Mid-South Conference 2023

Photogrammetric software are tested using drone data
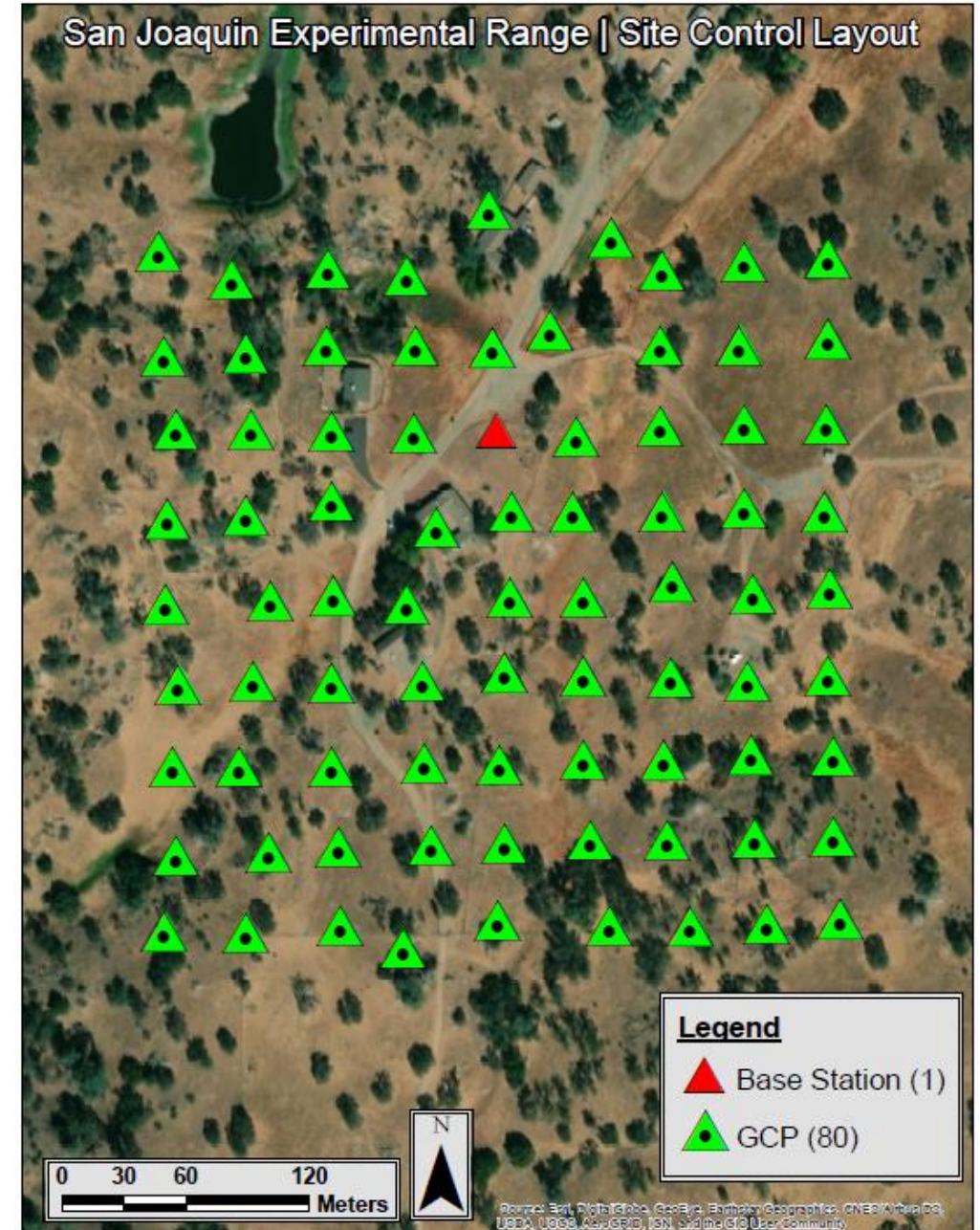
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Test Site and Flight

81 control points laid out in a 9-by-9 grid spaced approximately 40 m apart throughout a 320 m by 320 m area.

The terrain of the area is rolling hills with sparse vegetation, structures and roads.

The control point flight targets were designed to be circular, black and white, and measured about 47 cm in diameter.

These control points were surveyed to 1 cm horizontal and 0.3 cm vertical accuracies, both at one sigma confidence level.

The aircraft platform used was a Phantom 4 RTK UAV, a vertical-take-off-and-landing platform with a quad rotor.

