Reconstructing Florida Current Transport from Paleo Data

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Acknowledgements

- NOAA Atlantic Oceanographic and Meteorological Laboratory (AOML)
- Cooperative Institute for Marine and Atmospheric Studies (CIMAS), University of Miami Rosenstiel School of Marine, Atmospheric, and Earth Science
- Mentors: Dr. Marlos Goes and Dr. Denis Volkov

Background

The **Florida Current** is a strong ocean current that originates in the Gulf of America and flows along the east coast of Florida through the Florida Straits, into the open North Atlantic Ocean, where the flow becomes the Gulf Stream.

The current carries heat and salt northward in the subtropical North Atlantic and is a major contributor to the northward flow of the upper limb of the AMOC

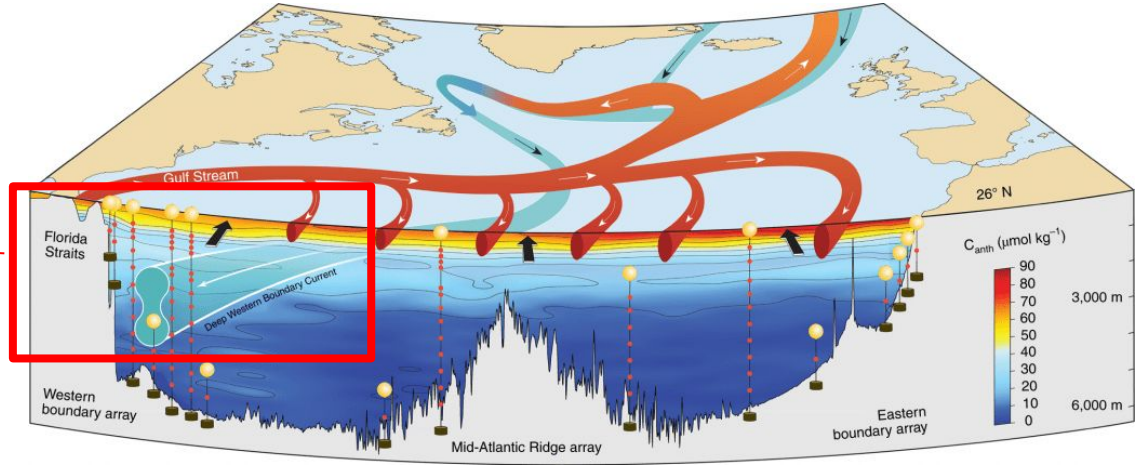


Figure: Schematic of the RAPID/MOCHA/WBTS Array in relation to meridional overturning circulation pattern. Image credit: University of Miami

Motivation

Sport Culture Lifestyle The Guardian US

e crisis Middle East Ukraine US immigration Soccer Business Environment Tech Science Newsletters Wellness

This article is more than 1 year old

Gulf Stream could collapse as early as 2025, study suggests

A collapse would bring catastrophic climate impacts but scientists disagree over the new analysis

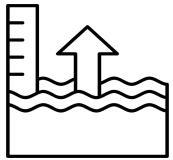
Amoc carries warm ocean water northwards towards the pole where it cools and sinks, driving the Atlantic's currents. Photograph: Henrik Egede-Lassen/Zoomedia/PA

> "The Gulf Stream system could collapse as soon as 2025, a new study suggests. The shutting down of the vital ocean currents, called the Atlantic Meridional Overturning Circulation (AMOC) by scientists, would bring catastrophic climate impacts."

Impacts:

Weather & Climate

Sea Levels



Ecosystems

Research Goal and Objectives

Goal

Reconstruct the strength (transport) of the Florida Current over the past 10,000 years using paleo data.

