Real-time TC Impact Information for Emergency and Operational Decision Making: Hurricane Matthew

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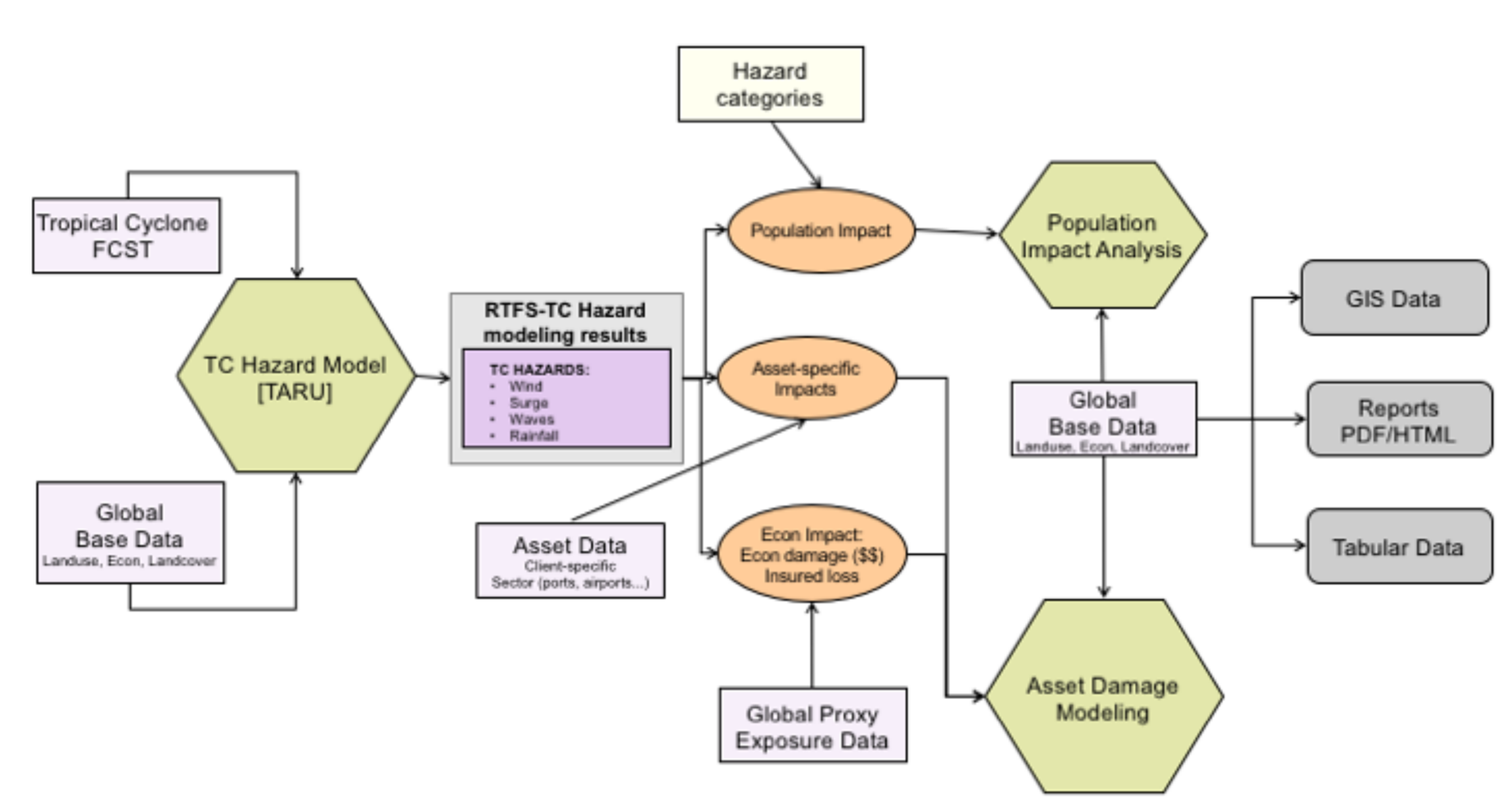
TC Hazard & Impact Model Platform

Emergency and operations managers depend upon accurate and timely tropical cyclone hazard and impact intelligence to support the challenging decisions that must be made to protect and support people, facilities, assets and investments under potential threat from an impending tropical system. Kinetic Analysis' Real-Time Forecasting System [RTFS] for Tropical Cyclones [TC] , or RTFS-TC, models the core meteorological TC hazards (wind, storm surge, waves and rainfall) and takes that a step further by translating them into tangible impacts, facilitating the ability for emergency planning officials to focus efforts on risk planning and mitigation efforts and less time distilling complex meteorological scenarios.

