Validation of X-TRACK coastal altimetry on the West Florida Shelf

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Outline

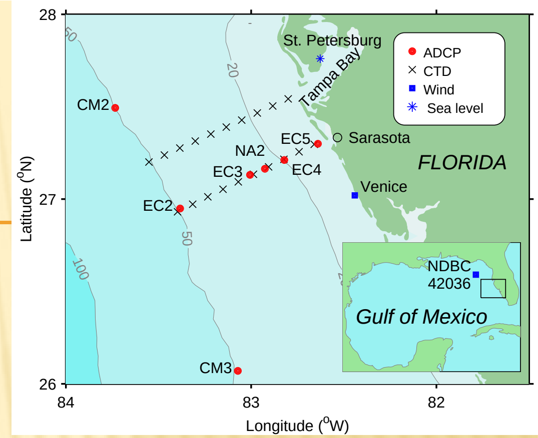
- ➢Introduction
- ➢Moored ADCP and HF radar observations
- ➢X-TRACK product and surface geostrophic velocity calculation
- ➢Comparison with ADCP near-surface velocity
- ➢Comparison with HF radar current radial component
- ➢Summary and discussions

Introduction

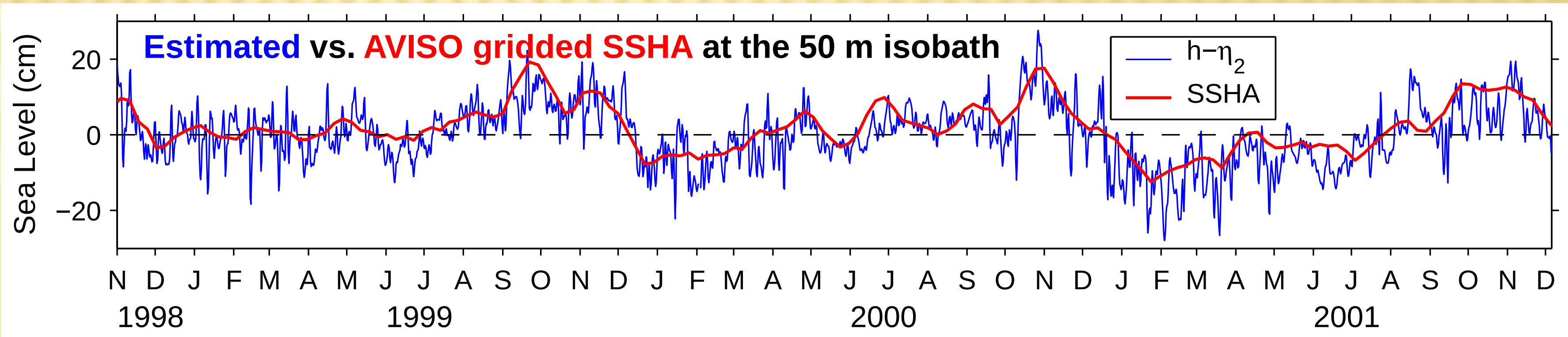
Based on dominant inner-shelf momentum balance, Liu & Weisberg (2007) proposed a method for estimating absolute SSH near the coast by integrating in situ coastal ocean observations (velocity, hydrography, bottom pressure, coastal tide gauge and winds) along a transect. The estimated SSH time series at the 50 m site compare well with the satellite SSHA.

What about a reverse calculation – estimating surface geostrophic velocity anomaly from satellite SSHA, especially from improved coastal altimetry (e.g., Vignudelli et al. 2005)? Many studies focused on narrow shelves where the waters are deep, e.g., Strub et al. (1997), Saraceno et al. (2008), etc.

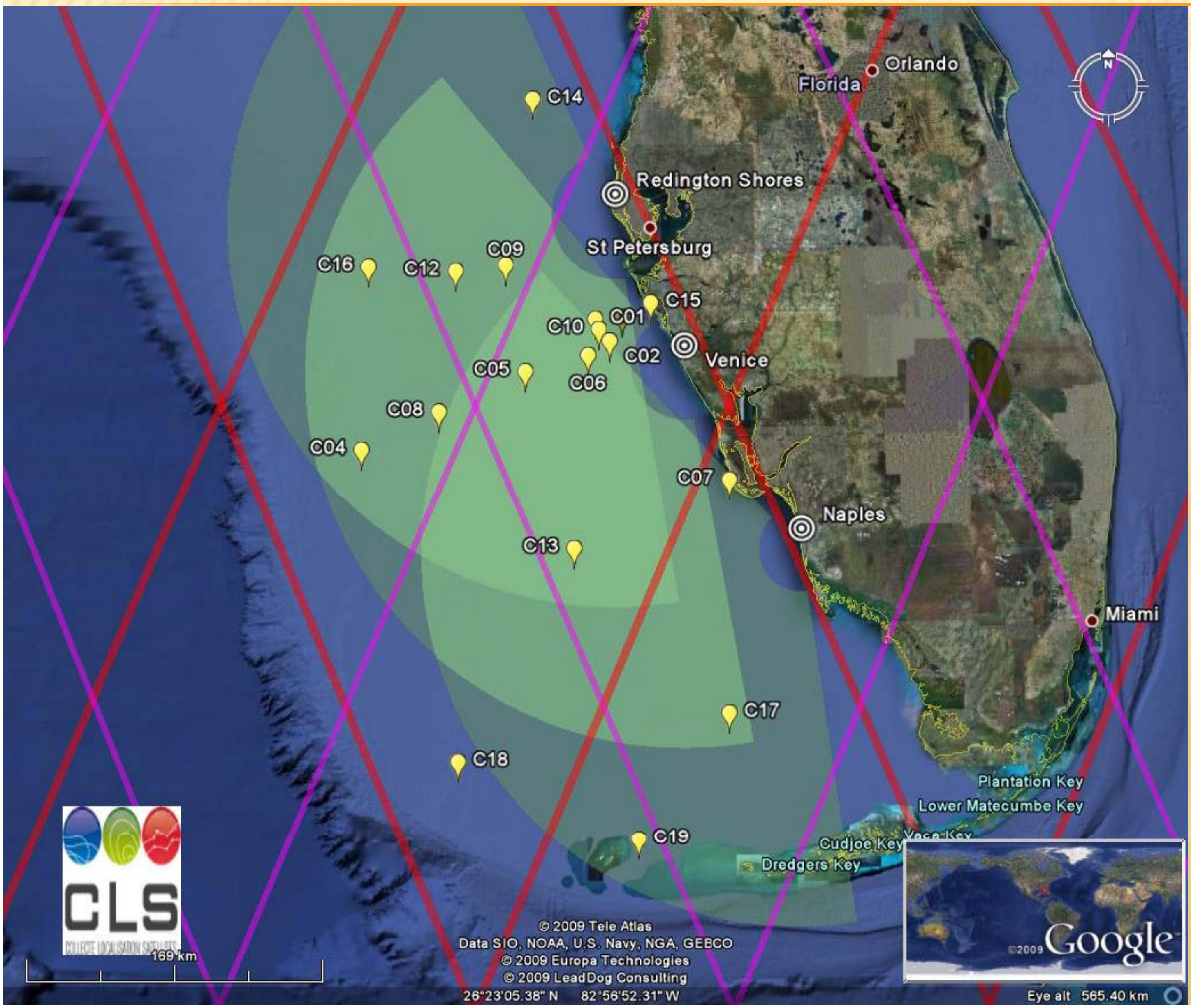
The purpose of this study is to assess the usefulness of the along-track SSHA in estimating surface geostrophic velocity over typical shallow waters – the West Florida Shelf. How different between the satellite-derived and in situ observed surface velocities?



Liu Y., and R.H. Weisberg (2007), Ocean current structures and sea surface heights estimated across the West Florida Shelf. *J. Phys. Oceanogr.*, 37, 1697–1713.



