Black Swan Tropical Cyclones

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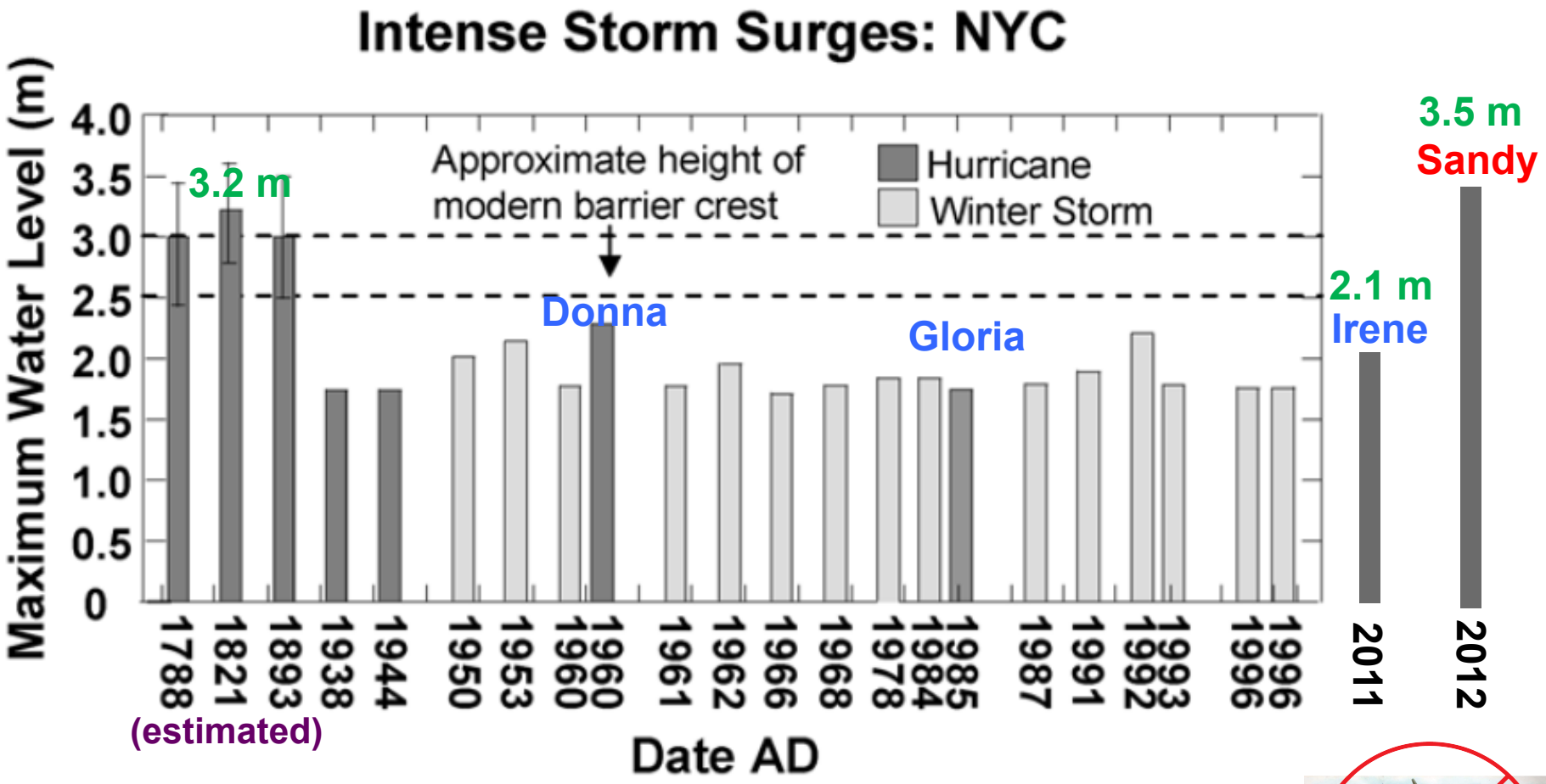
Essential Aspects of Black Swans:

- The event is a surprise (to the observer).
- The event has a major impact.
- For the purposes of this talk, we define a "Black Swan" event as one that could not reasonably be anticipated based on historical records alone.

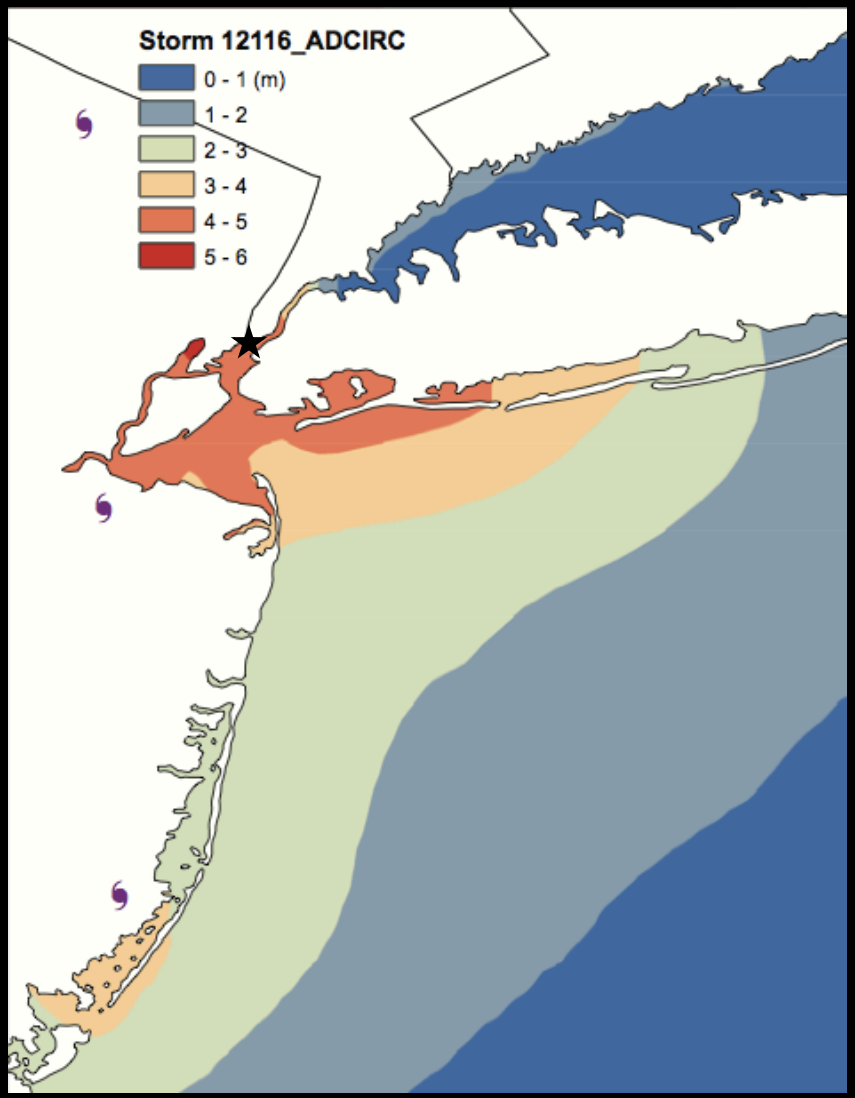
…based on Nassim Taleb.

Was Sandy a Black Swan?

