North Carolina Floodplan Mapping Program Intermediate Submission Number Three Report on Production Simulations and Statistical Analyses

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North Carolina Floodplain Mapping Program

Intermediate Data Submission Number Three

Report on Production Simulations and Statistical Analyses

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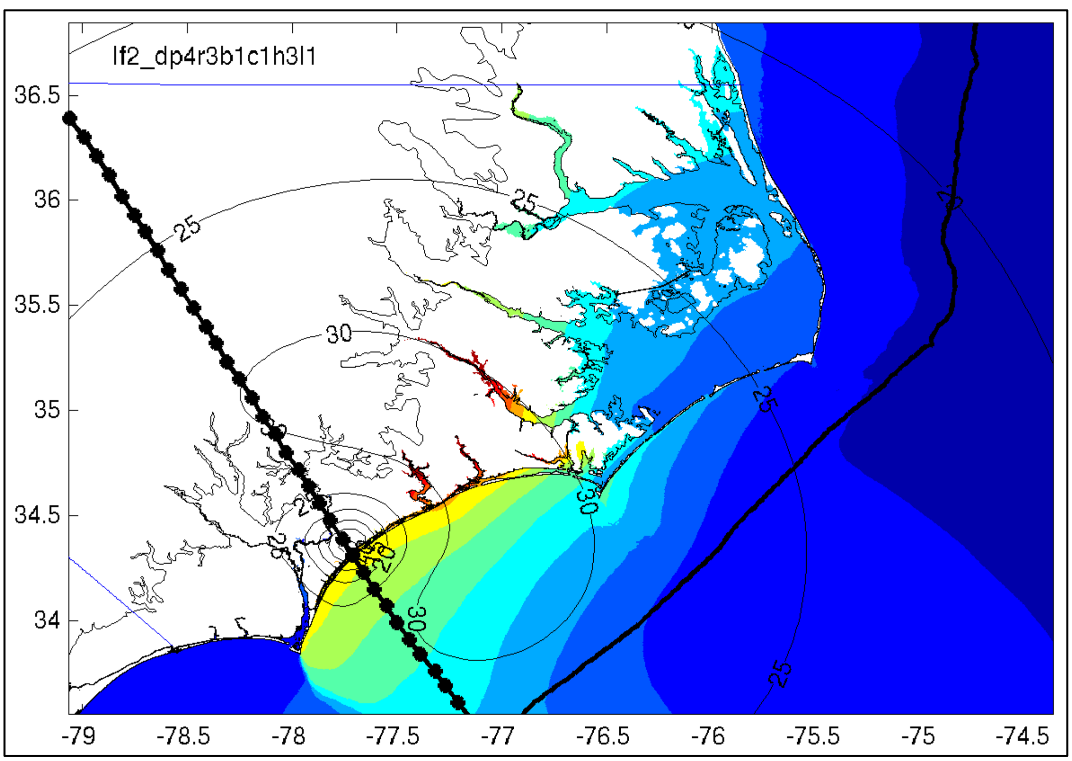

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Overview

As part of the State of North Carolina Department of Emergency Management Floodplain Modernization Program, a partnership was assembled to develop a state-of-the-art system to compute surge water levels and waves along the North Carolina coastal region waters. Experts in the fields of coastal storm surge, hurricane and extra-tropical winds, wind-driven waves, geospatial information systems (GIS), and high-performance computational systems have worked together in this effort to further advance North Carolina's leading role in flood analysis and mapping. The Renaissance Computing Institute (RENCI), the Institute of Marine Sciences (IMS), Applied Research Associates, the US Army Corps of Engineers, and Dewberry have worked together to complete the production simulation and statistical analysis phase of the project.

In previous phases of this FEMA Flood Insurance Study (FIS), comprehensive inputs to the overall system have been developed (seamless DEM, high-resolution ADCIRC grid, validation studies, and hurricane climate representation via JPM) and described in previous Submittal documents. Submittal One was approved by FEMA March 23, 2009, Submittal Two received conditional approval from FEMA on November 1, 2010 and final responses to comments on Submittal Two were provided to FEMA on September 8, 2011. In Submittal Three, we describe the various aspects of the production phase of the project, in which the probabilistic hurricanes and historical extratropical storms are used to drive the comprehensive modeling system to determine the surge and wave hazard levels at specified return periods. While this is a computationally intensive process, the bulk of the work leading up to this phase is critical to ensure that this phase is as robust and efficient as possible. The production phase of this project is where prior work comes together into a statistical dataset that will subsequently be used in the mapping phase of the FIS.

Computation of storm responses

The mechanism through which the production simulations are conducted is the comprehensive modeling system established previously and described in Submittal I. This exact same system was used to conduct the validation studies. To review, this system couples through file exchange the far-field wave model WaveWatch3, the nearshore wave model SWAN, and the storm surge and tidal model ADCIRC, driven by specification of a storm. The storm is either an extratropical storm represented by an OceanWeather, Inc., best winds analysis, or a tropical storm computed using the Applied Research Associates hurricane boundary layer model. The computational system does not distinguish between the two storm types.

Each storm simulation includes computing the deep water wave field (WW3), the surge-only water level (ADCIRC.0), the nearer shore wave field (SWAN), and the final surge + setup solution (ADCIRC.1). Recall that the SWAN simulations are actually four different simulations on the two outer and two inner grids. Thus, each storm simulation is composed of seven simulations. Each component (WW3, ADCIRC.0, SWAN, ADCIRC.1) runs sequentially. The SWAN outer simulations run concurrently, and then the inner grids are run. This is fully described in project Submittal One.

All production simulations were conducted using the ADCIRC grid version 9.81. This grid version has advanced from the version used in the project validation studies, primarily due to issues in the Cape Fear associated with strong storm forcing that did not occur during the six validation storms. Differences between these grid versions are described below.

There are a total of 697 simulations in the production storm suite: 675 tropical storms and 22 extratropical storms. Extratropical storm time periods, tropical storm parameters, and general storm characteristics are fully described in Submittal I. The tropical storm population was revised to be equally spaced in March 2010, and these storms were used in the production runs and statistical analyses. The complete set of tropical storm parameters are listed in Appendix D herein. Production simulations occurred starting 15 Nov 2010, using 75% of RENCI's IBM Bluegene/L (3072 cores) and ~20% of RENCI's Blueridge Nehalem cluster (256 cores). The last simulation finished on approximately 15 January 2011.

ADCIRC Grid V9.81

The ADCIRC grid version used for production is v9.81, while the version used in the validation studies is v9.35. Changes to the ADCIRC grid were required to address terrain features identified through coordination meetings with Virginia and South Carolina and issues that arose during preliminary tests of the production simulations using storms that excited instabilities in the computed solution that were not excited in the validation storm suite. The areas of the grid that were modified are as follows:

- ***SC/NC border area***: There was concern about water backing up because while the grid continued to the SC area, it was not defined well enough to have the channel and water areas defined in the v9.35 version of the grid. It was decided to take part of the SC FEMA project grid and add it into the NC grid. Minor modifications were required for stability and smooth merging of the bathymetry and topography. See Figure 1.
- ***Lockwood's Folly area***: It was noted that the grid bathymetry/topography did not match up well with what was seen on satellite images of the area. The DEM did not provide additional guidance and charts for the areas are incomplete. We thus used satellite images to guide grid edits. See Figure 2.
- ***Northern Outer Banks area:*** Another problem noted was that some dunes along the northern Outer Banks ended abruptly. Resolution was added along the dune line from up to the Virginia line. Also in the northern NC area, several locations in the ICWW channel did not have sufficient cross-channel resolution. This was fixed with additional control points. See Figure 3.
- ***Cape Fear River area:*** Additional grid resolution was provided in the Cape Fear River and adjacent land areas in the vicinity of Wilmington and in areas upstream of Wilmington to eliminate model instabilities that occurred in these areas during initial production simulations. Additional grid resolution was also added downstream of these areas to make the resolution more consistent in all areas of the Cape Fear River. See Figure 4.
- ***Lower Virginia Coast, between NC/VA border and Virginia Beach:*** It was noticed, when comparing preliminary results between the NCFMP and FEMA Region 3 projects, that the dune heights north of the NC/VA border were lower in the NC grid. The result was that too much water was entering NC through the northern part of Currituck Sound for a subset of storms. Examination of available imagery and the Region 3 grid indicated that the NC grid topographic elevations should be raised. See Figure 5.

These grid modifications had no significant impact on the previously reported validation and skill assessment. This is expected since the modifications listed above are limited in extent. The validation storms were recomputed, and comparisons to both the validation data and v9.35 simulations were conducted. Figure **6** shows the peak water levels from the high water marks and NOAA gauges for all storms for both the v9.35 and v9.81 simulations. There is very little difference between results on the different grids, with a mean and standard deviation of -0.015 and 0.025 m respectively.

QA/QC and Post-processing procedures

Each simulation produces a suite of graphical output to aide in the QA/QC procedure. Each graphical output has been examined to gain an overall perspective of the simulations. During this phase, no systematic issues were discovered. Examples of the maximum water level and maximum significant wave height are shown in Figure 7, for the landfalling storm lf2_dp4r3b1c1h3l1. In addition to visual inspection of results from each simulation, the gradient in the maximum elevation was computed and screened for large elevation gradients. The gradient evaluations were conducted because, after the validation process, several production storms caused instabilities on the v9.35 grid. This led to a sequence of grid modifications and test simulations using production storms until an updated grid exhibited smooth and expected results. The final grid version is v9.81, reflecting the many versions in between 9.35 and 9.81 that did not pass the gradient evaluations.

The primary data from each simulation is the maximum water level (ADCIRC) and significant wave height (SWAN) at each model node. These fields are output at the end of each simulation, along with the time at which the local maximum occurs. The latter field is subsequently used to determine the significant wave height and period that co-occurs with the maximum water level. Figure 8 shows an example of this process, where the primary model system outputs are shown at an open coast node near the White Oak River, for the landfalling storm lf2_dp4r3b1c1h3l1. (This is the same storm as shown in Figure 7.) At this location, the maximum surge (2.1 m) occurs at day 4.875, and the maximum significant wave height (3.1 m) also occurs at this time. It is thus both the maximum significant wave height as well as the wave height that co-occurs with the maximum surge. The maximum peak period at this node is 13.75 sec, but the peak period that co-occurs with the co-occurring wave height is lower, at 12.1 sec. A table is constructed from each simulation that contains the maximum surge, maximum significant wave height, co-occurring significant wave height, and co-occurring peak period. Return levels for surge and wave height are then computed using this data (see detailed example below in Statistical Methods).

Statistical Methods

The North Carolina area is situated in a region where its coastal areas are impacted by both tropical and extratropical coastal storms. The tropical storm threat from a direct landfalling storm is largest south of Cape Hatteras. North of Cape Hatteras (into Region 3 and further) is dominated by extratropical coastal storms with lesser contributions from tropical systems to the total hazard.

As described in previous submittals, tropical storms can be parametrically represented via the Joint Probabilities Method (JPM). This produces a set of candidate tropical storms that are probable to occur over some long time period. In the NC case, 675 storms were specified, with an annual occurrence rate of .343 storms/year. Each storm is assigned a statistical weight, which is the product of the probabilities of the storm parameters that define that storm (i.e., the joint probability).

The comparatively complex nature of extratropical storms (meaning that it requires a considerably larger perspective on the mesoscale meteorology to adequately describe) generally means that a parametric description of extratropical storms is difficult to define, if at all possible. Consequently, selecting specific historical storms and computing the surge/wave responses to these storms define the extratropical hazard. The subsequent surge return levels are determined using the Empirical Simulation Technique (EST).

The EST is based on a "Bootstrap" resampling-with-replacement, interpolation and subsequent smoothing technique in which random sampling of a finite length database is used to generate a larger database. The only assumption is that future events will be statistically similar in magnitude and frequency to past events (Scheffner, et.al.). Further detail of the EST methodology can be found in Appendix A: EST Methodology at the end of this document.

Here, we demonstrate the computation of the JPM return levels and associated wave heights and periods at one model node on the NC open coast, ignoring tides (addressed below). It is required that at least 40% of the tropical storms (>=270 of 675 storms) wet a node for that node to be computed. After some tests, 40% was found to be the minimum percent wet that ensured that all annual chance levels were resolved in the CDFs across the entire project region.

1. Load all simulation results. This includes the maximum water levels for the ADCIRC.0 and ADCIRC.1, the significant wave height that co-occurs with the maximum water level in the ADCIRC.1 solution, and the peak wave period that co-occurs with the co-occurring significant wave height;
2. At each model node that wets during the simulations, rank-order the max surge responses (Figure 9);
3. Permute the storm weights according to the ranking in Step 2. This results in a Cumulative Distribution Function for the response at this node (Figure 9);
4. From the CDF, compute the return period according to the following equation:

$$R = \frac{1}{1 - e^{-\alpha(1-CDF)}}$$

   where R is the return period in years, α is the annual occurrence rate of tropical storms (.343 storms/year), and CDF is the cumulative distribution function computed in step 3. This results in the relationship between the return period and the storm surge response. The return levels associated with the 10%, 4%, 2%, 1%, 0.2%, and 0.1% annual chance levels are then interpolated from this relationship (Figure 10);
5. From Step 4, find the storm that is closest to the computed 1% surge level and get the co-occurring wave height and period from the table generated in the post-processing step (described above). This step thus associates a wave height and period that co-occurs with the 1% storm surge value at every model node.

Incorporation of Tides and Errors into JPM analysis

Other projects (e.g. Niedoroda et al, 2010) have included tides as a constant (in space and time) addition to the JPM integral error term. In regions where the tides are relatively of the same amplitude and generally in phase, this is an appropriate choice. However, tides along the North Carolina coast exhibit large changes in amplitude and phase. Tidal amplitudes, as indicated by the tidal range "highest amplitude tide" (Figure 12), range from about 1.3 m at the NC/SC border to 0.75 m at Cape Hatteras, and back up to about 0.90 m north of Duck. Additionally, tides are generally small in the Pamlico-Albemarle Sounds. This complexity renders using a constant tidal value unreasonable.

We have incorporated tides into the JPM analysis by replicating the surge response data and adding tidal heights randomly selected from the cumulative distribution functions of the tides. This is done at each model node as follows, where we describe the procedure at one model node.

1. Replicate surge responses at each node N times. This results in N replicates each of which is 675 surge responses. The weights of the storms are also replicated and normalized by N so that the sum of the probabilities is still 1.0. Sensitivity analysis of the computed return levels to the number of tidal replicates indicates that N=100 is sufficient. This is shown in Figure 11, where the water levels at an open-coast location near Wrightsville Beach at the 10%, 4%, 2%, 1%, 0.2%, and 0.1% annual chance levels are computed with varying N, from 0 (no tides) to 1000. The computed data is shown in .
2. Note that there is no more than one cm (0.01 m) between the N=100 and N=1000 results for all return periods.

Table 1: Water Levels computed with increasing numbers of tidal replicates (n) for an open-coast location near Wrightsville Beach, NC.

	Annual Chance of Occurrence [%]					
	10	4	2	1	0.2	0.1
N=0	1.17	2.00	2.51	3.00	4.10	4.29
N=1	1.33	2.28	2.80	3.44	4.30	4.64
N=10	1.38	2.25	2.80	3.32	4.37	4.76
N=100	1.39	2.28	2.80	3.31	4.37	4.71
N=1000	1.39	2.28	2.80	3.31	4.38	4.70

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3. For each storm, sample the tidal CDF N times (Figure 13) add this tidal value to the surge value. If the resulting combined tides+surge value is lower than the topography/bathymetry, set this tides+surge value to 0, meaning that this storm at this location (node) and at the selected tide level did not produce a positive water level. The results of this step are shown in Figure 13, where the surge-only response is in blue, and the N tides+surge levels are drawn with the red dots.
4. Rank-order the new water levels and re-order the weights accordingly (Figure 14).
5. Finally, compute the return period in the same manner as above (for surge-only), and interpolate the resulting period/levels to the standard return periods (Figure 15).

Concurrent with the addition of the random tides, an error term is also included that represents errors in modeling skill. The project high water mark analysis (reported on in Submittal Number 2) indicates that the overall error distribution is relatively Gaussian, with a mean (bias) of -.01 m and a standard deviation of 0.33 m. For each of the tidal replicates, a modeling error is sampled from the error distribution and added to the total surge response (modeled + tidal + error).

Note that Niedoroda et al, 2010, describes an error term with four contributions for the recent Mississippi coastal hazard study. The NCFMP error term is similar to their "modeling skill" term (their contribution number 2). Their additional terms are either directly incorporated into the production runs (Holland-B—their error component 2—is an explicit parameter in the NCFMP JPM storm parameters; the wind model used for the NCFMP production storm simulations is the same as that used in the tropical validation simulation—their error term 4), or incorporated into the final JPM analysis (tides—their error component 1).

Combining return levels from JPM and EST

After the return levels are computed for each storm type (JPM and EST), the final return levels at the 10%, 4%, 2%, 1%, and 0.2% annual chances are computed. Statistical independence between the two storm populations (tropical and extratropical) is assumed. The method is as follows, more fully described in the EST User's Manual (Scheffner et al, 1999). Over the range 0 to 5 meters, at an interval of 0.1 meters, the probabilities of exceedance at these levels are interpolated from the hazard curves for JPM and EST. The new probability of exceedance is then

$$P_c = 1 - (1 - P_j)(1 - P_e)$$

where P_j is the probability of exceeding the specified level from the JPM return levels, P_e is the probability of exceeding the specified level from the EST return levels, and P_c is the probability of exceeding the specified level in the combined probabilities. Since the JPM and EST probabilities are annual values, the resulting combined probability is also annual and the annual percent chance of exceedance is the $T_c = 1/P_c$. After looping over the return level range, the result is a new hazard curve, from which the new return levels are interpolated. This process is illustrated Figure 16 using hypothetical return levels. At the water level 1.0 m, the probability of exceedance for JPM is 0.1 (since 1.0 m is the 10-y return level for JPM). Thus P_j = 0.1, and similarly P_e = 0.01. Then,

$$\begin{aligned} P_c &= 1 - (1 - P_j)(1 - P_e) \\ &= 1 - (1 - 0.1)(1 - 0.01) \\ &= 1 - 0.9 \times 0.99 \\ &= 0.109 \end{aligned}$$

Lastly, the new return period for the 1.0 meter level is 1/0.109 = 9.2 years (green dot in Figure 16). At the 2.0 meter level, the EST probability is very low, and thus the term (1-P_e) is essentially 1, and $P_c \sim P_j$. So in this example, the combined levels are the same as the JPM levels, except at the 1% level, which is determined by interpolating the combined curve at 10 years. In this example, the combined 1% level is 1.05 m (green dot in Figure 16).

We give one more illustrative example. Consider that the highest EST level is lower than the lowest JPM level (Figure 16). In this case, the contributions of the EST values to the combined levels are insignificant, and the resulting combined levels are the same as the JPM levels. This is a typical case on the North Carolina coast wherever the extratropical storm impacts are lower than the 1% JPM levels. In other words, in many locations, the two datasets do not substantially interact.

Computed return levels

Return periods analysis results for JPM, EST, and the combined values are shown in Figure 17 - Figure 19. The units in the figures are meters relative mean sea level. However, the data are reported in digital form in the project data files relative to both MSL and NAVD88.

JPM: Figure 17 shows the 2%, 1%, and 0.2% annual chance levels for surge and significant wave height levels for the surge+waves simulations (ADCIRC.1). Generally, the levels are lower north of Cape Hatteras than south of the cape. For example, at the 1% chance, the levels are 1.0-1.25 m along the open coast. South of Cape Hatteras, the levels increase from about 1.0 to 2.25 m at the SC/NC border. Levels in the Pamlico-Albemarle sounds range from 0.5-1.25 m, except up the Neuse River where levels reach 2.0 m. At the 0.2% chance, the surge levels are greater than 4.25 meters in the Wrightsville Beach area. Wave heights are generally at about the same level near the coast, since the wave field is relatively depth limited. This behavior is also seen in the closed sound system, with the wave levels fixed at about 4 meters in the middle of Pamlico Sound (for example). Offshore, the 1% wave heights are 10-11 m, and increase to 13-14 m at the 0.2% level.

EST: Results from the EST analysis are shown in Figure 18. The water levels are shown for the 2%, 1%, and 0.2% annual chances. Generally, the levels are highest along the seaward side of the northern Outer Banks (from Cape Hatteras to the NC/VA border) as well as along the open coast from about Wrightsville Beach toward the NC/SC border. Levels are highest in the Cape Fear area, driven largely by the storm surge response of the March 1993 "Super Storm".

Combined Levels: The results of combining the JPM and EST results are shown in Figure 19. Note that the combined levels are generally the same as the JPM levels, since the EST values are usually less than the JPM values. This is further illustrated in Figure **20**, where the return level curves are shown at four representative locations; the open coast near Duck and Wrightsville Beach, and sheltered locations up the Cape Fear near Wilmington and the western side of Pamlico Sound near Lowland. EST only contributes substantially to the 1% levels along the Outer Banks and in the Cape Fear River.

Comparison with Effective FIRM

Effective SWEL values were interpolated from the effective FIS for each county on a transect by transect basis. The previous surge models were not available for this study, and as such, the determination of the SWEL yielded only a single value per transect. In total 1464 effective SWEL values were compared, of which approximately 80 percent decreased relative to the effective flood study values. The total average change in SWELs at the comparison points showed an average decrease of 1.2-ft when compared to the effective SWEL values

In general, SWEL values decreased along the open coast north of Cape Hatteras, in the Pamlico and Albemarle Sounds, in New Hanover and Brunswick counties, and along the open coast of Pender county. SWEL values generally increased in Carteret and Onslow counties, along the intercoastal waterway in Pender County and in the Cape Fear River. Table 2 shows the results of this comparison by county. Refer to Appendix C for maps depicting the comparisons.

TABLE 2: TABLE COMPARING EFFECTIVE SWEL VALUES TO THE PROJECT COMBINED RESULTS.

County	Number of Comparison Points	Average Difference (ft)*	Maximum **Decrease** in SWEL from Effective (ft)	Maximum **Increase** In SWEL from Effective (ft)
Beaufort	94	+3.00	4.68	No Increase
Bertie	20	+2.13	2.46	No Increase
Brunswick	97	+2.31	4.09	0.91
Camden	7	+1.88	2.22	No Increase
Carteret	253	-0.48	2.82	4.13
Chowan	10	+1.82	2.00	No Increase
Craven	32	+0.27	1.72	0.69
Currituck	182	+1.88	4.54	No Increase
Dare	296	+2.46	4.64	0.45
Gates	4	+2.55	2.59	No Increase
Hertford	6	+2.56	2.58	No Increase
Hyde	41	+1.53	3.55	2.58
New Hanover	80	+1.37	2.20	2.08
Onslow	88	-1.71	1.08	6.92
Pamlico	32	+1.57	2.77	No Increase
Pasquotank	23	+1.51	2.30	No Increase
Pender	77	-0.62	1.29	3.55
Perquimans	34	+1.55	2.36	No Increase
Tyrrell	60	+0.32	1.85	0.46
Washington	28	+1.79	+2.29	+1.35

Comparison/Coordination with Virginia and South Carolina

The North Carolina project team has coordinated with Jeff Hansen, project lead for U. S. Army Corps of Engineers for the FEMA Region III Virginia storm surge project, and with the FEMA Region IV South Carolina storm surge project through meetings and the exchange of terrain data, ADCIRC meshes, methodologies, and preliminary surge results. The North Carolina team recently participated in a November FEMA co-regional Coast Hazards Workshop, where preliminary comparisons of SWEL values were made near the Virginia and North Carolina border. Results along the open coast of Virginia show close agreement between the VA and NC studies at the 1% annual chance levels. This is shown in Figure 21.

A meeting was held September 19, 2011 between FEMA Region IV, North Carolina and the South Carolina storm surge modeling team to compare preliminary SWEL values along the North Carolina and South Carolina border. At the meeting the project teams discussed current completion status; surge and mesh boundary issues; model wave, tide and surge validation results; historical storm parameterization and characterization; JPM method and definition of synthetic storm sets; handling of astronomical tides; wave set-up and SWEL results for WHAFIS. Following the meeting North Carolina has continued to share information and provide guidance to the South Carolina team in support of their surge study.

Summary

This report presents an overview of the production phase and statistical analyses of the North Carolina Flood Insurance Study. During this phase, the project team has conducted a thorough and extensive analysis of the extratropical and hurricane storm surge and wave hazard to be used in subsequent mapping activities. The computational system established for the validation study (reported on in Submittal #2) was used without modification for the production simulations. This software system links together state-of-the-art wind, wave, and surge models into a comprehensive tool for surge and wave hazard determination and has been extensively verified and validated in terms of both the individual model components and the networked/coupled system of models. The computational resources required to solve the complete problem specification are considerable, totaling more than 3 million computer hours and 5 terabytes of compressed stored model output.

The methods used to compute the individual storm surge and wave simulations as well as the statistical analyses represent the state of the art in terms of calculation of the surge and wave hazard for a coastal region. While these methods are generally similar to recent, previous studies, several differences are noted. The complexity of the North Carolina coast includes a large sheltered sound system, fronted by a thin and relatively continuous barrier island chain. Large rivers enter into both this sound and the coastal ocean in several places. Both of these features have led to a comprehensive representation of the coastal geometry in both a digital elevation model and the underlying ADCIRC and wave model grids. Substantial effort has been placed in the representation of the rivers and the Intracoastal Waterway. Additionally, the North Carolina coast is situated in the middle ground of two different storm types that define the full storm hazard; extratropical storms north of Cape Hatteras and tropical storms southward of Cape Hatteras. This mixture of storm types has required a substantial number of individual simulations and a combination of statistical methods.

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Figures and Tables

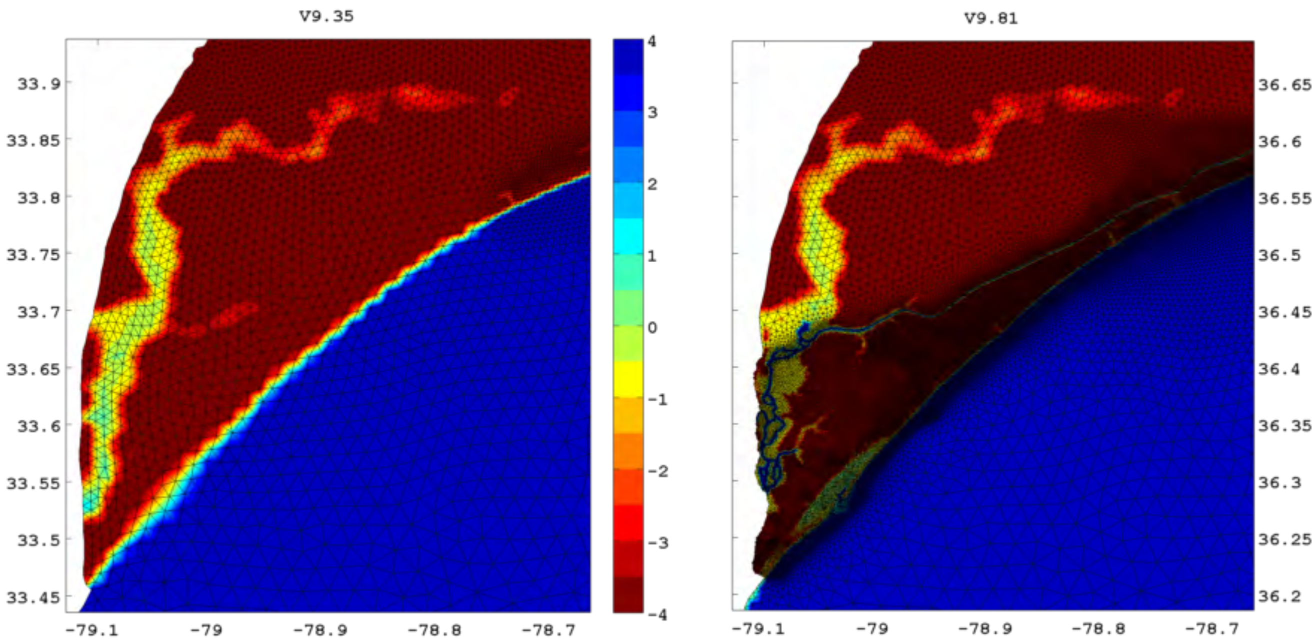


Figure 1: Grid differences in the SC/NC border area. The v9.35 grid is on the left, and the v9.81 grid is on the right. The grid elements are shown in the top row, and the grid topography/bathymetry is shown in the bottom row. Colors indicate grid elevations in meters relative to MSL.

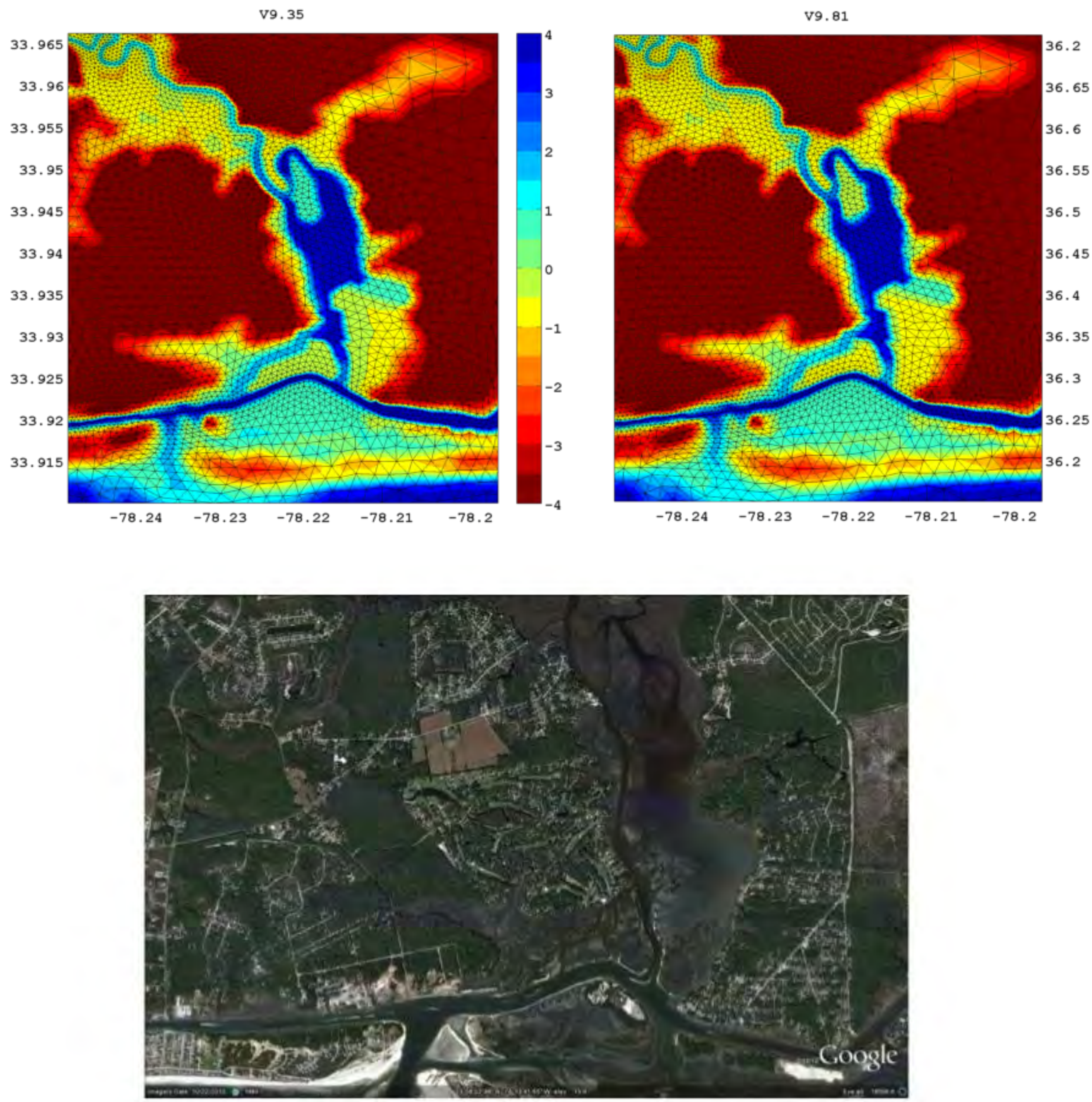


Figure 2: Lockwood's Folly area. (Top) The v9.35 grid is on the left, and the v9.81 grid is on the right. (Bottom) Satellite image from Google Earth showing the terrain in the area.

