THE VERSION 17.0 RMS NORTH ATLANTIC HURRICANE UPDATE

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RISK MANAGEMENT SOLUTIONS

MARCH 19, 2018

KEY APPLICATIONS OF CATASTROPHE MODELS

Portfolio Management

- Determine drivers of risk
- Evaluate capital adequacy
- Develop a consistent view of risk across an organization
- Insights on how to diversify you risk

Risk Transfer

- Determine reinsurance needs or alternative forms of capital
- Structure and price risk transfer
- Used as a "common currency"

Risk Selection, Underwriting and Pricing

- Analyze policy structures
- Differentiate risks more effectively
- Establish risk selection and underwriting guidelines
- Develop rating criteria

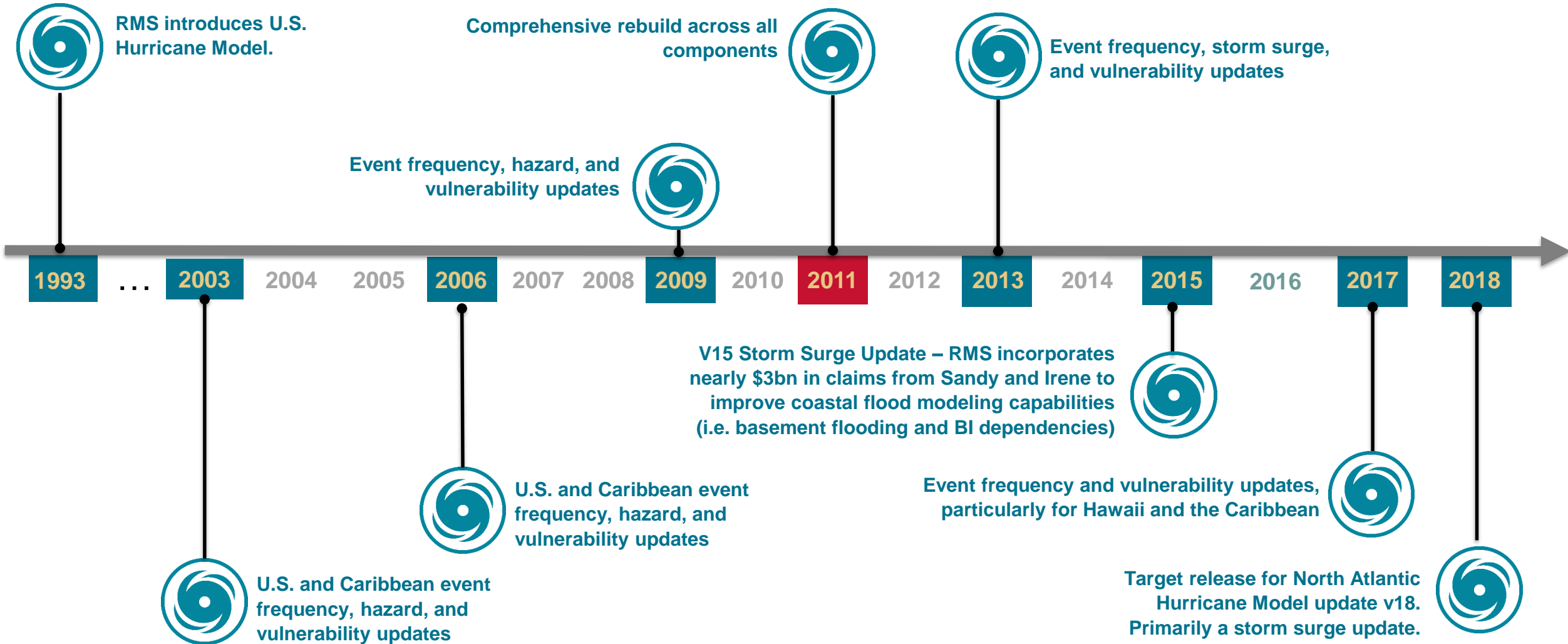# WHAT DRIVES MODEL AND DATA DEVELOPMENT AT RMS?

Market / External Priorities

- Client feedback
- Market trends/needs
- New data/science
- New technology/methods
- Real-time events
- Regulatory triggers (i.e. FCHLPM)

RMS / Internal Priorities

- RMS strategy
- RMS innovation
- Resources
- Delivery mechanism

TIMELINE OF RMS NORTH ATLANTIC HURRICANE MODELS

RMS introduces U.S. Hurricane Model.

Comprehensive rebuild across all components

Event frequency, storm surge, and vulnerability updates

Event frequency, hazard, and vulnerability updates

1993 . . . **2003** 2004 2005 **2006** 2007 2008 **2009** 2010 **2011** 2012 **2013** 2014 **2015** 2016 **2017** **2018**

V15 Storm Surge Update – RMS incorporates nearly $3bn in claims from Sandy and Irene to improve coastal flood modeling capabilities (i.e. basement flooding and BI dependencies)

U.S. and Caribbean event frequency, hazard, and vulnerability updates

Event frequency and vulnerability updates, particularly for Hawaii and the Caribbean

U.S. and Caribbean event frequency, hazard, and vulnerability updates

Target release for North Atlantic Hurricane Model update v18. Primarily a storm surge update.

