



DSM Generation Stereo Photogrammetry

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Analysis and Modelling (Remote Sensing) (SS23)



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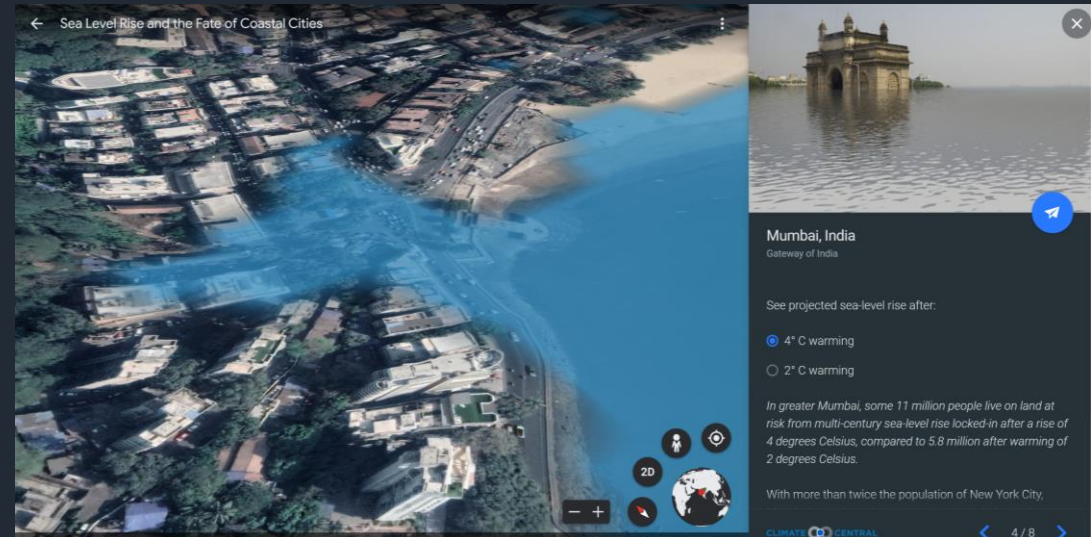
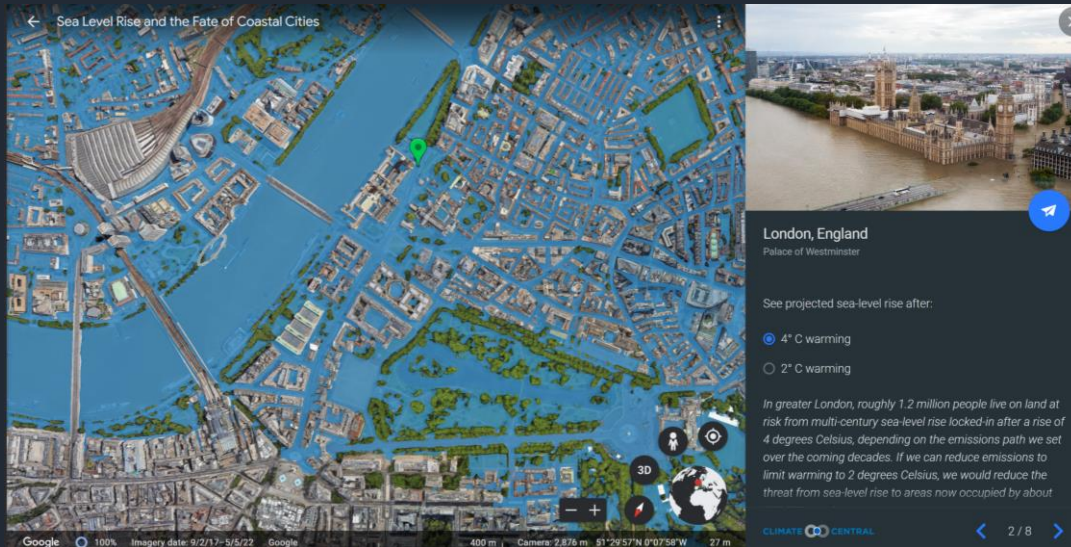
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Objectives

- Using existing tools (Open source (MicMac), Proprietary (Agisoft Matashape))
- Produce DSMs using available Pleaides Imagery (Salzburg, Shalla Lake)
- Compare results with reference (where available) and method efficiency

Motivation

Could not find DSMs for
anywhere in Africa on all
the Open source platforms!!!



An aerial photograph of a city, likely in the Middle East, showing a dense urban area with many small, light-colored buildings. A large, ornate, light-colored building with a central courtyard and a large, arched entrance is prominent in the center. The building has a complex, multi-tiered structure with many windows and balconies. The surrounding area is filled with smaller, similar buildings, creating a dense urban landscape.

