

# Assessing the risk of hypothetical storms, considering extremes and climate change

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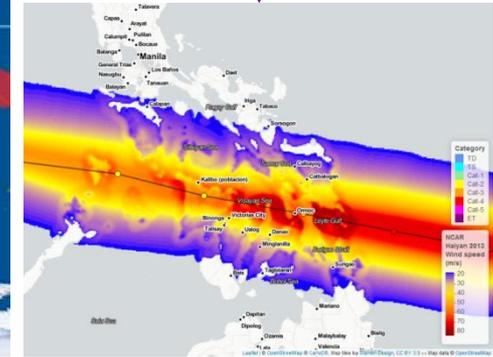
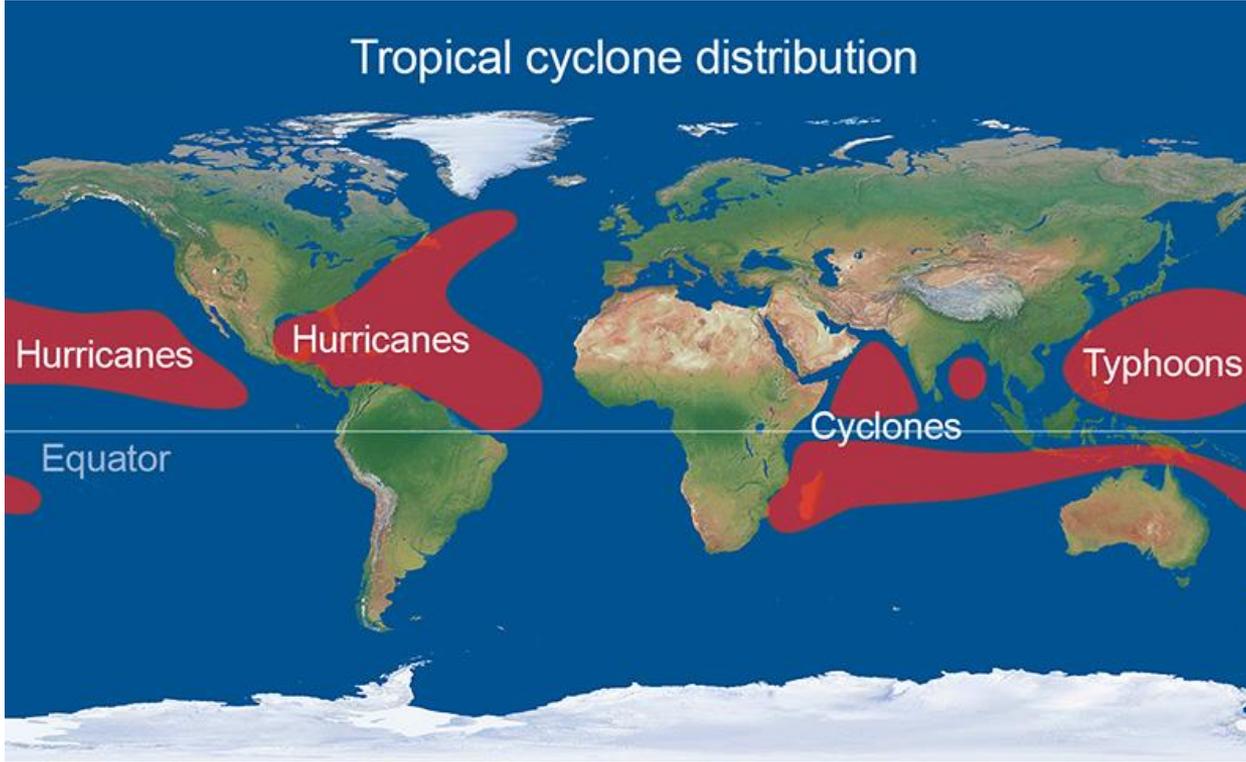
# A Note on Analytics, Innovation and Regulation

