

JASMIN and CEMS: An Overview

Petascale storage and cloud computing for big data challenges in environmental science

[Learn more »](#)



Alison Pamment

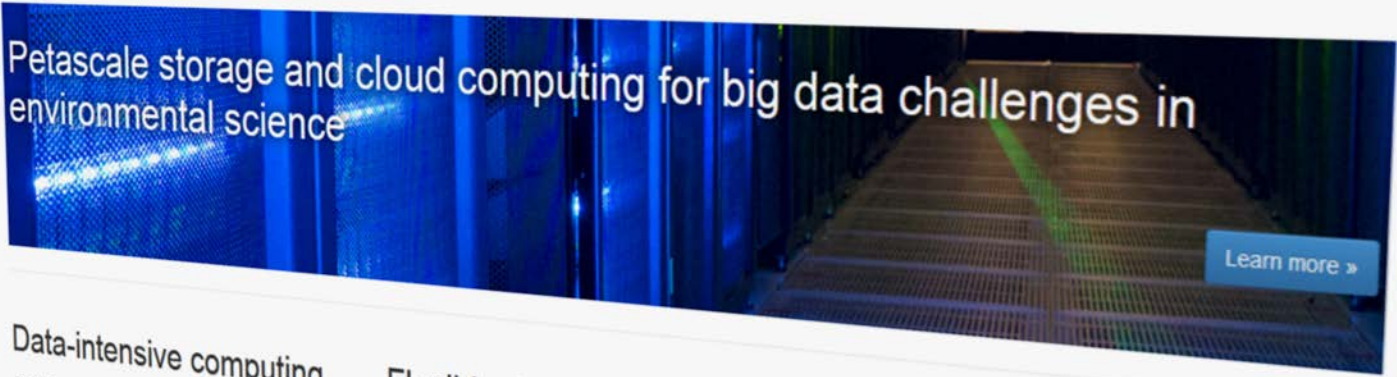
On behalf of the JASMIN team

(STFC:SCD, STFC/NERC:CEDA, NERC:NCAS, NERC:NCEO)

Setting the scene

- Overview of JASMIN/CEMS
 - Funding
 - Who runs it
 - Purpose and usage
 - Recent expansion

[JASMIN](#) [What is JASMIN?](#) [Services](#) [Users](#) [Get Access](#) [How to Use](#) [Help](#) [FAQ](#)



Petascache storage and cloud computing for big data challenges in environmental science

[Learn more »](#)

Data-intensive computing



JASMIN provides the UK and European climate and earth-system science communities with an efficient data analysis environment. Many datasets, particularly model data, are too big to be easily shipped around: JASMIN enables scientists to bring their processing to the data.

Flexible data access

JASMIN provides new ways for scientists to collaborate in self-managing group workspaces, enabling models and algorithms to be evaluated alongside curated archive data, and for data to be shared and evaluated before being deposited in the permanent archive.

Scalable future

JASMIN enables [CEDA](#) to carry out its mission of data curation and facilitation more efficiently. Fast, parallel, scalable storage provides a home for in-demand archive data, while a virtualised server infrastructure provides a more capable base for delivery of CEDA's data centre services to the science community.



JASMIN: Joint Analysis System

J is for Joint

Jointly *delivered* by STFC:

CEDA (RAL Space) and SCD.

Joint *users* (initially):

Entire NERC community & Met Office

Joint *users* (target):

Industry (data users & service providers)

Europe (wider environ. academia)

A is for Analysis

Private (Data) Cloud

Compute Service

Web Service Provision

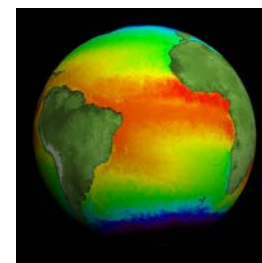
For

Atmospheric Science

Earth Observation

Environmental Genomics

... and more.



S is for System

£10m investment
at RAL

#1 in the world
for big data
analysis
capability?

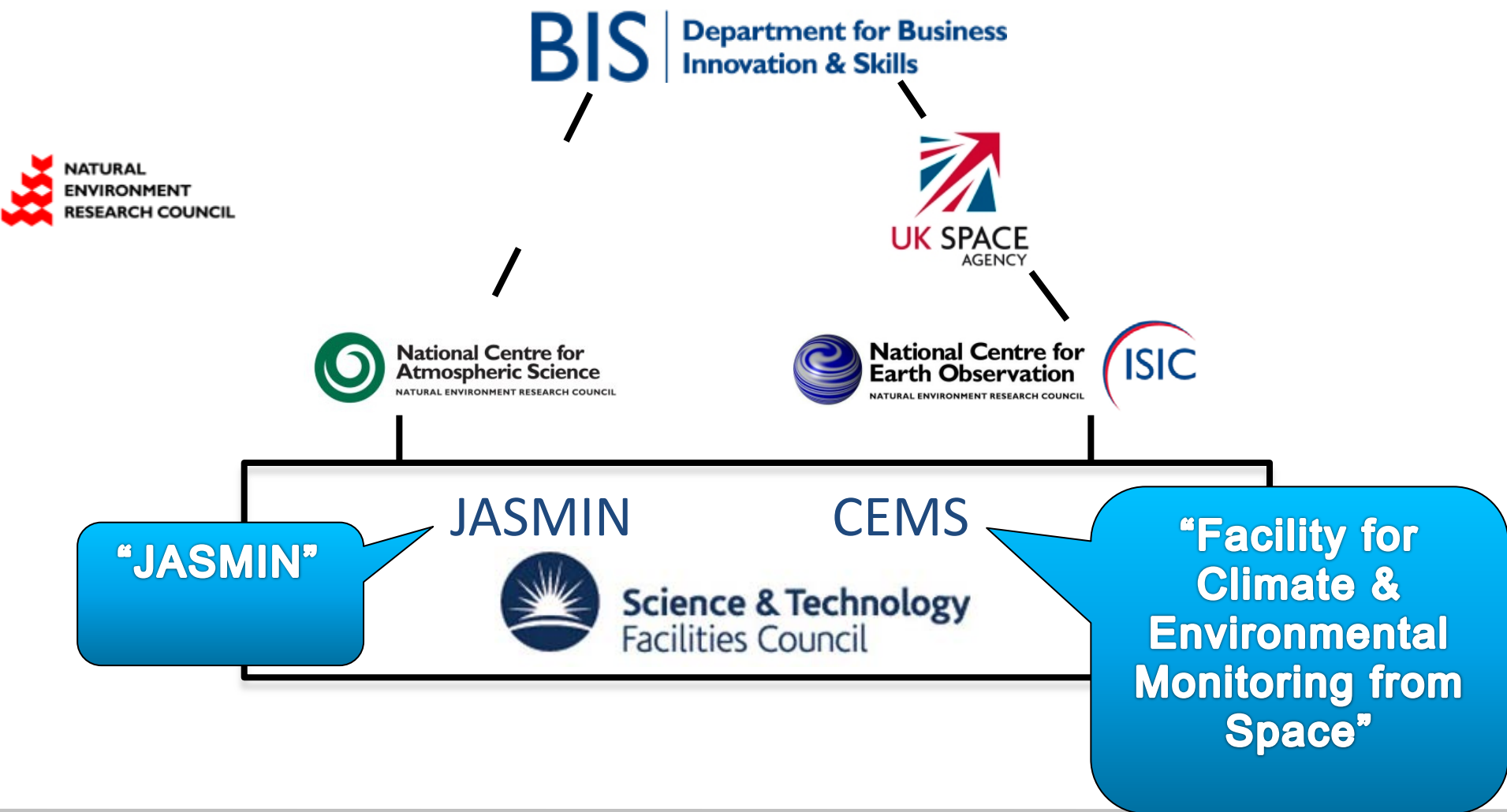


Opportunities

JASMIN is a collaboration platform!
***within* NERC** (who are the main investor)
***with* UKSA** (& the S.A. Catapult via CEMS*)
***with* EPSRC** (joined up national e-
infrastructure)
***with* industry** (as users, cloud providers,
SMEs)

