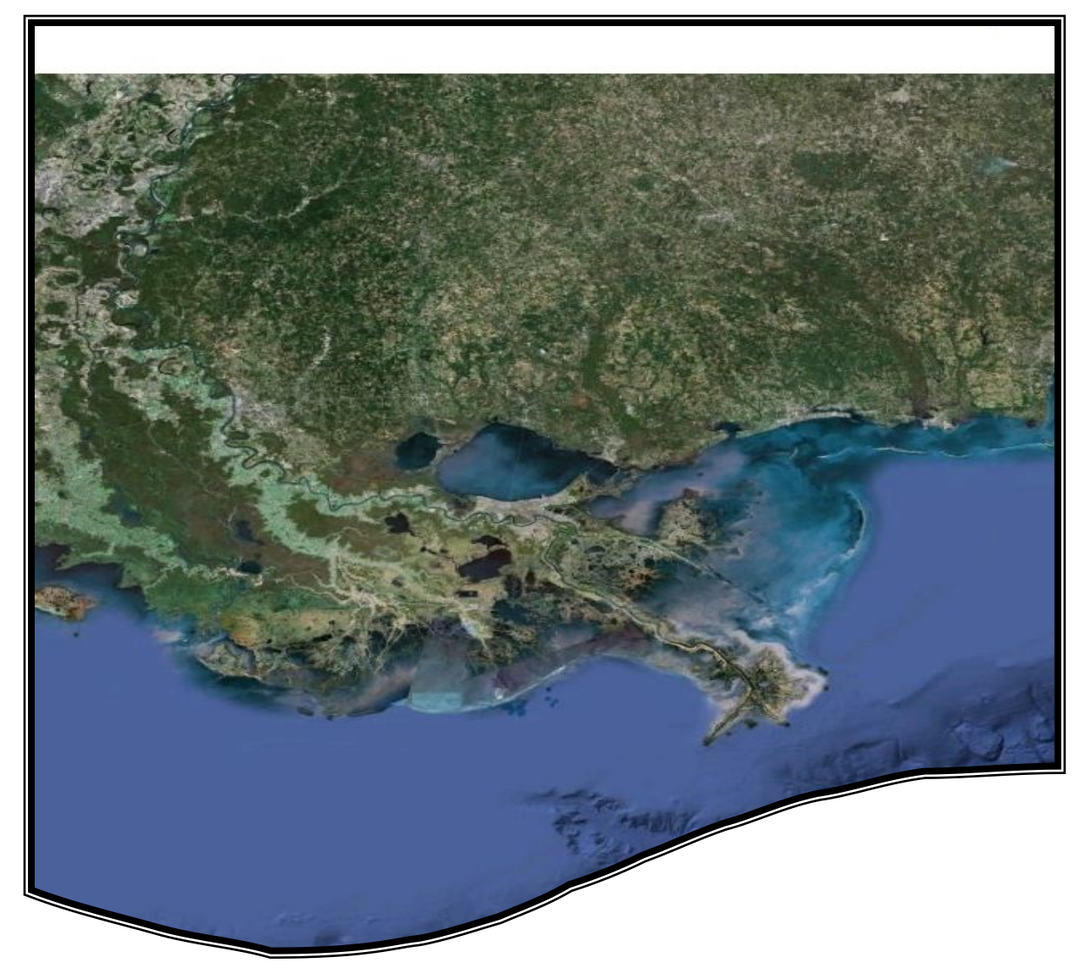

BOTES: A Methodology for Quickly Assessing Tropical Storm Surge

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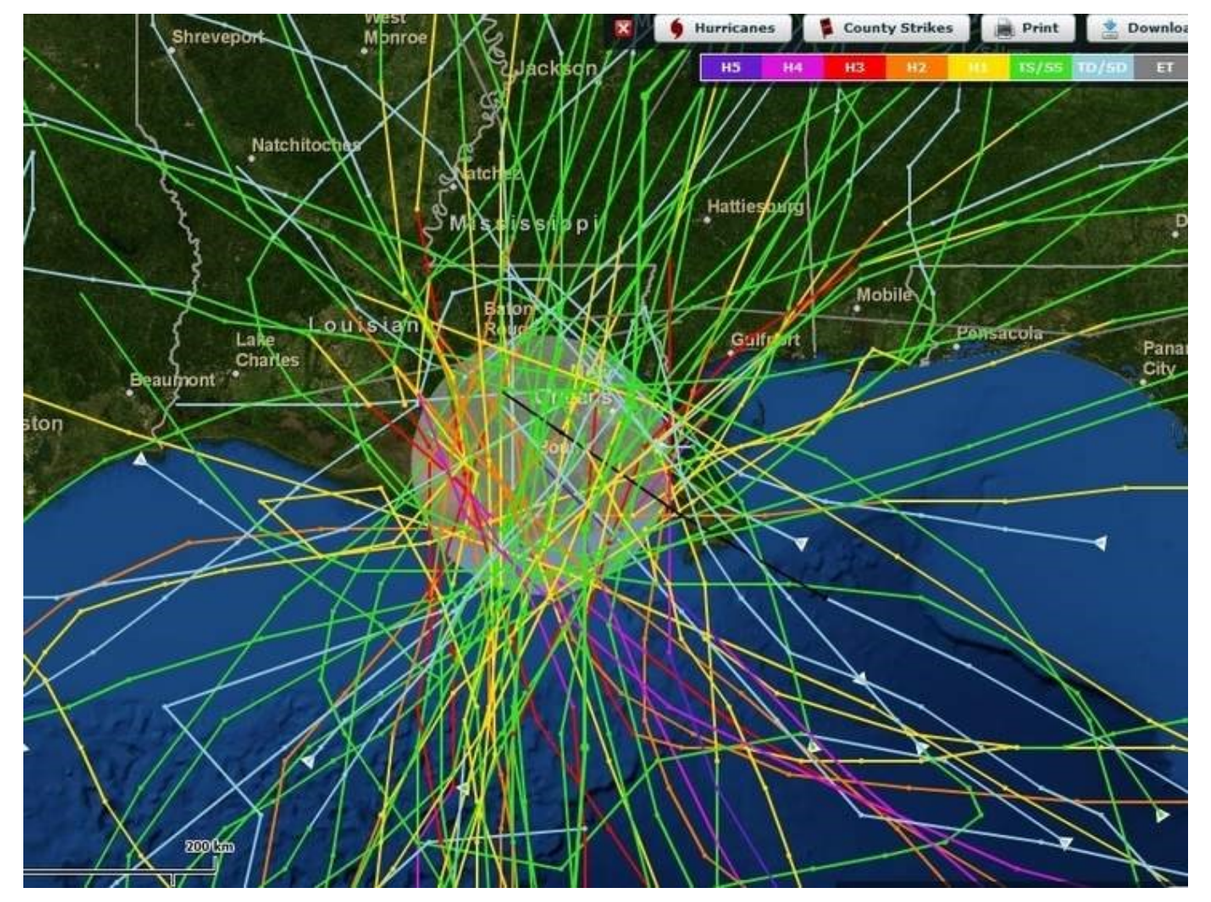
P1.47