## Re/insurance of Natural Catastrophes

- Quantitative revolution in re/insurance industry in late 1980s/early 1990s
  - Business need: prospect of widespread insurance company insolvencies from 'natcat'
  - Subject matter experts and actuaries enter 'non-life' property insurance
  - Maturation of geospatial data-handling technologies
- A 'wild west' period of methodological innovation
  - Relatively rapidly coalescing around 'cat modelling' principles
  - 'Comparing apples with apples', data standards, output metrics
  - Push towards greater transparency
  - Eventual codification in regulation e.g. Solvency II
- Does *climate risk analytics* represent another innovative frontier?
  - EPSRC vs. NERC? (and not just 'more/better data...')

# Tropical Cyclones

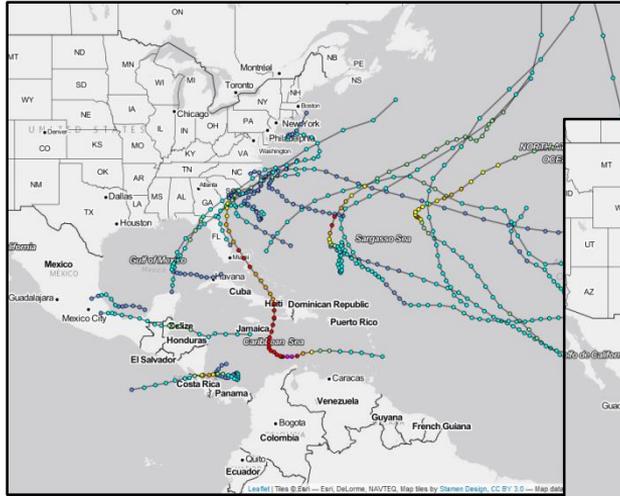
## Introduction



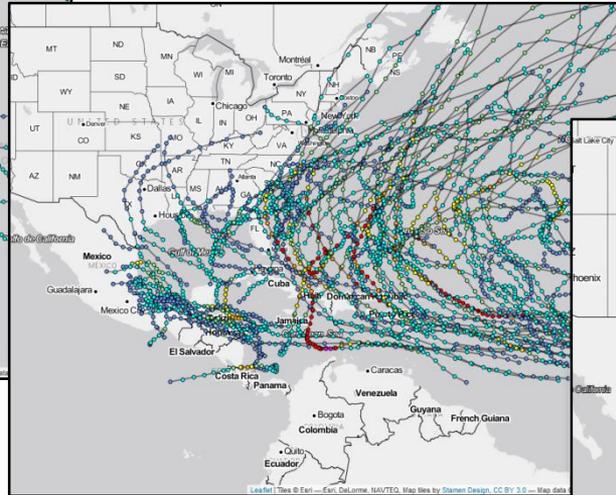
# Motivation

## Assessing risk beyond historical data

### 2016 Hurricane Season



### 2010-2016 Hurricane Seasons



### 1961 Hurricane Carla



# Motivation

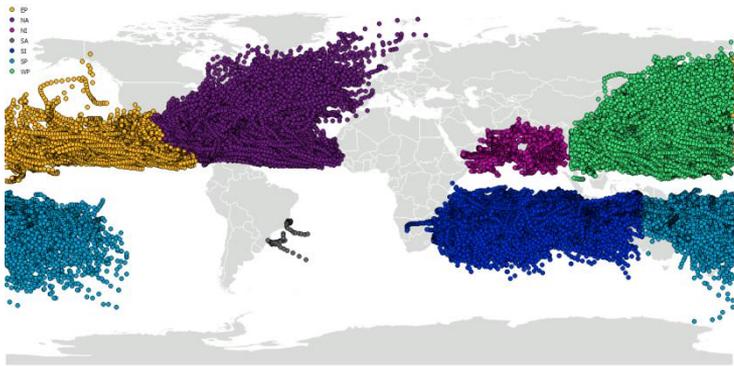
## Overview

- Assessing the financial risk of natural catastrophes is essential
  - Insurers need to ensure they have adequate capital and re-insurance
- ‘Catastrophe models’
  - Stochastic catalogue of events e.g. 10,000 years of tropical cyclones
  - Events have a probability of occurrence or return period assigned to them by simply ranking the events by loss and considering the length of the catalogue
- Realistic disaster scenarios / counterfactual scenarios also widely used
  - Assessment of potential damage
  - No method of establishing probability of occurrence
  - Regulatory role

