Climate Science, Risk Quantification, & Building Resiliency

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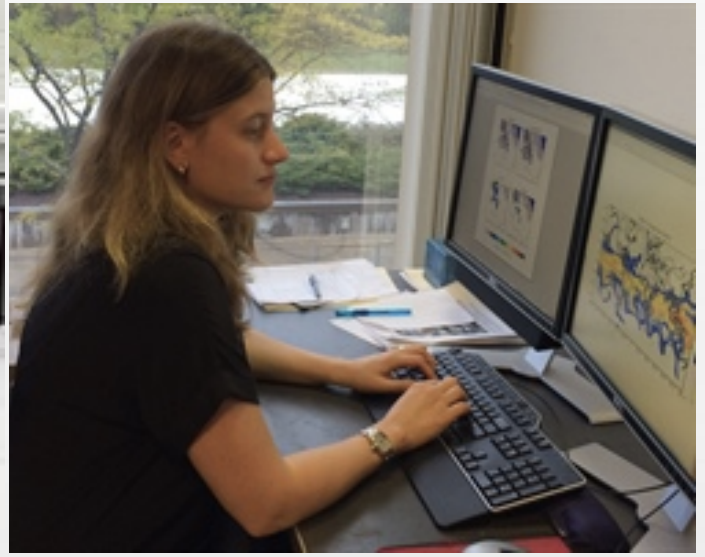
What work do I do?

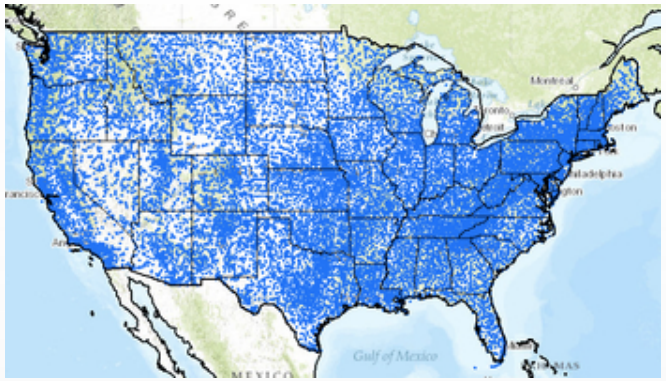
Geophysical Fluid Dynamics Laboratory (GFDL)

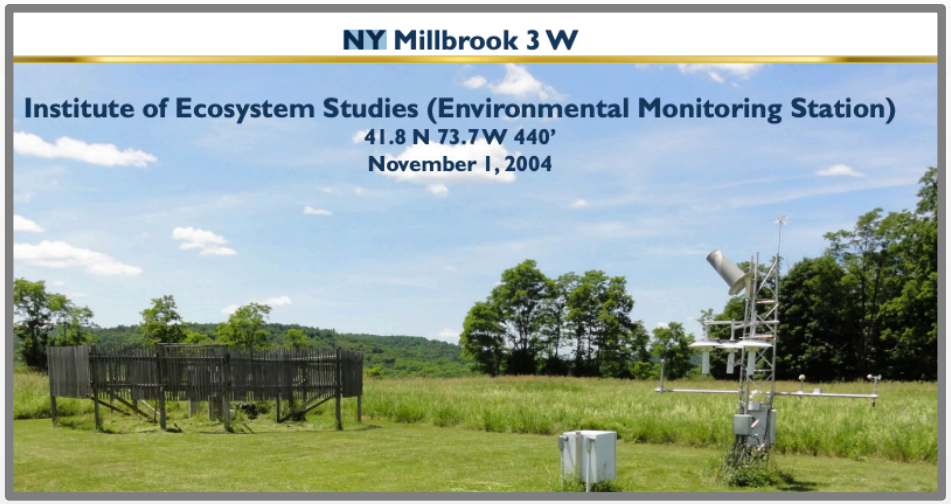
Princeton University Forrestal Campus

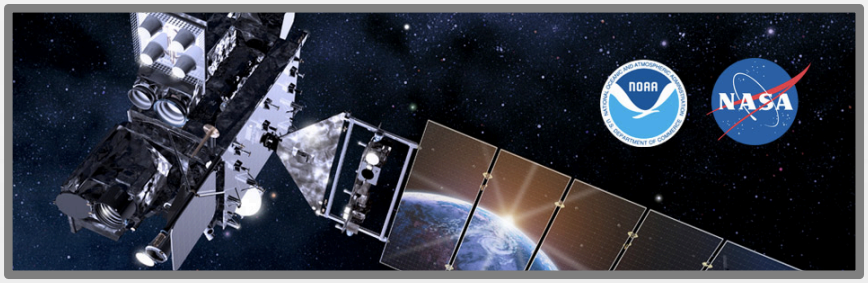


How do we monitor weather and climate?

Observed Climate







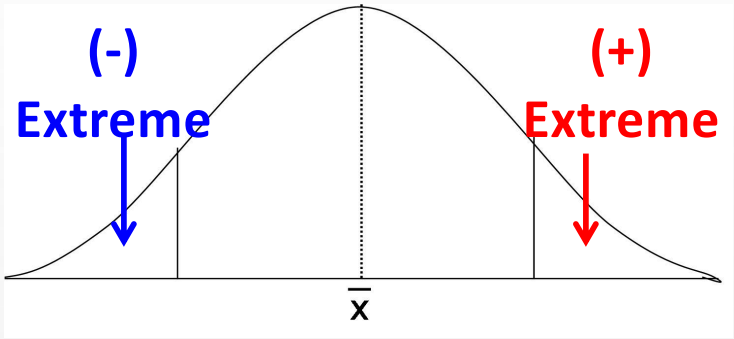
Modeled Changes

Can create model "experiments" with different worlds:

- What is the climate without changes to greenhouse gases? Aerosols? Solar cycles?
- What does it look like in the future given various pathways (e.g. farming, greenhouse gases, aerosols, wildfire)?

Defining Weather Extremes

- A weather event that causes harm to lives and property
- In statistics, an “extreme events” refers to low probability events in the “tail” of a distribution of events



- Difficulty of quantifying extreme risks: by definition, they do not happen often. We must rely on the limited historical observations and/or use models to generate large data sets to understand their probabilities & causes

We use climate data to answer:

- How has the climate been changing in the past?
- For a specific climate extreme "X":
  - What is the probability of the event?
  - Is the probability or type of event changing?
  - Why is it changing (or not)?
  - What is the probability going to be in the future?
- What causes uncertainty in our quantification of risk in the past, present, future?
- How might we be able to use this information to protect lives and property?

