# Oceanic Response to Diurnal Forcing in the Gulf of Mexico: Observations and Models

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# Outline

- Introduction
  - Motivation
  - Goals
- Observations
  - Data/Methods/Results
- Numerical Simulations (D.C. Smith)
  - Model setup
  - Result
- Conclusions

# Diurnal Cycling

- Largest non-storm induced currents on shelf (LATEX observations) (> 60 cm/s)
- Observed shelf-wide and deep Gulf
- Near-surface currents of 24-hr period
- Inertial period (latitude is 30°N) and diurnal sea breeze forcing are near-resonant
- Seasonal (summertime)

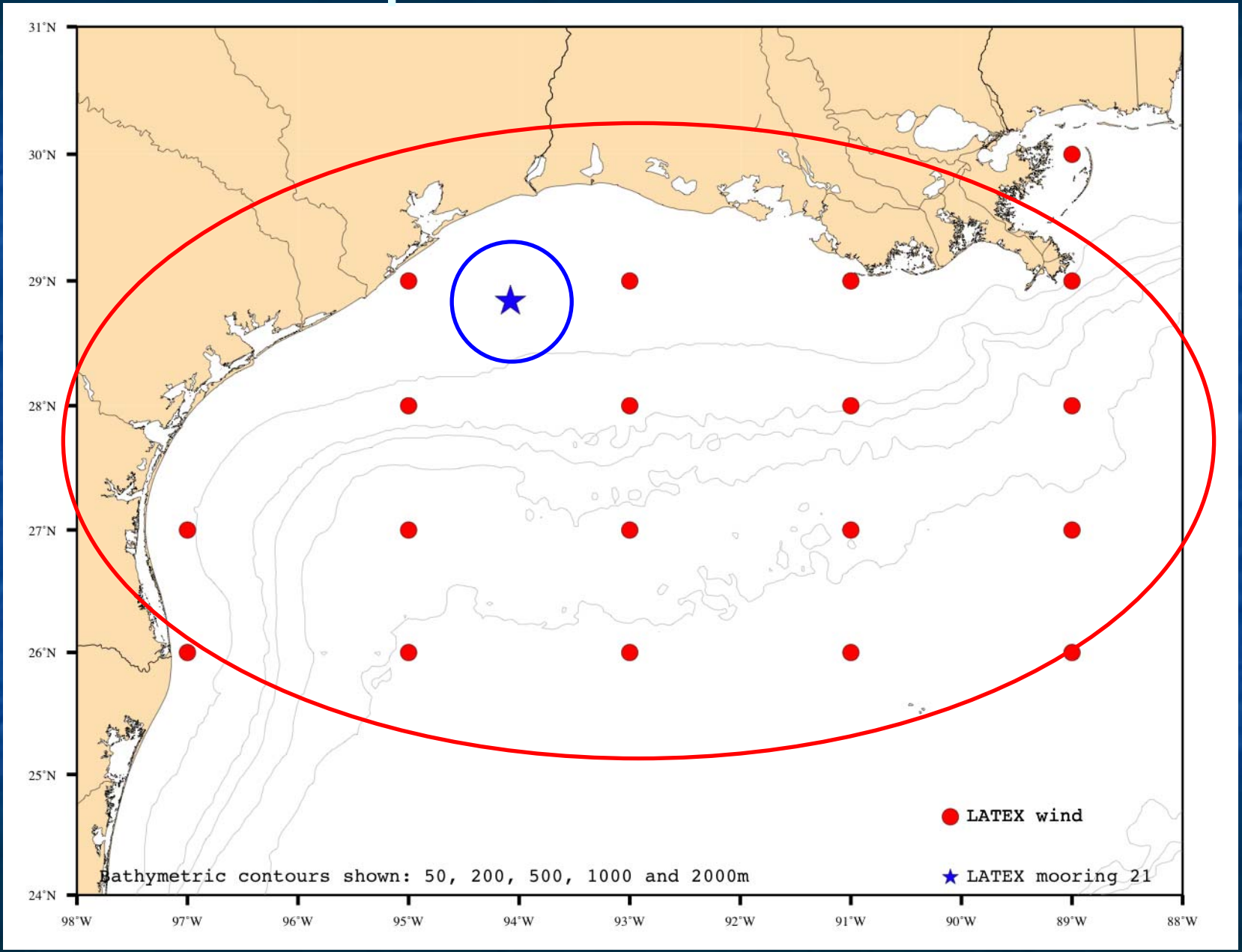
# Study Objectives

- Explore mechanisms that lead to summer enhancement of diurnal currents
  - Winds
  - Stratification
  - Solar insolation
- Investigate role of curved coastline on sea breeze
- Idealized and realistic numerical modeling investigations
  - Vertical structure of currents, density and mixed layer thickness

# Part 1. Observations

- Wind Forcing
  - LATEX gridded wind product
    - Spatial distribution of diurnal wind ellipses
- Oceanic response
  - LATEX mooring 21 current measurements
  - LATEX mooring 21 salinity measurements

# Basemap for All the Stations



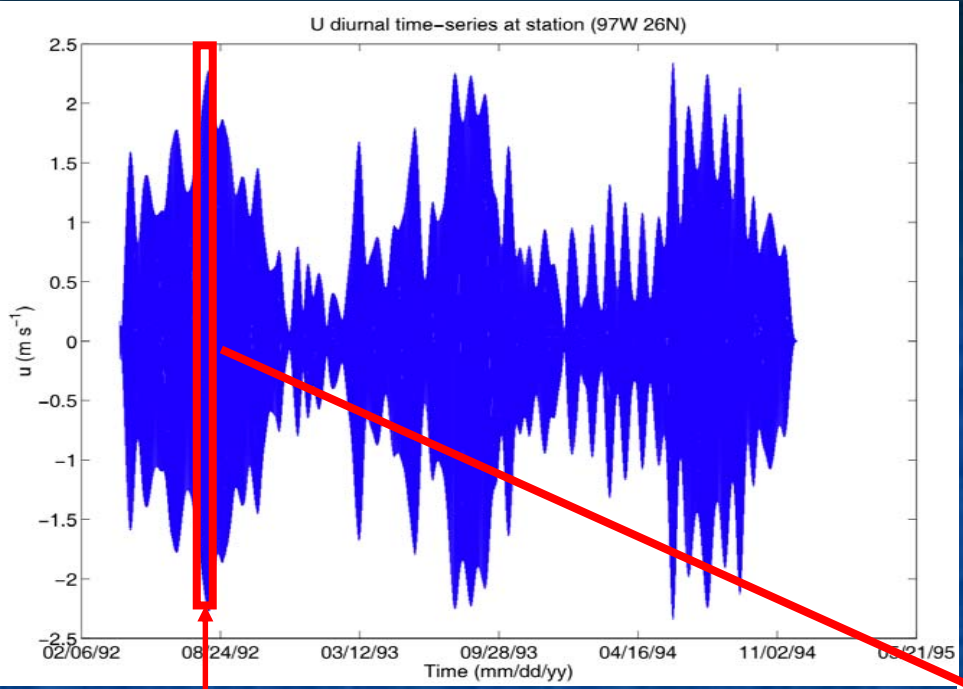
# Methods

- Tidal analysis
  - 8 constituents (method of cyclic descent)
- Band-pass filter
  - Butterworth digital filter
- Wavelet analysis
  - Morlet wavelet

