Large-scale sea level changes and coastal inundation

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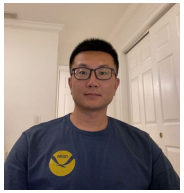
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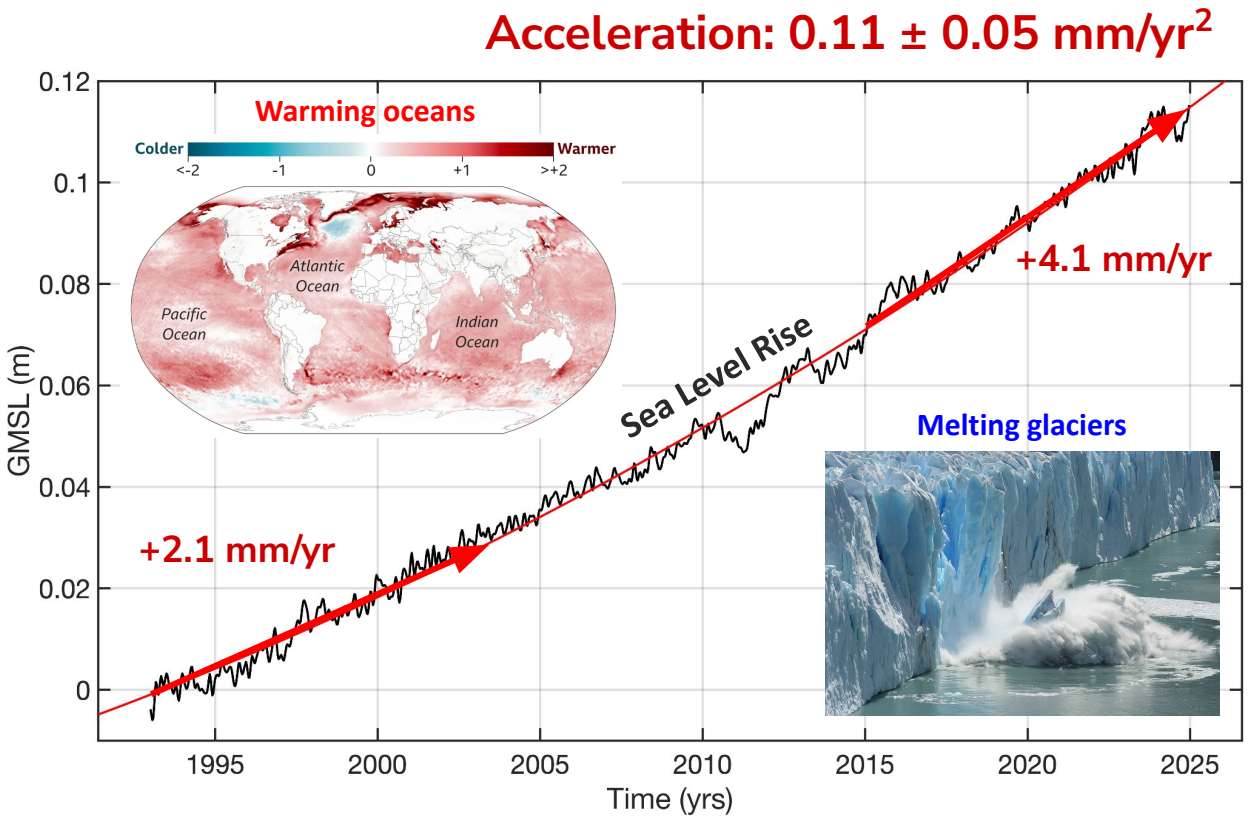
Kandaga Pujiana