# Global Tropical Cyclone Data

## Event sets

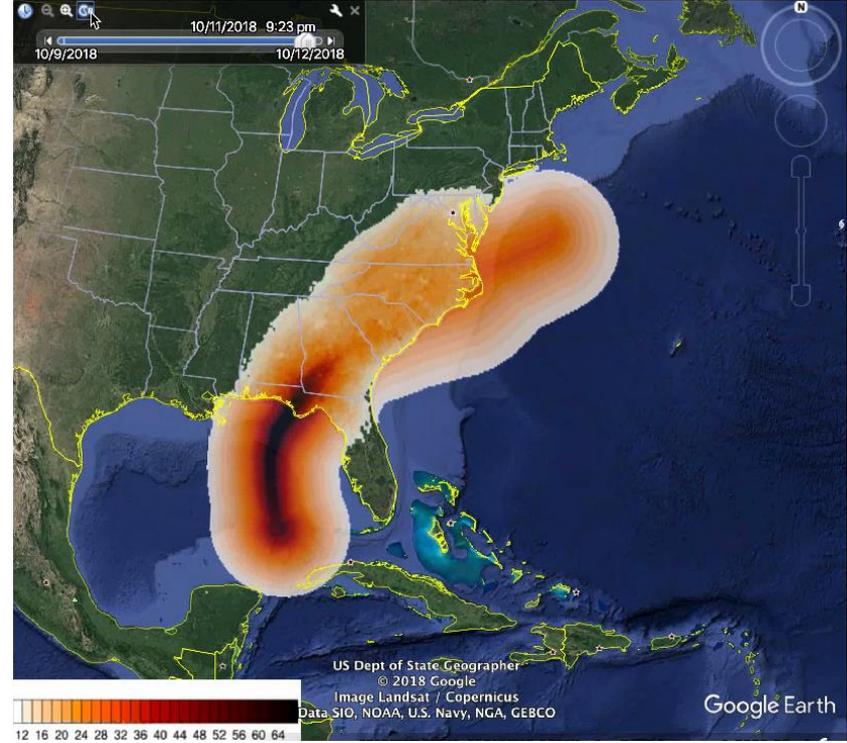
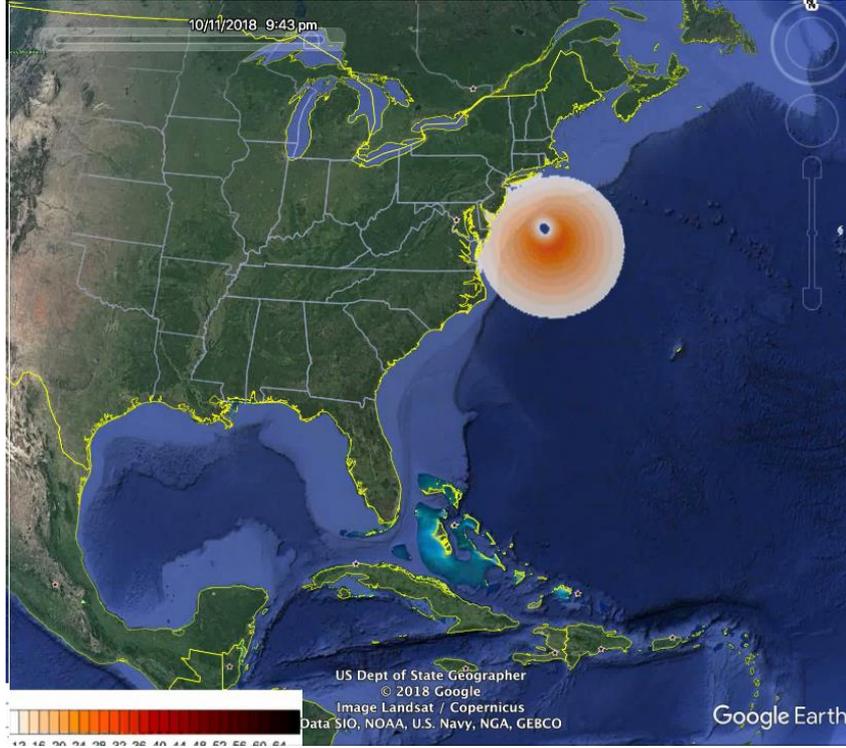
- Position and intensity of storms back to 1851 dependent on basin
- Important fields:
  - Latitude, Longitude, Time, Central Pressure



