



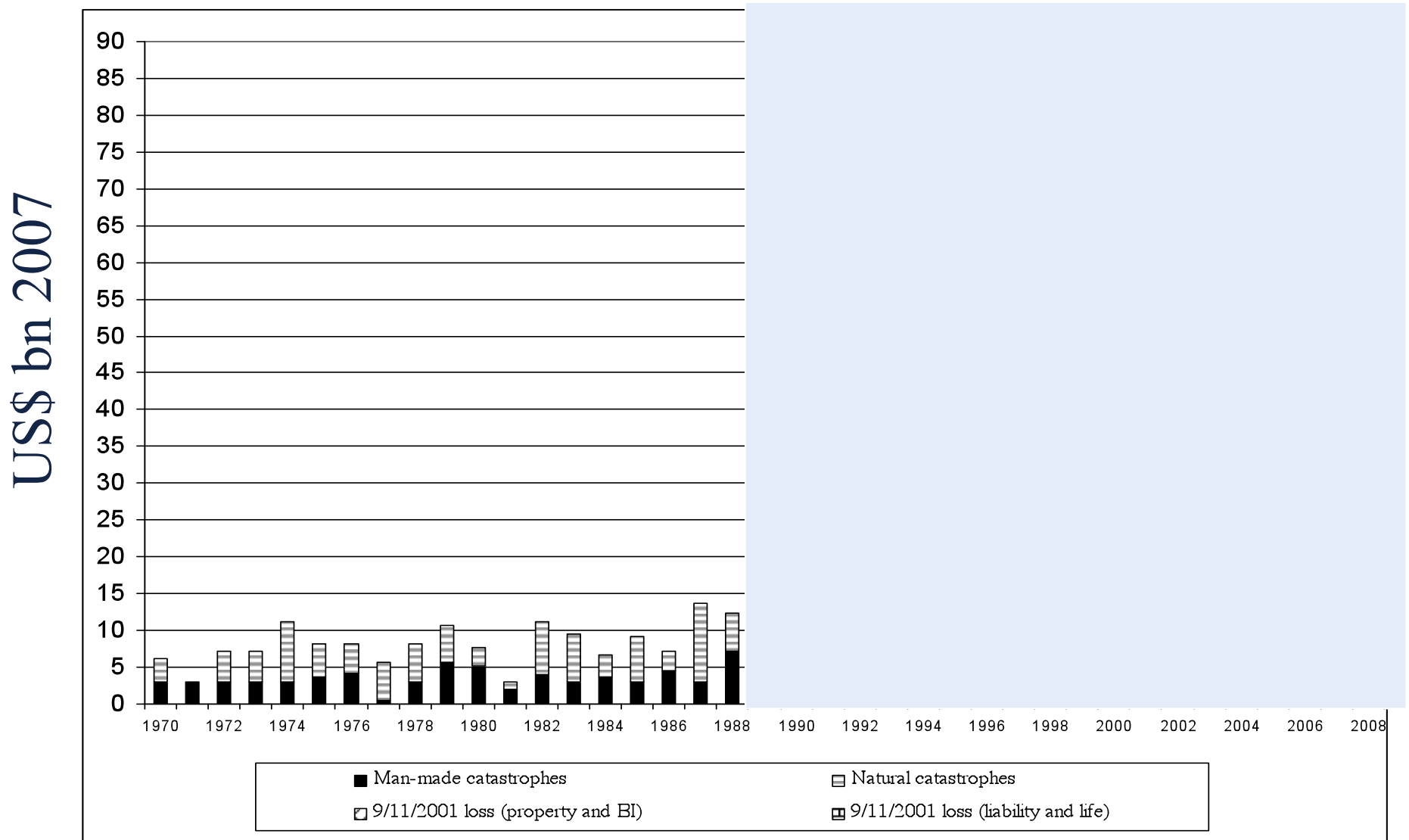
# Hurricane Impacts, Climate Variability and Change

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Sandra Maina

NCAR is Sponsored by NSF and this work is partially supported by the  
Willis Research Network and the Research Partnership to Secure Energy for America

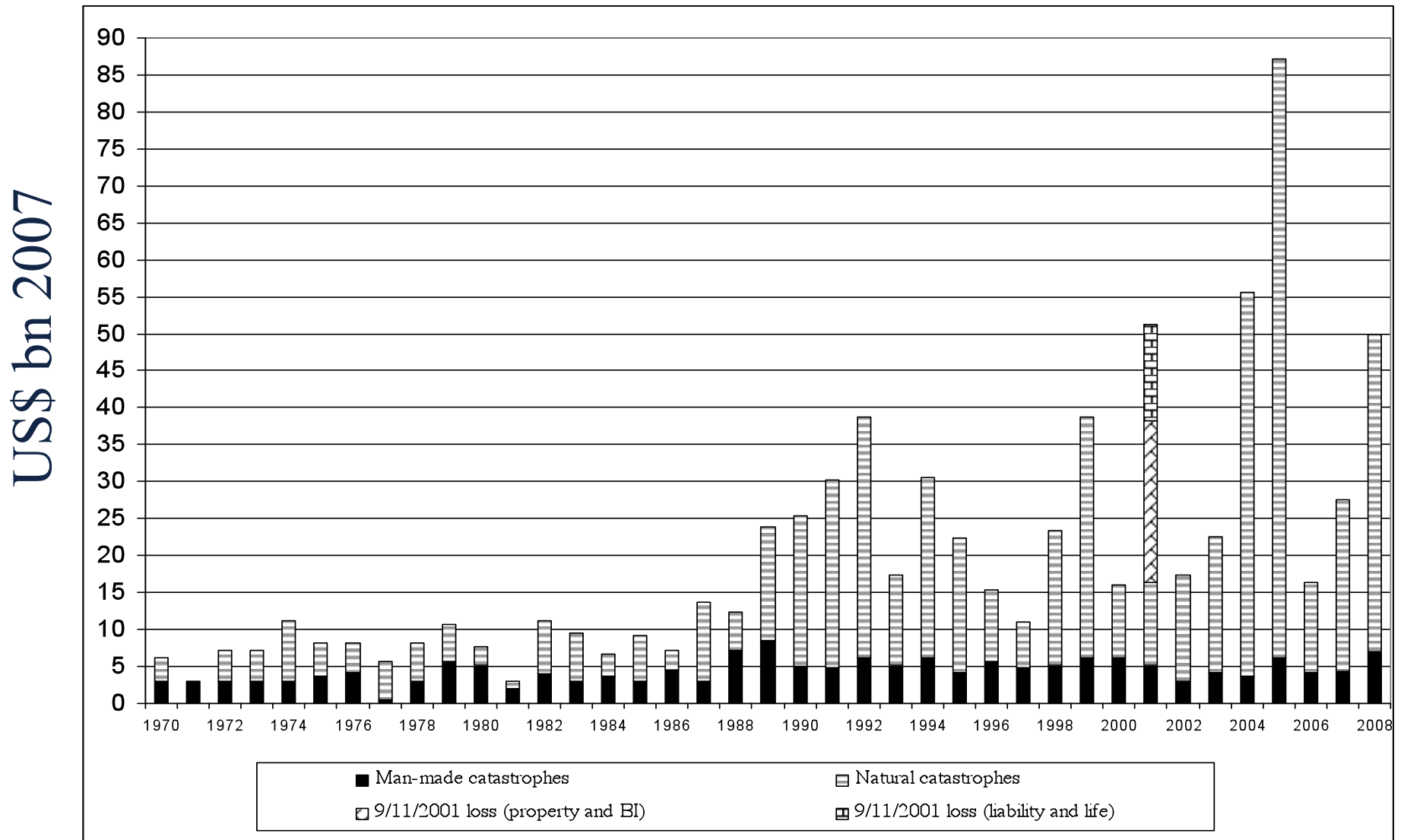
# Global Insured Losses, 1970-2008



(Property and business interruption (BI); in U.S.\$ billion indexed to 2007, except 2008 which is current)

