FLORIDA ATLANTIC UNIVERSITY
Harbor Branch
Oceanographic Institute

TRANSPORT AND SALINITY BUDGET OF THE FLORIDA BAY

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Our motivation

Seagrass – The Florida Guidebook

- Florida Bay
  - Wide variety of goods and services.
- Poorly quantified salinity budget.
  - Complex bathymetry and transport circulation make balance calculations complicated.
  - Implications for biological cycles.
- Anthropogenic impacts.
  - Direct and climate-related salinity extremes.
  - Comprehensive Everglades Restoration Program (CERP)

Purpose

To develop a high-resolution nested hydrodynamic model within a regional ocean model to better understand the Florida Bay's transport and connectivity throughout its morphologically different regions.

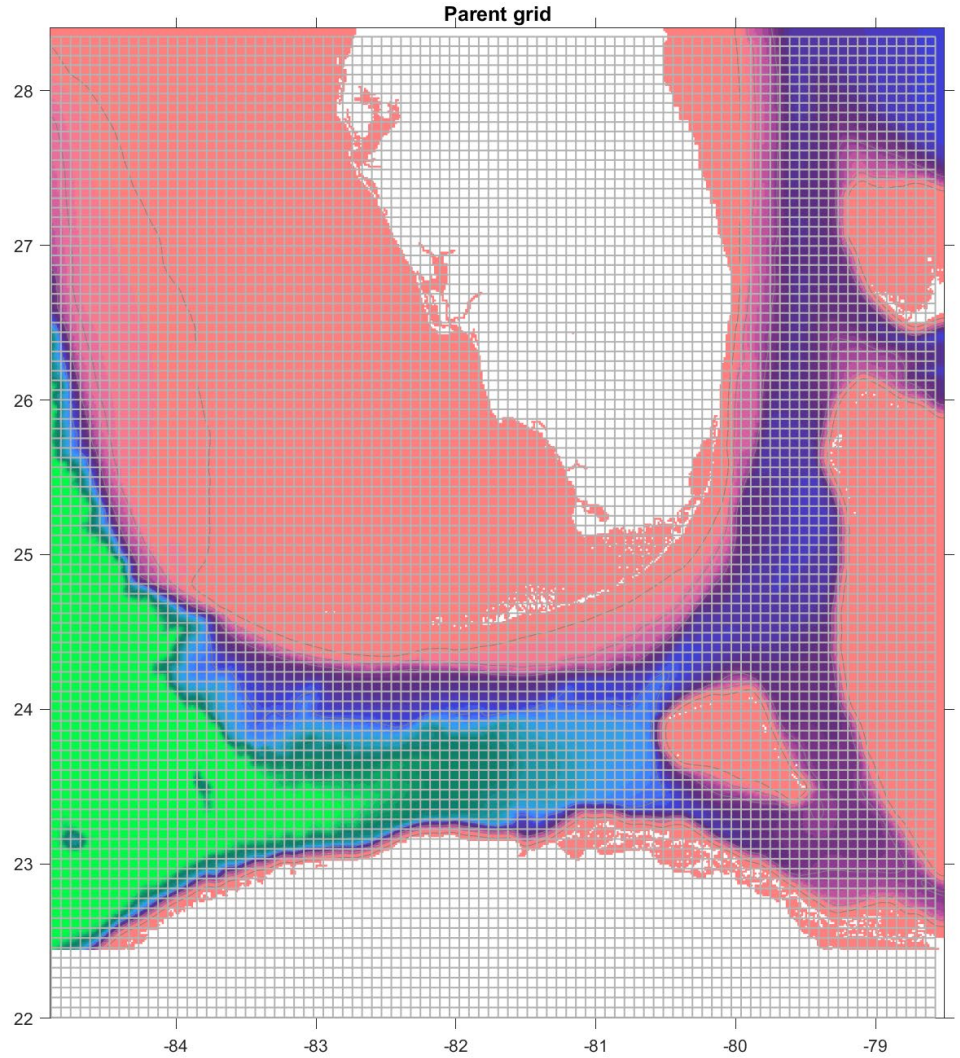
1. Improve model performance in capturing transport pathways and connectivity.
2. Better understand the processes controlling the salinity in the bay.
3. Assess impacts of climate and CERP.

The Regional Ocean Modeling System (ROMS)

- A modeling system originally developed for relatively larger, regional studies (Shchepetkin and McWilliams, 2005).
  - “Free-surface, terrain-following, primitive equations ocean model”
- Highly modular.
  - Used in a wide range of applications.

The Regional Ocean Modeling System (ROMS)

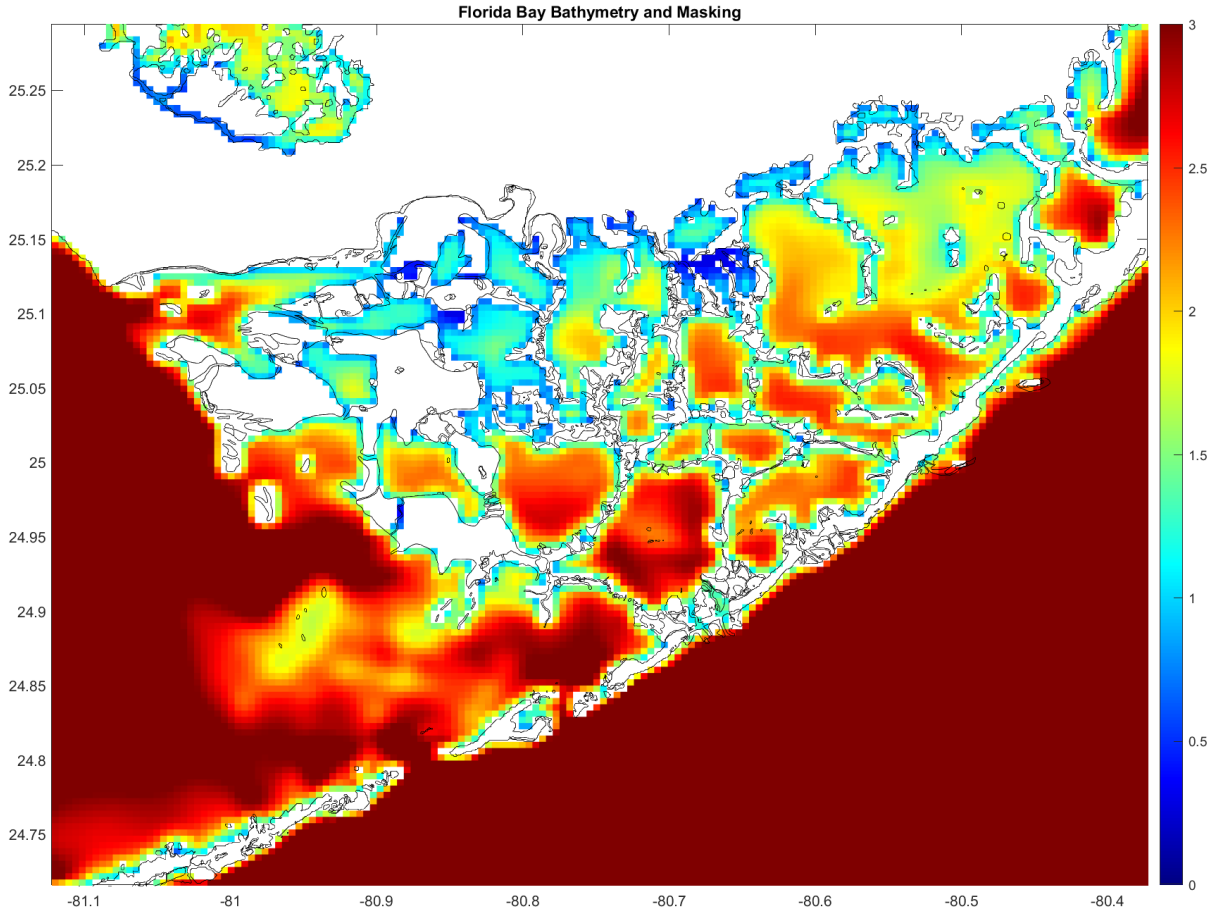
- Model Domain
  - Southern Florida shelf, Florida Straits, northern Cuba coastal region, and the western Great Bahamas Bank.
    - Horizontal grid resolution of 1.5km
    - 35 vertical sigma layers concentrated at the surface.
- Model Forcings
  - Tides
    - ¼° global tidal TPX08 model
  - Water quality (Temperature, salinity, currents, and water levels)
    - 1/12° global HYbrid Coordinate Ocean Model (HYCOM)
  - Sea-surface height
    - HYCOM, corrected using data from the Archiving, Validation, and Interpretation of Satellite Oceanographic (AVISO) data center.
  - Meteorological forcing
    - 32-km North American Regional Reanalysis (NARR) model