Kinetic Analysis RTFS-TC Hazard and Impact Model Platform



Hurricane Matthew: Storm History & Impacts in Context

Hurricane Matthew was a prime example of the type / level of forecast and impact uncertainty that arises with tropical cyclone forecasts. The storm initially looked to pass safely east of Florida and later adjusted westward enough that the state experienced severe impacts in the form of wind and coastal inundation from storm surge. Some storm forecasts also projected a potential second landfall in FL, with a retrograde of the storm back to the west; that scenario never came to fruition.

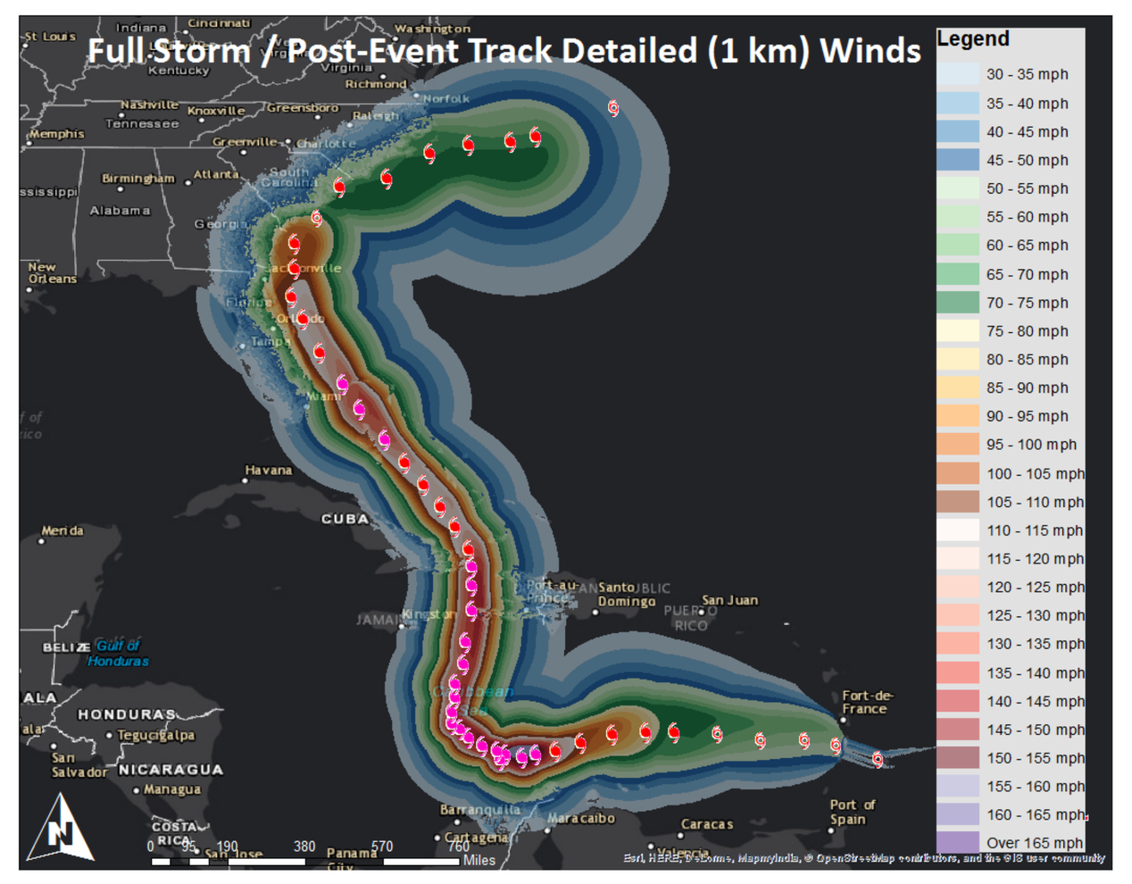
Areas affected by hurricane Matthew in eastern FL have experienced significant population growth over the past few decades, the impact based approach being a good way for Emergency Managers to better asses risk and evacuation plans by taking into account actual assets and socioeconomic exposures in the path of the storm.

