GeoSat ReSeArch
Lab of Geophysical-Satellite Remote Sensing and Archaeoenvironment

FORTH
Institute for Mediterranean Studies

From field-work to… “air-work”:

photogrammetric applications in Neolithic landscape reconstruction

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index

- "Neolithic Thessaly"
- A/RS "Hardware" (methods/methodology)
- Software (photogrammetric workflow)
  - Acquisition/checking
  - Archiving/cataloguing
  - AutoGR-Toolkit 3.2 (w/ photogrammetry module)

“Neolithic Thessaly”

Outline of the project

“Neolithic Thessaly”

- **IGEAN** (Innovative Geophysical Approaches for the Study of Early Agricultural Villages of Neolithic Thessaly)
  - Implemented under the "ARISTEIA" Action of the "Operational Programme Education and Lifelong Learning"
  - co-funded by the European Social Fund (ESF) and National Resources

  - It consists in the development of methodologies for the **registration** and **mapping** of the specific Neolithic settlements through geomorphological and aerial remote sensing approaches.

“Neolithic Thessaly”

1901-1903: Excavations at Sesklo and Dimini
1908: Excavations at Zerelia

1960-1977: Trial Excavations at several neolithic sites by D.R. Theocharis and Vl. Milojcic
1977-1979: Excavations at Dimini by G. Hourmouziades

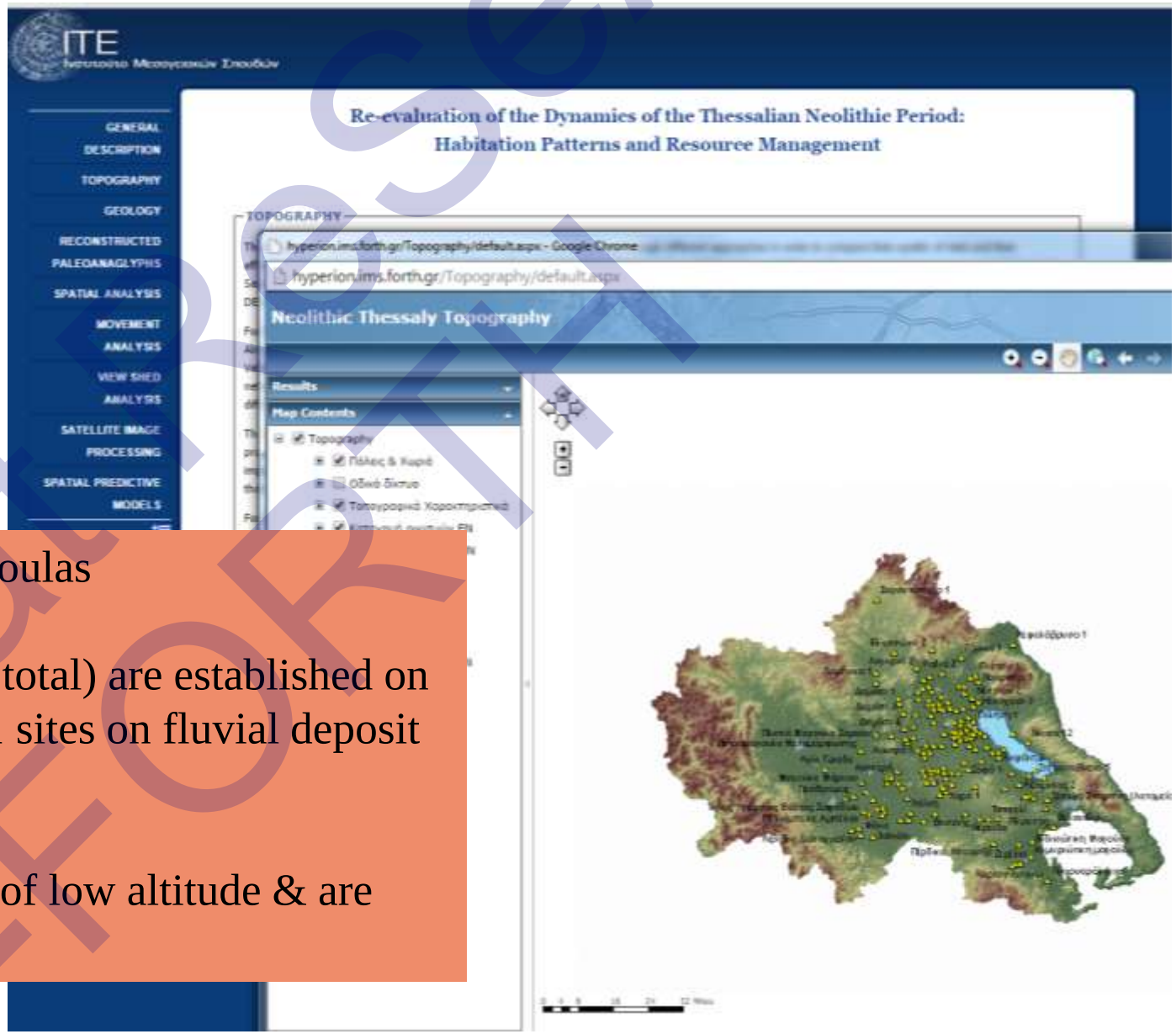
1984: Halstead’s catalogue of prehistoric sites in Thessaly, based on a survey made by French
1992: Gallis’ catalogue of sites in E. Thessaly.

1990-present: Field survey in Almiros plain 13th EPCA & the Netherland Institute at Athens
1990-2005: Rescue excavations (national road, Lake Karla)

2005-present: Extensive satellite R.S. & geophysical survey by GeoSat ReSeArch Lab of IMS (FORTH). PENED (2005-2007), INSTAP (2006-2010), ARISTEIA (2013-2015)

“Neolithic Thessaly”

http://neolithicthessaly.ims.forth.gr/



- 342 documented magoulas
- 181 sites (53% of the total) are established on alluvial deposits & 81 sites on fluvial deposit areas.
- These formations are of low altitude & are ideal for cultivation.

“Neolithic Thessaly”

Area of interest

A/RS "Hardware"

A/RS "Hardware" (methods/methodology)

Methodologies
Multi-magnetometer Techniques (large scale scanning)

Sensorik & Systemtechnologie (SENSYS)
MX Compact system

8 multi-channel measurement system
Equipped with FGM600 fluxgate gradiometers separated by 0.25-0.5m & connected to a DGPS navigation system

Bartington single sensor unit also in use in thick vegetation areas

Methodologies
Electromagnetic Techniques (large scale scanning)

GEM2 - Geophex

CMD Mini explorer– GF Instruments

Depth of investigation

	GEM2		CMD Mini explorer			
Electrical conductivity	HCP	2.5 m	HCP	0.5 m	1 m	2 m
			VCP	0.3 m	0.7 m	1.3 m
Magnetic susceptibility	HCP	1.7 m	HCP	0.2 m	0.5 m	1 m
			VCP	0.3 m	0.7 m	1.3 m

Methodologies
GPR

8 channels MALA MIRA GPR,
400 MHz antennas
Sampling 10 x 2.5 cm

Sensors & Software
Noggin Plus System w/ 250MHz antennas
Sampling 50 x 2.5 cm

Penetration Depth ~2.5m

Methodologies
Soil Resistance Techniques

Geoscan Research RM85 resistance meter

Twin Probe array of electrodes with spacing a=1m

Penetration Depth ~1.5m

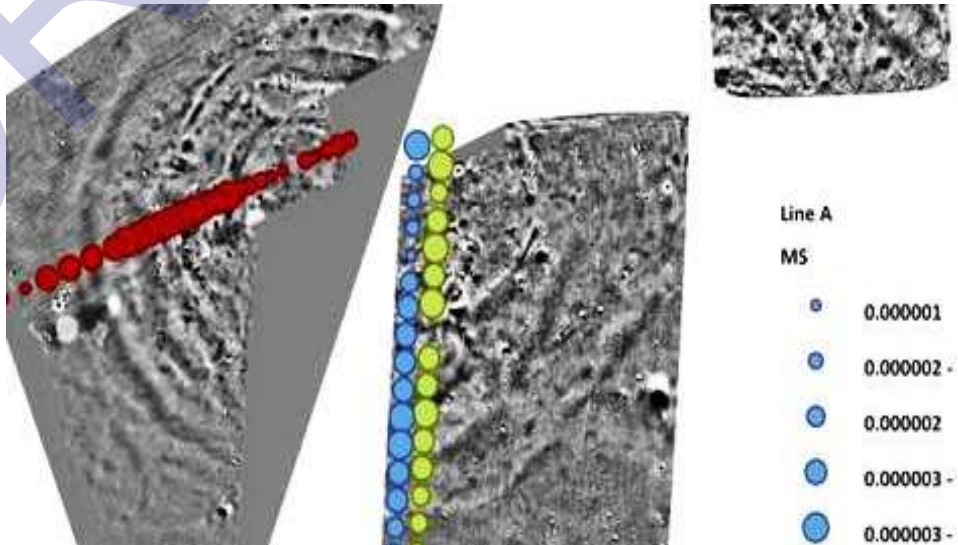
Methodologies

Magnetic Susceptibility Measurements

Coring and soil analysis in the Lab.