RATIONALE FOR VERSION 17.0 RMS NORTH ATLANTIC HURRICANE UPDATE

- Keep the view of hurricane risk up-to-date

- Reflect the RMS commitment to continuous improvement of our cat models

- Demonstrate commitment to hurricane modeling outside of mainland United States

- Comply with the standards of the Florida Commission on Hurricane Loss Projection Methodology (FCHLPM)

Not a complete rebuild of the model -- interim update

Released Spring 2017

EVENT FREQUENCY UPDATES

LONG TERM RATES (LTR) – AT A GLANCE

- Long term rates assume that future average activity matches the historical average

- RMS uses HURDAT2 data since 1900 to find track intersections with gates ('landfall')

- Smoothing process prevents 'overfitting' to data at too small of a scale

- LTRs are updated every 2 years in the U.S. to comply with standards put forth by the FCHLPM
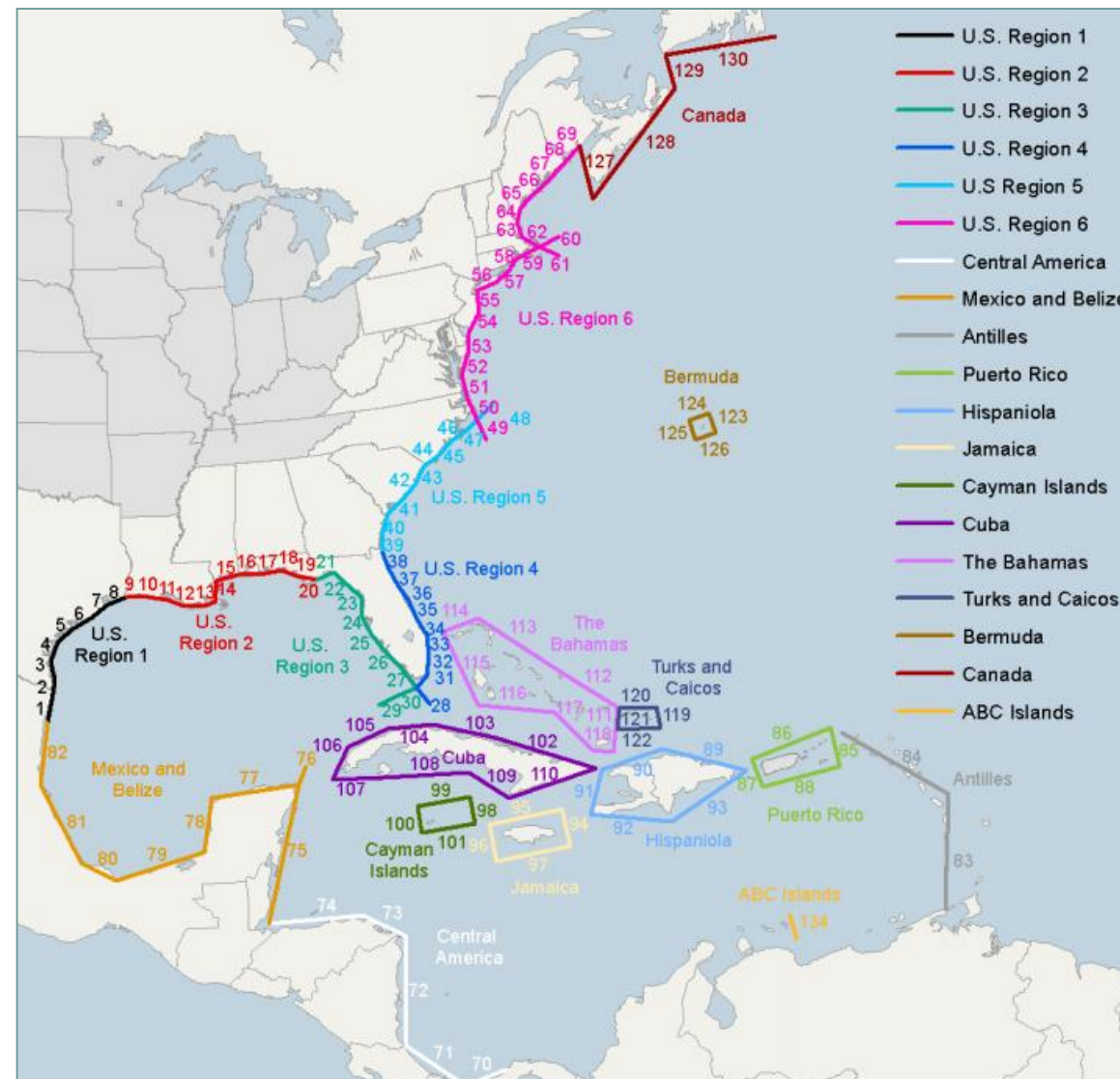
VERSION 17 LONG-TERM RATES UPDATE

