Early Warning System for Flash Floods – the Theoretical Background and Realization in the Krkonoše Mts. – Czech Republic

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What is it a Flash Flood?

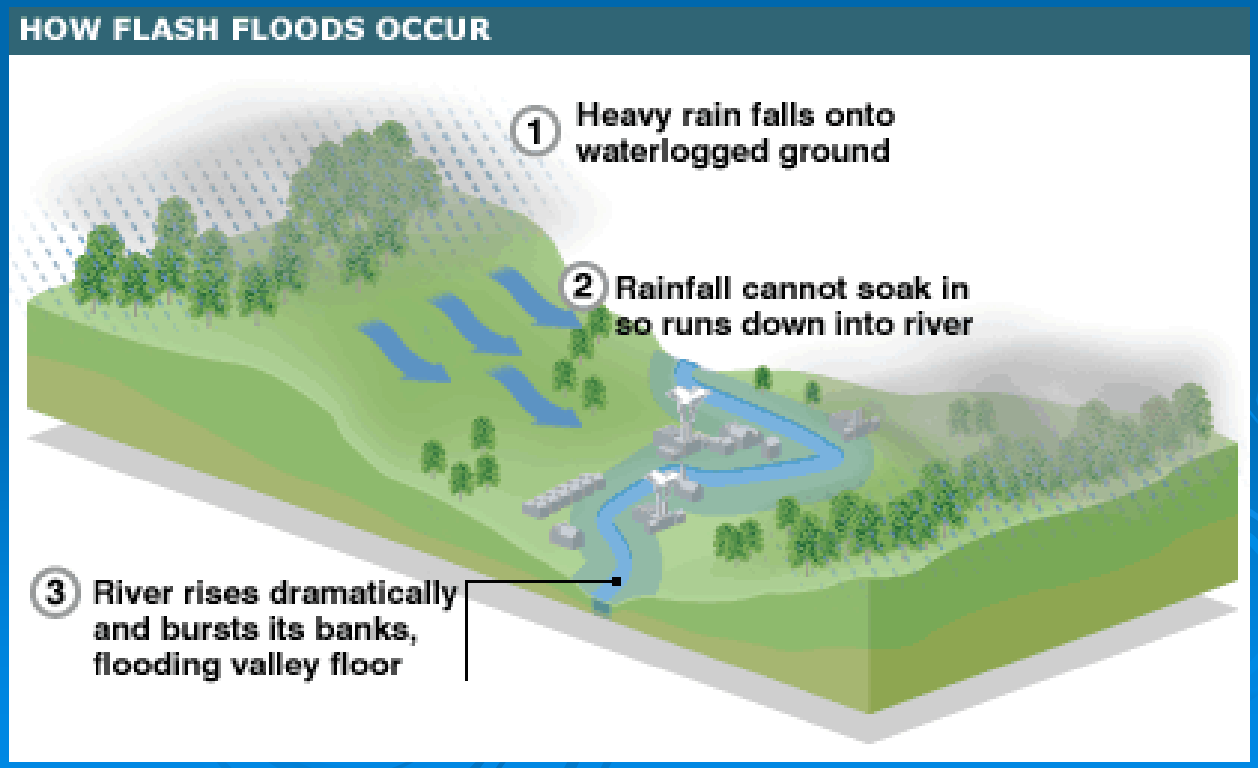
World Meteorological Organization: „… a flood of short duration with a relatively high peak discharge“.

American Meteorological Society: „… a flood that rises and falls quite rapidly with little or no advance warning, usually as the result of intense rainfall over a relatively small area“.

U.S. National Weather Service: „… a rapid and extreme flow of high water into a normally dry area, or a rapid water level rise in a stream or creek above a predetermined flood level, beginning within six hours of the causative event (e.g., intense rainfall, dam failure, ice jam)“…..

How Flash Floods Occur

Flash flooding occurs when precipitation falls rapidly on saturated soil or dry soil that has poor absorption ability. The runoff collects in gullies and streams and, as they join to form larger volumes, often forms a fast flowing front of water and debris.



Flash Flood Generation

Hydrometeorological influences

- Rain intensity and total
- Streamflow

Hydrological influences

- Soil moisture
- Soil permeability, soil cover hydrophoby
- Soil profile – actual retention capacity

