JACIE

Joint Agency Commercial Imagery Evaluation

ULTRACAM

CALIBRATING THE ULTRACAM OSPREY OBLIQUE AERIAL SENSOR

JACIE 2014

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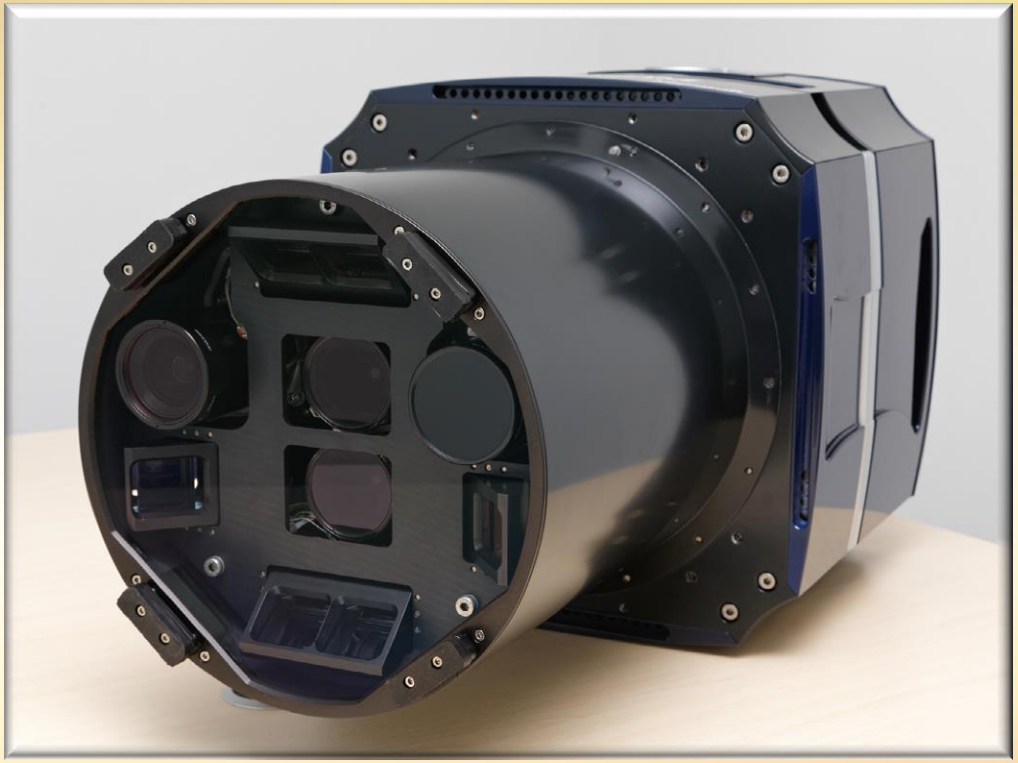
UltraCam Osprey



Combine Nadir and Oblique

UltraCam Osprey

- Camera design
  - 3rd generation UltraCam architecture
  - 2.0 seconds frame rate
  - 3.3 TB SSD storage

- Camera Operation
  - 10cm GSD (nadir) @ 850m AGL
  - Wing image GSD between 7.5cm (inner) and 12.5cm (outer) on a flat terrain
  - 80% frontlap @ 145kts

UltraCam Osprey

Focal Lens/ Pixel Size

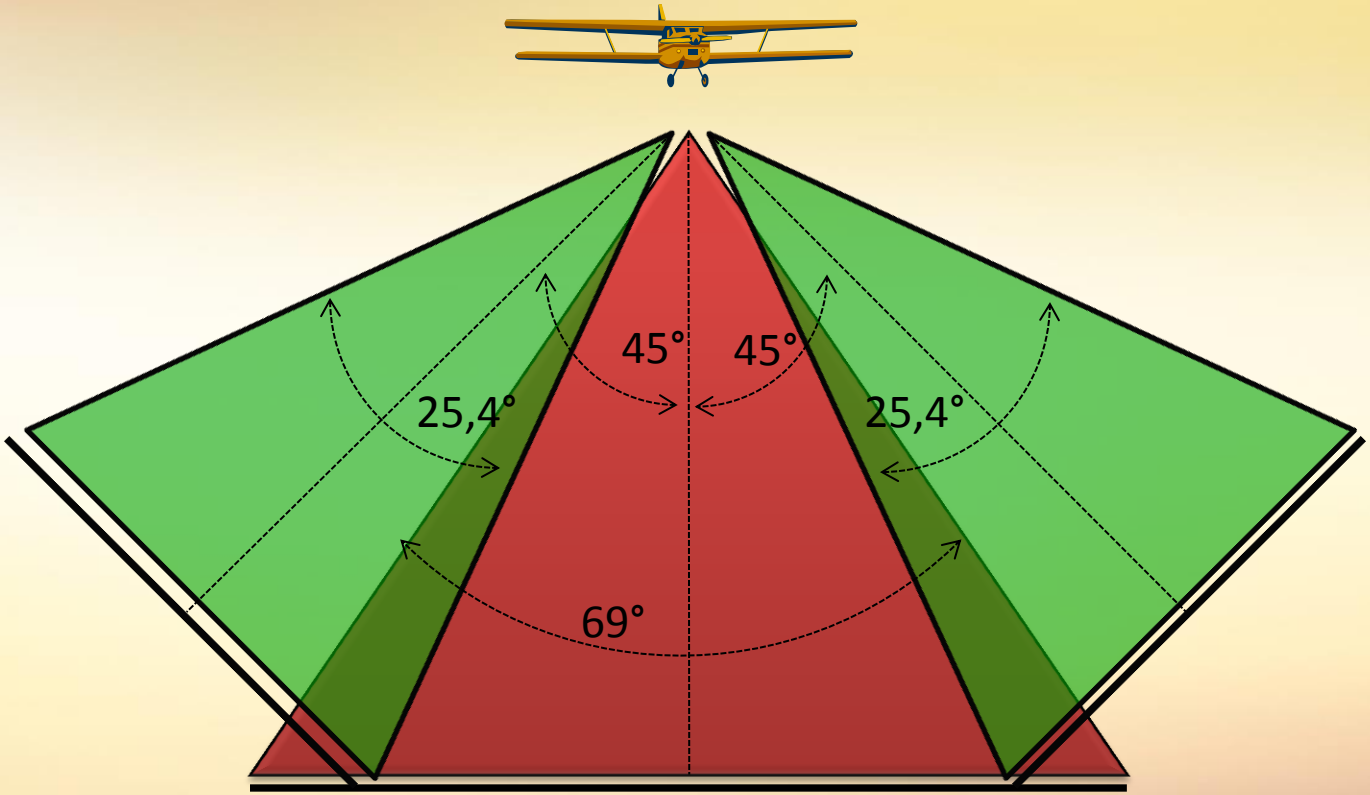
Nadir PAN	51.0 mm	6.0 µm
Nadir RGB and NIR	25.5 mm	5.2 µm
Oblique Sensor Heads	80.0 mm	5.2 µm

Frame Format / Pixel Size

Nadir PAN	11674 * 7514	6.0 µm
Nadir RGB and NIR	6735 * 4335	5.2 µm
Oblique Sensor Heads	6870 * 4520	5.2 µm
Fwd/Bwd (together)	13490 * 4520	

