Quality and timing of crowd-based water level class observations

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Abstract

Crowd-based hydrological observations can supplement existing monitoring networks and allow data collection in regions where otherwise no data would be available. In the citizen science project CrowdWater, repeated water level observations using a virtual staff gauge approach result in time series of water level classes. To investigate the quality of these observations, we compared the water level class data for a number of locations where water levels were also measured and assessed when these observations were submitted. We analysed data for nine locations where citizen scientists reported multiple observations using a smartphone app and stream level data were also available. At twelve other locations, signposts were set up to ask citizens to record observations on a form that could be left in a letterbox. The results indicate that the quality of the data collected with the app was higher than for the forms. A possible explanation is that for each app location, most contributions were made by a single person, whereas at the locations of the forms almost every observation was made by a new contributor. On average, more contributions were made between May and September than during the other months. Observations were submitted for a range of flow conditions, with a higher fraction of high flow observations for the data collected with the app. Overall, the results are encouraging for citizen science approaches in hydrology and demonstrate that the smartphone application with its virtual staff gauge is a promising approach for crowd-based water level class observations.

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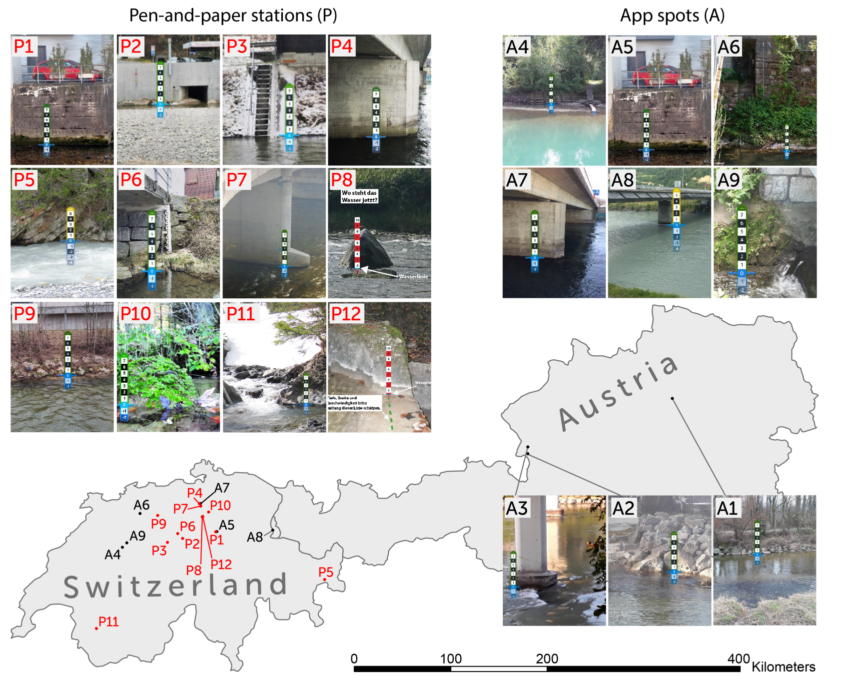
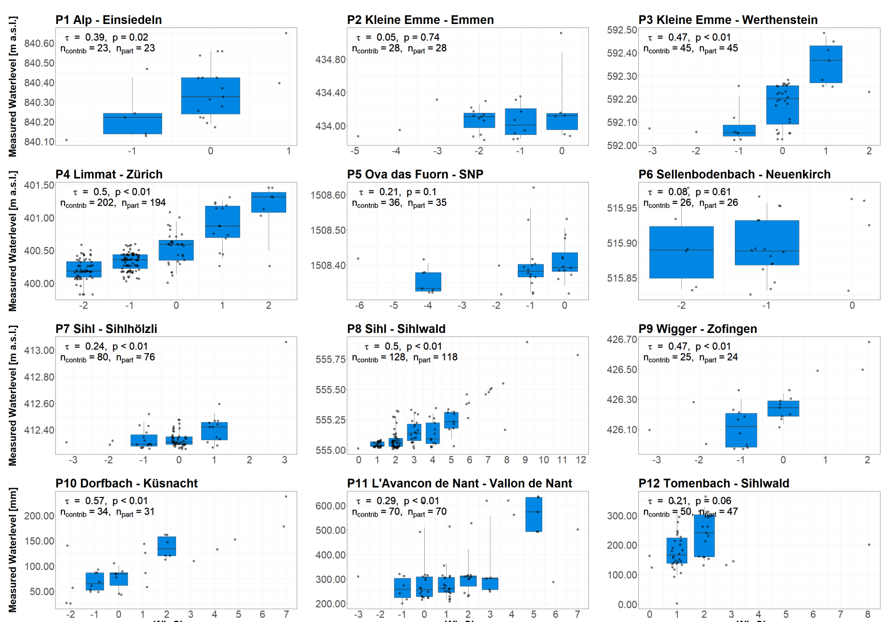
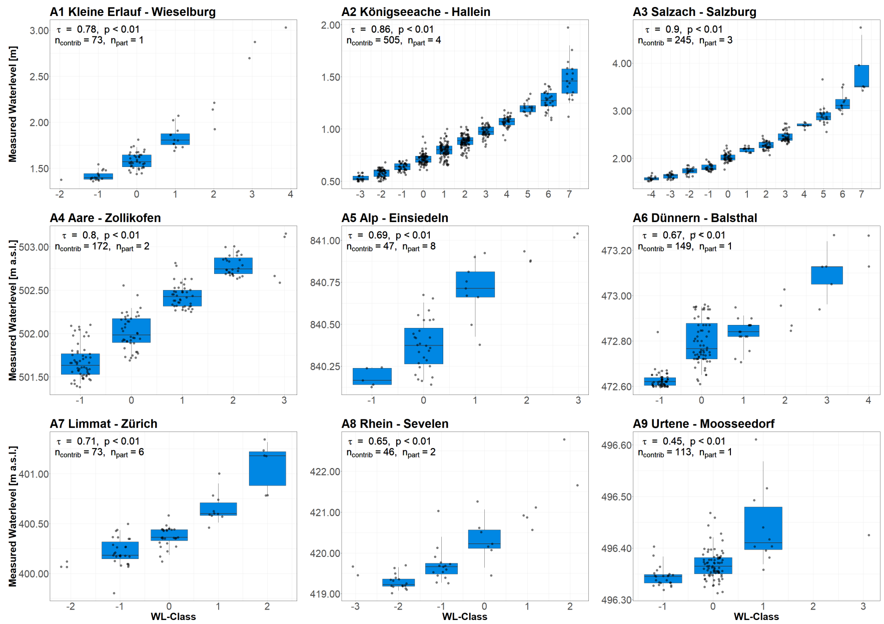
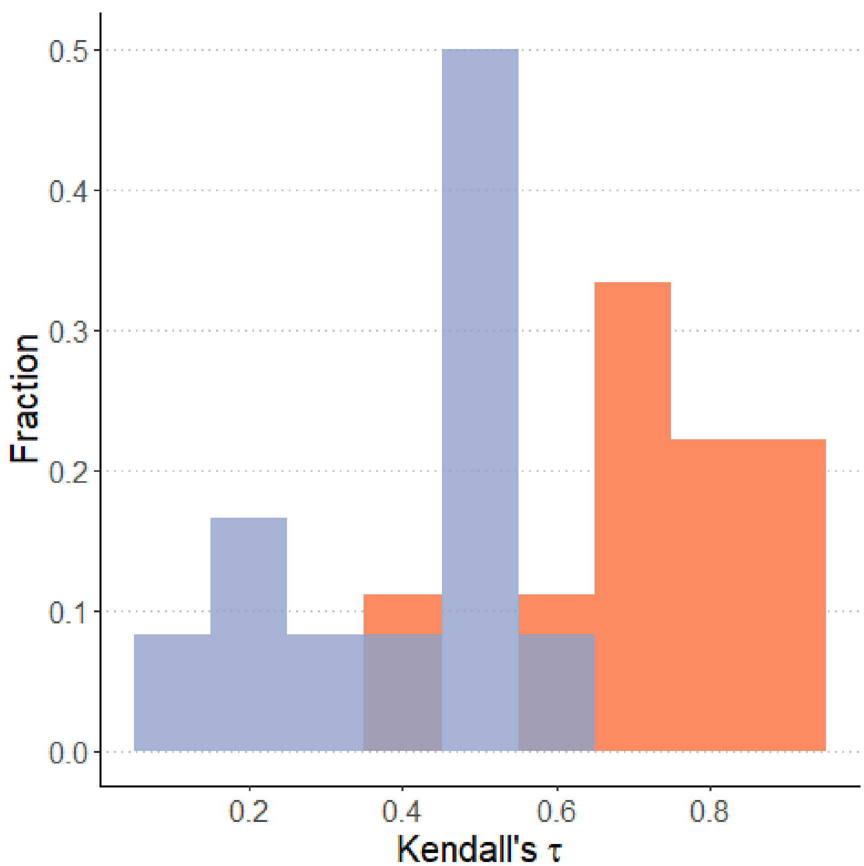
Table 1 *Names and coordinates (decimal degrees N and E) of the app spots and pen-and-paper stations used in this study, the location of the water level measurements, the number of observations, the number of contributors, the correlation between the WL-class observations and the measured water levels (Kendall's* ⍰*) and the corresponding p-values. The water level data were obtained from the state departments of hydrology of Niederösterriech (Amt der Niederösterreichischen Landesregierung – Abteilung für Hydrologie und Geoinformation; NOE) and Salzburg (German: Amt der Salzburger Landesregierung – Abteilung Wasser; ASL), the Bavarian Hydrological Service (Gewässerkundlicher Dienst Bayern; GKD), the Swiss Federal Office for the Environment (FOEN), the Departments of Hydrometry for two Swiss cantons, or our own measurements using Keller DCX-22 pressure sensors and water levels measured by the École Polytechnique Fédérale de Lausanne (EPFL) using TruTrack WT-HR 1000 water level loggers.*

