# The contribution of GIA to projections of RSL change
## along the Atlantic and Gulf coasts of North America

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# Why we need confident uncertainty assessment of GIA and RSL change projections

- Millions of people and billions of USD of assets at risk due to RSL rise on US East Coast alone (Hanson et al. 2011, Hauer et. al. 2016)

- Local sea level can be markedly different from global mean & uncertainty estimates needed by policy makers

- GIA is a significant contributor to RSL change on North American East and Gulf Coasts



IPCC AR5, Fig 13-22
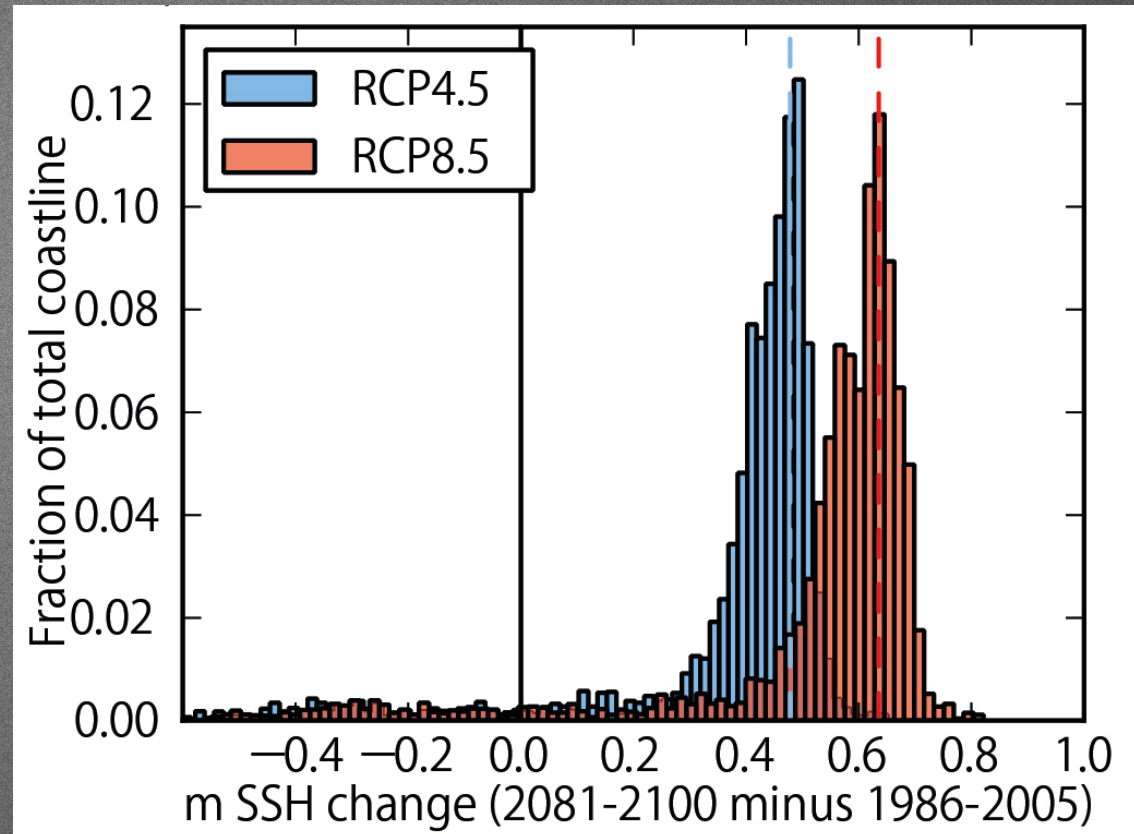
# Predicting Local Sea Level Change



