

# **Observational evidence of present day global sea level acceleration started in late 18<sup>th</sup> century**

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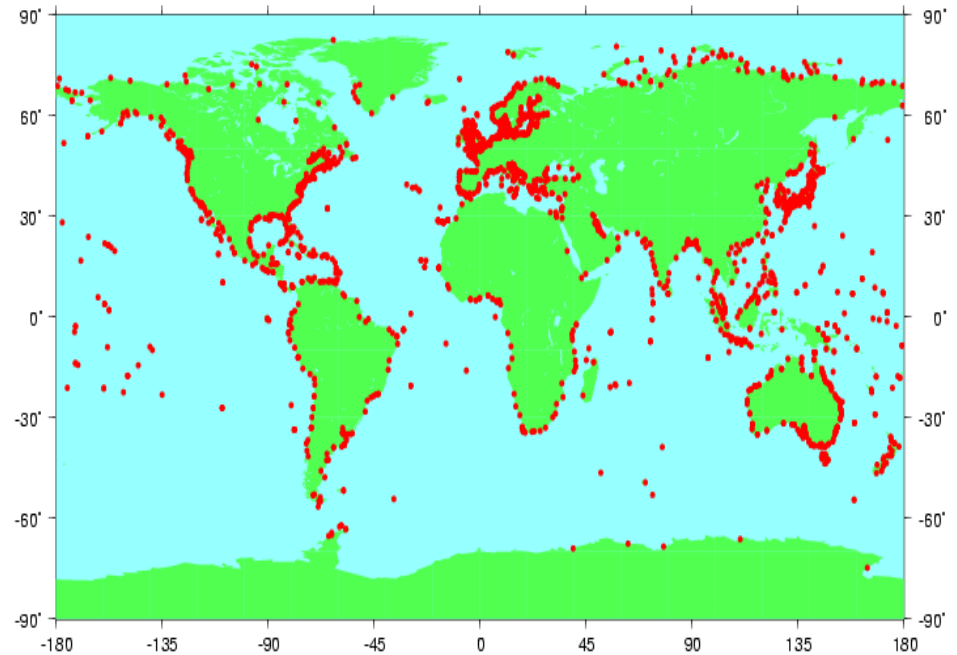
# Outline

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- PSMSL
- Motivation
- Objectives
- Data (global sea level reconstruction since 1700)
- Results
- Conclusion

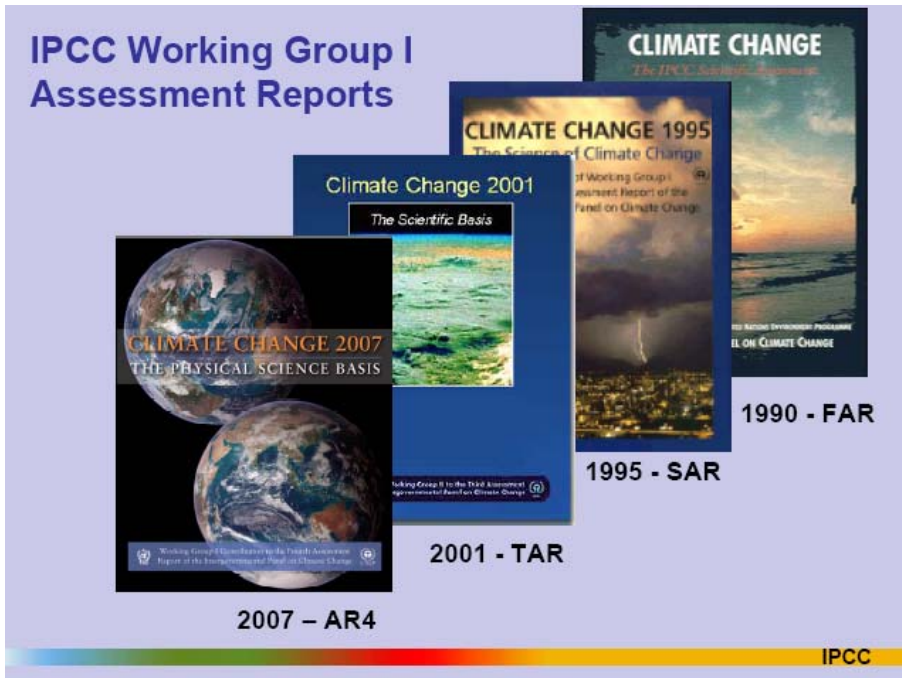
# Distribution of PSMSL tide gauge data

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- **oceanography**
- **geology**
- **geodesy**
- **climate change**

# Contribution to IPCC reports



.....global sea level had risen during the 20th century by  $1.8 \pm 0.5$  mm per year, increasing to over  $3.1 \pm 0.7$  mm per year in the 1990s.

# Motivation

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Intergovernmental Panel of Climate Change (IPCC) reports suggest:

- 0.22 mm/yr<sup>2</sup> in the IPCC [1995] (models)
- 0.014 mm/yr<sup>2</sup> in the IPCC [2001] (models)

The recent IPCC report [2007] suggests a 20th century acceleration of about 0.013 mm/yr<sup>2</sup>.

The rate of global mean sea level rise over the last decade (1993-2003) determined from TOPEX/Poseidon altimeter measurements is 3.1 mm/yr [IPCC, 2007], which is significantly larger than estimates (1.7 mm/yr) of the 20th century linear trend for sea level rise [IPCC, 2007], and has reignited the discussion on whether sea level rise is accelerating.

# Motivation

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Results from analysis of individual long term observational records do not present enough evidence for an unambiguous global acceleration.

There are two main problems in the detection of acceleration in observational records [*Douglas*, 1992; *Woodworth*, 1990, 1999]:

- inadequate approaches to overcome interannual and decadal variability in sea level time series
- and the lack of globally distributed long term tide gauge records

# Questions

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- Is there acceleration in global sea level calculated from observations during 1700-2003?
- When did recent global sea level acceleration start?
- How does acceleration change over time?

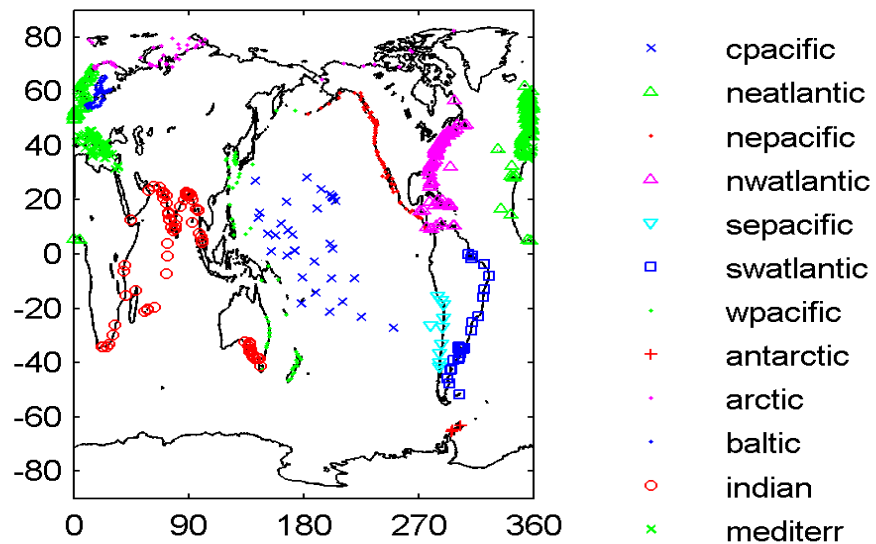
# Objectives

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- To reconstruct global sea levels since 1700 using the tide gauge data available from PSMSL
- Using advanced statistical methods to provide estimates of global sea level acceleration



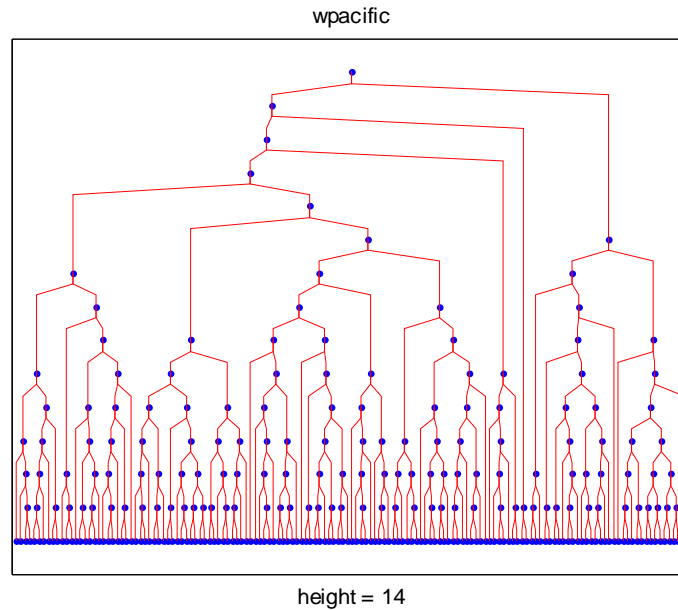
# Data



Location of 1023 tide gauges included in this study

1. RLR sea level data from PSMSL (1023 stations)
2. GIA corrections from Peltier (2001)
3. No pressure corrections
4. 12 regions

## 'Virtual station' method

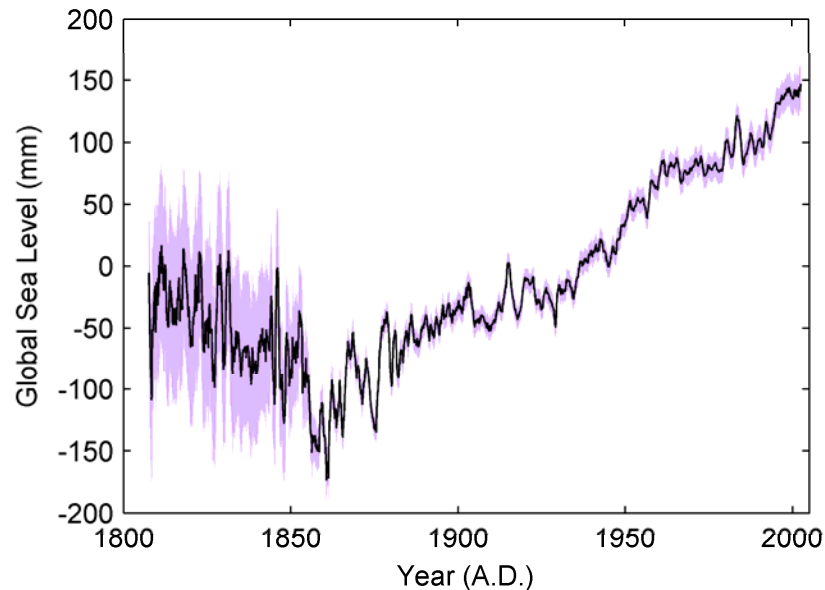


Binomial tree to illustrate the 'virtual station' stacking method. Top-node represents the regional average, bottom nodes the tide gauge records (147 tide gauges)

# Results

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## Global sea level reconstruction 1807-2002



### Additional data

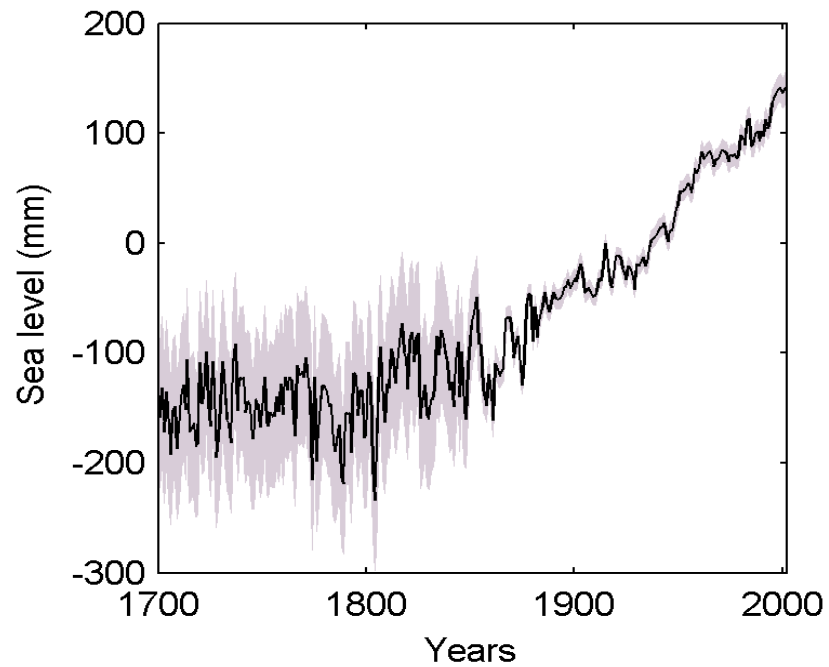
Amsterdam, since 1700  
Liverpool, since 1768  
Stockholm, since 1774

Global sea level reconstruction data are available from  
[www.pol.ac.uk/psmsl/author\\_archive/jevreja\\_et\\_al.\\_jgr.html](http://www.pol.ac.uk/psmsl/author_archive/jevreja_et_al._jgr.html)

# Results

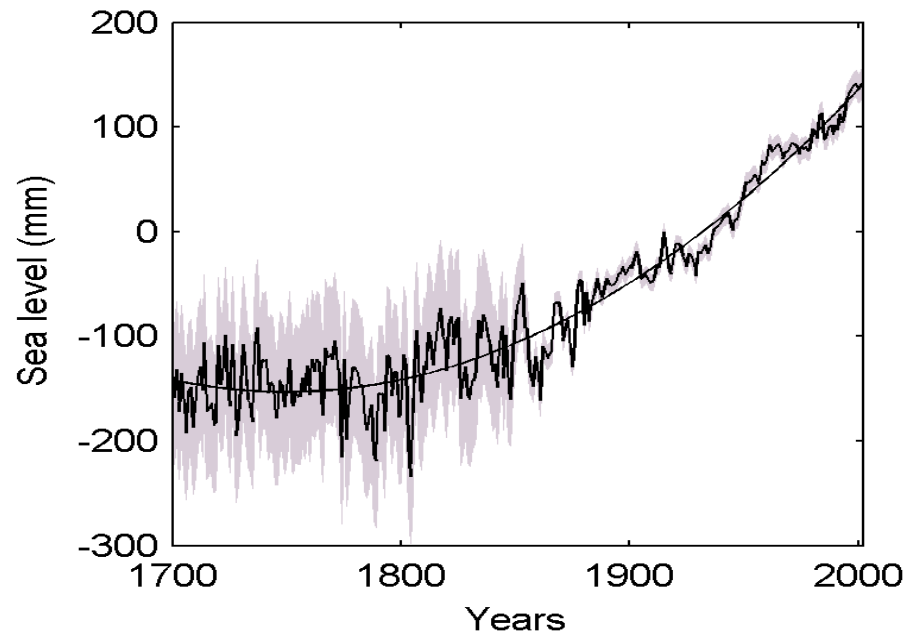
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Global sea level reconstruction since 1700



# Results

Global sea level acceleration since 1700



Sea level rise

1700-1800 2cm

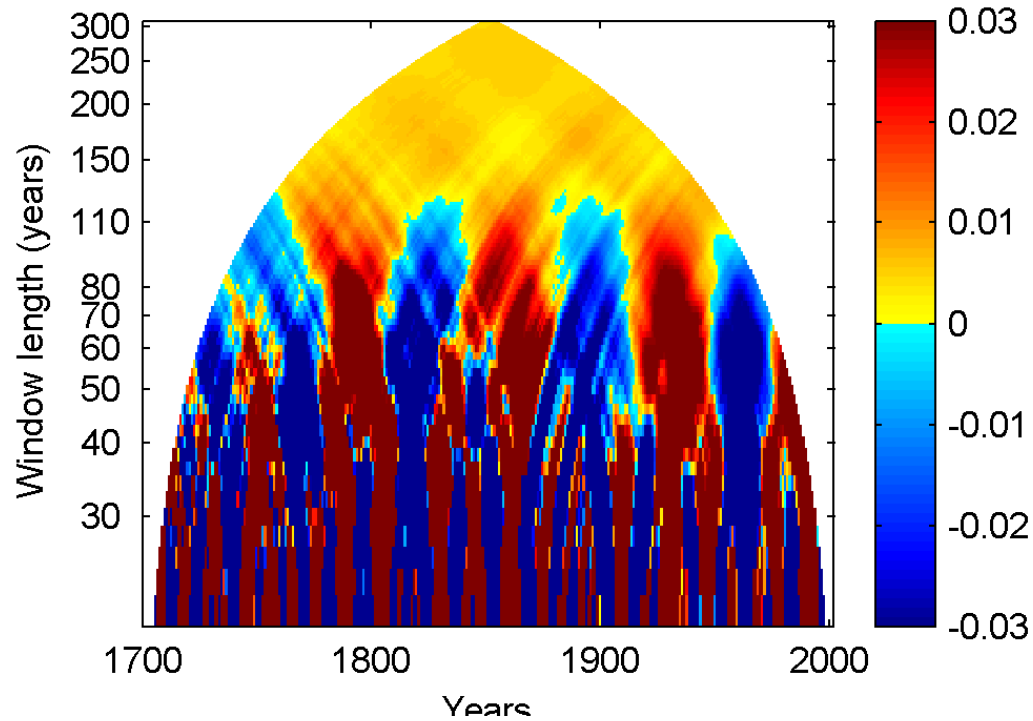
1800-1900 6cm

1900-2000 18cm

0.01 mm/yr<sup>2</sup>

# Global sea level acceleration

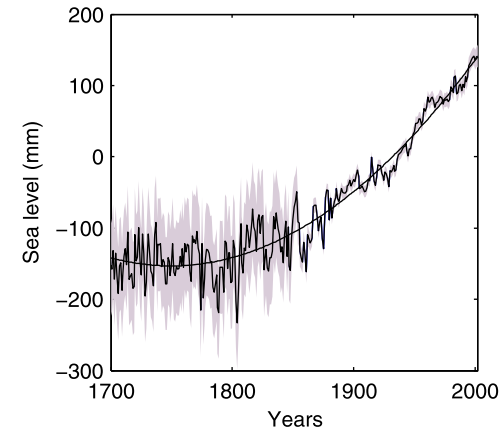
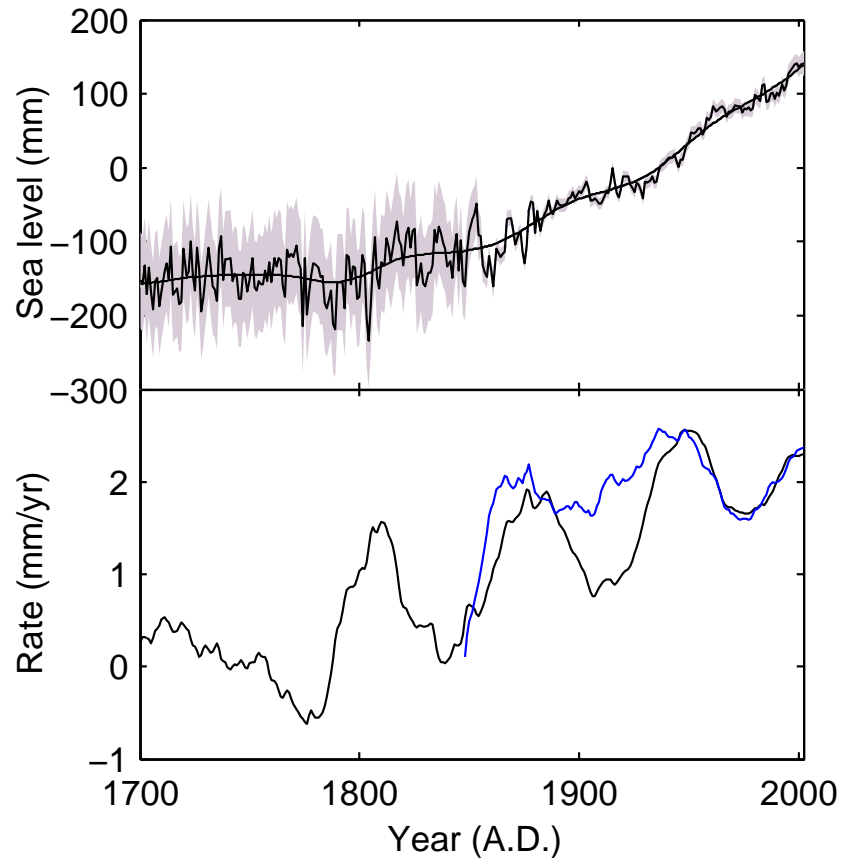
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Acceleration calculated using moving windows (10-290 years)

# Evolution of global sea level rise

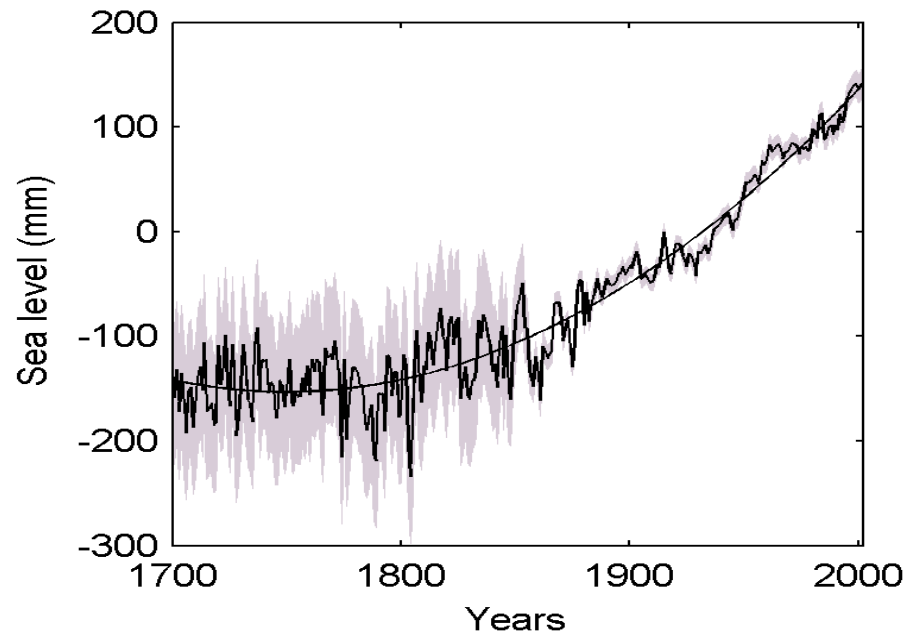
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Time series of global sea level and time variable trend detected by method based on MC-SSA with 30 –year windows (top) and the evolution of the rate of the trend (bottom) since 1700.

# What is next?

Global sea level acceleration since 1700



Sea level rise

1700-1800 2cm

1800-1900 6cm

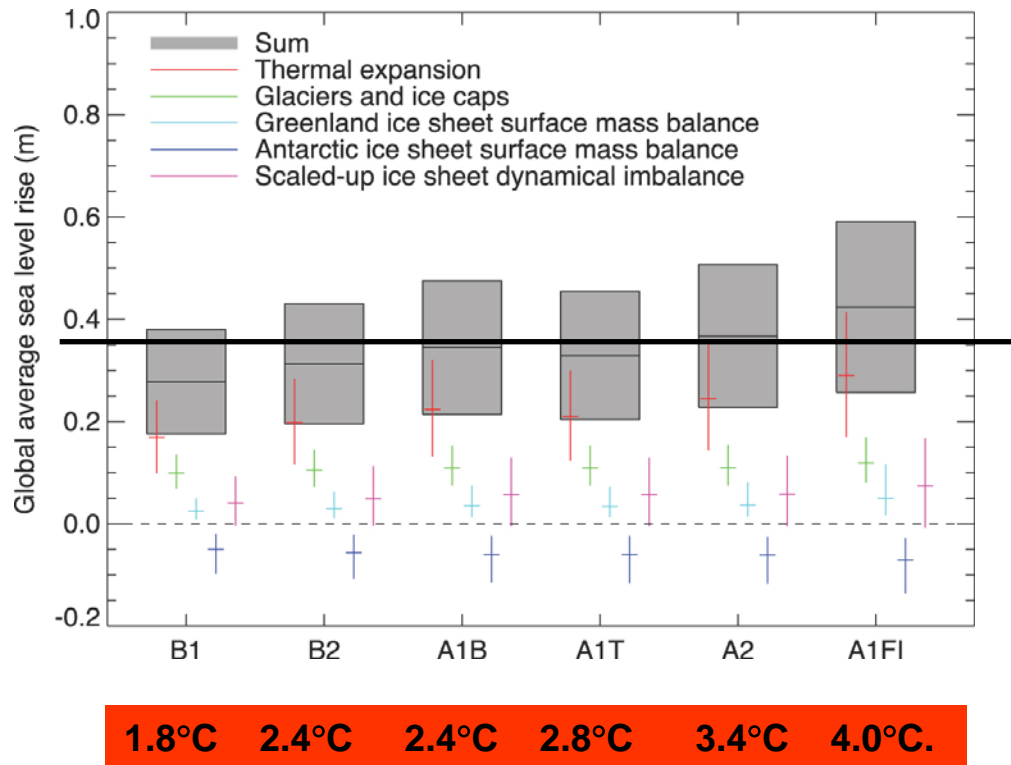
1900-2000 18cm

0.01 mm/yr<sup>2</sup>

**2000-2090 34 cm**



# What is next?



# Conclusion

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1. Using tide gauge records we have made a reconstruction of global sea level since 1700.
2. Our global sea level reconstruction suggests
  - 2 cm sea level rise during 1700-1799,
  - 6 cm sea level rise during 1800-1899;
  - 18 cm sea level rise 1900-1999.
3. Present global sea level acceleration ( $0.01 \text{ mm/yr}^2$ ) started at the end of 18<sup>th</sup> century.

# Conclusion

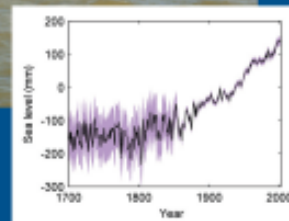
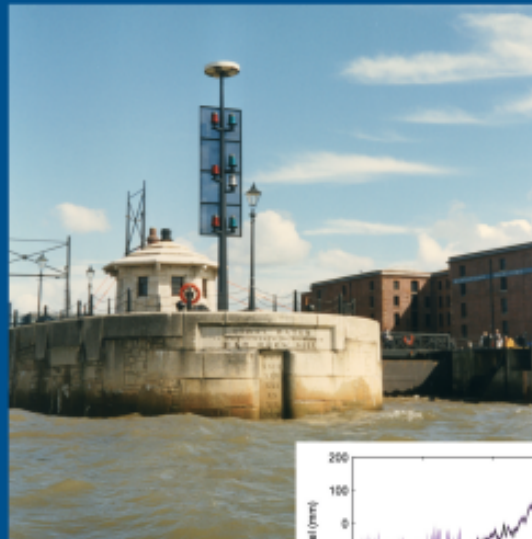
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4. The rate of sea level rise is clearly increasing, despite periods of fast and slow sea level rise associated with a 60-70 year variability.

5. If conditions that established the acceleration continue, then sea level will rise 34 cm over the 21st century. Long time constants in oceanic heat content and increased ice sheets melting imply that Intergovernmental Panel of Climate Change (IPCC) [2007] estimates of sea level are too low.

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- Did recent accelerations in global sea level rise start more than 200 years ago?
- Topography and stress patterns in the central Andes
  - Mantle downwelling causing the U.S. east coast to subside
  - Ozone hole recovery and climate change