CESM Load Balancing Development

Optimizer Study

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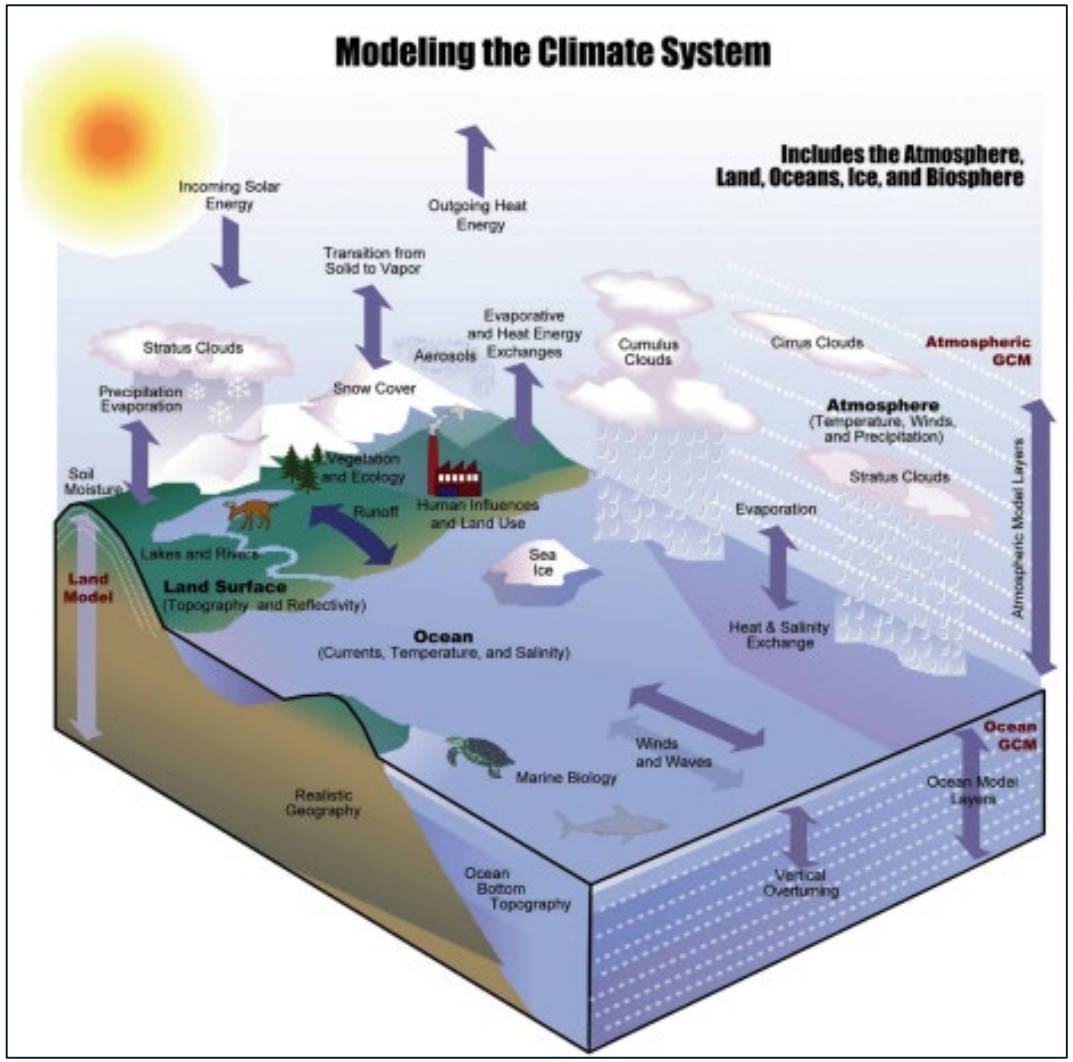
OUTLINE

- Introduction
- Project Goals
- Optimizer study
- Case Study
- Results
- Conclusions & Future Work

