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**DIGITAL ELEVATION MODEL OF TATITLEK, ALASKA:  
PROCEDURES, DATA SOURCES AND ANALYSIS**

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

## 1. INTRODUCTION

The National Geophysical Data Center (NGDC), an office of the National Oceanic and Atmospheric Administration (NOAA), has developed a bathymetric–topographic digital elevation model (DEM) centered on Tatitlek, Alaska (Fig. 1). The DEM was developed for the National Tsunami Hazard Mitigation Program (NTHMP; <http://nthmp.tsunami.gov/>) in support of the State of Alaska’s tsunami inundation modeling efforts led by the Geophysical Institute at the University of Alaska at Fairbanks (UAF). The 8/15 arc-second<sup>1</sup> DEM is nested within the extents of the previously developed Prince William Sound 8 arc-second and 8/3 arc-second DEMs (see Fig. 4; Caldwell et al., 2009). The coastal DEM will be used as input for the university-developed modeling system to simulate tsunami generation, propagation, and inundation (<http://www.aeic.alaska.edu/tsunami/>). The DEM was generated from diverse digital datasets in the region and was designed to represent modern morphology. Primary data sources and grid development methodology are described in the technical report for the Prince William Sound DEMs (Caldwell et al., 2009; see link above). Additional datasets used in developing the Tatitlek DEM are described in this report, which provides a summary of the supplemental data sources and quality control procedures used in developing the Tatitlek DEM.

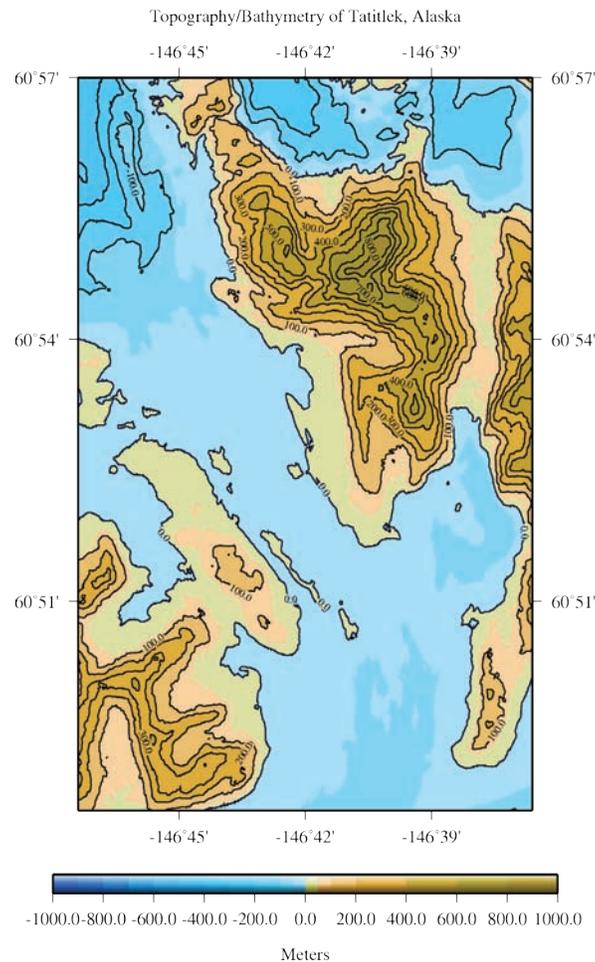


Figure 1. Contour map of the Tatitlek 8/15 arc-second DEM. Contour interval is 100 meters. Image is in Mercator projection.

1. The Tatitlek DEM is built upon a grid of cells that are square in geographic coordinates (latitude and longitude), however, the cells are not square when converted to projected coordinate systems such as UTM zones (in meters). At the latitude of Tatitlek, Alaska, (60° 51' 53"N, 146° 40' 43"W) 1 arc-second of latitude is equivalent to 30.95 meters; 1 arc-second of longitude is equivalent to 15.09 meters.

## 2. STUDY AREA

The community of Tatitlek is situated on a generally flat plain with the adjacent Ellamar and Copper Mountains climbing to over 800 meters (Figs. 2 and 3). Tatitlek is located in the Chugach National Forest approximately 30 kilometers southwest of Valdez and 60 kilometers northwest of Cordova in the northern portion of Prince William Sound (Fig. 4). The population of Tatitlek according to the U.S. Census Bureau in 2000 was 107.

Tatitlek is in an earthquake prone region, which makes the area highly vulnerable to tsunamis. The second most powerful earthquake in the twentieth century occurred on March 27, 1964. Its epicenter was located approximately 90 miles west of Valdez. Measuring 9.2 on the Richter scale, the earthquake caused major vertical displacements in and around Prince William Sound, with uplift reported up to 15 meters and maximum subsidence of 2.3 meters relative to sea level (<http://www.drgeorgepc.com/Earthquake1964Alaska.html>). The town of Tatitlek only exhibited uplift during the 1964 earthquake with limited damage in town due to the dampening of the waves by Bligh Island. These semi-permanent, vertical displacements of the seafloor have reduced the accuracy and reliability of pre-1965 hydrographic surveys.



Figure 2. Photograph of Tatitlek looking northeast. Ellamar Mountain is in the background. Source: University of Alaska at Fairbanks.



Figure 3. Photograph of Tatitlek looking east-northeast. Copper Mountain is in the background. Source: University of Alaska at Fairbanks.

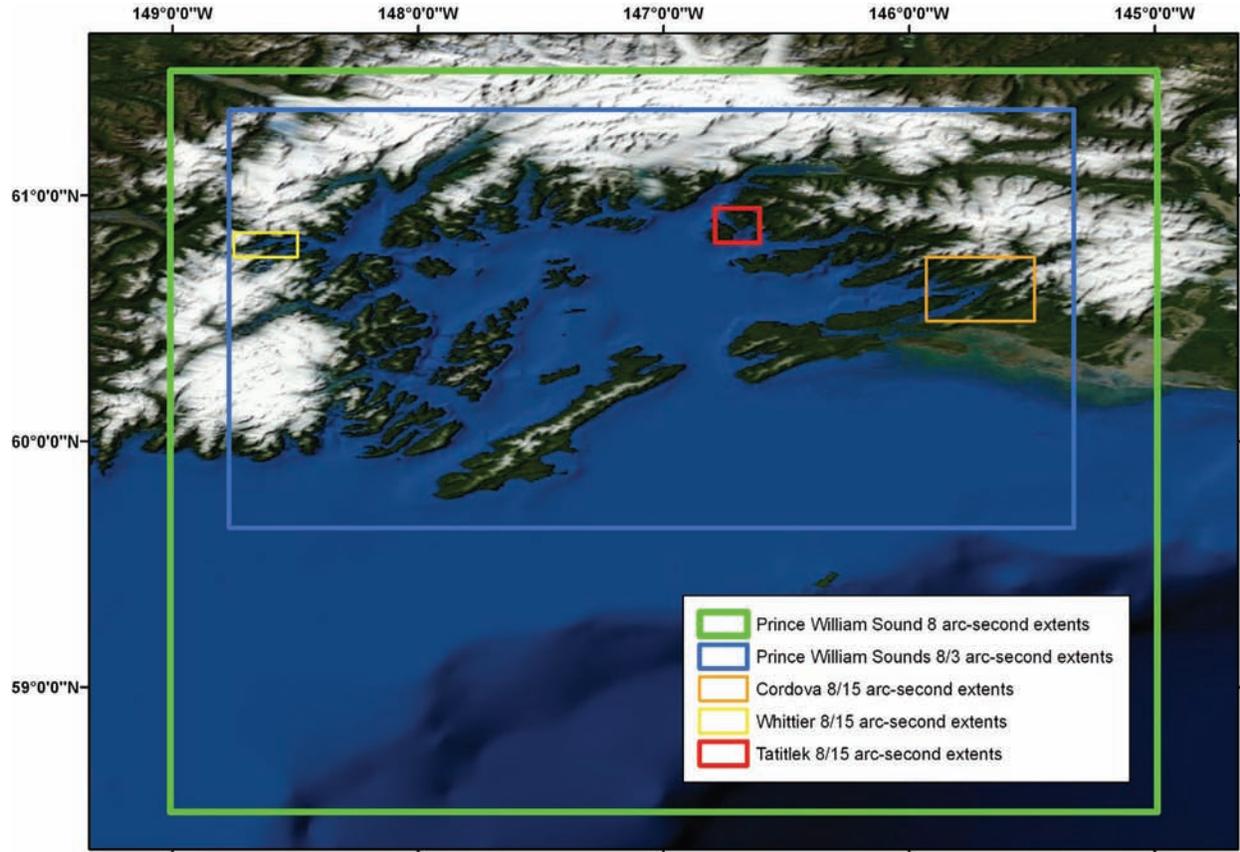


Figure 4. Map of the Prince William Sound region with extents of the Tatitlek DEM and previous Prince William Sound DEMs (e.g., Cordova and Whittier) shown. ESRI World 2D Imagery shown in the background.

