Digital Elevation Model of Tutuila, American Samoa: Procedures, Data Sources, and Analysis

Prepared for the National Tsunami Hazard Mitigation Program (NTHMP) by the NOAA National Geophysical Data Center (NGDC)

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Summary

In July of 2013, NOAA's National Geophysical Data Center (NGDC) developed an integrated bathymetric–topographic digital elevation model (DEM) of Tutuila, American Samoa for the National Tsunami Hazard Mitigation Program (NTHMP). The 1/3 arc-second Tutuila DEM is an update to the previously developed Pago Pago, American Samoa DEM and will be used to support the modeling system to simulate tsunami generation, propagation, and inundation. This DEM covers the area immediately surrounding the island of Tutuila and Aunu'u, American Samoa. The extents of this DEM, procedures, data sources, and analysis are described below. The methodologies used by NGDC in developing DEMs are described in the NOAA Technical Memorandum NESDIS NGDC-36 of Pago Pago, American Samoa (Lim et al., 2010).

DEM Specifications

The Tutuila DEM was built to the specifications listed in Table 1. Figure 1 shows the new 1/3 arc-second DEM boundary in green and the previously developed 3 arc-second American Samoa regional DEM boundary in red.

Table 1. Specifications for the Tutuila, AS DEM.

Grid Area	American Samoa
Coverage Area	170.45° to 170.95° W, 14.40° to 14.18° S
Coordinate System	Geographic decimal degrees
Horizontal Datum	World Geodetic System 1984 (WGS 84)
Vertical Datum	Mean High Water (MHW)
Vertical Units	Meters
Cell Size	1/3 arc-seconds

