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School of Engineering Sciences

Environmental Simulations on the NGS

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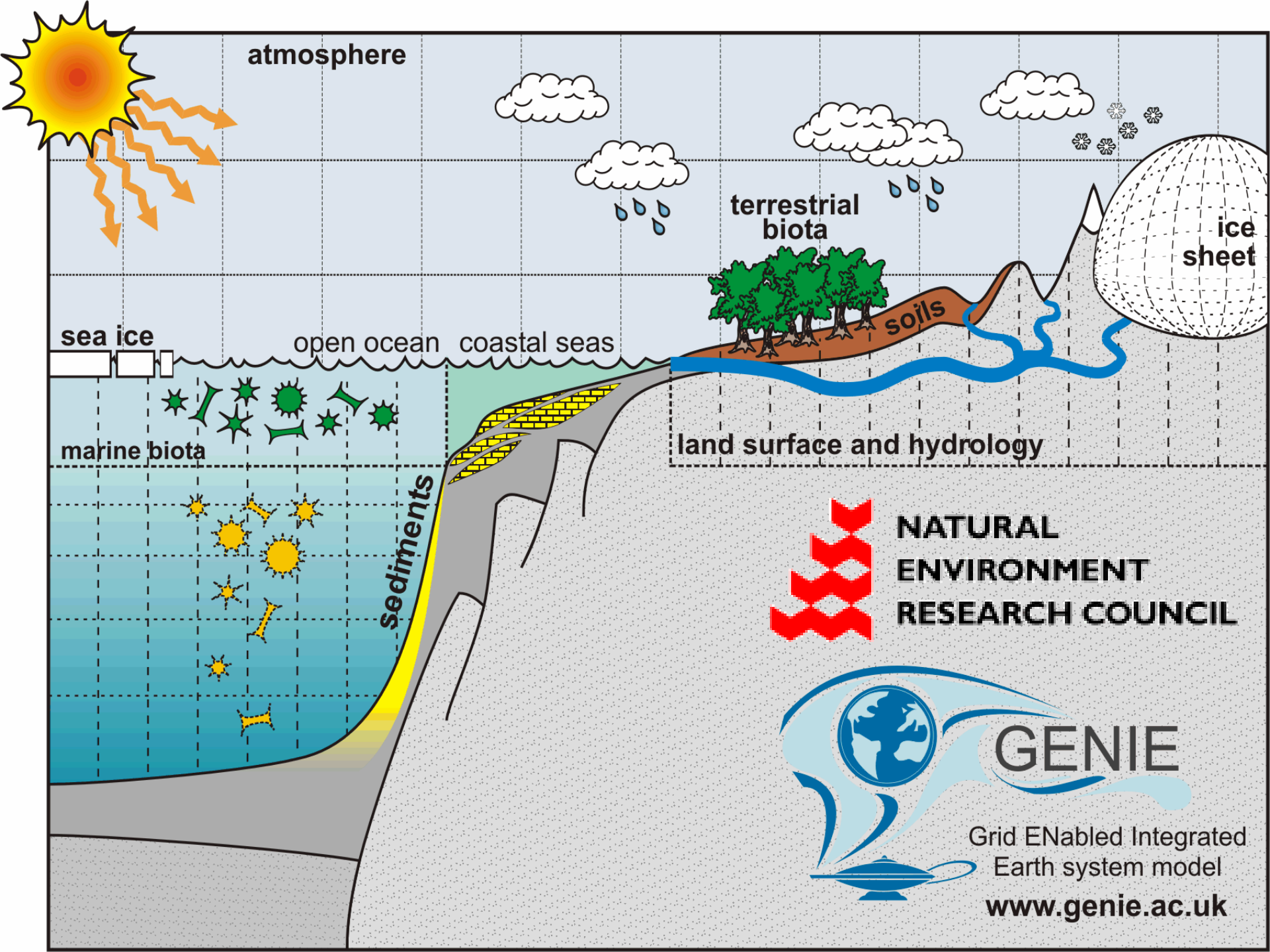
10 April 2008

Overview

- GENIE Project
- Grid computing infrastructure
  - Compute
  - Data
  - Workflow
  - Collaborative Study
- GENIE model studies on the National Grid Service


atmosphere
terrestrial biota
ice sheet
soils
sea ice
open ocean
coastal seas
marine biota
sediments
land surface and hydrology
NATURAL ENVIRONMENT RESEARCH COUNCIL
GENIE
Grid ENabled Integrated Earth system model
www.genie.ac.uk

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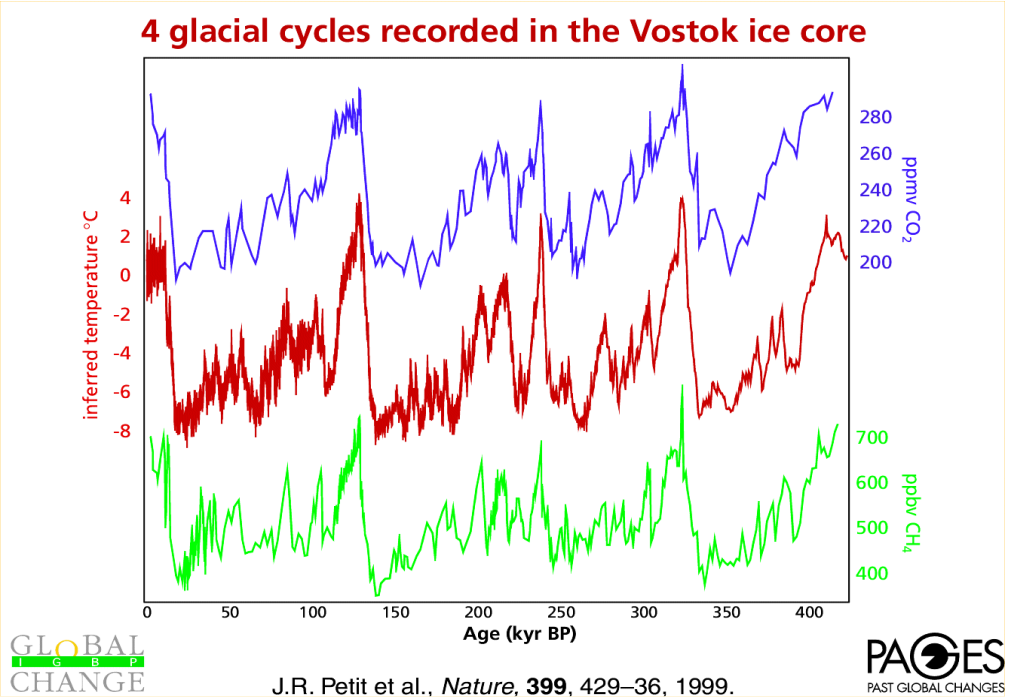
Scientific Aims

- Orbital parameters affect incident radiation and climate
- Biological and geological processes interact with, and feedback upon, the climate (via, for instance, CO_2)

