Acquisition Directorate

Research & Development Center

UAS Characterization of Oil in Ice

Volume II: Supplemental Laboratory Data

February 2022

Homeland Security

N O T I C E

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16. Abstract (MAXIMUM 200 WORDS)
The U.S. Coast Guard Research and Development Center and the National Oceanic and Atmospheric Administration executed an experiment on remote sensing of fresh (non-emulsified) and emulsified oil in ice at the Cold Regions Research and Engineering Laboratory (CRREL). "UAS Characterization of Oil in Ice – Volume I: Laboratory Results" discusses results and findings from the CRREL experiments; this report contains appendices that include imageries and other raw data that the project team collected to serve as potential resources for future research work with sensors on Unmanned Aircraft System or remotely operated vehicles.

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1 UAS DATA

1.1 04/19/2021 Flight # 3 Raw Data

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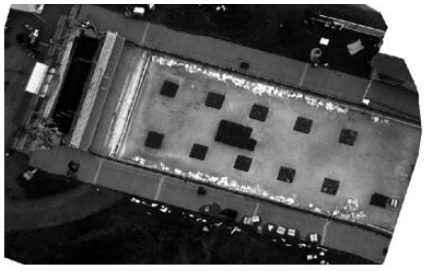
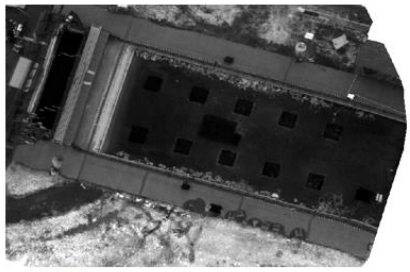


Red Edge (717 nm)

560nm

Near IR (840 nm)

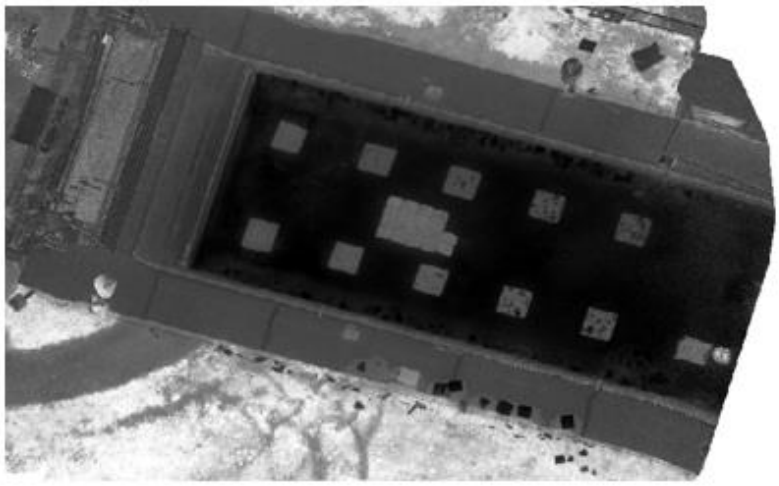


668 nm

RGB

1.2 04/19/2021 Flight # 3 Data Products

NDVI



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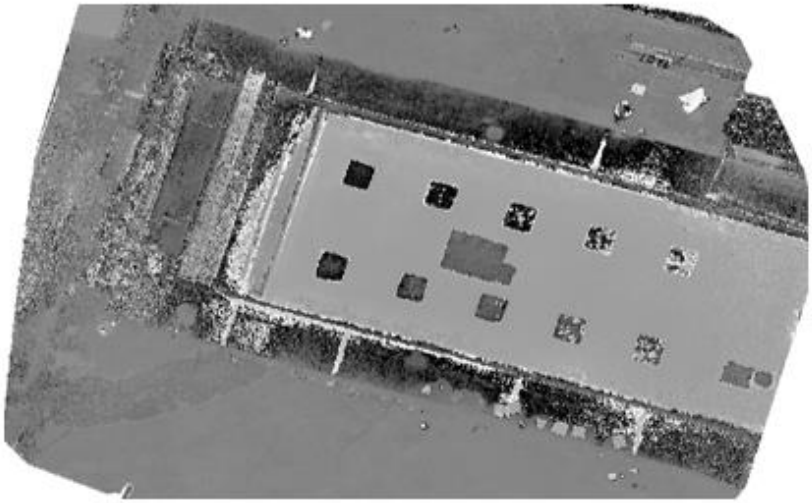

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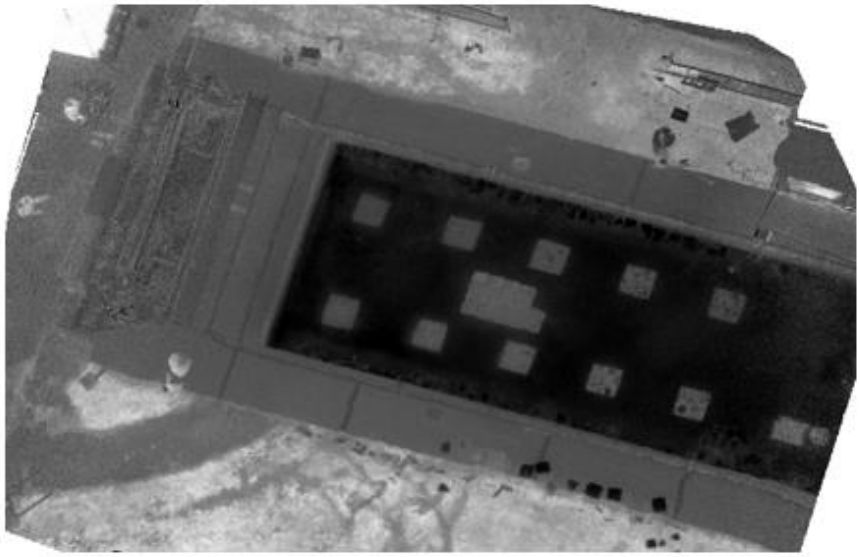

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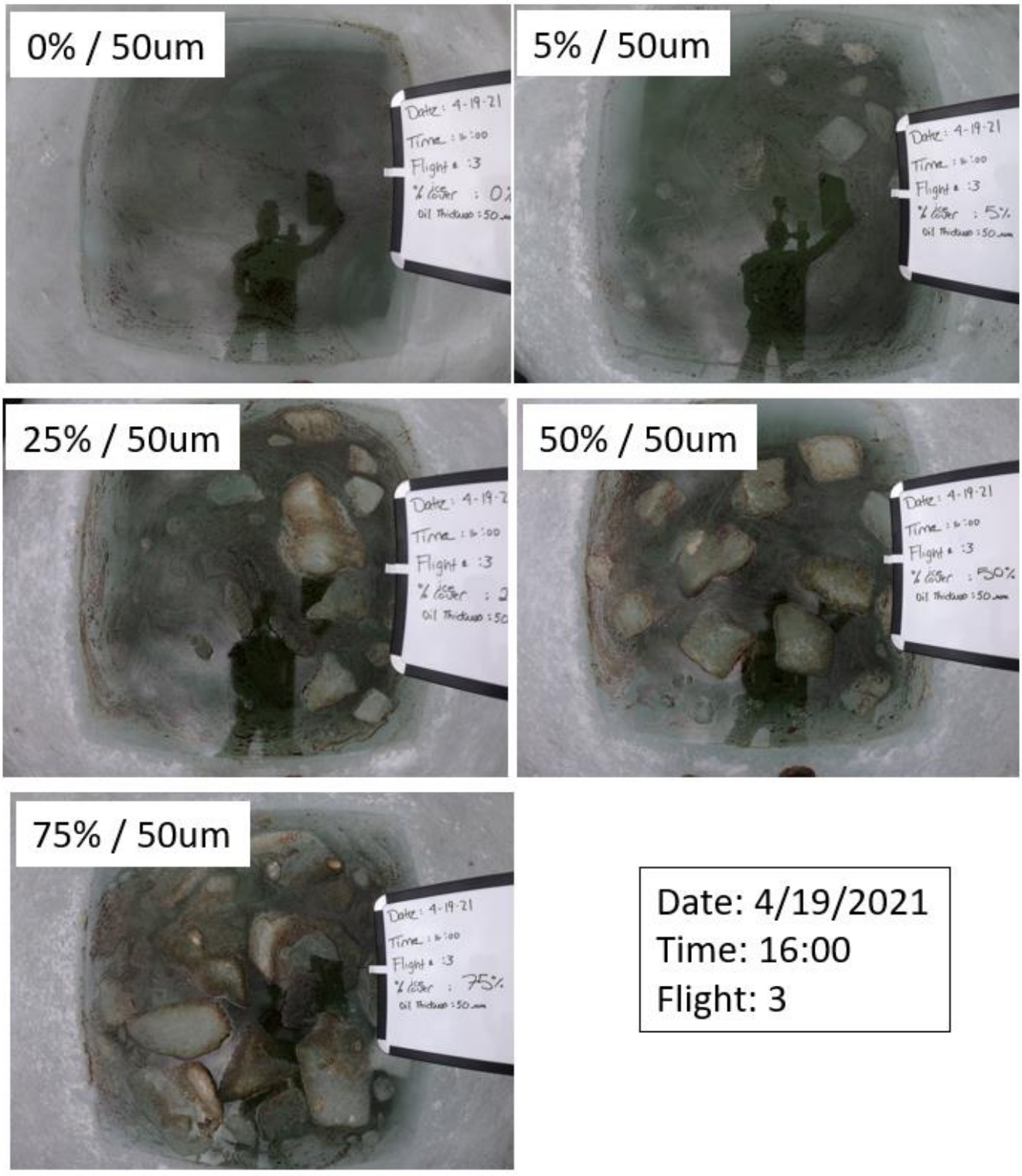

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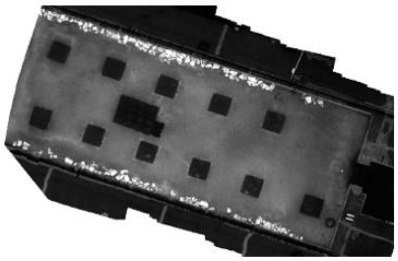

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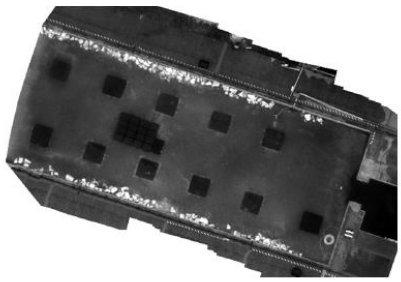
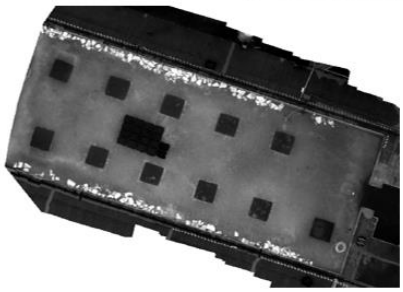


560nm



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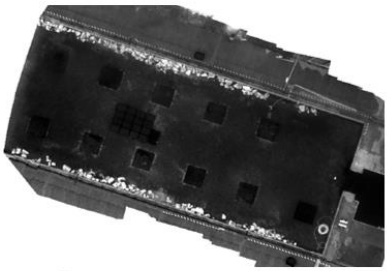

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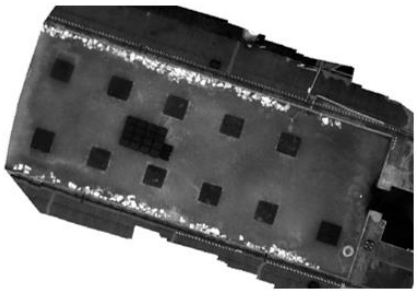

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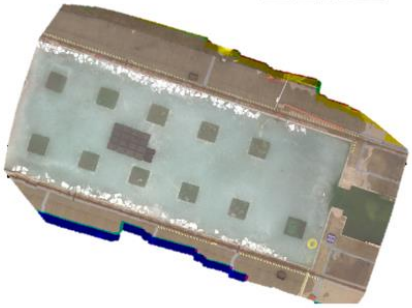

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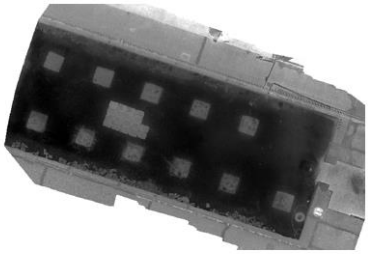

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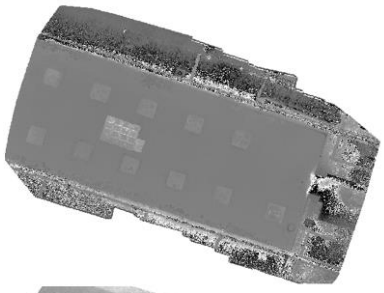

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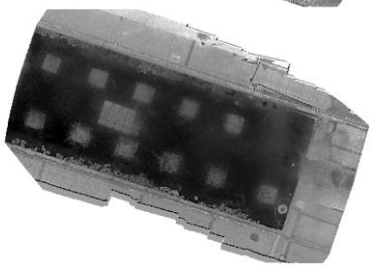

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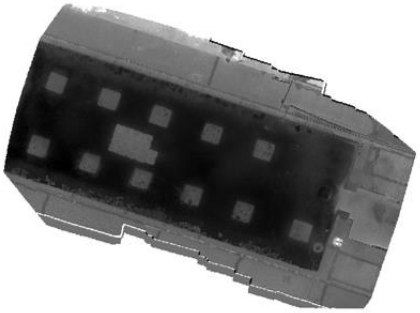

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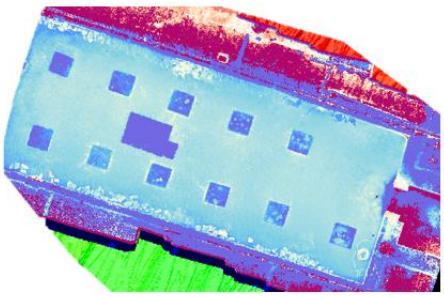

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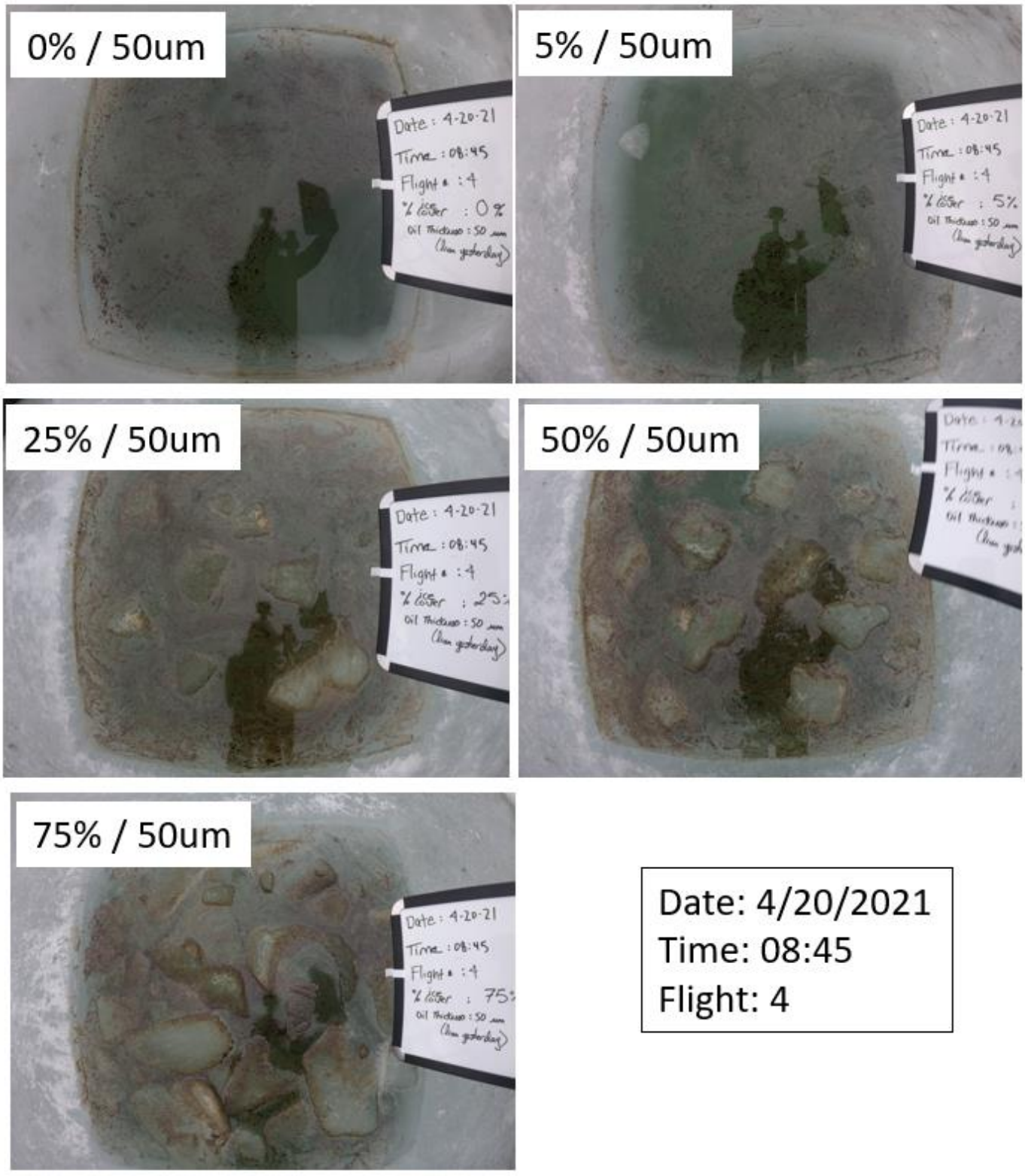

