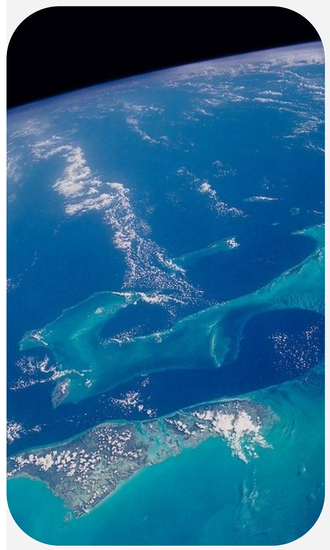
# Quantifying Economic Impacts of Sea Level Rise

**Nolan Chu** ncchu@ucsd.edu
**Desmond Vu** d6vu@ucsd.edu
**Ritvik Mohindru** rmohindru@ucsd.edu
**Mentor: Duncan Watson-Parris** dwatsonparris@ucsd.edu

Check out our Website!

UC San Diego
HALICIOĞLU DATA SCIENCE INSTITUTE

## Intro to Sea Level Rise: An Imminent Threat



**Process:**
1. Humans are emitting **greenhouse gases (GHGs)** into the air, causing **anthropogenic climate change**
2. One factor of climate change is **sea level rise (SLR)**
   - Thermal expansion of oceans
   - Melting of glaciers and ice sheets
3. This will cause threats and damage to coastal settlements and economy
- Predicted cost of **$1.2-6.9 trillion per year**
- **Billions of people** worldwide under SLR risk

**Facts:**
1. Too late to stop sea level rise (but can minimize it!)
   - Long timescale of response
   - Unavoidable for **100's to 1000's of yrs**
2. Increasing at a constant rate of **~4 mm/yr**
3. If the Antarctic ice sheet fully melts, seas will rise **~57 m**

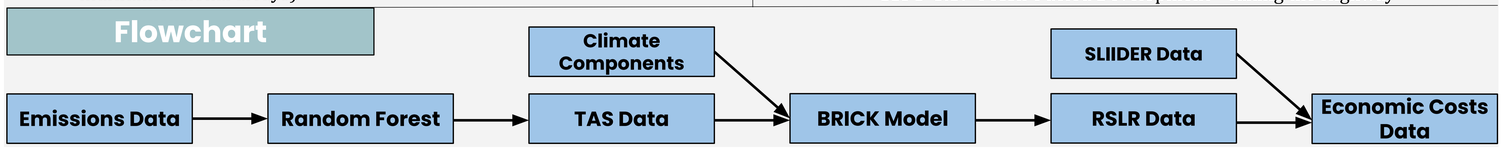
**What we did:**
1. Predict regional sea level rise by 2100 using BRICK framework
2. Project corresponding economic impacts via pyCIAM model

## Data & Methodology

**Models/Datasets:**
1. **Surface Air Temperature (TAS)** Data
   - Process: **Random Forest** model
   - Inputs: different historical emissions data (**$CO_2$**, **$CH_4$**, **$SO_2$**, **Black Carbon**)
   - Outputs: TAS data from **2015-2100**
2. **Regional Sea Level Rise (RSLR)** Data
   - Process: **BRICK** modeling framework.
   - Inputs: **TAS data** and various components that cause SLR
   - Output: RSLR indexed by **latitude**, **longitude**, and **year** from **2015-2100**
     - 1 **NetCDF** file per SSP (multidimensional arrays read by xarray library) and **5,508,000** data points per SSP
3. **Economic Costs** Data
   - Process: **pyCIAM** modeling framework
   - Inputs: **RSLR** data, **SLIIDERS** Dataset (accounts elevation, region, scenario)
   - Output: **Economic costs** for regions until **2100** in a **Zarr** file (stores multidimensional arrays)

**Frameworks:**
1. **BRICK Modeling Framework**
   - Breaks down global sea level rise into 4 components
   - Converts global SLR to regional SLR via sea level fingerprints
2. **PyCIAM Modeling Framework**
   - Outputs 6 cost categories which we summed up (capital, life, relocation, protection, inundated land, wetlands)
   - Simulations based on different adaptation scenarios and time periods
3. **Shared Socioeconomic Pathways (SSPs)**
   - Each represent different trajectory humans can take in regards to population growth, economic development, emissions, etc.
   - Models iterated over each SSP we used below
     - **SSP1-2.6**: "Sustainability - Taking the Green Road"
     - **SSP2-4.5**: "Middle of the Road" - Current Path
     - **SSP3-7.0**: "Regional Rivalry - A Rocky Road"
     - **SSP5-8.5**: "Fossil-Fueled Development - Taking the Highway"

