Met Office HPC Update

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Thanks to:
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HPC Facilities
Met Office HPC Systems

- 3 top 40 systems at launch
- Architected for reliability
- 7PF and 2x 2.8PF (HPL)
- Intel Xeons. Mostly Broadwell, some Haswell.
- 6 Lustre filesystems totalling 24 PB
- Cray Aries interconnect
- PBS Pro scheduling and Cray/Intel compilers
- 50/50 Weather/Climate usage
2018 Operational Models

**UK 1.5km** 70L (80 km top)
- 12 hrs – 16/day
- 54 hrs – 6/day
- 120 hrs – 2/day
+12 member ensemble 2.2 km
  - 54 hrs – 4/day

**Global 10km** 70L (80 km top)
- 66 hrs – 2/day
- 144 hrs – 4/day
+18 member ensemble 20 km
  - 144 hrs – 4/day

**Driving**

**Seasonal** 85L (85 km top)
- ¼ degree Ocean
- Ensemble at 60 km
- 7 months – 2/day
• Early Cray development system now Knights Landing and Analytics

• Partner with GW4 Alliance for Isambard

• EPSRC funded, multi-architecture platform including NVIDIA GPU and Intel KNL

• Will have significant 64-bit ARM partition

• For details – see Simon McIntosh-Smith’s talk!
### Single Node Comparisons

#### Broadwell
Swan - Intel Xeon (Broadwell),
2 × 22-core @ 2.2GHz

#### Skylake
Swan - Intel Xeon (Skylake),
2 × 28-core @ 2.1GHz

#### KNL
XCK – Intel Xeon Phi (Knights landing),
64-core @ 1.3Ghz

#### TX2
Isambard – Cavium ThunderX2
2 × 32-core @ 2.2GHz
Operational 10km Global
Parallel Suite 39; The Problem

- Scalability projections suggested we could afford to run a 10km global model (N1280L70) even though benchmarks had been at 12km (N1024L70)
- Initial experiments on the brand-new XCS system gave runtime of 55 minutes on 518 nodes for 7 day runs
- BUT, Early runs in PS 39 took up to 74 minutes. Limit is 60 minutes!
- Operationally unacceptable timescales
- Runtimes too variable
Hypothesis: Noise on Interconnect

Run on quiet system

Run on busy system
• 518 nodes spread over 7 electrical groups
• Minimise Rank 3 exposure
• New placement set; quartet
• Bias routing to minimal path for job
• Minimise other jobs on quartet; oversized reservation

• Later: bias routing for I/O traffic
2 vs 7 Electrical Groups

Many more very short timesteps

A few very long timesteps
• >70 minutes down to ~52 minutes
• Variability reduced
• Operationally acceptable times
• Affordable cost
• Required close Met Office / Cray collaboration
Experiments in 32-bit Physics
Large Scale Precipitation chosen as a pilot study

- Tightly defined area with clean interface
- Expensive in regional models
- Compile-time choice of precision
- What impact to scientific accuracy?
- What impact on runtimes?
Science payload varies between GA6, GA7 and UKV
Performance gain depends on configuration, build optimisation and other factors

<table>
<thead>
<tr>
<th>Build/decomposition</th>
<th>N512 GA6 2 day</th>
<th>N48 GA7 AMIP 30 day</th>
<th>UKV 1.5 km 24 hour</th>
</tr>
</thead>
<tbody>
<tr>
<td>UM speed-up</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LSP scheme speed-up</td>
<td>33.5%</td>
<td>14.9%</td>
<td>38.0%</td>
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<tr>
<td></td>
<td>4.5%</td>
<td>1.3%</td>
<td>2.5%</td>
</tr>
<tr>
<td></td>
<td>High</td>
<td>Safe 12x9</td>
<td>Safe 8x33</td>
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<tr>
<td></td>
<td>10x23</td>
<td>Safe 16X9</td>
<td>Safe 12x22</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>High 6x41</td>
</tr>
</tbody>
</table>
Scalability Improvements
Auto-Tuning Segmentation

- Increased use of segmentation to allow adaptation for cache and threading
- Require tuning for each configuration and architecture
- Previously used expensive brute-force search taking many model runs
- New tuning code using simulated annealing
- Only 1 run to tune
- Improving OpenMP over many versions and years
- With Cray XC40 – OpenMP a primary parallelisation strategy
- Better coverage / better balance
- Now running at 3-4 threads / task
- Serial performance improving too
- More to do e.g. regional, ESM.

OpenMP Improvements

N768 model, strong scaling
1 thread/core, 12 – 108 nodes

![Graph showing parallel efficiency vs threads for different versions of the model.]
Operational Suite 40 Improvements

- Global 10km model on 18k cores
- 55 minutes down to 44
- ~200 nodes freed up
- Start-up reduced
- Shutdown reduced
- Less weather dependence
- Significant HPC cost saved => more science done and better forecasts!
- More reliable delivery.
High Resolution Scalability

- N2048L70 Global model (6km)
- At vn10.4
  - Poor scaling
  - High start-up cost
  - Operational runtimes couldn’t be met

- At vn11.1
  - Improved scaling
  - Small start-up cost
  - Potentially able to meet operational runtimes
Thank You! Questions?