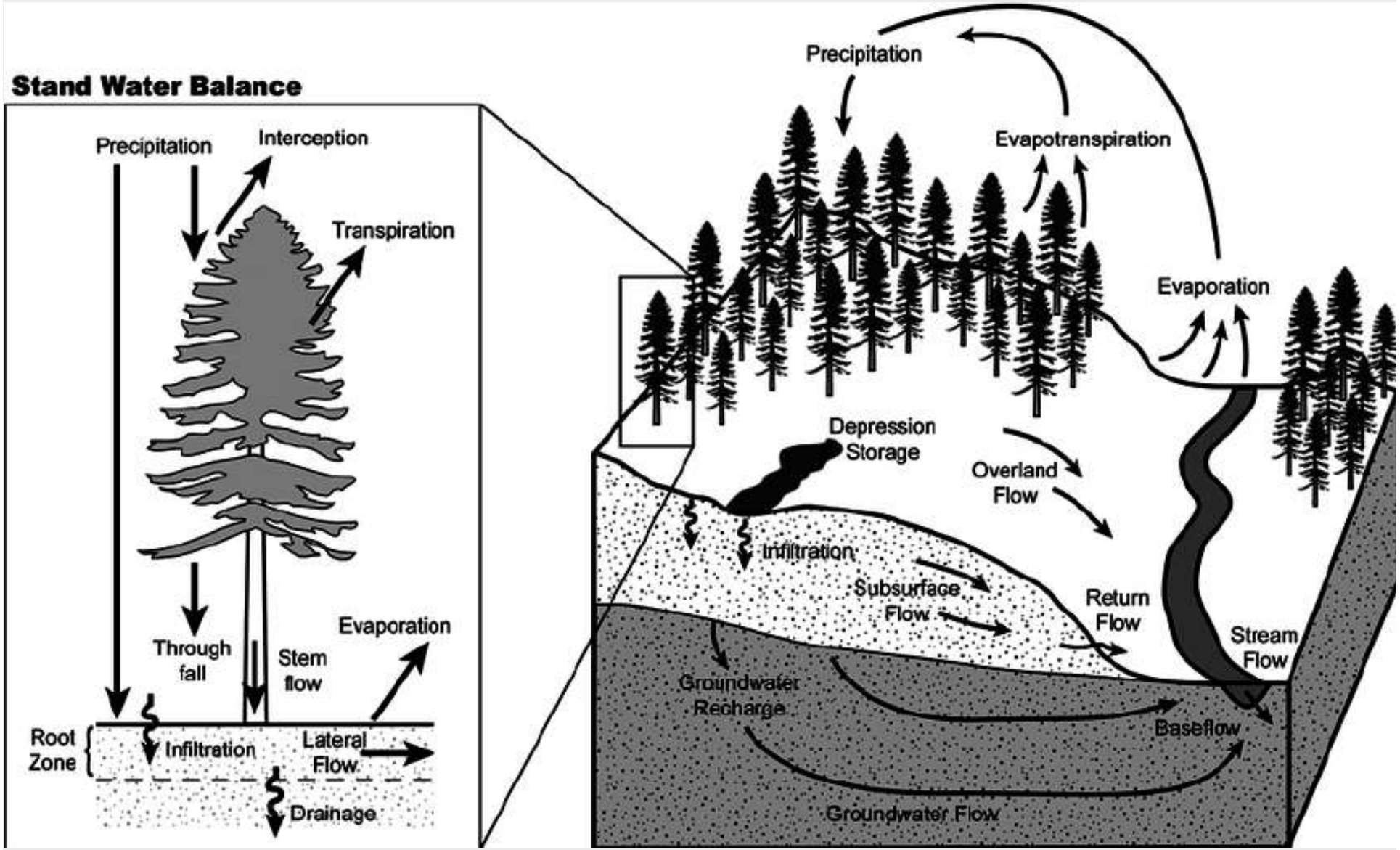


Catchment/drainage basins/watershed



The effect of forests on runoff generation

- Interception – water stopped by the canopy (evaporates from leaves)
- Transpiration – water sucked out from the soil by roots used to sustain growth
- Evaporation – from canopy/surface/water
- Infiltration – from surface to deeper soil
- Streamflow– water in the stream (surface runoff)


Stand Water Balance
Precipitation
Interception
Transpiration
Through fall
Stem flow
Evaporation
Root Zone
Infiltration
Lateral Flow
Drainage
Precipitation
Evapotranspiration
Evaporation
Depression Storage
Overland Flow
Infiltration
Subsurface Flow
Return Flow
Stream Flow
Groundwater Recharge
Baseflow
Groundwater Flow

Hydrological/water balance

$P = E + T + Q + \Delta S$

P – precipitation (rain, snow, fog)

E – evaporation (from surface)

T – transpiration (by plants for growth)

Q – runoff (surface, subsurface, basal)

ΔS – change in water storage

How to measure the components of Water Balance

Department of Landscape Management

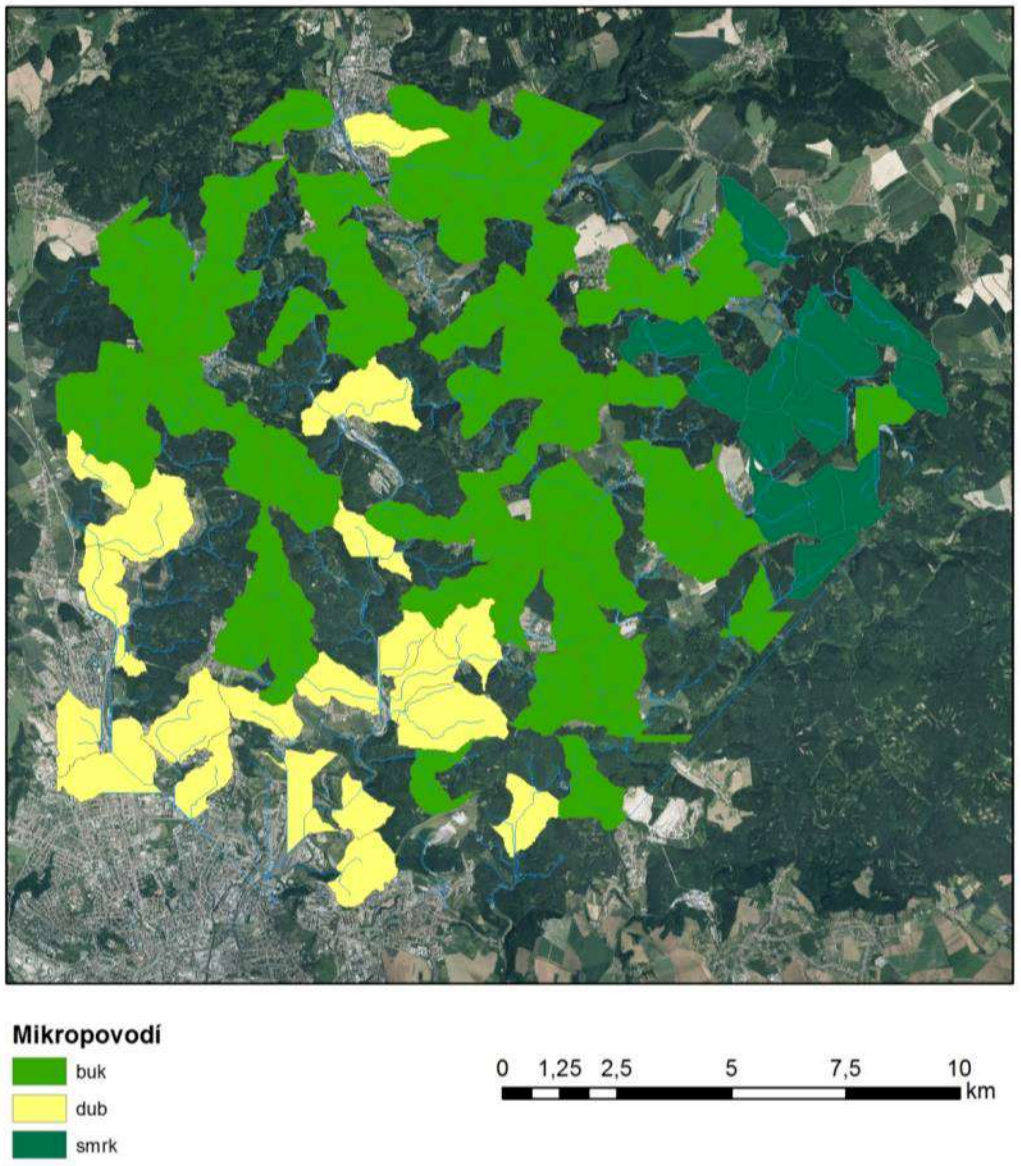
- Experimental catchments /microwatersheds in TFE (training forest enterprise) - streamflow measurements, soil survey, transpiration measurements
- Network of climatic stations – precipitation, temperature, soil moisture

