UNIVERSITY OF MIAMI
ROSENSTIEL SCHOOL of MARINE & ATMOSPHERIC SCIENCE

Coastal Ocean Observing in the Straits of Florida using HF Radar

An Overview of Recent Work

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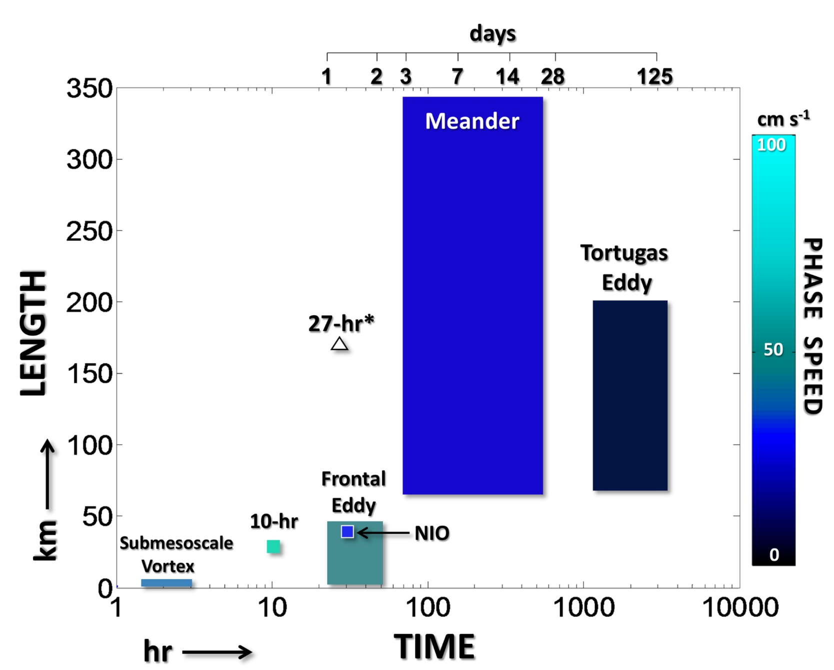
1 INTRODUCTION

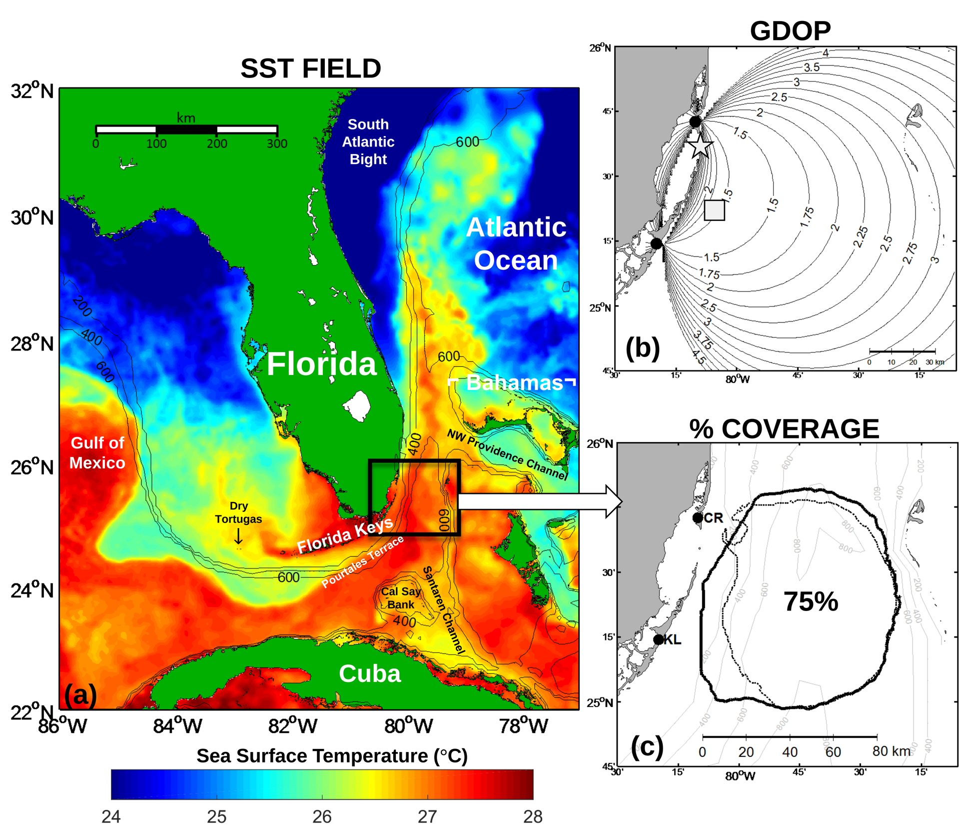
- The **Florida Current** is one of the fastest ocean currents in the world, connecting the Loop Current in the Gulf of Mexico to the Gulf Stream in the North Atlantic.
- At the **large scale**, this current system plays a key role in redistributing heat in the ocean, and can impact climate on a global scale.
- At the **small scale** offshore of Miami, the Florida Current influences both local ecosystems and maritime operations (e.g. search and rescue, tracking an oil spill).
- Since transient eddy events in coastal regions are not easily observed by traditional in-situ instruments or satellites, there is still **uncertainty** about the **small-scale variability** of the currents.

