# COASTAL CITIES AND CLIMATE CHANGE

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Princeton University
at
Federal Reserve Bank of NY
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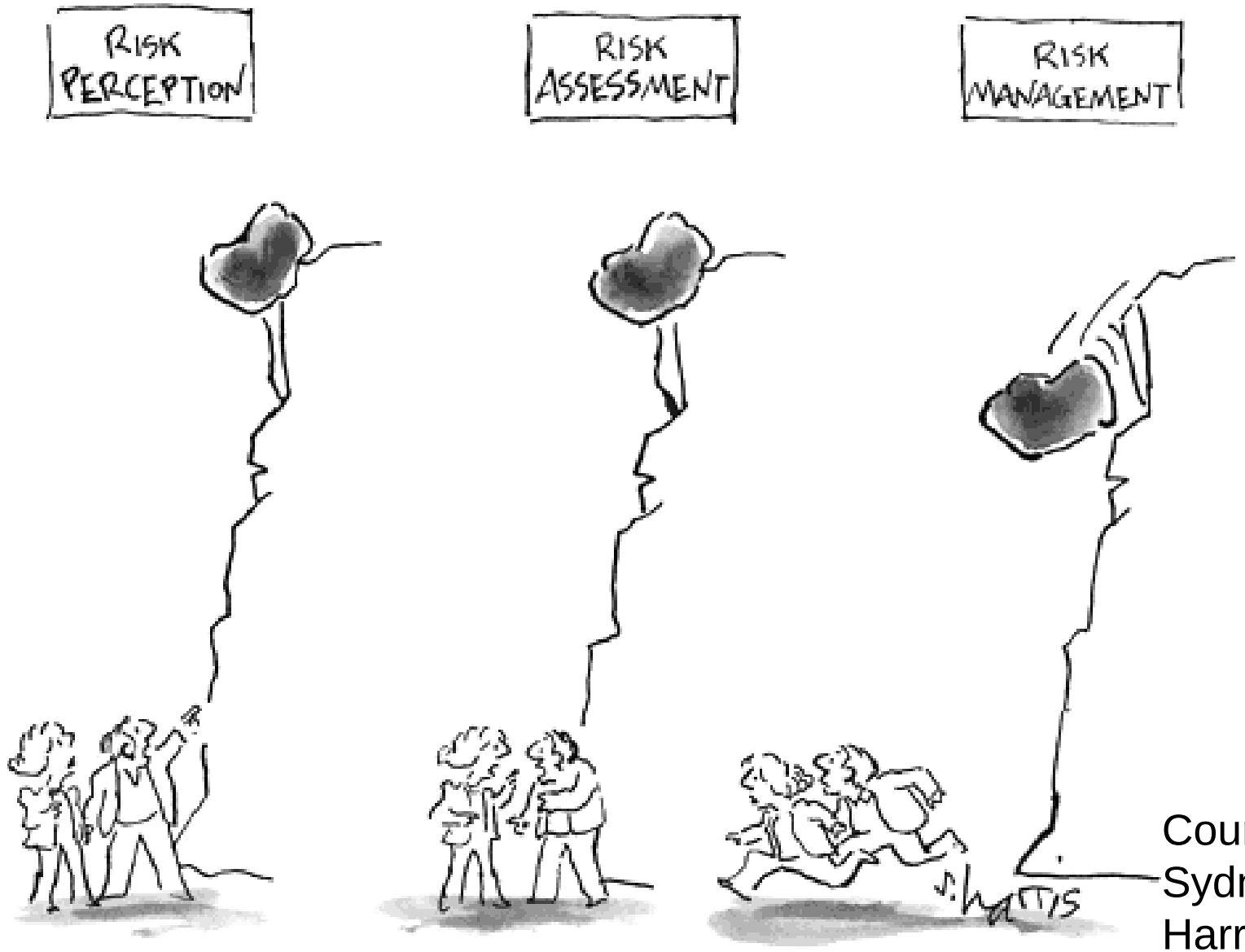
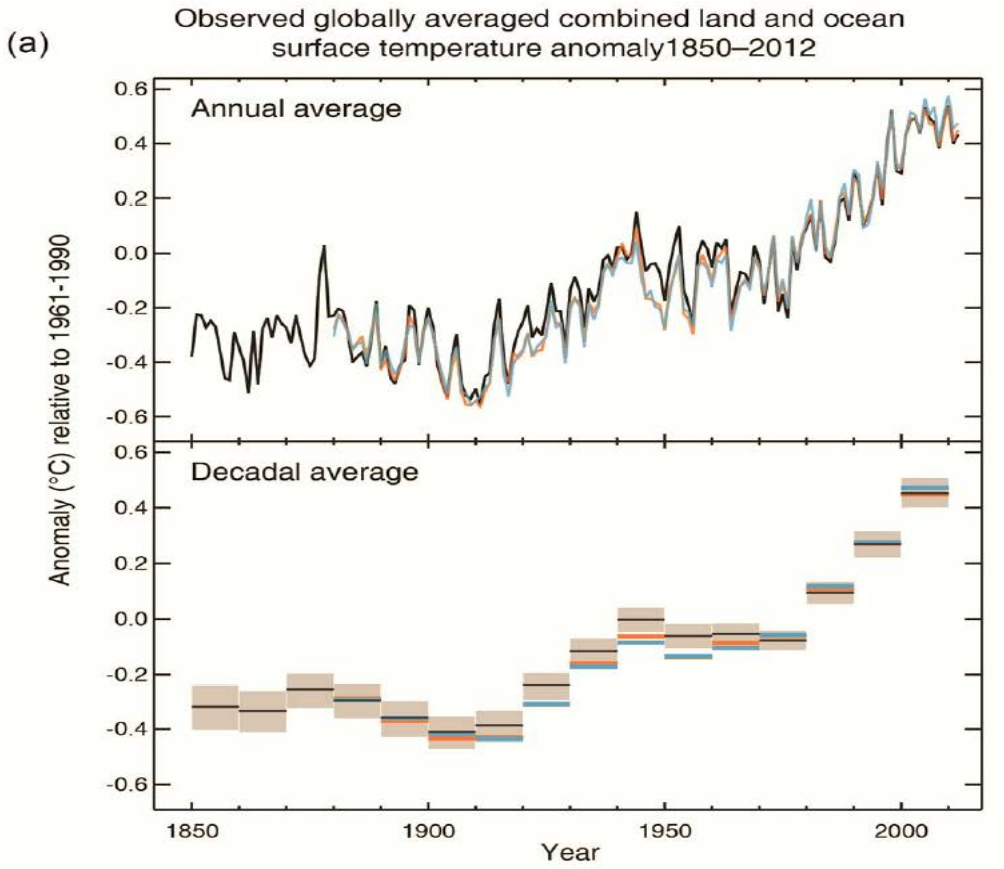
# Roadmap to this talk

- How global climate will change in ***this*** century
- Emphasis on risks from ***extremes*** of weather, climate, sea level rise, mainly eastern US, NYC
- Risk Management: Need to focus on emissions reduction ***and*** adaptation

