Porting CESM+MOM6 Ocean Models to Multiple Architectures

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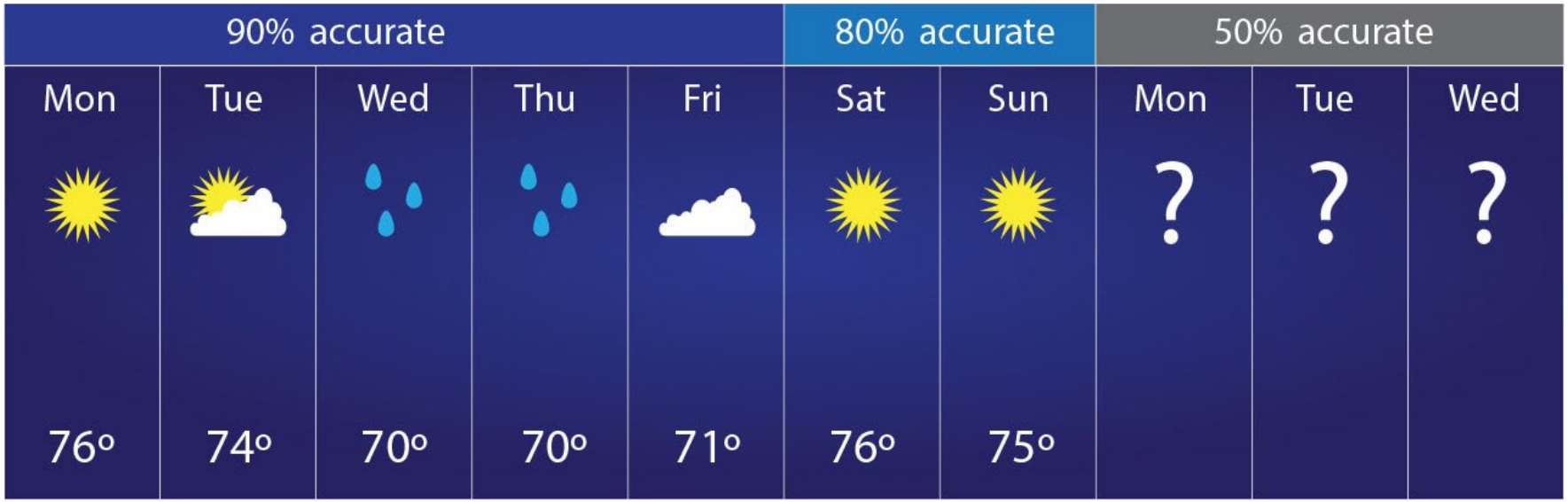
Contents

- Project Goals
- Background
- Challenges
- Development Cycle
- Results
- Lessons Learned
- Future Work

Project Goals

- Port CESM2+MOM6 onto Graphical Processing Units (GPUs)
  - Portability
  - Reasonable performance gains
  - Minimal Code Change
- Train me to continue University of Wyoming and NCAR collaboration on this and other projects
- Enhance the portability of CESM

How accurate is your forecast?



