Exploiting 15+ Years of HF Radar Surface Current Observations Off Cape Hatteras, N.C. to Examine Gulf Stream Variability

Zaid Al-Attabi[1], Mike Muglia[1], Harvey Seim[2], John M. Bane[2], Magdalena Andres[3], Sara Haines[2], Patterson Taylor[1], and Yubeen Jeong[2]

[1]Coastal Studies Institute, East Carolina University, Wanchese, NC

[2]Department of Marine Sciences, University of North Carolina at Chapel Hill, Chapel Hill, NC

[3]Physical Oceanography Department, Woods Hole Oceanographic Institution, Woods Hole, MA

alattabiz21@ecu.edu, mugliam@ecu.edu, hseim@email.unc.edu

Abstract

The causes and the effects of Gulf Stream (GS) variability are being explored near Cape Hatteras. Because of the large spatial scale of its velocity structure and transport, monitoring the GS is challenging. We are investigating the impacts of GS variability on the circulation and dynamics in the Cape Hatteras region using more than fifteen years of HF radar surface current observations.

Objectives

- Develop a Cape Hatteras Gulf Stream Time Series (CHGSTS) that provides long-duration, high temporal-resolution measures of five GS characteristics which can be utilized to examine GS variability.
- Use CHGSTS to address main questions:
  1) What causes variability in the GS separation position at Cape Hatteras?
  2) How do GS meanders near Cape Hatteras relate to upstream variability in the GS approaching Cape Hatteras along the South Atlantic Bight?
  3) How does GS variability at Cape Hatteras relate to downstream variability in the separated GS, Slope Sea and on the Mid Atlantic Bight shelf?