# Can policy makers think ahead?




Courtesy Sydney Harris

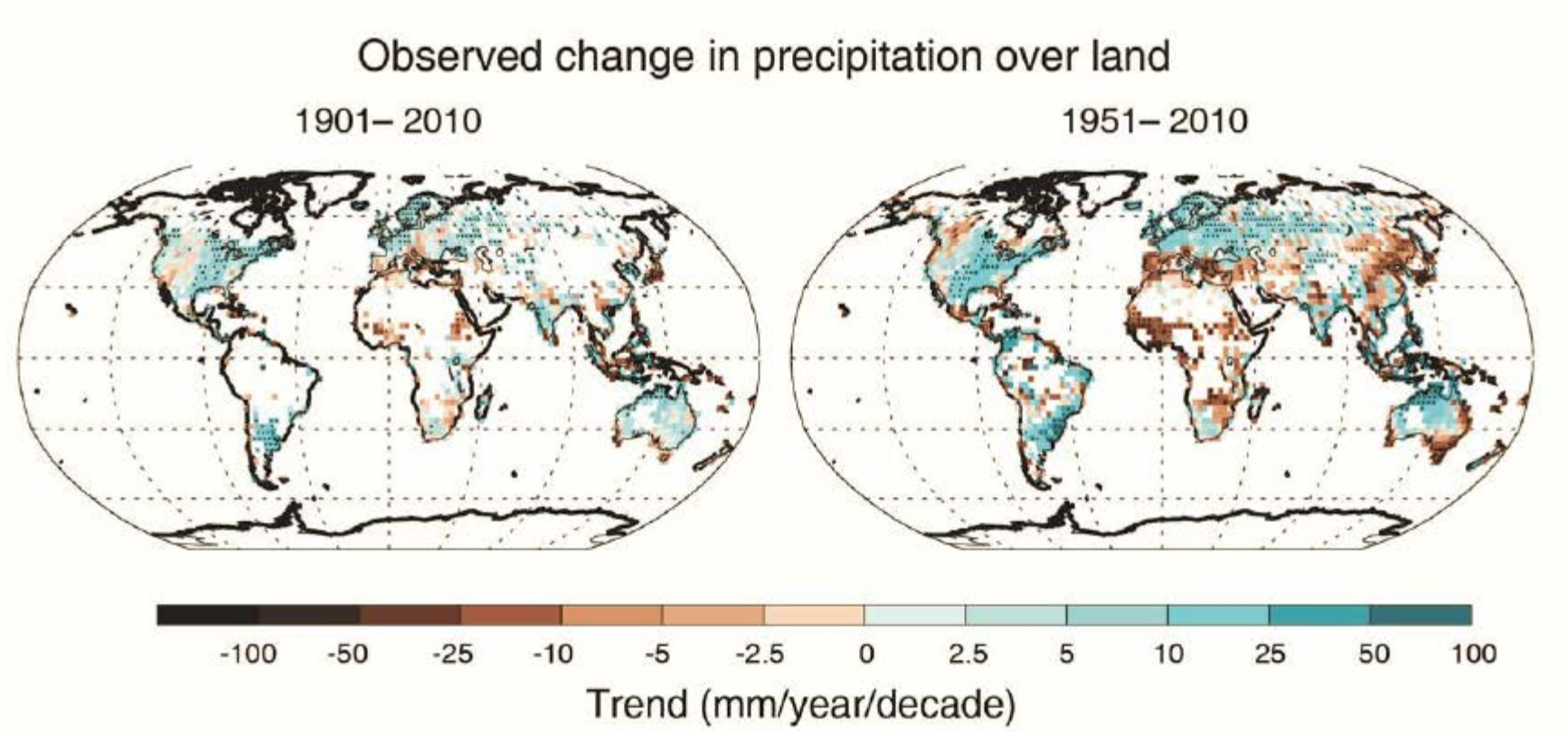


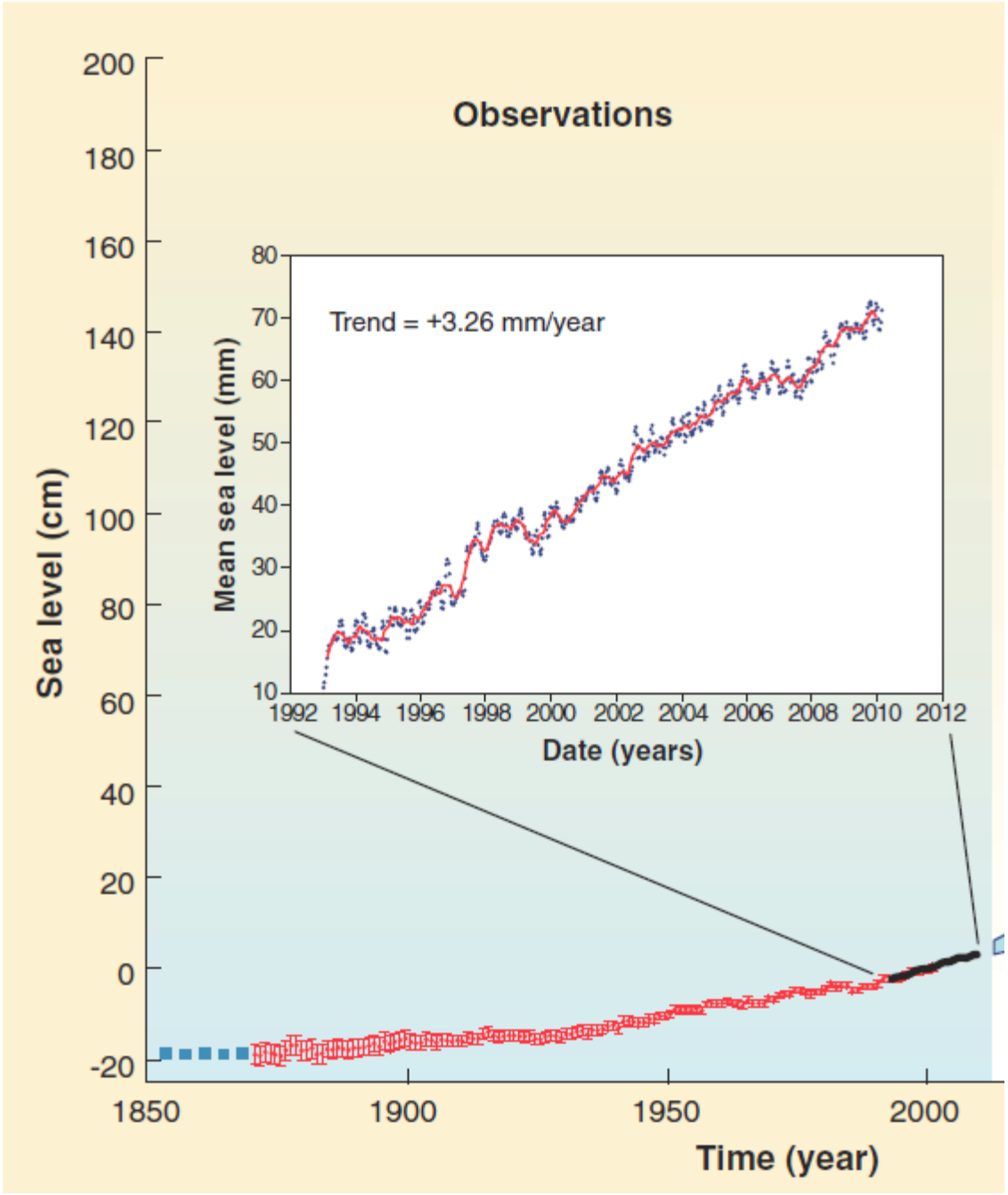

# Recent Warming

(IPCC 2013)

# Recent Drying

(IPCC 2013)