### Flowchart

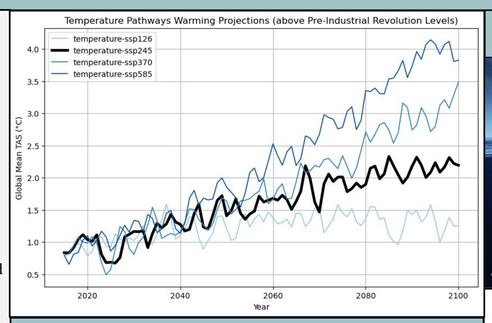



## Results & Visualizations

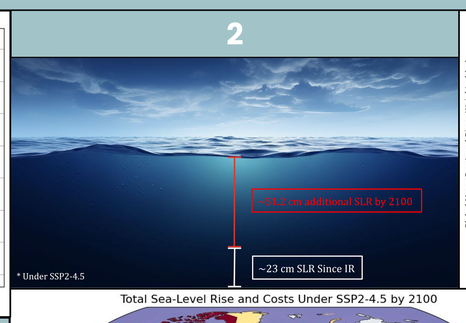
**Metrics:** 1. **TAS** 2. **RSLR** 3. **Costs**
**Key Variables**
1. **SSPs**
2. **Adaptation** (Ex. "Protect10")
   - Retreat from or protect coast
   - Years of action

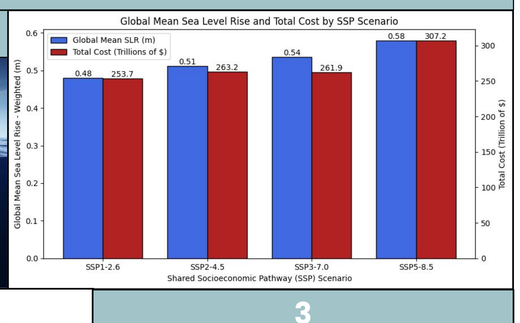
**Graphs**
1. **Line plot** of TAS for SSPs (2015-2100)
2. **Visual of SLR** under SSP2-4.5
3. **Barplot** of total global weighted mean SLR and Ccsts under different SSPs by 2100
4. **Choropleth Graph** of total SLR and costs under SSP2-4.5 by 2100
5. **Table** of min, max, and mean annual SLR and costs for Florida from 2015-2100 for the worst-case (case = "retreat10", SSP5-8.5) & optimal (case = "optimalfixed", SSP1-2.6) scenarios, also shows total SLR and costs

1

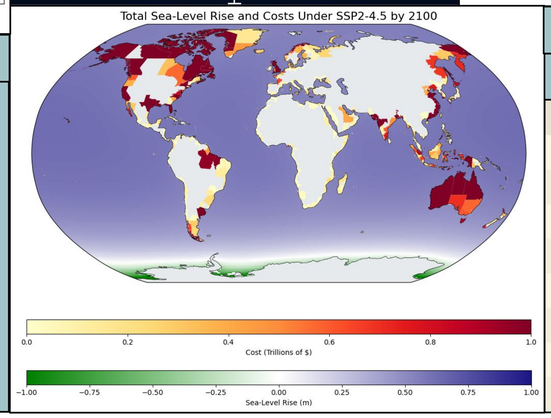



2




3




4

**Key Takeaways**
1. TAS predicted to increase **2.2°C** from pre-industrial revolution (IR) levels by 2100
2. Global Mean SLR (weighted average) predicted to increase additional **½ meter** if current trends in human emissions continue, has already increased > **20 cm** since IR
3. Over **$300 trillion** in total costs predicted if humans increase emissions to the SSP5-8.5 scenario.
   **Anomaly**: total costs under SSP3-7.0 lower than SSP2-4.5
4. **High impact Areas**: Canada, US, Oceania, southeast Asia, China, India, and eastern South America
   **Anomaly**: sea levels are decreasing near Antarctica rather than increasing everywhere else
5. Florida, a area vulnerable to SLR, has significantly higher annual SLR and Costs in the worst-case scenario than the optimal scenario for SLR
   This underscores the **variable outcomes** of SLR and its economic impacts based on human emissions and adaptation

5

| | SSP126 | SSP585 |
|---|---|---|
| Min SLR (mm/yr) | 5.737669 | 6.013827 |
| Max SLR (mm/yr) | 6.979601 | 9.813347 |
| Mean SLR (mm/yr) | 6.346524 | 7.639689 |
| Total SLR (m) | 0.539455 | 0.649374 |
| Min Cost ($B/yr) | 1.526183 | 1.240015 |
| Max Cost ($B/yr) | 24.949074 | 194.725970 |
| Mean Cost ($B/yr) | 9.365833 | 68.229912 |
| Total Cost ($T) | 0.805462 | 5.867773 |

## Implications & Future Steps

**Implications of Results**
- Development of issues in our lifetime
  - Sea level projected to rise
  - Major coastal cities and islands **underwater**
  - **Trillions of dollars** in economic damages

**Taking Action**
1. Reducing Carbon Footprint
   - **Carbon Footprint**: total amount of GHGs emitted by person
2. Electing Policymakers supporting cause against climate change
   - 2015 **Paris Climate Agreement**: 194 nations aim to limit global warming to **< 2°C** since pre IR levels
3. Spreading the Word
   - **More people** with knowledge about SLR and how to combat it

**Conclusion**

Global warming is causing sea level rise which will impact billions of people and cost trillions of dollars. We can minimize damage through reduced emissions. It's our responsibility to fix mistakes and provide a sustainable world for future generations