Quantifying cross-shelf exchange in the Hudson Shelf Valley

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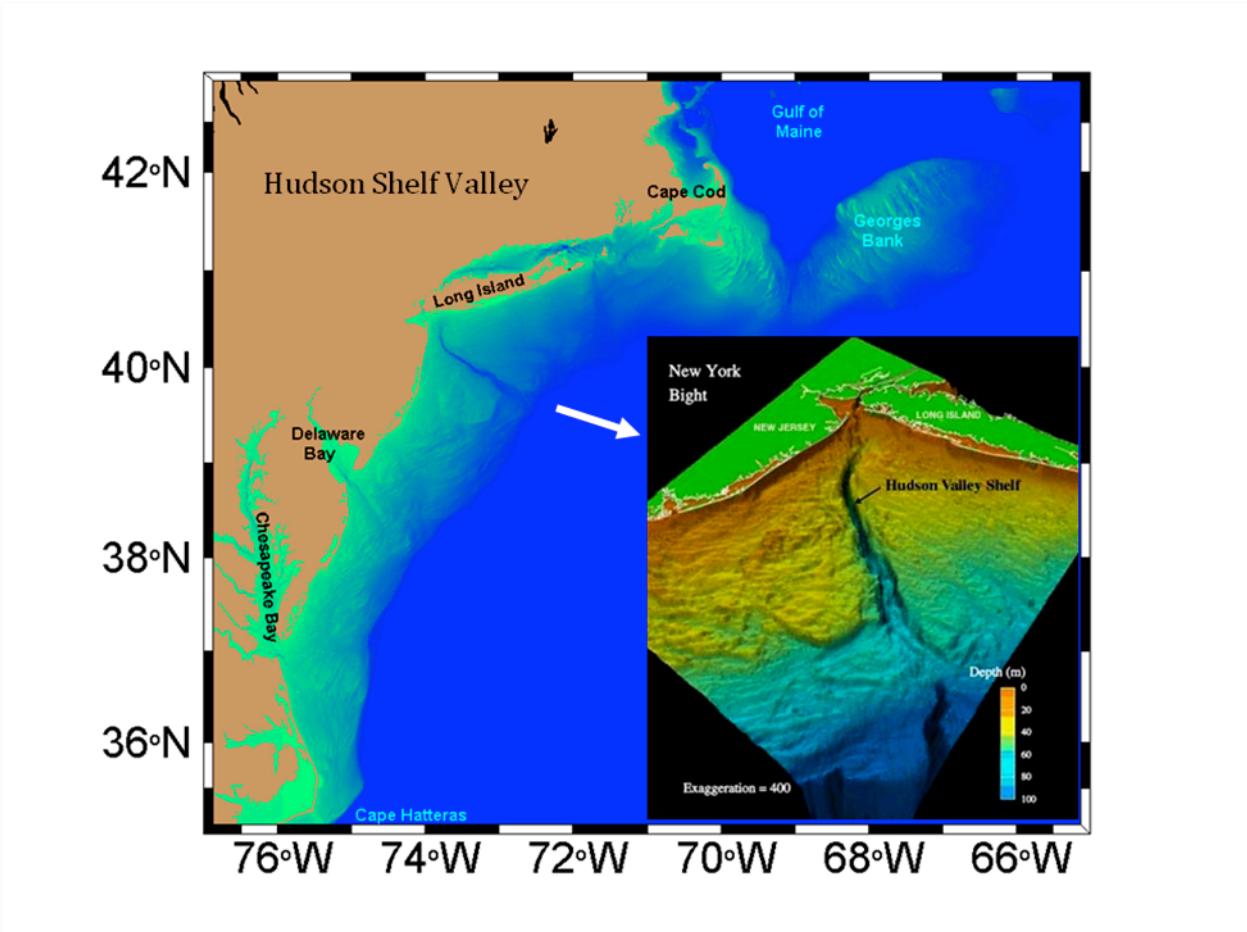
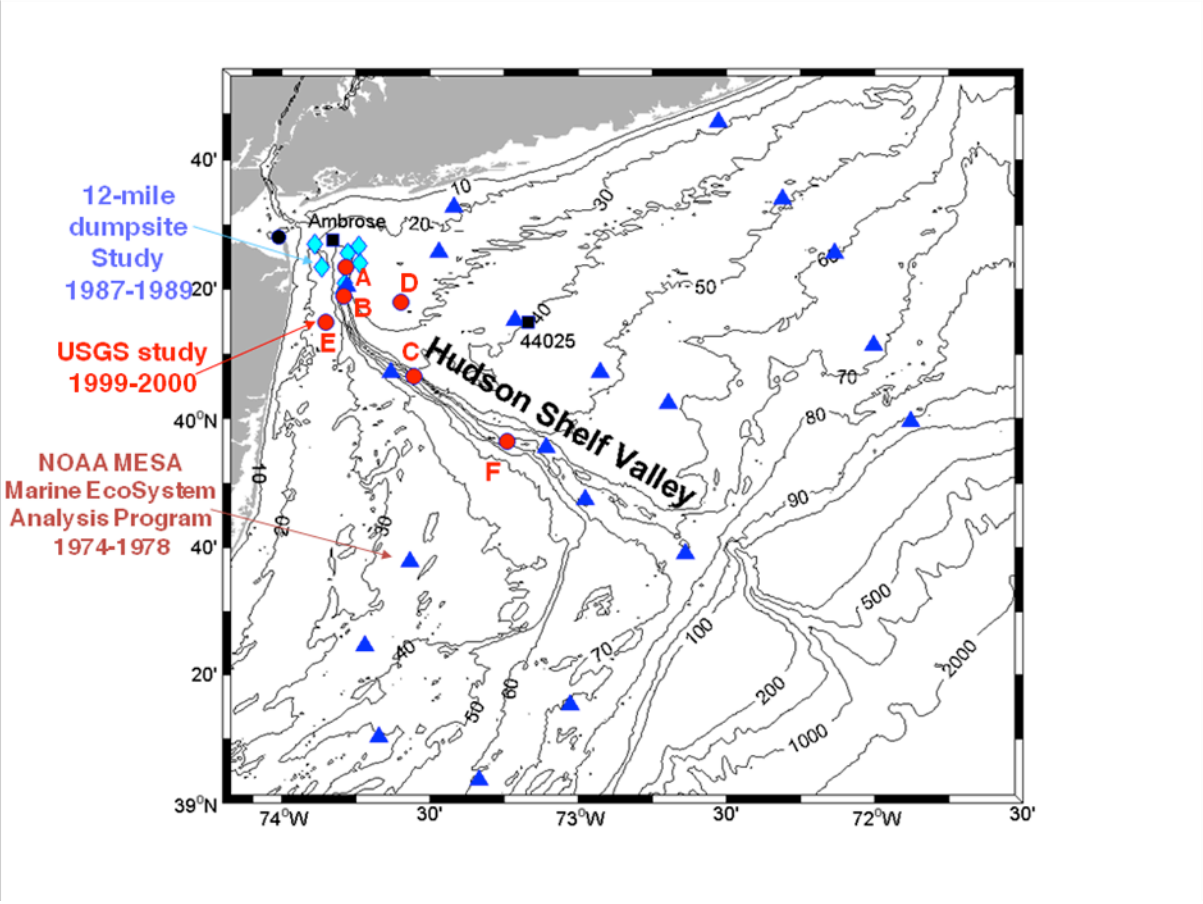
Hudson Shelf Valley is a 70-m deep canyon extending 150 km from near the coast at New York City to the outer edge of the continental shelf. Hudson Shelf Valley is the only canyon in the Middle Atlantic Bight, between Cape Hatteras and Cape Cod, that cuts across the entire continental shelf. Oceanographers are interested in canyons because they can be important conduits for exchange between the shallow near-shore waters and the deeper offshore waters. For example, Hudson



