Deep-C

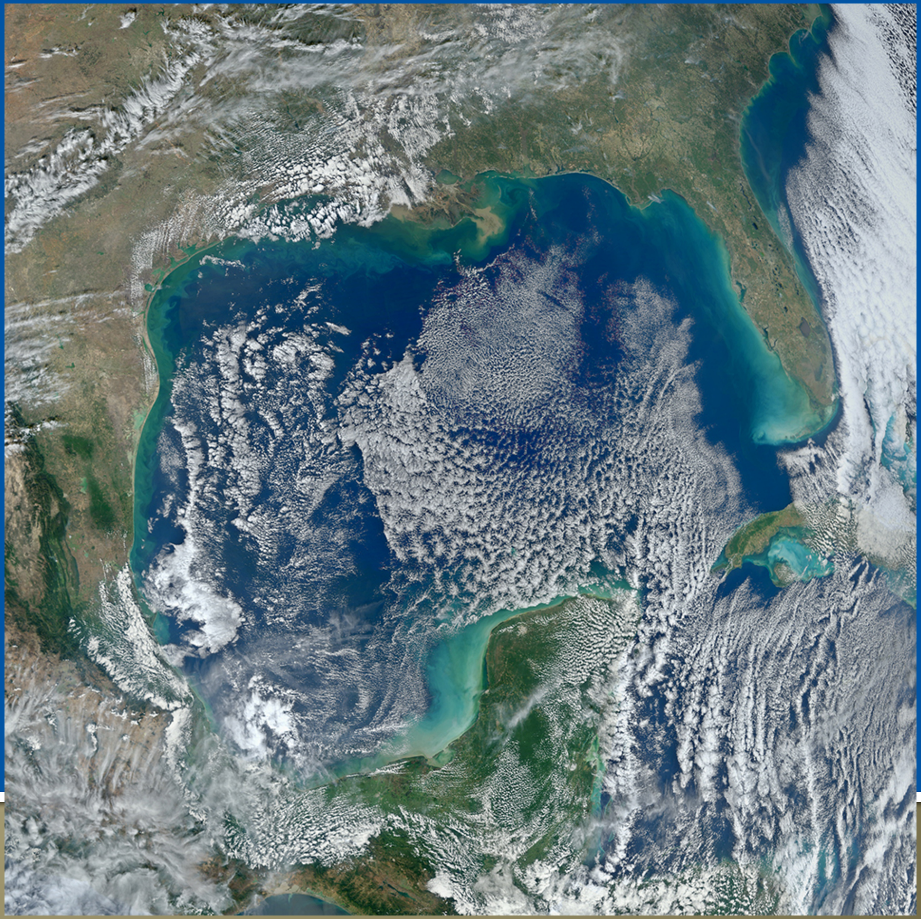
CONSORTIUM

Deep-C Consortium

An interdisciplinary study of deep sea to coast connectivity

In the Northeastern Gulf of Mexico

What are the environmental consequences of petroleum hydrocarbon release in the deep sea on living marine resources and ecosystem health?



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GULF OF MEXICO RESEARCH INITIATIVE

Deep-C Study Area
Northeast Gulf of Mexico

Three reasons compel Deep-C researchers to focus on the northeastern Gulf of Mexico:

1. Reported observations of the movement of surface oil slicks and subsurface plumes suggest that the De Soto Canyon acted as a natural conduit or escalator that guided oil toward the coast. And by what mechanism did this occur?

2. The region is a hotspot of biological diversity and biological productivity in the Gulf of Mexico

3. Hydrocarbon resources invite future energy development.

The De Soto Canyon is an erosional valley that cuts through the broad continental shelf in the northern part of the Gulf of Mexico.

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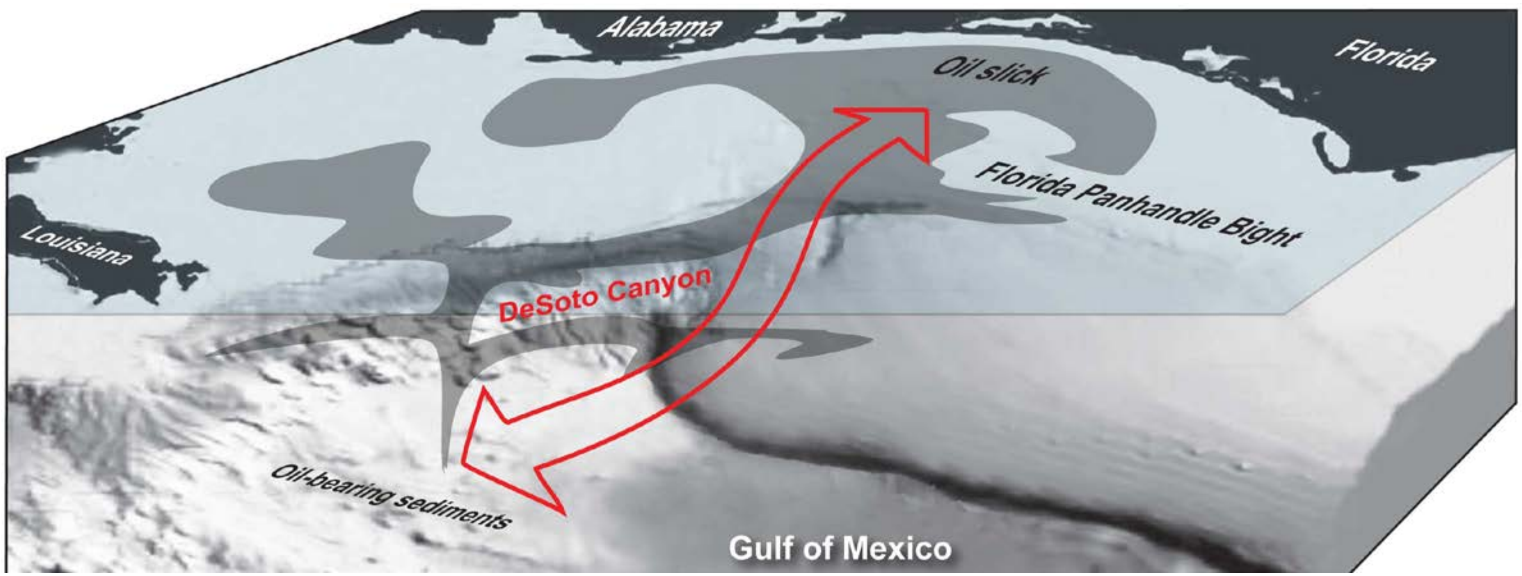
Project Goals

