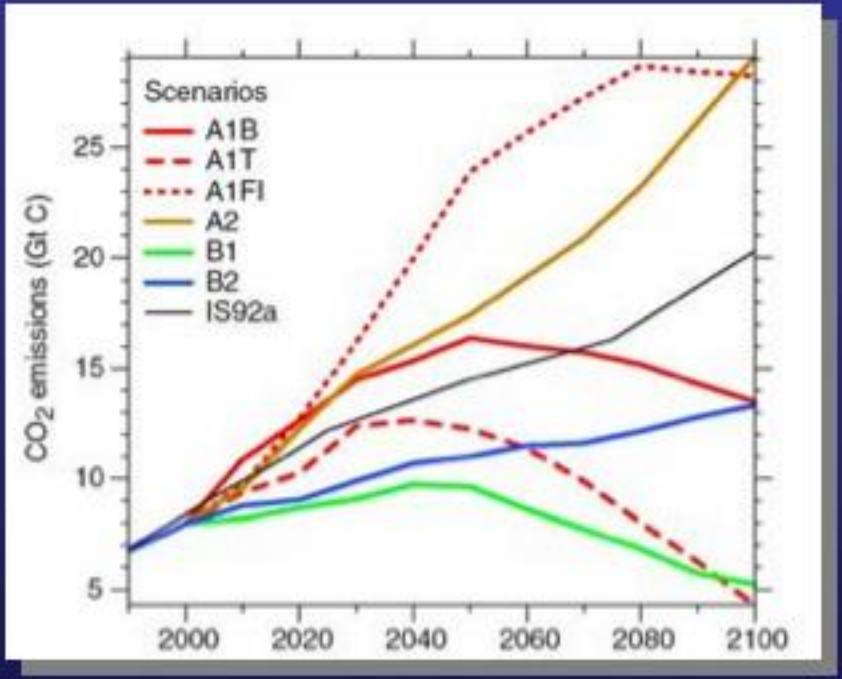
Global Warming and The Impact of Sea Level Rise on Rhode Island

John King
Professor of Oceanography
Graduate School of Oceanography
University of Rhode Island

UNIVERSITY OF Rhode Island

The Problem

What's going on?

