VÝSKUMNÉ CENTRUM
ŽILINSKEJ UNIVERZITY V ŽILINE

RESEARCH FOR PEOPLE

Contribution to unconventional monitoring methods of selected environmental parameters - precipitation and snow

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„Podporujeme výskumné aktivity na Slovensku/Projekt je spolufinancovaný zo zdrojov EÚ".

Operačný program Výskum a vývoj

Európska únia

Unconventional monitoring methods of selected environmental parameters

This contribution is aimed to give a survey of unconventional methods monitoring some environmental parameters in the atmosphere and on the ground. The development of the electronics systems and their miniaturization together with the enormous growth of the numerical micro-controllers computational capacity enable the use of indirect methods of environmental data collection and their fusion for getting the relevant information that are hardly accessible by using standard methods.

This presentation covers:

- observing the dynamics of the heat diffusivity in soil and snow

- emissivity of electromagnetic energy of rock and ice

- radio-frequency methods of rainfall monitoring with using of passive detection of UHF electromagnetics sources

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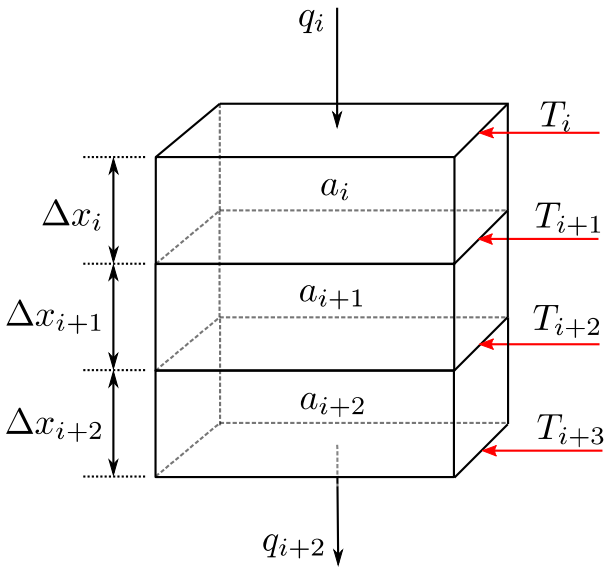
Observing the dynamics of the heat diffusivity

Physical background

- Based on a one-dimensional heat conduction equation
- The changes in diffusivity can be caused by the change of water content in the soil or by the change of the structure of snow layer



