Digital Elevation Model of Easter Island, Chile: Procedures, Data Sources, and Analysis

Prepared for NOAA's Pacific Marine Environmental Laboratory and the National Weather Service by the NOAA's National Centers for Environmental Information (NCEI)
January 6, 2017
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Summary

In January of 2017, NOAA's National Centers for Environmental Information (NCEI) developed an integrated bathymetric–topographic digital elevation model (DEM) of Easter Island for NOAA's National Weather Service (NWS) and Pacific Marine Environmental Laboratory (PMEL). The DEM will be used to support modeling tsunami generation, propagation, and inundation. The 3 arc-second DEM of Easter Island (Isla de Pascua or Rapa Nui) covers approximately 110,000 sq. km of the island and surrounding Southeast Pacific ocean. Geographic 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 Easter Island DEM were built to the specifications listed in Table 1. Figure 1 shows the 3 arc-second Easter Island integrated topographic–bathymetric DEM boundary in green.

Table 1. Specifications for the Easter Island, Chile DEM.

Cell Size	3 arc-second
Coverage	107.5° to 111.2° W, 25.8°S to 28.5° S
Coordinate System	Geographic decimal degrees
Horizontal Datum	World Geodetic System 1984 (WGS 84)
Vertical Datum	Mean Sea Level
Vertical Units	Meters
Grid Format	ASCII raster grid