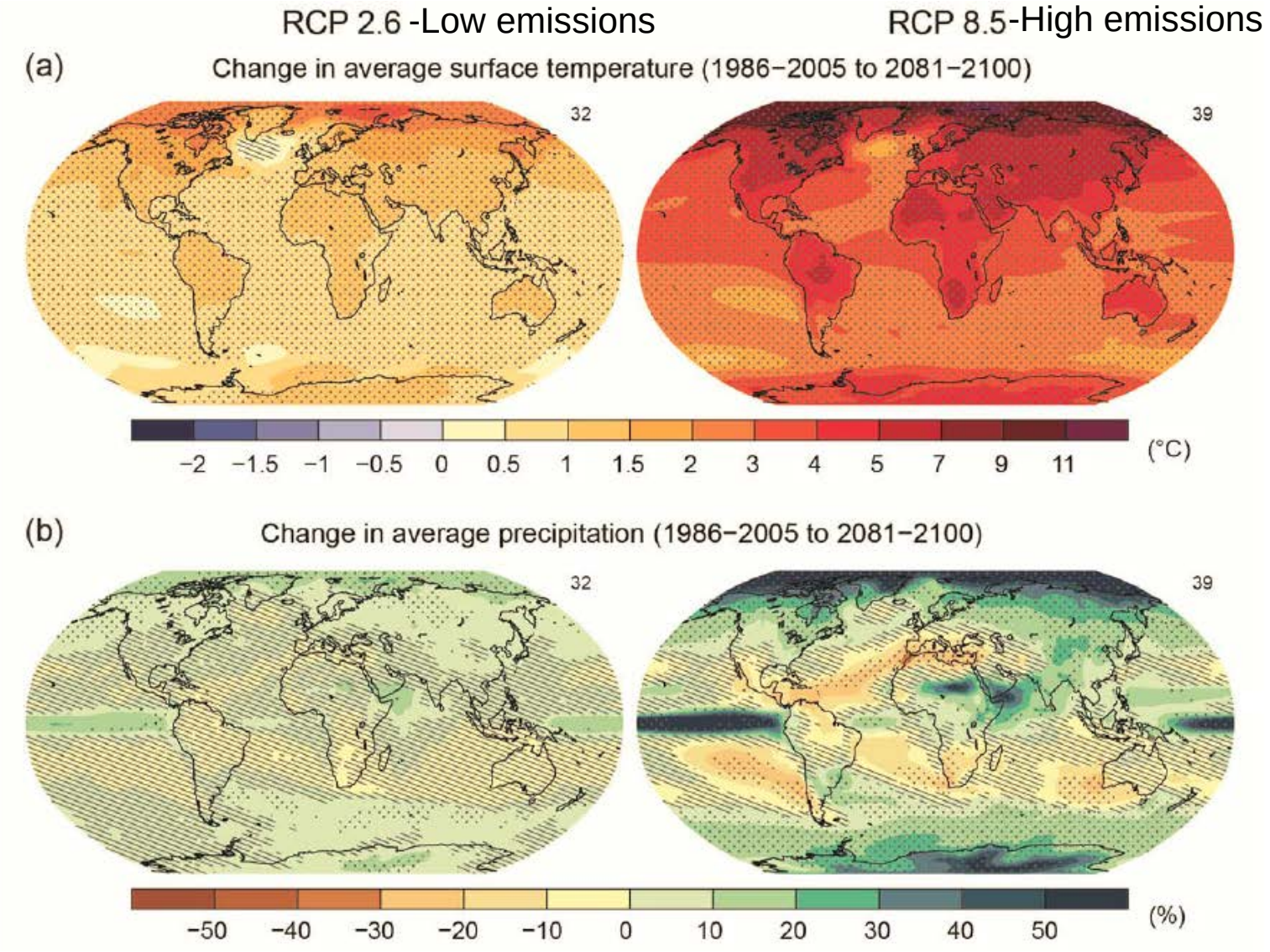


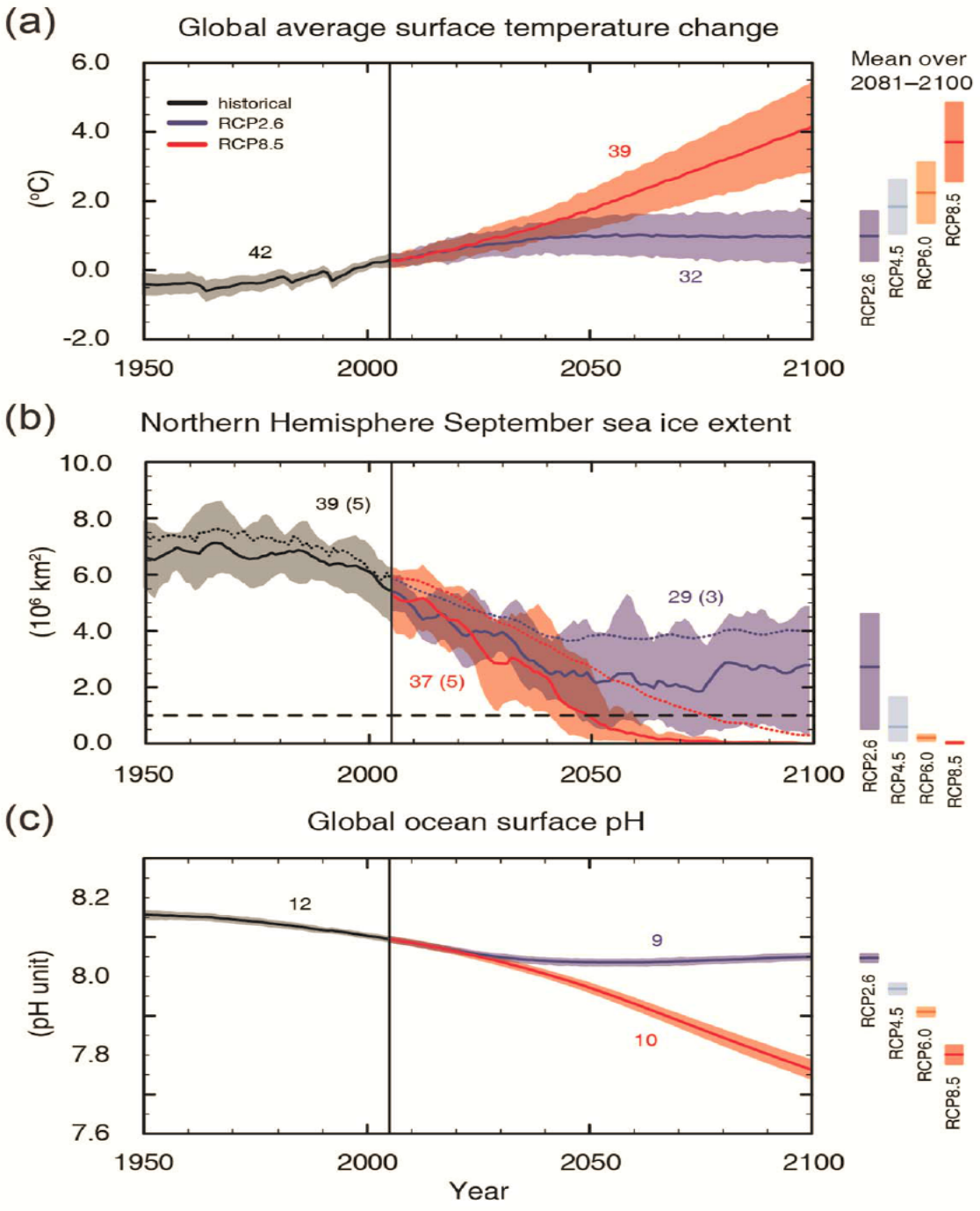

# Global mean sea level – observed trend

(Casanave and Nicholls, *Science* 2012)

# Projected warming, low-latitude drying

(IPCC 2013)






# Projected warming, Arctic sea ice loss, ocean acidification

(IPCC 2013)

