Performance Portability of Shallow Water Model with DPC++

Leila Ghaffari[1,2] and Zephaniah Connell[1,3]

[1]National Center for Atmospheric Research
[2]Univeristy of Colorado Boulder
[3]University of Wyoming

Motivation

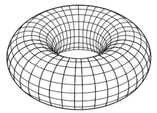
- ❏ Portability is a desired capability which enables us to run our code on ever-changing hardware and software platforms.
- ❏ It can be difficult and time-consuming to port or develop multiple versions of code that only run on specific architectures.
- ❏ DPC++ is a new framework that advertises the ability to execute the same code on CPU or accelerators with limited or no modifications.

Goal

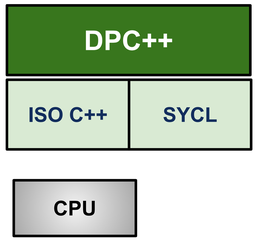
- ❏ Port the Shallow Water Model mini-app to DPC++ with limited modifications
- ❏ Optimize the performance of the ported code on different hardware architectures

Introduction to the Shallow Water Model (SWM) mini-app

SWM is a venerable 2D shallow water model benchmark on staggered finite difference equations on a torus.



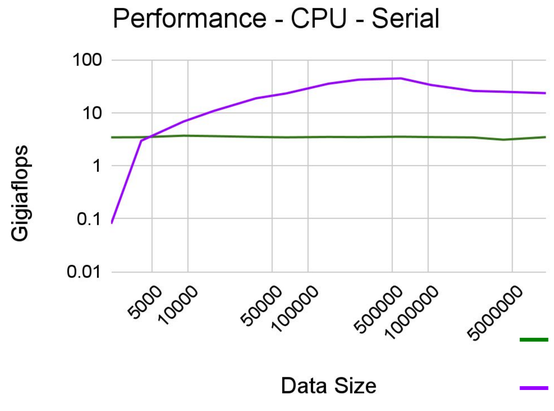
Introduction to DPC++



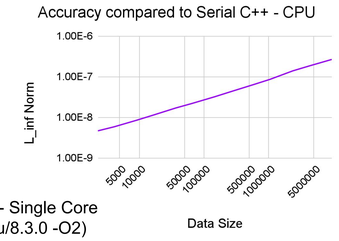
Memory Models:

- ❏ **Unified Shared Memory (USM)**
  Pointer-based approach
- ❏ **Buffer**
  Encapsulate data in a SYCL application

Performance & Accuracy - CPU



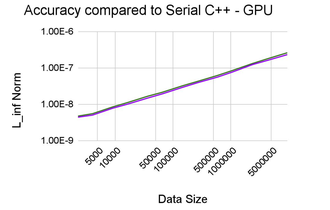
Up to ~20x faster than Serial C++



Skylake - Single Core
C++ (gnu/8.3.0 -O2)

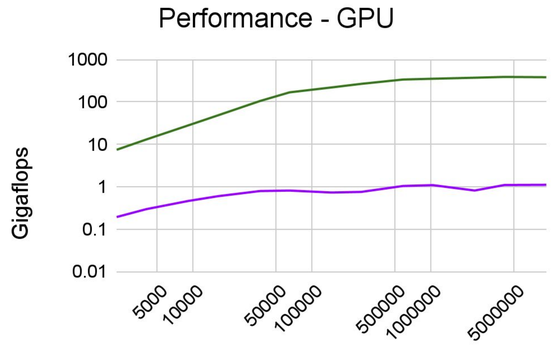
Skylake - Single Core
DPC++ (dpcpp -O2)

Performance & Accuracy - GPU



Casper V100
OpenACC (nvhpc/21.3 cuda/10.2 -O2)

Intel® Iris® Xe MAX
DPC++ (dpcpp -O2)



Up to ~150x slower than OpenACC and ~70 slower than Serial DPC++

Conclusions

Unified Shared Memory:

- ❏ The porting is completed
- ❏ Device memory allocation doesn't seem to be feasible
- ❏ Up to 20x faster than C++ on CPU for large problem sizes
- ❏ Up to 150x slower than OpenACC on GPU

Buffer:

- ❏ Memory management issues with large problem sizes
- ❏ The porting process had some challenges and was time consuming
- ❏ No performance study has been done yet

Future Work

- ❏ Run the ported code on Nvidia and AMD GPUs
- ❏ Compile and run the SWM code on FPGAs
- ❏ Add support for OpenMP
- ❏ More investigation on the buffer model
- ❏ More optimization on the USM model
- ❏ Change the data structure to be more compatible with DPC++ compiler which might serve both models

References

The Dynamics of Finite-Difference Models of the Shallow-Water Equations, by Robert Sadourny, J. Atm. Sciences, Vol 32, No 4, April 1975, p.680-688.

J. Reinders, B. Ashbaugh, J. Brodman, M. Kinsner, J. Pennycook, X. Tian, vectors. In: Data Parallel C++, p. 259–276. Apress (2020).

Acknowledgements

Mentors: Supreeth Suresh, Cena Miller, Jian Sun, and John Dennis
Research Support: Richard Loft and Thomas Hauser
SIParCS Admins and CODE Assistants: AJ Lauer, Virginia Do, Jerry Cyccone, Max Cordes Galbraith