Map server

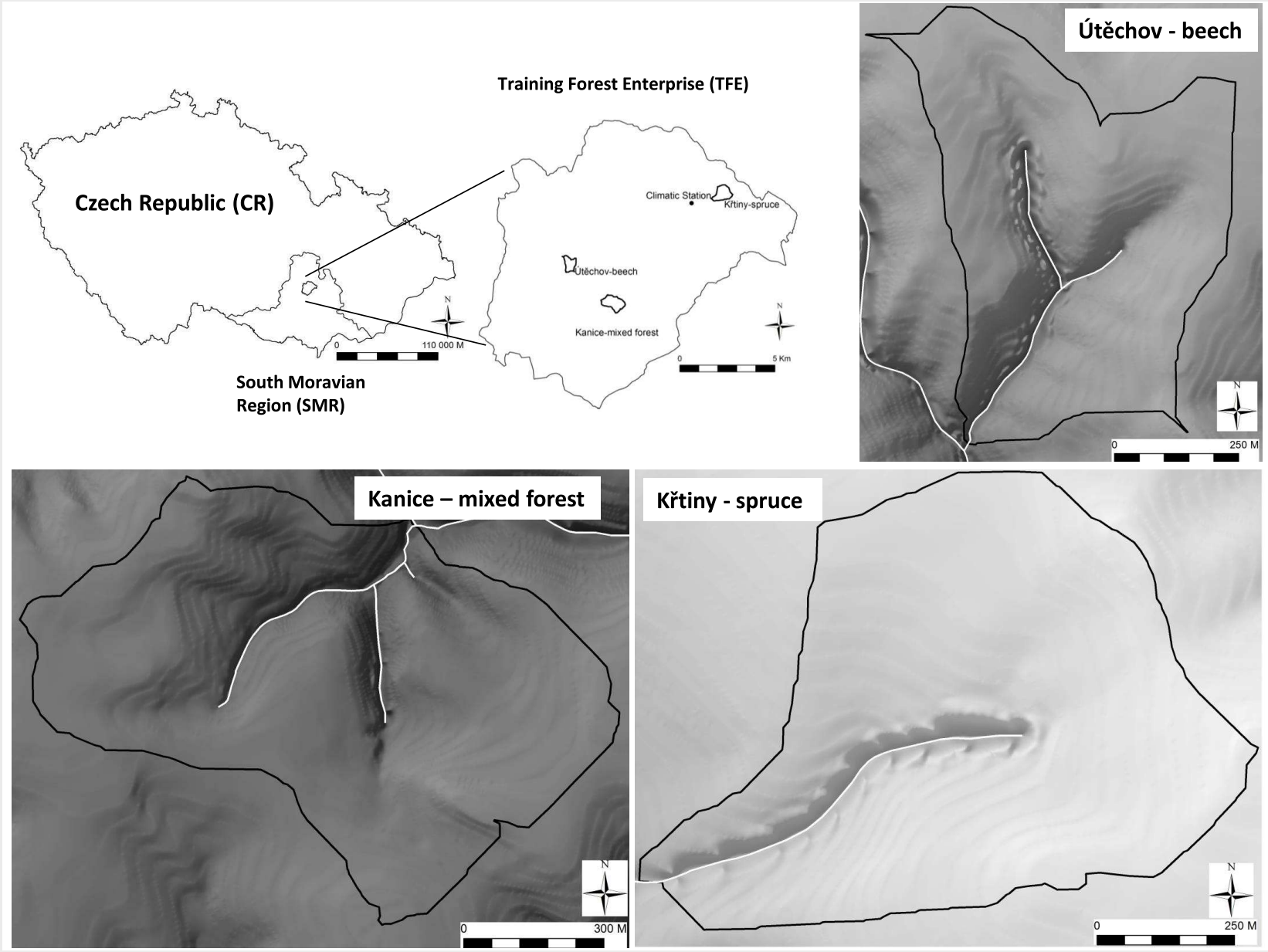
Beech (*Fagus sylvatica*)

Oak (*Quercus* sp.)

Norway spruce (*Picea abies*)



