Digital Elevation Model of Niue: Procedures, Data Sources, and Analysis

Prepared for the Pacific Marine Environmental Laboratory (PMEL) by the NOAA National Centers for Environmental Information (NCEI)
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Lancaster, M.N.[1], K.S. Carignan[1], B.W. Eakins[1], M. Love[1] and M. Sutherland[1]

[1]Cooperative Institute for Research in Environmental Sciences, University of Colorado at Boulder

Summary

In August of 2016, NOAA's National Centers for Environmental Information (NCEI) developed an integrated bathymetric–topographic digital elevation model (DEM) of the island nation of Niue for the Pacific Marine Environmental Laboratory (PMEL). The DEM will be used to support modeling tsunami generation, propagation, and inundation. The DEM covers Niue Island including the communities of Alofi Township, Makefu Village, Tuapa Village, Namukulu Village, Hikutavake Village, Toi Village, Mutalau Village, Lakepa Village, Liku Village, Hakupu Village, Vaiea Village, Avatele Village and Tamakautoga Village. Extents of this DEM, procedures, data sources, and analysis are described below. The methodologies used by NCEI in developing DEM are described in the NOAA Technical Memorandum-52 for Central California and San Francisco Bay (Carignan et al., 2011).

DEM Specifications

The Niue DEM was built to the specifications listed in Table 1. Figure 1 shows this 3 arc-second Niue integrated topographic–bathymetric DEM boundary in red, the 2009 Pago Pago, American Samoa 3 arc-second MHW DEM in green and the 2013 Tutuila, American Samoa 1/3 arc-second MHW DEM in yellow.

Table 1. Specifications for the Niue DEM.

Cell Size	3 arc-second
Coverage	169.20° to 172.85° W, 17.50° to 20.00° S
Coordinate System	Geographic decimal degrees
Horizontal Datum	World Geodetic System 1984 (WGS 84)
Vertical Datum	Mean Sea Level (MSL)
Vertical Units	Meters
Grid Format	ASCII raster grid

