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BASELINE OBSERVATIONS AND MODELING FOR THE REEDSPORT WAVE ENERGY SITE, DOUGLAS COUNTY, OREGON: MONITORING BEACH AND SHORELINE MORPHODYNAMICS

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(cover image) Development of an erosion scarp along the north Umpqua Spit as a result of the seasonal increase in wave energy during the 2009/2010 winter. Photo taken on January 25th, 2010 by Jonathan Allan.

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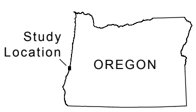
INTRODUCTION

The wave climate offshore the Pacific Northwest (PNW) coasts of Oregon and Washington has been identified as a potential environment for the establishment of wave energy devices that can be used to harness the energy potential provided by ocean waves. Because wave energy arrays by definition will remove a portion of the energy of the waves and will create a shadow region of lower wave energy landward of the devices, there remain concerns about the potential effects such devices may have on the morphodynamics of beaches adjacent to wave energy farms.

To understand the potential effects of wave energy arrays on sediment transport processes, a collaborative team of investigators from Oregon State University (OSU) and the Oregon Department of Geology and Mineral Industries (DOGAMI) initiated a field-based monitoring program in May 2009 in order to begin documenting the natural variability of the beach, nearshore, and wave climate adjacent to the proposed Ocean Power Technology (OPT) Reedsport wave energy site, located offshore from the north Umpqua Spit, Douglas County, Oregon. Core elements of the monitoring program included measurements of the waves and currents in the vicinity of the planned wave energy array, numerical modeling of the background wave climate, and nearshore bathymetry and shoreline observations to document the baseline conditions at the project site (Ozkan-Haller and others, 2009). Phase 1 of the project (funded by the Oregon Wave Energy Trust [OWET]), focused on documenting baseline conditions at the Reedsport OPT site, commenced in May 2009 and concluded on December 31, 2009. Early in 2010, additional funding was provided by OWET that enabled the period of baseline data collection to be extended over the latter half of the 2009/2010 winter and throughout spring and early summer, capturing one full year of beach and nearshore observations.



This report describes and summarizes baseline observations from one component of the observation program focused on monitoring the response of the beach and shorelines along approximately 16 km of the north Umpqua Spit shoreline.

METHODOLOGY

Approaches for Monitoring Beaches

Beach profiles orientated perpendicular to the shoreline can be surveyed using a variety of approaches, including a simple graduated rod and chain, surveying level and staff, total station theodolite and reflective prism, light detection and ranging (lidar) airborne altimetry, and real-time kinematic differential Global Positioning System (RTK-DGPS) technology. Traditional techniques such as leveling instruments and total stations are capable of providing accurate representations of the morphology of a beach but are demanding in terms of time and effort. At the other end of the spectrum, high-resolution topographic surveys of the beach derived from lidar are ideal for capturing the three-dimensional state of the beach over an extended length of coast within a matter of hours. Other forms of lidar technology are now being used to measure nearshore bathymetry out to moderate depths, but these are dependent on water clarity. Lidar technology remains expensive and is impractical along small segments of shore and, more importantly, the high cost effectively limits the temporal resolution of the surveys and hence the ability of the end-user to understand short-term changes in the beach morphology (Bernstein and others, 2003).

Within the range of surveying technologies, the application of RTK-DGPS for surveying the morphology of both the subaerial and subaqueous portions of the beach has effectively become the accepted standard (Bernstein and others, 2003; Ruggiero and others, 2005; Allan and Hart, 2007) and is the surveying technique used in this study. The Global Positioning System (GPS) is a worldwide radio-navigation system formed from a constellation of 30 satellites and their ground stations, originally developed by the U.S. Department of Defense. In its simplest form, GPS can be thought of as triangulation with the GPS satellites acting as reference points, enabling users to calculate their positions to within several meters (e.g., with off-the-shelf hand-held units) or enabling users to calculate positional and elevation measurements that are accurate to a centimeter (e.g., with survey-grade GPS units). At least four satellites are needed to determine mathematically an exact position, although more satellites are generally available. The process is complicated because all GPS receivers are subject to error, which can significantly degrade the accuracy of the derived position. These errors include the GPS satellite orbit and clock drift plus signal delays caused by the atmosphere and ionosphere and multipath effects (where the signals bounce off features and create a poor signal). For example, hand-held autonomous receivers have positional accuracies that are typically less than about 10 m (<~30 ft), but accuracies can be improved to less than 5 m (<~15 ft) using the Wide Area Augmentation System (WAAS). This latter system is essentially a form of differential correction that accounts for the above errors, which is then broadcast through one of two geostationary satellites to WAAS-enabled GPS receivers.

Greater survey accuracies are achieved with differential GPS (DGPS) using two or more GPS receivers to simultaneously track the same satellites, enabling comparisons to be made between two sets of observations. One receiver is typically located over a known reference point, and the position of an unknown point is determined relative to that reference point. With the more sophisticated 24-channel dual-frequency RTK-DGPS receivers, positional accuracies can be improved to the subcentimeter level when operating in static mode and to within a few centimeters when in RTK mode (i.e., as the rover GPS is moved about). In this study we used a Trimble® 24-channel dual-frequency 5700/5800 GPS, which consists of a GPS base station (5700 unit), Zephyr Geodetic™ antenna, HPB450 radio modem, and 5800 "rover" GPS (Figure 1). Trimble reports that 5700/5800 GPS systems have horizontal errors of approximately ±1 cm + 1 ppm (parts per million × the baseline length) and ±2 cm in the vertical (Trimble, 2005).

To convert a space-based positioning system to a ground-based local grid coordinate system, a precise mathematical transformation is necessary. While some of these adjustments are accomplished by specifying the map projection, datum, and geoid model prior to commencing a field survey, an additional transformation is necessary whereby the GPS measurements are tied to known ground control points. This latter step is called a *GPS site calibration*, such that the GPS measurements are calibrated to ground control points with known vertical and horizontal coordinates using a rigorous least-squares adjustments procedure. Calibration is initially undertaken in the field using the Trimble TSC2™ GPS controller and then re-evaluated in the office using Trimble's Geomatics Office™ software. However, in order to undertake such a transformation, it is necessary either to locate pre-existing monuments used by surveyors or to establish new monuments in the project area that can be tied to an existing survey network.

Survey Benchmarks and GPS Control

In order to establish a dense GPS beach monitoring network, we initially identified the approximate locations of the profile sites used in this study in a Geographical Information System (GIS). A reconnaissance trip was undertaken in late April 2009 with the objectives of:

1. Locating existing survey benchmarks in the vicinity of the field site;
2. Field checking potential new survey benchmark locations and installing these in the vicinity of the beach; and,
3. Laying out and initiating the first survey of the beach monitoring network.

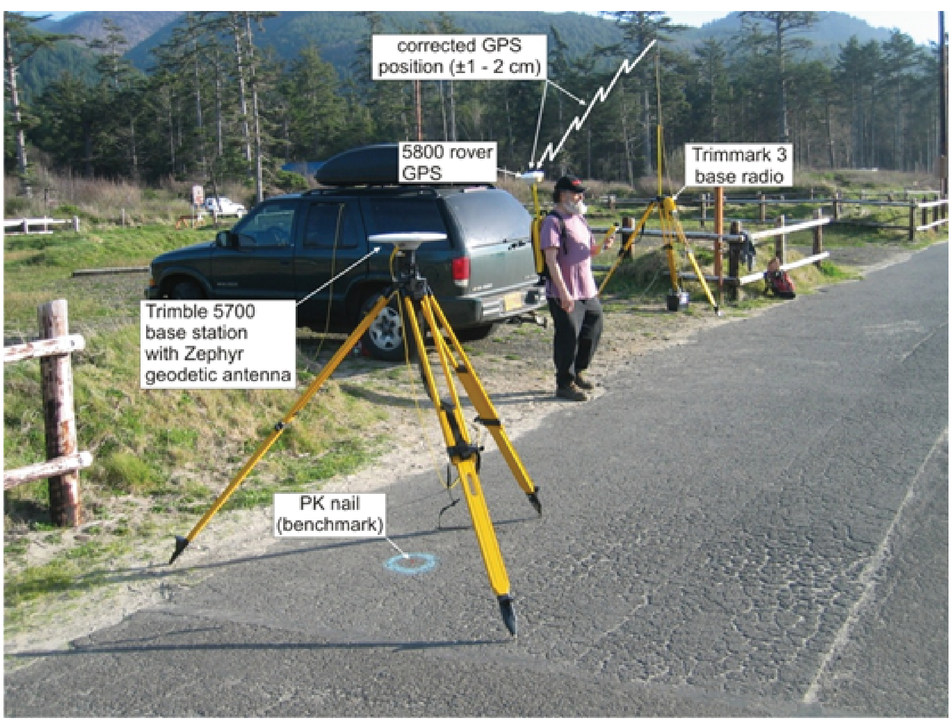


Figure 1. The Trimble 5700 base station antenna located over a known reference point at Cape Lookout State Park. Corrected GPS position and elevation information is then transmitted by a radio modem to the 5800 GPS rover unit.

Figure 2 shows the general layout of the final survey network, which consists of 26 profiles sites spaced approximately 500 m apart and extending from the north Umpqua jetty in the south to Tahkenitch Creek in the north. As can be seen in the figure, three permanently monumented survey benchmarks were established by DOGAMI that serve as GPS control for the beach profile surveys, bathymetry survey[1], and rectification of Argus[2] video imagery. The benchmarks (OWET 1–3) were installed on April 26, 2009

1 Surveys of the bathymetry were undertaken on two separate occasions (July 6–9, 2009 and July 13–17, 2010) by Dr. Peter Ruggiero, Department of Geosciences, Oregon State University, Corvallis, Oregon.

2 Argus video images were collected by Dr. Robert Holman, College of Oceanic and Atmospheric Sciences, Oregon State University, Corvallis, Oregon.

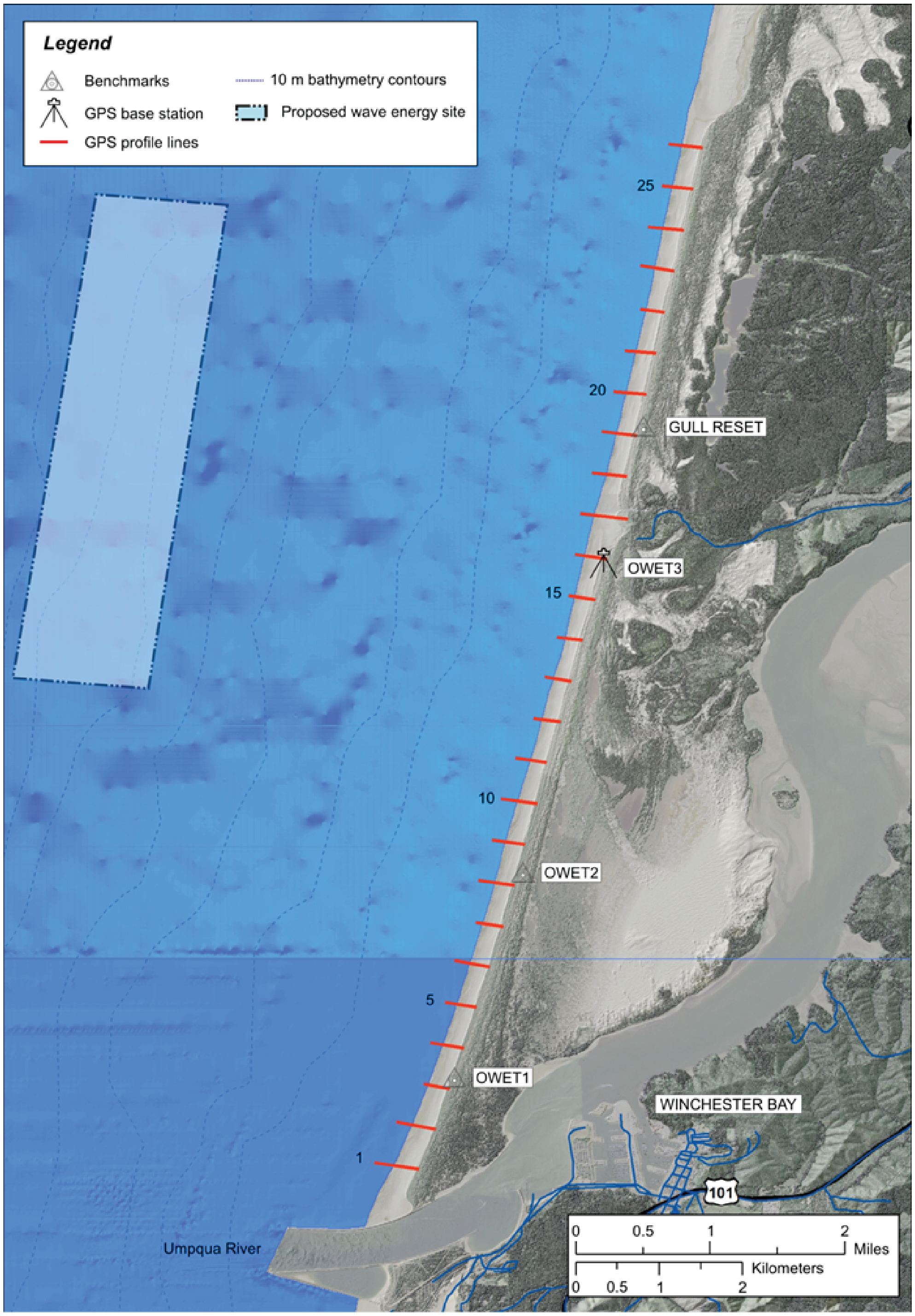


Figure 2. Map showing the location of the study site, beach monitoring network, and DOGAMI survey monuments.

Figure 3. A) Installation of survey benchmarks involved digging a 1 m (3 ft) deep (10-inch diameter) hole, B) hammering sectional aluminum rods to depths of 4–8 m (12–24 ft), then C) capping the rods and concreting in place. D) GPS observation of the OWET 1 survey monument. E) Site calibration is performed on the OWET 2 benchmark using the Trimble TSC2 controller.

and were constructed by first digging 1-m deep, 10-inch diameter, holes, into which aluminum sectional rods were inserted and hammered to additional depths of approximately 4–8 m (12–24 ft; Figures 3A and 3B). The rods were then capped with a 2½-inch aluminum cap (Oregon Department of Geology and Mineral Industries stamp on top), and concreted in place (Figure 3C).

Survey control along the north Umpqua Spit shore was initially established by occupying two Watershed Sciences benchmarks[3] and one National Geodetic Survey (NGS) monument (Table 1). Additional survey control and field checking was provided using the Online Positioning User Service (OPUS) maintained by the NGS (http://www.ngs.noaa.gov/OPUS/). OPUS provides a simplified way to access high-accuracy National Spatial Reference System (NSRS) coordinates using a network of continuously operating GPS reference stations (CORS, http://www.ngs.noaa.gov/CORS/). In order to use OPUS, static GPS measurements are typically made using a fixed height tripod for periods of 2 hours or greater (Figure 3D). OPUS returns a solution report with positional accuracy confidence intervals for adjusted coordinates and elevations for the observed point. In all cases we used the Oregon State Plane coordinate system, southern zone (meters), and the North American Vertical Datum of 1988 (NAVD88).