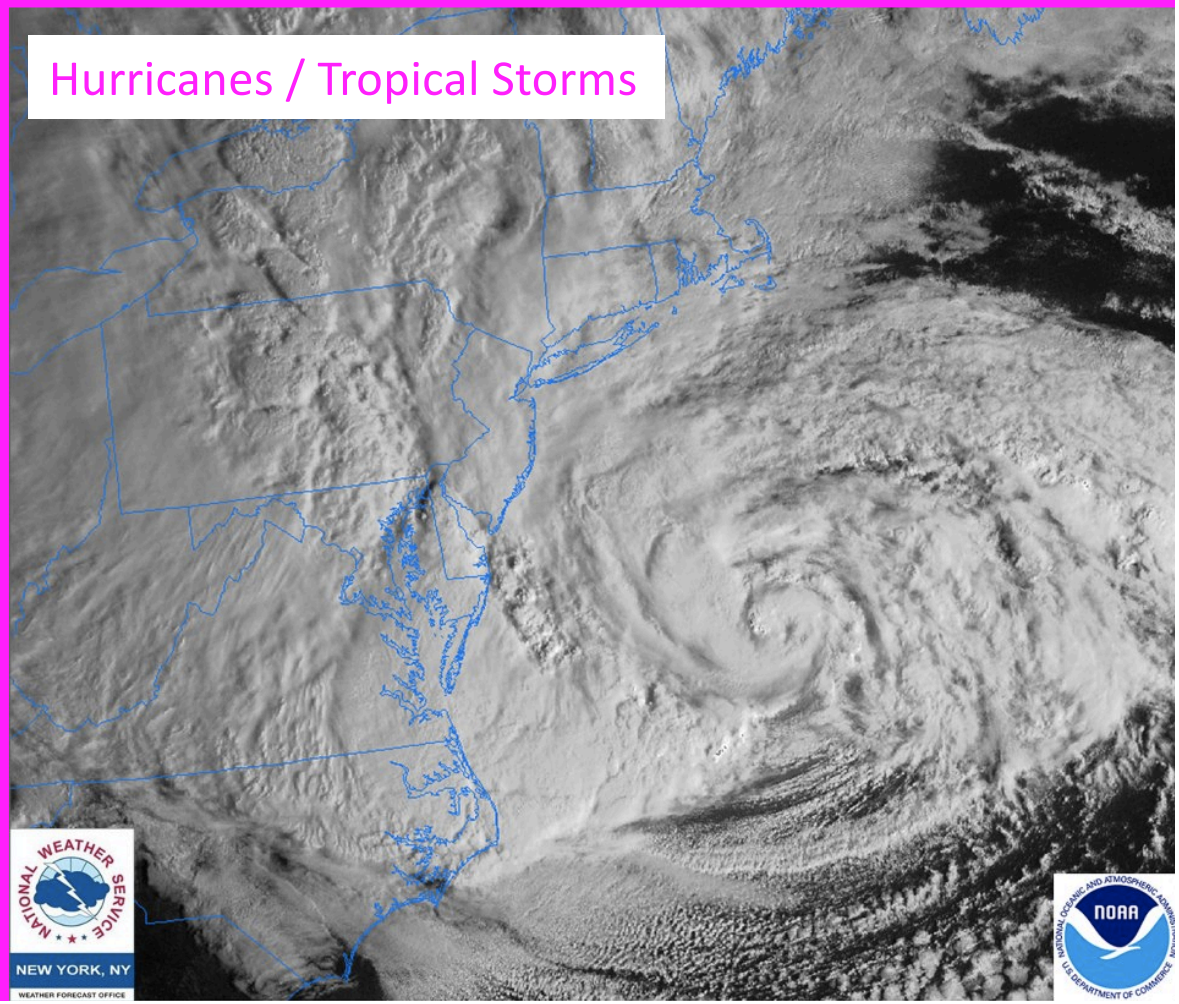
Extreme Event Risks in NY & Northeast Region