The camera model was FC6310R, with a focal length of 8.8mm, pixel size of 2.4 microns, and an electronic/global shutter.

https://www.dji.com/phantom-4-rtk

Four data sets are used in this study. Additionally, 65-75% side/forward overlap is maintained throughout the survey.

| Flying height above ground level	Number of photographs
60	947
90	485
90 RTN	485
120	296

Results

The images that were acquired by the four flights described above were processed using:

- ➢ Agisoft

- ➢ Pix4D

- ➢ Inpho

Number of check points used for each processing.

Flying height above ground level	Agisoft	Pix4D	Inpho
60	36	37	35
90	38	38	36
90 RTN	38	38	36
120	38	37	34

To eliminate digitizing error from software to software, a Python script was written to translate the control and check point image coordinates that were digitized in Agisoft to Pix4D and Inpho.
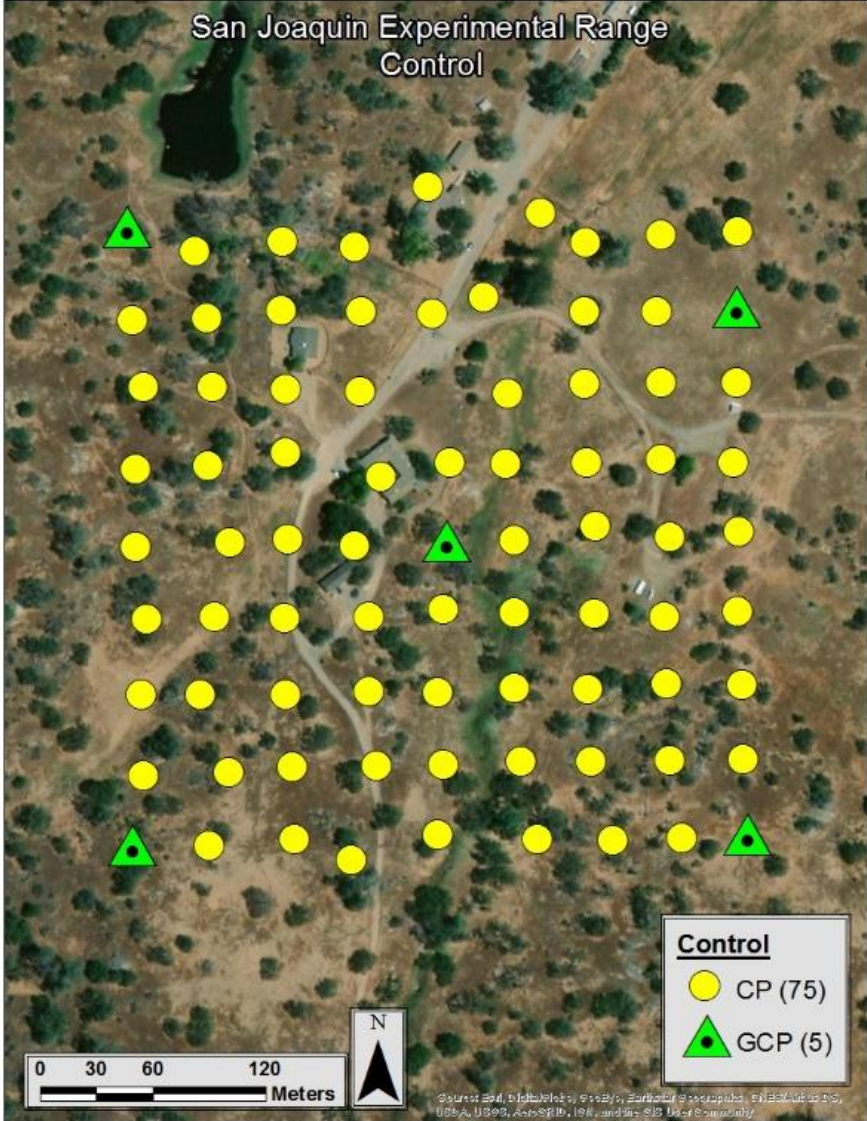
Results are analyzed using RMS, Standard Deviation, Mean, Minimum, Maximum and Range.

