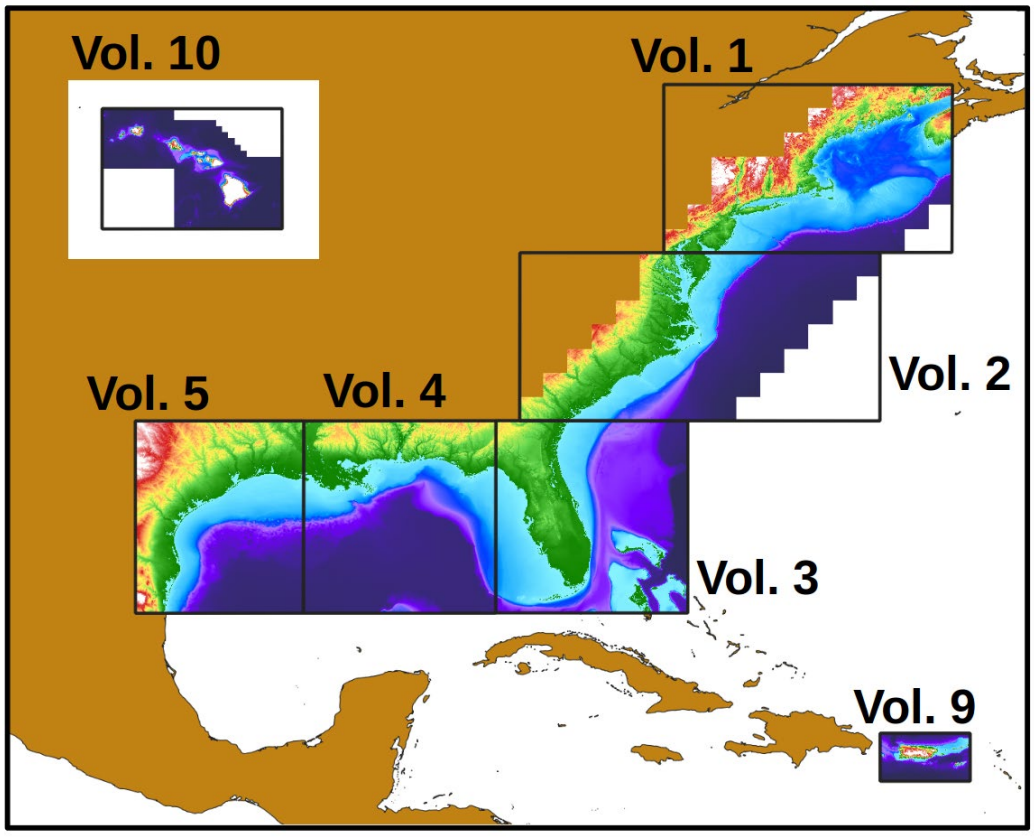
Coastal Relief Models
2023 Release – User Guide



National Centers for Environmental Information

CIRES

1. Intent of this Document and POC

1.1 This document is intended to provide a basic understanding of the data product including points of contact, data sources used to develop the product, quality control practices, and steps taken to validate the accuracy of the product. References are provided at the end of this document for users interested in further technical details.

1.2 Technical points of contact for this dataset:

Michael MacFerrin (michael.macferrin@noaa.gov) (developer)

Matthew Love (matthew.love@noaa.gov) (developer)

Christopher Amante (christopher.amante@noaa.gov) (developer and project co-manager)

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2. Product Overview and Intended Uses

2.1 CRM Overview

Coastal Relief Models (CRMs) are moderate-resolution regional digital elevation models (DEMs) with combined topographic and bathymetric elevations of coastal regions in the United States (U.S.) and U.S. territories. The CRMs are currently split into 12 regions, noted as "volumes." CRMs are distributed in GeoTiff (.tif) and NetCDF (.nc) formats containing identical elevation data. This update in October 2023 spans volumes 1-5 (covering the U.S. East Coast and the Gulf of Mexico), volume 9 (Puerto Rico), and volume 10 (Hawaii), as noted in the cover figure. Other volumes remain unchanged by this update. CRMs are released at 1-arc-second horizontal resolution, with the following naming convention:

crm_vol[#]_[YYYY][.tif]

with the following information in place of the brackets [ ]:

[#] - Volume number

[YYYY] - Year of release

[.tif] - File extension: .tif (GeoTiff) or .nc (NetCDF) formats.

