User Manual

Hurricane Power Outage Model GeoViewer

Developed by Faculty and Students at The Ohio State University

Resources and Technical Support

Our HPOM GeoViewer can be accessed at chapmanrebecca.com/AppliedClimate/index.html. If you have further questions about this product, please contact us at:

Steven Quiring

Professor

Department of Geography

Ohio State University

154 N Oval Mall, Columbus, Ohio 43210

quiring.10@osu.edu

Emily Sambuco

Masters Student

Department of Geography

Ohio State University

154 N Oval Mall, Columbus, Ohio 43210

sambuco.8@osu.edu

Yuechun Wang

PhD Student

Department of Geography

Ohio State University

154 N Oval Mall, Columbus, Ohio 43210

wang.8869@osu.edu

Rebecca Chapman

Masters Student

Department of Geography

Ohio State University

154 N Oval Mall, Columbus, Ohio 43210

chapman.751@osu.edu

Contents

Introduction and Background

Welcome to the Hurricane Power Outage Model GeoViewer

Hurricanes devastate the Gulf Coast each year, with billions of dollars in damages, millions of people left without power, and human lives put at risk. Hurricanes present both direct and indirect hazards as they progress along their track. However, indirect hurricane-related hazards are often overlooked or difficult to predict. For example, hurricane-related power outages are among the most prevalent and hazardous effects of severe hurricanes, often lasting days or even weeks after a storm makes landfall. Model projections can predict the locations and durations of outages but can be hard to interpret for emergency decision-making.

The Hurricane Power Outage Model GeoViewer provides a user-friendly web-based application to help make hurricane preparedness and response decisions. This product incorporates projections from the Hurricane Power Outage Prediction Model (HPOM), developed by McRoberts et al. (2016), into a decision-support tool. This easy-to-use interface can represent HPOM output in conjunction to locations of critical public facilities, water treatment facilities, and geographic areas of vulnerability to better equip emergency managers with the tools to make informed decisions.