Sources: Kunreuther and Michel-Kerjan, *At War with the Weather* (2009) - data from Swiss Re and Insurance Information Institute

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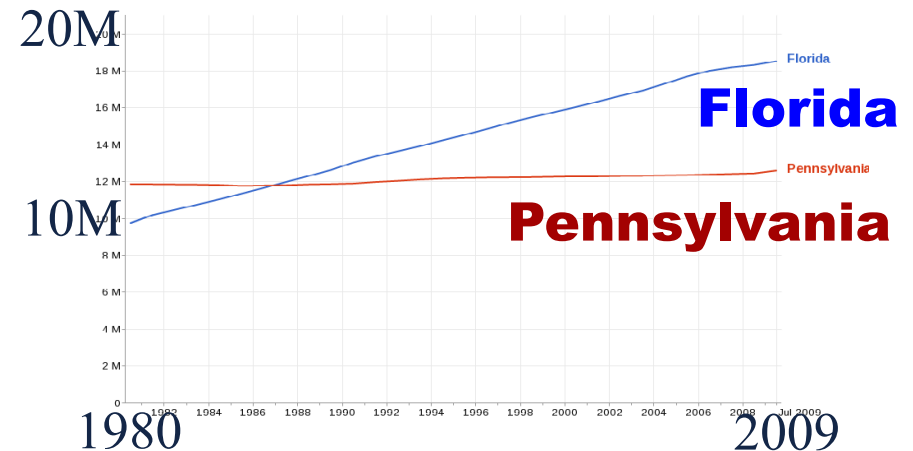
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# Attribution

## *Population increase and migration:*

e.g. population of Florida

increasing at a rate of 300,000/year

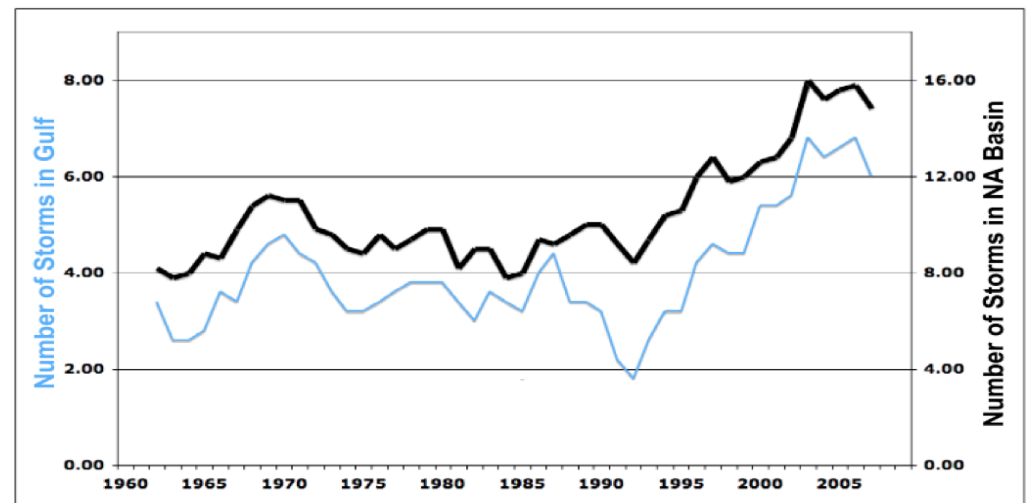


## *Climate variability and change:*

Tropical cyclones have recently become more frequent and intense in the North Atlantic.

## *Future?*

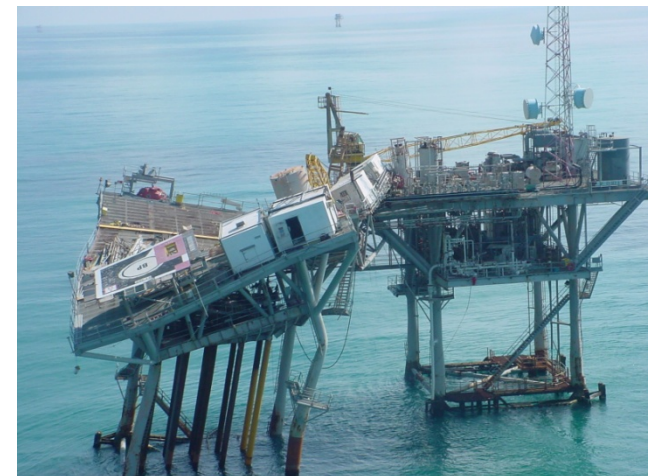
Increasing population in vulnerable regions and possible scenario of more damaging hurricanes -> continued increase in losses.



# Hurricane Impacts on the Offshore Energy Industry

- **Generate waves up to 90 ft**
- **Damage infrastructure**
  - production platforms
  - pipelines
  - refineries (50% of U. S. capacity)
  - logistical support, e.g. shore bases
- **Evacuation costs & personnel risks (\$100-\$500 M/yr)**
- **Cost of new facilities**