Grid Format	ASCII raster grid

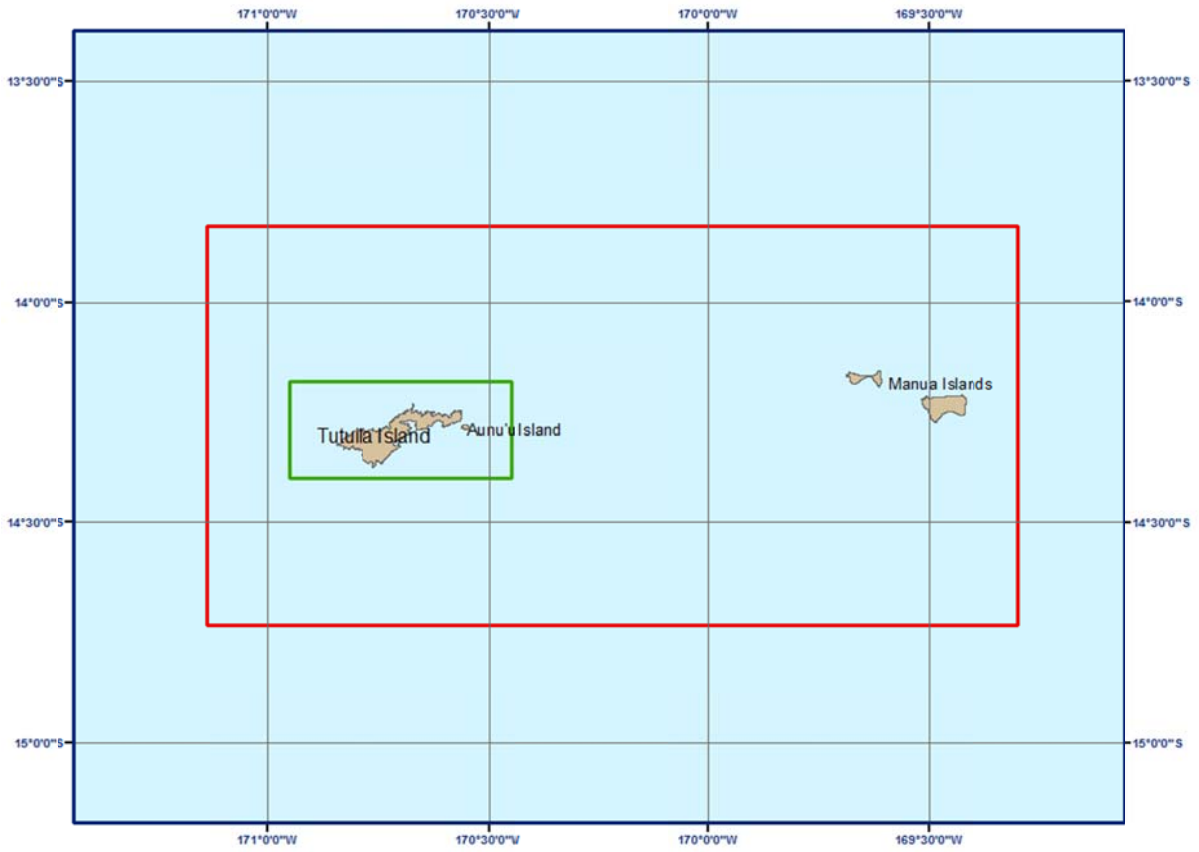

Figure 1. Map image of the DEM boundaries for the new 1/3 arc-second Tutuila, AS DEM in green, and the 3 arc-second American Samoa DEM in red.

Data Sources and Processing

The digital coastline used in the Pago Pago, AS DEM was originally downloaded from NOAA's Coastal Service Center (CSC) and edited based on ESRI World Imagery basemap. It was reused in the Tutuila DEM. Bathymetry data used in the compilation of the Tutuila DEM included shallow-water multibeam data for Fagatele Bay National Marine Sanctuary (FBNMS) archived at Oregon State University, NOAA Electronic Navigational Chart (ENC) soundings, US Naval Oceanographic Office (NAVOCEANO) bathymetric–topographic lidar data filtered to remove topography, and NGDC multibeam survey data (Figure 2, Tables 2-4). ENC sounding data were extracted from NOAA's Office of Coast Survey (OCS) ENC Direct to GIS online extraction service. In deeper water, NGDC downloaded and gridded at 1 arc-second the multibeam swath sonar data from NGDC's multibeam database (Table 4).