### 3. METHODOLOGY

The Tatitlek DEM was developed in the World Geodetic System 1984 (WGS 84) geographic horizontal datum and Mean Higher High Water (MHHW) vertical datum in vertical units of meters. NGDC developed the DEM at extents slightly larger (~ 5 percent) than required by UAF. The best available bathymetric and topographic digital data were obtained by NGDC and shifted to common horizontal and vertical datums: North American Datum of 1983<sup>2</sup> (NAD 83) and MHHW, for modeling of maximum flooding, respectively.

Table 1. Specifications for the Tatitlek, Alaska DEM.

<i>Grid Area</i>	Tatitlek, Alaska
<i>Coverage Area</i>	146.79° to 146.61° W; 60.81° to 60.95° N
<i>Grid Spacing</i>	8/15 arc-second
<i>Coordinate System</i>	Geographic decimal degrees
<i>Horizontal Datum</i>	World Geodetic System 1984 (WGS 84)
<i>Vertical Datum</i>	Mean Higher High Water (MHHW)
<i>Vertical Units</i>	Meters
<i>Grid Format</i>	NetCDF

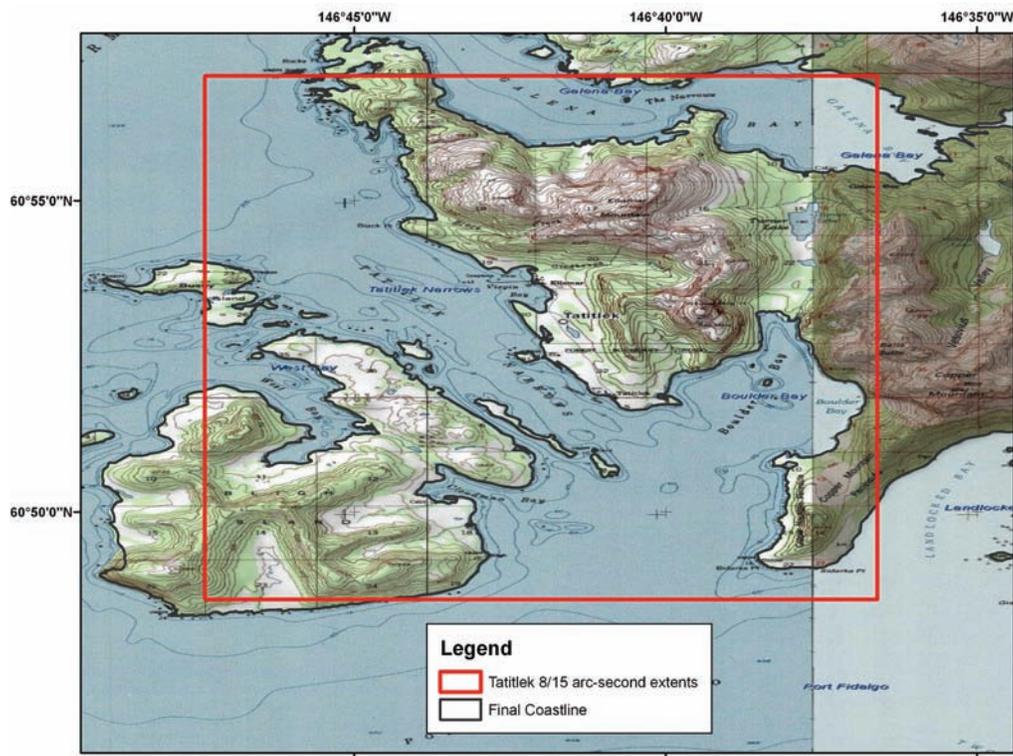


Figure 5. Extents of the Tatitlek 8/15 arc-second DEM. ESRI U.S. Topographic Maps layer in background.

2. The horizontal difference between the North American Datum of 1983 (NAD 83) and World Geodetic System of 1984 (WGS 84) geographic horizontal datums is approximately one meter across the contiguous U.S., which is significantly less than the cell size of the DEM. Most GIS applications treat the two datums as identical, so do not actually transform data between them, and the error introduced by not converting between the datums is insignificant for our purposes. NAD 83 is restricted to North America, while WGS 84 is a global datum. As tsunamis may originate most anywhere around the world, tsunami modelers require a global datum, such as WGS 84 geographic, for their DEMs so that they can model the wave's passage across ocean basins. This DEM is identified as having a WGS 84 geographic horizontal datum even though the underlying elevation data were typically transformed to NAD 83 geographic. At the scale of the DEM, WGS 84 and NAD 83 geographic are identical and may be used interchangeably.

### 3.1 Supplemental Data Sources and Processing

Source datasets for the Tatitlek DEM were comprised primarily of the datasets listed in the Prince William Sound technical report (Caldwell et al., 2009). Several newer or higher resolution datasets, however, were available for use in building the Tatitlek DEM, including: a 2008 National Ocean Service (NOS) hydrographic survey (H11743) and a U.S. Forestry Service (USFS) topographic DEM (Fig. 6). In addition, UAF provided point elevation measurements in the immediate vicinity of Tatitlek (Fig. 6). Finally, high-resolution aerial photographs of the Tatitlek shoreline in 2005 were downloaded from the State of Alaska's Division of Community and Regional Affairs (DCRA) for use in digitizing a final coastline (see Fig. 7).

Safe Software's *Feature Manipulation Engine (FME)*<sup>3</sup> data translation tool and *Proj4*<sup>4</sup> were used to shift datasets to NAD 83 geographic horizontal datum. *FME*, *GDAL*<sup>5</sup>, and *OGR*<sup>6</sup> were used to convert the datasets into ESRI *ArcGIS* shapefiles and xyz format. The shapefiles and xyz files were then displayed with *ArcGIS* and Applied Imagery's *Quick Terrain Modeler (QT Modeler)* to assess data quality and manually edit datasets. *QT Modeler* and Interactive Visualization System's *Fledermaus* software were used to evaluate processing and gridding techniques.