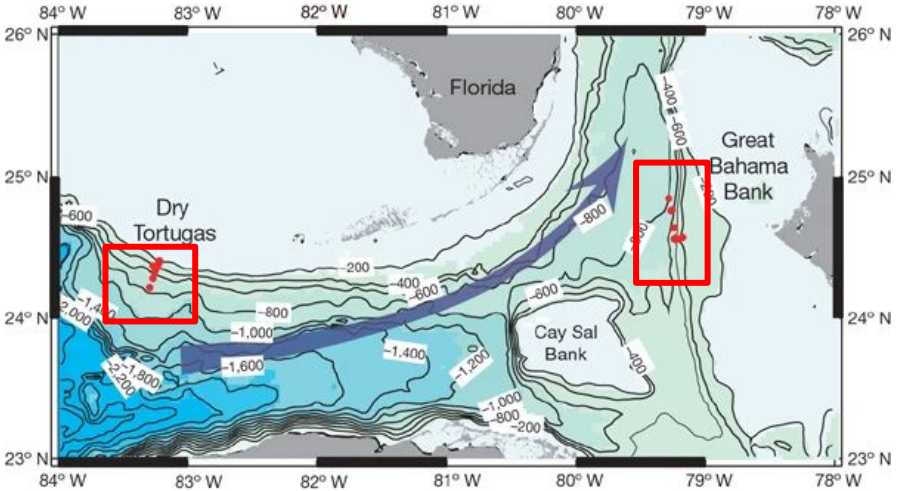


Figure: Location of sediment core samples (Lund et al., 2006)

Objectives

1. Calibrate seawater properties with direct transport measurements.
2. Estimate Florida Current velocity using oxygen isotope profiles preserved in marine carbonates (foraminifera).

Data and Methods

Modern

- CTD profiles (oxygen, temperature, salinity, density.)
- ADCP measurements (transport)
- Cable Transport Data
- GLORYS reanalysis

Paleo proxies offer a unique opportunity to infer Florida Current transport in the past.

Measurements with submarine cables and ship sections started in 1982.

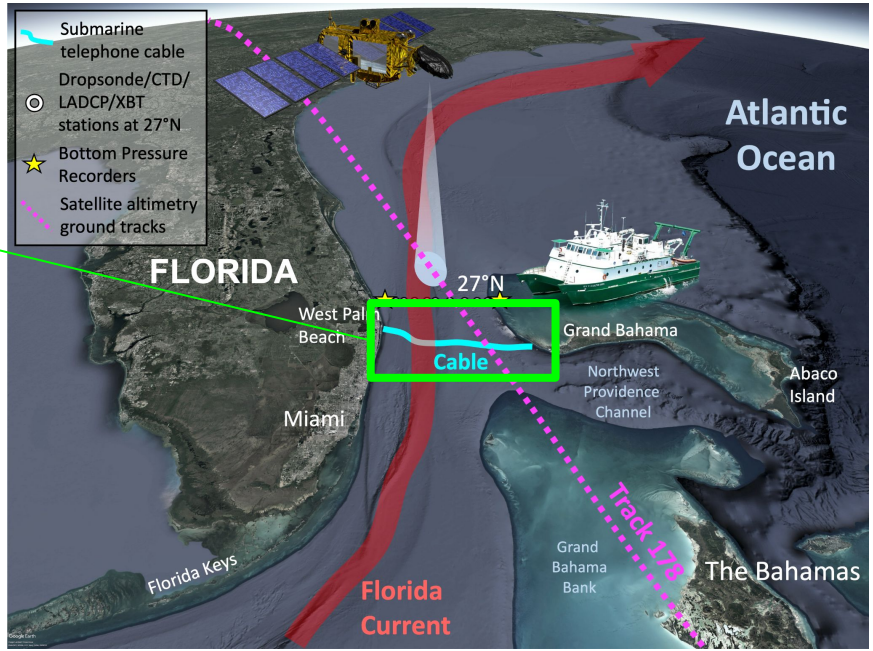
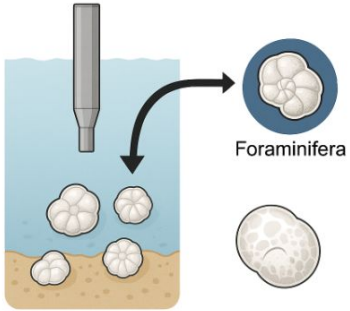