3 As part of calibrating the collection of lidar data on the southern Oregon coast in 2008, Watershed Sciences, Inc., Corvallis, Oregon, established numerous survey monuments on the south coast. Coordinates assigned to these monuments were derived from multi-hour occupations of the monuments and were processed using the Online Positioning User Service (OPUS) maintained by the NGS. (http://www.ngs.noaa.gov/OPUS/). In many cases the same benchmarks were observed multiple times and the horizontal and vertical coordinates were continually updated.

Table 1. Survey benchmarks used to initially calibrate GPS surveys of the beach near Reedsport.

Name	Northing (m)	Easting (m)	Elevation (m)
6NCM2 - WS	232574.125	1209536.395	5.498
6NCM1 - WS	257724.630	1215506.527	66.410
SOOS - NGS	252644.942	1209669.065	5.500

NGS denotes National Geodetic survey monument, WS denotes Watershed Sciences monument.

For the initial Reedsport survey, the 5700 GPS base station was located on the OWET1 monument (Figure 2) using a 2.0-m fixed-height tripod. Survey control was provided by undertaking 180 GPS epoch measurements (~ 3 minutes of measurement per calibration site) using the three control sites identified in Table 1, enabling us to perform a GPS site calibration that brought the survey into a local coordinate system (Figure 3E). This step is critical in order to eliminate various survey errors that may be compounded by factors such as poor satellite geometry, multipath, and poor atmospheric conditions, which, when combined, can increase the total error to several centimeters. In addition, because the 5700 GPS base station was located on each of the OWET (1–3) benchmarks for several hours (typically 2–6 hours, over multiple days), the measured GPS data from the base station and rover GPS were able to be submitted to OPUS for online processing. Table 2 shows the final derived coordinates assigned to the three benchmarks and their relative uncertainty based on multiple occupations. It is these final coordinates that are used to perform a GPS site calibration each time a field survey of the beach and shoreline is performed.

Table 2. Final coordinates and elevations derived for the three DOGAMI Oregon Wave Energy Trust (OWET) benchmarks established on the north Umpqua Spit.

	OWET 1 (m)	Variance (± m)	OWET 2 (m)	Variance (± m)	OWET 3* (m)	Variance (± m)
Northing	231039.181	0.004	233473.260	0.003	1203406.530	0.003
Easting	1201842.604	0.014	1202548.920	0.004	237078.110	0.004
Elevation	8.416	0.011	11.629	0.005	9.184	0.039

The variance reflects the standard deviation derived from multiple occupations. Asterisk signifies the location of the GPS base station during each respective survey.

BEACH MONITORING

Having performed a GPS site calibration, a surveyor wearing the 5800 GPS rover unit mounted on a backpack acquires cross-shore beach profiles (Figure 4). Surveys are undertaken during periods of low tide, enabling more of the beach to be surveyed. The approach was to generally walk from the landward edge of the primary dune or bluff edge down the beach face and out into the ocean to approximately wading depth. A straight line perpendicular to the shore was achieved by navigating along a predetermined line displayed on a hand-held Trimble TSC2 computer controller connected to the 5800 rover. The computer shows the position of the operator relative to the survey line and indicates the deviation of the GPS operator from the line. The horizontal variability during the survey is generally minor, typically less than about ±0.25 m either side of the line, which results in negligible vertical uncertainties due to the relatively uniform nature of beaches characteristic of much of the Oregon coast (Ruggiero and others, 2005). From our previous research at numerous sites along the Oregon coast, this method of surveying can reliably detect elevation changes on the order of 4-5 cm, well below normal seasonal changes in beach elevation, which typically varies by 1 to 2 m (3 to 6 ft) (Allan and Hart, 2007, 2008).

Table 3 indicates the dates when field surveys were performed. To supplement the GPS beach survey data and to extend the time series, light detection and ranging (lidar) data measured by USGS/NASA/NOAA[4] in April 1998 (post 1997/1998 El Niño) and in 2002 (post extreme 1998/1999 winter season) have been also analyzed, along with more recent lidar data collected by Watershed Sciences, Inc. in summer 2008 for DOGAMI. The USGS/NASA/NOAA Lidar data were downloaded from NOAA's Coastal

Table 3. Dates when beach profile field surveys were undertaken on the north Umpqua Spit.

Beach Profile Survey Date
27-28 April 2009
6-9 July 2009
17–19 September 2009
17–18 November 2009
25-26 January 2010
4-5 March 2010
10-11 June 2010
13-14 July 2010

4 U.S. Geological Survey (USGS), National Aeronautics and Space Administration (NASA), National Oceanic and Atmospheric Administration (NOAA).

Figure 4. (left) Laura Stimely from DOGAMI surveys the top of a dune erosion scarp on the north Umpqua Spit. (right) Beach surveys are extended out across the surf zone to wading depth.

Lidar website (http://www.csc.noaa.gov/digitalcoast/data/coastallidar/index.html) and were separately processed, gridded, and analyzed in a Geographical Information System (GIS) (e.g., ArcGIS and MapInfo), enabling their integration into the beach profile dataset.

Analysis of the beach survey data involved a number of stages. The data were first imported into MathWorks® MATLAB® using a customized script. A least-squares linear regression was then fit to the profile data. The purpose of this script is to examine the reduced data and to eliminate data point residuals that exceed a ±0.5 m threshold (i.e., the outliers) on either side of the predetermined profile line. The data are then exported into an Microsoft® Excel® database for archiving purposes. A second MATLAB script uses the Excel profile database to plot the survey data (relative to the earlier surveys) and outputs the generated figure as a Portable Network Graphics (.png) file (Figures 5 and 6).

Figures 5 and 6 provide two representative examples of the range of beach profile changes measured at the Reedsport 15 and 8 profile sites. Both figures incorporate results from lidar analyses flown in 1998 and 2002 by USGS/NASA/NOAA and in 2008 by DOGAMI. In both cases the ***light grey*** shading highlights maximum and minimum beach changes (excluding the lidar data, which exhibits a lot of noise at lower beach elevations that probably is a reflection of wave swash on the lower beachface), while the ***dark grey*** shading indicates the typical range of variability determined as ±1 standard deviation about the mean profile. As more beach change information is collected, the dark grey shading will be constrained further and will provide an indication of the normal expected ranges of beach responses.

As can be seen in Figure 5, the seasonal variability of the beach is on the order of 1 to 2 m, depending on location on the beach. Higher on the beach face between the 2- and 4-m elevation contours, a berm can be observed in Figure 5 that developed in late summer 2009 and reflects the normal post-winter aggradation of the beach. Of interest, our most recent survey in July 2010 indicated that many of the beach profile sites had beach elevations that were typically at the

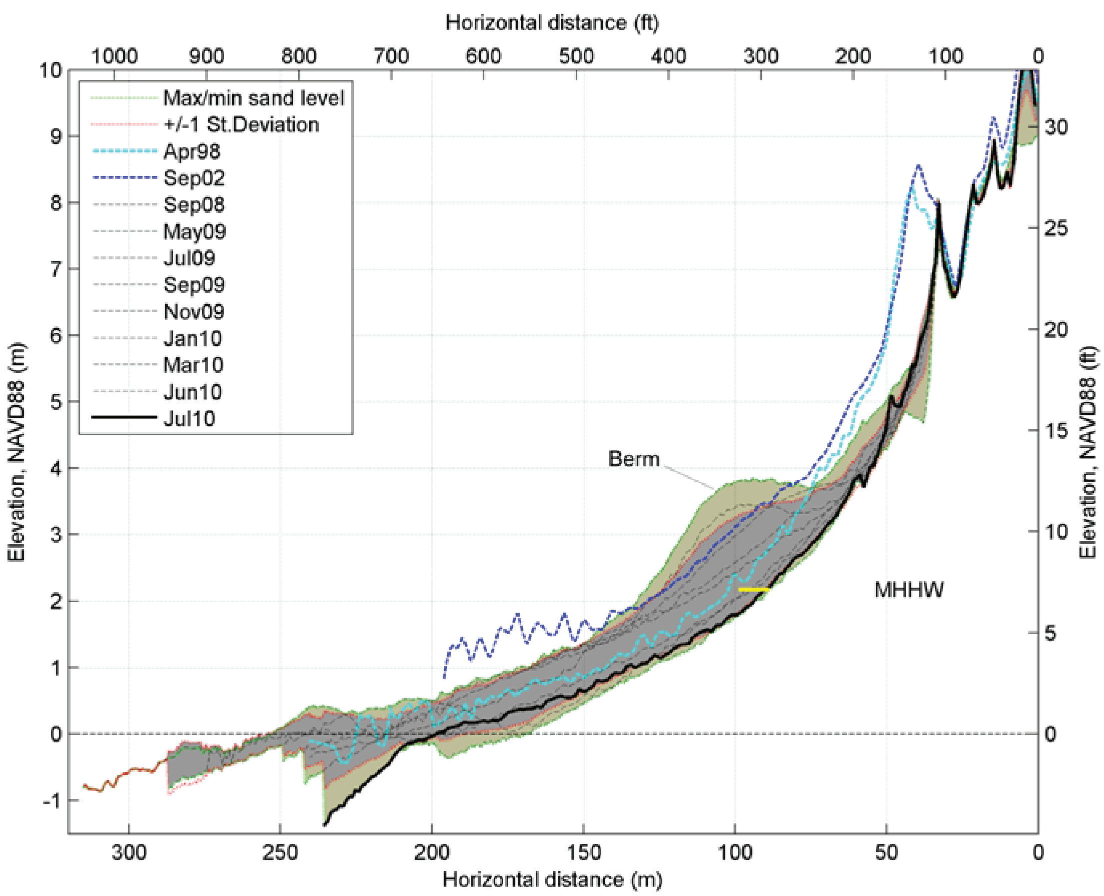


Figure 5. Example of beach profile changes measured at the Reedsport 15 beach profile site. Dark gray shading denotes ±1σ of variability about the mean profile (excluding lidar), while the light grey shading indicates the maximum and minimum elevation of the beach measured.

lower end of the normal range (e.g., Figure 5) and may be a function of the unusually high wave heights observed in the 2010 spring and early summer.

The Reedsport 8 profile site indicates a similar seasonal range of beach elevations, which varies from 1 to 2 m (Figure 6). However, it can be seen that our most recent survey undertaken in July 2010 was well below the normal range. This deviation can be attributed to the development of a large rip embayment that formed in spring 2010 and that produced localized scouring of the beach face, causing the beach foreshore elevation to be significantly lowered (Figure 6). Furthermore, over a period of a few months the rip embayment began to migrate northward, widening slightly adjacent to the Reedsport 8 profile site. This is shown in Figure 7, which highlights the change in the mean shoreline position between the two surveys. From this the alongshore extent of the embayment was on the order of 720 m in length.

Finally, the complete suite of beach profile measurements has been uploaded to the Oregon Beach and Shore-

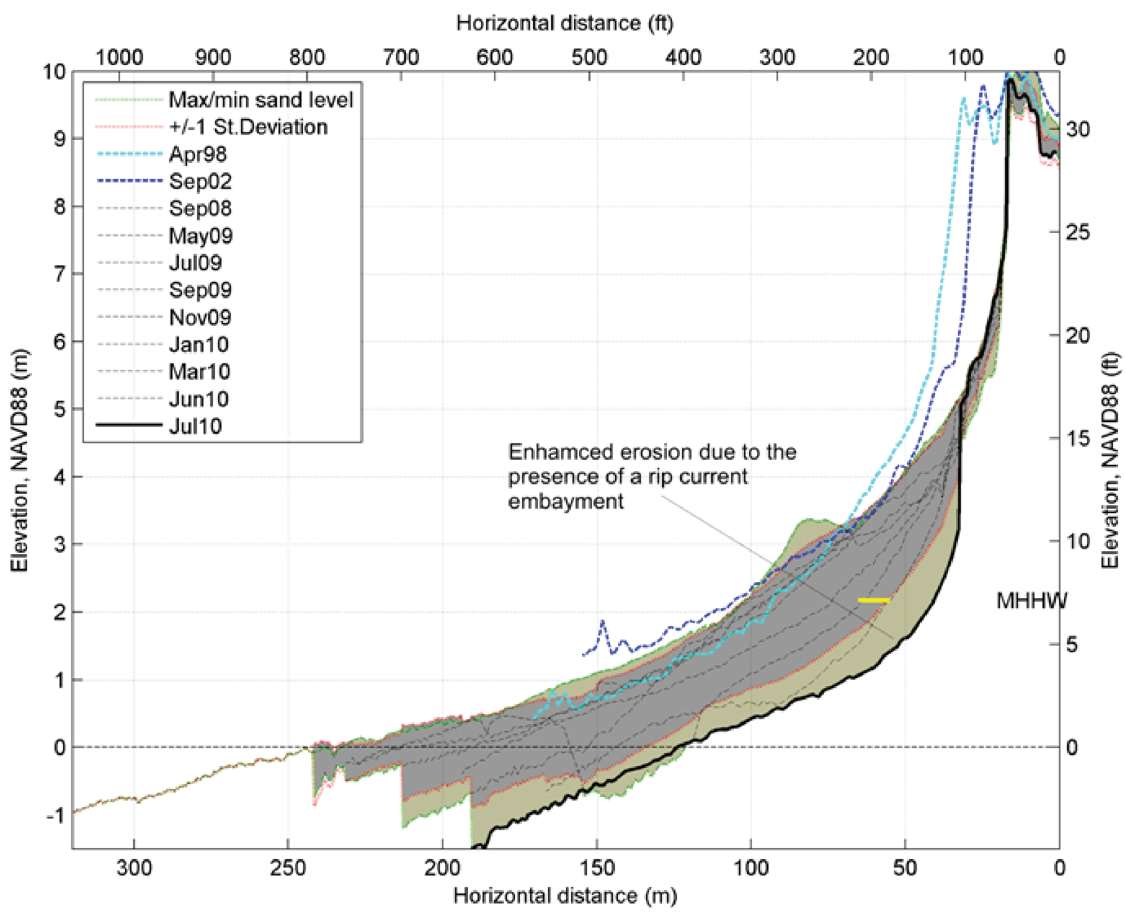


Figure 6. Example of beach profile changes measured at the Reedsport 8 beach profile site. Dark gray shading denotes ±1σ of variability about the mean profile (excluding lidar), while the light grey shading indicates the maximum and minimum elevation of the beach measured.

