

Unmanned aerial vehicle as a tool for checking the correctness of flood inundation models



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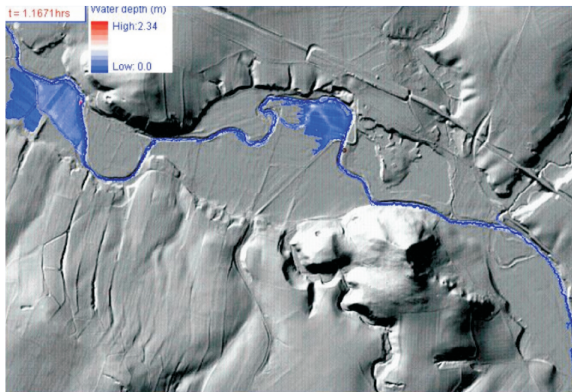
INVESTMENTS IN EDUCATION DEVELOPMENT

Outline

- Context
- Feasibility study
 - UAV survey
 - Experimental results

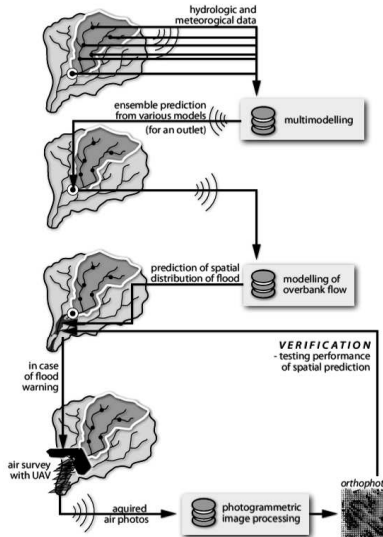
Presented material is supposed to be submitted to Journal of Hydrology within one month.

Modelling and prediction of inundation



Visualization courtesy of Dr Dapeng Yu (Loughborough University, UK). For visualization purposes the map presents non-calibrated model.

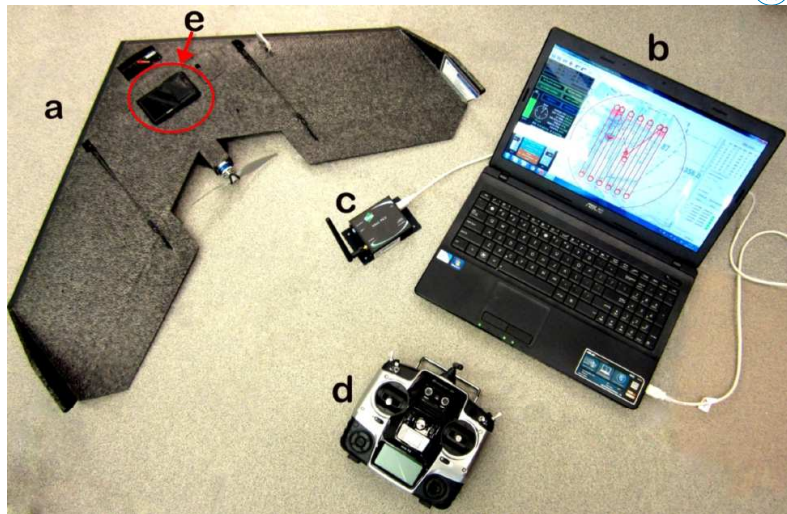
Pointwise and spatial hydrologic predictions



Research hypothesis

Even small inundation can be easily detected using the 3 cm/px UAV-taken photographs, and such a detection is statistically significant.