|    | A  | B      | C   | D     | E         | F         | G          | H      | I         | J         | K          | L          | M       | N          | O          | P          |
|----|--|--------|-----|-------|-----------|-----------|------------|--------|-----------|-----------|------------|------------|---------|------------|------------|------------|
| 1  | IBTrACS WMO: International Best Tracks Archive for Climate Stewardship -- WMO DATA ONLY -- Version: v03r10 |        |     |       |           |           |            |        |           |           |            |            |         |            |            |            |
| 2  | Serial_Nur   | Season | Num | Basin | Sub_basin | Name      | ISO_time   | Nature | Latitude  | Longitude | Wind(W/MC) | Pres(W/MC) | Center  | Wind(W/MC) | Pres(W/MC) | Track_type |
| 3  | N/A  | Year   | #   | BB    | BB        | N/A       | YYYY-MM/NA |        | deg_north | deg_east  | kt         | mb         | N/A     | %          | %          | N/A        |
| 4  | 1848011S   | 1848   | 2   | SI    | MM        | XXXX8480C | 1848-01-11 | NR     | -8.6      | 79.8      | 0          | 0          | reunion | -100       | -100       | main       |
| 5  | 1848011S   | 1848   | 2   | SI    | MM        | XXXX8480C | 1848-01-12 | NR     | -9        | 78.9      | 0          | 0          | reunion | -100       | -100       | main       |
| 6  | 1848011S   | 1848   | 2   | SI    | MM        | XXXX8480C | 1848-01-12 | NR     | -10.4     | 73.2      | 0          | 0          | reunion | -100       | -100       | main       |
| 7  | 1848011S   | 1848   | 2   | SI    | MM        | XXXX8480C | 1848-01-14 | NR     | -12.8     | 69.9      | 0          | 0          | reunion | -100       | -100       | main       |
| 8  | 1848011S   | 1848   | 2   | SI    | MM        | XXXX8480C | 1848-01-14 | NR     | -13.9     | 68.9      | 0          | 0          | reunion | -100       | -100       | main       |
| 9  | 1848011S   | 1848   | 2   | SI    | MM        | XXXX8480C | 1848-01-14 | NR     | -15.3     | 67.7      | 0          | 0          | reunion | -100       | -100       | main       |
| 10 | 1848011S   | 1848   | 2   | SI    | MM        | XXXX8480C | 1848-01-17 | NR     | -16.5     | 67        | 0          | 0          | reunion | -100       | -100       | main       |
| 11 | 1848011S   | 1848   | 2   | SI    | MM        | XXXX8480C | 1848-01-14 | NR     | -18       | 67.4      | 0          | 0          | reunion | -100       | -100       | main       |
| 12 | 1848011S   | 1848   | 2   | SI    | MM        | XXXX8480C | 1848-01-14 | NR     | -20.6     | 69.8      | 0          | 0          | reunion | -100       | -100       | main       |
| 13 | 1848011S   | 1848   | 2   | SI    | MM        | XXXX8480C | 1848-01-20 | NR     | -22.8     | 72        | 0          | 0          | reunion | -100       | -100       | main       |