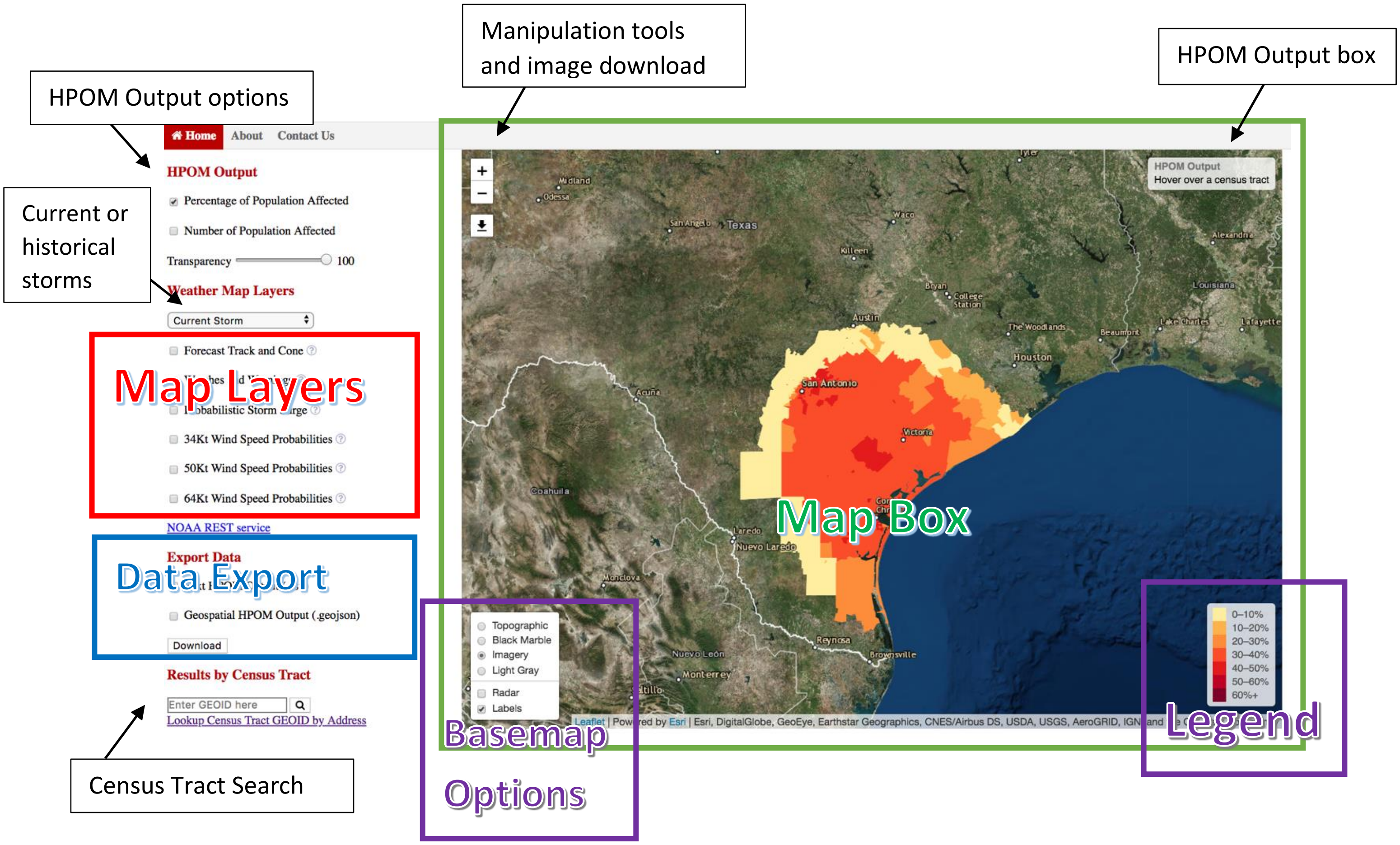
With this newly-developed geographic interface, users will have access to:

a) Near real-time Hurricane and tropical cyclone power outage tracking
b) An integrative interface displaying spatial data layers of additional weather parameters
c) Additional hurricane and tropical cyclone forecasts
d) Downloadable model outputs, geographic files, and images

The app can be used for:

- Preparedness – "What-if" alternate hurricane and tropical cyclone scenarios
- Timely Response – Real-time weather forecasts and outage information
- Mitigation and Planning – Additional hazardous forecast layers that can be viewed in conjunction to power outages

Exploring the GeoViewer Workspace



GeoViewer Map Box

The HPOM GeoViewer site displays a large geographic map tool, with manipulation capabilities and alternative viewing options.

Map Manipulation

- Zoom capabilities – Users can zoom in or out to any desired location on the map, by either scrolling with a mouse or utilizing the (+/-) icons on the upper-left side of the Map Box.
- Hover tool – By hovering the mouse over a county of interest, more information appears in the top right HPOM output box, overlaid onto the top right-hand corner of the Map Box. By hovering over an individual county, users are able to determine specific Tract ID numbers and HPOM percentages. Additionally, a user can click on a county of interest and the Map Box will zoom to the desired county.
- HPOM Output is viewable in either (%) of census population affected or number of people affected in each census tract. HPOM Output options can be clicked on and off in the upper left-hand side of the GeoViewer site.

HPOM Output Legend

- The HPOM Legend is located on the right side of the GeoViewer map.
- Depending on the HPOM Output viewing option selected, the model legend depicts either the percent of customers within each census tract effected by power outage or the number of people effected in each census tract. The legend automatically updates and depicts a sequential 7-color yellow-orange-red multi-hue palette, with red being most severe.

Basemap Options

A table of Basemap options and additional overlay options can be found in the bottom left-hand corner of the GeoViewer Map Box. Due to the nature of Basemap layers, only one can be selected at a time. Each Basemap option lays at the bottom of the map, serving as a "base" for any other additional layers to be overlaid.

