

Climate Change and Sea Level Rise in Coastal NH : Past, Present, and Future

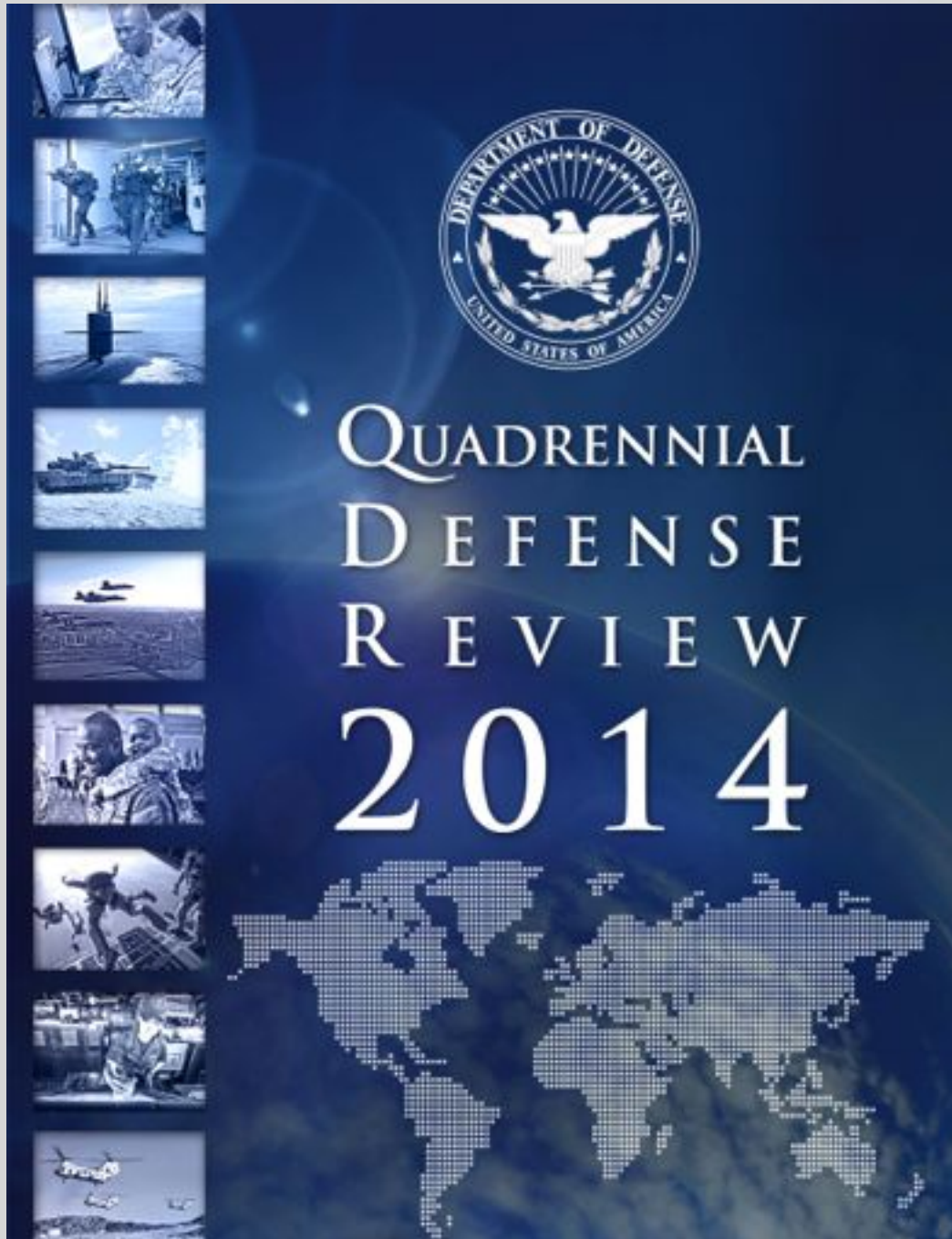
Cameron Wake

**Institute for the Study of Earth, Oceans, and Space (EOS)
Josephine A Lamprey Professor in Climate & Sustainability
University of New Hampshire**



**@TheClimateDr
<http://CarbonSolutionsNE.org>**

Preparing for Climate Change in Rye NH 1 April 2014



Climate change poses another significant challenge for the United States and the world at large. As greenhouse gas emissions increase, sea levels are rising, average global temperatures are increasing, and severe weather patterns are accelerating. . . . These effects are threat multipliers that will aggravate stressors abroad such as poverty, environmental degradation, political instability, and social tensions

www.climate.gov

Global Climate Dashboard

▼ Climate Change

► Climate Variability

► Climate Projections

Global Average Temperature (°C)

The temperature near Earth's surface is rising; the bars show each year's average temperature compared to the 20th century average.

[Learn More >>](#)



Sun's Energy (W/m²)

The sun's energy rises and falls slightly on an 11-year cycle, with little net change over the last century.

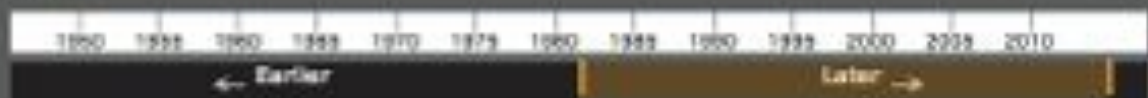
[Learn More >>](#)



Global Average Sea Level (mm)

The ocean's surface is rising; water expands as it warms, and melting of ice sheets and glaciers on land adds water to the ocean.

[Learn More >>](#)



▲ Temperature

► Carbon Dioxide

► Snow

▲ Sea Level

► Arctic Sea Ice

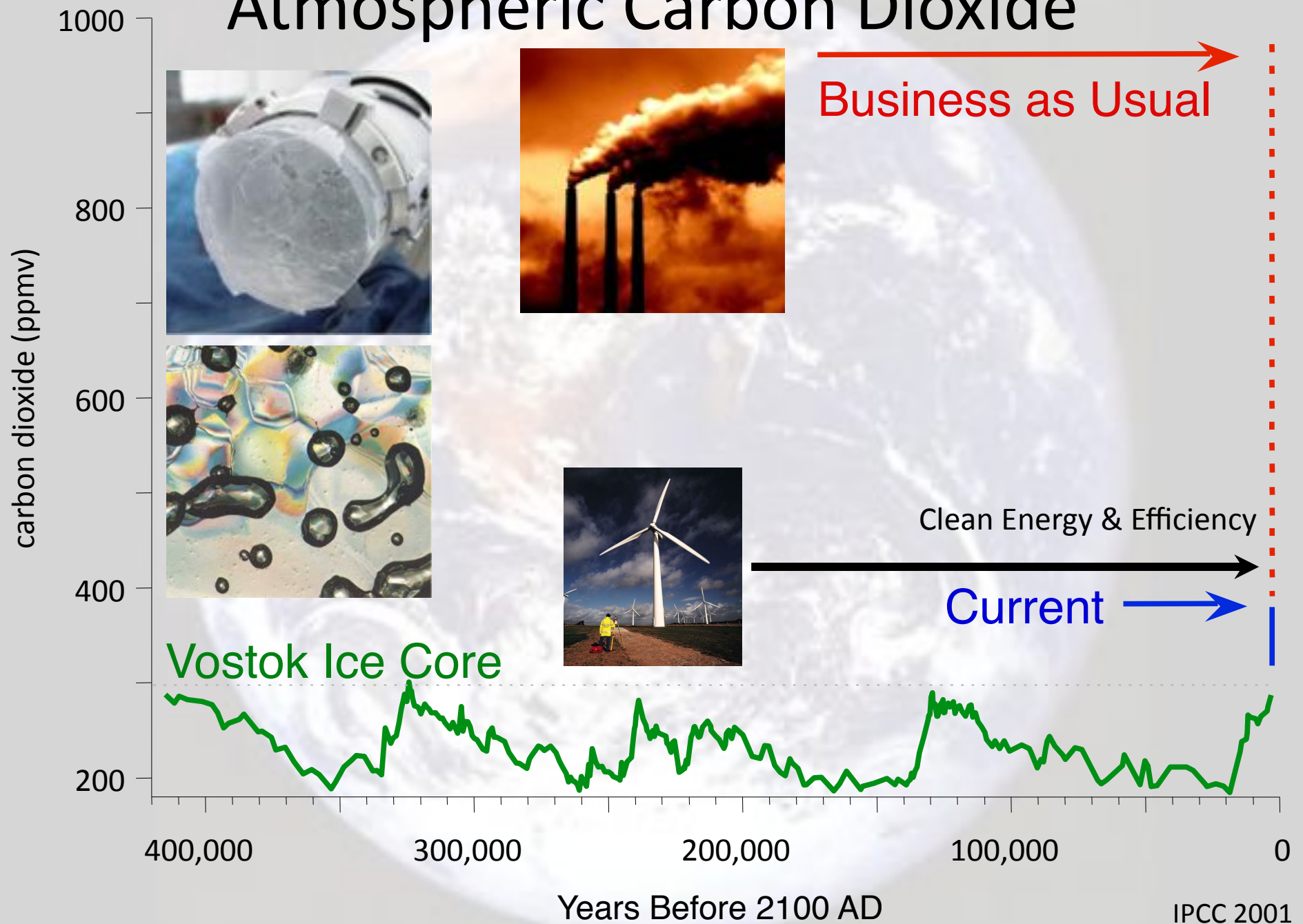
► Ocean Heat

▲ Sun's Energy

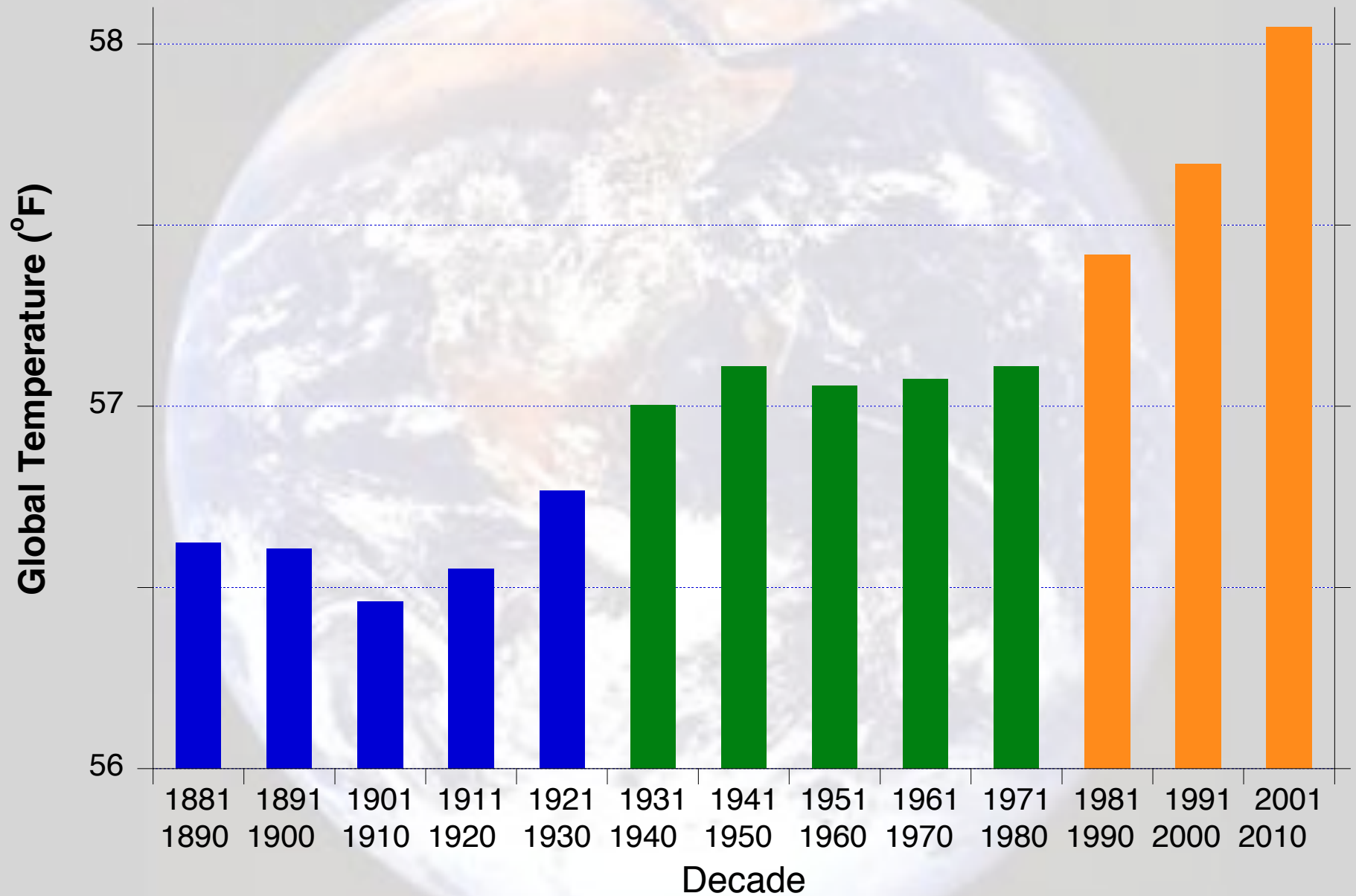
► Glaciers

► Heat-Trapping Gases

Atmospheric Carbon Dioxide



Decadal global surface-air temperature (land and SST)



WMO 2013

Were You Ready for the Storm?



