Adapting to Climate Change Challenges – Learning from the New York City Experience

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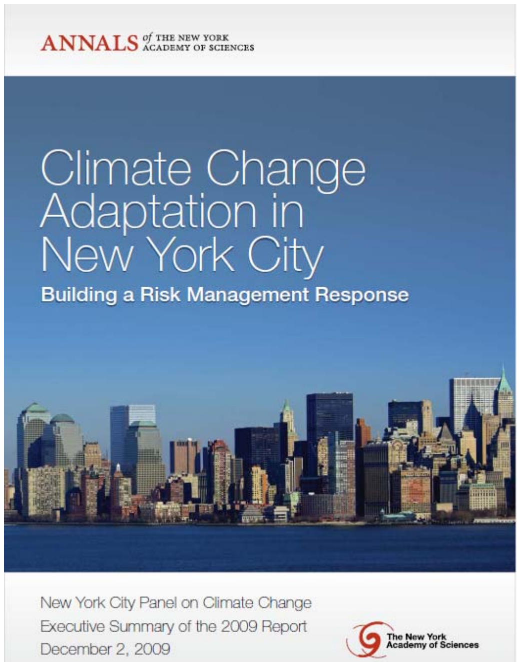
Key CCSR Adaptation Projects

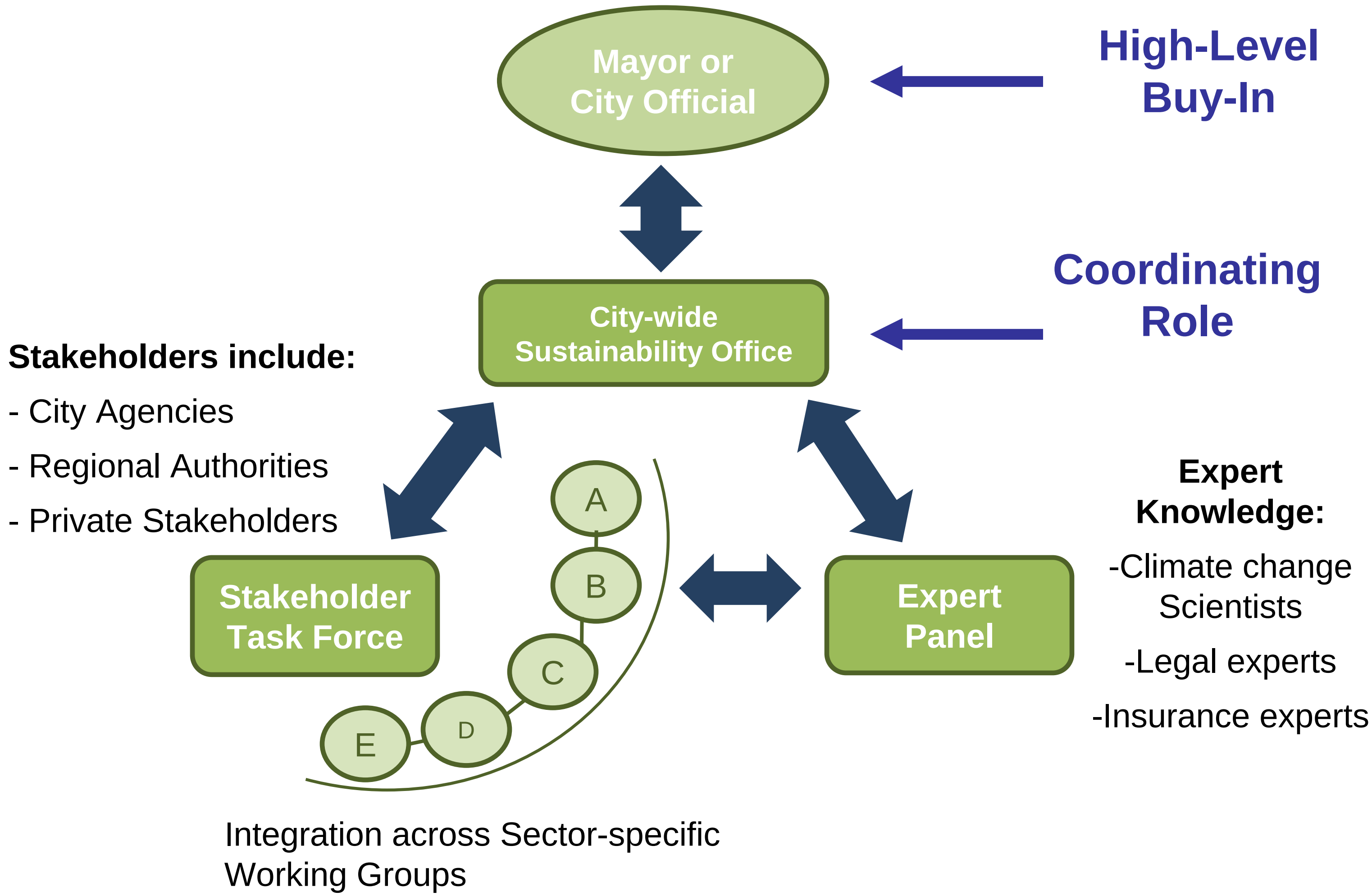
YEAR	REPORT TITLE	ORGANIZATION/PUBLICATION
2001	Climate Change and a Global City: The Potential Consequences of Climate Variability and Change	*Columbia Earth Institute*
2007	August 8, 2007 Storm Report	*Metropolitan Transit Authority*
2008	NYC DEP Climate Change Program Assessment and Action Plan	*New York City Department of Environmental Protection*
2010-2015	*Climate Change Risks in the Urban Northeast (U.S.)*	*NOAA-RISA*
2010	***New York City Climate Change Adaptation Task Force &*** ***New York City Panel on Climate Change***	***NYC Office of Long Term Planning & Sustainability***
Underway - 2010	*Climate Change Adaptation at NASA Centers*	*NASA*

