

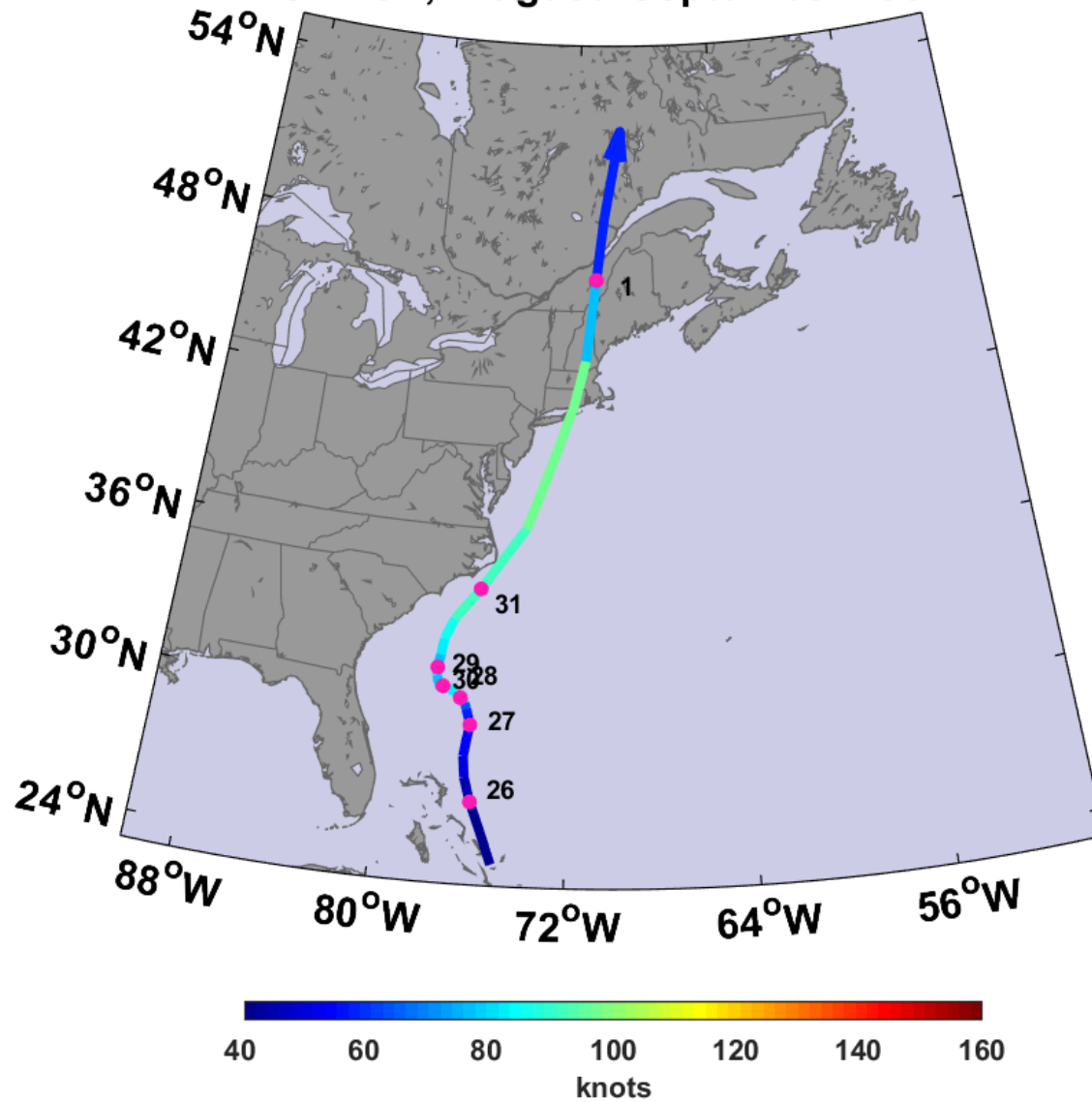
# Hurricanes in Maine: Past, Present, & Future

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Massachusetts Institute of Technology



# Some Famous Maine Hurricanes

# CAROL, August -September 1954



# Hurricane Carol of 1954 in Maine

- Three deaths in Maine; 65 deaths and 1,000 injuries in New England
- \$10 million in damages in Maine (\$250 million in 2019 dollars)
- \$500 million in damages, New England (\$12.5 billion 2019)
- Peak wind gusts of 78 MPH in mid-coast Maine
- 2.25 inches of rain in places (not that much, but played into the Edna disaster a few weeks later)
- Power lost in all of greater Portland
- Most lobster fisherman reported damage
- Three-quarters of the Maine apple crop destroyed





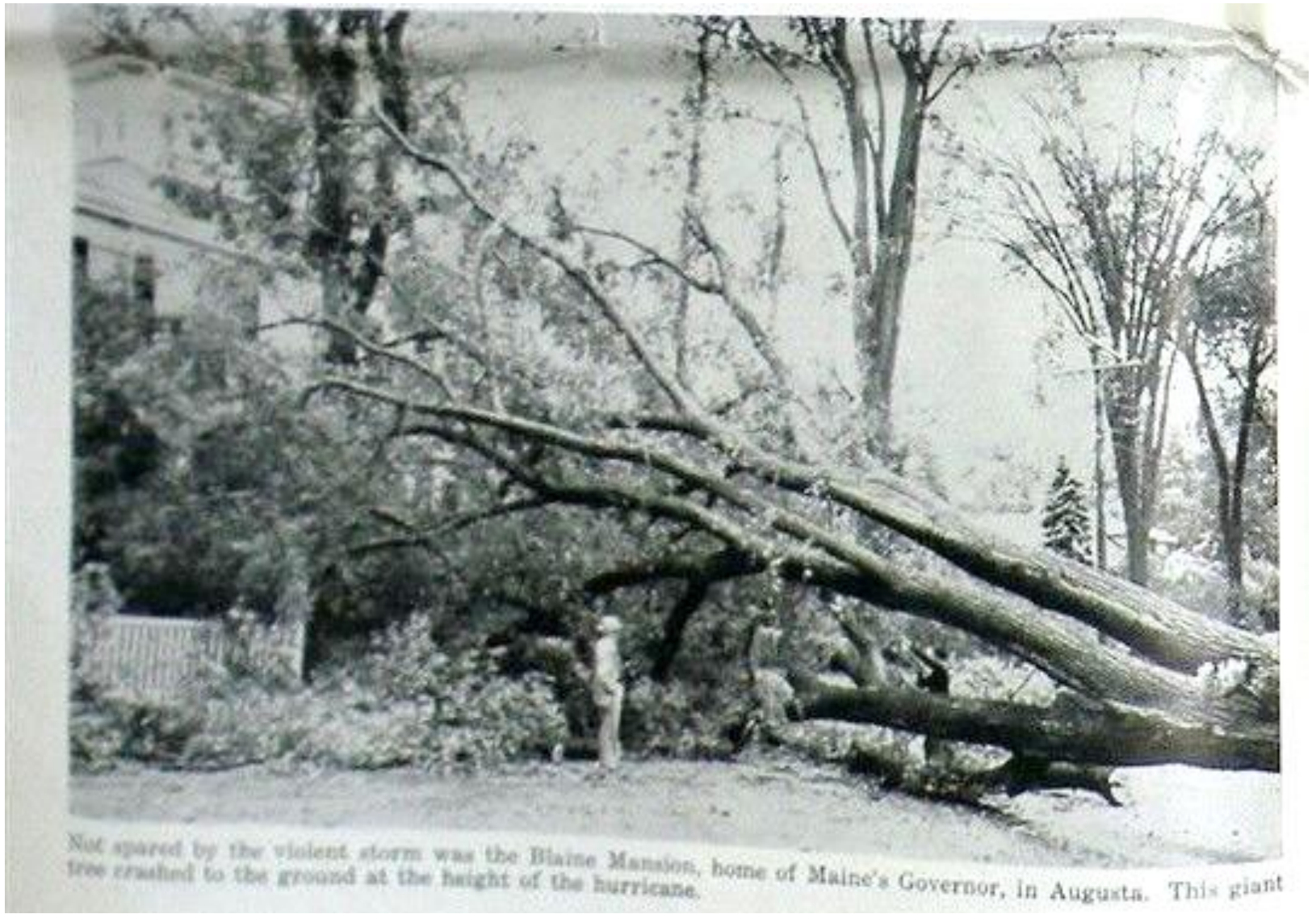
Wrecked by the mighty winds of Hurricane Carol which lashed Maine on August 31, the 36-foot twin-screw cruiser *Wassie* lies splintered and broken on the shore at Falmouth. She was one of many coastal vessels lost.



Workmen speedily haul a giant elm from the rooftop of a Portland home after Hurricane Carol had wreaked havoc in Maine's biggest city. Scenes like this were typical throughout the state on Sept. 1, day after the big storm.

Falmouth, ME

Portland, ME



Not spared by the violent storm was the Blaine Mansion, home of Maine's Governor, in Augusta. This giant tree crashed to the ground at the height of the hurricane.

## The Blaine Mansion, Augusta





A scene in Maine during Carol

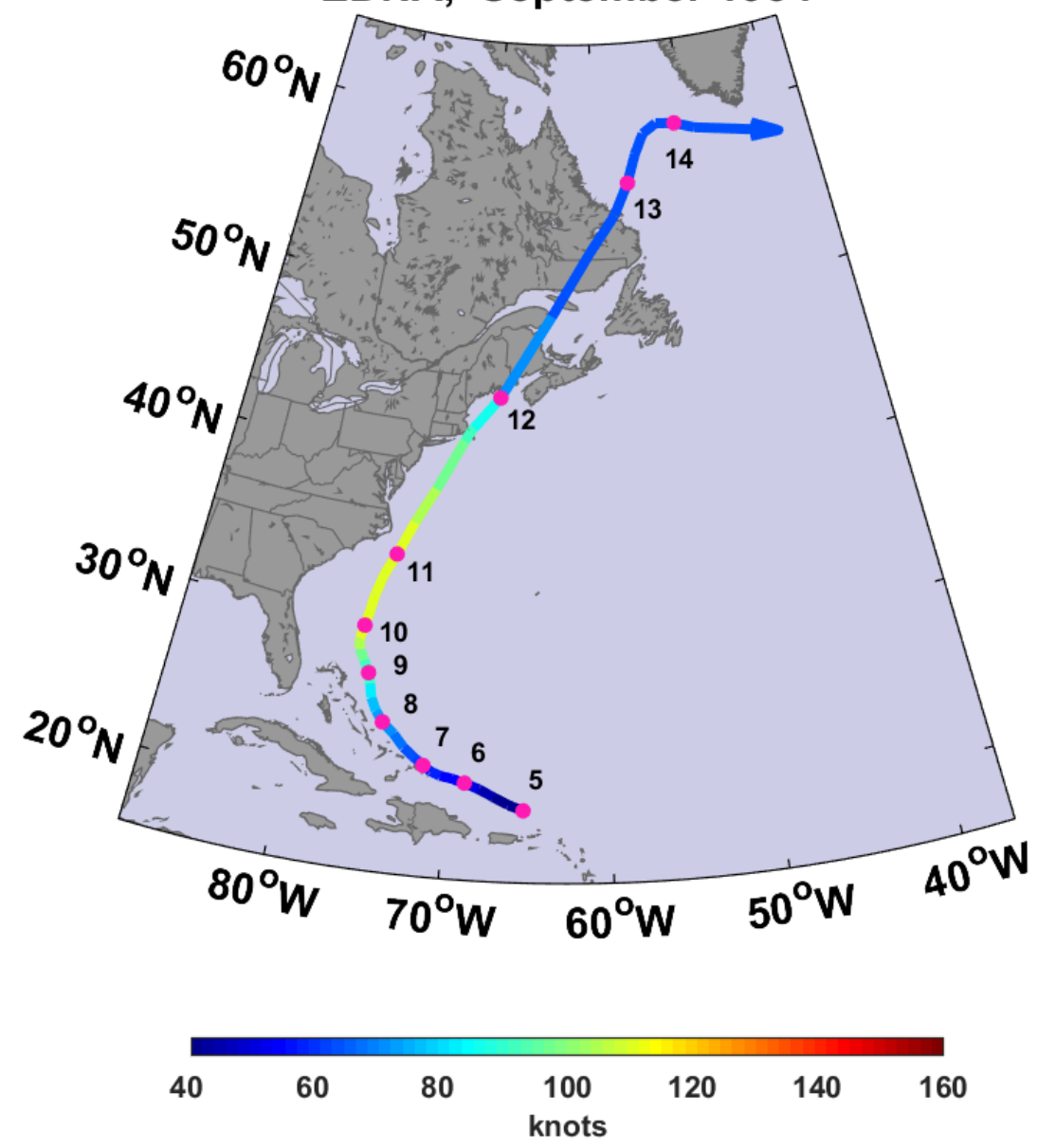


Looking SW from Ocean Point, Boothbay during Carol



148-year-old steeple of the Old North Church in Boston falling during Hurricane Carol, 1954

# EDNA, September 1954



# Hurricane Edna of 1954 in Maine

- Eight deaths in Maine
- \$25 million damage in Maine (\$240 million in 2019 dollars)
- Peak wind gusts of 75 MPH in Maine
- Rainfall totals as high as 7.5 inches
- The Androscoggin and Kennebec rivers both reached above-normal levels, causing flooding and washing out roads
- President Eisenhower declared Maine a disaster area





Harvard Beal's Bait Scow and Beal's Boat Yard,  
Southwest Harbor, during Hurricane Edna



Memorial Highway near Dunn's Corner, Yarmouth (now Rt. 9)



Damage to dam in Limestone, ME



Remains of the drive-in movie theater in Rockport, ME, after Edna



## OUR WINDSWEPT CORRESPONDENTS

### THE EYE OF EDNA

TWO hurricanes have visited me recently, and except for a few rather hasty observations of my own (which somehow seem presumptuous), all I know about these storms is what I've heard on the radio. I live on the Maine coast, to the east of Penobscot Bay. Formerly, this coast was not in the path of hurricanes, or if it was we didn't seem to know it, but times change and we must change with them. My house is equipped with three small, old-fashioned radios, two of them battery sets, one a tiny plug-in bedside model on which my wife sometimes manages to get the Giants after I have turned in. We do not have TV, and because of this curious omission we are looked upon as eccentrics, possibly radicals.

Hurricanes, as all of us know to our sorrow, are given names nowadays—girls' names. And, as though to bring things full circle, newborn girl babies are being named for hurricanes. At the height of the last storm, one of the most

and my reaction was normal. I simply buttoned up the joint and sat down to wait. The wait proved interminable. The buttoning-up was not difficult—merely a couple of hours of amusing work, none of it heavy. I first went to the shore, hauled my twelve-foot boat up above high-water mark, and tied it to a stump. I closed and barricaded the boathouse doors. Then I came back up through the meadow, tolled the sheep into the barn, hooked the big doors on the north side, and drove nails in next to the hooks, so they couldn't pull out when the doors got slatting around. I let the geese in and fed them some apples—windfalls left over from Hurricane Carol. There was no good reason to shut the geese in, as they had roamed all over the place during Carol, enjoying the rough weather to the hilt and paying frequent visits to the pond at the height of the storm, but I shut them in from tidiness, and because the

radio was insisting that everyone stay indoors. I got a couple of two-by-fours and some pegs, and braced the cedar fence on the west side of the terrace. Anticipating power failure, I drew extra water for drinking and cooking, and also set a pail of water next to each toilet, for a spare flush. My wife, who enters quickly into the spirit of disaster, dug up a kerosene lamp, and there was a lot of commotion about cleaning the globe and the chimney—until it was discovered that there was no wick. The potted fuchsia was moved indoors, and also the porch rocker, lest these objects be carried aloft by the wind and dashed against windows. The croquet set was brought in. (I was extremely skeptical about the chance of croquet balls' coming in through the window, but it presented a vivid picture to the imagination and was worth thinking about.) The roof of the pullet house had blown off during Carol, and

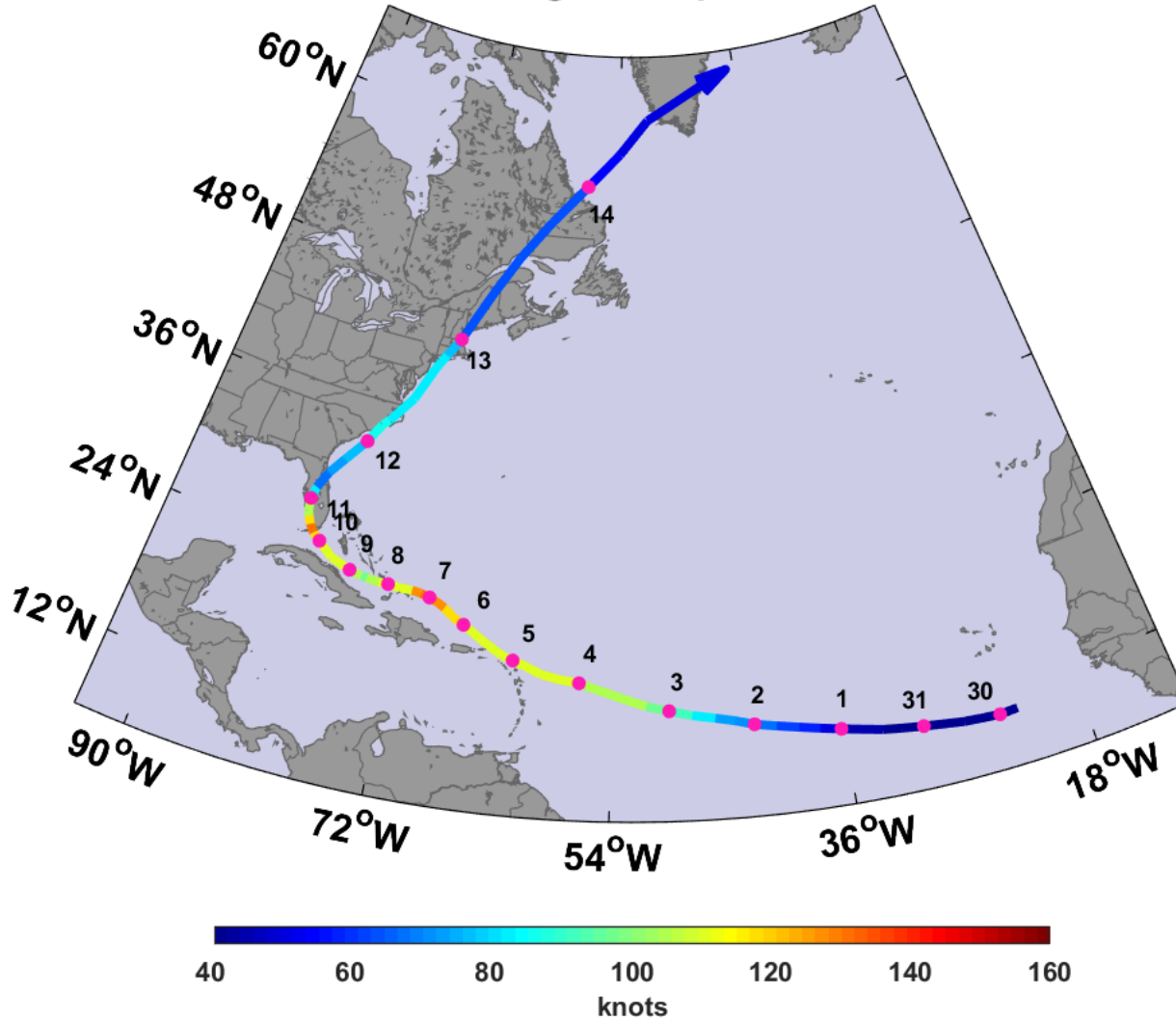
Article by E.B. White, *The New Yorker*, Sept. 25<sup>th</sup> 1954  
(White resided in North Brooklin, Maine)



***Menemsha hurricane*** - Thomas Hart Benton (1954). The painting depicts 1954's Hurricane Edna which highly damaged the coast of New England. Menemsha, a small fishing village on Martha's Vineyard, was hit especially hard.