Northeast US 30 October 2011



Newmarket, NH April 2007

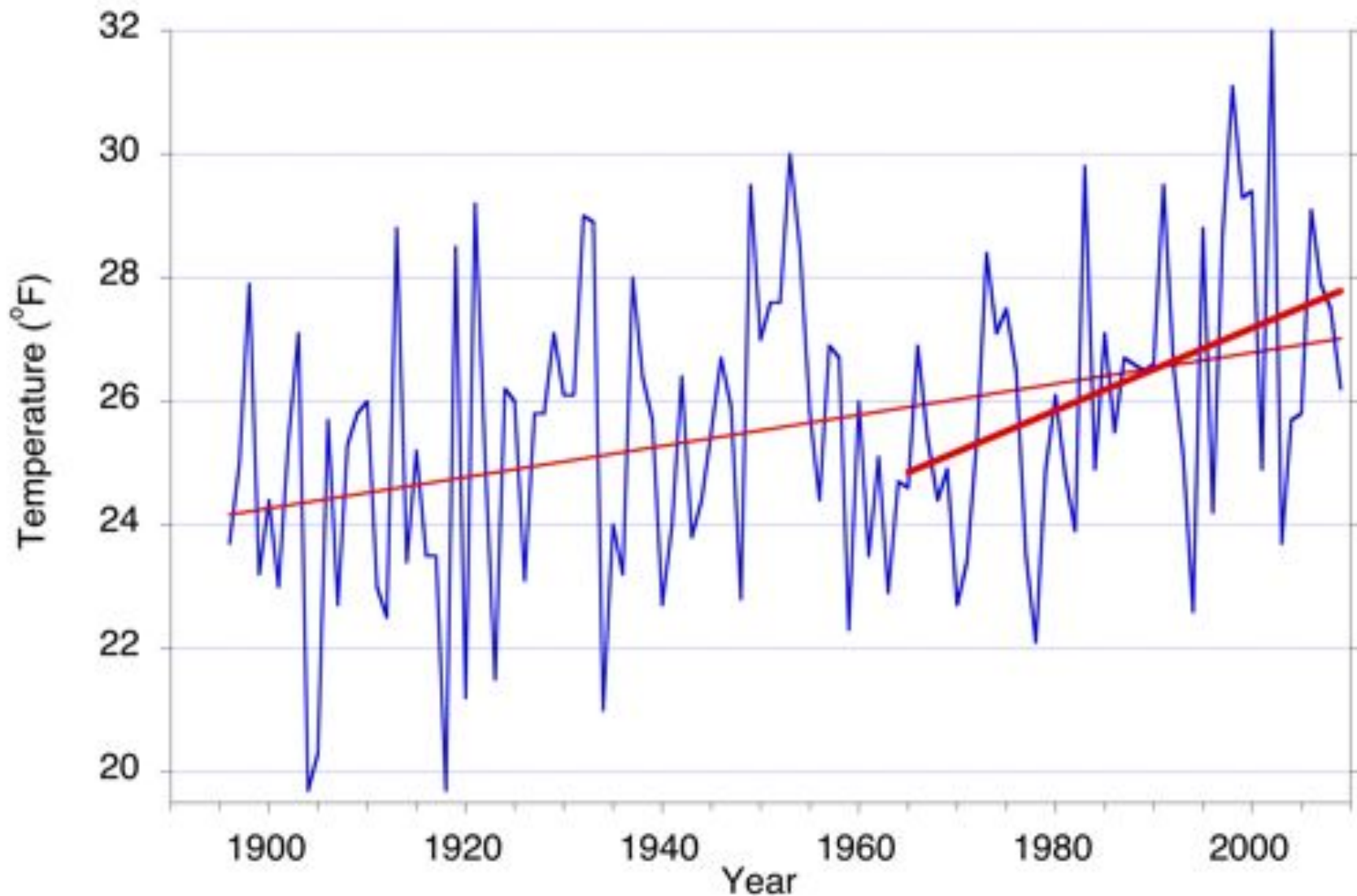


Woodford, VT 28 Aug 2011



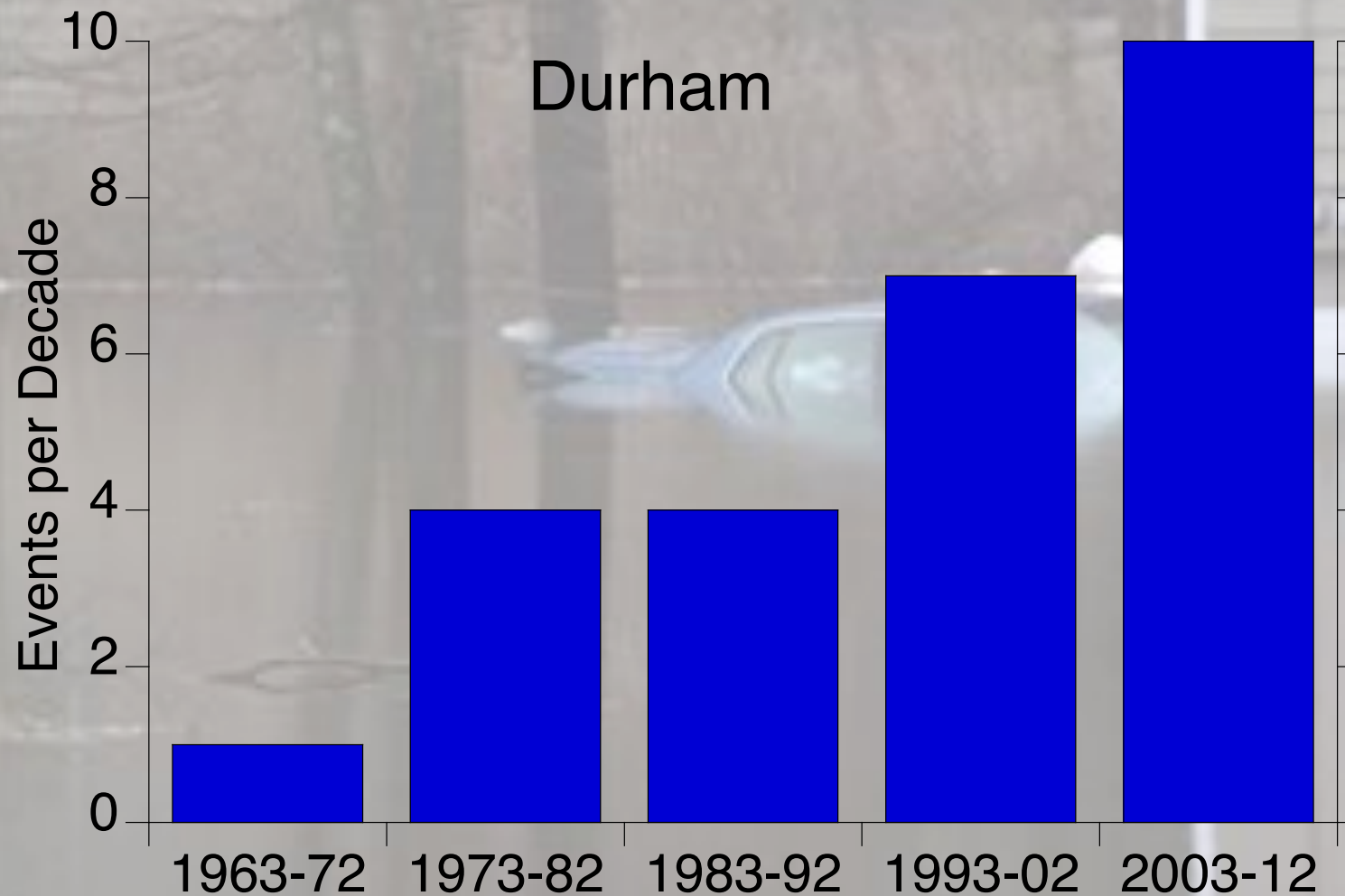
Seaside Heights, NJ Nov 2012

Northeast Winter Temperature Trends 1895-2008

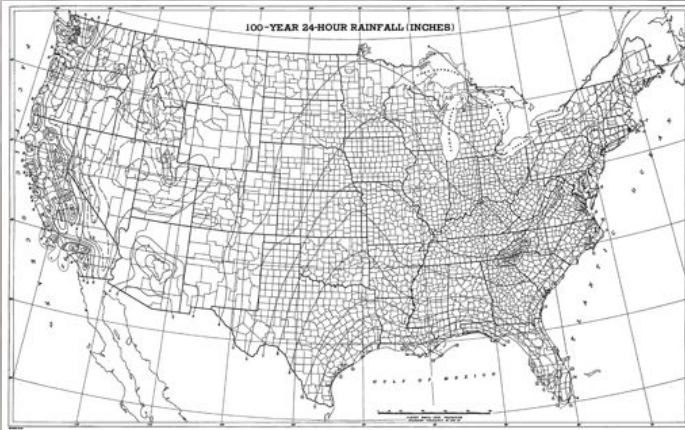


Burakowski et al., 2008, JGR

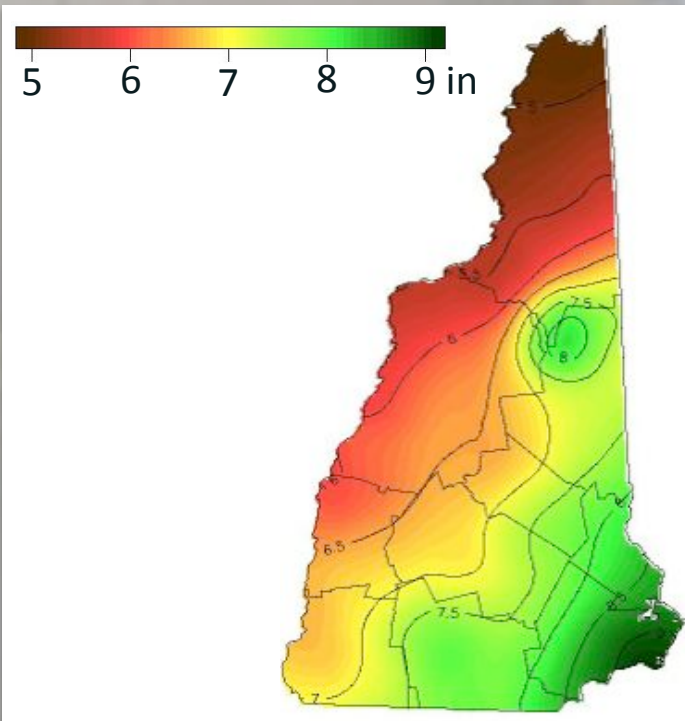
4 Inch Precipitation Events by Decade 1963 – 2012



Updated 24-hour 100-year Design Storm



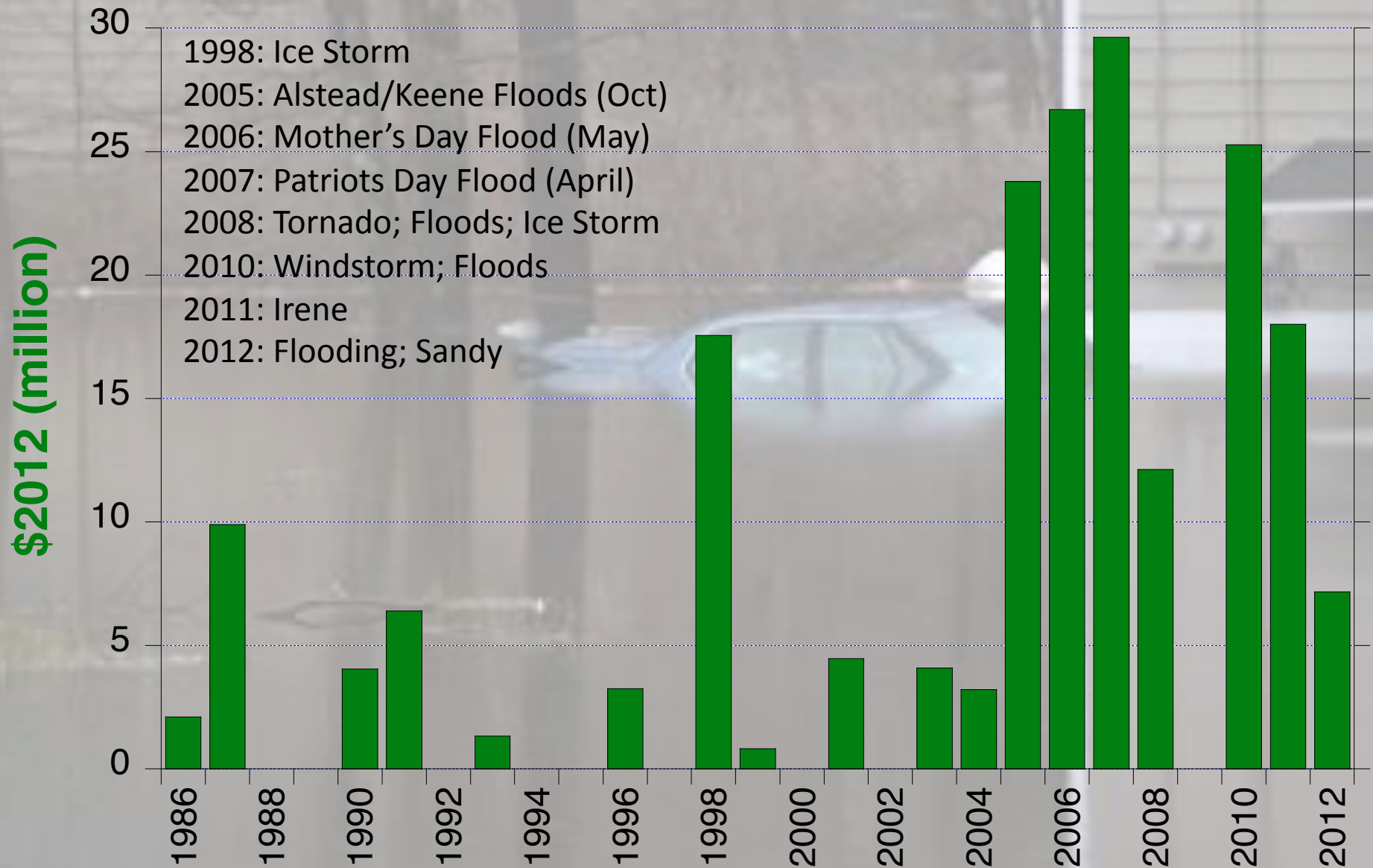
TP-40 (Hershfield 1961)
Rainfall Frequency Atlas
24 hr 100-year rainfall = 6.3"
1938-1957