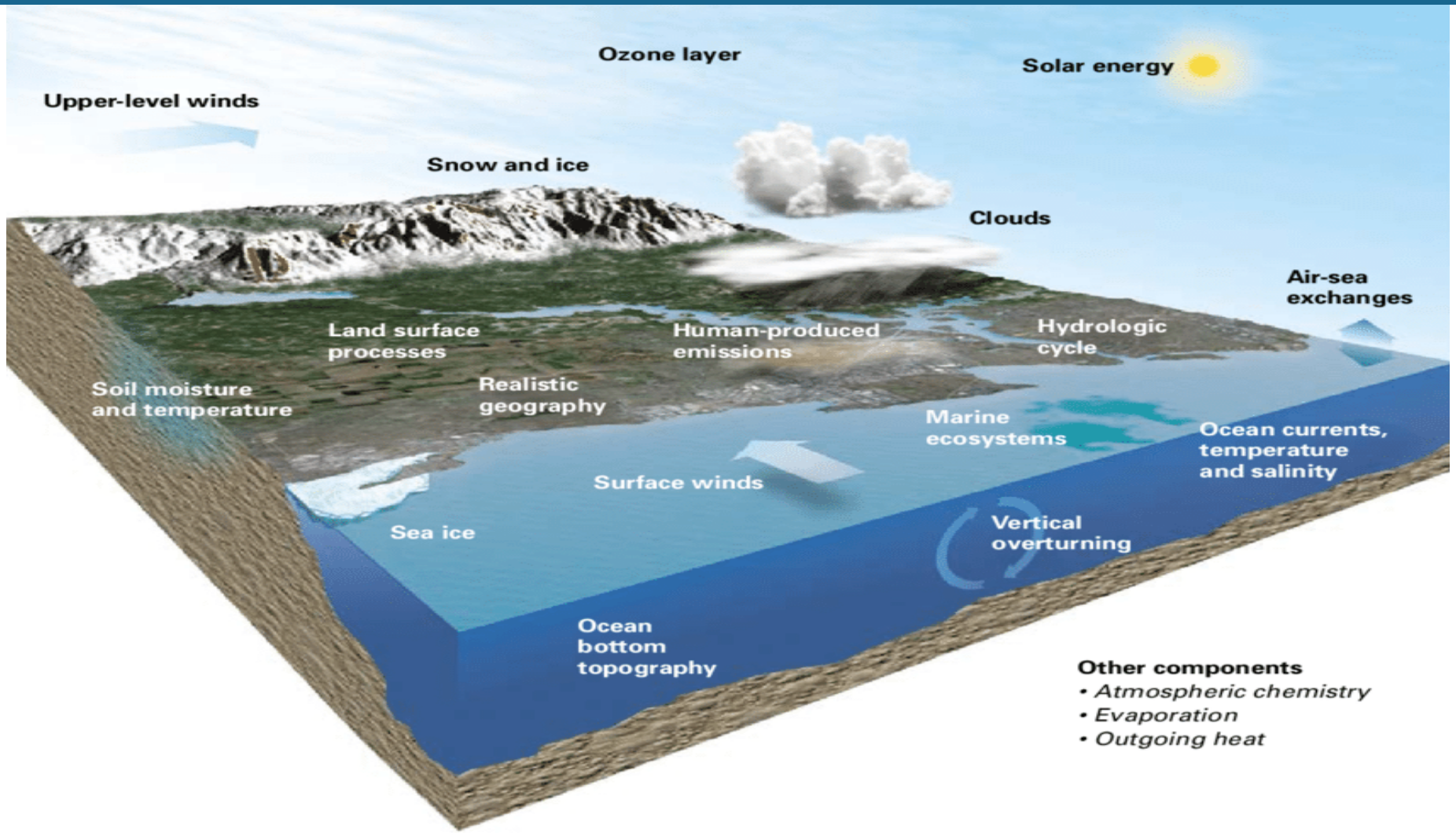
What about seasonal models/forecasts?