Changes in future hurricanes  
will affect all of the above

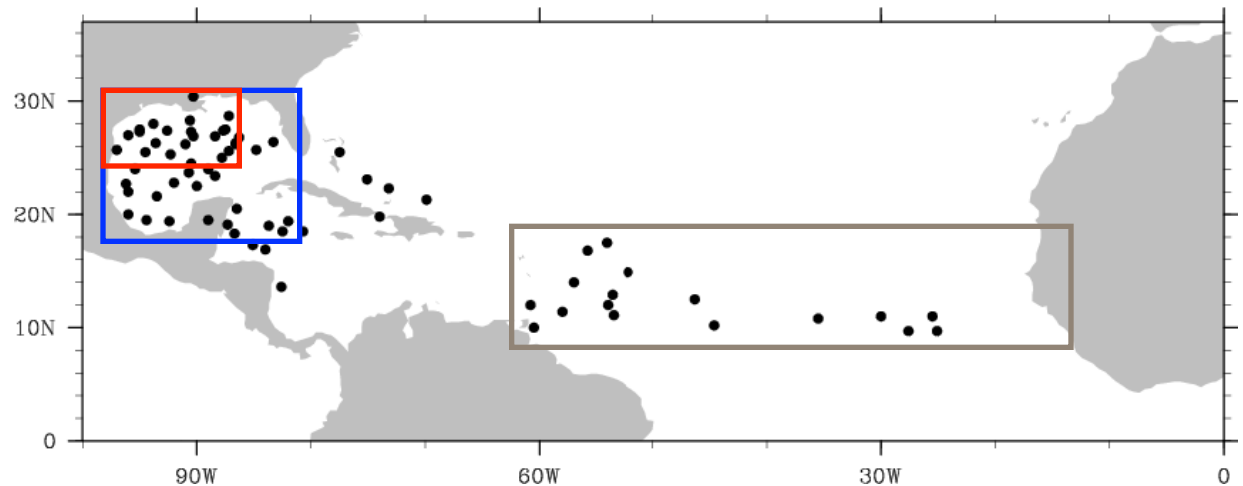




# Historical Storms in the Gulf of Mexico

1966-2008: Average 4.0 storms/yr in blue box,  
1.7 storms/yr in red box

Genesis locations of storms that entered the red box.



One quarter of storms that entered the Northern Gulf formed out in the tropical North Atlantic.

# Large-Scale Drivers of Gulf Storms

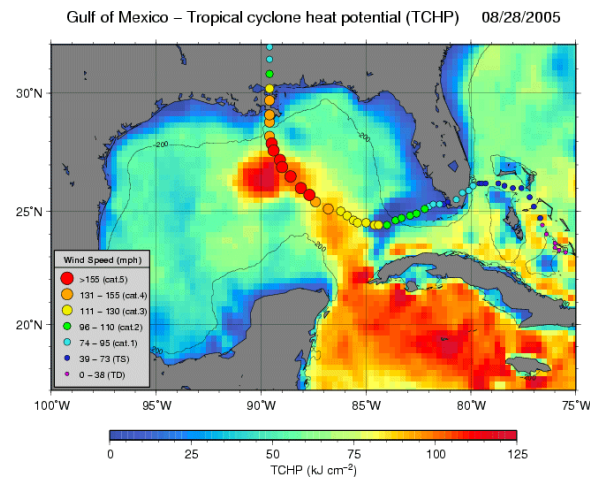
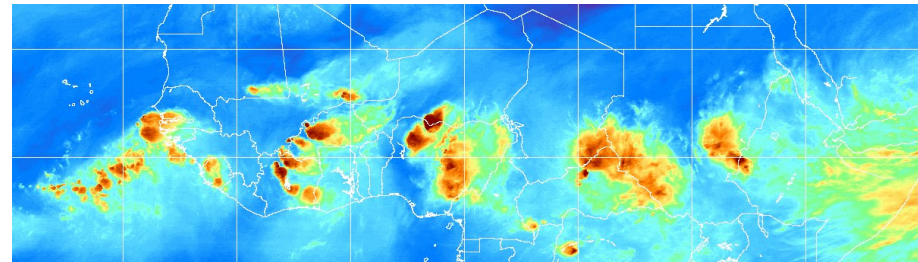
The favorable summer climate is modulated by variability on a range of temporal and spatial scales.

- Atmospheric Drivers:

- low latitude disturbances,
- amplification zones.

- Oceanic Drivers:

- loop current



- Coupled Drivers: El-Nino, Atlantic Meridional Mode and the Atlantic Multi-Decadal Oscillation . . .



# Key Research Questions

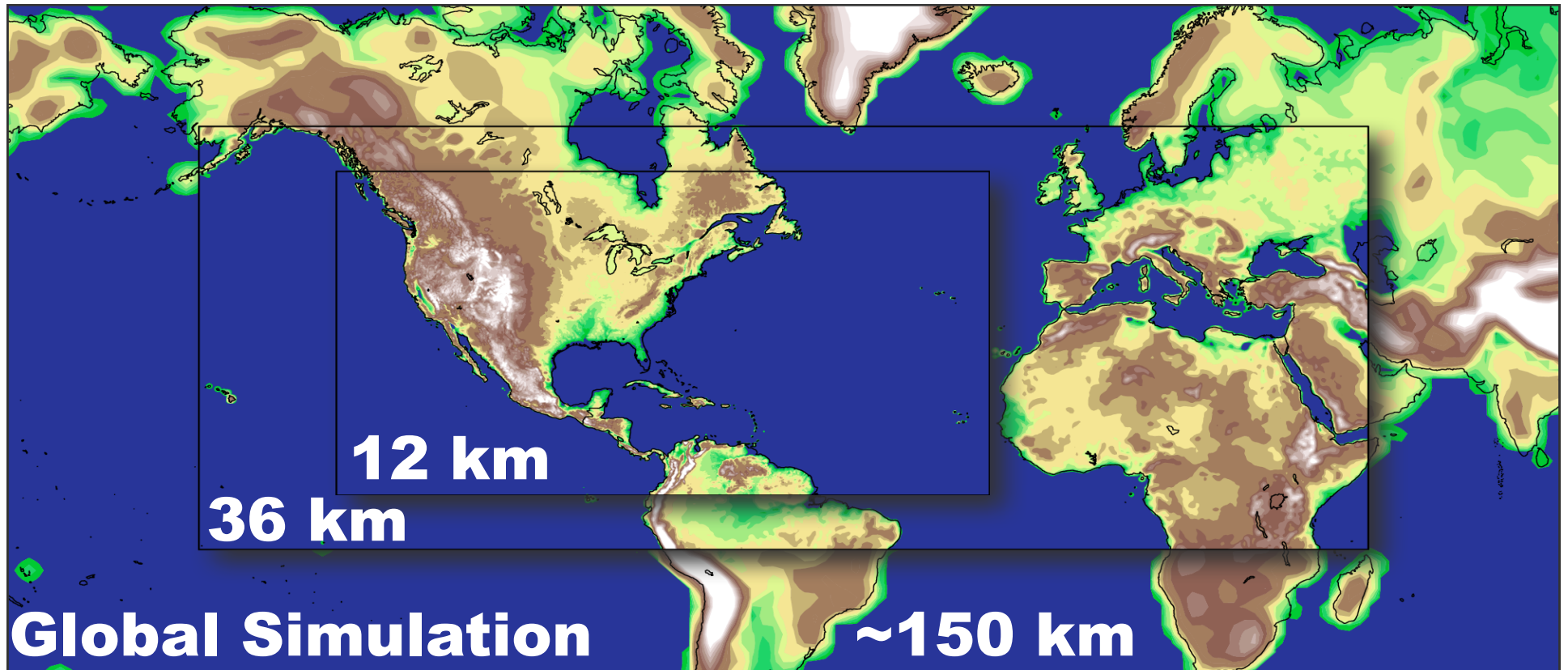
How does climate variability and change influence future hurricane activity?

To what extent are changes in hurricane activity predictable?