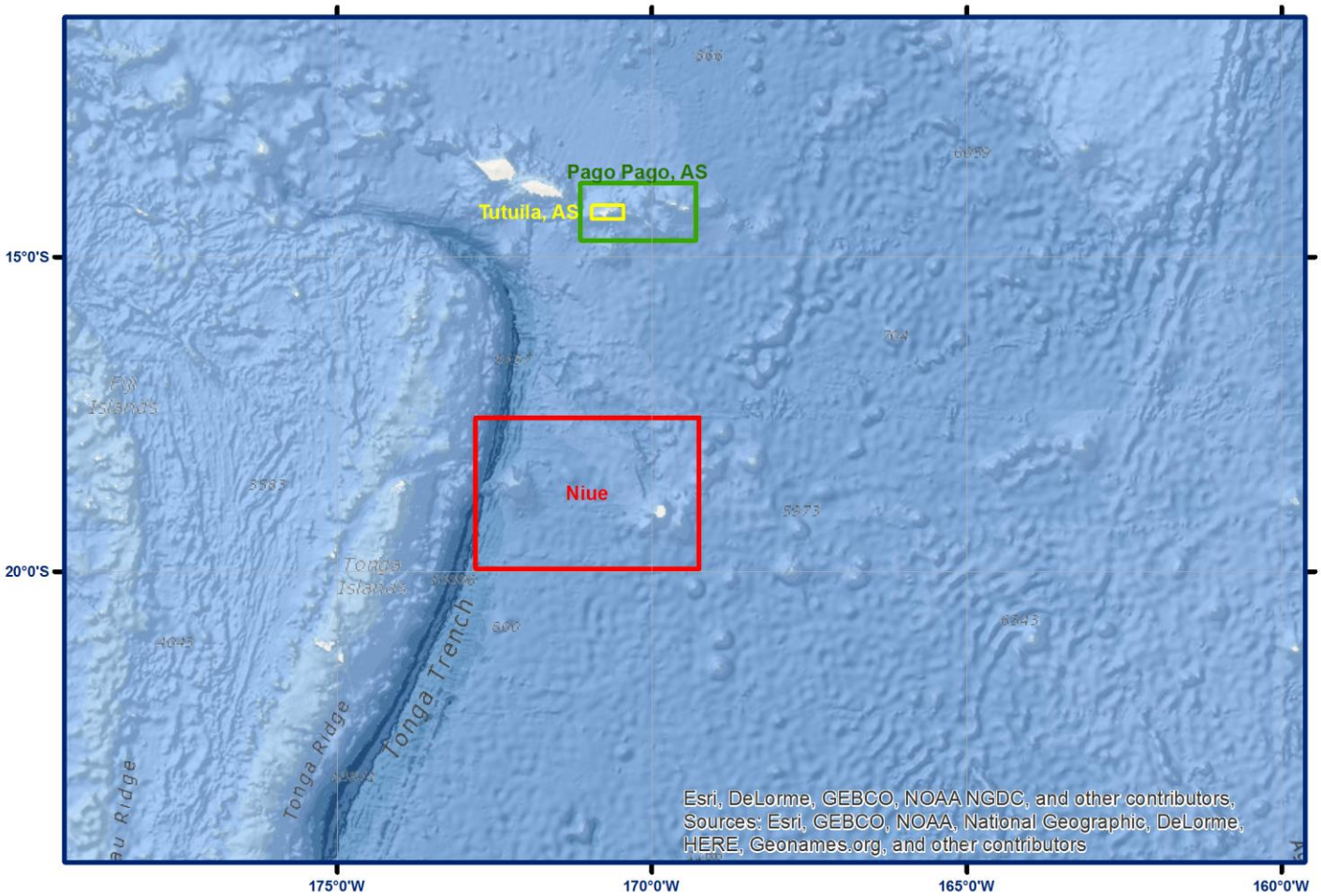

Figure 1. Map image of the boundaries for the 3 arc-second Niue DEM in red and the previously developed DEMs of Pago Pago, AS in green and Tutuila, AS in yellow.

Data Sources and Processing

Digital shoreline data were obtained from the National Geospatial-Intelligence Agency (NGA). Near-shore Alofi harbor and fore-reef slope bathymetric data and bathymetric charts derived from satellite used to digitize near-shore contours were obtained from Pacific Islands Applied Geoscience Commission (SOPAC); Alofi harbor bathymetric data were transformed to latitude-longitude coordinates using MB-System coordinate conversion controls. Remaining bathymetric data were downloaded from NOAA/NCEI and the General Bathymetric Chart of the Oceans (GEBCO). Satellite topographic data were downloaded from the USGS Earth Explorer (http://earthexplorer.usgs.gov/). Figure 2 shows the source and coverage of the datasets used in developing the Niue DEM.