$$\frac{dT}{dt} - \frac{\lambda}{\rho c}\frac{d^2T}{dx^2} = 0$$

$$a = \frac{\lambda}{\rho\, c}$$

Thermal conductivity

Specific heat capacity

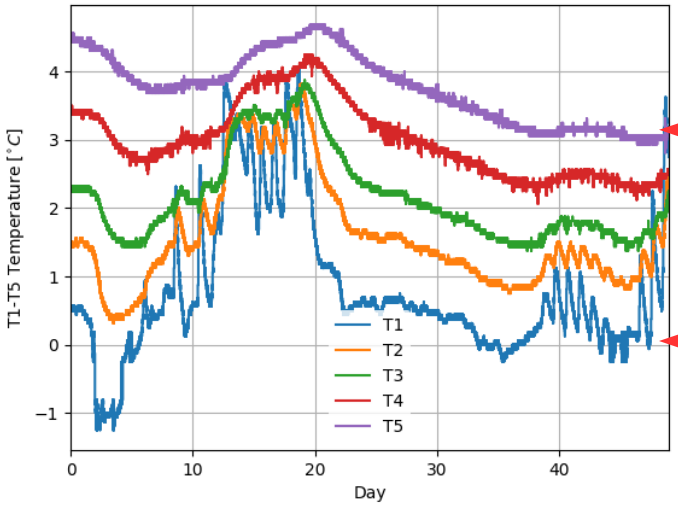
Thermal diffusivity

Mass density

Observing the dynamics of the heat diffusivity

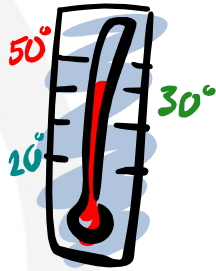
Sensor design

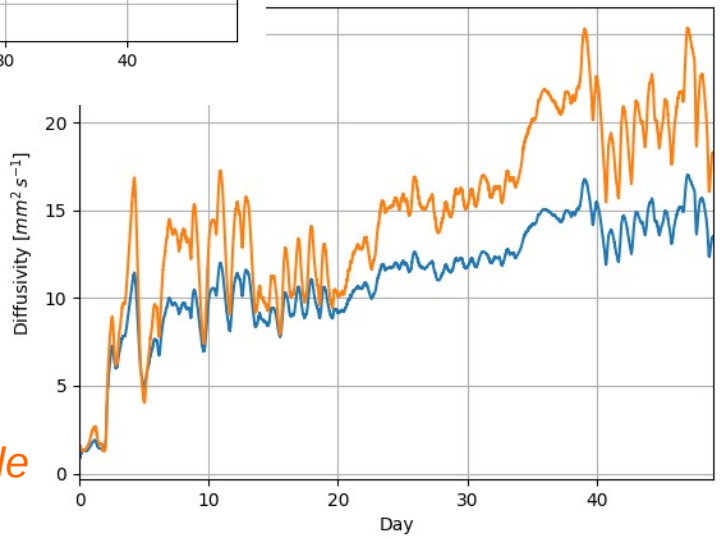
- *Internal sensor construction and measurement during the winter period (5.1-23.2.2014)*



Surface - 45cm

Surface - 5cm





Individually addressable temperature sensor

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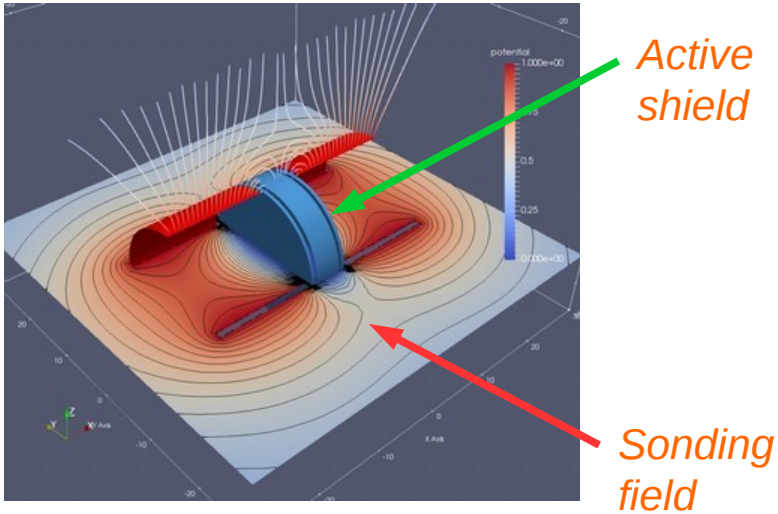
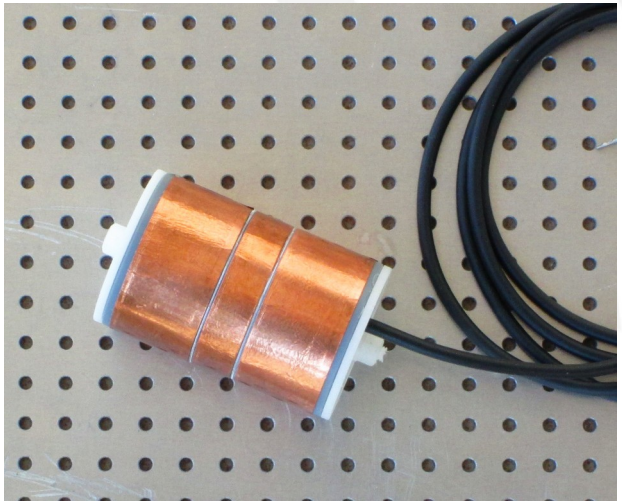
Impedance spectroscopy for soil and snow

Physical background

- The principle of the sensor is based on the creation of sonding electrostatic field and on the measurements of complex conductivity between the electrodes by impendance convertor in the frequency interval 0.1-100 Hz