The following options are classified as Basemaps and can be clicked on and off:

Topography

- This option shows normal topography as a base. Roads, city/state names, and hydrologic features are easily viewed with this Basemap option.

Black Marble

- This option depicts the Earth at night, allowing for easier viewing of high-energy-consumption areas. This product is made available through NASA's satellite VIIRS.

Imagery

- This option shows satellite imagery of land surface. This option allows for easy viewing of land surface characteristics.

Light Grey

- This option shows a neutral grey tone Basemap containing basic topographic information. This viewing option is a simplified version of the "Topography" option and shows only subtle state names and boundaries. This simplified Basemap allows for easy viewing of multiple, complex layers overtop.

In addition to the Basemap options above, additional overlay options are listed in the Basemap options table. The following options are not classified as Basemaps and can be overlaid with any desired Basemap:

Radar

- This option shows current radar in the United States and can lay overtop of any Basemap. The radar image is static and automatically generates the most recent information from NexRad. This is a static radar overlay and is available to click on and off.

Labels

- This layer draws state and country boundaries, city names, and county names. This layer can be added overtop of any desired Basemap to allows for easy area identification.

GeoViewer Map Layers

On the left side of the GeoViewer Map Box, additional layers are listed with check-boxes to the left. Each layer is clickable and able to be turned on and off of the GeoViewer Map. A more outlined description of each layer can be found in subsequent sections.

Hurricane Tracking Layers

- Forecast Track and Cone
- Watches and Warnings
- Probabilistic Storm Surge
- 34Kt Wind Speed Probabilities
- 50Kt Wind Speed Probabilities
- 64Kt Wind Speed Probabilities

Additional Layer Information – (?) Icon

To the right of each layer, there is a (?) icon. When clicked, this question-mark icon reveals a brief description of the layer, what is being displayed, and in what units the product appears. To make the information box disappear, click the (?) icon once more.

There is also an option to view layer metadata. This link is located directly underneath the "Map Layers" section. The link will navigate you away from the GeoViewer page and to the NOAA National Hurricane Center GIS Products service site. A more detailed description of each layer can be found at this site.

In addition to the "NOAA Rest Services" link, there are further links at the bottom of the web page directing the GeoViewer user to external data source sites.

Current and Historical Storm Options

At the top of the "Map Layers" section, there is a drop-down box with options to view either current storms or sample historical storms. To make a selection, click the drop-down box and select the preferred storm option. Once this option is selected, each subsequent map layer will correspond to the selected storm. For example, if "Sample- Harvey 2017 #15" is selected, each map layer added will show historical Hurricane Harvey data.

File Export

The file export section is located in the bottom left-hand side of the web page, to the left of the GeoViewer Map. This tool allows for exportation of HPOM data files.

HPOM Output

- This option allows for ".csv" or Comma Separated Value files to be exported from the GeoViewer.
- By clicking the box next to this option, and then clicking the "Download" button below, a file will automatically start to download.

Merged HPOM Output and Tract ID

- This option allows for ".geojson" or a Json file with spatial geometries to be exported from the GeoViewer.
- By clicking the box next to this option, and then clicking the "Download" button below, a file will automatically start to download.

GeoViewer Information

Development

Hurricane Power Outage Model (HPOM)

The GeoViewer site utilizes a Hurricane Power Outage Model (HPOM) that has been previously developed by faculty and students from The Ohio State University, Texas A&M, the University of Michigan, and Johns Hopkins University. A full list of citations can be found in subsequent sections.

Developed by McRoberts et al. (2016), this model incorporates climatological and environmental conditions relating to tree stability and strength, specific power system data, and forecasted hurricane data. The HOPM currently projects the percent of the population in each grid cell that will lose power due to severe hurricane activity, using forecasted hurricane track and strength. The model incorporates geographic climatological conditions, aspects of the grid, and hazardous hurricane conditions.

