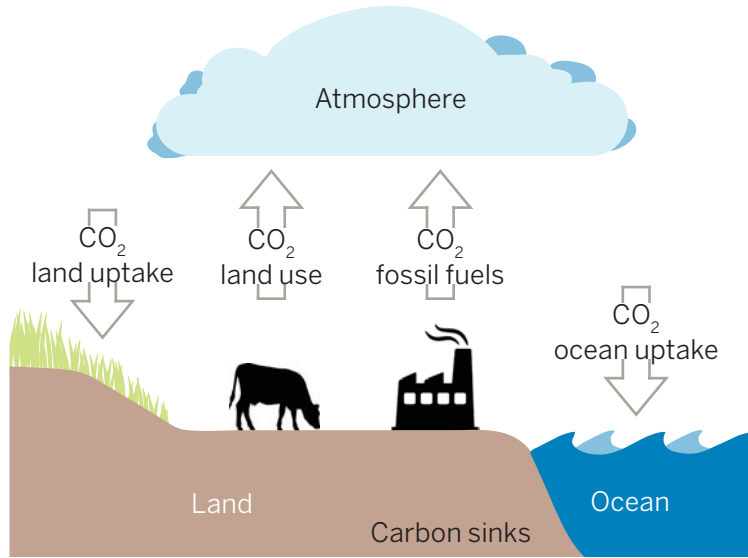


# Climate cause & effect

Drives distinct fields of study

## Cause



### Transition risks...

Policy & regulation

- Carbon pricing to reduce future emissions
- Carbon sinks to remove existing emissions

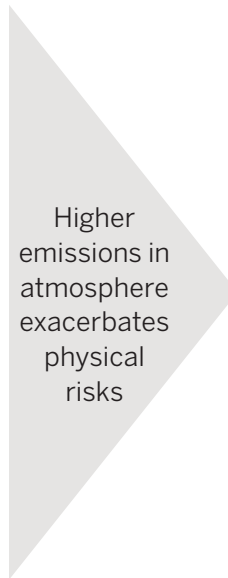
Technological disruption

- Renewable energy
- Electric vehicles

Litigation

Societal pressure & behavior

...drive need for mitigation



## Effect

Chronic



Heat



Drought



Water access

Acute



Flooding



Hurricanes



Wildfire

### Physical risks...

Chronic risks are long-term shifts in climate patterns

Acute risks are event-driven and increasing in severity

Changing climate will impact regions at different paces and magnitudes

Impacts to: societies, economies, private & public spending, infrastructure

...drive need for adaptation

## Understanding how climate change affect investments

### Partnership with Woods Hole Research Center

Began multi-year research collaboration with Woods Hole Research Center in September 2018

- #1 ranked global climate think tank by ICCG<sup>1</sup> over the last four years
- Collaborators include The World Bank, NASA, USAID, The Nature Conservancy
- Staff of 70 working around the globe

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Research collaboration focused on physical climate risk

- Implications of heat, drought, wildfire, hurricanes, floods, water access
- Bridging the gap between science and finance



*"I could give 100 more speeches and nothing will change but if we get 100 security prices to move, something may change"*

– Phil Duffy, Executive Director  
Woods Hole Research Center

<sup>1</sup>International Center for Climate Governance

# Understanding how climate change affect investments

## Physical climate risk research

### National Weather Service (NWS) heat index

Humans are most susceptible to combination of heat and humidity

| Relative humidity (%) | Temperature, °F |    |     |     |     |     |     |     |     |     |     |     |     |     |     |     |
|-----------------------|-----------------|----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
|                       | 80              | 82 | 84  | 86  | 88  | 90  | 92  | 94  | 96  | 98  | 100 | 102 | 104 | 106 | 108 | 110 |
| 40                    | 80              | 81 | 83  | 85  | 88  | 91  | 94  | 97  | 101 | 105 | 109 | 114 | 119 | 124 | 130 | 136 |
| 45                    | 80              | 82 | 84  | 87  | 89  | 93  | 96  | 100 | 104 | 109 | 114 | 119 | 124 | 130 | 137 |     |
| 50                    | 81              | 83 | 85  | 88  | 91  | 95  | 99  | 103 | 108 | 113 | 118 | 124 | 131 | 137 |     |     |
| 55                    | 81              | 84 | 86  | 89  | 93  | 97  | 101 | 106 | 112 | 117 | 124 | 130 | 137 |     |     |     |
| 60                    | 82              | 84 | 88  | 91  | 95  | 100 | 105 | 110 | 116 | 123 | 129 | 137 |     |     |     |     |
| 65                    | 82              | 85 | 89  | 93  | 98  | 103 | 108 | 114 | 121 | 128 | 136 |     |     |     |     |     |
| 70                    | 83              | 86 | 90  | 95  | 100 | 105 | 112 | 119 | 126 | 134 |     |     |     |     |     |     |
| 75                    | 84              | 88 | 92  | 97  | 103 | 109 | 116 | 124 | 132 |     |     |     |     |     |     |     |
| 80                    | 84              | 89 | 94  | 100 | 106 | 113 | 121 | 129 |     |     |     |     |     |     |     |     |
| 85                    | 85              | 90 | 96  | 102 | 110 | 117 | 126 | 135 |     |     |     |     |     |     |     |     |
| 90                    | 86              | 91 | 98  | 105 | 113 | 122 | 131 |     |     |     |     |     |     |     |     |     |
| 95                    | 86              | 93 | 100 | 108 | 117 | 127 |     |     |     |     |     |     |     |     |     |     |
| 100                   | 87              | 95 | 103 | 112 | 121 | 132 |     |     |     |     |     |     |     |     |     |     |