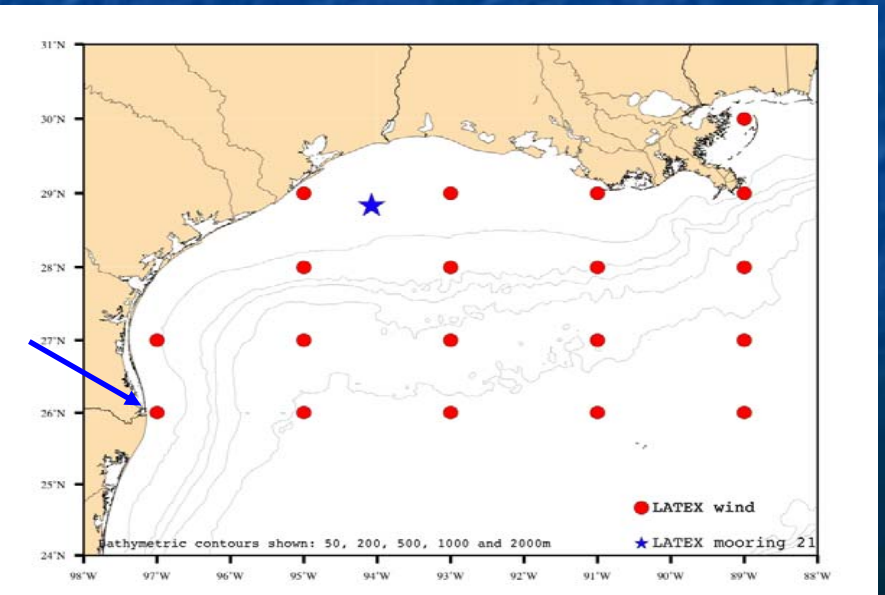
# 1. Diurnal wind ellipses from the LATEX gridded wind product

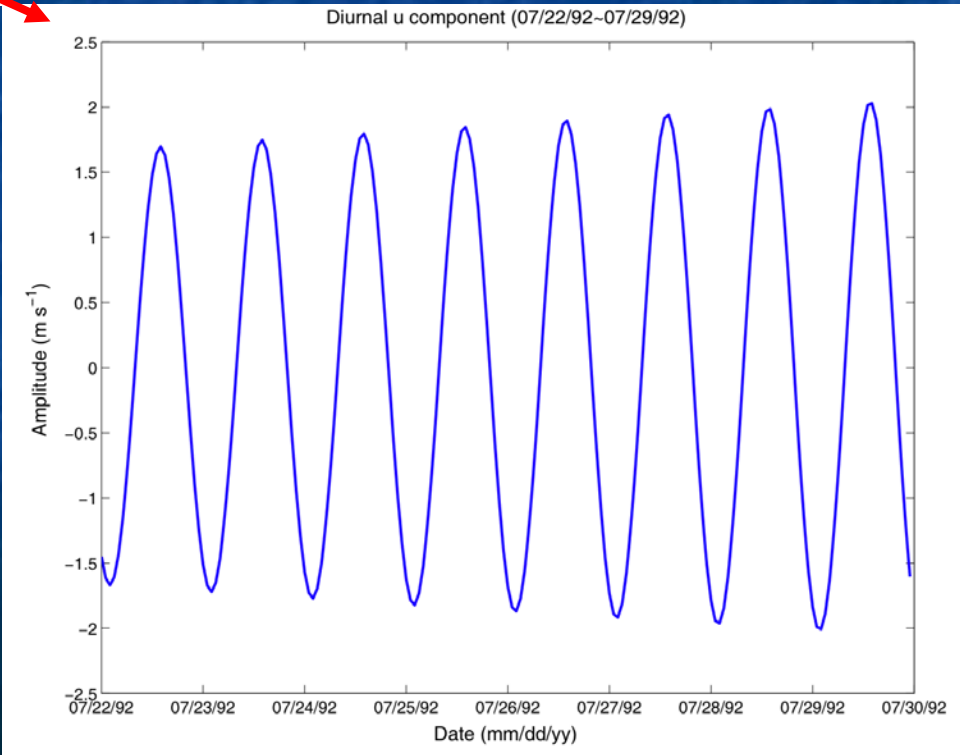
# LATEX Gridded Winds

- Station (97W 26N)
  Wind u component
- Three years
  (Apr. 1992~Nov.1994)
- Butterworth digital band-pass filter (0.95~1.05 cpd)