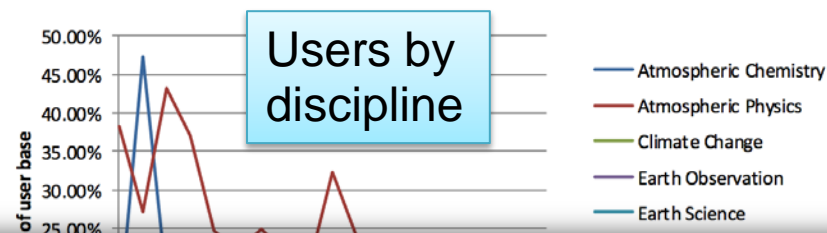
(*CEMS - :the facility for Climate and Environmental Monitoring from Space)

Funded through



STFC Centre for Environmental Data Archival

Exist: *“to support environmental science, further environmental data archival practices, and*



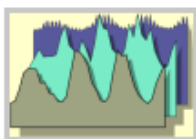
The British Atmospheric Data Centre

The British Atmospheric Data Centre (BADC), NERC's designated data centre for the UK atmospheric science community, covering climate, composition, observations and NWP data.



NERC Earth Observation Data Centre

The NEODC is NERC's designated data centre for Earth Observation data and is part of NERC's National Centre for Earth Observation.



The UK Solar System Data Centre

The UK Solar System Data Centre, co-funded by STFC and NERC, curates and provides access to archives of data from the upper atmosphere, ionosphere and Earth's solar environment.



IPCC Data Distribution Centre

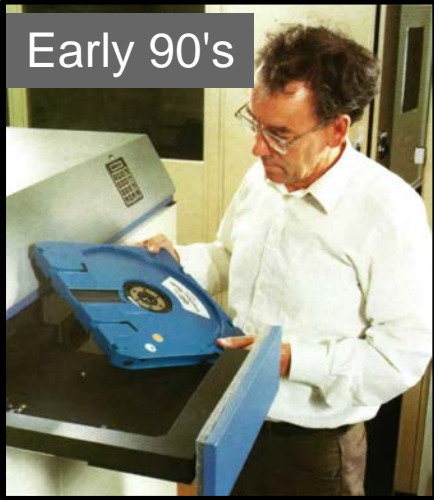
The Intergovernmental Panel on Climate Change (IPCC) DDC provides climate, socio-economic and environmental data, both from the past and also in scenarios projected into the future. Technical guidelines on the selection and use of different types of data and scenarios in research and assessment are also provided. UK Climate Projections.

+ active research in curation practices!

Cloud Services, Parallelisation)

CEDA Evolution

Early 90's



2008



2014

Hosted by STFC Scientific Computing Department

“Computing Expertise across length scales from processes within atoms to environmental modelling”

- Applications development and support,
- Compute and data facilities and services
- Research and Training
- Numerical Analysis

Data Services

- STFC: Facility Archives (ISIS, Diamond)
- LHC: UK Hub (Tier 1 archive)
- BBSRC: Institutes data archive
- MRC: Data Support Service
- NERC: CEDA backup and JASMIN elastic tape



High Performance Computing

- Emerald GPU cluster for Oxford, UCL, Southampton, Bristol.
- SCARF HPC for RAL
- Hartree: Blue Joule bluegene HPC
- Hartree: Blue Wonder idataplex HPC
- JASMIN: NERC super data cluster

Close working partnership with industry



Who is allowed access?

Primary communities...



**JASMIN Industrial
Research Partner**

...and **special cases** addressing environmental challenges,
delivering new science, driving UK innovation, economic growth
and societal wellbeing

<http://www.jasmin.ac.uk/jasmin-users/who-can-use-jasmin/>

Allocation of resources – Application and decision-making

- Any project/group can apply to have a:
 - Group Workspace(s)
 - Dedicated VM(s)
 - Virtual Organisation
- Access is decided based on “research” priorities
- Collaborations involving “*.ac.uk” are given higher priority
- Scale is also important – small projects can be more diverse if using little resource
- Moving to a “**consortium**” model for each domain: Atmos Sci, Hydrology, BioInformatics, etc.

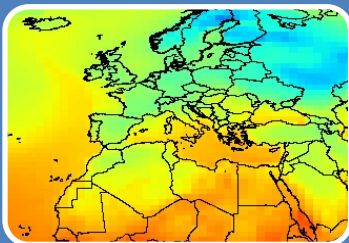


JASMIN functions



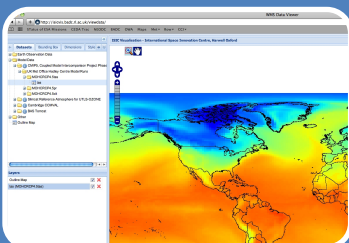
CEDA data storage & services

- Curated data archive
- Archive management services
- Archive access services (HTTP, FTP, Helpdesk, ...)



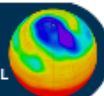
Data intensive scientific computing

- Global / regional datasets & models
- High spatial, temporal resolution
- Private cloud



Flexible access to high-volume & complex data for climate & earth observation communities

- Online workspaces
- Services for sharing & collaboration

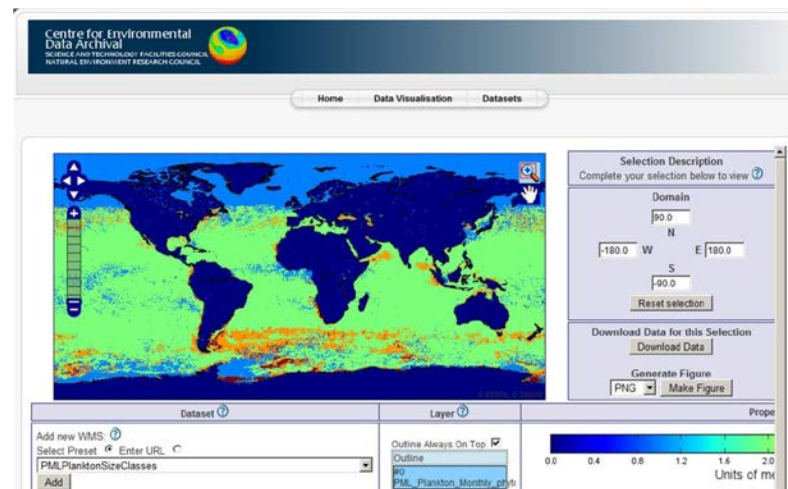
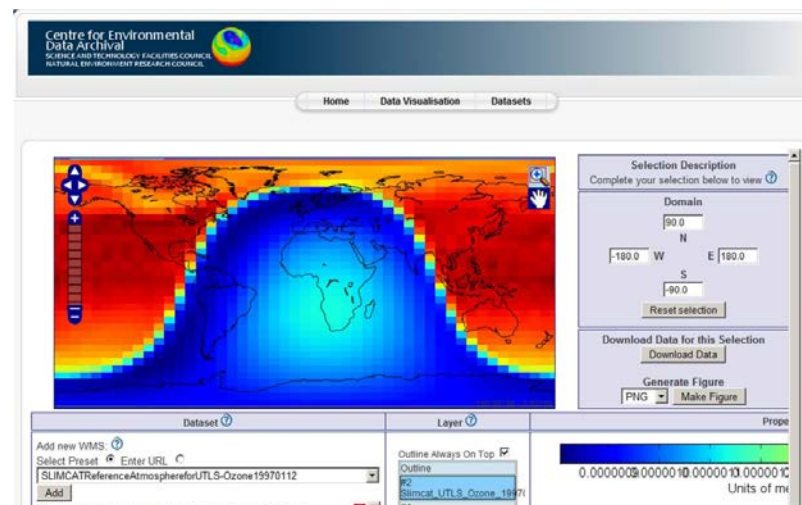


