

Benchmark on Image Matching

Comparison and discussion of computed DSM results

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Delivered data sets

Friday, June 7, 2013



- § Results presented during workshop
 - § C. Ginzler (WSL - Swiss Federal Institute for Forest, Snow and Landscape Research)
 - § B. Brunner (FMM - Forest Mapping and Management, Salzburg)
 - § R. Schneider (Digital Photogrammetry GEOSYSTEMS GmbH, Germany)
 - § P. Nonin (GEO-Information Services Astrium Services)
 - § C. Ressler (GEO TU Wien, Vienna)
 - § M. Idrissa (Royal Military Academy, Brussels)
 - § K. Gutjahr (Joanneum Research, Graz)
 - § M. Pierrot-Deseilligny (IGN France)
 - § M. Rothermel (ifp, University of Stuttgart)
- § Results made available to project team
 - § H. Hirschmüller (German Aerospace Center, DLR)
 - § **DLR-SGM**
 - § K. Legat (AVT Photogrammetrie und Bildflug)
 - § **Ultramap, Match-T**
 - § J. Gonçalves (University of Porto)
 - § **AgiSoft**



Evaluation of DSM from image matching



- § Use of LiDAR as reference data set?
 - § Vaihingen/Enz: DSM differences due to different acquisition time and measurement principle
 - § Insufficient LiDAR resolution (München 10cm GSD, LiDAR: 4 pts/m²)

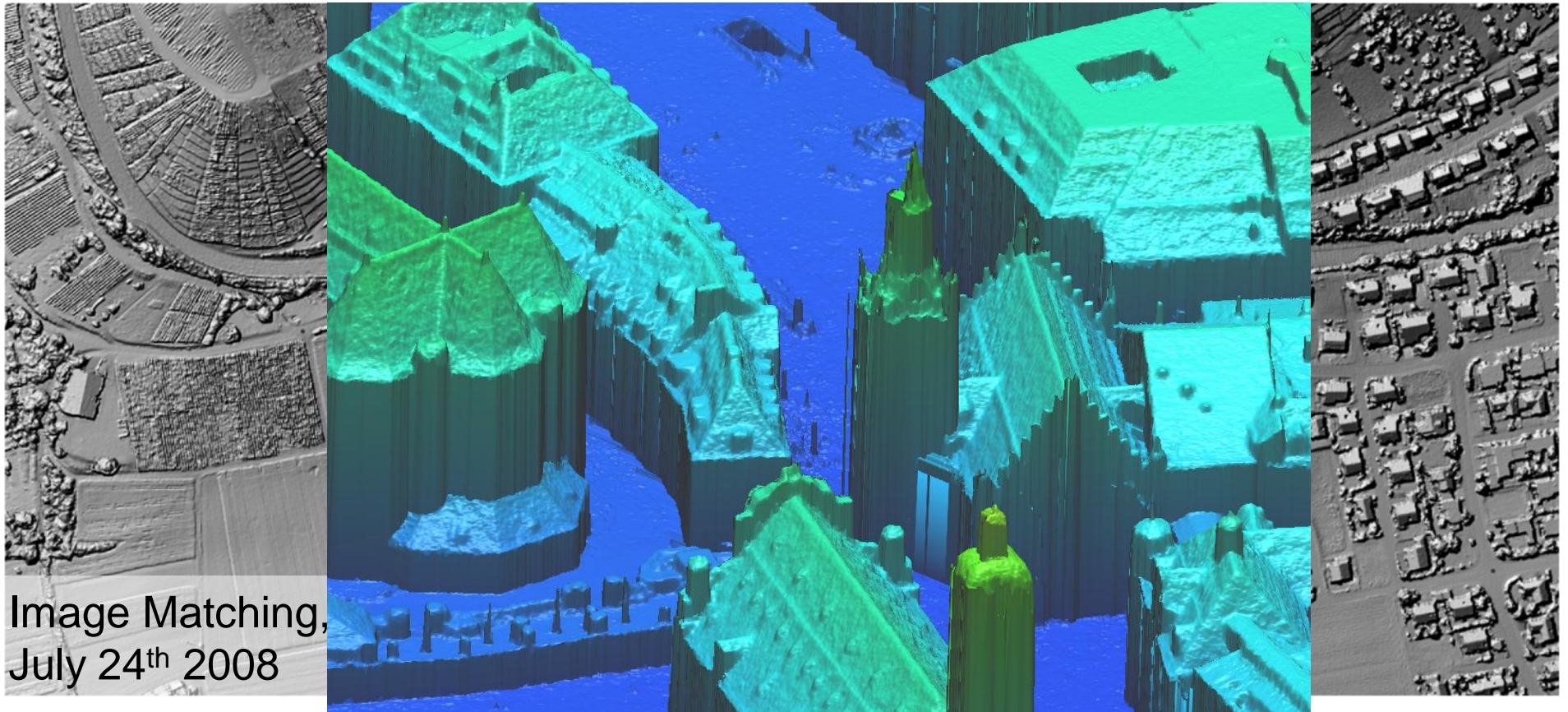


Image Matching,
July 24th 2008



Evaluation of DSM from image matching: Suitable reference surfaces



- § Multiple DSM available from participating groups
 - § DSM differences should give a hint to achieved quality and potential problems
- § Compute median DSM as reference surface
 - § Median more robust against outliers than mean
 - § Assumes symmetric distribution of results – might not be valid
- § Not valid as ground truth
 - § Useful for comparison to show differences between various results



DSM evaluation

Differences to Median Surface



/Muc_Astrium.tif

Found 100% valids, thereof 10.4118% differnt to median surface
Found 100% valids, thereof 11.6784% differnt to median surface
Found 100% valids, thereof 9.49517% differnt to median surface

if/Muc_DLR.tif

Found 100% valids, thereof 26.7972% differnt to median surface
Found 100% valids, thereof 33.7773% differnt to median surface
Found 100% valids, thereof 24.176% differnt to median surface

/Muc_Geosystems.tif

Found 99.9998% valids, thereof 18.6543% differnt to median surface
Found 99.9998% valids, thereof 19.6153% differnt to median surface
Found 100% valids, thereof 15.7233% differnt to median surface

/Muc_Goncalves.tif

Found 36.6189% valids, thereof 18.8195% differnt to median surface
Found 0% valids, thereof -nan% differnt to median surface
Found 0% valids, thereof -nan% differnt to median surface

/Muc_JR.tif

Found 100% valids, thereof 10.7313% differnt to median surface
Found 99.9905% valids, thereof 13.5536% differnt to median surface
Found 99.8979% valids, thereof 13.2869% differnt to median surface

Muc_MicMac.tif

Found 100% valids, thereof 23.7144% differnt to median surface
Found 100% valids, thereof 27.6457% differnt to median surface
Found 100% valids, thereof 17.3618% differnt to median surface

Processing/media/Solid/EuroSDR/MedianMapMuc/Tif/Muc_RMA.tif

Found 100% valids, thereof 14.1263% differnt to median surface
Found 100% valids, thereof 17.0455% differnt to median surface
Found 100% valids, thereof 15.139% differnt to median surface

Processing/media/Solid/EuroSDR/MedianMapMuc/Tif/Muc_SocetSet.tif

Found 100% valids, thereof 52.4746% differnt to median surface
Found 100% valids, thereof 56.3571% differnt to median surface
Found 100% valids, thereof 28.5879% differnt to median surface

Processing/media/Solid/EuroSDR/MedianMapMuc/Tif/Muc_TUVienna.tif

Found 100% valids, thereof 16.6987% differnt to median surface
Found 99.9996% valids, thereof 15.378% differnt to median surface
Found 100% valids, thereof 11.5786% differnt to median surface

Processing/media/Solid/EuroSDR/MedianMapMuc/Tif/Munich_Ip.tif

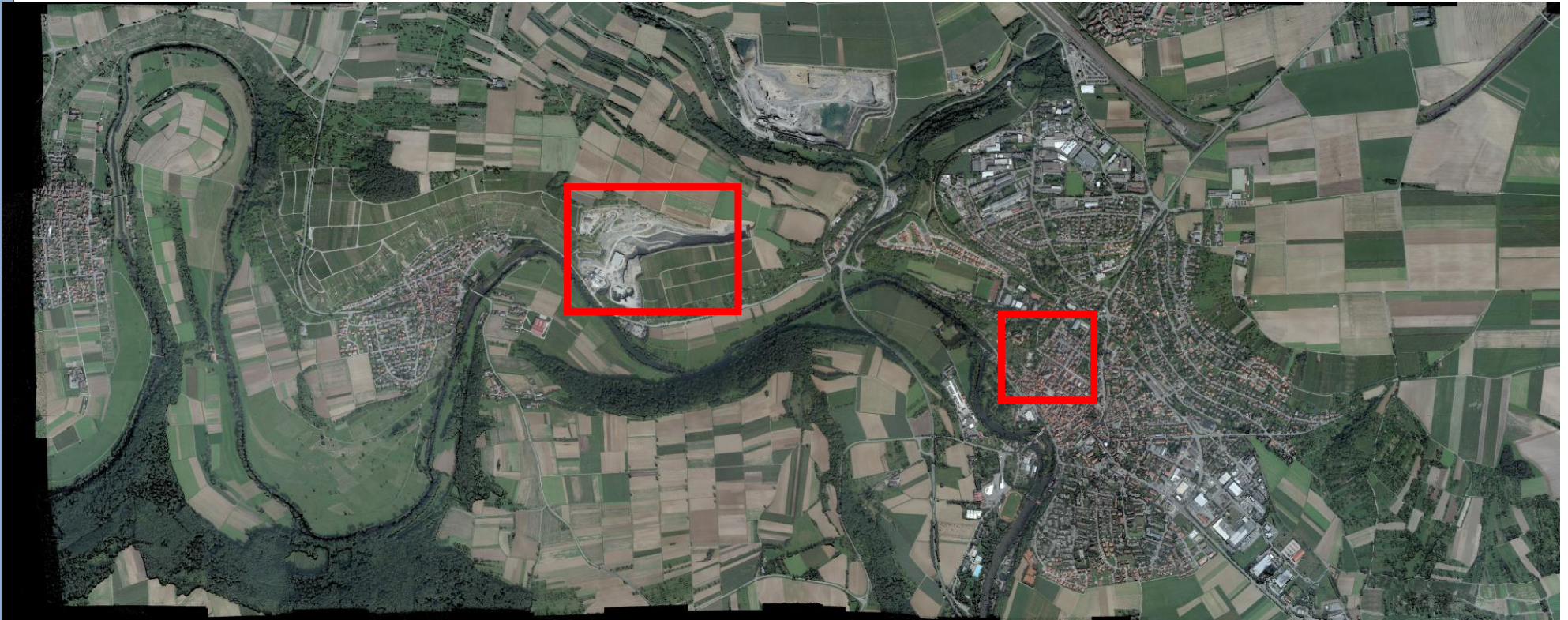
Found 100% valids, thereof 10.2598% differnt to median surface
Found 100% valids, thereof 13.1973% differnt to median surface
Found 100% valids, thereof 12.9169% differnt to median surface

% of points with differences to median DSM > 3*GSD (München)

- § Overall differences difficult for interpretation
- § Visual analysis for selected areas of interest



