Present and Future Computing Requirements

Anthropogenic Climate Change Using Super-Parameterization

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and
COLA

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1. Project Description

- Objective: Conduct and analyze simulations of anthropogenic climate change within a framework in which the atmosphere model has a cloud-resolving model embedded in each grid column.

- Our present focus is to conduct simulations in which the cloud-resolving model is 2D.

- By 2017 we expect to conduct simulations in which the cloud-resolving model is 3D.
1. Project Description

- CAM
- CLM
- POP
- CSIM
- CPL
- TOA

- ~100 km
- ~100 km
- 3 km
- Nx = 32

Diagram showing the integration of CLM, CPL, POP, and CSIM with 2D CRM and TOA parameters.
1. Project Description

<table>
<thead>
<tr>
<th>Project</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>~100km</td>
<td>CAM</td>
</tr>
<tr>
<td>3 km</td>
<td>N = 8\times 8 = 64</td>
</tr>
<tr>
<td>POP</td>
<td>CLM</td>
</tr>
<tr>
<td>CPL</td>
<td>CICE</td>
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3D CRM

~100km

~100km
2. Computational Strategies

- We approach this problem computationally at a high level using MPI
  - Dynamical core: Finite Volume
  - ATM: $N_x = 288$, $N_y = 192$, $N_z = 30$; CRM: $N_x = 32$, $N_z = 28$;
  - LND: $N_x = 288$, $N_y = 192$;
  - OCN: $N_x = 320$, $N_y = 384$, $N_z = 60$;
  - ICE: $N_x = 320$, $N_y = 384$;

Mixed Mode Execution

<table>
<thead>
<tr>
<th>Runtime</th>
<th>ATM (4096 tasks x 1 thread)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>ICE (1024 tasks x 1 thread)</td>
</tr>
<tr>
<td>1024</td>
<td>CPL (2880 tasks x 1 thread)</td>
</tr>
<tr>
<td>1216</td>
<td>OCN 128</td>
</tr>
<tr>
<td>4096</td>
<td></td>
</tr>
<tr>
<td>4224</td>
<td></td>
</tr>
</tbody>
</table>
2. Computational Strategies

- ATM: \(N_x = 288, N_y = 192, N_z = 30\); CRM: \(N_x = 32, N_Z = 28\);
- CRMs = 288 \(\times\) 192 = 55,296
- The maximum number of MPI processes used in the latitude-vertical decomposition is 64 \(\times\) 4 = 256;
- 13.5 CRM calculations per core;

- The CRM uses a finite difference representation with stretched vertical and uniform horizontal grids;
- The advection of momentum is computed with the second order finite differences in the flux form with kinetic energy conservation;
- The equation of motions are integrated using the third-order Adam-Bashforth scheme with a variable time step;

- We expect our computational approach not to change by 2017 but the code will change to include improved physics;
3. Current HPC Usage

• Machines: Hopper, Kraken

• Hours used in 2012: NERSC = 10.3M; NICS = 5M

• Typical parallel concurrency: variable
• Run time: 16 hours; number of runs per year: 3

• Data read/written per run: 4.75TB

• Memory used per core: 1.33GB

• Necessary software: pgi/fortran; netCDF/pnetCDF; mpich; libsci

• Data resources used HPSS: ~8TB
4. HPC Requirements for 2017

• Compute hours needed ~50-60M

• Changes to parallel concurrency: 2; number of runs per year: 5

<table>
<thead>
<tr>
<th>Experiment</th>
<th>Resolution</th>
<th>Simulated Years</th>
<th>Ensembles</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>1deg/3km</td>
<td>100</td>
<td>1</td>
</tr>
<tr>
<td>Climate Change</td>
<td>1deg/3km</td>
<td>100</td>
<td>4</td>
</tr>
</tbody>
</table>

• Changes to data read/written: 6TB/run

• Changes to memory needed per core: 4GB

• Changes to necessary software, services or infrastructure: none
5. Summary

• Regional and Global Climate Modeling Program
  • Use very high spatial resolution simulations to understand climate variability and change at regional and global scales
  • Shed some light on the nature of tropical biases
  • Gain a better understanding of multivariate extremes

• What "expanded HPC resources" are important for your project?
  • Increased memory per core
  • Tools for making the data available to large groups of users