Shelf Valley may play an important role in carrying shelf sediments offshore into the deep ocean. The head of Hudson Shelf Valley lies near the site where sewage sludge and other industrial waste from New York and New Jersey were dumped for several decades and some of this material now resides in Hudson Shelf Valley. Understanding the circulation and associated sediment transport within the valley is essential to predicting the fate of these contaminants. Finally, transport within the valley may provide an important mechanism for bringing nutrients in the deep water near the surface where they can be utilized by phytoplankton.

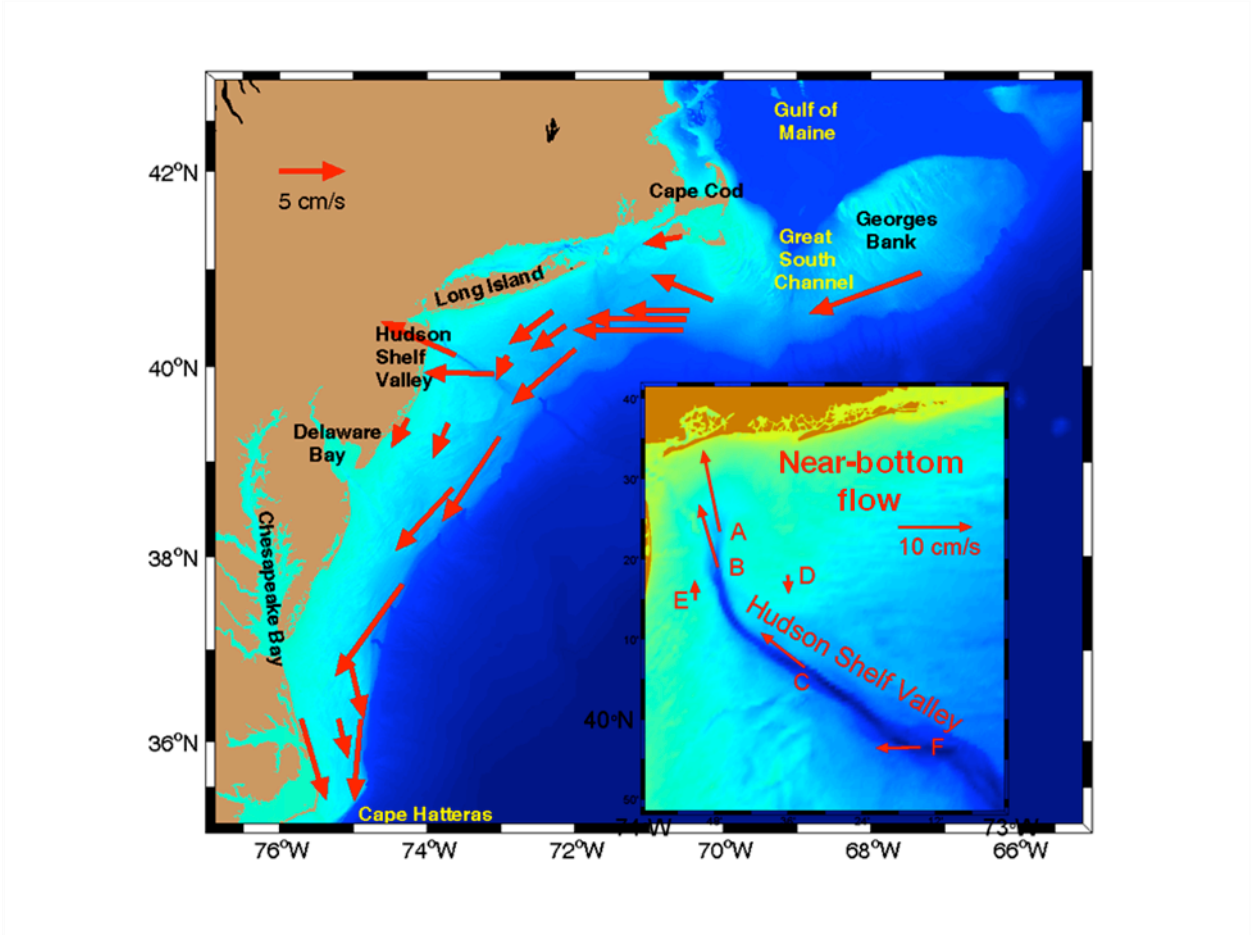
Motivated by these issues, we proposed to study the circulation in Hudson Shelf Valley by compiling and analyzing existing current observations from several previous studies of the Hudson Shelf Valley and the surrounding area. The objectives of the study were to: 1) to quantify the cross-shelf flow in the valley; 2) to determine what drives the flow in the valley, i.e. the dynamics of the flow; 3) use the results of the dynamical analysis to relate along-valley transport to winds and sea level for which there are longer time series.

Current observations from three studies were collected and analyzed: the 1974-1978 Marine Ecosystem Analysis project in the New York Bight (Mayer 1982) , a 1987-1989 study of sediment transport at the New York Bight 12-mile dumpsite which included near-bottom current measurements near the head of Hudson Shelf Valley (Manning et al., 1994), and more recent current measurements collected by US Geological Survey (USGS) in the winter of 1999-2000 (Harris et al, 2003) and the spring of 2006.