UltraCam Osprey

Nadir and L/R wing cross flight direction



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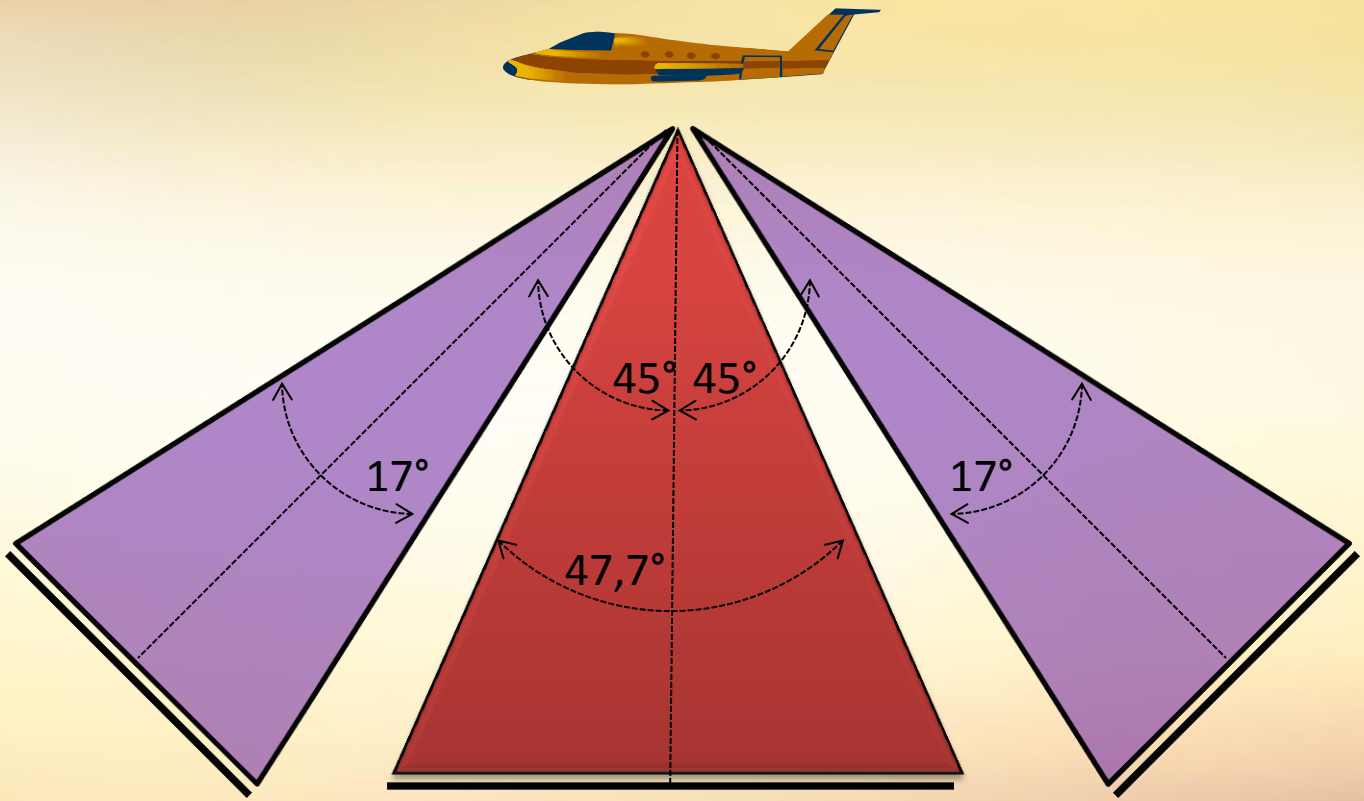
Nadir and F/B wing along flight direction

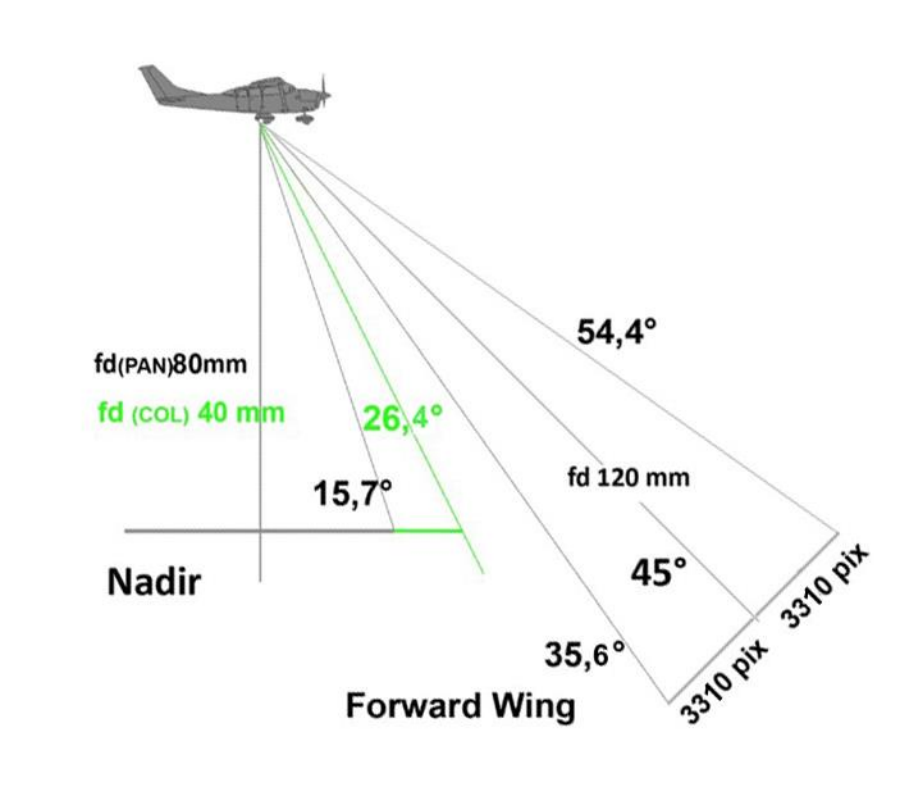


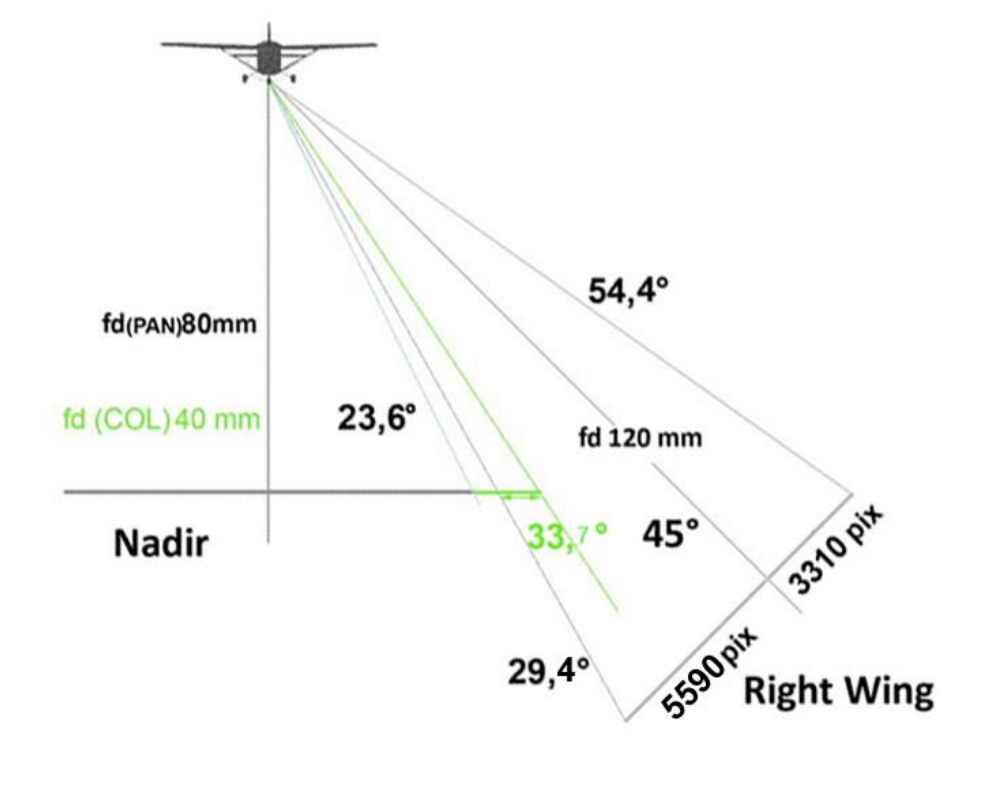
UltraCam Osprey V2

	Focal Lens	Pixel Size
Nadir PAN	80.0 mm	6.0 µm
Nadir RGB and NIR	40.0 mm	5.2 µm
Oblique Sensor Heads	120.0 mm	5.2 µm