Winter Storms

Heat Waves

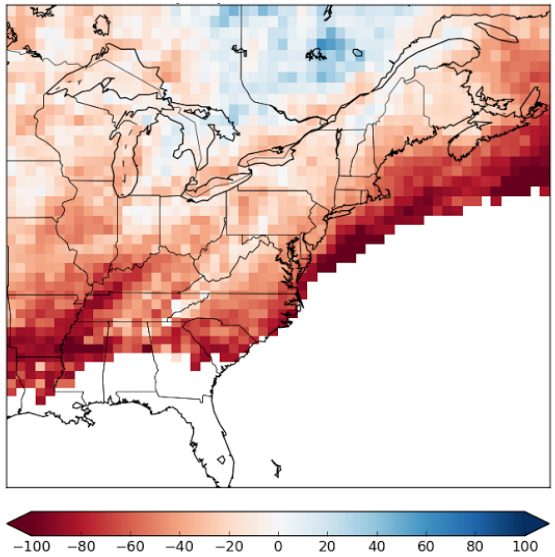
Coastal & River Flooding

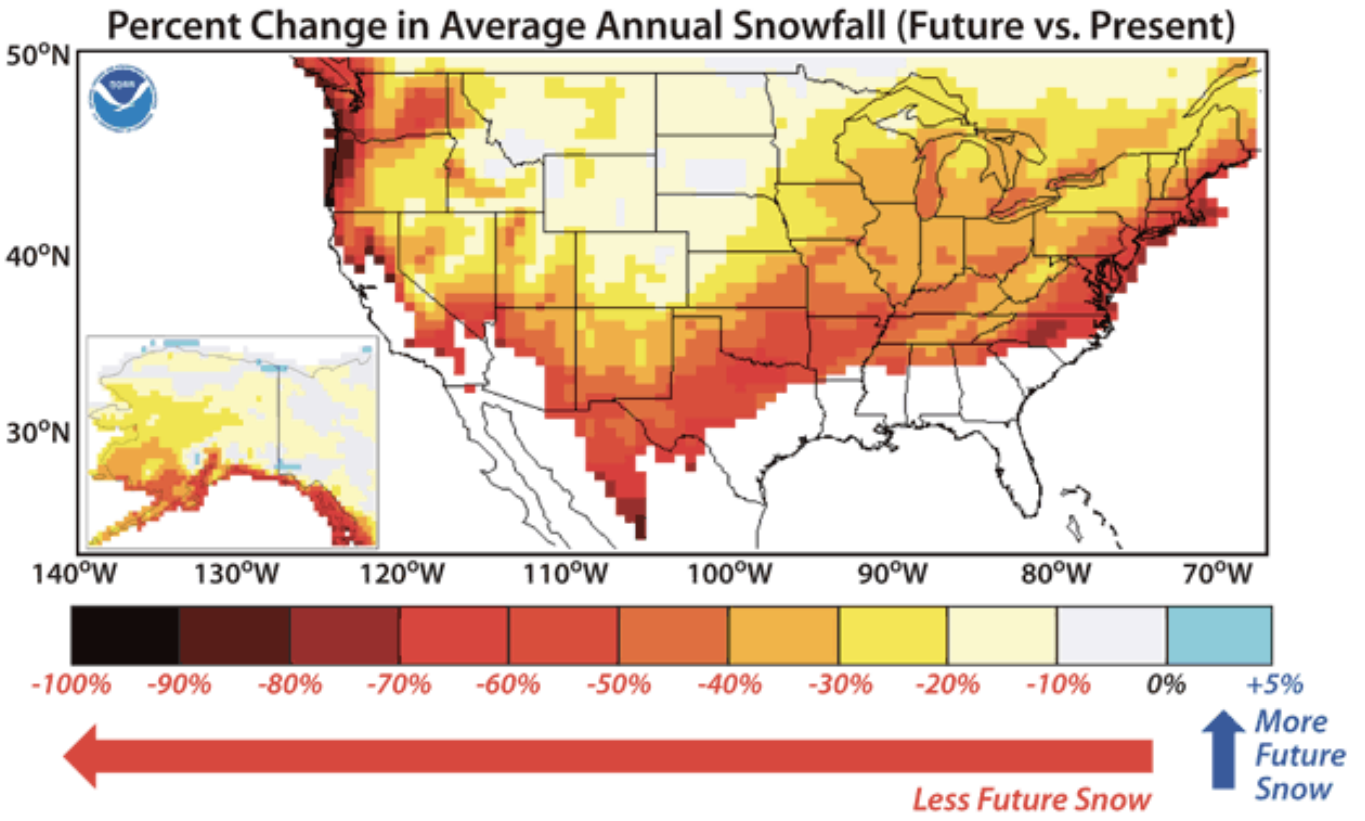
Hurricanes / Tropical Storms



Changes in winter storms & snowfall

East Coast High Wind/Snow Events

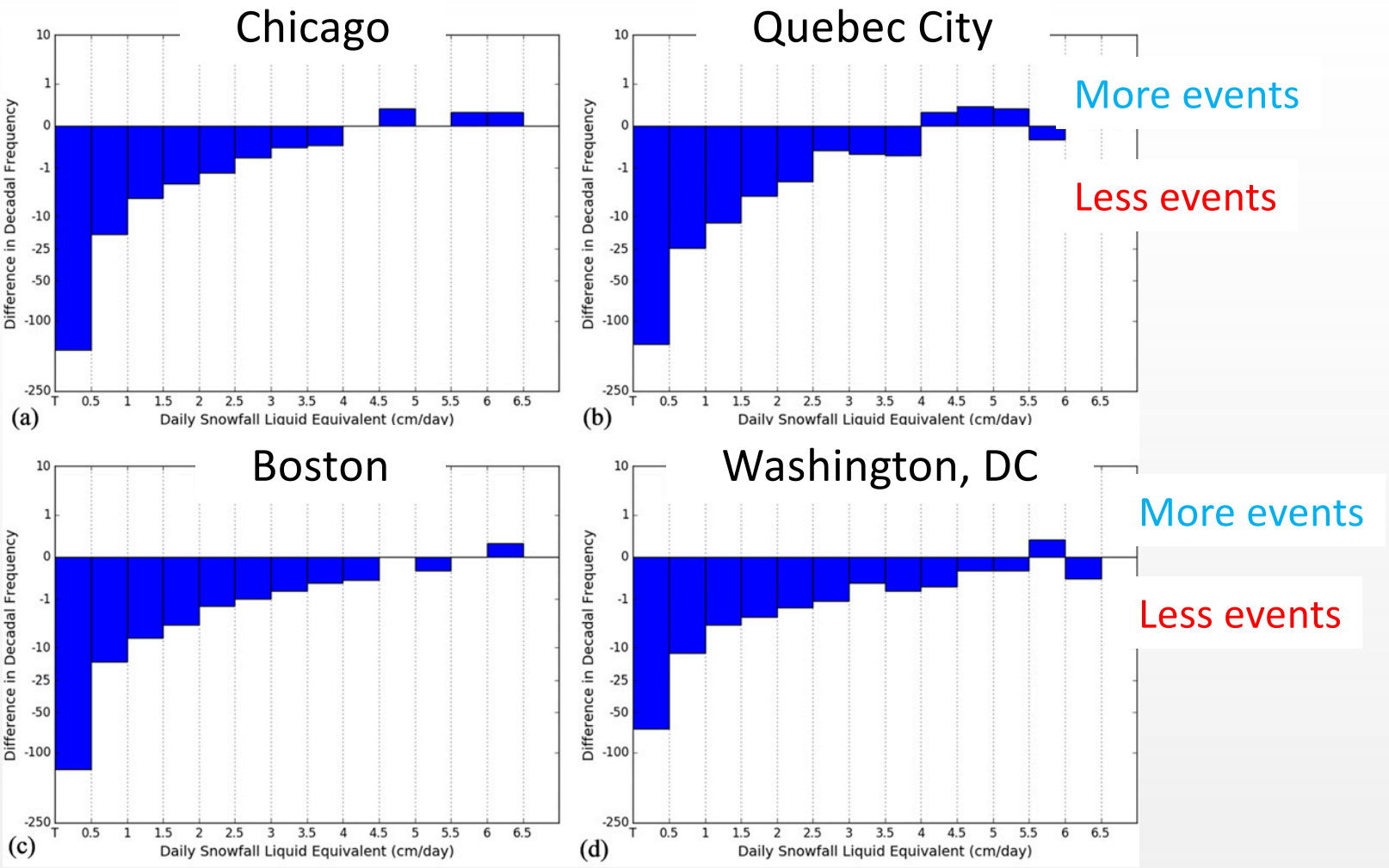




Summary: fewer storms in NY, less snow on average

Source: Kapnick and Delworth, J Climate, 2013.doi:10.1175/JCLI-D-12-00528.1
Janoski et al, J Climate, 2018. doi:10.1175/JCLI-D-17-0756.1

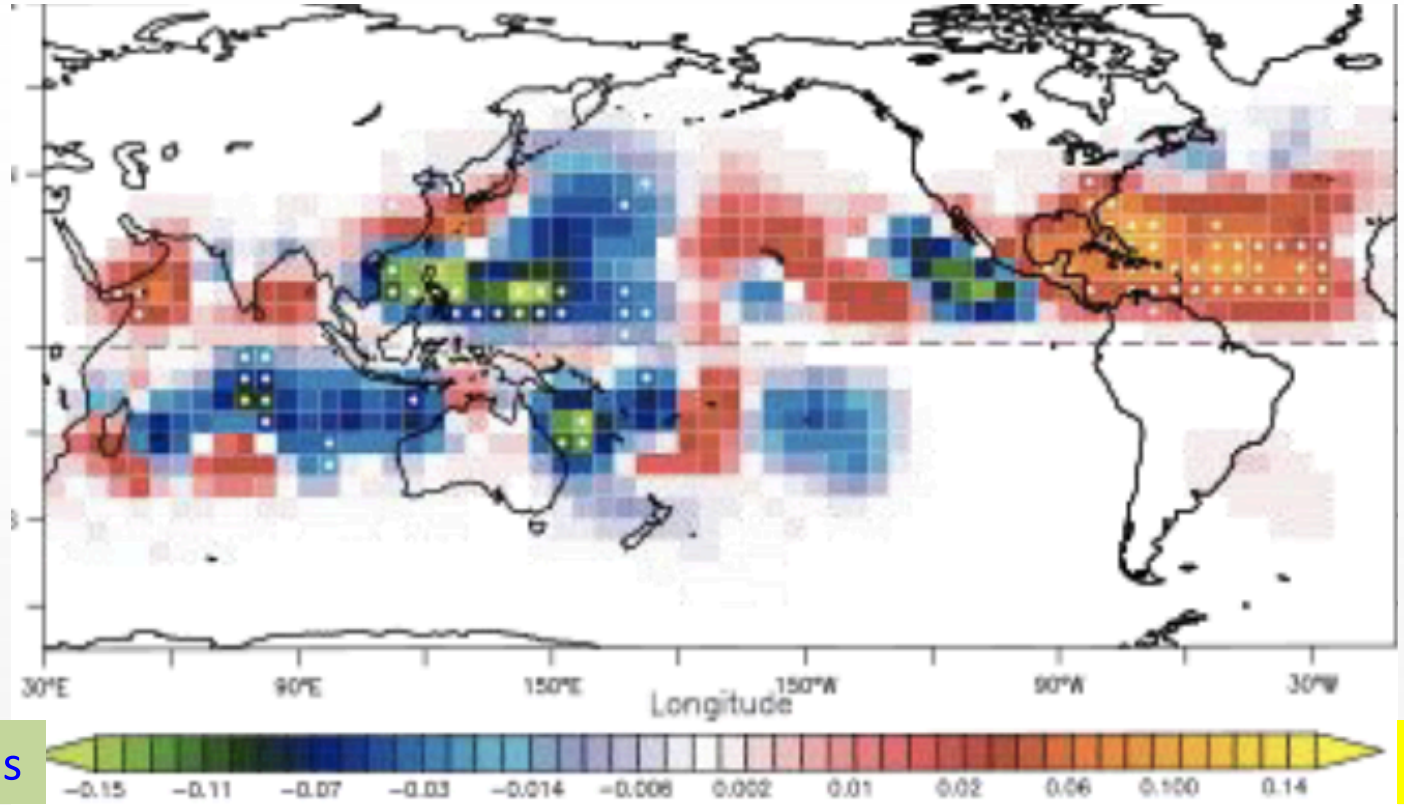
Uncertainty: Potential simultaneous increase in the most extreme snowfall & decline in lower values



