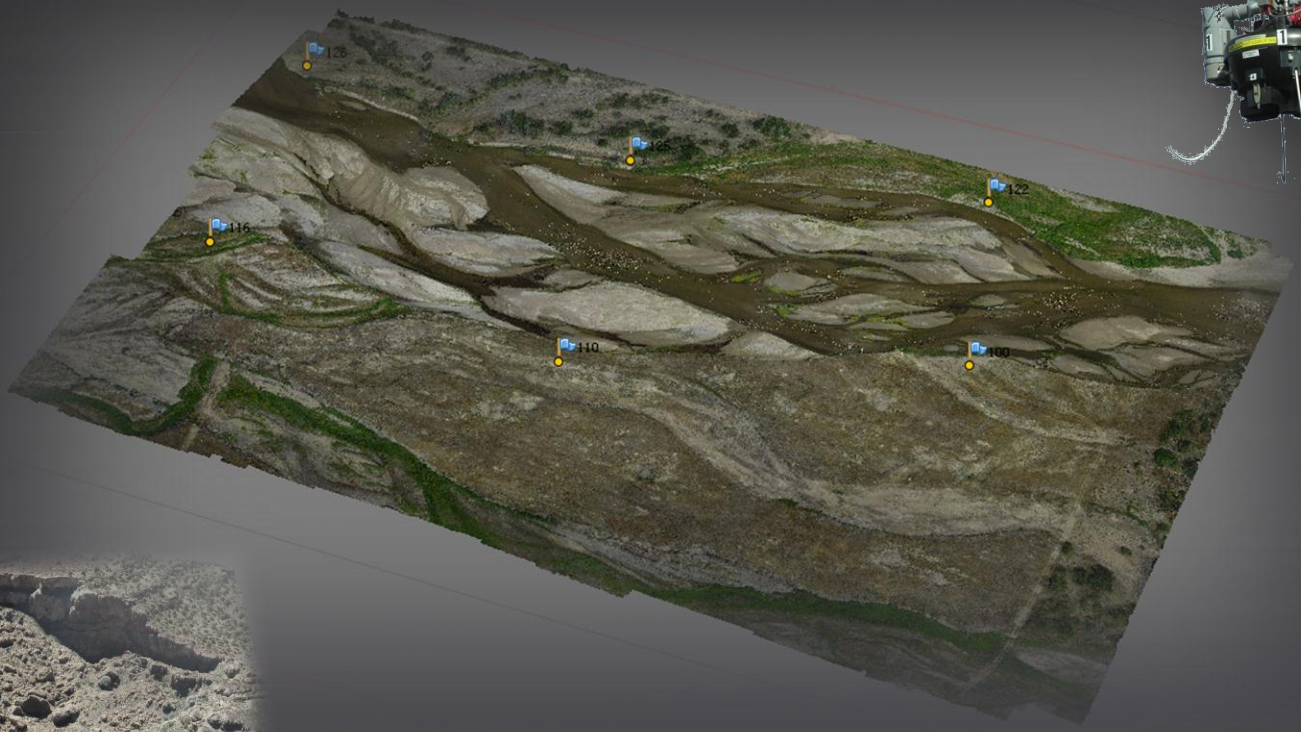
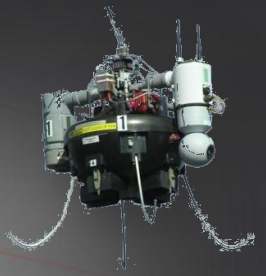
Structure from Motion
UAS Point Cloud, Dem, Orthophoto Data Processing





Debeque Landslide, CO

South Platte River, NE

USGS

LANDSAT 40

UAS Point Cloud, Dem, Orthophoto Data Processing

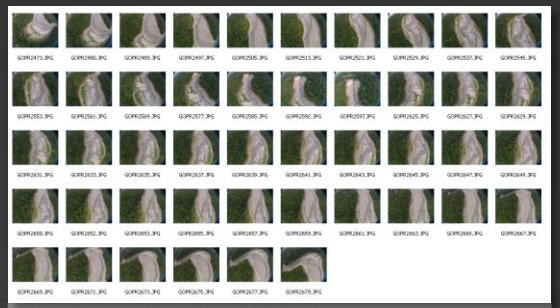
Canon SX230, GoPro Hero 2/3

- Low Cost Solution
- Higher Resolution (36x more pixels than stock camera)
- Light weight and Size
- HD Video and 11 or 12 megapixel stills to utilize tie point automation tools.
- Canon SX230 is GPS enabled for .exif metadata tagging.
- Canon SX230 is triggered using Canon's CHDK developers kit via a intervalometer.

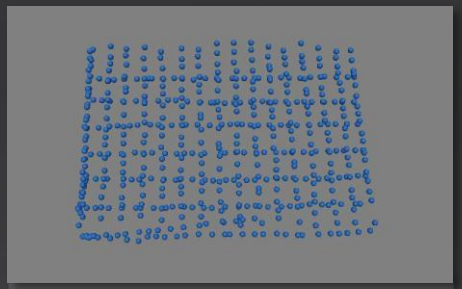
UAS Point Cloud, Dem, Orthophoto Data Processing

General Workflow (Photoscan)

