Attempt for Quantitative Evaluation of Warm Water Cooling using LINPACK and GeoFEM on the JCAHPC OFP

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Oakforest-PACS (OFP)

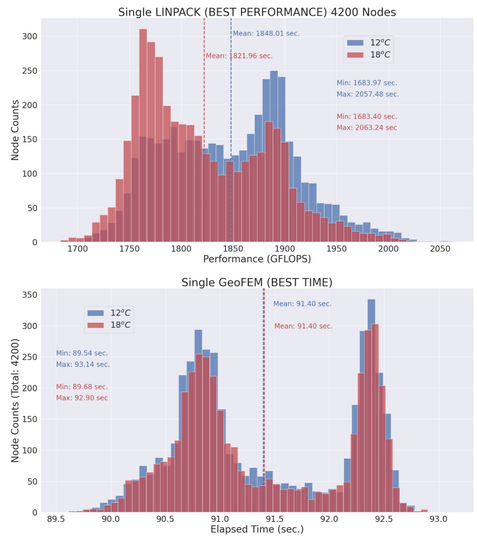
13.55 PF (HPL) [25 PF Peak]

- **69 Compute Racks**
  - **8,208 Nodes**
    - Intel Xeon Phi 7250
      - 1.4 GHz, 68 cores
      - 215W TDP
- Cooling
  - CPU: Direct Liquid
  - Compute Racks: Rear Door
  - Others: Air

JCAHPC University of Tsukuba, The University of Tokyo

Large-Scale HPC Challenge
May 25, 2021
Nov. 24, 2021

Allocated nodes: **4,200 (40 Racks)**
MCDRAM: Flat mode
Period: 9:00 - 17:00
Cooling water temperature
12°C (regular operation)
➔ **18°C**, 9°C



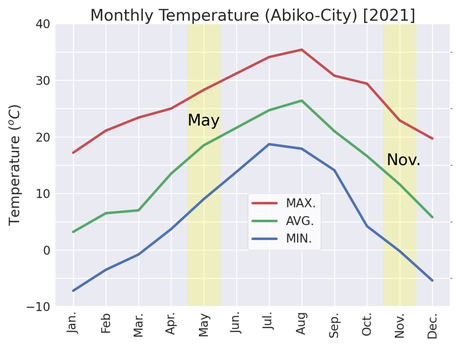
Intel LINPACK
Single Node
Problem Size
65,000

GeoFEM
Single Node
Problem Size
256x128x128

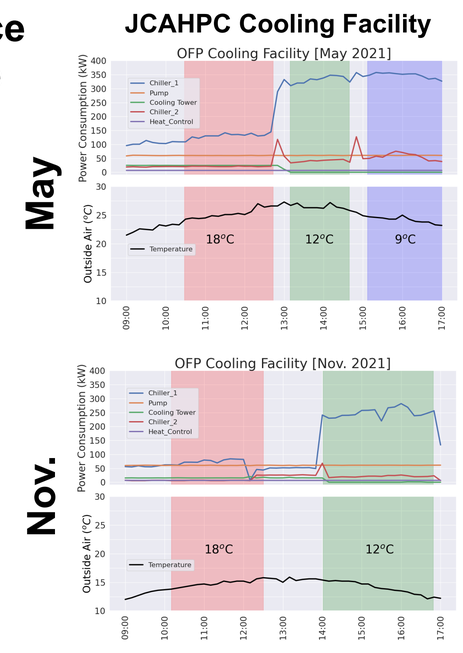
Warm Water Cooling

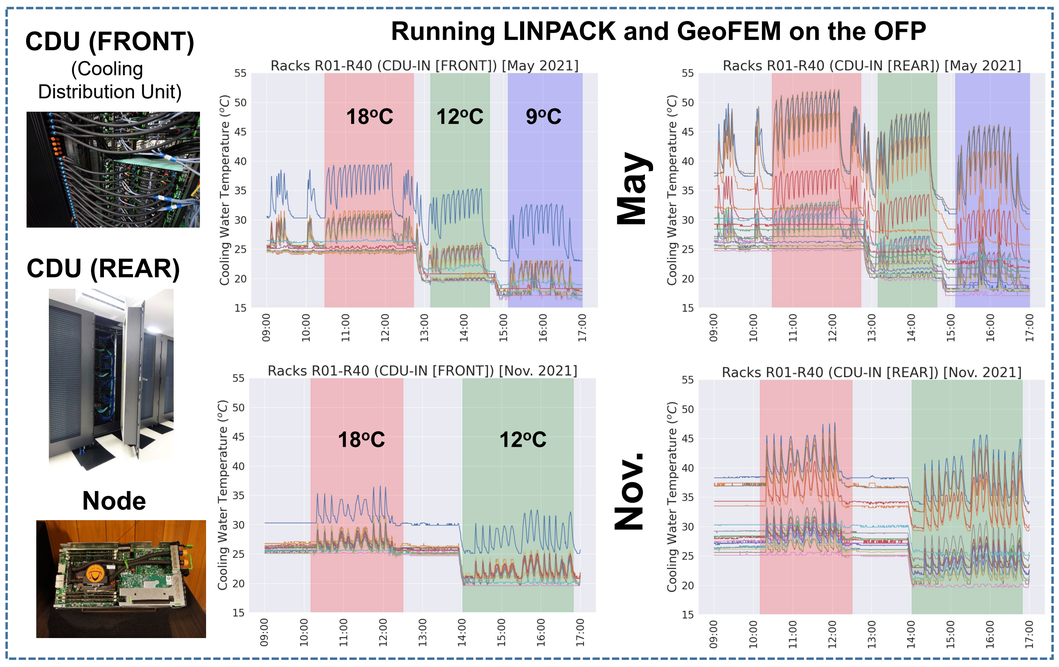
Energy efficiency is already an important topic for the HPC sites, and its importance has become even more evident with the steep rise in global energy prices. The warm water cooling technique has been widely recognized as an effective approach for improving the energy efficiency of HPC and Data Centers. We tried to evaluate this in practice, using the JCAHPC (Joint Center for Advanced HPC) OFP (OakForest-PACS) supercomputer, via "Large-Scale HPC Challenge" program [1].