Processing big data: the issues

- Parallel processing in the Environmental Sciences has historically focussed on **highly-parallel models**
- Data analysis was typically run **sequentially** because:
 - It was a smaller problem
 - It didn't have parallel resources available
 - The software/scientists were not equipped to work in parallel
- Now we generate enormous datasets (e.g. UPSCALE - 300 Tb):
 - Processing big data **requires** a parallel approach
 - Platforms, tools, and programmers are becoming better equipped

JASMIN Use cases

- Processing large volume EO datasets to produce:
 - Essential Climate Variables
 - Long term global climate-quality datasets
- Data validation & intercomparisons
 - Evaluation of models relying on the required datasets (EO datasets, in situ and simulations) being in the same place



JASMIN Use cases

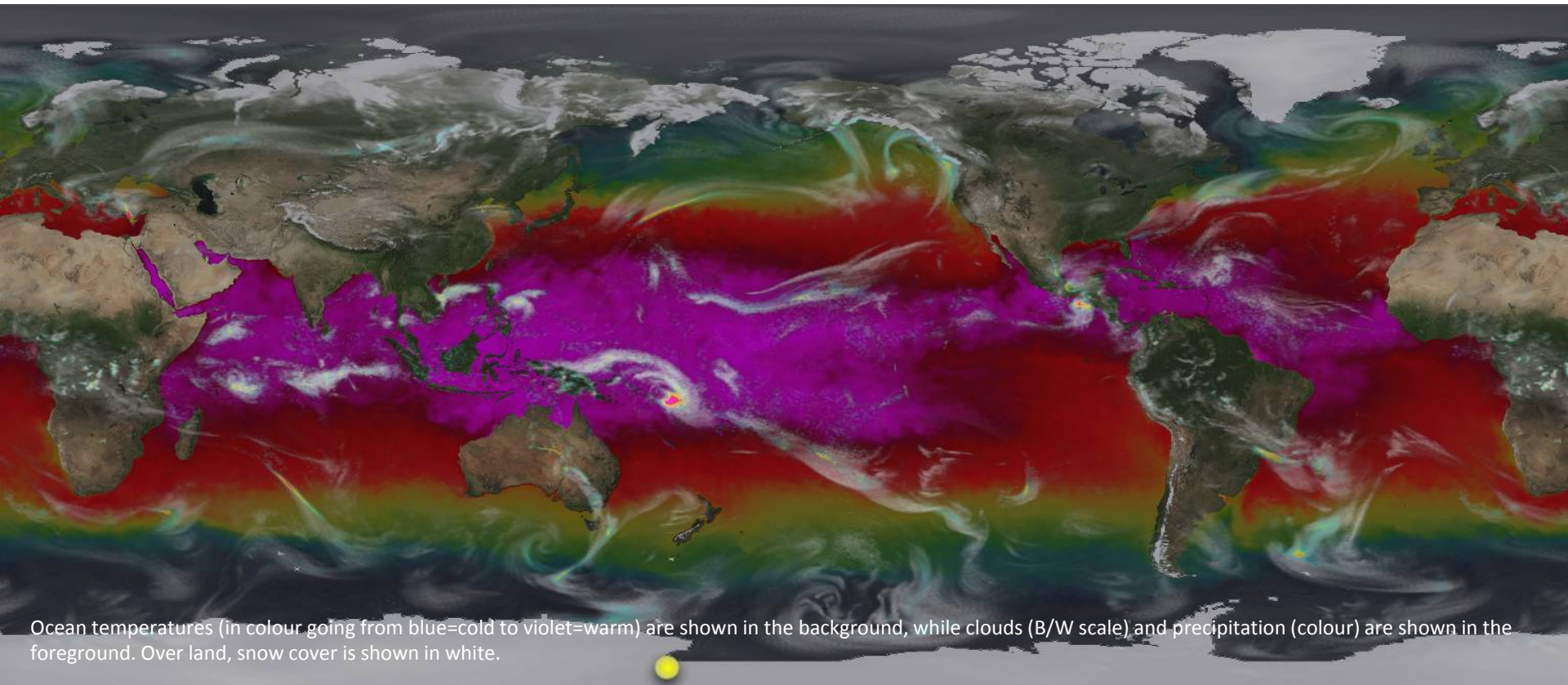
- User access to 5th Coupled Model Intercomparison Project (**CMIP5**)
 - Large volumes of data from best climate models
 - Greater throughput required
- Large model analysis facility
 - Workspaces for scientific users. Climate modellers need 100s of Tb of disk space, with high-speed connectivity
 - **UPSCALE project**

“We would never have been able to store, nor analyse that volume of data, without the existence of the [JASMIN] service...” –
UPSCALE spoke-scientist

- 250 Tb in 1 year
- PRACE supercomputing facility in Germany (HERMIT)
- Being shipped to RAL at present
- To be analysed by Met Office as soon as available
- Deployment of VMs running custom scientific software, co-located with data
- Outputs migrated to long term archive (BADC)

JASMIN Use Case: UPSCALE

Picture courtesy of P-L Vidale & R. Schiemann, NCAS)



Ocean temperatures (in colour going from blue=cold to violet=warm) are shown in the background, while clouds (B/W scale) and precipitation (colour) are shown in the foreground. Over land, snow cover is shown in white.

HadGEM3-A (N512, GA3.0)

01 NOV 1986 01h UTC

25 km resolution model run

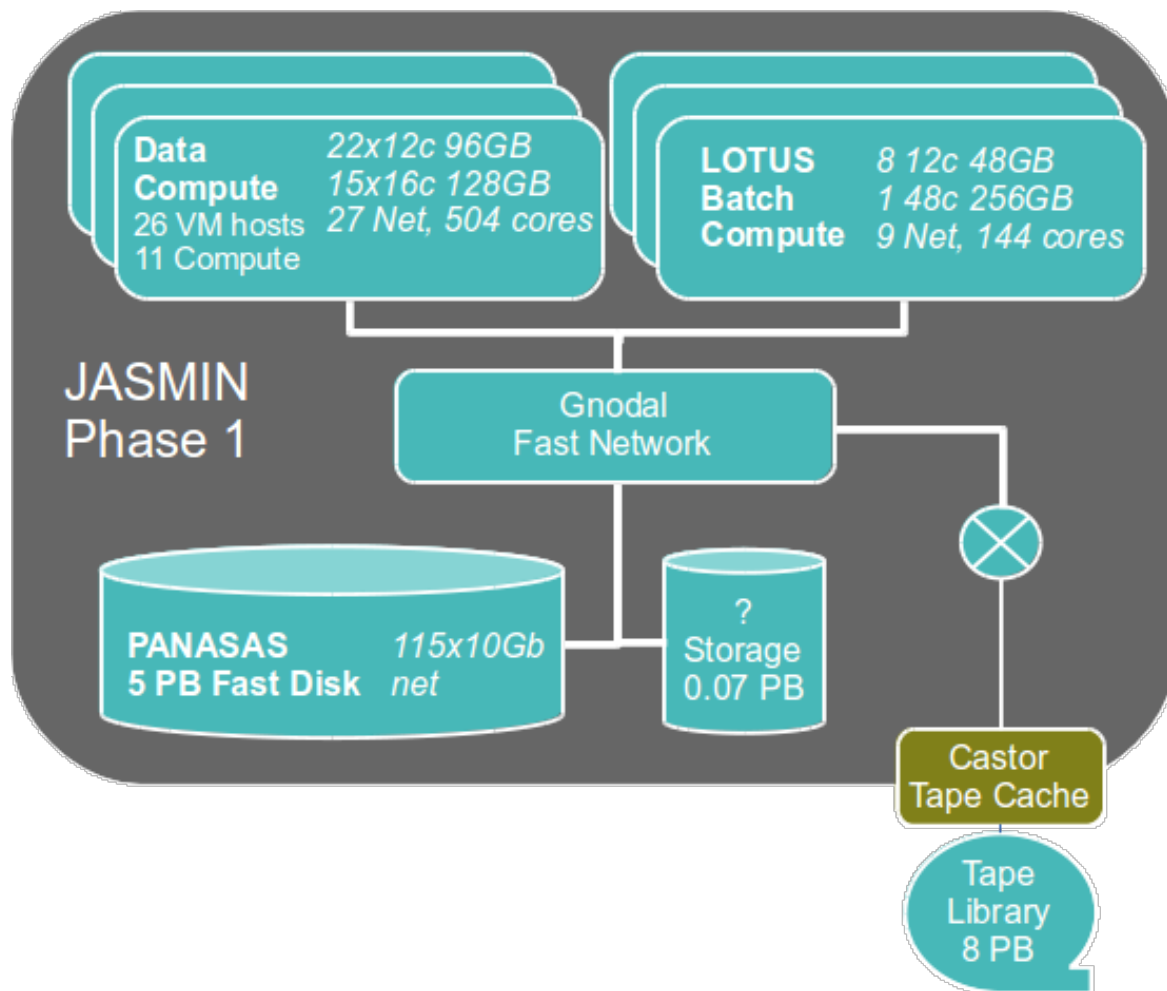
Model and animation by the JWCPR High-Resolution Climate Modelling Team