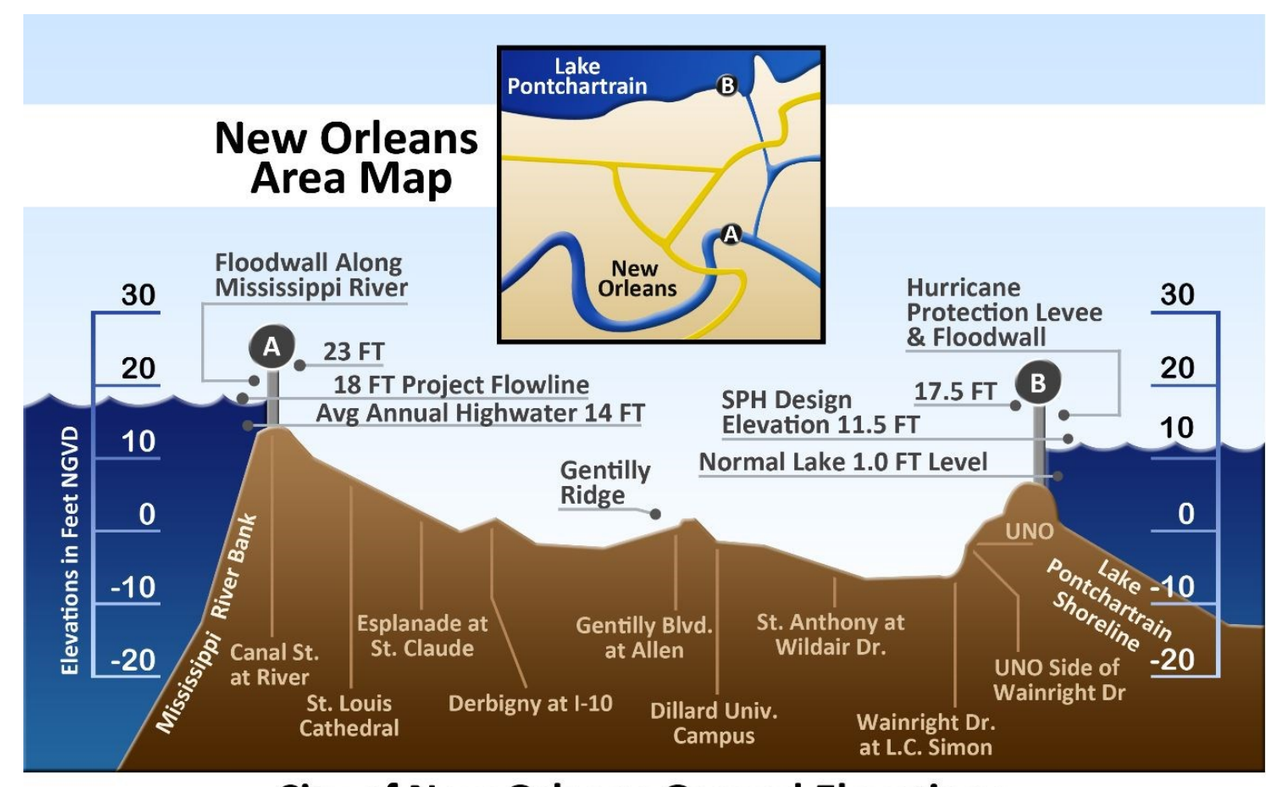
Background

The central Gulf Coast region is one of the most vulnerable stretches of coastline in the United States in regards to tropical cyclone threats and their direct impacts.

