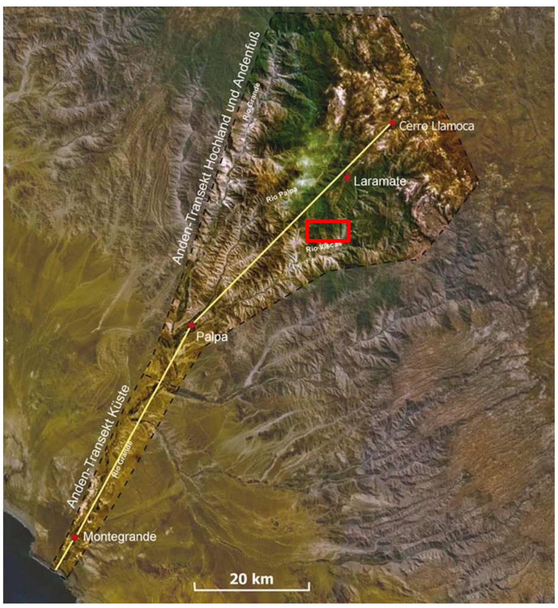
Documentation of remote archaeological sites

A comparison between long-range laser scanning
and UAV-photogrammetry

Anden-Transekt-Project

In cooperation with German archaeological institute (DAI)

http://maps.google.com



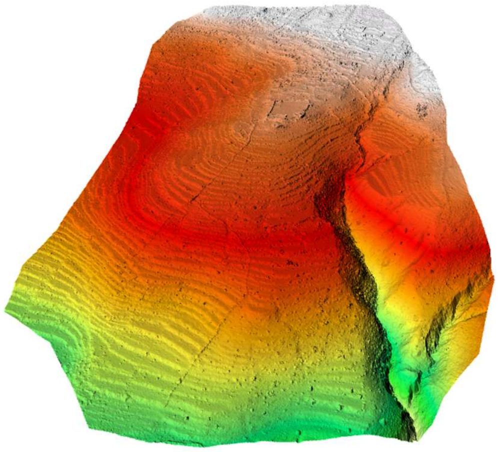
http://www.dainst.org

Geodetic tasks within the Anden-Transekt-Project

Geodetic documentation of remote archaeological sites

- Generation of digital terrain models
  - visualisation
  - further analysis

- Detailed acquisition of objects of interest



Sites to be mapped

Cutamalla (3300 m.a.s.l, 0.5 km^2)

Visible from below (highest peak)

Low and sparse vegetation

Santa Maria (2800 m.a.s.l, 0.2 km^2)

Visible from above (valley's slope)

Denser vegetation

Applied methods

UAV-photogrammetry

- Flying altitude 60 meters above ground
- Ground sampling distance 2.5 cm
- Ground control points measured with D-GNSS

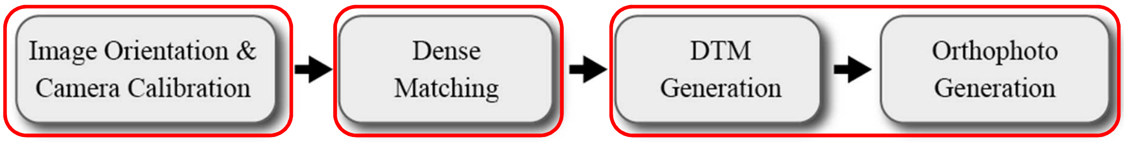
➢ **DSM** and **orthophoto** with rastersize of **5 cm** (Re-rasterized to 10cm for comparison)

Terrestrial LR-LS

- Max measurement distance of 1.2 km (counter slope)
- Resolution at largest distance ~5 cm (orthogonal)
- (Some) scan stations measured with D-GNSS