Analysis on the influence of outside temperature



Although monthly average temperature for May and Nov. had just a slight difference, the scheduled days for the Large-Scale HPC Challenge had distinct temperature ranges.





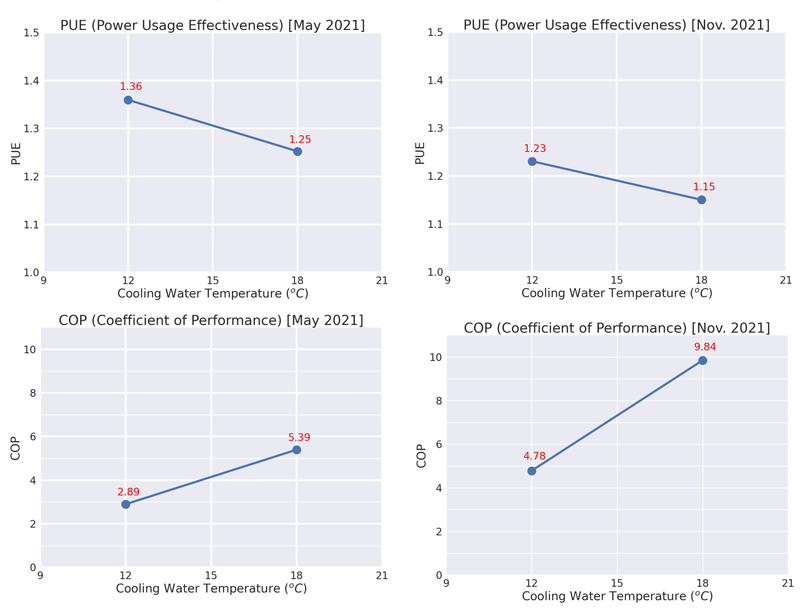
PUE and COP [2]

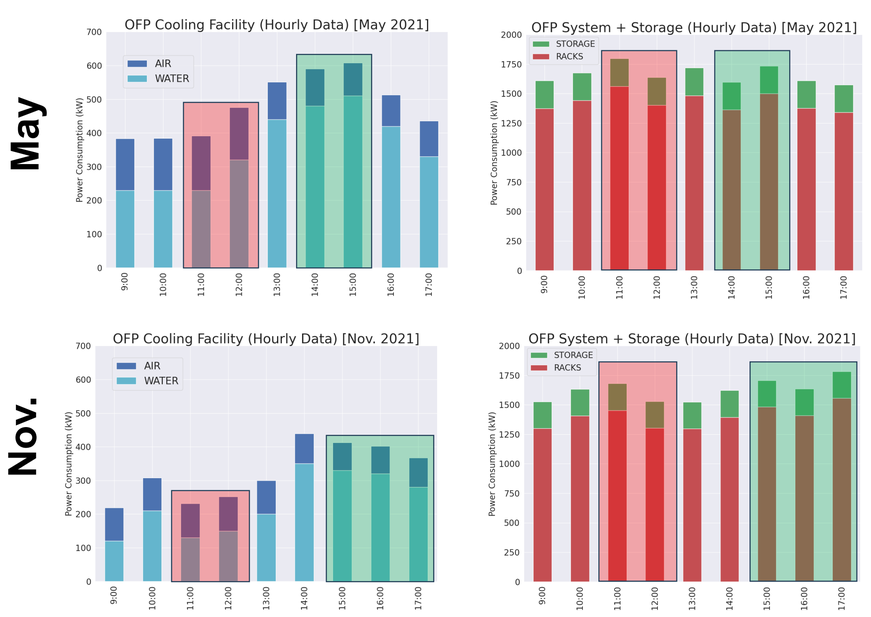
1) PUE is used to measure the energy efficiency of HPC/Data Centers, and as lower is the PUE value, better is the energy efficiency.

