

Looking Back at an Active 2017 Hurricane Season

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AIR WORLDWIDE®

Meet the Speakers



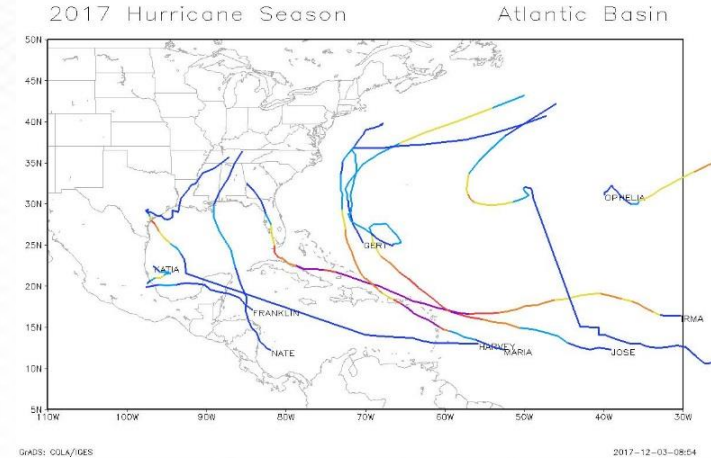
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Senior Engineer
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Agenda

- Season overview
- Noteworthy records
- Details of Irma and Maria

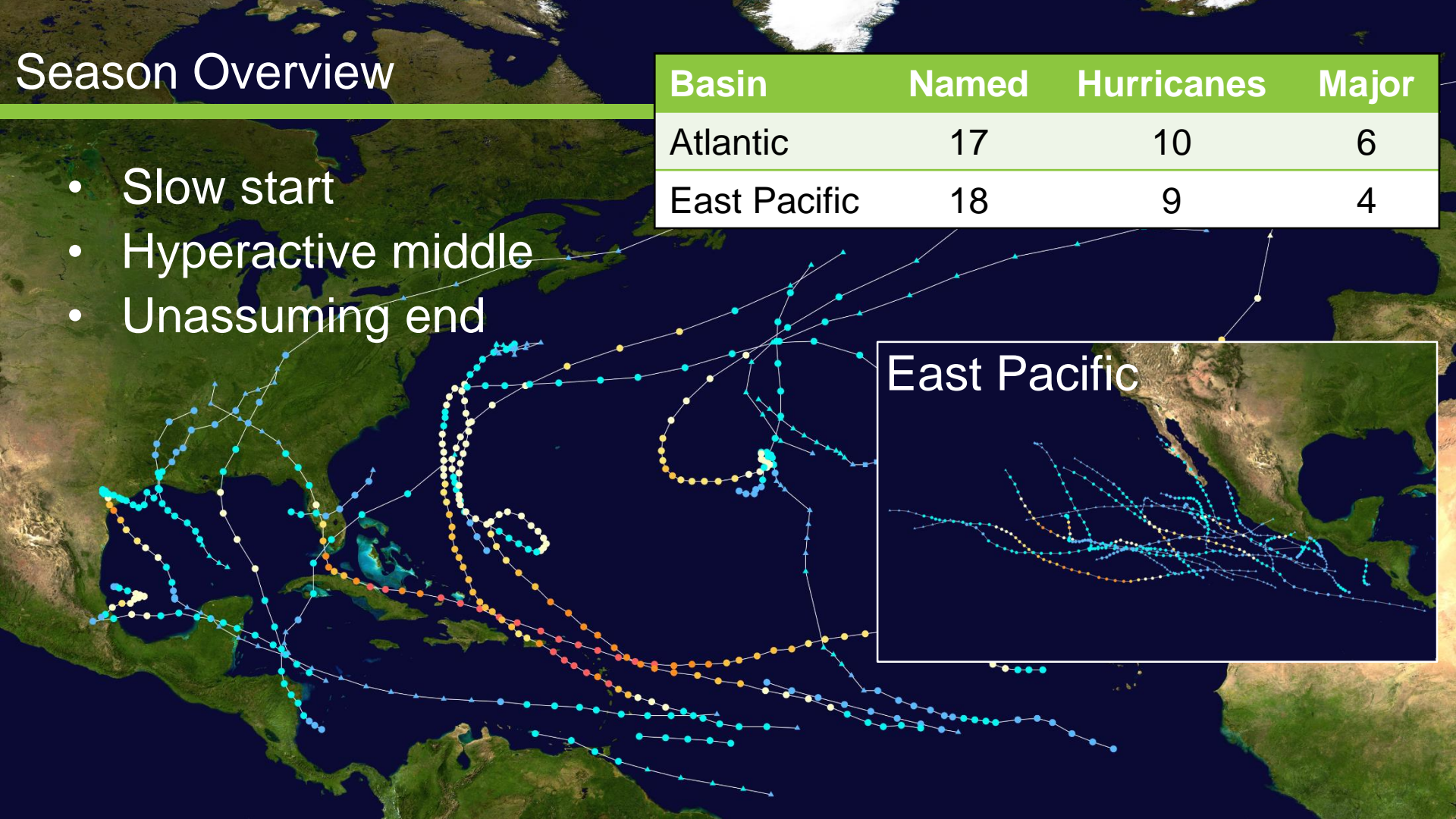


- Maria damage survey
- Irma and Maria loss estimate breakdowns
- Q & A

Season Overview

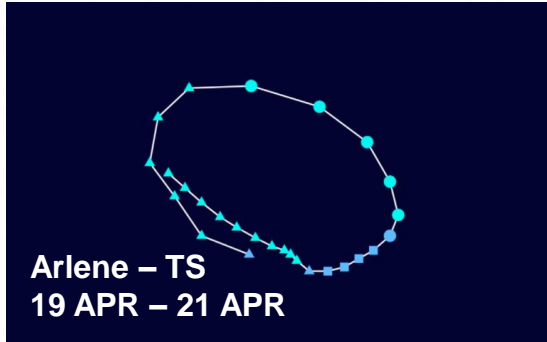
- Slow start
- Hyperactive middle
- Unassuming end

Basin	Named	Hurricanes	Major
Atlantic	17	10	6
East Pacific	18	9	4



In the Beginning...

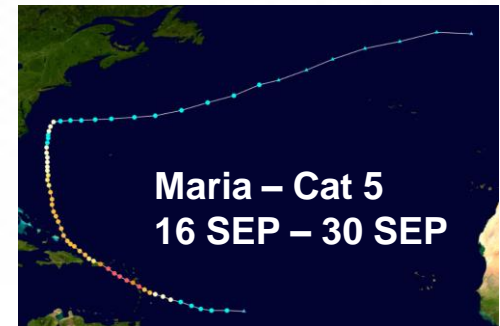
- Early start, then not much activity
- Six storms and just one hurricane (Franklin)
- Similar to 2011



Then It Got Interesting—and *Really* Intense!



- Frequency and intensity increase dramatically
- Harvey breaks the drought
- Irma wreaks havoc
- Maria bisects Puerto Rico



The Season Ends Quietly

- Only one more hurricane landfall after Maria (Nate)
- Less landfall activity than in '04 or '05

Year	Named	Hurricanes	U.S. Mainland	
			Hurricane Landfalls	Major Hurricane Landfalls
2017	17	10	3	2
2004	15	8	4	4
2005	28	15	6	4

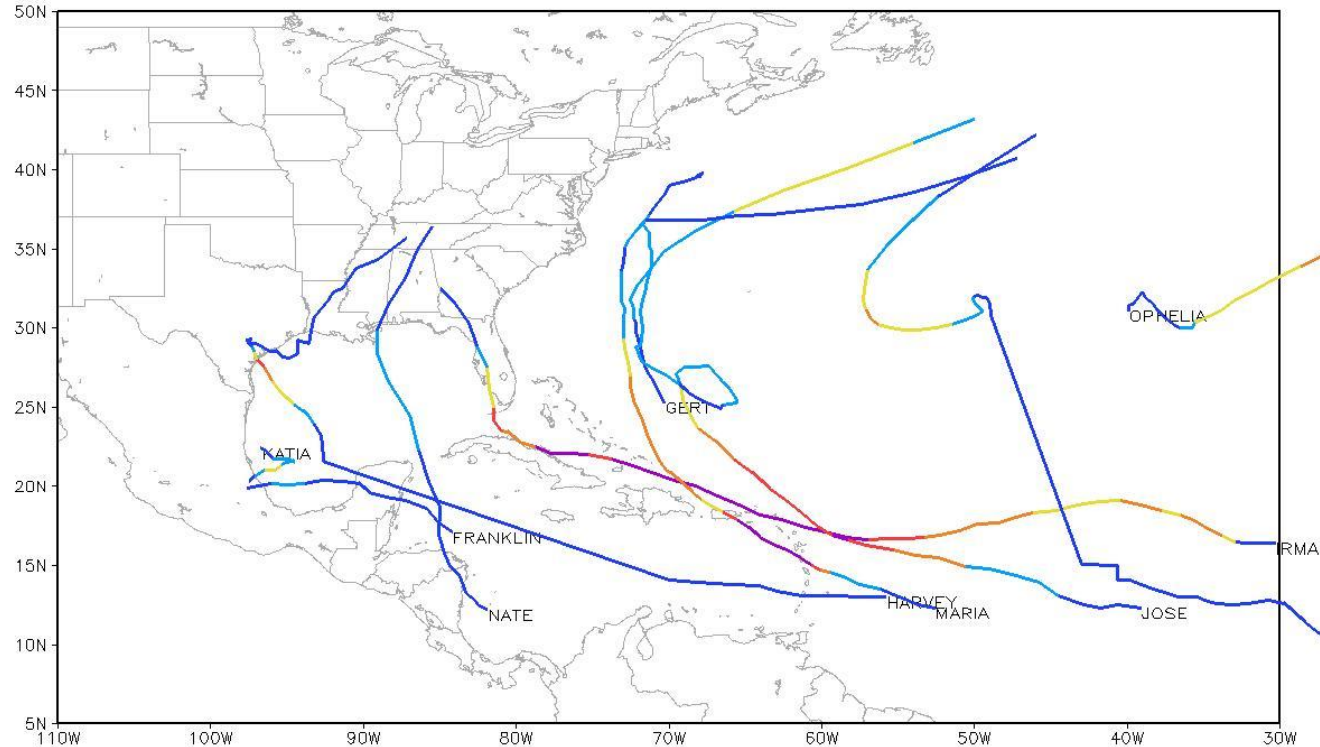


Some Noteworthy Records Set in 2017

- 2 Cat 4 landfalls in 15 days
- 2 Cat 4s at the same time
- 3 hurricanes at same time
- 3 Cat 4 landfalls in U.S./Territories
- 4 hurricanes in August
- 10 hurricanes in a row

2017 Hurricane Season

Atlantic Basin



How Well Did the Seasonal Forecasts Perform?

