

Digital Elevation Model of Miami, Florida: 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 January of 2015, NOAA's National Geophysical Data Center (NGDC) developed an integrated bathymetric–topographic digital elevation model (DEM) of Miami, Florida for the National Tsunami Hazard Mitigation Program (NTHMP). The DEM will be used to support modeling tsunami generation, propagation, and inundation. The DEM covers Miami, Florida including the communities of Hillsboro Beach, Pompano Beach, Fort Lauderdale, Dania Beach, Miami Beach, Miami, Key Biscayne, Homestead A.F.B., Grayvik, and Ocean Reef Club. Extents of this DEM, procedures, data sources, and analysis are described below. The methodologies used by NGDC 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 Miami, Florida DEM was built to the specifications listed in Table 1. Figure 1 shows this 1/3 arc-second Miami, Florida integrated topographic–bathymetric DEM boundary in red, the 2011 Key West and 2010 Palm Beach integrated topographic–bathymetric 1/3 arc-second DEMs in green.

Table 1. Specifications for the Miami, Florida, Florida DEM.

<i>Cell Size</i>	1/3 arc-second
<i>Coverage</i>	79.40° to 80.41° W, 25.25° to 26.32° N
<i>Coordinate System</i>	Geographic decimal degrees
<i>Horizontal Datum</i>	World Geodetic System 1984 (WGS 84)
<i>Vertical Datum</i>	NAVD 88
<i>Vertical Units</i>	Meters
<i>Grid Format</i>	ASCII raster grid

