Panel 1 Against All Odds?

How well do we understand the factors that contributed to the natural and social vulnerabilities associated with Hurricane Sandy?
Did Climate Change Contribute to Sandy?

**YES! - In At Least 5 Ways**

- Block strengthened, extended northward, or prolonged by warm Arctic?
  - We think so.

As oceans warm, hurricane seasons may lengthen, storms can survive farther north, and perhaps interact more frequently with jet-stream troughs.

J.A. Francis
Understanding vulnerabilities: meteorological & climatological perspectives

Named storm tracks 1851-2011

Max gusts

Pcp

What Sandy wrought meteorologically

Why Sandy? A unique confluence of circumstances

Again? Atmosphere & ocean are primed for extremes

Forecast without satellite input

Sandy forecast

Surges & sea level rise

Not to forget the human perspective

10/26

Yes, worse things could happen

Irene pcp.
Hurricane Irene
August 26, 2011
• Strong Stratification
• Limited storm surge
• Mixing cooled surface
• Limited intensity

Hurricane Sandy
October 29, 2012
• After fall transition
• Single layer ocean
• No mixing/cooling
• No escape for surge
Rising seas of the Common Era

 SEA-LEVEL SCENARIOS, 2100
   High 6.6 feet
   Intermediate high 4.0 feet
   Intermediate low 1.7 feet
   Low 0.6 feet

Zero is set to sea level in 1992.

Reconstructed from sediment samples

Projected

© Kemp, Horton and others (National Geographic 2013)
Five sea level rise scenarios for New Jersey

Globally:
- Thermal expansion
- Land ice melt
- Groundwater depletion

Regional:
- Ocean dynamics
- Mass redistribution
- Glacial isostatic adjustment

On the shore:
- Sediment compaction
- Groundwater depletion

Worst case for 2100 (very low probability, all systems near physical limits): 2.5 m [8.2'] globally, 2.9 m [9.5'] at NYC, 3.0 m [9.8'] on the shore

After Miller, Kopp, Horton, Browning & Kemp (in rev.)
Sandy surge: extreme sea-level event

By 2100, a “2 to 5 year storm” will have the flooding of a “100 year storm” (modified after Psuty, 1986 Miller et al., in review)

Sandy storm tide 13.9 ft above MLLW

Best (solid) and high (dashed)sea-level projections (Miller et al., in review)

<table>
<thead>
<tr>
<th>Year</th>
<th>Global</th>
<th>Bedrock</th>
<th>Coastal</th>
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<tbody>
<tr>
<td>2050</td>
<td>1.3 ft</td>
<td>0.7 ft</td>
<td>0.4 ft</td>
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<tr>
<td>2100</td>
<td>3.1 ft</td>
<td>1.6 ft</td>
<td>0.9 ft</td>
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</tbody>
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NJ projections: Global + regional subsidence + local (Miller et al., in review)

By 2100, a “2 to 5 year storm” will have the flooding of a “100 year storm” (modified after Psuty, 1986 Miller et al., in review)
Against All Odds: How Well Do We Understand the Factors That Led to Hurricane Sandy and Associated Impacts?

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14 October 2013

- We knew but we didn’t act.
- Regulatory regimes and our culture could not accommodate change.
- We have governance tools.