

Digital Elevation Model of Kodiak, Alaska: Procedures, Data Sources, and Analysis

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Summary

In November of 2013, NOAA's National Geophysical Data Center (NGDC) developed an integrated bathymetric-topographic digital elevation model (DEM) of Kodiak, Alaska for NOAA's West Coast and Alaska Tsunami Warning Center (WC/ATWC) and Pacific Marine Environmental Laboratory (PMEL). The 1/3 arc-second DEM will be used to support modeling tsunami generation, propagation, and inundation. The DEM covers the northeastern corner of Kodiak Island immediately surrounding the communities of Kodiak and Ouzinkie and includes Chiniak Bay and portions of Marmot Bay and Kizhuyak Bay. 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-4 of Dutch Harbor (Taylor et al., 2008).

DEM Specifications

The Kodiak DEM was built to the specifications listed in Table 1. Figure 1 shows the previously developed 1, 3, and 8 arc-second Kodiak DEM boundaries in green and this higher resolution 1/3 arc-second Kodiak DEM boundary in red.

Table 1. Specifications for the 1/3 arc-second Kodiak, Alaska DEM.

Grid Area	Kodiak, Alaska
Coverage Area	152.00° to 152.80° W, 57.58° to 58.00° N
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

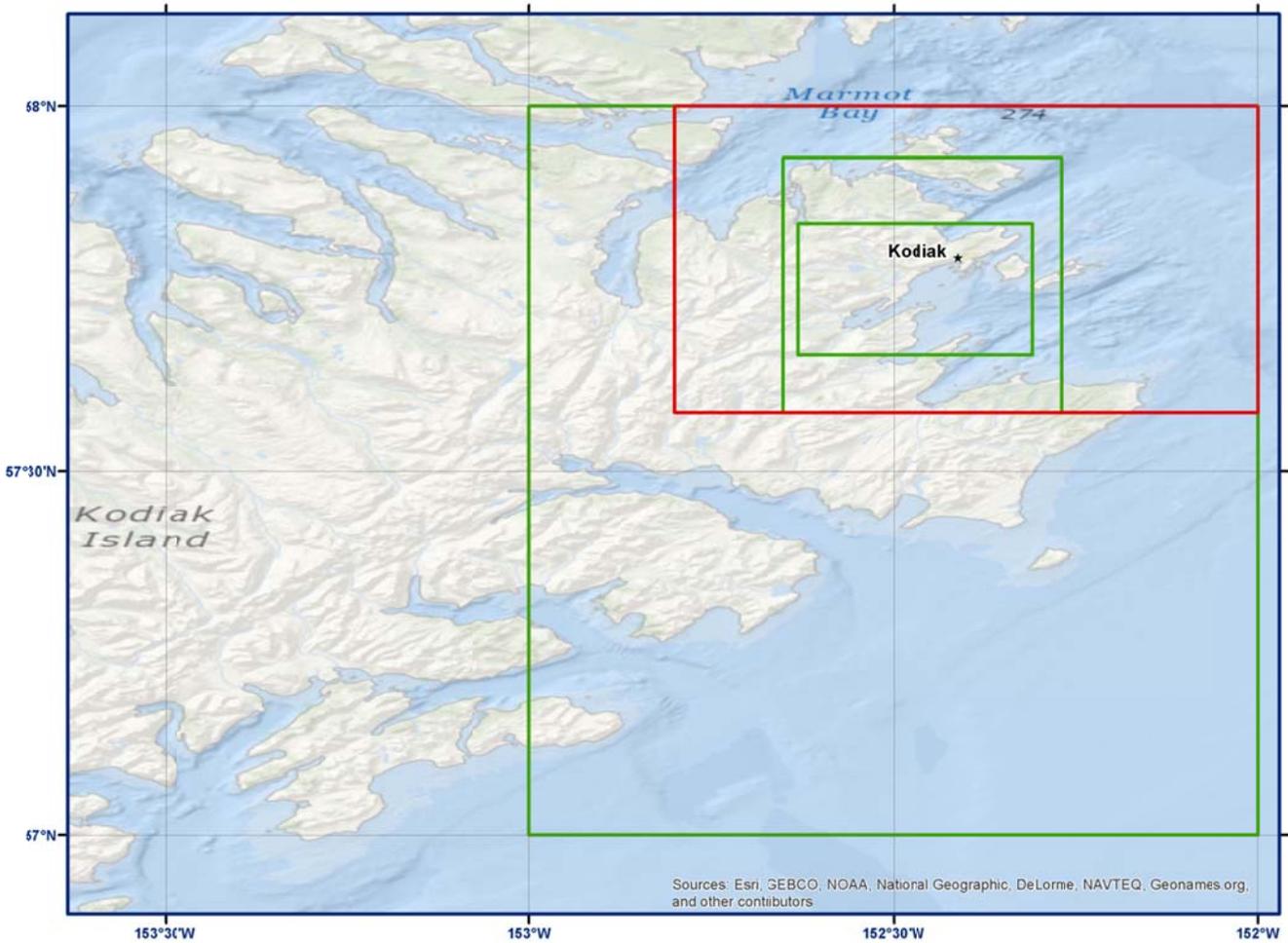


Figure 1. Map image of the boundaries for the 1, 3, and 8 arc-second Kodiak DEMs, in green and the 1/3 arc-second Kodiak DEM in red.

Data Sources and Processing

Digital coastlines were extracted from NOAA’s Office of Coast Survey (OCS) ENC Direct to GIS online extraction service (http://nauticalcharts.noaa.gov/csdl/ctp/encdirect_new.htm). The coastlines were merged and edited to match recent Alaska Mapped high resolution imagery (<http://www.alaskamapped.org/>), ESRI’s World Imagery map service (<http://www.arcgis.com/features/maps/imagery.html>), and topographic data.