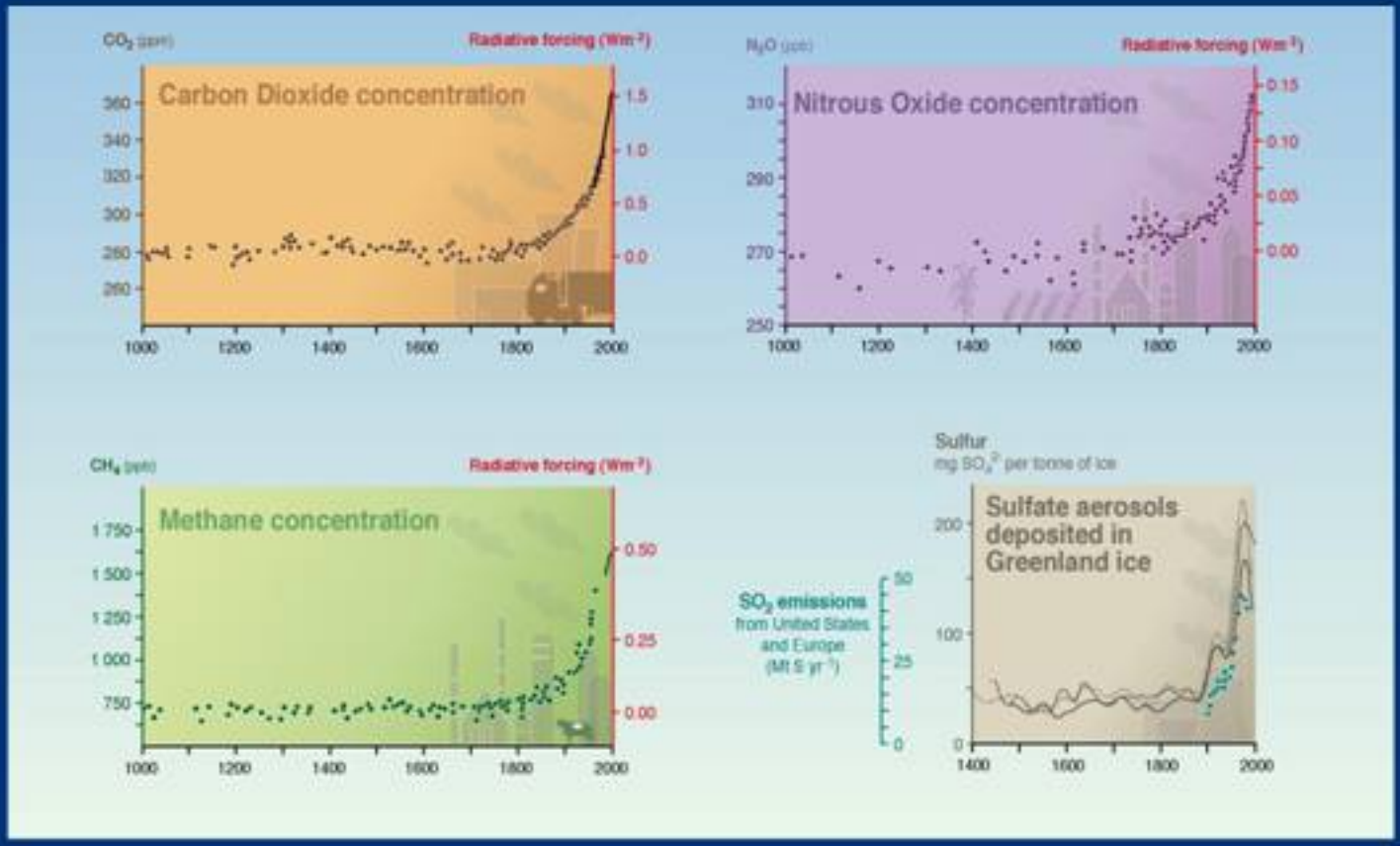


Increased Carbon Emissions

Rising Temperatures

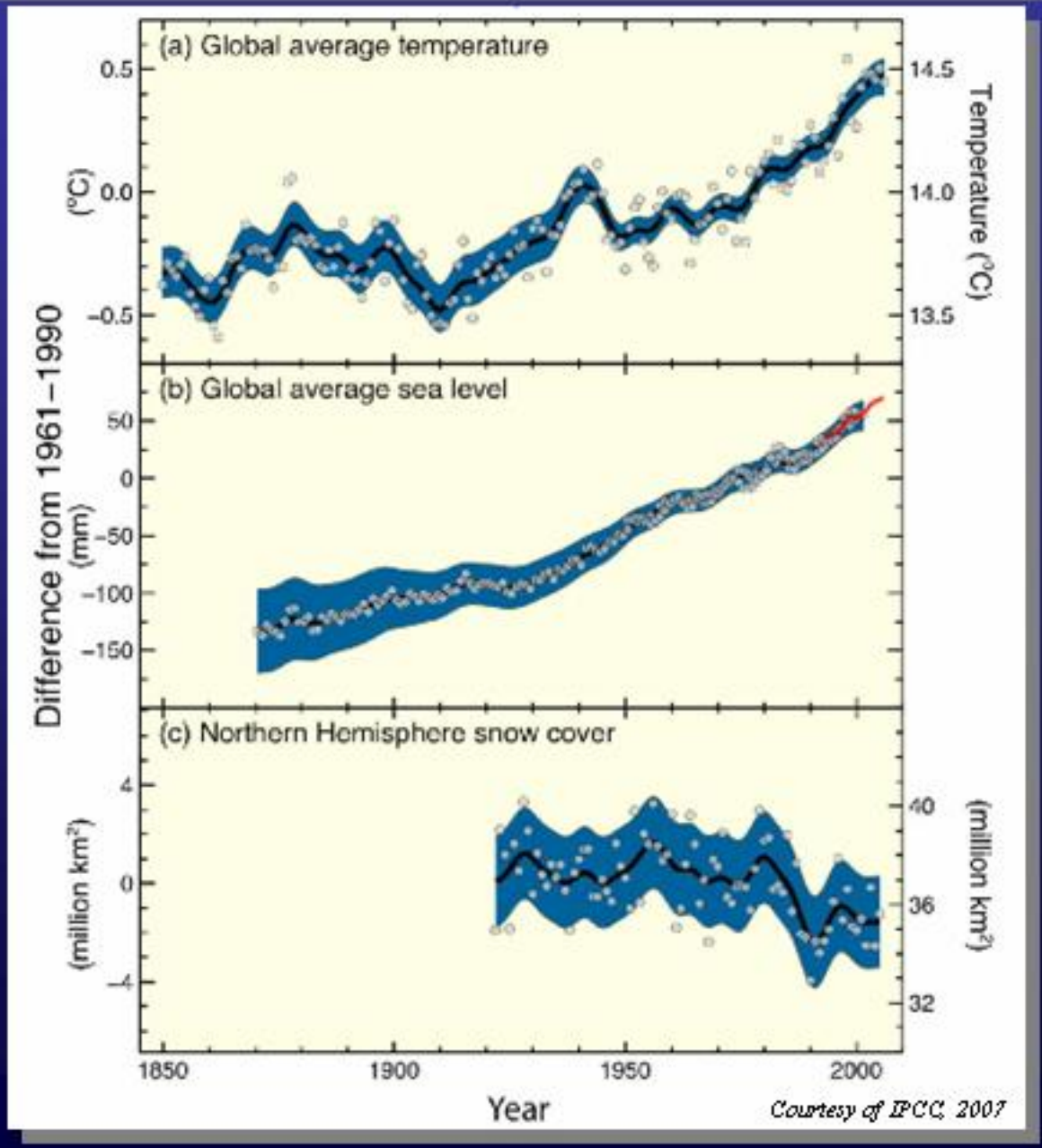
Rising Sea Level

Indicators of human influence on the atmosphere



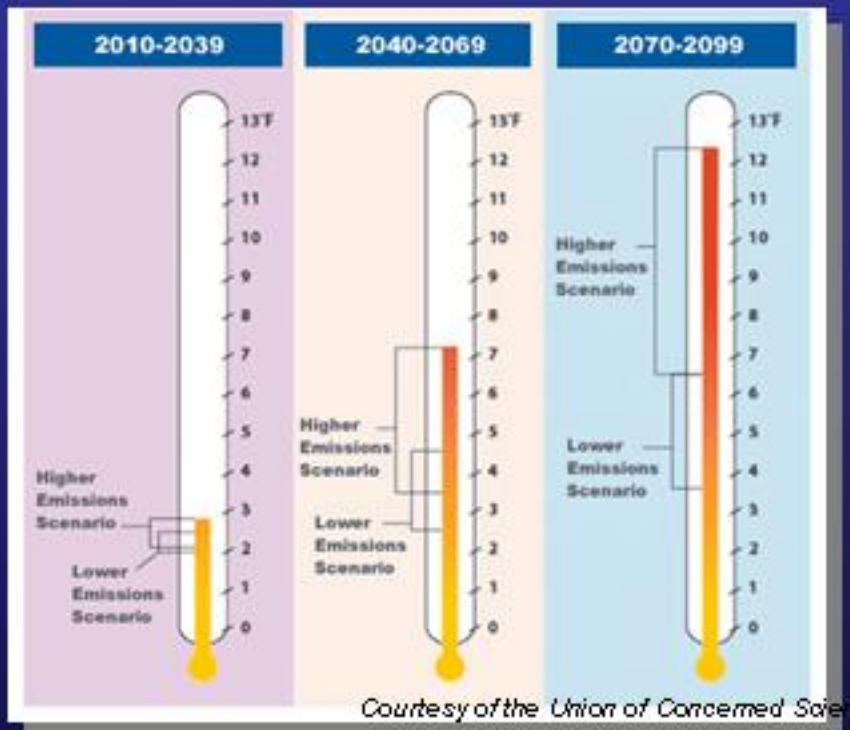
SYR - FIGURE 2-1
WG1 FIGURE SPM-2

Changes in Temperature, Sea Level and Northern Hemisphere Snow Cover



Rising Temperatures

Rising Temperatures



Global and Continental Temperature Change

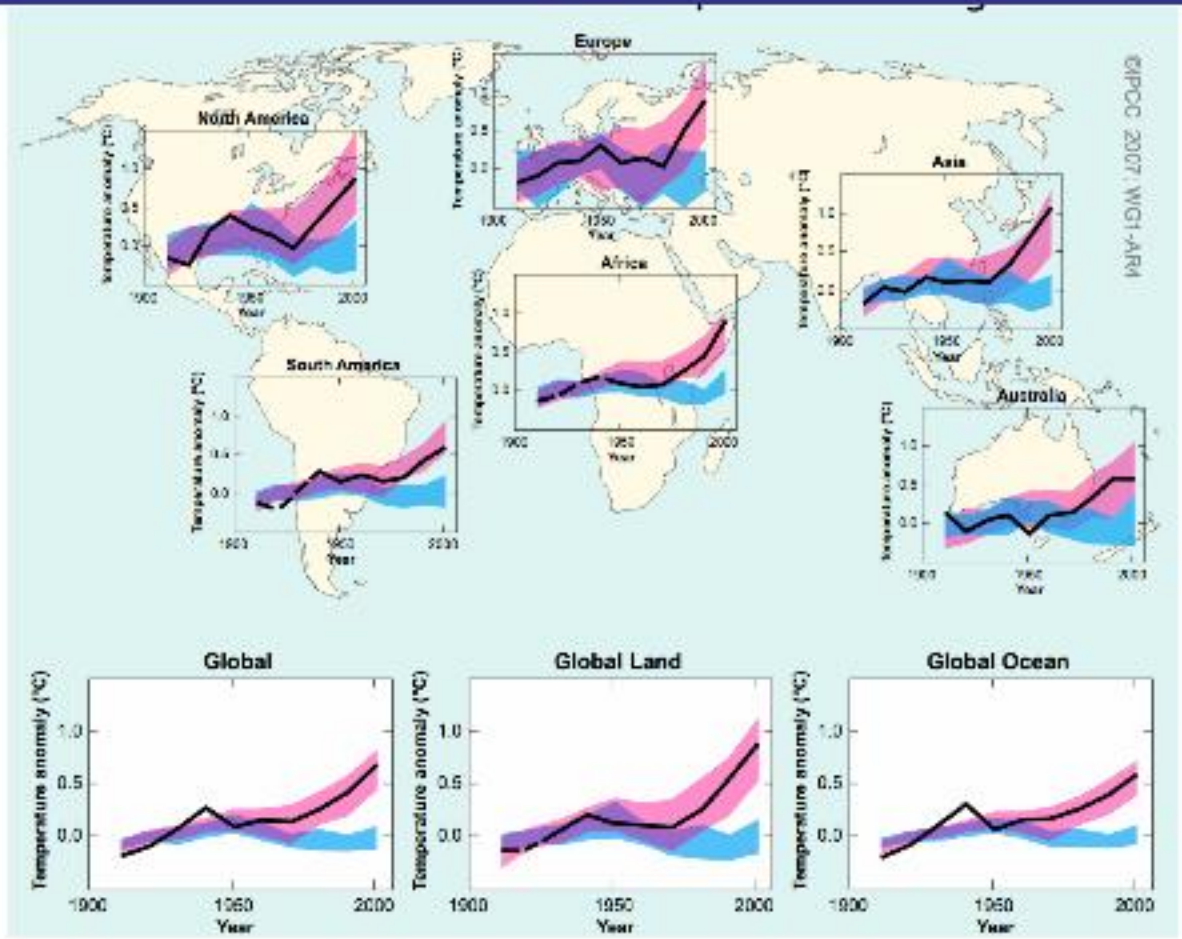
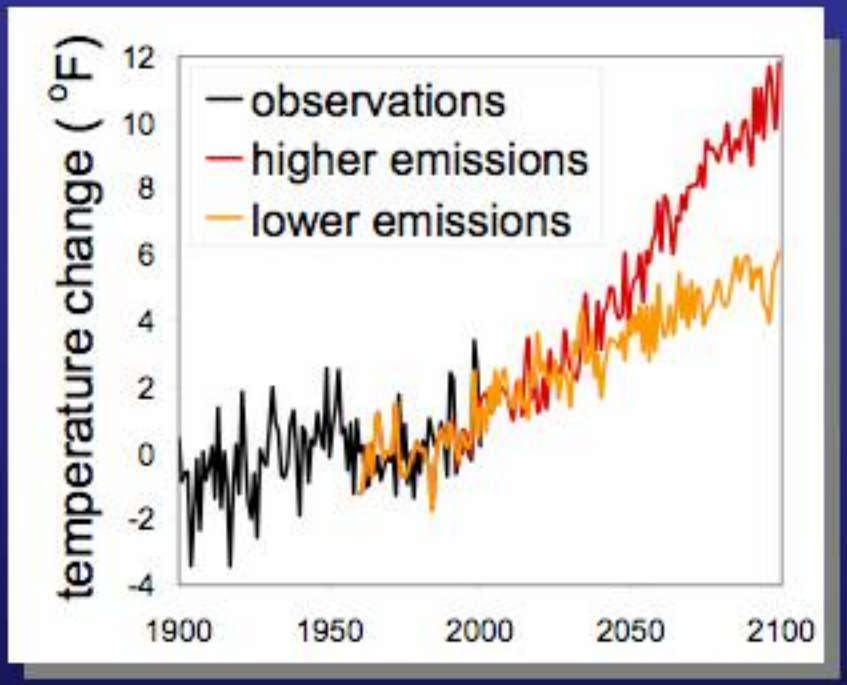


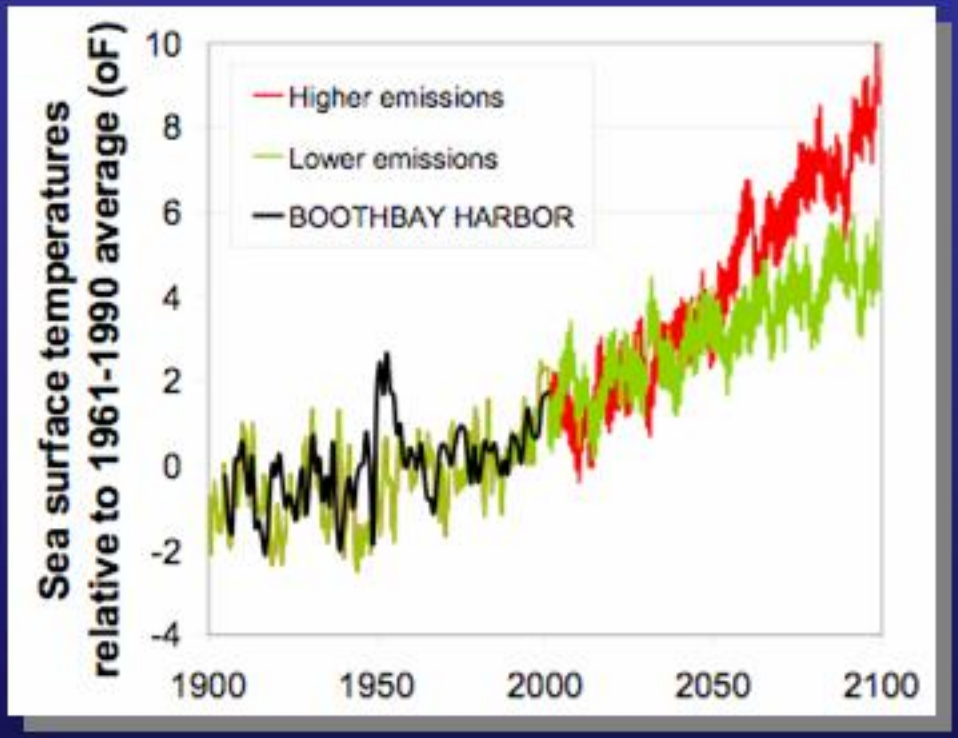
FIGURE SPM-4. Comparison of observed continental- and global-scale changes in surface temperature with results simulated by climate models using natural and anthropogenic forcings. Decadal averages of observations are shown for the period 1906–2005 (black line) plotted against the centre of the decade and relative to the corresponding average for 1901–1950. Lines are dashed where spatial coverage is less than 50%. Blue shaded bands show the 5–95% range for 19 simulations from 5 climate models using only the natural forcings due to solar activity and volcanoes. Red shaded bands show the 5–95% range for 58 simulations from 14 climate models using both natural and anthropogenic forcings. {FAQ 9.2, Figure 1}

Courtesy of IPCC, 2007

Changes in annual average temperature in the Northeast



Changes in sea surface temperature - Maine



Rhode Island climate "migration"

Summer in Rhode Island could feel like the typical summer in coastal South Carolina or Georgia by the end of the century unless we take action to reduce heat-trapping emissions today.

