Despacito

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Motivation

Venice ‘on its knees’ after second-worst flood ever recorded
VENICE, Italy (AP) — The worst flooding in Venice in more than 50 years prompted calls Wednesday to better protect the historic city from rising sea levels as officials calculated hundreds of millions of euros in damage.

Chilling reality of Arctic ice melt
Antarctica’s ice shelves have 40% since 1997 according to a comprehensive new study of the region and researchers say global warming is a likely cause. (October 12).

Seas have drastically risen along southern U.S. coast in past decade
Multiple new studies highlight a rate of sea level rise that is ‘unprecedented in at least 120 years’ along the Gulf of Mexico and southeastern U.S. coast.

Study: Rising sea levels
SEATTLE (AP) — A climate change study shows that sinking US cities increase the risk of flooding from rising seas.

Subsidence linked to extraction of gas and weight of buildings pressuring the ground.
Motivation

Challenges:

• Sea level is increasing at an alarming rate.
• Coastal areas are particularly vulnerable to the impacts of Sea Level Rise (SLR).
• Prediction of SLR and its impact is becoming crucial.

Gap:

• The probability of extreme scenarios like rapid Antarctic ice sheet loss is currently unknown, making it difficult to account for in projections.[1][2]
• There is a lack of consistent methodologies for projecting sea level rise at local scales, which is critical for risk assessment and adaptation planning.[4][5]
• The unpredictability of human behavior controlling these trends poses a challenge for modeling.[4][5]

Opportunity:

• Data-driven models to determine the global/local trend in SLR and its threat.
Global Sea Level Rise

- The trend line reveals a steady increase in global sea levels over three decades, underscoring climate change’s growing impact.
- The U.S. Mainland faces a greater-than-average sea level rise, indicating an increased risk and urgency for protective action.
US Sea Level Analysis

Average Absolute Dynamic Topography (ADT) increased by 10 cm over 30 years
Potential Causes of Sea Level Rise

Global Warming

Glacier Melting
Global Temperature

Temperature increased 0.5 – 2.5 °F over 20 years
US Temperature – Spatial Analysis

Temperature increased 6.74 °F in Arizona
Impacts of Glacier melting

**Hypothesis:** The ongoing melting of glaciers worldwide is causing a significant rise in sea levels across U.S. coastal regions.

The cumulative loss of glacier mass is accelerating, following the equation:

\[
\text{Cumulative Loss} = -8.73y^2 + 3.5 \times 10^4y - 3.46 \times 10^7 \text{ Gt}
\]

Where \( y \) is the number of years.

Since 2021, more than 1000 Gigatons of glacier ice have melted = \( 1 \times 10^{15} \) Liters of extra ocean water.

To put that into perspective, since 2021, the projected SLR* will vary regionally:
- North Atlantic: 10.49 mm rise
- North Pacific: 12.17 mm rise
- Gulf of Mexico: 15.49 mm rise

* The analysis will be discussed in detail in the next slides
Modeling and Analysis of US SLR

Preparing the model:

- We divided the US sea regions into three parts: North Atlantic, North Pacific, and Gulf of Mexico.
- Analysis was performed and the model was created separately for different US sea regions.
- Savitzky-Golay filtering, often abbreviated as SavGol filtering, was used for smoothing and removing noise from data.
- A sinusoid + linear regression model was used to curve-fit the filtered data.
- The model was then extended to make future predictions.

North Atlantic Projection Model

\[ S = -49.34 \sin(6.27y + 2.5) + 3.25y - 6504 \]

\( y \): # years, \( S \): Estimated Sea Level (mm)
Modeling and Analysis of US SLR (cont.)

Projected Impacts:

- 10-14 inches (0.25-0.36 meters) rise over the next 30 years.
- Up to 4.9 feet (1.5 meters) rise by 2100 under higher emissions.
- Millions of residents and infrastructure at risk of:
  - Flooding from high tides and storm surges
  - Permanent inundation of low-lying areas

Key Takeaways:

- Growing concerns about coastal impacts and ecosystem effects.
- Implications for resettlement and adaptation strategies.
- LSTM neural networks did not accurately model historical trends.
Time-series analysis

- Copernicus dataset from Jun 2018 to Jun 2023
- Latitude-longitude time-series are noisy, and have different behavior (mean/standard deviation)
- Savitzky-Golay (Low pass) filter is used to denoise time-series

- Denoised time-series show a seasonal trend in the boxplot for each month
- The seasonal trend still shows outliers, thus, further analysis is needed
Time-series analysis

- Our analysis focus on the East-coast
- The mean and standard deviation of each time-series show that a segmentation is suitable
- Coast regions have less SLR mean
- Large values of standard deviation are located in the intersection of the Gulf Stream and Labrador ocean currents
Clustering analysis on time-series

- Principal Component Analysis (PCA) is performed on each time-series
- Clustering analysis is performed using the 3 PCA components and K-means algorithm
- The segmentation defines regions of interest on the East area
- We select clusters in the coast to perform further analysis
Clustering analysis on time-series (cont.)

- Each cluster defines sub-regions of interest along the East Coast
- Cluster 6 and 0 are candidates for larger SLR, with potential impact in these sub-regions
- Cluster 2 is stable among clusters, because less variations in the time series
- Building models for each cluster might reveal more information
• Climate change is spurring sea level rise, threatening coastal floods and erosion, with significant risks of displacement and economic impact.
• Affluent U.S. East Coast counties are particularly at risk from sea level rise, posing economic and demographic challenges.
At-Risk Coastal Zones

- Red zones on the map identify low-lying coastal areas, vulnerable to sea level rise.
- Highlighted regions along the U.S. East and Gulf Coasts face immediate submersion risks.
- This map guides urgent action for vulnerable communities and ecosystems.
Global Marshlands & Wetlands at Risk of Submergence

- Map shows at-risk global marshlands/wetlands from sea level rise; darker colors mark greater risk.
- Data underlines the need for strategic environmental planning and urgent conservation.
- The map aids policy-making to protect climate-threatened ecosystems.
Conclusions & Future Works

Conclusion:
• Clear evidence of accelerated sea level rise due to global warming and ice melting
  • $3.45 \times 10^{16}$ tones of ice mass lost by 2024
  • 0.15m rise in global sea levels
• Disproportionate impact on US coastal cities at heightened flood risk
• Urgent need for mitigation and adaptation strategies highlighted

Future Work:
• Develop localized ADT prediction models for each cluster
• Account for coastal morphology changes
• Incorporate human-induced subsidence patterns
• Model impacts of extreme weather events
• Aiming for a research publication

The Time to Act is Now!
Thank you!

https://tamids24-slr.streamlit.app/
References

[1] https://www.nature.com/articles/s41612-020-0121-5
Potential Causes of Sea Level Rise

*Hypothesis:*
- Global temperature increase is one of the major causes of SLR.
- Glacier Melting is also causing SLR.