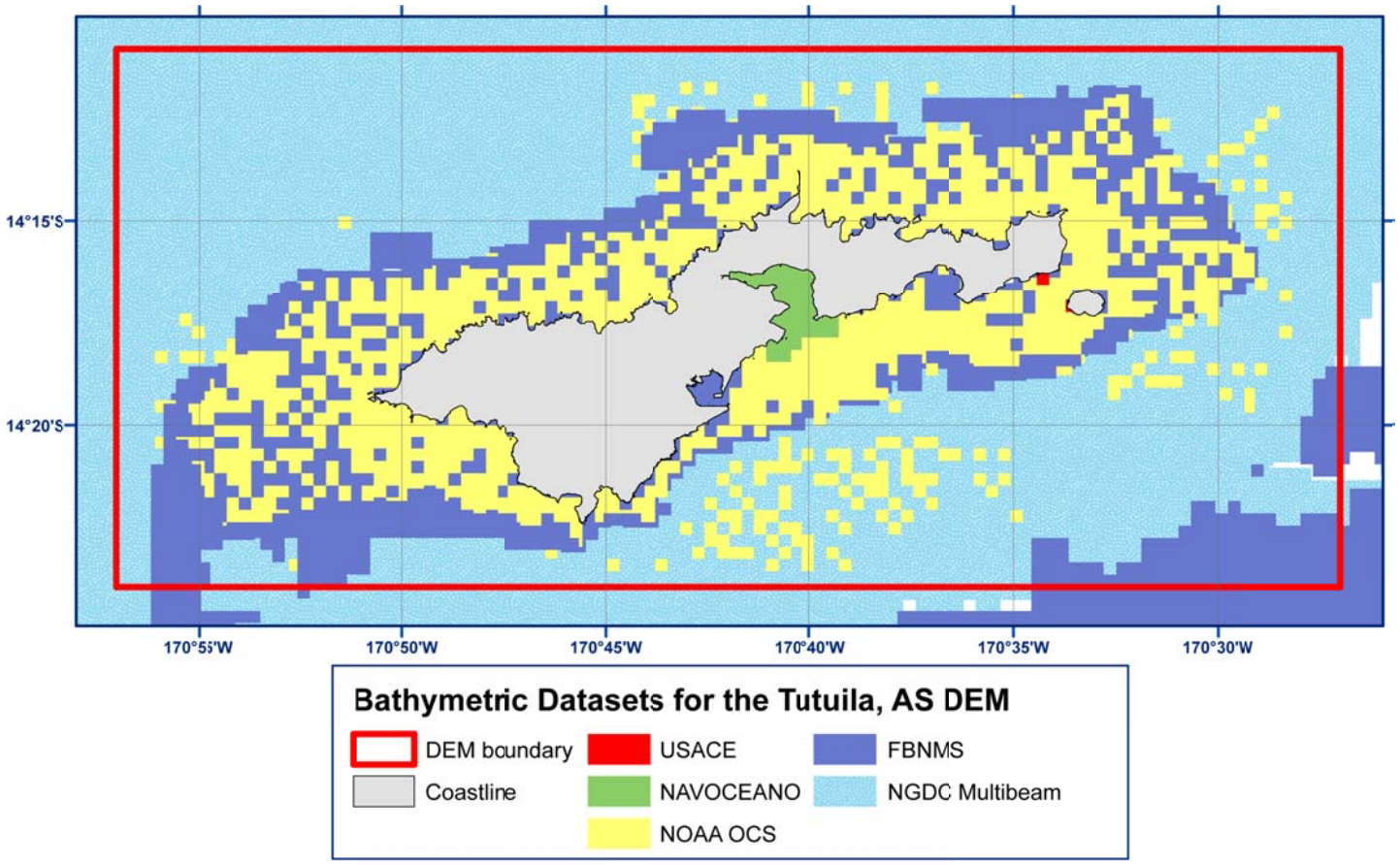

Figure 2. Coverage of the bathymetric data sources used in developing the Tutuila, AS DEM.

Table 2: Bathymetric data sources used in compiling the Tutuila, AS DEM.

Source	*Date*	*Data Type*	*Spatial Resolution*	*Horizontal Datum*	*Vertical Datum*
FBNMS	2001 to 2006	Multibeam swath sonar	Varies from 1 m to 200m gridded data	NAD 27 geographic, WGS 84 UTM 2 South, WGS 84 geographic	MLLW
NOAA OCS	2012	Extracted chart soundings	50 to ~700 meters	WGS 84 geographic	MLLW
NAVOCEANO	2006	Bathymetric-Topographic Lidar	5 meters	WGS 84 geographic	MSL
USACE	2012	Hydrographic sounding data	< 1 meter points spacing and ~ 2 meter line spacing	WGS 84 UTM 2 South (feet)	MLLW
NGDC multibeam	1984 to 2009	Multibeam swath sonar	Gridded to 1 arc-second	NAD 83 geographic	Assumed Mean Sea Level (MSL)

Table 3: FBNMS Shallow-water multibeam used in compiling the Tutuila, AS DEM.

Name	*Date*	*Spatial Resolution*	*Horizontal Datum*	*Vertical Datum*
Eastern Samoa Compilation*	2001 to 2007	200 meters	NAD 27 geographic	MSL
Derived and MB Bathymetry of Tutuila**	2009	5 meters	WGS 84 UTM 2 South	MLLW
Fagaitua Bay	2001	1 meter	WGS 84 geographic	MLLW

*Compilation includes multibeam surveys KOK0510 and KOK0511.