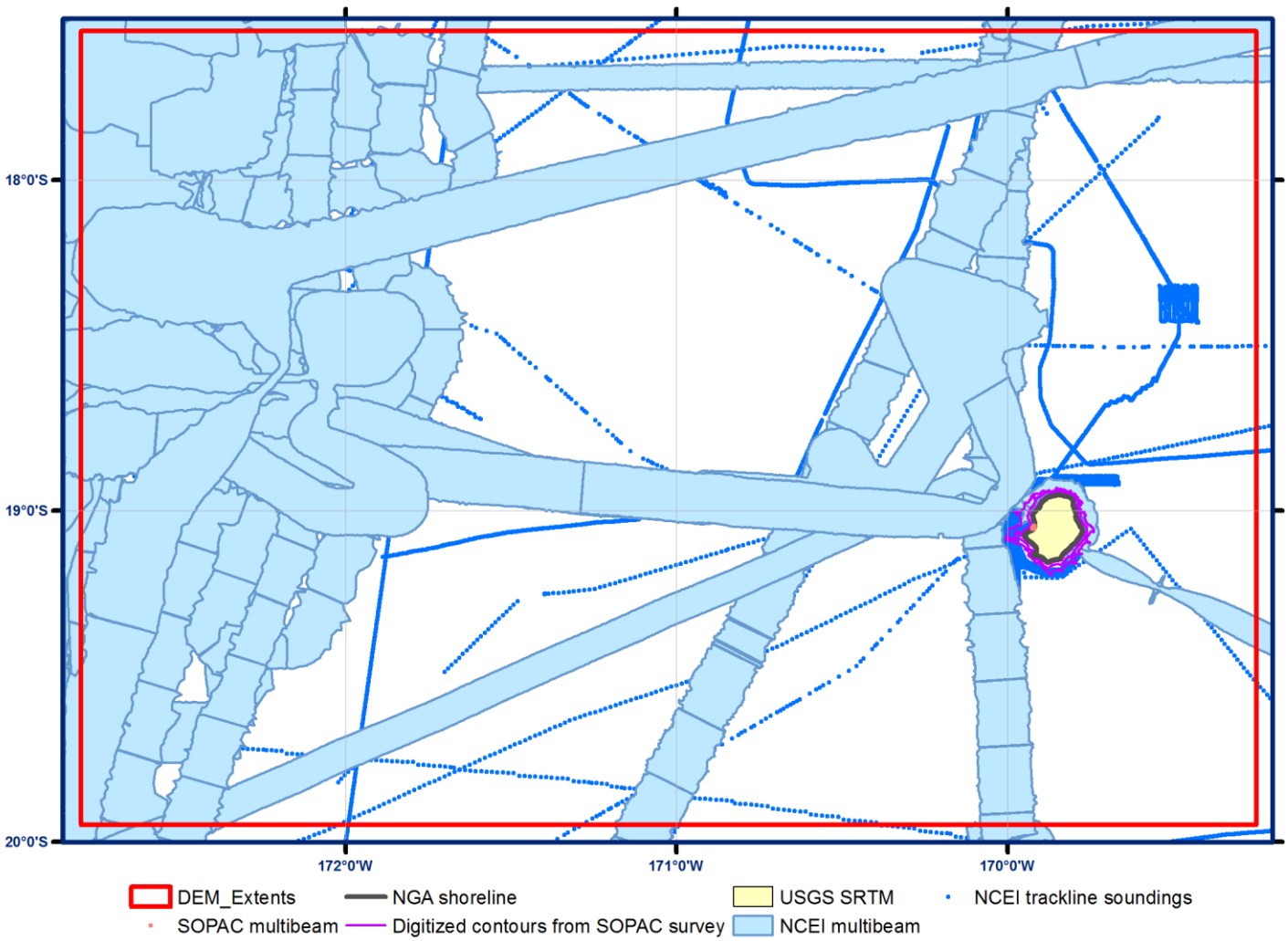

Figure 2. Source and coverage of the datasets used in compiling the Niue DEM.

Table 2 lists the bathymetry data used in the compilation of the Niue DEM including the SOPAC survey (Appendix A), NOAA/NCEI multibeam surveys (Appendix B), and NOAA/NCEI single-beam trackline surveys (Appendix C).

Table 2: Bathymetric data sources used in compiling the Niue DEM.

Source	*Date*	*Data Type*	*Spatial Resolution*	*Horizontal Datum*	*Vertical Datum*
SOPAC	2005	Multibeam bathymetry	1 meter	WGS 84 geographic	Mean Sea Level (MSL)
SOPAC	2005	Digitized contours	1:50000	WGS 84 geographic	Assumed Mean Sea Level (MSL)
GEBCO	2015	Bathymetric DEM	30 arc-second	undefined	Assumed Mean Sea Level (MSL)
NCEI	1962 to 2003	Trackline bathymetry	~ 25 meters to > 100 meters	WGS 84 geographic	Assumed Mean Sea Level (MSL)
NCEI	1984 to 2008	Multibeam bathymetry	10 to 30 meter grid	WGS 84 geographic	Assumed Mean Sea Level (MSL)

Bathymetric data and digitized contour data were converted to xyz format before combining with the shoreline data (Table 3), which was likewise converted to xyz format, to generate a bathymetric pre-surface at 3 arc-seconds. This bathymetric surface grid was converted to xyz format before incorporating in the final DEM.

Table 3: Shoreline data source used in compiling the Niue DEM.

Source	*Date*	*Data Type*	*Spatial Resolution*	*Horizontal Datum*	*Vertical Datum*
NGA	2010	Shoreline shapefile	Decimal degrees to 6 decimals	WGS 84 geographic	High Water Line

The SRTM topographic data (Table 4) were transformed to WGS 84 geographic using GDAL and converted to xyz format. The converted xyz data files were clipped to the shoreline to remove NoData values and returns over water.

Table 4: Topographic data source used in compiling the Niue DEM.