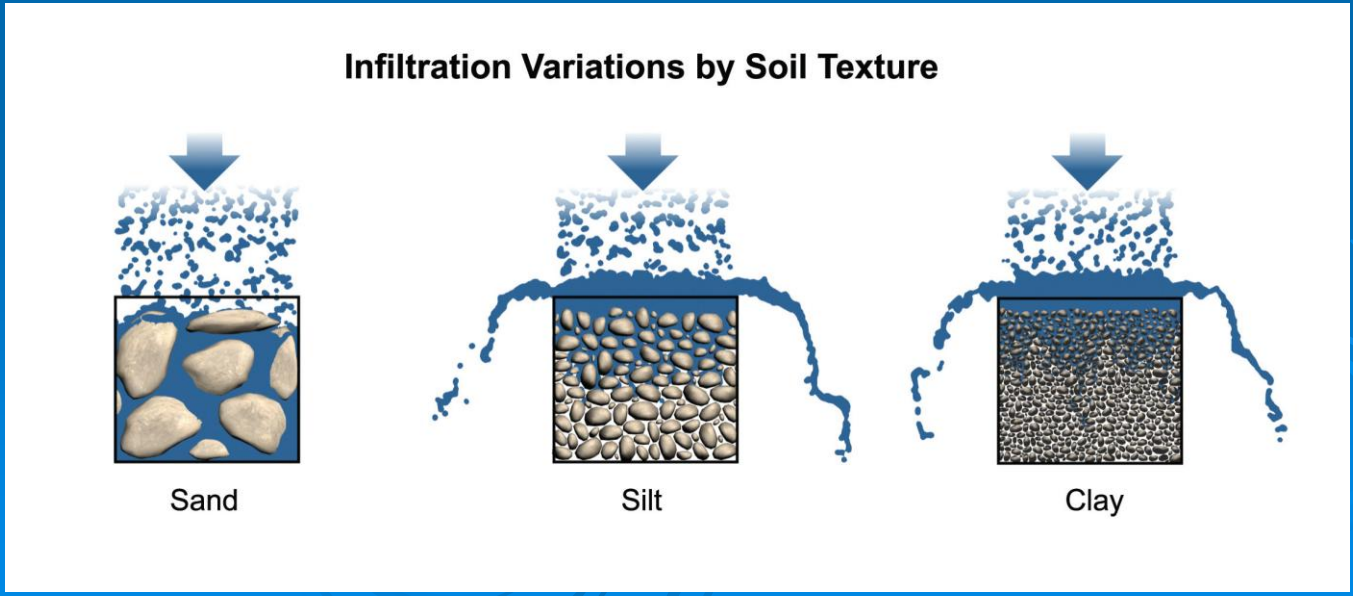
Basin influences

- Shape and Size
- Slope
- Roughness
- Stream Density

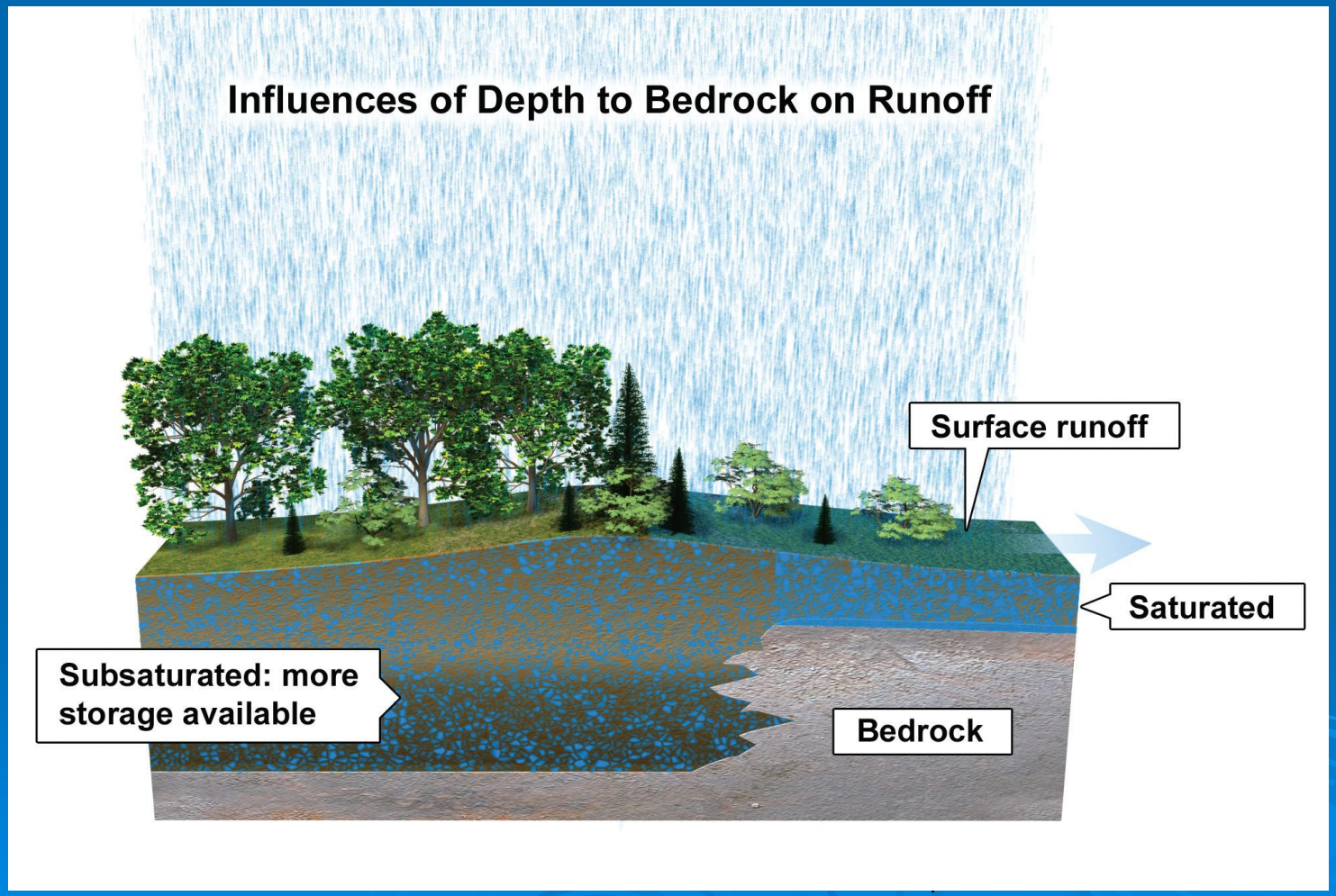
Hydrologic influences of the ground surface can have a major impact on the timing, location, and severity of flash flooding. In some cases, runoff production processes may be more important than rainfall characteristics.

Soil moisture, and in particular the **degree of saturation** -the most important soil factor for rapid runoff and flash flooding. It has a direct influence on the infiltration process.

Permeability of the soil profile is determined by the crust formation, soil compaction, soil contraction and expansion, microbial activity, soil hydraulic conductivity, and root distribution. A commonly used indicator of soil permeability is soil texture.