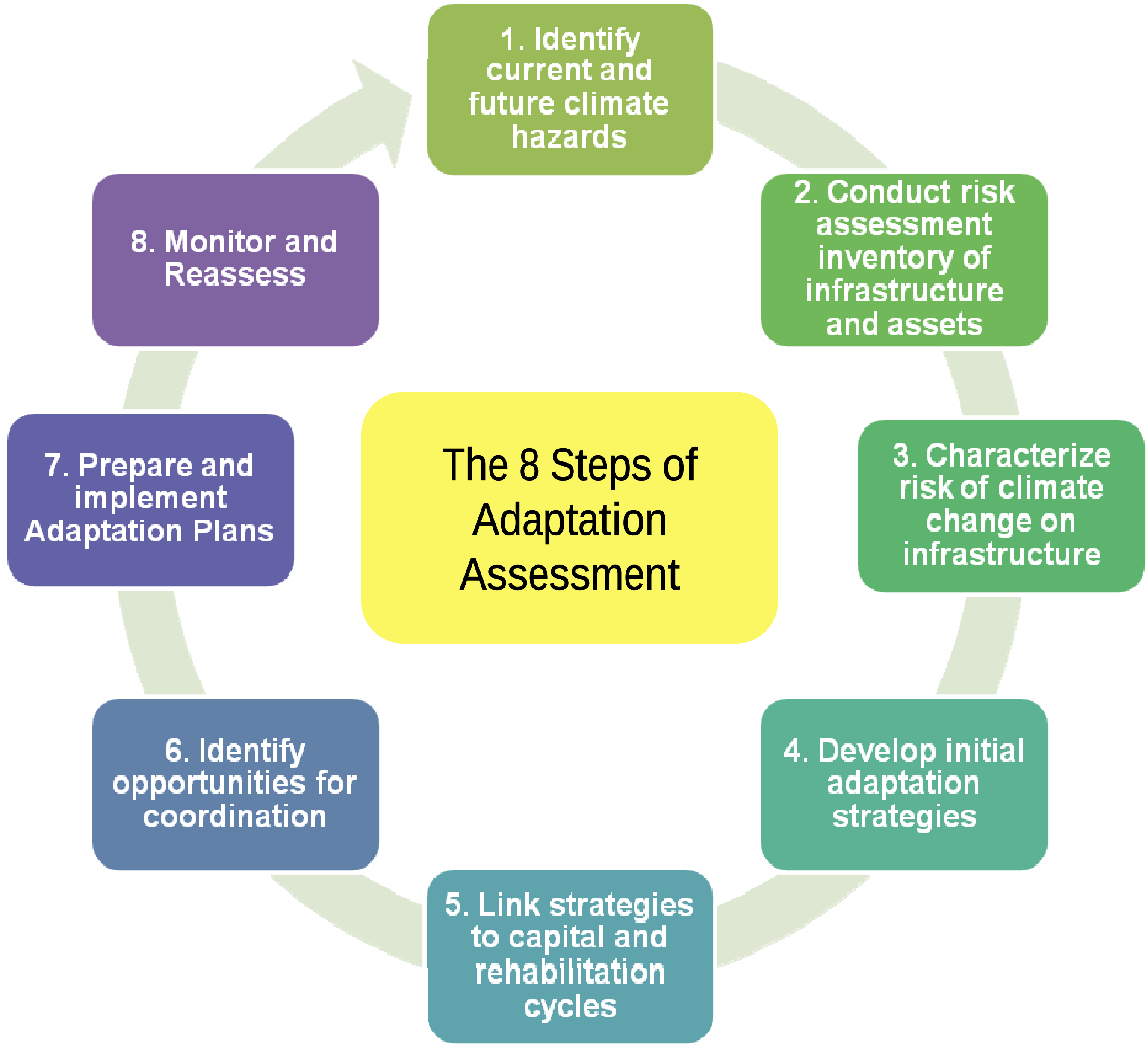
New York City
Panel on Climate Change



- **Convened by Mayor Bloomberg in August 2008**
- **Served as an independent advisory body for the New York City Climate Change Adaptation Task Force**
- **Composed of climate change and impacts scientists, legal, insurance and risk management experts**
- **Focused on adaptation and infrastructure**
- **Tasked with producing a foundation report and tools to assist Task Force stakeholders**