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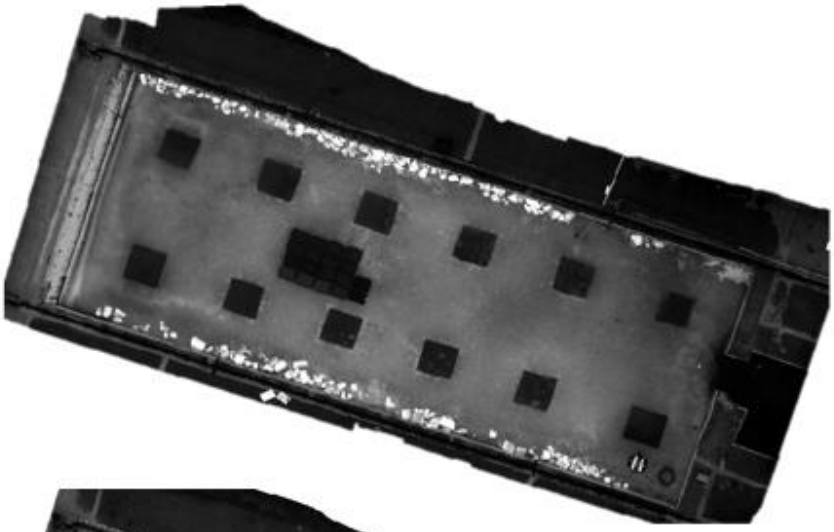
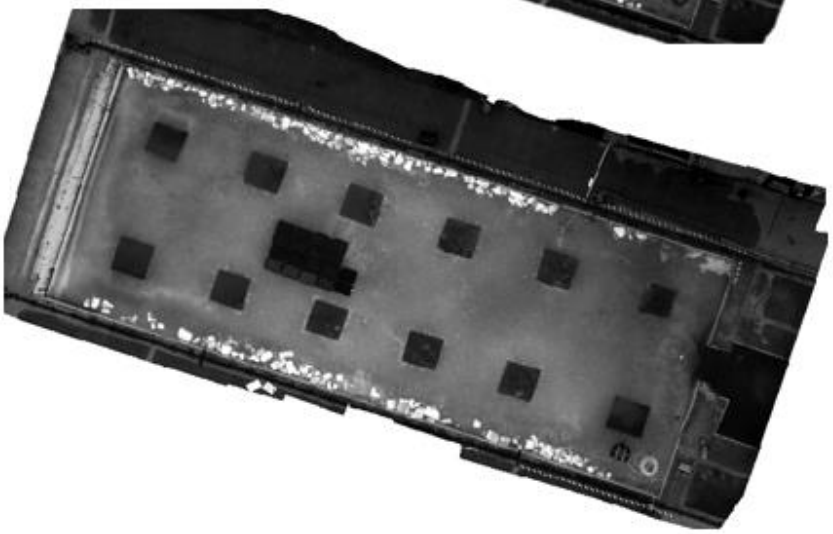
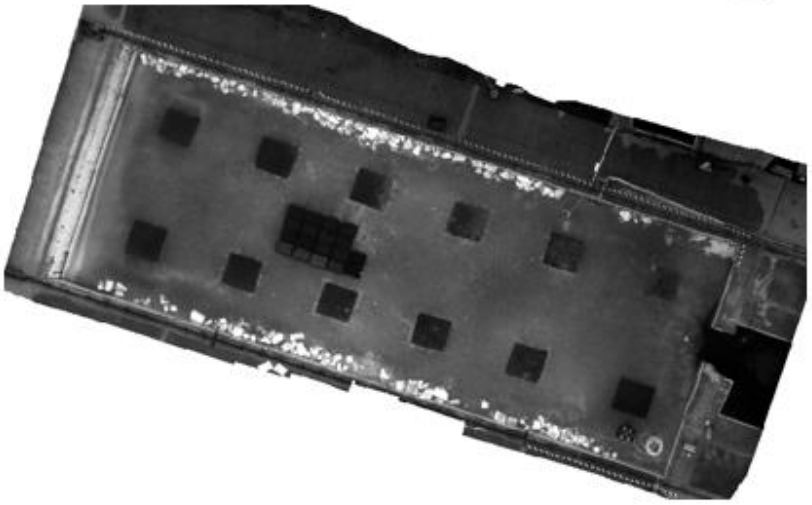


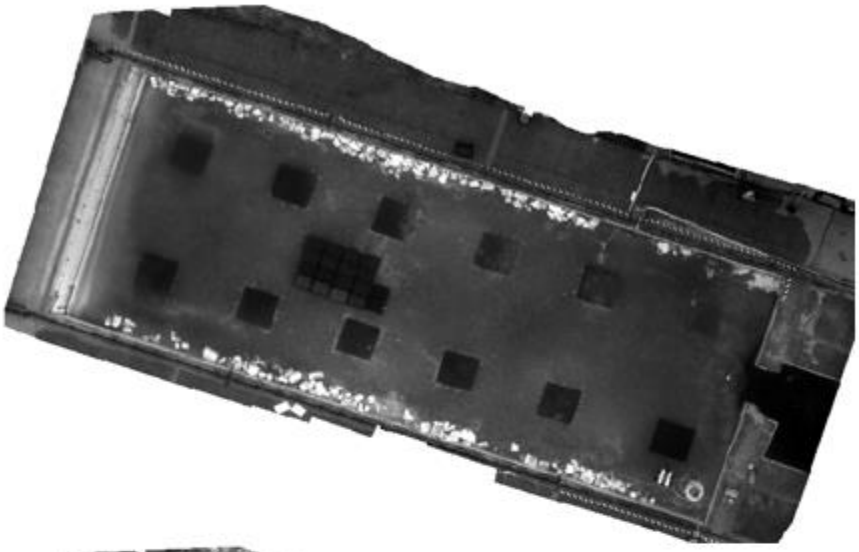
560nm



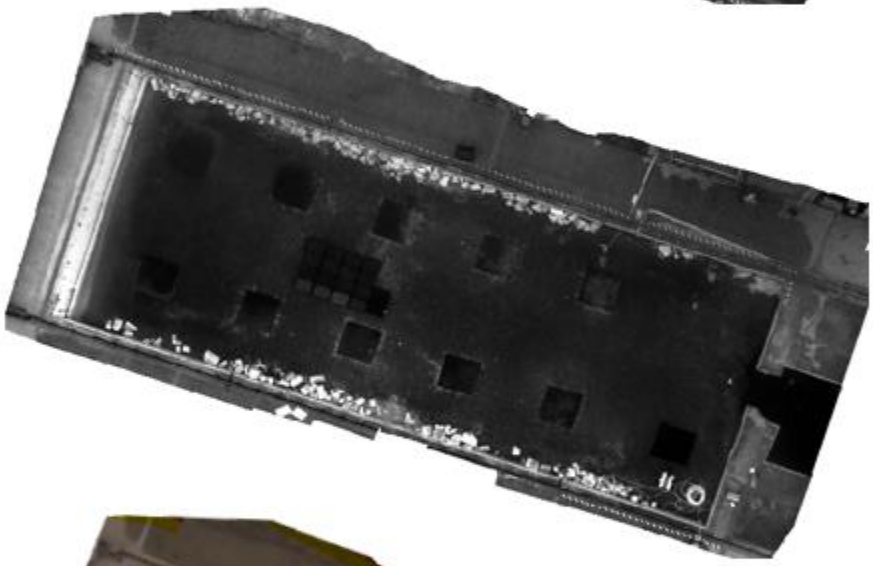
668 nm



Red Edge (717 nm)



Near IR (840 nm)



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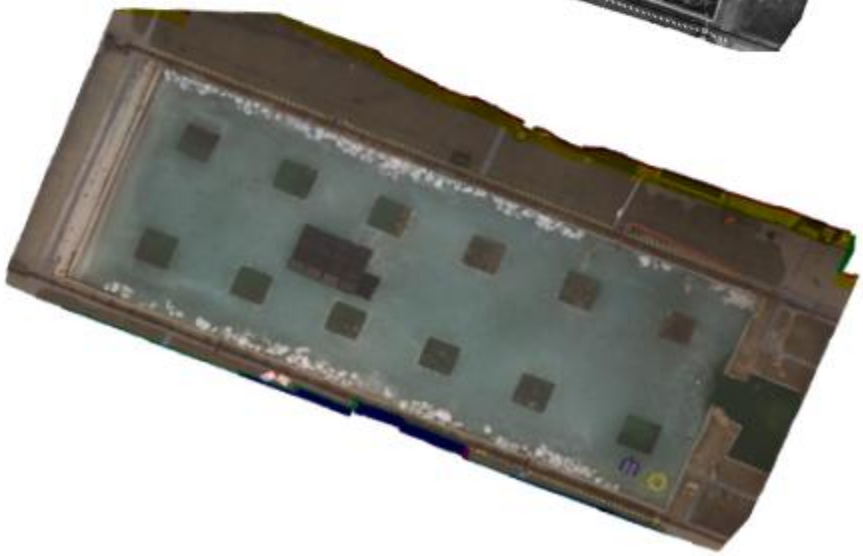

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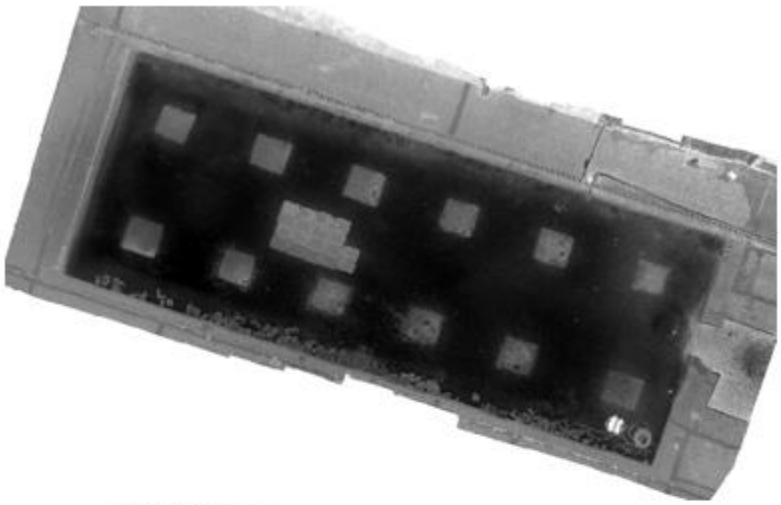
NDVI



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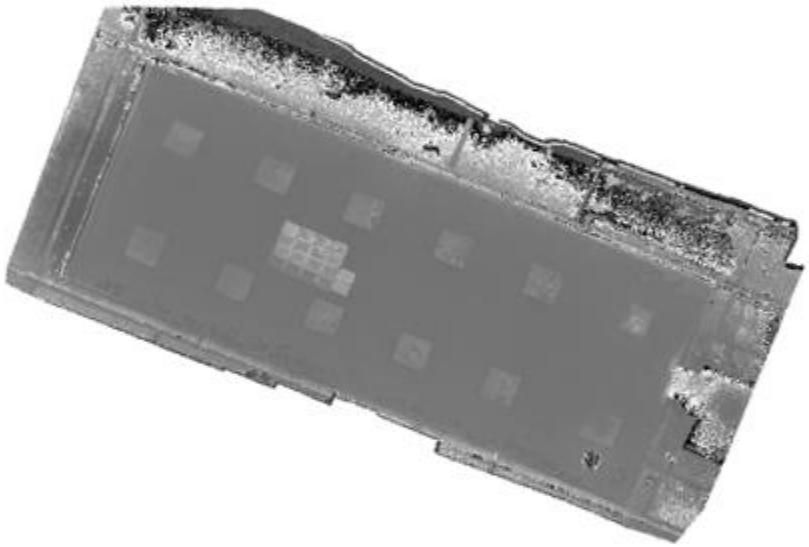

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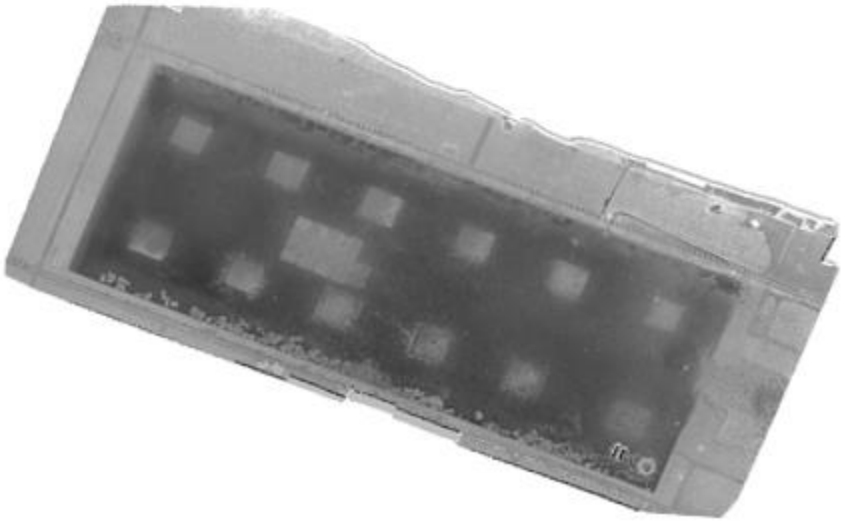

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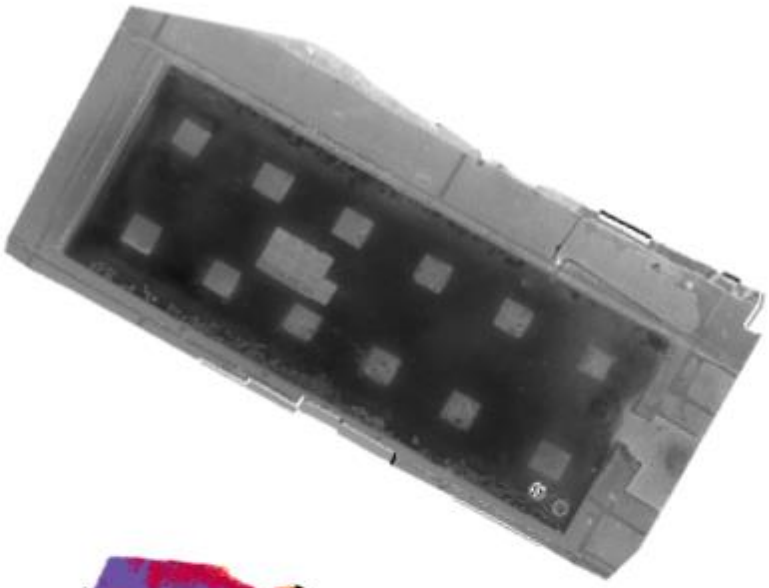

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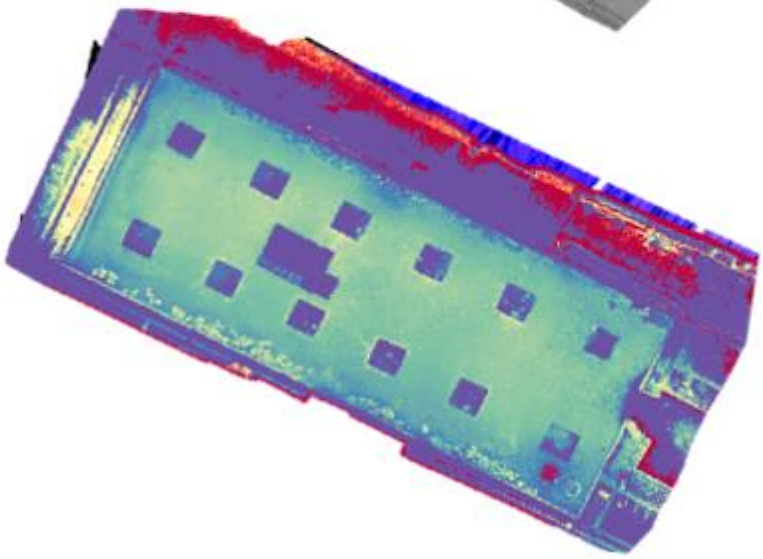
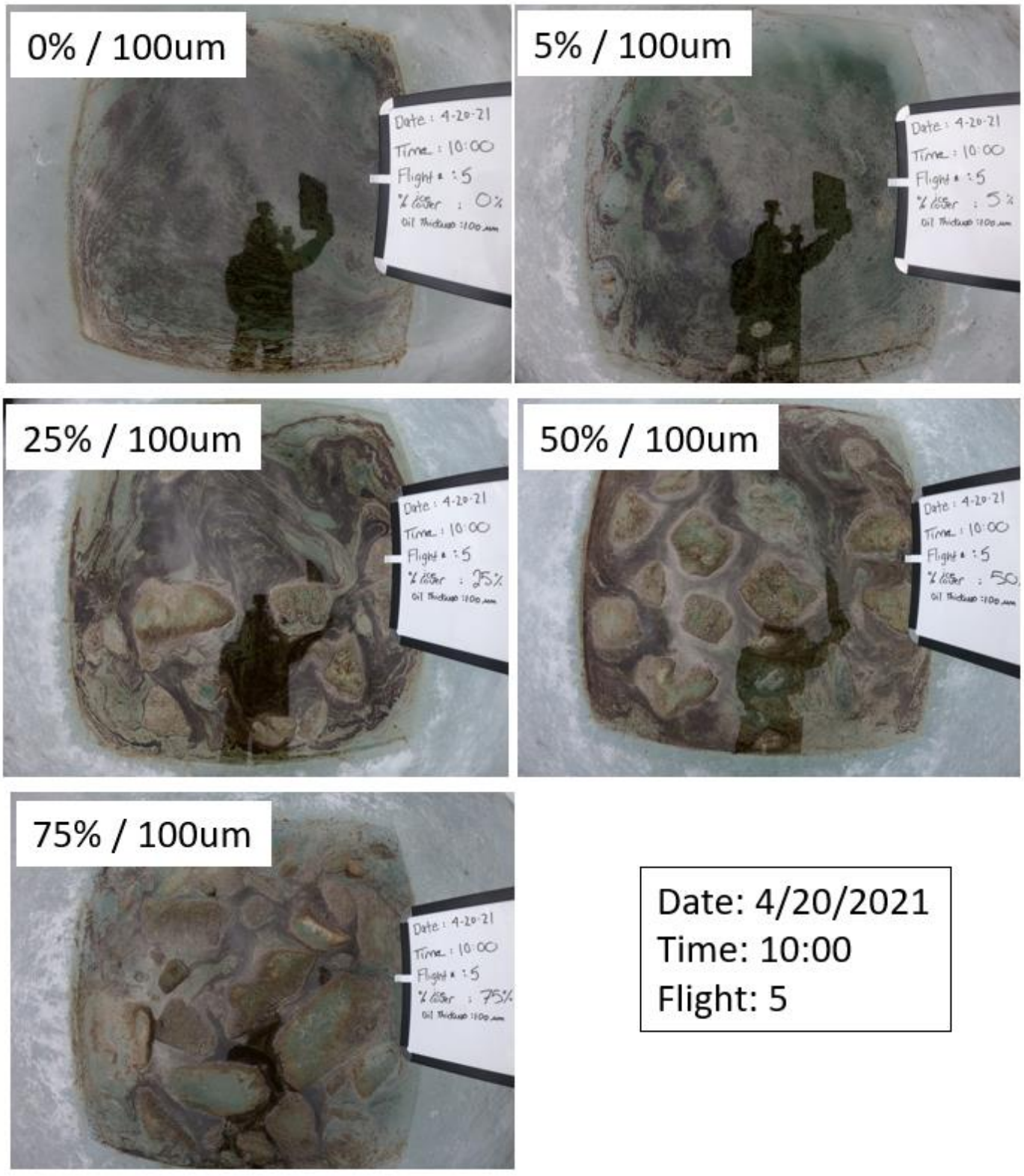
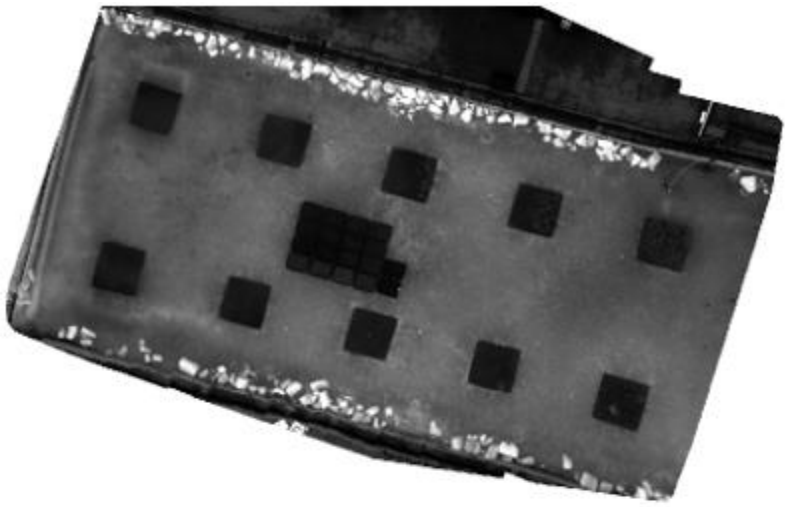