Image Collection



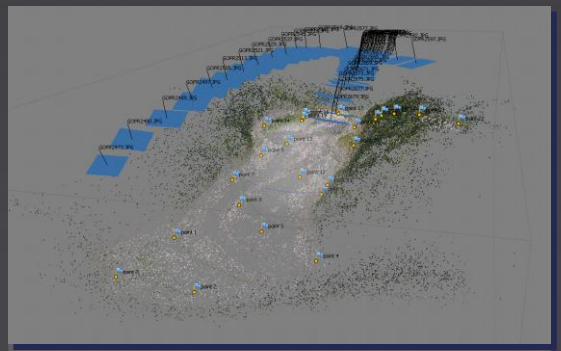
Review Image Tags and Image Alignment



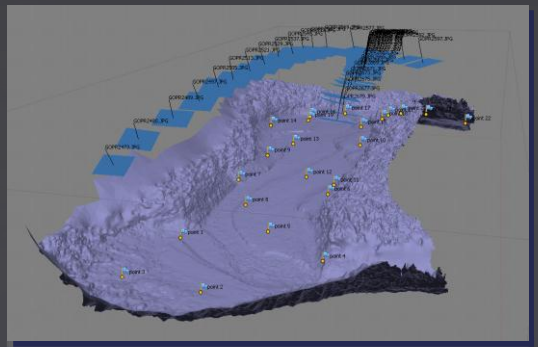
Adding Control

Markers	X/East	Y/North	Z/Altitude	Error (m)	Projections
point 1	-123.568210	48.086959	0.000000	17.144047	22
point 10	-123.562803	48.090145	0.000000	25.312213	28
point 11	-123.564366	48.088317	0.000000	9.612649	28
point 12	-123.564913	48.088804	0.000000	6.895548	27
point 13	-123.564621	48.090891	0.000000	4.743305	27
point 14	-123.564992	48.092181	0.000000	7.886112	24
point 15	-123.561988	48.092058	0.000000	8.820255	21
point 16	-123.563177	48.093653	0.000000	11.291840	17
point 17	-123.561608	48.094250	0.000000	18.108633	12
point 18	-123.560840	48.092864	0.000000	7.182387	17
point 19	-123.563411	48.093172	0.000000	7.471582	17
point 2	-123.567941	48.085551	0.000000	29.852659	10
point 20	-123.559153	48.094606	0.000000	27.087896	9
point 21	-123.560142	48.093762	0.000000	10.095377	13
point 22	-123.556914	48.093873	0.000000	35.939475	4
point 23	-123.557877	48.094949	0.000000	40.091408	8
point 24	0.000000	0.000000	0.000000	0.000000	0
point 3	-123.569360	48.086028	0.000000	28.336538	14
point 4	-123.565498	48.085975	0.000000	14.828336	11
point 5	-123.566355	48.086917	0.000000	10.722515	22
point 6	-123.564695	48.087855	0.000000	11.913958	26
point 7	-123.566647	48.088789	0.000000	5.142936	30
point 8	-123.566677	48.087817	0.000000	3.147138	27
point 9	-123.565667	48.089832	0.000000	15.302667	29
Total Error				18.230015	

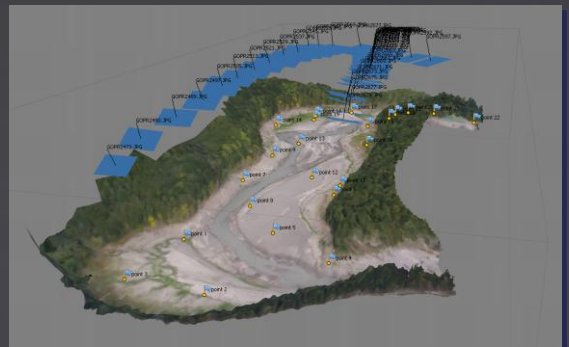
Point Cloud Generation, Camera Calibration and Optimization



Build Geometry



Build Texture and Export Products



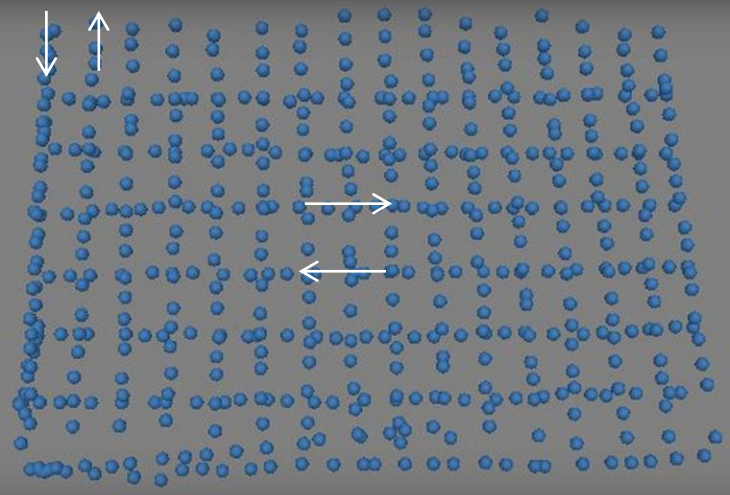
USGS

LANDSAT 40

UAS Point Cloud, Dem, Orthophoto Data Processing

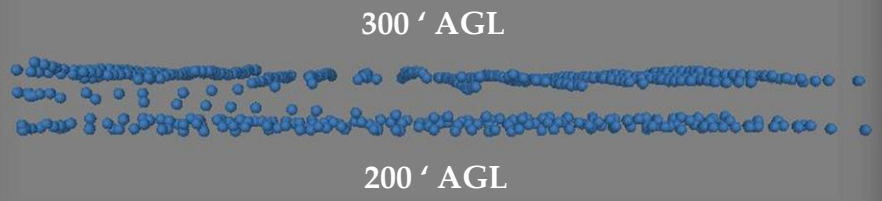
Image Collection Guidelines

- Focal Length needs to be fixed
- Photos taken near NADIR
- Collect 60% in-track overlap
- Collect 50% side-track overlap
- Dual Pass Flight Plans preferred
- A second flight flown perpendicular to the initial flight plan at 1.5 to 2 times the 1st GSD helps create geometry in areas with difficult terrain.
- Shutter speeds should be set to 1/1600 of a second or faster to reduce image blur.
- Turn off image stabilization on lens
- Use wide angle lens, avoid fisheye lens.