How do these changes relate to expected loss?



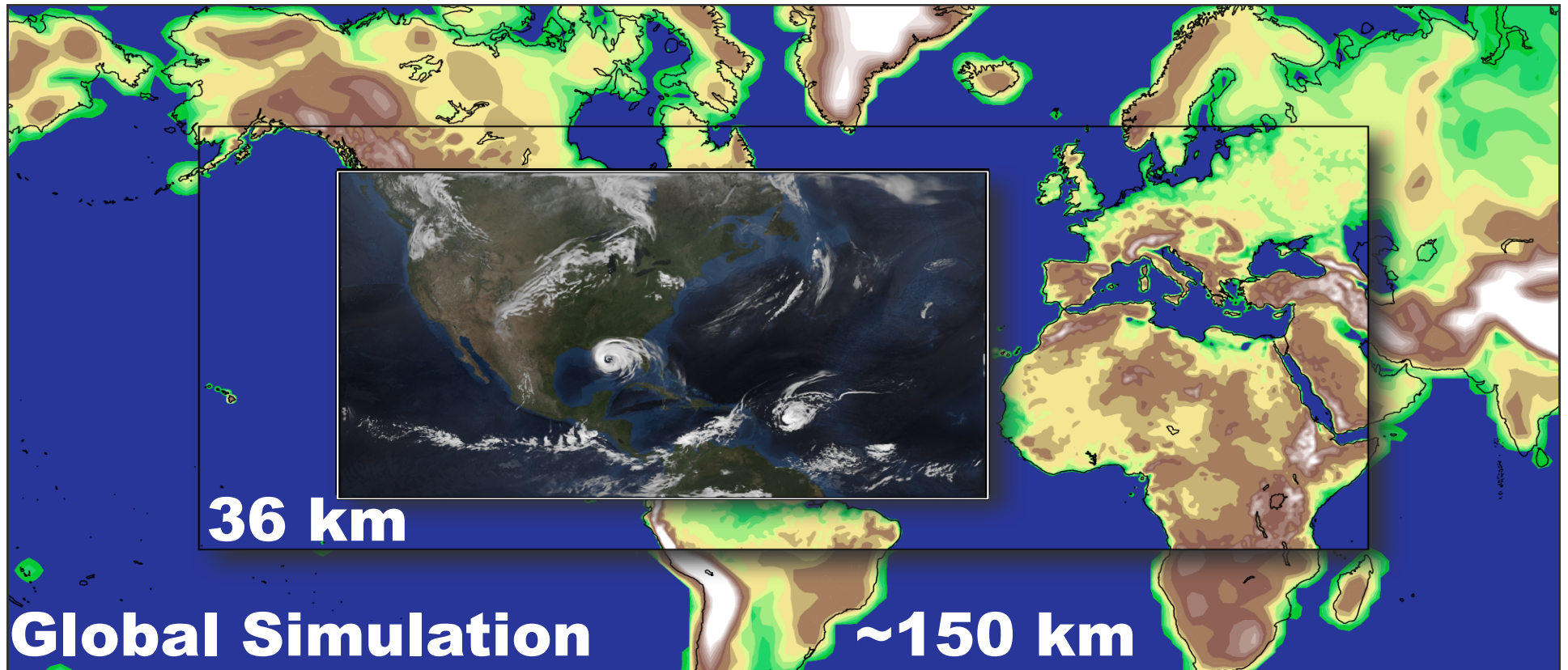
# Zooming in on Hurricanes



Global Model (CCSM3): - 1950 to 2100 under A2 scenario.

Nested Model (WRF):  
- 3 time slices: 1995-2005, 2020-2030 and 2045-2055  
- 36km and 12 km.

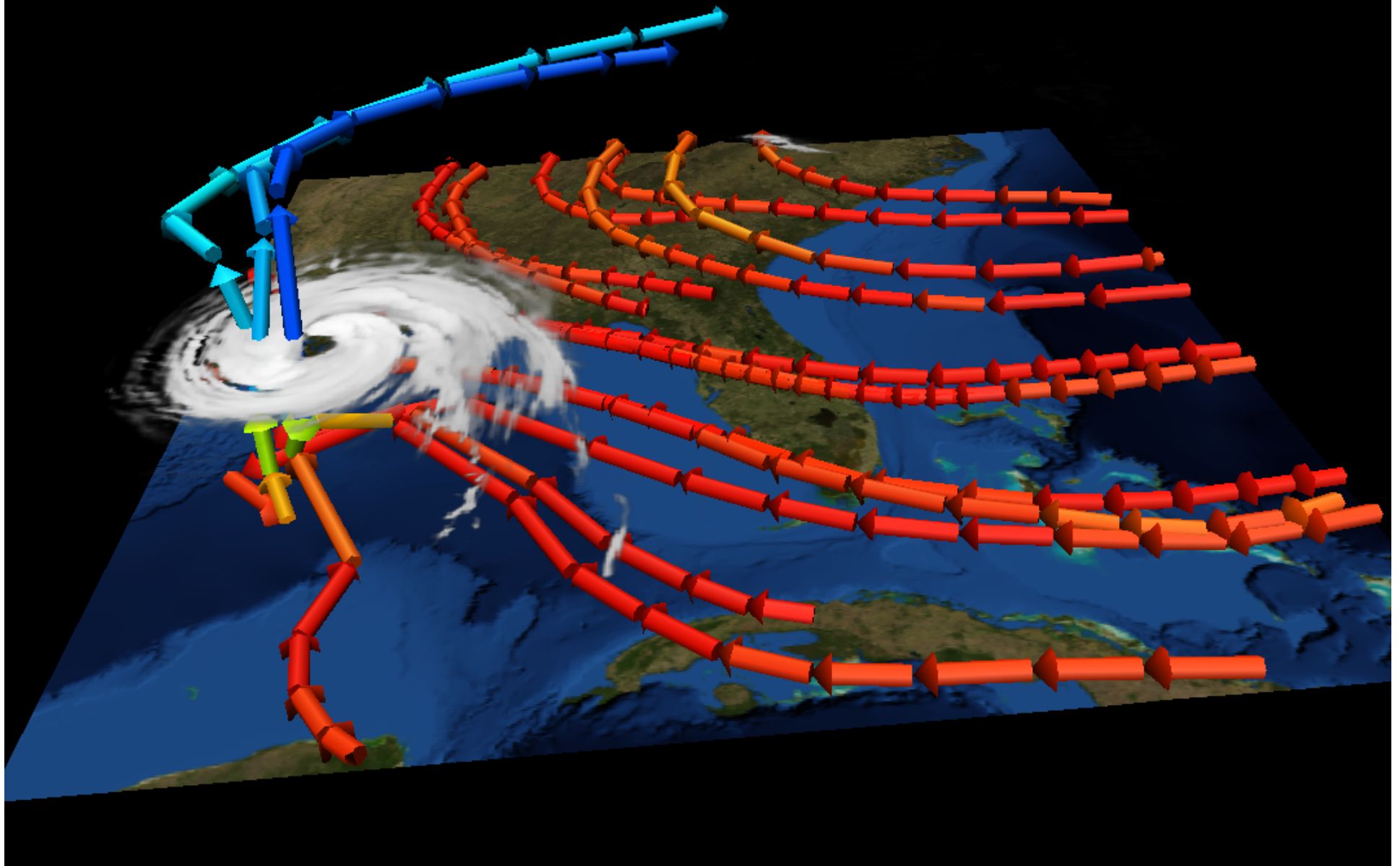
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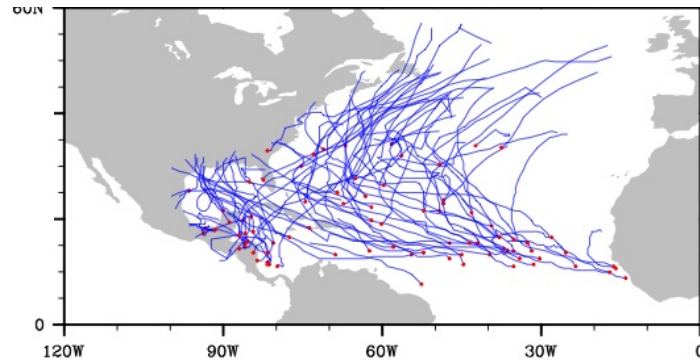
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# Simulated Hurricane in Sept 2055