Figure: Direct measurement illustration of Florida Current

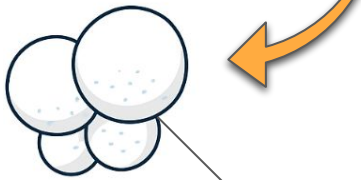
Data and Methods

Paleo

- Oxygen isotopes from foraminifera sediment cores (Lynch-Stieglitz et al. 2009)
- Estimate temperature from delta 18 O
- Estimate salinity from temperature relationships
- Calculate density

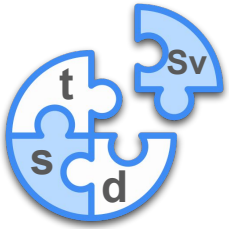


Foraminifera samples are collected from ocean sediments using coring devices, which retrieve layers of seafloor deposits containing preserved shells.



$$\delta^{18}O = \left[\frac{\left(\frac{^{18}O}{^{16}O}\right)_{sample}}{\left(\frac{^{18}O}{^{16}O}\right)_{standard}} - 1 \right] \times 1000$$

Isotope analysis of foraminifera measures the $^{18}O/^{16}O$ ratio, which reflects past seawater temperature and ice volume



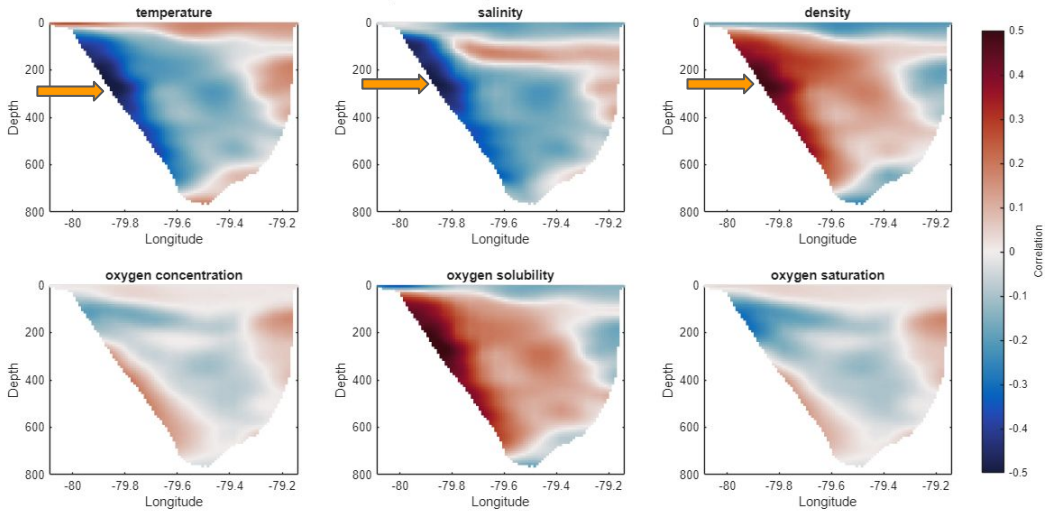
Linear Calibration

Reconstructed paleo transport

Modern Florida Current Variability & Key Depths

Examine the relationship between Florida Current transport and key seawater properties to determine the most reliable proxy for estimating transport.

Correlation: Transport Anomaly with CTD Variable Anomalies



Insights:

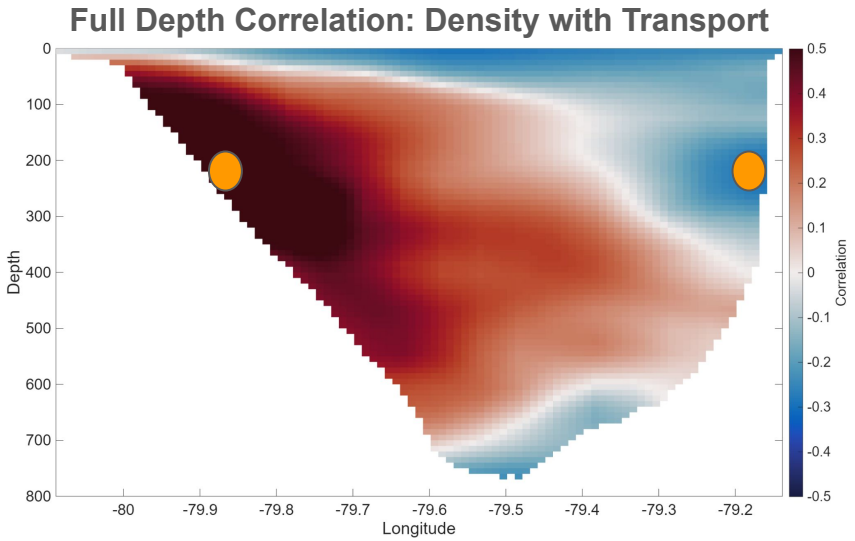
Density is found to be the best proxy for the Florida Current transport

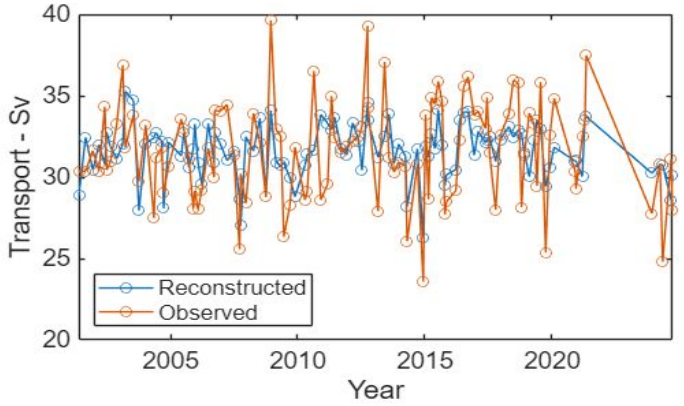
The strongest correlations are found between 200m - 400m.

These depths inform the gradient-based index used for reconstruction (geostrophy).

Modern Florida Current Variability

Develop a gradient-based index from east–west differences in density at the depth of strongest correlation with transport, serving as a proxy for Florida Current variability.





The reconstructed index (blue) closely matches observed transport (orange), validating the gradient-based approach

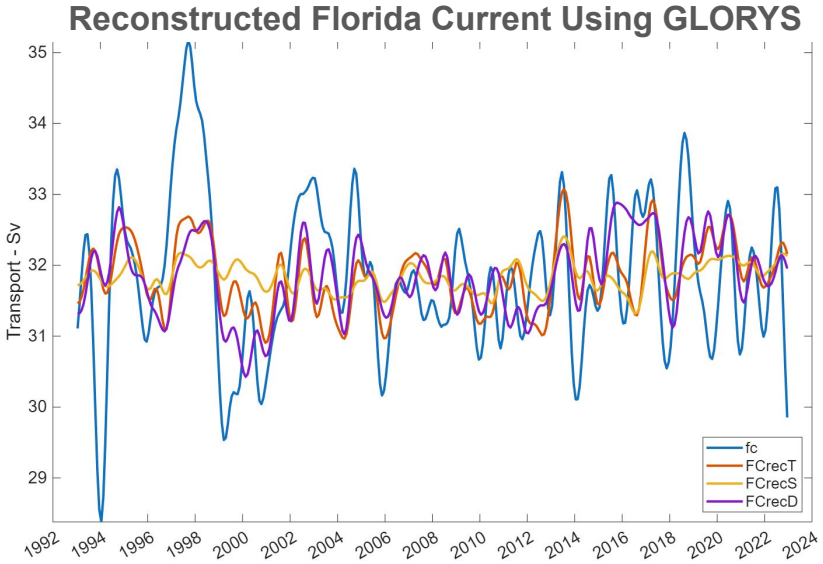
Calibrating the Florida Current Transport Index

Estimate regression coefficients for the transport and property gradients between locations of the two sediment cores using GLORYS reanalysis.