Northeast Regional Climate Ctr
Atlas for Extreme Precipitation
24 hr 100-year rainfall = 8.5"
Data up through 2008

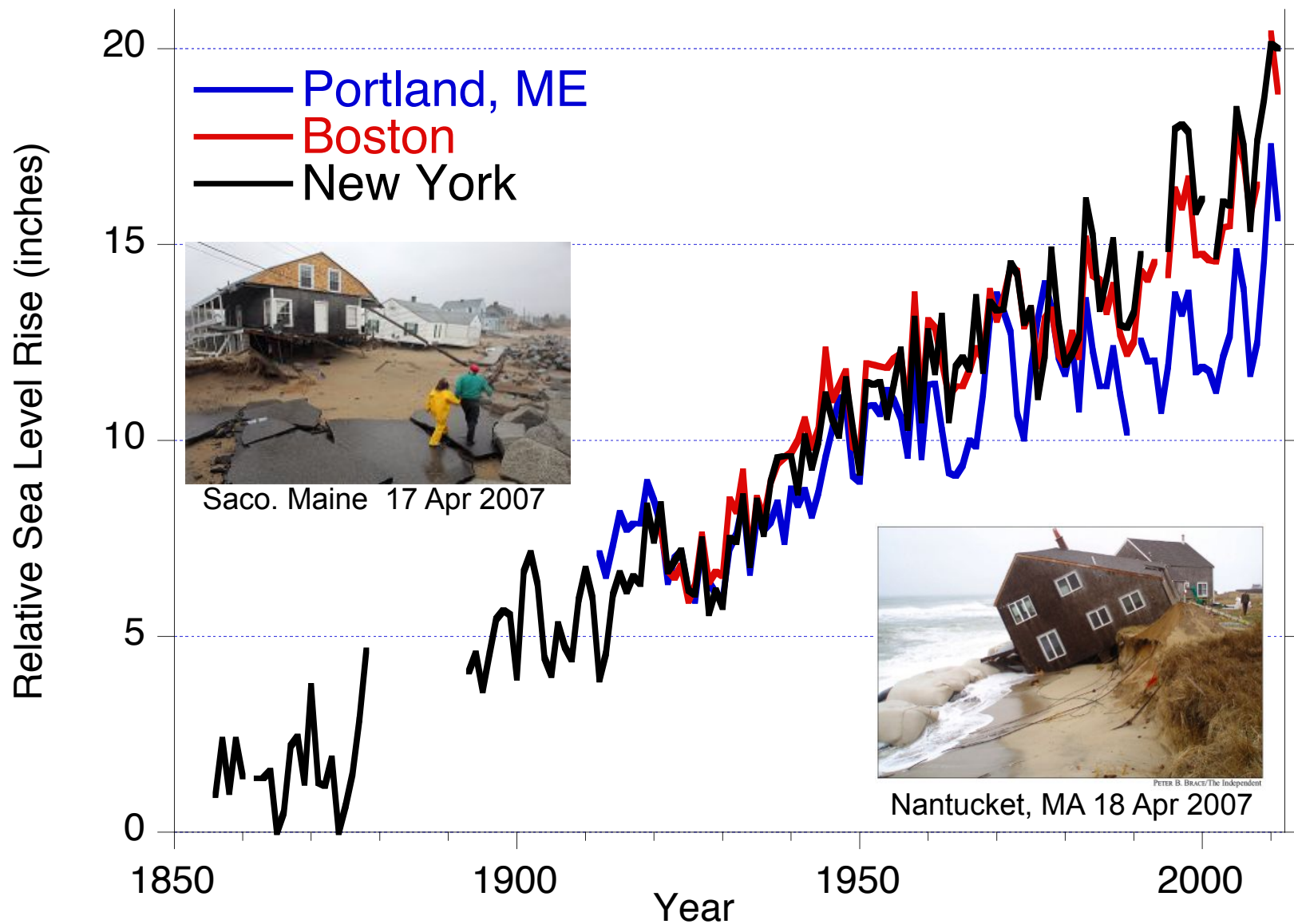
<http://precip.eas.cornell.edu/>

Federal Expenditures on Presidentially Declared Disasters And Emergency Declarations in NH



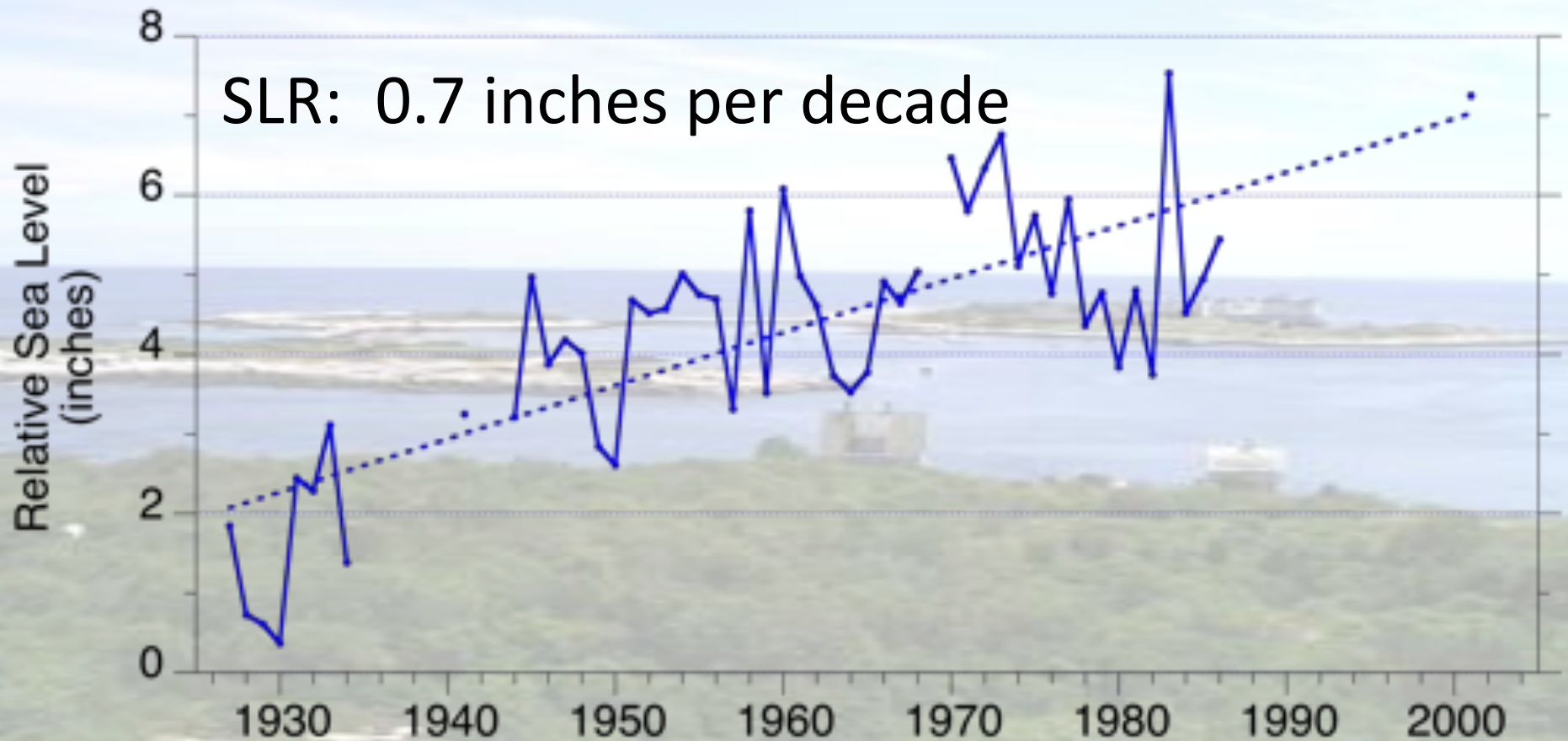
Data from www.fema.gov/disasters/grid/state-tribal-government

Relative Sea Level Rise 1956 - 2011



Data from Permanent Service for Mean Sea Level <http://www.psmsl.org>

Sea Level Rise at Portsmouth Harbor 1927 - 2001



Northeast Climate Impacts Assessment

A Report of the Northeast Climate Impacts Assessment

Confronting Climate Change in the U.S. Northeast



SCIENCE, IMPACTS, AND SOLUTIONS

JULY 2007

- Collaboration between Union of Concerned Scientists and 50 independent scientists
- **Geographic Scope**
Nine Northeast states, from Maine to Pennsylvania
- **Peer Review**
Climate Dynamics, 2007
14 papers in *Adaptation and Mitigation of Climate Change*, 2008

www.climatechoices.org

CARBON SOLUTIONS
NEW ENGLAND
CarbonSolutionsNE.org



Climate Change in the Piscataqua/Great Bay Region: Past, Present, and Future

ClimateSolutionsNE.org



Climate Change in Southern New Hampshire

PAST, PRESENT, AND FUTURE

A PUBLICATION OF THE SUSTAINABILITY INSTITUTE AT THE UNIVERSITY OF NEW HAMPSHIRE

UNIVERSITY
of NEW HAMPSHIRE



Climate Change in Northern New Hampshire

PAST, PRESENT, AND FUTURE

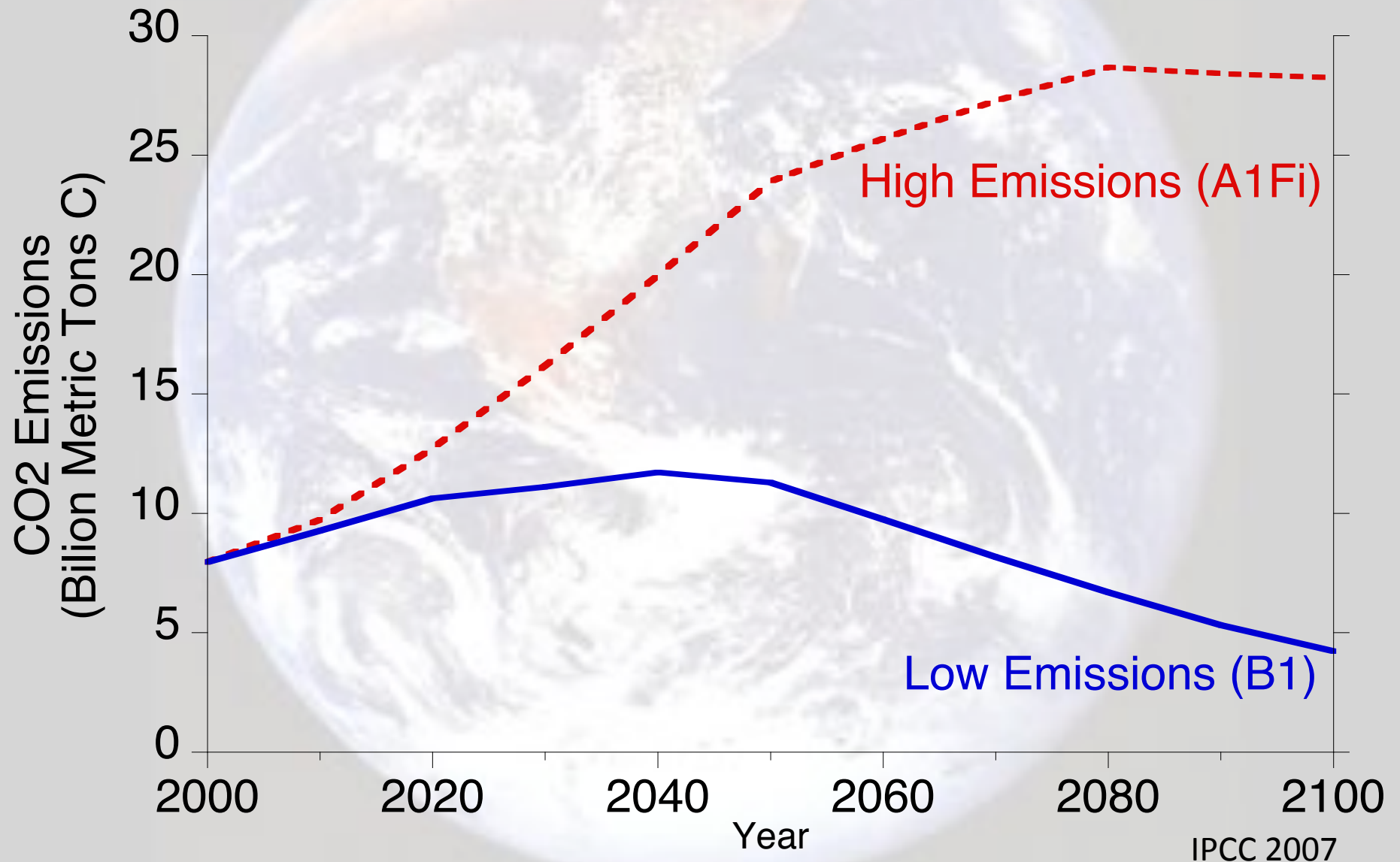
A PUBLICATION OF THE SUSTAINABILITY INSTITUTE AT THE UNIVERSITY OF NEW HAMPSHIRE