# Extremes of Climate

(Based on IPCC 2013, courtesy M. Prather)

| Phenomenon | Trend | Observed to 2010 | Attributed (GHG) | Projected to 21st C. |
|---|---|---|---|---|
| $CO_2$ | ↑ | **** | **** | **** |
| Global Average Surface Temperature | ↑ | **** | *** | **** |
| Continental Average Surface Temperature | ↑ | **** | ** | **** |
| Global Mean Sea Level (steric) | ↑ | **** | *** | **** |
| Arctic Sea Ice | ↓ | ** | * | **** |
| Hot Days and Nights | ↑ | ** | ** | **** |
| Cold Days and Nights | ↓ | ** | ** | **** |
| Heat Waves | ↑↓ | | * | ** |
| Heavy Precipitation Events | ↑↓ | * | | ** |
| Drought Frequency or Intensity | ↑↓ | | | * |
| Tropical Cyclone Intensity | ↑ | | | |
| N. Hemisphere Snow Cover | ↓ | X | X | * |
| N. Hemisphere Precipitation | ↑ | | X | X |
| River Runoff | ↑ | ✕ | X | X |
| Extratropical Cyclones move Poleward | ↑ | * | | * |
| Monsoons Change | ~ | | | |
| Economic Loss from Weather & Climate Extremes | ↑ | | X | X |

Trend Assessment

- ↑ Increasing overall
- ↓ Decreasing overall
- ↑↓ More regions increas decreasing
- ↓↑ More regions decrea increasing
- ~ No definite trend

Confidence Assessment

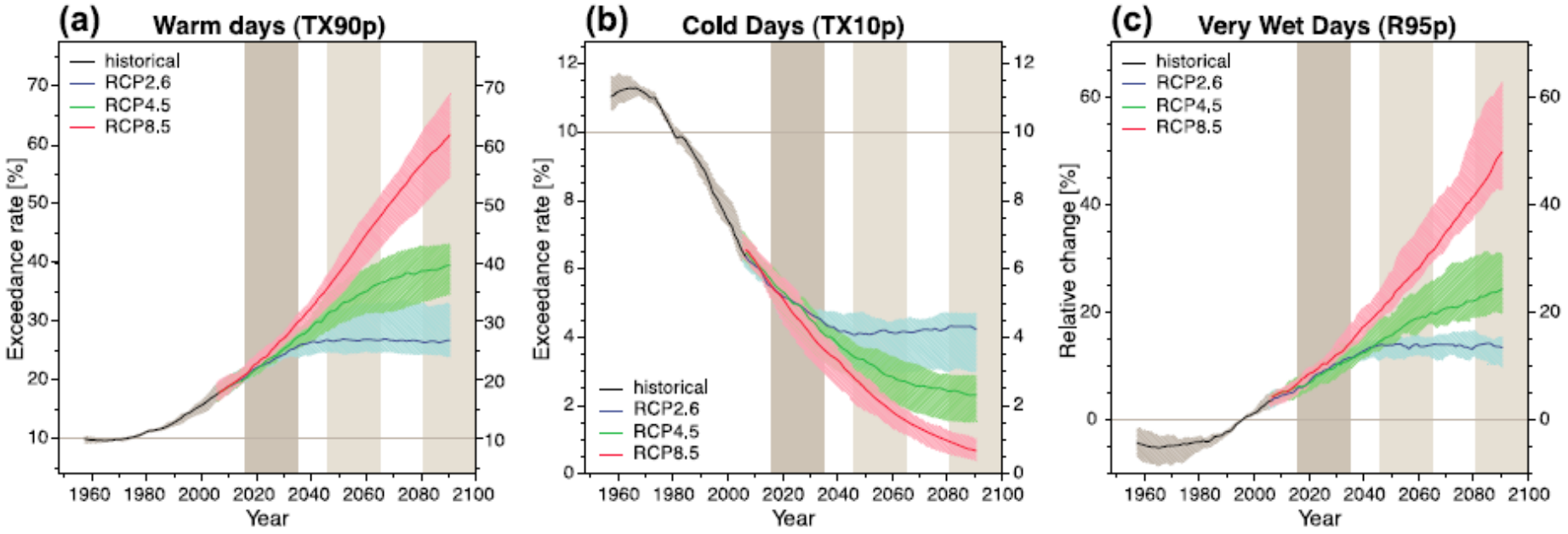
- High confidence
- Medium confidence
- Low confidence
- ✕ Very low or no confidence
- X No assessment made

Likelihood Assessment

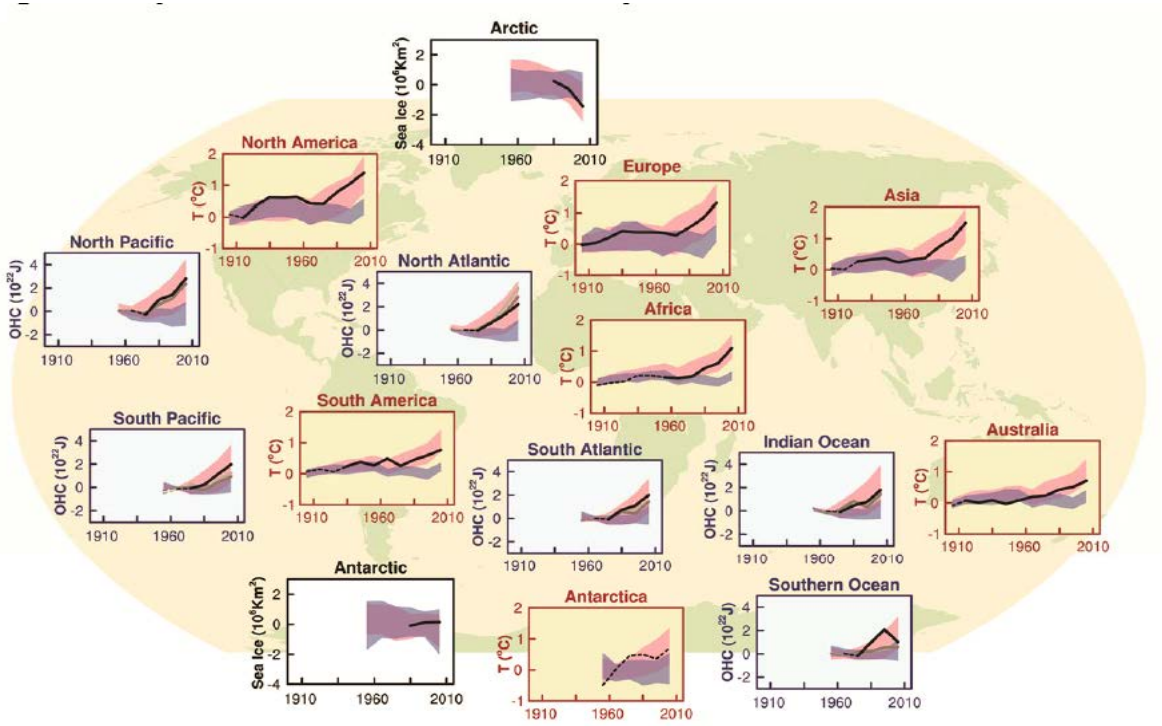
- **** *Virtually Certain* 99% - 100%
- *** *Extremely Likely* 95% - 100%
- ** *Very Likely* 90% - 100%
- * *Likely* 66% - 100%

