Bringing Climate Change Home How do we know it is happening & what does it mean for me?

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Earth Scientist.

















Photos: H. Roop

Established 1995

CLIMATE

The **Climate Impacts Group** supports the development of climate resilience by *advancing understanding* and *awareness* of climate risks. We work closely with public & private entities *to apply* this information as they act to shape

society's future.

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HOW IS CLIMATE CHANGE CONNECTED TO OUR COASTS?

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SEA LEVEL RISE

How do we measure sea level change?





GPS for land surface elevation change.



Global sea level is rising, and the rate of change is increasing



NCA 2014, Figure 2.26

Modified by UW Climate Impacts Group

Major determinants of regional SLR include both global & local components



FIGURE 1.4 Processes that influence sea level on global to local scales. SOURCE: Modified from Milne et al. (2009).

Shifting Coastlines

FIGURE 3: Vertical land movement best estimate rates (left) expressed in rates of feet/century, and their uncertainties (1 standard deviation, right) as estimated for Washington's coastline.



Miller et al., 2018



Sea level change...



Declining sea level found where uplift exceeds rate of sea level rise.

Data from NOAA, 2018



Projections for **171** coastal locations



bit.ly/waslr

Absolute Sea Level Rise versus Relative Sea Level Rise



UW Climate Impacts Group

FIGURE 2: Absolute sea level rise projections, through 2100, for a high greenhouse gas scenario (RCP 8.5), for Washington State. Projections are based on Kopp et al. (2014) and observed variations in absolute sea level are shown for 1907-2007.⁴ All results are shown relative to the average for 1991-2009. The probability values are "probabilities of exceedance", i.e., the current best assessment of the likelihood that absolute sea level will rise by at least a given change in elevation.



Projected Absolute Sea Level Rise Under a High Greenhouse Gas Scenario

PROJECTED RELATIVE SEA LEVEL CHANGE FOR 2100

(feet, averaged over a 19-year time period)

Location	Vertical Land Movement Estimate	Greenhouse Gas Scenario	Central Estimate (50%)	Likely Range (83-17%)	Higher magnitude, but lower likelihood possibilities			
					10% probability of exceedance	1% probability of exceedance	0.1% probability of exceedance	
Tacoma (47.3N, 122.4W)	-0.5 ± 0.2	Low	2.1	1.5-2.7	3	4.6	7.9	
		High	2.5	1.9-3.3	3.6	5.3	8.8	
Neah Bay (48.4N, 124.6W)	1.1 ± 0.3	Low	0.5	-0.1 - 1.2	1.5	3.1	6.3	
		High	1	0.3 - 1.7	2	3.8	7.4	
Taholah (47.4N, 124.3W)	0.3 ± 0.5	Low	1.3	0.6-2.1	2.4	3.9	7.1	
		High	1.7	1.0-2.6	2.9	4.6	8.1	

Anacortes	-0.1 ± 0.3 ft	Low	1.6 ft	1.0–2.3 ft	2.6 ft	4.2 ft	7.4 ft
	0.1 - 0.5 10	High	2.1 ft	1.4-2.9 ft	3.2 ft	4.9 ft	8.3 ft

We need to consider more than sea level rise...

Increased storm surge and related episodic flooding will present a significant near-term challenge.

• A one foot of sea level rise turns a 100 year tidal surge event into a 10 year event.

 A two foot sea level rise turns a 100 year tidal surge event into an annual event.

Near-term Challenges of SLR

Sea level rise increases storm surge and the risk of:

- flooding,
- erosion,
- habitat loss,
- toxics mobilization

These impacts will affect coastal areas long before permanent inundation.



Sea level rise increases the potential for higher tidal & storm surge reach, and increased coastal inundation, erosion & flooding.



Mauger et al., 2015; Photo: H. Roop with aerial support from LightHawk

Coastal Floods Are Increasing





* At Seattle water level station, 63 miles from Anacortes. This is the nearest station analyzed for these statistics. (?)

- · Humans are causing climate change, which is causing global sea level to rise.
- This graph shows just how much more flooding has come from this rise, plus the floods that would have taken place anyway.
- Flood definition: water level exceeds a local threshold set by the National Weather Service for "minor" flooding, based on
 observed impacts such as flooding roads.
- Findings come from a 2016 <u>Climate Central study covered by the New York Times</u>.

When Are the Risks?

ANACORTES AREA* Multi-year risk of flooding above 5 ft V PPT PRE NG XLS

Risk of at least one flood from 2016 through each year shown



*At Seattle water level station, 63 miles from Anacortes 📀 🌞

Analysis uses median local sea level projections based on the intermediate scenario from NOAA Technical Report NOS CO-OPS 083 (2017), intended for the 2018 U.S. National Climate Assessment. <a>? <a><u>key notes</u>

Tutorial video (j)





Mauger et al., 2015

TIMING OF STREAMFLOW

Most Puget Sound watersheds will be rain dominant by the end of the 21st century







Mauger et al., 2015

BUT, WHERE DOES THE HEAT COME FROM?



Greenhouse gases create Earth's "duvet".

The Greenhouse Effect

Some solar radiation is reflected by the Earth and the atmosphere. Some of the infrared radiation passes through the atmosphere. Some is absorbed and re-emitted in all directions by greenhouse gas molecules. The effect of this is to warm the Earth's surface and the lower atmosphere.

Most radiation is absorbed by the Earth's surface and warms it.

Atmosphere

Infrared radiation is emitted by the Earth's surface.

Earth's surface



GHG = Greenhouse Gas

Released through natural (volcanic eruptions) & human activities (deforestation, land use changes & burning fossil fuels).

H H Methane (CH₄)

Carbon

dioxide (CO₂)

Produced by natural sources & human activities, including the decomposition of waste in landfills, agriculture, rice cultivation, and ruminant digestion.

Image: NASA/GSFC

> The most abundant GHG. Water vapor increases as the atmosphere warms.

s. Water vapor (H₂O)

Nitrous oxide (N₂O)



Produced by the use of commercial & organic fertilizers, fossil fuel combustion, nitric acid production & biomass burning.

Modified from NASA.gov



From: IPCC, 2014

~1.8°F warming globally since the late 1800's



Created by H. Roop from NASA GISS, NOAA ESRL, NOAA NCEI data



There is high confidence (>95%) that human-produced greenhouse gases have caused much of the observed increase in Earth's temperature over the past 50 years.

IPCC, 2014; Images: H. Roop



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ppm= parts per million

Emissions of Greenhouse Gases Determine Temperature Rises







HOW HAS CLIMATE CHANGED?



Ice!

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FROM ICE CORES WE HAVE DIRECT MEASUREMENTS OF GREENHOUSE GASES BACK 800,000 years!

May, 2019 **CO2 413 ppm**

Pre-industrial (late 1800's) co₂ 280 ppm

ppm= parts per million



Image: P. Neff

800,000 yrs of CO₂ & Temperature



From: P. Neff; Data: Jouzel et al., 2007; Luthi et al., 2008

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800,000 yrs of CO₂ & Temperature

410 ppm today



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Universe Today



"The global climate continues to change rapidly compared to the pace of the natural variations in climate that have occurred throughout Earth's history."

> - 4th National Climate Assessment November 2017

So we have evidence that today is different.



What can we do about it?

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HOW WE 'FEEL' FUTURE CLIMATE CHANGE DEPENDS ON:

Our actions **now** to reduce emissions of greenhouse gases

(*mitigation*)



How well we **prepare** our communities & the systems we rely on (*adaptation*)



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"We need to adapt to climate change even as we seek to mitigate it."

- Nives Dolsak & Aseem Prakash, 2018

What are the options for adapting to sea-level rise?



How Can I Prepare for Flooding?

Smaller interventions tend to be faster and less expensive, but also less effective for long-term preparation. Larger interventions tend to be slower and more expensive, but also more effective for long-term preparation.

Tailor Options Based on Speed, Expense and Effectiveness



http://bit.ly/2zQ8O3t





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