New York City Process





New York City Panel on Climate Change, 2009

Climate Factors and Methods

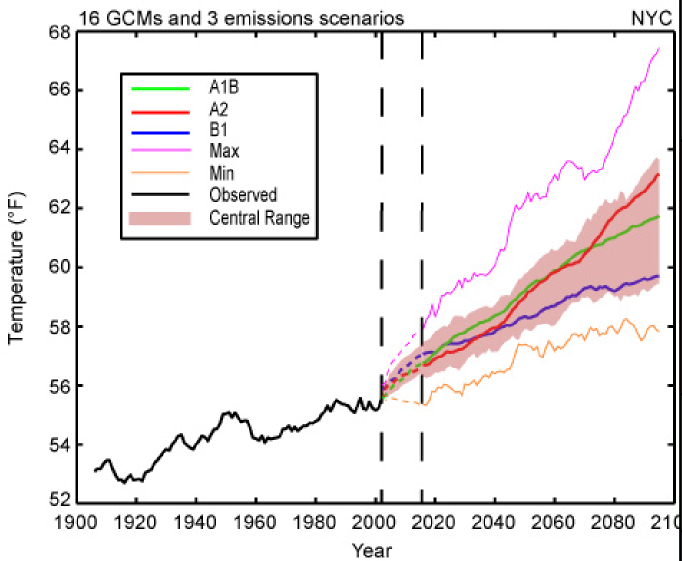
Climate Factors

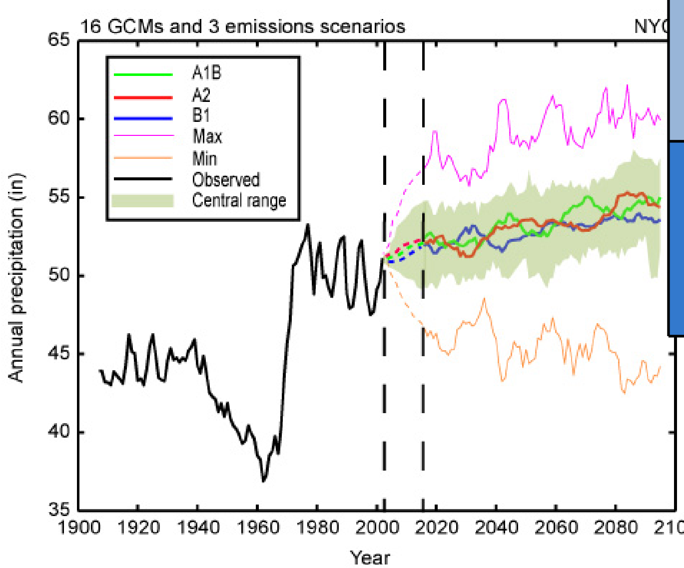
- **Mean annual changes (temperature, precipitation, and sea level rise)**
- **Extreme Events--quantitative (heat waves, cold air events, intense precipitation at daily timescales, droughts, and storm surges)**
- **Extreme events--qualitative (heat indices, hourly/sub-hourly precipitation events, extreme winds, tropical cyclones and nor'easters, lightning, and frozen precipitation)**

Methods

- **Mean annual changes: Subtract/divide 30 year model climatologies for the 1971-2000 base period from 30 year climatologies for three future time slices centered around the 2020s, 2050s, and 2080s**
- **Extreme Events--quantitative: Apply monthly changes, as above, to observed historical data at high temporal resolution to calculate frequency of occurrence or recurrence interval**
- **Extreme events--qualitative: Based on published literature and expert judgment, assess possible directional change, with an associated likelihood**