1.9 04/20/2021 Flight # 5 Ground Level Observations

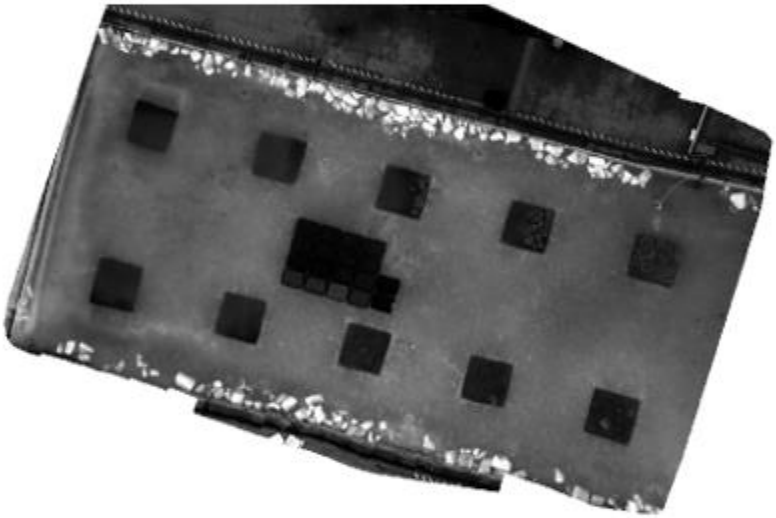


1.10 04/20/2021 Flight # 6 Raw Data

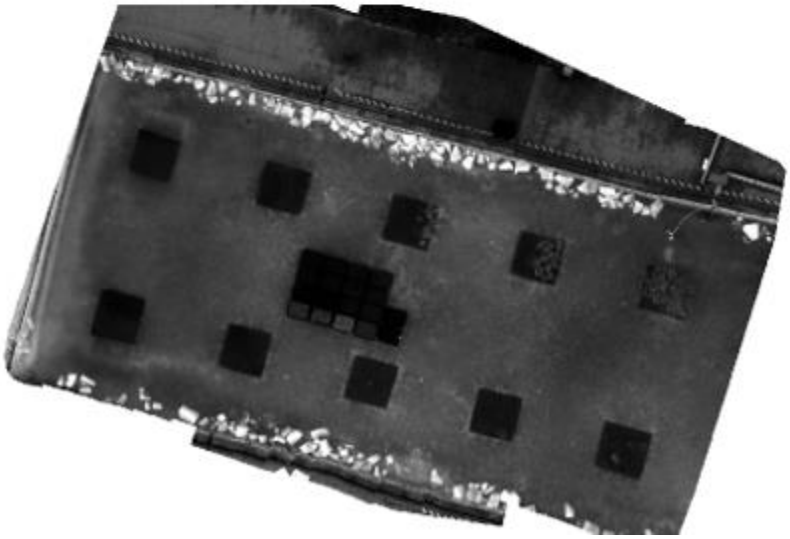
UV (475 nm)



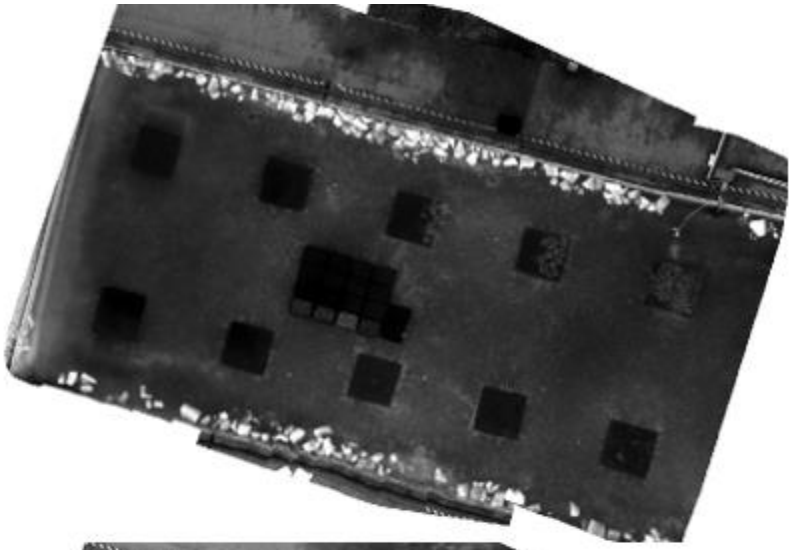
560nm



668 nm



Red Edge (717 nm)



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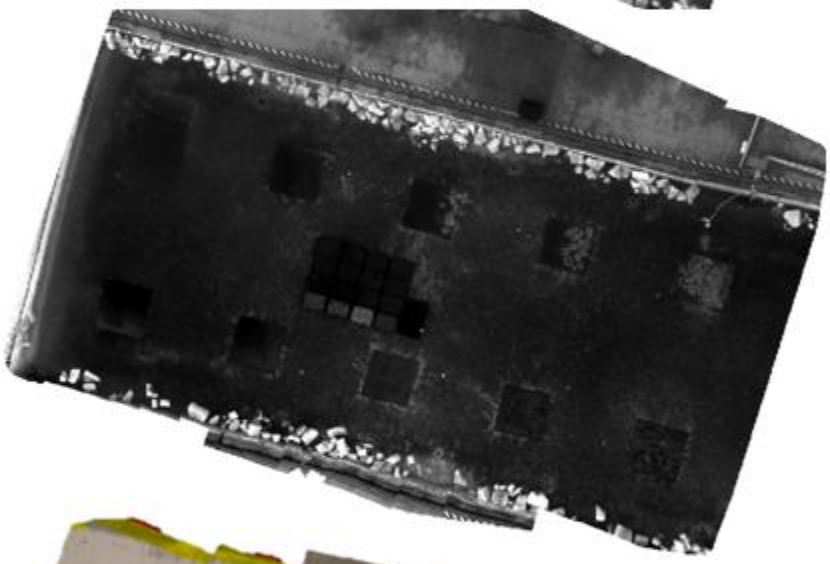

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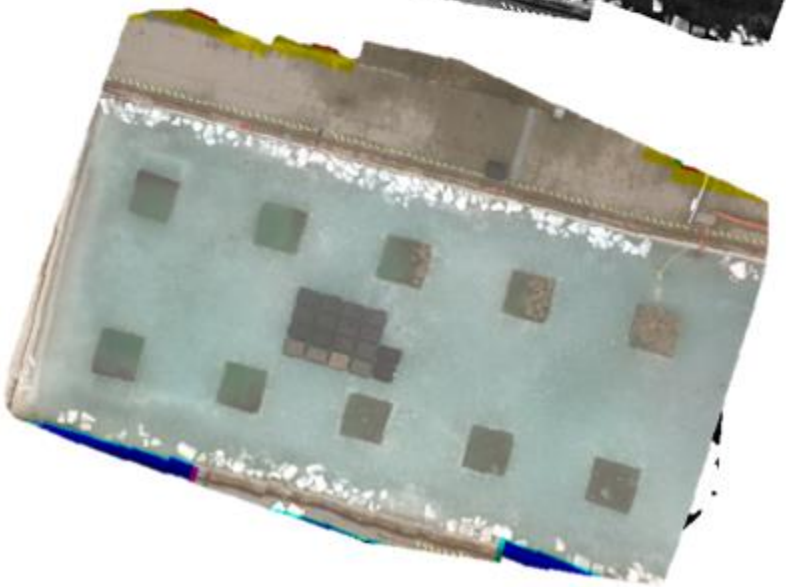
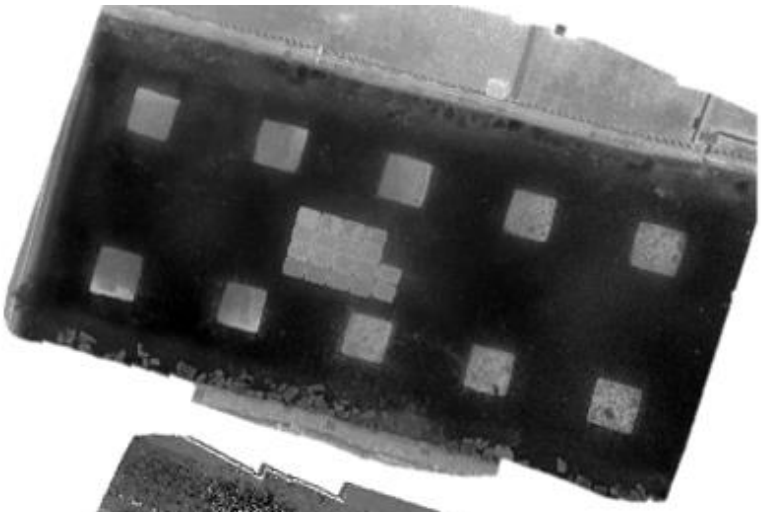


1.11 04/20/2021 Flight # 6 Data Products

NDVI



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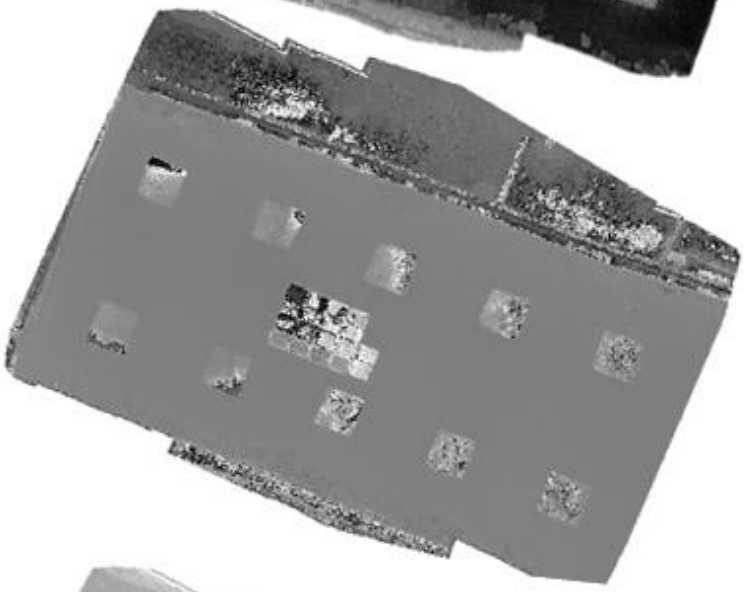

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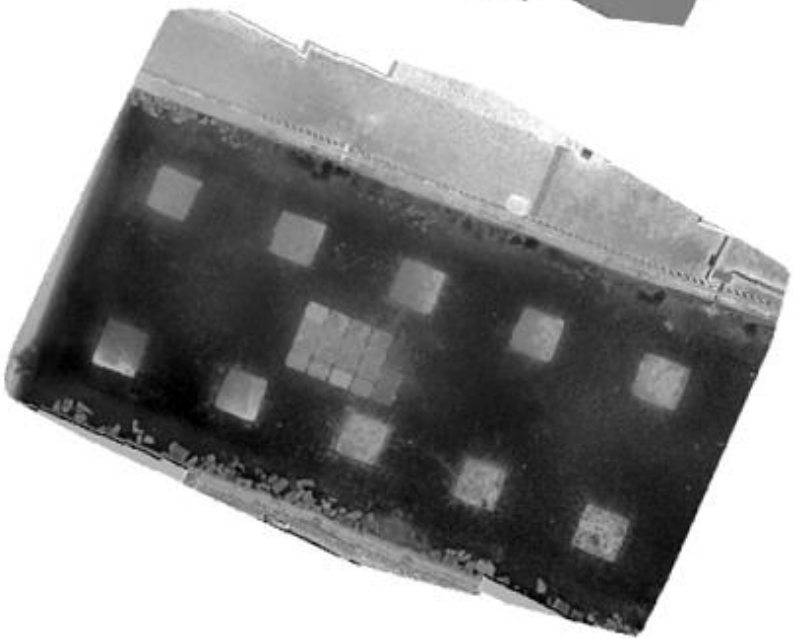

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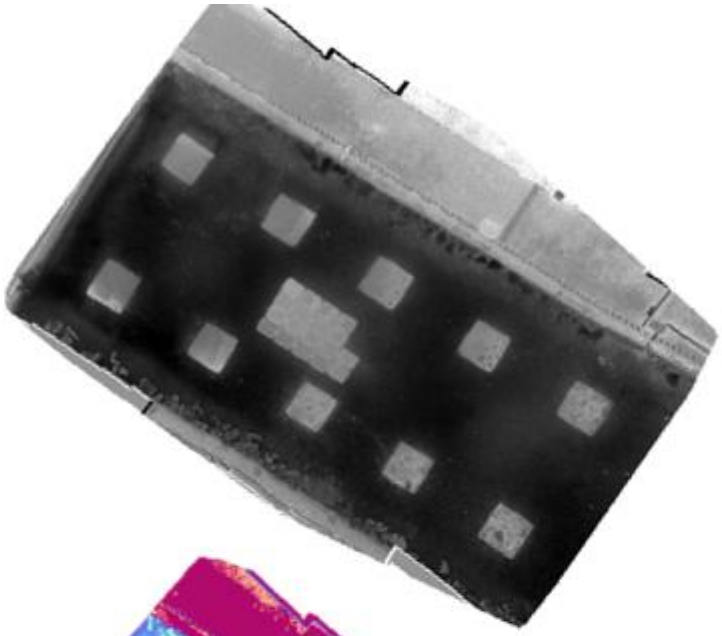

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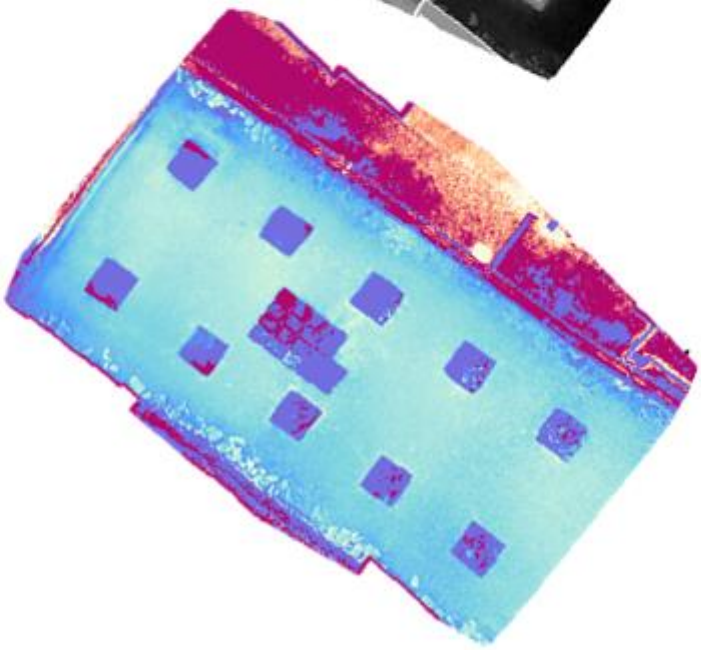
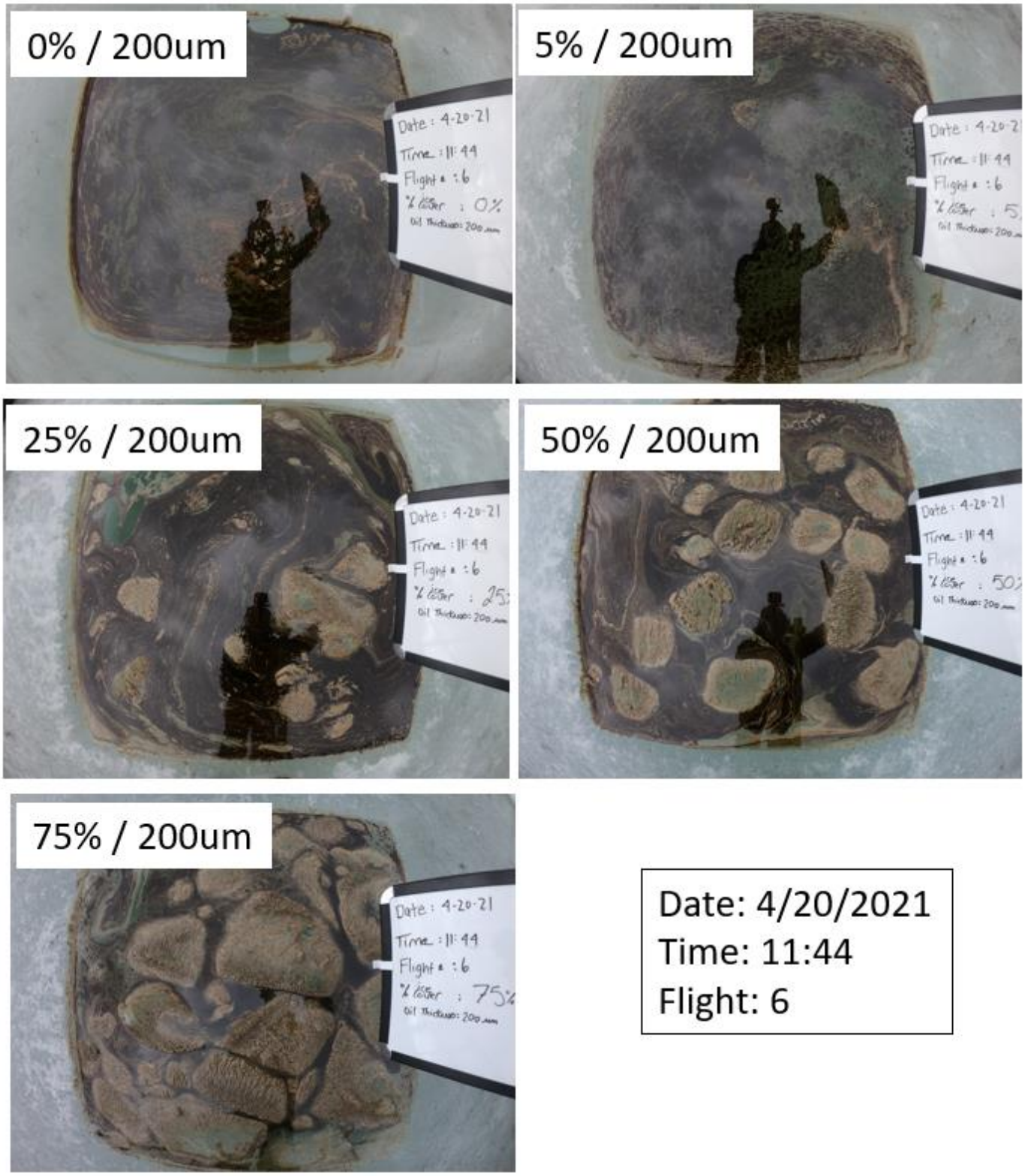
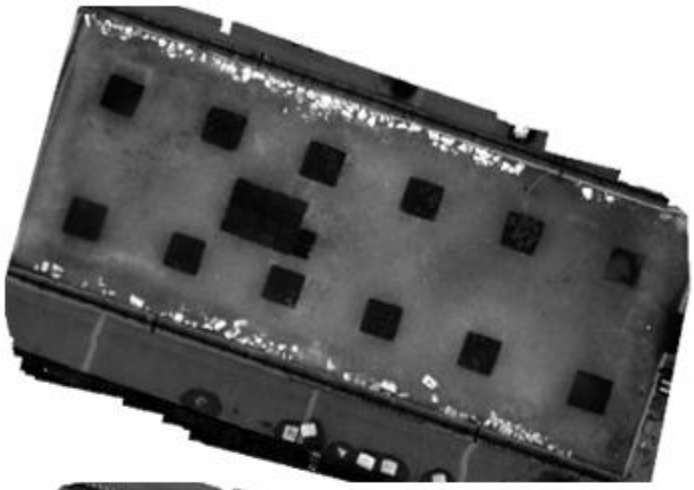