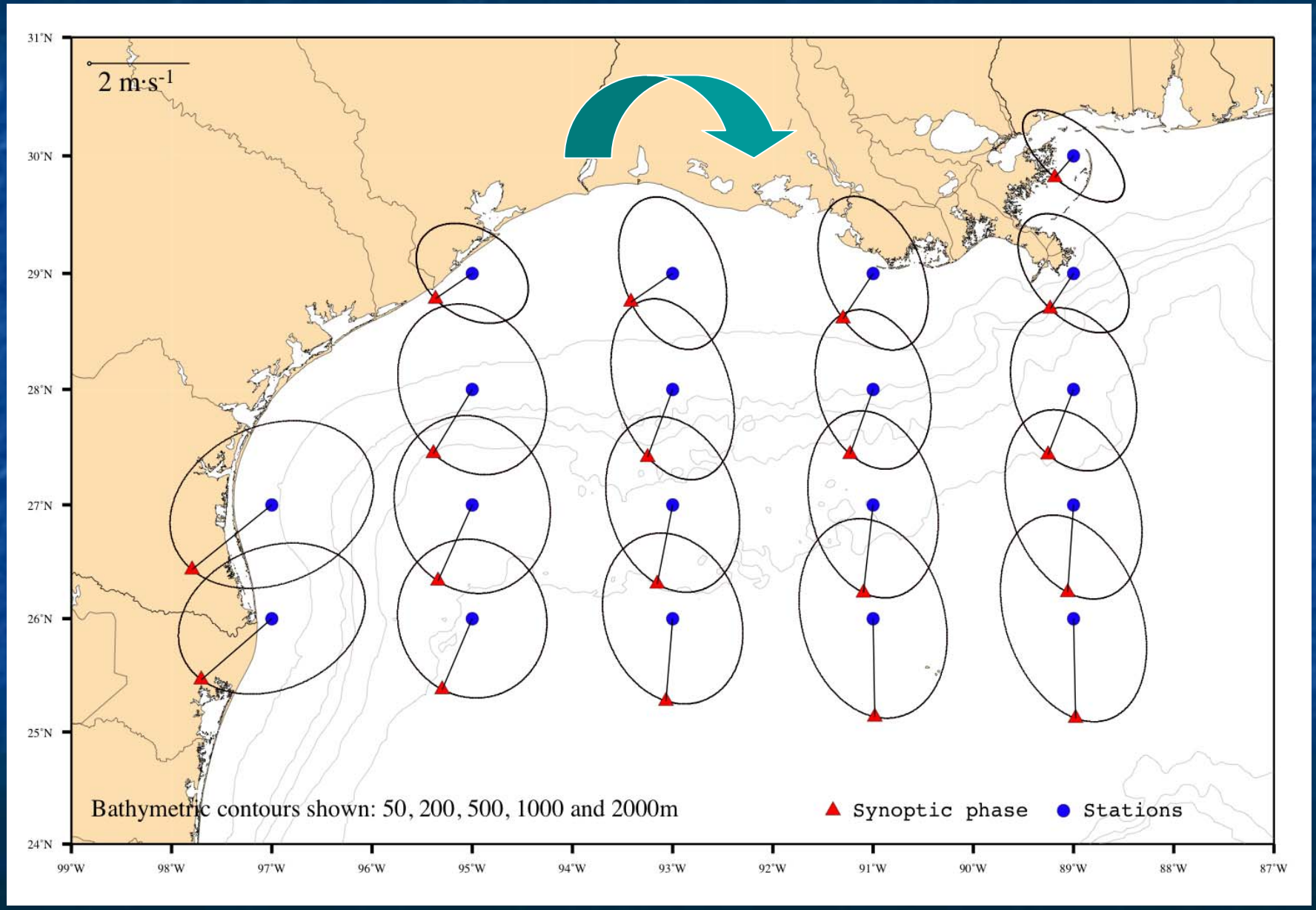



07/22/92~07/29/92

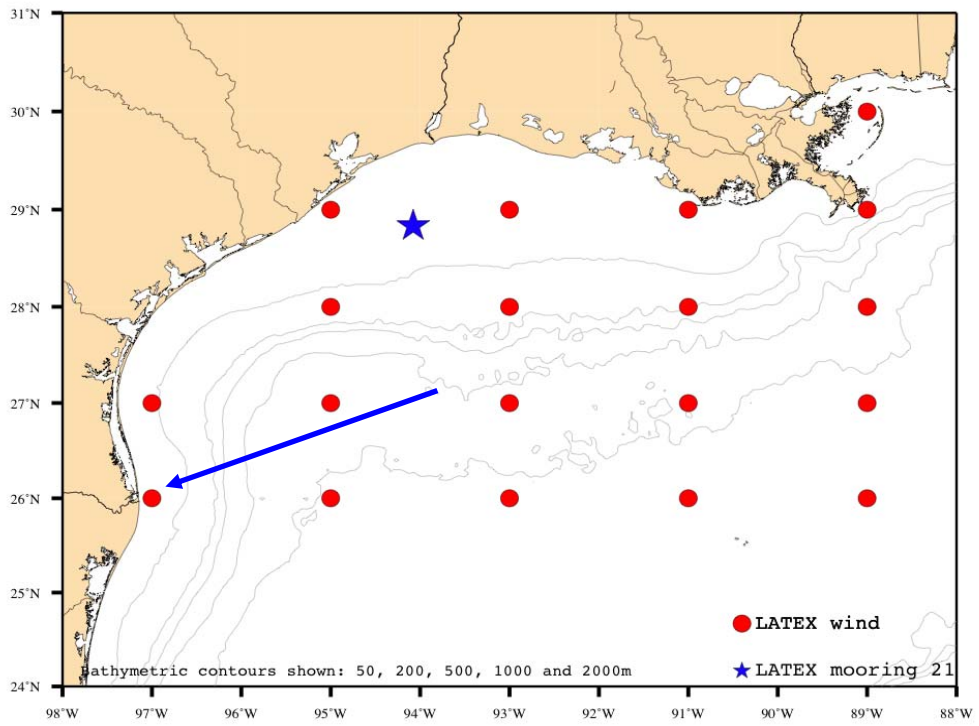


# Diurnal Wind Ellipses Calculated from the LATEX Wind data (Period: 07/22/92~07/29/92)



# 2. Temporal evolution of diurnal wind energy

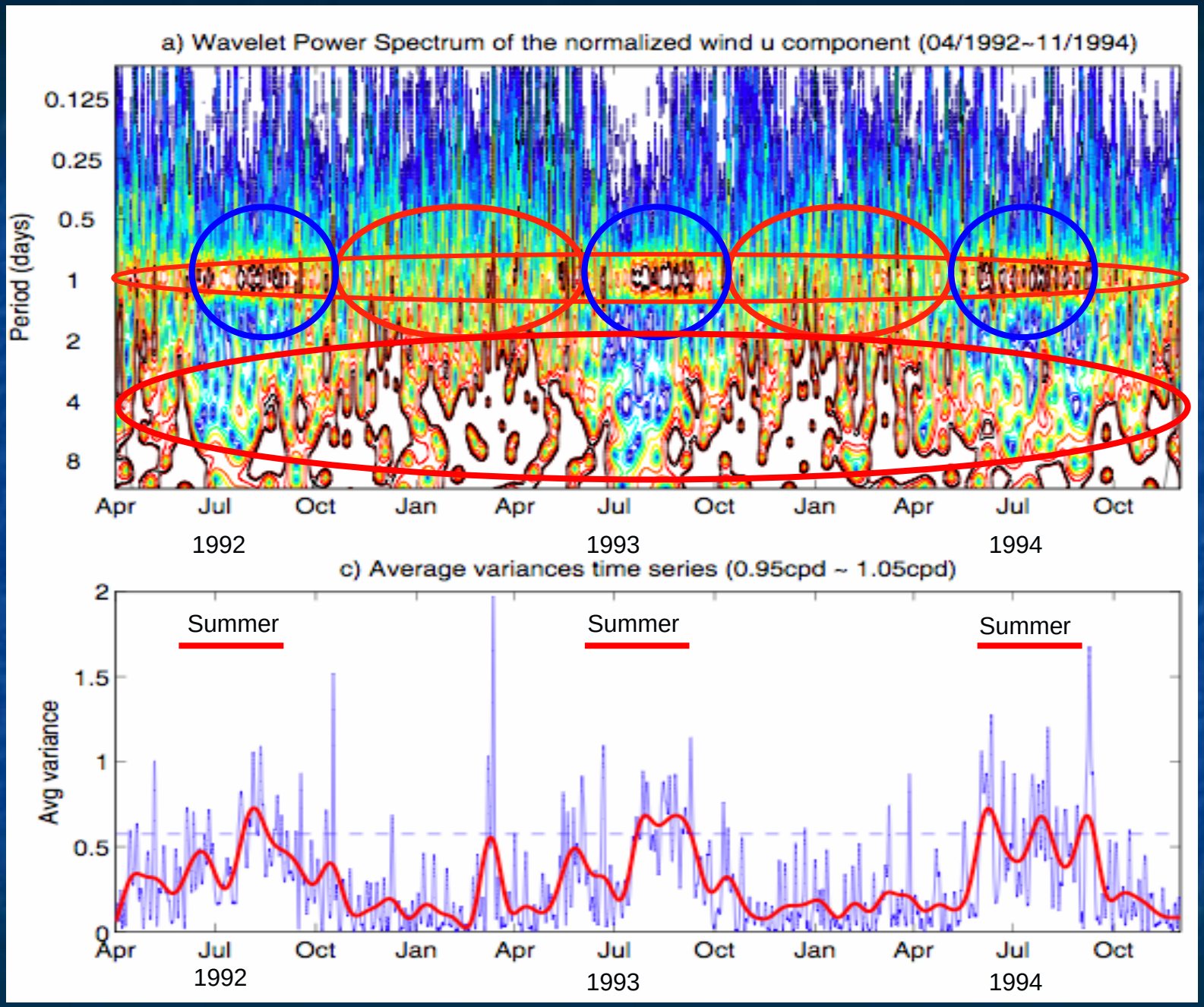