| 14 | 1848011S   | 1848   | 2   | SI    | MM        | XXXX8480C | 1848-01-21 | NR     | -27.2     | 75.8      | 0          | 0          | reunion | -100       | -100       | main       |
| 15 | 1848011S   | 1848   | 3   | SI    | MM        | XXXX8480C | 1848-01-11 | NR     | -15.2     | 57.4      | 0          | 0          | reunion | -100       | -100       | main       |
| 16 | 1848011S   | 1848   | 3   | SI    | MM        | XXXX8480C | 1848-01-12 | NR     | -15.8     | 56.6      | 0          | 0          | reunion | -100       | -100       | main       |
| 17 | 1848011S   | 1848   | 3   | SI    | MM        | XXXX8480C | 1848-01-12 | NR     | -20.3     | 49.9      | 0          | 0          | reunion | -100       | -100       | main       |
| 18 | 1848011S   | 1848   | 3   | SI    | MM        | XXXX8480C | 1848-01-14 | NR     | -26.1     | 46.7      | 0          | 0          | reunion | -100       | -100       | main       |
| 19 | 1848011S   | 1848   | 3   | SI    | MM        | XXXX8480C | 1848-01-14 | NR     | -33.2     | 50.4      | 0          | 0          | reunion | -100       | -100       | main       |
| 20 | 1848011S   | 1848   | 3   | SI    | MM        | XXXX8480C | 1848-01-14 | NR     | -34.1     | 51.1      | 0          | 0          | reunion | -100       | -100       | main       |
| 21 | 1848061S   | 1848   | 5   | SI    | MM        | XXXX8480C | 1848-03-01 | NR     | -11.4     | 75.5      | 0          | 0          | reunion | -100       | -100       | main       |
| 22 | 1848061S   | 1848   | 5   | SI    | MM        | XXXX8480C | 1848-03-02 | NR     | -11.7     | 74        | 0          | 0          | reunion | -100       | -100       | main       |
| 23 | 1848061S   | 1848   | 5   | SI    | MM        | XXXX8480C | 1848-03-02 | NR     | -14.4     | 64.6      | 0          | 0          | reunion | -100       | -100       | main       |
| 24 | 1848061S   | 1848   | 5   | SI    | MM        | XXXX8480C | 1848-03-04 | NR     | -17.6     | 57.6      | 0          | 0          | reunion | -100       | -100       | main       |
| 25 | 1848061S   | 1848   | 5   | SI    | MM        | XXXX8480C | 1848-03-04 | NR     | -24.5     | 56.5      | 0          | 0          | reunion | -100       | -100       | main       |
| 26 | 1848061S   | 1848   | 5   | SI    | MM        | XXXX8480C | 1848-03-04 | NR     | -29.6     | 59.9      | 0          | 0          | reunion | -100       | -100       | main       |
| 27 | 1848061S   | 1848   | 5   | SI    | MM        | XXXX8480C | 1848-03-07 | NR     | -34.5     | 69.3      | 0          | 0          | reunion | -100       | -100       | main       |
| 28 | 1851080S   | 1851   | 2   | SI    | MM        | XXXX8510C | 1851-03-21 | NR     | -15.1     | 62.5      | 0          | 0          | reunion | -100       | -100       | split      |
| 29 | 1851080S   | 1851   | 2   | SI    | MM        | XXXX8510C | 1851-03-22 | NR     | -15.9     | 61        | 0          | 0          | reunion | -100       | -100       | split      |