GCM-based Regional Projections--Mean Changes





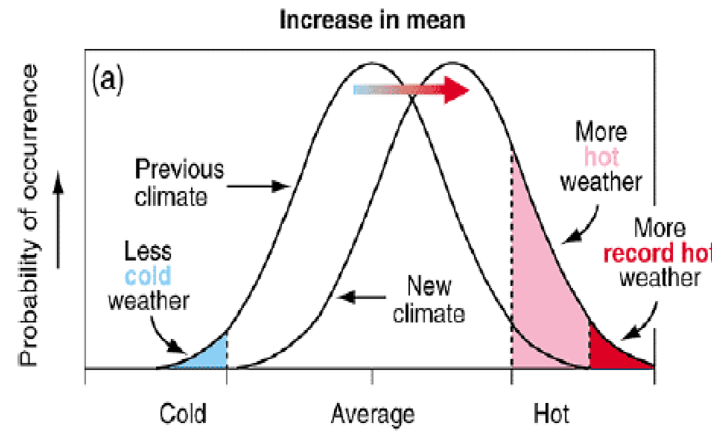
	Base 1971-2000	2020s	2050s	2080s
Air Temperature Central Range[2]	55˚F	+ 1.5 to 3.0˚F	+ 3.0 to 5.0˚F	+ 4.0 to 7.5˚F
Precipitation Central Range	46.5 in[3]	+ 0 to 5 %	+ 0 to 10 %	+ 5 to 10%
Sea level rise[3] Central Range	NA	+ 2 to 5 in	+ 7 to 12 in	+ 12 to 23 in
Rapid ice-melt scenario[4]	NA	~ 5 to 10 in	~ 19 to 29 in	~ 41 to 55 in

Combined observed and projected temperature and precipitation. The thick lines (green, red, and blue) show the average for each emissions scenario across the 16 GCMs. Shading shows central range. The bottom and top lines, respectively, show each year's minimum and maximum projections across the suite of simulations. A ten-year filter has been applied to the observed data and model output. The dotted area represents the period that is not covered due to the smoothing procedure.

Source: Columbia Center for Climate Systems Research

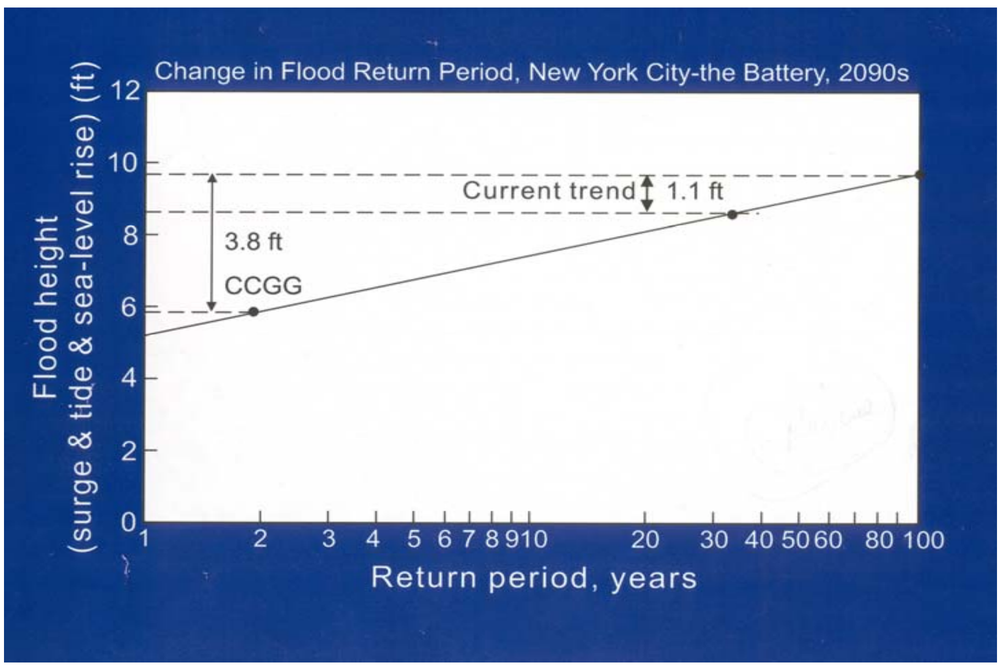
GCM-based Regional Projections--Extreme Events

Extreme Event	Baseline (1971-2000)	2020s	2050s	2080s
# of days/year with maximum temperature exceeding:				
90° F	14	23 to 29	29 to 45	37 to 64
100° F	0.4[1]	0.6 to 1	1 to 4	2 to 9
# of heat waves/year[2]	2	3 to 4	4 to 6	5 to 8
Average duration (in days)	4	4 to 5	5 to 5	5 to 7
# of days/year with minimum temperature below 32° F:	72	53 to 61	45 to 54	36 to 49
1-in-10 yr flood to reoccur, on average	~once every 10 yrs	~once every 8 to 10 yrs	~once every 3 to 6 yrs	~once every 1 to 3 yrs
Flood heights associated with 1-in-10 yr flood (in feet)	6.3	6.5 to 6.8	7.0 to 7.3	7.4 to 8.2



1) Natural variability will continue

2) Large impacts when natural variability combines with gradual mean changes



3) Subtle shifts in mean values can lead to large changes in the frequency of extremes

4) This suggests policy-relevance, although uncertainties associated with extreme event projections are large

