

# Montenegro in Miniature

An Analysis of the Historical Relief of Montenegro in Cetinje

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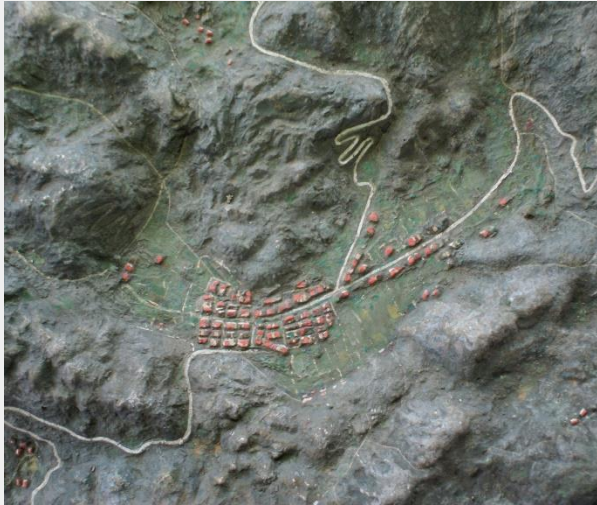


# The Relief

- At former royal palace in Cetinje
- Commissioned by the k&k Generalgouverneur in 1916 after the capitulation of Montenegro
- Built in 1916 / 1917
- Made from concrete
- 1:10.000
- 256m<sup>2</sup> (16m x 16m)