Experimental catchments

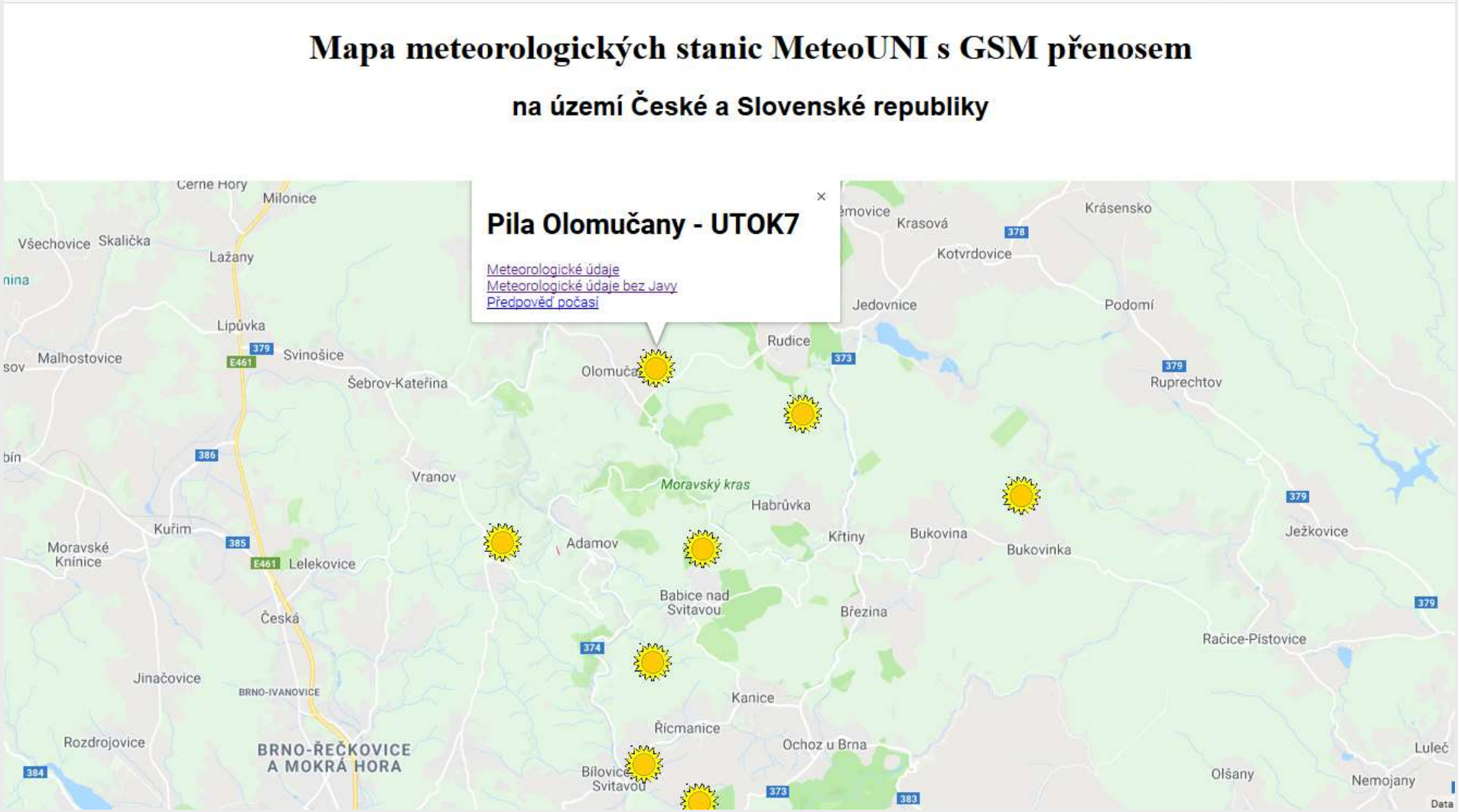


Precipitation

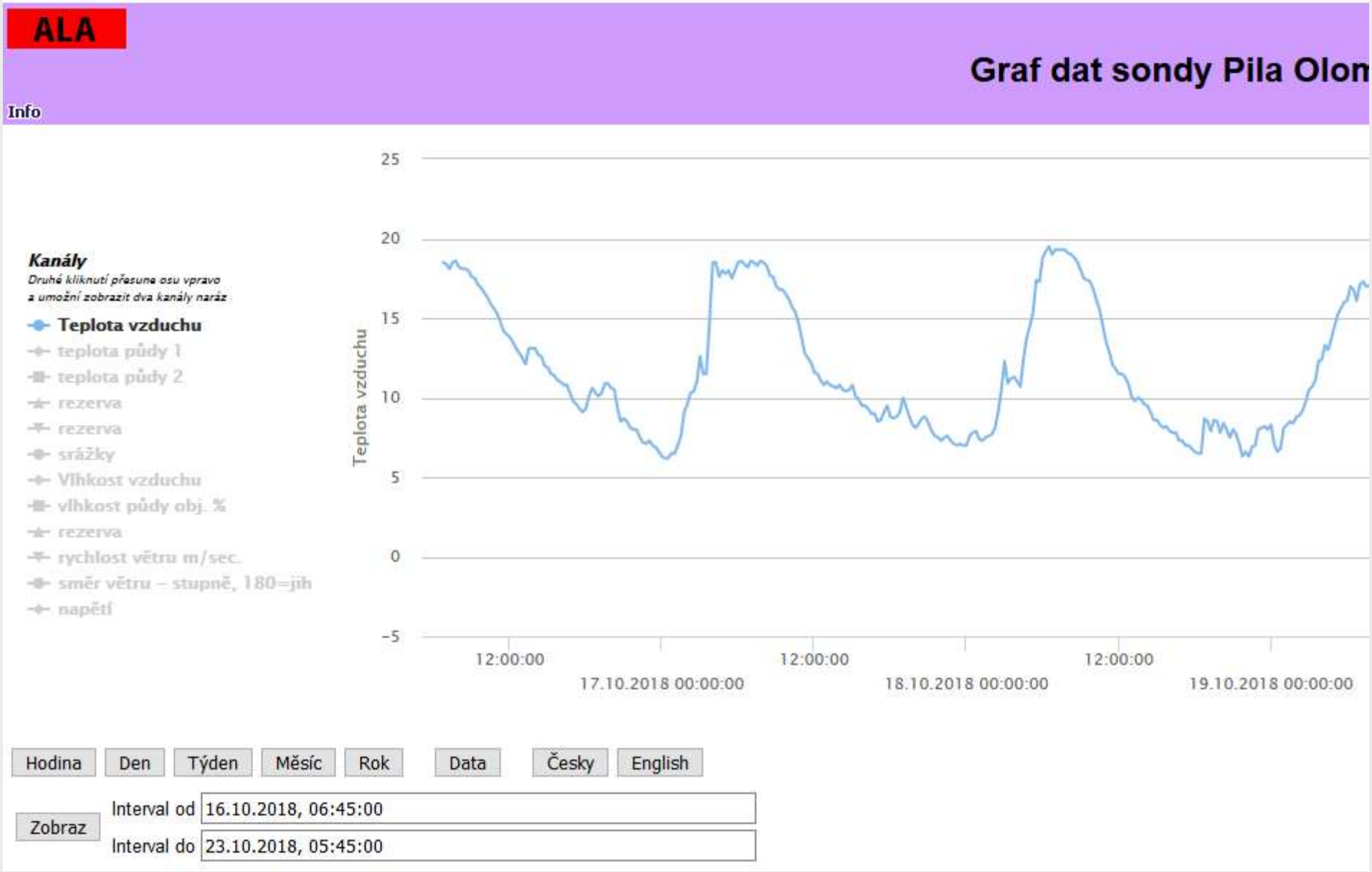
- **Precipitation – the only source of water in headwater areas**
  - A network of climatic stations (http://www.amet.cz/)
  - Air temperature, soil temperature, precipitation, soil humidity, wind direction and speed, soil moisture, solar radiation

Climatic station

Climatic stations - localisation

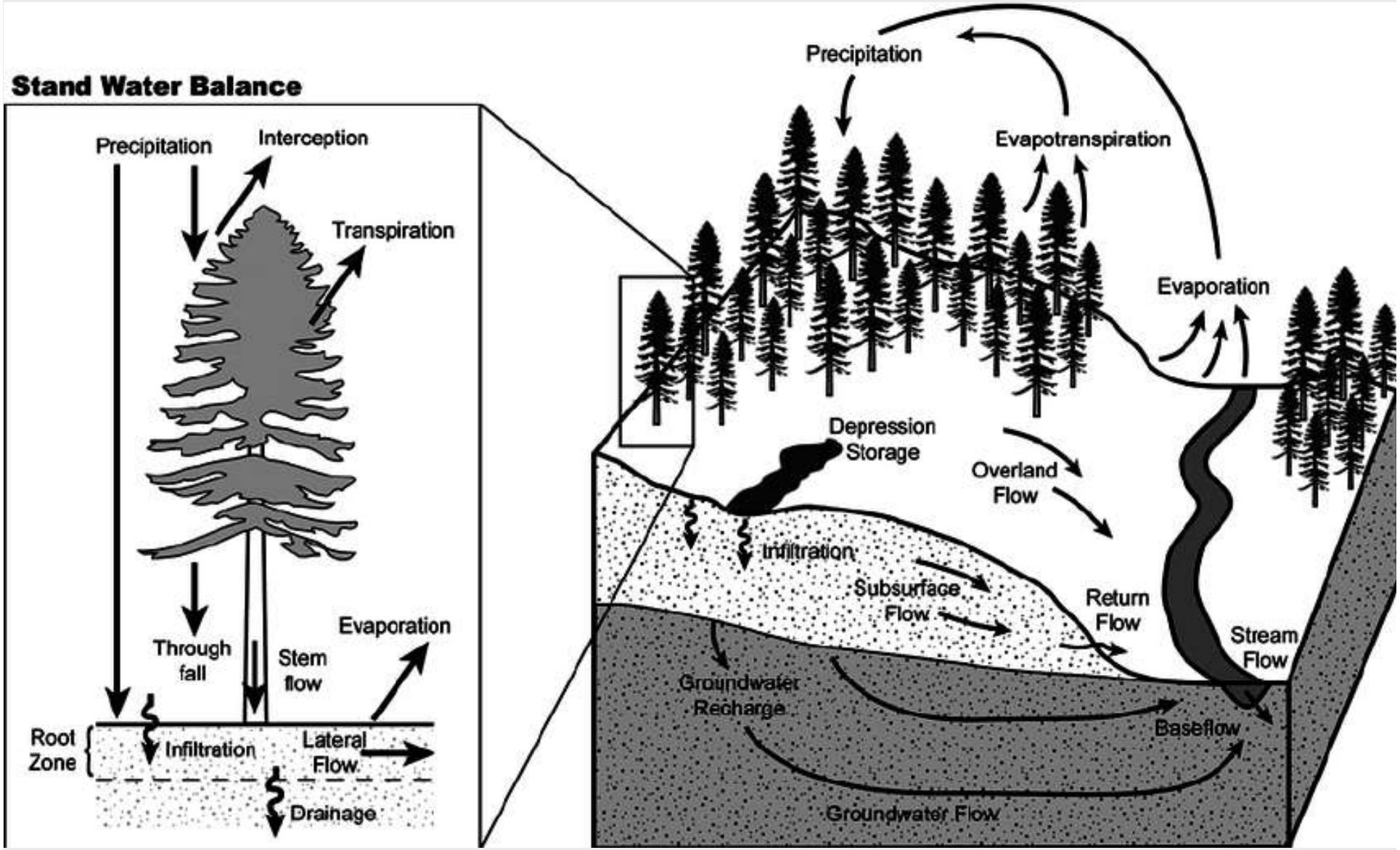


Climatic stations – data/interface



Interception

- **Water retained on the surface of crown/leaves**
  - Depends on the area, shape and amount of leaves
  - It can be estimated via:
    - Model from LAI (leaf area index)
    - Measurements of throughfall and stemflow
  - Phenology is important for deciduous trees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Throughfall, Stemflow, LAI

