Examining a Process for Developing a Learning Progression for Sea Level Rise

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Project MADE-CLEAR

Maryland and Delaware Climate Change Assessment and Research Project

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www.madeclear.org

www.ClimateEdResearch.org

Why Sea Level Rise?

- A major impact of climate change.
- Little research on student understanding of SLR.
- Highly relevant to students in MD and DE.

Research Question

How can learners come to understand sea level rise in a progressively more sophisticated manner?

Goal

Develop an conditional empirically supported learning progression on the topic of sea level rise.

Theoretical Perspectives

Learning progressions as descriptions of the increasingly sophisticated ways that learners think about a science topic over time (Duschl, Schweingruber, & Shouse, 2007).

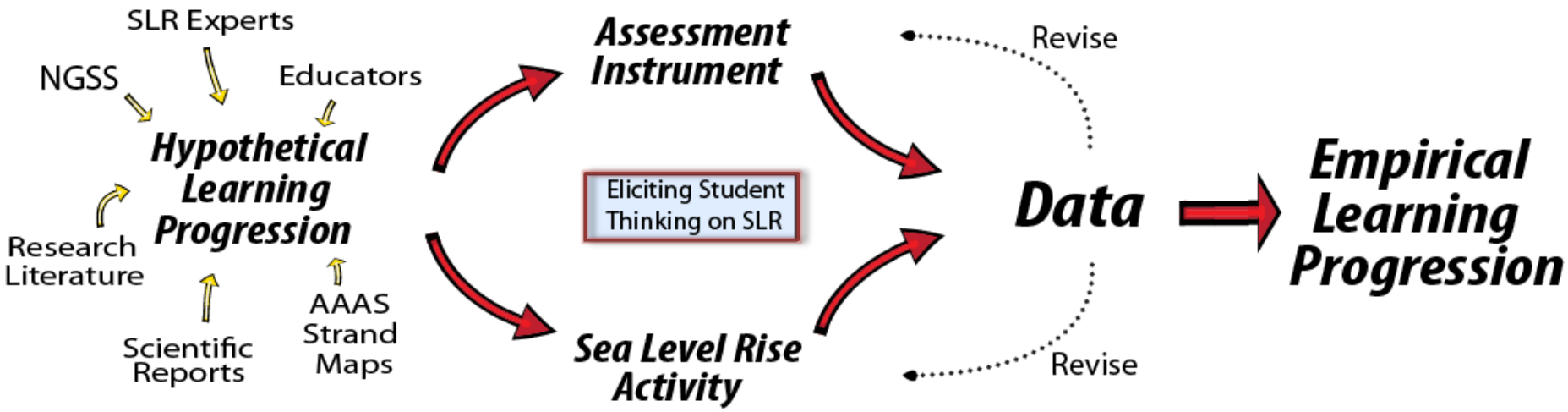
Section of the Conditional SLR Learning Progression: Impacts of Sea Level Rise

	Level 1 (Lower Anchor)	**Level 2**	**Level 3**	**Level 4** (Upper Anchor)
Potential SLR LP indicator about impacts of sea level rise "I" stands for impacts	I1: Students identify that an impact of sea level rise is that some land in coastal areas and islands will be underwater, though they are not able to elaborate on specific consequences of sea level rise.	I2: Students understand that sea level is projected to rise in the future and are able to identify a limited number of specific consequences, though they do not understand that sea level change will have local effects including those related to storm surge.	I3: Students understand that local impacts of sea level changes can differ, but cannot explain primary factors that can cause this difference. Students are able to elaborate on specific consequences of sea level rise such as loss of habitat, in-land flooding during storms, property loss, and erosion.	I4: Students understand that local sea level changes can differ from global trends based on regional variations in factors such as geographic uplift or subsidence and ocean currents. Students are able to elaborate on specific consequences of local sea level rise. Students recognize that sea level rise projections are based on available data and may be lower or higher than predicted.

Theoretical Perspectives

Literature on conceptual change and alternative conceptions contributed to the development of our assessment instrument and learning progression.

Research Design



Sea Level Rise Assessment Instrument

- Developed based on our LP.
- Piloted with middle school students (N=60).
- Tested and revised with:
  - pre-service teachers (N=50)
  - in-service teachers (N=30)
  - middle school students (N=5)

- Received feedback from sea level rise experts (N=3).

Sea Level Rise Assessment Item

Description of Situation	The amount of greenhouse gases in the atmosphere is increasing.
Question	How is this related to sea level rise?
Select the ***best*** response.	***More greenhouse gases will lead to an increase in global temperature causing***: **A.** oxygen and nitrogen gases to dissolve in water, increasing sea volume. **B.** ice on land melting and thermal expansion of sea water, increasing sea volume. **C.** the number and size of water molecules to increase, increasing sea volume. **D.** the atmospheric pressure above the seas to increase and push water towards land.