June 1 Forecasts:

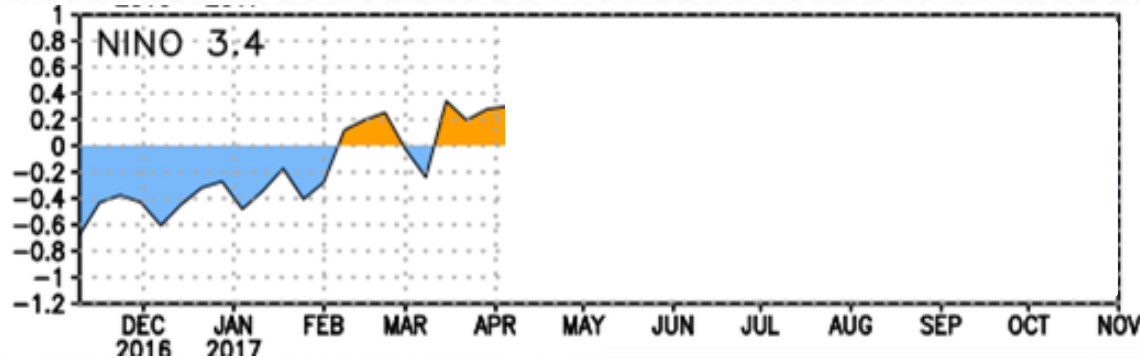
Source	Named Storms	Hurricanes	Major Hurricanes
Climatological Average	12.1	6.4	2.7
Tropical Storm Risk	10 - 18	3 - 9	1 - 5
Colorado State Univ.	14	6	2
Weather.com	14	7	3
N. Carolina State Univ.	11 - 15	4 - 6	1 - 3
AccuWeather	10	5	3
NOAA	11 - 17	5 - 9	2 - 4

The Forecast Picture Changed by August...

August 1 Forecasts:

Source	Named Storms	Hurricanes	Major Hurricanes
Climatological Average	12.1	6.4	2.7
Tropical Storm Risk	17(± 3)	7(± 2)	3 (± 1)
Colorado State Univ.	16	8	3
Weather.com	15	8	3
N. Carolina State Univ.	11-15	4-6	1-3
AccuWeather	11-15	6-9	3-4
NOAA	14-19	5-9	2-5
Actuals	17	10	6

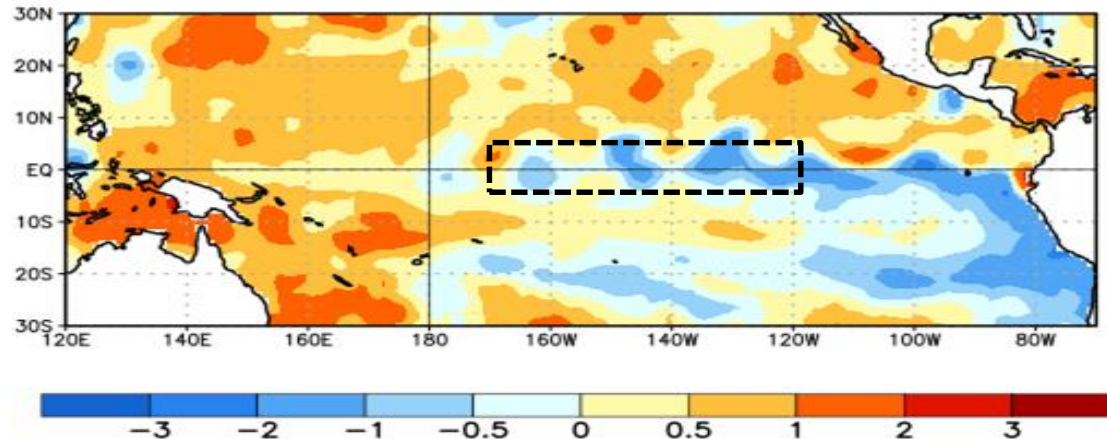
No El Niño Meant Increased Activity



- In April, models and climate experts were predicting an El Niño to develop
- By July, that looked to be the case

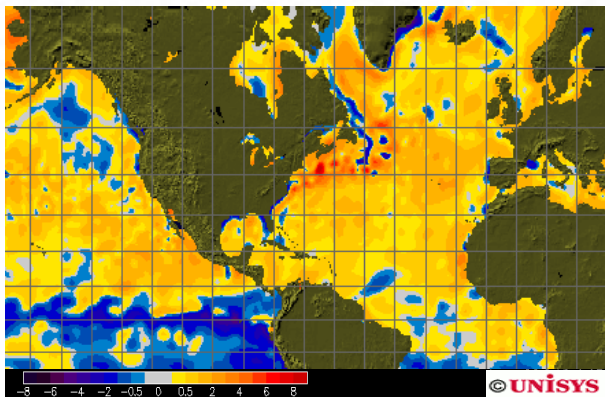
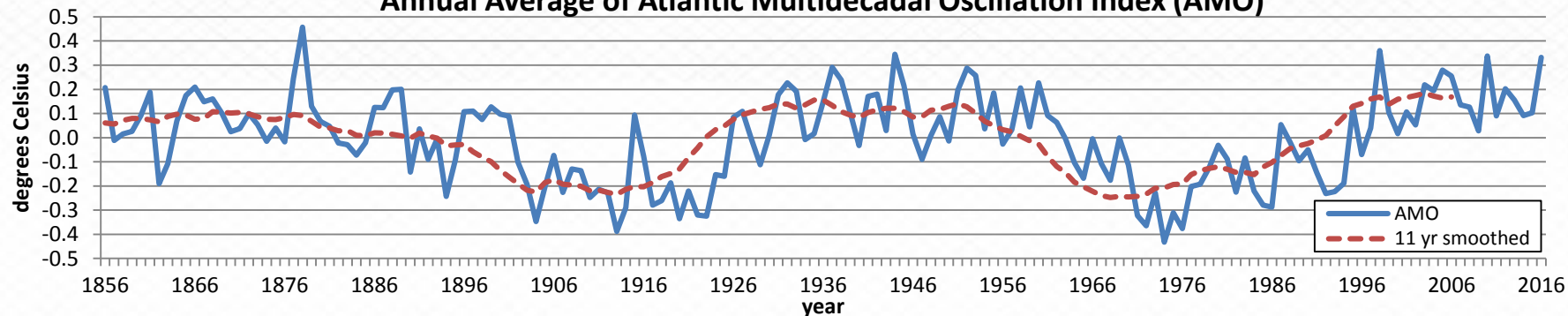
- Late July forecasts called for a weak La Niña to develop
- Where did we end up?

SST Anomalies (°C)
01 NOV 2017

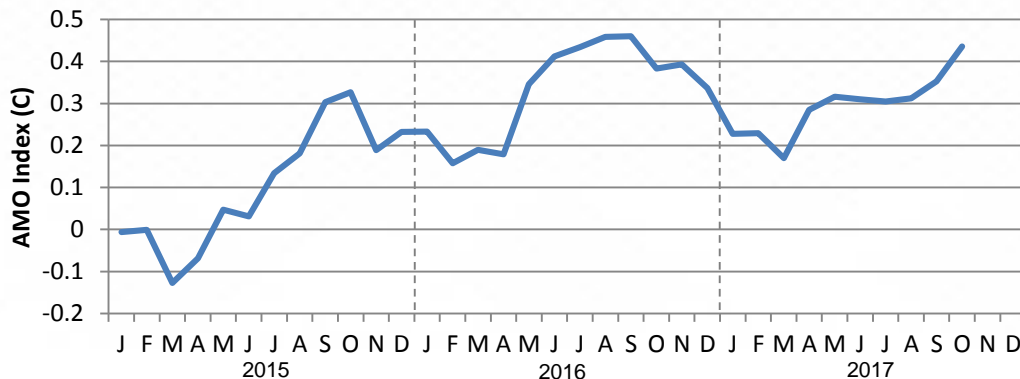


The AMO Stayed Positive

Annual Average of Atlantic Multidecadal Oscillation Index (AMO)



AMO Index From Jan 2015-Oct 2017





Read more on our blog: [The AMO – Staying Positive and Defying Expectations](#)

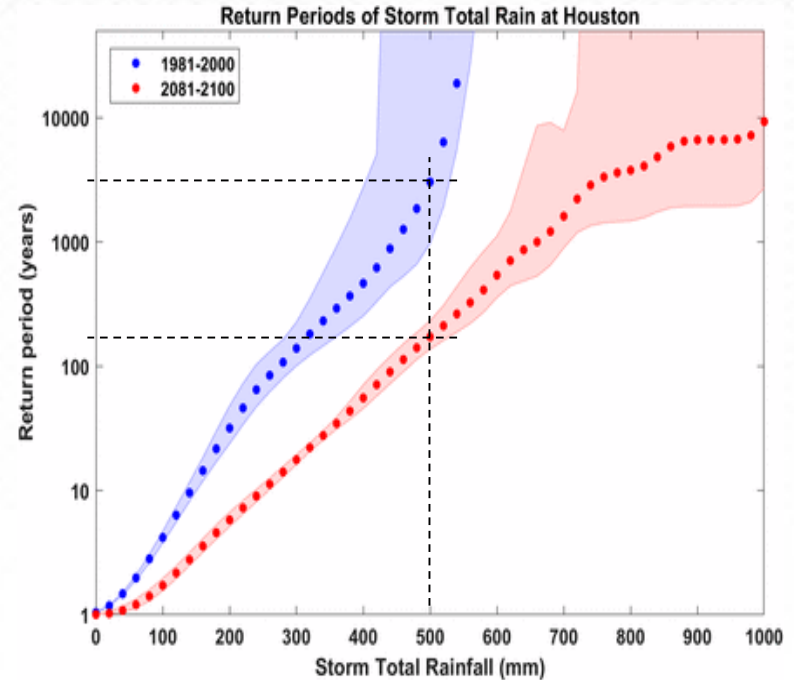
Did Climate Change Play a Role?