Coupled Simulation

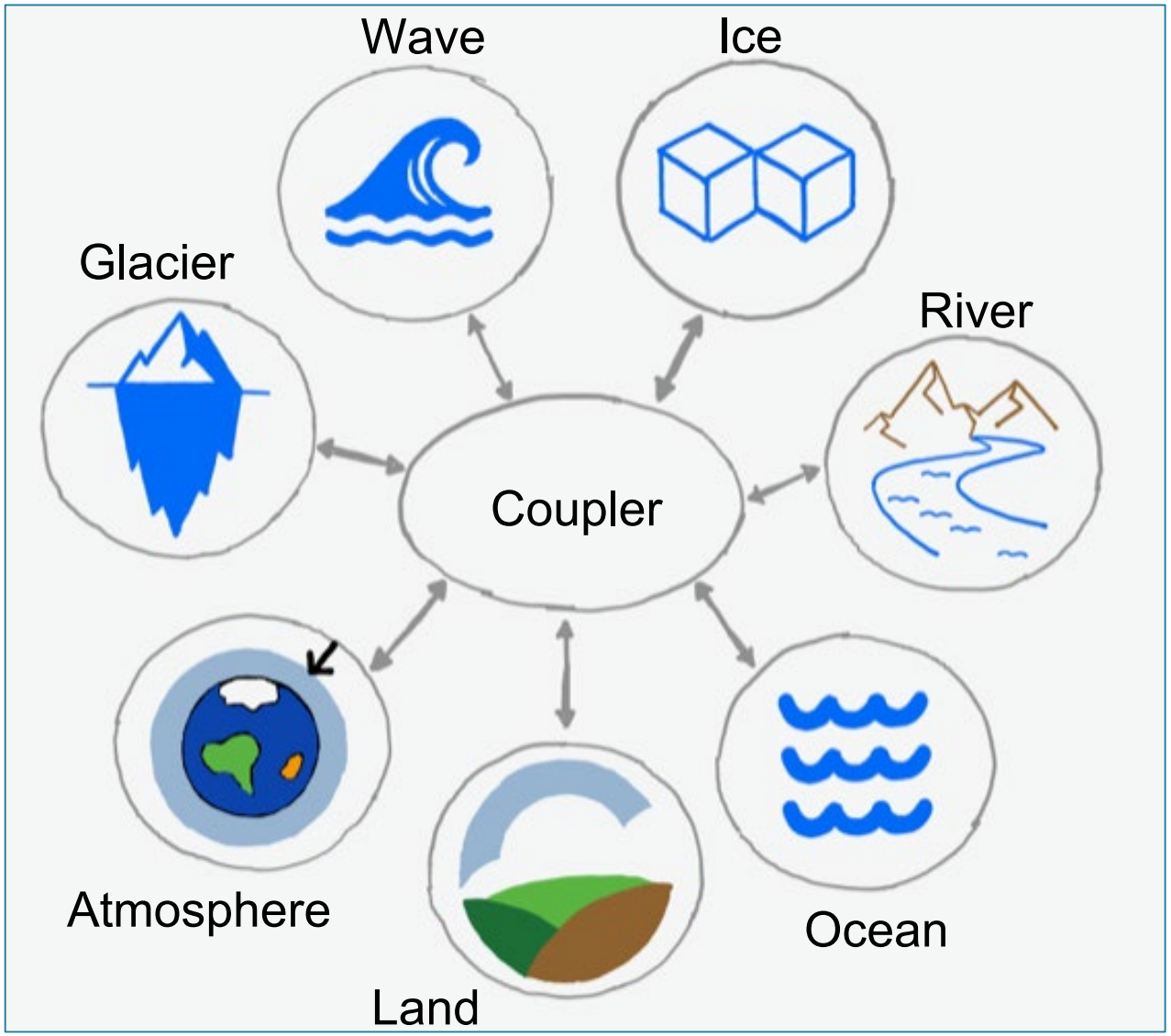
Coupled versus **standalone** approach:

- ✓ Time scales
- ✓ Mesh requirements
- ✓ Numerical methods
- ✓ Use of legacy codes



Modeling the climate system-Karl and Trenberth 2003.

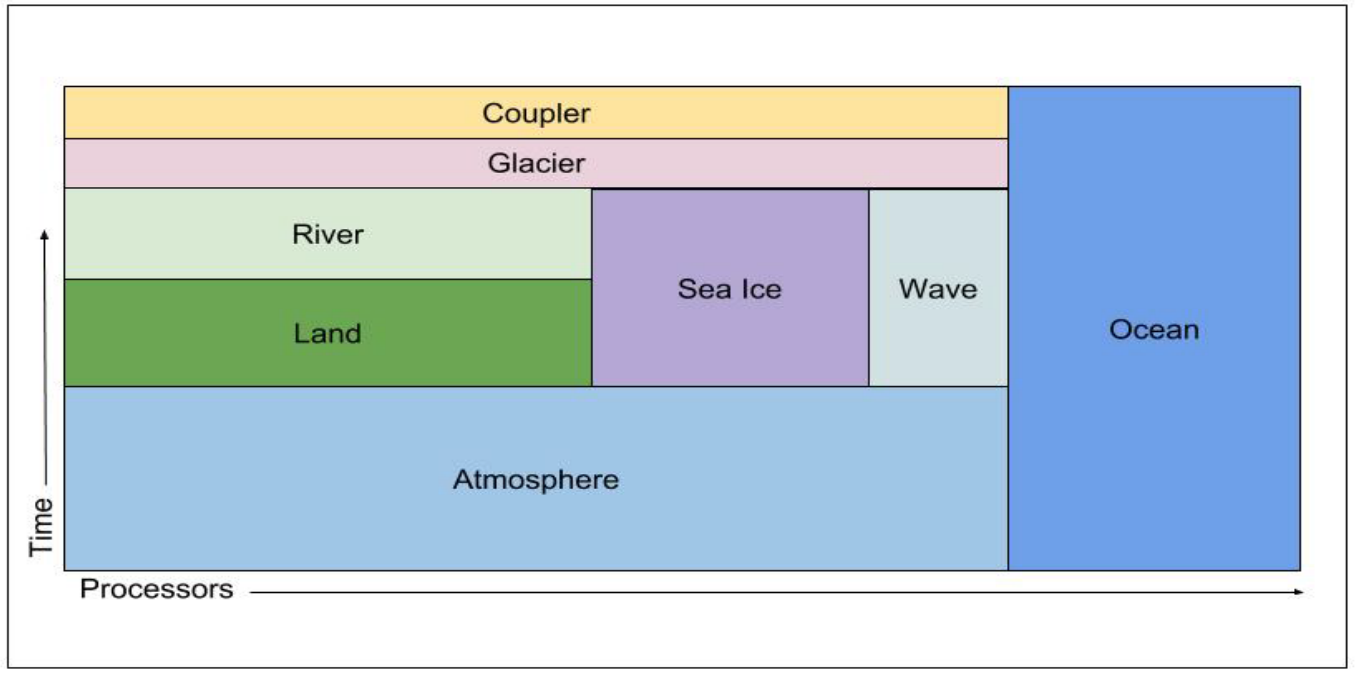
Community Earth System Model (CESM)