GLORYS Reanalysis Regression Results

	temperature (t)	salinity (s)	density (d)
correlation	0.43	0.18	**0.49**
Coefficients (a,b) **Y = a*x + b**	0.8662, 26.7532	2.0241, 29.9144	**6.6628, 27.6007**

Density gradient is able to explain about 25% of the variance of the Florida Current cable transport

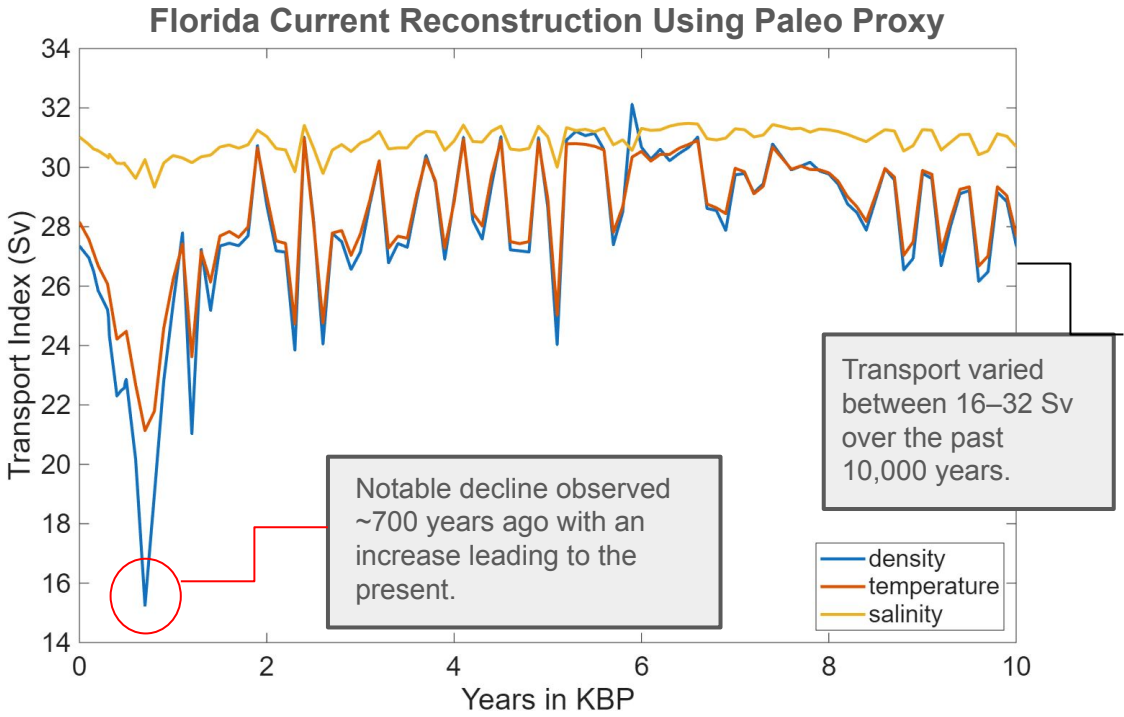


Paleo Reconstruction

Apply the calibrated regression model to paleo proxy records to reconstruct historical Florida Current transport.

Reconstructing Paleo Transport:

- Temperature is calculated from the $\delta^{18}O$ isotope ratio (Gaskell et al. 2023).
- Salinity is derived from temperature using method (Goes et al. 2018).
- Density is calculated from temperature and salinity and used to reconstruct Florida Current transport.



Conclusion

- Subsurface observations revealed stronger correlations between the Florida Current transport and metrics like density, temperature,and salinity.
- Oxygen isotopes from paleo sediment data can be used to reconstruct Florida Current transport in the past.
- The reconstructed transport shows substantial variability, with a notable decline around 700 years ago.

Future perspectives:

Further investigation of this past decline could provide valuable insight into long-term circulation shifts (ex: AMOC, gyre circulation).

Leveraging Machine Learning models to improve accuracy of reconstructed forecasts.

Resources

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