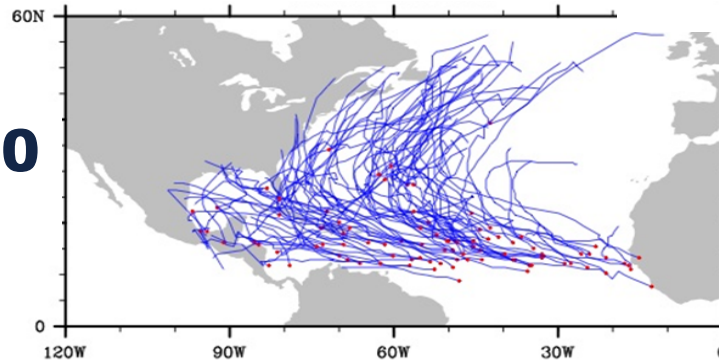


# Storm Tracks

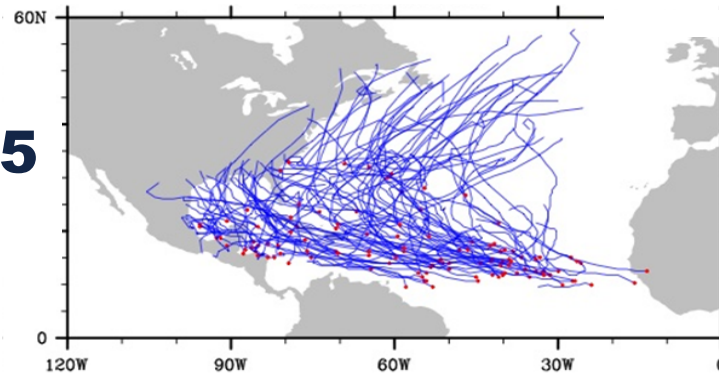
**Base  
Climate  
(7.6/yr)**



**2020-2030  
(8.5/yr)**



**2045-2055  
(10.4/yr)**



# Direct Impact Assessments

Integration of impact modeling with the latest weather and climate modeling.

Develop decision support tools for societal, industry planning and adaptation activities.

*Gilchrist, Texas after Hurricane Ike  
September 14, 2008.*



**(David J. Phillip-Pool/Getty Images)**

# Importance of Indices

- The decisions of individuals to evacuate are closely tied to the forecast Saffir-Simpson storm category (Zhang et al, 2007).
- Indices are highly effective communication and decision making tools, yet Saffir-Simpson does not correlate well with impacts/damage:
  - explains only ~10% of variance in total economic damage for 13 recent landfalling storms;
  - highlighted by Hurricane Ike.

Saffir-Simpson Scale	Hurricane Damage Considerations
Wind Speed	<b><i>Hurricane parameters:</i></b> Wind speed, central pressure, translation speed, size, duration of winds, rainfall.
	<b><i>Coastal variability:</i></b> amount of development, building codes, susceptibility to storm surge, topography etc.

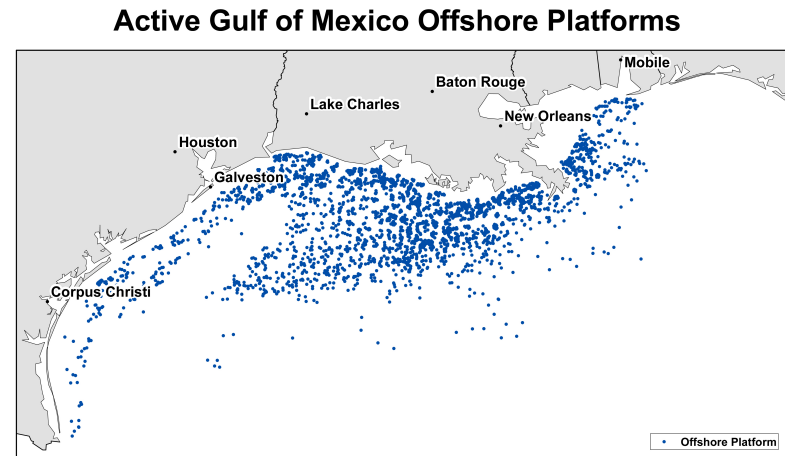
# New Hurricane Damage Indices: Approach

- Identify relationships between hurricane parameters and damage using historical data.
- Combine relationships into a damage index based on physical principles with limited tuning to the available data.
- Two versions in development:
  - Offshore
  - Onshore
- Applications:
  - real-time damage forecasts;
  - impact of climate variability and change on hurricane damage.



# Offshore Index Development: Data and Methods

- Willis Energy Loss Data (WELD) for the Gulf of Mexico (7 hurricanes) inflated by CEPCI (Arnold and Chiltern 1963) to 1998 values;



## Critical Hurricane Parameters:

- The amount of energy dissipated at the surface by maximum winds
- The radial extent and character of the surface wind field (n mile)
- The translational speed of the hurricane (kt).

Combined these are a proxy for waves, currents and storm surge.



