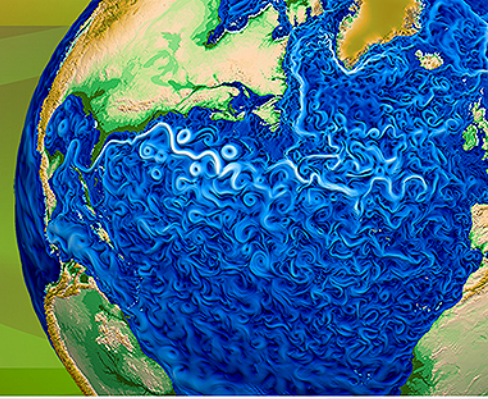




Accelerated Climate Modeling
for Energy



Computational Status 1,5 and 10 Year Vision

Mark Taylor

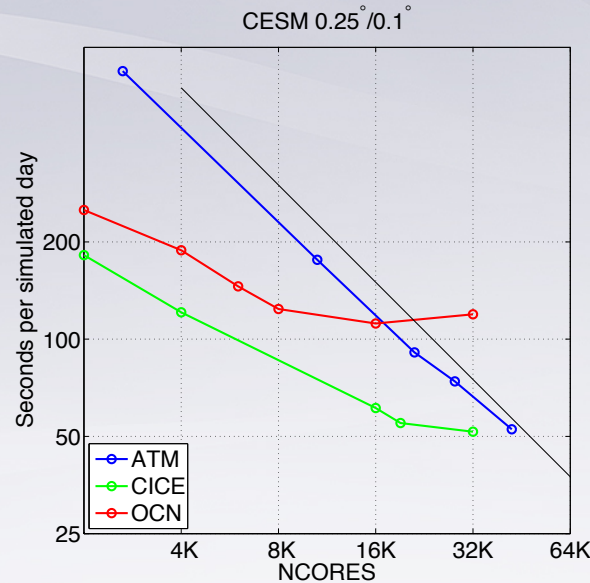
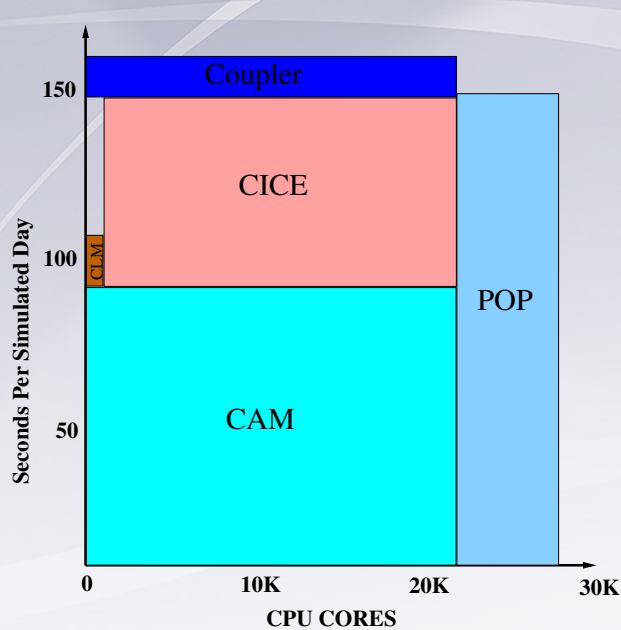
ACME All Hands Meeting

June 8, 2016

Rockville

1 Year Vision

ACME v0 (CESM1.3)



CAM Component	% time
Transport	0.43
Dynamics	0.20
Physics/Chem	0.20
Coupler/other	0.17

- Computational performance of ACME v0 starting point
- $\frac{1}{4}^\circ$ atmosphere, $\frac{1}{10}^\circ$ ocean/ice, on Titan
- What about ACME v1?
 - 1° ATM, EC 60-30km: Running since Jan 2016
 - $\frac{1}{4}^\circ$ ATM, RRS 15-5km: First runs completed June 2016

ACME v1 on Edison

- 1° ATM, EC 60-30km
 - 12.2 SYPD on Edison.
 - Cost: 25K core-hours per simulated year
- ¼° ATM, RRS 15-5km:
 - No data yet – but assume perfect weak parallel scaling
 - ESTIMATES:
 - 3.1 SYPD on Edison
 - Cost: 1.6M core-hours per simulated year
 - Good agreement with our ACME v0 “water cycle prototype”

ACME on today's systems

- NERSC Edison
 - 5600 Nodes,
 - 24 cores (dual Intel Ivy Bridge)
 - Watercycle Prototype: 3.1 SYPD
- OLCF Titan
 - 19K Nodes.
 - 16 core AMD Opteron + NVIDIA GPU
 - Watercycle Prototype: 2.2 SYPD
- ALCF Mira
 - 49K Nodes
 - 16 core PowerPC
 - Watercycle Prototype: 0.9 SYPD
 - Need better scaling, or can run effectively via ensembles



