

ESTIMATION OF FLOW VELOCITY DURING FLASH FLOODS WITH THE SYNERGY OF UNMANNED AERIAL SYSTEMS (UAS) DATA AND GROUND OBSERVATIONS: THE CASE OF 2017 MANDRA FLASH FLOOD, GREECE

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Abstract

Unmanned Aircraft Systems (UAS) can be used to enhance monitoring of a wide range of environmental parameters, including acquiring data on various types of hydro-geomorphic phenomena.

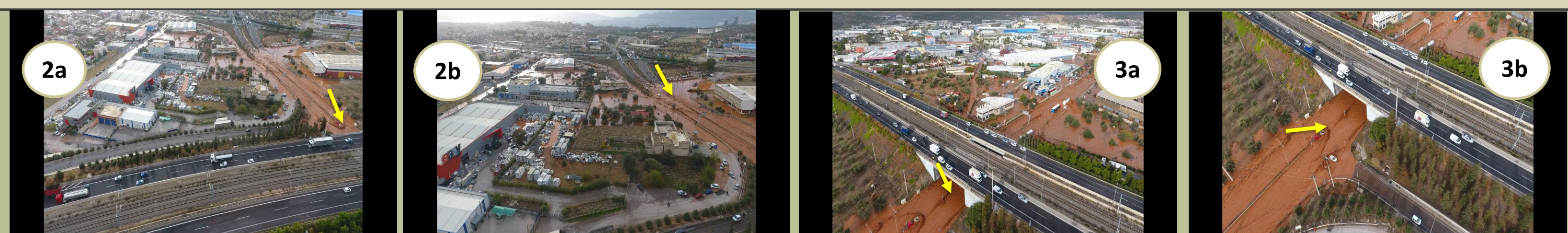
Their capabilities to provide on-demand images and videos of high resolution are particularly useful in the case of flash flood phenomena, which occur in spatial and temporal scales that do not favor traditional monitoring processes.

In this work, flow velocity is estimated using aerial imaging acquired by means of an Unmanned Aircraft Vehicle (UAV) as well as ground observations during the catastrophic flash flood event of November 2017 in Mandra, Greece.

In these imaging detailed tracing of various floating objects and particles such as light trash, debris, etc. was carried out using multiple high-resolution video frames with specific time marks. Water velocity estimations were also cross-examined using flood mark-derived velocity hydraulic heads extracted by ground observations after the flood.

The analysis was applied at a variety of locations across the study area, leading to a map of velocities for parts of the floodplain. Velocity values varied significantly depending on location, reaching up to 10m/s.

Methodology



Video snapshots were collected using UAS imagery at the starting point of the obstacle like the example of images 2a, 3a, and at the final point like 2b, 3b. The obstacles were georeferenced as shown on images 4 and 5 which correspond to images 2a, 2b, and the 3a, 3b respectively. The measurements were carried out by two researchers to assess the mean velocity during the flash flood as for the results be confirmed.

FRD	Shape	ID	Seconds	Distance1	Velocity1	Distance2	Velocity2	MeanVel	Vel1	Vel2
0	Point ZM	1	35	19.7	0.5	19.7	0.5	0.5	1	1
1	Point ZM	2	51	45	0.8	44.9	0.8	0.8	1.6	1.6
2	Point ZM	3	64	67.2	1	66.9	1	1	2	2
3	Point ZM	4	31	125	4	124.8	4	4	8	8
4	Point ZM	5	3	16	5.3	15.9	5.3	5.3	10.6	10.6
5	Point ZM	6	2	13.9	6.9	13.4	6.7	6.8	13.6	13.6
6	Point ZM	7	23	25.7	1.1	25.3	1.1	1.1	2.2	2.2
7	Point ZM	8	14	11.6	0.8	11.4	0.8	0.8	1.6	1.6
8	Point ZM	9	6	6.1	1	6	1	1	2	2
9	Point ZM	10	6	37.9	4.7	37.6	4.7	4.7	9.4	9.4
10	Point ZM	11	3	20.8	6.9	20.7	6.9	6.9	13.8	13.8
11	Point ZM	12	5	44.3	8.8	44	8.8	8.8	17.6	17.6
12	Point ZM	13	7	32.5	4.6	32.3	4.6	4.6	9.2	9.2
13	Point ZM	14	4	14.7	3.6	14.5	3.6	3.6	7.2	7.2
14	Point ZM	15	4	23.8	5.9	23.8	5.9	5.9	11.8	11.8
15	Point ZM	16	10	28.9	2.8	28.6	2.8	2.8	5.6	5.6
16	Point ZM	17	2	7.6	3.8	7.7	3.8	3.8	7.6	7.6
17	Point ZM	18	9	15.8	1.7	15.8	1.7	1.7	3.4	3.4
18	Point ZM	19	27	117.6	4.3	117.2	4.3	4.3	8.6	8.6
19	Point ZM	20	2	7.6	3.8	7.9	3.9	3.9	7.8	7.8
20	Point ZM	21	21	23.2	1.1	23.7	1.1	1.1	2.2	2.2
21	Point ZM	22	18	5.7	0.3	5.3	0.2	0.2	0.5	0.5
22	Point ZM	23	4	23	5.7	23.5	5.8	5.7	11.5	11.5

Table 1: Database of measurements to assess the mean velocity in GIS ArcMap environment.