1.12 04/20/2021 Flight # 6 Ground Level Observations

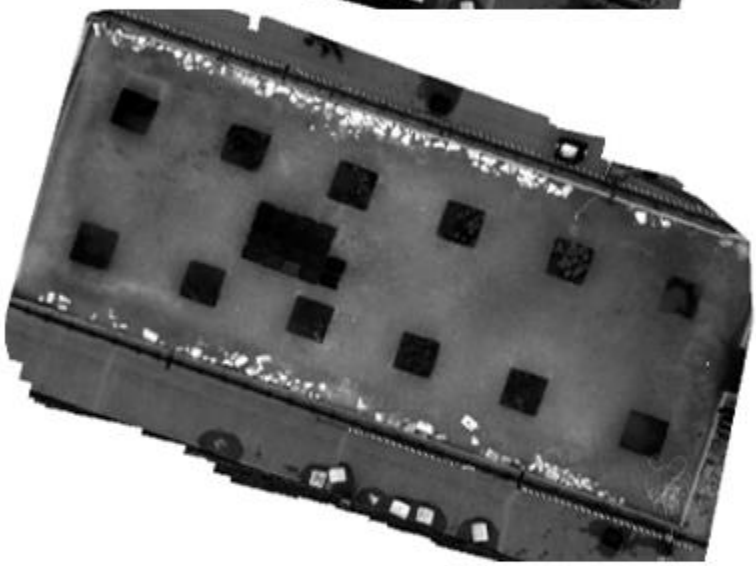


1.13 04/20/2021 Flight # 7 Raw Data

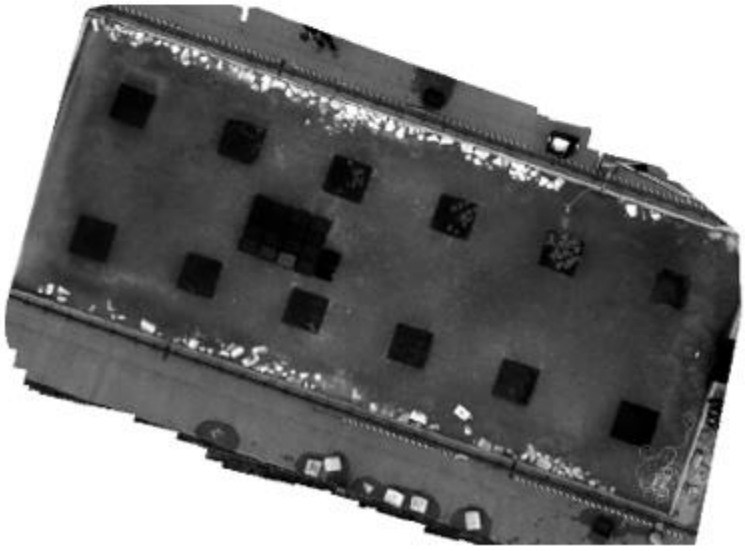
UV (475 nm)



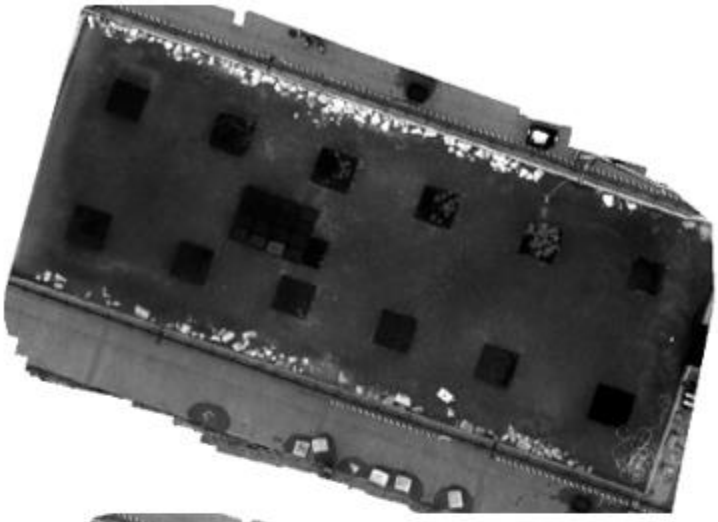
560nm



668 nm



Red Edge (717 nm)



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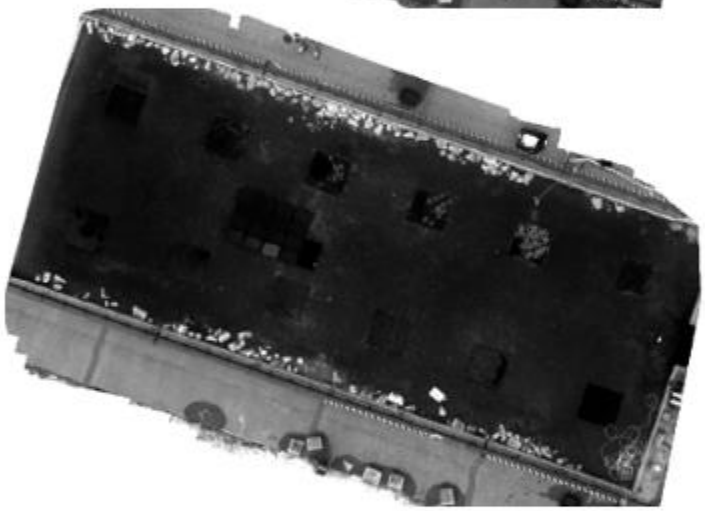
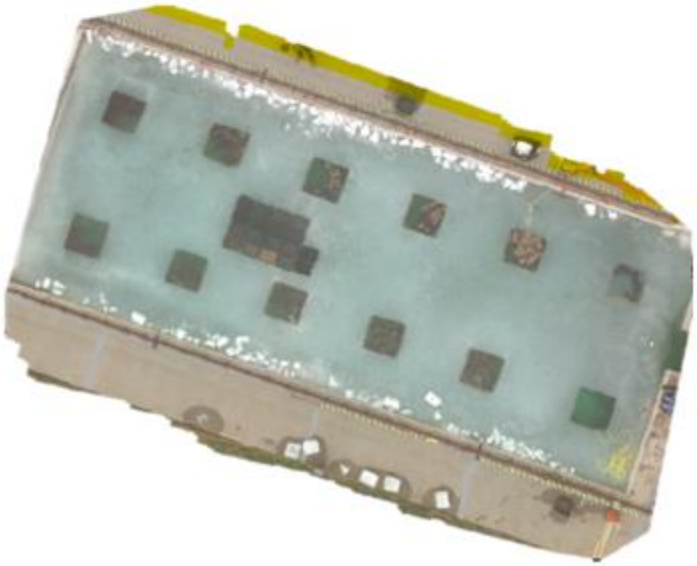
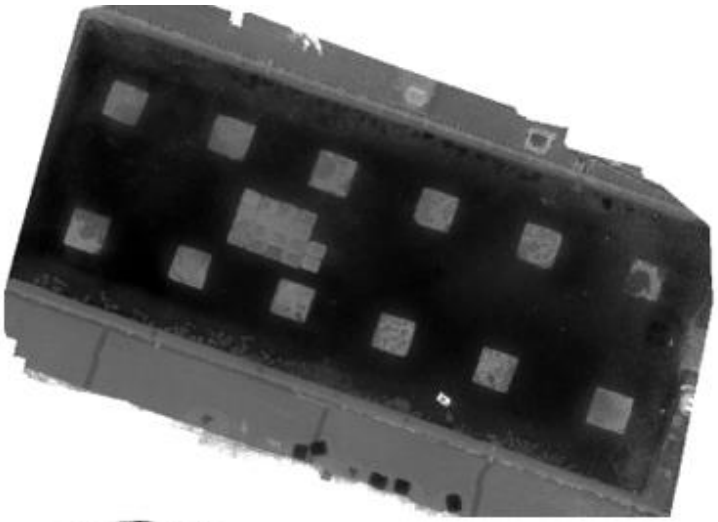


