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Analysis and Application of Low-cost Sensor Measurements for the Assessment of Hydrometeorological Extreme Events

Geospatial Sensor Webs Conference 2018

Münster (Westfalen) 04.09.2018

EXTRUSO Project (Extreme events in small and medium sized catchments)

Overview

- Research group @ TUD; funded by European Social Fund
- 3-years project; 07/2016 06/2019
- 8 researchers (5 PhD, 3 PostDoc) from 4 disciplines (Meteorology, Hydrology, Photogrammetry, Geoinformatics)
- Main goals:
 - Monitoring and analysis of flash flood events in small and medium-sized catchments
 - Development of new tools for the prediction of flash floods
 - Development of strategies and methods for collaborative information and early warning systems





Motivation



Spitzkunnersdorf (Eastern Saxony, Germany) 14.05.2017

Increasing Occurrence of Flash flood Events





Motivation

Spitzkunnersdorf small ungauged catchment ca. 8km²







Outline







Tipping gauge Davis Vantage Pro

- 0.2mm resolution tipping gauge
- considered semi-professional
- 60€ low-cost ?
- Several campaigns to test the usability and accuracy of the sensor









Longtime calibration

- Sensor was installed at the Tharandt Climate Station (TUDD) in May 17
- Time series 07/17 06/18
- Benchmarked against three professional rain gauges



Rain Gauge	Davis Rain Sensor	Young Tipping Gauge	Ott Pluvio	Hellmann Cylinder (reference)
Price	ca. 60€	ca. 600€	ca. 8000€	ca. 300€
Туре	Tipping Gauge	Tipping Gauge	Weighing Gauge	Measuring cylinder (passive)
Sum TS	512.8mm	531.3mm *	527.0mm **	690.6mm
Difference Reference	- 177.8mm - 25.7%	- 148.7mm - 21.5%	- 91.6mm - 13.3%	









Sources of error

• Blockage of the funnel (leaves, insects) (Sep - Nov 17)

	Hellmann	Pluvio	Young	Davis
28.10.2017	12.4	10.8	2.3	7.4
29.10.2017	10.6	10.1	0.0	4.0
30.10.2017	0.0	0.0	0.0	5.4

• Funnel is not heated → several occasions where funnel was blocked by ice and snow (Jan – Mar 17)

	Hellmann	Pluvio	Young	Davis
16.03.2018	8.1	7.6	1.7	1.6
17.03.2018	0.6	0.0	0.0	0.0
18.03.2018	0.0	0.0	0.0	2.2
19.03.2018	0.0	0.0	0.0	1.0

• Under reading on high rain intensities









Assessment of factory calibration

 Array of 20 rain gauges installed on Tharandt Climate Station (08/18) – goal is to analyse the variation in the measured data













Assessment of factory calibration

- rain data since 08.08.18
- Results:
 - Amount of rain 35.6mm ...42.2mm
 - Average 39.1mm, stdev 2.1mm
 - until now sensors tend to read consistently high or low







Low cost sensor system I

Development of a modular sensor system (RasPI)

Startingpoint:

 Low-cost camera-based system for monitoring waterlevel and flow velocity (Raspi 3)

Idea:

- Extend the system with different sensors
- Include options for transferring data
- Optimize energy consumption
- Low cost









Low cost sensor system I

Development of a modular sensor system (RasPI)

- Combined system of Raspberry PI Zero W + Arduino Mini Pro
- Arduino switches Raspberry PI on / off when need to minimize Energy Consumption (active 0.75W – 3W / off 0.05W)
- Powered by PV / Battery (expensive)
- Data transmission via UMTS (expensive)
- Price for combined Camera / Rain Gauge 230 €









Low cost Sensor System II

Development of a Arduino sigfox based sensor system

- Simple alternative to the RasPI system
- Useful for basic data logging tasks (f.e. precipitation)
- Cheap data transmission is included but payload is limited (6 messages with 12bytes / hour)
 - → Message protocol depending on use case
 - → Precipitation 1min resolution every 10min (10byte)
 - \rightarrow Temp, Hum, Prec, Press with 5m in resolution every 10m in (8-12byte)
- Energy efficient (can run on batteries for month)
- Price for Rain Gauge system ~ $130 \in (incl. sigfox for 2 years)$









Low cost sensor systems – use cases

- RasPI camera system (PV + Battery) deployed at the Große Ohe (Bavarian Forest)
- RasPI camera system (PV + Battery) deployed at the Wesenitz (Stolpen, Saxony)
- RasPI Rain Gauge + Weather Sensors (Wifi + energy provided by Citizen scientists) -1 + 2 stations deployed in the lower ore mountain region (Saxony)
- 5 Arduino Rain Gauge + Weather Sensors built and operated by Master students deployed at Tharandter Wald
- 2 Arduino Rain Gauge + Weather Sensors operated by Citizen scientists to be deployed in the lower ore mountain region





Low cost sensor systems - Extruso information system







Low cost sensor systems - Extruso information system



https://opensensorweb.de/





Conclusions

- Davis Rain Gauge has shown potential for use in low-cost sensor networks
- factory calibration of the rain gauge has to be further investigated
- We developed two sensor systems which can be adjusted to the given task /infrastructure





Thank you for your attention!



These investigations are part of the research project 'Extreme events in small and medium catchments (EXTRUSO)" funded by the EU ESF Nachwuchsforschergruppen' program under grant no. 100270097.

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