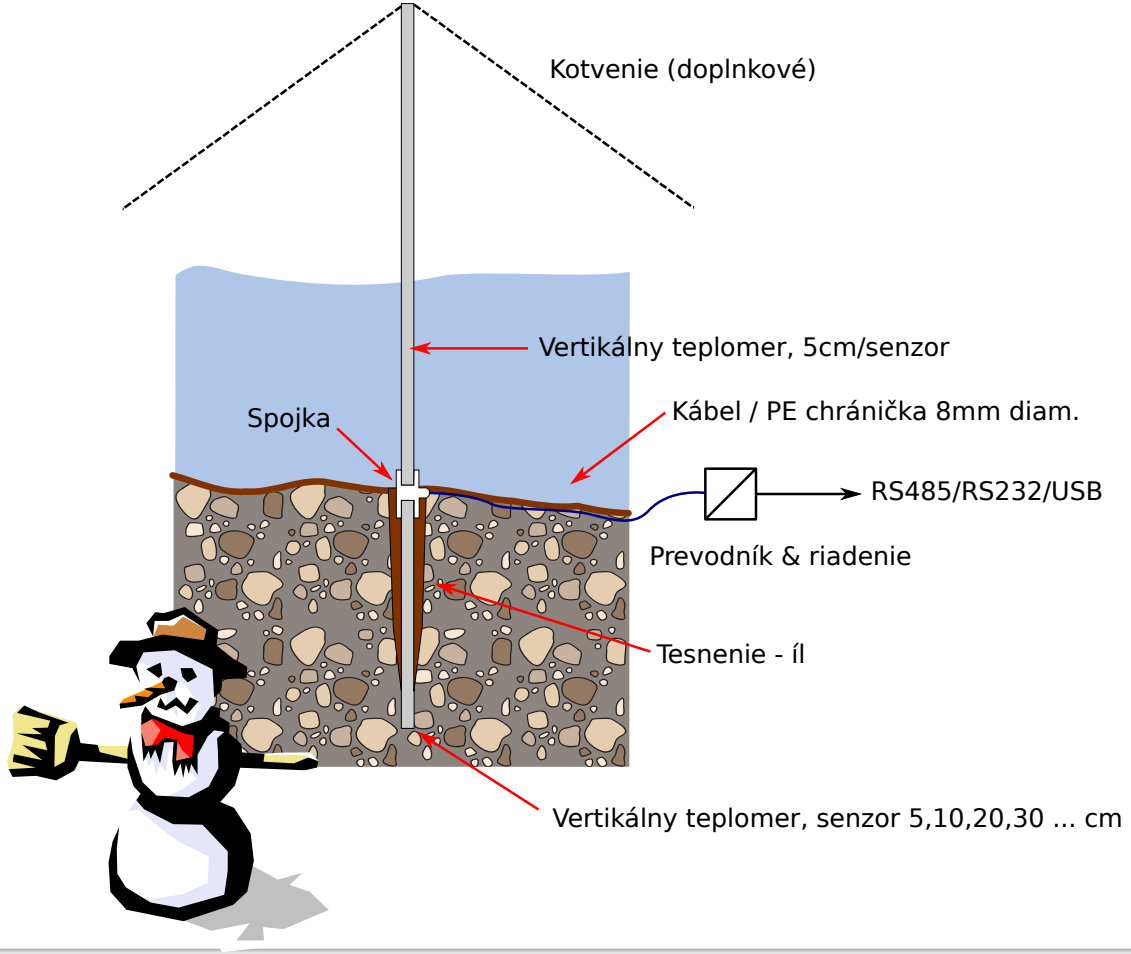


- Simulation and sensor design (without a dielectric housing)

Observing the dynamics of the heat diffusivity

Applications

- *Design and development of sensor for soil and snow diagnostic*



Points of interest

1. *Determining the vertical profile of system variables:*
   - *temperature*
   - *mass density*
   - *heat capacity*
   - *thermal conductivity*
   - *permitivity and dielectric losses*

2. *Determining derived values as a function of time, i.e : snow depth, mass density, mixture of ice and water, accumulated heat ...*

3. *Creation of a predictive model of time evolution of system variables based on sensor fusion and meteo forecast via Kalman filter*