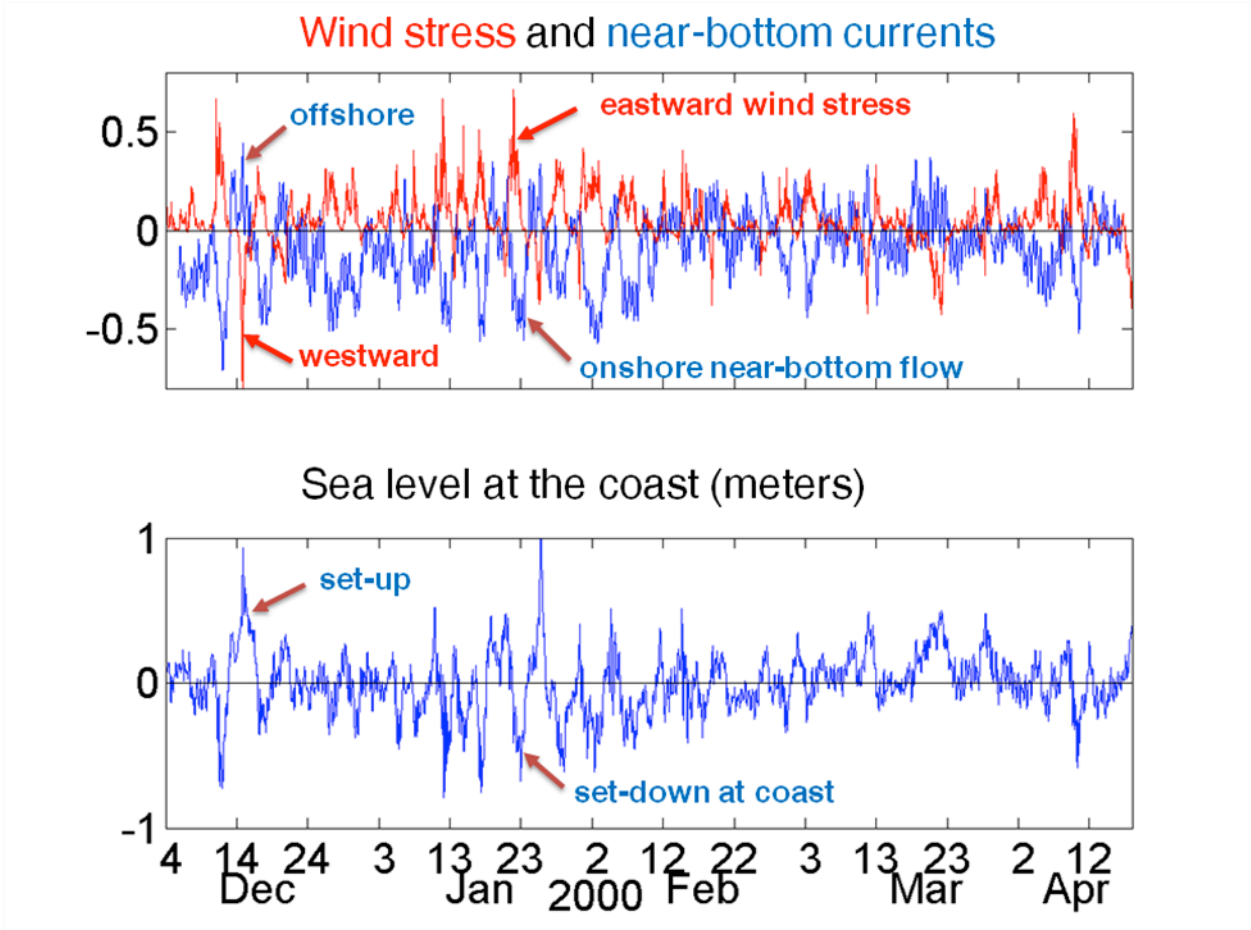


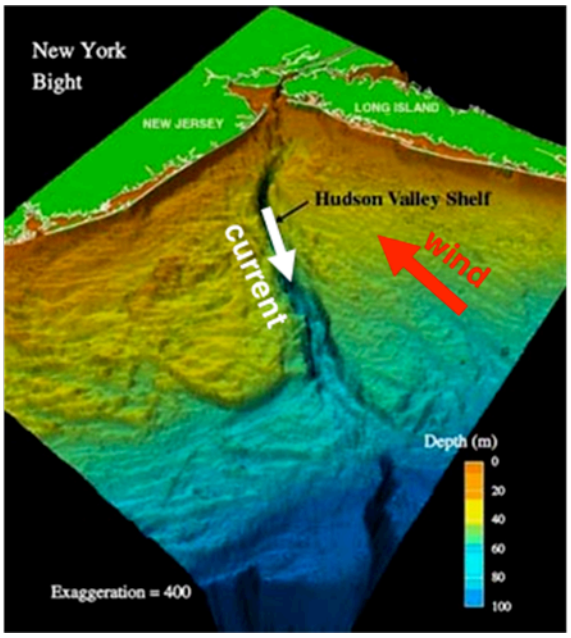
Of particular interest in this study are the current measurements within the Valley. The USGS studies included current profilers that measured currents from near the bottom of the valley to near the surface providing the first detailed description of the vertical structure of the flow at several locations within the valley.

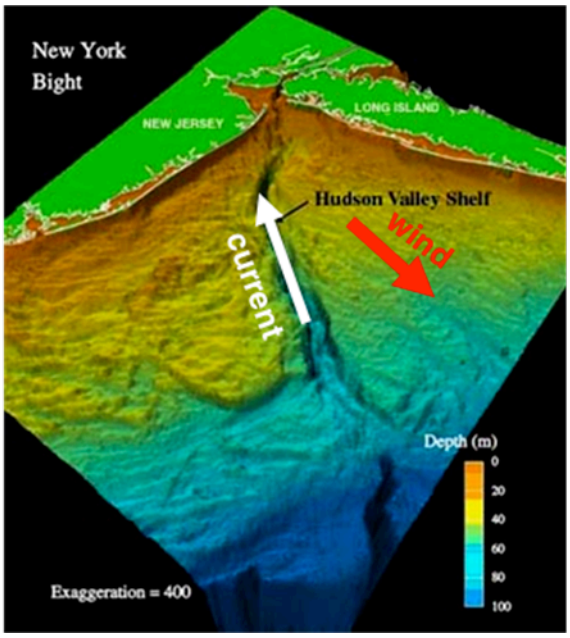
Mean currents over the Middle Atlantic Bight continental shelf tend to be oriented parallel to the coast (alongshore), with the notable exception of Hudson Shelf Valley where the mean currents are toward the coast (onshore). This onshore mean flow in the valley is a consistent of all the current observations and supports the notion that Hudson Shelf Valley is an important pathway for cross-shelf exchange.



The flow in the valley is wind-driven and actually consists of numerous very strong pulses of onshore or offshore flow lasting a few days or less (see figure next page). Eastward (offshore) winds drive onshore flow in the valley and westward (onshore) winds drive offshore flow in the valley (bottom panels). This counter-intuitive response of valley flows in the opposite direction to the wind can be understood as follows. Westward winds push near-surface waters onshore, causing the water to pile up near the coast increasing the sea level height at the coast (set-up). The sea level rise and associated increased pressure near the coast pushes the water in the