- Objective

  – Keep RMS view of hurricane risk up-to-date by incorporating recent research, data on hurricane activity rates
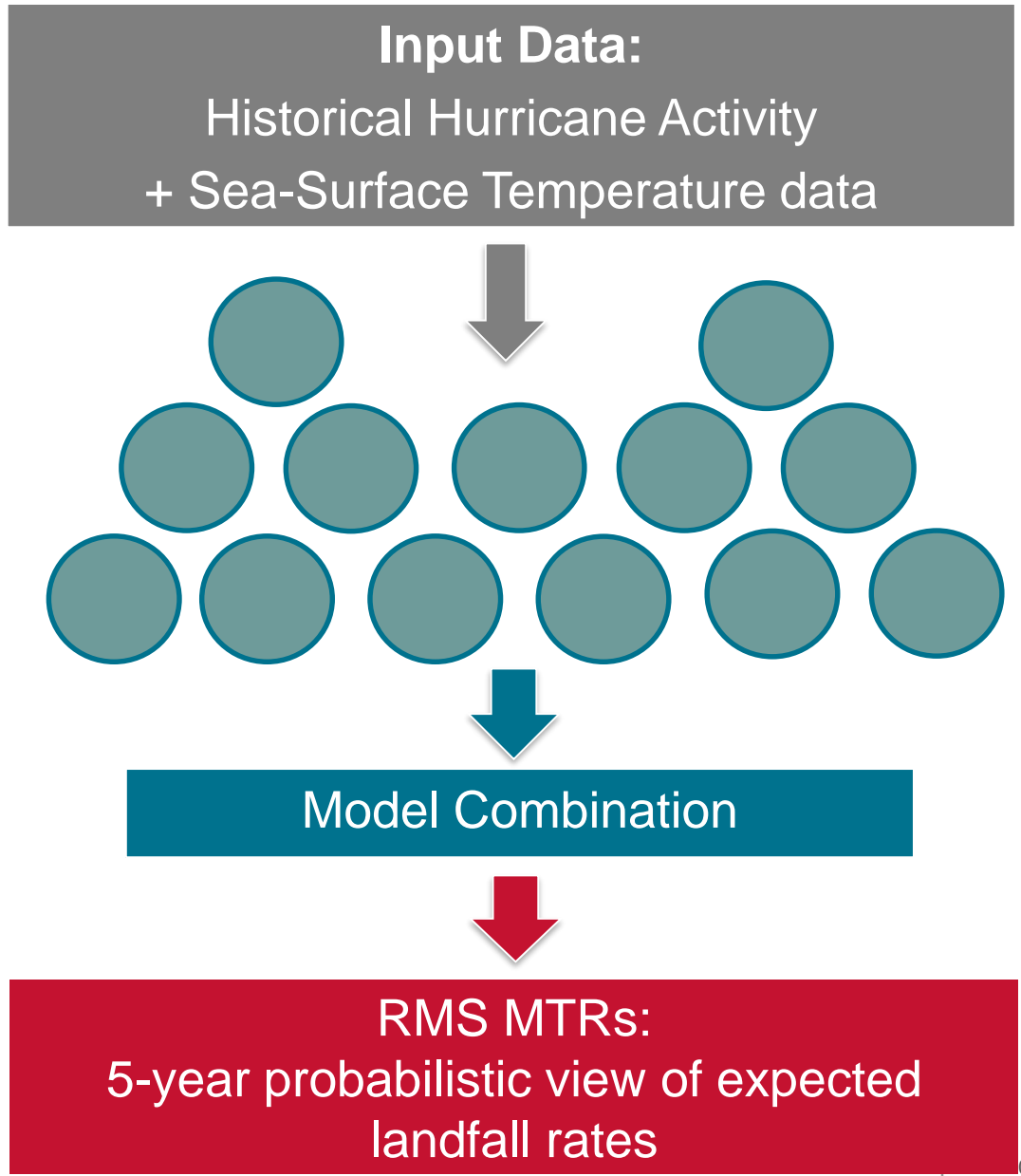
- Scope

  – All N. Atlantic hurricane regions:

    • Two additional seasons of N. Atlantic Basin hurricane data (2013 and 2014)

    • Updated tracks and/or wind fields for 25 historical storms (1946-1955) as part of HURDAT2 Reanalysis project

  – Hawaii

    • Eight additional years of hurricane data (2007-2014)

	Version 15	**Version 17**
Years	1900-2012	1900-2014
HURDAT2 Reanalysis	Up to 1945	Up to 1955*

* Prior updates to HURDAT have been reflected in previous releases

March 29, 2018

MEDIUM-TERM RATES (MTR) – AT A GLANCE

- RMS reference view of North Atlantic hurricane risk

- **Annually reviewed forecast of expected landfalling hurricane activity over five years**

  - Projects hurricane landfall activity given current climate state

  - Based on a weighted average of 13 statistical forecast models

  - Models support different theories and assumptions explaining the multi-decadal variability of Atlantic hurricane activity

  - Models weighted by how well they hindcast past historical activity

Input Data:
Historical Hurricane Activity
+ Sea-Surface Temperature data

Model Combination

RMS MTRs:
5-year probabilistic view of expected landfall rates

VERSION 17 MEDIUM-TERM RATES UPDATE

- Objective

  – Keep RMS view of hurricane risk up-to-date by incorporating recent research, data on hurricane activity rates

- Scope

  – New forecast applies to 2017-2021 period

  – New methods and enhancements

  – New data

    • Three additional seasons of N. Atlantic Basin hurricane data

    • Updated historical sea surface temperatures

    • Forecast sea surface temperatures

    • Updates to select historical storms (1951-1960) as part of HURDAT2 Reanalysis

VULNERABILITY UPDATES

RMS

VULNERABILITY – AT A GLANCE

- Models incorporate hundreds of unique vulnerability curves across multiple lines of business, regions, and building characteristics

- Developed using historical loss data, building codes, published studies, and consultations with engineering experts