Bartington MS2B Double Frequency sensor

Low & High Frequency susceptibility & Frequency dependent susceptibility



Methodologies
UAV photography/photogrammetry

Methodologies
UAV photography/photogrammetry

Quadrocopter DroidWorx CX4
- DJI navigation, viewpoint and failsafe
- Average altitude 100-200 m above surface
- Autonomy ~13-15min with camera load

Methodologies
UAV photography/photogrammetry

Methodologies
UAV photography/photogrammetry

Methodologies
UAV photography/photogrammetry

Quadrocopter DroidWorx CX4

- DJI navigation, viewpoint and failsafe
- Average altitude 100-200 m above surface
- Autonomy ~15-18min (with camera load)

Canon S100

Methodologies
UAV photography/photogrammetry

LegGiaDrone 1.0

Methodologies
UAV photography/photogrammetry

GCP
(in case the GPS fails)

SITE	COVERAGE (in hectares)			
	Magnetics	EM	GPR	UAV
1. Almiriotiki	8.42	7.75	1.28	20.84
2. Almiros 2	6.60	2.39	0.37	7.31
3. Bakalis	0.45	0.36	0.29	-
4. Belitsi	1.32	1.78	0.37	11.74
5. Eleutherochori	-	0.18	0.18	-
6. Kamara	0.88	1.06	0.10	-
7. Karatsangliou	2.96	1.20	0.37	13.22
8. Karatsantagli	2.71	0.58	0.20	12.38
9. Kastro Kokkinas	1.08	0.72	0.09	-
10. Nikonanou	2.91	1.37	-	-
11. Mati	3.33	2.40	0.32	-
12. Perdika 1	5.19	2.32	0.44	-
13. Perdika 2	3.90	2.21	0.32	-
14. Rizomilos 2	10.48	3.16	0.36	-
15. Visviki	5.12	-	1.90	-
16. Zerelia	4.83	1.88	0.72	33.88
TOTAL (<5 weeks fieldwork)	60.18	29.36	7.31	99.37

Methodologies
UAV photography/photogrammetry

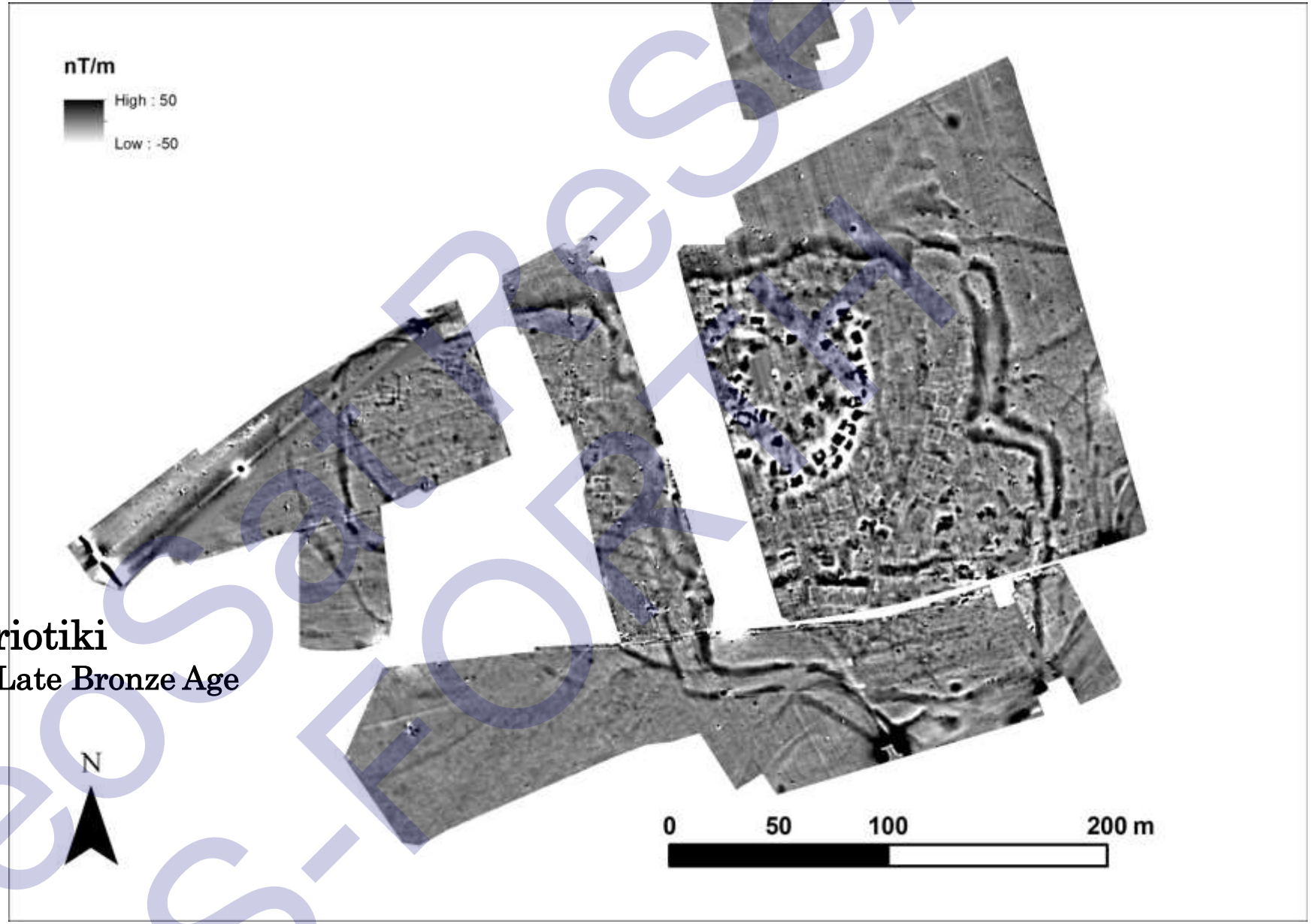
Site INDEX	Merged photogrammetric patches (hectare)	Hectare coverage per minute
Almiriotiki	20.7	0.56
Almiros 2	8.12	0.78
Belitsi	11.73	0.42
Karatsagliou	13.07	1.58
Karatsantagli	12.39	1.04
Zerelia	32.2	0.90

About 1 hectare/minute

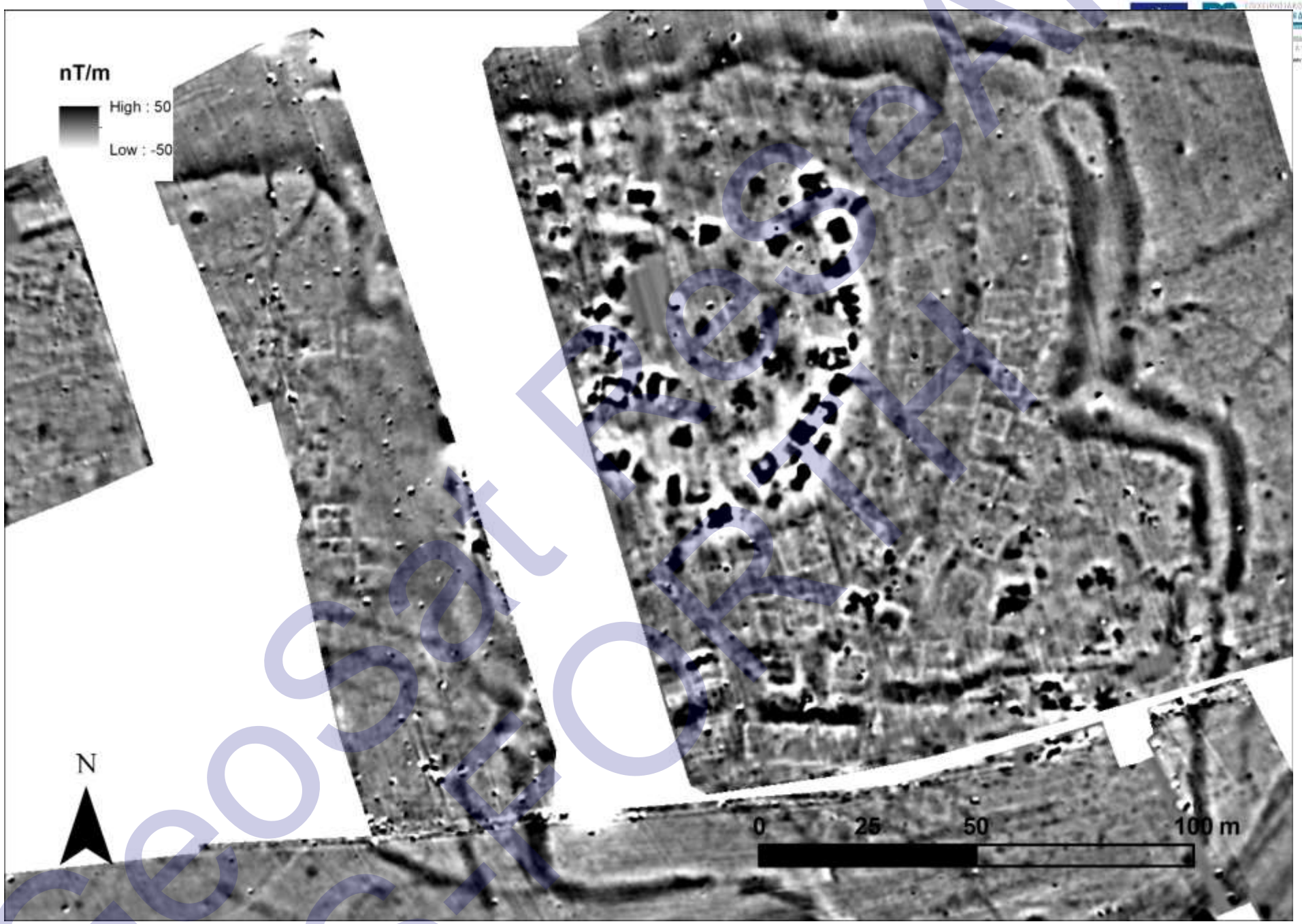
Methodologies
UAV photography/photogrammetry

Magoula Almiriotiki
Early Neolithic – Late Bronze Age

Methodologies
UAV photography/photogrammetry



Magoula Almiriotiki
Early Neolithic – Late Bronze Age



Methodologies
UAV photography/photogrammetry

Methodologies
UAV photography/photogrammetry

Methodologies
UAV photography/photogrammetry

Software

Software .:. Commercial

- Commercial solutions
  - Pix4D

Software .:. Commercial

- Commercial solutions
  - MosaicMill

MosaicMill

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Products

Software for UAVs

- EnsoMOSAIC UAV
- EnsoMOSAIC 3D
- Camera Calibration
- Terrain modelling
- Image pre-processing
- Seamline editing

Software for manned operations

- EnsoMOSAIC
- EnsoMOSAIC 3D
- Flight planning
- NavCam
- Camera Calibration
- Terrain modelling
- Image pre-processing
- Seamline editing

Hardware

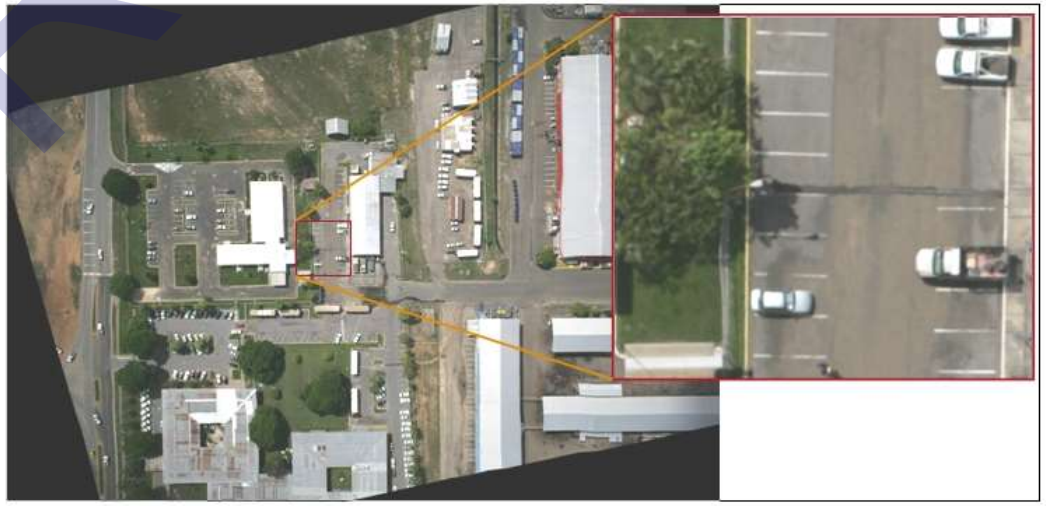
- Flight control for manned operations
- Cameras for UAVs and manned operations

