ADVANCED REGIONAL & DECADAL PREDICTIONS OF COASTAL INUNDATION

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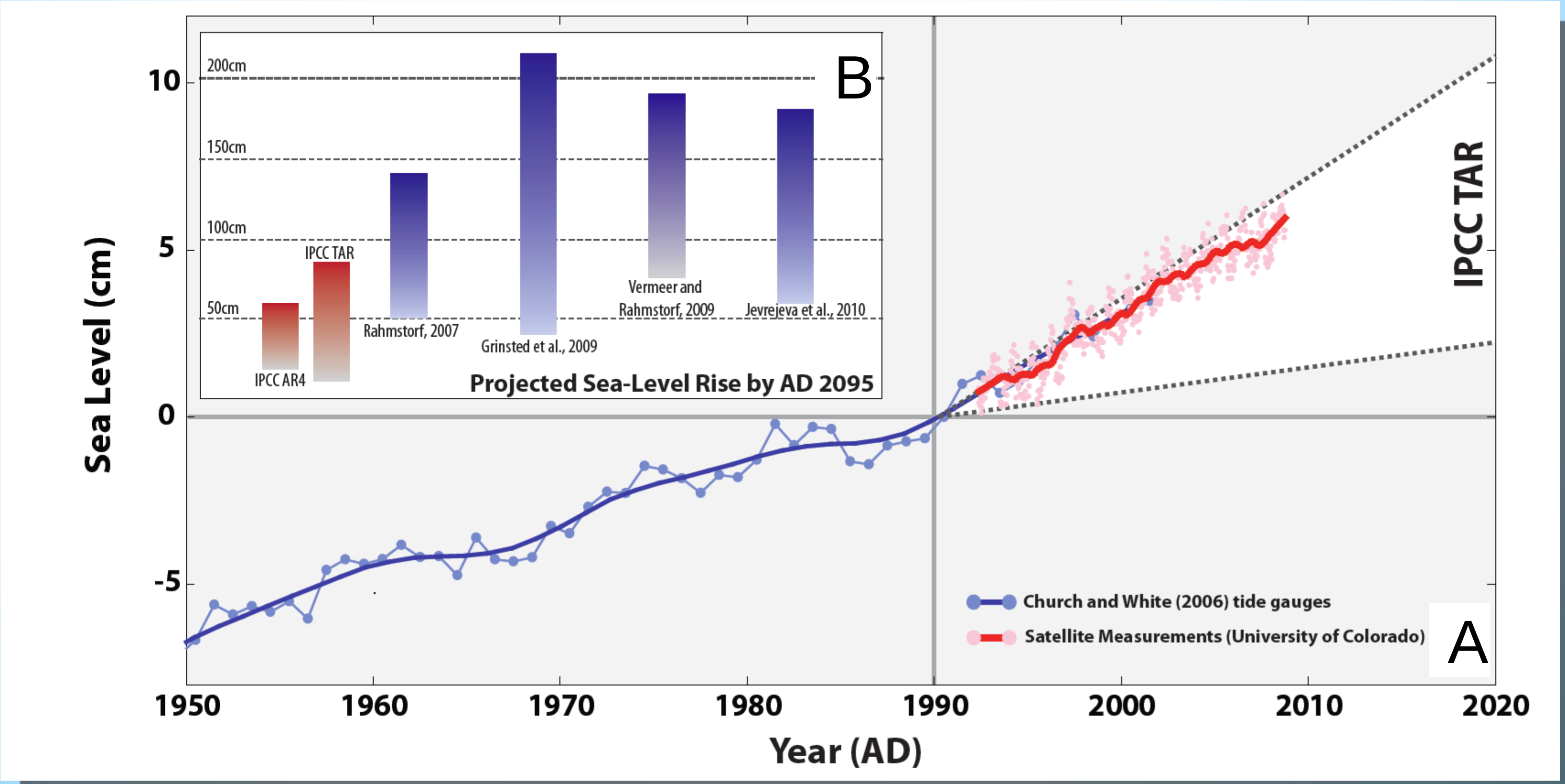
Improving NOAA's Climate Services for the Coastal Zone: A Special Competition

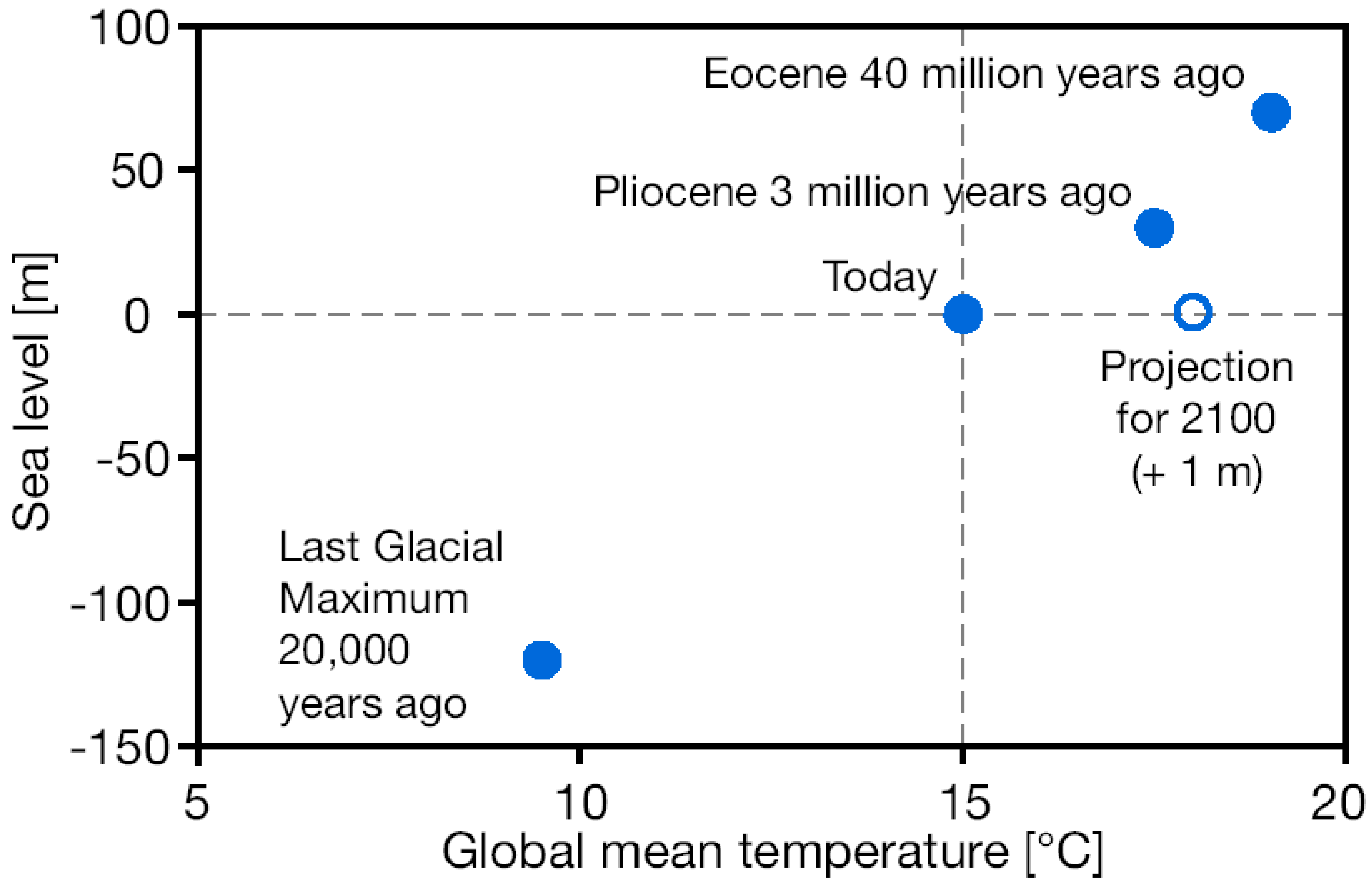
Integrated work across the four thematic areas (observations, modeling, Earth system science, and **decision support**) would contribute to an improved ability to address the needs of coastal decision makers by providing tools that better reflect an understanding of how the expected extent of coastal inundation may change through time.

Identification of the problem: sea level rise



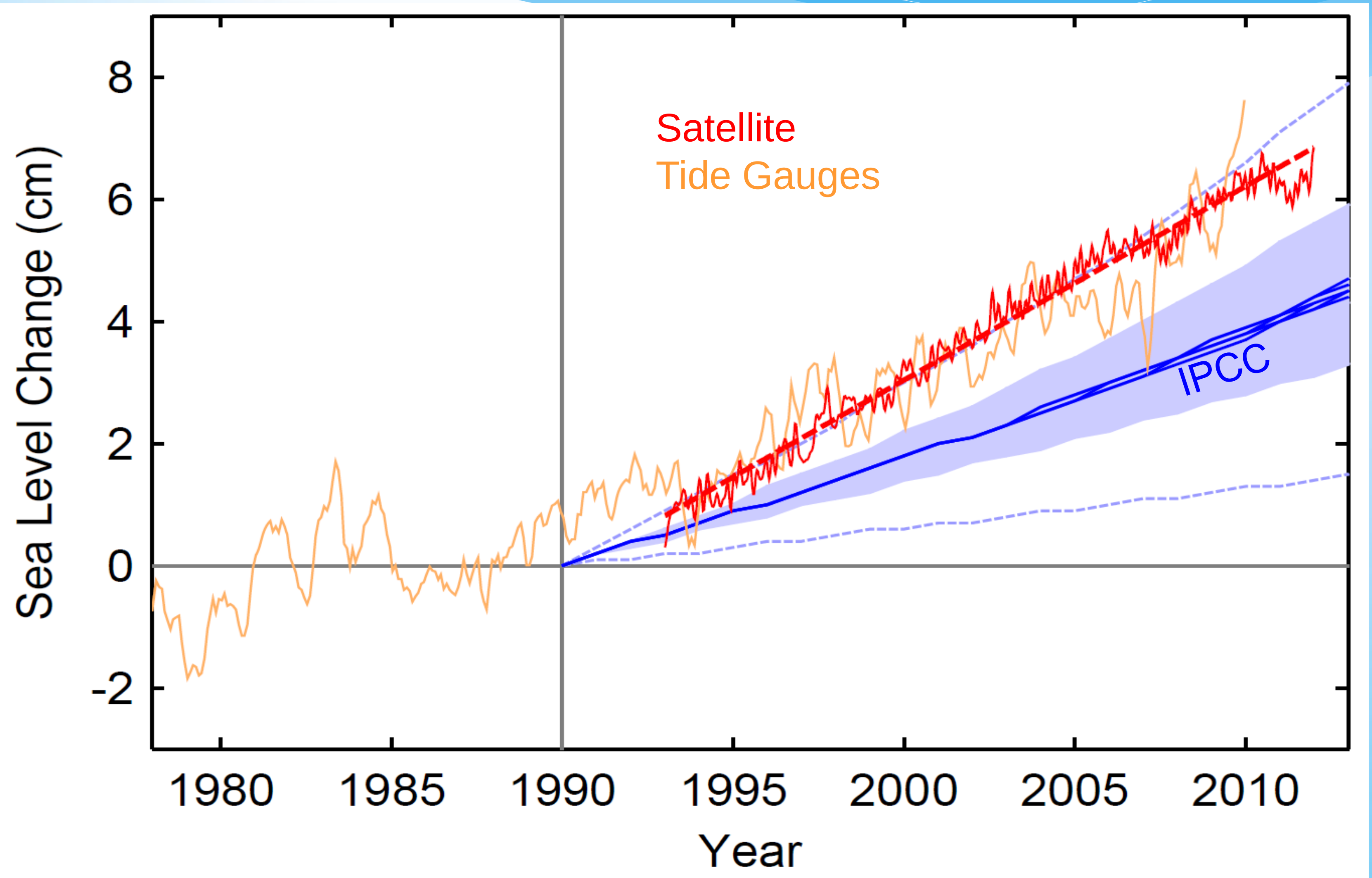
(A) Tide gauge and satellite measurements of sea level since AD1880 with IPCC TAR projection to AD 2020. (B) Projections of 21st century sea-level rise including IPCC AR4 and TAR (red)and semi-empirical models (blue).

Past sea level vs. temperature

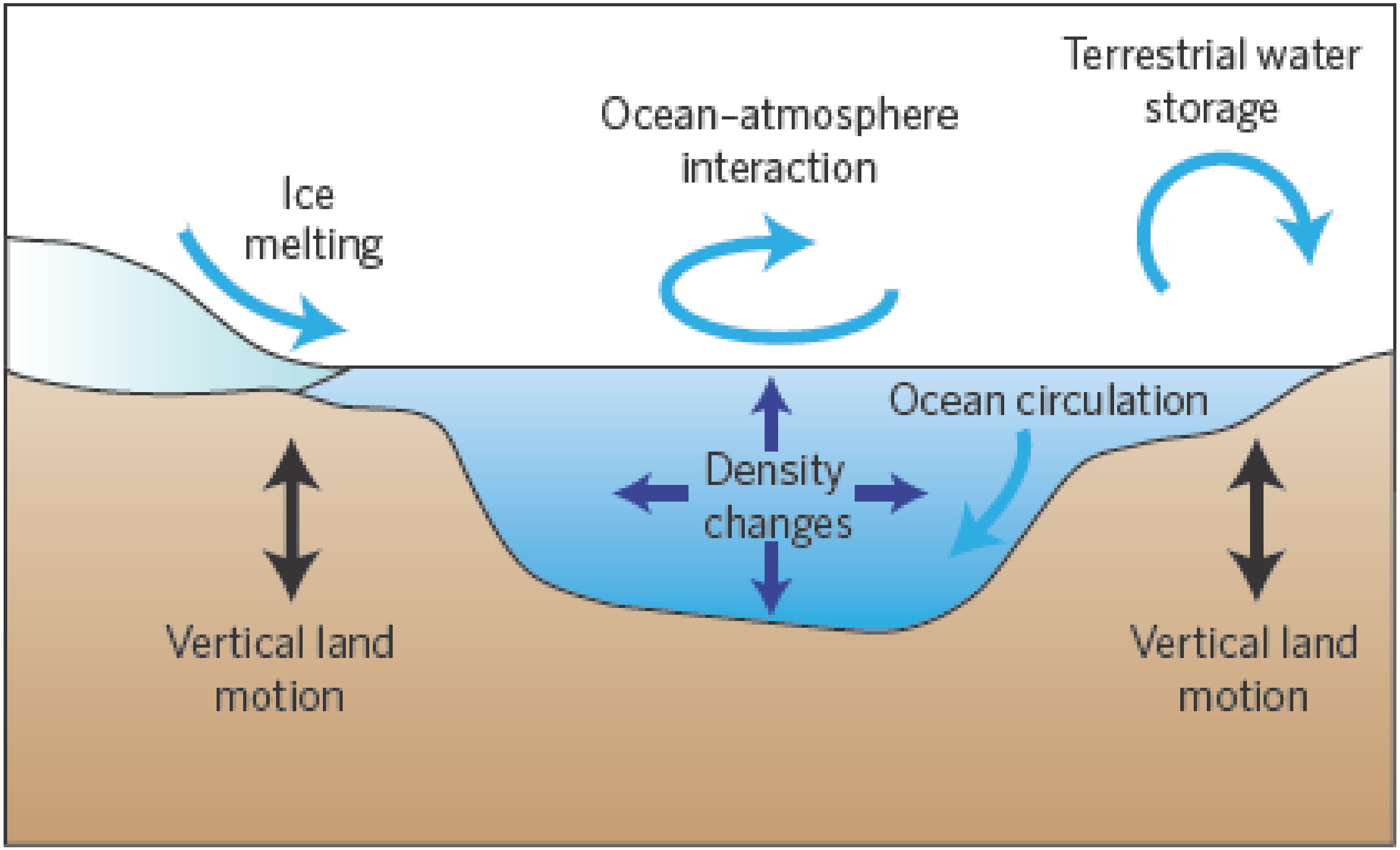


(WBGU, after Archer 2006)

Global sea level rising faster than expected

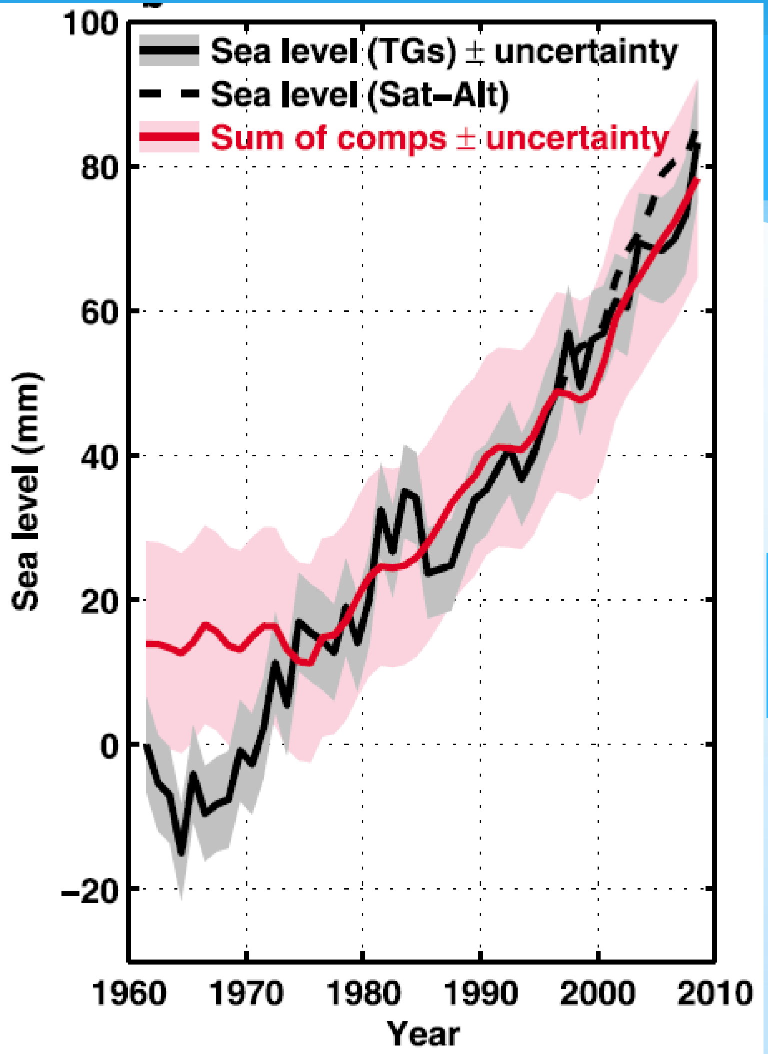


Complex causes of sea level change



SLR= Oceans + Land

Contributions to global sea level rise



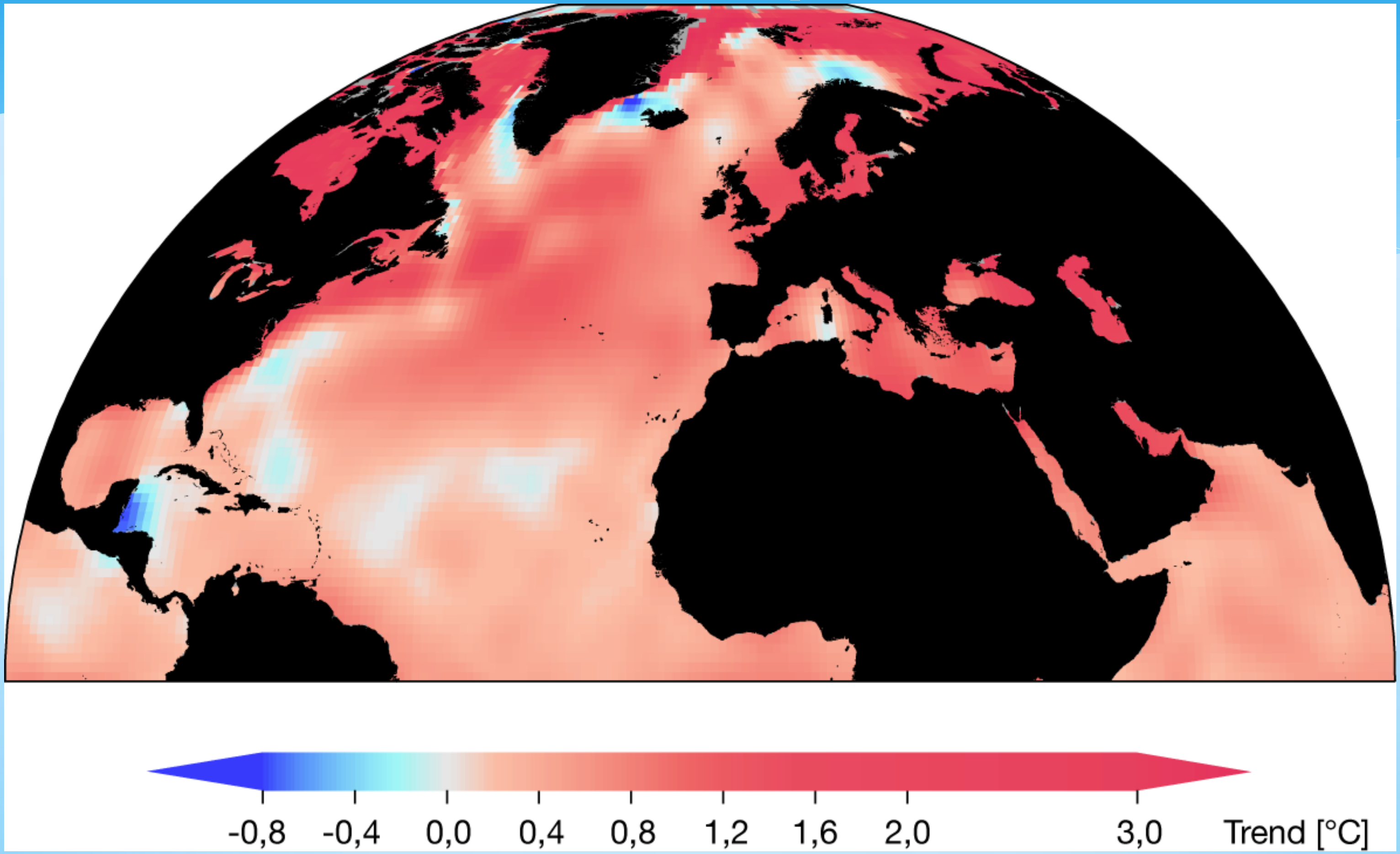
For 1972-2008: 1.8 mm/yr:
(Source: Church et al., GRL 2011)

- Thermal expansion (ca. 40 %)
- Glaciers and ice caps (ca. 35 %)
- Continental ice sheets (ca. 25 %)

For 2003-2008: 2.5 mm/yr:
(Source: Cazenave et al., GPC 2008)

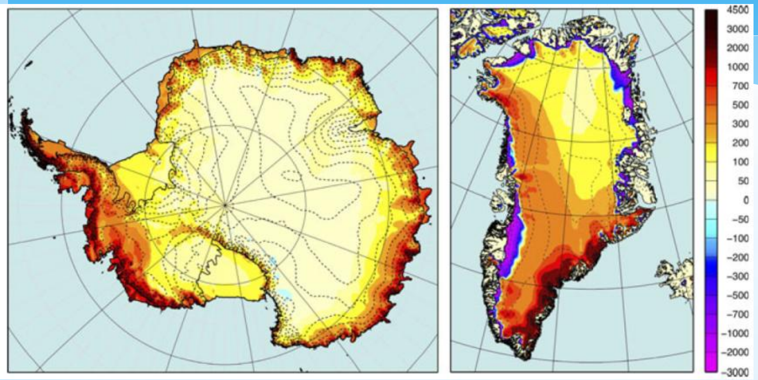
- Thermal expansion (ca. 20%)
- Glaciers and ice caps (ca. 40 %)
- Continental ice sheets (ca. 40 %)

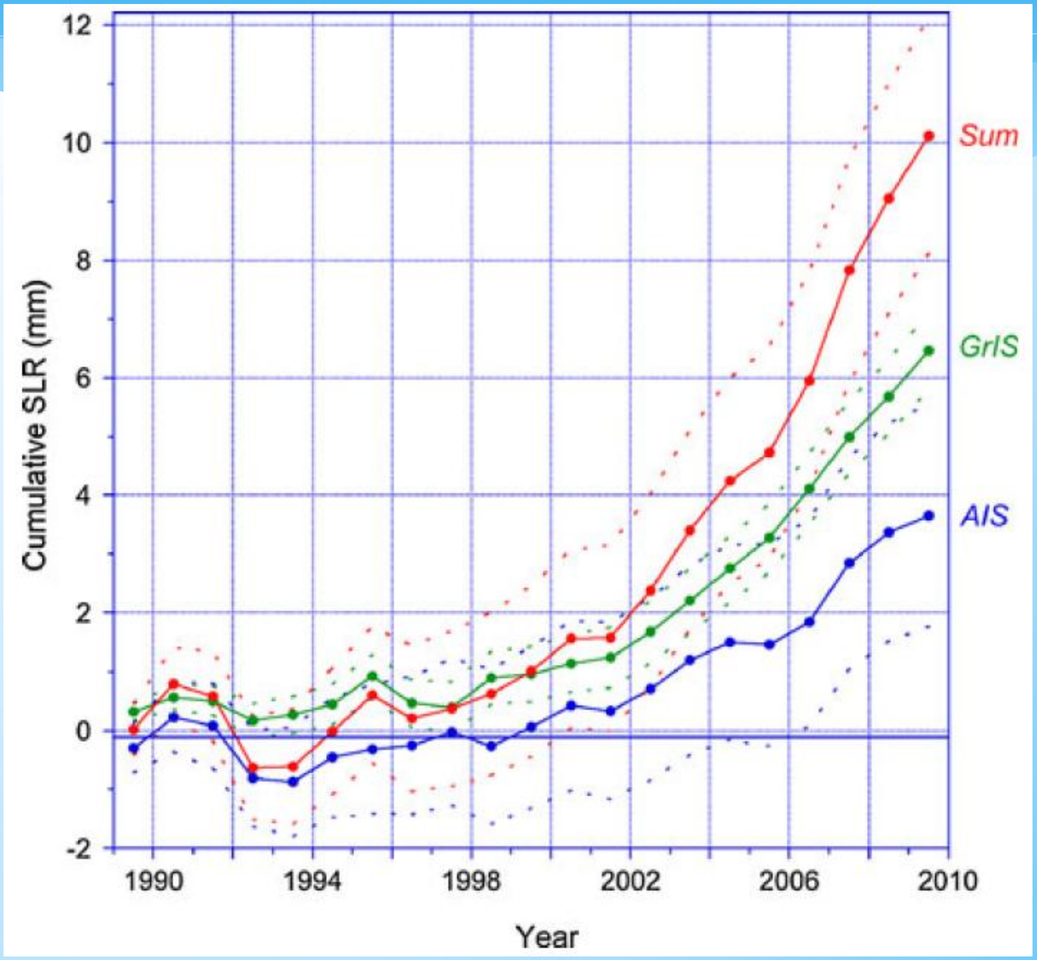
Thermal Expansion



Trend of sea surface temperatures 1978 - 2002

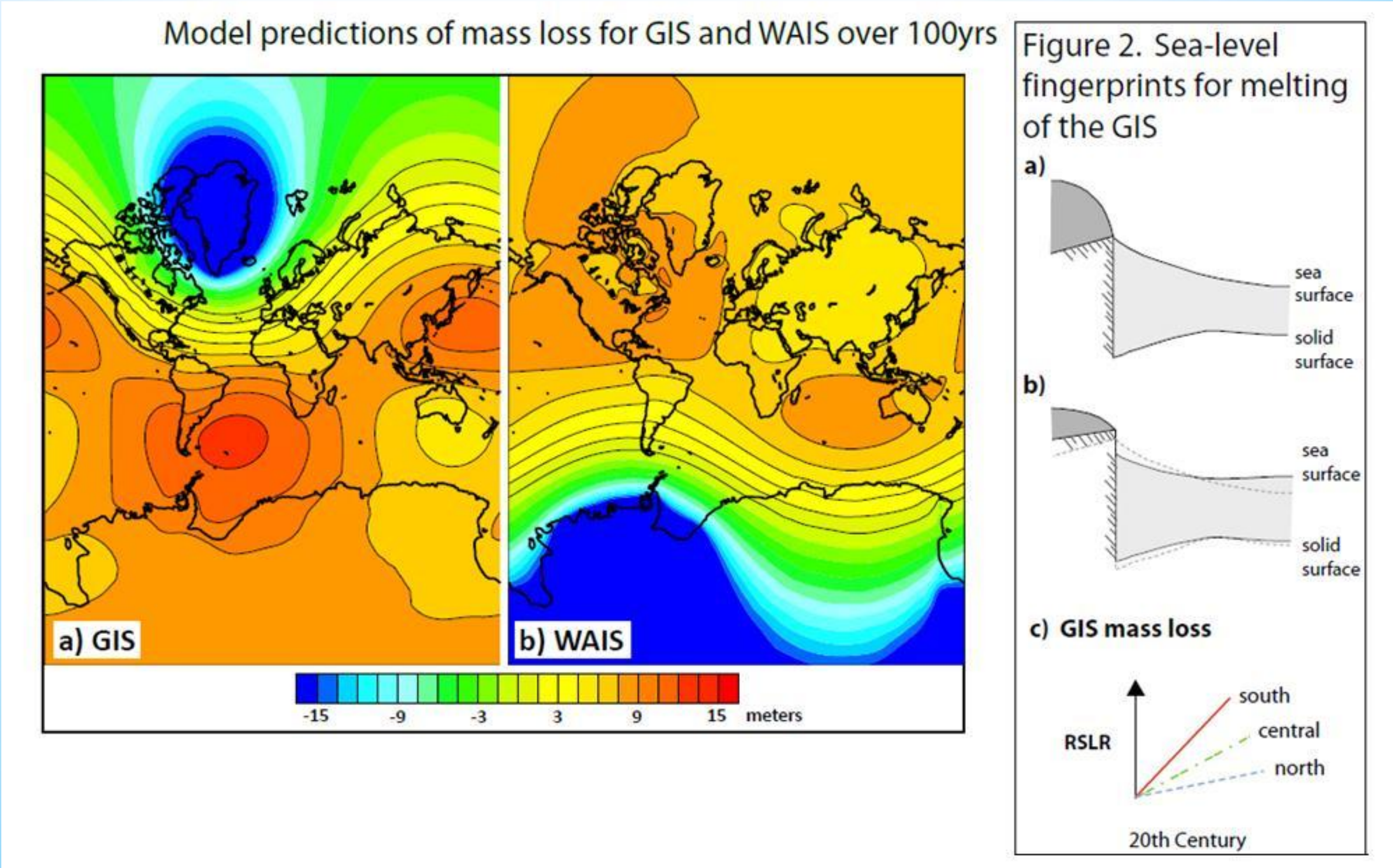
Ice sheet contributions to sea level





Van den Broeke et al. Surv. Geophys. 2011

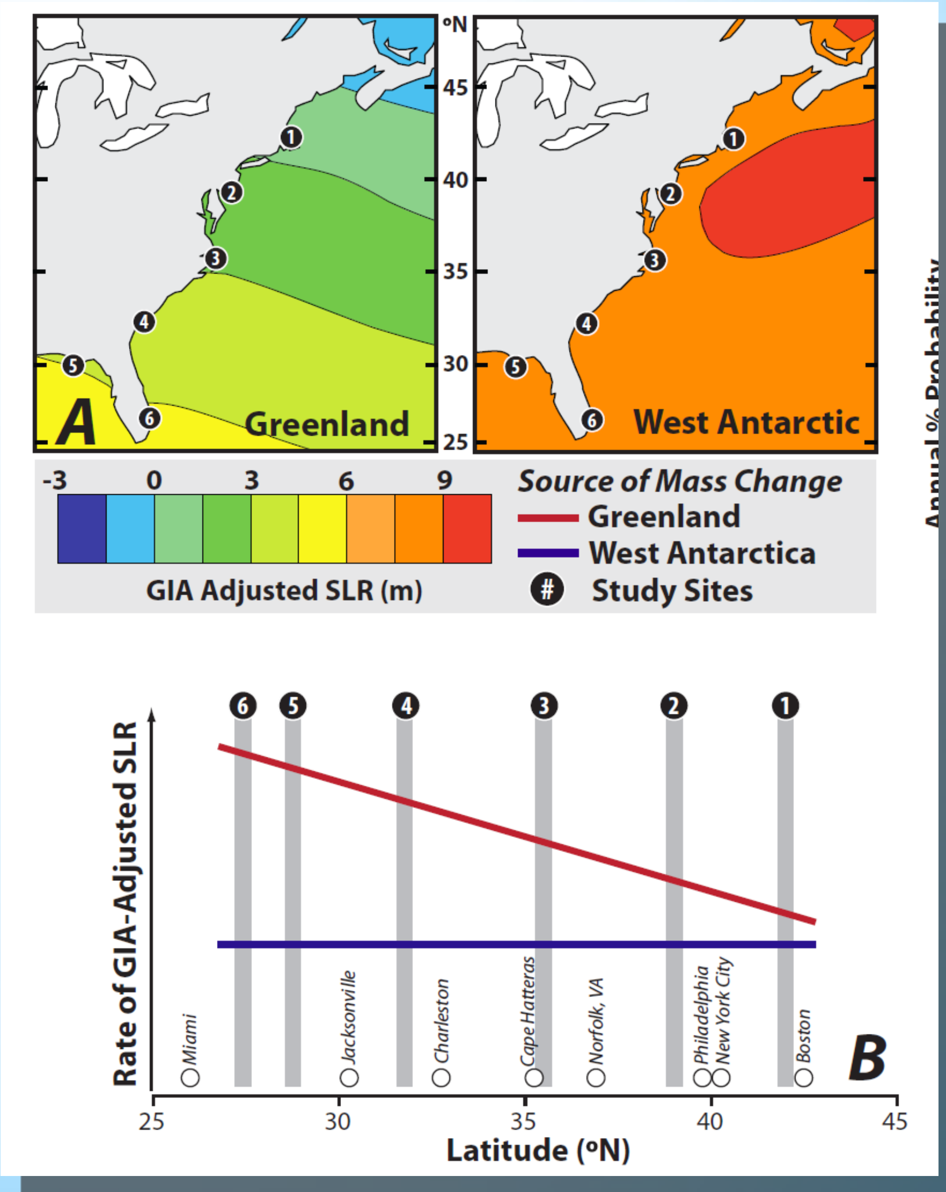
Regional variability: sea level fingerprint



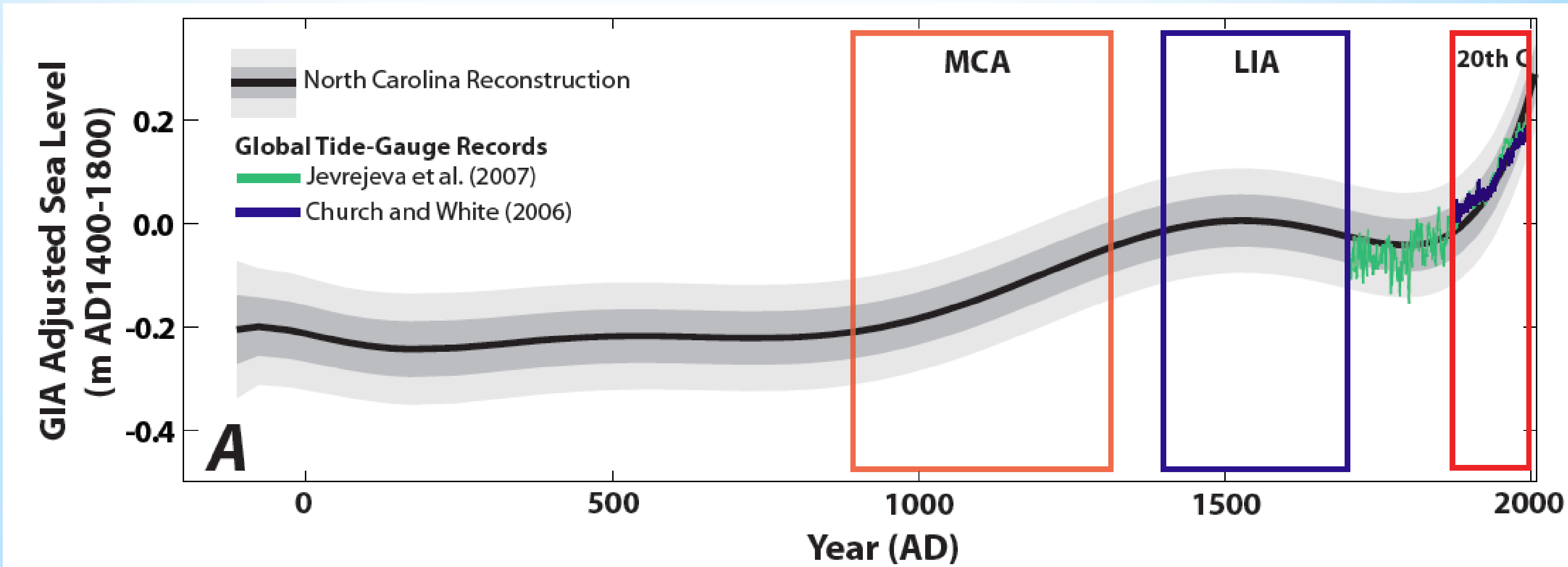
If the ice sheet melts, the attraction is reduced and SLR increases in areas geographically distal to the melting ice sheet

Selection of study sites

Modeled pattern of sea-level rise along the US Atlantic and Gulf coast when the Greenland Ice Sheet (left) or Western Antarctic Ice Sheet (right) are the sources of meltwater

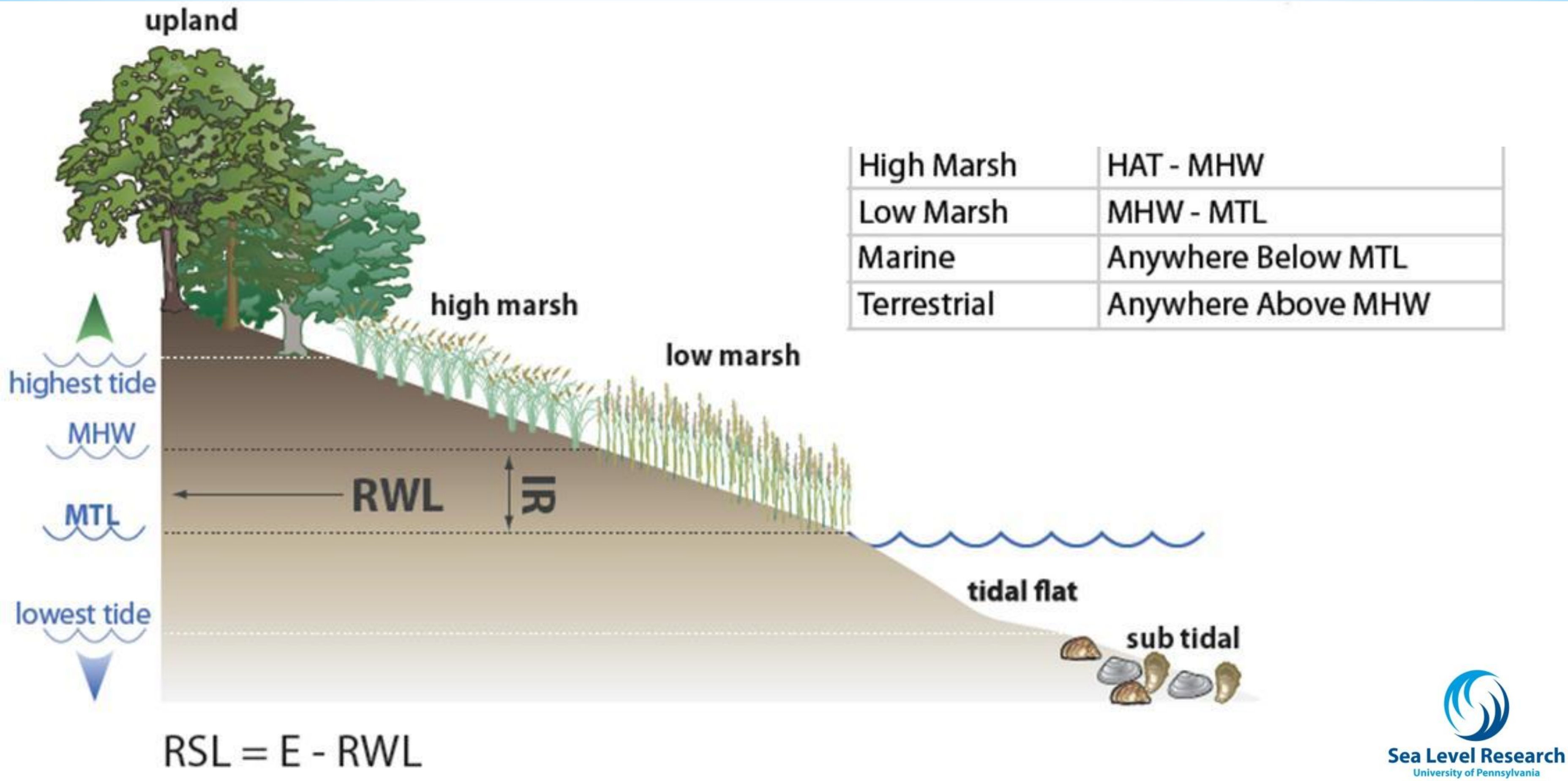


Identify past sea-level variations



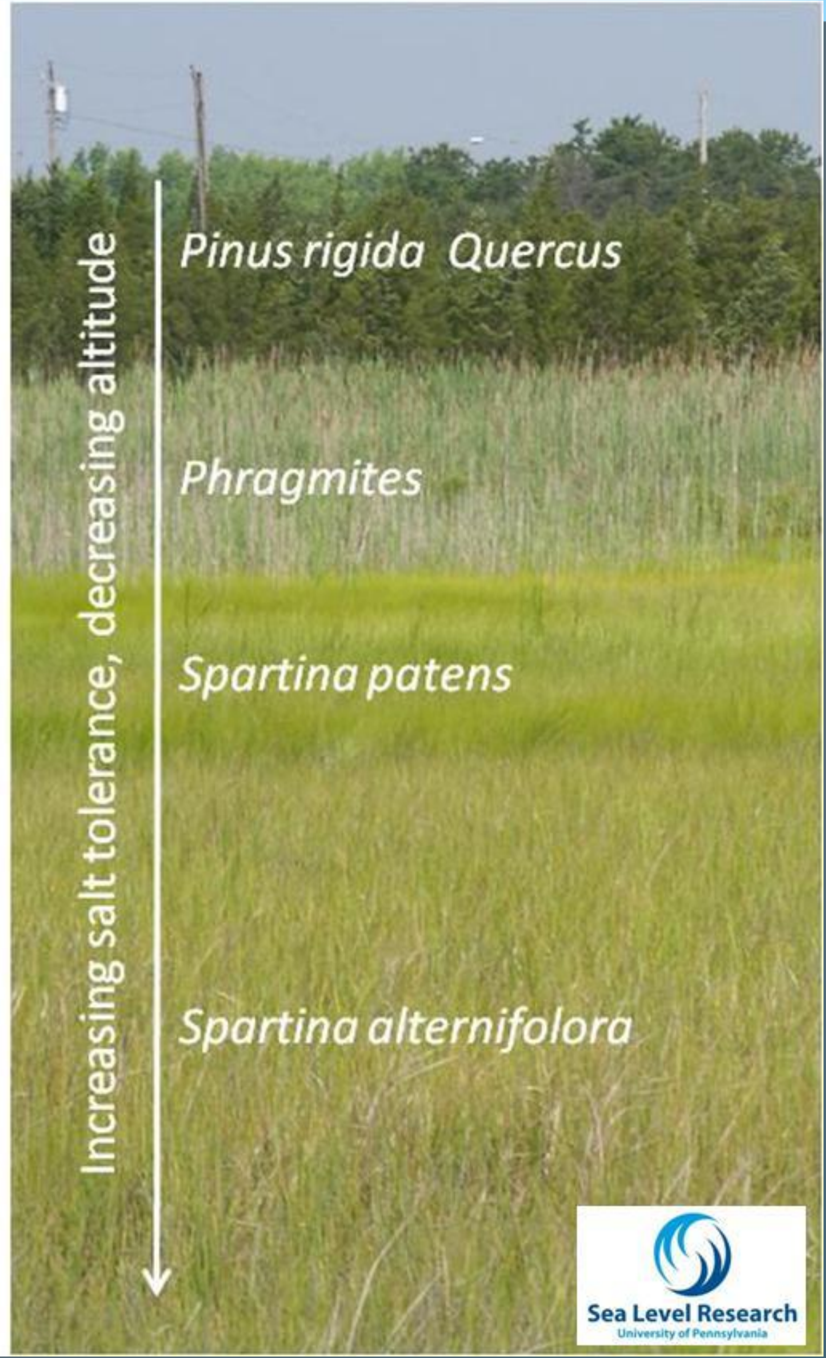
Summary sea-level reconstruction from North Carolina (grey band of 1 and 2 sigma errors) corrected for glacio-isostatic adjustment. Global tide gauge compilations shown for comparison aligned on same vertical scale

How do you reconstruct former sea-levels?

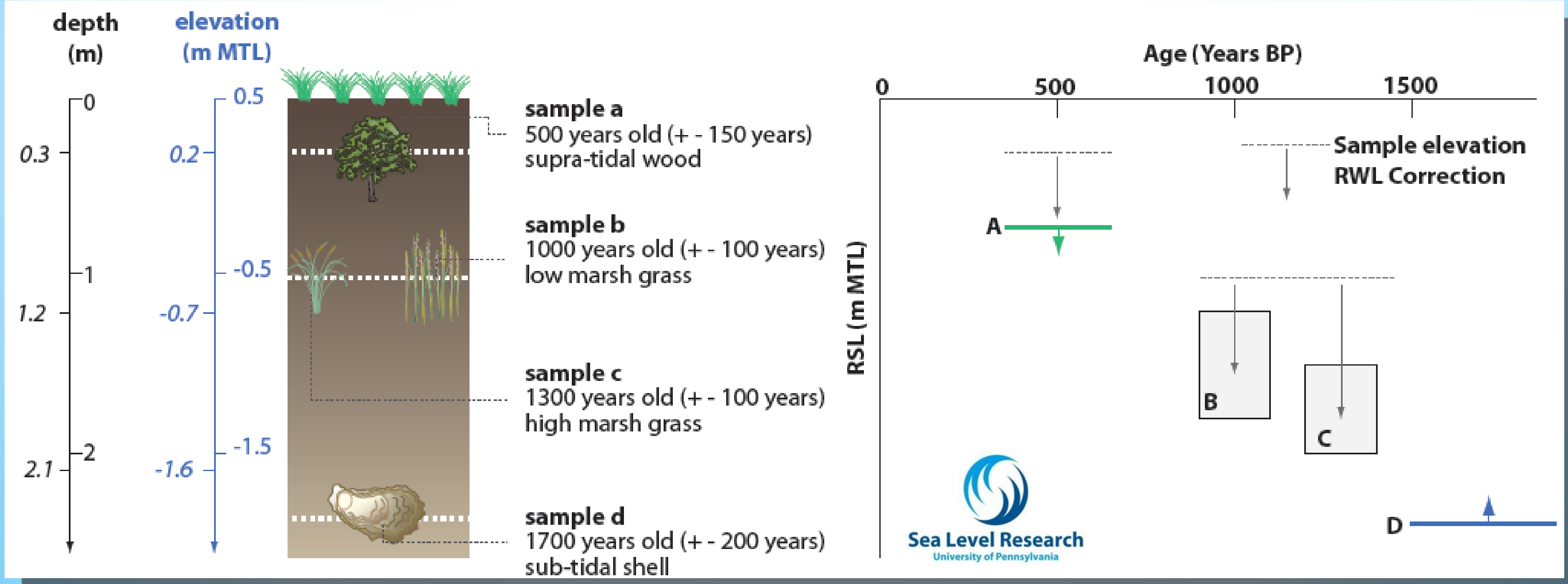


High Marsh	HAT - MHW
Low Marsh	MHW - MTL
Marine	Anywhere Below MTL
Terrestrial	Anywhere Above MHW

We define the relationship between a sea-level indicator and a tide level (e.g. mean tide level) in the modern environment


Increasing salt tolerance, decreasing altitude
Pinus rigida Quercus
Phragmites
Spartina patens
Spartina alternifolora
Sea Level Research
University of Pennsylvania

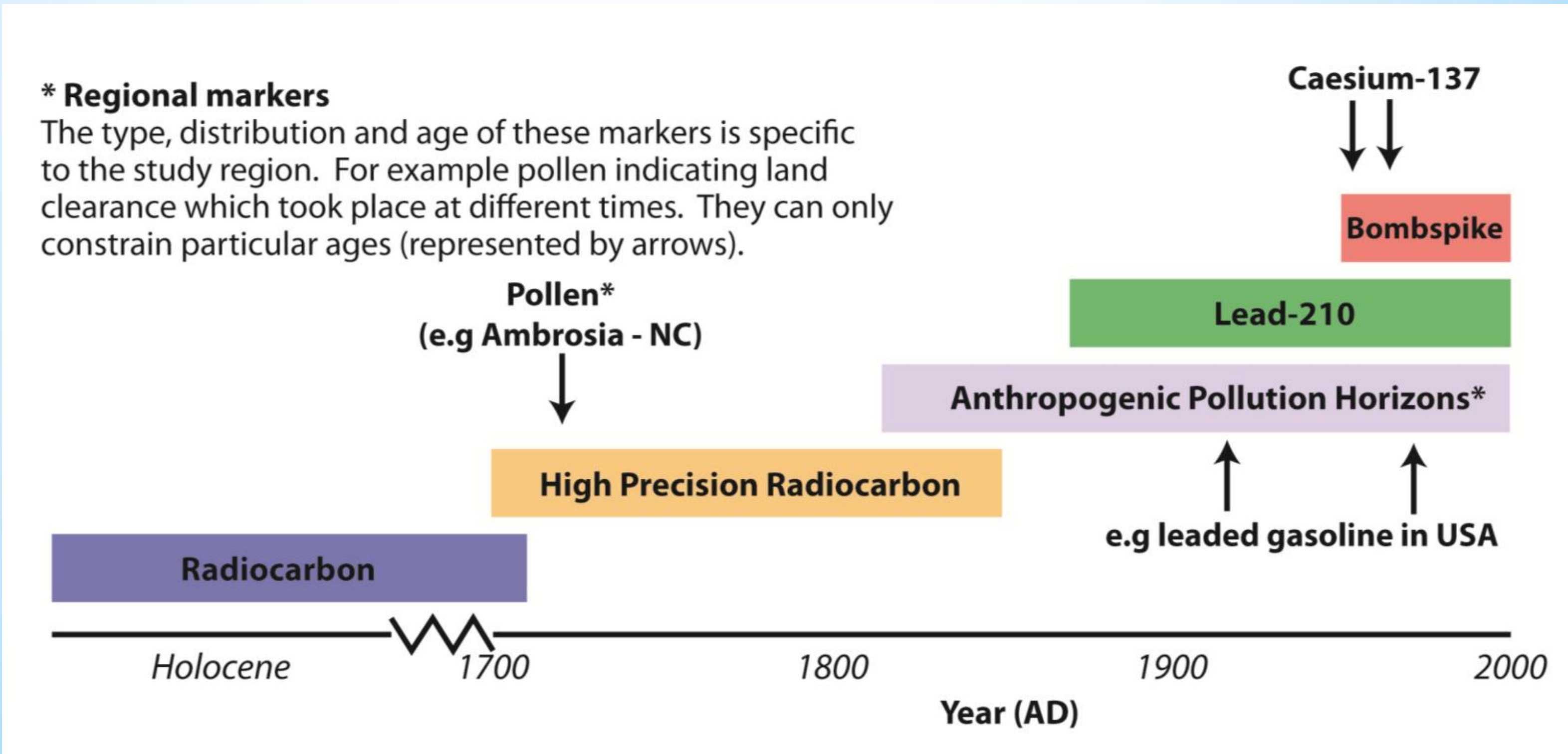
Fossil salt marsh environment



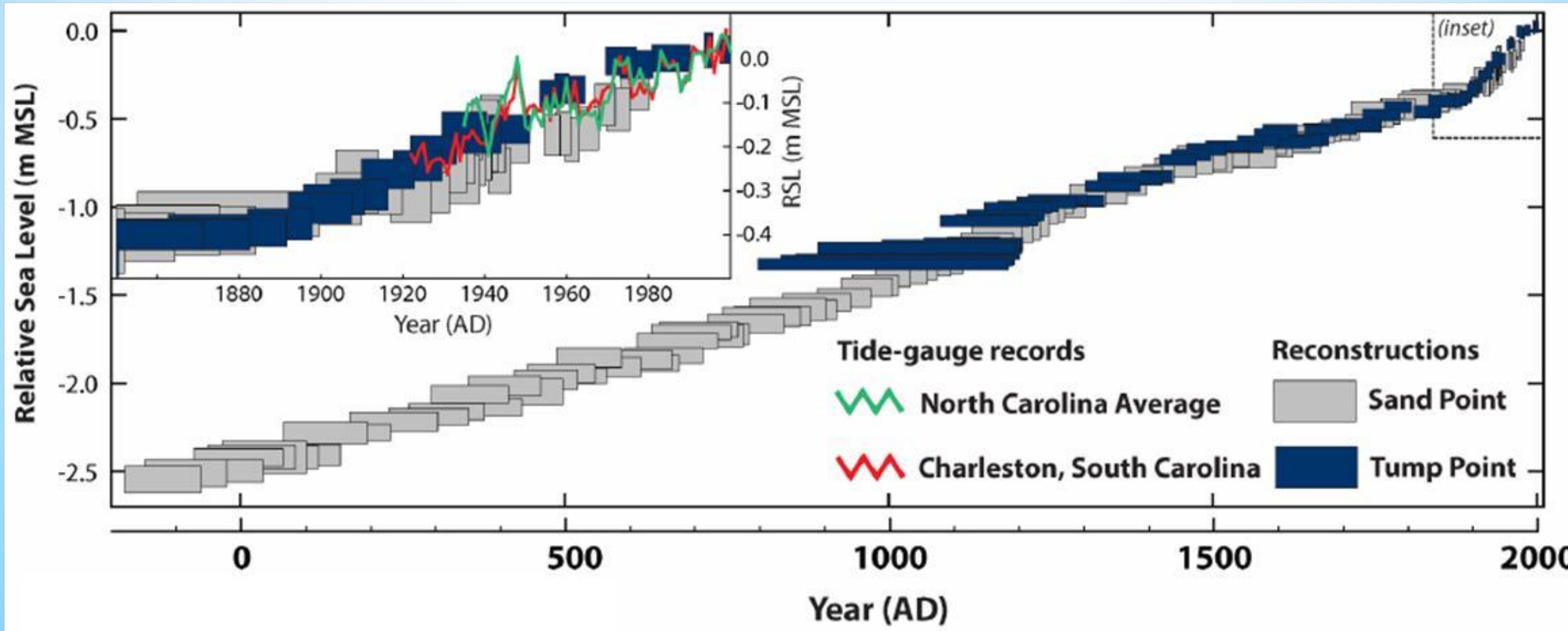
SL is calculated by subtracting the tide level from the elevation of the dated sample

History of changing sea level

Composite Chronologies

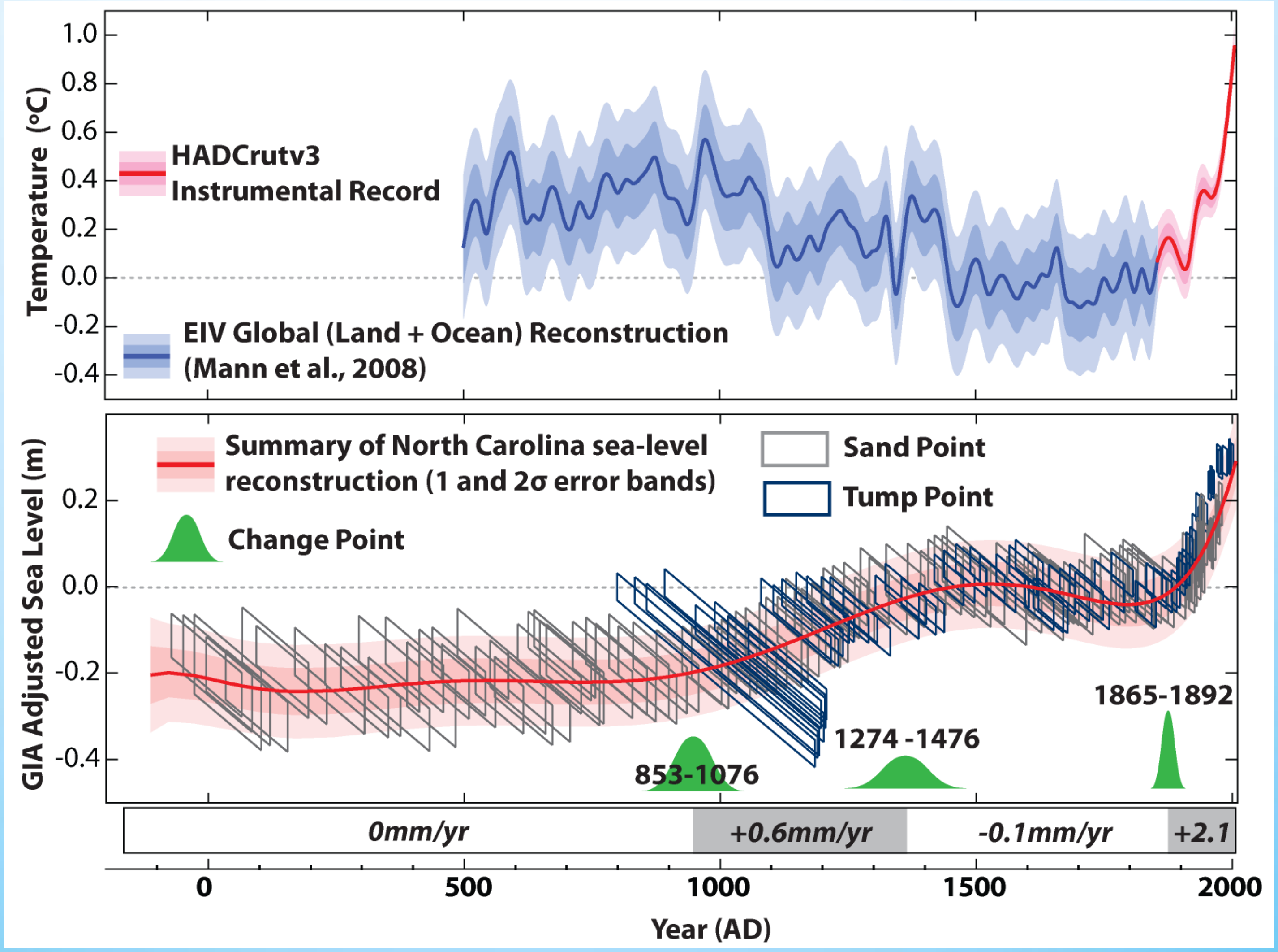


Sea levels for the last 2200 years for North Carolina

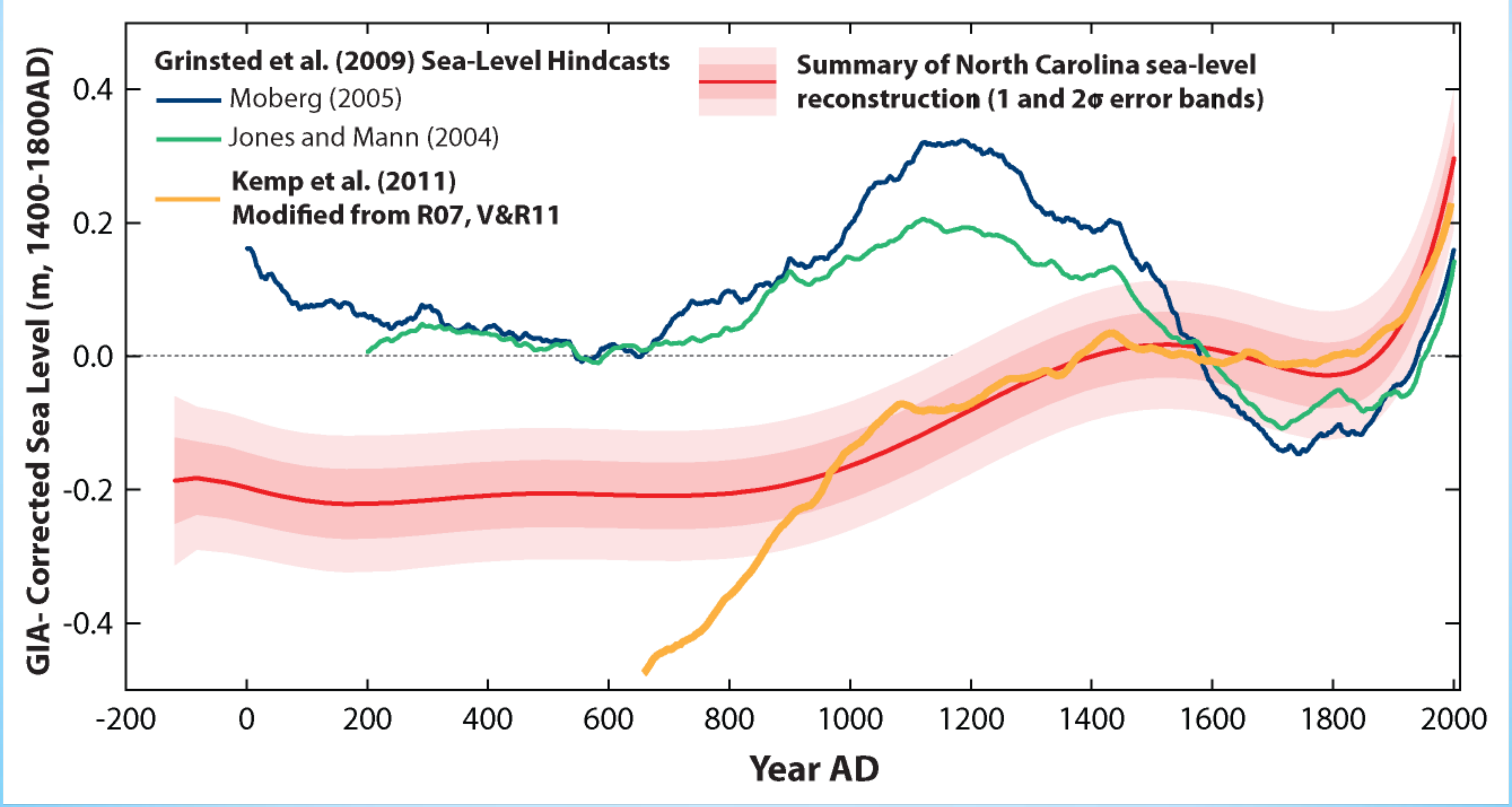


- Records from Sand Point and Tump Point are in agreement, and reconciliation of tide gauge records provides provide confidence
- 2 sites are >120 km apart and in different water bodies so local (and tectonic) factors assumed to be negligible

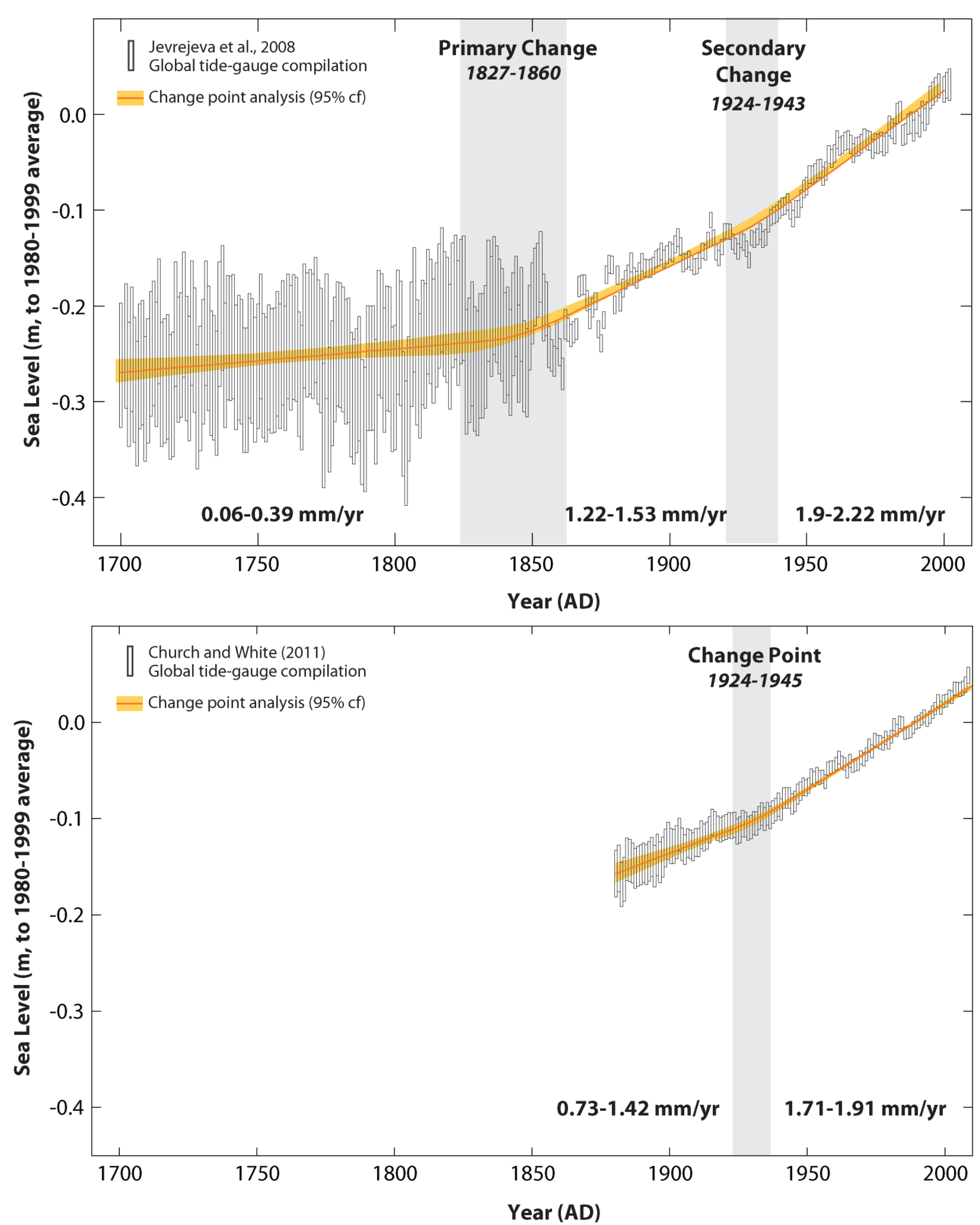
Reliable projections of sea-level rise



Semi-Empirical Models of Sea-Level Rise



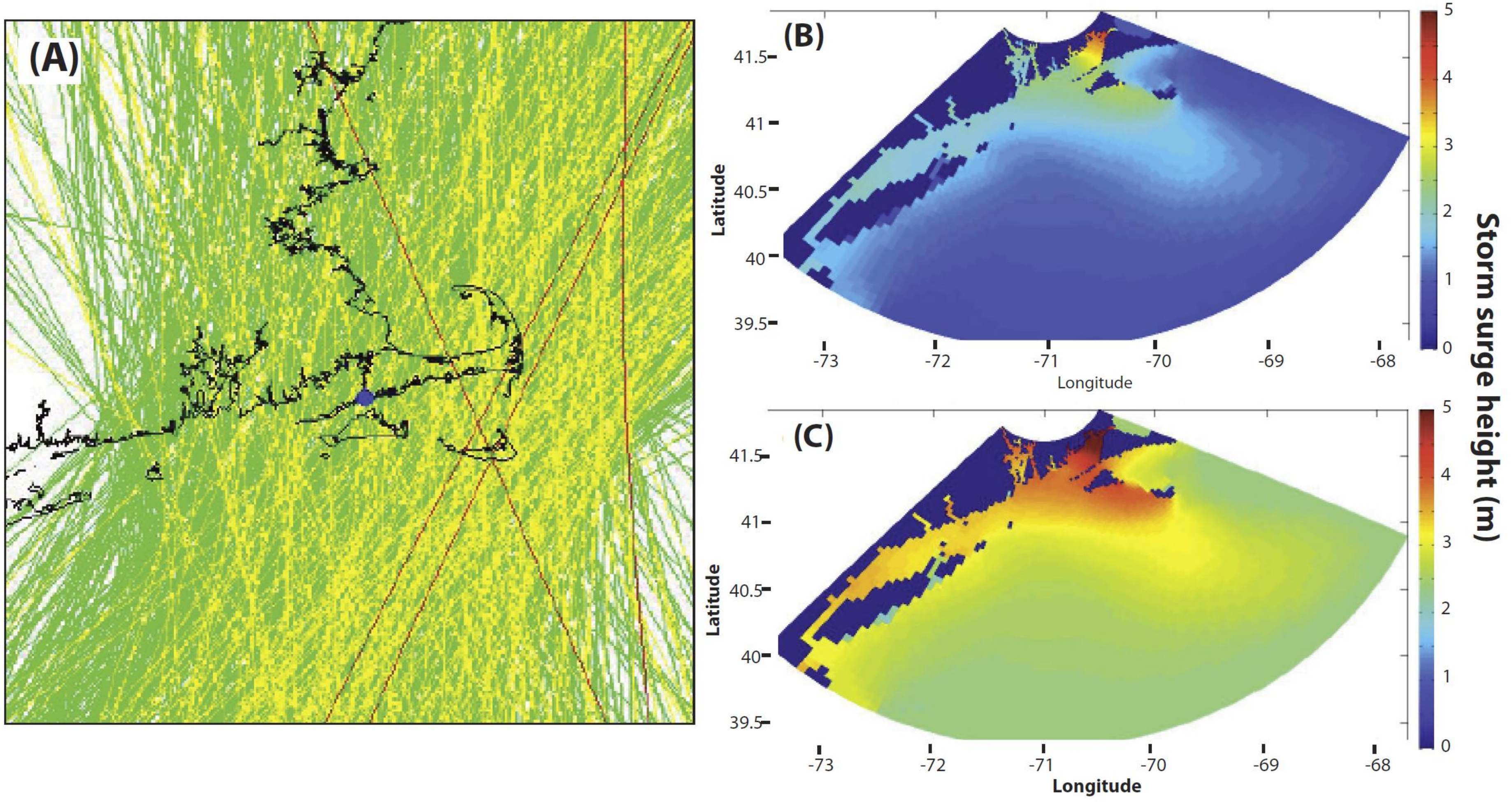
* Semi-empirical models feature in IPCC AR5
* Proxy data uniquely extend calibration period to include stable sea level, long term response
* Proxy data show misfit – are projections reliable?



When Did Modern Sea-Level Rise Begin?

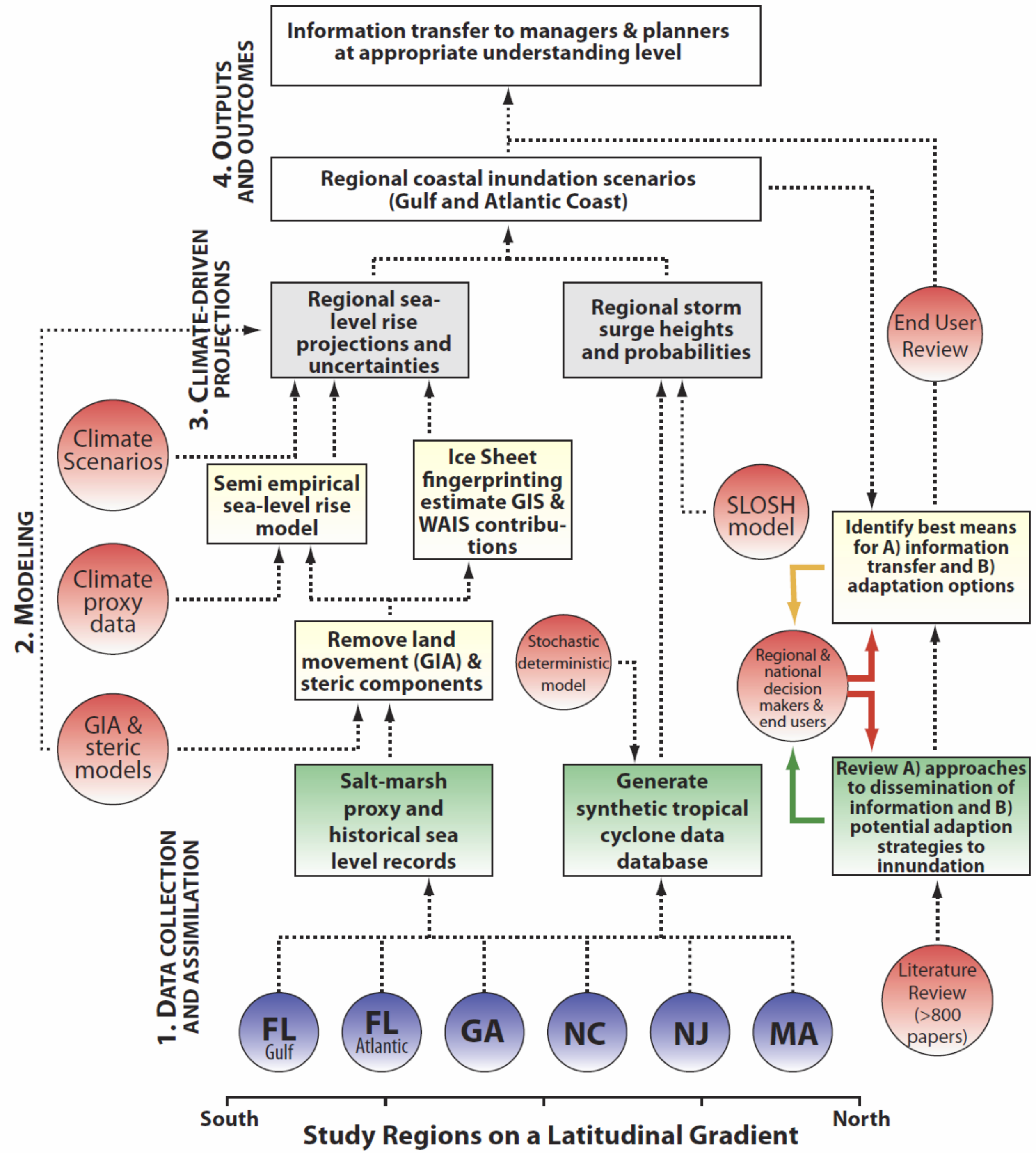
* Instrumental rate>background rate
* 1924-1943 but global tide gauges are too short to catch primary switch
* 1827-1860, but based on only 3 gauges in Europe
* NJ (1835-1869) and NC (1865-1892)

Couple tropical cyclone climatologies and sea level rise



Optimize information transfer on coastal inundation to planners and managers

- We plan to process the most important information regarding sea-level rise and tropical cyclone activity into advanced, yet, readily interpretable suites of information products for decision making.
- To do this we need your input



4. OUTPUTS AND OUTCOMES
Information transfer to managers & planners at appropriate understanding level
Regional coastal inundation scenarios (Gulf and Atlantic Coast)
3. CLIMATE-DRIVEN PROJECTIONS
Regional sea-level rise projections and uncertainties
Regional storm surge heights and probabilities
End User Review
2. MODELING
Climate Scenarios
Semi empirical sea-level rise model
Ice Sheet fingerprinting estimate GIS & WAIS contributions
SLOSH model
Identify best means for A) information transfer and B) adaptation options
Climate proxy data
Remove land movement (GIA) & steric components
Stochastic deterministic model
Regional & national decision makers & end users
GIA & steric models
Salt-marsh proxy and historical sea level records
Generate synthetic tropical cyclone data database
Review A) approaches to dissemination of information and B) potential adaption strategies to innundation
1. DATA COLLECTION AND ASSIMILATION
FL Gulf
FL Atlantic
GA
NC
NJ
MA
Literature Review (>800 papers)
South
North
Study Regions on a Latitudinal Gradient

In summary

The products of our research will raise the bar for the scientific prediction of region-specific inundation probabilities in terms of semi-empirical proxy data, hindcast- and forecast-driven sea-level modeling and tropical cyclone forecasting.