Caution
  Extreme caution
  Danger
  Extreme danger

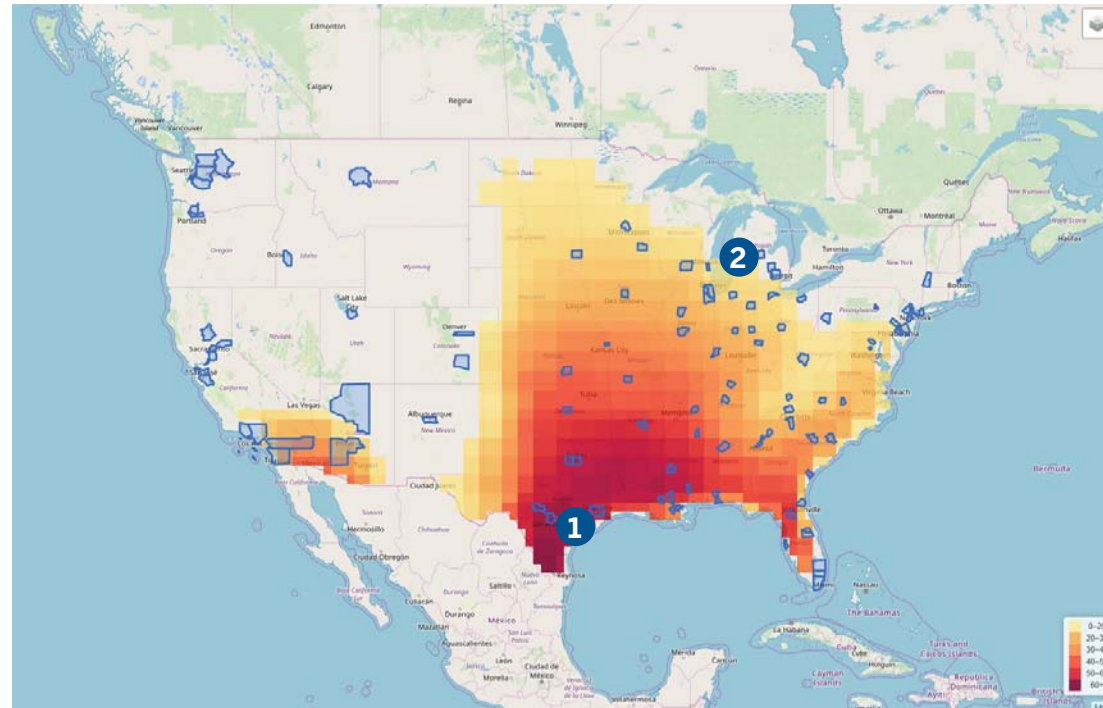
| Classification  | Heat index (°F) | Effect on the body   |
|-----------------|-----------------|--|
| Caution         | 80 – 90         | Fatigue possible with prolonged exposure and/or physical activity  |
| Extreme caution | 90 – 103        | Heat stroke, heat cramps, or heat exhaustion possible with prolonged exposure and/or physical activity           |
| Danger          | 103 – 124       | Heat cramps or heat exhaustion likely, and heat stroke possible with prolonged exposure and/or physical activity |
| Extreme danger  | 125 or higher   | Heat stroke highly likely  |

NWS Heat Index is based on a 1979 study conducted by R.G. Steadman to measure the impacts of high temperatures and high humidity on the human body. Since heat index values were devised for shady, light wind conditions, exposure to full sunshine can increase heat index values by up to 15° F. | This approach has not be updated by NWS in recent years; however, we believe the NWS Heat Index and the impacts presented are still accurate. Not representative of an actual investment. Not to be considered investment advice.