## Fourier Spectrum

- Assume the timeseries is stationary
- Decomposing a timeseries into frequency space only

## Wavelet Spectrum

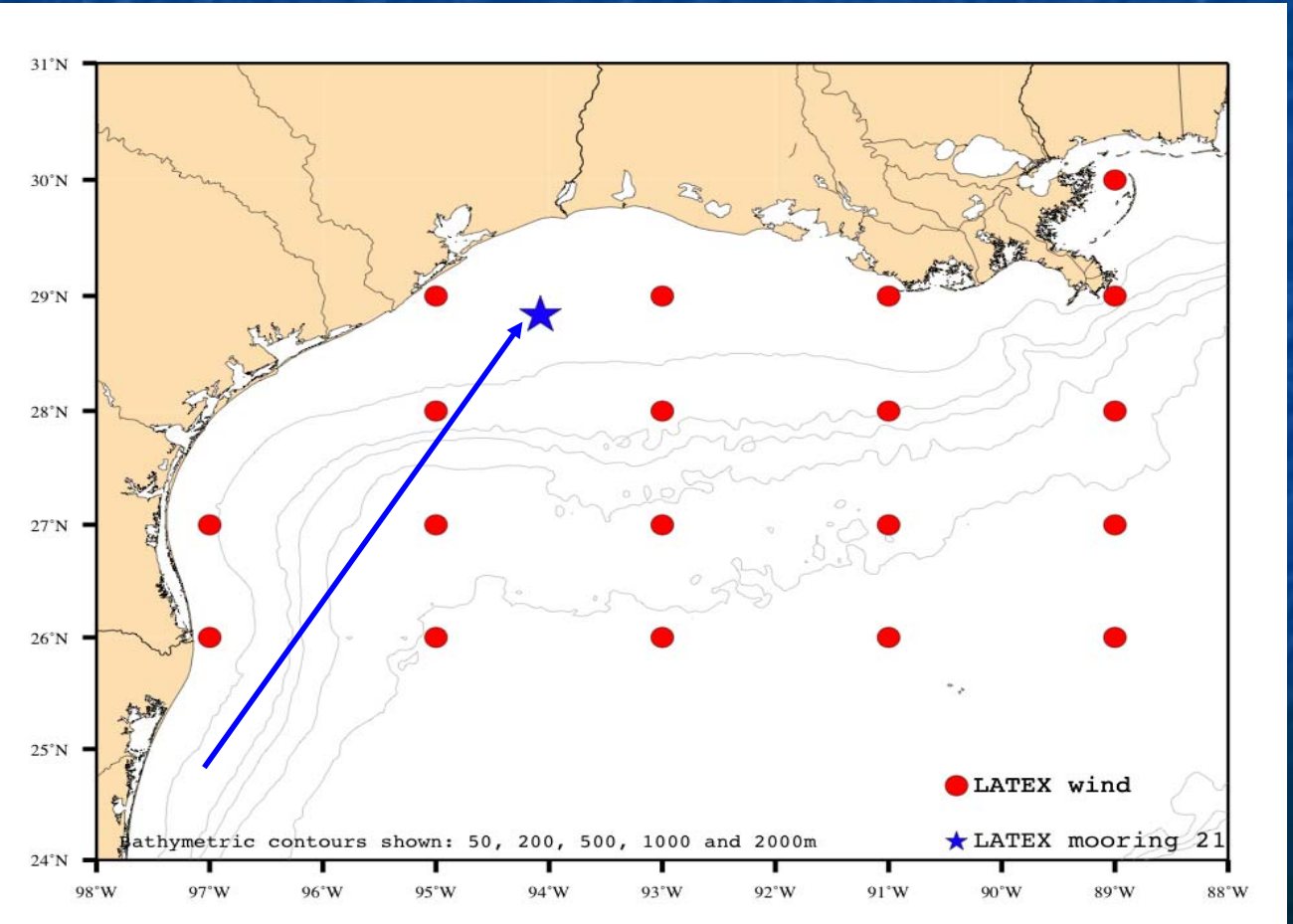
- Non-stationary timeseries
- Decomposing a timeseries into time/frequency space simultaneously
- Temporal evolution of spectral components