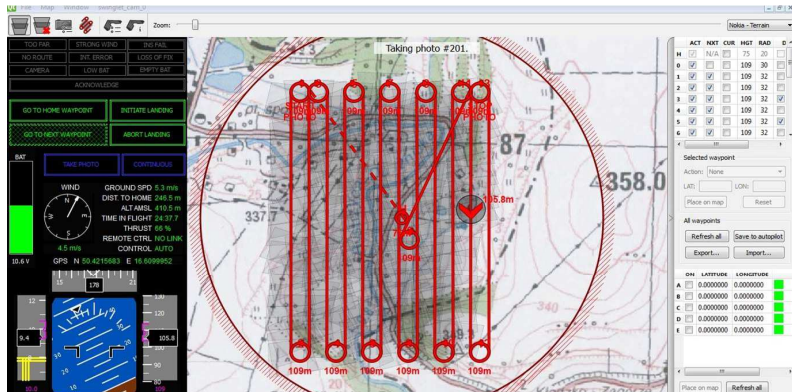
swinglet CAM



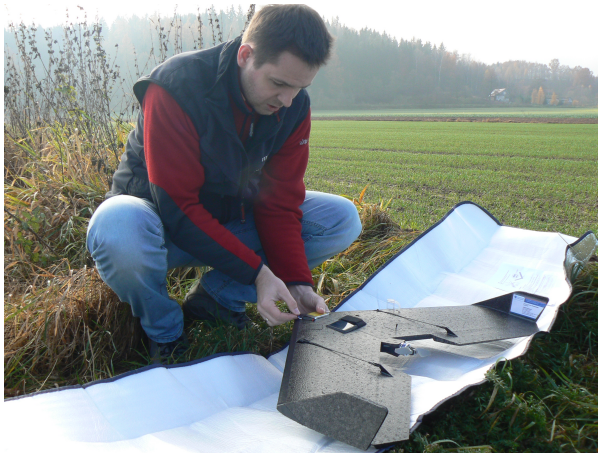
swinglet CAM – the system



swinglet CAM – ground base station



swinglet CAM – field work



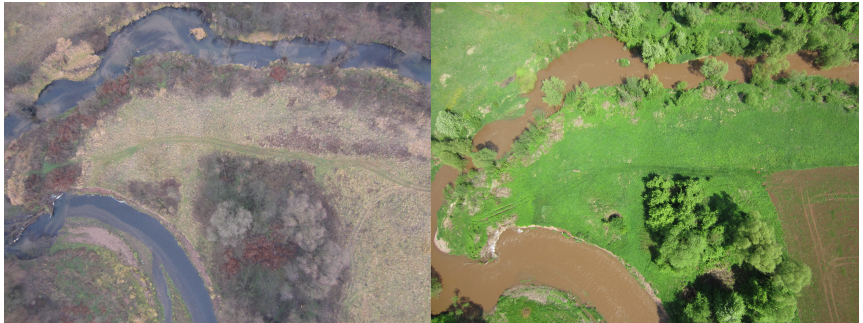
UAV in flight – Żelazno site



Individual photograph in the central projection



Individual photographs in the central projection



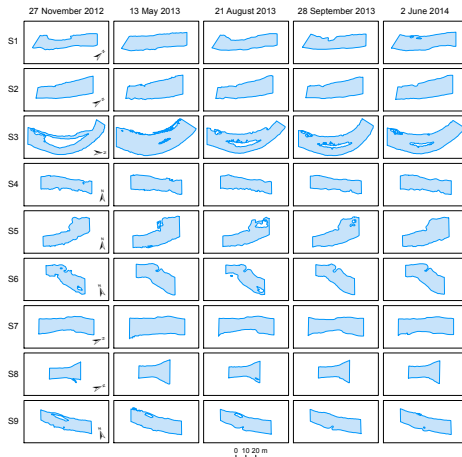
Study area and five study sites



Test sites depicted on the orthophoto image, Gorzuchów



UAV-observed inundation, Gorzuchów



Data

Site ID	Inundated areas from UAV observations [m^2]				
	2012.11.27	2013.05.13	2013.08.21	2013.09.27	2014.06.02
1	650.3	835.0	716.4	721.5	813.3
2	790.1	904.6	794.7	811.1	869.0
3	1000.1	1559.1	1168.2	1248.0	1271.3
4	577.8	664.4	582.6	602.1	656.5
5	651.9	804.1	628.4	747.6	803.5
6	545.0	654.7	542.6	602.5	649.6
7	778.6	931.7	779.6	800.3	826.9
8	369.2	456.4	385.5	403.0	428.2
9	584.8	708.8	658.0	678.1	692.3

Site ID	Inundated areas from UAV observations [% of all inundated areas on site]				
	2012.11.27	2013.05.13	2013.08.21	2013.09.27	2014.06.02
1	0.1740493	0.2234691	0.1917280	0.1930965	0.2176572
2	0.1894891	0.2169462	0.1906052	0.1945397	0.2084198
3	0.1601036	0.2495942	0.1870089	0.1997824	0.2035109
4	0.1873955	0.2154739	0.1889361	0.1952771	0.2129174
5	0.1793246	0.2211887	0.1728388	0.2056331	0.2210147
6	0.1820142	0.2186308	0.1812148	0.2012082	0.2169321
7	0.1891137	0.2262997	0.1893503	0.1943887	0.2008475
8	0.1807901	0.2234572	0.1887525	0.1973374	0.2096628
9	0.1760263	0.2133752	0.1980779	0.2041224	0.2083982