Development of the HPOM has been ongoing, with Nateghi et al. (2011) improving predictive accuracy of an original model and setting the stage for further work. From there Guikema et al. (2014) incorporated a statistical Random Forest predictive model (from Nataghi et al. (2013)) to create the HPOM. McRoberts et al. (2016) continued to improved the model, leading to the output that is utilized in the GeoViewer.

GeoViewer

The GeoViewer site was developed by R. Chapman, Y. Wang, and E. Sambuco.

Using leaflet:

Basemap Layers

The standard GeoViewer Basemap layer options (Topography, Imagery, and Light Gray) and additional Labels layer, were made available through Leaflet. The site can be accessed here: http://leaflet-extras.github.io/leaflet-providers/preview/. These standard viewing options appear in the bottom left-hand side of the GeoViewer map box and are able to be clicked on and off.

Topography

- This option shows normal topography as a base. Roads, city/state names, and hydrologic features are easily viewed with this Basemap option. This layer is an Esri Basemap layer, drawn using the command L.esri.basemapLayer("Topographic").

Imagery

- This option shows satellite imagery of land surface. This option allows for easy viewing of land surface characteristics. This layer is an Esri Basemap layer, drawn using the command L.esri.basemapLayer("ImageryClarity").

Light Gray

- This option shows a neutral grey tone Basemap containing basic topographic information. This viewing option is a simplified version of the "Topography" option and shows only subtle state names and boundaries. This simplified Basemap allows for easy viewing of multiple, complex layers overtop. This layer is an Esri Basemap layer, drawn using the command L.esri.basemapLayer("Gray").

Labels

- This option is located at the bottom of the Basemap layer list. This option is clickable on and off, and it is able to be overlaid with the Basemap options.
- Although this layer is an Esri Basemap layer, drawn using the command L.esri.basemapLayer("ImageryLabels"), it can be drawn overtop of any Basemap.

Additional layers were provided, using external source data, for alternative Basemap viewing options. Links to layer sources can be found under each description.

Black Marble

- This option depicts the Earth at night, allowing for easier viewing of high-energy-consumption areas. This product is made available through NASA's satellite VIIRS. This Basemap is tiled and uses the command "L.tileLayer" to be drawn.
- Link to Basemap url: https://map1.vis.earthdata.nasa.gov/wmts-webmerc/VIIRS_Black_Marble/default/{time}/{tilematrixset}{maxZoom}/{z}/{y}/{x}.{format}

Radar

- This option shows current radar in the United States and can lay overtop of any chosen Basemap. The radar image is static and automatically generates most recent information. This layer is drawn using an "L.esri.dynamicMapLayer" command.
- Link to layer url: https://nowcoast.noaa.gov/arcgis/rest/services/nowcoast/radar_meteo_imagery_nexrad_time/MapServer/

Map Layers

Forecast Track and Cone

- This layer displays a cone, representing the probable track of the center of the most current tropical cyclone. It is formed by enclosing the area encompassing a set of circles along the forecast track (at 12, 24, 36, 48, 72, 96, 120 hours). This layer is formatted as an Esri dynamic map layer, using the "L.esri.dynamicMapLayer" drawing command.
- Layer url: https://idpgis.ncep.noaa.gov/arcgis/rest/services/NWS_Forecasts_Guidance_Warnings/NHC_Atl_trop_cyclones/MapServer/
- Layers: 5, 6, 16, 17, 27, 28, 38, 39, 49, 50

Watches and Warnings

- This layer shows coastal areas under current tropical cyclone watches or warnings, delimited by specific geographical locations known as "breakpoints". This layer consists of one or more lines connecting the breakpoints displaying any current watches or warnings. This layer is an Esri dynamic map layer, using the "L.esri.dynamicMapLayer" drawing command.
- Layer url: https://idpgis.ncep.noaa.gov/arcgis/rest/services/NWS_Forecasts_Guidance_Warnings/NHC_Atl_trop_cyclones/MapServer/
- Layers: 7, 18, 29, 40, 51