[Download the Whitepaper](#)

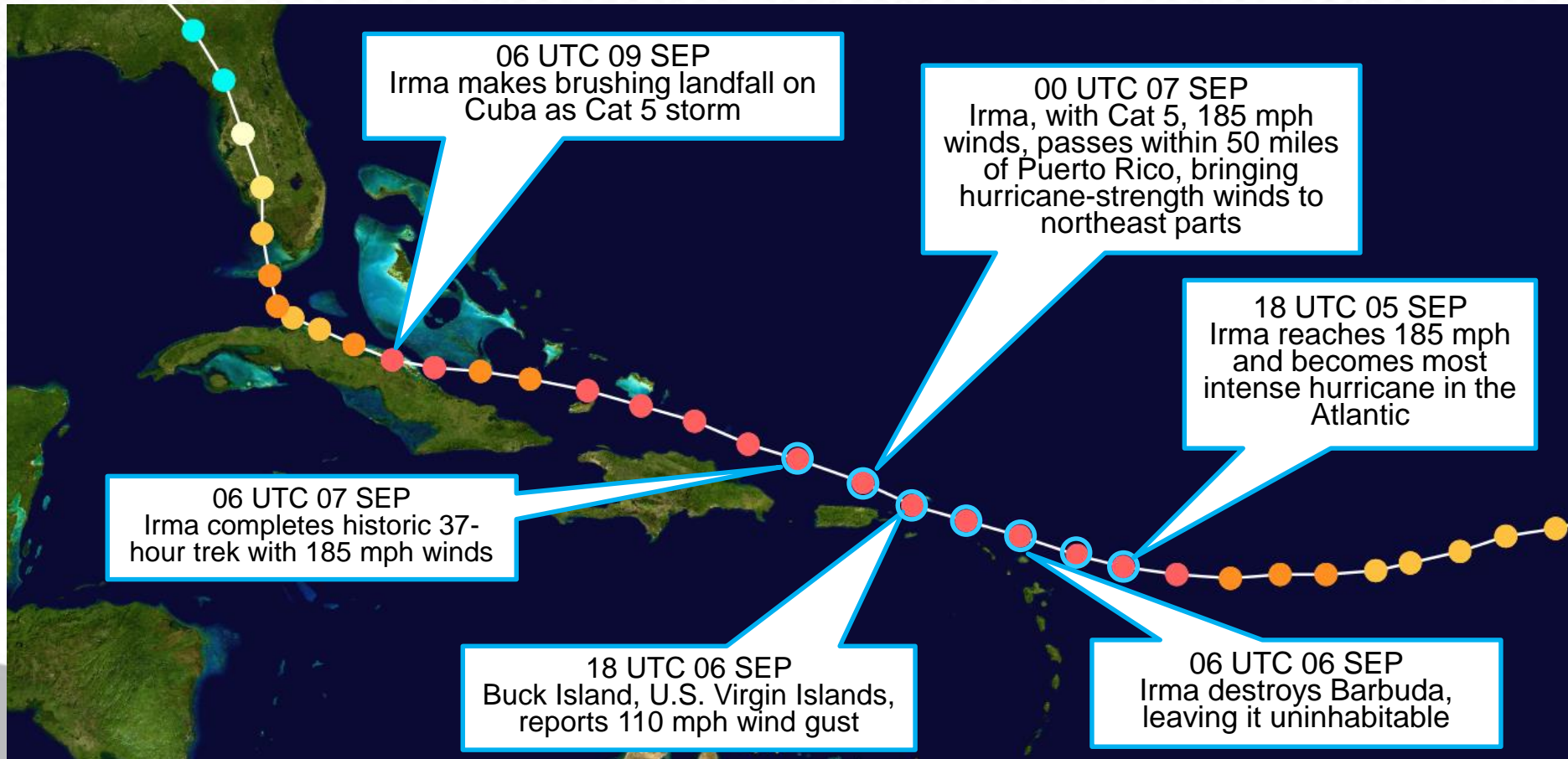


 weak to moderate
 strong to extreme

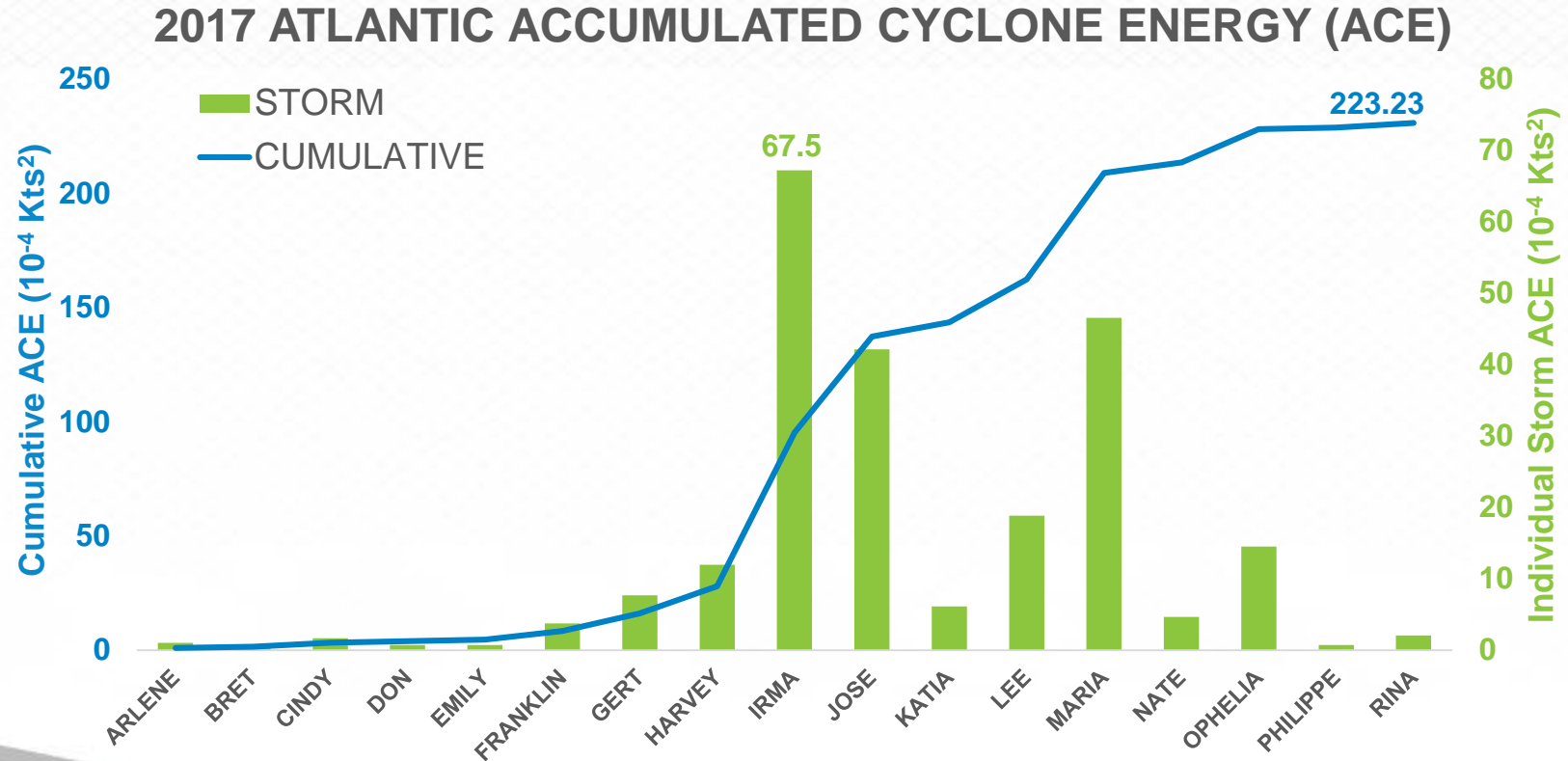


Source: Kerry Emanuel (PNAS, Oct 2017)

Irma Was Noteworthy Because of Its *Sustained* Intensity



Irma Generated a Season's Worth of ACE



Maria Bisected Puerto Rico



NWS radar

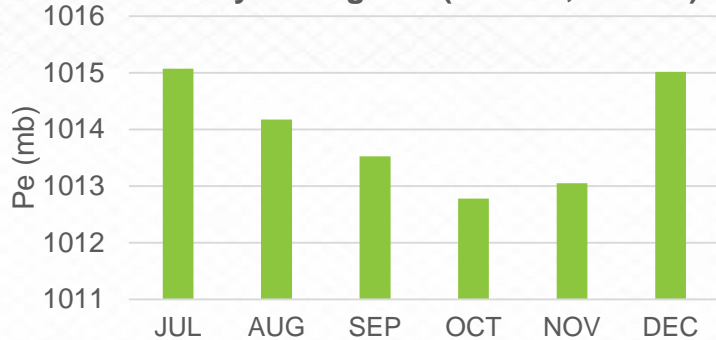


Josh Morgerman of iCyclone records time trace of sea-level pressure 6 miles north of where Maria makes landfall

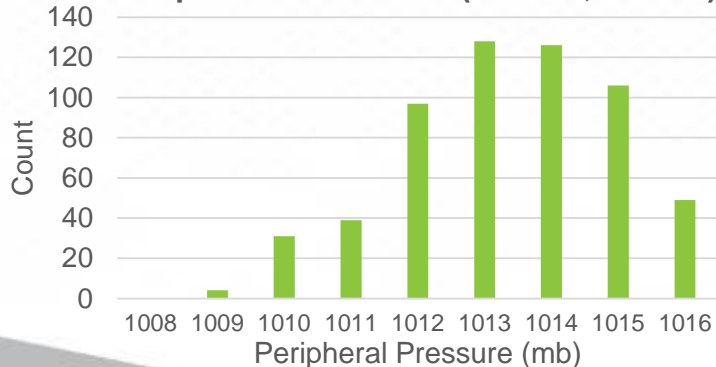
Maria makes LF at 6:45 AST 20 SEP near Yabucoa, PR, as a strong Cat 4 hurricane