RGB

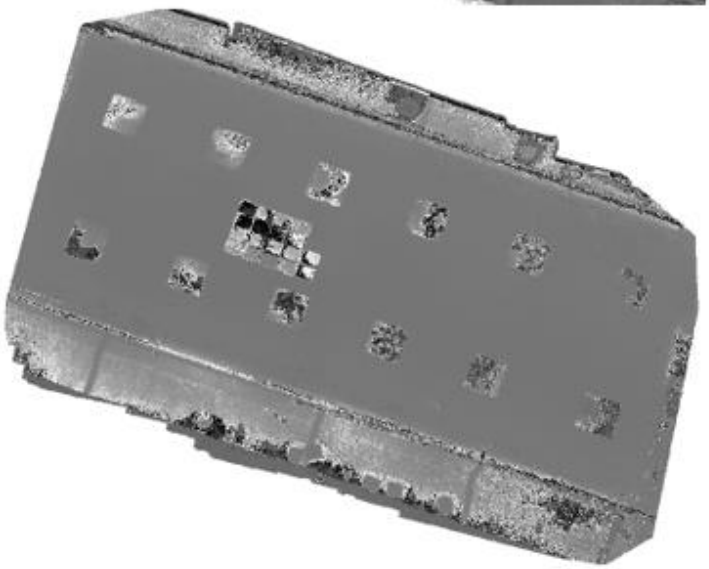


1.14 04/20/2021 Flight # 7 Data Products

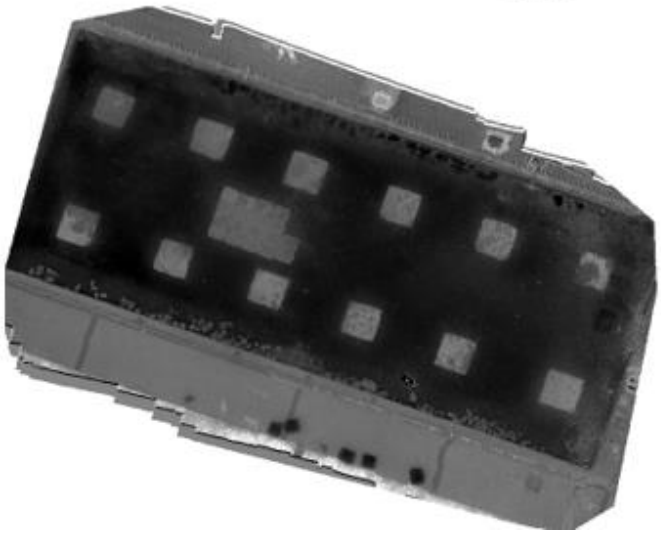
NDVI



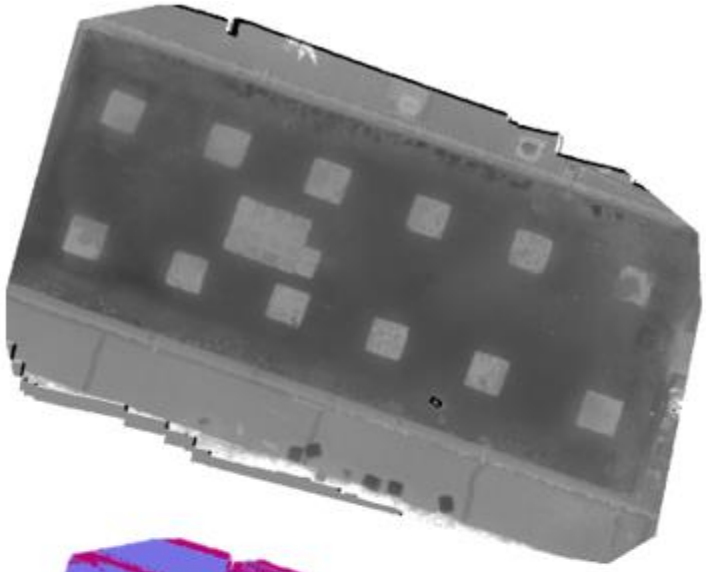
MSCI



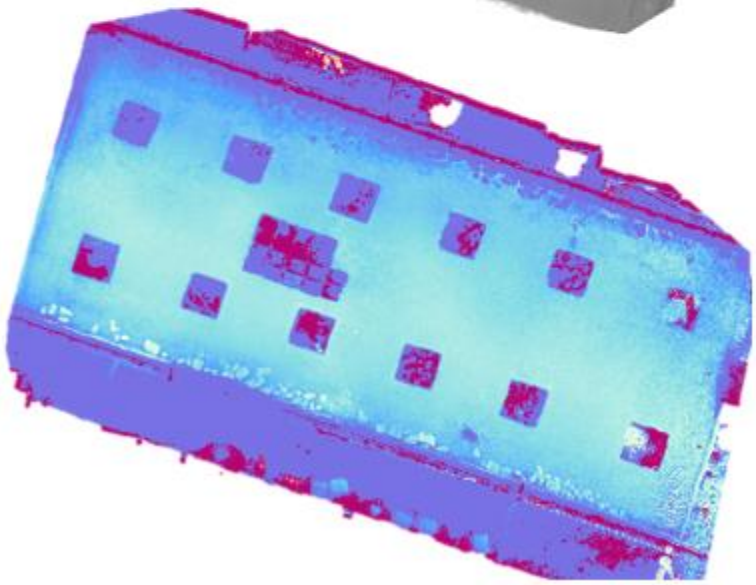
NDRE



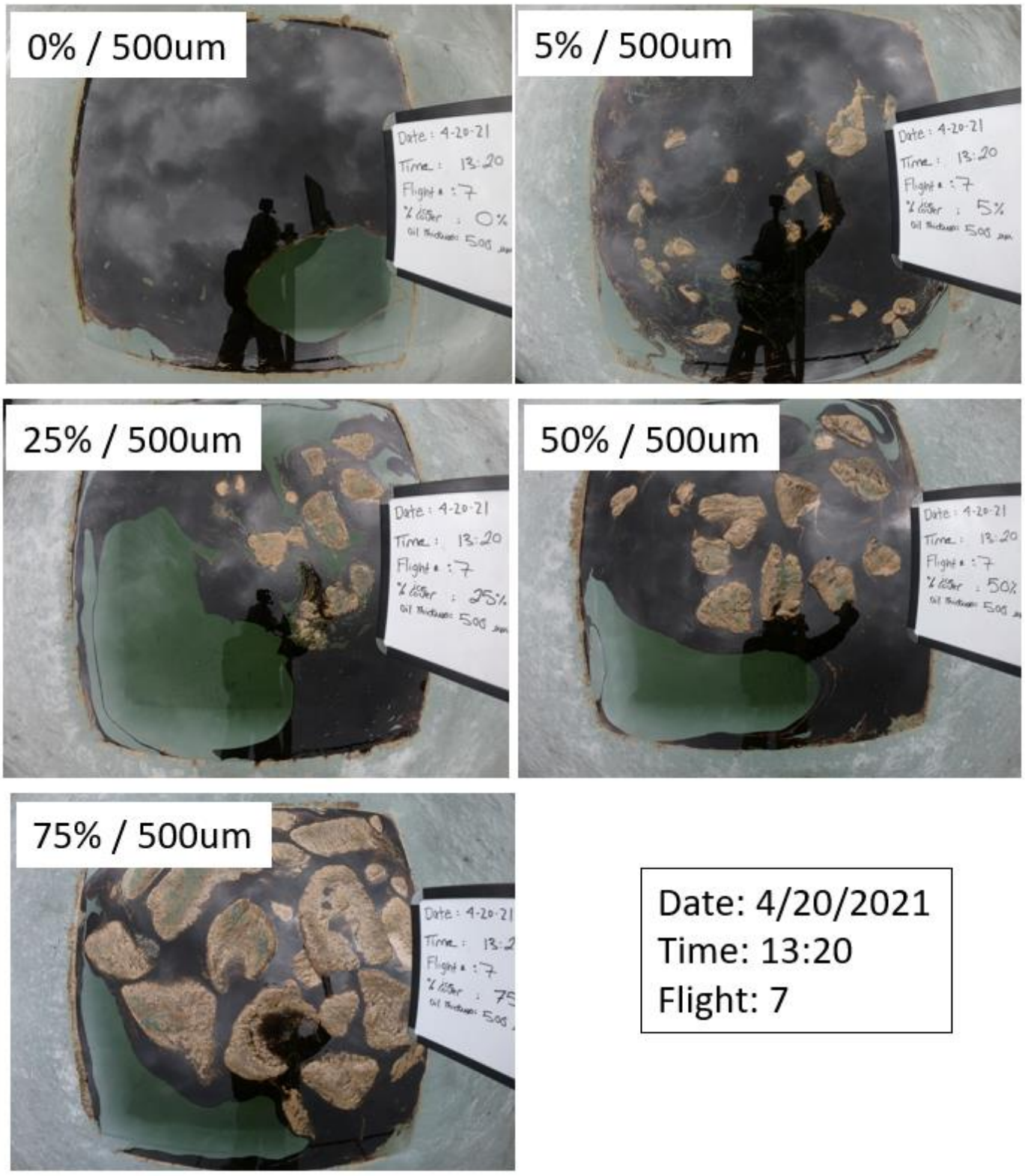
OSAVI



DSM

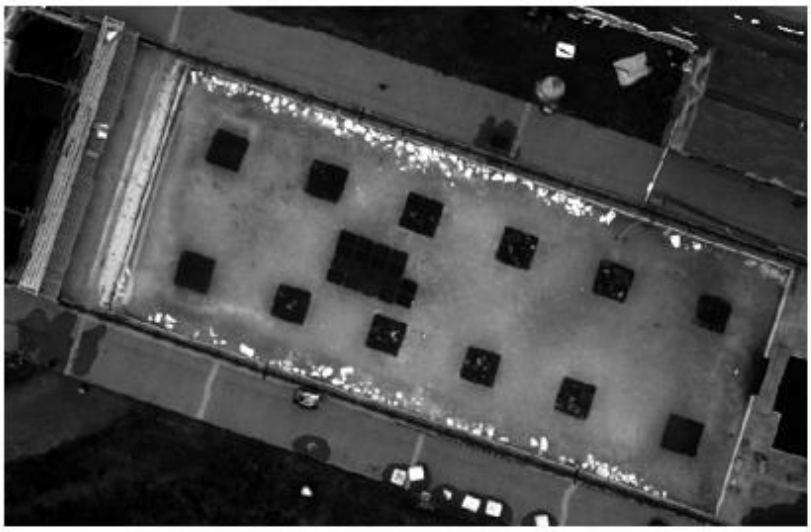


1.15 04/20/2021 Flight # 7 Ground Level Observations

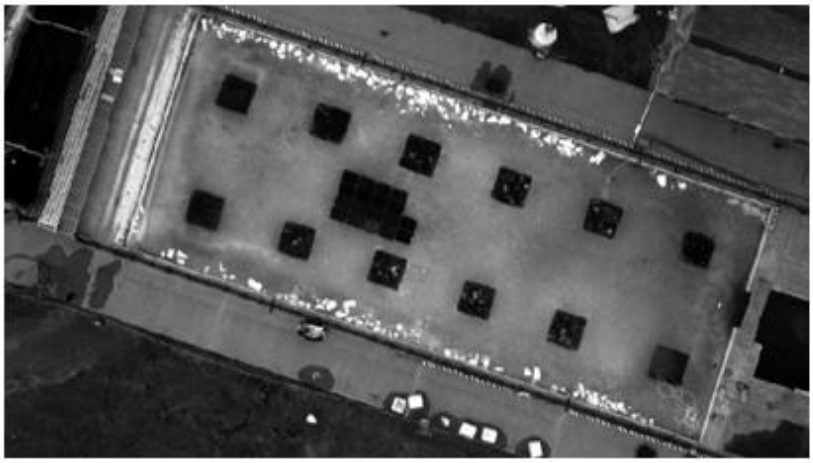


1.16 04/20/2021 Flight # 8 Raw Data

UV (475 nm)



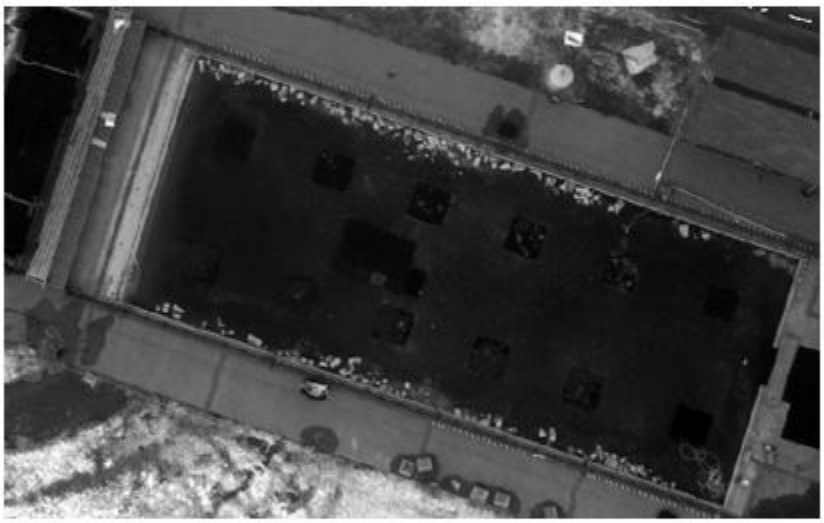
560nm



668 nm

Red Edge (717 nm)

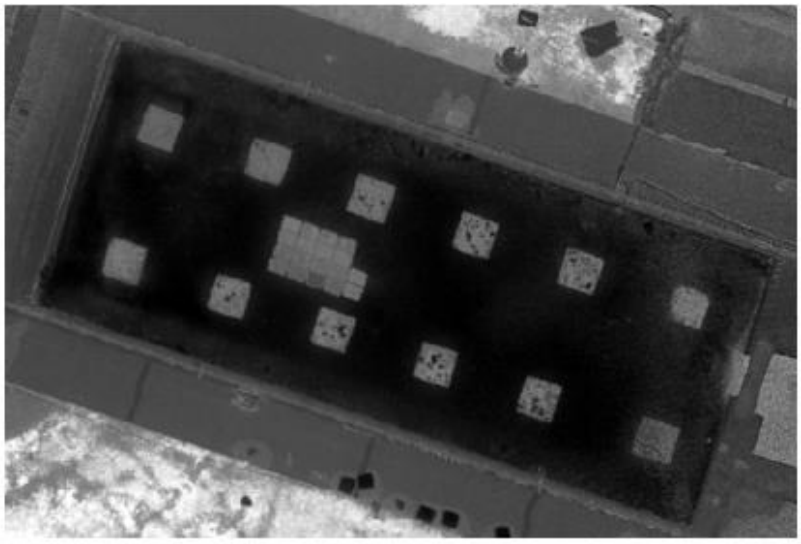
Near IR (840 nm)



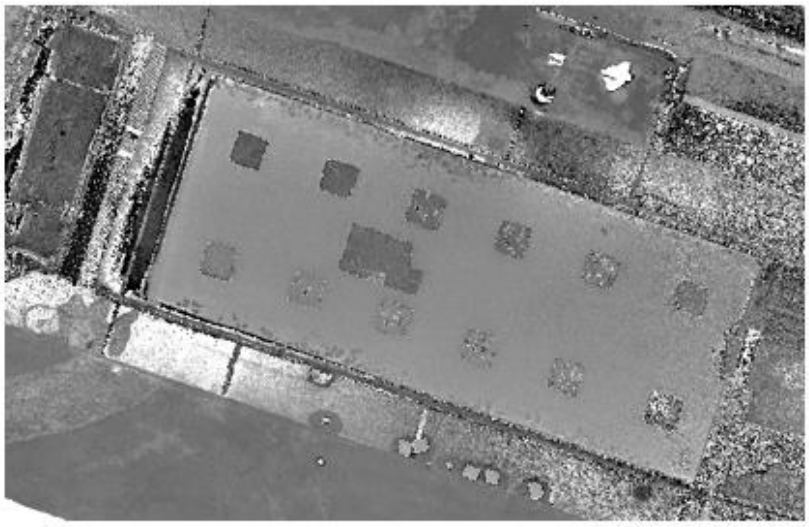
RGB

1.17 04/20/2021 Flight # 8 Data Products

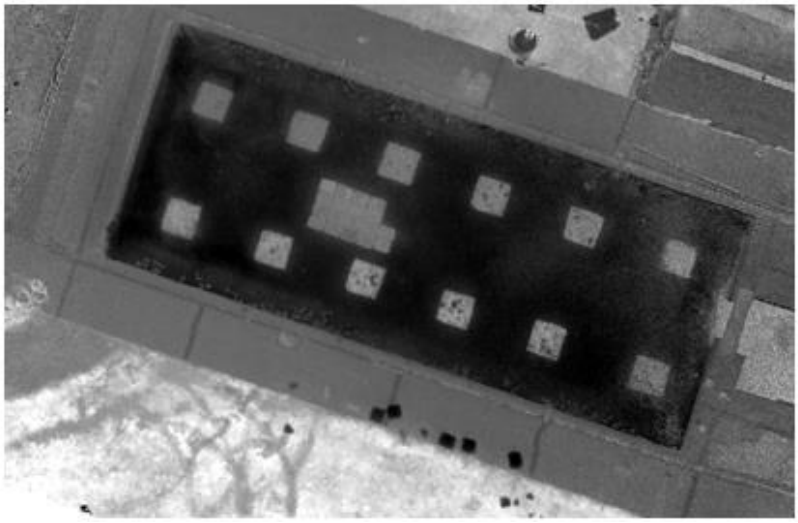
NDVI



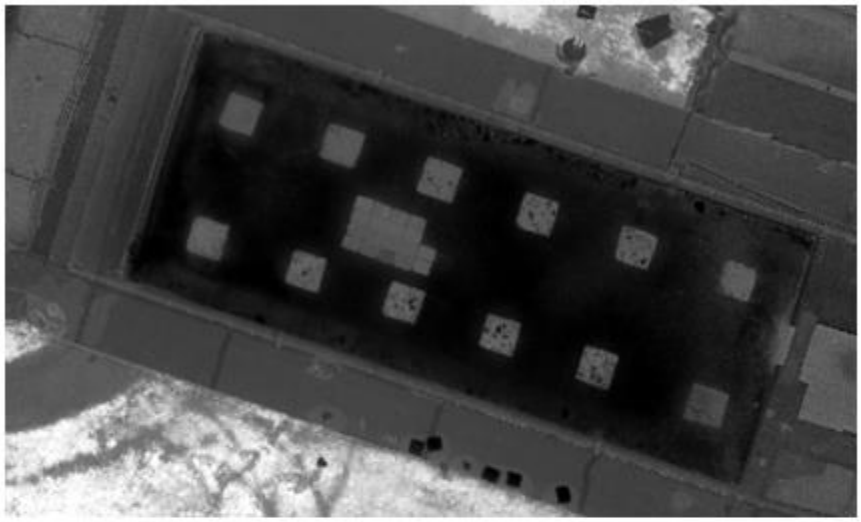
MSCI



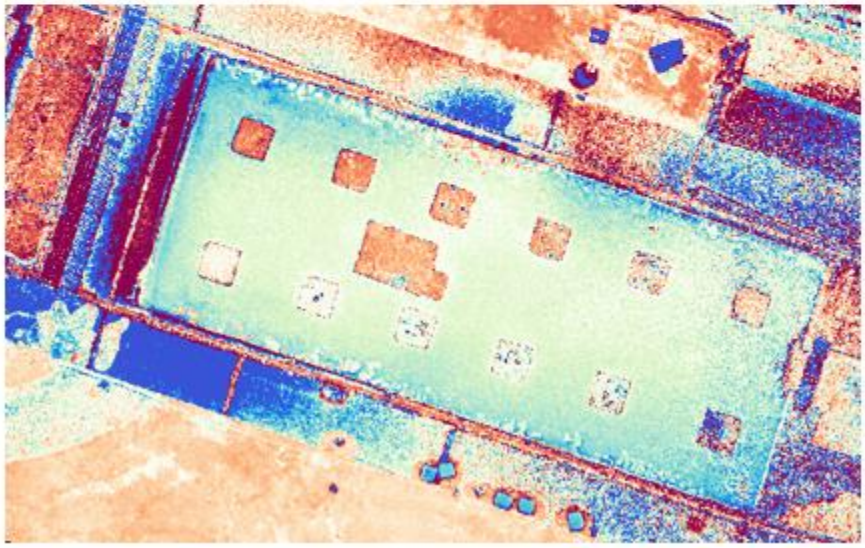
NDRE



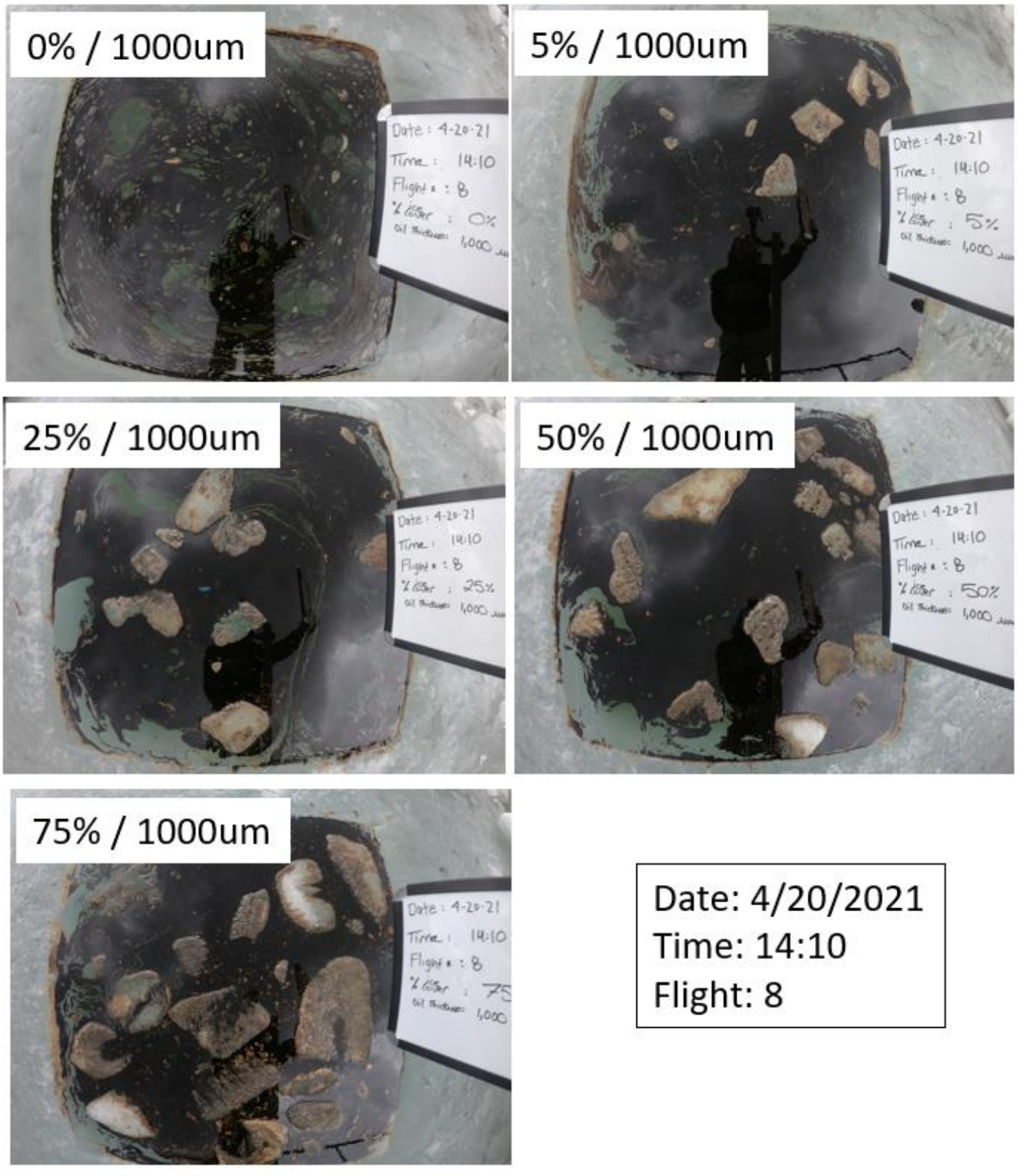
OSAVI



DSM

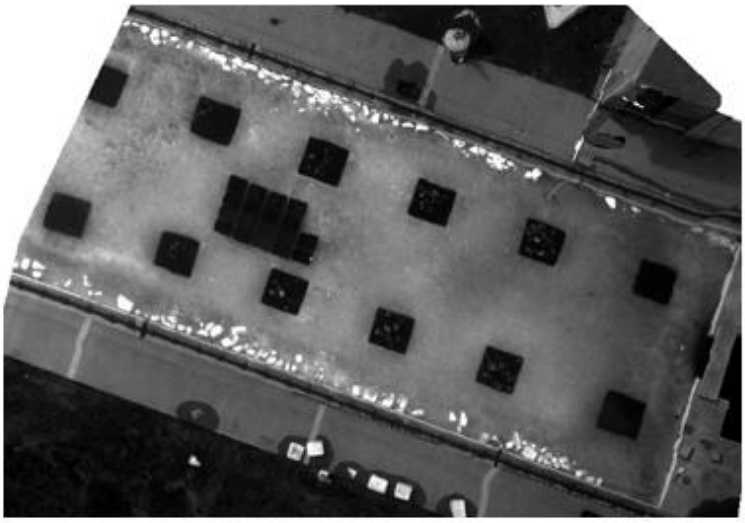


1.18 04/20/2021 Flight # 8 Ground Level Observations

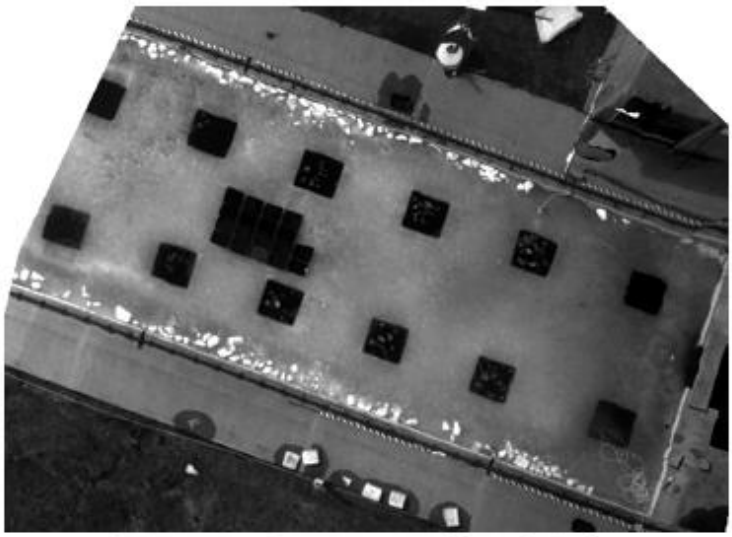


1.19 04/20/2021 Flight # 9 Raw Data

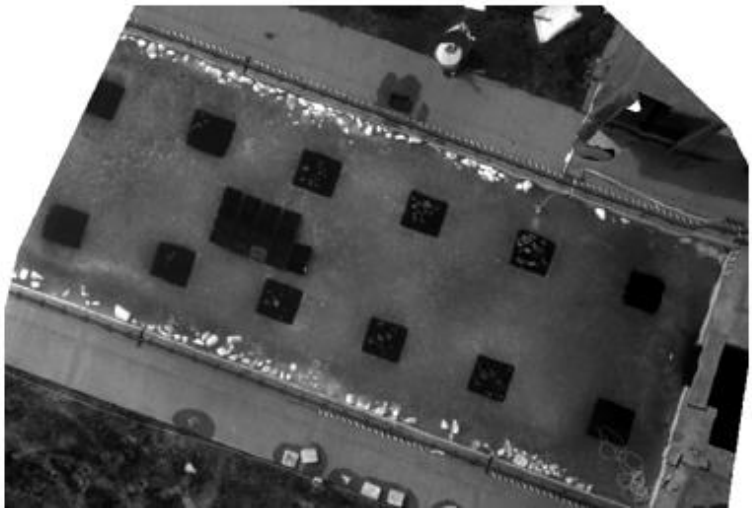
UV (475 nm)