Objectives

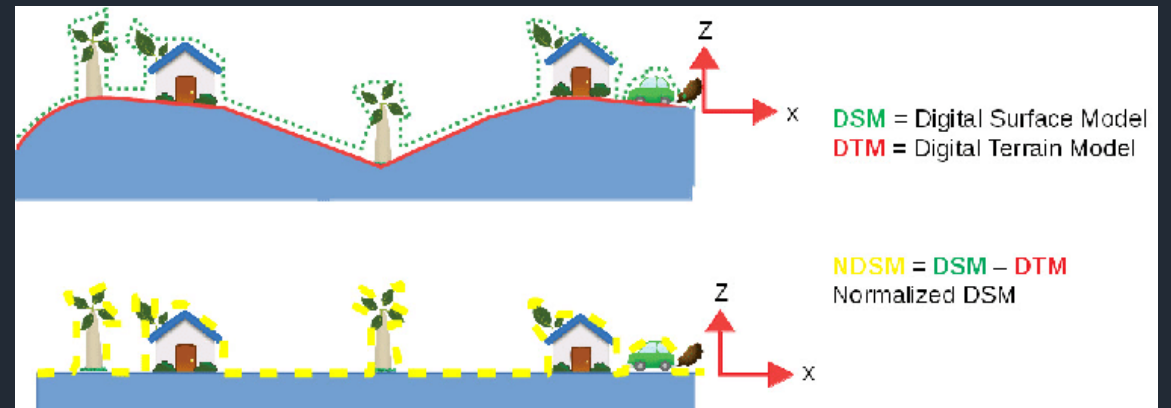
- Using existing tools (open source (MicMAc), Proprietary (Agisoft Matashape))
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DSM Overview

- Disaster Management (Flood Modeling and prediction, Damage Assessment)
- Urban Planning (Visibility (LOS) assessment, Solar Potential, Telecommunication etc.)
- Environmental Monitoring, Land use change.



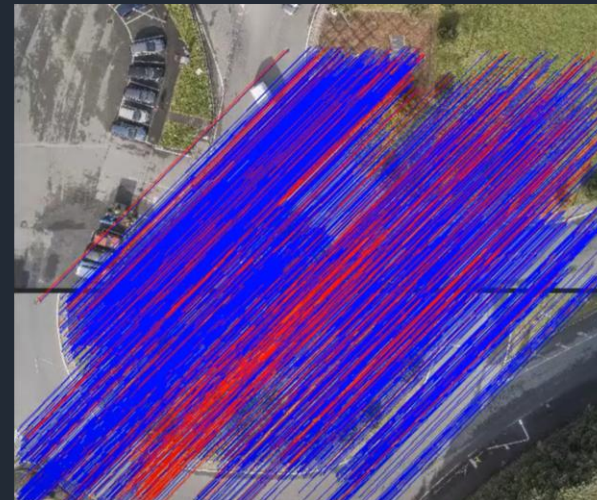
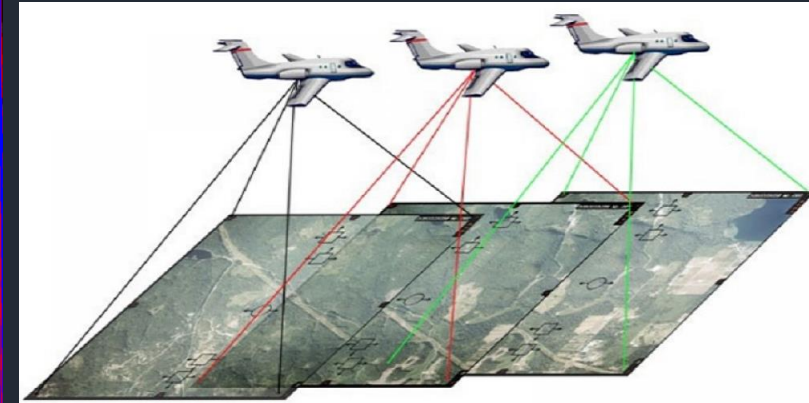
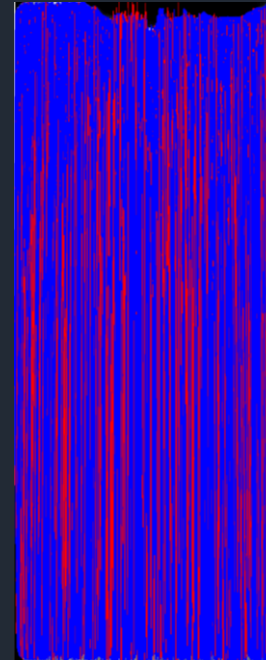
Markis et.al. 2023



UP42

Some DSM Generation Methods

- Lidar: Most advanced and accurate
 - High acquisition and processing costs, not readily available
- Aerial Imagery: (Aerial Photogrammetry) using Drones, UAVs etc.
- Satellite Stereo Photogrammetry(VHR): Similar to Aerial Imagery but offers significant advantages.
 - Very large areas can be acquire relatively quicker and cheaper (EoS). E.g. 0.50m res [Pleiades-1A](#) 20km Swath at nadir (stereo imaging capability 20km x 280km).
 - Significant overlap is achieved unlike ariel photos.



Stereo Photogrammetry: Overview

- The principle of Stereo Photogrammetry is used in Ariel Photogrammetry and Satellite Image Photogrammetry.
- Stereo Photogrammetry is based on the principle of Stereo Matching.
- Stereo Matching is used for finding corresponding pixels in a pair of images, which allows 3D reconstruction by Triangulation, using well known intrinsic and extrinsic orientation of the cameras.
- It is very similar to Structure from motion.
 - But SfM uses more images from various angles, and requires further scaling to real world coordinates.