Maria's Pressure Was LOW—Even at the Periphery

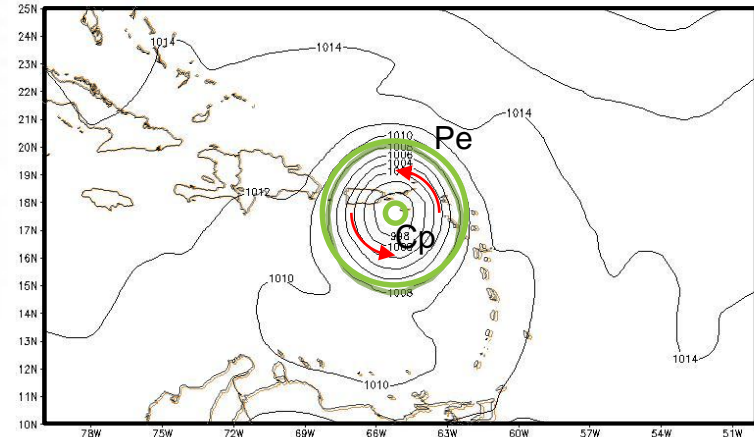
Monthly Average Pe (85-55W; 15-25N)



Sept. Pe Distribution (85-55W; 15-25N)

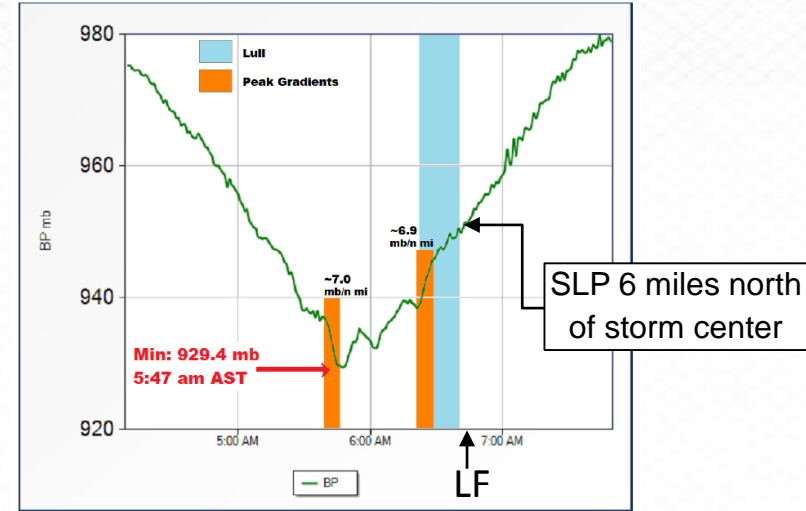
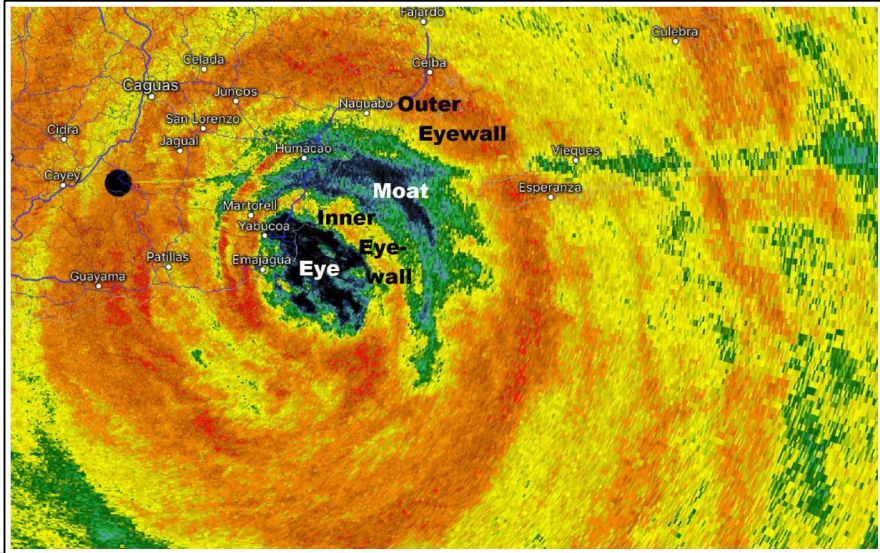


- Peripheral Pressure (Pe) is an important part of the gradient wind calculation; $V_{gr} \propto (Pe - Cp)$
- Pe represents the edge of the storm circulation
- Pe depends on season but also adjacent weather systems
- 1013 mb is AIR's Caribbean hurricane model default, but Maria had Pe of 1008 mb



Maria Was Weakening as It Approached Puerto Rico

- Eyewall replacement cycle was partially responsible for the weakening
- Sea level pressure (SLP) trace was used to estimate landfall central pressure (Cp)



HURRICANE MARIA: 20 Sep 2017
Palmas Del Mar, Humacao, Puerto Rico, USA
18.08149N 65.79847W - ref el 25 ft **DEVICE 1 (CLOSE VIEW)**

Time series of SLP recorded strong gradients within eyewall

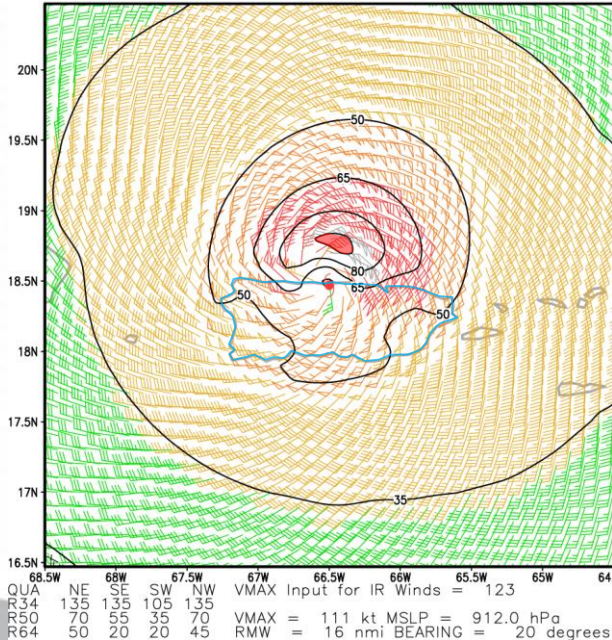
Source: Josh Morgerman, iCyclone
[iCyclone Chase Report: Hurricane Maria](#)