Soil profiles can also influence flash flood hydrologic processes but the influence of soil profile can be small compared to soil moisture and soil permeability. Soil profile characteristics are tightly related to the capacity of the soil to store water and to the infiltration rate.



Hydrodynamic mechanism of flash floods generation

A sudden oscillating discharge of water from porous material – soil into the watercourse (known as fill and spill effect) was frequently observed in hydrological monitoring in river basins around the world.

The phase of **„fill“ = filling of soil profile by water infiltrating** from the rainfall. This phase is fully decribable by the Richards' equation (diffusion-like flow)

The phase of **„spill“ = gravity-driven flow** (based on the percolation theory) = a sudden oscillating discharge of big amount of water from porous material causes a flash flood generation.

Fill and spill mechanism

Krkonoše Mts.

September 2001

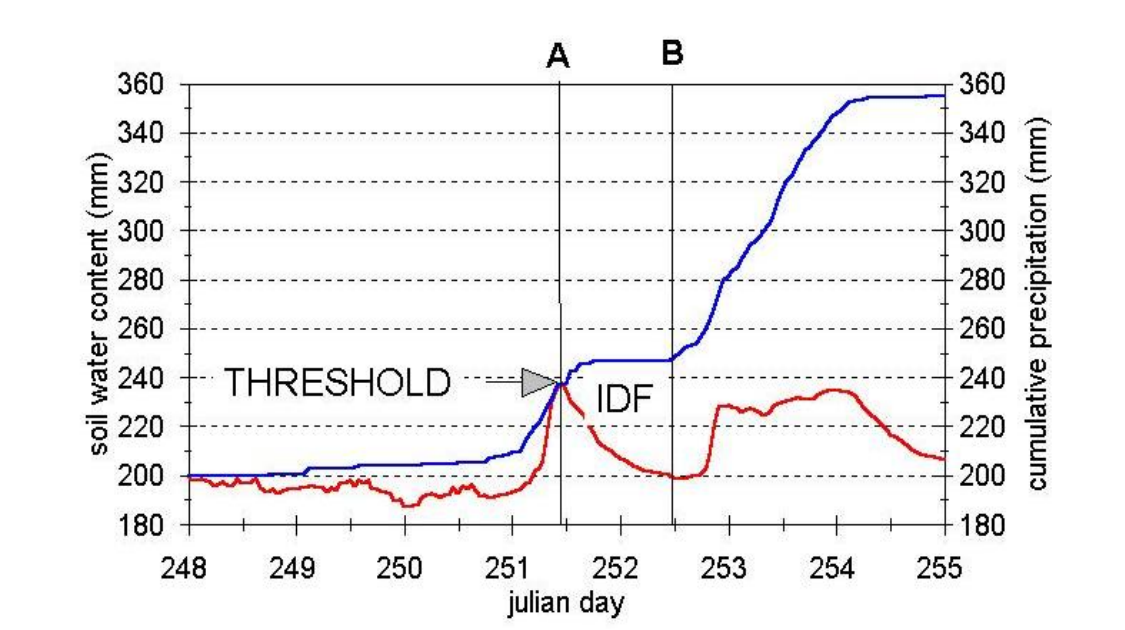
Rainfall total

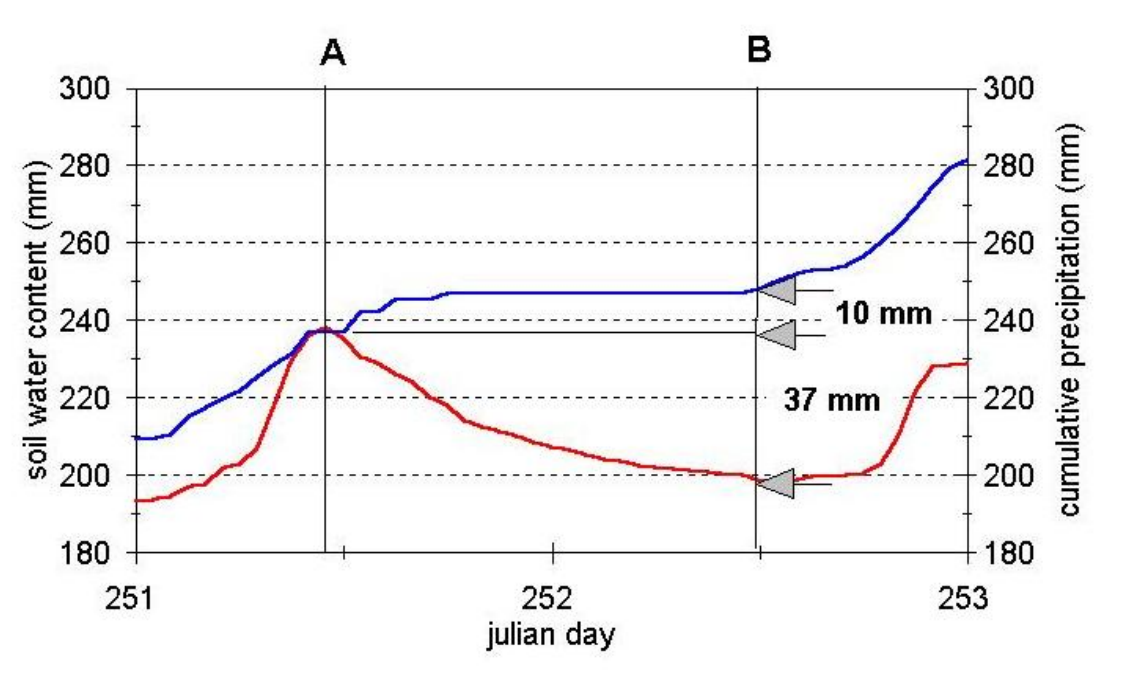
Fill = 10 mm

Causes

Outflow of

Spill = 47 mm





Hydrological Concequences in the Krkonoše Mts.