# Extremes: by 2040, hot days currently occurring up to 10% of time increase to up to 30%

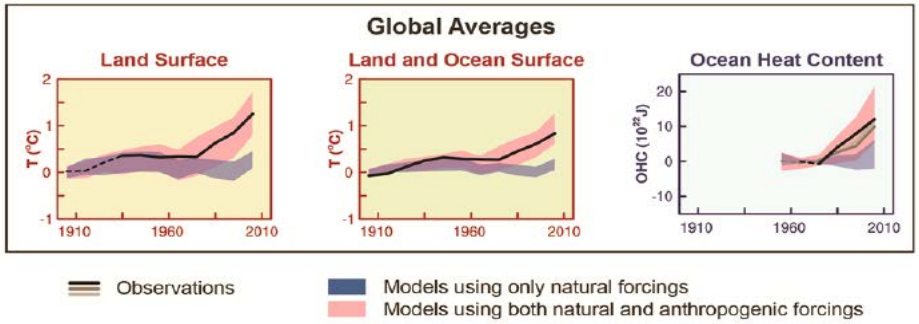
(IPCC 2013)



# Can we trust these projections? Models reproduce past trends well

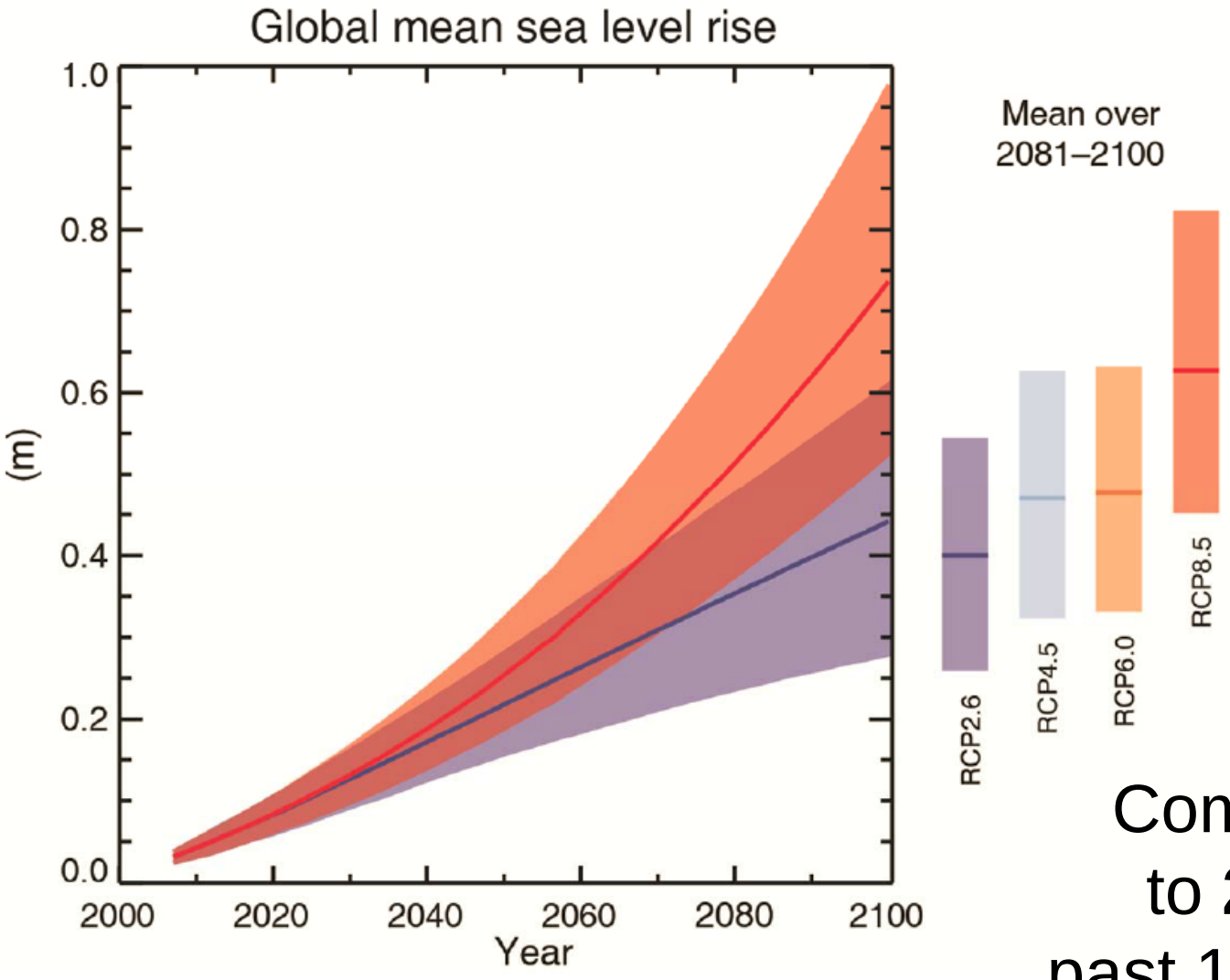



IPCC 2013



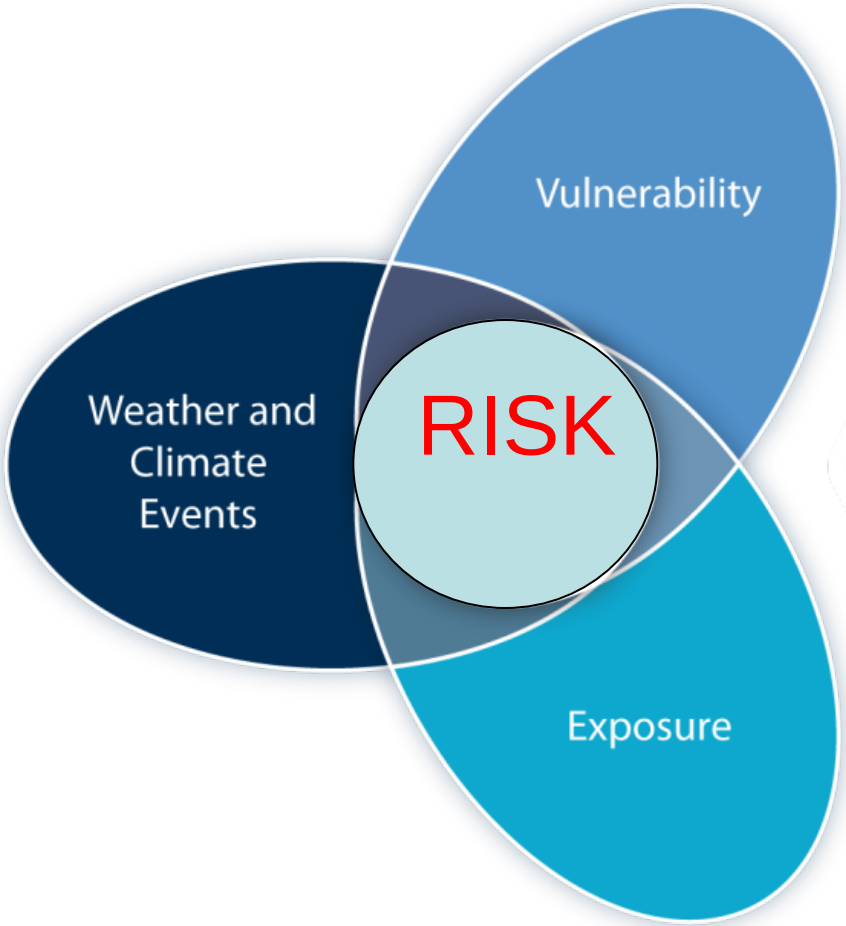
# **Sea Level Projections (**Global**)**

(IPCC 2013)