Snowboarder at Powder Mountain

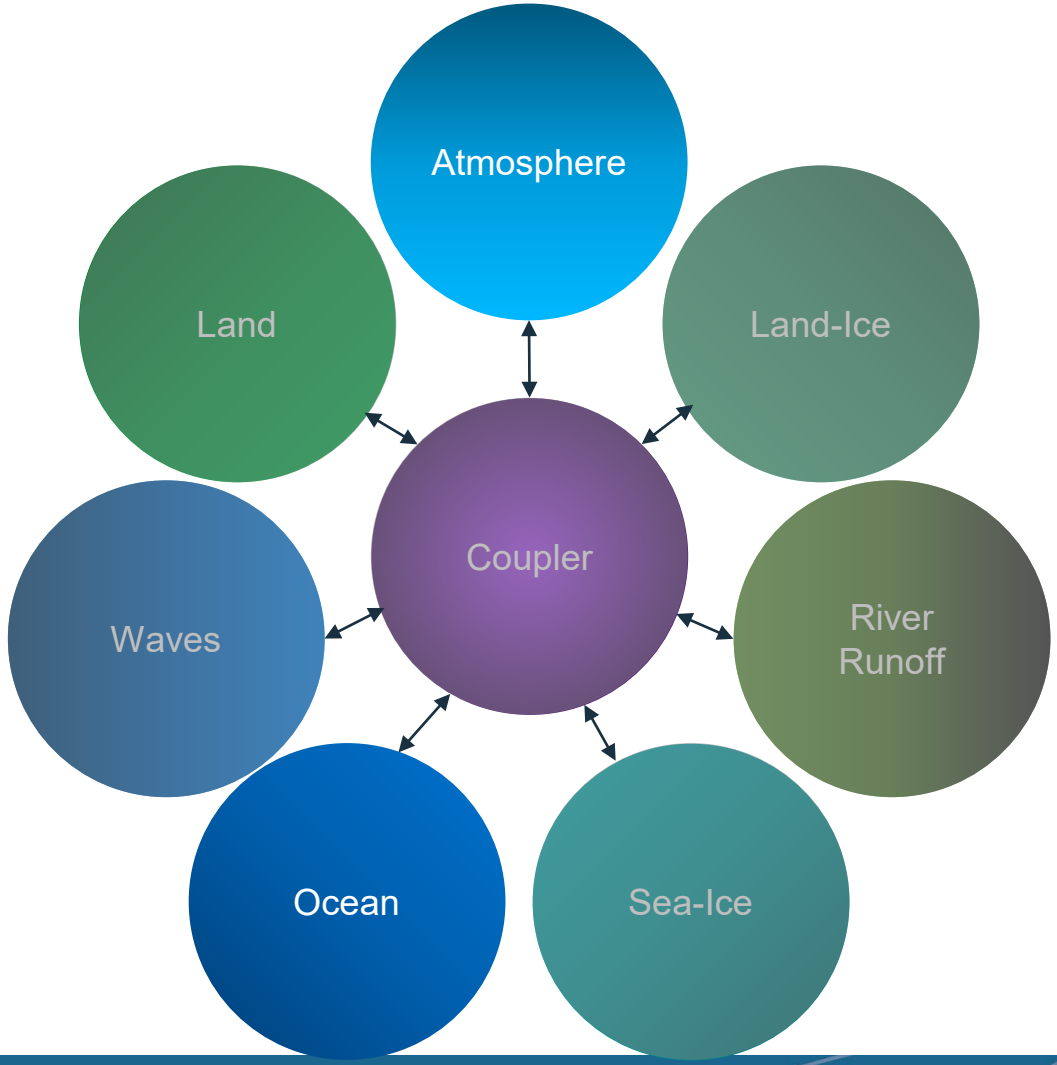
Campsite on Casper Mountain

Harvesting on a farm in Kansas

The Community Earth System Model



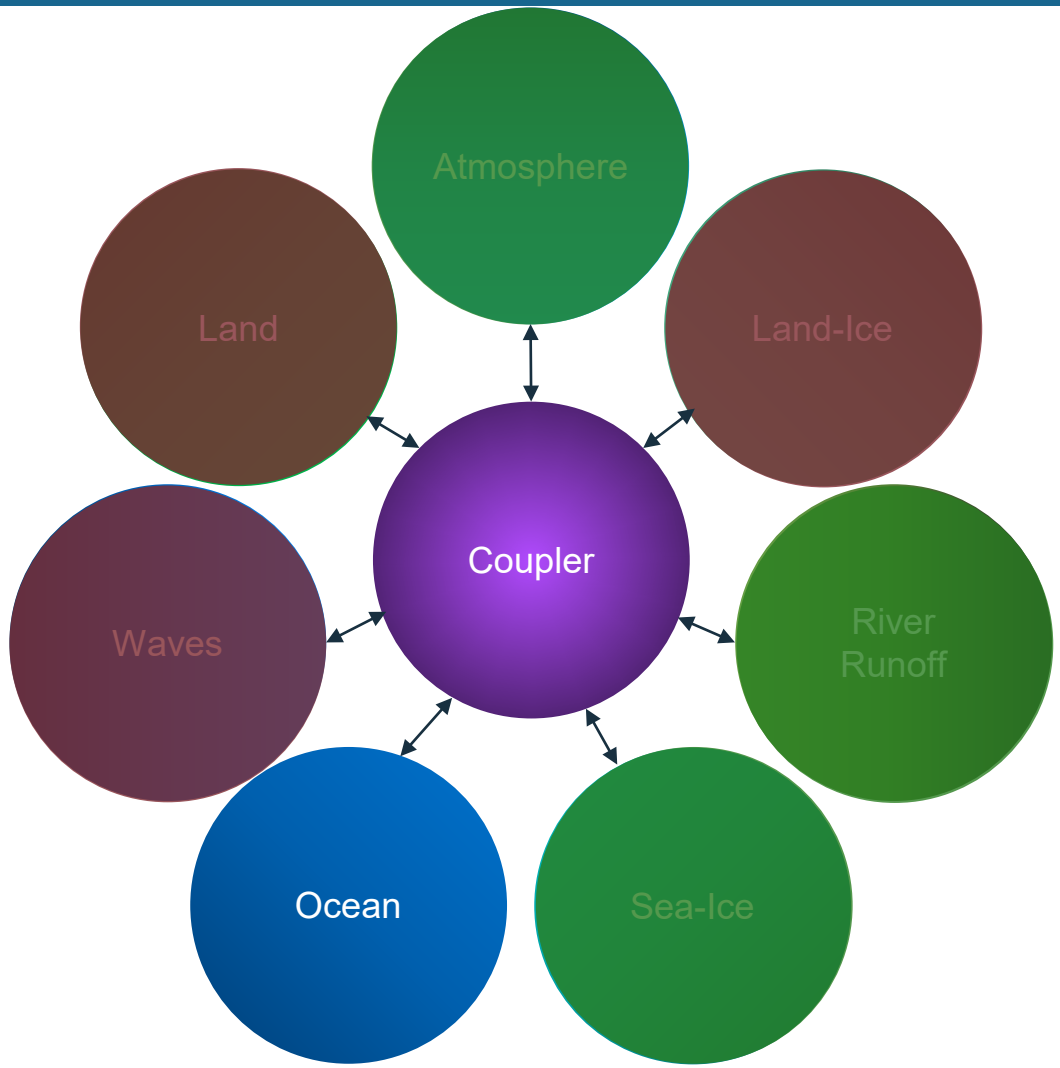
Parts of CESM



Component Set

Short Name: CMOM

Long Name:
2000_DATM%NYF_SLND_
DICE%SSMI_MOM6_DROF
%NYF_SGLC_SWAV



Features of MOM6
- Highly scalable
- Open source
- Robust

Challenges

- Learning Fortran and MPI
  - Find $Z = aX + Y$ and then use a matrix library to find inverse in Fortran90
  - Build utilizing Makefiles
  - Decomposing work among MPI-tasks
  - Add OpenACC directives to utilize GPUs
- Submit and run jobs on Casper and Cheyenne