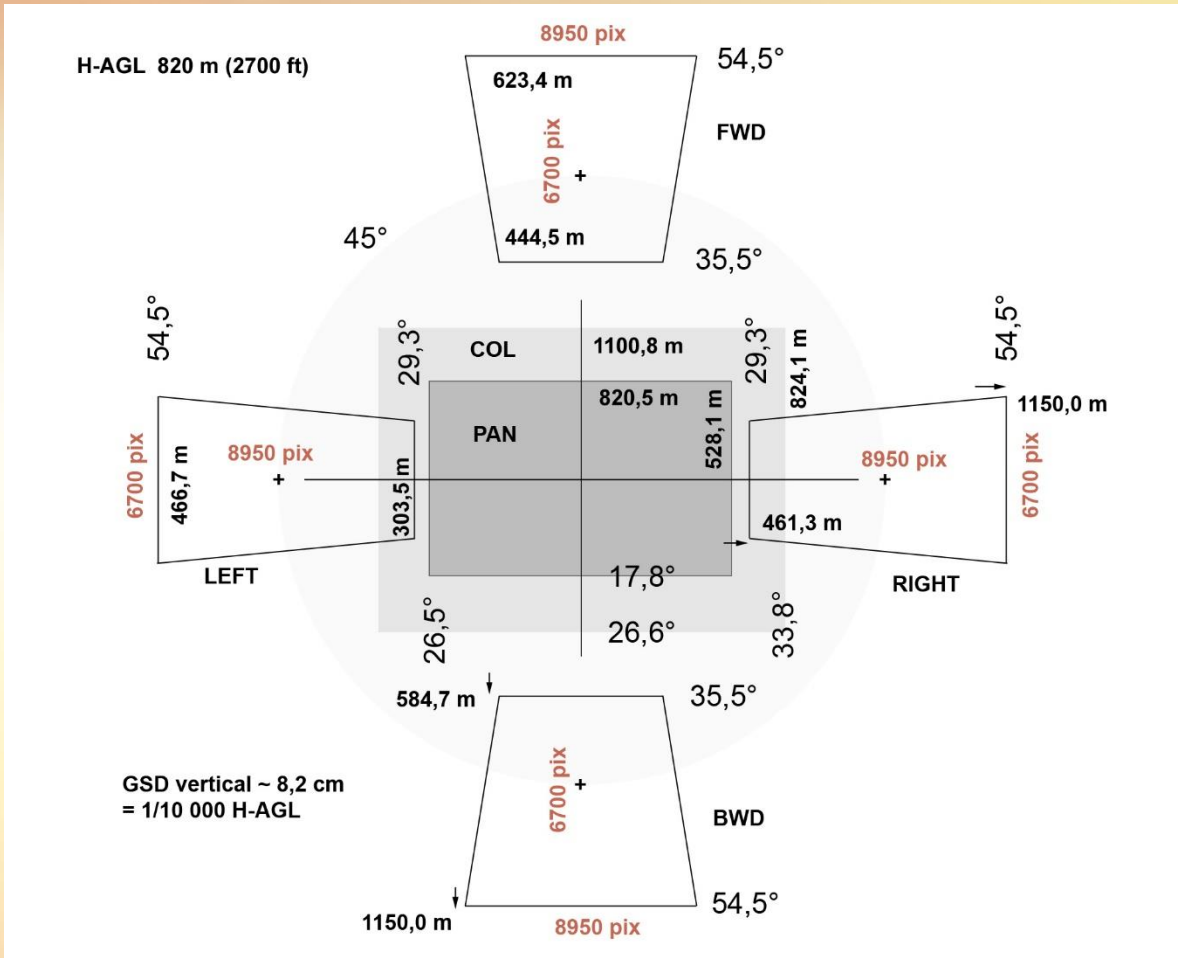
	Frame Format	Pixel Size
Nadir PAN	11674 * 7514	6.0 µm
Nadir RGB	8900 * 6620	6.0 µm
Nadir NIR	6870 * 4520	5.2 µm
Left/Right/Fwd/Bwd	8900 * 6620	6.0 µm

UltraCam Osprey P



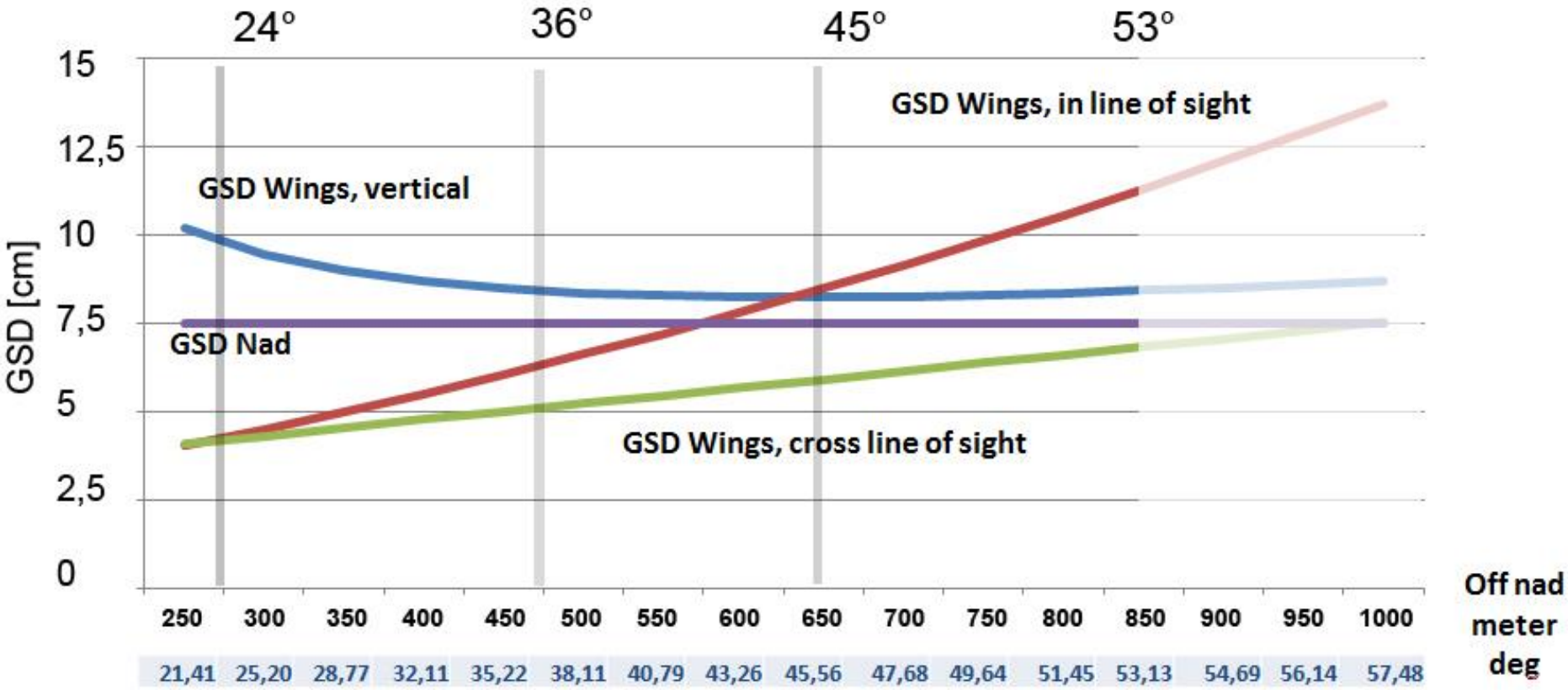


UltraCam Osprey P



Spacial Resolution UltraCam O

GSD Nad = 7,5 cm, H_agl 637 m



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City of Graz, 900 m AGL, Nadir GSD 10,5 cm
Footprint 1230 m by 800 m

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UltraCam Osprey Calibration

Extended Calibration Lab
RMSE of Image Points < 0,5 Pixel
Redundant set of images
Single Head Calibration and Platform Calibration
Nadir EO results used for eccentricity computation

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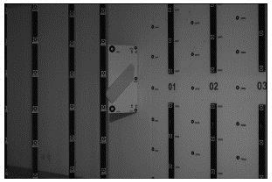