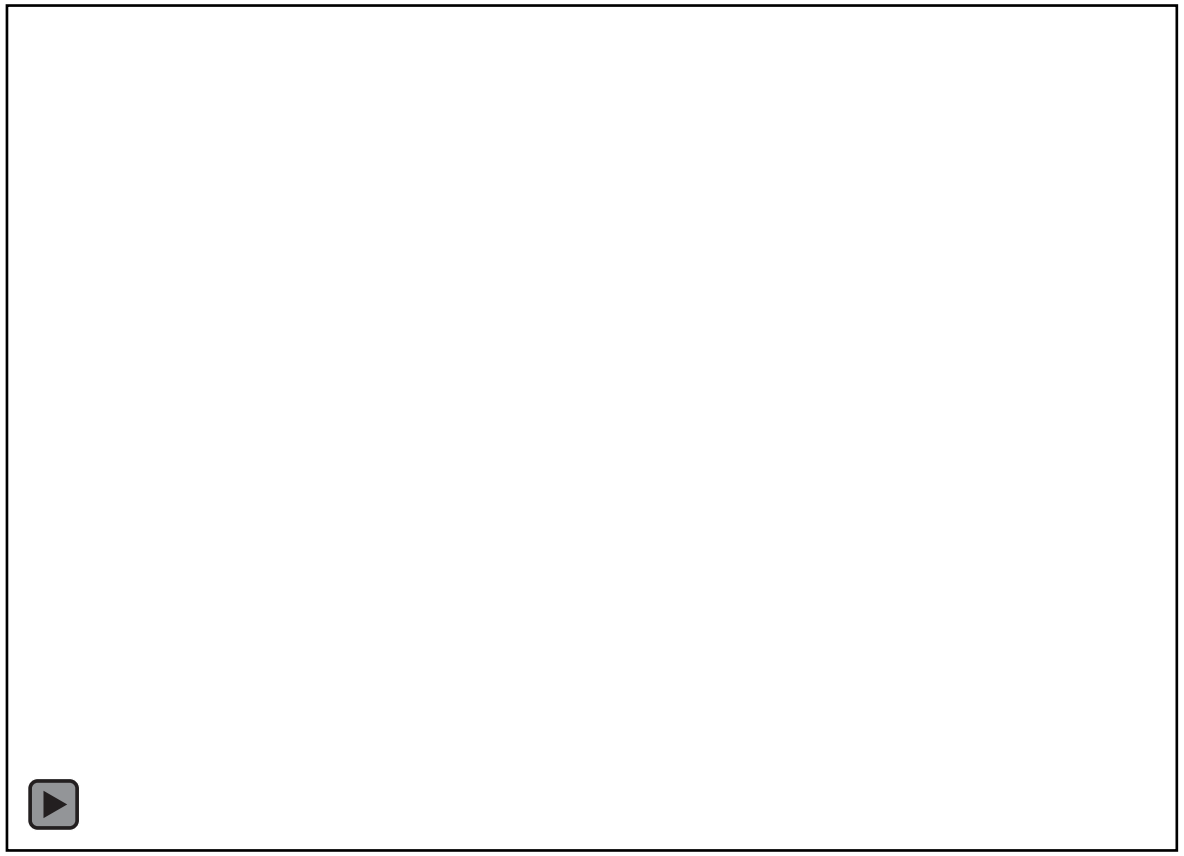
- Numerical schemes for momentum equations:
  - 3rd order upstream scheme for horizontal advection.
  - 4th order centered difference scheme for vertical advection.
- Numerical schemes for tracer equations:
  - 3rd order HSIMT-TVD scheme (Wu and Zhu, 2010).
- Horizontal pressure gradient:
  - Standard parabolic splines density Jacobian.
- Turbulent closure:
  - Mellor-Yamada 2.5 scheme.

Child Grid

- Required specific treatment due to complex bathymetry.
- Higher spatiotemporal resolution
  - 500m resolution - can include mudbanks, small islands, and channels.
- Domain covers the greater Florida Bay including the Florida Keys and much of the Florida Reef Tract



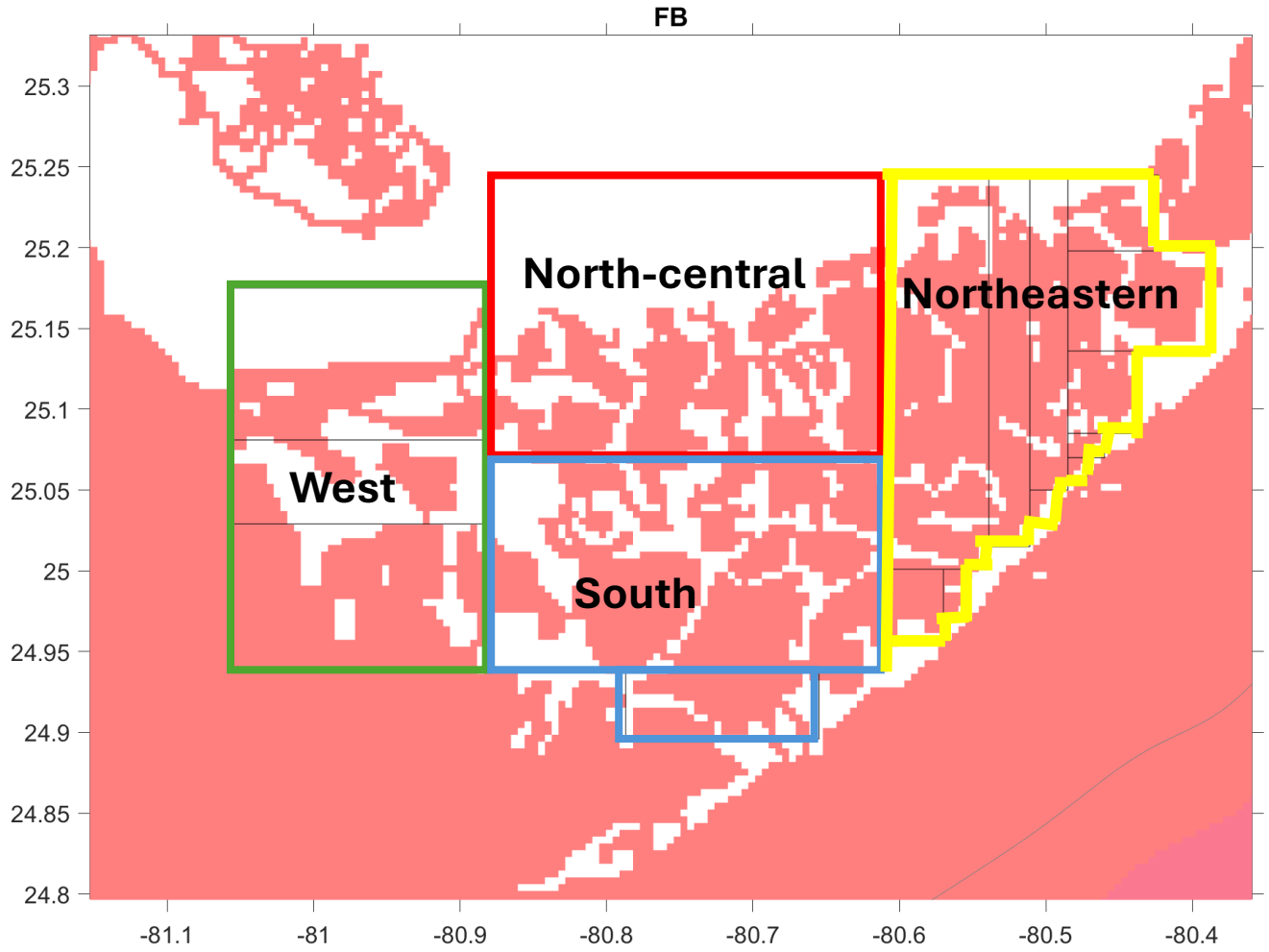
Two-Way Nested Model



- Based on previous efforts by Pan et al. (2017) and Jiang et al. (2020).
  - Major improvements:
    - Evaporation and precipitation effects on water level.
    - Revised and more accurate model bathymetry allows inclusion of mudbanks, small islands, and channels.
- 2 different grids
  - Parent model ~ 1.5km resolution
  - Child (nested) model at 1:3 aspect ratio, ~500m resolution.
    - Shorter baroclinic and barotropic timesteps.
- January 1, 2011 -December 31, 2011

Two-Way Nested Model

- Only child model results used for analysis.
  - To identify spatial variability, area was divided into the regions shown to the right.



