Climate Adaptation Decision Making Under Deep Uncertainty:

Water Supply and Sea Level Rise

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San Francisco
Public Utilities Commission

National Adaptation Forum
Madison, Wisconsin
April 24, 2019
Uncertainty

• **Water Supply and Water Managers:**
  • We know it. Think about it every day. It’s a planning parameter.
  • *Bring it on.*

• **Sea Level Rise and Coastal Land Managers:**
  • Not particularly comfortable. Not helpful.
  • *New, and not in a good way.*
Mission: Collaboratively advancing water utility climate change adaptation
Options for Improving Climate Modeling to Assist Water Utility Planning for Climate Change

Decision Support Planning Methods: Incorporating Climate Change Uncertainties into Water Planning
Temperature and Precipitation

![Graph showing global surface warming over time]

- Historical (42)
- RCP 2.6 (26)
- RCP 4.5 (32)
- RCP 6.0 (17)
- RCP 8.5 (30)
Still, there’s uncertainty and there’s UNCERTAINTY

California temperature (°F) and precipitation (inches) anomalies from January 1895 to November 2014, plotted as 3-y anomalies relative to 1901–2000 mean.

Climate change and California drought
Michael E. Mann, Peter H. Gleick
Proceedings of the National Academy of Sciences Mar 2015, 112 (13) 3858-3859; DOI:10.1073/pnas.1503667112
> 1 Uncertainty

The diagram illustrates the relationship between uncertainty and the importance of various factors, categorized into different classes: Environmental, Financial, Technological, and Societal. The factors include Financial, Water Rights, Political and Legislative, Human Resources, Water Demand, Environmental Regulations, Natural Hazards, Climate Change, and Regionalization.
Great Science, Ambiguous Application


2016's top 10 climate papers for news and social media attention

[1] Contribution of Antarctica to past and future sea-level rise
   Nature

   PNAS

   Geophysical Research Letters

[4] The Anthropocene is functionally and stratigraphically distinct from the Holocene
   Science

   Nature Climate Change

[6] Climate change decouples drought from early wine grape harvests in France
   The Lancet

   Science

[8] The broad footprint of climate change from genes to biomes to people
   National Geographic

[9] Greening of the Earth and its drivers
   Nature Climate Change

[10] Consequences of 21st century policy for multi-millennial climate and sea-level change
    Nature Climate Change

*Note: The Allmetric score provides an indicator of the attention the paper received, combining data from social media, news outlets, blogs and elsewhere (not all shown).
Climate and Environment

The alarming science driving much higher sea level projections for this century

By Chris Mooney
March 30, 2016
A New Challenge: High End Projections

Authoritative Sources: 2012-2017

- National Research Council 2012
  * SLR = 55”

- National Climate Assessment 2013 (Parris et al)
  66*

- IPCC Fifth Assessment Report 2014
  79

- Rising Seas in California 2017
  122

And California’s new state guidance
A widely reported study in 2016 that suggested Antarctica could add more than a metre to sea levels by 2100 was likely an “overestimate”, new research says. Most dire projection of sea-level rise is a little less likely, reports say. Collapsing ice cliffs may not contribute to sea level rise. A new study questions a controversial hypothesis suggesting such rapid crumbling could occur. A Terrifying Sea-Level Prediction Now Looks Far Less Likely.
“(S)cientists . . . sometimes fail to carefully discriminate between what is well understood and what remains uncertain,” said Kimberly Thompson, an associate professor of risk analysis and decision science at Harvard.

“Whiplash,” starring JK Simmons and Miles Teller.
## Table 1. GSL Projections

<table>
<thead>
<tr>
<th>Component</th>
<th>RCP 8.5</th>
<th>RCP 4.5</th>
<th>RCP 2.6</th>
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<tr>
<td>cm</td>
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<tr>
<td>2100—Components</td>
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<tr>
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<td>18</td>
<td>13</td>
<td>12</td>
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<tr>
<td>GIS</td>
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<td>6</td>
</tr>
<tr>
<td>AIS</td>
<td>4</td>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td>TE</td>
<td>37-28-46</td>
<td>26-18-34</td>
<td>19-13-26</td>
</tr>
<tr>
<td>LWS</td>
<td>5</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>Total</td>
<td>79</td>
<td>59</td>
<td>50</td>
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</table>