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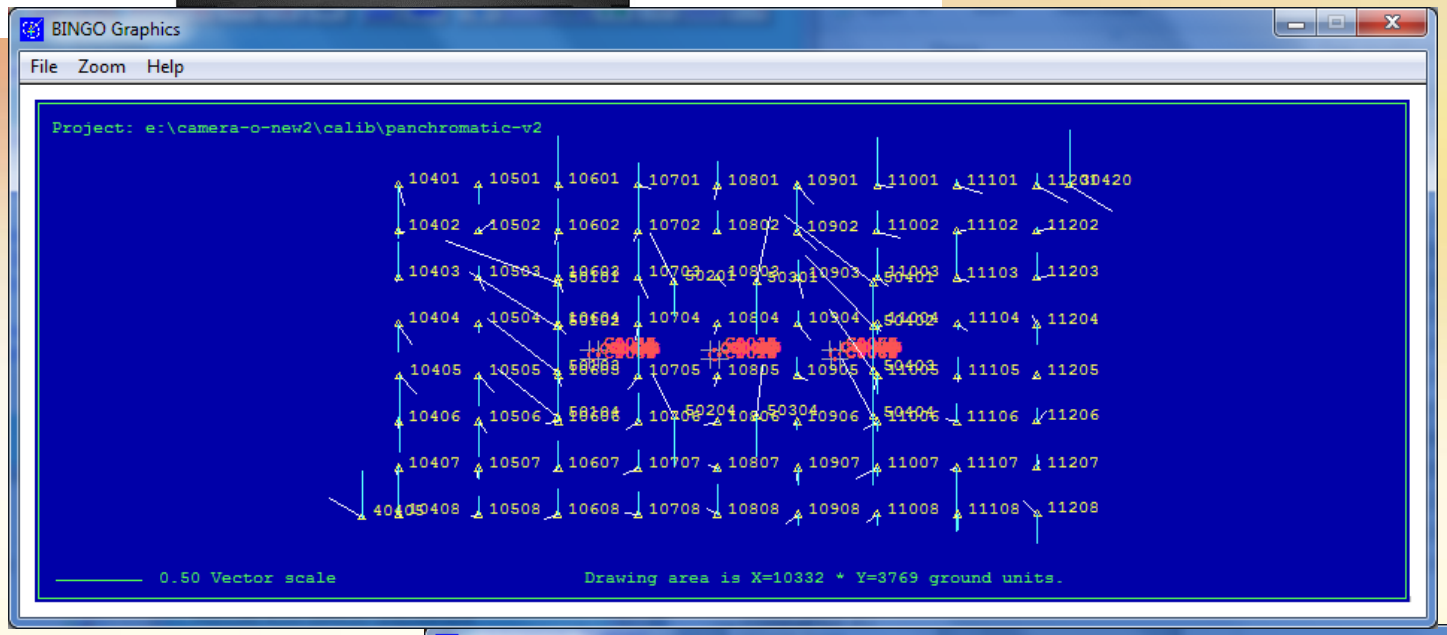

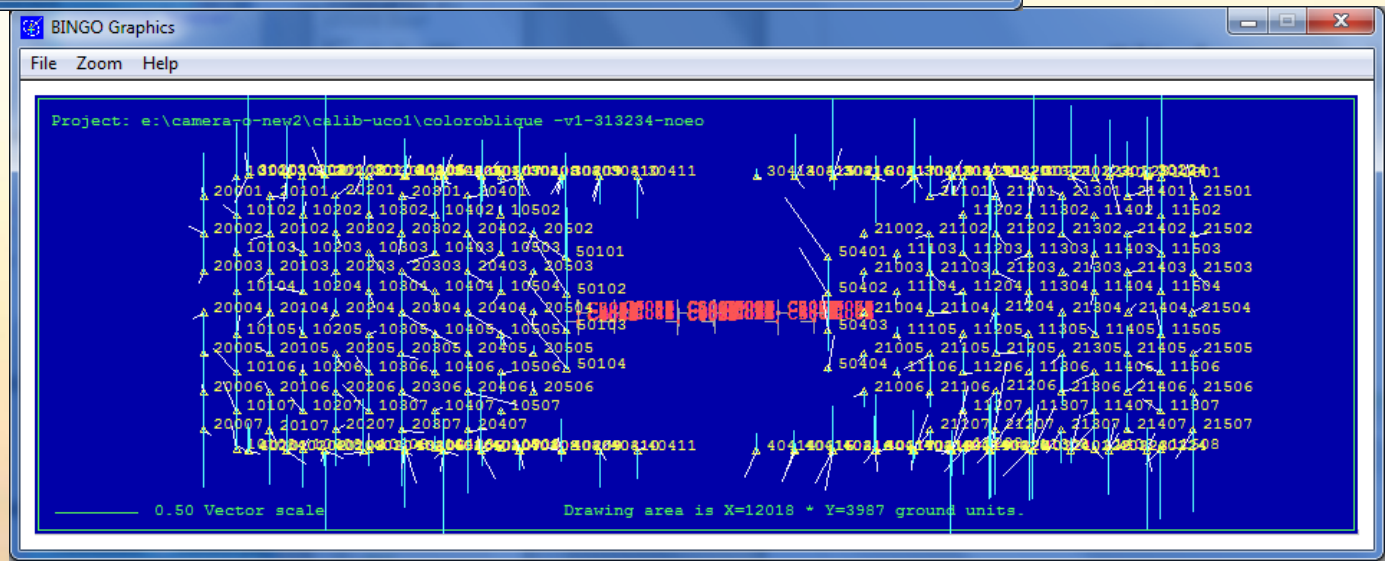

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RESULTS OF ADJUSTMENT SIGMA 0 = 0.95
Nadir PAN SIGMA 0 = 0.79

RMS precision values of photo orientations from Qxx matrix
(X,Y,Z,phi,omega,kappa): (1/1000)

200.	99.	204.	3.6	2.9	1.6

Poorest precision values of photo orientations from Qxx matrix
(X,Y,Z,phi,ome,kap): (1/1000)

324.	135.	314.	12.3	10.1	9.7

Eccentricities of oblique cameras wrt nadir

C4	-37.9675	124.4535	-103.4782	0.1110	-49.8492	0.0290
C5	36.6477	124.0719	-103.2620	0.4059	-50.0955	-0.0748
C6	-125.7413	-37.9701	-106.0217	-49.9858	-0.0584	-0.0007
C7	125.6432	-37.8230	-105.9708	50.0001	0.0764	0.0367
C8	-37.4731	-124.2071	-104.4258	-0.3107	49.9585	-0.1362
C9	37.0895	-124.1808	-103.8412	0.0621	49.9728	-0.1330

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RESULTS from oblique cameras

RMS control point residuals:	184.	175.	469.	(1/1000)
Maximum control point residuals:	1073.	637.	2182.	(1/1000)
RMS position residuals:	77.	64.	71.	(1/1000)
Maximum position residual:	329.	255.	263.	(1/1000)
RMS orientation residuals:	1.3	2.6	4.4	(1/1000)
Maximum orientation residuals:	3.5	7.8	12.8	(1/1000)

Nadir

RMS control point residuals:	114.	154.	176.	(1/1000)
Maximum control point residuals:	599.	822.	656.	(1/1000)

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UltraCam Osprey Aerotriangulation

Project Area Graz
GSD Nadir 10 cm

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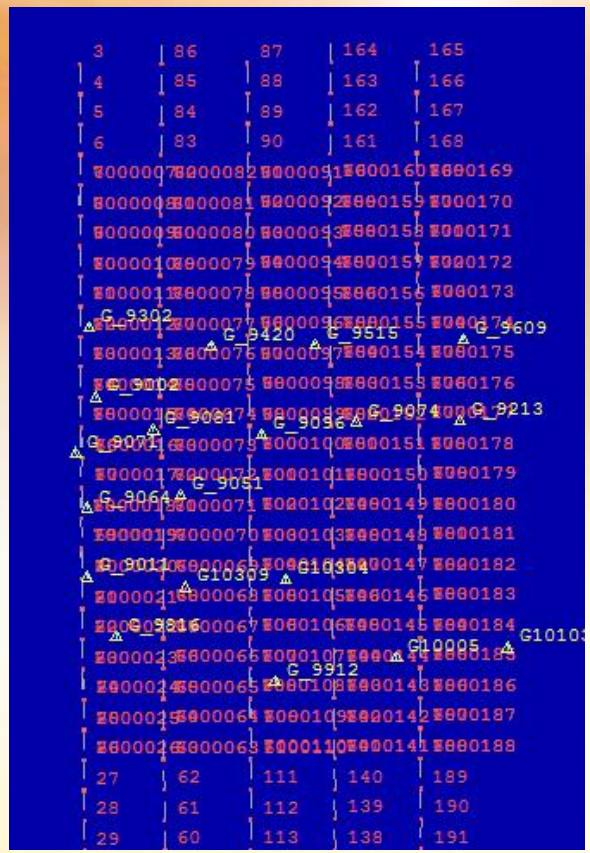