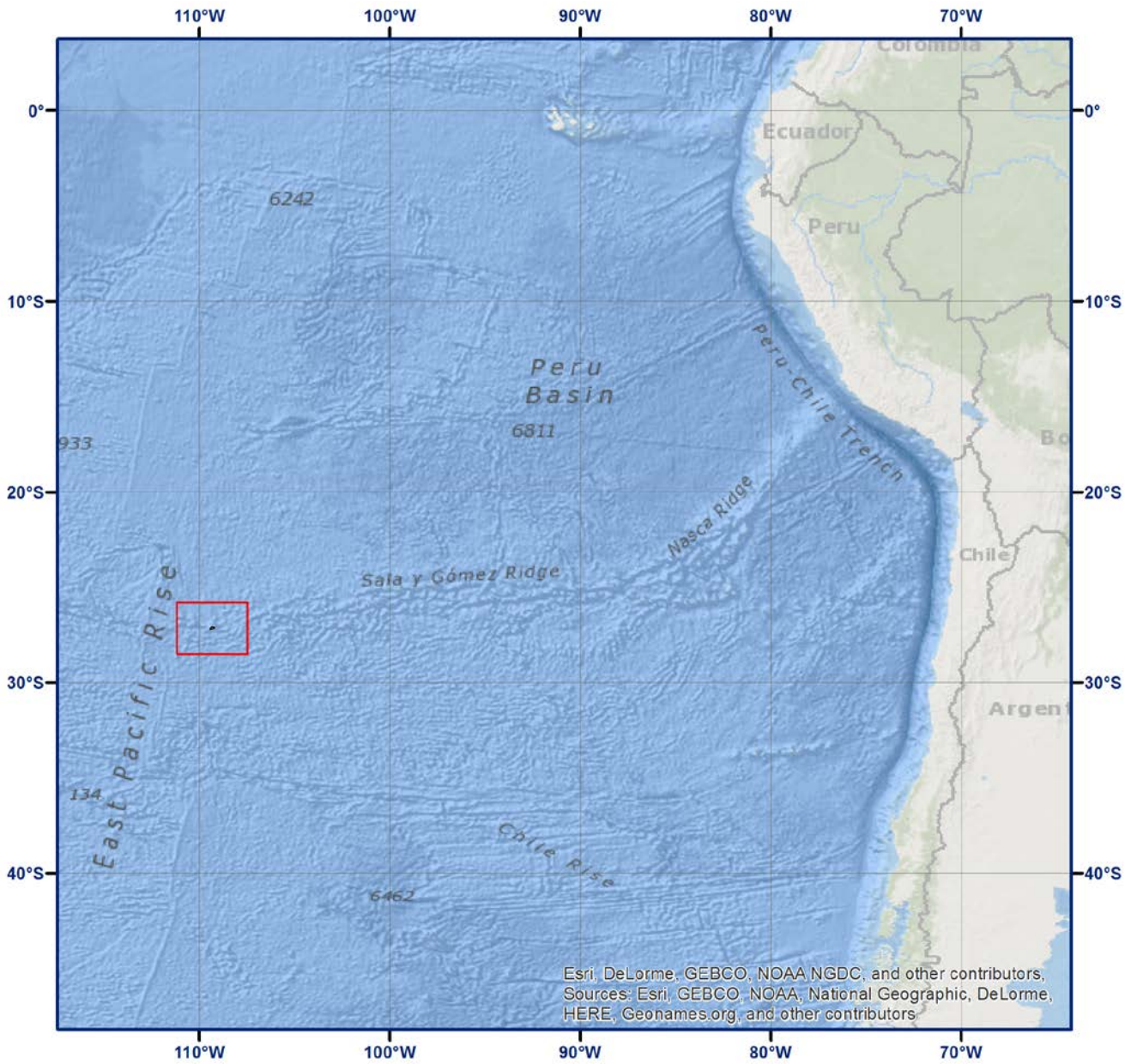

Figure 1. Map image of the boundaries for the 3 arc-second Easter Island DEM in green.

Data Sources and Processing

A coastline shapefile was digitized using ESRI World Imagery basemap layer and the Ministry of Agriculture, Chile web map services (http://ide.minagri.gob.cl/geoweb). The shapefile was converted to xyz points with elevation set at zero and used as source dataset and converted to a raster mask for generating the bathymetric surface. Bathymetric data were downloaded from a number of online sources including: General Bathymetric Chart of the Oceans (GEBCO), SeaDataNet, and NCEI. The SRTM topographic DEM was downloaded from USGS Earth Explorer (https://earthexplorer.usgs.gov). Figure 2 shows the source and coverage of the datasets used in developing the Easter Island DEM.