Available Software for Stereo Image Processing (Satellites)

- Commercial
 - pix4D
 - Agisoft Metashape
- Open Source
 - NASA ASP (Ames Stereo Pipeline)
 - MicMac



An aerial photograph of a city, showing a large stadium with a distinctive roof structure in the center. The surrounding area includes residential buildings and green spaces.

DSM from Stereo Photogrammetry Pipeline (Satellite Imagery (with RPC))

1. Image Alignment
2. Tie Point Creation
3. Bundle Adjustment (with or without GCPs)
4. Disparity estimation
5. Depth Map Creation/Point Cloud Generation
6. Point cloud cleaning and classification
7. DSM Creation (Interpolate depth map/point cloud to create final DSM)

Further Optional Steps

- Alignment to existing Lidar Points

DSM from Stereo Photogrammetry Pipeline (In Detail)

Camera Calibration using RPC (Agisoft)

- Adjusts the cameras to the exact intrinsic and extrinsic positions when the images are taken, correcting for sensor and acquisition specific errors (jitters e.t.c).
- Pleaides product ships with both exact(DIM) and approximate (RPC) sensor model ([ASP Docs](#)).
- RPC model represents calibrated intrinsic and extrinsic parameters of the sensor.
- Rigorously corrected for sensor specific errors or artifacts (already corrected Ephemeris and Attitude). But Bundle Adjustment may be used to further optimize this.

Camera Calibration

Camera type: RPC

Pixel size (mm): x

Focal length (mm):

Rolling shutter compensation: Disabled

☐ Film camera with fiducial marks

Initial Adjusted Bands GPS/INS Offset

☐ Normalize band sensitivity

	Band	Black level	Sensitivity
1		0	1

Layer index:

Image	Resolution	Camera model	Focal length	Date & time	F
IMG_PHR1...	19836x23270			2018:01:26T08:...	0.9

OK Cancel

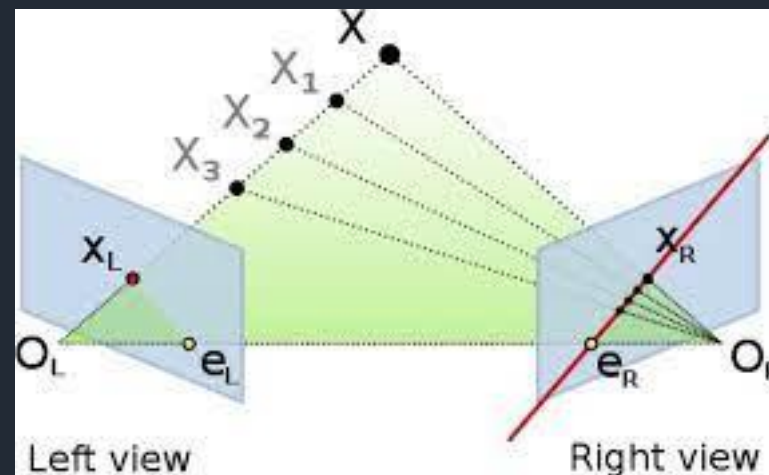


DSM from Stereo Photogrammetry Pipeline (Satellite Imagery (with RPC))

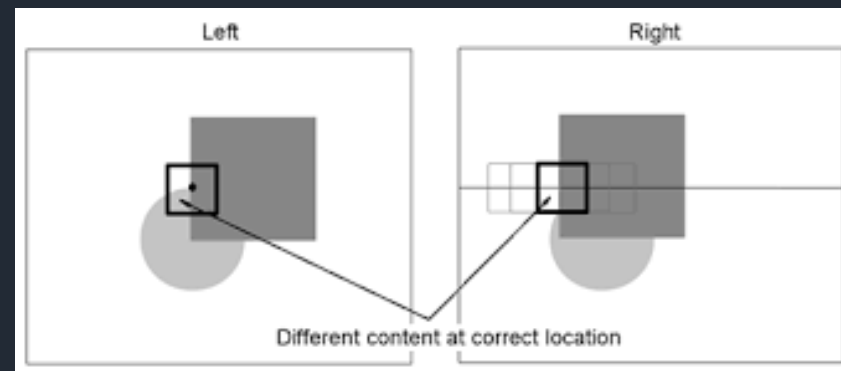
Image Alignment

- The images in a stereo pair are aligned to ensure similar position and orientation in the feature space.
- Alignment process is needed to narrow down the amount of image pixels that must be searched through to find correspondences among the two images used in stereo.*computers eyes and brains don't work like ours*
- Enables the use of Epipolar Geometry in Tie point search (next step). (1D rather than 2D search for matching points).
- Popular in literature is Affine Epipolar**
- More on Epipolar Geometry ([See here](#))

***affine transformation is applied to both the left and right images to make the epipolar lines approximately horizontal (thus similar)*



Epipolar geometry in an image pair
(Gutjahr et al., 2014)



Semi-Global Matching(SGM) H.Hirschmüller, 2011

DSM from Stereo Photogrammetry Pipeline (Satellite Imagery (with RPC))

Tie Point Generation

Done simultaneously with Alignment in Agisoft
Correlation Algorithms in ASP
Tapioca in MicMac