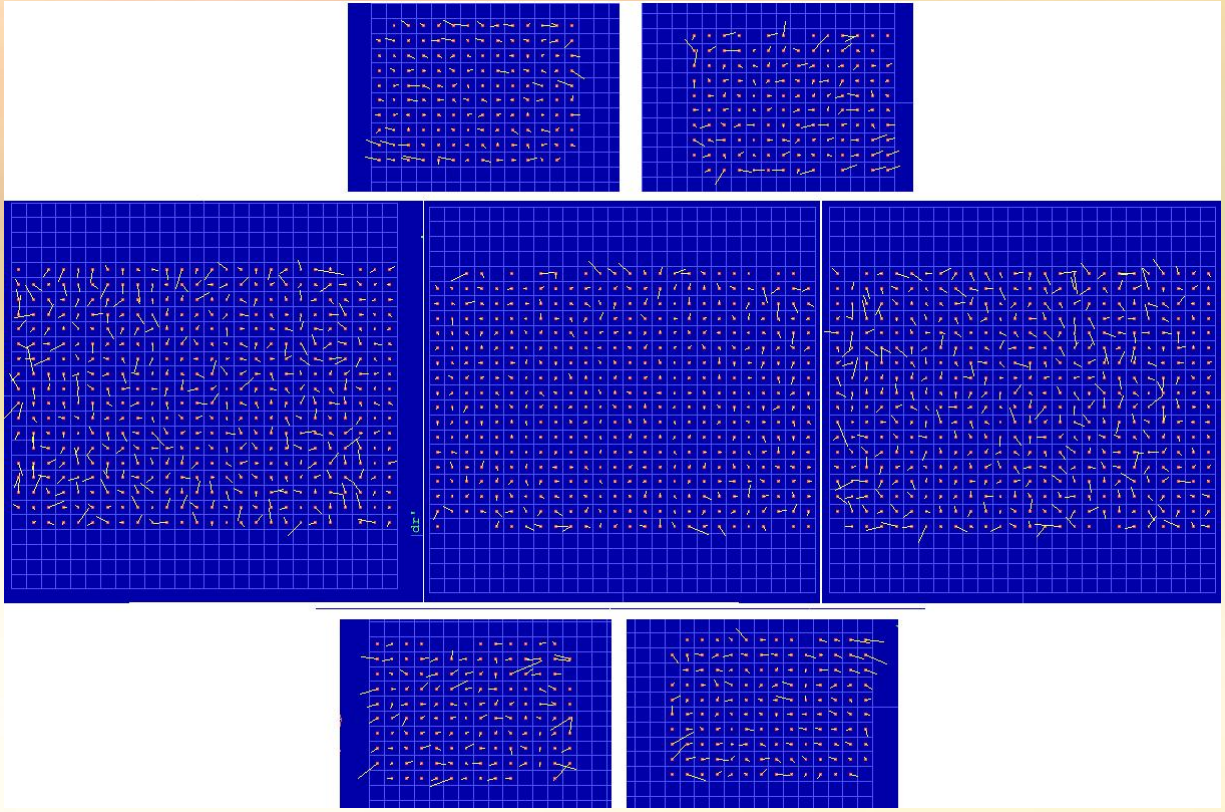

RESULTS OF ADJUSTMENT SIGMA 0 = 2.82

RMS control point residuals: 34. 33. 43. (mm)

Maximum control point residuals: 76. 72. 93. (mm)

Residuals of photo measurements (x', y') in photo space:

RMS	1.9	2.4
MAX	19.1	19.3

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Oblique Registration Investigations

by Andreas Klaus & Joachim Bauer

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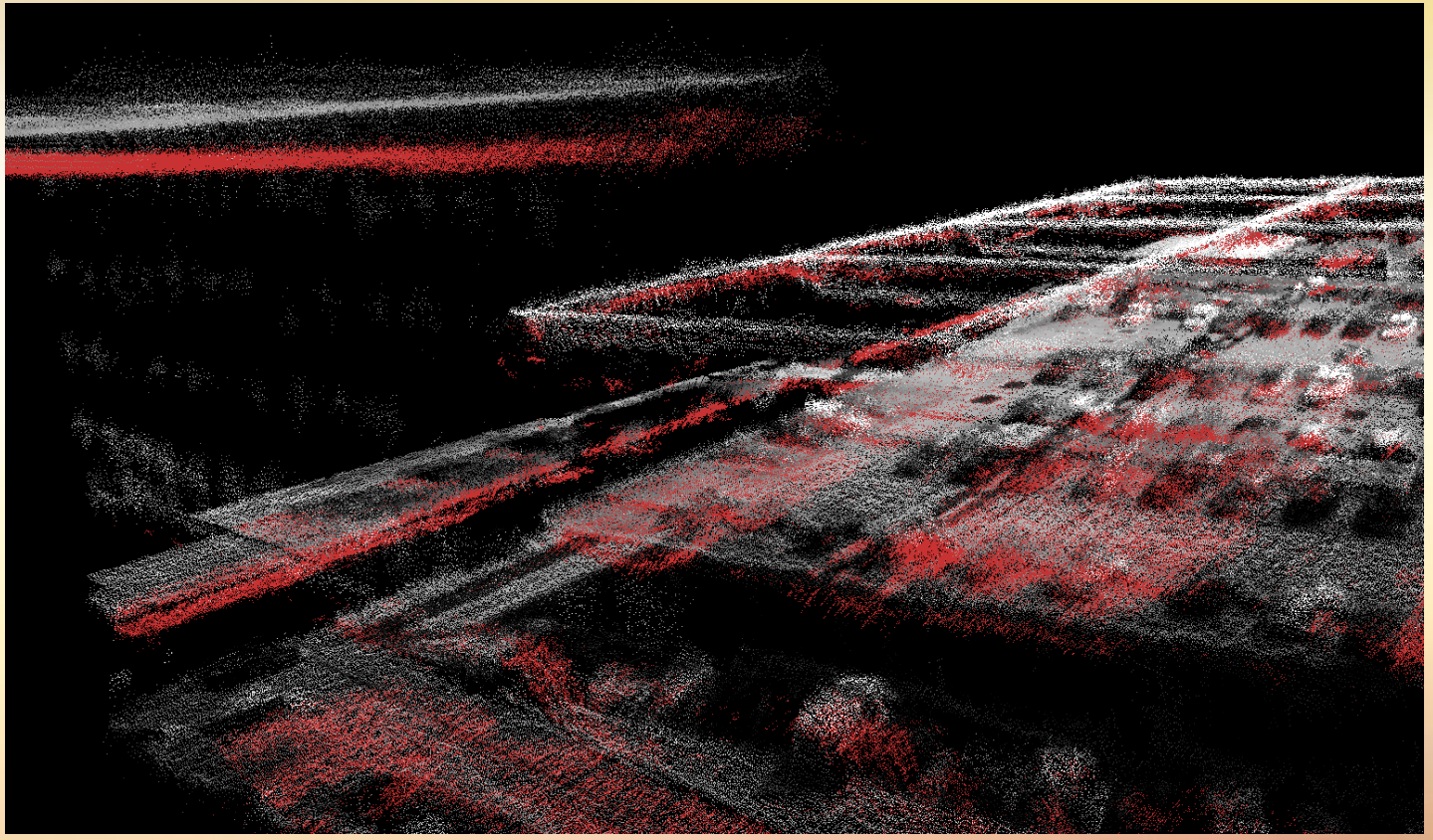
Traced reason for double structures: systematic depth offset between nadir and oblique images