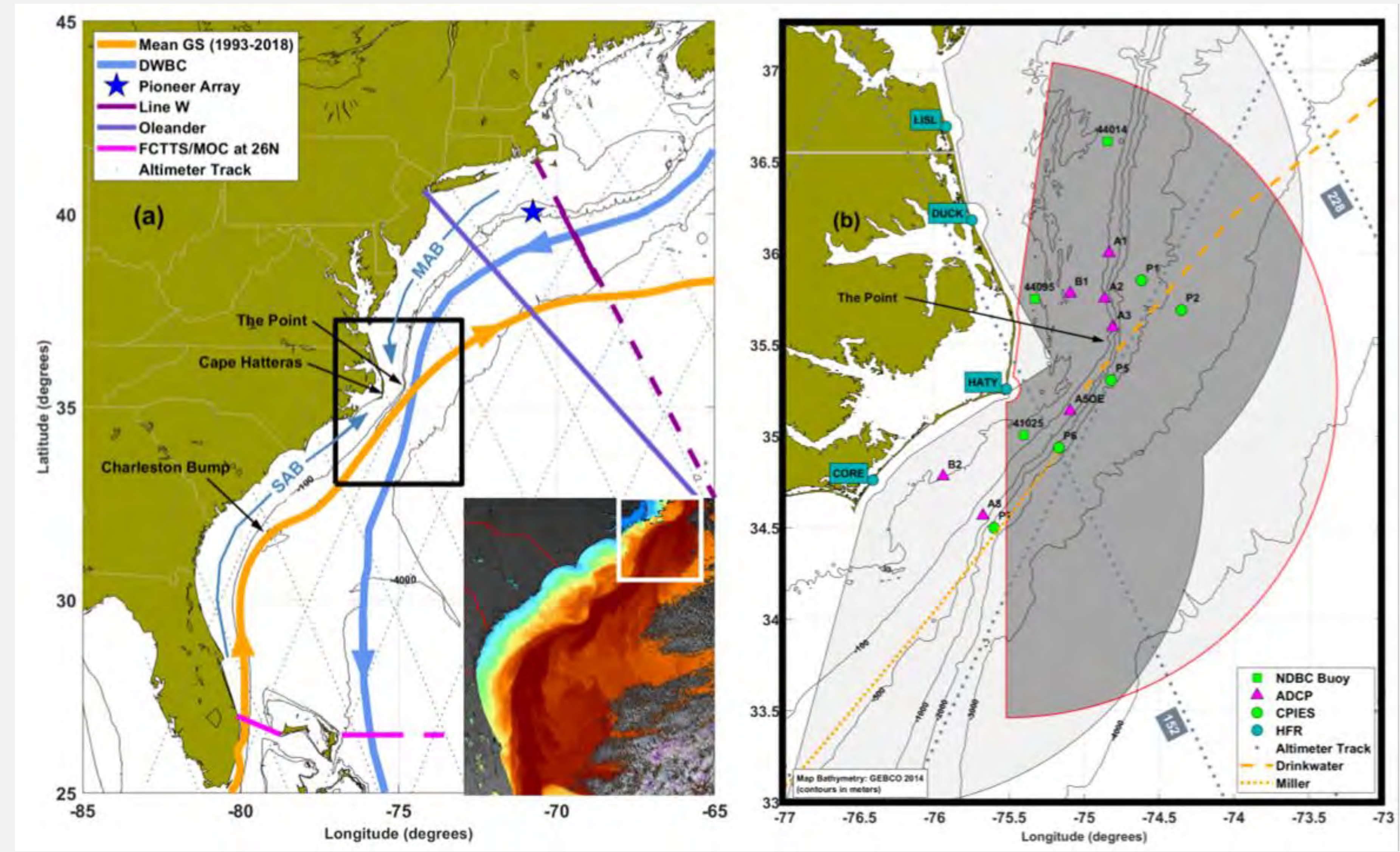
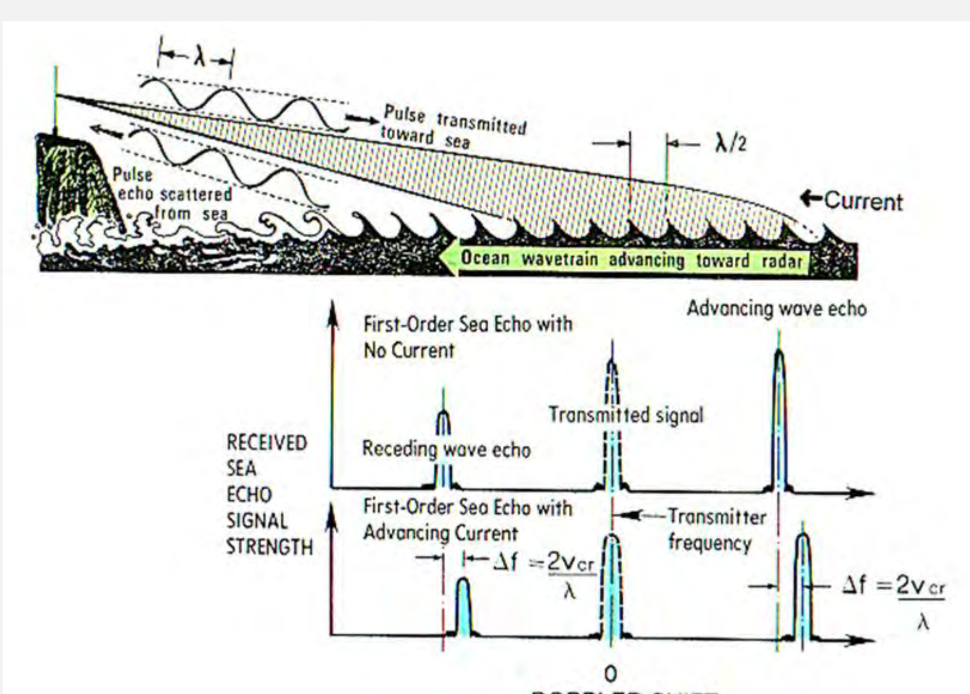
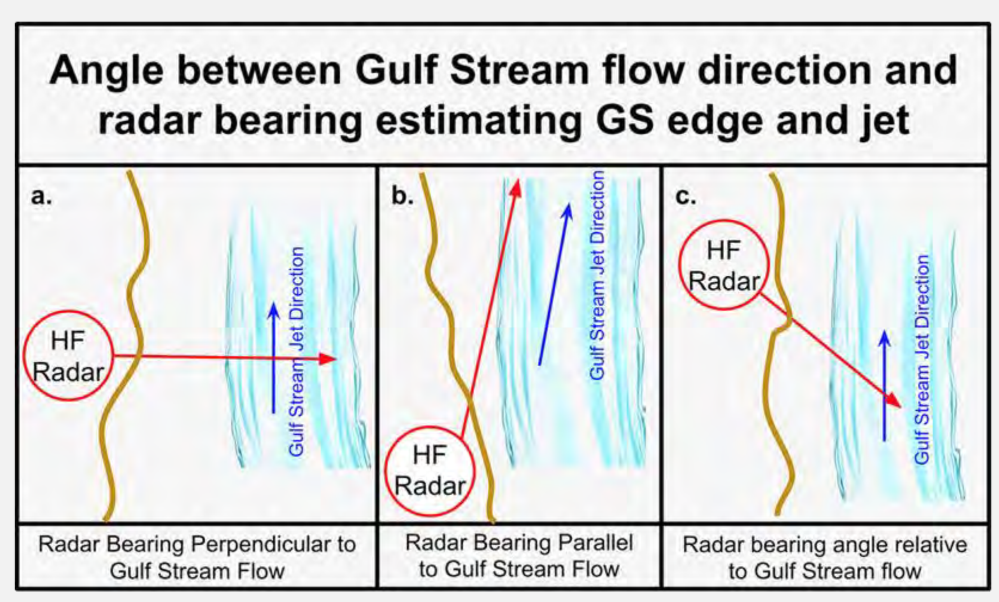