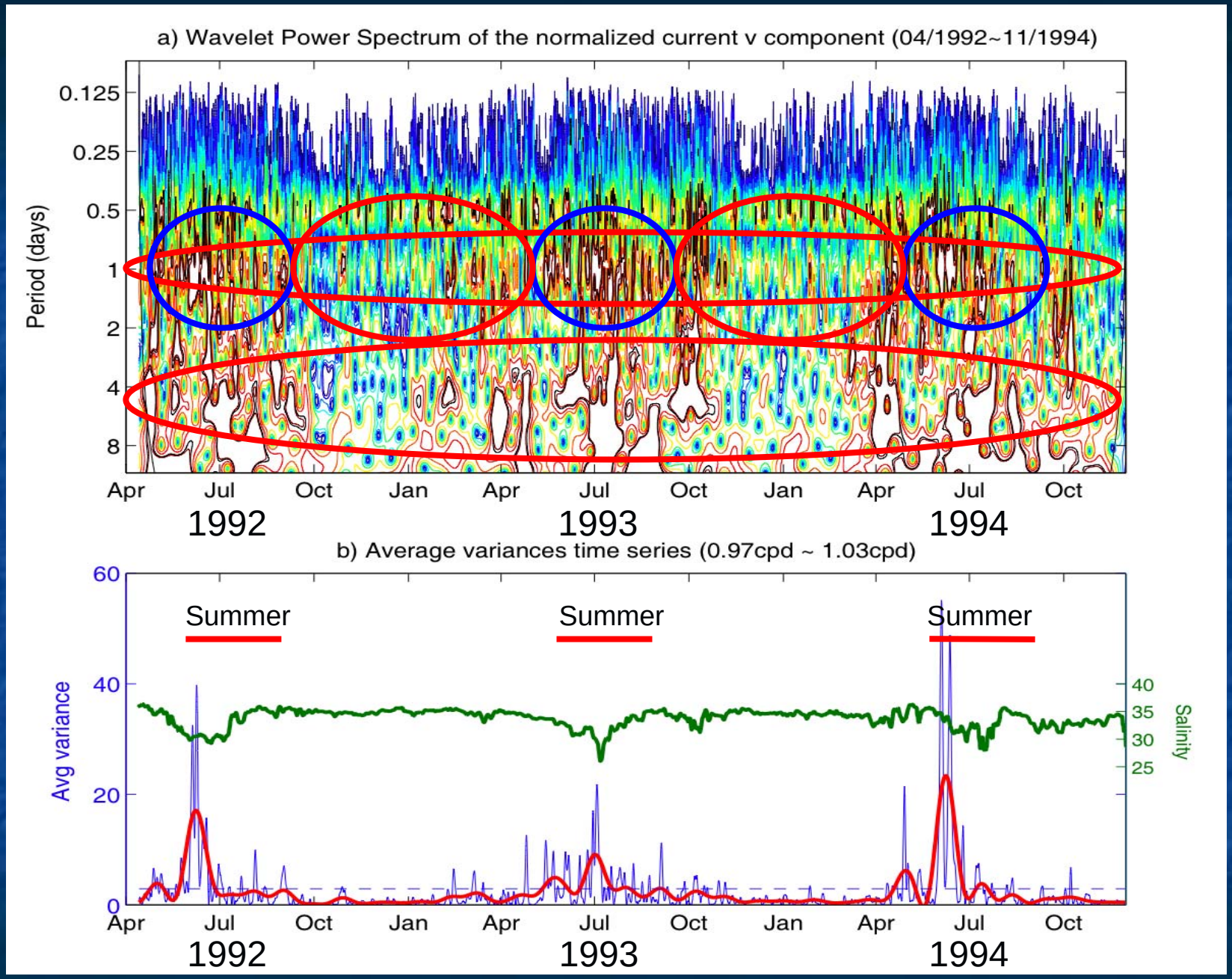

Wavelet of u component (LATEX wind product) at 97W 26N

# 3. Current Observations and Oceanic Response to Diurnal Forcing

Mooring 21 from the LATEX project




94.1° W
28.8° N




Wavelet of v component (current) at mooring 21 (instrument depth 14 m)

# Conclusions

- Diurnal winds (sea breeze)
  - Extend far offshore (> 300 km)
    - Not trapped to coast
  - Phase propagates offshore
- Ocean Response
  - Peak diurnal currents in summer combination of three forcings
    - Summer sea breeze (maximum June-August)
    - High freshwater occurrence offshore (maximum late June)
    - Maximum insolation (solstice)
  - HOWEVER weather band (2-10 day) currents also peak in summer coincident with high freshwater input although the weather band wind forcing is weak.