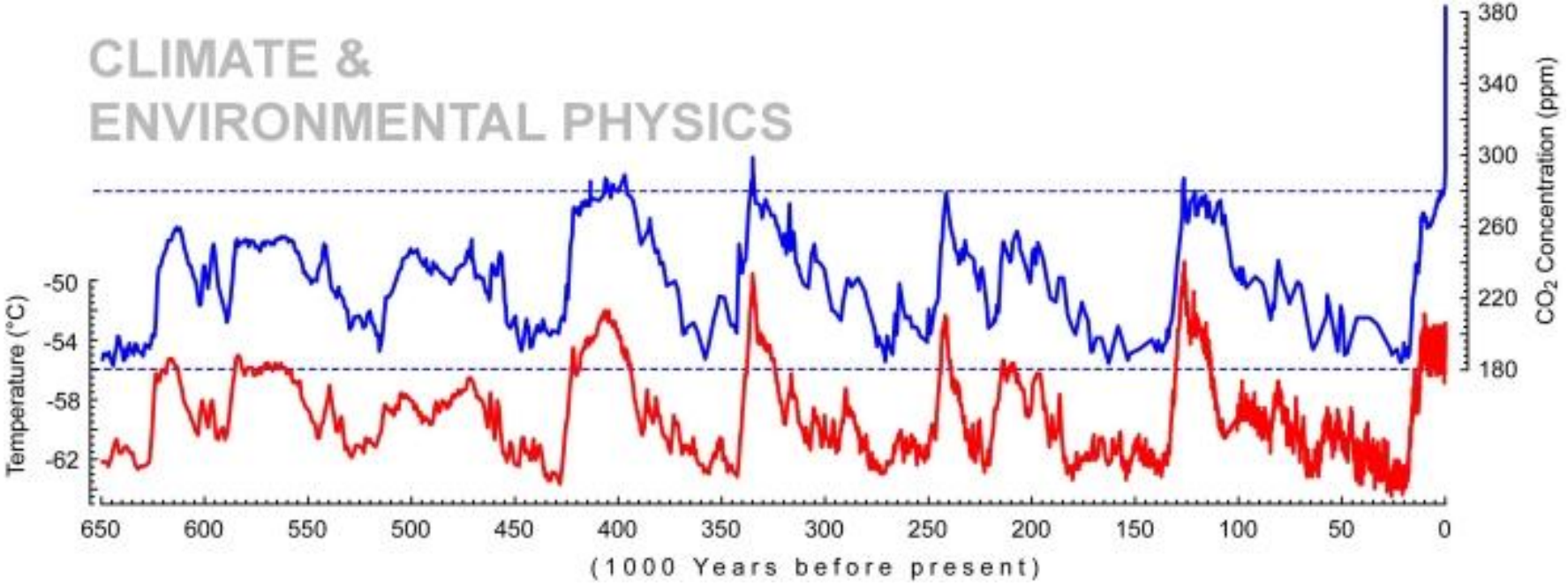


J.R. Petit et al., *Nature*, **399**, 429–36, 1999.

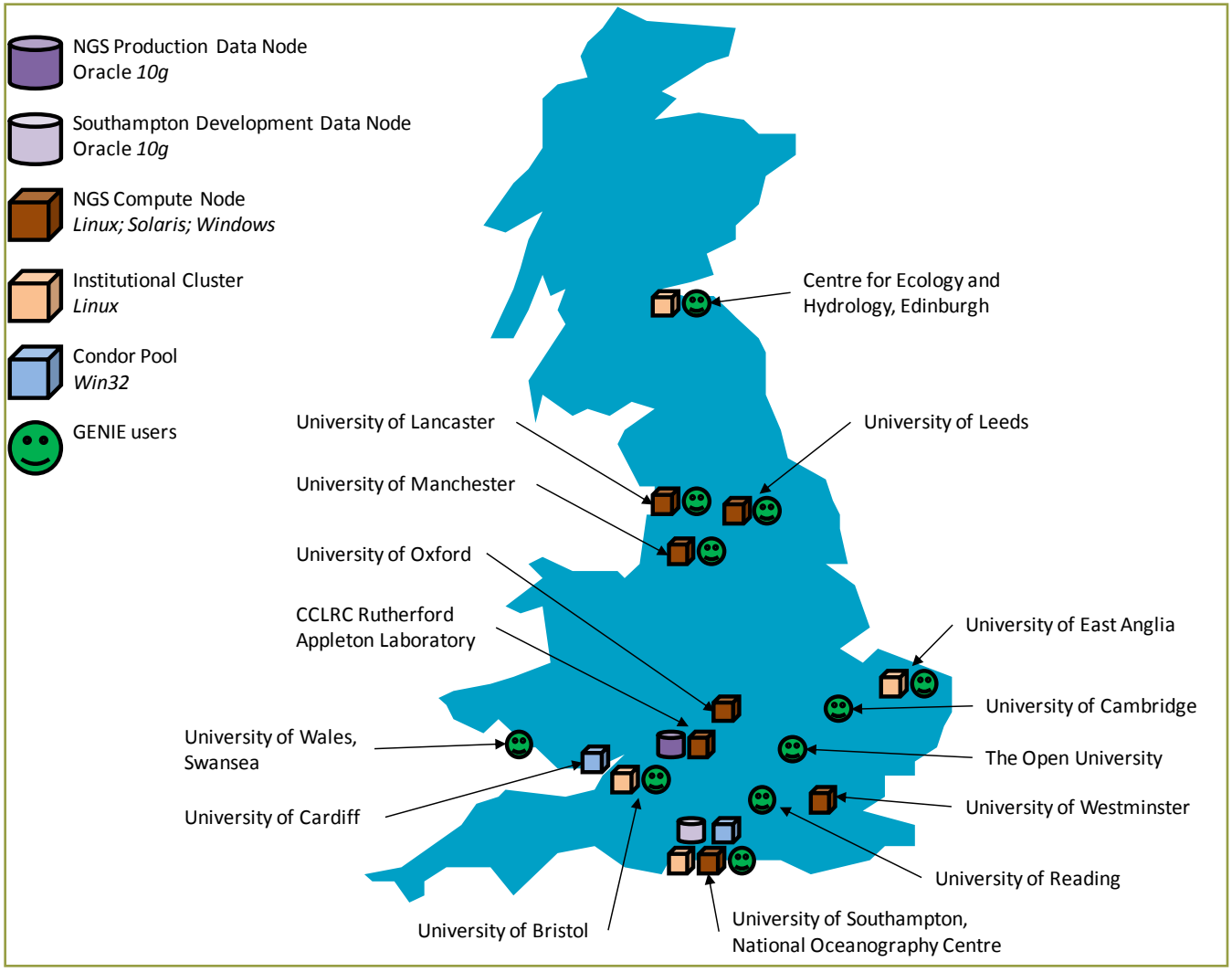
The mechanisms that have driven the most fundamental changes of planet Earth are not yet fully understood.

Climate Change

- Source: http://www.climate.unibe.ch/



GENIE UK Community



The GENIE user base is primarily UK based with a growing number of international collaborators and users. The Grid computing software is used to exploit compute and data resources on the UK National Grid Service and institutional clusters and Condor pools.

