BLUE WATERS
SUSTAINED PETASCALE COMPUTING

Allocation: BW Professor/300 Knh

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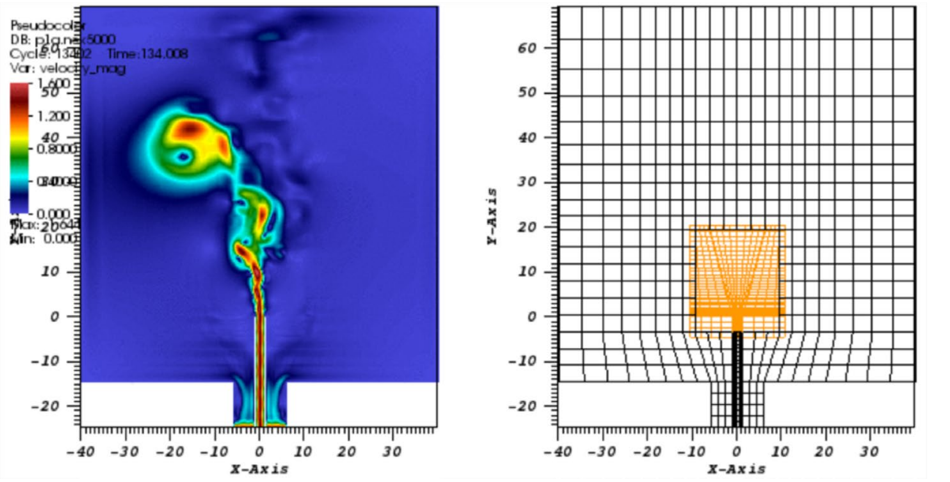
Physics & Engineering



Left: velocity magnitude from a NekNek simulation of a turbulent jet entering a container. Right: two subdomains (orange and black) decomposed from the global domain.

HIGH-ORDER METHODS FOR TURBULENT TRANSPORT IN ENGINEERING AND GEOSCIENCES

Research Challenge

The goal of this effort is to develop new algorithms for large-scale high-fidelity turbulence simulations for different research problems. The team applies the new apparatus to:

- Better understand how biofilm growth affects the flow hydrodynamics and fine-particle transport at the unprecedent spatial and temporal resolutions.
- Address problems that either have complicated meshes, involve disparate spatial scales, or have moving boundaries that would require the remeshing of standard conforming meshes

Methods & Codes

The turbulence simulations are based on the open-source spectral element code Nek5000. The spectral element method (SEM) is a domain-decomposition approach in which the solution is represented by tensor-product polynomials that cover the entire domain. The team conducted for the first time spectrally accurate direct numerical simulations of a channel with complex natural roughness.

Results & Impact

The team conducted simulations of the flow over biofilm with a bulk Reynolds number of 8,000 with mesh resolutions ranging from 20 million to 200 million grid points. The results show the coherent turbulent structures in the flow caused by the biofilm. The team also used a recently developed method called NekNek to simulate a jet flowing into a tank. The results showed appreciable agreement among simulations with Nek5000 and NekNek, with around 20% reduction in computation cost.

Why Blue Waters

The team conducted simulations using up to 296 million computational points, with the code demonstrating linear speed-up for this problem out to 32,768 MPI ranks. High computation requirements combined with the need for fast turnaround times for the parameter sweep made Blue Water ideal for the task.