ENERGETIC INSTABILITIES AT MANY SCALES EXIST ALONG THE FLORIDA CURRENT



2 HF RADAR DATA

HF RADAR IN THE STRAITS OF FLORIDA



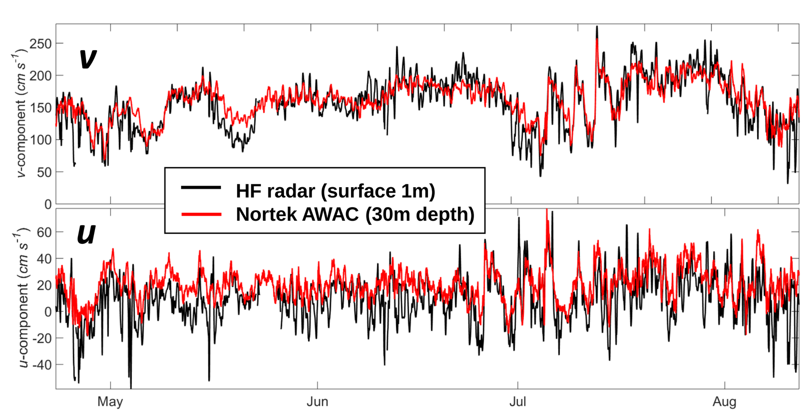
- Since 2003, WERA radars have been deployed in phased array mode along the southeast Florida coastline to collect remote measurements of ocean **surface currents**, **waves** and **winds**.
- Operating at frequencies of 12 and 16 MHz, the radars collect data at **20-min intervals** with a typical range of 80-km, and **1.2 km resolution** in the horizontal.
- **Advantages of HF radar** for ocean observing in the Straits of Florida include:
  1) High resolution in time and space
  2) Long-term monitoring of the same area
  3) Coverage over areas never before measured

How Does HF Radar Data Compare to an *in situ* ADCP?

ANSWER: Very well, considering their very different sampling strategies! (e.g. point versus area average, sampling averages, depth of measurement)[2]. Overall RMS difference is consistent with previous studies in the Florida Straits[3,4] :

u : 17 cm s⁻¹
v : 22 cm s⁻¹

TIMESERIES OF HF RADAR AND *IN SITU* DATA REVEALS GOOD LOW FREQUENCY COMPARISON



OVERVIEW

We present recent results[1] using high frequency (HF) radar to investigate shear zone instability along the frontal regions of the Florida Current, including:

1) Examination of how the flow field kinematics are significantly altered during the passage of a frontal eddy; and,
2) Analysis of a near-inertial velocity signal in the anticyclonic shear zone that has not been previously addressed in the literature.

→ **These energetic fluctuations have important implications for cross-shelf exchange of water properties, and a better knowledge of their dynamics are vital for enhancing search and rescue operations and pollution mitigation.**

ONGOING WORK

- Quantify the pattern of energy exchange between the mean and fluctuating flow.
- Investigate the most energetic signals in time and space over a 2.5 year period.