Land loss due to subsidence and sea level rises will increase the vulnerability of future surges from hurricanes, particularly in Southeast Louisiana.

In providing Decision Support Services to key decision-makers during tropical storm and hurricane threats, it is critical that timely provision of surge guidance with confidence is produced.





City of New Orleans Ground Elevations
From Canal St. at the Mississippi River to the Lakefront at U.N.O.

BOTES = Back Of The Envelope Surge

BOTES is a quick assessment model to provide operational forecasters insight on potential impacts.

It utilizes a Microsoft EXCEL ™ spreadsheet template that includes all the necessary equations for computing an areal storm surge based on the latest National Hurricane Center storm advisories, an in-situ pressure field and astronomical tide data from NOAA NOS established locations as input parameters.

Precursor scheme was the Tabletop First Guess Storm Surge Model (Ricks, 2007)

Hydrostatic based equation using pressure differential **$(\Delta Z = -\varrho g \Delta P)$**

with a distance weighting **(1-d/r)** applied along a radial outward from the storm's center.

The final surge calculation simplifies to **$3.28*(1-d/r)*\Delta P/12.28$** or

$$\text{Surge (ft-MSL)} = 0.26775*(1-d/r)*\Delta P$$

A pressure-wind relationship profile is attained using Kraft (1961) and NHC (Brown, Franklin, Landsea 2008) to compute a central pressure estimate at each advisory time step.

Haversine trigonometry equation (Williams and Phythian, 1989) is used to compute distances and bearings from storm center to forecast point locations.

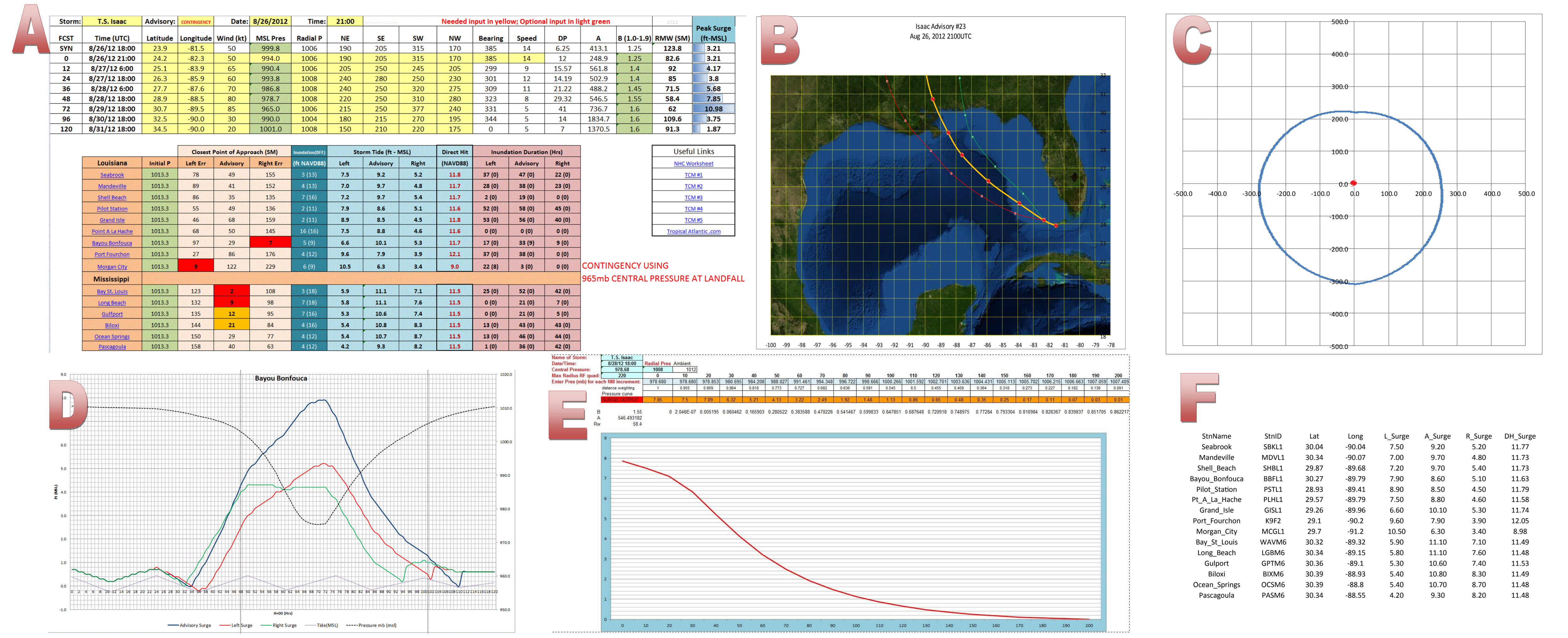
Holland (1980 and 2010) pressure-wind relationship hyperbolic curves are utilized to determine the station pressure relative to the distance from storm.