Visualisation of results



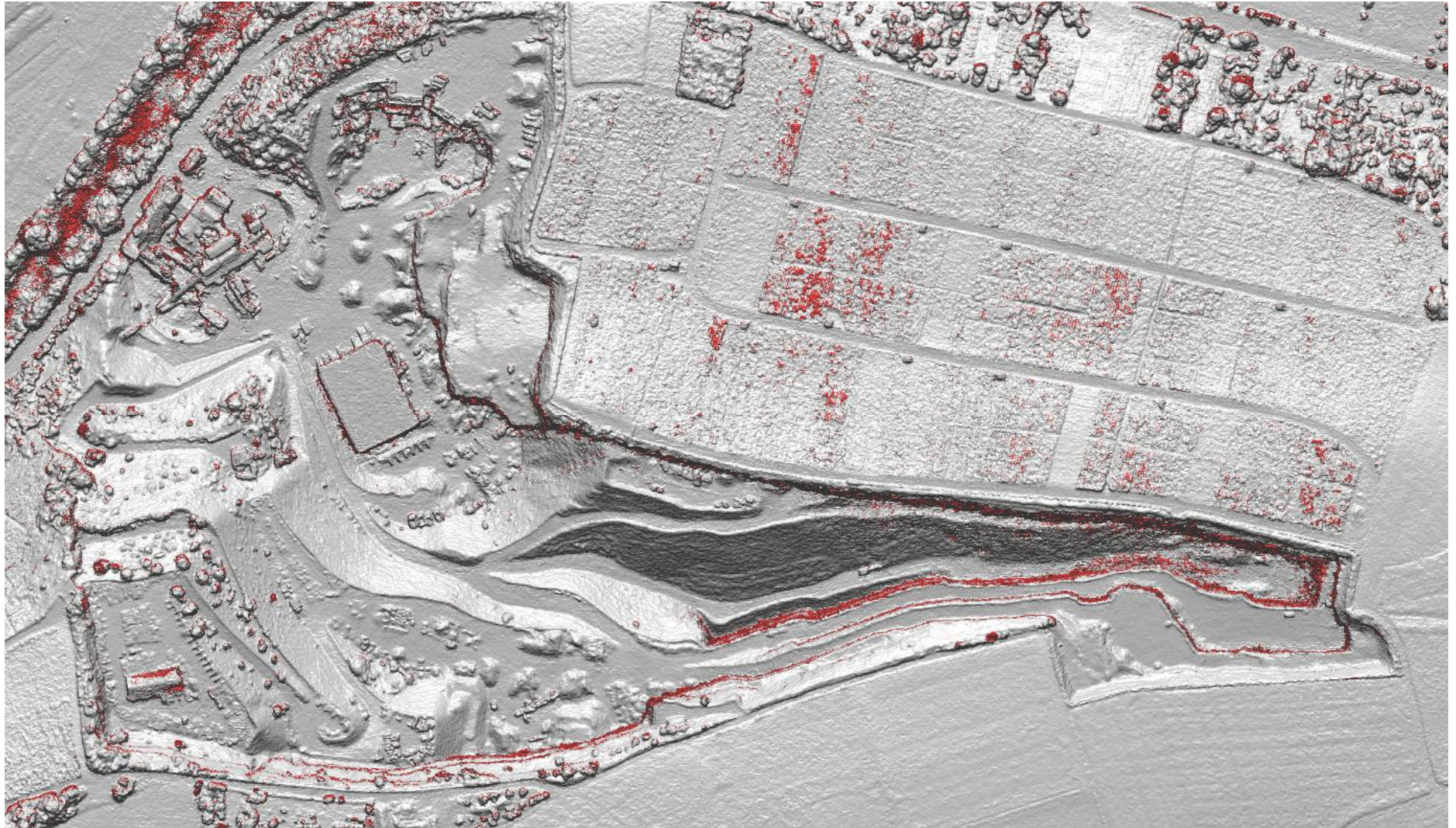
- § Investigate selected patches of interest
- § 3D visualizations of DSM differences to identify potential problems
- § Color coding of differences to median DSM
 - § Differences $>\pm 3$ GSD colored red
 - § Vaihingen $\pm 60\text{cm}$, München $\pm 30\text{cm}$