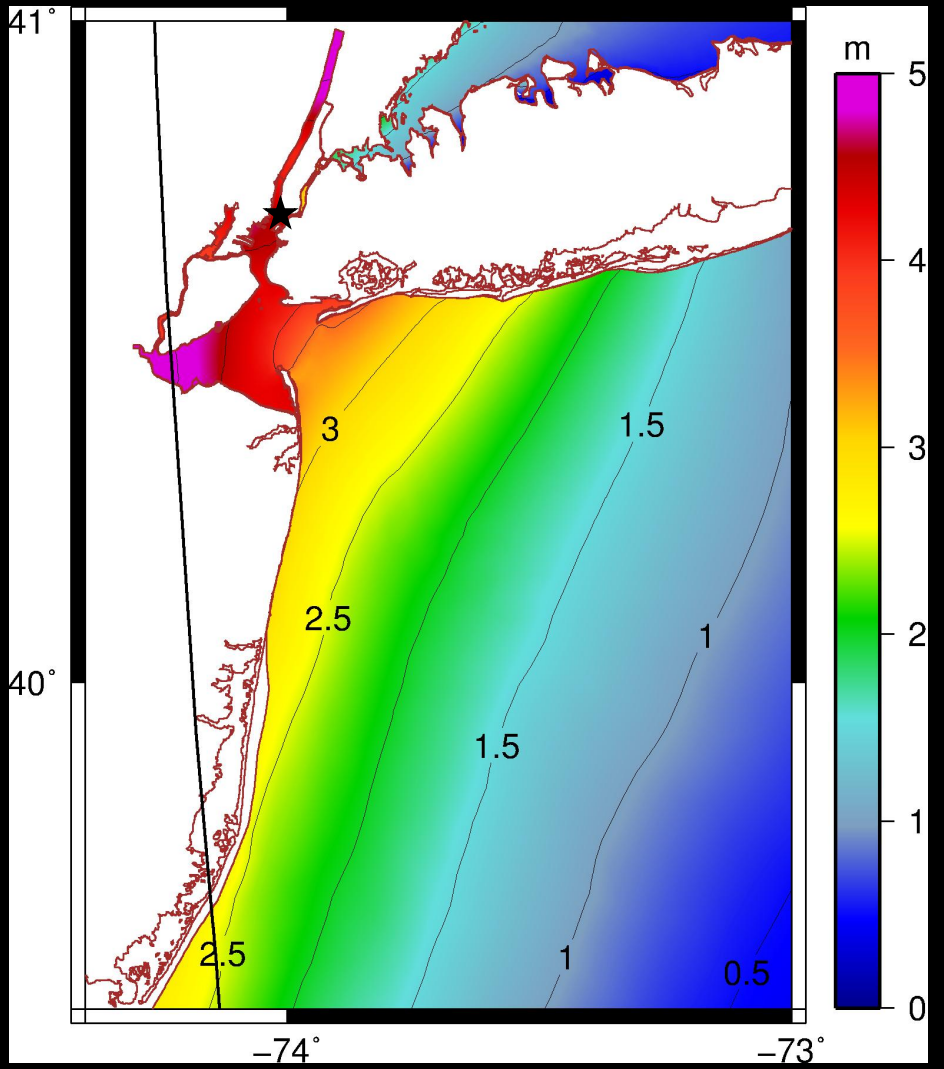


Scileppi and Donnelly (2007)

