

Capabilities and Challenges in Modeling the Coastal Ocean and Climate

Michael Alexander
CLIVAR Summit, Boulder, CO
July 2025

“High” Resolution (~10 km resolution) Reanalyses

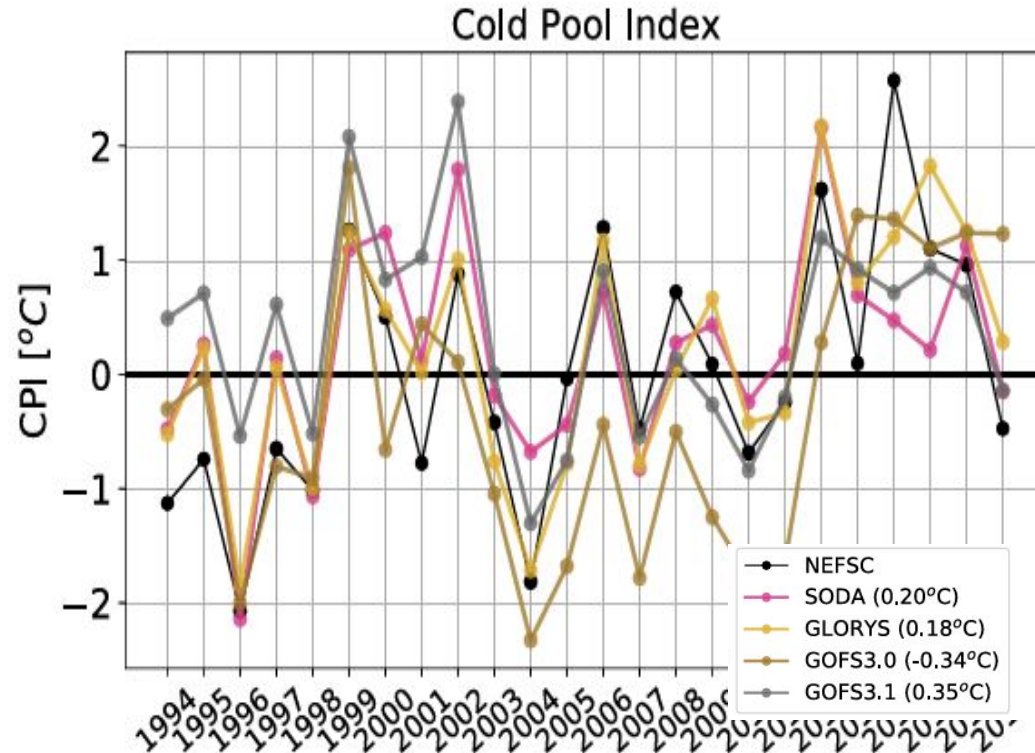
- **Global**

- GOFS, GLORYS, BRAN,
- Evaluations (US east & west coast)
- Amaya et al. (2023). Prog. Oceanogr.
- Castillo-Trujillo et al. 2023 Prog. Oceanogr
 - Improved over previous reanalyses
 - Not designed to be coastal
 - “Pretty good” but not obs.

- **Regional**

- UC Santa Cruz: US west coast
- He et al. (NW Atlantic 4 km)