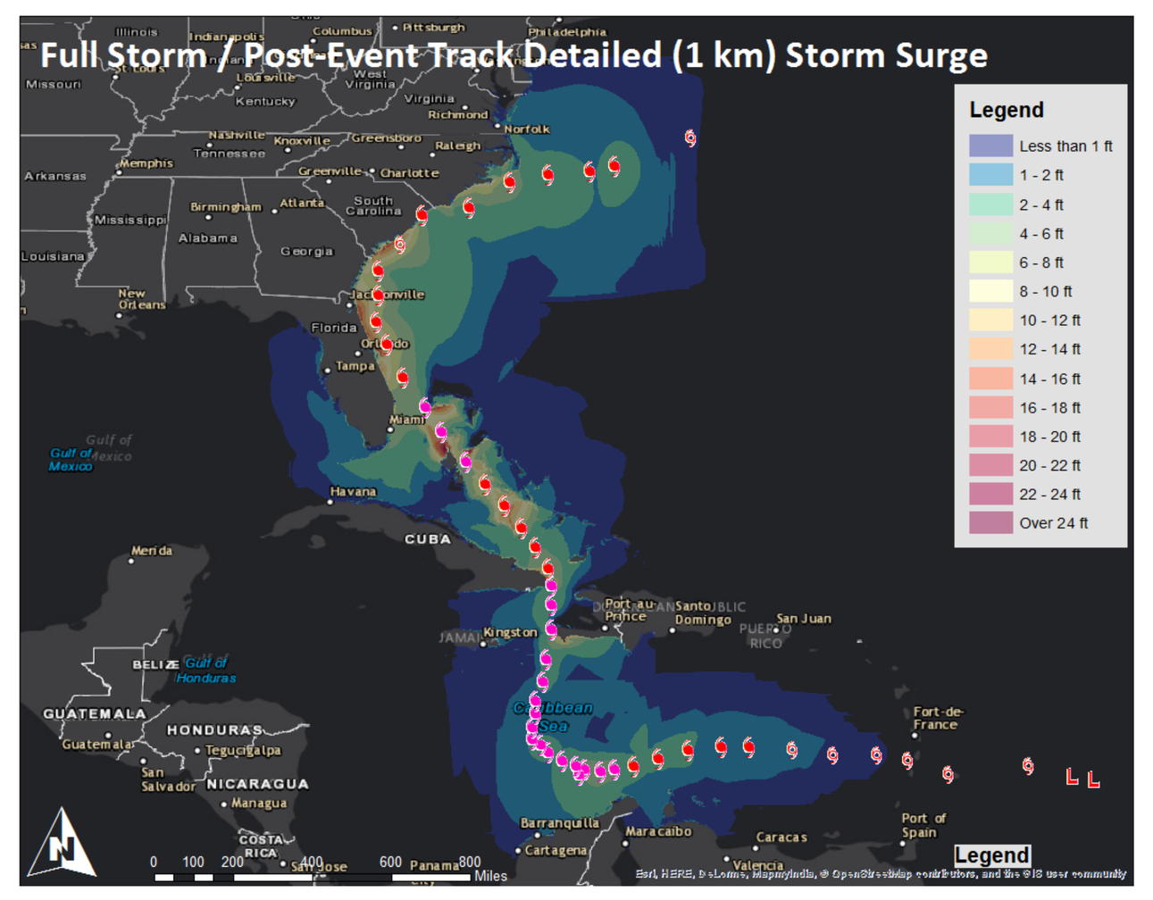
Detailed Hazard-Level Intelligence

Hazard footprints depict the extent of TC perils and severities across areas expected to be affected by the storm as forecast. This information enables identification of locations and assets at risk, and provides concrete estimates of hazard severities at specific locations, for use in emergency decision planning and evaluation.

Specific footprints of the damaging tropical cyclone perils (individually and in combination) and the severities of those hazards across the landscape determine what is at risk of damage from the storm. Tropical cyclone forecasts focus on winds, the primary TC hazard, along with the other core TC perils: storm surge, wave, and rainfall.

Through the RTFS, Kinetic Analysis applies its integrated tropical cyclone hazard and damage modeling platform to convert storm track and intensity forecasts into detailed hazard footprints and damage / impact estimates—such as those shown below—for use in critical emergency and risk management decisions.





RTFS-TC for Operational Decision Making

The RTFS tropical cyclone hazard and impact model platform empowers stakeholders with a holistic view of the potential impacts of an event by translating detailed hazard level intelligence into tangible impacts. Matthew's unique track paralleling the Florida coast affected a large area of exposures vulnerable to wind and surge.