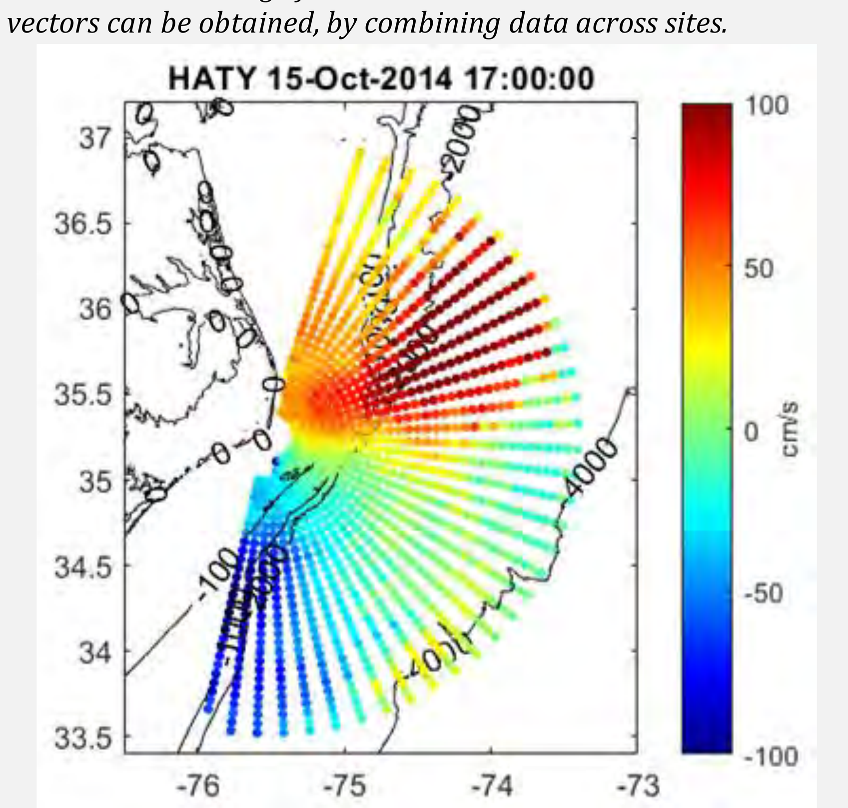
Figure shows Map of NW Atlantic geographic and oceanographic features; the inset SST image from Jan 30, 2003 displays meanders characteristic of the GS in the SAB; the time-mean path of the GS and the DWBC are shown; (b) Map of moored assets and HFR coverage near Cape Hatteras. Light shading indicates HFR radial coverage for 3 HFR sites, with HATY's outlined in red; dark shading indicates maximum area within which total velocity vectors can be obtained, by combining data across sites.

HF Radar

Three 5 MHz HFR at Cape Hatteras are remarkable because the GS falls within their measurement footprint (hourly with spatial resolution of 5.8 km).