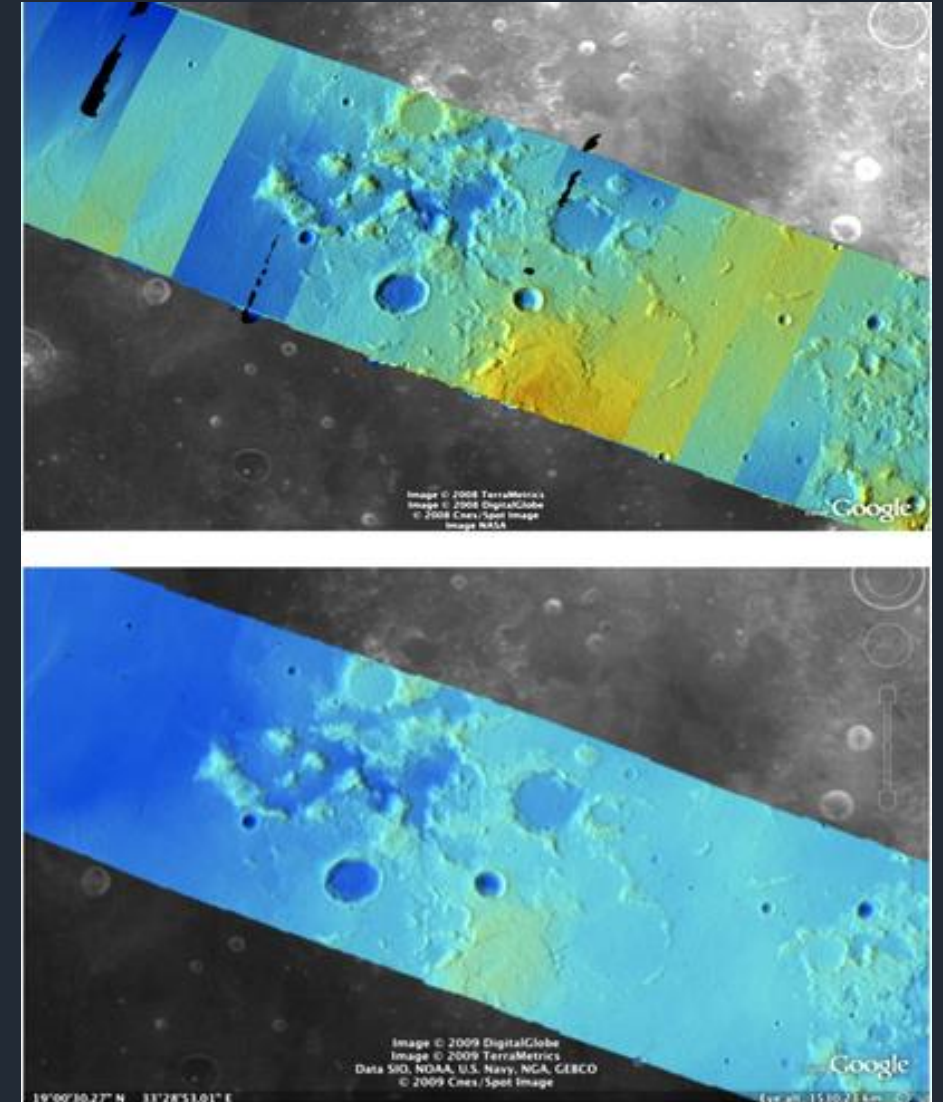
- Within the image space, similar points are identified in the overlapping region of the image.
- A collection of algorithms are run to compute these correspondences between pixels in the left and right images. (*SIFT is used in MicMac, Agisoft*)
- The resulting map of these correspondences is a disparity map.
- The resulting points have x and y image coordinates. But no depth at this point.
- Popular Algorithms are Semi-Global Matching (SGM), More Global Matching (MGM), Block Matching etc.



DSM from Stereo Photogrammetry Pipeline (Satellite Imagery (with RPC))

Bundle Adjustment

- This is iterative triangulation on all images (stereo) to ensure minimum error between points measures in the image and on the ground.
- It utilizes all possible intrinsic and extrinsic parameters to iteratively determine the exact conditions at the time of capture, keeping possible errors to the minimum.
- Optimally done with Ground Control Points (GCPs)
- Does not necessarily contribute to vertical or horizontal accuracy of resulting DSM



DSM from Stereo Photogrammetry Pipeline (Satellite Imagery (with RPC))