Some “worst-case” surges (tides not included) under NCEP/NCAR 1981-2000 climate

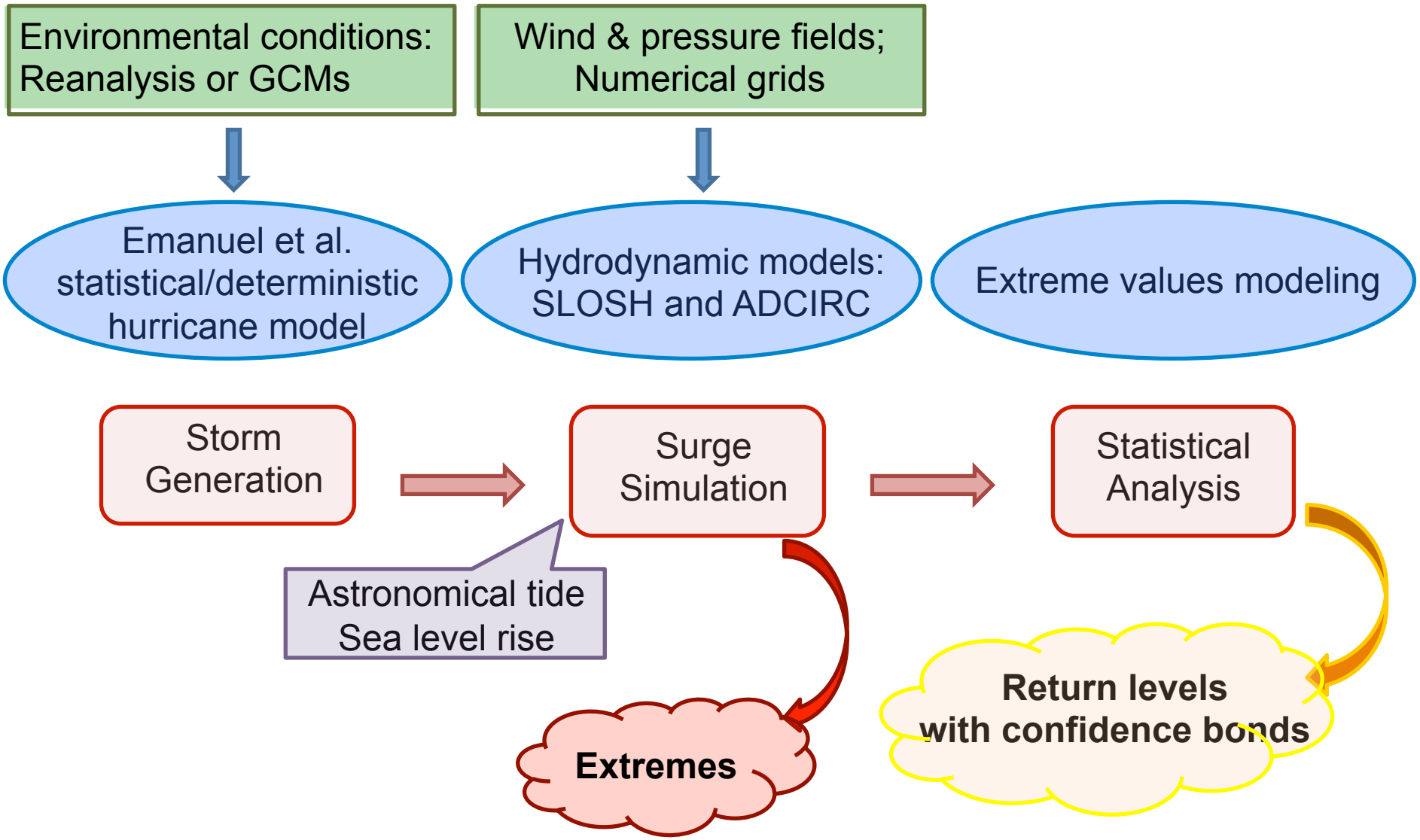


Lin et al. 2010 Sep. - JGR



Lin et al. 2012 Feb. - NCC

Hurricane Surge Risk Assessment

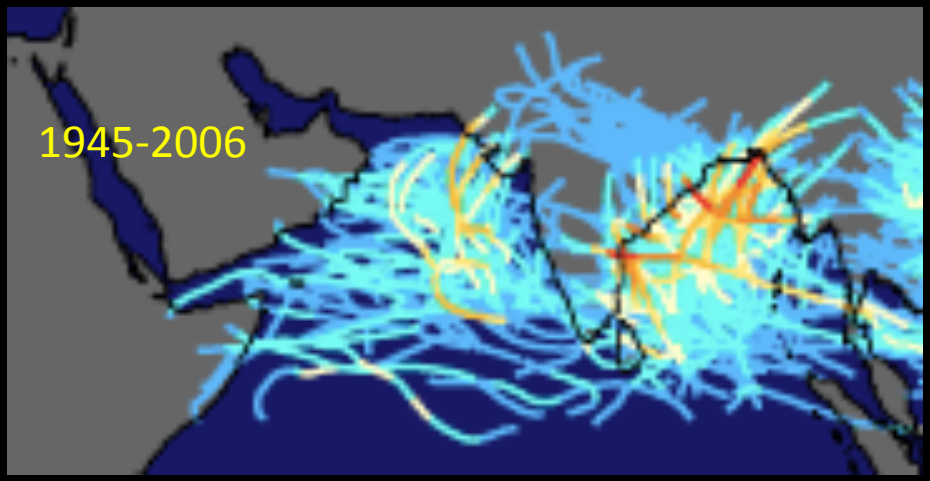


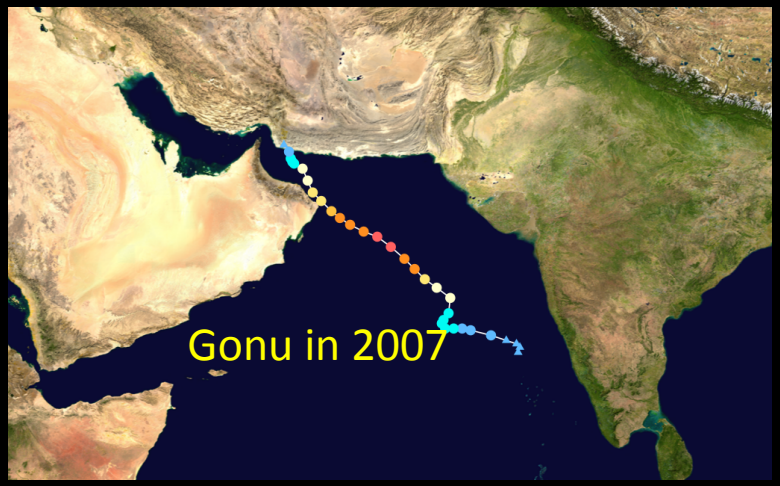
Storm Generation

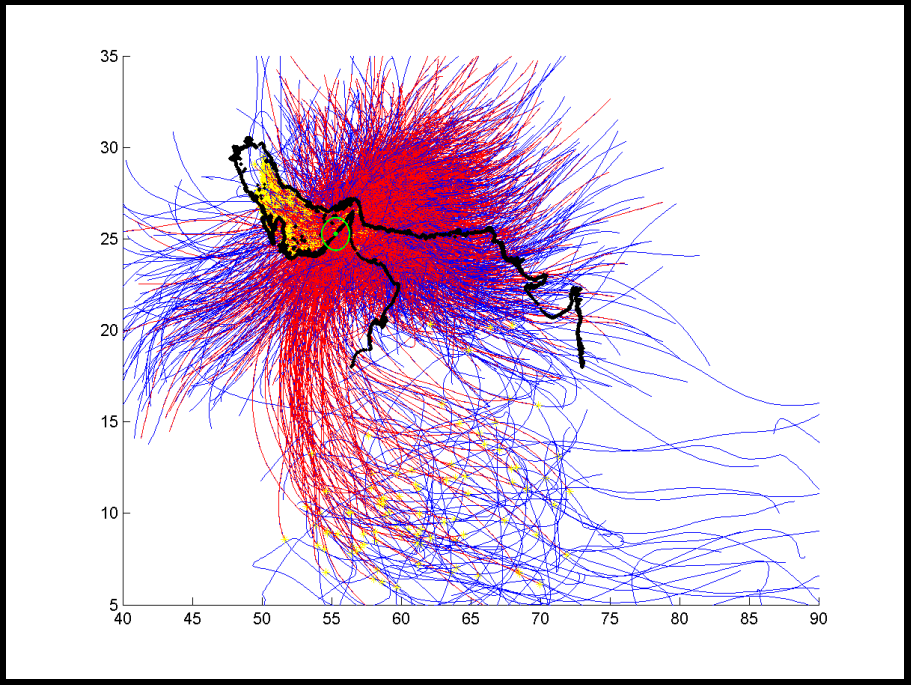
- **Step 1**: Seed each ocean basin with a very large number of weak, randomly located cyclones
- **Step 2**: Cyclones are assumed to move with the large scale atmospheric flow in which they are embedded, plus a correction for beta drift
- **Step 3**: Run the CHIPS model for each cyclone, and note how many achieve at least tropical storm strength
- **Step 4:** Using the small fraction of surviving events, determine storm statistics

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

Persian Gulf







Dubai

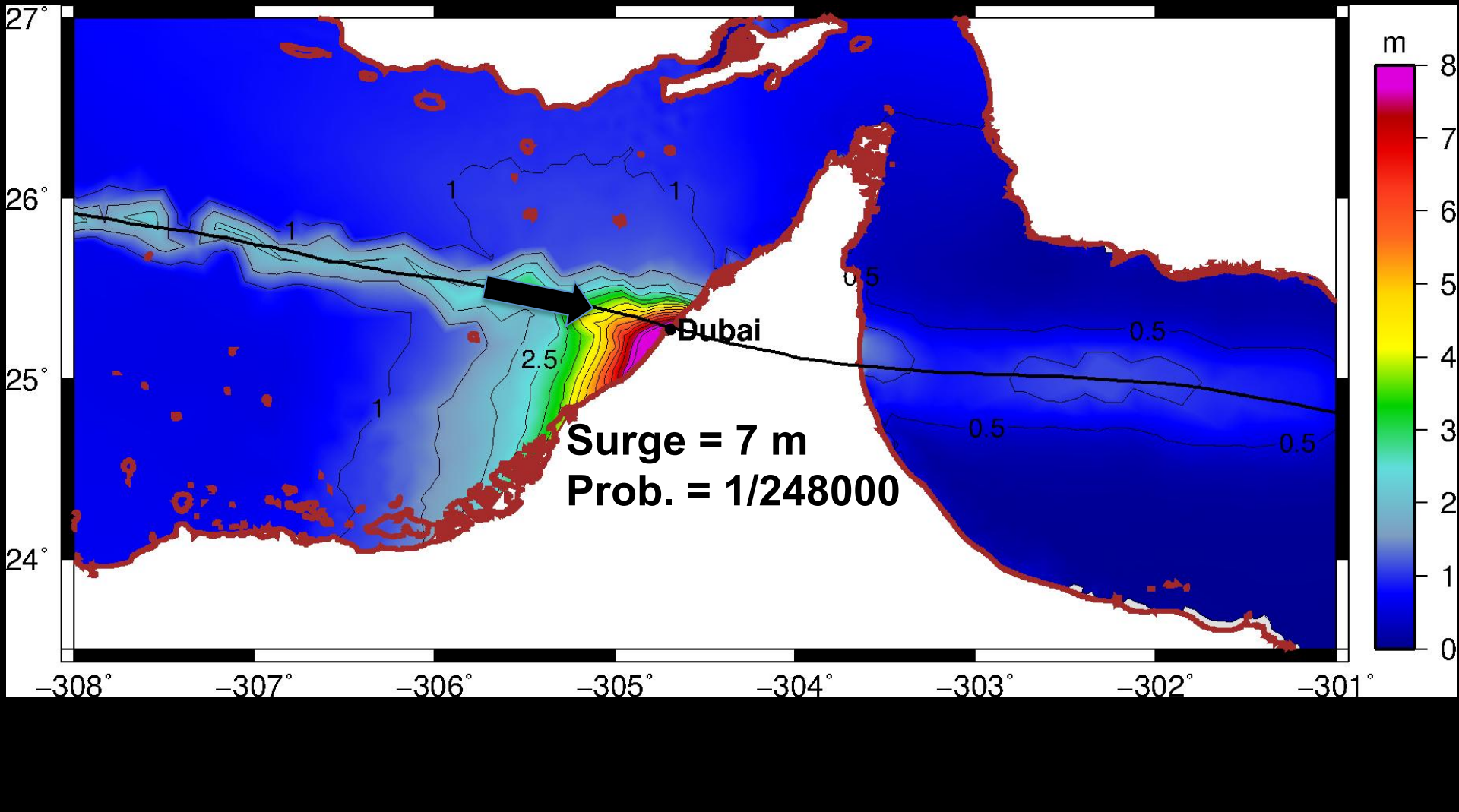
3100 tracks passing within 100 km with wind speed greater than 40 knots

Annual Frequency = 0.025

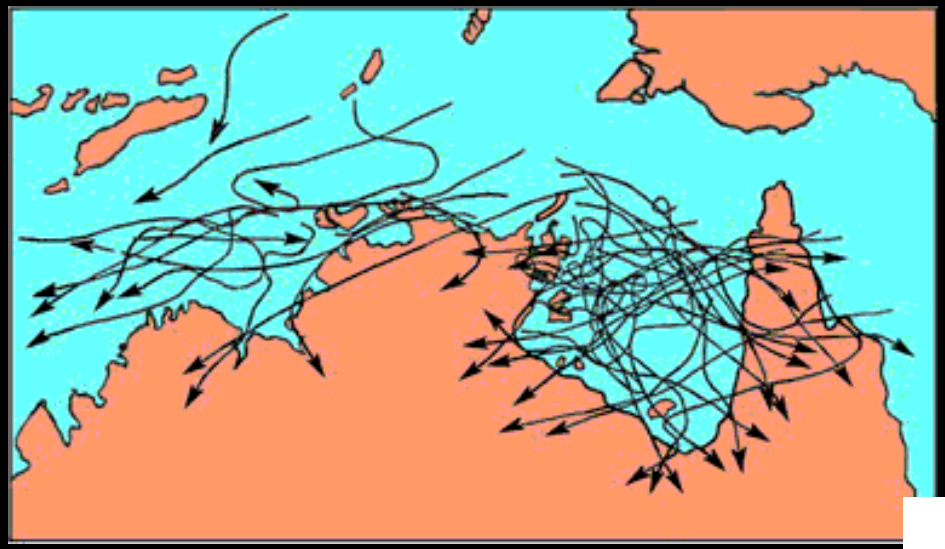
Many of them move into or generate within Persian Gulf