Bathymetry data used in the compilation of the Kodiak DEM included NOS hydrographic surveys, NOAA Electronic Navigational Chart (ENC) soundings, USACE harbor surveys, and NGDC multibeam survey data (Table 2). ENC sounding data were extracted from NOAA’s Office of Coast Survey (OCS) ENC Direct to GIS online extraction service (http://nauticalcharts.noaa.gov/csdl/ctp/encdirect_new.htm). The USACE Alaska District provided NGDC with hydrographic condition survey for St. Herman Harbor and St. Paul Harbor. NOS hydrographic survey data were downloaded from NGDC (Table 3). Multibeam surveys were downloaded from

NGDC as 10 meter gridded point data (Table 4). This multibeam data was edited in *QT Modeler* removing overlapping data and eliminating errors in data collection. The data was merged into one file and re-gridded using *Fledermaus* to generate a 1 second smoothed surface retaining gaps in data coverage. The resulting grid was converted to xyz format before combining with other bathymetric data to generate a bathymetric pre-surface.

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

Source	Date	Data Type	Spatial Resolution	Horizontal Datum	Vertical Datum
NOAA NOS	1907 to 2012	Hydrographic survey soundings	1 meter to several kilometers	Unknown, Early Alaska Datums, NAD 1927, NAD 83 geographic, or NAD 83 UTM Zone 5	Mean Lower Low Water (MLLW)
NOAA OCS	1981 to 2012	Extracted chart soundings	20 meters to hundreds of meters	WGS 84 geographic	MLLW
USACE	2009	Hydrographic condition survey	1 meter to 10 meters	NAD 83 AK (CORS96) State Plane Zone 5 (feet)	MLLW
NGDC multibeam	2002 to 2011	Multibeam swath sonar	Gridded to 1/3 arc-second	NAD 83 geographic	Assumed Mean Sea Level (MSL)

