Sea-Level Rise in the Delaware River Basin

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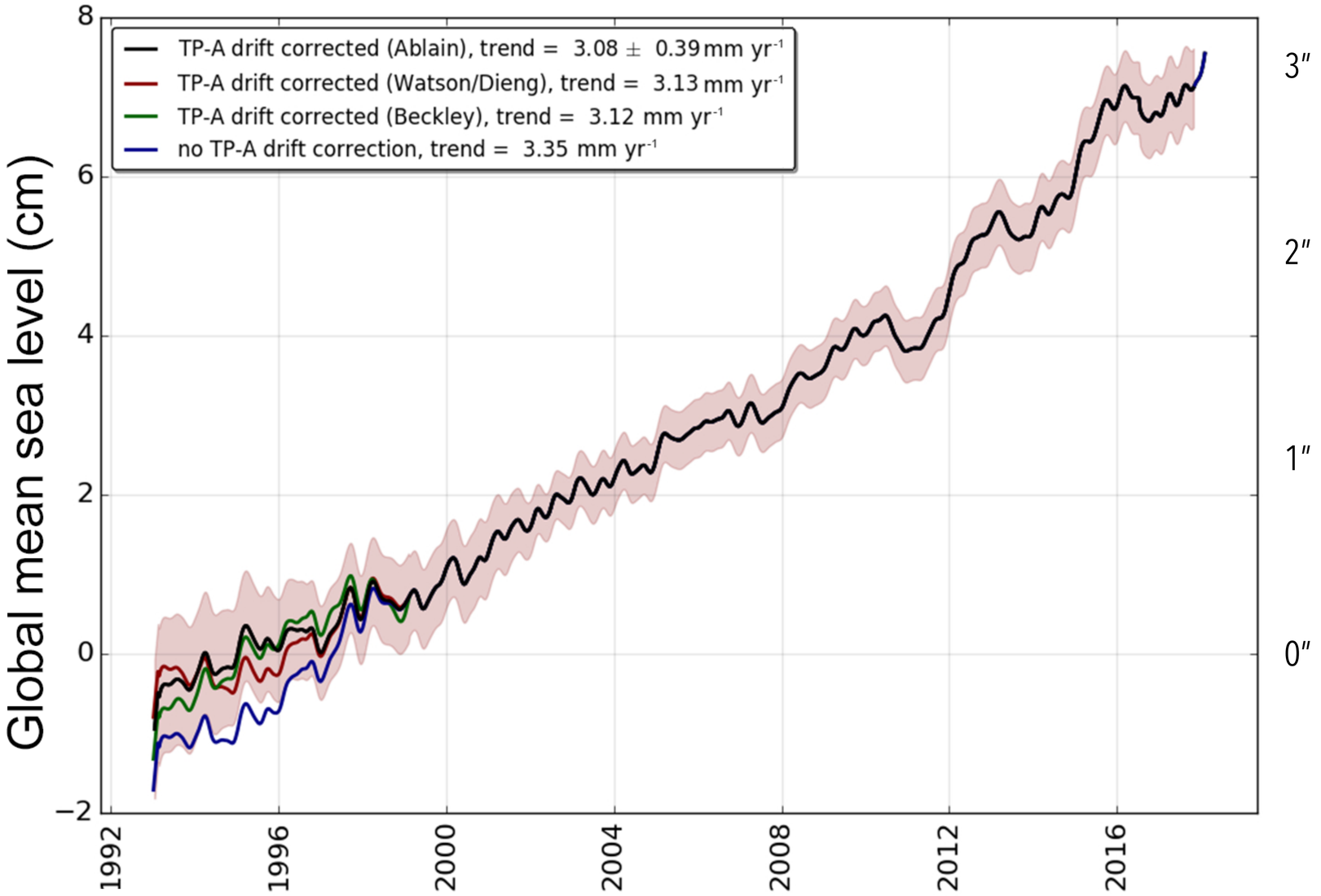
Climate Impact Lab

NSF NASA

RUTGERS | NJ Climate Change Resource Center

Global average sea level is rising at an accelerating rate.



WCRP Global Sea Level Budget Group (2018)

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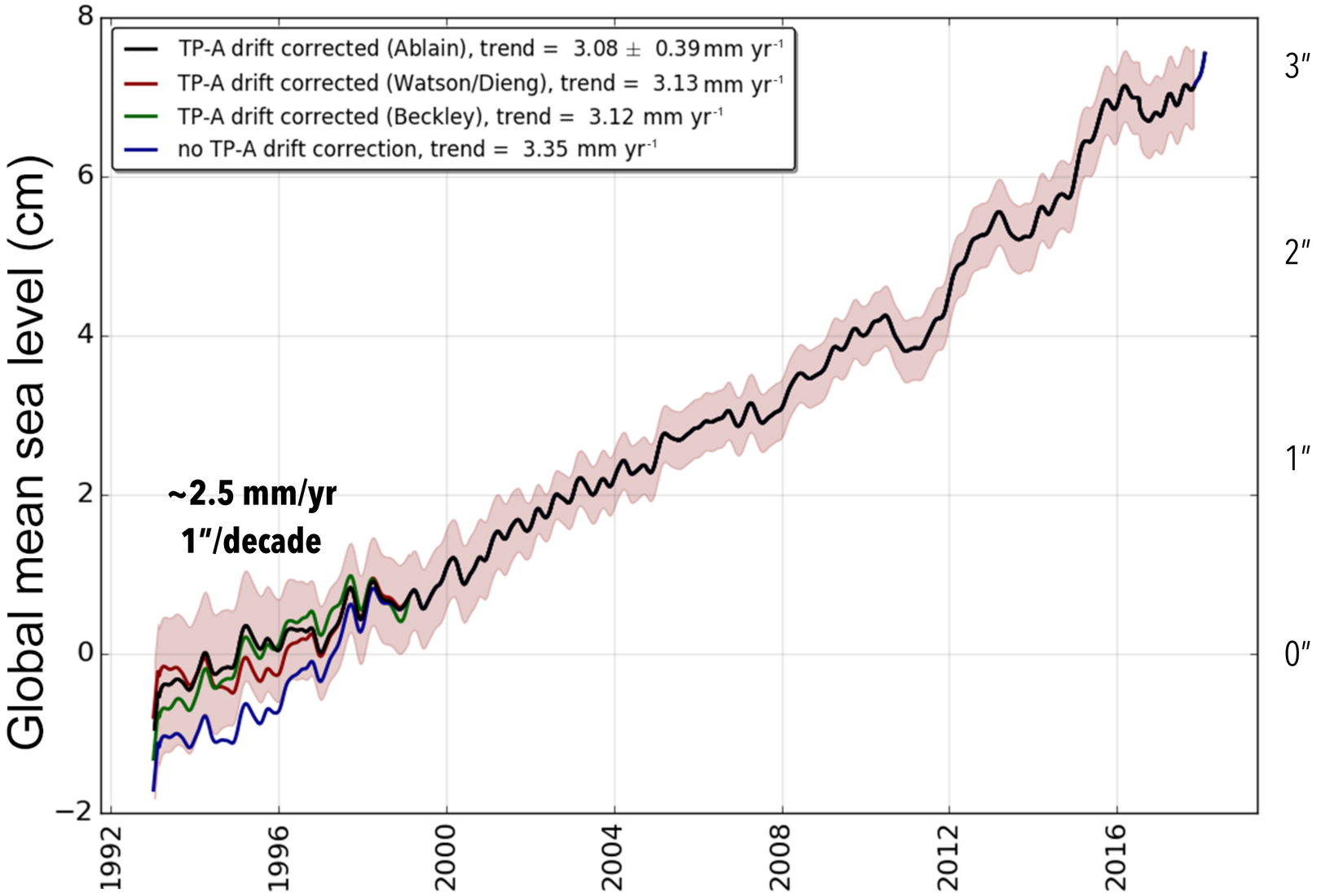

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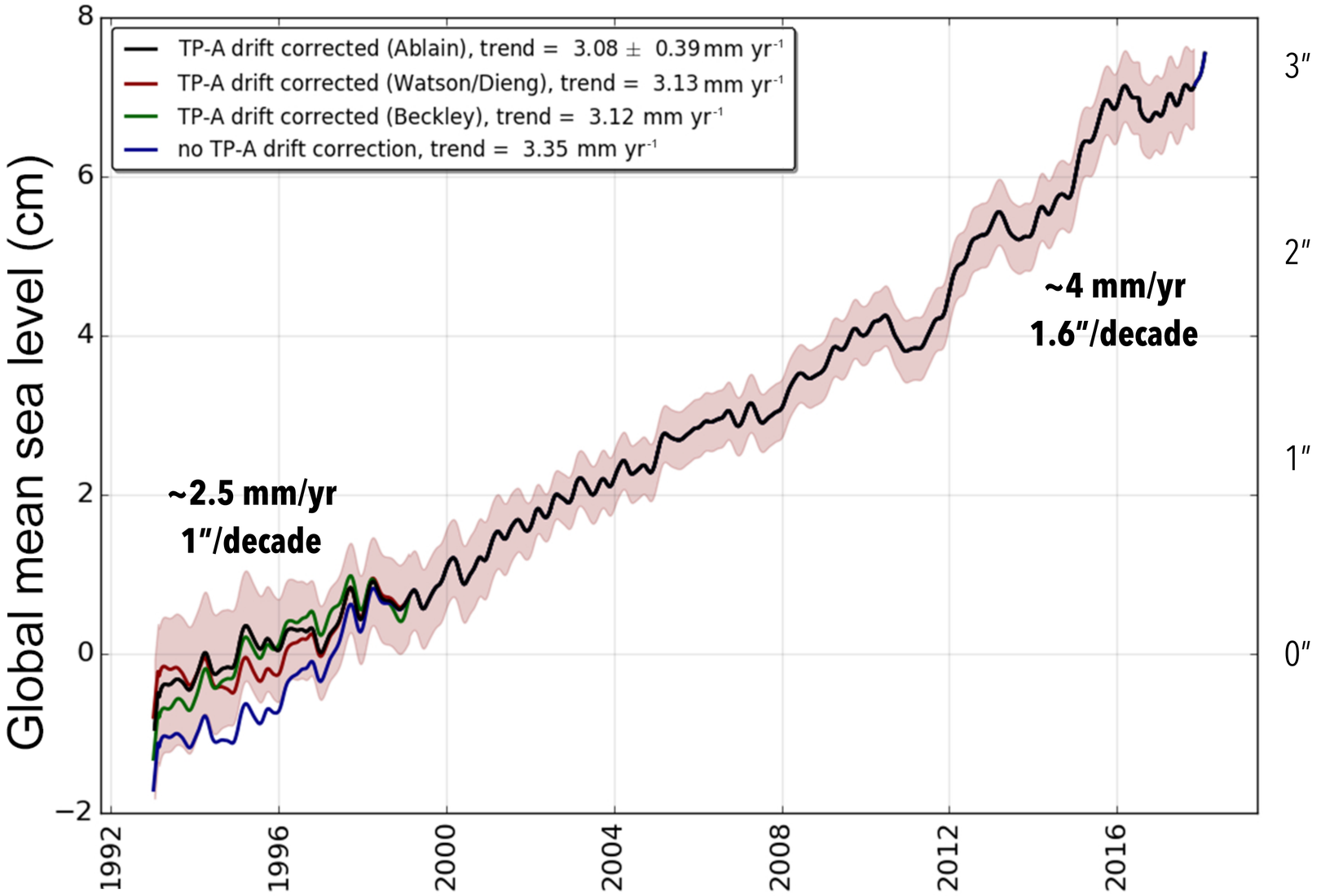

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Using statistical and physical models, we can piece together geological records and tide gauges from around the world.

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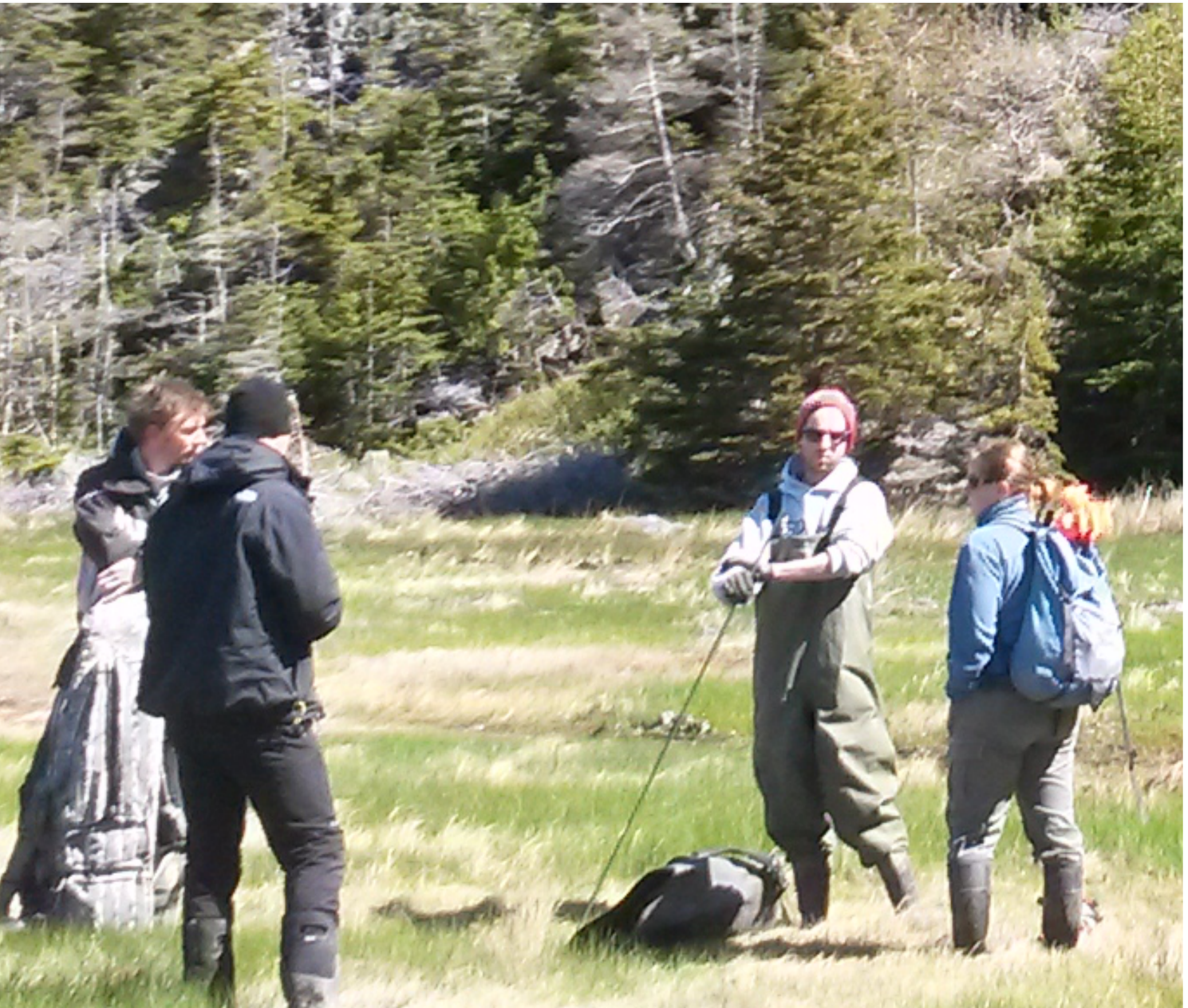

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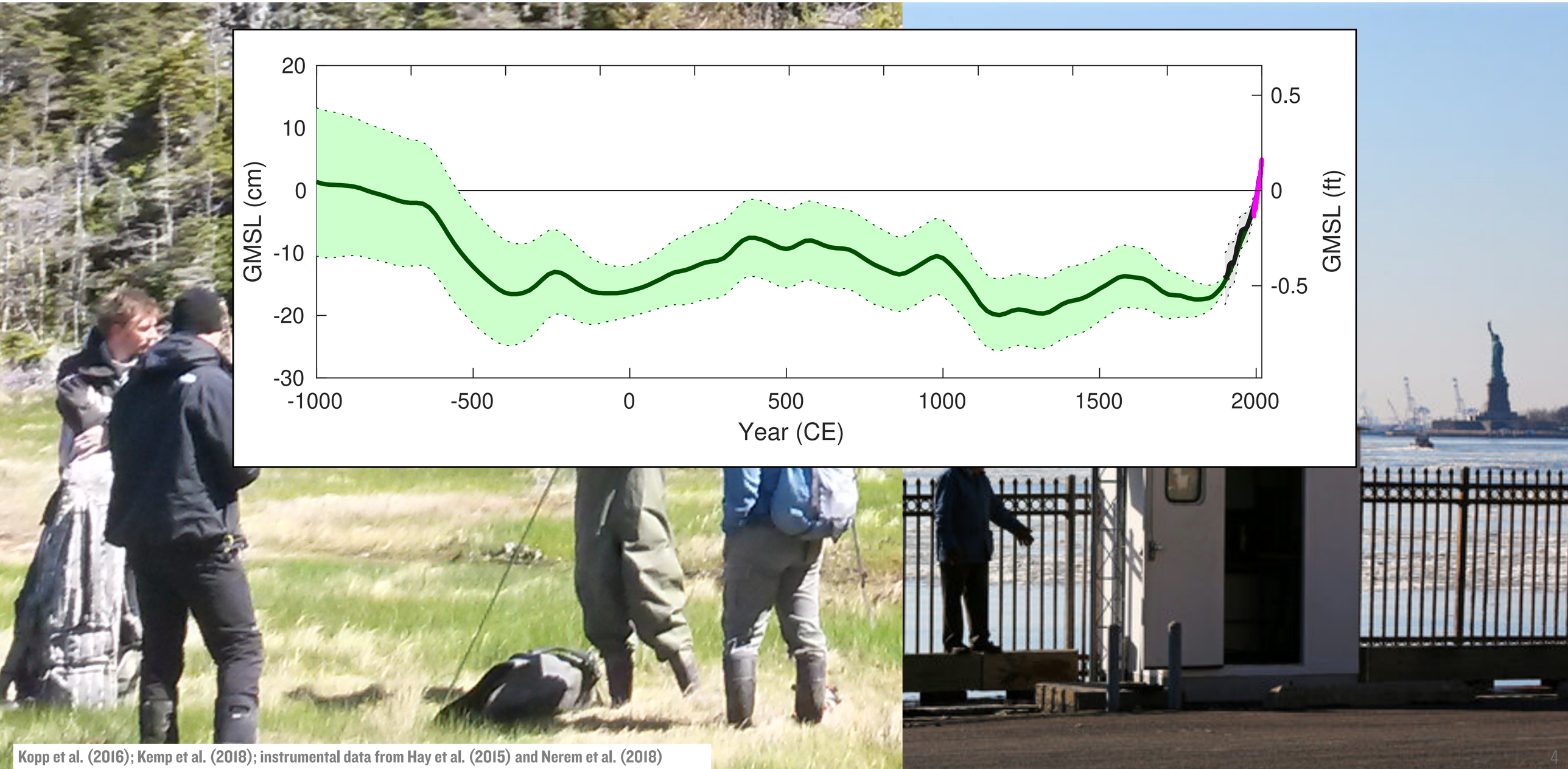

Kopp et al. (2016); Kemp et al. (2018); instrumental data from Hay et al. (2015) and Nerem et al. (2018)

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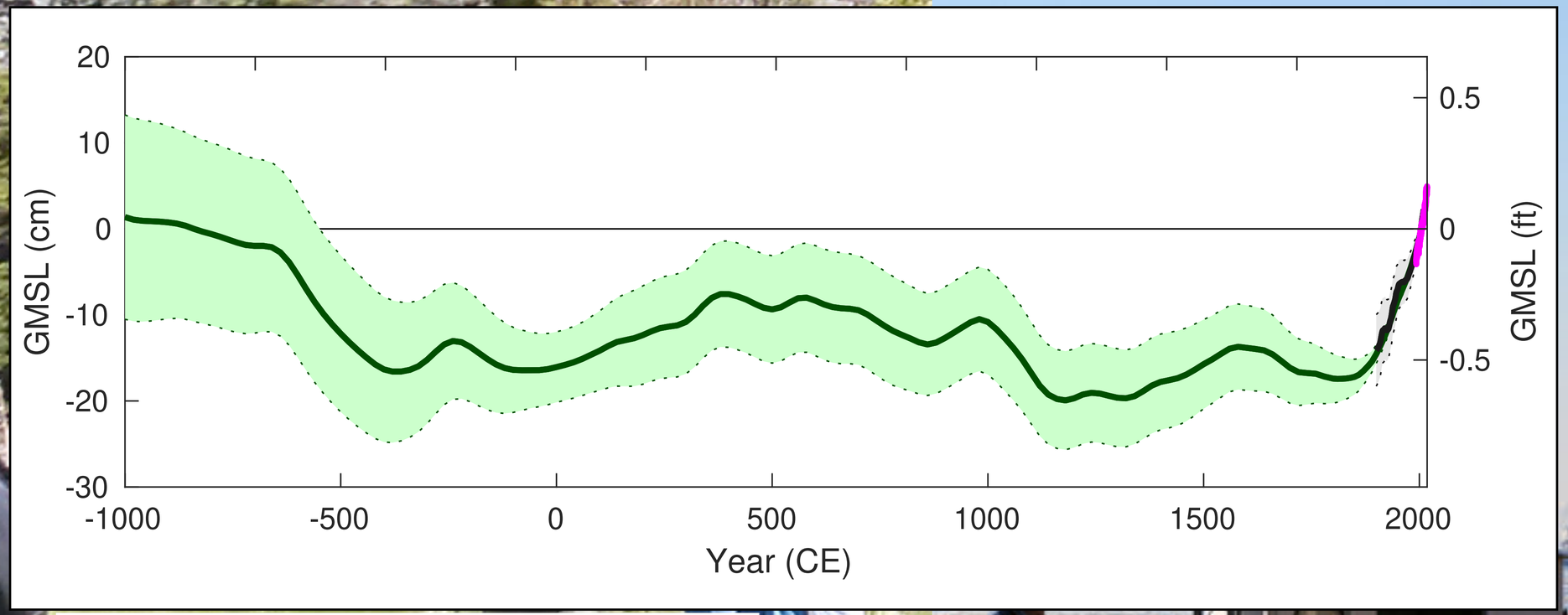

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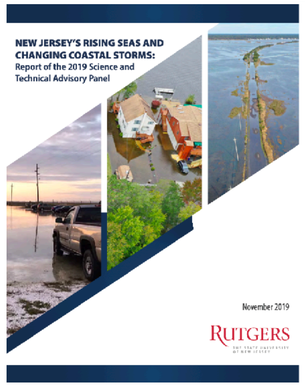
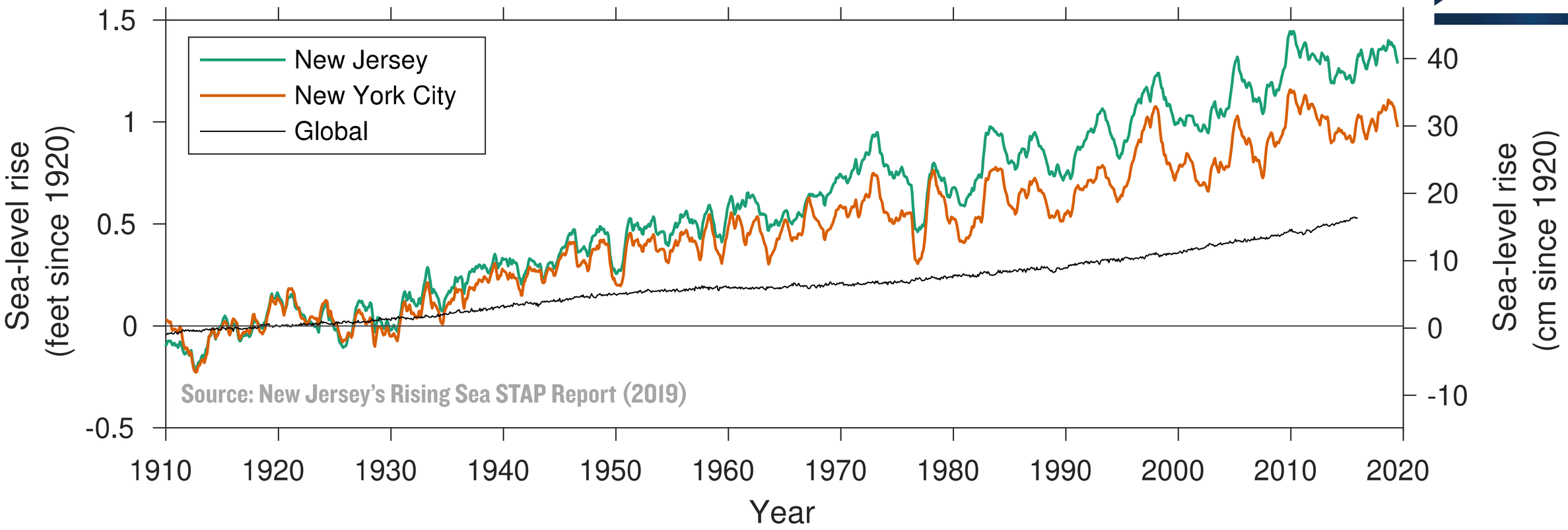
The ocean is rising even faster in the mid-Atlantic than in the global average.





Since 1911, sea level in coastal New Jersey has risen by about 18 inches, compared to about 8 inches in the global average. The difference is largely due to natural land subsidence (about 7 inches), enhanced by groundwater withdrawal (about 3 inches).

Sea-level rise is making high-tide flooding more common.

Ventor, NJ
Nov. 5, 2017

Photo by Steve Jaisecki / JC NERR #CaptureTheKing
Sweet and Park (2014)

The number of high-tide flooding days in Atlantic City have increased from less than 1/year in the 1950s to an average of 8/year over the last decade – a period over which sea level rose by about 9 inches.

Sea-level rise is making high-tide flooding more common.

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Sea-level rise is enhancing storm-driven flooding.

FDR Drive, Manhattan
October 30, 2012

David Shankbone / WikiCommons ; Strauss et al. (ju rev.)

Human-caused sea-level rise was responsible for about 18% ($11 billion) of the Sandy recovery costs in New York and New Jersey and exposed about 100 thousand people to Sandy's flooding.

Sea-level rise is enhancing storm-driven flooding.

FDR Drive, Manhattan
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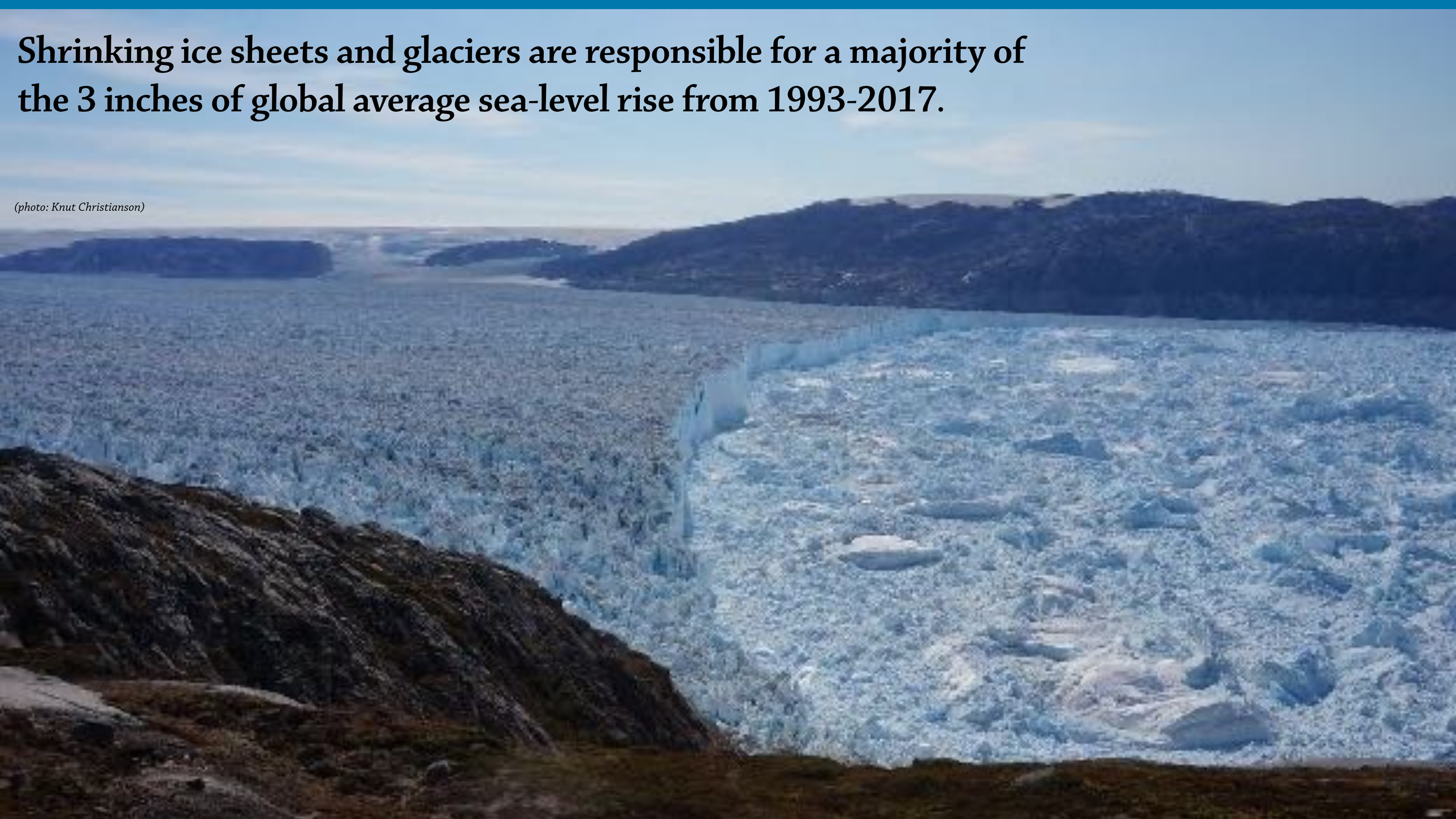
So what’s driving sea-level rise?

Shrinking ice sheets and glaciers are responsible for a majority of the 3 inches of global average sea-level rise from 1993-2017.



(photo: Knut Christianson)

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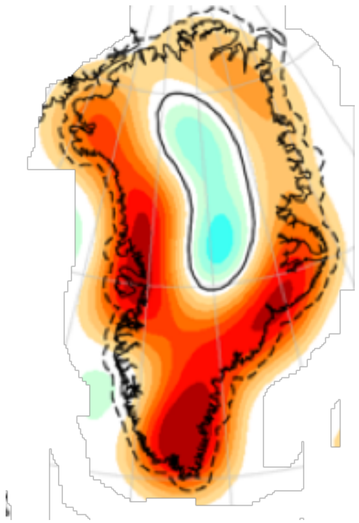
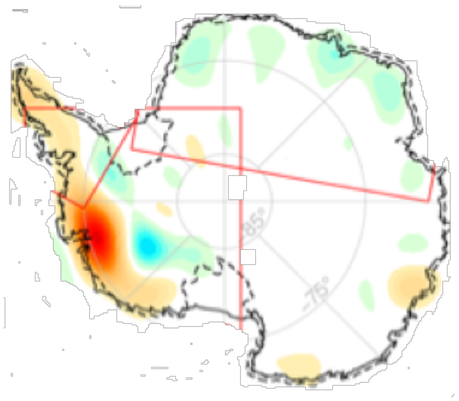


Greenland:
About 0.5 inches since 1993



Antarctica:
About 0.3 inches since 1993

Mountain glaciers:
About 0.7 inches since 1993

Harig et al. (2015, 2016); WCRP (2018); Rignot et al. (2019)

And the potential for sea-level rise from land-ice loss is much larger.

Lemke et al. (2007); Bamber et al. (2001); Lythe et al. (2001)

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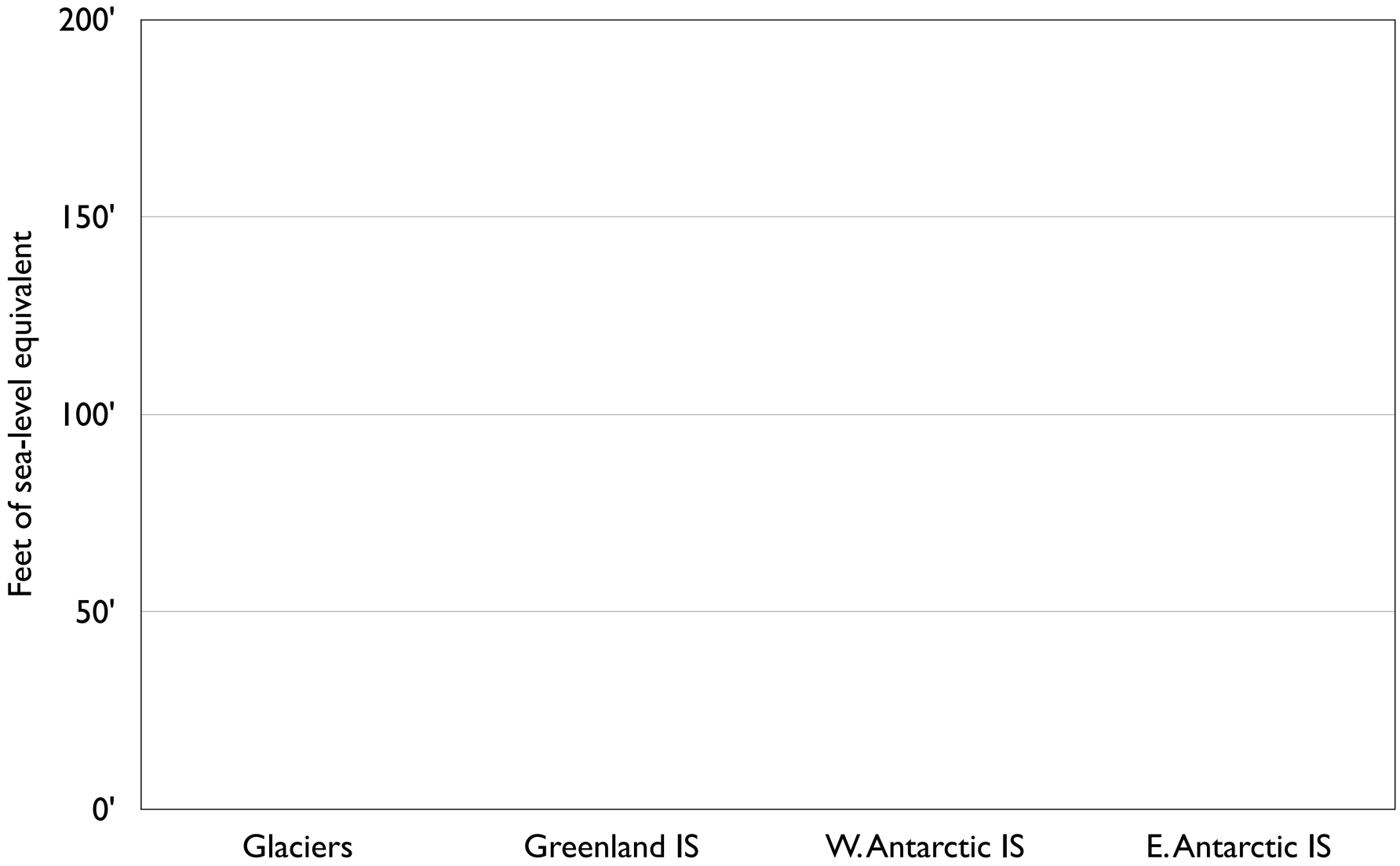

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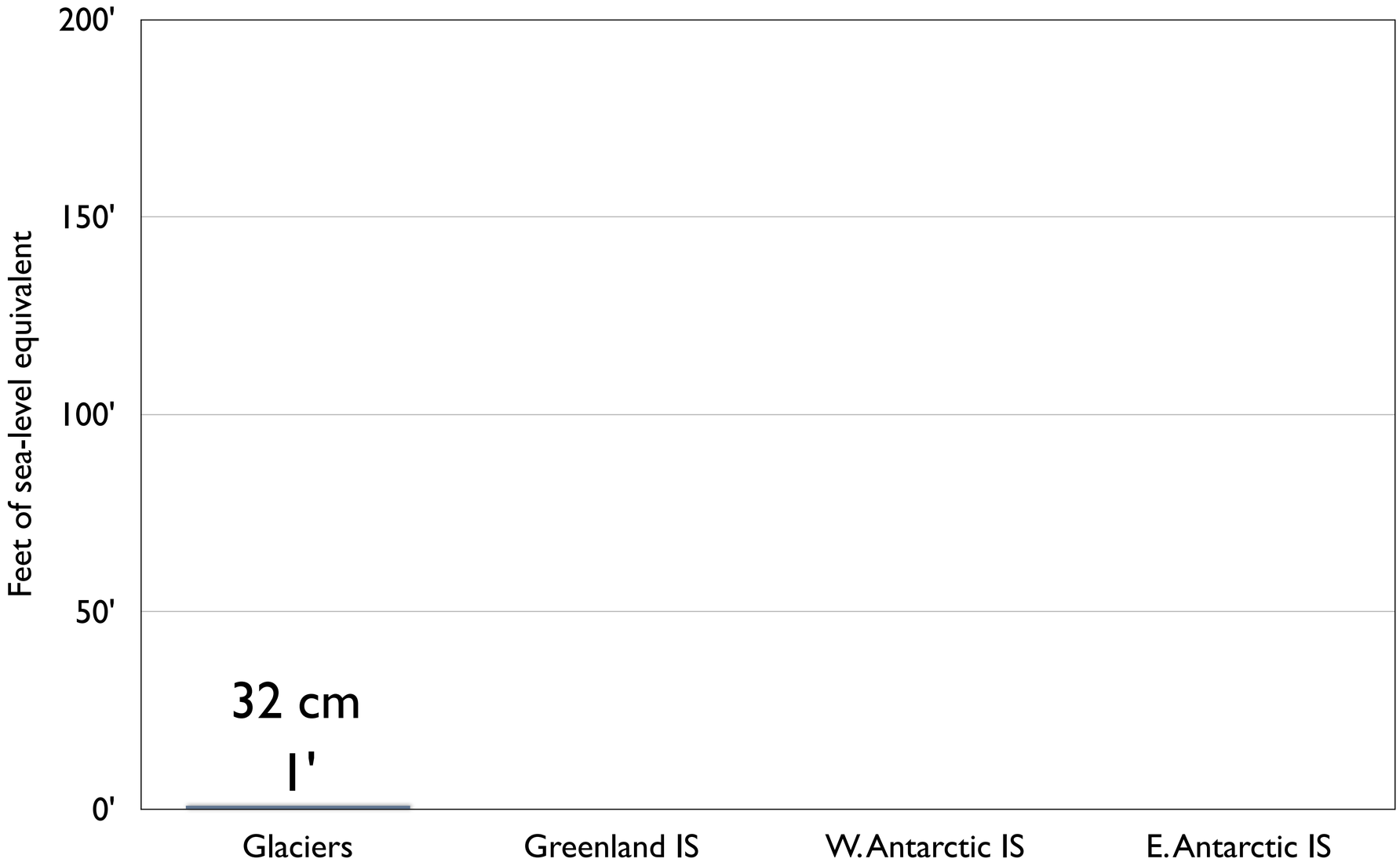

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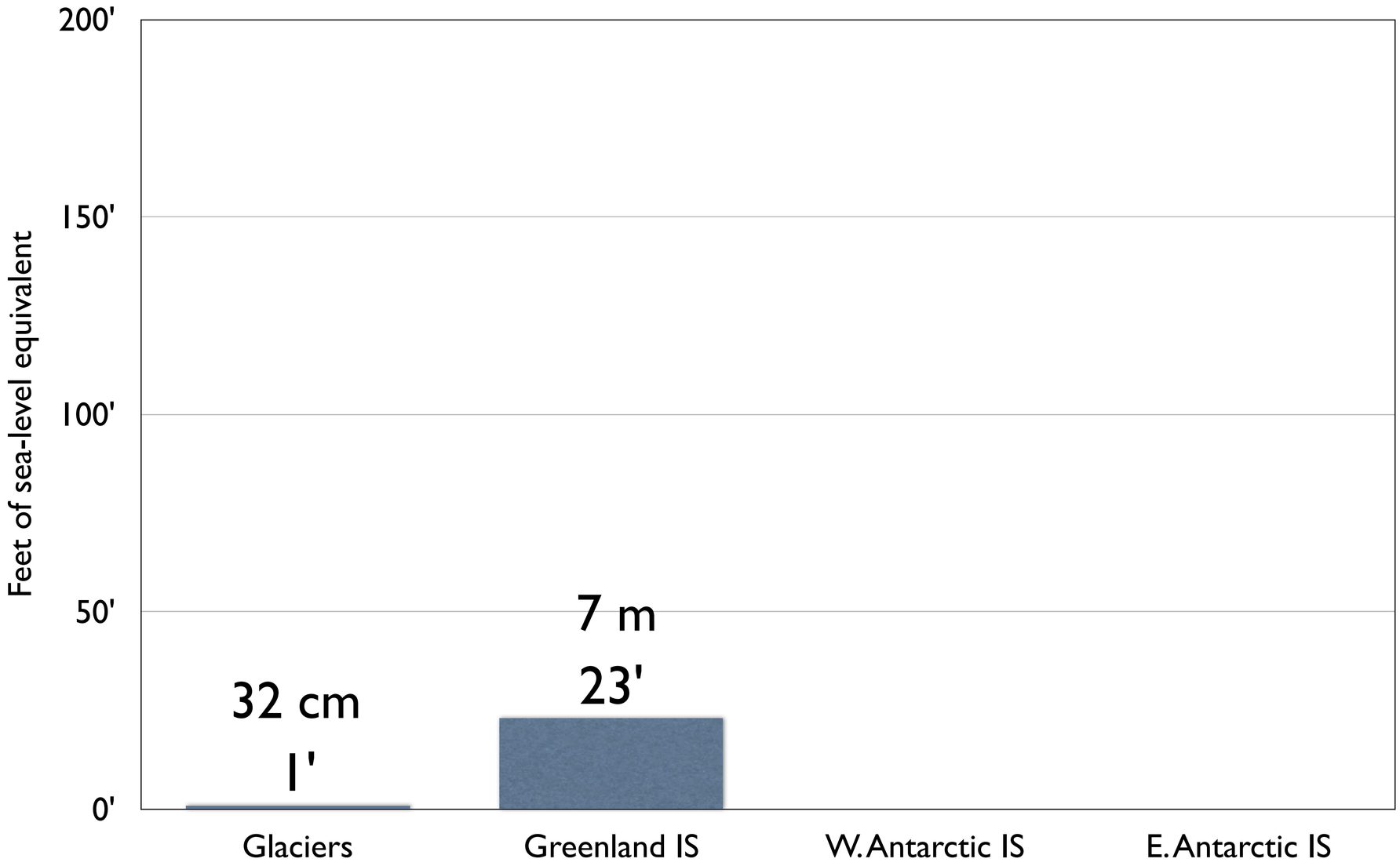

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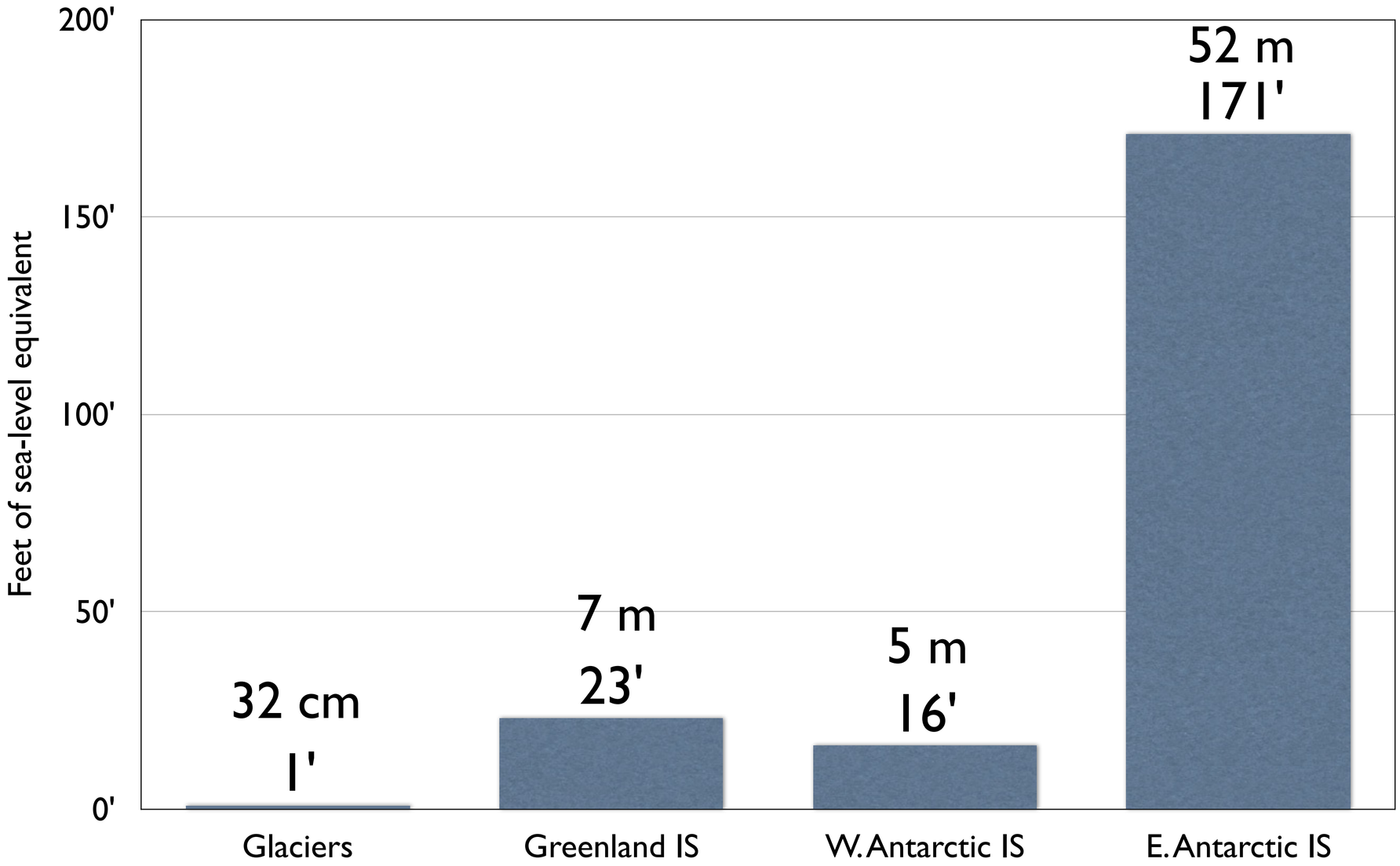

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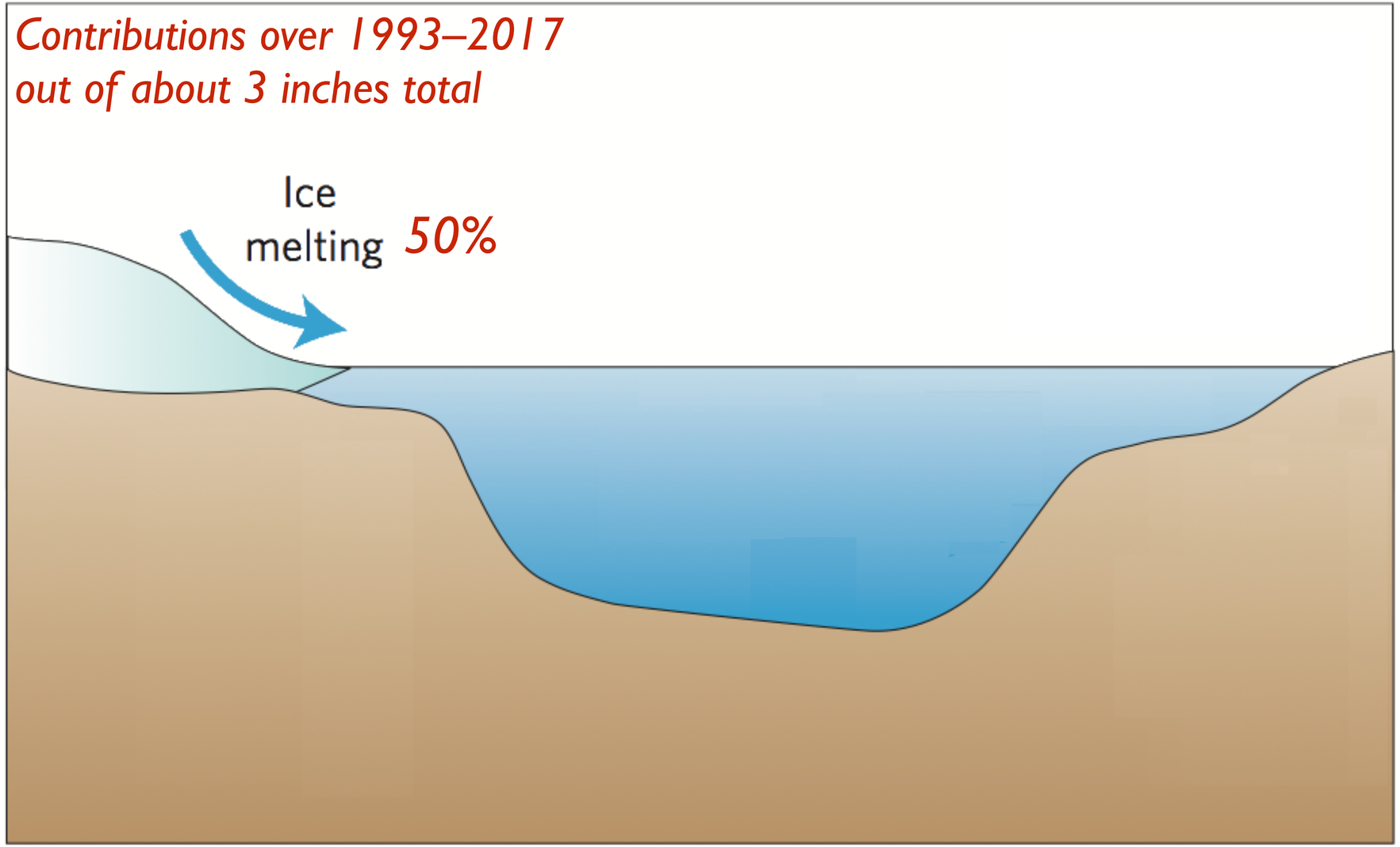
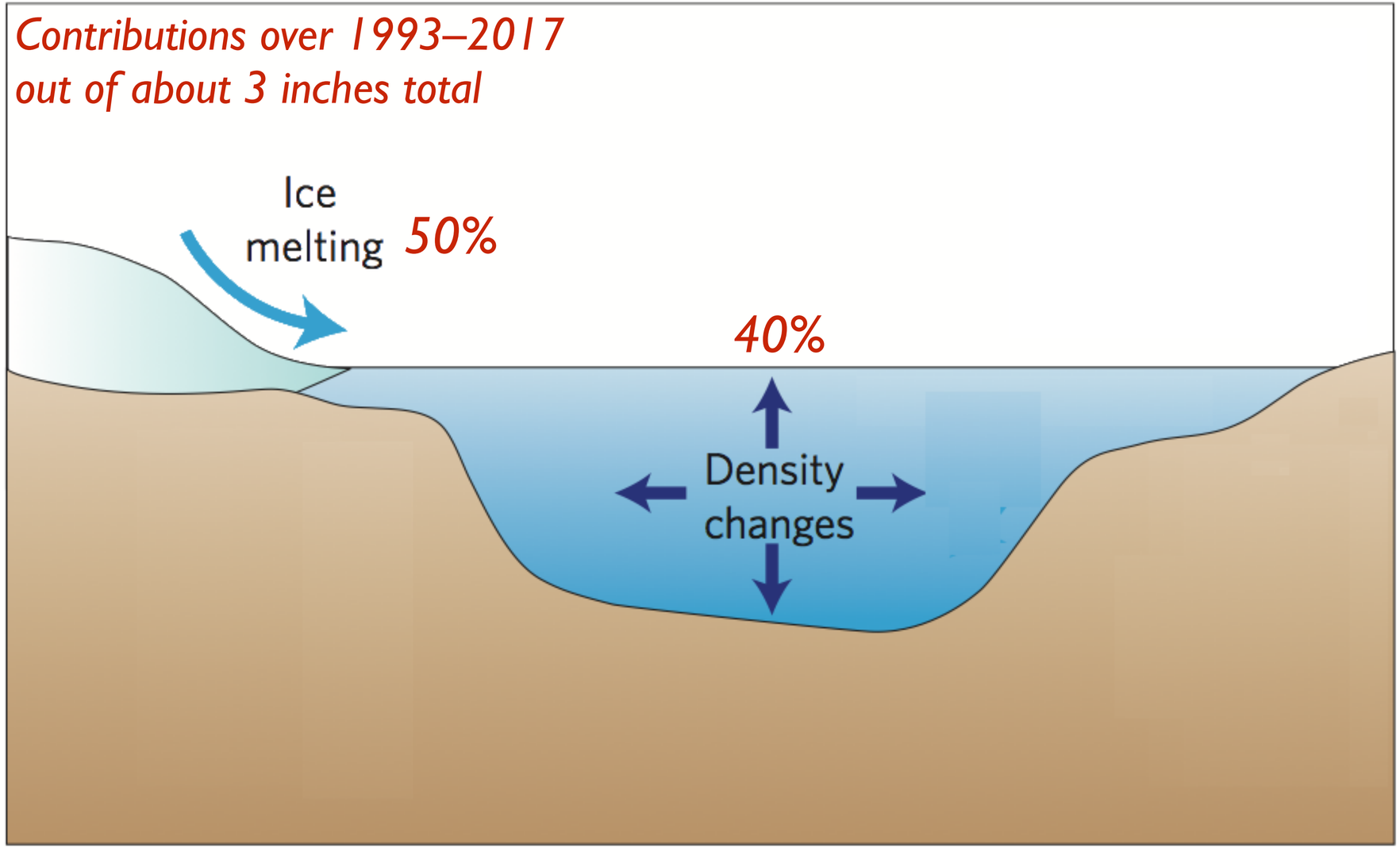
Shrinking ice sheets and glaciers are responsible for a majority of global average sea-level rise.



Milne et al. 2009

Most of the rest of global rise is due to the ocean expanding in volume as it warms.



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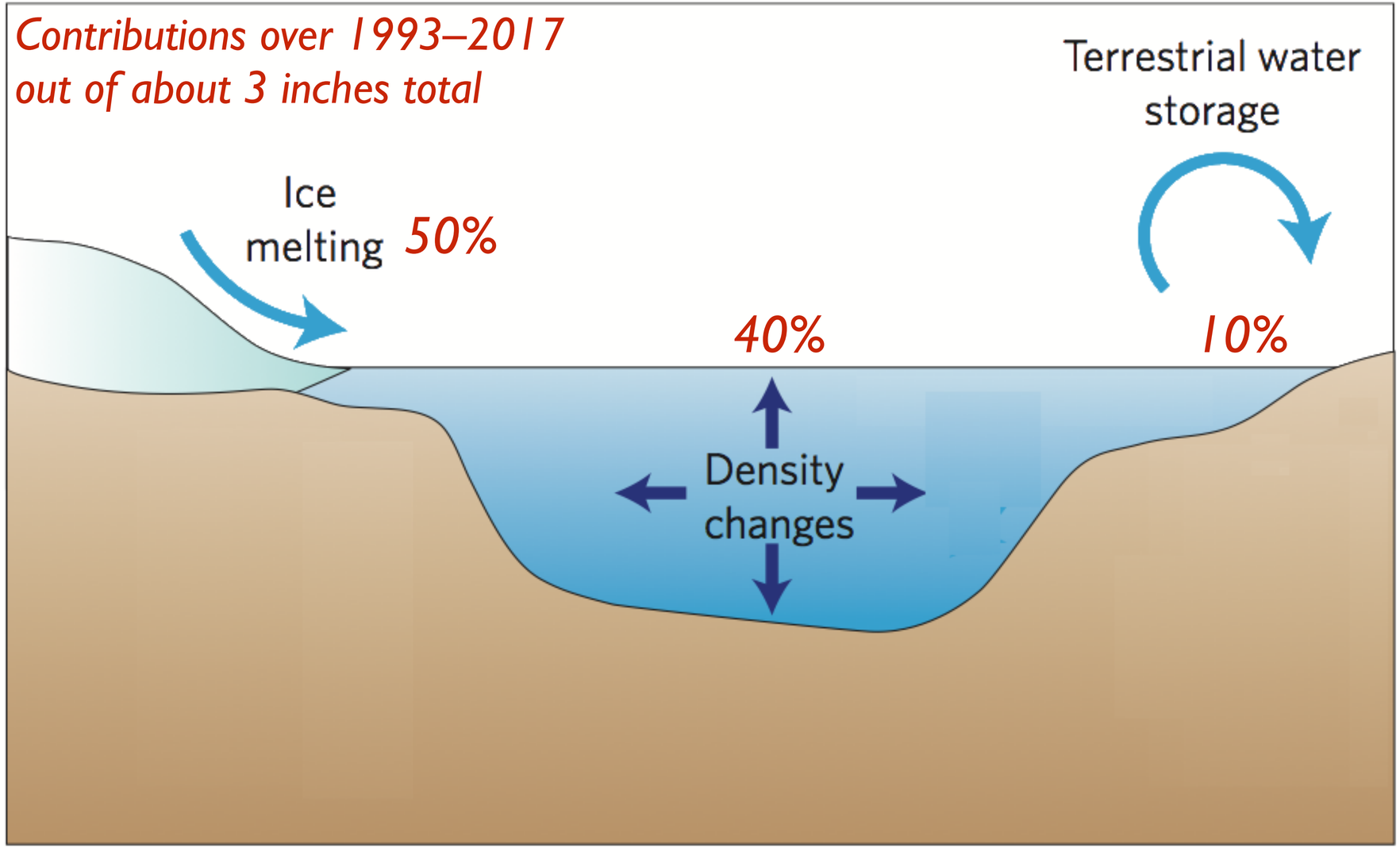
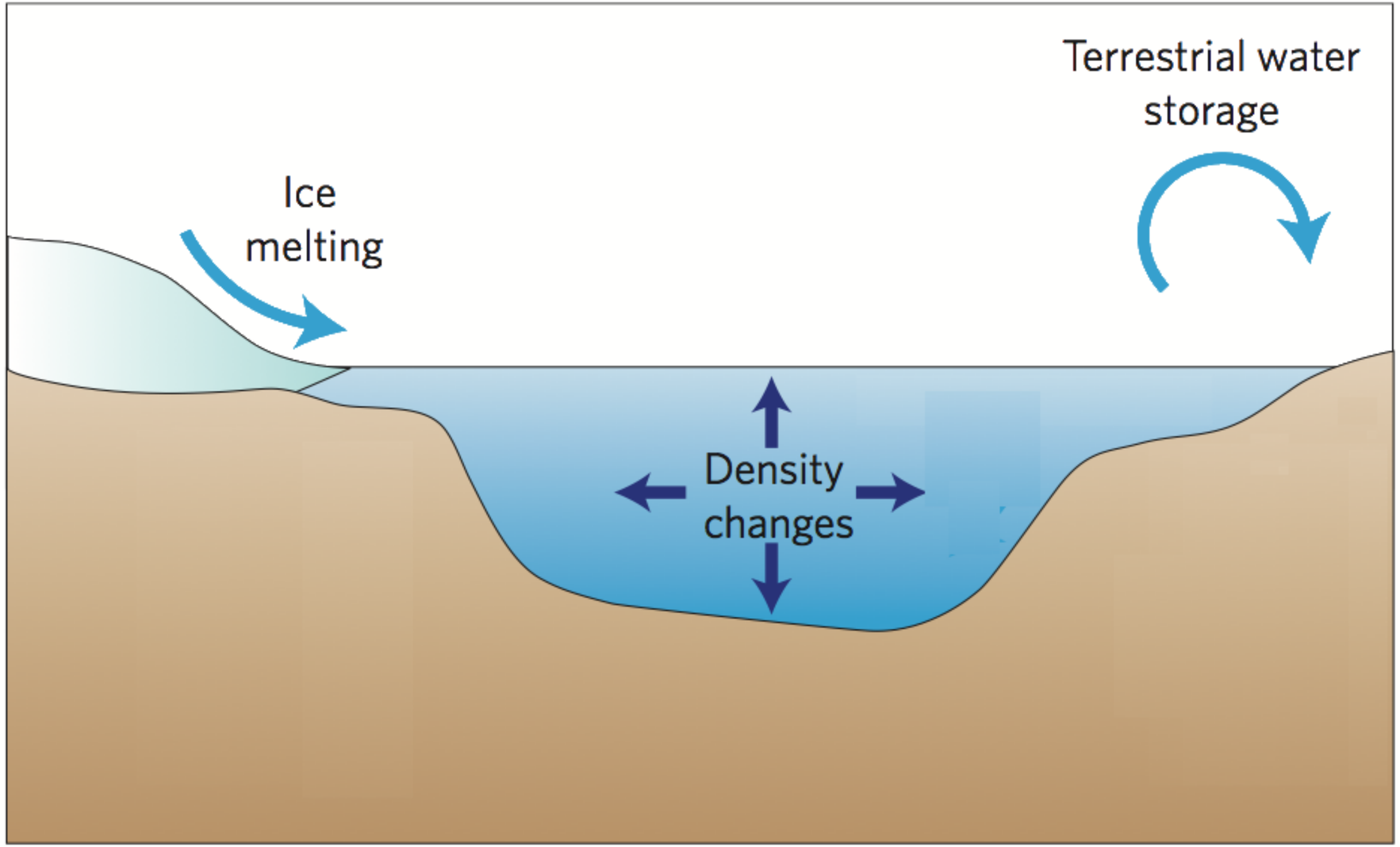
Changes in the water stored on land (e.g., in groundwater) accounts for a small amount.



Milne et al. 2009; budget based on WCRP Global Sea Level Budget Group (2018)) and Rignot et al. (2019)

The story becomes more complex when you start looking at specific places!



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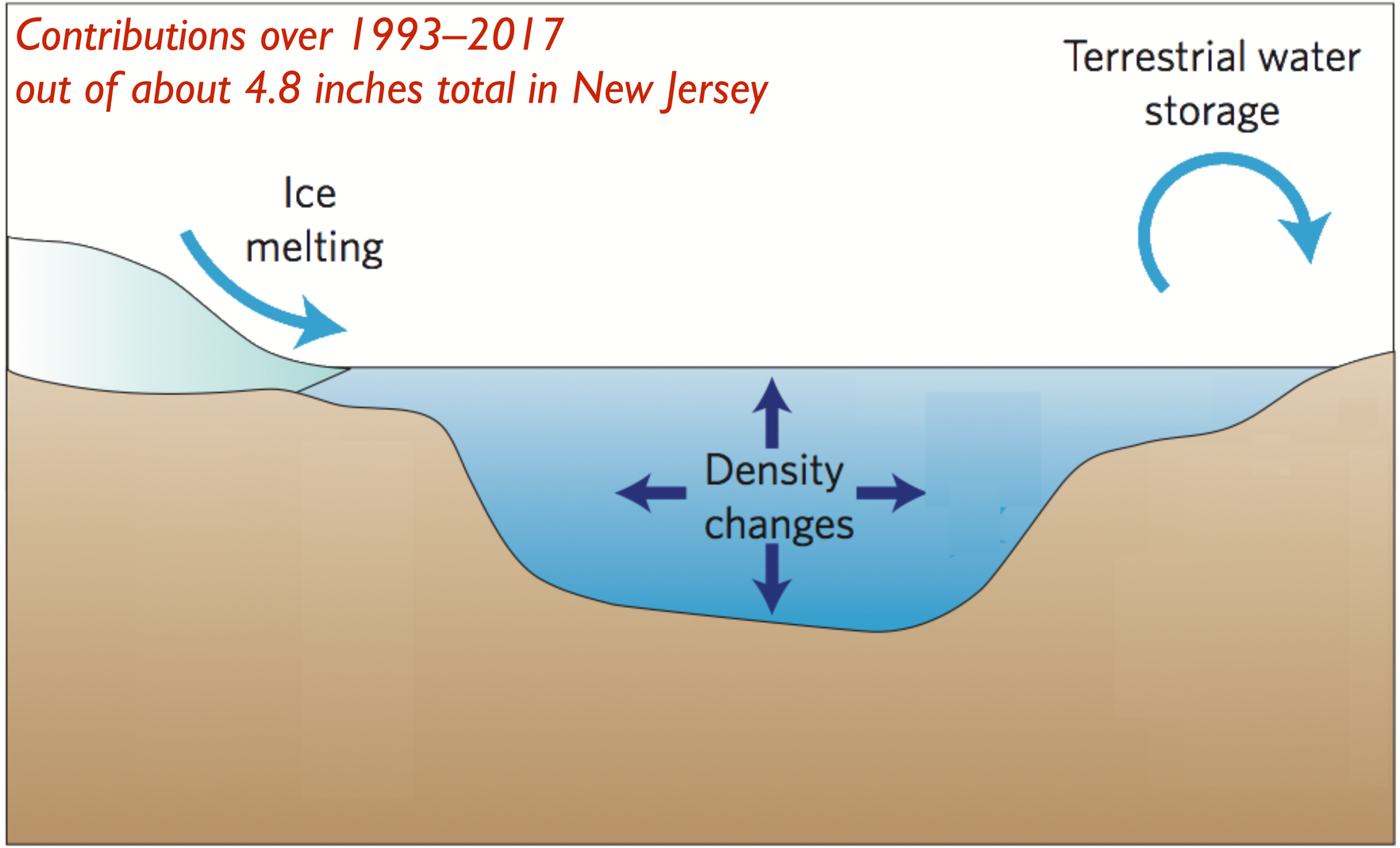

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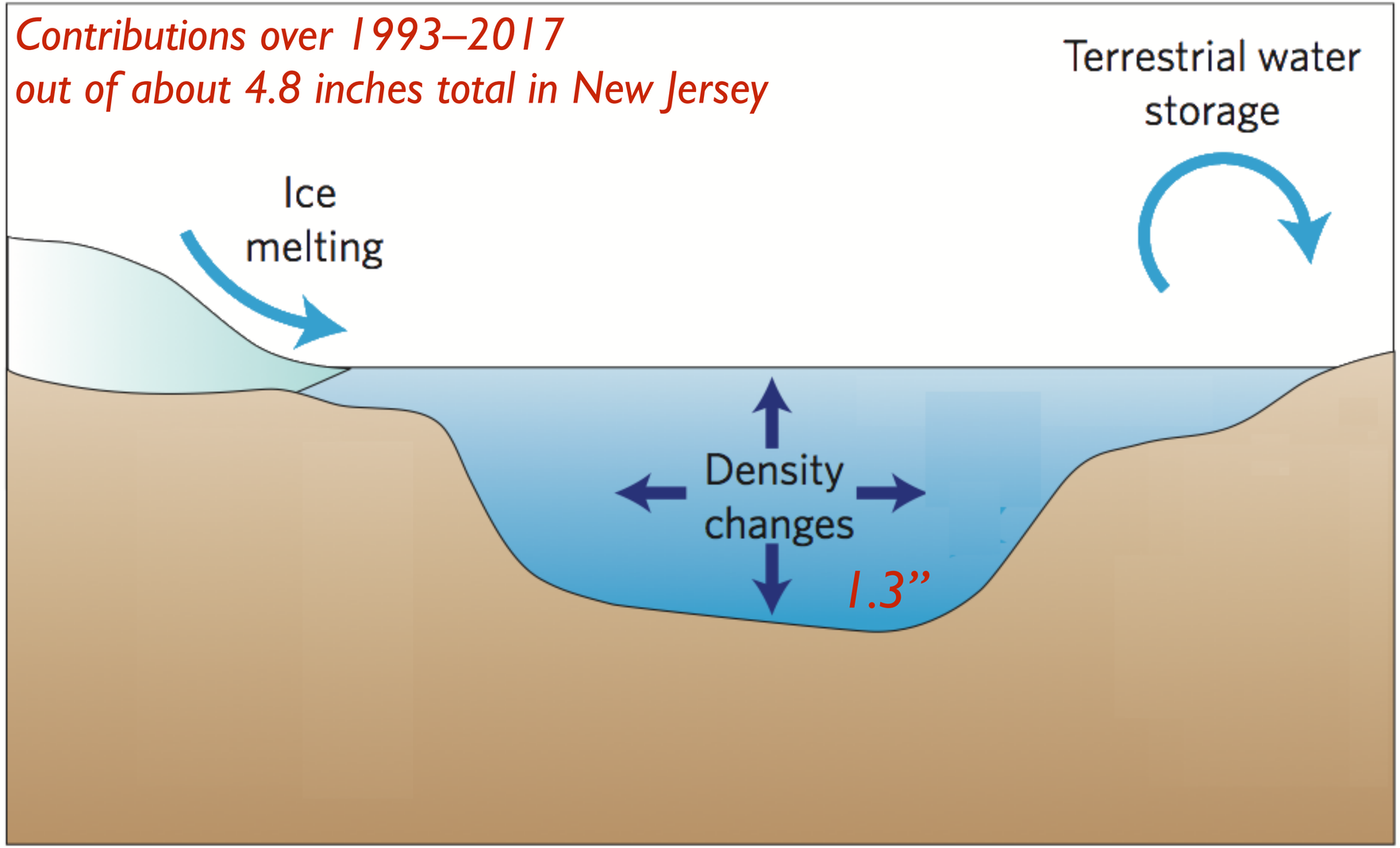
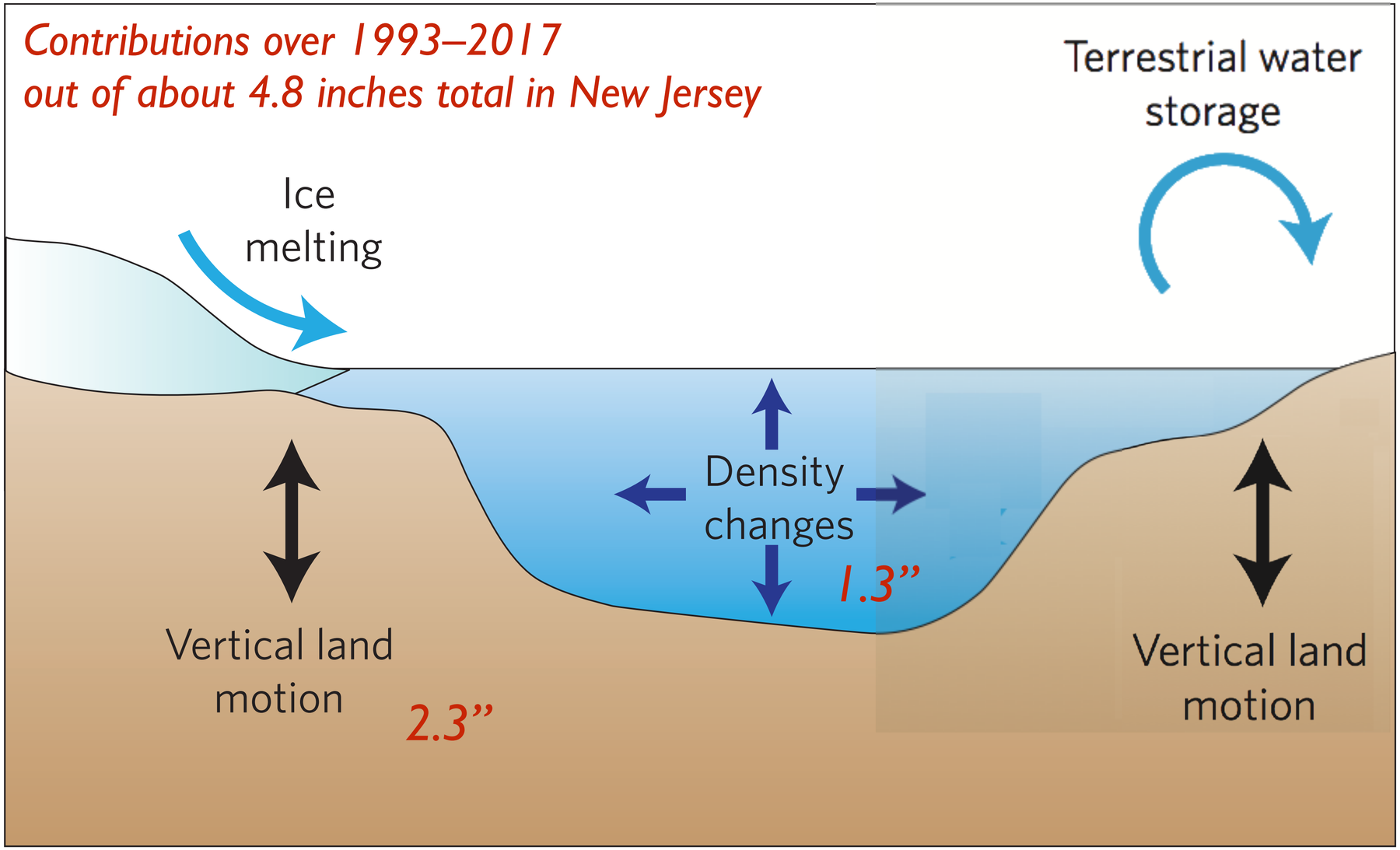


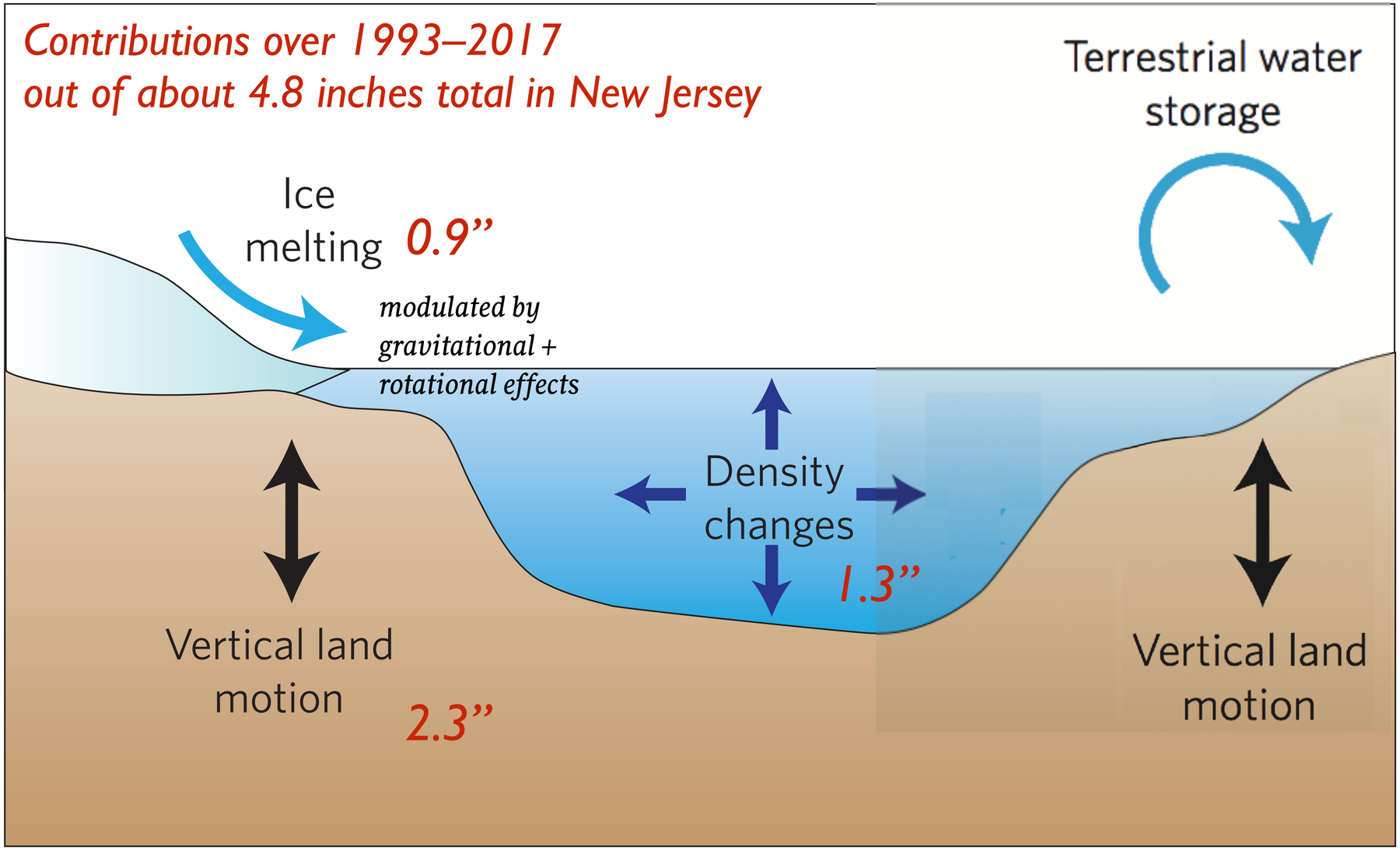
Milne et al. 2009

In New Jersey, the land is sinking due to both natural and human processes.



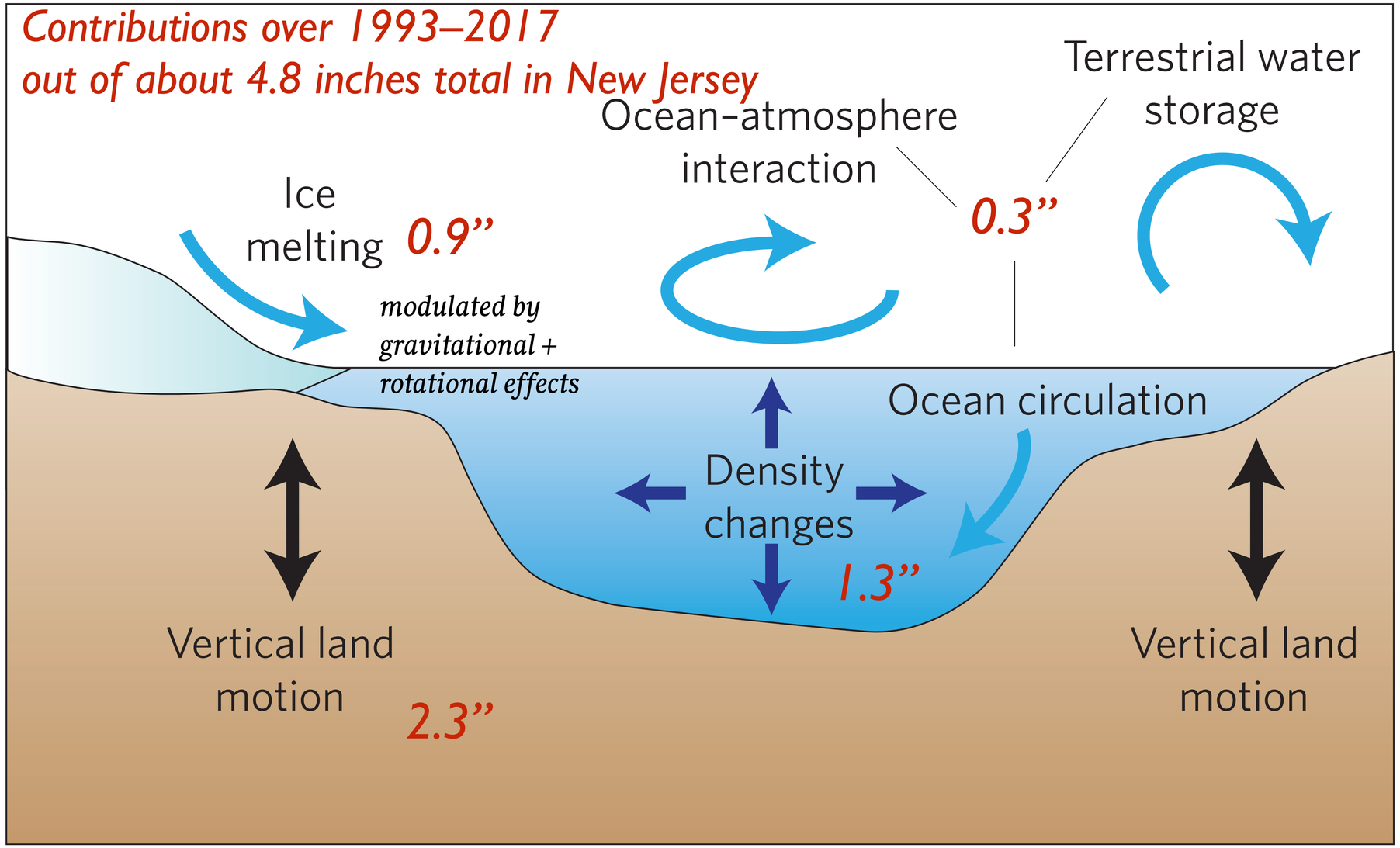
Milne et al. 2009

Shrinking land ice does not cause the same amount of sea-level rise everywhere.



Milne et al. 2009

Changes in winds and currents also contribute to regional sea-level rise.



Milne et al. 2009

What sea-level rise can we anticipate in the future?

To project future changes, we need to project all these processes.

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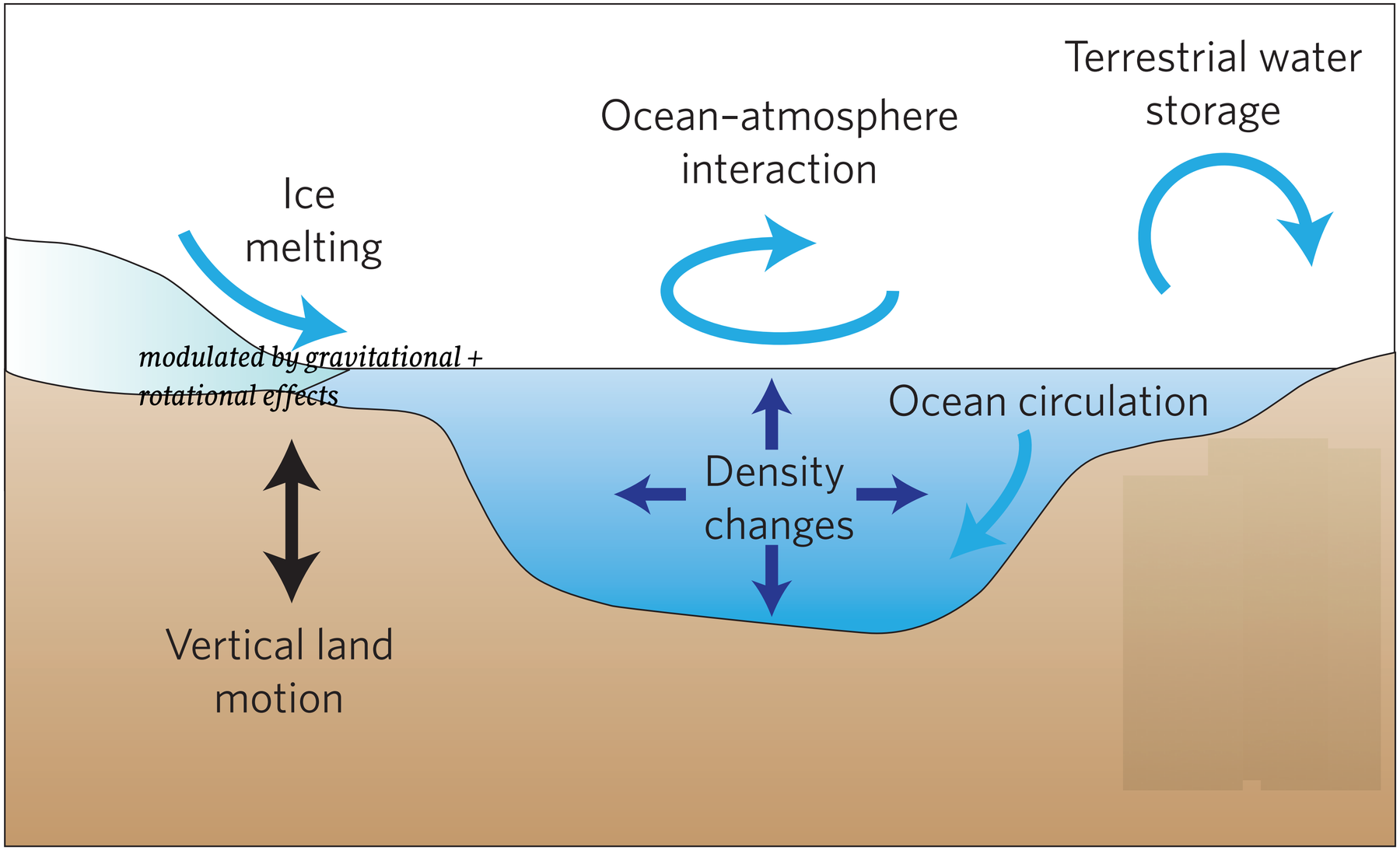

Framework of Kopp et al. (2014)

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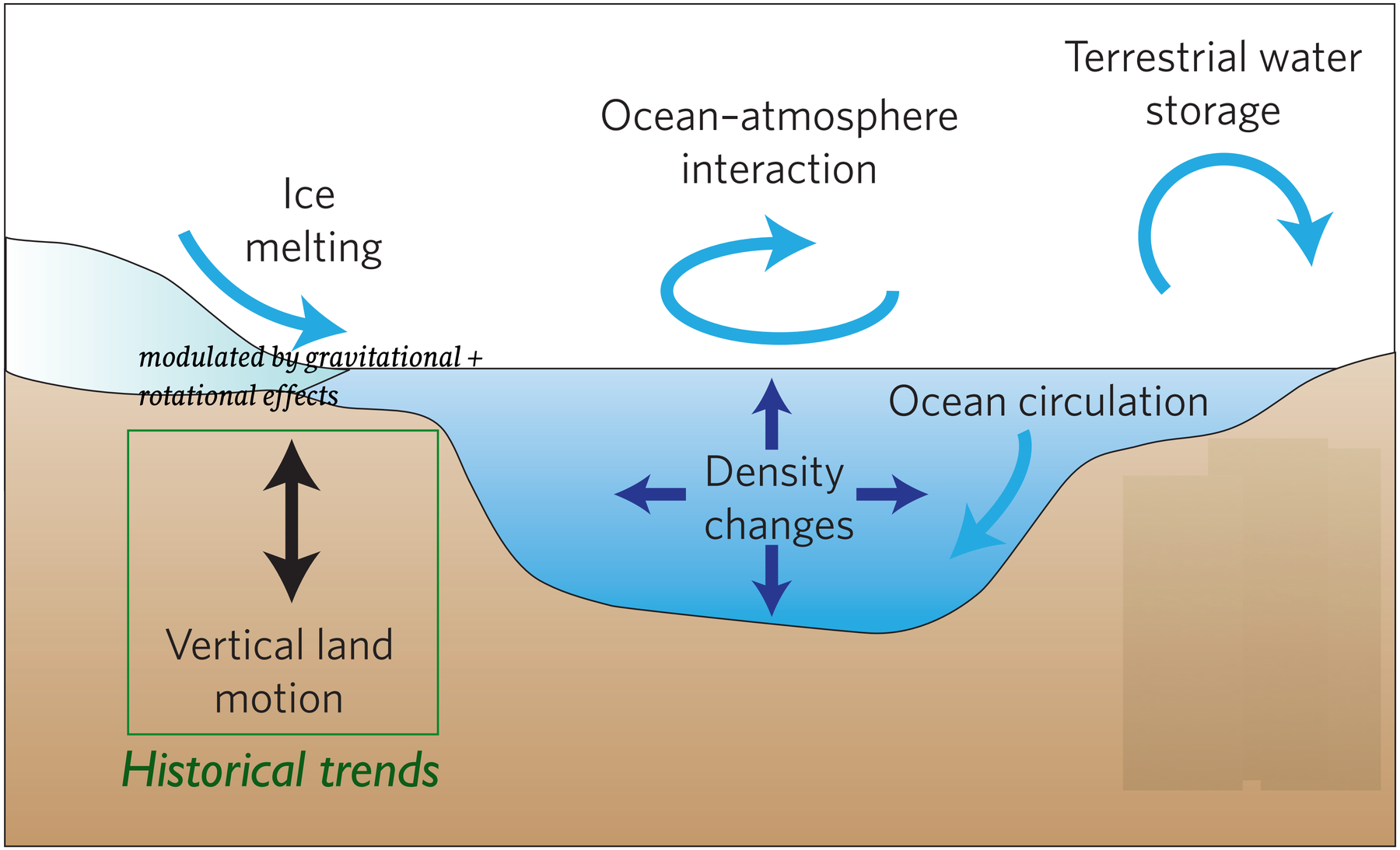

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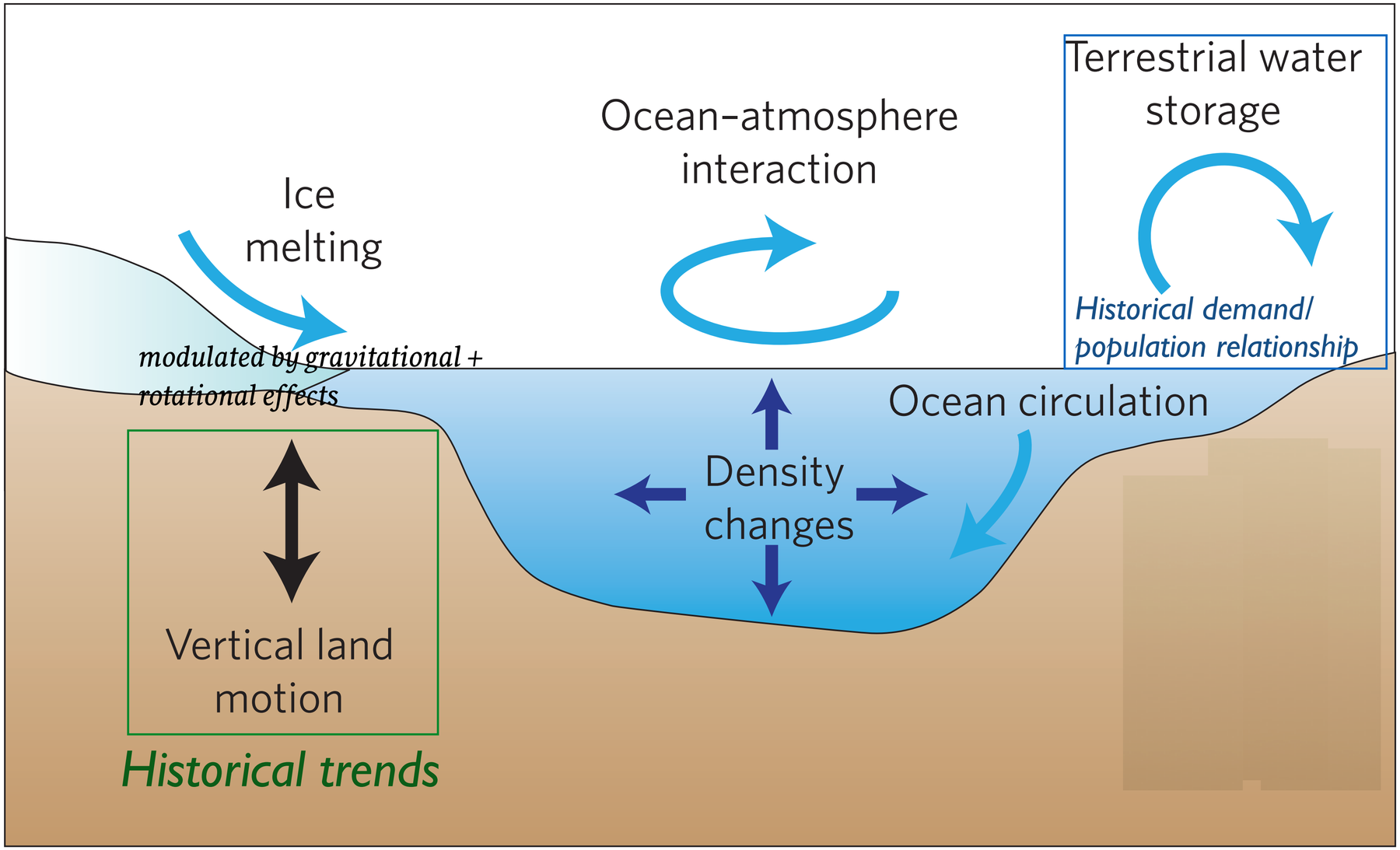

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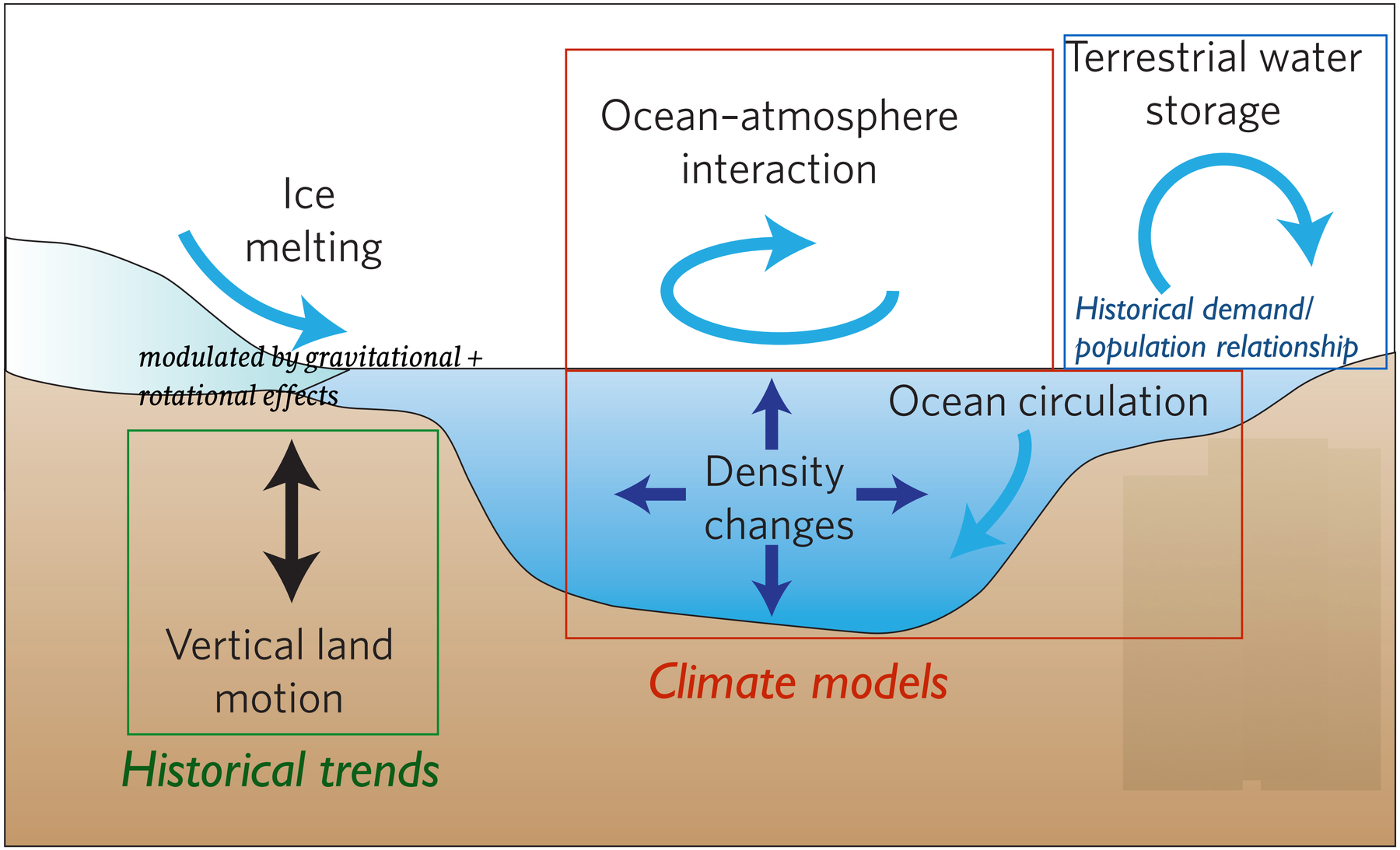

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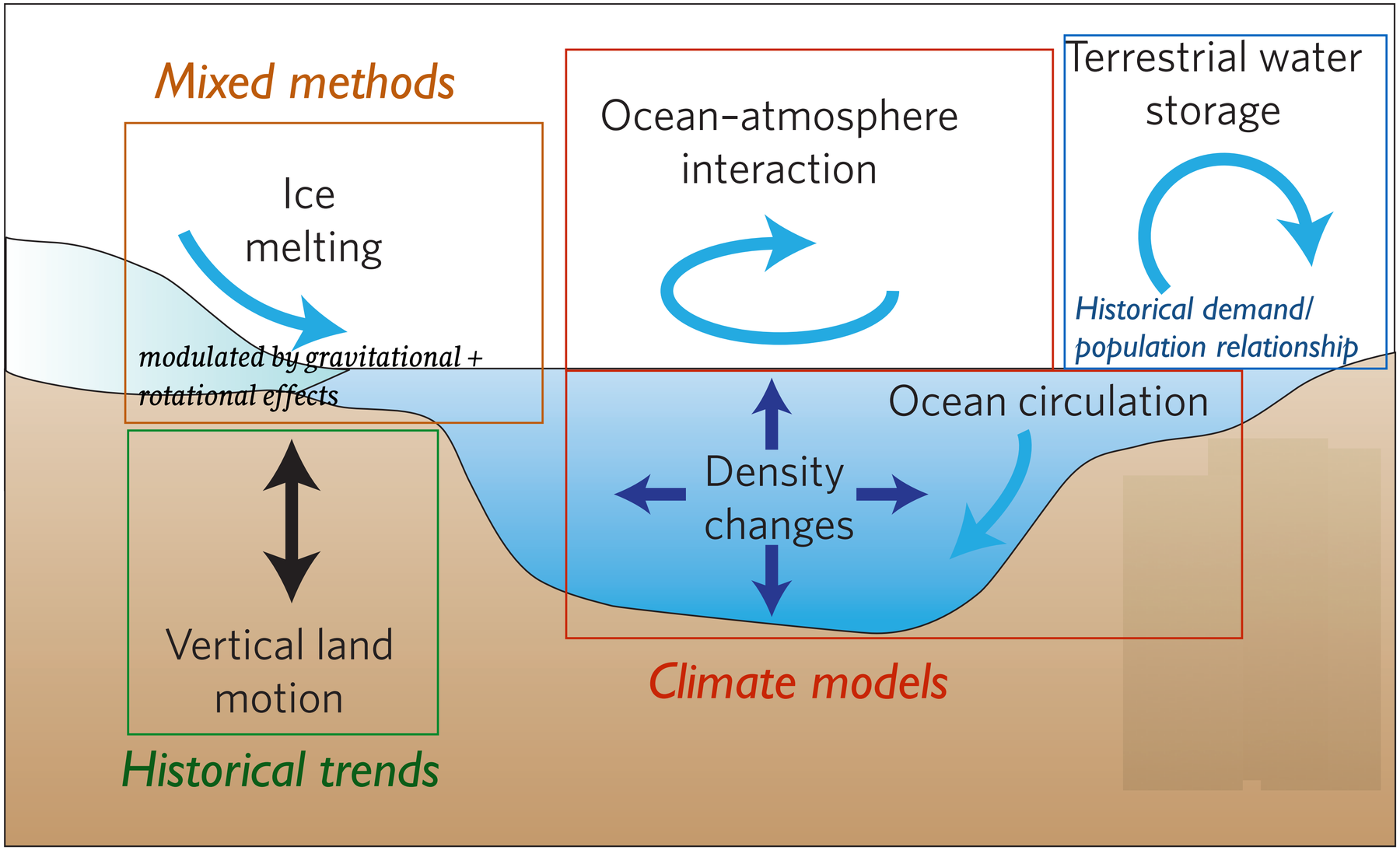

Framework of Kopp et al. (2014)

Our open-source framework (± modifications) has been widely used in US stakeholder-driven assessments

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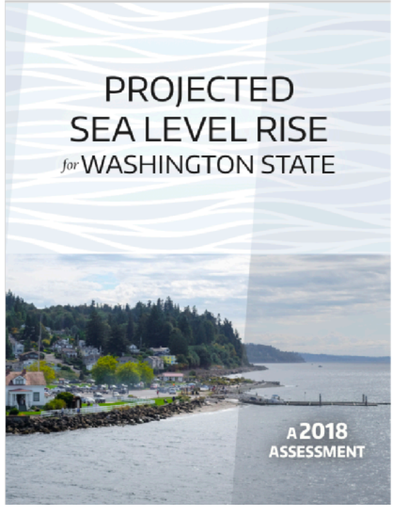
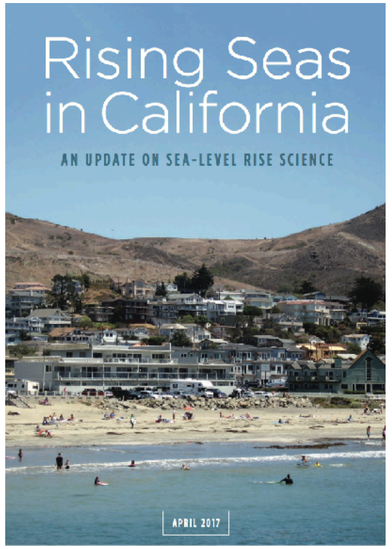
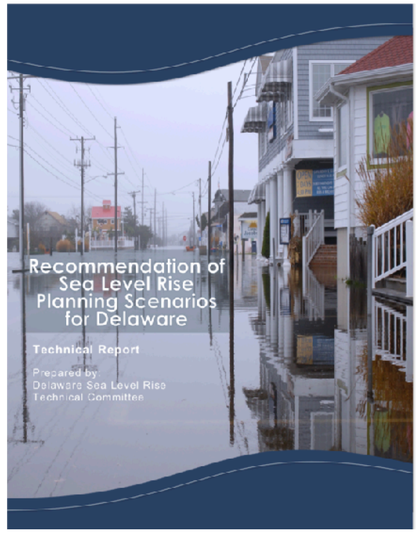
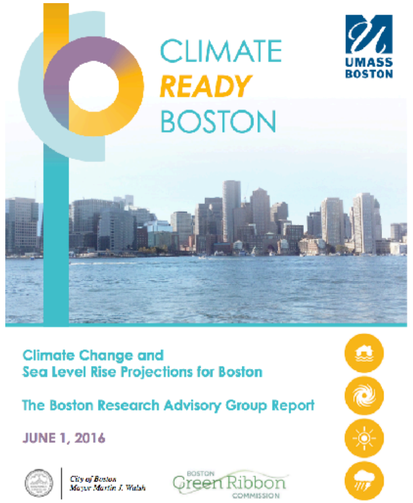
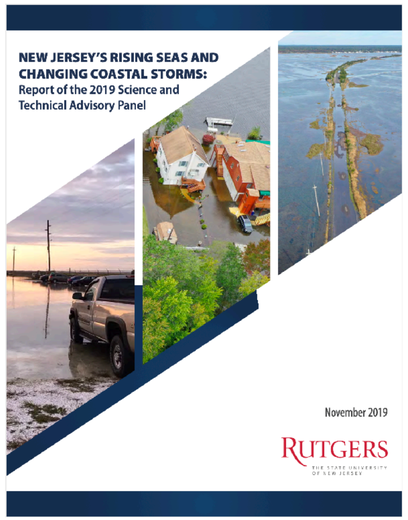




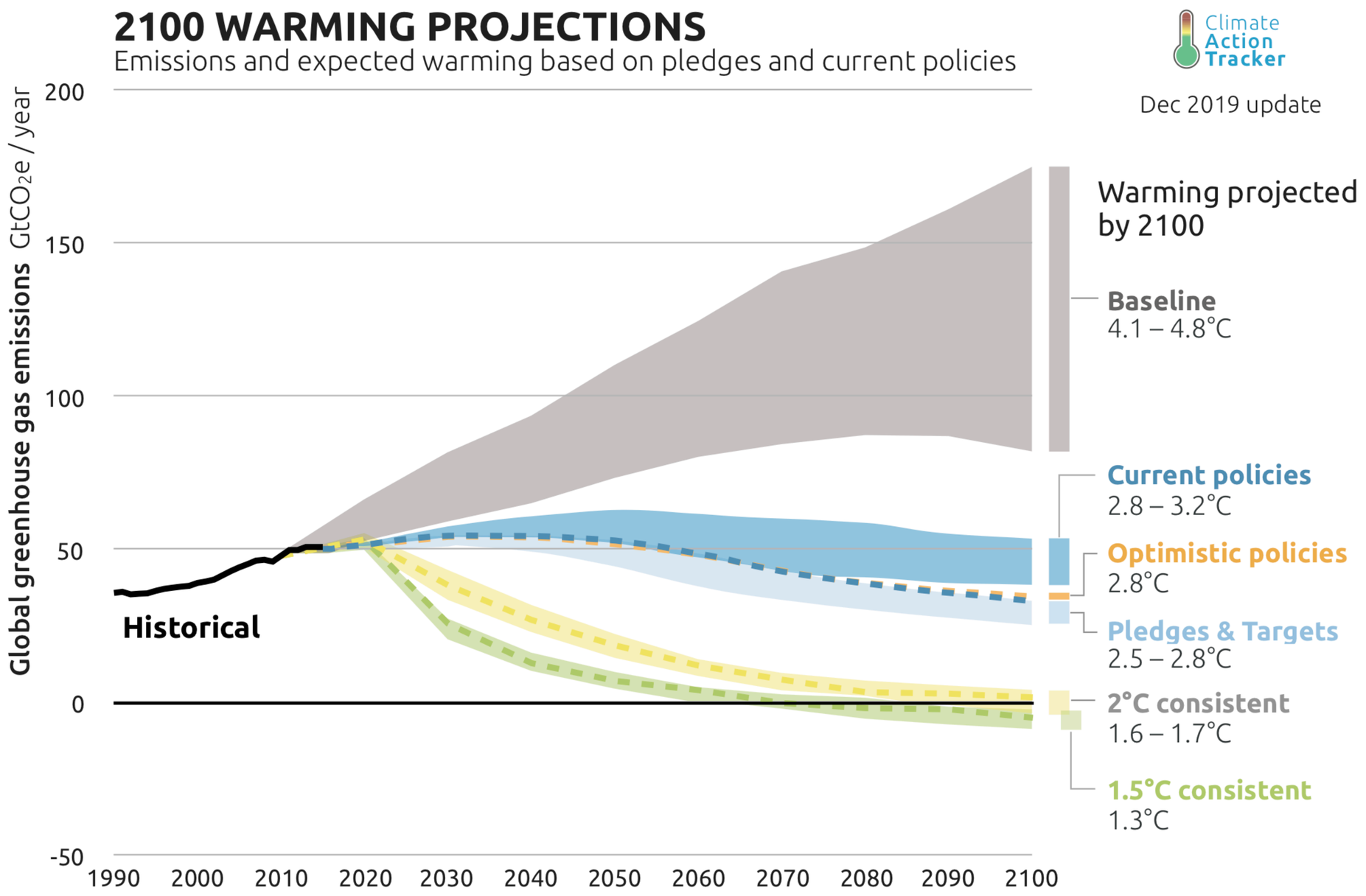






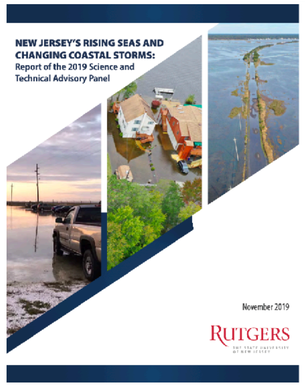
github.com/bobkopp/LocalizeSL

A key driver of the range of possible futures is the range of possible human emissions.



Another key driver of the range of projections is the incomplete, rapidly evolving scientific understanding of how ice sheets and the ocean interact.

Through 2050, we are likely looking at 0.7-2 feet of rise in the Delaware River Basin, regardless of emissions.



Projected sea-level rise at Philadelphia
Feet above year 2000 baseline

	Chance SLR Exceeds	2030	2050
Low End	> 95% chance	0.3	0.5
***Likely* Range**	> 83% chance	**0.4**	**0.7**
	~50 % chance	**0.7**	**1.2**
	<17% chance	**1.0**	**1.9**
High End	< 5% chance	1.2	2.4

Projected sea-level rise at Cape May
Feet above year 2000 baseline

	Chance SLR Exceeds	2030	2050
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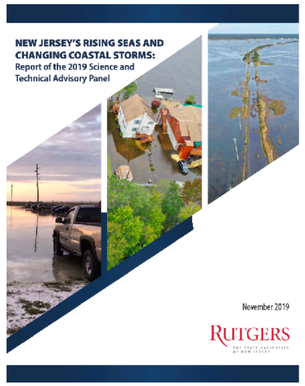
***2010 (2001-2019 average) Observed = 0.15 ft at Philadelphia, 0.18 ft at Cape May**

Beyond 2050, projected rise is increasingly sensitive to level of emissions – especially for high-end risks.



Projected sea-level rise at Philadelphia
Feet above year 2000 baseline

		2030	2050	2060			2100			2150		
				Emissions								
	Chance SLR Exceeds			Low	Mod.	High	Low	Mod.	High	Low	Mod.	High
Low End	> 95% chance	0.3	0.5	0.6	0.7	0.7	0.8	1.0	1.2	0.8	1.6	2.4
***Likely* Range**	> 83% chance	**0.4**	**0.7**	**0.9**	**1.0**	**1.1**	**1.4**	**1.7**	**2.0**	**1.8**	**2.5**	**3.2**
	~50 % chance	**0.7**	**1.2**	**1.4**	**1.6**	**1.7**	**2.4**	**3.0**	**3.6**	**3.6**	**4.6**	**5.6**
	<17% chance	**1.0**	**1.9**	**1.9**	**2.2**	**2.5**	**3.6**	**4.8**	**5.9**	**5.7**	**7.8**	**9.8**
High End	< 5% chance	1.2	2.4	2.4	2.8	3.2	4.6	6.6	8.5	7.5	13.3	19.0

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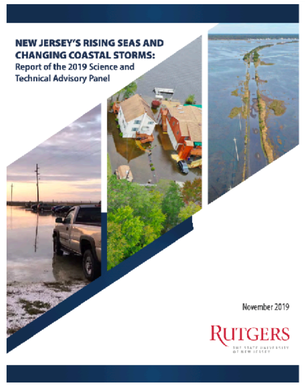

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Feet above year 2000 baseline

		2030	2050	2060			2100			2150		
				Emissions								
	Chance SLR Exceeds			Low	Mod.	High	Low	Mod.	High	Low	Mod.	High
Low End	> 95% chance	0.4	0.7	0.8	0.9	0.9	1.0	1.3	1.5	1.2	2.0	2.8
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	~50 % chance	**0.7**	**1.3**	**1.5**	**1.7**	**1.9**	**2.7**	**3.3**	**3.8**	**4.1**	**5.1**	**6.1**
	<17% chance	**1.0**	**2.0**	**2.1**	**2.4**	**2.7**	**3.9**	**5.1**	**6.2**	**6.2**	**8.3**	**10.3**
High End	< 5% chance	1.2	2.5	2.6	3.0	3.3	5.0	6.9	8.8	8.0	13.8	19.6

***2010 (2001-2019 average) Observed = 0.15 ft at Philadelphia, 0.18 ft at Cape May**

Expected number of flood events increases significantly with sea-level rise.

Expected number of extreme sea level events at Atlantic City

Water level: Historic 10% probability extreme sea level events (3.3’ above high tide line)

Moderate emissions, *likely* rise (1.4′ by 2050, 3.3′ by 2100)

2000:
10% chance per year

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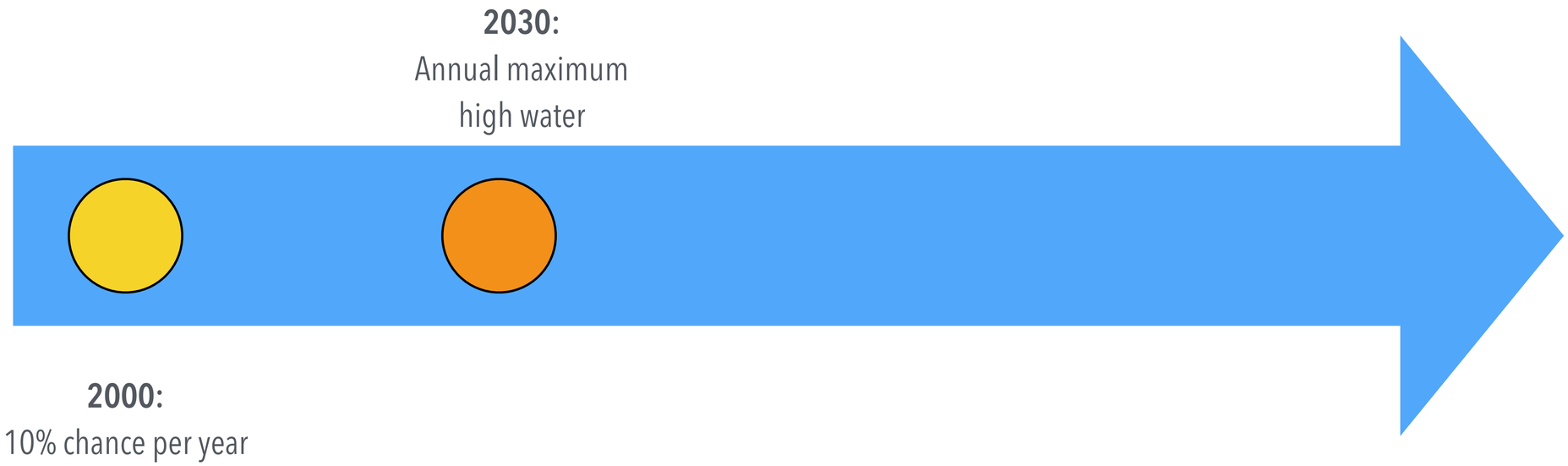

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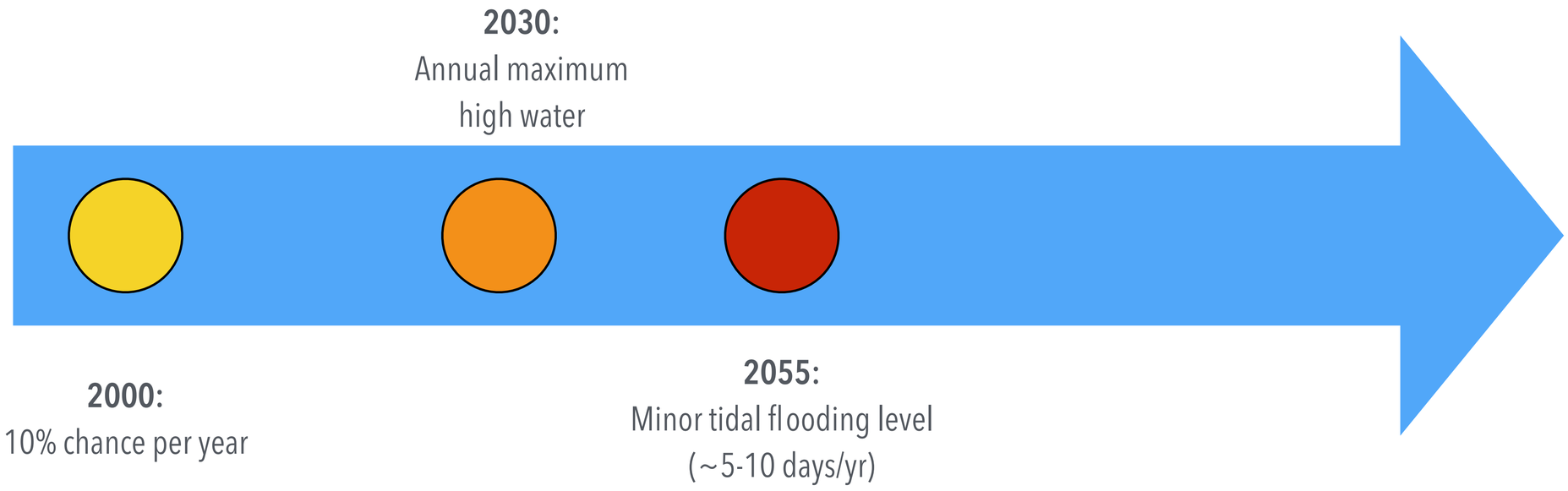
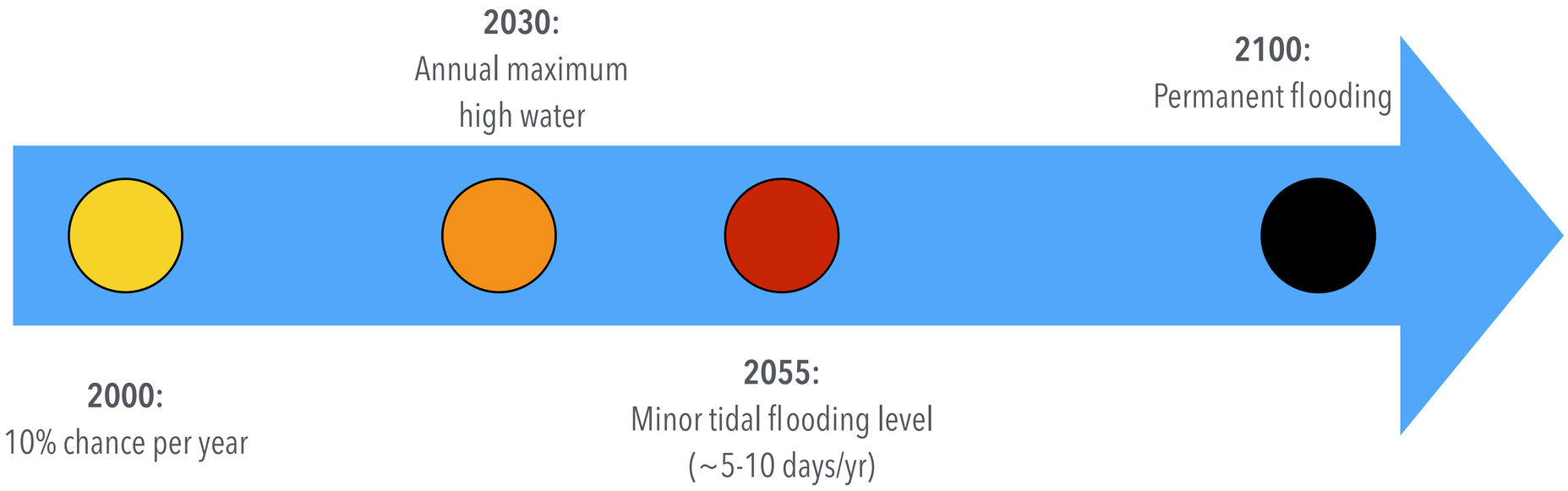


Expected number of flood events increases significantly with sea-level rise.

Expected number of extreme sea level events at Atlantic City

Water level: Historic 10% probability extreme sea level events (3.3' above high tide line)

Moderate emissions, *likely* rise (1.4' by 2050, 3.3' by 2100)

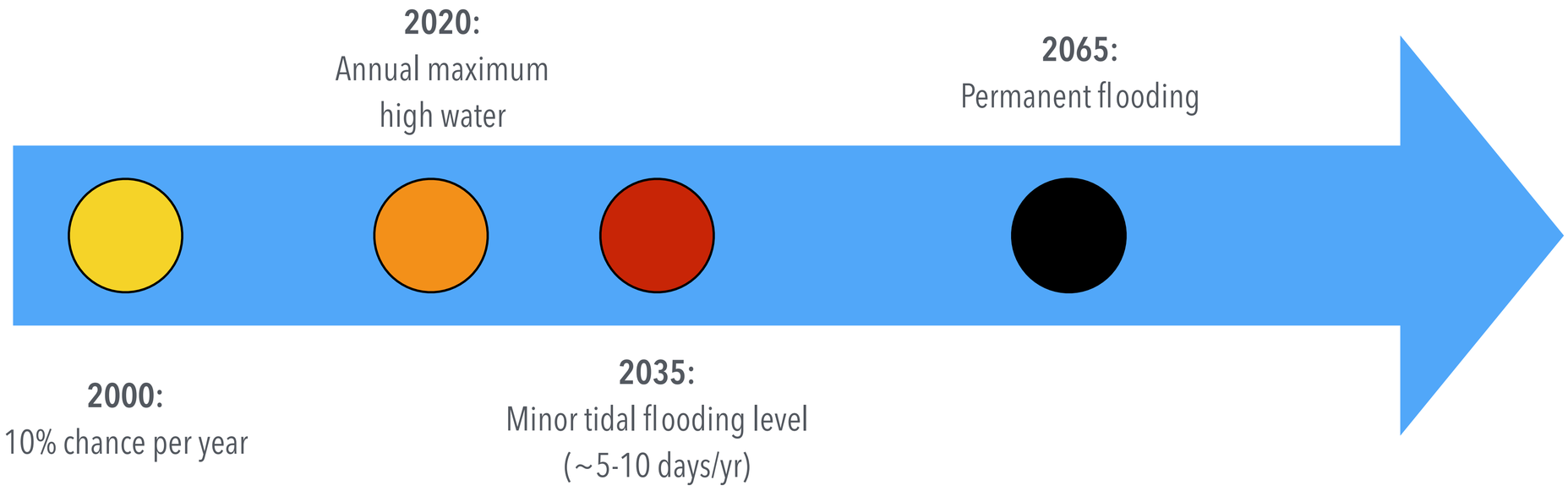


Expected number of flood events increases significantly with sea-level rise.

Expected number of extreme sea level events at Atlantic City

Water level: Historic 10% probability extreme sea level events (6.9’ above high tide line)

Moderate emissions, high-end rise (2.6′ by 2050, 6.9′ by 2100)



Coastal Climate Risk & Resilience Initiative

AMERICAN LITTORAL SOCIETY

OFFICE FOR COASTAL MANAGEMENT
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

STATE OF NEW JERSEY
DEPARTMENT OF ENVIRONMENTAL PROTECTION

THE William Averette Anderson FUND

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COUNTY OF MONMOUTH NEW JERSEY

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Sea-Level Rise in the Delaware River Basin

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