A Black Swan Event in Dubai

A Black Swan Event in Dubai



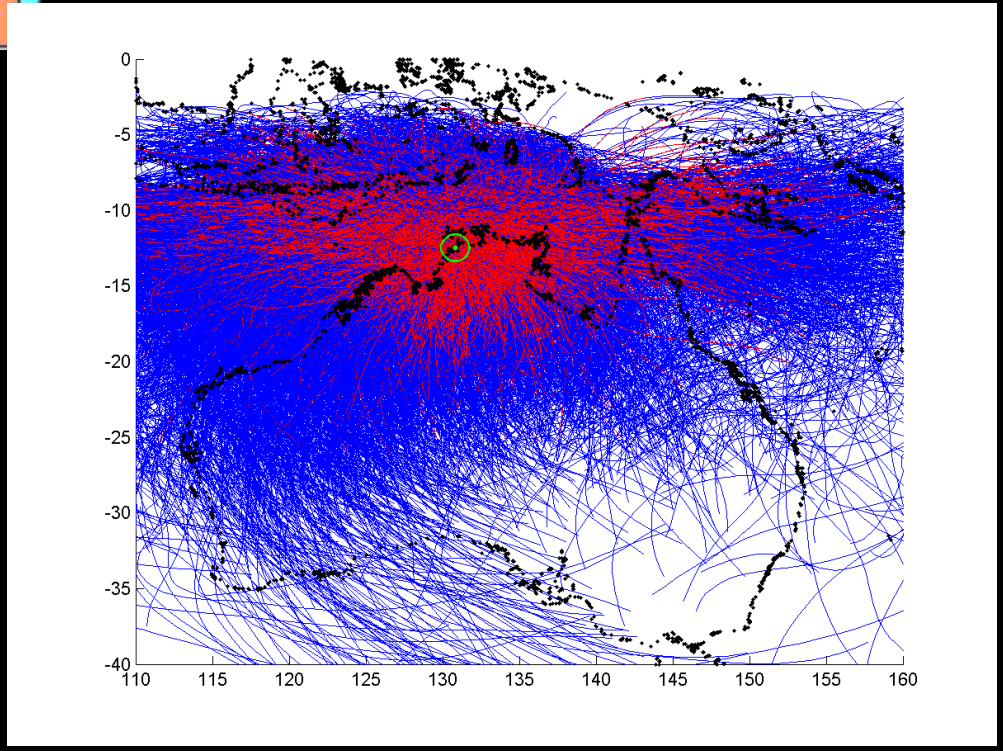
Darwin, Australia



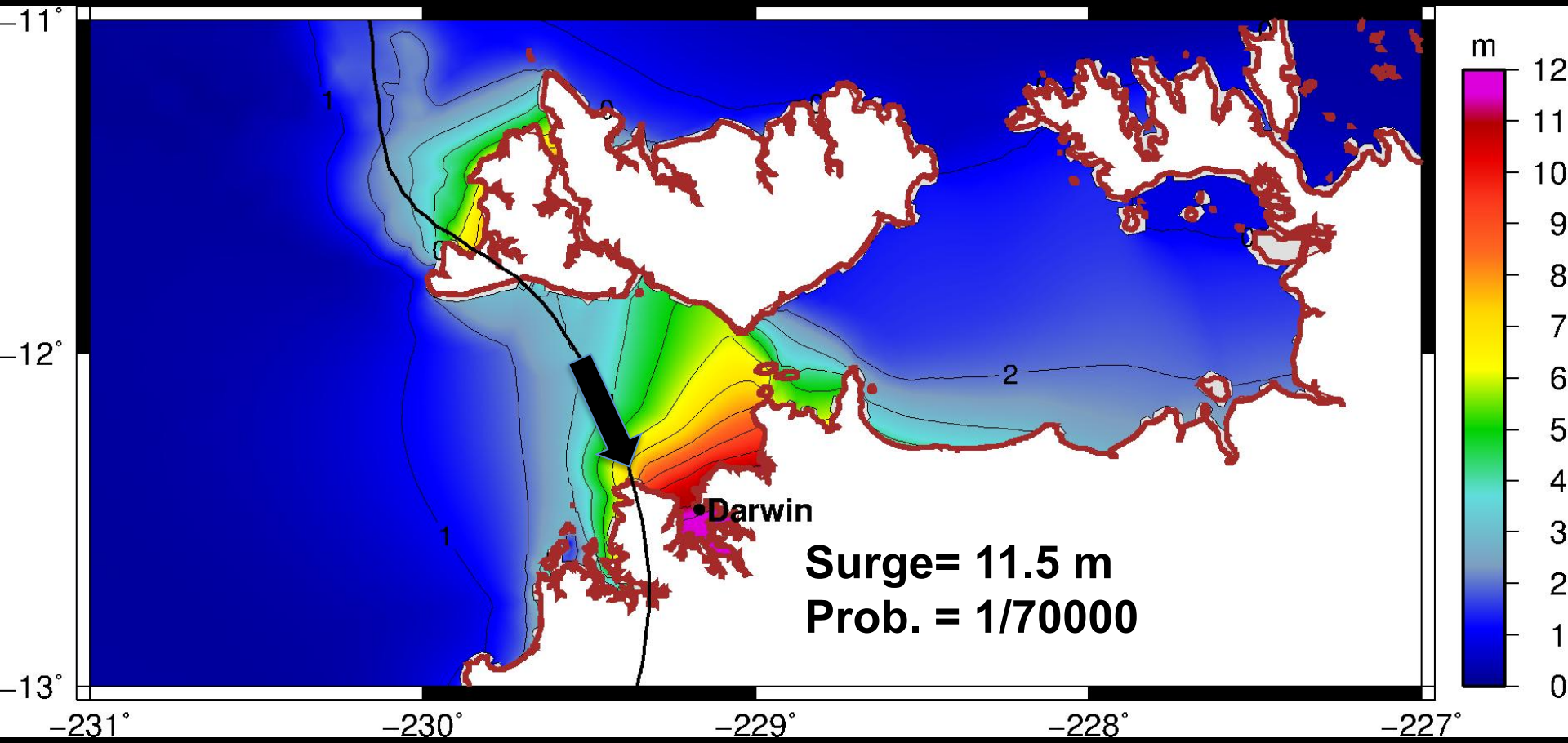
Tracks over a 20 year period
in the Northern Territory.
(Bureau of Meteorology)

Cyclone Tracy of 1974 generated
a surge of 1.6 m at Darwin

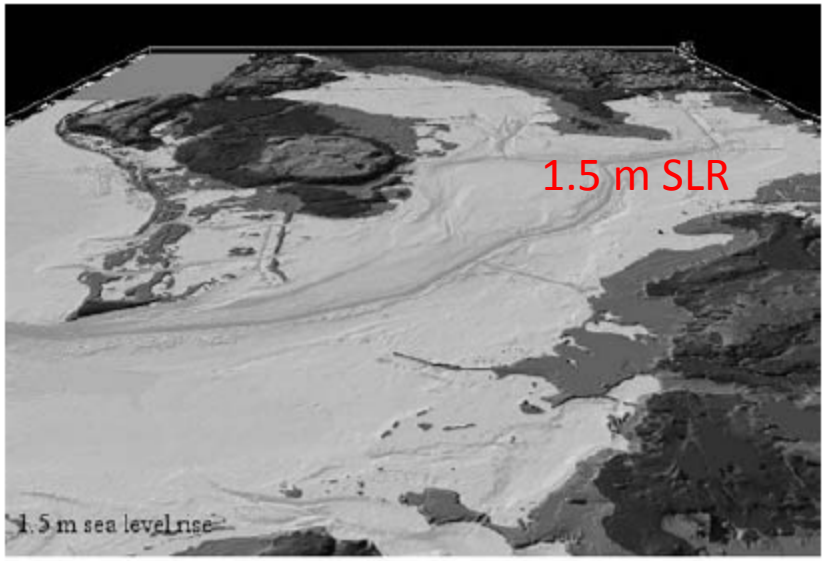
6200 Synthetic tracks
under NCAR/NCEP 1981-2000 Climate
Annual Frequency =0.18