<http://ncas-climate.nerc.ac.uk/HRCM>

The **largest ever** PRACE computational project, led by the UK, **dependent on CEDA-BADC** to provide the data links and data analysis environment!



JASMIN Phase I hardware



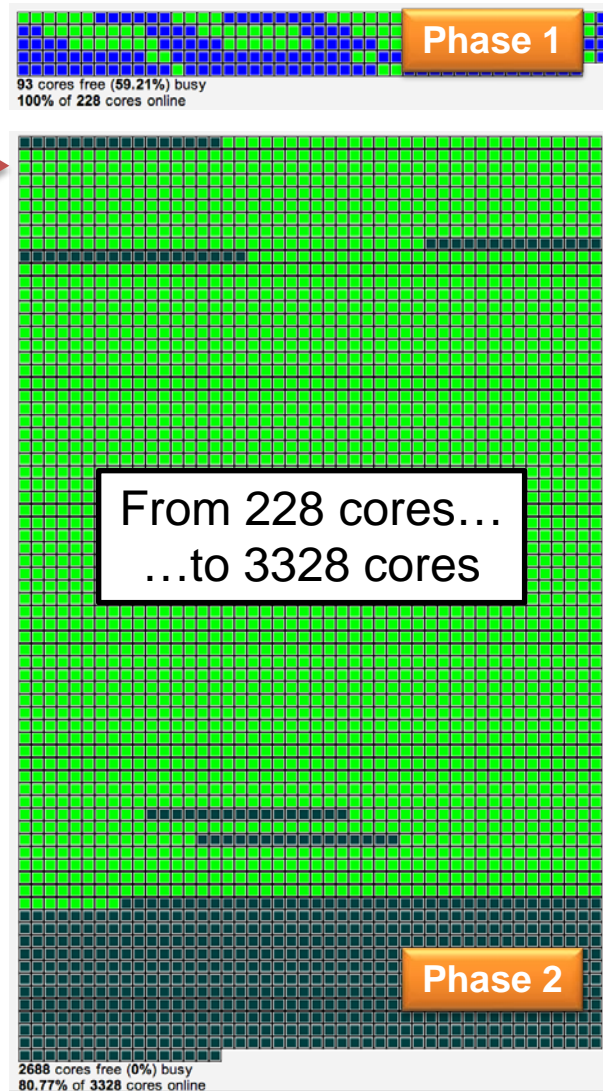
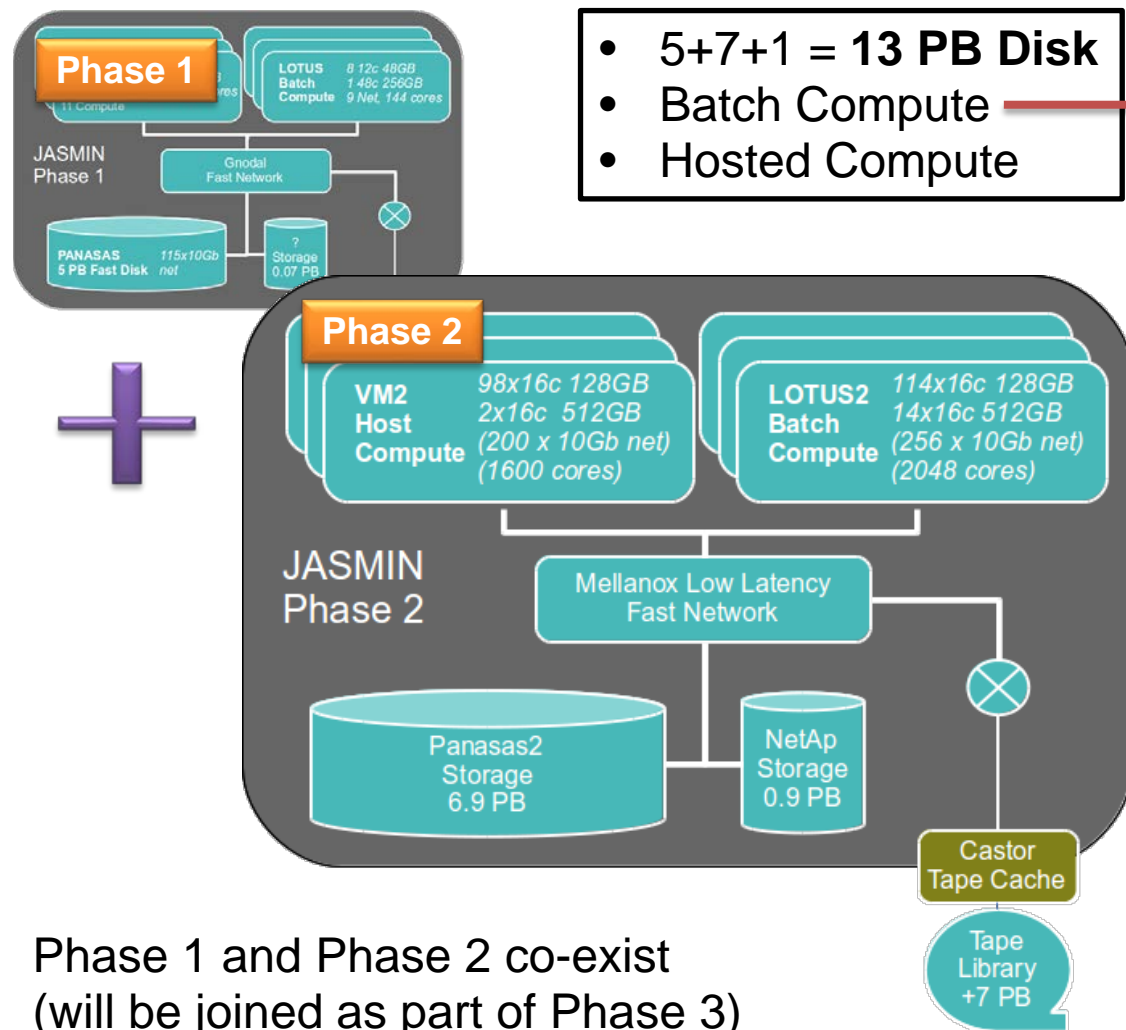
JASMIN is configured as a storage and analysis environment.