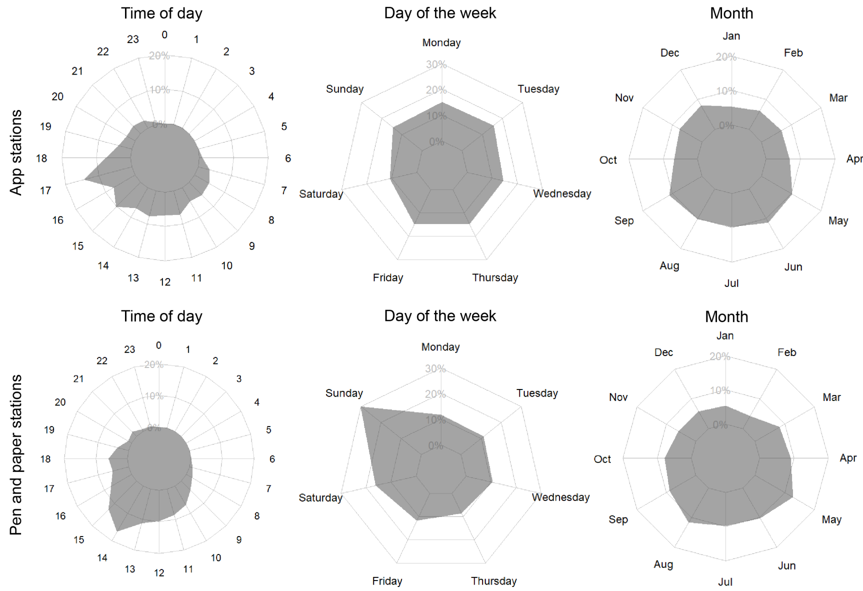
Number	Station Name	Observation period	Coordinates WL measure-ments [N, E]	Source water level data	Coordinates WL-class observations [N, E]	Distance between WL and WL-class locations [km]	Number of obser-vations	Number of partici-pants	Kendall's τ	p-value
					App spots in Austria					
A1	Kleine Erlauf - Wieselburg	30.03.2018 – 02.08.2019	48.1273, 15.1330	NOE	48.1255, 15.1292	0.3	73	1	0.78	<0.01
A2	Königseeache - Hallein	05.01.2018 – 10.09.2018	47.6458, 13.0303	GKD	47.7261, 13.0650	9.3	505	4	0.86	<0.01
A3	Salzach - Salzburg	26.08.2018 – 21.09.2019	47.7982, 13.0539	ASL	47.7896, 13.0686	1.5	245	3	0.90	<0.01
					App spots in Switzerland					
A4	Aare - Zollikofen	10.09.2017 – 30.04.2019	46.9333, 7.4480	FOEN	46.9904, 7.4508	6.4	172	2	0.80	<0.01
A5	Alp-Einsiedeln	29.11.2017 – 30.05.2019	47.1508, 8.7393	FOEN	47.1277, 8.7432	2.6	47	8	0.69	<0.01
A6	Dünnern-Balsthal	19.06.2018 – 22.06.2019	47.3022, 7.6975	Canton of Solothurn	47.3034, 7.6950	0.2	149	1	0.67	<0.01
A7	Limmat-Zürich	05.05.2017 – 17.02.2019	47.3908, 8.5257	FOEN	47.3919, 8.5233	0.2	73	6	0.71	<0.01
A8	Rhein-Sevelen	26.05.2018 – 11.06.2019	47.3067, 9.5710	FOEN	47.1301, 9.5114	20.2	46	2	0.65	<0.01
A9	Urtene Moosseedorf	21.06.2018 – 27.06.2019	47.0728, 7.5426	Canton of Bern	47.0301, 7.5116	5.3	113	1	0.45	<0.01