- GSD = pixel size x flight height (AGL) / focal length

- Pixel Size = sensor size and format



USGS

LANDSAT 40

UAS Point Cloud, Dem, Orthophoto Data Processing

Canon sx230 Image

592 Images Aligned for South Platte, NE

USGS

LANDSAT 40

UAS Point Cloud, Dem, Orthophoto Data Processing

Point Cloud

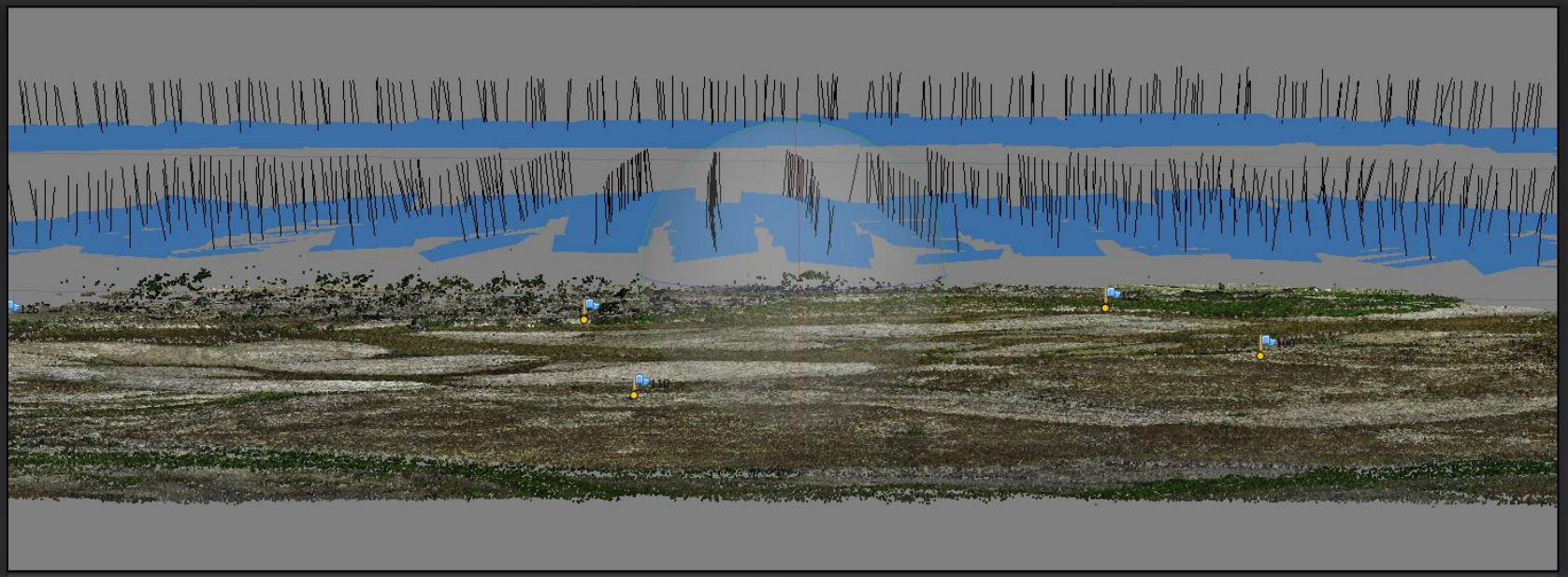
592 images

UAS Point Cloud, Dem, Orthophoto Data Processing

Point Cloud

200 Ft AGL

300 Ft AGL



USGS

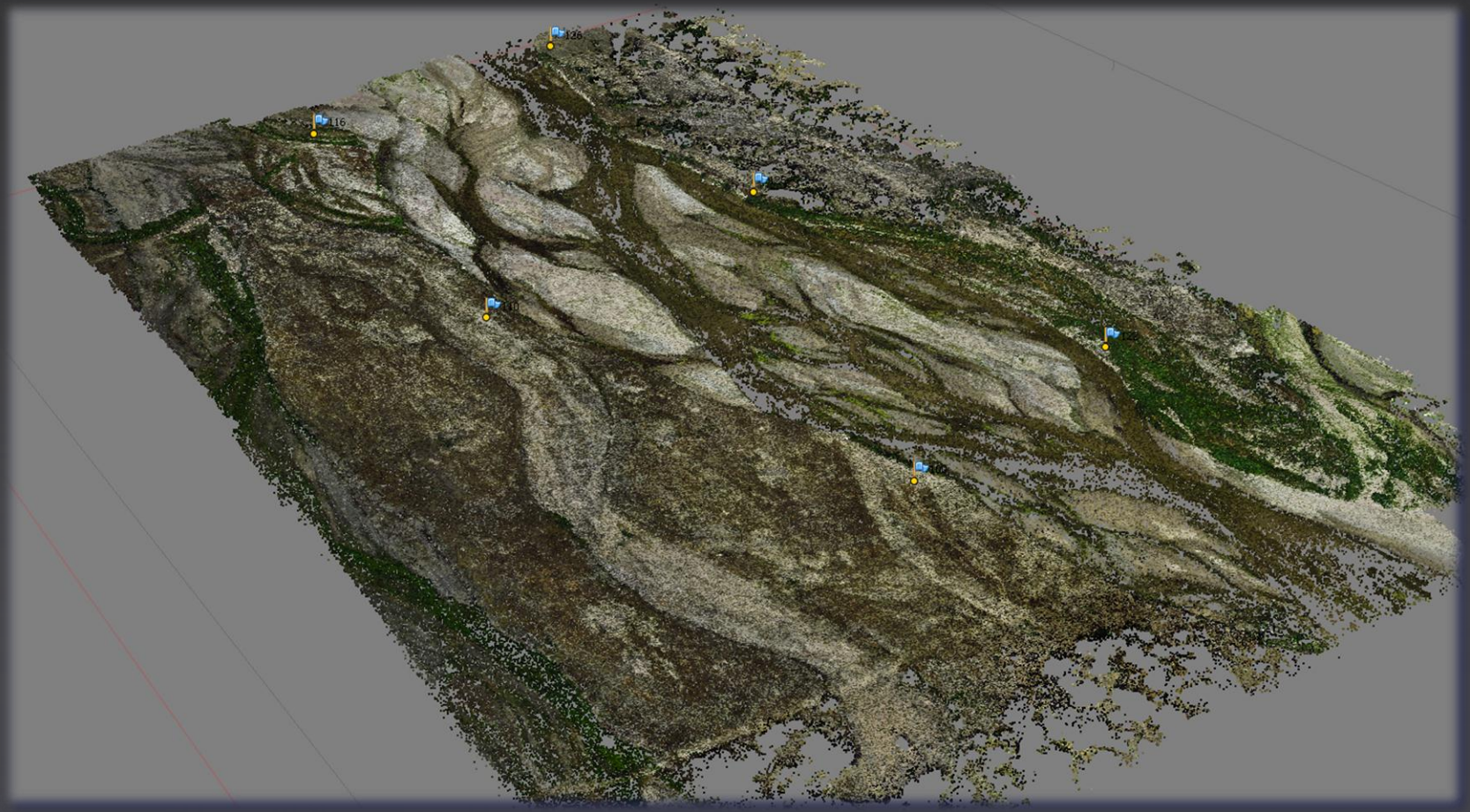
LANDSAT 40

UAS Point Cloud, Dem, Orthophoto Data Processing

