Project Topic: Estimating Mangrove Response to Cold Snaps

Abstract

Global warming associated with climate change is linked with altered distribution and abundance of species and ecosystems worldwide. However, the ecological impacts of changes in the frequency of extreme events have not been as well documented, especially for coastal and marine environments (Cavanaugh et al., 2014a). Under global warming, mangrove forests will undergo significant alteration in their distribution patterns. Several studies also show that the main drivers of this projected shift and alterations are attributed to changes in precipitation, air temperature, and suitable periods of soil inundation associated with sea level variations (Friess et al., 2022a). Understanding the potential impacts of these drivers is essential for predicting changes in long term global mangrove ecosystem status.

Here we assess and estimate the impact of extreme freezing events on the distribution and abundance of mangroves under different climate change and future scenarios ("moderate emissions": SSP2-4.5 and "high emissions": SSP3-7.0) and SRM scenarios (ARISE SAI; Richter et al., 2022) using the NSF supported Community Earth System Model v. 2 (CESM2; Danabasoglu et al., 2020).

Background / Introduction

Mangroves, seagrass, and saltmarshes provide high capture and storage rates of organic carbon, and these coastal ecosystems are therefore termed as "blue carbon" ecosystems (Chatting et al., 2022). These ecosystems occupy a relatively limited spatial area of approximately 0.2% of the Earth's surface but are major sinks of organic carbon (Chatting et al., 2022). Amongst these ecosystems, mangroves have particularly gained recognition due to the ability to store and sequester relatively high amounts of carbon in both biomass and soils, storing up to five times as much organic carbon as tropical forests (Friess et al., 2022)**.** In a recent study, it was estimated that the tree and sediment of mangrove forests along the world's coastlines hold ~ 3 billion metric tons of carbon - more than tropical forests (Friess et al., 2022).Understanding the changes in mangroves extent has become increasingly significant due to this carbon storage and sequestration capacity.

Mangrove ecosystems are critical to biodiversity and provide vital ecosystem services, including serving as nursing grounds for fishes, coastal protection and carbon sequestration.

However, mangrove distribution is largely restricted to tropical and subtropical regions due to their sensitivity to freezing temperatures. With rising global temperatures driven by climate change, there is increasing potential for mangroves to expand their range. Studies, such as those

by Gouvêa et al., 2022 and Cavanaugh et al., 2014, suggest that the expansion of mangroves correspond to the frequency of cold events in these regions, with certain temperature thresholds serving as ecological limits for mangrove survival and growth. This project aims to explore the relationship between cold snaps and mangrove distribution.

Research Questions

1. How do variations in coastal cold snap frequency and intensity influence mangrove distribution under different climate scenarios (SSP2-4.5, SSP3-7.0, and SRM scenarios)?
2. What are the projected impacts of extreme freezing events on mangrove survival rates in current and potential future mangrove habitats, and how might these events reshape mangrove distribution in tropical and subtropical coastal areas?

Method

1. **Identify critical temperature-related ecological thresholds** for mangrove survival and growth reviewing key ecological and climate literature.
2. **Analyze temporal changes in coastal temperatures** using historical and future climate model projections, focusing on regions where mangroves currently exist or may potentially expand.
3. **Estimate mangrove presence or absence** under different temperature scenarios, based on established thresholds, to predict potential shifts in mangrove distribution under changing temperature conditions.

The primary programming tool to be used in this study will be python.

By integrating ecological thresholds with climate model data, this project seeks to contribute to our understanding of how climate change may influence the future distribution of mangroves, particularly in regions that are currently constrained by cold temperature events.

Timeline

Task	Week 1	Week 2	Week 3	Week 4
Data extraction and exploration				
Masking, Interpolation, Cold snaps, and freezing durations				
Data analysis				
Report writing				

Figures

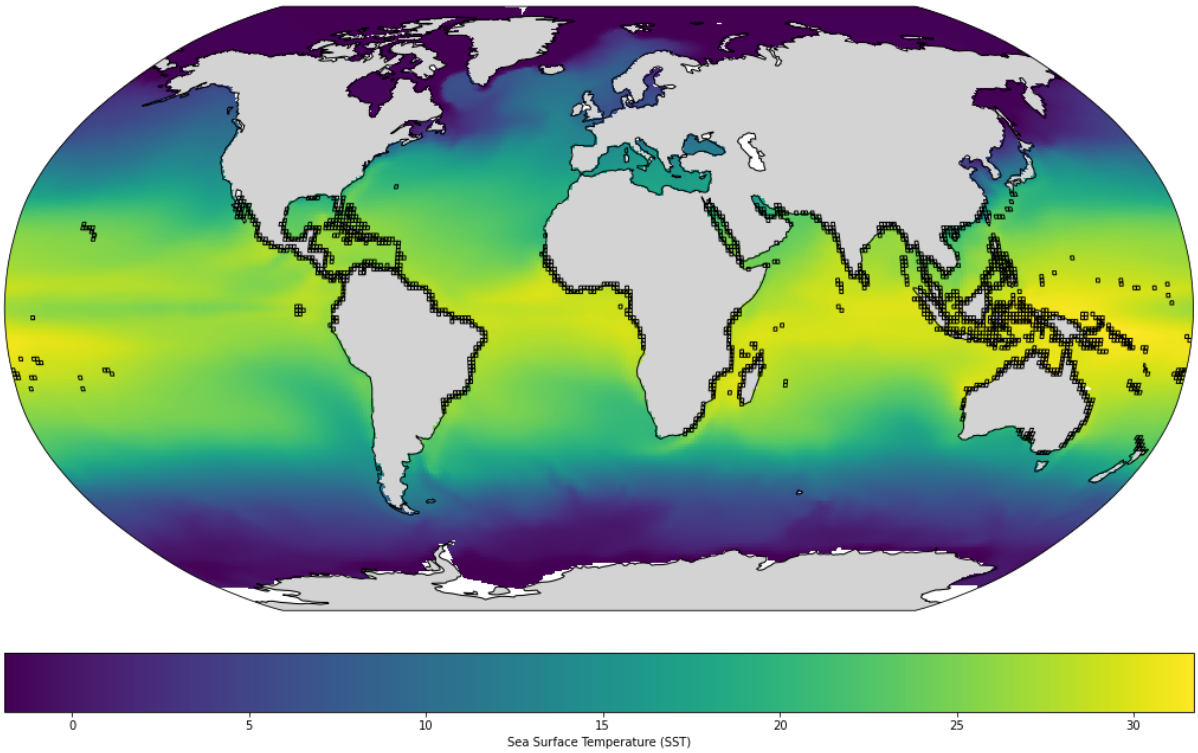

Figure 1: Map of current mangrove regions on the CESM model grid. Mangrove regions are from Global Mangrove Watch (Bunting et al. 2022).

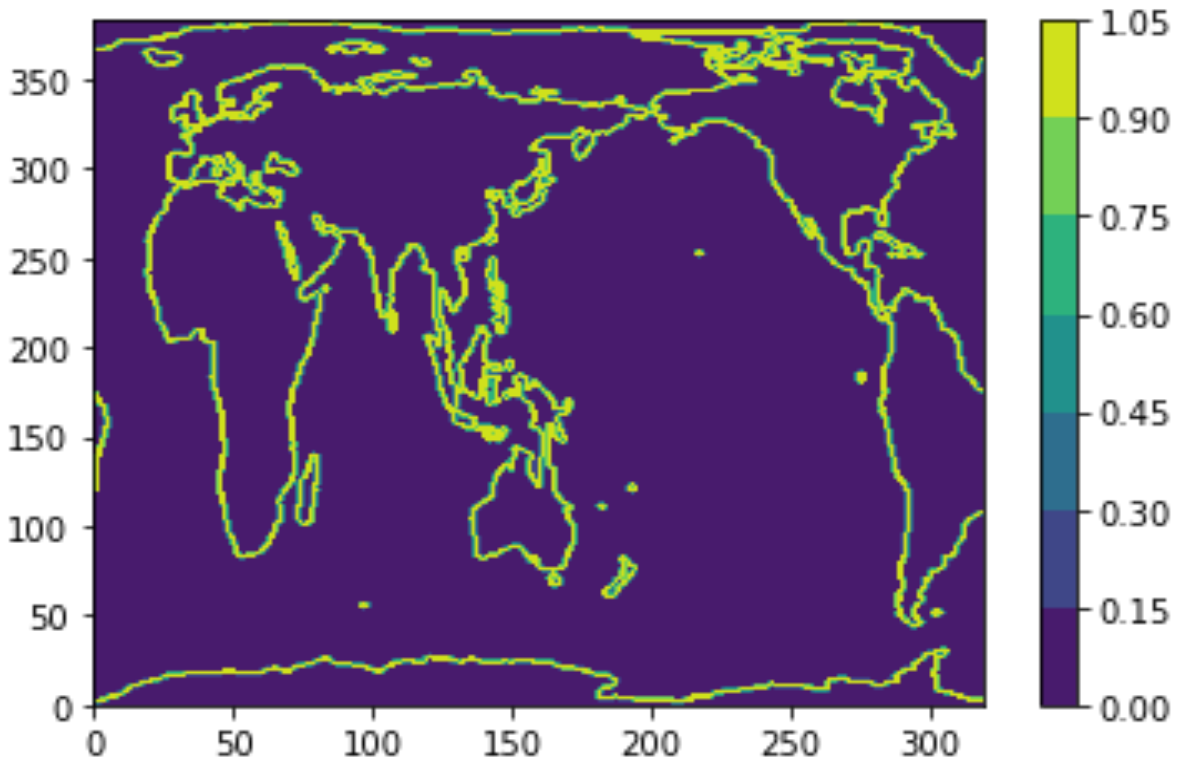

Figure 2: Global Coastal Mask

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