- Validated against extensive location-level claims and exposure data
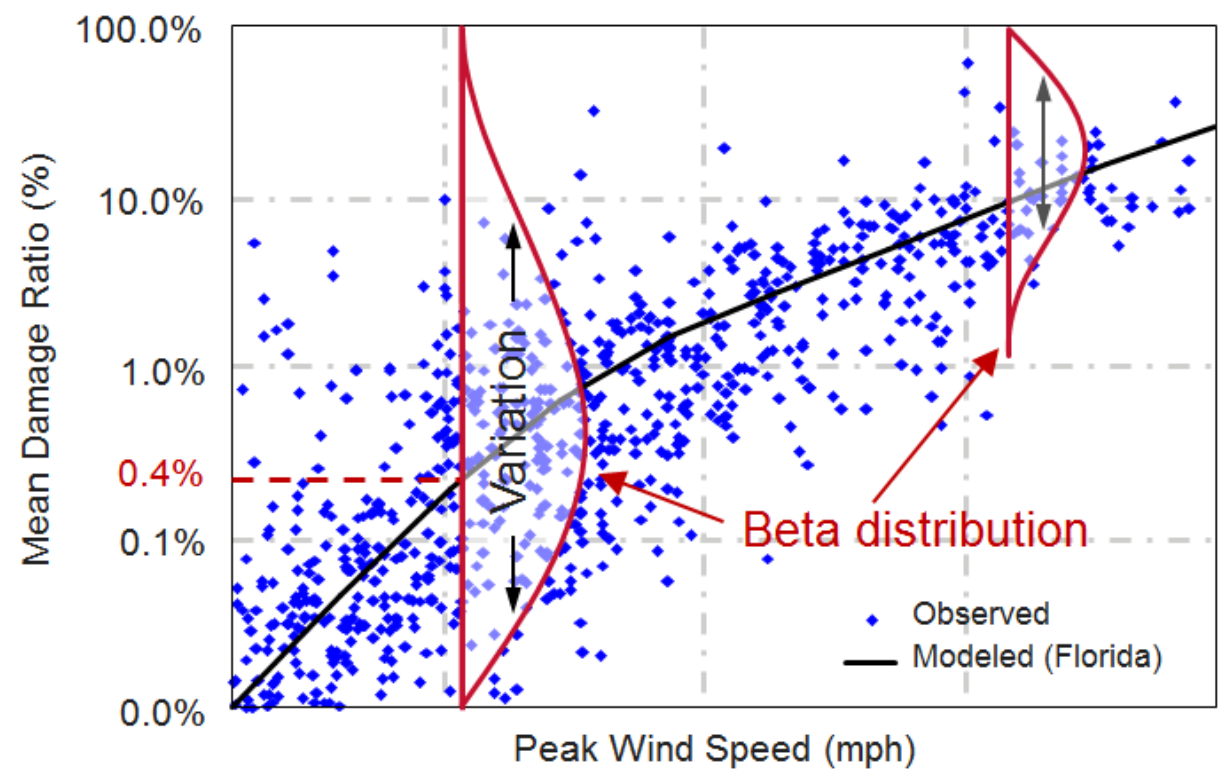
VERSION 17 VULNERABILITY UPDATES

- Objective

  – Strengthen vulnerability modeling, particularly outside the U.S. mainland

  – Develop higher fidelity representations of structures at risk to support more granular risk differentiation, selection, and pricing decisions

  – Better reflect latest market practices

- Rationale

  – New claims data from recent events

  – Reanalysis of existing claims from past hurricane seasons (2004, 2005, 2012)

  – New insights into local building codes, construction practices, and structural performance driven by RMS proprietary research and reconnaissance

  – Published research from the Insurance Institute for Business and Home Safety (IBHS)