References

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2. Archer, M. R., L. K. Shay & J. Martinez-Pedraja, 2015. Evaluation of WERA HF Radar Observations: Currents, Winds and Waves. *CWTM IEEE/OES 11th*.
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4. Shay, L. K., Cook, T. M., Peters, H., Mariano, A. J., Weisberg, R., An, P. E. and Luther, M., 2002. Very high-frequency radar mapping of surface currents. *Journal of Oceanic Engineering* (*IEEE*), *27*(2), 155-169.
5. Futch, V., 2009. The Lagrangian properties of the flow west of Oahu. *Thesis, University of Hawaii, Manoa.*

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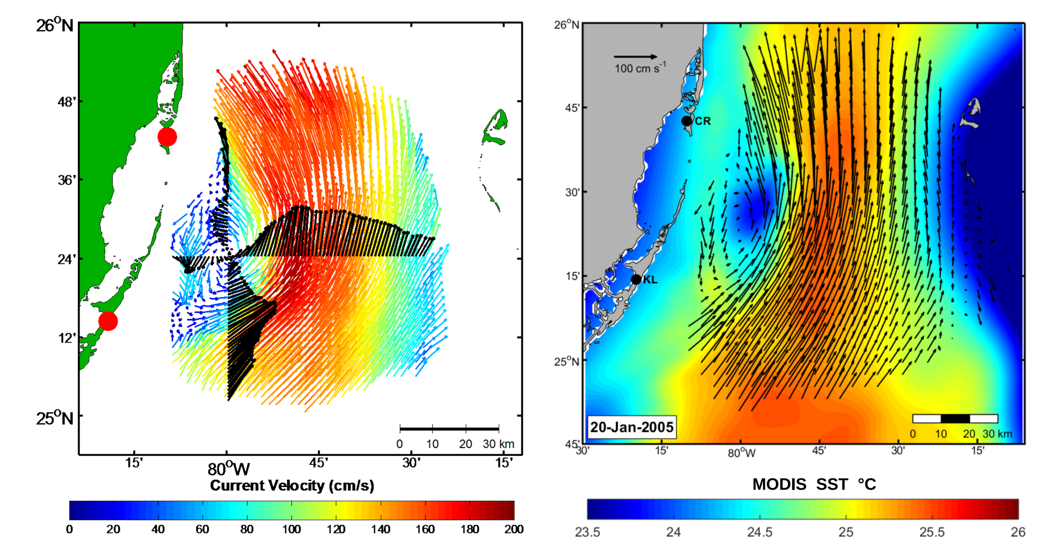
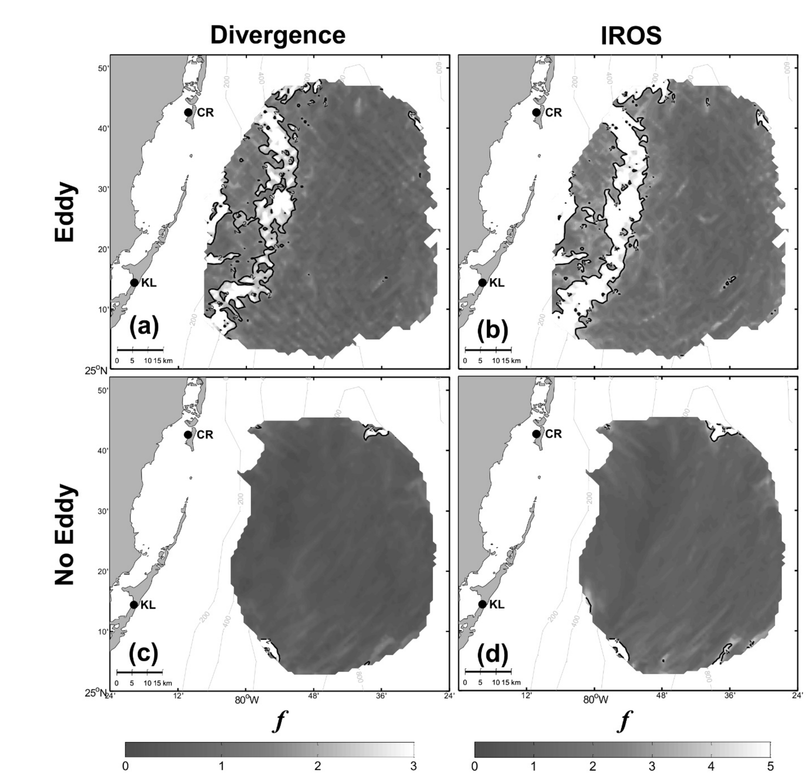
3 ON THE WESTERN FRONT

SUBMESOSCALE CYCLONIC FRONTAL EDDY



- During the eddy passage, the vorticity field revealed a Rossby number that greatly exceeded unity, implying the flow field was governed by **submesoscale dynamics**.
- Strong **horizontal current divergence** near the core of the eddy was associated with anomalously cold water brought to the surface by **upwelling**, observed in MODIS SST satellite imagery.