GENIE Project Aims

- Develop a Grid-based computing framework
  - to flexibly couple together state-of-the-art components to form a unified Earth System Model (ESM)
  - to execute the resulting ESM across a computational Grid
  - to share the distributed data produced by simulation runs
  - to provide high-level open access to the system, creating and supporting virtual organisations of Earth System modellers

Geodise Toolboxes

Geodise Compute Toolbox

- Grid access from the Desktop
- Matlab and Jython interfaces
- Globus and Condor support

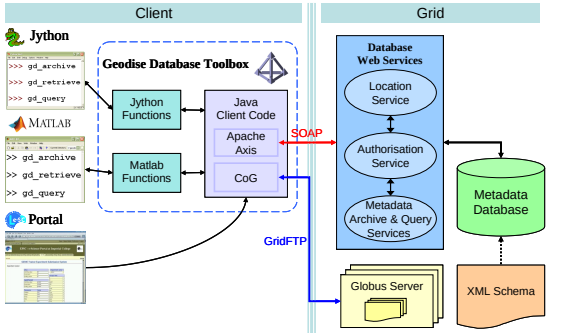
Geodise Database Toolbox

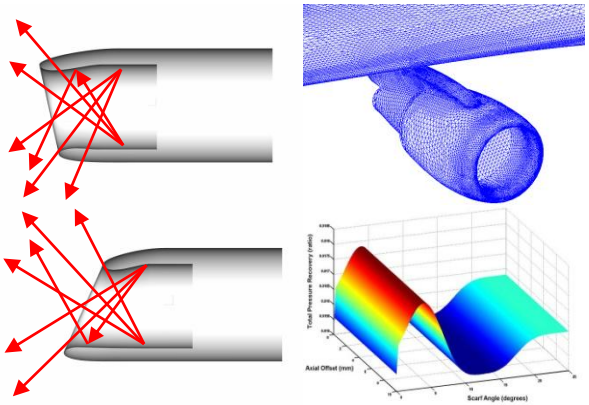
- Associate metadata with data
- Programmatic and GUI access

OptionsMatlab

- Engineering Design Optimisation
- Suite of multi-dimensional optimisation algorithms

Geodise Compute Toolbox	gd_createproxy.m	Creates a Globus proxy certificate for the user's credentials
	gd_destroyproxy.m	Destroys the local copy of the user's Globus proxy certificate
	gd_jobsubmit.m	Submits a compute job to a Globus GRAM job manager
	gd_jobstatus.m	Gets the status of a Globus GRAM job
	gd_putfile.m	Puts a remote file using GridFTP
	gd_getfile.m	Retrieves a remote file using GridFTP
	gd_rmfile.m	Deletes a remote file using GridFTP
	gd_makedir.m	Creates a remote directory using GridFTP
	gd_rmdir.m	Deletes a remote directory using GridFTP
Geodise Database Toolbox	gd_archive.m	Archives a file or data structure to the database
	gd_query.m	Query the database for data matching specified criteria.
	gd_retrieve.m	Retrieves a file or data structure from the database





Grid Computation

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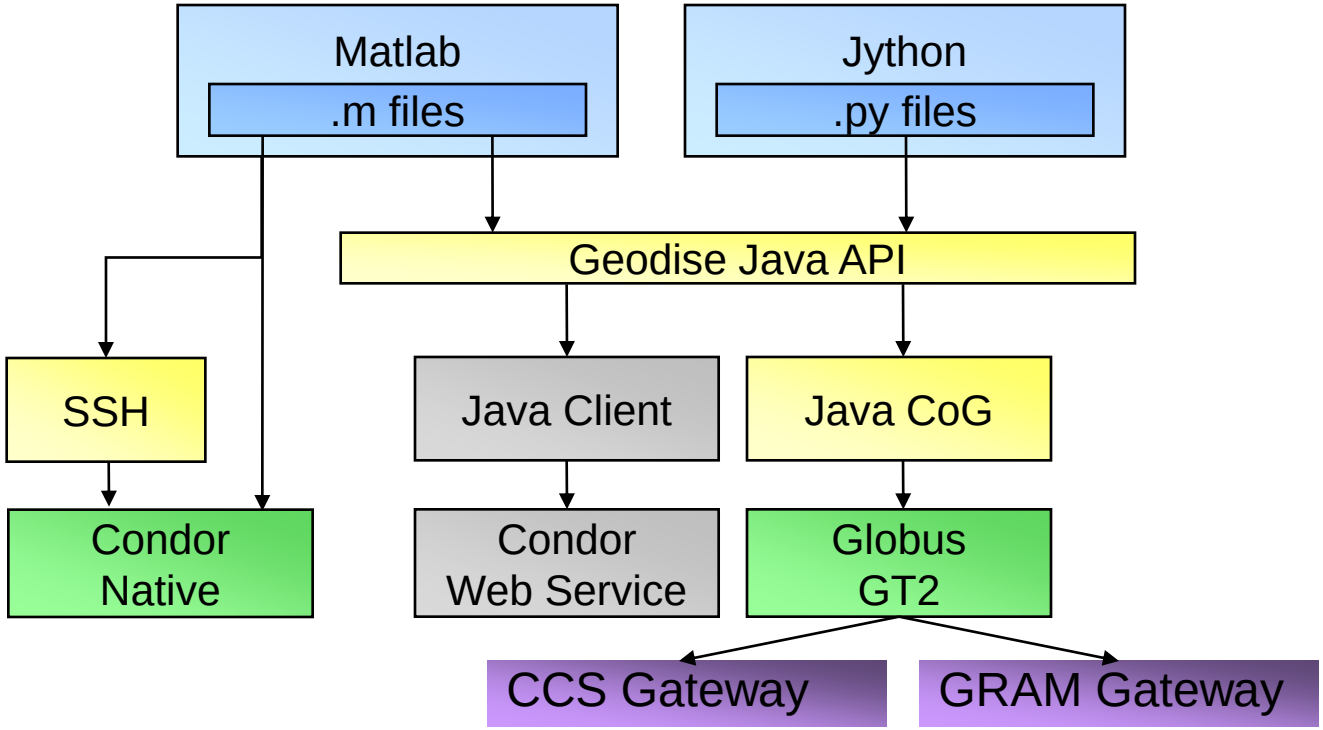
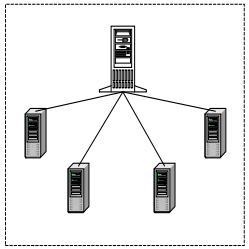


Condor Pool

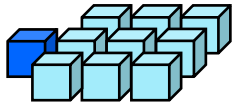


Microsoft Compute Cluster Server

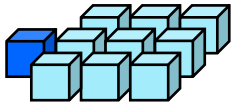
Institutional Resources (GT2)

UK National Grid Service (GT2)