Why is this the best explanation?

AAAS Project 2061, n.d.; Herrmann-Abell & DeBoer, 2008

Sea Level Rise Assessment Item

Description of Situation	Sea level is projected to rise between 1 and 4 feet by the year 2100, with an additional rise of 2 feet possible*.
Question	Why is sea level rising?
Select the ***best*** response.	**A.** Increased ultraviolet radiation reaching the earth due to the hole in the ozone layer. **B.** Increased rain and snowfall are adding to the amount of water in the seas. **C.** Shifts in plate tectonics reorganizing the shape of the sea floor. **D.** An increase in global temperatures is causing ice on land to melt, increasing sea volume.

Why is this the best explanation?

* U.S. Global Change Research Program (2014). Chapter 2: Our Changing Climate (p. 45). In *Climate change impacts in the United States: The Third National Climate Assessment*. Available at: http://nca2014.globalchange.gov/report/our-changing-climate/sea-level-rise

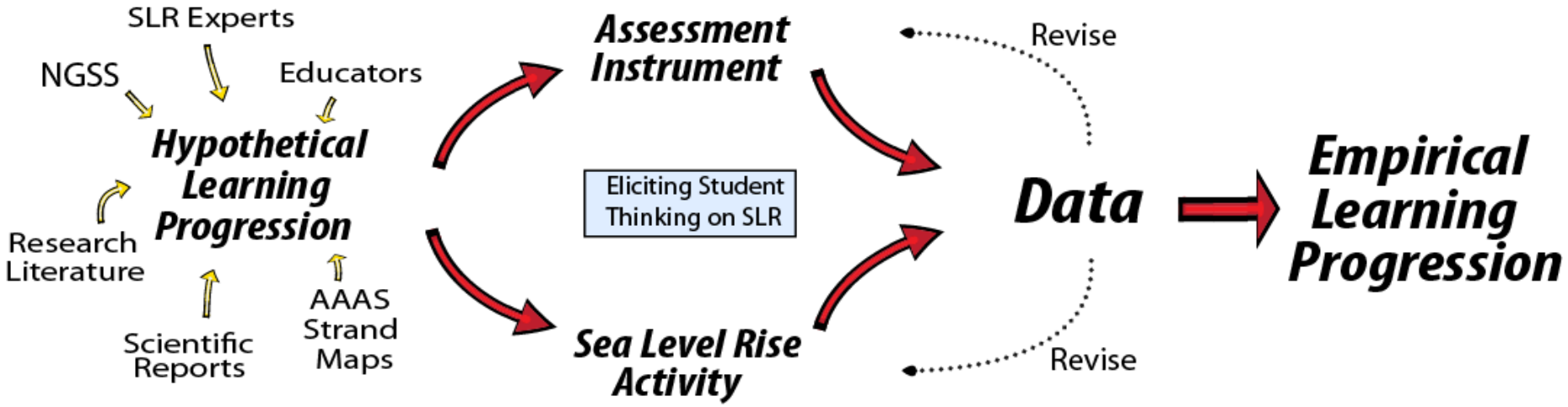
Dove (1996); Ekborg & Areskoug (2006); Hestness et al. (2011), Lambert et al. (2012); Matkins & Bell (2007); Michail et al. (2007); Papadimitriou (2004); Wise (2010)

Climate Change Alternative Conceptions

Alternative Conceptions	Study
Global warming is caused by a hole in the ozone	Dove (1996); Ekborg and Areskoug (2006); Hestness et al. (2011); Lambert et al. (2012); Matkins and Bell (2007); Michail et al. (2007); Papadimitriou (2004); Wise (2010)
Global warming causes skin cancer	Dove (1996); Ekborg and Areskoug (2006); Groves and Pugh (1999); Michail et al. (2007)
The greenhouse effect is caused by a lid or blanket that traps heat	Dove (1996); Ekborg and Areskoug (2006); Lambert et al. (2012); Papadimitriou (2004)
The carbon cycle acts like a filter that cleans the air	Lambert et al. (2012)
Confusion about weather vs. climate	Lambert et al. (2012); Papadimitriou (2004)
Greenhouse gases are "trapped" in the atmosphere	Lambert et al. (2012)
Global warming will cause decreased precipitation (drier conditions) in all locations	Dove (1996)
Global warming will enhance photosynthesis through increased solar radiation	Dove (1996)
Climate change is controversial in the scientific community	Matkins and Bell (2007); Wise (2010)
Increasing the greenhouse effect would increase earthquake frequency	Groves and Pugh (1999)
Using unleaded gasoline can reduce the greenhouse effect	Groves and Pugh (1999)
Nuclear power or weapons contribute to the greenhouse effect as much as coal power	Groves and Pugh (1999); Papadimitriou (2004)
Environmental pollution generally causes global warming	Papadimitriou (2004)
Acid rain causes global warming	Groves and Pugh (1999); Papadimitriou (2004)
The greenhouse effect is unnatural	Matkins and Bell (2007); Michail et al. (2007)