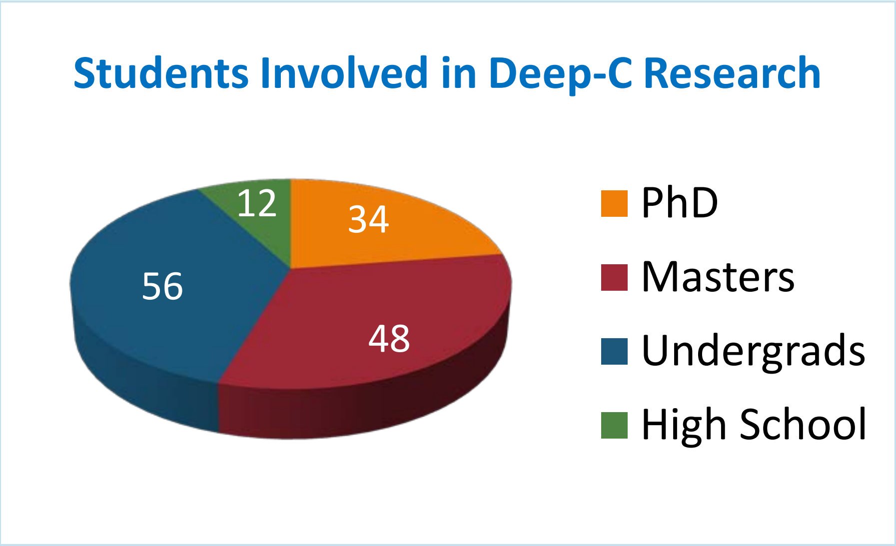
- What are the spatial and temporal scales of hydrodynamic processes that transport particles and dissolved substances from the deep Gulf to the shelf waters in the northeastern Gulf of Mexico?
- How are these influenced by canyon and shelf topography?
- How does the transport of these particles and dissolved substances influence geochemical and biological processes?



Participation and Productivity

Broad Participation

- 12 Member Institutions and 2 Associated Institutions
- 63 Research Scientists
- 20 Post Doctoral Scientists
- 149 Students
- 53 Other Staff (Research, Data, Outreach & Education, Support)



High Productivity

- 104 Peer-reviewed Articles
- 122 Datasets
- 438 Conference Presentations

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Some Research Highlights

Findings, Accomplishments, and Impacts

Microbial Degradation of Buried Oil in Florida Beaches

- In a two year time series, the in situ response and recovery of microbial communities was coupled to the chemical evolution of petroleum hydrocarbons from DWH oil
- The majority of hydrocarbons that came ashore were degraded within 6 months, and after one year, most of the oil had disappeared.
- Temperature was a pivotal factor: During warm summer temperatures oil degraded three times faster than during colder winter months.
- Buried oil layers consumed four to five times more oxygen and produced up to six times more carbon dioxide than the unpolluted beach sand, revealing strong aerobic microbial decomposition activities.
- Modeling of the time series allows calculation of decomposition rates for specific oil components under in-situ conditions and predictions of the beach recovery period.
- *The results can be used for designing responses to future beach oil contamination events.*