Satellite-Derived Wind Speeds Confirmed the Weakening

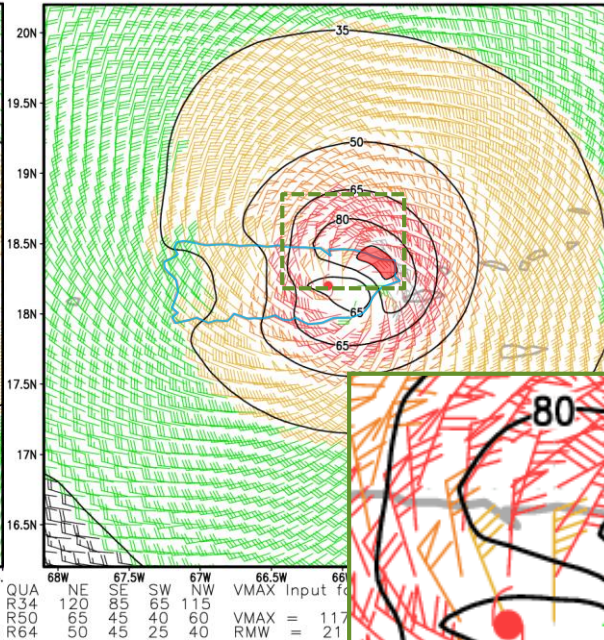


← Time

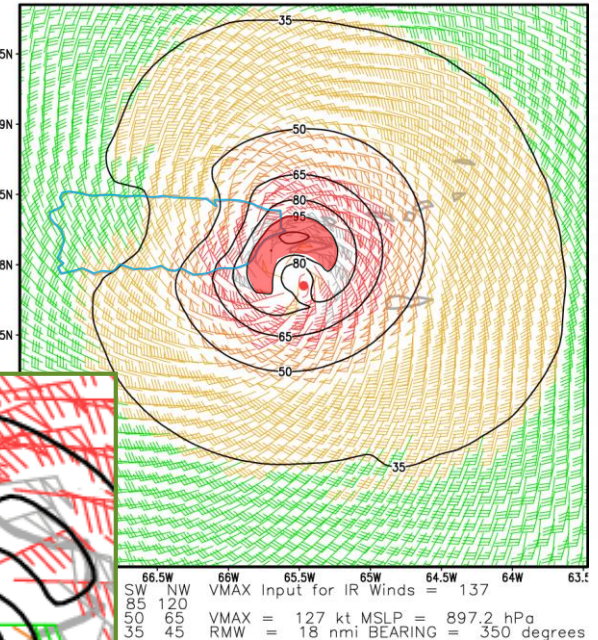
AL1517 MARIA 2017 20 Sep 15UTC



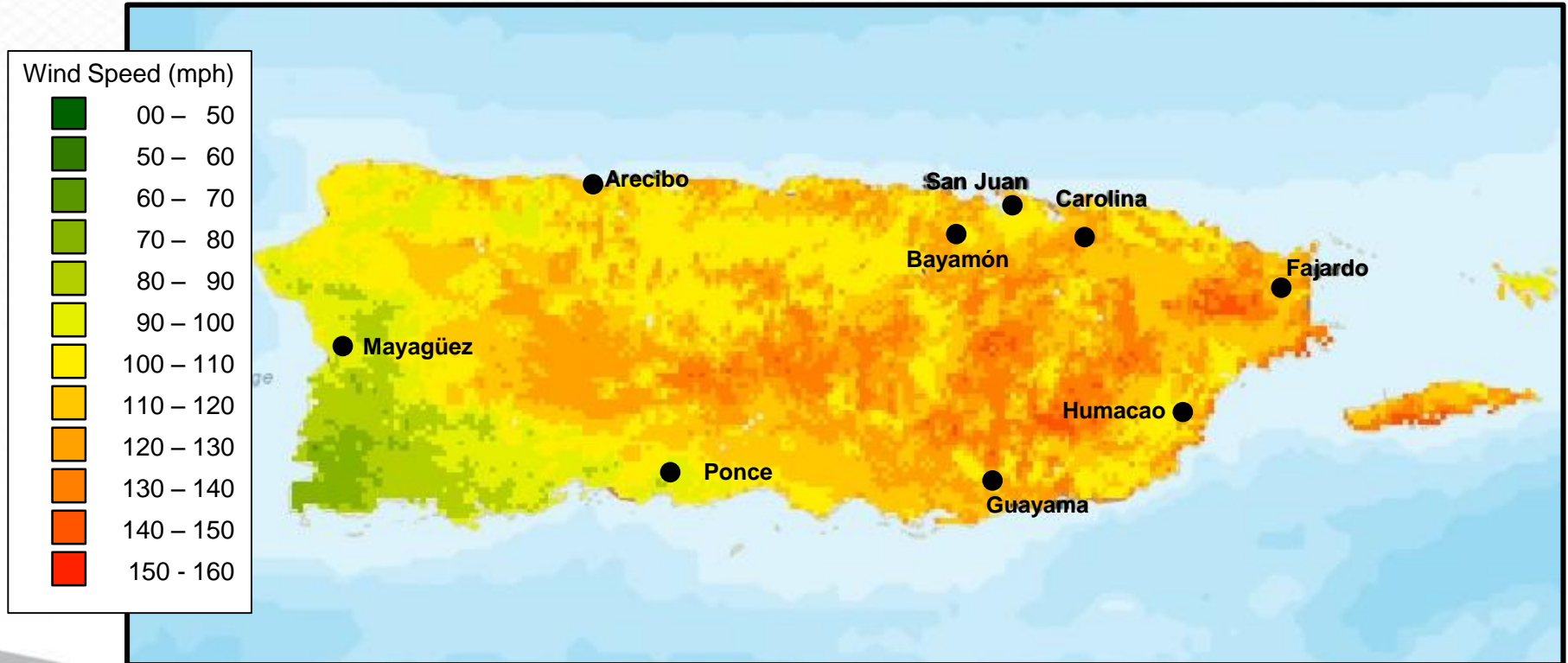
AL1517 MARIA 2017 20 Sep 12UTC



AL1517 MARIA 2017 20 Sep 09UTC



AIR Estimated Maximum Wind Speeds for Maria



Damage Assessment and Modeled Losses

*Beachside condominium building in San Juan, Puerto Rico,
with significant wind damage from 2017 Hurricane Maria*

Source: AIR Worldwide





Collateral wind damage to properties in
Old San Juan, Puerto Rico



Source: AIR Worldwide

AGENDA

- Hurricane Irma in the Caribbean
- AIR's View of Industry Loss Estimates from Hurricane Irma in the Caribbean
- Learnings from Hurricane Maria Damage Survey
- AIR's View of Industry Loss Estimates from Hurricane Maria in the Caribbean

Damage to homes
in St. Thomas,
U.S. Virgin
Islands, by
Hurricane Irma



Source: The New York Times

Damage to homes in Tutu, St. Thomas, USVI, by Hurricane Irma



Source: The New York Times

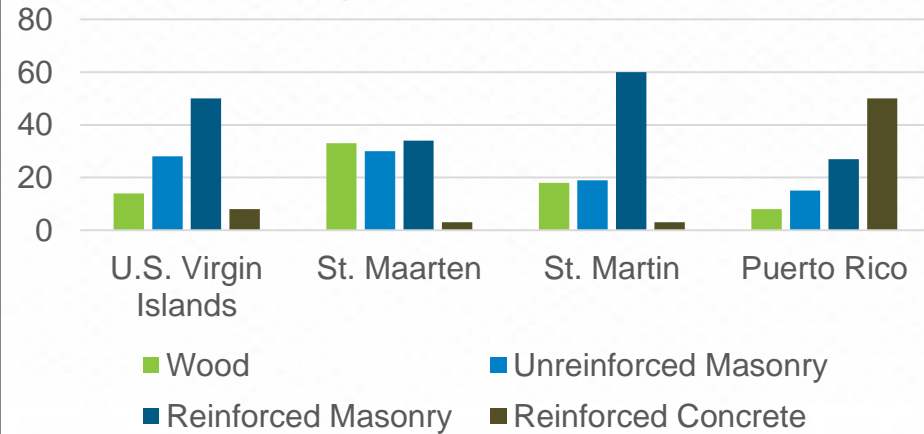
An aerial photograph showing the aftermath of a hurricane in Orient Bay, Saint Martin. The image captures a residential area with numerous houses and buildings that have suffered severe structural damage. Many roofs are missing or partially collapsed, and debris is scattered across the landscape. Palm trees are uprooted or snapped, and the ground is covered in sand and rubble. A semi-circular swimming pool is visible in the center-right. The overall scene depicts near-total destruction of the built environment.

Near total destruction in Orient Bay, Saint Martin

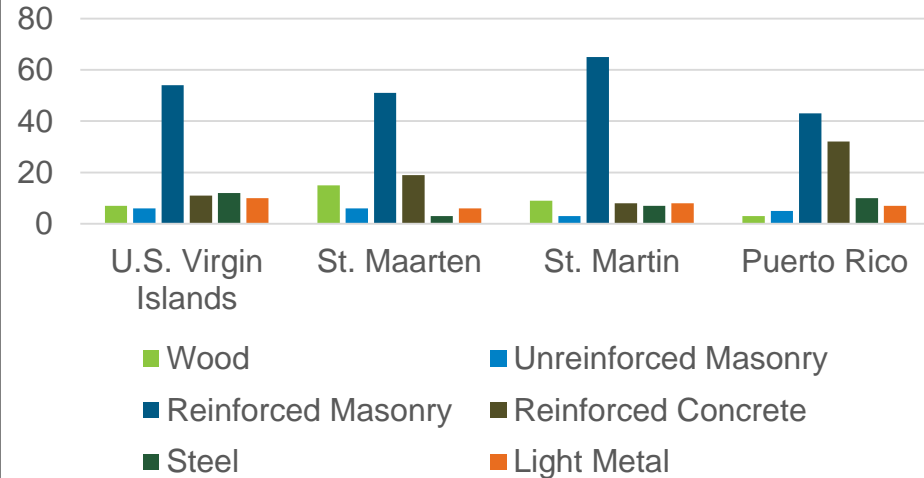
*Source: Dutch Department of Defense
Agence France-Presse*

Territories Affected by Hurricane Irma Have a Similar Construction Mix as the Mainland U.S.

Construction materials distribution for single-family homes



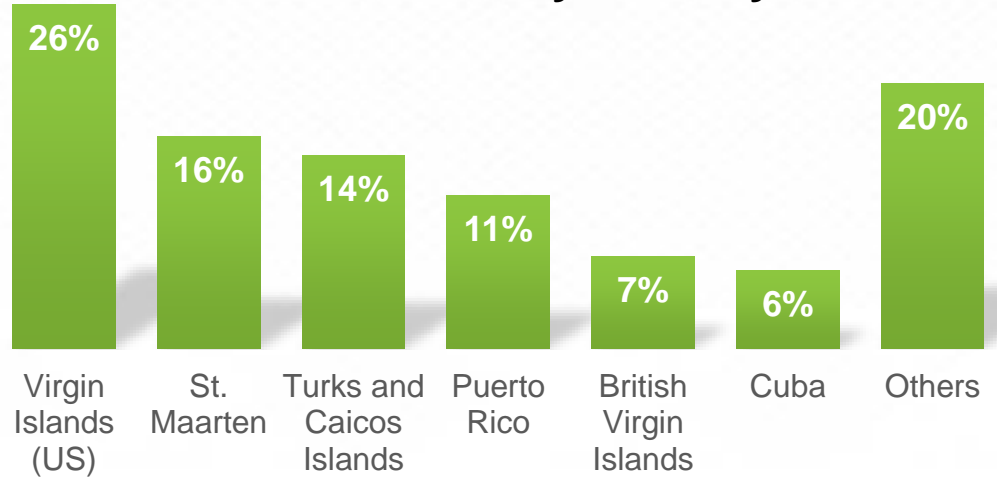
Construction materials distribution for commercial buildings



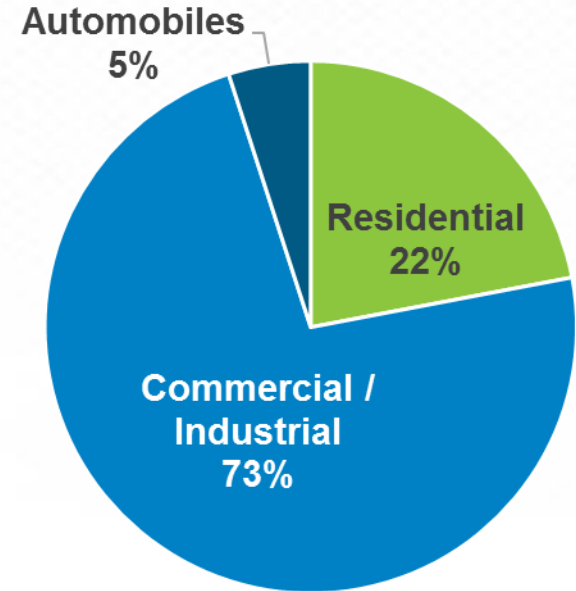
AIR's View of Industry Insured Losses from Hurricane Irma in the Caribbean

Industry insured wind and flood gross loss range with demand surge: **USD 7 – 15 Billion**