All CRMs in this release are horizontally referenced to the WGS84 geographic reference frame and coordinate system (EPSG[1]:4326). Elevation values in Volumes 1-5 are vertically referenced to the EGM2008 geoid (EPSG:3855), while Volumes 9 and 10 are vertically referenced to "Mean Sea Level" (EPSG:5714).

[1] EPSG: European Petroleum Survey Group, a commonly used set of reference coordinate systems. http://epsg.io

3. Data Field Description

Table 1: CRM high-level data description

Variable names and units in product	Elevation (meters), negative is down.
Spatial resolution	1 arc-second longitude & latitude (WGS84 coordinates)
Temporal resolution and extent	Data is compiled from a variety of sources (see Section 5) spanning individual lead-line bathymetric surveys from 1851, up to multi-beam sonar data collected in 2023.
Coverage	-161 to -64.25 (W) longitude (WGS84 coordinates) +17 to 46 (N) latitude Elevation range: -6613.0 m to 4197.9 m

4. Dataset Usage and Citation

CRM tiles are freely available to use for all private, academic, or commercial purposes. Data is available for download on the CRM landing page.

To reference the CRM 2023 tiles, please cite the following:

> NOAA National Centers for Environmental Information. (2023). Coastal Relief Models (CRMs) [Data set]. NOAA National Centers for Environmental Information. https://doi.org/10.25921/5ZN5-KN44. Accessed [date].

CRM metadata is available here: CRM Metadata Record

5. Data Sources and Processing

CRM Volumes 1-5 were built using raster-stacking and filtering methods, similar to the ETOPO 2022 dataset (NCEI, 2022). The following source data layers were included in their creation.

Table 2: CRM volumes 1-5 data sources

Source Name	Vertical datum	Creator	Link[2]	Primary Use
GEBCO[3] 2022	MSL[4]	GEBCO Compilation	GEBCO	Sea

[2] Website links are active at the time of creation of this document.
[3] GEBCO = General Bathymetric Chart of the Oceans
[4] Mean sea level

Source Name	Vertical datum	Creator	Link[2]	Primary Use
		Group (2022)	2022	bathymetry base layer
NOAA[5] Estuarine DEMs	various	NOAA / NCEI[6] (archived)	NOAA Estuarine DEMs	Sea bathymetry
NOAA Regional DEMs	various	NOAA / NCEI (archived)	NOAA Regional DEMs Catalog	Sea bathymetry
GMRT[7] v4.0	MSL	GMRT.org, Lamont-Doherty Earth Observatory	GMRT Image Server	Sea bathymetry
BlueTopo	NAVD88[8]	NOAA OCS[9]	NOAA OCS AWS[10]	Sea bathymetry
BOEM[11] Gulf of Mexico Bathymetry	MSL	BOEM	BOEM GoM Deepwater Bathymetry	Gulf of Mexico bathymetry
ShallowBathyEverywhere	EGM2008	Oregon State University	ShallowBathyEverywhere	Sea bathymetry (select areas)
FABDEM[12]	EGM2008	European Space Agency and Bristol University	FABDEM Release Page	Land topography (Mexico, Bahamas)
USGS[13] The	NAVD88	United States Geological	USGS	Land

[5] National Oceanic and Atmospheric Administration
[6] National Centers for Environmental Information
[7] Global Multi-Resolution Topography
[8] North American Vertical Datum of 1988
[9] Office of the Coast Survey
[10] Amazon Web Services
[11] Bureau of Ocean Energy Management
[12] Forest and Buildings Removed Copernicus DEM
[13] United States Geological Survey

Source Name	Vertical datum	Creator	Link[2]	Primary Use
National Map		Survey, 3-DEP program	3DEP	topography
HRDEM[14] Canada	CGVD2013[15]	Canadian High-Resolution Digital Elevation Models	HRDEM Website	Land Topography (Canada)
CUDEM[16]	NAVD88	NOAA / NCEI Coastal DEM Team	CUDEM 1/3-arc-sec and 1/9-arc sec catalogs[17]	Land topography and sea bathymetry (US & territories)

CRM Volumes 9 and 10 were produced with a mixed-data approach primarily using the methodology employed for the creation of higher-resolution Continuously-Updated Digital Elevation Models (CUDEMs) (Amante et al., 2023). Data sources are outlined below.