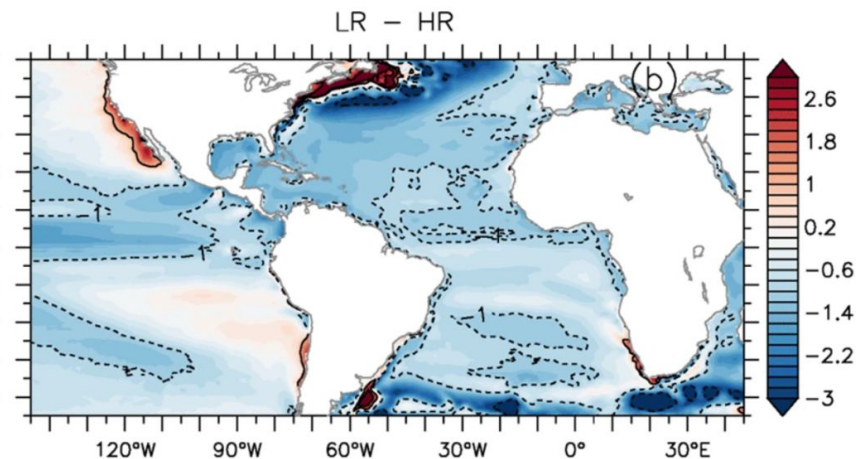
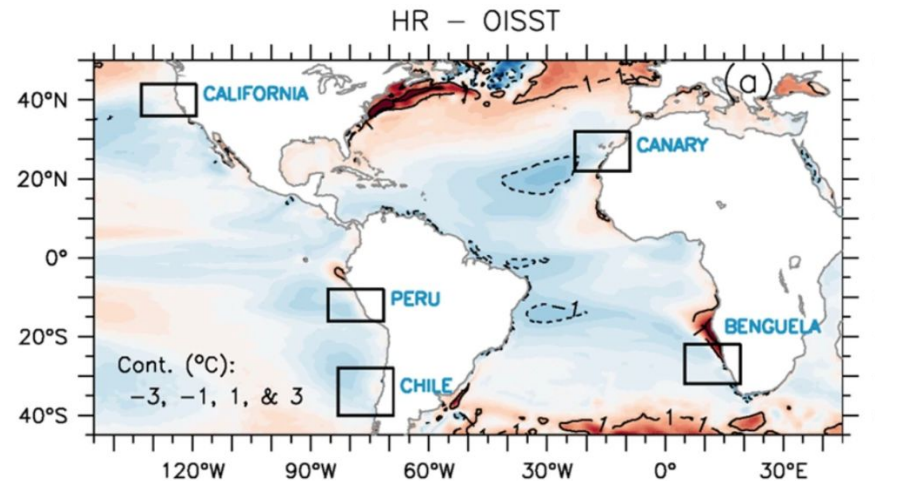
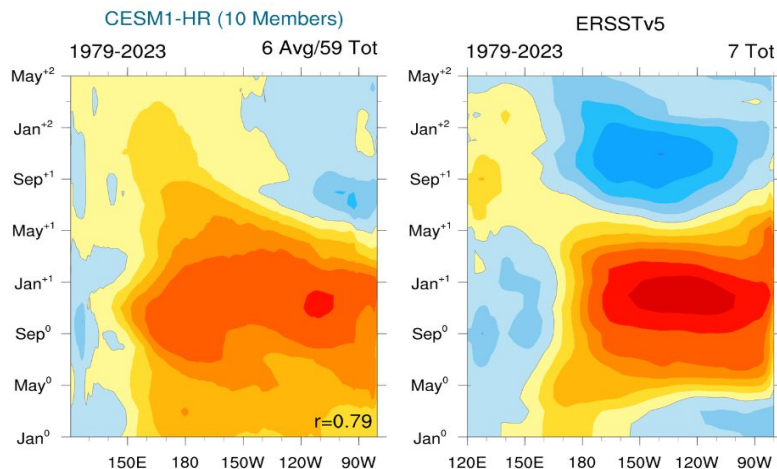
- Include some coastally trapped processes
 - e.g. CTWs
- Fronts and eddies may be more difficult
- < 30 years long



[Castillo-Trujillo et al., 2023, Prog. Oceanogr.](#)

High Resolution Global Models

- [High Resolution MIP \(CMIP 6 & 7\)](#)
- MESoscale Atmosphere-Ocean Interactions in Seasonal-to-Decadal Climate Prediction ([MESACLIP](#))
 - Suite historical & future CESM1 simulations
 - Atm 25 km; ocean 10 km
 - Improved upwelling regions
 - ENSO weak, reduced spectral peak



Chang et al. 2023, Commun Earth Environ

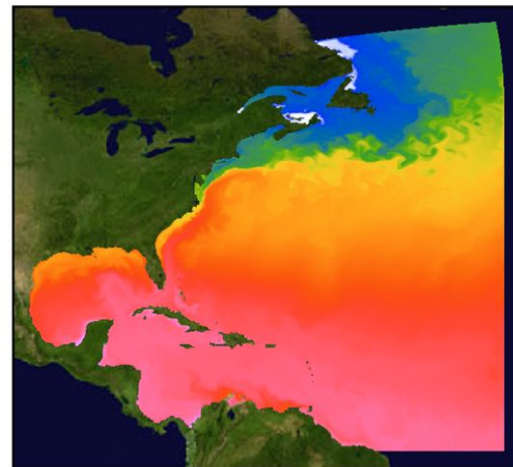
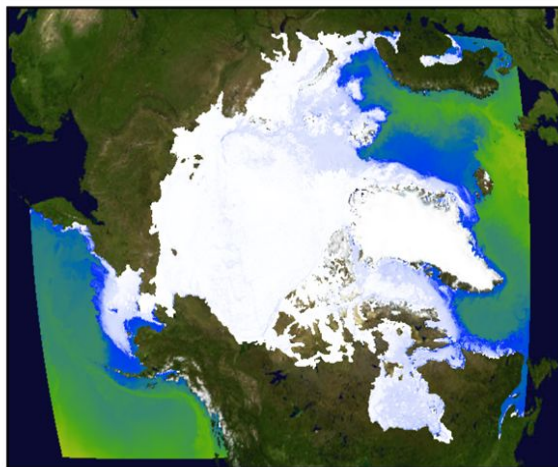
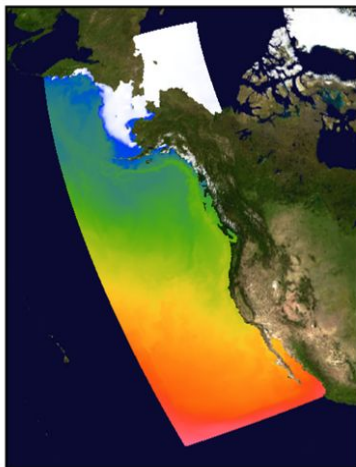
Regional Models

ROMS continues
to be a workhorse

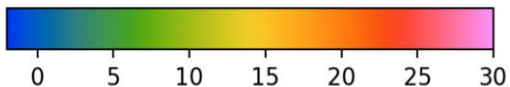
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Changing Ecosystem and Fishery Initiative (CEFI)

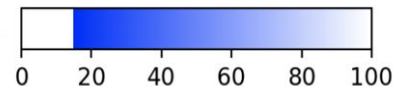
- MOM6 Physics and COBALT(+) BGC
- Seasonal and decadal forecasts, projections
- Served through the [CEFI portal](#):
- 8 - 10 km resolution
- East & West coasts, Arctic, Great lakes, Pacific Islands



1980-04-01 sea surface temperature (°C)

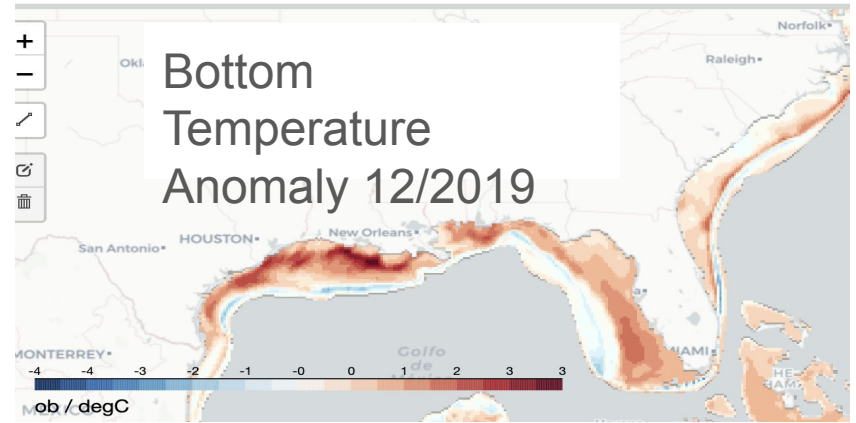
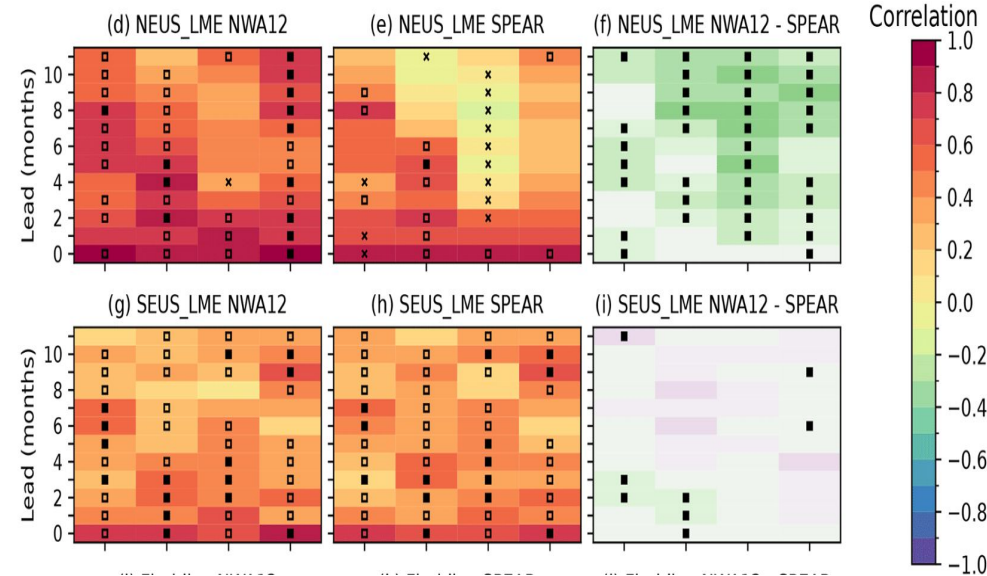


sea ice (%)