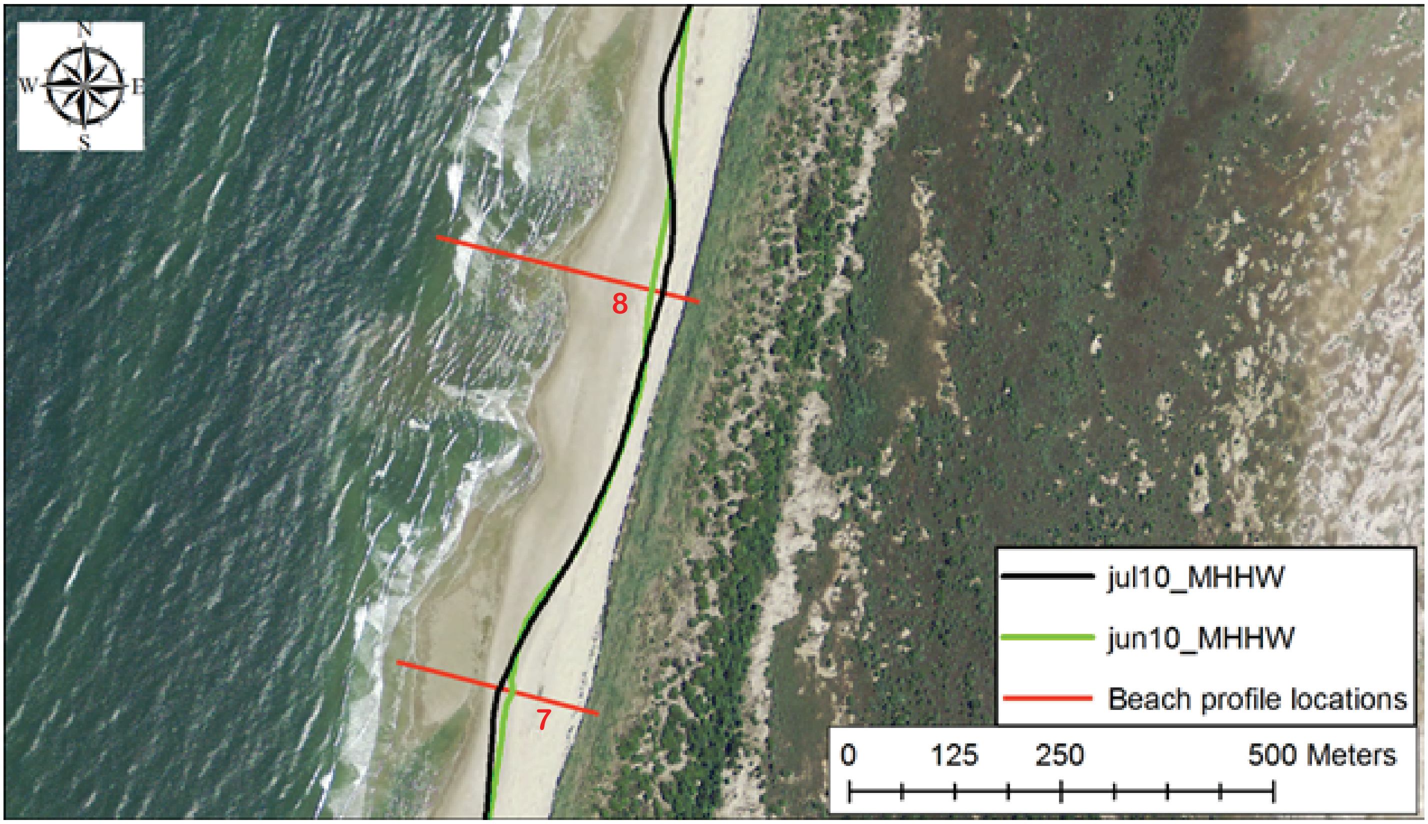


Figure 7. A rip embayment that formed adjacent to the Reedsport 8 profile site is visible as a crescentic landward deflection of the shorelines between the two profile locations.

line Mapping and Analysis (OBSMAP) website[5] maintained by DOGAMI for easy viewing and in the appendix at the end of this report.

Shoreline Changes

While beach profiles provide important information about the cross-shore and to some degree the longshore response of the beach as a result of variations in the incident wave energy, nearshore currents, tides, and sediment supply, it is also necessary to understand the alongshore variability in shoreline response that may reflect the development of large morphodynamic features such as rip embayments (e.g., Figure 6), beach cusps, and the alongshore transport of sediment. To complement the beach profile surveys initiated along the Umpqua Spit, surveys of a tidal datum-based shoreline were also undertaken. For the purposes of this study we used the Mean Higher High Water (MHHW) tidal datum measured at the Charleston tide gauge as a shoreline proxy and is located at an elevation of 2.17 m NAVD88. Measurement of the shoreline was undertaken by mounting the rover 5800 GPS on to the side of a vehicle and driving two lines above and below the MHHW contour in order to bracket the shoreline. The GPS data were then gridded in GIS in order to extract the 2.17 m shoreline proxies (Figure 8).

Besides the measurement of contemporary datum-based shorelines, historical shoreline positions were also compiled in a GIS. These latter datasets were originally mapped by early National Ocean Service (NOS) surveyors for select periods on the Oregon coast including the 1920s, 1950s, and 1970s. In addition, Ruggiero and others (2007) are presently completing a study of long-term trends of coastal change for the Pacific Northwest coasts of Oregon and Washington. In this latter study, Ruggiero and colleagues have digitally orthorectified a suite of aerial photographs flown in 1967 along the Oregon coast to derive a 1967 shoreline for the entire coast.

Figure 8 provides an example of the complete suite of shoreline positions determined for the north Umpqua Spit and immediately adjacent to the north jetty. The black

5 http://www.oregongeology.org/sub/Nanoos1/Beach%20profiles/OWET_Cell.htm.

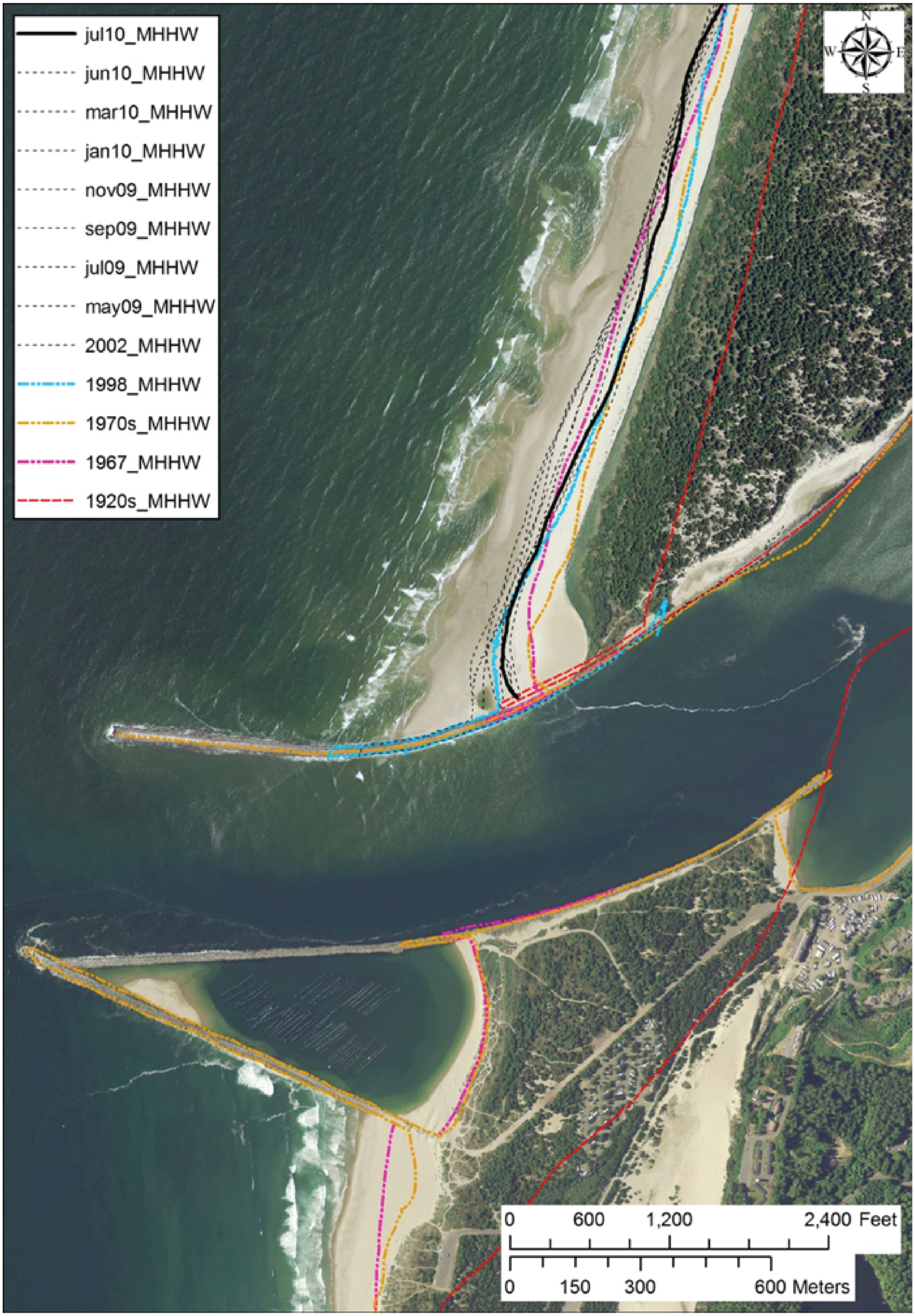


Figure 8. Historical and contemporary shoreline changes at the north Umpqua Spit derived from multiple data sources including National Ocean Service topographic "T" sheets, lidar data flown in 1998, 2002, and 2008, and RTK-DGPS surveys of a tidal datum-based shoreline.

dashed lines indicate the most recent measurements of the mean shoreline position determined by GPS (multiple measurements undertaken between May 2009 and June 2010) and from lidar analyses (2002 and 2008). Included in the figure is the position of the shoreline in 1998, immediately following the major 1997/1998 El Niño (cyan-colored line), and the position of the shore in 1967 (magenta), 1970s era (orange), and 1920s era (red). Several important shoreline characteristics worth noting can be identified from these data:

1. The contemporary beach (i.e., shoreline changes during the past decade) exhibits considerable cross-shore and alongshore variability in the shoreline positions, which range from horizontal excursions as low as 10 m to as much as 100 m;
2. The large shoreline excursion identified at the Reedsport 2 beach profile site in 1998 (Figure 8, cyan line) can be attributed to the development of a rip embayment that formed in late winter/early spring 1998. This latter feature is analogous to the rip embayment that formed between the Reedsport 7 and 8 profile sites shown in Figure 7.
3. The 1920s era shoreline was located some 150 to 300 m farther west of its present position. This latter result reflects the effects of jetty construction at the mouth of the Umpqua River.

Shoreline changes due to jetty construction at the mouth of the Umpqua River have clearly had the most significant effect on shoreline variability over the past 100 years. Figure 9 presents a summary of these changes for selected periods and is based on the analyses of Lizarraga-Arciniega and Komar (1975). The north jetty was the first to be constructed and was built between 1923 and 1930. Figure 9A indicates the pre-jetty shorelines in 1903 and 1916. Following jetty construction, the shoreline rapidly advanced in order to produce a straight shoreline essentially parallel to the prevailing wave climate such that the beach would, in time, again begin to experience a zero net sand drift. To the south, the uncontrolled shoreline fluctuated widely. Construction of the south jetty was initiated in 1933 (Figure 9B), and immediately resulted in sand building up to its south, while the shoreline within the mouth began to recede landward. To the north, the shoreline continued to prograde seaward, albeit at a slower pace. To counteract the erosion between the jetties, the U.S. Army Corps of Engineers constructed a middle jetty (Figure 9C), which immediately resolved the erosion problem. Over time, the shorelines to the north and south of the jetties reached a new equilibrium (Figure 9D), such that they now fluctuate in response to the prevailing wave climate, variations in the storm tracks, and change in ocean water levels.

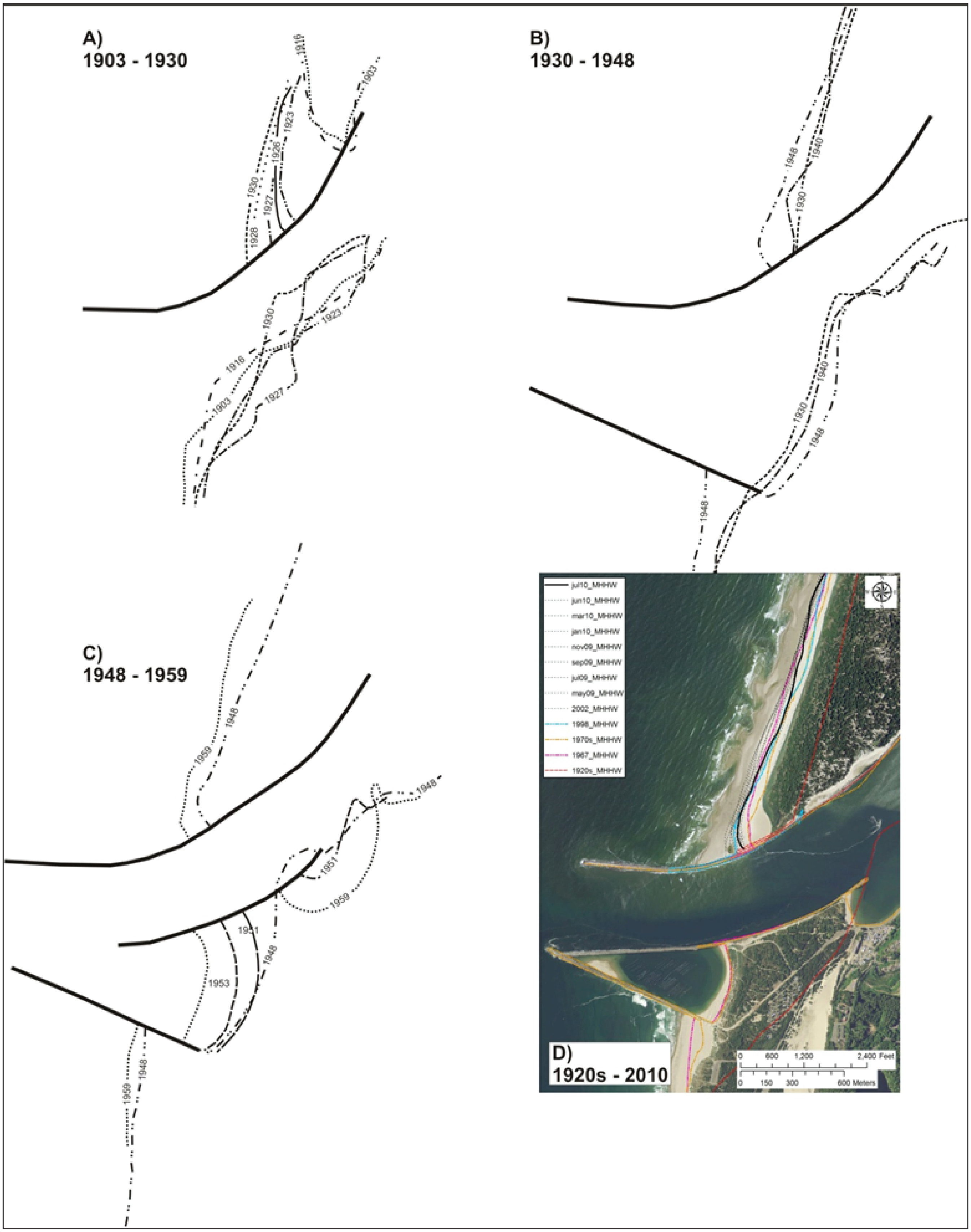


Figure 9. Compilation of shoreline changes due to jetty construction on the Umpqua River (after Lizarraga-Arciniega and Komar (1975).

Finally, Figure 10 presents a synthesis of recent shoreline changes and has been determined from all the beach profile data. The top plot in Figure 10 shows the response of the 6 m (18 ft) contour over the past decade and provides a measure of the response of the beach to ocean storms, while the lower plot provides a measure of the normal seasonal range of variability determined lower down the beach face at the 3 m (9 ft) contour elevation. In all cases, we have used the 1998 shoreline as the baseline against which all subsequent changes are compared. In Figure 10 (top), the green dots denote the position of the dune face as of July 2010, while the blue dots indicate the position of the dune in 2002. As can be seen in the top plot, the southern profile sites (particularly profiles 3–9) have experienced significant erosion over the past decade, with the dune face having eroded landward by some 20–30 m (60–100 ft); this response is not surprising and is consistent with observations undertaken elsewhere on the Oregon coast (Allan and Komar, 2002; Allan and others, 2003, 2009). Only three of the profile transects indicate some nominal evidence of accretion (profiles 11, 21, and 22).