Visualisation of results

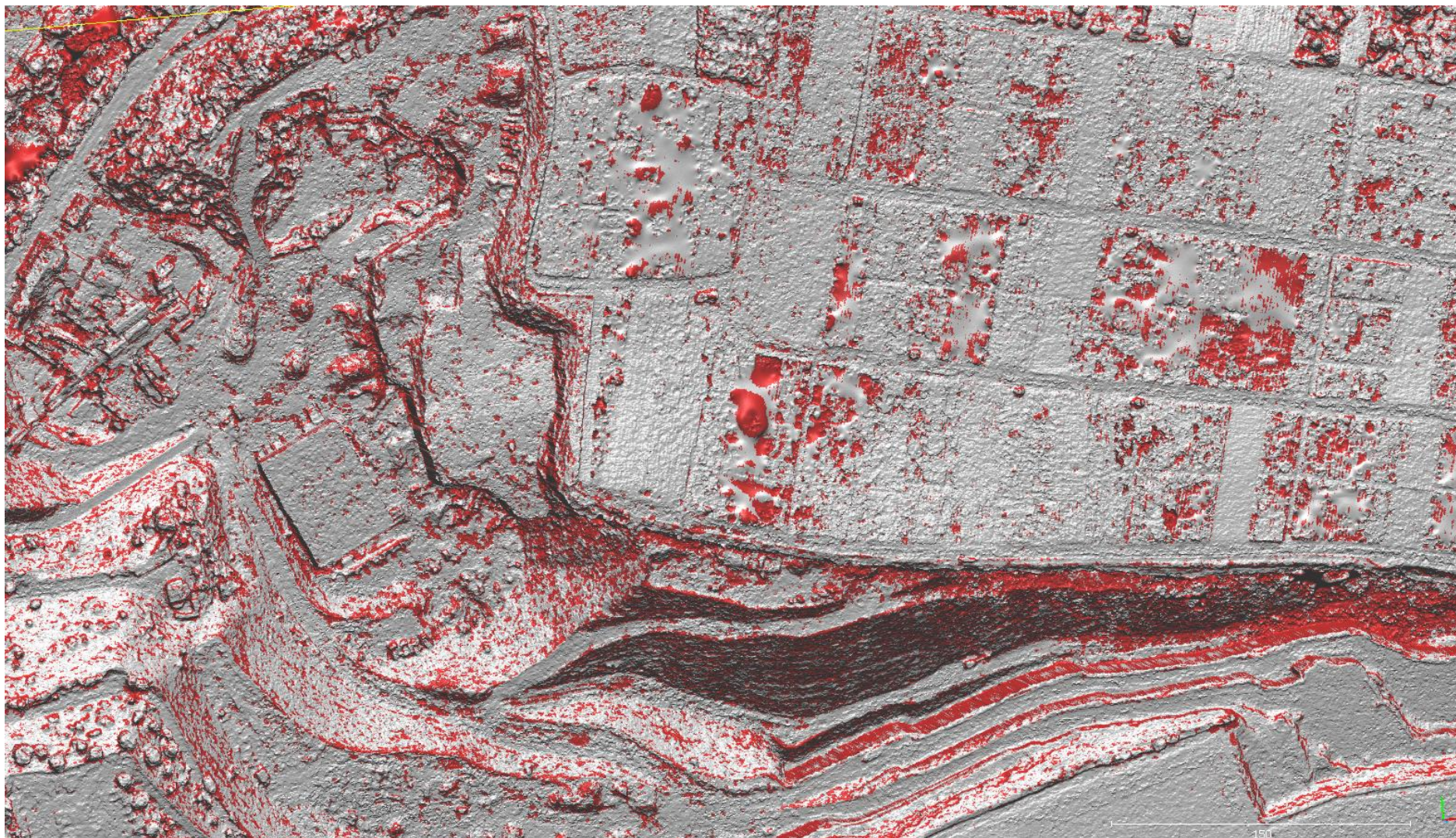
Quarry, Vaihingen/Enz



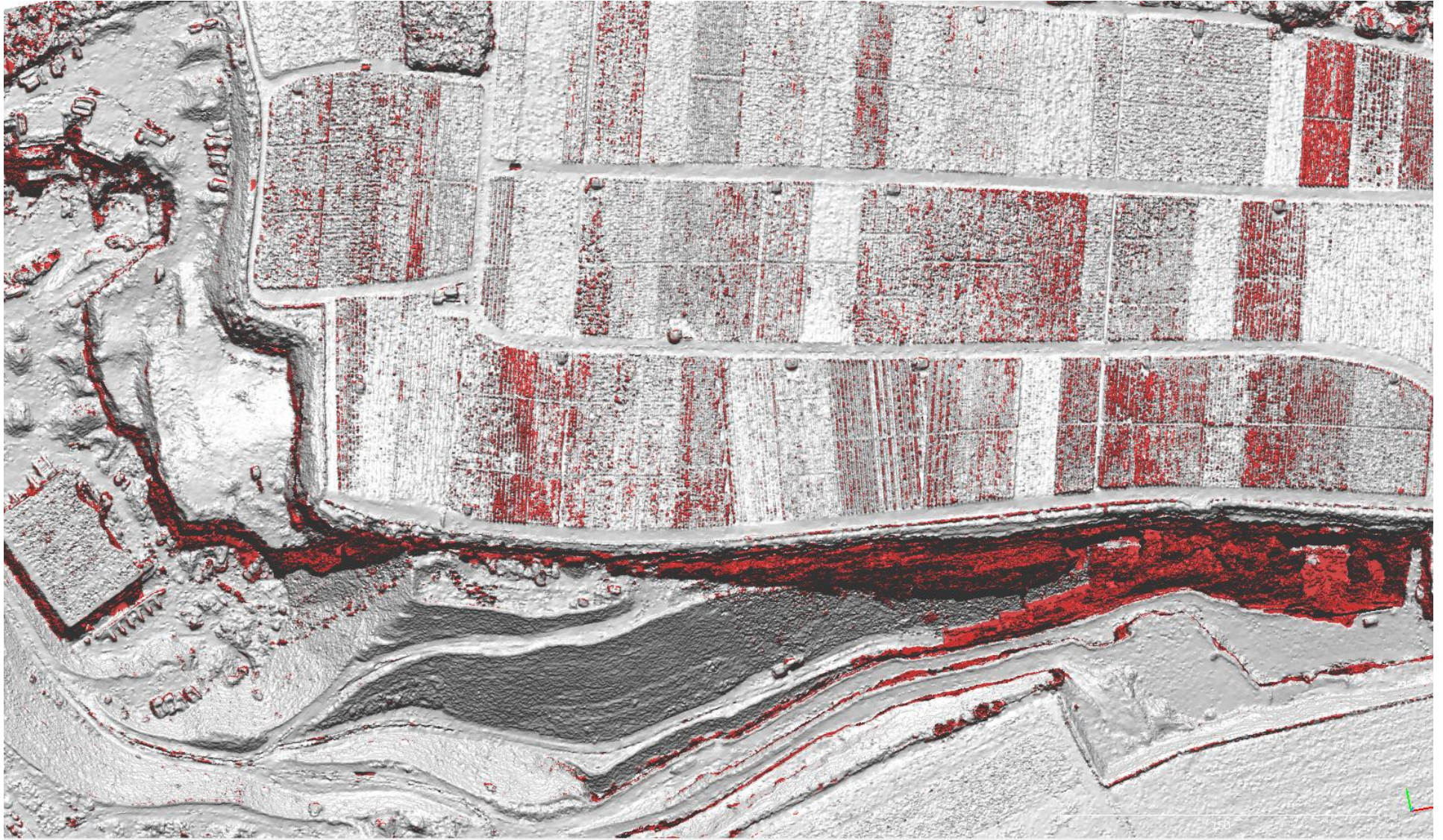




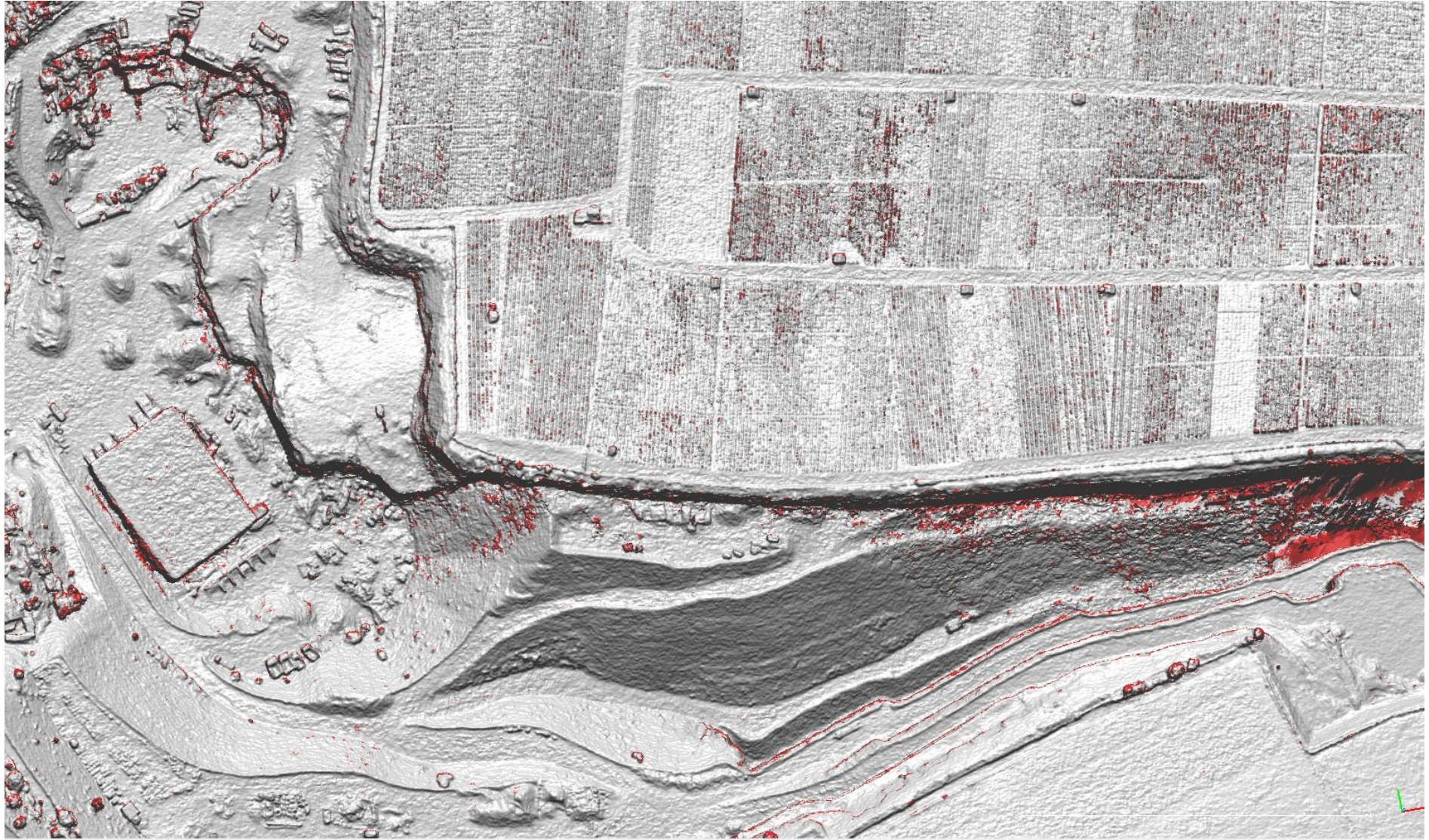
DLR



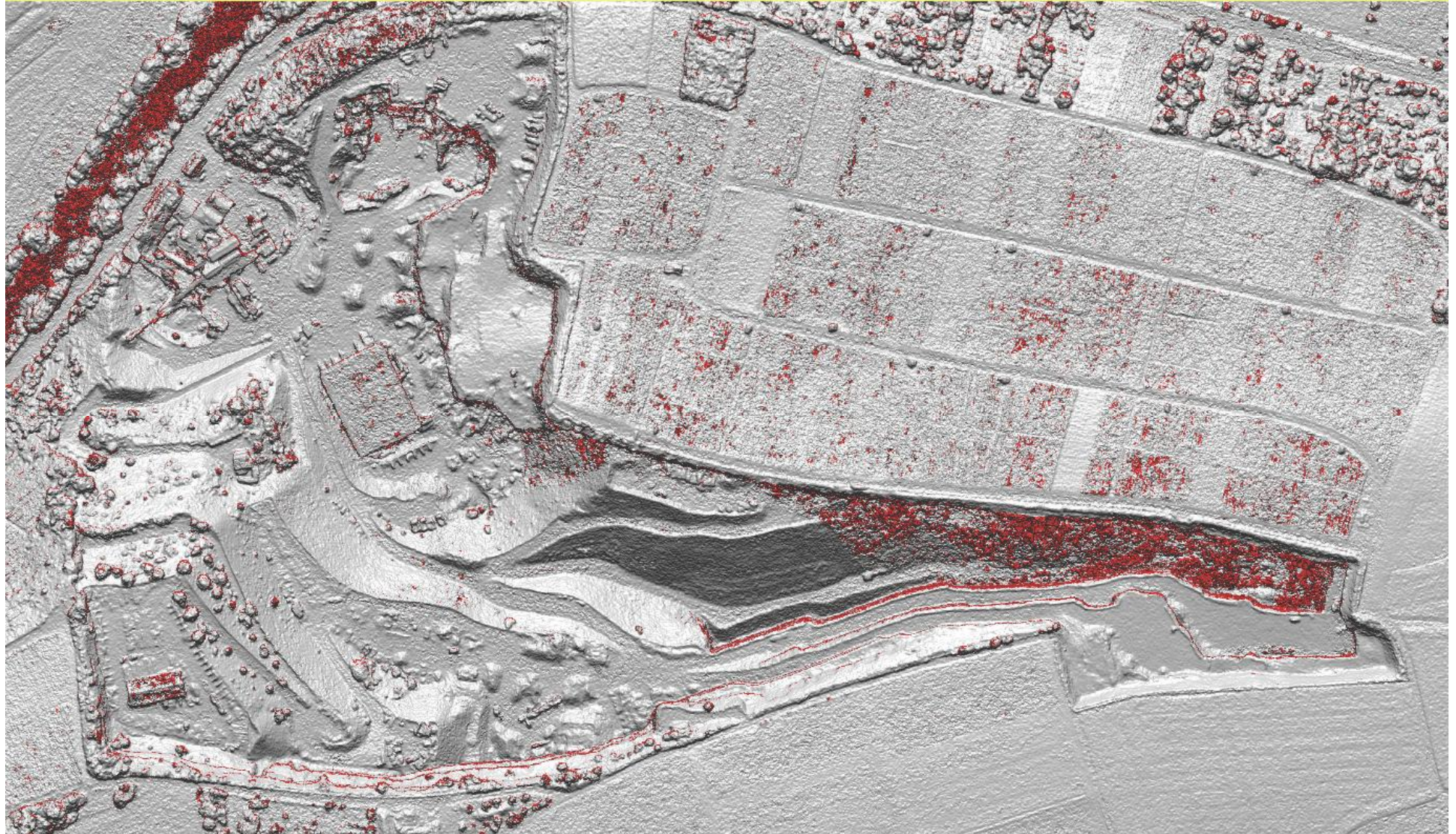
MicMac



Astrium



Royal Military Academy