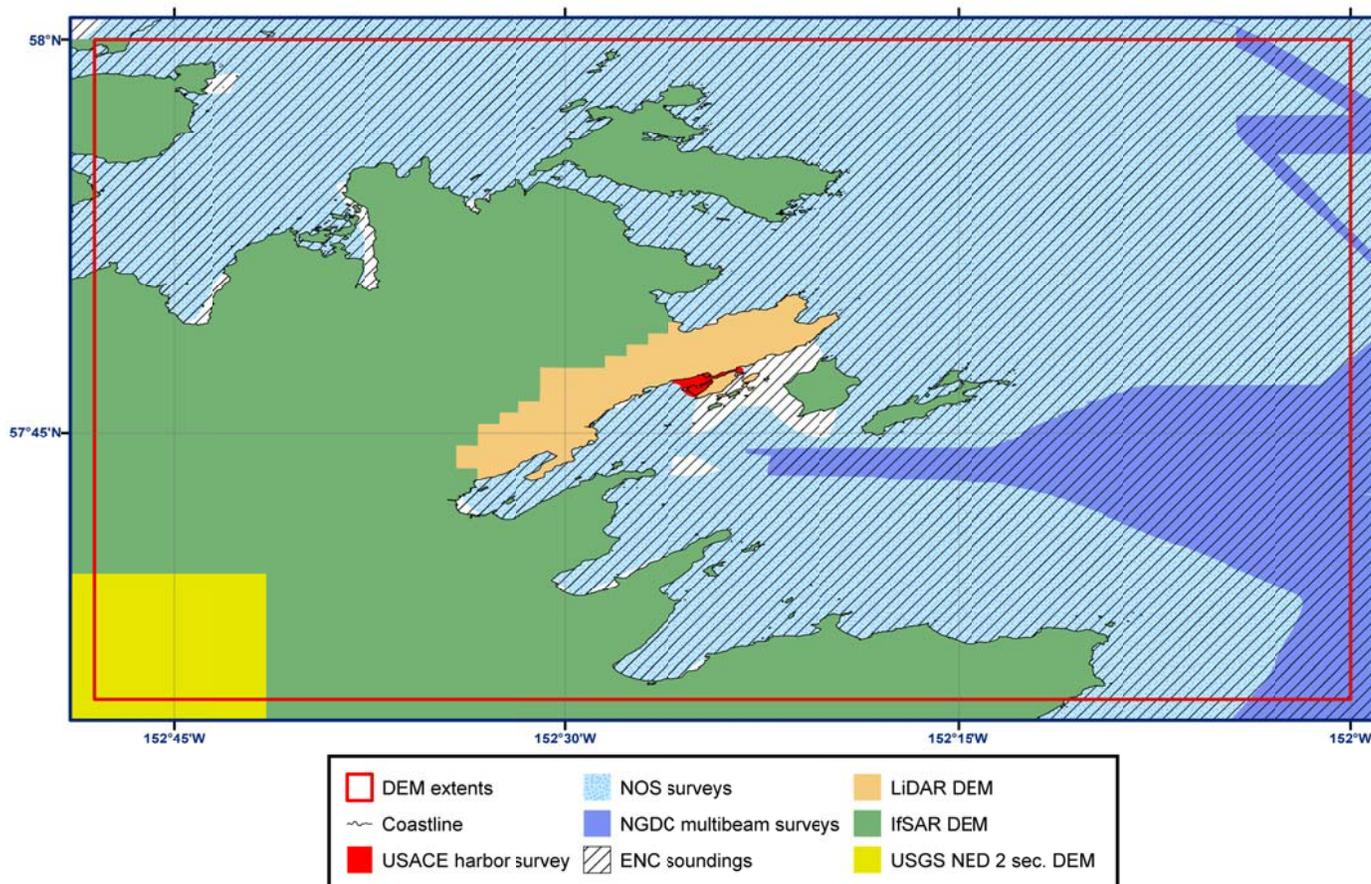


Figure 2. Source and coverage of the datasets used in compiling the Kodiak DEM.