Probabilistic Storm Surge

- This layer shows the probability (in percent) of a specified storm surge exceeding the specified height (in feet) during forecasting period. This forecast includes tides. This layer is an Esri dynamic map layer, using the "L.esri.dynamicMapLayer" drawing command.
- Layer url: https://idpgis.ncep.noaa.gov/arcgis/rest/services/NWS_Forecasts_Guidance_Warnings/NHC_Atl_trop_cyclones/MapServer/
- Layers: 14, 25, 36, 46, 58

34Kt Wind Speed Probabilities

- This layer maps 34 knot, 120 hour cumulative wind speed probabilities for current forecasted storms. Wind Speed Probability grids show regularly spaced, 5 km areas where sustained surface winds equal or exceed 34 knots (1 minute averages at 10 meters above ground). This layer is an Esri dynamic map layer, using the "L.esri.dynamicMapLayer" drawing command.
- Layer url: https://idpgis.ncep.noaa.gov/arcgis/rest/services/NWS_Forecasts_Guidance_Warnings/NHC_Atl_trop_cyclones/MapServer/
- Layer: 59

50Kt Wind Speed Probabilities

- This layer maps 50 knot, 120 hour cumulative wind speed probabilities for current forecasted storms. Wind Speed Probability grids show regularly spaced, 5 km areas where sustained surface winds equal or exceed 50 knots (1 minute averages at 10 meters above ground). This layer is an Esri dynamic map layer, using the "L.esri.dynamicMapLayer" drawing command.
- Layer url: https://idpgis.ncep.noaa.gov/arcgis/rest/services/NWS_Forecasts_Guidance_Warnings/NHC_Atl_trop_cyclones/MapServer/
- Layer: 60

64Kt Wind Speed Probabilities

- This layer maps 64 knot, 120 hour cumulative wind speed probabilities for current forecasted storms. Wind Speed Probability grids show regularly spaced, 5 km areas where sustained surface winds equal or exceed 64 knots (1 minute averages at 10 meters above ground). This layer is an Esri dynamic map layer, using the "L.esri.dynamicMapLayer" drawing command.
- Layer url: https://idpgis.ncep.noaa.gov/arcgis/rest/services/NWS_Forecasts_Guidance_Warnings/NHC_Atl_trop_cyclones/MapServer/
- Layer: 61