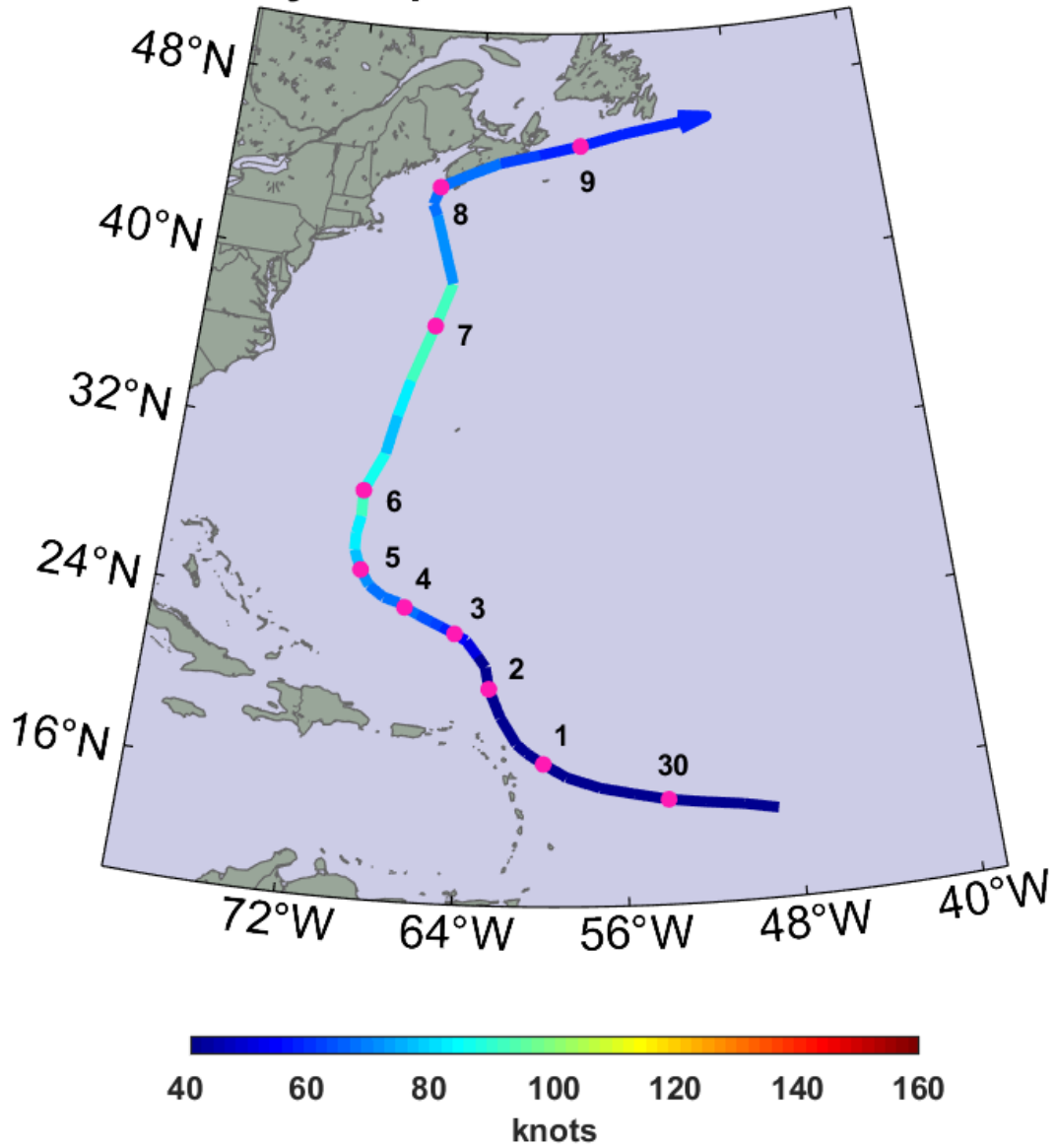
# DONNA, August -September 1960



Relatively light damage in Maine, but 20-40% of apple crop destroyed



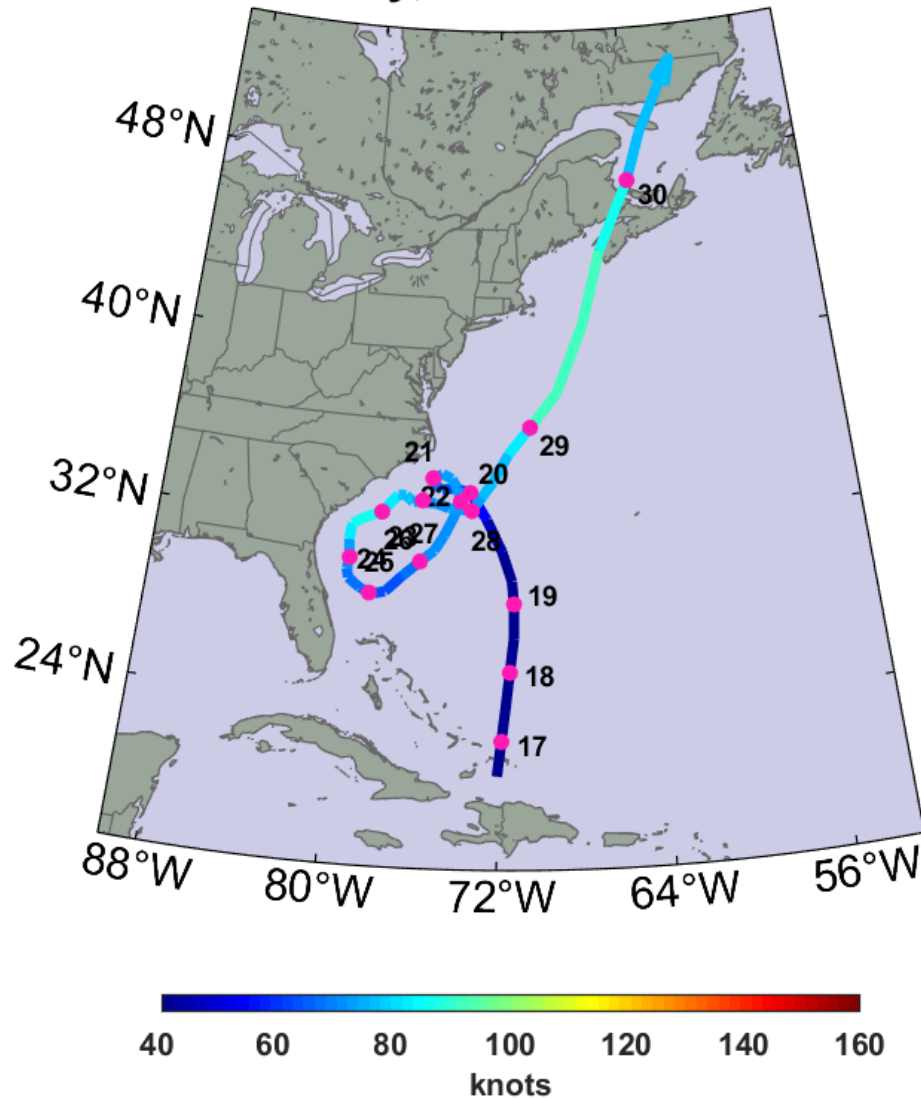
# Daisy, September -October 1962



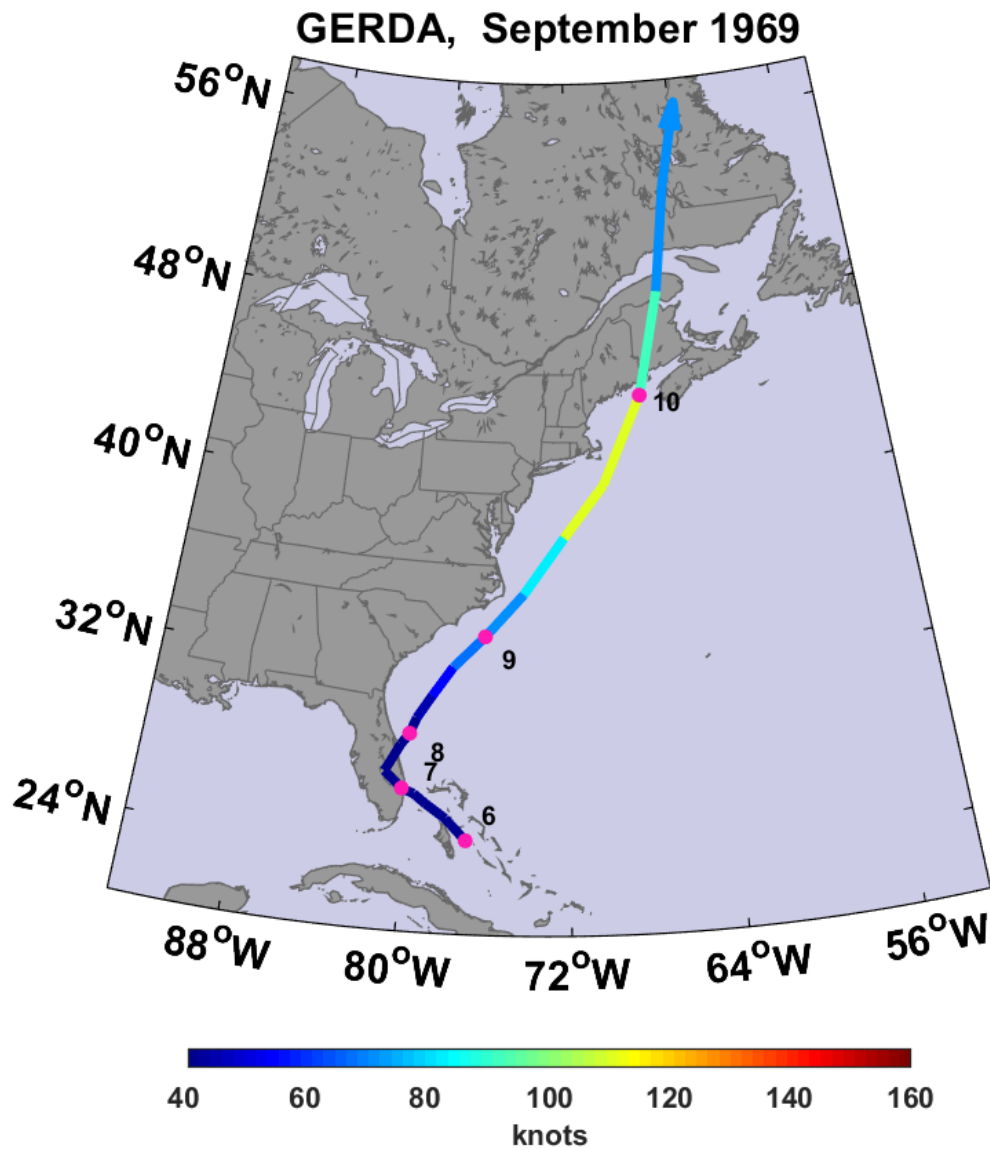
# Hurricane Daisy in Maine

- Two deaths from falling branches, in Thomaston and Rockland
- 9.5 inches of rain fell in Portland, an all-time record that held until Hurricane Bob of 1991
- Wind gusts to 70 MPH in coastal Maine

# Ginny, October 1963

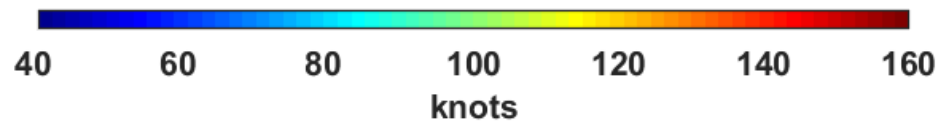
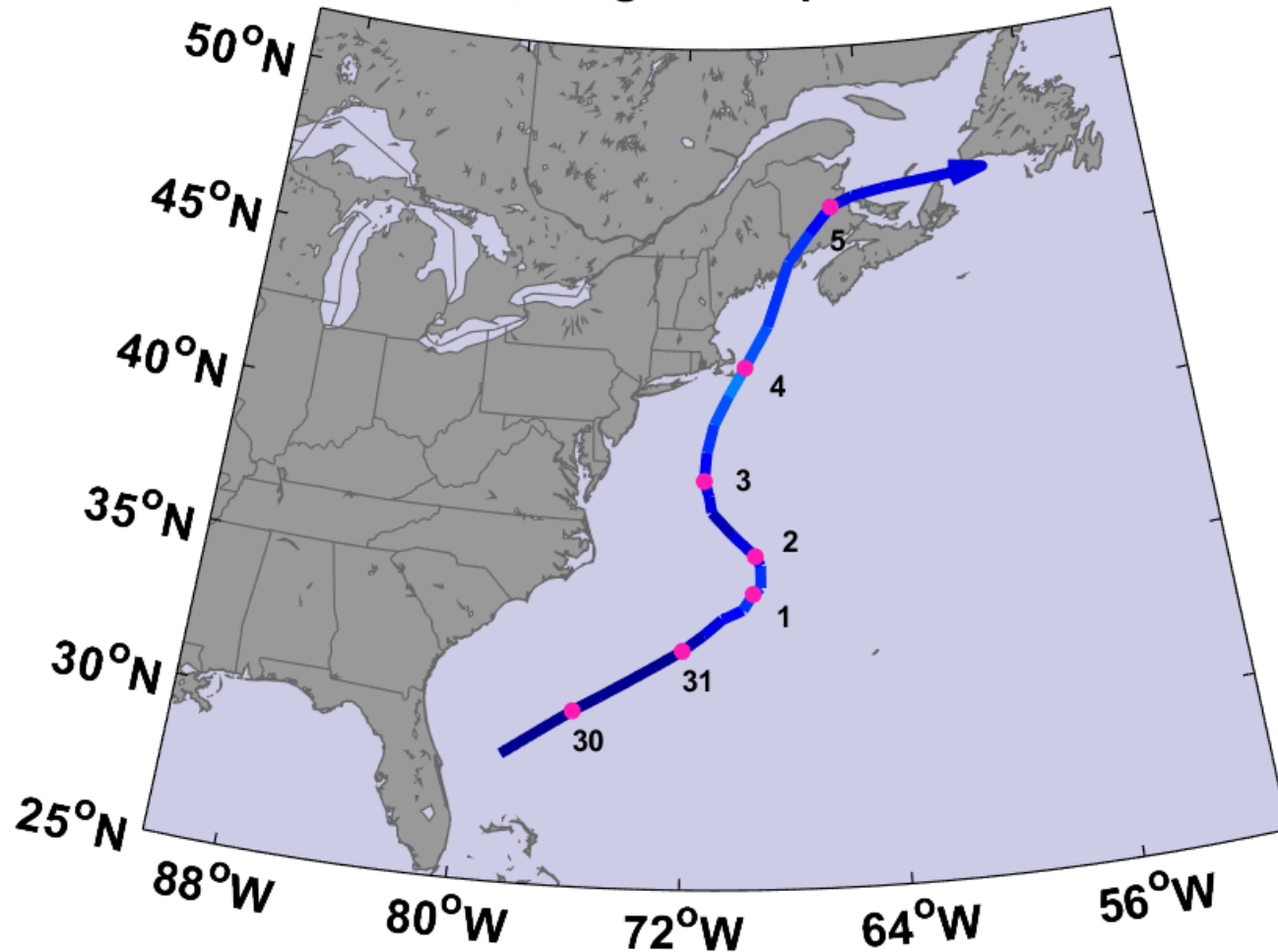


Gusts to 100 MPH at Rockland Coast Guard station. Many trees were knocked over and a barn at the Maine State Prison farm in South Warren was destroyed.



Landfall near Eastport as a Category 2 hurricane...probably strongest hurricane to strike Maine in recorded history.