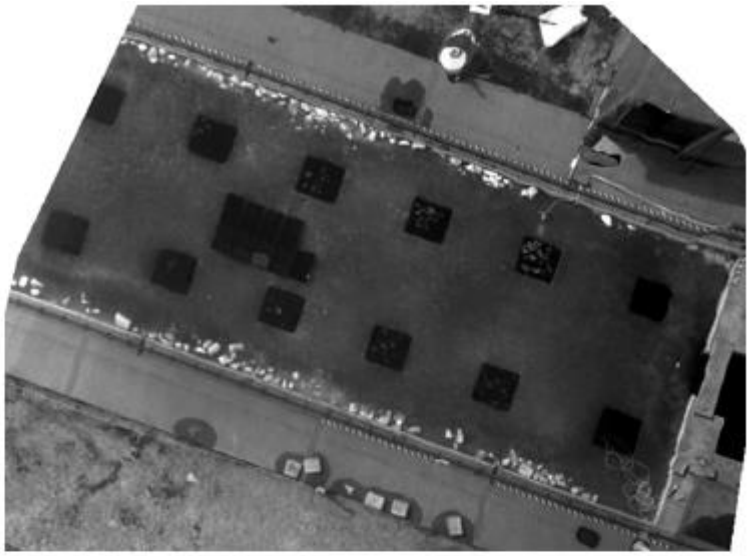
560nm



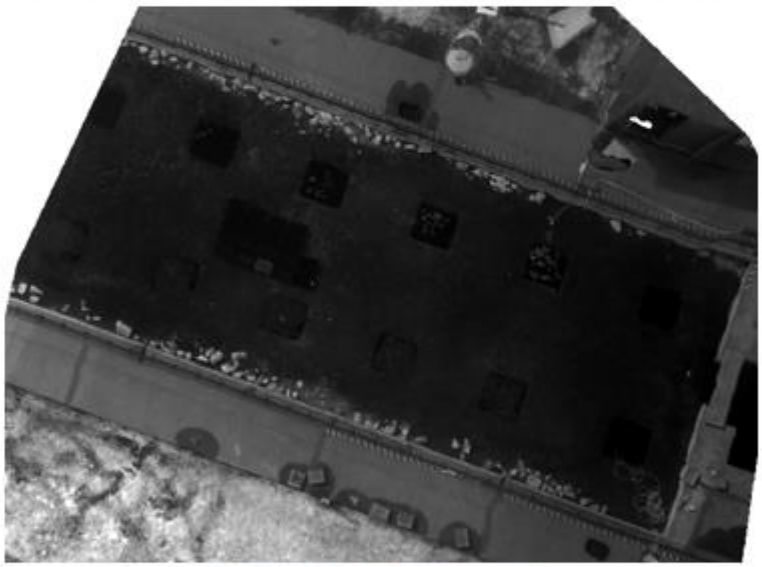
668 nm



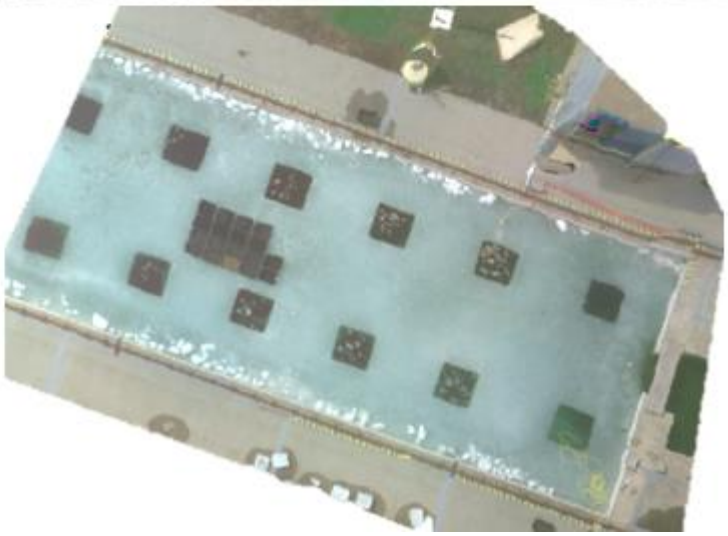
Red Edge (717 nm)



Near IR (840 nm)

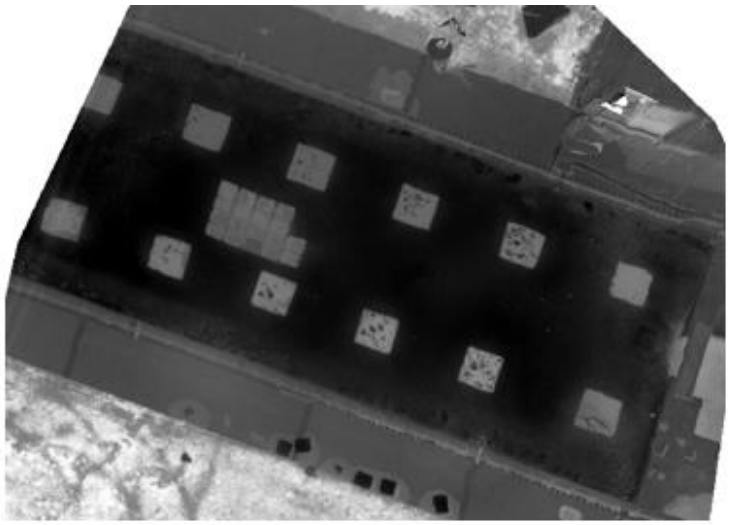


RGB

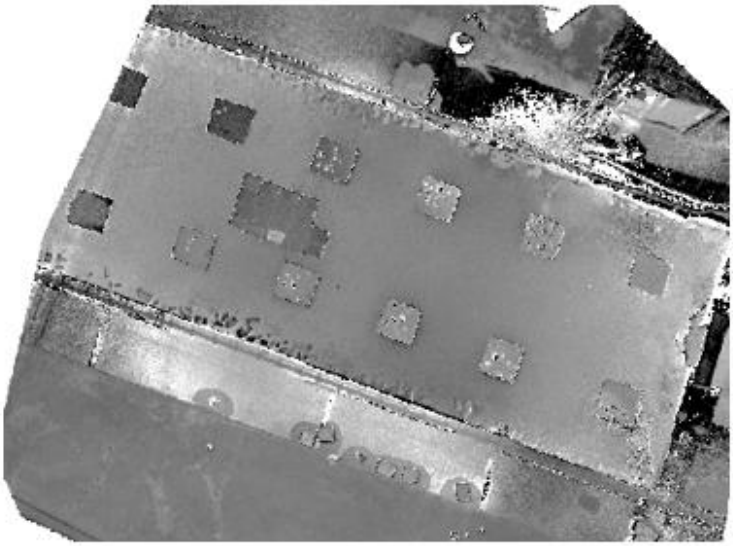


1.20 04/20/2021 Flight # 9 Data Products

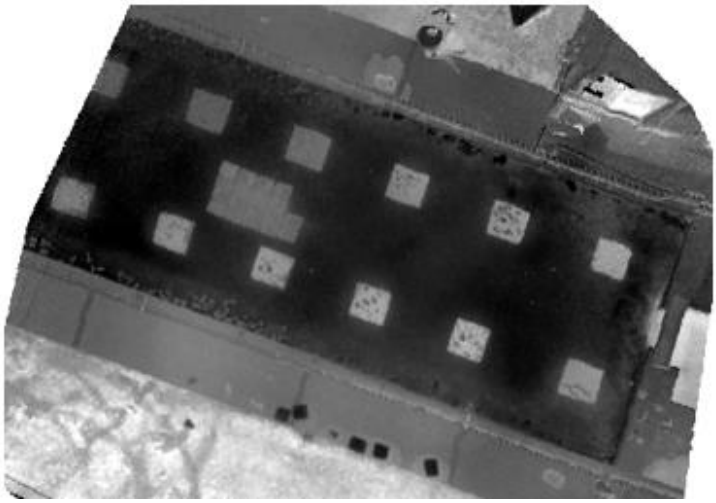
NDVI



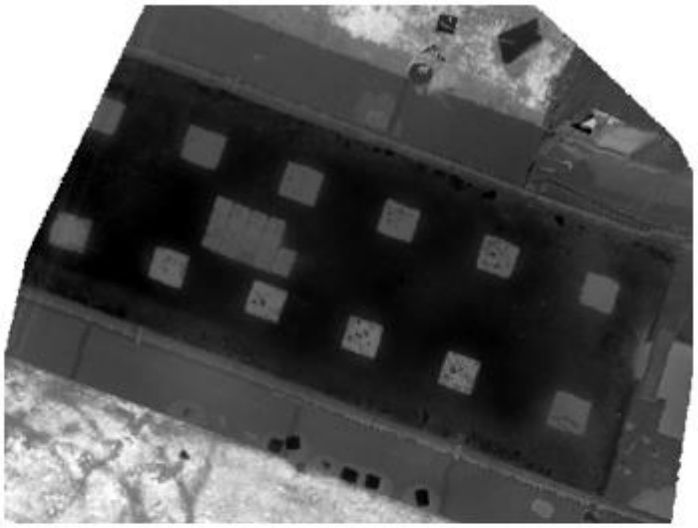
MSCI



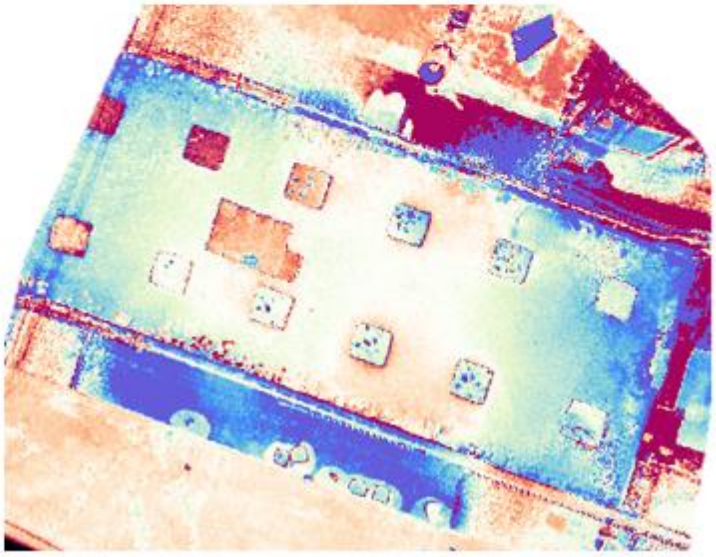
NDRE



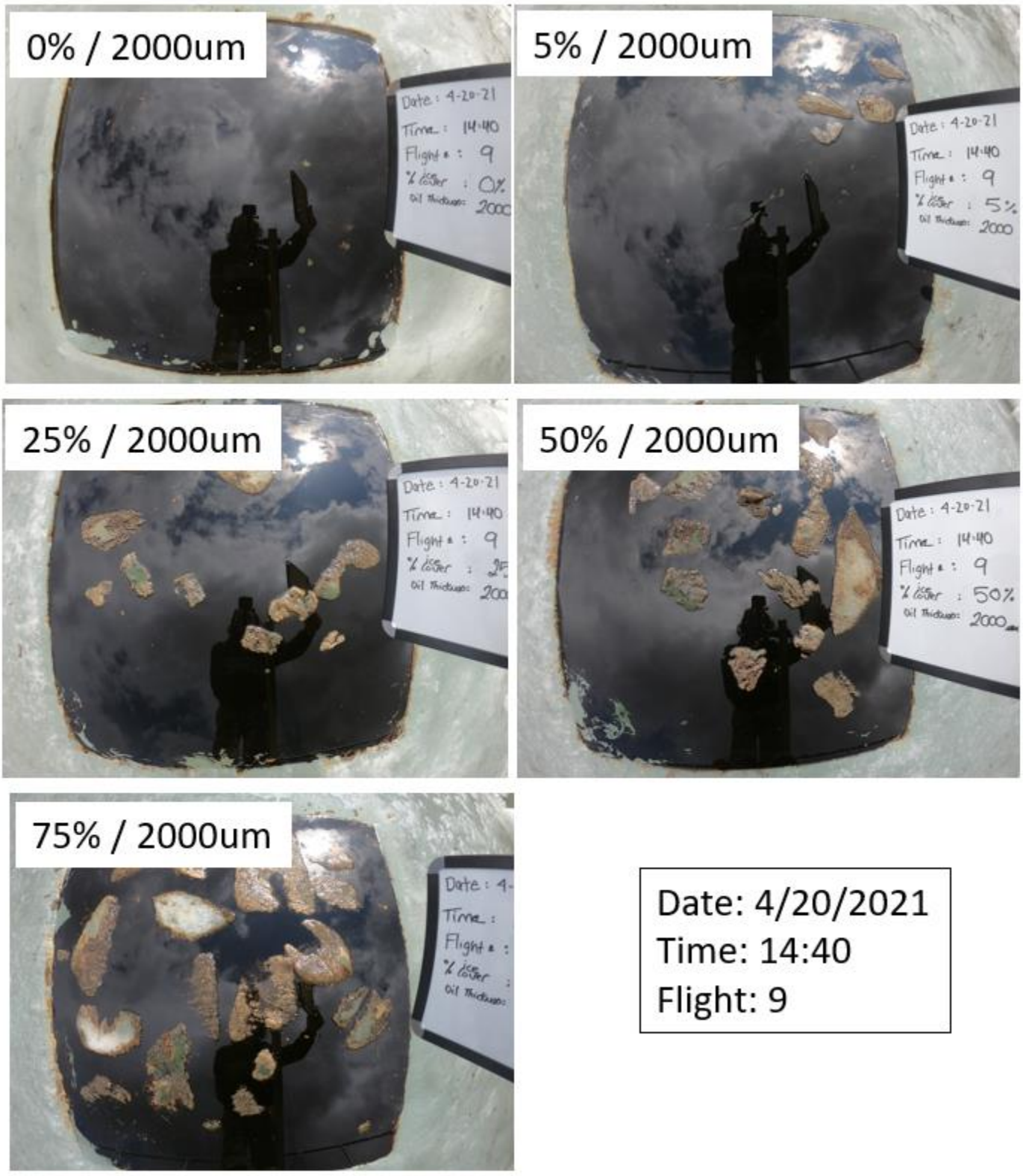
OSAVI



DSM

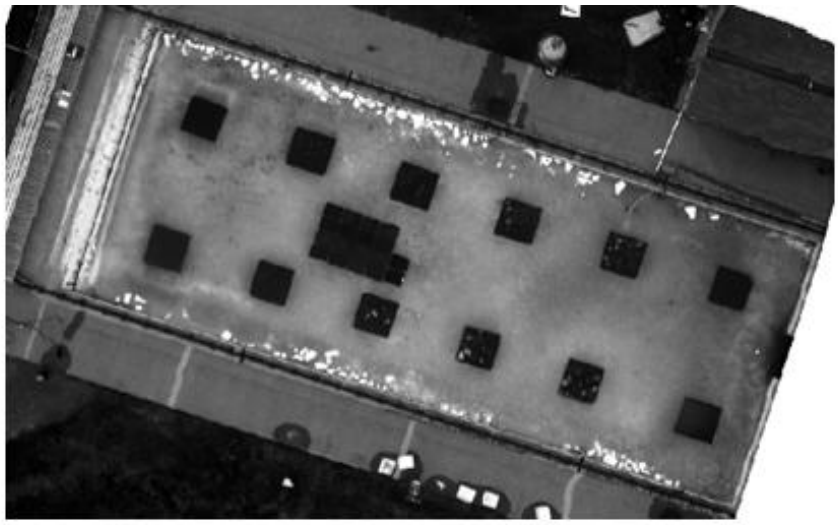


1.21 04/20/2021 Flight # 9 Ground Level Observations



1.22 04/20/2021 Flight # 10 Raw Data

UV (475 nm)

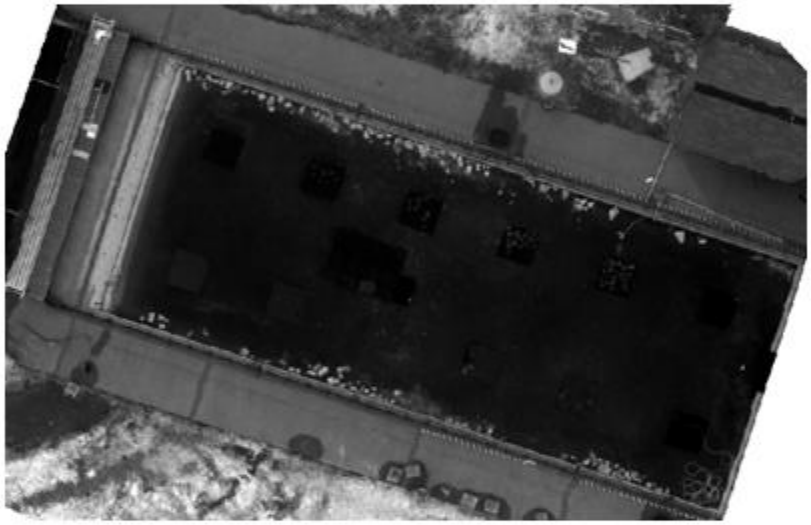


560nm

668 nm

Red Edge (717 nm)

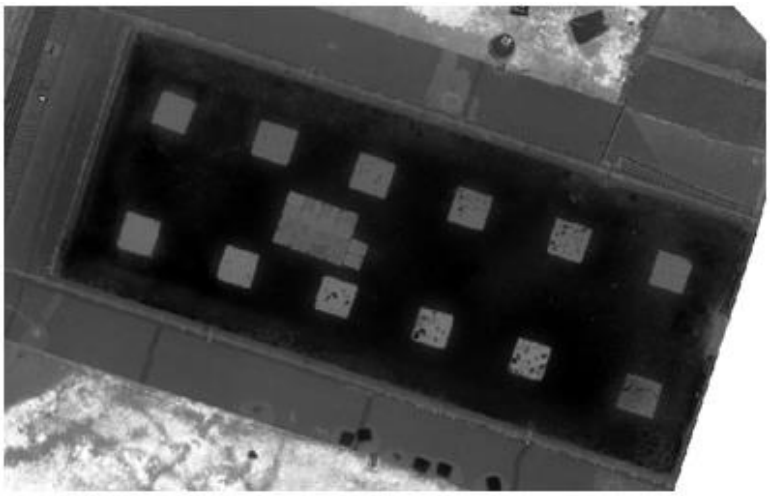
Near IR (840 nm)



