Effects of climate change and water management on West Florida Shelf's dynamics

Robert Burgman[1] and Laurent Cherubin[2]

[1]Florida International University

[2]Florida Atlantic University

Summary

In the present study we evaluated, in a high-resolution simulation (1.5 km), the separate and combined effects of freshwater discharge management and climate warming by 1 °C on the Loop Current (LC) intrusions on the West Florida Shelf (WFS) and its dynamics in the subtropical western Atlantic. Based on a one-year simulation in which a LC and its eddy intruded on the WFS, either the increase of freshwater discharge or the climate warming led to a change in the stratification properties of the WFS significant enough to affect the type of LC intrusions. Increased freshwater discharge contributed to the intensification of shelf water mixing that favors surface intrusion of LC waters. On the contrary, 1 °C warming led to increased shelf waters stratification that favors bottom intrusions. Either type of intrusion leads to a different oceanographic regime on the shelf to which the ecosystem might respond differently. Our study suggests, however, that increased freshwater discharge could mitigate the effect of climate warming on the WFS by reducing shelf waters stratification

Introduction

The continental shelf is the submerged extension of a continent and as such it is at the crossroad of terrestrial, oceanic, and atmospheric influences. This confluence is the lead driver of the high biological productivity that often characterizes the continental shelf regions.

Characterized by vertical density stratification that stabilizes in the Spring-Summer with increase solar forcing and freshwater input after turbulent mixing of winter.

The West Florida Shelf (WFS) often described as oligotrophic, supports abundant fisheries, experiences harmful algal blooms. Impingement of loop current and upwelling is important for renewal of inorganic nutrients.

With climate change and proposed restoration of paleo freshwater fluxes in the future, how might these dynamics change on the WFS?

Methodology

- South Florida Regional Ocean Modeling System (ROMS) Telescoping grid to 1.5 km resolution
- Surface forcing 3 hourly National Center for Environmental Predictions/North American Regional Reanalysis (NCEP/NARR) for the year 2004.
- Radiation (NCEP/NCAR) reanalysis
- Lateral boundary conditions TPXO7 tide model and by the Gulf of Mexico-HYCOM

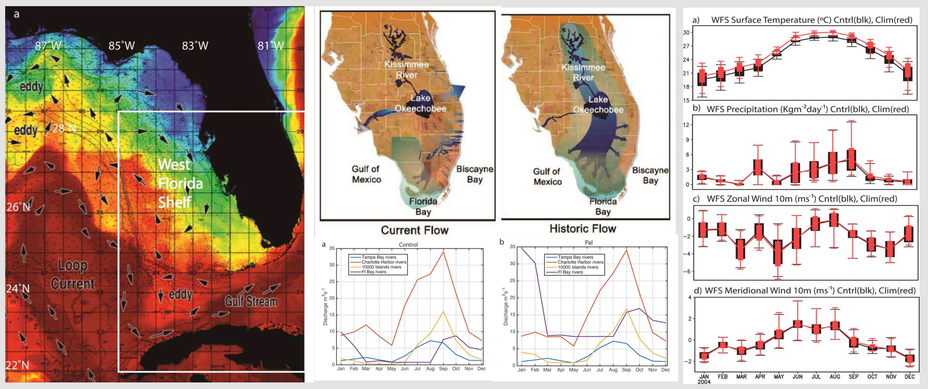
- Climate change – seasonal cycle of anomalies centered about 1˚C GMST increase from present values. Multi-model mean of 19 member models using RCP8.5 scenario CMIP5.

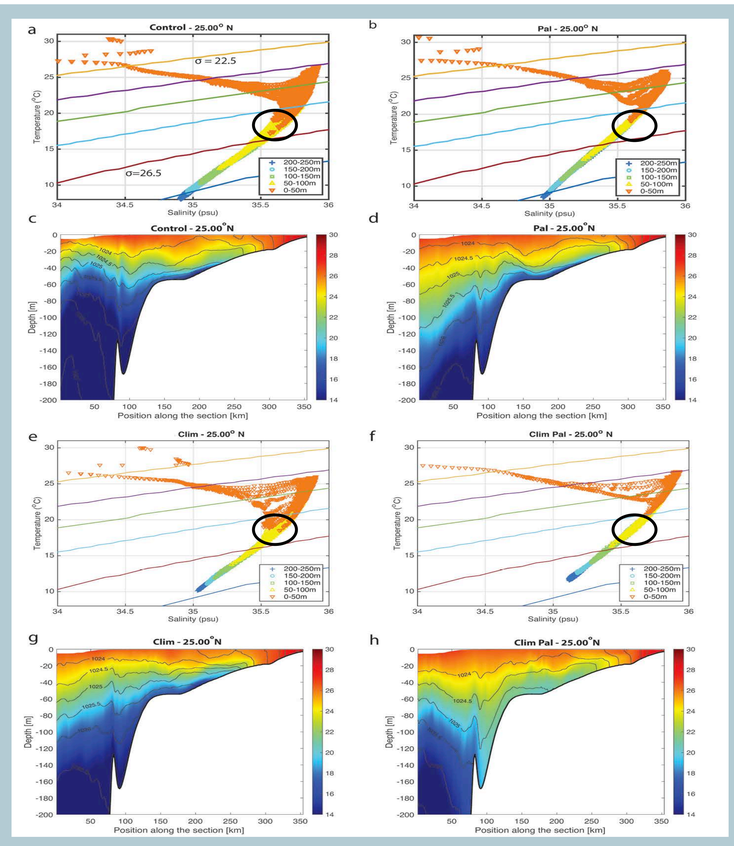
- River discharge -full restoration scenario (CERP) from the South Florida Water Management District's Natural System Model (NSM). Flow rates for all point sources in the affected region (i.e., Shark River Slough and south) were tripled. Flow rate from the Caloosahatchee River point source was reduced.

Model Domain

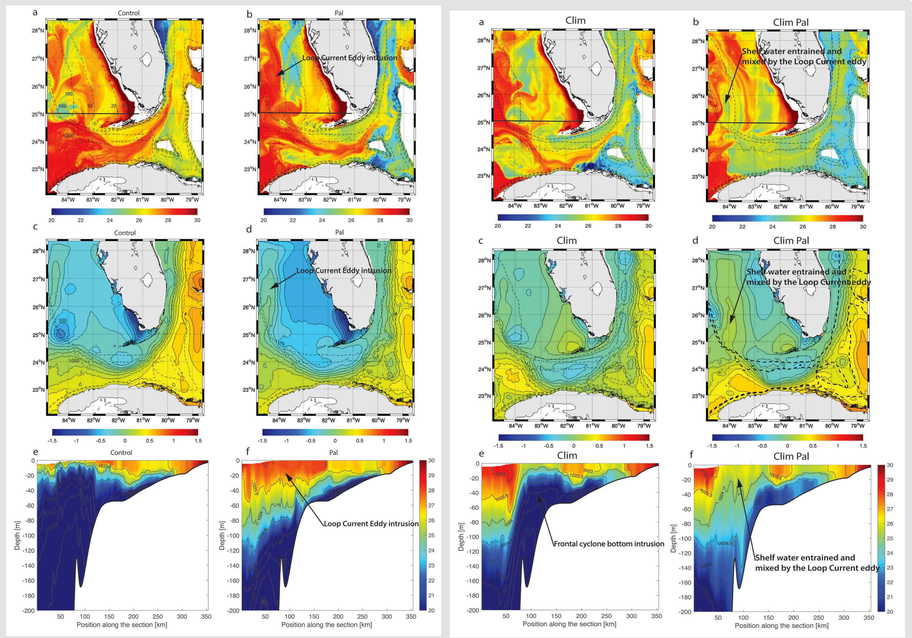
Freshwater Scenarios

Climate Change





Temperature Salinity diagrams and respective 2-wk mean temperature (°C) cross-section at 25.00°N at the peak of dry season in May 2004



Sea surface temperature (°C) , sea surface height (m), and temperature (°C) cross-section at 25.00°N on model day 12 June, 2004

Simulations

Climate and Water Management Combination Scenarios.
In the present study we used four combinations of climate and water management scenarios defined as follows:
Control: no CERP discharges and 2004 climate which will be our control scenario in the present study;
Pal: CERP discharges and 2004 climate;
Clim: no CERP discharges and 1 °C warmer GMST climate anomalies superimposed on 2004 climate; and
Clim-Pal: CERP discharges and 1 °C warmer GMST climate anomalies superimposed on 2004 climate.

Results

- Either type of intrusion leads to a different oceanographic regime on the shelf to which the ecosystem might respond differently.
- Increased freshwater discharge contributed to the intensification of shelf water mixing that favors surface intrusion of Loop Current waters.
- 1 °C warming led to increased shelf waters stratification that favors bottom intrusions.
- For a warmer future with increase freshwater flows our study suggests, however, that increased freshwater discharge could mitigate the effect of climate warming on the WFS by reducing shelf waters stratification.
- The WFS response to cold air outbreaks that are common in the fall and winter months was also analyzed (not shown). It showed that under a warmer climate, the increased stratification due to the freshwater discharge at the end of the boreal summer wet season is cancelled by the warmer climate and reduces the available potential energy on the shelf, limiting coastal upwelling, instabilities, and shelf convection.

Future Work

- CMIP6 HighResMip Boundary forcing
- Larger Sampling of years, including natural modes of variability (ENSO,AWP,NASH variability)
- Multiple ensembles

For more details:

Chérubin, L. M., & Burgman, R. J. (2022). Effects of climate change and water management on West Florida Shelf's dynamics. *Bulletin of Marine Science, 98*(3), 393-418. doi:10.5343/bms.2021.0054