Sea-Level Rise for the Coasts of California, Oregon, and Washington: Past, Present, and Future—NRC Committee findings

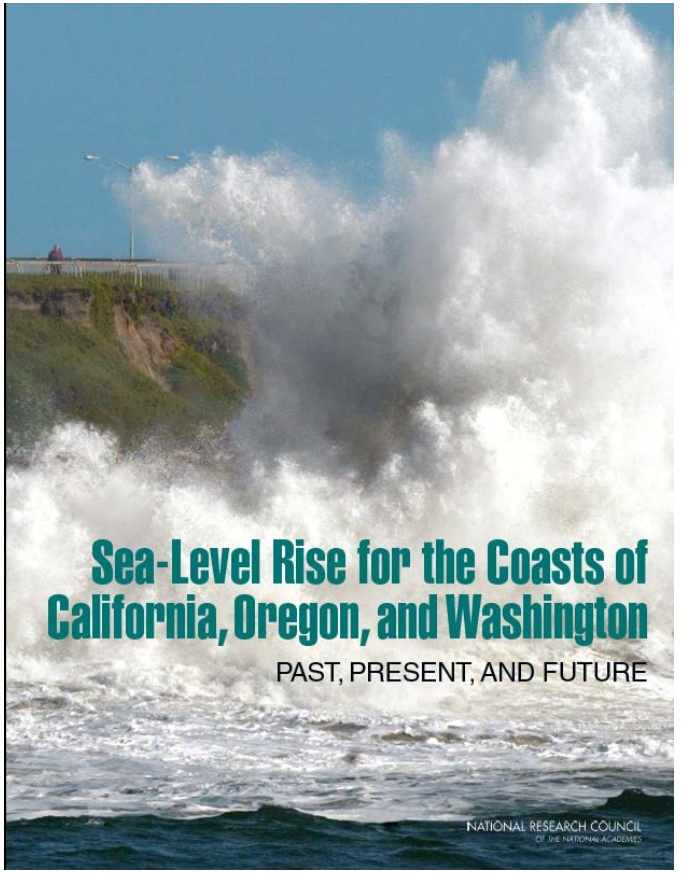
Dr. Dan Cayan

Scripps Institution of Oceanography, UC San Diego