Fortran Code: https://github.com/gdicker1/MPI_practice

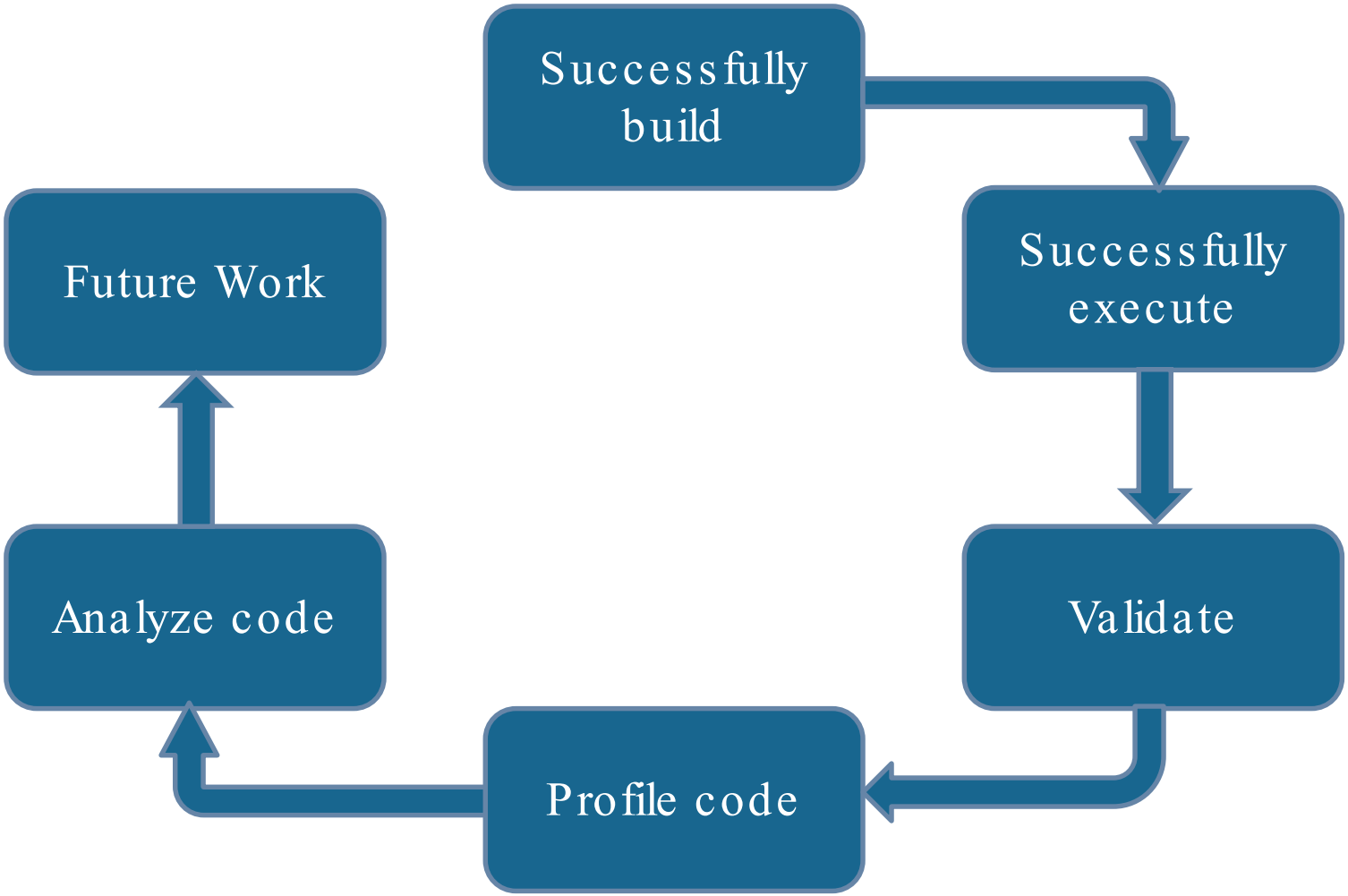
Challenges

- Working with CESM, CIME, and MOM6
  - How to build and execute CESM
  - How to change configuration parameters in CIME
    - Adding Casper system to machine list
    - Configuring for PGI compiler on Casper
    - Updating PGI compiler configuration for Cheyenne
  - Configuring a case
    - Changing run parameters, especially required number of tasks

Challenges

- Non-uniform software stacks
- Intel and PGI interpret standards differently
- HPC upgrades and outages
- Code modifications on GitHub
- Profiling information from MOM6