VERSION 17 HURRICANE VULNERABILITY UPDATES

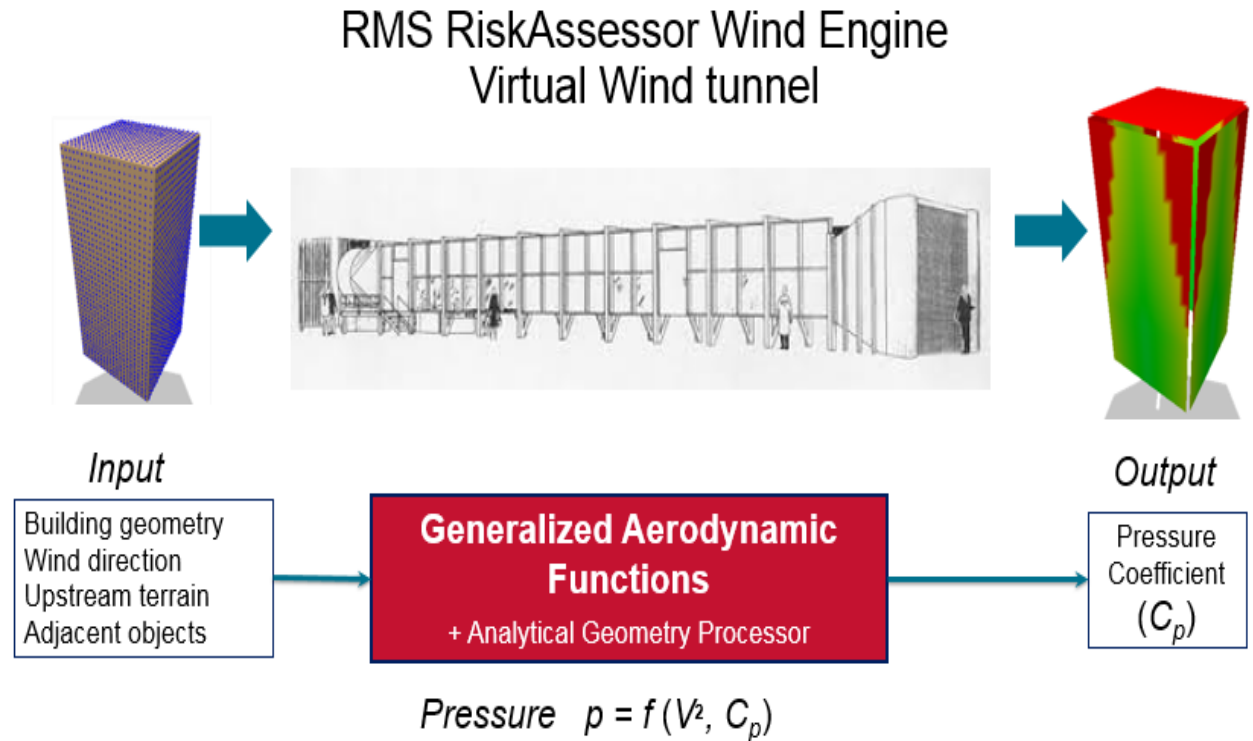| Update	U.S. mainland	Hawaii	Canada	Caribbean	Mexico / Central America
Residential vulnerability updates • Multi-family dwelling recalibration • Manufactured home differentiation	X	*	X	*	*
Primary characteristic updates • Newly supported masonry construction classes • New floor-area bands for low-rise commercial	X	X	X	X	X
Regional recalibration		X		X	X
Secondary modifier option updates	X	X	X	X	X
Changes to specific lines of business	X	X	X	X	X

RESIDENTIAL VULNERABILITY UPDATES
MULTI-FAMILY DWELLING RECALIBRATION

- Revised curves for multi-family dwelling and condominium curves

- Based on the following:

  - Proprietary analytical models simulating expected exterior and interior damage during hurricanes for typical building configurations

  - Reanalysis of location-level claims data from recent events, enhanced with information on building height

RMS RiskAssessor Wind Engine
Virtual Wind tunnel

Input
Building geometry
Wind direction
Upstream terrain
Adjacent objects

Generalized Aerodynamic Functions
+ Analytical Geometry Processor

Output
Pressure Coefficient (C_p)

Pressure $p = f(V^2, C_p)$

RESIDENTIAL VULNERABILITY UPDATES
MULTI-FAMILY DWELLING RECALIBRATION: BROWNSTONES

- Mid-rise, masonry MFDs built before 1994

- Prevalent in Northeast and Mid-Atlantic

- Brownstone-style features typically consist of

  – Fewer exposed openings

  – Increased roof area

  – Reduced edge zones

- All contribute to a lower overall susceptibility to hurricanes
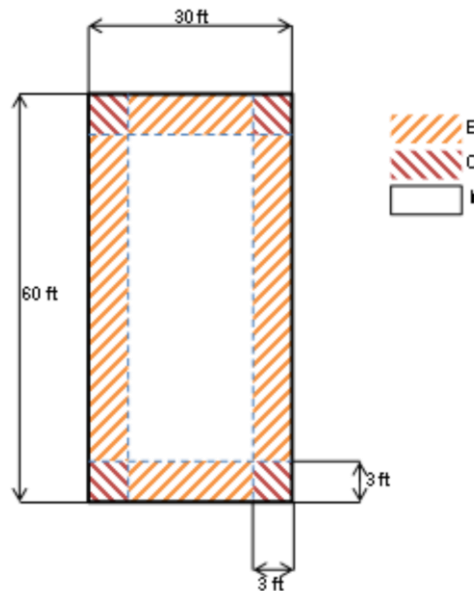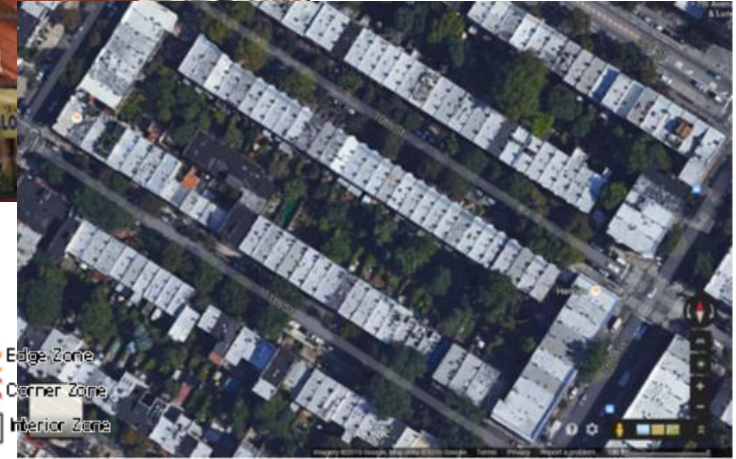
RESIDENTIAL VULNERABILITY UPDATES
MANUFACTURED HOMES

- New and revised year-built bands

- Based on updated installation standards, new claims data, reanalysis of existing claims, and IBHS research