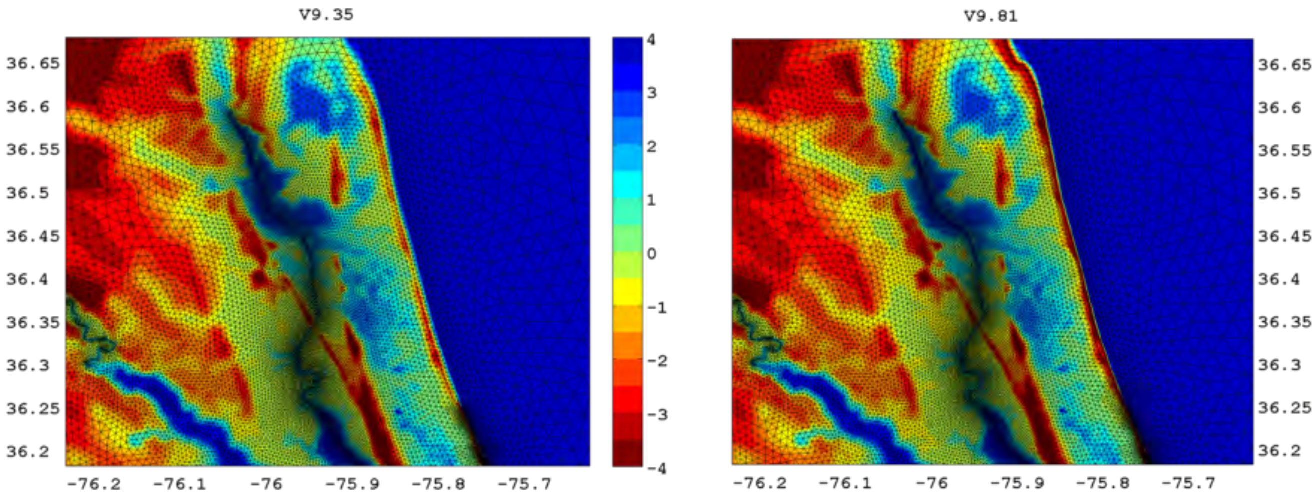


Figure 3: Grid differences in the northern NC area. The v9.35 grid is on the left, and the v9.81 grid is on the right. Colors indicate grid elevations in meters relative to MSL.

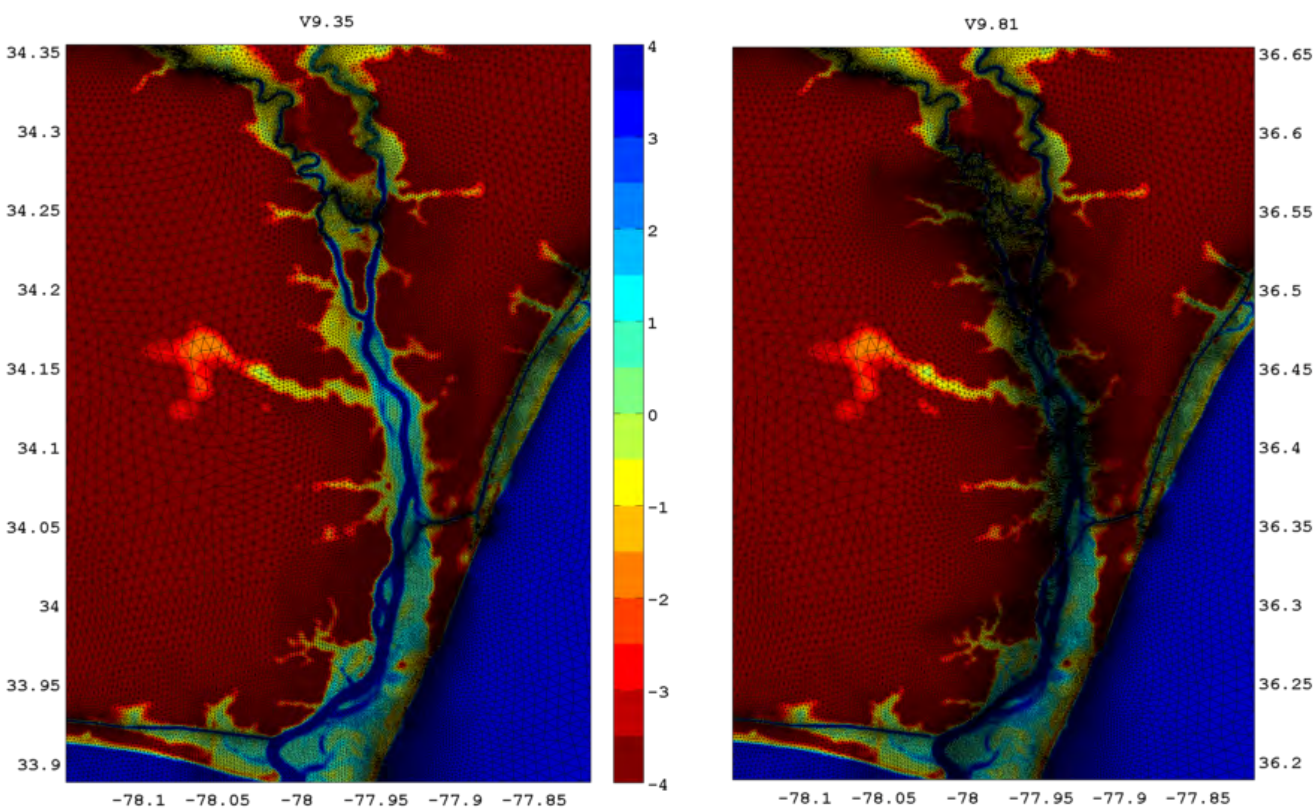


Figure 4: Grid Resolution in the Cape Fear River area. The v9.35 grid is on the left, and the v9.81 grid is on the right.

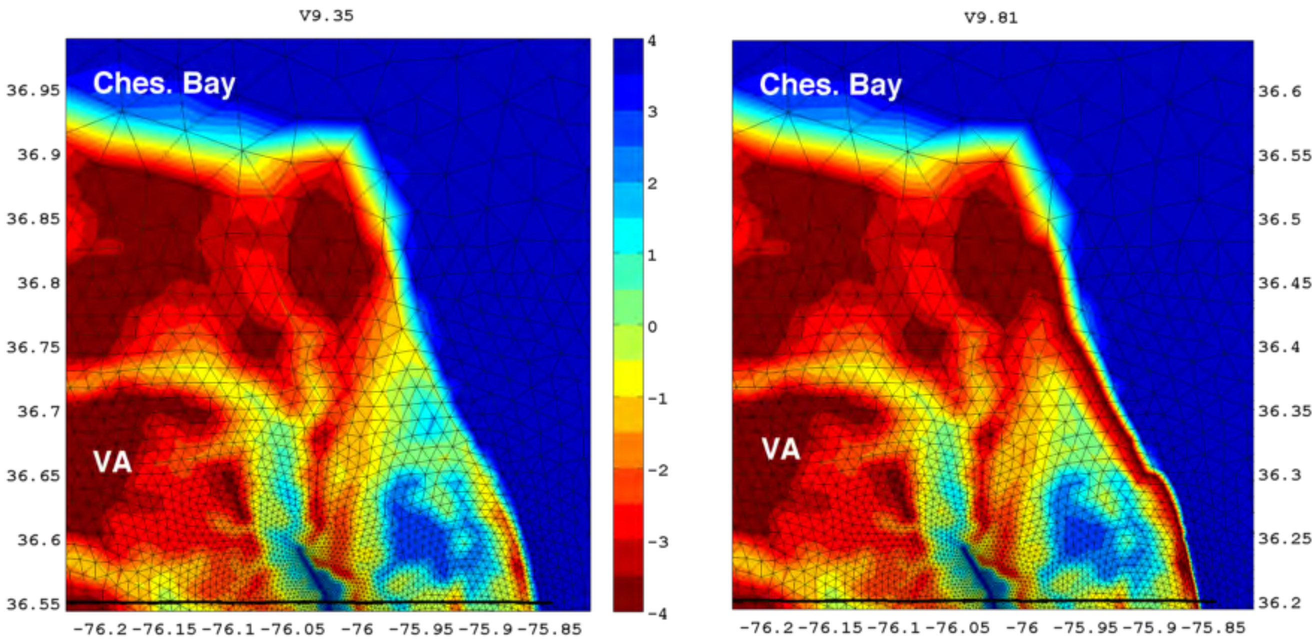


Figure 5: Grid differences in the lower coastal Virginia region. The v9.35 grid is on the left, and the v9.81 grid is on the right. The topography differences occur along thecoast. Colors indicate grid elevations in meters relative to MSL.

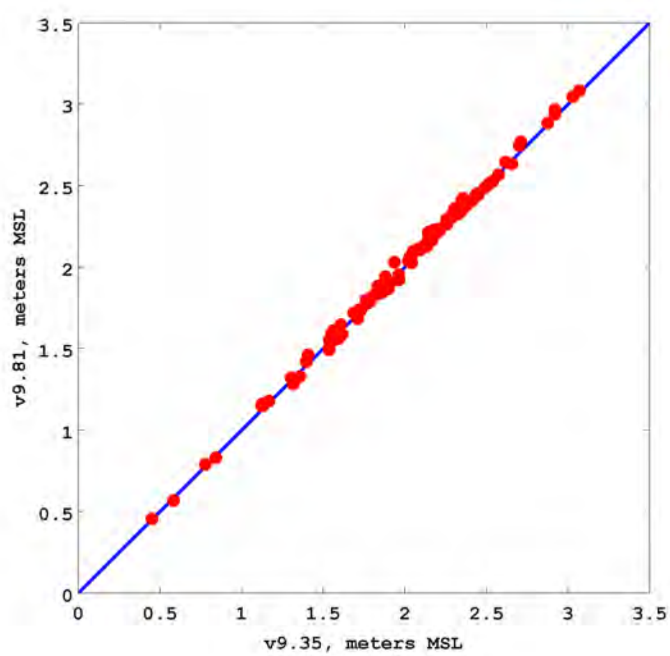


Figure 6: Comparison of peak water levels, across all validation storms, between the validation simulations described in IDS #2 and the validation simulations on the v9.81 grid used for the production simulations. The mean difference is -0.015 m, and the standard deviation is 0.025 m.

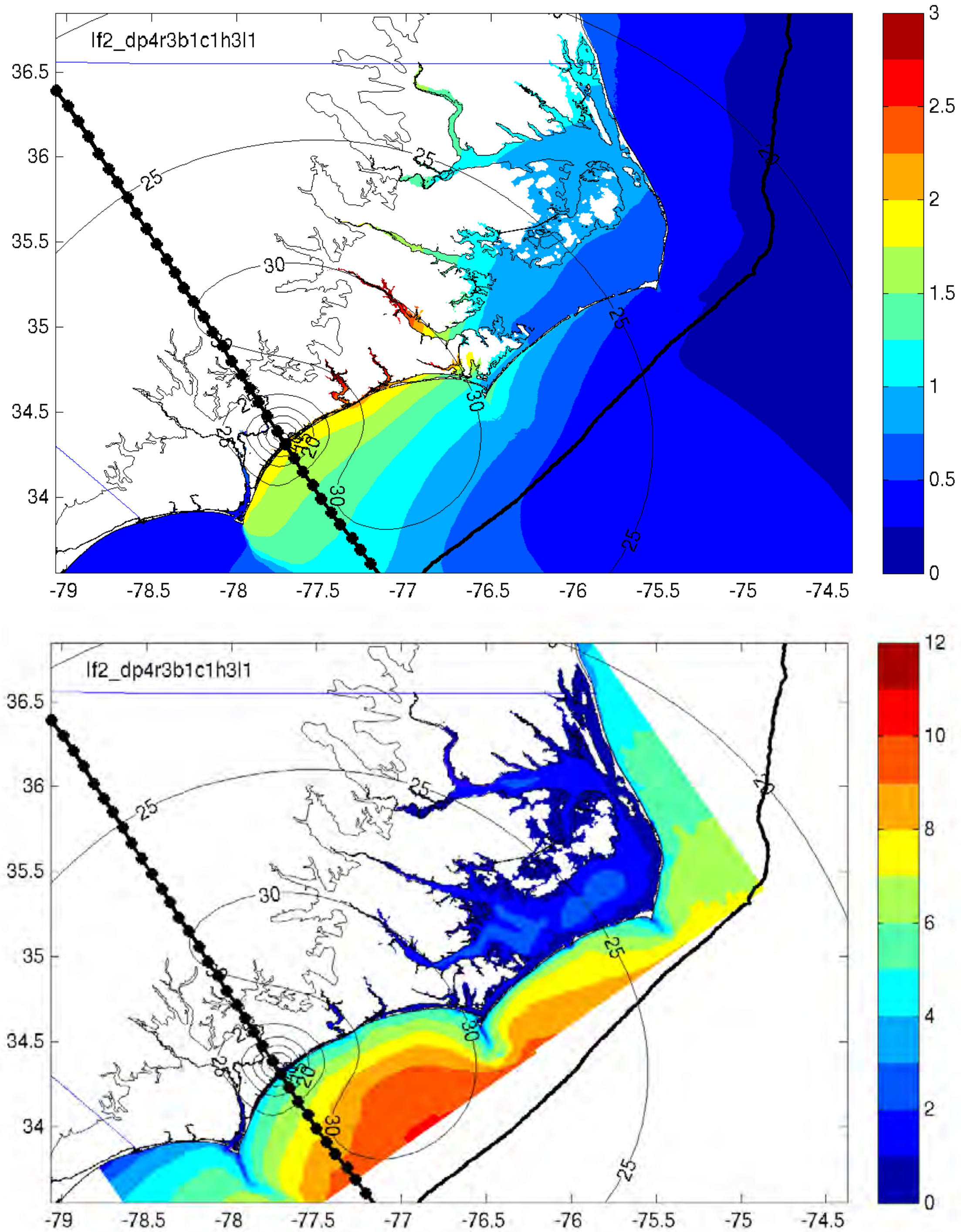


Figure 7: Example of production simulation output for the landfalling storm lf2_dp4r3b1c1h3l1 showing maximum water level in m above MSL (Top) and Maximum significant wave height in m above MSL (bottom). The hourly positions of the storm are shown with the black dots. The 100-m isobath is shown with the thick black line. Wind speeds [m/s] at landfall are shown with thin black contours.

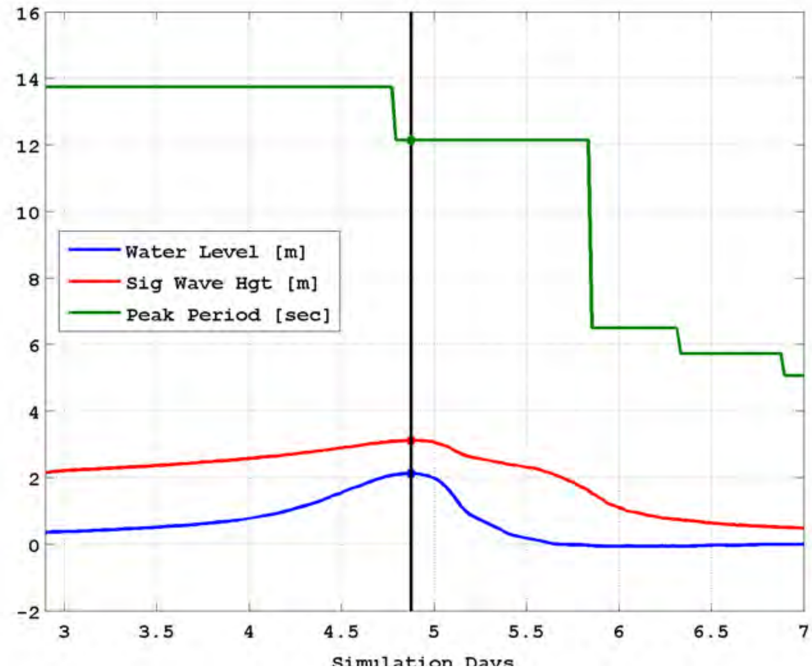


Figure 8: Example of data processing from production simulations. This shows the model system results (water level, significant wave height, and peak period) at a node on the open coast near the White Oak River.

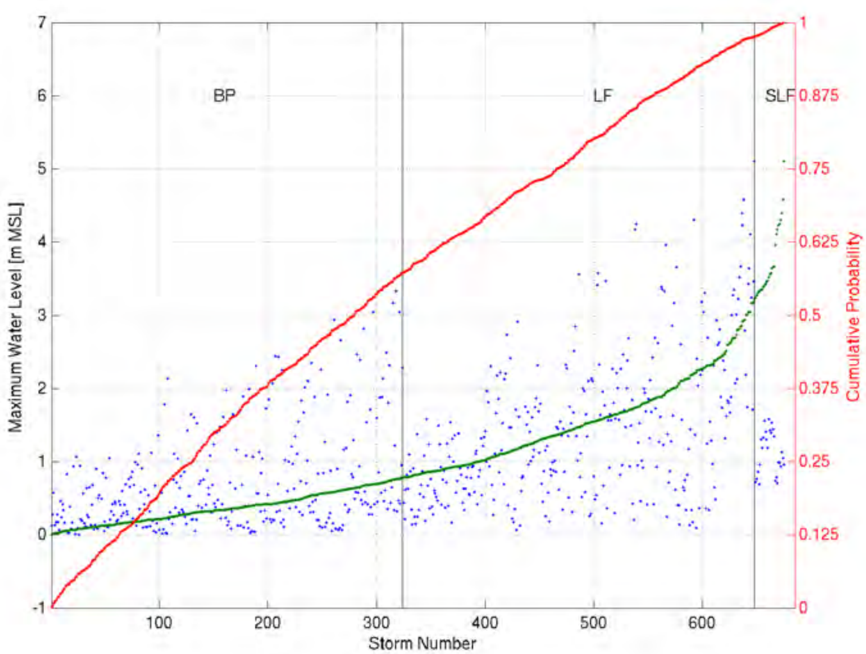
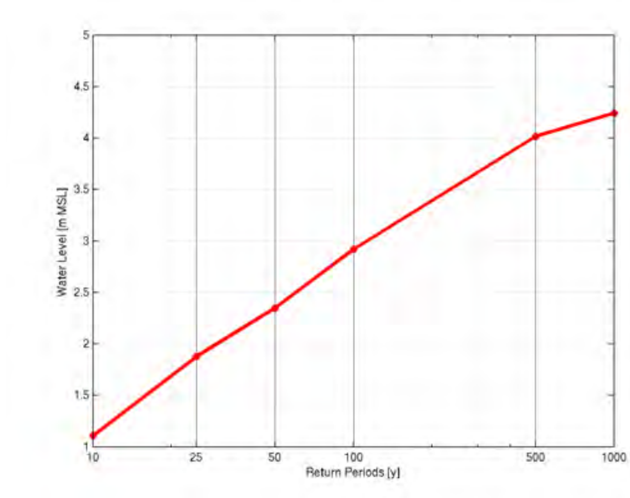


Figure 9: Storm surge response at example node. The blue dots are the unranked maximum surge by storm number, with bypassing, landfalling, and stalling-landfalling groups indicated. The green dots are the ranked storm surge. The red line is the cumulative sum of the ranked storm weights, the CDF for this node. It is relative to the vertical axis on the right (red). There are 675 storms in the tropical storm population.



Annual Chance of Occurrence [%]	Level Without Tides [m MSL]	Level With Tides [m MSL]
10	1.1	-
4	1.9	-
2	2.4	-
1	2.9	-
0.2	4.0	-
0.1	4.2	-

Figure 10: FLood levels for a node near Wrightsville Beach. (Left) hazard curve, without tides (red). (Right) Numerical values.

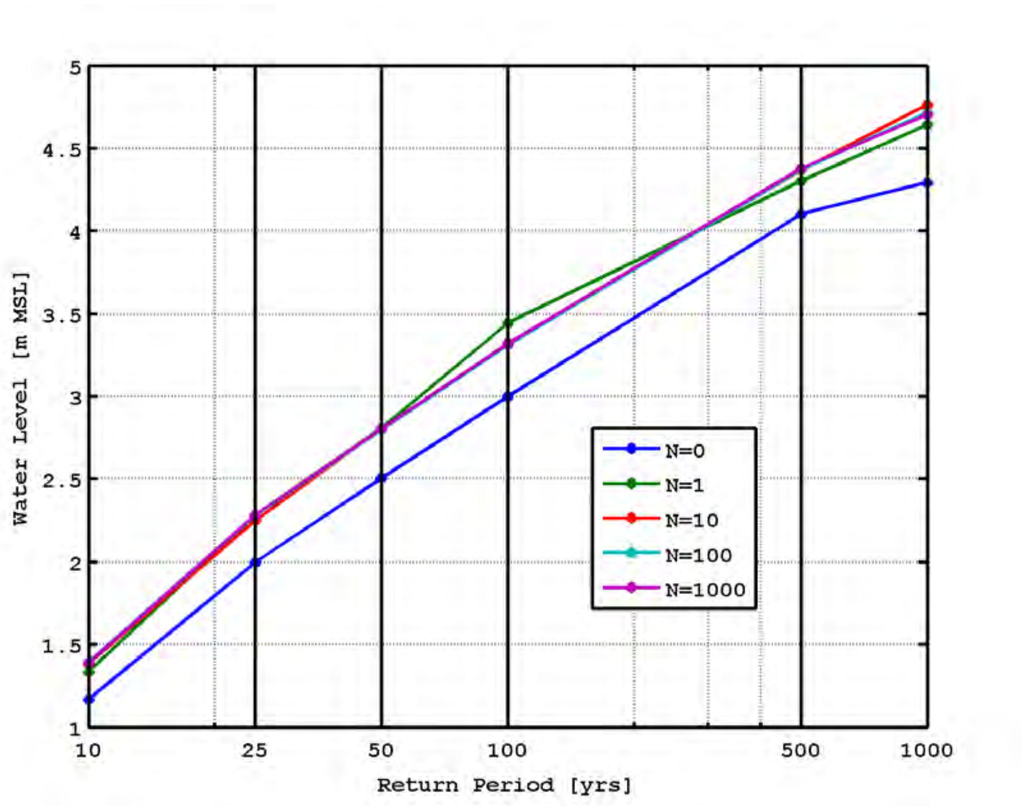


Figure 11: Sensitivity of return levels to number of tidal replicates.

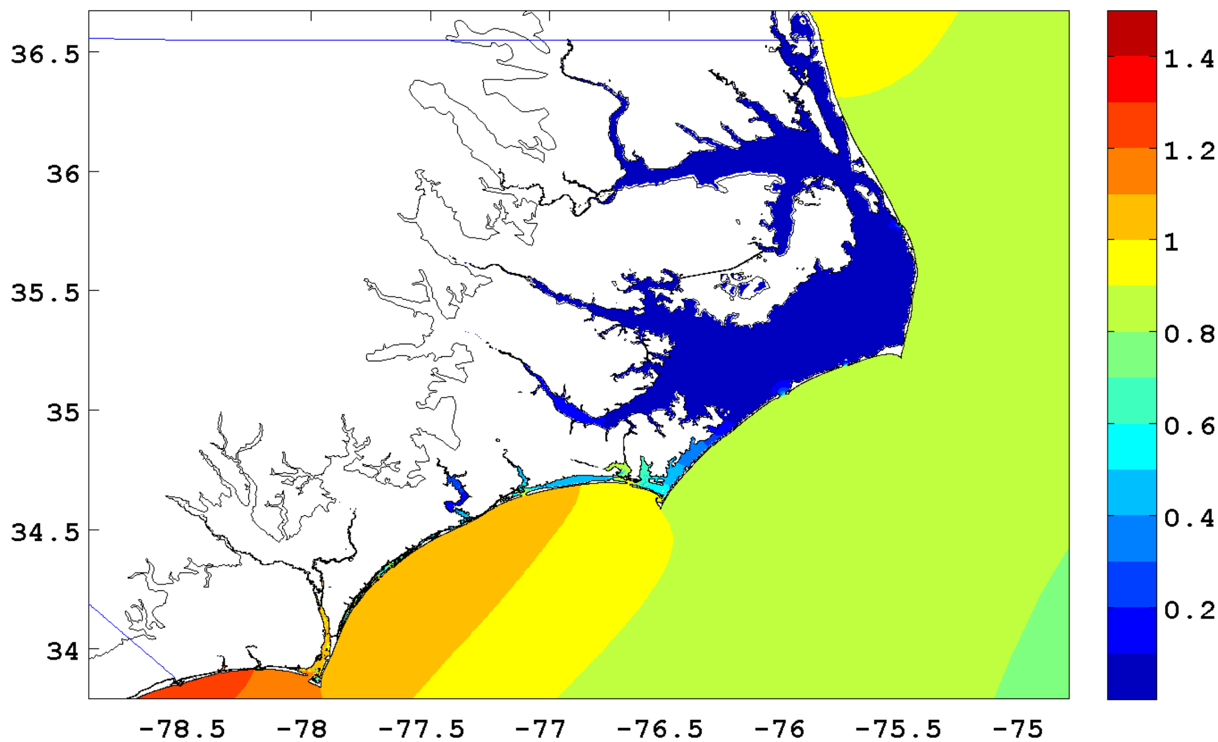


Figure 12: Highest Amplitude Tide [m above MSL] tidal level for Study area, computed from the equilibrium tidal solution used in the tidal validation.

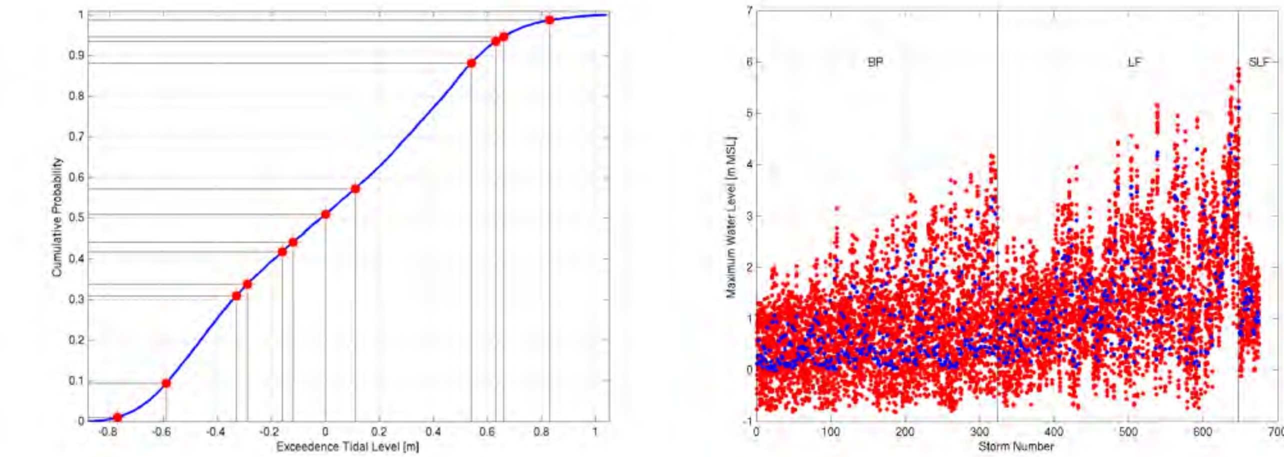


Figure 13: Example of Tidal CDF and replicated storm surge response for tides. Left) CDF (blue) and sampling of CDF (red) for the example node and one storm, N=12. Right) surge-only response (blue) with surge+tides replicates (red).

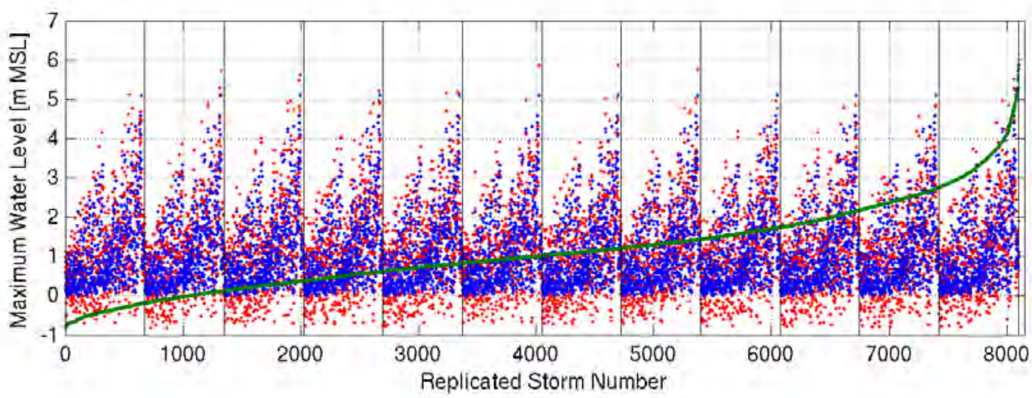
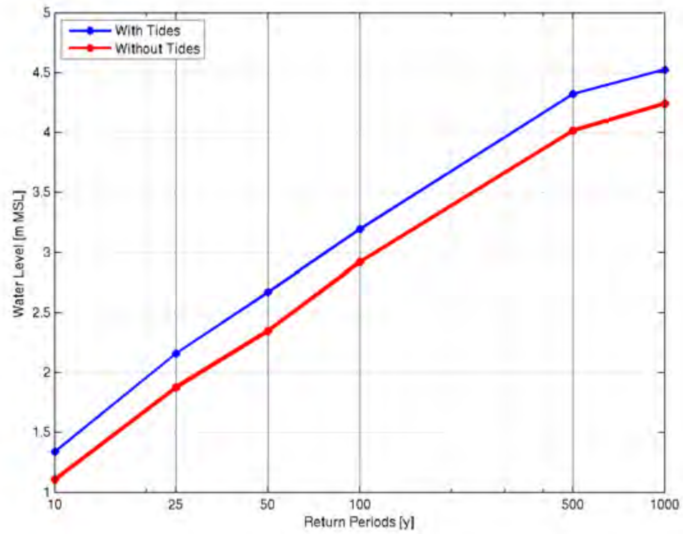


Figure 14: Replicated surge response with each replicate shown separately. The replicated surge-only response is shown with blue dots and the surge+tides is shown with red dots. This is the same data as in Figure 13. The ranked surge+tides is shown with the green dots.



Annual Chance of Occurrence [%]	Level Without Tides [m MSL]	Level With Tides [m MSL]
10	1.1	1.3
4	1.9	2.2
2	2.4	2.7
1	2.9	3.2
0.2	4.0	4.3
0.1	4.2	4.5

Figure 15: Flood levels for a node near Wrightsville Beach. Left) hazard curves; With Tides (blue), without tides (red). Right) Numerical values.

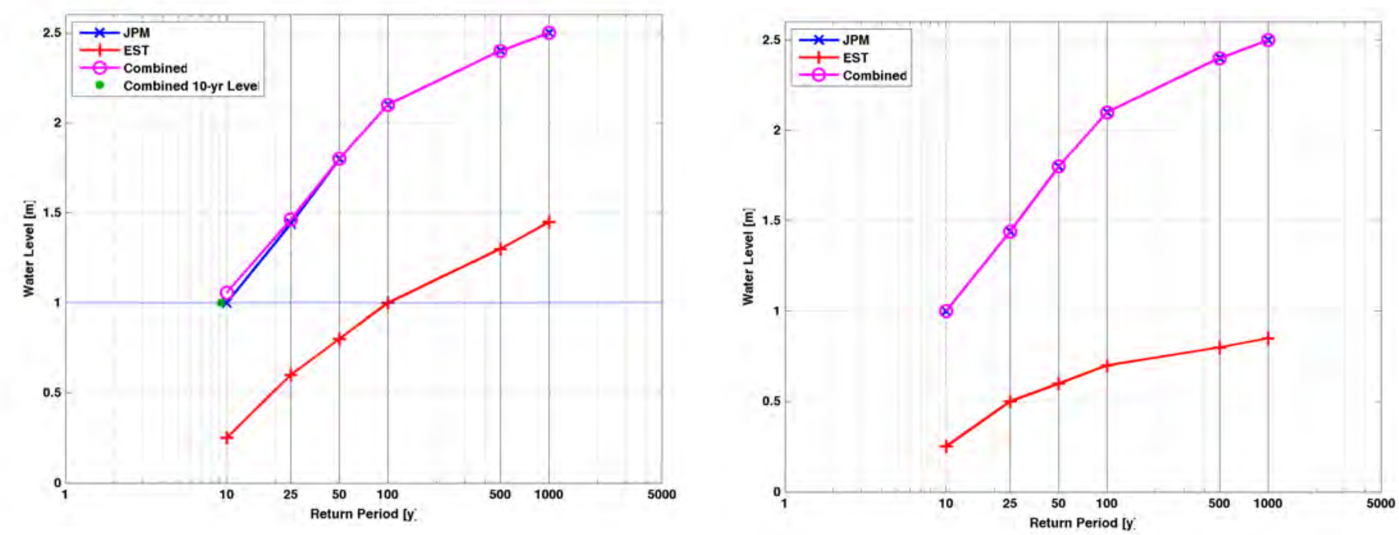


Figure 16: Examples of combining return levels from JPM and EST. The JPM return levels are shown in blue, the EST levels in red, and the combined levels in magenta. Left) The example calculation for the combined 1-m period is shown with the green dot (at 9.2 years). Right) the respective levels do no overlap; the largest EST level is smaller than the smallest JPM level. The resulting combined levels are the same as the JPM levels.