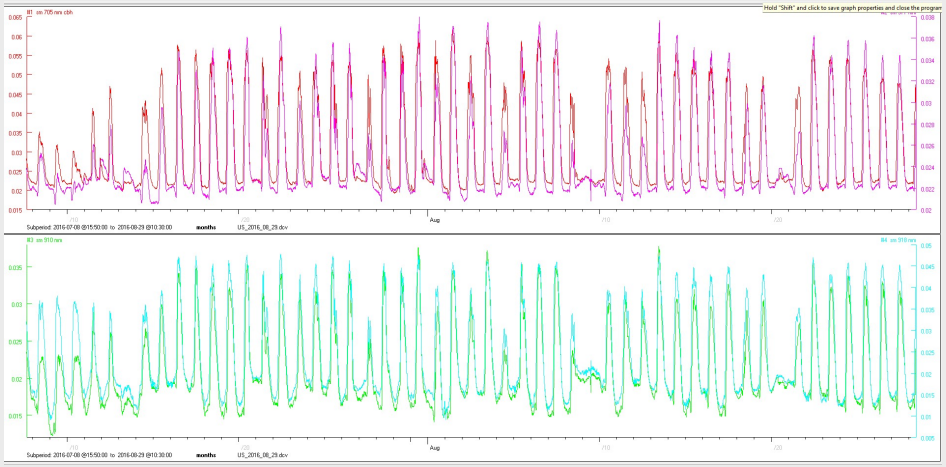
Interception

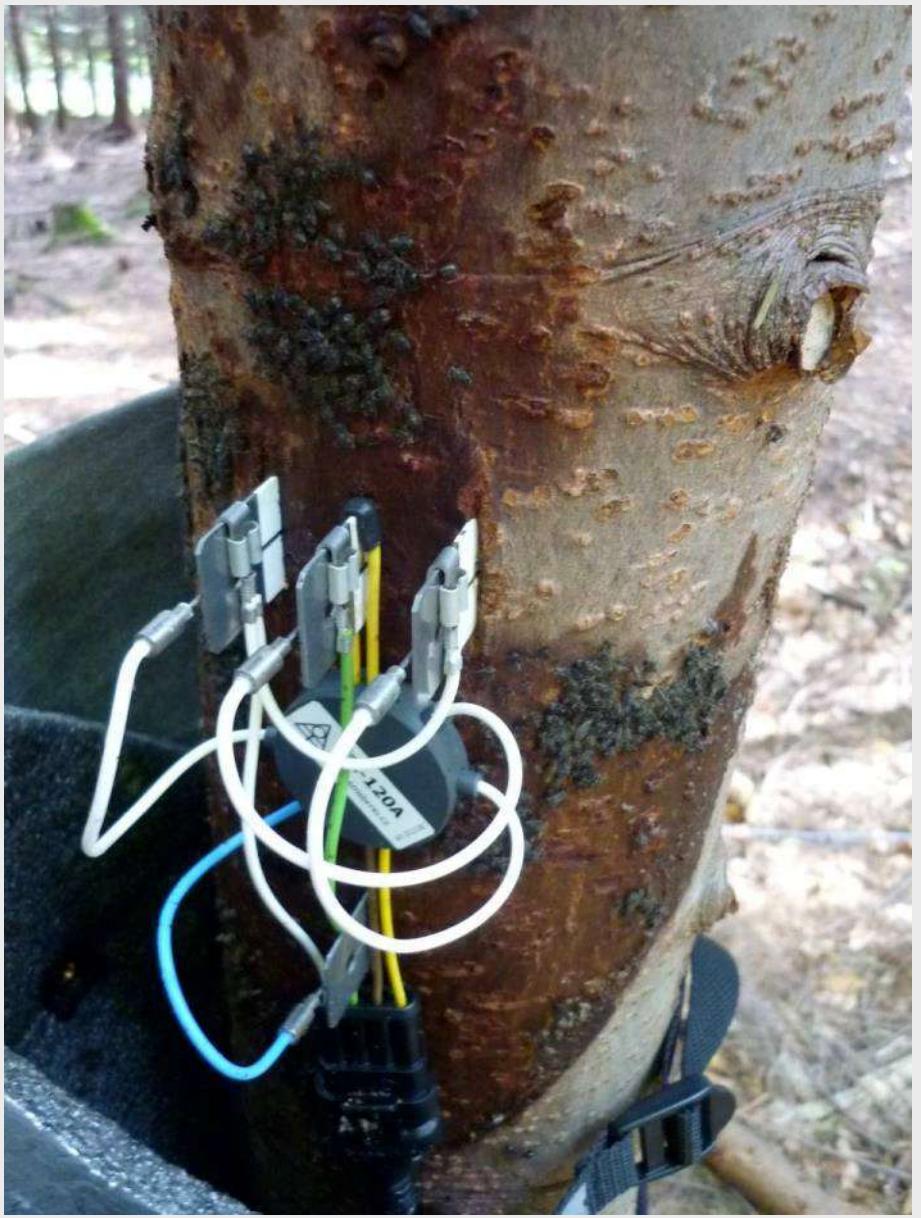
April to October 2016			not measured (cca 1%)		
Spruce	Clear site	Throughfall	Stemflow	T+S	Interception
mm/m2	368.8	219.8	3.7	223.5	145.3
%	100%	60%	1%	61%	39%
Beech 10 years	Clear site	Throughfall	Stemflow	T+S	Interception
mm/m2	368.8	314.4	3.7	318.1	50.7
%	100%	85%	1%	86%	14%
Beech 40 years	Clear site	Throughfall	Stemflow	T+S	Interception
mm/m2	368.8	227.4	41.5	268.9	99.9
%	100%	62%	11%	73%	27%
Beech 70 years	Clear site	Throughfall	Stemflow	T+S	Interception
mm/m2	368.8	232.9	11.7	244.5	124.2
%	100%	63%	3%	66%	34%
Beech 80 years	Clear site	Throughfall	Stemflow	T+S	Interception
mm/m2	368.8	276.7	10.8	287.5	81.3
%	100%	75%	3%	78%	22%

Transpiration

- **Water used for tree growth**
  - Most important component of water balance in forested areas
  - Affected by climatic and physiological factores (temperature, sunlight, humidity, wind, wood properties, healtch, leaves, etc.)
  - In situ measurements – heat balance method-sap flow measurements