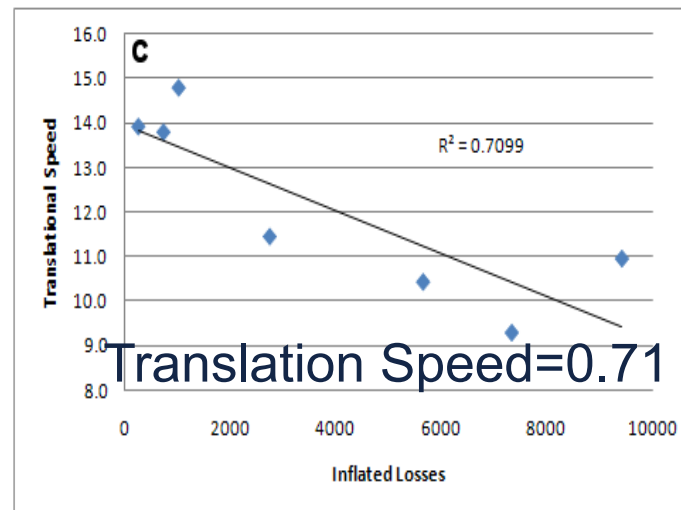
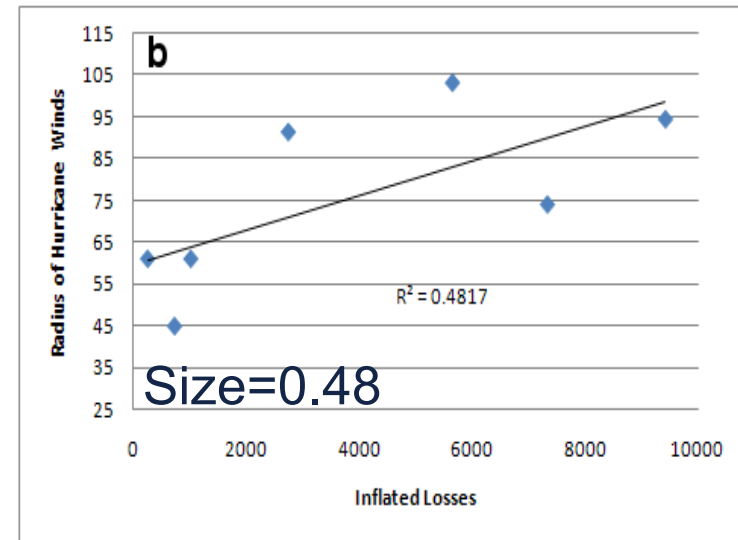
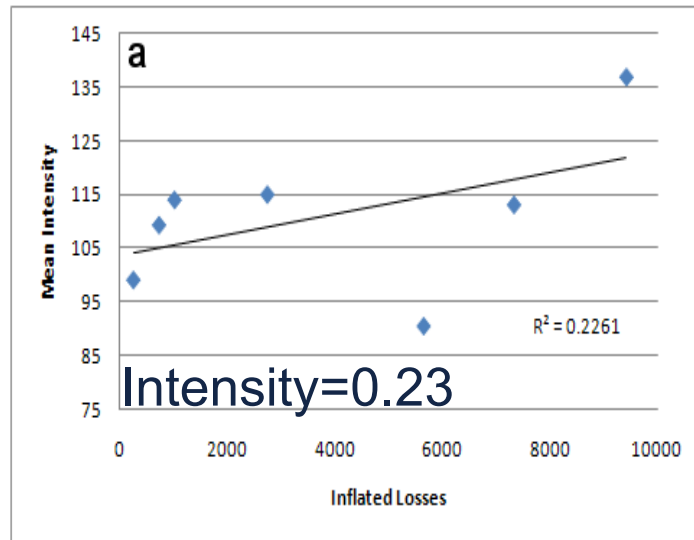
# Data and Method ctd.

Method: Combine the three critical factors in an additive formula:

$$WHI = a \left( \frac{v_m}{v_{m0}} \right)^{aa} + b \left( \frac{R_h}{R_{h0}} \right)^{bb} + c \left( \frac{v_t}{v_{t0}} \right)^{-cc},$$

*WHI – Willis Hurricane Index*

# Parameter Contributions





# The WHI for the Gulf of Mexico

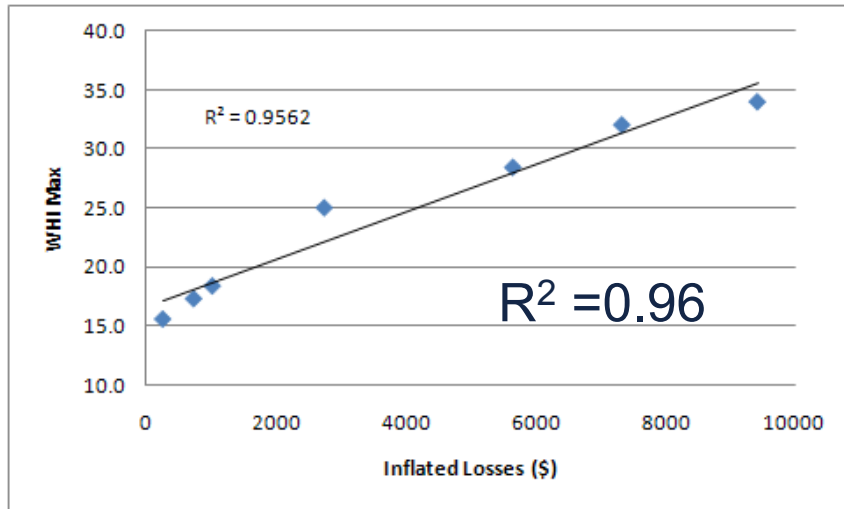
$$WHI = \left(\frac{v_m}{65}\right)^3 + 5\left(\frac{R_h}{50}\right) + 5\left(\frac{v_t}{15}\right)^{-2}$$