Source: Janoski et al, J Climate, 2018. doi:10.1175/JCLI-D-17-0756.1

Tropical Cyclones

**Hurricanes are tropical cyclones with winds >74 mph



Fewer storms

More storms

- More tropical cyclones observed over 1980-2018 in the Atlantic (map above), but model simulations suggest less hurricanes by the end of the century
- Uncertainty: aerosols may have a countering effect to greenhouse gases (reducing aerosols—air pollution—may increase storm activity in the Atlantic). The frequency and strength of future tropical cyclones in the Atlantic requires further research

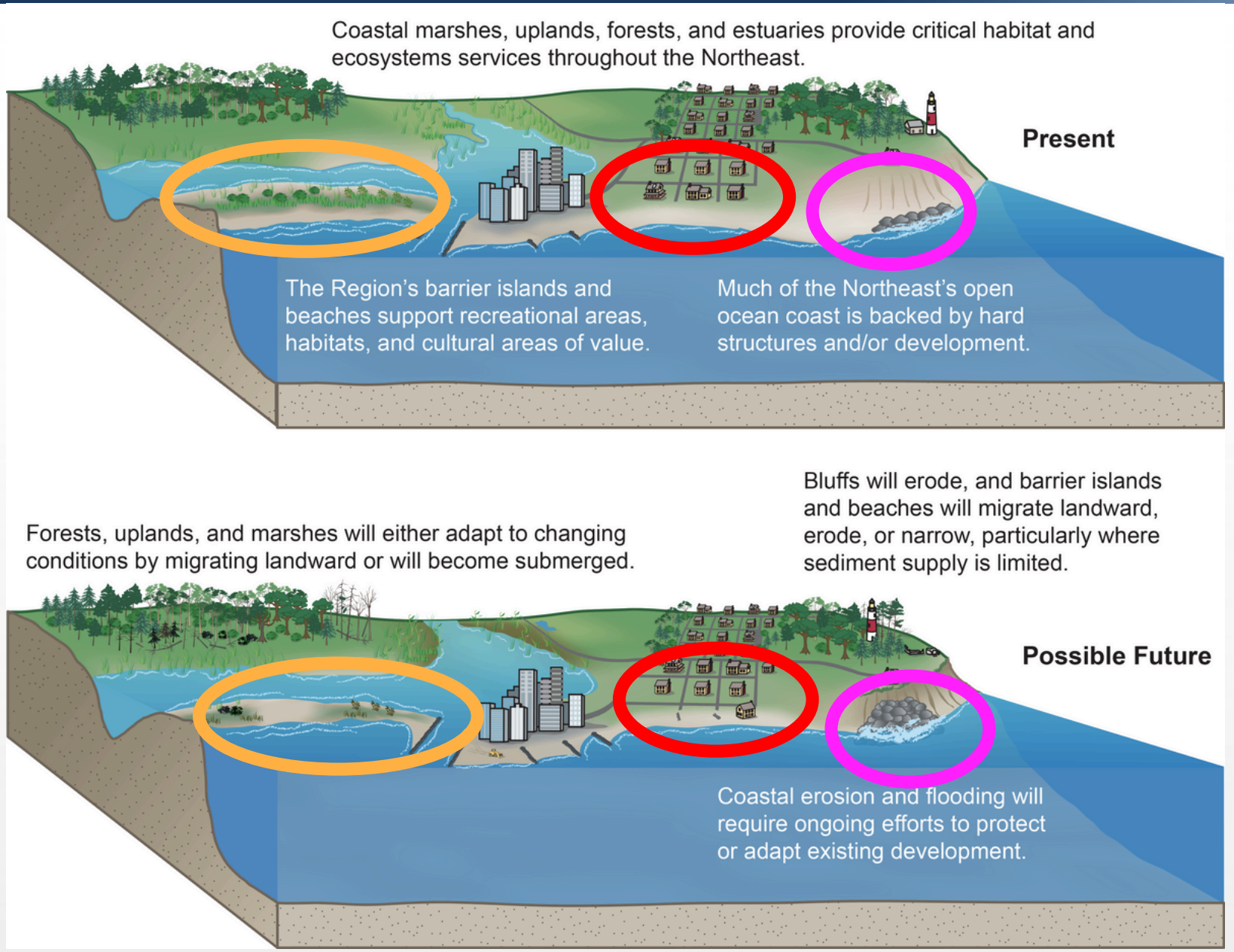
Source: Murakami et al., Proc. Natl. Acad. Sci., In Press

Sea level rise

- Sea level in the region has increased by ~1’ since 1900
- Global sea level increases due to two factors:
  - Thermal expansion of water
  - Melting of glaciers and ice sheets
- Even if storms stay the same, storm surge risk increases without changes to coastal communities due to rising sea level
- By 2060, scenarios suggest for NYC:
  - ~1’ rise (intermediate low) to ~3-5’ (extreme)
  - That is the difference between a dry & underwater lower Manhattan, Coney Island