Point Cloud

1.8 million points

Area: 0.5 km x 0.4 km

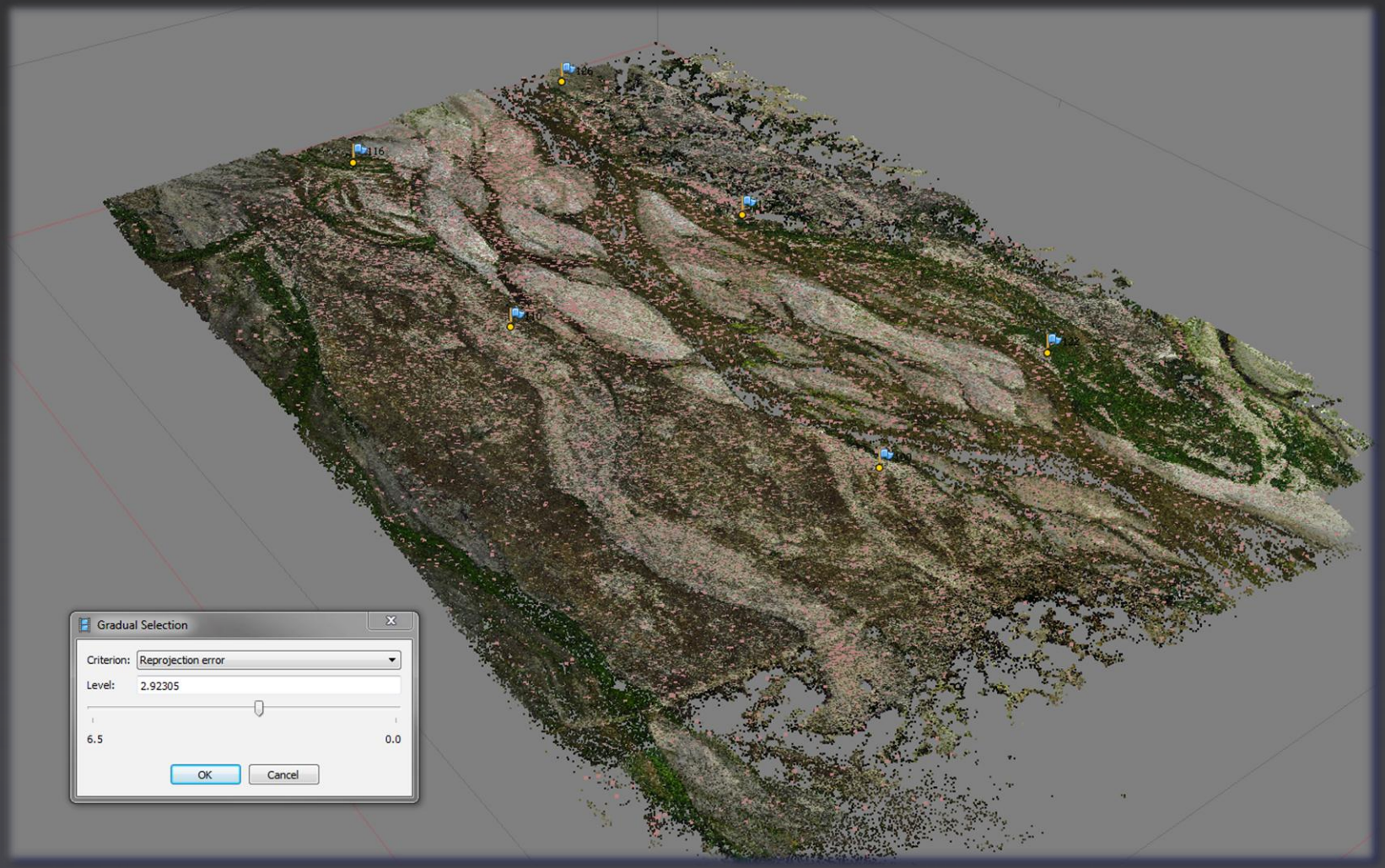


USGS

LANDSAT 40

UAS Point Cloud, Dem, Orthophoto Data Processing

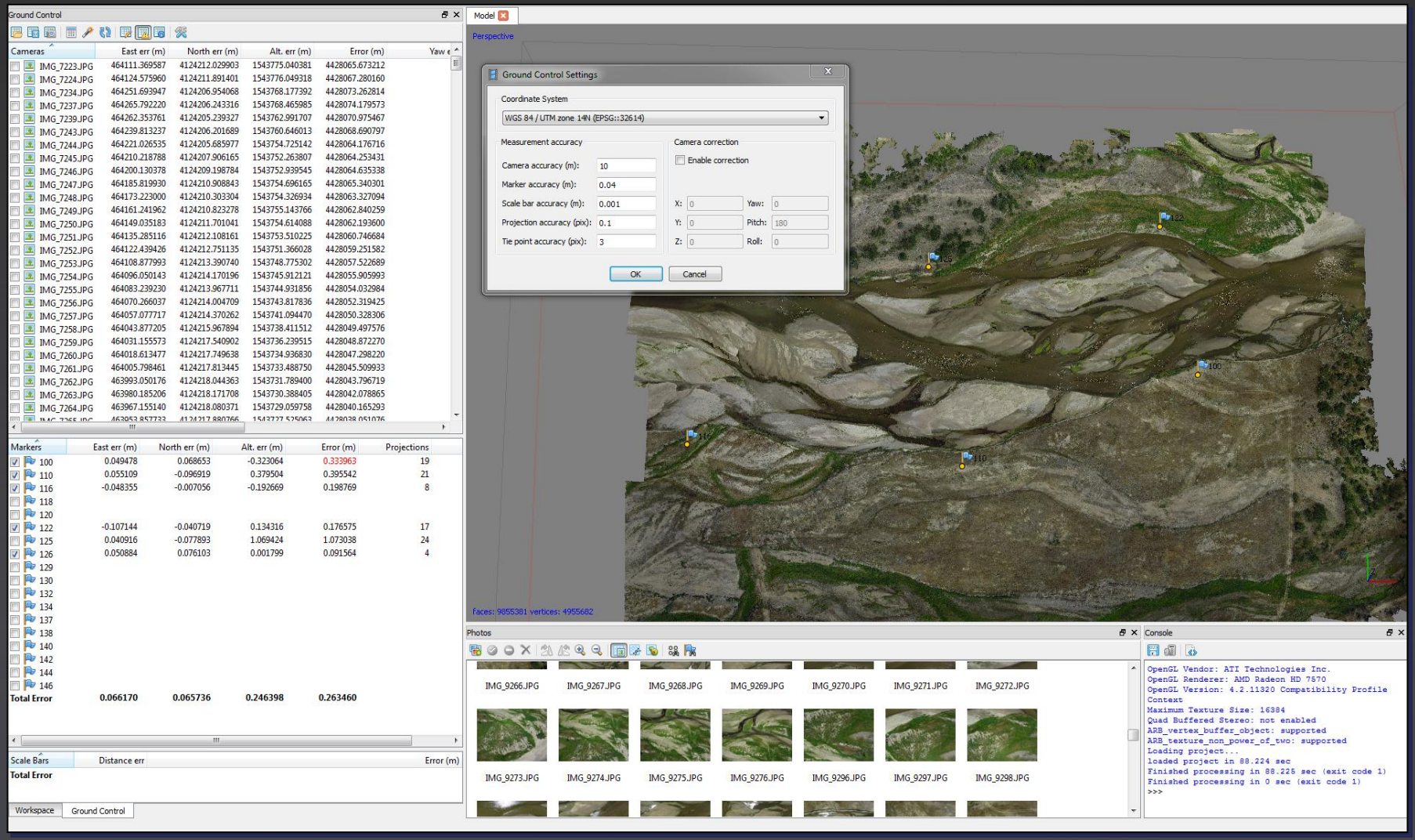
Gradual Selection



UAS Point Cloud, Dem, Orthophoto Data Processing

Setting Ground Control

Target selection and Optimization (Browns Model)



UAS Point Cloud, Dem, Orthophoto Data Processing

Setting Ground Control

Targets

At 200′ AGL flight height target has about 17 pixels

Coordinate collection using Real Time Kinematic (RTK) system.