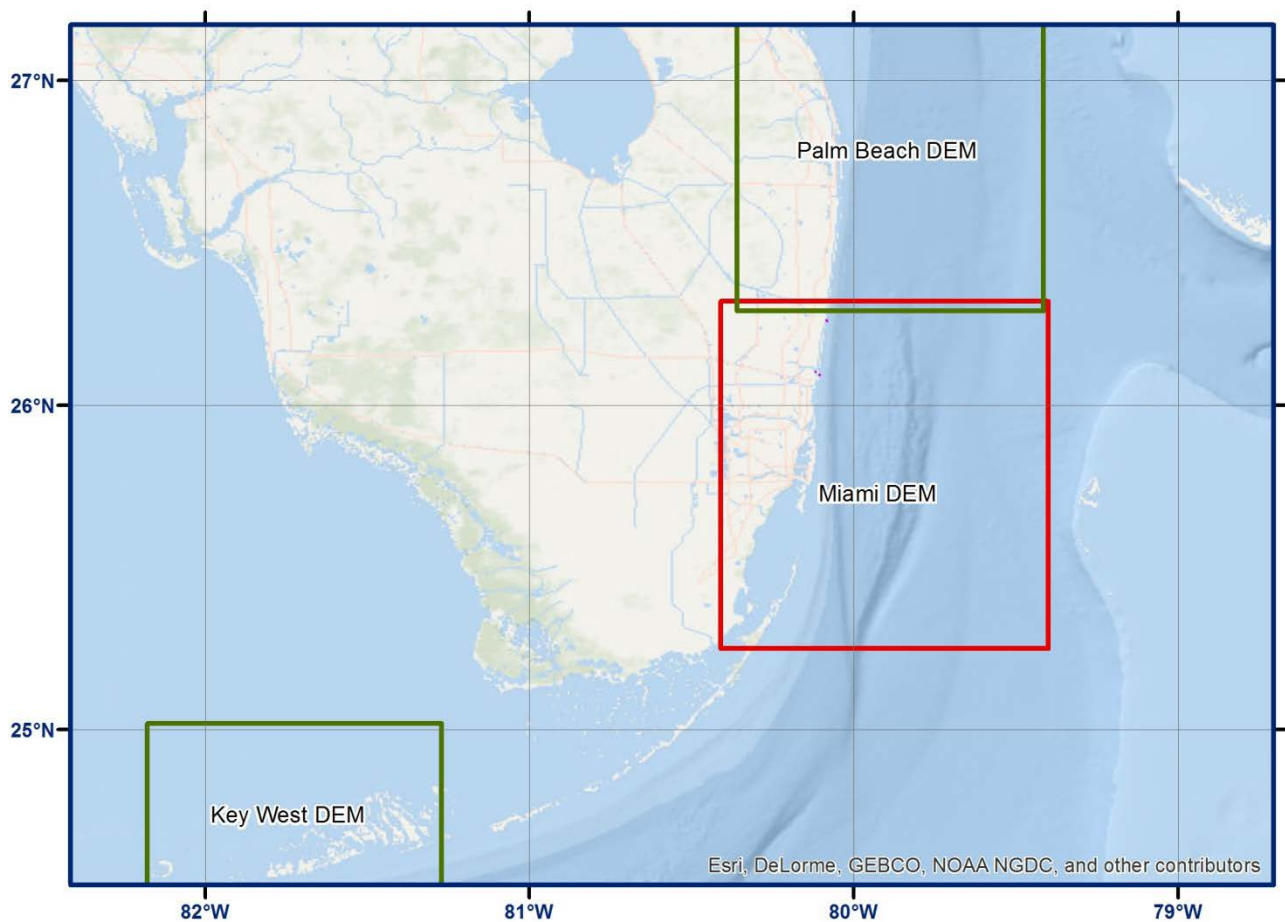


Figure 1. Map image of the boundaries for the 1/3 arc-second Miami, Florida DEM in red and the previously developed DEMs in green.

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). These coastlines were merged and edited to match either recently acquired high resolution lidar data or imagery available via Google Earth and ESRI's World Imagery map service (<http://www.arcgis.com/features/maps/imagery.html>). Bathymetric and topographic data were downloaded from NOAA's Office for Coastal Management (OCM) and Office of Coast Survey (OCS), the U.S. Army Corps of Engineers (USACE), the U.S. Geological Society (USGS), Florida Fish and Wildlife Conservation Commission – Fish and Wildlife Research Institute (FWRI), and NGDC. Figure 2 shows the source and coverage of the datasets used in developing the Miami, Florida DEM.