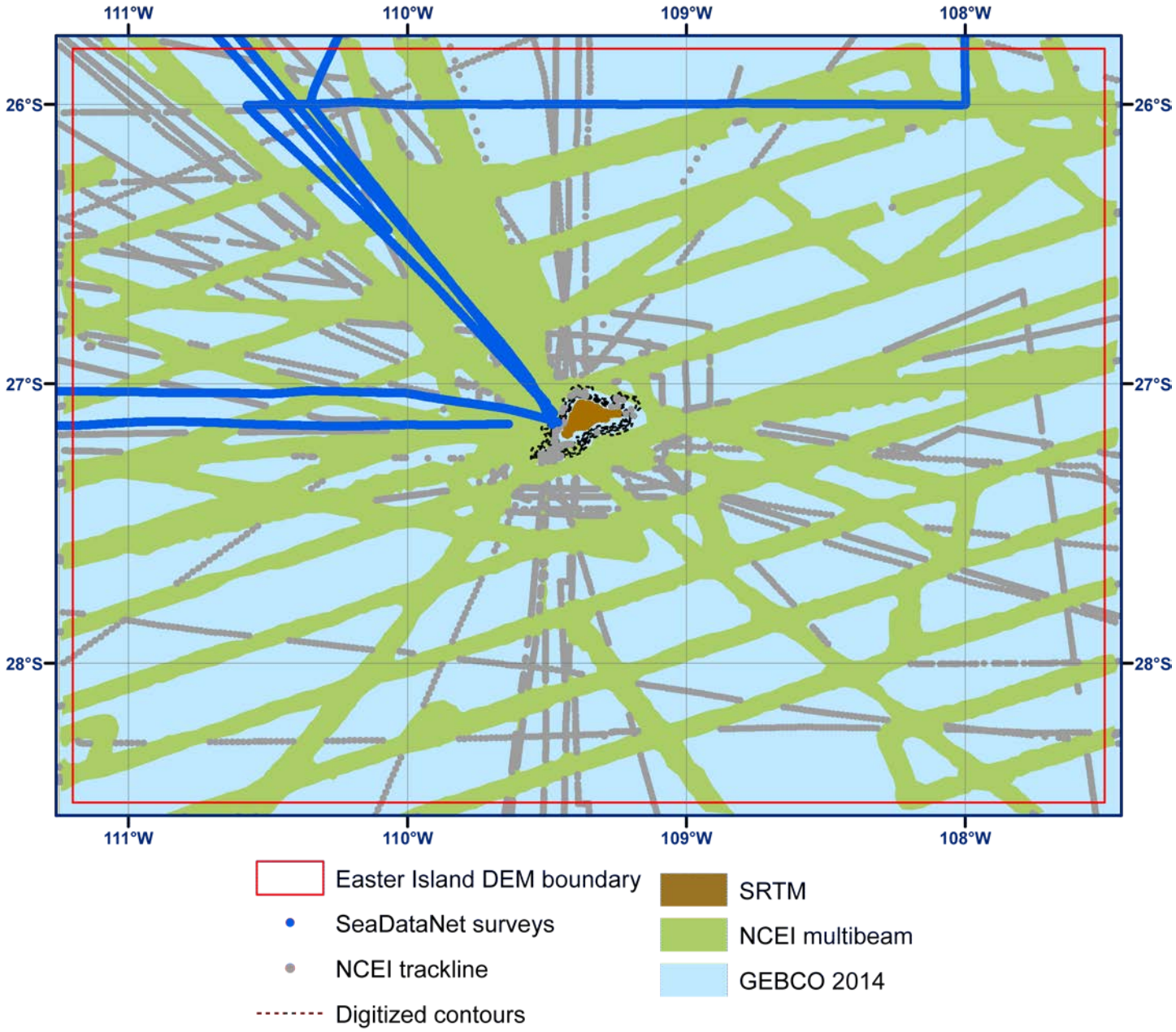

Figure 2. Source and coverage of the datasets used in compiling the Easter Island DEM.

Table 2 lists the bathymetry data used in the compilation of the Easter Island DEM including NCEI multibeam and trackline surveys (Appendix A and B), SeaDataNet bathymetric surveys (Appendix C), and the GEBCO 2014 gridded bathymetry dataset.

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

Source	*Date*	*Data Type*	*Spatial Resolution*	*Horizontal Datum*	*Vertical Datum*
SeaDataNet	1980 to 1987	Single beam bathymetry	200 to 400 meter point spacing	WGS 72 geographic	undefined
NCEI	1957 to 2001	Single-beam Trackline Bathymetry	~ 100 meters to > than 300 meters	NAD 83 geographic	Assumed MSL
NCEI	1983 to 2010	Multibeam bathymetry	90 meter grid	NAD 83 geographic	Assumed MSL
GEBCO	2014	Bathymetric DEM	30 arc-second	undefined	Assumed MSL

Bathymetric data were transformed to WGS 84 geographic using GDAL as needed and where recent, higher resolution data exists, older data were superseded. A bathymetric contour map (Vezzoli, L. et al., 2009) was georeferenced and contours were digitized. After editing to better match the multibeam data, the contours were converted to points and used as an additional data set to improve the transition between deeper water bathymetry and topographic data. Use of measured near-shore hydrographic data would improve the accuracy of the DEM in this region. These bathymetric data were converted to xyz format before combining with the coastline data to generate a bathymetric pre-surface at 3 arc-seconds. This bathymetric surface grid was further processed by running ArcGIS focal statistics tool on the resulting gridded data. This smoothed surface was used as a single data source and reused along with only the higher resolution bathymetry data to create the 3 arc-second pre-surface used in the final gridding process.

The SRTM topographic DEM was converted to xyz format. SRTM data were also filtered to remove elevation values exceeding the known topographic limits for each island and clipped to the coastline to remove values over water.

Table 3: Topographic data source used in compiling the Easter Island DEM.

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

DEM Development

Development of the Easter Island 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-second. Gridding weight was modified to Table 4.