Infrastructure Impacts

Climate Risk Factor → Likelihood → Potential Implications for NYC Infrastructure

- Degradation of and increased strain on materials
- Increase in peak electricity load, resulting in more frequent power outages
- Increase of demand on HVAC systems

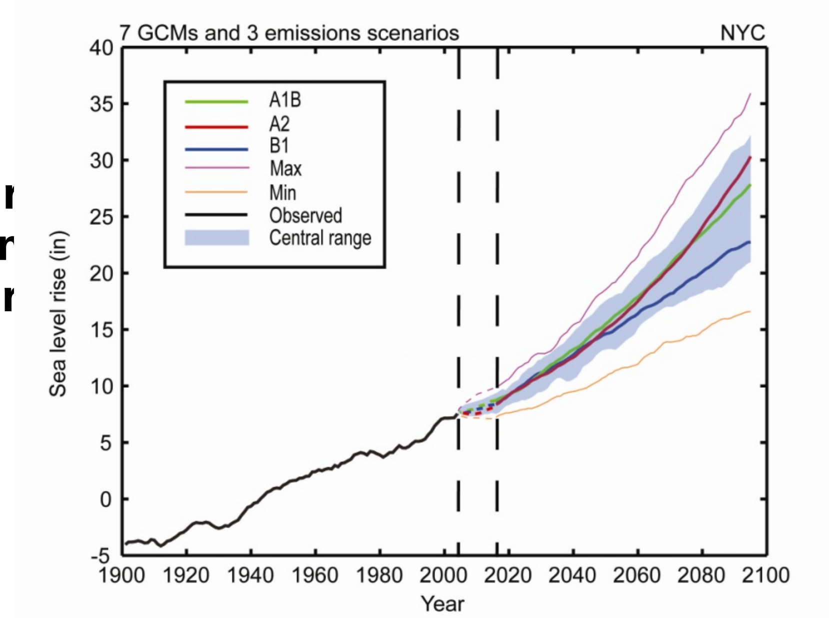
- Increase of street, basement and sewer flooding
- Increase in delays on public transportation and low-lying highways
- Decrease in average reservoir storages

- Encroachment of saltwater on freshwater sources and ecosystems
- Increase in pollution released from brownfields & other waste sites
- Increase in structural damage to infrastructure from flooding and wave action

Sea Level Rise

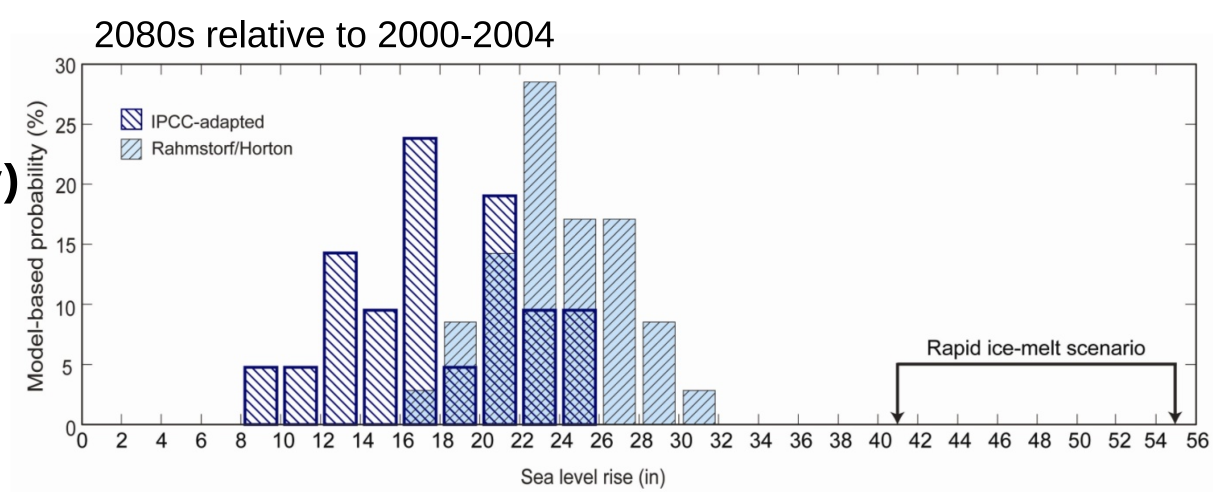
Three sets of sea level rise projections are generated:

1) The IPCC model-based approach includes four terms: local land subsidence, local relative ocean height, global thermal expansion, and meltwater from land-based ice



2) The Rahmstorf (Science, 2007) 'semi-empirical approach' applied to the IPCC AR4 models (Horton et al, GRL, 2008) assumes the ~150 year relationship between global temperature and sea level rise holds with higher modeled temperatures in the 21st Century. (Results globalized using Peltier (GIA) dataset.)