# Details



Cetinje

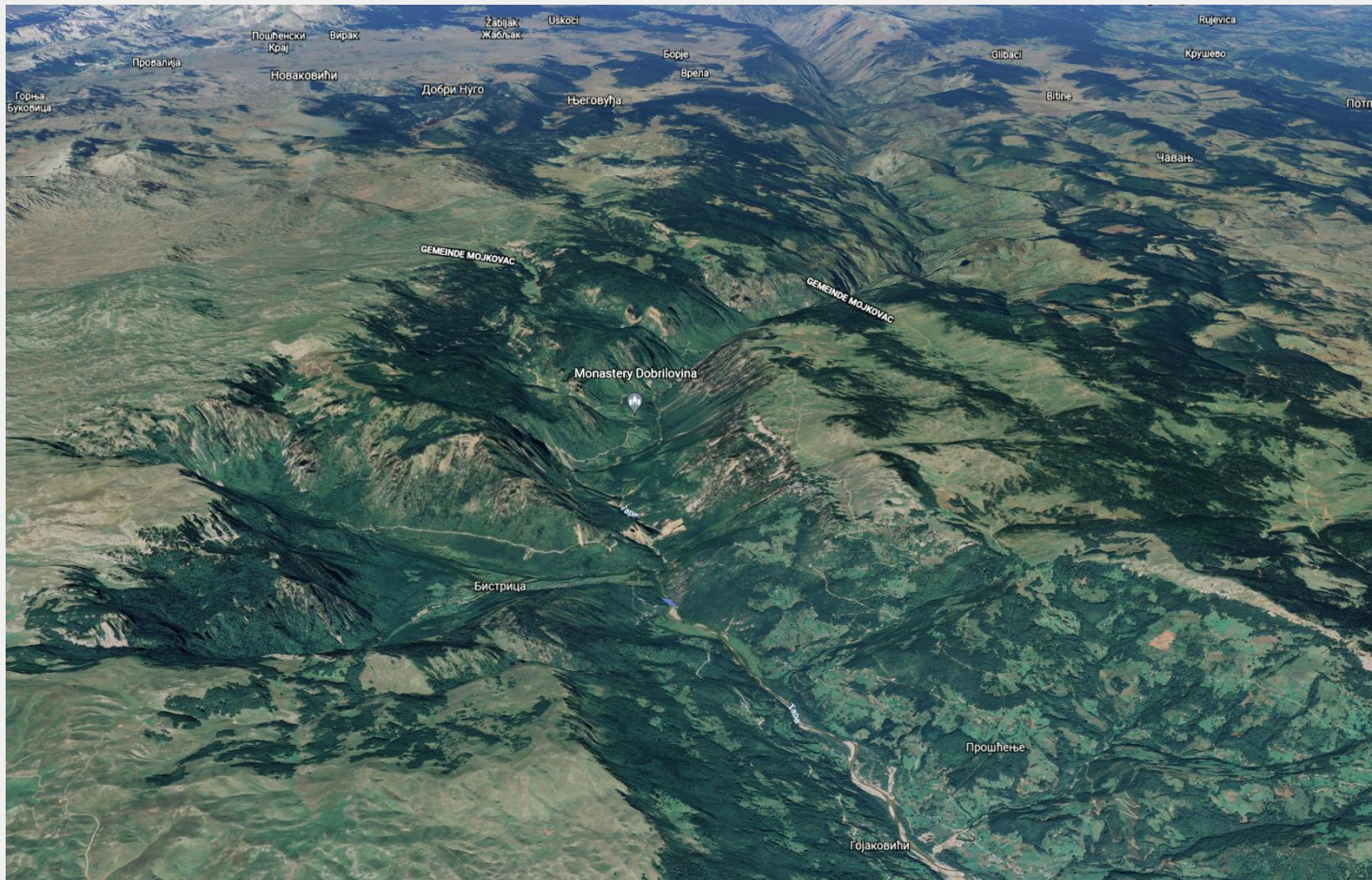


Dubrovnik



Tara Canyon





Tara Canyon in Google Earth, 2021

# Scanning

- Photogrammetry
  - „Structure from Motion“
  - Pictures taken with digital camera
  - Software creates 3D point cloud
- Difficult to get pictures from above
- Photos and Photogrammetry by Moisés Hernandez-Cordero (Austrian Academy of Sciences)

# The Scans

- Massive point cloud
- Mesh (textured polygons)
  
- Orthophoto
- Digital Elevation Model (DEM)
  - Comparison to real-world data

# Georeferencing

- Unknown map projection of relief
- Ground control points (GCP) necessary for georeferencing
  - Correlation between historical landmarks in the relief and in present-day online maps. (Google Maps, Open Street Map)
- 27 GCPs used to georeference the orthophoto
- Orthophoto was used to reference the DEM