Complete solution for manned operations

MosaicMill software for UAVs

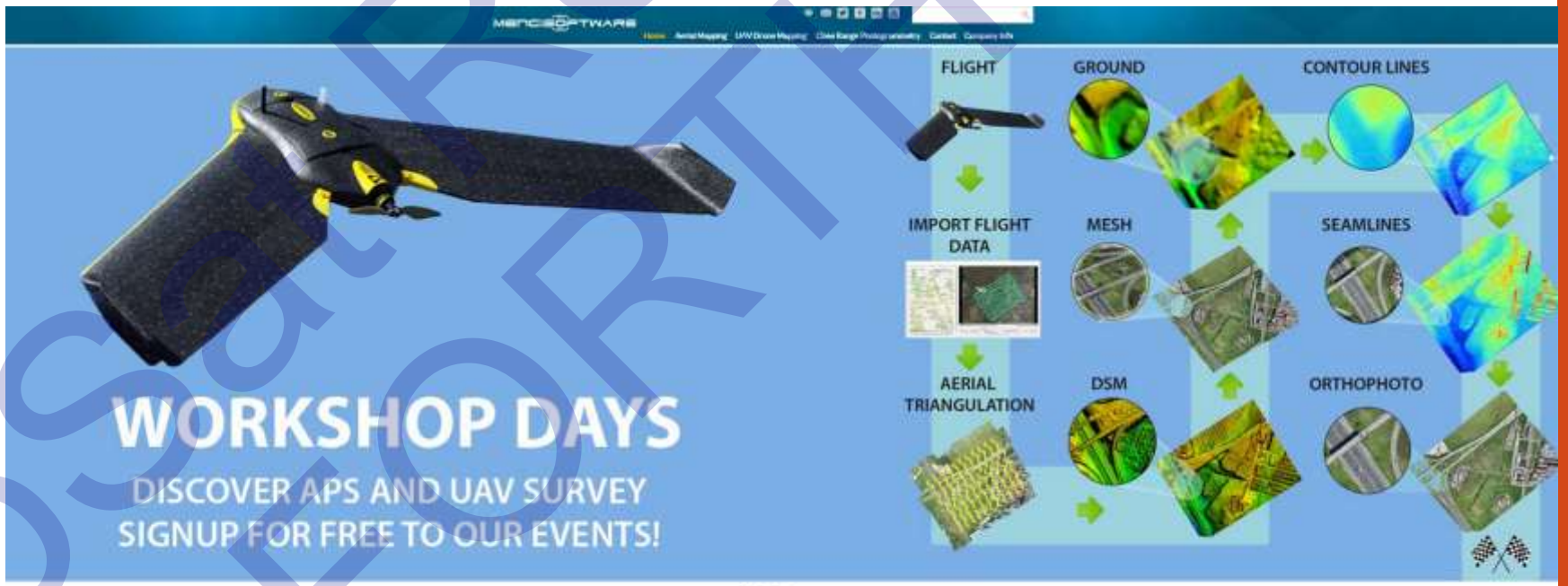
EnsoMOSAIC software consist of core items and supportive programs. The software components are listed here with a brief description. For full details please select an item of the left panel.

- **EnsoMOSAIC UAV** - photogrammetric software for aerial triangulation and orthomosaicking - all you need to start mapping
- **EnsoMOSAIC 3D** - 3D mapping software for data extraction and point cloud management
- **Camera calibration** - calibration software for calculation of camera internal orientation
- **Terrain modelling** - point cloud software, creates "lidar point cloud" from oriented images
- **Image pre-processing** - preprocessing software for optimizing RAW CIR and RGB images
- **Seamline editing** - software for improving mosaics of city and town areas



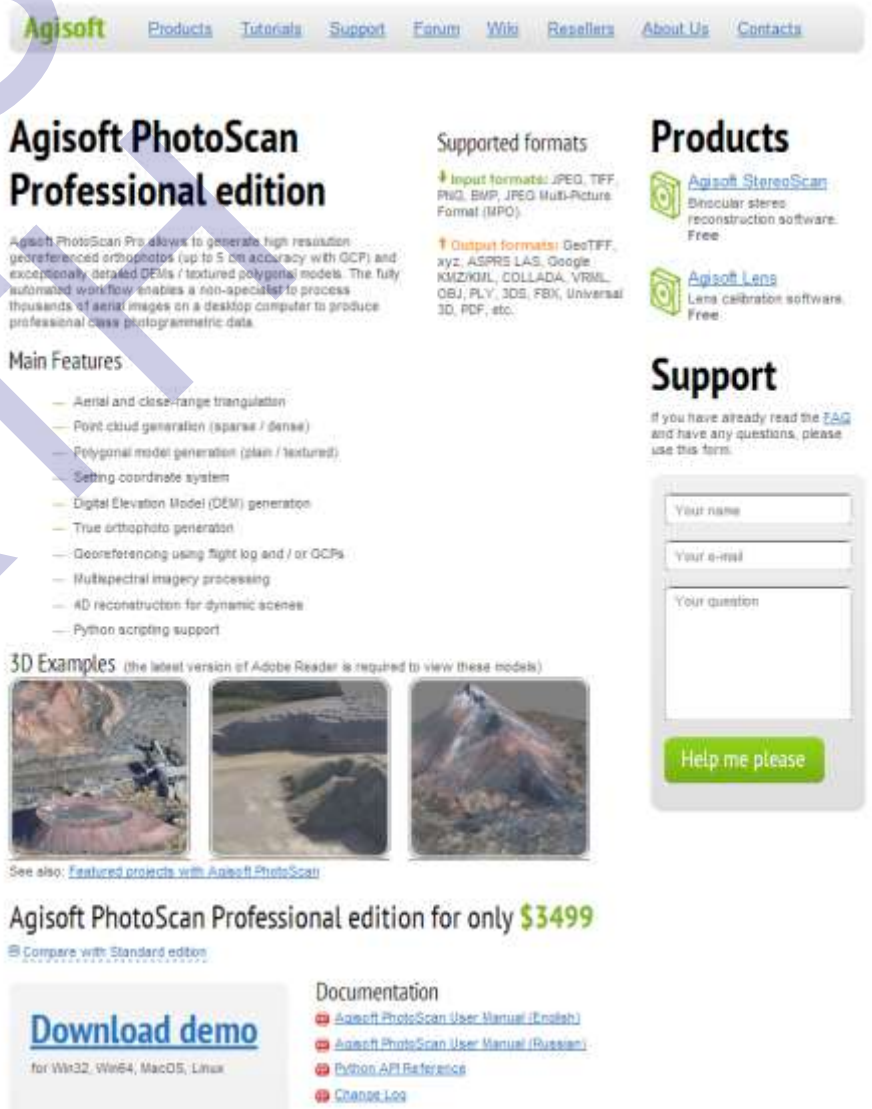
Software .:. Commercial

- Commercial solutions
  - MenciSoftware



Software .:. Commercial

- Commercial solutions
  - Agisoft Photoscan



Software .:. Free

- Free or Open Source software
  - Online – cloud based
  - “Bundler” based
  - VisualSFM

Software .:. Free

- Main issues:
  - Orthophotos or textured models
  - Georeferencing

Software .∴. Free | | Textured model

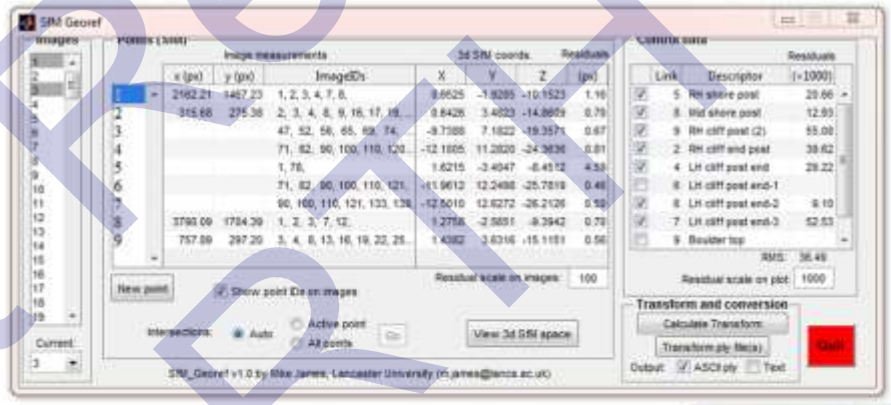
- **Online cloud solution**
  - Good results but sometimes…
    - with limitation or image compression

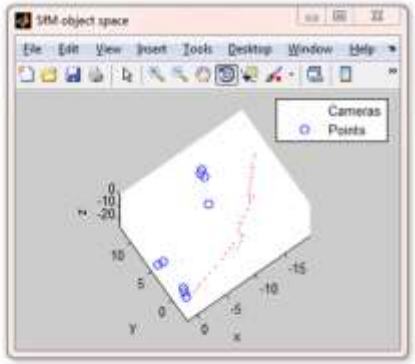
Software .∴. Free | | Textured model

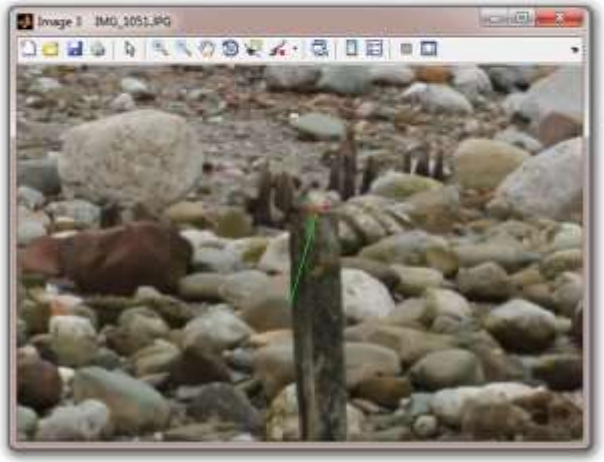
- **Desktop solution**
  - CloudCompare
    - Great for surface creation but no texture
    - Great for “cleaning” and refinement
    - Possibility to export ortho-view
  - Meshlab
    - Good for texture (raster projection)
    - Good for surface
    - Possibility to export ortho-view
    - … if it doesn’t crash!?!