Challenges

Reaching high performance is challenging with CESM:

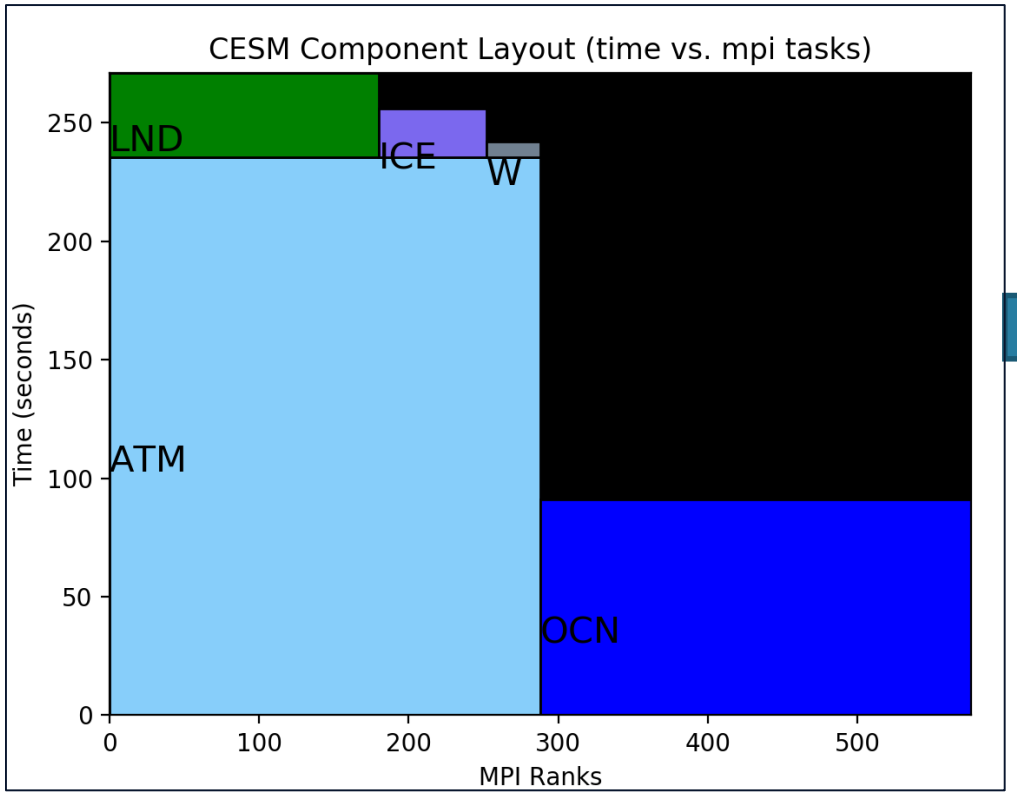
- ✗ Size of the problem
- ✗ Multi-component nature
- ✗ Scientific requirements



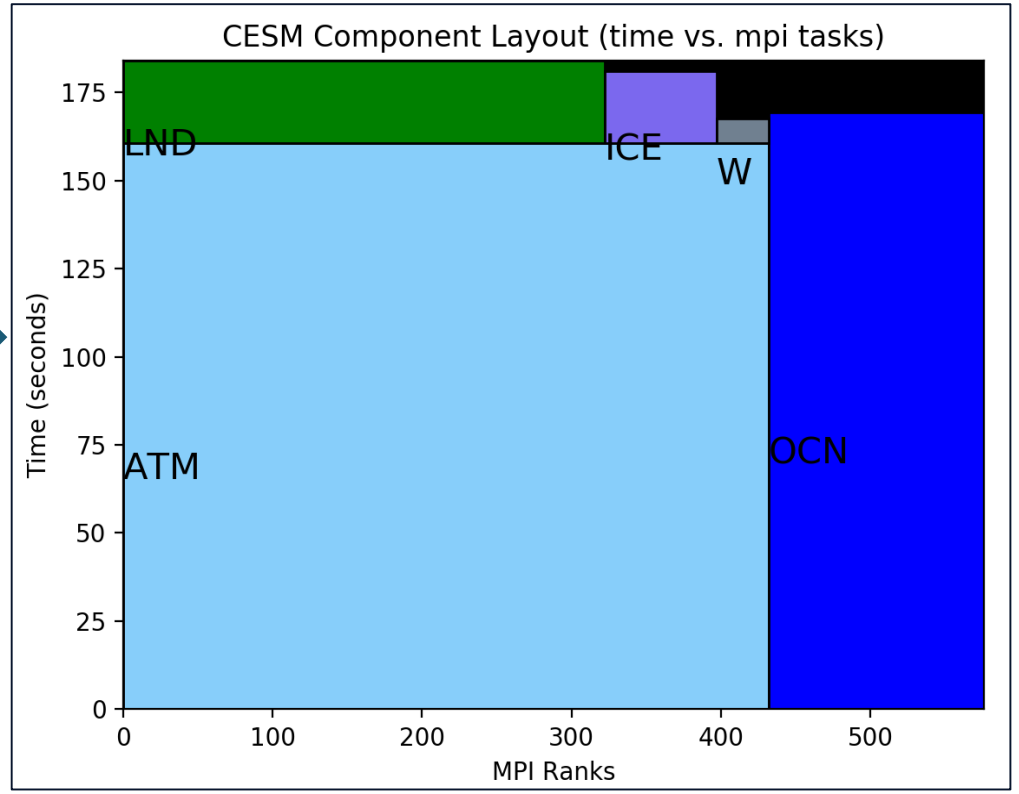
CESM Processor and timing layout - Sheri Mickelson 2020.