Flash Flood in June 2nd, 2013

Hydrological Concequences in the Krkonoše Mts.

Flash Flood in June 2nd, 2013

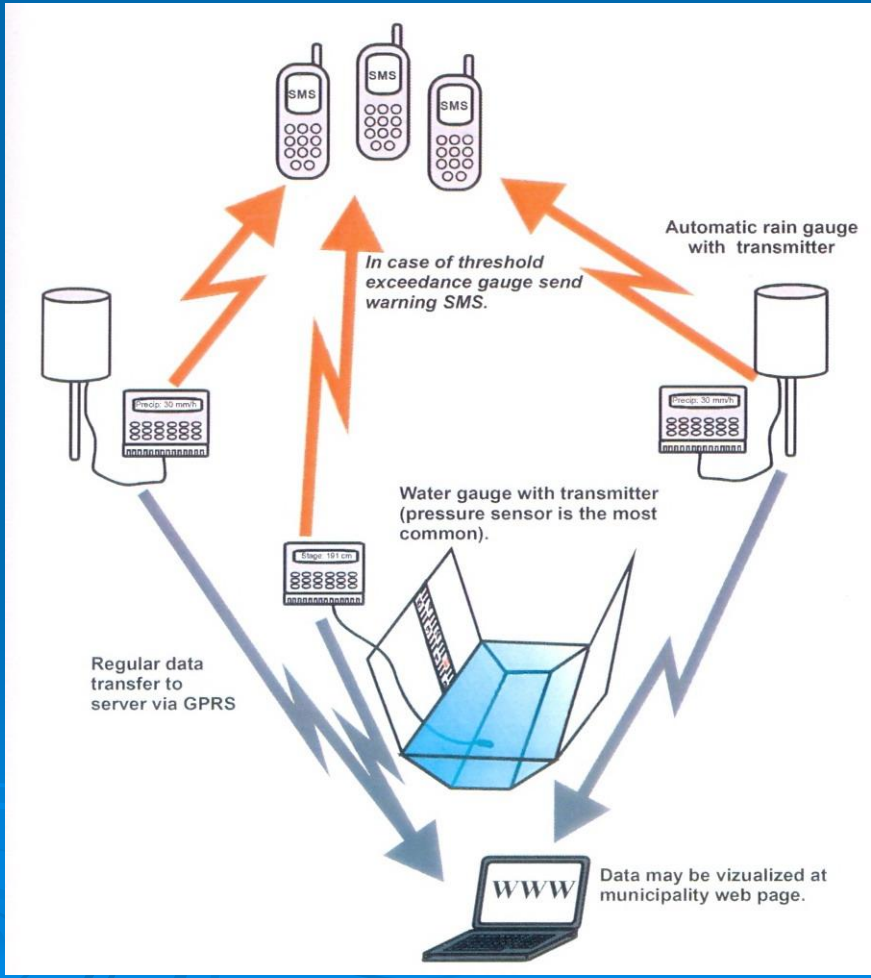
Hydrological Concequences in the Krkonoše Mts.

Flash Flood in June 2nd, 2013

Early Warning System for Flash Floods

Flash floods represent forecast and detection challenges because they are not always caused simply by meteorological phenomena. Flash floods result when specific meteorological *and* hydrological conditions exist together.

Some countries have established Flash Flood Early Warning Systems (EWS)



Early Warning System for Flash Floods

The components of an effective EWS include:

- Detecting and forecasting hazards and developing hazard warning messages
- Assessing potential risks and integrating risk information into warning messages
- Disseminating timely, reliable, and understandable warning messages to authorities and at-risk public
- Community-based emergency planning, preparedness and training focused on eliciting an effective response to warnings to reduce potential impact on lives and livelihoods

Early Warning System for Flash Floods in the Krkonoše Mts.

This system involves:

(i) instrumentation: (1) stream gauge monitoring stations with data transfer to the internet, (2) monitoring stations (equipped by rain gauge, air and soil thermometers, soil water tensiometers and soil moisture meters) with data transfer to the internet;

(ii) software: (1) the internal software of the stream gauge and monitoring stations for the measurement, storage and transfer the data to the dispatching center, (2) software of a central data repository, (3) software for data transmission in the internet browser, (3) software for the forecasting of flood risk and sending flood allert;

(iii) dispatching center: (1) operating of the data repository, (2) forecasting of the water level for the each of connected stream gauge station, (3) sending flood allert;

(iv) handbooks and user's Guids: (1) hydrological and soil surveying, (2) EWS design, (3) operation and maintenance of the EWS;

(v) complete projection documentation of the EWS;

(vi) installation of the EWS in a catchment;

(vii) testing and routine operation of the EWS.

Early Warning System for Flash Floods in the Krkonoše Mts.

The sophisticated early warning system (EWS) for detection of local flash floods is built in the Krkonoše Mts. in the upper part of the Úpa river with the closing profile at Horní Maršov (573–1602 m a.s.l., 81.70 km^2). Additionally the catchment was extended by the Lysečinský brook basin (569–1182 m a.s.l., 18,32 km^2).

The theoretical background of the Early Warning System:

Šír M. & Tesař M. 2013: Water retention and runoff formation in the Krkonoše Mts. Opera Corcontica 50/S: 97–106.