Source: https://coast.noaa.gov/slr/#

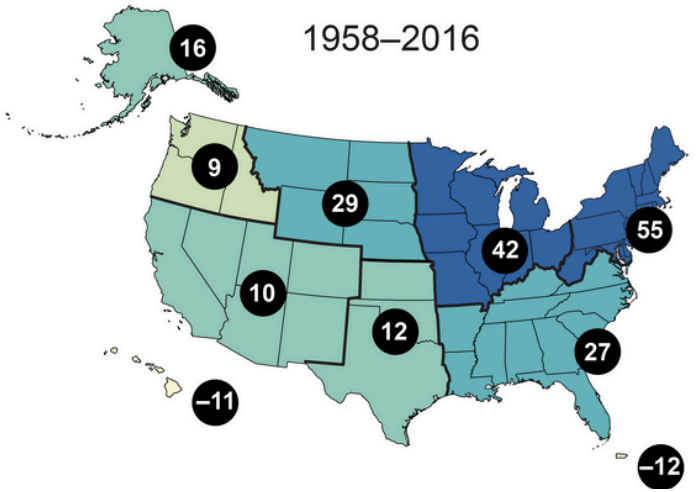
Coastal Adaptations / Changes

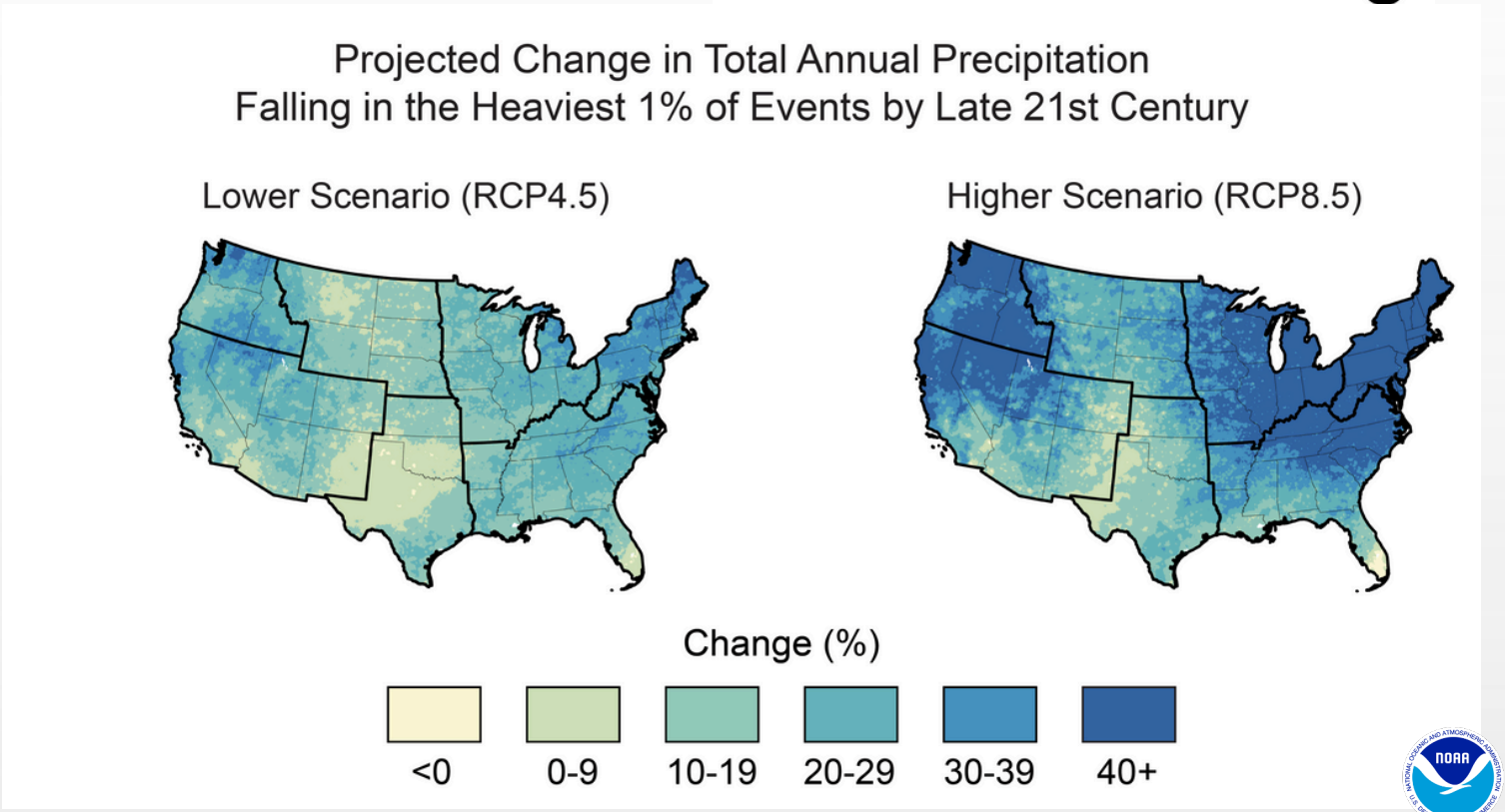


Source: National Climate Assessment, From Figure 18.7 (Source: U.S. Geological Survey)

Extreme precipitation

- Historically, the NE has seen the greatest rise in extreme precipitation in the U.S.
- This trend is expected to continue
- Extreme precipitation can:
  - Cause flooding
  - Damage crops
  - Lead to water quality issues





Source: 4th National Climate Assessment, Chapter 2

Heat Waves

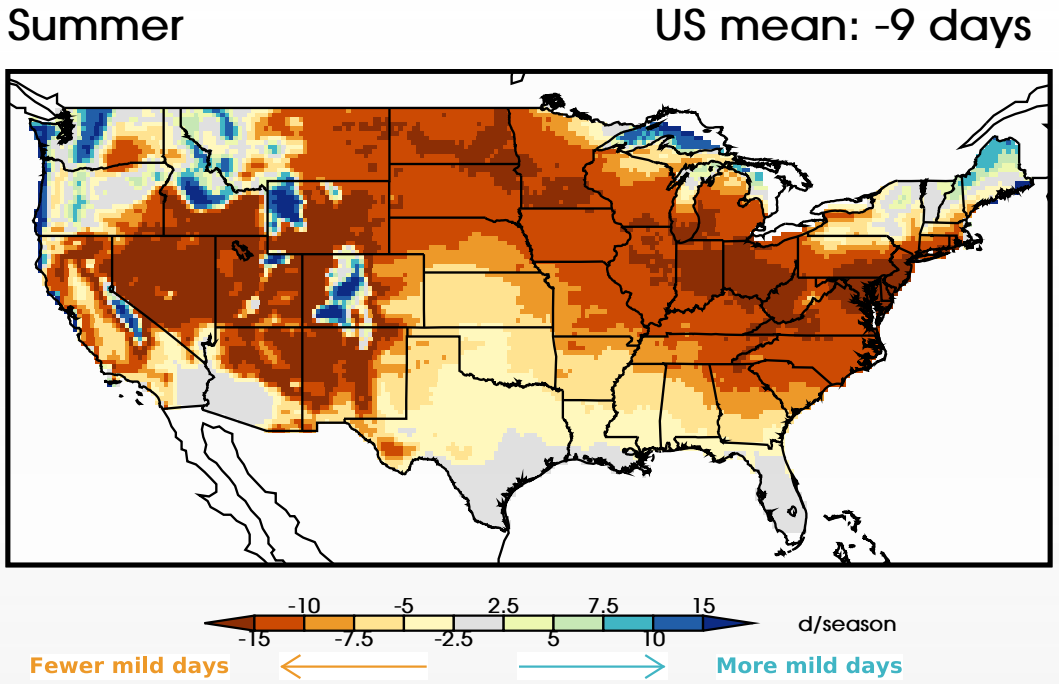
- By 2050, average annual temperatures in the Northeast are expected to increase by 4.0°F (2.2°C) under the lower scenario (RCP4.5) and 5.1°F (2.8°C) under the higher scenario (RCP8.5) relative to the near present (1975–2005)
- In the Northeast we can expect approximately 650 more excess deaths per year caused by extreme heat by 2050 under either a lower or higher scenario (RCP4.5 or RCP8.5) and 960 (under RCP4.5) to 2,300 (under RCP8.5) more excess deaths per year by 2090