Motivation

Saves lots of core hours!!!



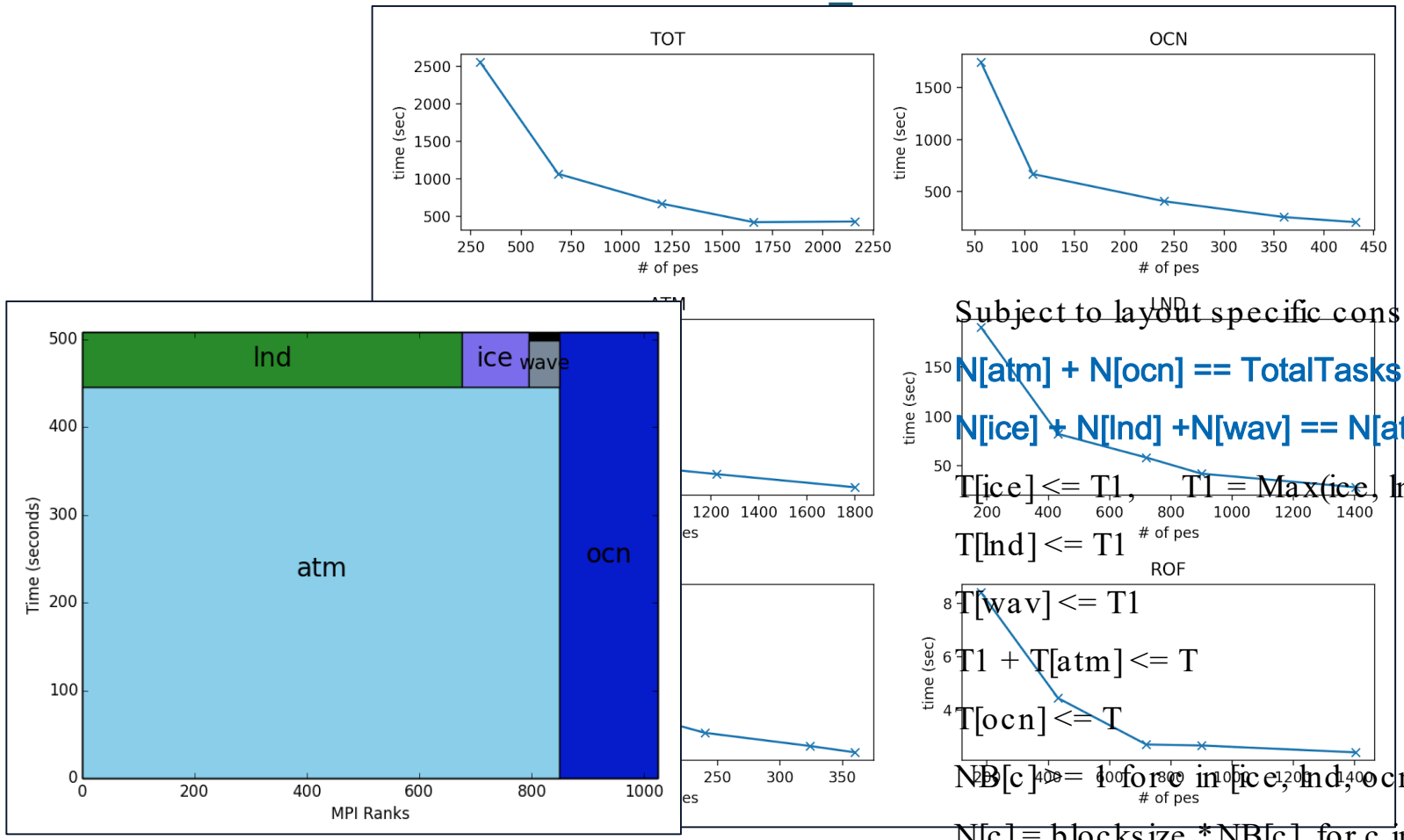
Unbalanced Layout



Balanced Layout

CESM Load Balancing

1) Getting benchmarking data.



Subject to layout specific constraints:

N[atm] + N[ocn] == TotalTasks

N[ice] + N[lnd] +N[wav] == N[atm]

T[ice] <= T1, T1 = Max(ice, lnd, wav)

T[lnd] <= T1

T[wav] <= T1

T1 + T[atm] <= T

T[ocn] <= T

NB[c] >= 1 for c in [ice, lnd, ocn, wav, atm]

N[c] = blocksize * NB[c], for c in [ice, lnd, ocn, wav, atm]

CESM component scalability plots - Sheri Mickelson 2020.