Huettel (FSU) and Kostka (GaTech) Labs

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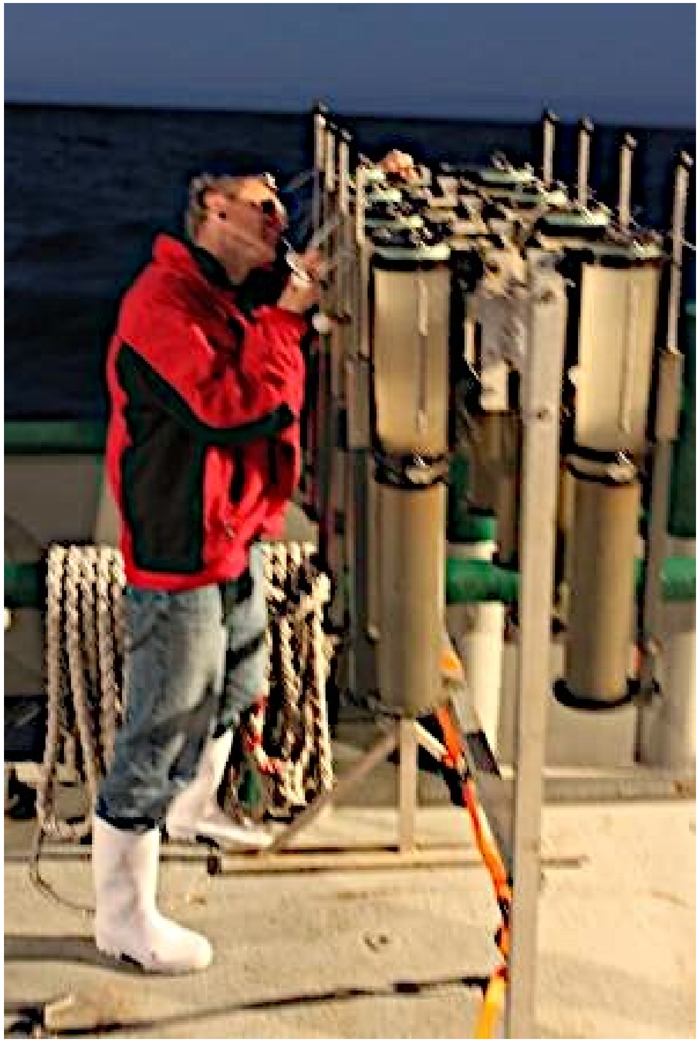
Corexit Mobilizes Oil Buried in Inter- and Subtidal Sands

Huettel Lab, FSU

- Crude oil attaches readily to sand grains and thereby the transport of oil components into marine sands for the hydrophobic components is limited to a few centimeters sediment depth.
- Corexit detaches oil coating of sand grains and reduces adhesion of oil to sands, thereby enhancing mobility of oil components in submerged coastal sands.
- Through this mechanism, potentially harmful polycyclic aromatic hydrocarbons (PAHs) can penetrate tens of decimeters into the sediment and may reach groundwater level in shore environments.
- The mobility of the PAHs through the sand is controlled by the hydrophobicity of the PAHs.
- *These results can be used for planning of detergent application in coastal environments.*

Oil Snow Deposition Alters Oxygen Availability at the Seafloor

- Deposition of oil snow removes oxygen from the water layer at the sediment surface similar to settled algae.
- This effect is much more pronounced in the warm shelf waters as compared to the cold deep sea environment.
- The oxygen consumption by the settling oil can result in a slowing of the oil degradation process and thus a preservation of oil in marine surface sediment layers.
- The resulting preservation of oil layers can influence the organisms living at the seafloor and thereby the benthic food web.
- *These results can be used for assessing the potential damage settling oil snow had on seafloor ecosystems.*



Huettel Lab, FSU

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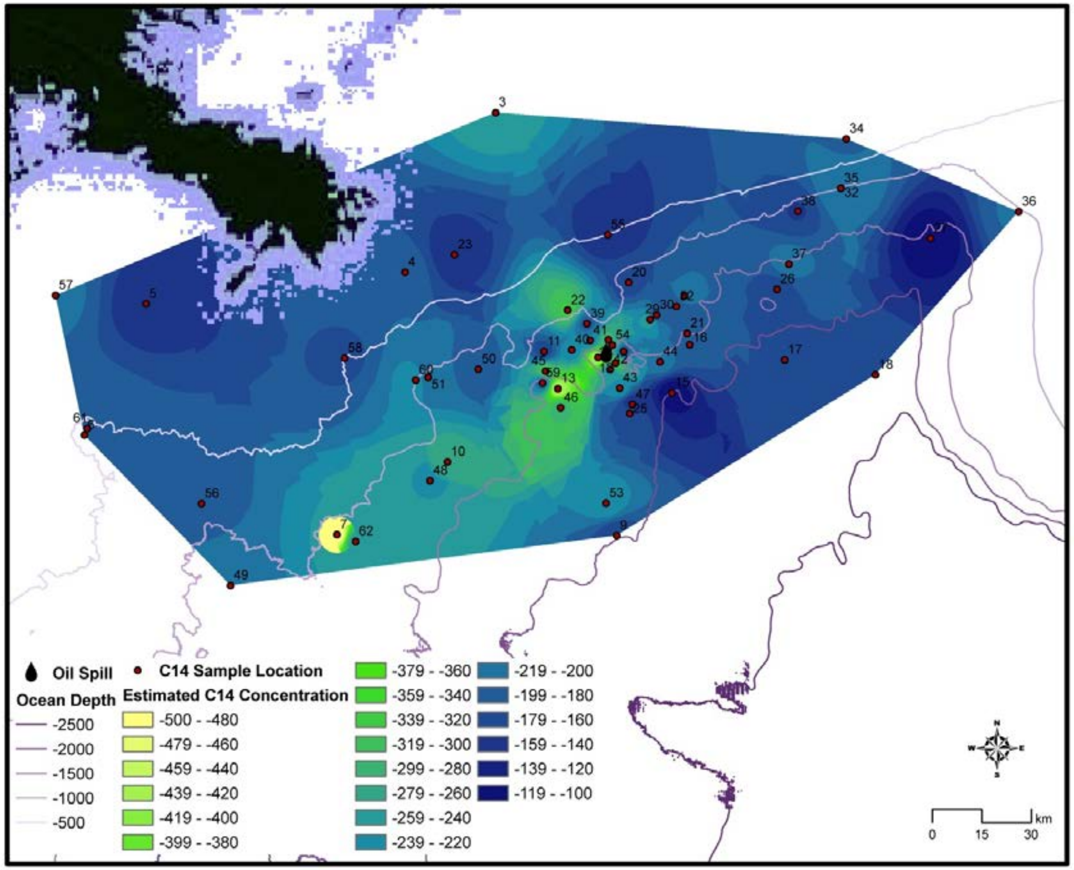
Radiocarbon Analysis of the Gulf Oil Spill