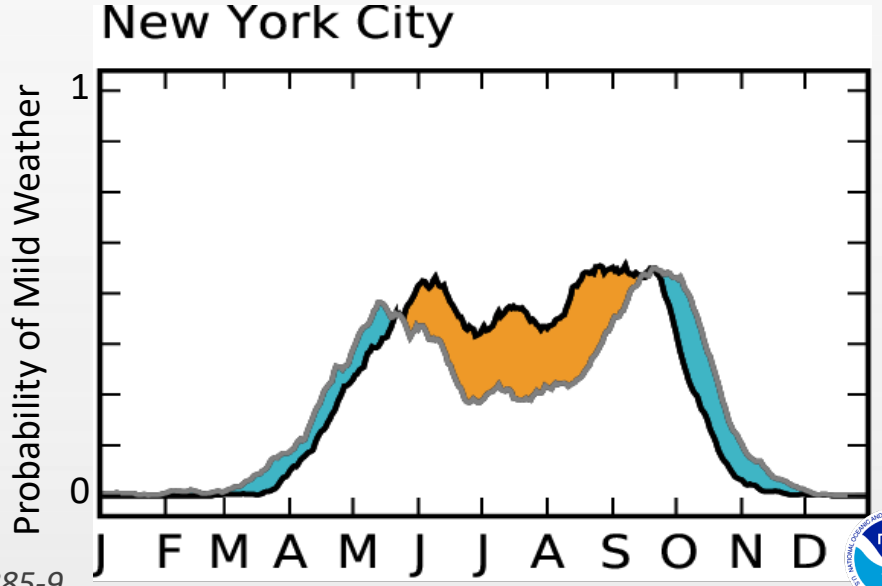
Source: 4th National Climate Assessment, Chapter 18

Change in "Mild Weather" Days

2081-2100 vs. 1986-2005, middle of the road scenario

- Definition of a Mild Weather Day:
  - Daily maximum temperature between 64-86°F
  - Virtually no precipitation
  - Daily average dewpoint less than 68°F
- New York historically had **44** mild weather days during the summer, by the end of the century, we lose **17** (lost probability highlighted in orange to the right)





Source: Van der Wiel et al, Climatic Change, 2017. doi:10.1007/s10584-016-1885-9

Understanding Risk to Reduce Impacts

- **Risk Assessment** (before or after an event happens):
  - What is the likelihood of an event today?
  - What causes an event?
  - How are risks changing? Is the risk today different than the past? What do we expect in the future?

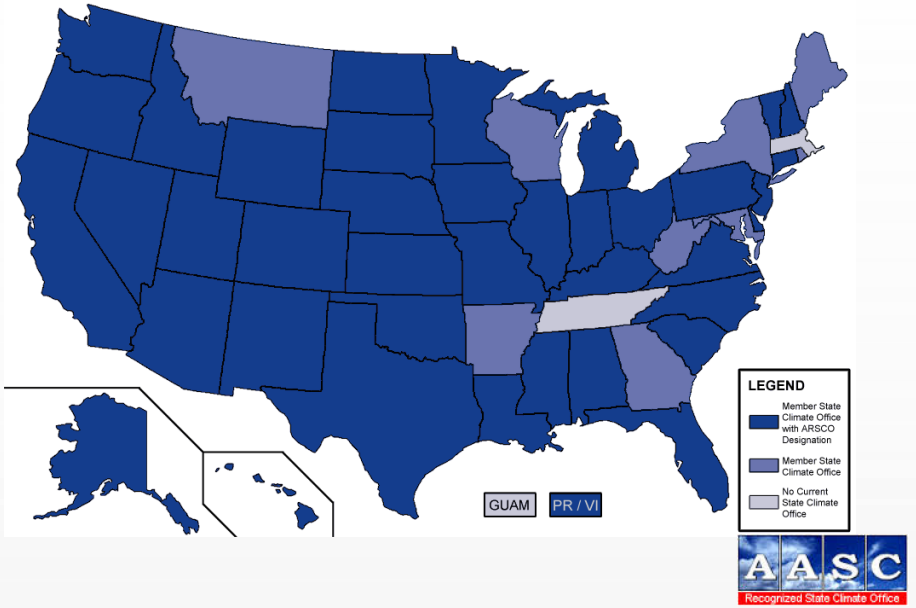
- **Risk Management** (reducing negative impacts):
  - Is an event predictable? How far in advance (weeks, months, seasons)?
  - How can we apply our knowledge of changing risks and prediction skill to inform risk management solutions via operations or data?
  - Can we provide better data for decision makers?