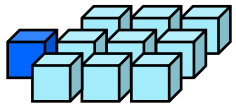
Oxford



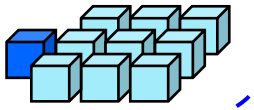
Leeds



RAL



Manchester



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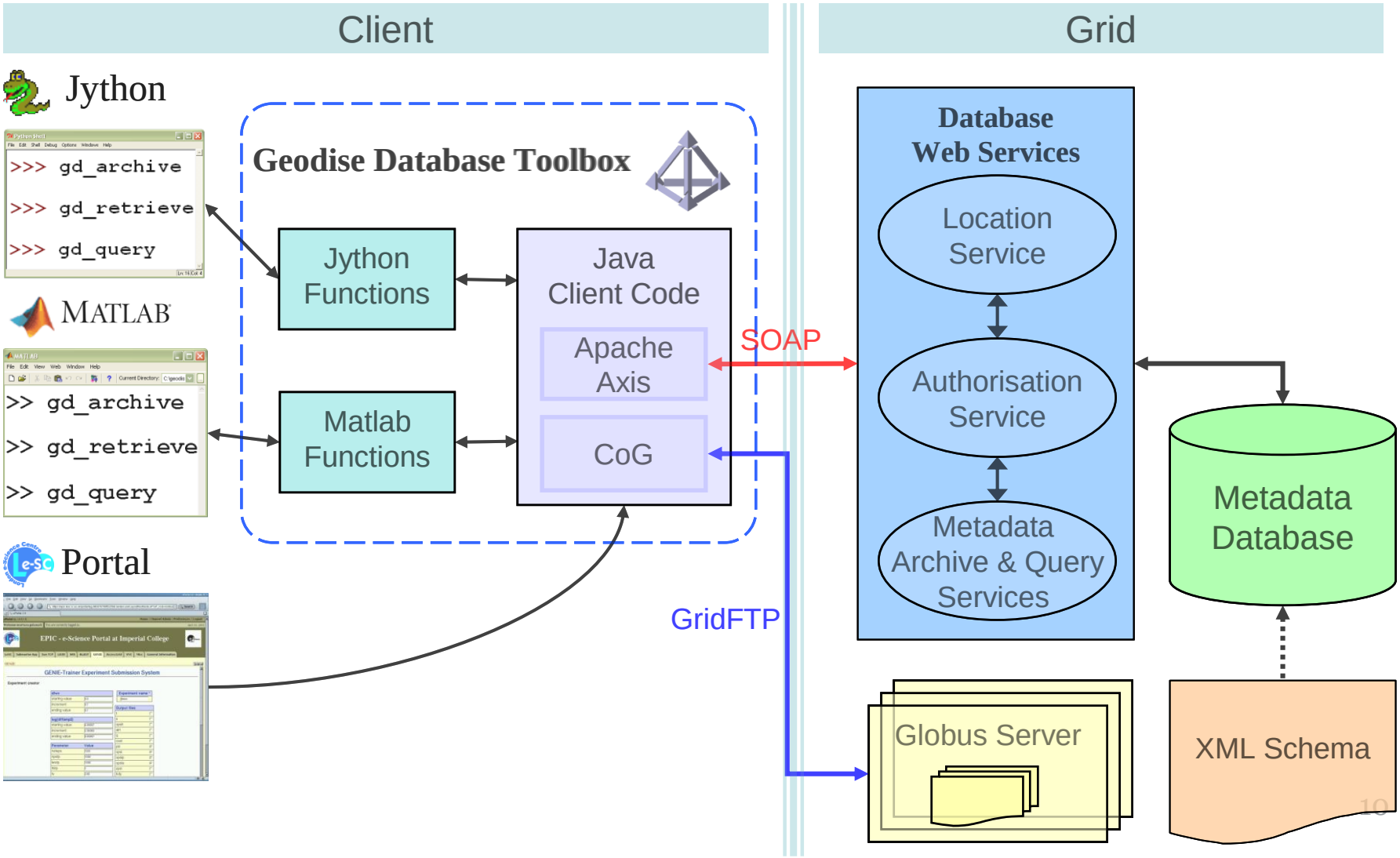
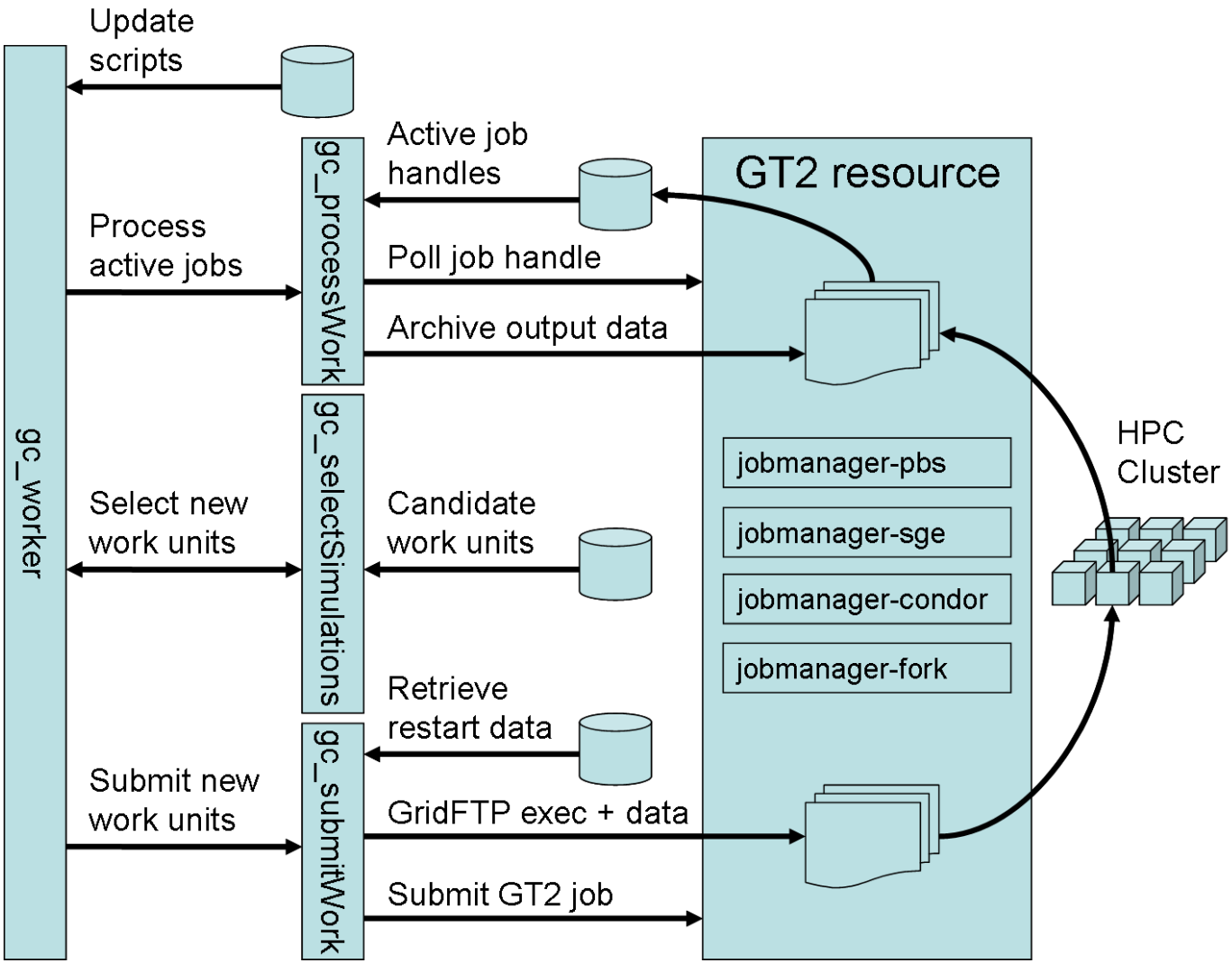
Data Management System