Table 4: Data hierarchy used to assign gridding weight in MB-System for 3 arc-second DEM.

Dataset	*Relative Gridding Weight*
SRTM 1 sec. DEM	100
Bathymetric surface	10
NCEI multibeam surveys	10
Coastline	1
NCEI trackline surveys	.1
SeaDataNet surveys	.1

DEM Analysis

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

Acknowledgement

Data were provided through SeaDataNet Pan-European infrastructure for ocean and marine data management (http://www.seadatanet.org).

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.

ESRI World Imagery. Source: ESRI, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS USER Community.

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

Vezzoli, L. et al. (2009) Easter Island, SE Pacific: An end-member type of hotspot volcanism. Figure 2. Geological Society of America Bulletin 121(5-6):869, http://dx.doi.org/10.1130/B26470.1.

Appendix A: NCEI Multibeam surveys

Survey ID	*Date*	*Ship*	*Institution*	*Original Horizontal Datum*	*Original Vertical Datum*
AT03L27	1998	Atlantis	Woods Hole Oceanographic Institution (WHOI)	NAD 83 geographic	Assumed MSL
AT03L28	1998	Atlantis	WHOI	NAD 83 geographic	Assumed MSL
EW9106	1991	Maurice Ewing	Marine Geoscience Data System (MGDS)	NAD 83 geographic	Assumed MSL
COOK17MV	2001	Melville	University of California, Scripps Institution of Oceanography (UC/SIO)	NAD 83 geographic	Assumed MSL
GLOR02MV	1992	Melville	UC/SIO	NAD 83 geographic	Assumed MSL
GLOR03MV	1992	Melville	UC/SIO	NAD 83 geographic	Assumed MSL
GLOR05MV	1993	Melville	UC/SIO	NAD 83 geographic	Assumed MSL
GLOR06MV	1993	Melville	UC/SIO	NAD 83 geographic	Assumed MSL
GLOR07MV	1993	Melville	UC/SIO	NAD 83 geographic	Assumed MSL
GLOR08MV	1993	Melville	UC/SIO	NAD 83 geographic	Assumed MSL
PANR05MV	1998	Melville	UC/SIO	NAD 83 geographic	Assumed MSL
DRFT06RR	2001	Roger Revelle	University of South Florida (USF)	NAD 83 geographic	Assumed MSL
PASC02WT	1983	Thomas Washington	UC/SIO	NAD 83 geographic	Assumed MSL
PASC03WT	1983	Thomas Washington	UC/SIO	NAD 83 geographic	Assumed MSL
PASC04WT	1983	Thomas Washington	UC/SIO	NAD 83 geographic	Assumed MSL
RAPA02WT	1990	Thomas Washington	UC/SIO	NAD 83 geographic	Assumed MSL
MV1015	2010	Melville	UNOLS R2R	NAD 83 geographic	Assumed MSL
PANR04MV	1998	Melville	UC/SIO	NAD 83 geographic	Assumed MSL
MV1016	2010	Melville	UNOLS R2R	NAD 83 geographic	Assumed MSL
RAPA03WT	1991	Thomas Washington	UC/SIO	NAD 83 geographic	Assumed MSL
DRFT07RR	2001	Roger Revelle	UC/SIO	NAD 83 geographic	Assumed MSL
RAPA04WT	1991	Thomas Washington	UC/SIO	NAD 83 geographic	Assumed MSL