Dongmin Kim


Sang-Ki Lee


Fabian Gomez

Global Mean Sea Level

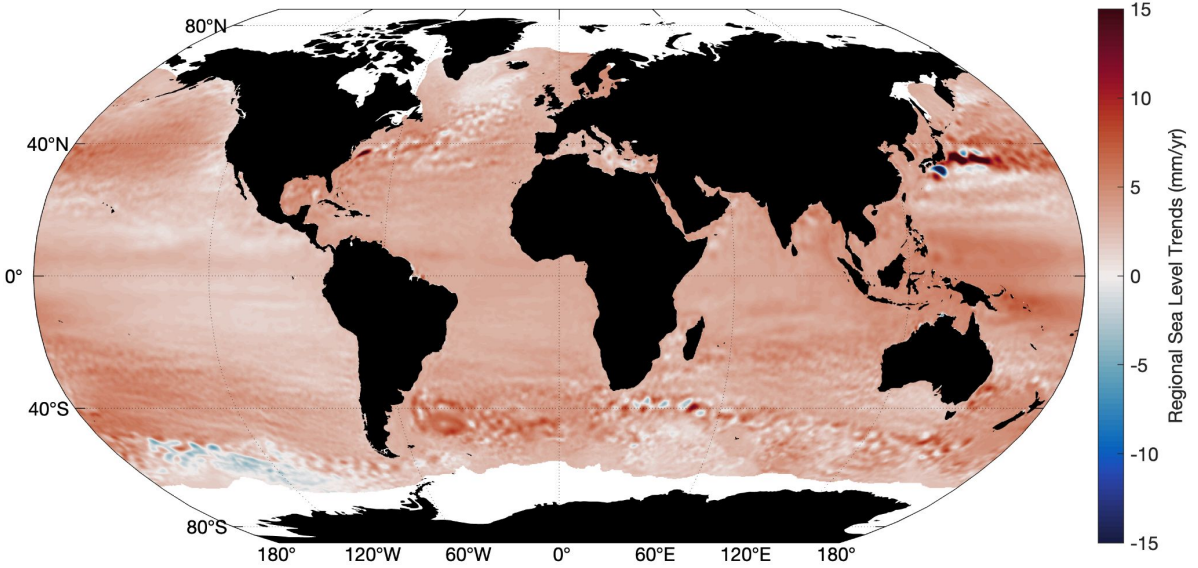


As the ocean is warming and terrestrial glaciers and ice sheets are melting, the Global Mean Sea Level (GMSL) rise is accelerating, with a present rate of 4.1 mm/yr.

Regional Sea Level Changes

Ocean and atmosphere dynamics make sea level changes **spatially non-uniform**.

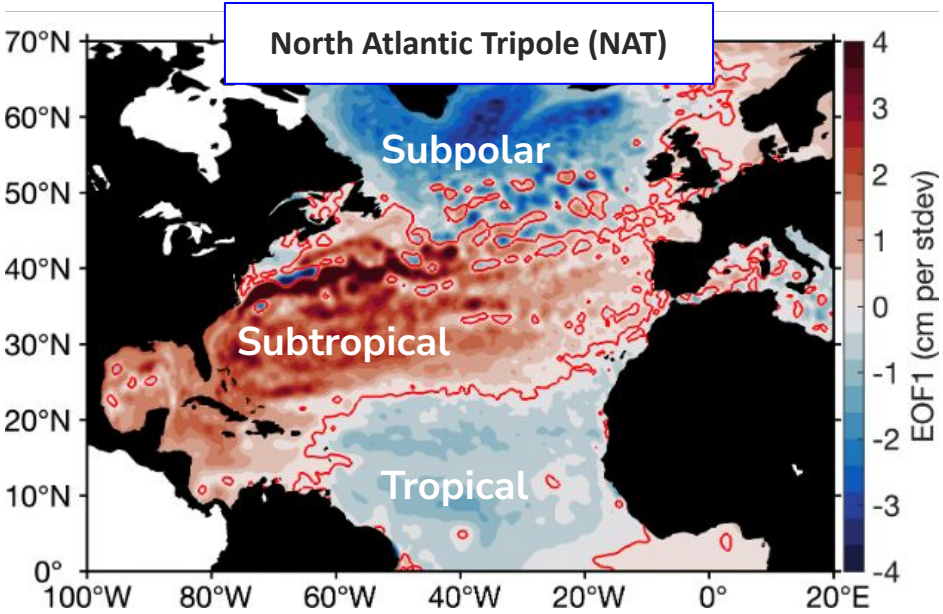
Coastal communities are mainly concerned with regional sea level changes and coastal inundation.