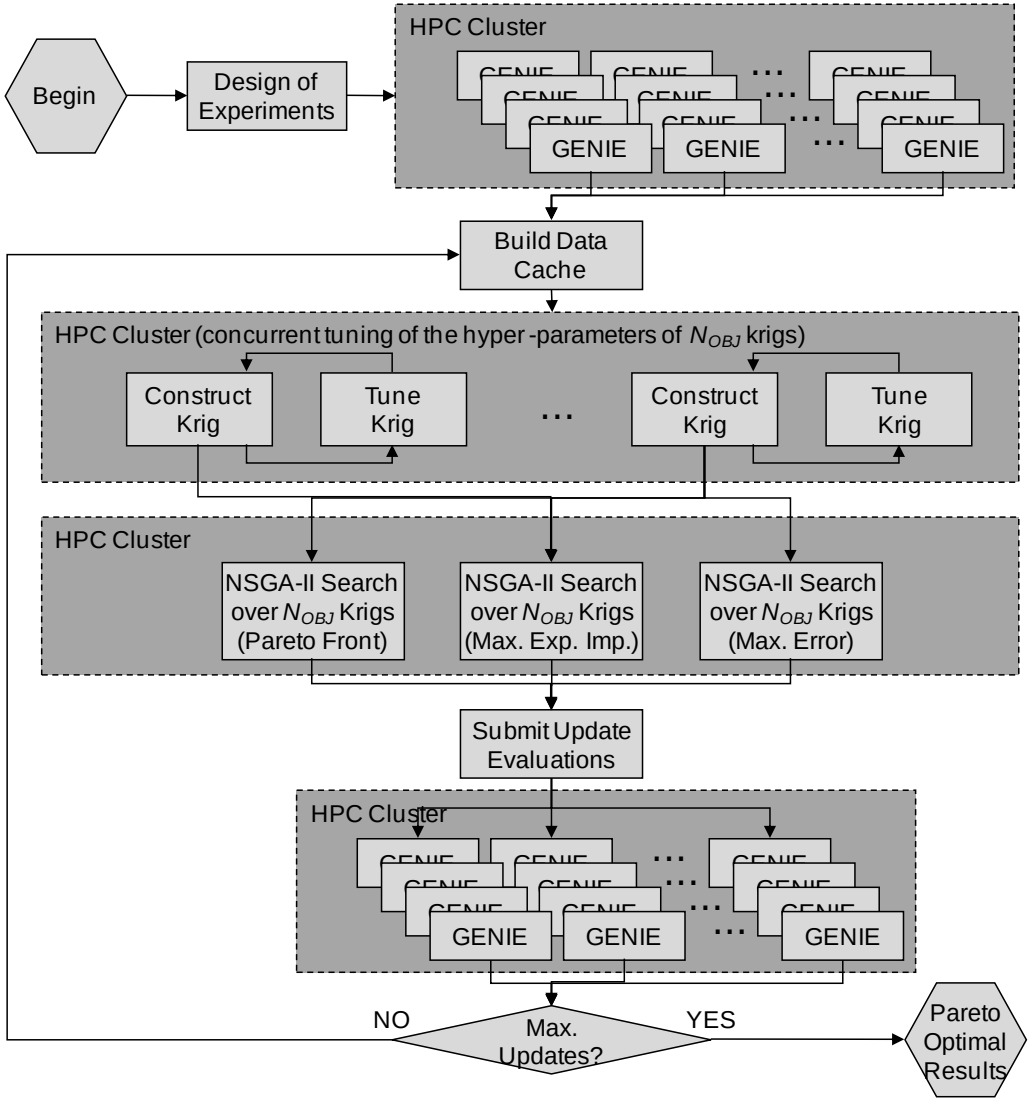


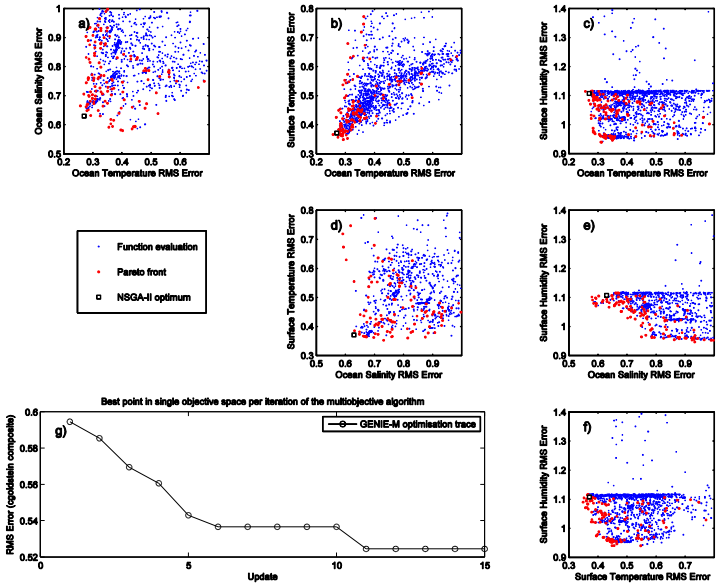
Workflow



Workflow schematic for the activities of the gc_worker script. Simulations are advanced through to completion be the automated submission of compute jobs