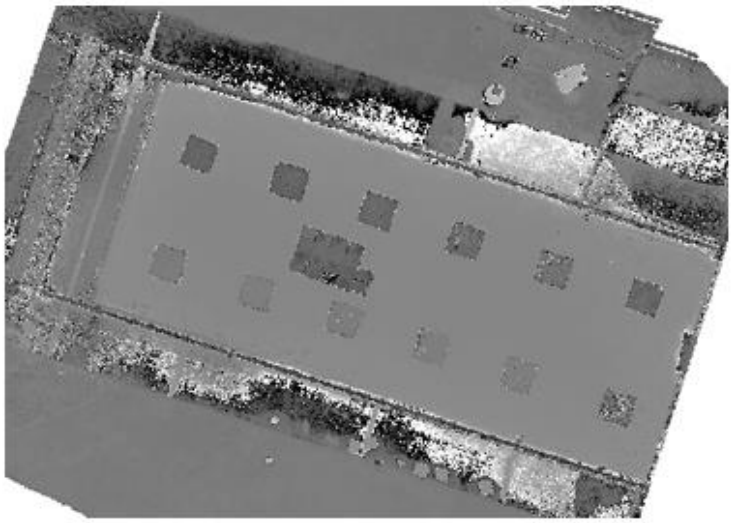
RGB

1.23 04/20/2021 Flight # 10 Data Products

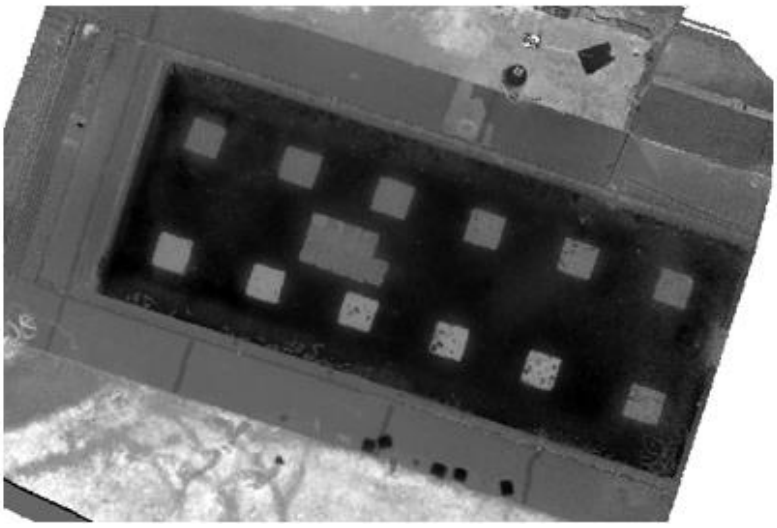
NDVI



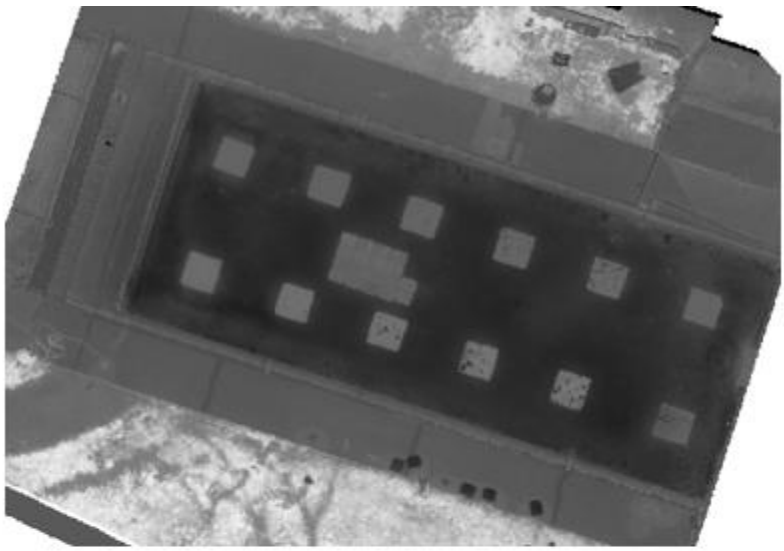
MSCI



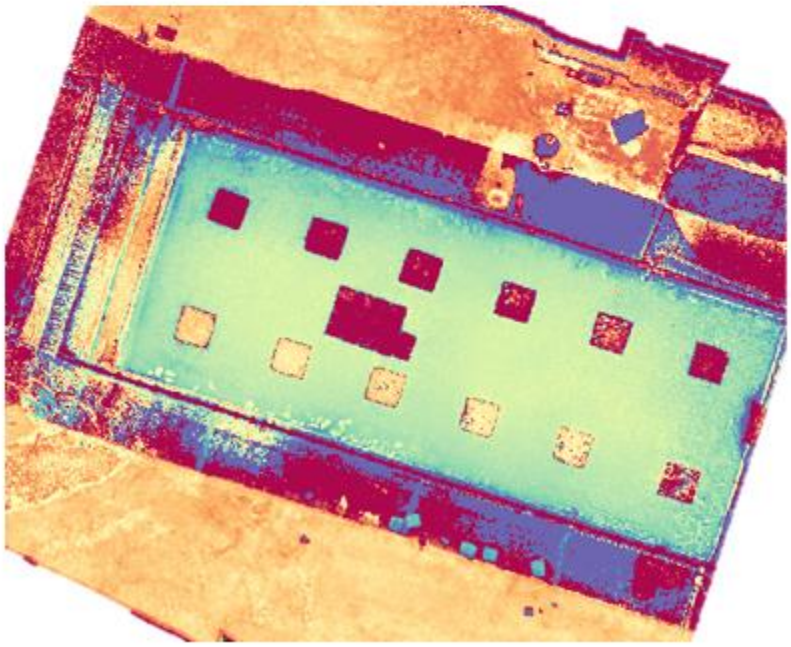
NDRE



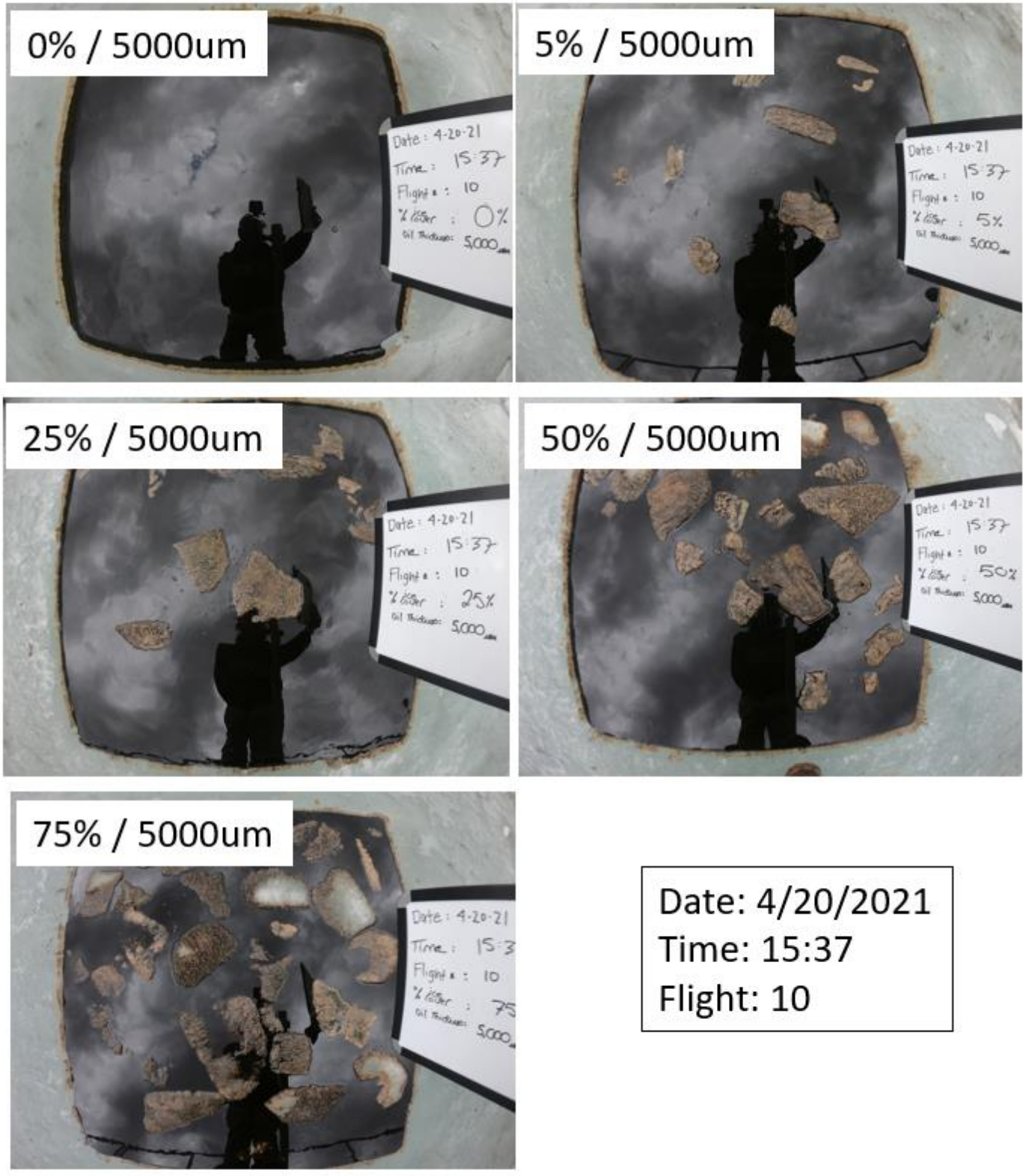
OSAVI



DSM



1.24 04/20/2021 Flight # 10 Ground Level Observations



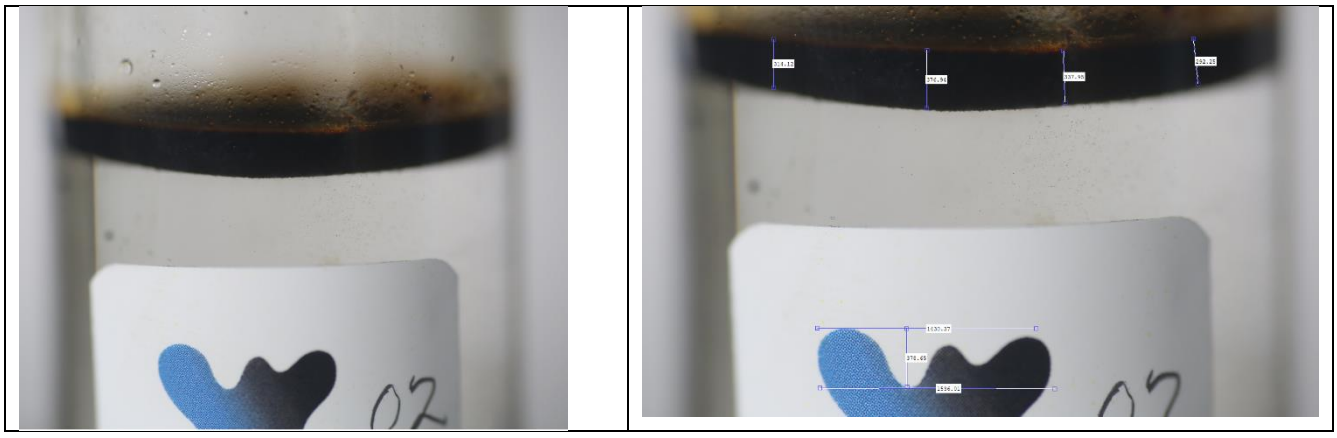
2 OIL THICKNESS SAMPLING

2.1 Emulsion: 50/50 Oil Thickness: 500 µm

Sampling Site: Cold Regions Research and Engineering Laboratory (CRREL)
Date: 04/22/2021
Sample ID: WM_02 Time: 14:02 Target Setup: 50/50 / 500 µm

Sample Extraction

Sample Processing



Measurements

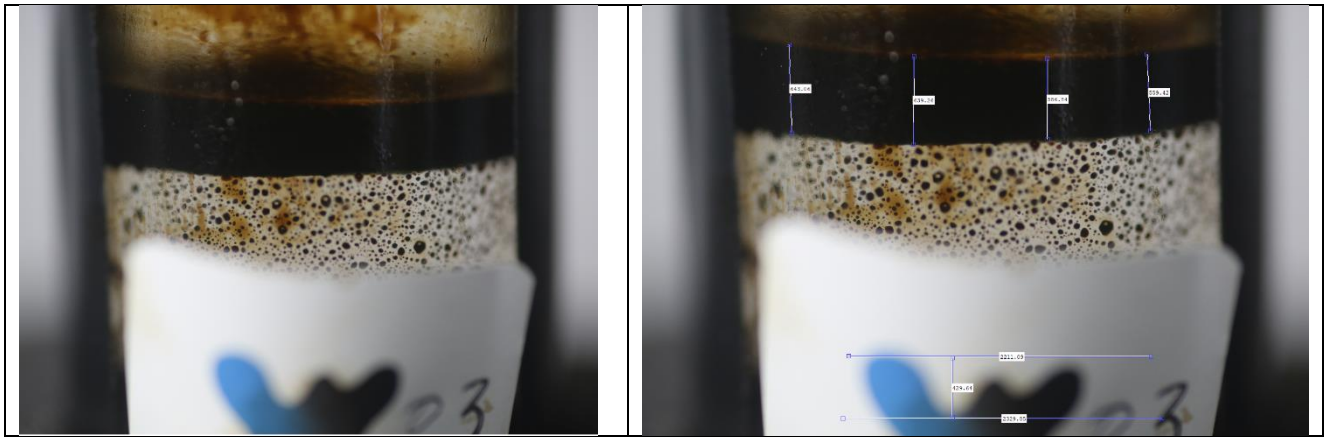
Oil Line: 314, 377, 338, 292 pixels Avg: 330 pixels Line Thickness: 2,612 µm
Reference: 379 pixels (3,000 µm)

2.2 50/50 / 5,000 µm

Sampling Site: CRREL
Date: 04/22/2021
Sample ID: WM_03 Time: 14:13 Target Setup: 50/50 / 5,000 µm

Sample Extraction

Sample Processing



Measurements

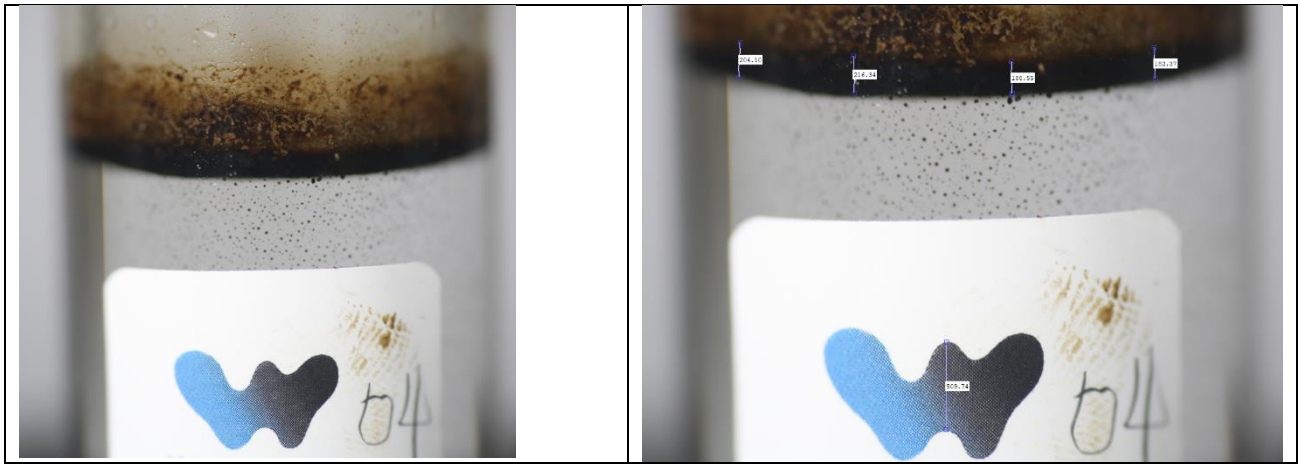
Oil Line: 643, 639, 587, 559 pixels Avg: 607 pixels Line Thickness: 4,235 µm
Reference: 430 pixels (3,000 µm)

2.3 **30/70 / 50 µm**

Sampling Site: CRREL
Date: 04/22/2021
Sample ID: WM_04 Time: 14:27 Target Setup: 30/70 / 50 µm

Sample Extraction

Sample Processing



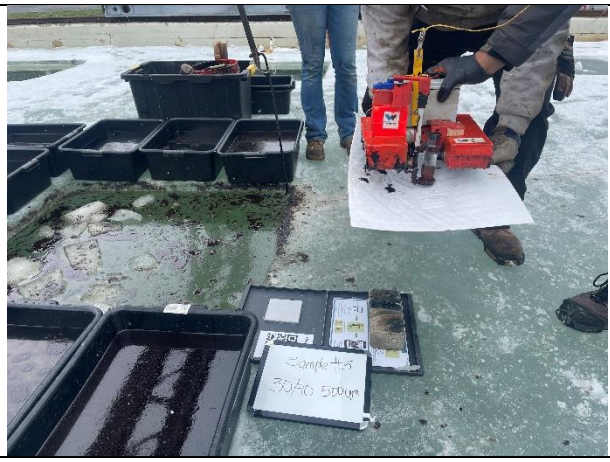
Measurements

Oil Line: 204, 216, 189, 182 pixels Avg: 198 pixels Line Thickness: 1,747 µm
Reference: 510 pixels (4,500 µm)

2.4 **30/70 / 500 µm**

Sampling Site: CRREL
Date: 04/22/2021
Sample ID: WM_05 Time: 14:36 Target Setup: 30/70 / 500 µm

Sample Extraction



Sample Processing

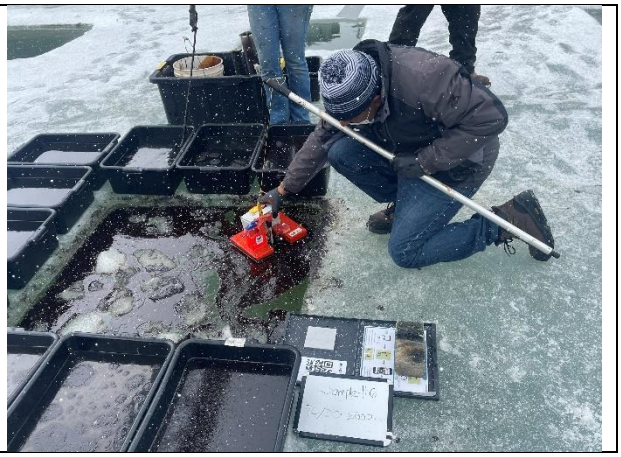
Measurements

Oil Line: 195, 213, 195, 184 pixels Avg: 197 pixels Line Thickness: 1,759 µm
Reference: 504 pixels (4,500 µm)