- Documented and quantified the abrupt changes observed in the sedimentary system in the deepwater Gulf
- Determined effects of rapid sediment deposition event on forams and redox sensitive metals
- Evidence that that 3 to 5% of oil from blowout was deposited on the sea floor of the deep Gulf
- Evidence that petro-carbon from methane oxidation entered food web from particulate organic carbon (POC)
- Evidence that the Hg cycle and the planktonic and coastal food webs were impacted



Chanton Lab, FSU

- *These results underscore the need to determine the long-term fate of the oil on the seafloor*

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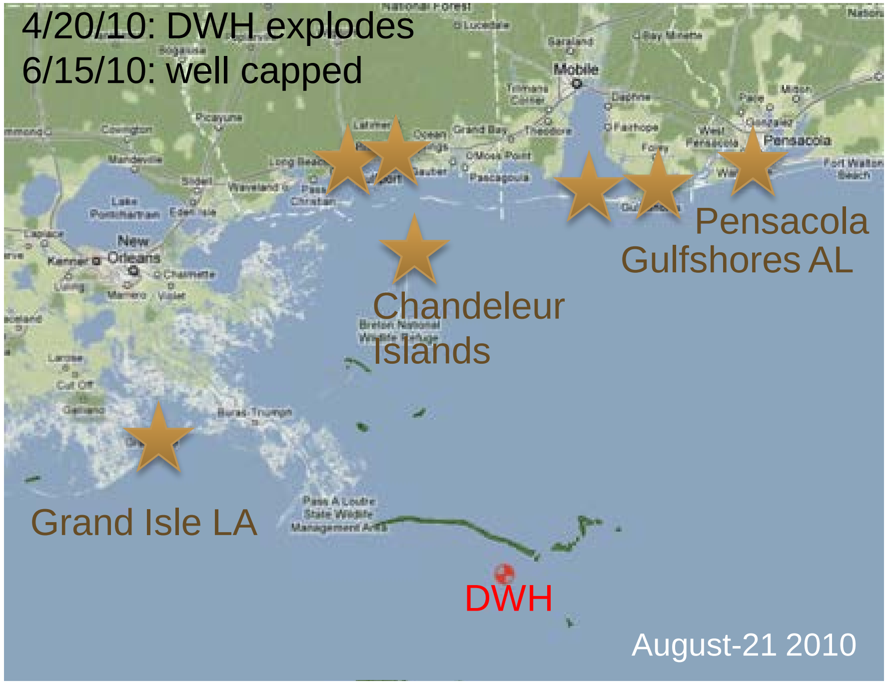
Studying the Fate of Compounds beyond PAHs

Degradation of compounds and transformation products

- Performed 25 field operations
- Collected 1,000 samples along the Gulf



NOAA / EPA / USCG *www.geoplatform.gov/gulfresponse*

Reddy Lab, WHOI

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Transformative Chemical Analysis Techniques

- Identified a new pool of non-native, transformational products in the Macondo well oil: oxygenated hydrocarbons, OxHC.
- Developed a new approach for expanding the analytical window for studying oil spills (WHOI/Mag Lab).
- Rapid response studies on 2012 Hurricane Ivan, 2012 mystery sheens at MC252, 2014 Texas City spill, and 2014 Bangladesh spill
- Calculated mass balances on released oil found on beaches.
- Developed new index of biodegradation for saturates.
- Redefined views on the recalcitrance of biomarkers.