Methodology

1. Enter elements common to NHC Atlantic tropical cyclone advisory
   — Latitude, Longitude, Max Wind, Min Central Pressure, Direction/Speed of storm
2. Enter initial ambient pressure field obtained from an objective analysis scheme at coastal forecast locations
3. Temporally interpolate the advisory elements for 1-hour resolution time steps
4. Compute the wind-pressure relationship equations for each 1-hour time step
   - Kraft & NHC methods
5. Apply Haversine equation to compute distance of storm center from forecast locations for each time step.
6. Compute the Holland curves and retrieve forecast location pressure corresponding to Haversine distance/bearing.
7. Apply Ricks surge equation for each forecast location at each 1-hour time step.
8. Compute steps 3-7 for left and right tracks of the NHC seasonal error cone.
9. Generate .csv file of results for particular advisory with left, right and advisory track computed surge values for each forecast location.
10. Using ArcMap with previously obtained QC LIDAR high resolution topographic map of the forecast area, merge the .csv file with the elevation data; subtract surge values from ground elevations to produce inundation maps.

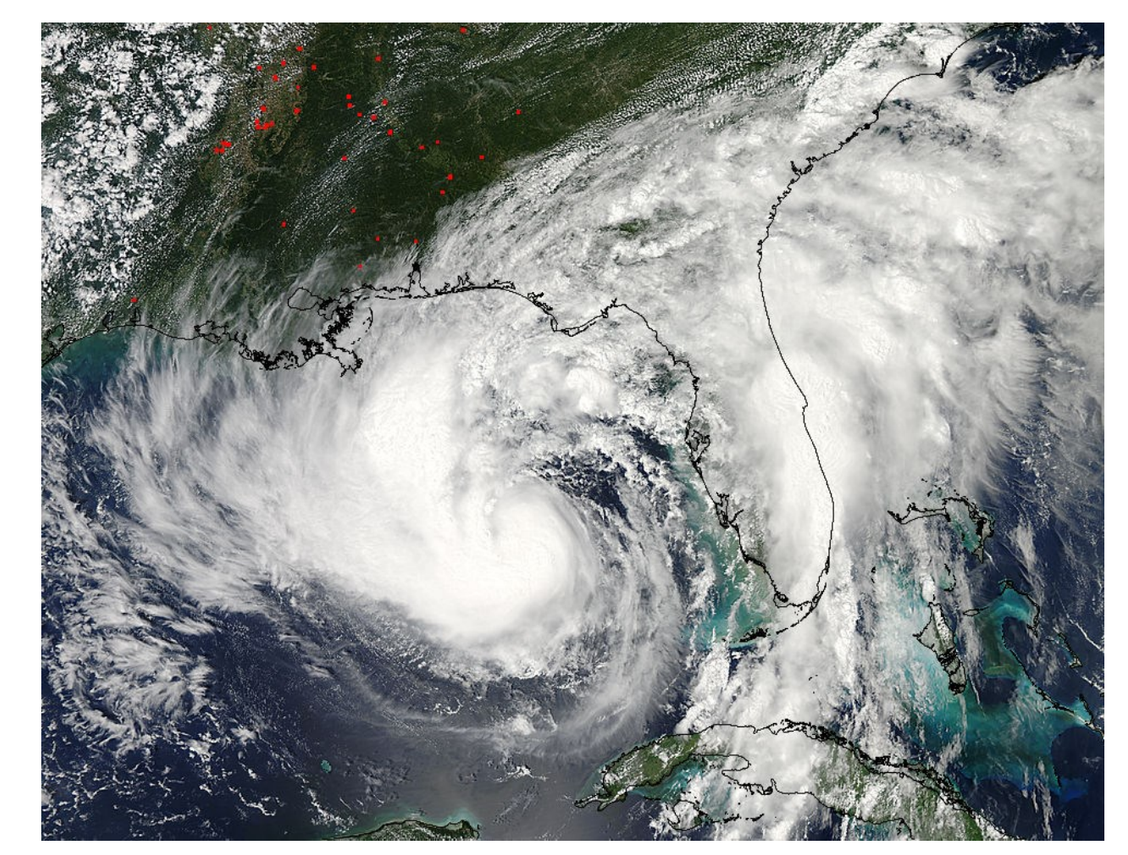
- The spreadsheet approach allows for a single page input of the advisory information, with highlighted cells of required (yellow) and optional (green) input elements.
- Input and output tables are concisely placed to produce a one-page printout for briefing purposes.
- Individual tabs compute the Haversine, Kraft and Ricks math and associated surge hydrographs.
- Annual astronomical tide data are included for each forecast location.
- Bathymetric factor can be applied (set to 1.0 for shallow-sloped shores common to the forecast area.)