SURGE LEVELS | **SIGNIFICANT WAVE HEIGHT LEVELS**

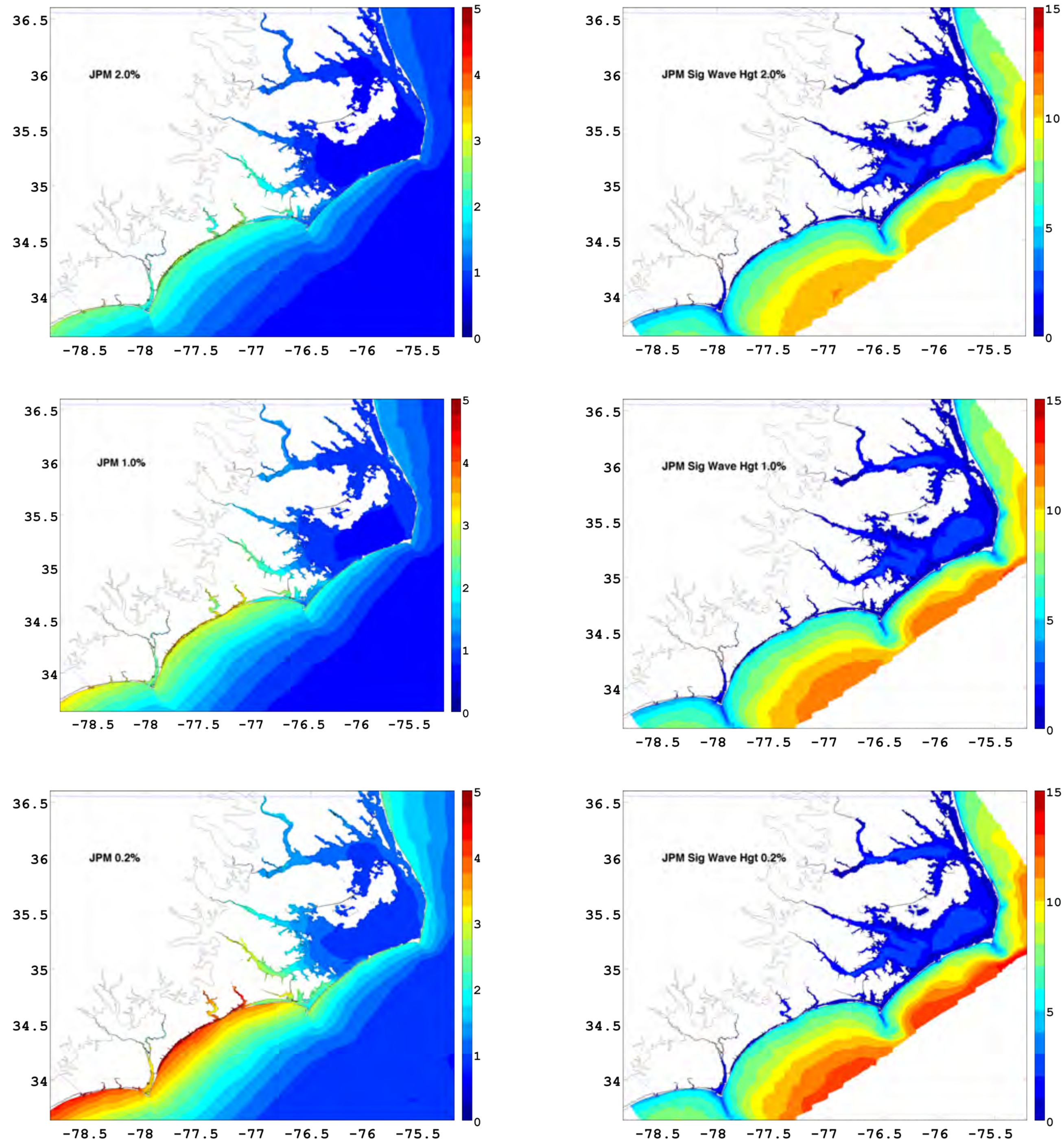


Figure 17: 2%, 1%, and 0.2% water level and significant wave height from the JPM storm population. Units are meters above Mean Sea Level.

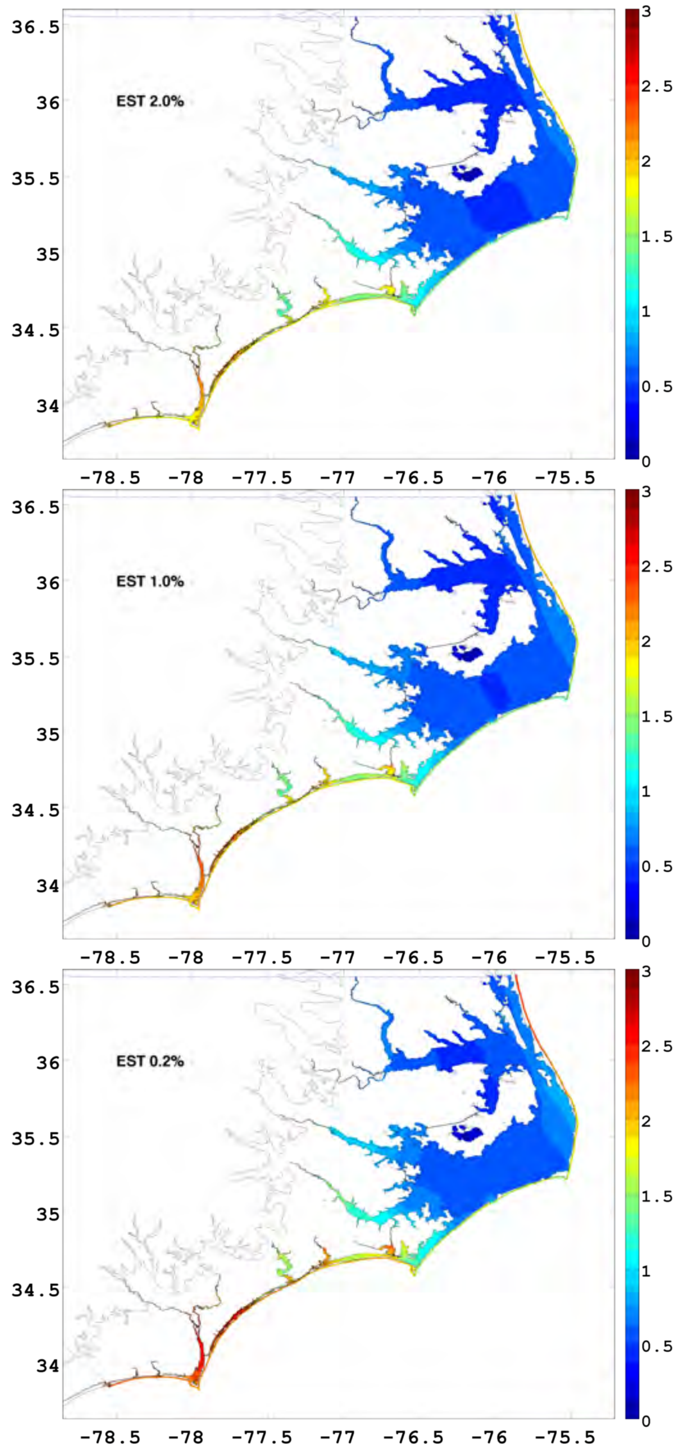


Figure 18: 2%, 1%, and 0.2% water levels (in meters above MSL) from the EST analysis. Note that the color scale is NOT the same as the scale used for the JPM levels in Figure 17.

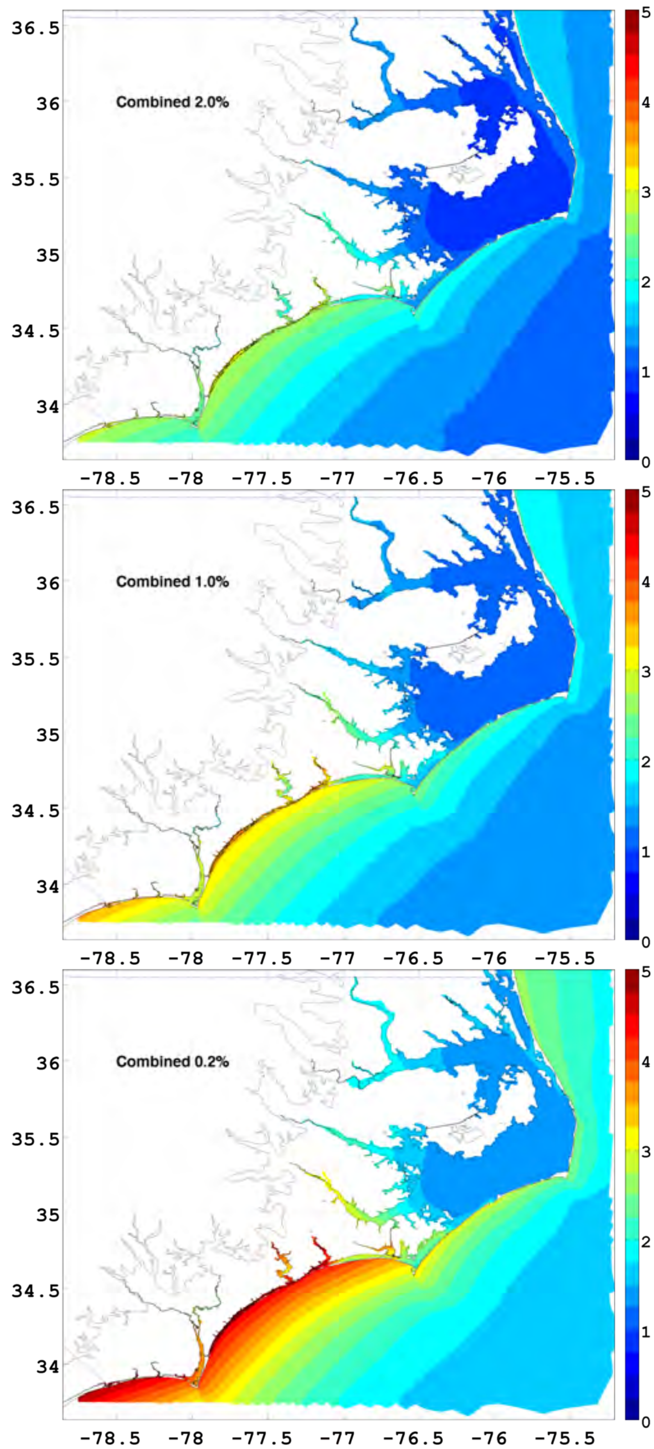


Figure 19: 2%, 1%, and 0.2% water levels (in meters above MSL) from the Combined JPM and EST analysis.

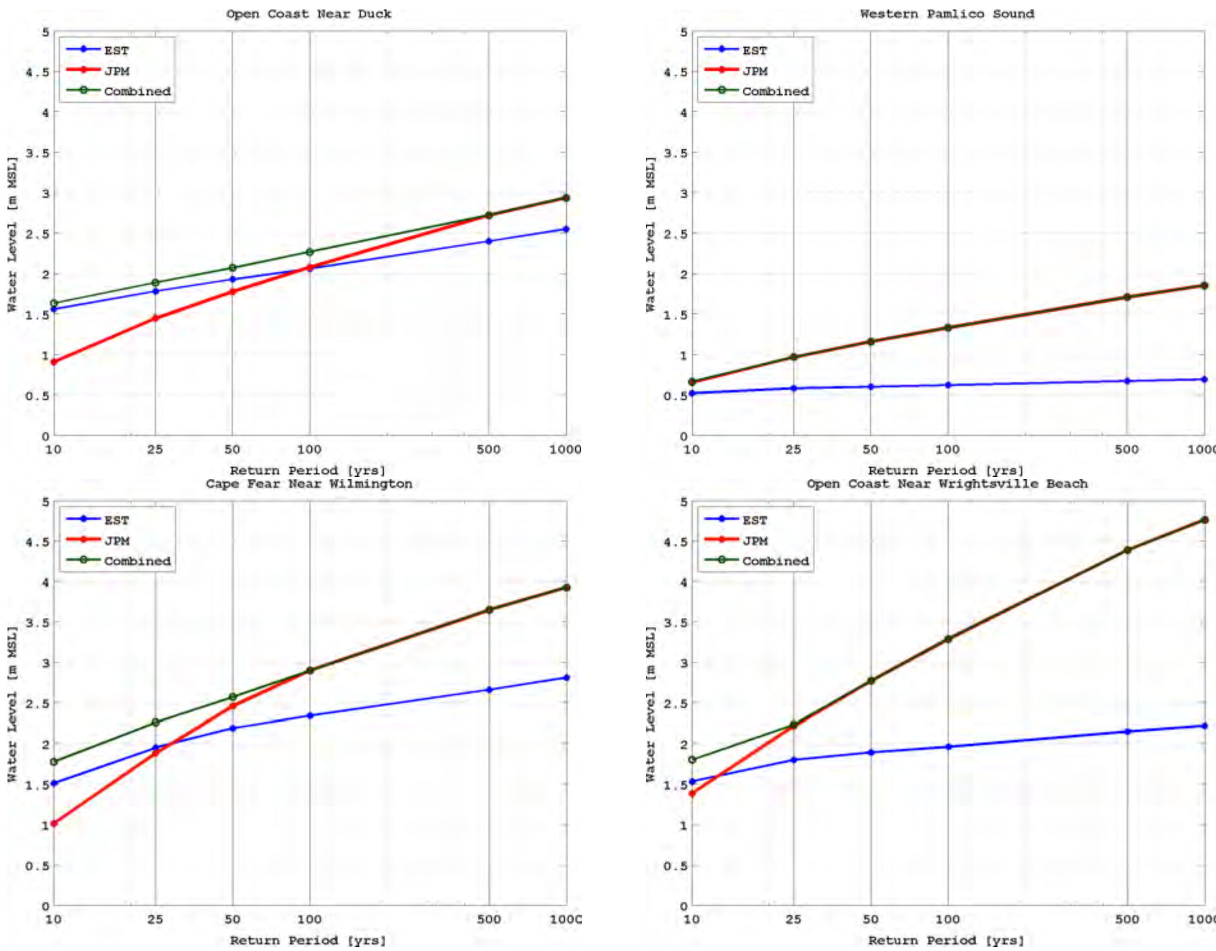


Figure 20: Example return levels at four locations. The JPM, EST, and combined results are shown at representative locations to illustrate the effect of the extratropical (EST) levels on the combined results. Generally, the EST values are less than the JPM values (except in the 10%-4% range), resulting in combined values that are dominated by the JPM values.

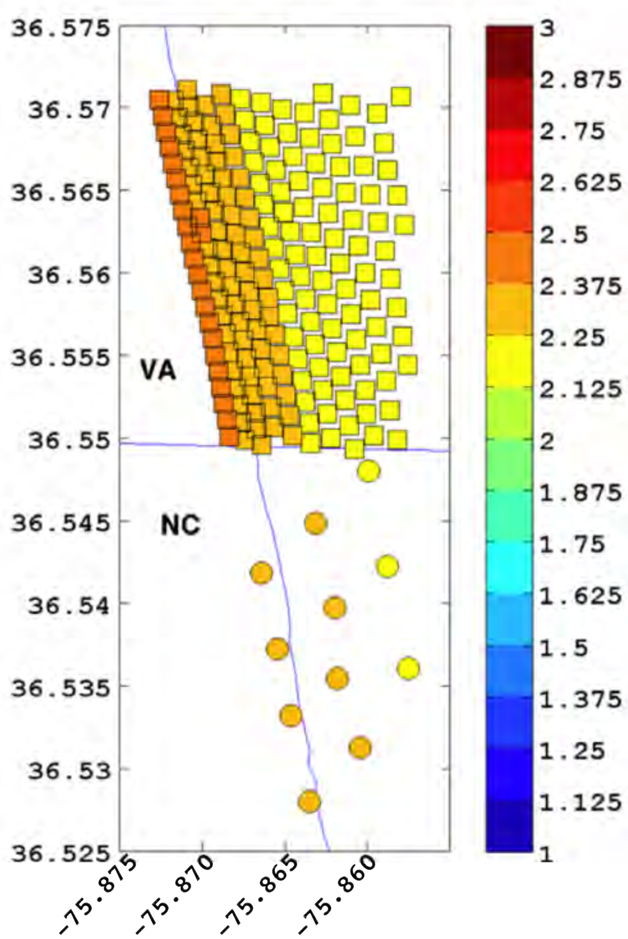


Figure 21: Qualitative comparison between the NC and Region III project results at the 1% annual chance level. The units are meters relative to MSL. The Region III ADCIRC grid has much higher resolution in this area, compared to the North Carolina grid.

APPENDIX A – EST METHODOLOGY

ELEVATIONS FOR THE NORTH CAROLINA STORM SURGE STUDY - *REVISED*

This document was modified in October 2011 to incorporate updates of the EST computation process. *These modified and updated items are highlighted in blue italicized text.*

Overview

The methodology detailed herein explains an approach for calculating flood elevations and corresponding flood frequencies resulting from extratropical storms using the Empirical Simulation Technique (EST). Return period elevations for tropical storms were determined separately using the Joint Probability Method (JPM). JPM analysis is not suitable for extratropical events, and at the present time EST is the preferred method for calculating return period elevations for this type of event. The extratropical storm return period elevations calculated here will later be merged with tropical storm return period elevations determined by the Joint Probability Method (JPM) to determine the final combined storm surge flood frequency elevation for the study area.

EST Approach

The Empirical Simulation Technique was developed by Scheffner et al. (1999) to provide a robust statistical method for frequency analysis. In this application, EST utilizes values of storm surge simulated by the numerical hydrodynamic model ADCIRC to determine the return period elevations for storm surge associated with extratropical storms. Tidal variations are accounted for by introducing multiple response inputs based on the tidal range around each event landfall.

EST analyzes the input data via a bootstrap resampling-with-replacement and parameter interpolation scheme for simulating multiple life cycle simulations of non-deterministic multi-parameter systems such as storm events and their corresponding environmental impacts at each response input location. This method effectively expands a smaller sample population and provides a robust statistical solution for frequency analysis (Scheffner et al 1999).

EST relies on the following:

- The behavior and magnitude of individual input events must be similar to historic events. Future events are statistically similar in magnitude and frequency to past events.
- Past events are accurately represented by the input data.
- Inter-relationships between the input and response vectors are realistic.
- The inter-relationship between input and response parameters is highly nonlinear.
- Frequency of storm events in the future will remain the same as in the past.
- Storm frequency follows a Poisson distribution.

EST derives a number of benefits from its unique approach. To start with, probabilities are not reliant on assumed fixed parametric relationships. There is no assumed parameter independence, thus interdependence of storm parameters is preserved. Probabilities are site-specific, and input parameters are derived from historic events and faithfully represent natural occurrences. Therefore unrealistic events are precluded from analysis through the nearest neighbor approach implemented in the analysis. The statistical approach allows for storms to be both less and more intense than the training dataset. Of primary concern here, EST is well suited for extratropical storms, where it is difficult to parameterize and develop parameter distributions from the storm event. Random occurrence of the storm surge with tides can also be accounted for by resampling of input data. Finally, EST provides an error estimate for the return frequency calculations.

Despite these benefits, EST has some shortfalls. Of primary concern is that probabilities are founded on past events. This can be problematic in cases where the available record may be too limited for adequate sampling in terms of number and magnitude of events. This is not the case in North Carolina, where a sufficient record of extratropical events was available for sampling. Storm selection for EST must properly represent spectrum of event magnitudes, otherwise results can become biased (applicable to any statistical analysis). The selection for this study was tailored to provide adequate sampling across the range of storm surge magnitude produced by northeasters in the study area (See Section 6 of North Carolina Storm Surge Methodology Report, FEMA Submittal No. 1).

Storm Training Set

A total of twenty-two extratropical storms were included in the production storm suite, nineteen of which were selected for developing extratropical return period elevations. The selection methodology, described in Section 6 of the North Carolina Storm Surge Methodology Report, identified these storms through a combination of meteorological records and primarily NOAA National Water Level Network (NWLON) hydrographs. The period of record ranged from 1980 to 2007. A criterion of 2 ft (0.61 m) was applied as a lower surge limit on event selection. Of these twenty storms, two were identified outside of the period of record due to historical significance (1962 and 1973 events). The final storm selection is listed in Table 1.

As mentioned, the 1962 and 1973 storms were added due to historical significance, even though they did not occur within the storm surge selection period of record. Water level data were not available to investigate additional events meeting the selection criteria in the intermediate time frame. Due to the potential for bias of the training set from these events, the storms are being conditionally included. EST analysis will be conducted with training sets that include and exclude these events.

A sensitivity test was conducted on the 1962 and 1973 extratropical storms on a selected area of the NC Coast to determine the contribution of these storms to the overall EST results. The test was conducted such that one set of EST statistics was calculated using the 2 storms and one set of statistics was computed without. The result showed conclusively that exclusion of these 2 storms would not bias the final results, and thus, the 1962 and 1973 storms were removed from the final extratropical dataset.

Additionally, Tropical Storm Ernesto was removed from the final dataset due to the being included in the JPM analysis. A detailed analysis of the storm could not conclusively determine when the storm transitioned from tropical to extratropical. It was noted in the National Hurricane Center's storm summary that TS Ernesto made landfall in NC as a tropical event and transitioned from tropical to extratropical somewhere over NC.

TABLE 3. FINAL STORM SELECTION

~~Ash Wed Storm, 1962 Northeaster~~*
~~February 8, 1973 Wind event~~*
March 1-2, 1980 Winter Storm
March 24-25, 1983 Winter Storm
January 1, 1987 Winter Storm
December 22-24, 1989 Winter Storm
October 22, 1990 Wind event
Halloween Storm, 1991 Northeaster
March 12-14, 1993 Winter Storm
February 16, 1996 Winter Storm
January 25, 2000 Winter Storm
March 21, 2001 Winter Storm
December 13-14, 2003 Winter Storm
March 07, 2004 High Wind Event
December 26, 2004 Winter Storm
January 19, 2005 Winter Storm
February 3, 2005 Winter Storm
February 27-28, 2005 Winter Storm
April 02-03, 2005 High Wind Event
May 6, 2005 Northeaster

~~Tropical Storm Ernesto (August 31 & September 1, 2006)~~ *
Thanksgiving Week 2006 Northeaster

*Removed from final EST dataset

Software

The Coastal Engineering Design and Analysis System (CEDAS) EST version 4.03, was used in this application. The software developer, Veri-Tech Inc, was contracted to upgrade the EST software to allow for global import of input data to facilitate analysis at the large number of stations. These upgrades were provided in the form of updated executable and dynamic link library files for EST. No analytical aspects of the software were modified.

In late June 2011, it was discovered via a conference call with the US Army Corp of Engineers (USACE) that the EST code implemented by the CEDAS software contained errors in computation of the "tail-end" of the frequency analysis. This could potentially result in higher EST WSEL at the 100- and 500- year return periods. An updated Fortran source code of the EST software was provided and utilized for the final WSEL calculations.

Stations

One of the goals of the study was to create an accurate, high-resolution stillwater surface. To achieve this goal a relatively dense grid of JPM/EST analysis stations was generated for the coastal floodplain of North Carolina. The station grid was spaced at an interval of 2,000 ft (610 m) from 2,500 ft (762 m) offshore to the 30 ft (9.1 m) NAVD elevation contour. The offshore buffer was considered necessary to ensure a minimum of one point located in the open ocean domain of the ADCIRC grid. The grid was generated in Cartesian coordinates and then converted to the Mercator projection of the ADCIRC mesh. This conversion resulted in a slight rotation of the grid in the Mercator projection. In total, the grid contains 74,719 points, 68% (50,558) of which are overland and 32% (24,161) are over water.

The EST computational domain was modified during the summer of 2011 to include all ADCIRC nodes within NC and within a 5 mile buffer to the north into Virginia and to the south in South Carolina. This decision to increase the domain was a direct result of easing the effort needed to combine the EST and JPM results. This resulted in a total of 161,557 nodes being included in the EST computation.

EST Setup Parameters

EST requires the user to specify the number simulations, the length of simulations and the Random Number Seed. The number of simulations (*N*) specifies the total number of random simulations that EST will conduct during the analysis. The suitability of an *N* value can be evaluated by adjusting the Random Number Seed and comparing results. An adequate value of *N* is achieved once the results exhibit minimal variability. An *N* value of 500 was found to be suitable for this study. The length of simulations (*T*) is simply the upper limit of the return period analysis. Return period elevations up to the 500-yr frequency were desired for this study, therefore *T* was set to 500. The Random Number Seed determines how storms and parameters are selected for random walking and sampling. This parameter can be specified or set to randomly generate. Here, the Random Number Seed was set to user specified at the default value of 123456 to retain consistency across the multiple analysis runs. Sensitivity analysis (discussed later) has shown that results are not sensitive to this parameter.

Event Frequency

Given the mean frequency of storm events for a particular region, EST uses a Poisson distribution to determine the average number of expected events in a given year. The Poisson distribution can be written in the following form:

$$\Pr(s;\lambda) = \frac{\lambda^s e^{-\lambda}}{s}$$

where probability Pr(s;λ) defines the probability of having s events per year where λ is the historically based number of events per year. As discussed, two storm selections were evaluated, one spanning 1962 to 2007, and the other from 1980 to 2007. These selections define λ as:

1962-2007 Extratropical events: λ= 0.4888 (22 events/45 years)
1980-2007 Extratropical events: λ= 0.7407 (20 events/27 years)
Final value used in EST computations: λ= .7037 (19 events/27 years)

Response Parameter Threshold

The Response Parameter Threshold allows the user to specify a minimum value for each response parameter for any given year within the EST life-cycle simulation. In this application, this parameter provides the routine with a combined surge and tide elevation for a year without a response vector. For this study, the Response Parameter Threshold was set at local mean higher high water (MHHW). In the absence of a storm event, MHHW would be the expected lower limit of water level for any station.

Calculation of MHHW

MHHW for each node of the ADCIRC mesh were computed by re-synthesizing the tidal signal over the National Tidal Datum Epoch (midnight 1 January 1983 to midnight 1 January 2002, or 19 calendar years). The tidal constituents MNS_2, $2MN_6$, and MSN_6 are neglected since the means to compute nodal factors and equilibrium arguments for these is unavailable. The relative magnitude of these constituents is negligible, thus exclusion should not perceptively change the results. Nodal factors and equilibrium arguments were recomputed for each calendar year. Each tidal day was considered separately at a time step of 1/256 tidal day. The tidal day was computed as $4\pi/T_{M2}$ where T_{M2} is the period associated with the M_2 tidal constituent, 0.0001405189025 rad/s, as specified in the ADCIRC model.

In order to ground-truth the MHHW calculations, values were compared against reported MHHW elevations at five NOAA tidal stations within the study area. Results of the calculations compared well to the NOAA reported values with differences in the range of two centimeters.

Zonal Division of MWWH

The study area comprises a large geographic reach with mixed open coast and back-bay environments. These conditions produce a calculated range of MHHW values between 0.11 and 0.85 m MSL. Although EST is not especially sensitive to the Lower Response Threshold (LRT), an incorrect value would result in allowing lower return period elevation values than physically possible (LRT value too low) or truncation of the frequency curve (LRT value too high). Thus, assignment of a LRT value should coincide with the localized value of MHHW in order to prevent these errors.

Calculated MHHW values were sorted and classified into an initial set of groups. Each group corresponds to the calculated value of MHHW, rounded to 0.1 m. Outliers were occasionally present in the dataset, these MHHW values were adjusted to neighboring values where necessary. The calculated MHHW group selection is shown in Figure 22A.

Group boundaries were extended inland to include all JPM points and assigned a value 0-9, corresponding to the MHHW value multiplied by 10 (Figure 22B). The groups generally follow topographic extremes. For example, mean higher high waters on opposite sides of a barrier conservatively; that is, if the JPM point lies at the peak of the ridge (or very near it) the higher MHHW value is assigned. Note that one group of JMP points, near the extreme southwest extent, is not connected to the other JMP points, and so the method of extending group boundaries does not apply. In this special case, the points were connected to the Waccamaw River, which has an MHHW of approximately 0.5 m. In the central northwestern part of the state, Group 2 was extended inland along a river watershed to faithfully represent MHHW results.

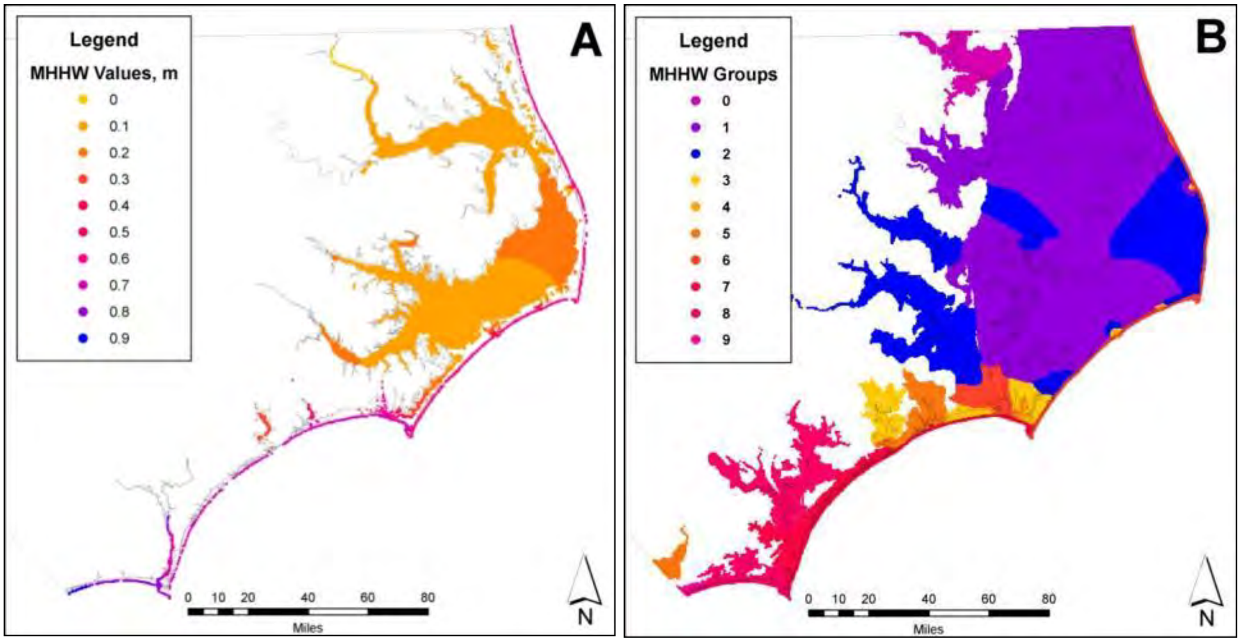


Figure 22 A). Representative MHHW value groups for overwater areas, these results were extrapolated inland; B). Geographic plot of grouped MHHW clusters for all JPM/EST stations.

Input and Response Vectors

Required input data for EST consists of a set of input vectors and response vectors for each station. For extratropical events, two input vectors have been defined:

I1. Tidal stage, representing potential tidal stage levels over the lunar cycle.

I2. Peak surge elevation, as simulated by the ADCIRC for each event.

The response vector provides a description of the physical impact that can be attributed to the passage of a storm event being parameterized by the input vectors. A single response vector was defined as:

R1. Combined tide and surge elevation

Here, tidal stage is sampled at 5 elevations, representing the potential coincident lunar tidal stages for an extratropical storm impact. The surge elevation is then resampled at each tidal elevation, giving the following input for each storm:

March 1962 Northeaster, storm surge elevation of 0.65 m

Storm	Tidal Stage (I1)	Storm Surge (I2)	Combined Tide + Surge (R1)
19621312_1	0.58	0.65	1.23
19621312_2	0.61	0.65	1.26
19621312_3	0.64	0.65	1.29
19621312_4	0.71	0.65	1.37
19621312_	0.76	0.65	1.41

5			

The internal handling of the input vector data and calculations performed by EST are discussed in detail in Militello and Scheffner (1998) and Scheffner et al (1999) and will not be repeated here.

Probabilities

Each storm event at each station must be assigned a probability of occurrence. As discussed in the preceding section, each storm event is resampled five times representing the potential of storm occurrence at any point over the lunar tidal cycle. Redistribution of the tidal elevation probability density function into the five bins (discussed in detail in the following section) effectively weights the elevations into equal probability elements. This is accomplished by having a single bin representing the minimum and maximum elevations (neap and spring tide stages) and three bins representing the mid-tide ranges, which occur more frequently between the neap and spring tides. Each bin is then input into EST with an equal probability of 1 to reflect the equal probability that the event could occur at any of the five tidal stages. Past applications have decomposed the lunar spring-neap cycle into four equal probability (of 1) inputs for each storm, with the mean tide level weighted twice and spring and neap weighted once (Scheffner and Mark 1997, Scheffner et al 1999a, Scheffner et al 1999b, Scheffner and Carson 2001, Scheffner and Mack 2004). The five bin approach employed here is similar, but provides a more robust sampling of the lunar tidal cycle range.

Treatment of Tidal Fluctuations

Extratropical events typically occur over a time-interval measured in days, as opposed to tropical events that affect a coast over a matter of tens of hours. Therefore, an extratropical event can be expected to occur coincident with the diurnal high tide, whereas a tropical storm may occur at any stage in the diurnal tidal cycle (low, mean, or high tide). The longer duration of the extratropical event requires consideration of the variation of the high tide elevation over a monthly lunar tidal cycle, specifically spring-neap cycle. The 31-day lunar tidal cycle is shown in Figure 23 for the Cape Hatteras Fishing Pier NOAA NWLON station.

To appropriately represent the potential occurrence of a storm event at any tidal stage over lunar cycle, the diurnal (daily) peak high tides were sampled at each JPM station. Sampling was conducted for 15-day window prior and subsequent to each storm landfall, illustrated by Figure 24. A probability density function (pdf) was constructed from the sampled tidal range, and then resampled into five equal probability bins, as shown in Figure 25. The bin mean is then taken as a representative elevation of each bin for input into EST. Figure 26 demonstrates the representation of the lunar tidal curve by the five bins.