Transpirace





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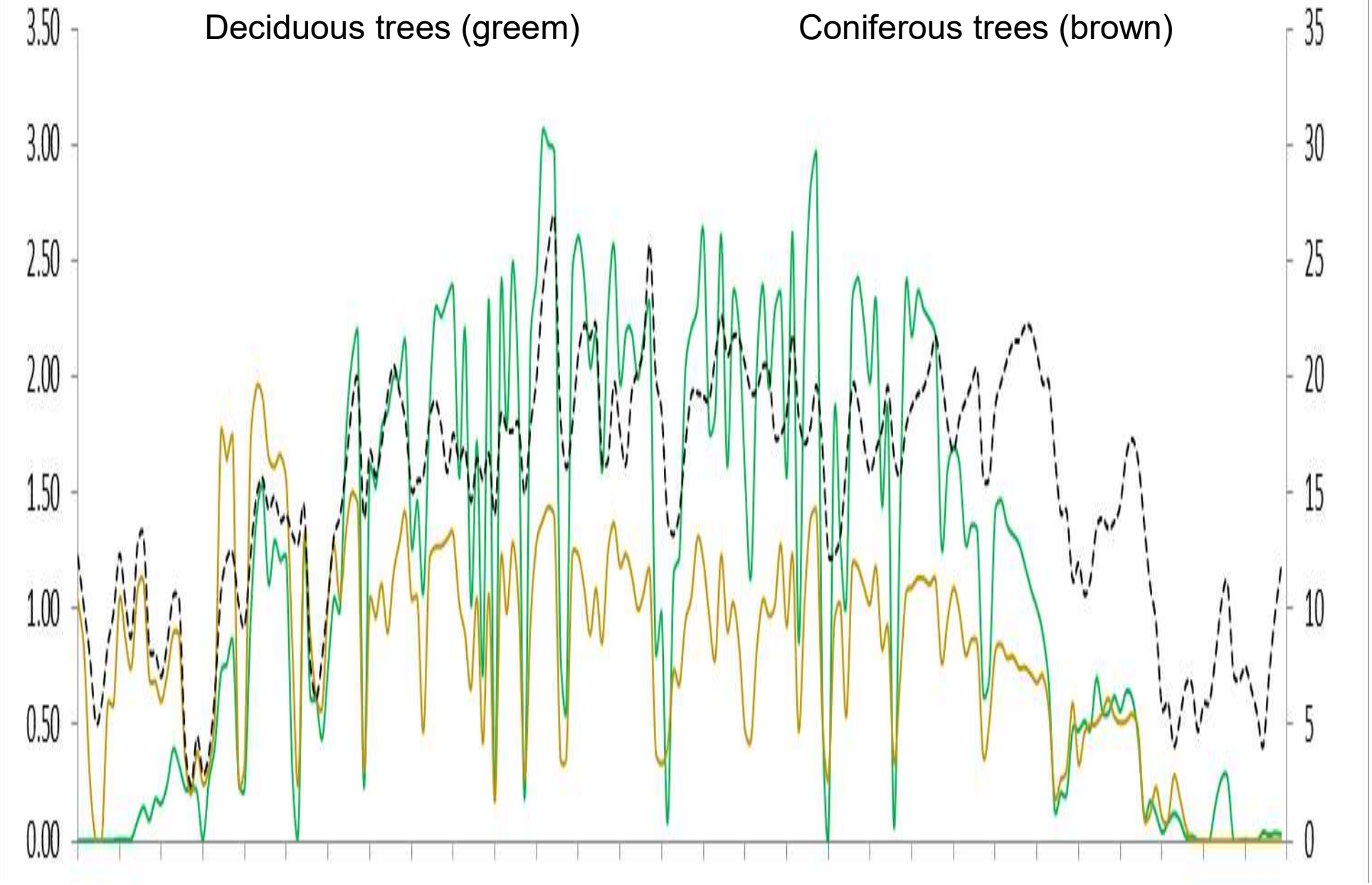


Measured Transpiration

- In growing season of 2016 (April to October):
  - Daily maximum cca 3mm (D) 2mm (C)
  - Average ca 1,6 mm (D) 1,2 mm (C)
  - Growing season duration ca 175 days (D) 205 days (C)

Streamflow measurements

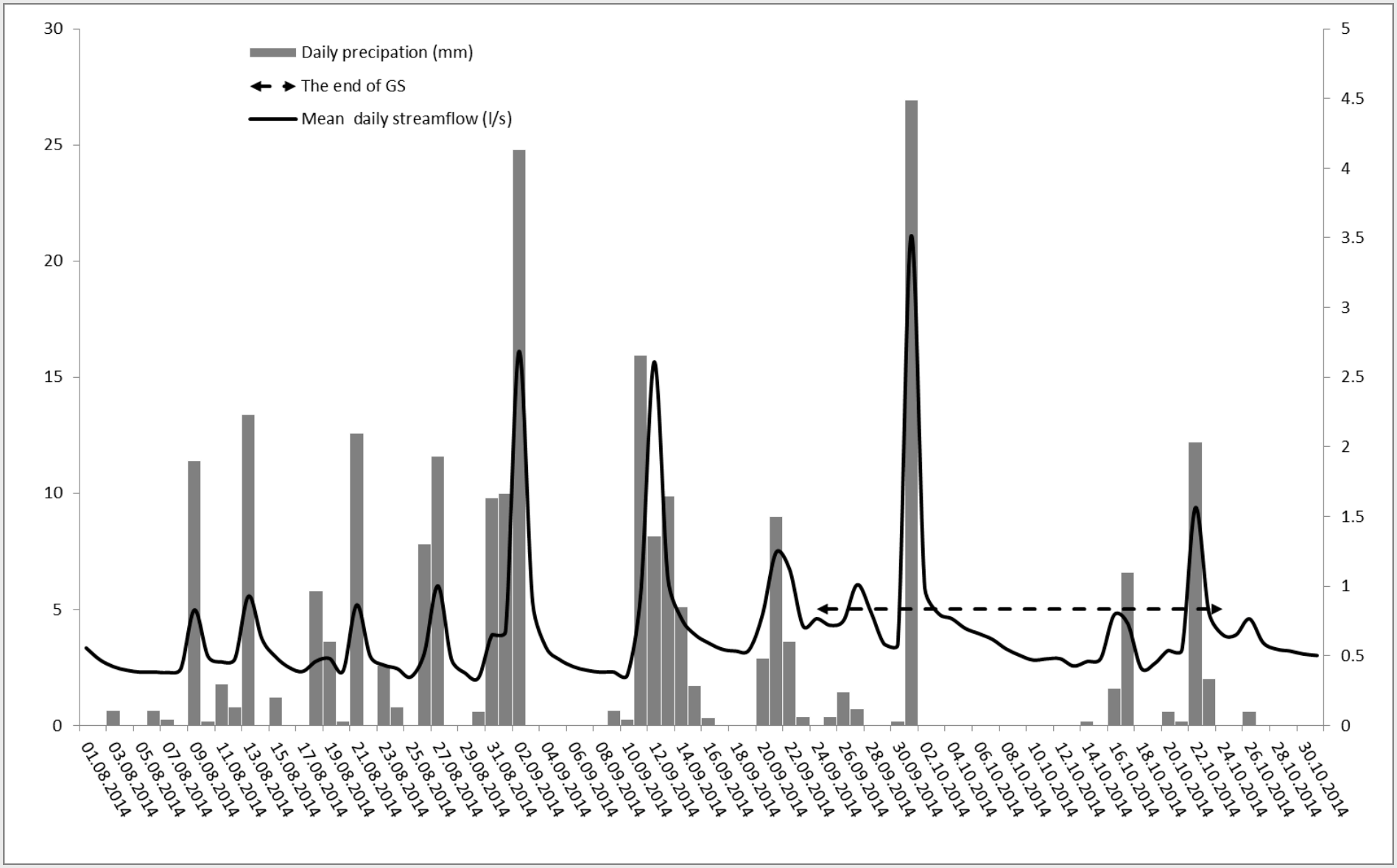
Streamflow

- **Streamflow in the discharge point**
- Thomson weir – known rating curve

Rating curve for flow into Old Thomson River from the weir pool. Water surface elevation is metres AHD in the weir pool.