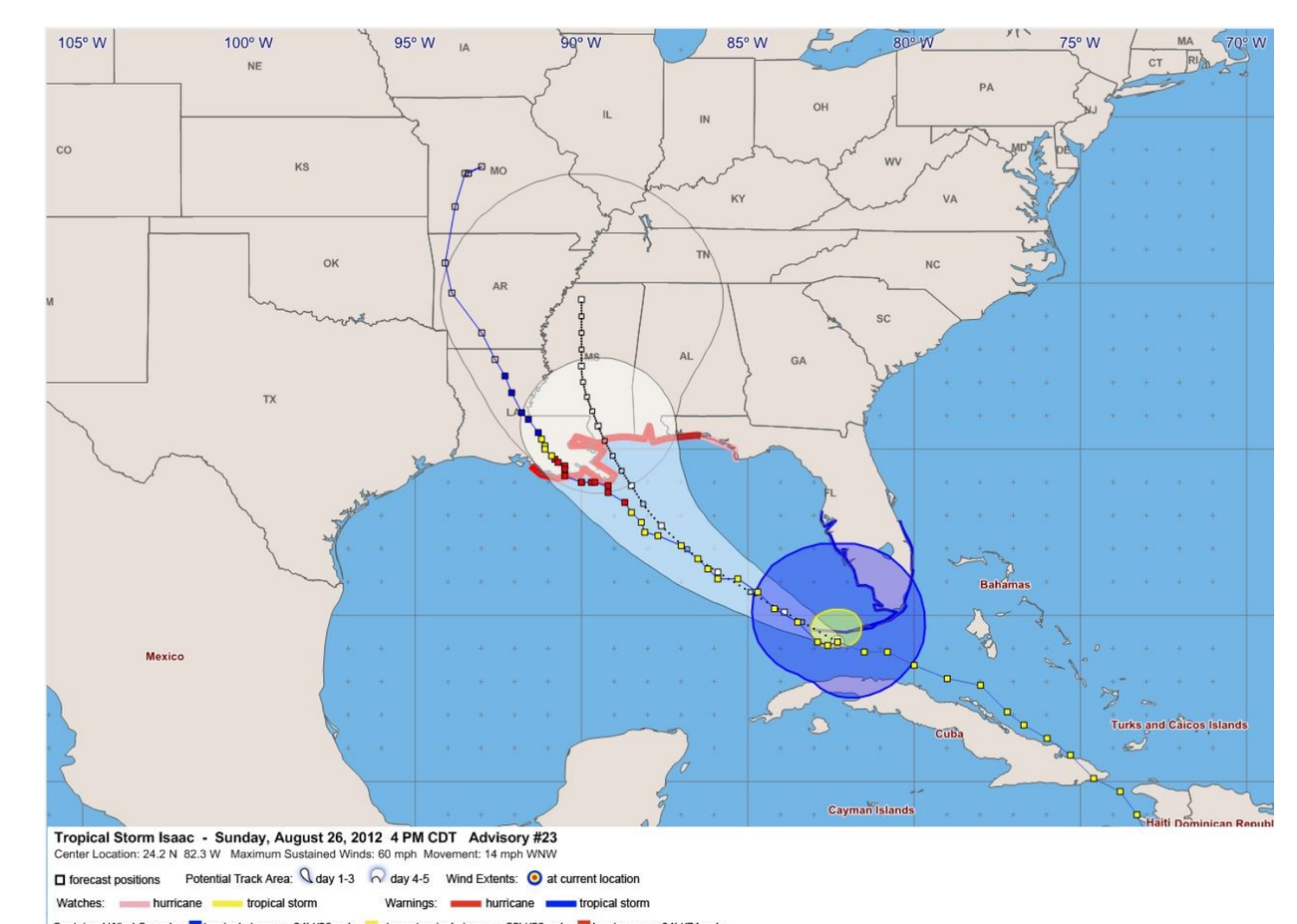
Functionality of BOTES

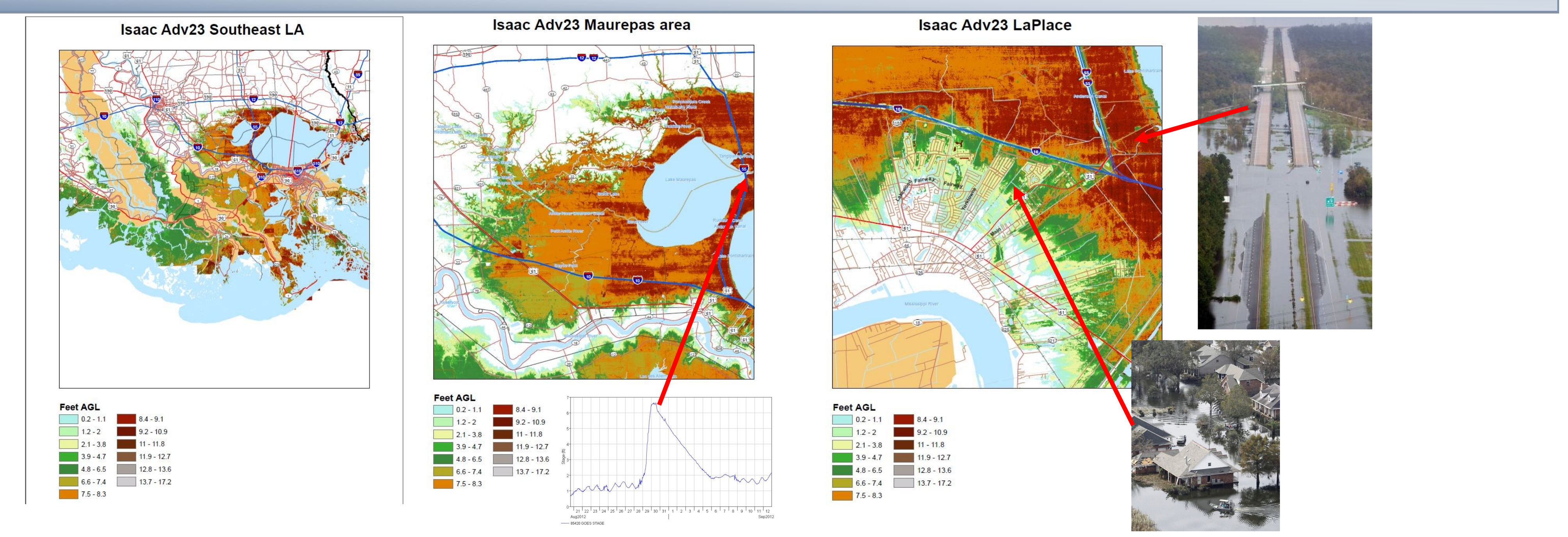


A. Input and output tables on one tab of EXCEL workbook. **B.** BOTES plot of advisory track with left and right error tracks. **C.** Radial pressure profile for advisory 48 hour forecast time-step. **D.** A sample hydrograph for Bayou Bonfouca (Slidell, LA) with advisory surge forecast (blue), left error surge forecast (red), right error surge forecast (green), and astronomical tide (lavender). **E.** The 48 hour Holland curve with Ricks equation applied. **F.** Sample .csv output file from EXCEL exported to GIS computer for inundation mapping applications.

Hurricane Isaac (August 28-29, 2012)