Compared to **20cm** past 100 years

# Vulnerability + Exposure interact with climate change to produce added Risk




***Vulnerability:***

The predisposition of a person or group to be adversely affected

***Exposure:***

Being in the wrong place at the wrong time

# Risk along the east coast, particularly urban areas

- Structural density, hard & impermeable surfaces → *urban heat island, pluvial flooding*
- Human density → *air and water quality degraded*
- Infrastructure stacked well below as well as above grade → *enhanced coastal vulnerability*
- Impact “hotspots” →*e.g., smog + heat island*

# Growth in exposure to *current* 100-yr flooding by 2070

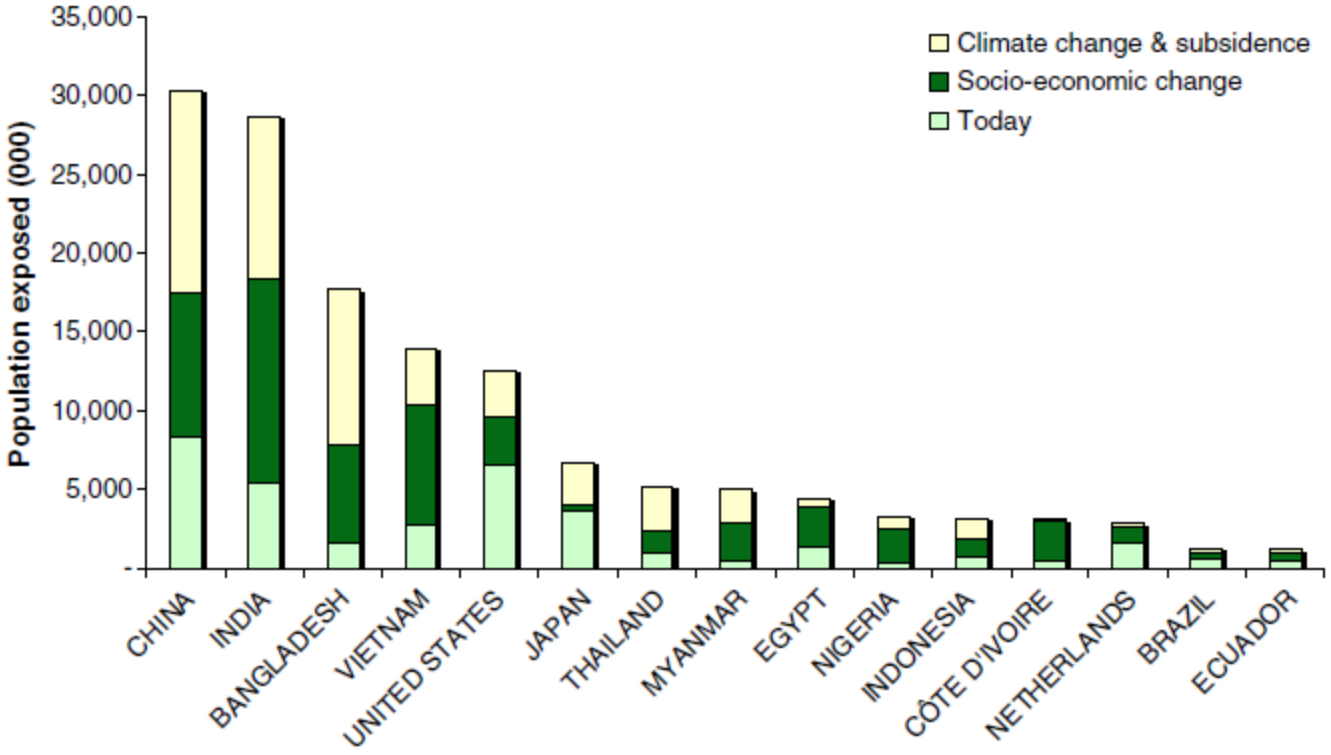
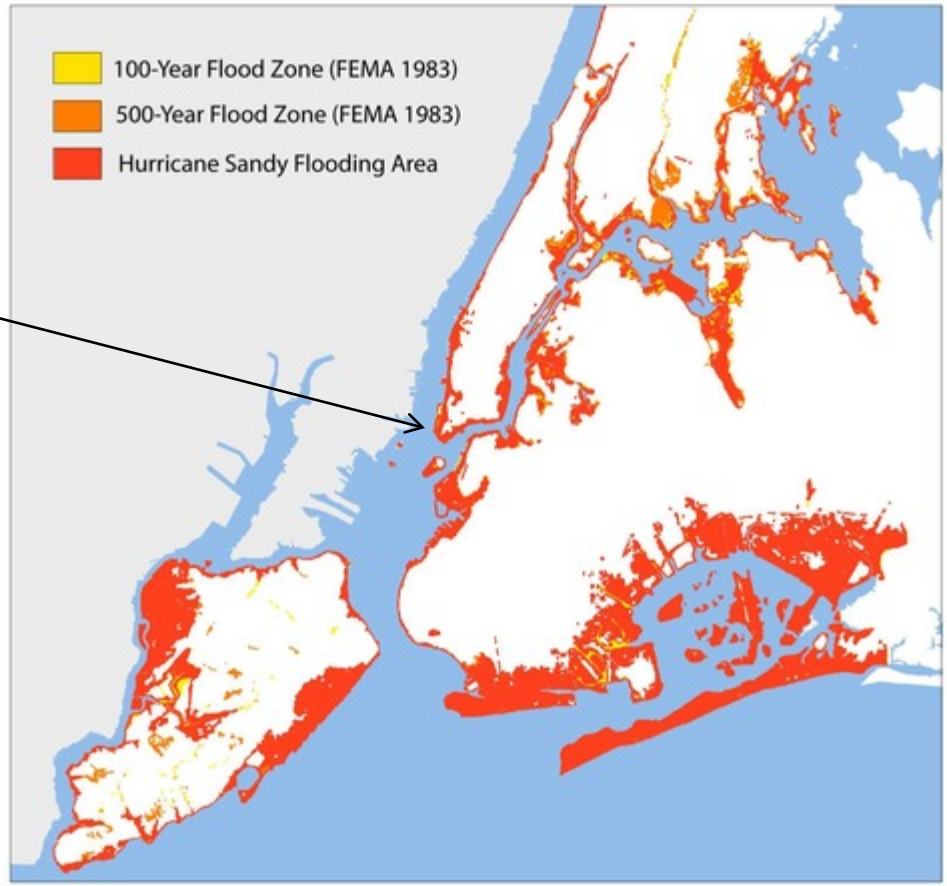



**Fig. 4** Population exposure for the top 15 countries in the 2070s under scenario FAC showing the proportions associated with current exposure, climate change and subsidence and socio-economic change