and U.S. Geological Survey

---

from a presentation by

Dr. Robert A. Dalrymple,
Chair, NRC West Coast SLR Committee
Johns Hopkins University



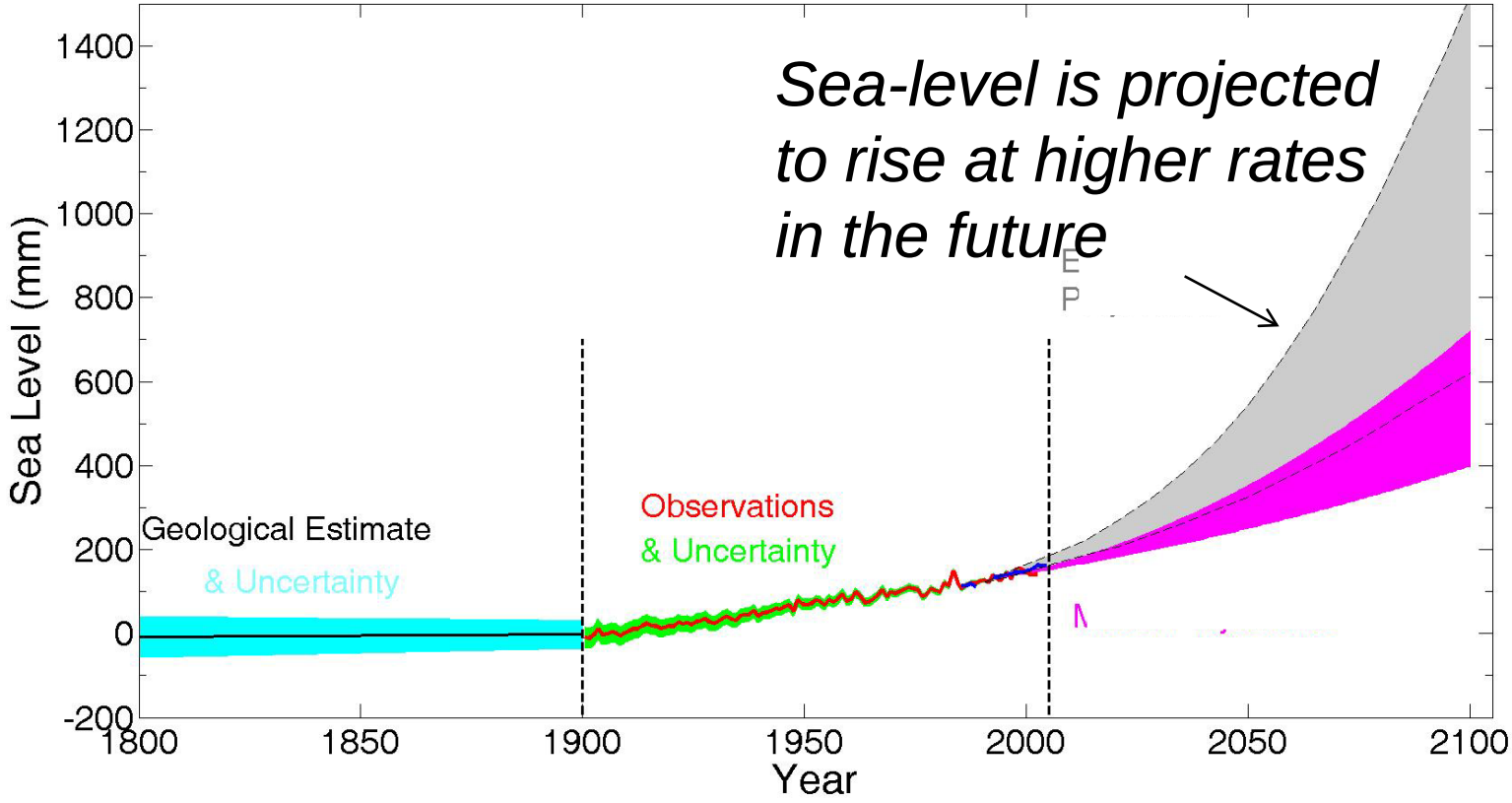
California Ocean Protection Council
September 13, 2012