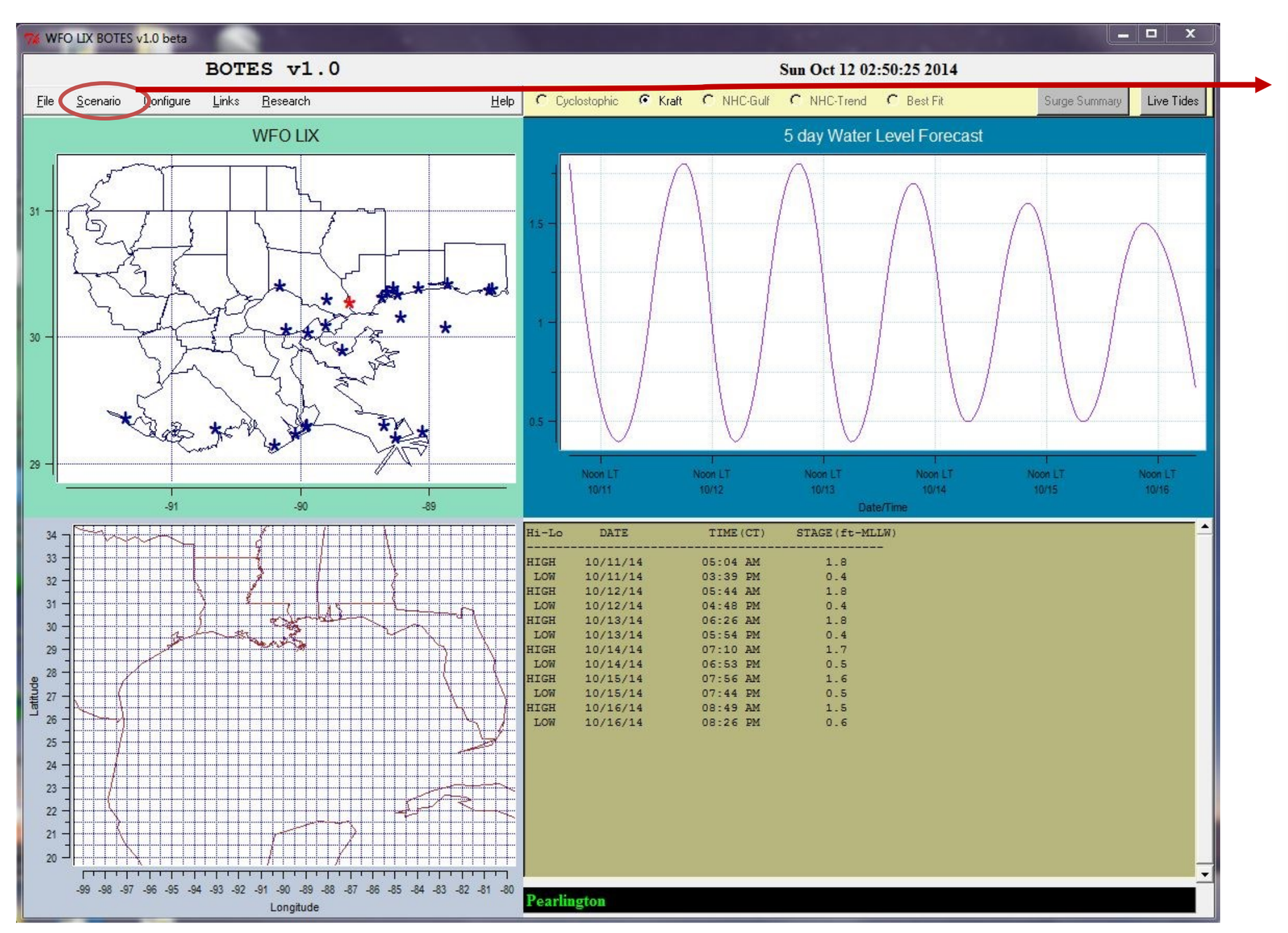


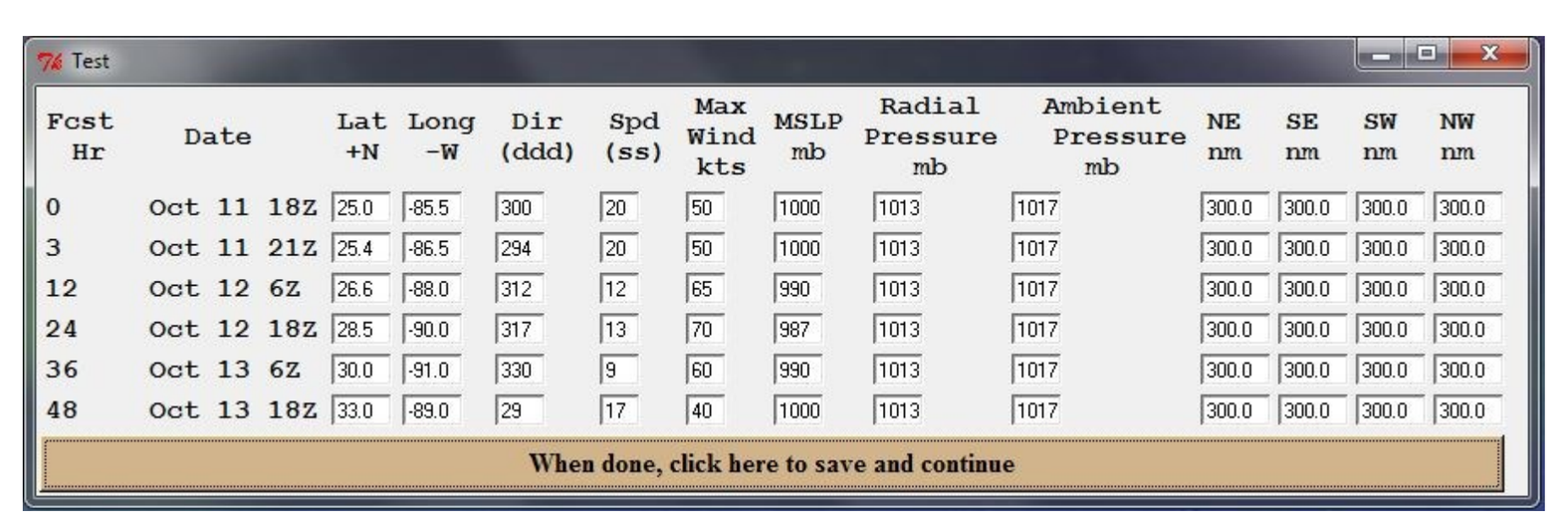


On Sunday, August 26, 2012, NHC Advisory #23 was issued for Tropical Storm Isaac (track map, left). The advisory forecast track indicated a passage to the east of the Mississippi River. The actual storm track was west of the Mississippi River into western Barataria Bay. BOTES was applied on the forecast track with the resultant output applied to GIS mapping to produce inundation mapping of the forecast area in real-time. Despite the ultimate track error, the subsequent surge impacts were realized as indicated by the BOTES methodology. The images above are the actual output graphics from ArcMap using high resolution LIDAR elevation data subtracted from the surge values to produce expected above ground inundation. Image left is the larger CWA surge footprint for Southeast Louisiana, center image is the tighter view of west side of Lake Pontchartrain and Lake Maurepas area. The rightmost image is a neighborhood subset scale of Laplace, LA where 3 to 4 feet of inundation took place.