Slangen 2012, Modified
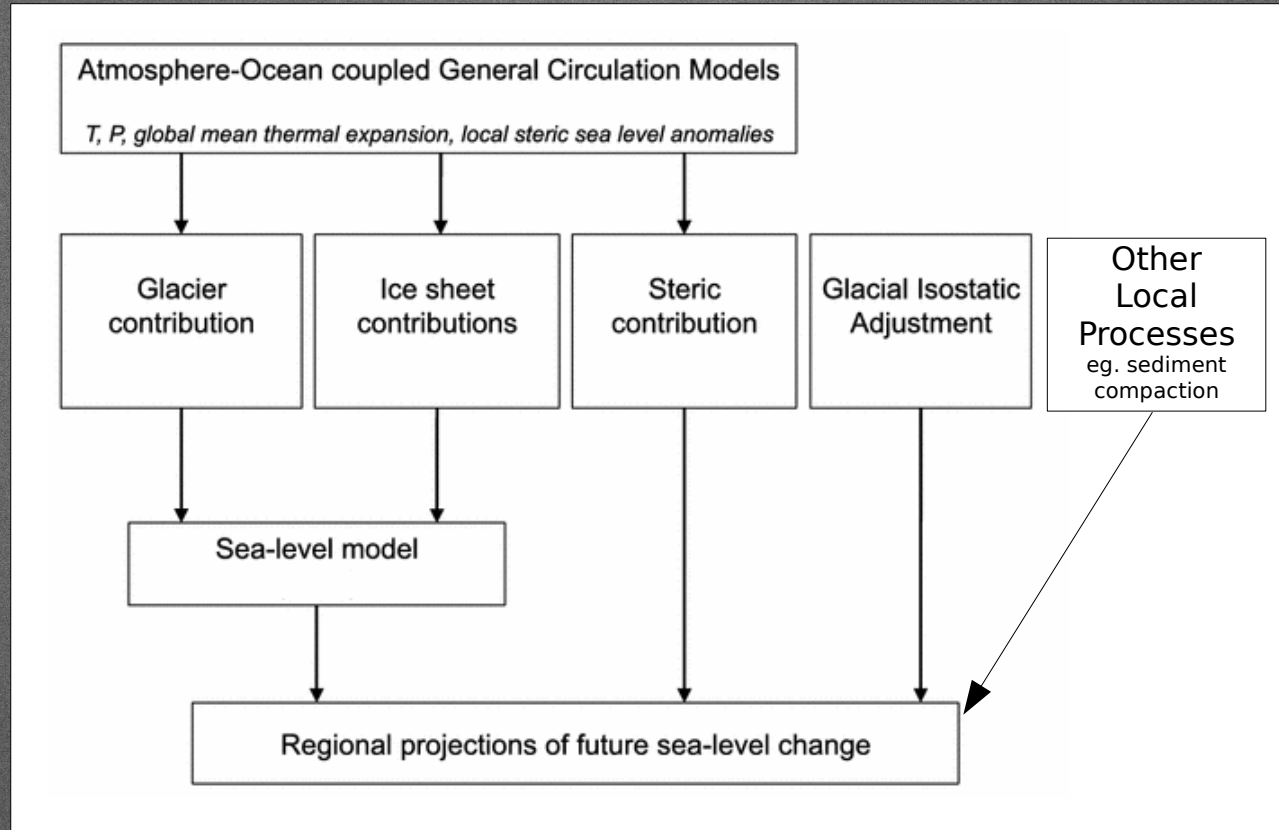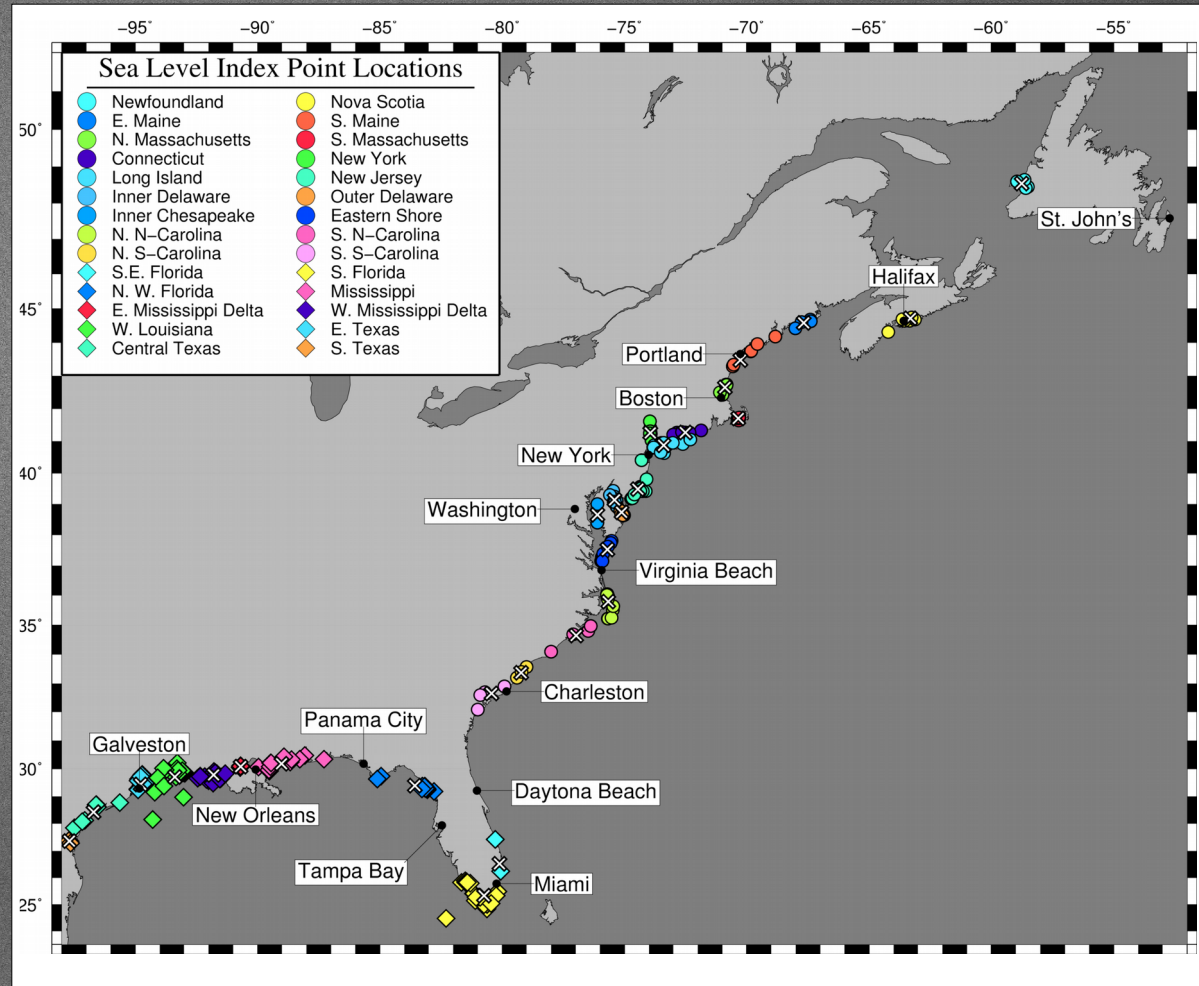
# Relative Sea Level Database

- Atlantic Coast sea level data from Engelhart and Horton 2012

  - 469 Sea Level Index Points

  - 194 Limiting Points

- Gulf Coast sea level database published in Love 2016

  - 291 SLIPs and 587 Limiting

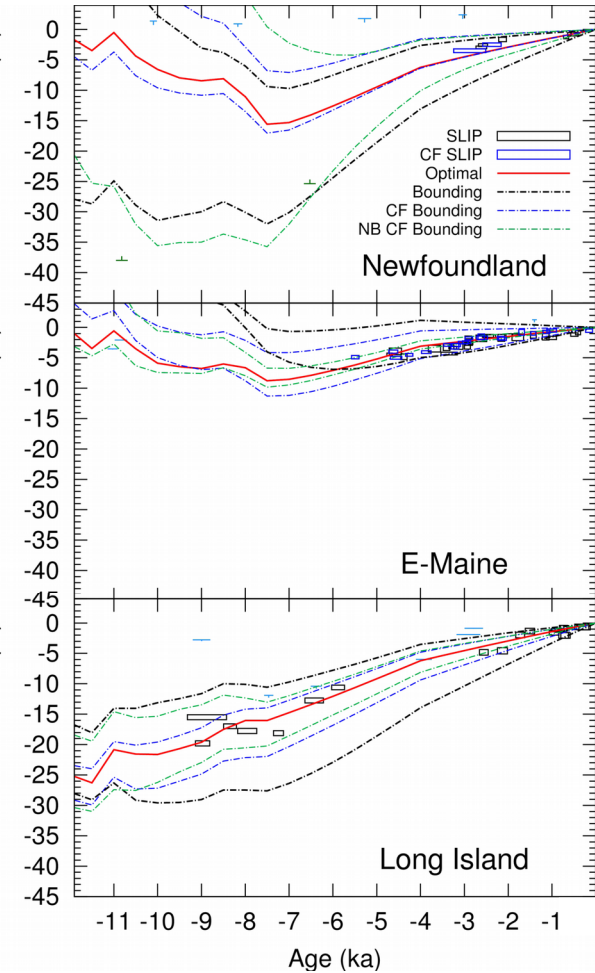- Critically assessed datasets ideal for regional GIA model parameter estimation
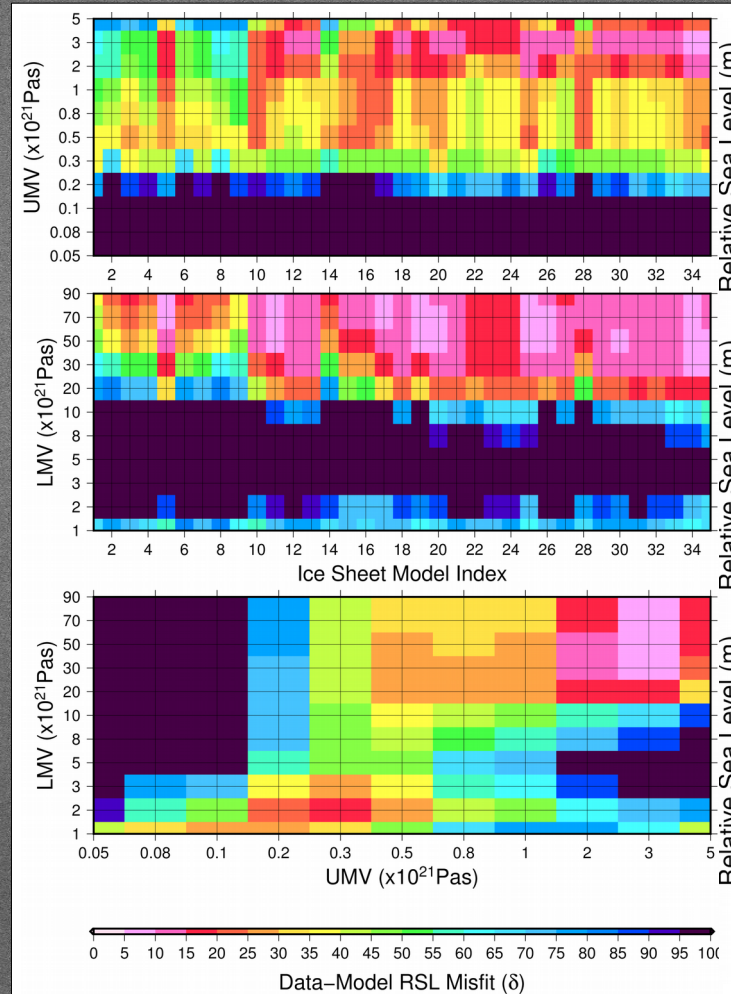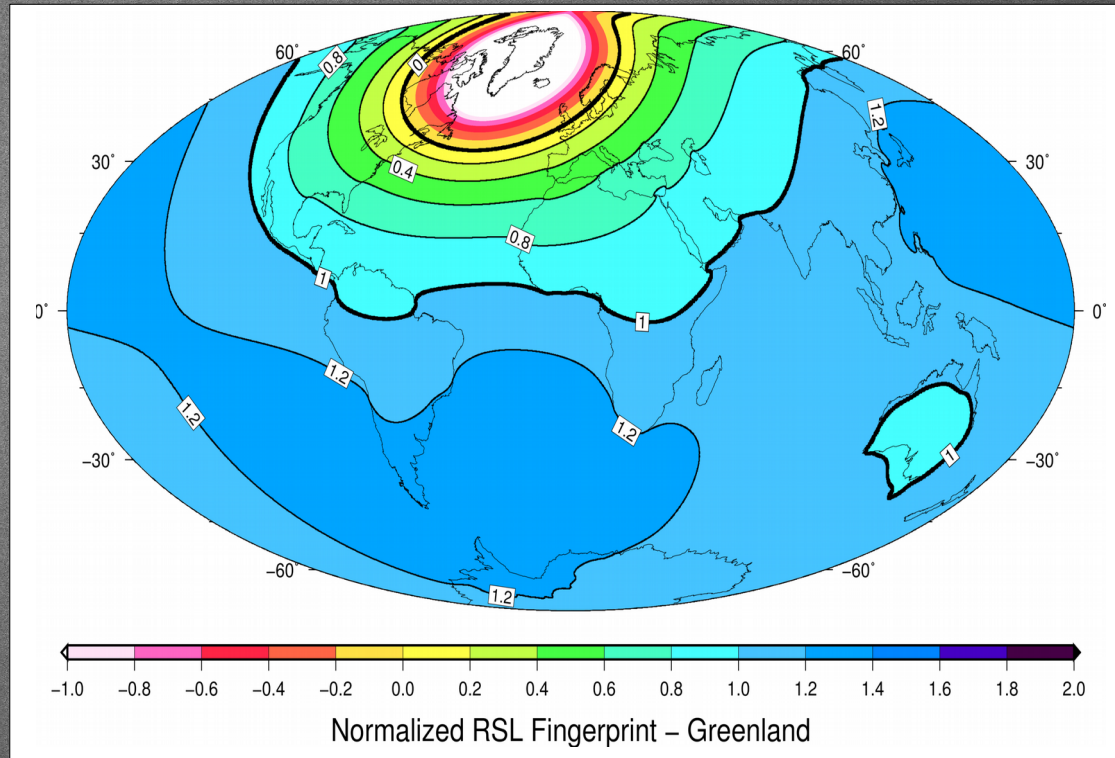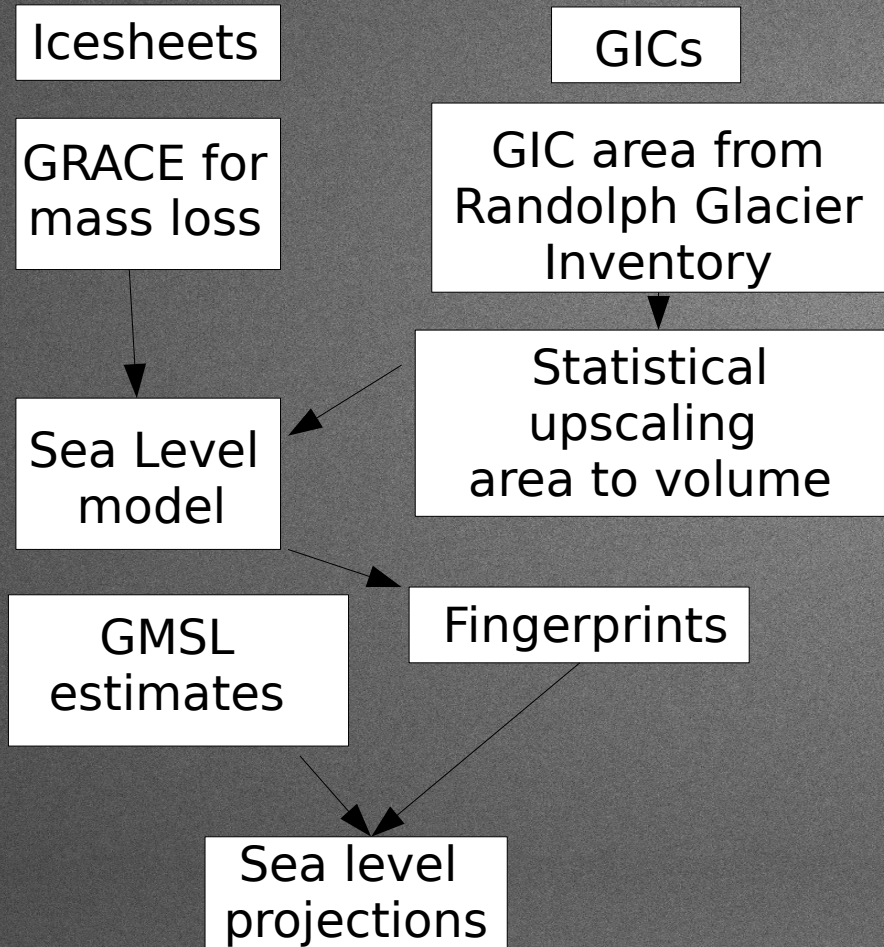
# GIA Models