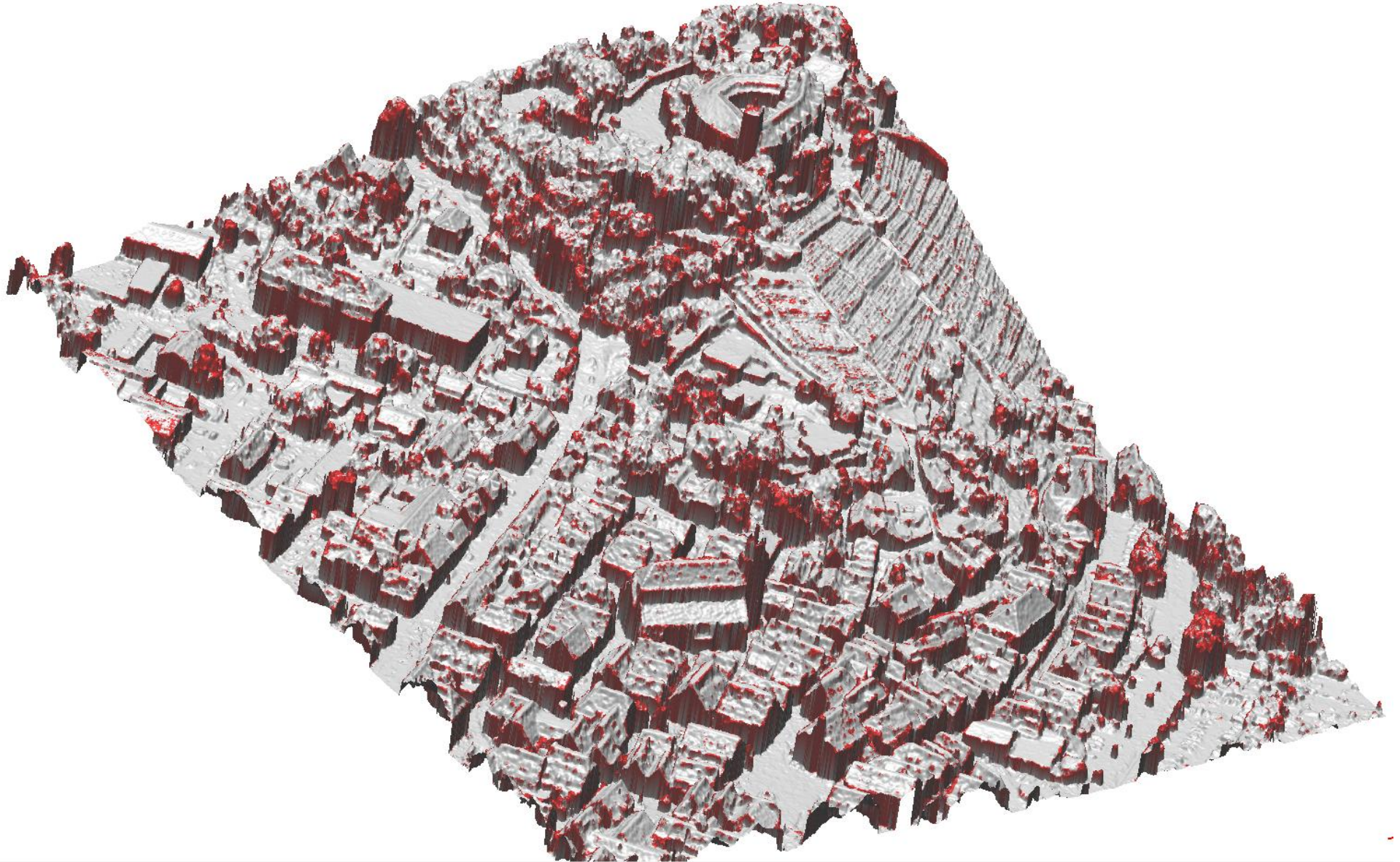


Visualisation of results

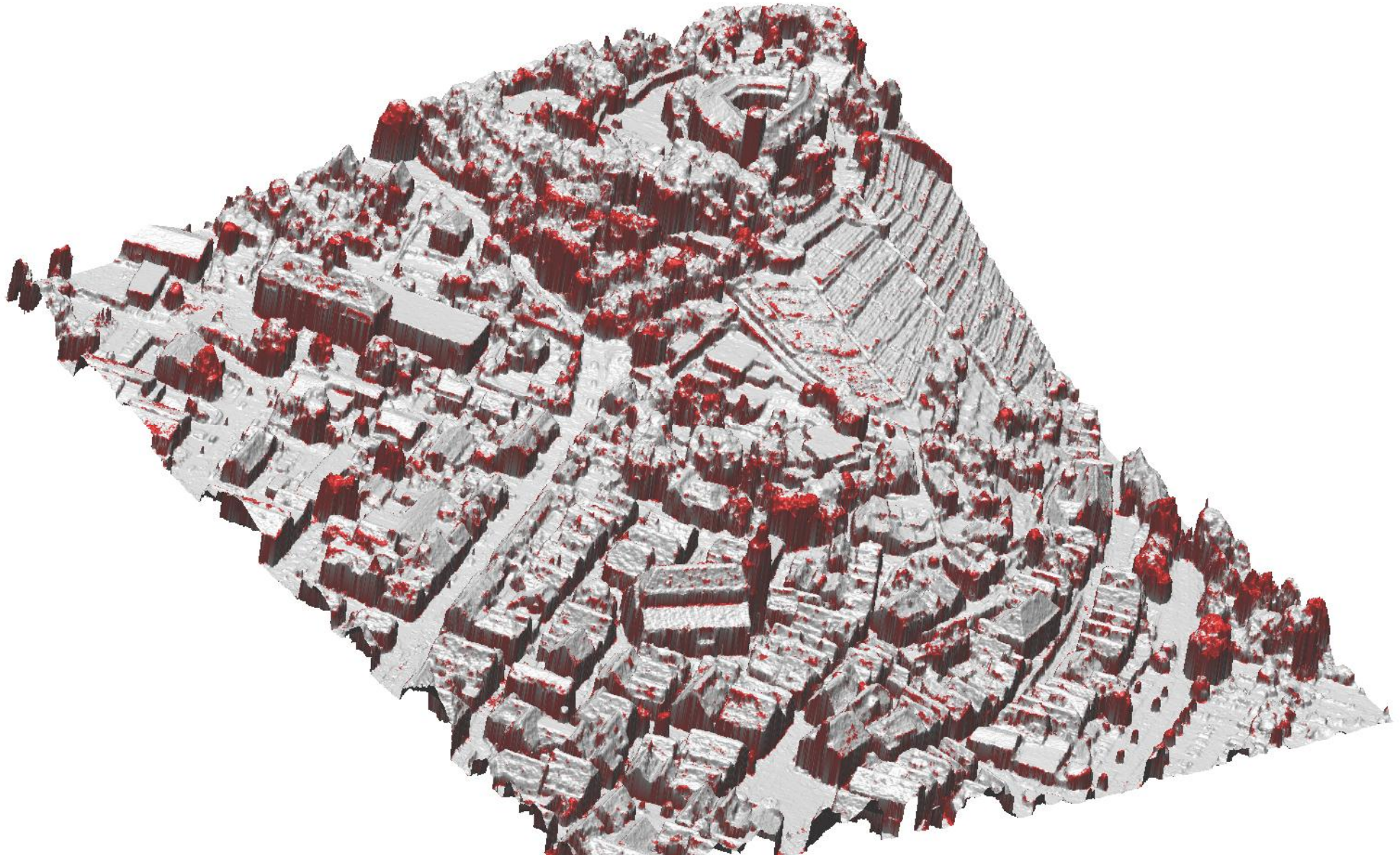
City, Vaihingen/Enz



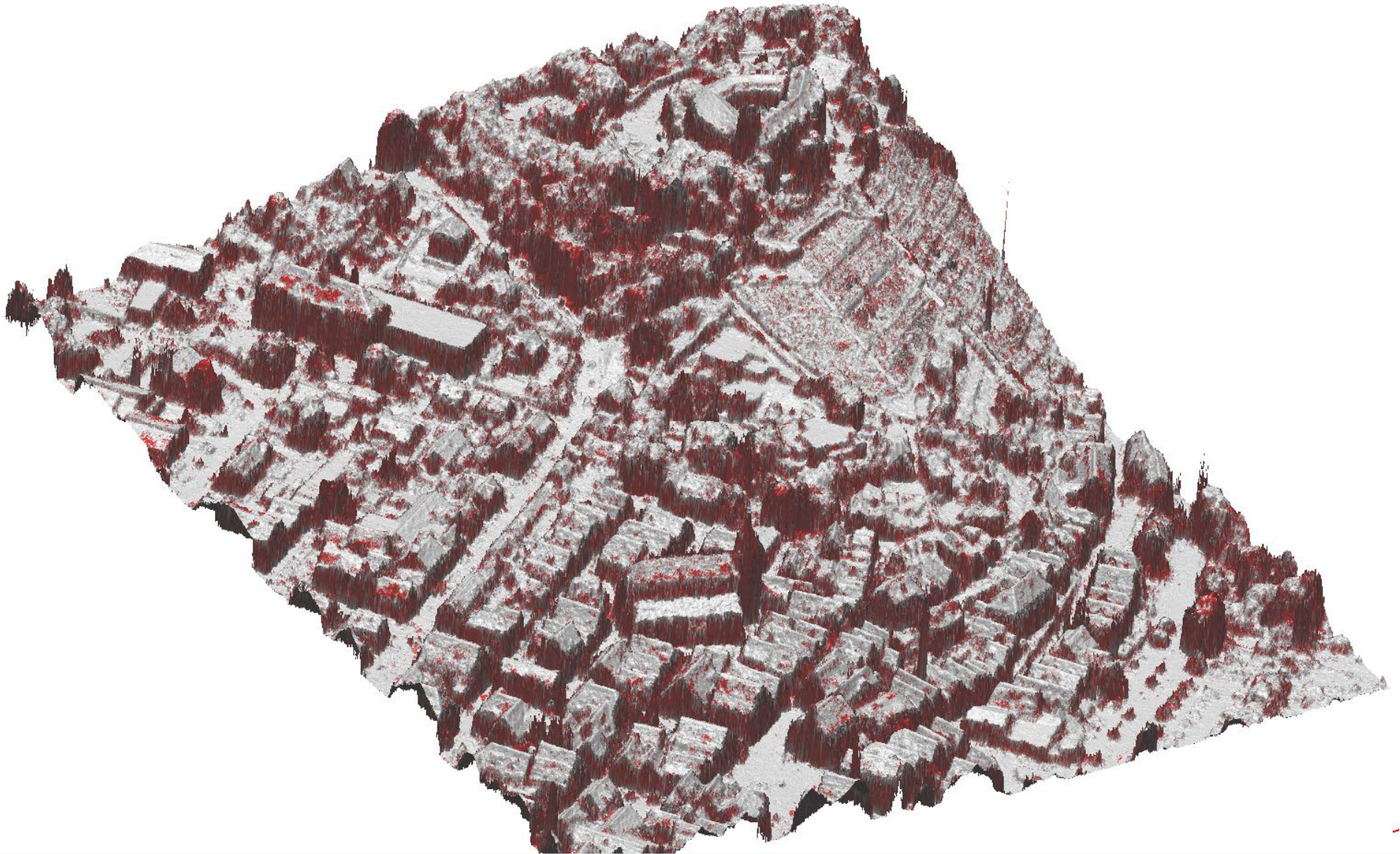
Astrium



IfP, Uni Stuttgart

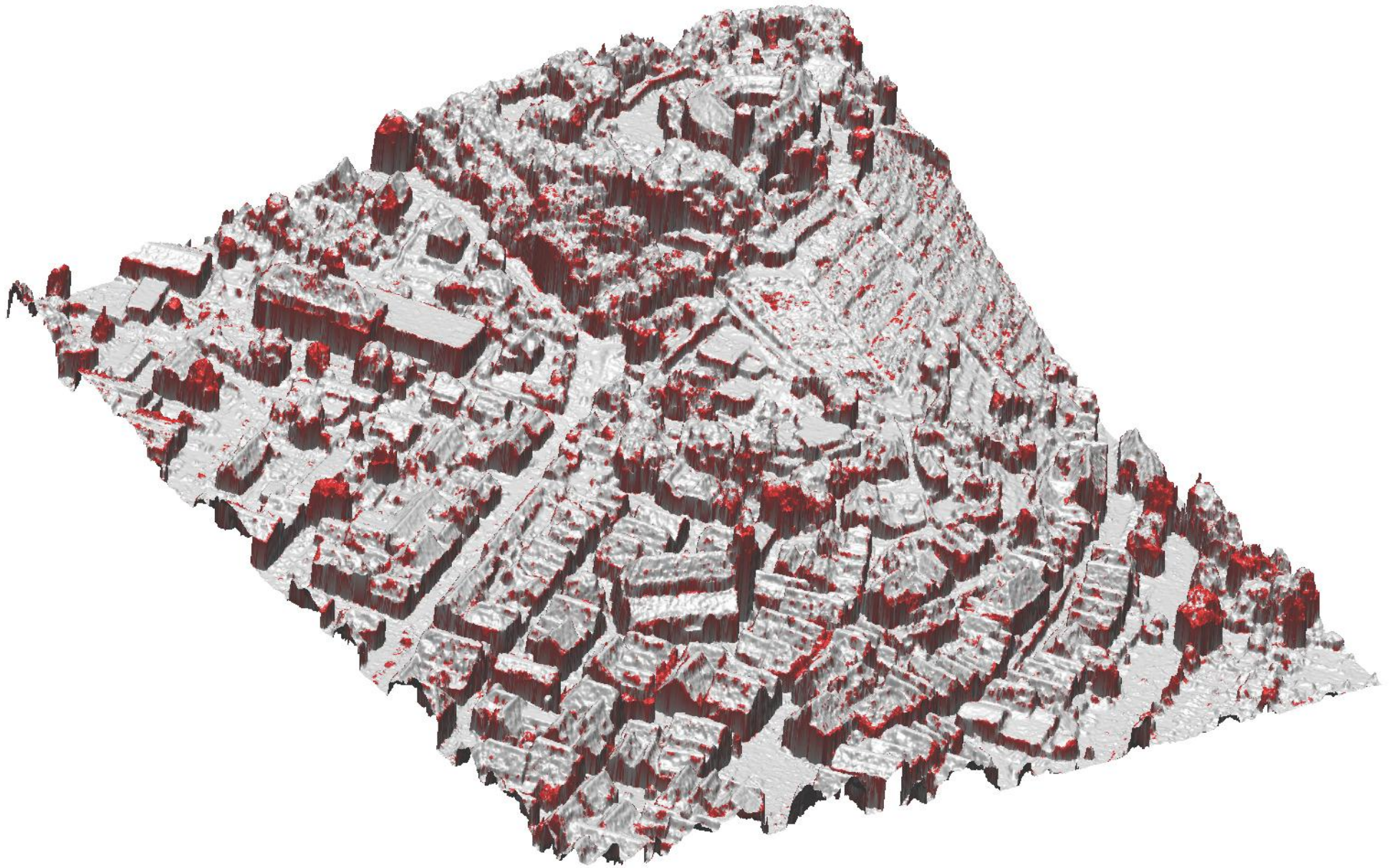


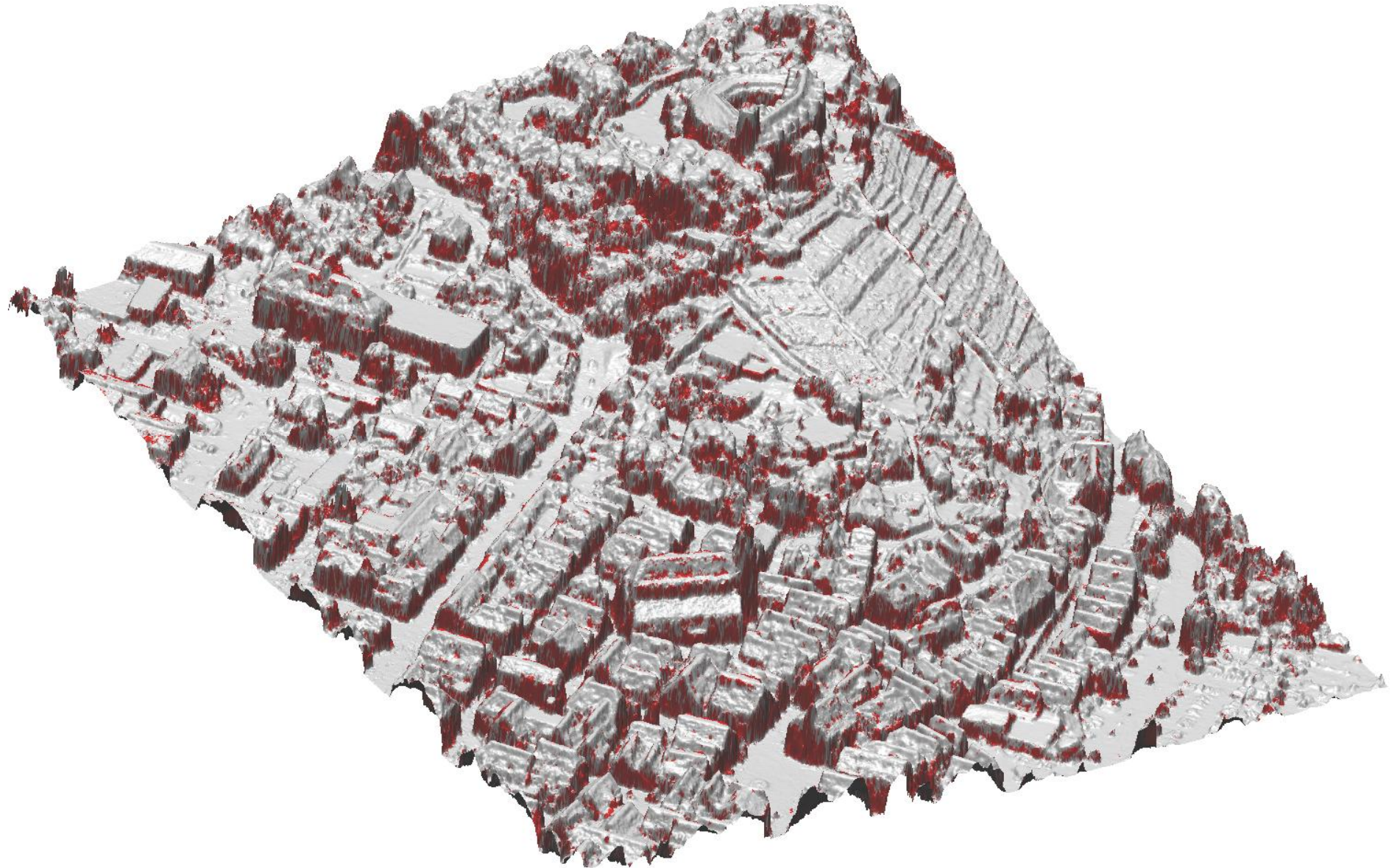
GeoSystems



