Jetstream – Early Operations Performance, Adoption, and Impacts

David Y. Hancock – dyh@iu.edu

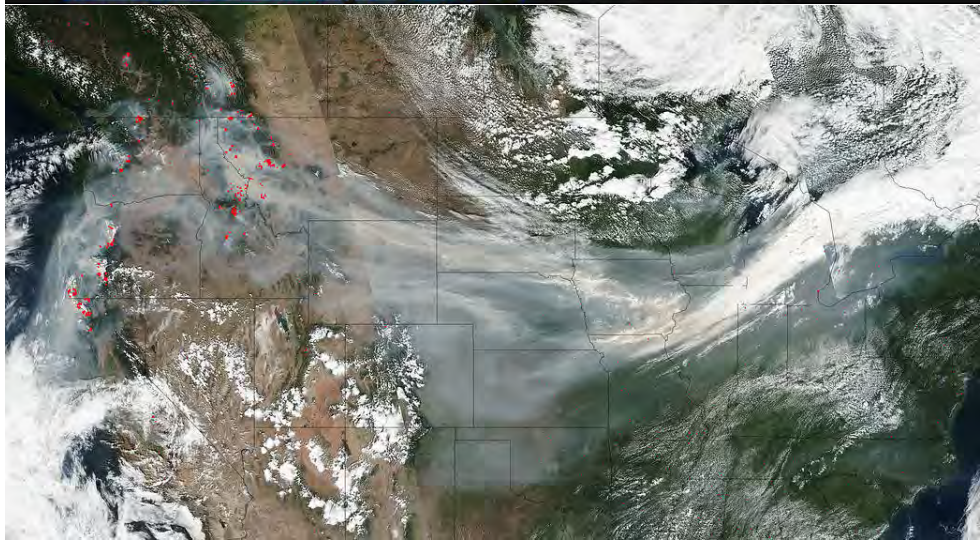
UCC / BDCAT '17

Acting Principal Investigator – Jetstream
Program Director – Advanced Cyberinfrastructure
Indiana University Pervasive Technology Institute

December 6, 2017

What is “the” Jetstream?

- Fast moving air currents
- Hot/Cold air boundaries
- An NSF-funded cloud environment



NASA's Suomi NPP satellite collected this natural-color image using the VIIRS (Visible Infrared Imaging Radiometer Suite) instrument on Sept. 4, 2017. Actively burning areas are outlined in red. NASA image courtesy Jeff Schmaltz LANCE/EOSDIS MODIS Rapid Response Team, GSFC

National Science Foundation – Funding in HPC

- Traditionally concentrated on enabling peta-scale capability via track I/II programs
  - Blue Waters – 13.3 petaflops, 2012 (under re-compete)
  - Stampede – 9.6 petaflops, 2013 (extended to Stampede 2)
  - Comet – ~2.0 petaflops, 2014
- Have funded research into building clouds and computer science testbeds
  - CloudLab
  - Chameleon (renewed for second phase)
- Now funding clouds to do research
  - Bridges (Hybrid system)
  - Jetstream

Jetstream
http://jetstream-cloud.org/

NSF funded by the National Science Foundation
Award #ACI-1445604

What is Jetstream and why does it exist?

- NSF's first production cloud facility
- Focus on ease-of-use, broad accessibility
- Encourage collaboration and community development
- User-selectable library of preconfigured virtual machines
- Provides on-demand *interactive* computing and analysis or persistent services such as gateways (e.g. SEAGrid, Galaxy, GenApp, and others)
- Enables *configurable* environments and ***programmable cyberinfrastructure***
- Reproducibility: Share VMs and then store, publish via IU Scholarworks (DOI)

Jetstream
http://jetstream-cloud.org/

funded by the National Science Foundation
Award #ACI-1445604

Jetstream – Expanding NSF XD's reach and impact

Around 350,000 researchers, educators, & learners received NSF support in 2015

- **Less than 2%** completed a computation, data analysis, or visualization task on XD/XSEDE program resources
- Less than 4% had an XSEDE Portal account
- **70%** of researchers surveyed* claimed to be **resource constrained**

Why are the people not using XD/XSEDE systems not using them?

- Perceived **ease of access** and use
- HPC resources – the traditional view of what XSEDE offers - are often **not well-matched** to their needs
- They just don't need *that much* capability

*XSEDE Cloud Survey Report - http://hdl.handle.net/2142/45766

Jetstream
http://jetstream-cloud.org/

funded by the National Science Foundation
Award #ACI-1445604

Who uses Jetstream?