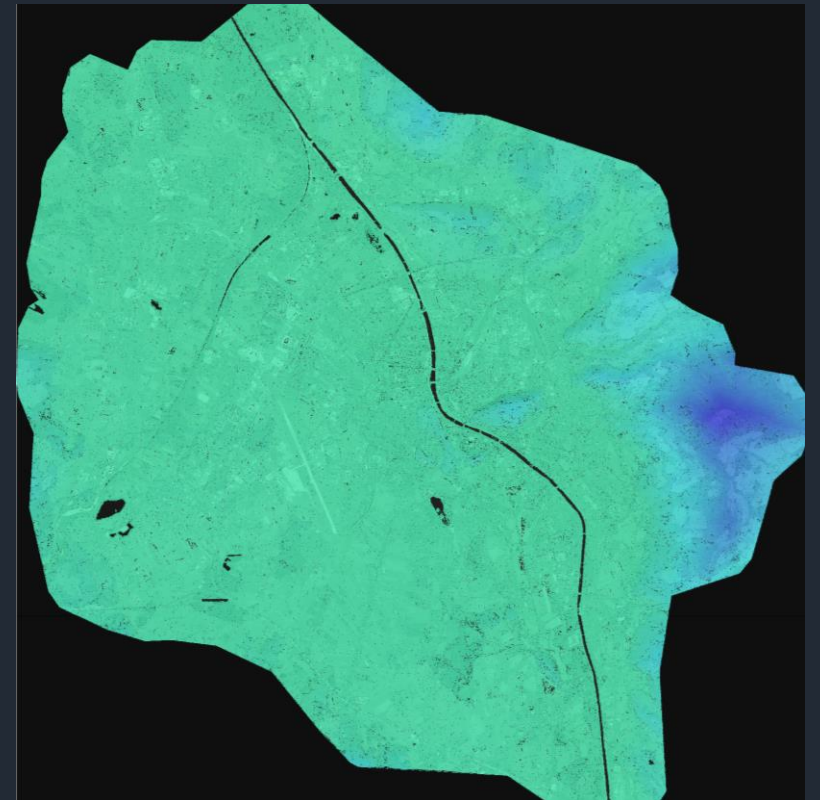
Depth Map Creation/Point Cloud Generation/DSM Creation

*In ASP (Stereo Triangulation)
In Agisoft Depth Map is created automatically when DSM creation tool is
run)
In MicMac, Malt command*

- Through the process of Triangulation, disparity map is converted to Depth Map.
 - Depth Map is a 3D image map for which every pixel has a x, y and z dimension. E.g. In ASP, result in a 4 band raster representing x, y z ad z error.
- Point Cloud is created (points instead of a continuous surface). Similar to tie points but now with x,y,z dimensions and scaled to real world coordinates (based on specified project reference system)
- This is where the ASP tool stops.

DSM Generation

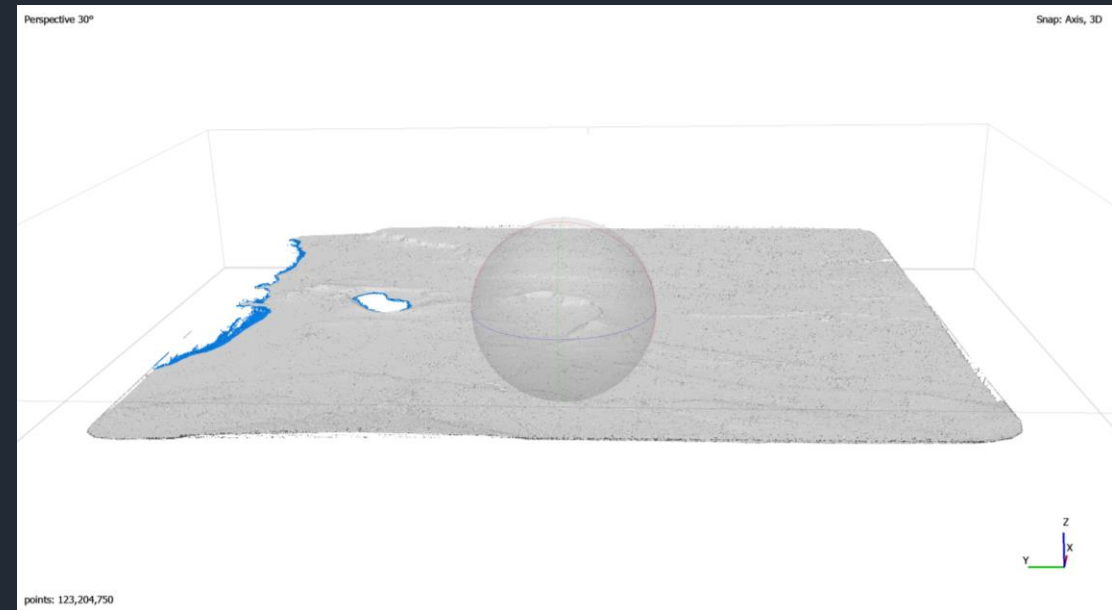
- DSM Creation from Depth Map/Point Cloud: Here interpolation (for point cloud) and georeferencing is done to bring the results into real world coordinates.



DSM from Stereo Photogrammetry Pipeline (Satellite Imagery (with RPC))