Contribution by Country



Breakdown by Line of Business

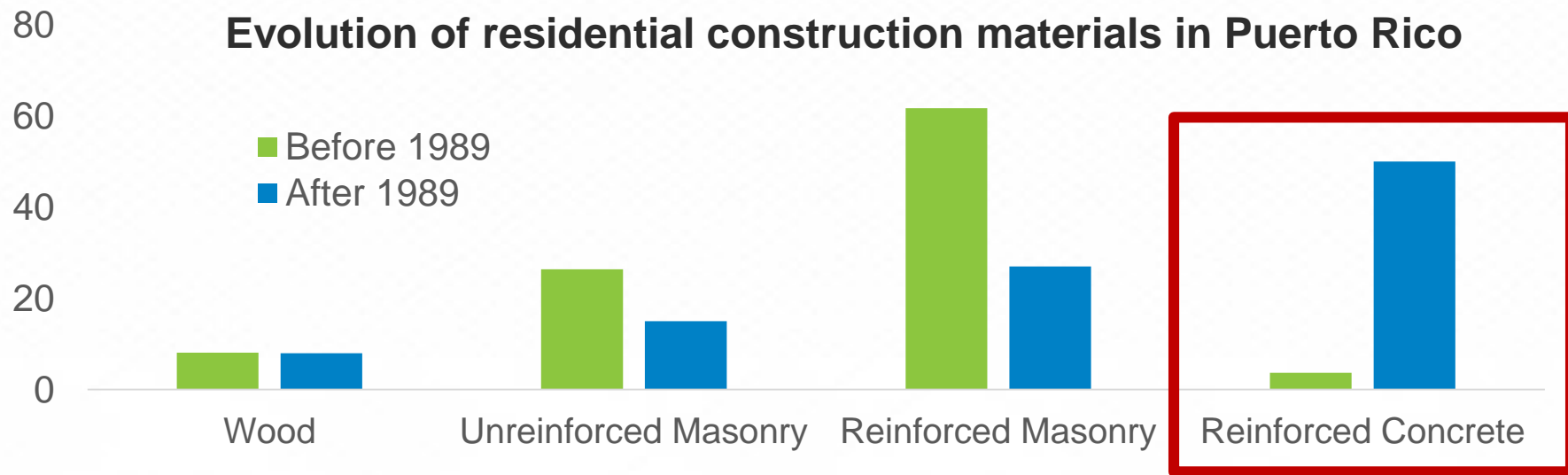


Learnings from Post-Maria Damage Survey in Puerto Rico



Puerto Rico's Residential Building Inventory Has Evolved Since Hurricane Hugo in 1989

Since 1989, a substantial number of single-family homes have been built with reinforced concrete—typically referred to as “bunker style” construction



Puerto Rico's Bunker Style Housing

Bunker construction single-family homes and apartment buildings are built of reinforced concrete walls (sometimes combined with reinforced or unreinforced masonry), and concrete slab floor and ceilings



Figure 1: Reinforced concrete slab



Figure 2: Steel Reinforcement



Figure 3: Finished concrete walls

Puerto Rico's Bunker Style Construction

Ocean Park, San Juan, Puerto Rico

Source: AIR

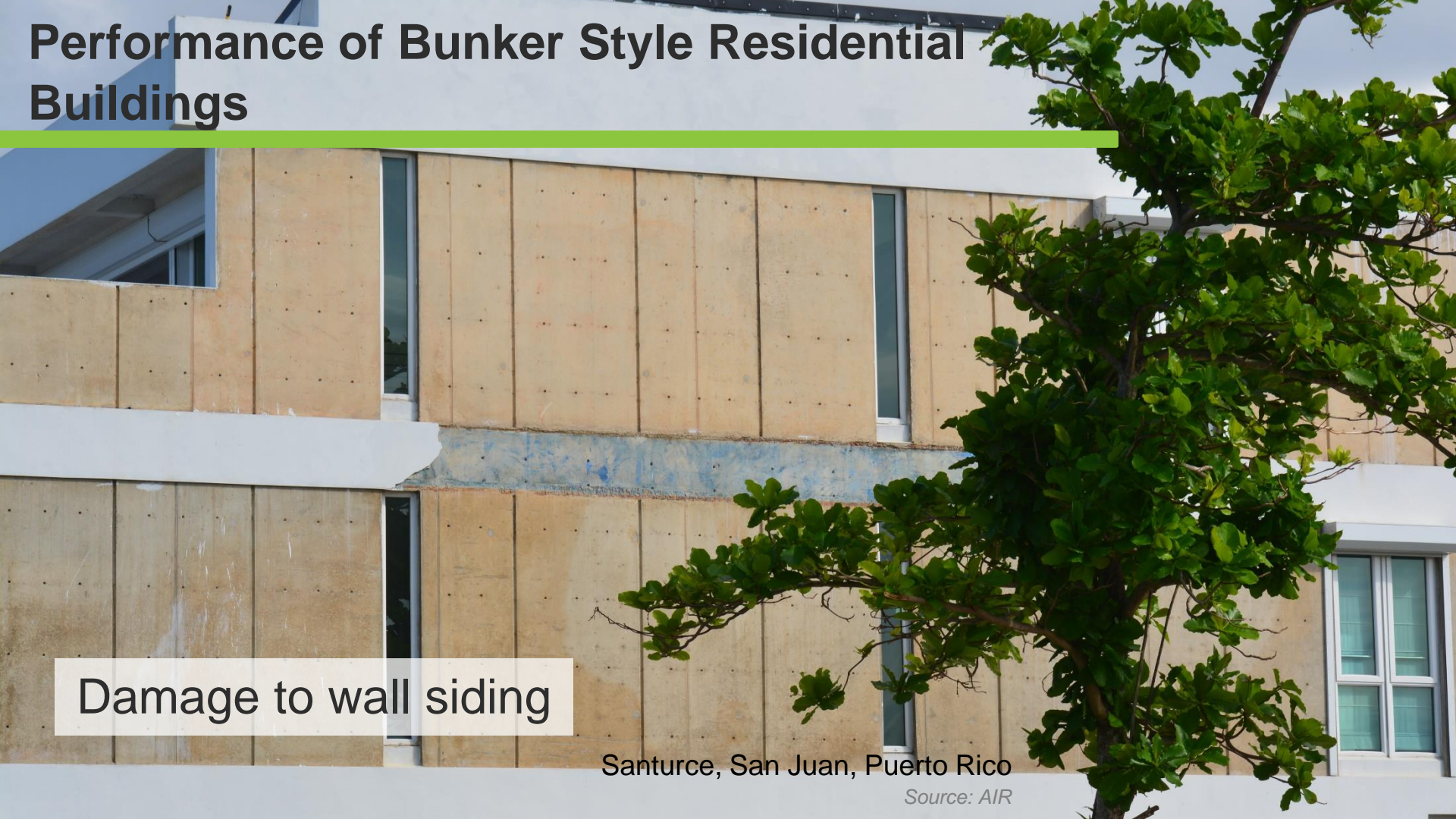


Performance of Bunker Style Residential Buildings

Damage to wall siding

Santurce, San Juan, Puerto Rico

Source: AIR



Performance of Bunker Style Residential Buildings



San Juan, Puerto Rico

Source: AIR

- Damage to openings—
windows, sliding doors
- Consequences associated
with wind-driven rain

Performance of Bunker Style Residential Buildings

Fajardo, Puerto Rico

Source: AIR

Damage to other components such as garage doors, rooftop equipment, in addition to cosmetic damage due to loss of wall paint, exterior lighting fixtures



Masonry Structures with Wood Framed Roof Systems

- Lack of continuous load path
- Internal pressurization

Old San Juan, Puerto Rico

Source: AIR



Performance of Masonry Residential Structures

Lack of continuous load path

Old San Juan, Puerto Rico
Source: AIR



Insufficient Connections Between Wall and Roof

Old San Juan, Puerto Rico
Source: AIR



Mixed Construction: Concrete/Masonry and Wood Frame

San Juan, Puerto Rico

Source: AIR





Inadequate and/or incomplete connection

Mixed Construction: Concrete/Masonry and Wood Frame

San Juan, Puerto Rico

Source: AIR



Poor or absent connection between the wood frame on second floor and the concrete floor slab (first floor roof)



Residential Insurance Practices in Puerto Rico

Dwelling policies

- The most prevalent type of residential policy
- Excludes coverage for contents and additional living expenses
- Mandatory for homes that are mortgaged

Homeowners policies

- Includes coverage for buildings, contents, and additional living expenses

Significant uncertainty exists in the percentage breakdown of dwelling vs. homeowners policies in the Puerto Rican residential market

Residential Insurance Practices in Puerto Rico

- Damage due to water ingress is not covered without envelope breach
 - This is true even if the property has flood insurance
 - Cases where water enters the house from under the front doors without breaking the door (without envelope breach) would not be covered



Damage to Commercial Buildings



Performance of Engineered Mid- and High-Rise Buildings

Breach in the envelope due to damage to windows or openings in general—wind pressures or wind-borne debris impacts

San Juan, Puerto Rico

Source: AIR



Condado, San Juan, Puerto Rico

Source: AIR



Performance of Engineered Mid- and High-Rise Buildings

- Damage to wall siding
- Failure of soffits



San Juan, Puerto Rico

Source: AIR

Performance of Engineered Mid- and High-Rise Buildings

San Juan, Puerto Rico

Source: AIR

Failure of opening protection systems

Significant damage to the interiors and contents due to wind and wind-driven rain impacts associated with envelope breach

San Juan, Puerto Rico

Source: AIR



Performance of Roof Systems



Loss of roof cover, damage to deck leading to water infiltration



Performance of Roof Systems

Damage to reinforced concrete roofs was limited to failure of rooftop equipment due to improper anchorage

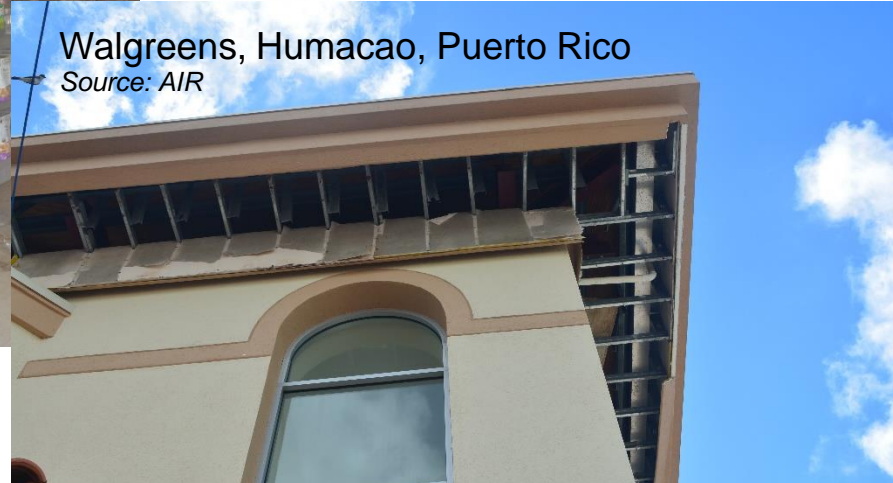


Significant Losses Also Expected from Commercial Lines Other than Condos and Hotels



Several retail stores in areas close to where Maria made landfall are still waiting to clean up and rebuild