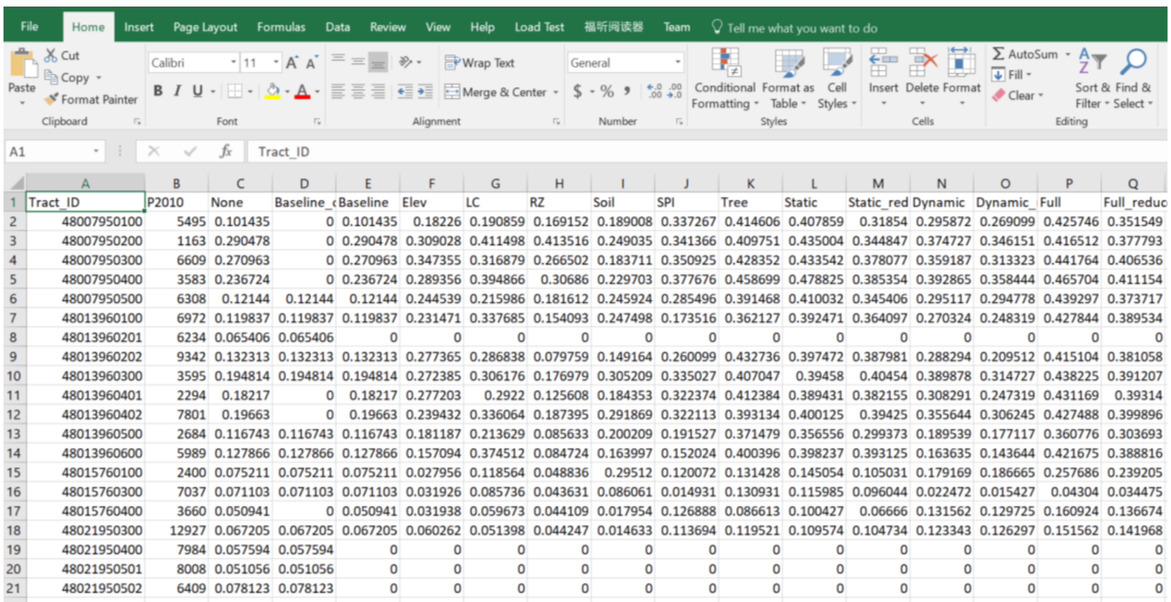
Exporting Files

HPOM Features

The HPOM model is computed through R and run under Linux system. The CSV file will be updated automatically every 6 hours. Each file includes:

- Tract_ID – county code
- P2010 – number of population
- Full_reduced – percentage of population influenced

Example HPOM Output



	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q
1	Tract_ID	P2010	None	Baseline_(	Baseline	Elev	LC	RZ	Soil	SPI	Tree	Static	Static_red	Dynamic	Dynamic_	Full	Full_reduc
2	48007950100	5495	0.101435	0	0.101435	0.18226	0.190859	0.169152	0.189008	0.337267	0.414606	0.407859	0.31854	0.295872	0.269099	0.425746	0.351549
3	48007950200	1163	0.290478	0	0.290478	0.309028	0.411498	0.413516	0.249035	0.341366	0.409751	0.435004	0.344847	0.374727	0.346151	0.416512	0.377793
4	48007950300	6609	0.270963	0	0.270963	0.347355	0.316879	0.266502	0.183711	0.350925	0.428352	0.433542	0.378077	0.359187	0.313323	0.441764	0.406536
5	48007950400	3583	0.236724	0	0.236724	0.289356	0.394866	0.30686	0.229703	0.377676	0.458699	0.478825	0.385354	0.392865	0.358444	0.465704	0.411154
6	48007950500	6308	0.12144	0.12144	0.12144	0.244539	0.215986	0.181612	0.245924	0.285496	0.391468	0.410032	0.345406	0.295117	0.294778	0.439297	0.373717
7	48013960100	6972	0.119837	0.119837	0.119837	0.231471	0.337685	0.154093	0.247498	0.173516	0.362127	0.392471	0.364097	0.270324	0.248319	0.427844	0.389534
8	48013960201	6234	0.065406	0.065406	0	0	0	0	0	0	0	0	0	0	0	0	0
9	48013960202	9342	0.132313	0.132313	0.132313	0.277365	0.286838	0.079759	0.149164	0.260099	0.432736	0.397472	0.387981	0.288294	0.209512	0.415104	0.381058
10	48013960300	3595	0.194814	0.194814	0.194814	0.272385	0.306176	0.176979	0.305209	0.335027	0.407047	0.39458	0.40454	0.389878	0.314727	0.438225	0.391207
11	48013960401	2294	0.18217	0	0.18217	0.277203	0.2922	0.125608	0.184353	0.322374	0.412384	0.389431	0.382155	0.308291	0.247319	0.431169	0.39314
12	48013960402	7801	0.19663	0	0.19663	0.239432	0.336064	0.187395	0.291869	0.322113	0.393134	0.400125	0.39425	0.355644	0.306245	0.427488	0.399896
13	48013960500	2684	0.116743	0.116743	0.116743	0.181187	0.213629	0.085633	0.200209	0.191527	0.371479	0.356556	0.299373	0.189539	0.177117	0.360776	0.303693
14	48013960600	5989	0.127866	0.127866	0.127866	0.157094	0.374512	0.084724	0.163997	0.152024	0.400396	0.398237	0.393125	0.163635	0.143644	0.421675	0.388816
15	48015760100	2400	0.075211	0.075211	0.075211	0.027956	0.118564	0.048836	0.29512	0.120072	0.131428	0.145054	0.105031	0.179169	0.186665	0.257686	0.239205
16	48015760300	7037	0.071103	0.071103	0.071103	0.031926	0.085736	0.043631	0.086061	0.014931	0.130931	0.115985	0.096044	0.022472	0.015427	0.04304	0.034475
17	48015760400	3660	0.050941	0	0.050941	0.031938	0.059673	0.044109	0.017954	0.126888	0.086613	0.100427	0.06666	0.131562	0.129725	0.160924	0.136674
18	48021950300	12927	0.067205	0.067205	0.067205	0.060262	0.051398	0.044247	0.014633	0.113694	0.119521	0.109574	0.104734	0.123343	0.126297	0.151562	0.141968
19	48021950400	7984	0.057594	0.057594	0	0	0	0	0	0	0	0	0	0	0	0	0
20	48021950501	8008	0.051056	0.051056	0	0	0	0	0	0	0	0	0	0	0	0	0
21	48021950502	6409	0.078123	0.078123	0	0	0	0	0	0	0	0	0	0	0	0	0
22	48021950600	5184	0.068427	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Original HPOM Output (.csv)