THE NATIONAL ACADEMIES
Advisers to the Nation on Science, Engineering, and Medicine

Rising seas increase coastal erosion, shoreline retreat, and wetland loss; increases the risk of coastal flooding, and increases coastal damage from storms.

Global sea-level is rising primarily because land ice is melting and ocean water expands as it warms.

1.7 mm per year over 20th century (from tide gages)
3.1 mm per year since 1993 (from satellites & tide gages)



Study Origin

- 2008 California Executive Order
  - Directed state agencies to plan for sea-level rise and coastal impacts
  - Asked the National Research Council to assess sea-level rise
- The states of Oregon and Washington, NOAA, USACE, and USGS joined California in sponsoring this NRC study

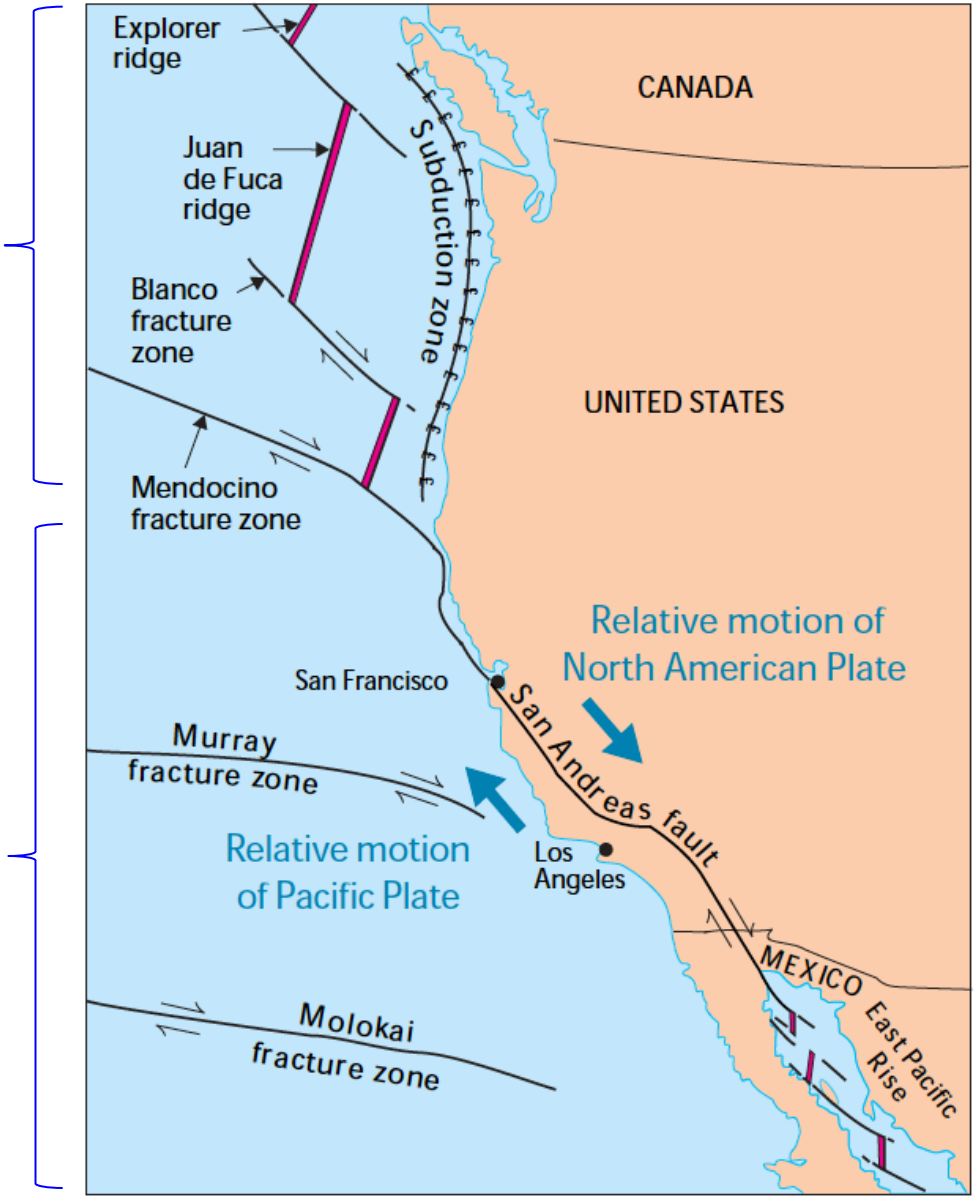
Study Scope

- Task 1: Global Sea-Level Rise
- Task 2: Sea-Level Rise in CA, OR, and WA
  - 2 a Storminess Changes
  - 2 b,c Shoreline Responses