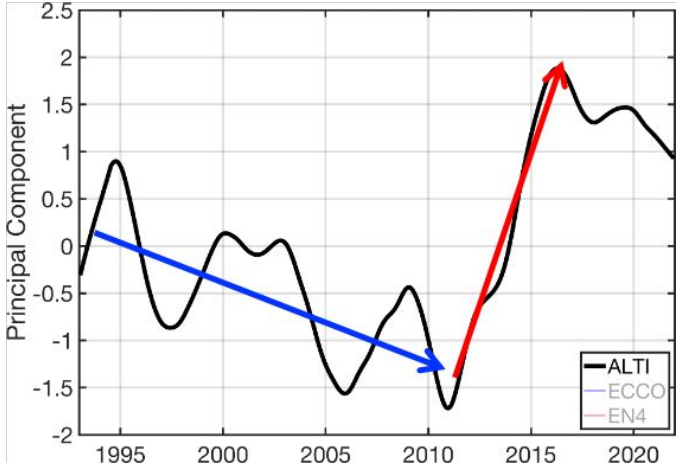


Our Goal:

To investigate large-scale dynamic (not related to GMSL rise) and coastal sea level changes in the North Atlantic, explore how these changes relate to Atlantic Meridional Overturning Circulation (AMOC) , and how they affect coastal inundation → improve sea level predictions

Dynamic Sea Level Changes in the North Atlantic





Dynamic interannual sea level changes in the North Atlantic are characterized by a tripole pattern, showing a general **decrease of sea level in 1993-2010** and a **rapid increase in 2011-2015** in the subtropical band and vice versa in the tropical and subpolar bands.

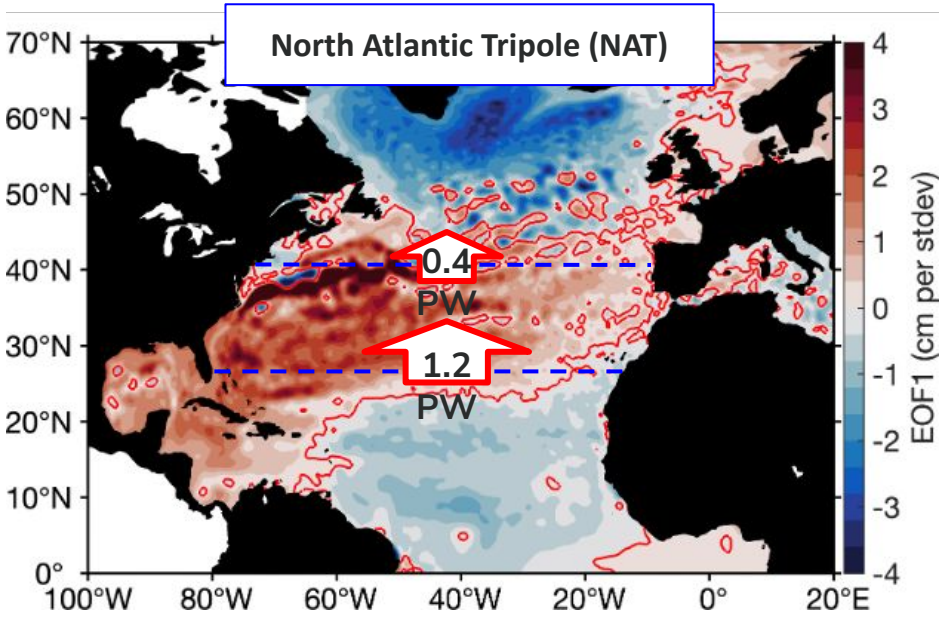
Volkov et al., 2019, 2022
Pujiana et al., 2024