# Understanding how climate change affect investments

## Integrated spatial finance example – muni bonds

Additional days per year in NWS danger zone throughout the 2020 – 2029 decade  
US based on 1951 – 1980 reference period



| Location 1      | Texas        |
|-----------------|--------------|
| S&P rating      | AA           |
| Yield           | 2.43         |
| Maturity date   | 1 April 2040 |
| Heat percentile | 66.8         |

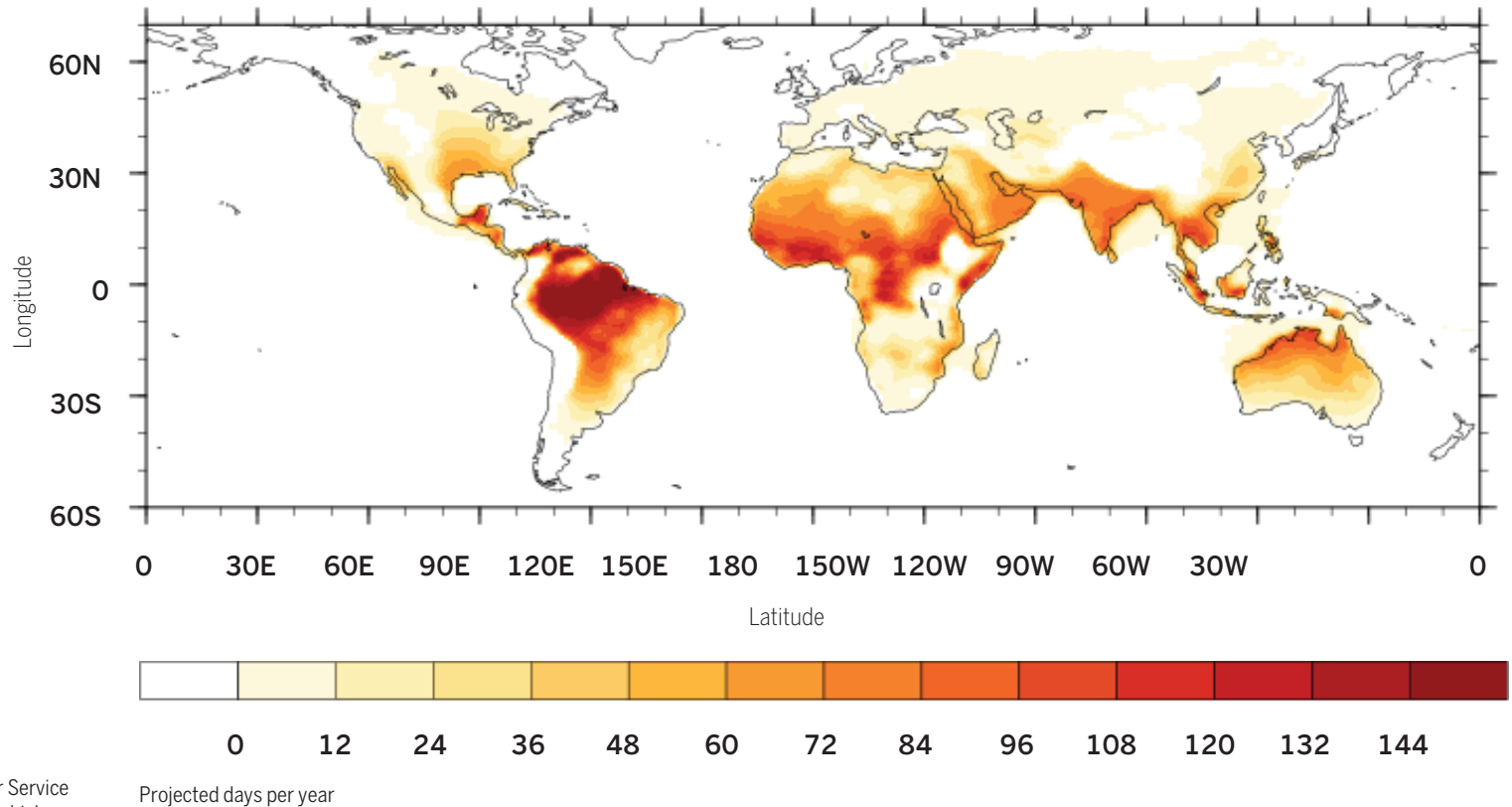
| Location 2      | Michigan   |
|-----------------|------------|
| S&P rating      | AA         |
| Yield           | 2.39       |
| Maturity date   | 1 May 2041 |
| Heat percentile | 29.6       |

For illustrative purposes only | Sources: Standard & Poor's, Investortools, Woods Hole Research Center | The projected data presented is hypothetical in nature. No assurance or guarantee is made that any projected data can or will be realized. Actual experience may be outside of stated ranges. All investments are subject to risk of loss.

# Understanding how climate change affect investments

## Integrated spatial finance example

Additional days per year in NWS danger zone throughout the 2020 – 2029 decade  
World based on 1951 – 1980 reference period



Danger zone is defined as the National Weather Service Heat Index danger and extreme danger zones, which include heat index values above 103°F. This is the source for heat advisories. Source: National Weather Service. | The target data presented is hypothetical in nature. No assurance or guarantee is made that any target data can or will be achieved. Actual experience may not reflect all of the data or may be outside of stated ranges. For illustrative purposes only.