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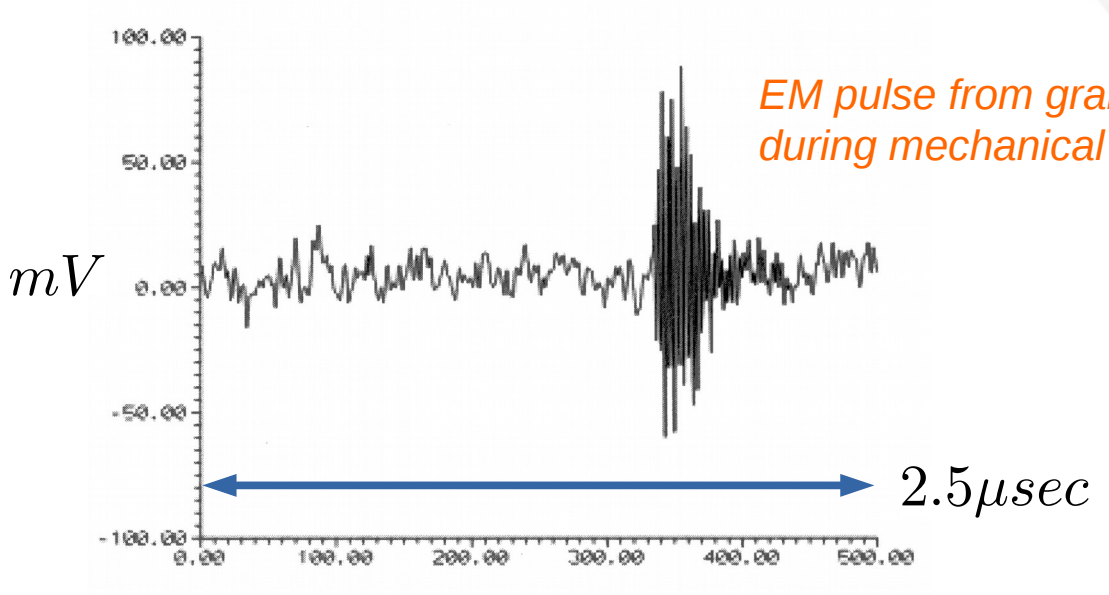
Emisivity of eletromagnetic radiation of rock and ice

Physical principle and possibilities of use

- *Emisivity of electromagnetic radiation from piezoelectric polycrystalic substances is prooved both experimentally and theoretically*
- *We assume that it is possible to utilise the respective effects to monitor the dynamics of the snow movements and its ice parts (firn) in avalanche slopes under mechanical stress of polycristalic forms of snow in compact layers*



EM pulse from granite
during mechanical stress

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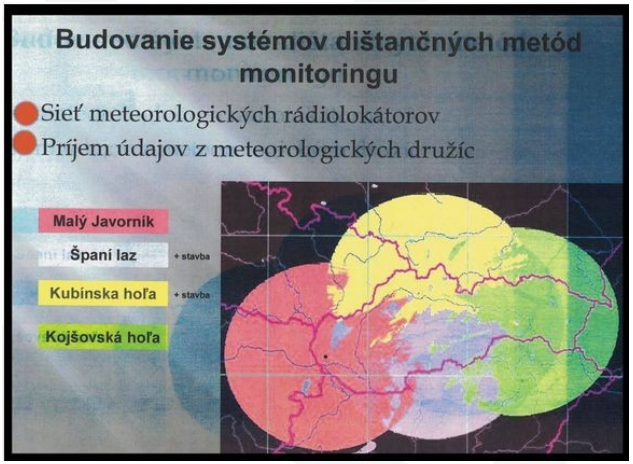
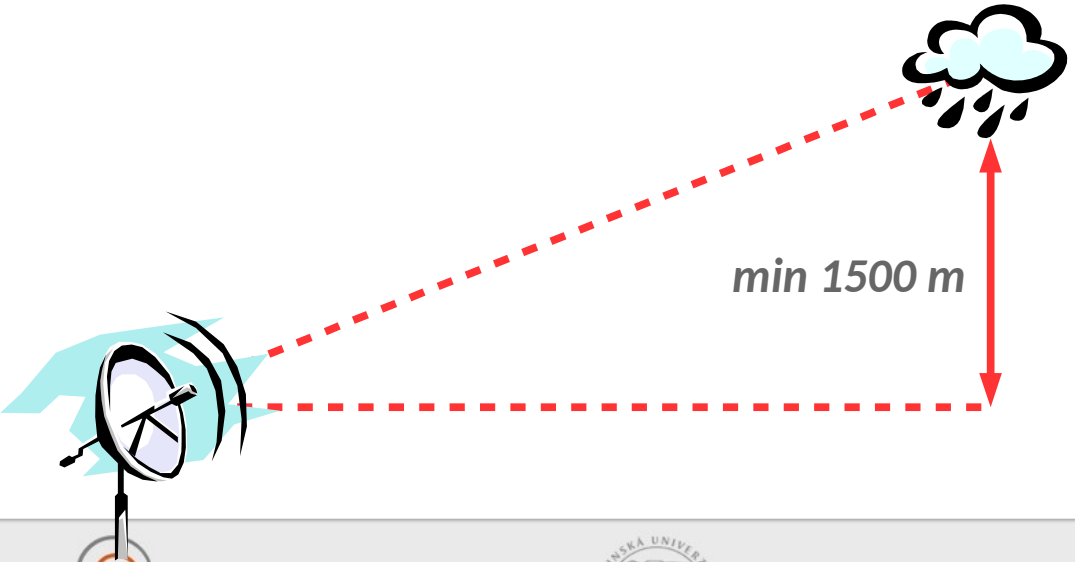
Radio-frequency methods of rainfall monitoring