Table 3. Data sources for CRM volumes 9 and 10

Source	Vertical Datum	Horizontal Datum	Date	Data Type	Spatial Resolution
NOAA OCS electronic navigational chart (ENC) extracted soundings	Mean Lower Low Water (MLLW)	WGS84	1966 - 2019	XYZ	< 10 meters to several kilometers
NOAA NCEI multibeam bathymetric surveys	Assumed instantaneous water level	NAD83	2008 - 2016	XYZ	~1 to 10 meters
NOAA BAG	Mean Lower Low Water (MLLW)	UTM 15N	2017	Gridded Bathymetry	< 1 meter to ~10 meters

[14] High-Resolution Digital Elevation Model (HRDEM), CanElevation Series
[15] Canadian Geodetic Vertical Datum of 2013 (EPSG:6647)
[16] Continuously-Updated Digital Elevation Models
[17] Current released data tiles through August 2022

Source	Vertical Datum	Horizontal Datum	Date	Data Type	Spatial Resolution
NOAA NOS hydrographic surveys	Mean Lower Low Water (MLLW)	WGS84	1934 - 2006	XYZ	< 10 meters to several kilometers
Moby Multibeam Grids	Local Mean Sea Level (LMSL)	WGS84	2016	Bathymetry DEM	varies
MBARI Gridded Bathymetry	LMSL	WGS84	2014	Bathymetry DEM	varies
2013 USACE NCMP Topobathy Lidar: Lanai (HI)	LMSL	varies	2013	Lidar	< 1 meter
2013 USACE NCMP Topobathy Lidar: Kauai (HI)	LMSL	varies	2013	Lidar	< 1 meter
2013 USACE NCMP Topobathy Lidar: Maui (HI)	LMSL	varies	2013	Lidar	< 1 meter
2013 USACE NCMP Topobathy Lidar: Molokai (HI)	LMSL	varies	2013	Lidar	< 1 meter
2013 USACE NCMP Topobathy Lidar: Oahu (HI)	LMSL	varies	2013	Lidar	< 1 meter

Source	Vertical Datum	Horizontal Datum	Date	Data Type	Spatial Resolution
2013 USACE NCMP Topobathy Lidar: Hawaii (Big Island)	LMSL	varies	2013	Lidar	< 1 meter
2007 USACE NCMP Topobathy Lidar: Hawaiian Islands	LMSL	varies	2007	Lidar	< 1 meter
2013 USACE NCMP Topobathy Lidar DEM (LMSL): Niihau, HI	LMSL	varies	1999 - 2020	DEM	< 1 meter
SHOALS Topobathy	LMSL	WGS84	2015	Lidar	varies
USGS National Elevation Dataset 1/3 Arc-second	LMSL	WGS84	2020	DEM	1/3 arc second
2005 NOAA Lidar: Oahu & Maui (HI)	Geoid12a	varies	2005	Lidar	< 1 meter
2003 NOAA Lidar: Oahu Coastline (HI)	Geoid12a	varies	2003	Lidar	< 1 meter
2005 HI Office of Planning Lidar: Kilauea Crater	Geoid12a	varies	2005	Lidar	< 1 meter

Source	Vertical Datum	Horizontal Datum	Date	Data Type	Spatial Resolution
2013 NOAA Lidar: Oahu, HI	Geoid12a	varies	2013	Lidar	< 1 meter
2015 NOAA Lidar: Pelekane Watershed, HI	LMSL	varies	2015	Lidar	< 1 meter

6. Validation and Error Estimates

CRM elevations over land regions were compared to spaceborne lidar data from NASA's Ice, Cloud, and Land Elevation Satellite-2 (ICESat-2). Grid cells in which five or more photons from ICESat-2 landed within a grid cell, the mean of the inter-decile range (10-90 %) of photon heights were compared against the CRM elevation at that location. Volumes 1-5 (Continental US and Gulf of Mexico) were validated separately from volume 9 (Puerto Rico) and volume 10 (Hawaii), owing to the differences in input datasets between them. Generally speaking, bare-earth elevations over the Continental US are more accurate owing to the larger volume of post-processed airborne lidar data available in that region, both from NOAA and USGS. Additionally, the steeper terrains covered in volumes 9 and 10 inherently increase uncertainties in mean elevation compared to point data provided by ICESat-2. As such, root-mean-square errors presented here should be interpreted as "upper bound" error estimates in the CRMs.