Pen-and-paper stations (P)
App spots (A)
P1
P2
P3
P4
P5
P6
P7
P8
P9
P10
P11
P12
A1
A2
A3
A4
A5
A6
A7
A8
A9
Austria
Switzerland
0
100
200
400
Kilometers


P1 Alp - Einsiedeln
τ = 0.39, p = 0.02
$n_{contrib}$ = 23, n_{part} = 23
P2 Kleine Emme - Emmen
τ = 0.05, p = 0.74
$n_{contrib}$ = 28, n_{part} = 28
P3 Kleine Emme - Werthenstein
τ = 0.47, p < 0.01
$n_{contrib}$ = 45, n_{part} = 45
P4 Limmat - Zürich
τ = 0.5, p < 0.01
$n_{contrib}$ = 202, n_{part} = 194
P5 Ova das Fuorn - SNP
τ = 0.21, p = 0.1
$n_{contrib}$ = 36, n_{part} = 35
P6 Sellenbodenbach - Neuenkirch
τ = 0.08, p = 0.61
$n_{contrib}$ = 26, n_{part} = 26
P7 Sihl - Sihlhölzli
τ = 0.24, p < 0.01
$n_{contrib}$ = 80, n_{part} = 76
P8 Sihl - Sihlwald
τ = 0.5, p < 0.01
$n_{contrib}$ = 128, n_{part} = 118
P9 Wigger - Zofingen
τ = 0.47, p < 0.01
$n_{contrib}$ = 25, n_{part} = 24
P10 Dorfbach - Küsnacht
τ = 0.57, p < 0.01
$n_{contrib}$ = 34, n_{part} = 31
P11 L'Avancon de Nant - Vallon de Nant
τ = 0.29, p < 0.01
$n_{contrib}$ = 70, n_{part} = 70
P12 Tomenbach - Sihlwald
τ = 0.21, p = 0.06
$n_{contrib}$ = 50, n_{part} = 47
Measured Waterlevel [m a.s.l.]
Measured Waterlevel [mm]
WL-Class


A1 Kleine Erlauf - Wieselburg
τ = 0.78, $p < 0.01$
$n_{contrib}$ = 73, n_{part} = 1
A2 Königseeache - Hallein
τ = 0.86, $p < 0.01$
$n_{contrib}$ = 505, n_{part} = 4
A3 Salzach - Salzburg
τ = 0.9, $p < 0.01$
$n_{contrib}$ = 245, n_{part} = 3
A4 Aare - Zollikofen
τ = 0.8, $p < 0.01$
$n_{contrib}$ = 172, n_{part} = 2
A5 Alp - Einsiedeln
τ = 0.69, $p < 0.01$
$n_{contrib}$ = 47, n_{part} = 8
A6 Dünnern - Balsthal
τ = 0.67, $p < 0.01$
$n_{contrib}$ = 149, n_{part} = 1
A7 Limmat - Zürich
τ = 0.71, $p < 0.01$
$n_{contrib}$ = 73, n_{part} = 6
A8 Rhein - Sevelen
τ = 0.65, $p < 0.01$
$n_{contrib}$ = 46, n_{part} = 2
A9 Urtene - Moosseedorf
τ = 0.45, $p < 0.01$
$n_{contrib}$ = 113, n_{part} = 1
Measured Waterlevel [m]
Measured Waterlevel [m a.s.l.]
Measured Waterlevel [m a.s.l.]
WL-Class
WL-Class
WL-Class


Fraction
Kendall's τ



Time of day
Day of the week
Month
App stations
Pen and paper stations
Monday
Tuesday
Wednesday
Thursday
Friday
Saturday
Sunday
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec