Polar Ice melt and Sea Level Rise



Antarctic Ice Sheet (Visualization from NASA's mission Operation IceBridge dataset BEDMAP2)

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Learning Objectives and Module Overview

In this module you will explore:

- Why is sea level rising and how are polar regions contributing?
- What is storm surge and how will it affect us?
- How should we prepare?



From Climate Central (https://www.climatecentral.org/outreach/alertarchive/2017/2017SeaLevelCM-TVM.html)

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New York City, 2100

Extreme sea level scenario

Storm Surge

- Storm surge is a rise in sea level due to an intense storm.
- Sea level rise adds to storm surge.



- Flooding
- Severe damage
- Loss of lives

By SuperManu - Image:Surge big.jpg by Robert Simmon, NASA GSFC, via NOAA. Uploaded by Pierre cb, Public Domain, https://commons.wikimedia.org/w/index.php?curid=2264485

Storm Surge

Katrina (2005)

- 26 feet
- Levees breached
- \$125 billion

Hurricane Sandy (2012)

- 9 feet
- \$65 billion
- Hurricane Harvey (2017)
- 10 feet
- \$125 Billion



Damage from Hurricane Ike's storm surge (2008). Picture courtesy of the U.S. National Weather Service.

https://www.britannica.com/event/Hurricane-Katrina https://www.nhc.noaa.gov/news/UpdatedCostliest.pdf https://www.weather.gov/okx/HurricaneSandy https://www.nhc.noaa.gov/data/tcr/AL182012_Sandy.pdf https://www.nhc.noaa.gov/data/tcr/AL092017_Harvey.pdf

How will sea level rise impact your local region through increased storm surges and flooding?

- 1. Go to the Surging Seas <u>Risk Finder website</u> that shows various impacts from flooding in coastal cities in the U.S. (https://riskfinder.climatecentral.org/)
- 2. Type in your city of interest (e.g. Tacoma)
- 3. Watch the video Intro to riskfinder website, then take 5 minutes to explore the website. (video URL: https://people.nwra.com/rowe/public/penguin /high/sea_level_rise/SLR2a_surgingSeasIntro.mov)



From Climate Central (https://riskfinder.climatecentral.org/)

Exploring the Risk Finder website:

4. Watch the video about When are the Risks?

(video URL: https://people.nwra.com/rowe/public/penguin/ high/sea_level_rise/SLR2b_surgingSeasWhen.mov)



From Climate Central (https://riskfinder.climatecentral.org/)



Figure 8. This study's six representative GMSL rise scenarios for 2100 (6 colored lines) relative to historical geological, tide gauge and satellite altimeter GMSL reconstructions from 1800–2015 (black and magenta lines; as in Figure 3a) and central

Adapted from Sweet, William V., et al, Global and regional sea level rise scenarios for the United States (2017). NOAA report.



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Pause for Analysis 3: What are the sea level rise scenarios?



From Climate Central (https://riskfinder.climatecentral.org/)

Optional:

Watch the video about <u>What are the Risks?</u> (video URL: https://people.nwra.com/rowe/public/penguin/ high/sea_level_rise/SLR2c_surgingSeasWhat.mov)

- How many people in the population of your city are at risk given a water level of 6 ft?
- How many homes are at risk given 8 ft of flooding?

Total population below 4 ft in Tacoma	
Population: All v	Total
Population	
Low social vulnerability population	
Caucasian population	
Hispanic population	
Population of color	
African-American population	
Native American population	

From Climate Central (https://riskfinder.climatecentral.org/)

With higher sea levels come increased storm surge and flooding. What will the damages be?

Our end goal is to calculate the Marginal Damage. *For this project, the Marginal Damage is the extra damage for every additional foot of sea level rise.* We'll compare the marginal damage to the cost of building a sea wall.

Pause for Analysis 4: Write down the meaning of Marginal Damage given above. Discuss or think about what marginal damage is and how you would calculate it, and how you would compare it to the cost of avoiding the damage.

We will calculate marginal damage by estimating the damage to homes for each level of flooding based on

- Median home value and
- The number of additional homes impacted at each flood level.

Median Home Value

- For Tacoma: Assume a median home value of \$350,000
- For other locations: look up the median home value from <u>Zillow</u> (<u>https://www.zillow.com/home-values/</u>).



From Climate Central (https://riskfinder.climatecentral.org/) 14

- On the Surging Seas <u>Risk Finder website</u> (https://riskfinder.climatecentral.org/), scroll down to "What is at Risk?"
- 2. Open the student worksheet.
- 3. Make sure you click the tab at the lower left of your worksheet, "Damage Tables."
- 4. Look at Table 1.

Flood Level Total homes		Additional homes	Marginal Damage	Marginal Damage
(ft) (number)		(number)	(\$)	(millions of \$)
1		0	0	0.0
2		0	0	0.0

Table 1. Homes exposed to flood and total property values by flood level

Next we will show how we calculated the number of homes affected by 2 feet of sea level rise.

Water ?	What Is at Risk?	<u>Tutorial video</u> (j) 🏟
	Population Buildings Infrastructure Contamination	Risks
-10- -9-	Total population below 4 ft in Tacoma	
-8-	Population: All 🔻	Total
- 7 -	Population	702
- 6 -	Low social vulnerability population	647
-5-	Caucasian population	533
4	Hispanic population	301
-3-	Population of color	179
-2-	African-American population	57
-1-1	Native American population	40
	Sources: Raw population data, Census 2010; elevation data, lidar; administrati	ive boundaries, <u>City of Tacoma</u> . <u>Details</u>
	Values exclude sub-4ft areas potentially protected by levees or other f	eatures. 🥐
Choose a threat to Total hom	map using the scrotlable list above es below 4ft in Tacoma by neighborhood council dis Homes	strict ▼ Prre Pres
	Legend values are	bin upper limits
	Top threats on	map
100	Tacoma Neigh	borhood Council Dist New Tacoma 6 borhood Council Dist West End 3:
	Tacoma Neigh Tacoma Neigh	borhood Council Dist North East 20
	Tacoma Neigh	ibornood Council Dist Eastside

clude sub-4ft areas potentially protected by levees or other features.

(https://riskfinder.climatecentral.org/)

From Climate Central

Go back to "What is at Risk?" on Water level (f the Risk Finder website.

-10-

- 8 -

Щ

- **Click Buildings.** 2.
- **Click Homes.** 3
- If needed, click "exclude" to 4. toggle it to read "include."
- Set the water level to 2 feet. 5.
- Note the number of homes 6. below the water level.
- Check out the map to see where 7. the homes are.

Image From Climate Central (https://riskfinder.climatecentral.org/)

	-
Total buildings below 2 ft in Tacoma	XLS -
Buildings: All 🔻	Total
Property value	\$317 Mil
► Homes	
van 23 include sub-zit areas potentially protected by le	vees or the lor realtires. (7)
Choose a threat to manual using the scrollable list above	
Choose a threat to may using the scrollable list above Total homes below 2 ft in Tacoma by	city council district 🔻 🏧
Choose a threat to move using the scrollable list above Total homes below 2 ft in Tacoma by	city council district ▼ PPT Homes
Choose a threat to more using the scrollable list above Total homes below 2 ft in Tacoma by	city council district ▼ PPT ● Homes 160 30 0
Choose a threat to may using the scrollable list above Total homes below 2 ft in Tacoma by RES XLS	EXAMPLE 160 Homes 160 30 0 160 30 0 160 30 0

Enter number of homes.

Click cell, type value, and hit enter. (Note: your numbers may differ)

1	Α	в	с	D	E					
6	Table 1. Regional homes exposed to flood and total property values by flood									
7	Flood Level Total homes Additional homes Additional homes		Additional Damage	Additional Damage						
8	(ft)	(number)	(number)	(\$)	(millions of \$)					
9	1	125	125	0	0.0					
10	2	•								
11	3	229	229	0	0.0					
12	4	287	58	0	0.0					
13	5	358	71	0	0.0					
14										
15	7	508	508	0	0.0					
16	8	615	107	0	0.0					
17	9	696	81	0	0.0					
18	10	758	62	0	0.0					

Repeat these steps to get Total homes for 6 feet of sea level rise

1	Α	В	С	D	E
6	Table 1. Re	egional homes e	xposed to flood a	nd total property va	lues by flood level
7	Flood Level	Total homes	Additional homes	Additional Damage	Additional Damage
8	(ft)	(number)	(number)	(\$)	(millions of \$)
9	1	125	125	0	0.0
10	2	190	65	0	0.0
11	3	229	39	0	0.0
12	4	287	58	0	0.0
13	5	358	71	0	0.0
14					
15	7	508	508	0	0.0
16	8	615	107	0	0.0
17	9	696	81	0	0.0
18	10	758	62	0	0.0

Additional Homes Impacted

Calculate the number of additional homes affected for each additional foot of sea level rise.

1	Α	В	с
6	Table 1. Re	egional homes ex	posed to flood an
7	Flood Level	Total homes	Additional homes
8	(ft)	(number)	(number)
9	1	125	125
10	2	190	65
11	3	229	39
12	4	287	58
13	5	358	71
14			
15	7	508	508
16	8	615	107
17	9	696	81
18	10	758	62
10			

Additional homes =

Total homes – Previous total homes

Example for 2 feet of SLR:

Additional homes = 190 homes – 125 homes

This is cell B10 – B9.

This was calculated by clicking on cell C10 and then typing

=B10-B9.

• How would you get it for 6 feet? Enter it into your worksheet.

Calculating the Damage Cost of Flooding

Enter the median housing price to calculate the damages from flooding based on the number of homes that will be impacted at various flood levels.