Two types of compute:

- virtual/cloud environment
- batch compute

Both sets of compute connected to 5 PB of parallel fast disk

JASMIN Now (Phase 2) hardware



From 228 cores...
...to 3328 cores

Phase 1 and Phase 2 co-exist
(will be joined as part of Phase 3)

Network: internal

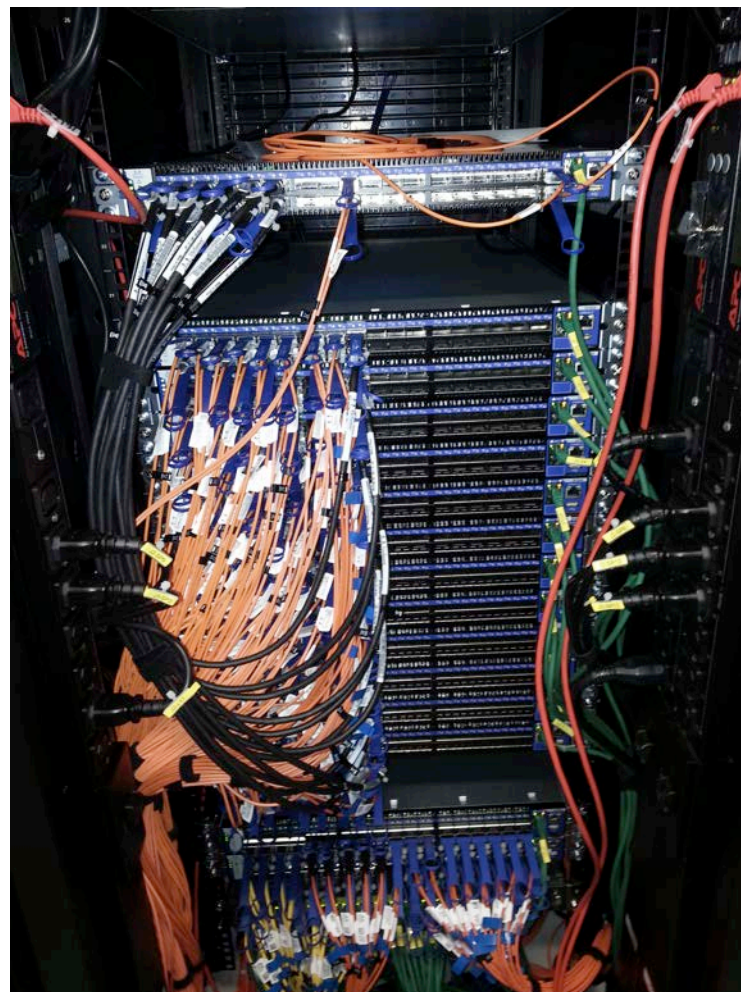
12 x 40Gb Mellanox switches

- 1 connection to each bottom-of-rack switches
- Complete redundant mesh

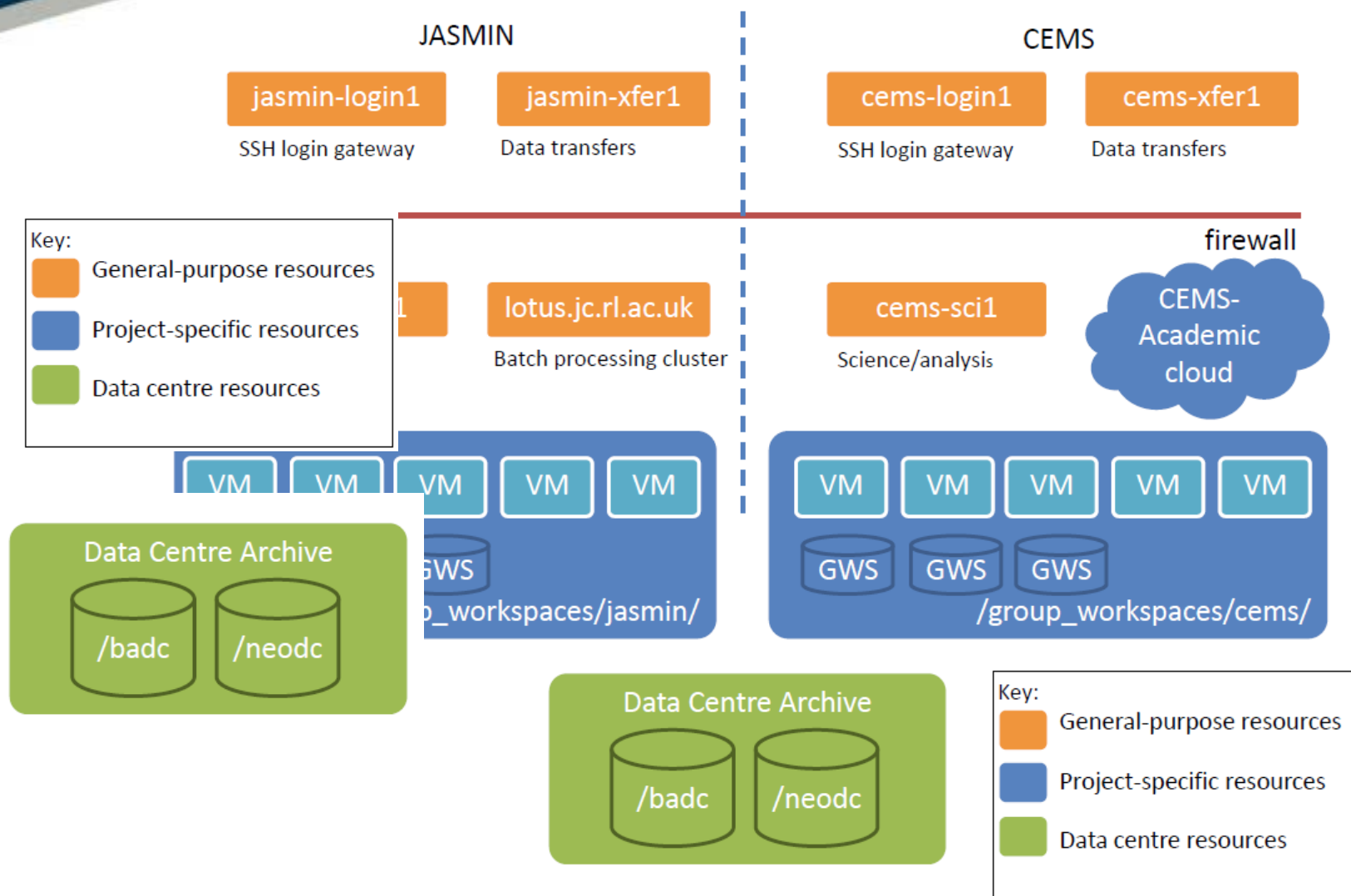
RAL site has 40Gb connection to JANET/internet using same 40Gb connections!

204 x 40Gb cables provides bandwidth of over 1 Terbyte / sec internal to JASMIN2

Phase 3 connects JASMIN1 to JASMIN2 via yellow 56Gbit cables

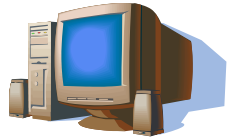


JASMIN/CEMS system architecture



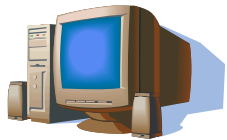


VM Types



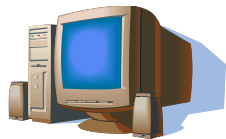
Login [1]

- **jasmin-login1.ceda.ac.uk**; acts as a gateway to other JASMIN nodes; only one; no functionality.