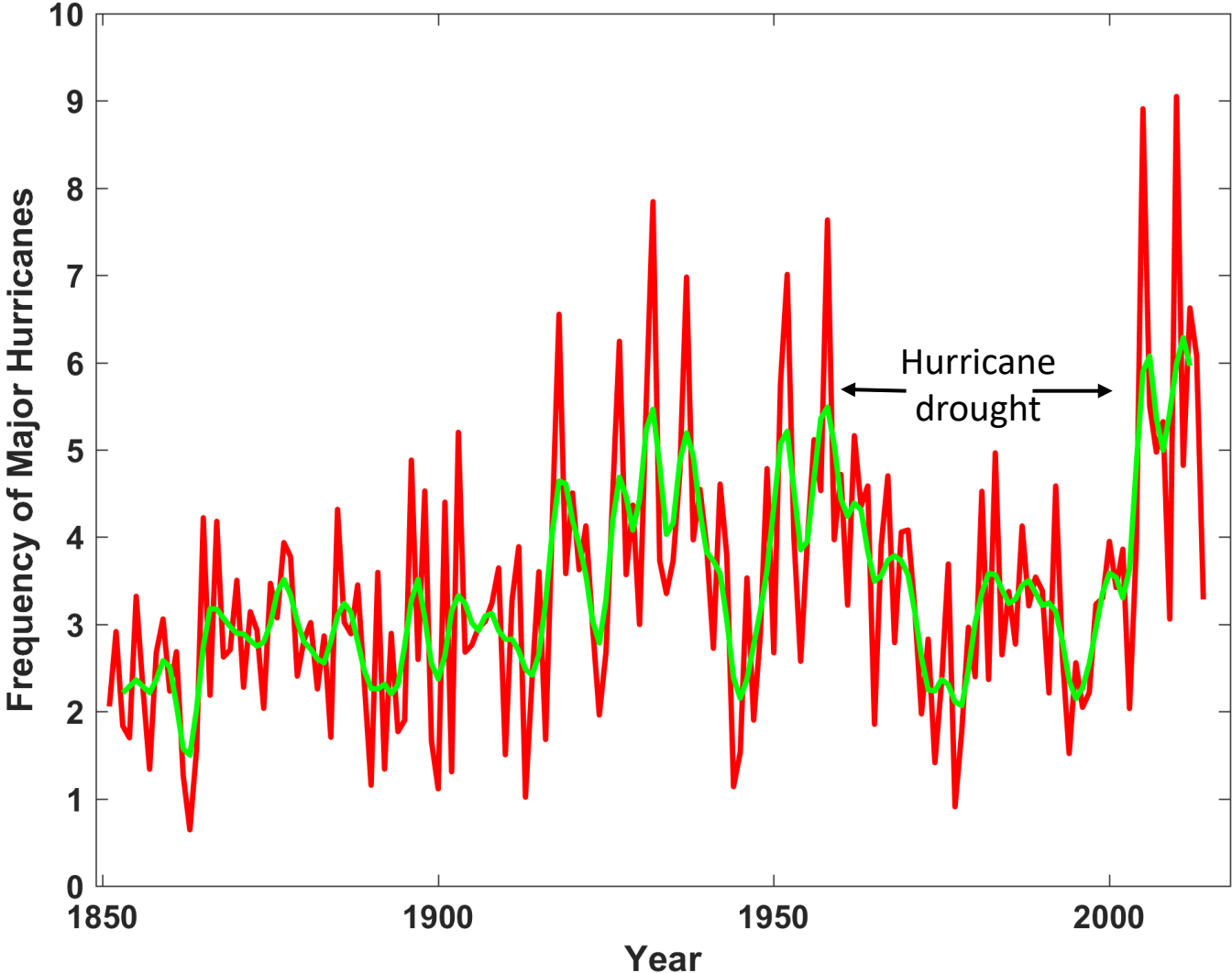
# CARRIE, August -September 1972



Two deaths in Maine from high surf

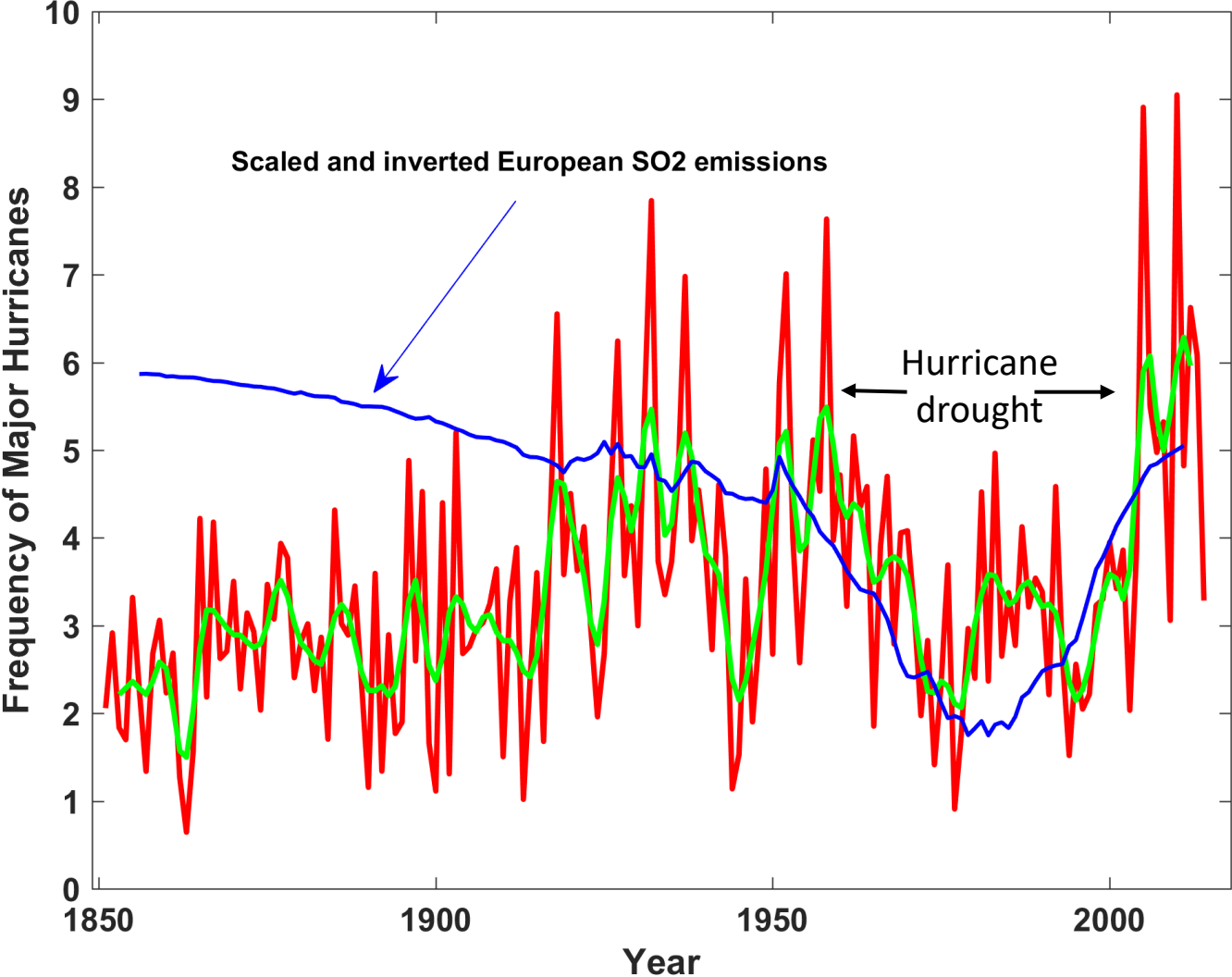
# North Atlantic Major Hurricanes Downscaled from NOAA 20<sup>th</sup> Century Reanalysis

(Forced by sea surface temperature, surface pressure, and sea ice only)

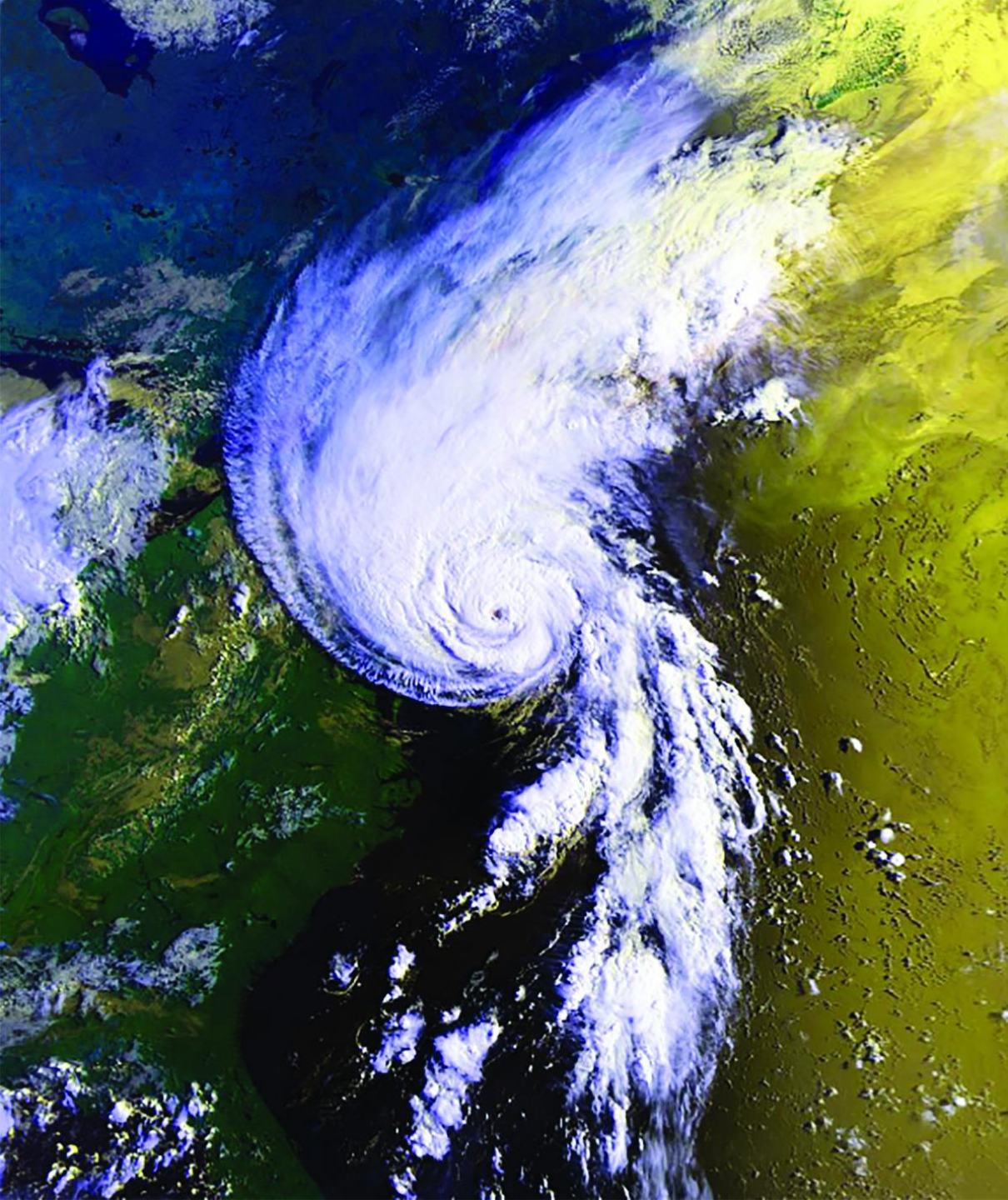


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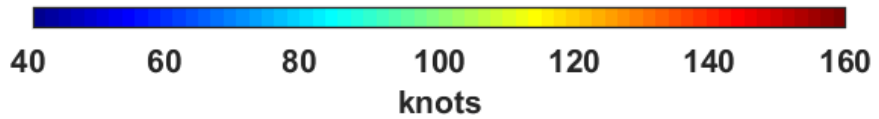
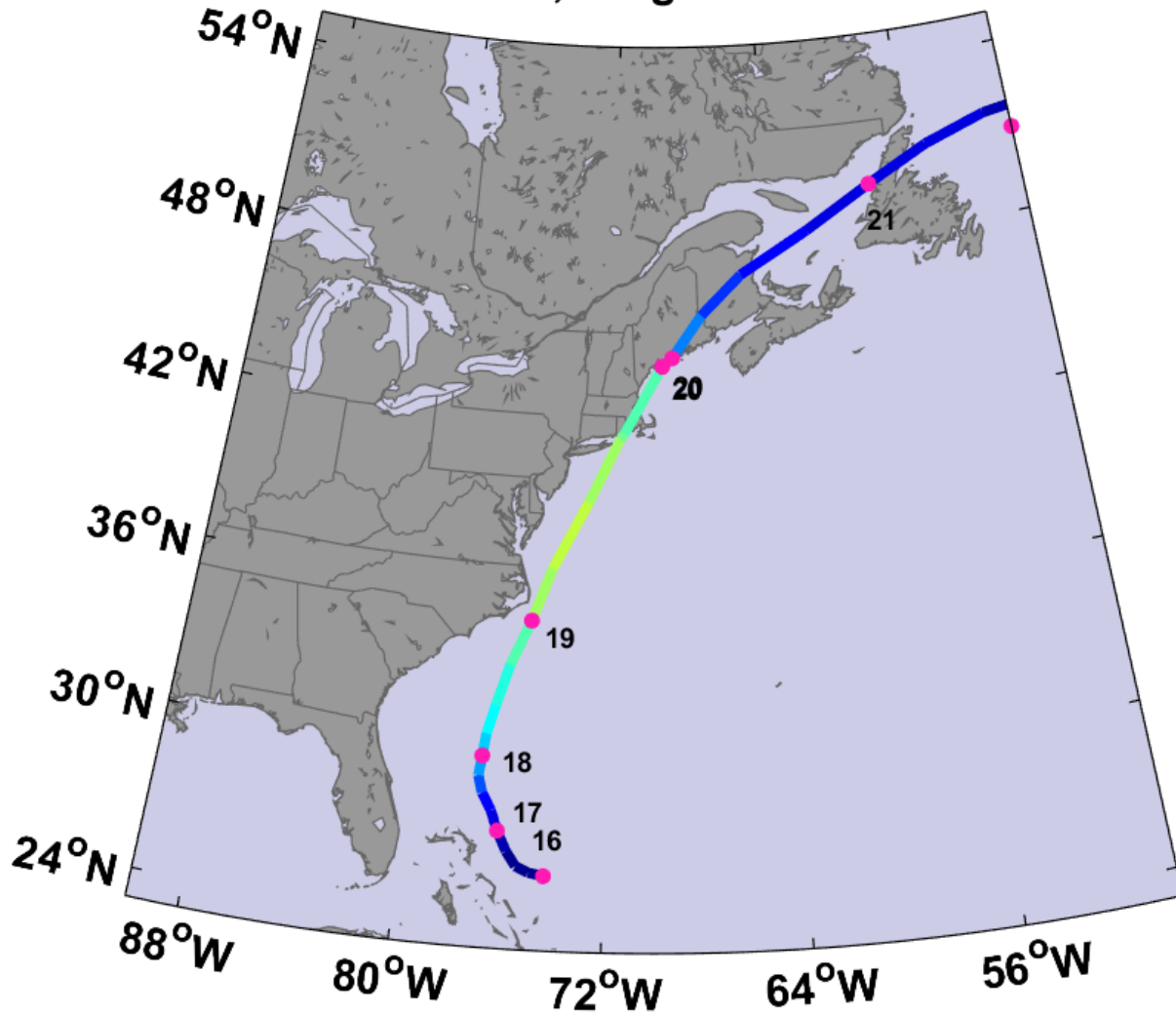






Hurricane Bob  
approaching Maine,  
August 20, 1991

# BOB, August 1991

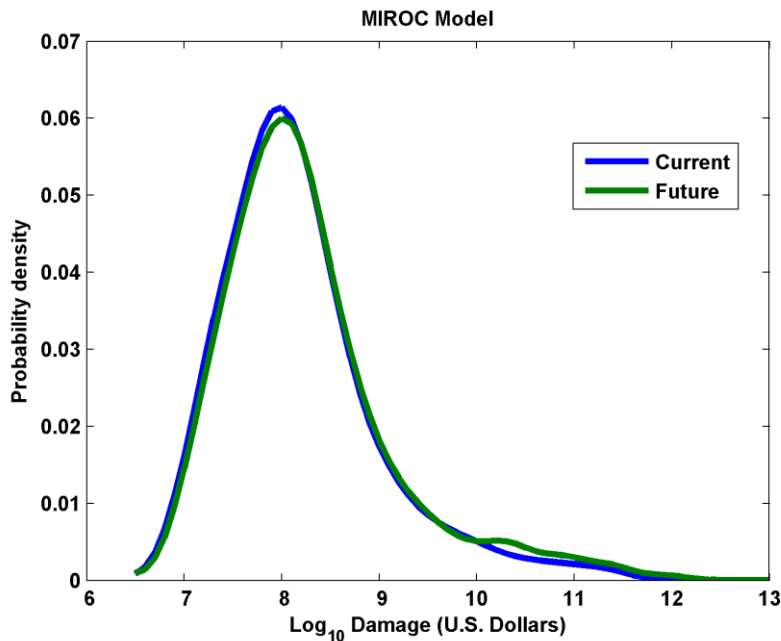


# Hurricane Bob in Maine

- Landfall near Rockland, ME
- One of the costliest hurricanes ever to strike New England...  
\$1.5 billion 1991 dollars (\$2.75 billion in 2019)
- 3 deaths in Portland
- Gusts to 70 MPH in Portland, 92 MPH in Wiscasset
- 8.25 inches of rain at Portland
- 170,000 lost power, some for more than a week
- Tornado at St. Albans (unconfirmed)
- 2-3 ft storm surge
- River flooding washed out five bridges and roads across southwestern Maine

