Optimal Spectral Decomposition (OSD) Method for Ocean Observing System

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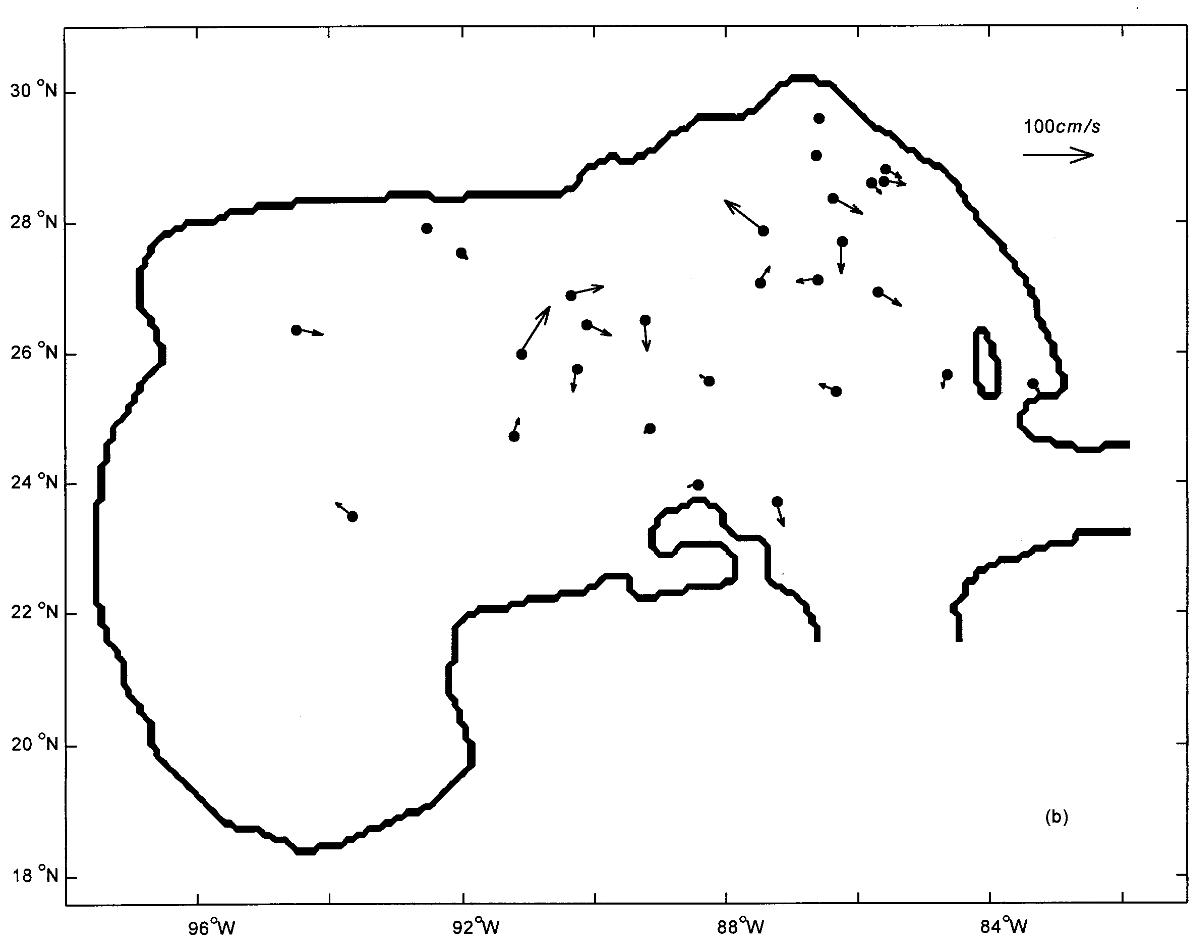
References

- Chu, P.C., L.M. Ivanov, T.P. Korzhova, T.M. Margolina, and O.M. Melnichenko, 2003a: Analysis of sparse and noisy ocean current data using flow decomposition. Part 1: Theory. Journal of Atmospheric and Oceanic Technology, 20 (4), 478-491.