60 m flying height (cm)

	Agisoft			Pix4D			Inpho		
	X	Y	Z	X	Y	Z	X	Y	Z
RMS	1.1	1.2	2.5	1.0	0.9	1.1	2.0	1.0	2.4
Std Dev	0.9	0.8	2.1	1.0	0.9	1.0	2.1	1.0	2.4
Mean	-0.5	0.9	1.3	-0.2	0.2	-0.4	0.0	0.0	-0.7
Min	-2.1	-0.7	-2.9	-2.2	-2.1	-3.6	-3.7	-2.0	-5.3
Max	1.5	2.6	5.8	2.6	2.4	1.3	4.8	2.3	6.3
Range	3.7	3.3	8.7	4.8	4.4	4.9	8.5	4.3	11.6

90 m flying height (cm)

	Agisoft			Pix4D			Inpho		
	X	Y	Z	X	Y	Z	X	Y	Z
RMS	1.1	1.0	2.1	1.0	1.0	1.5	3.1	1.1	3.2
Std Dev	1.0	0.9	1.9	1.0	1.0	1.5	3.1	1.1	2.9
Mean	-0.4	0.5	0.9	0.3	0.2	0.0	0.1	-0.1	-1.4
Min	-2.4	-1.6	-4.2	-2.0	-1.8	-3.1	-6.7	-2.7	-6.2
Max	1.7	2.5	4.3	2.7	2.7	2.7	6.9	2.0	8.2
Range	4.2	4.1	8.5	4.7	4.4	5.8	13.6	4.7	14.4

90 m flying height using real-time network solutions (cm)

	Agisoft			Pix4D			Inpho		
	X	Y	Z	X	Y	Z	X	Y	Z
RMS	1.8	2.5	1.5	1.1	1.0	1.0	2.9	1.1	2.7
Std Dev	1.0	0.8	1.5	1.1	0.9	1.0	2.9	1.1	2.7
Mean	-1.6	2.4	-0.3	0.0	0.3	0.1	-0.2	0.0	-0.4
Min	-3.5	0.1	-4.1	-2.6	-1.6	-1.6	-6.0	-2.7	-5.2
Max	0.6	4.2	2.3	2.0	2.9	2.8	6.0	1.9	6.0
Range	4.1	4.0	6.4	4.6	4.6	4.5	12.0	4.6	11.2

120 m flying height (cm)

	Agisoft			Pix4D			Inpho		
	X	Y	Z	X	Y	Z	X	Y	Z
RMS	1.0	1.3	1.7	1.0	0.9	1.3	3.8	1.8	3.5
Std Dev	1.0	0.8	1.5	1.0	0.9	1.3	3.8	1.8	3.3
Mean	0.1	1.0	0.8	0.2	0.2	-0.1	-1.0	0.0	1.2
Min	-1.9	-0.6	-3.5	-2.1	-2.3	-2.2	-8.2	-3.7	-4.2
Max	2.1	3.0	3.0	2.2	2.1	3.0	5.3	2.9	8.6
Range	4.0	3.5	6.6	4.3	4.4	5.2	13.5	6.6	12.8

Results and analysis without reverse strips

60 m flying height without reverse strips (cm)

	Agisoft			Pix4D			Inpho		
	X	Y	Z	X	Y	Z	X	Y	Z
RMS	1.4	0.9	2.7	0.9	1.0	1.4	1.7	1.1	2.6
Std Dev	1.0	0.8	2.5	0.9	0.8	1.4	1.7	1.0	2.5
Mean	-1.0	0.4	1.1	0.0	0.6	-0.3	-0.3	0.5	-0.9
Min	-3.0	-1.6	-7.0	-1.8	-1.3	-3.3	-2.9	-1.4	-4.6
Max	1.2	2.0	6.1	2.0	1.9	3.4	4.0	2.1	4.8
Range	4.2	3.6	13.1	3.9	3.1	6.7	6.9	3.5	9.4

90 m flying height without reverse strips (cm).

	Agisoft			Pix4D			Inpho		
	X	Y	Z	X	Y	Z	X	Y	Z
RMS	1.1	0.9	2.2	1.2	1.0	1.4	2.3	1.5	3.7
Std Dev	1.0	0.9	1.9	1.2	0.9	1.2	2.4	1.2	3.1
Mean	-0.5	0.2	1.1	0.5	0.4	0.7	0.2	0.9	-2.0
Min	-2.6	-1.8	-4.2	-1.7	-1.6	-1.8	-3.8	-2.0	-8.2
Max	1.6	2.2	4.7	3.1	2.6	3.1	6.6	2.4	6.2
Range	4.2	4.0	8.9	4.8	4.2	4.9	10.4	4.4	14.4

90 m flying height using real-time network solutions without reverse strips (cm).