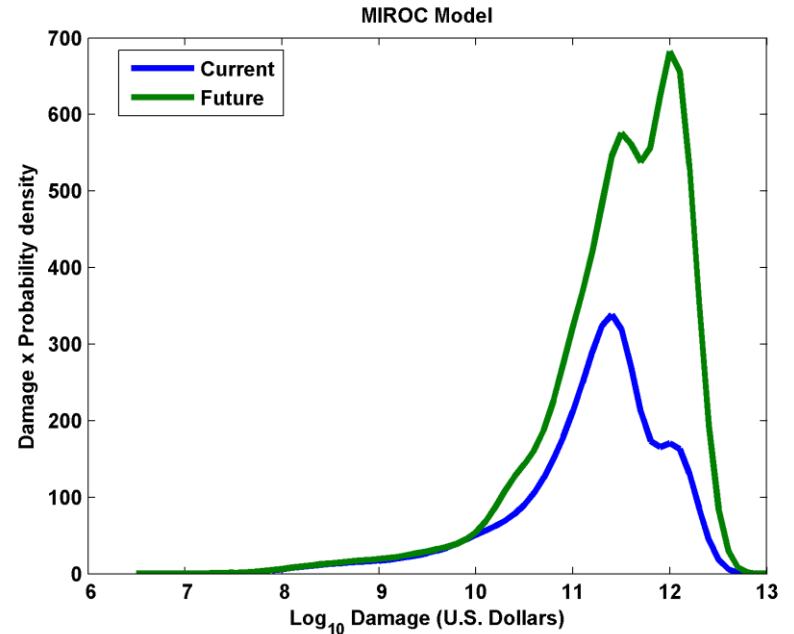
# Hurricane Risk Assessment: The Problem

## Event Probability



Current and Future Probability Density of U.S. TC Wind Damages

## Damage Probability



Current and Future Damage Probability

# The Heart of the Problem:

- Societies are usually well adapted to frequent events ( $> 1/100$  yr)
- Societies are often poorly adapted to rare events ( $< 1/100$  yr)
- Robust direct estimates of the character of  $\sim 100$  yr events require  $\sim 1,000$  years of data
- We do not have  $\sim 1,000$  years of meteorological observations



# MIT Approach: Use Physics to Estimate Hurricane Risk

- **Embed high-resolution, fast coupled ocean-atmosphere hurricane model in global climate model or climate reanalysis data**
- **Coupled Hurricane Intensity prediction Model (CHIPS) has been used for 16 years to forecast real hurricanes in near-real time**

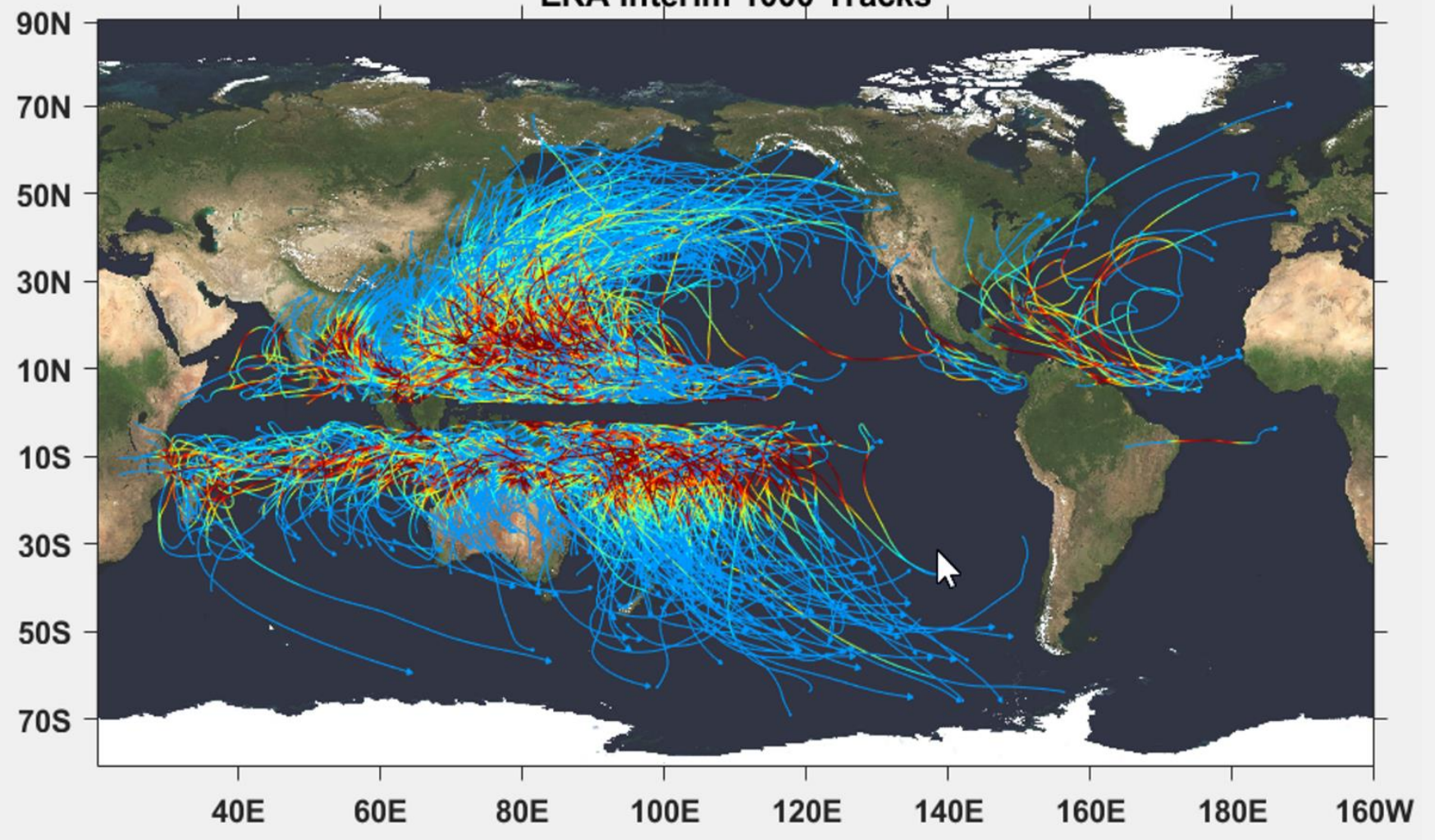
# Risk Assessment Approach:

- **Step 1:** Seed each ocean basin with a very large number of weak, randomly located cyclones
- **Step 2:** Cyclones are assumed to move with the large scale atmospheric flow in which they are embedded, plus a correction for the earth's rotation and sphericity
- **Step 3:** Run hurricane intensity model for each cyclone, and note how many achieve at least tropical storm strength
- **Step 4:** Using the small fraction of surviving events, determine storm statistics. Can easily generate 100,000 events

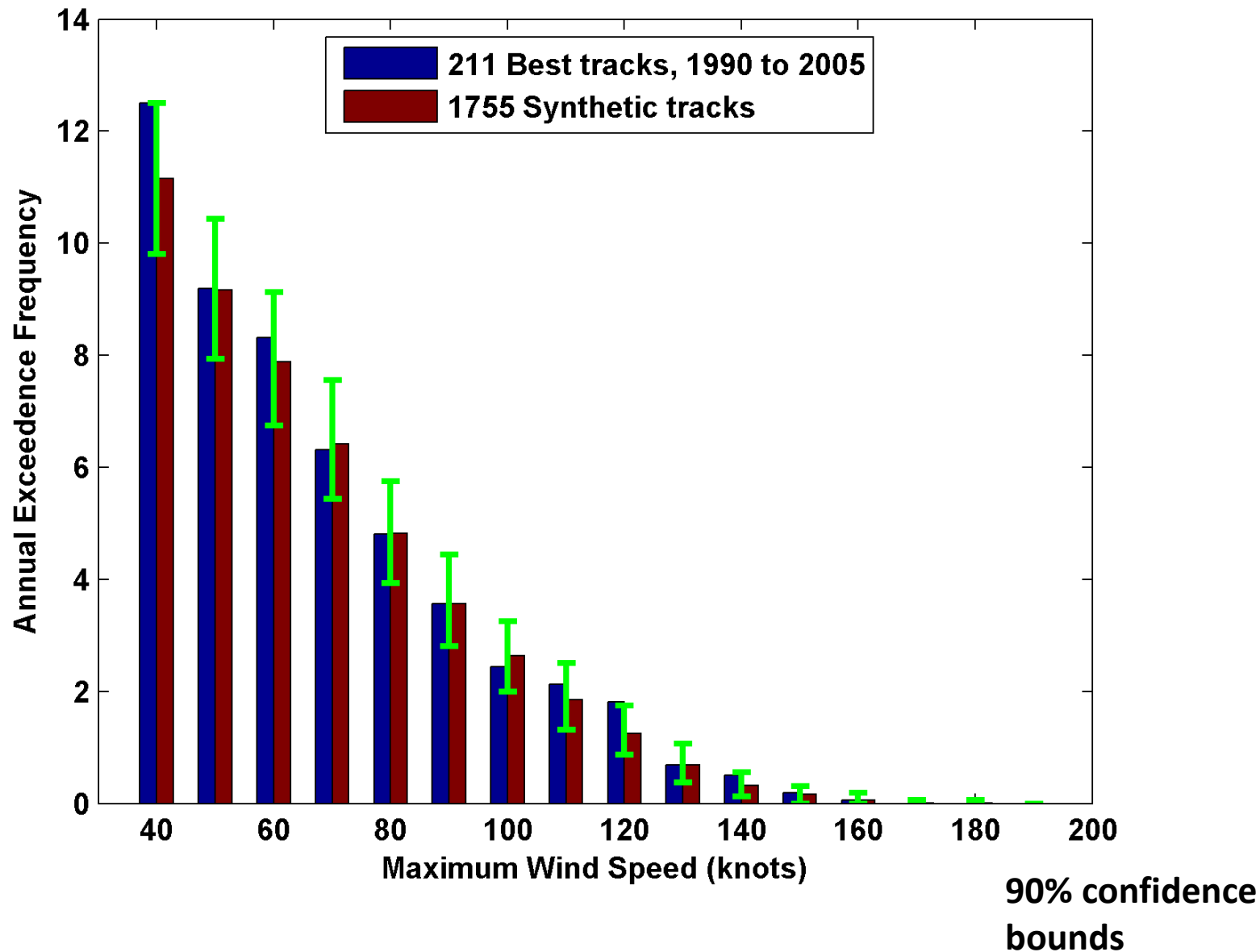
Details: Emanuel et al., *Bull. Amer. Meteor. Soc.*, 2008