Lower-Emissions Scenarios: *a shift away from fossil fuels in favor of clean energy technologies, causing heat-trapping emissions to decline by mid-century*

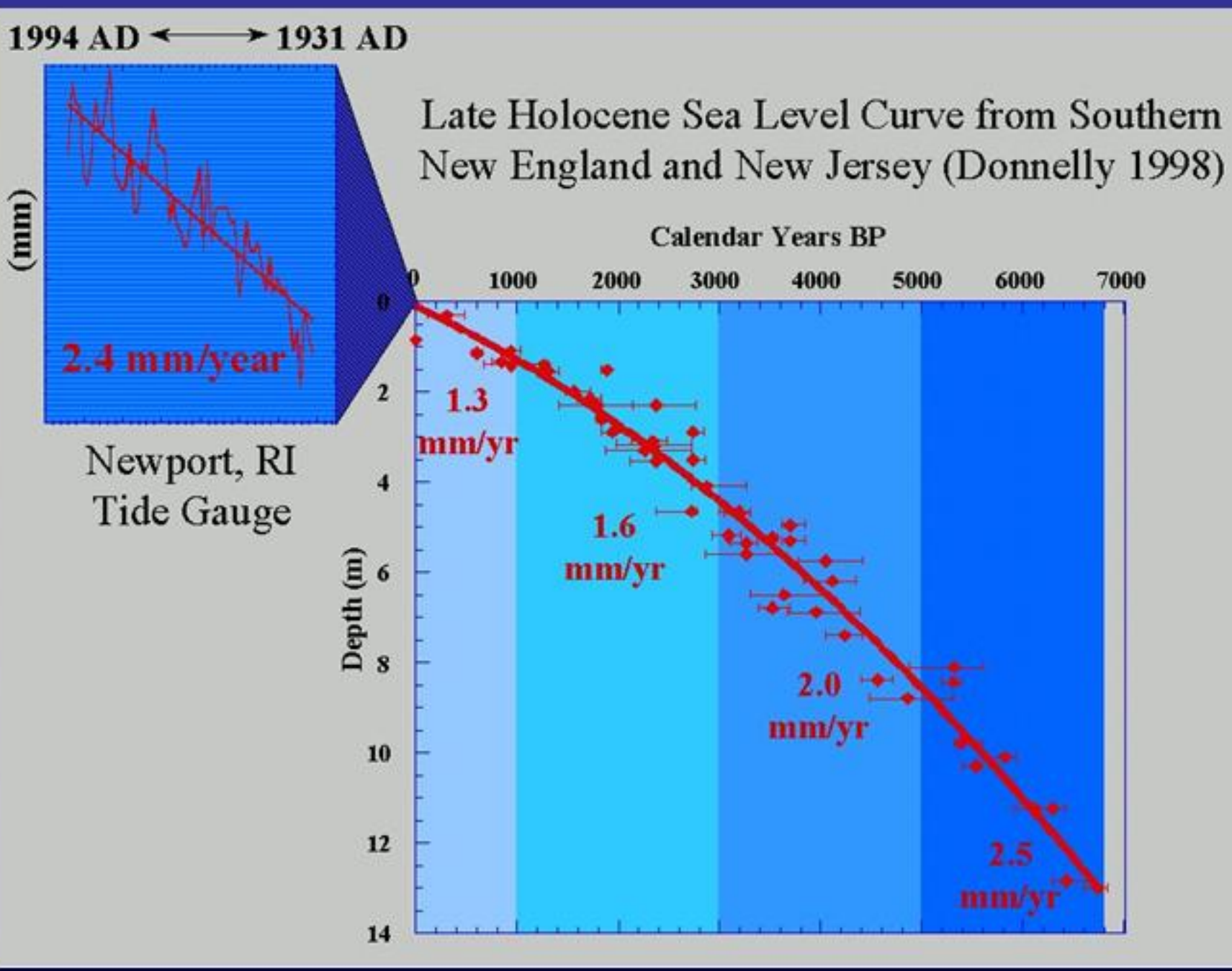
Higher-Emissions Scenarios: *continued heavy reliance on fossils fuels, causing heat-trapping emissions to rise rapidly over the century*

Courtesy of the Union of Concerned Scientists

Rising Sea Level

Four contributions to sea level rise

1. Thermal expansion of seawater
2. Melting of glaciers and ice caps
3. Ice sheet surface mass balance
   - snowfall - melting
4. Ice sheet surface dynamical imbalance
   - increased flow rate


1994 AD ← → 1931 AD
(mm)
2.4 mm/year
Newport, RI
Tide Gauge
Late Holocene Sea Level Curve from Southern New England and New Jersey (Donnelly 1998)
Calendar Years BP
0
1000
2000
3000
4000
5000
6000
7000
Depth (m)
0
2
4
6
8
10
12
14
1.3 mm/yr
1.6 mm/yr
2.0 mm/yr
2.5 mm/yr

Sea Level Rise: Observed vs. Projected

Interval	Model Prediction mm/year	Observed mm/year
1993 - 2003	2.6	3.1
1961 - 2003	1.2	1.8

Projected globally averaged surface warming & sea level rise at the end of the 21st century

Case	Temperature Change (°C at 2090-2099 relative to 1980-1999) [a]		Sea Level Rise (m at 2090-2099 relative to 1980-1999)
	Best estimate	*Likely* range	Model-based range excluding future rapid dynamical changes in ice flow
Constant Year 2000 concentrations [b]	0.6	0.3 – 0.9	NA
B1 scenario	1.8	1.1 – 2.9	0.18 – 0.38
A1T scenario	2.4	1.4 – 3.8	0.20 – 0.45
B2 scenario	2.4	1.4 – 3.8	0.20 – 0.43
A1B scenario	2.8	1.7 – 4.4	0.21 – 0.48
A2 scenario	3.4	2.0 – 5.4	0.23 – 0.51
A1FI scenario	4.0	2.4 – 6.4	0.26 – 0.59

Table notes:

[a] These estimates are assessed from a hierarchy of models that encompass a simple climate model, several Earth Models of Intermediate Complexity (EMICs), and a large number of Atmosphere-Ocean Global Circulaion Models (AOGCMs).

[b] Year 2000 constant composition is derived from AOGCMs only.