Hanson at al Climatic Change 2011

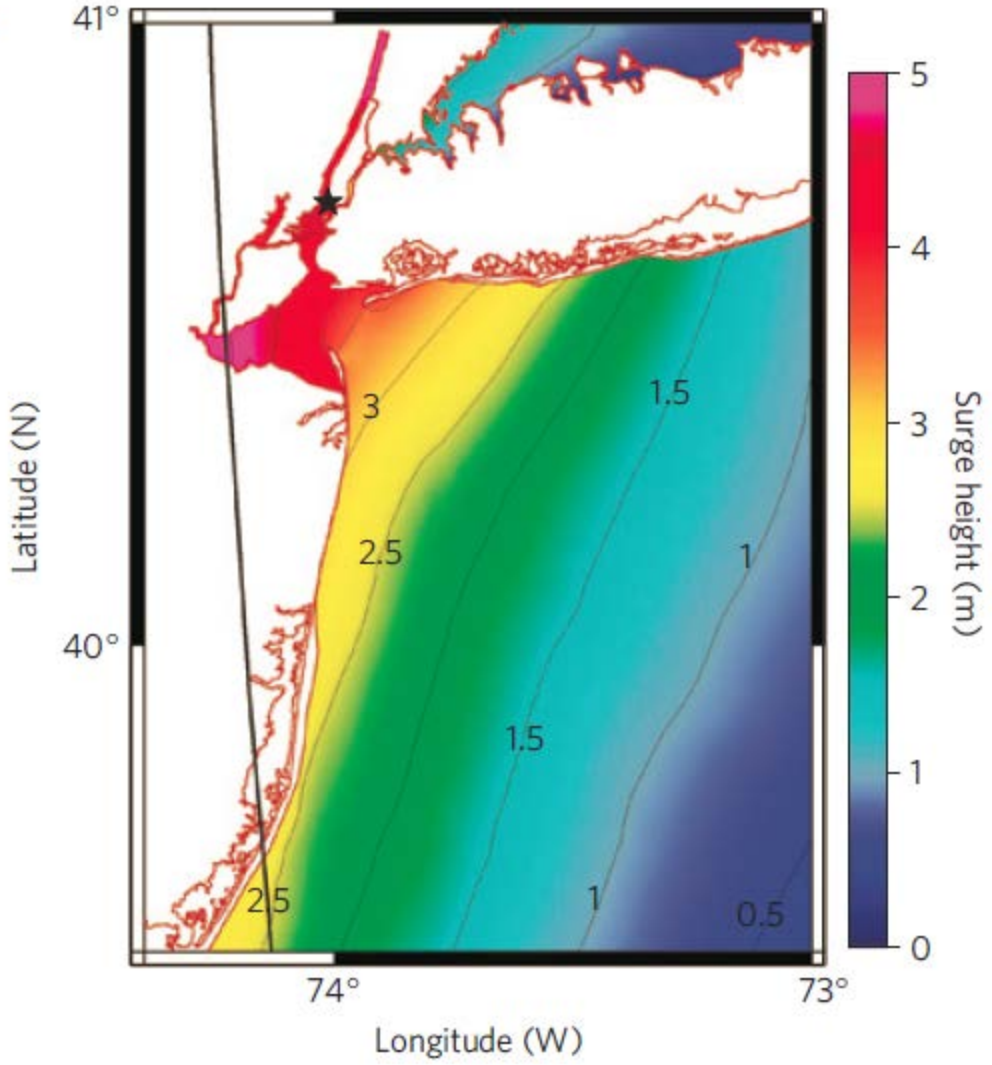
# Sandy presented an unusual combination of circumstances, but…

Flood level
3.7m
(above
NAVD88)




NYC Mayor's Office Flickr

Hurricane Sandy reached
>500-yr flood level in NYC




# Sea Level Rise and Intensifying Tropical Cyclones present an increasing, double-barreled hazard for the US East Coast

Current "worst case" hurricane surge for NYC area - greater than Sandy's

# Big increase in hazard by mid-century

NYC Panel on Climate Change 2012)

Table 3. Baseline Climate and Mean Annual Changes

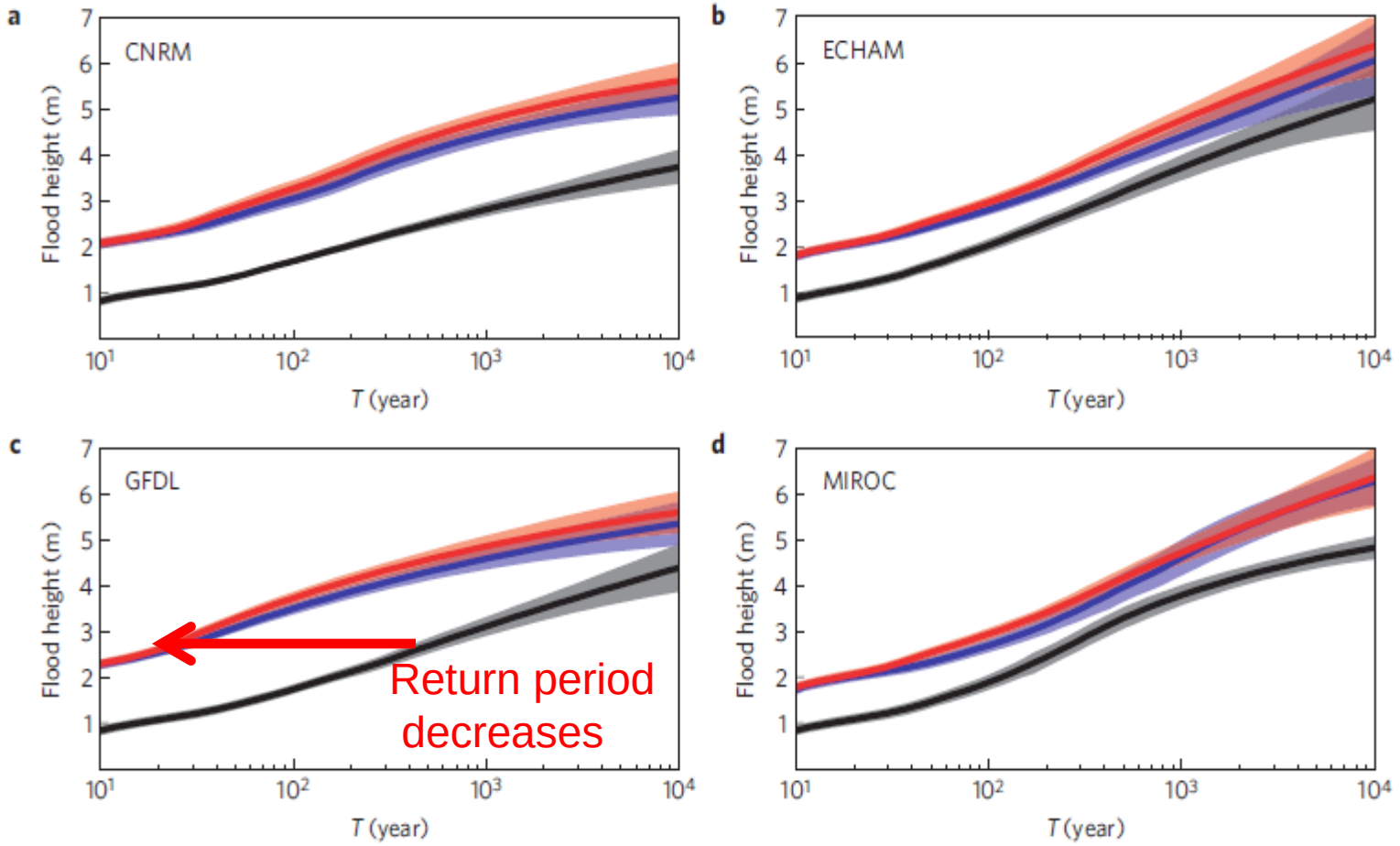
| Air temperature<br>Baseline (1971 - 2000) 54°F | Low-estimate<br>(10th percentile) | Middle range<br>(25th to 75th percentile) | High-estimate<br>(90th percentile) |
|---|---|---|---|
| 2020s | + 1.5°F | + 2.0°F to + 3.0°F | + 3.0°F |
| 2050s | + 3.0°F | + 4.0°F to + 5.5°F | + 6.5°F |
| **Precipitation<br>Baseline (1971 - 2000) 50.1 inches** | **Low-estimate<br>(10th percentile)** | **Middle range<br>(25th to 75th percentile)** | **High-estimate<br>(90th percentile)** |
| 2020s | 0 percent | 0 to + 10 percent | + 10 percent |
| 2050s | 0 percent | + 5 to + 10 percent | + 15 percent |
| **Sea level rise<br>Baseline (2000-2004) 0 inches** | **Low-estimate<br>(10th percentile)** | **Middle range<br>(25th to 75th percentile)** | **High-estimate<br>(90th percentile)** |
| 2020s | 2 inches | 4 to 8 inches | 11 inches |
| 2050s | 7 inches | 11 to 24 inches | 31 inches |

Based on 35 GCMs (24 for sea level rise) and two Representative Concentration Pathways. Baseline data are from the National Oceanic and Atmospheric Administration (NOAA) National Climatic Data Center (NCDC) United States Historical Climatology Network (USHCN), Version 2 (Menne et al., 2009). Shown are the 10th percentile, 25th percentile, 75th percentile, and 90th percentile 30-year mean values from model-based outcomes.Temperature values are rounded to the nearest 0.5°F, percipitation values are rounded to the nearest 5 percent, and sea level rise values rounded to the nearest inch.