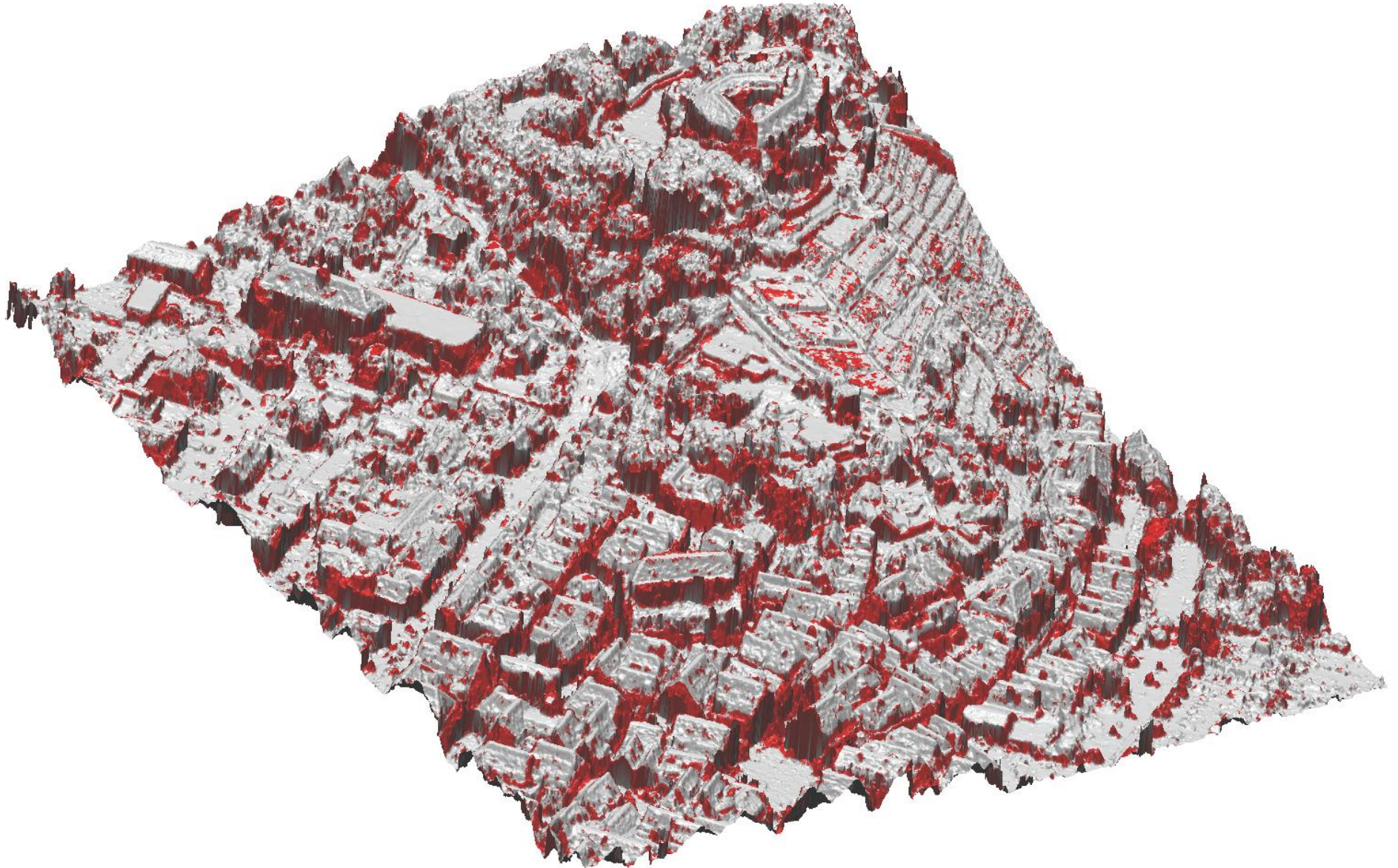
Royal Military Academy

ifp

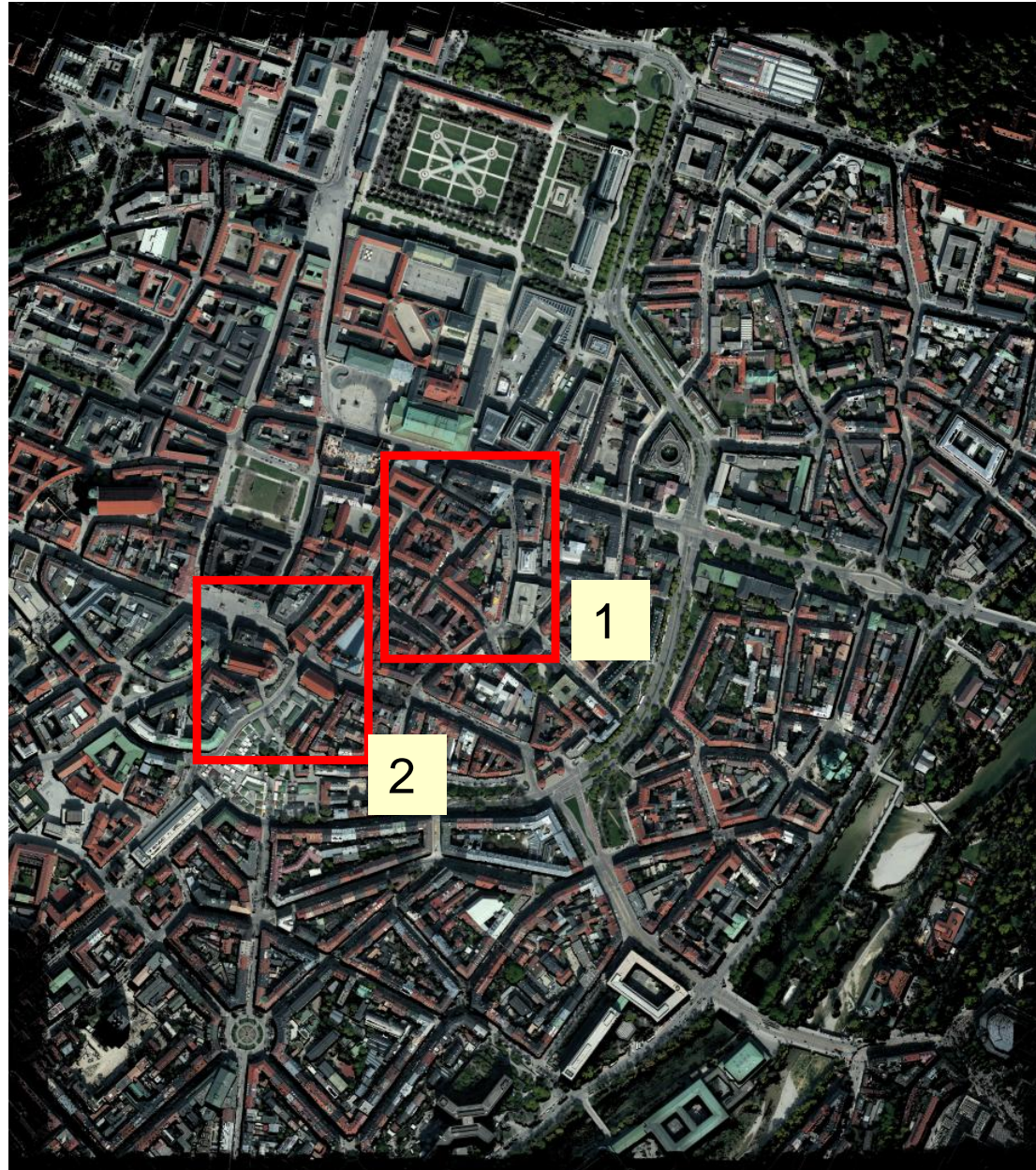




IGN, MicMac



München: Patches to be visualized



IfP, Uni Stuttgart





SocetSet



MicMac



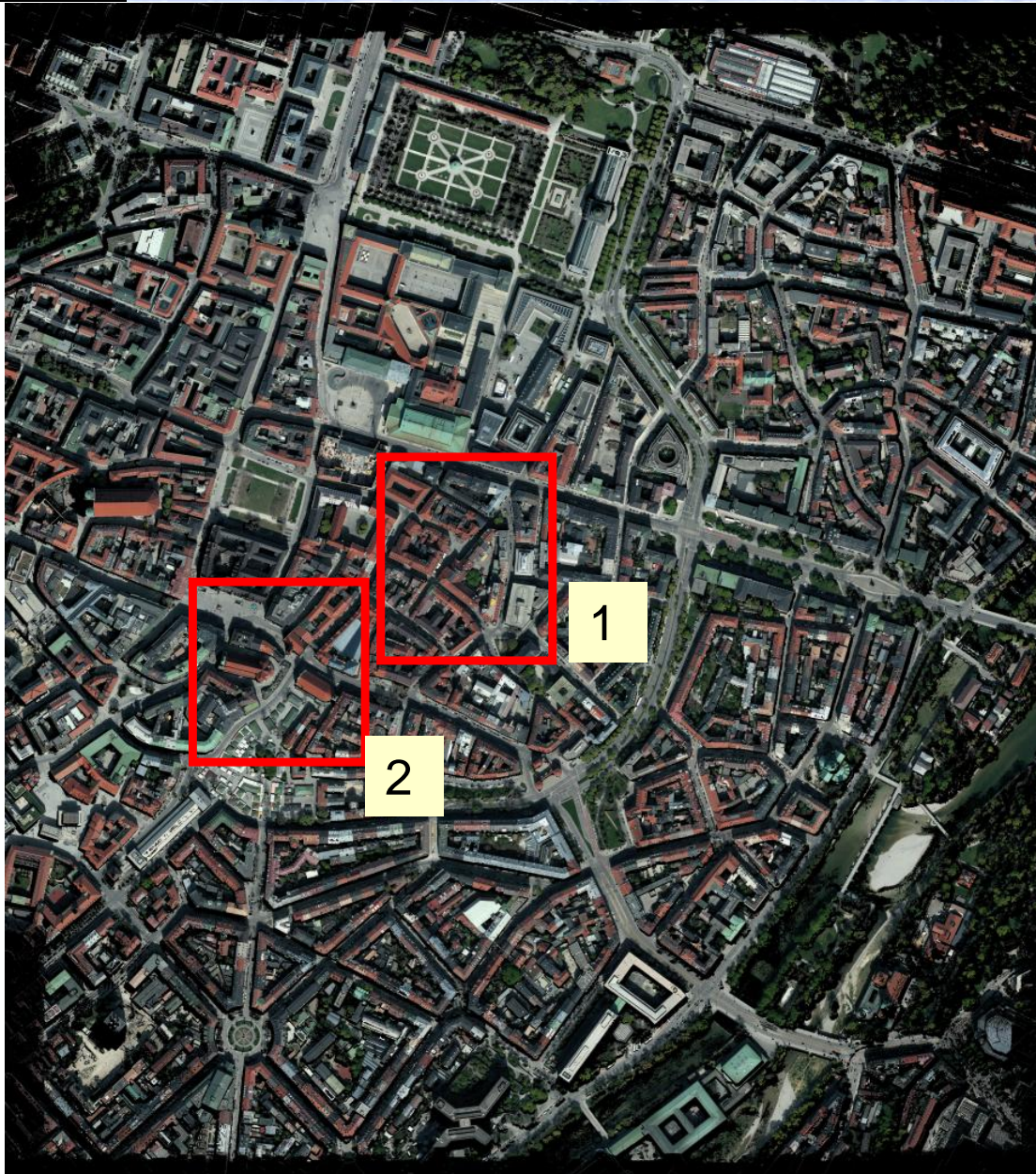
GeoSystems



Astrium