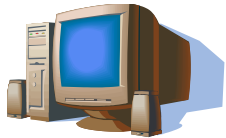
Transfer [1..*]

- **jasmin-xfer1.ceda.ac.uk**; for copying data in/out; currently SCP & RSYNC; GridFTP; read-write to GWS.



Analysis [1..*]

- **jasmin-sci[12].ceda.ac.uk**; for general scientific analysis; common software build; access to GWSs and archive.



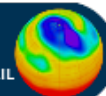
Project-specific [*]

- ***.ceda.ac.uk** – requested by specific projects/users; ROOT access for trusted partners; read-write access to GWS.

NOTE: CEMS
equivalents also exist of these VM types...but they are fundamentally the same.



Climate, Environment &
Monitoring from Space



General purpose scientific analysis VMs

- Scalable – create multiple VMs as required
- SSH access via JASMIN login node
- Supported set of common software (including Iris and IDL)
- Repeatable build process developed in a managed way
- Process for requesting software installs/upgrades
- Read-access to BADC & NEODC archives (for authorised users)
- Write-access to cache disk
- Read/write-access to GWS (for authorised users)
- Home directories

Currently we have: jasmin-sci1, jasmin-sci2 and cems-sci1

Dedicated (project-specific) VMs

Projects can request VMs for their own specific use:

- Logins limited to collaborators only
- Automated registration process (authorised by manager)
- Specification designed with manager (limited O/S)
- Can mount relevant Group Workspaces
- Root access allowed
- Can install packages from “JASMIN Analysis Platform” and/or your own requirements

Example Dedicated VMs

upscale-mo1.ceda.ac.uk

upscale-nerc1.ceda.ac.uk

precis1.ceda.ac.uk

jasmin-name1.ceda.ac.uk, jasmin-name2.ceda.ac.uk

nemo1.ceda.ac.uk

um-conv1.ceda.ac.uk

leicester_proc02.cems.rl.ac.uk -> leicester-proc12.cems.rl.ac.uk

edinburgh-proc01.cems.rl.ac.uk -> edinburgh-proc09.cems.rl.ac.uk and edinburgh-proc12.cems.rl.ac.uk

ecmwf-svc1.ceda.ac.uk

mms1.cems.rl.ac.uk

mohc-test.ceda.ac.uk

pml-proc01.cems.rl.ac.uk -> pml-proc04.cems.rl.ac.uk

ukcp-batch1.ceda.ac.uk

ukmo-01.cems.rl.ac.uk -> ukmo-03.cems.rl.ac.uk

Group Workspaces (GWS)

- For “projects” that want to:
 - Share a LARGE network-accessible disk.
 - Allow access from a number of institutions.
 - Pull/push data from/to external sites to a common location.
 - Move data from MONSooN/ARCHER to share with others.
 - Use to store third-party data sets required by project.
 - Process/analyse the data using VMs/LOTUS.
 - Process/analyse the data in conjunction with other *archived* or *group workspace* datasets.
 - Work up data ready for the BADC/NEODC archives.
 - From **2 Tbytes to 380 Tbytes** in volume (so far).
 - Share data through HTTP access (restricted or public).



Example Group Workspaces

JASMIN - Future Weather (NCAS)

JASMIN - GLOCON

JASMIN - GRIP

JASMIN - HIGEM

JASMIN - JULES Big Data

JASMIN - MO-GC2 (Met Office Global Coupled Model Evaluation runs)

JASMIN - NAME

JASMIN - NCAS-CMS

JASMIN - NEMO

JASMIN - PRECIS

JASMIN - RAINGAIN

JASMIN - TIFF

JASMIN - UKCA

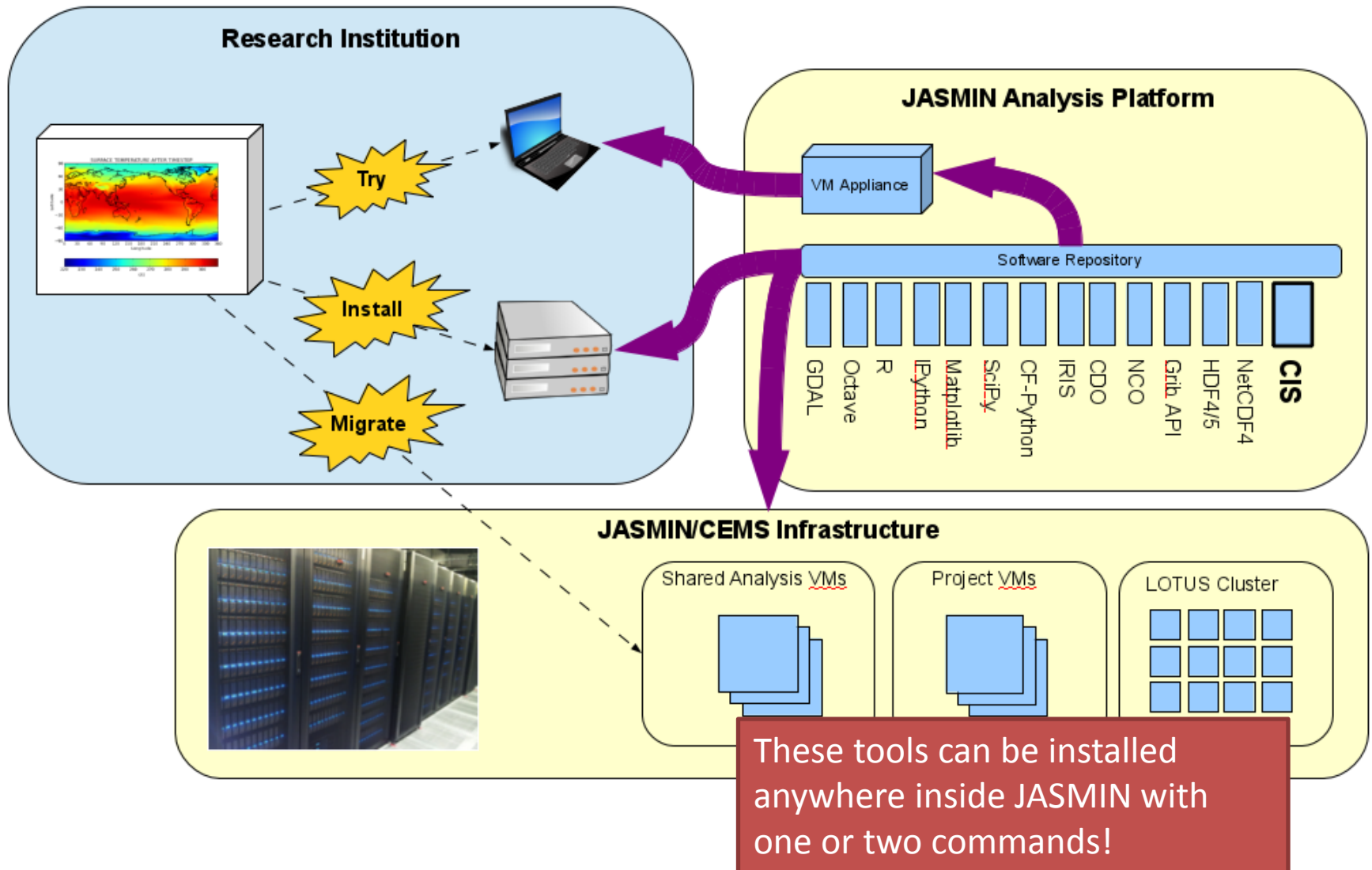
JASMIN - UPSCALE

CEMS - Cloud-ECV (CCI/NCEO cloud products)

CEMS - ESACCI Phase 1 Ocean Colour

CEMS - ESACCI SST

The “JASMIN Analysis Platform” – a re-usable, re-deployable bundle of common tools



What JAP Provides

Standard Analysis Tools:

- NetCDF4, HDF5, Grib
- Operators: NCO, CDO
- Python Stack
 - Numpy, SciPy, Matplotlib
 - IRIS, cf-python, cdat_lite
 - Ipython
- GDAL, GEOS
- NCAR Graphics, NCL
- R, octave
- ...