Classical method - meteorological radar

Slovak radar network currently consists of four meteorological radars, operating at a wavelength of 5 cm (C band) type SELEX METEOR 735 CDP with peak power more than 400 kW.

General restrictions of radar measurements - information is limited to spatial resolution with minimum height,does not provide data on precipitation in the lower layers of the troposphere.





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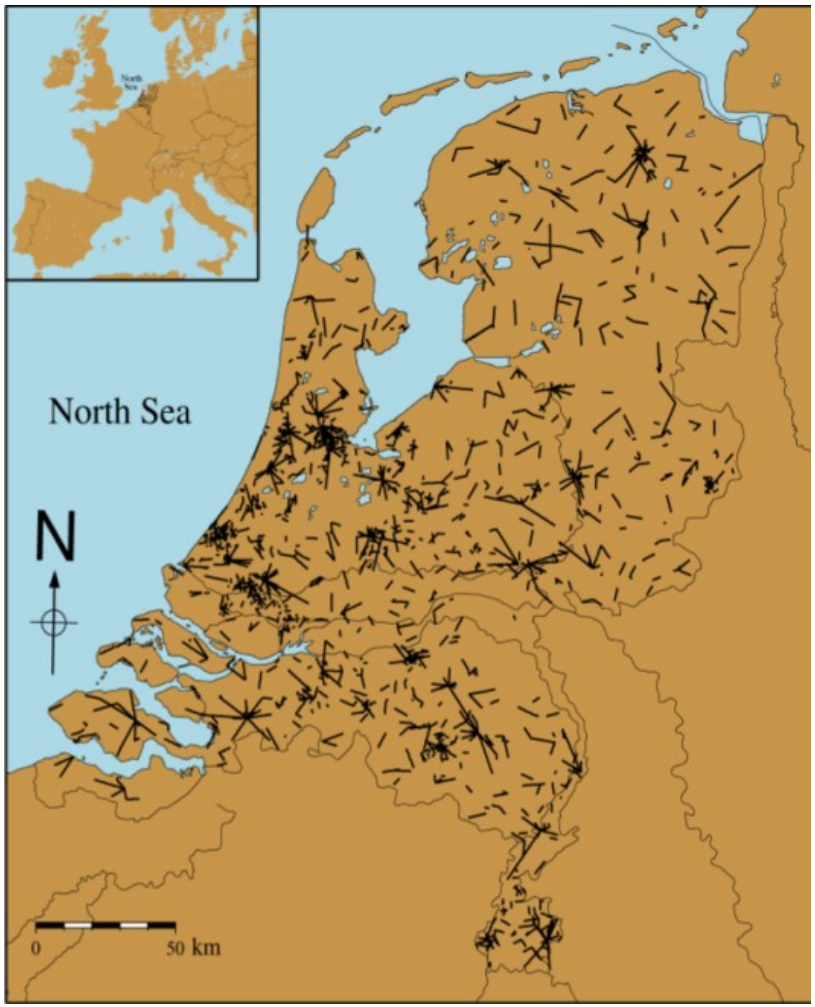
Radio-frequency methods of rainfall monitoring

Experimental method - Usage of directional communication connections in the 10GHz band



Netherlands project

Measuring urban rainfall using microwave links from commercial cellular communication networks

Overeem, A. , Leijnse, H. , Uijlenhoet, R. Water Resources Research 47 (2011)

Attenuation of microwave paths were used to refine local precipitation profiles of connections paths and extrapolated using radar measurements.