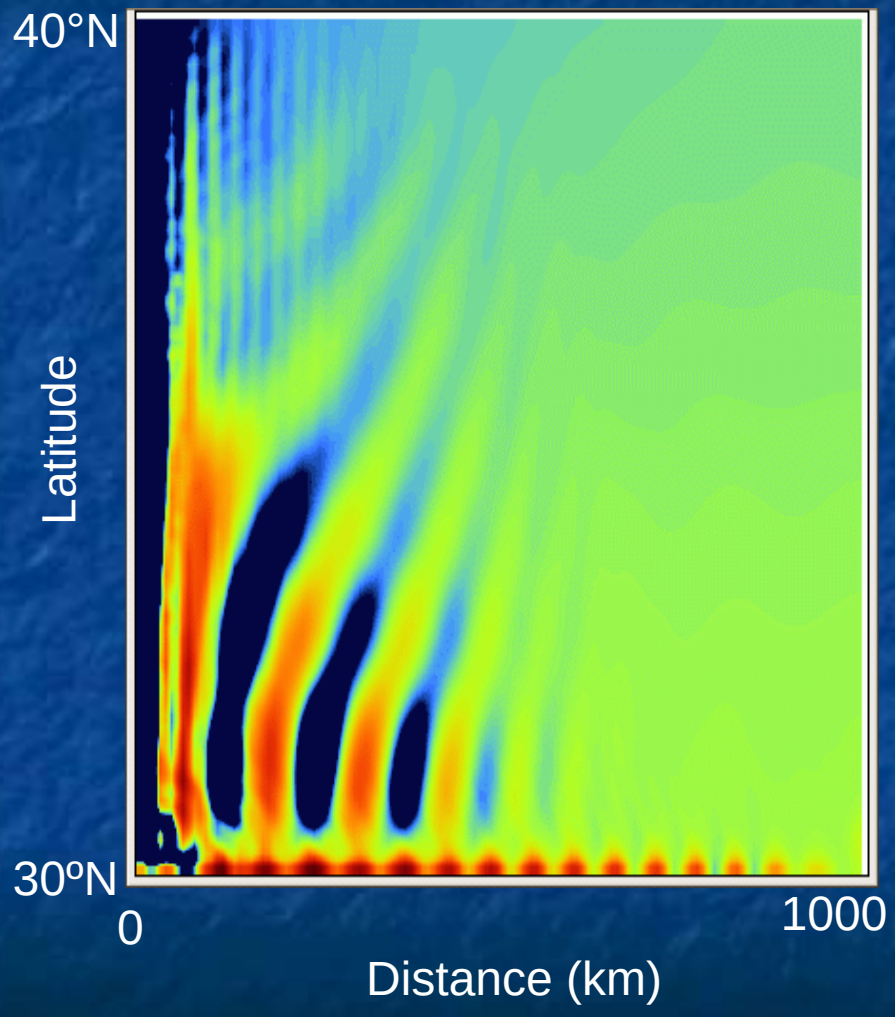
# Part 2. Numerical model

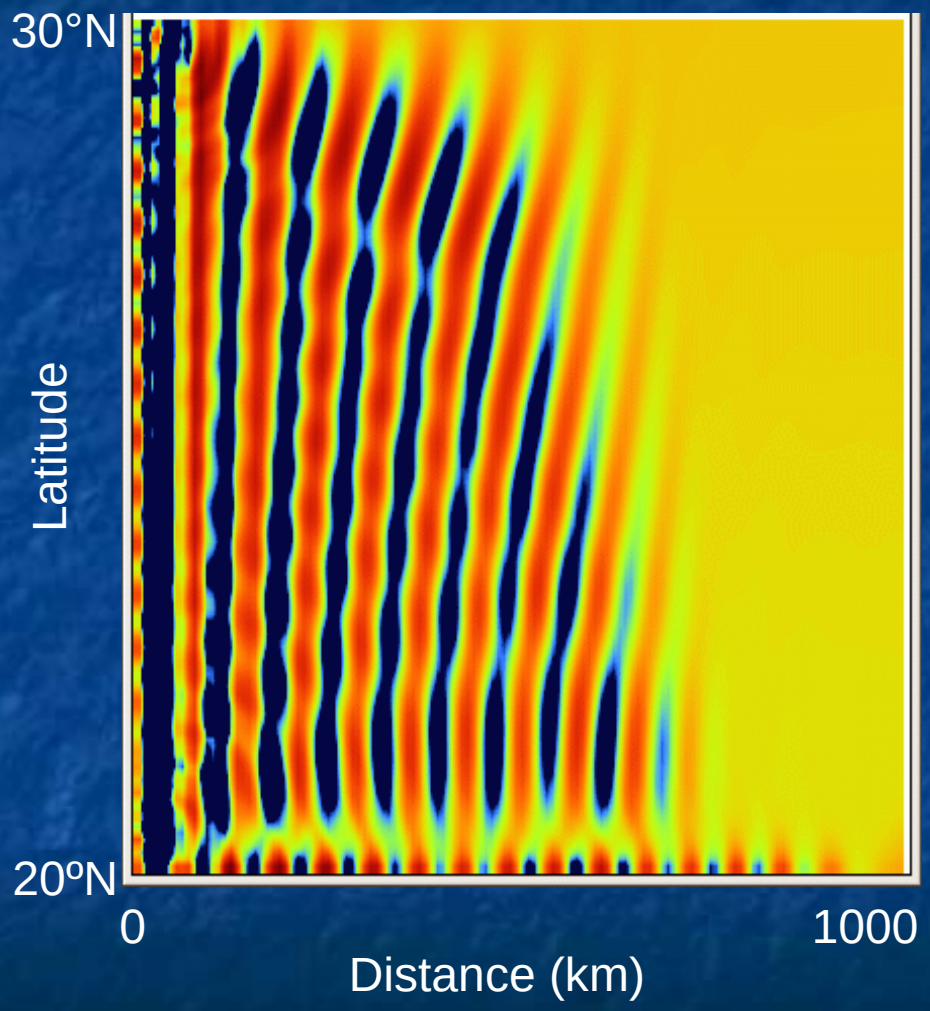
- Idealized and Realistic
  - ROMS – Regional Ocean Modeling System
- 30 levels in vertical
- Curvilinear grid ~ 5 km resolution
- Diurnal wind forcing – coastal strip 100km wide
- No other forcing

# Model Results

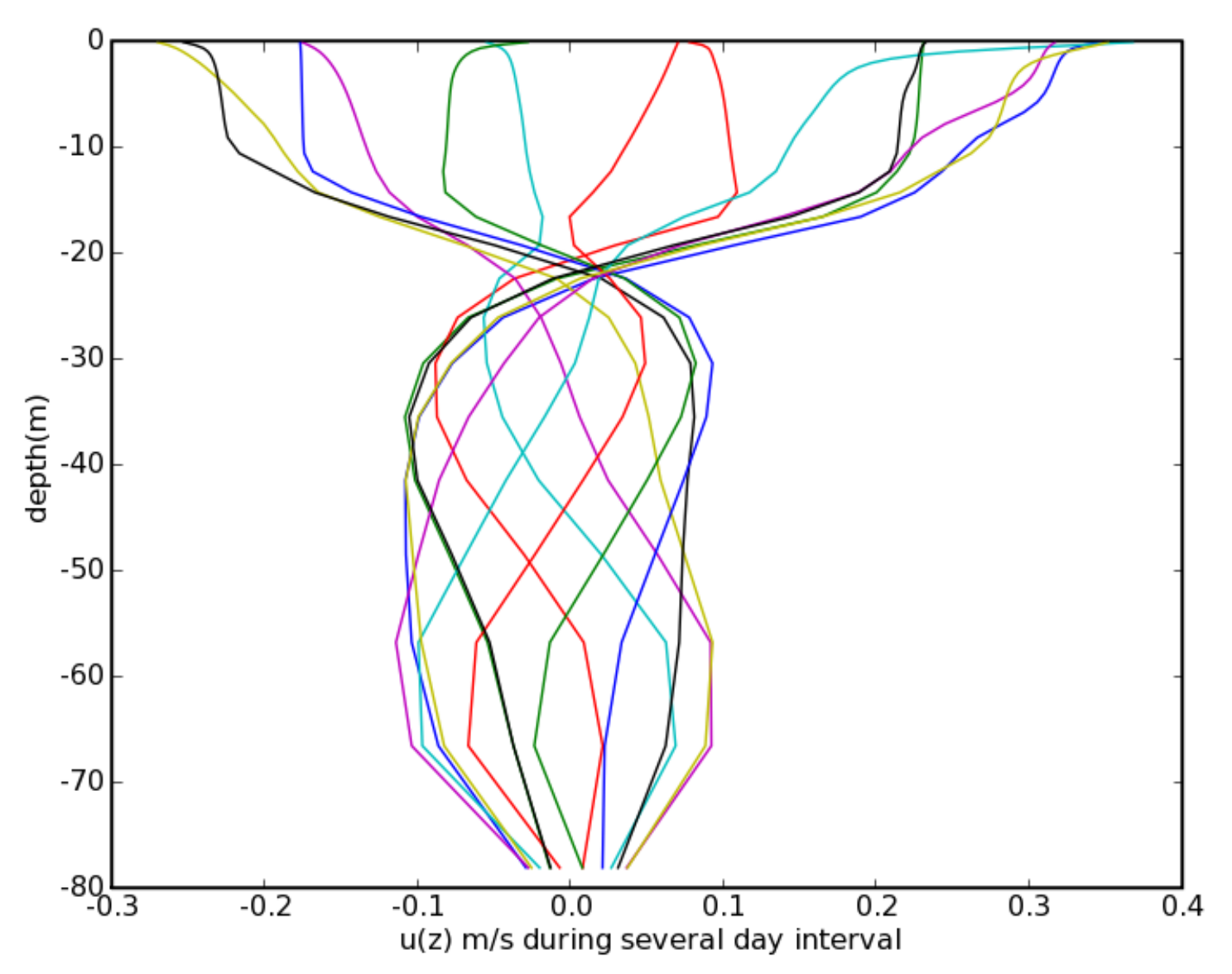
- Response is geographically variable
- Not stationary on shelf
- Resulting wave field controlled by latitude and bathymetry curvature
- Propagating inertial gravity waves strongest in SW Gulf
- Mixed layer depth response to waves also geographically variable