By translating the hazards into specific socioeconomic impacts and asset specific damages better decisions can be made in terms of where to mobilize resources for disaster response and recovery efforts and where to focus scarce resources. Broader publicly available forecast information can be too difficult to interpret, or lacking in site-specific details for those that need quick, actionable information for making decisions to protect life and property.

Key RTFS features that empower operational decision making

Rapidly available and detailed hazard level information: key information/insights available in time to inform critical decisions

- ❑ Full suite of hazard and impact products available for every new forecast issued.
- ❑ Standard resolution products 5-15 minutes after forecast issuance, with detailed hazards within 30 minutes.
- ❑ Wind, storm surge, waves and rainfall depict core hazards across the landscape that are more detailed than those available from publically available sources.

Multi-Model viewpoint: for difficult decisions in the midst of forecast uncertainty

- ❑ Official forecast hazards are complemented by a suite of global and regional hurricane model tracks to project the envelope of possible outcomes not possible with one deterministic dataset.

Socioeconomic and Impact related intelligence: to better understand the expected effects and impacts of current forecasts

- ❑ Population impacts: How many people are affected by specific hazard level severities.
- ❑ Economic damages: Depicts the range of economic damages projected to occur based on the hazards.
- ❑ Asset-specific damages: Asset level damages are dependent upon their response to hazards.

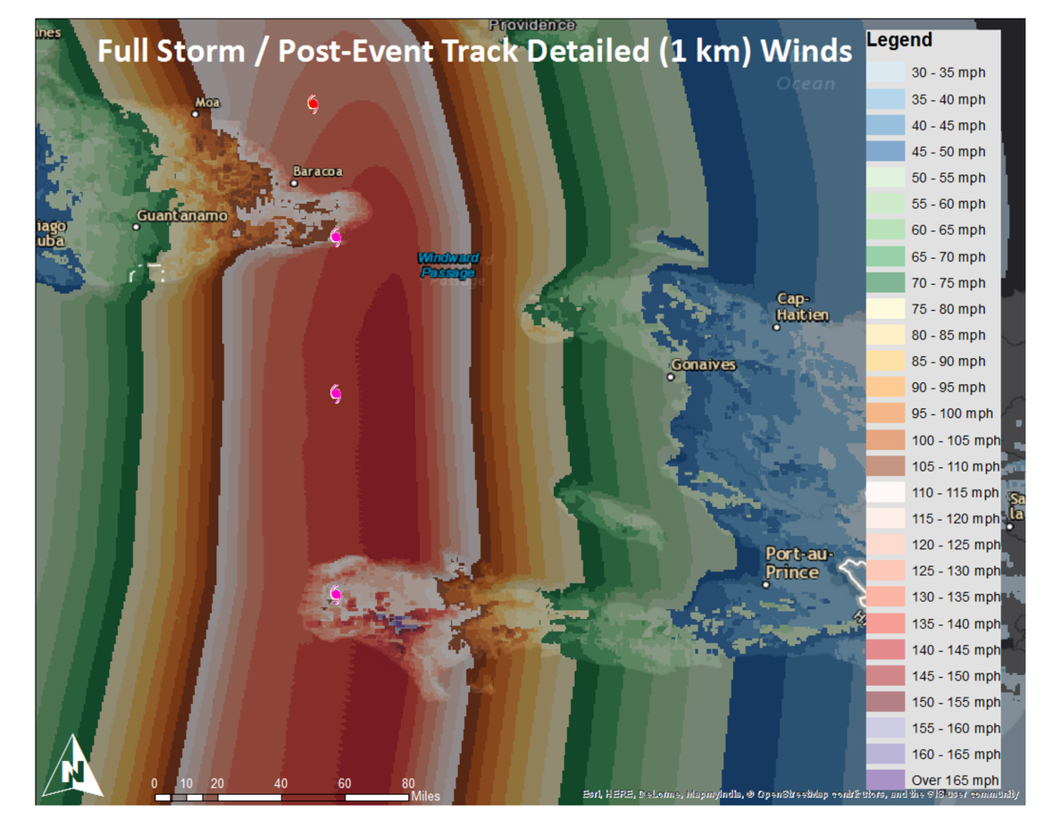
Data formatting and reporting advantages: for easy integration into your workflows