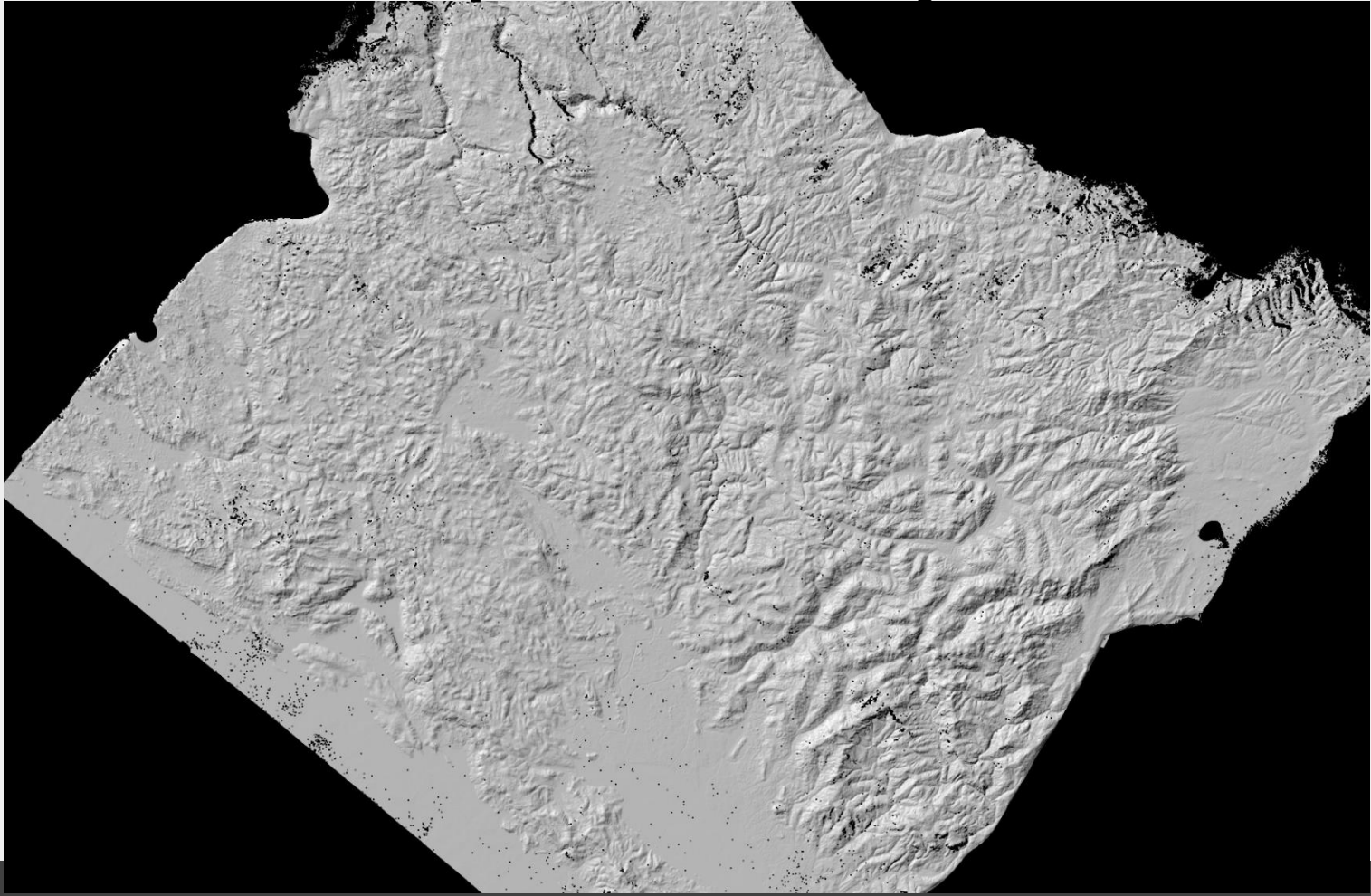




# Preparation

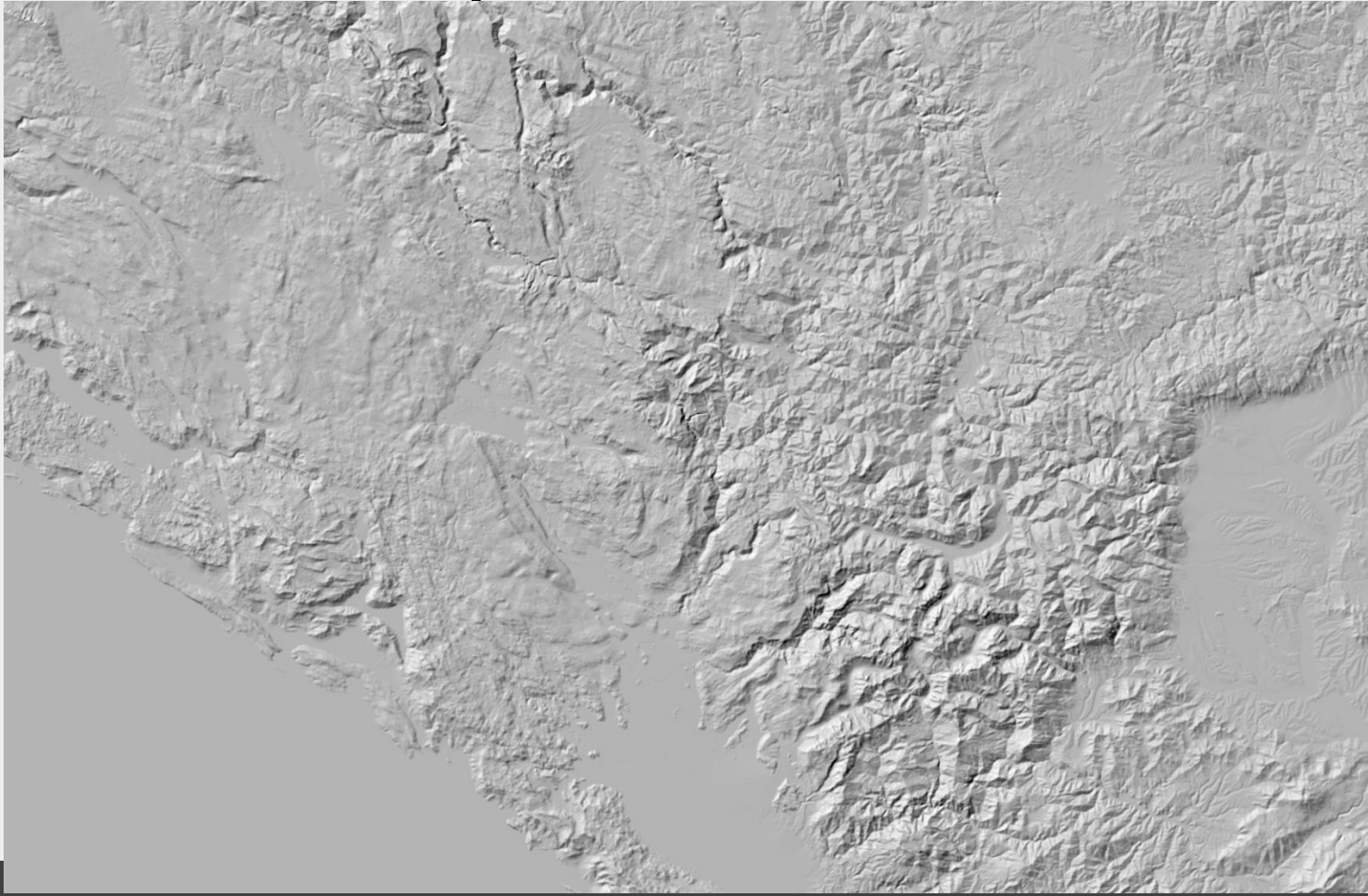
- Adjust DEM of relief to real-world DEM
  - Define lowest and highest points
- Calculate hillshade depictions
- Reduce resolution to mitigate georeferencing inaccuracy
- Compare elevation of both DEM