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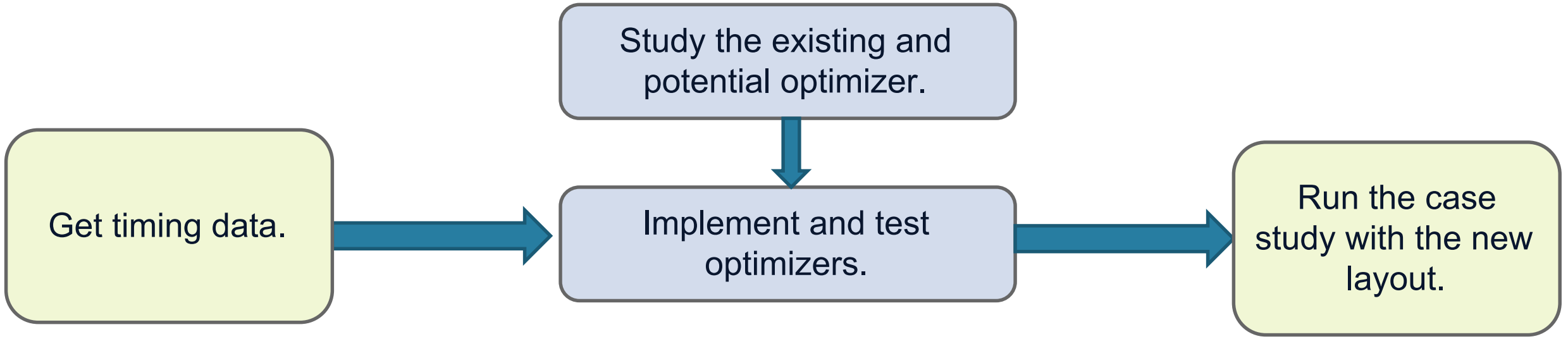
Project Goals

Study the potential automatic load balancing capability for CESM.



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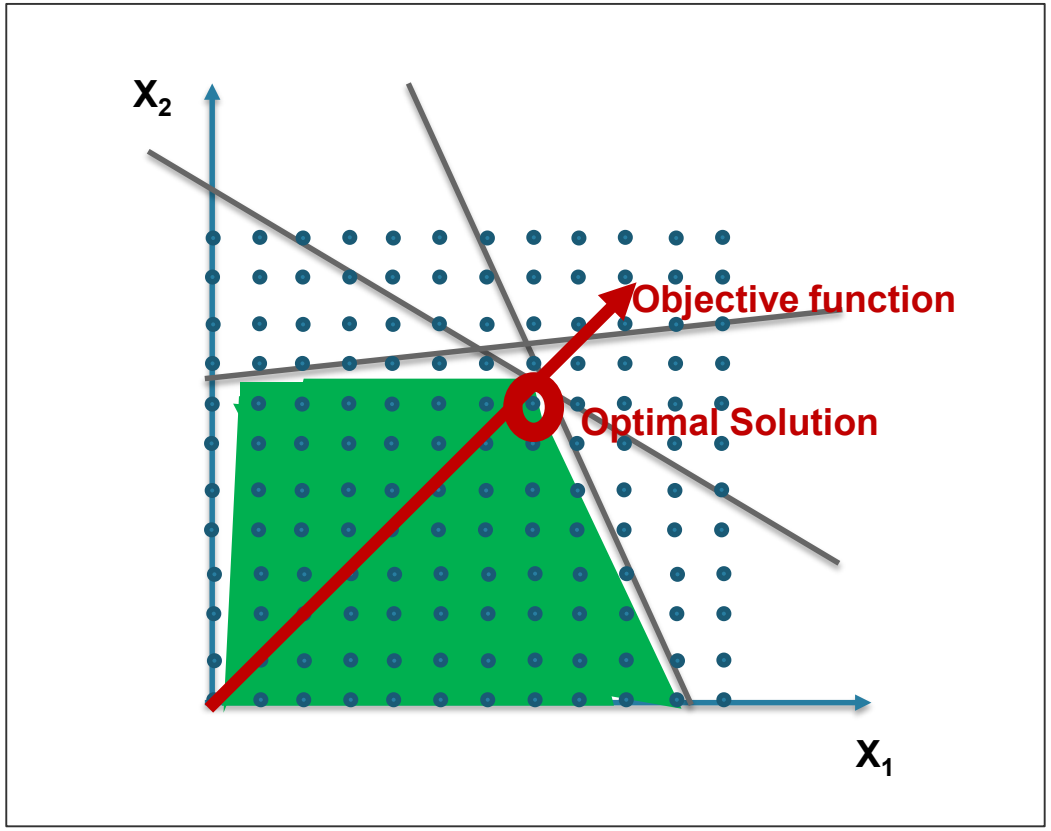
Mixed Integer Linear Programming (MILP)

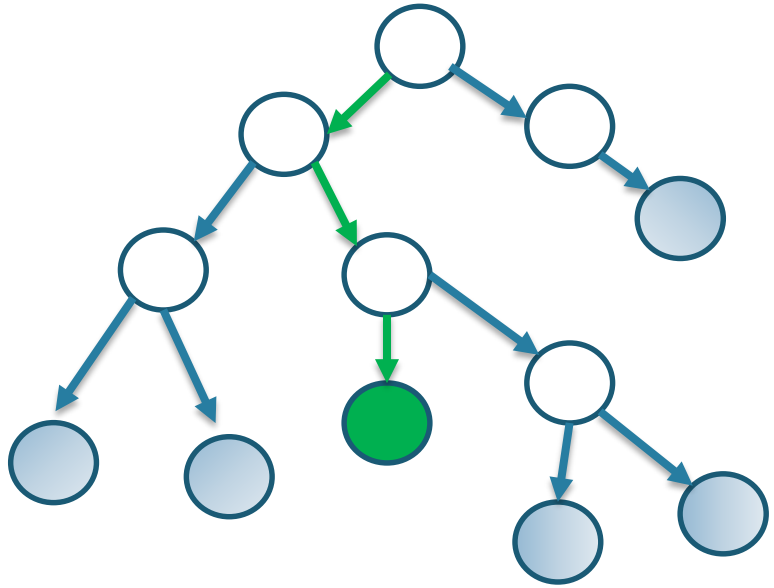


Optimizer Options

- Selected open source optimizers:

1) PuLP
   - ✓ COIN-OR - (CBC) - Branch and Cut
   - ✓ GNU Linear Programming Kit (GLPK) – Branch and Bound

2) SciPy
   - ✓ CVXOPT - (GLPK) - Branch and Bound



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Case Study

- 5-day Runs

Compset	Scientific Grid	Mesh Resolution
B1850	f09_g17	1deg ATM = 192 x 288 x 32 1deg OCN = 320 x 394 x 60

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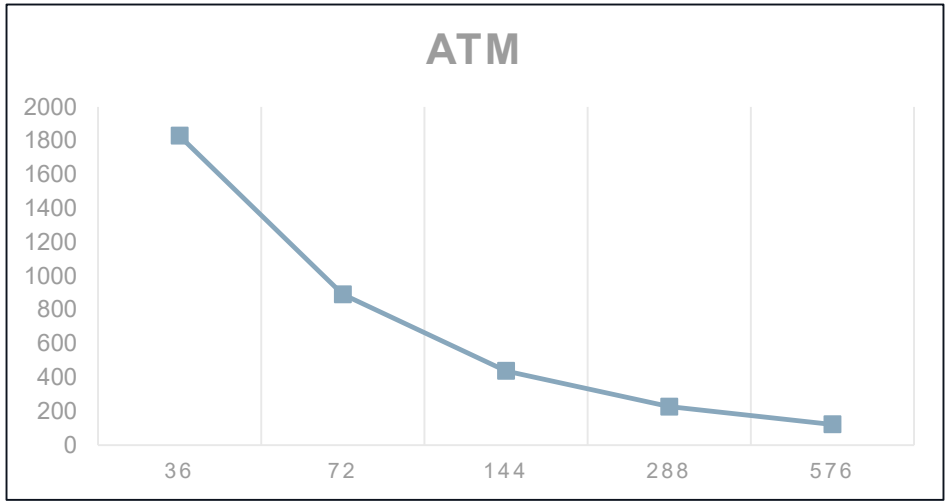
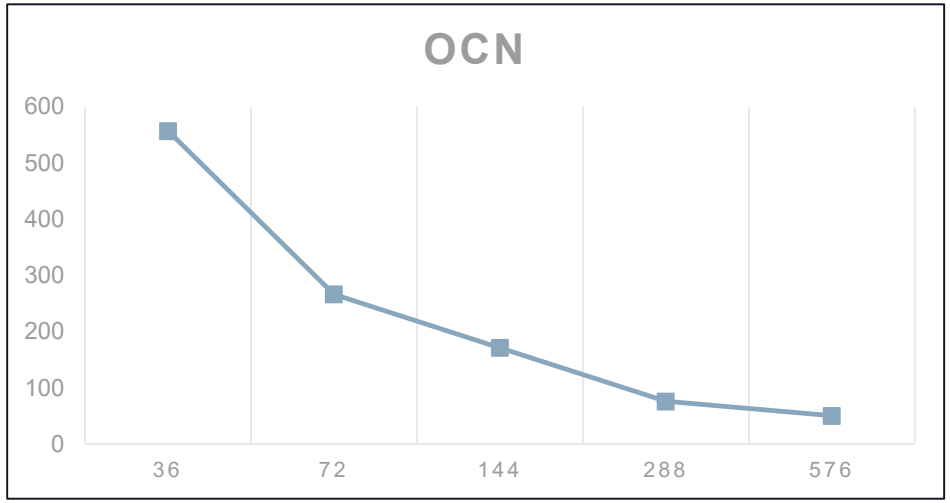
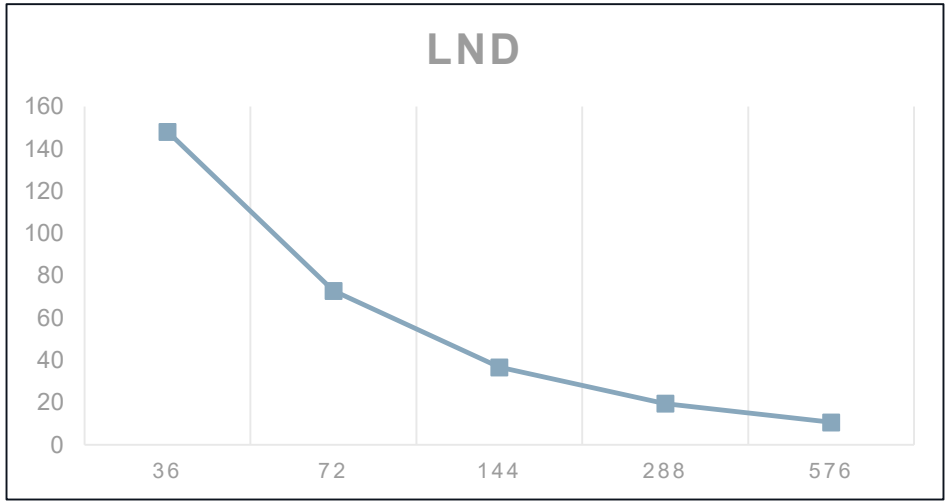
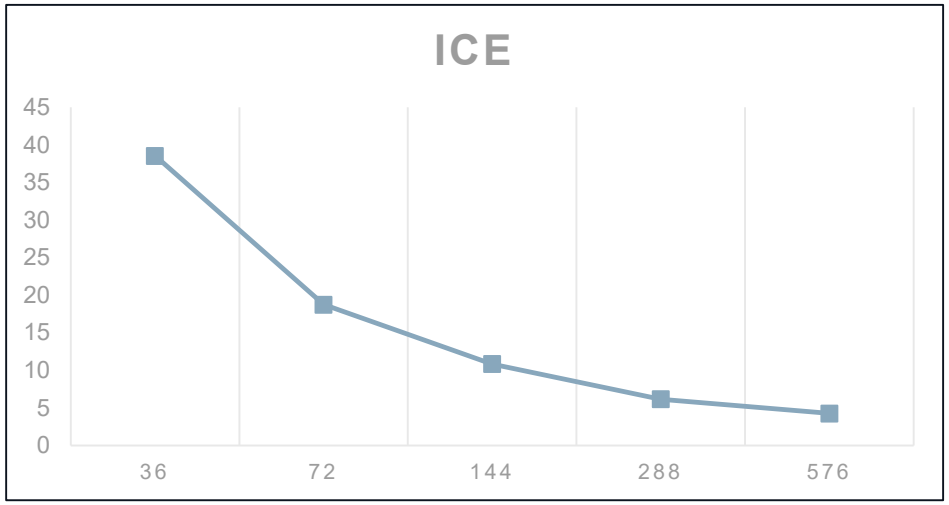
Performance Curves