OPERA CORCONTICA

http://opera.krnap.cz/_pdf/50/Sir_OC50S.pdf

The description of the Early Warning System in the Krkonoše Mts:

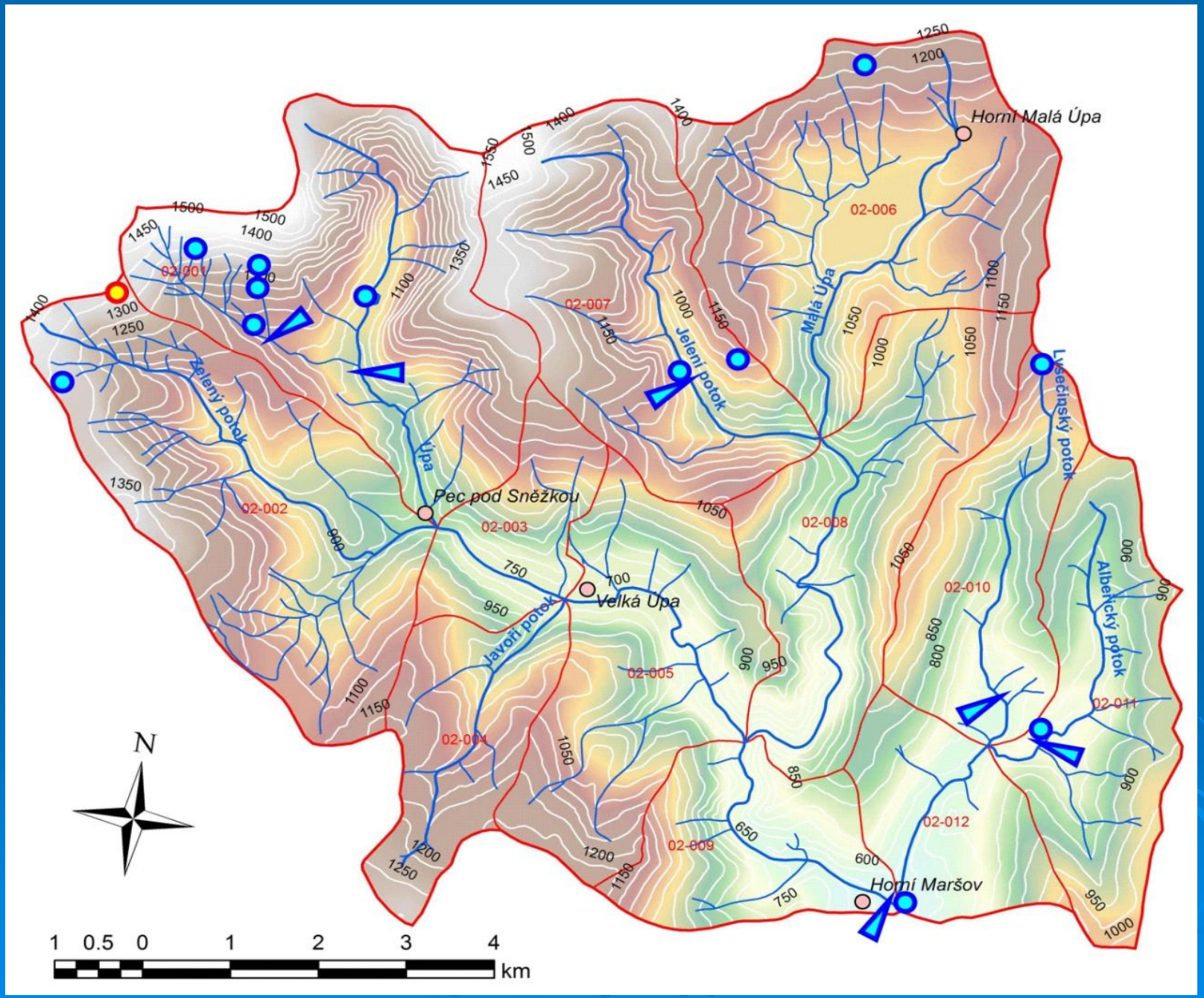
Tesař M. & Šír M. 2013: Early warning system for flash floods in the Krkonoše Mts. Opera Corcontica 50/S: 107–112.