CRM volumes 1-5 showed a root-mean-square error (RMSE) of 0.85 m compared to ICESat-2 (Figure 1), indicating sub-meter accuracy of the CONUS CRMs. Comparatively, volumes 9 and 10 had RMSEs of 3.09 m and 8.08 m, respectively, compared to ICESat-2.

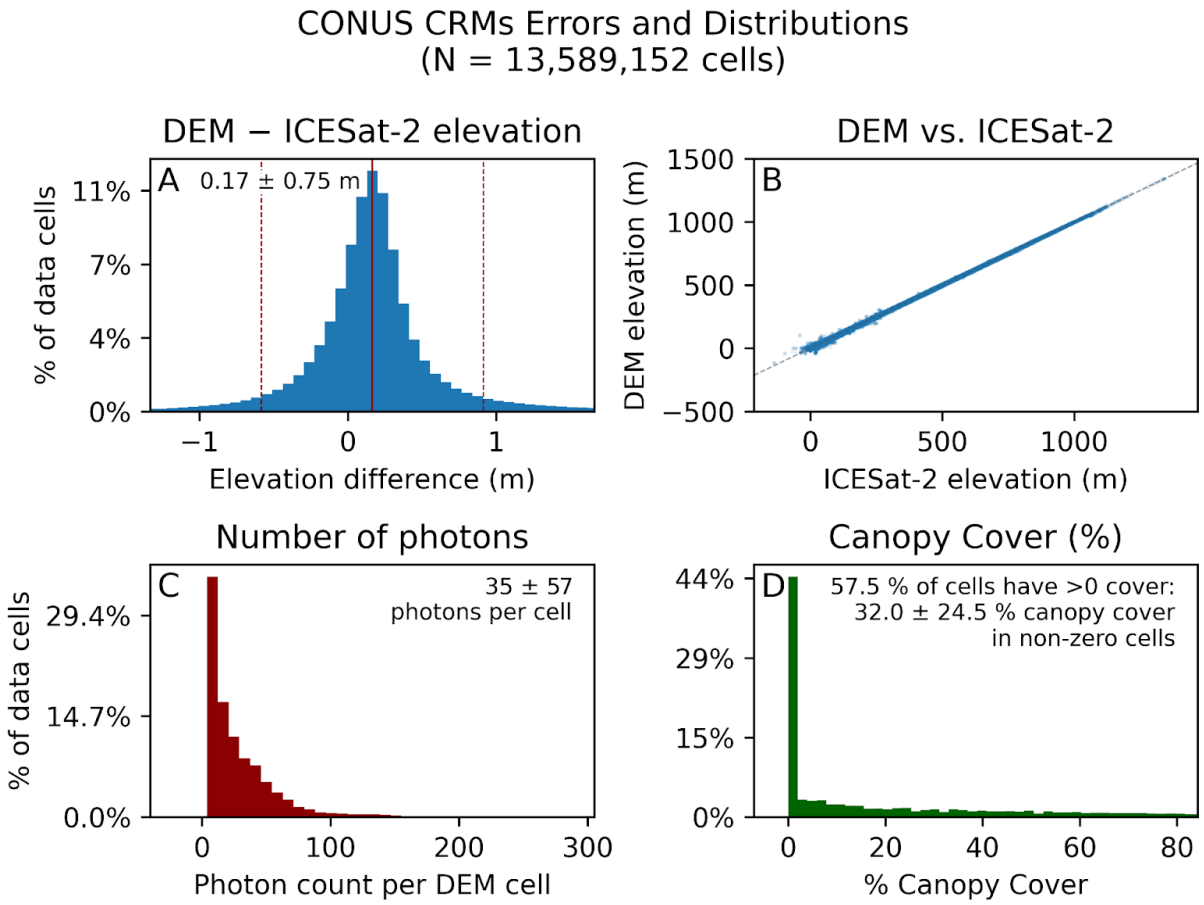

Figure 1. CRM Volumes 1-5 statistics compared to ICESat-2.

7. References

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Shallow Bathymetry Everywhere: https://shallowbathymetryeverywhere.com/

8. Dataset and Document Revision History

Rev 1.0 – 23 October 2023 - Original document.