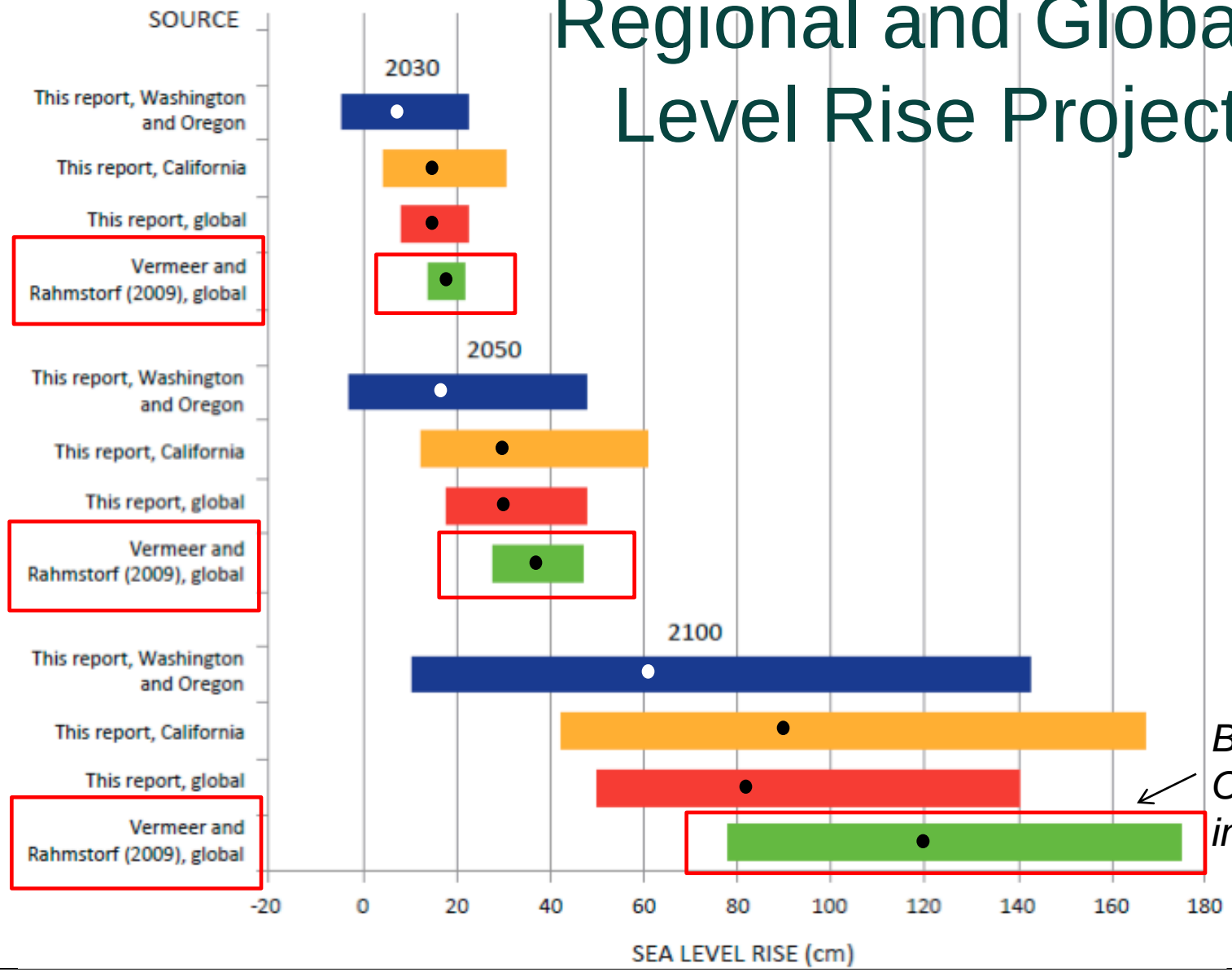
Tectonics

The ocean plate is descending below North America at the Cascadia Subduction Zone, causing local coastal areas to rise.

Ocean and North America plates are sliding past one another along the San Andreas Fault, causing no vertical motion.



Regional and Global Sea-Level Rise Projections



Being used by California for interim planning

Uncertainties….

- Regional projections are more uncertain than global projections because there are more components.
- Uncertainties grow as the projection period lengthens:
  - Incomplete understanding of the climate system
  - Difficulty of modeling all components
  - Shortage of data at appropriate scales
  - Need for assumptions about future conditions
- Confidence in the projections:
  - High for 2030 and perhaps 2050
  - By 2100, we are confident only that the value will fall within the uncertainty bounds

Conclusions

- Sea-level in California (south of Cape Mendocino) is expected to rise nearly 1 m by 2100, about the same as global sea-level rise

- The projected rise is lower in Washington, Oregon, and California north of Cape Mendocino, about 60 cm, because the land is rising as seismic strain builds up

A great earthquake (magnitude 8 or larger) along the Cascadia Subduction Zone would cause immediate subsidence and sea-level rise of an additional 1-2 m.