**Projections by year**

<table>
<thead>
<tr>
<th>Year</th>
<th>RCP 8.5</th>
<th>RCP 4.5</th>
<th>RCP 2.6</th>
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<tbody>
<tr>
<td>2030</td>
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<tr>
<td>2050</td>
<td>29</td>
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<tr>
<td>2100</td>
<td>79</td>
<td>59</td>
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<td>2150</td>
<td>130</td>
<td>90</td>
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<tr>
<td>2200</td>
<td>200</td>
<td>130</td>
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</table>

**Other projections for 2100**

<table>
<thead>
<tr>
<th>Component</th>
<th>RCP 8.5</th>
<th>RCP 4.5</th>
<th>RCP 2.6</th>
</tr>
</thead>
<tbody>
<tr>
<td>ARS</td>
<td>73</td>
<td>52</td>
<td>43</td>
</tr>
<tr>
<td>H14</td>
<td>70-120</td>
<td>75</td>
<td>57</td>
</tr>
<tr>
<td>J12</td>
<td>110</td>
<td>90</td>
<td>75</td>
</tr>
<tr>
<td>S12</td>
<td>81-165</td>
<td>64-121</td>
<td>52-96</td>
</tr>
</tbody>
</table>

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TE: Thermal expansion, LWS: Land water storage, H14: Horton et al. [2014], J12: Jevrejeva et al. [2012], S12: Schaeffer et al. [2012].

All values are cm above 2000 CE baseline except for ARS, which is above a 1986–2005 baseline.
<table>
<thead>
<tr>
<th>Sea Level Rise State of the Science Report (Jurisdiction)</th>
<th>Are probabilistic projections used in the report?</th>
</tr>
</thead>
<tbody>
<tr>
<td>North Olympic Peninsula (2015)</td>
<td>Yes</td>
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<tr>
<td>Southeast Florida (2015)</td>
<td>Yes</td>
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<tr>
<td>New York City (2015)</td>
<td>Yes</td>
</tr>
<tr>
<td>Boston (2016)</td>
<td>Yes</td>
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<tr>
<td>New Jersey (2016)</td>
<td>Yes</td>
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<tr>
<td>Oregon (2017)</td>
<td>Yes</td>
</tr>
<tr>
<td>California (2017)</td>
<td>Yes</td>
</tr>
<tr>
<td>Puget Sound (2015)</td>
<td>No</td>
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</table>

Probabilistic Projections: Not without controversy

Hall et al 2016:

“Given the uncertainties inherent with climate change… strictly probabilistic approaches are not feasible. . .

Hinkel et al 2015:

“Improving the current approach applied by IPCC WGI to generate scenarios based on model ensembles in order to come up with probability ranges that would satisfy high-risk coastal management decisions (say 99% or 99.9%) does not seem to be a feasible way forward in the near future.” 2


Perception: Adaptation Professionals

What words describe the current ecosystem of adaptation / resilience services?

National Adaptation Forum session led by Missy Stults, Lara Hansen, David Herring
May, 2017
“Actionable Science”

Actionable science provides data, analyses, projections, or tools that can support management of the risks and impacts of climate change.

It is ideally co-produced by scientists and decision makers and creates rigorous and accessible products to meet the needs of stakeholders.

Federal Advisory Committee on Climate Change and Natural Resource Science, 2015

(emphasis added)
Antidote? Embrace Deep Uncertainty

Water Reliability

Vulnerable

Robust
Adaptation Pathways

An adaptation pathways map shows different possible sequences of decisions to achieve objectives. A scorecard helps to evaluate the pathways and decisions.

**Current situation**

**Action A**

**Action B**

**Action C**

**Action D**

**Changing conditions**

Time low-end scenario

Time high-end scenario

Transfer station to new policy action

Adaptation Tipping Point of a policy action (Terminal)

Policy action effective

**Time horizon 100 years**

<table>
<thead>
<tr>
<th>Pathway</th>
<th>Costs</th>
<th>Benefits</th>
<th>Co-benefits</th>
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</thead>
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<td>+++</td>
<td>+</td>
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</tr>
<tr>
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<tr>
<td>9</td>
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</tbody>
</table>
Thank you!

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