West Florida Shelf Observation Systems



- **ADCP array**
- **HF radar array**
- **Satellite tracks**

T/P & J2 tracks

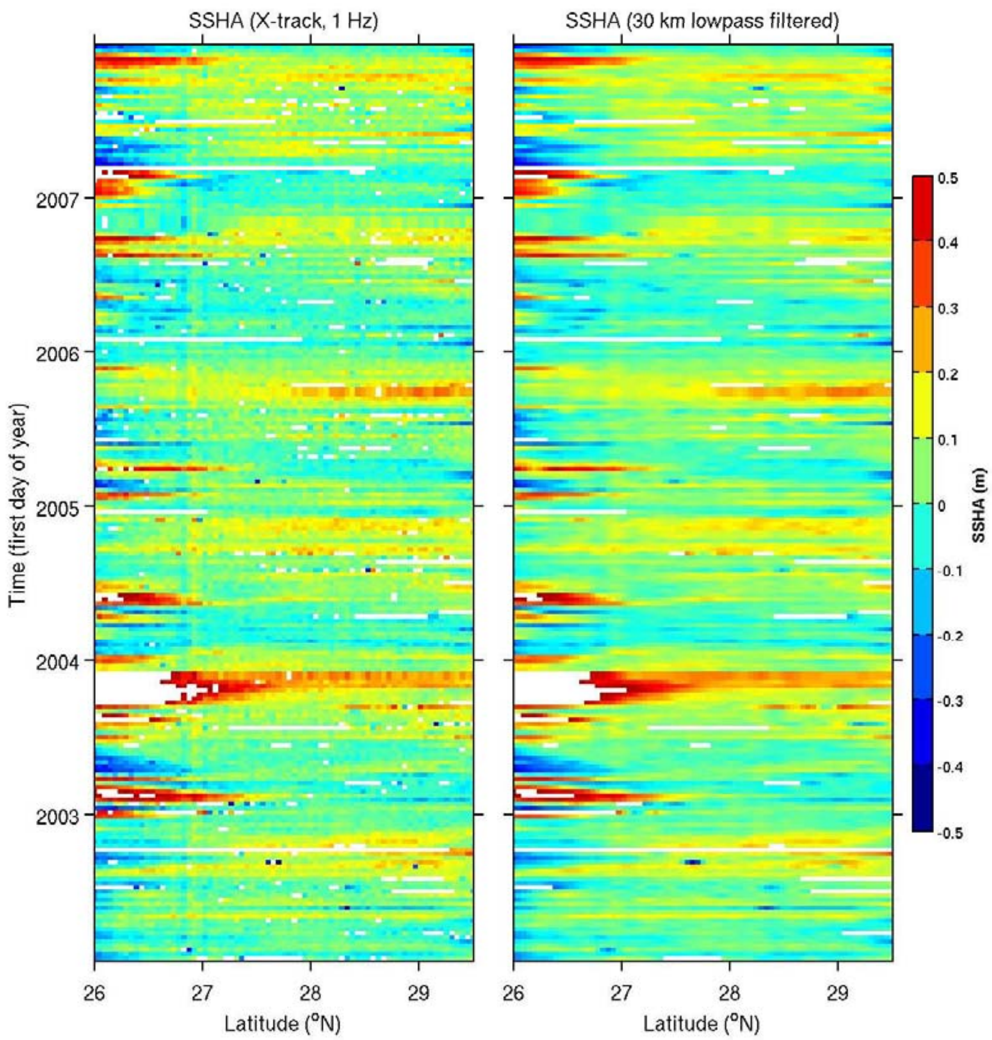
T/P2 tracks

Many moorings, but they are not located on satellite tracks.

Data Processing

SLA_corrected = SLA – corr2 – corr3 – corr4 – corr5

The original and filtered SLA



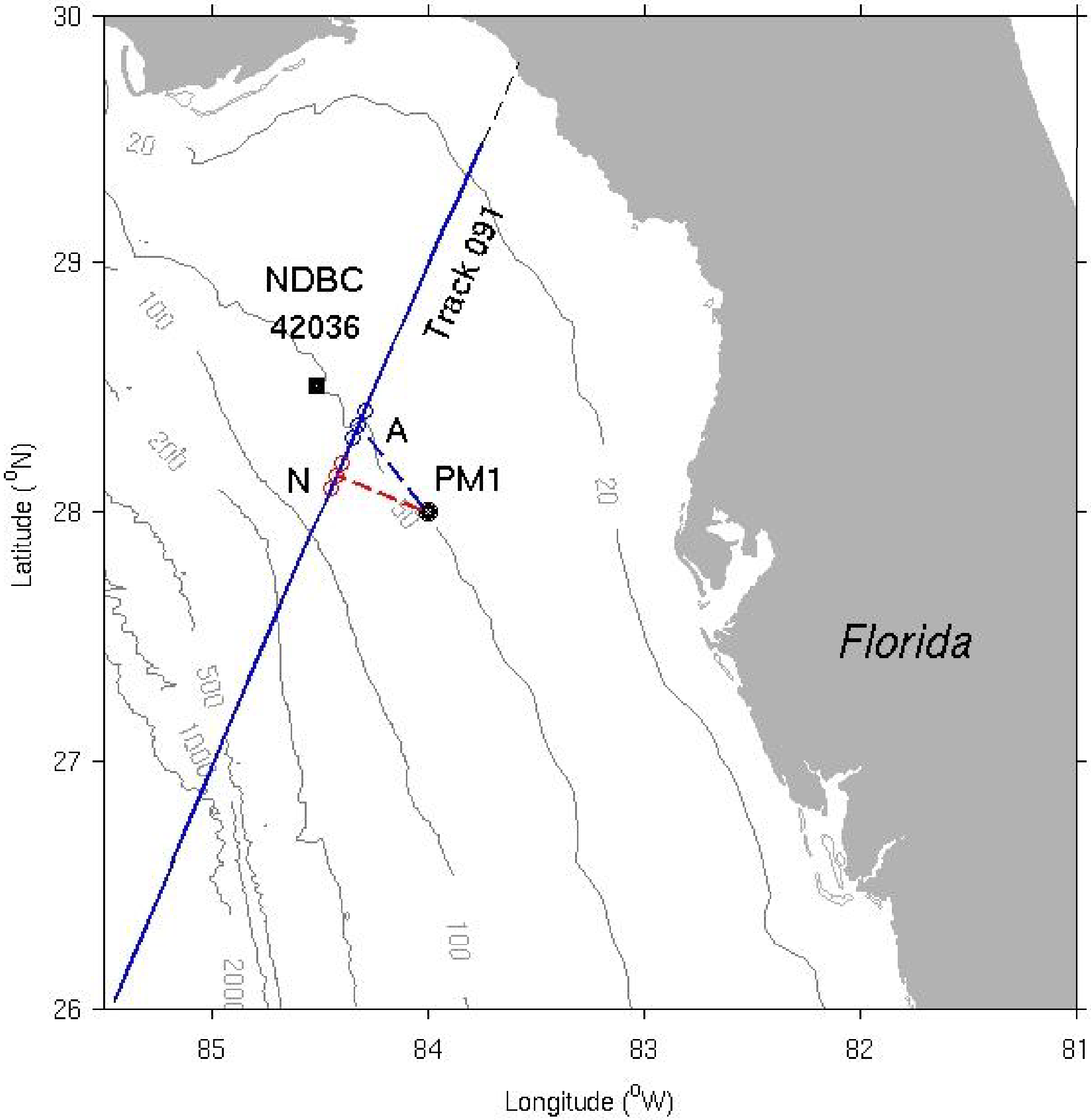
SLA: sea level anamoly
Corr2: atmospheric loading effects:
MOG2D-G model sea level
Corr3: loading tide effects
Corr4: solid earth tide
Corr5: GOT4.7 ocean tide

1 Hz X-TRACK data.

A **30 km lowpass filter** is applied to each cycle of the track to remove the high-frequency gravity waves.

The along-track sea level slope is smoothed using the optimal filter (Powell and Leben, 2004) with a cut-off of 60 km. A slope **noise of 4~6 cm/s is expected**.

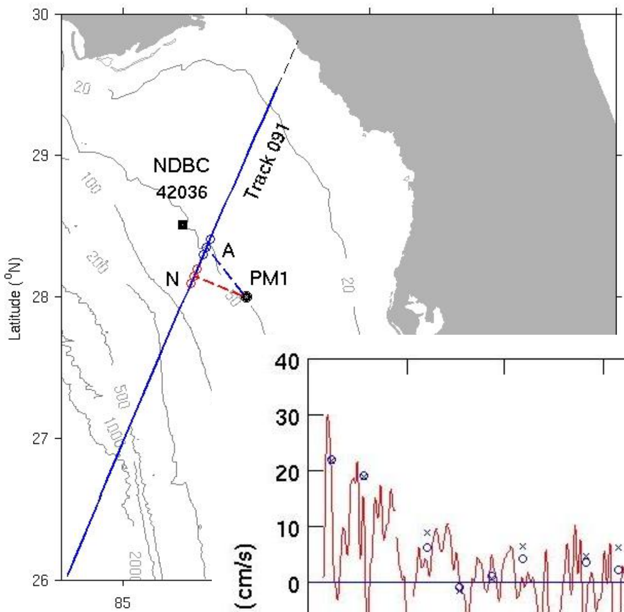
T/P Track #091 and ADCP Mooring PM1



Compare altimeter-derived surface geostrophic velocity and ADCP near-surface velocity anomalies in two directions:

1. **Perpendicular to the satellite track (Points N and PM1)**
2. **Along-shelf direction (Points A and PM1)**

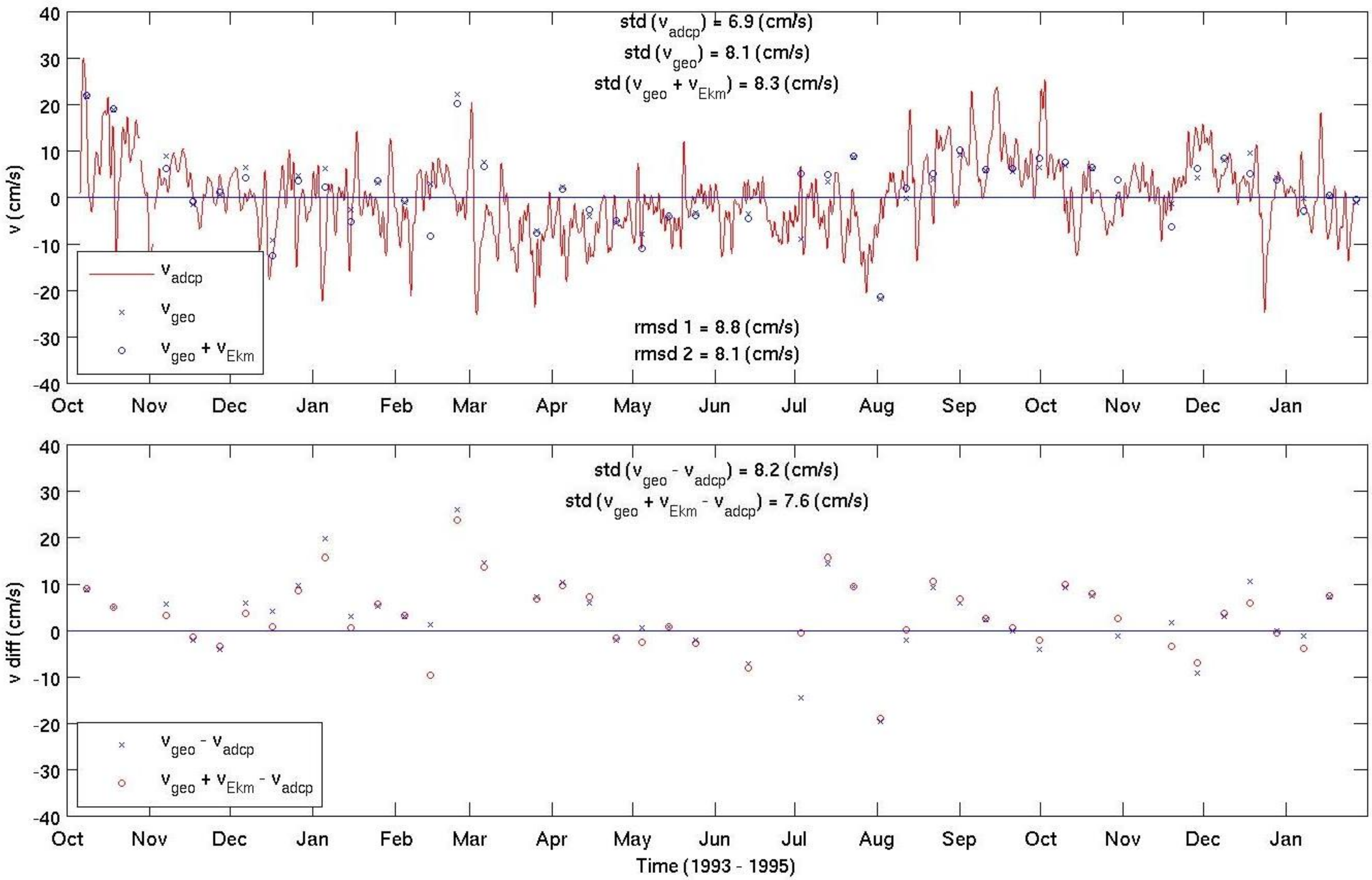
T/P data available: 1992.11 ~ 2002.08
PM1 ADCP data: 1993.10 ~ 1995.01



Surface geostrophic velocity (+ Ekman velocity) vs. ADCP near-surface (4 m) velocity anomalies

(ADCP and wind time series are 36-hr lowpass filtered)

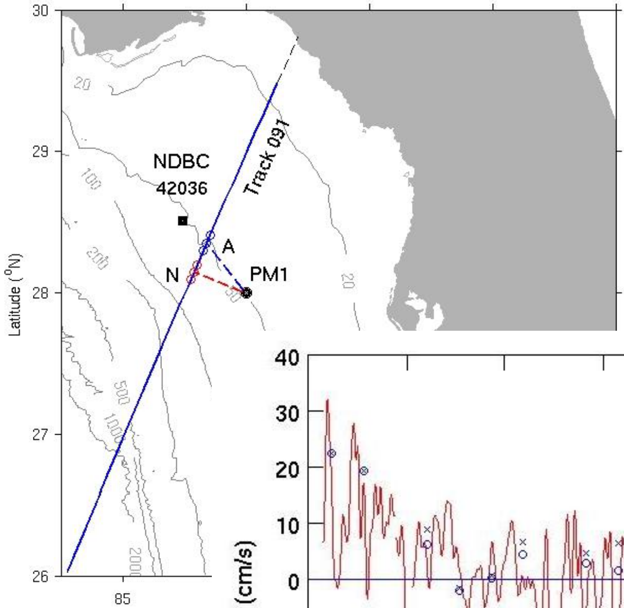
Velocity component perpendicular to the satellite track (Points N and PM1)

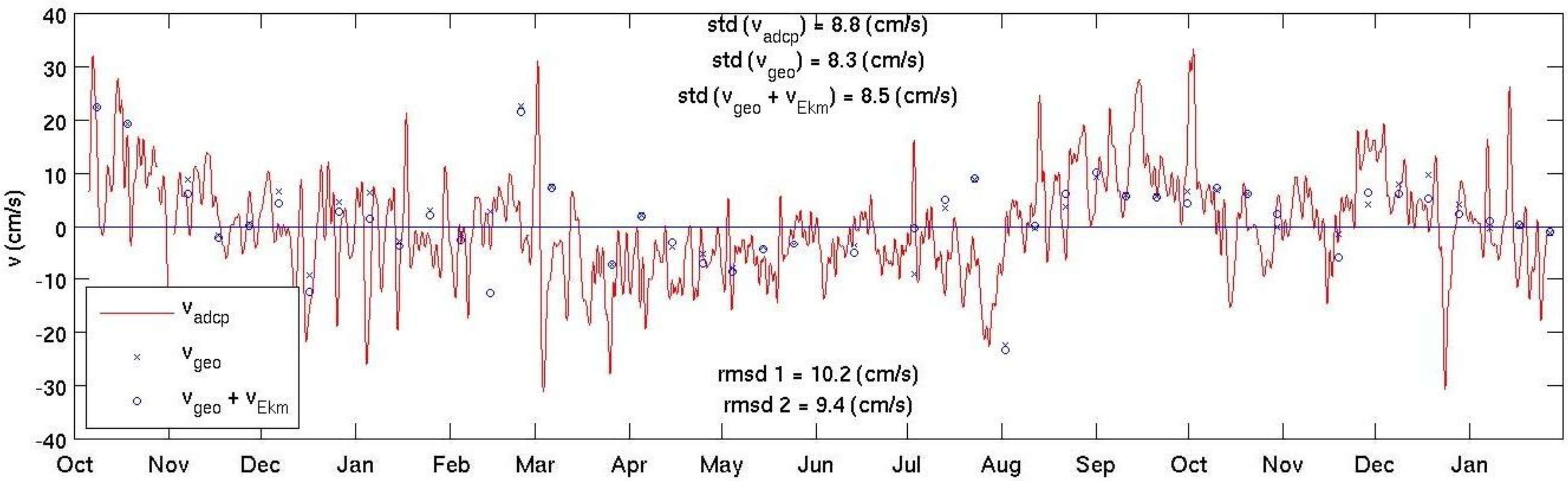


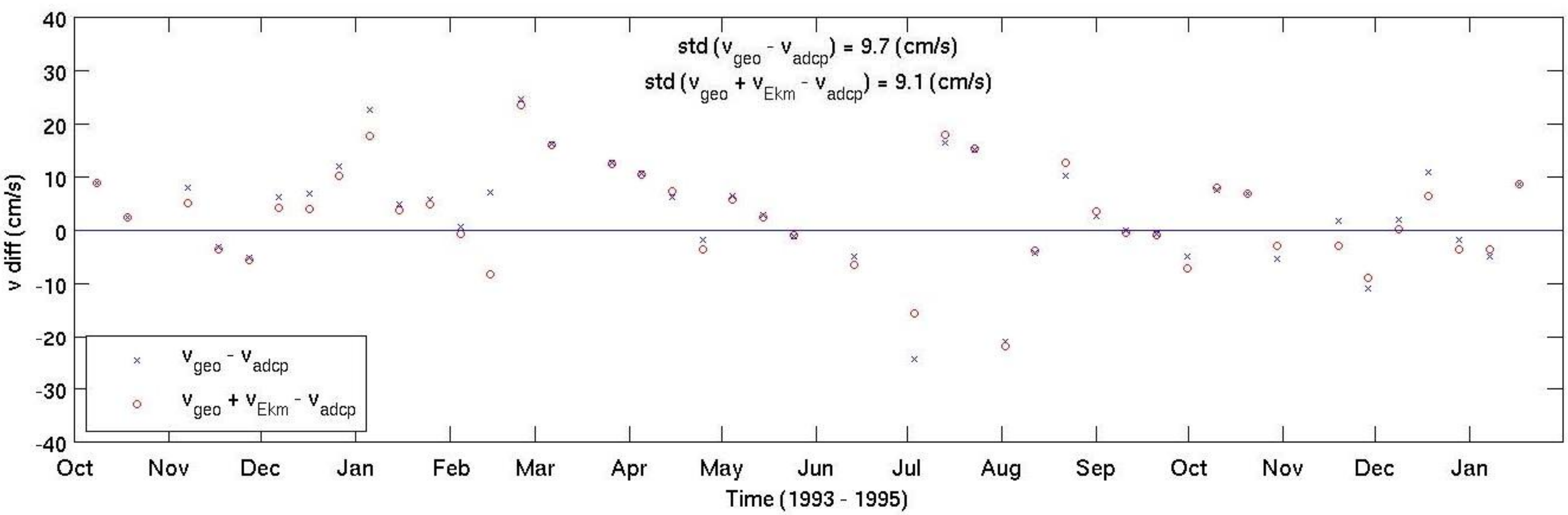
Surface geostrophic velocity (+ Ekman velocity) vs. ADCP near-surface (4 m) velocity anomalies

(ADCP and wind time series are 36-hr lowpass filtered)

Along-shelf velocity component at the 50 m isobath (Points A and PM1)

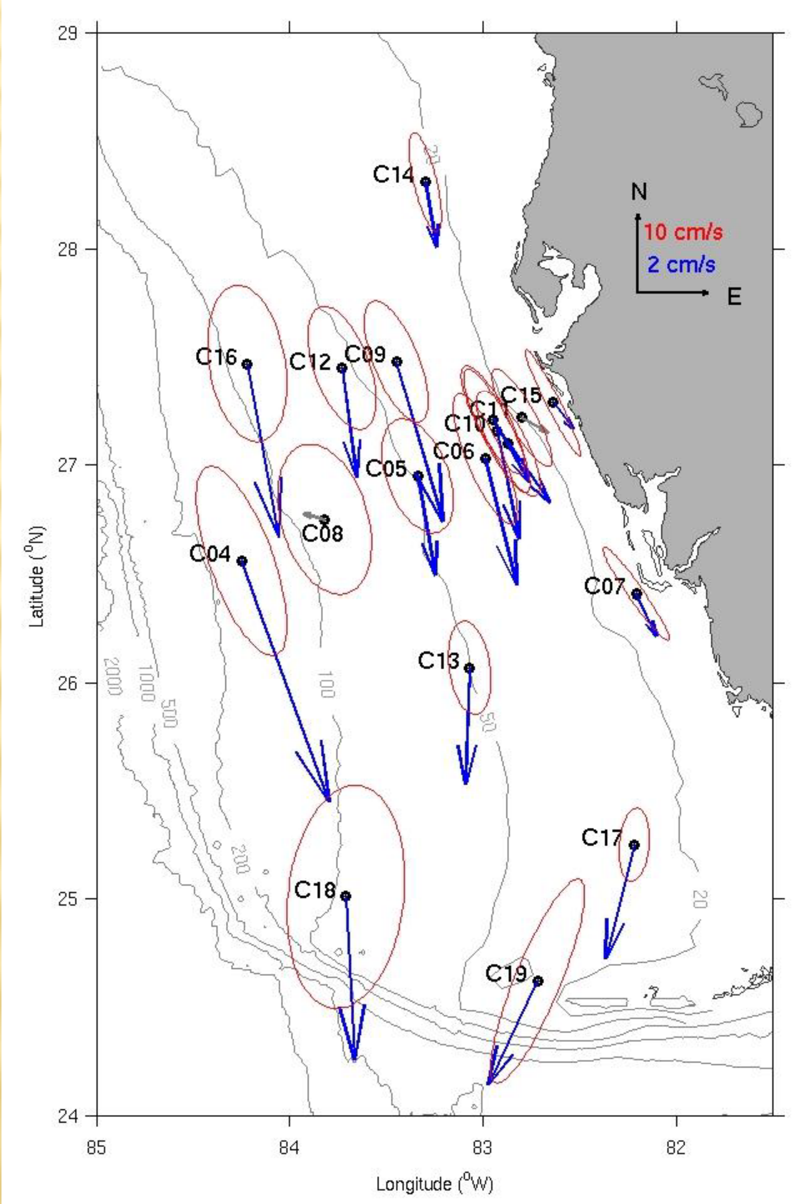


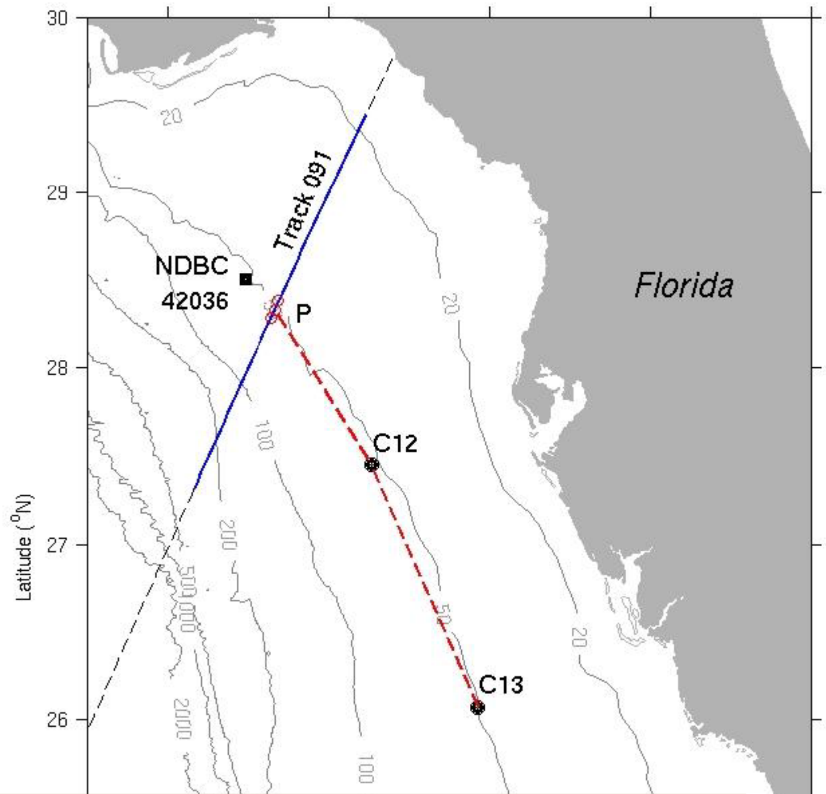




Depth-averaged mean velocity and principal axis currents

(Weisberg, R.H., Y. Liu, & D.A. Mayer (2009), West Florida Shelf mean circulation observed with long-term moorings, *Geophys. Res. Lett.*, in press)

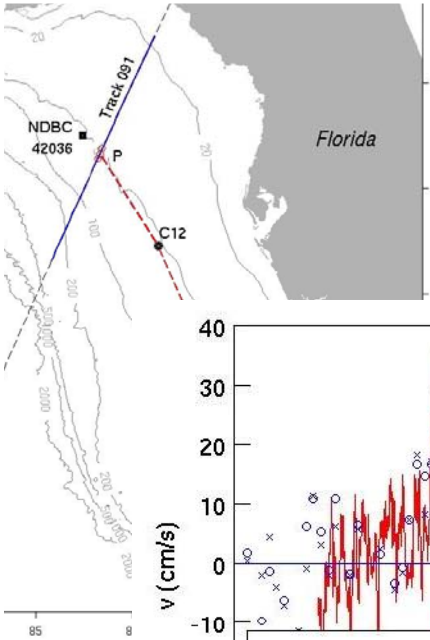




On subtidal time scales, principal axes of the currents align with the isobaths. Decorrelation scales are larger in the along-shelf direction than in the across-shelf direction.

This makes a basis to compare the along-shelf currents at two points that are on the same isobath but not far away from each other.

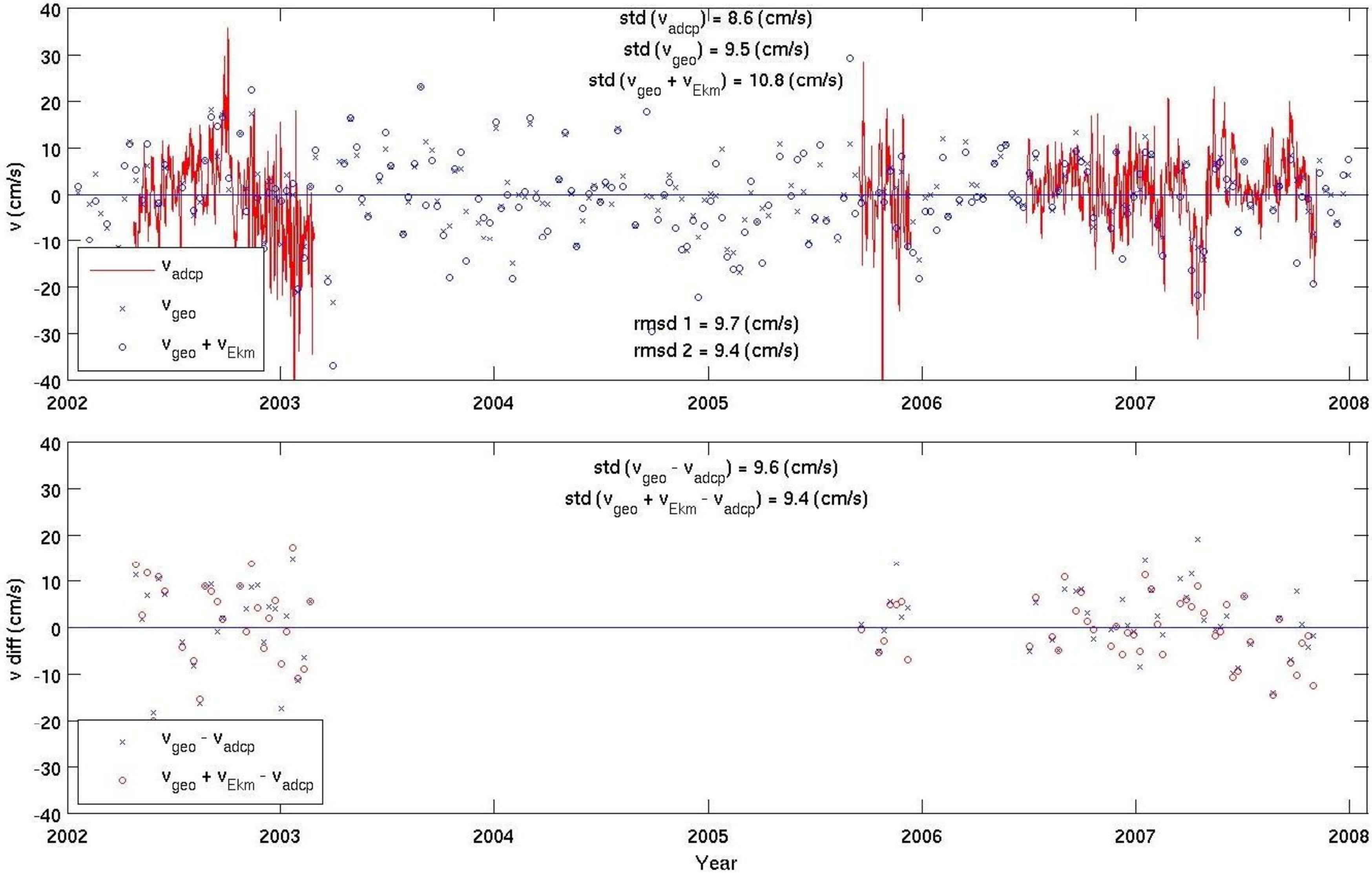
The 50 m isobath is fairly "Straight".