Source	*Date*	*Data Type*	*Spatial Resolution*	*Horizontal Datum*	*Vertical Datum*
USGS	2000	Satellite (SRTM) topography	1 arc-second	WGS 84 geographic	EGM96 (Earth Gravitational Model 1996) ellipsoid

DEM Development

Development of the Niue DEM followed procedures documented in NOAA Technical Memorandum NGDC-52 for Central California and San Francisco Bay (Carignan et al., 2011). Exceptions being the bathymetric pre-surface was generated at 3 arc-seconds. Gridding weight was modified to Table 5.

Table 5: Data hierarchy used to assign gridding weight in MB-System.

Dataset	*Relative Gridding Weight*
Alofi harbor multibeam survey	1000
Bathymetric surface	100
SRTM topographic data	100
GEBCO grid	50

DEM Analysis

The completed Niue DEM were compared to chart contour data and high resolution imagery. Inconsistencies were evaluated and resolved based on most current or reliable data available.

Acknowledgement

Data used in this study were acquired with the assistance of Mr. Robert Smith of Pacific Islands Applied Geoscience Commission.

Reference

Carignan, K.S., L.A. Taylor, B.W. Eakins, R.J. Caldwell, D.Z. Friday, P.R. Grothe, E. Lim (2011). Digital Elevation Models of Central California and San Francisco Bay: Procedures, Data Sources and Analysis. NOAA Technical Memorandum NESDIS NGDC-52, NOAA, pp. 49.

GEBCO_2014 Grid, version 20150318, http://www.gebco.net [accessed July 2016].

Pearce, H. (2007). Inventory of Geospatial Data Available and Options for Tsunami Inundation & Risk Modelling, Niue. Tsunami Hazard & Risk Assessment Project Report 02. Secretariat of the Pacific/Geoscience Australia (SOPAC/GA).

Appendix A: SOPAC Multibeam survey

Survey ID	*Ship*	*Date*	*Institution*	*Original Horizontal Datum*	*Original Vertical Datum*
n/a	RV Summer Spirit	2005	SOPAC/EU	WGS 84 geographic	Mean Sea Level (MSL)

Appendix B: NCEI Multibeam surveys

Survey ID	*Ship*	*Date*	*Institution*	*Original Horizontal Datum*	*Original Vertical Datum*
BMRG08MV	Melville	1996	University of California, Scripps Institution of Oceanography (UC/SIO)	NAD 83 geographic	assumed MSL
BMRG09MV	Melville	1996	University of California, Scripps Institution of Oceanography (UC/SIO)	NAD 83 geographic	assumed MSL
COOK14MV	Melville	2001	University of California, Scripps Institution of Oceanography (UC/SIO)	NAD 83 geographic	assumed MSL
DRFT09RR	Roger Revelle	2002	University of California, Scripps Institution of Oceanography (UC/SIO)	NAD 83 geographic	assumed MSL
EW0003	Maurice Ewing	2000	Marine Geoscience Data System (MGDS)	NAD 83 geographic	assumed MSL
EW9106	Maurice Ewing	1991	Marine Geoscience Data System (MGDS)	NAD 83 geographic	assumed MSL
KIWI05RR	Roger Revelle	1997	University of California, Scripps Institution of Oceanography (UC/SIO)	NAD 83 geographic	assumed MSL
KIWI11RR	Roger Revelle	1998	University of California, Scripps Institution of Oceanography (UC/SIO)	NAD 83 geographic	assumed MSL
KM0413	Kilo Moana	2004	UNOLS R2R	NAD 83 geographic	assumed MSL
KM0703	Kilo Moana	2007	UNOLS R2R	NAD 83 geographic	assumed MSL
KM0803	Kilo Moana	2008	UNOLS R2R	NAD 83 geographic	assumed MSL
MRTN06WT	Thomas Washington	1984	University of California, Scripps Institution of Oceanography (UC/SIO)	NAD 83 geographic	assumed MSL
NBP0304C	Nathaniel B. Palmer	2003	Marine Geoscience Data System (MGDS)	NAD 83 geographic	assumed MSL
WEST05MV	Melville	1994	University of California, Scripps Institution of Oceanography (UC/SIO)	NAD 83 geographic	assumed MSL
WEST06MV	Melville	1994	University of California, Scripps Institution of Oceanography (UC/SIO)	NAD 83 geographic	assumed MSL
WEST12MV	Melville	1995	University of California, Scripps Institution of Oceanography (UC/SIO)	NAD 83 geographic	assumed MSL