Forcing Mechanisms

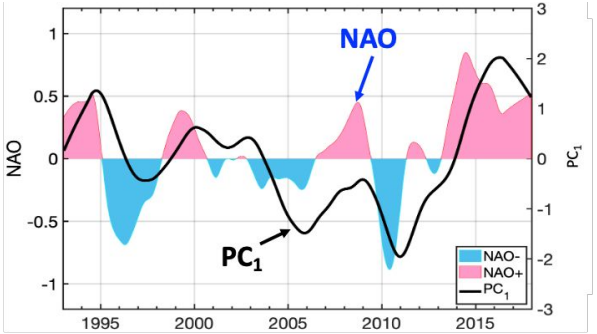
The tripole-related heat content and sea level changes are driven by:

⏩ Winds, associated with North Atlantic Oscillation (NAO)

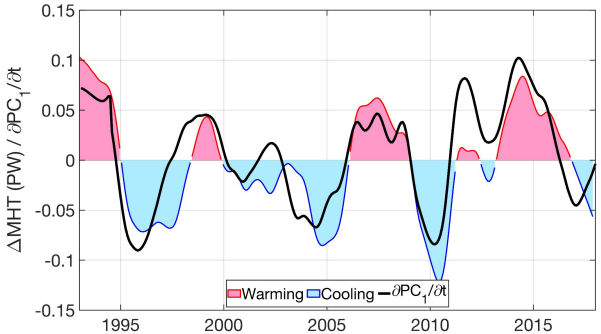
⏩ Meridional heat transport (MHT) divergence, associated with the AMOC.