5 Year Vision 2016-2021 Pre-Exascale (Cori/Summit/Aurora)

ACME v1 on Cori Phase 2

- NERSC Cori Phase 2 (late 2016)
 - 9300 Nodes
 - Intel Phi KNL, 72 cores x 4 threads
- Expectations:
 - 1.25x speedup over Edison (per node)
 - openMP in MPAS components
 - Nested openMP in Atmosphere
 - 2x improvement w/ 4x more resources
- ACME v1 $\frac{1}{4}^\circ$ / RRS15-5
 - Achieve > 5 SYPD



ACME v1 on Aurora

- ALCF Aurora 2019
 - 50K Nodes, 3rd gen Intel Phi
- Larger system & faster nodes as compared to Cori Phase 2
- Promising machine for $\frac{1}{4}^\circ$ / RRS15-5 resolution



ACME v1 on Summit

- OLCF Summit 2019
 - 3400 Nodes
 - Multiple IBM power9 and NVIDIA GPUs
- Harder to estimate performance
- Potential for larger performance gains
- More labor required to port code
- Expectations:
 - Reasonable estimates based on NDA information suggest 8x speedup over Titan-CPU only
 - ACME v1 $\frac{1}{4}^\circ$ / RRS15-5: ~ 15 SYPD



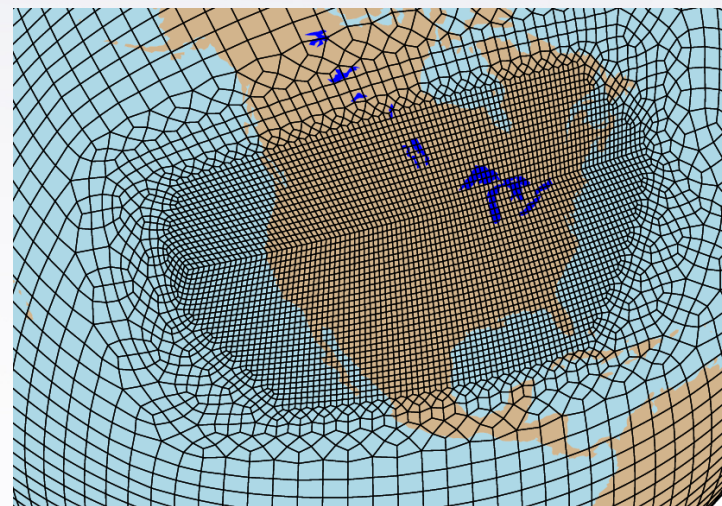
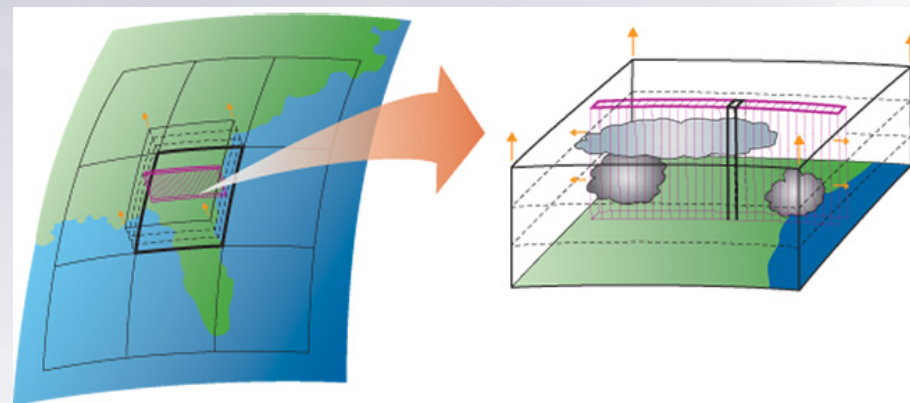
10 Year Vision 2026 Exascale Regime

Exascale Machines ~ 2023

- Exascale Machines: 10-100x faster than Aurora/Summit
- Increasing resolution is expensive:
- Compared to $\frac{1}{4}^\circ$ / RRS15-5
 - 3km resolution: 700x
 - 1km resolution: 20,000x

Approaches for ~1km Resolution

- Multiscale (super-parameterization or subcolumn physics)
 - ACME Exascale Computing Project (ECP) proposal
- Variable Resolution
 - ACME v1 will be the first Earth System Model to support variable resolution in every component
 - Just starting to be used in v1



Vision for v2/v3

- **Unified coupled modeling system for global high-resolution with ultra-high regional resolution**
 - ACME v1 first ESM to support variable resolution in all components
- **Cloud Resolving Atmosphere**
 - Global: Multiscale/Multiphysics approaches (SP, multicolumn)
 - Regional: Cloud resolving (1km) and LES (100m)
- **Eddy resolving global ocean**
 - Global: eddy resolving RRS15 -5km
 - Regional: Coastal modeling (100m-1km), inundation
 - LES: <100m. Boundary layer mixing
- **Antarctic embayment resolution (land & ice) 100m**
- **Sub-watershed resolution in the land model (30m)**

Thanks!