The bottom plot in Figure 10 highlights the range in shoreline response caused largely by the seasonal shift from summer wave conditions to winter conditions. From these data (including the previously flown lidar data), the mean seasonal shoreline excursion for the north Umpqua Spit is 26 m (85 ft), with a standard deviation of ±10.8 m (35.4 ft). Thus the typical seasonal range of beach response varies from as little 15.2 m (50 ft) to as much as 36.8 m (120.7 ft). These results will be further refined as additional data are collected.

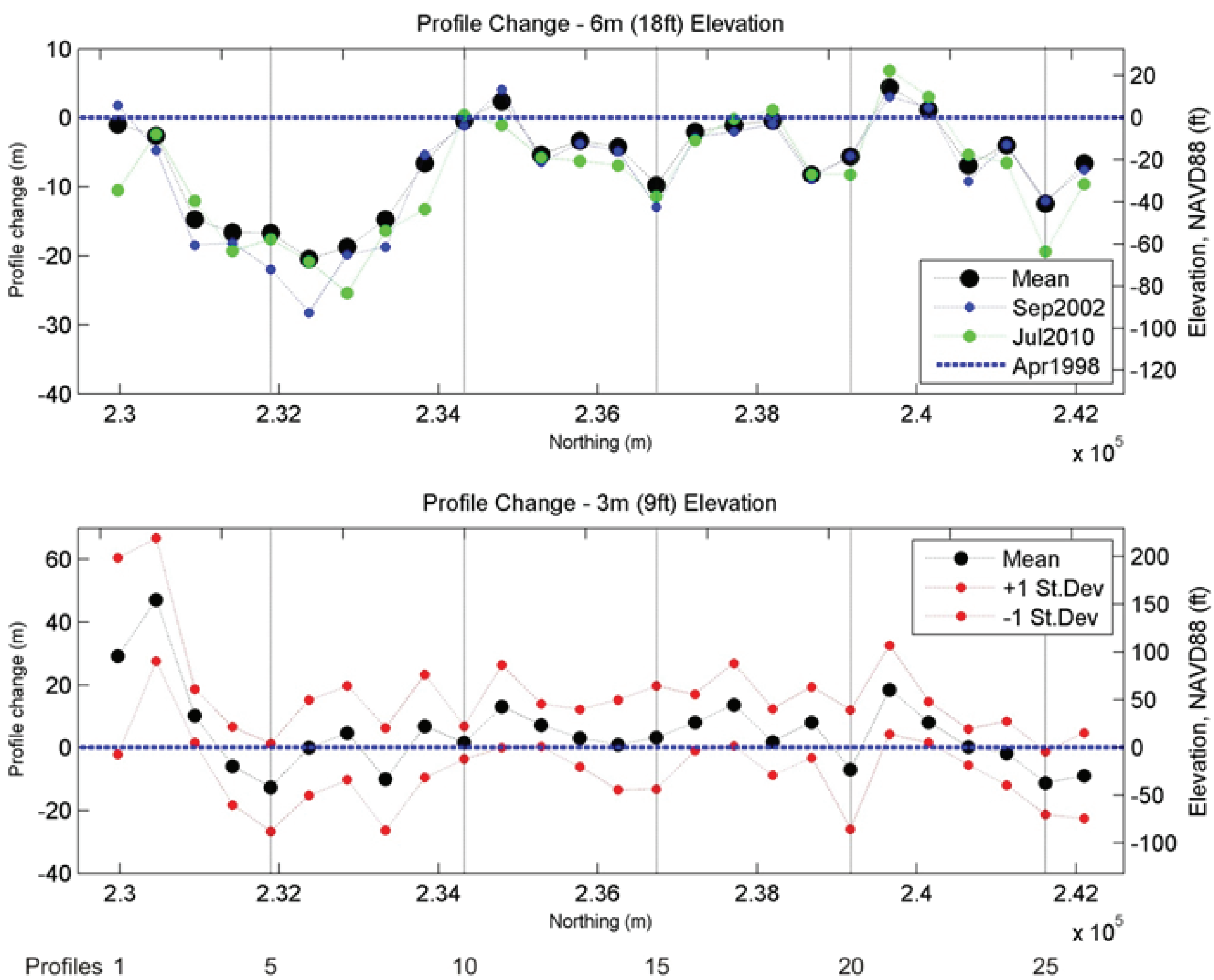


Figure 10. Alongshore response in the 6 m (18 ft) and 3 m (9 ft) contour elevations, highlighting recent storm effects (upper plot) and the typical range in shoreline response (lower plot) along the north Umpqua Spit.

SUMMARY

In April 2009, DOGAMI staff installed a beach monitoring program to assist with characterizing the baseline level of beach variability along the north Umpqua Spit and especially landward of the proposed Reedsport wave energy array. Over the past 12 months, DOGAMI has collected a total of 208 beach profile surveys along the spit and has derived multiple GPS shorelines as well as assimilated historical shorelines from early NOS Topographic "T" sheets. In addition, DOGAMI staff have assisted colleagues at OSU by providing survey control for the collection of nearshore bathymetry and Argus video images of the nearshore. Over time as more data are collected and synthesized, an improved understanding of the natural level of beach and shoreline morphodynamics will be gained, providing researchers with the necessary information to better characterize any potential future effects to the beach system in response to the installation of wave energy arrays.

ACKNOWLEDGMENTS

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Finally, we would like to note the passing of Roger Hart on February 27, 2011. Roger was an integral member of the DOGAMI coastal field office providing technical support with fieldwork between 2004 and 2010. He had an intense love for the Oregon coast and will be sadly missed.

REFERENCES

Allan, J. C., and Hart, R., 2007, Assessing the temporal and spatial variability of coastal change in the Neskowin littoral cell: developing a comprehensive monitoring program for Oregon beaches: Portland, Oreg., Oregon Department of Geology and Mineral Industries Open-File Report O-07-01, 27 p.

Allan, J. C., and Hart, R., 2008, Oregon beach and shoreline mapping and analysis program: 2007-2008 beach monitoring report: Portland, Oreg., Oregon Department of Geology and Mineral Industries Open-File Report O-08-15, 60 p.

Allan, J. C., and Komar, P. D., 2002, Extreme storms on the Pacific Northwest coast during the 1997-98 El Niño and 1998-99 La Niña: Journal of Coastal Research, v. 18, no. 1, p. 175–193.

Allan, J. C., Komar, P. D., and Priest, G. R., 2003, Shoreline variability on the high-energy Oregon coast and its usefulness in erosion-hazard assessments, *in* Byrnes, M. R., Crowell, M., and Fowler, C. (eds.), Shoreline mapping and change analysis: technical considerations and management implications: Journal of Coastal Research Special Issue, 38, p. 83–105.

Allan, J. C., Witter, R. C., Ruggiero, P., and Hawkes, A. D., 2009, Coastal geomorphology, hazards, and management issues along the Pacific Northwest coast of Oregon and Washington, *in* O'Connor, J. E., Dorsey, R. J., and Madin, I. P. (eds.), Volcanoes to vineyards: geologic field trips through the dynamic landscape of the Pacific Northwest: Boulder, Colo., Geological Society of America, Field Guide 15, p. 495–519.

Bernstein, D. J., Freeman, C., Forte, M. F., Park, J.-Y., Gayes, P. T., and Mitasova, H., 2003, Survey design analysis for three-dimensional mapping of beach and nearshore morphology, *in* Davis, R., and Howd, P. (eds.), Coastal Sediments '03, American Society of Civil Engineers, St. Peterburg, Fla.

Lizarraga-Arciniega, J. R., and Komar, P. D., 1975, Shoreline changes due to jetty construction on the Oregon coast: Corvallis, Oreg., Oregon State University, Publication ORESU-T-75-004, 90 p.

Ozkan-Haller, H. T., Allan, J. C., Barth, J. A., Haller, M. C., Holman, R.A., and Ruggiero, P., 2009, Baseline observations and modeling for the Reedsport Wave Energy Site: Corvallis, Oreg., Oregon State University and Portland, Oreg., Oregon Department of Geology and Mineral Industries, 35 p.

Ruggiero, P., Kaminsky, G. M., Gelfenbaum, G., and Voight, B., 2005, Seasonal to interannual morphodynamics along a high-energy dissipative littoral cell: Journal of Coastal Research, v. 21, no. 3, p. 553–578.

Ruggiero, P., Reid, D., Kaminsky, G., and Allan, J., 2007, Assessing shoreline change trends along U.S. Pacific Northwest beaches: National Oceanic and Atmospheric Administration, Proceedings of Coastal Zone '07, Portland, July 22–26, 2007, Portland, Oreg.

Trimble, 2005, Trimble 5700 GPS system datasheet: Dayton, Ohio, Trimble Navigation Limited, 2 p.

APPENDIX: REEDSPORT BEACH PROFILE MEASUREMENTS

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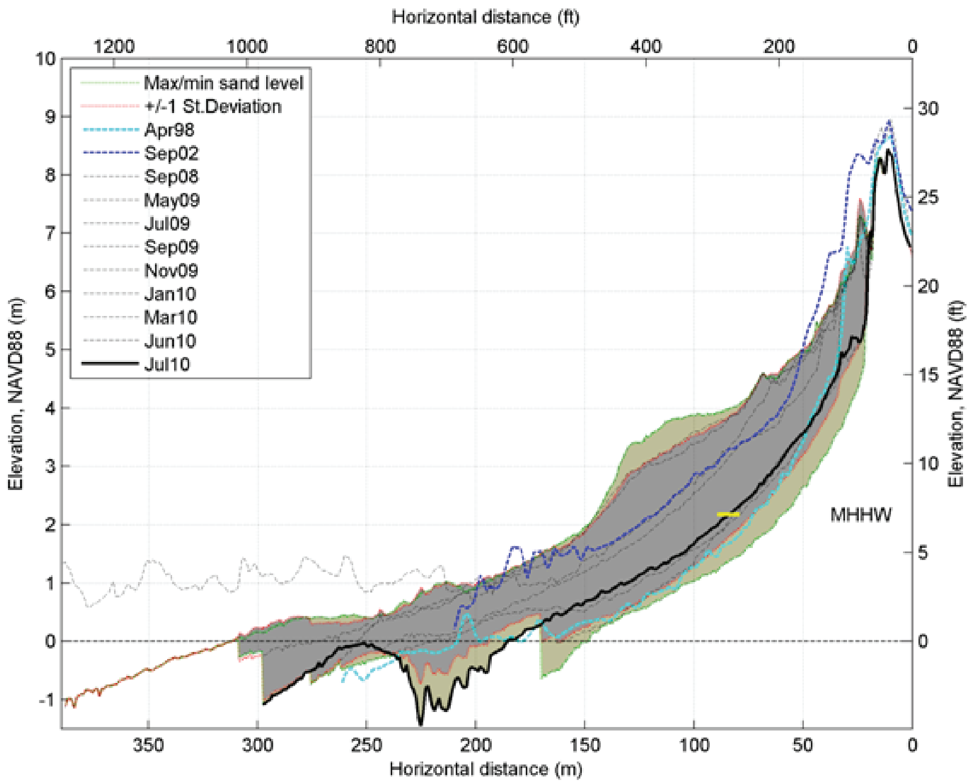

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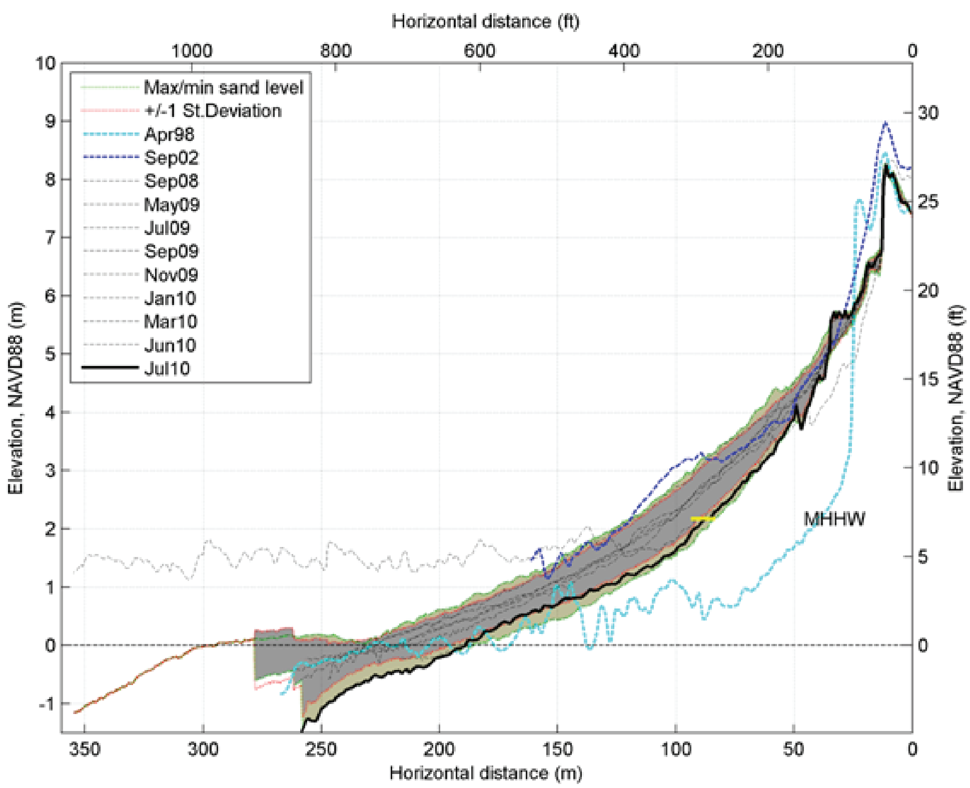