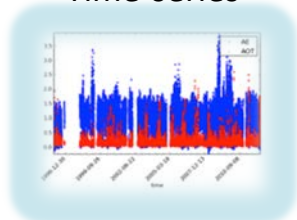
Parallelisation and Workflow:

- Python MPI bindings
- Jug (simple Python task scheduling)
- IPython notebook
- IPython-parallel
- JASMIN Community
- Inter-comparison Suite

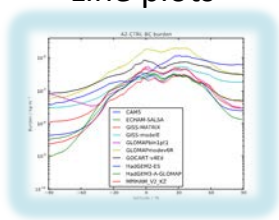
Community Intercomparison Suite (CIS)

(CIS = Component of JAP)

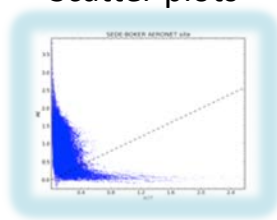
Time-series



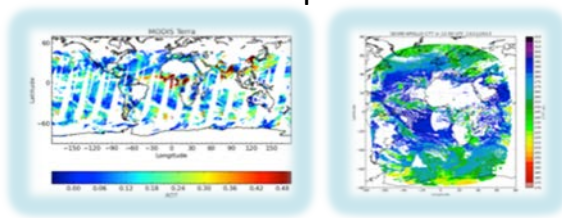
Line plots



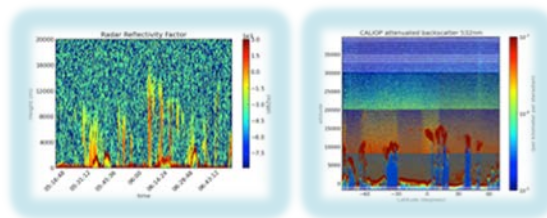
Scatter plots



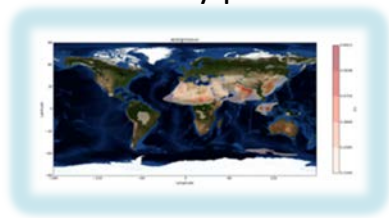
Global plots



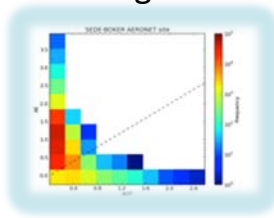
Curtain plots



Overlay plots



Histograms



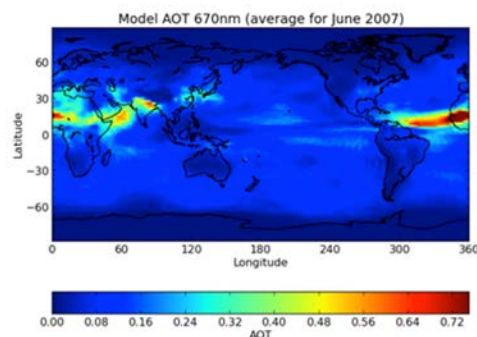
Dataset	Format
AERONET	Text
MODIS	HDF
CALIOP	HDF
CloudSAT	HDF
AMSRE	HDF
TRMM	HDF
CCI aerosol & cloud	NetCDF
SEVIRI	NetCDF
Flight campaign data	RAF
Models	NetCDF

CIS – Co-location

```
cis col <variable>:<source file> <sampling file>:colocator=lin -o <new file>
cis plot <variable>:<new file> <variable>:<sampling file> --type comparativescatter \
--logx --xlabel 'Observations AOT 675nm' --xmin 1.e-3 --xmax 10 \
--logy --ylabel 'Model AOT 670nm' --ymin 1.e-3 --ymax 10
```

Model gives global
output every 3
hours for a full
month

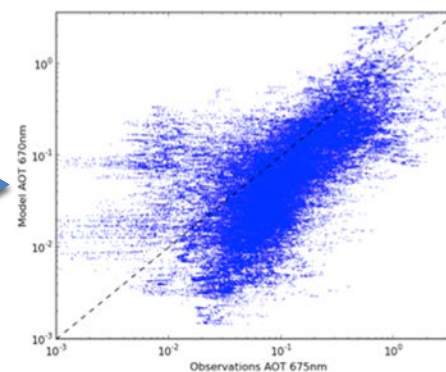
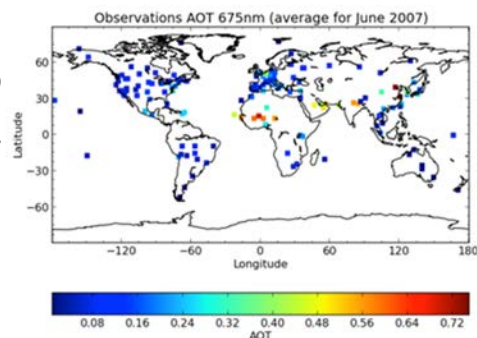
Source



Collocation

Observations are day-
time site measurements,
every 15 min for a full
month

Sampling



LOTUS compute cluster

- JASMIN Scientific Analysis Servers are limited in resources – LOTUS is bigger!
- High performance computing facility
- Cluster of both physical and virtual machines
- High speed access to Panasas storage
 - BADC and NEODC Archive
 - Group workspaces
 - Users' home directories
 - Scratch area (read/write)
 - /tmp

<http://www.ceda.ac.uk/help/users-guide/lotus/>

LOTUS Hardware

Model	Processor	Cores	Memory
194 x Viglen HX525T2i	Intel Xeon E5-2650 v2 “Ivy Bridge”	16	128GB
14 x Viglen HX545T4i	Intel Xeon E5-2650 v2 “Ivy Bridge”	16	512GB
6 x Dell R620	Intel Xeon E5-2660 “Sandy Bridge”	16	128GB
8 x Dell R610	Intel Xeon X5690 “Westmere”	12	48GB
3 x Dell R610	Intel Xeon X5675 “Westmere”	12	96GB
1 x Dell R815	AMD Opteron	48	256GB