Additional damages = number of additional homes x median home value

\sim	А	В	с	D	E			
1	Part 1: Es	timating the exp	ected margina	I damages from fl	ooding due to se			
2								
3	Median ho	ome value in Regio						
4								
5								
6	Table 1. Regional homes exposed to flood and total property values by flood lev							
7	Flood Level	Total homes	Additional homes	Additional Damage	Additional Damage			
8	(ft)	(number)	(number)	(\$)	(millions of \$)			
9	1	125	125	0	0.0			
10	2	190	65	0	0.0			
11	3	229	39	0	0.0			
12	4	287	58	0	0.0			
13	5	358	71	0	0.0			
14								
15	7	508	508	0	0.0			
16	8	615	107	0	0.0			
17	9	696	81	0	0.0			
18	10	758	62	0	0.0			

Enter the median housing price from the previous slide: click on cell D3, type in the value, then hit 'enter'.

Note that the additional damages fill in automatically.

Pause for Analysis 5: Think about or discuss the following with a partner:

- What assumptions are we making about how flood damages will impact houses?
- What other damages are occurring that we are ignoring? (Look at some of the other tabs on the Riskfinder site, for other types of buildings, infrastructure, etc).
- Do you think this is an over- or under-estimate of flood damages?

Calculating the Damage Cost of Flooding

With climate change comes a lot of risk and uncertainty.

- How much will sea level rise?
- What is the maximum flood levels associated with each SLR scenario?

One way to incorporate this risk into decision-making is by estimating the **expected damages** given the probability that floods will reach a certain height.

Expected Damage = Damage at flood level x Probability of flood level

Calculating the Damage Cost of Flooding

Now you will use the formula from the previous slide to calculate the expected additional damages for a flood level of your choice in Table 2. First we'll work through the example of 2 feet flood level together.

1	А	В	С	D	4.			
22	Table 2. Expected marginal damages from flooding by 2100							
23			S	low				
24	Flood level	Damage	Probability	Exp. Mar. Damage	=			
25	(ft)	(millions of \$)		(millions of \$)				
26	1	0.0	100%	0.0	th			
27	2	0.0	100%	0.0				
28	T	T	Т					
	1. Type in the flood level you want to calculate. 2. C		3. Type in the flood level scenario at in the next opy and paste the age from Table 1	he probability of that for the given SLR 2050 – see direction slide. for	t 1S			
	the given flood level.							

4. Expected damage = damage x probability

In the cell, for this example, you would type

= B27*C27

then hit the enter key

Getting the Probability of Flooding

In the Surging Seas

1. Make sure the setting is for "Multi-year risk of flooding" **Riskfinder website:** Tacoma, Washington, USA When Are the Risks? Tutorial video () level (ft) ? Water TACOMA A EA* -10-Multi-year risk of flooding above 4 ft V PPTC PNG XLS -9-Risk of at least one flood from 2016 through each year shown - 8 -100% --7-51% multi-year likelihood (2016-2050) of -6-Sea level a flood of 4 ft or more above current 2. Select the scenario high tide line. - 5 -Extreme water level of Risk (% Li 40% Fast rise your choice. 3. Select Medium the "Slow" 20% Slow rise sea level Advanced 0% 2020 2040 2060 2080 2100 2120 2140 2160 2180 2200 scenario End year

4. Hover over the year of interest on the bar chart (2100) to see the probability of at least one flood of that height by 2100.

Calculating the Damage Cost of Flooding

Repeat the steps in the previous two slides for the medium scenario, the fast scenario, and the extreme scenario to finish filling out the new row of the table.

22 Table 2. Expected marginal damages from flooding by 2100 by SLR scenairo

23			Slow		Medium		Fast		Extreme	
24	Flood level	Damage	Probability	Exp. Mar. Damage	Probability	Exp. Mar. Damage	Probability	Exp. Mar. Damage	Probability	Exp. Mar. Damage
25	(ft)	(millions of \$)		(millions of \$)						
26	1	0.0	100%	0.0	100%	0.0	100%	0.0	100%	0.0
27	2	0.0	100%	0.0	100%	0.0	100%	0.0	100%	0.0
20										



Fill in your row and be prepared to share the results with the class.

Note: Enter the probability as a percent. Make sure there is a percent sign.



When getting the probabilities, be sure to choose the corresponding scenario (Extreme, Fast, Medium, or Slow)

Pause for Analysis 6:

Discuss or think about how you would interpret the expected marginal damage from your table. The multi-year likelihood is the probability of at least one flood occurring in the given period (e.g. through 2100), though there could be more.

 Considering the assumptions made in this analysis so far, would more than one flood occurring in the period affect the damage costs? In the next PowerPoint, you will compile the expected damages for all the different scenarios and flood levels for 2100 using data collected from different groups in your class.