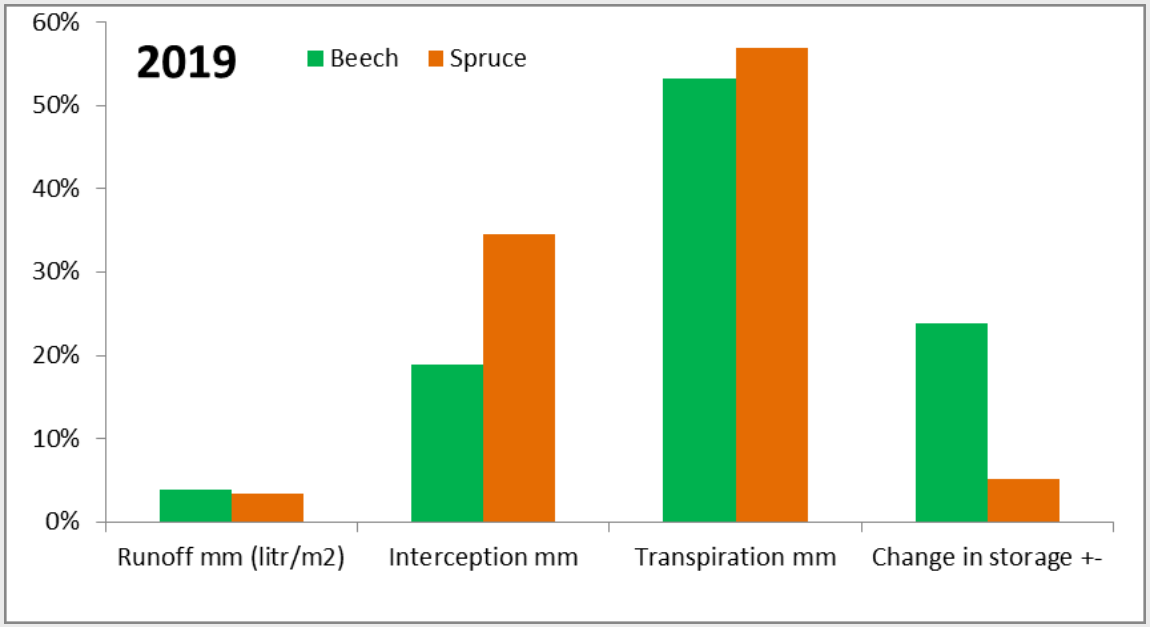
Thomson weir

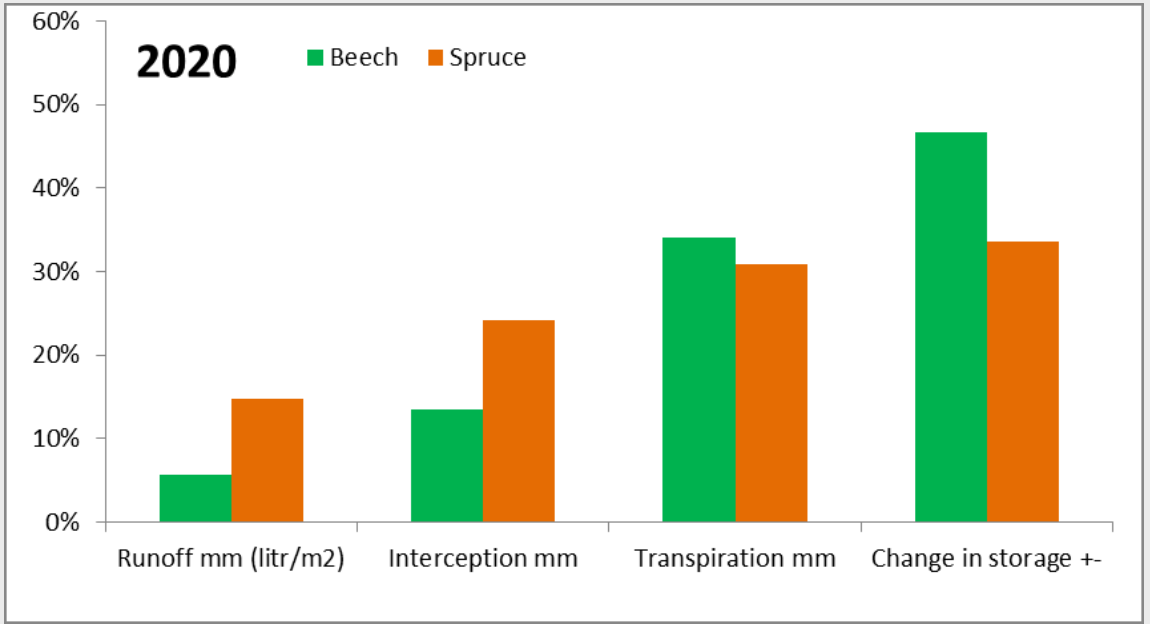
Streamflow evaluation - Hydrograph



Annual water balance - example

Water Balance in 2019-20, Spruce and Beech catchments



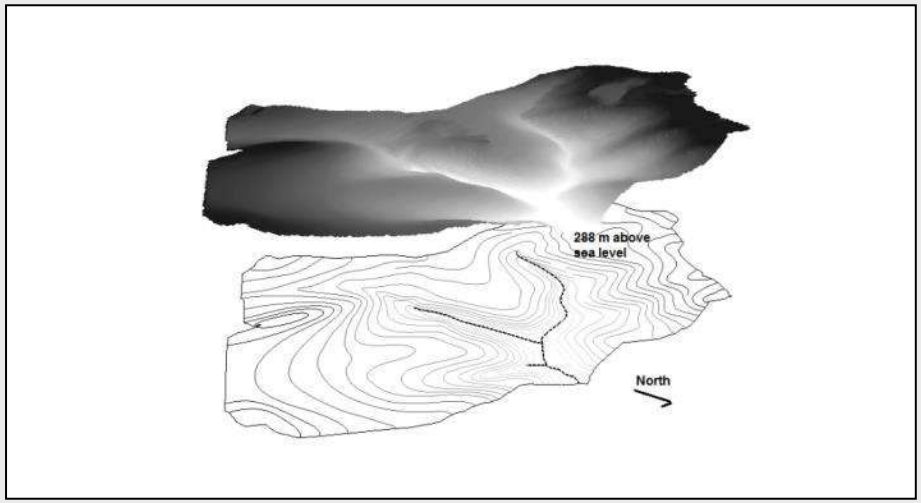


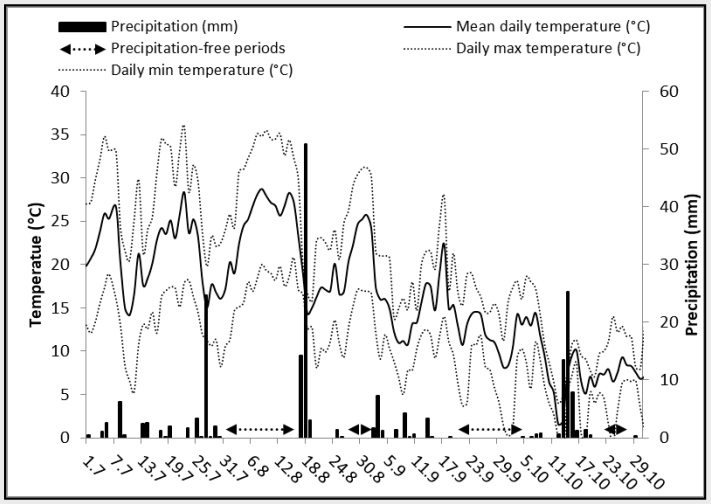
- 2019 precipitation normal year
- 2020 precipitation abundant year
- Beech - more water stays in soils (better water retention)
- Beech retain effective retention even during drier years

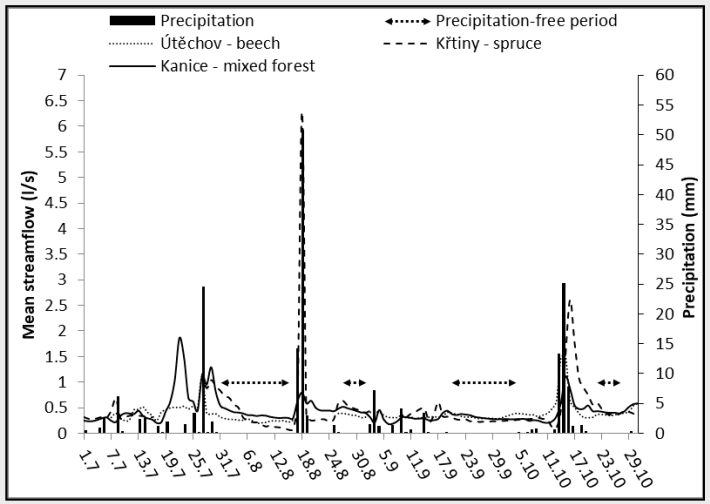
Water Balance in 2019-20, Spruce and Beech catchments