EDDY DRIVES DIVERGENCE, UPWELLING & PARTICLE DISPERSION



- "Instantaneous rate of separation" (**IROS**) is a metric of particle dispersion[5], calculated as the sum of divergence d, shear strain s_s and normal s_n strain.

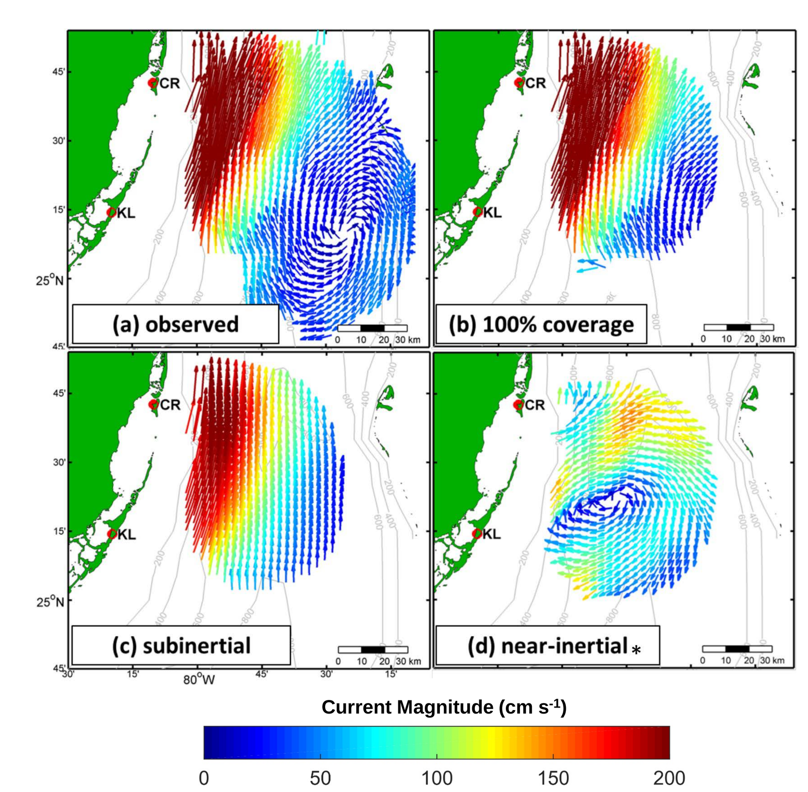
$$d = \frac{\partial u}{\partial x} + \frac{\partial v}{\partial y}; \quad s_n = \frac{\partial u}{\partial x} - \frac{\partial v}{\partial y}; \quad s_s = \frac{\partial v}{\partial x} + \frac{\partial u}{\partial y}$$

- High values of IROS were associated with the eddy, indicating the potential for **strong dispersion of a passive tracer** (e.g. larvae, oil). This has important implications for cross-shelf exchange of water properties between offshore and coastal waters.

4 ON THE EASTERN FRONT

- A transient, coherent signal in the near-inertial passband was identified for the first time. This energetic fluctuation can increase cross-shelf exchange of water properties across the continental shelf.
- The strongly sheared Florida Current partially masked the structure of the near-inertial oscillation, which manifested as a succession of clockwise-rotating eddies in the observed surface currents. The wave trough was not evident when embedded in a laterally sheared northward background flow.
- The dominant frequency was shifted by 13% below f in the average, which is consistent with a near-inertial wave propagating in a background regime with negative vorticity.
- Near-inertial energy peaked in the negative vorticity trough along the Florida Current's eastern flank, indicative of wave trapping in the horizontal.

FREQUENCY DECOMPOSITION OF CURRENT VECTORS



*colorbar scale for near-inertial currents is from 0 to 50 cm s⁻¹