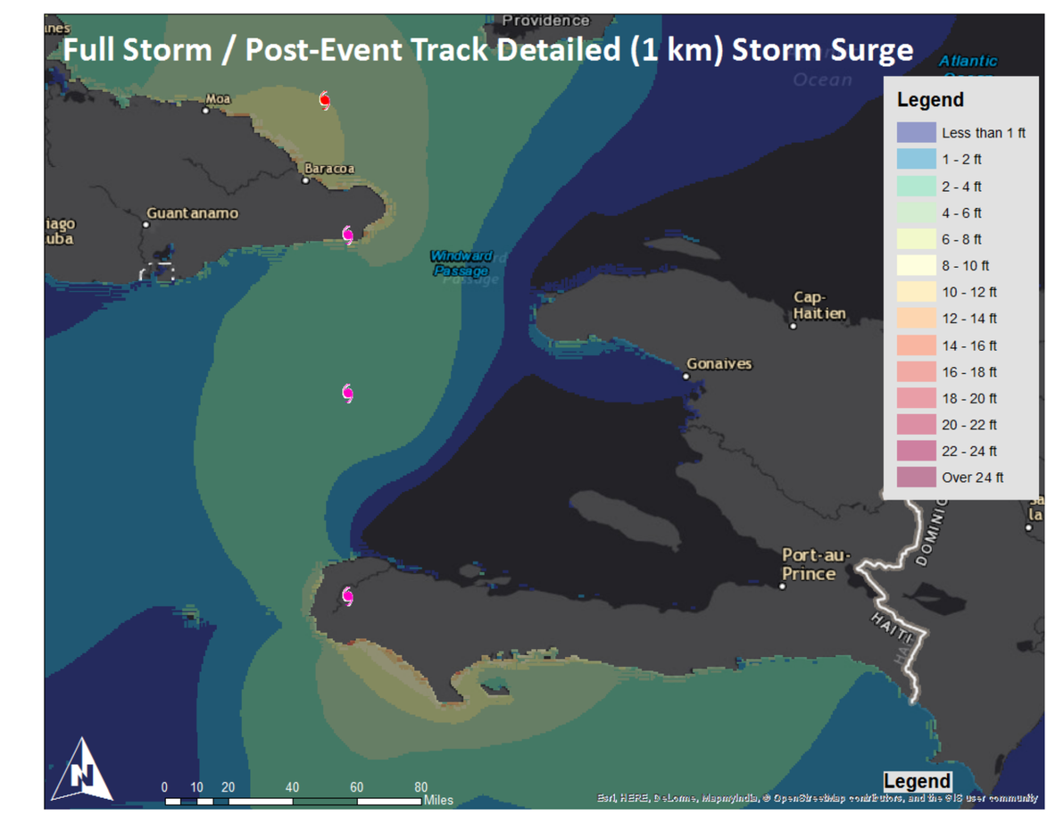
- ❑ Hazards are distributed in GIS formats for easy integration into decision making platforms and operational dashboards.
- ❑ Flexible system allows for a wide variety of situational intelligence reports (PDF, HTML and tabular)
  - ❑ Users can harness the capabilities of the RTFS with or without a GIS enabled system.

Hurricane Matthew Impacts: Haiti

Matthew caused causalities and severe property damage across the Caribbean, with Haiti being particularly hard hit. Economic damages are a lead indicator of the extent and severity of damaging hazard forces and their impact on the type, value and vulnerability of assets exposed to those forces.

Through the Caribbean-based risk insurance pool, CCRIF SPC, Haiti received a payment of just over US $20 million within weeks of the event to support critical response, recovery, and risk reduction measures. Kinetic Analysis' tropical cyclone modeling technology has been used since 2009 by CCRIF to evaluate policy triggers and to calculate payouts for countries with active policies that are affected by tropical cyclone events.





Wind intensity (Saffir-Simpson)	Population Affected (number affected, % of total in Department) Grand'Anse		Nippes		Sud	
- Weak Tropical Storm	424,623	100.0%	307,970	100.0%	726,420	100.0%
- Strong Tropical Storm	424,623	100.0%	306,331	99.5%	726,420	100.0%
- Category 1 (74-95mph)	424,623	100.0%	192,717	62.6%	684,612	94.2%
- Category 2 (95-110mph)	424,623	100.0%	57,757	18.8%	622,410	85.7%
- Category 3 (111-129mph)	403,476	95.0%	8,347	2.7%	480,033	66.1%
- Category 4 (130-156mph)	156,186	36.8%			233,181	32.1%
- Category 5 (over 157mph)	2,857	0.7%			7,510	1.0%