UAS Point Cloud, Dem, Orthophoto Data Processing

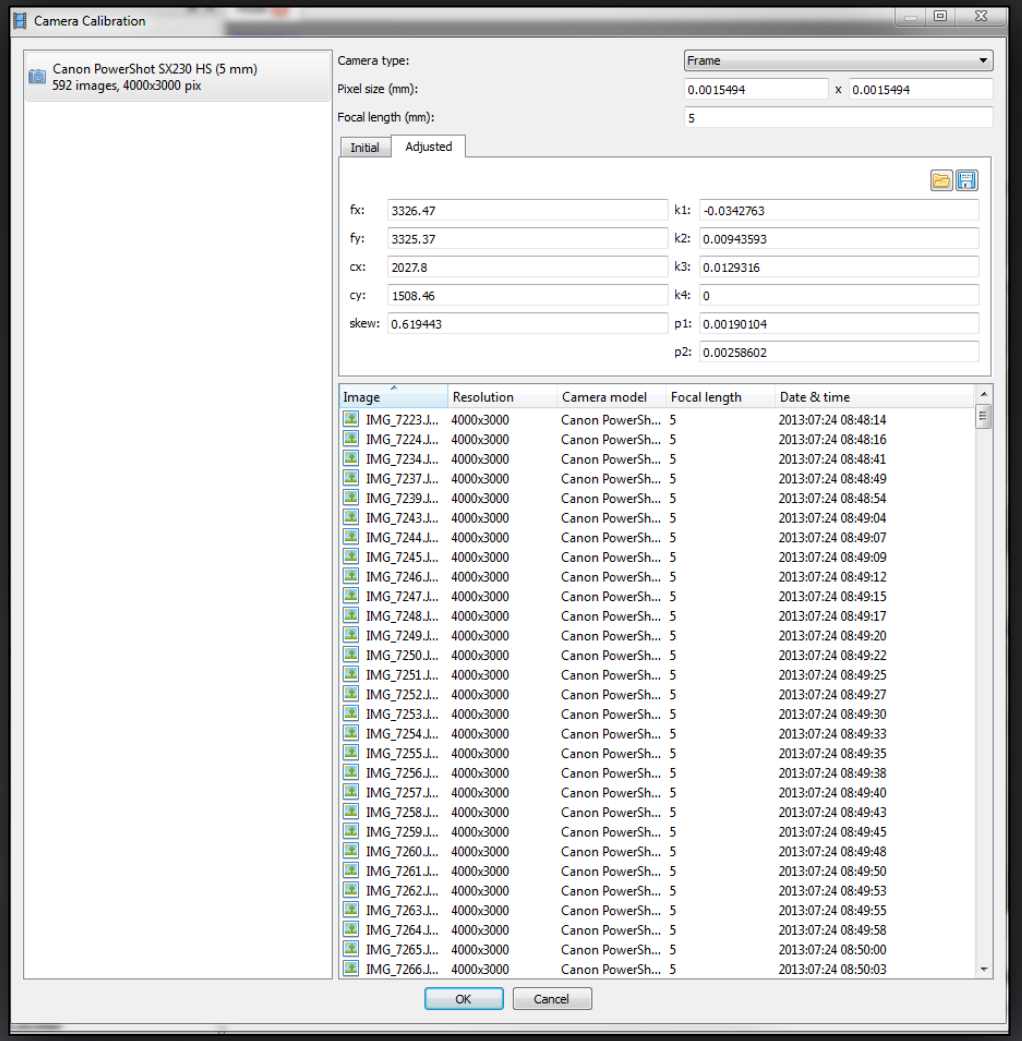
Setting Ground Control

Target selection, Camera Calibration, Optimization (Browns Model)

Initial calibration data is calculated during the align photos processing step.

During georeferencing the model is linearly transformed, the nonlinear component (lens distortion) is not removed.

The optimization process is used to correct nonlinear deformations.



Camera Calibration Parameters

Fx Fy – Focal Length in x and y dimensions measured in pixels.