Model validations

Observations

Monitoring stations from the Everglades National Park Services (ENPS)

In situ temperature and salinity from the South Florida Water Management Districts (SFWMD) efforts (DBHYDRO)

AOML Regional Surveys

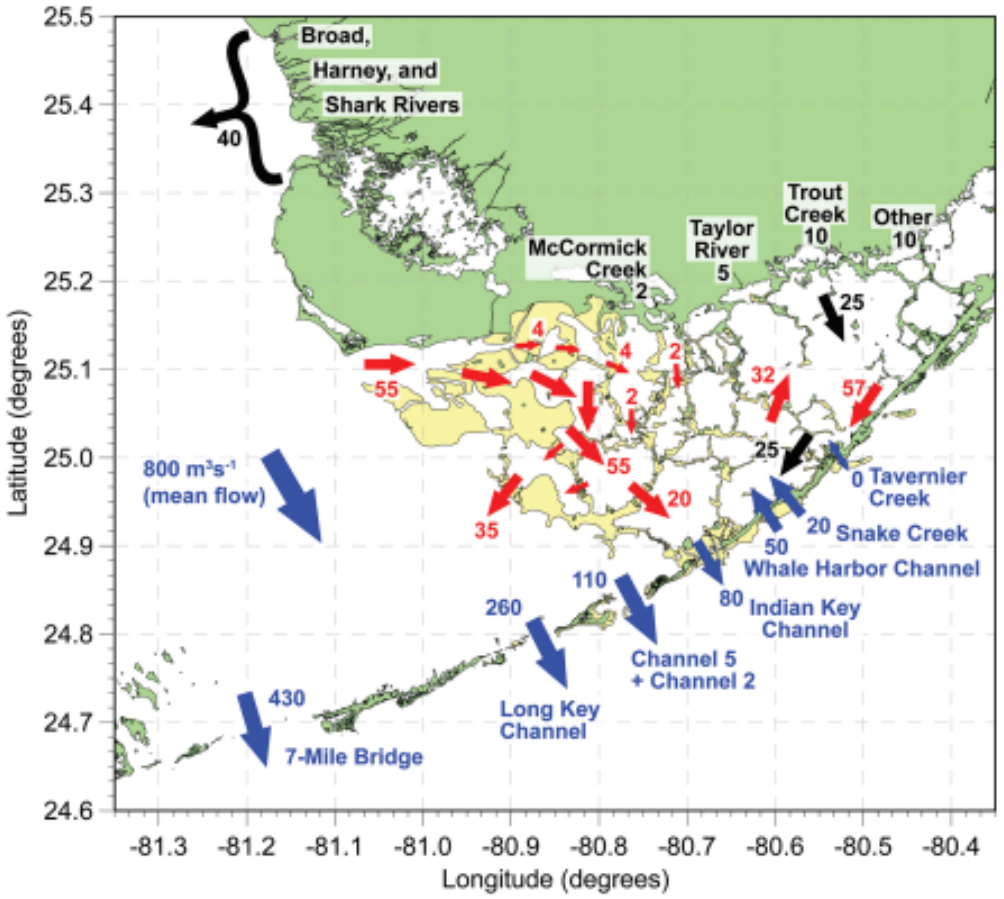
Historical Results

Lee et al. (2016)

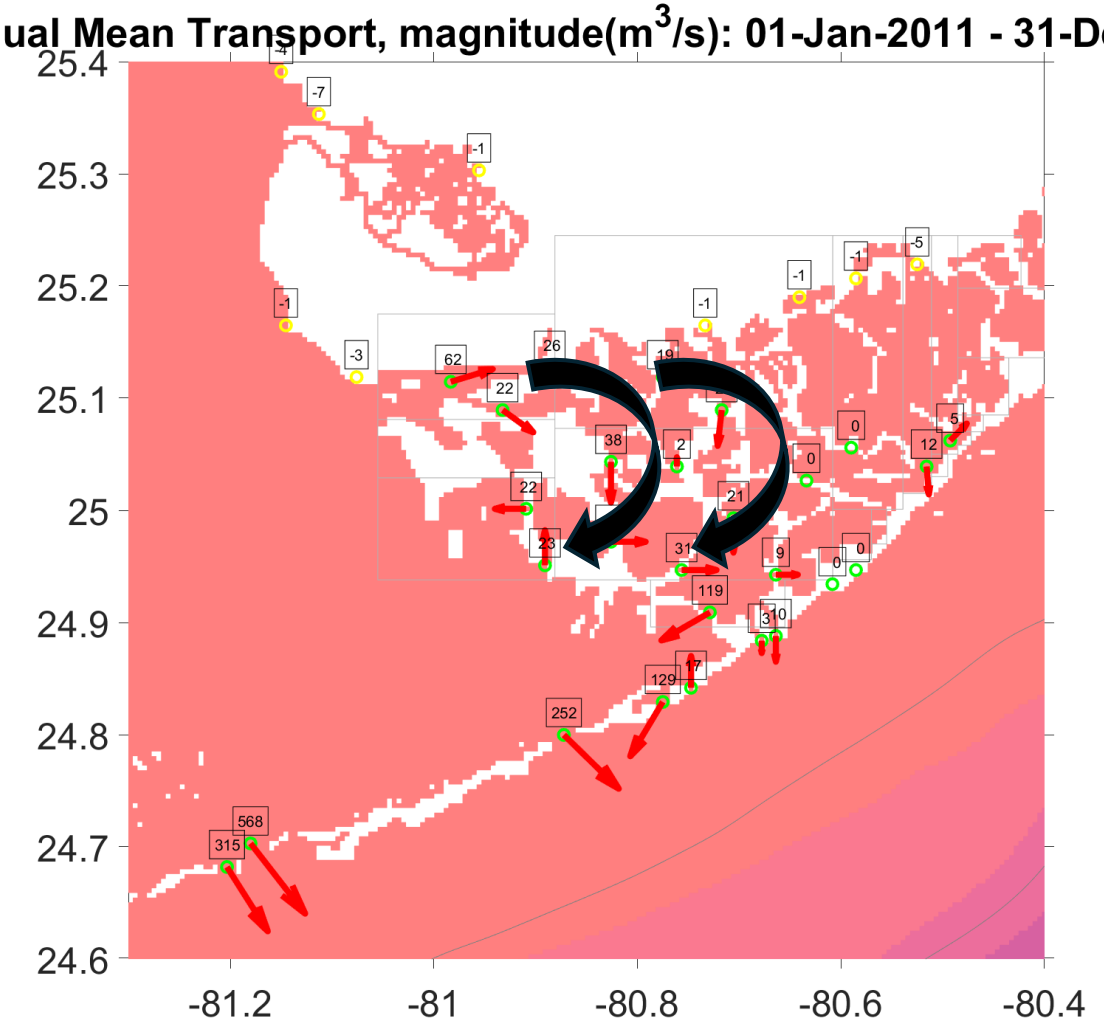
Kelble et al. (2007)

Smith and Lee (2002)