NAT vs NAO

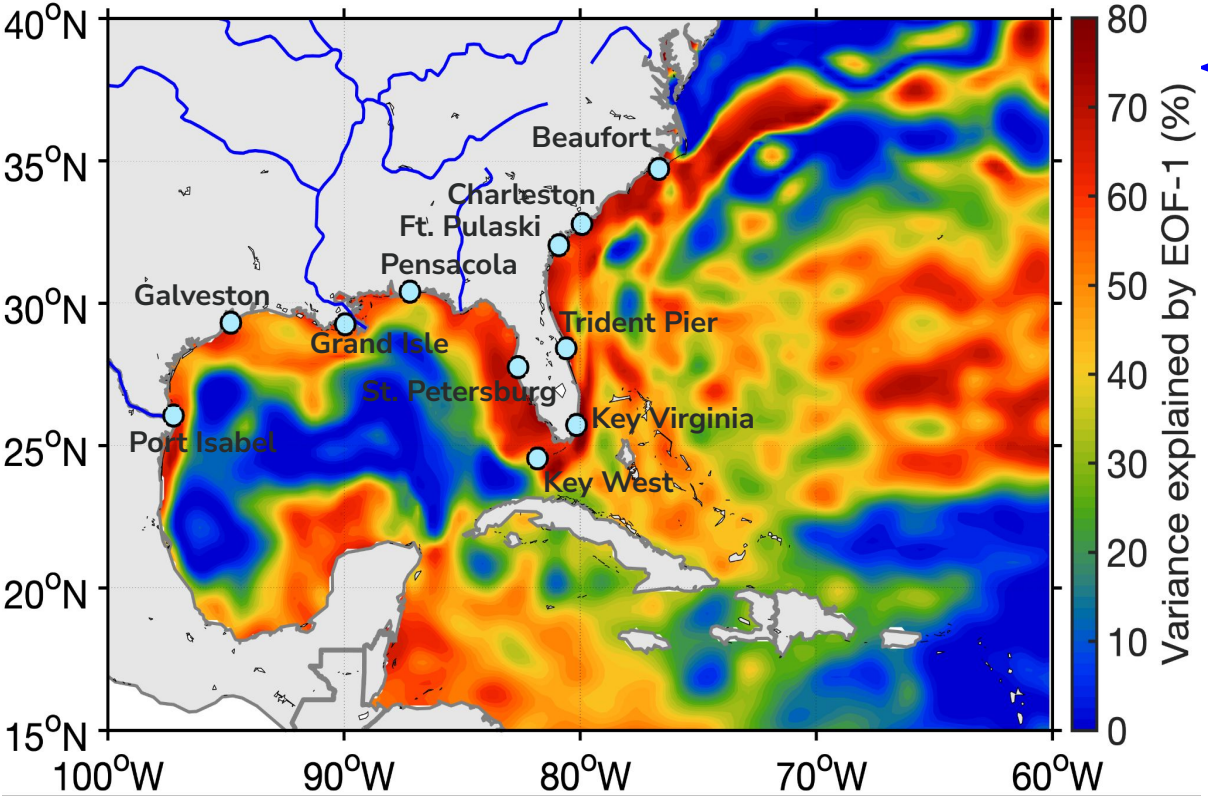


NAT vs MHT divergence



Volkov et al., 2019, 2023

Relation to coastal sea level

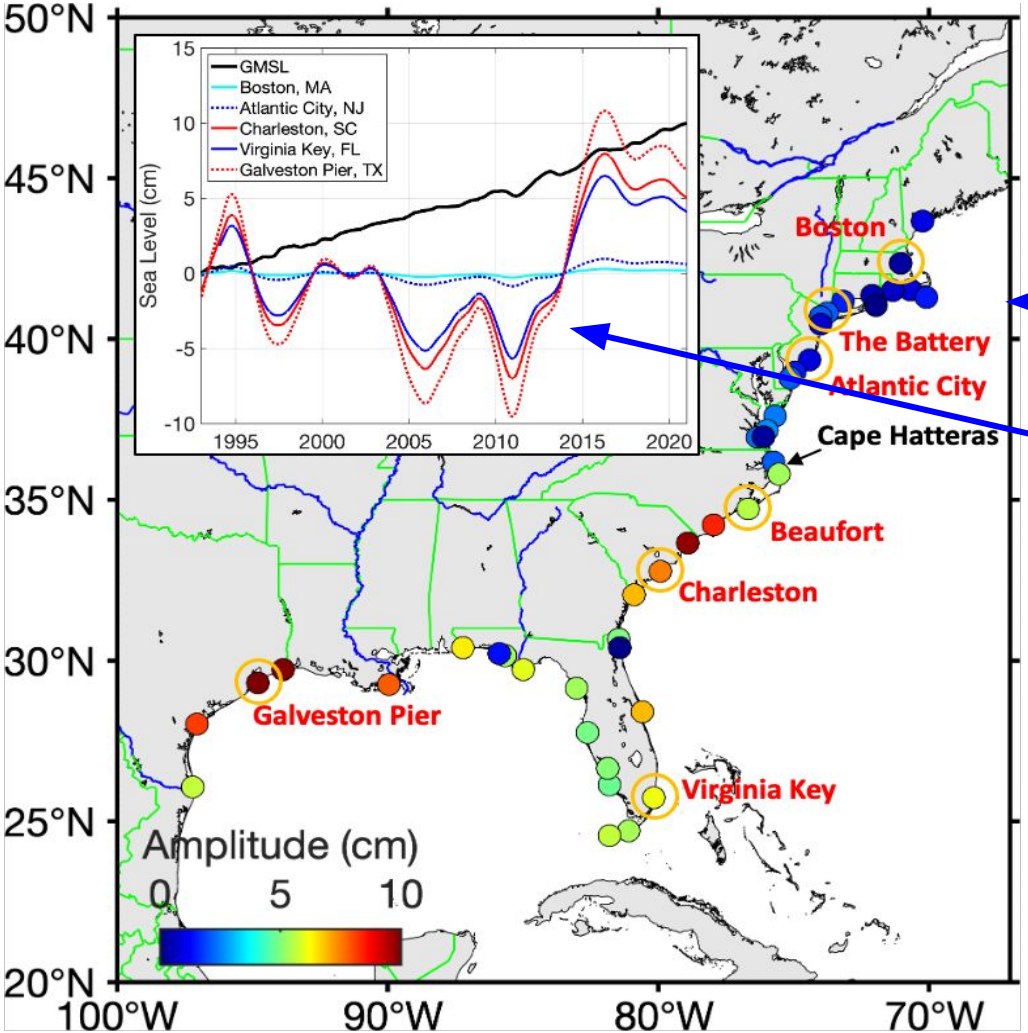


Portion of the interannual sea level variance explained by the North Atlantic Tripole

The North Atlantic Tripole explains 60-80% of the interannual sea level variance along the U.S. southeast coast.

Volkov et al., 2019

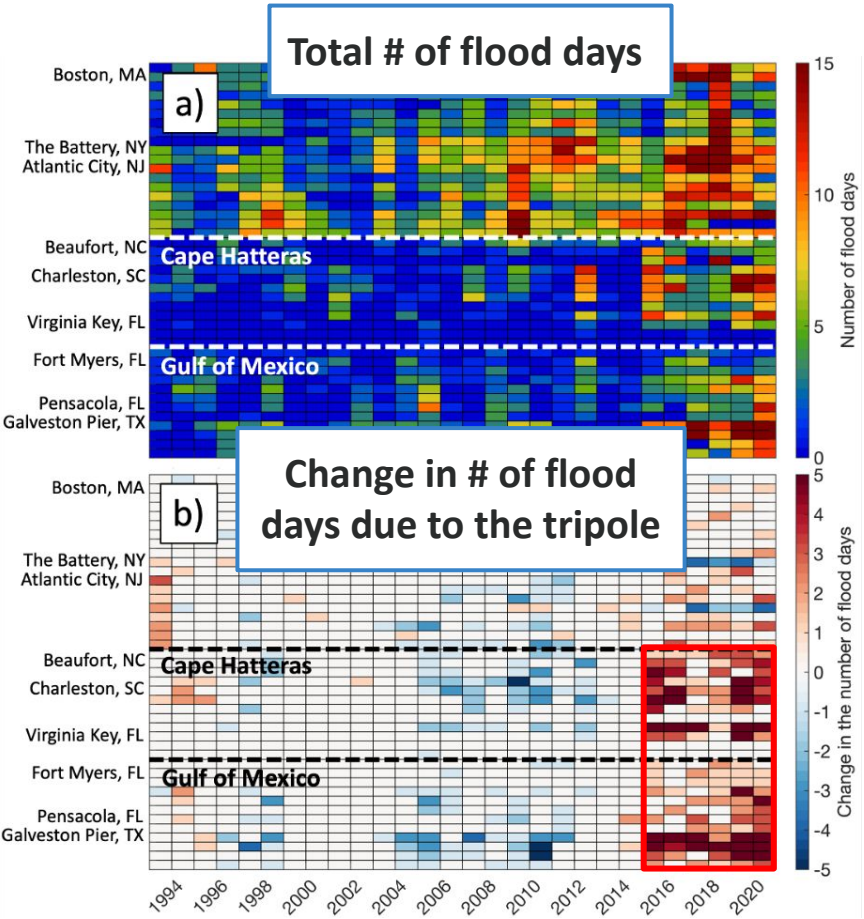
Relation to coastal sea level



Amplitudes of the tripole-related sea level changes at the U.S. tide gauges

The **tripole variability** and **GMSL rise** equally provide background conditions for high-frequency and large-amplitude processes (e.g., storm surges) leading to coastal inundation.

Volkov et al., 2023



Volkov et al., 2023

nature communications

Article

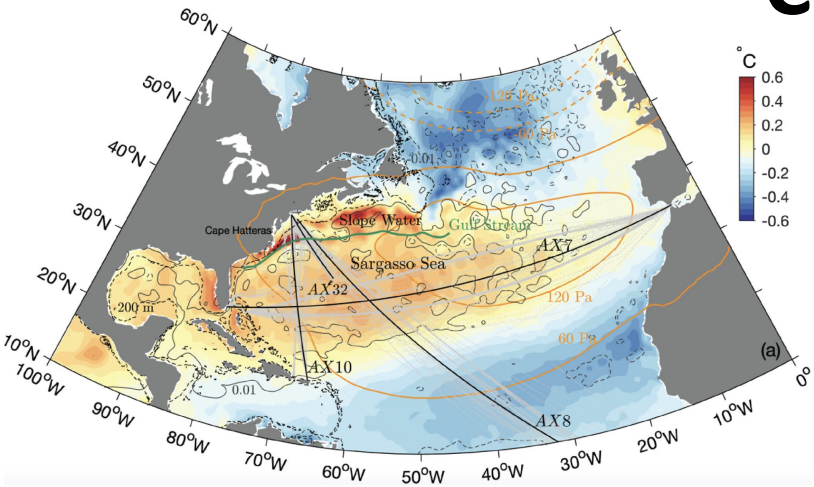
https://doi.org/10.1038/s41467-023-40848-z

