Exploring the potential of Sentinel-1 InSAR for Pleistocene glacier reconstruction at Rumija, Montenegro

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Exploring the potential of Sentinel-1 InSAR for Pleistocene glacier reconstruction in Montenegro

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Background

Significant variation in the timing and presence of Pleistocene glaciation has emerged with the application of advanced dating techniques, both within and between regions of the Mediterranean (Hughes and Woodward 2016). In order gain a better understanding of the causes, we must look to obtain a more complete record of Mediterranean glaciation. Some areas, such as Rumija in littoral Montenegro, are yet to be explored for evidence of Pleistocene glaciation. Digital Elevation Models (DEMs) offer a method of identifying glacial geomorphology (Smith, Rose and Booth, 2006). But for most areas in the Mediterranean, only a 30m resolution Shuttle Radar Topography Mission (SRTM) DEM is freely available, which is too coarse grained for some landforms.

Initial research has highlighted the potential of Sentinel-1 derived DEMs as an alternative to the SRTM DEM (Nikolakopoulos and Kyriou, 2015).

Study Aims

To generate a DEM using Sentinel-1 interferometry and critically assess this against the SRTM 30m DEM. Use the DEM to carry out geomorphological mapping of Rumija and reconstruct Pleistocene glaciation.

Methodology

Interferometric process
- Identify a suitable interferometric pair
- Interferogram generation
- Goldstein filter and Coherence
- Phase unwrapping
- Polynomial refinement and Reflattening
- Phase to height and Geocoding

Visual comparison
- Preprocessing of topography
- Specific morphological features
- Orientation profile
- Elevation points plotted
- Statistical assessment
- Root mean square error

Land surface products (LSPs) derived
- Shape, hillshade and Curvature
- Contours and Hydrological analysis
- Interpret LSPs knowledge of local geomorphological from studies within region and field visits
- Sentinel 2 and WorldView-3: m agery assistance
- Ascertainment into GIS
- Glacier reconstruction
- Glacier shape from geomorphology
- Area Accumulation
- Rate for ELA using O.5 baseline rate

Results

A DEM was successfully created which captures the large scale hydrological network of the surrounding Albanian Alps (Figure 2). Elevation is overestimated by up to 200m in low elevation ranges, with rough and uneven terrain displayed at a known flat polje floor. This is attributed to low coherence in these areas.

Several types of landforms were identified, including dolines, poljes, landslides and moraines. Though other possible glacial geomorphology has been noted, only one cirque can be confidently identified (Figure 1). The main R2 glacier is reconstructed with an ELA of 1282m and area of 0.147km squared, while the smaller R1 has insufficient evidence for classification (Figure 5). This correlates with the ELA ranges of Marine Isotope Stage 12 glaciers identified at nearby Orjen (Hughes et al., 2010).

Conclusion

There is scope for using Sentinel-1 to create DEMs. However improvements of the DEM quality and accuracy are required.

The Sentinel-1 DEM was suited to geomorphological mapping in the uplands of this region. Evidence of glaciation at Rumija has been established, making it one of the lowest mountains glaciated during the Pleistocene in the Mediterranean.

References


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Figure 1. Map of Rumija cirque and LSPs used for classification. (A) Outline of watershed basin and two moraines ridges mapped. (B) Polishing from 1 degree Azimuth and 45 degree solar elevation. (C) Shape profile curvature. Image derived from ESA Copernicus Sentinel data (2016)

Figure 2. Basic output of InSAR DEM workflow before subsetting. Image derived from ESA Copernicus Sentinel data (2016)

Figure 3. Comparison of elevation profiles across Rumija. Sentinel-1 good representation of topography, while underestimating elevation (Figure 3).

Figure 4. Graph of Sentinel-1 elevation error across Rumija elevation range (based on SRTM values)

Figure 5. Reconstructed glaciers at Rumija cirque. Slope and azimuth sections with arrows indicating direction of flow. (Main) Larger R2 glacier. (Inset) Smaller R1 glacier. Image derived from ESA Copernicus Sentinel data (2016)