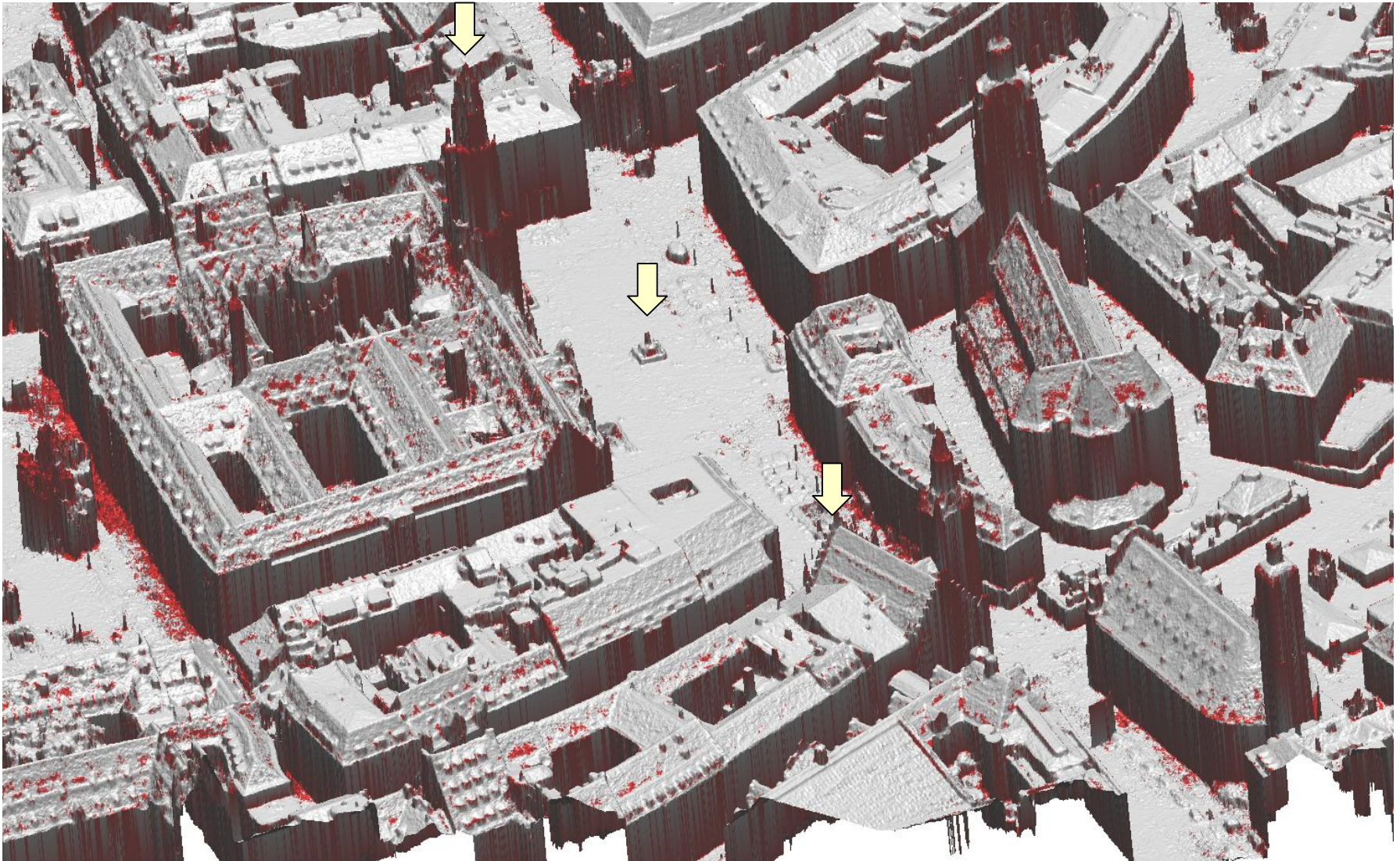
München: Patches to be visualized



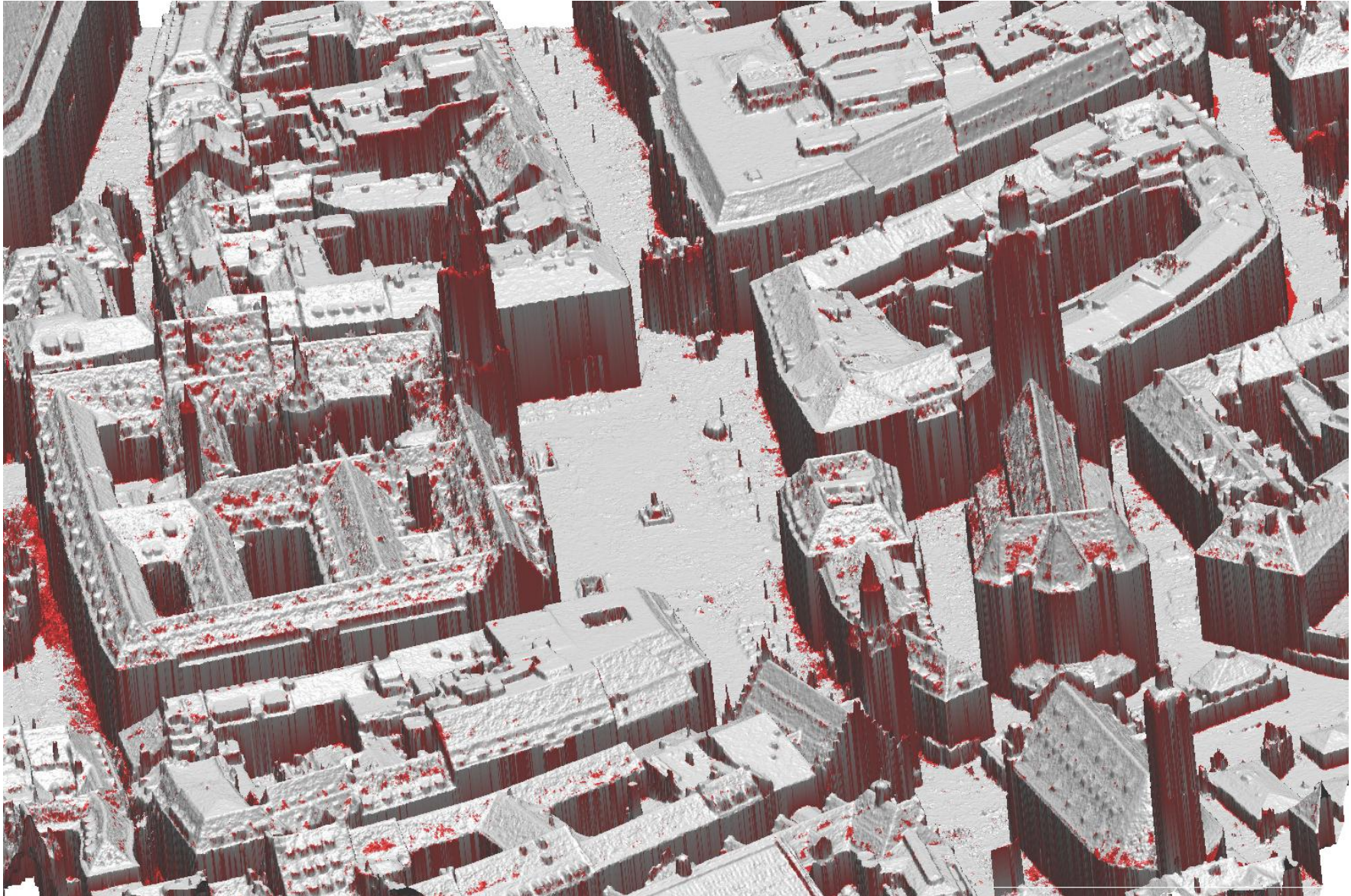
- § 80%/80% overlap
 - § up to fifteen-folded overlap
 - § Patch 1
 - § central part, maximum overlap
 - § Patch 2
 - § Outer part, reduced overlap
- § Occluded areas
- § Reduced redundancy