*For*  $v_m > 65,$

*If*  $v_t < 7, v_t = 7,$

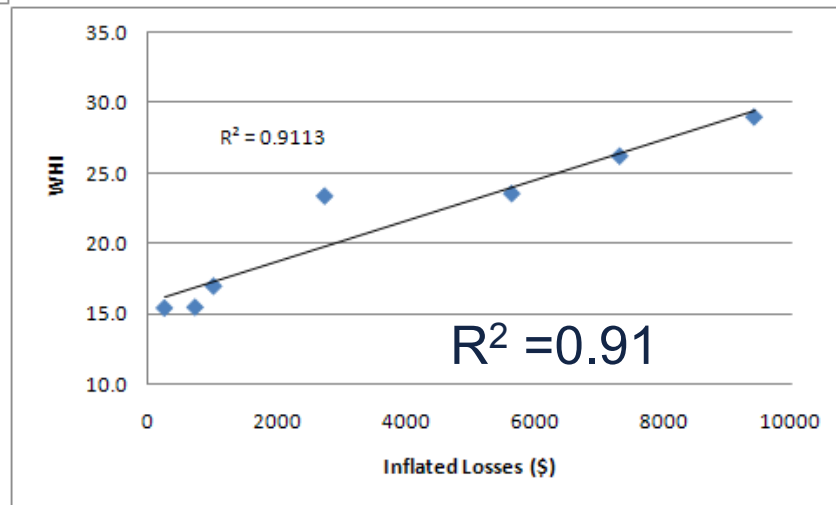


# Application to Gulf Losses

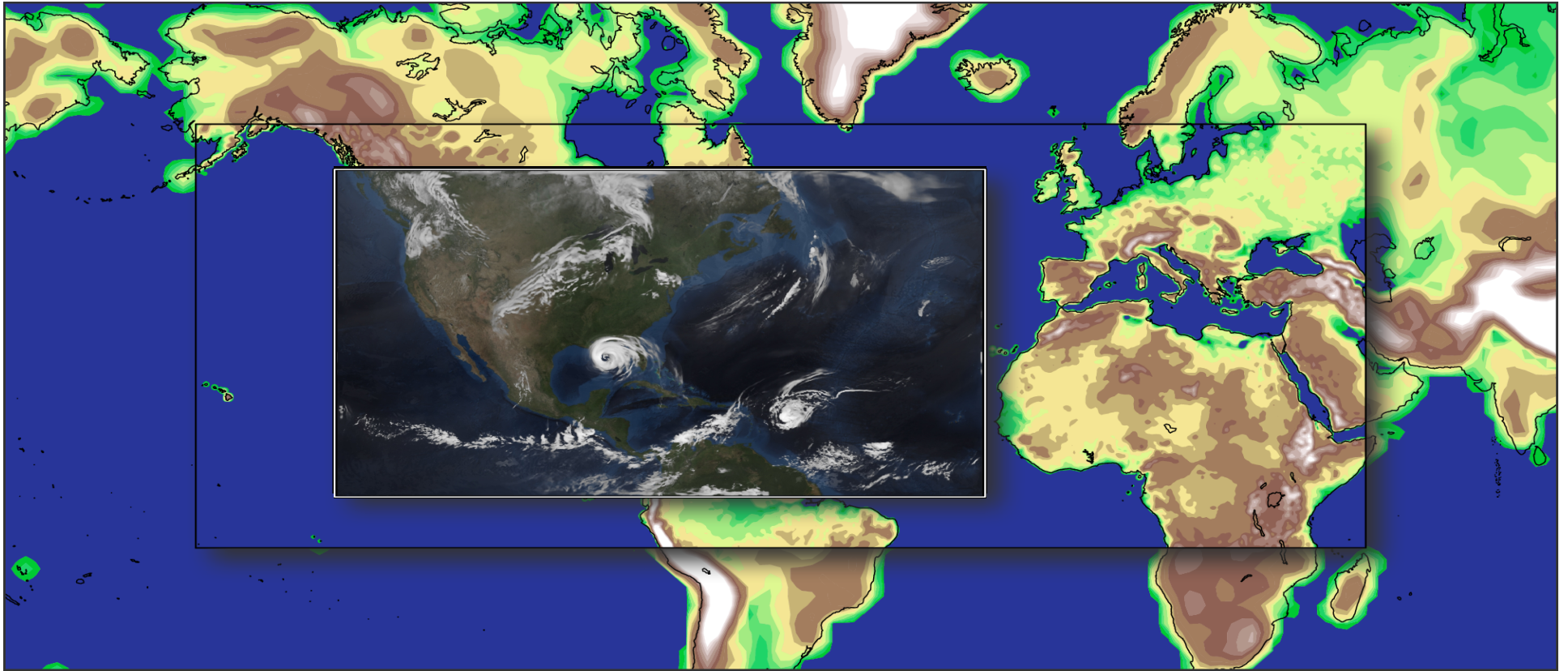


Maximum WHI vs Losses

Average WHI vs. Losses

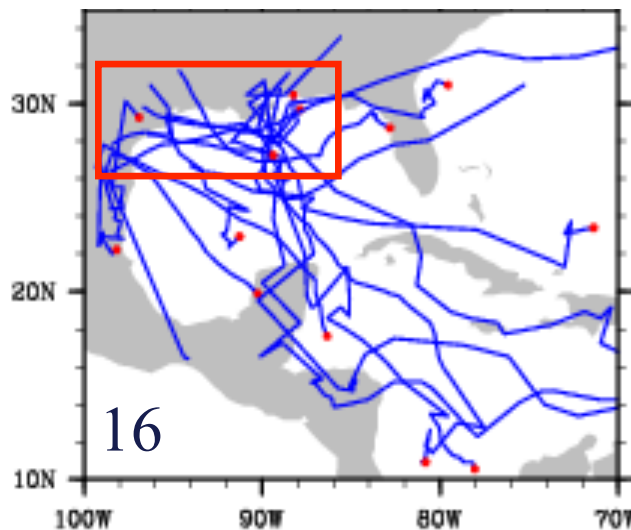


# Application to Current and Future Hurricanes

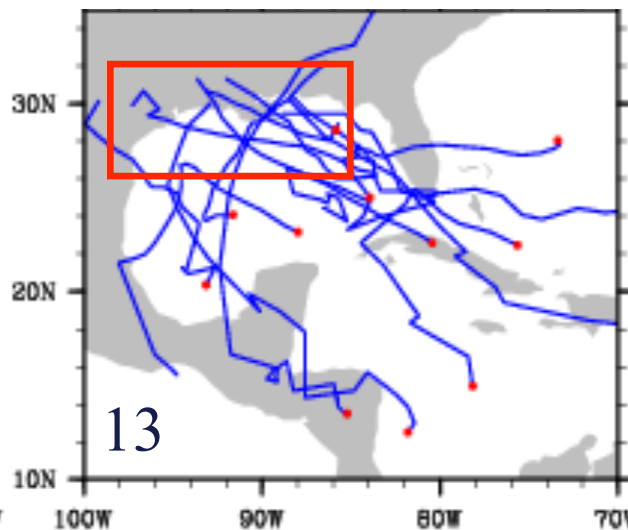


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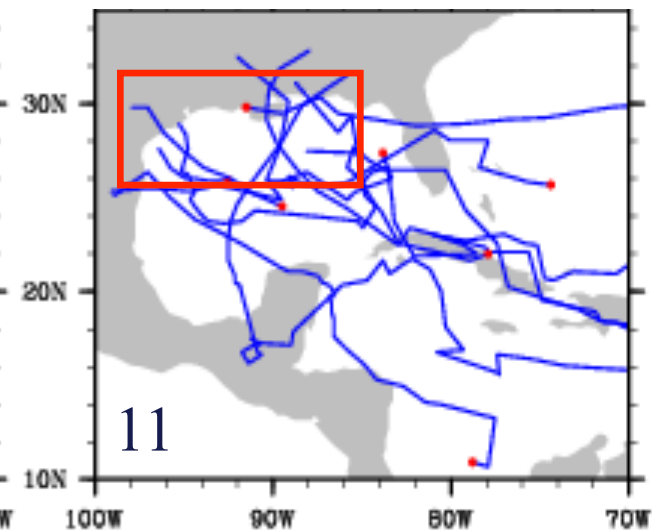
Base Climate