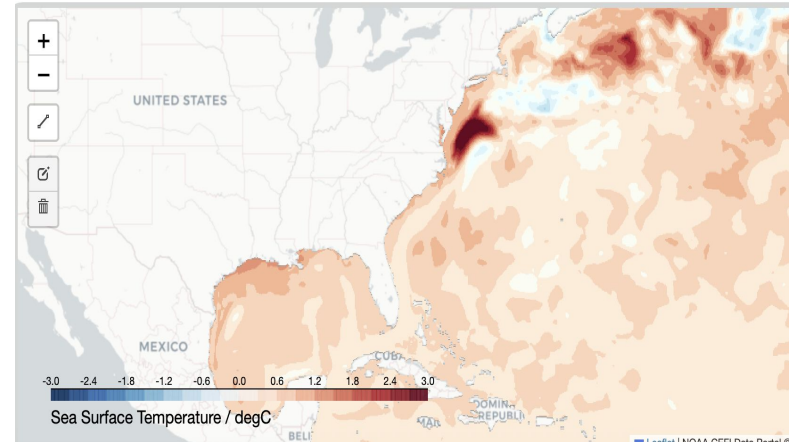


CEFI: NWA MOM6

(Re-) Forecast Skill SST: ACC

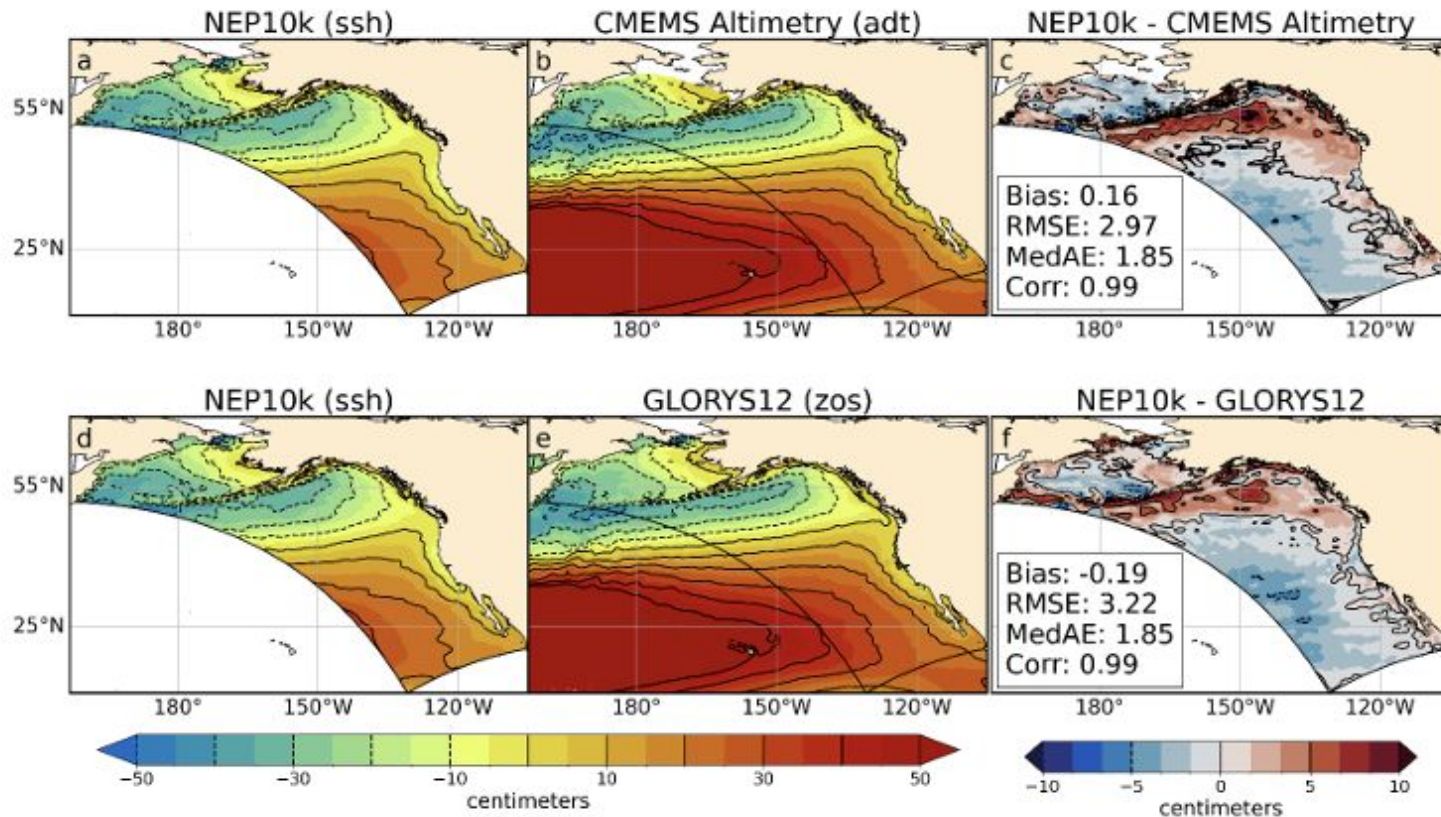


6.5 month SST forecast Initialized 4/25



[Ross et al., 2024: Ocean Science](#)

CEFI: NEP-10k Historical Simulation (1993-2019)