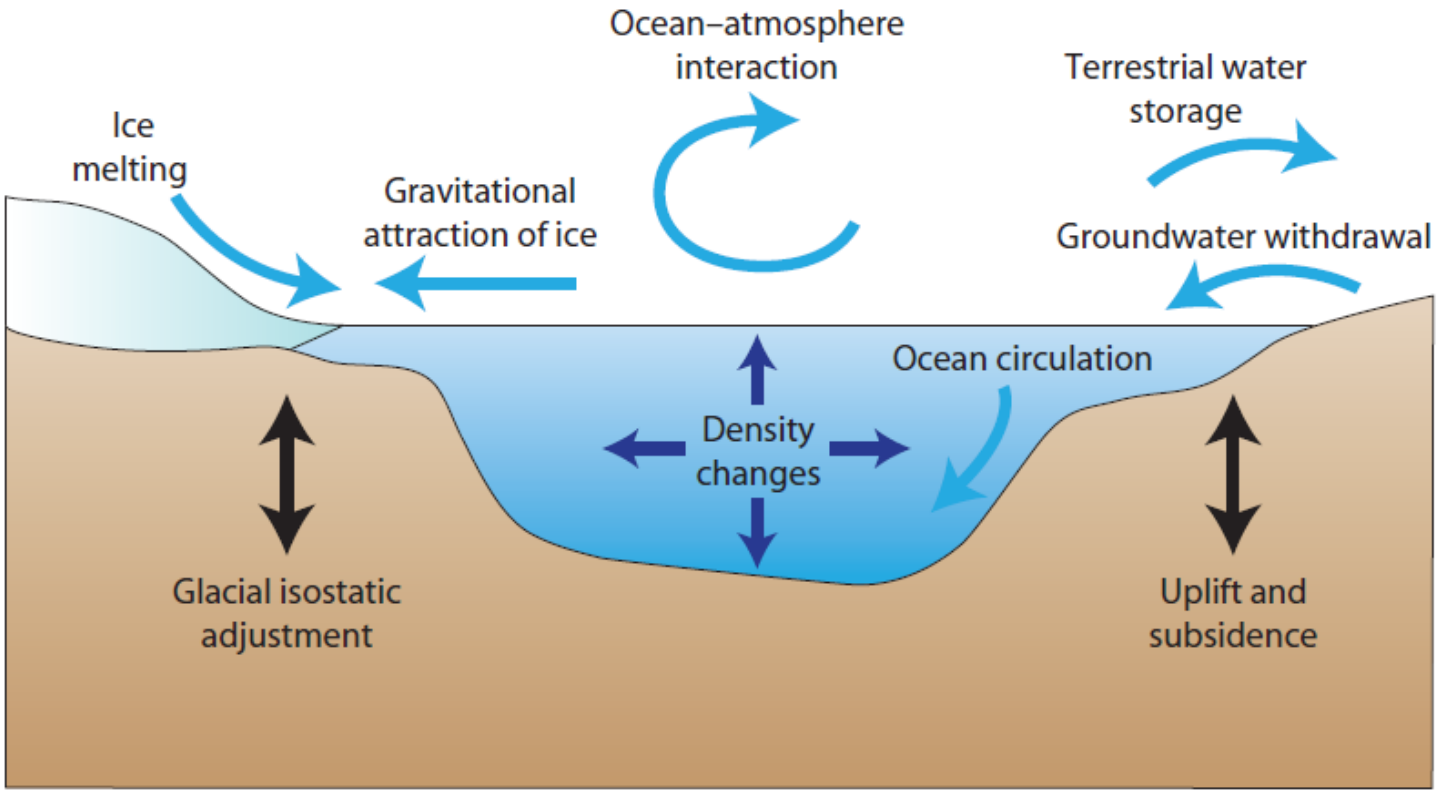
Conclusions Continued

- Sea-level rise will magnify the adverse impact of storm surges and high waves on the coast.

- Wetlands mitigate some impacts, but will need high sedimentation, accommodation space, and/or uplift to survive after 2050.

Next Steps….

Components of Global and Regional Sea-Level Rise



Sea level at a particular place can be higher or lower than the global mean due to regional effects

Factors that Affect Sea-Level Rise Along the U.S. West Coast

Local sea level rises if the ocean rises and/or the land sinks

- Global sea-level rise
- Atmosphere-ocean circulation patterns in the Pacific (e.g., El Niño), which affect ocean levels
- Melting of modern and Ice Age glaciers and ice sheets, which affect ocean and land levels
- Tectonics and fluid withdrawal/recharge, which affect land levels

Committee Projections for California, Oregon, and Washington

- Based on climate models and extrapolations of observed trends
- Account for regional variations in ocean density, sea-level fingerprint of land ice melt, and vertical land motion along the coast
- Projections made for two tectonic regions
  - North of Cape Mendocino, California (land is rising)
  - South of the cape (land is sinking)

Catastrophic Coastal Storms

- Most coastal damage is caused by the confluence of large waves, storm surges, and high astronomical tides during a strong El Niño
  - Such an event in 1982-83 caused more than $200 M in damage to California

- Water levels during these events can exceed projections for 2100
  - Their additive effects are significant

Future Storminess

- No consensus whether the number and severity of storms in the northeast Pacific will change
- Some models predict a northward shift in North Pacific storm tracks
  - If so, winter storm impacts would decrease in southern California and might increase in Oregon and Washington
- Some observational studies report that largest waves are getting higher and winds are getting stronger
  - If so, the frequency and magnitude of extremely high coastal wave events will likely increase
- Observational records are not long enough to confirm whether these are long-term trends

Future Coastal Change

- Storms and sea-level rise are causing coastal cliffs, beaches, and dunes to retreat at rates from a few cm/yr to several m/yr