Development Cycle



Profiling System Information

Test case: CMOM compset

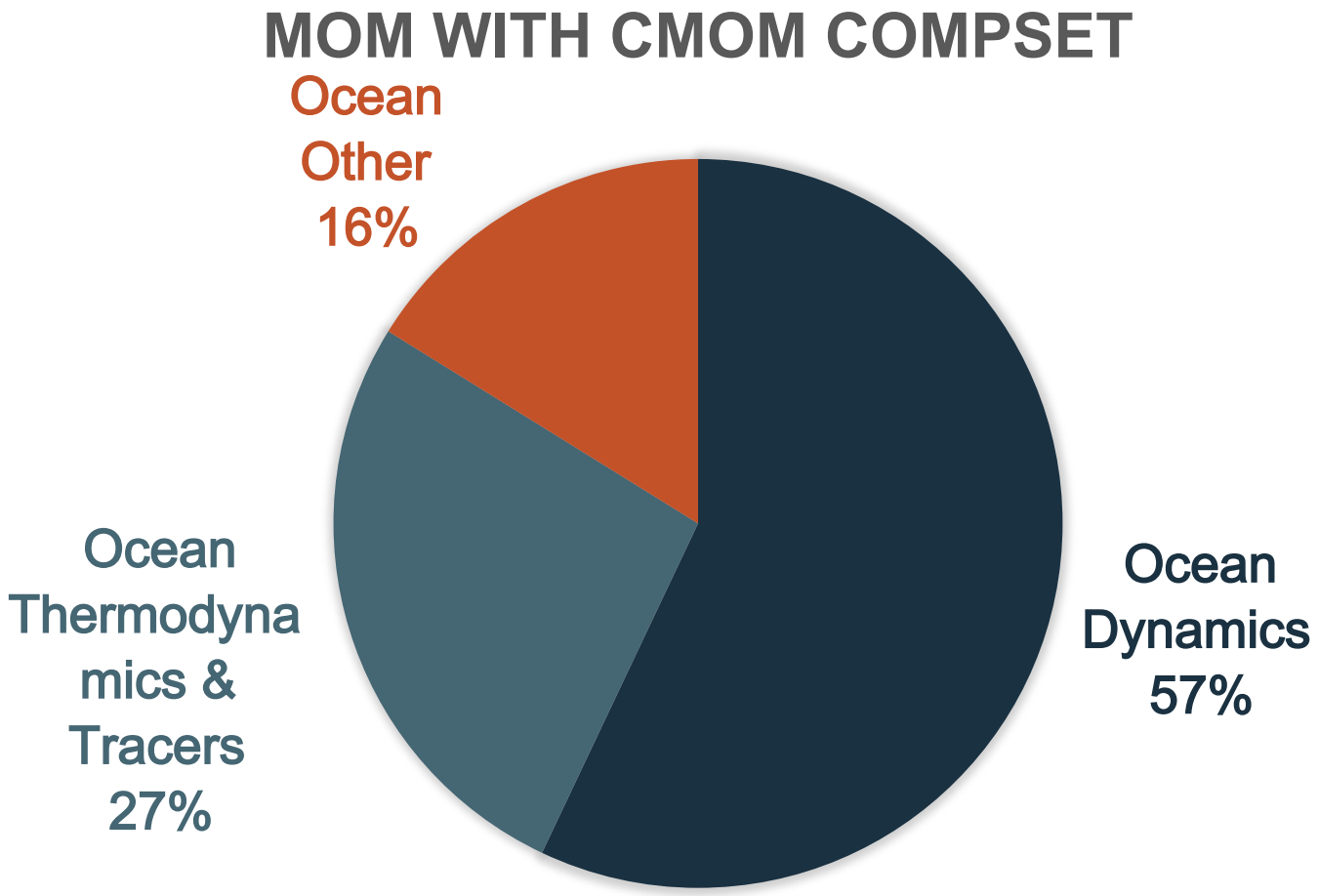
Using NCAR Cheyenne Supercomputer

- 2x 18-core Intel Xeon version 4 (Broadwell)
- PGI compiler version 19.3
  - MPI Library: OpenMPI version 3.1.4
- Intel compiler version 17.0.1
  - MPI Library: MPT version 2.16
- 1x EDR IB interconnect