Logarithm of data

Site ID	Inundated areas from UAV observations [log of % of all inundated areas on site]				
	2012.11.27	2013.05.13	2013.08.21	2013.09.27	2014.06.02
1	-1.748417	-1.498482	-1.651678	-1.644565	-1.524834
2	-1.663424	-1.528106	-1.657551	-1.637119	-1.568201
3	-1.831934	-1.387919	-1.676599	-1.610527	-1.592036
4	-1.674534	-1.534916	-1.666346	-1.633336	-1.546851
5	-1.718558	-1.508739	-1.755396	-1.581662	-1.509526
6	-1.703671	-1.520371	-1.708072	-1.603415	-1.528171
7	-1.665407	-1.485895	-1.664156	-1.637895	-1.605209
8	-1.710419	-1.498535	-1.667318	-1.622841	-1.562255
9	-1.737122	-1.544703	-1.619095	-1.589035	-1.568305

Statistical analysis

Test	P-value for a given observation campaign				
	2012.11.27	2013.05.13	2013.08.21	2013.09.27	2014.06.02
Independence (Ljung-Box)	0.059	0.158	0.446	0.925	0.841
Normality (Shapiro-Wilk)	0.171	0.013	0.219	0.370	0.843
Symmetry (D'Agostino)	0.232	0.068	0.299	0.643	0.950
Mesokurticity (Anscombe-Glynn)	0.142	0.012	0.144	0.319	0.542

Date	P-value of Fisher's test between two observation campaigns				
	2012.11.27	2013.05.13	2013.08.21	2013.09.27	2014.06.02
2012.11.27	1.000	0.732	0.390	0.029	0.173
2013.05.13	0.732	1.000	0.601	0.060	0.301
2013.08.21	0.390	0.601	1.000	0.162	0.603
2013.09.27	0.029	0.060	0.162	1.000	0.369
2014.06.02	0.173	0.301	0.603	0.369	1.000

Statistical analysis

Date	P-value of student's test between two observation campaigns				
	2012.11.27	2013.05.13	2013.08.21	2013.09.27	2014.06.02
2012.11.27	1.00000	0.00000	0.06493	0.00009	0.00000
2013.05.13	0.00000	1.00000	0.00000	0.00000	0.00941
2013.08.21	0.06493	0.00000	1.00000	0.00165	0.00000
2013.09.27	0.00009	0.00000	0.00165	1.00000	0.00022
2014.06.02	0.00000	0.00941	0.00000	0.00022	1.00000

Student's test with two-sided alternative

Date	P-value of Bootstrapped student's test between two observation campaigns				
	2012.11.27	2013.05.13	2013.08.21	2013.09.27	2014.06.02
2012.11.27	1.00000	0.00000	0.04862	0.00002	0.00000
2013.05.13	0.00000	1.00000	0.00000	0.00000	0.00527
2013.08.21	0.04854	0.00000	1.00000	0.00057	0.00000
2013.09.27	0.00002	0.00000	0.00058	1.00000	0.00008
2014.06.02	0.00000	0.00529	0.00000	0.00009	1.00000

Student's test with two-sided alternative, $B = 100000$

Some flood-prone sites in orthophoto image



Conclusions

- When UAV observation during low flow is assumed to be a reference data (27/11/2012 or 21/08/2013)
 - all situations (13/05/2013, 27/09/2013, 02/06/2014) except another low flow (21/08/2013) are found to reveal significant differences in mean inundation from mean extent of water observed on 27/11/2012
 - all situations (13/05/2013, 27/09/2013, 02/06/2014) except another low flow (27/11/2012) are found to reveal significant differences in mean inundation from mean extent of water observed on 21/08/2013
- When UAV observation during moderate or peak flow is assumed to be a reference data (13/05/2013, 27/09/2013, 02/06/2014)
 - all remaining situations are found to reveal significant differences in mean inundation from mean extent of water observed on 27/11/2012 or 27/09/2013 or 02/06/2014

Acknowledgements



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Thank you for your attention

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