3) The rapid ice melt scenario replaces the model- based meltwater term with sea level rise rates (43 +/- 4 in/century) observed during the last deglaciation (Fairbanks, 1989; Bard et al., 1990; Peltier and Fairbanks, 2006).



The IPCC 2007 approach to sea level rise may be too conservative

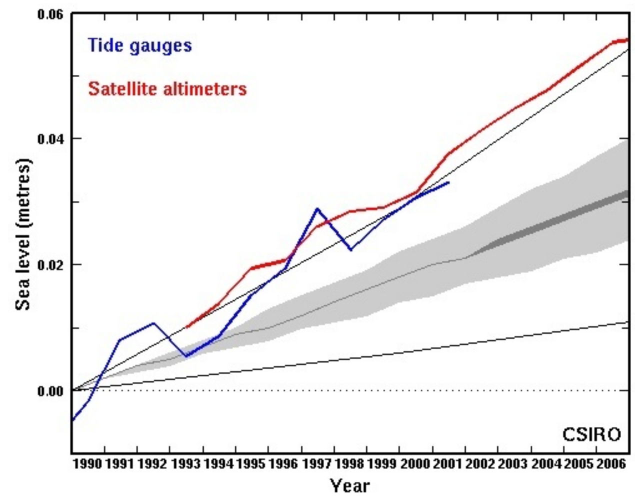
Observed sea level has been tracking slightly above the high end IPCC projections

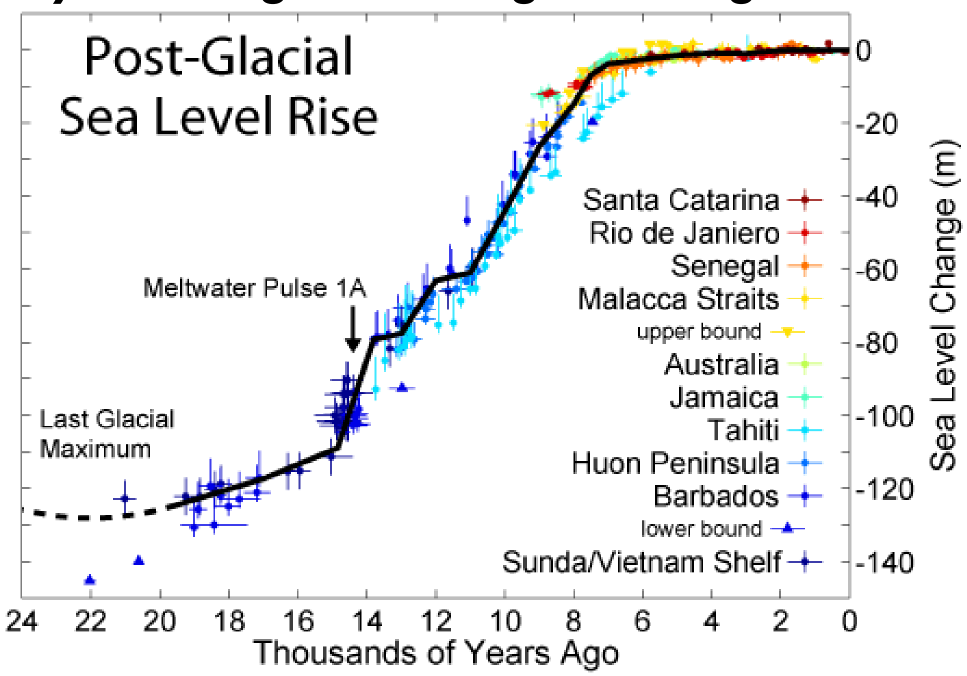
Climate models, due to low spatial resolution and incomplete physics, cannot capture important dynamical ice melt processes that are being observed, especially:

1) meltwater ponds and basal lubrication of glaciers

2) thinning of buttressing ice shelves that hold back land-based ice

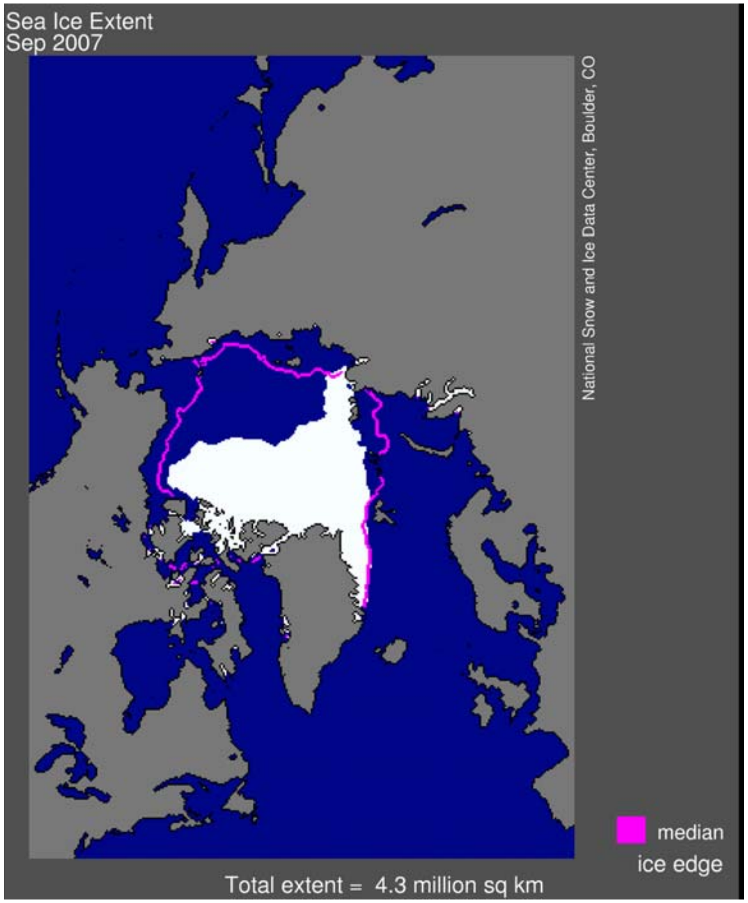
3) thinning of ice at grounding lines

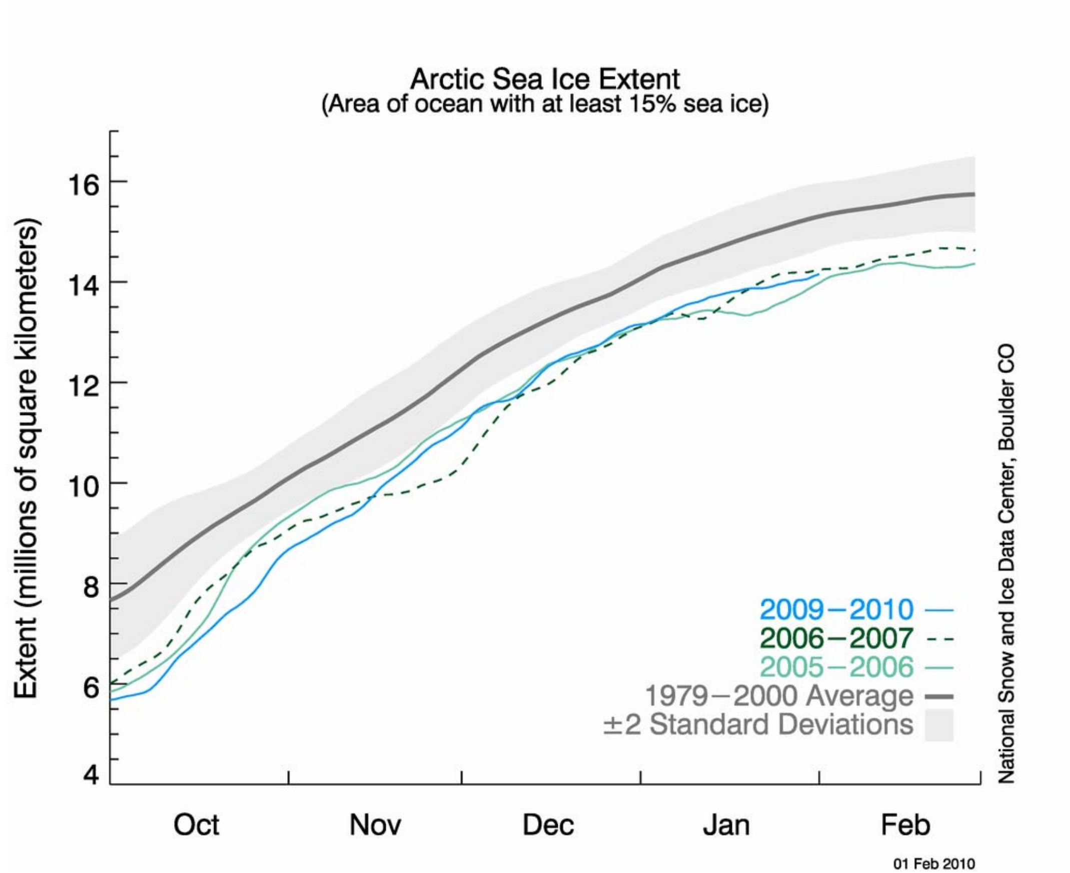




Arctic Sea Ice Loss--Underestimated by GCMs

September 2007





September 2007 sea ice extent was 36 % below the 27-year average, 23 % below the prior minimum, and approximately 50 % below the average values of the 1950s

Implications for the U.S.?