| 30 | 1851080S   | 1851   | 2   | SI    | MM        | XXXX8510C | 1851-03-22 | NR     | -16.8     | 59        | 0          | 0          | reunion | -100       | -100       | split      |
| 31 | 1851080S   | 1851   | 2   | SI    | MM        | XXXX8510C | 1851-03-24 | NR     | -17.1     | 57        | 0          | 0          | reunion | -100       | -100       | split      |
| 32 | 1851080S   | 1851   | 2   | SI    | MM        | XXXX8510C | 1851-03-24 | NR     | -17.4     | 54.6      | 0          | 0          | reunion | -100       | -100       | split      |
| 33 | 1851080S   | 1851   | 2   | SI    | MM        | XXXX8510C | 1851-03-24 | NR     | -18       | 52        | 0          | 0          | reunion | -100       | -100       | split      |
| 34 | 1851080S   | 1851   | 2   | SI    | MM        | XXXX8510C | 1851-03-27 | NR     | -18.9     | 49        | 0          | 0          | reunion | -100       | -100       | split      |
| 35 | 1851080S   | 1851   | 2   | SI    | MM        | XXXX8510C | 1851-03-24 | NR     | -19.4     | 48.1      | 0          | 0          | reunion | -100       | -100       | split      |
| 36 | 1851080S   | 1851   | 3   | SI    | MM        | XXXX8510C | 1851-03-21 | NR     | -21.2     | 59.5      | 0          | 0          | reunion | -100       | -100       | split      |
| 37 | 1851080S   | 1851   | 3   | SI    | MM        | XXXX8510C | 1851-03-22 | NR     | -22.9     | 59.5      | 0          | 0          | reunion | -100       | -100       | split      |
| 38 | 1851080S   | 1851   | 3   | SI    | MM        | XXXX8510C | 1851-03-22 | NR     | -26.8     | 61.6      | 0          | 0          | reunion | -100       | -100       | split      |
| 39 | 1851175N   | 1851   | 1   | NA    | GM        | UNNAMEC   | 1851-06-24 | TS     | 28        | -94.8     | 80         | 0          | atcf    | 85.15      | -100       | main       |
| 40 | 1851175N   | 1851   | 1   | NA    | GM        | UNNAMEC   | 1851-06-24 | TS     | 28        | -95.4     | 80         | 0          | atcf    | 85.15      | -100       | main       |
| 41 | 1851175N   | 1851   | 1   | NA    | GM        | UNNAMEC   | 1851-06-24 | TS     | 28        | -96       | 80         | 0          | atcf    | 85.15      | -100       | main       |
| 42 | 1851175N   | 1851   | 1   | NA    | GM        | UNNAMEC   | 1851-06-24 | TS     | 28.1      | -96.5     | 80         | 0          | atcf    | 85.15      | -100       | main       |
| 43 | 1851175N   | 1851   | 1   | NA    | GM        | UNNAMEC   | 1851-06-24 | TS     | 28.2      | -96.8     | 80         | 0          | atcf    | 85.15      | -100       | main       |
| 44 | 1851175N   | 1851   | 1   | NA    | NA        | UNNAMEC   | 1851-06-24 | TS     | 28.2      | -97       | 70         | 0          | atcf    | 78.944     | -100       | main       |
| 45 | 1851175N   | 1851   | 1   | NA    | NA        | UNNAMEC   | 1851-06-24 | TS     | 28.3      | -97.6     | 60         | 0          | atcf    | 69.835     | -100       | main       |