Software .∴. Free | | Georeferencing

- Sfm_georef
  - Manual georeferencing
    - on photos
      (manual correspondences)





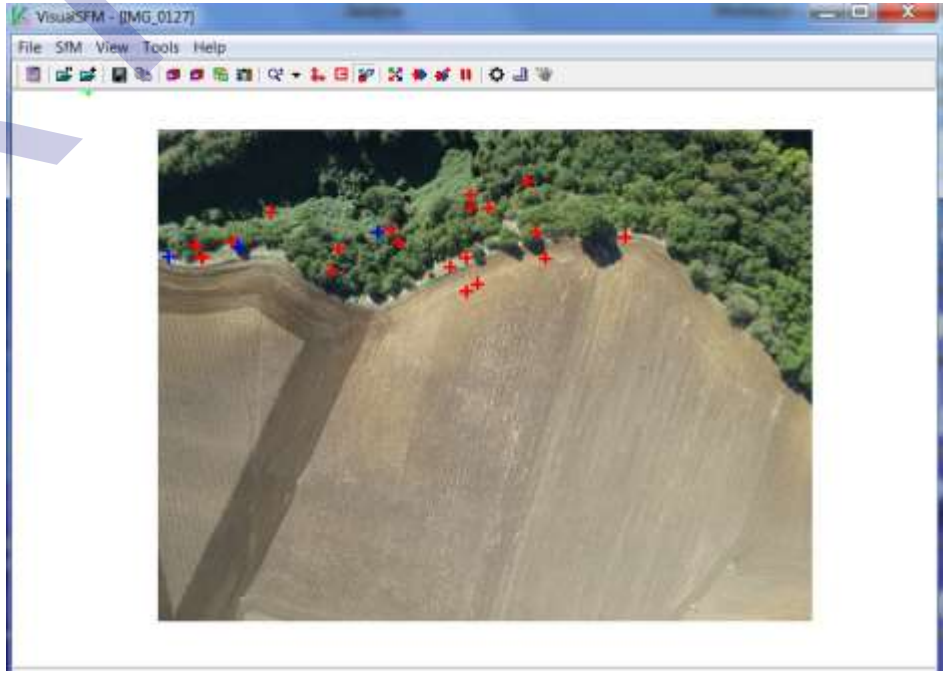


Software .∴. Free | | Georeferencing

- **VisualSFM**
  - **Manual** georeferencing
    - on photos
    - on point-cloud
  - **Automatic** georeferencing
    - via GPS (EXIF) or GCPX
  - **Semi Automatic** georeferencing
    - GCP file

Software .∴. Free | | Georeferencing

- VisualSFM
  - GCP file
    - filename image_point_x image_point_y 3d_point_x 3d_point_y 3d_point_z
    - <u>Requirements</u>: at least 3 points visible in at least 3 images each!



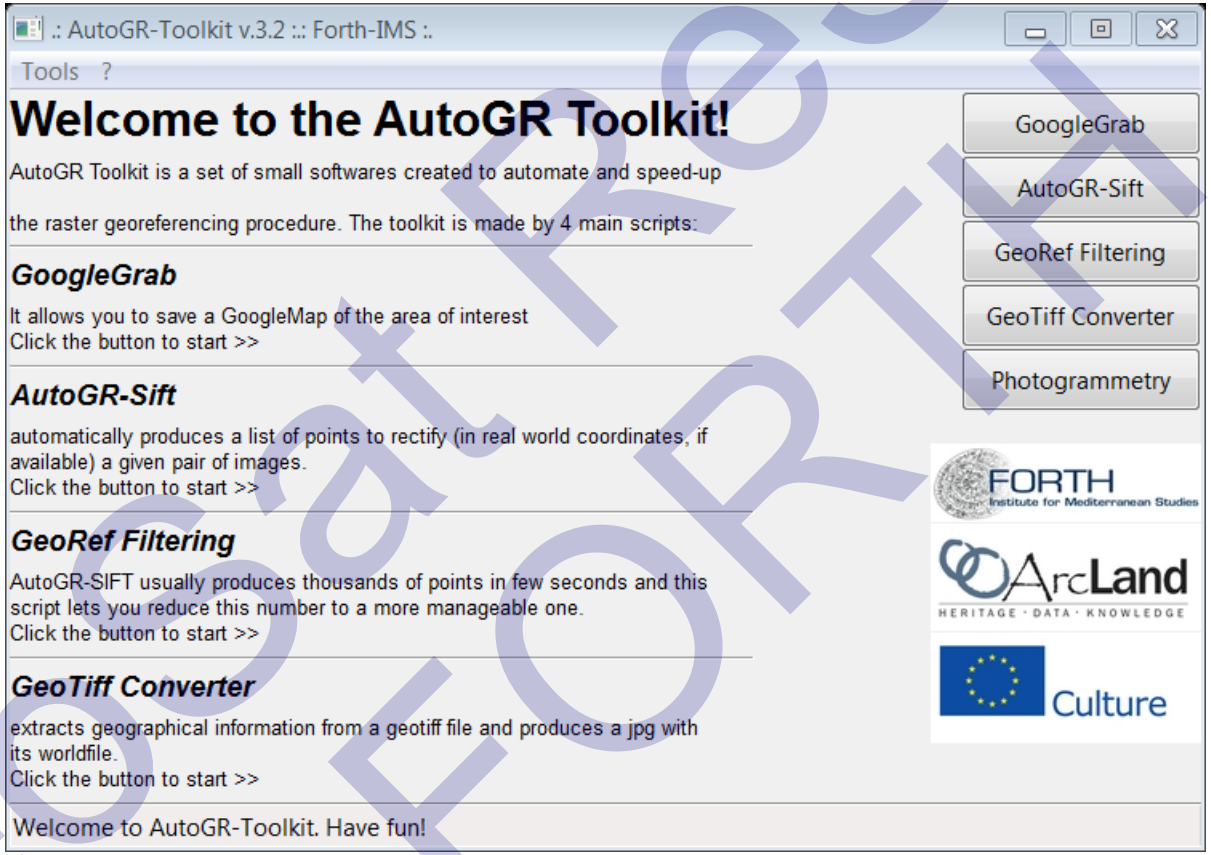
Software .∴. Free | | Georeferencing

- VisualSFM
  - GCP file
    - filename image_point_x image_point_y 3d_point_x 3d_point_y 3d_point_z
    - Requirements: at least 3 points visible in at least 3 images each!

- HOW TO GET POINTS AUTOMATICALLY AND ACCURATELY?

AutoGR-Toolkit 3.2

AutoGR-Toolkit 3.2



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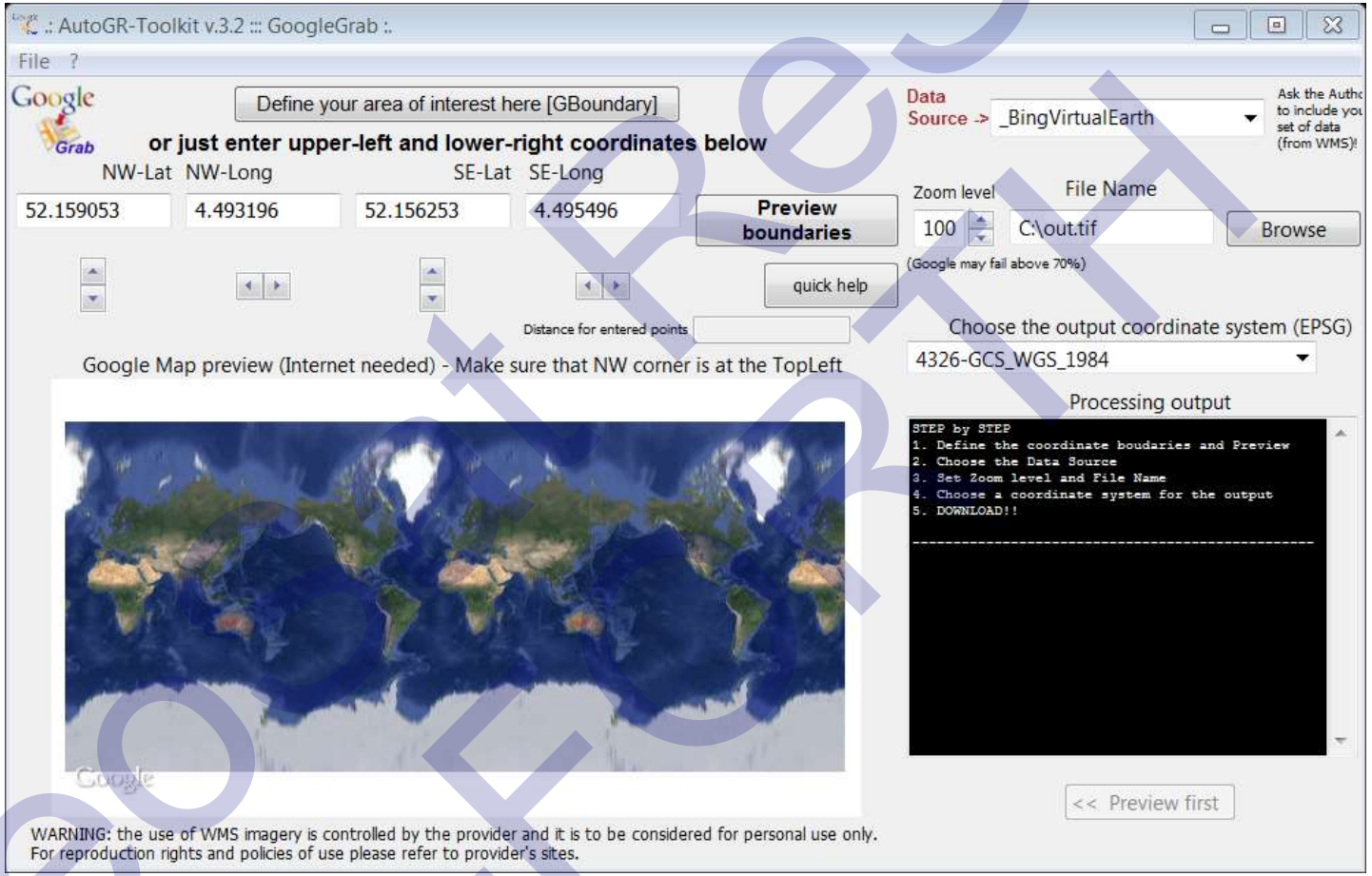