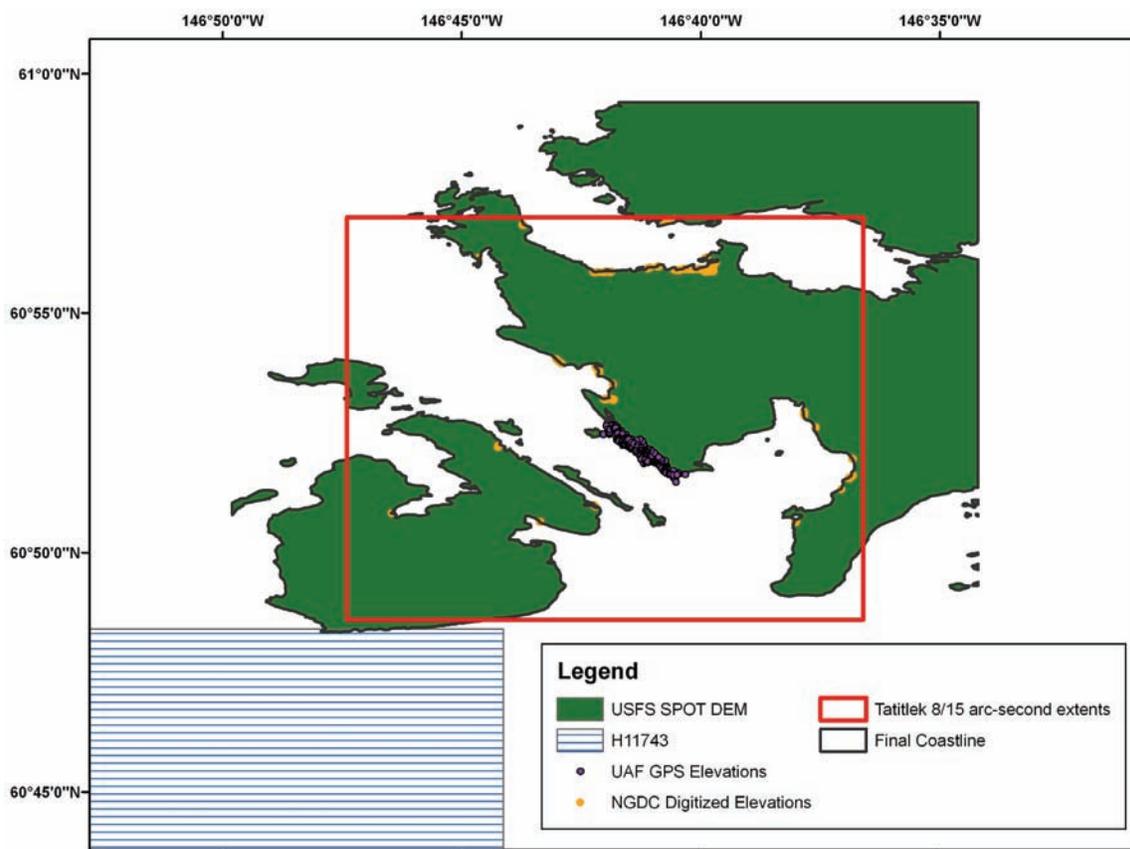


Figure 6. Source and coverage of supplemental datasets used in compiling and evaluating the Tatitlek DEM.

3. *FME* uses the North American Datum Conversion Utility (NADCON; <http://www.ngs.noaa.gov/TOOLS/Nadcon/Nadcon.shtml>) developed by NOAA's National Geodetic Survey (NGS) to convert data from NAD 27 to NAD 83. NADCON is the U.S. Federal Standard for NAD 27 to NAD 83 datum transformations.

4. *Proj4* is a cartographic projections library, originally written by Gerald Evenden, then of the USGS. The software is released under an MIT style Open Source license. *Proj4* was used to horizontally transform datasets that originated in State Plane datums before vertical transformations were performed.

5. *GDAL* is a translator library for raster geospatial data formats that is released under an X/MIT style Open Source license by the Open Source Geospatial Foundation. As a library, it presents a single abstract data model to the calling application for all supported formats. It also comes with a variety of useful commandline utilities for data translation and processing.

6. The *OGR* Simple Features Library is a C++ open source library and commandline tools providing read and write access to a variety of vector file formats, including ESRI shapefiles. *OGR* is a part of the *GDAL* library.

### 3.1.1 Shoreline

Four high-resolution aerial photographs of Tatitlek were downloaded from the DCRA (<http://www.commerce.state.ak.us/dca/profiles/profile-maps.htm>). These photographs were georeferenced to the Prince William Sound coastline using *ArcMap* (e.g., Fig 7). The Prince William Sound coastline was adjusted using the digital photographs as reference to produce a final coastline for Tatitlek (see Fig. 6). The final coastline was subsequently modified to include large offshore rocks and small islets shown on the larger-scale NOAA raster nautical charts (RNCs) and clipped to 0.05 degrees larger than the 8/15 arc-second DEM boundary. Piers and docks were deleted from the coastline.

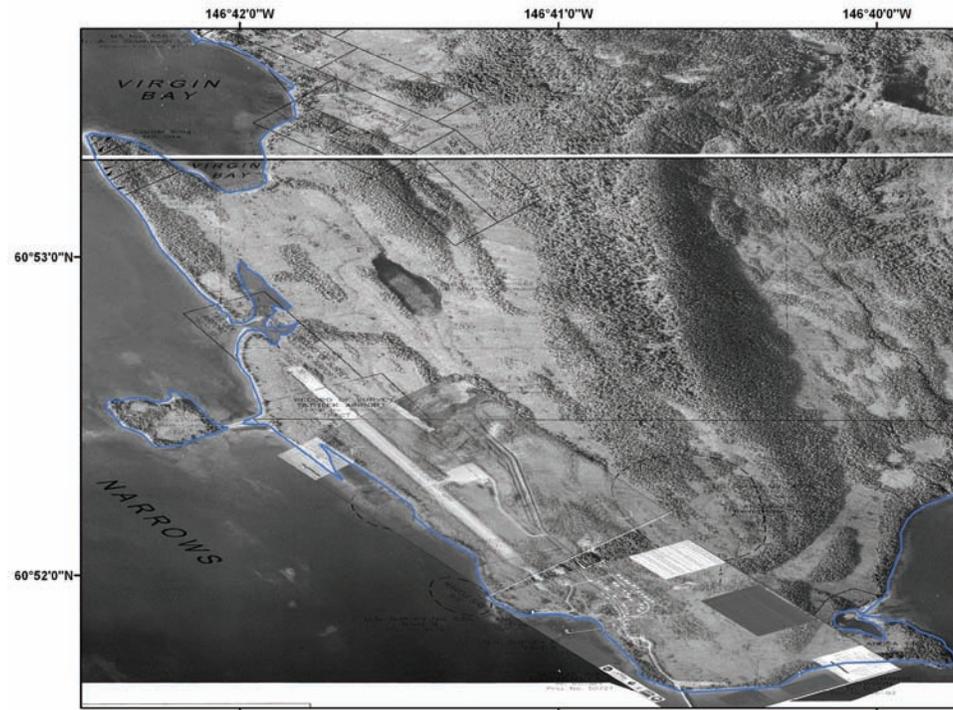


Figure 7. Example of georeferenced DCRA aerial imagery used in developing the final coastline of the Tatitlek region. Final coastline in blue.

### 3.1.2 Bathymetry

Only one additional bathymetric survey was available for use in the compilation of the Tatitlek DEM. NOS hydrographic survey H11743 (2008) was downloaded as a bathymetric attributed grid (BAG) and converted to xyz format using *GDAL*. The original horizontal datum was WGS 84 UTM Zone 6 North and vertical datum was mean lower low water (MLLW). Horizontal were performed with *Proj4*. The vertical transformations were performed using the Prince William Sound ‘MLLW to MHHW’ offset grid (Caldwell et al., 2009) and *GDAL*. The spatial coverage of H11743 did not fall within the 8/15 arc-second DEM extents; however, the depths from the survey were included in the bathymetric surface to provide interpolation control along the edges of the 8/15 arc-second DEM.

### 3.1.3 Topography

A USFS high-resolution stereo digital elevation model (SPOT5) covering the Chugach National Forest area was downloaded from Alaska’s Statewide Digital Mapping Initiative website (Fig. 8; <http://www.alaskamapped.org>). The non-bare-earth, Chugach SPOT5 DEM<sup>7</sup> was downloaded at 20 meter resolution with a vertical datum of altitude above Earth’s Gravitational Model of 1996 (EGM 96) Geoid, and horizontal datum of WGS 84/UTM Zone 6 North. The vertical and horizontal accuracies of the DEM are 10 and 15 meters, respectively, at the 90 percent confidence level.

7. The SPOT5 (Satellite Pour l’Observation de la Terre) is a high-resolution, optical imaging Earth observation satellite system operating from space. SPOT5 was launched on May 4, 2002 and features a high-resolution stereo (HRS) imaging instrument operating in panchromatic mode. The HRS instrument points forward and backward of the satellite. Thus, it is able to take stereopair images almost simultaneously to map relief.

The Chugach SPOT5 DEM was shifted to WGS 84 and MHHW horizontal and vertical datums, respectively, before clipping to the final coastline and converting the grid to xyz using *GDAL*. Values less than 1 meter were then set to 1 meter to eliminate negative values on land. NGDC also reviewed the United States Geological Survey National Elevation Dataset (NED; <http://ned.usgs.gov/>) 2 arc-second gridded topography, the National Aeronautics and Space Administration (NASA) Shuttle Radar Topography Mission (SRTM; <http://srtm.usgs.gov>) 1 arc-second gridded topography, and the 1 arc-second NASA/Japan's Ministry of Economy, Trade, and Industry Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER; <http://asterweb.jpl.nasa.gov/gdem.asp/>) global digital elevation model.

In addition, UAF provided GPS point elevation values from a field survey in Summer 2010 at MHHW vertical datum. To select the most representative topographic dataset for the Tatitlek DEM, NGDC performed an initial analysis to compare the GPS measurements to each topographic dataset. The quality check revealed biases in both the NED and ASTER datasets (Figs. 9 -10). Positive/negative values in Figures 9 -11 indicate under/over-estimated elevations in the topographic DEM.

The USGS NED dataset was derived from USGS quadrangle maps and aerial photographs based on topographic surveys conducted in the 1970s and 1980s. The NED data were not used in the development of the Tatitlek DEM due to: morphological changes in regions of rapid deglaciation across Alaska; lateral shifts in the NED discovered during prior DEM development in Alaska (see Caldwell et al., 2009 for further details); and lower resolution than other available topographic datasets. The SRTM did not provide coverage of the Tatitlek region; and, the ASTER data showed a distinct bias to under-estimate elevations along the coast.

The quality assessment of the SPOT data indicated a near-normal distribution of differences in the histogram with clustering around zero and most errors +/- 4 meters (Fig. 11). Qualitative analysis of the SPOT data indicated gridding artifacts in the form of artificial steps in elevation that were oriented generally from north to south (Fig. 12). This did not appear to impact the quality of the DEM and most steps were on the order of several meters.

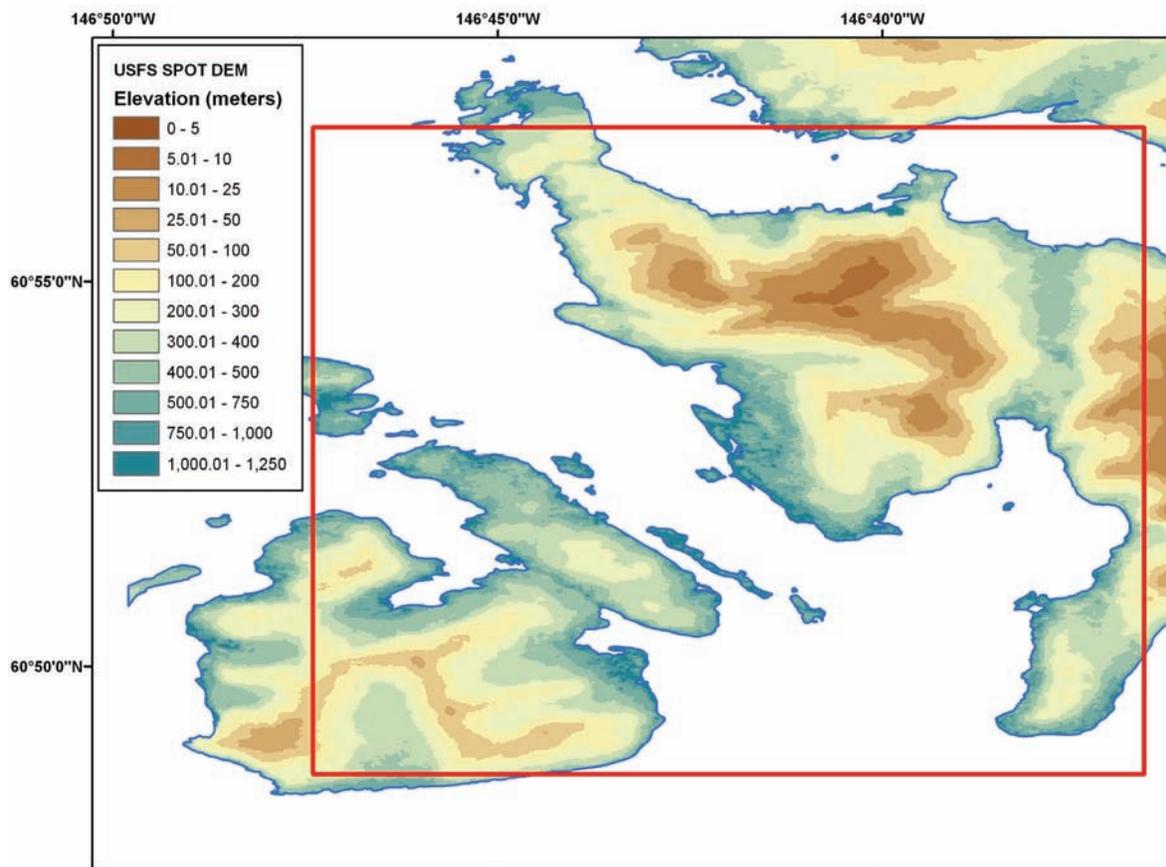


Figure 8. USFS SPOT DEM coverage and elevations in the Tatitlek region. Final coastline in blue. DEM extents in red.

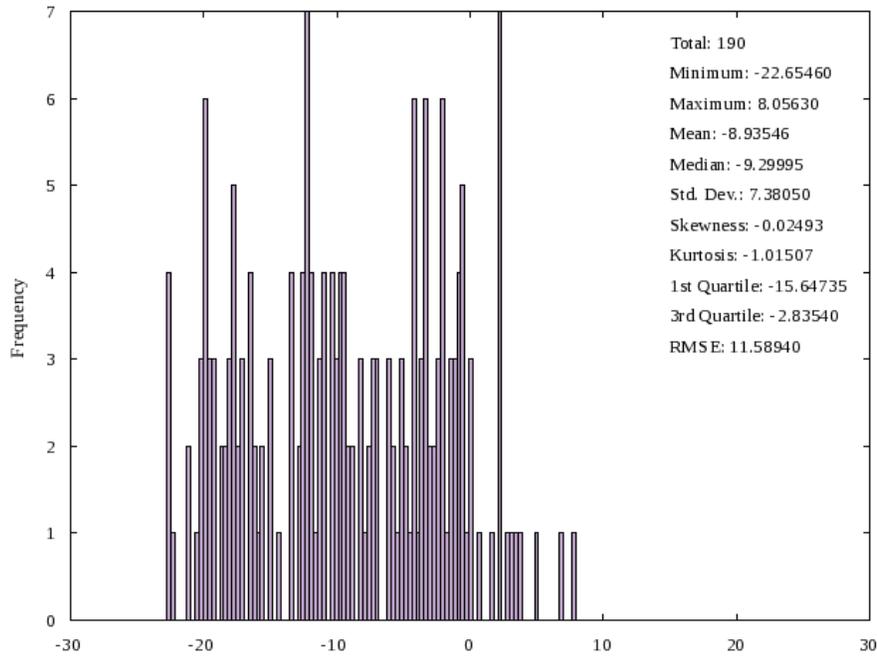


Figure 9. Histogram of the differences between the UAF GPS elevation measurements and the NED topographic DEM. Positive/negative values indicate under/over-estimated elevations in the topographic DEM. The NED generally over-estimates elevations relative to the UAF GPS measurements.

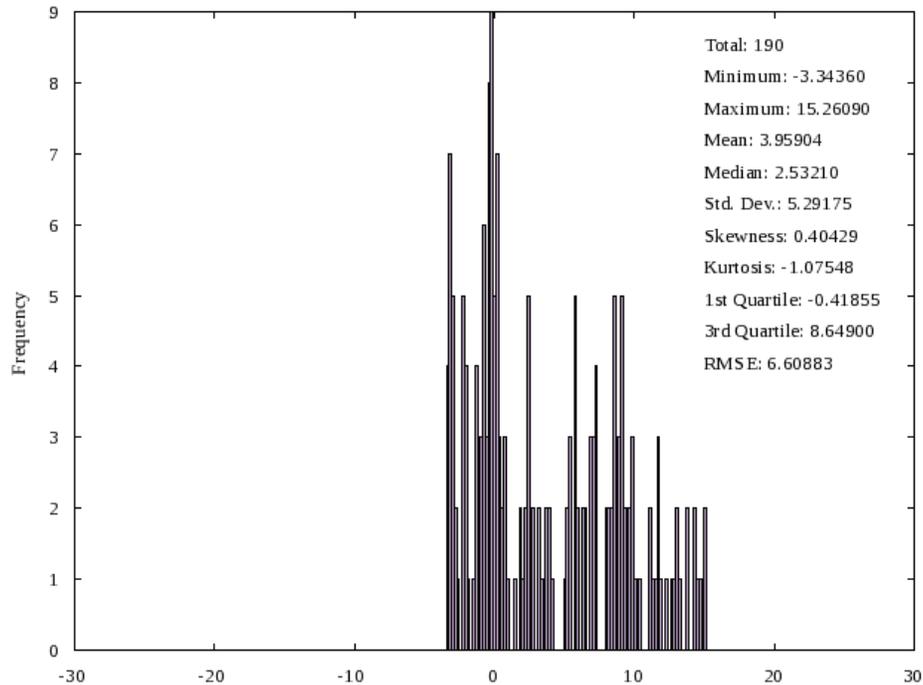


Figure 10. Histogram of the differences between the UAF GPS elevation measurements and the ASTER topographic DEM. Positive/negative values indicate under/over-estimated elevations in the topographic DEM. The ASTER generally under-estimates elevations relative to the UAF GPS measurements.

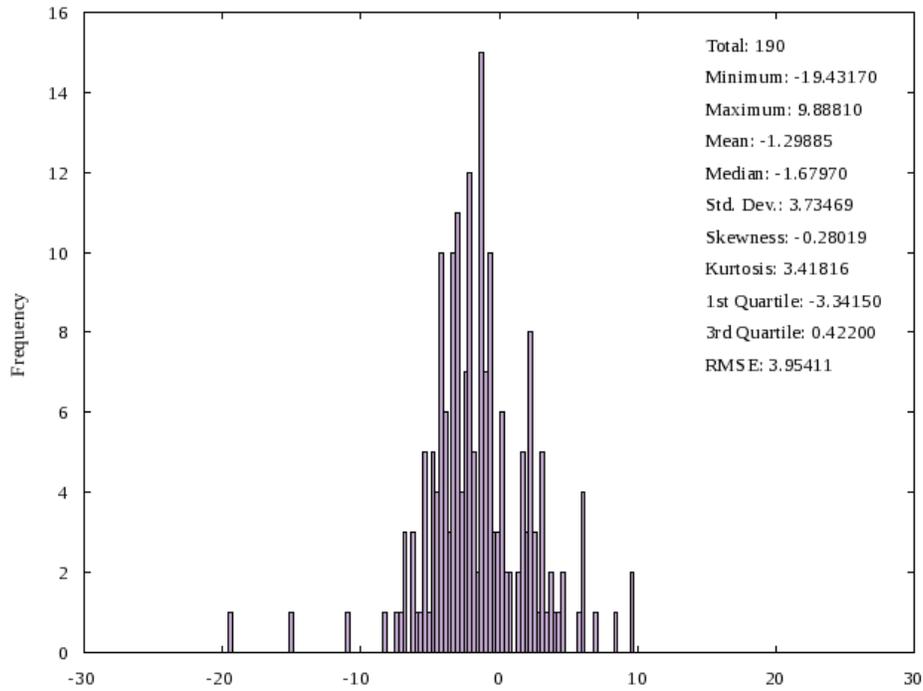


Figure 11. Histogram of the differences between the UAF GPS elevation measurements and the SPOT topographic DEM. Positive/negative values indicate under/over-estimated elevations in the topographic DEM. Differences with the SPOT data cluster around zero with no obvious bias as in the NED and ASTER data.

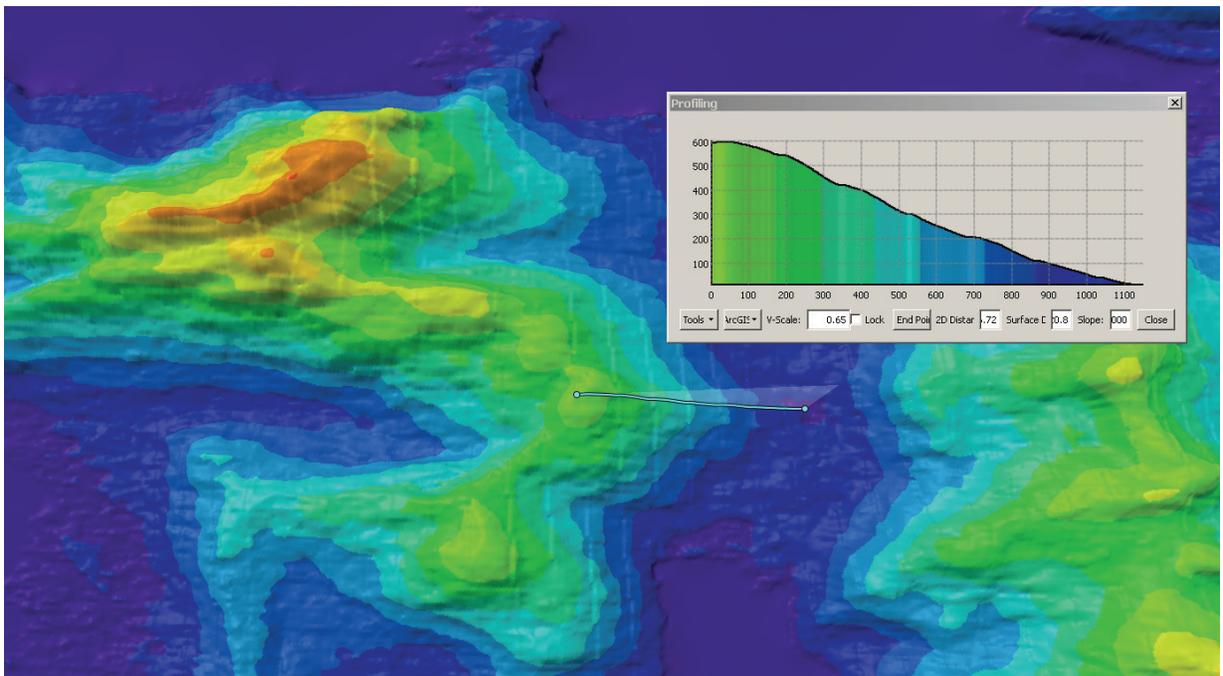


Figure 12. Example of artificial steps in the SPOT DEM. Perspective image of the sample region in the background with profile image indicating artificial steps in the SPOT data. Blue line indicates location of the profile. Images created using Fledermaus.

Due to the steep slopes along the coastline in some regions of the Tattilek DEM, the spline interpolation generated small regions of negative elevations onshore. To correct this issue, NGDC digitized points (see Fig. 6) with elevation values of 1 meter to better represent the actual morphology in these locations by mitigating the introduction of interpolation artifacts in the grid.

NGDC also digitized points to represent the airport in Tattilek (Fig. 13). The GPS elevations provided by UAF were used to generate a 1 arc-second interpolation grid using the inverse distance weighting (IDW) tool in *Arc-Map*. The IDW grid was converted to xyz format and then clipped to a polygon representing the airport using GDAL. The SPOT data were subsequently removed from the same region to avoid gridding artifacts due to overlapping data-sets of different resolutions and quality.

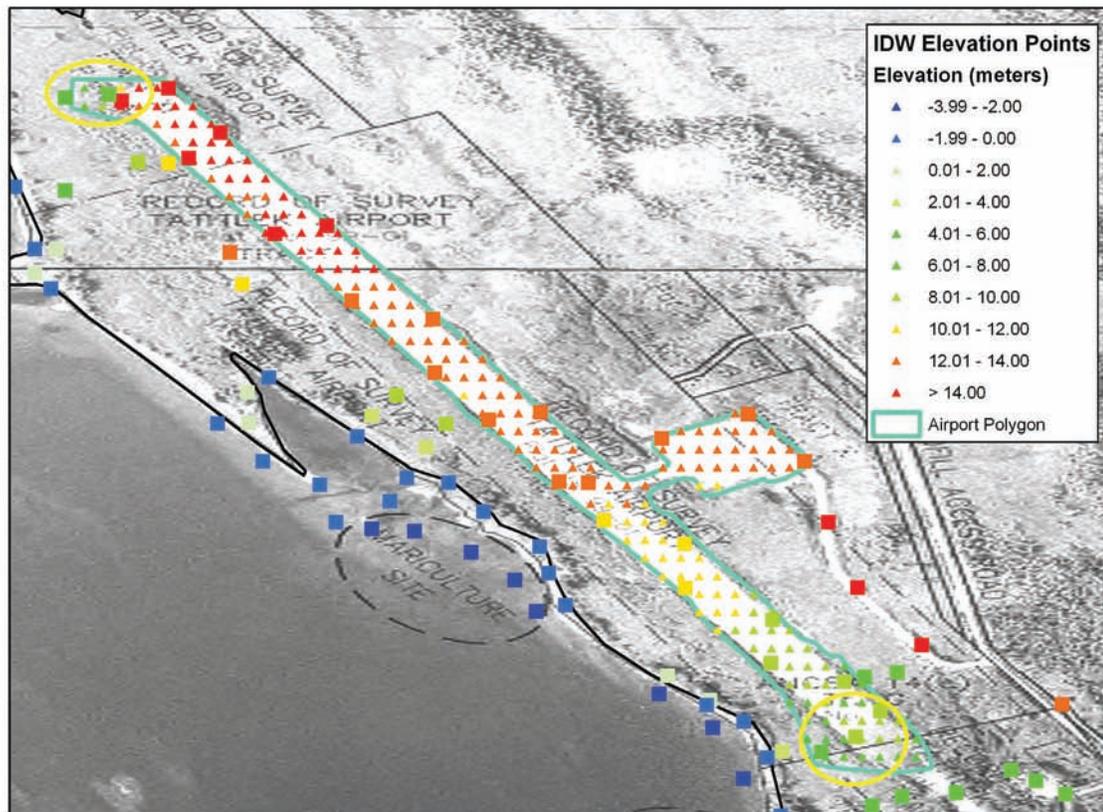


Figure 13. Interpolated points at Tattilek. Elevation points from the inverse distance weighting (triangles) and UAF GPS measurements (squares) are shown in same color scale. The interpolated points have been clipped to the airport polygon (light blue). The yellow circles indicate areas of steep slopes that were included in the airport region. The polygon was also used to remove the SPOT data from the final gridding. DCRA imagery is in the background. Coastline is shown in black.

## 3.2 Establishing Common Datums

### 3.2.1 Vertical datum transformations

Datasets used in the compilation and evaluation of the Tatitlek DEM were originally referenced to a number of vertical datums including MLLW (meters) and EGM 96 Geoid (assumed to be mean sea level (MSL)). All datasets were transformed to MHHW for modeling of maximum flooding. Vertical datum transformations to MHHW were accomplished using *FME* and *GDAL*, and the offset grids developed for the Prince William Sound DEMs.

#### 1) Bathymetric data

The NOS BAG survey was transformed from MLLW to MHHW by adding the corresponding grid value to the point elevation value using *GDAL*.

#### 2) Topographic data

The SPOT topographic dataset was originally referenced to the EGM 96 Geoid. There are no survey markers in the vicinity of Tatitlek that relate the geodetic datum to local tidal datums. Therefore, it was assumed that the datum is essentially equivalent to MSL in this area. Conversion to MHHW, using *GDAL*, was accomplished by adding the 'MSL to MHHW' offset grid. Values less than 1 meter following the conversion were set equal to 1 meter, as the SPOT data are in integer format.

### 3.2.2 Horizontal datum transformations

Datasets used to compile the Tatitlek DEM were originally referenced to WGS 84/UTM Zone 6 North. The relationships and transformational equations between the horizontal datums are well established. Transformations to NAD 83 geographic were accomplished using *Proj4*.

### 3.3 Digital Elevation Model Development

#### 3.3.1 Verifying consistency between datasets

After horizontal and vertical transformations were applied, the resulting ESRI shapefiles were checked in *ArcMap* and *QT Modeler* for inter-dataset consistency. Problems and errors were identified and resolved before proceeding with subsequent gridding steps. The evaluated and edited ESRI shapefiles were then converted to xyz files in preparation for gridding. Problems included:

- Inconsistent, overlapping high-resolution bathymetric datasets. Older datasets were clipped to newer datasets when possible. Datasets were weighted based on quality and year during the gridding process.
- Data values over the ocean in the SPOT DEM dataset. The dataset required automated clipping to the final coastline or were edited manually.
- Steep slopes in the SPOT DEM along coastal areas led to interpolation artifacts in the DEM. NGDC digitized elevation points to provide additional control to mitigate negative values in onshore locations.

#### 3.3.2 Smoothing of bathymetric data

The older hydrographic survey data are generally sparse at the resolution of the DEM in both deep water and in some areas close to shore. In order to reduce the effect of artifacts in the form of lines or “pimples” in the DEM due to the low resolution datasets, and to provide effective interpolation into the coastal zone, ‘pre-surface’ bathymetric grids in MHHW vertical datum were generated using *GMT*<sup>8</sup>, an NSF-funded software application designed to manipulate data for mapping purposes (<http://gmt.soest.hawaii.edu/>). Additional information on the methodology to develop a pre-surface bathymetric grid can be found in Caldwell et al. (2009).

#### 3.3.3 Quality Assessment of the Bathymetric Surface

The bathymetric surface was compared with the original soundings to ensure grid accuracy, and then exported as an xyz file for use in the final gridding process. The statistical analyses of the differences between the 8/15 arc-second bathymetric surface at Tatitlek with the NOS hydrographic surveys show that the majority of the surveys are in good agreement (Fig. 14) with the bathymetric surface. The few exceptions where the differences reached up to 136.62 meters are attributed primarily to overlapping datasets. These differences are consistent with the chart comparison in the NOS descriptive report for survey H11351 (<http://surveys.ngdc.noaa.gov/mgg/NOS/coast/H10001-H12000/H11351/DR/H11351.pdf>), which indicates differences up to 47 fathoms (~86 meters) between older and newer surveys. In addition, large differences also occurred where two or more closely positioned points were averaged to obtain the elevation of one grid cell. Some inconsistencies were identified while merging the bathymetric datasets due to the range in ages and resolutions of the surveys. In areas where more recent data were available, the older surveys were either edited or not used. The gridded bathymetric surface was then converted to an xyz file for use in building the final DEM.

8. *GMT* is an open source collection of ~60 tools for manipulating geographic and Cartesian data sets (including filtering, trend fitting, gridding, projecting, etc.) and producing Encapsulated PostScript File (EPS) illustrations ranging from simple x-y plots via contour maps to artificially illuminated surfaces and 3-D perspective views. *GMT* supports ~30 map projections and transformations and comes with support data such as GSHHS coastlines, rivers, and political boundaries. *GMT* is developed and maintained by Paul Wessel and Walter H. F. Smith with help from a global set of volunteers, and is supported by the National Science Foundation. It is released under the GNU General Public License. URL: <http://gmt.soest.hawaii.edu/> [Extracted from *GMT* web site.]

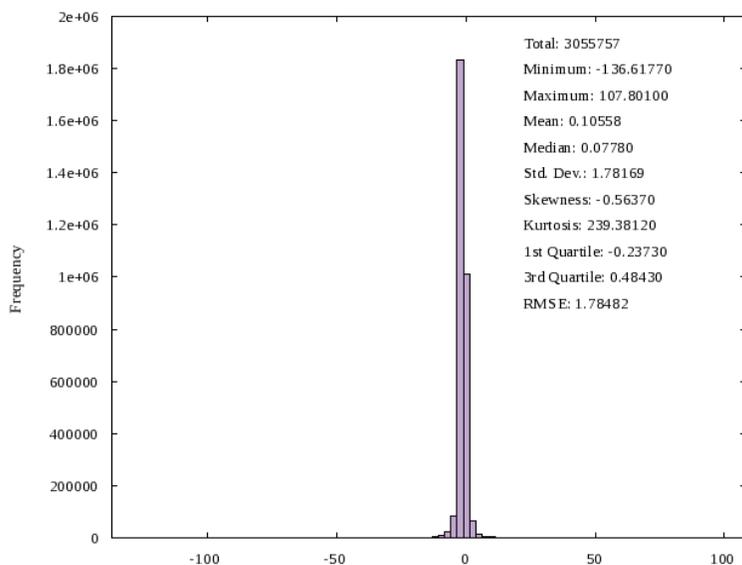


Figure 14. Histogram of the differences between NOS hydrographic surveys and the 8/15 arc-second pre-surfaced bathymetric grid.

### 3.3.4 Building the DEM using MB-System

*MB-System*<sup>9</sup> was used to create the Tatitlek DEM. The *MB-System* tool ‘mbgrid’ was used to apply a tight spline tension to the xyz data, and interpolate values for cells without data. The data hierarchy used in the ‘mbgrid’ gridding algorithm, as relative gridding weights, is listed in Table 2. For Tatitlek, greatest weight was given to the NOS BAG data and the NGDC digitized features. Least weight was given to the pre-surfaced bathymetric grid. Only those datasets denoted with an ‘\*’ were used to compile the Tatitlek DEM.

Table 2. Data hierarchy used to assign gridding weight in *MB-System*.

Dataset	Relative Gridding Weight
USACE surveys	100
USGS NED topographic DEM	100
ENC soundings	100
NGDC digitized features *	100
UAF Valdez DEM	100
NOS BAG H11743 *	100
SPOT topographic DEM *	10
SRTM topographic DEM	10
NOS hydrographic surveys *	10
Final coastline *	10
Higher resolution DEMs	10
NGDC hydrographic sonar multibeam	10
Pre-surfaced bathymetric grid *	1
Trackline soundings	0.1

\* indicates supplemental datasets used in compiling the Tatitlek DEM.

9. *MB-System* is an open source software package for the processing and display of bathymetry and backscatter imagery data derived from multibeam, interferometry, and sidescan sonars. The source code for *MB-System* is freely available (for free) by anonymous ftp (including “point and click” access through these web pages). A complete description is provided in web pages accessed through the web site. *MB-System* was originally developed at the Lamont-Doherty Earth Observatory of Columbia University (L-DEO) and is now a collaborative effort between the Monterey Bay Aquarium Research Institute (MBARI) and L-DEO. The National Science Foundation has provided the primary support for *MB-System* development since 1993. The Packard Foundation has provided significant support through MBARI since 1998. Additional support has derived from SeaBeam Instruments (1994-1997), NOAA (2002-2004), and others. URL: <http://www.ldeo.columbia.edu/res/pi/MB-System/> [Extracted from *MB-System* web site.]

### 3.4 Quality Assessment of the DEM

#### 3.4.1 Horizontal accuracy

The horizontal accuracy of topographic and bathymetric features in the Tatitlek DEM is dependent upon DEM cell size and source datasets. Topographic features have an estimated horizontal accuracy equivalent to that of the SPOT data, ~15 meters. Bathymetric features are resolved only to within a few hundreds of meters in deep-water areas. Shallow, near-coastal regions, rivers, and harbor surveys have an accuracy approaching that of sub-aerial topographic features. Positional accuracy is limited by the sparseness of deep-water soundings and potentially large positional uncertainty of pre-satellite navigated (e.g., GPS) NOS hydrographic surveys.

#### 3.4.2 Vertical accuracy

Vertical accuracy of elevation values in the Tatitlek DEM is also dependent upon the source datasets contributing to DEM cell values. Topographic data have a stated vertical accuracy of approximately 10 meters for the SPOT DEM, though a comparison with the UAF GPS elevations indicated an accuracy of 1-2 meters. Bathymetric values have an estimated accuracy between 0.1 meters and 5% of water depth. Those values were derived from the wide range of sounding measurements from the early 20<sup>th</sup> century to recent, GPS-navigated multibeam swath sonar survey. Gridding interpolation to determine bathymetric values between sparse, poorly located NOS soundings degrades the vertical accuracy of elevations in deep water.

#### 3.4.3 Slope map and 3-D perspectives

ESRI *ArcCatalog* was used to generate a slope grid from the 8/15 arc-second Tatitlek DEM to allow for visual inspection and identification of artificial slopes along boundaries between datasets (Fig. 15). The DEM was transformed to NAD 83 UTM Zone 6 North coordinates (horizontal units in meters) in *ArcCatalog* for derivation of the slope grid; equivalent horizontal and vertical units are required for effective slope analysis. Analysis of preliminary grids using *QT Modeler* and *Fledermaus* revealed suspect data points, which were corrected before recompiling the DEM. Again, the north-south oriented, artificial steps in the SPOT data are clearly visible in the slope analysis. Figure 1 shows a color image of the 8/15 arc-second Tatitlek DEM in its final version. Figure 16 shows a perspective rendering of the final 8/15 arc-second Tatitlek DEM.

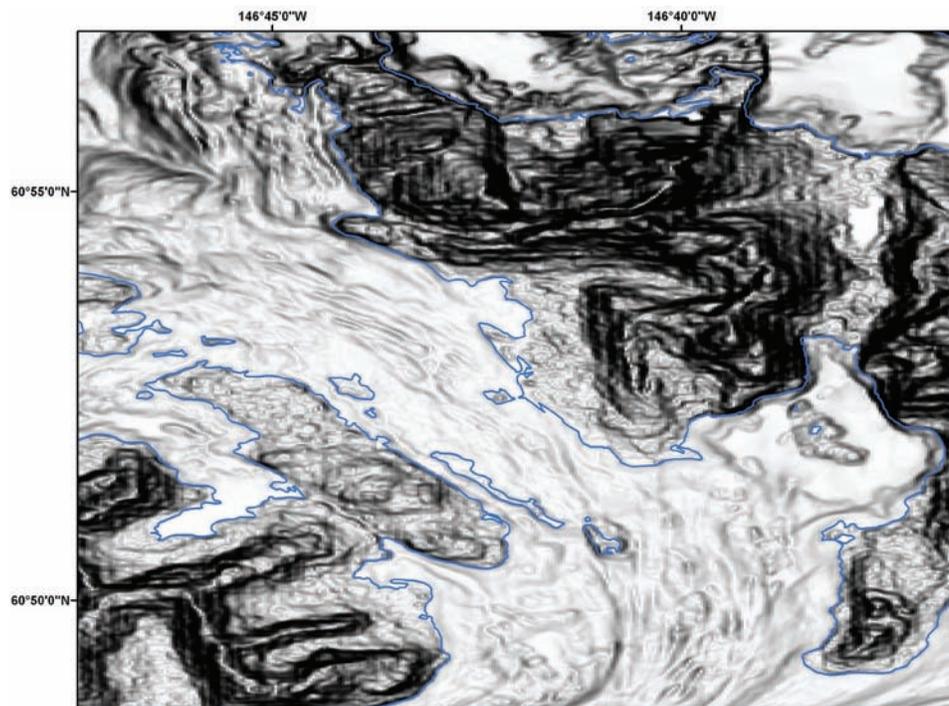
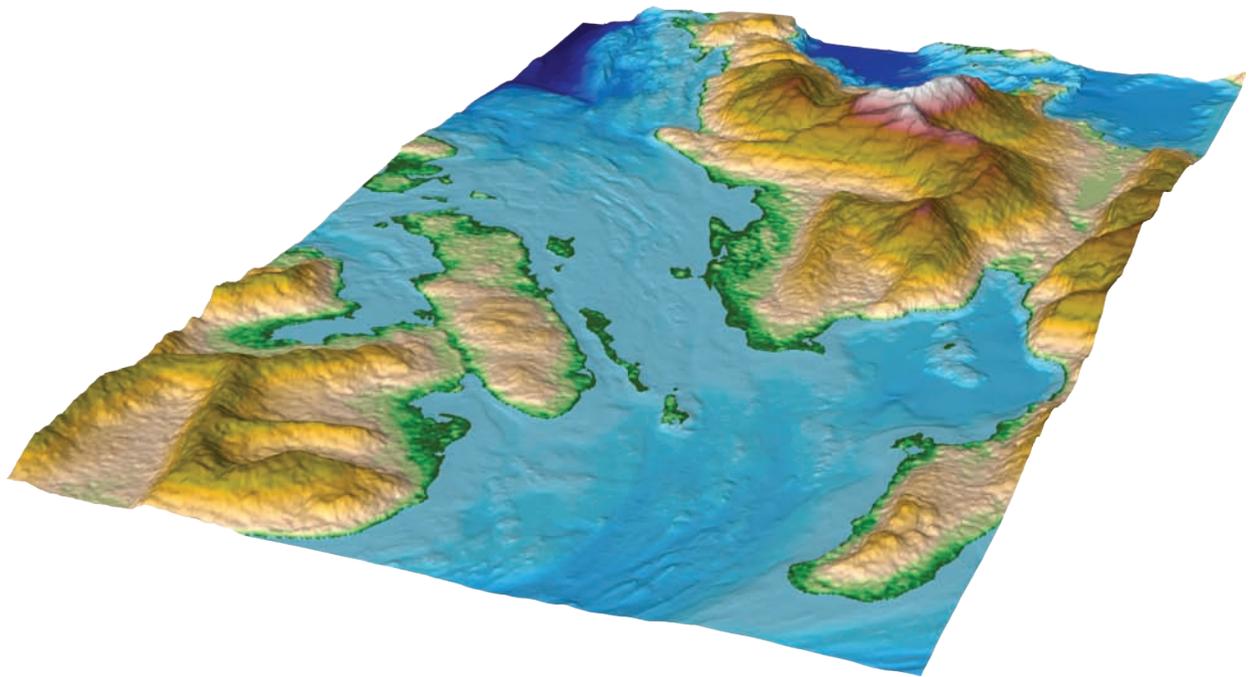


Figure 15. Slope map of the 8/15 arc-second Tatitlek DEM. Flat-lying slopes are shown in white; dark shading denotes steep slopes; final coastline indicated in blue. Steepest slopes exist over land.



*Figure 16. Perspective view from the northeast of the 8/15 arc-second Tatitlek DEM. No vertical exaggeration.*



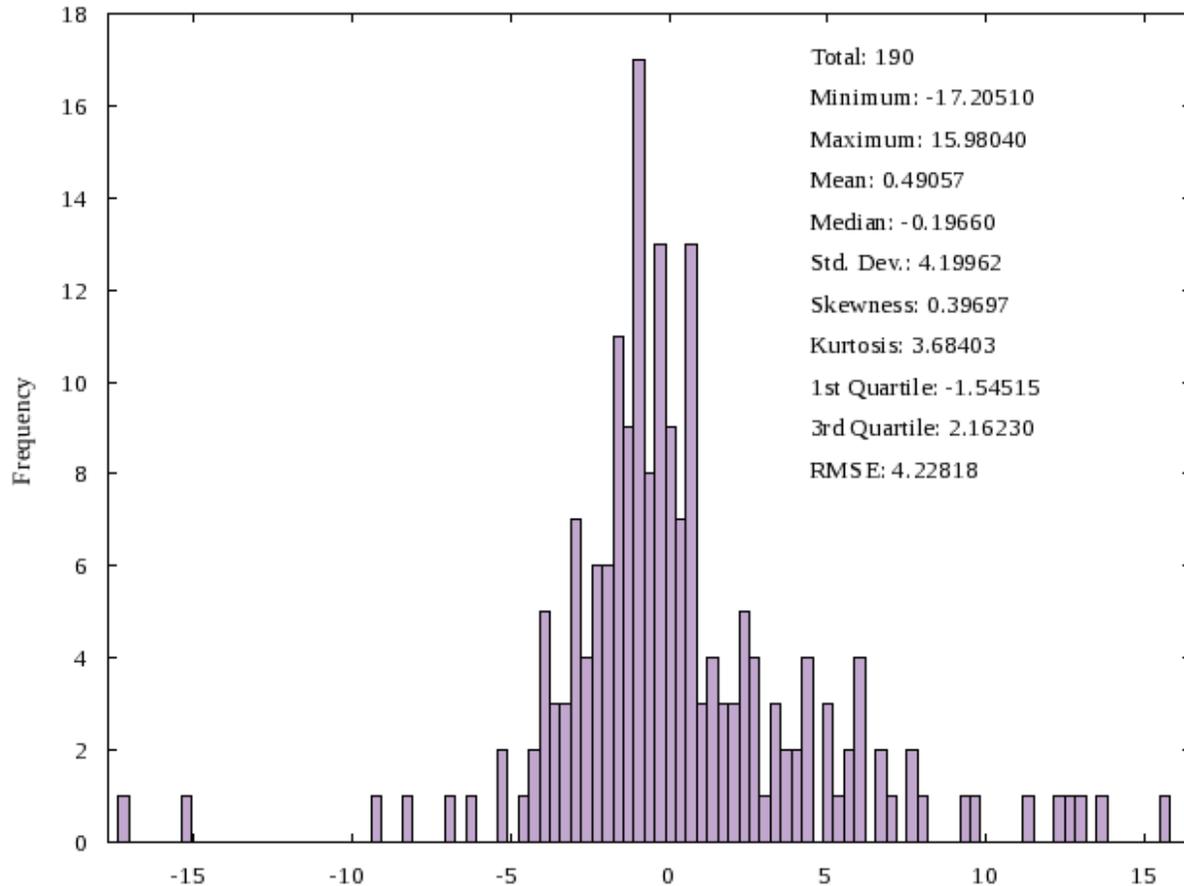


Figure 18. Histogram of the differences between UAF GPS elevations and the 8/15 arc-second Tatitlek DEM.

### 3.4.5 Comparison with NOAA Raster Nautical Charts

Elevations were also compared against five raster nautical charts (RNCs) in the area, including: 531, 16013, 16700, 16707, and 16708. Manual inspection of the DEM elevations revealed only small differences from elevations indicated on the RNCs. For complete reference information on these RNCs, see the Caldwell et al. (2009) report on the Prince William Sound DEMs.

#### 4. SUMMARY AND CONCLUSIONS

An integrated bathymetric–topographic digital elevation model of the Tatitlek, Alaska region, with a cell size of 8/15 arc-second, was developed for the National Tsunami Hazard Mitigation Program in support of the State of Alaska’s tsunami inundation modeling efforts led by the Geophysical Institute at the University of Alaska at Fairbanks. The best available digital data from U.S. federal, state, local, and academic agencies were obtained by NGDC, shifted to common horizontal and vertical datums, and evaluated and edited before DEM generation. The data were quality checked, processed and gridded using ESRI *ArcGIS*, ESRI *ArcGIS World Imagery 2-D*, *FME*, *Fledermaus*, *GMT*, *MB-System*, *QT Modeler*, *GDAL*, *OGR*, *Proj4*, and *VDatum* software.

Recommendations to improve the Tatitlek DEM, based on NGDC’s research and analysis, are listed below:

- Conduct high-resolution topographic surveys, including lidar, of the Tatitlek region.
- Establish, via survey, relationships between tidal and geodetic datums in the Tatitlek region.
- Correct horizontal shift evident in the NED data and process SPOT and ASTER data to bare earth.

#### 5. ACKNOWLEDGMENTS

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#### 6. REFERENCES

Caldwell, R.J., B.W. Eakins, and E. Lim, 2011. Digital Elevation Models of Prince William Sound, Alaska: Procedures, Data Sources, and Analysis, U.S. Department of Commerce, NOAA Technical Memorandum, NESDIS, NGDC-40.

Descriptive Report to Accompany Hydrographic Survey H11351, 2004. Approaches to Valdez Arm and Tatitlek Narrows. Scale 1:10,000. U.S. Department of Commerce, NOAA, National Ocean Service, Project OPR-P132-RA-04, <http://surveys.ngdc.noaa.gov/mgg/NOS/coast/H10001-H12000/H11351/DR/H11351.pdf>.

## 7. DATA PROCESSING SOFTWARE

ArcGIS v. 9.3.1 – developed and licensed by ESRI, Redlands, California, <http://www.esri.com/>.

ESRI World Imagery (ESRI\_Imagery\_World\_2D) – ESRI ArcGIS Resource Centers <http://resources.esri.com/arcgisonlineservices/>.

FME 2010 GB – Feature Manipulation Engine, developed and licensed by Safe Software, Vancouver, BC, Canada, <http://www.safe.com/>.

Fledermaus v. 7.0.0 – developed and licensed by Interactive Visualization Systems (IVS 3D), Fredericton, New Brunswick, Canada, <http://www.ivs3d.com/products/fledermaus/>

GDAL v. 1.7.1 – Geographic Data Abstraction Library is a translator library maintained by Frank Warmerdam, <http://gdal.org/>.

GEODAS v. 5 – Geophysical Data System, freeware developed and maintained by Dan Metzger, NOAA National Geophysical Data Center, <http://www.ngdc.noaa.gov/mgg/geodas/>.

GMT v. 4.3.4 – Generic Mapping Tools, freeware developed and maintained by Paul Wessel and Walter Smith, funded by the National Science Foundation, <http://gmt.soest.hawaii.edu/>.

Gnuplot v. 4.2, free software developed and maintained by Thomas Williams, Colin Kelley, Russell Lang, Dave Kotz, John Campbell, Gershon Elber, Alexander Woo, <http://www.gnuplot.info/>.

MB-System v. 5.1.0 – shareware developed and maintained by David W. Caress and Dale N. Chayes, funded by the National Science Foundation, <http://www.ldeo.columbia.edu/res/pi/MB-System>

Proj4 v. 4.7.0, free software developed by Gerald Evenden and maintained by Frank Warmerdam, <http://trac.osgeo.org/proj/>.

Quick Terrain Modeler v. 7.0.0 – LiDAR processing software developed by John Hopkins University’s Applied Physics Laboratory (APL) and maintained and licensed by Applied Imagery, <http://www.appliedimagery.com/>.

VDatum Transformation Tool, developed and maintained by NOAA’s National Geodetic Survey (NGS), Office of CoastSurvey (OCS), and Center for Operational Oceanographic Products and Services (CO-OPS), <http://vdatum.noaa.gov/>.

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