Walgreens, Humacao, Puerto Rico
Source: AIR



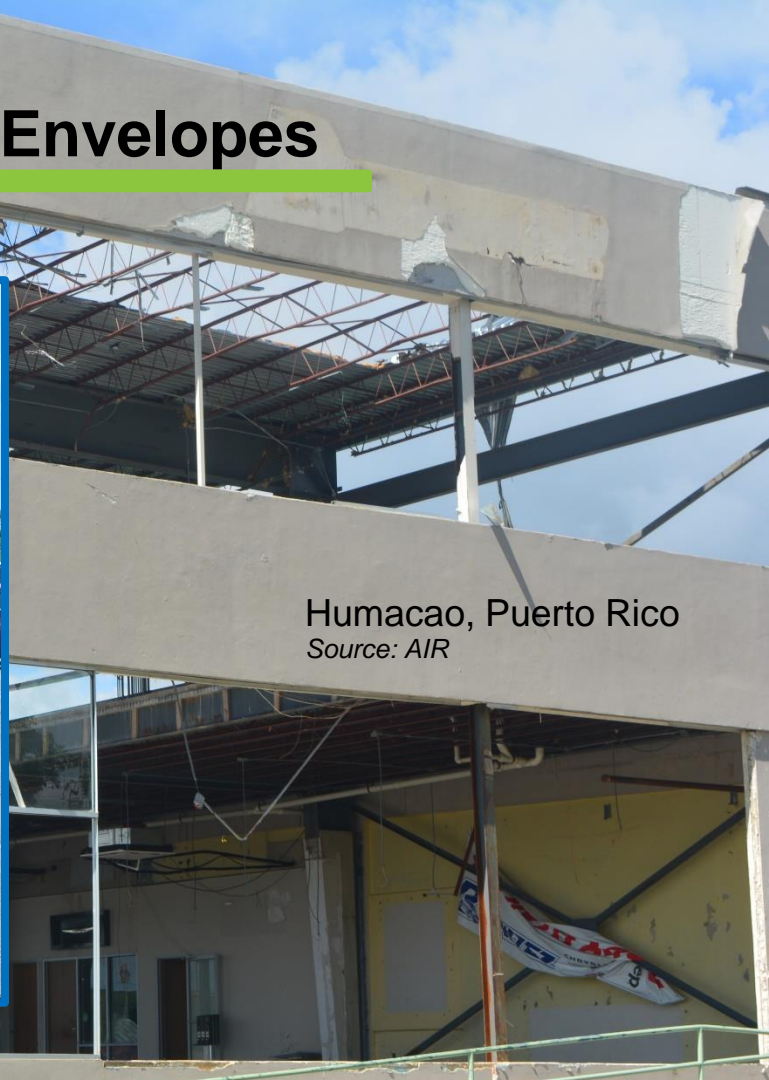
Sam's Club, Humacao, Puerto Rico
Source: AIR



Performance of Light Metal Building Envelopes



Humacao, Puerto Rico
Source: AIR



Performance of Essential Facilities

San Juan Luis Muñoz Marín Airport

- Replacement value is expected to be more than USD 1 billion
- Damage to the terminal and baggage collection areas, hangars, and other airport facilities
- Peeling of built-up roof, envelope breach, wind-driven rain-related damages



Damage to Industrial Buildings

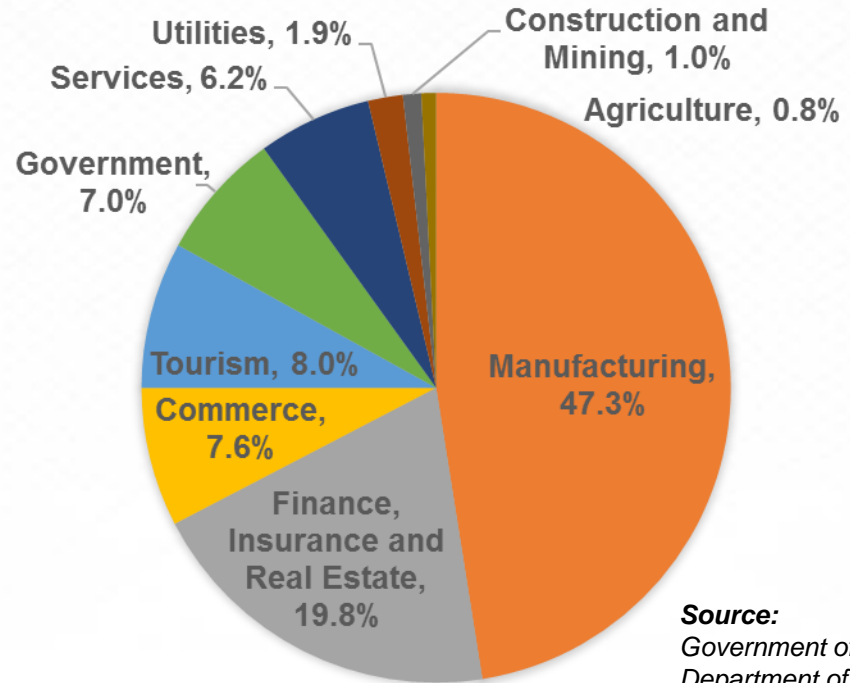


Manufacturing Accounts for Half of Puerto Rico's Gross Domestic Product (GDP)

Highly diversified industrial base

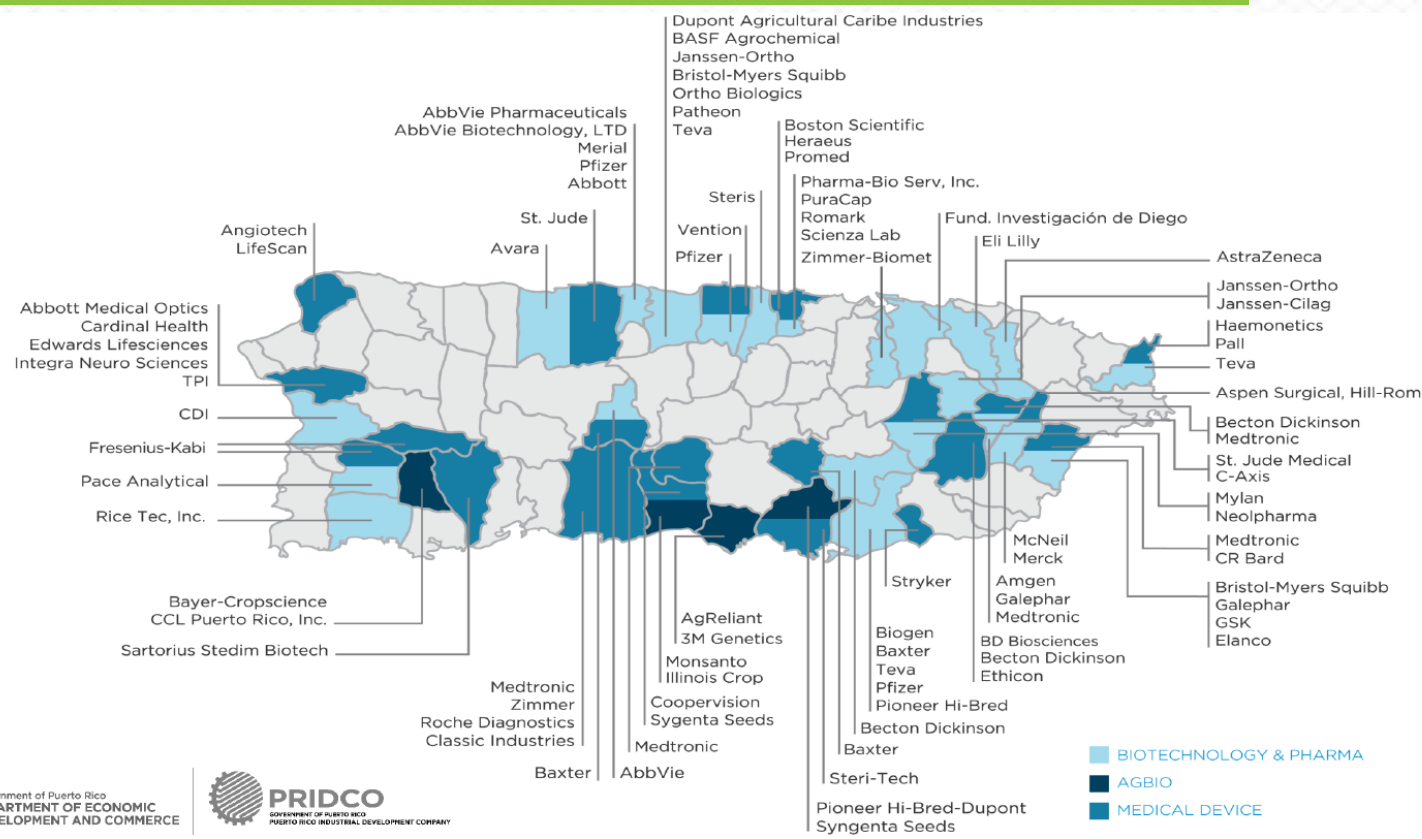
- Life Sciences
- Aerospace
- Information Tech
- Finance, Banking and Insurance
- Export Services
- Creative Services
- Food Processing
- Logistics & Supply Chain
- Puerto Rican Rum

GDP SHARE BY MAIN ECONOMIC SECTOR FY 2016



Source:
Government of Puerto Rico
Department of Economic
Development and
Commerce

Bio-Pharma Industry Contributes 23% of the GDP and Employs ~80,000 People



Damage to Bio-Pharma Facilities

Bristol-Myers Squibb (BMS)

Humacao, Puerto Rico
Source: AIR

“BMS is still assessing the full situation around its pharmaceutical operations in Puerto Rico ... the company is executing contingency plans to mitigate product supply risk ... working to bring operations back online.”

Source: www.biopharminternational.com, September 27, 2017



Damage to Bio-Pharma Facilities

Praxair, Humacao, Puerto Rico

Source: AIR



Damage to Bio-Pharma Facilities

CR Bard, Humacao, Puerto Rico

Source: AIR



Damage to Bio-Pharma Facilities

Galephar Pharmaceutical Research



Source:
Google Earth

“... the facility in Humacao sustained damage to the exterior of the production building; however, the production suites and equipment were unaffected ... expects to have the facility operational by mid- to late November ... does not anticipate an interruption in supply.”

