CFD Kernels Acceleration with Xilinx Alveo

Boosting CFD performance and efficiency

byteLAKE XILINX

INTRODUCTION

CFD, Computational Fluid Dynamics tools combine numerical analysis and algorithms to solve fluid flows problems. A range of industries such as automotive, chemical, aerospace, biomedical, power and energy, and construction rely on fast CFD analysis turnaround time. It is a key part of their design workflow to understand and design how liquids and gases flow and interact with surfaces.

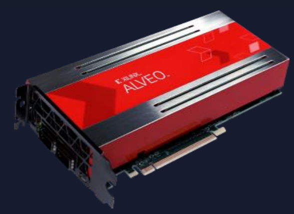
Typical applications include weather simulations, aerodynamic characteristics modelling and optimization, and petroleum mass flow rate assessment.

KEY BENEFITS

- Highly optimized CFD kernels for Xilinx® Alveo™ Datacenter accelerator cards
- Compatible with geophysical models like EULAG
- Fully configurable code
- Simpler, lower cost server infrastructure

SOLUTION BRIEF

XILINX ALVEO™



- Faster time to results and more efficient processing compared to CPU-only nodes
- **4x** faster
- **80%** lower energy consumption
- **6x** better performance per Watt

SOLUTION OVERVIEW

The ever-increasing demand for accuracy and capabilities of the CFD workloads produces an exponential growth of the required computational resources. Moving to heterogeneous HPC (High Performance Computing) configurations powered by Xilinx Alveo helps significantly improve performance within radically reduced energy budgets.

byteLAKE has created a set of highly optimized CFD kernels that leverage the speed and energy efficiency of Xilinx Alveo FPGA accelerator cards to create a high-performance platform for complex engineering analysis.

Kernels can be directly adapted to the geophysical models such as EULAG (Eulerian/semi-Lagrangian) fluid solver, designed to simulate the all-scale geophysical flows.
The algorithms have been extended by additional quantities as forces (implosion, explosion) and density vectors. In addition, they allow users to a fully configure the border conditions (periodic, open).

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LIST OF KERNELS

Kernel: Advection (movement of some material, dissolved or suspended in the fluid)
First-order step of the non-linear iterative upwind advection MPDATA (Multidimensional Positive Definite Advection Transport Algorithm) schemes.

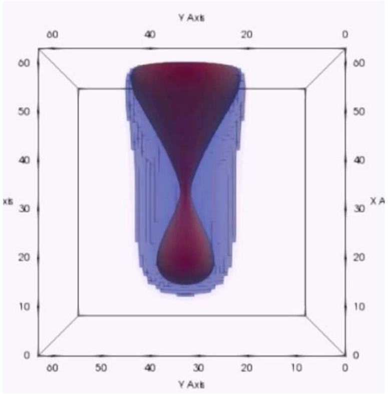
Kernel: Pseudo velocity (approximation of the relative velocity)
Computation of the pseudo velocity for the second pass of upwind algorithm in MPDATA.

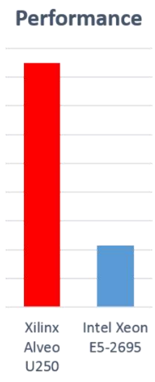
Kernel: Divergence (measures how much of fluid is flowing into/ out of a certain point in a vector field)
Divergence part of the matrix-free linear operator formulation in the iterative Krylov scheme.

Kernel: Thomas algorithm (simplified form of Gaussian elimination for tridiagonal system of equations)
Tridiagonal Thomas algorithm for vertical matrix inversion inside preconditioner for the iterative solver. Preconditioner operates on the diagonal part of the full linear problem. Effective preconditioning lies at the heart of multiscale flow simulation, including a broad range of geoscientific applications.

RESULTS *

- 4x faster results
- 80% lower energy consumption
- Up to 6x better Performance per Watt
- Compatible with geophysical models like EULAG
- Configurable code
  (domain settings, border conditions,
  data precision, and hardware characteristics)





(*) Benchmark results for example CFD Kernels running on Xilinx Alveo U250 + Intel ® Xeon™ E5-2695 CPU (management) vs. CPU-only architecture based on Intel Xeon E5-2695 CPU.

Other measurements (not mentioned here) included comparison between Xilinx Alveo U250 powered heterogeneous configurations vs. highly optimized versions of the CFD Kernels for Intel Xeon Gold 6148 CPU.
Result: speedup of up to 2x, improved Performance per Watt up to 4x.

TAKE THE NEXT STEP

Learn more about Alveo accelerators
Learn more about byteLAKE: www.byteLAKE.com
Reach out to our team at welcome@byteLAKE.com to learn more.