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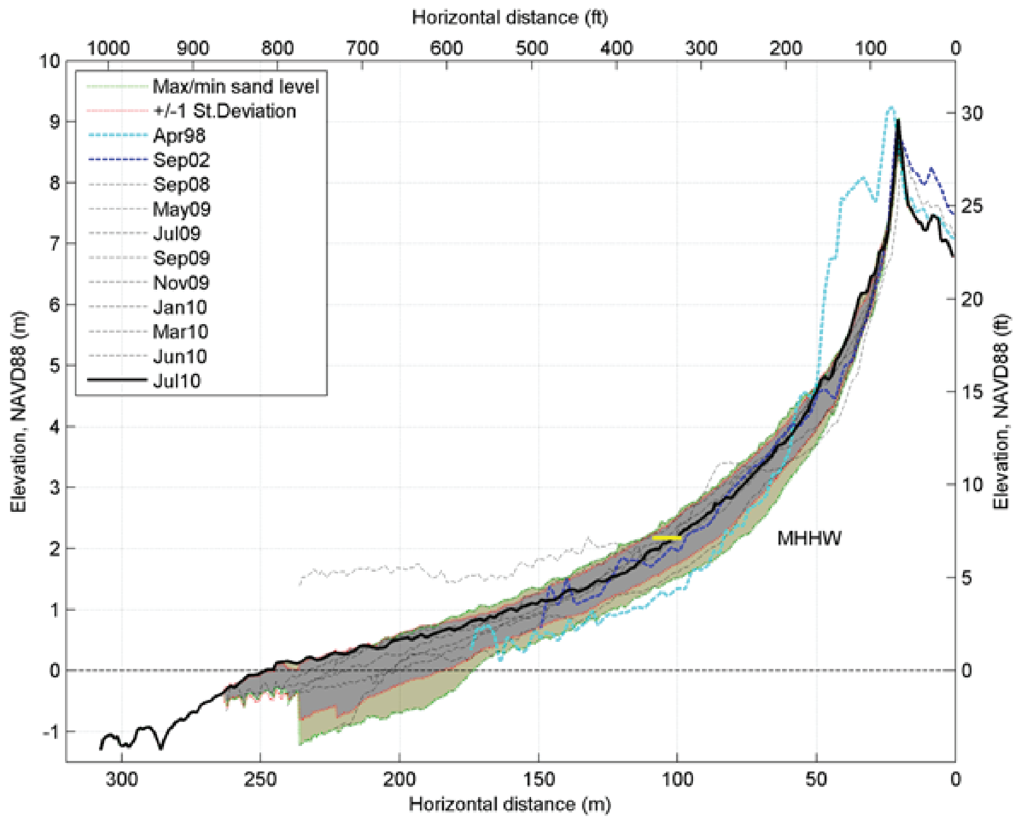

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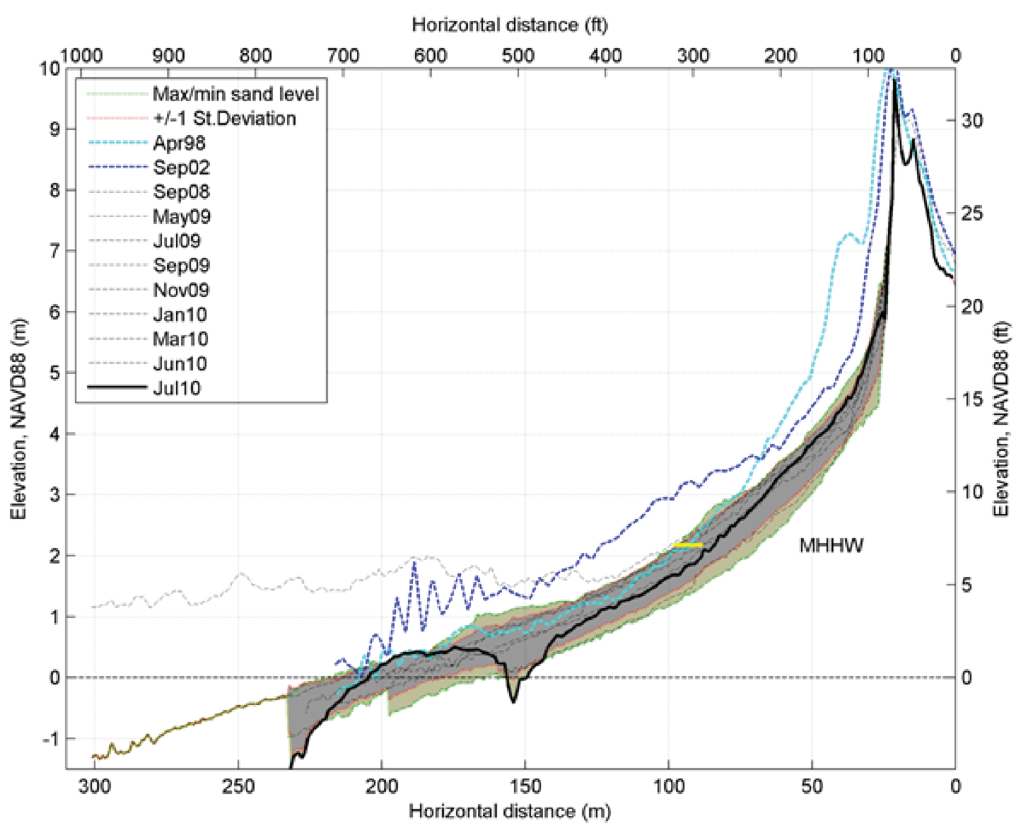

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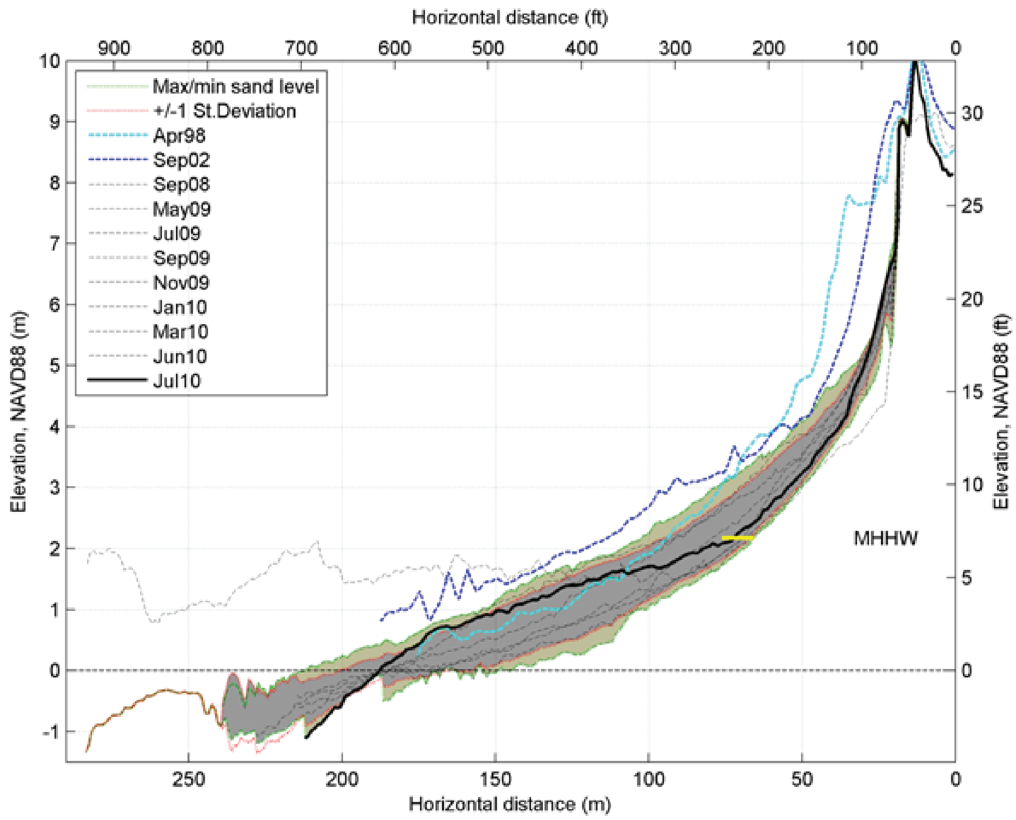

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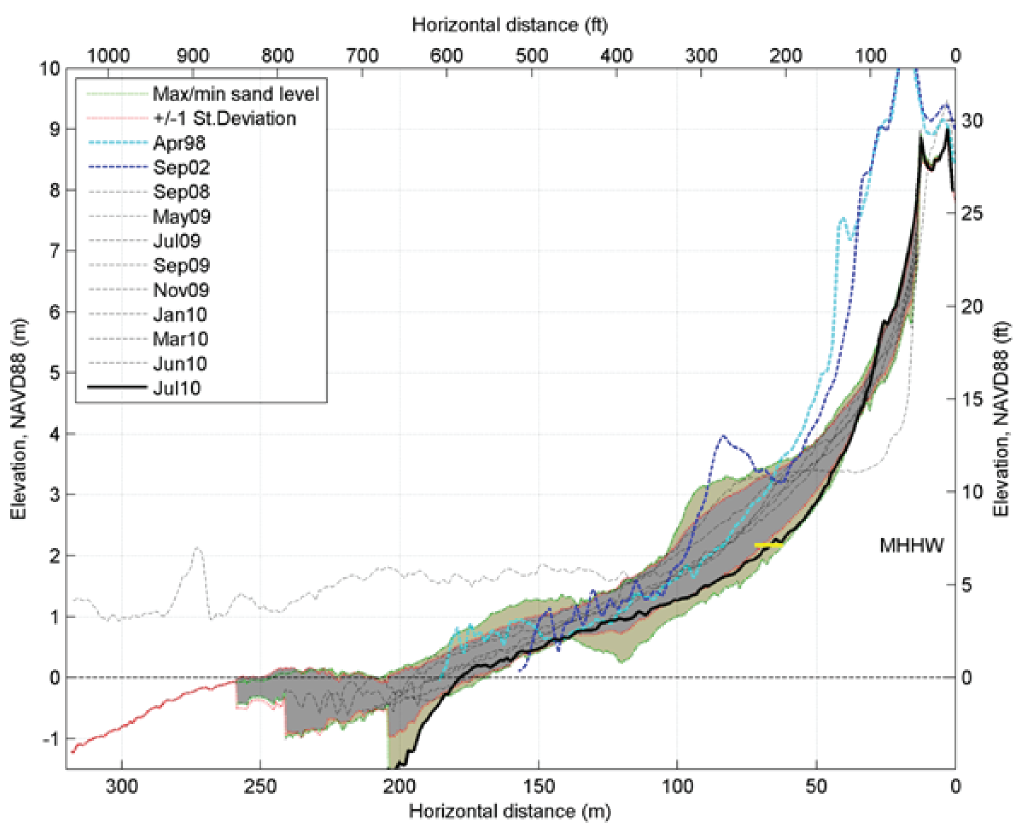

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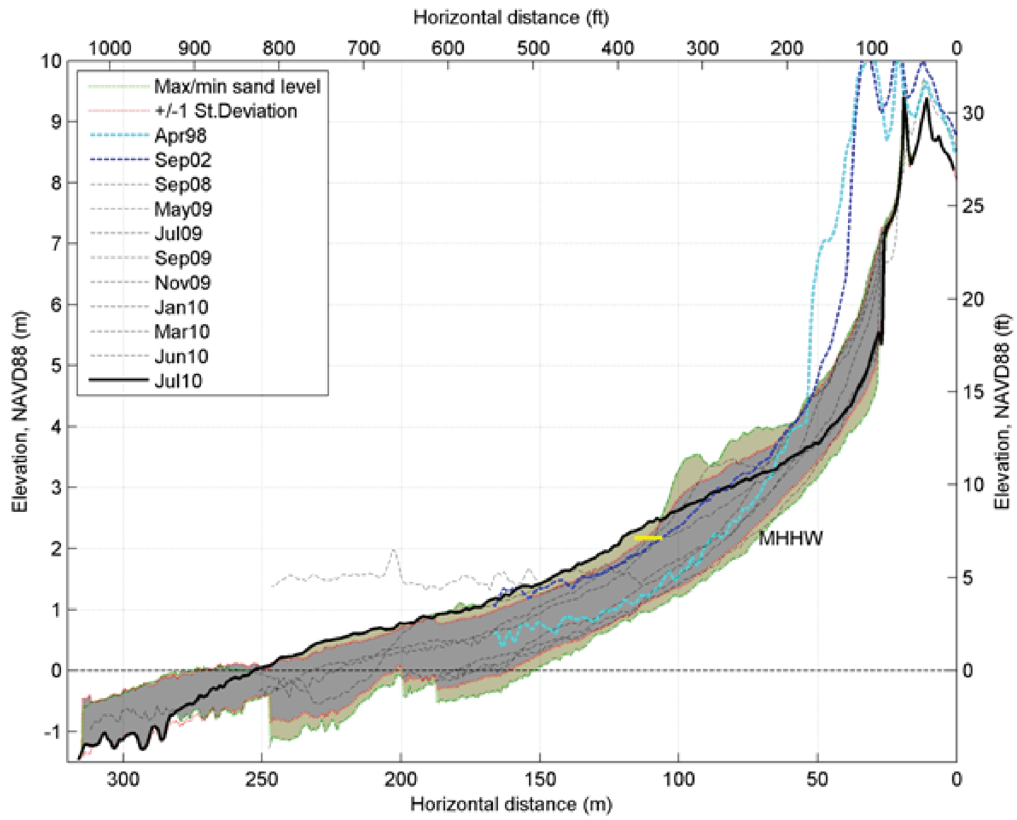

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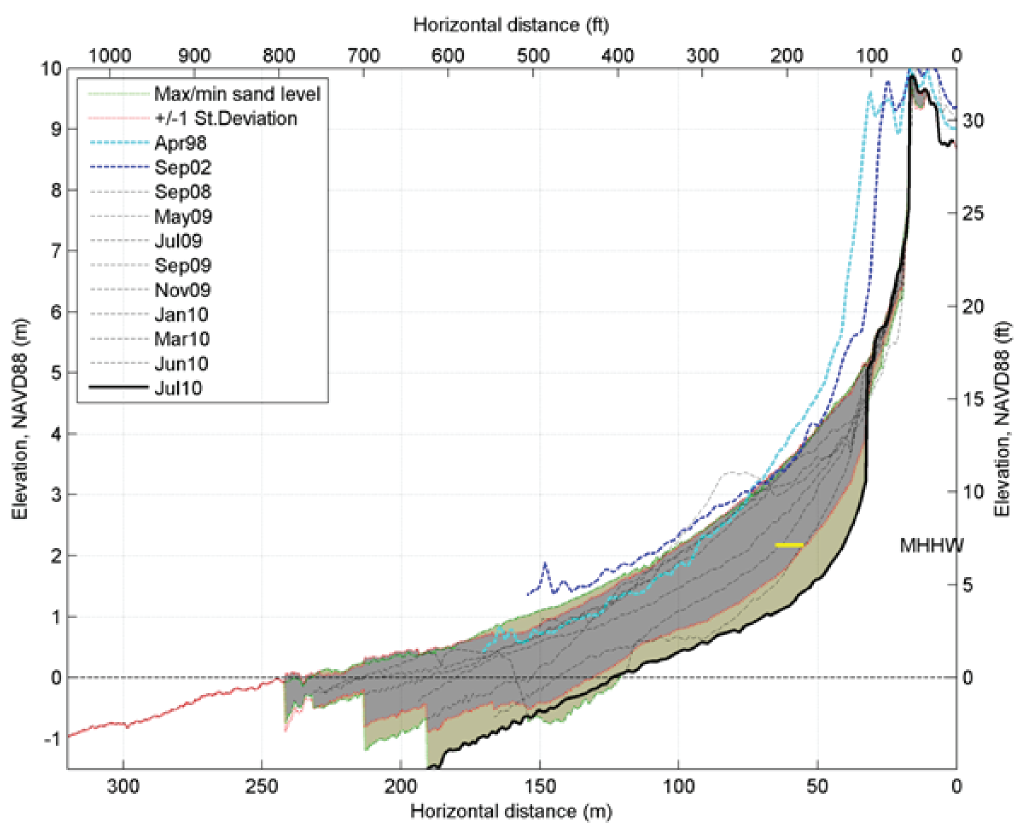