Table 3: NOS hydrographic surveys

<i>Survey ID</i>	<i>Date</i>	<i>Scale</i>	<i>Original Horizontal Datum</i>	<i>Original Vertical Datum</i>
F00238	1981	10000	Early Alaska Datums	Mean Lower Low Water
F00558	2008	10000	North American Datum 1983	Mean Lower Low Water
F00618	2012	5000	North American Datum 1983	Mean Lower Low Water
H02922	1907	20000	UNKNOWN	Mean Lower Low Water
H02926	1907	20000	UNKNOWN	Mean Lower Low Water
H05250	1932	40000	Early Alaska Datums	Mean Lower Low Water
H05251	1932	20000	Early Alaska Datums	Mean Lower Low Water
H05253	1932	40000	Early Alaska Datums	Mean Lower Low Water
H05254	1932	20000	Early Alaska Datums	Mean Lower Low Water
H05437	1933	20000	Early Alaska Datums	Mean Lower Low Water
H05438	1933	20000	Early Alaska Datums	Mean Lower Low Water
H05439	1933	20000	Early Alaska Datums	Mean Lower Low Water
H05440	1933	20000	Early Alaska Datums	Mean Lower Low Water
H05442	1933	40000	Early Alaska Datums	Mean Lower Low Water
H05443	1933	40000	Early Alaska Datums	Mean Lower Low Water
H05444	1933	160000	Early Alaska Datums	Mean Lower Low Water
H06479	1939	5000	Early Alaska Datums	Mean Lower Low Water
H06481	1939	10000	Early Alaska Datums	Mean Lower Low Water
H06679	1941	10000	Early Alaska Datums	Mean Lower Low Water
H07874	1950	5000	Early Alaska Datums	Mean Lower Low Water
H08118	1954	10000	Early Alaska Datums	Mean Lower Low Water
H08284	1956	5000	Early Alaska Datums	Mean Lower Low Water
H09003	1968	5000	Early Alaska Datums	Mean Lower Low Water
H09762	1978	5000	Early Alaska Datums	Mean Lower Low Water
H09763	1978	5000	Early Alaska Datums	Mean Lower Low Water
H09949	1981	10000	North American Datum 1927	Mean Lower Low Water
H10032	1982-1983	5000	Early Alaska Datums	Mean Lower Low Water
H10912	1999	5000	North American Datum 1983	Mean Lower Low Water
H10913	1999	10000	North American Datum 1983	Mean Lower Low Water
H10916	1999-2000	5000	North American Datum 1983	Mean Lower Low Water
H12317	2011	10000	North American Datum 1983	Mean Lower Low Water
H12320	2011	40000	North American Datum 1983	Mean Lower Low Water

Table 4: NGDC Multibeam swath sonar surveys

<i>Survey ID</i>	<i>Date</i>	<i>Ship</i>	<i>Source</i>
AT07L15	2002	Atlantis	Woods Hole Oceanographic Institution (WHOI)
EW0205	2002	Maurice Ewing	Marine Geoscience Data System (MGDS)
EW0206	2002	Maurice Ewing	Marine Geoscience Data System (MGDS)
EW0408	2004	Maurice Ewing	Marine Geoscience Data System (MGDS)
EW0409	2004	Maurice Ewing	Marine Geoscience Data System (MGDS)
HLY06TH	2006	Healy	UNOLS Rolling Deck to Repository (R2R) Program
HLY06TI	2006	Healy	UNOLS Rolling Deck to Repository (R2R) Program
HLY08TD	2008	Healy	UNOLS Rolling Deck to Repository (R2R) Program
HLY08TG	2008	Healy	UNOLS Rolling Deck to Repository (R2R) Program
HLY08TI	2008	Healy	UNOLS Rolling Deck to Repository (R2R) Program
HLY09TB	2009	Healy	UNOLS Rolling Deck to Repository (R2R) Program
HLY09TE	2009	Healy	UNOLS Rolling Deck to Repository (R2R) Program
HLY10TE	2010	Healy	UNOLS Rolling Deck to Repository (R2R) Program
HLY11TD	2011	Healy	UNOLS Rolling Deck to Repository (R2R) Program
HLY11TE	2011	Healy	UNOLS Rolling Deck to Repository (R2R) Program
HLY0901	2009	Healy	UNOLS Rolling Deck to Repository (R2R) Program
KM0308	2003	Kilo Moana	UNOLS Rolling Deck to Repository (R2R) Program
KM0314	2003	Kilo Moana	UNOLS Rolling Deck to Repository (R2R) Program
KM0514	2005	Kilo Moana	University of New Hampshire, Center for Coastal and Ocean Mapping (UNH/CCOM)
KM0515	2005	Kilo Moana	UNOLS Rolling Deck to Repository (R2R) Program
MGL1108	2011	Marcus G. Langseth	UNOLS Rolling Deck to Repository (R2R) Program
MGL1109	2011	Marcus G. Langseth	UNOLS Rolling Deck to Repository (R2R) Program