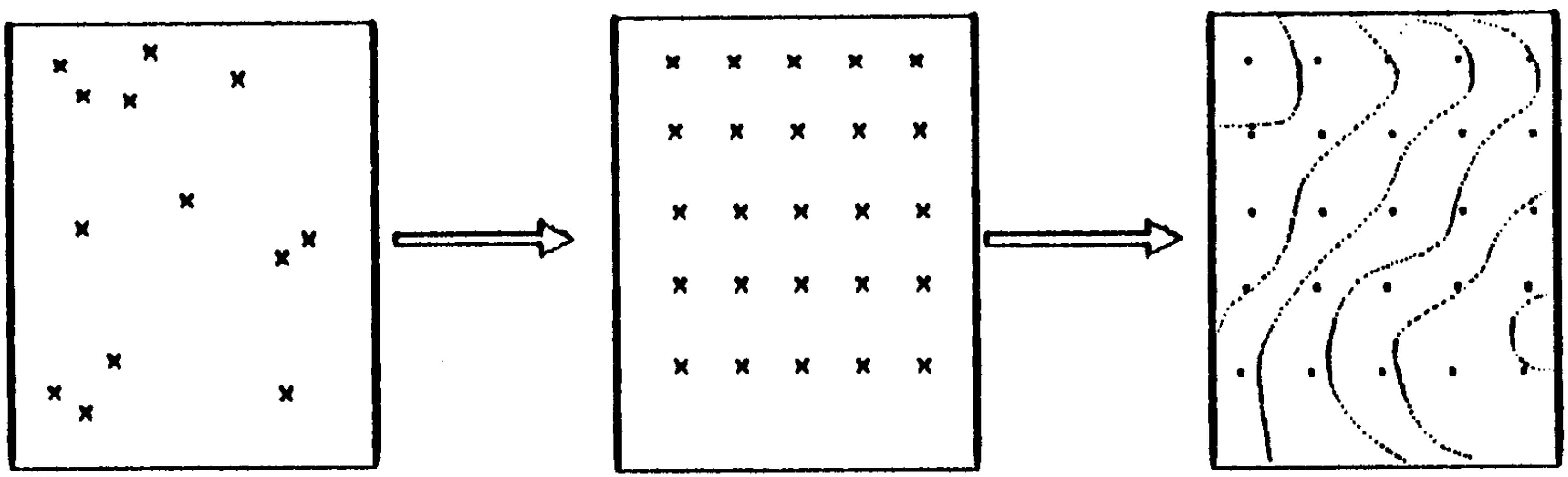
- Chu, P.C., L.M. Ivanov, T.P. Korzhova, T.M. Margolina, and O.M. Melnichenko, 2003b: Analysis of sparse and noisy ocean current data using flow decomposition. Part 2: Application to Eulerian and Lagrangian data. Journal of Atmospheric and Oceanic Technology, 20 (4), 492-512.

- Chu, P.C., L.M. Ivanov, and T.M. Margolina, 2004: Rotation method for reconstructing process and field from imperfect data. International Journal of Bifurcation and Chaos, 14(8), 2991-2997.

Observational Data (Sparse and Noisy)



Most Popular Method for Ocean Data Analysis: Optimum Interpolation (OI)



Three Necessary Conditions For the OI Method

- (1) First guess field
- (2) Autocorrelation functions
- (3) Low noise-to-signal ratio

Ocean velocity data

- (1) First guess field (?)
- (2) Unknown autocorrelation function
- (3) High noise-to-signal ratio

It is not likely to use the OI method to process ocean velocity data.