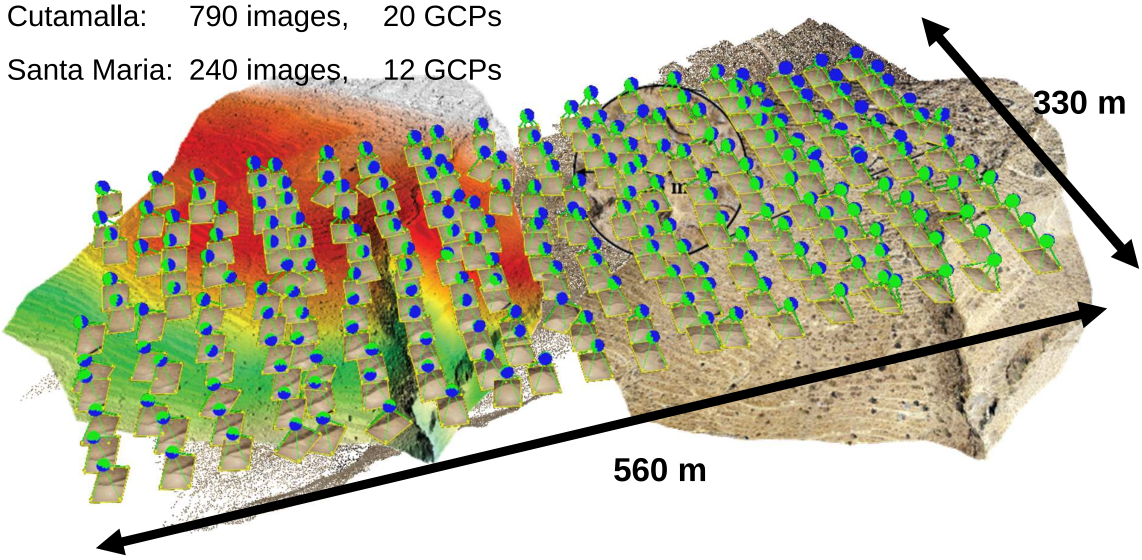
➢ **DSM** with rastersize of **10 cm**

Model generation – UAV-photogrammetry



Cutamalla: 790 images, 20 GCPs

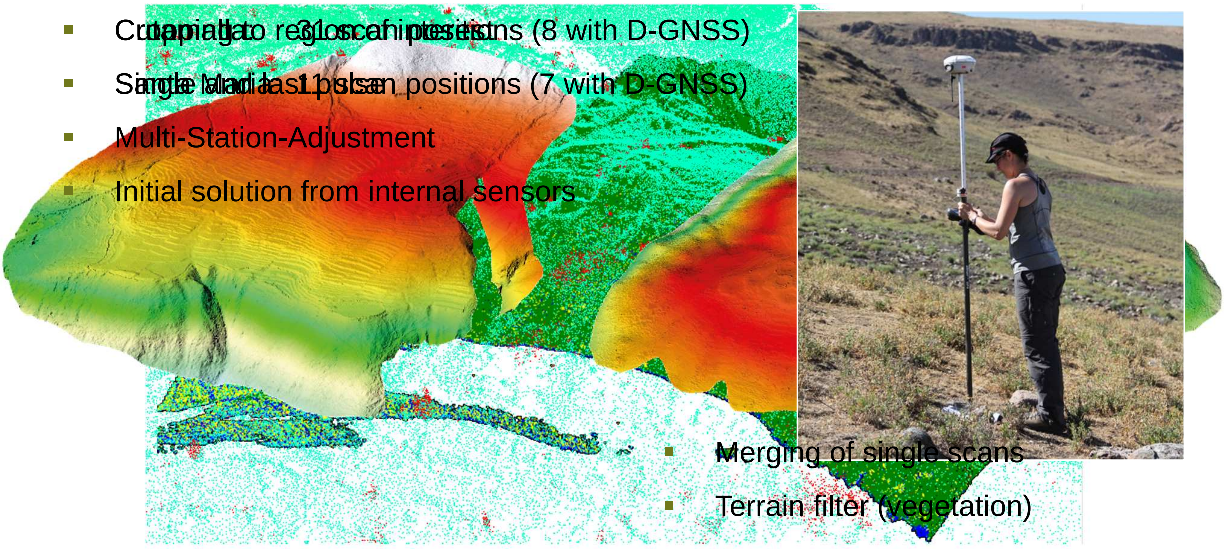
Santa Maria: 240 images, 12 GCPs



Model generation – LRLS

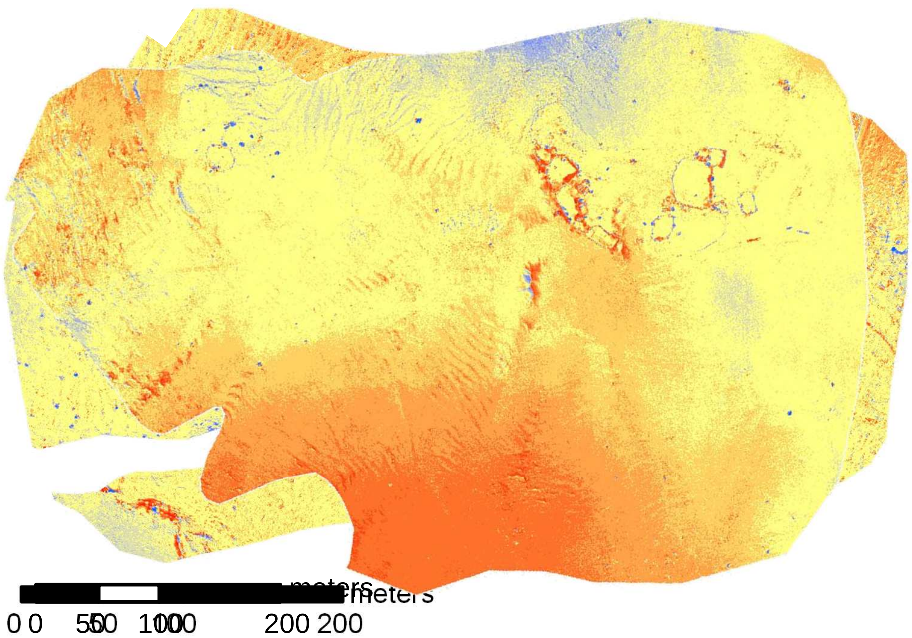
RIEGL esri

Registration & Georeferencing → Single Scan Filtering → Combining Scans & 2nd Filtering → Rasterization & Interpolation



- Cropping to region of interest / Campaign ... 31 scan positions (8 with D-GNSS)
- Single last pulse / Campaign ... 11 scan positions (7 with D-GNSS)
- Multi-Station-Adjustment
- Initial solution from internal sensors
- Merging of single scans
- Terrain filter (vegetation)

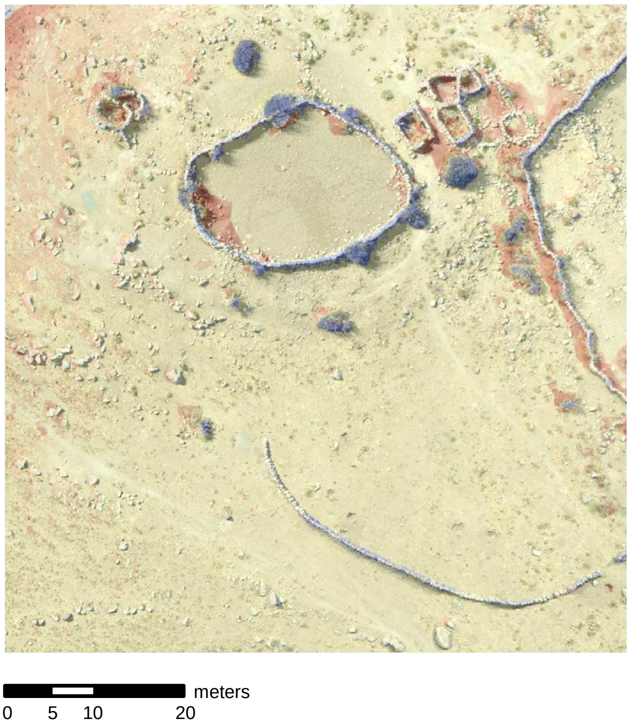
Model comparison



	-5.0 - -2.0
	-2.0 - -1.0
	-1.0 - -0.5
	-0.5 - -0.3
	-0.3 - -0.1
	-0.1 - 0.1
	0.1 - 0.3
	0.3 - 0.5
	0.5 - 1.0
	1.0 - 2.0
	2.0 - 5.0

Differences in meters

Model comparison



Deviations: UAV – LRLS

Differences arise mostly at the edges of man-made structures and at dense vegetation

- Missing LRLS data (occlusion)
- Different filtering strategies
- Different observation angle

Quantitative comparison

	Santa Maria	Cutamalla
No. compared raster cells	12.8 Mio	19.8 Mio
Mean* in m	- 0.11	- 0.03
StdDev* in m	0.22	0.18
Outlier > 0.5 m	4.6%	1.8%

*Mean height differences (Mean) and the corresponding 1σ standard deviations (StdDev) include the outliers.

Method comparison

UAV-photogrammetry	Terrestrial LRLS

Conclusion

- Both methods are **suited** to generate high resolution digital terrain models
- Archaeological surveying **demands** were fulfilled: visualization of complete site and basis for further analysis (e.g. man made structures are visible)
- Internal **quality checks** of the single models state accuracies of a **few cm**, but the comparison showed model differences up to **some dm**
  - ➔ Problems mainly in steep areas, and close to structures (vegetation, walls)
  - ➔ Further analysis would require independent field measurements of **control objects**
- Investigated methods are **complementary** if area consists of nearly vertical and horizontal parts ➔ **combination** makes sense and should be investigated

Thank you for your attention