Source: Press Release, October 10, 2017



Source:
Hurricane Maria
Imagery
(NOAA)

Galephar Pharmaceutical Research
Humacao, Puerto Rico
Source: AIR





Galephar Pharmaceutical Research
Humacao, Puerto Rico
Source: AIR

Galephar Pharmaceutical Research
Humacao, Puerto Rico
Source: AIR



Damage to Food Manufacturing Facilities

Goya de Puerto Rico, Inc.

- Significant damage to the roof and envelope, and intrusion of wind-driven rain



Damage to Food Distribution Facilities

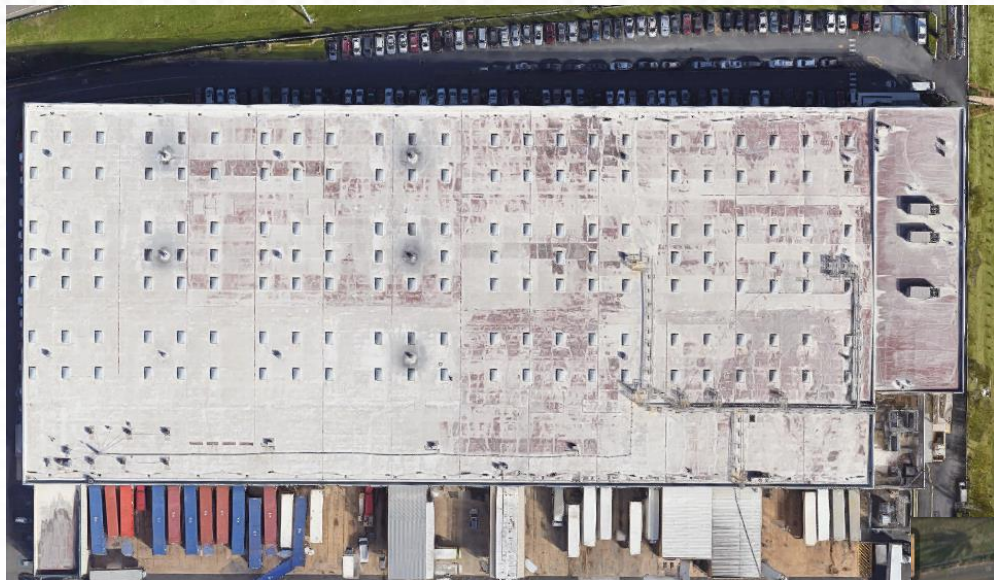
- Significant damage to the roof and envelope, and intrusion of wind-driven rain



Bayamon, Puerto Rico

Source: AIR

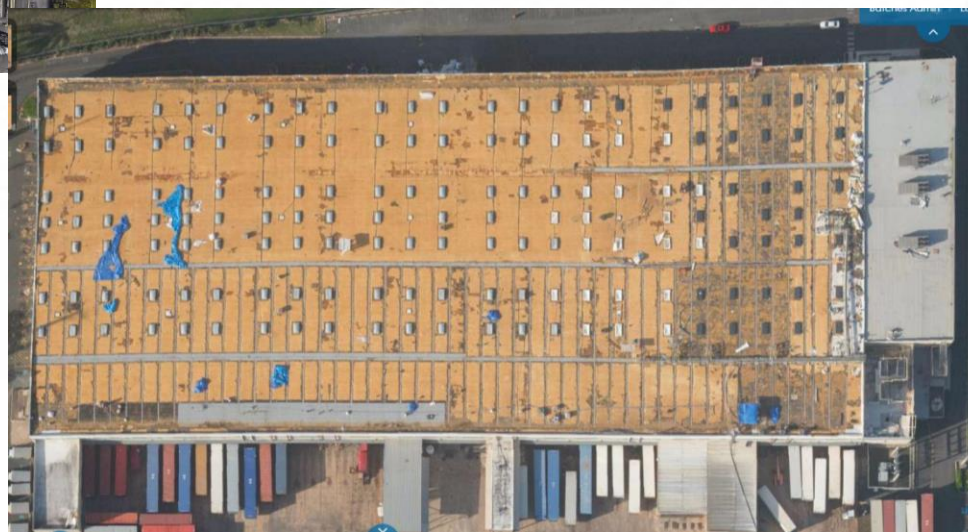




Source:
Google Earth

Before

After



Variability in Commercial/Industrial Losses

Uncertainty in coverage-specific losses

Wide variability in make and form of insurance policies

- Policy structures with captives
- Variable deductibles
- Role of endorsements in dictating what is covered vs. not covered
 - Commercial policies need special endorsements specifically for business interruption (BI) payouts in the absence of physical property damage: endorsements for utility services, communication lines, and water
- Presence of qualifiers for BI trigger
- Percentage self-insured vs. carrying traditional insurance

What Changed AIR's Loss Estimates?

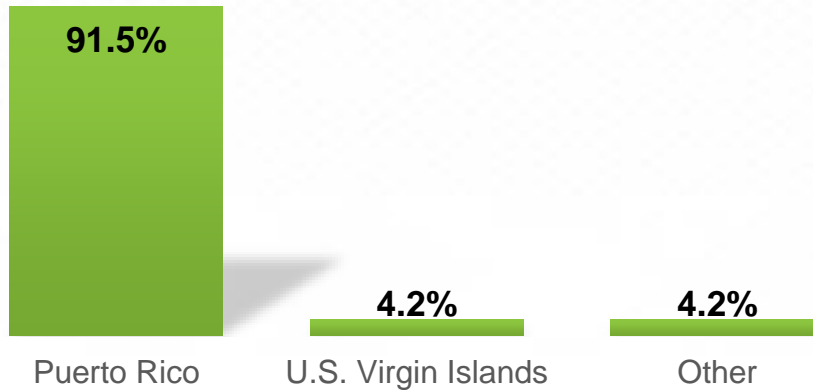
- Re-analysis of winds from Hurricane Maria over Puerto Rico
- Post Maria damage survey
- Review of insurance practices and policies in Puerto Rico

AIR's View of Industry Insured Losses from Hurricane Maria in the Caribbean

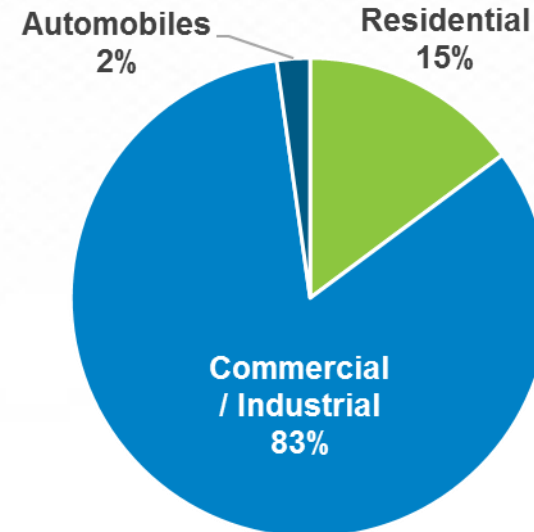
Industry insured wind and flood gross loss range
with demand surge:

USD 27 – 48 Billion in Caribbean

Contribution by Country/Territory



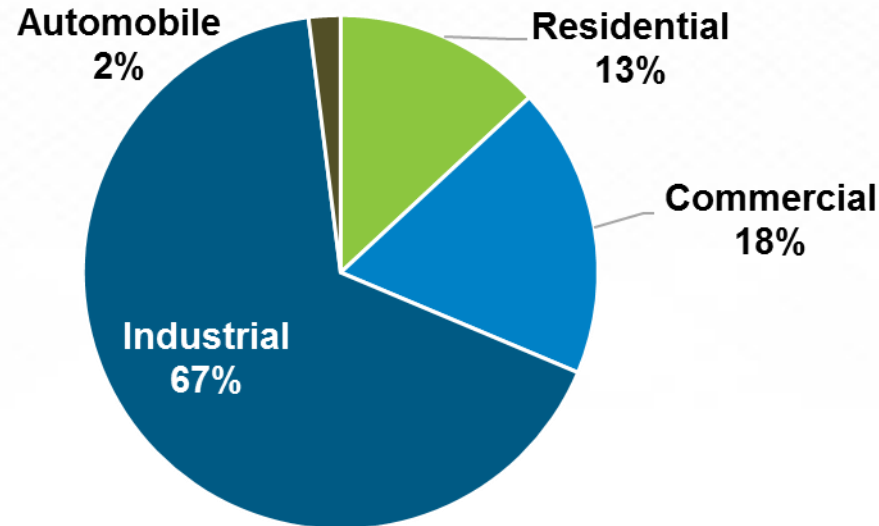
Breakdown by Line of Business



AIR's View of Industry Insured Losses from Hurricane Maria in Puerto Rico

Industry insured wind and flood gross loss range
with demand surge:
USD 25 – 43 Billion

Contribution by Line of Business



What AIR's Modeled Insured Loss Estimates Include/Do Not Include

- Modeled insured loss estimates **include:**

- Insured physical damage to onshore property and auto due to wind and precipitation-induced flooding
- Insured loss to contents for homeowners policies only (not dwelling policies), and commercial and industrial policies
- 2017 indexed take-up rates
- Losses due to business interruption
- Losses to industrial facilities
- Additional living expenses (ALE) for residential claims
- In Puerto Rico and the U.S. Virgin Islands:
 - For residential lines: 10% of modeled precipitation-induced flooding damage under wind policies
 - For commercial lines: Insured physical damage to structures, contents, and BI directly caused by precipitation-induced flooding, assuming a 10% take-up rate for commercial flood policies
- Outside of Puerto Rico and the U.S. Virgin Islands:
 - 100% of flood losses for residential and commercial lines
- For business interruption losses, direct and indirect losses for insured risks that experience physical loss
- Demand surge

- Modeled insured loss estimates **do not include:**

- Losses to infrastructure
- Losses from hazardous waste cleanup, vandalism, or civil commotion, whether directly or indirectly caused by the event
- Losses to offshore properties, pleasure boats, and marine craft
- Losses resulting from the compromise of existing defenses (e.g., levees)
- Losses to uninsured properties
- Other non-modeled losses, including loss adjustment expenses

Thank you for attending!

We will email the recording of today's webinar and a PDF version of the slides in the next few days

**Please reach out
to your AIR
representative or
airconference@air-worldwide.com
with any additional questions!**

References:

**Morgerman, Josh. "iCyclone Chase Report: Hurricane MARIA." iCyclone. 20 September 2017.
http://icyclone.com/upload/chases/maria/iCyclone_Chase_Report_MARIA2017.pdf.**