[Drenkard et al. 2025 \(in press\)](#), GMD

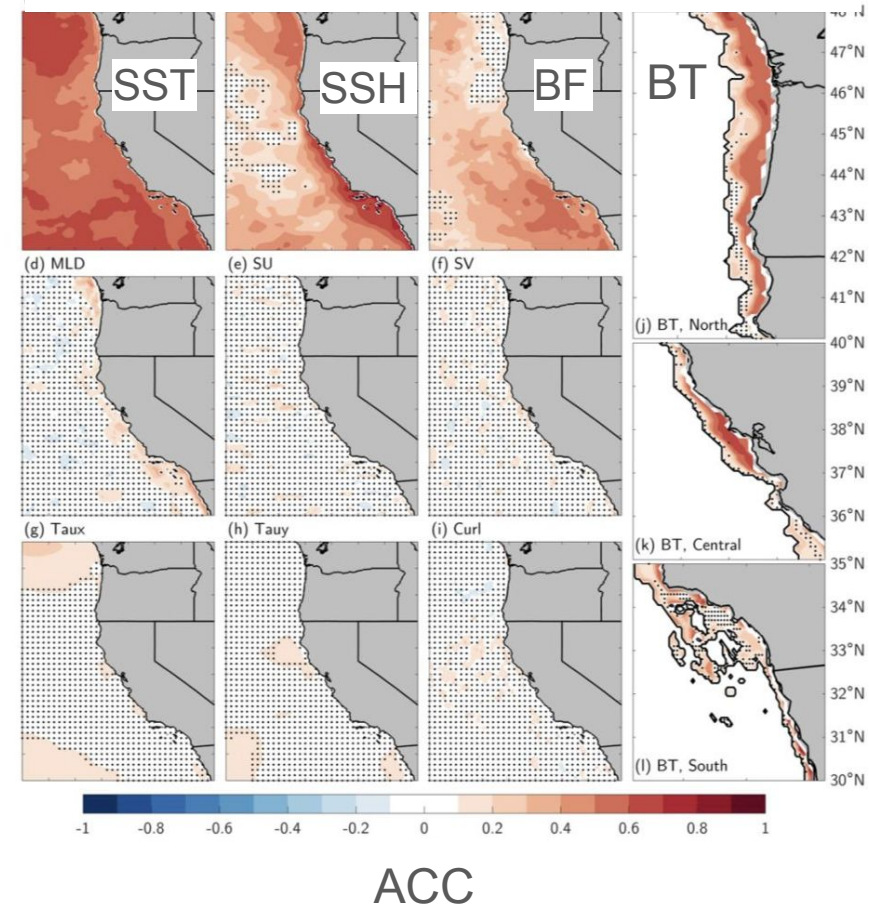
Model Formulation: Opportunities/Challenges

- Fate of CEFI unknown
- Resolution:
 - While high resolution Global and CEFI models simulations provide coast-wide and length simulations likely still coarse for many analyses
 - West coast shelf < 25 km in many locations
 - Rossby radius narrow and decreases with latitude
- Higher resolution simulations < 5 km but limited duration/spatial scale
- Variable resolution models
 - e.g. FVCOM
- Air-sea interaction
 - Forcing is often at a coarser resolution than the ocean model
 - Regional coupled models exist but have seen limited implementation
 - e.g. [SCOAR](#), [R-CESM](#) (ROMS-WRF)
- River input/simulating estuaries

Methods

- Use of statistics & AI
 - Improving model parameter values
 - Post processing of model output
 - Surface Forcing
 - Forecast methods:
 - Model analogs
 - Forecasts obtained from analogs in previous model simulations
 - Can be used for model verification and identifying important processes
 - Linear Inverse Models (LIM)