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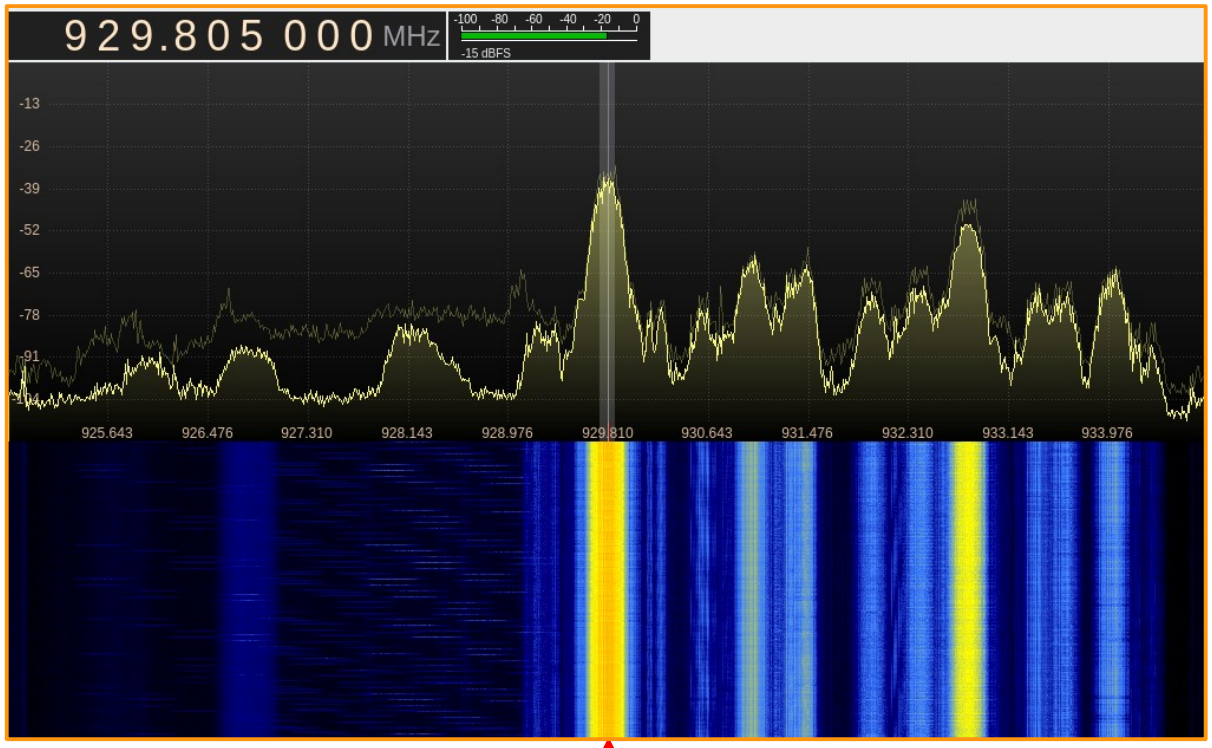
Radio-frequency methods of rainfall monitoring

Parameters of electromagnetic energy sources in 1 GHz band

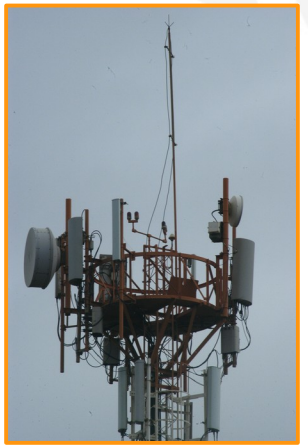


GSM G2 mobile phone network pilot signal

UHF broadcast sources

DVBT (180-860 MHz)

- Internet (2.4, 3, 5.4 GHz)
- GPS, SAT TV
- BTS mobilných sietí G2 GSM 920-960 MHz