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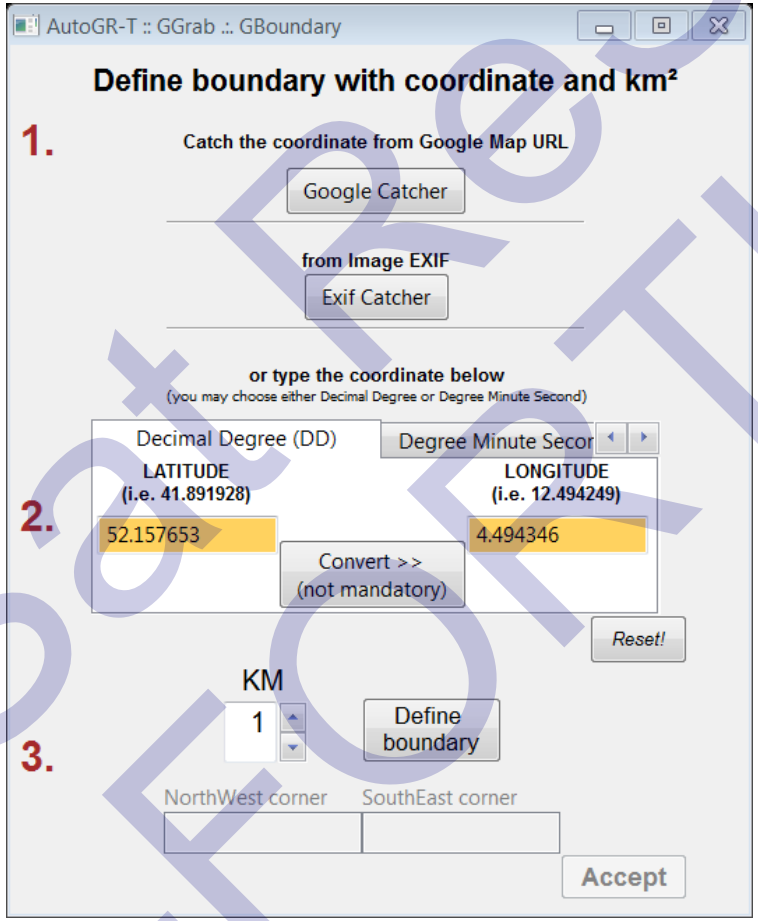

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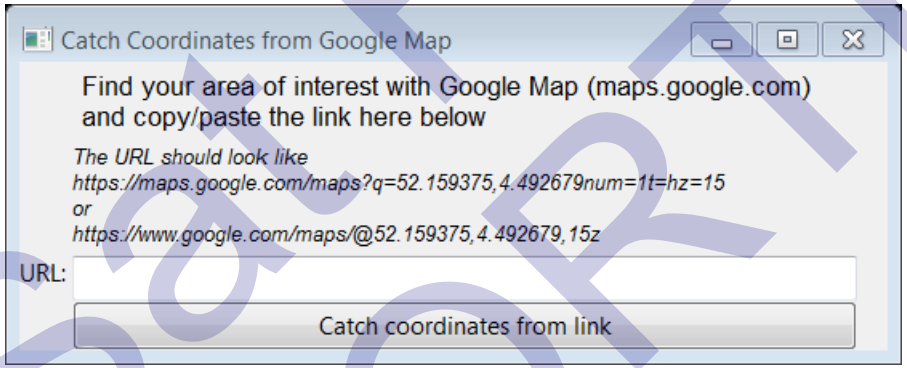

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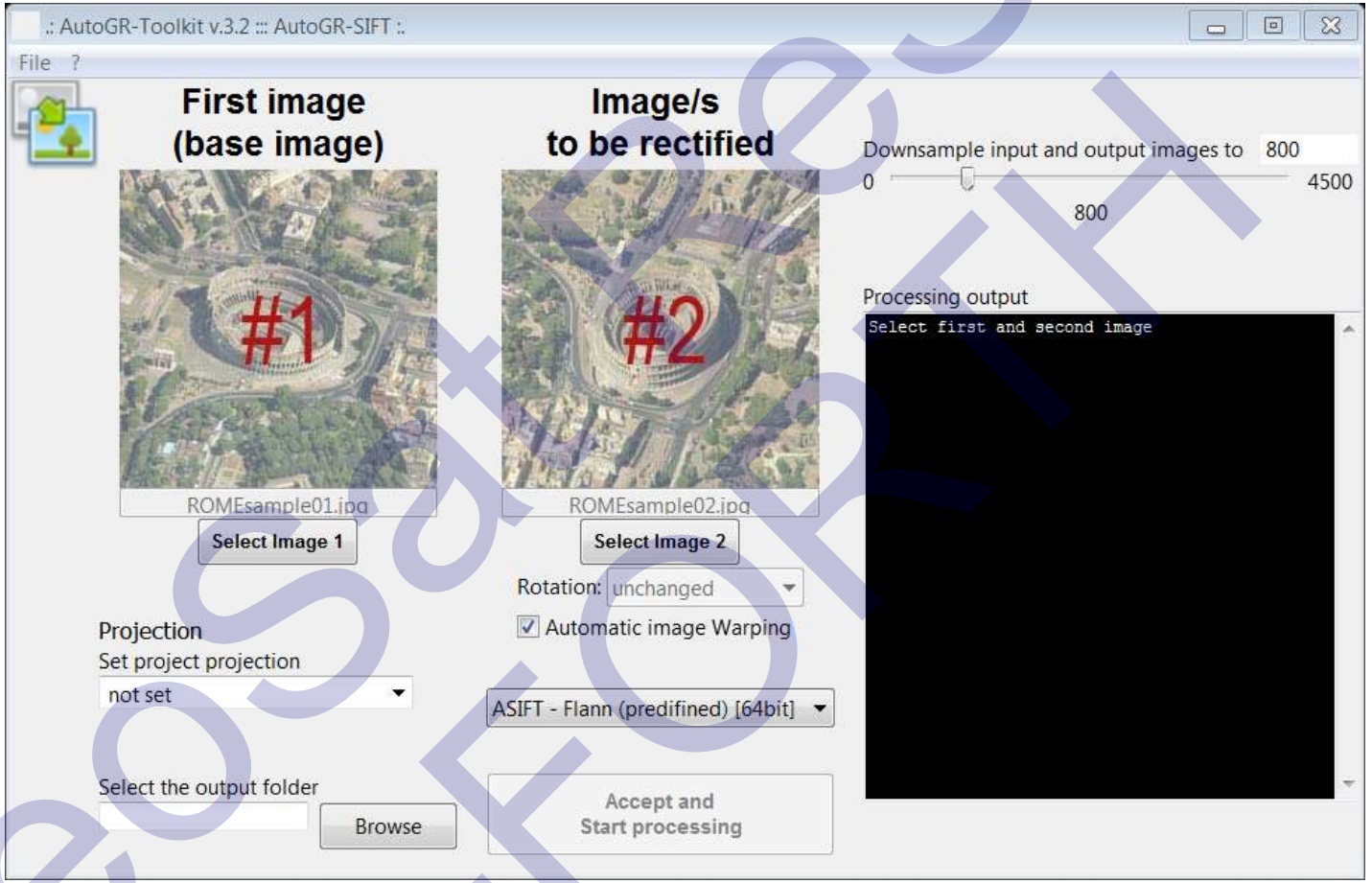

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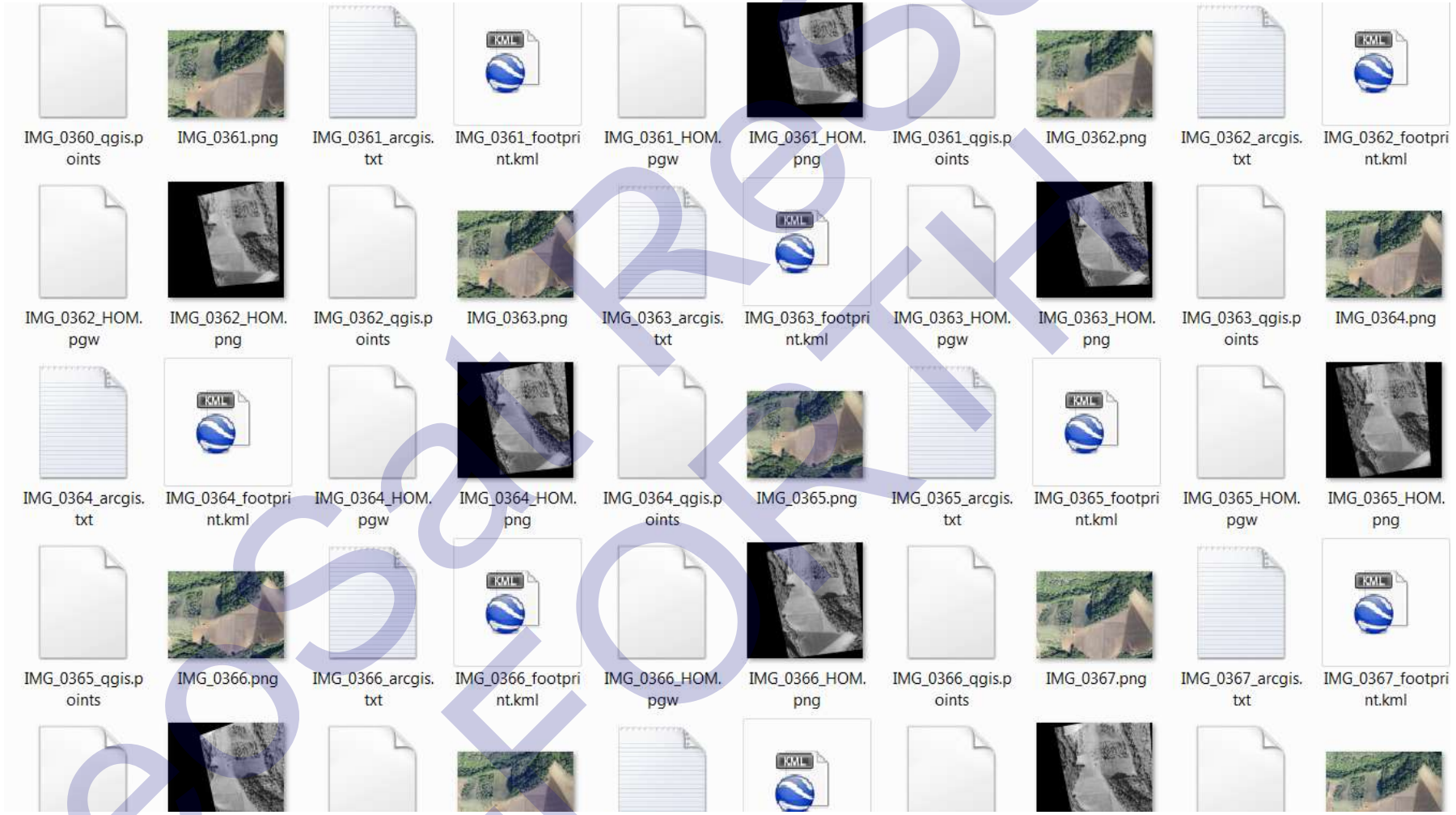