Reddy Lab, WHOI

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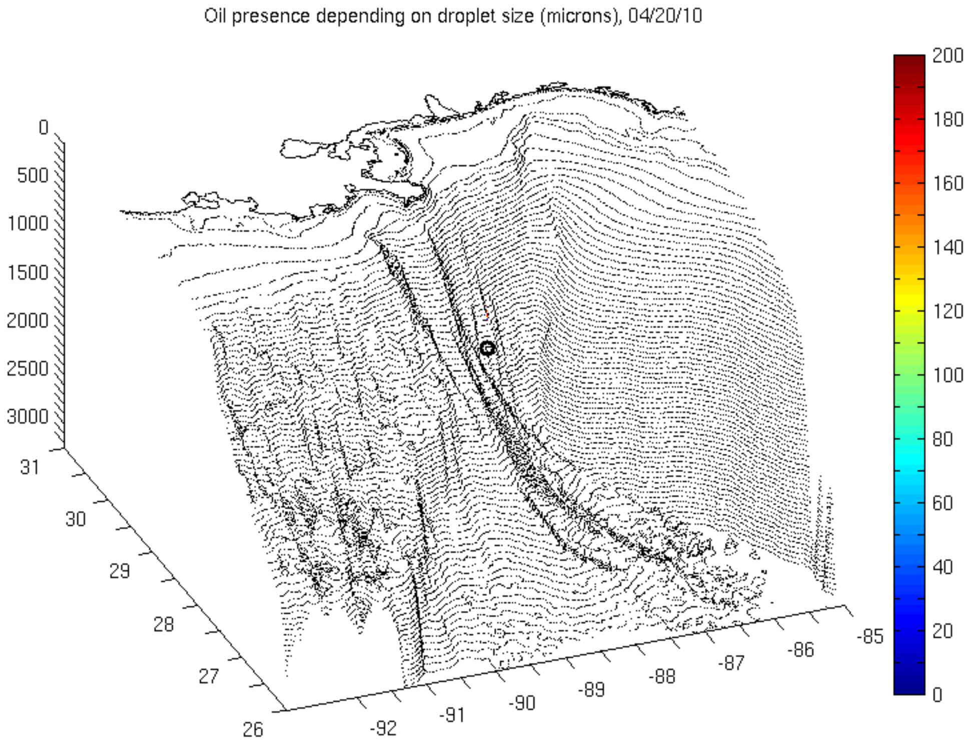
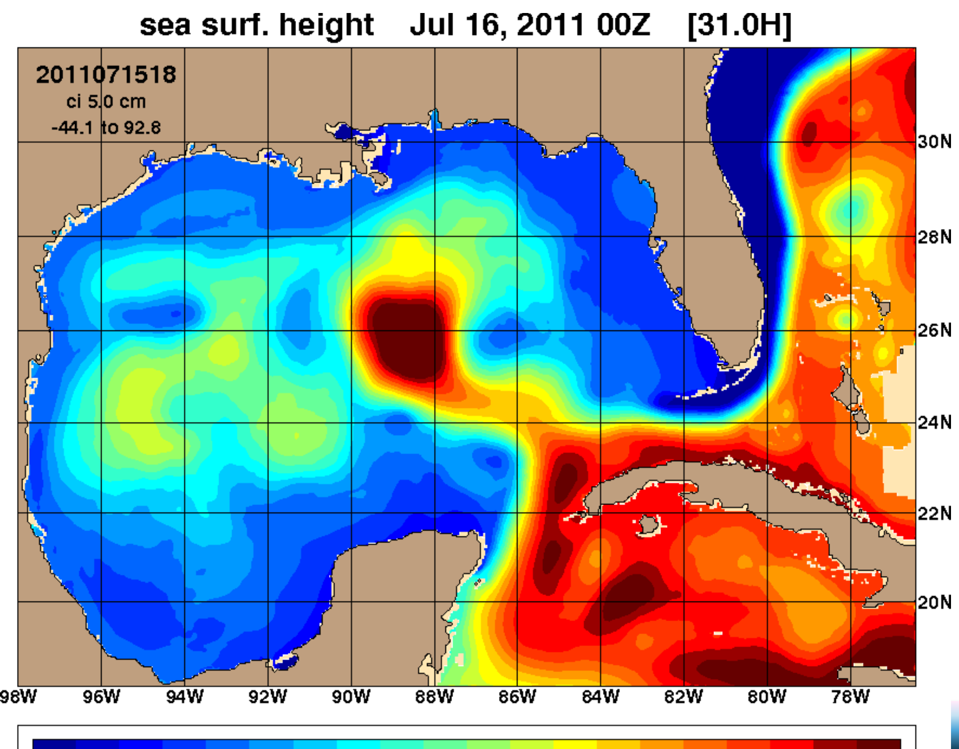
Regional 3D Earth System Model





Includes interfacial exchange processes between sediment, water, and atmosphere; biogeochemical processes, the transport of organisms, and the effects of petroleum hydrocarbons on all of these processes.