- Main parameter space exploration done with 1D spherically symmetric model (Mitrovica & Milne, 2003)

  - 3 Layer viscosity structure

  - Other Earth parameters from PREM

  - Includes rotational feedback and dynamic coastlines

  - Speed and versatility allows for detailed parameter space exploration

- Effects of lateral Earth structure explored with 3D model of Latychev et al. 2005

- Influence of lateral structure significant and so data partitioned into three regions: Atlantic Canada, US east and Gulf coasts

- 3D model is too computationally expensive to map out parametric uncertainty

# 1D Model Parameter Ranges and Estimation

- Upper mantle viscosity between 0.05-5 x 10²¹ Pas

- Lower mantle viscosity between 1-90 x 10²¹ Pas

- Lithosphere between 71-120km

- 35 calibrated North American Deglacial chronologies

- ~13,000 RSL runs

- Misfit parameter includes both RSL and time uncertainty

# Ice Sheets, Glaciers, and Ice Caps

Icesheets

GRACE for mass loss

Sea Level model

GMSL estimates

GICs

GIC area from Randolph Glacier Inventory

Statistical upscaling area to volume

Fingerprints

Sea level projections



Normalized RSL Fingerprint – Greenland
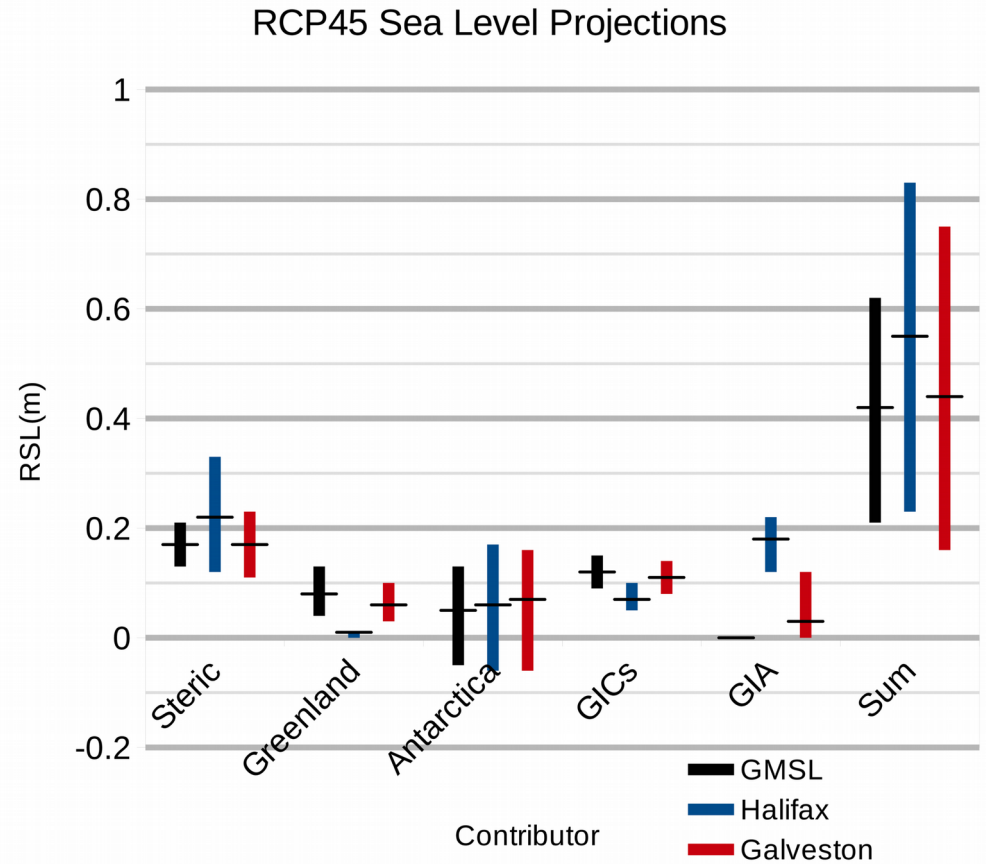
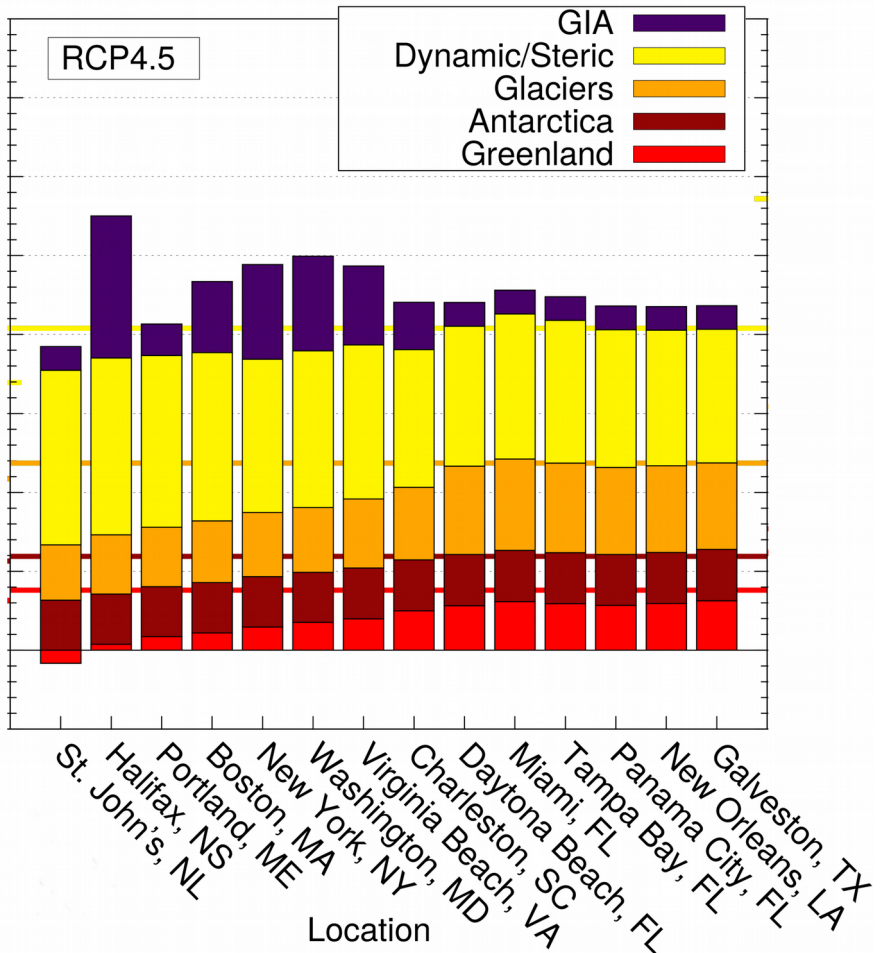# Contribution from Ocean Steric/Dynamic Changes