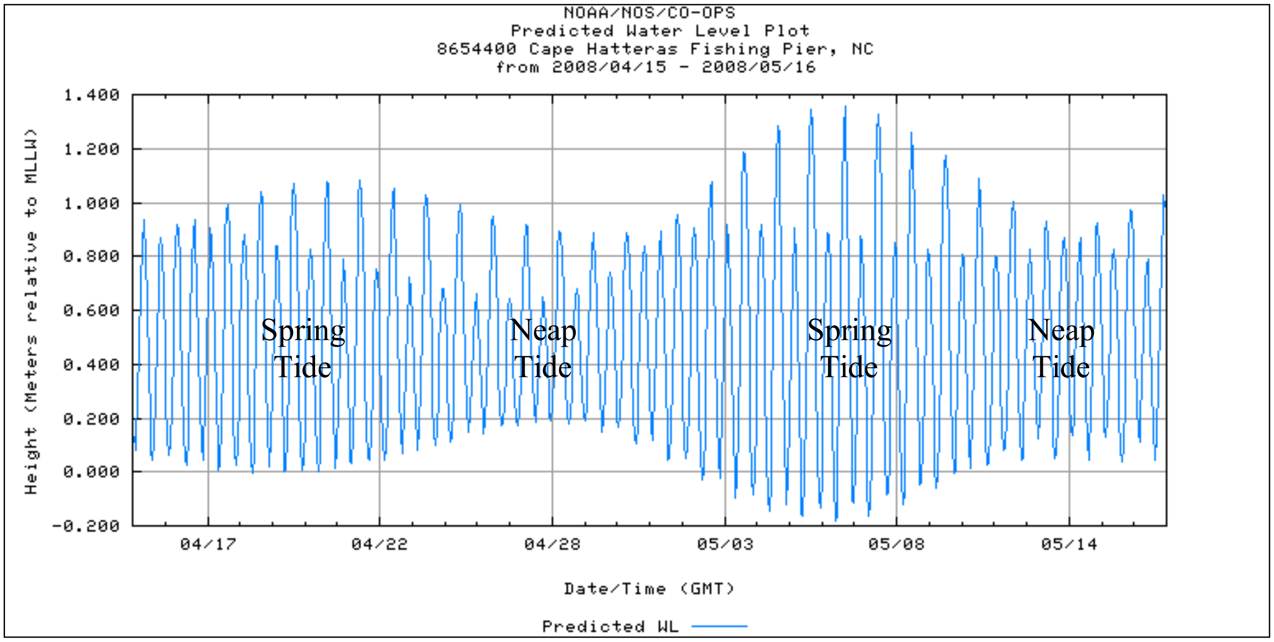


Figure 23. Lunar spring-neap tidal cycle at Cape Hatteras Pier, NC.

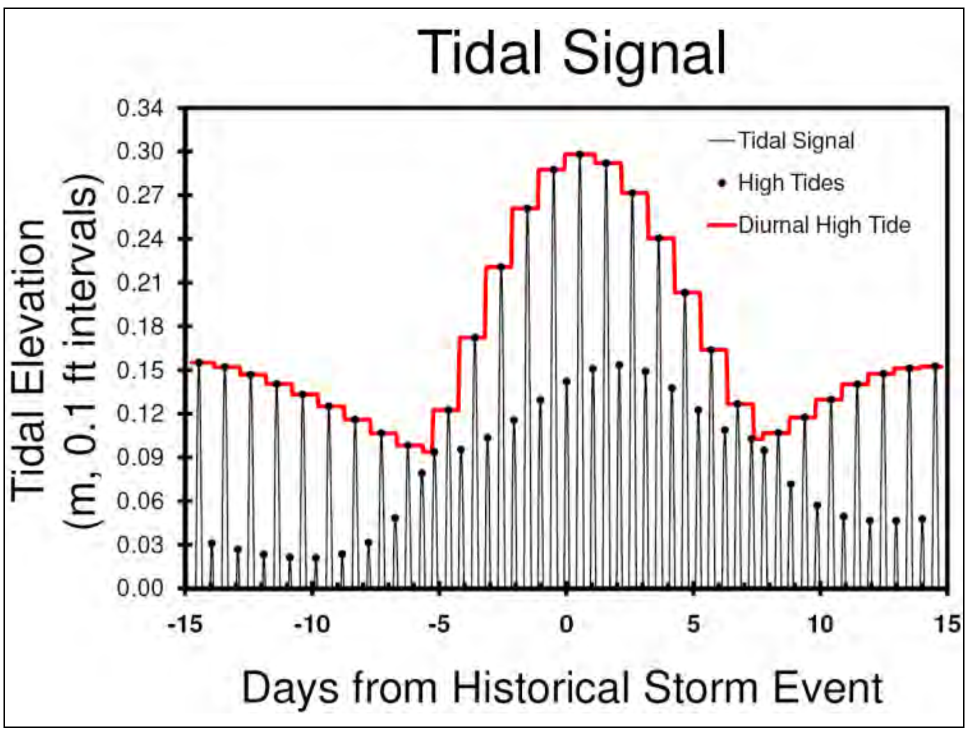


Figure 24. Sampling of the tidal record for diurnal high tides to facilitate population of the tidal elevation probability density function (pdf).

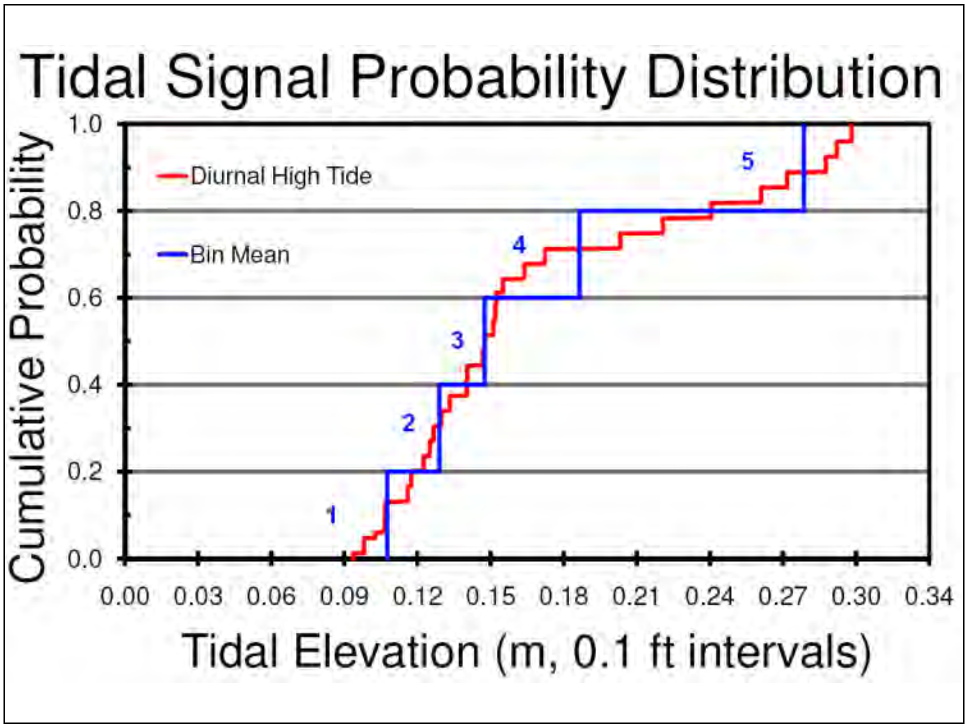


Figure 25. Probability density function representing diurnal high tide elevation range over the lunar tidal cycle.

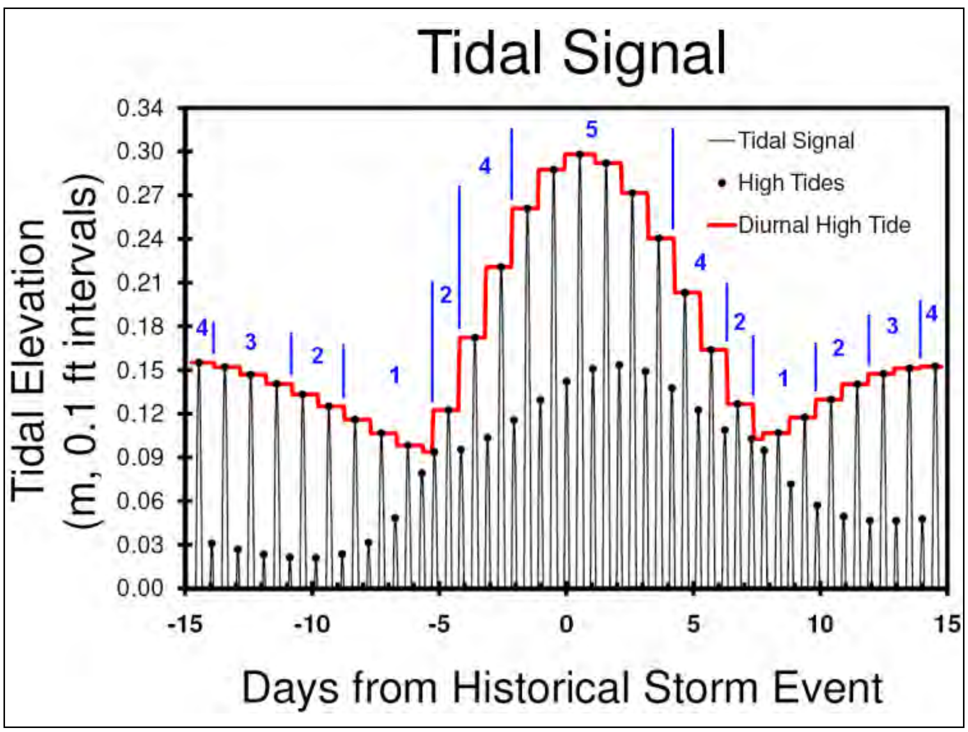


Figure 26. Tidal elevation bins as related to the sampled tidal signal.

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Estimates of the Tide

The tidal signals that would have been in effect during the lunar months of each storm in the storm database are computed by applying nodal factors and equilibrium arguments to the equilibrium tides computed by the ADCIRC model. For each storm, a modified version of the tide_fac.f code (available at http://adcirc.org/Utility_programs.html) was used to compute nodal factors and equilibrium arguments for the 37 tidal constituents used by the NOAA National Ocean Service (NOS) for tidal harmonic analysis. The duration of each simulation was set to 31 days, with the start of the simulation set to 15 days prior to the occurrence of peak surge.

Twenty of the 23 tidal constituents of the ADCIRC model contribute to the tidal signal used in generating the tidal probability density function (pdf). MNS_2, $2MN_6$, and MSN_6 are excluded, as nodal factors and equilibrium arguments for these constituents are not available via tide_fac.f. See Appendix I, Details on Tidal Signal Processing, for more information.

Generation of Tidal Signals

For each storm and wet station, a tidal signal (ζ) is generated by a Fortran program using:

$$\zeta = \Sigma_i \{f_i A_i \cos [\omega_i(t - t_0) + v_i - \varphi_i] \}$$

where:

f_i = nodal factor for constituent i
A_i = amplitude of tidal constituent i (units of length)
ω_i = frequency of tidal constituent i (rad / time)
I = time at which to compute the tidal signal
t_0 = start time used for the computation of the nodal factors and equilibrium arguments
v_i = equilibrium argument for tidal constituent i (rad)
φ_i = phase of tidal constituent i

The tidal signal is generated around the time of the storm, for a duration of one lunar month (synodical month, 29.530588 days ≈ 2,551,443 s) plus one Q1 cycle (Q1 is the longest-period, diurnal tidal wave, 100,822 s). A wet station is one for which the ADCIRC elevation time series output remains non-negative for the duration of the tidal simulation. The time step is 6 minutes. Therefore, the times at which to compute the tidal signals are: -1,325,880, -1,325,820, … , -1,275,480, -1,275,420, … , 1,275,420, 1,275,480, … , 1,325,820, and 1,325,880 s, relative to the time of peak surge (assumed to be the date corresponding to the storm ID, e.g., 19620302 = March 2, 1962).

Generation of Probability Density Functions for the Tidal Signals

In order to generate the probability density function (pfd), the diurnal maximum tide is sampled throughout the tidal signal. This is accomplished by a Fortran program that located the point of maximum tide centered on a time interval duration equivalent to a Q_1 cycle. The (local) maximum tidal elevations are then sorted from low to high and the mean values are calculated within equally sized bins from the sorted list. Note that for the purposes of generating the pdf's, each JPM point is considered to be located at the node of the ADCIRC mesh that is nearest in the Carte-parallelogramatique projection (CPP) with a latitude of 35°. These values become the probability density function (pdf) for input into EST, where each bin of the pdf has equal probability. The number of probability bins is arbitrary, but should be small enough to be manageable in EST. An odd number of bins is preferred so that the median tidal elevation falls in the center of the central bin. The number of bins was set to five to accommodate these factors in addition to retaining a value similar to past applications of EST. Finally, the datums for the pdf's and for the surge peak water levels are reconciled.

Sensitivity Tests

A series of sensitivity tests were conducted to determine if the selection of various parameters induced bias into the results. Sensitivity tests were completed for the number of simulations (N), the Random Number Seed, probability assignment and variation of input vectors.

N

The EST User's Manual states that the suitability of an *N* value can be evaluated by adjusting the Random Number Seed and comparing results. Once the results exhibit minimal variability, the *N* value is deemed acceptable. *N* values ranging from 200 (default) to 1000 were tested. An *N* value of 500 was found to be suitable for this study.

Random Number Seed

Sensitivity to the Random Number Seed (RNS) was carried out in conjunction to the *N* sensitivity test. Three random RNS values were generated between 100000 and 999999 using Microsoft Excel's random number generator (777516, 168983, 351951). Test runs were conducted at 11 stations using all three values with the length of simulation and number of simulations parameters both set to 500. Resultant values for the three tests had an average standard deviation of 0.003. Given this low variance, it was concluded that results were not sensitive to changes in the Random Number Seed at *N* values of 500.

Probability

The approach utilized in this study is consistent with documented applications of EST for extratropical storms. These studies utilized an equal relative probability of 1 for all input data. Justification is that the storm has an equal probability of landfalling at each of the five tidal stages. It could be argued that resampling of each storm at the five tidal elevations splits the probability into fifths. For example, each storm should be input at a 1/5 of the probability of the original (0.2). EST sensitivity to this change in relative probability was tested by changing the probability of the input data and re-running the statistical analysis. The relative probability of each event remained equal and consequently no meaningful change in return period elevations was observed.

Input vectors

A sensitivity test was conducted to determine the influence of the inclusion of input vectors to the return period elevations determined by EST. The EST User's Guide (Scheffner et al 1999a) discusses examples of EST application to extratropical storms have included a additional input vector corresponding to the sine of lunar tidal phasing, equal to -1, 0, 1, 0 and corresponding to near, mean, spring, and mean tidal phases, respectively. This application forgoes this parameter due to the non-traditional sampling of the lunar tidal phases. Sensitivity tests were ran with and without inclusion of this input vector to determine the influence on results. Minimal sensitivity to inclusion of this parameter was noted, consisting of subtle changes to the smoothness of the frequency curve. No meaningful change to return period elevations was observed. For this study the input vectors are, therefore, limited to the tidal stage and the peak surge elevation signals.

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Scheffner, N.W., Mark, D.J., Lin, L., Brandon, W.A., and Miller, M.C. (1999b). Development of Water-Surface Elevation Frequency-of-Occurrence Relationships for the Brunswick, North Carolina, Nuclear Power Plant Site.

Technical Report CHL-99-12. U.S. Army Engineer Research and Development Center, Coastal and Hydraulics Laboratory, Vicksburg, MS, 85 p.

Scheffner, N.W., and Carson, F.C. (2001). Coast of South Caroline Storm Surge Study. Technical Report ERDC/CHL TR-01-11. U.S. Army Engineer Research and Development Center, Coastal and Hydraulics Laboratory, Vicksburg, MS, 59 p.

Scheffner, N.W., and Mack, C. (2004). Hilton Head Island and Vicinity Storm Surge Study. Technical Report TS-DH CER-004. U.S. Army Corps of Engineers District Charleston. Charleston, SC, 83 p.

Details on Tidal Signal Processing

Impact of Tidal Constituents on Tidal Signal

In this study, it is not sufficient to consider only the M2 tidal constituent. For example, the M_2 amplitude is 0.6 m at the Wilmington, NC tidal station (NOS Station ID 8658120). Consideration of only this tidal constituent would yield a high tide of 0.6 m above the mean tide. However, consideration of all eight major tidal constituents, for storm 20000120 (20 Jan 2001) indicates that during the month surrounding the date of the storm, the high tide was about 0.9 m 21% of the time, 0.8 m 11% of the time, and 0.7 m 43% of the time. In this case, considering only the M_2 tide would result in underestimating the tidal contribution to the total water level by up to 0.3 m (1 ft).

The nodal factors for the M_1 and L_2 tidal constituents are set to 1.0 rather than 0.0 as in the received version of tide_fac.f. According to the comments contained in the source code, there is some problem with the equations used to compute these nodal factors. We suppose that 1.0 is a better approximation of the correct value for the nodal factors than 0.0. In this study, the M_1 tidal constituent contributes 1 cm to the tidal signal, while the L_2 contributes up to about 6 cm (4% of the total tidal signal) based on the data available for the seven NOS tidal stations within the study area.

Note that the ADCIRC model does not apply all of the same tidal constituents that are considered in tide_fac.f. Specifically, MNS_2, $2MN_6$, MSN_6, and M_{10} are not included. The nodal factor for M_{10} is computed by raising the nodal factor for M_2 to the fifth power, while the equilibrium argument may be computed by multiplying the equilibrium argument for M_2 by five. For this study, the former three tidal constituents are considered negligible, and their nodal factors are set to zero.

The minor tidal constituents make up over 10% of the sum of tidal elevation constituent amplitudes. Given a tidal range of up to about 2 m, it is expected that the minor tidal constituents, causing the tide to vary approximately ± 0.2 m, with their nodal factors and equilibrium arguments, significantly impact the tidal probability distribution.

Sensitivity of Probability Density Function to Nodal Factors and Equilibrium Arguments

Note that the nodal factors and equilibrium arguments influence the probability distribution significantly. Computation of the probability distributions corresponding to the first 11 storms of the study (19620302 to 20000120 inclusive) for the Wilmington, NC tidal station, using the major tidal constituents only, demonstrated that the maximum tidal elevation achieved within the probability distribution ranged from 0.8 to 1.0 m (here, probability bin boundaries were rounded to the nearest 0.1 m instead of being assigned equal probability). These maximum values are associated with probabilities ranging from 9% to 51%. Therefore, the nodal factors and equilibrium arguments impact the upper tail (i.e., corresponding to 100 to 500 + yr return period or 0.1% to 0.02% annual chance) of the joint probability associated with tides and storm surge together. Consider a 10-yr surge atop maximum tides.

That the nodal factors and equilibrium arguments impact the tidal probability distribution suggests that applying tidal harmonics from the present National Tidal Datum Epoch ("new epoch," 1983–2001) to an event outside that epoch (e.g., 1962–1982, during which three storms in the study occur) may lead to errors in the probability distributions for those events. However, as the goal of the project is prediction, as opposed to hindcasting, the implicit projection of the current tidal datum epoch onto the earlier events is preferred.

APPENDIX B – EST 1000-YEAR FREQUENCY DETERMINATION

Extrapolation of EST Values to 1000-Year Frequency

At the inception of the North Carolina Storm Surge modeling study, Dewberry anticipated calculation of EST results to the 500-year frequency, and presented such in the document "*Application of the Empirical Simulation Technique to Extratropical Storm Surge Frequency Elevations for the North Carolina Storm Surge Study.*" The resulting multi-frequency EST results would be combined with the JPM results to produce the final still water elevations for the 10-, 25-, 50-, 100-, and 500-year frequency. The method for combining the JPM and EST results are determined as follows:

$$P_c \quad = \quad 1-(1-P_j)(1-P_e)$$

where P_j is the probability of exceeding the specified level from the JPM return levels, P_e is the probability of exceeding the specified level from the EST return levels, and P_c is the probability of exceeding the specified level in the combined probabilities. It became evident that errors may exist when calculating the combined EST/JPM results at the 500-year frequency, as no EST values were present past this frequency.

Two methods were evaluated to develop the 1000-year EST flood frequencies. The first was to re-run EST, and assign the *NYI* (number of intervals of years) to 1000, which would allow EST to calculate out to the 1000-year frequency.

The second method was to extrapolate the 1000-year frequency from the EST results. EST output (.freqout) provides frequency values at recurrence intervals in addition to those being assessed in this study (i.e. 150-, 200-, 250-, year) and using these additional values results in better curve fitting for the extrapolation of the 1000-year EST values. The extrapolation technique used was a $\log_{10}$ based regression defined by:

$Y = a + bx$
$\text{Slope}(b) = (N\Sigma XY - (\Sigma X)(\Sigma Y)) / (N\Sigma X^2 - (\Sigma X)^2)$
$\text{Intercept}(a) = (\Sigma Y - b(\Sigma X)) / N$
Where:
N = Number of data points
ΣXY = the sum of $\log_{10}X * \log_{10}Y$
ΣX = sum of $\log_{10}X$
ΣY = sum of $\log_{10}Y$

In order to validate the second method, a subset of 49 points (Image 1) were chosen along the open coast (i.e. along the Atlantic Ocean), and EST was run to the 1000-year frequency. Subsequently, the 1000-year values were extrapolated at the same locations. The resulting combined JPM/EST statistics showed minute differences of less than 1 inch between the calculated and extrapolated 100-year frequency return periods and no differences were observed at the 500-year return period Based on the fact that little variation was observed between the combined JPM/EST water surface elevations using log extrapolated and the calculated 1000-year EST values, the 1000-year log regression technique was utilized to estimate the 1000-year EST flood frequencies for this study.

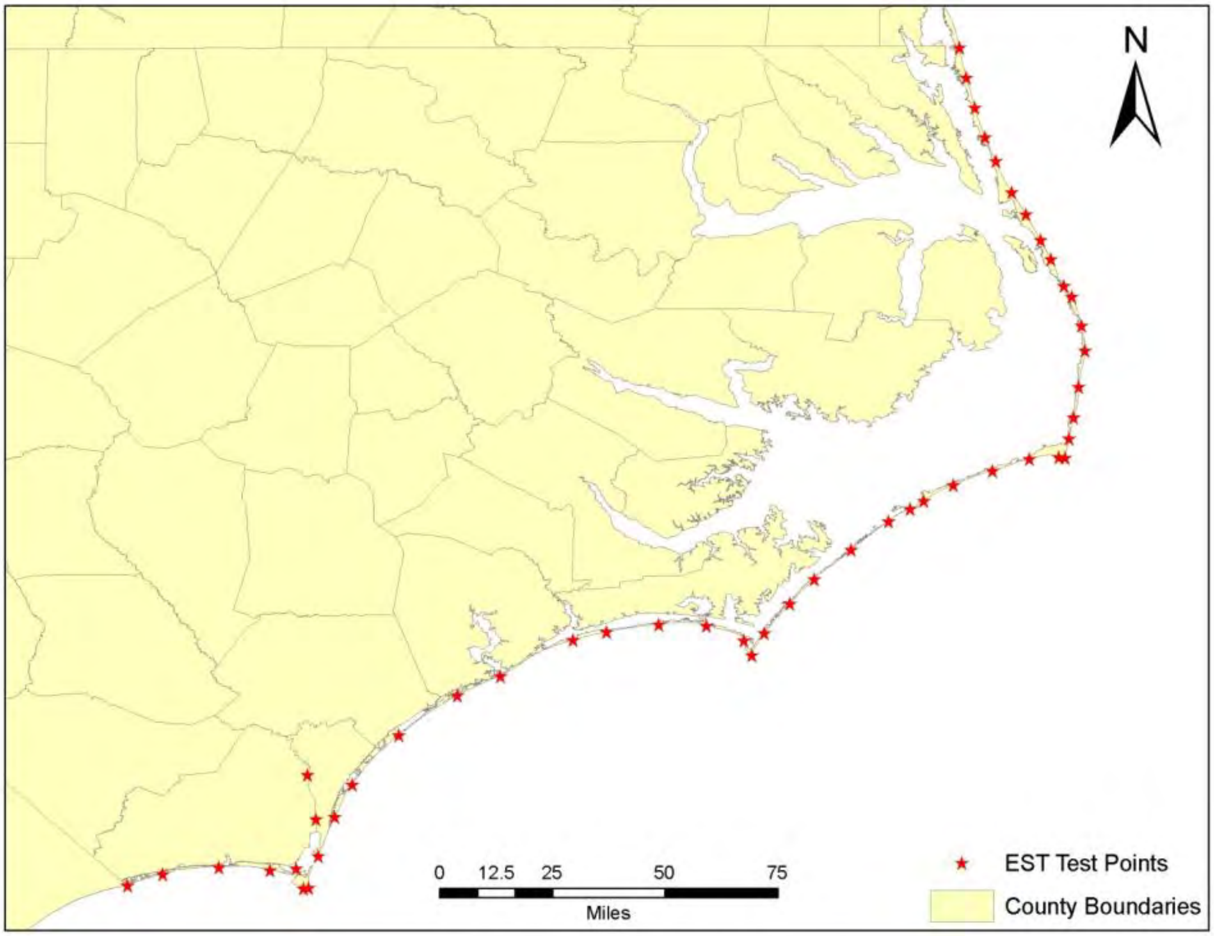


Figure 1: Location of 49 points.

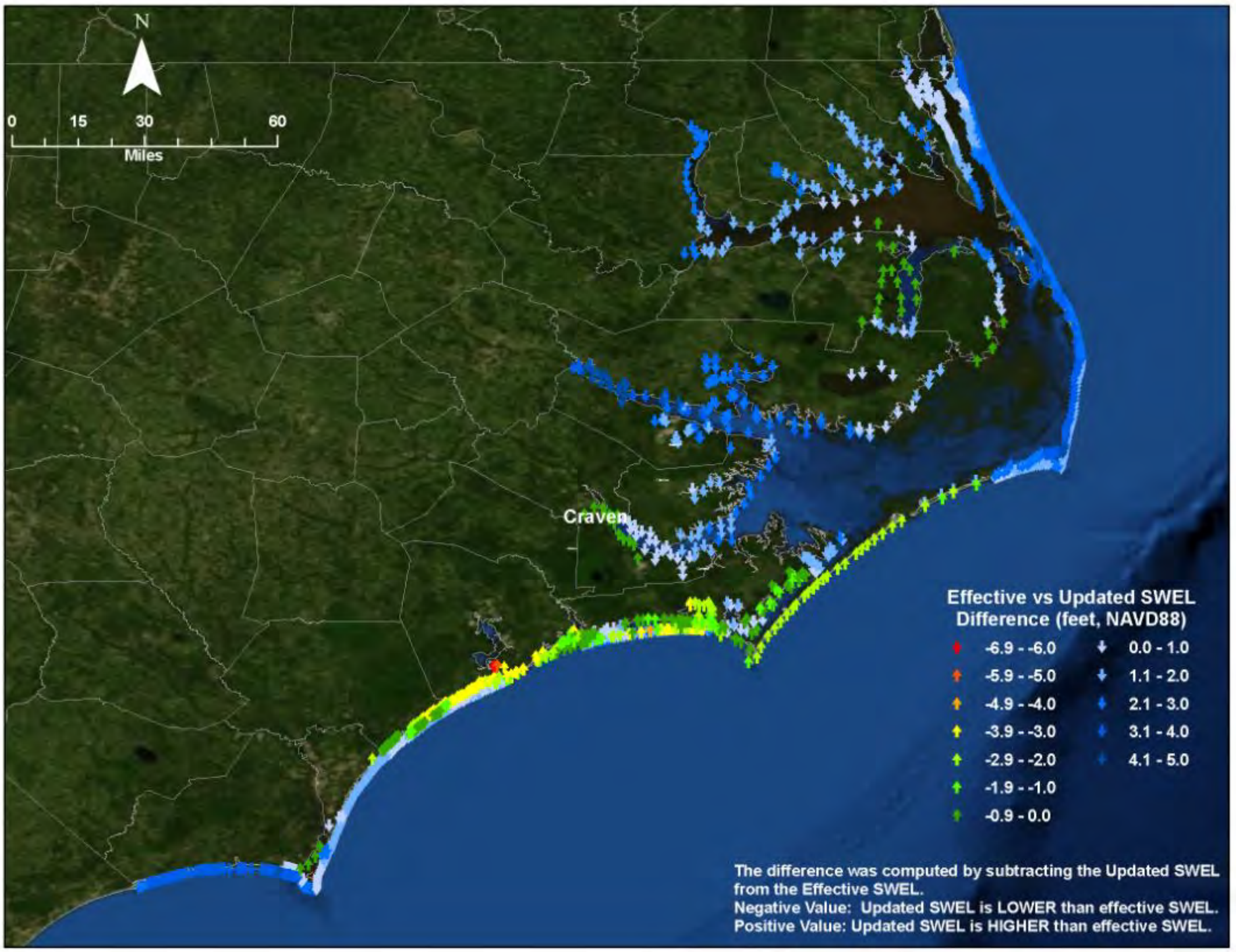
The following table shows the computed and extrapolated 1000-year return period EST results, as well as their difference in meters and inches.