Source: IBHS

PRIMARY CHARACTERISTIC UPDATES
NEWLY-SUPPORTED MASONRY CONSTRUCTION CLASSES

- New vulnerability curves for unreinforced and reinforced masonry classes

- Based on IBHS testing

- Ultimate loss changes dependent upon year of construction

PRIMARY CHARACTERISTIC UPDATES
LOW-RISE COMMERCIAL FLOOR AREA

- Expands ability to differentiate low-rise commercial risks by total building square footage

- Based on claims data analysis and research from previous model updates, which determined that normalized loss ratios tend to decrease with increasing building size

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VULNERABILITY UPDATES
HAWAII
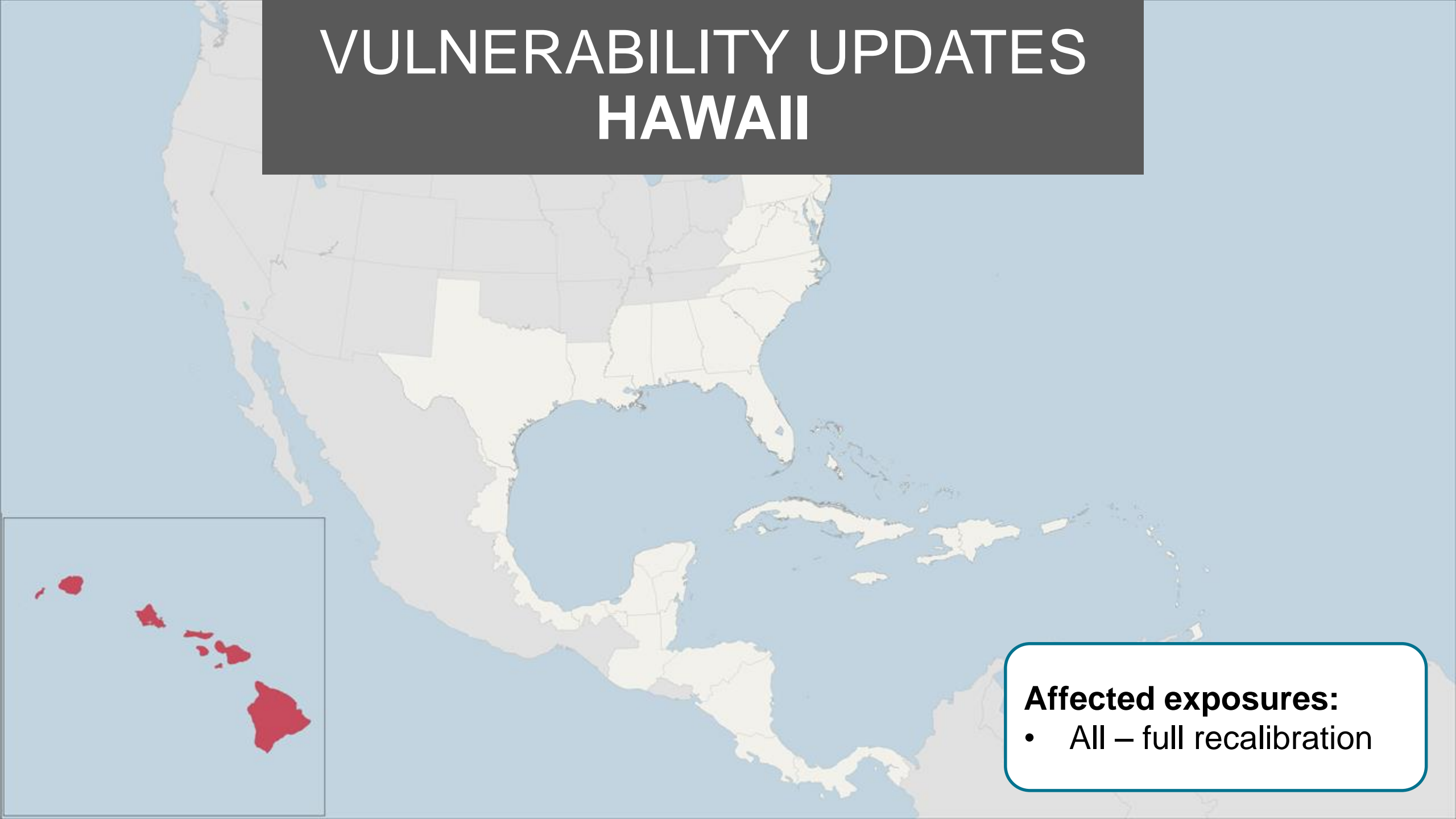
Affected exposures:
- All – full recalibration