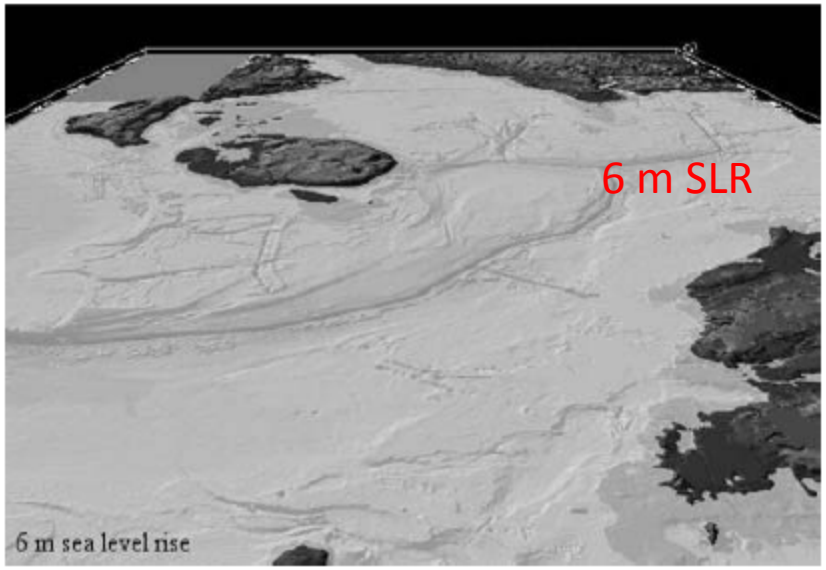


A Black Swan Event in Darwin



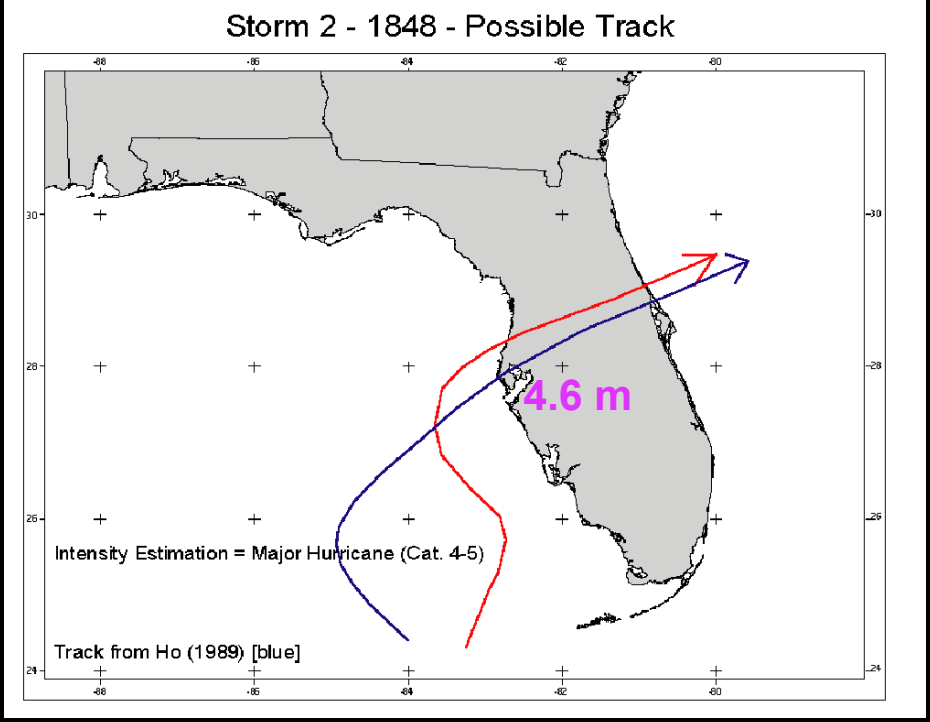
Tampa/St. Petersburg:
Population: 4.2 million



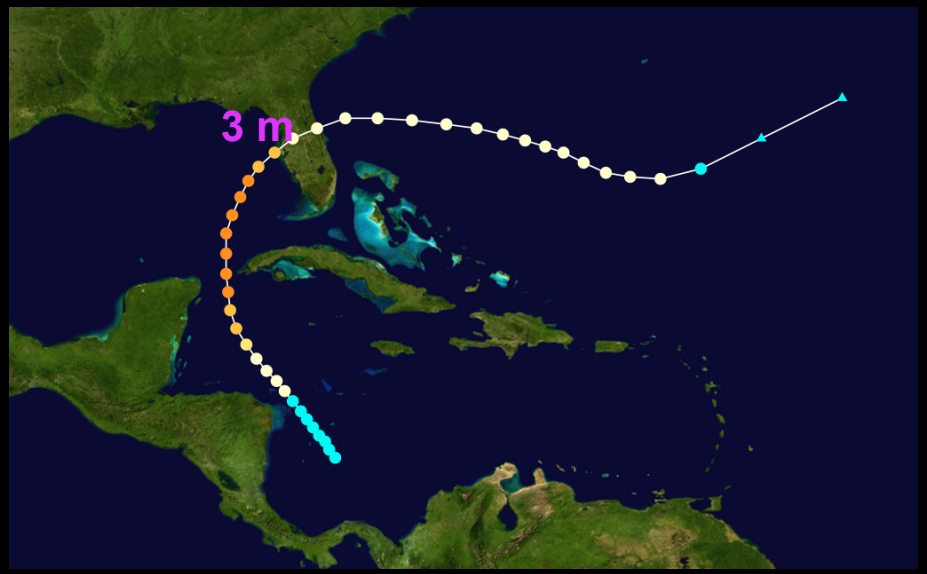


Weisberg and Zheng (2006)