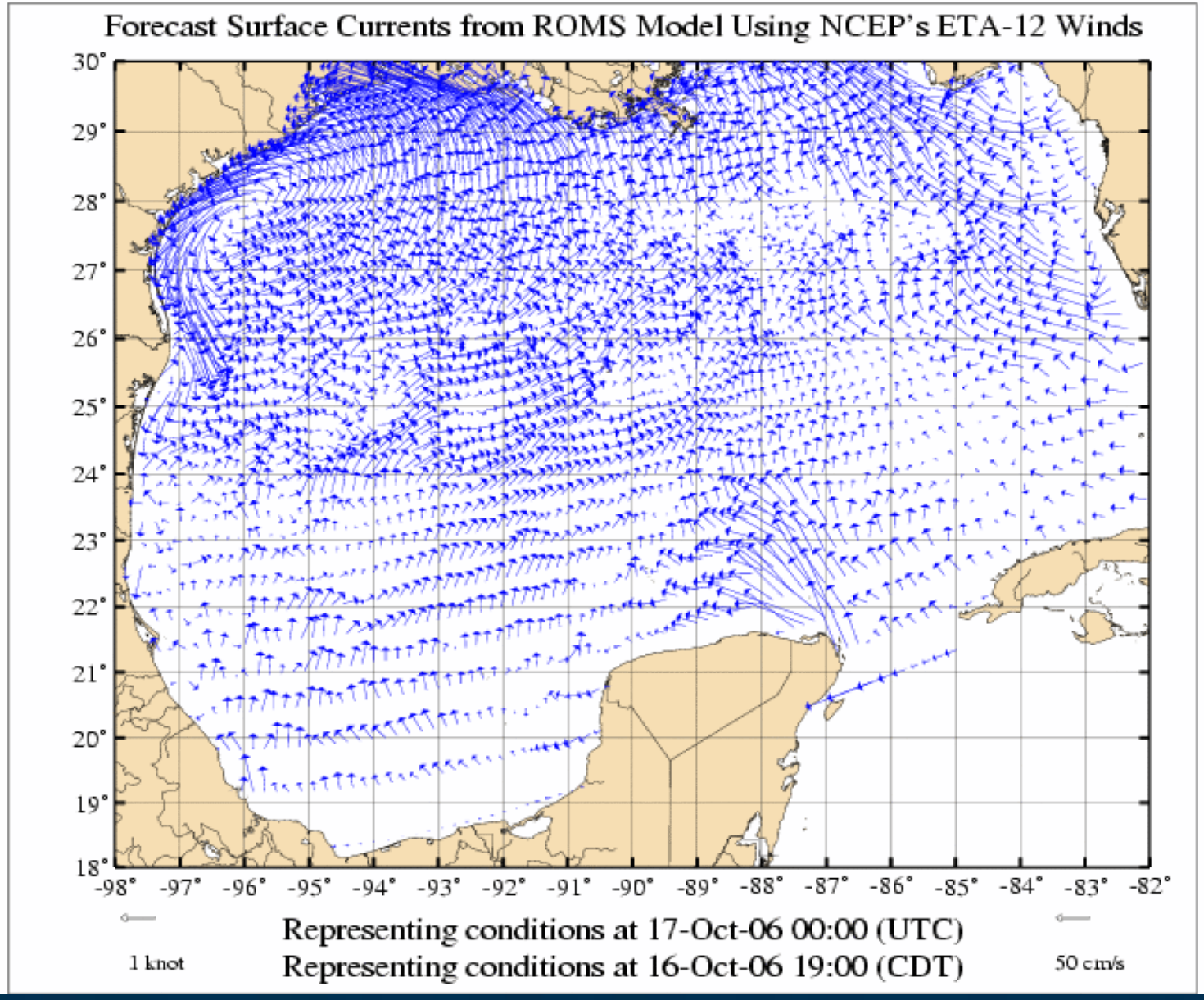
# Sea Surface Height (Day 10 Idealized Case)



# Velocity Profile




Forecast Surface Currents from ROMS Model Using NCEP's ETA-12 Winds
30°
29°
28°
27°
26°
25°
24°
23°
22°
21°
20°
19°
18°
-98° -97° -96° -95° -94° -93° -92° -91° -90° -89° -88° -87° -86° -85° -84° -83° -82°
1 knot
Representing conditions at 17-Oct-06 00:00 (UTC)
Representing conditions at 16-Oct-06 19:00 (CDT)
50 cm/s