WHERE TO GO FOR FURTHER MATERIALS

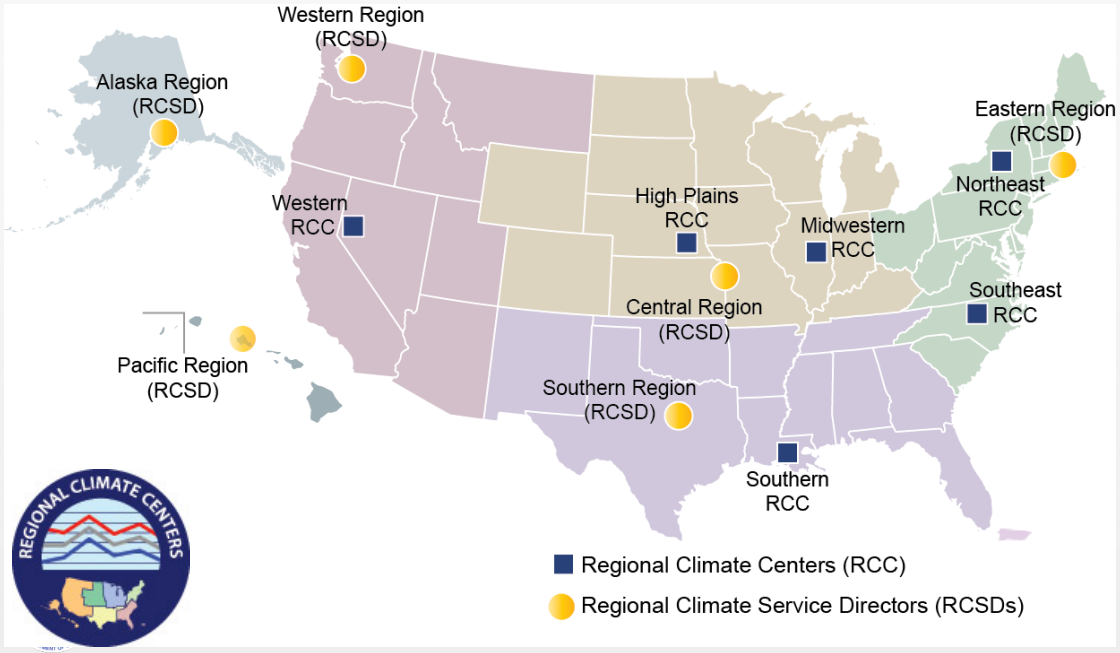
Local Climate Knowledge & Services

NOAA's Regional Climate Services & State Climatologists

- State Climatologists: http://stateclimate.org/

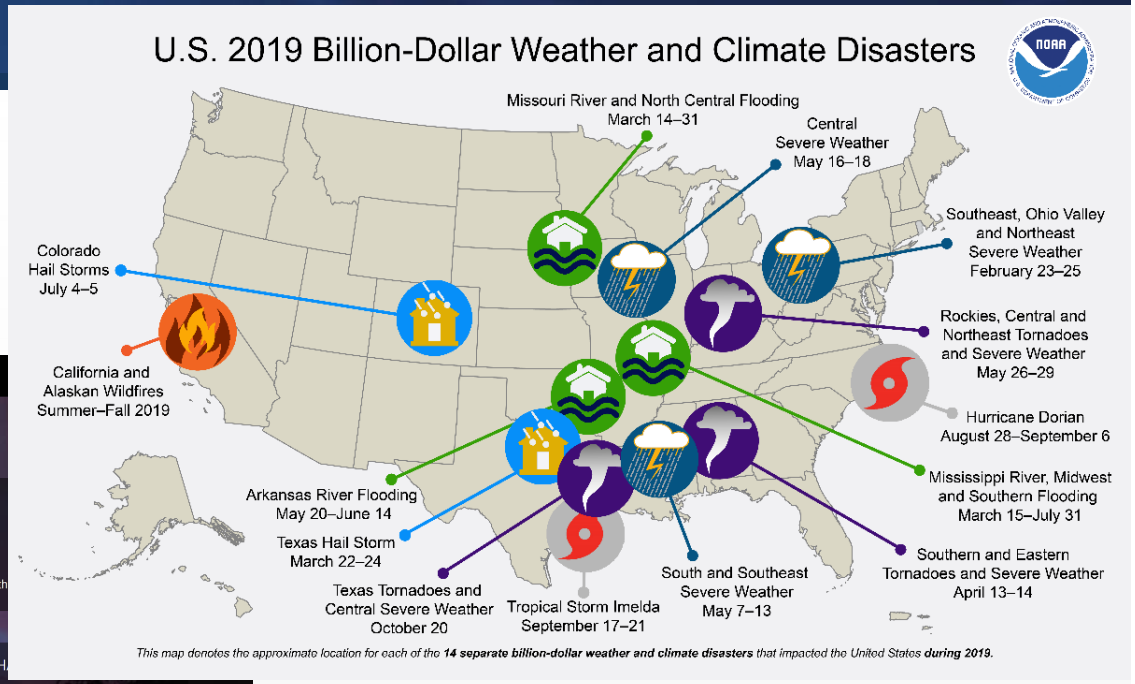


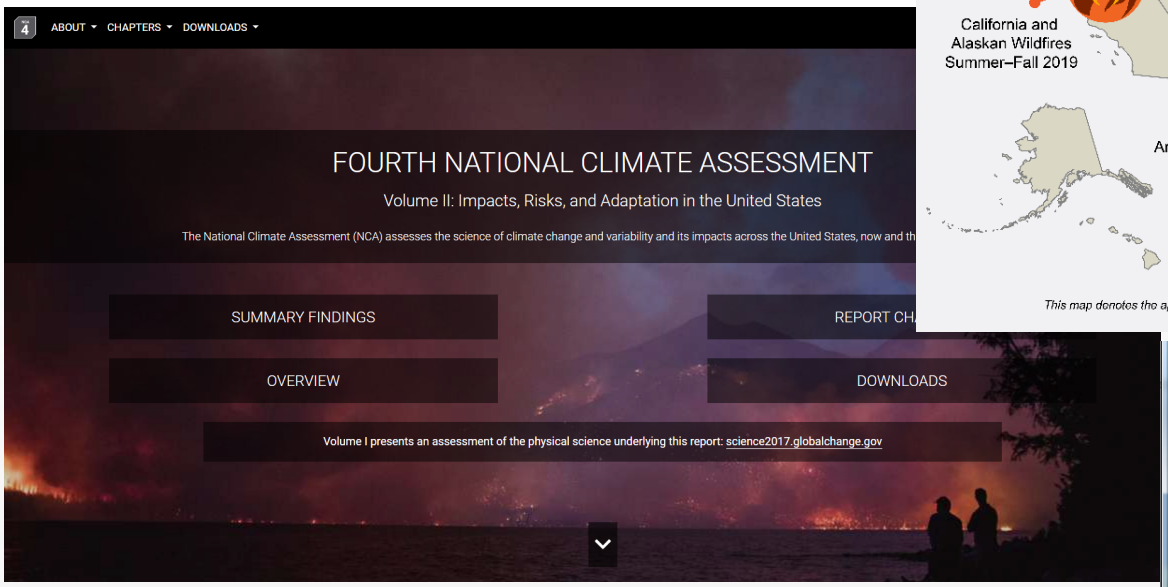
- Regional Climate Centers: https://www.ncdc.noaa.gov/customer-support/partnerships/regional-climate-centers
- Regional Climate Services Directors: https://www.ncdc.noaa.gov/rcsd