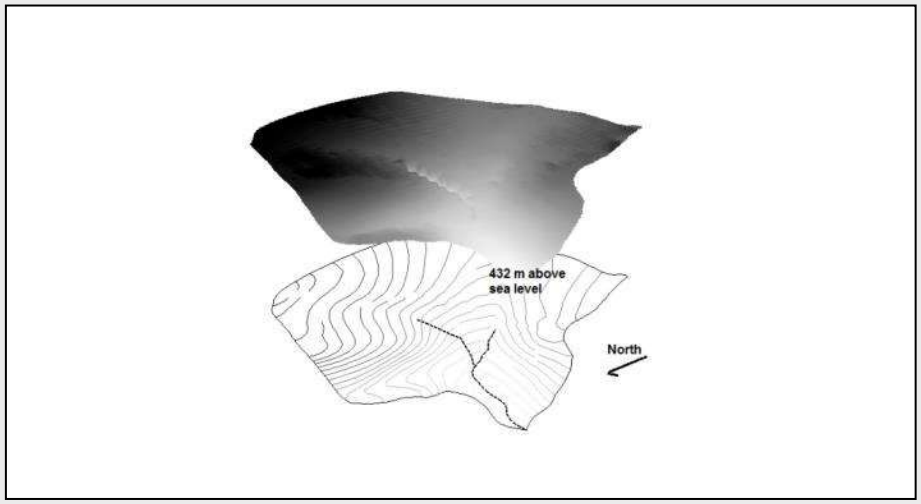
2019	Beech growing season	Beech dormancy	Spruce growing season	Spruce dormancy
Days in period	196	169	249	116
Precipitation mm	100%	100%	100%	100%
Runoff mm (litr/m2)	3%	6%	3%	7%
Interception mm	20%	16%	29%	58%
Transpiration mm	78%	0%	72%	0%
Change in storage +-	-2%	78%	-3%	35%
2020	**Beech growing season**	**Beech dormancy**	**Spruce growing season**	**Spruce dormancy**
Days in period	187	179	226	140
Precipitation mm	100%	100%	100%	100%
Runoff mm (litr/m2)	4%	8%	10%	25%
Interception mm	16%	10%	22%	28%
Transpiration mm	59%	0%	42%	0%
Change in storage +-	20%	83%	26%	48%

Thank you for your attention







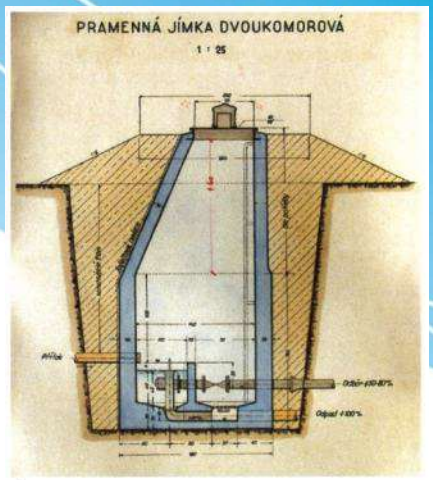


IMPACT OF CLIMATE CHANGE AND DEFORESTATION ON SHALLOW GROUNDWATER RESOURCES USED TO SUPPLY DRINKING WATER TO THE POPULATION

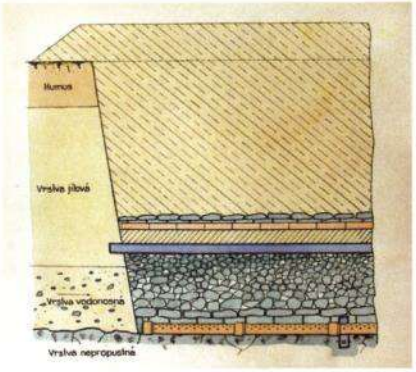
Ing. Michal Ondráček

Water source HERALTICE – spring wells

water source protected area II. – forest area 1200 ha
pipe length- 9 958 m
yield of the spring: cca 20 l/s



Řez pramenní jímkou



Řez jímacím zářezem

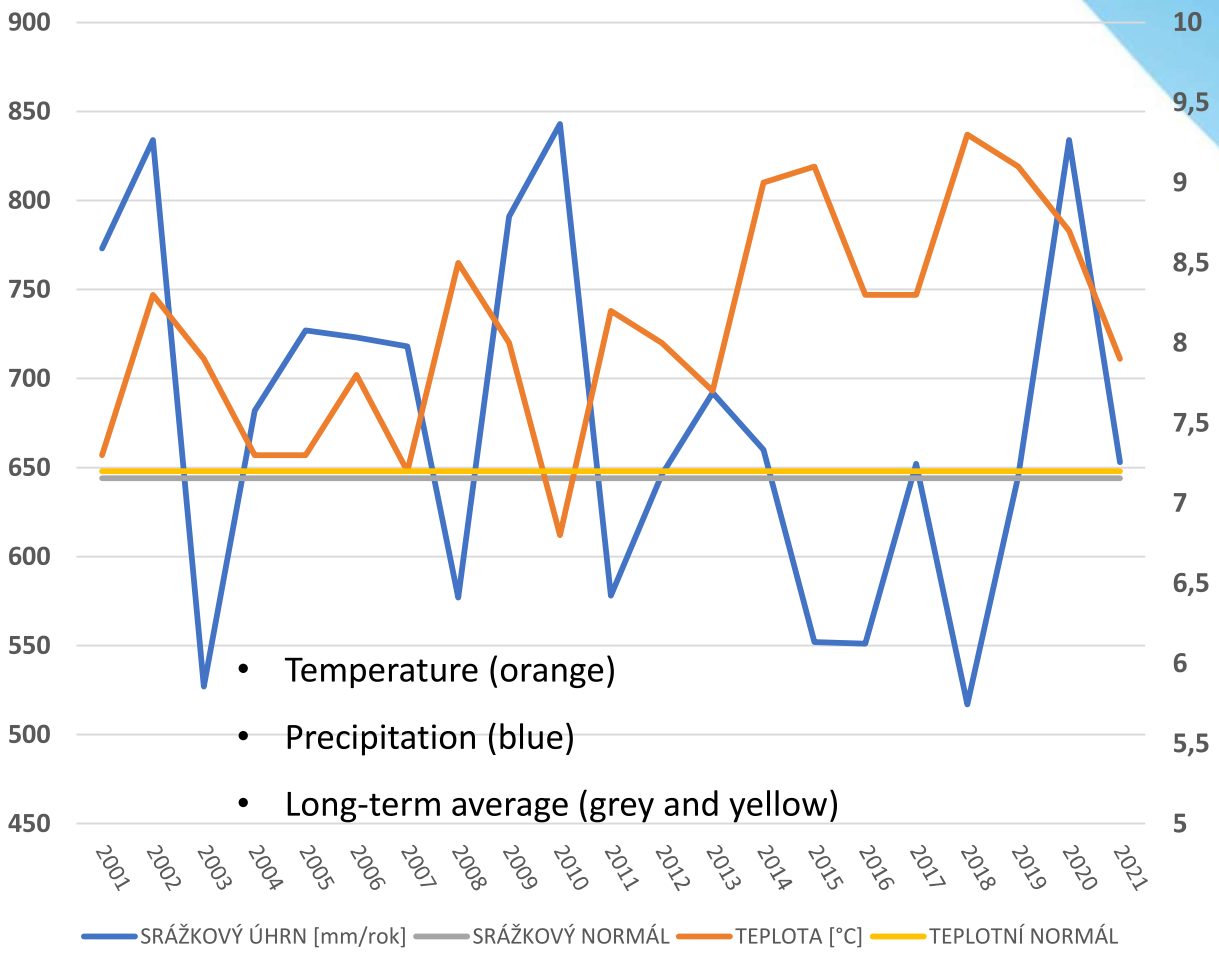
Water source HERALTICE – before barkbeetle calamity

VODÁRENSKÁ AKCIOVÁ SPOLEČNOST, a. s.

Water source HERALTICE – after barkbeetle calamity

VODÁRENSKÁ AKCIOVÁ SPOLEČNOST, a. s.