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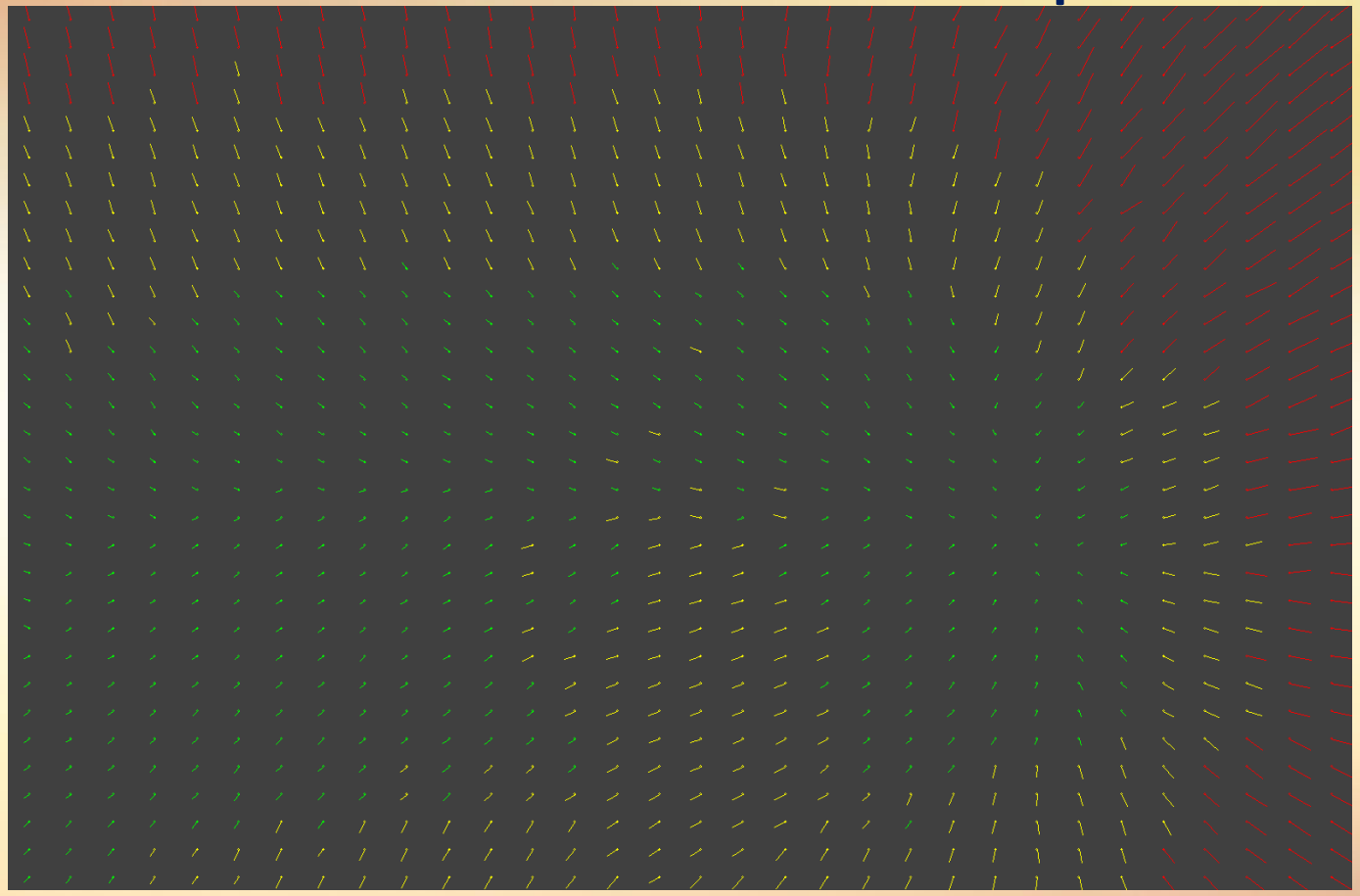
Salzburg UCO cam 17 before update

mean error = 1.6 max error = 7.1 pixel



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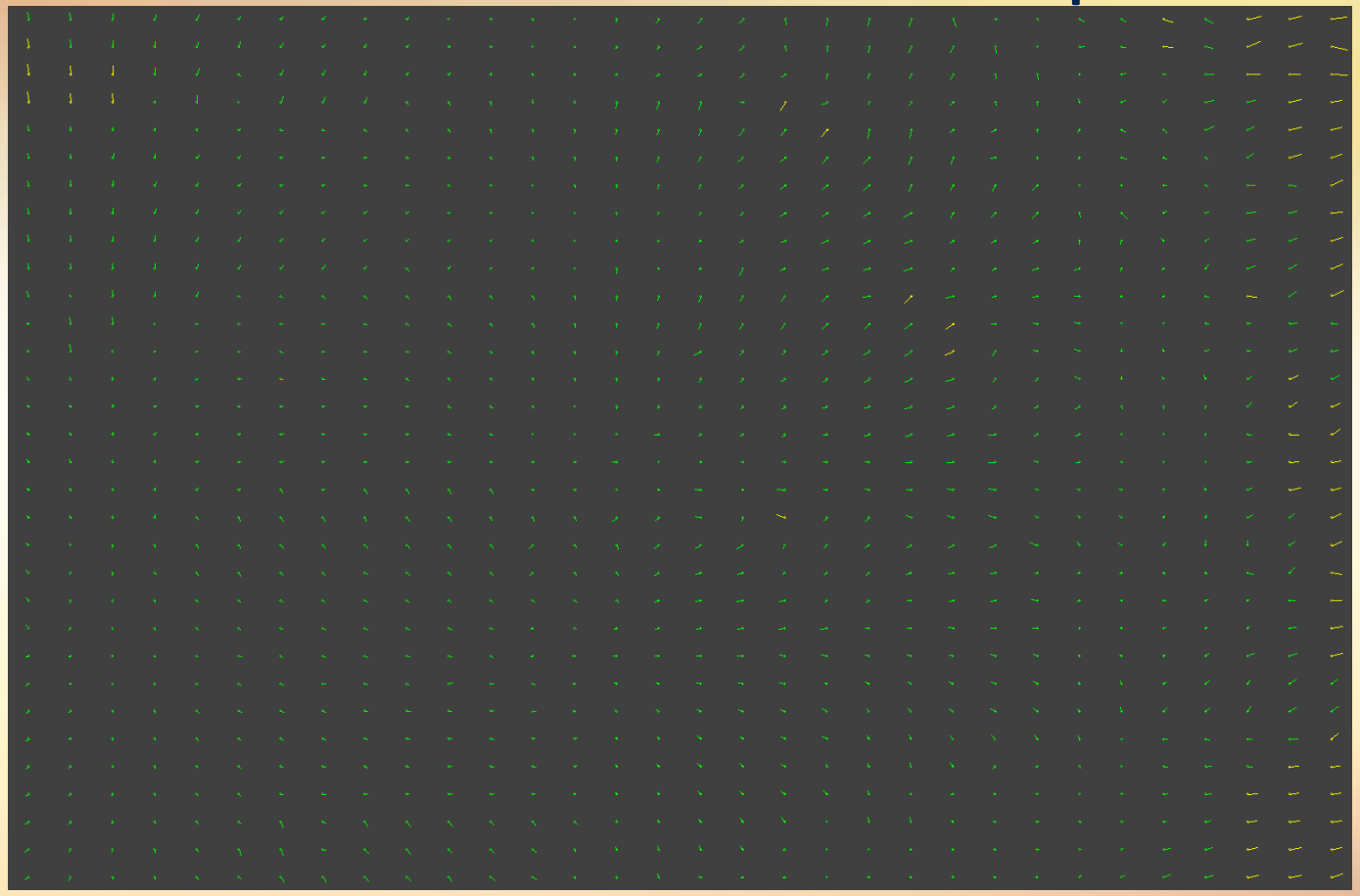
Salzburg UCO cam 17 after update

mean error = 0.48 max error = 1.8 pixel



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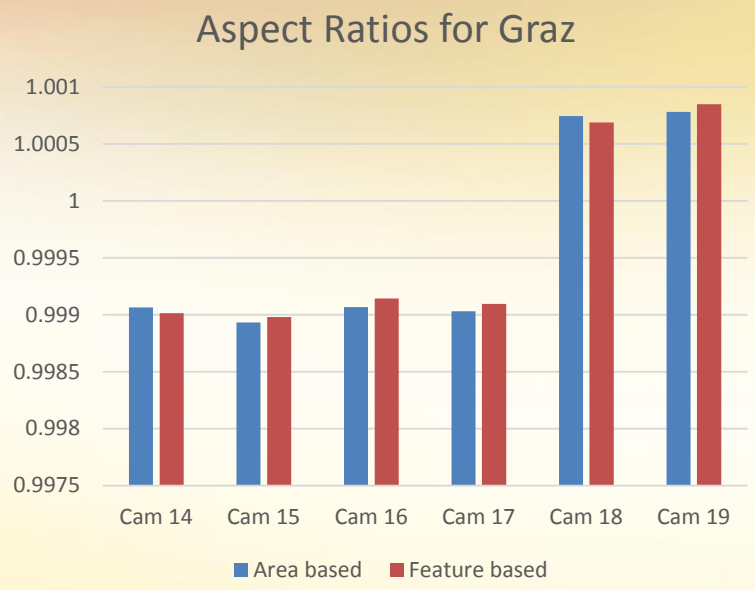
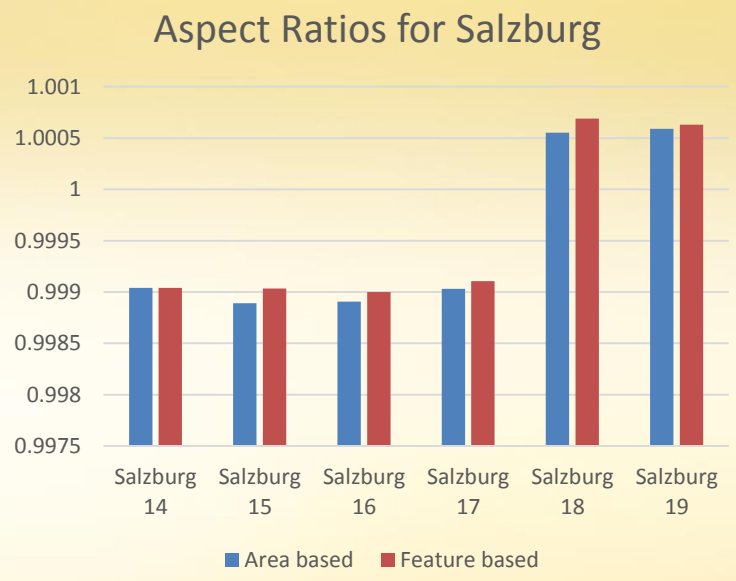
Aspect Ratios for different projects