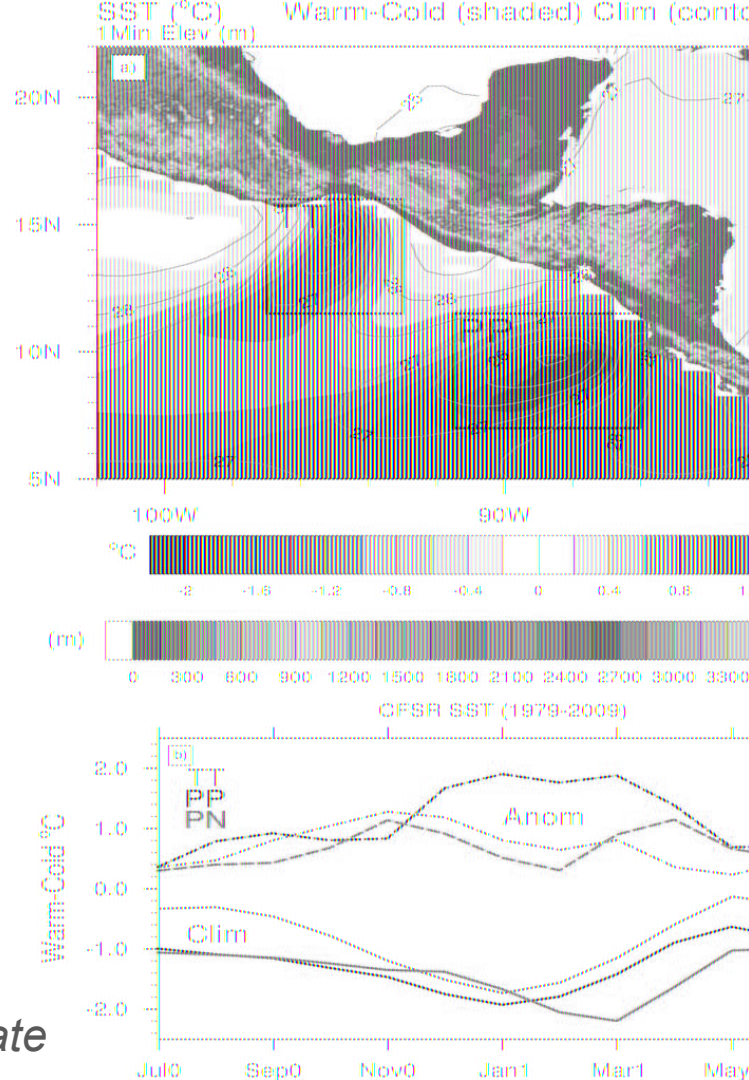
Analog forecast skill 3-month lead



Science: Large-Scale => Coastal

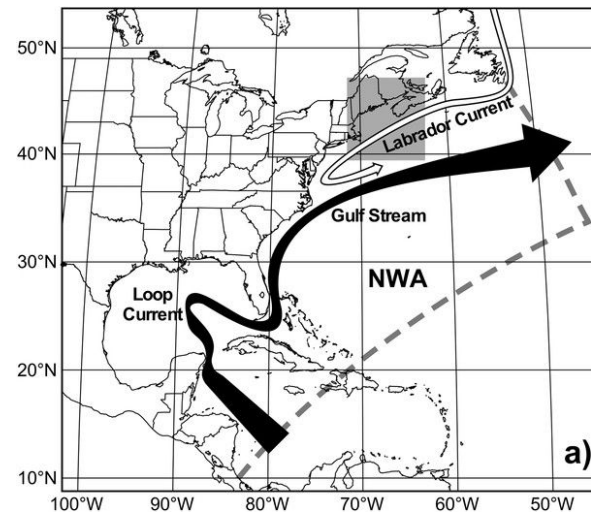
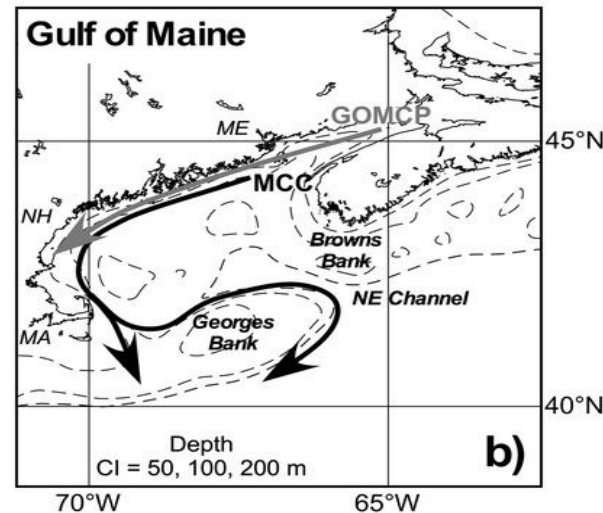
- ENSO
 - Wind driven upwelling
 - Coastally trapped waves
 - From the tropics
 - Wind driven
 - Heat Fluxes (atmospheric bridge)
 - More important offshore
 - Gulf of Mexico & Atlantic, importance?
 - Impact on 3D structure/higher order modes
- Influence: fronts, eddies, coastal currents
- Role of Climate change
 - buoyancy frequency => Wave speed
 - Is there a Change in distribution in addition to the mean change => extremes