OPERA CORCONTICA

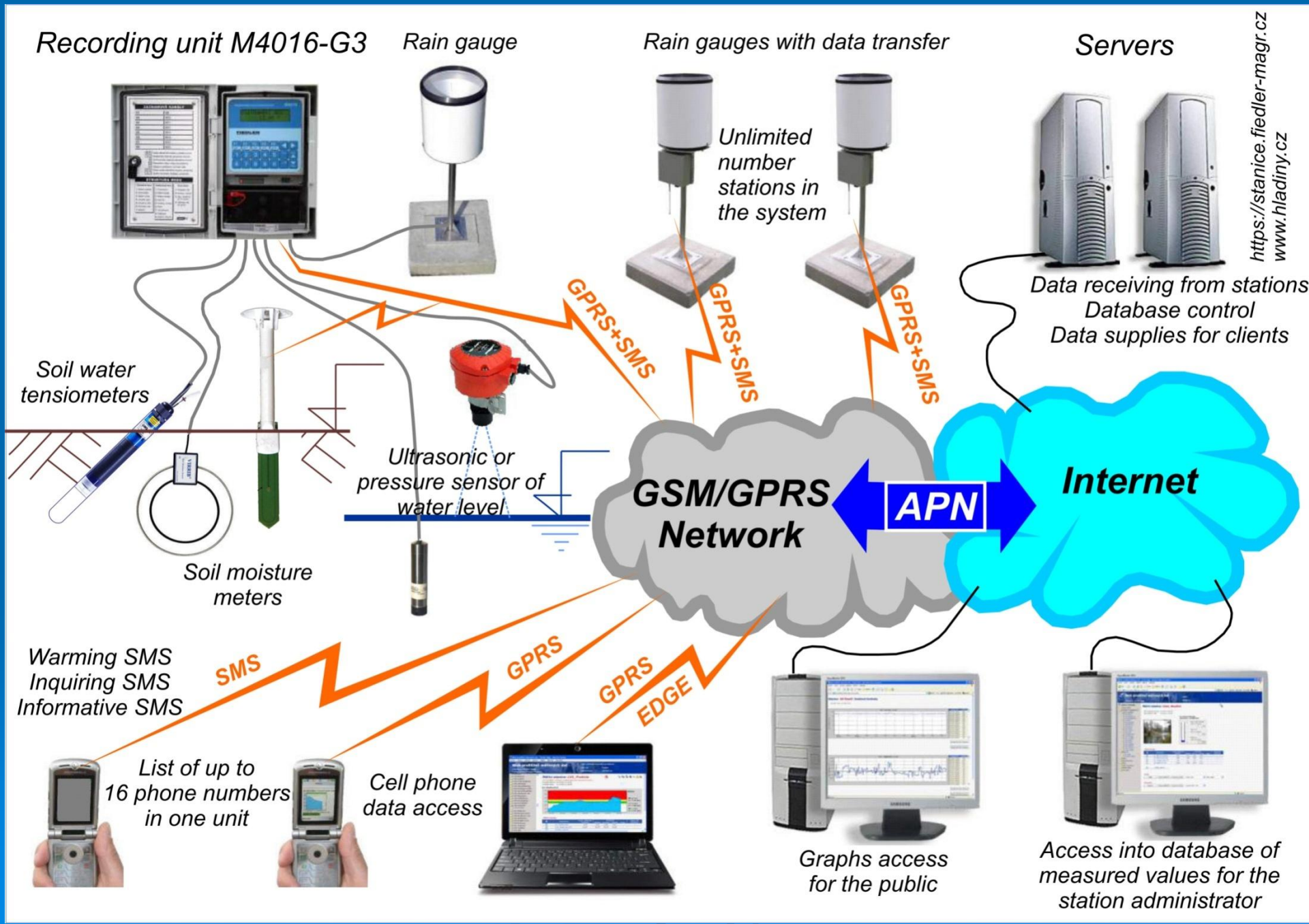
http://opera.krnap.cz/_pdf/50/Tesar_OC50S.pdf

The described EWS is supported by the Technology Agency of the Czech Republic (Project TA02021451).

Early Warning System for Flash Floods in the Krkonoše Mts.



Early Warning System for Flash Floods built up in the Krkonoše Mts. - scheme

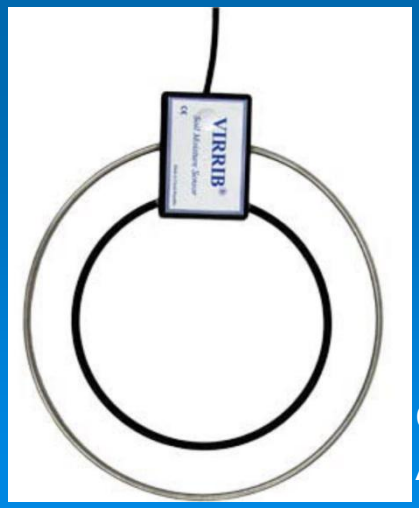


Monitoring of Water in the Soil Profile

State of water in the soil profile
(i.e. monitoring of the water potential)

e.g. Water Tensiometers UMS GmbH, Germany

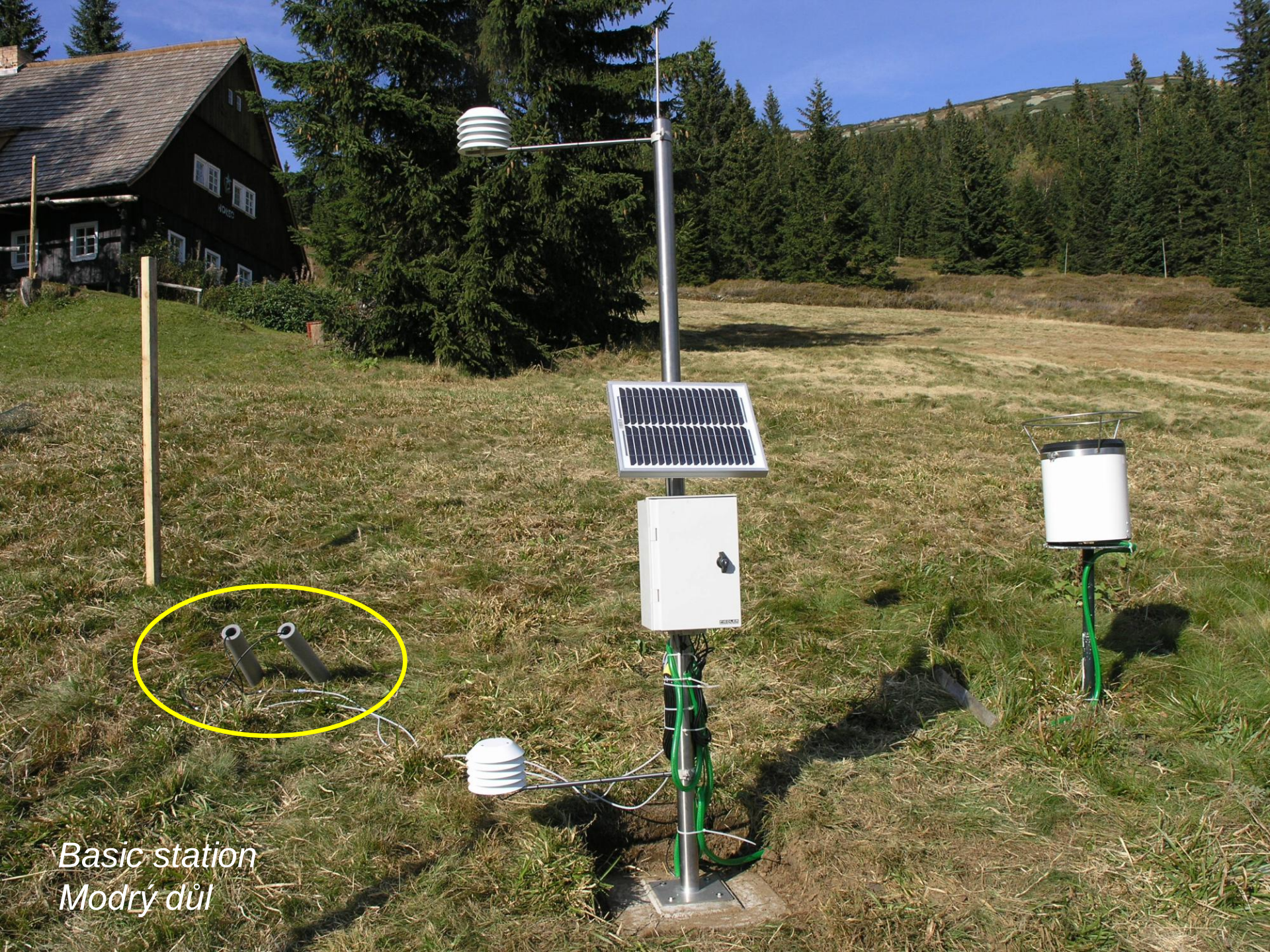
Amount of water in the soil profile (i.e. monitoring of the soil moisture)