Flow Decomposition

- 2 D Flow (Helmholtz)

$$\mathbf{u}_H = \mathbf{r} \times \boldsymbol{\nabla}_H A_1 + \boldsymbol{\nabla}_H A_3$$

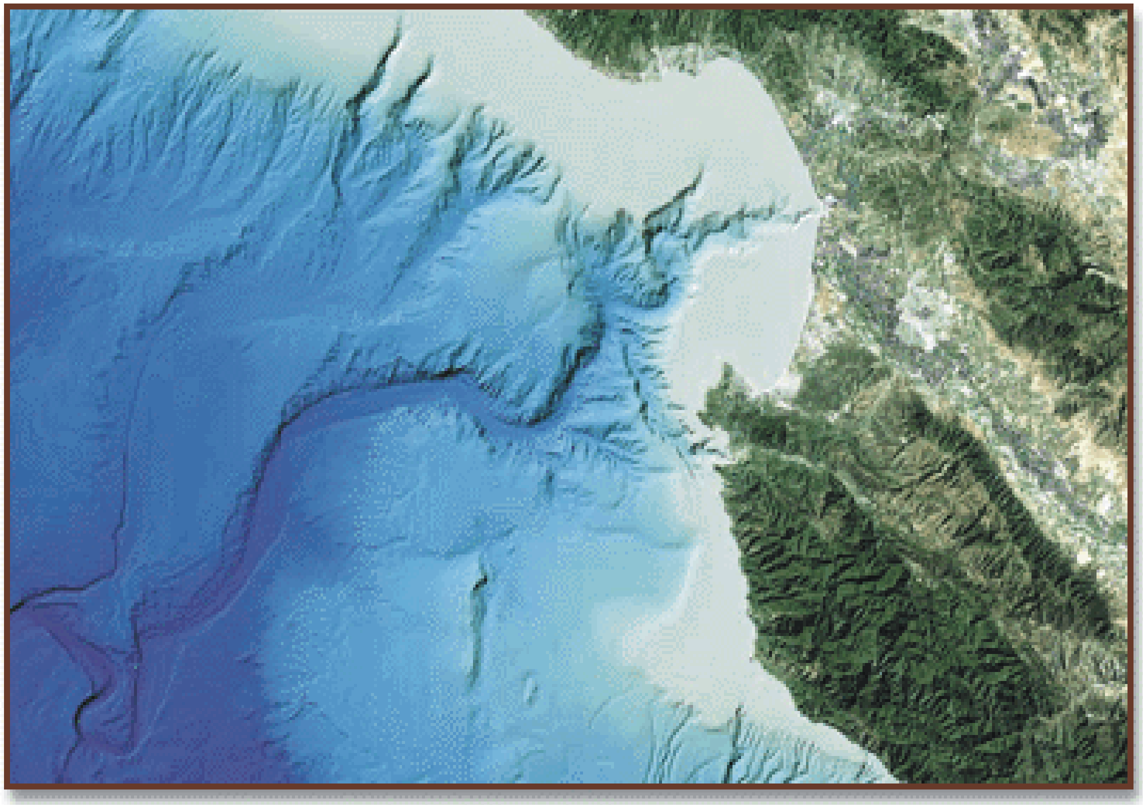
- 3D Flow (Toroidal & Poloidal): Very popular in astrophysics
-

$$\mathbf{u} = \mathbf{r} \times \boldsymbol{\nabla} A_1 + \mathbf{r}\mathbf{A}_2 + \boldsymbol{\nabla} A_3$$