National Resources

https://www.ncdc.noaa.gov/billions/





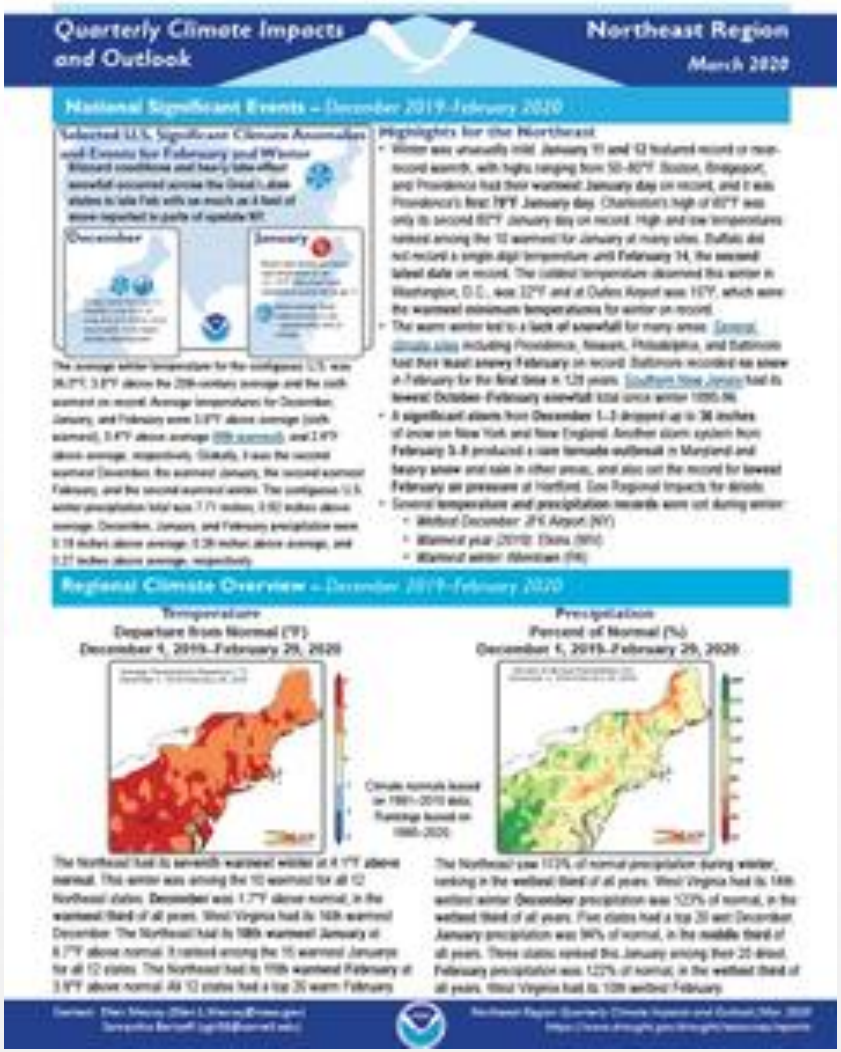
The US National Climate Assessment

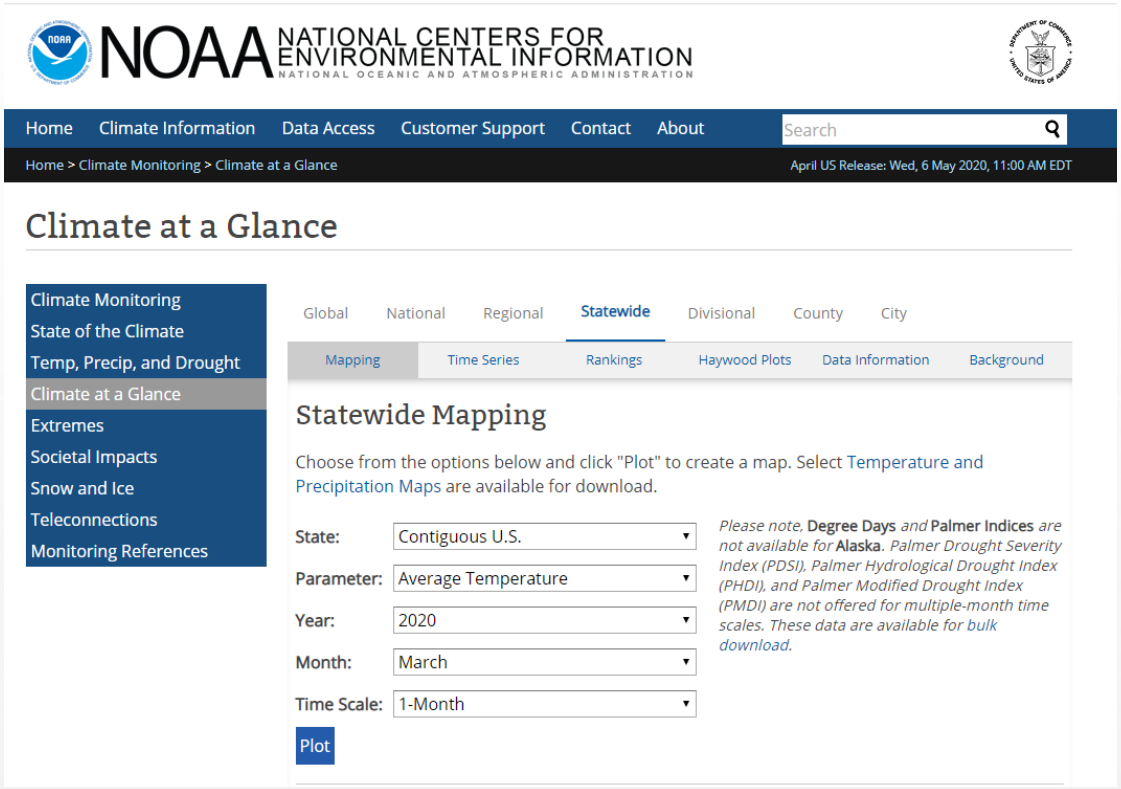
https://nca2018.globalchange.gov/

US Climate Resilience Toolkit:

http://toolkit.climate.gov/

Drought & User Friendly Maps





https://www.ncdc.noaa.gov/cag/statewide/mapping

https://www.drought.gov/drought/resources/reports

THANK YOU

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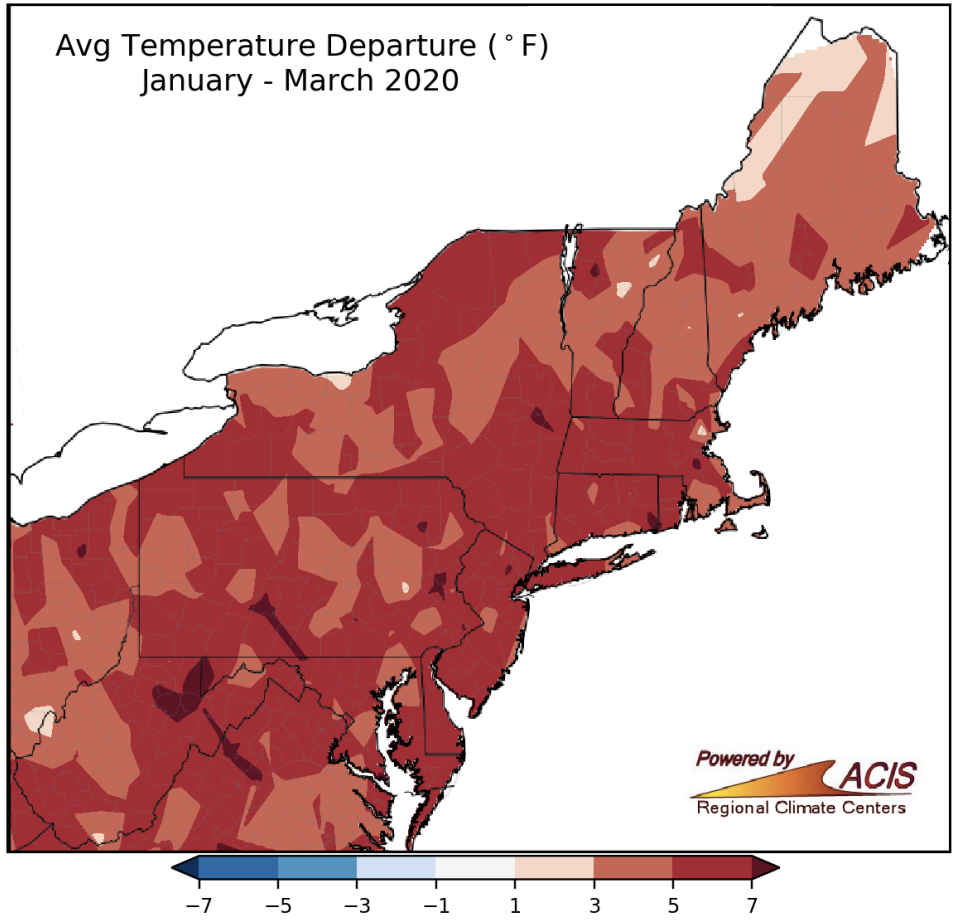
Recently experienced climate

- 7th warmest winter (Dec-Feb) in NE region (+4.1°F) since 1895
- January 11th & 12th had a few days with record highs across the region, reaching 50-80°F



Map generated at: www.nrcc.cornell.edu/regional/monthly/monthly.html
Departure from 1981-2010 average