Cx, Cy Principal point coordinate – Coordinates of lens optical axis interception with sensor plane

Skew – Skew transformation coefficient

K1, k2,k3,k4 – Radial Distortion coefficients

P1, p2 – Tangential Distortion coefficients

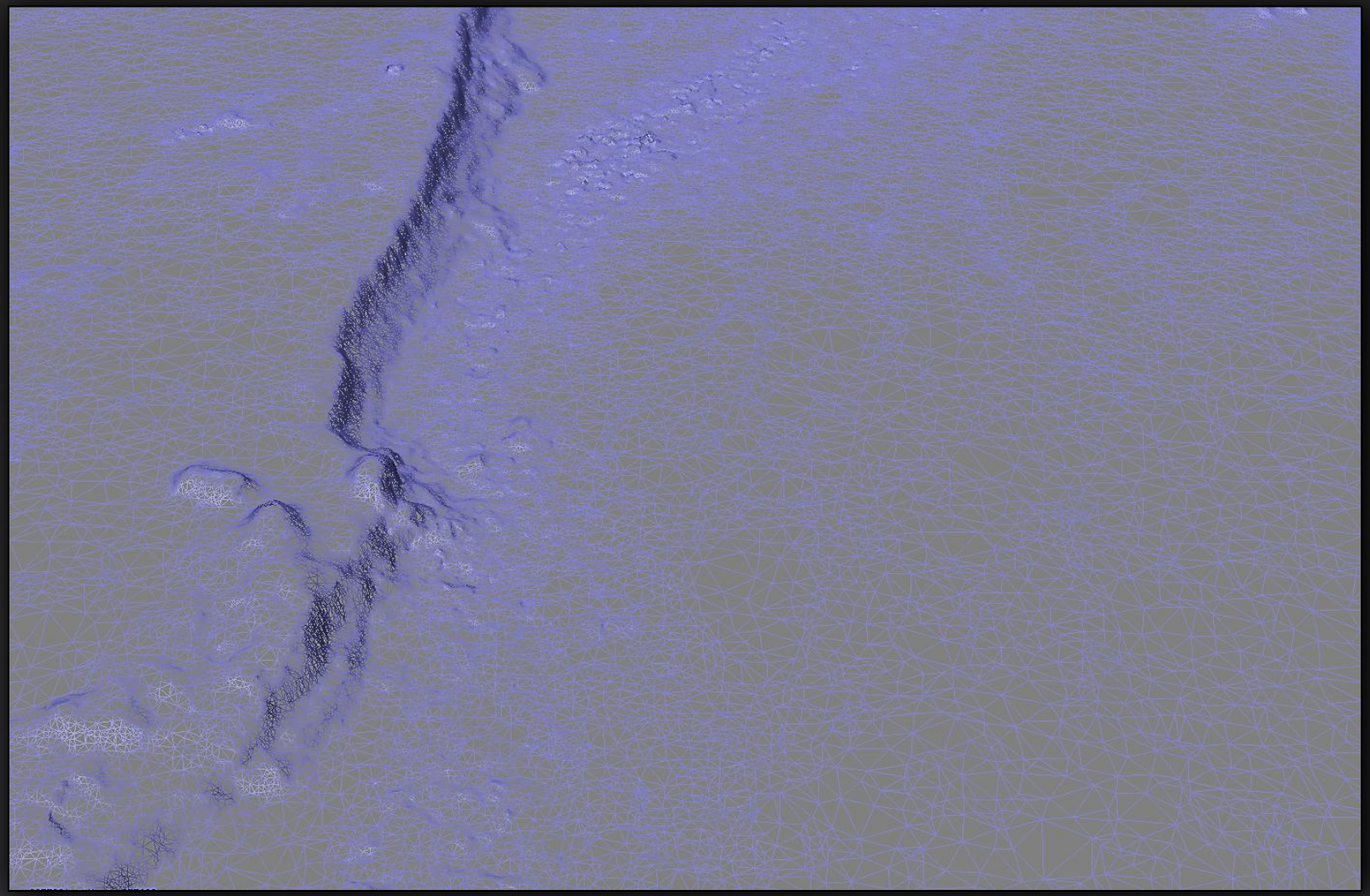
USGS

LANDSAT 40

UAS Point Cloud, Dem, Orthophoto Data Processing

DSM Example

Wire Frame - 10 million faces



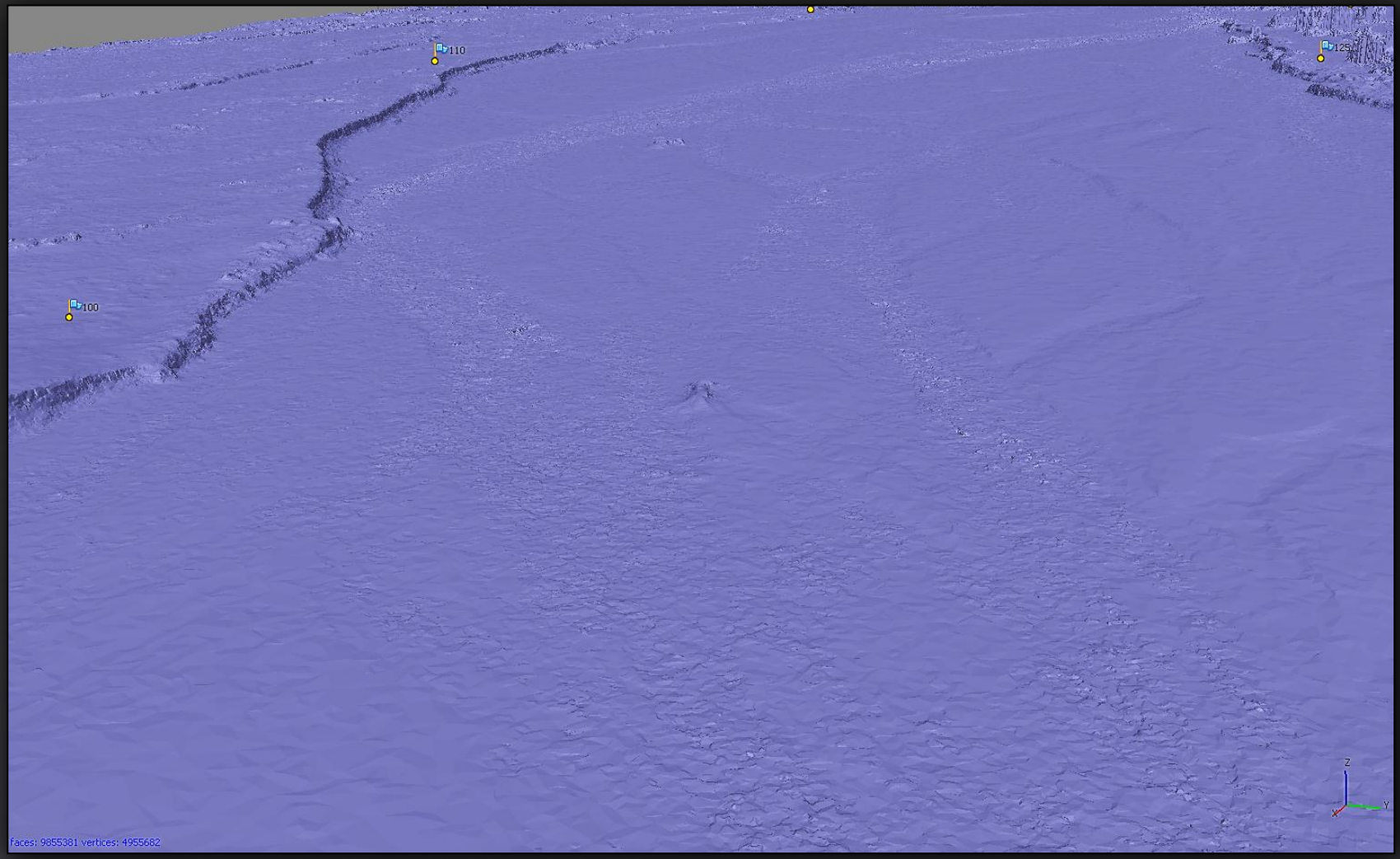
USGS

LANDSAT 40

UAS Point Cloud, Dem, Orthophoto Data Processing

DSM Example

10 million faces



USGS