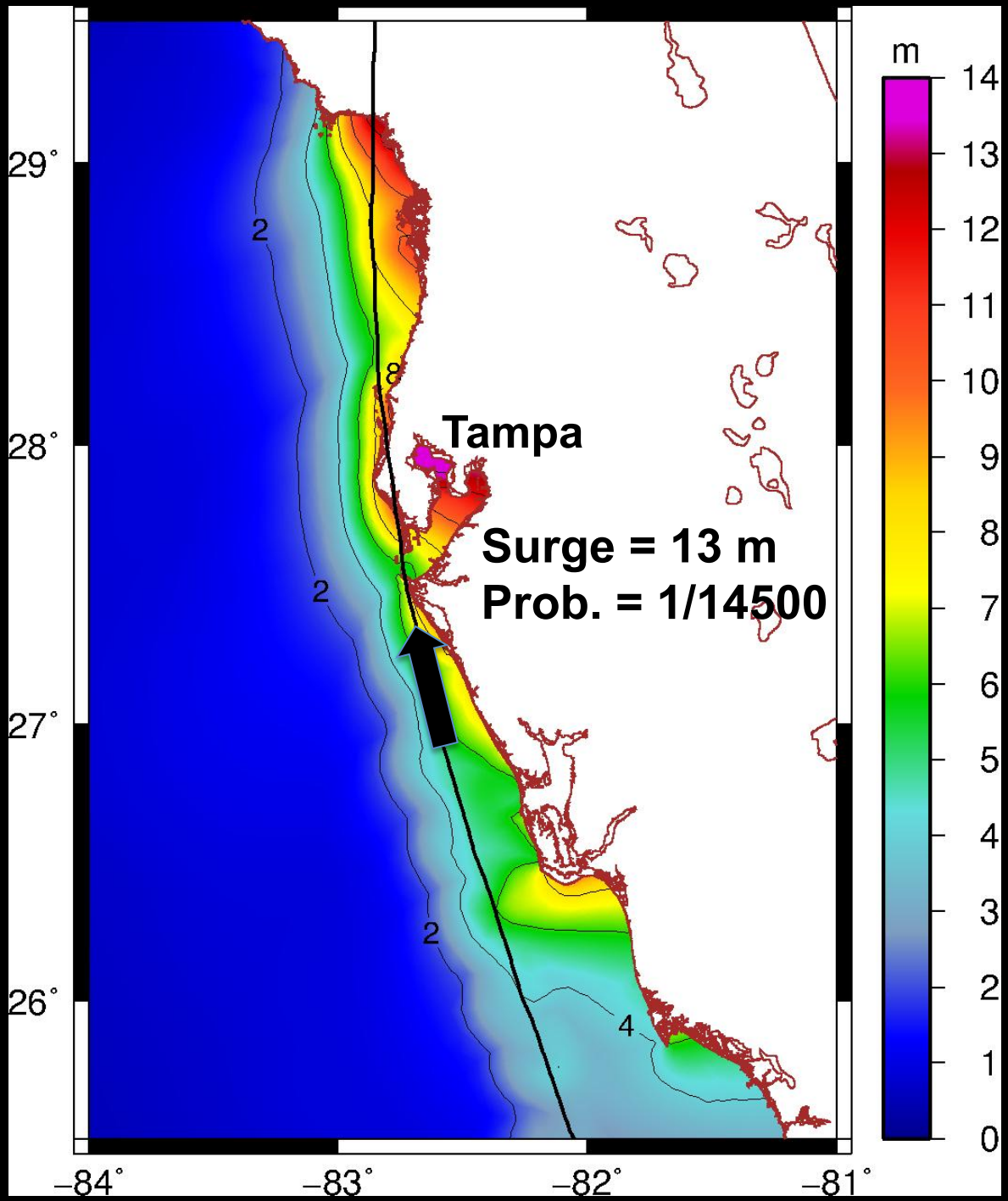
The Great Tampa Gale of 1848

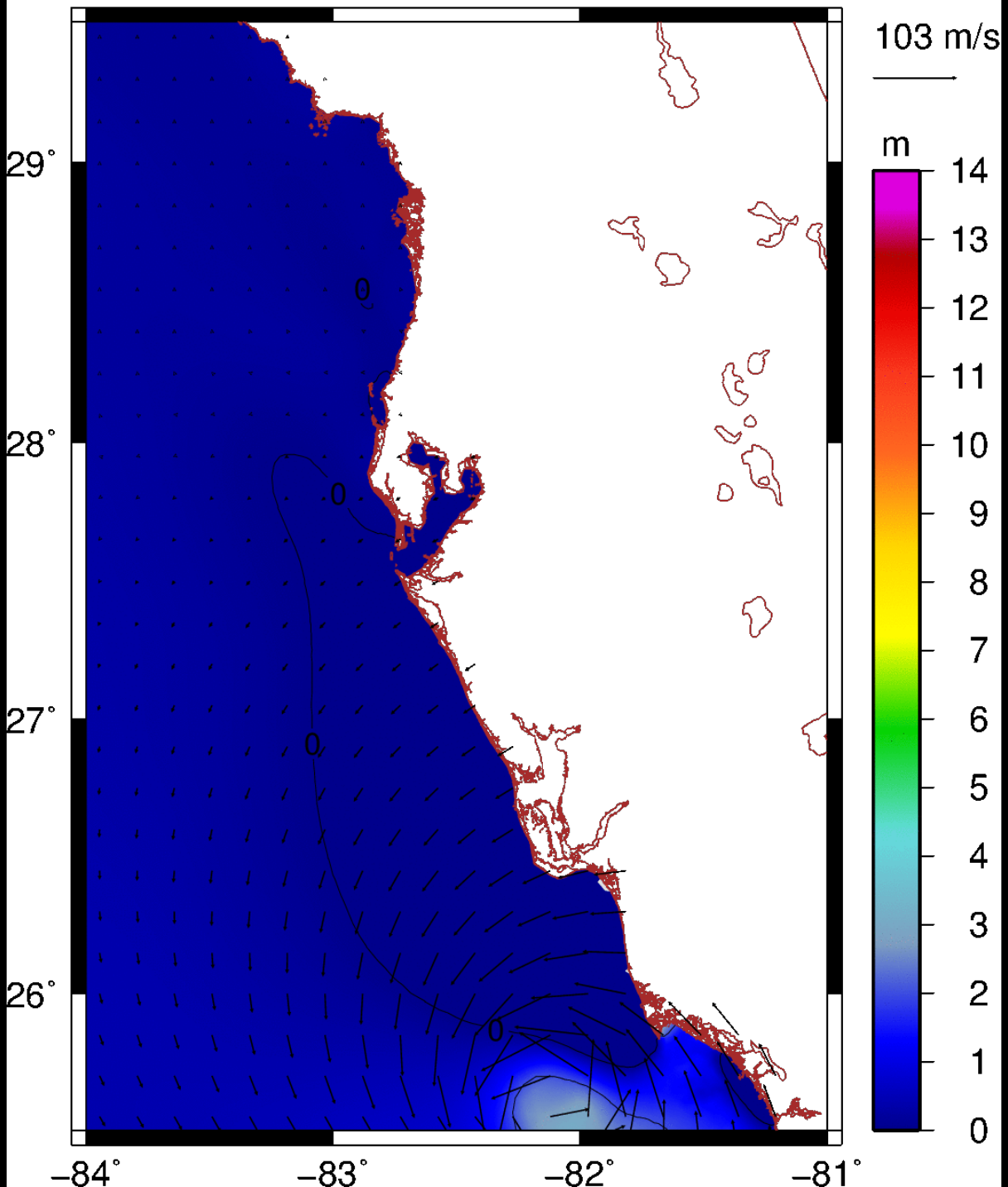


The Tampa Bay hurricane of 1921

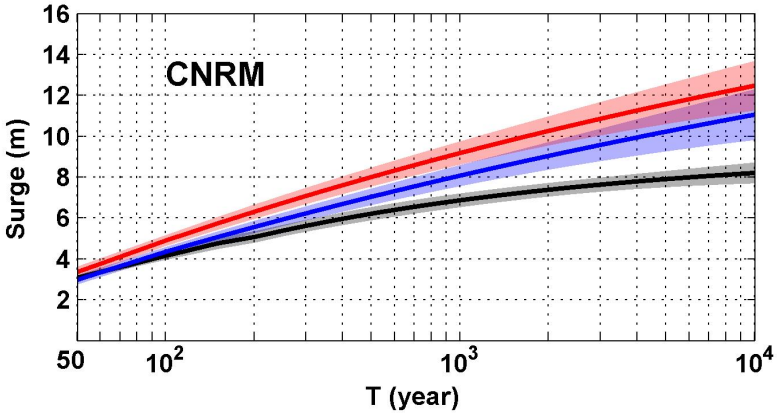


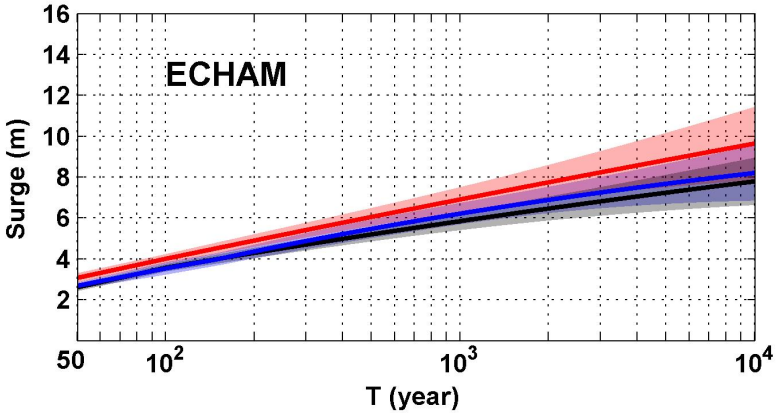
Possible Tracks for the 1848 Tampa Hurricane. image courtesy of James B. Elsner, Department of Geography Florida State University

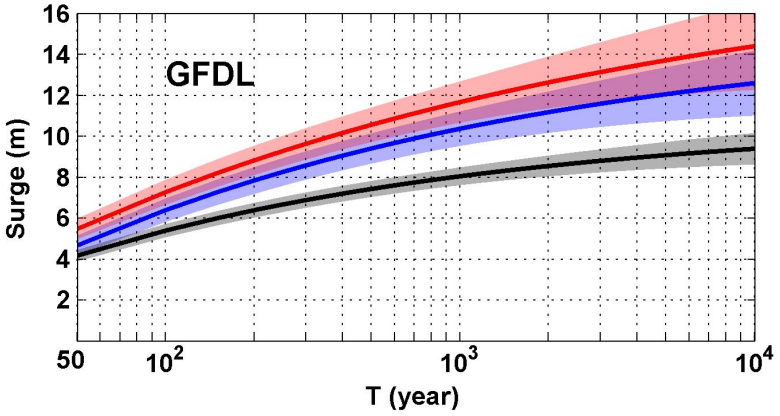

Tampa
Surge = 13 m
Prob. = 1/14500
m
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
29˚
28˚
27˚
26˚
−84˚
−83˚
−82˚
−81˚
2
8
2
2
4

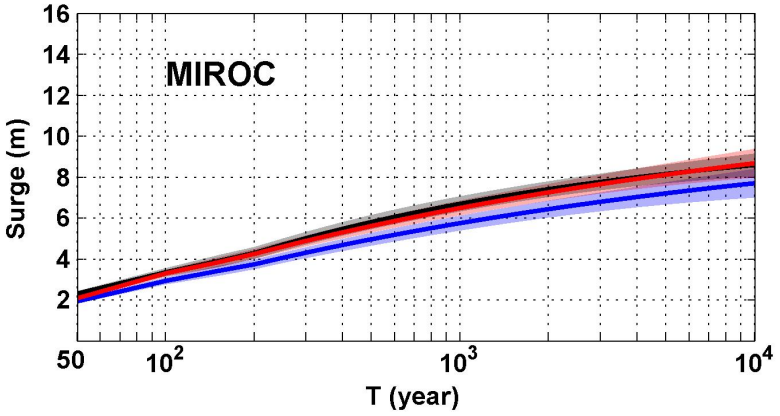

103 m/s
m
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
29°
28°
27°
26°
−84°
−83°
−82°
−81°

GCM storm surge return level for Tampa, FL









Black: Current climate (1981-2000)

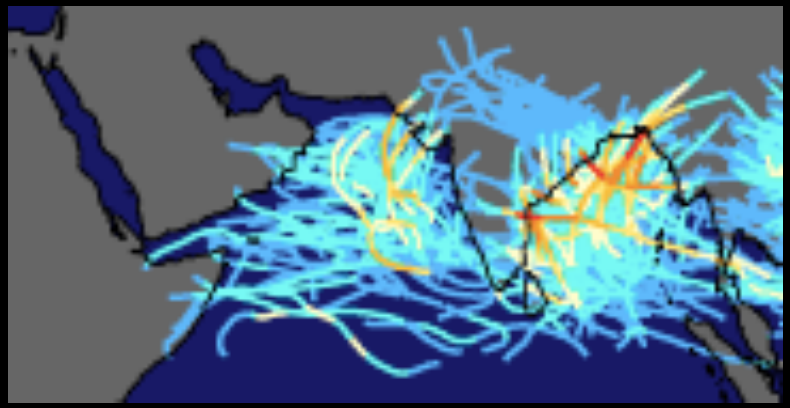
Blue: A1B future climate (2081-2100)

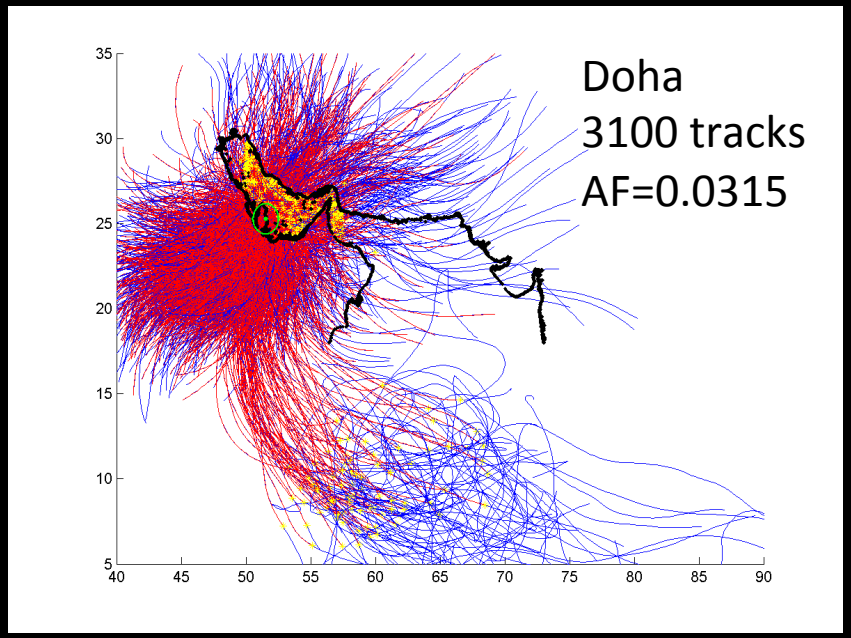
Red: A1B future climate (2081-2100) with R_0 increased by 10% and R_m increased by 21%