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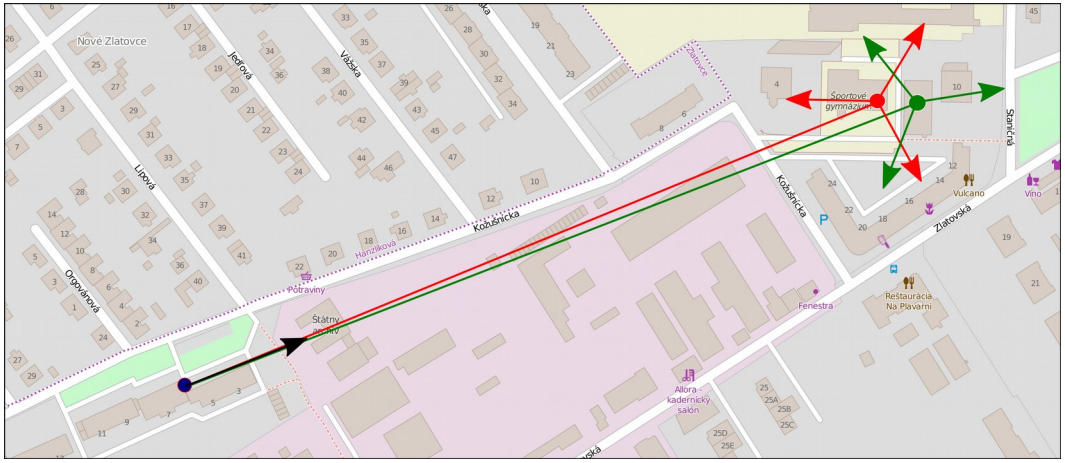
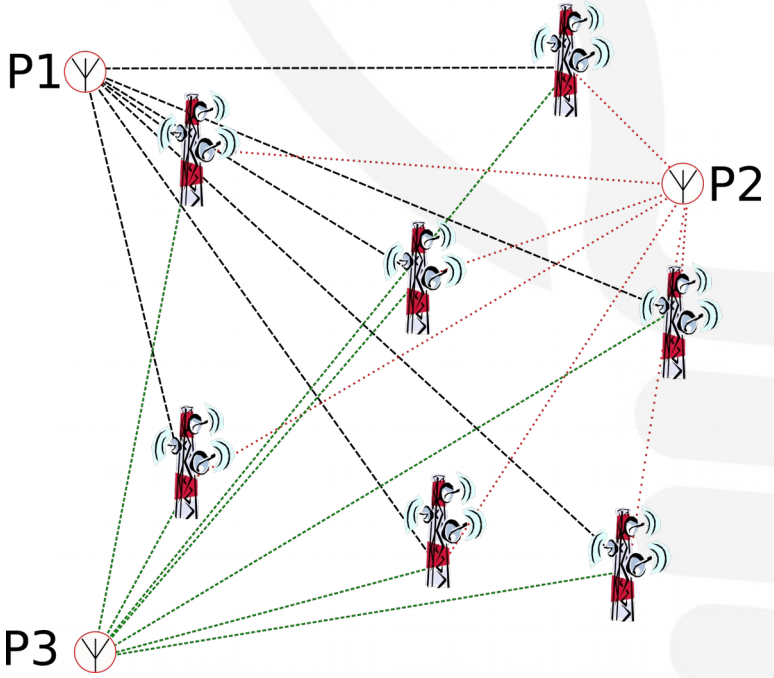
Radio-frequency methods of rainfall monitoring

Experimental passive monitoring of UHF broadcasting sources

- The method is based on the evaluation of correlated atmospheric changes caused by rain or snow. Uses passive monitoring of broadcast sources (BTS, mobile phone network) using methods of frequency and spatial diversity reception
- The combination of several transmitters and receivers creates a virtual network of channels, from which it is possible to determine the spatial localization of precipitation