Transport and Connectivity

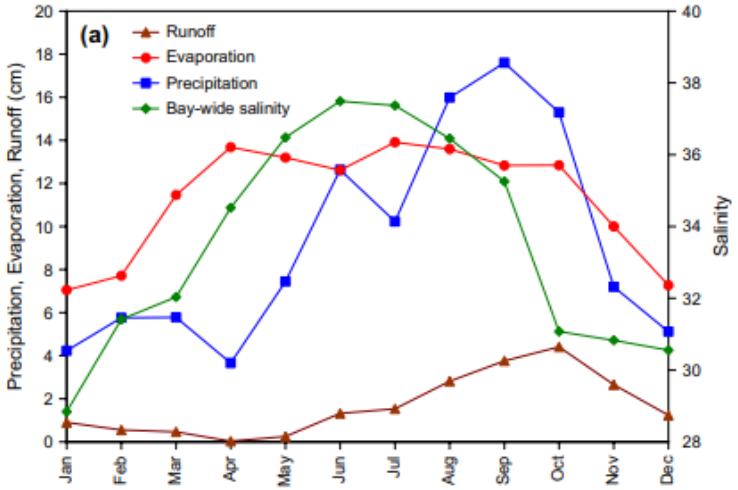


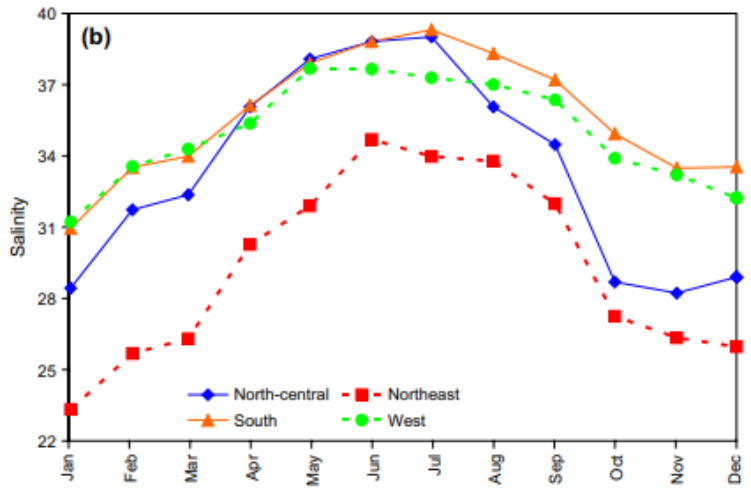
Lee et al. (2016)

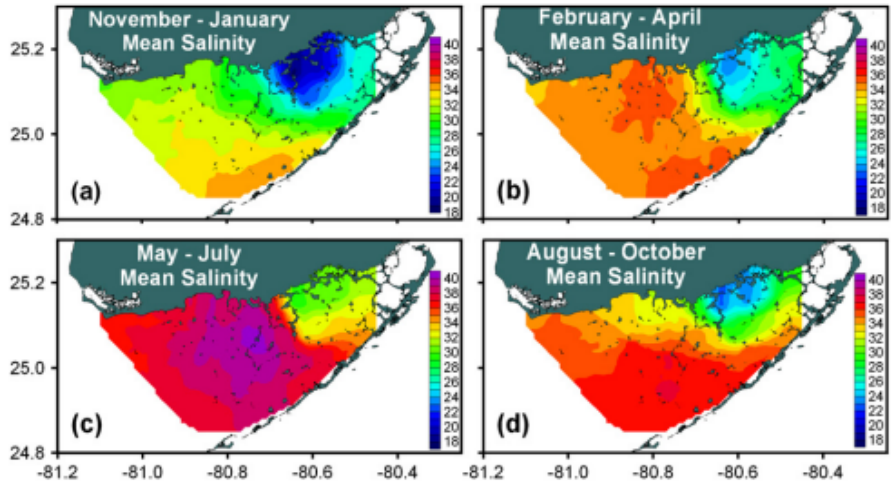


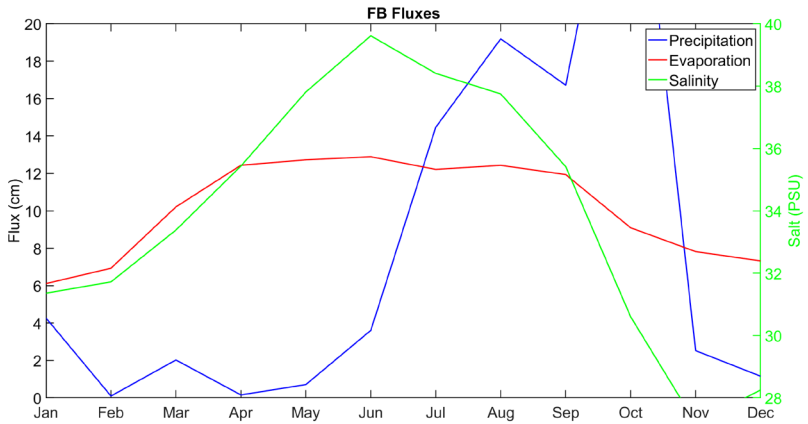
Salinity Fluxes

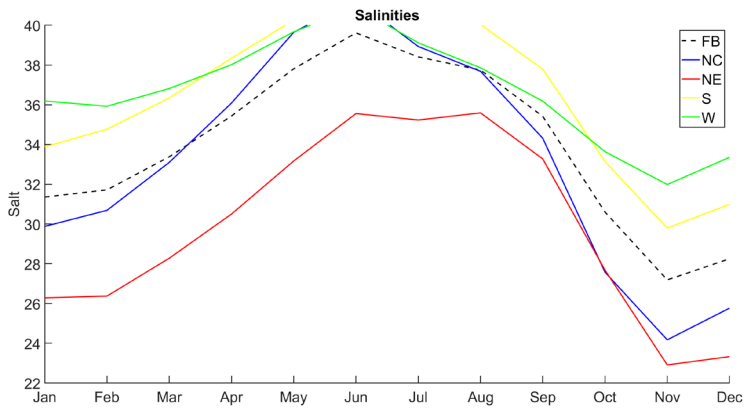
Kelble et al. (2007)

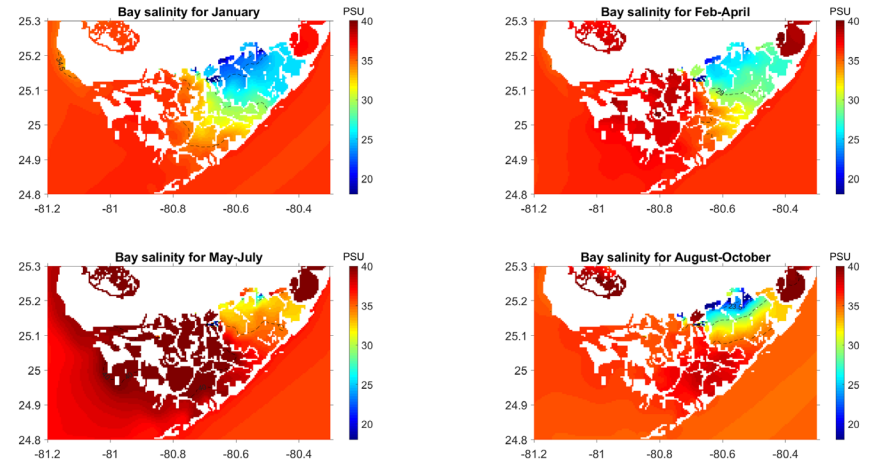




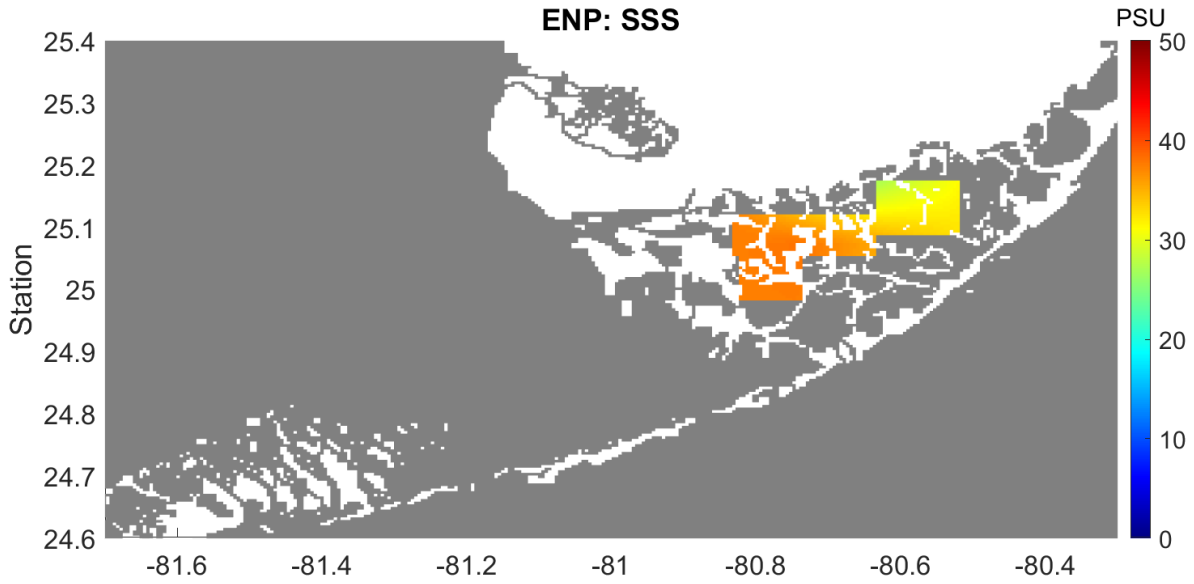


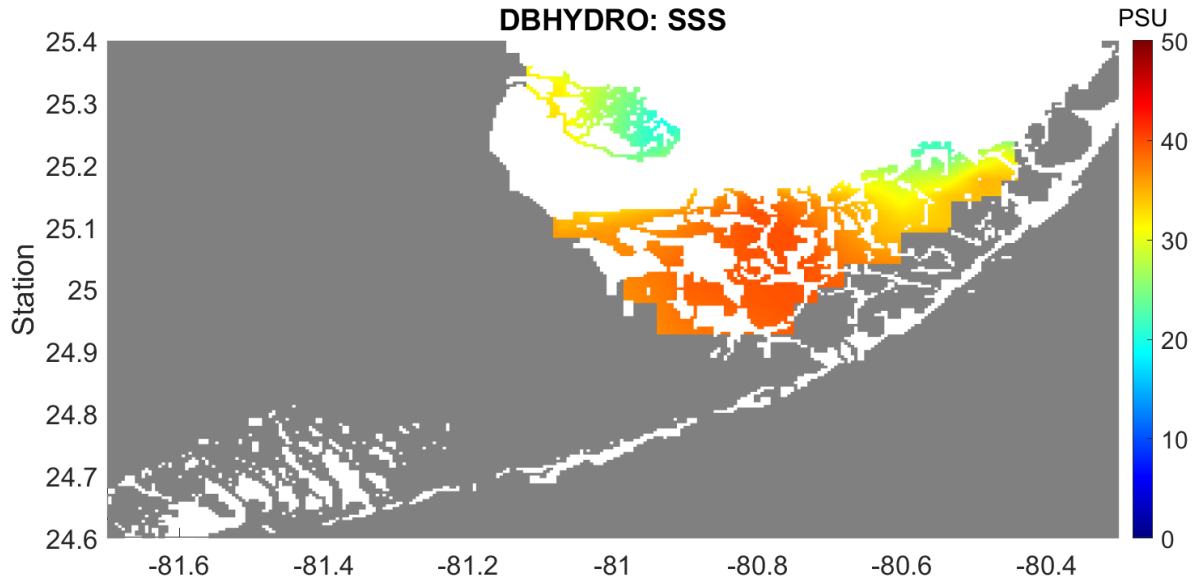


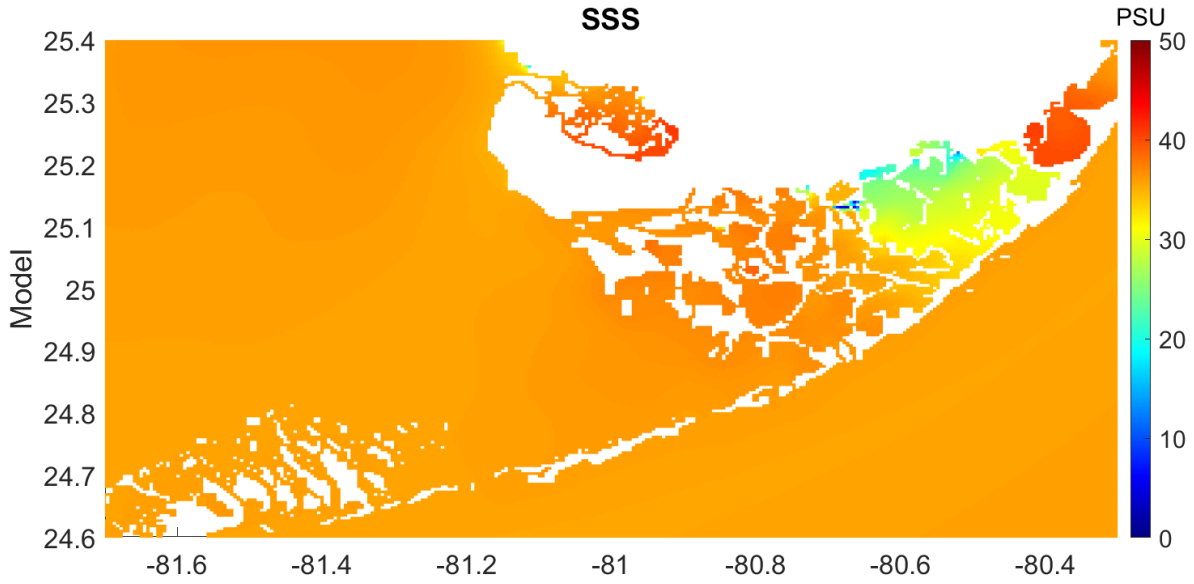


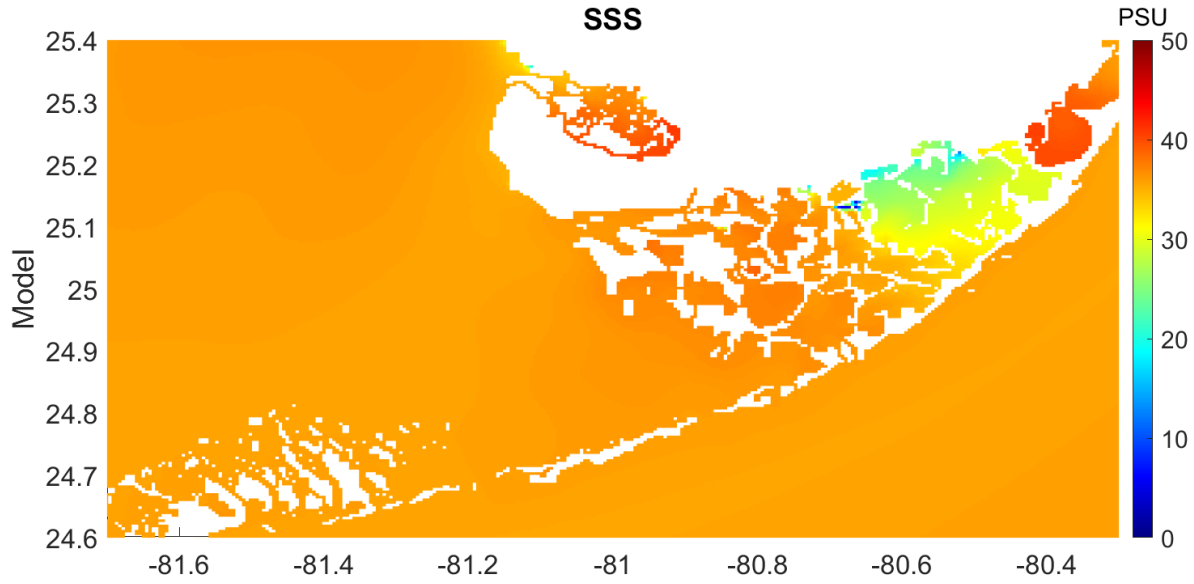


Model vs Observations

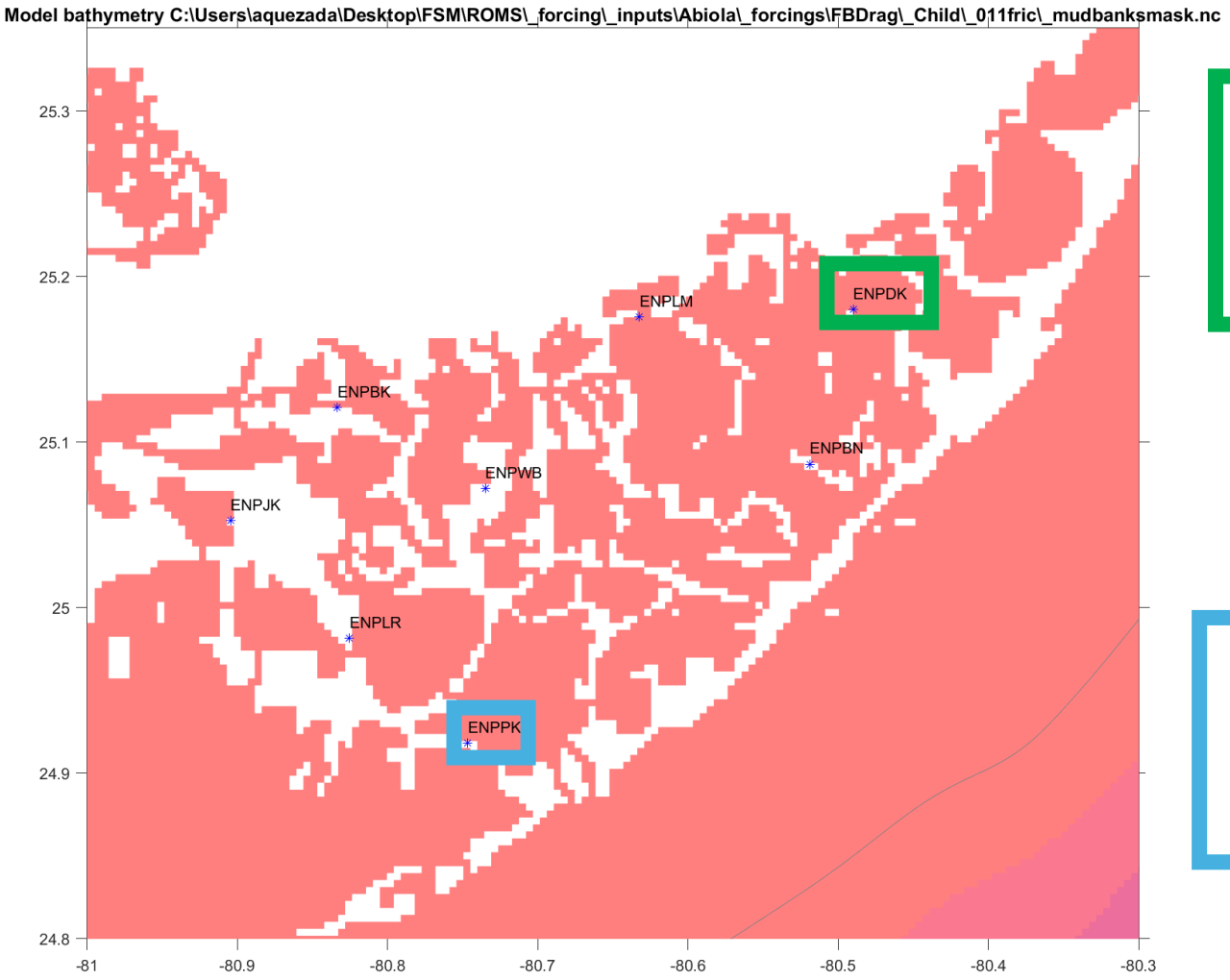


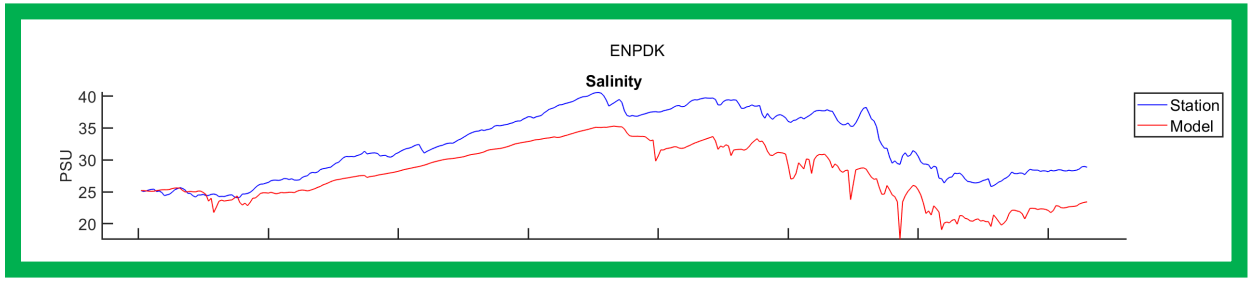


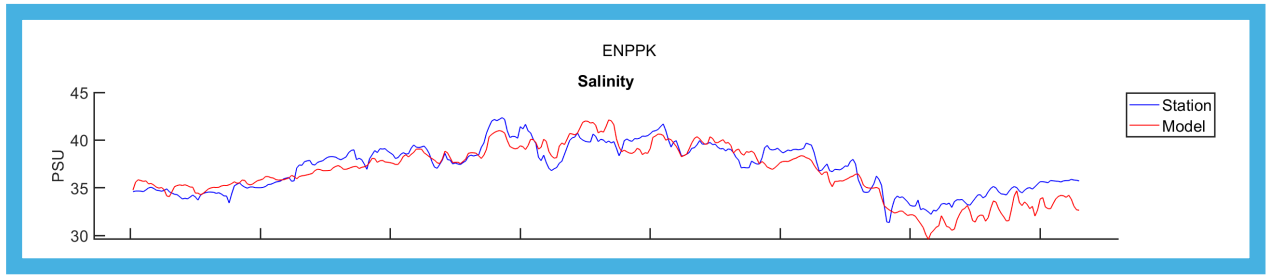




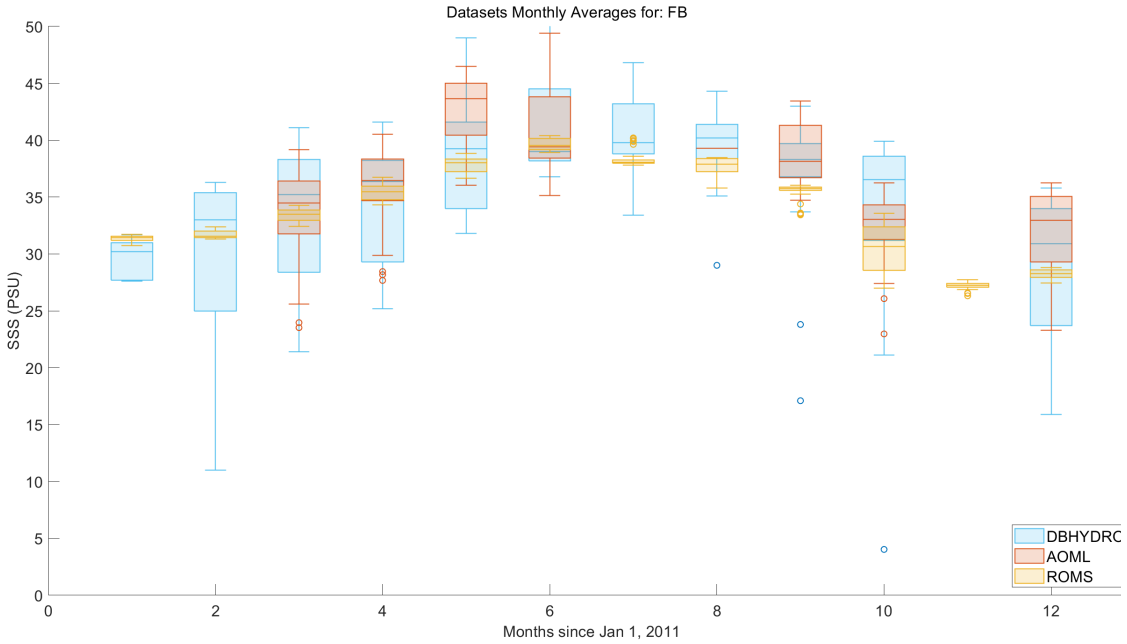
Everglades National Park Services (ENPS)

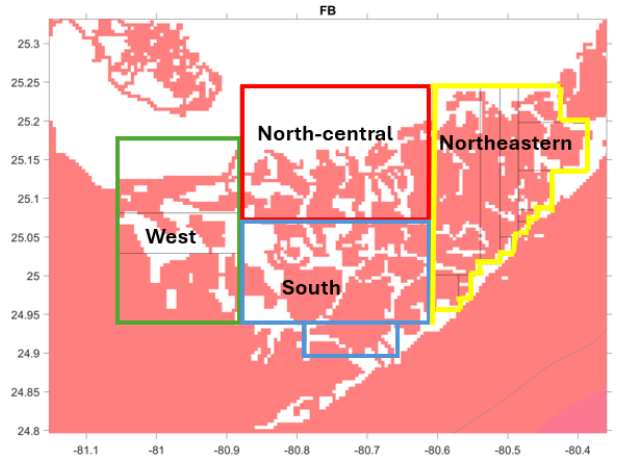


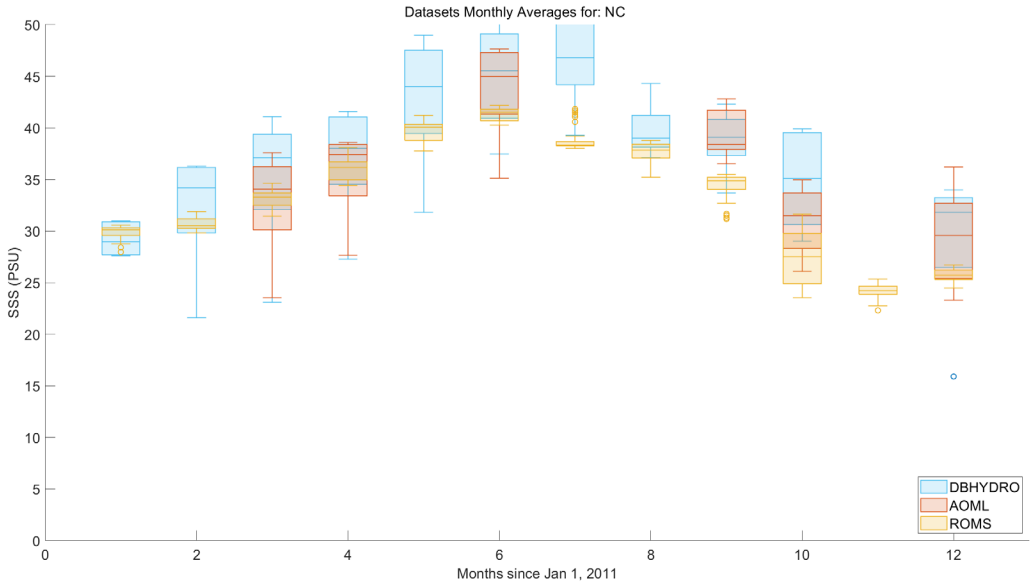


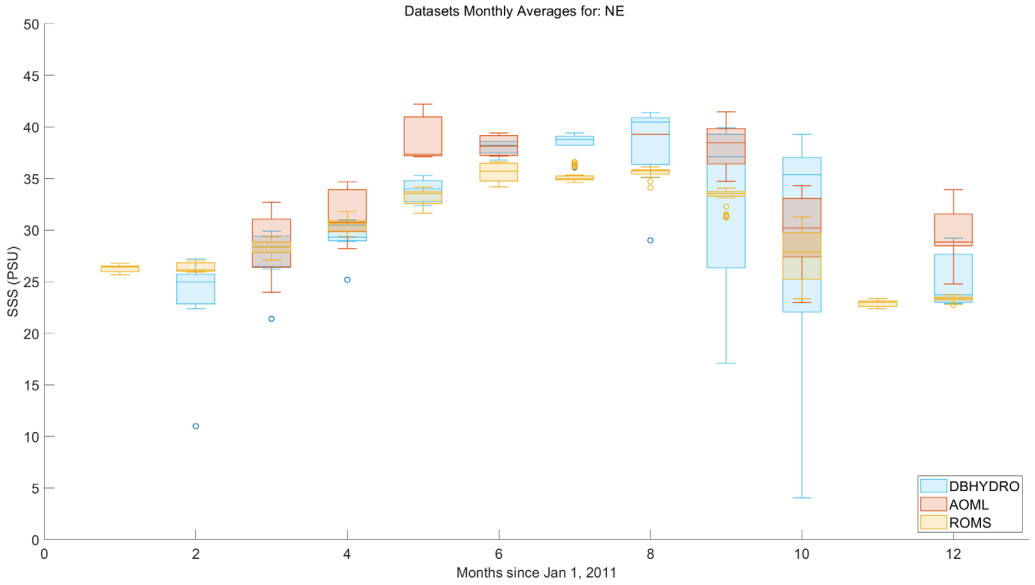


Regional Averages









Salinity budget equations

$$S_{rate} = H_{adv} + H_{diff} + \frac{(E-P)[S]}{density} - \frac{R * [S]}{volume}$$

S_{rate} = salinity variation rate (/s)

H_{adv}= Horizontal advective salt fluxes across the boundary (/s)

H_{diff} = Horizontal diffusive salt fluxes across the boundary (/s)

$(E-P)$ = evaporation minus precipitation (kgm^{-2}/s)

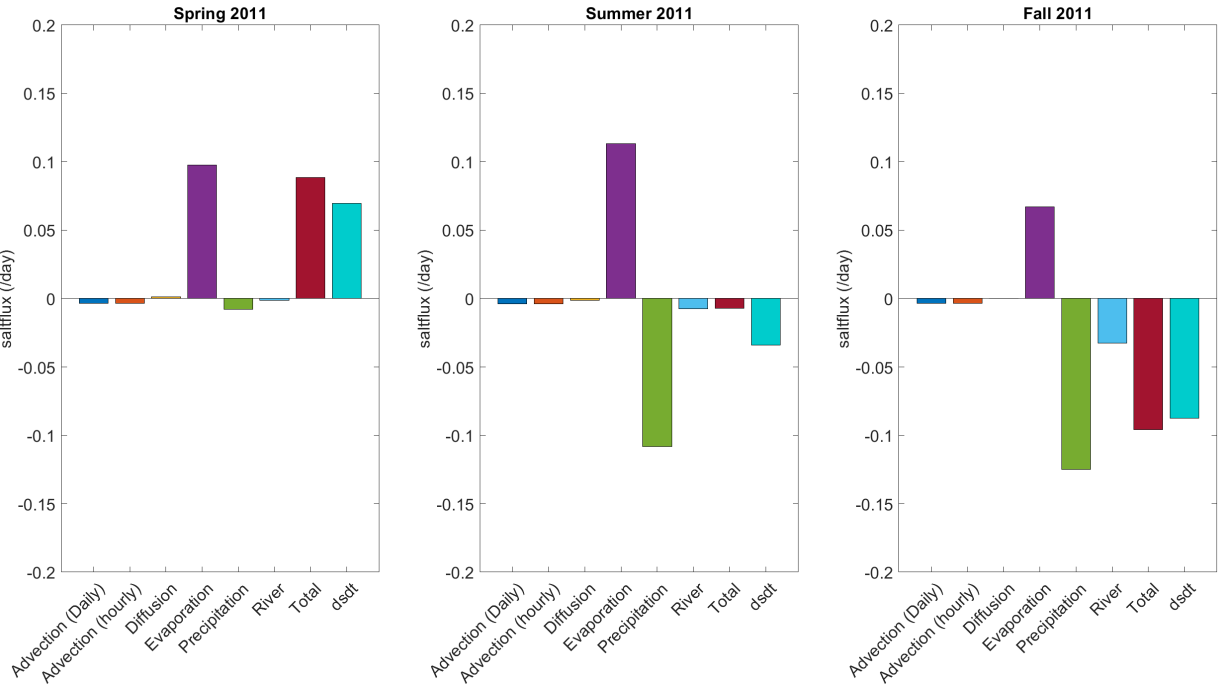
R = river runoff (m^3/s)

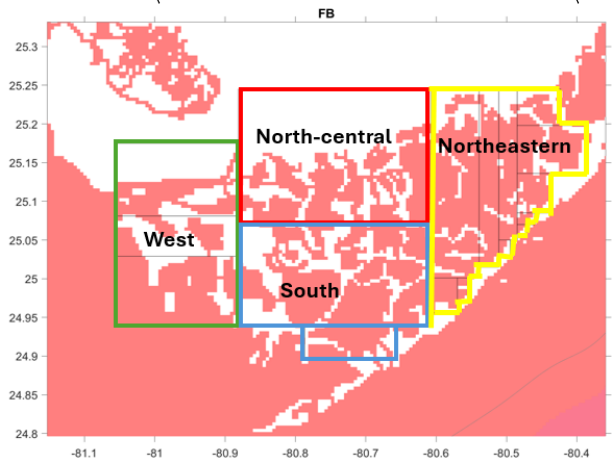
$[S]$ = time varying and volume-averaged salinity of the domain (psu)

Because the bay is shallow, and with a solid bottom boundary, it is assumed to be well-mixed, and V_{adv}, V_{hdiff} are therefore not considered.

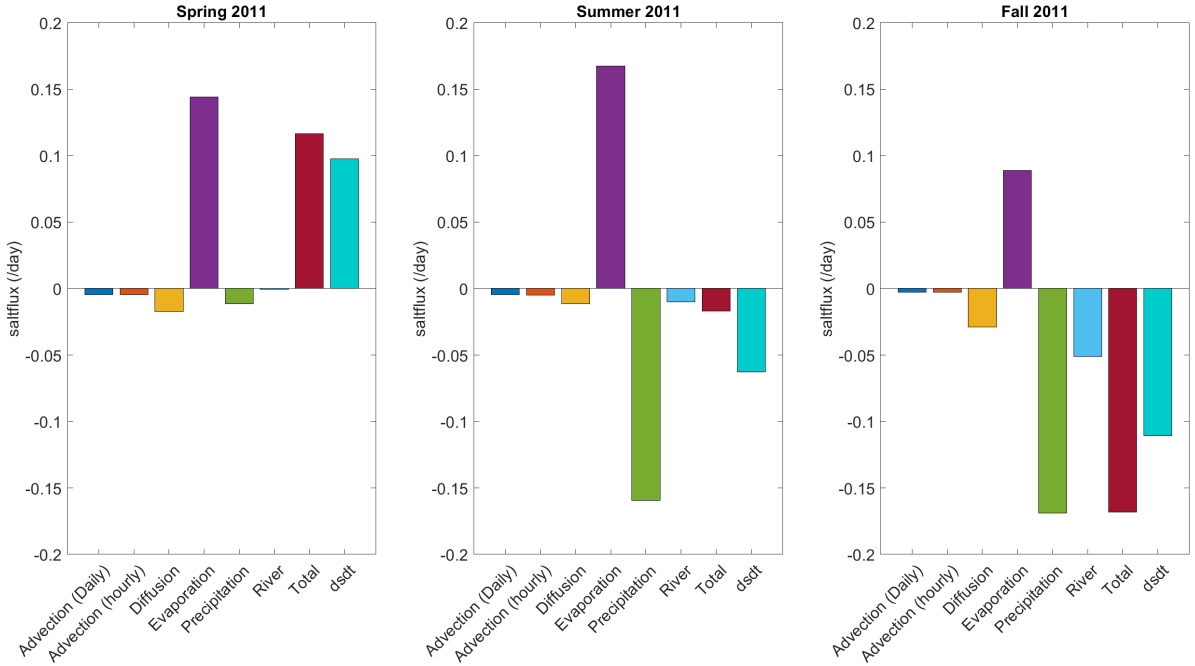
Salinity Budget

FB

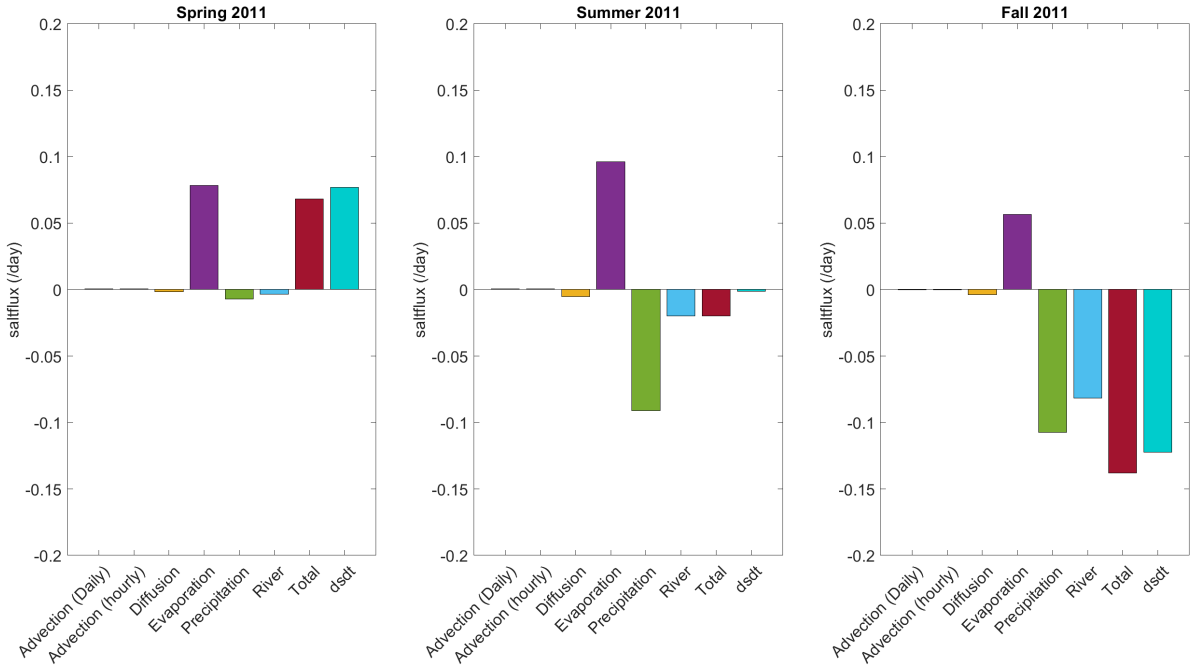




NC



NE



Conclusions, Limitations, and Future Steps

- We developed a high-resolution hydrodynamic model nested within a regional ocean model, based on ROMS, that can accurately replicate observed hydrodynamics, transport, temperatures, and concentrations.
- Some limitations include:
  - Limited sufficiently high-resolution meteorological data
  - Lack of empirical measurements in parts of the Bay.
  - Variable responses by region due to an incomplete understanding of their drivers.
  - Computational requirements
- Future Steps
  - Further testing of model to increase accuracy – modifying internally computed evaporation rate.
  - Implement surface algal vegetation (SAV) cycles (Jiang et al. 2020).
  - Researching the effects of the CERP freshwater reallocation efforts.
  - Testing increased sea level rise and sea surface temperature scenarios.
  - For more on these future steps please refer to our lab's other poster sessions and talks.
    - "Effects of Bottom Morphological Features During Storms: A Case Study of Hurricane Isaac in 2011" by Abiola Adebiyi (Today)
    - "Modeling Seagrass Distributions in the Greater Florida Bay and Impacts of Climate Change" by Dr. Mingshun Jiang (Tomorrow)

References

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