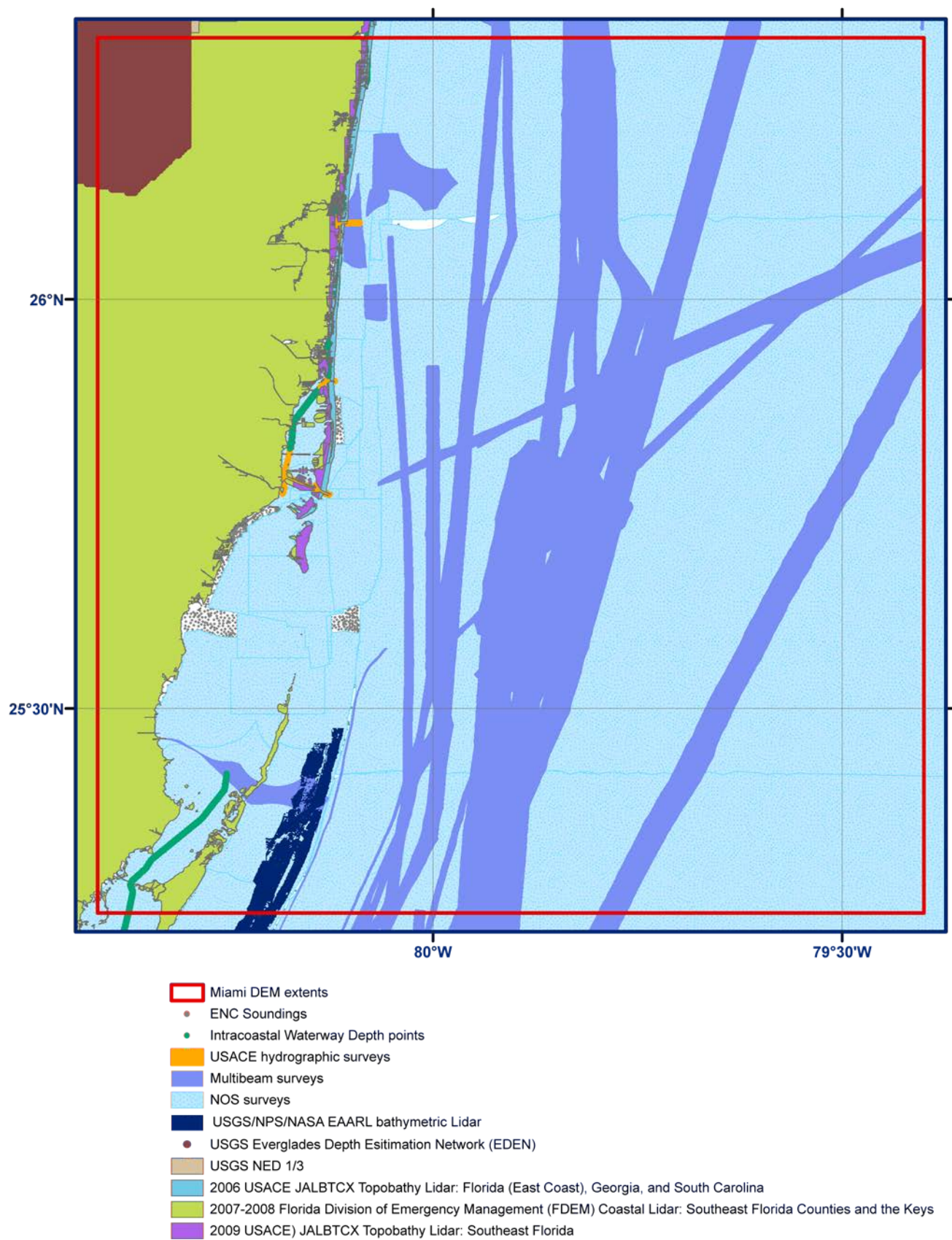


Figure 2. Source and coverage of the datasets used in compiling the Miami, Florida DEM.

Table 2 lists the bathymetry data used in the compilation of the Miami, Florida DEM including NOS hydrographic surveys (Appendix A) and multibeam surveys (Appendix B), and USACE harbor surveys.

Table 2: Bathymetric data sources used in compiling the Miami, Florida DEM.

<i>Source</i>	<i>Date</i>	<i>Data Type</i>	<i>Spatial Resolution</i>	<i>Horizontal Datum</i>	<i>Vertical Datum</i>
NOAA NOS	1928 to 2014	Hydrographic survey soundings	< 1 meter to several kilometers	Unknown, NAD 27 geographic, NAD 83 geographic, or NAD 83 UTM Zone 17 North	Mean Low Water (MLW), or Mean Lower Low Water (MLLW)
USACE	2009 to 2014	Hydrographic condition survey	< 5 meter point spacing and ~ 30 meter line spacing	NAD 83 Florida State Planes, East Zone, US Foot	MLLW
NGDC	1996 to 2014	Multibeam bathymetry	10 meter grid	NAD 83 geographic	Assumed Mean Sea Level (MSL)
OCS	1964 to 2014	ENC	1:20,000 to 1:200,000	WGS 84 geographic	MLLW
FWRI	1996	Intracoastal Waterway depth	Digitized project control data maps	NAD 83 PCS Albers	unknown
USGS/NPS/NASA	2006	EAARL bathymetric lidar DEM	1 meter	NAD 83 UTM Zone 17	NAVD 88

Bathymetric data were transformed to WGS 84 geographic and NAVD 88 using GDAL and NOAA's VDatum transformation tool. Appendix C illustrates the range of vertical datums within Miami, Florida. Where recent, higher resolution data exists, older data were superseded. EAARL bathymetric lidar DEMs were edited to remove anomalous elevation values at the edges. The bathymetric data were converted to xyz format before combining with the coastline data to generate a bathymetric pre-surface at 1/3 arc-second. This bathymetric surface grid was converted to xyz format before incorporating in the final DEM.