# Conclusions

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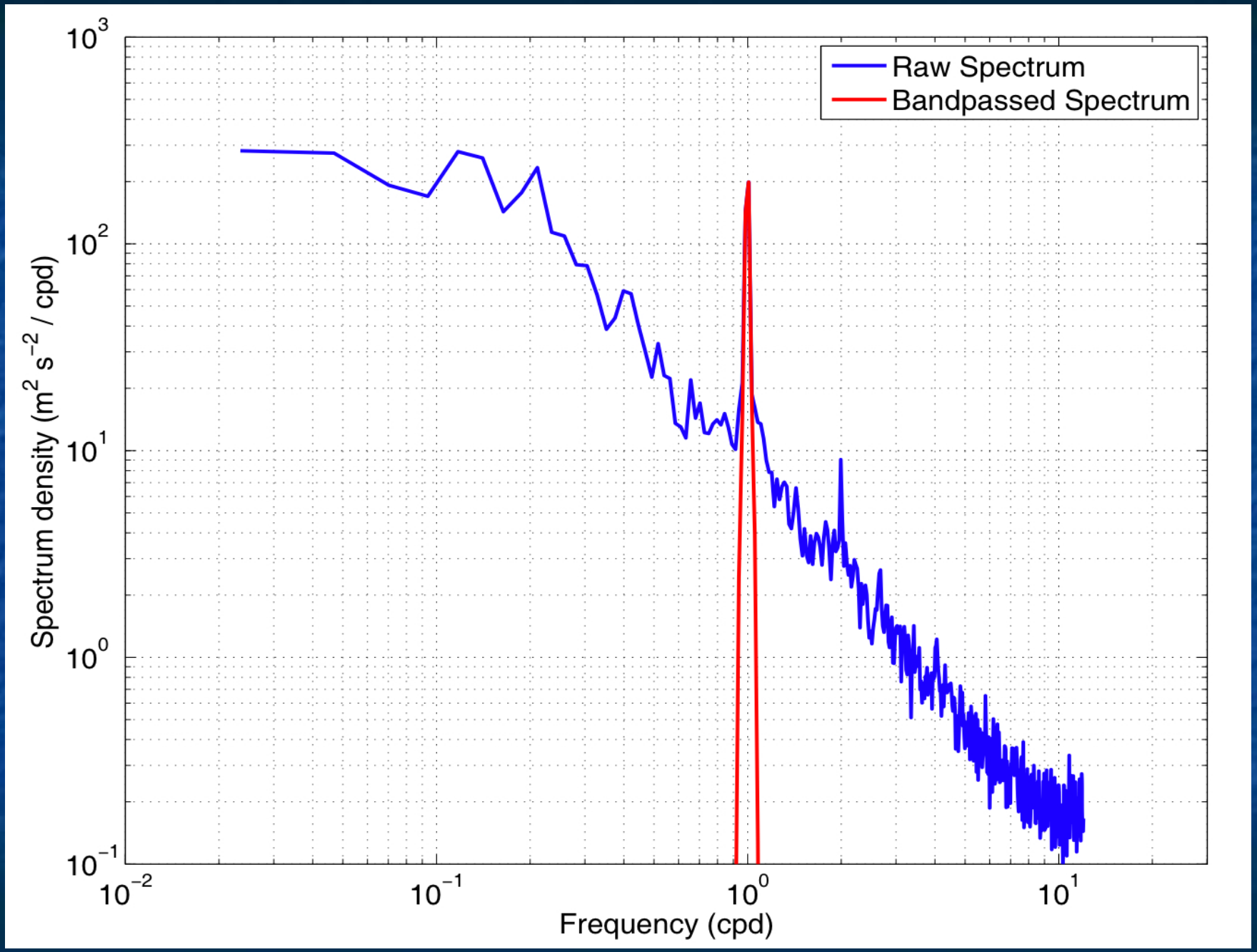
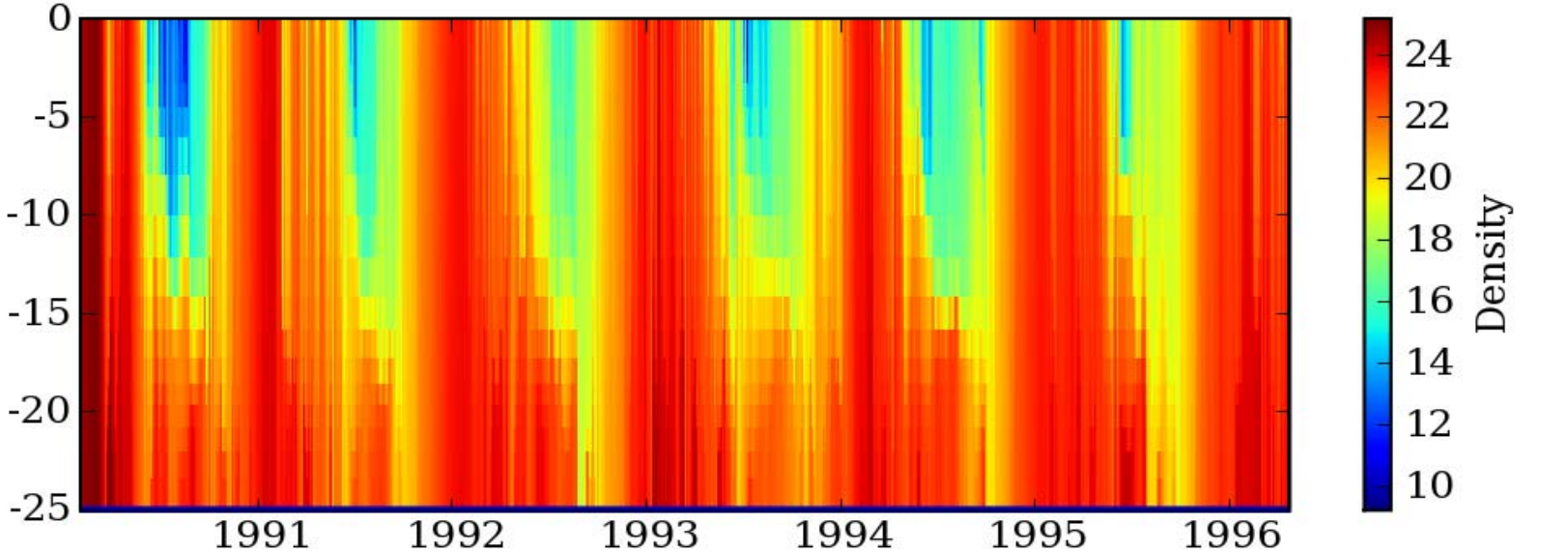
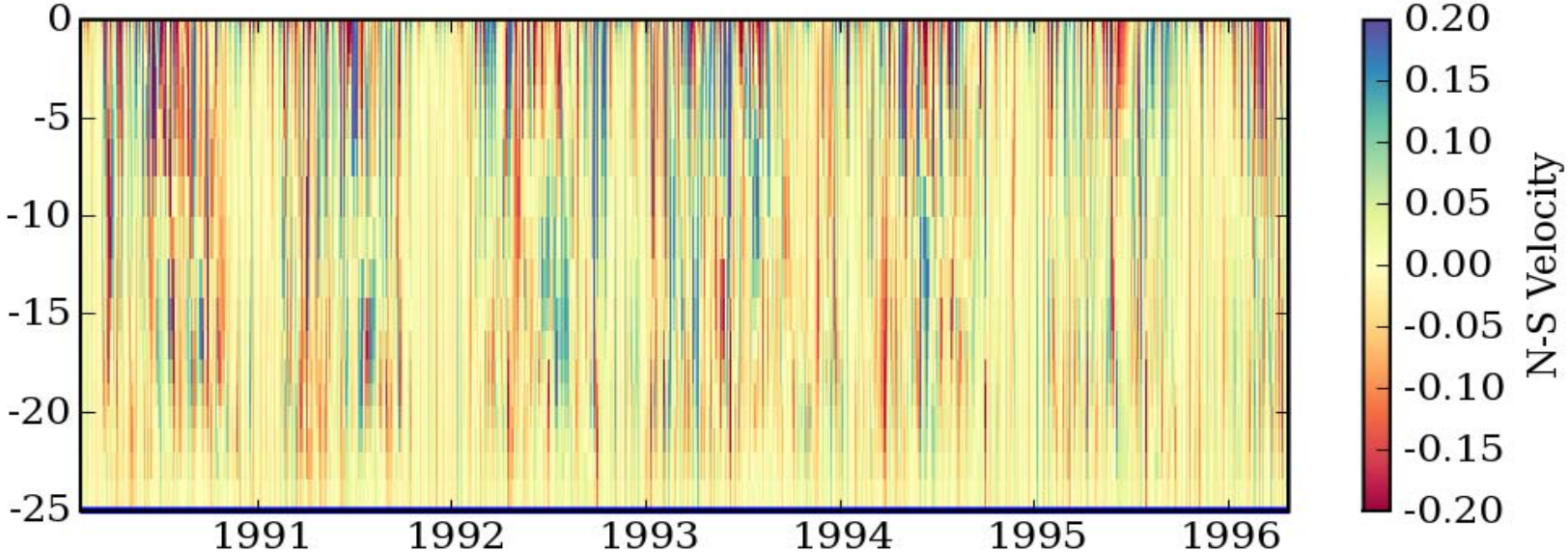
- Modeling
  - Waves intensify south of 30°
  - Wave hot spots due to realistic coastline/topography
  - Southward propagating inertial waves clearly seen Gulf-wide in TABS modeling results.


Raw Spectrum
Bandpassed Spectrum
Spectrum density (m$^2$ s$^{-2}$ / cpd)
Frequency (cpd)
$10^3$
$10^2$
$10^1$
$10^0$
$10^{-1}$
$10^{-2}$
$10^{-1}$
$10^0$
$10^1$


0
-5
-10
-15
-20
-25
1991
1992
1993
1994
1995
1996
24
22
20
18
16
14
12
10
Density


0
-5
-10
-15
-20
-25
1991
1992
1993
1994
1995
1996
0.20
0.15
0.10
0.05
0.00
-0.05
-0.10
-0.15
-0.20
N-S Velocity