Hestness, E., McDonald, R. C., Breslyn, W., McGinnis, J. R., & Mouza, C. (2014). Science Teacher Professional Development in Climate Change Education Informed by the Next Generation Science Standards. *Journal of Geoscience Education*, *62*(3), 319-329.

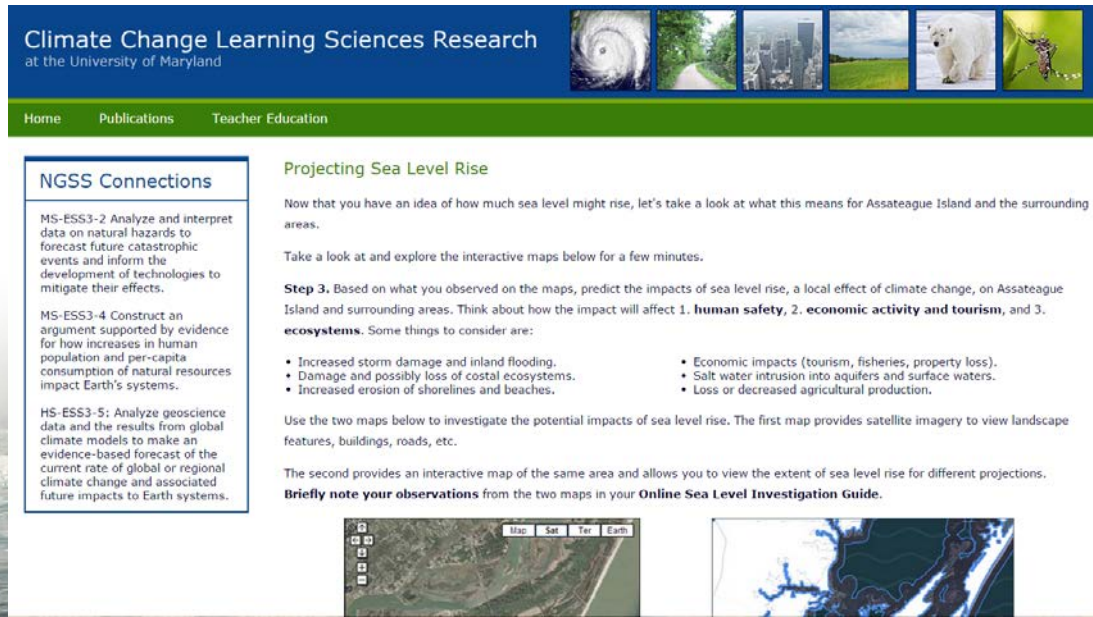
Research Design



Sea Level Rise Online Activity

- Developed based on our LP.
- Tested and revised with:
  - pre-service teachers (N=60 in 2013 & N=60 in 2014)
  - in-service teachers (N=30)
  - middle school students (N=5)

- Generated data for the *Impacts* component of the LP.



Sea Level Rise Activity

Write down three things you already know about sea level rise e.g., (why it's happening, factors causing it, impacts on communities and ecosystems).