# Scenarios

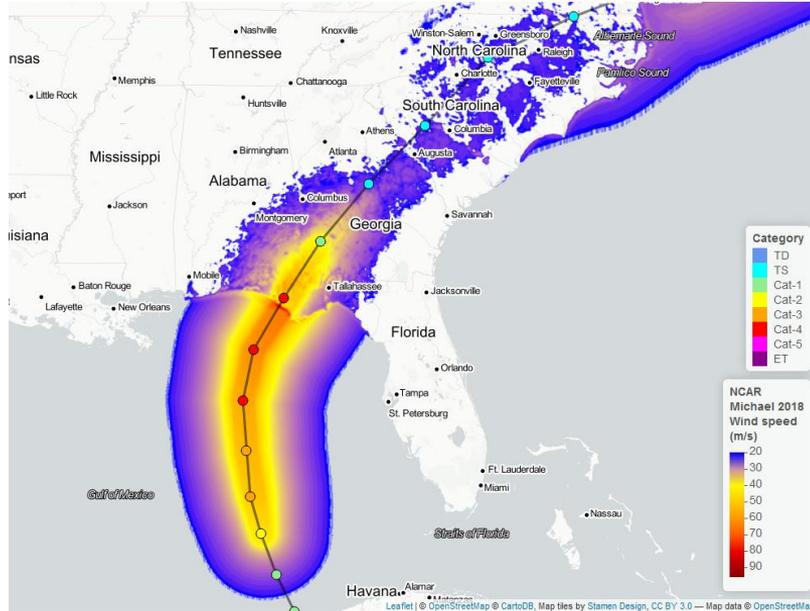
Hurricane Michael, Oct 2018: \$25bn (\$10bn insured loss)



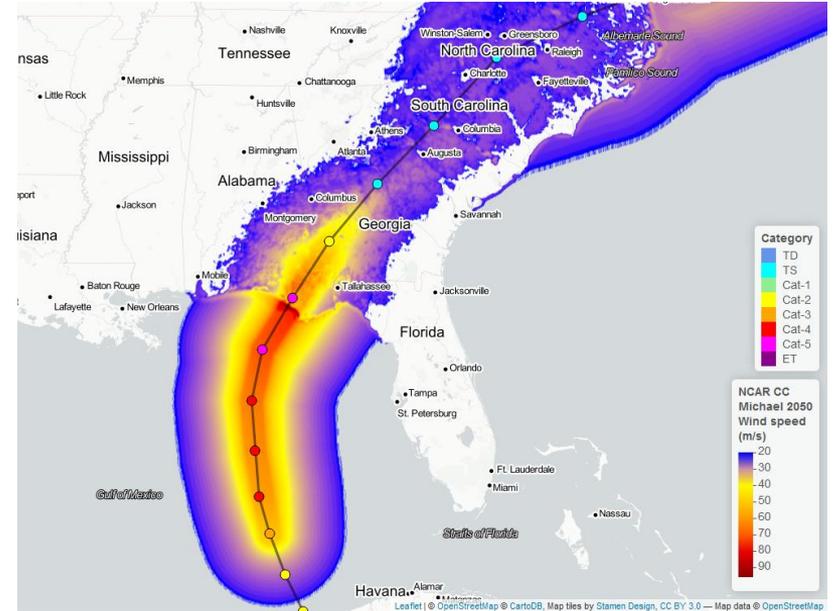
# Scenarios

What Michael could have been like under continued climate change?