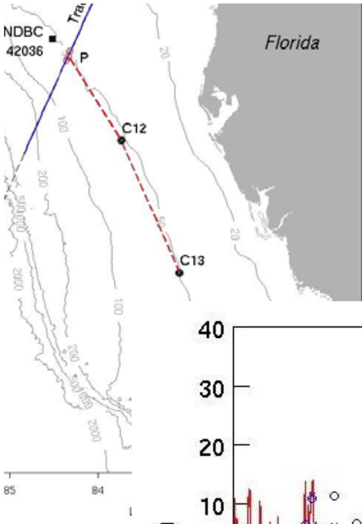


Surface geostrophic velocity (+ Ekman velocity) vs. ADCP near-surface (5 m) velocity at mooring C12

(ADCP and wind time series are 36-hr lowpass filtered)

Along-shelf velocity anomalies at the 50 m isobath

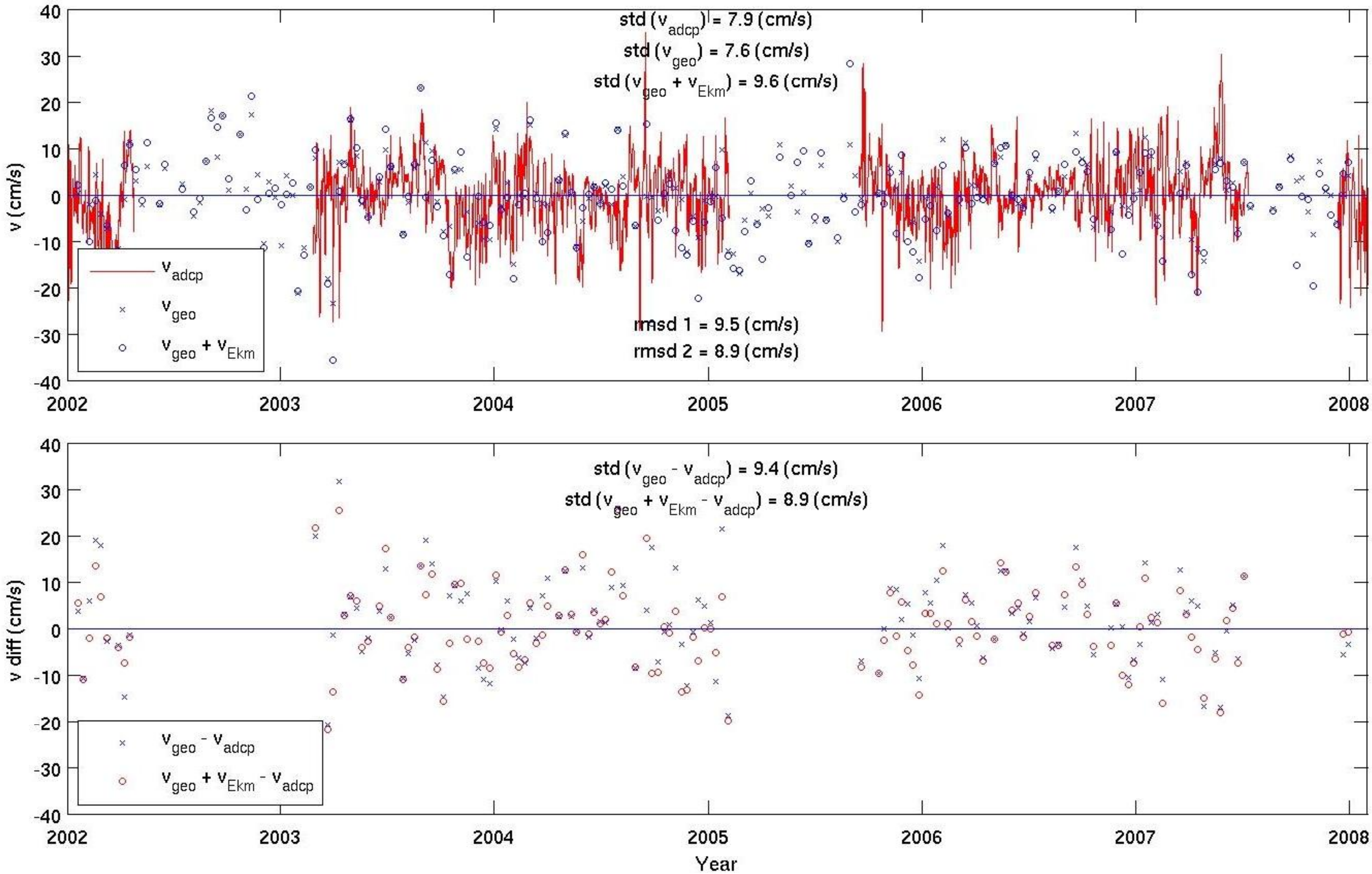


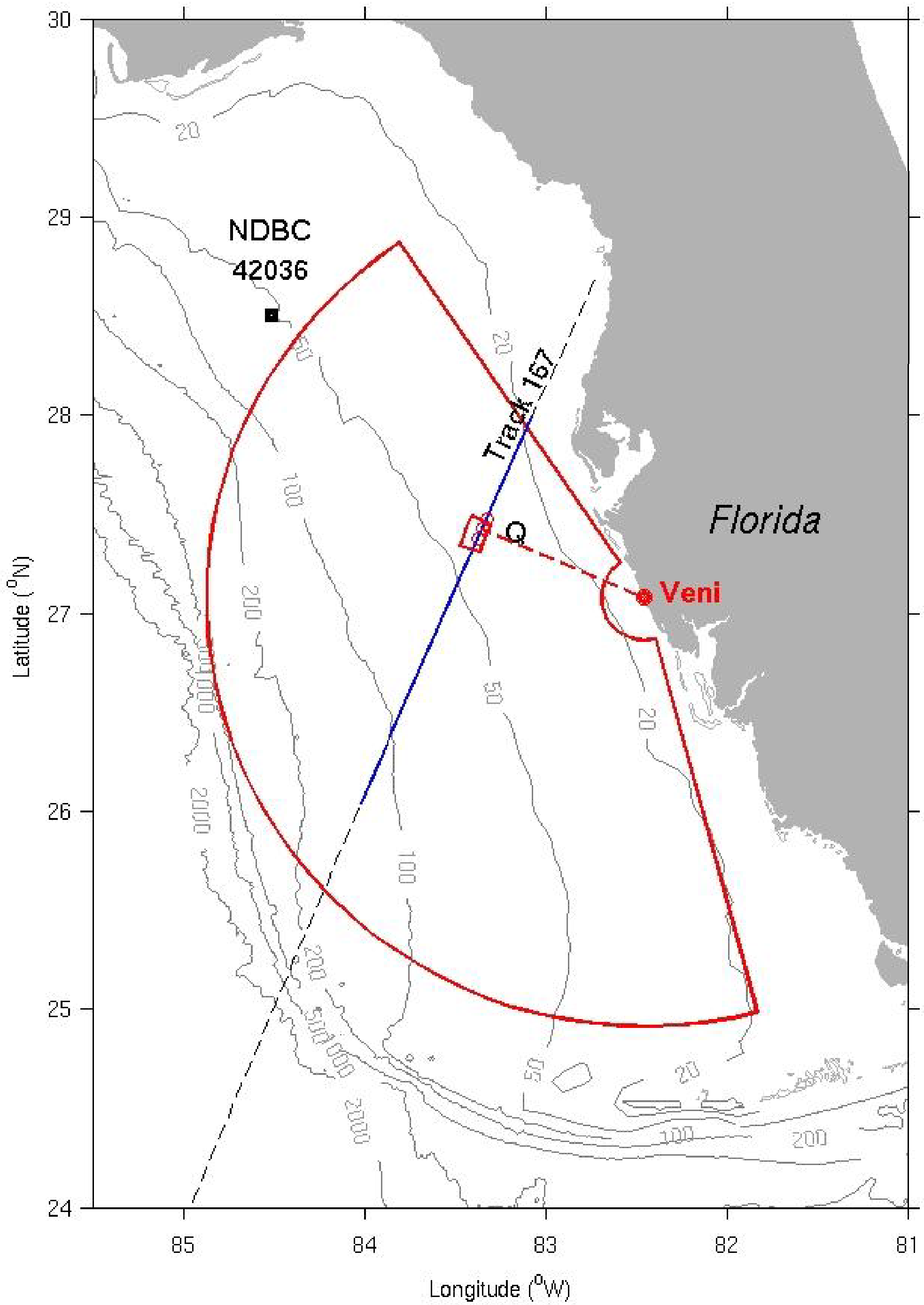


Surface geostrophic velocity (+ Ekman velocity) vs. ADCP near-surface (5 m) velocity at mooring C13

(ADCP and wind time series are 36-hr lowpass filtered)

Along-shelf velocity anomalies at the 50 m isobath



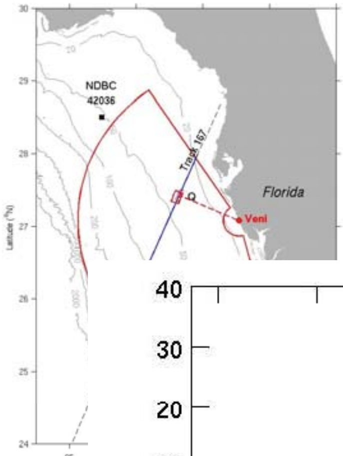


T/P2 Track #167 and HF Radar Radial Coverage

The surface geostrophic velocity estimated from along-track SSHA (v_{geo}) and the HF radar surface radial velocity (v_{rad}) are in **the same direction** at point Q. Thus, v_{geo} and v_{rad} should be comparable if both satellite & HF radars work well.