Topographic-bathymetric data (Table 3) were transformed to WGS 84 geographic using GDAL. Bathymetric values were separated from topographic values and used only in the bathymetric surface. Topographic values in these two lidar datasets were clipped to the coastline and filtered above

Topographic data used in developing the Miami, Florida DEM are listed in Table 4. Transformations to WGS 84 geographic were done using GDAL. As all topographic data were available in NAVD 88, no vertical datum changes were necessary. All topographic data were converted to xyz format for the final gridding process. The

converted xyz data files were clipped to the coastline to remove NoData values and returns over water. Jetties and breakwaters at Port Everglades and Fisher Harbor that were not completely resolved in the topographic data were supplemented by digitizing the features and creating additional data points with elevation values matching surrounding data.

Table 3: Topographic-Bathymetric data source used in compiling the Miami, Florida DEM.

<i>Source</i>	<i>Date</i>	<i>Data Type</i>	<i>Spatial Resolution</i>	<i>Horizontal Datum</i>	<i>Vertical Datum</i>
2006 U.S. Army Corps of Engineers (USACE) JALBTCX Topobathy Lidar:	2006	Topographic-Bathymetric Lidar DEM	2 meter	NAD 83 geographic	NAVD 88
2009 U.S. Army Corps of Engineers (USACE) JALBTCX Topobathy Lidar: Southeast Florida	2009	Topographic-Bathymetric Lidar DEM	2 meter	NAD 83 geographic	NAVD 88

Table 4: Topographic data sources used in compiling the Miami, Florida DEM.

<i>Source - Title</i>	<i>Date</i>	<i>Data Type</i>	<i>Spatial Resolution</i>	<i>Horizontal Datum</i>	<i>Vertical Datum</i>
USGS Sofia	2011	DEM	400 meters	NAD 83 UTM Zone 17 (meters)	NAVD 88
OCM - 2007-2008 Florida Division of Emergency Management (FDEM) Coastal Lidar: Southeast Florida Counties and the Keys	2007 to 2008	Lidar GeoTIFF	2 meters	NAD 83 geographic	NAVD 88
USGS NED	2013	Topographic DEM	1/3 arc second	NAD 83 geographic	NAVD 88

DEM Development

Development of the Miami, Florida 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 1/3 arc-second. Gridding weight was modified to Table 5.

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

<i>Dataset</i>	<i>Relative Gridding Weight</i>
OCM - 2007-2008 Florida Division of Emergency Management (FDEM) Coastal Lidar: Southeast Florida Counties and the Keys	1000
NGDC digitized points	1000

NOS hydrographic surveys (post 1985)	100
USACE hydrographic surveys	100
OCS ENC soundings	100
Bathymetric pre-surface	10
USGS Biscayne	10
OCM - 2009 U.S. Army Corps of Engineers (USACE) JALBTCX Topobathy Lidar	10
USGS Sofia DEM	10
Coastline	1
NGDC multibeam surveys	1
USGS NED 1/3 DEM	1

MHW DEM Development

The MHW Miami, Florida DEM was developed by generating a conversion grid based on VDatum software. The completed conversion grid was then applied to the NAVD 88 DEM.

DEM Analysis

The completed Miami, Florida DEMs were compared to ENC sounding data, topographic benchmarks, and high resolution imagery. Inconsistencies were evaluated and resolved based on most current or reliable data available.

Acknowledgement

The authors acknowledge the Everglades Depth Estimation Network (EDEN) project and the US Geological Survey for providing the [insert data type here] for the purpose of this research/report.

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.

Yang, Z., E. Myers, I. Jeong, S. White (2012). VDatum for Coastal Waters from the Florida Shelf to the South Atlantic Bight: Tidal Datums, Marine Grids, and Sea Surface Topography. NOAA Technical Memorandum NOS CS 27.