$$1)\ PUE = \frac{OFP\ Sytem + Cooling\ Facility}{OFP\ System}$$

2) COP is used to measure the energy efficiency of cooling and heating equipment, and high COP values represent high efficiency.

$$2)\ COP = \frac{OFP\ System\ (Racks)}{Cooling\ Facility\ (Water)}$$

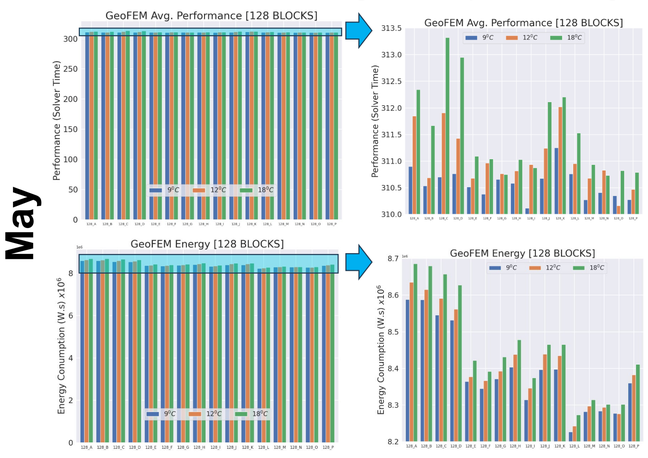




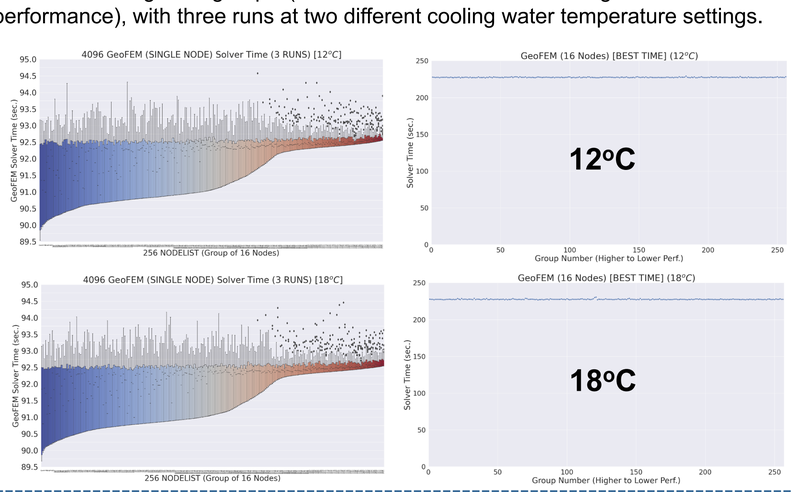
Analysis on the influence onto the performance and energy consumption

We have investigated the influence of the cooling water temperature on the parallel processing performance and energy consumption of GeoFEM [1], following the impact analysis to the single-node performance and energy consumption of Intel LINPACK, which is a generalization of the LINPACK 1000 benchmark. Differently to the previous observations [3], we could only observe a small impact onto the performance and energy consumption.

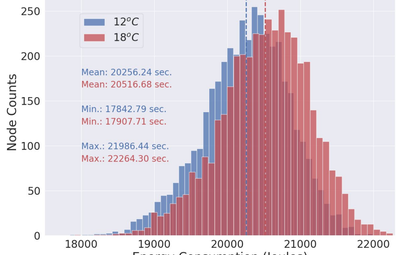
Evaluation using 16 groups (128 contiguous nodes each), with three runs at three different cooling water temperature settings.



Evaluation using 256 groups (16 sorted nodes based on single-node GeoFEM performance), with three runs at two different cooling water temperature settings.



We observed a performance variation of 1.1 % (12°C) and 1.7% (18°C) for the best time among 256 groups. We can also mention that the maximum energy consumption for the single-node GeoFEM increased 1.26% when raising the cooling water temperature.



References

[1] Fumiyoshi Shoji, Jorji Nonaka, and Toshihiro Hanawa. 2023. An attempt for the quantitative evaluation of the warm water cooling efficiency. Supercomputing News (ITC, The University of Tokyo) Vol. 25, No. 1, pp. 52-57 (in Japanese).

[2] Jorji Nonaka, Toshihiro Hanawa, and Fumiyoshi Shoji. 2020. Analysis on the Impact of the Cooling Water Temperature on the HPC System and Facility – Case Study: OakForest-PACS (OFP) System and Facility. Research poster of ISC 2020.

[3] Jorji Nonaka, Toshihiro Hanawa, and Fumiyoshi Shoji. 2020. Analysis of Cooling Water Temperature Impact on Computing Performance and Energy Consumption. In 2020 IEEE International Conference on Cluster Computing (CLUSTER). 169–175. https://doi.org/10.1109/CLUSTER49012.2020.00027

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