Climatic conditions

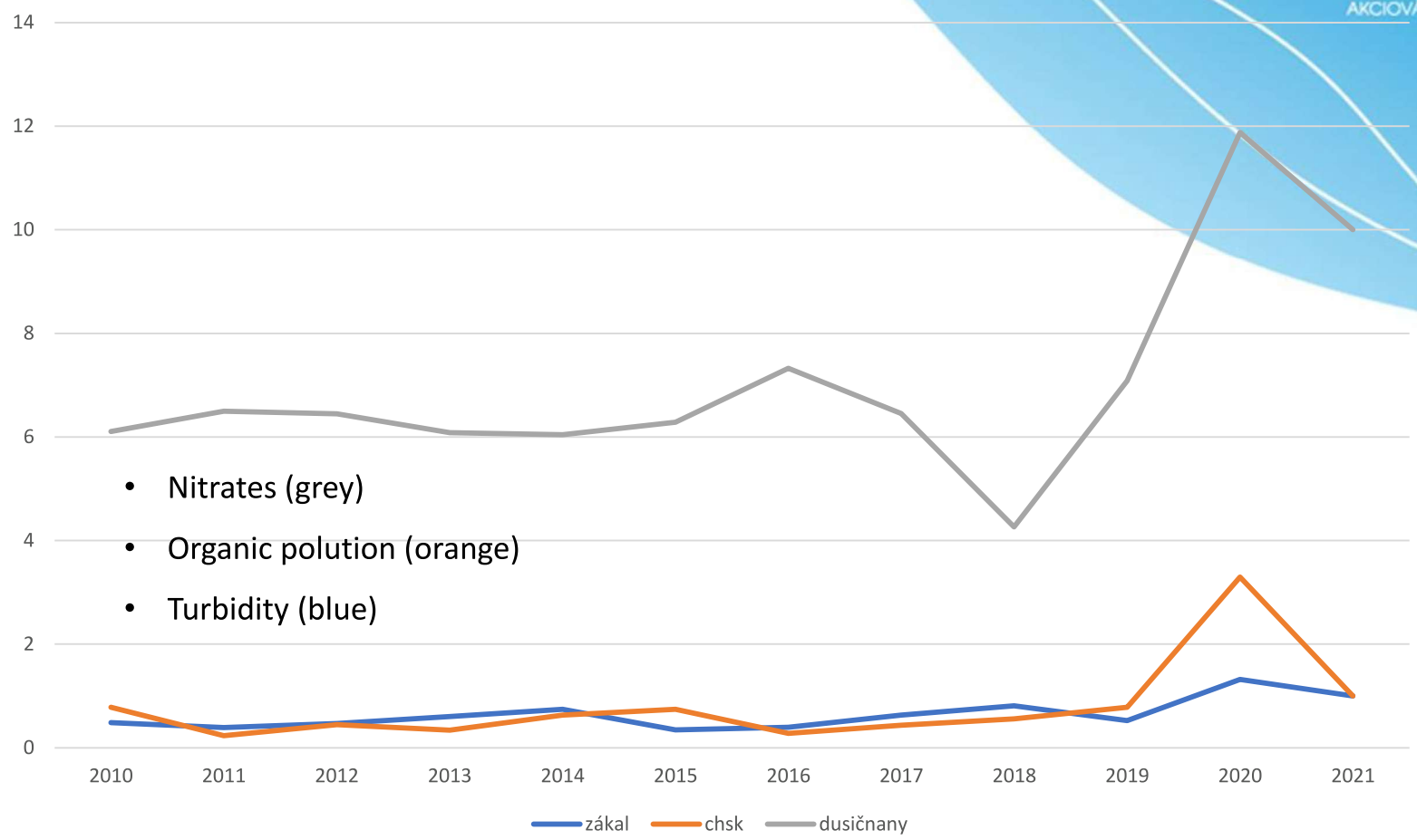


- Temperature (orange)
- Precipitation (blue)
- Long-term average (grey and yellow)

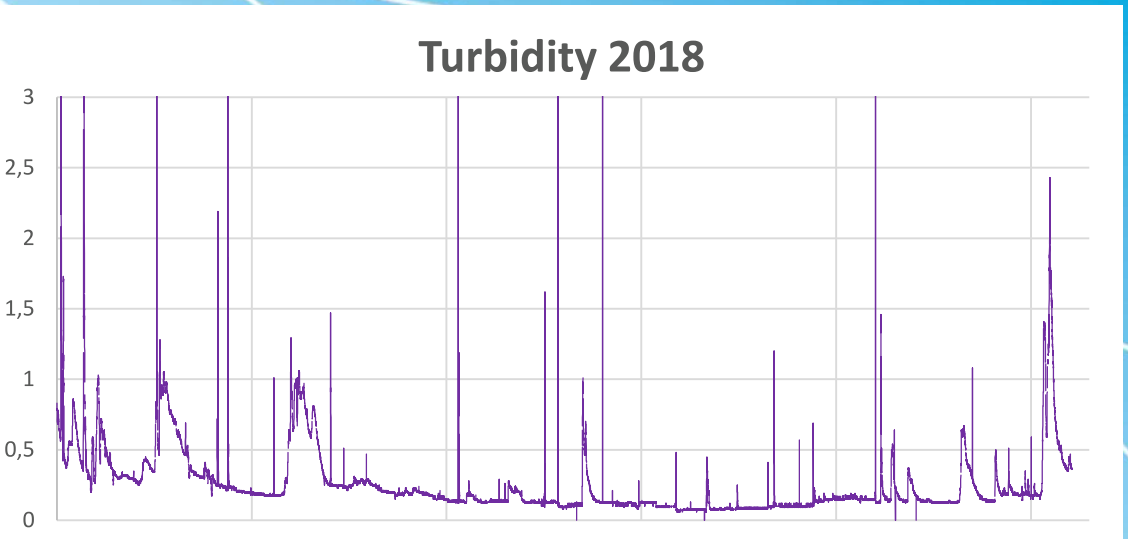
- 2014 – 2019 dry warm years
- 2019 and 2020 1000 of 1200 ha harvested
- 2020 rainfall abundant
- Topsoil damage
- Organic matter leakage

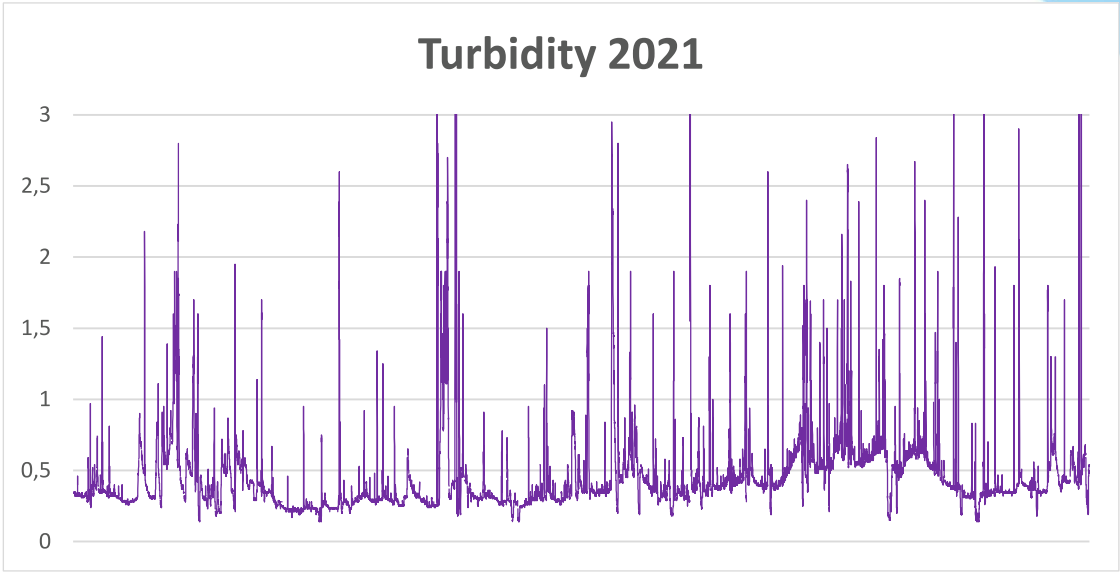
Water quality parameters

Mean annual values – response peaks after rainfall not visible



- Nitrates (grey)
- Organic polution (orange)
- Turbidity (blue)





2018 Forested – decrease in quality only after extrememm precipitation (few time per year)

2021 Deforested – overall decreased wuality

Fast response to even small rainfall

How to fix it?

- Fast forest regeneration
- Remediation of the spring area disturbed by harvesting
- Construction of new wells
- Cleaning of the pipelines
- Better monitoring

Thank you for your attention