climate
solutions
new england

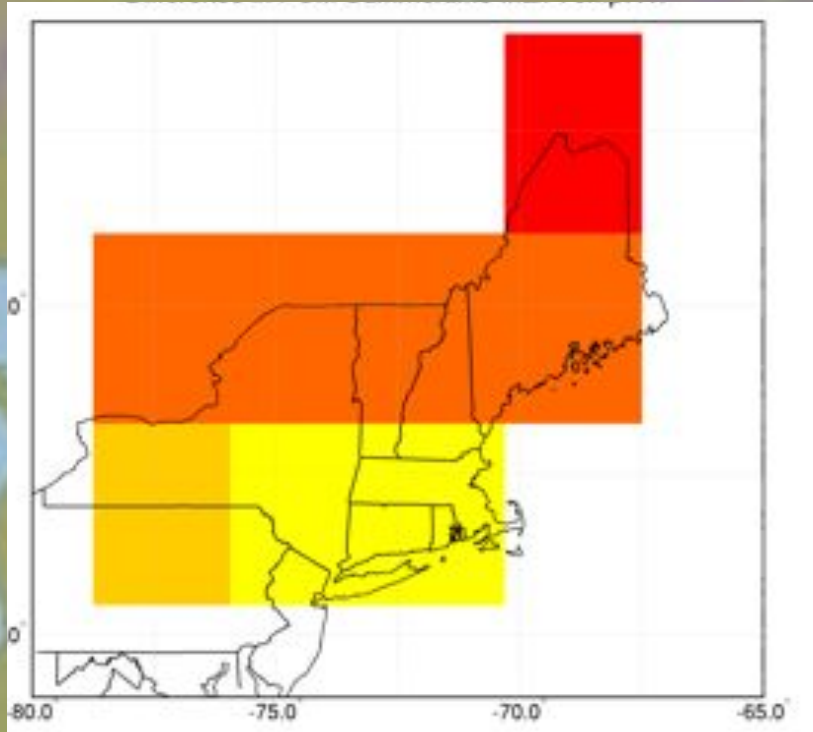
climate
solutions
new england

Global Greenhouse Gas Emission Scenarios

Key Input for GCM projections of future climate change



Projecting Future Climate Change for the Northeast: Downscale Global Projections to Regional Level



Projections from 3 or 4 different climate models:

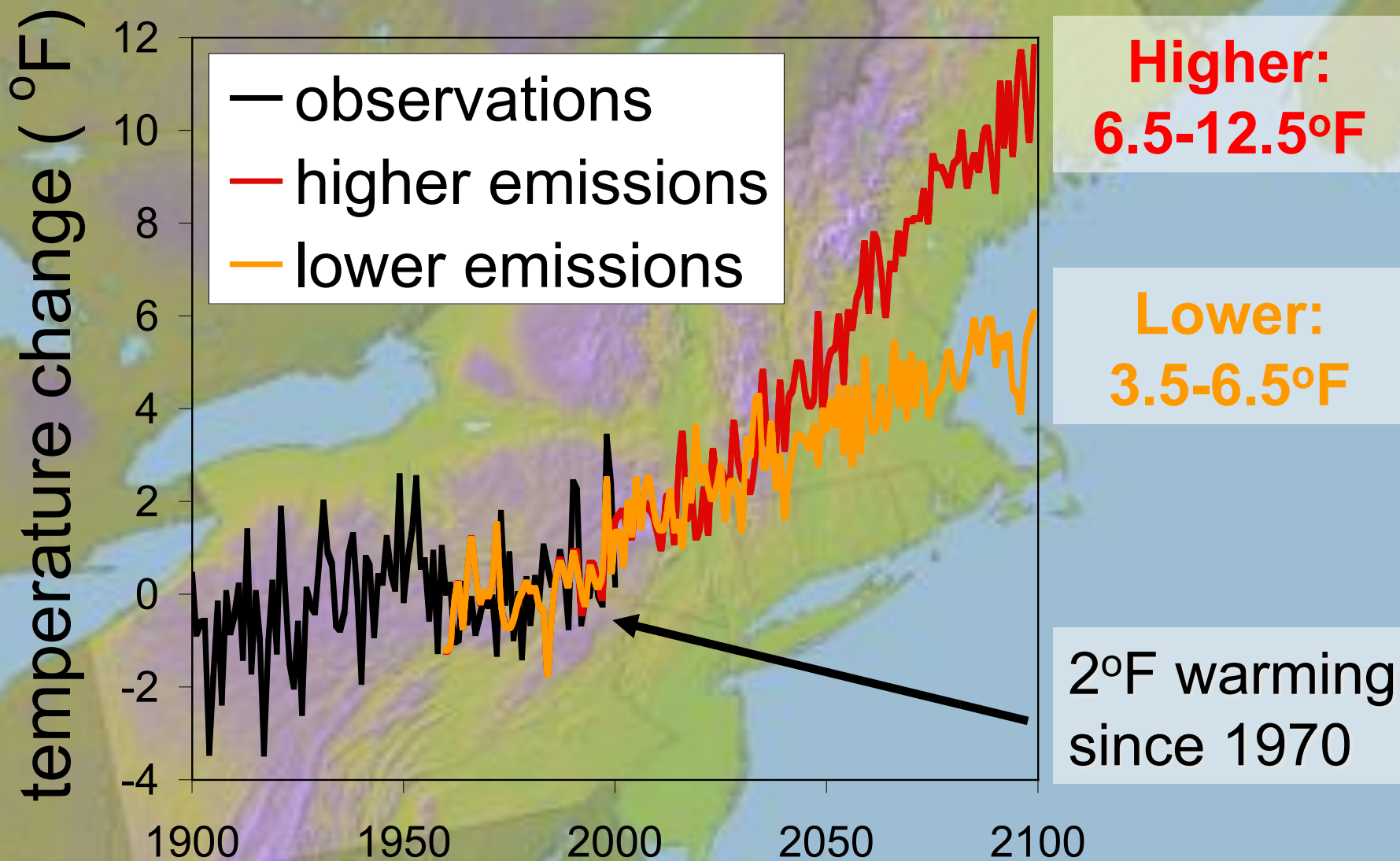
NOAA – GFDL

UKMO – HadCM3

NCAR – PCM

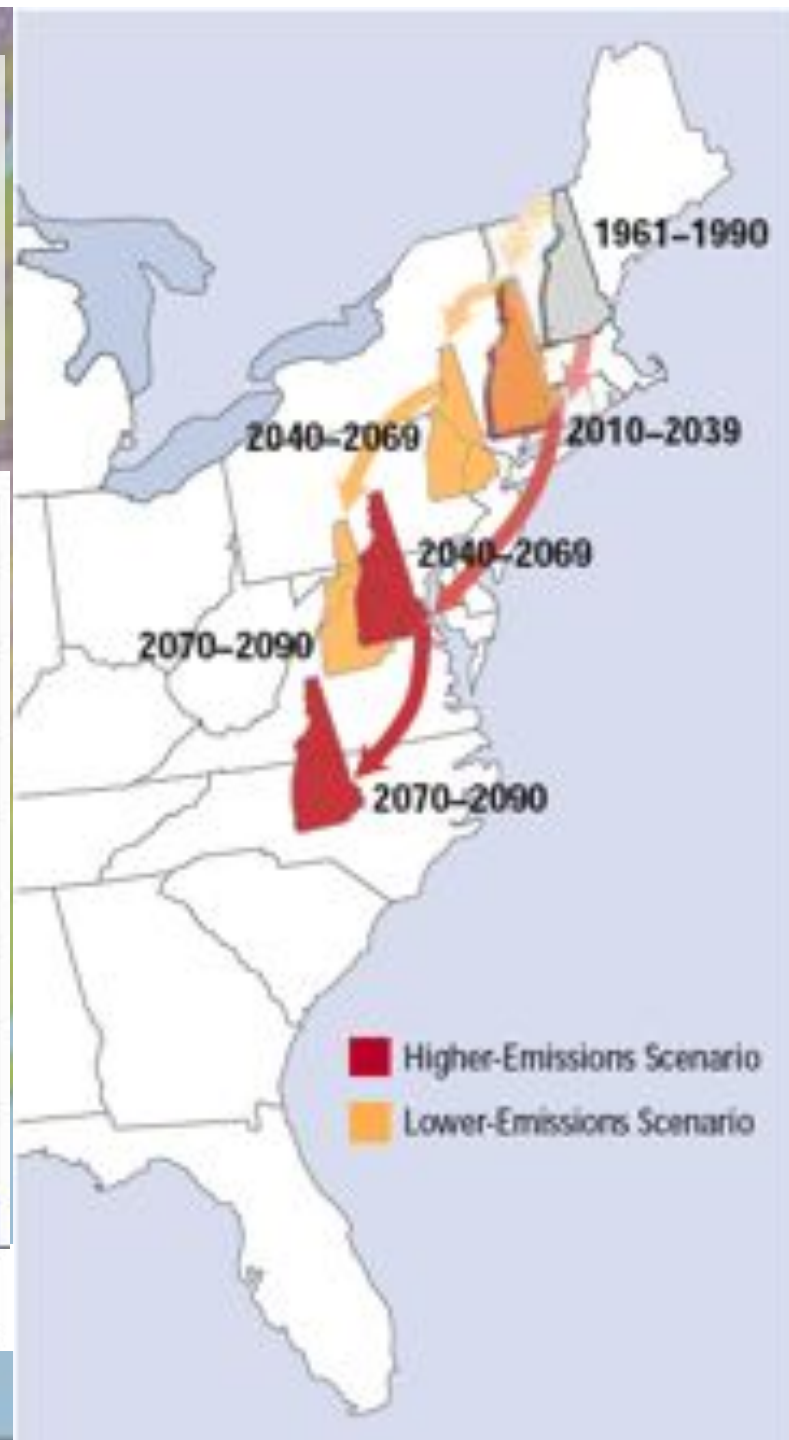
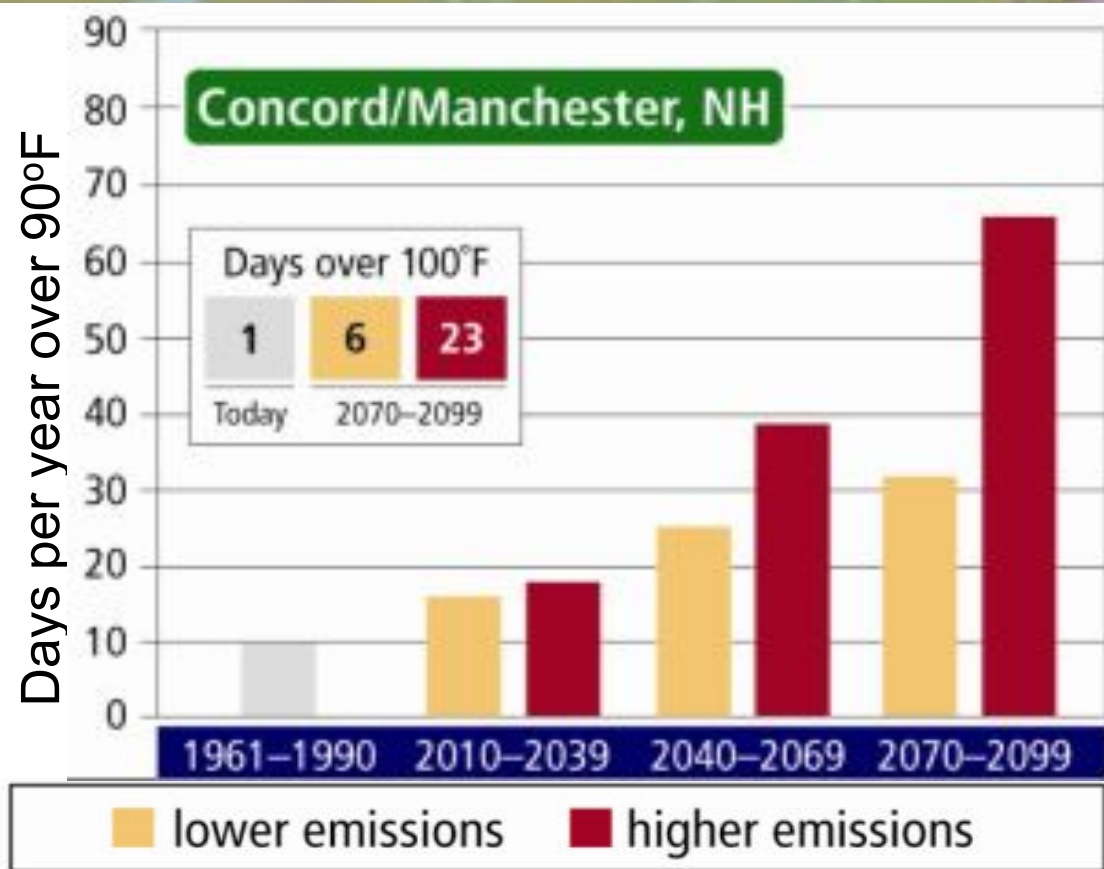
NCAR – CCSM3