Appendix B: NCEI Trackline surveys

Survey ID	*Date*	*Vessel*	*Institution*
72110806	1973	Kana Keoki	University of Hawaii
72110807	1973	Kana Keoki	University of Hawaii
73002311	1973	Noroit	France CNEXO
74010903	1974	Kana Keoki	University of Hawaii
74010904	1974	Kana Keoki	University of Hawaii
80001711	1980	Jean Charcot	France CNEXO
87000111	1987	Jean Charcot	France IFREMER
87000211	1987	Jean Charcot	France IFREMER
87000311	1987	Jean Charcot	France IFREMER
ARES1AWT	1970	Thomas Washington	University of California, Scripps Institution of Oceanography (UC/SIO)
ARES1BWT	1970	Thomas Washington	UC/SIO
AT03L27	1998	Atlantis	Woods Hole Oceanographic Institution (WHOI)
AT03L28	1998	Atlantis	WHOI
CARR01BD	1964	Spencer F. Baird	UC/SIO
CATO04MV	1972	Melville	UC/SIO
CD3588	1988	Charles Darwin	UK Institute of Oceanographic Sciences
DNWB-DBD	1958	Spencer F. Baird	UC/SIO
DNWH-DHO	1958	Horizon	UC/SIO
DRFT06RR	2001	Roger Revelle	UC/SIO
DRFT07RR	2001	Roger Revelle	UC/SIO
ELT29	1967	Eltanin	Lamont-Doherty Earth Observatory (LDEO)
EW9106	1991	Maurice Ewing	LDEO
GLOR02MV	1992	Melville	UC/SIO
GLOR03MV	1992	Melville	UC/SIO
GLOR05MV	1993	Melville	UC/SIO
GLOR06MV	1993	Melville	UC/SIO
GLOR07MV	1993	Melville	UC/SIO
GLOR08MV	1993	Melville	UC/SIO
HELI02MV	1987	Melville	UC/SIO
HELI03MV	1987	Melville	UC/SIO
MW8711	1987	Moana Wave	University of Hawaii
MW8712	1987	Moana Wave	University of Hawaii
OB3C	1957	Ob	Russia Vernadsky Institute of Geochemistry
PANR04MV	1998	Melville	UC/SIO
PANR05MV	1998	Melville	UC/SIO
PASC02WT	1983	Thomas Washington	UC/SIO
PASC03WT	1983	Thomas Washington	UC/SIO
PASC04WT	1983	Thomas Washington	UC/SIO
PIQR05WT	1969	Thomas Washington	UC/SIO
POL7008	1970	Oceanographer	NOAA POL
POL7101	1971	Surveyor	NOAA POL
POL7303	1973	Oceanographer	NOAA POL
PROT01MV	1983	Melville	UC/SIO
PROT02MV	1983	Melville	UC/SIO
RAPA02WT	1990	Thomas Washington	UC/SIO
RAPA03WT	1991	Thomas Washington	UC/SIO

Survey ID	*Date*	*Vessel*	*Institution*
RC1502	1971	Robert D. Conrad	LDEO
RC1714	1974	Robert D. Conrad	LDEO
RP-1-70	1970	Oceanographer	NOAA

Appendix C: SeaDataNet surveys

Survey ID	*Date*	*Ship*	*Institution*	*Original Horizontal Datum*	*Original Vertical Datum*
SEARISE II	1980	Atalante	IFREMER / IDM / SISMER - Scientific Information Systems for the SEA (486);UNIVERSITE DE BRETAGNE OCCIDENTALE (UBO) /UMR 6538 DU CNRS DOMAINES OCEANIQUES" (1079)"	WGS 72 geographic	Assumed MSL
MANRAP	1987	Atalante	IFREMER / IDM / SISMER - Scientific Information Systems for the SEA (486);UNIVERSITE DE BRETAGNE OCCIDENTALE (UBO) /UMR 6538 DU CNRS DOMAINES OCEANIQUES" (1079)"	WGS 72 geographic	Assumed MSL
RAPANUI 1	1987	Atalante	IFREMER / IDM / SISMER - Scientific Information Systems for the SEA (486);UNIVERSITE DE BRETAGNE OCCIDENTALE (UBO) /UMR 6538 DU CNRS DOMAINES OCEANIQUES" (1079)"	WGS 72 geographic	Assumed MSL
RAPANUI 2	1987	Atalante	IFREMER / IDM / SISMER - Scientific Information Systems for the SEA (486);UNIVERSITE DE BRETAGNE OCCIDENTALE (UBO) /UMR 6538 DU CNRS DOMAINES OCEANIQUES" (1079)"	WGS 72 geographic	Assumed MSL