	Agisoft			Pix4D			Inpho		
	X	Y	Z	X	Y	Z	X	Y	Z
RMS	2.2	3.0	1.5	1.3	1.0	1.5	2.1	1.4	3.5
Std Dev	1.1	0.8	1.5	1.2	0.9	1.6	2.1	1.2	3.2
Mean	-2.0	2.9	-0.3	-0.6	0.5	0.0	-0.4	0.6	-1.3
Min	-3.9	0.8	-4.0	-3.1	-1.5	-3.7	-3.6	-3.3	-7.2
Max	0.3	4.8	2.3	1.9	2.4	3.8	4.8	2.6	6.2
Range	4.2	4.0	6.3	5.1	3.9	7.4	8.4	5.9	13.4

120 m flying height without reverse strips (cm).

	Agisoft			Pix4D			Inpho		
	X	Y	Z	X	Y	Z	X	Y	Z
RMS	1.0	0.9	1.7	1.0	0.9	1.7	2.3	1.3	3.3
Std Dev	1.0	0.8	1.5	1.0	0.9	1.6	2.1	1.2	3.2
Mean	0.0	0.2	0.8	0.0	0.0	-0.8	-1.0	0.6	-0.7
Min	-2.2	-1.7	-2.3	-2.5	-1.7	-3.9	-5.2	-1.9	-4.8
Max	2.1	2.2	3.2	2.2	1.5	2.3	2.6	2.3	7.1
Range	4.3	3.9	5.5	4.7	3.2	6.1	7.8	4.2	11.9