Courtesy of IPCC, 2007

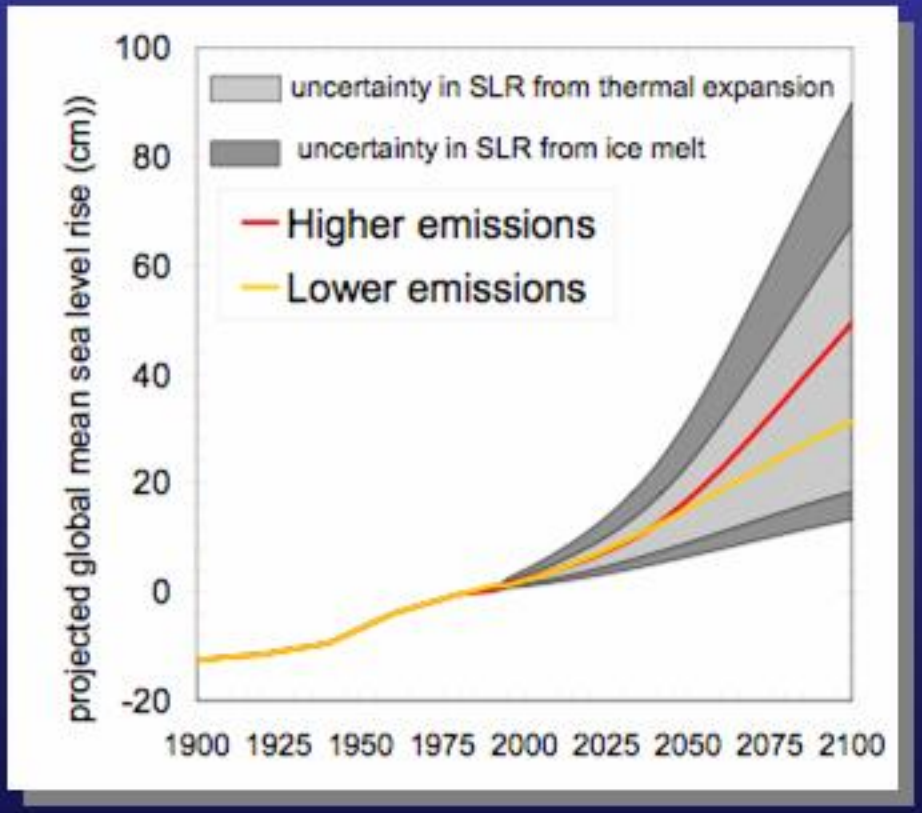
2006 - IPCC estimate

1. Thermal expansion of seawater ..... 28 cm
2. Glaciers and ice caps ..... 12 cm
3. Mass balance ..... - 3 cm
4. Increased flow ..... + 3 cm