Optimisation Workflow





Pareto optimal results indicated in red

Parameter estimation workflow using the NSGA-II method with surrogate modelling

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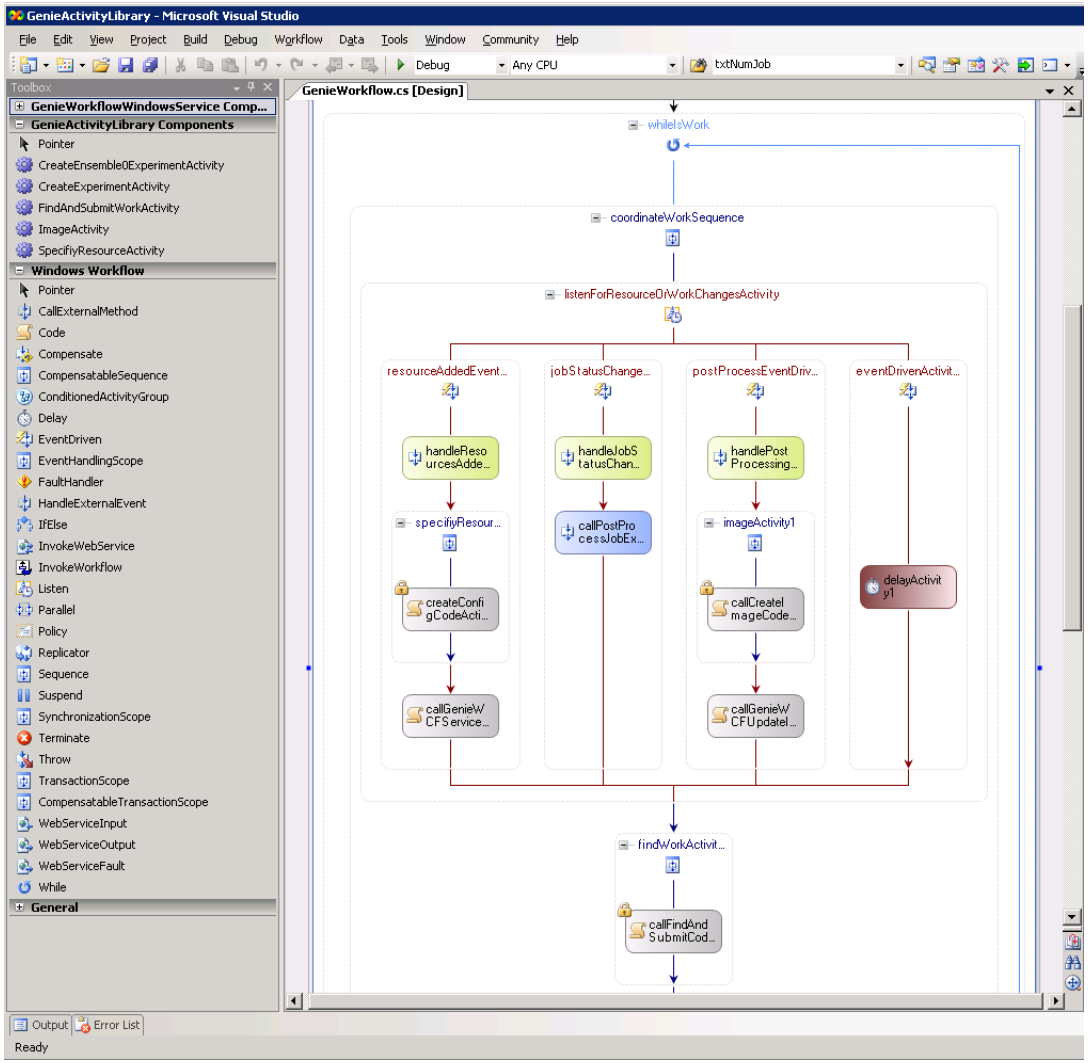
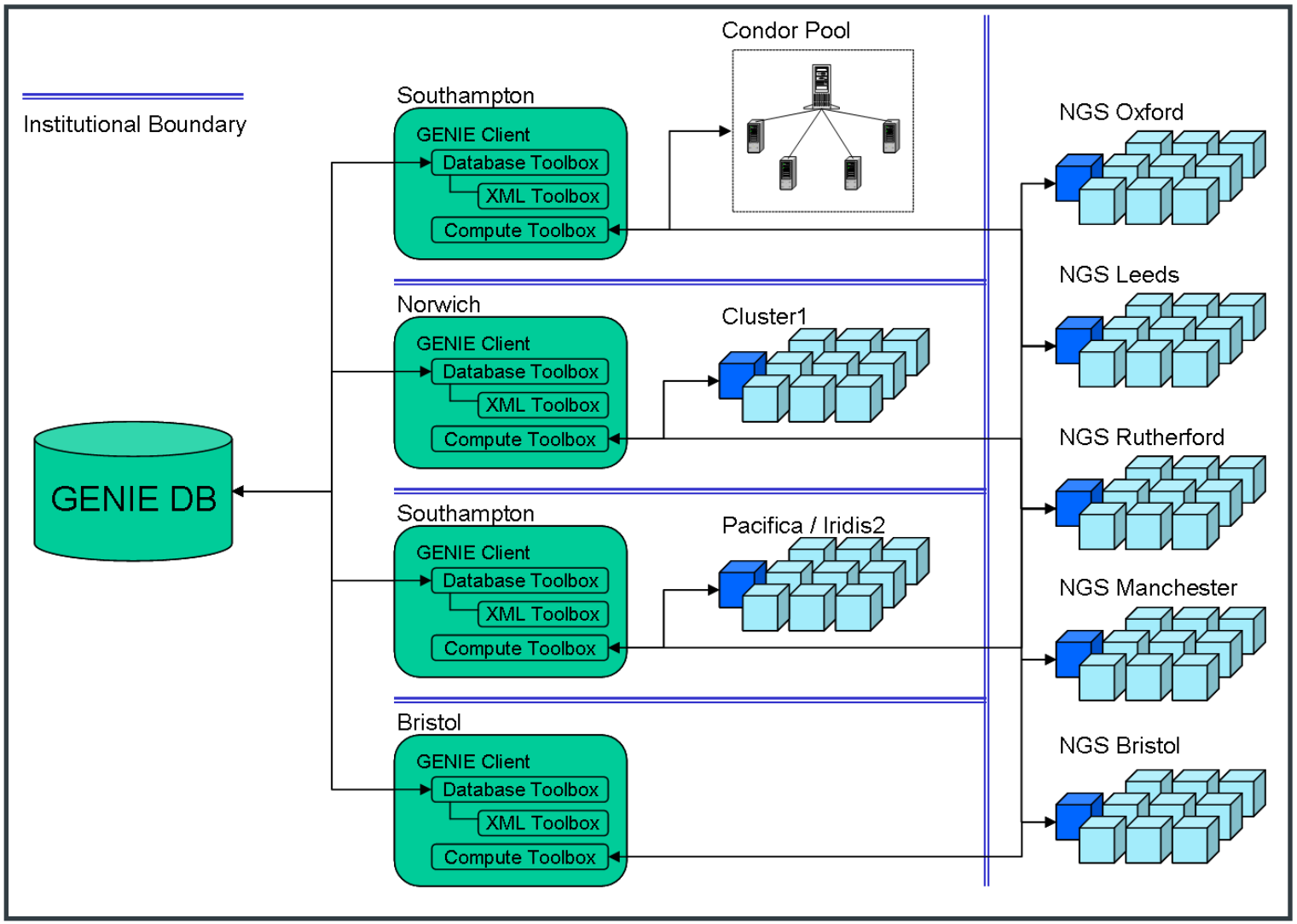
Windows Workflow Foundation



Re-usable components are composed to form the desired workflow in Visual Studio.

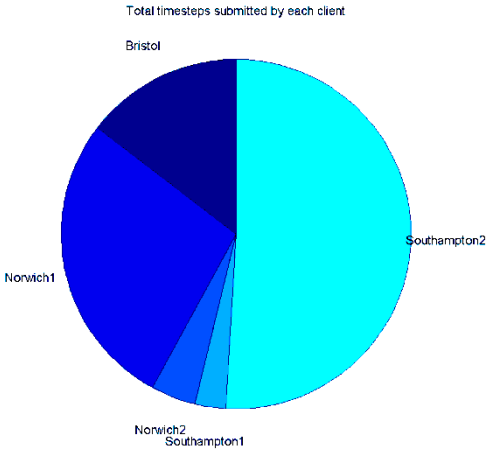
Collaborative Study

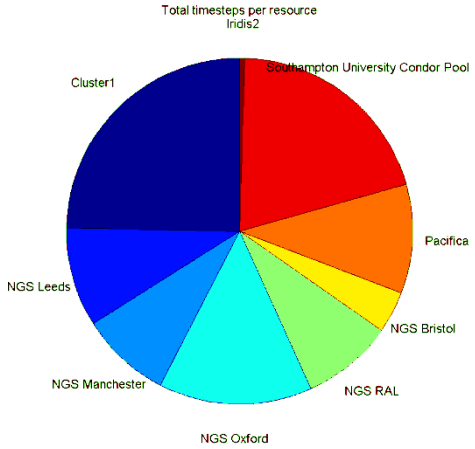


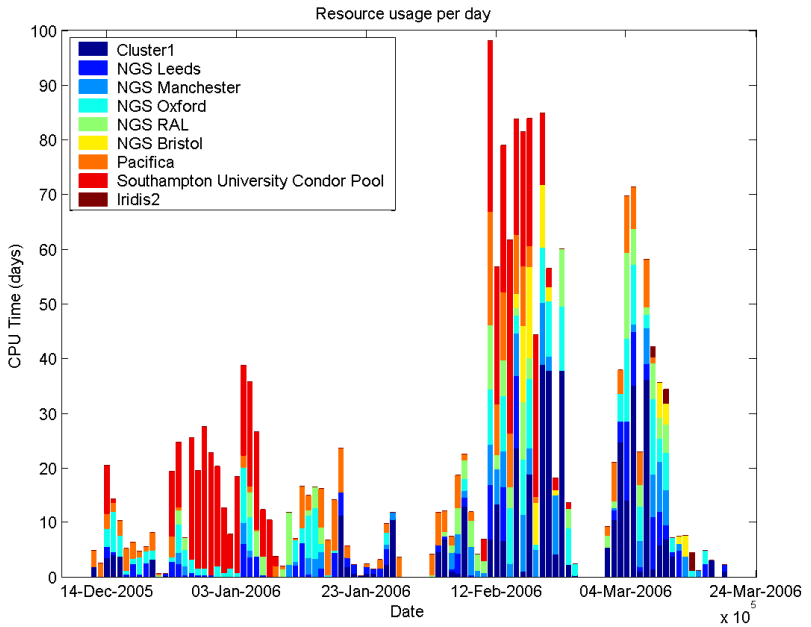
Schematic of GENIE client deployments at member institutes and the resources exploited to perform large ensemble calculations mediated by the GENIE database.

Use of Grid Computing

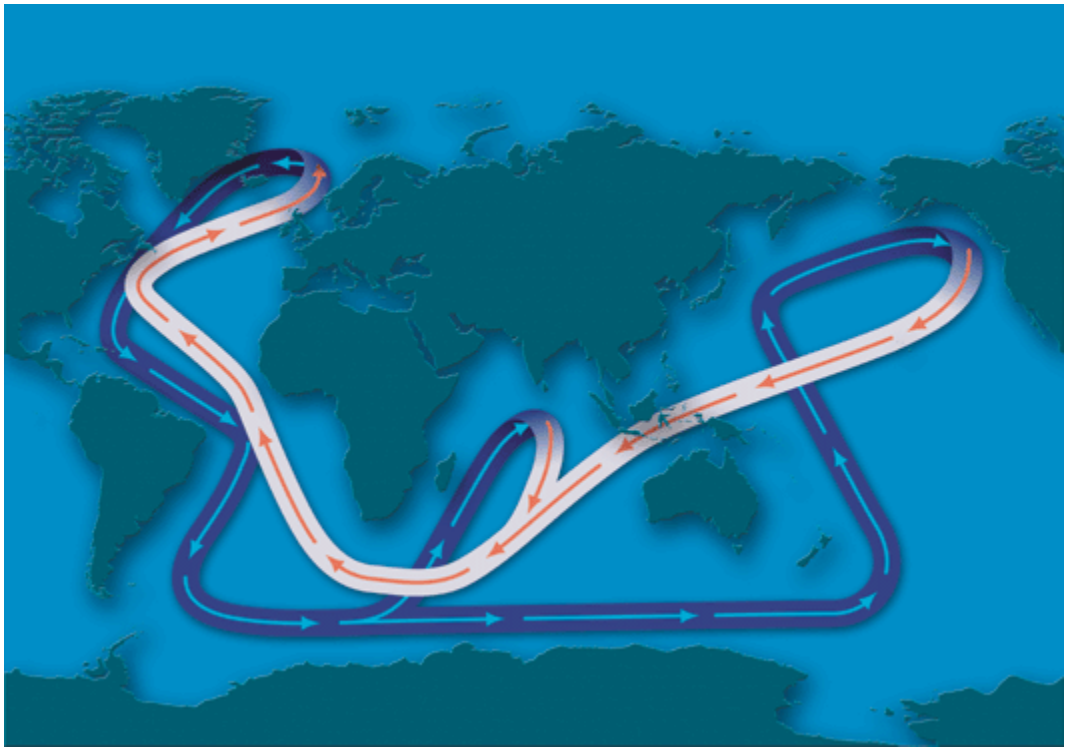
- No single institute had sufficient computing resource
- 12 ensemble studies
  - 362 simulations
  - 428,000 model years
  - 3,736 compute tasks
- 46,992 CPU hours
  - 1958 days = 5.36 years
- 9 compute resources
  - 5 nodes of UK National Grid Service
  - 3 Institutional HPC Clusters
  - Southampton University Condor pool





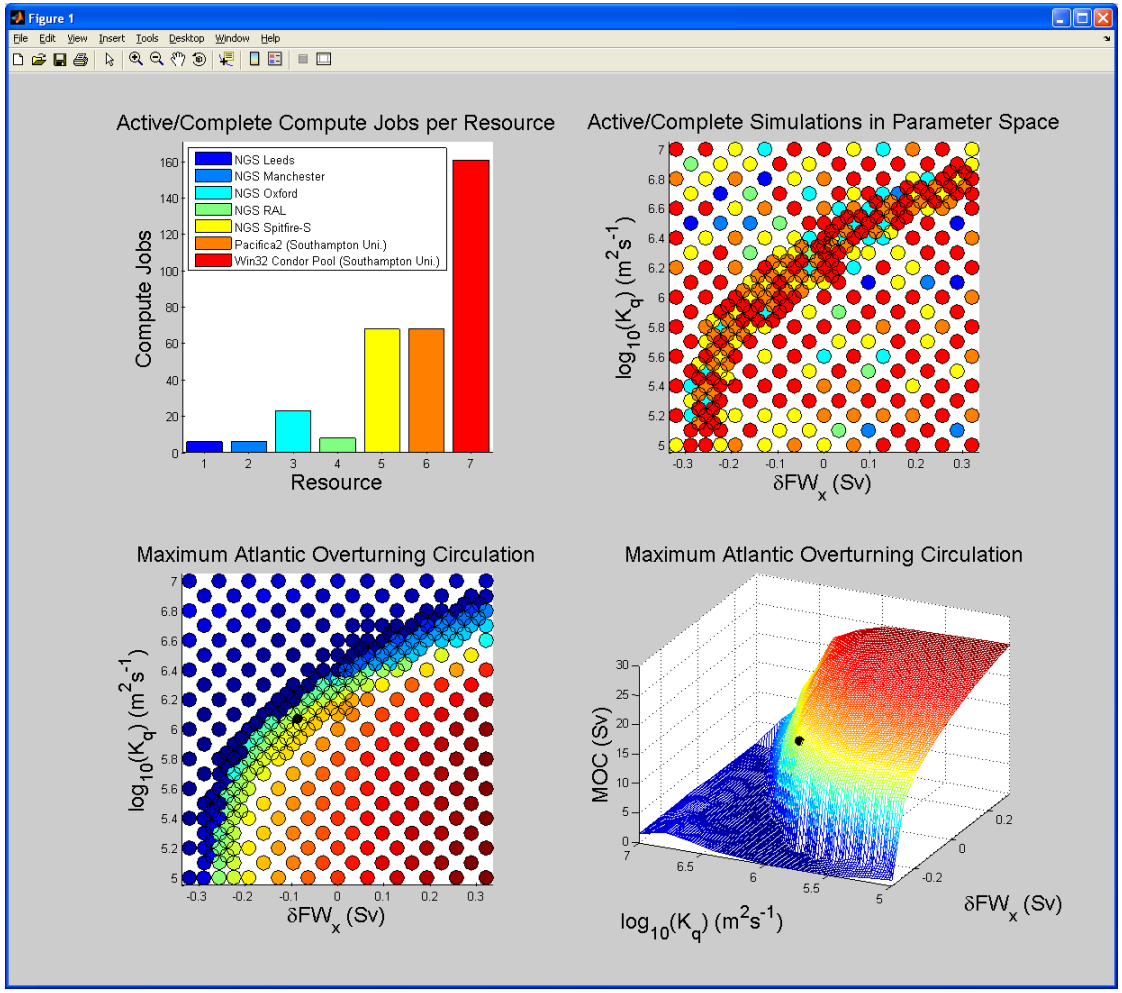


Thermohaline Circulation



The Earth's oceans are linked by a system of currents, driven by temperature and salinity, collectively known as the Global Conveyor Belt.