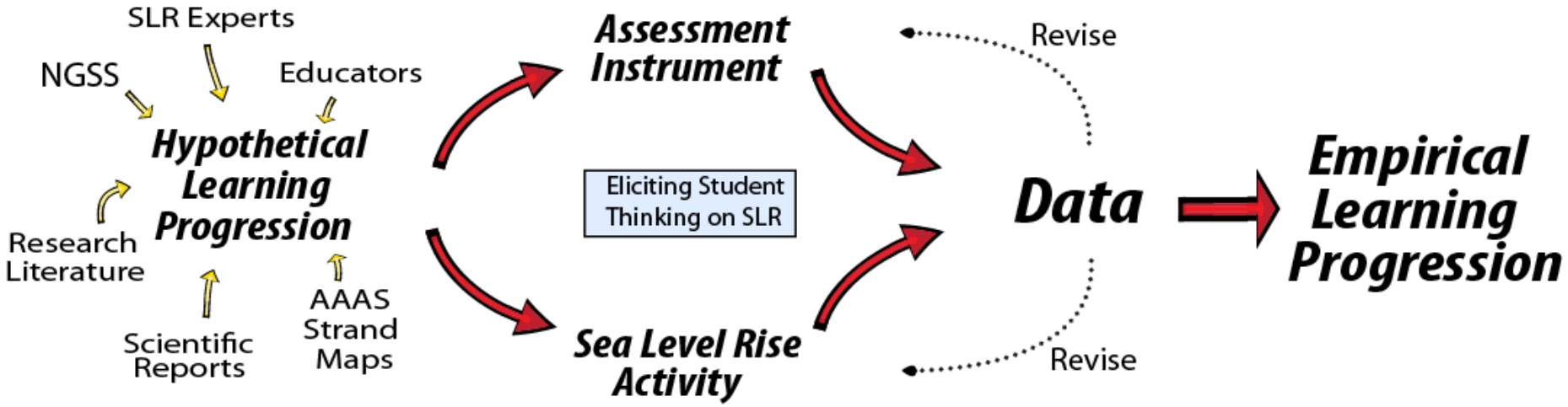
Middle School Students

In the Online SLR Activity, middle school students responded to the prompt "*Write down three things (or more) you already know about sea level rise…"* in a more limited manner citing melting of ice sheets, ozone as a cause of sea level rise, and global warming as a cause for sea level rise. For impacts the focus was on flooding and on polar bears and penguins.

Elementary Science Methods Students (Preservice Teachers)

Impacts of Sea Level Rise		
Flooding (15)	More powerful storms (6)	Human habitats affected (2)
Islands/Beaches/Land disappearing (12)	Coastlines under water (4)	Coastal cities uninhabitable. (1)
Erosion (10)	Pop. near coast affected (2)	Threat to communities below sea level. (1)
Property loss (6)	Communities will need to relocate. (2)	Longer planting seasons. (1)
	Land "sinks" (not subsidence) (2)	Negative impact on farmland/plants. (1)

Research Design



Conditional SLR Learning Progression

Mechanisms of Sea Level Rise

	Level 1 (Lower Anchor)	**Level 2**	**Level 3**	**Level 4** (Upper Anchor)
Potential SLR LP indicator based on Gunckel, Covitt, Salinas & Anderson (2012, p. 854) "SM" stands for scale and mechanisms	SM1: Students explain sea level rise on a macroscopic scale only, focusing on immediately visible structures or phenomena without including mechanisms for phenomena.	SM2: Students explain sea level rise on a broad macroscopic to large-scale focus across familiar and visible dimensions. Students can identify a mechanism, though they rely on actors or agents.	SM3: Students explain sea level rise on the microscopic to the landscape scale, though they may refer to smaller particles such as atoms or molecules. Students are able to put events in order, but do not include driving forces or constraining factors.	SM4: Students explain sea level rise on the atomic-molecular scale. Students use driving forces (e.g. gravity), as well as constraining factors (e.g. topography) to explain changes in sea level.

Representations of Sea Level Rise

	Level 1 (Lower Anchor)	**Level 2**	**Level 3**	**Level 4** (Upper Anchor)
Potential SLR LP indicator based on Gunckel, Covitt, Salinas & Anderson (2012, p. 854) "R" stands for	R1: Students are able to obtain useful information from representations related to sea level rise, though they are not able to connect these	R2: Students are able to make limited connections between the physical world and representations related to sea level rise.	R3: Students are able to connect representations of sea level rise to the three-dimensional physical world, but do not infer driving forces or constraining	R4: Students are able to interpret driving forces and constraining factors related to sea level changes based on representations.