Point Q is located at the 40 m isobath.

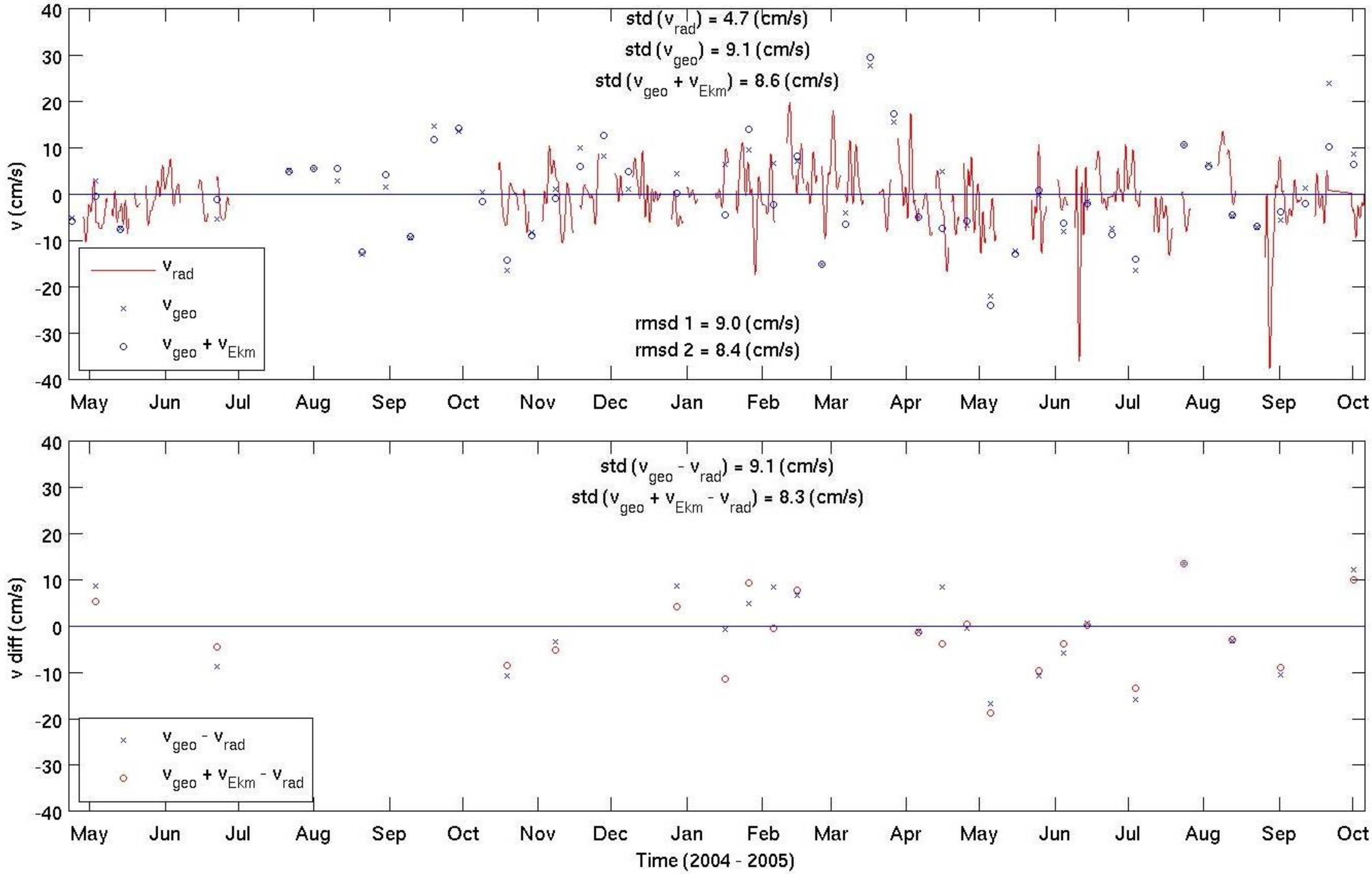
HF radar at Venice, Florida: long-range, CODAR SeaSonde, 5 MHz operating frequency, radial sectors: 5^o in bearing angle and 6 km in range, velocity in the top 1~2 m.