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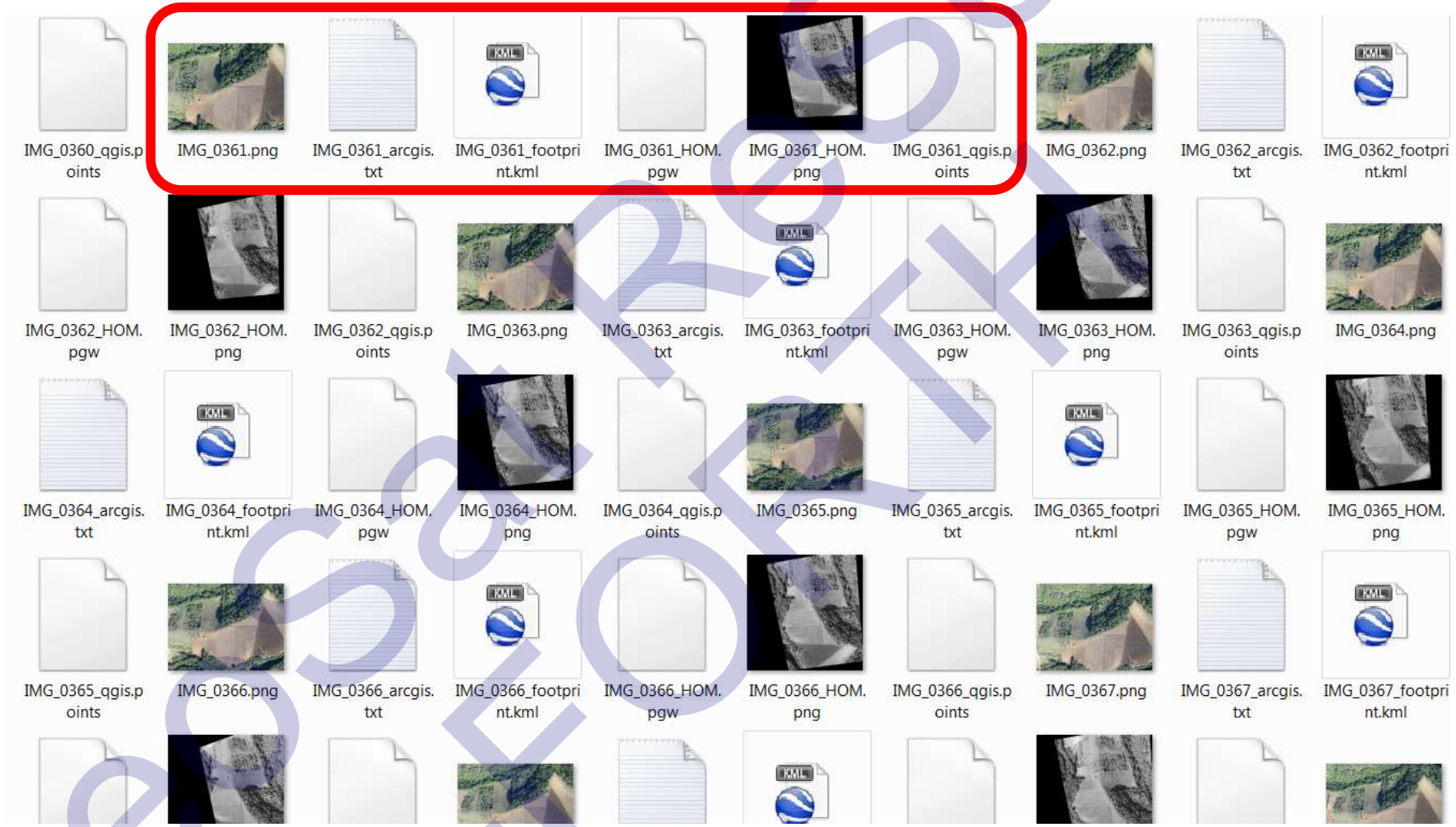

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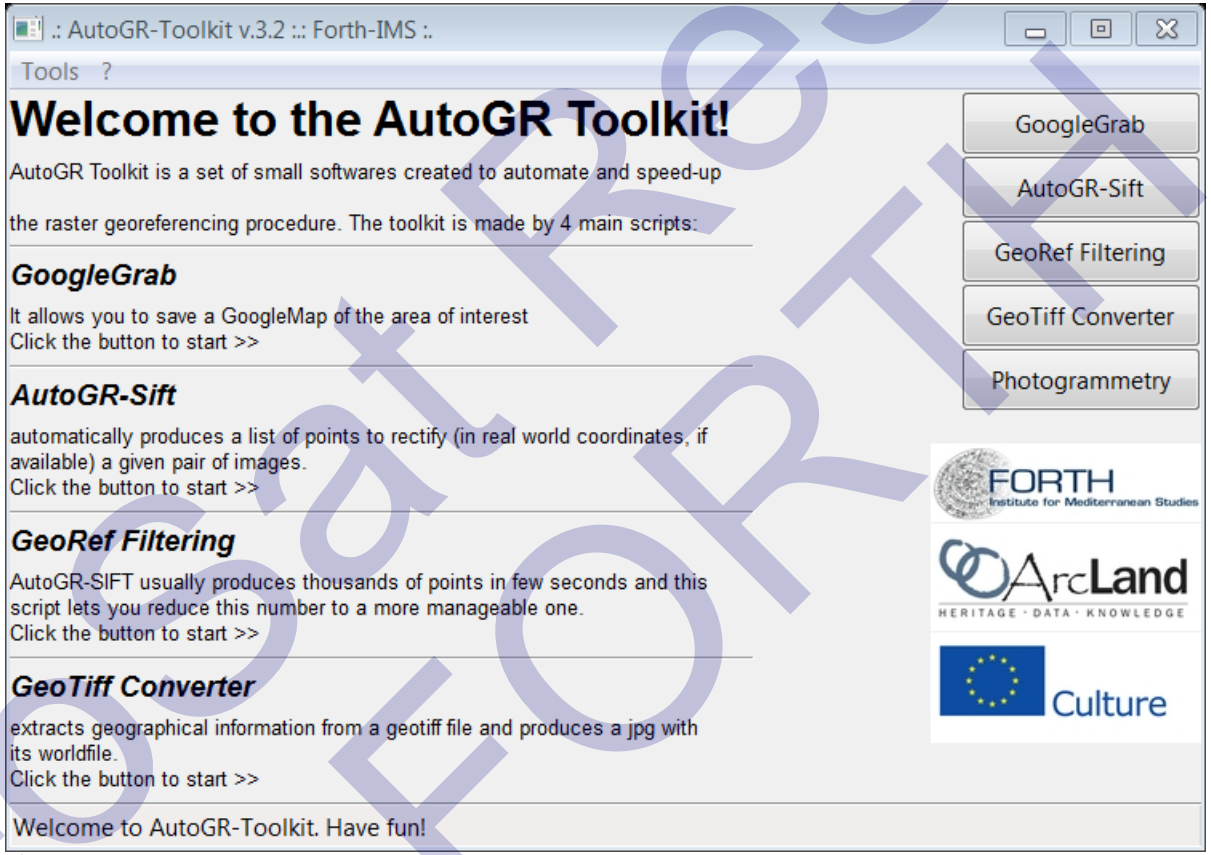

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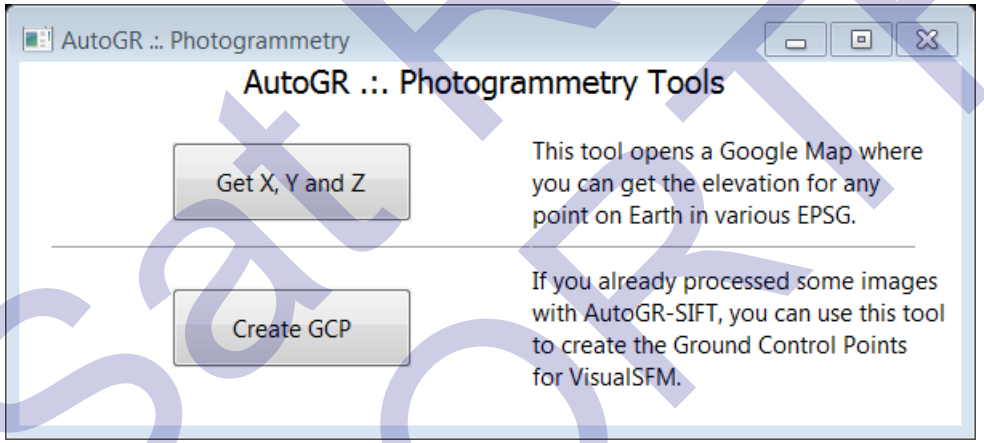