[Alexander et al., 2012](#), *J. Climate*



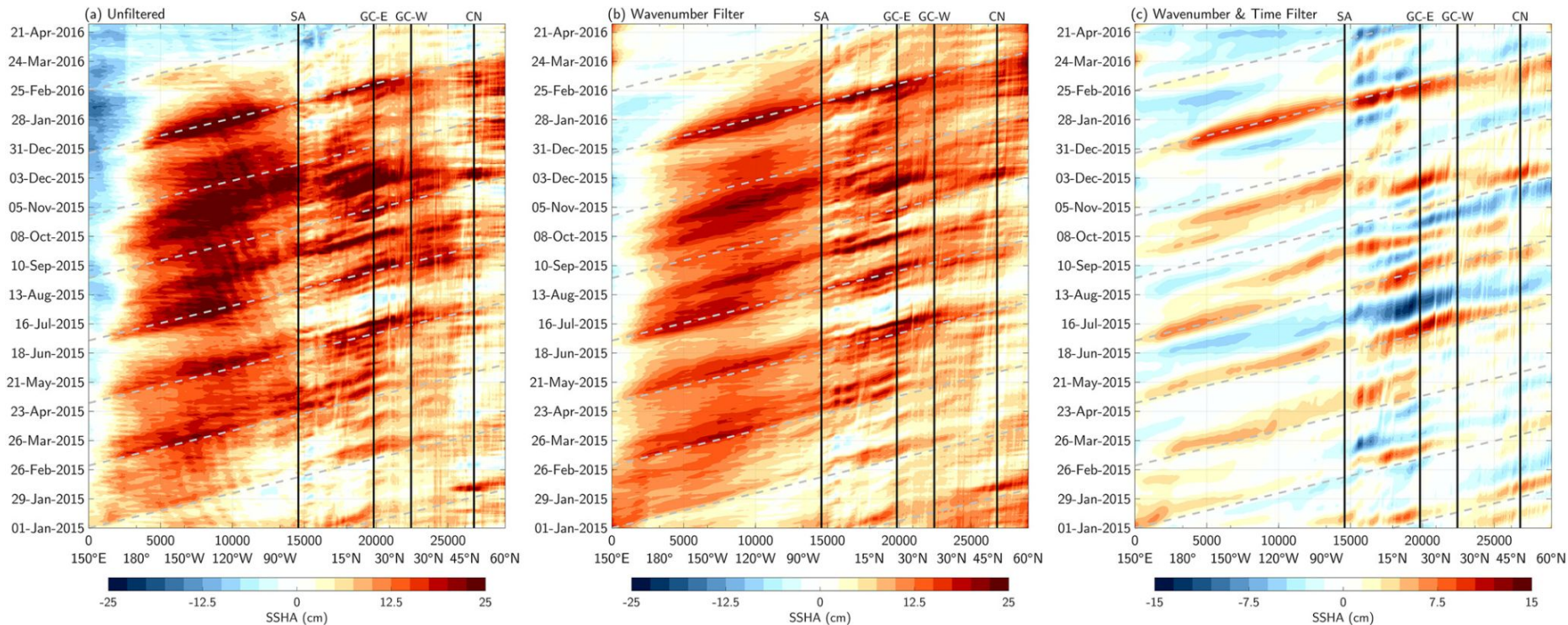
Science

- Multiple factors influencing variability
 - Competing current systems
 - Advection: $V \cdot \nabla T'$ in addition to $V' \cdot \nabla T$
 - Eddy shedding => coast
 - GS, Loop current
 - Vary by depth
 - Interaction with bathymetry
 - Tides important for ocean state
 - Importance are Rossby waves and southward propagating Kelvin waves on the shelf?
 - NAO forcing
 - Process understanding not necessarily leading to predictability.



Challenging Climate!

GLORYS SSH along the equator and US west Coast



Forecast skill Kelvin wave intensity (SSH) from European Center S2S forecasts