**Includes multibeam surveys from Ahi and Hi'ialakai and IKONOS imagery.

Table 4: NGDC Multibeam swath sonar surveys

Survey ID	*Date*	*Ship*	*Source*
AVON02MV	1999	Melville	University of California, Scripps Institution of Oceanography (UC/SIO)
AVON03MV	1999	Melville	UC/SIO
BMRG08MV	1996	Melville	UC/SIO
BMRG09MV	1996	Melville	UC/SIO
DRFT09RR	2002	Roger Revelle	UC/SIO
DRFT10RR	2002	Roger Revelle	UC/SIO
DRFT11RR	2002	Roger Revelle	UC/SIO
KIWI05RR	1997	Roger Revelle	UC/SIO
KIWI11RR	1998	Roger Revelle	UC/SIO
KM0507	2005	Kilo Moana	Rolling Deck to Repository (R2R) Program
KM0803	2008	Kilo Moana	Rolling Deck to Repository (R2R) Program
MRNT06WT	1984	Thomas Washington	UC/SIO
NBP9806A	1998	Nathaniel B. Palmer	Columbia University, Lamont-Doherty Earth Observatory (CU/LDEO)
PPTU03WT	1985	Thomas Washington	UC/SIO
PPTU04WT	1986	Thomas Washington	UC/SIO
RNDB15WT	1989	Thomas Washington	UC/SIO
RNDB16WT	1989	Thomas Washington	UC/SIO

Bathymetric data were transformed to WGS 84 and MHW as needed and where more recent, higher resolution data existed, older data were edited. Vertical datum transformations were based on the NOAA tide station (#1770000) located in Pago Pago, American Samoa (Table 5).

Table 5: Relationship between MHW and other vertical datums in the Tutuila, AS region.

Vertical Datum	*Difference from MLLW (meters)*
MHHW	0.828
MHW	0.784
MTW	0.401
MSL	0.401
ASVD 2002	0.399
MLW	0.018
MLLW	0.0

The coverage of the updated topographic datasets for the Tutuila, AS DEM are shown in Figure 3 and listed in Table 6. Since the previous Pago Pago DEM was developed, two new lidar datasets have been released. The 2012 CSC lidar and 2011 mobile lidar data were gridded to 1 meter resolution and were the primary topographic data source for the new Tutuila, AS DEM. The USGS NED topographic DEMs were also downloaded and provided full coverage of the American Samoa region although weighted significantly lower than the lidar data in the final gridding process. All topographic data were transformed to MHW vertical datum and WGS 84 before converting to xyz format.