To download original HPOM output in .csv format, simply select the option "original HPOM output" underneath the "Export Files" section and press "download". The .csv file should automatically begin downloading. This file should look identical to the example output displayed above.

Merged HPOM Output and Tract ID (.geojson)

Along with original output, there is also a .geojson file download option. TO download this file type, select the check box next to the "Merged HPOM Output and Tract ID" option underneath the "Export Files" section and then press "download".

Site Information

Site Code

The site code for the Hurricane Power Outage GeoViewer is freely available through a Public GitHub Repository. GitHub (https://github.com/) is an open-sourced version control system that allows for seamless development of web-based applications and sites. Code is housed in repositories, edited by contributors, and maintained through constant collaboration.

Link to repository: https://github.com/rebeccachapman/AppliedClimate

The repository for the HPOM GeoViewer houses important files containing code that makes the site run. There is a main HTML file, titled "index.html" that contains all main HTML code found in the site. There is also main CSS and JavaScript files housed in the repository that contain main style code for the site. These are titled "index.js" and "styles.css".

GeoViewer layers were added to the site using Leaflet code.

Maintenance

In order to maintain the site, certain links must stay active

Future directions – add multiple scenarios

Additional HPOM Information

Listed below are scientific articles containing background information on the development of the hurricane power outage model. These papers describe model development, the validation process, variables used in the model, and model performance.

References

Guikema, S. D., R. Nateghi, S. M. Quiring, A. Staid, A. C. Reilly, and M. Gao, 2014: Predicting Hurricane Power Outages to Support Storm Response Planning. IEEE Access, 2, 1364–1373, doi:10.1109/ACCESS.2014.2365716.

McRoberts, D. B., S. M. Quiring, and S. D. Guikema, 2016: Improving Hurricane Power Outage Prediction Models Through the Inclusion of Local Environmental Factors: Improving Hurricane Power Outage Prediction Models. Risk Analysis, doi:10.1111/risa.12728.

Nateghi, R., S. D. Guikema, and S. M. Quiring, 2011: Comparison and Validation of Statistical Methods for Predicting Power Outage Durations in the Event of Hurricanes: Comparison and Validation of Statistical Methods. Risk Analysis, 31, 1897–1906, doi:10.1111/j.1539-6924.2011.01618.x.

Quiring, S. M., L. Zhu, and S. D. Guikema, 2011: Importance of soil and elevation characteristics for modeling hurricane-induced power outages. Natural Hazards, 58, 365–390, doi:10.1007/s11069-010-9672-9.