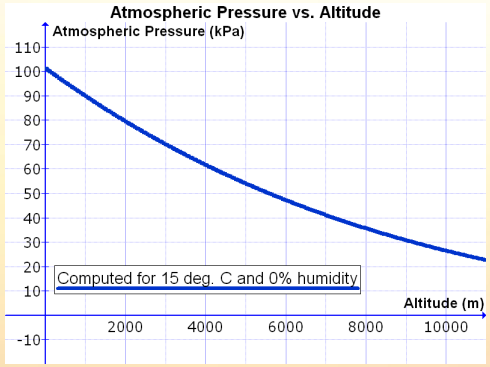
What´s causing different Aspect Ratios?

- **Earth Curvature**

  $y = L^2 / (2 * 6371000)$

  7,84 cm bei 1 km
  1,96 m bei 5 km
  7,85 m bei 10 km

- **Atmospheric Refraction**



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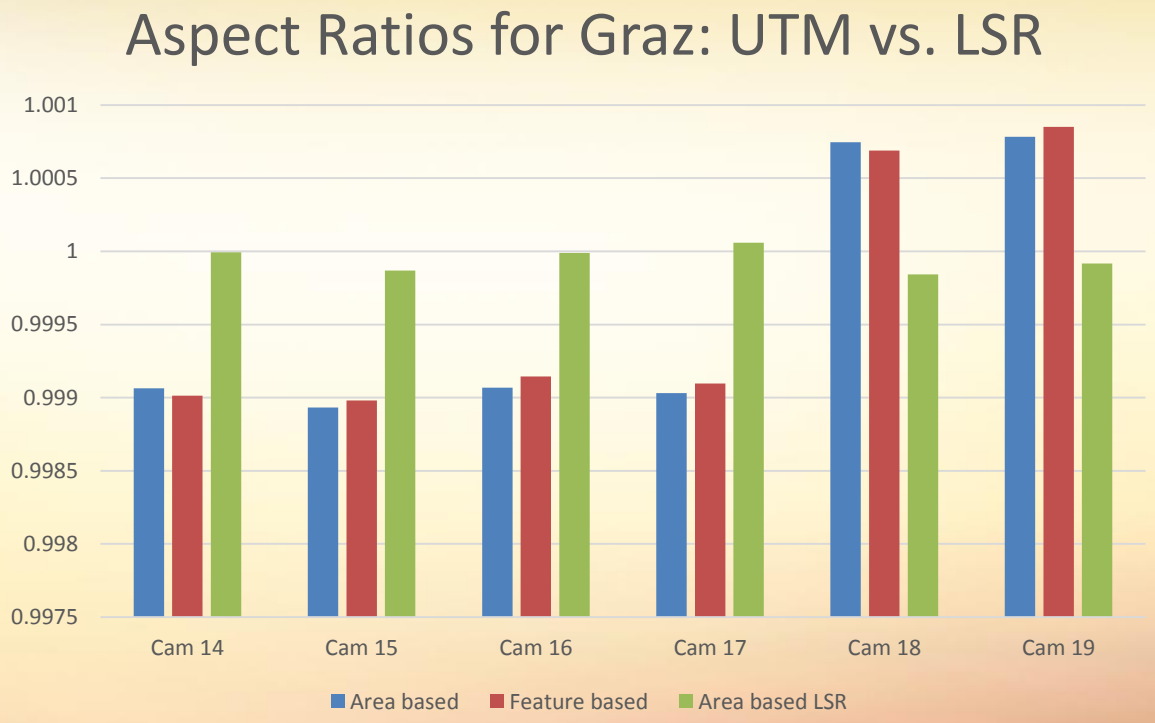
Verification that UTM is causing deviation

1. Processed Lvl02 for Graz without geo bias
2. Calculated new AT in LSR instead of UTM Re-processed area based Nadir-Oblique registration



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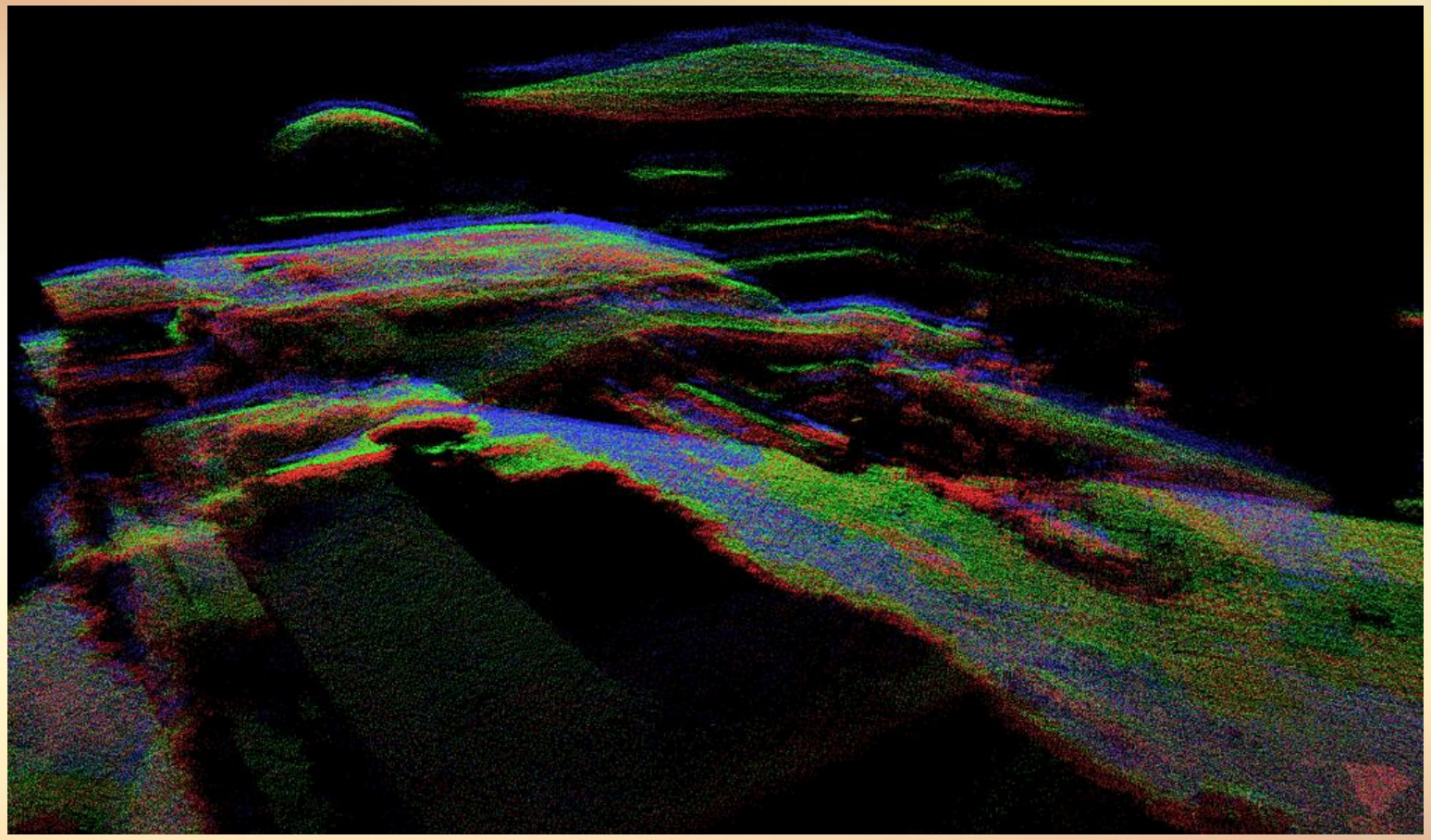
Pointcloud: UCO Graz UTM