- Largest contributor but also largest source of uncertainty in RSL projections

- Obtained from Climate Model Intercomparison Phase 5 (CMIP5) archive
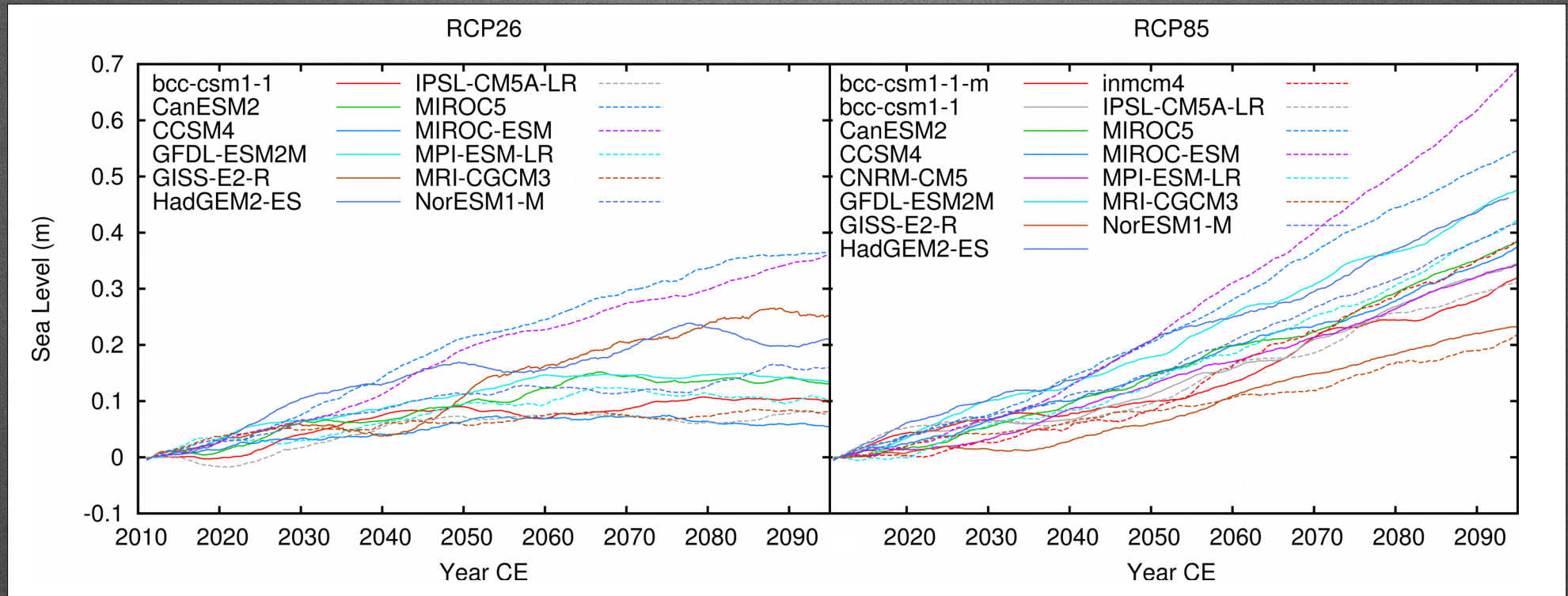


Thermosteric contribution at St. John's, Newfoundland, Canada

# Results: Regional Sea Level Projections

# Concluding Remarks

- We address the need for improved GIA estimates with robust uncertainty intervals for the East and Gulf coasts of North America

- The GIA contribution to future RSL range from a few centimeters (e.g., 3 [−1 to 9] cm Miami) to a few decimeters (e.g., 18 [12–22] cm, Halifax)  (2085–2100 relative to 2006–2015)

- GIA is the dominating component of RSL spatial variability north of ~35N

- Model output and Gulf Coast database available in Love, R., Milne, G. A., Tarasov, L., et. al. (2016), Earth's Future; doi:10.1002/2016EF000363; Open Access

# Ongoing and Future Work

· Sediment Isostatic Adjustment: See Kuchar et. al. 2017 and **G21A-0856**: The Influence of Sediment Isostatic Adjustment on Sea-Level Change and Land Motion along the US Gulf Coast (Tuesday Session)

· A similar study, Yousefi et. al. , for the west coast (BC down to California) is currently under review in QSR as part of the PALSEA special edition.

· Future work will use 3D GIA model to consider why such large viscosity values are found for US East and Gulf coasts as well as estimate structural error associated with the application of 1D model to constrain GIA signal.