On these images, superelevations in front of obstacles located in the flow as walls, bridges, and others may be visible. This superlevation is related to the assessment of flow velocity. The application of the Bernoulli equation gives the range of possible values for this velocity, where y_1 and V_1 represent depth the water depth, and the mean velocity respectively in the area surrounding the obstacle, y_2 represents the water depth in front of the obstacle and $g = 19.62$.

File	Shape	ID	Height1	Height2	Height3	Height4	Height5	Height6	Height7	Height8	Height9	Height10	Height11	Height12	Height13	Height14	Height15	Height16	Height17	Height18	Height19	Height20	Height21	Height22	Height23	Height24	Height25	Height26	Height27	Height28	Height29	Height30	Height31	Height32	Height33	Height34	Height35	Height36	Height37	Height38	Height39	Height40	Height41	Height42	Height43	Height44	Height45	Height46	Height47	Height48	Height49	Height50	Height51	Height52	Height53	Height54	Height55	Height56	Height57	Height58	Height59	Height60	Height61	Height62	Height63	Height64	Height65	Height66	Height67	Height68	Height69	Height70	Height71	Height72	Height73	Height74	Height75	Height76	Height77	Height78	Height79	Height80	Height81	Height82	Height83	Height84	Height85	Height86	Height87	Height88	Height89	Height90	Height91	Height92	Height93	Height94	Height95	Height96	Height97	Height98	Height99	Height100	Height101	Height102	Height103	Height104	Height105	Height106	Height107	Height108	Height109	Height110	Height111	Height112	Height113	Height114	Height115	Height116	Height117	Height118	Height119	Height120	Height121	Height122	Height123	Height124	Height125	Height126	Height127	Height128	Height129	Height130	Height131	Height132	Height133	Height134	Height135	Height136	Height137	Height138	Height139	Height140	Height141	Height142	Height143	Height144	Height145	Height146	Height147	Height148	Height149	Height150	Height151	Height152	Height153	Height154	Height155	Height156	Height157	Height158	Height159	Height160	Height161	Height162	Height163	Height164	Height165	Height166	Height167	Height168	Height169	Height170	Height171	Height172	Height173	Height174	Height175	Height176	Height177	Height178	Height179	Height180	Height181	Height182	Height183	Height184	Height185	Height186	Height187	Height188	Height189	Height190	Height191	Height192	Height193	Height194	Height195	Height196	Height197	Height198	Height199	Height200	Height201	Height202	Height203	Height204	Height205	Height206	Height207	Height208	Height209	Height210	Height211	Height212	Height213	Height214	Height215	Height216	Height217	Height218	Height219	Height220	Height221	Height222	Height223	Height224	Height225	Height226	Height227	Height228	Height229	Height230	Height231	Height232	Height233	Height234	Height235	Height236	Height237	Height238	Height239	Height240	Height241	Height242	Height243	Height244	Height245	Height246	Height247	Height248	Height249	Height250	Height251	Height252	Height253	Height254	Height255	Height256	Height257	Height258	Height259	Height260	Height261	Height262	Height263	Height264	Height265	Height266	Height267	Height268	Height269	Height270	Height271	Height272	Height273	Height274	Height275	Height276	Height277	Height278	Height279	Height280	Height281	Height282	Height283	Height284	Height285	Height286	Height287	Height288	Height289	Height290	Height291	Height292	Height293	Height294	Height295	Height296	Height297	Height298	Height299	Height300	Height301	Height302	Height303	Height304	Height305	Height306	Height307	Height308	Height309	Height310	Height311	Height312	Height313	Height314	Height315	Height316	Height317	Height318	Height319	Height320	Height321	Height322	Height323	Height324	Height325	Height326	Height327	Height328	Height329	Height330	Height331	Height332	Height333	Height334	Height335	Height336	Height337	Height338	Height339	Height340	Height341	Height342	Height343	Height344	Height345	Height346	Height347	Height348	Height349	Height350	Height351	Height352	Height353	Height354	Height355	Height356	Height357	Height358	Height359	Height360	Height361	Height362	Height363	Height364	Height365	Height366	Height367	Height368	Height369	Height370	Height371	Height372	Height373	Height374	Height375	Height376	Height377	Height378	Height379	Height380	Height381	Height382	Height383	Height384	Height385	Height386	Height387	Height388	Height389	Height390	Height391	Height392	Height393	Height394	Height395	Height396	Height397	Height398	Height399	Height400	Height401	Height402	Height403	Height404	Height405	Height406	Height407	Height408	Height409	Height410	Height411	Height412	Height413	Height414	Height415	Height416	Height417	Height418	Height419	Height420	Height421	Height422	Height423	Height424	Height425	Height426	Height427	Height428	Height429	Height430	Height431	Height432	Height433	Height434	Height435	Height436	Height437	Height438	Height439	Height440	Height441	Height442	Height443	Height444	Height445	Height446	Height447	Height448	Height449	Height450	Height451	Height452	Height453	Height454	Height455	Height456	Height457	Height458	Height459	Height460	Height461	Height462	Height463	Height464	Height465	Height466	Height467	Height468	Height469	Height470	Height471	Height472	Height473	Height474	Height475	Height476	Height477	Height478	Height479	Height480	Height481	Height482	Height483	Height484	Height485	Height486	Height487	Height488	Height489	Height490	Height491	Height492	Height493	Height494	Height495	Height496	Height497	Height498	Height499	Height500	Height501	Height502	Height503	Height504	Height505	Height506	Height507	Height508	Height509	Heig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