Atlantic meridional overturning circulation increases flood risk along the United States southeast coast

The rapid tripole-related warming of the subtropical gyre in 2011-2015 was responsible for 30-50% of flood days south of Cape Hatteras in 2015-2020.

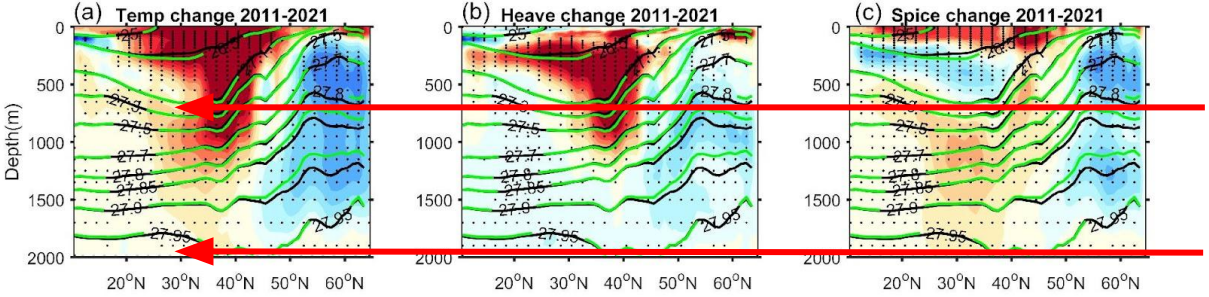
Hurricane Irma sends a storm surge crashing over a seawall at the mouth of the Miami River in Florida.
Credits: NPR.

Current and future research



Pujiana et al., 2024

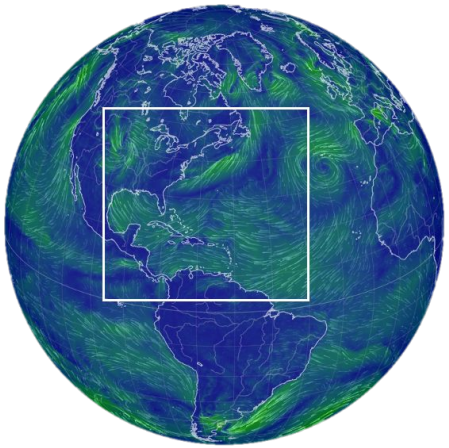
- Exploring the vertical structure of the North Atlantic Tripole in the subtropical gyre using XBT and Argo observations.
- Investigating the mechanisms of the subtropical gyre warming since 2010.



Huang et al., submitted.

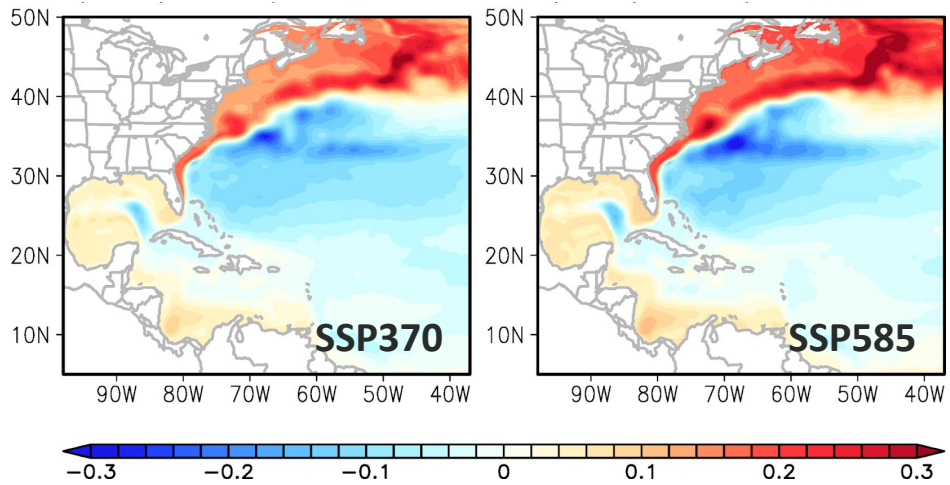
The mid-depth ocean (700-2000 m) contributed 40% of warming.