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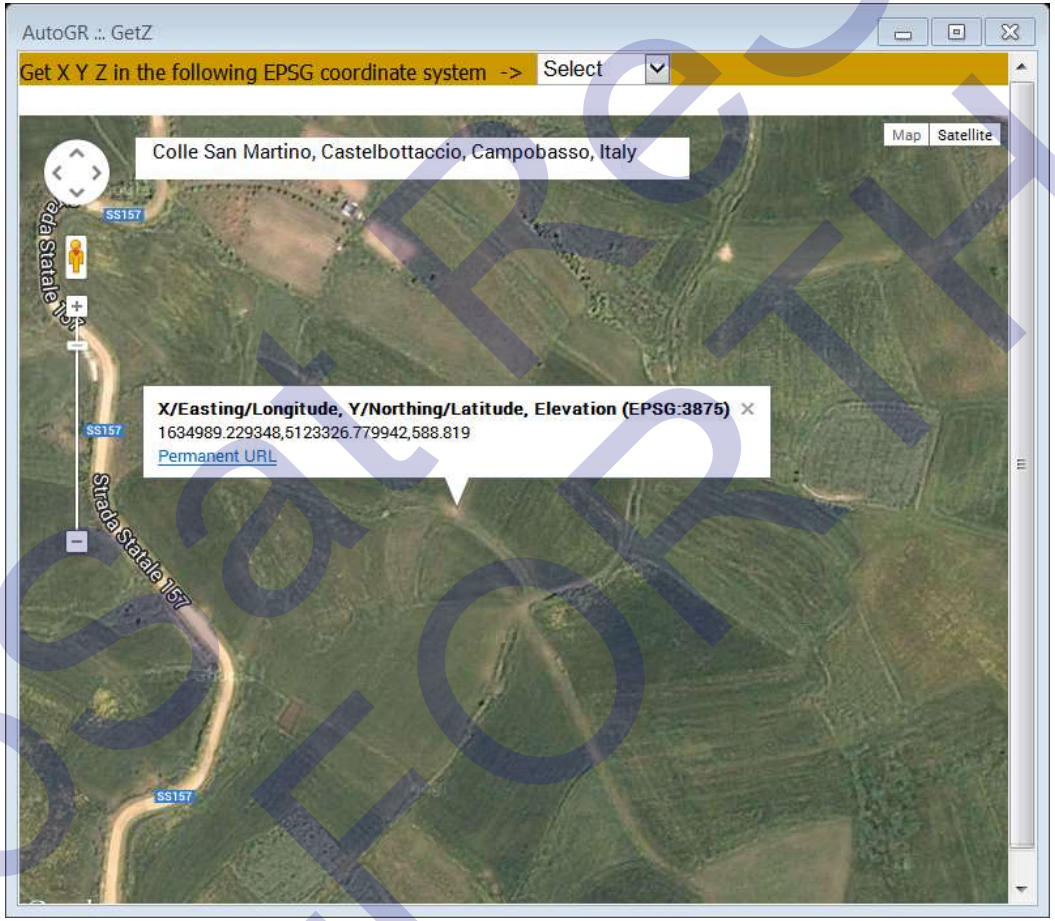

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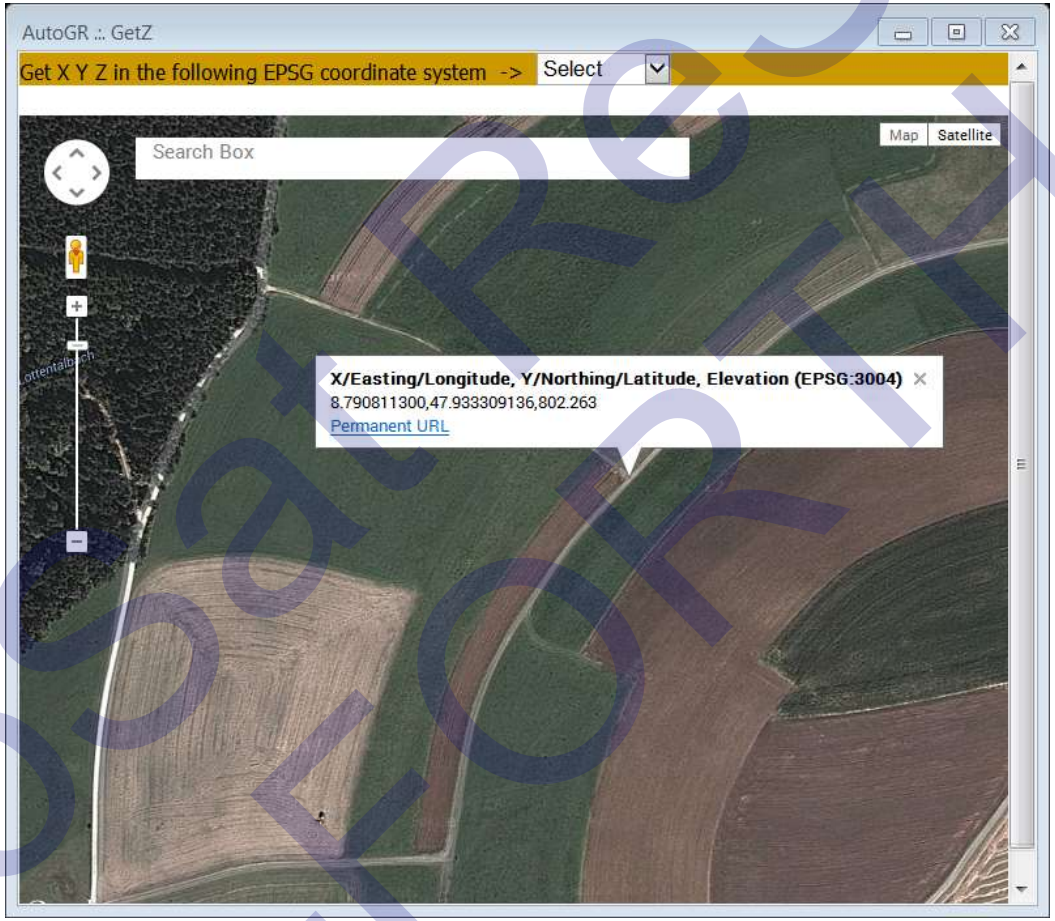

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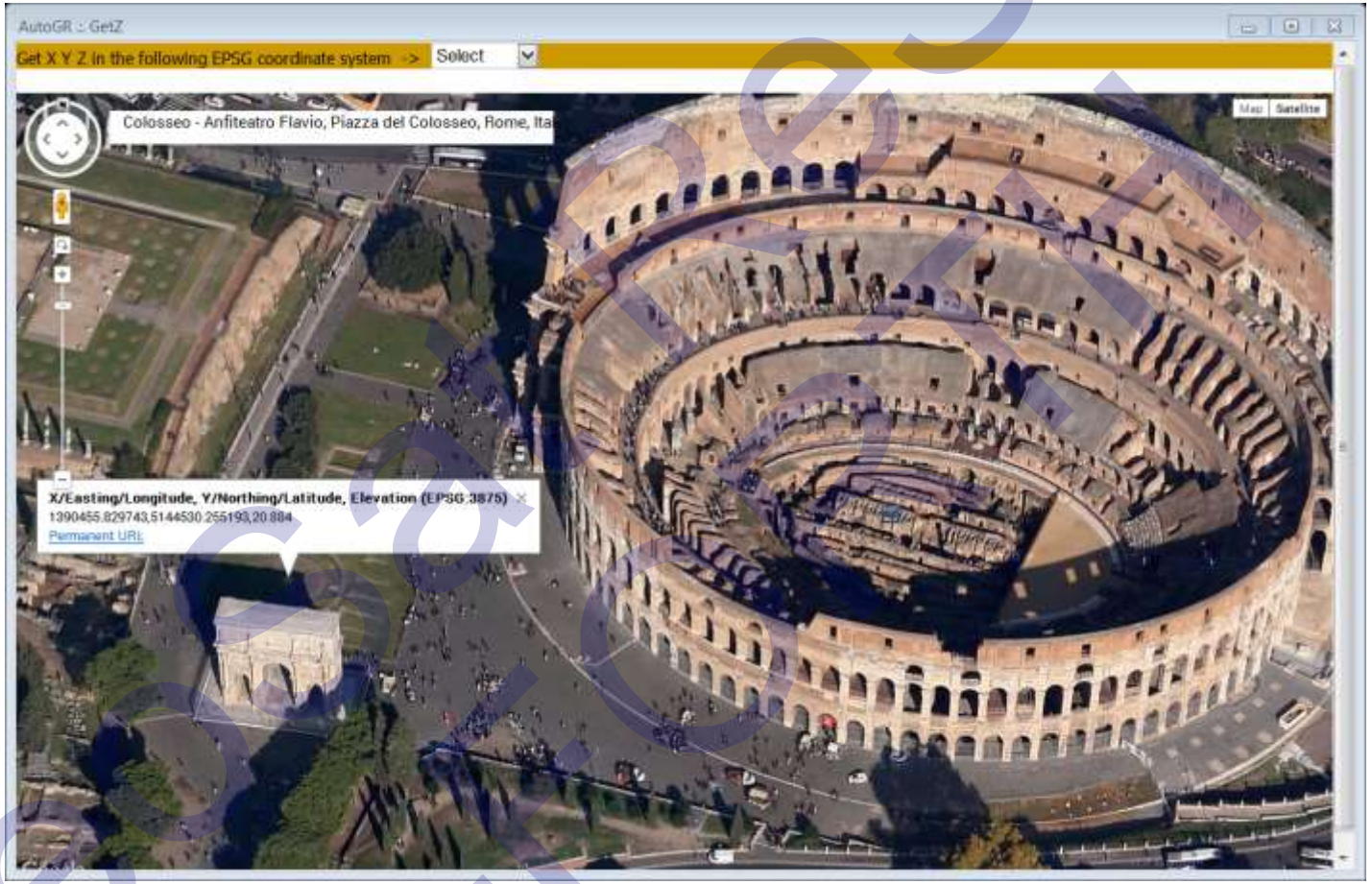
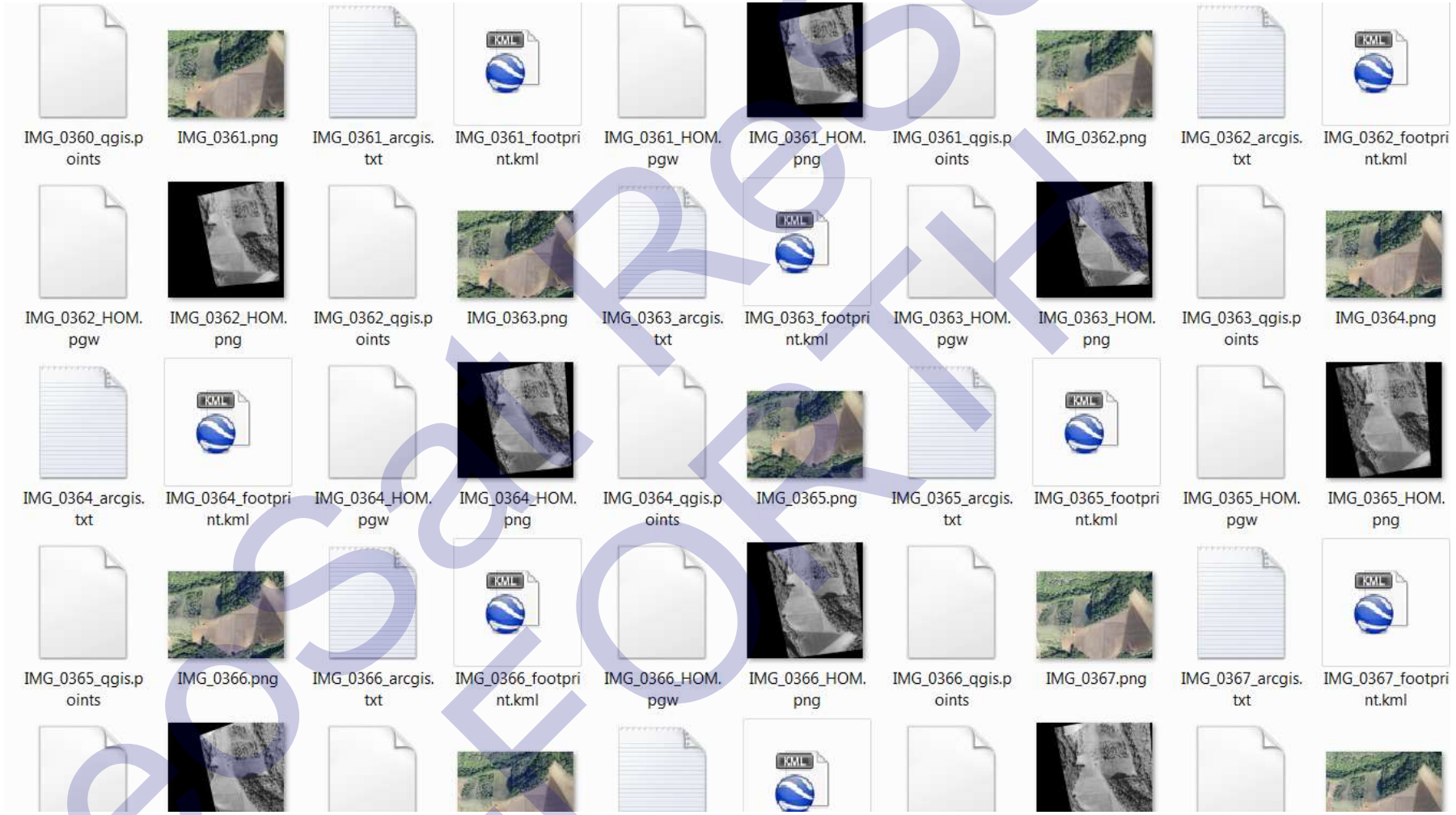