  Cliffs could retreat more than 30 m by 2100

- Wetlands protect inland areas by reducing flooding and wave height and energy

  Extent depends on vegetation, topography, and bathymetry

- Wetlands likely to keep pace with sea level until 2050

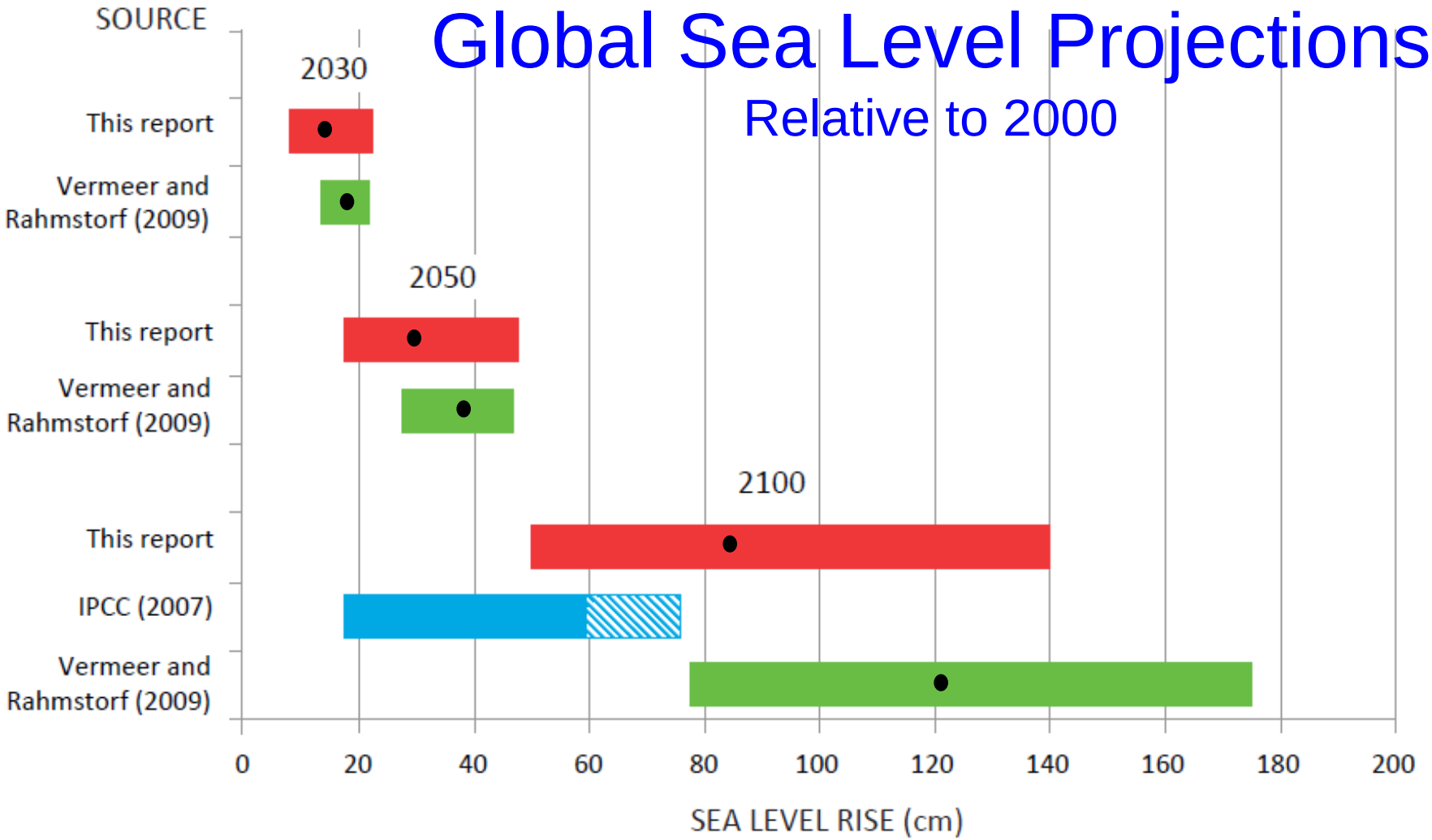
Survival to 2100 depends on maintaining elevation through high sedimentation, accomodation area, or uplift

Methods for Making Global Projections

- Climate models (IPCC)
  Based on knowledge of physical processes
  Underestimate land ice contribution
- Semi-empirical methods (Vermeer & Rahmstorf)
  Based on the observation that sea level rises faster as the Earth gets warmer
  Reproduce past sea-level rise, but ice behavior is changing
- Climate models + extrapolations of observed trends in ice loss rates (this report)
  Accounts for rapid changes in ice sheets and glaciers (ice dynamics)

Global Sea Level Projections

Relative to 2000



Committee projections for 2100 are higher than IPCC (2007) and lower than Vermeer and Rahmstorf (2009)