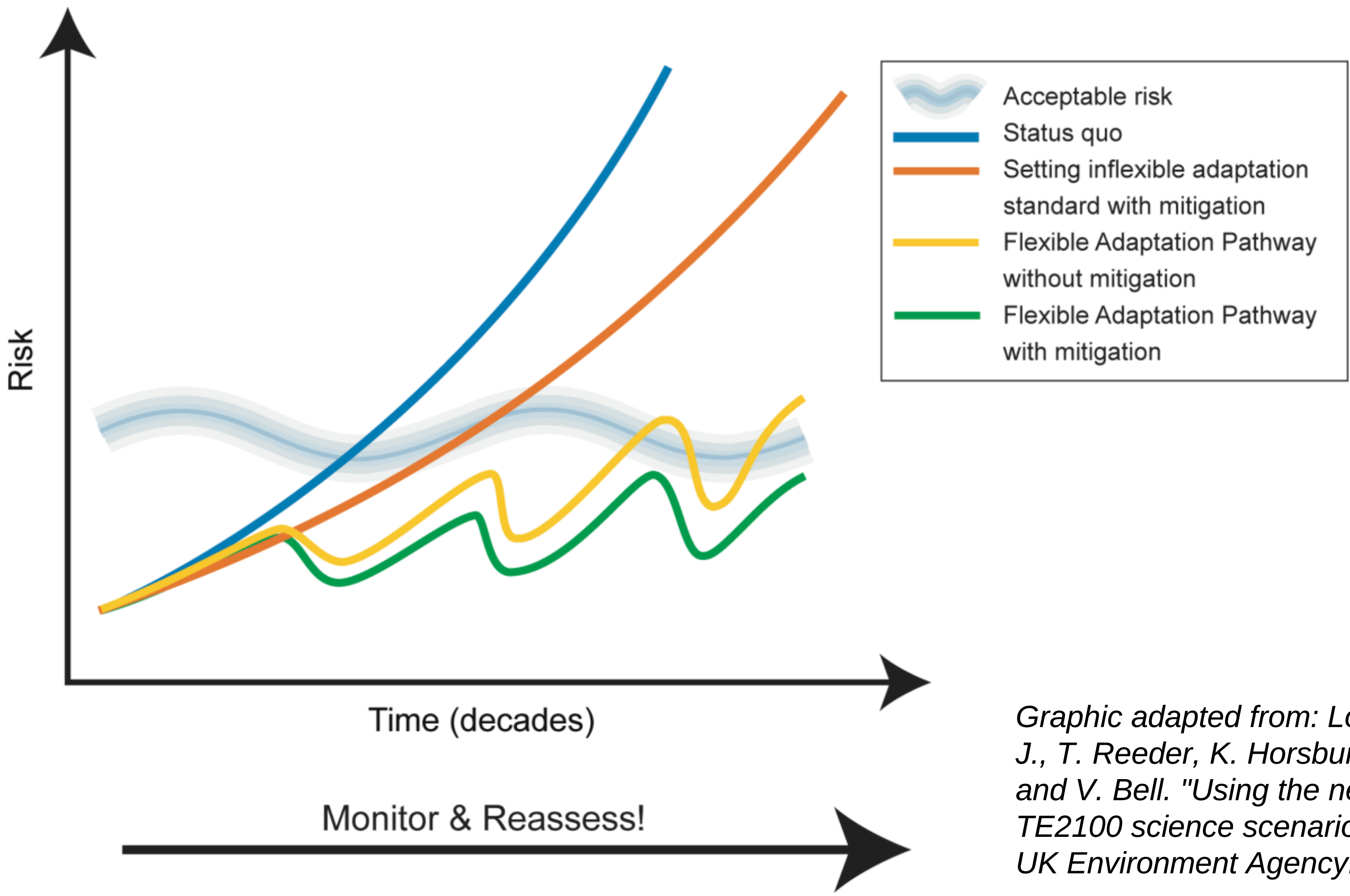
-Cold air outbreaks?

-Storm tracks?

-Indirect sea level rise effects?

Source: National Snow and Ice Data Center

Flexible Adaptation Pathways



Graphic adapted from: Lowe, J., T. Reeder, K. Horsburgh, and V. Bell. "Using the new TE2100 science scenarios." UK Environment Agency.

Conclusions

- **Climate change is extremely likely to bring warmer temperatures to New York City. Heat waves are very likely to become more frequent, intense, and longer duration. Total precipitation more likely than not will increase and precipitation associated with brief, intense rainstorms is likely to increase. More likely than not, droughts will also become more severe. Rising sea levels are extremely likely, and are very likely to lead to more frequent and damaging flooding related to coastal storm events in the future.**

- **Climate change should be considered in the context of historical climate and climate variability**

- **Small shifts in mean climate variables can lead to large changes in extreme events**

- **Sound risk management is based on the principle that uncertainty should be emphasized/embraced**

- **The model-based probability approach has merit, but because it does not reflect the full range of possible outcomes, additional techniques are necessary**