Runs on Casper Supercomputer

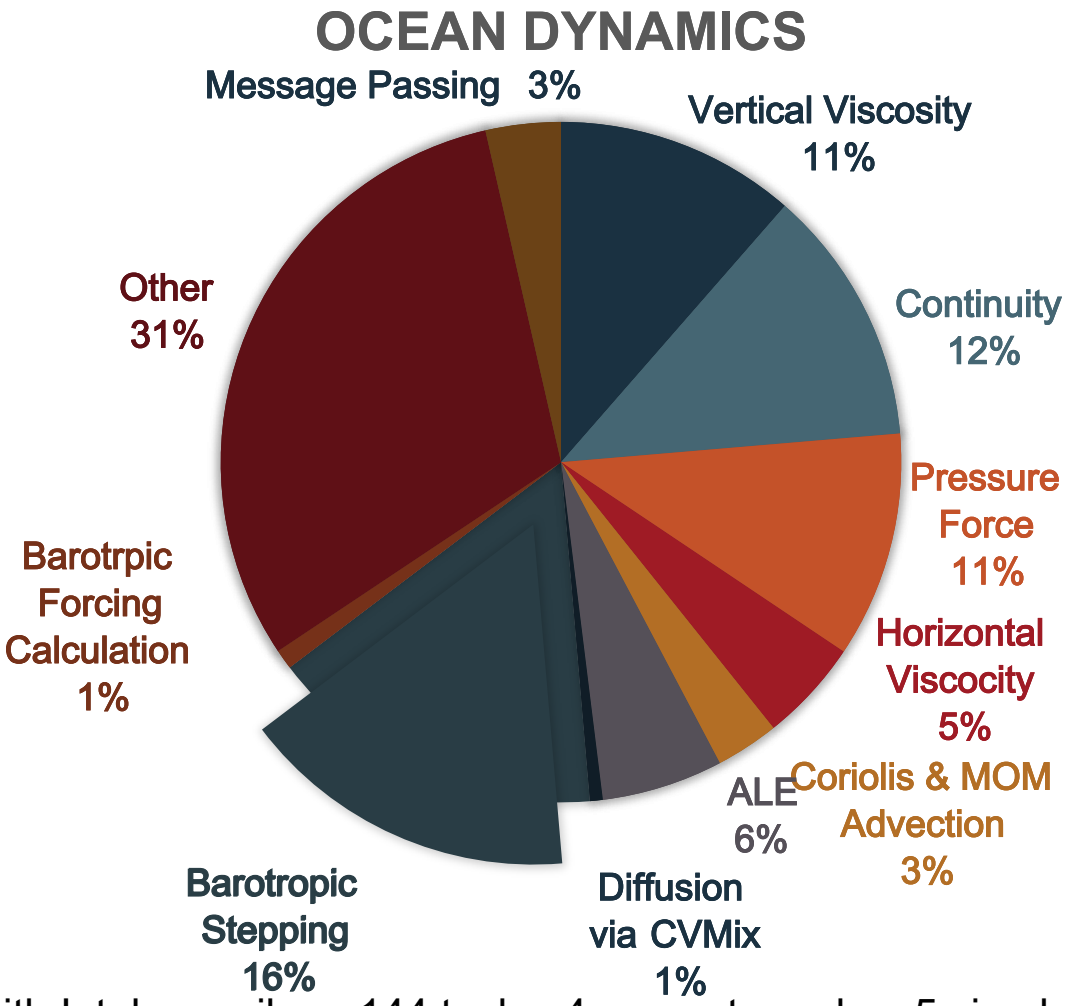
- 2x 18-core Intel Xeon Gold 6140 (Skylake)
- PGI compiler version 19.4
  - MPI Library: OpenMPI version 3.1.4