2.5 30/70 / 5,000 µm

Sampling Site: CRREL
Date: 04/22/2021
Sample ID: WM_06 Time: 14:42 Target Setup: 30/70 / 5,000 µm

Sample Extraction



Sample Processing

Measurements

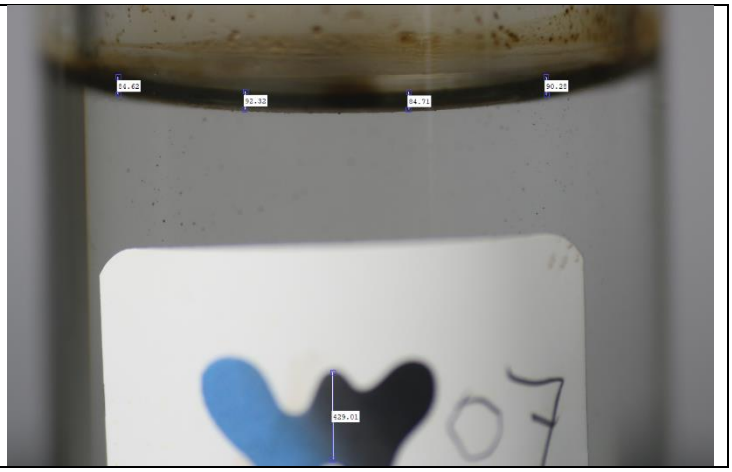
Oil Line: 354, 395, 401, 351 pixels Avg: 375 pixels Line Thickness: 3,102 µm
Reference: pixels 544 (4,500 µm)

2.6 Non-emulsified / 50 µm

Sampling Site: CRREL
Date: 04/22/2021
Sample ID: WM_07 Time: 15:02 Target Setup: Non-emulsified / 50 µm

Sample Extraction


Sample Processing

Measurements

Oil Line: 85, 92, 85, 90 pixels Avg: 88 pixels Line Thickness: 923 µm
Reference: 429 pixels (4,500 µm)

2.7 Non-emulsified / 500 µm

Sampling Site: CRREL
Date: 04/22/2021
Sample ID: WM_08 Time: 15:07 Target Setup: Non-emulsified / 500 µm

Sample Extraction

Sample Processing

Measurements

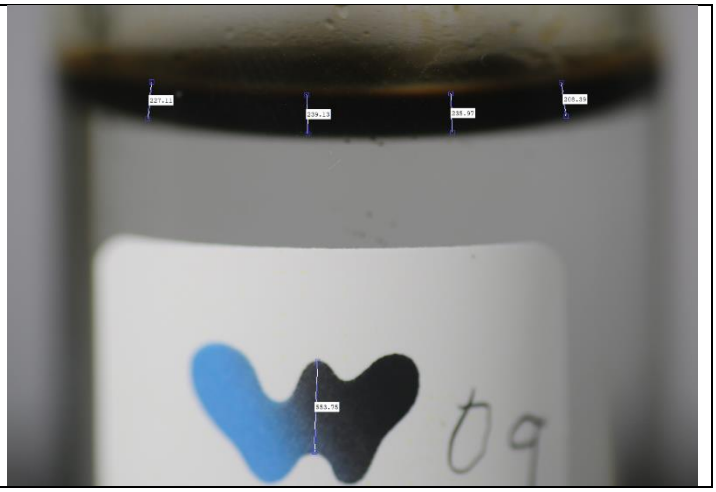
Oil Line: 191, 186, 176, 176 pixels Avg: 182 pixels Line Thickness: 1,578 µm
Reference: 519 pixels (4,500 µm)

2.8 Non-emulsified / 1,000 µm

Sampling Site: CRREL
Date: 04/22/2021
Sample ID: WM_09 Time: 15:23 Target Setup: Non-emulsified / 1,000 µm

Sample Extraction

Sample Processing



Measurements

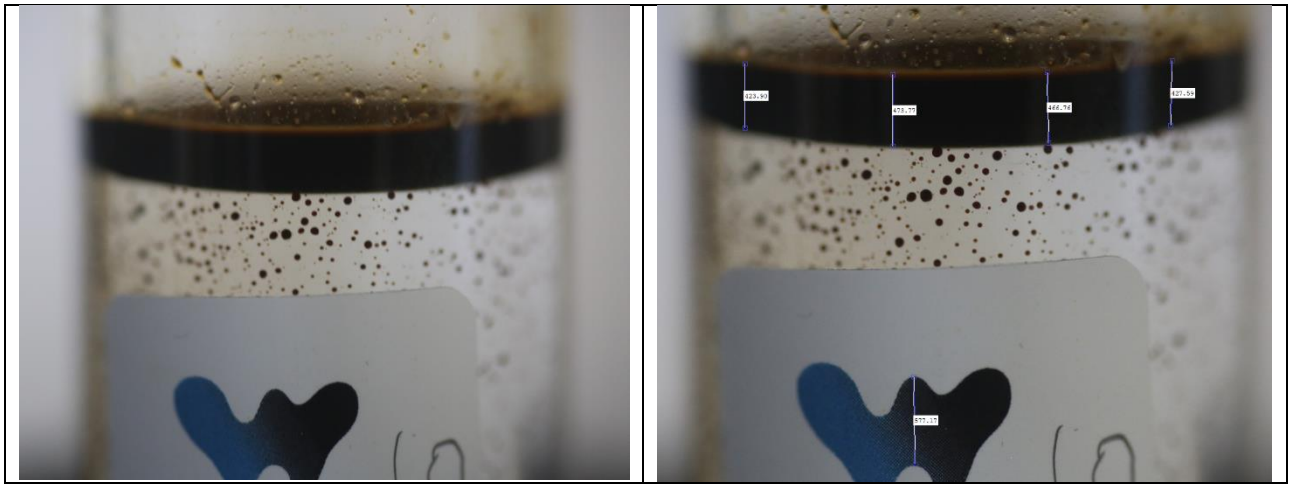
Oil Line: 227, 239, 236, 208 pixels Avg: 228 pixels Line Thickness: 1,852 µm
Reference: 554 pixels (4,500 µm)

2.9 Non-emulsified / 5,000 µm

Sampling Site: CRREL
Date: 04/22/2021
Sample ID: WM_10 Time: 15:31 Target Setup: Non-emulsified / 5,000 µm

Sample Extraction

Sample Processing



Measurements

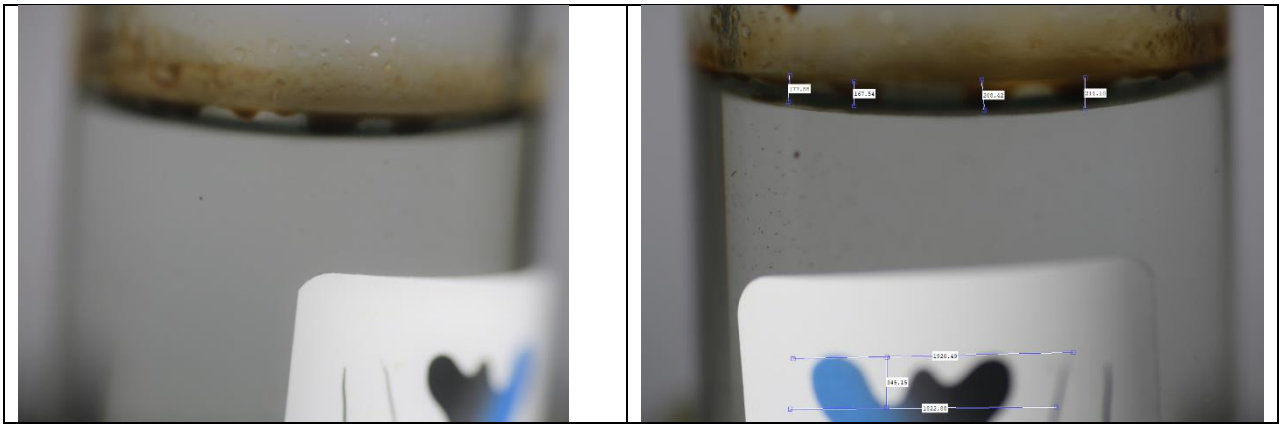
Oil Line: 424, 474, 467, 428 pixels Avg: 448 pixels Line Thickness: 3,494 µm
Reference: 577 pixels (4,500 µm)

2.10 **Non-emulsified / 200 µm**

Sampling Site: CRREL
Date: 04/22/2021
Sample ID: WM_11 Time: 15:42 Target Setup: Non-emulsified / 200 µm

Sample Extraction

Sample Processing



Measurements

Oil Line: 178, 168, 208, 211 pixels Avg: 191 pixels Line Thickness: 1,661 µm
Reference: 345 pixels (3,000 µm)

3 24-HOUR TIME LAPSE DATA

The project team collected apparent temperature data during the 24-hour time lapse experiment. Each column represents the thicknesses and the rows represent the 15-minute average apparent temperature of targets under the shade of the A-Frame.

	Non-emulsified Oil Thickness			50/50 Emulsion Thickness			70/30 Emulsion Thickness		
Time	50 µm	200 µm	500 µm	50 µm	1,000 µm	5,000 µm	500 µm	50 µm	500 µm
11:48:45	43.3	47.05	50.9	44.6	56.15	64.75	49.9	47.1	49
12:03:45	42.2	43.85	49.65	42.5	52.75	58	46.7	44.5	47.8
12:18:45	43.7	45.75	49.6	45.3	53.3	56.55	48.2	44.9	47.8
12:33:45	44.85	46.8	50.1	45.5	53.75	56.05	49.7	46.3	48.9
12:48:45	41.05	43.5	46.7	41.5	48.65	51	45.6	42.3	45.2
13:03:45	38	39.65	42.8	38.4	45	46.45	41.3	41	41.9
13:18:45	42.5	43.85	47.3	42.9	49.7	52.55	46.9	42.9	45.7
13:33:45	49.4	50.95	54.65	51.6	57.25	59.15	54.7	48.9	53.1
13:48:45	45.8	47.2	50.85	51.3	44.6	45.2	46.1	47.1	52.1
14:03:45	41.15	42.2	45.8	41.2	48	50.45	43.8	42.2	43.2
14:18:45	47	48.55	51.4	49.1	52.35	53	50.6	46.3	49.1
14:33:45	46.7	49.1	53.2	46.6	55.5	59.6	50.6	46.8	48.1
14:48:45	41.8	43.5	47.1	41.95	48.8	50.45	43.1	41.9	44.1
15:03:45	32.65	34.55	38	30.3	40.5	41.9	33.1	34.3	35
15:18:45	45	47.05	51.1	45.2	52.95	56	44.6	44.5	47.5
15:33:45	43.4	46.25	50.6	42.8	52.85	56.3	46	45.2	47.1
15:48:45	43.25	45.7	50.1	42.2	51.9	54.45	45.2	44.1	44.8
16:03:45	47.85	49.75	53	48.5	54.25	54.35	52	47.7	50.1
16:18:45	45.2	47.75	50.9	45.2	52.95	56.4	46.5	45.9	46.6
16:33:45	39.85	42.45	46	38.3	47.25	49.3	39.5	40.7	41.5
16:48:45	42.3	44.7	49.1	41.6	48.95	50.3	44.5	43.4	44.6
17:03:45	37.05	40	45.5	36.6	46.4	50.55	38.9	38.8	38.6
17:18:45	39.25	41.05	45	38.3	45.8	46.9	38.7	38.9	39.7
17:33:45	42.25	43.4	46.1	41.5	47	48.2	42.4	42.3	43.3
17:48:45	39.65	40.9	43.3	38.6	44.25	45.75	39	39.8	40.8
18:03:45	41.2	42.5	44.6	40.5	45.55	47.2	42.2	41.9	42.6
18:18:45	39.3	40.5	42.8	37.8	43.5	45.05	38.9	40.4	41.3
18:33:45	35.55	36.5	38.8	33.4	39.5	41.45	34.2	36.9	37.9
18:48:45	38.85	39.25	40.8	38.2	41.65	43.05	39.6	40.8	41.8
19:03:45	38.65	39	40.5	38.7	41.2	42.65	40	40.1	41.2
19:18:45	39.65	39.65	41.3	39.8	41.45	42.25	41.3	41.5	42.5
19:33:45	40.3	40.15	41.3	39.9	42	43.35	41.3	41.6	42.2
19:48:45	37.95	38.2	39.5	37.4	40.25	41.55	38.8	40	40.8
20:03:45	37.15	37.15	38.3	36.9	39.2	40.65	38.2	39.5	40.3

	Non-emulsified Oil Thickness			50/50 Emulsion Thickness			70/30 Emulsion Thickness		
Time	50 µm	200 µm	500 µm	50 µm	1,000 µm	5,000 µm	500 µm	50 µm	500 µm
20:18:45	35.3	35.1	36.7	34.1	37.65	39.05	35.3	37.5	38.3
20:48:45	36.75	36.8	37.7	36.7	38.5	39.75	37.8	38.7	39.6
21:18:45	35.3	35.2	36.7	35.6	36.75	37.6	36.5	37.5	38.1
21:33:45	34.8	34.85	36.3	34.9	36.4	37.9	35.9	37.4	37.9
21:48:45	35.9	35.9	36.9	35.7	37.6	38.85	36.9	38.2	39
22:03:45	34.6	34.7	36.2	34.4	36.25	37.7	35.3	37.2	37.7
22:18:45	34.1	33.9	35.3	34	35.95	37.35	35.4	36.8	37.6
22:33:45	35.25	35.1	36.8	35.3	36.65	37.9	36.4	37.5	38.3
22:48:45	31.75	31.4	33	31.5	33.25	34.75	32.4	34.7	35.2
23:03:45	31.65	31.35	33.1	31.7	32.9	34	32.7	34	35
23:18:45	30	29.95	32	29.8	31.9	33.1	30.6	33	33.6
23:33:45	30.05	29.75	31.9	29.8	31.75	32.45	30.4	32.8	33.1
23:48:45	28.25	28.25	30.2	27.5	30.35	31.5	28	31.5	31.8
00:03:45	29.9	29.2	31.4	29.5	31.35	31.95	30.5	32.5	33.1
00:18:45	28.6	28.05	30.1	28.3	30.1	30.85	29.3	31.5	32.1
00:33:45	27.5	27.3	29.5	26.6	29.2	30.4	27.6	30.5	30.9
00:48:45	27.7	27.35	29.5	27.1	29.65	30.75	28	31.2	31.6
01:03:45	28.15	27.8	29.5	27.8	29.4	30.9	28.8	31	31.7
01:18:45	26.65	25.95	28	26.3	28.1	29.45	26.7	29.8	30.5
01:33:45	28.35	27.85	29.5	28	29.6	30.45	28.7	31.3	32.2
01:48:45	27.5	26.95	28.8	27.1	28.65	29.8	27.9	30.6	32.5
02:03:45	26.4	26.35	27.8	26.5	28.05	29.15	27	30.6	31.7
02:18:45	26.8	27.5	28.1	26.7	28.2	30	28.1	31.5	32.1
02:33:45	26.45	26.95	27.7	26.1	27.8	29.3	28	31	31.6
02:48:45	27.1	27.25	28.3	26.9	28.35	30.05	29.1	31.9	32.3
03:03:45	27.65	27.8	28.4	27.3	28.7	30.45	29.3	31.6	32.1
03:18:45	28.3	28.3	28.9	27.9	29.85	31.85	29.6	31.9	32.6
03:33:45	30.05	29.7	24.95	29.2	31.3	32.9	30.4	32.8	33.3
03:48:45	27.5	27.6	27.55	26.6	28.5	30.35	28	30.7	31.2
04:03:45	27.15	27.3	28.7	26.7	29.05	31.2	28.2	30.6	31.1
04:18:45	27.95	27.95	29.2	27.6	29.9	32	29.3	31.8	32.8
04:33:45	28.1	28.25	29.2	27.3	29.9	31.95	28.8	31.2	31.8
04:48:45	26.75	26.75	28.3	26.1	28.65	30.5	27.6	31	31
05:03:45	27.9	28.05	29.2	27	29.55	31.5	28.5	31.2	31.8
05:18:45	29.65	29.85	30.8	29	31.15	32.95	30.8	33	33.3
05:33:45	29.5	29.3	30	29	31.1	33	30.1	32.4	33
05:48:45	28	28.25	29.1	28	30.3	32.15	28.5	31.3	32.2
06:03:45	30.05	29.85	31	29	31.8	33.95	29.8	32.4	33
06:18:45	29.65	29.25	30.5	29.3	31.5	33.45	29.8	32.3	33.5

	Non-emulsified Oil Thickness			50/50 Emulsion Thickness			70/30 Emulsion Thickness		
Time	50 µm	200 µm	500 µm	50 µm	1,000 µm	5,000 µm	500 µm	50 µm	500 µm
06:33:45	30.5	30	31.4	30.1	32.75	35.2	30.5	32.5	33.2
06:48:45	29.9	29.65	32	29.6	32.45	34.9	30	32.5	32.9
07:03:45	30.65	31.35	33	31	34.05	37.25	32	33.4	35.4
07:18:45	30.05	30.4	32.6	30.5	33.95	36.85	30.9	31.9	32.7
07:33:45	33.5	34.2	36.7	33.9	38.15	41.95	35.3	34	38.4
07:48:45	34	35.55	38.5	36.4	41.2	40.6	39.1	37.1	40.9
08:03:45	35.95	36.25	41.3	38	43.95	42.8	40.5	40.2	44.2
08:18:45	36.15	36.55	44.1	41.9	46.7	42.3	44	43.2	47.7
08:33:45	36.65	37.25	47	43	50.35	54.25	46.7	45.8	49.2
08:48:45	36.95	38.05	40.8	42.8	48.5	55.5	46.8	44.6	49.4
09:03:45	42.7	40.1	45.6	45.8	49	57.9	51	48.4	52.4
09:18:45	43.3	42.85	48.6	45.4	49.15	50.45	50	48.3	51.5
09:33:45	51.65	51.25	54.9	52.3	54.85	56.1	59.4	54.7	55.7
09:48:45	38.2	39.15	45	31.4	48.25	53	41	42.6	44.8
10:03:45	52.7	53.8	58.3	47.1	59.65	63.85	61.4	52	61.6
10:18:45	53.95	55.85	61.2	49.2	62.7	57.2	61.1	51.8	63.3
10:33:45	59.5	61.15	66.5	58.7	58.9	63.45	68.8	59.5	68.2
10:48:45	56.5	59.05	57.1	55.2	56.2	62.7	56.2	49.9	53.7
11:18:45	57.95	54.8	62	55.8	64.9	74.1	62.8	52.9	57.5
11:33:45	61.05	61.65	65.9	61.1	69.55	75.75	68.4	58.6	61.4
11:48:45	55.1	57.35	63.8	52.3	67.1	73.65	60.1	54.9	54.6