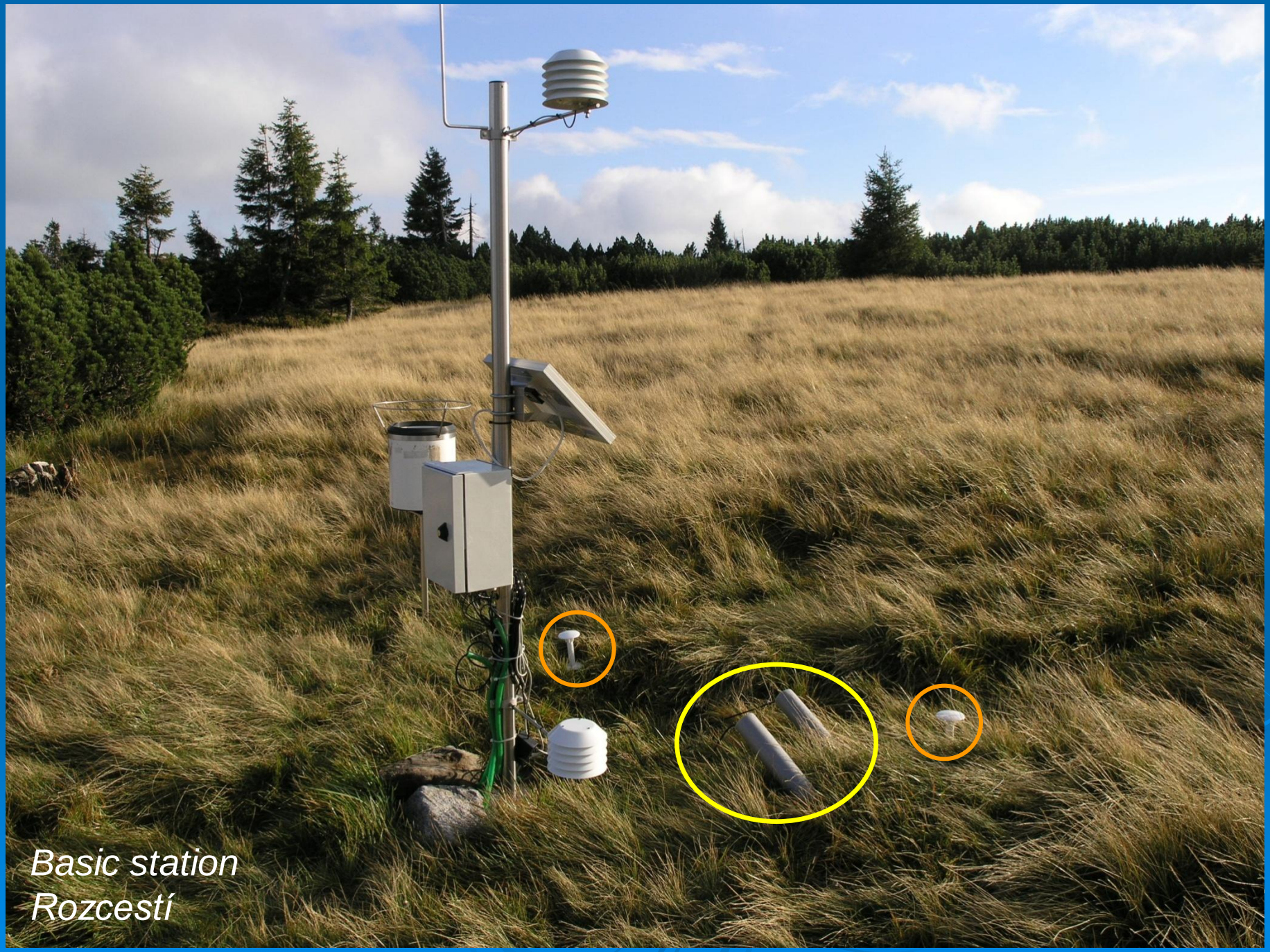
e.g. Soil Moisture Meter VIRRIB AMET, Czech Republic