Appendix C: NCEI Trackline surveys

Survey ID	*Ship*	*Date*	*Institution*	*Original Horizontal Datum*	*Original Vertical Datum*
19920013	Britannia	1988	UK Hydrographic Office	NAD 83 geographic	assumed MSL
71042603	Kana Keoki	1971	Hawaii, U of	NAD 83 geographic	assumed MSL
72110802	Kana Keoki	1972	Hawaii, U of	NAD 83 geographic	assumed MSL
87001211	Jean Charcot	1987	France IFREMER	NAD 83 geographic	assumed MSL
BMRG08MV	Melville	1996	University of California, Scripps Institution of Oceanography (UC/SIO)	NAD 83 geographic	assumed MSL
BMRG09MV	Melville	1996	University of California, Scripps Institution of Oceanography (UC/SIO)	NAD 83 geographic	assumed MSL
COOK14MV	Melville	2001	University of California, Scripps Institution of Oceanography (UC/SIO)	NAD 83 geographic	assumed MSL
DRFT09RR	Melville	2002	University of California, Scripps Institution of Oceanography (UC/SIO)	NAD 83 geographic	assumed MSL
ELT31	Eltanin	1967	University of California, Scripps Institution of Oceanography (UC/SIO)	NAD 83 geographic	assumed MSL
EVA700	Coriolis	1978	France ORSTOM	NAD 83 geographic	assumed MSL
EW9106	Maurice Ewing	1991	Lamont-Doherty Earth Obs	NAD 83 geographic	assumed MSL
GECS-FMV	Melville	1974	University of California, Scripps Institution of Oceanography (UC/SIO)	NAD 83 geographic	assumed MSL
KH6804-B	Hakuho Maru	1991	Lamont-Doherty Earth Obs	NAD 83 geographic	assumed MSL
KIWI05RR	Roger Revelle	1997	University of California, Scripps Institution of Oceanography (UC/SIO)	NAD 83 geographic	assumed MSL
KIWI11RR	Roger Revelle	1998	University of California, Scripps Institution of Oceanography (UC/SIO)	NAD 83 geographic	assumed MSL
MRTN06WT	Thomas Washington	1984	University of California, Scripps Institution of Oceanography (UC/SIO)	NAD 83 geographic	assumed MSL
MW9003	Moana Wave	1990	Hawaii, U of	NAD 83 geographic	assumed MSL
NATSUS84	Natsushima	1984	University of California, Scripps Institution of Oceanography (UC/SIO)	NAD 83 geographic	assumed MSL

Survey ID	*Ship*	*Date*	*Institution*	*Original Horizontal Datum*	*Original Vertical Datum*
NBP0304B	Nathaniel B. Palmer	2003	Lamont-Doherty Earth Obs	NAD 83 geographic	assumed MSL
NBP98-6A	Nathaniel B. Palmer	1998	Lamont-Doherty Earth Obs	NAD 83 geographic	assumed MSL
NOVA07AR	Argo	1967	University of California, Scripps Institution of Oceanography (UC/SIO)	NAD 83 geographic	assumed MSL
NOVA08AR	Argo	1967	University of California, Scripps Institution of Oceanography (UC/SIO)	NAD 83 geographic	assumed MSL
ODP135JR	JOIDES Resolution	1990	ODP/Texas A and M	NAD 83 geographic	assumed MSL
RC1713	Robert D. Conrad	1974	Lamont-Doherty Earth Obs	NAD 83 geographic	assumed MSL
SOPAC94	Monowai	1994	New Zealand Navy	NAD 83 geographic	assumed MSL
V1813	Vema	1962	University of California, Scripps Institution of Oceanography (UC/SIO)	NAD 83 geographic	assumed MSL
WEST05MV	Melville	1994	University of California, Scripps Institution of Oceanography (UC/SIO)	NAD 83 geographic	assumed MSL
WEST06MV	Melville	1994	University of California, Scripps Institution of Oceanography (UC/SIO)	NAD 83 geographic	assumed MSL
WEST12MV	Melville	1995	University of California, Scripps Institution of Oceanography (UC/SIO)	NAD 83 geographic	assumed MSL