Conclusion and Future Developments

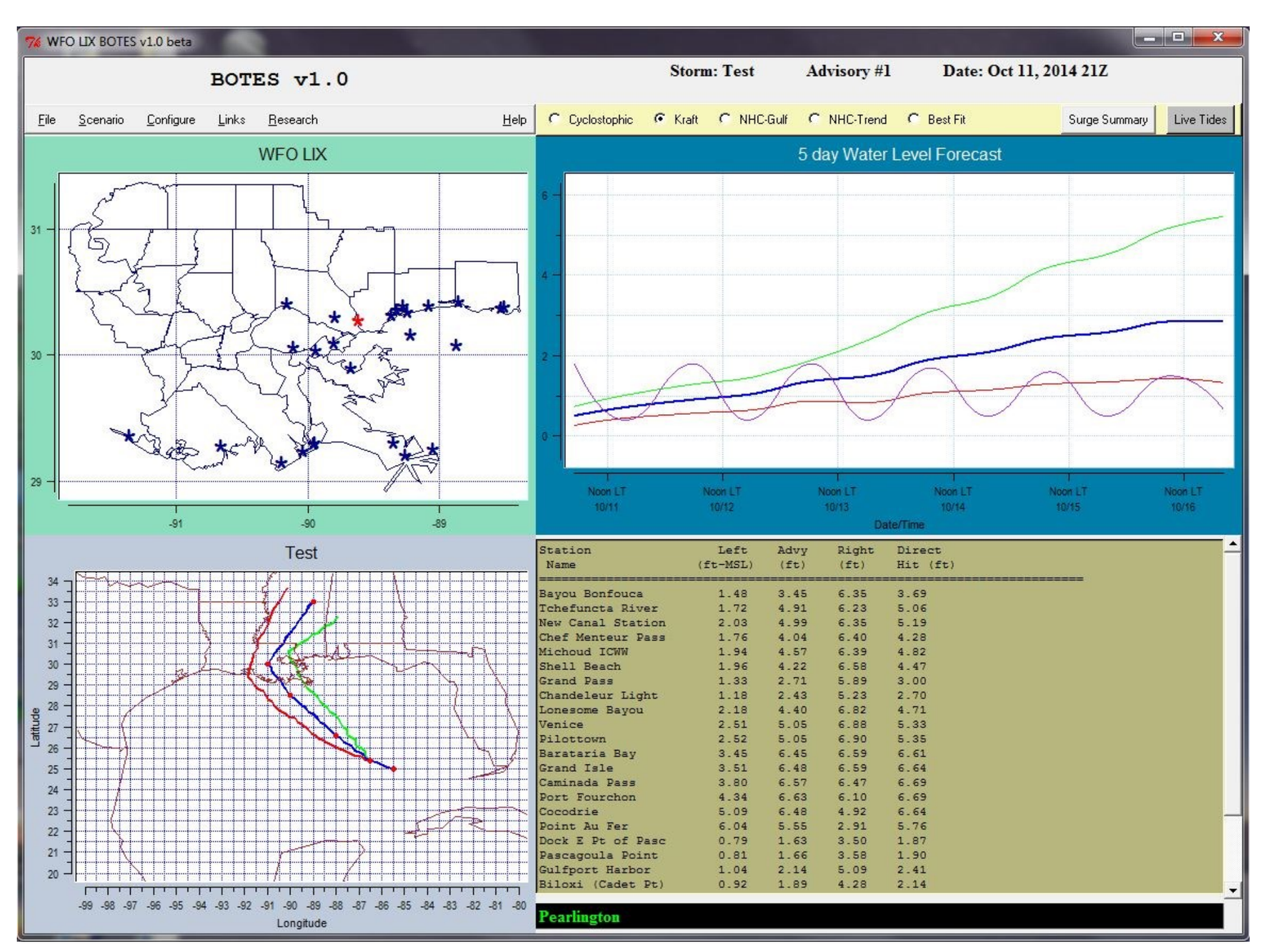
- BOTES is a quick assessment tool to produce a "Back of the envelope" calculation of storm surge potential.
- The technique utilizes scientifically established equations to compute a comprehensive first guess storm surge value.
- Computations on NHC error tracks provide a range of surge values with a forecast confidence of 67 percent within the error cone.
- Application on past storms and in situ operations have produced acceptable results adequate to provide confidence in conducting Decision Support Services to decision-makers and stakeholders.
- The short turnaround methodology provides an efficient interface to ArcMAP plotting and computing of storm surge inundation.
- A Graphical User Interface (GUI) script is being developed in Tcl/Tk and Python to provide an integrated tool for data entry, graphical interactions and briefing tools output (printouts, summary tables, etc.)





Fcst Hr	Date	Lat +N	Long -W	Dir (ddd)	Spd (ss)	Max Wind kts	MSLP mb	Radial Pressure mb	Ambient Pressure mb	NE nm	SE nm	SW nm	NW nm
0	Oct 11 18Z	25.0	-85.5	300	20	50	1000	1013	1017	300.0	300.0	300.0	300.0
3	Oct 11 21Z	25.4	-86.5	294	20	50	1000	1013	1017	300.0	300.0	300.0	300.0
12	Oct 12 6Z	26.6	-88.0	312	12	65	990	1013	1017	300.0	300.0	300.0	300.0
24	Oct 12 18Z	28.5	-90.0	317	13	70	987	1013	1017	300.0	300.0	300.0	300.0
36	Oct 13 6Z	30.0	-91.0	330	9	60	990	1013	1017	300.0	300.0	300.0	300.0
48	Oct 13 18Z	33.0	-89.0	29	17	40	1000	1013	1017	300.0	300.0	300.0	300.0

When done, click here to save and continue



LEFT: The user selects one of several available forecast locations. A 5 day astronomical tide curve is drawn along with an accompanying tide table (from NOAA NOS tide data).

User can apply a scenario (NHC advisory, gulf low or gradient wind).

CENTER: An input table is invoked for user input.

RIGHT: The advisory track is plotted along with left and right error tracks, based on NHC 5-year average error; A hydrograph of surge and tide with color-coordination of tracks; a summary table for all the forecast locations.

Acknowledgements and References

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