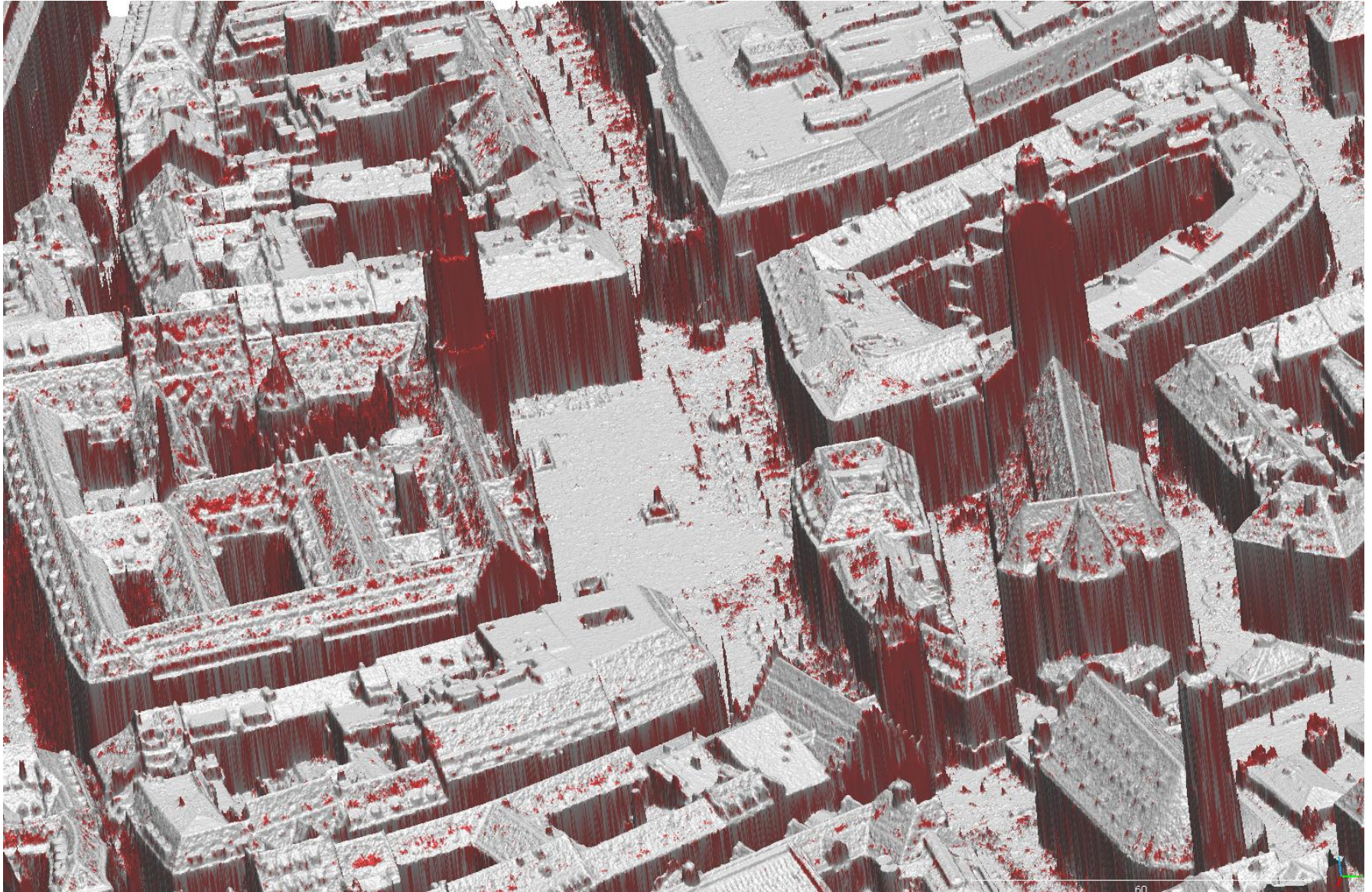


IfP, Uni Stuttgart

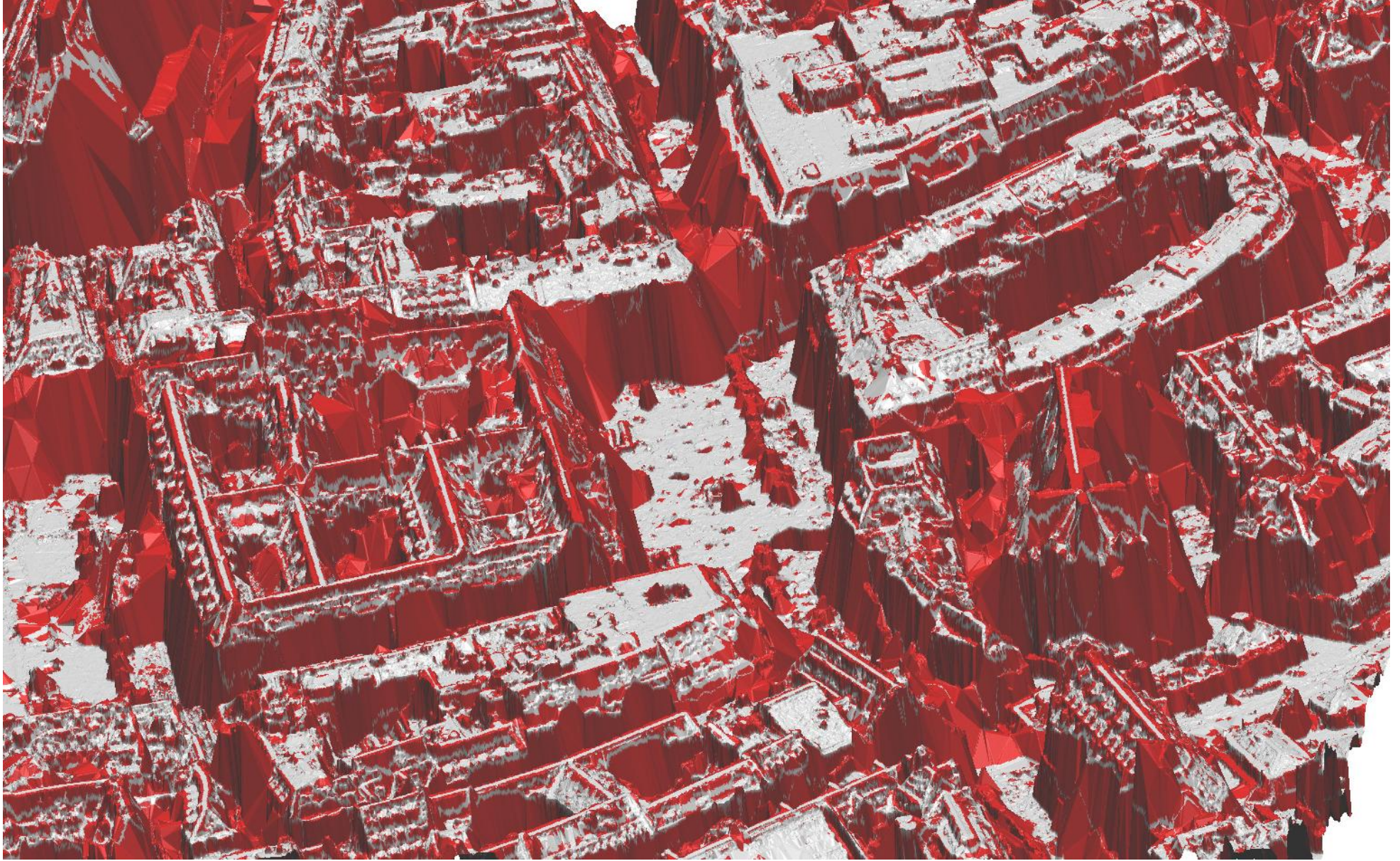


IfP, Uni Stuttgart

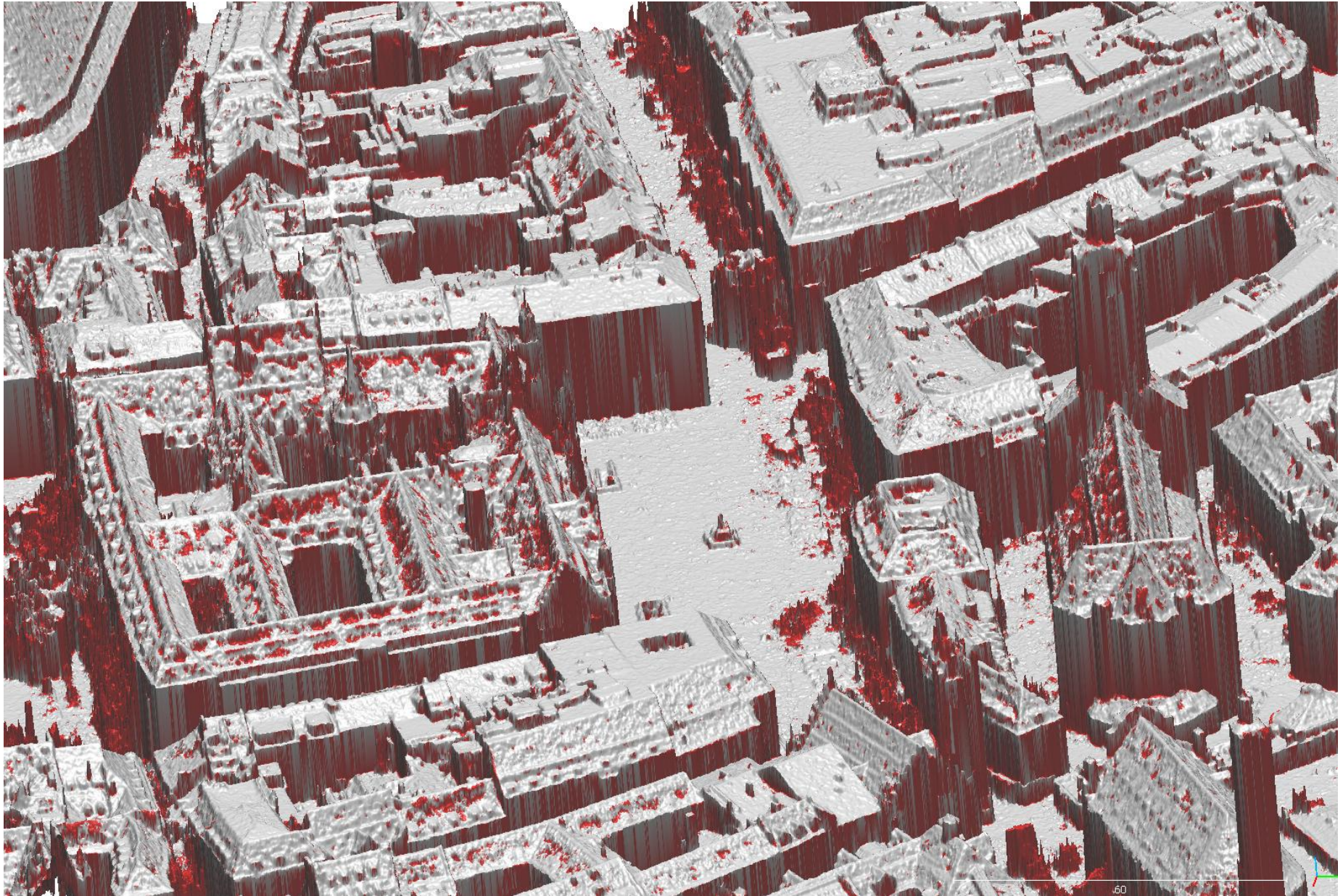


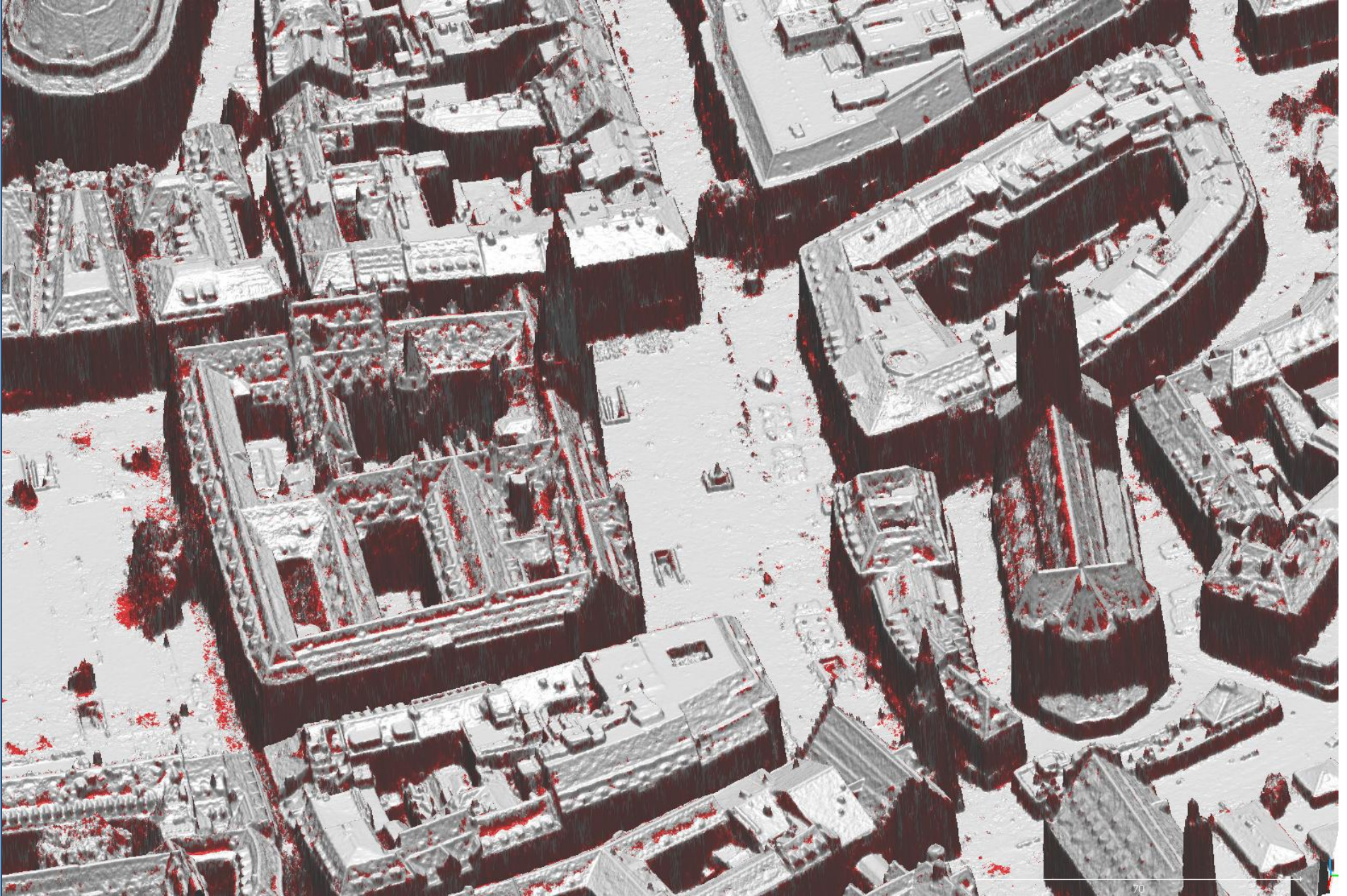


Socet Set



Royal Military Academy





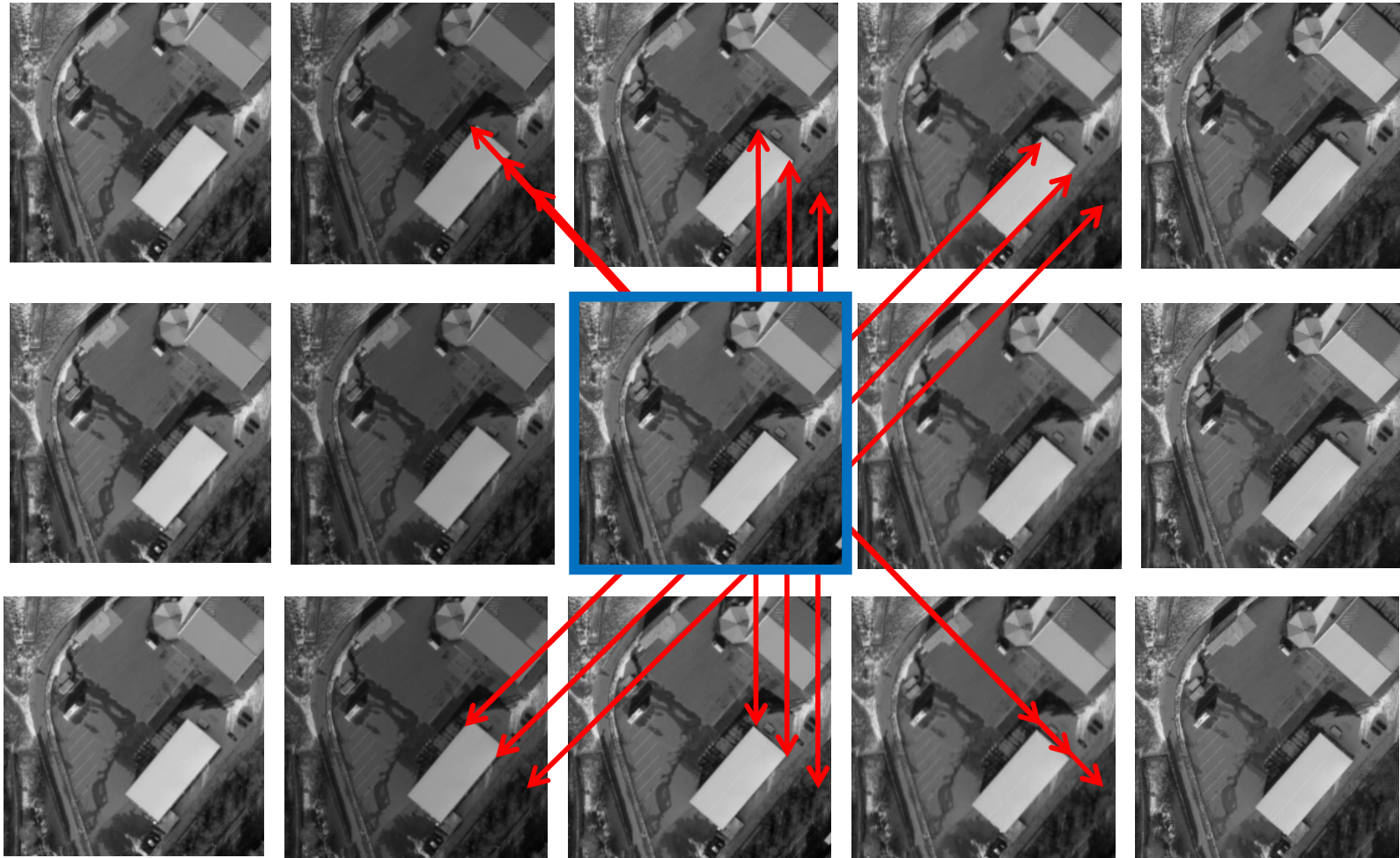
Comparison and discussion of computed DSM results



- § Vaihingen 20cm GSD, 60%/60%
 - § Quarry: partially problems at steep surfaces, small structures at vegetated areas
 - § City: partially problems at small structures
- § München 10cm GSD, 80%/80%
 - § good results for high overlaps from most systems
 - § Quality partly decreasing for reduces overlap
 - § Main differences at very fine 3D structures and breaklines
- § Extensive evaluation to allow a ranking not possible (or wanted?)
 - § Difference to median DSM
 - § Measurement of point cloud quality mainly by visual interpretation



Point cloud accuracy from multi-stereo matching



- § Match multiple neighbors against central base image
 - § Transfer each base-image pixel to multiple images
- § Multi-ray 3D surface reconstruction
 - § High redundancy during spatial intersection for 3D point determination

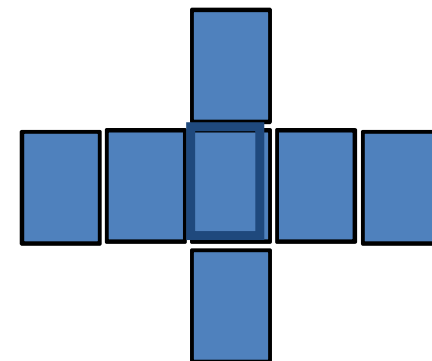
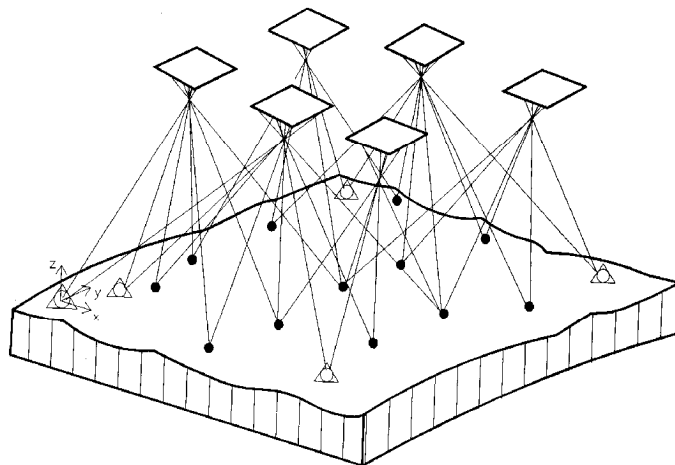


Multi-stereo matching for redundant point determination

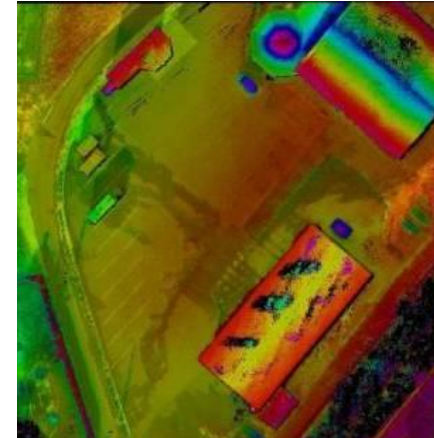
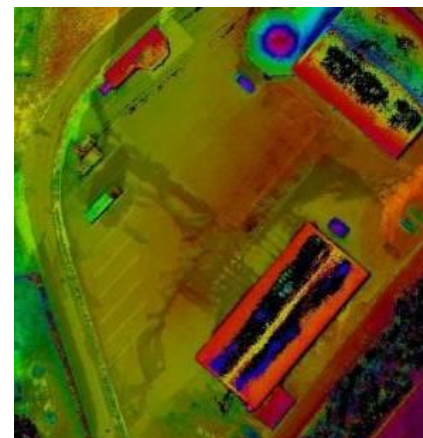
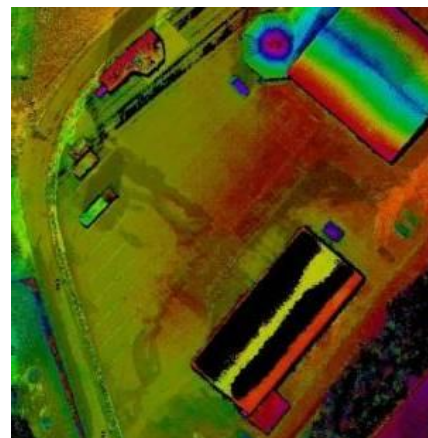
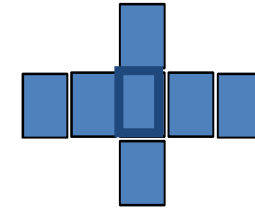
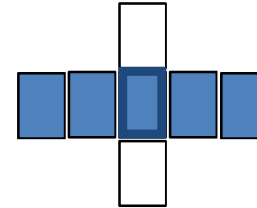