AutoGR-Toolkit 3.2

AutoGR-Toolkit – 3D matching



AutoGR-Toolkit – 3D matching

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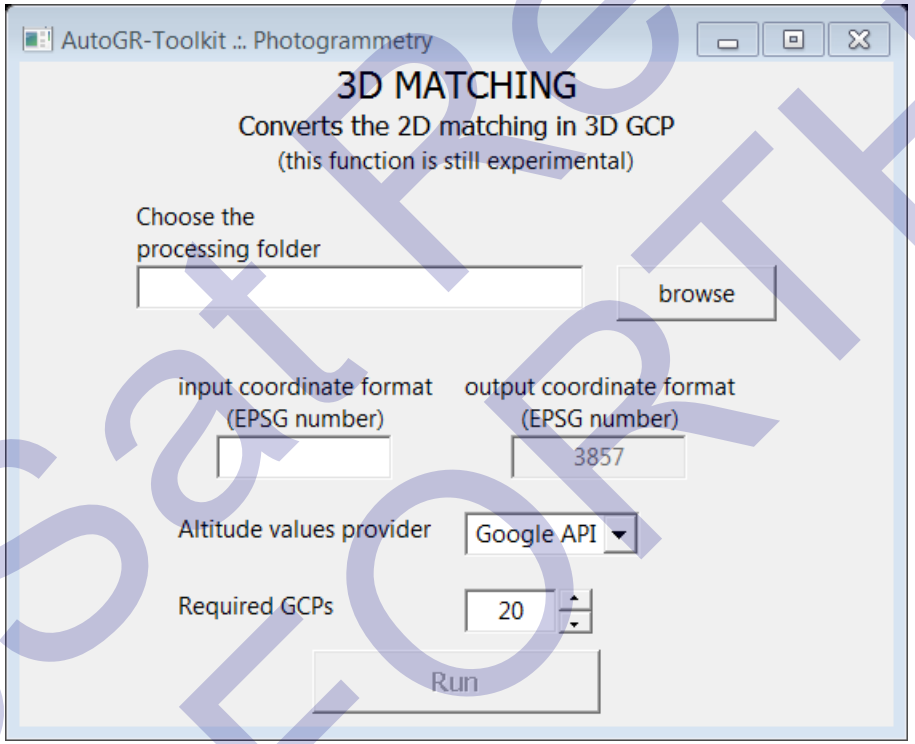
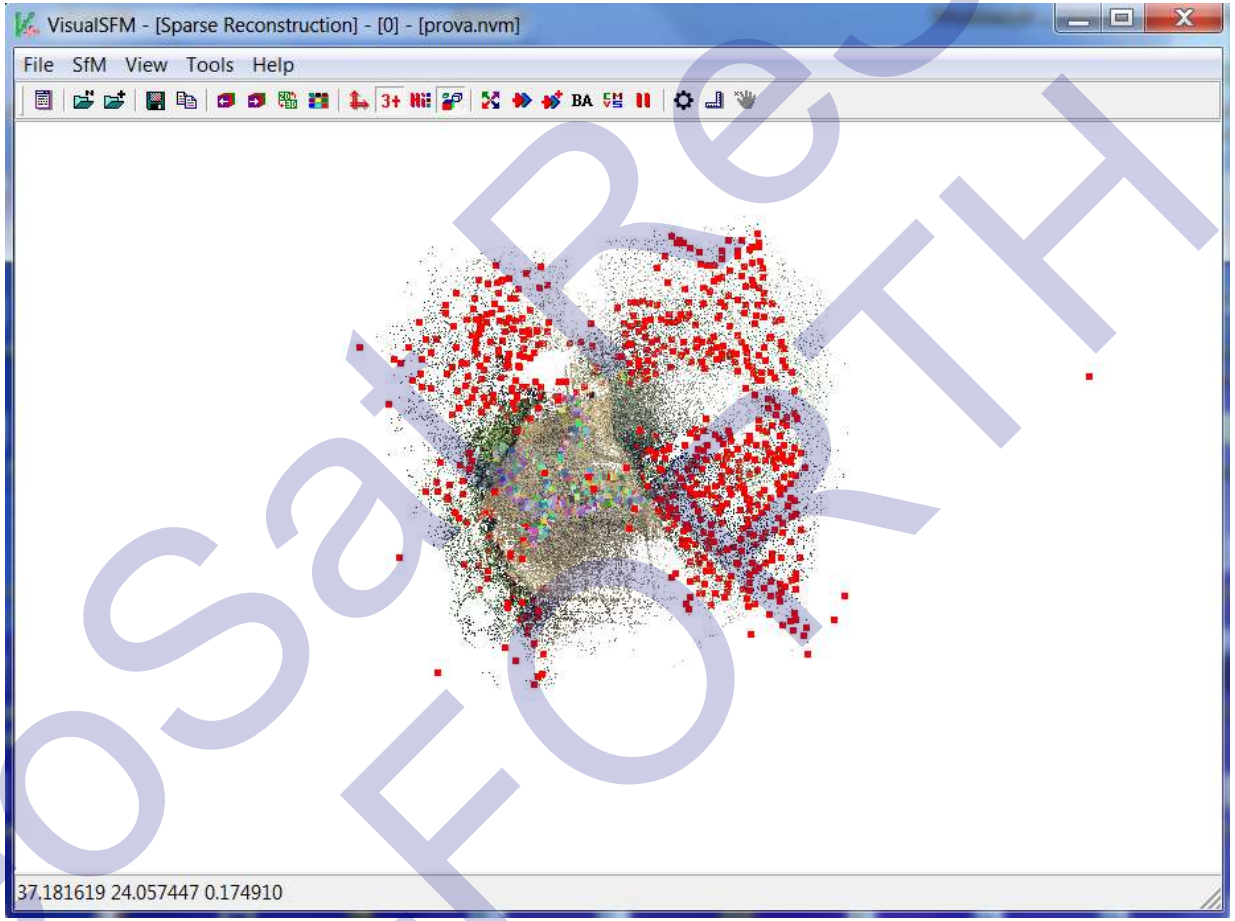
AutoGR-Toolkit – 3D matching

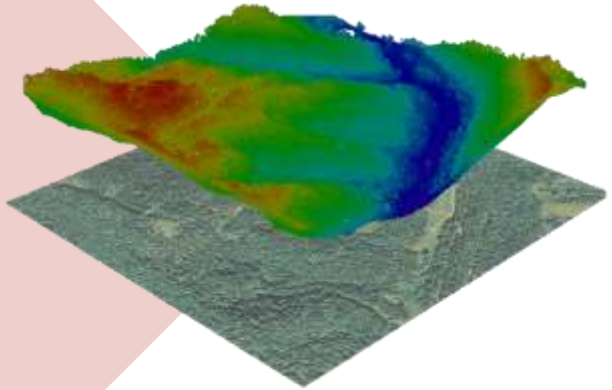


AutoGR-Toolkit – 3D matching



Workflow

4-500m



AutoGR-Toolkit – 3D matching

Workflow

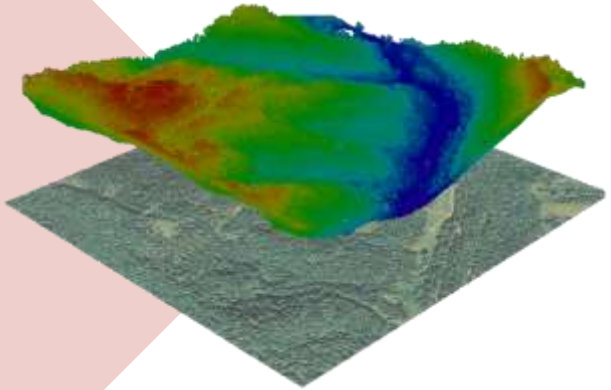
4-500m

Automatic georeferencing with AutoGR-SIFT

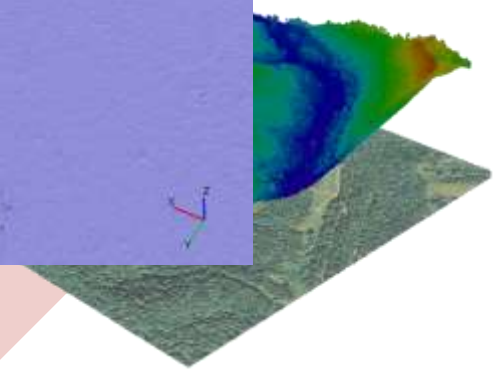
Manual Georeferencing

1-200m
(good overlapping)

Georef. 3D cloud with AutoGR-Photogrammetry
(GetZ or GCP creation)



Workflow



4-500

Thank you!

From field-work to… "air-work":
photogrammetric applications in Neolithic landscape reconstruction

FORTH Institute for Mediterranean Studies
GeoSat ReSeArch Lab of Geophysical-Satellite Remote Sensing and Archaeoenvironment

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