Projecting Future Climate Change for the Northeast: Rising Annual Temperatures

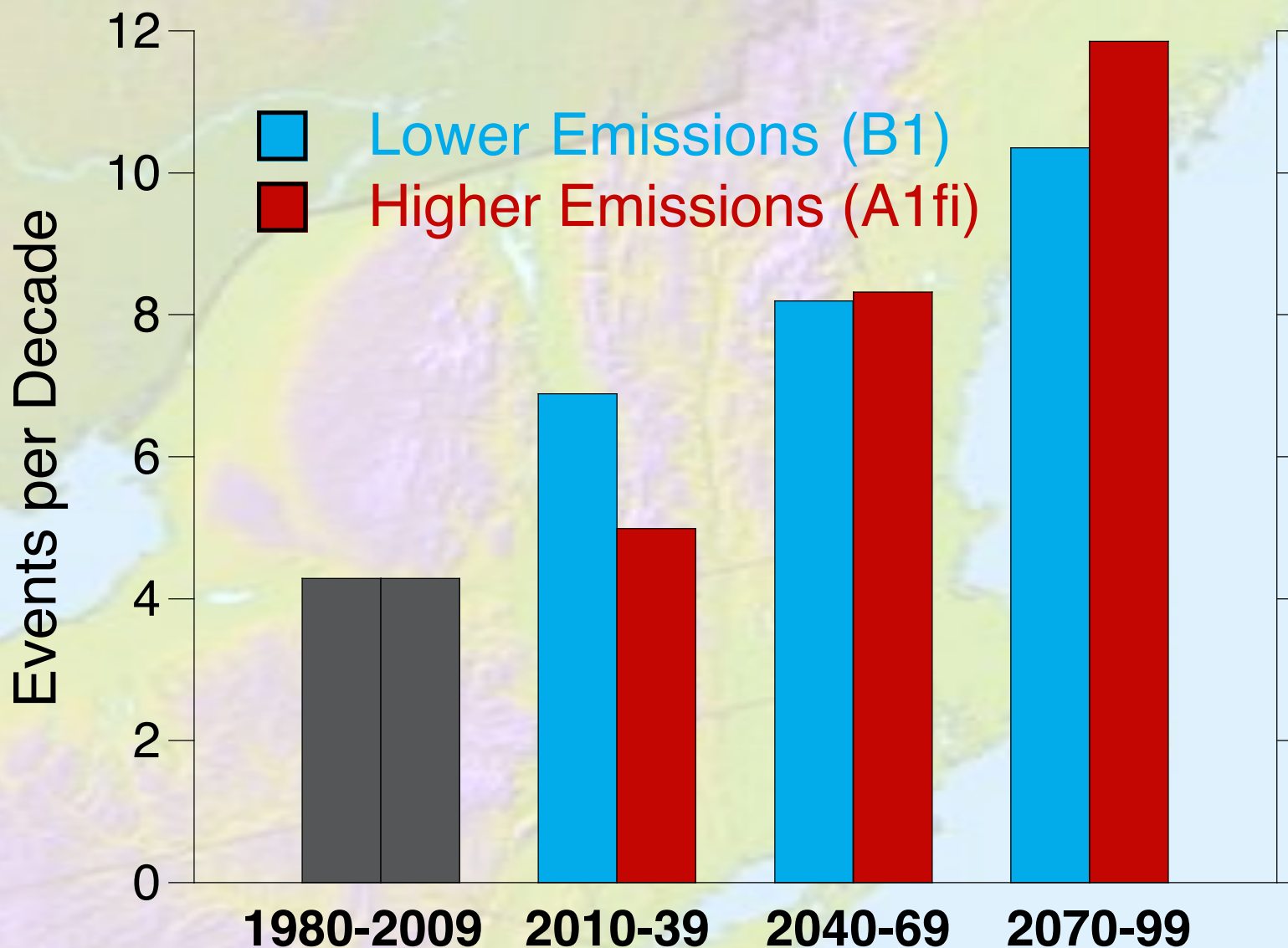


Summer heat index:

*How hot summers will “feel” in
New Hampshire*



Precipitation Events >4" in 48 hrs per Decade (30 year averages) for Southern NH (41 Stations)



Drought



1961-1990

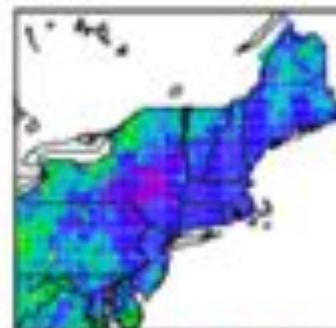
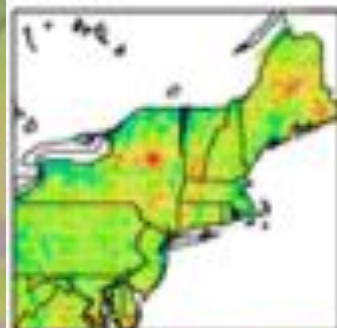


0 5 10 15 20 25 30

0 1 2 3 4 5

0 0.5 1 1.5 2

Lower Emissions (B1)

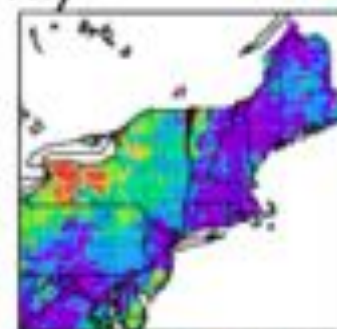
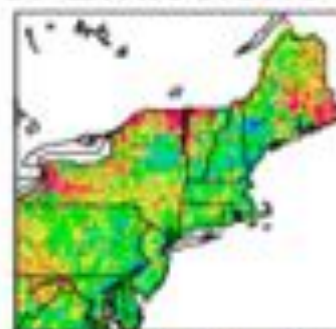
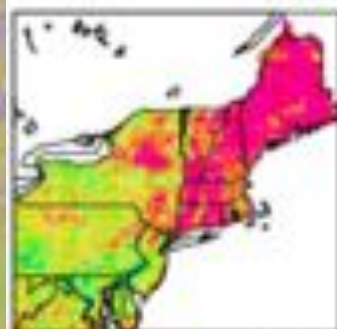


0 5 10 15 20 25 30

0 1 2 3 4 5

0 0.5 1 1.5 2

Higher Emissions (A1fi)