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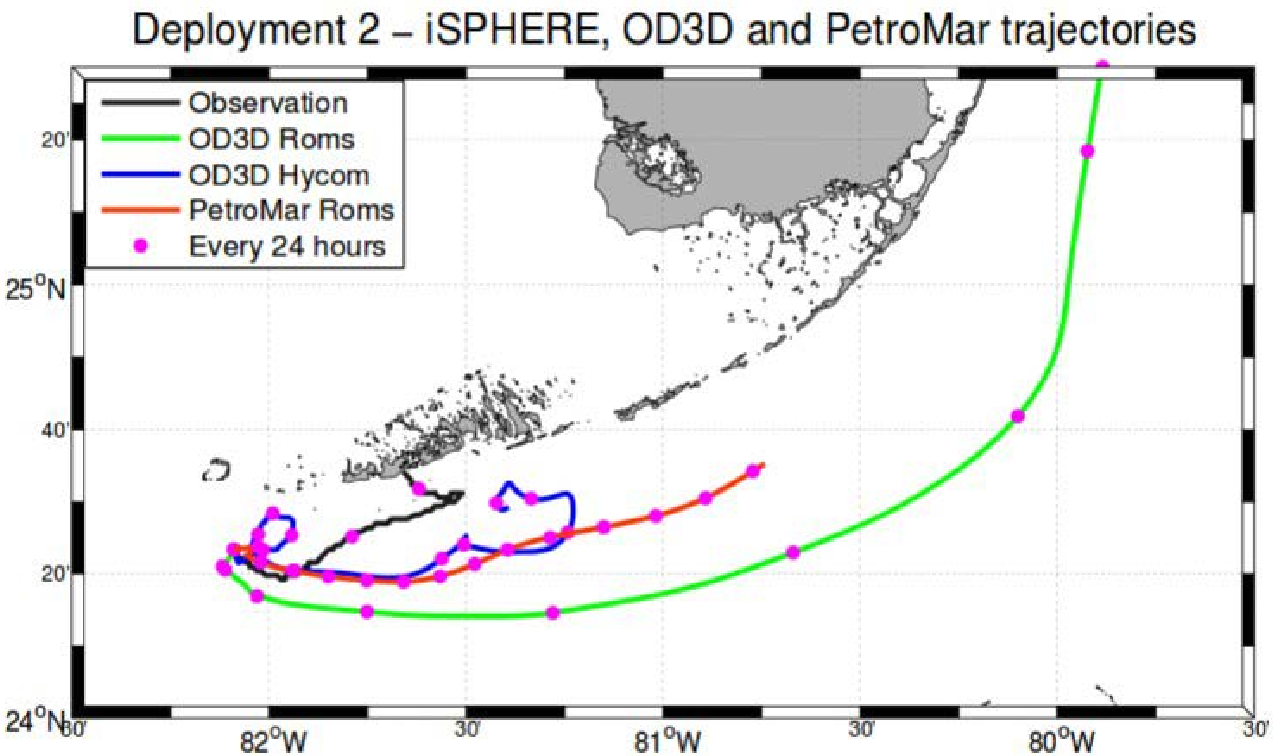
Oil Drift Simulations and Isphere

- Stokes drift (wave drift) can considerably alter the drift pattern of oil particles. It has been confirmed by drifter studies that the speed can be up to 1 m/s.
- Forcing of oil drift models can yield very different scenarios.
- *Oil drift simulations need be probabilistic, using model ensembles*



Hole Lab, Met.no

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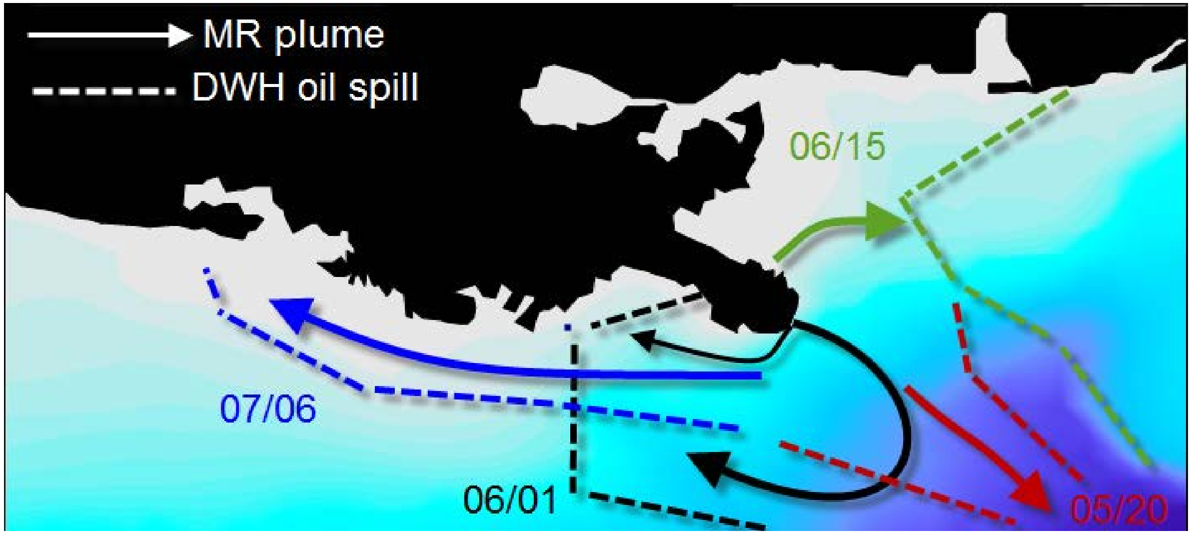
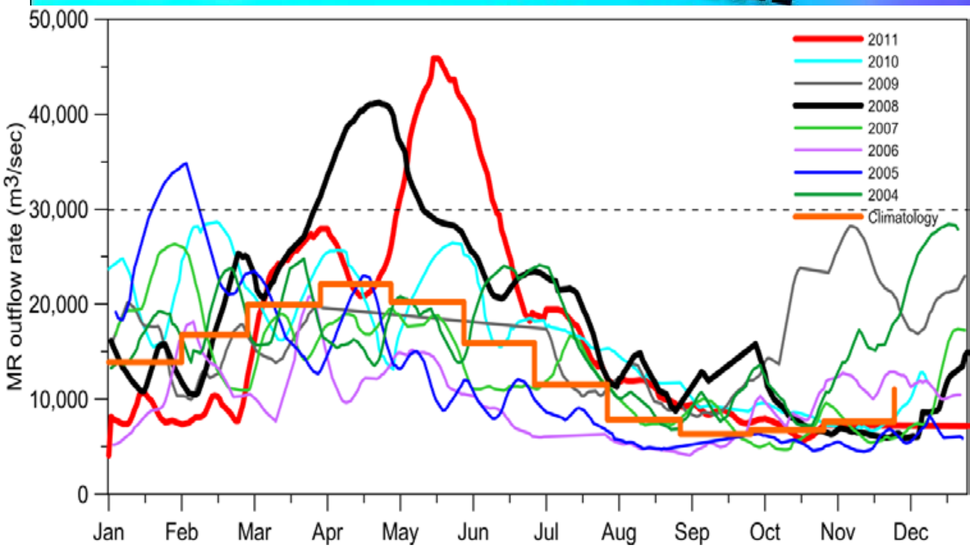
Mississippi River Plume: Impact on DwH Oil Pathways