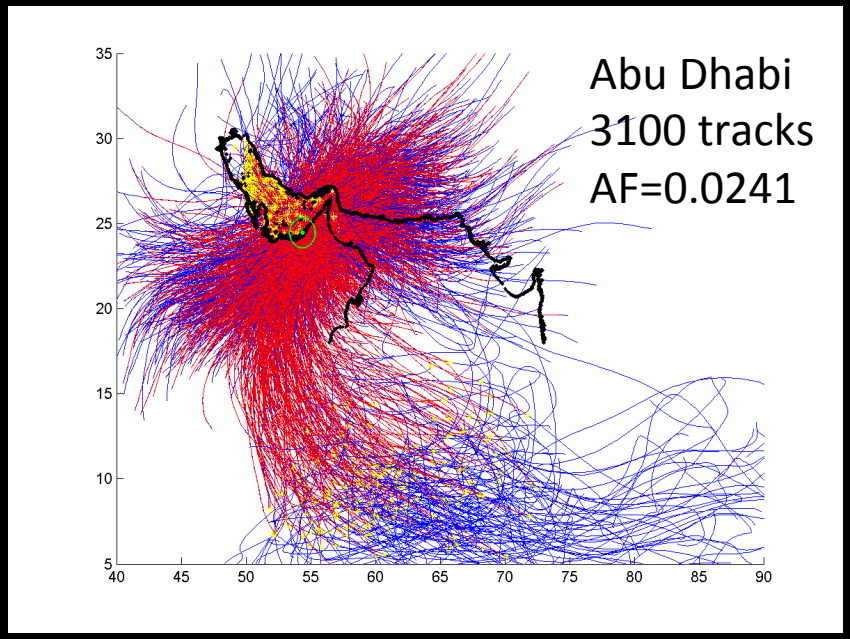
Summary:

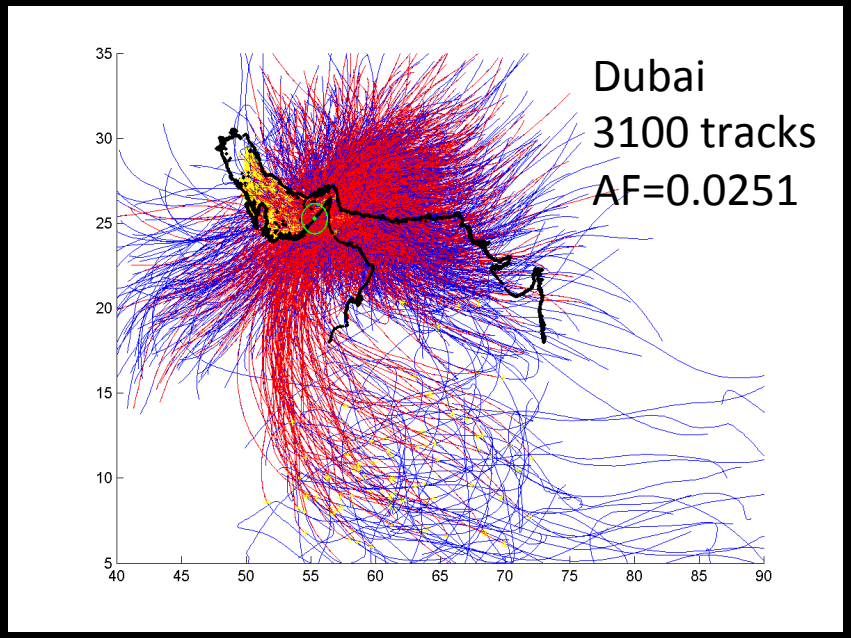
- The history of intense, landfalling storms is short.
- We have developed a technique for downscaling global models or reanalysis data sets, using high resolution, atmospheric-ocean coupled TC and hydrodynamic models.
- This technique, which can produce >1,000 years worth of events, shows potentially large vulnerability in places (like Dubai) where TCs have never been recorded, and larger- than-expected storm and surge risk in many places (such as Darwin and Tampa).