REGIONAL RECALIBRATION – HAWAII

- Full recalibration of wind and surge vulnerability curves

  - U.S. mainland experience and past model updates

    - Commercial height band revisions

    - Single-family dwelling floor area revisions

  - Updated storm surge vulnerability curves

- Represent unique features of Hawaiian Islands

  - Detailed research of local building practices

    - Wood construction

    - New year-built bands

    - Temporary lodging, agriculture, and education

- Building inventory updates

- Updated Builders Risk Model

- Updated Industrial Facilities Model

Most significant update since 2007
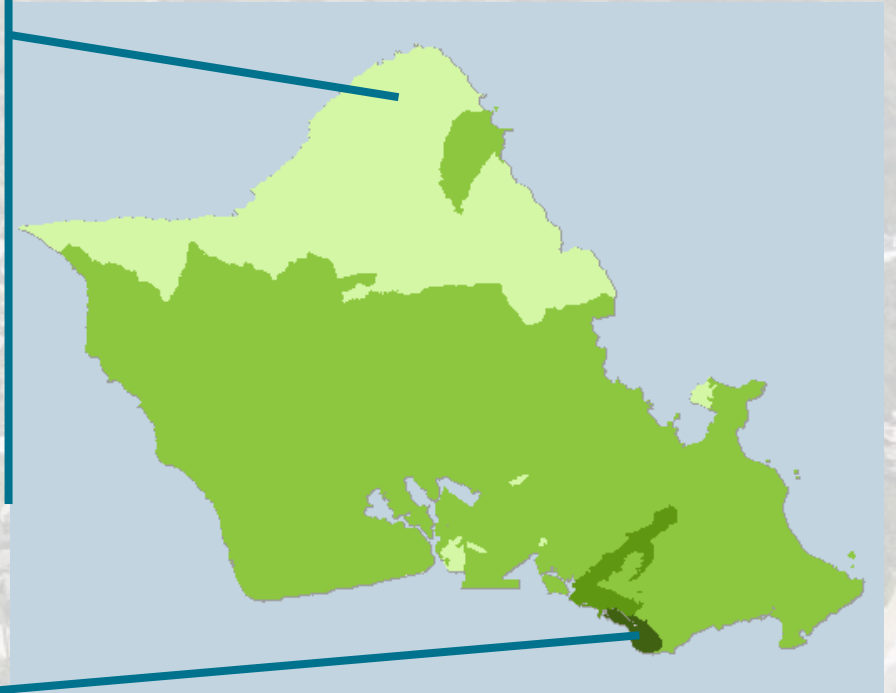
HAWAII VULNERABILITY

WOOD CONSTRUCTION
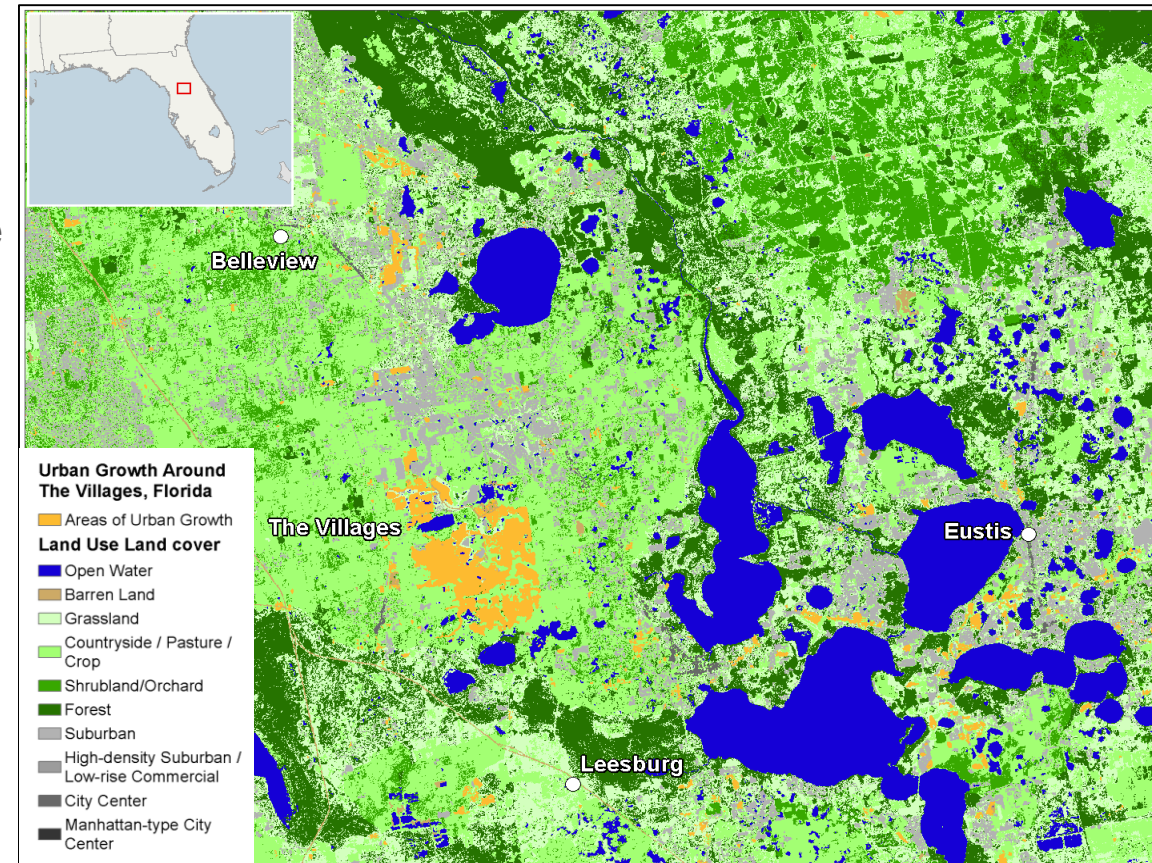
SINGLE WALL

DOUBLE WALL

HAWAII VULNERABILITY

BUILDING INVENTORY

VERSION 17 RMS NORTH ATLANTIC HURRICANE UPDATE
APPLICATIONS: UNDERWRITING AND RATEMAKING

- Identify, select, and underwrite hurricane risk with confidence that it reflects a current view of the hurricane risk landscape

- Implement wind-related risk selection and underwriting guidelines at the local level in Florida, based on a more accurate representation of local wind hazard

- Differentiate risks with granularity within and across regions and building characteristics utilizing the suite of vulnerability updates

- Set rating factors or by-peril rating plans, and define territories using up-to-date loss and loss cost metrics

- Quantify the impacts of mitigation against a broader suite of secondary modifiers to inform more suitable pricing

Urban Growth Around The Villages, Florida
- Areas of Urban Growth

Land Use Land cover
- Open Water
- Barren Land
- Grassland
- Countryside / Pasture / Crop
- Shrubland/Orchard
- Forest
- Suburban
- High-density Suburban / Low-rise Commercial
- City Center
- Manhattan-type City Center

Land use-land cover data – The Villages, Florida

WHAT'S NEXT?