Experimental channel setup, BTS positions Trenčín, Slovakia



Virtual channel network

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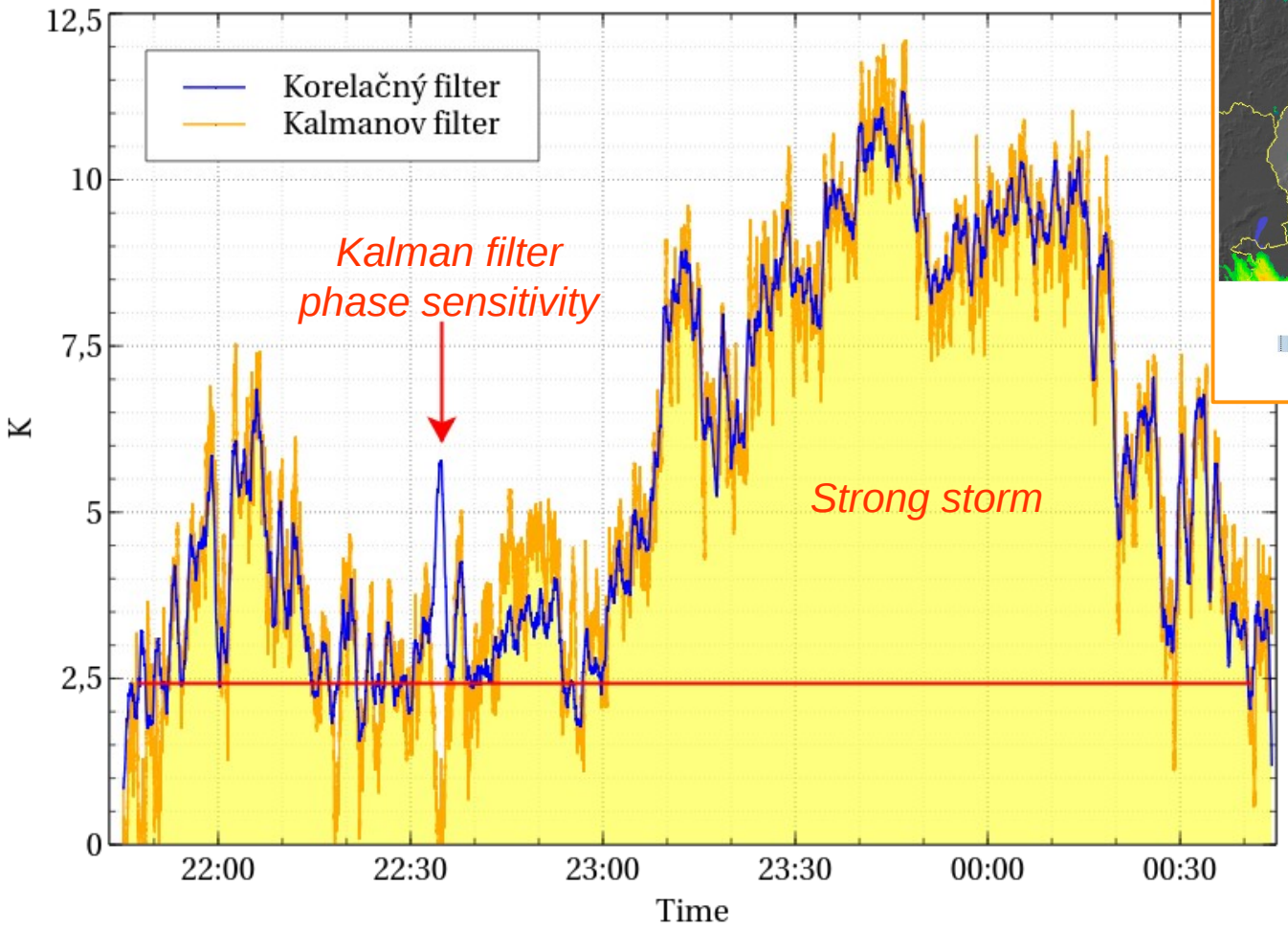
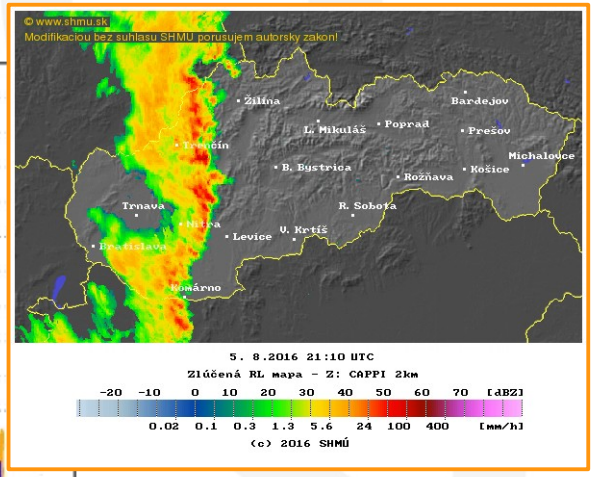
Radio-frequency methods of rainfall monitoring

Evaluation of data by the Kalman filter, K-integral correlation





Experimetal results during cold front passage 6.8.2016 Trenčín, Slovakia

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Conclusion

- *presented methods are under the development and only first experimental results are available*
- *their practical application will require thorough and long time verification, the results will have to be compared with standard methods of measurements of these type of phenomenon*
- *methods need validation and calibration*
- *methods are not replacement for classical meteorological method and measurements, nevertheless, when applying the right interpretation they can contribute to the classical measurements*

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Thank you for your attention

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