Current and future research



- Dynamical downscaling of CMIP6 models for the Northwest Atlantic using a high-resolution MOM6

SSH: Future - Historical



Goal: To investigate the potential increase of sea level along the United States east coast under different emission scenarios and the states of the AMOC.

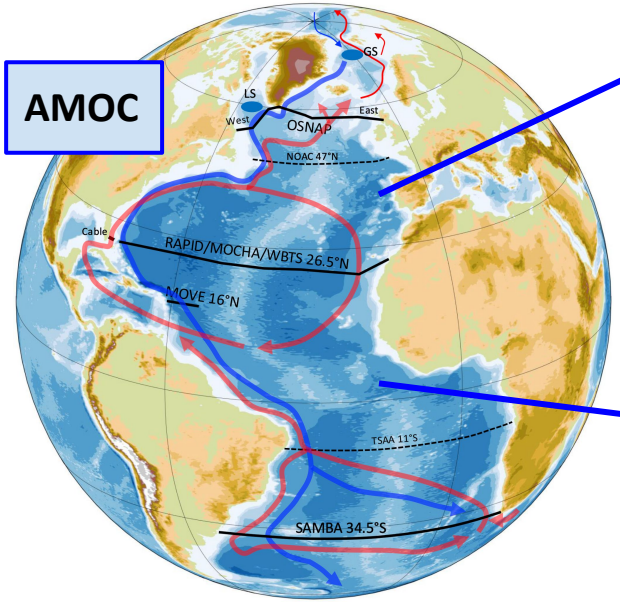
Kim et al., 2024

Future strategy

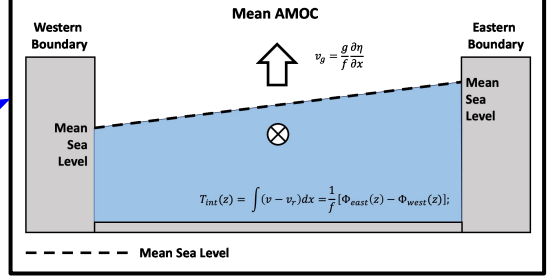
Goal: Investigate how changes in the AMOC on decadal-centennial time scales impact sea level.

2025 → 2030

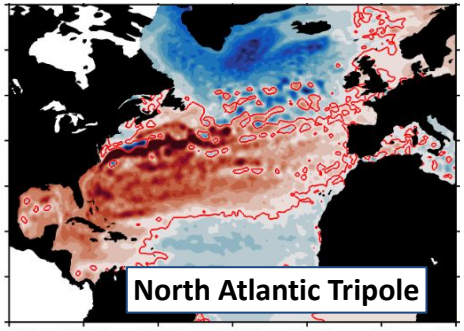
AMOC



Direct Mechanism



Indirect Mechanism



Transitions

Improved sea level predictions/ projections

Work with NOS, local authorities

Flood risk assessment

Collaborators

Jet Propulsion Laboratory
California Institute of Technology

Ocean Surface Topography Science Team
(NASA, NOAA, ESA, CNES)

UNIVERSITY OF MIAMI
COOPERATIVE INSTITUTE
for MARINE & ATMOSPHERIC
STUDIES

NORTHERN GULF INSTITUTE
a NOAA cooperative institute

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