Fronts associated with the variability of the Mississippi River plume (under the influence of winds, topography and Loop Current intrusions) influence hydrocarbon pathways.





Time series of daily Mississippi discharge

Synergistic transport pathways were found for the near surface advection of Mississippi waters *(solid lines)* and of the DwH surface oil pathways *(dashed lines)*, over distinct oil spill periods

Kourafalou and Androulidakis JGR, 2013

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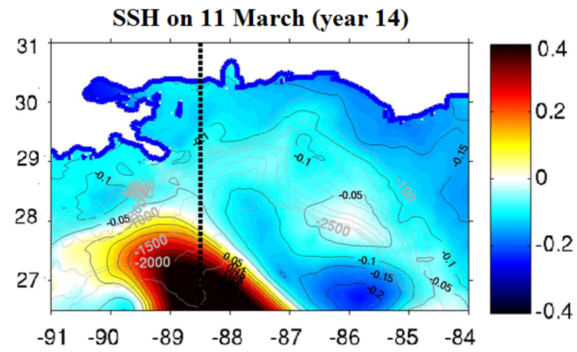
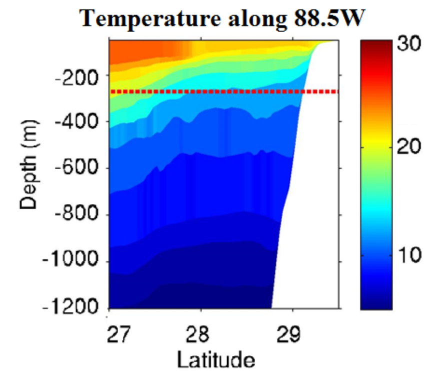
Cross-Slope Flows in the DeSoto Canyon

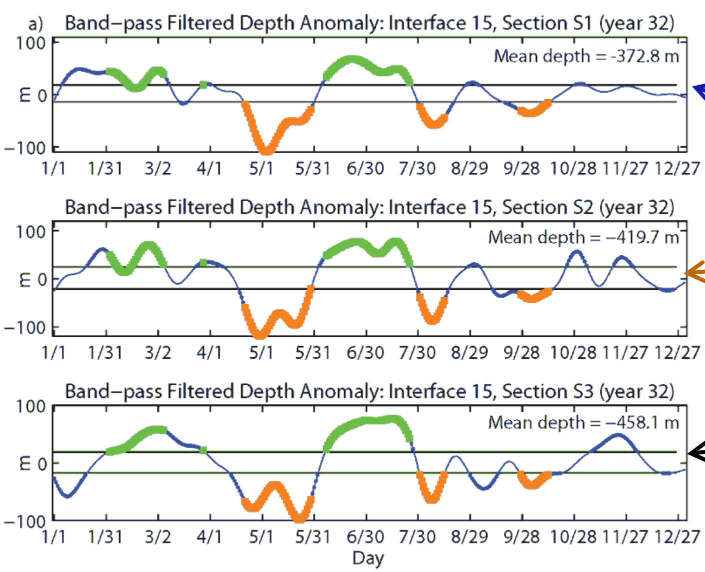
A 54-year HYCOM simulation is analyzed to quantify low-frequency upwelling/downwelling across the continental slope in the canyon.