# Hillshade Comparison - Cetinje Relief





# Hillshade Comparison – EU-DEM





# Hillshade Detail – Cetinje Relief

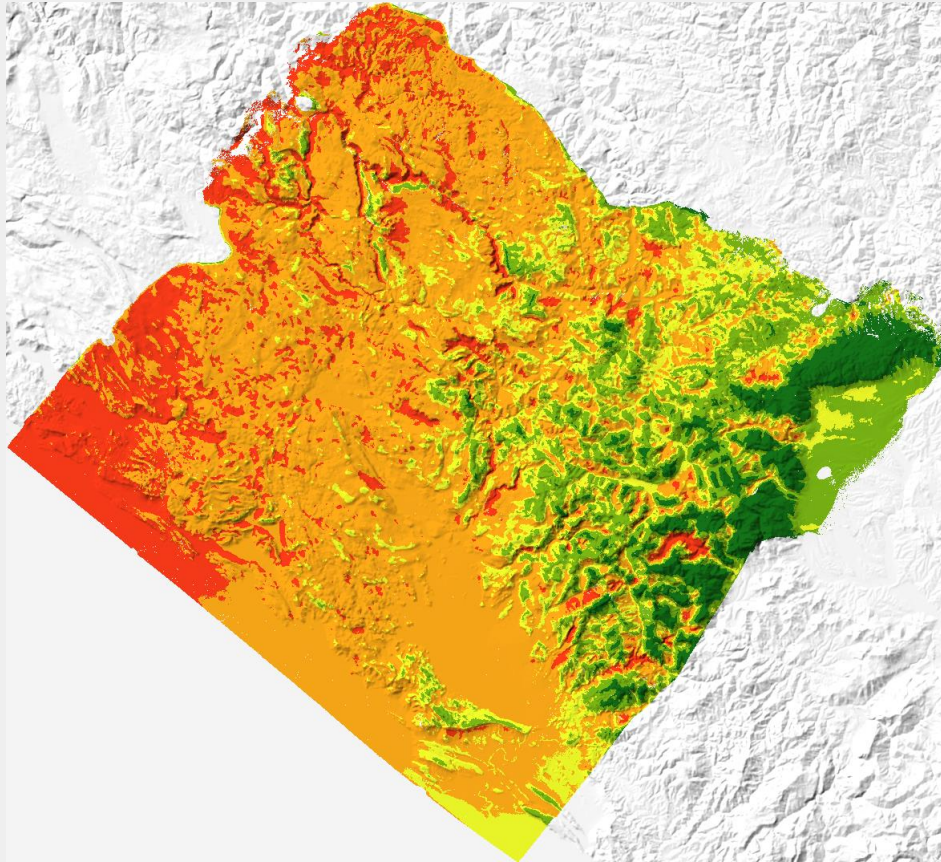


# Hillshade Detail - EU-DEM





# Elevation comparison



Cetinje Relief subtracted from EU-DEM



- Negative values (green): Cetinje relief higher than EU-DEM
- Positive values (red): Cetinje relief lower than EU-DEM

# Results

- Height difference changes from east to west
  - Cetinje relief in the west lower than EU-DEM, in the east higher
  - Geodetic datum of relief unknown, corresponding heights only calculated in GIS
- Hillshade depiction reveals artifacts from construction method



# Interpretation

- Different purposes – different priorities
- Historical relief
  - Not for cartometric analyses
  - Map details are not accessible, due to the size of the relief
  - Representation of the land – political statement?
  - Military planning – presentation of military planning?

# Conclusion

- Historical relief is an interesting and unique artifact
- Settlements and roads during World War I
- Absolute accuracy of relief is hard to determine
  - Probably was not the goal during construction
- Adequate visualisation of the landscape
- **Outlook**
  - Do relative heights of mountain peaks correspond to the heights in real world?
    - Most likely served as constructon guides

# Thank you for your attention!

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