0 5 10 15 20 25 30

0 1 2 3 4 5

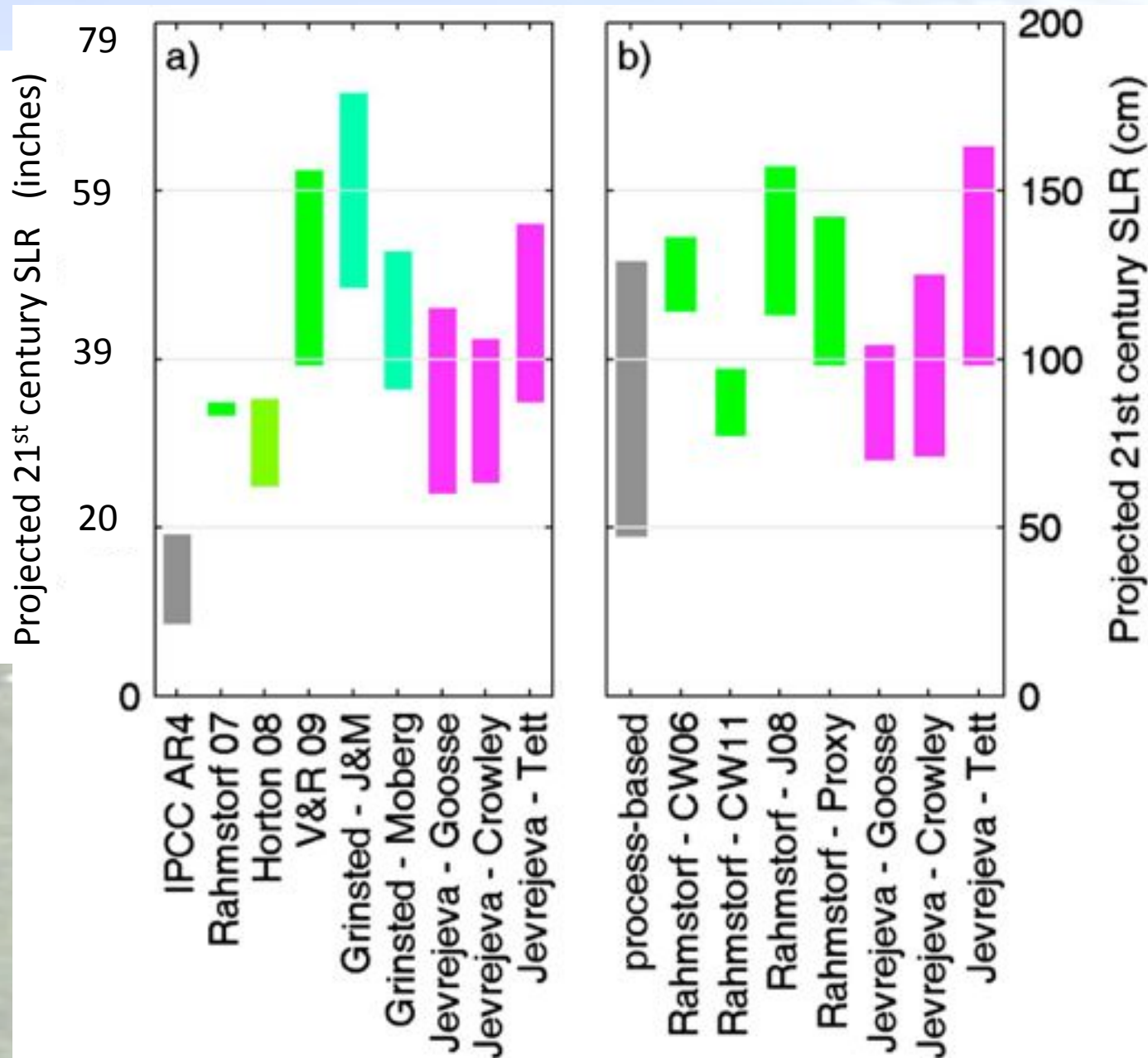
0 0.5 1 1.5 2

1-3 months

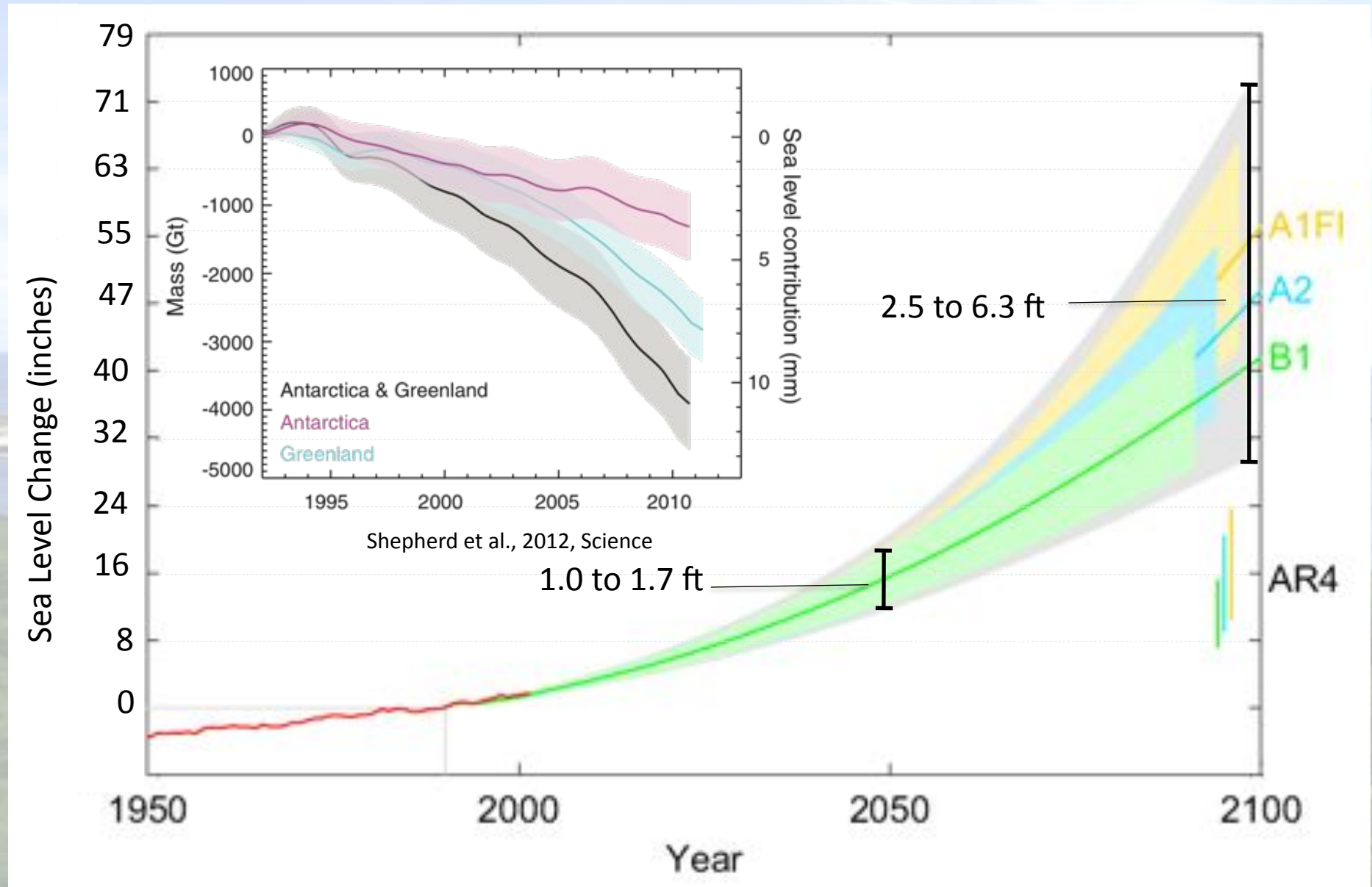
3-6 months

>6 months

Projected 21st Century Sea Level Rise

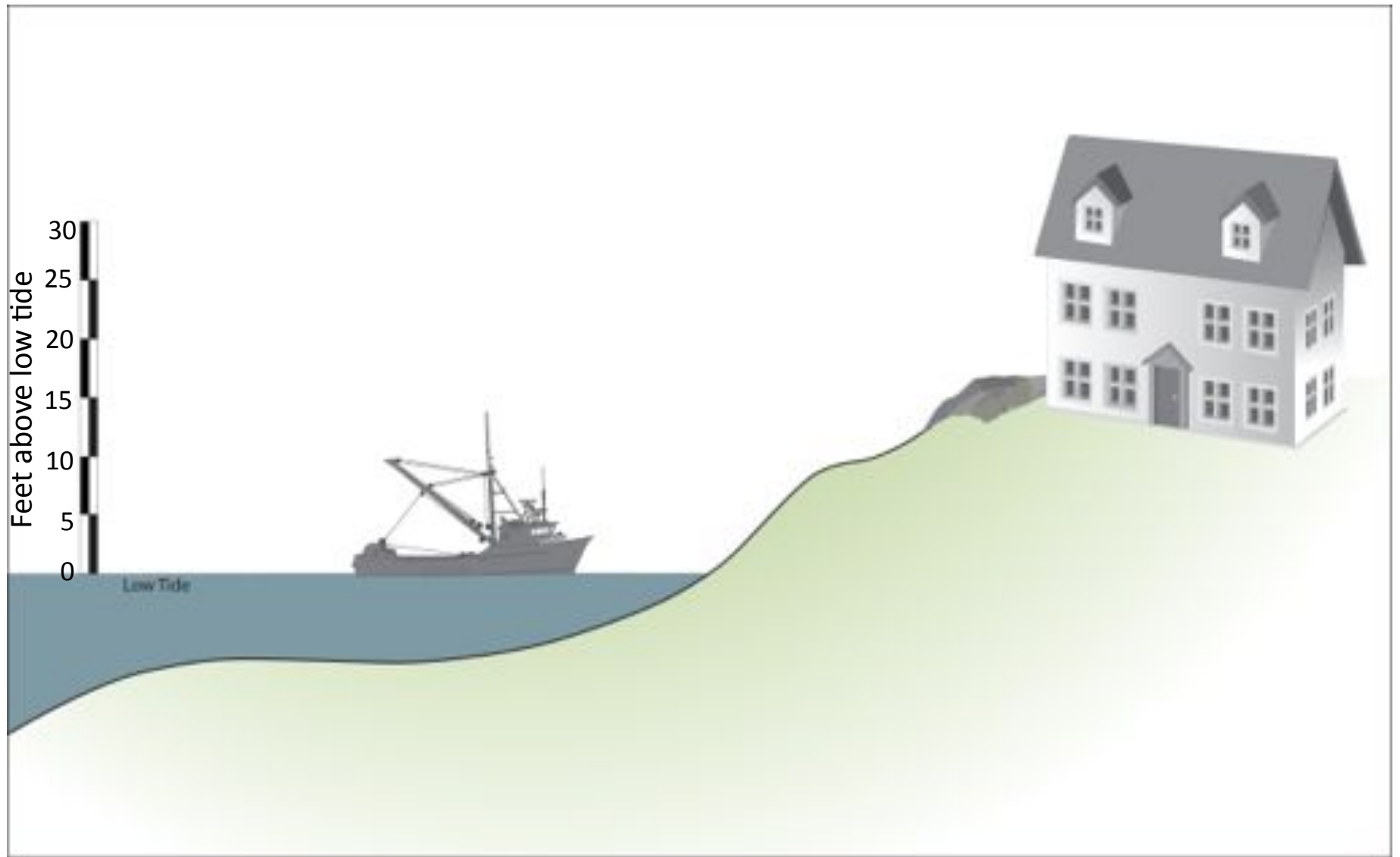


Projection of Sea Level Rise from 1990 to 2100

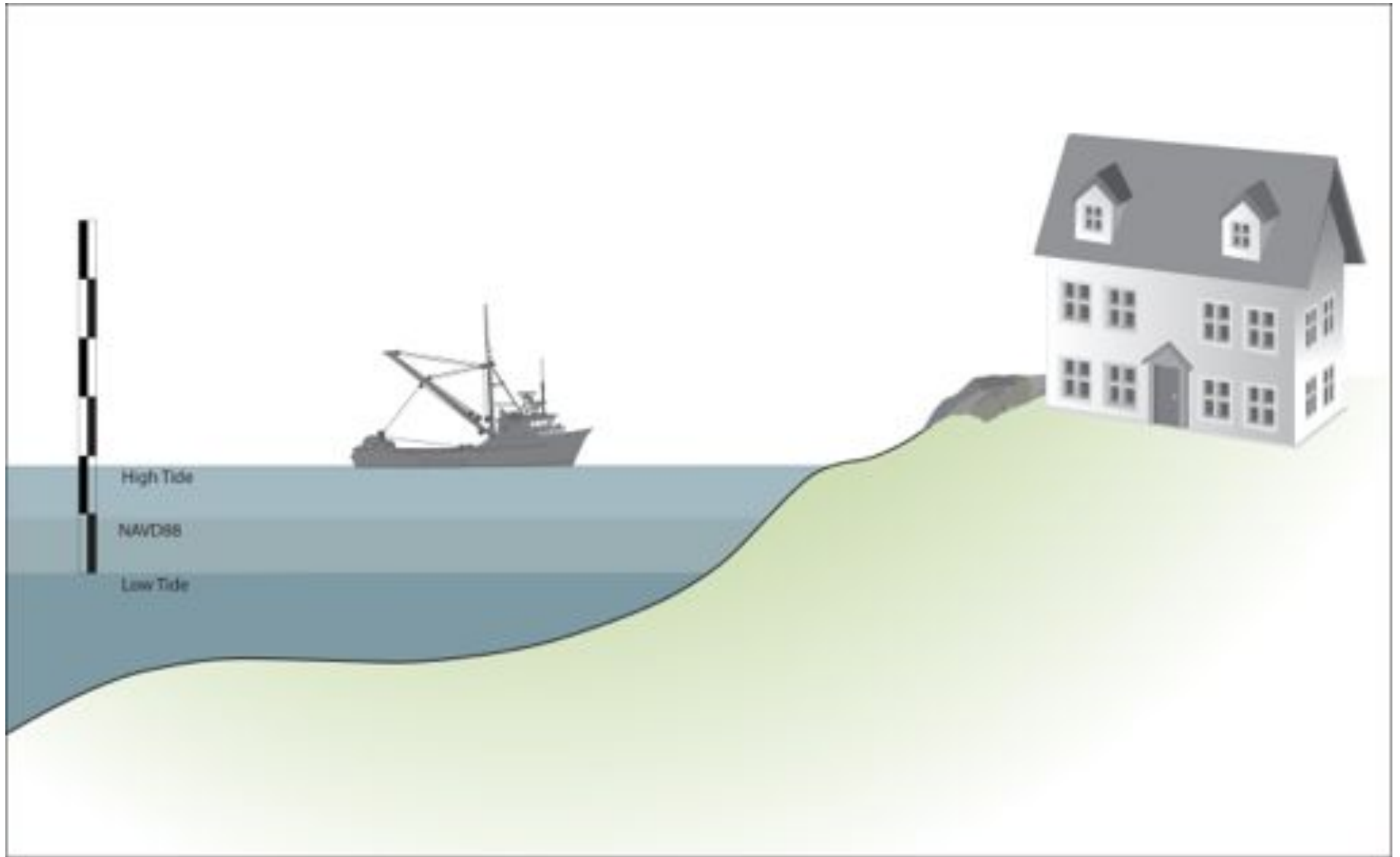


Vermeer and Rahmstorf 2009 PNAS

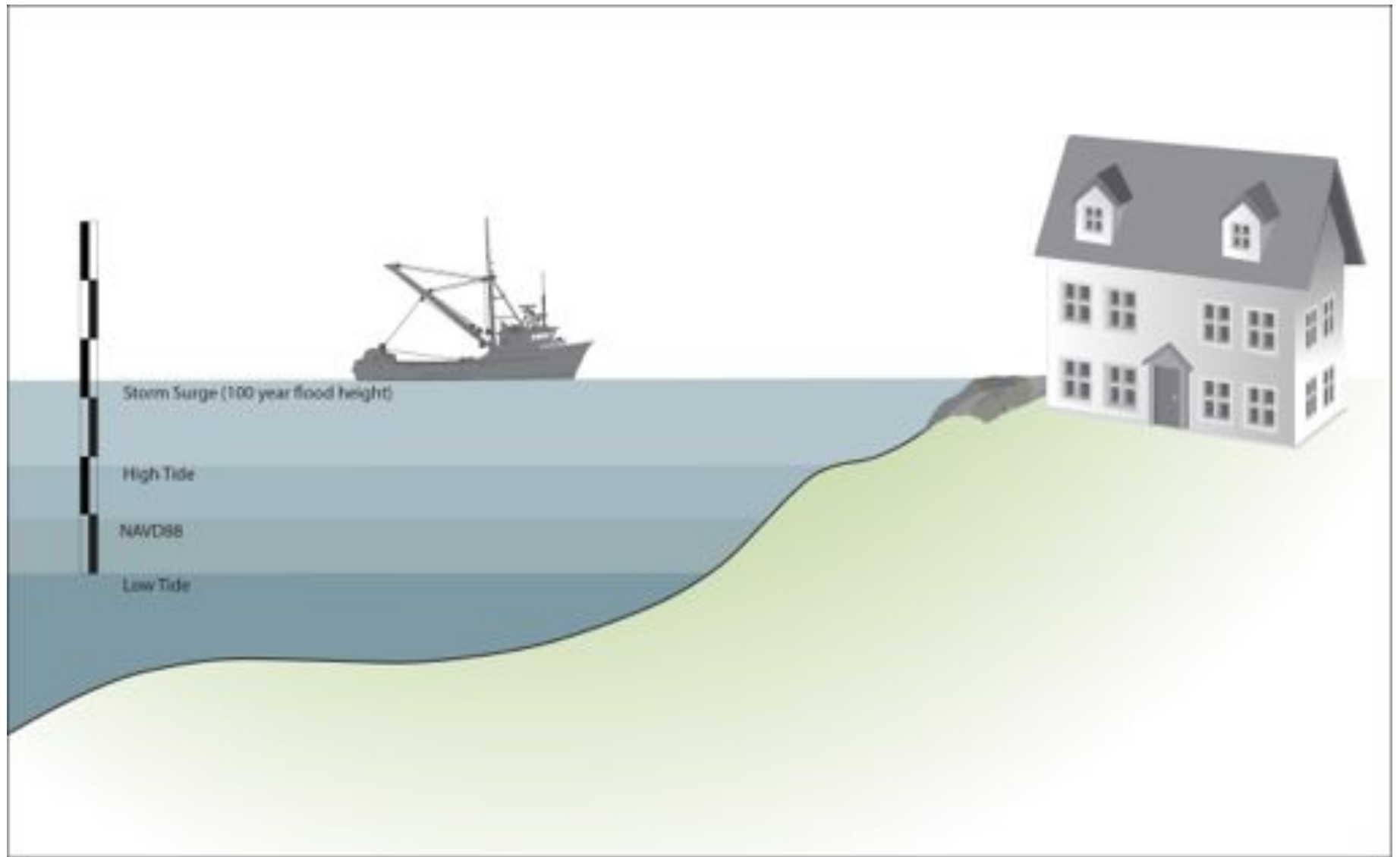
Stillwater Elevations for New Hampshire Seacoast