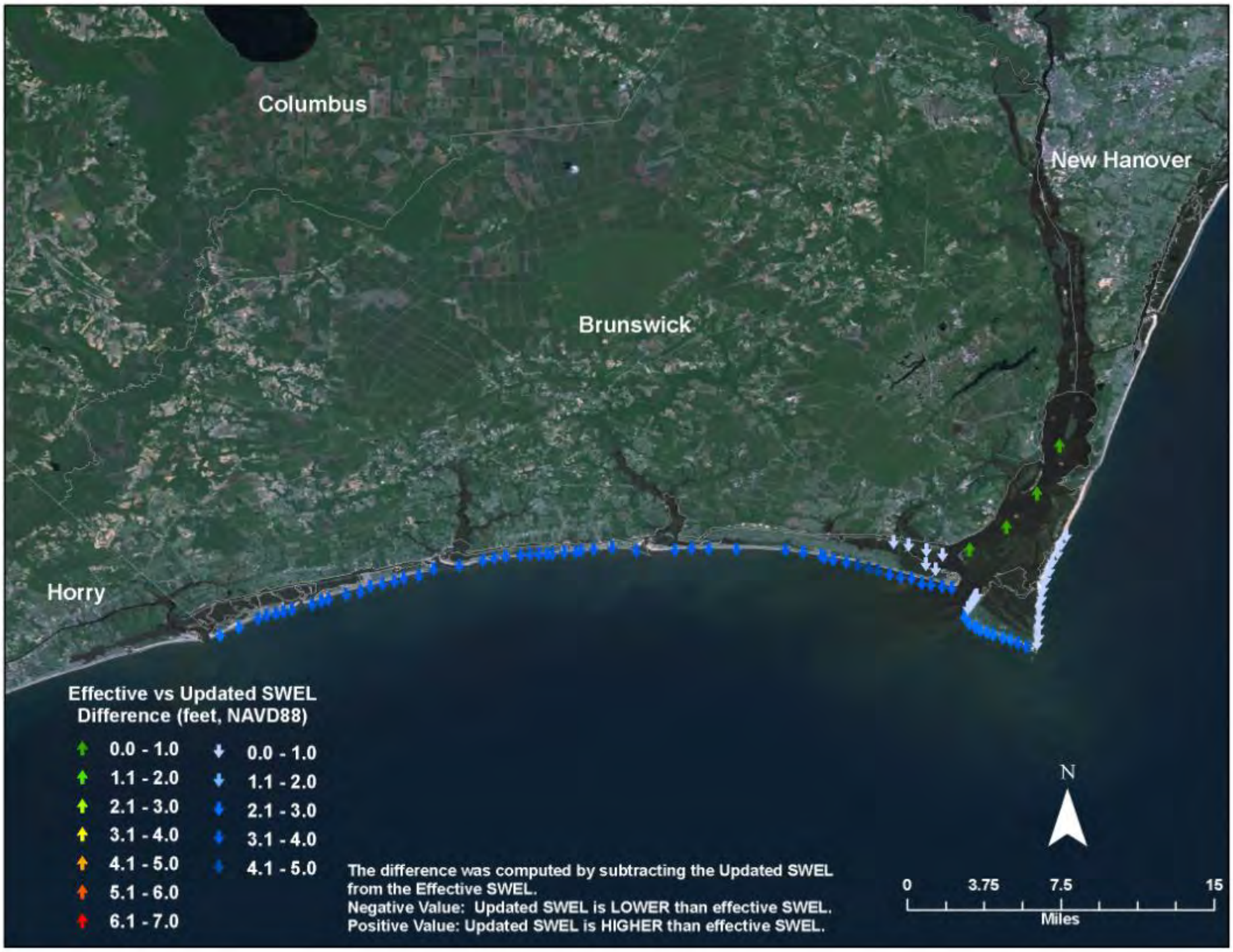
	Computed (m)*		Extrapolated (m)**		Difference (m)***		Difference (inches)	
Node	100-yr	500-yr	100-yr	500-yr	Delta 100	Delta 500	Delta 100	Delta 500
150663	2.2995	2.7579	2.2995	2.7579	0.0000	0.0000	0.0000	0.000
157966	2.2775	2.7251	2.2775	2.7251	0.0000	0.0000	0.0000	0.000
165670	2.2466	2.6952	2.2466	2.6952	0.0000	0.0000	0.0000	0.000
191115	2.2583	2.7072	2.2583	2.7072	0.0000	0.0000	0.0000	0.000
208955	2.1879	2.6096	2.1879	2.6096	0.0000	0.0000	0.0000	0.000
209037	2.2305	2.6613	2.2305	2.6613	0.0000	0.0000	0.0000	0.000
236284	2.1410	2.5433	2.1410	2.5433	0.0000	0.0000	0.0000	0.000
240694	2.1283	2.5377	2.1284	2.5377	-0.0001	0.0000	-0.0003	0.000
249575	2.1158	2.5181	2.1158	2.5181	0.0000	0.0000	0.0000	0.000
267802	2.0234	2.4424	2.0234	2.4424	0.0000	0.0000	0.0000	0.000
276991	2.0298	2.4848	2.0319	2.4848	-0.0021	0.0000	-0.0069	0.000
290842	2.0372	2.5399	2.0450	2.5399	-0.0078	0.0000	-0.0256	0.000
312078	3.2899	4.4255	3.2899	4.4255	0.0000	0.0000	0.0000	0.000
314749	2.0212	2.5797	2.0212	2.5797	0.0000	0.0000	0.0000	0.000
318526	3.4508	4.7208	3.4508	4.7208	0.0000	0.0000	0.0000	0.000
319585	2.0856	2.6454	2.0856	2.6454	0.0000	0.0000	0.0000	0.000
333819	3.5697	4.8326	3.5697	4.8326	0.0000	0.0000	0.0000	0.000
334468	2.0183	2.5528	2.0183	2.5528	0.0000	0.0000	0.0000	0.000
339490	2.0187	2.5684	2.0187	2.5684	0.0000	0.0000	0.0000	0.000
358305	1.8060	2.3368	1.8060	2.3368	0.0000	0.0000	0.0000	0.000
375968	2.2814	2.8864	2.2814	2.8864	0.0000	0.0000	0.0000	0.000
376121	2.0449	2.6201	2.0449	2.6201	0.0000	0.0000	0.0000	0.000
402796	2.9798	3.9404	2.9798	3.9404	0.0000	0.0000	0.0000	0.000
407872	2.4907	3.0559	2.4907	3.0559	0.0000	0.0000	0.0000	0.000
407948	2.4012	3.0008	2.4012	3.0008	0.0000	0.0000	0.0000	0.000
408103	1.9660	2.4763	1.9660	2.4763	0.0000	0.0000	0.0000	0.000
409747	3.3178	4.3335	3.3178	4.3335	0.0000	0.0000	0.0000	0.000
411883	3.0963	4.1399	3.0963	4.1399	0.0000	0.0000	0.0000	0.000
429853	2.7095	3.6142	2.7095	3.6142	0.0000	0.0000	0.0000	0.000
430672	2.5734	3.2411	2.5734	3.2411	0.0000	0.0000	0.0000	0.000
432696	3.4191	4.5601	3.4191	4.5601	0.0000	0.0000	0.0000	0.000
438289	3.0418	4.1710	3.0418	4.1710	0.0000	0.0000	0.0000	0.000
442951	3.3079	4.5412	3.3079	4.5412	0.0000	0.0000	0.0000	0.000
444068	2.5347	3.1538	2.5347	3.1538	0.0000	0.0000	0.0000	0.000
444205	2.1107	2.6436	2.1107	2.6436	0.0000	0.0000	0.0000	0.000
444701	1.9357	2.3483	1.9382	2.3483	-0.0025	0.0000	-0.0082	0.000

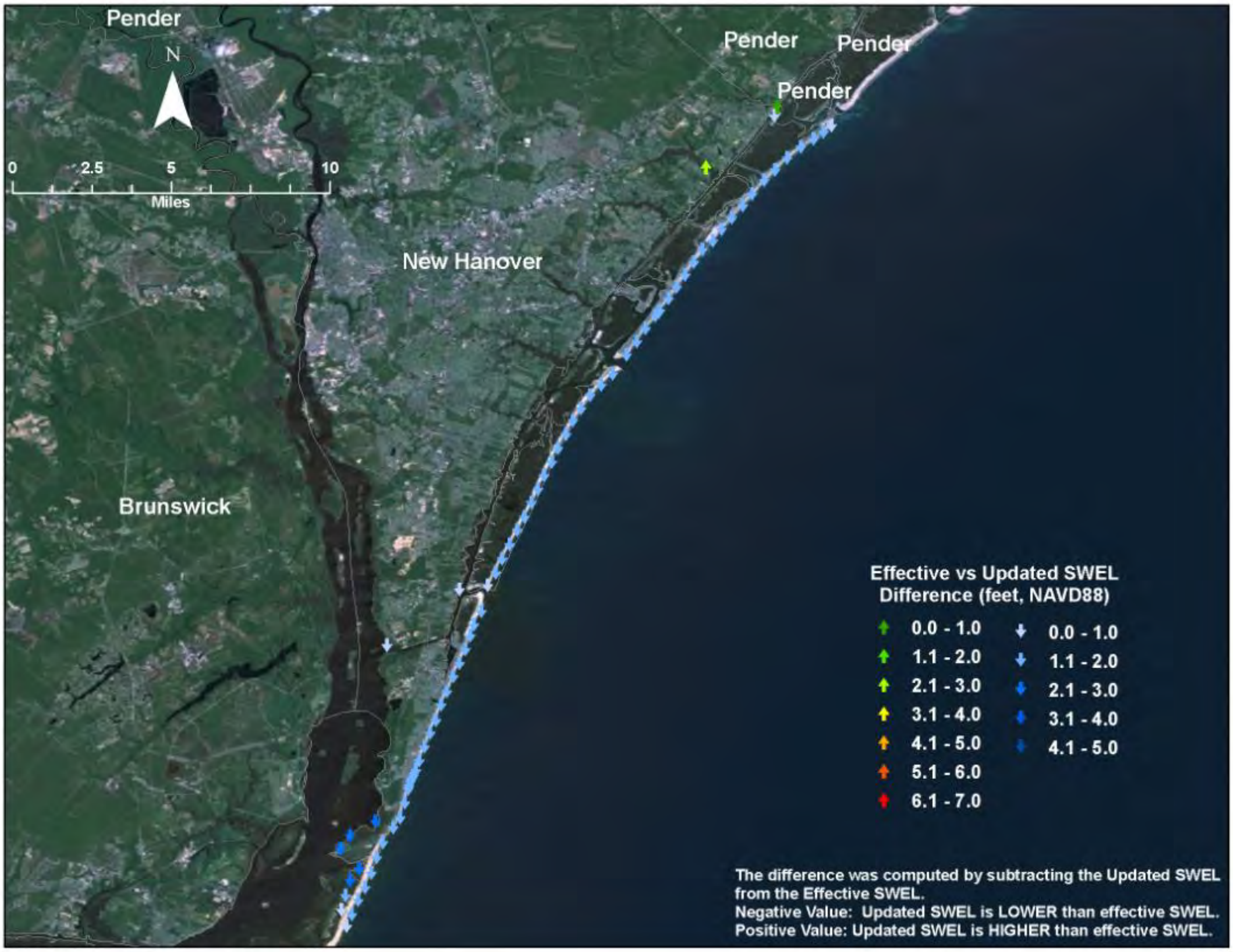
	Computed (m)*		Extrapolated (m)**		Difference (m)***		Difference (inches)	
Node	100-yr	500-yr	100-yr	500-yr	Delta 100	Delta 500	Delta 100	Delta 500
447628	3.2570	4.2802	3.2570	4.2802	0.000	0.000	0.000	0.000
448249	2.5053	3.1671	2.5053	3.1671	0.000	0.000	0.000	0.000
452341	2.5774	3.3010	2.5774	3.3010	0.000	0.000	0.000	0.000
460033	3.3577	4.3880	3.3577	4.3880	0.000	0.000	0.000	0.000
468211	3.1053	3.9570	3.1053	3.9570	0.000	0.000	0.000	0.000
468568	3.3512	4.4389	3.3512	4.4389	0.000	0.000	0.000	0.000
486232	2.5694	3.2444	2.5694	3.2444	0.000	0.000	0.000	0.000
489507	3.2109	4.1761	3.2109	4.1761	0.000	0.000	0.000	0.000
494554	2.6924	3.5302	2.6924	3.5302	0.000	0.000	0.000	0.000
515719	2.4042	3.1561	2.4042	3.1561	0.000	0.000	0.000	0.000
549665	2.8474	3.6799	2.8474	3.6799	0.000	0.000	0.000	0.000
565930	2.8300	3.8126	2.8300	3.8126	0.000	0.000	0.000	0.000
577471	2.8687	3.6199	2.8687	3.6199	0.000	0.000	0.000	0.000

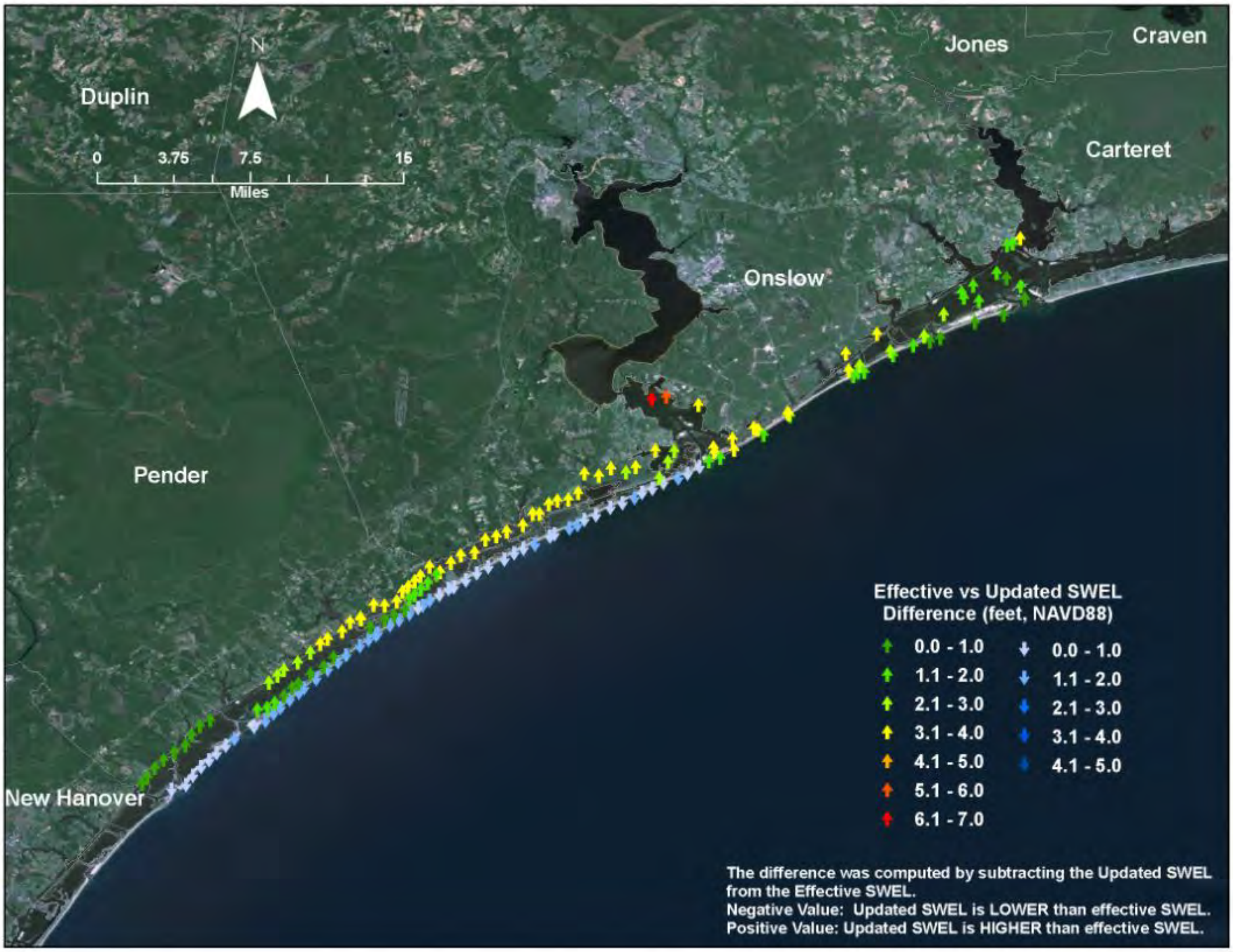
* Computed values are the combined JPM/EST return period results using the 1000-year return period EST values as calculated by the EST program.
** Extrapolated values are the combined JPM/EST return period results using the extrapolated 1000-year return period EST values.
*** The difference was found by subtracting the extrapolated values from the computed values.

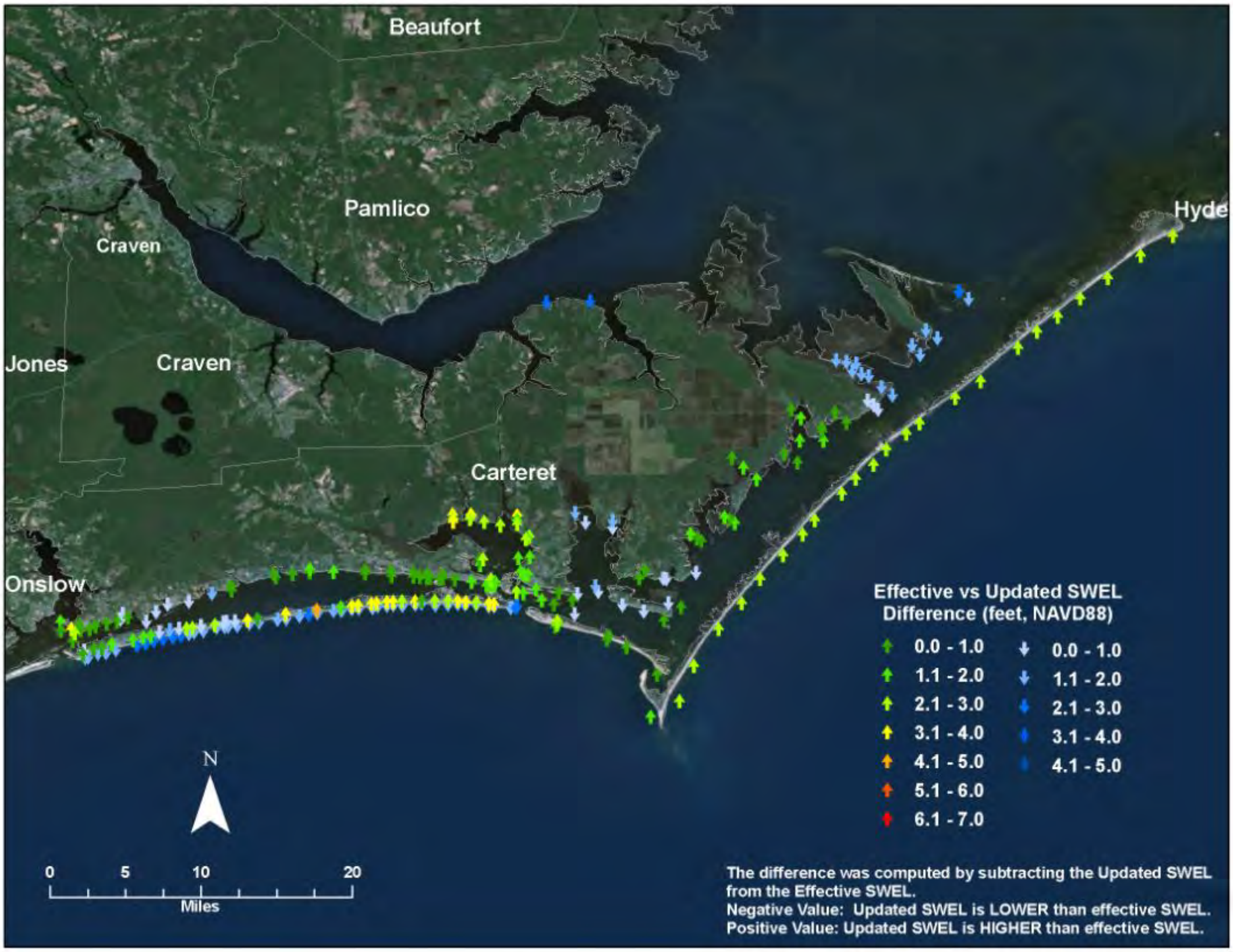
APPENDIX C – COMPARISON TO EFFECTIVE SWELS

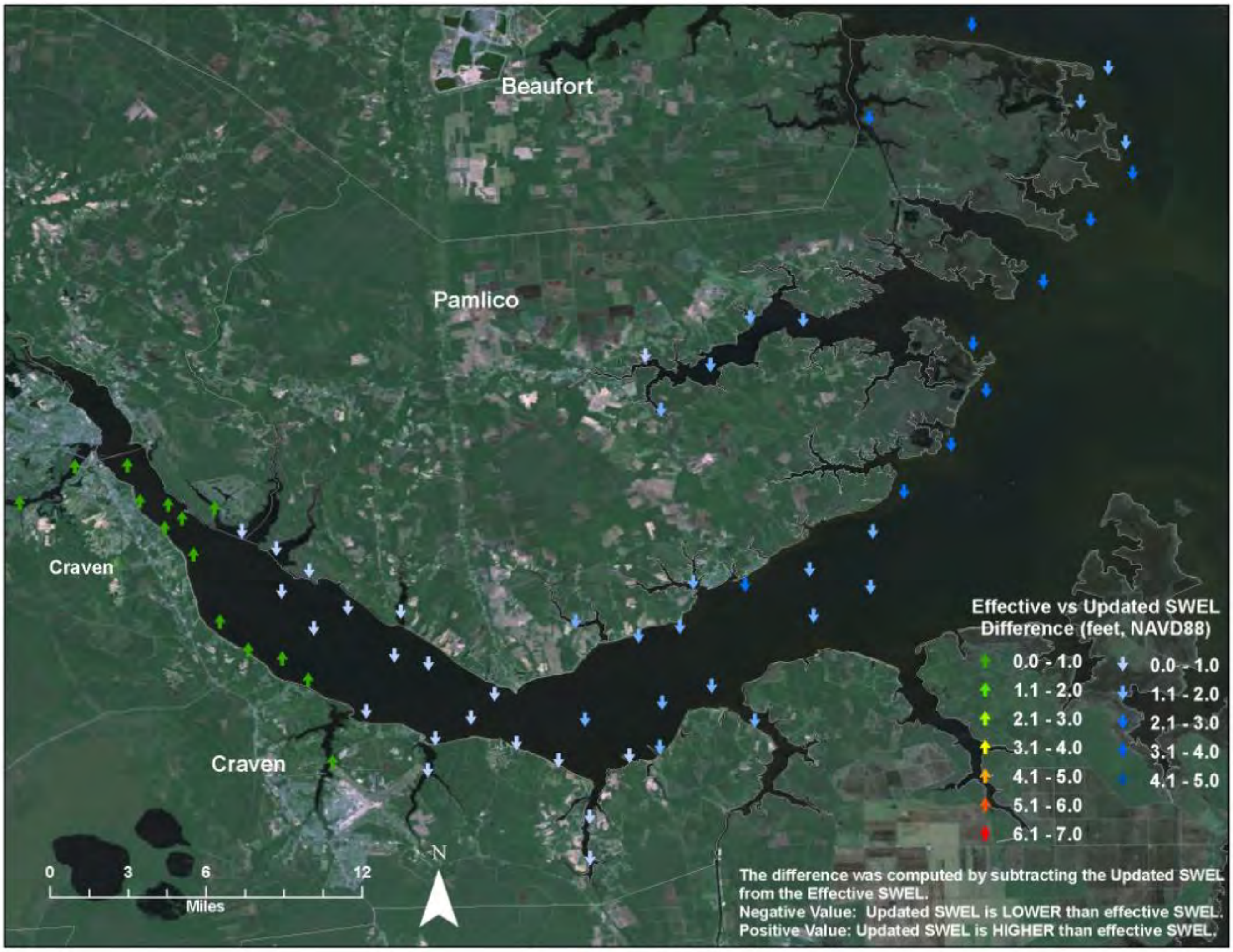



Columbus
New Hanover
Brunswick
Horry
Effective vs Updated SWEL
Difference (feet, NAVD88)
0.0 - 1.0
1.1 - 2.0
2.1 - 3.0
3.1 - 4.0
4.1 - 5.0
5.1 - 6.0
6.1 - 7.0
0.0 - 1.0
1.1 - 2.0
2.1 - 3.0
3.1 - 4.0
4.1 - 5.0
The difference was computed by subtracting the Updated SWEL from the Effective SWEL.
Negative Value: Updated SWEL is LOWER than effective SWEL.
Positive Value: Updated SWEL is HIGHER than effective SWEL.
N
0
3.75
7.5
15
Miles

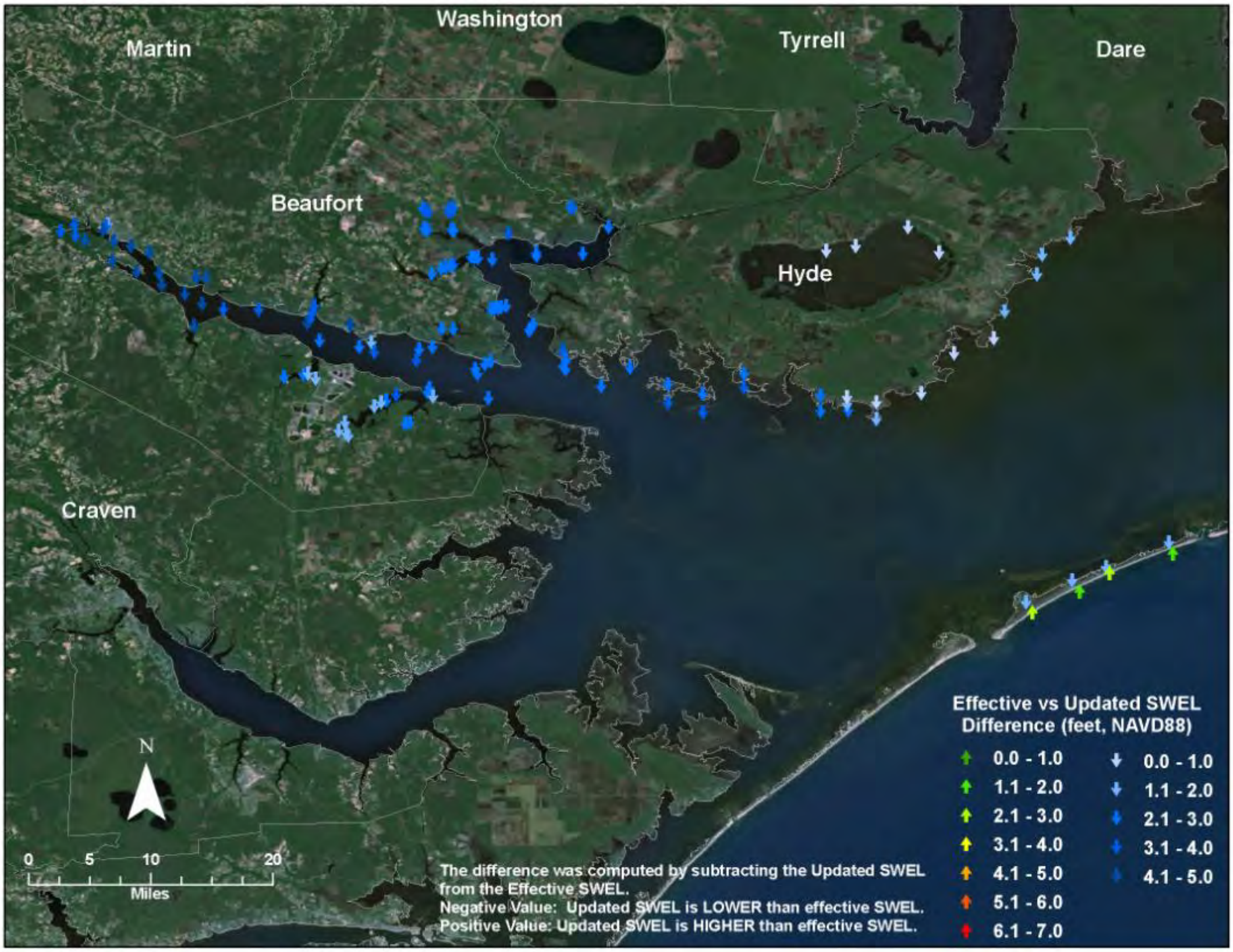

Pender
N
0
2.5
5
10
Miles
Pender
Pender
Pender
New Hanover
Brunswick
Effective vs Updated SWEL
Difference (feet, NAVD88)
0.0 - 1.0
1.1 - 2.0
2.1 - 3.0
3.1 - 4.0
4.1 - 5.0
5.1 - 6.0
6.1 - 7.0
0.0 - 1.0
1.1 - 2.0
2.1 - 3.0
3.1 - 4.0
4.1 - 5.0
The difference was computed by subtracting the Updated SWEL from the Effective SWEL.
Negative Value: Updated SWEL is LOWER than effective SWEL.
Positive Value: Updated SWEL is HIGHER than effective SWEL.

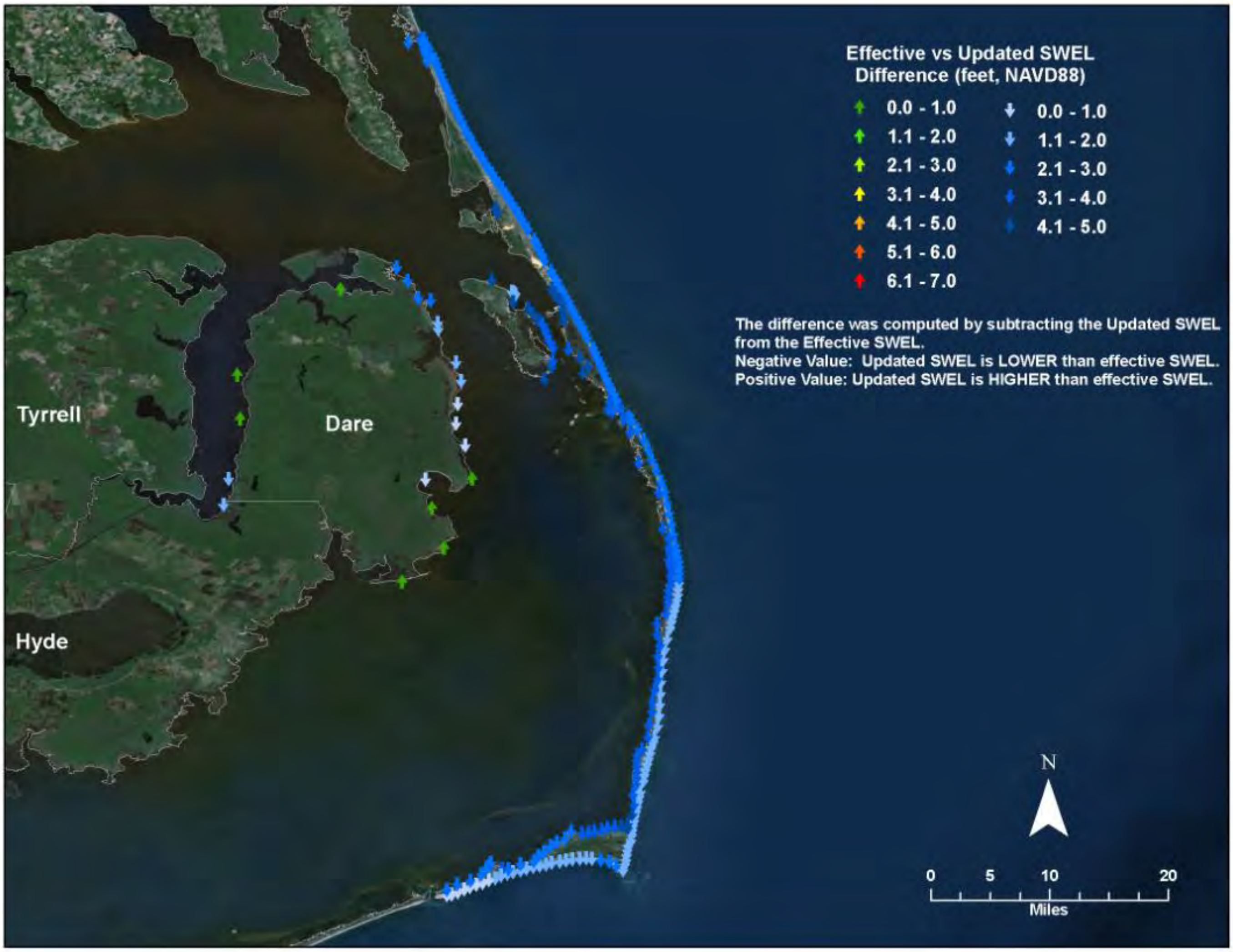

Duplin
Jones
Craven
Carteret
Onslow
Pender
New Hanover
N
0
3.75
7.5
15
Miles
Effective vs Updated SWEL
Difference (feet, NAVD88)
0.0 - 1.0
1.1 - 2.0
2.1 - 3.0
3.1 - 4.0
4.1 - 5.0
5.1 - 6.0
6.1 - 7.0
0.0 - 1.0
1.1 - 2.0
2.1 - 3.0
3.1 - 4.0
4.1 - 5.0
The difference was computed by subtracting the Updated SWEL from the Effective SWEL.
Negative Value: Updated SWEL is LOWER than effective SWEL.
Positive Value: Updated SWEL is HIGHER than effective SWEL.

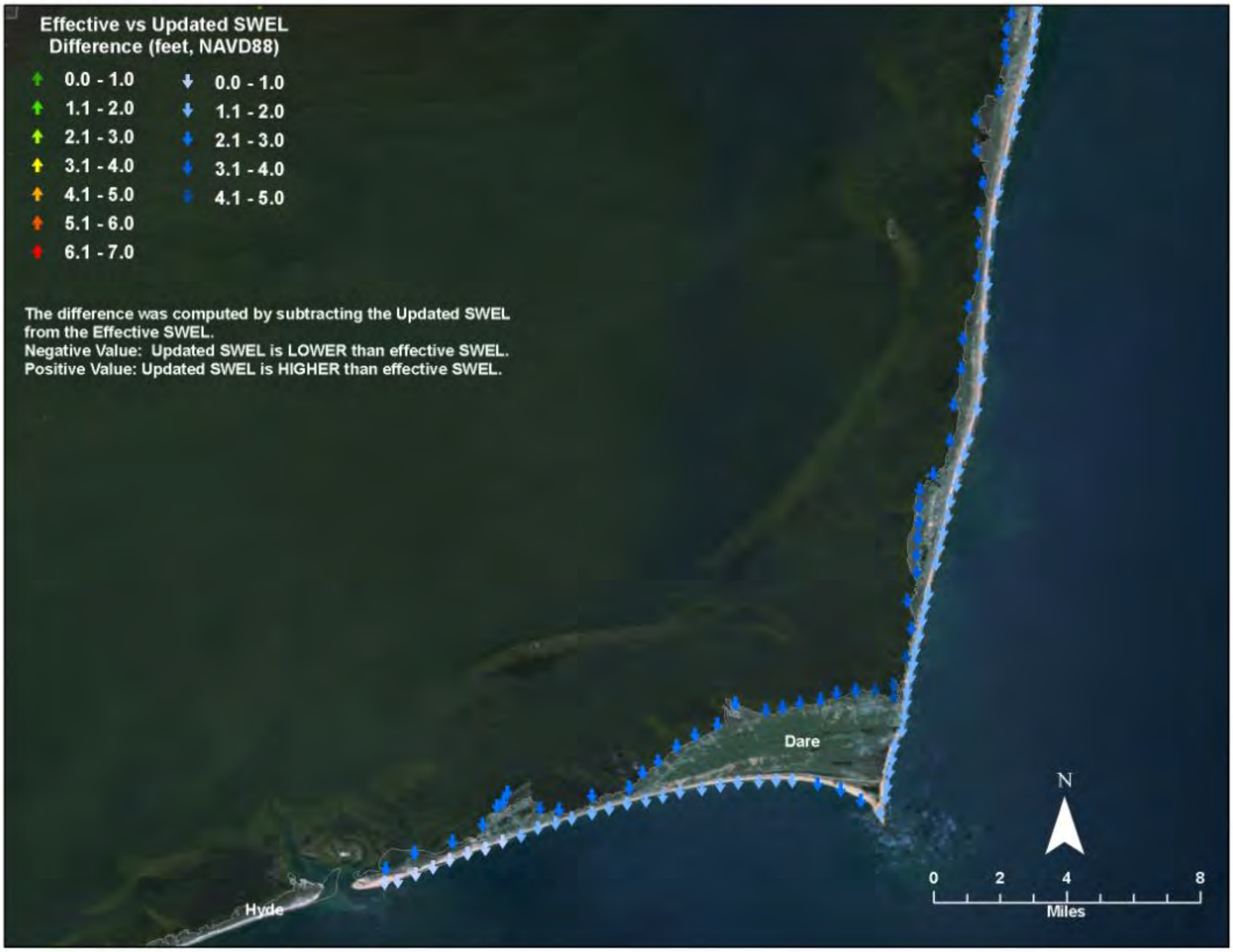

Beaufort
Pamlico
Craven
Jones
Craven
Carteret
Onslow
Hyde
Effective vs Updated SWEL
Difference (feet, NAVD88)
0.0 - 1.0
1.1 - 2.0
2.1 - 3.0
3.1 - 4.0
4.1 - 5.0
5.1 - 6.0
6.1 - 7.0
0.0 - 1.0
1.1 - 2.0
2.1 - 3.0
3.1 - 4.0
4.1 - 5.0
N
0 5 10 20
Miles
The difference was computed by subtracting the Updated SWEL from the Effective SWEL.
Negative Value: Updated SWEL is LOWER than effective SWEL.
Positive Value: Updated SWEL is HIGHER than effective SWEL.