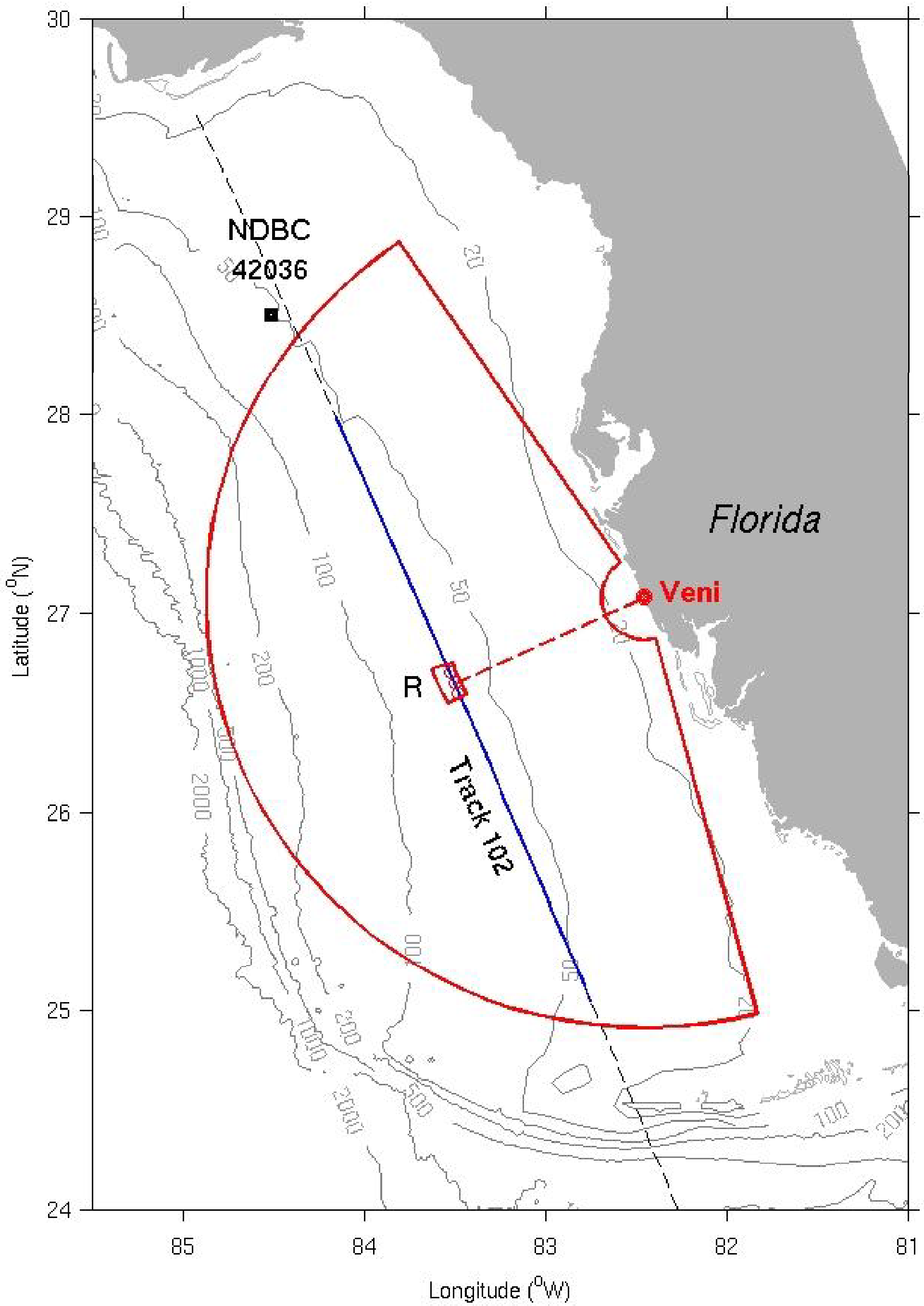


Surface Geostrophic Velocity vs. HF Radar Radial Velocity Anomalies

(HF radar and wind time series are 36-hr lowpass filtered)

T/P2 Track #167 and HF Radar at Venice, Florida





Another Satellite Track

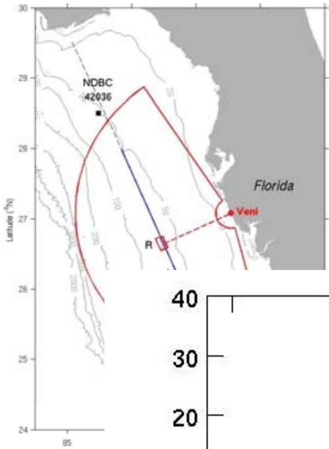
T/P2 Track #102
and HF Radar at Venice, Florida

Point R is located around the 60~70 m isobaths. The across-shelf velocity component are compared.

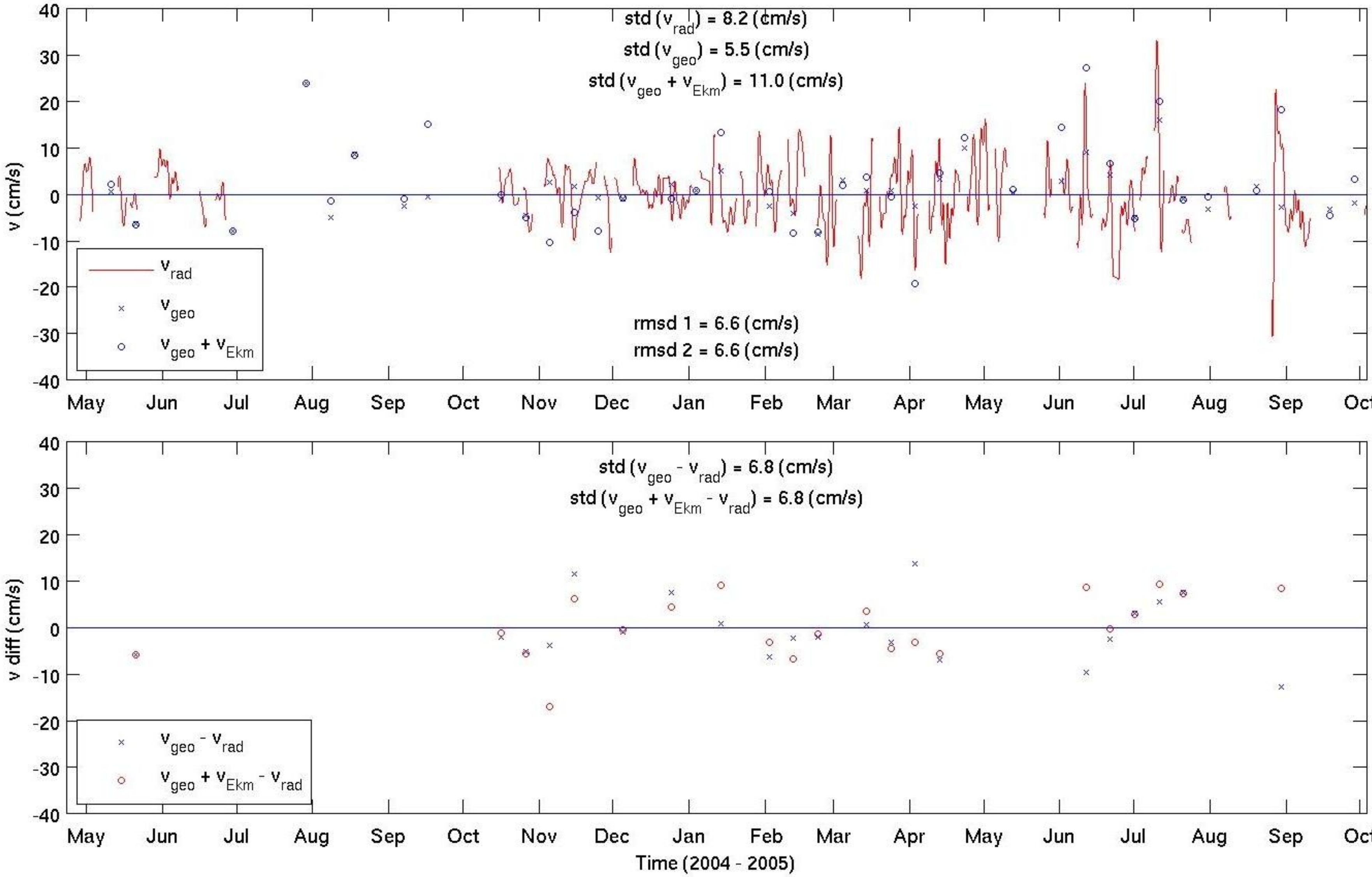
T/P2 data available: 2002 ~ 2005
HF radar at Venice site: 2004 ~ present
The overlapped period: 2004~2005

Surface Geostrophic Velocity vs. HF Radar Radial Velocity Anomalies

(ADCP and wind time series are 36-hr lowpass filtered)



T/P2 Track #102 and HF Radar at Venice, Florida



SUMMARY

- The performance of coastal altimetry (X-TRACK version 4) over a wide continental shelf is assessed using multi-year ocean current observations of HF radar and ADCP moorings on the West Florida Shelf (WFS).
- Across-track, surface geostrophic velocity anomalies, calculated from the T/P and Jason-1 along-track sea level anomalies, are compared with the near surface currents observed at adjacent ADCP moorings on subtidal time scales.
- The across-track velocity anomalies are further rotated to the along-shelf direction, and compared with the ADCP near-surface along-shelf currents.
- The altimeter-derived velocity anomalies are also compared with the HF radar surface currents in the radial direction perpendicular to the satellite track.
- The root-mean-squared difference of the estimated and observed velocities range from 8 to 10 cm/s for ADCP comparisons and from 7 to 9 cm/s for the HF radar comparisons, respectively.
- Given expected velocity errors 4~6 cm/s from the optimal filter (Powell and Leben, 2004), and rmsd of ~6 cm/s for deep oceans (e.g., Strub et al., 1997), these 7~10 cm/s rmsd values are encouraging. This indicates usefulness of the X-TRACK product on the WFS. Note there is a rmsd of 3~6 cm/s between WFS HF radar and ADCP near-surface velocities on subtidal time scales (Liu et al., 2009).
- When the surface Ekman velocity is considered, both the rmsd values and the standard deviations of the velocity residuals are reduced.
- Future improvements: local tidal model …

ACKNOWLEDGEMENTS

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- USF Ocean Circulation Group staff are responsible for the success of the field program, specifically, Messrs R. Cole, J. Donovan, J. Law, and Dr. C. Merz.