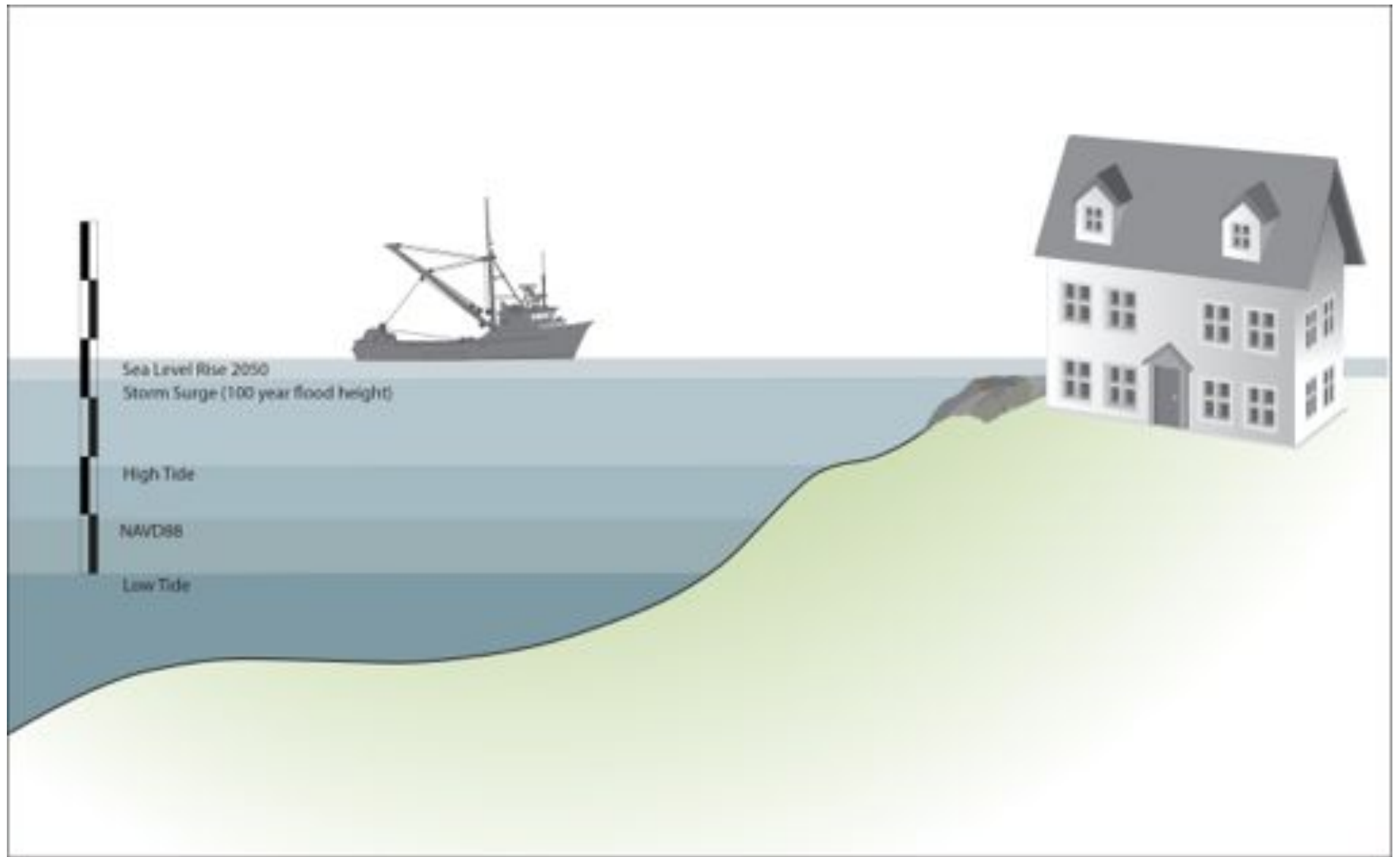
Stillwater Elevations for New Hampshire Seacoast



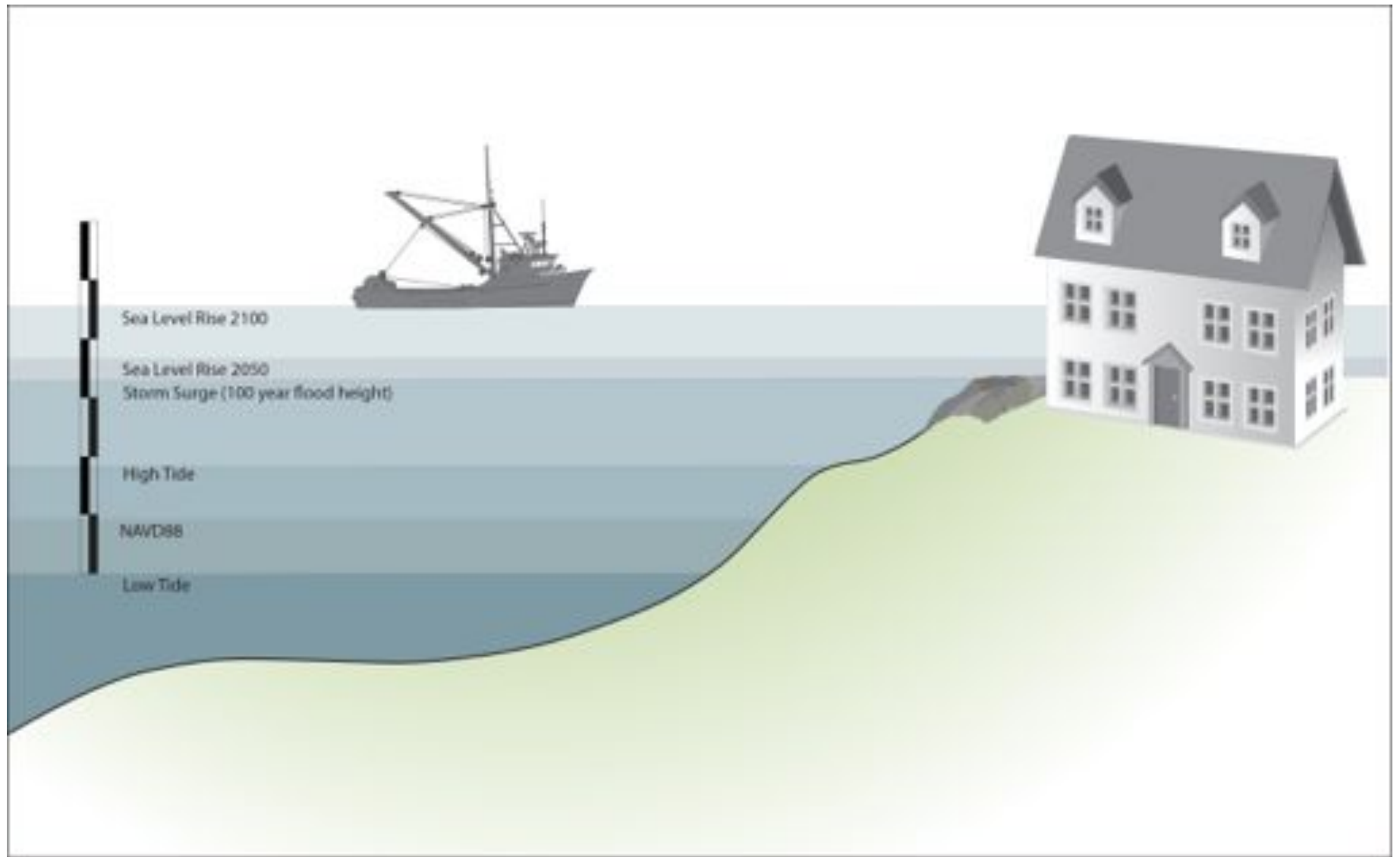
Stillwater Elevations for New Hampshire Seacoast



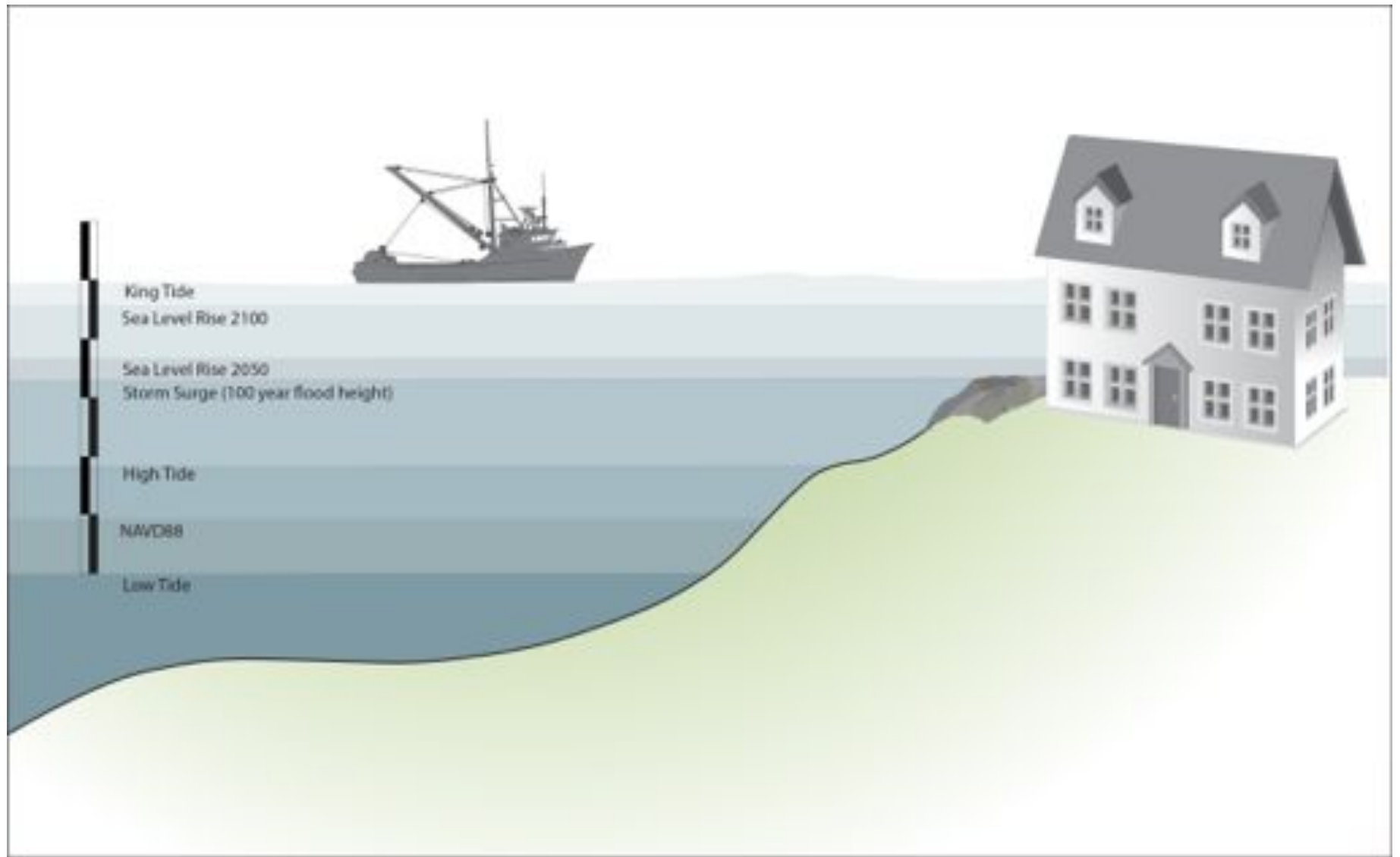
Stillwater Elevations for New Hampshire Seacoast



Stillwater Elevations for New Hampshire Seacoast



Stillwater Elevations for New Hampshire Seacoast



Stillwater Elevations for New Hampshire Seacoast

Range in 100-year flood elevations (now to 2100)

6.8 to 15.3 feet above MHHW

Event	LOWER SLR (feet)	HIGHER SLR (feet)
King Tide	11.5	15.3
SLR 2100	9.3	13.1
SLR 2050	7.8	8.5
100 yr flood	6.8	6.8
High Tide	0.0	0.0

NOTE: maps to follow are for 12 feet above MHHW

In coastal NH, NAVD + 4.4 feet = MHHW

High Tide + 12 feet Rye, NH





Cable Road

This is an aerial photograph of a coastal region, likely in Alaska, showing a mix of land and water. The land on the left is covered in dense green forest. A road, labeled 'Cable Road', runs diagonally from the upper left towards the center. The water area is overlaid with a color-coded bathymetric map. The colors range from light blue (shallow) to dark blue (deep), with intermediate colors of green, yellow, orange, and red indicating different depth zones. The map shows a complex coastline with several inlets and a small island or peninsula in the center-right. The text 'Cable Road' is written in white, sans-serif font across the middle of the image.

What path will we take to the future?