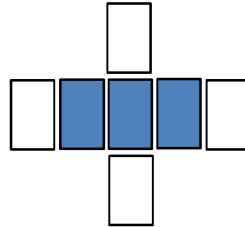
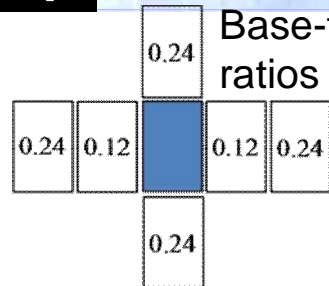


- § Aerial triangulation / bundle block adjustment
 - § Feature based matching to generate tie points at overlapping image patches
- § Multiple rays to estimate camera parameters
 - § Accuracy analysis
 - § 3D coordinates of tie point as by-product

- § 3D point clouds / DSM generation
 - § Dense stereo matching between base image and respective stereo images
- § Spatial intersection of multiple rays to estimate 3D point coordinates
 - § Accuracy analysis
 - § Elimination of gross errors



Point determination from multiple matches



UltraCamXp
GSD 10cm

$\sigma_z = 4.85\text{cm}$
 $n_{\text{Pts}} = 81.6\%$

$\sigma_z = 3.67\text{cm}$
 $n_{\text{Pts}} = 86.8\%$

$\sigma_z = 2.78\text{cm}$
 $n_{\text{Pts}} = 91.6\%$

- § Increasing redundancy for 2,4,6 matches
- § Eliminate single matching errors using residuals in image space
- § 3D point coordinates still available from remaining matches
- § Highest accuracy and completeness



Evaluation of DSM from Image Matching



- § Multi-stereo matching to estimate 3D point error from spatial intersection of multiple rays
 - § Measures point cloud noise
- § Reconstructed amount of detail difficult to evaluate due to missing ground truth
- § If multiple images are available a per pixel 3D reconstruction is feasible
 - § Larger differences between DSM results for decreasing overlaps
- § Demands depend on aspired further products