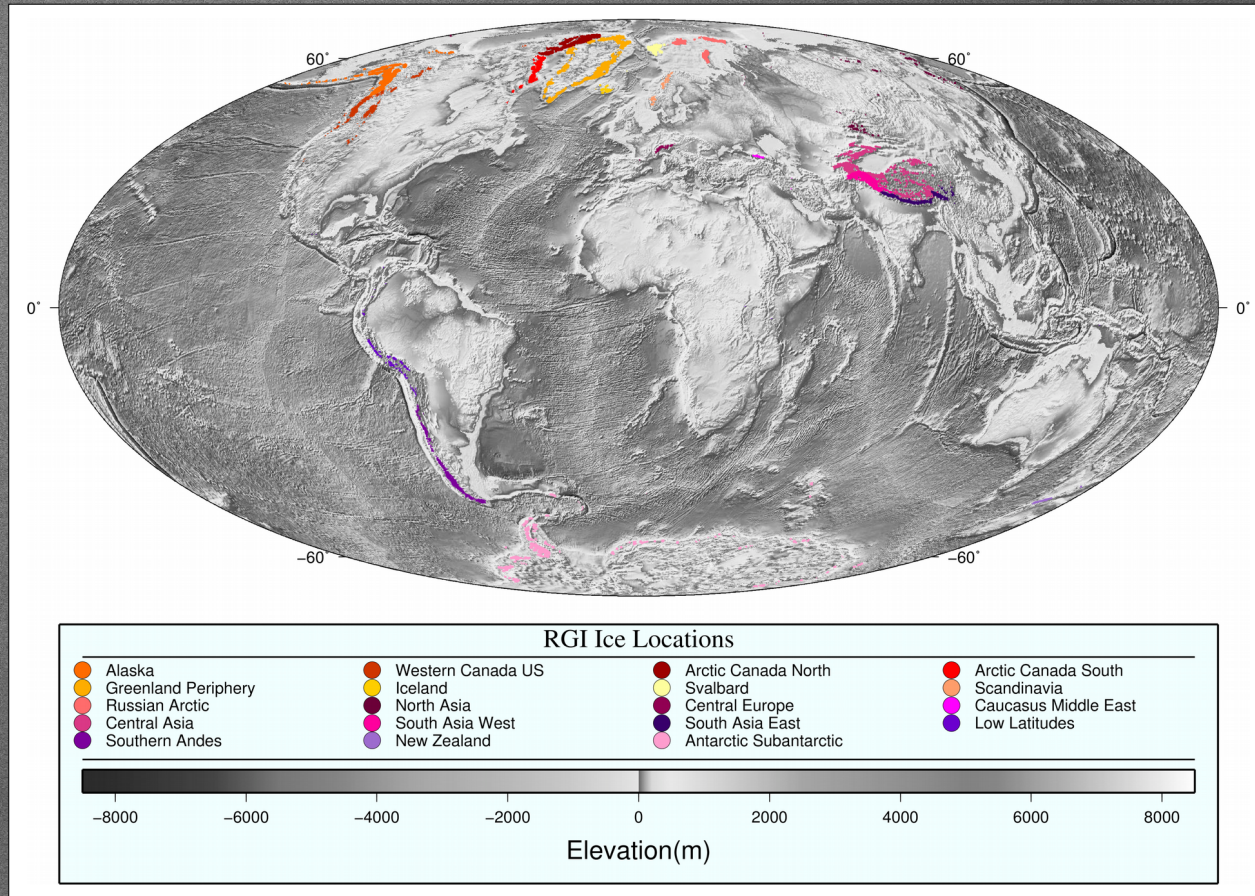Questions?

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# Bonus

# Investigating Lateral Structure

- 3D Structure inferred from seismic models

- 3-Layer background viscosity structure from best scoring runs of 1D simulation

- Compare to 3D model running in spherically symmetric configuration equivalent to 1D model

- 3D structure for future projections adds to uncertainty but not primary contributor