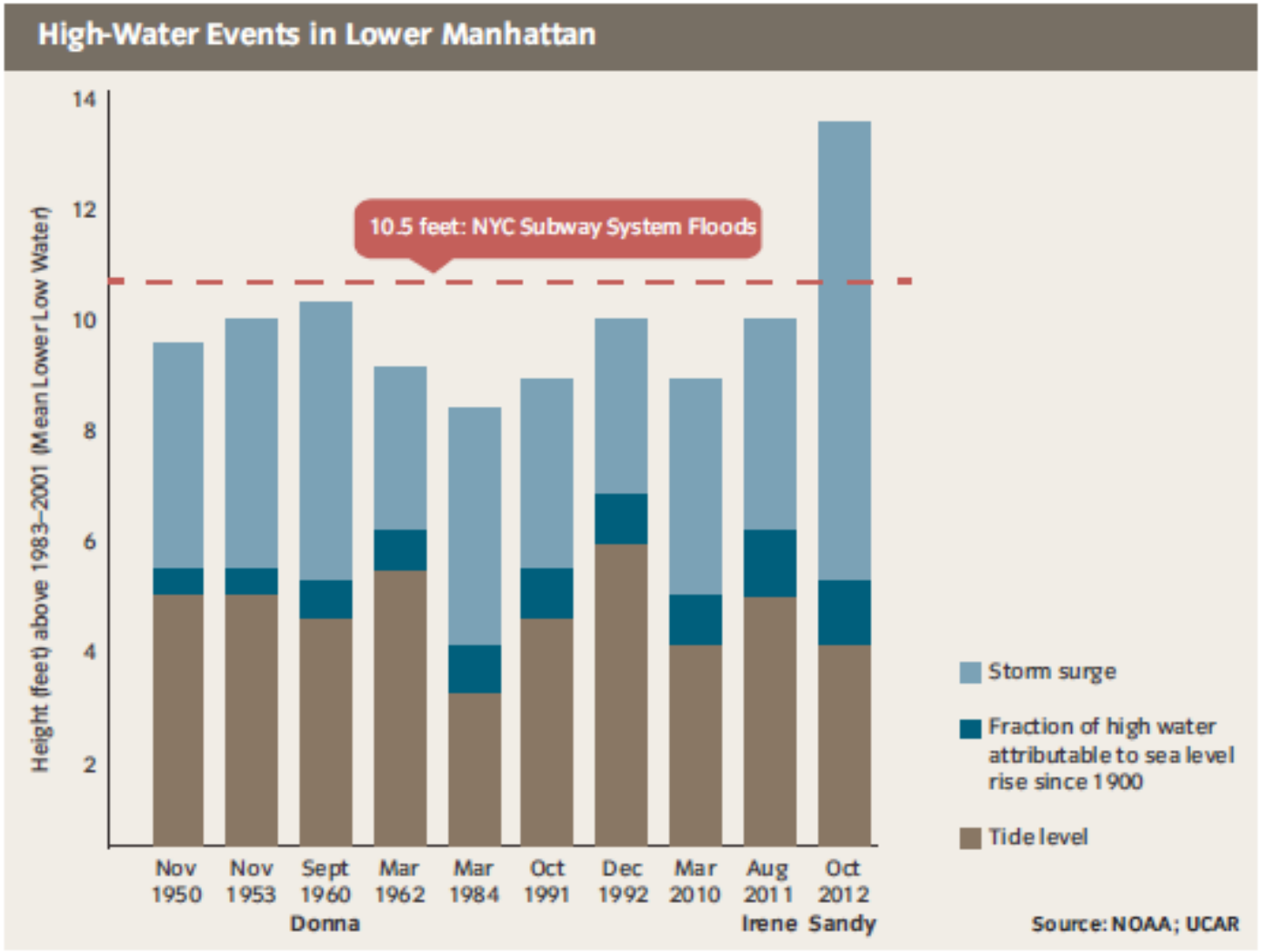
# Rate of sea level rise higher than global mean along NE coast

# Sea level and ocean temperature of 2100:

Sandy-like flood (3.7m) returns more often due to higher sea level (up to 1m) and strong tropical cyclones (Lin et al 2012)



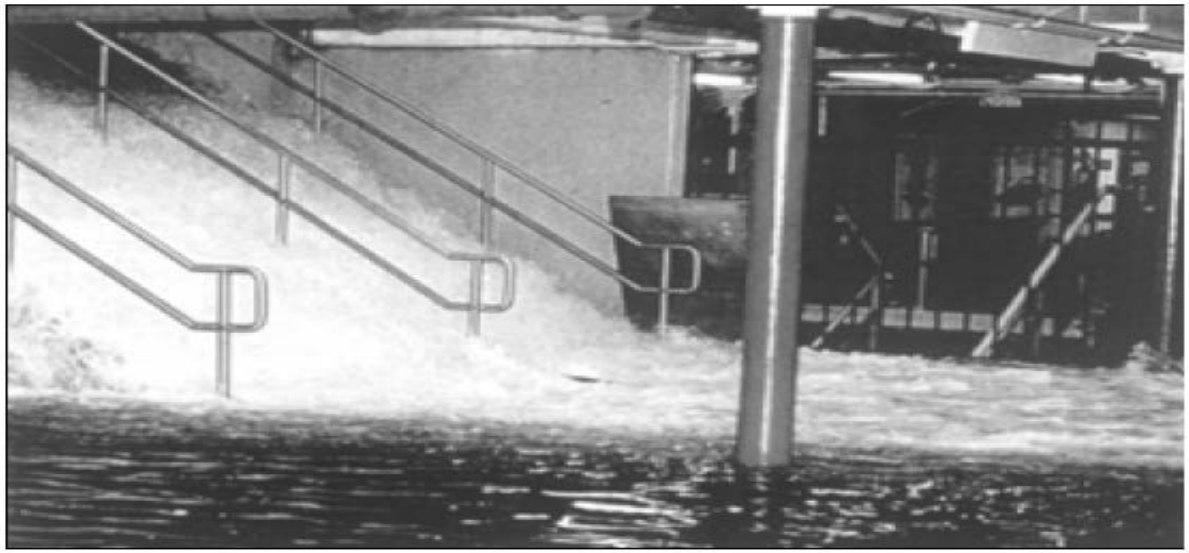
# Exposure of Networked Infrastructure



**Thames Barrier, London:**

Should NYC plan now on this scale?

# Obstacles to Timely Action



Memories are short…
even among those responsible for risk management

**Hoboken subway station 2012 - - - and 1992**

# After enough damage, even with low resources, some people and governments learn to do better as risk increases – Can we?

In Bangladesh, concrete bunkers + early warning systems cut death rate in cyclones (Jeff Masters' wunderblog)