- B1850-1degATM/1degOCN (5 day run)





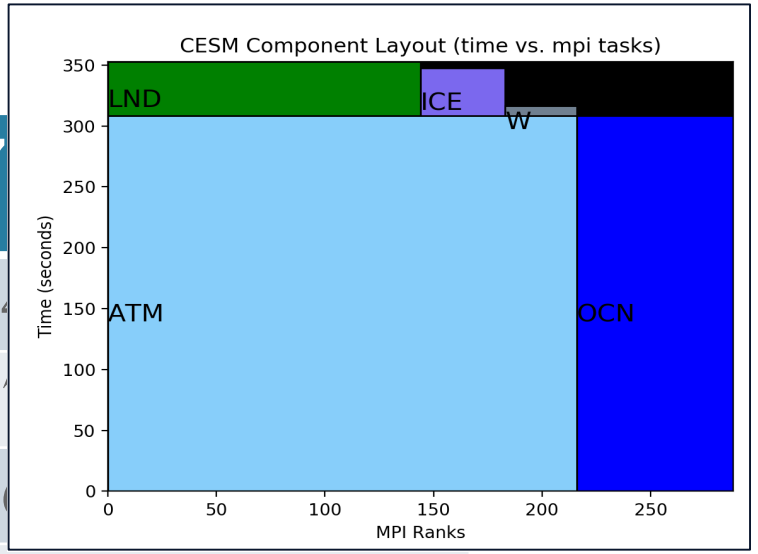


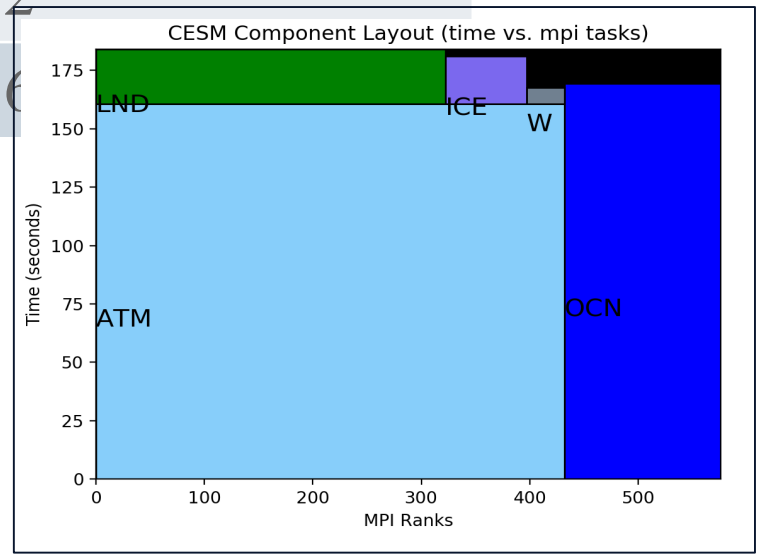


Optimizer Layouts

- B1850-1degATM/1degOCN (5 day run)

Total Number of Processors	288	576	7
OCN	72	144	1
ATM	216	432	5
LND	144	322	4
ICE	39	75	72
WAV	33	35	3