Bathymetric data were transformed to WGS 84 and MHW as needed and where recent, higher resolution data exists, older data were deleted. Vertical datum transformations were based on the NOAA tide stations located in Womens Bay and St. Paul Harbor (Table 5). Elevation differences in vertical datums at the two stations were averaged and used as conversion values.

Table 5: Relationship between MHW and other vertical datums in the Kodiak region.

<i>Vertical Datum</i>	<i>Difference to MHW (meters)</i>
MHHW	0.279
MHW	0.000
MTW	-1.021
MSL	-1.022
MLW	-2.043
MLLW	-2.384

Topographic data used in developing the Kodiak DEM is listed in Table 6. The City of Kodiak provided NGDC with both the LiDAR and IfSAR datasets. The USGS NED 2 arc-second topographic DEM were downloaded and filled in a small area not covered by IfSAR. The USACE harbor survey also provided detailed topographic coverage of the harbor areas. The IfSAR DEM is not bare-earth so this dataset was used inland and in less populated areas. The conversion value from NAVD 88 to MHW was derived from USACE survey control points.

Table 6: Topographic data sources used in compiling the Kodiak DEM.

<i>Source</i>	<i>Date</i>	<i>Data Type</i>	<i>Spatial Resolution</i>	<i>Horizontal Datum</i>	<i>Vertical Datum</i>
City of Kodiak	2010	Bare-earth LiDAR DEM	5 meter	NAD 83 UTM Zone 5 (meters)	Assumed NAVD 88
City of Kodiak	2003	IfSAR DEM	3 meter	NAD 83 UTM Zone 5 (meters)	MSL
NED	2001	Topographic DEM	2 arc second	NAD 83 geographic	NAVD 88
USACE	2009	Topographic points	~ 10 meter point spacing	NAD 83 AK (CORS96) State Plane Zone 5 (feet)	NAVD 88

DEM Development

Development of the Kodiak DEM followed procedures documented in NOAA Technical Memorandum NGDC-4 for Kodiak (Taylor et al., 2008). Exceptions being the bathymetric pre-surface was generated at 1/3 arc-second. This bathymetric pre-surface included pre-1939 NOS survey data, coastal scale ENC soundings data, and digital points generated at 5 meter spacing from the coastline. These three datasets were not used in the final gridding process. Gridding weight was modified to Table 7.

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

<i>Dataset</i>	<i>Relative Gridding Weight</i>
Bare-earth LiDAR DEM	1000
USACE topographic points	1000
USACE hydrographic survey	100
NOS surveys (no pre-1939)	100
NED topographic DEM	10
IfSAR DEM	10
Bathymetric pre-surface	10
Extracted ENC approach and harbor soundings	1
NGDC multibeam swath sonar	.1

DEM Analysis

The completed 1/3 arc-second Kodiak DEM was compared to nautical charts, topographic maps, and high resolution imagery as only two NGA monuments are available for this area. Inconsistencies were evaluated and resolved based on most reliable data available.

Acknowledgement

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Reference

L.A. Taylor, B.W. Eakins, K.S. Carignan, R.R. Warnken, D.C. Schoolcraft, T. Sazonova, G.F. Sharman (2008)
Digital Elevation Model of Dutch Harbor, Alaska: Procedures, Data Sources and Analysis
NOAA Technical Memorandum NESDIS NGDC-4, NOAA, pp. 25.