Causes of Sea Level Rise

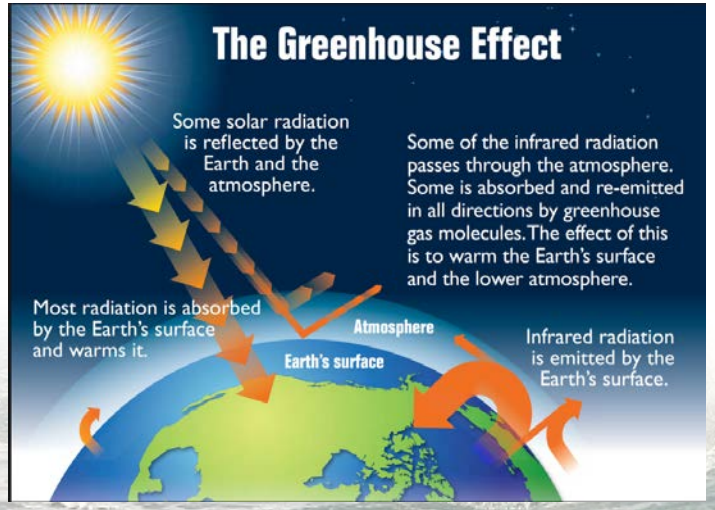
	Level 1 (Lower Anchor)	**Level 2**	**Level 3**	**Level 4** (Upper Anchor)
Potential SLR LP indicator about causes of sea level rise "C" stands for causes	C1: Students identify global warming due to the enhanced greenhouse effect as a cause of sea level rise.	C2: Students recognize that global warming causes sea level rise, but are not able to identify factors such as thermal expansion and ice melt (not distinguishing between terrestrial and see ice). Students are also able to identify a mechanism that relies on actors or agents.	C3: Students understand that sea level rise scenarios are based on thermal expansion and ice melt (not distinguishing between terrestrial and see ice), though they do not consistently relate these factors to atomic-molecular models.	C4: Students understand that sea level rise scenarios are based on thermal expansion and terrestrial ice melt, and they are able to explain these factors using atomic-molecular models consistently.

Impacts of Sea Level Rise

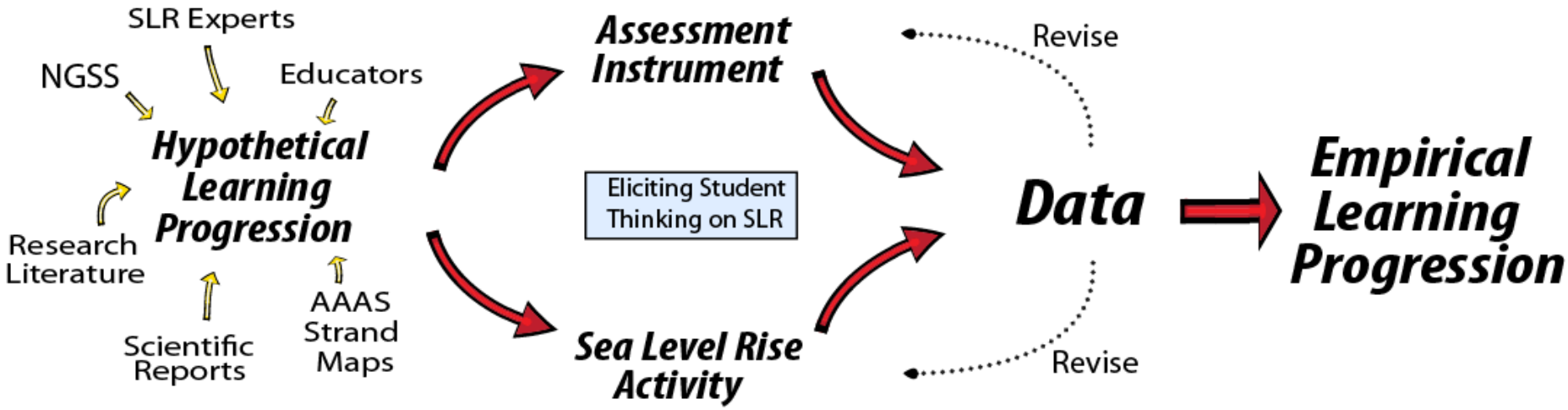
	Level 1 (Lower Anchor)	**Level 2**	**Level 3**	**Level 4** (Upper Anchor)
Potential SLR LP indicator about impacts of sea level rise "I" stands for impacts	I1: Students identify that an impact of sea level rise is that some land in coastal areas and islands will be underwater, though they are not able to elaborate on specific consequences of sea level rise.	I2: Students understand that sea level is projected to rise in the future and are able to identify a limited number of specific consequences, though they do not understand that sea level change will have local effects including those related to storm surge.	I3: Students understand that local impacts of sea level changes can differ, but cannot explain primary factors that can cause this difference. Students are able to elaborate on specific consequences of sea level rise such as loss of habitat, in-land flooding during storms, property loss, and erosion.	I4: Students understand that local sea level changes can differ from global trends based on regional variations in factors such as geographic uplift or subsidence and ocean currents. Students are able to elaborate on specific consequences of local sea level rise. Students recognize that sea level rise projections are based on available data and may be lower or higher than predicted.

SLR Alternative Conceptions

- **Significance of Scale** of sea level rise.
- **Timeframe** over which sea level rise takes place.
- **Role of Ozone**



Sea Level Rise Learning Progression



Next Steps: Collect further data and refine LP.

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