Comparison with Baseline

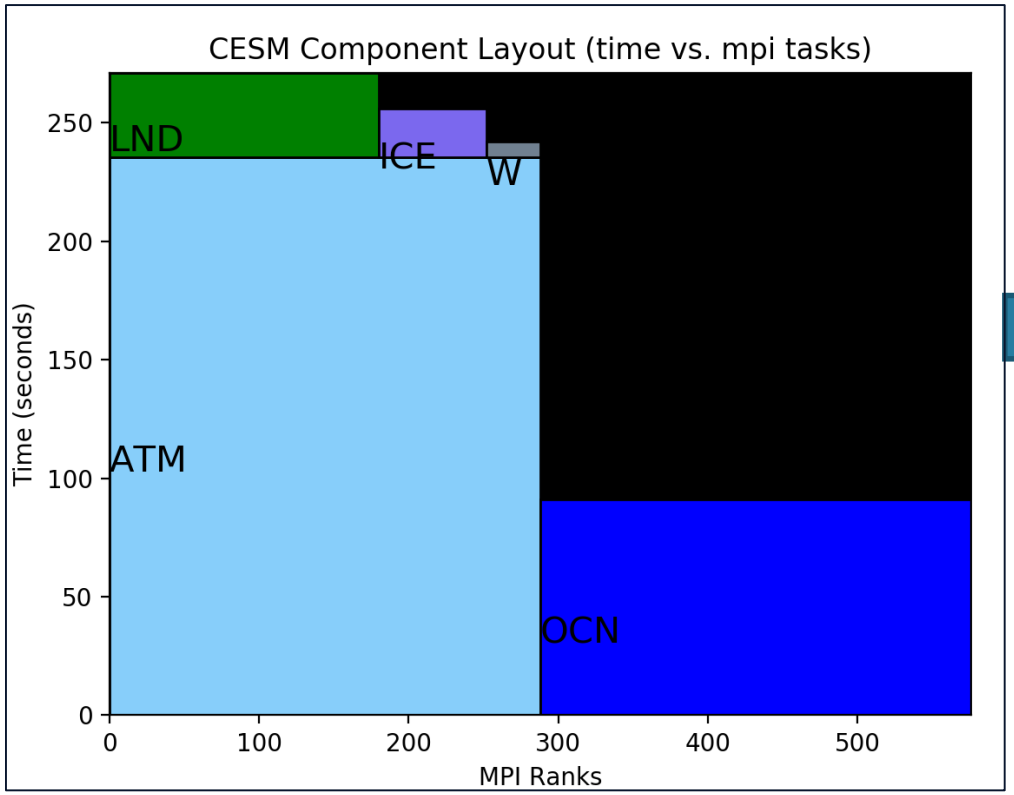
- B1850-1degATM/1degOCN (5 day run)

Relative to Baseline (720 -core run)			
	288	576	720
Total time (s)	1.94	1.06	1.00
Cost/year	0.78	0.85	1.00

576-core vs 720 -core
40.23 secs/day vs 38.04 secs/day
6% slower but 15% more efficient!

Layouts

- B1850-1degATM/1degOCN (5 day run)



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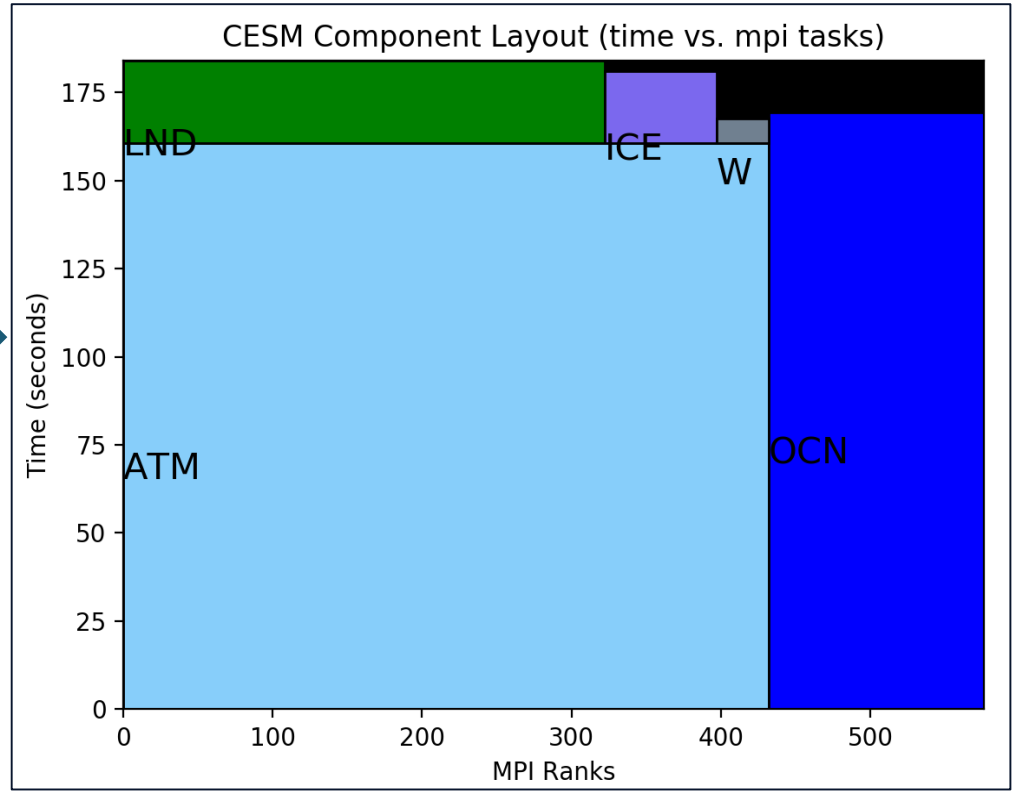

Balanced Layout

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Conclusions and Future Work

- ✓ Researched and implemented candidate optimizers.
- ✓ Benchmarked the different optimizers for a typical and widely used compsets.

Future Work

- ✓ Use the Load balancer and optimizer on more cases.
- ✓ Add other components (GLC and River) to the optimization problem.
- ✓ Research on more accurate algorithms for creating scalability curves.
- ✓ Try modeling the optimization problem as a non-linear problem.

ACKNOWLEDGMENT

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CODE team

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THANK YOU!!

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Sarich,J.,Edwards,J.,CIME Load Balancing Tool, 2017,GitHub Repository, **https://github.com/ESMCI/cime/tree/master/tools/load_balancing_tool**