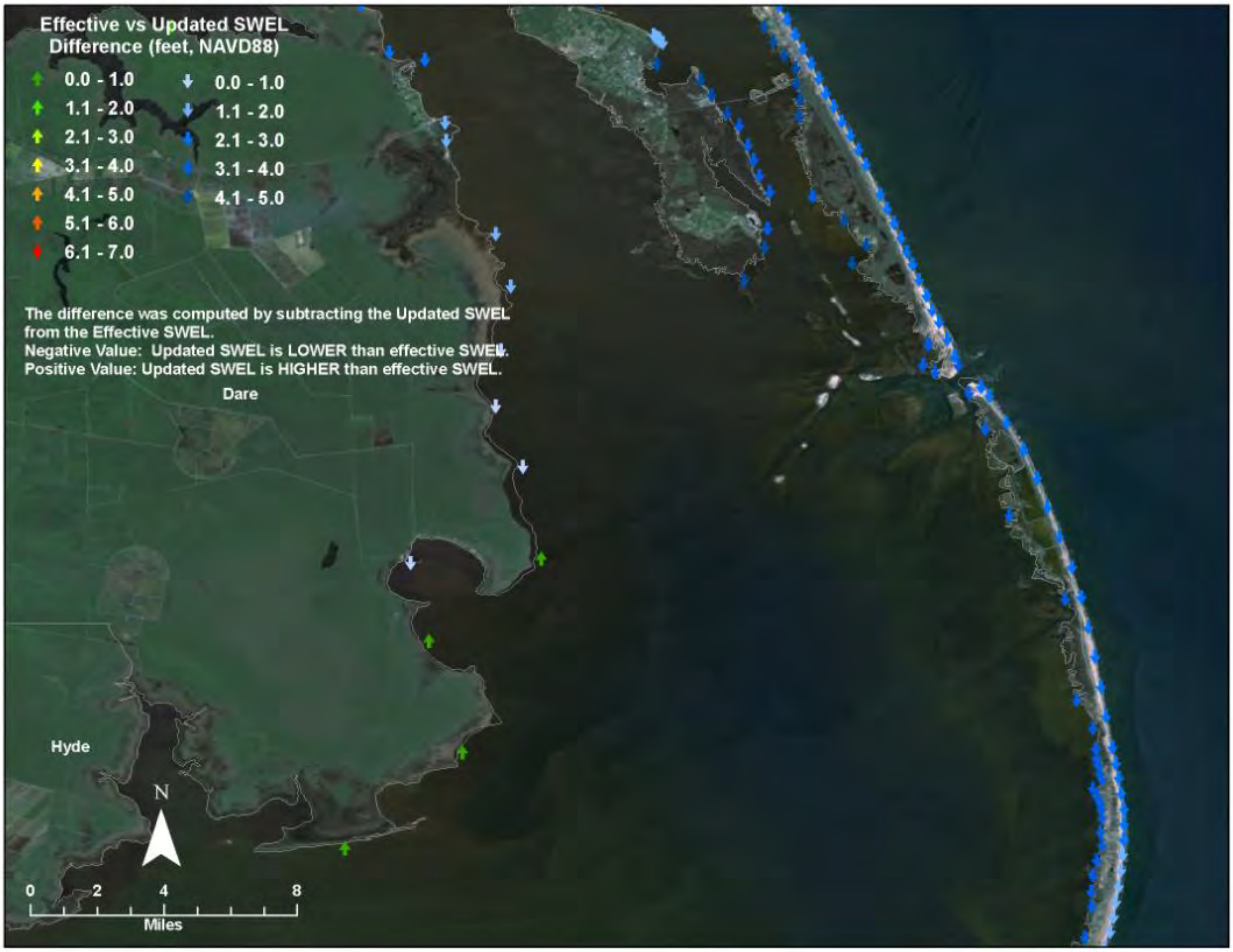


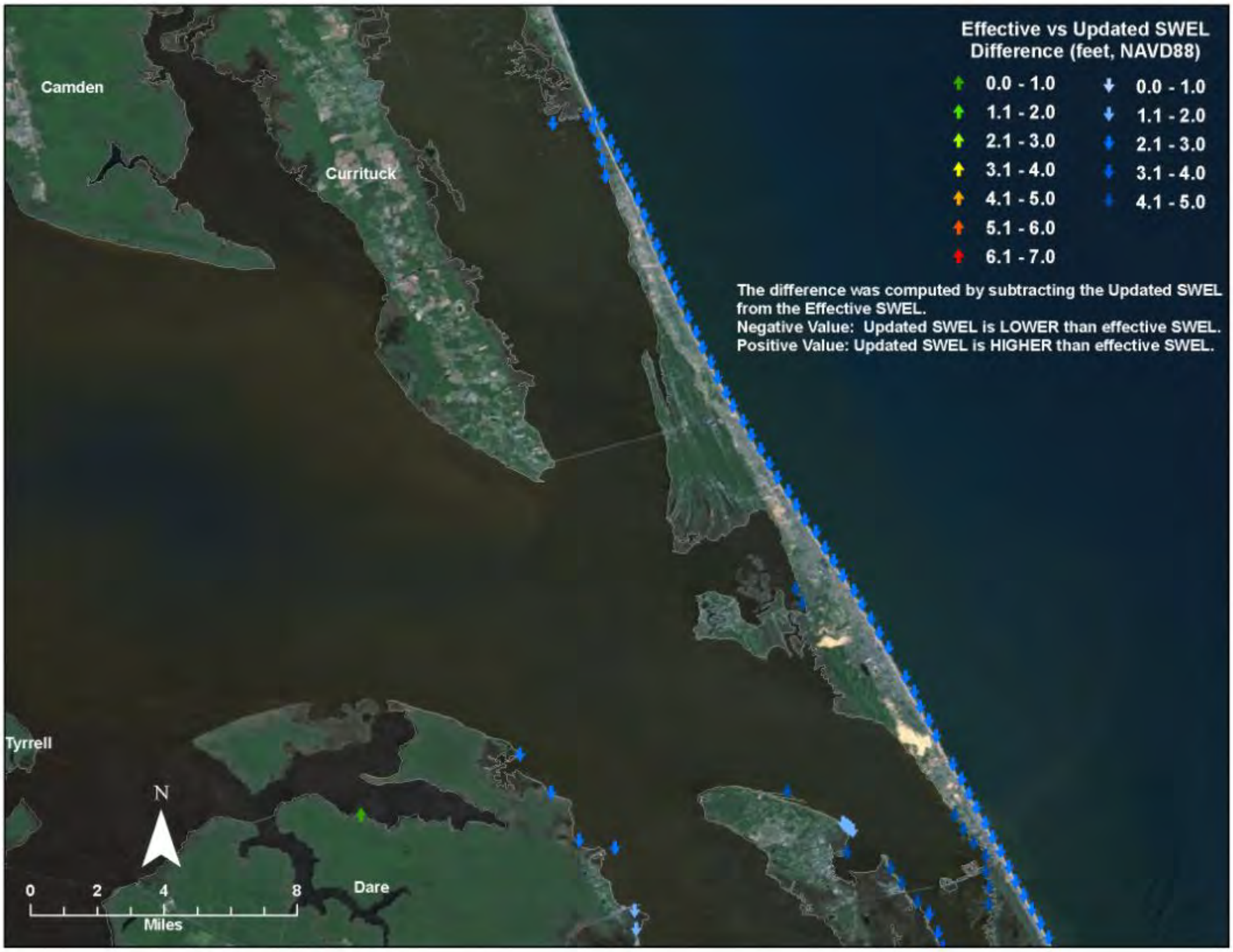
Beaufort
Pamlico
Craven
Craven
Effective vs Updated SWEL
Difference (feet, NAVD88)
0.0 - 1.0
1.1 - 2.0
2.1 - 3.0
3.1 - 4.0
4.1 - 5.0
5.1 - 6.0
6.1 - 7.0
0.0 - 1.0
1.1 - 2.0
2.1 - 3.0
3.1 - 4.0
4.1 - 5.0
0
3
6
12
Miles
N
The difference was computed by subtracting the Updated SWEL from the Effective SWEL.
Negative Value: Updated SWEL is LOWER than effective SWEL.
Positive Value: Updated SWEL is HIGHER than effective SWEL.


Washington
Martin
Tyrrell
Dare
Beaufort
Hyde
Craven
N
0 5 10 20
Miles
Effective vs Updated SWEL
Difference (feet, NAVD88)
0.0 - 1.0
1.1 - 2.0
2.1 - 3.0
3.1 - 4.0
4.1 - 5.0
5.1 - 6.0
6.1 - 7.0
0.0 - 1.0
1.1 - 2.0
2.1 - 3.0
3.1 - 4.0
4.1 - 5.0
The difference was computed by subtracting the Updated SWEL from the Effective SWEL.
Negative Value: Updated SWEL is LOWER than effective SWEL.
Positive Value: Updated SWEL is HIGHER than effective SWEL.


Effective vs Updated SWEL
Difference (feet, NAVD88)
0.0 - 1.0
1.1 - 2.0
2.1 - 3.0
3.1 - 4.0
4.1 - 5.0
5.1 - 6.0
6.1 - 7.0
0.0 - 1.0
1.1 - 2.0
2.1 - 3.0
3.1 - 4.0
4.1 - 5.0
The difference was computed by subtracting the Updated SWEL from the Effective SWEL.
Negative Value: Updated SWEL is LOWER than effective SWEL.
Positive Value: Updated SWEL is HIGHER than effective SWEL.
Tyrrell
Dare
Hyde
N
0
5
10
20
Miles

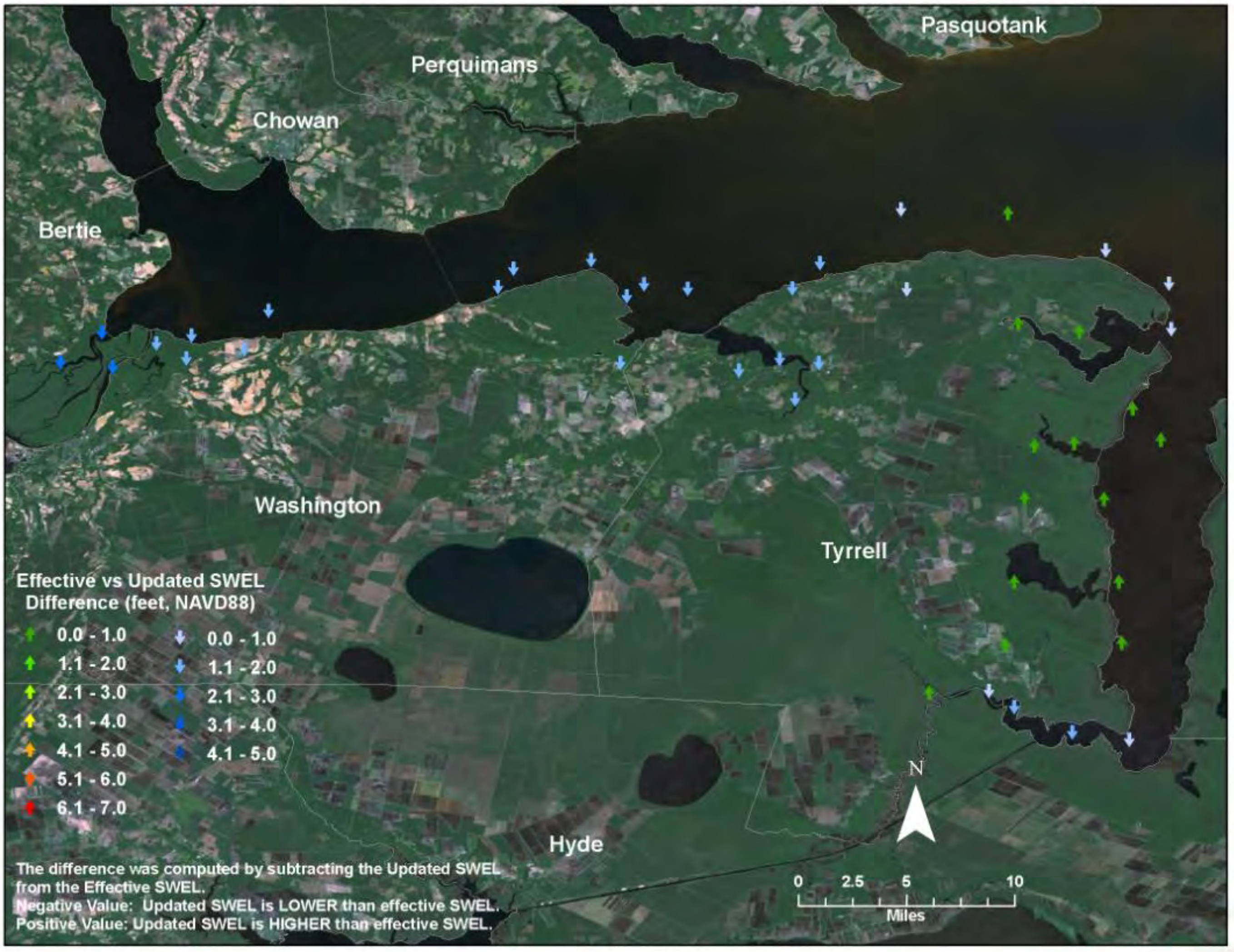

Effective vs Updated SWEL
Difference (feet, NAVD88)
0.0 - 1.0
1.1 - 2.0
2.1 - 3.0
3.1 - 4.0
4.1 - 5.0
5.1 - 6.0
6.1 - 7.0
0.0 - 1.0
1.1 - 2.0
2.1 - 3.0
3.1 - 4.0
4.1 - 5.0
The difference was computed by subtracting the Updated SWEL from the Effective SWEL.
Negative Value: Updated SWEL is LOWER than effective SWEL.
Positive Value: Updated SWEL is HIGHER than effective SWEL.
Dare
Hyde
N
0
2
4
8
Miles

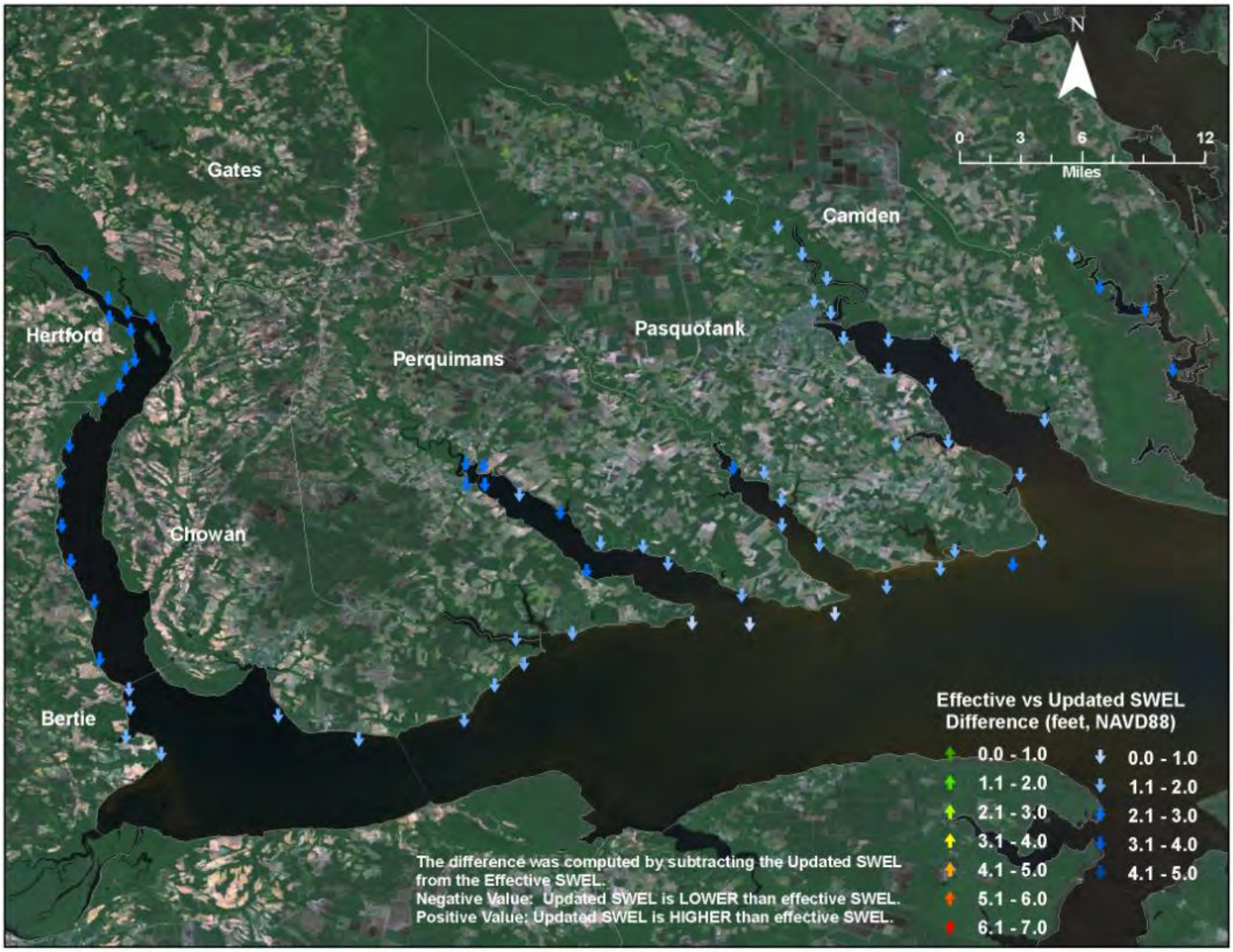

Effective vs Updated SWEL
Difference (feet, NAVD88)
0.0 - 1.0
1.1 - 2.0
2.1 - 3.0
3.1 - 4.0
4.1 - 5.0
5.1 - 6.0
6.1 - 7.0
0.0 - 1.0
1.1 - 2.0
2.1 - 3.0
3.1 - 4.0
4.1 - 5.0
The difference was computed by subtracting the Updated SWEL from the Effective SWEL.
Negative Value: Updated SWEL is LOWER than effective SWEL.
Positive Value: Updated SWEL is HIGHER than effective SWEL.
Dare
Hyde
N
0 2 4 8
Miles



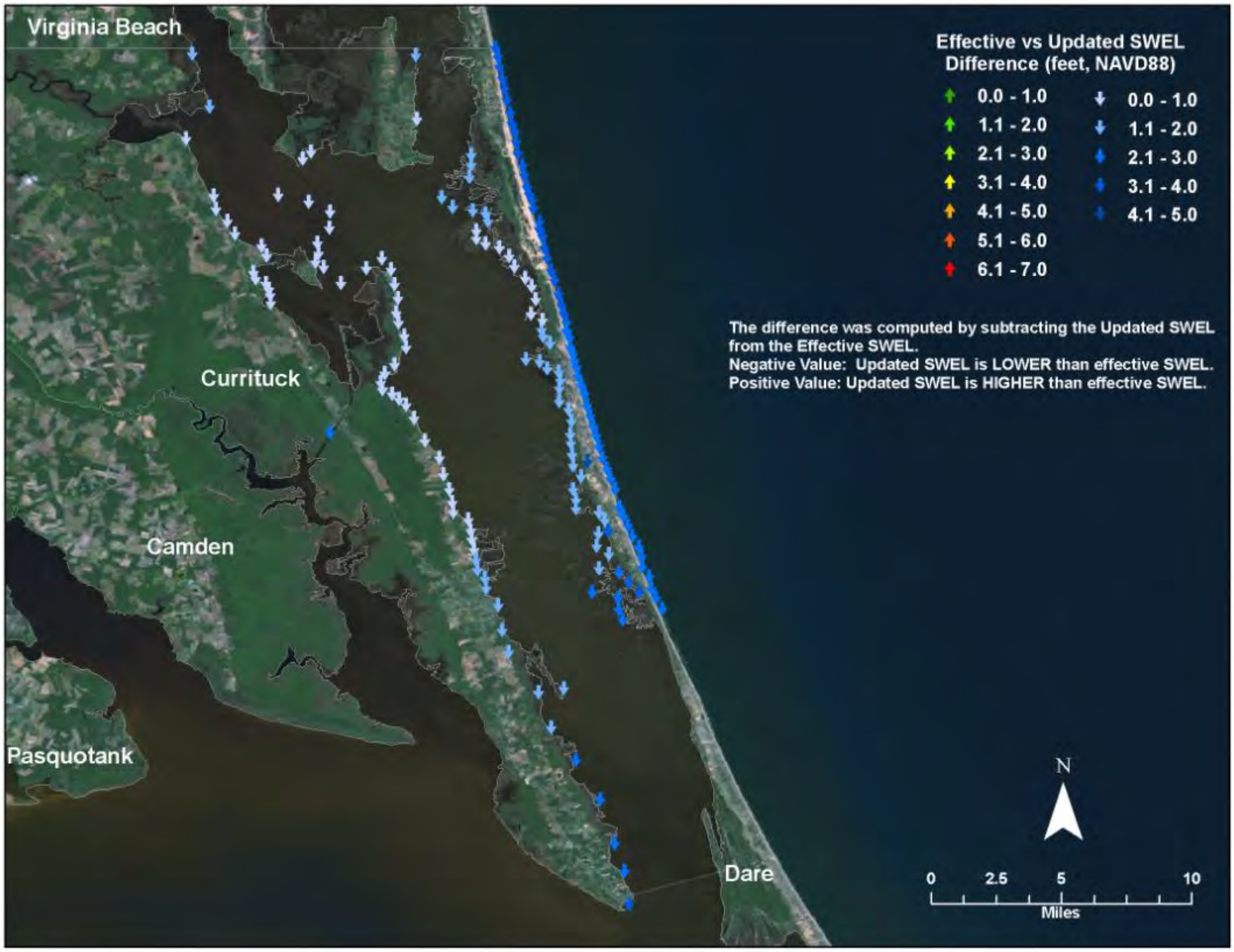
Effective vs Updated SWEL
Difference (feet, NAVD88)
0.0 - 1.0
1.1 - 2.0
2.1 - 3.0
3.1 - 4.0
4.1 - 5.0
5.1 - 6.0
6.1 - 7.0
0.0 - 1.0
1.1 - 2.0
2.1 - 3.0
3.1 - 4.0
4.1 - 5.0
The difference was computed by subtracting the Updated SWEL from the Effective SWEL.
Negative Value: Updated SWEL is LOWER than effective SWEL.
Positive Value: Updated SWEL is HIGHER than effective SWEL.
Camden
Currituck
Tyrrell
Dare
N
0
2
4
8
Miles

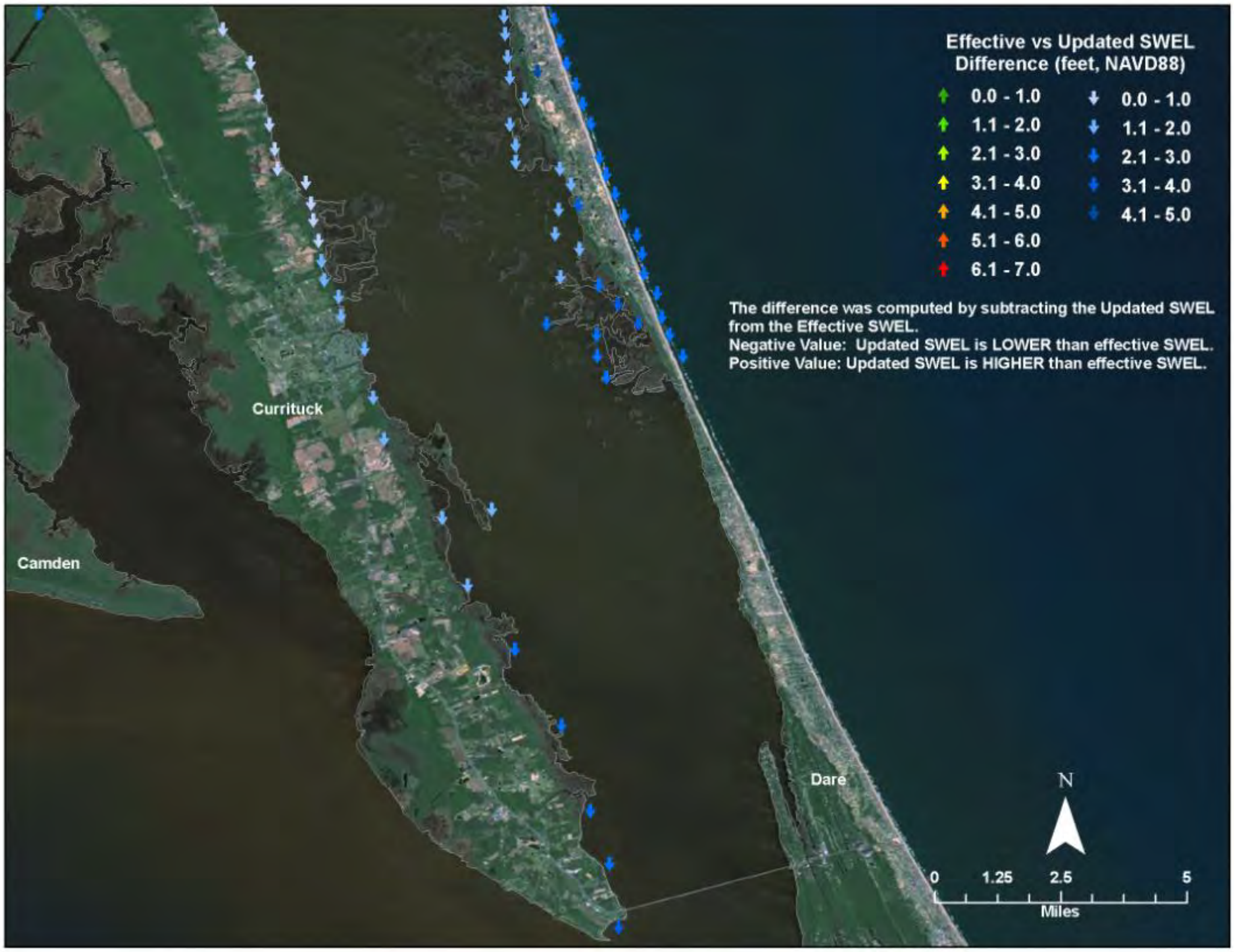
N
0 2 4 8
Miles
Tyrrell
Dare
Hyde
Effective vs Updated SWEL
Difference (feet, NAVD88)
0.0 - 1.0
1.1 - 2.0
2.1 - 3.0
3.1 - 4.0
4.1 - 5.0
5.1 - 6.0
6.1 - 7.0
0.0 - 1.0
1.1 - 2.0
2.1 - 3.0
3.1 - 4.0
4.1 - 5.0
The difference was computed by subtracting the Updated SWEL
from the Effective SWEL.
Negative Value: Updated SWEL is LOWER than effective SWEL.
Positive Value: Updated SWEL is HIGHER than effective SWEL.

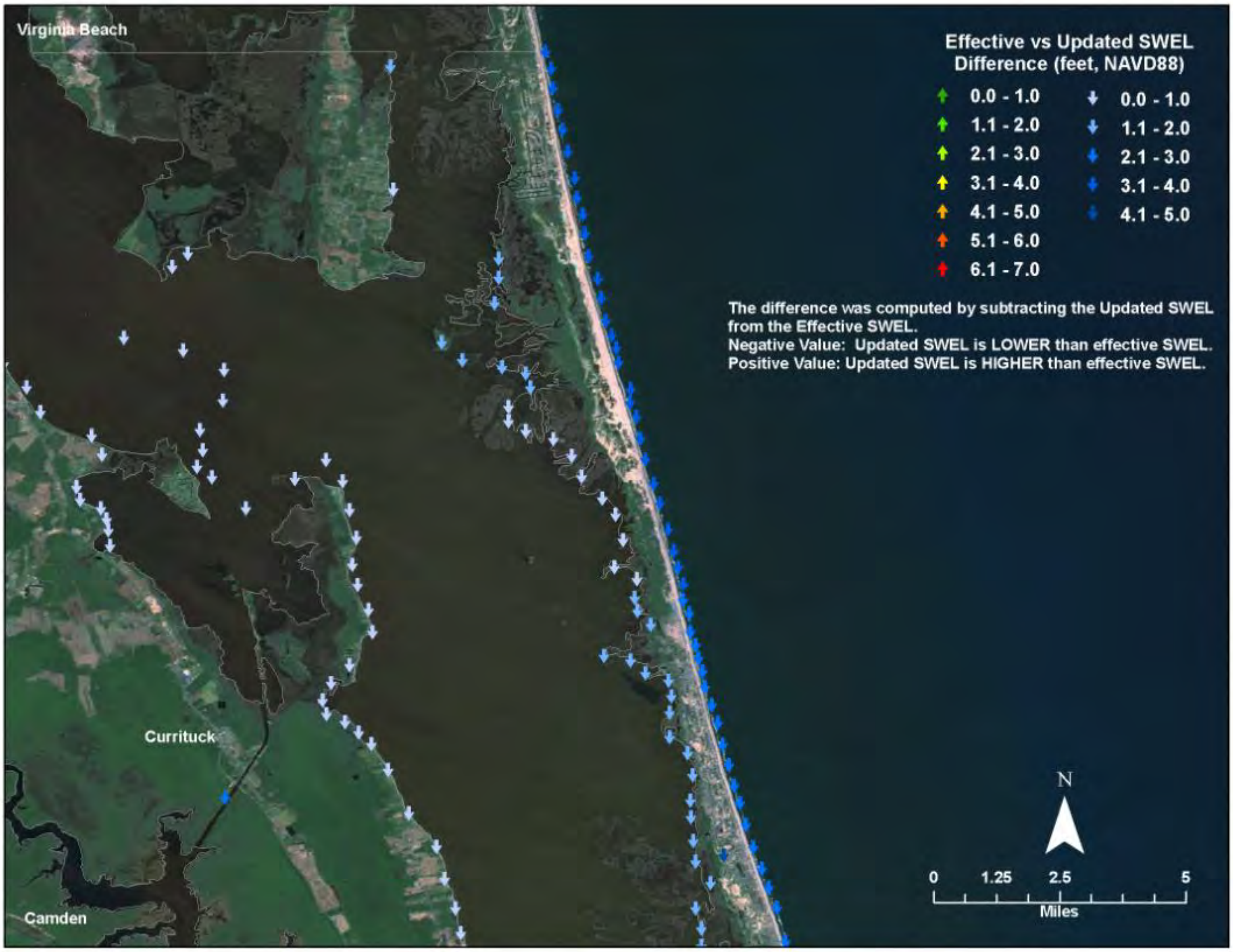

Pasquotank
Perquimans
Chowan
Bertie
Washington
Tyrrell
Hyde
Effective vs Updated SWEL
Difference (feet, NAVD88)
0.0 - 1.0
1.1 - 2.0
2.1 - 3.0
3.1 - 4.0
4.1 - 5.0
5.1 - 6.0
6.1 - 7.0
0.0 - 1.0
1.1 - 2.0
2.1 - 3.0
3.1 - 4.0
4.1 - 5.0
The difference was computed by subtracting the Updated SWEL from the Effective SWEL.
Negative Value: Updated SWEL is LOWER than effective SWEL.
Positive Value: Updated SWEL is HIGHER than effective SWEL.
N
0
2.5
5
10
Miles



Gates
Camden
Hertford
Pasquotank
Perquimans
Chowan
Bertie
N
0
3
6
12
Miles
Effective vs Updated SWEL
Difference (feet, NAVD88)
0.0 - 1.0
1.1 - 2.0
2.1 - 3.0
3.1 - 4.0
4.1 - 5.0
5.1 - 6.0
6.1 - 7.0
0.0 - 1.0
1.1 - 2.0
2.1 - 3.0
3.1 - 4.0
4.1 - 5.0
The difference was computed by subtracting the Updated SWEL from the Effective SWEL.
Negative Value: Updated SWEL is LOWER than effective SWEL.
Positive Value: Updated SWEL is HIGHER than effective SWEL.