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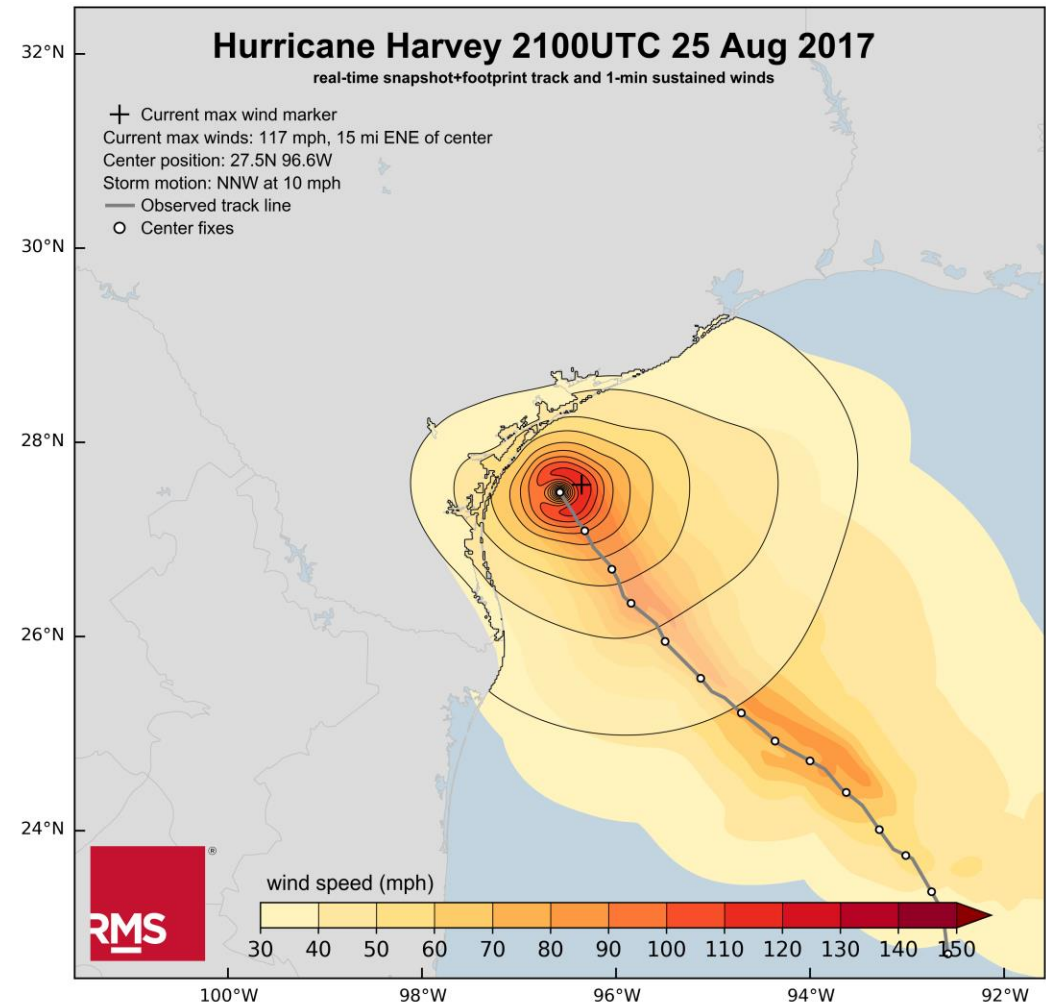
RMS NORTH ATLANTIC HURRICANE MODELS 2-YR ROADMAP

- Planned updates in 2018 and 2019

- Continue to keep the view of hurricane risk up-to-date and expand the comprehensiveness of the model suite for use within the (re)insurance market

- Use real-time events as an opportunity to further validate and understand where the models are working well, and where there is opportunity for improvement

- Continue to comply with regulatory requirements (i.e. FCHLPM)

RMS HWind Continuous Wind Hazard Footprint

Source: RMS

SUMMARY AND CONCLUSIONS

- In 2017, RMS updated its North Atlantic Hurricane Model suite, which consisted of enhancements to the event frequency and vulnerability components. The release helped reflect a current and accurate view of hurricane risk, supporting key underwriting and ratemaking applications

- However, even as models like RMS North Atlantic Hurricane continue to improve, uncertainty remains and learning is ongoing. One size doesn't fit all

- When using models, it's important to own your view of risk by asking questions, and understanding model sensitivities, limits, and uncertainties

- Catastrophe models only represent part of the risk assessment, underwriting, and ratemaking process. Other information must be considered as well, such as the data quality, sources of non-modeled loss, and the overall goals of the organization