Validation of DEM data derived from World View 3 stereo imagery for low elevation Majuro Atoll, Marshall Islands

Ross S. Lunetta¹, Donna S. Davis², and Mark H. Stege³

¹U.S. Environmental Protection Agency, National Exposure Research Laboratory, 109 TW Alexander Dr., Research Triangle Park, NC 27711
²The Cisneros Center for New Americans, University of Arkansas, 208 Main, Fayetteville, AR 72701
³Columbia Law School, Sabin Center for Climate Change Law, 435 W 116th Street, New York, NY 10027

ABSTRACT

The availability of surface elevation data for the Marshall Islands has been identified as a “massive” data gap for conducting vulnerability assessments and the subsequent development of climate change adaptation strategies. Specifically, digital elevation model (DEM) data are needed to support modeling efforts to assess vulnerabilities to extreme tide events, storm surge wave events, and unusual swell conditions. The only data currently available for the entire Majuro Atoll are the National Geospatial-Intelligence Agency (NGA) digital terrain elevation data (DTED) which have a 30 m spatial and 5.0 m vertical resolution. Due to the low elevation profile (< 3.0 m), small land mass (< 10 km²), and narrow geographic profile (0.5 km wide) of Majuro Atoll, high spatial (1.0 m) and vertical (< 0.5 m) resolution DEMs are required to support inundation vulnerability modeling efforts. The cost effective application of new higher resolution World View 3 (WV3) stereo satellite imagery with a nominal spatial resolution of 0.31 m will be used to create high resolution elevation data. DEM specification objectives are an absolute vertical 90% linear error (LE90) of approximately 0.35 m. To validate the adherence to required DEM specifications, a statistically robust reference database was needed.

METHODS

An in situ ground survey will be initiated to provide elevation data for use as both ground control points (GCPs) to support photogrammetric model calibration and to provide reference data for subsequent validation of high resolution DEM products. The reference database will consist of surveyed elevation points across Majuro Atoll from the Peace Park located approximately 2.5 km west of Amata Kabua International Airport, extending to the east including the downtown area, and to the north terminating the high tide mark in Rita (Figure 1). To provide a statistically robust reference database, a systematic unaligned design was first developed incorporating a systematic unaligned design to provide relatively equally distributed randomly selected points. Next, random points were generated for each segment including both primary and secondary points. All points were then plotted over the WV2 imagery and assessed for potential collectability. Problematic points (i.e., landing on structures, dense vegetation, etc.) were eliminated and a final Excel database of sampling coordinates (n=120), including both primary (n=60) and secondary (n=60) points, was created to support the field survey data collection effort.

DISCUSSION

For quality assurance (QA) purposes, all randomly generated points were then examined in order to determine potential collectability. The point landed on or near the coastline or on a building, it was deemed uncollectable and was replaced by the next point until two collectable points were identified. Sampling point collectability was first assessed using visual interpretation of high resolution WV2 natural color (Figure 3b) and near infrared (Figure 3c) imagery with the random sampling points displayed. A secondary QA was performed by a resident of the study area, who was able to identify unstable land areas that necessitated additional sampling point replacement.

A total of 44 segments had a primary point eliminated because they were determined to be non-collectable and were replaced by a secondary point. Likewise, 33 segments had both the primary and secondary point eliminated as non-collectable and were replaced by a third or higher point. One segment had 23 random points that were non-collectable with the 24th designated as the primary collection point. The generation of numerous replacement points was a clear reflection of the irregular shape, geology, and urban density of the study area. Accordingly, the systematic unaligned design provided a relatively equally distributed sampling segments for the generation of random sampling points that often required multiple iterations. The reference database was developed to support a statistically robust assessment of the DEM data being developed for Majuro Atoll.