- More investigation required, presently difficult due to computational expense
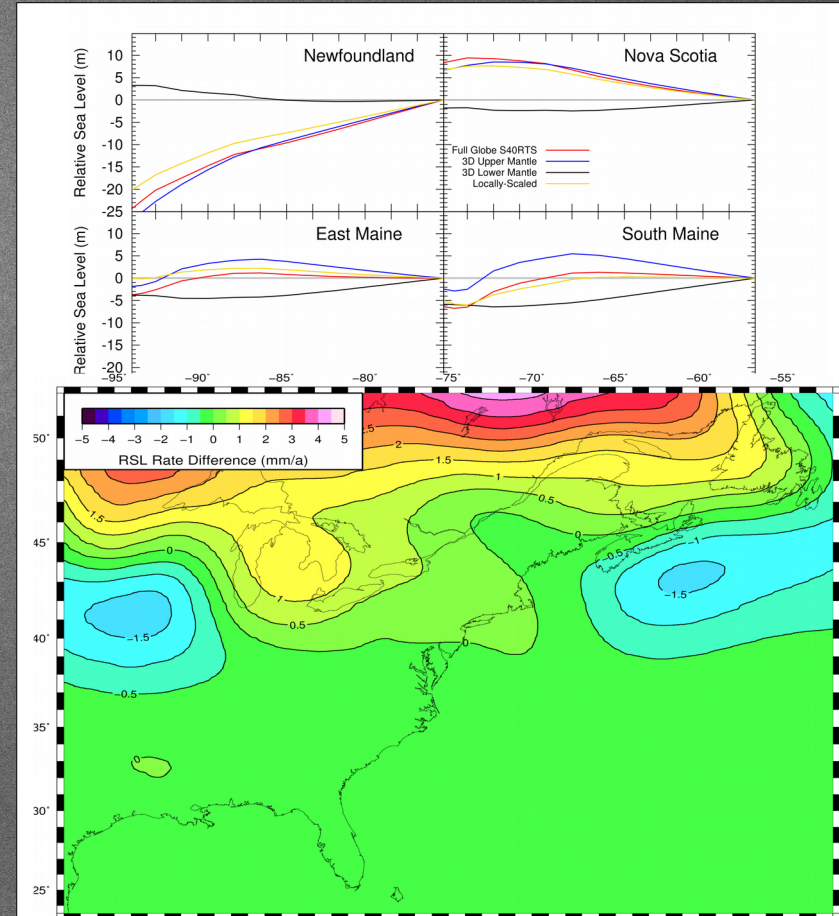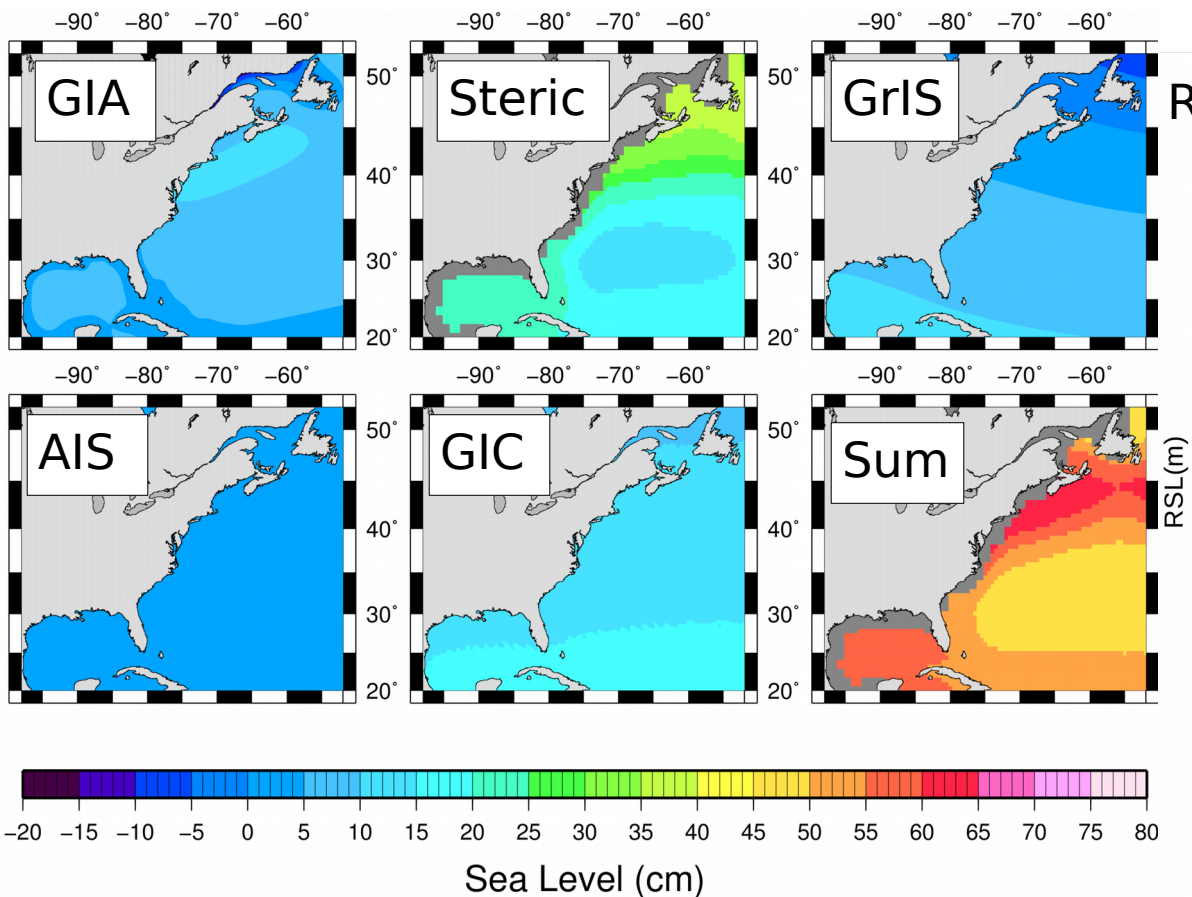
# Glaciers, Ice Caps & Sea Level Fingerprints

- Area of glaciers estimated through Randolph Glacier Inventory (RGI)

- Area converted to volume through Huss and Farinotti upscaling

- Volume used to determine sea level fingerprints

- GMSL estimates from Marzeion et. al. surface mass balance model



RGI Ice Locations

- Alaska
- Greenland Periphery
- Russian Arctic
- Central Asia
- Southern Andes
- Western Canada US
- Iceland
- North Asia
- South Asia West
- New Zealand
- Arctic Canada North
- Svalbard
- Central Europe
- South Asia East
- Antarctic Subantarctic
- Arctic Canada South
- Scandinavia
- Caucasus Middle East
- Low Latitudes

Elevation(m)

# Results: Regional Sea Level Projections