226 physical hosts

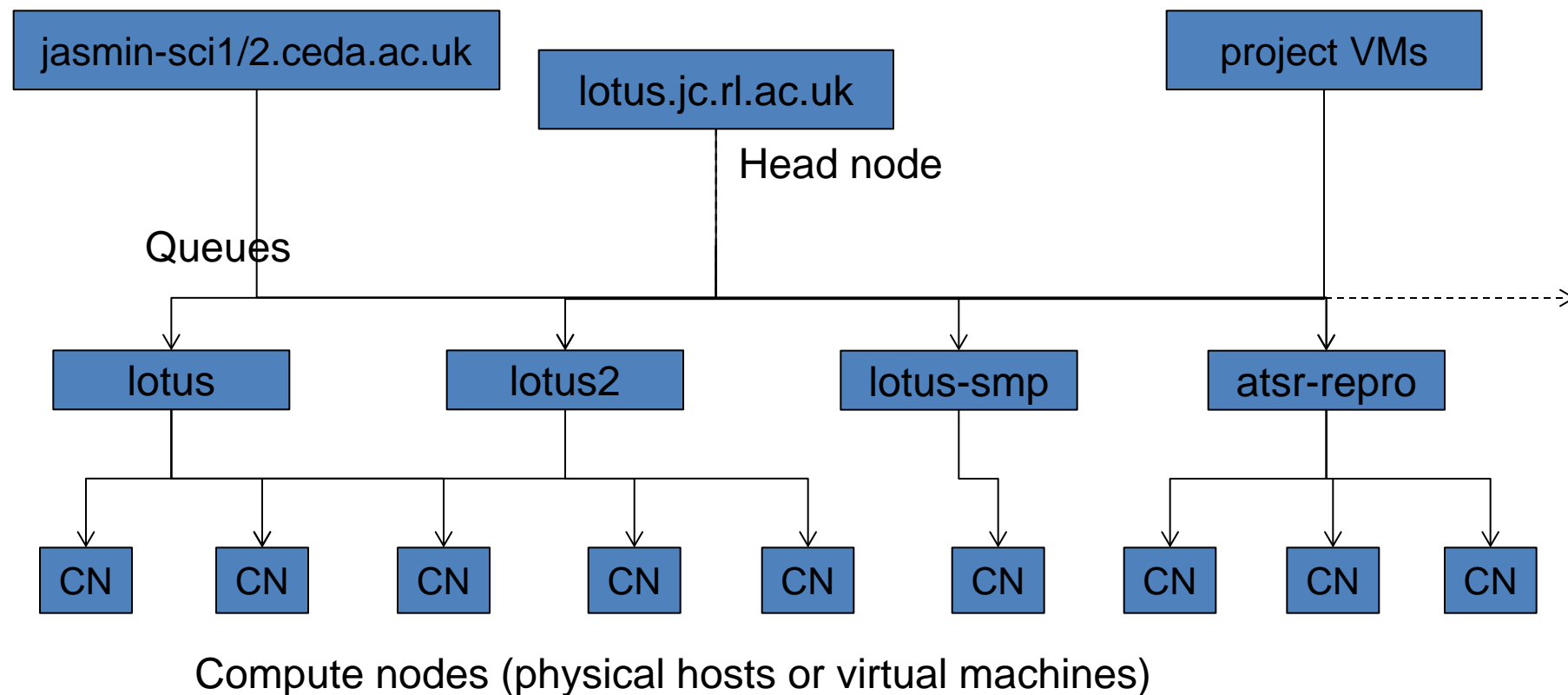
3556 cores

Intel/AMD processors

17 large memory hosts

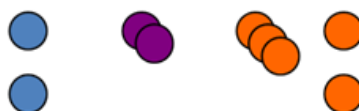
Mix of generations/specs

LOTUS Configuration



Job Submission

Jobs are submitted using the LSF scheduler
Resources are allocated as they become available
Fair share of resources between users



JASMIN links



JASMIN Dedicated Network Connections

Link	Notes
RAL - ARCHER	2 x 1Gbit/s lightpath to data component of the UK National Supercomputing Service in Edinburgh.
RAL – MONSooN (Met Office)	1 Gbit/s lightpath to UK Met Office supercomputer in Exeter.
RAL - KNMI/WUR	Dynamic lightpath via SURFnet to KNMI (Dutch Met Office) and Wageningen University (NL)
RAL - University of Leeds	Lightpath to enable efficient connection of JASMIN-North satellite node.

High Performance Transfer Server

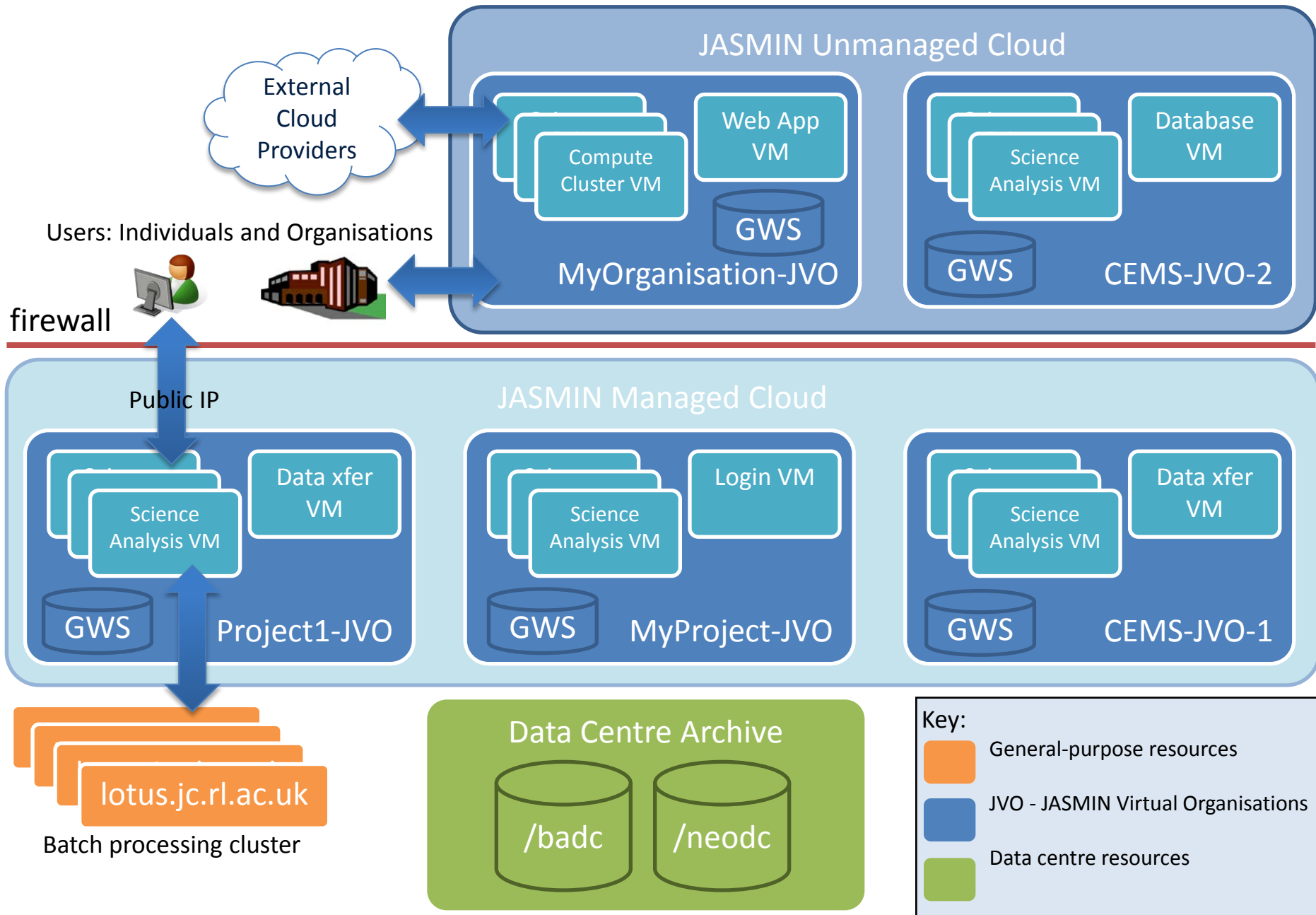
- As well as the standard “xfer” VMs there is a dedicated server set up to achieve fast transfers for special cases.
- The High Performance Data transfer service is a machine with optimised network connectivity to permit rapid transfer of data in and out of JASMIN. The service allows transfers into the Group Workspaces using **rsync**, **scp** and **bbcp**

<http://www.jasmin.ac.uk/services/high-performance-data-transfer/>

“Elastic” Tape

- A tape storage system is currently in its testing phase
- Projects can apply for volumes of tape storage to optimise how they store data between high-performance and tape:
 - If it is not being used for significant period of time then it is cost-effective to push data onto tape

JASMIN Phase 2 Cloud Infrastructure



Finding out more

JASMIN documentation pages

<http://www.jasmin.ac.uk>

Technical details (paper explaining JASMIN Phase 1 set up)

[doi:10.1109/BigData.2013.6691556](https://doi.org/10.1109/BigData.2013.6691556)

JASMIN Phase 2 launch presentations

<http://jasmin.ac.uk/what-is-jasmin/jasmin-launch-event/>

CEMS and the Satellite Applications Catapult

<https://sa.catapult.org.uk/cems>