VDatum Version 3.3, Florida/Georgia – Coastal Waterways, Fort Lauderdale, FL to Sapelo Island, GA. v.1 (2011). <http://vdatum.noaa.gov/welcome.html> [October 2014].

Appendix A: NOS Surveys

<i>Survey ID</i>	<i>Date</i>	<i>Scale</i>	<i>Original Horizontal Datum</i>	<i>Original Vertical Datum</i>
H04811	1928	20000	unknown	MLW
H05015	1929	20000	unknown	MLW
H05058	1930	20000	unknown	MLW
H05535	1934	20000	unknown	MLW
H05536	1934	20000	unknown	MLW
H05542	1934	20000	unknown	MLW
H05578	1934	20000	unknown	MLW
H05614	1934	5000	unknown	MLW
H05726	1934	20000	unknown	MLW
H05727	1935	10000	unknown	MLW
H05779	1935	10000	unknown	MLW
H08735	1963	100000	NAD 1927	MLW
H08736	1963	100000	NAD 1927	MLW
H08782	1964	100000	NAD 1927	MLW
H09926	1980 to 1981	10000	NAD 1927	MLW
H10473	1993	10000	NAD 1983	MLLW
H10474	1993	10000	NAD 1983	MLLW
H10493	1993	10000	NAD 1983	MLLW
H10748	1997	10000	NAD 1983	MLLW
H10748A	1998	10000	NAD 1983	MLLW
H10749A	1998	10000	NAD 1983 UTM 18	MLLW
F00532	2007	10000	NAD 1983 UTM 17	MLLW
H11868	2008	10000	NAD 1983 UTM 17	MLLW
H11869	2008	10000	NAD 1983 UTM 17	MLLW
H11870	2008	10000	NAD 1983 UTM 17	MLLW
H11871	2008	10000	NAD 1983 UTM 17	MLLW
H12008	2008	10000	NAD 1983 UTM 17	MLLW
H12116	2008	10000	NAD 1983 UTM 17	MLLW
H12117	2008	10000	NAD 1983 UTM 17	MLLW
H12118	2008	10000	NAD 1983 UTM 17	MLLW
H11896	2009	10000	NAD 1983 UTM 17	MLLW
H11897	2009	10000	NAD 1983 UTM 17	MLLW
H11898	2009	10000	NAD 1983 UTM 17	MLLW
F00640	2014	5000	NAD 1983 UTM 17	MLLW

Appendix B: NGDC Multibeam surveys

<i>Survey ID</i>	<i>Date</i>	<i>Ship</i>	<i>Institution</i>	<i>Original Horizontal Datum</i>	<i>Original Vertical Datum</i>
EW9609	1996	Maurice Ewing	Marine Geoscience Data System (MGDS)	NAD 1983 geographic	Assumed MSL
EW9701A	1997	Maurice Ewing	MGDS	NAD 1983 geographic	Assumed MSL
USF1999	1999	Bellows	University of South Florida (USF)	NAD 1983 geographic	Assumed MSL
USF2000	2000	Bellows	USF	NAD 1983 geographic	Assumed MSL
KM0201	2002	Kilo Moana	University of Hawaii (UH)	NAD 1983 geographic	Assumed MSL
KN166L02	2002	Knorr	Woods Hole Oceanographic Institution (WHOI)	NAD 1983 geographic	Assumed MSL
EW0401	2004	Maurice Ewing	MGDS	NAD 1983 geographic	Assumed MSL
KN182L02	2005	Knorr	WHOI	NAD 1983 geographic	Assumed MSL
NF-07-09-GRNMS	2007	Nancy Foster	National Oceanic and Atmospheric Administration (NOAA)	NAD 1983 geographic	Assumed MSL
NF-07-14-FKNMS	2007	Nancy Foster	NOAA	NAD 1983 geographic	Assumed MSL
KNOX18RR	2008	Roger Revelle	University of California, Scripps Institution of Oceanography (UC/SIO)	NAD 1983 geographic	Assumed MSL
KNOX20RR	2008	Roger Revelle	UC/SIO	NAD 1983 geographic	Assumed MSL
NF-08-03-FACE	2008	Nancy Foster	NOAA	NAD 1983 geographic	Assumed MSL
LCE2010	2010	Lost Coast Explorer	NOAA	NAD 1983 geographic	Assumed MSL
EX1106	2011	Okeanos Explorer	NOAA	NAD 1983 geographic	Assumed MSL
AT18-18	2012	Atlantis	UNOLS R2R	NAD 1983 geographic	Assumed MSL
EX1202Leg1	2012	Okeanos Explorer	NOAA	NAD 1983 geographic	Assumed MSL
EX1203	2012	Okeanos Explorer	NOAA	NAD 1983 geographic	Assumed MSL
NF-13-10T	2013	Nancy Foster	NOAA	NAD 1983 geographic	Assumed MSL
EX1402L1	2014	Okeanos Explorer	NOAA	NAD 1983 geographic	Assumed MSL
EX1403	2014	Okeanos Explorer	NOAA	NAD 1983 geographic	Assumed MSL