Inpho 60 m GNSS photo position residuals
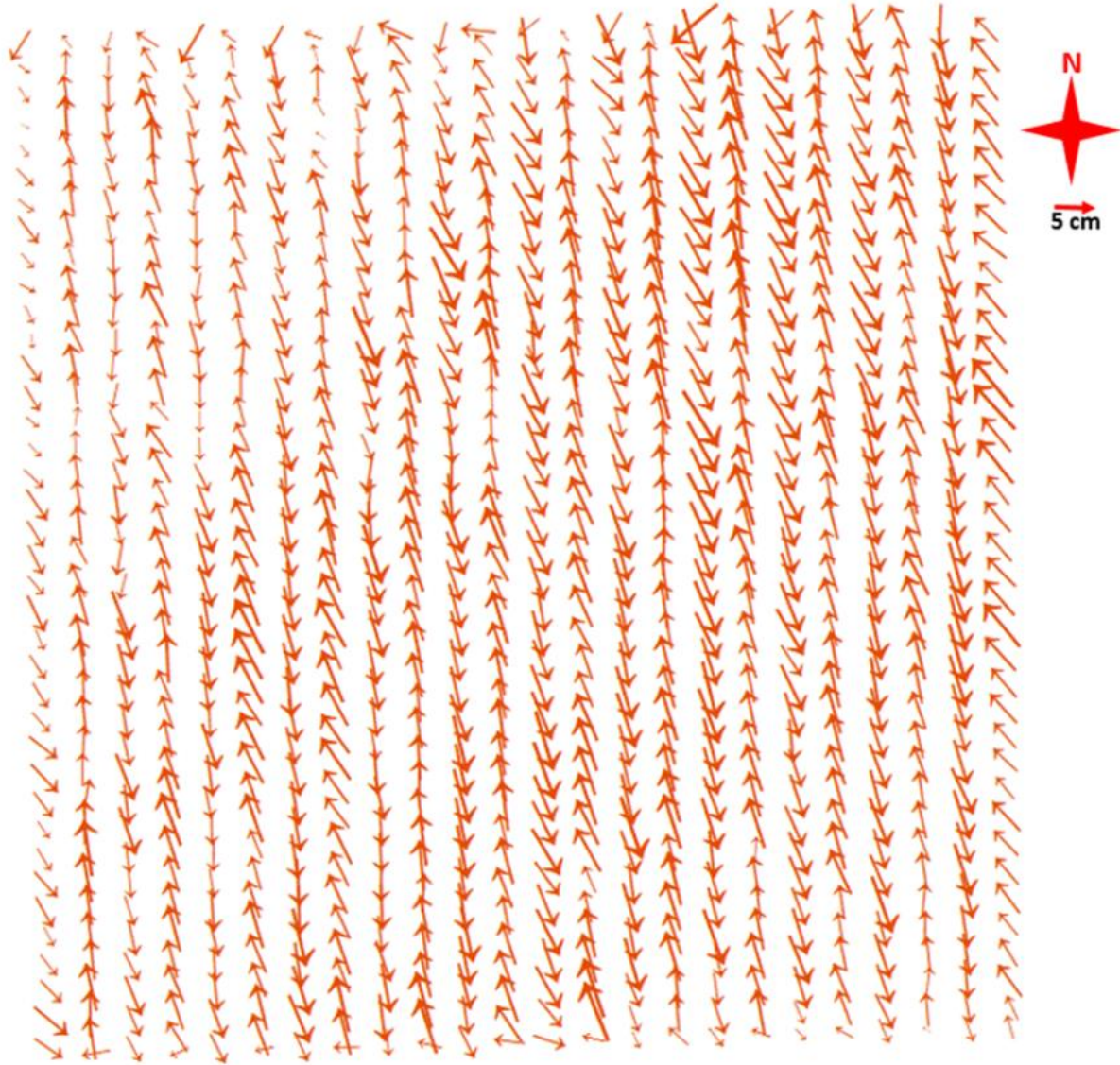
Inpho 60 m GNSS photo position residuals without reverse strips.
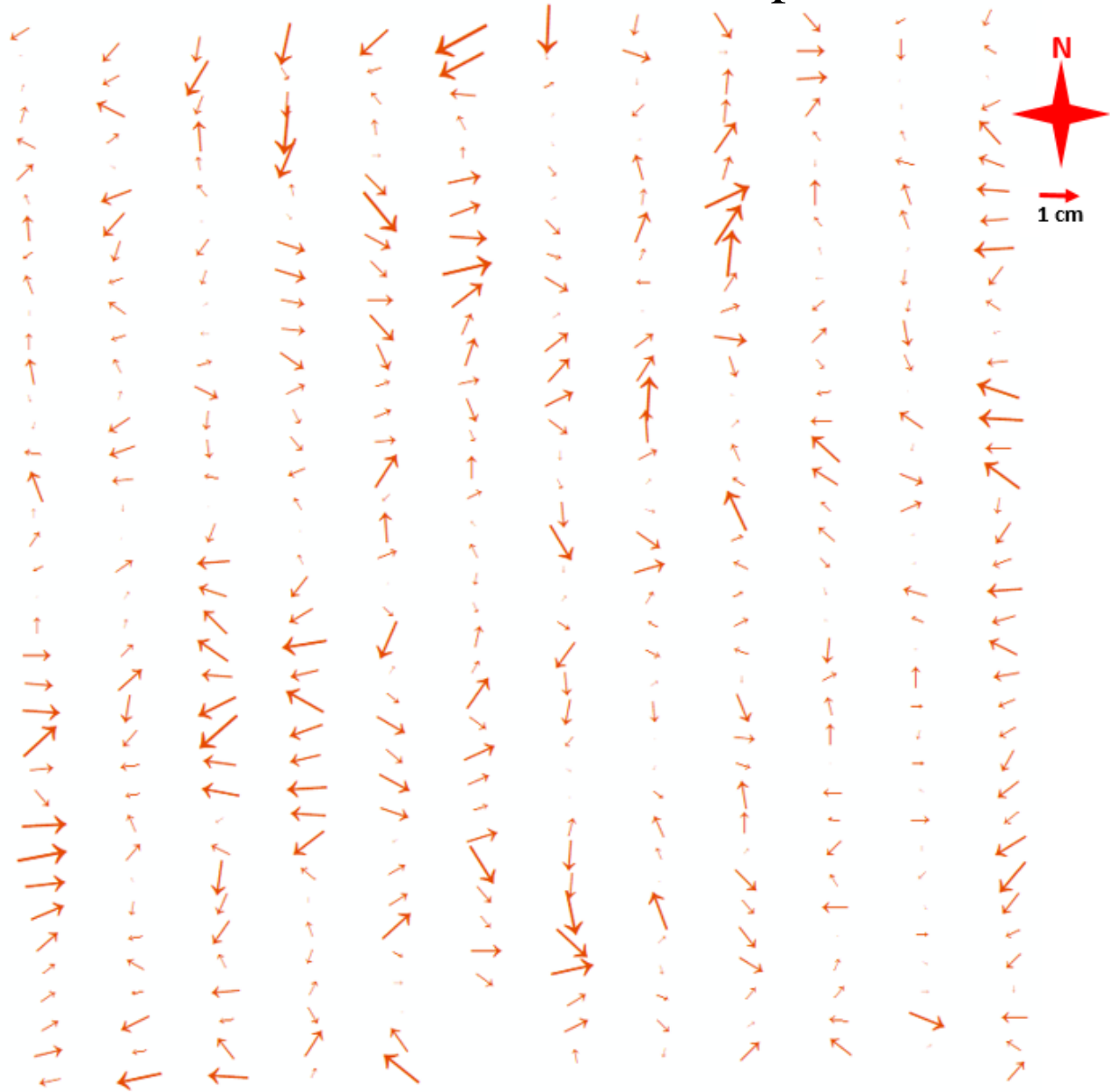
As can be seen, 2D displacement vectors for the results without reverse strips got smaller and systematic bias is removed i.e., arrows show a random pattern.

