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Integration of high-resolution space-borne and terrestrial topographic data sets - Case study Tristan da Cunha

Dietmar Backes and Felix Norman Teferle
University of Luxembourg, FSTC, Luxembourg, Luxembourg (dietmar.backes@uni.lu)

Freely accessible medium resolution digital elevation data from the Shuttle Radar Topography mission (SRTM) and the Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) Global Digital Elevation Map (GDEM) provide an invaluable resource of topographic data to support a multitude of scientific studies and commercial applications. However, it is widely acknowledged that many scientific modelling and monitoring applications would greatly benefit from high quality digital elevation models with better spatial resolution and improved accuracy. Since the acquisition of such resolution data sets can be costly, we investigate the use of low-cost archived very high-resolution (VHR) spaceborne and low altitude drone imagery as alternative sources to create high-resolution topographic data sets.

The volcanic island of Tristan da Cunha is located in the center of the Southern Atlantic Ocean, provided an ideal study object to investigate the integration of VHR satellite as well as drone imagery in order to generate a high-resolution topographic dataset. Its remote location, rough climatic conditions and consistent cloud coverage pose exceptional challenges for terrestrial, aerial as well as spaceborne data acquisition. So far, the island lacks adequate topographic mapping data despite the presence of several geohazards (mudslides, flash flooding and volcanic eruptions) with potentially severe effects on the small island population.

For this case study, the Digital Globe Foundation provided a rich dataset of VHR spaceborne images from Quick Bird, WorldView2 and WorldView 3, which covered the whole island at approx. 0.5 m spatial resolution. Low altitude drone imagery as well as ground truth data, based on GNSS and terrestrial survey, was collected over a limited local area during a research visit. Applying established photogrammetric methodologies and best practice, high resolution DEMs were derived from these data sets. The quality of the direct georeference from both image sources was assessed based on ground control points (GCP) derived from the local Geodetic Control Network (GCN). All datasets where examined in terms of coregistraiton, absolute georeferencing, resolution and overall data quality during a thorough cross-validation. Finally, the wide-area model from spaceborne data and the local model from drone photogrammetry where merged using a controlled georeferenced approach.

The study demonstrates the integration of DEMs derived from spaceborne and low altitude drone images following a practical approach preserving extend by preserving accurate georeferencing, extend and level of detail. Using archived VHR satellite image high-resolution DEMs with 1m ground sample distance (GSD) were created following a conservative photogrammetric workflow. The spaceborne WorldView3 images deployed showed an exceptional accuracy of approx. 0.5 pixel or 25cm whilst the geolocation of the drone imagery showed a shift in height of approx. 200m compared to the geodetic ground control. The final pointclould showed an average sampling distance of 1 m, whist preserving the fine local detail captured by the drone. In this way and by extending the drone coverage to the inhabited areas of the island the derived high-resolution model could be used for geoscientific modelling and monitoring applications.