LANDSAT 40

UAS Point Cloud, Dem, Orthophoto Data Processing

DSM

GSD 0.091 m = 3.5112″

USGS

LANDSAT 40

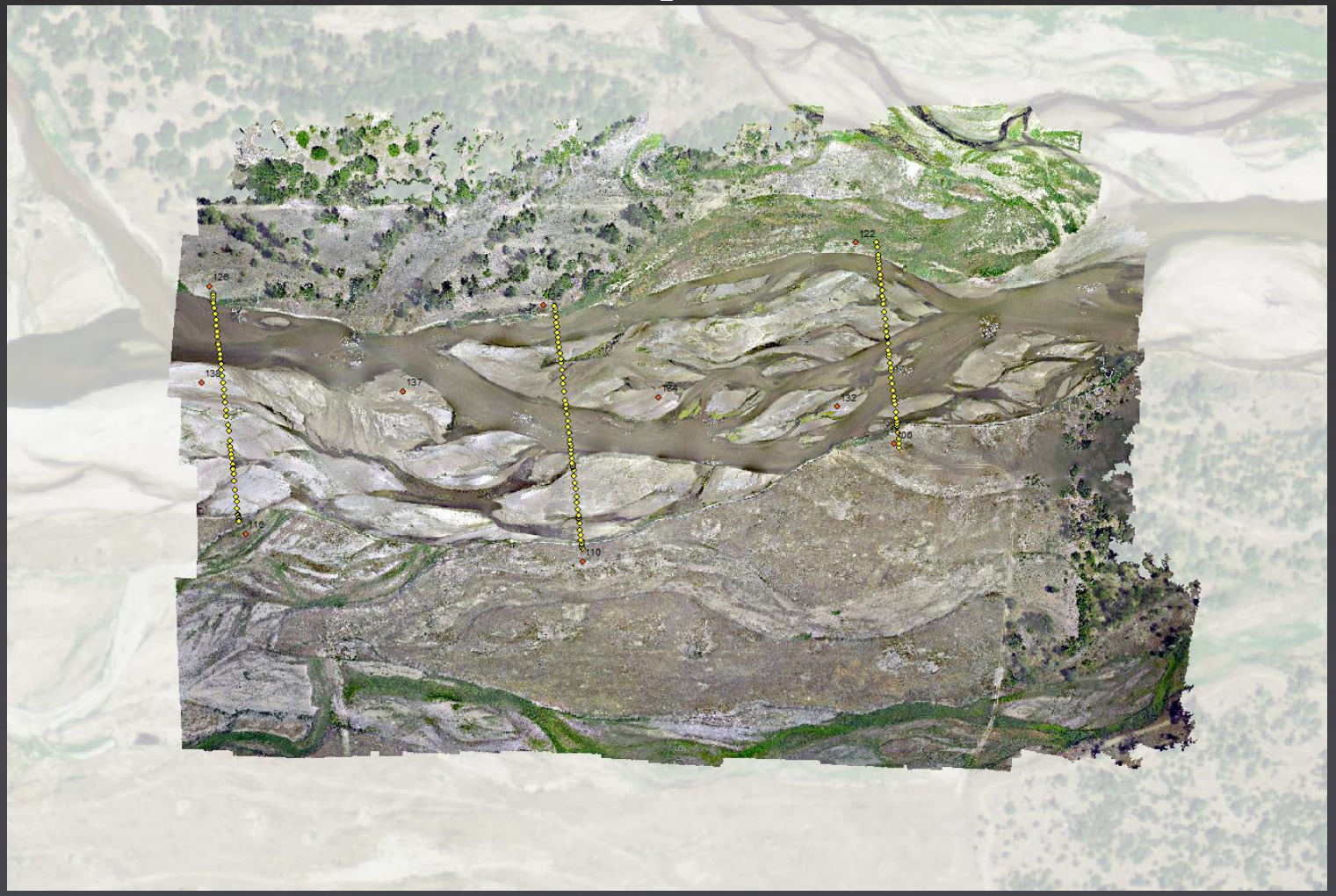
UAS Point Cloud, Dem, Orthophoto Data Processing

Orthophoto

GSD = 0.0222 m or 0.8778″

Area: 0.5 km x 0.4 km

=



USGS

LANDSAT 40

UAS Point Cloud, Dem, Orthophoto Data Processing

Orthophoto

UAS Point Cloud, Dem, Orthophoto Data Processing

NAIP Orthophoto at similar scale

USGS

LANDSAT 40

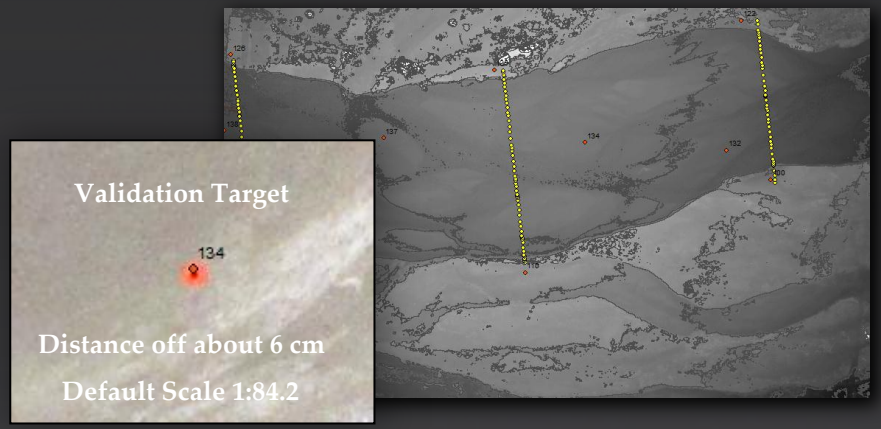
UAS Point Cloud, Dem, Orthophoto Data Processing