Virginia Beach
Currituck
Camden
Pasquotank
Dare
Effective vs Updated SWEL
Difference (feet, NAVD88)
0.0 - 1.0
1.1 - 2.0
2.1 - 3.0
3.1 - 4.0
4.1 - 5.0
5.1 - 6.0
6.1 - 7.0
0.0 - 1.0
1.1 - 2.0
2.1 - 3.0
3.1 - 4.0
4.1 - 5.0
The difference was computed by subtracting the Updated SWEL from the Effective SWEL.
Negative Value: Updated SWEL is LOWER than effective SWEL.
Positive Value: Updated SWEL is HIGHER than effective SWEL.
N
0
2.5
5
10
Miles


Effective vs Updated SWEL
Difference (feet, NAVD88)
0.0 - 1.0
1.1 - 2.0
2.1 - 3.0
3.1 - 4.0
4.1 - 5.0
5.1 - 6.0
6.1 - 7.0
0.0 - 1.0
1.1 - 2.0
2.1 - 3.0
3.1 - 4.0
4.1 - 5.0
The difference was computed by subtracting the Updated SWEL from the Effective SWEL.
Negative Value: Updated SWEL is LOWER than effective SWEL.
Positive Value: Updated SWEL is HIGHER than effective SWEL.
Currituck
Camden
Dare
N
0
1.25
2.5
5
Miles


Virginia Beach
Currituck
Camden
Effective vs Updated SWEL
Difference (feet, NAVD88)
0.0 - 1.0
1.1 - 2.0
2.1 - 3.0
3.1 - 4.0
4.1 - 5.0
5.1 - 6.0
6.1 - 7.0
0.0 - 1.0
1.1 - 2.0
2.1 - 3.0
3.1 - 4.0
4.1 - 5.0
The difference was computed by subtracting the Updated SWEL from the Effective SWEL.
Negative Value: Updated SWEL is LOWER than effective SWEL.
Positive Value: Updated SWEL is HIGHER than effective SWEL.
N
0
1.25
2.5
5
Miles

APPENDIX D: TROPICAL STORM TRACK PARAMETERS AND JPM WEIGHTS

Track Name	dp	r	b	c	h	Weight
	[mb]	[km]		[m/s]	[deg]	
bp2_dp1r1b1c1h1l1	36	36.40	0.95	6.5	11	0.0015946
bp2_dp1r1b1c1h2l1	36	36.32	0.95	6.5	29	0.0016365
bp2_dp1r1b1c1h3l1	36	36.38	0.95	6.5	58	0.0009651
bp2_dp1r1b1c2h1l1	36	36.40	0.95	16.0	11	0.0015941
bp2_dp1r1b1c2h2l1	36	36.36	0.95	16.0	29	0.0016360
bp2_dp1r1b1c2h3l1	36	36.36	0.95	16.0	58	0.0009648
bp2_dp1r1b1c3h1l1	36	36.35	0.95	23.5	11	0.0015941
bp2_dp1r1b1c3h2l1	36	36.33	0.95	23.5	29	0.0016360
bp2_dp1r1b1c3h3l1	36	36.41	0.95	23.5	58	0.0009648
bp2_dp1r1b2c1h1l1	36	36.37	1.22	6.5	11	0.0015941
bp2_dp1r1b2c1h2l1	36	36.36	1.22	6.5	29	0.0016360
bp2_dp1r1b2c1h3l1	36	36.41	1.22	6.5	58	0.0009648
bp2_dp1r1b2c2h1l1	36	36.40	1.22	16.0	11	0.0015936
bp2_dp1r1b2c2h2l1	36	36.38	1.22	16.0	29	0.0016355
bp2_dp1r1b2c2h3l1	36	36.43	1.22	16.0	58	0.0009646
bp2_dp1r1b2c3h1l1	36	36.36	1.22	23.5	11	0.0015936
bp2_dp1r1b2c3h2l1	36	36.43	1.22	23.5	29	0.0016355
bp2_dp1r1b2c3h3l1	36	36.41	1.22	23.5	58	0.0009646
bp2_dp1r1b3c1h1l1	36	36.42	1.49	6.5	11	0.0015941
bp2_dp1r1b3c1h2l1	36	36.33	1.49	6.5	29	0.0016360
bp2_dp1r1b3c1h3l1	36	36.34	1.49	6.5	58	0.0009648
bp2_dp1r1b3c2h1l1	36	36.33	1.49	16.0	11	0.0015936
bp2_dp1r1b3c2h2l1	36	36.43	1.49	16.0	29	0.0016355
bp2_dp1r1b3c2h3l1	36	36.43	1.49	16.0	58	0.0009646
bp2_dp1r1b3c3h1l1	36	36.34	1.49	23.5	11	0.0015936
bp2_dp1r1b3c3h2l1	36	36.33	1.49	23.5	29	0.0016355
bp2_dp1r1b3c3h3l1	36	36.42	1.49	23.5	58	0.0009646
bp2_dp1r2b1c1h1l1	36	62.26	0.81	6.5	11	0.0015941
bp2_dp1r2b1c1h2l1	36	62.23	0.81	6.5	29	0.0016360
bp2_dp1r2b1c1h3l1	36	62.18	0.81	6.5	58	0.0009648
bp2_dp1r2b1c2h1l1	36	62.26	0.81	16.0	11	0.0015936
bp2_dp1r2b1c2h2l1	36	62.13	0.81	16.0	29	0.0016355
bp2_dp1r2b1c2h3l1	36	62.20	0.81	16.0	58	0.0009646
bp2_dp1r2b1c3h1l1	36	62.24	0.81	23.5	11	0.0015936
bp2_dp1r2b1c3h2l1	36	62.25	0.81	23.5	29	0.0016355
bp2_dp1r2b1c3h3l1	36	62.30	0.81	23.5	58	0.0009646
bp2_dp1r2b2c1h1l1	36	62.27	1.08	6.5	11	0.0015936
bp2_dp1r2b2c1h2l1	36	62.30	1.08	6.5	29	0.0016355
bp2_dp1r2b2c1h3l1	36	62.14	1.08	6.5	58	0.0009646
bp2_dp1r2b2c2h1l1	36	62.27	1.08	16.0	11	0.0015931
bp2_dp1r2b2c2h2l1	36	62.18	1.08	16.0	29	0.0016351
bp2_dp1r2b2c2h3l1	36	62.17	1.08	16.0	58	0.0009643
bp2_dp1r2b2c3h1l1	36	62.19	1.08	23.5	11	0.0015931
bp2_dp1r2b2c3h2l1	36	62.22	1.08	23.5	29	0.0016351
bp2_dp1r2b2c3h3l1	36	62.26	1.08	23.5	58	0.0009643
bp2_dp1r2b3c1h1l1	36	62.27	1.35	6.5	11	0.0015936
bp2_dp1r2b3c1h2l1	36	62.20	1.35	6.5	29	0.0016355
bp2_dp1r2b3c1h3l1	36	62.22	1.35	6.5	58	0.0009646

bp2_dp1r2b3c2h1l1	36	62.24	1.35	16.0	11	0.0015931
bp2_dp1r2b3c2h2l1	36	62.30	1.35	16.0	29	0.0016351
bp2_dp1r2b3c2h3l1	36	62.26	1.35	16.0	58	0.0009643
bp2_dp1r2b3c3h1l1	36	62.23	1.35	23.5	11	0.0015931
bp2_dp1r2b3c3h2l1	36	62.19	1.35	23.5	29	0.0016351
bp2_dp1r2b3c3h3l1	36	62.14	1.35	23.5	58	0.0009643
bp2_dp1r3b1c1h1l1	36	106.54	0.56	6.5	11	0.0015941
bp2_dp1r3b1c1h2l1	36	106.33	0.56	6.5	29	0.0016360
bp2_dp1r3b1c1h3l1	36	106.53	0.56	6.5	58	0.0009648
bp2_dp1r3b1c2h1l1	36	106.35	0.56	16.0	11	0.0015936
bp2_dp1r3b1c2h2l1	36	106.59	0.56	16.0	29	0.0016355
bp2_dp1r3b1c2h3l1	36	106.27	0.56	16.0	58	0.0009646
bp2_dp1r3b1c3h1l1	36	106.54	0.56	23.5	11	0.0015936
bp2_dp1r3b1c3h2l1	36	106.37	0.56	23.5	29	0.0016355
bp2_dp1r3b1c3h3l1	36	106.53	0.56	23.5	58	0.0009646
bp2_dp1r3b2c1h1l1	36	106.38	0.83	6.5	11	0.0015936
bp2_dp1r3b2c1h2l1	36	106.27	0.83	6.5	29	0.0016355
bp2_dp1r3b2c1h3l1	36	106.52	0.83	6.5	58	0.0009646
bp2_dp1r3b2c2h1l1	36	106.39	0.83	16.0	11	0.0015931
bp2_dp1r3b2c2h2l1	36	106.36	0.83	16.0	29	0.0016351
bp2_dp1r3b2c2h3l1	36	106.57	0.83	16.0	58	0.0009643
bp2_dp1r3b2c3h1l1	36	106.37	0.83	23.5	11	0.0015931
bp2_dp1r3b2c3h2l1	36	106.40	0.83	23.5	29	0.0016351
bp2_dp1r3b2c3h3l1	36	106.54	0.83	23.5	58	0.0009643
bp2_dp1r3b3c1h1l1	36	106.48	1.10	6.5	11	0.0015936
bp2_dp1r3b3c1h2l1	36	106.43	1.10	6.5	29	0.0016355
bp2_dp1r3b3c1h3l1	36	106.27	1.10	6.5	58	0.0009646
bp2_dp1r3b3c2h1l1	36	106.33	1.10	16.0	11	0.0015931
bp2_dp1r3b3c2h2l1	36	106.45	1.10	16.0	29	0.0016351
bp2_dp1r3b3c2h3l1	36	106.55	1.10	16.0	58	0.0009643
bp2_dp1r3b3c3h1l1	36	106.55	1.10	23.5	11	0.0015931
bp2_dp1r3b3c3h2l1	36	106.34	1.10	23.5	29	0.0016351
bp2_dp1r3b3c3h3l1	36	106.57	1.10	23.5	58	0.0009643
bp2_dp2r1b1c1h1l1	51	34.21	0.97	6.5	11	0.0038270
bp2_dp2r1b1c1h2l1	51	34.29	0.97	6.5	29	0.0039277
bp2_dp2r1b1c1h3l1	51	34.28	0.97	6.5	58	0.0023163
bp2_dp2r1b1c2h1l1	51	34.26	0.97	16.0	11	0.0038258
bp2_dp2r1b1c2h2l1	51	34.29	0.97	16.0	29	0.0039265
bp2_dp2r1b1c2h3l1	51	34.22	0.97	16.0	58	0.0023156
bp2_dp2r1b1c3h1l1	51	34.26	0.97	23.5	11	0.0038258
bp2_dp2r1b1c3h2l1	51	34.30	0.97	23.5	29	0.0039265
bp2_dp2r1b1c3h3l1	51	34.24	0.97	23.5	58	0.0023156
bp2_dp2r1b2c1h1l1	51	34.22	1.23	6.5	11	0.0038258
bp2_dp2r1b2c1h2l1	51	34.27	1.23	6.5	29	0.0039265
bp2_dp2r1b2c1h3l1	51	34.31	1.23	6.5	58	0.0023156
bp2_dp2r1b2c2h1l1	51	34.22	1.23	16.0	11	0.0038247
bp2_dp2r1b2c2h2l1	51	34.29	1.23	16.0	29	0.0039253
bp2_dp2r1b2c2h3l1	51	34.30	1.23	16.0	58	0.0023149
bp2_dp2r1b2c3h1l1	51	34.28	1.23	23.5	11	0.0038247
bp2_dp2r1b2c3h2l1	51	34.26	1.23	23.5	29	0.0039253
bp2_dp2r1b2c3h3l1	51	34.27	1.23	23.5	58	0.0023149
bp2_dp2r1b3c1h1l1	51	34.26	1.50	6.5	11	0.0038258

bp2_dp2r1b3c1h2l1	51	34.25	1.50	6.5	29	0.0039265
bp2_dp2r1b3c1h3l1	51	34.26	1.50	6.5	58	0.0023156
bp2_dp2r1b3c2h1l1	51	34.25	1.50	16.0	11	0.0038247
bp2_dp2r1b3c2h2l1	51	34.23	1.50	16.0	29	0.0039253
bp2_dp2r1b3c2h3l1	51	34.27	1.50	16.0	58	0.0023149
bp2_dp2r1b3c3h1l1	51	34.25	1.50	23.5	11	0.0038247
bp2_dp2r1b3c3h2l1	51	34.29	1.50	23.5	29	0.0039253
bp2_dp2r1b3c3h3l1	51	34.21	1.50	23.5	58	0.0023149
bp2_dp2r2b1c1h1l1	51	58.65	0.83	6.5	11	0.0038258
bp2_dp2r2b1c1h2l1	51	58.64	0.83	6.5	29	0.0039265
bp2_dp2r2b1c1h3l1	51	58.52	0.83	6.5	58	0.0023156
bp2_dp2r2b1c2h1l1	51	58.51	0.83	16.0	11	0.0038247
bp2_dp2r2b1c2h2l1	51	58.54	0.83	16.0	29	0.0039253
bp2_dp2r2b1c2h3l1	51	58.59	0.83	16.0	58	0.0023149
bp2_dp2r2b1c3h1l1	51	58.68	0.83	23.5	11	0.0038247
bp2_dp2r2b1c3h2l1	51	58.66	0.83	23.5	29	0.0039253
bp2_dp2r2b1c3h3l1	51	58.51	0.83	23.5	58	0.0023149
bp2_dp2r2b2c1h1l1	51	58.64	1.10	6.5	11	0.0038247
bp2_dp2r2b2c1h2l1	51	58.68	1.10	6.5	29	0.0039253
bp2_dp2r2b2c1h3l1	51	58.66	1.10	6.5	58	0.0023149
bp2_dp2r2b2c2h1l1	51	58.67	1.10	16.0	11	0.0038235
bp2_dp2r2b2c2h2l1	51	58.56	1.10	16.0	29	0.0039241
bp2_dp2r2b2c2h3l1	51	58.59	1.10	16.0	58	0.0023142
bp2_dp2r2b2c3h1l1	51	58.55	1.10	23.5	11	0.0038235
bp2_dp2r2b2c3h2l1	51	58.57	1.10	23.5	29	0.0039241
bp2_dp2r2b2c3h3l1	51	58.58	1.10	23.5	58	0.0023142
bp2_dp2r2b3c1h1l1	51	58.60	1.37	6.5	11	0.0038247
bp2_dp2r2b3c1h2l1	51	58.60	1.37	6.5	29	0.0039253
bp2_dp2r2b3c1h3l1	51	58.56	1.37	6.5	58	0.0023149
bp2_dp2r2b3c2h1l1	51	58.66	1.37	16.0	11	0.0038235
bp2_dp2r2b3c2h2l1	51	58.53	1.37	16.0	29	0.0039241
bp2_dp2r2b3c2h3l1	51	58.52	1.37	16.0	58	0.0023142
bp2_dp2r2b3c3h1l1	51	58.58	1.37	23.5	11	0.0038235
bp2_dp2r2b3c3h2l1	51	58.53	1.37	23.5	29	0.0039241
bp2_dp2r2b3c3h3l1	51	58.59	1.37	23.5	58	0.0023142
bp2_dp2r3b1c1h1l1	51	100.23	0.60	6.5	11	0.0038258
bp2_dp2r3b1c1h2l1	51	100.11	0.60	6.5	29	0.0039265
bp2_dp2r3b1c1h3l1	51	100.17	0.60	6.5	58	0.0023156
bp2_dp2r3b1c2h1l1	51	100.29	0.60	16.0	11	0.0038247
bp2_dp2r3b1c2h2l1	51	100.23	0.60	16.0	29	0.0039253
bp2_dp2r3b1c2h3l1	51	100.21	0.60	16.0	58	0.0023149
bp2_dp2r3b1c3h1l1	51	100.11	0.60	23.5	11	0.0038247
bp2_dp2r3b1c3h2l1	51	100.15	0.60	23.5	29	0.0039253
bp2_dp2r3b1c3h3l1	51	100.16	0.60	23.5	58	0.0023149
bp2_dp2r3b2c1h1l1	51	100.34	0.87	6.5	11	0.0038247
bp2_dp2r3b2c1h2l1	51	100.36	0.87	6.5	29	0.0039253
bp2_dp2r3b2c1h3l1	51	100.35	0.87	6.5	58	0.0023149
bp2_dp2r3b2c2h1l1	51	100.32	0.87	16.0	11	0.0038235
bp2_dp2r3b2c2h2l1	51	100.33	0.87	16.0	29	0.0039241
bp2_dp2r3b2c2h3l1	51	100.33	0.87	16.0	58	0.0023142
bp2_dp2r3b2c3h1l1	51	100.15	0.87	23.5	11	0.0038235
bp2_dp2r3b2c3h2l1	51	100.38	0.87	23.5	29	0.0039241

bp2_dp2r3b2c3h3l1	51	100.37	0.87	23.5	58	0.0023142
bp2_dp2r3b3c1h1l1	51	100.18	1.14	6.5	11	0.0038247
bp2_dp2r3b3c1h2l1	51	100.09	1.14	6.5	29	0.0039253
bp2_dp2r3b3c1h3l1	51	100.14	1.14	6.5	58	0.0023149
bp2_dp2r3b3c2h1l1	51	100.28	1.13	16.0	11	0.0038235
bp2_dp2r3b3c2h2l1	51	100.16	1.14	16.0	29	0.0039241
bp2_dp2r3b3c2h3l1	51	100.38	1.13	16.0	58	0.0023142
bp2_dp2r3b3c3h1l1	51	100.28	1.13	23.5	11	0.0038235
bp2_dp2r3b3c3h2l1	51	100.25	1.13	23.5	29	0.0039241
bp2_dp2r3b3c3h3l1	51	100.30	1.13	23.5	58	0.0023142
bp2_dp3r1b1c1h1l1	64	31.94	0.98	6.5	11	0.0019135
bp2_dp3r1b1c1h2l1	64	32.00	0.98	6.5	29	0.0019638
bp2_dp3r1b1c1h3l1	64	31.97	0.98	6.5	58	0.0011582
bp2_dp3r1b1c2h1l1	64	32.00	0.98	16.0	11	0.0019129
bp2_dp3r1b1c2h2l1	64	31.95	0.98	16.0	29	0.0019632
bp2_dp3r1b1c2h3l1	64	32.01	0.98	16.0	58	0.0011578
bp2_dp3r1b1c3h1l1	64	31.94	0.98	23.5	11	0.0019129
bp2_dp3r1b1c3h2l1	64	31.97	0.98	23.5	29	0.0019632
bp2_dp3r1b1c3h3l1	64	31.97	0.98	23.5	58	0.0011578
bp2_dp3r1b2c1h1l1	64	31.96	1.25	6.5	11	0.0019129
bp2_dp3r1b2c1h2l1	64	31.94	1.25	6.5	29	0.0019632
bp2_dp3r1b2c1h3l1	64	31.98	1.25	6.5	58	0.0011578
bp2_dp3r1b2c2h1l1	64	32.01	1.25	16.0	11	0.0019123
bp2_dp3r1b2c2h2l1	64	31.95	1.25	16.0	29	0.0019627
bp2_dp3r1b2c2h3l1	64	31.99	1.25	16.0	58	0.0011575
bp2_dp3r1b2c3h1l1	64	32.02	1.25	23.5	11	0.0019123
bp2_dp3r1b2c3h2l1	64	31.99	1.25	23.5	29	0.0019627
bp2_dp3r1b2c3h3l1	64	31.95	1.25	23.5	58	0.0011575
bp2_dp3r1b3c1h1l1	64	31.98	1.52	6.5	11	0.0019129
bp2_dp3r1b3c1h2l1	64	31.99	1.51	6.5	29	0.0019632
bp2_dp3r1b3c1h3l1	64	32.02	1.51	6.5	58	0.0011578
bp2_dp3r1b3c2h1l1	64	31.94	1.52	16.0	11	0.0019123
bp2_dp3r1b3c2h2l1	64	31.94	1.52	16.0	29	0.0019627
bp2_dp3r1b3c2h3l1	64	32.03	1.51	16.0	58	0.0011575
bp2_dp3r1b3c3h1l1	64	31.93	1.52	23.5	11	0.0019123
bp2_dp3r1b3c3h2l1	64	31.97	1.52	23.5	29	0.0019627
bp2_dp3r1b3c3h3l1	64	31.98	1.52	23.5	58	0.0011575
bp2_dp3r2b1c1h1l1	64	54.77	0.85	6.5	11	0.0019129
bp2_dp3r2b1c1h2l1	64	54.75	0.85	6.5	29	0.0019632
bp2_dp3r2b1c1h3l1	64	54.68	0.85	6.5	58	0.0011578
bp2_dp3r2b1c2h1l1	64	54.64	0.85	16.0	11	0.0019123
bp2_dp3r2b1c2h2l1	64	54.63	0.85	16.0	29	0.0019627
bp2_dp3r2b1c2h3l1	64	54.75	0.85	16.0	58	0.0011575
bp2_dp3r2b1c3h1l1	64	54.73	0.85	23.5	11	0.0019123
bp2_dp3r2b1c3h2l1	64	54.78	0.85	23.5	29	0.0019627
bp2_dp3r2b1c3h3l1	64	54.72	0.85	23.5	58	0.0011575
bp2_dp3r2b2c1h1l1	64	54.71	1.12	6.5	11	0.0019123
bp2_dp3r2b2c1h2l1	64	54.71	1.12	6.5	29	0.0019627
bp2_dp3r2b2c1h3l1	64	54.66	1.12	6.5	58	0.0011575
bp2_dp3r2b2c2h1l1	64	54.63	1.12	16.0	11	0.0019118
bp2_dp3r2b2c2h2l1	64	54.78	1.12	16.0	29	0.0019621
bp2_dp3r2b2c2h3l1	64	54.76	1.12	16.0	58	0.0011571

bp2_dp3r2b2c3h1l1	64	54.69	1.12	23.5	11	0.0019118
bp2_dp3r2b2c3h2l1	64	54.75	1.12	23.5	29	0.0019621
bp2_dp3r2b2c3h3l1	64	54.68	1.12	23.5	58	0.0011571
bp2_dp3r2b3c1h1l1	64	54.67	1.39	6.5	11	0.0019123
bp2_dp3r2b3c1h2l1	64	54.71	1.39	6.5	29	0.0019627
bp2_dp3r2b3c1h3l1	64	54.75	1.39	6.5	58	0.0011575
bp2_dp3r2b3c2h1l1	64	54.74	1.39	16.0	11	0.0019118
bp2_dp3r2b3c2h2l1	64	54.64	1.39	16.0	29	0.0019621
bp2_dp3r2b3c2h3l1	64	54.76	1.39	16.0	58	0.0011571
bp2_dp3r2b3c3h1l1	64	54.66	1.39	23.5	11	0.0019118
bp2_dp3r2b3c3h2l1	64	54.65	1.39	23.5	29	0.0019621
bp2_dp3r2b3c3h3l1	64	54.66	1.39	23.5	58	0.0011571
bp2_dp3r3b1c1h1l1	64	93.52	0.64	6.5	11	0.0019129
bp2_dp3r3b1c1h2l1	64	93.61	0.63	6.5	29	0.0019632
bp2_dp3r3b1c1h3l1	64	93.54	0.64	6.5	58	0.0011578
bp2_dp3r3b1c2h1l1	64	93.54	0.64	16.0	11	0.0019123
bp2_dp3r3b1c2h2l1	64	93.58	0.64	16.0	29	0.0019627
bp2_dp3r3b1c2h3l1	64	93.44	0.64	16.0	58	0.0011575
bp2_dp3r3b1c3h1l1	64	93.48	0.64	23.5	11	0.0019123
bp2_dp3r3b1c3h2l1	64	93.56	0.64	23.5	29	0.0019627
bp2_dp3r3b1c3h3l1	64	93.43	0.64	23.5	58	0.0011575
bp2_dp3r3b2c1h1l1	64	93.68	0.90	6.5	11	0.0019123
bp2_dp3r3b2c1h2l1	64	93.56	0.90	6.5	29	0.0019627
bp2_dp3r3b2c1h3l1	64	93.50	0.90	6.5	58	0.0011575
bp2_dp3r3b2c2h1l1	64	93.59	0.90	16.0	11	0.0019118
bp2_dp3r3b2c2h2l1	64	93.53	0.90	16.0	29	0.0019621
bp2_dp3r3b2c2h3l1	64	93.46	0.90	16.0	58	0.0011571
bp2_dp3r3b2c3h1l1	64	93.65	0.90	23.5	11	0.0019118
bp2_dp3r3b2c3h2l1	64	93.65	0.90	23.5	29	0.0019621
bp2_dp3r3b2c3h3l1	64	93.45	0.90	23.5	58	0.0011571
bp2_dp3r3b3c1h1l1	64	93.70	1.17	6.5	11	0.0019123
bp2_dp3r3b3c1h2l1	64	93.50	1.17	6.5	29	0.0019627
bp2_dp3r3b3c1h3l1	64	93.68	1.17	6.5	58	0.0011575
bp2_dp3r3b3c2h1l1	64	93.65	1.17	16.0	11	0.0019118
bp2_dp3r3b3c2h2l1	64	93.66	1.17	16.0	29	0.0019621
bp2_dp3r3b3c2h3l1	64	93.61	1.17	16.0	58	0.0011571
bp2_dp3r3b3c3h1l1	64	93.47	1.17	23.5	11	0.0019118
bp2_dp3r3b3c3h2l1	64	93.61	1.17	23.5	29	0.0019621
bp2_dp3r3b3c3h3l1	64	93.69	1.17	23.5	58	0.0011571
bp2_dp4r1b1c1h1l1	82	28.32	1.00	6.5	11	0.0006378
bp2_dp4r1b1c1h2l1	82	28.38	1.00	6.5	29	0.0006546
bp2_dp4r1b1c1h3l1	82	28.33	1.00	6.5	58	0.0003861
bp2_dp4r1b1c2h1l1	82	28.38	1.00	16.0	11	0.0006376
bp2_dp4r1b1c2h2l1	82	28.37	1.00	16.0	29	0.0006544
bp2_dp4r1b1c2h3l1	82	28.36	1.00	16.0	58	0.0003859
bp2_dp4r1b1c3h1l1	82	28.38	1.00	23.5	11	0.0006376
bp2_dp4r1b1c3h2l1	82	28.30	1.00	23.5	29	0.0006544
bp2_dp4r1b1c3h3l1	82	28.36	1.00	23.5	58	0.0003859
bp2_dp4r1b2c1h1l1	82	28.35	1.27	6.5	11	0.0006376
bp2_dp4r1b2c1h2l1	82	28.32	1.27	6.5	29	0.0006544
bp2_dp4r1b2c1h3l1	82	28.31	1.27	6.5	58	0.0003859
bp2_dp4r1b2c2h1l1	82	28.32	1.27	16.0	11	0.0006374

bp2_dp4r1b2c2h2l1	82	28.32	1.27	16.0	29	0.0006542
bp2_dp4r1b2c2h3l1	82	28.34	1.27	16.0	58	0.0003858
bp2_dp4r1b2c3h1l1	82	28.35	1.27	23.5	11	0.0006374
bp2_dp4r1b2c3h2l1	82	28.35	1.27	23.5	29	0.0006542
bp2_dp4r1b2c3h3l1	82	28.32	1.27	23.5	58	0.0003858
bp2_dp4r1b3c1h1l1	82	28.32	1.54	6.5	11	0.0006376
bp2_dp4r1b3c1h2l1	82	28.30	1.54	6.5	29	0.0006544
bp2_dp4r1b3c1h3l1	82	28.30	1.54	6.5	58	0.0003859
bp2_dp4r1b3c2h1l1	82	28.36	1.53	16.0	11	0.0006374
bp2_dp4r1b3c2h2l1	82	28.36	1.54	16.0	29	0.0006542
bp2_dp4r1b3c2h3l1	82	28.33	1.54	16.0	58	0.0003858
bp2_dp4r1b3c3h1l1	82	28.34	1.54	23.5	11	0.0006374
bp2_dp4r1b3c3h2l1	82	28.35	1.54	23.5	29	0.0006542
bp2_dp4r1b3c3h3l1	82	28.35	1.54	23.5	58	0.0003858
bp2_dp4r2b1c1h1l1	82	48.40	0.89	6.5	11	0.0006376
bp2_dp4r2b1c1h2l1	82	48.43	0.89	6.5	29	0.0006544
bp2_dp4r2b1c1h3l1	82	48.51	0.89	6.5	58	0.0003859
bp2_dp4r2b1c2h1l1	82	48.45	0.89	16.0	11	0.0006374
bp2_dp4r2b1c2h2l1	82	48.50	0.89	16.0	29	0.0006542
bp2_dp4r2b1c2h3l1	82	48.46	0.89	16.0	58	0.0003858
bp2_dp4r2b1c3h1l1	82	48.54	0.89	23.5	11	0.0006374
bp2_dp4r2b1c3h2l1	82	48.51	0.89	23.5	29	0.0006542
bp2_dp4r2b1c3h3l1	82	48.48	0.89	23.5	58	0.0003858
bp2_dp4r2b2c1h1l1	82	48.46	1.01	6.5	11	0.0006374
bp2_dp4r2b2c1h2l1	82	48.46	1.01	6.5	29	0.0006542
bp2_dp4r2b2c1h3l1	82	48.46	1.01	6.5	58	0.0003858
bp2_dp4r2b2c2h1l1	82	48.44	1.01	16.0	11	0.0006373
bp2_dp4r2b2c2h2l1	82	48.45	1.01	16.0	29	0.0006540
bp2_dp4r2b2c2h3l1	82	48.47	1.01	16.0	58	0.0003857
bp2_dp4r2b2c3h1l1	82	48.43	1.01	23.5	11	0.0006373
bp2_dp4r2b2c3h2l1	82	48.50	1.01	23.5	29	0.0006540
bp2_dp4r2b2c3h3l1	82	48.50	1.01	23.5	58	0.0003857
bp2_dp4r2b3c1h1l1	82	48.42	1.11	6.5	11	0.0006374
bp2_dp4r2b3c1h2l1	82	48.49	1.11	6.5	29	0.0006542
bp2_dp4r2b3c1h3l1	82	48.52	1.11	6.5	58	0.0003858
bp2_dp4r2b3c2h1l1	82	48.41	1.11	16.0	11	0.0006373
bp2_dp4r2b3c2h2l1	82	48.40	1.11	16.0	29	0.0006540
bp2_dp4r2b3c2h3l1	82	48.42	1.11	16.0	58	0.0003857
bp2_dp4r2b3c3h1l1	82	48.42	1.11	23.5	11	0.0006373
bp2_dp4r2b3c3h2l1	82	48.40	1.11	23.5	29	0.0006540
bp2_dp4r2b3c3h3l1	82	48.49	1.11	23.5	58	0.0003857
bp2_dp4r3b1c1h1l1	82	82.96	0.69	6.5	11	0.0006376
bp2_dp4r3b1c1h2l1	82	82.98	0.69	6.5	29	0.0006544
bp2_dp4r3b1c1h3l1	82	82.87	0.69	6.5	58	0.0003859
bp2_dp4r3b1c2h1l1	82	82.89	0.69	16.0	11	0.0006374
bp2_dp4r3b1c2h2l1	82	82.79	0.70	16.0	29	0.0006542
bp2_dp4r3b1c2h3l1	82	82.98	0.69	16.0	58	0.0003858
bp2_dp4r3b1c3h1l1	82	82.83	0.70	23.5	11	0.0006374
bp2_dp4r3b1c3h2l1	82	82.92	0.69	23.5	29	0.0006542
bp2_dp4r3b1c3h3l1	82	82.91	0.69	23.5	58	0.0003858
bp2_dp4r3b2c1h1l1	82	82.83	0.96	6.5	11	0.0006374
bp2_dp4r3b2c1h2l1	82	82.96	0.96	6.5	29	0.0006542

bp2_dp4r3b2c1h3l1	82	82.84	0.96	6.5	58	0.0003858
bp2_dp4r3b2c2h1l1	82	82.91	0.96	16.0	11	0.0006373
bp2_dp4r3b2c2h2l1	82	82.86	0.96	16.0	29	0.0006540
bp2_dp4r3b2c2h3l1	82	82.83	0.96	16.0	58	0.0003857
bp2_dp4r3b2c3h1l1	82	82.86	0.96	23.5	11	0.0006373
bp2_dp4r3b2c3h2l1	82	82.87	0.96	23.5	29	0.0006540
bp2_dp4r3b2c3h3l1	82	82.99	0.96	23.5	58	0.0003857
bp2_dp4r3b3c1h1l1	82	82.83	1.11	6.5	11	0.0006374
bp2_dp4r3b3c1h2l1	82	82.91	1.11	6.5	29	0.0006542
bp2_dp4r3b3c1h3l1	82	82.99	1.11	6.5	58	0.0003858
bp2_dp4r3b3c2h1l1	82	82.84	1.11	16.0	11	0.0006373
bp2_dp4r3b3c2h2l1	82	82.98	1.11	16.0	29	0.0006540
bp2_dp4r3b3c2h3l1	82	82.91	1.11	16.0	58	0.0003857
bp2_dp4r3b3c3h1l1	82	82.97	1.11	23.5	11	0.0006373
bp2_dp4r3b3c3h2l1	82	82.96	1.11	23.5	29	0.0006540
bp2_dp4r3b3c3h3l1	82	82.93	1.11	23.5	58	0.0003857
lf2_dp1r1b1c1h1l1	36	35.70	0.96	6.5	-35	0.0008041
lf2_dp1r1b1c1h2l1	36	35.70	0.96	6.5	10	0.0010614
lf2_dp1r1b1c1h3l1	36	35.40	0.97	6.5	35	0.0010292
lf2_dp1r1b1c2h1l1	36	34.50	0.98	16.0	-35	0.0008041
lf2_dp1r1b1c2h2l1	36	34.20	0.99	16.0	10	0.0010614
lf2_dp1r1b1c2h3l1	36	35.10	0.97	16.0	35	0.0010292
lf2_dp1r1b1c3h1l1	36	34.40	0.98	23.5	-35	0.0008041
lf2_dp1r1b1c3h2l1	36	35.20	0.97	23.5	10	0.0010614
lf2_dp1r1b1c3h3l1	36	34.70	0.98	23.5	35	0.0010292
lf2_dp1r1b2c1h1l1	36	35.10	1.24	6.5	-35	0.0008041
lf2_dp1r1b2c1h2l1	36	34.80	1.24	6.5	10	0.0010614
lf2_dp1r1b2c1h3l1	36	35.80	1.23	6.5	35	0.0010292
lf2_dp1r1b2c2h1l1	36	33.80	1.26	16.0	-35	0.0008041
lf2_dp1r1b2c2h2l1	36	35.80	1.23	16.0	10	0.0010614
lf2_dp1r1b2c2h3l1	36	35.90	1.23	16.0	35	0.0010292
lf2_dp1r1b2c3h1l1	36	34.40	1.25	23.5	-35	0.0008041
lf2_dp1r1b2c3h2l1	36	36.30	1.22	23.5	10	0.0010614
lf2_dp1r1b2c3h3l1	36	36.30	1.22	23.5	35	0.0010292
lf2_dp1r1b3c1h1l1	36	34.90	1.51	6.5	-35	0.0008041
lf2_dp1r1b3c1h2l1	36	34.50	1.52	6.5	10	0.0010614
lf2_dp1r1b3c1h3l1	36	35.90	1.50	6.5	35	0.0010292
lf2_dp1r1b3c2h1l1	36	34.20	1.52	16.0	-35	0.0008041
lf2_dp1r1b3c2h2l1	36	35.10	1.51	16.0	10	0.0010614
lf2_dp1r1b3c2h3l1	36	34.20	1.52	16.0	35	0.0010292
lf2_dp1r1b3c3h1l1	36	33.80	1.53	23.5	-35	0.0008041
lf2_dp1r1b3c3h2l1	36	33.60	1.53	23.5	10	0.0010614
lf2_dp1r1b3c3h3l1	36	36.30	1.49	23.5	35	0.0010292
lf2_dp1r2b1c1h1l1	36	58.50	0.85	6.5	-35	0.0008041
lf2_dp1r2b1c1h2l1	36	58.90	0.85	6.5	10	0.0010614
lf2_dp1r2b1c1h3l1	36	61.60	0.82	6.5	35	0.0010292
lf2_dp1r2b1c2h1l1	36	61.30	0.82	16.0	-35	0.0008041
lf2_dp1r2b1c2h2l1	36	62.00	0.81	16.0	10	0.0010614
lf2_dp1r2b1c2h3l1	36	58.70	0.85	16.0	35	0.0010292
lf2_dp1r2b1c3h1l1	36	61.00	0.82	23.5	-35	0.0008041
lf2_dp1r2b1c3h2l1	36	61.80	0.81	23.5	10	0.0010614
lf2_dp1r2b1c3h3l1	36	59.10	0.84	23.5	35	0.0010292