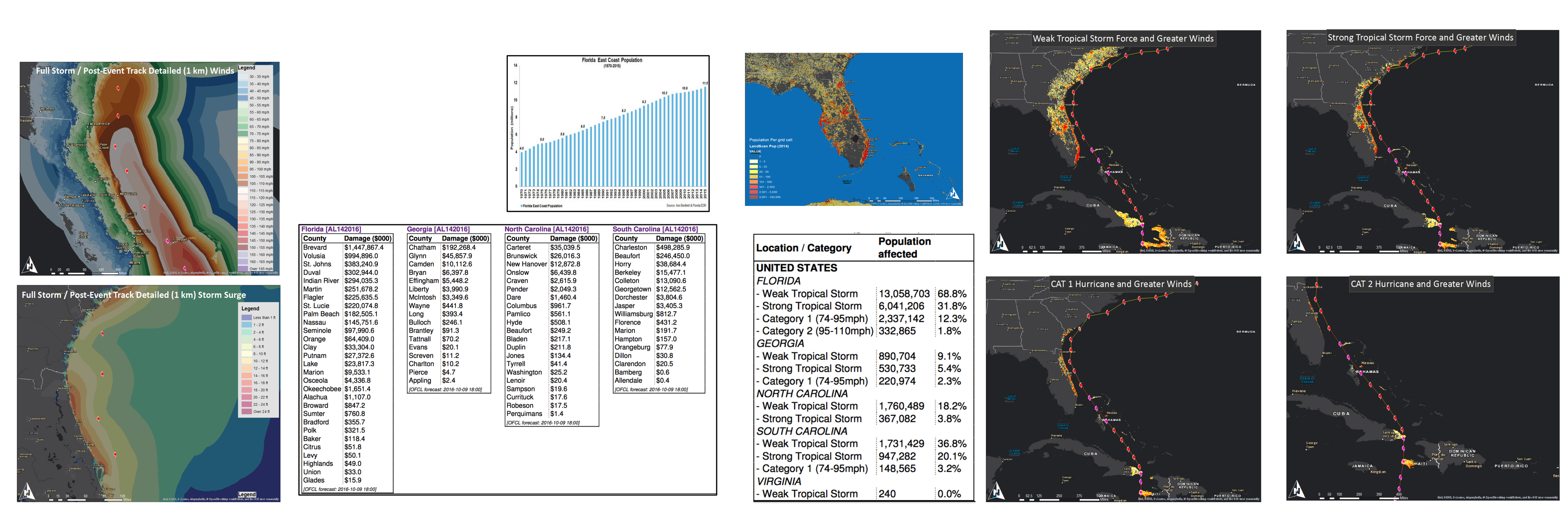
[Note: population counts are inclusive of population affected by weaker wind categories.]

HAITI		
ARTIBONITE	$0.42	$0.00
CENTRE	$0.01	$0.00
GRAND" ANSE	$126.28	$0.45
NIPPES	$12.77	$0.04
NORD	$0.04	$0.00
NORD-EST	$0.00	$0.00
NORD-OUEST	$1.91	$0.00
OUEST	$1.24	$0.00
SUD	$211.66	$0.79
SUD-EST	$0.54	$0.00

Hurricane Matthew Impacts: United States

Areas affected by Hurricane Matthew in Eastern Florida have experienced significant coastal population growth over the past few decades. An impact-based approach is a good way for emergency managers to better assess risk and evacuation plans by considering actual assets.