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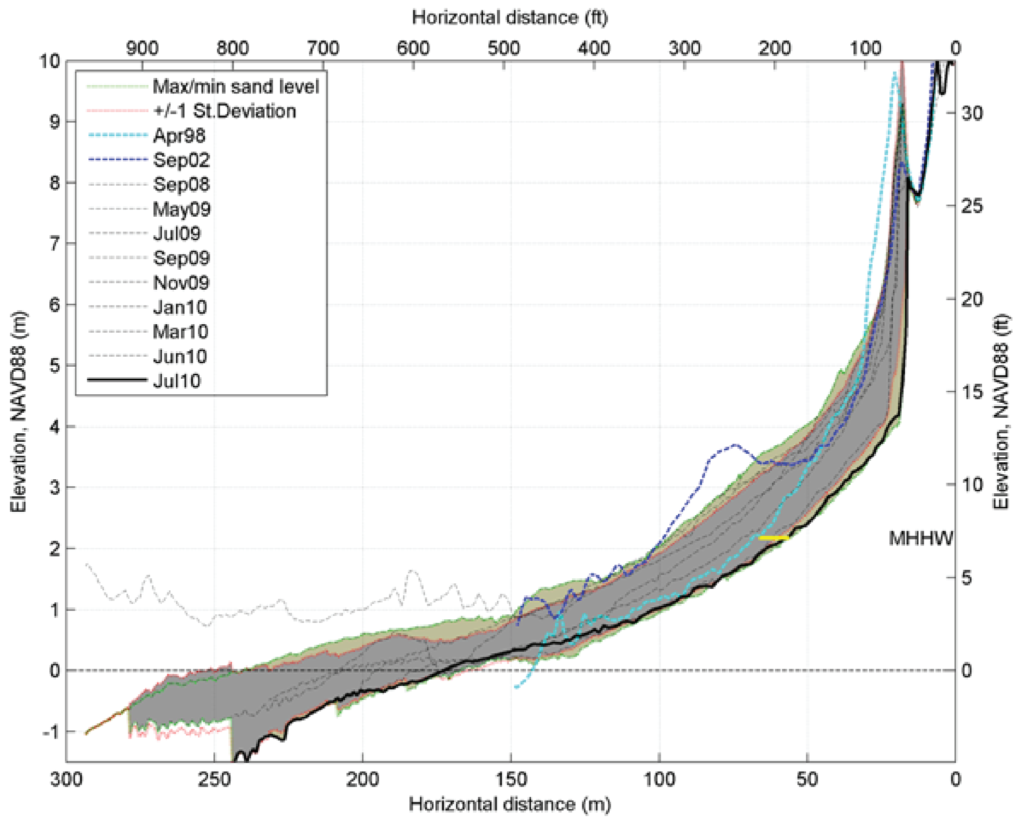

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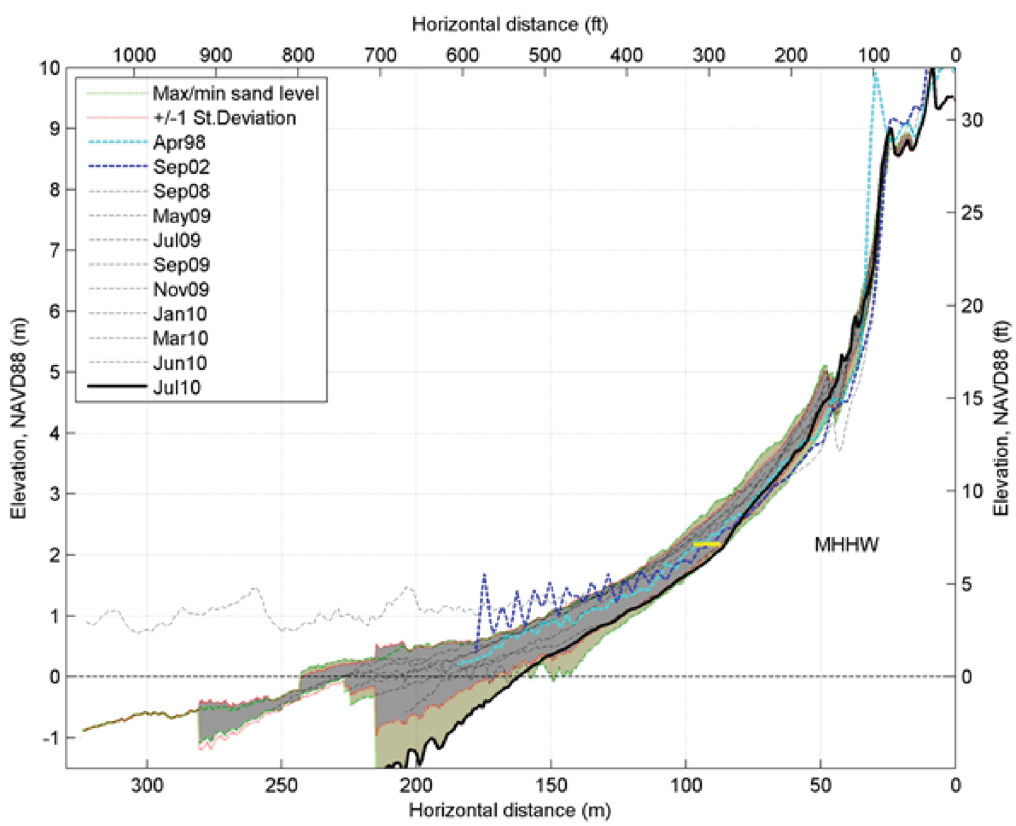

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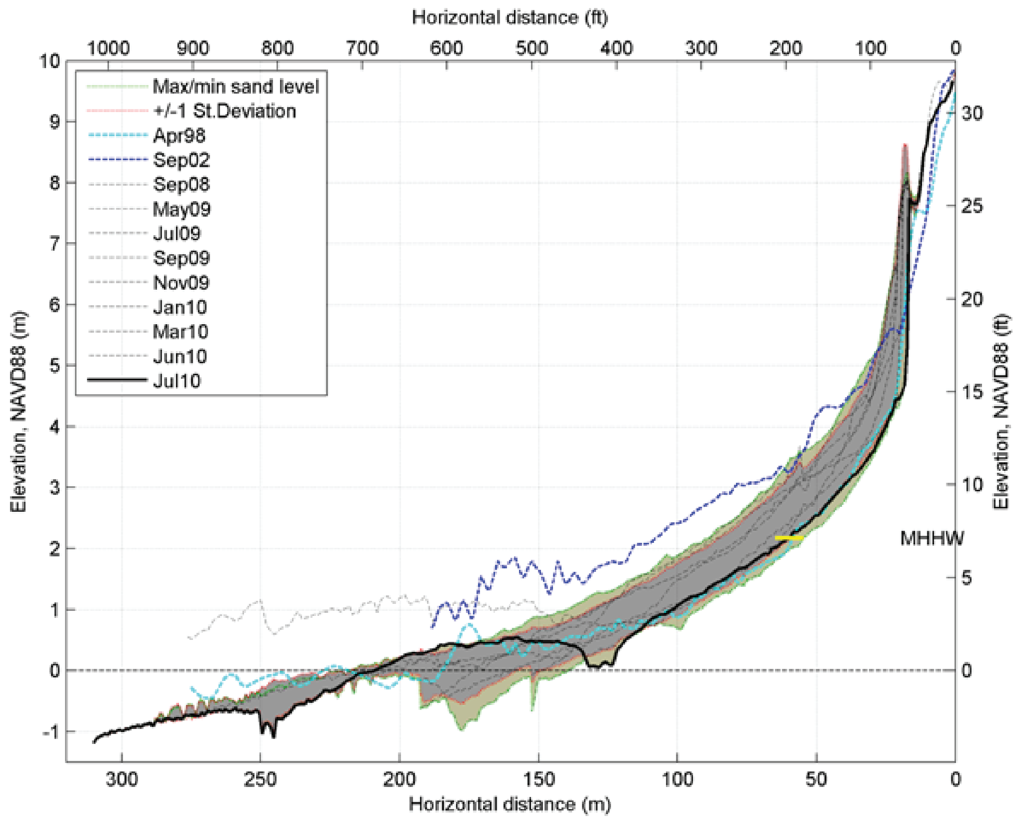

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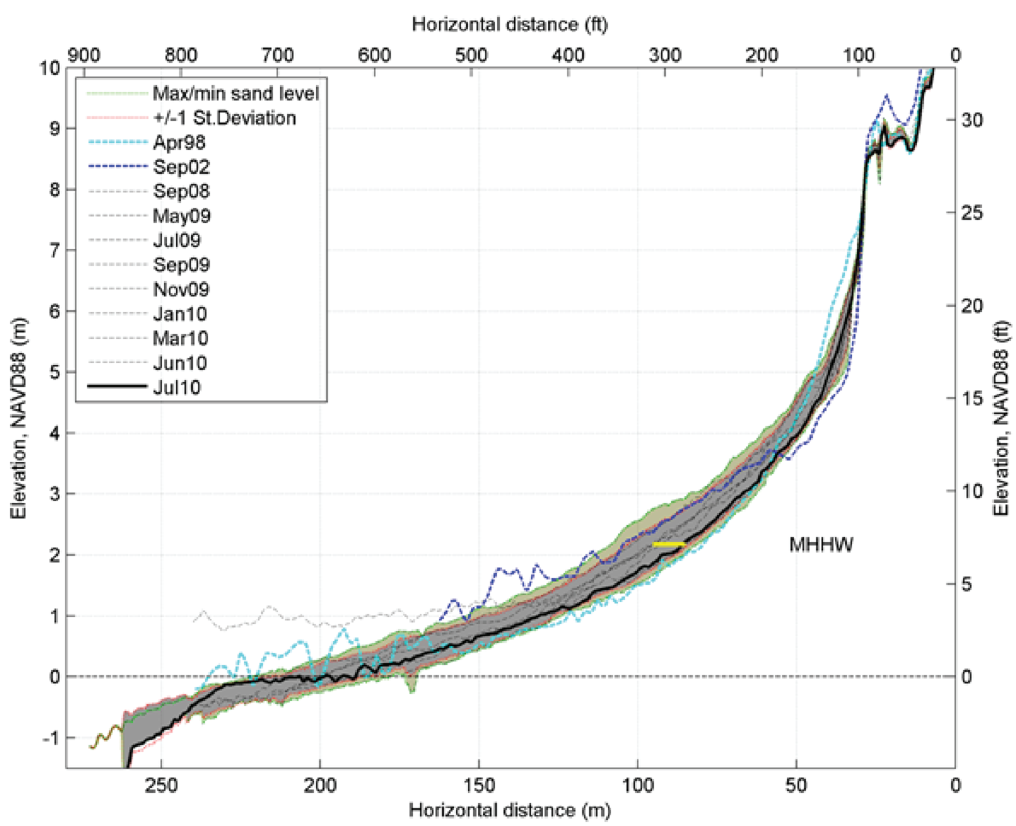

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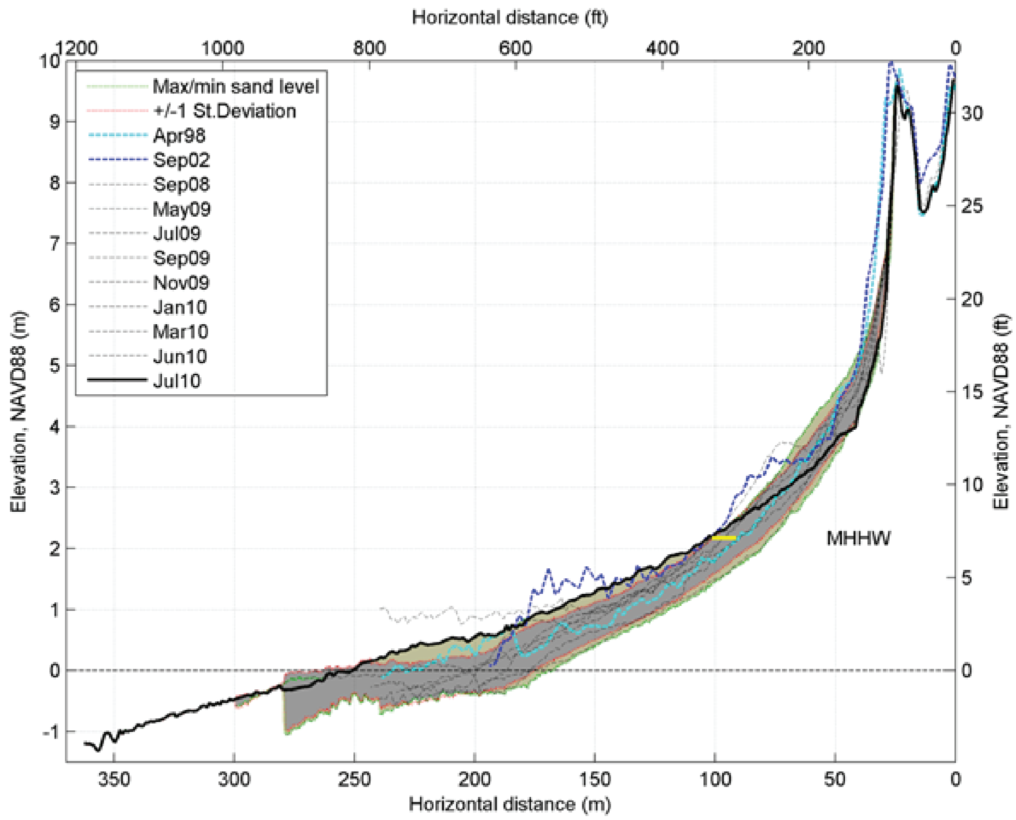

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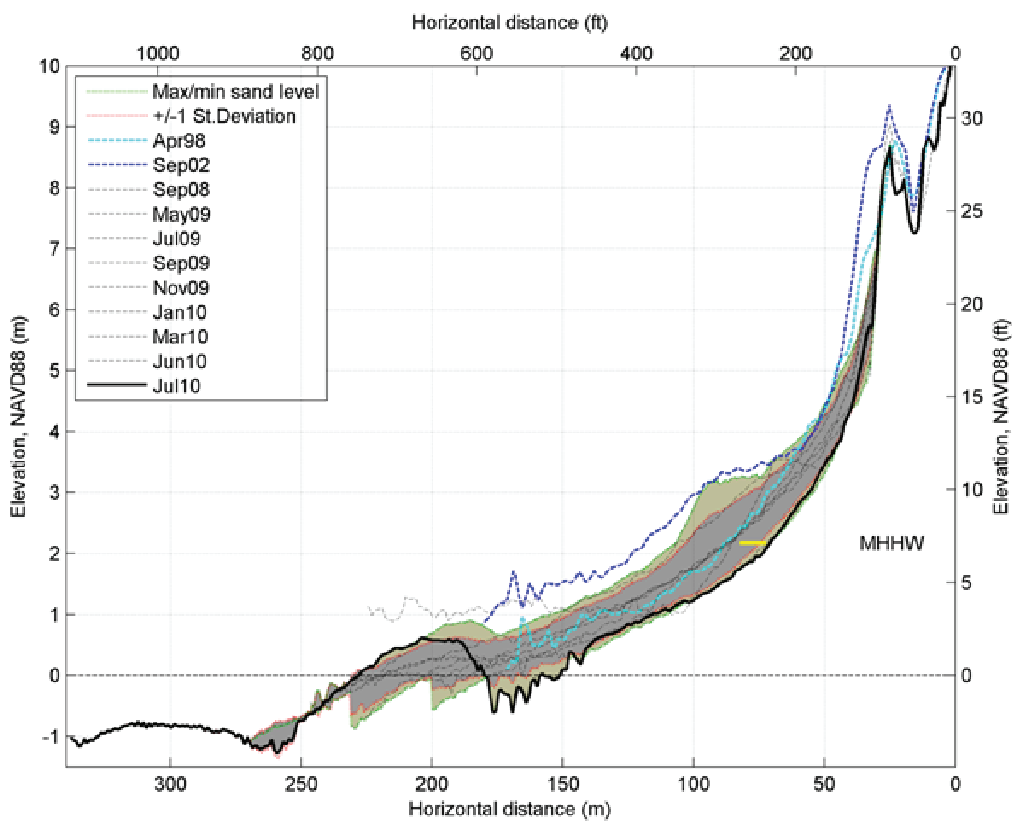