valley offshore. Similarly, eastward winds draw water offshore, reducing sea level at the coast (set down), which draws water onshore in the valley. Since the mean wind stress is eastward the mean flow within Hudson Shelf Valley is onshore. This physical understanding of the flow in Hudson Shelf Valley provides a basis for determining the impact of the valley on processes such as offshore sediment transport or onshore nutrient flux.


Wind stress and near-bottom currents
offshore
eastward wind stress
0.5
0
-0.5
westward
onshore near-bottom flow
Sea level at the coast (meters)
set-up
1
0
-1
set-down at coast
4 14 24 3 13 23 2 12 22 3 13 23 2 12
Dec Jan 2000 Feb Mar Apr


New York
Bight
NEW JERSEY
LONG ISLAND
Hudson Valley Shelf
current
wind
Depth (m)
0
20
40
60
80
100
Exaggeration = 400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Depth (m)
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References

Harris, C. K., B. Butman, and P. Traykovski, 2003. Winter-time circulation and sediment transport in the Hudson Shelf Valley. Continental Shelf Research, **23**, 801-820.

Manning, J.P., L. Y. Oey, D. Packer, J. Vitaliano, T. W. Finneran, K. W. You, and S. Fromm, 1994. Observations of bottom currents and estimates of resuspended sediment transport at the New Your Bight 12-mile dumpsite. Journal of Geophysical Research, **99**, 10221-10239.

Mayer, D. A., 1982. The structure of circulation: MESA physical oceanographic studies in New York Bight, 2. Journal of Geophysical Research, **87**, 9579-9588.