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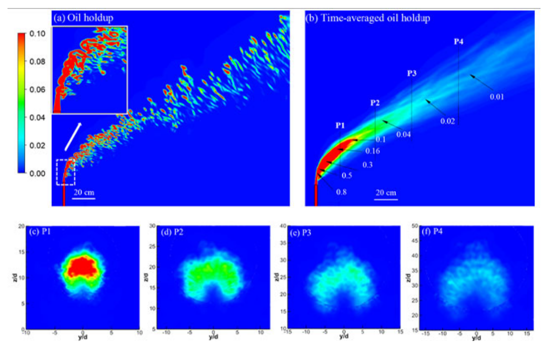
High-Performance Computing Aids in Predicting Oil Dispersal During Spills

Supercomputer simulations detail oil's behavior during cross-flow waves

According to the National Oceanic and Atmospheric Administration (NOAA), thousands of oil spills occur each year in the United States. Although the majority of incidents involve less than one barrel, the spills have wreaked economic and environmental devastation for decades. To better understand the fate of oil droplets for effective countermeasures, researchers recently created simulations using supercomputers, including *Comet* at the San Diego Supercomputer Center (SDSC) at UC San Diego and *Bridges* at the Pittsburgh Supercomputing Center.



Researchers from the New Jersey Institute of Technology recently published this supercomputer-enabled simulation detailing what happens when oil disperses during a water cross-flow. They relied on Comet at the San Diego Supercomputer Center to conduct their simulations since the high-fidelity models need high spatial and temporal resolution of the turbulent flow structures which was achieved in a reasonable time using many nodes in parallel on Comet. Credit: Center for Natural Resources, New Jersey Institute of Technology

The systems provided the perfect resources for Cosan Daskiran, a postdoctoral researcher and senior engineer at New Jersey Institute of Technology (NJIT), to model studies on how oil dilutes under specific conditions. "We used the supercomputers to create high-fidelity, large eddy simulations of underwater oil blowout in water crossflow conditions," explained Daskiran. "The main goal was to understand the fluid dynamics and estimate the trajectory of different-sized oil droplets, which is important for the countermeasures following oil spill incidents."

Daskiran's supercomputer simulations showed that large oil droplets rose faster and separated from the oil plume without spreading spatially much within the plume due to their higher individual buoyancy. Meanwhile, small droplets were trapped in a counter-rotating vortex pair, which is considered a signature of the jets in crossflow.

Daskiran worked with Michel Boufadel, a professor at the Civil and Environmental Engineering Department at NJIT who has spent much of his career examining the dispersal of oil after a spill. The research team compared Daskiran's simulations with actual oil dispersal experiments before publishing their findings in the October issue of *International Journal of Heat and Fluid Flow*.

"We used Ohmsett, short for the Oil and Hazardous Materials Simulated Environmental Test Tank, here in New Jersey to create a life-like oil spill in a controlled environment," said Boufadel. "Ohmsett is operated by the U.S. Navy and provided us an environmentally safe place to conduct tests for this project."

Specifically, the researchers conducted experiments of an oil jet by towing pipe horizontally in the Ohmsett wave tank and then created simulations on *Comet* and *Bridges* based on this study.

By incorporating the findings from predictive numerical simulations with experimental results into the models estimating oil droplet size distribution, the results were more accurate when dealing with an accidental oil spill. Some numerical models might have assumptions which may not represent the actual physics of the problem, such as prior models for the jet in crossflow where researchers assumed a Gaussian profile for the oil concentration and mixture velocity across the plume.

"However, this is not the case," said Daskiran. "The formation of the CVP vortices changes the hydrodynamics dramatically, and the oil concentration and velocity do not have an axisymmetric, Gaussian distribution across the plume, assuming so will result in inaccurate estimation of the droplet size distribution which is important for the fate of oil droplets."

Daskiran credited a great deal of the study's success to *Comet* and *Bridges*. "The supercomputers helped us see things in finer detail; for instance, to capture small flow structures (i.e. eddies in the turbulent flow), we needed a high spatial and temporal resolution of the flow which was achieved using many nodes on *Comet* and *Bridges*," he said. "The supercomputers were also good for large file sizes, but the main contribution of *Comet* and *Bridges* was using many nodes in parallel which decreased the simulation time and allowed us to see the details of the flow."

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