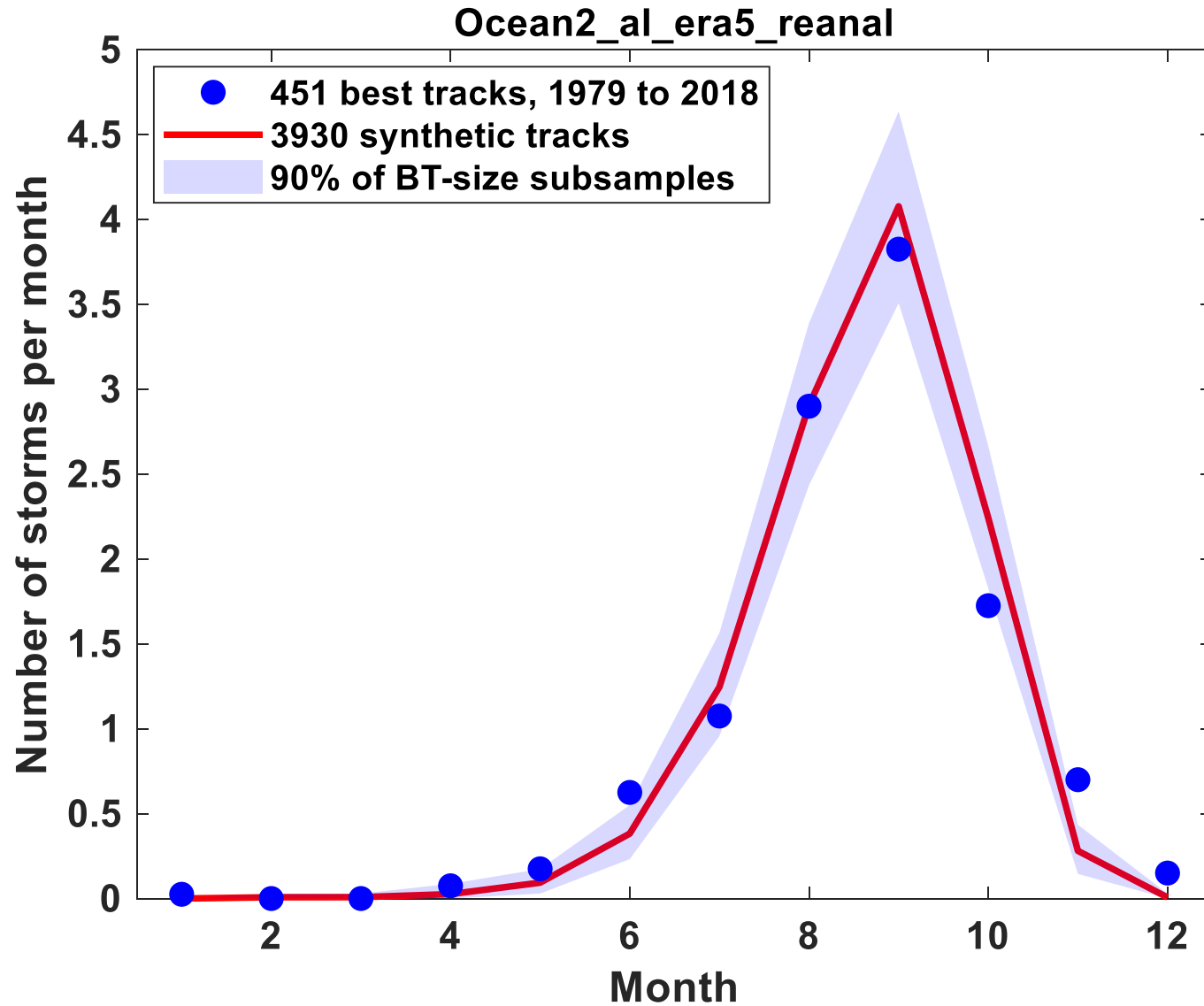
### ERA Interim 1000 Tracks



# Cumulative Distribution of Storm Lifetime Peak Wind Speed, with Sample of 1755 Synthetic Tracks

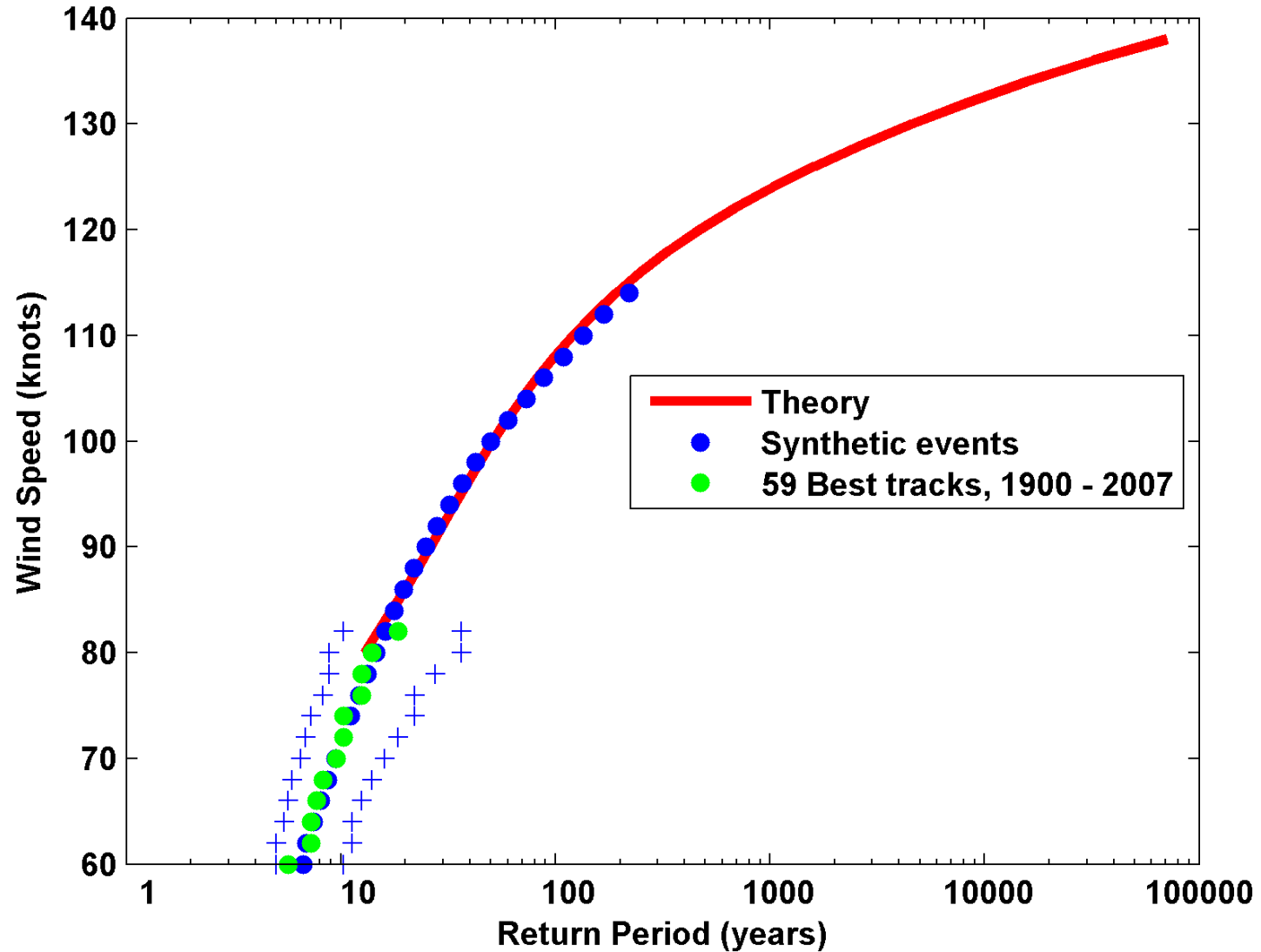


# Atlantic Annual Cycle

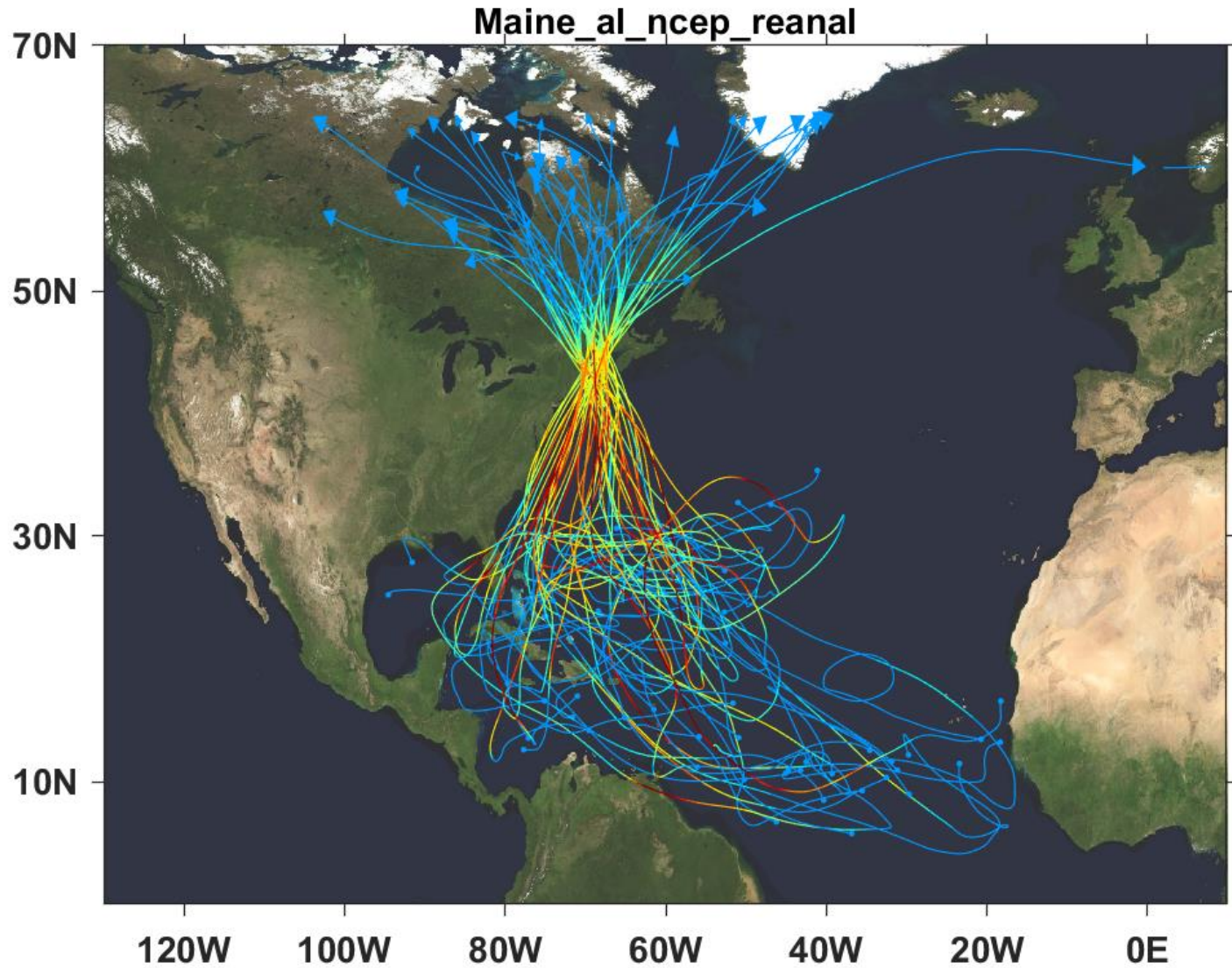


# Return Periods

## New England



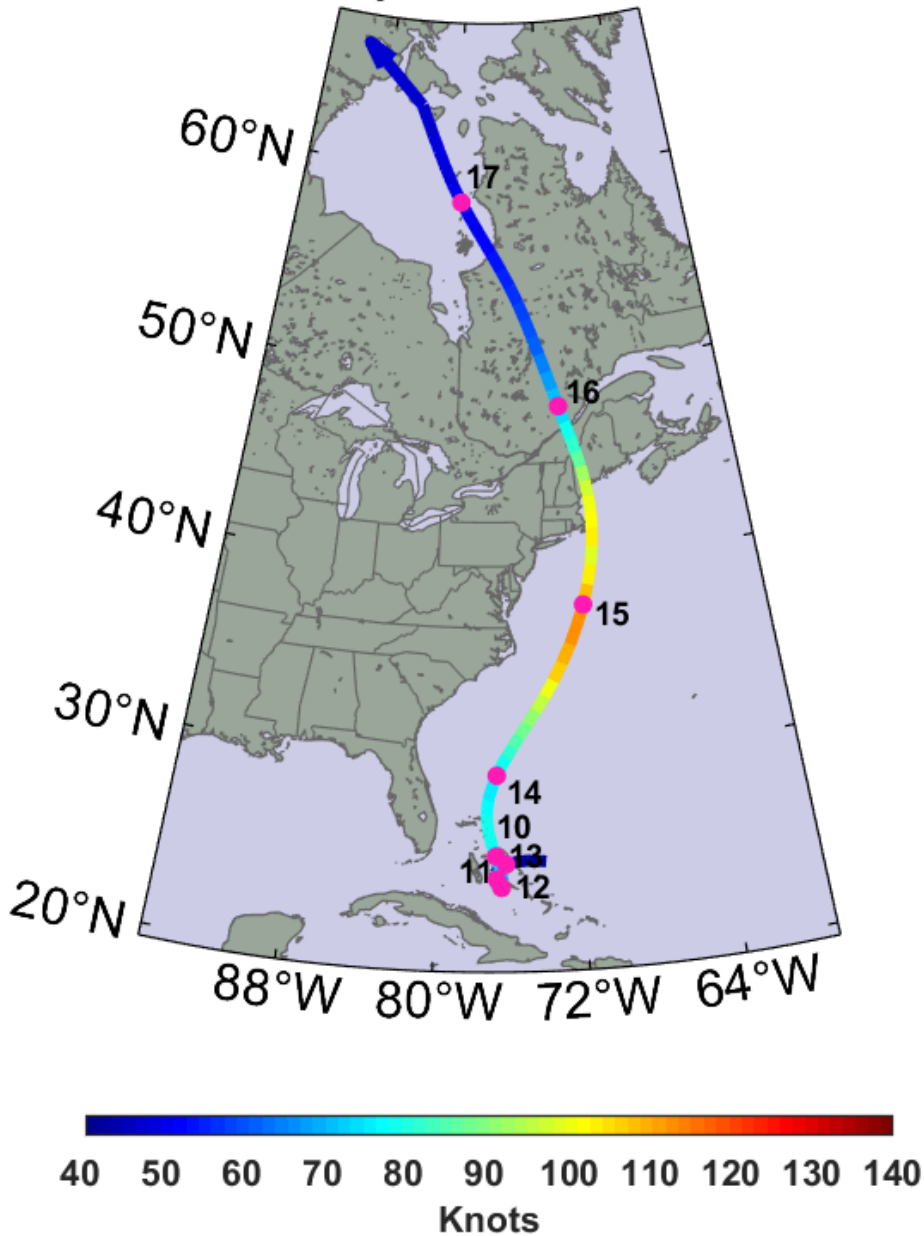
# Top 50 of 1800 tropical cyclones affecting the coast of Maine





# Maine\_al\_ncep\_reanal track number 132

September 1982

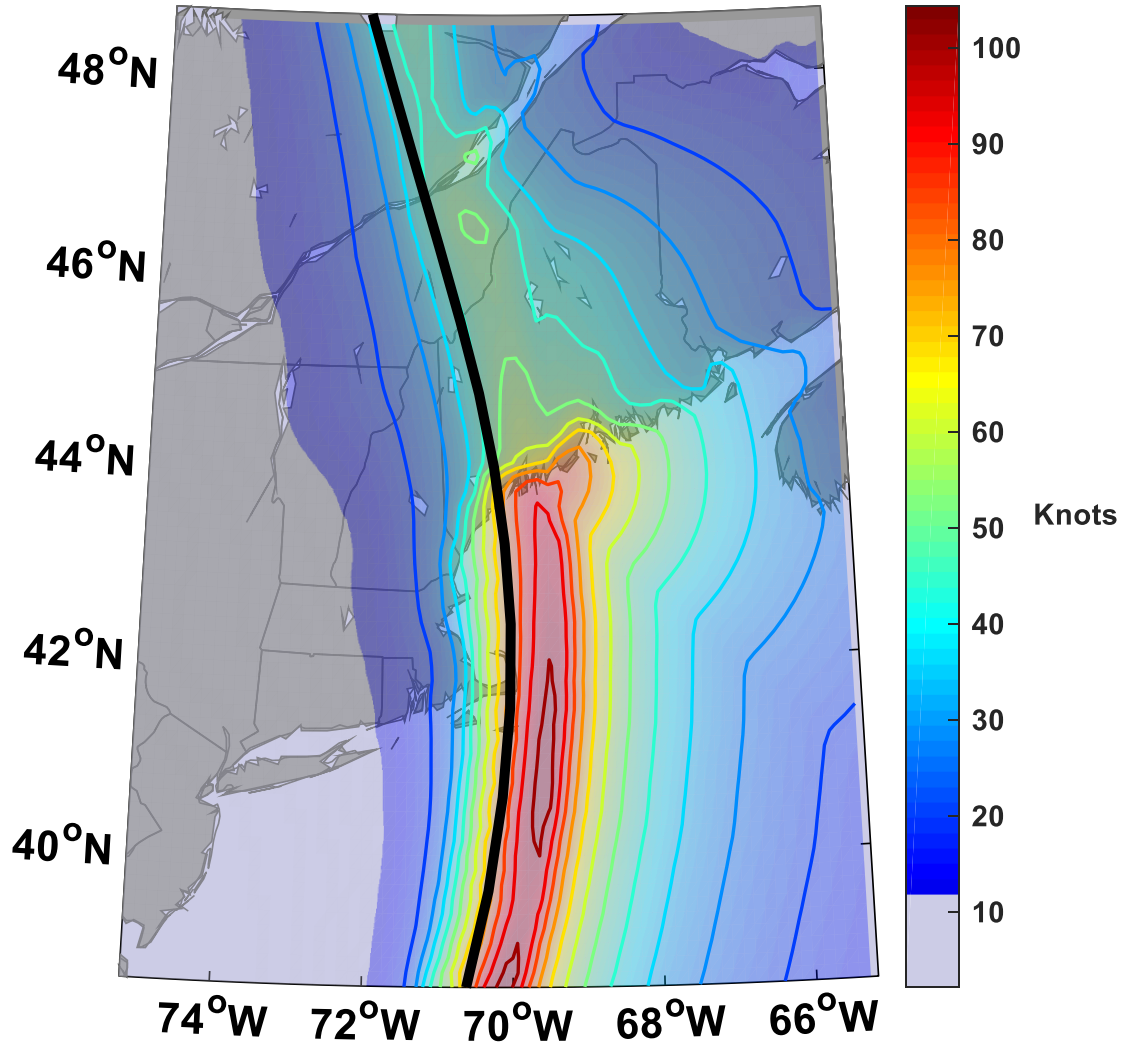


A 500-year  
windstorm in  
mid-coast  
Maine

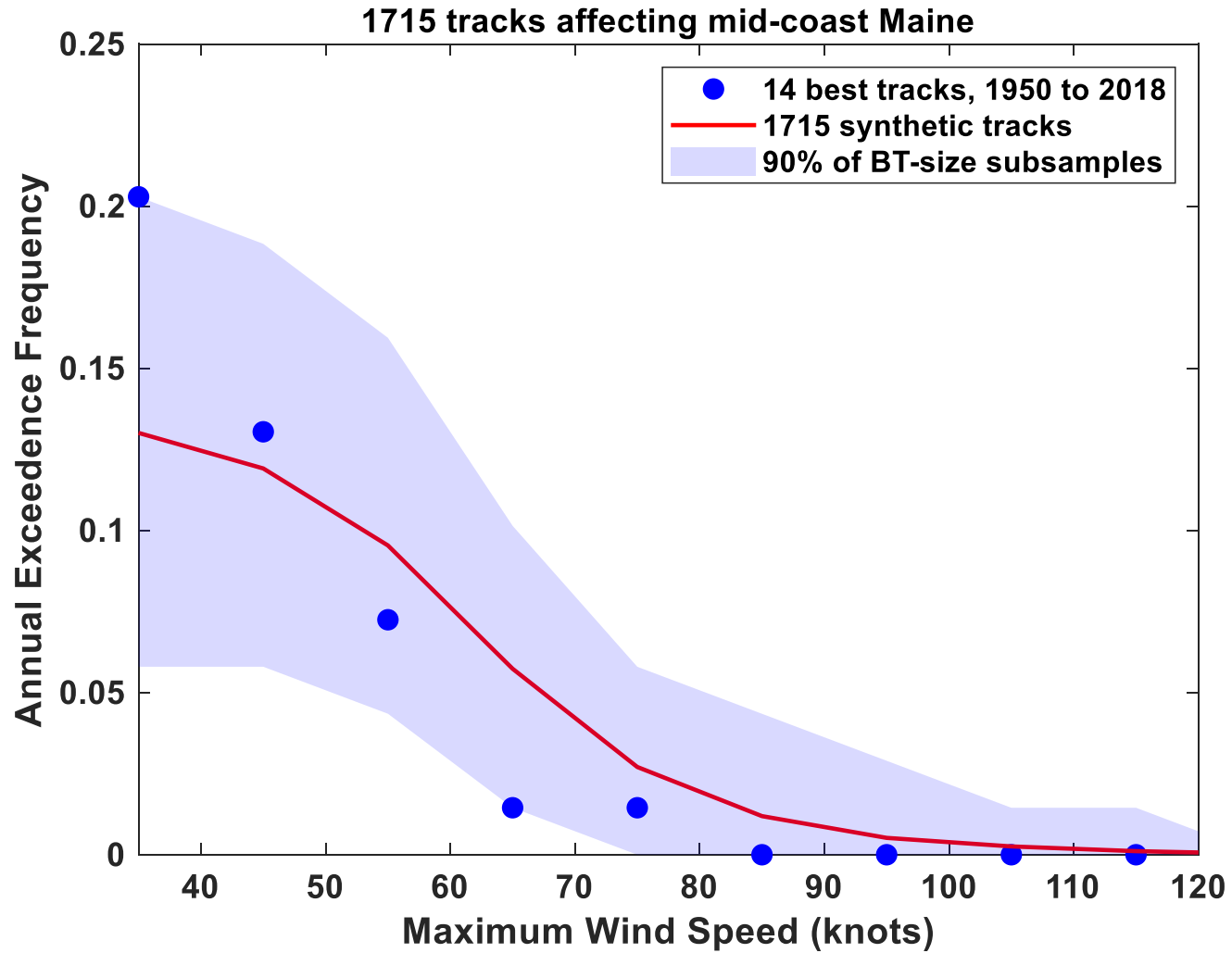


# A 500-Year Wind Storm

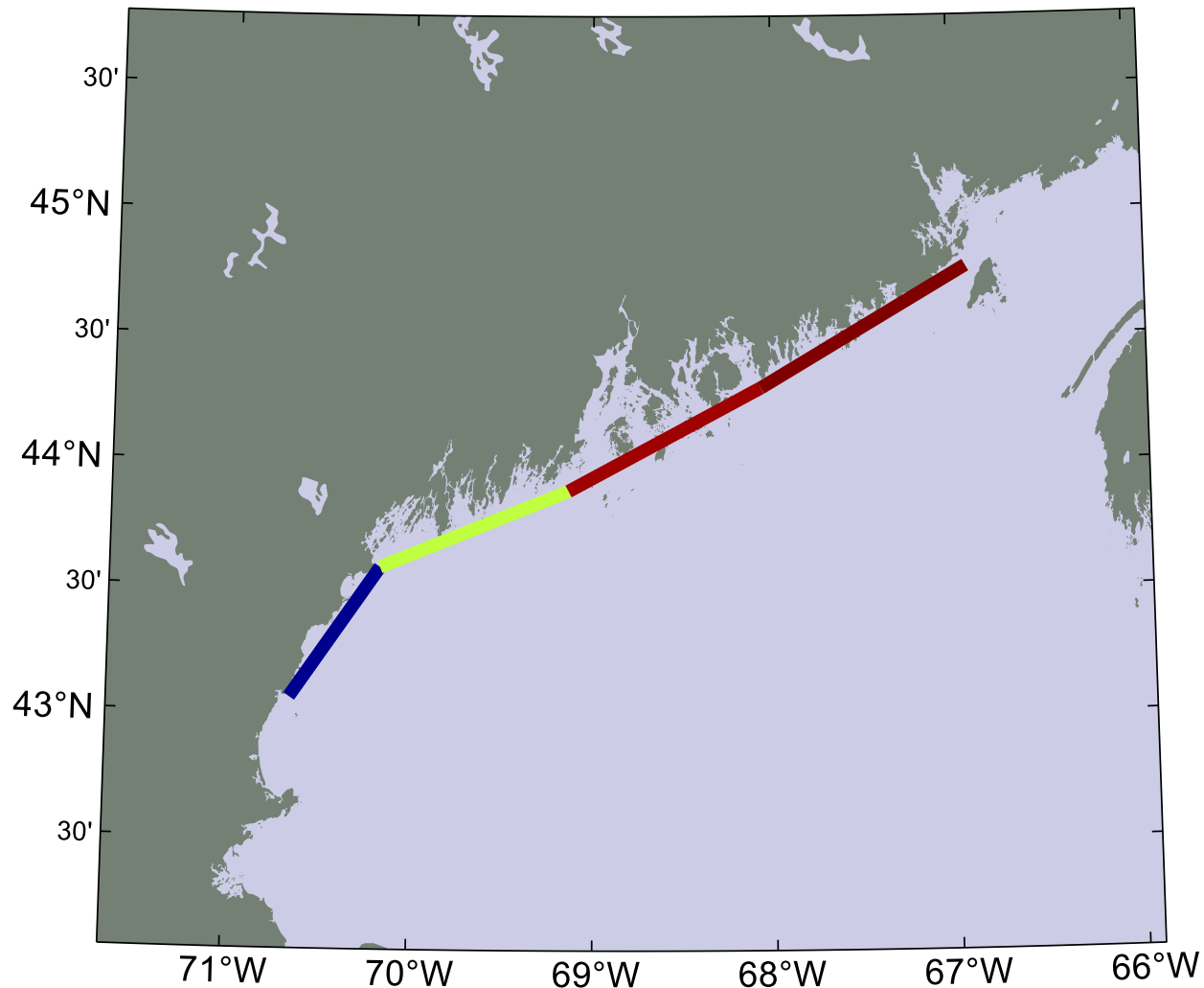
Maine\_al\_ncep\_reanal track number 132  
September 1982