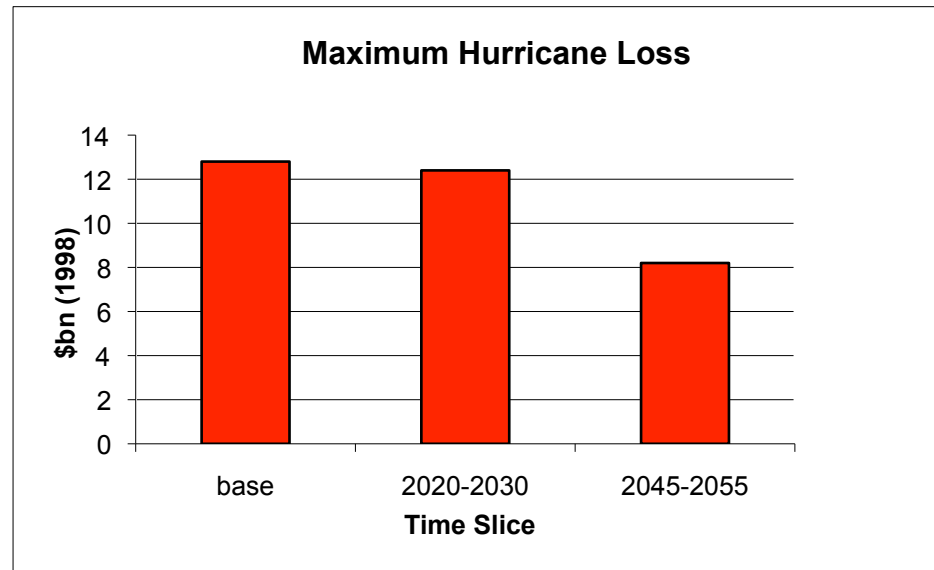
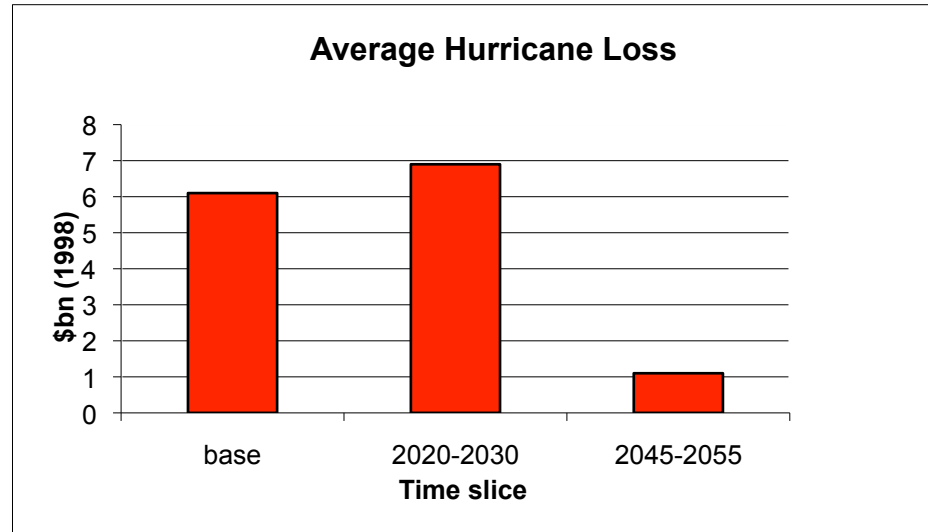
2020 – 2030



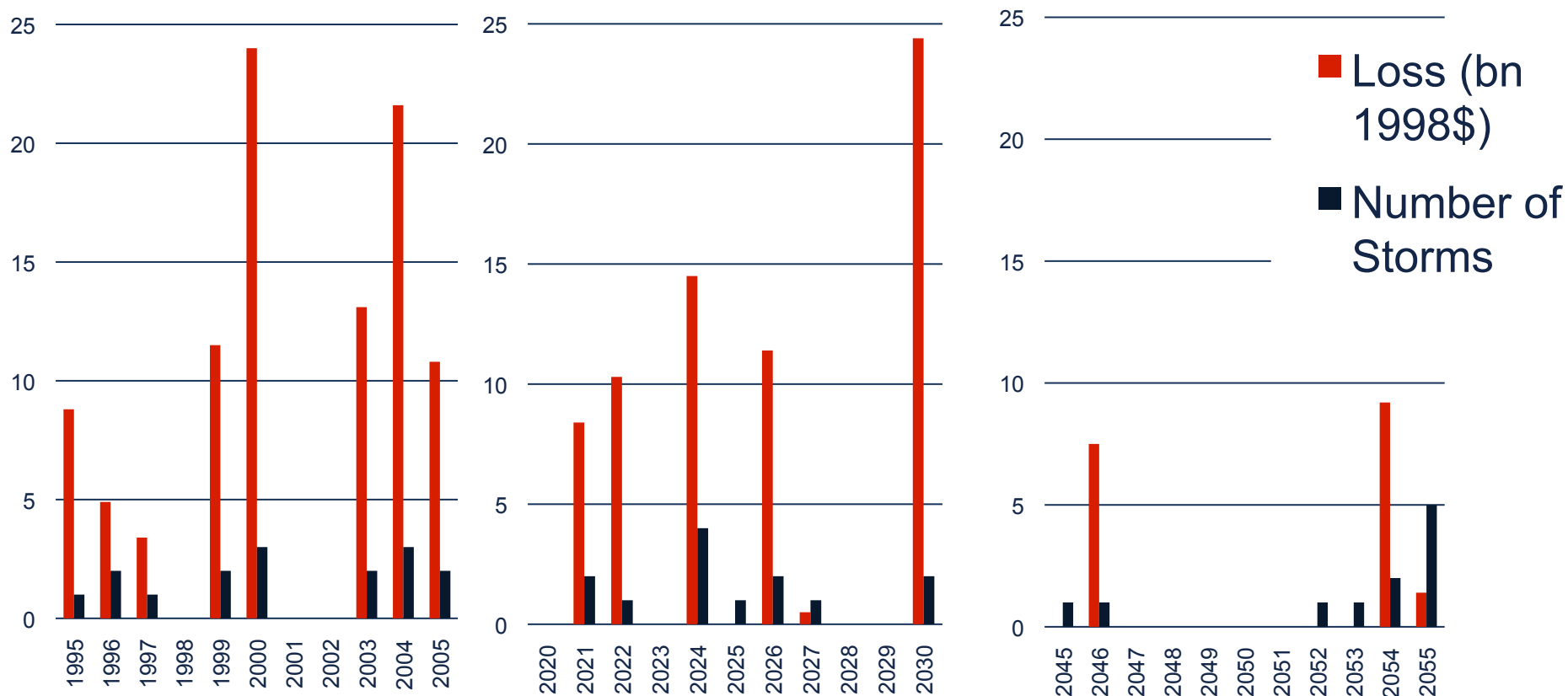
2045 - 2055



# Hurricane Losses



# Total Annual Losses



# Summary

- Our simulations of current and future storms shows North Atlantic storms will become more frequent and more intense.
- Willis Hurricane Index provides a first order assessment of likely changes in net damage to off-shore facilities.



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# Future Work

- Real-time testing of WHI during the 2011 hurricane season.
- New simulation system:

