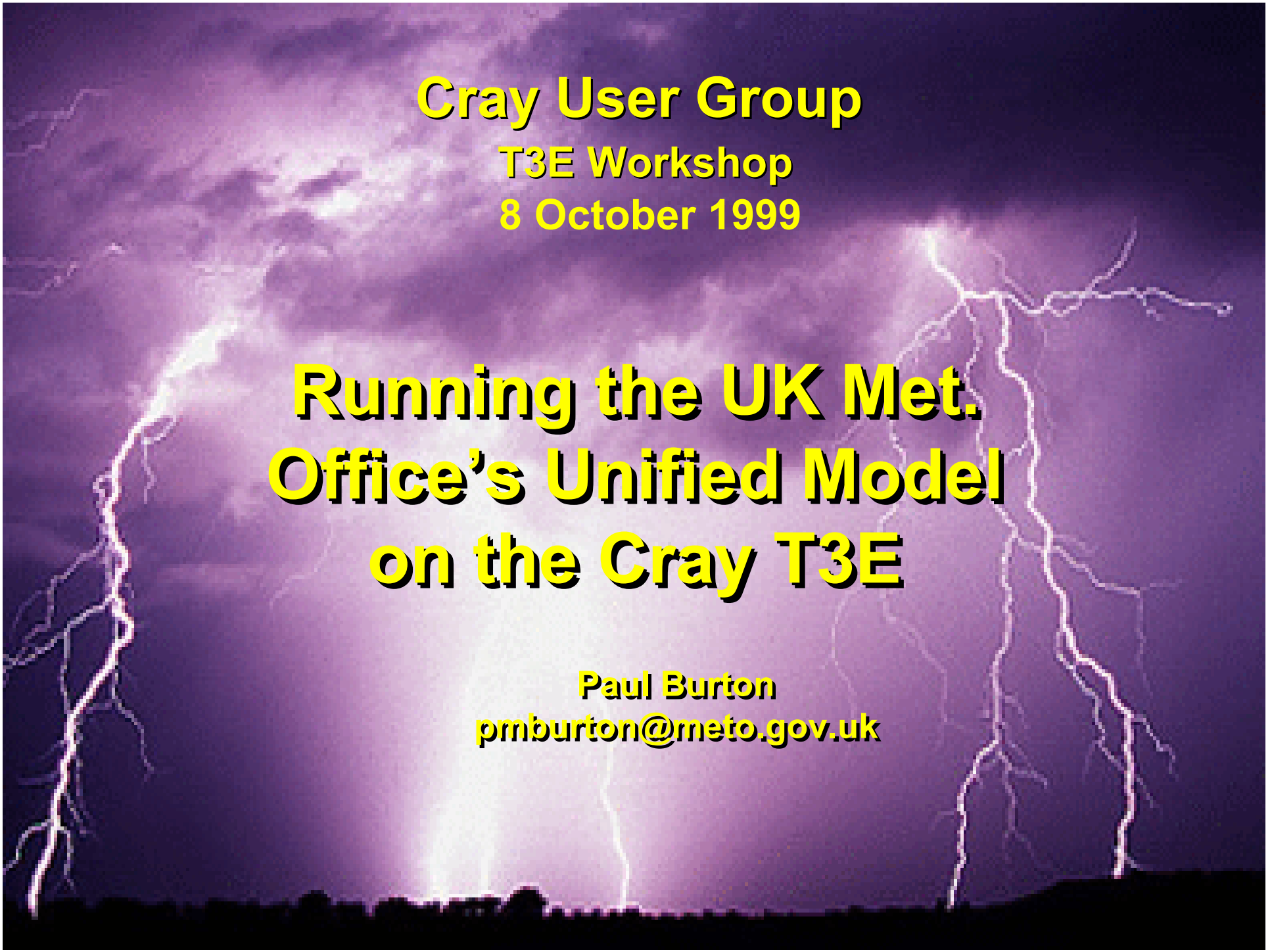

Cray User Group
T3E Workshop
8 October 1999
Running the UK Met. Office's Unified Model on the Cray T3E
Paul Burton
pmburton@meto.gov.uk

Running the Unified Model on the Cray T3E

- The Unified Model
- Our Computers
- Our Experiences
- The future...

The Unified Model

What's it all about?

- **Unified**
  - Numerical Weather Prediction (global/mesoscale)
  - Climate modelling
  - Data assimilation (3D-VAR)
- **Model**
  - Atmosphere model
  - Ocean model
  - Coupled atmosphere/ocean
- **System**
  - Highly configurable (GUI)
  - Extensive diagnostic output

The Met Office

The Unified Model

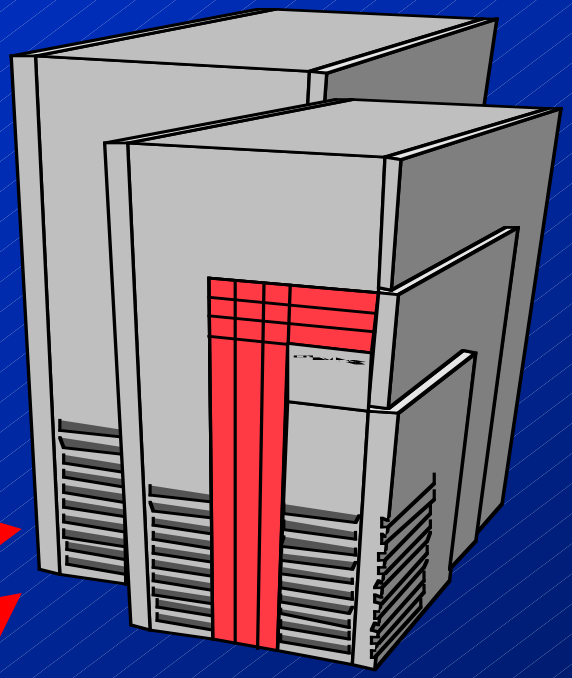
Inputs and Outputs

User Interface

Start Dumps

Boundary conditions

Observations



Unified Model

Atmosphere

Ocean

Dumps

Boundary conditions

Diagnostics

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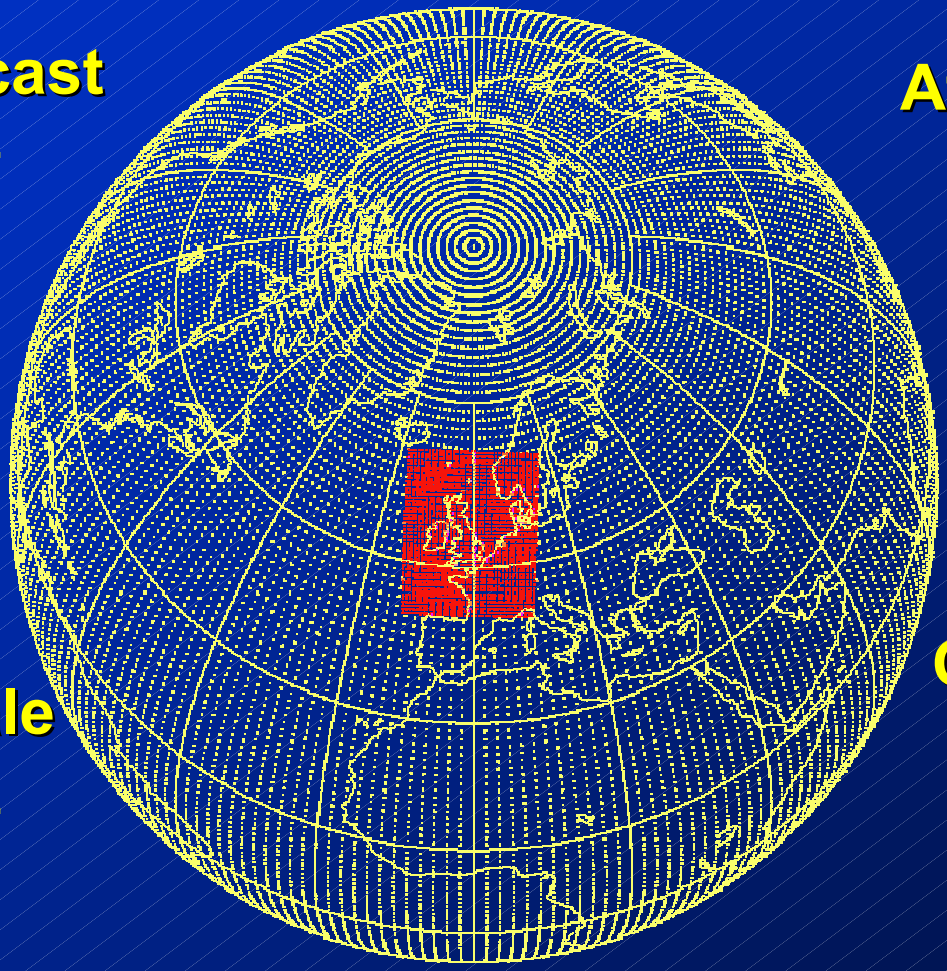
The Unified Model

Model Configurations

Global Forecast
- 432 x 325 x 30L
- 60 km
- 20 min



Atmos. Climate
- 96 x 73 x 19L
- 270 km
- 30 min

UK Mesoscale
- 146 x 182 x 38L
- 12 km
- 5 min

Ocean Climate
- 288 x 144 x 20L
- 90 km
- 60 min

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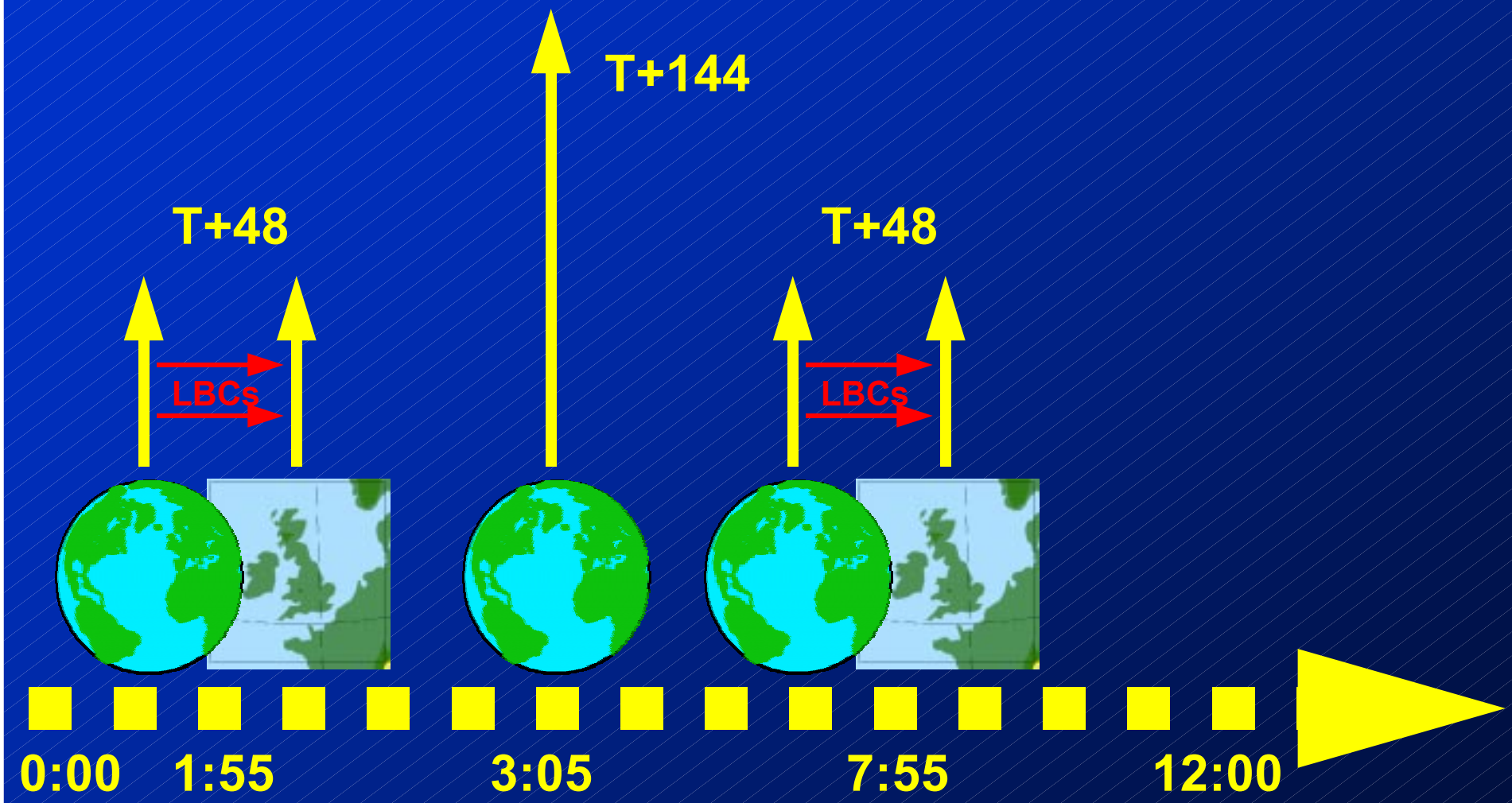
The Unified Model

Operational Schedule



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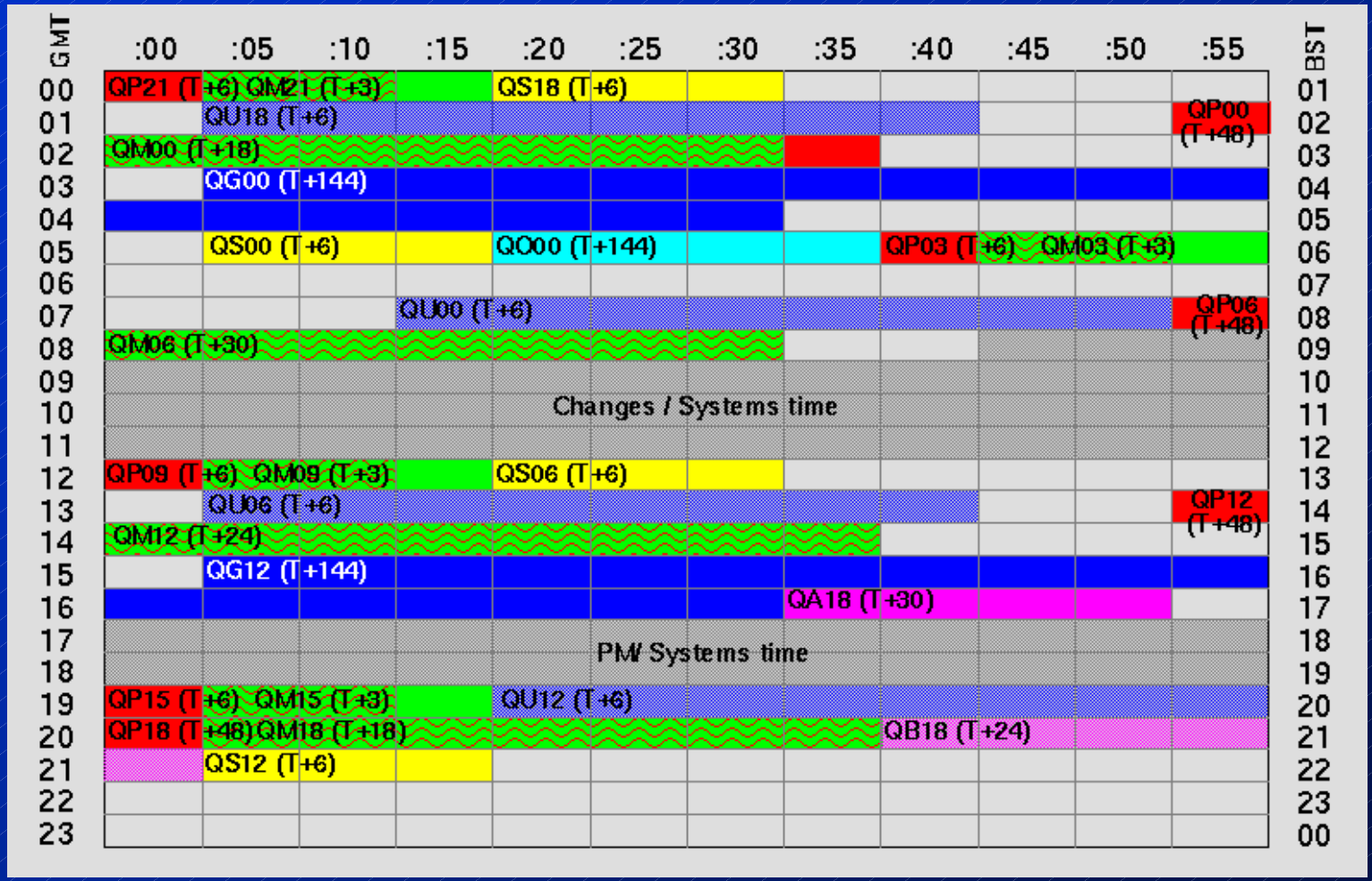
The Unified Model

Operational Schedule



The Met.Office

Our Computers

Impressive statistics

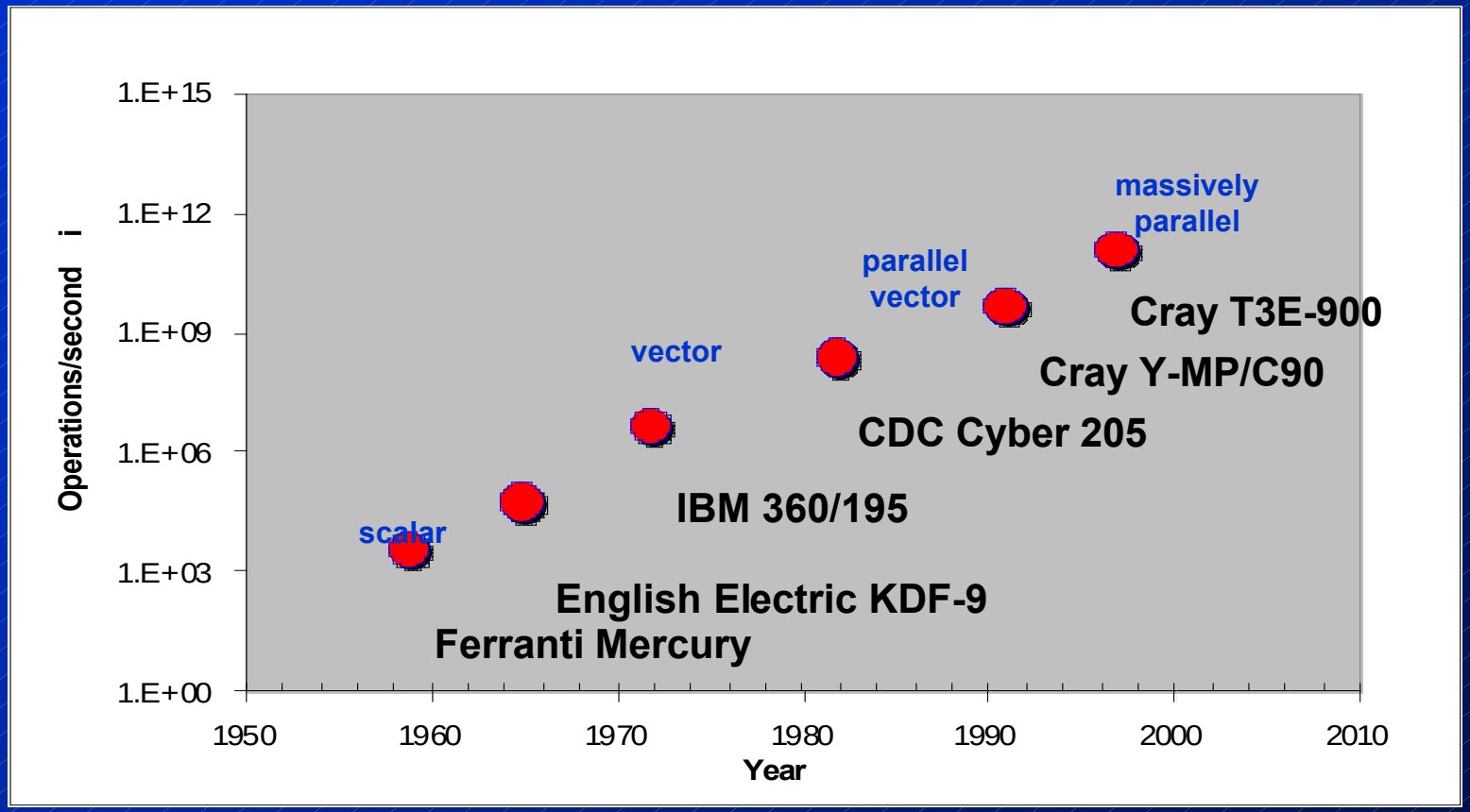
Every day:

- 10 million observations processed
- 40 operational forecasts produced by our computer models
- 3,000 tailored forecasts and briefings provided to our customers
- 40 years of climate integration carried out
- 0.5 Tb of data output

The Met Office

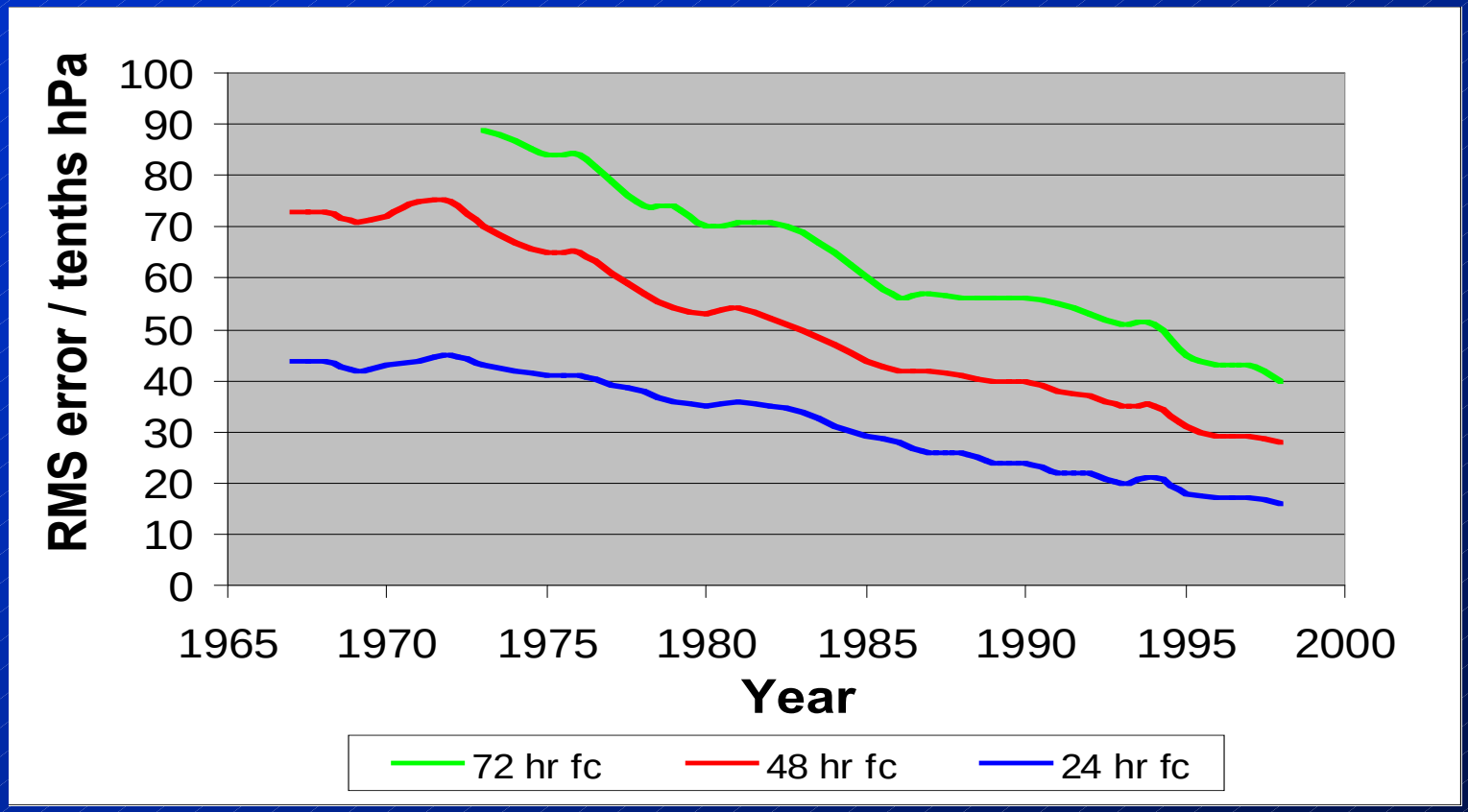
Our Computers

Met. Office Computers



Our Computers

Improvement in forecast skill



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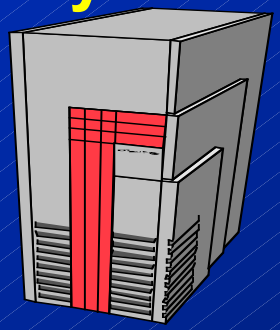
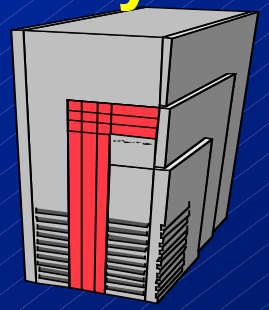
Our Computers

Recent History





	Cray C90	Cray T3E-900	Cray T3E-1200
Number of PEs	16	880	600
Peak Mflops/PE	1000	900	1200
Sust. Mflops/PE	400	90	100
Memory (Gbytes)	2	120	150
Disk (Gbytes)	140	1600	1600

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Our Experiences

Domain Decomposition

2D Decomposition

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Our Experiences

Interprocessor Communication

- **Requirements:**
  - **Portability - consistent interface**
    - across machines
    - across message passing libraries
  - **High Performance**
    - use manufacturer specific libraries
  - **Maintainable**
- **Solution - GCOM (General COMmunications)**
  - **Calls a range of libraries (MPI, PVM, SHMEM...)**
  - **Low overhead**
  - **Small Fortran library**

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Our Experiences

Optimisation

- **Communications**
  - high communications to computations ratio
  - requires high bandwidth/low latency comms.
  - GCOM (Using Cray SHMEM)
  - direct SHMEM calls for halo updates
- **Single Processor Performance**
  - cache reuse
    - loop unrolling
    - loop merging
  - streams
    - loop splitting

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Our Experiences

Load Imbalance

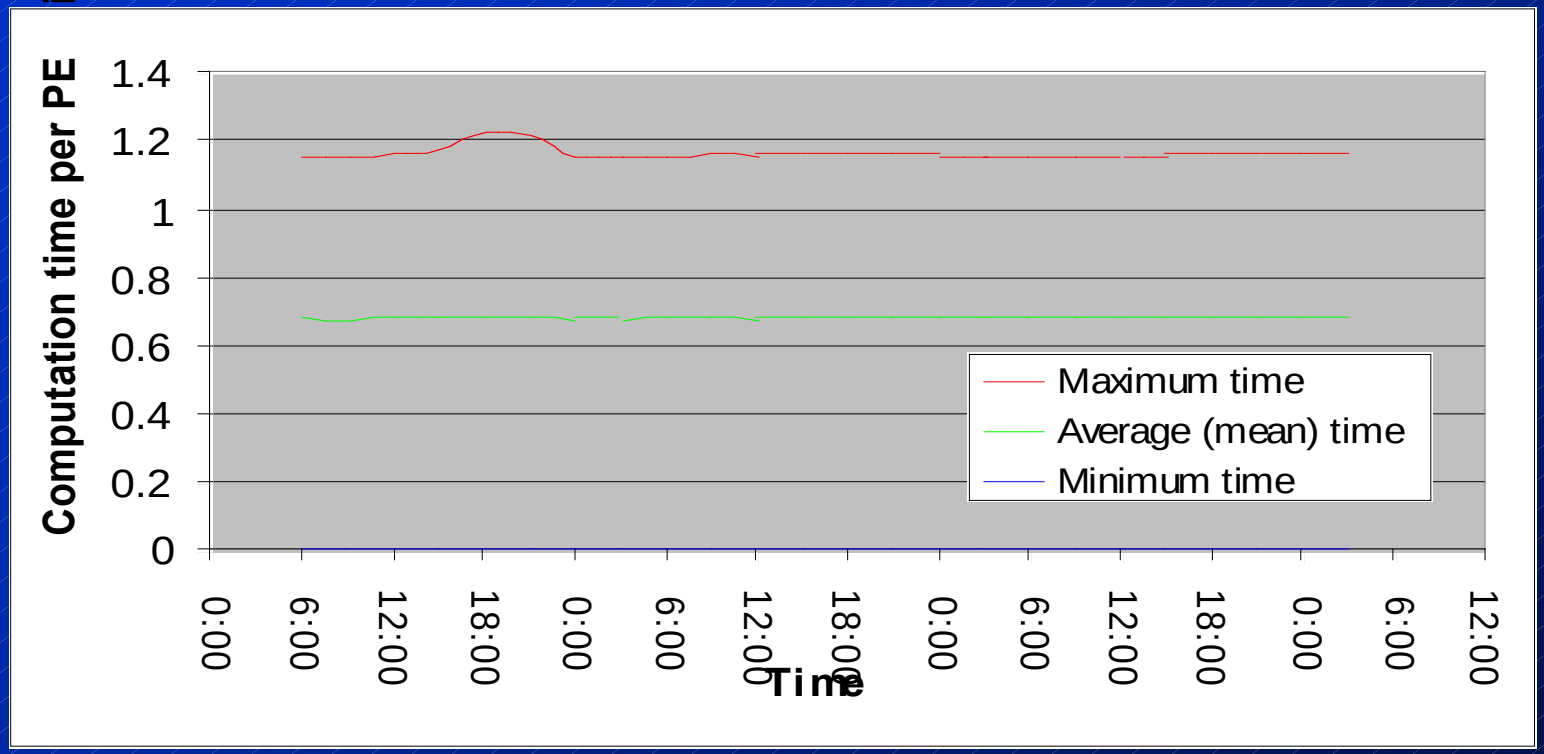
- **Short-wave radiation**
  - around 10% of runtime in climate models
  - sunlight only falls on half the globe
  - half the processors have no work to do

- **Convection**
  - around 15% of runtime in operational forecast
  - equatorial regions - lots of convection
  - mid latitudes - driven by passage of weather systems
  - polar regions - virtually no convection

Our Experiences

Short-wave radiation Load Imbalance

Before...



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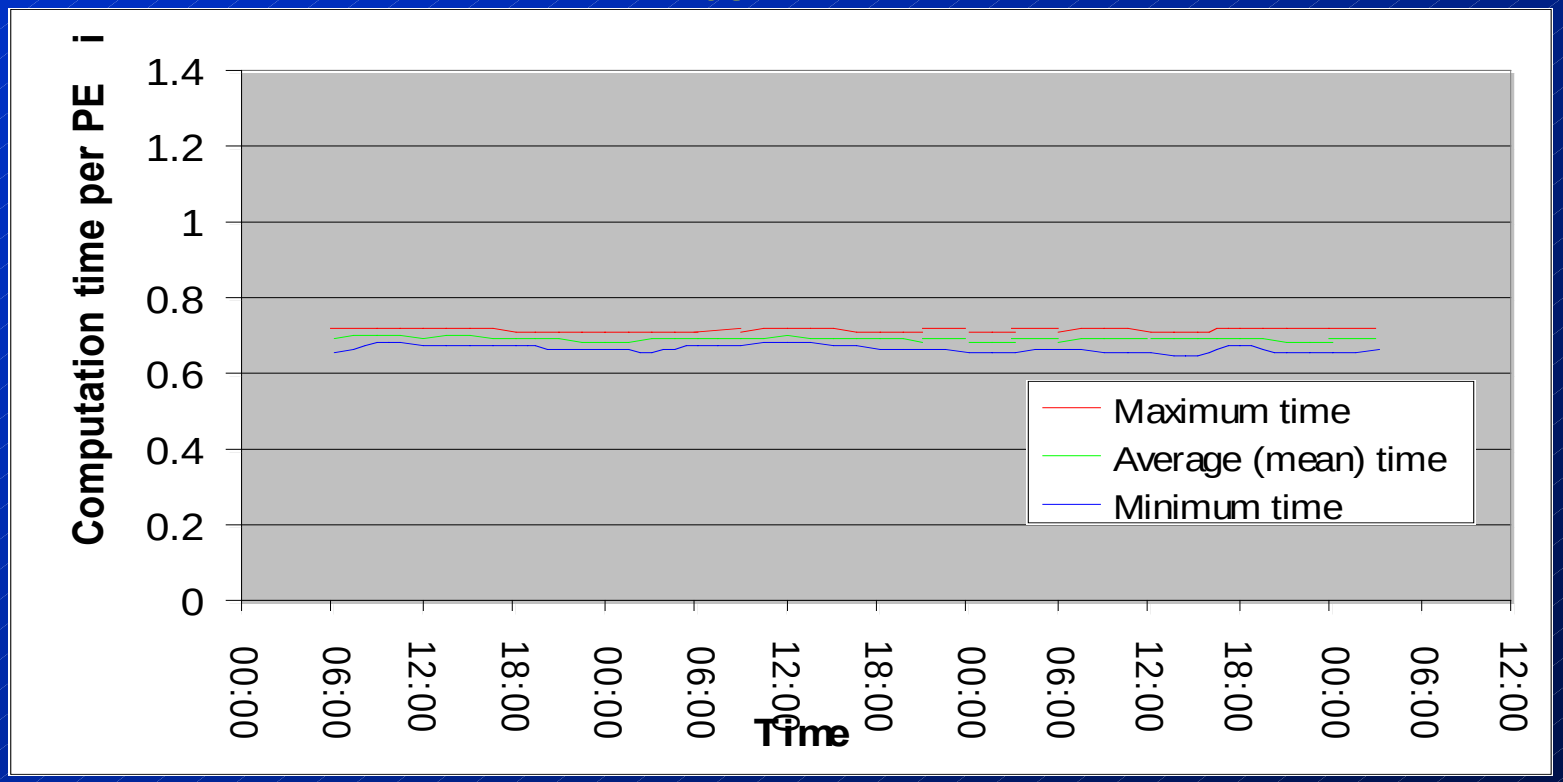
Our Experiences

Short-wave radiation Load Imbalance

After...



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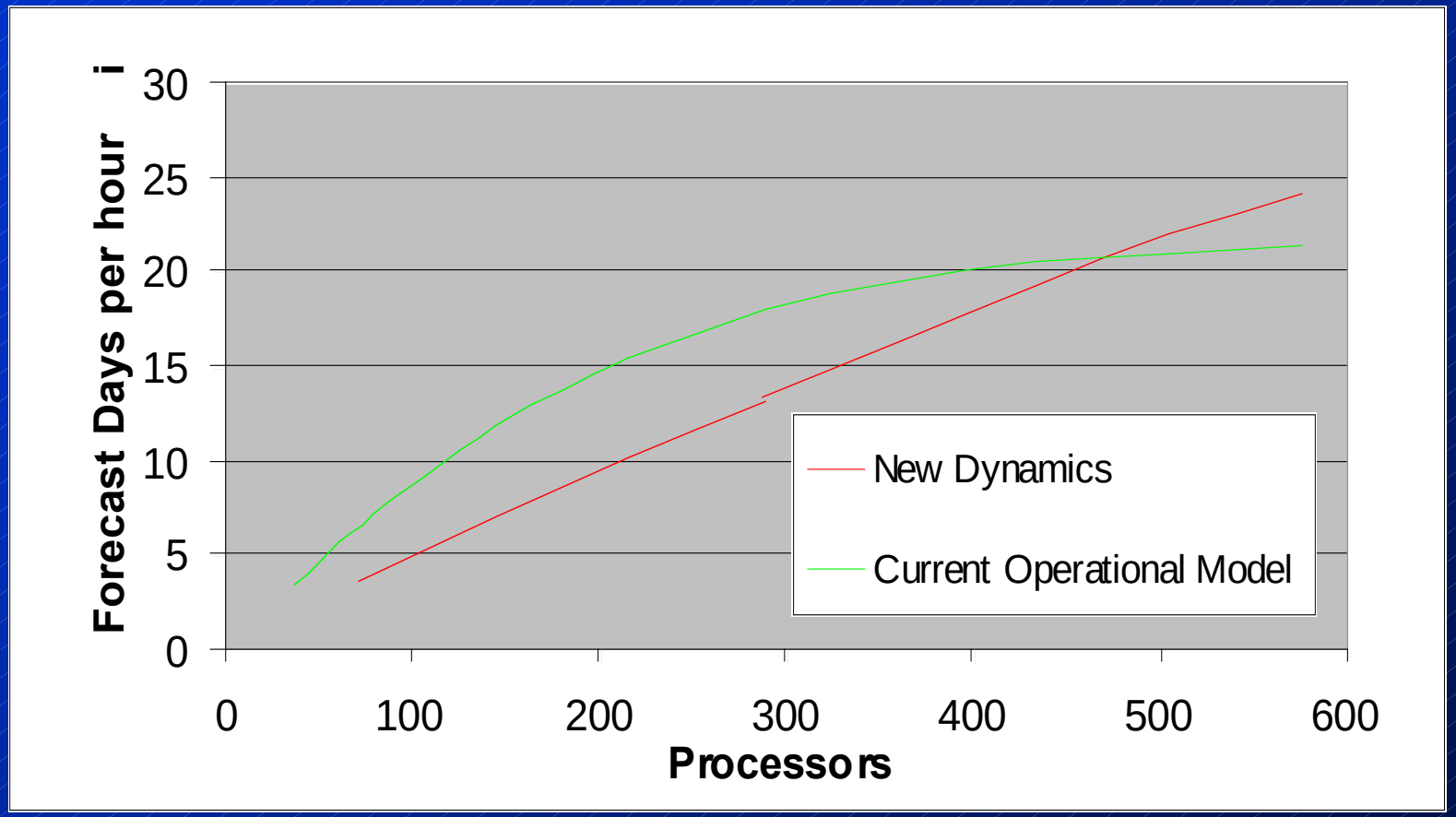
Our Experiences

Scalability



Our experiences

Job requirements

- **Operational forecast**
  - must start immediately
  - 144/288 PEs
  - runtimes 10-30 mins
- **Climate Integrations**
  - 24/36/72 PEs
  - typically run for several months
- **R&D Work (varied workload)**
  - 1-288 PEs
  - runtimes 1min - 12hrs
  - good turnaround essential

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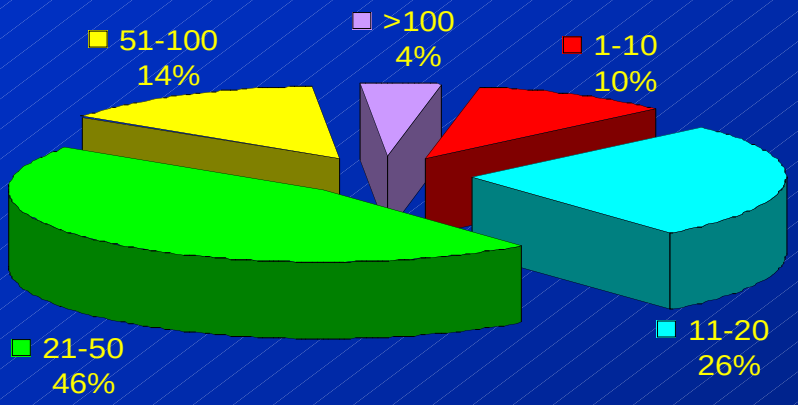
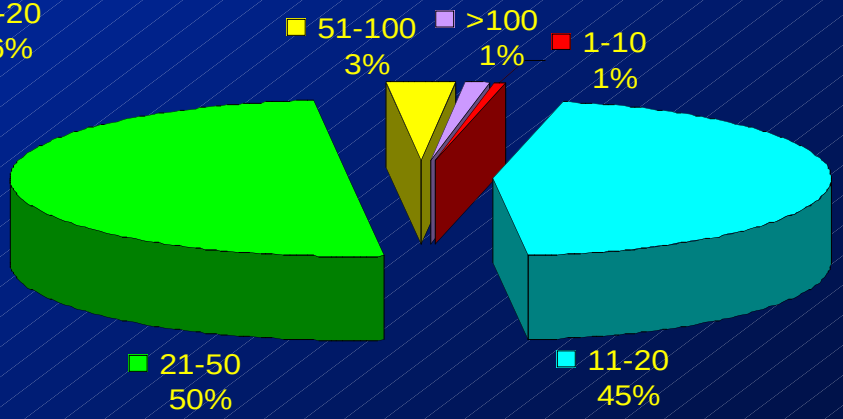
Our Experiences

Job size mix

Number of jobs run



CPU time used



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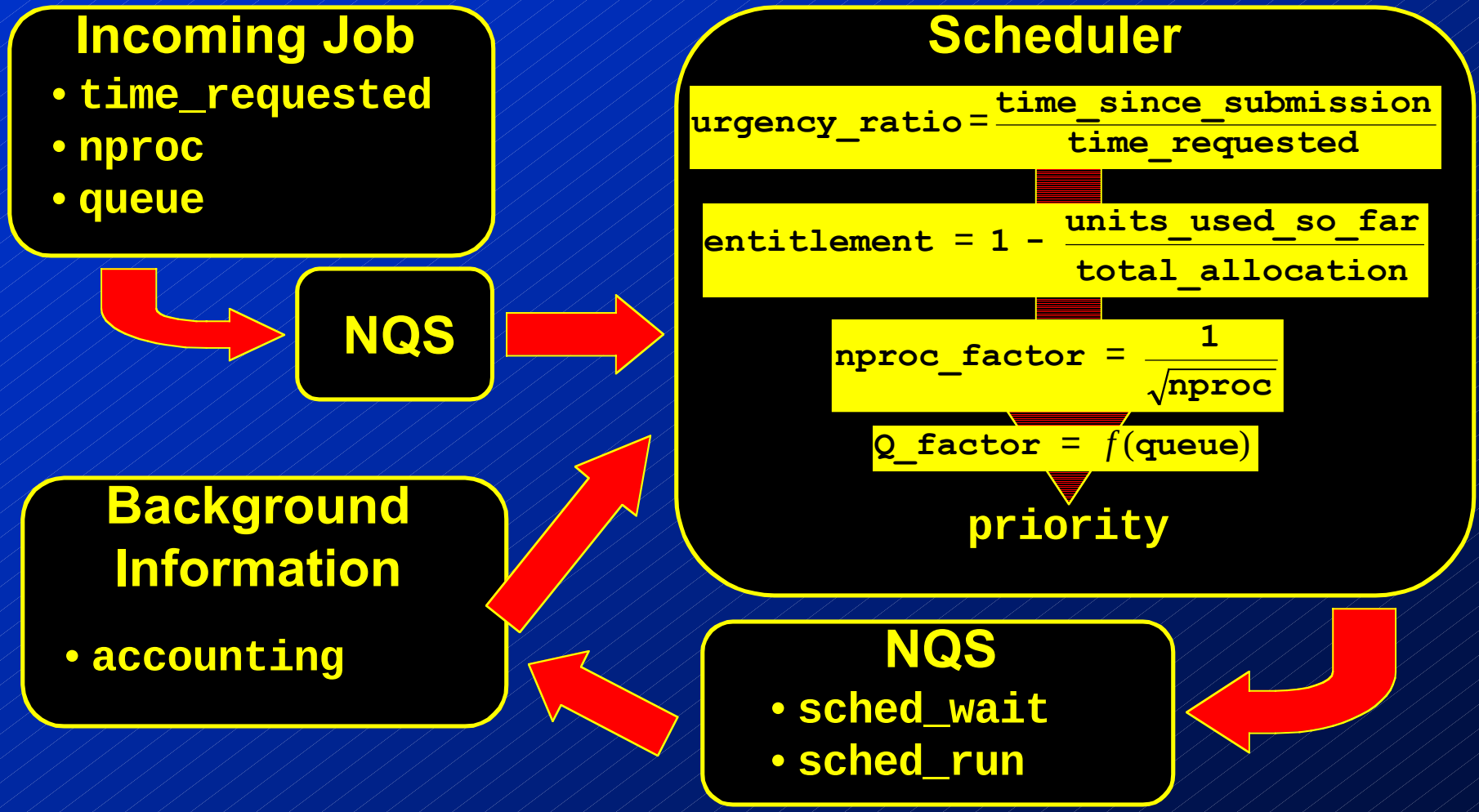
Our Experiences

Job Scheduling



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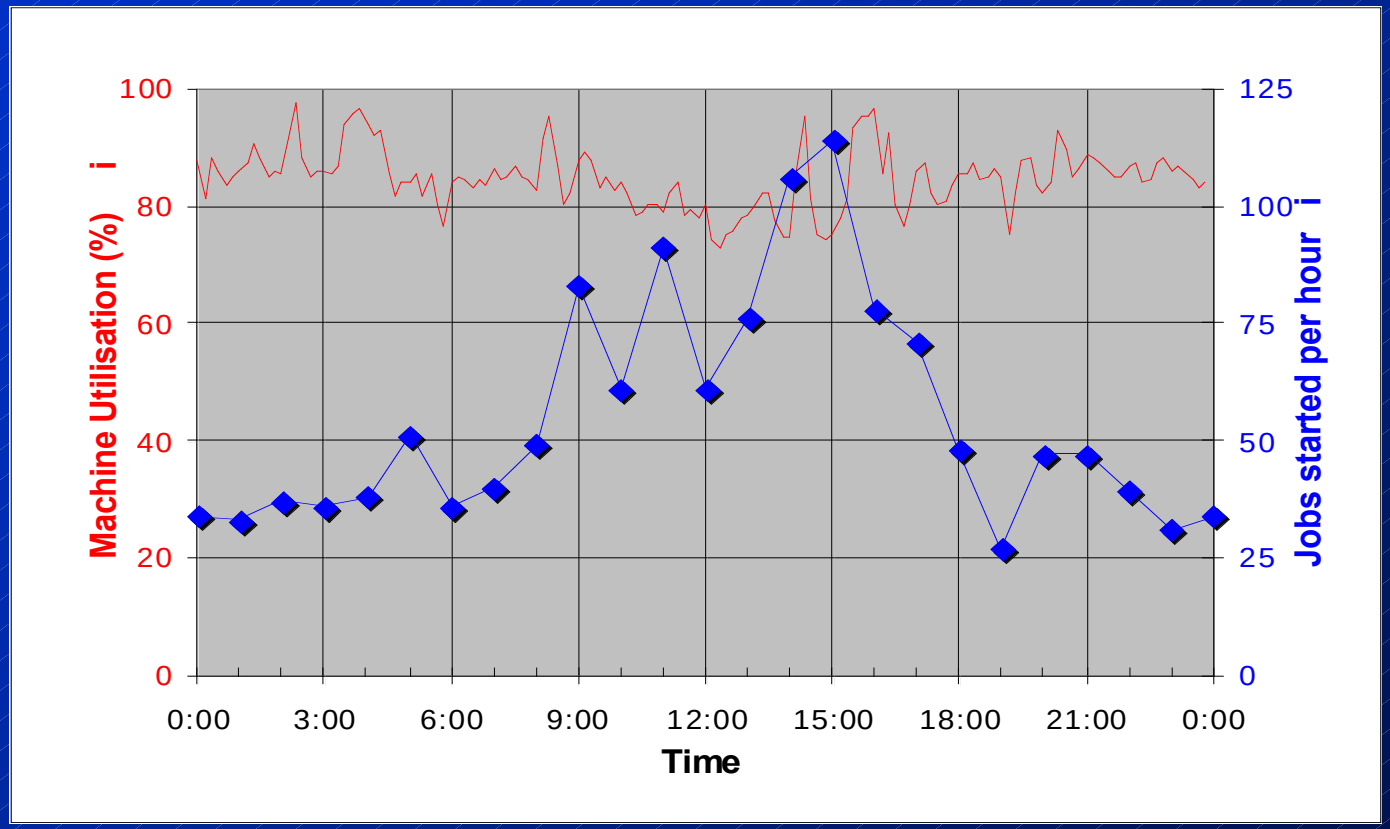
Our Experiences

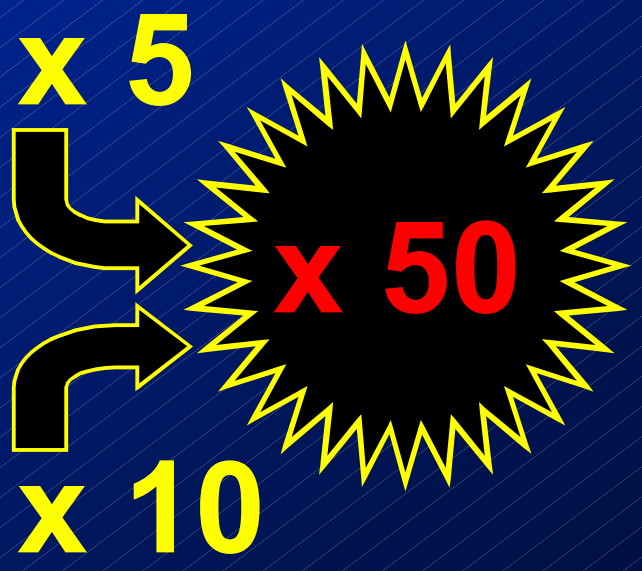
Machine Utilisation



The future

Plans for the next 5 years

- **Improvements to Science**
  - New dynamics
  - 4D VAR data assimilation
  - Directly model effects of climate change (eg. hydrology, crops)
  - Atmospheric chemistry models
  - Utilise new satellite data
- **Brute force**
  - Increase resolution (horizontal and vertical)
  - Ensembles



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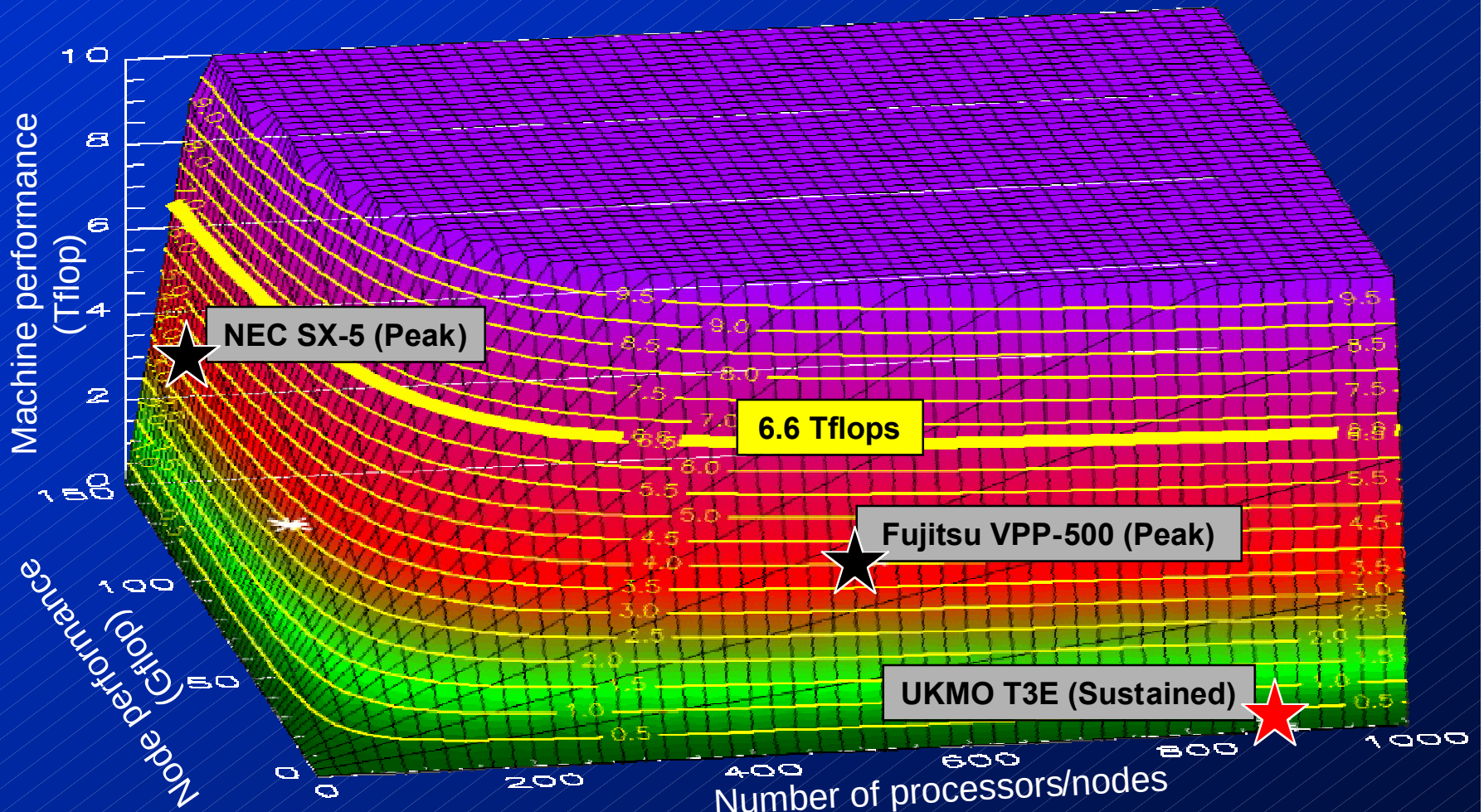
The future...

Teraflop Mountain



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