# Wind Risk on the Maine Coast

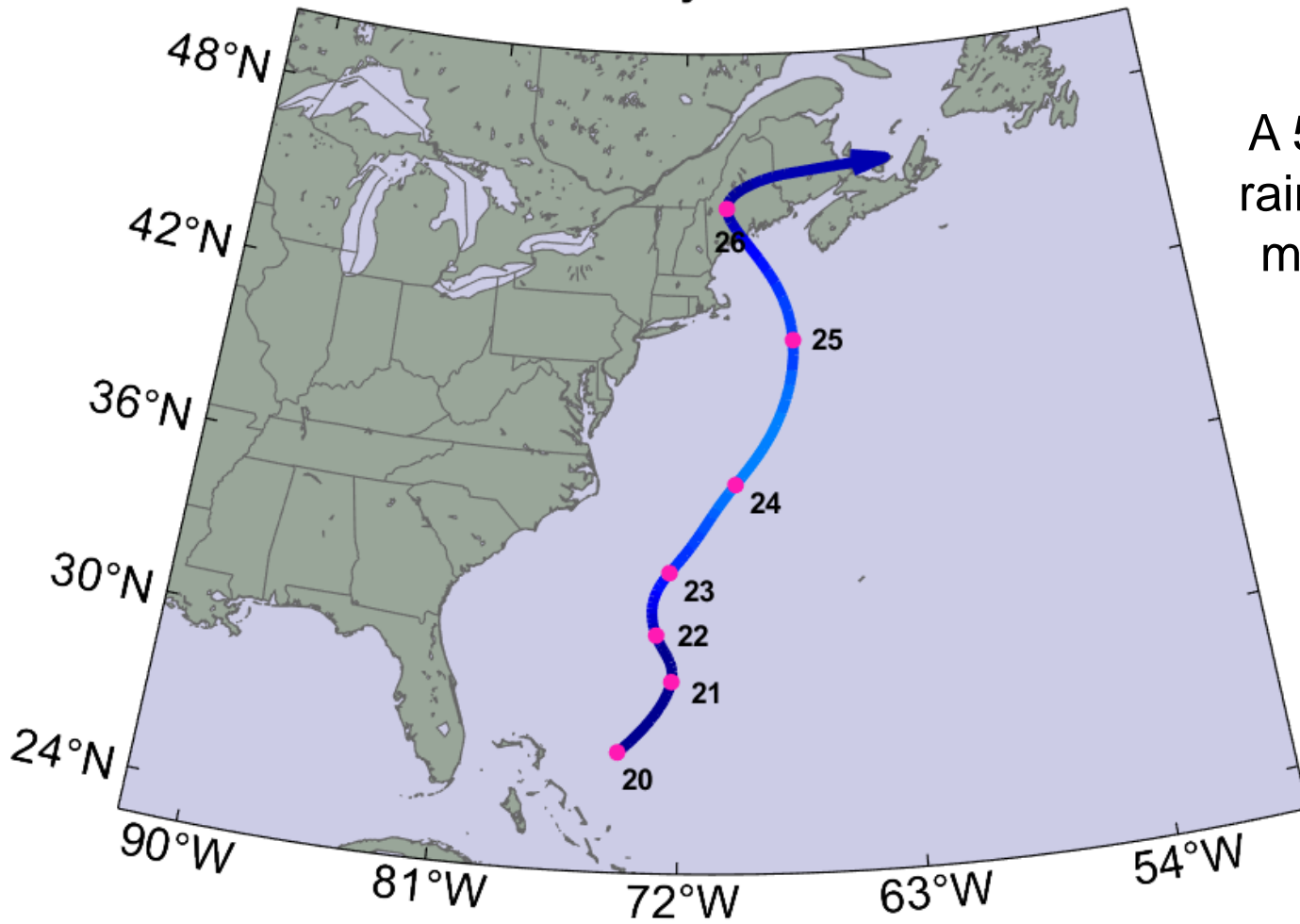


This chart shows power dissipation ,a measure of destructive potential, per unit length along 4 segments of the Maine coast. Power dissipation is largest from Penobscot Bay eastward.

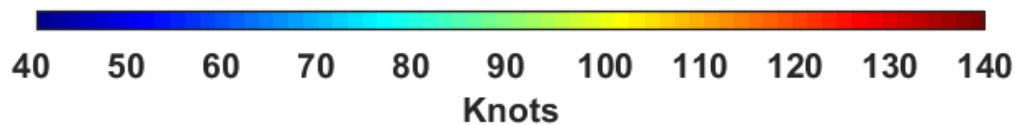


# Maine\_al\_ncep\_reanal track number 1359

July 2007

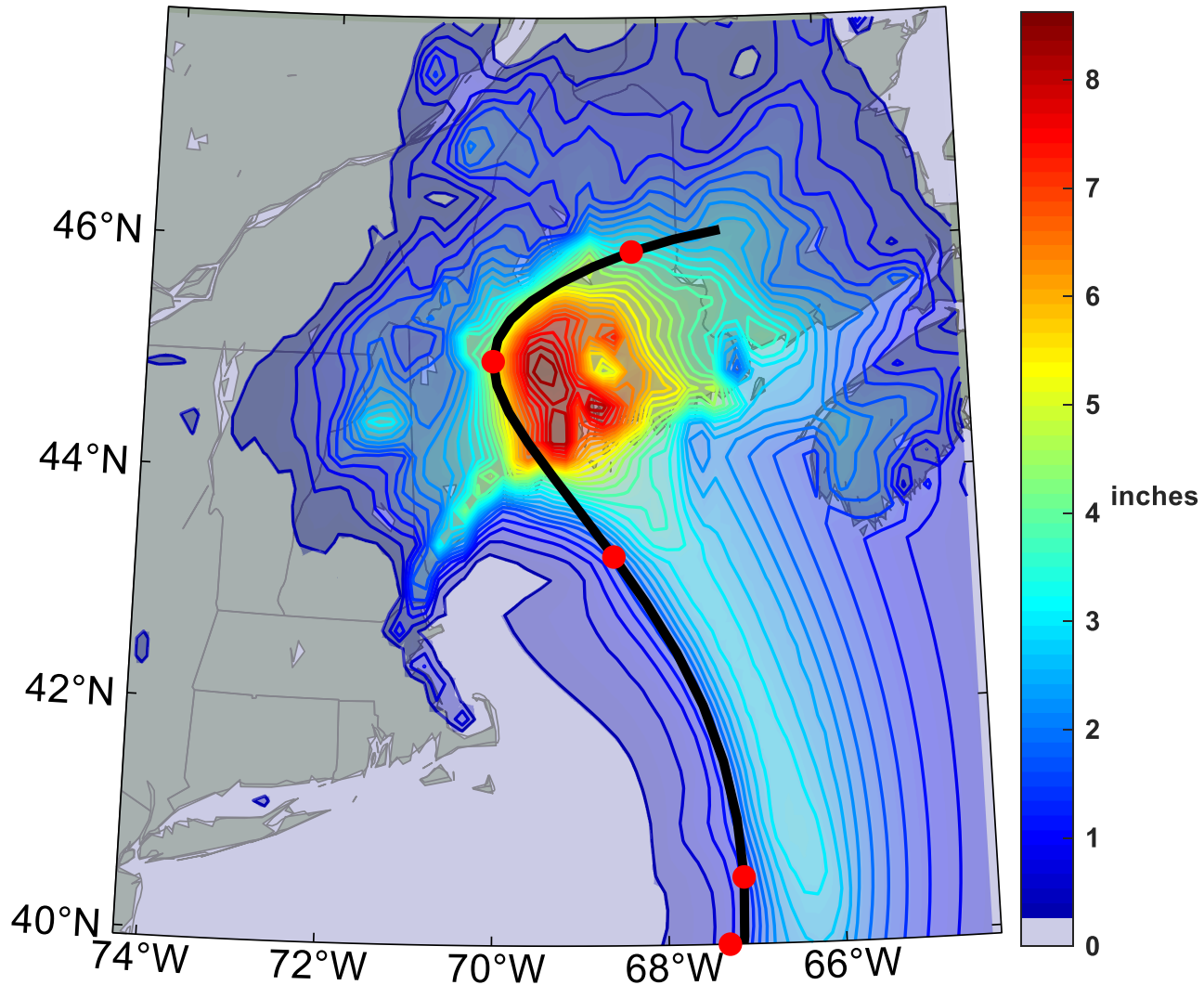


A 500-year  
rainstorm in  
mid-coast  
Maine



# A 500-Year Rain Storm

Maine\_AL\_NCEP\_Reanal  
Track number 1359, year 2007



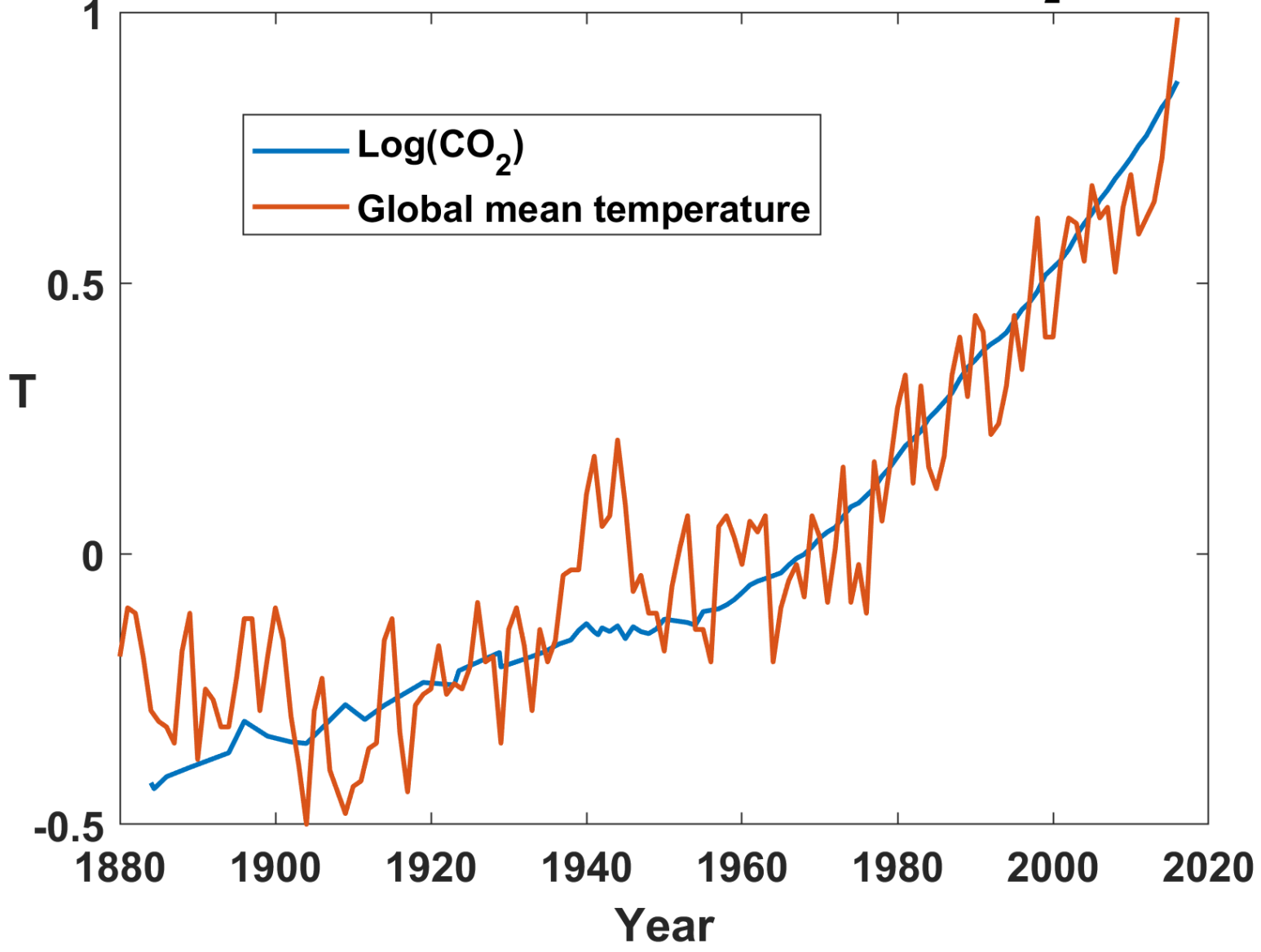
# Svante Arrhenius, 1859-1927



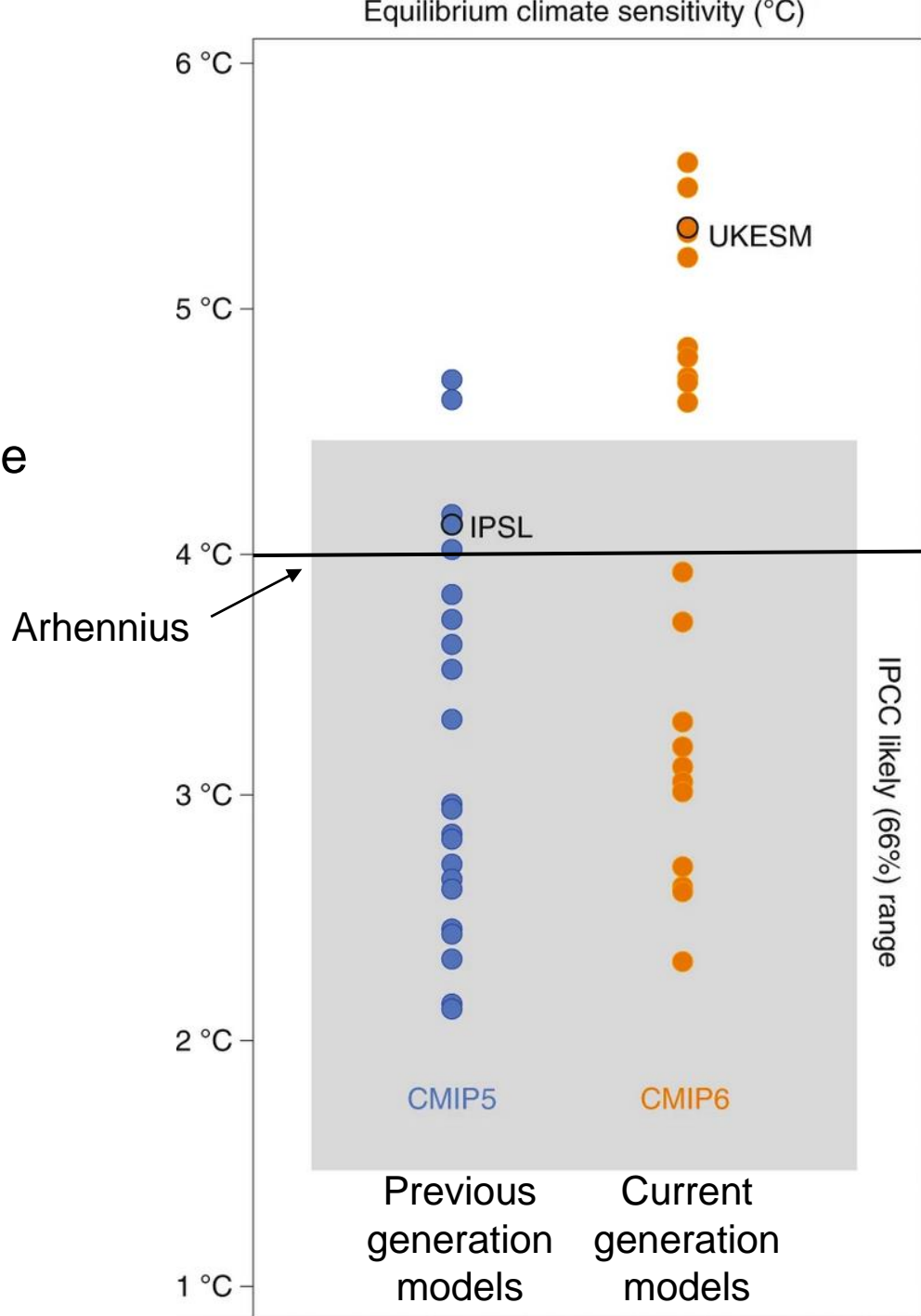
*“Any doubling of the percentage of carbon dioxide in the air would raise the temperature of the earth's surface by 4°; and if the carbon dioxide were increased fourfold, the temperature would rise by 8°.”* – *Världarnas utveckling* (Worlds in the Making), **1906**