Persian Gulf

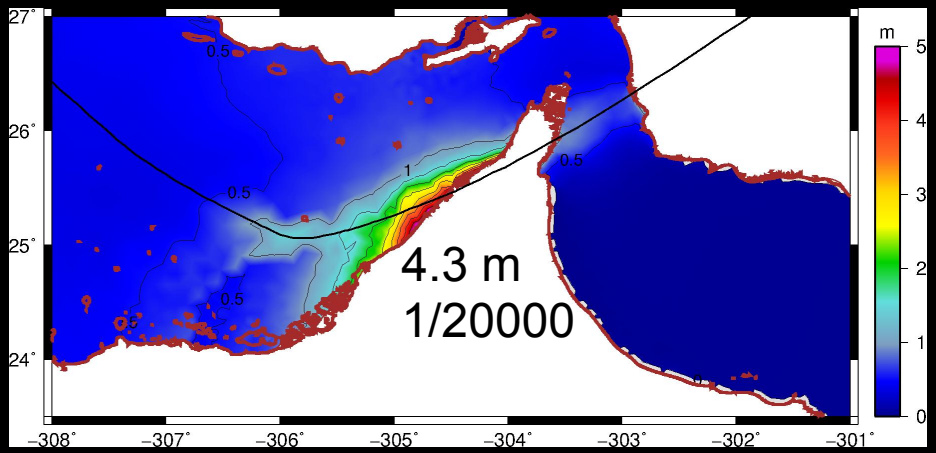


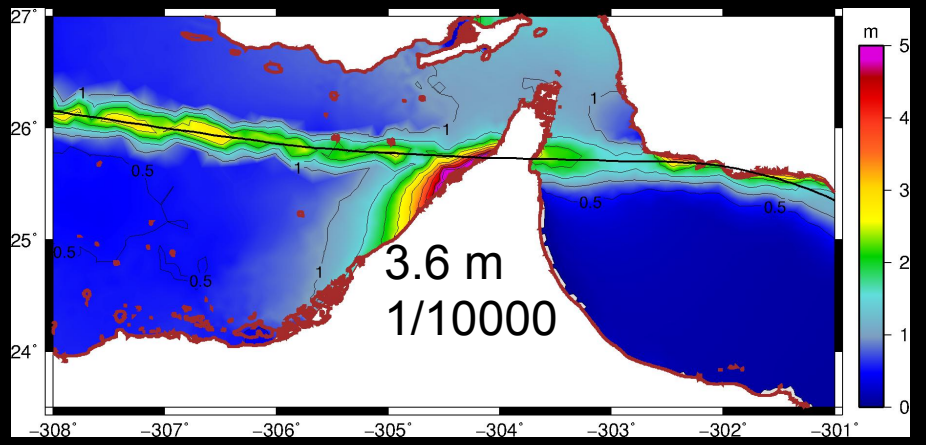


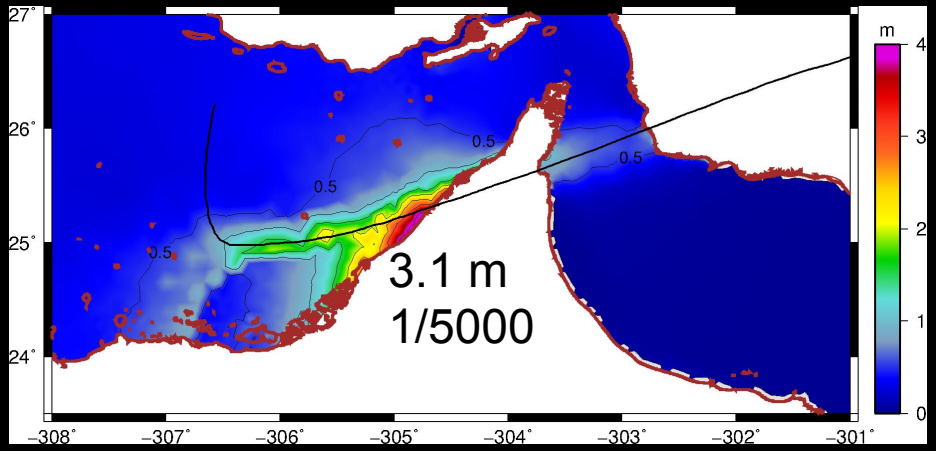


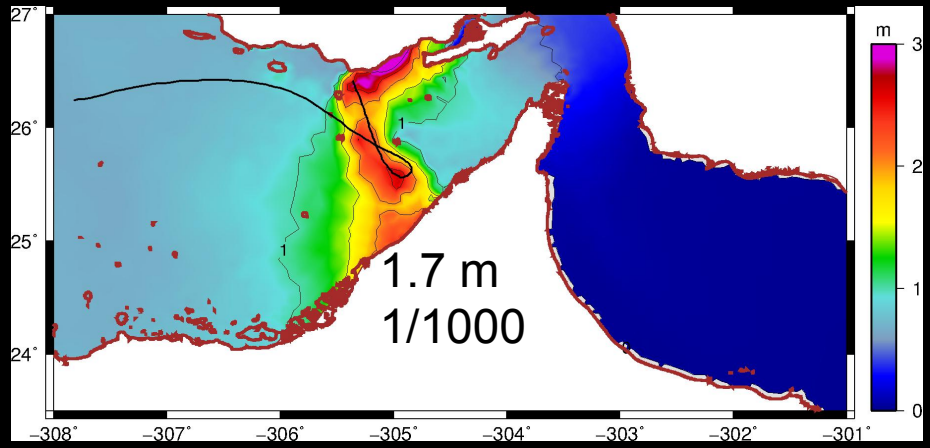


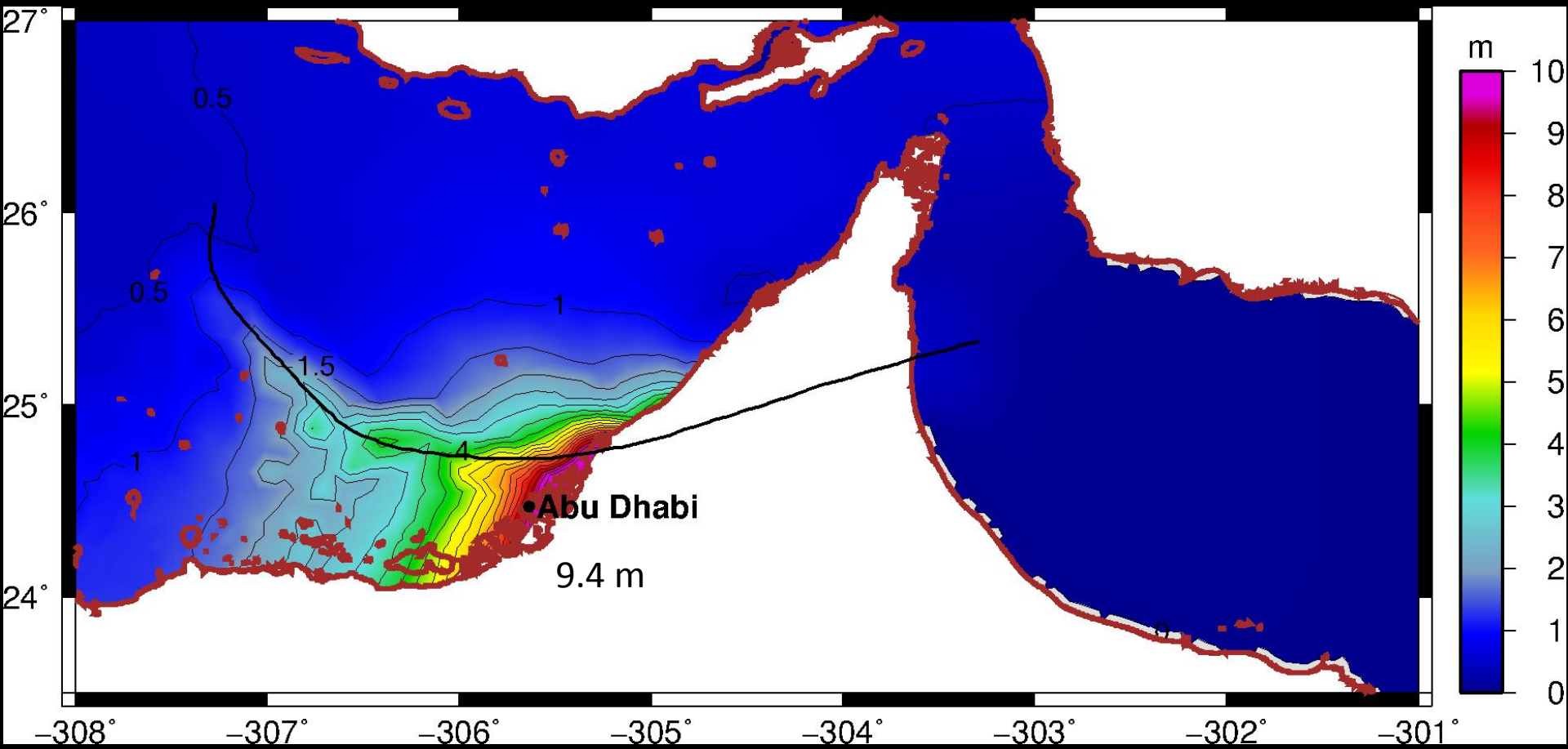
Dubai










27˚
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Abu Dhabi
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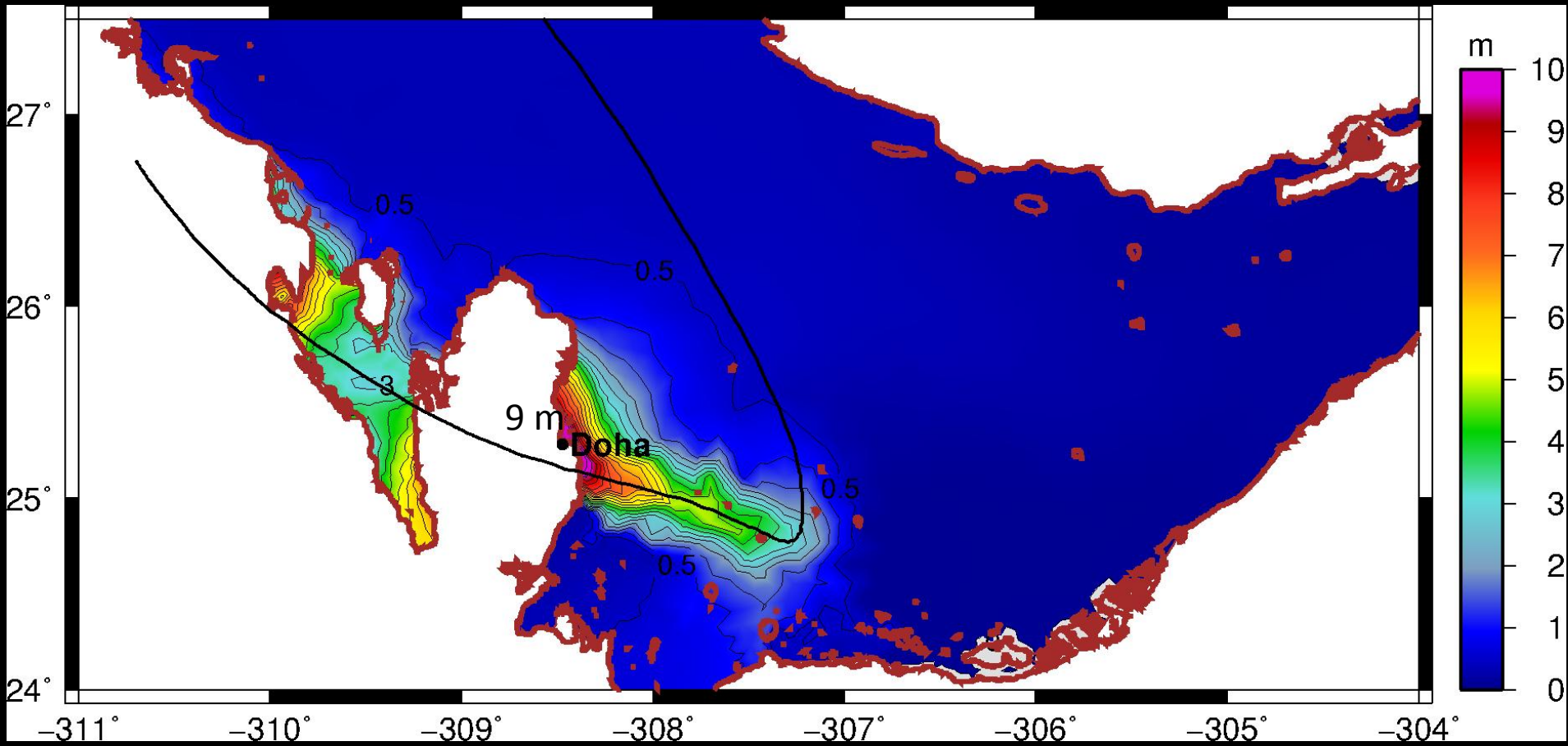
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−309˚
−308˚
−307˚
−306˚
−305˚
−304˚
0.5
0.5
3
9 m
Doha
0.5
0.5

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Track number 261, August 16, 08:00 GMT