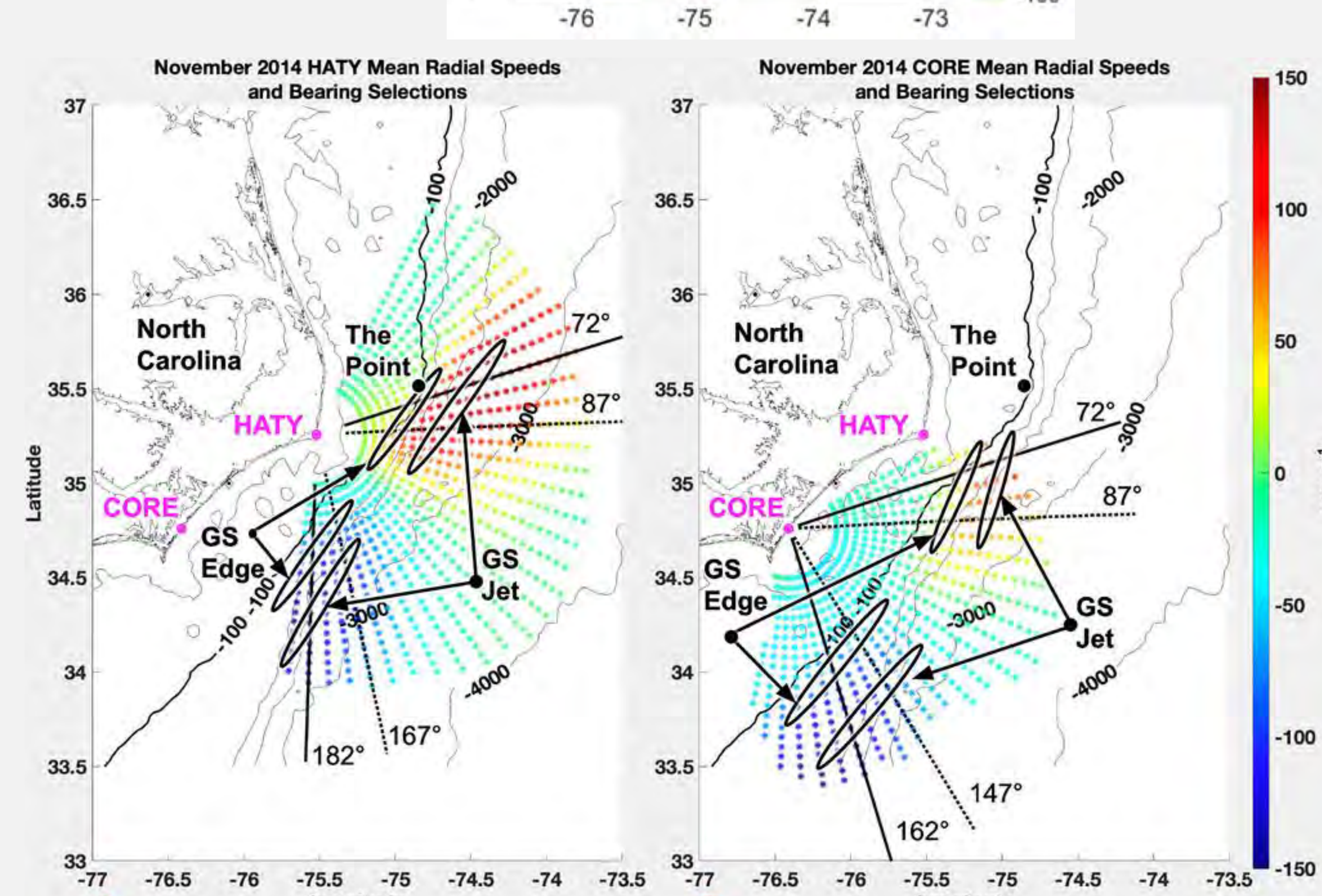




Method

Extract GS characteristics : (1) GS position and path, (2) GS orientation/curvature, and (3) a metric for the width of the GS cyclonic shear zone. (4) the total surface velocity fields and (5) estimates of surface transport.