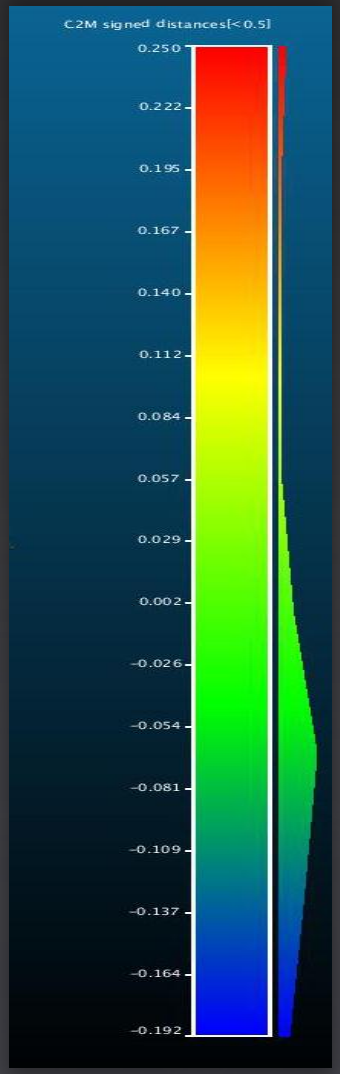
Ground Sampled Distance

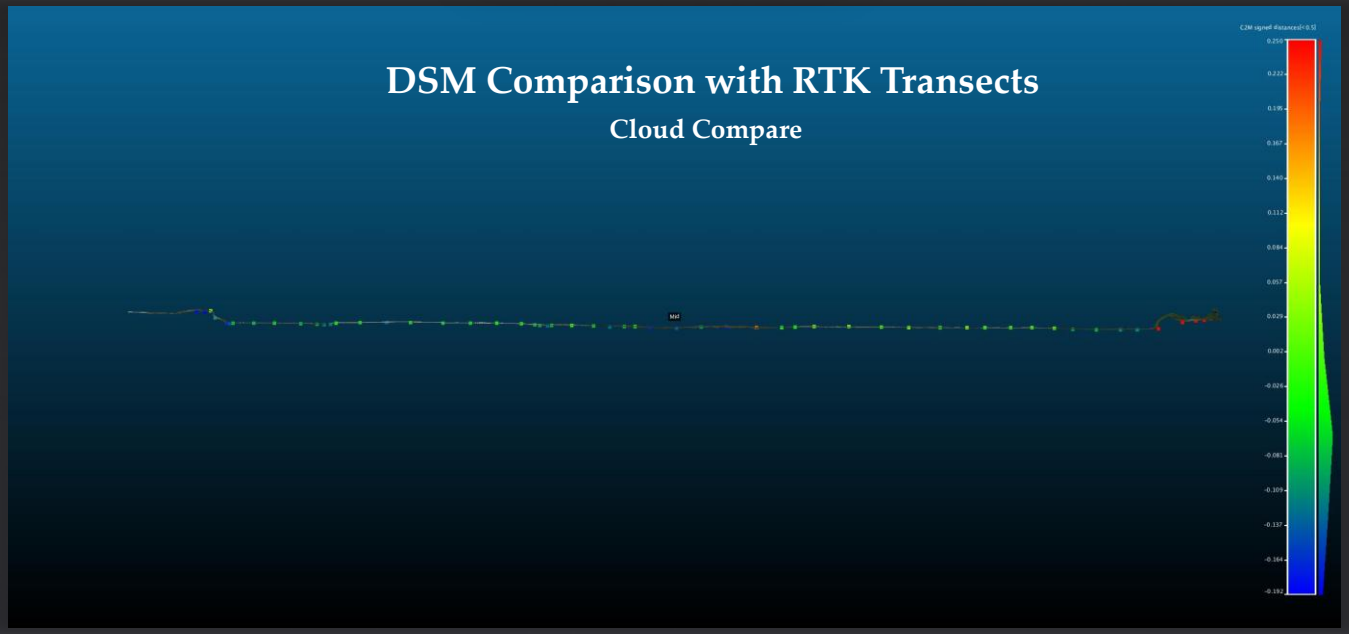
DSM GSD = 5.28 cm, 2.08 in
Ortho GSD = 2.22 cm, 0.87 in

Initial Accuracy

East X – RMS = 6.2 cm
North Y –RMS = 6.7 cm
Alt Z –RMS = 24 cm
Error (Pixel) = 1.265 pix







UAS Point Cloud, Dem, Orthophoto Data Processing

Limitations

UAS Point Cloud, Dem, Orthophoto Data Processing

Limitations

USGS

LANDSAT 40

UAS Point Cloud, Dem, Orthophoto Data Processing

Camera Selection Tips

Source: Photo Modeler and Photoscan

- High resolution: most high quality cameras support resolutions of 5-8 mega pixels or better.
- Used high quality fixed lens and try to avoid digital zoom. Digital zoom settings manipulates the photo without actually adjusting the focal length.
- Do not use vibration reduction or image stabilization lenses.
- Use a wide angle lens. Wide angle lenses suit better for reconstructing spatial relations between objects than telephoto. However wide angle lens typically have more lens distortions.

Shooting Tips

- Avoid shiny and transparent objects. Shoot under a cloudy sky if need be.
- Avoid unwanted foregrounds and moving objects.
- Avoid not textured and flat objects.
- Shoot pictures with a lot of overlap.
- Do not crop or geometrically transform the images.
- More photos are better than not enough.
- Collect images from different directions.

Questions?

Contact Information:

Mike Hutt	(303) 236-1203	mehutt@usgs.gov
Jill Cress	(303) 236-1248	jjcress@usgs.gov
Jeff Sloan	(303) 236-1308	jlsloan@usgs.gov
Susan Goplen	(303) 236-1231	segoplen@usgs.gov
Mark Bauer	(303) 236-1247	mabauer@usgs.gov
Mark Feller	(303) 236-1308	mrfeller@usgs.gov

http://uas.usgs.gov/

USGS

LANDSAT 40