## Michael: Original

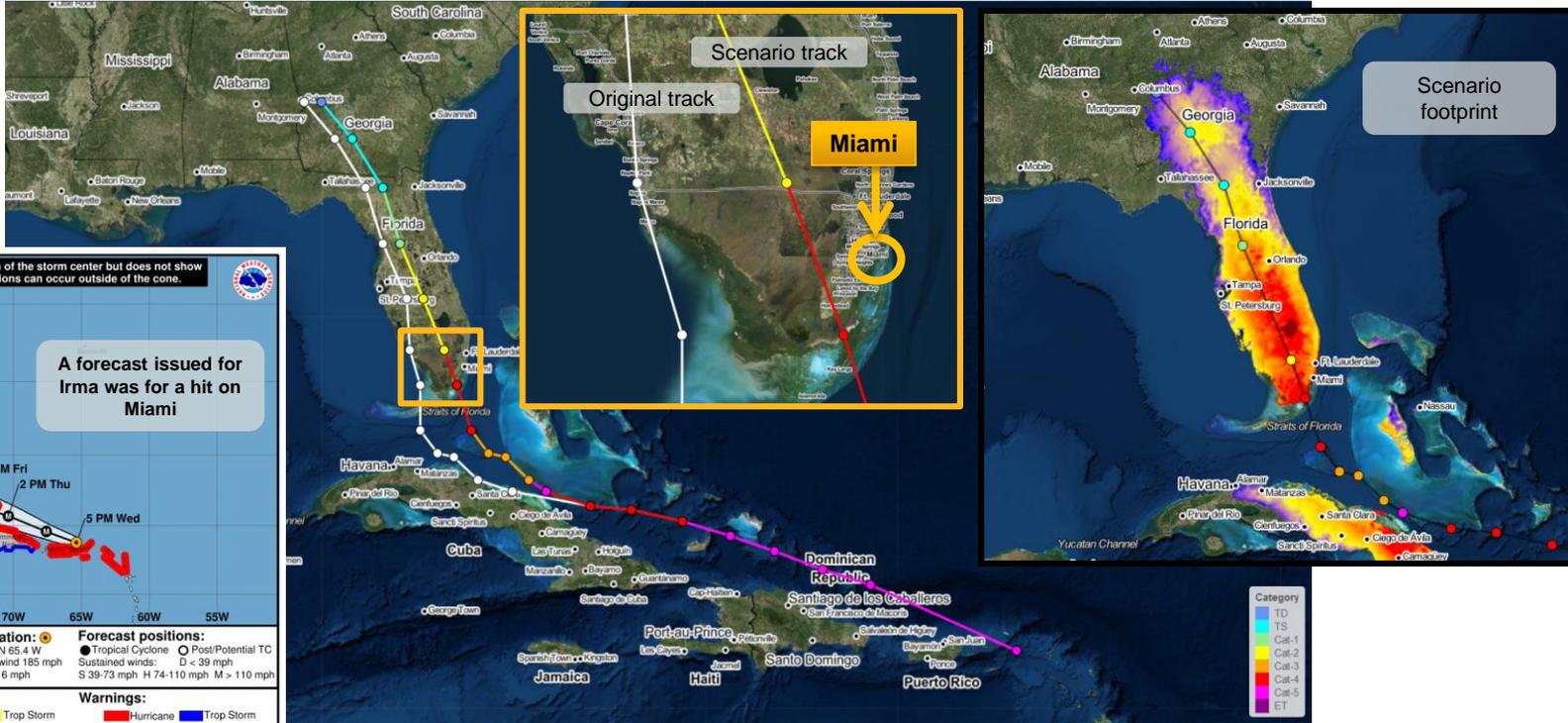


## Michael: Category 5



# What if Irma hit Miami?

Establishing a method of assigning occurrence probability to hypothetical TCs



# Towards a Climate Risk Analytics

## Broader finance sector engagement: asset management / banking

- Regulatory and business opportunity drivers
  - TCFD, PRA, ESG...
- UN Climate Summit, Sept 2019, WTW lead (with DFID and WEF) the formation of Coalition for Climate Resilient Investment (CCRI)
  - To integrating climate risks into infrastructure investment
  - Develop analytical tools including a physical risk pricing framework and methodology
    - COP26 in 2020, Glasgow
- Emerging 'disruptive' analytical innovations from outside the re/insurance industry

# A CERN for Global Climate Models?

## Extreme Earth – a 2018 EU Flagship project bid

Either higher resolution models (1km<sup>2</sup>)...

- Exascale computing developments needing new paradigms
  - Co-design with hardware vendors, software engineers, computer and climate scientists
  - Tim Palmer, professor of climate physics, University of Oxford
    - Nature Reviews, Physics, volume 1, pages 463–471(2019)

Or randomising sub-grid processes

- Partial differential equations describing physical climate system are deterministic
  - Computational representations of these equations should be stochastic
    - Such representations better respect scaling symmetries of Navier-Stokes equation
    - Stochasticity in parameterised representations of sub-grid processes improves skill
      - E.g. clouds, ocean eddies, soil water retention

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