e.g. Soil Moisture Meter TMS3 TOMST LTD., Czech Republic


Meteorological station
Výrovka



Basic station
Modrý důl


Basic station
Rozcestí

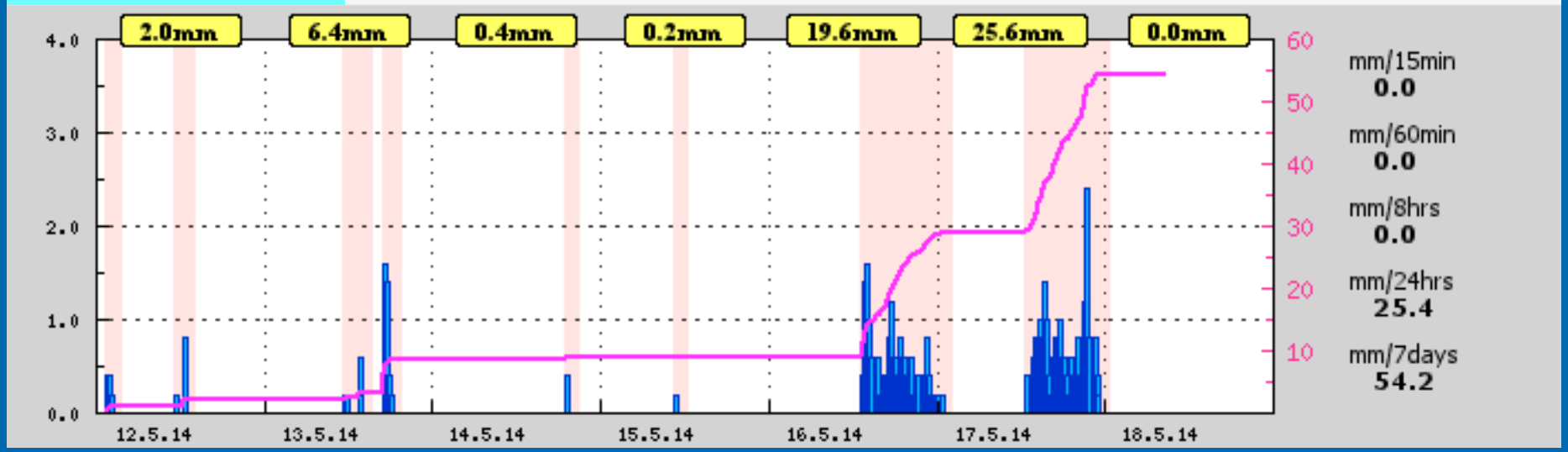
Water stage station
Obří důl

Water stage station
Jelení potok

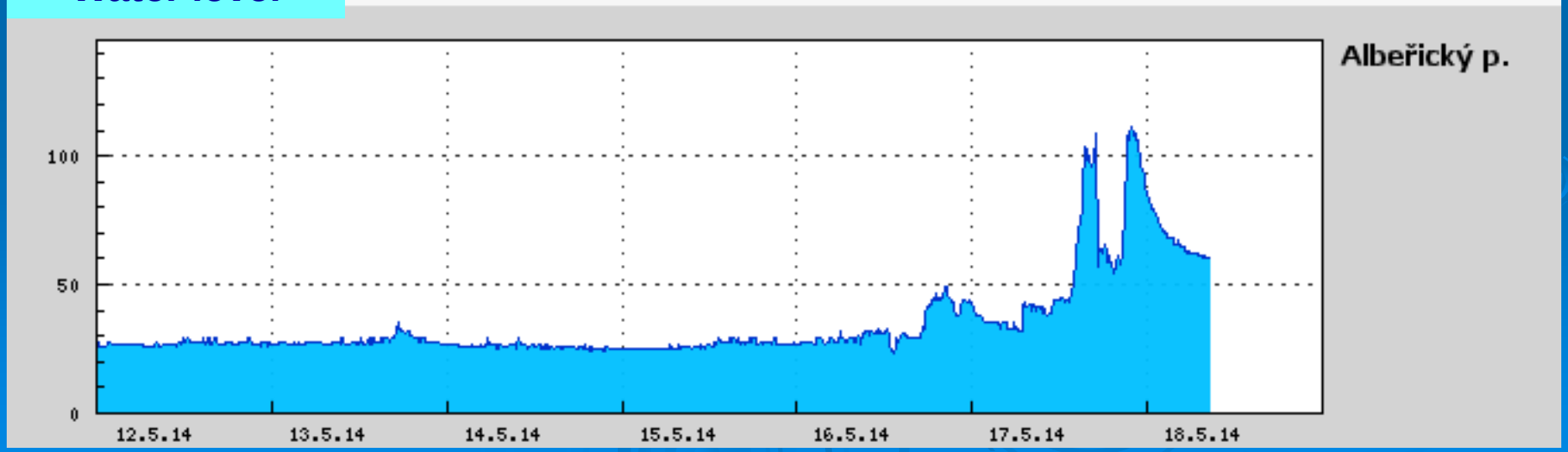
Water stage station
Dolní Albeřice

Water stage station Dolní Albeřice – example of the measurement

Rainfall



Water level




Water stage station
Horní Maršov

Telemetric station H7

- Completely new telemetric station developed and manufactured in the framework of the Project No. TA02021451 supported by the Technology Agency of the Czech Republic.
- Quite negligible electricity consumption (telemetric station is able to work without the battery exchange 1 year including the regular data transfer via GSM Modem).
- Telemetric station H7 can be equipped by both GSM and radio modules for the data transfer.
- Telemetric station H7 is equipped by the graphical coloured tactile display.
- 100 recording channels.
- ... and a lot of more features.

Thanks for your attention

Technology Agency
of the Czech Republic

Project No. TA02021451