Appendix C: Difference between tidal datums at select tide stations in the DEM region.

<i>Station ID</i>	8722861	8722899	8722939	8722951	8723050	8723073	8723080	8723089	8723165
<i>Station Name</i>	Hillsboro Inlet, Inside	Lauderdale-by-the-Sea	Ft. Lauderdale Bahia Yacht Club	Port Everglades, Lake Mabel	North Miami Beach	Haulover, Inside	Haulover Pier, N. Miami Beach	Biscayne Creek, ICWW	Biscayne Bay
MHHW	0.849	0.873	0.808	0.856	0.841	0.671	0.818	0.718	0.723
MHW	0.807	0.836	0.773	0.821	0.809	0.651	0.797	0.697	0.7003
NAVD88	0.715	0.701	0.697	0.684	0.727	0.59	0.687	0.644	0.643
MTL	0.428	0.443	0.411	0.435	0.43	0.345	0.419	0.369	0.371
MSL	0.426	0.446	0.411	0.437	0.435	0.331	0.423	0.366	0.371
MLW	0.048	0.051	0.049	0.049	0.051	0.038	0.042	0.041	0.04
MLLW	0	0	0	0	0	0	0	0	0
<i>Time Period</i>	12 mo.	1 yr.	1 yr.	3 yr.	12 mo.	12 mo.	10 yr.	1 yr.	2 yr.

Appendix C: Difference between tidal datums at select tide stations in the DEM region.

<i>Station ID</i>	8723170	8723178	8723214	8723289	8723350	8723423	8723519	8723534	8723574
<i>Station Name</i>	Miami Beach	Miami Beach Gov. Cut	Virginia Key	Cutler, Biscayne Bay	Ragged Key #3	Turkey Point, Biscayne Bay	Ocean Reef Harbor, Key Largo	Card Sound Bridge	Manatee Creek, Barnes Sound
MHHW	0.823	0.762	0.667	0.649	0.567	0.543	0.772	0.193	
MHW	0.798	0.749	0.651	0.631	0.544	0.525	0.763	0.18	
NAVD88	0.721		0.602	0.592		0.536	0.688	0.325	0.296
MTL	0.423	0.396	0.343	0.336	0.293	0.279	0.413	0.099	
MSL	0.428	0.396	0.335	0.334	0.288	0.271	0.422	0.099	0
MLW	0.049	0.043	0.035	0.4	0.041	0.033	0.064	0.018	
MLLW	0	0	0	0	0	0	0	0	
<i>Time Period</i>	9 yr.	1 yr.	13 yr.	1 yr.	1 yr.	1 yr.	1 yr.	1 yr.	1 yr.