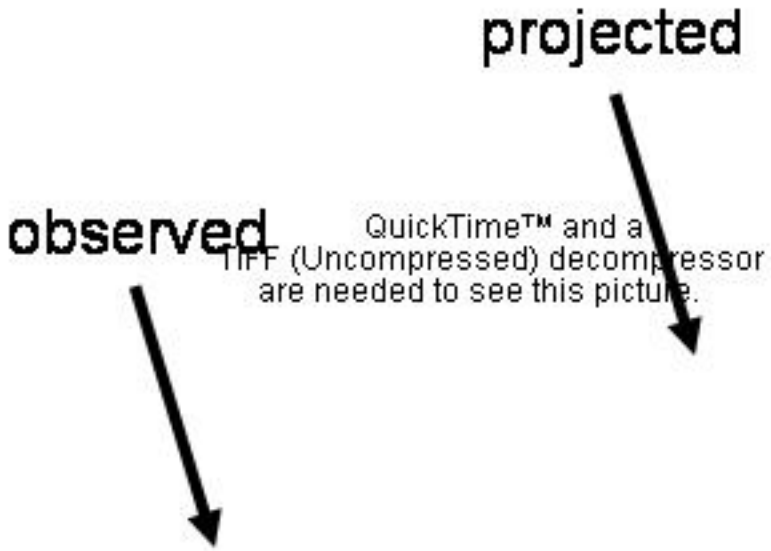
Total: 40 cm

Range of Estimates: 18-59 cm

Sea level rise projections

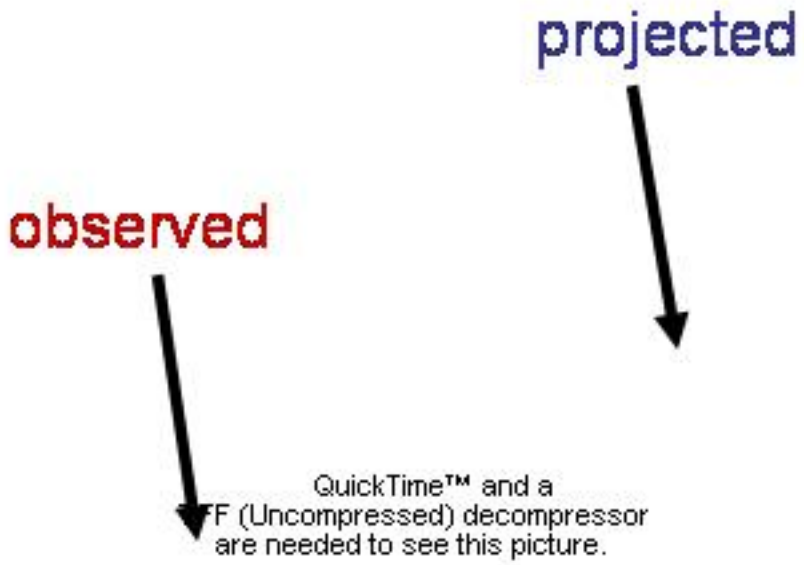


Observed and Projected Sea Level Rise by 2100



Church & White, 2006, Courtesy of IPCC, 2007

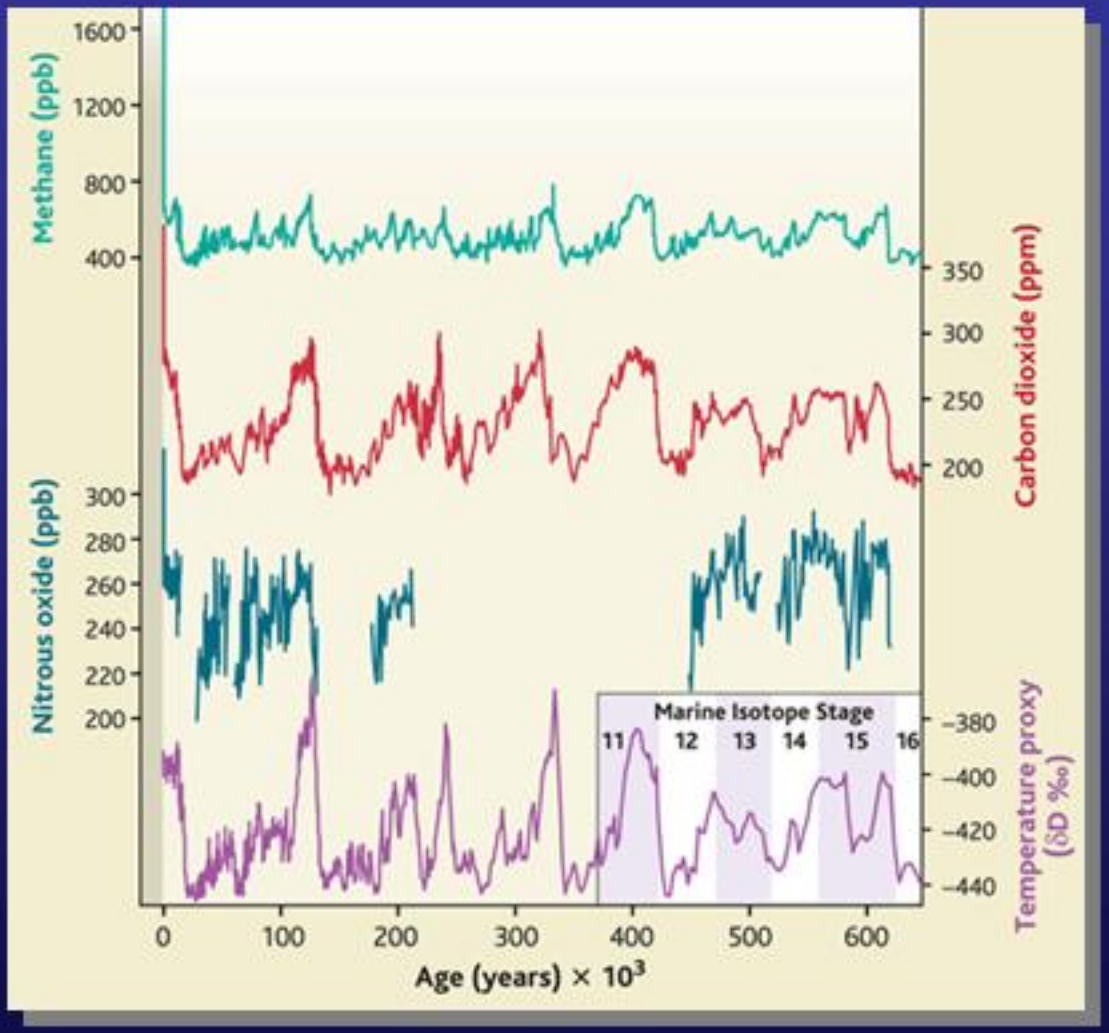
Sea Level Rise: Observed = Projected



Sea Level Rise: New Estimates

Reference	By 2100 (feet)	Total Rise (feet)
Overpeck, *et al*, 2006	> 3	13 - 20
Rahmstorf, 2007	1.6 - 4.6	---