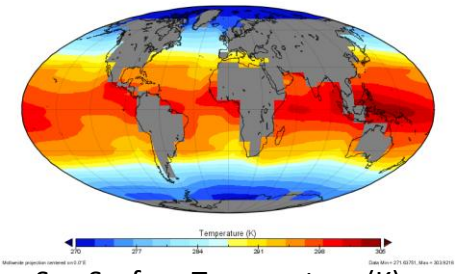
Interactive Monitoring GUI



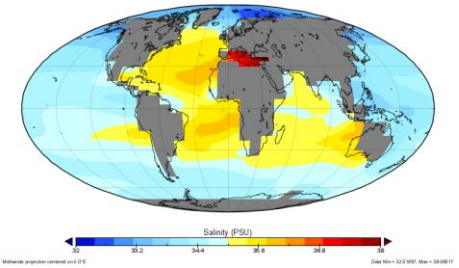
The existing Matlab GUI is also used for interactive analysis ansd post-processing of the experiment data sets.

Atlantic Overturning Circulation "ON"

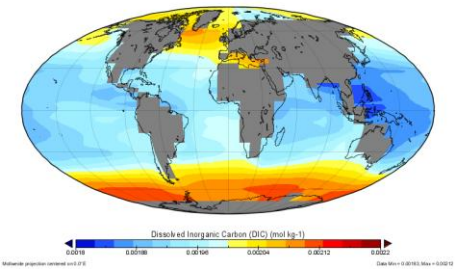
Difference: "ON" - "OFF"



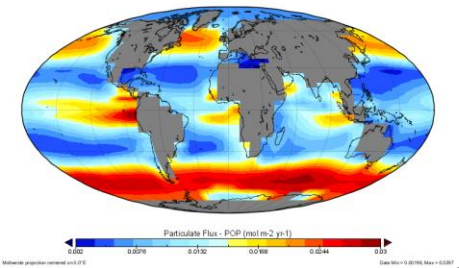
Sea Surface Temperature (K)



Sea Surface Salinity (PSU)



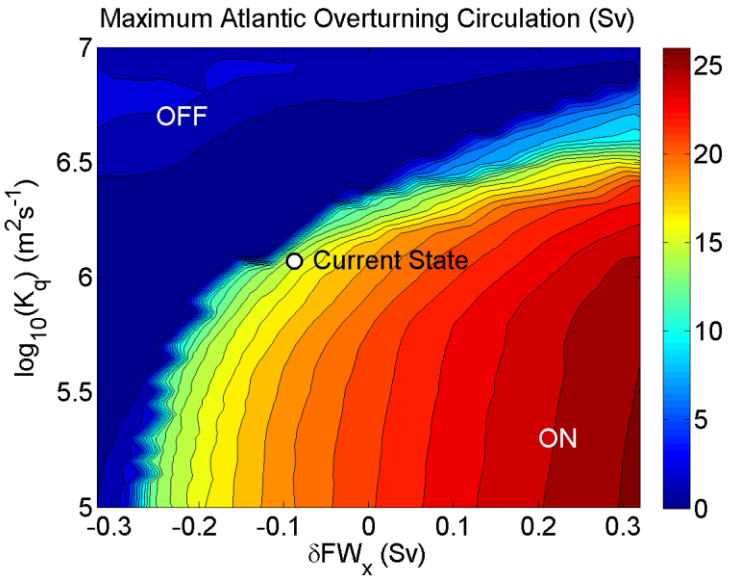
Dissolved Inorganic Carbon (mol kg^{-1})

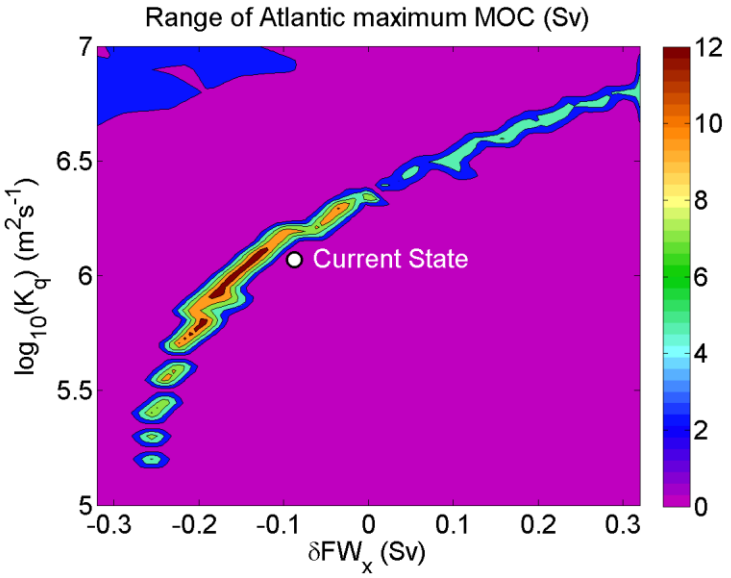


Biological Export Flux (mol m^{-2} yr^{-1})

Atmosphere **more** diffusive

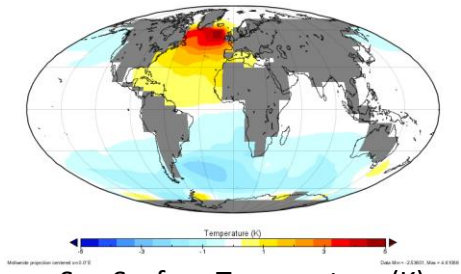
Atmosphere **less** diffusive



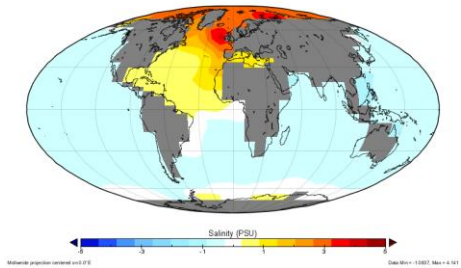


Atlantic **wetter**

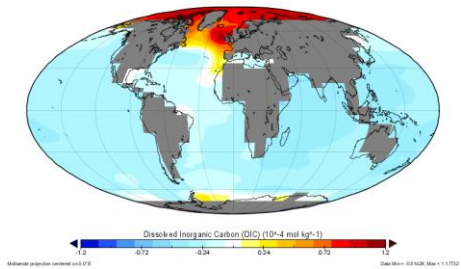
Atlantic **drier**



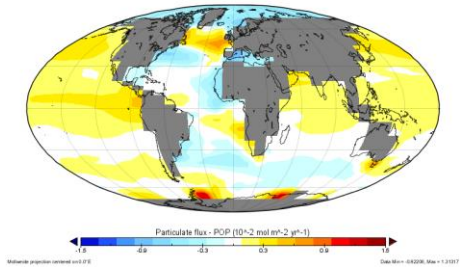
Sea Surface Temperature (K)



Sea Surface Salinity (PSU)



Dissolved Inorganic Carbon (mol kg^{-1})



Biological Export Flux (mol m^{-2} yr^{-1})

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The GENIE Team

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Graham Riley – *Manchester*
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Rachel Warren – *UEA Norwich*
Andrew Watson – *UEA Norwich*

The Open University