- Examines radial velocity as a function of range along two selected bearings.
- **GS position**: Find along each bearing (a) the maximum (or minimum) gradient of velocity, associated with the shoreward edge of the GS, and (b) the maximum (or minimum) velocity, associated with the axis of the GS jet.
- **Width of the cyclonic shear zone:** the distance between edge and jet locations on a given bearing is a metric for the width of the cyclonic shear zone.
- **Orientation:** derived from connecting the edges and the jet axis positions from the two adjacent bearings.



Validation and Results

Upstream influence on GS meander properties: Extracting meander properties (cross-slope amplitude, along-stream wavelength, propagation speed) will be based on examining the high-passed CHGSTS (< 14 day periods). We anticipate shifts in meander properties on longer time scales (> 2 week periods) that will relate to the deflection state of the GS at the Charleston Bump.

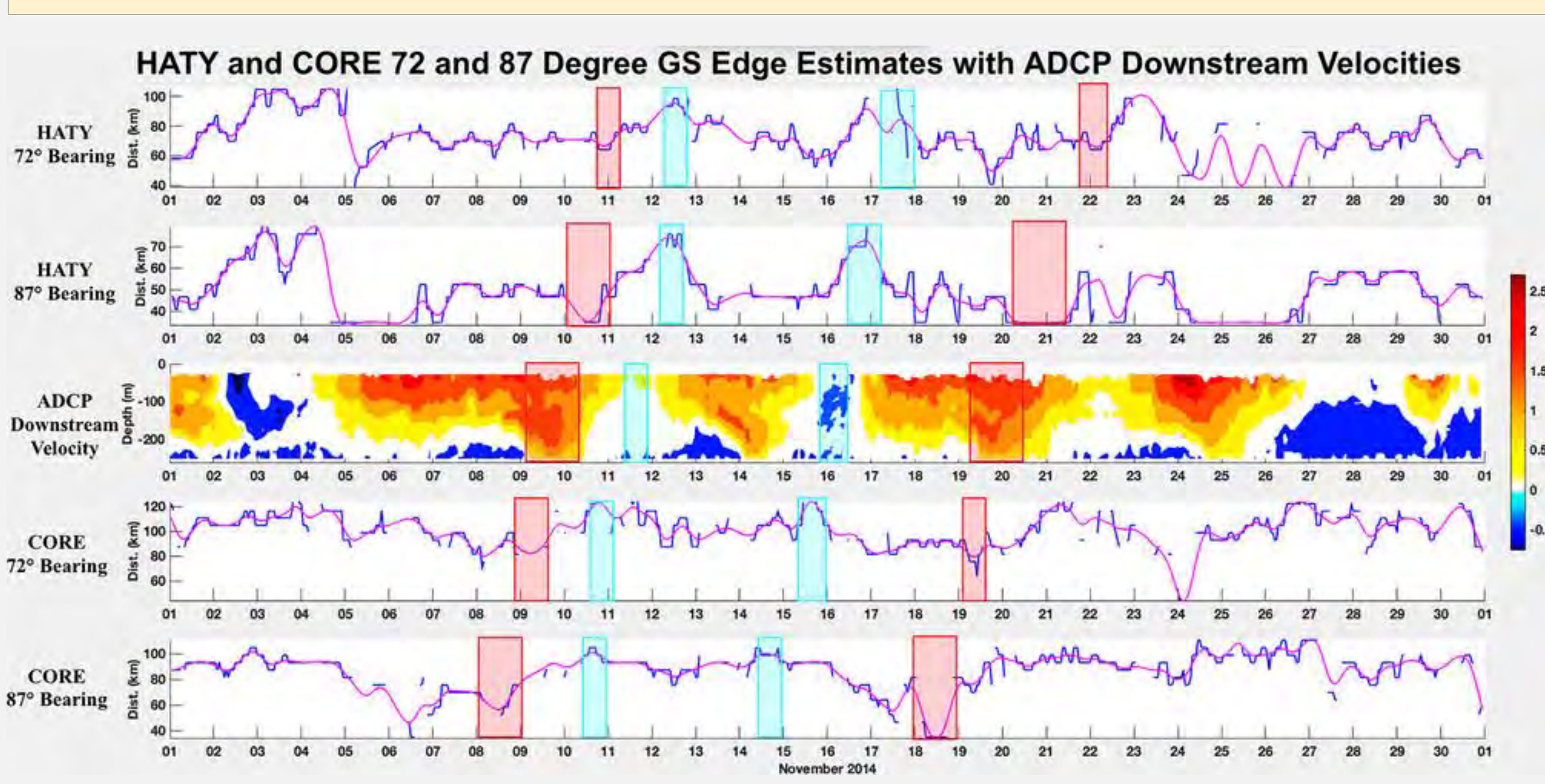
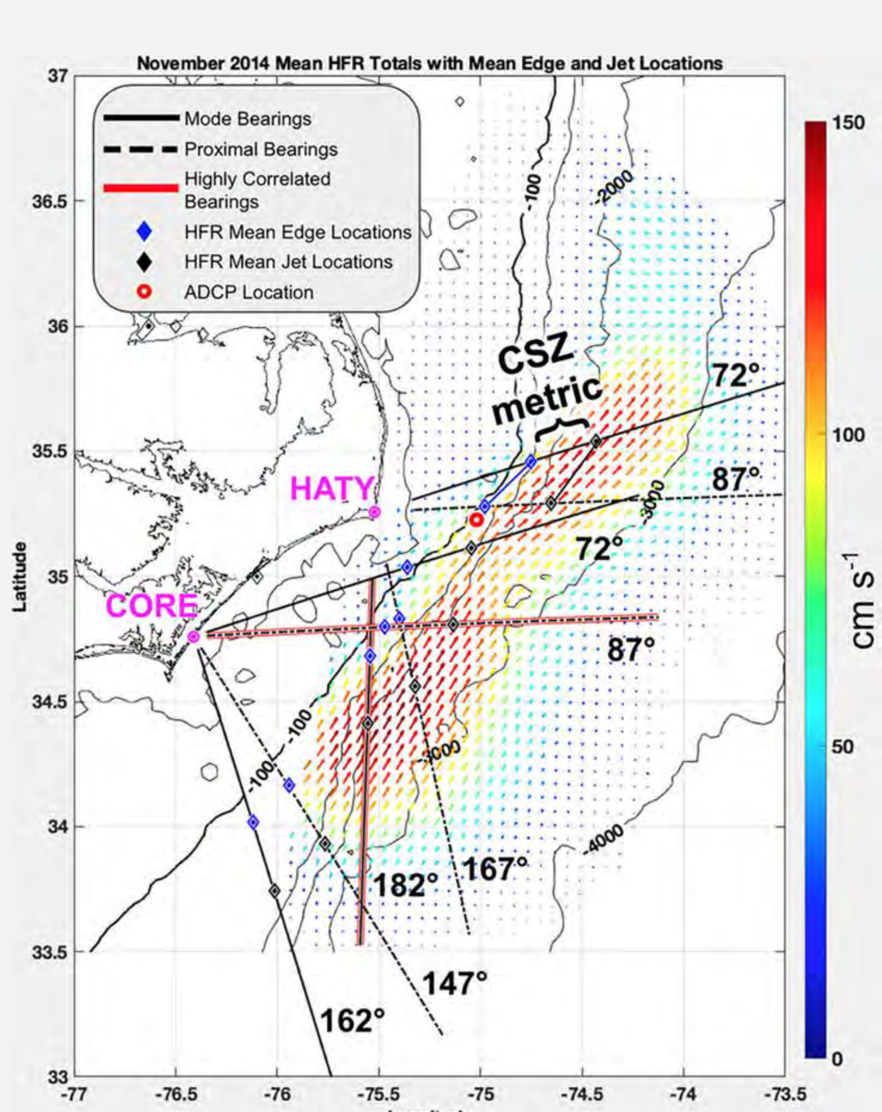
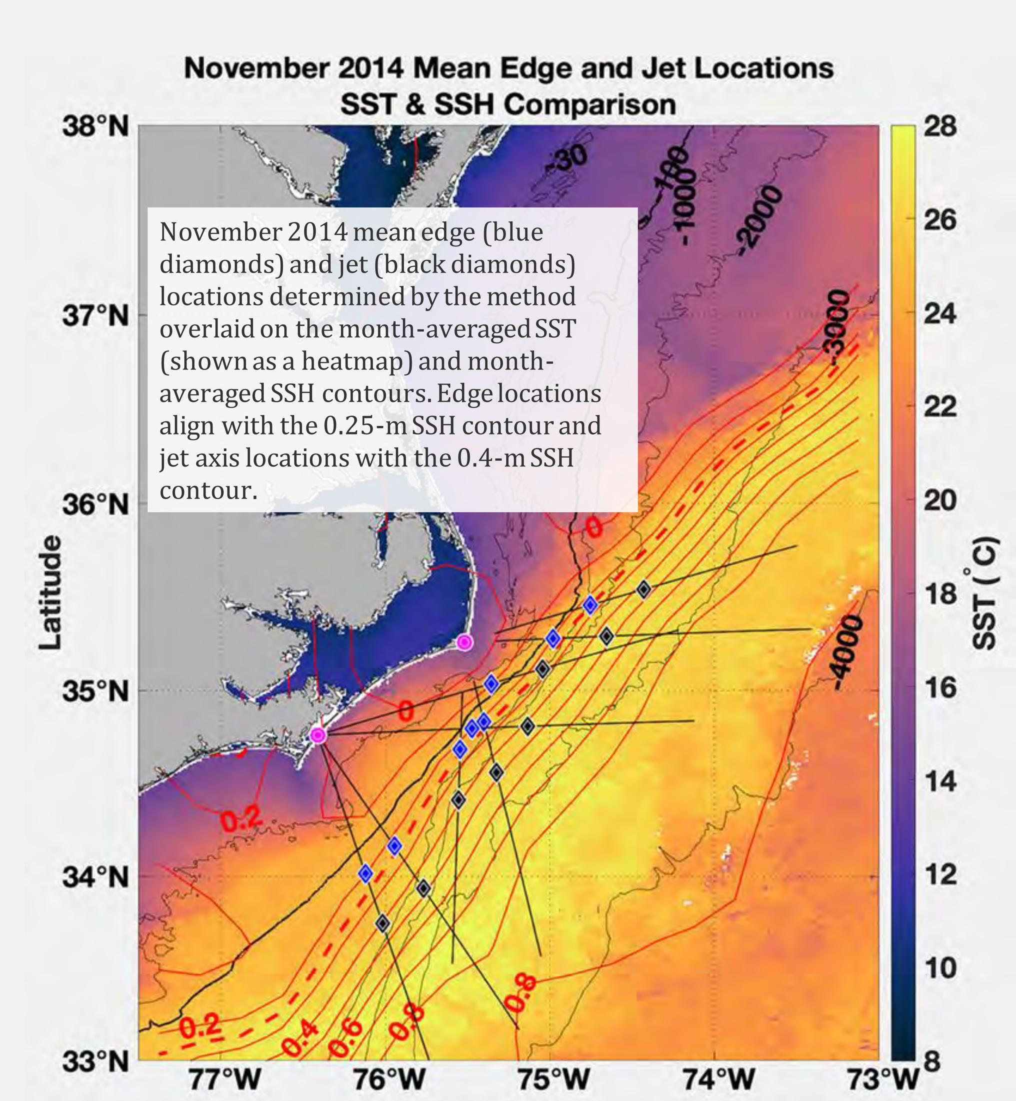


Figure show Edge range estimates from (top to bottom) HATY 72°, HATY 87°, CORE 72°, and CORE 87°, as compared to (middle) downstream velocity as a function of depth and time from the OE ADCP. The panels are arranged from (bottom) south to (top) north; see Fig. 6 for map view. Raw range estimates (blue) are overlain with 24-h cubic spline curves. Pink shading denotes meander crests and blue shading denotes meander troughs. Note the consistent downstream propagation rate of meander features.





Broader Impacts

- The time series of the GS characteristics will be broadly available for the meteorological community to help further understand the air-sea interactions over the GS at Cape Hatteras.
- Valuable validation information for numerical models to improve forecasting

Reference: Muglia, M., Seim, H. and Taylor, P., 2022. Gulf Stream Position, Width, and Orientation Estimated from HF Radar Radial Velocity Maps off Cape Hatteras, North Carolina. *Journal of Atmospheric and Oceanic Technology*, *39*(5), pp.689-705.