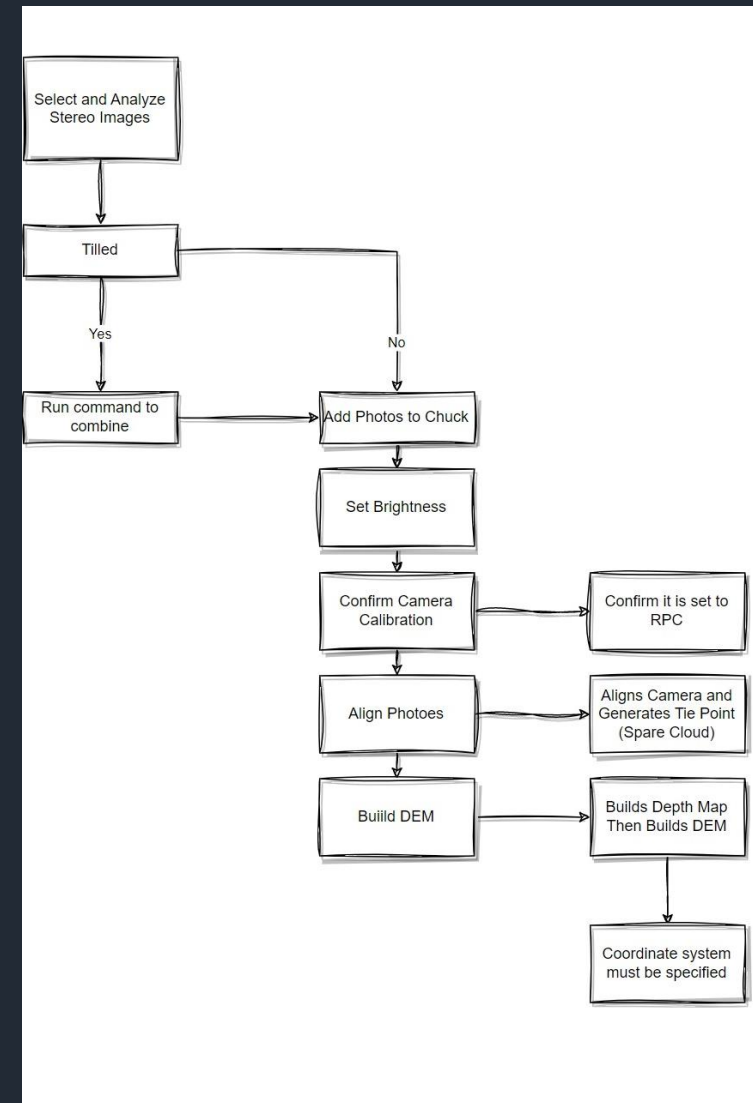
Optional Further Steps

- Alignment to existing Lidar Points (works like GCPs) to optimize vertical and horizontal accuracy. (Ames and Agisoft Supported)
- In Agisoft, point cloud cleaning and classification can be done easily (here ground points can be classified separately from surface points)
- Mesh(Agisoft), Tiled Model(Agisoft), Ortho Photo (Agisoft,Micmac) can further be created.

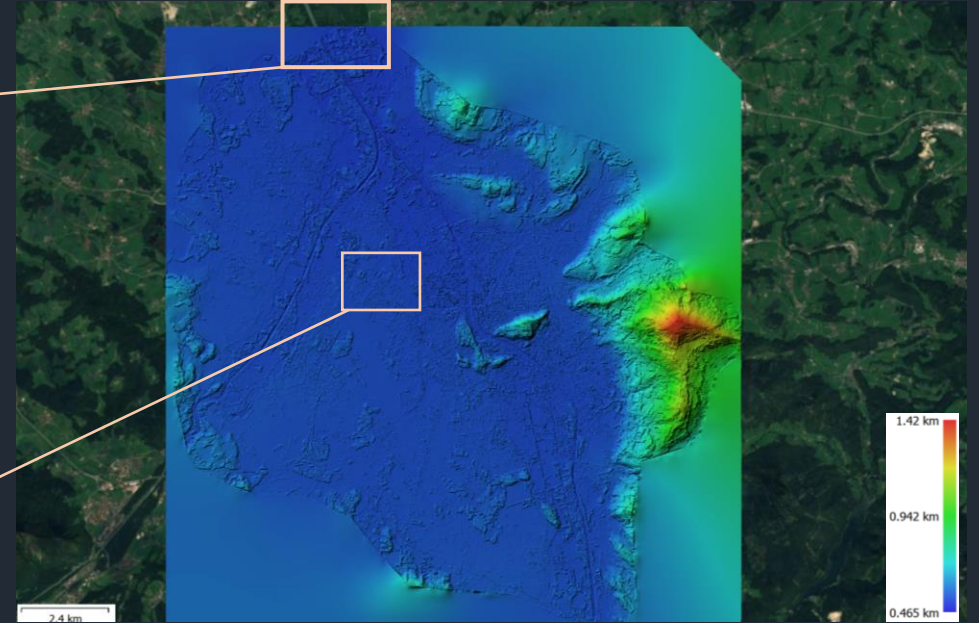
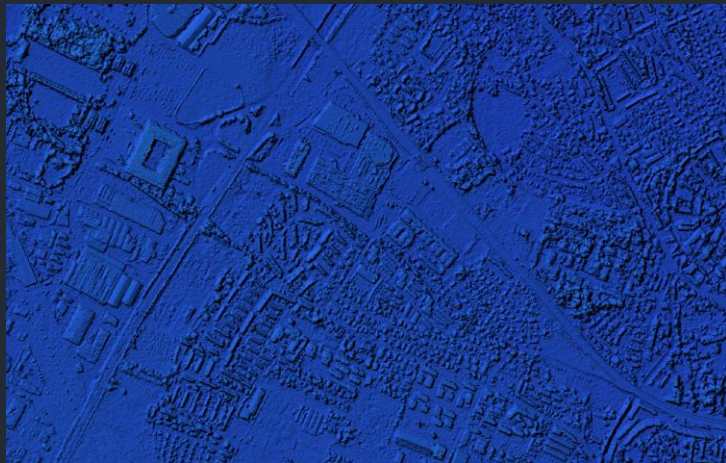