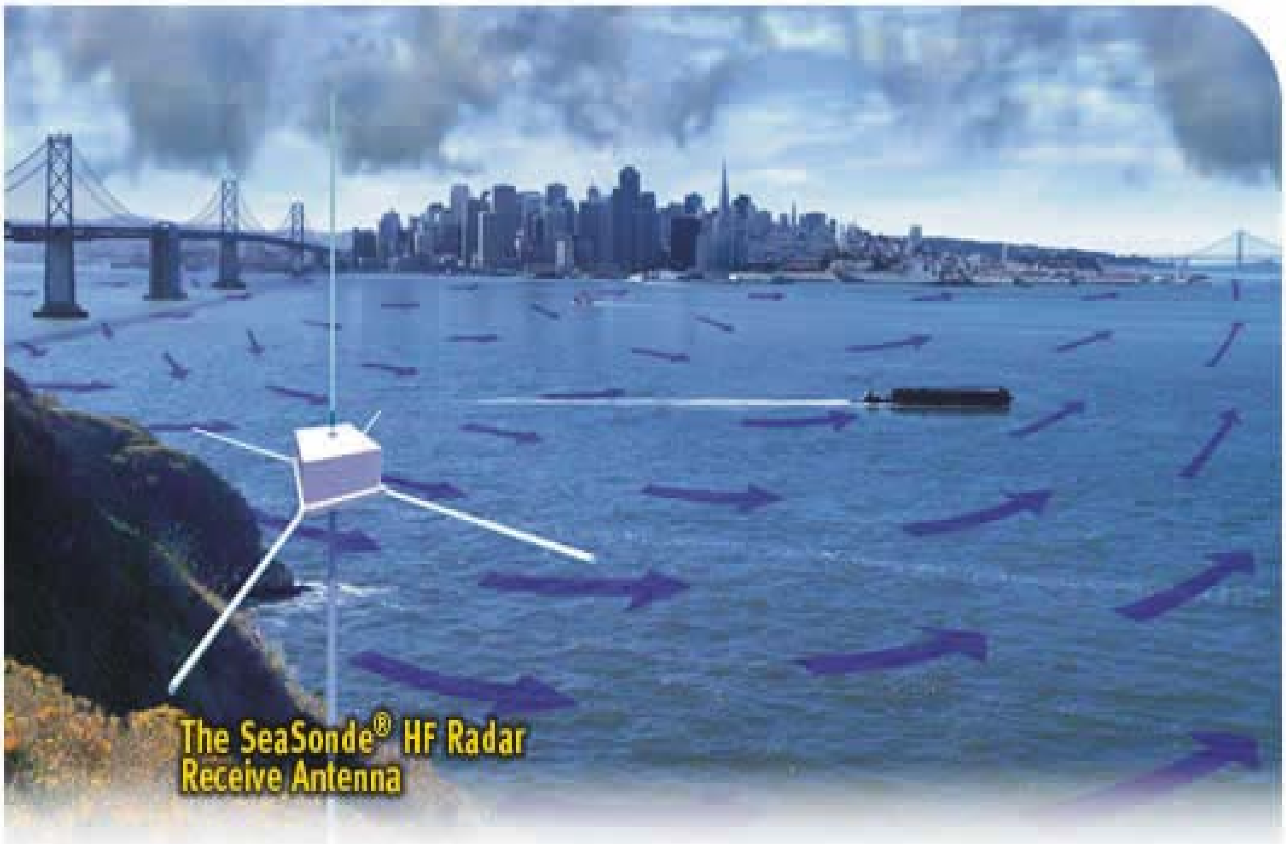
Spectral Representation - a Possible Alternative Method

$$c(\mathbf{x}, z_k, t) = A_0(z_k, t) + \sum_{m=1}^{M} A_m(z_k, t)\ \Psi_m(\mathbf{x}, z_k),$$