lf2_dp1r2b2c1h1l1	36	58.70	1.12	6.5	-35	0.0008041
lf2_dp1r2b2c1h2l1	36	60.80	1.09	6.5	10	0.0010614
lf2_dp1r2b2c1h3l1	36	61.80	1.08	6.5	35	0.0010292
lf2_dp1r2b2c2h1l1	36	58.10	1.12	16.0	-35	0.0008041
lf2_dp1r2b2c2h2l1	36	58.50	1.12	16.0	10	0.0010614
lf2_dp1r2b2c2h3l1	36	57.70	1.13	16.0	35	0.0010292
lf2_dp1r2b2c3h1l1	36	61.40	1.09	23.5	-35	0.0008041
lf2_dp1r2b2c3h2l1	36	58.10	1.12	23.5	10	0.0010614
lf2_dp1r2b2c3h3l1	36	58.50	1.12	23.5	35	0.0010292
lf2_dp1r2b3c1h1l1	36	59.20	1.38	6.5	-35	0.0008041
lf2_dp1r2b3c1h2l1	36	59.00	1.38	6.5	10	0.0010614
lf2_dp1r2b3c1h3l1	36	60.70	1.36	6.5	35	0.0010292
lf2_dp1r2b3c2h1l1	36	60.60	1.36	16.0	-35	0.0008041
lf2_dp1r2b3c2h2l1	36	59.00	1.38	16.0	10	0.0010614
lf2_dp1r2b3c2h3l1	36	59.80	1.37	16.0	35	0.0010292
lf2_dp1r2b3c3h1l1	36	60.90	1.36	23.5	-35	0.0008041
lf2_dp1r2b3c3h2l1	36	58.20	1.39	23.5	10	0.0010614
lf2_dp1r2b3c3h3l1	36	60.60	1.36	23.5	35	0.0010292
lf2_dp1r3b1c1h1l1	36	102.00	0.60	6.5	-35	0.0008041
lf2_dp1r3b1c1h2l1	36	104.50	0.58	6.5	10	0.0010614
lf2_dp1r3b1c1h3l1	36	98.70	0.63	6.5	35	0.0010292
lf2_dp1r3b1c2h1l1	36	103.90	0.58	16.0	-35	0.0008041
lf2_dp1r3b1c2h2l1	36	100.60	0.61	16.0	10	0.0010614
lf2_dp1r3b1c2h3l1	36	104.60	0.58	16.0	35	0.0010292
lf2_dp1r3b1c3h1l1	36	101.80	0.60	23.5	-35	0.0008041
lf2_dp1r3b1c3h2l1	36	102.40	0.60	23.5	10	0.0010614
lf2_dp1r3b1c3h3l1	36	98.40	0.63	23.5	35	0.0010292
lf2_dp1r3b2c1h1l1	36	100.00	0.89	6.5	-35	0.0008041
lf2_dp1r3b2c1h2l1	36	98.60	0.90	6.5	10	0.0010614
lf2_dp1r3b2c1h3l1	36	104.70	0.85	6.5	35	0.0010292
lf2_dp1r3b2c2h1l1	36	100.50	0.88	16.0	-35	0.0008041
lf2_dp1r3b2c2h2l1	36	104.00	0.85	16.0	10	0.0010614
lf2_dp1r3b2c2h3l1	36	104.30	0.85	16.0	35	0.0010292
lf2_dp1r3b2c3h1l1	36	101.20	0.88	23.5	-35	0.0008041
lf2_dp1r3b2c3h2l1	36	101.70	0.87	23.5	10	0.0010614
lf2_dp1r3b2c3h3l1	36	105.70	0.84	23.5	35	0.0010292
lf2_dp1r3b3c1h1l1	36	99.50	1.16	6.5	-35	0.0008041
lf2_dp1r3b3c1h2l1	36	100.10	1.15	6.5	10	0.0010614
lf2_dp1r3b3c1h3l1	36	105.00	1.11	6.5	35	0.0010292
lf2_dp1r3b3c2h1l1	36	98.80	1.17	16.0	-35	0.0008041
lf2_dp1r3b3c2h2l1	36	102.90	1.13	16.0	10	0.0010614
lf2_dp1r3b3c2h3l1	36	98.30	1.17	16.0	35	0.0010292
lf2_dp1r3b3c3h1l1	36	102.80	1.13	23.5	-35	0.0008041
lf2_dp1r3b3c3h2l1	36	103.70	1.12	23.5	10	0.0010614
lf2_dp1r3b3c3h3l1	36	105.20	1.11	23.5	35	0.0010292
lf2_dp2r1b1c1h1l1	51	32.20	1.00	6.5	-35	0.0020544
lf2_dp2r1b1c1h2l1	51	31.80	1.00	6.5	10	0.0027118
lf2_dp2r1b1c1h3l1	51	34.00	0.97	6.5	35	0.0026296
lf2_dp2r1b1c2h1l1	51	32.90	0.99	16.0	-35	0.0020544
lf2_dp2r1b1c2h2l1	51	33.90	0.97	16.0	10	0.0027118
lf2_dp2r1b1c2h3l1	51	33.40	0.98	16.0	35	0.0026296
lf2_dp2r1b1c3h1l1	51	31.70	1.00	23.5	-35	0.0020544

lf2_dp2r1b1c3h2l1	51	31.90	1.00	23.5	10	0.0027118
lf2_dp2r1b1c3h3l1	51	32.10	1.00	23.5	35	0.0026296
lf2_dp2r1b2c1h1l1	51	33.70	1.24	6.5	-35	0.0020544
lf2_dp2r1b2c1h2l1	51	33.70	1.24	6.5	10	0.0027118
lf2_dp2r1b2c1h3l1	51	32.60	1.26	6.5	35	0.0026296
lf2_dp2r1b2c2h1l1	51	33.80	1.24	16.0	-35	0.0020544
lf2_dp2r1b2c2h2l1	51	33.50	1.25	16.0	10	0.0027118
lf2_dp2r1b2c2h3l1	51	34.10	1.24	16.0	35	0.0026296
lf2_dp2r1b2c3h1l1	51	34.20	1.24	23.5	-35	0.0020544
lf2_dp2r1b2c3h2l1	51	31.90	1.27	23.5	10	0.0027118
lf2_dp2r1b2c3h3l1	51	34.10	1.24	23.5	35	0.0026296
lf2_dp2r1b3c1h1l1	51	33.50	1.51	6.5	-35	0.0020544
lf2_dp2r1b3c1h2l1	51	31.70	1.54	6.5	10	0.0027118
lf2_dp2r1b3c1h3l1	51	33.20	1.52	6.5	35	0.0026296
lf2_dp2r1b3c2h1l1	51	33.70	1.51	16.0	-35	0.0020544
lf2_dp2r1b3c2h2l1	51	33.10	1.52	16.0	10	0.0027118
lf2_dp2r1b3c2h3l1	51	33.10	1.52	16.0	35	0.0026296
lf2_dp2r1b3c3h1l1	51	34.20	1.50	23.5	-35	0.0020544
lf2_dp2r1b3c3h2l1	51	33.20	1.52	23.5	10	0.0027118
lf2_dp2r1b3c3h3l1	51	33.20	1.52	23.5	35	0.0026296
lf2_dp2r2b1c1h1l1	51	58.10	0.84	6.5	-35	0.0020544
lf2_dp2r2b1c1h2l1	51	54.80	0.87	6.5	10	0.0027118
lf2_dp2r2b1c1h3l1	51	54.20	0.88	6.5	35	0.0026296
lf2_dp2r2b1c2h1l1	51	58.00	0.84	16.0	-35	0.0020544
lf2_dp2r2b1c2h2l1	51	54.70	0.87	16.0	10	0.0027118
lf2_dp2r2b1c2h3l1	51	54.50	0.87	16.0	35	0.0026296
lf2_dp2r2b1c3h1l1	51	57.70	0.84	23.5	-35	0.0020544
lf2_dp2r2b1c3h2l1	51	56.90	0.85	23.5	10	0.0027118
lf2_dp2r2b1c3h3l1	51	56.00	0.86	23.5	35	0.0026296
lf2_dp2r2b2c1h1l1	51	54.60	1.14	6.5	-35	0.0020544
lf2_dp2r2b2c1h2l1	51	56.70	1.12	6.5	10	0.0027118
lf2_dp2r2b2c1h3l1	51	54.20	1.15	6.5	35	0.0026296
lf2_dp2r2b2c2h1l1	51	58.30	1.10	16.0	-35	0.0020544
lf2_dp2r2b2c2h2l1	51	55.30	1.13	16.0	10	0.0027118
lf2_dp2r2b2c2h3l1	51	58.00	1.11	16.0	35	0.0026296
lf2_dp2r2b2c3h1l1	51	57.20	1.11	23.5	-35	0.0020544
lf2_dp2r2b2c3h2l1	51	54.20	1.15	23.5	10	0.0027118
lf2_dp2r2b2c3h3l1	51	56.00	1.13	23.5	35	0.0026296
lf2_dp2r2b3c1h1l1	51	57.20	1.38	6.5	-35	0.0020544
lf2_dp2r2b3c1h2l1	51	56.50	1.39	6.5	10	0.0027118
lf2_dp2r2b3c1h3l1	51	55.80	1.40	6.5	35	0.0026296
lf2_dp2r2b3c2h1l1	51	54.80	1.41	16.0	-35	0.0020544
lf2_dp2r2b3c2h2l1	51	55.00	1.41	16.0	10	0.0027118
lf2_dp2r2b3c2h3l1	51	55.40	1.40	16.0	35	0.0026296
lf2_dp2r2b3c3h1l1	51	54.90	1.41	23.5	-35	0.0020544
lf2_dp2r2b3c3h2l1	51	54.30	1.41	23.5	10	0.0027118
lf2_dp2r2b3c3h3l1	51	54.40	1.41	23.5	35	0.0026296
lf2_dp2r3b1c1h1l1	51	96.00	0.63	6.5	-35	0.0020544
lf2_dp2r3b1c1h2l1	51	94.80	0.65	6.5	10	0.0027118
lf2_dp2r3b1c1h3l1	51	95.90	0.64	6.5	35	0.0026296
lf2_dp2r3b1c2h1l1	51	96.90	0.63	16.0	-35	0.0020544
lf2_dp2r3b1c2h2l1	51	93.70	0.65	16.0	10	0.0027118

lf2_dp2r3b1c2h3l1	51	94.80	0.64	16.0	35	0.0026296
lf2_dp2r3b1c3h1l1	51	96.60	0.63	23.5	-35	0.0020544
lf2_dp2r3b1c3h2l1	51	96.80	0.63	23.5	10	0.0027118
lf2_dp2r3b1c3h3l1	51	95.90	0.64	23.5	35	0.0026296
lf2_dp2r3b2c1h1l1	51	98.90	0.88	6.5	-35	0.0020544
lf2_dp2r3b2c1h2l1	51	97.40	0.89	6.5	10	0.0027118
lf2_dp2r3b2c1h3l1	51	94.50	0.92	6.5	35	0.0026296
lf2_dp2r3b2c2h1l1	51	97.70	0.89	16.0	-35	0.0020544
lf2_dp2r3b2c2h2l1	51	94.30	0.92	16.0	10	0.0027118
lf2_dp2r3b2c2h3l1	51	99.40	0.87	16.0	35	0.0026296
lf2_dp2r3b2c3h1l1	51	97.60	0.89	23.5	-35	0.0020544
lf2_dp2r3b2c3h2l1	51	98.10	0.89	23.5	10	0.0027118
lf2_dp2r3b2c3h3l1	51	98.60	0.88	23.5	35	0.0026296
lf2_dp2r3b3c1h1l1	51	95.10	1.18	6.5	-35	0.0020544
lf2_dp2r3b3c1h2l1	51	97.30	1.16	6.5	10	0.0027118
lf2_dp2r3b3c1h3l1	51	99.80	1.14	6.5	35	0.0026296
lf2_dp2r3b3c2h1l1	51	95.20	1.18	16.0	-35	0.0020544
lf2_dp2r3b3c2h2l1	51	95.10	1.18	16.0	10	0.0027118
lf2_dp2r3b3c2h3l1	51	94.00	1.19	16.0	35	0.0026296
lf2_dp2r3b3c3h1l1	51	94.40	1.19	23.5	-35	0.0020544
lf2_dp2r3b3c3h2l1	51	97.00	1.16	23.5	10	0.0027118
lf2_dp2r3b3c3h3l1	51	100.00	1.14	23.5	35	0.0026296
lf2_dp3r1b1c1h1l1	64	31.70	0.98	6.5	-35	0.0009810
lf2_dp3r1b1c1h2l1	64	30.50	1.00	6.5	10	0.0012949
lf2_dp3r1b1c1h3l1	64	31.30	0.99	6.5	35	0.0012556
lf2_dp3r1b1c2h1l1	64	30.10	1.01	16.0	-35	0.0009810
lf2_dp3r1b1c2h2l1	64	30.30	1.00	16.0	10	0.0012949
lf2_dp3r1b1c2h3l1	64	30.60	1.00	16.0	35	0.0012556
lf2_dp3r1b1c3h1l1	64	29.80	1.01	23.5	-35	0.0009810
lf2_dp3r1b1c3h2l1	64	30.50	1.00	23.5	10	0.0012949
lf2_dp3r1b1c3h3l1	64	31.50	0.99	23.5	35	0.0012556
lf2_dp3r1b2c1h1l1	64	30.30	1.27	6.5	-35	0.0009810
lf2_dp3r1b2c1h2l1	64	31.60	1.25	6.5	10	0.0012949
lf2_dp3r1b2c1h3l1	64	30.50	1.27	6.5	35	0.0012556
lf2_dp3r1b2c2h1l1	64	31.20	1.26	16.0	-35	0.0009810
lf2_dp3r1b2c2h2l1	64	31.90	1.25	16.0	10	0.0012949
lf2_dp3r1b2c2h3l1	64	30.80	1.26	16.0	35	0.0012556
lf2_dp3r1b2c3h1l1	64	30.80	1.26	23.5	-35	0.0009810
lf2_dp3r1b2c3h2l1	64	31.80	1.25	23.5	10	0.0012949
lf2_dp3r1b2c3h3l1	64	30.90	1.26	23.5	35	0.0012556
lf2_dp3r1b3c1h1l1	64	30.70	1.54	6.5	-35	0.0009810
lf2_dp3r1b3c1h2l1	64	29.70	1.55	6.5	10	0.0012949
lf2_dp3r1b3c1h3l1	64	30.10	1.54	6.5	35	0.0012556
lf2_dp3r1b3c2h1l1	64	29.80	1.55	16.0	-35	0.0009810
lf2_dp3r1b3c2h2l1	64	30.40	1.54	16.0	10	0.0012949
lf2_dp3r1b3c2h3l1	64	31.80	1.52	16.0	35	0.0012556
lf2_dp3r1b3c3h1l1	64	29.70	1.55	23.5	-35	0.0009810
lf2_dp3r1b3c3h2l1	64	30.90	1.53	23.5	10	0.0012949
lf2_dp3r1b3c3h3l1	64	31.90	1.52	23.5	35	0.0012556
lf2_dp3r2b1c1h1l1	64	54.10	0.86	6.5	-35	0.0009810
lf2_dp3r2b1c1h2l1	64	51.20	0.89	6.5	10	0.0012949
lf2_dp3r2b1c1h3l1	64	52.50	0.88	6.5	35	0.0012556

lf2_dp3r2b1c2h1l1	64	52.60	0.88	16.0	-35	0.0009810
lf2_dp3r2b1c2h2l1	64	54.60	0.85	16.0	10	0.0012949
lf2_dp3r2b1c2h3l1	64	51.90	0.88	16.0	35	0.0012556
lf2_dp3r2b1c3h1l1	64	51.20	0.89	23.5	-35	0.0009810
lf2_dp3r2b1c3h2l1	64	53.80	0.86	23.5	10	0.0012949
lf2_dp3r2b1c3h3l1	64	53.70	0.86	23.5	35	0.0012556
lf2_dp3r2b2c1h1l1	64	51.60	1.16	6.5	-35	0.0009810
lf2_dp3r2b2c1h2l1	64	51.40	1.16	6.5	10	0.0012949
lf2_dp3r2b2c1h3l1	64	52.90	1.14	6.5	35	0.0012556
lf2_dp3r2b2c2h1l1	64	53.60	1.13	16.0	-35	0.0009810
lf2_dp3r2b2c2h2l1	64	50.50	1.17	16.0	10	0.0012949
lf2_dp3r2b2c2h3l1	64	51.50	1.16	16.0	35	0.0012556
lf2_dp3r2b2c3h1l1	64	52.80	1.14	23.5	-35	0.0009810
lf2_dp3r2b2c3h2l1	64	50.80	1.16	23.5	10	0.0012949
lf2_dp3r2b2c3h3l1	64	54.00	1.13	23.5	35	0.0012556
lf2_dp3r2b3c1h1l1	64	53.40	1.40	6.5	-35	0.0009810
lf2_dp3r2b3c1h2l1	64	54.20	1.39	6.5	10	0.0012949
lf2_dp3r2b3c1h3l1	64	51.90	1.42	6.5	35	0.0012556
lf2_dp3r2b3c2h1l1	64	51.30	1.43	16.0	-35	0.0009810
lf2_dp3r2b3c2h2l1	64	54.50	1.39	16.0	10	0.0012949
lf2_dp3r2b3c2h3l1	64	53.70	1.40	16.0	35	0.0012556
lf2_dp3r2b3c3h1l1	64	50.80	1.43	23.5	-35	0.0009810
lf2_dp3r2b3c3h2l1	64	52.60	1.41	23.5	10	0.0012949
lf2_dp3r2b3c3h3l1	64	54.10	1.40	23.5	35	0.0012556
lf2_dp3r3b1c1h1l1	64	91.70	0.65	6.5	-35	0.0009810
lf2_dp3r3b1c1h2l1	64	89.10	0.68	6.5	10	0.0012949
lf2_dp3r3b1c1h3l1	64	88.20	0.68	6.5	35	0.0012556
lf2_dp3r3b1c2h1l1	64	87.20	0.69	16.0	-35	0.0009810
lf2_dp3r3b1c2h2l1	64	92.00	0.65	16.0	10	0.0012949
lf2_dp3r3b1c2h3l1	64	89.30	0.67	16.0	35	0.0012556
lf2_dp3r3b1c3h1l1	64	90.90	0.66	23.5	-35	0.0009810
lf2_dp3r3b1c3h2l1	64	90.70	0.66	23.5	10	0.0012949
lf2_dp3r3b1c3h3l1	64	86.80	0.70	23.5	35	0.0012556
lf2_dp3r3b2c1h1l1	64	87.30	0.96	6.5	-35	0.0009810
lf2_dp3r3b2c1h2l1	64	90.70	0.93	6.5	10	0.0012949
lf2_dp3r3b2c1h3l1	64	86.60	0.97	6.5	35	0.0012556
lf2_dp3r3b2c2h1l1	64	88.90	0.94	16.0	-35	0.0009810
lf2_dp3r3b2c2h2l1	64	87.00	0.96	16.0	10	0.0012949
lf2_dp3r3b2c2h3l1	64	88.10	0.95	16.0	35	0.0012556
lf2_dp3r3b2c3h1l1	64	88.40	0.95	23.5	-35	0.0009810
lf2_dp3r3b2c3h2l1	64	93.10	0.91	23.5	10	0.0012949
lf2_dp3r3b2c3h3l1	64	87.30	0.96	23.5	35	0.0012556
lf2_dp3r3b3c1h1l1	64	88.90	1.21	6.5	-35	0.0009810
lf2_dp3r3b3c1h2l1	64	87.20	1.23	6.5	10	0.0012949
lf2_dp3r3b3c1h3l1	64	87.10	1.23	6.5	35	0.0012556
lf2_dp3r3b3c2h1l1	64	91.50	1.19	16.0	-35	0.0009810
lf2_dp3r3b3c2h2l1	64	86.60	1.23	16.0	10	0.0012949
lf2_dp3r3b3c2h3l1	64	92.70	1.18	16.0	35	0.0012556
lf2_dp3r3b3c3h1l1	64	93.00	1.18	23.5	-35	0.0009810
lf2_dp3r3b3c3h2l1	64	89.90	1.20	23.5	10	0.0012949
lf2_dp3r3b3c3h3l1	64	90.80	1.20	23.5	35	0.0012556
lf2_dp4r1b1c1h1l1	82	26.60	1.03	6.5	-35	0.0005347

lf2_dp4r1b1c1h2l1	82	27.50	1.01	6.5	10	0.0007058
lf2_dp4r1b1c1h3l1	82	28.10	1.00	6.5	35	0.0006844
lf2_dp4r1b1c2h1l1	82	26.70	1.03	16.0	-35	0.0005347
lf2_dp4r1b1c2h2l1	82	28.20	1.00	16.0	10	0.0007058
lf2_dp4r1b1c2h3l1	82	27.10	1.02	16.0	35	0.0006844
lf2_dp4r1b1c3h1l1	82	28.30	1.00	23.5	-35	0.0005347
lf2_dp4r1b1c3h2l1	82	28.10	1.00	23.5	10	0.0007058
lf2_dp4r1b1c3h3l1	82	27.70	1.01	23.5	35	0.0006844
lf2_dp4r1b2c1h1l1	82	26.90	1.29	6.5	-35	0.0005347
lf2_dp4r1b2c1h2l1	82	26.30	1.30	6.5	10	0.0007058
lf2_dp4r1b2c1h3l1	82	27.90	1.27	6.5	35	0.0006844
lf2_dp4r1b2c2h1l1	82	27.70	1.28	16.0	-35	0.0005347
lf2_dp4r1b2c2h2l1	82	26.70	1.29	16.0	10	0.0007058
lf2_dp4r1b2c2h3l1	82	26.60	1.30	16.0	35	0.0006844
lf2_dp4r1b2c3h1l1	82	27.90	1.27	23.5	-35	0.0005347
lf2_dp4r1b2c3h2l1	82	26.80	1.29	23.5	10	0.0007058
lf2_dp4r1b2c3h3l1	82	27.10	1.29	23.5	35	0.0006844
lf2_dp4r1b3c1h1l1	82	26.90	1.56	6.5	-35	0.0005347
lf2_dp4r1b3c1h2l1	82	27.50	1.55	6.5	10	0.0007058
lf2_dp4r1b3c1h3l1	82	26.80	1.56	6.5	35	0.0006844
lf2_dp4r1b3c2h1l1	82	27.30	1.55	16.0	-35	0.0005347
lf2_dp4r1b3c2h2l1	82	26.40	1.57	16.0	10	0.0007058
lf2_dp4r1b3c2h3l1	82	26.20	1.57	16.0	35	0.0006844
lf2_dp4r1b3c3h1l1	82	27.50	1.55	23.5	-35	0.0005347
lf2_dp4r1b3c3h2l1	82	27.70	1.55	23.5	10	0.0007058
lf2_dp4r1b3c3h3l1	82	27.10	1.56	23.5	35	0.0006844
lf2_dp4r2b1c1h1l1	82	46.20	0.91	6.5	-35	0.0005347
lf2_dp4r2b1c1h2l1	82	47.00	0.90	6.5	10	0.0007058
lf2_dp4r2b1c1h3l1	82	47.10	0.90	6.5	35	0.0006844
lf2_dp4r2b1c2h1l1	82	45.10	0.91	16.0	-35	0.0005347
lf2_dp4r2b1c2h2l1	82	45.40	0.91	16.0	10	0.0007058
lf2_dp4r2b1c2h3l1	82	47.30	0.90	16.0	35	0.0006844
lf2_dp4r2b1c3h1l1	82	46.70	0.91	23.5	-35	0.0005347
lf2_dp4r2b1c3h2l1	82	47.10	0.90	23.5	10	0.0007058
lf2_dp4r2b1c3h3l1	82	46.20	0.91	23.5	35	0.0006844
lf2_dp4r2b2c1h1l1	82	45.20	1.01	6.5	-35	0.0005347
lf2_dp4r2b2c1h2l1	82	47.40	1.01	6.5	10	0.0007058
lf2_dp4r2b2c1h3l1	82	46.80	1.01	6.5	35	0.0006844
lf2_dp4r2b2c2h1l1	82	45.10	1.01	16.0	-35	0.0005347
lf2_dp4r2b2c2h2l1	82	46.10	1.01	16.0	10	0.0007058
lf2_dp4r2b2c2h3l1	82	46.30	1.01	16.0	35	0.0006844
lf2_dp4r2b2c3h1l1	82	45.30	1.01	23.5	-35	0.0005347
lf2_dp4r2b2c3h2l1	82	46.00	1.01	23.5	10	0.0007058
lf2_dp4r2b2c3h3l1	82	46.40	1.01	23.5	35	0.0006844
lf2_dp4r2b3c1h1l1	82	47.90	1.11	6.5	-35	0.0005347
lf2_dp4r2b3c1h2l1	82	47.10	1.11	6.5	10	0.0007058
lf2_dp4r2b3c1h3l1	82	47.30	1.11	6.5	35	0.0006844
lf2_dp4r2b3c2h1l1	82	45.70	1.11	16.0	-35	0.0005347
lf2_dp4r2b3c2h2l1	82	46.90	1.11	16.0	10	0.0007058
lf2_dp4r2b3c2h3l1	82	47.70	1.11	16.0	35	0.0006844
lf2_dp4r2b3c3h1l1	82	47.40	1.11	23.5	-35	0.0005347
lf2_dp4r2b3c3h2l1	82	44.80	1.11	23.5	10	0.0007058

lf2_dp4r2b3c3h3l1	82	45.40	1.11	23.5	35	0.0006844
lf2_dp4r3b1c1h1l1	82	78.80	0.73	6.5	-35	0.0005347
lf2_dp4r3b1c1h2l1	82	76.70	0.75	6.5	10	0.0007058
lf2_dp4r3b1c1h3l1	82	80.30	0.72	6.5	35	0.0006844
lf2_dp4r3b1c2h1l1	82	80.60	0.72	16.0	-35	0.0005347
lf2_dp4r3b1c2h2l1	82	81.30	0.71	16.0	10	0.0007058
lf2_dp4r3b1c2h3l1	82	78.60	0.74	16.0	35	0.0006844
lf2_dp4r3b1c3h1l1	82	77.20	0.75	23.5	-35	0.0005347
lf2_dp4r3b1c3h2l1	82	76.70	0.75	23.5	10	0.0007058
lf2_dp4r3b1c3h3l1	82	81.20	0.71	23.5	35	0.0006844
lf2_dp4r3b2c1h1l1	82	82.50	0.97	6.5	-35	0.0005347
lf2_dp4r3b2c1h2l1	82	79.60	0.99	6.5	10	0.0007058
lf2_dp4r3b2c1h3l1	82	79.40	1.00	6.5	35	0.0006844
lf2_dp4r3b2c2h1l1	82	81.00	0.98	16.0	-35	0.0005347
lf2_dp4r3b2c2h2l1	82	80.80	0.98	16.0	10	0.0007058
lf2_dp4r3b2c2h3l1	82	77.70	1.01	16.0	35	0.0006844
lf2_dp4r3b2c3h1l1	82	82.40	0.97	23.5	-35	0.0005347
lf2_dp4r3b2c3h2l1	82	78.20	1.01	23.5	10	0.0007058
lf2_dp4r3b2c3h3l1	82	77.50	1.01	23.5	35	0.0006844
lf2_dp4r3b3c1h1l1	82	77.00	1.11	6.5	-35	0.0005347
lf2_dp4r3b3c1h2l1	82	78.40	1.11	6.5	10	0.0007058
lf2_dp4r3b3c1h3l1	82	81.40	1.11	6.5	35	0.0006844
lf2_dp4r3b3c2h1l1	82	77.30	1.11	16.0	-35	0.0005347
lf2_dp4r3b3c2h2l1	82	79.40	1.11	16.0	10	0.0007058
lf2_dp4r3b3c2h3l1	82	81.40	1.11	16.0	35	0.0006844
lf2_dp4r3b3c3h1l1	82	80.80	1.11	23.5	-35	0.0005347
lf2_dp4r3b3c3h2l1	82	81.20	1.11	23.5	10	0.0007058
lf2_dp4r3b3c3h3l1	82	79.50	1.11	23.5	35	0.0006844
ls2_dp1r1b1c1h1l1	34	35.70	0.97	3.6	-78	0.0003216
ls2_dp1r1b1c2h1l1	34	35.70	0.97	4.0	-78	0.0003216
ls2_dp1r1b1c3h1l1	34	34.60	0.98	4.4	-78	0.0003216
ls2_dp1r1b2c1h1l1	34	35.00	1.24	3.6	-78	0.0003216
ls2_dp1r1b2c2h1l1	34	35.80	1.23	4.0	-78	0.0003216
ls2_dp1r1b2c3h1l1	34	34.80	1.25	4.4	-78	0.0003216
ls2_dp1r1b3c1h1l1	34	36.30	1.49	3.6	-78	0.0003216
ls2_dp1r1b3c2h1l1	34	34.00	1.53	4.0	-78	0.0003216
ls2_dp1r1b3c3h1l1	34	34.30	1.52	4.4	-78	0.0003216
ls2_dp1r2b1c1h1l1	34	61.10	0.82	3.6	-78	0.0003216
ls2_dp1r2b1c2h1l1	34	61.00	0.82	4.0	-78	0.0003216
ls2_dp1r2b1c3h1l1	34	60.70	0.83	4.4	-78	0.0003216
ls2_dp1r2b2c1h1l1	34	61.40	1.09	3.6	-78	0.0003216
ls2_dp1r2b2c2h1l1	34	61.40	1.09	4.0	-78	0.0003216
ls2_dp1r2b2c3h1l1	34	59.40	1.11	4.4	-78	0.0003216
ls2_dp1r2b3c1h1l1	34	61.40	1.36	3.6	-78	0.0003216
ls2_dp1r2b3c2h1l1	34	60.60	1.37	4.0	-78	0.0003216
ls2_dp1r2b3c3h1l1	34	60.40	1.37	4.4	-78	0.0003216
ls2_dp1r3b1c1h1l1	34	105.60	0.57	3.6	-78	0.0003216
ls2_dp1r3b1c2h1l1	34	100.90	0.61	4.0	-78	0.0003216
ls2_dp1r3b1c3h1l1	34	105.60	0.57	4.4	-78	0.0003216
ls2_dp1r3b2c1h1l1	34	101.50	0.88	3.6	-78	0.0003216
ls2_dp1r3b2c2h1l1	34	101.90	0.87	4.0	-78	0.0003216
ls2_dp1r3b2c3h1l1	34	106.10	0.84	4.4	-78	0.0003216

ls2_dp1r3b3c1h1l1	34	99.50	1.16	3.6	-78	0.0003216
ls2_dp1r3b3c2h1l1	34	101.40	1.14	4.0	-78	0.0003216
ls2_dp1r3b3c3h1l1	34	106.30	1.10	4.4	-78	0.0003216