# Global Mean Surface Temperature and CO<sub>2</sub>



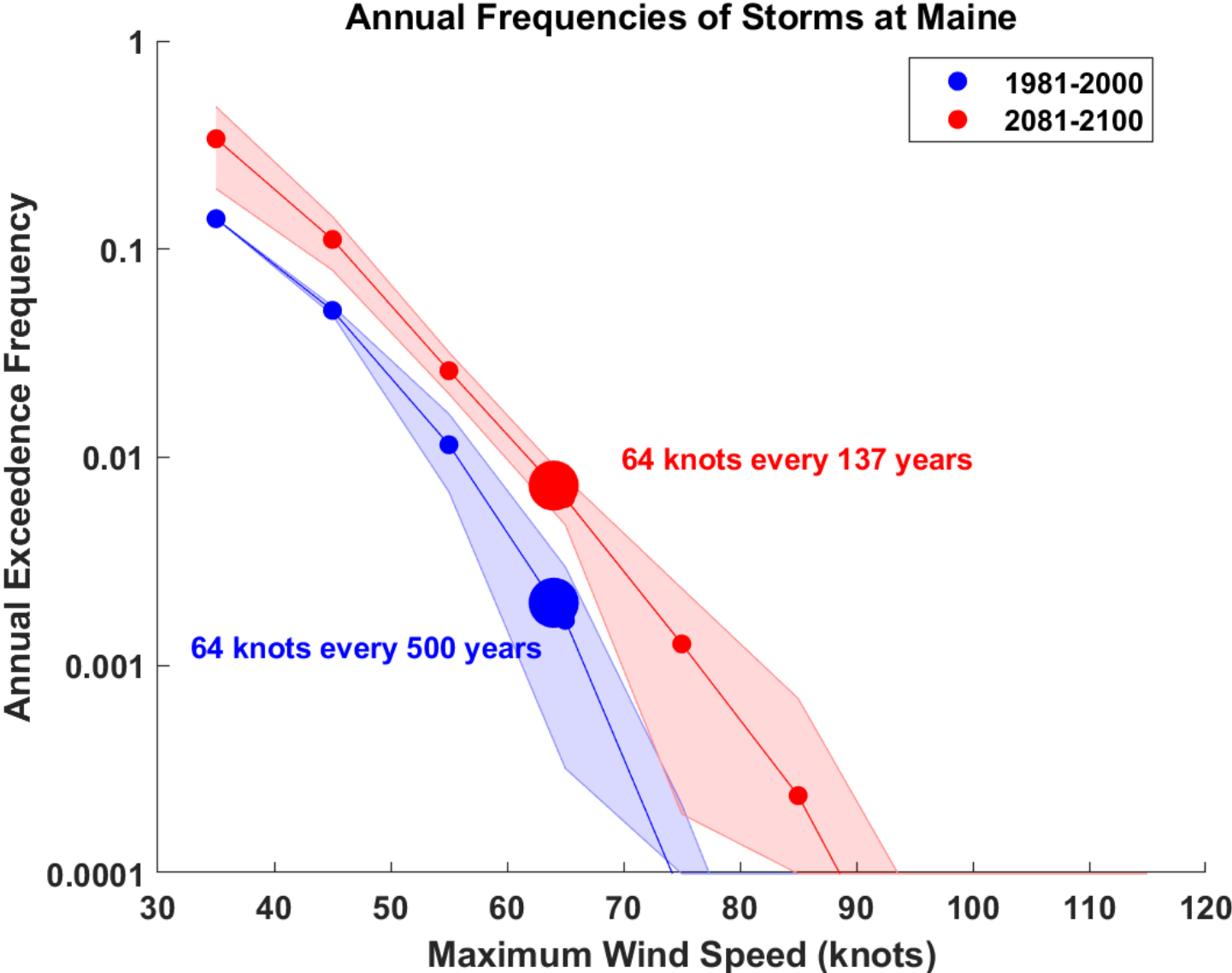
Equilibrium global temperature response to doubling of CO<sub>2</sub> in two generations of global climate models



# How will Climate Change Affect Main Hurricanes?

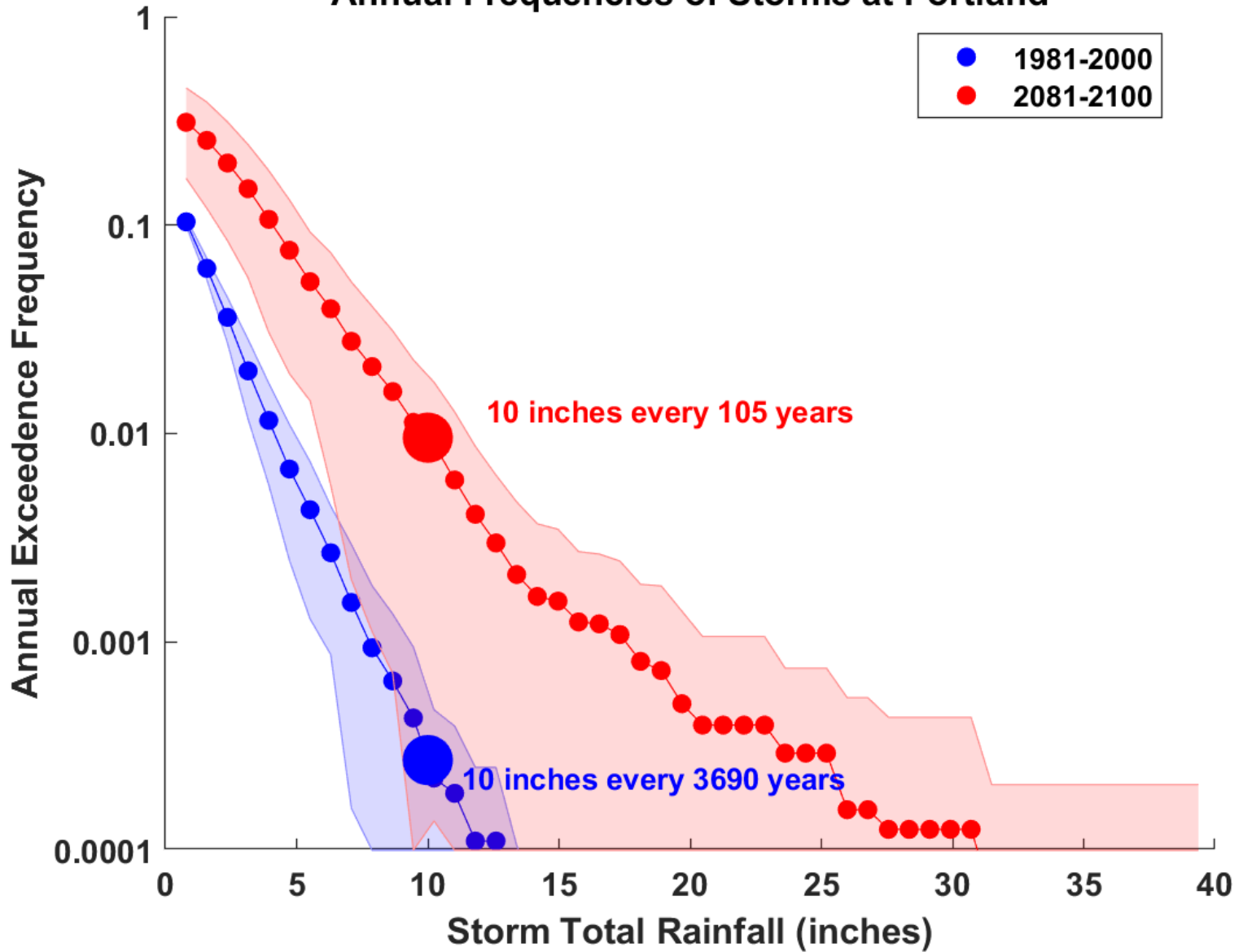
Apply technique to 5 global climate models, running 1,000 tracks for each model for each of two time periods: 1981-2000 and 2181-2100

Estimates of hurricane wind risk along the Maine coast from 5 climate models (shading shows spread among the different climate models)



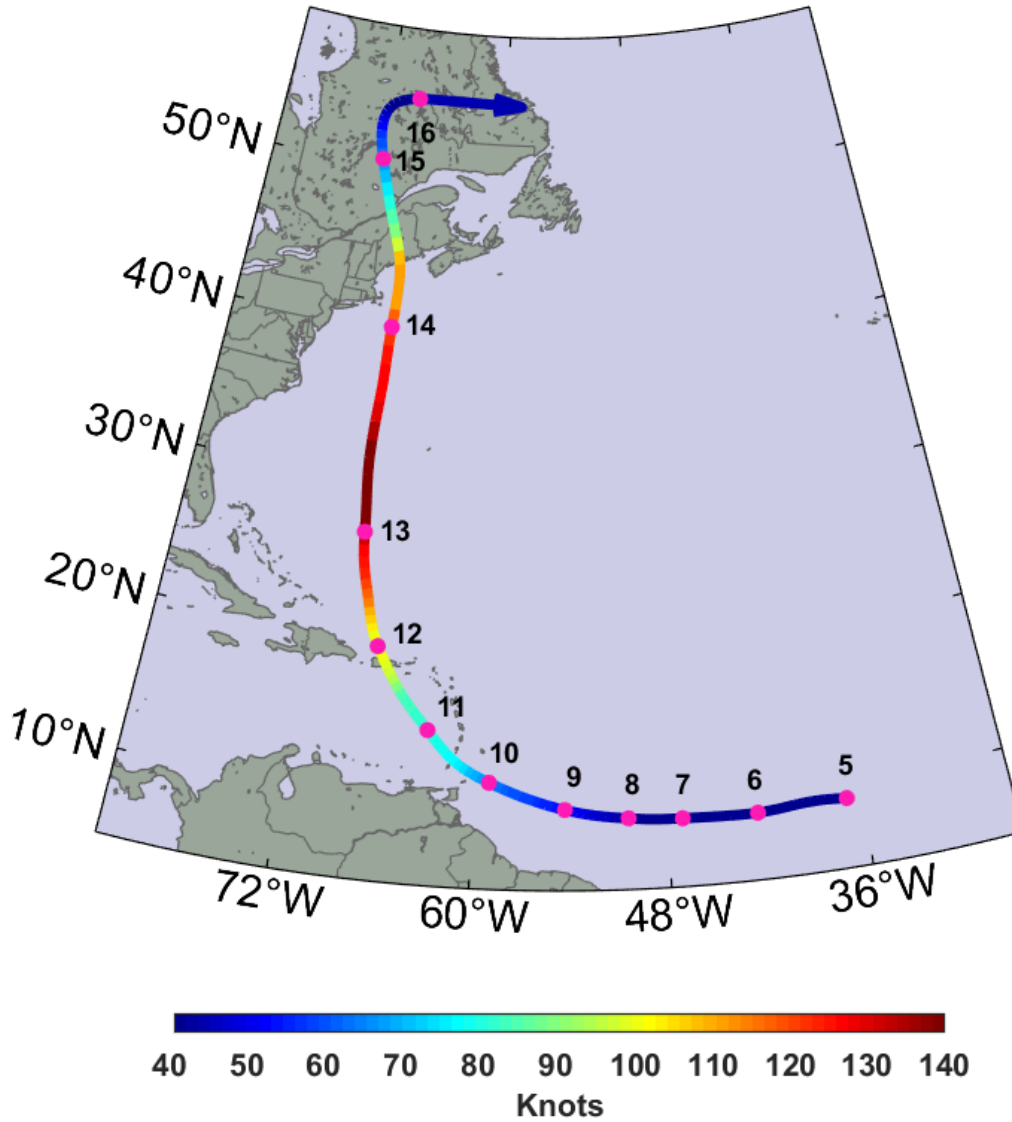
# Estimates of hurricane rain risk along the Maine coast from 5 climate models

## Annual Frequencies of Storms at Portland





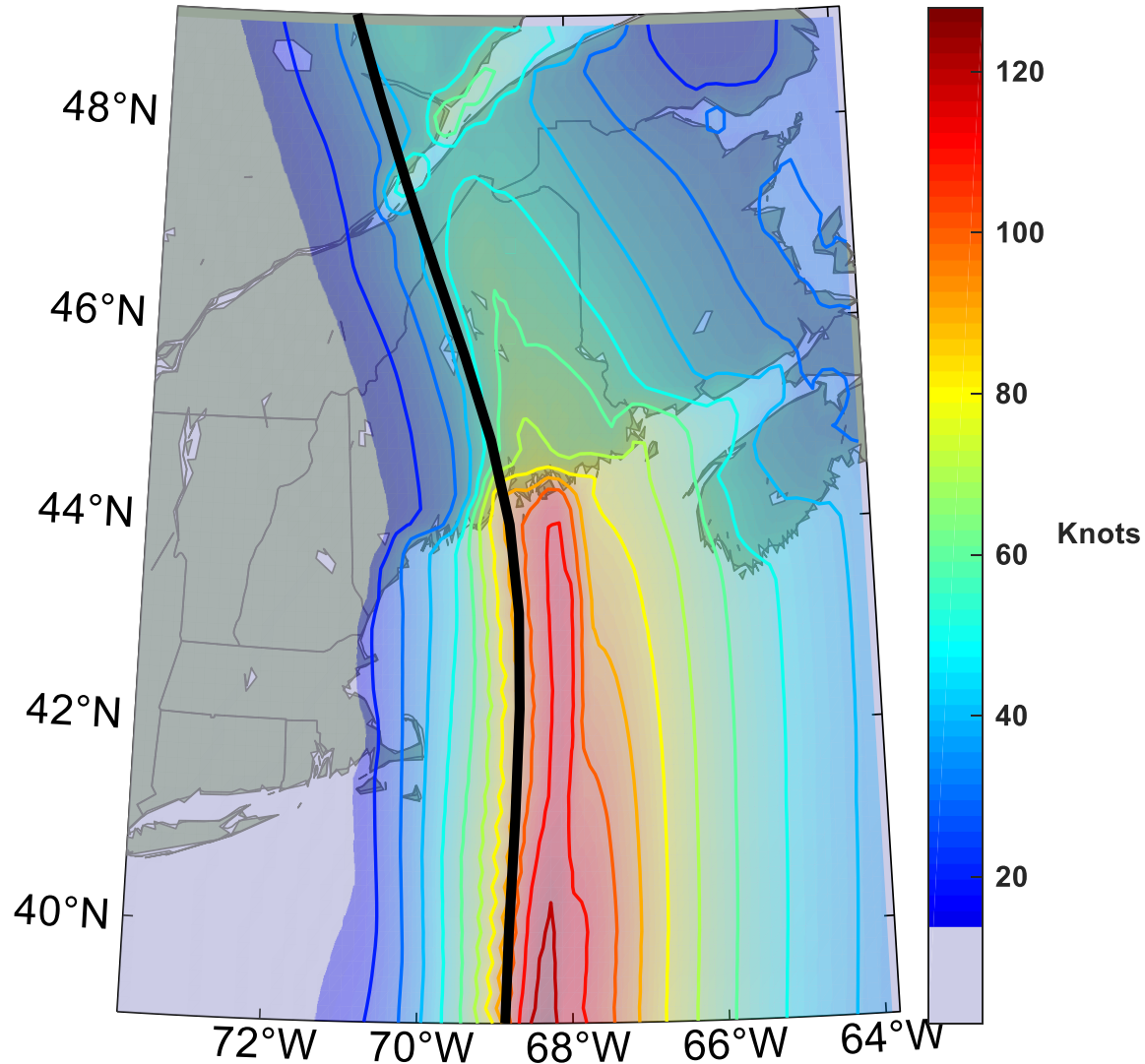
Maine\_al\_miroc5\_rcp85 track number 137  
October 2083



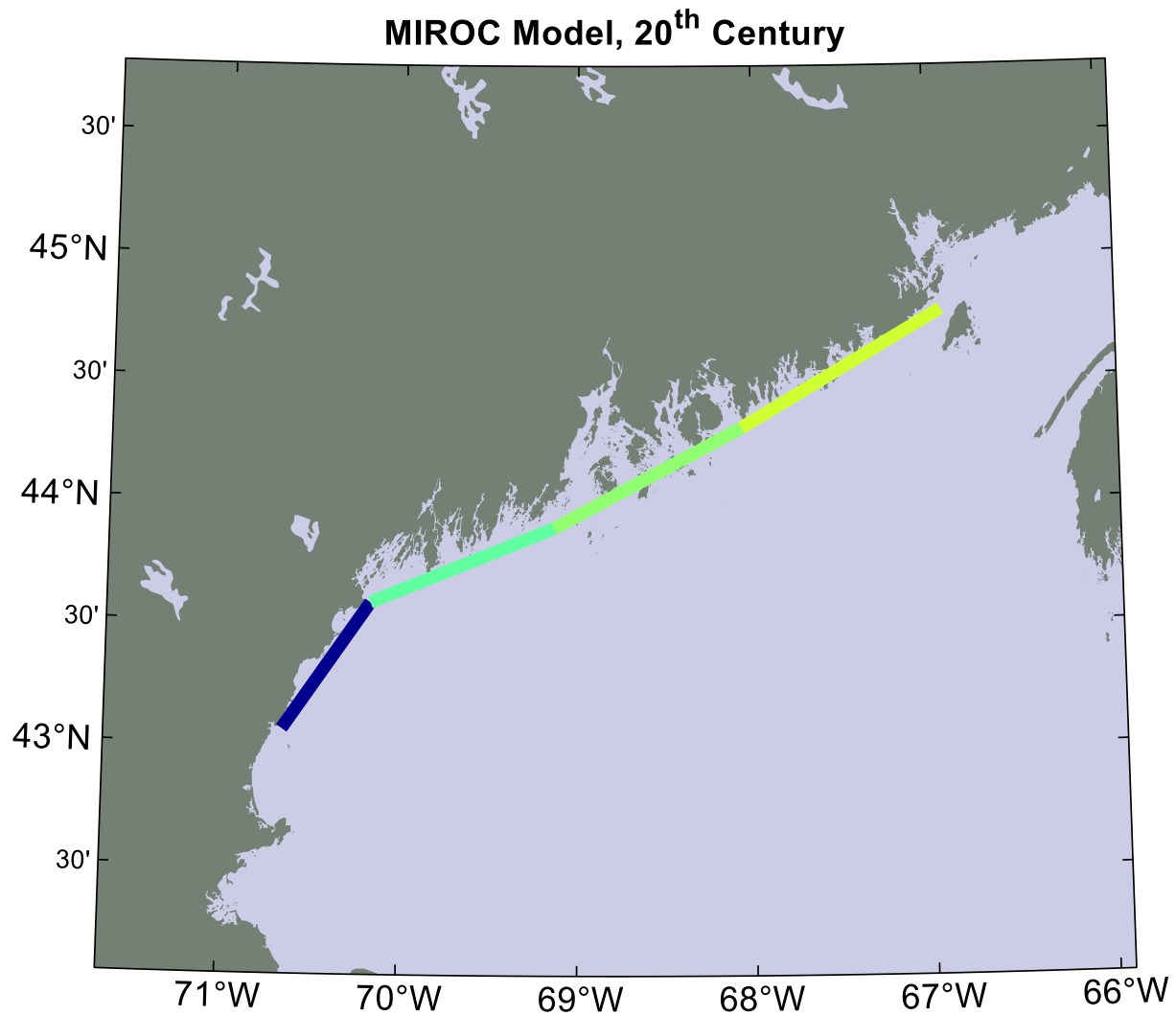
A 500-year  
windstorm in  
mid-coast  
Maine, in  
2083