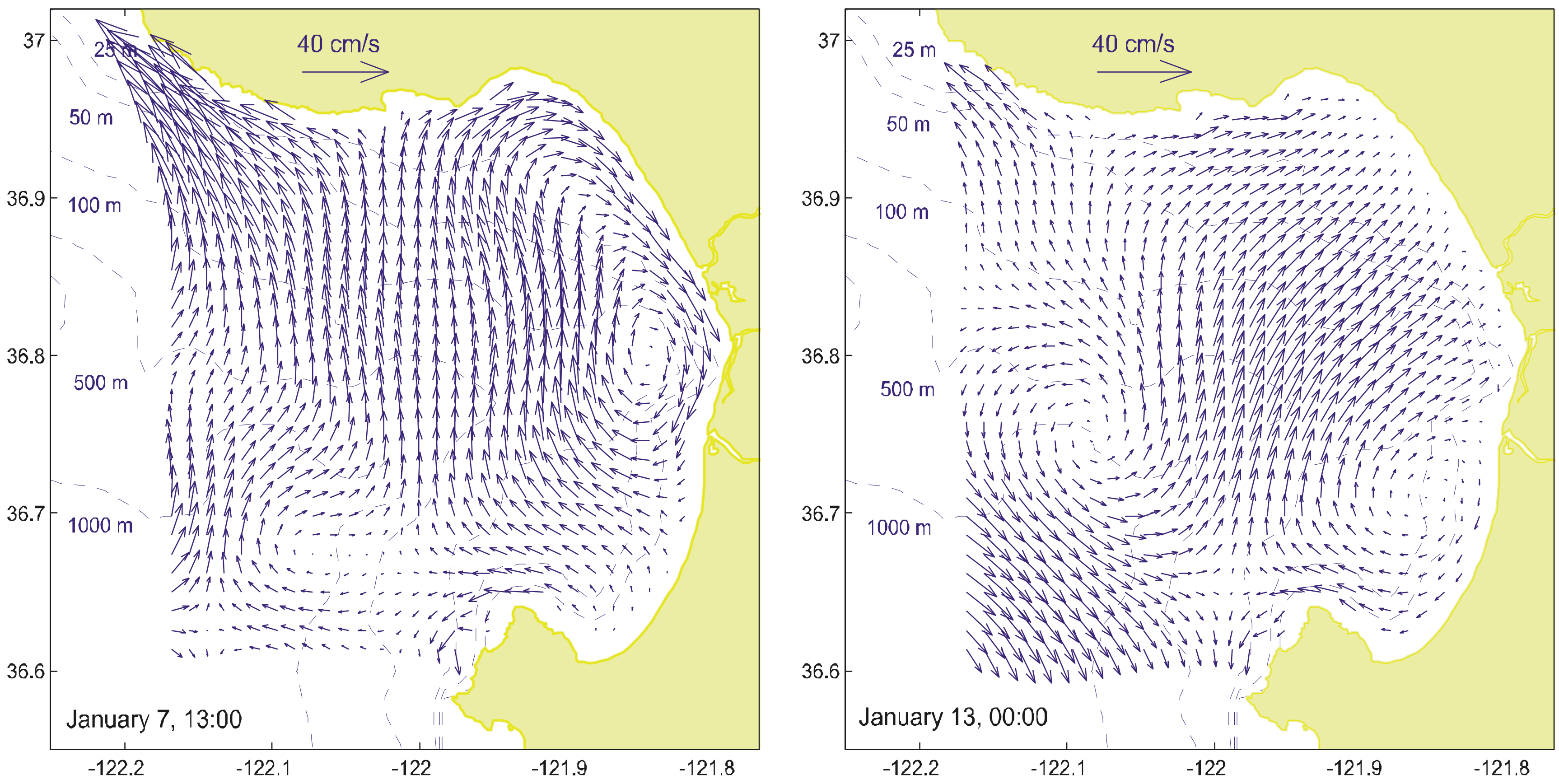
Example-1: Monterey Bay



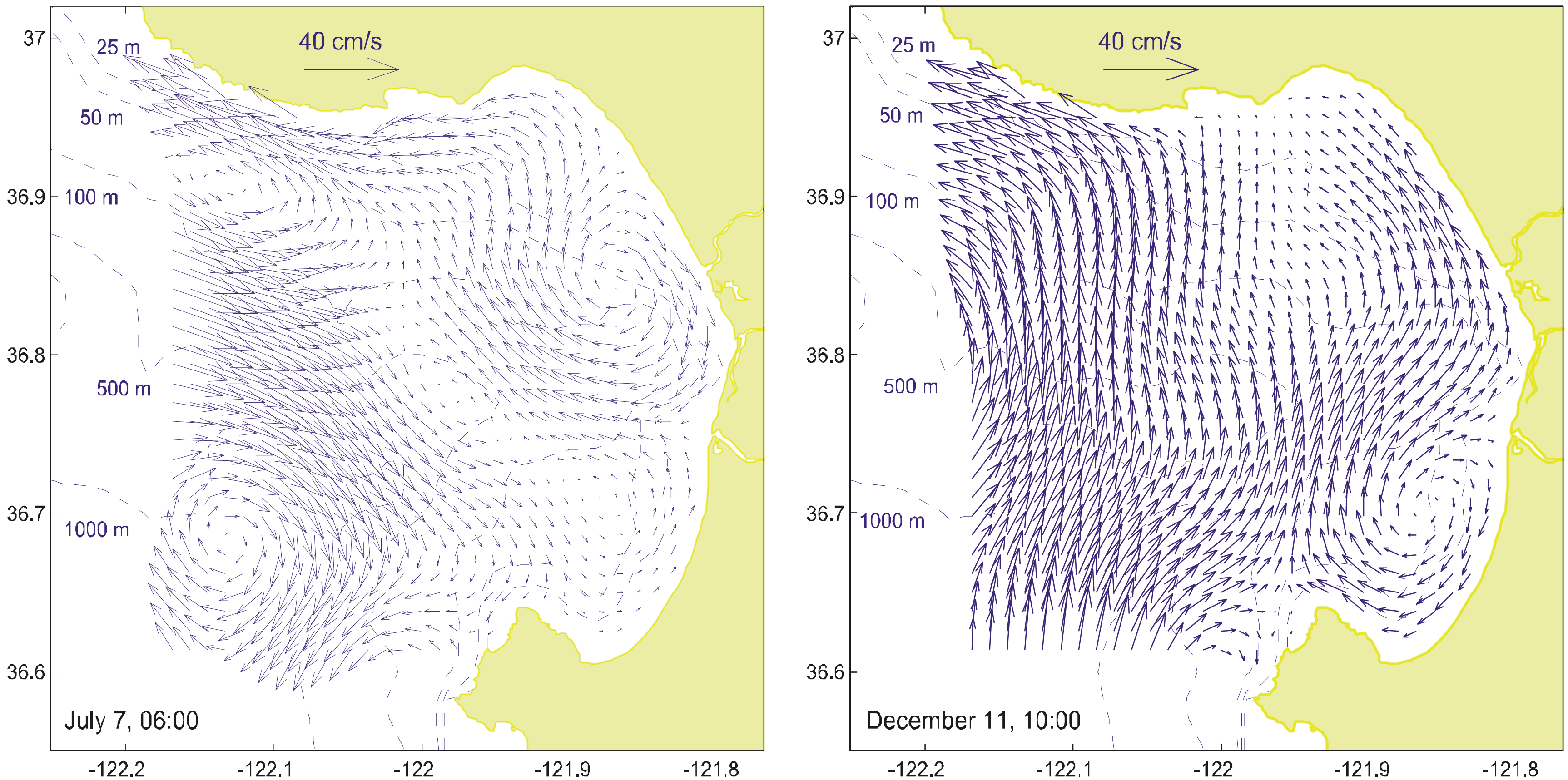
CODAR



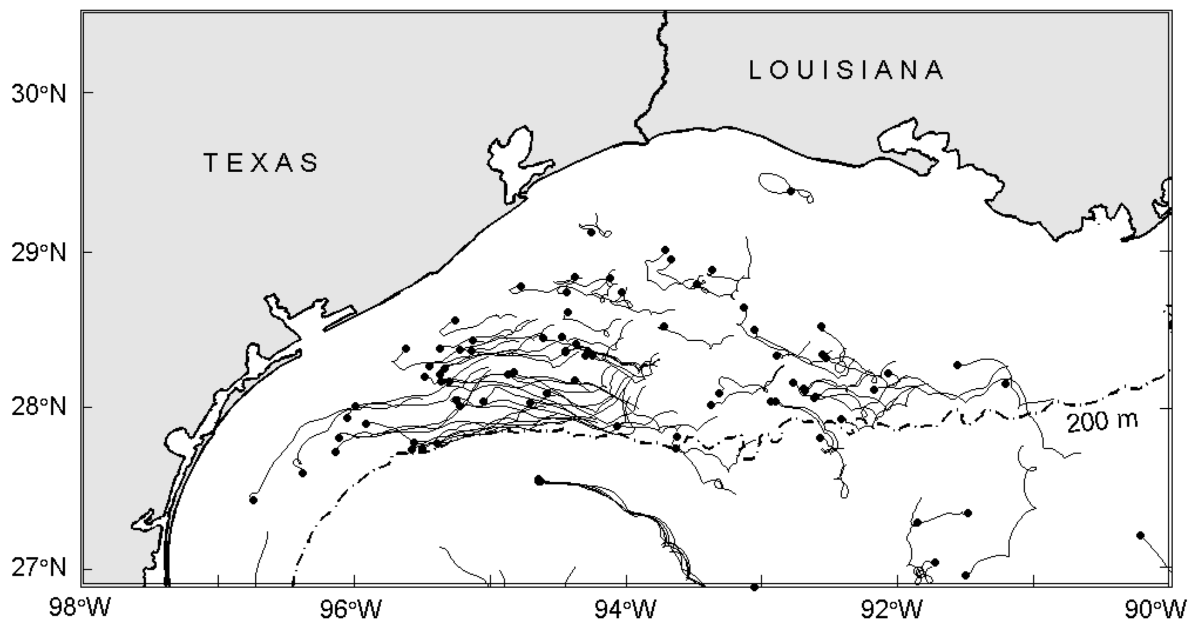
Temporally Varying Surface Circulation



Temporally Varying Surface Circulation



Example-2 Drift Data