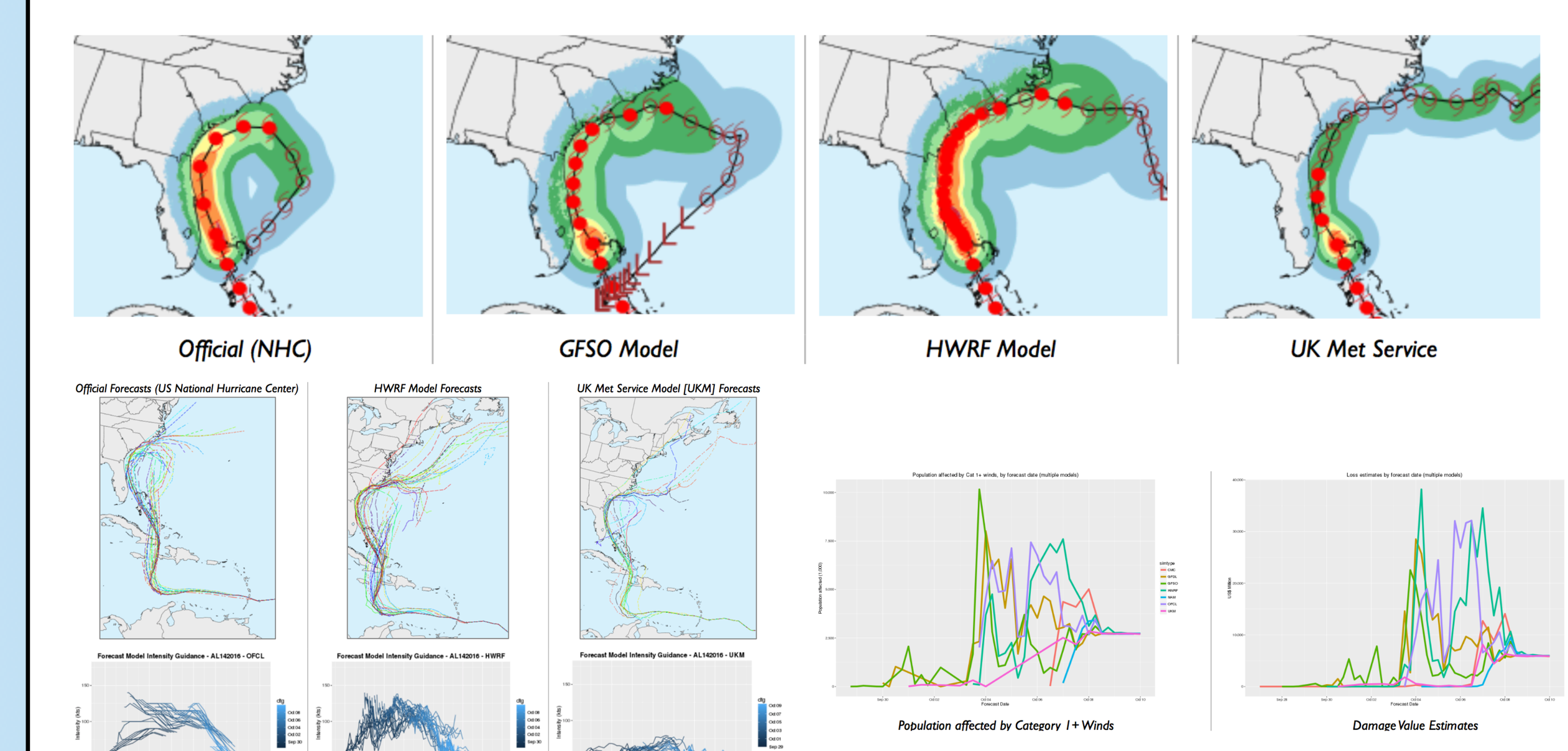
RTFS Population impacts are based upon the intersection of Kinetic Analysis' tropical cyclone wind hazard model footprint and the LandScan population gridded dataset. Underlying the wind hazard footprints (categorized by the Saffir-Simpson Hurricane Wind Scale) is the ambient population as depicted by the LandScan dataset. External socioeconomic information such as this gives decision makers and stakeholders further insight into the population at risk categorized by hazard severity.