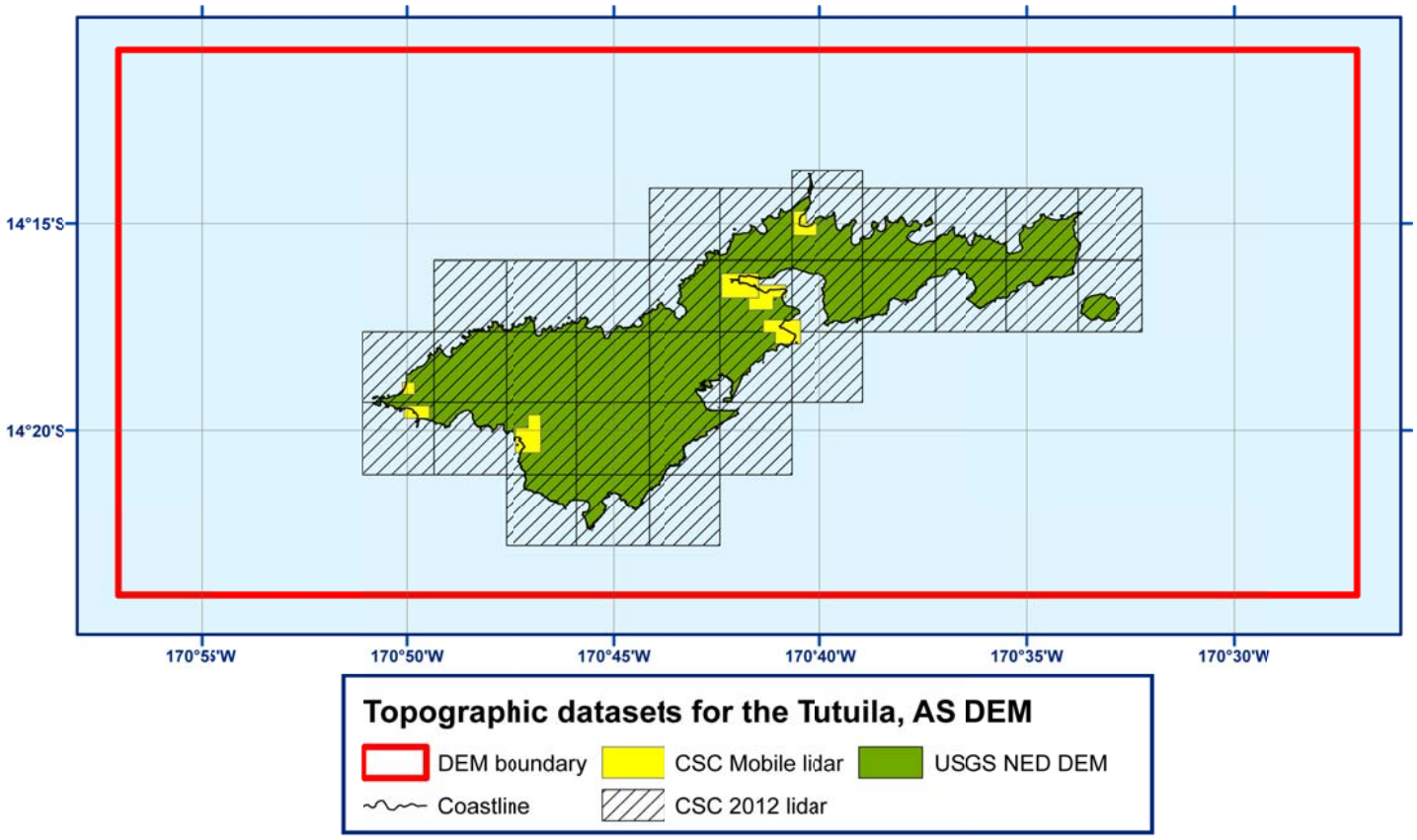

Figure 3. Coverage of the topographic data sources used in developing the Tutuila, AS DEM.

Table 6: Topographic data sources used in compiling the Tutuila, AS DEM.

Source	*Date*	*Data Type*	*Spatial Resolution*	*Horizontal Datum*	*Vertical Datum*
CSC lidar	2012	Gridded topographic lidar	1 meter	NAD 83 UTM 2 South	ASVD02
CSC Mobile lidar	2011	Gridded Mobile topographic lidar	1 meter	NAD 83 UTM 2 South	NAVD 88*
USGS NED	2009	Topographic DEM	1/3 arc second	NAD 83 geographic	Assumed MSL

*NAVD 88 is assumed to be equivalent to ASVD02.

DEM Development

Development of the Tutuila, AS DEM followed procedures documented in NOAA Technical Memorandum NGDC-36 for Pago Pago, American Samoa (Lim et al., 2010). Exceptions being the bathymetric pre-surface was generated at 1/3 arc-second as higher resolution data was available to support the change and gridding weight was modified to Table 7.

Table 7: Data hierarchy used to assign gridding weight in MB-System.

Dataset	*Relative Gridding Weight*
CSC 2012 topographic lidar	1000
USACE	100
CSC 2011 mobile lidar	100
Navy surveys	10
FBNMS	10
Bathymetric pre-surface	10
ENC	1
Coastline	1
USGS NED topographic DEM	.1
NGDC multibeam swath sonar	.1

DEM Analysis

Once the Tutuila, AS DEM was generated, the grid was compared to the NGA monuments. Over 70% of the monuments were with 1 meter of the DEM cell values. This is an improvement over the previous DEM in which less than 25% of the monuments were within 1 meter. The DEM was also compared to nautical chart contours. Inconsistencies were evaluated and resolved based on most reliable data available.

Reference

Lim E., L.A. Taylor, B.W. Eakins, K.S. Carignan, P.R. Grothe, R.J. Caldwell, and D.Z. Friday, 2010. Digital Elevation Models of Pago Pago, American Samoa: Procedures, Data Sources and Analysis, NOAA Technical Memorandum NESDIS NGDC-36, July 2010, 26 pp, ngdc.noaa.gov/mgg/coastal/coastal.html.