nadir forward/backward left/right



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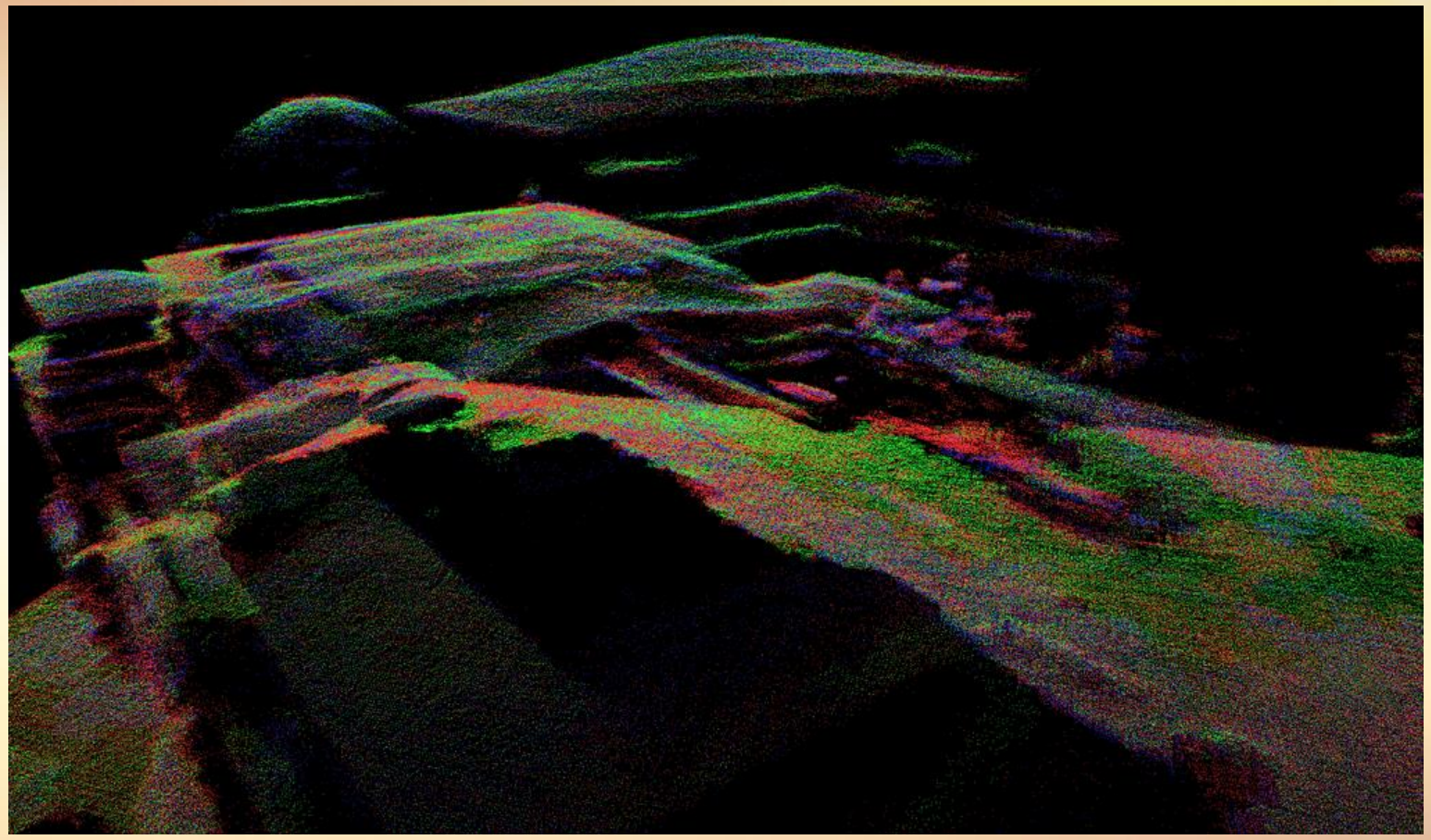
Pointcloud: UCO Graz LSR

nadir forward/backward left/right



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Conclusion

- Nadir serves as the geometry backbone
- Impact of refraction and earth curvature
- AT in UTM is problematic – especially for oblique images
- Geo bias depends on altitude, UTM zone and latitude
- LSR system allows to improve nadir-oblique registration

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UltraCam Osprey Project Results

Flight Mission Salzburg, May 2013
GSD (nadir) 10,5 cm, Height AGL 890 m

Flight Pattern 75% fwd OL, 65 % sdw OL
Base 142 m, line distance 305 m

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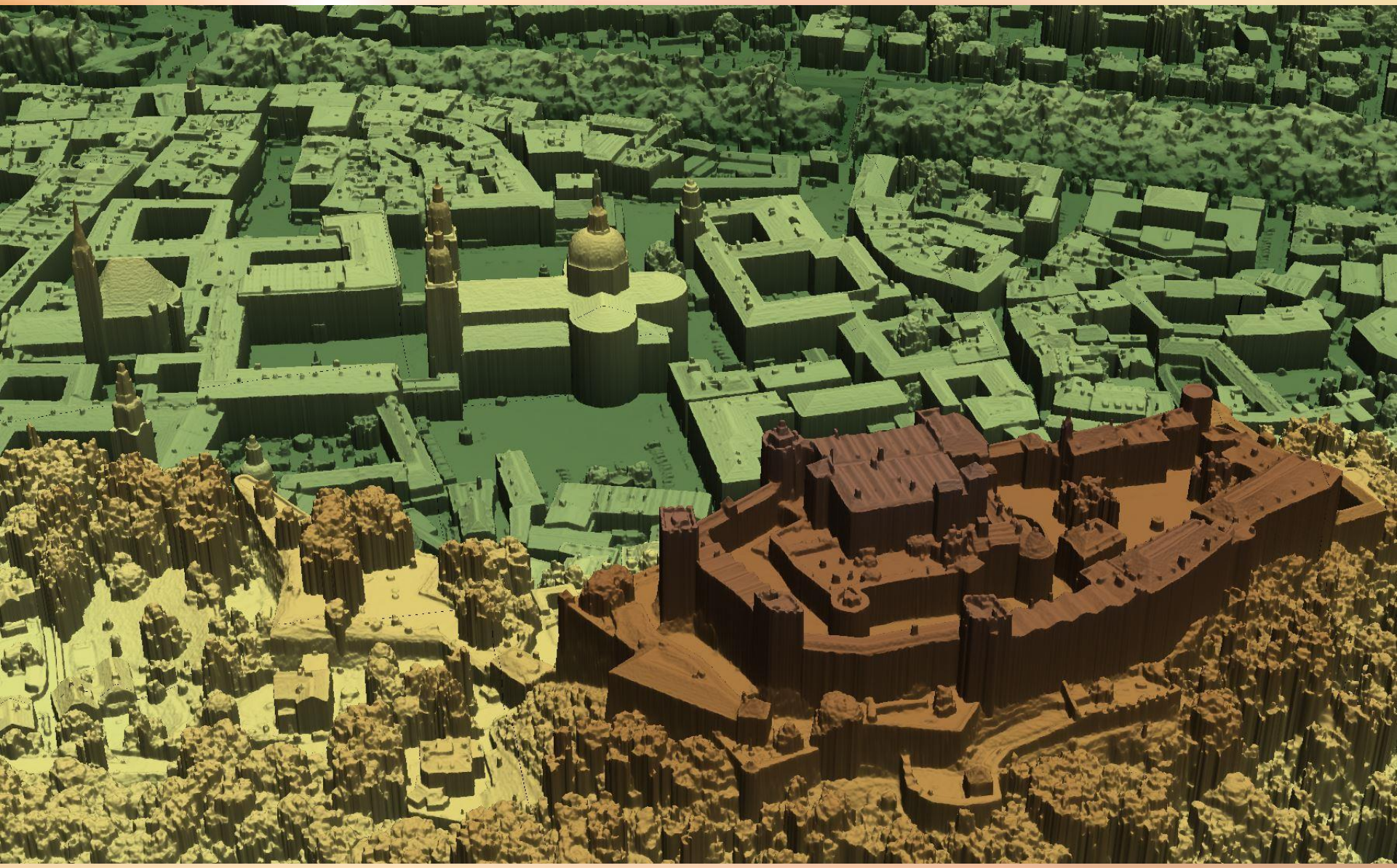

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Thank you very much

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