Agsisoft Metashape

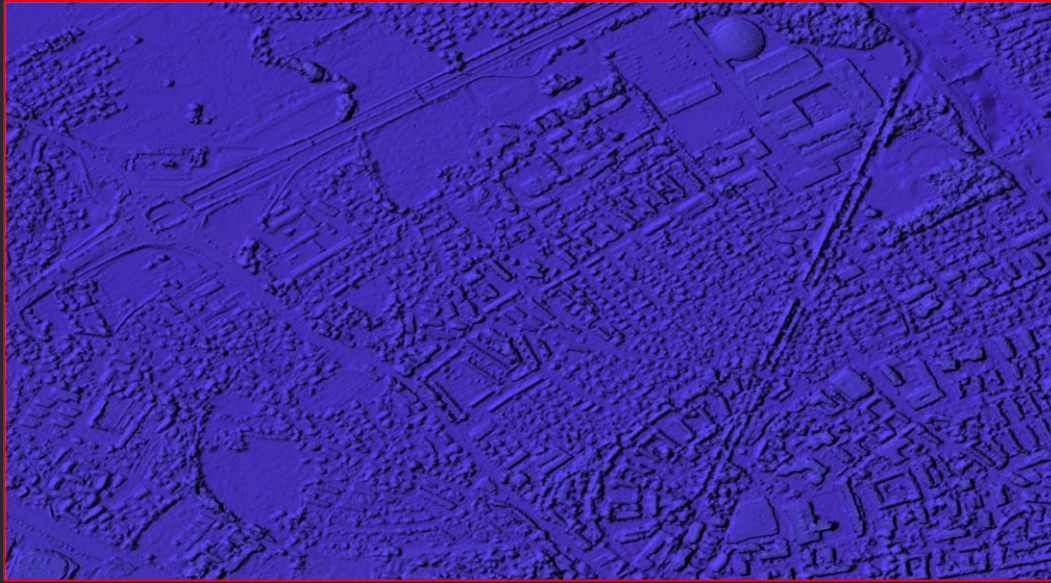
- Also built in C++ but is proprietary
- Possesses a GUI
- Offers free 30 day trial to get started
- Easy to use (backend processing not always clearly explained)
- Offers easily understood tutorials and documentation



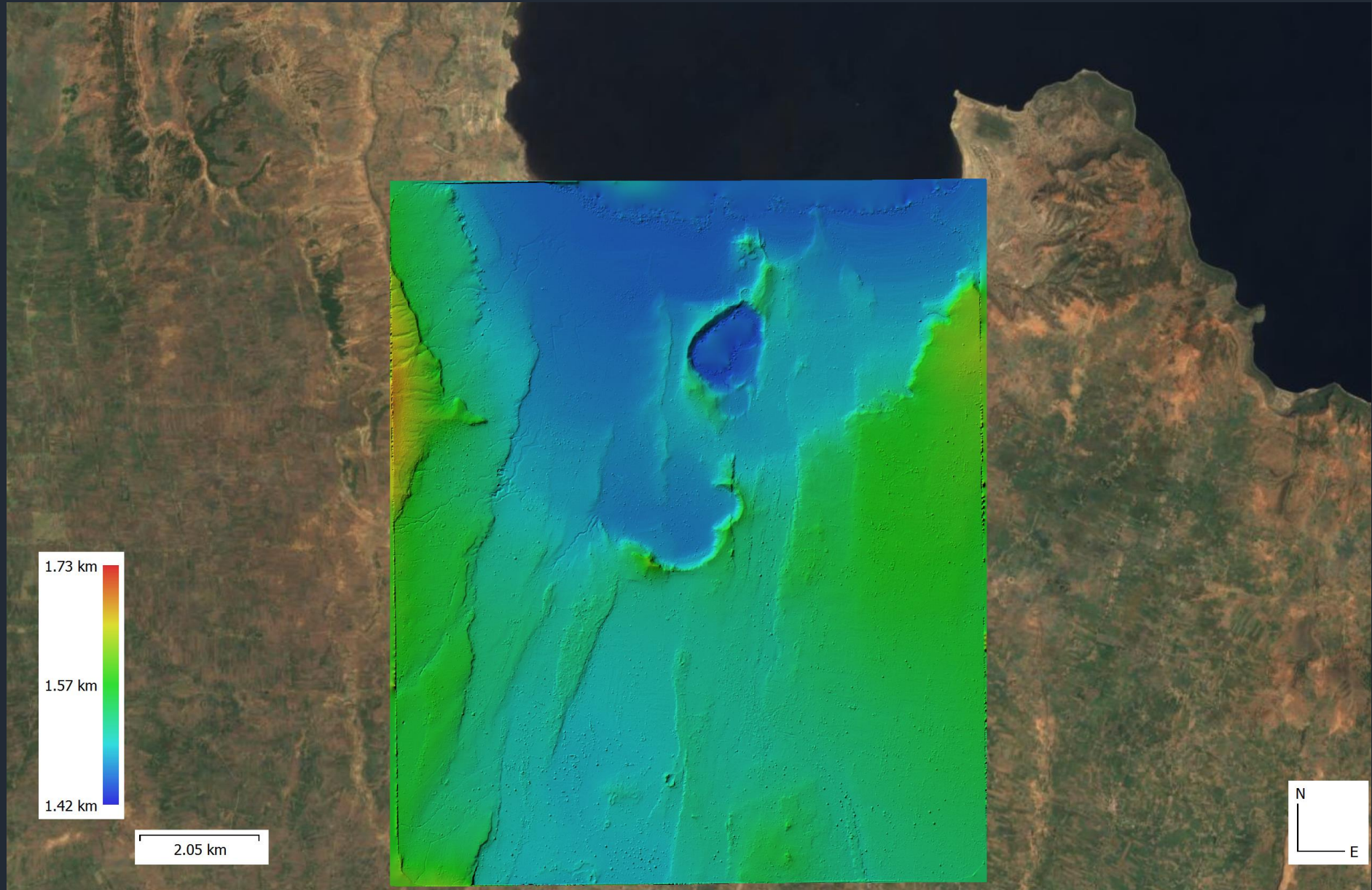
Agsisoft Metashape Results – Urban (Salzburg)