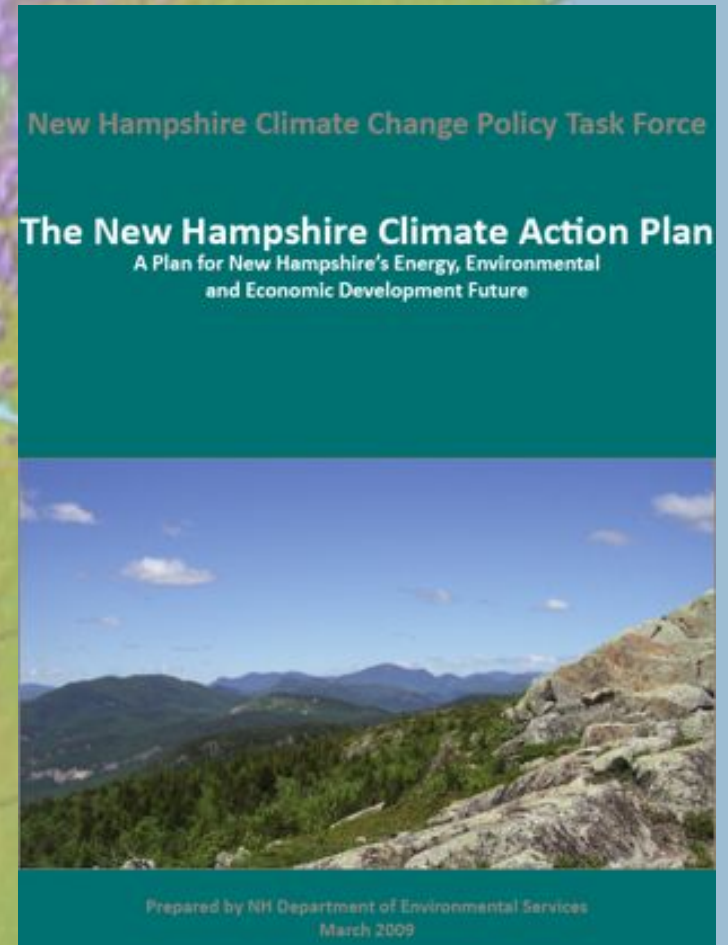


Two roads diverged in a wood, and I -
I took the one less traveled by,
And that has made all the difference.

Robert Frost

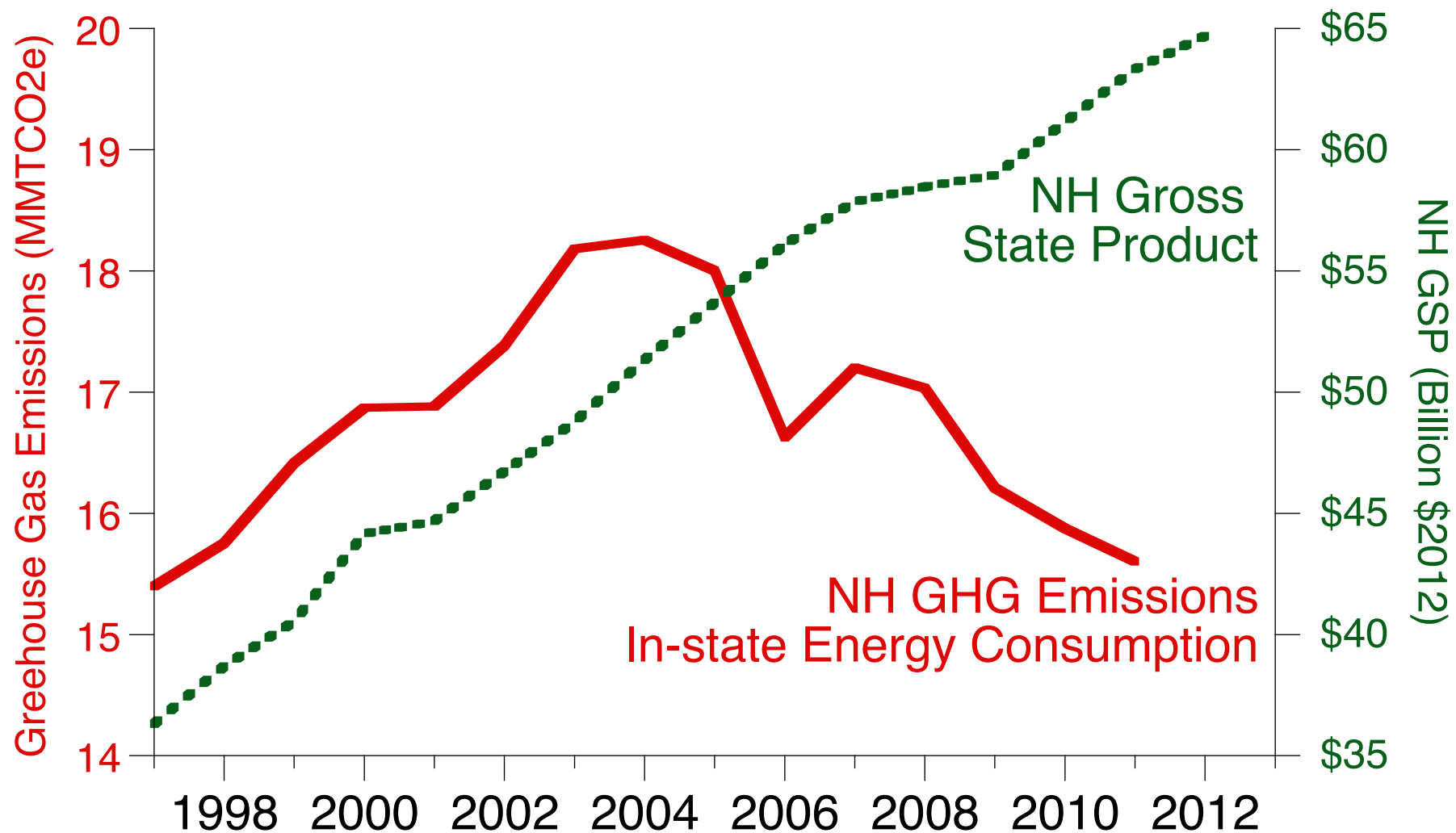
NH Climate Action Plan

- One of the largest, most diverse collections of leading NH citizens
- Promotes growth of new jobs and renewable energy development
- Reduces energy costs
- Identifies 67 recommended actions
 - buildings
 - electricity generation,
 - transportation & land use
 - natural resources
 - government action
 - adaptation
- Reduce greenhouse gas emissions
 - 44% below 2005 levels by 2025
 - 86% below 2005 levels by 2050



More info at:
<http://CarbonSolutionsNE.org>

Gross State Product & Greenhouse Gas Emissions





Laying a foundation for informed discussion and decisions

- ❑ Plan for “Here and Now” and “Prepare and Monitor” actions that are robust, yet flexible
- ❑ Adaptive approaches that change with conditions
 - ✓ Building codes and resilient design
 - ✓ Conditional development and exactions for maintenance of services
 - ✓ New development and rebuilding restrictions in high risk areas
 - ✓ Transfer of Development Rights / Acquisition and Buyout Programs
 - ✓ Rolling easements and buffers
 - ✓ Adaptive reuse plans for high risk areas (overlay zoning districts)



Wrestling with uncertainty about the future

- ❑ Consider **future conditions** for planning and investments
- ❑ Intersect municipal **planning** and public/private **investments**
- ❑ Need **citizens support** decision-makers
- ❑ Effective **communication** of information and solutions
- ❑ Encourage **action** based on best available information and guidance
- ❑ Municipalities have the power to **change their future**

NH Coastal Adaptation Workgroup (CAW)

<http://nh.stormsmart.org>

Federal State Regional Municipal Academic Non-profit Consulting



University of
New Hampshire



IV. HOW CAN NEW HAMPSHIRE'S COMMUNITIES RESPOND?

"America's response to climate change is ultimately about making choices in the face of risks: choosing, for example, how, how much, and when to reduce greenhouse gas emissions and to increase the resilience of human and natural systems to climate change."¹⁰

The results presented in Chapters II and III of this report (with results for specific towns in southern New Hampshire summarized in Appendix B), combined with the findings of recent regional,¹¹ national,¹² and international¹³ assessments, summarize the risks posed by climate change and provide strong motivation for assessing and implementing a wide range of proactive anticipatory and response efforts. A pressing need for significant action to limit the magnitude of climate change (via mitigation) and to prepare for its impacts (via adaptation) is clearly warranted given the environmental, economic, and humanitarian risks associated with our changing climate.¹⁴

Mitigation and Adaptation

Mitigation and adaptation at the global and continental level have been comprehensively addressed in the IPCC 2007 Working Group II (Impacts, Adaptation, and Vulnerability) and Working Group III (Mitigation of Climate Change) Fourth Assessment Reports.¹⁵ More recent research will be summarized in the IPCC Fifth Assessment Reports from Working Groups II and III due out in the spring of 2014.¹⁶ On the national level, a series of reports on America's Climate Choices and the recent National Climate Assessment provide advice on the most effective steps and most promising strategies that can be taken to respond to climate change, including adaptation and mitigation efforts.¹⁷

Effective responses aimed at reducing the risks of climate change to natural and human systems involve

COAST in Action:

2012 Projects from Maine and New Hampshire



High Tide on Marginal Way in Portland, Maine, October 2011. (M. Craig)

Private Property		
Barriers	Solutions	Opportunity

Public Facilities		
Barriers	Solutions	Opportunity

**Prepared for US EPA's Climate Ready Estuaries Program,
In collaboration with:
Casco Bay Estuary Partnership and
Piscataqua Region Estuaries Partnership**

By the New England Environmental Finance Center, Edmund S. Muskie School of Public
Service, University of Southern Maine,
with support of the University of New Hampshire

July 2012



http://www.cascobay.usm.maine.edu/pdfs/cre_coast_final_report.pdf



City of Portsmouth, New Hampshire
COASTAL RESILIENCE INITIATIVE

**Climate Change Vulnerability Assessment
and Adaptation Plan**

April 2, 2013



<http://www.planportsmouth.com/cri/maps.html>



Climate Adaptation Chapter:

Developing Strategies to Protect Areas at Risk from
Flooding due to Climate Change and Sea Level Rise

June 25, 2013

Final

Prepared By

Strafford Regional Planning Commission

150 Wakefield Street, Suite 12

Rochester, NH 03867





THE STATE OF NEW HAMPSHIRE
DEPARTMENT OF ENVIRONMENTAL SERVICES
LAND RESOURCES MANAGEMENT
ALTERATION of TERRAIN BUREAU

29 Hazen Drive, PO Box 95, Concord, NH 03302-0095
Phone: (603) 271-2147 Fax: (603) 271-6588

Website: <http://des.nh.gov/organization/divisions/water/aot/index.htm>

For Permit Status: http://www2.des.state.nh.us/OneStop/Wastewater_Engineering_Site_Specific_Query.aspx




ALTERATION OF TERRAIN PERMIT APPLICATION

NOTE: CHANGE IN STANDARD OF PRACTICE

DRAINAGE ANALYSES

Please double-side 8 1/2" x 11" sheets where possible but, **do not** reduce the text such that more than one page fits on one side.

- ☐ PE stamp
- ☐ Rainfall amount obtained from the Northeast Regional Climate Center- <http://precip.eas.cornell.edu/>. Include extreme precipitation table as obtained from the above referenced website.
- ☐ Drainage analyses, in the following order:
 - Pre-development analysis: Drainage diagram
 - Pre-development analysis: Area Listing and Soil Listing
 - Pre-development analysis: Node listing 1-year (if applicable), 2-year, 10-year and 50-year
 - Pre-development analysis: Full summary of the 10-year storm
 - Post-development analysis: Drainage diagram
 - Post-development analysis: Area Listing and Soil Listing
 - Post-development analysis: Node listing for the 2-year, 10-year and 50-year
 - Post-development analysis: Full summary of the 10-year storm



Sea Level Rise:

Understanding and Applying Trends and Future Scenarios for Analysis and Planning

2013
Massachusetts Office of
Coastal Zone Management
www.mass.gov/czm

Working on a similar report for NH Coastal Risks and Hazards Commission; due Summer 2014

References & More Info:

Carbon Solutions New England CarbonSolutionsNE.org

site for various regional climate assessments for New England

Sea Level Rise Maps: www.granit.sr.unh.edu/Projects/Details?project_id=264

Infrastructure and Climate Network: TheICNet.org

climate.gov

Intergovernmental Panel on Climate Change: www.ipcc.ch

World Meteorological Organization – Global Climate 2001-2010

www.wmo.int/pages/mediacentre/press_releases/pr_976_en.html

US 2013 National Climate Assessment: ncadac.globalchange.gov

Cornel Precipitation Atlas: precip.eas.cornell.edu/

Northeast Climate Impacts Assessment www.ClimateChoices.org

Climate Science explained

www.SkepticalScience.com/

www.RealClimate.org

Other Papers and Reports:

Wake CP, P Frumhoff, J McCarthy, J Melillo, S Moser, and D Wuebbles (Eds)(2008) Special Issue: Assessment of Climate Change, Impacts, and Solutions in the Northeast United States. *Mitigation and Adaptation Strategies for Global Change*, 13(5-6), 419-660.

Burakowski EA, CP Wake, et al. (2008) Trends in Wintertime Climate in the Northeast United States, 1965-2005. *Journal of Geophysical Research*. 113, D20114, doi:10.1029/2008JD009870.

Hayhoe K, CP Wake, et al. (2007) Past and future changes in climate and hydrological indicators in the U.S. Northeast. *Climate Dynamics* 28, 381–407. doi: 10.1007/s00382-006-0187-8