Profiling Results



Built with Intel compilers, 144 tasks, 4 compute nodes, 5 simulated days

Profiling Results



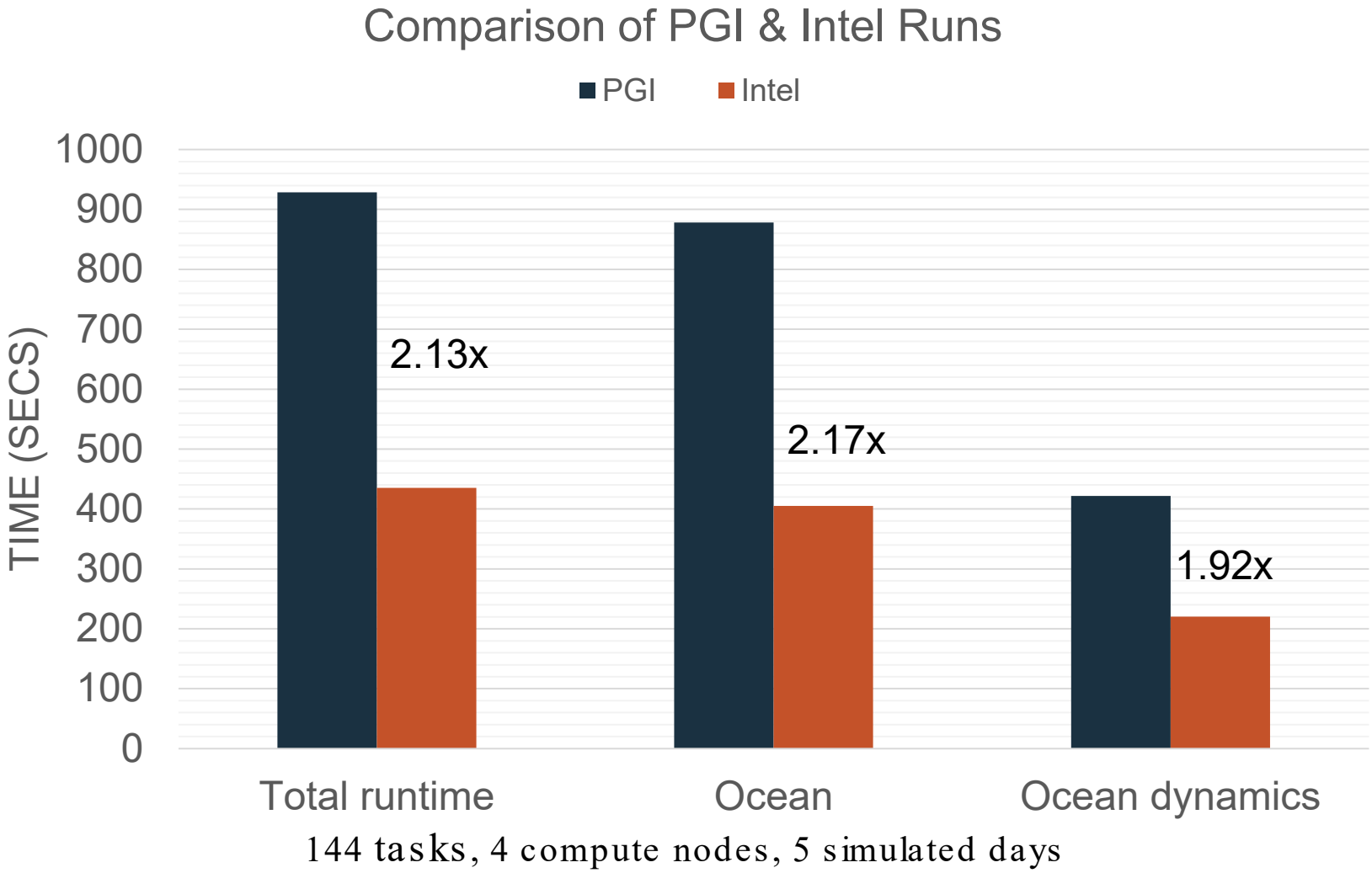
Built with Intel compilers, 144 tasks, 4 compute nodes, 5 simulated days

Results

Name	Average Time (secs)	Number of Source Code Lines	Call Depth
Vertical Viscosity	25.2	876	2
Continuity Equation	38.8	1396	2
Pressure Force	23.7	842	3
Barotropic Step	35.4	1880	1

Built with Intel compilers, 144 tasks, 4 compute nodes, 5 simulated days

Results


Comparison of PGI & Intel Runs
PGI
Intel
TIME (SECS)
1000
900
800
700
600
500
400
300
200
100
0
2.13x
2.17x
1.92x
Total runtime
Ocean
Ocean dynamics
144 tasks, 4 compute nodes, 5 simulated days

Future Work

- Train other students at University of Wyoming
- Correct results with PGI compiler
- Gather more profiling data
  - Especially calls per timestep
- Port and parallelize routines in Ocean Dynamics
- Extract parallelism across multiple GPUs
- Prepare poster for Supercomputing 2019

SC19
Denver, CO | hpc is now.

Lessons Learned

- Knowledge on programming in Fortran90 and parallelization with MPI
- Ported CESM to a new architecture
- Compiler interpret standards differently
- How to communicate of compiler errors
- Difficulty of applying profiling or debugging tools with a large project

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- Virginia Do – NCAR, CODE
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- Ingrid Jo, Clint Walker, and Samantha Williams for their pictures

Image Sources

All logo images were source from each organization's branding website

1. "How Reliable Are Weather Forecasts?" by SciJinks https://scijinks.gov/forecast-reliability/
2. Ingrid Jo for camping picture
3. Clint Walker for snowboarding picture
4. Samantha Williams for farming picture
5. *Climate Data Management System Specifications* by B. Bannerman, D. Stuber, R. Tolasz, R. Sebbari, S. Palmer, A. Xiong, and J. Flannery. WMO-No. 1131 https://www.researchgate.net/publication/264790227_Climate_Data_Management_System_Specifications
6. "Space Invaders." Wikipedia https://en.wikipedia.org/wiki/Space_Invaders#/media/File:SpaceInvaders-Gameplay.gif
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8. "Resources." Supercomputing https://sc19.supercomputing.org/attend/media/resources/#section1

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Thank You for Attending