Extreme Weather and Climate

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Heat
Heat Waves

Temperature anomaly (wrt 1961-90) °C

- Observations
- HadCM3 Medium-High (SRES A2)

- 2003
- 2040s
- 2060s
Sherwood and Huber, PNAS, 2010

Adaptation Limit: Maximum Tolerable Wet Bulb Temperature

12° increase in mean global T
Figure 1 | Spatial distributions of extreme wet bulb temperature and extreme temperature. 

\( TW_{\text{max}} \) and \( T_{\text{max}} \), Ensemble average of the 30-year maximum \( TW_{\text{max}} \) (a–c) and \( T_{\text{max}} \) (d–f) temperatures for each GHG scenario: historical (a,d), RCP4.5 (b,e) and RCP8.5 (c,f). Averages for the domain excluding the buer zone (DOM), land excluding the buer zone (LND) and the Arabian Peninsula (AP) are indicated in each plot. \( TW_{\text{max}} \) and \( T_{\text{max}} \) are the maximum daily values averaged over a 6-h window.
Hydrological Extremes Increase with Temperature

Floods
Blizzards
Drought
Hydrological Extremes

- Rainfall intensity (how hard it rains when/where it is raining) scales with the Clausius-Clapeyron equation, doubling for every 10° C temperature increase

- Wet places get wetter, dry places get drier; incidence of both floods and droughts increases

- Large potential effects on food and water supplies; major national security issue
Severe Thunderstorms
Hail Storms
Severe Convective Events

- Strong increase in rainfall intensity
- Little is known about how climate change affects the incidence of lightning, hail, severe thunderstorm straight-line winds, or tornadoes.
- We’re working on it!
Hurricanes
Annual Maximum Potential Intensity (m/s)
Trends in Thermodynamic Potential for Hurricanes, 1980-2010
(NCAR/NCEP Reanalysis)
Time series of the latitudes at which tropical cyclones reach maximum intensity.

From Kossin et al. (2014)
Global Hurricane Power under RCP 8.5

Power dissipation index

Year

1980 2000 2020 2040 2060 2080 2100

Power dissipation index

1.5 2.0 2.5 3.0 3.5 4.0 4.5 5.0 5.5

Graph showing the trend of global hurricane power under RCP 8.5 from 1980 to 2100.
Hurricanes Passing within 150 km of Boston
Downscaled from 5 climate models

Return Periods of Storms within 150 km of Boston

10,000,000

1,000,000

100,000

10,000

1,000

100

10

1

Return Period (years)

TCs  Hurs  Cat1  Cat2  Cat3  Cat4  Cat5

1981-2000  2081-2100
Rain Risk

Boston Hurricane Rainfall

Return Period (years) vs. Storm Total Rainfall (mm)

- 1981-2000
- 2081-2100
The climate is generally warming, owing to an increase in greenhouse gas concentrations.

Much of the tangible risk of climate change is in changing occurrence of extreme weather events.
Projections of climate change effects on weather extremes vary a great deal depending on type of event and model projections.

- Heat waves become more frequent, and cold waves less so.
- Incidence of floods increases fairly rapidly.
- Incidence of drought also increases rapidly.
Very little currently known about response of severe thunderstorms to climate change

Frequency of intense (destructive) hurricanes projected to increase

Hurricane-related flooding exacerbated by rising sea level, increased incidence of very strong storms, and enhanced rainfall