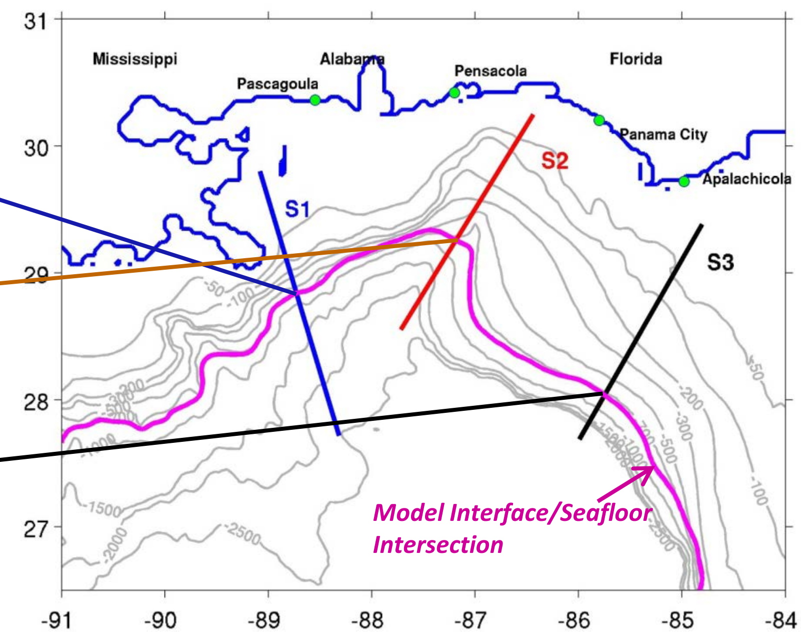




Vertical excursions may exceed 100m for weeks to over one month, and are coherent throughout the DeSoto Canyon region.

Nguyen et al., Geophys. Res. Lett., Submitted

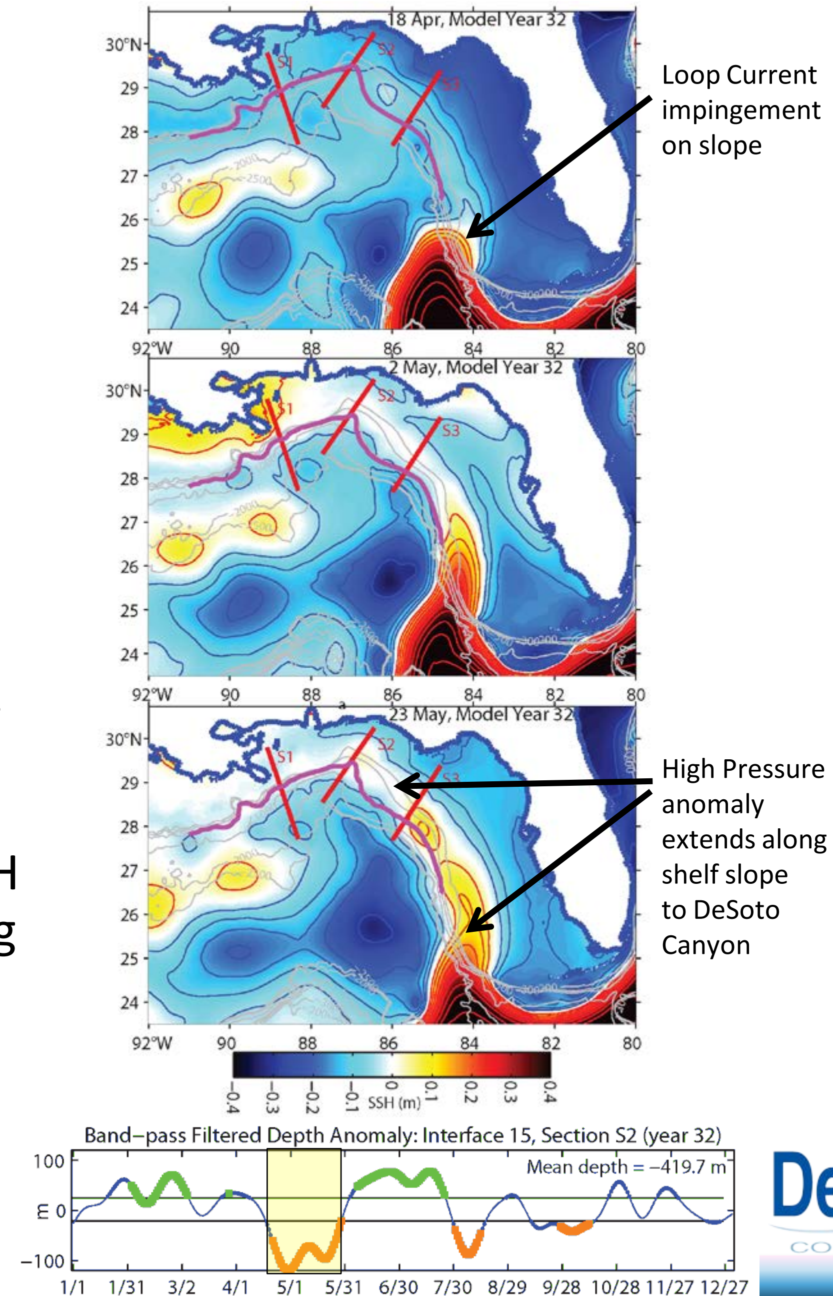




Cross-Slope Flows in the DeSoto Canyon

- Large-scale low-frequency downwelling events are 2 to 4 times more likely to occur when the Loop Current impinges on the continental slope along the southern West Florida Shelf, and upwelling events are more likely in absence of impingement.

- Loop Current contact with the continental slope spawns a high pressure (SSH) anomaly that transits the continental slope toward the Mississippi Delta in the topographic Rossby wave direction. This high SSH suppresses isopycnals below, causing downwelling and/or hindering upwelling.



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