# A 500-year wind storm at the end of the century

Maine\_al\_miroc5\_rcp85 track number 137  
October 2083

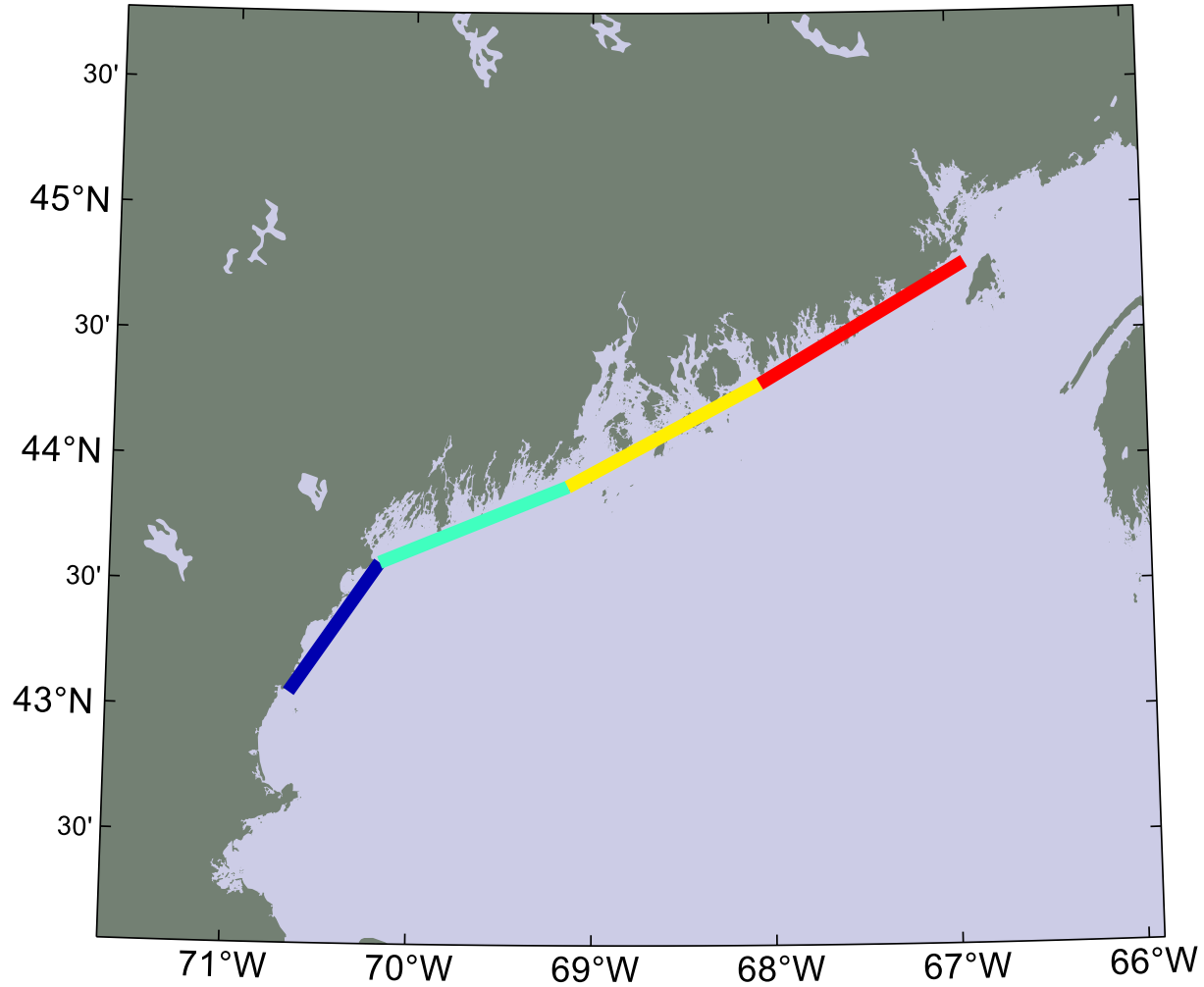


# Wind Power Dissipation, 1981-2000

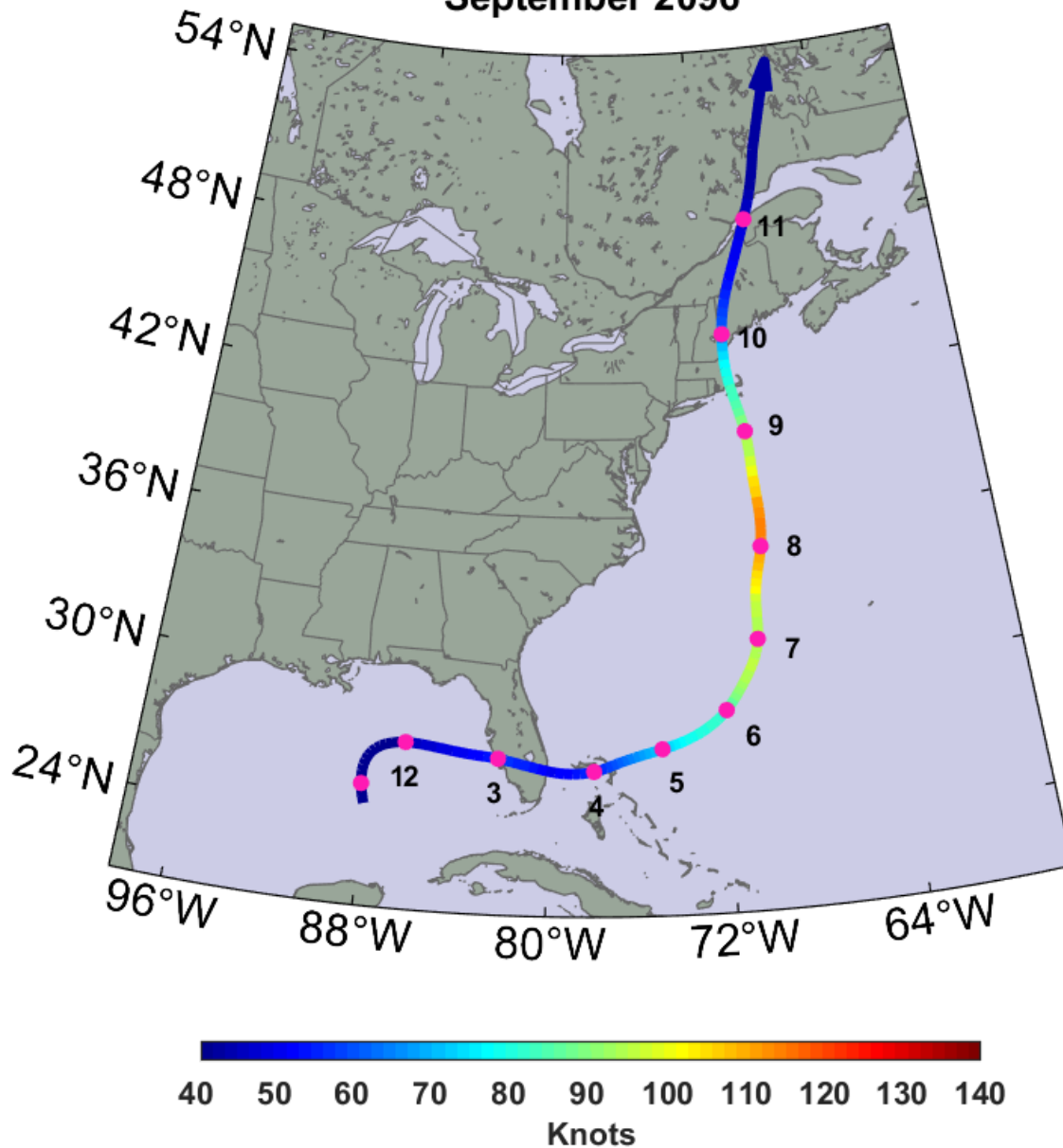


# Wind Power Dissipation, 2081-2100

MIROC Model, 21<sup>st</sup> Century



Maine\_al\_miroc5\_rcp85 track number 775  
September 2096

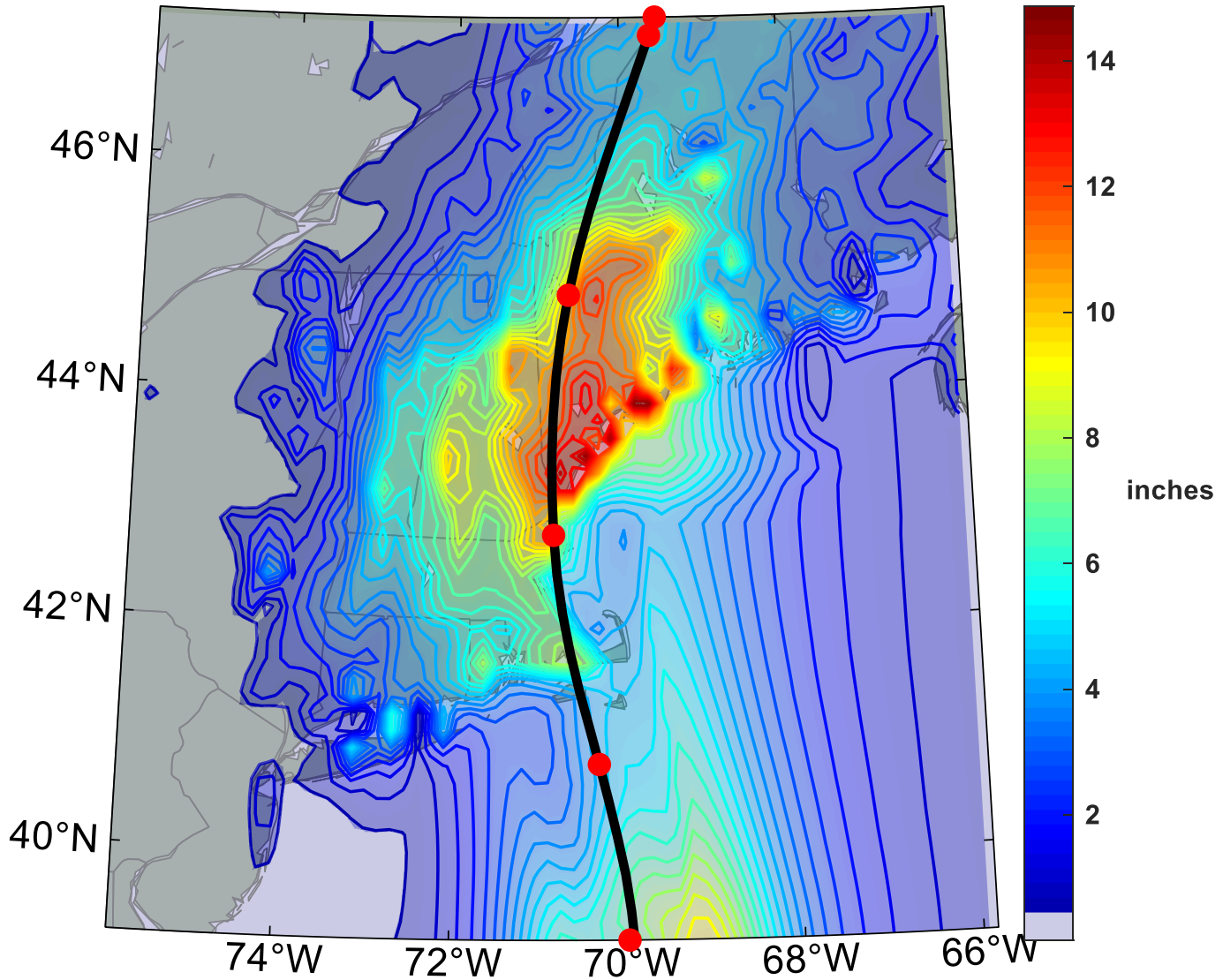


A 500-year  
rainstorm in  
mid-coast  
Maine, in  
2096



# A 500-year Rain Event, end of century

Maine\_AL\_MIROC5\_rcp85  
Track number 775, year 2096

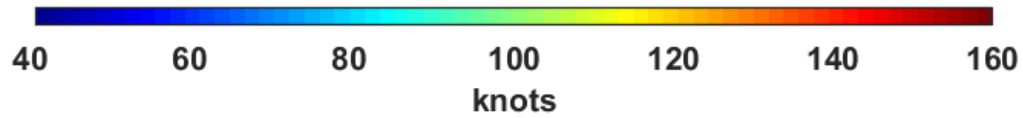
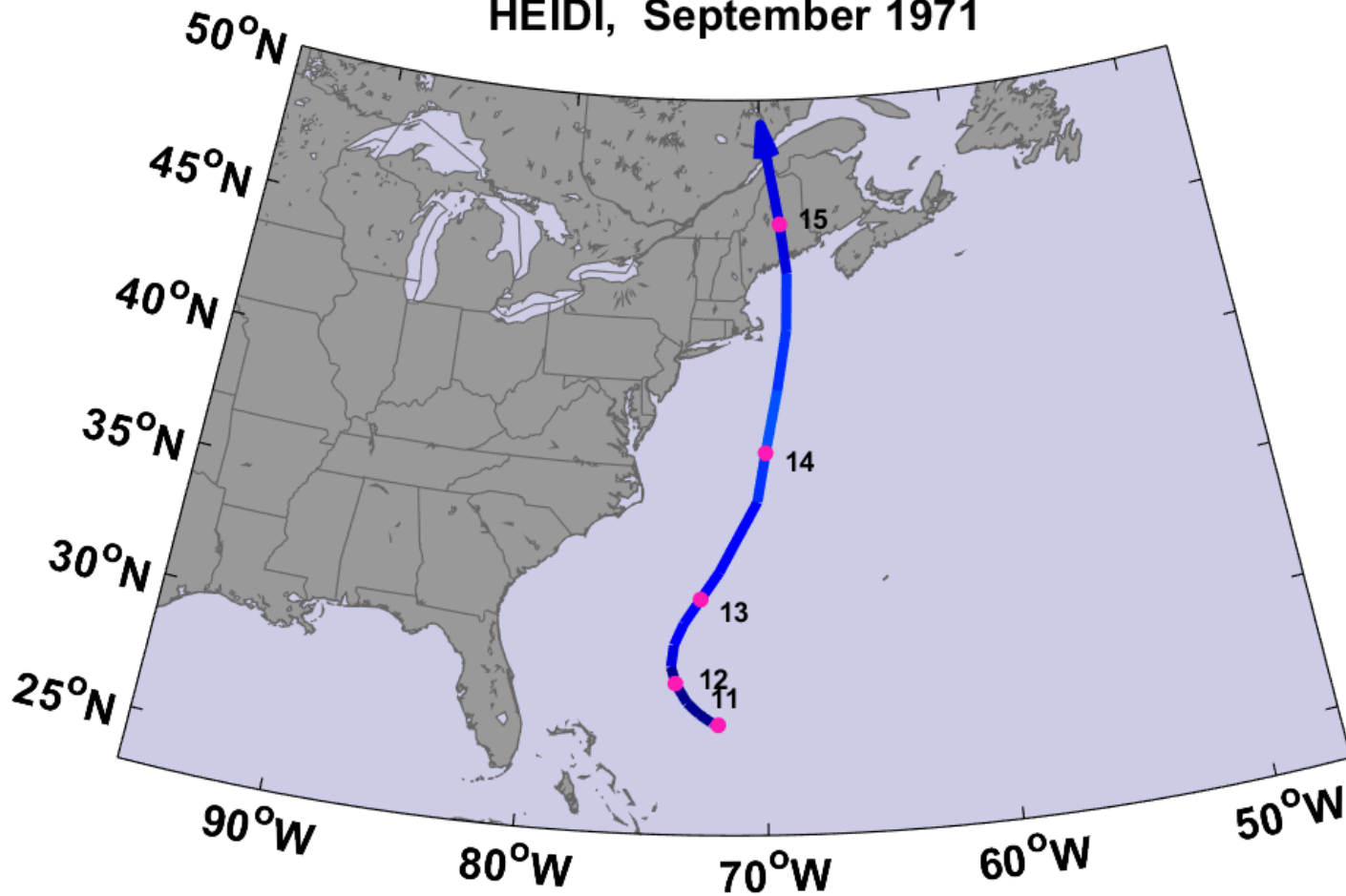


# Summary

- Maine is mostly protected from hurricane by cold water north of the Gulf Stream and by Cape Cod and the islands
- Nonetheless, it has experienced several low category hurricanes and tropical storms which have taken lives and caused much damage through Maine's history
- Hurricane risk increases going downeast along the coast
- Barring efforts to curb increases in greenhouse gases, projections suggest a modest increase in the frequency and severity of hurricanes in Maine by the end of this century
- Large projected increases in hurricane rainfall are of particular concern and could lead to substantially elevated flood risk

Spare Slides

# HEIDI, September 1971



# BERTHA, July 1996