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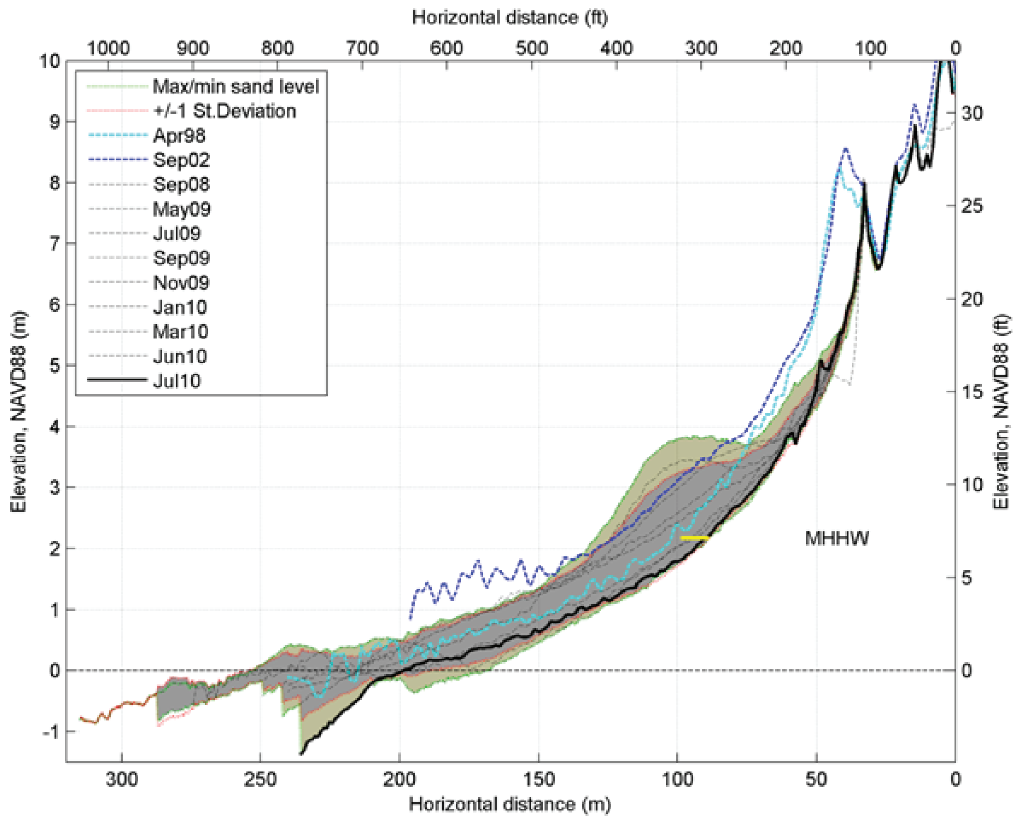

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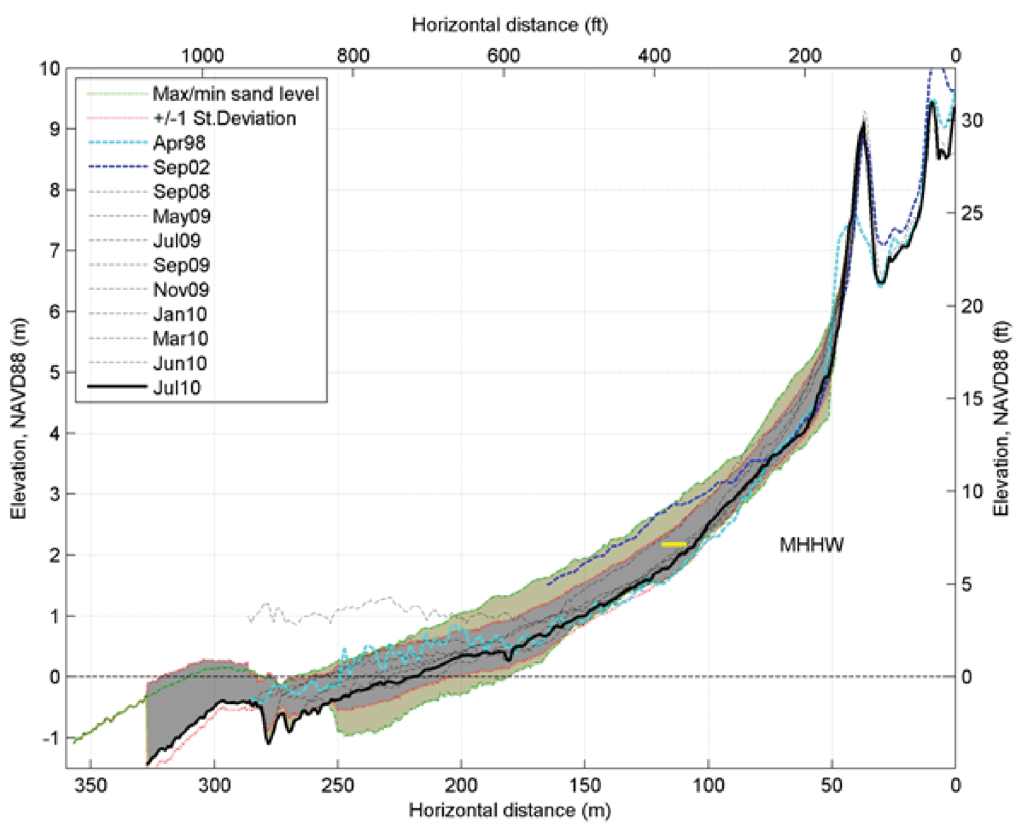

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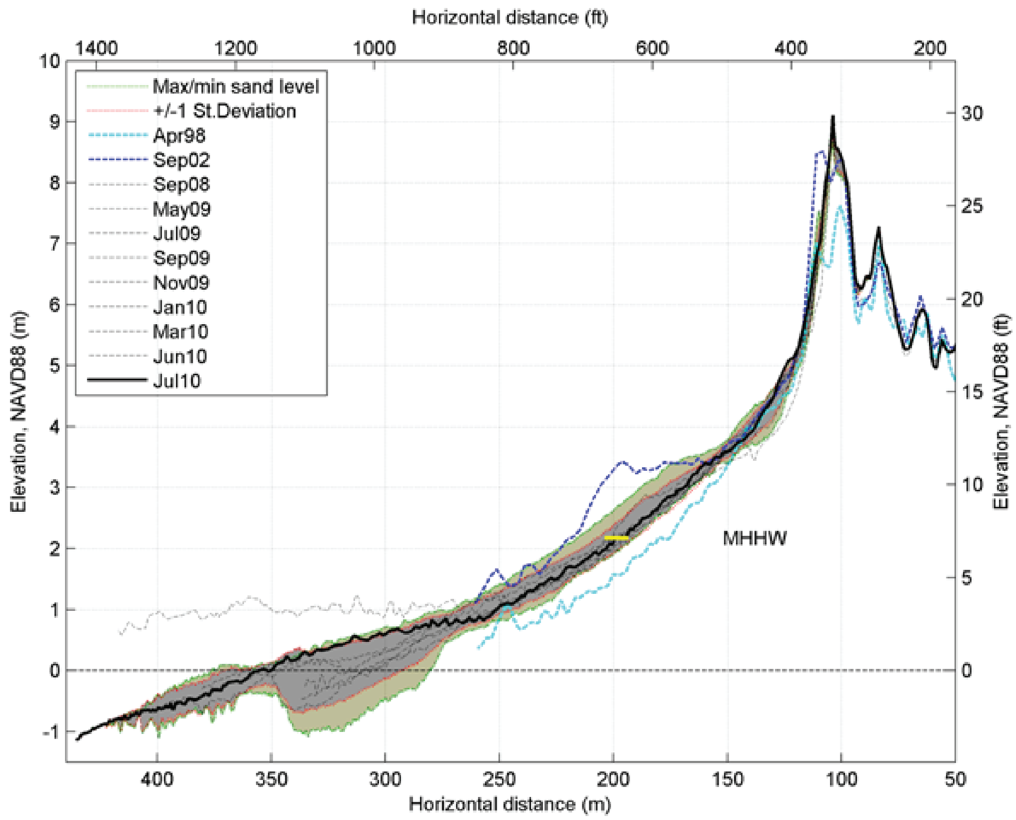

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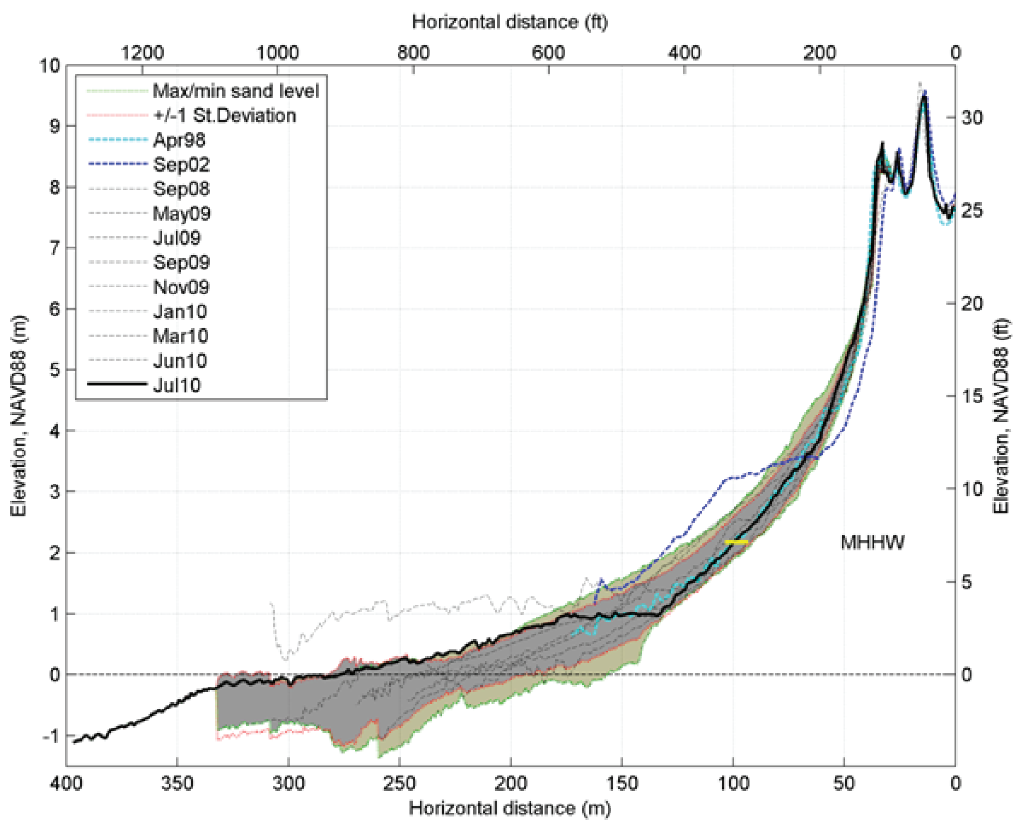

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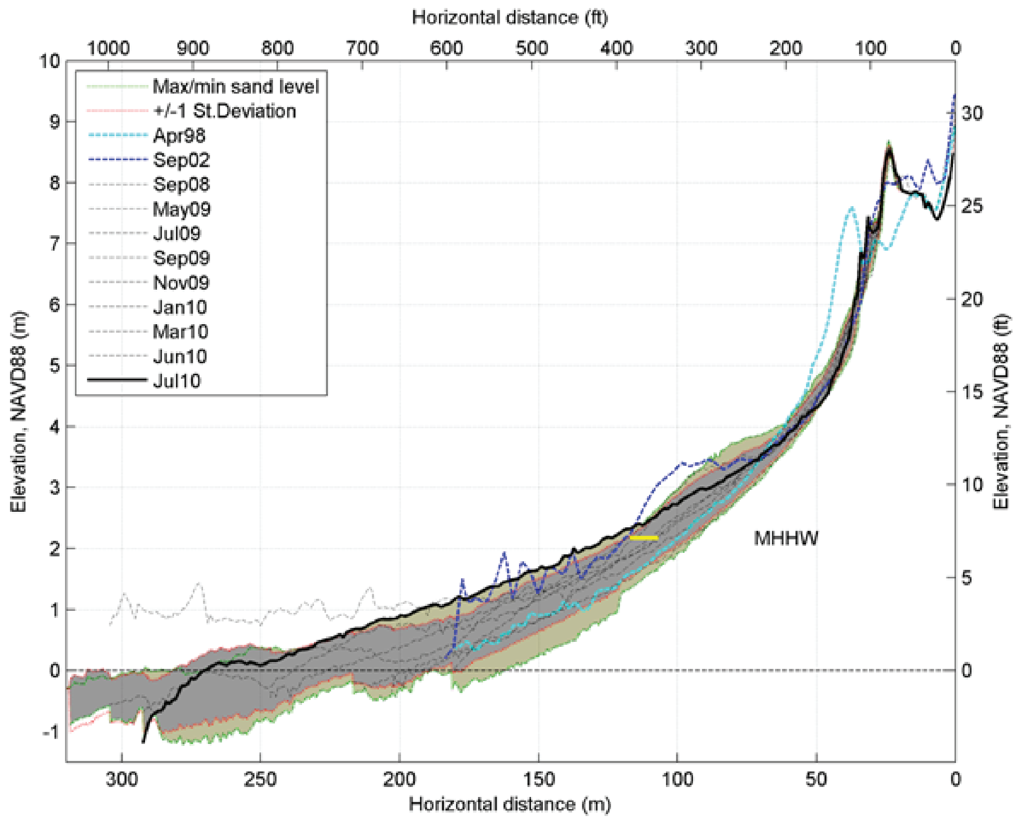

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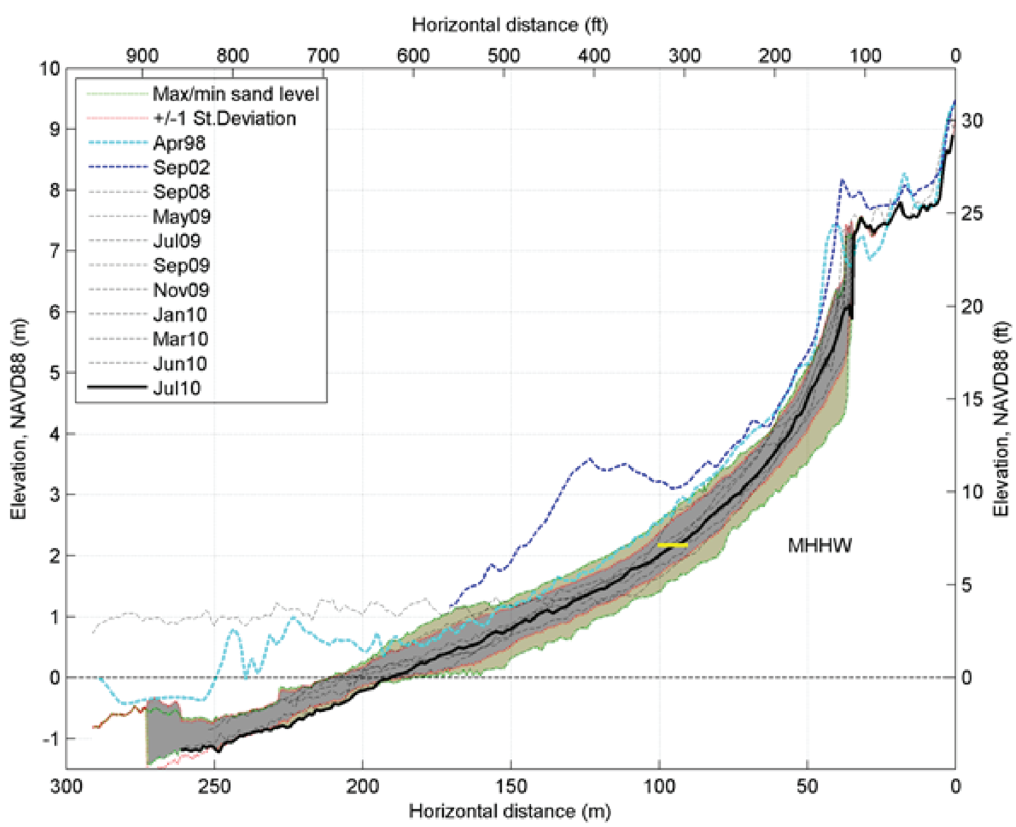

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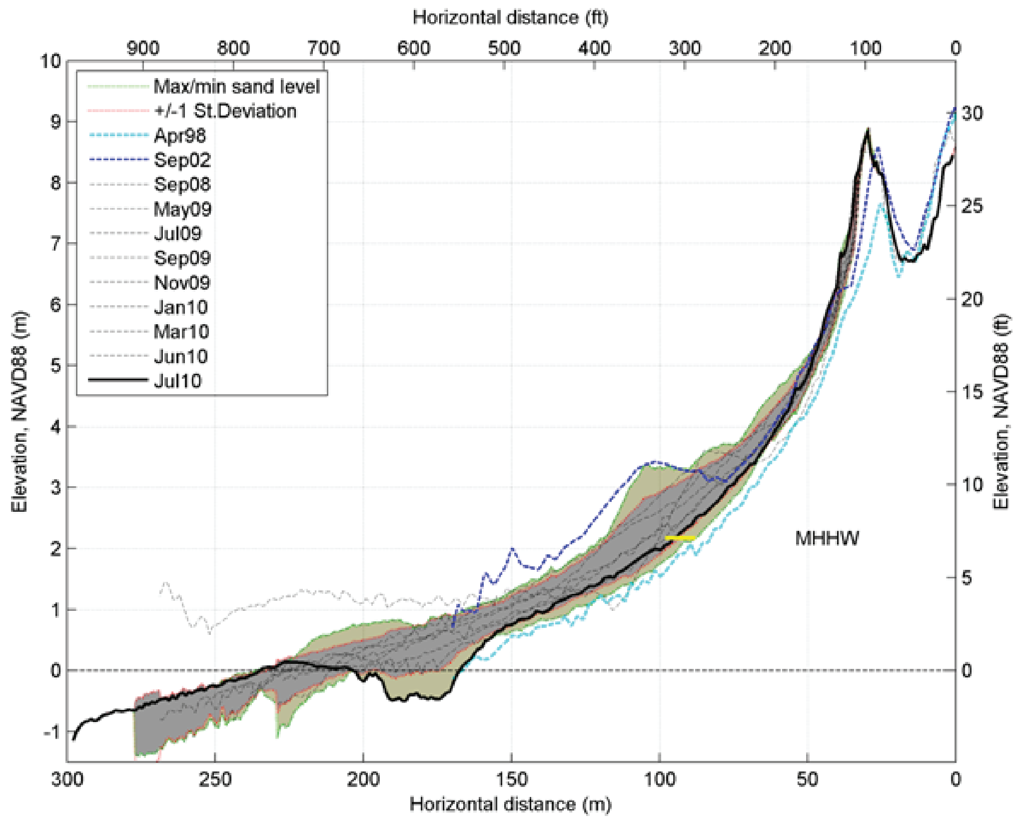

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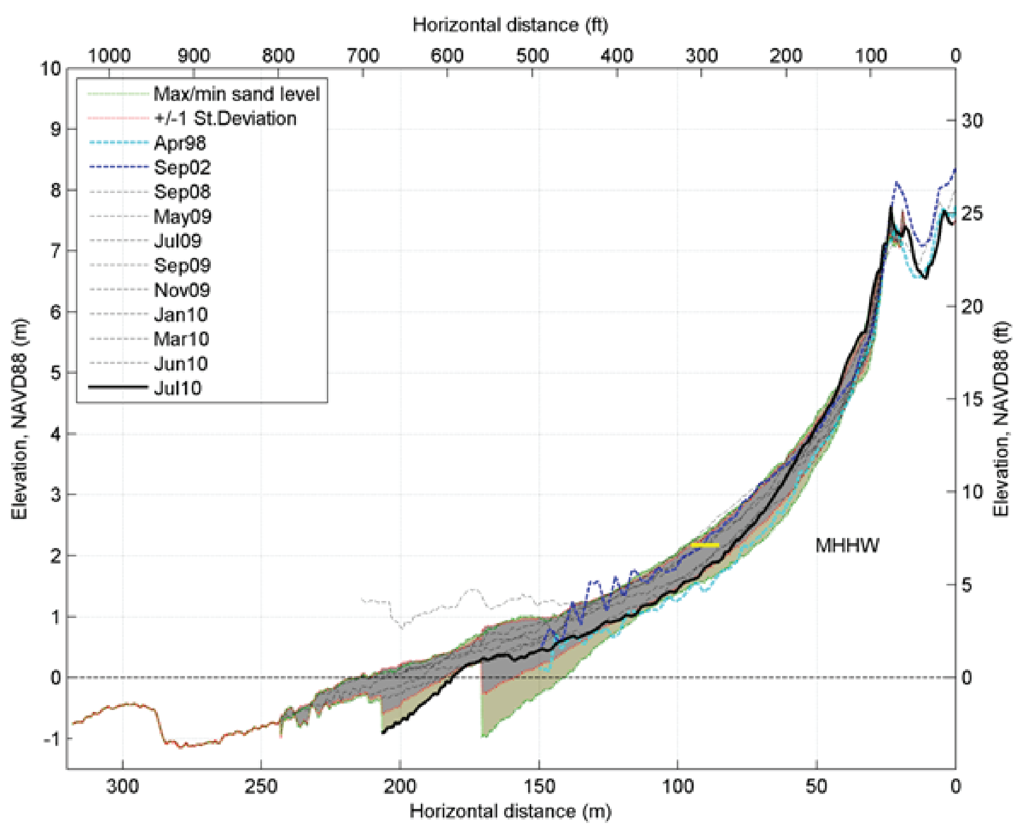

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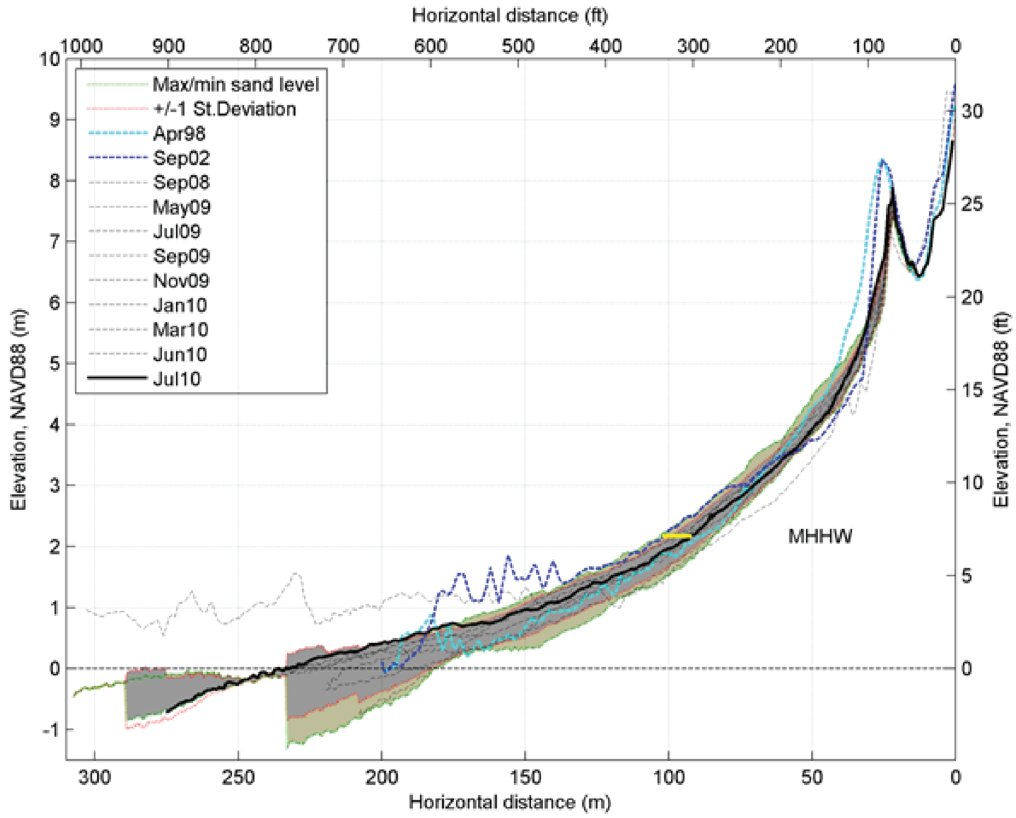

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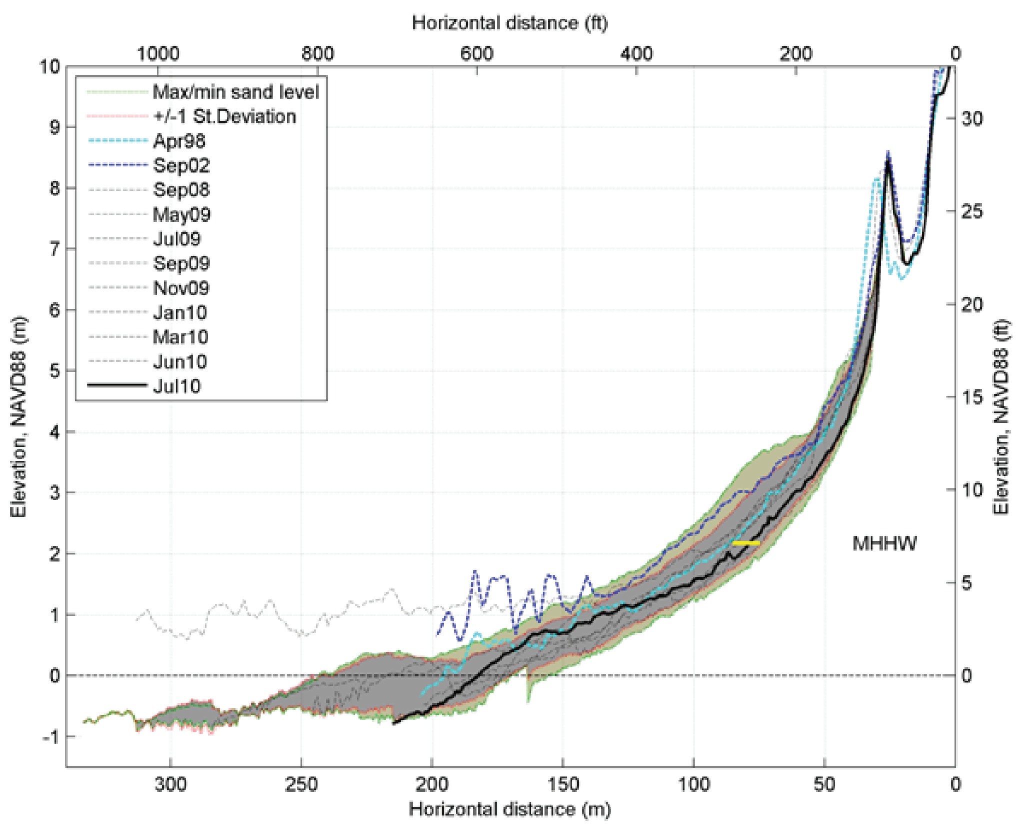

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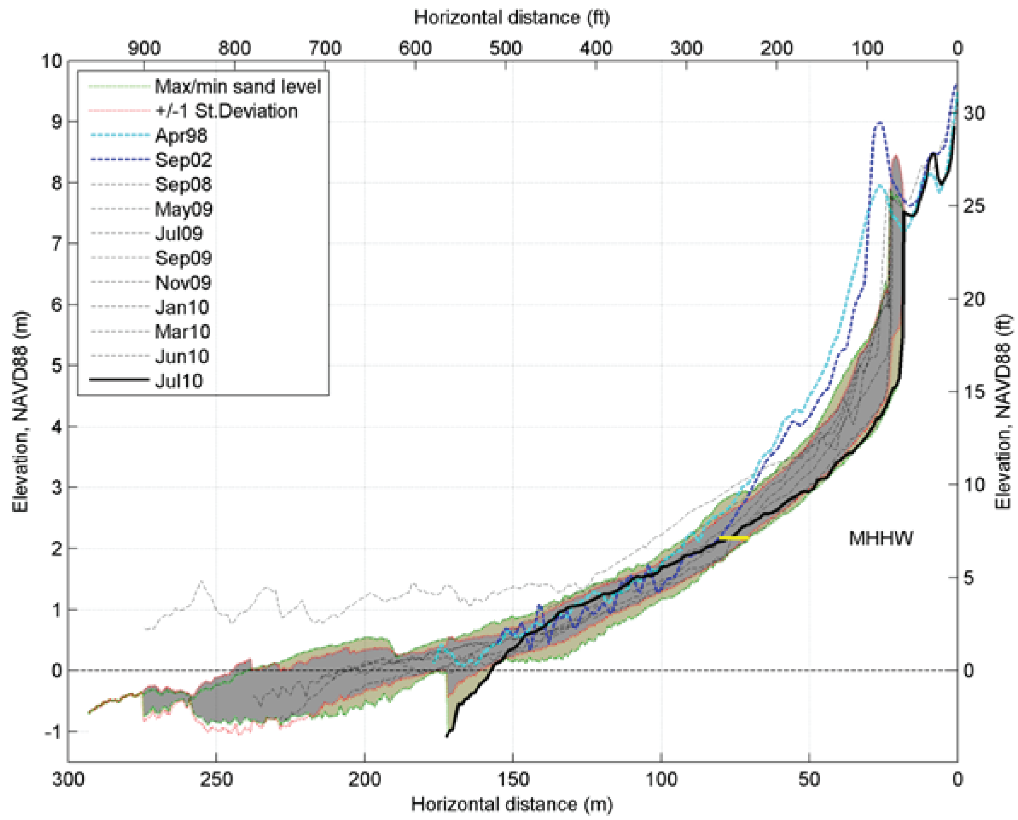

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