Even though the Inpho solution employs the block drift parameters in the processing, it does not resolve this issue. On the other hand, the SfM software did not display this behavior. In fact, their results look random.

Further, the SfM software accuracy did not deteriorate with flying height. Yet, Inpho results did.

InPho
Flying Height Versus RMSz
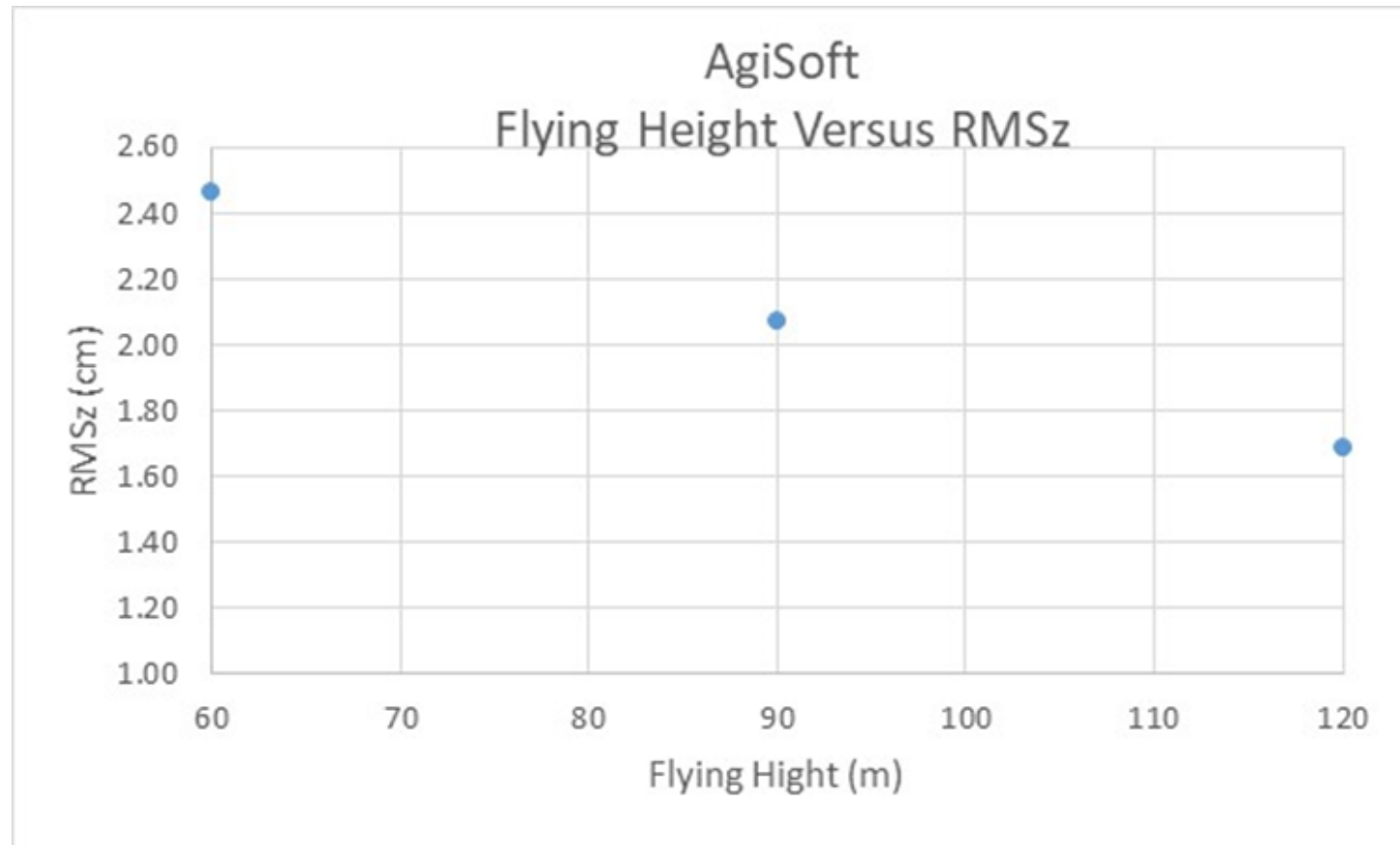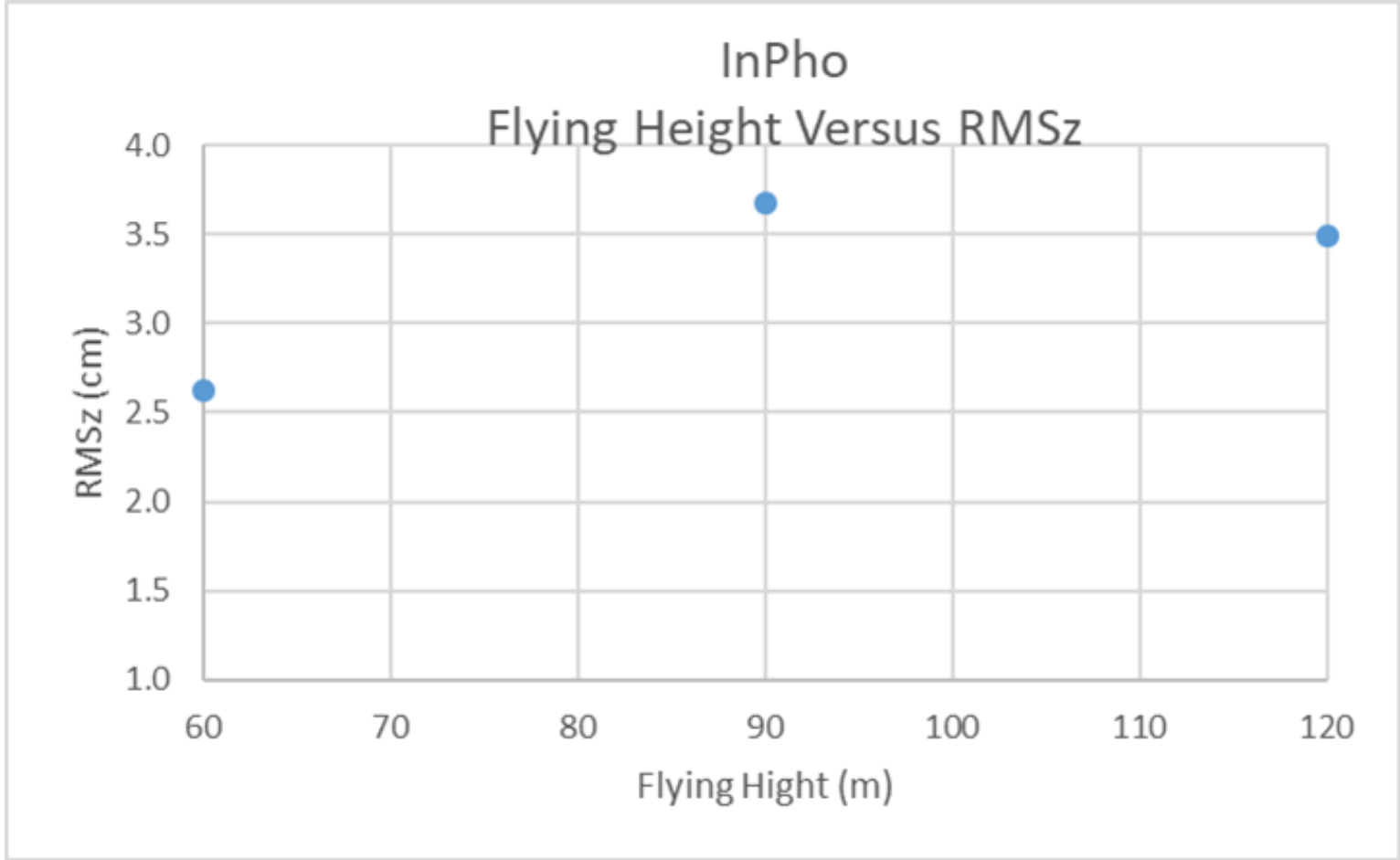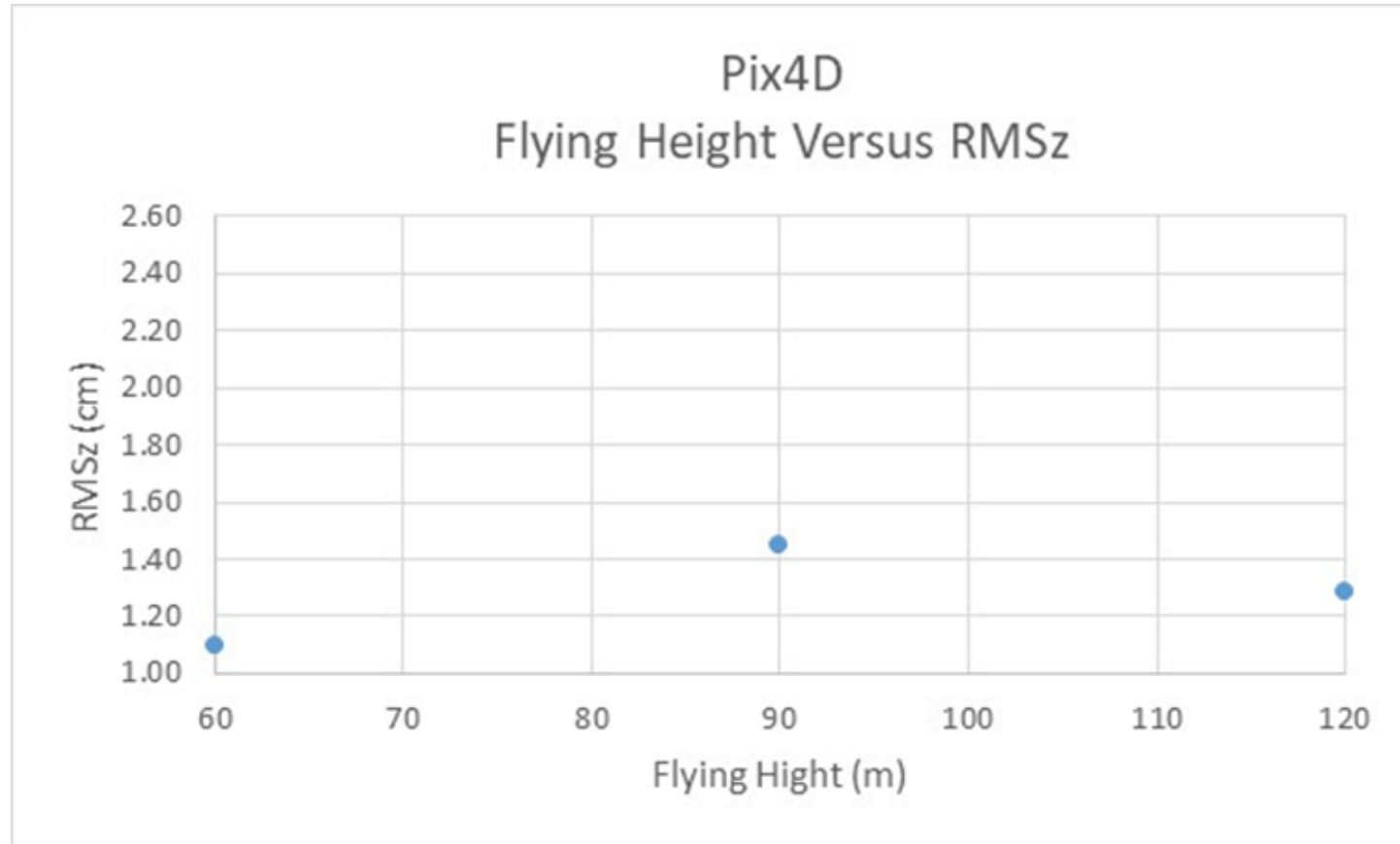
Agisoft results accuracy increased with flying height, Inpho results accuracy deteriorated with flying height and Pix4D accuracy is almost flat.

Conclusions

As the flying height increased, the results deteriorated. This was especially the case with Inpho.

Inpho is not sensitive to the biases created by reverse strips.

When the same data sets were processed without including the reverse strips, although some changes were experienced with the results time to time, some results, especially Inpho results, got better.

When displacement vectors were displayed for flights without reverse strips, the results got smaller and systematic bias was removed.

Moreover, Inpho results deteriorated with flying height.

Furthermore, although some slight changes were experienced from software to software and coordinate to coordinate, 90 m real-time network solutions showed the same performance as 90 m solutions without real-time network solutions.

THANK YOU FOR YOUR ATTENTION