Agsisoft Metashape Results – Urban (Salzburg)

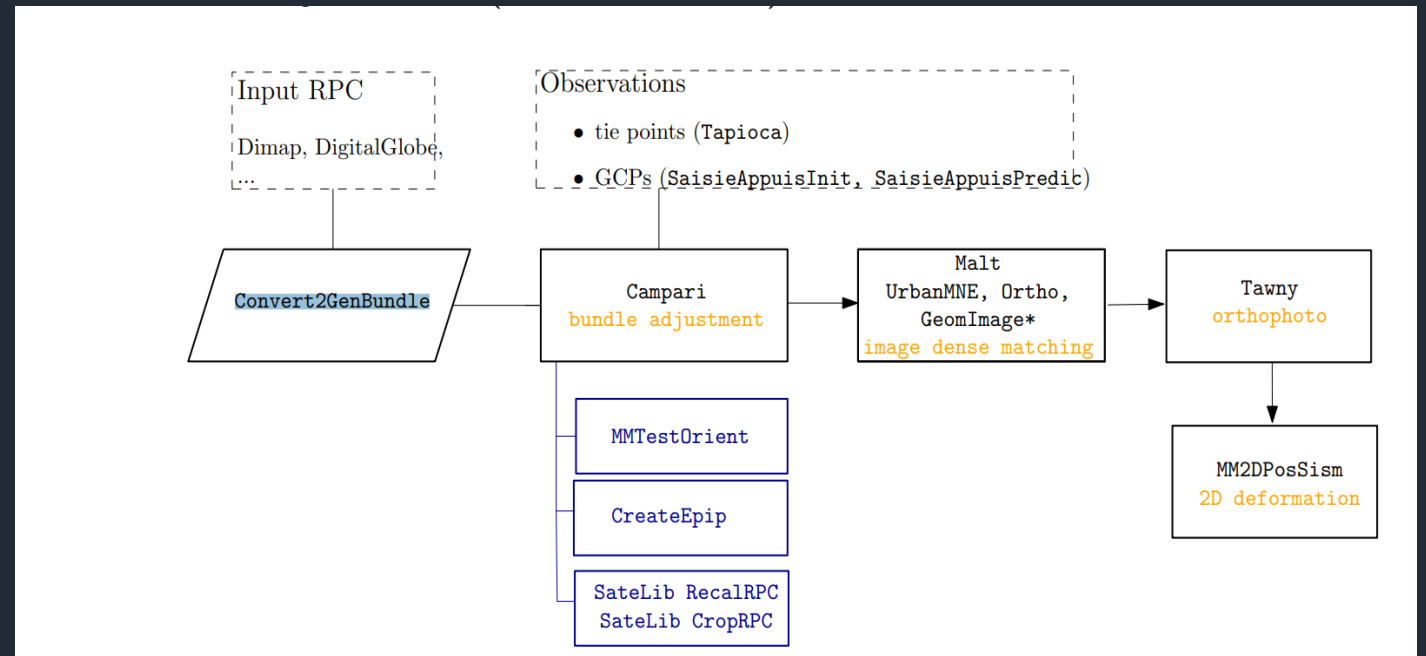


Agsisoft Metashape Results (Shalla)



MicMac

- Command line tool built in C++
- Free and Open Source
- Does it have a GUI
- Fairly complicated to use (general expressions, not very beginner friendly)
- Offers numerous tutorials to learn



An aerial photograph of a city, likely Salzburg, showing a dense urban area with a large stadium in the center. The stadium has a distinctive roof structure. The surrounding area is filled with buildings and greenery.

Next Steps

- Get results for Micmac
- Compare efficiency in terms of
 - Processing Time
 - Backend Processing Transparency
 - Documentation (Ease of Use)
- Test out my Salzburg DSM result in a coupled 1D-2D flood model using HEC-RAS
- Explore further the Ames Stereo Pipeline (ASP)



Thank You!!!

for your attention

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