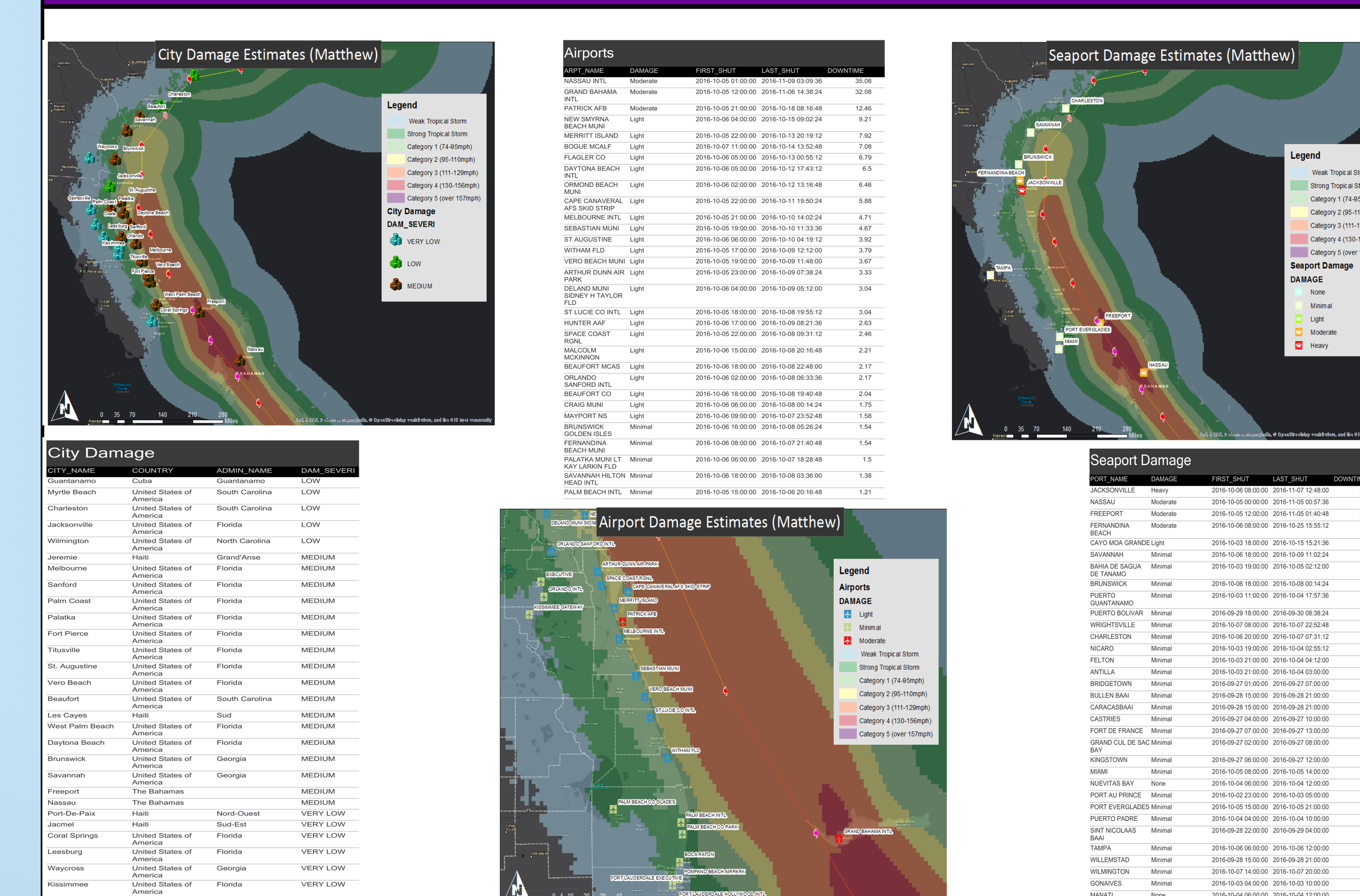
Multi-Forecast Model Impact Estimates

Understanding the strengths and limitations of available forecasts (these forecasts are produced by a variety of organizations such as government meteorological agencies, research centers) as well as the model's performance for a specific event is important in decision-making for an event and helps address—or take into account—the uncertainty inherent in tropical cyclone forecasting.

The figures below shows the track and intensity forecasts for three forecast sources (NHC OFCL, HWRF, UK Met) for Matthew over the full period during which Official forecasts were available; similar information is also available for other active forecast models during a storm's life. The multiple model hazard estimates enable an ensemble of impact estimates to be produced (e.g. damage values and population impacts).



Asset-Specific Impacts: Cities, Ports and Airports



Data Sources

- ❑ LandScan (2014)™ High Resolution global Population Data Set copyrighted by UT-Battelle, LLC, operator of Oak Ridge National Laboratory under Contract No. DE-AC05-00OR22725 with the United States Department of Energy. ORNL's LandScan is the community standard for global population distribution. At 30 arc-second (approximately 1 km) resolution, LandScan is the finest resolution global population distribution data available and represents an "ambient population" (average over 24 hours).
- ❑ Seaports compiled from the NGA World Port Index [http://www.nga.mil/NGAPortal/MSI.portal].
- ❑ Cities compiled from Natural Earth 1:10m ne_10m_populated_places public domain dataset.
- ❑ 'Multi Forecast Model Impact' maps created with NCL: The NCAR Command Language (Version 6.1.2) [Software]. (2013). Boulder, Colorado: UCAR/NCAR/CISL/TDD. http://doi.org/10.5065/D6WD3XH5

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