TLCS current reversal detected from SCULP-I drift trajectories.

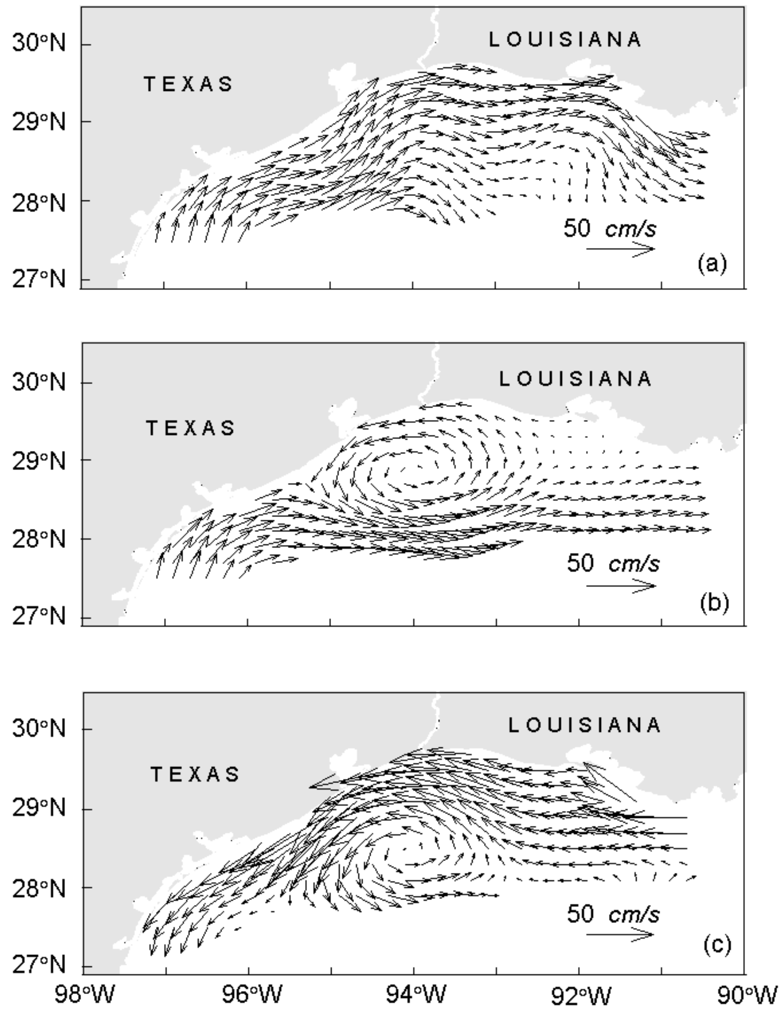


TLCS current reversal detected from the reconstructed velocity data

December 30, 1993

January 3, 1994

January 6, 1994



Conclusions

- OSD is a useful tool for processing real-time velocity data with short duration and limited-area sampling.
- The scheme can handle highly noisy data.
- The scheme is model independent.
- The scheme can be used for velocity data assimilation.
- Phase Space Consideration