Greenhouse Gases in Ice Cores

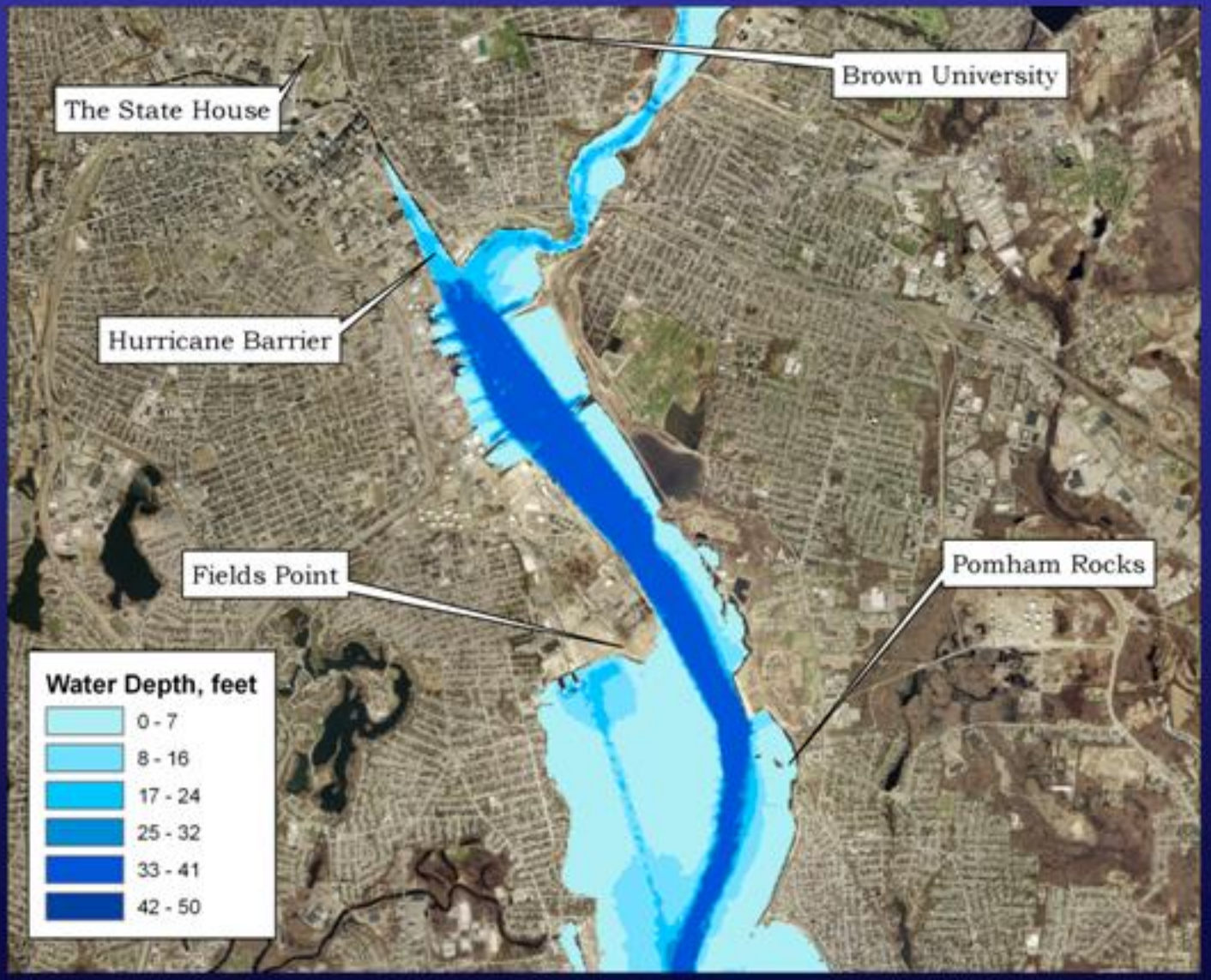


From Brook, E. J., 2005. Science , 25 vol. 310. no. 5752, pp. 1285 - 1287

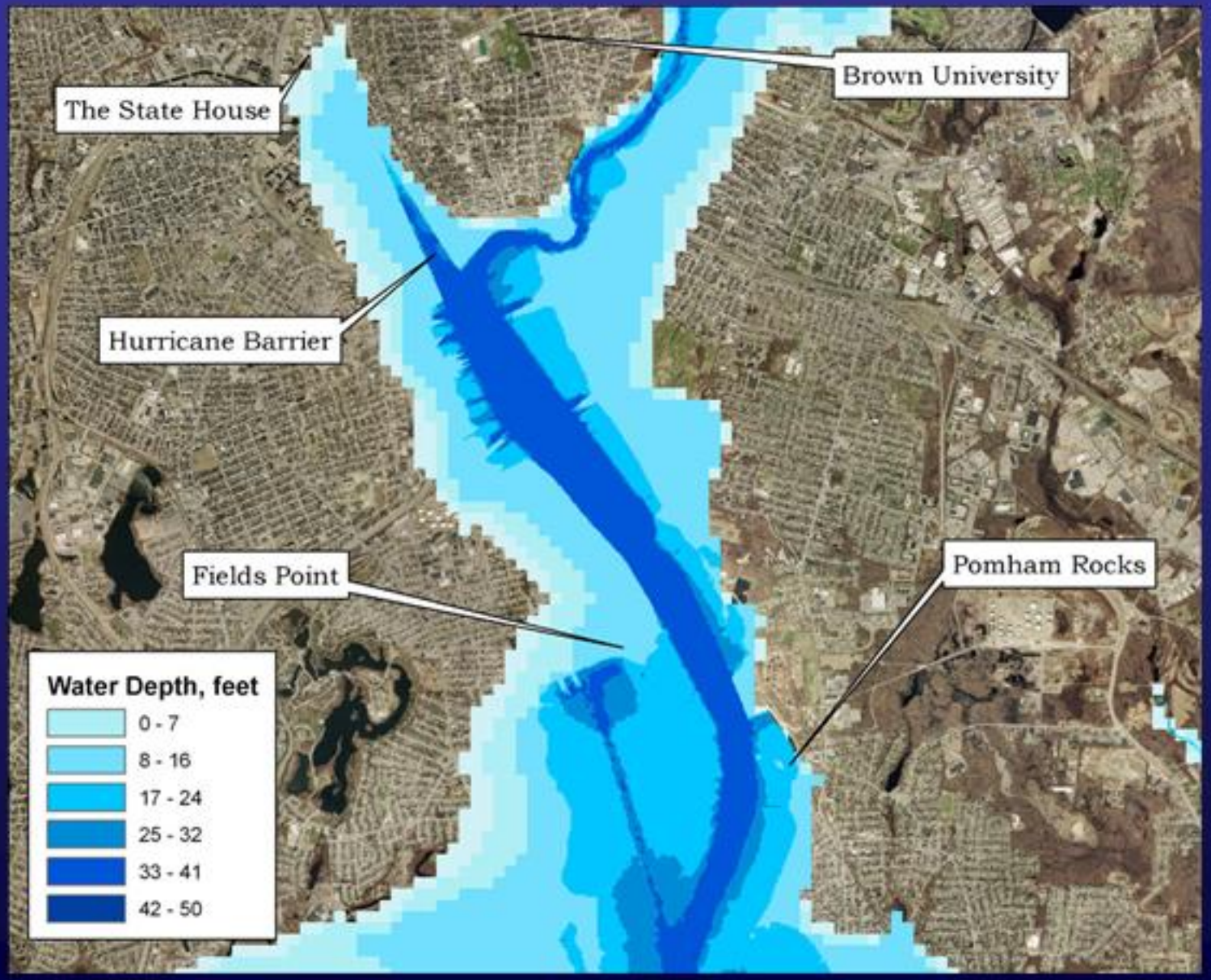
Rising Sea Level in Rhode Island ~

Providence

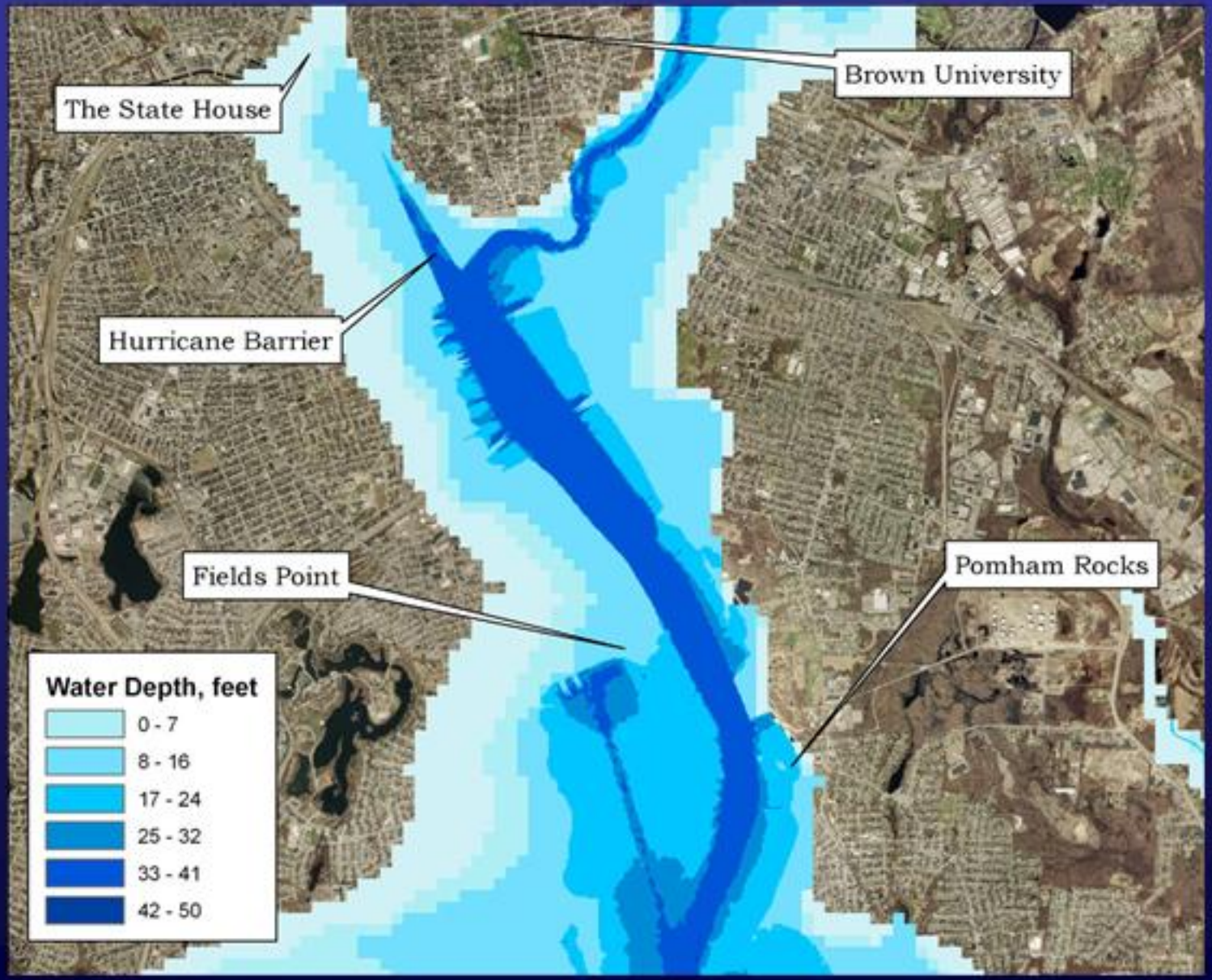
Providence: present sea level



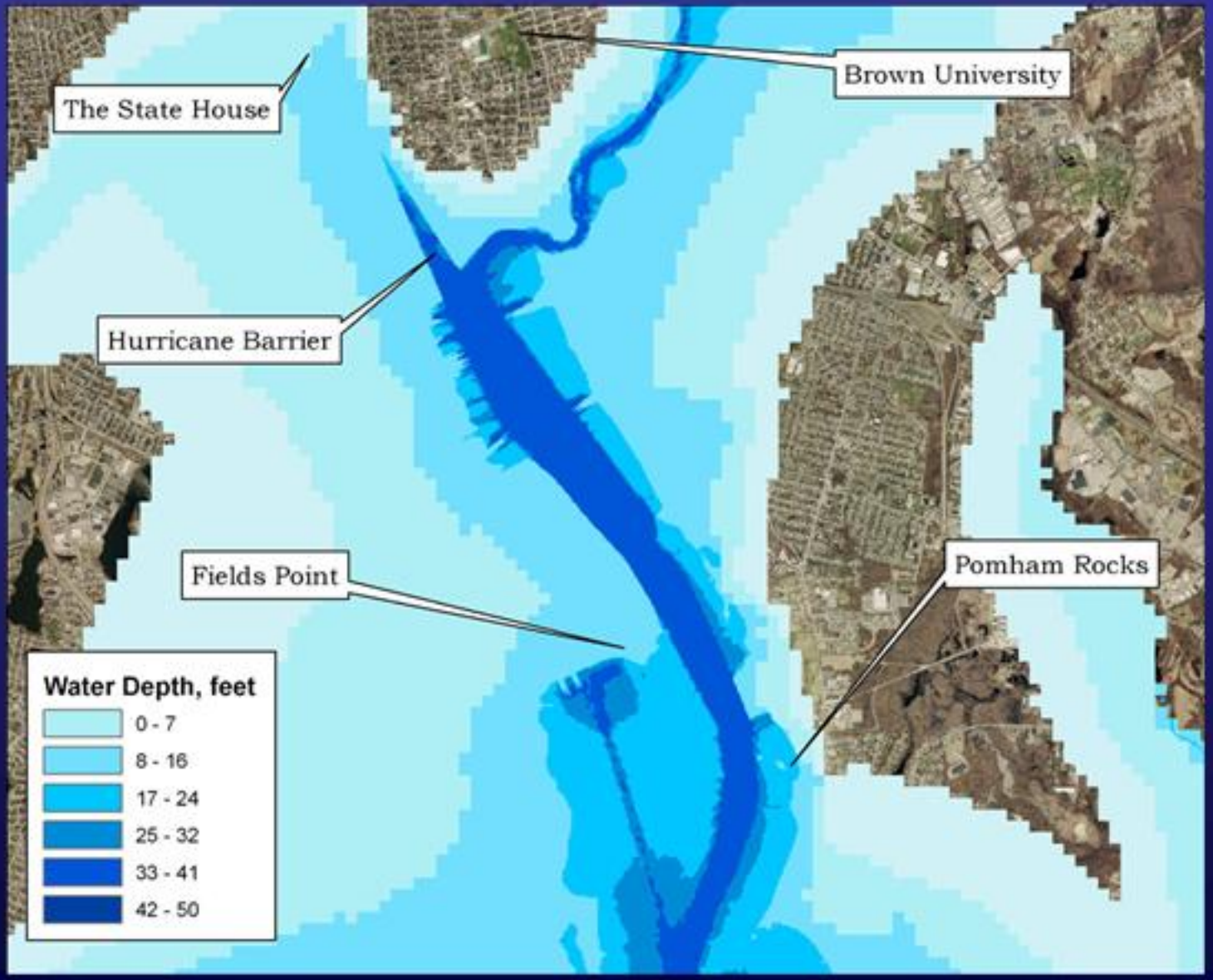
Providence: 3 ft. sea level rise



Providence: 5 ft. sea level rise



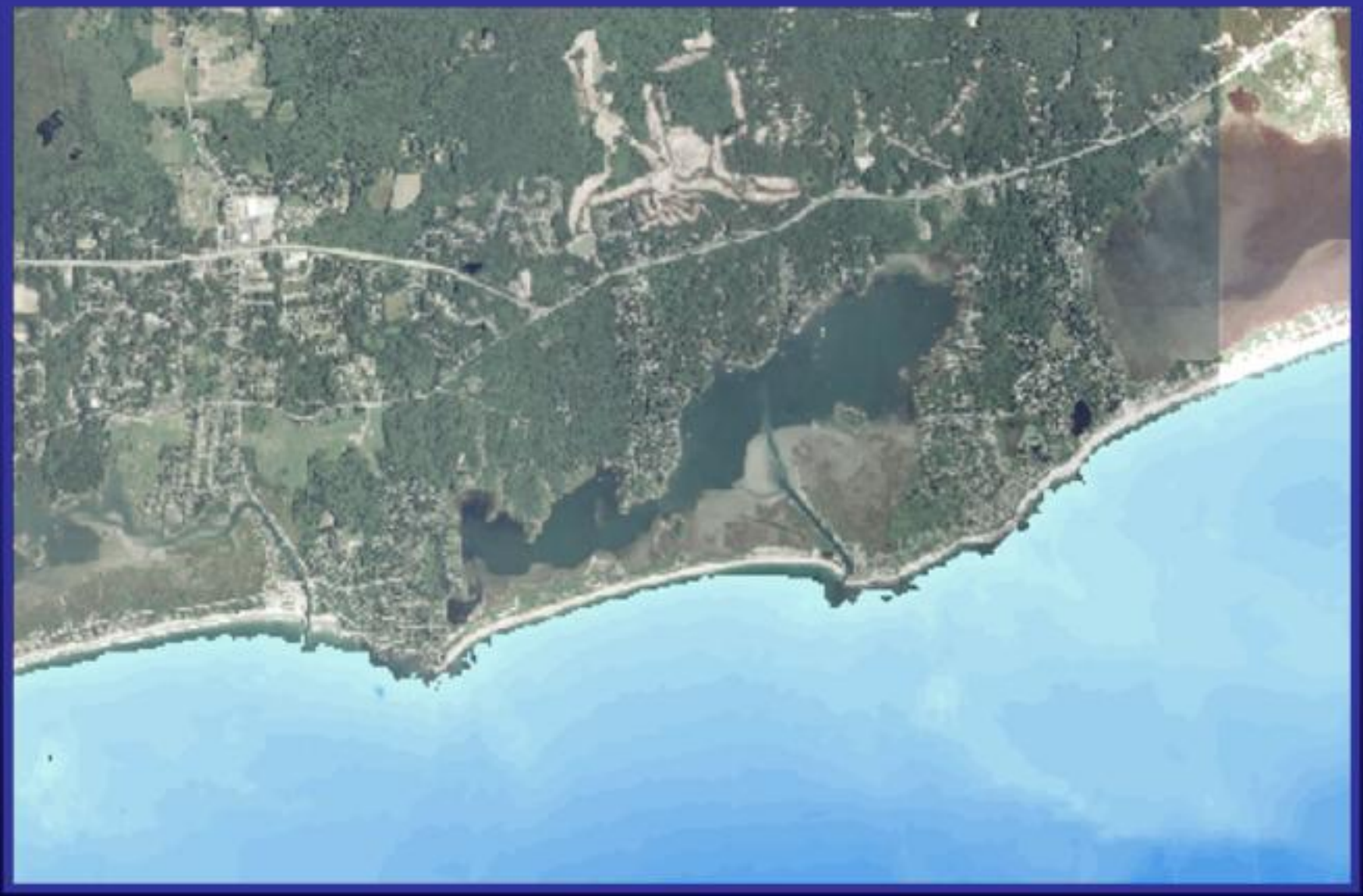
Providence: 20 ft. sea level rise



Rising Sea Level in Rhode Island ~

Southern Coastal Ponds

Quonnie Pond: present sea level



Quonnie Pond: 3 ft. sea level rise

Quonnie Pond: 20 ft. sea level rise

Planning Needs

1. Seamless digital terrain model for RI
   - LIDAR survey of coastline
   - High-resolution bathymetry of coastal waters

2. Inundation model
   - Storm surge with wave regime superimposed
   - Better understanding of coastal erosion style and rate
   - Expanded Rhode Island sea level and coastal erosion monitoring program

"Perhaps our epitaph will be:

The good Earth. We could have saved it, but we were too damn cheap and lazy."

~ Kurt Vonnegut