- The researcher needing a handful of cores (1 to 44/vCPU)
- Software creators and researchers needing to create their own customized virtual machines and workflows
- Science gateway creators using Jetstream as either the frontend or processor for scientific jobs
- STEM Educators teaching on a variety of subjects

Jetstream
http://jetstream-cloud.org/

funded by the National Science Foundation
Award #ACI-1445604

What Jetstream isn't…

- It's not traditional HPC
- There's no shared filesystem (think cloudy!)
- There's no high-end interconnect fabric (keep thinking cloudy!)
- There aren't GPUs (yet…stay tuned)
- It isn't Amazon, Azure, or GCE (similar, but…)

Jetstream
http://jetstream-cloud.org/

NSF funded by the National Science Foundation
Award #ACI-1445604

Jetstream and way of the cloud…

- **Cloudy Technologies**: clouds are more than just virtual machines (VM)
  - **Old way**: robust (expensive) infrastructure, weak (cheap) software
    - You expect the hardware to not fail
    - State in maintained in volatile data structures
  - **Cloudy way**: commodity infrastructure, robust software
    - Expect & plan for infrastructure to fail
    - Put intelligence into the software to handle infrastructure failure
  - **And my favorite…**

Jetstream
http://jetstream-cloud.org/

NSF funded by the National Science Foundation
Award #ACI-1445604

Thinking about VMs…

Flickr user Nanak26 - Normandie

- Cattle, not pets: pets take great amount of care, feeding, and you name them; cattle you intend to have high turnover and you give them numbers.

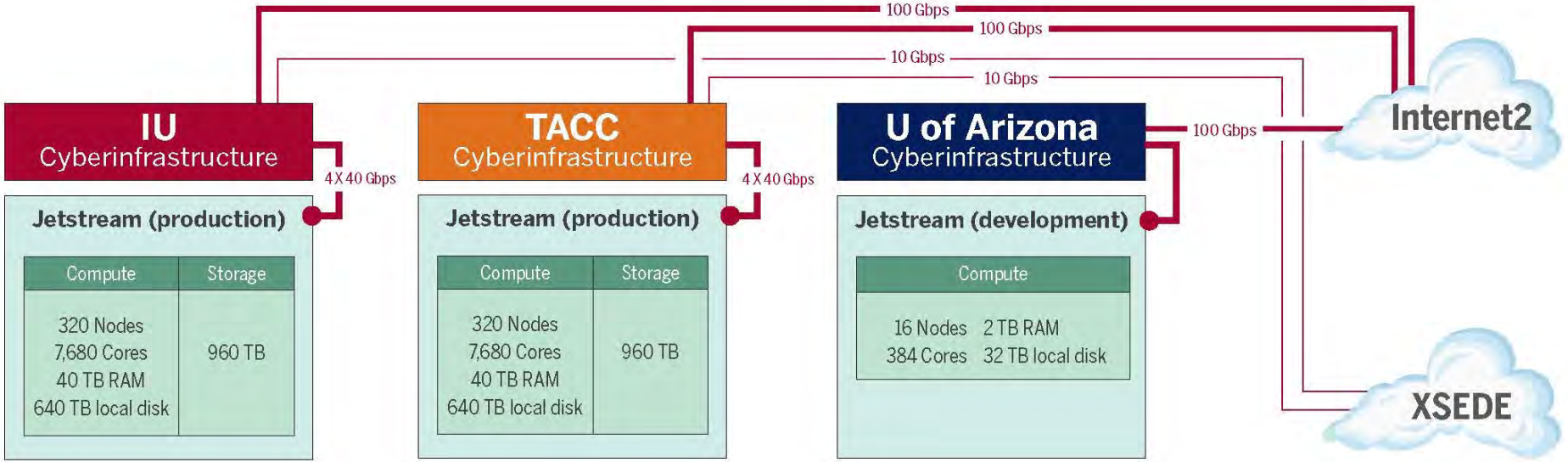
-- Mike Lowe (Jetstream architect)

** Some caveats for gateways, but…

Jetstream
http://jetstream-cloud.org/

funded by the National Science Foundation
Award #ACI-1445604

Jetstream System Overview



Jetstream
http://jetstream-cloud.org/

NSF
funded by the National Science Foundation
Award #ACI-1445604

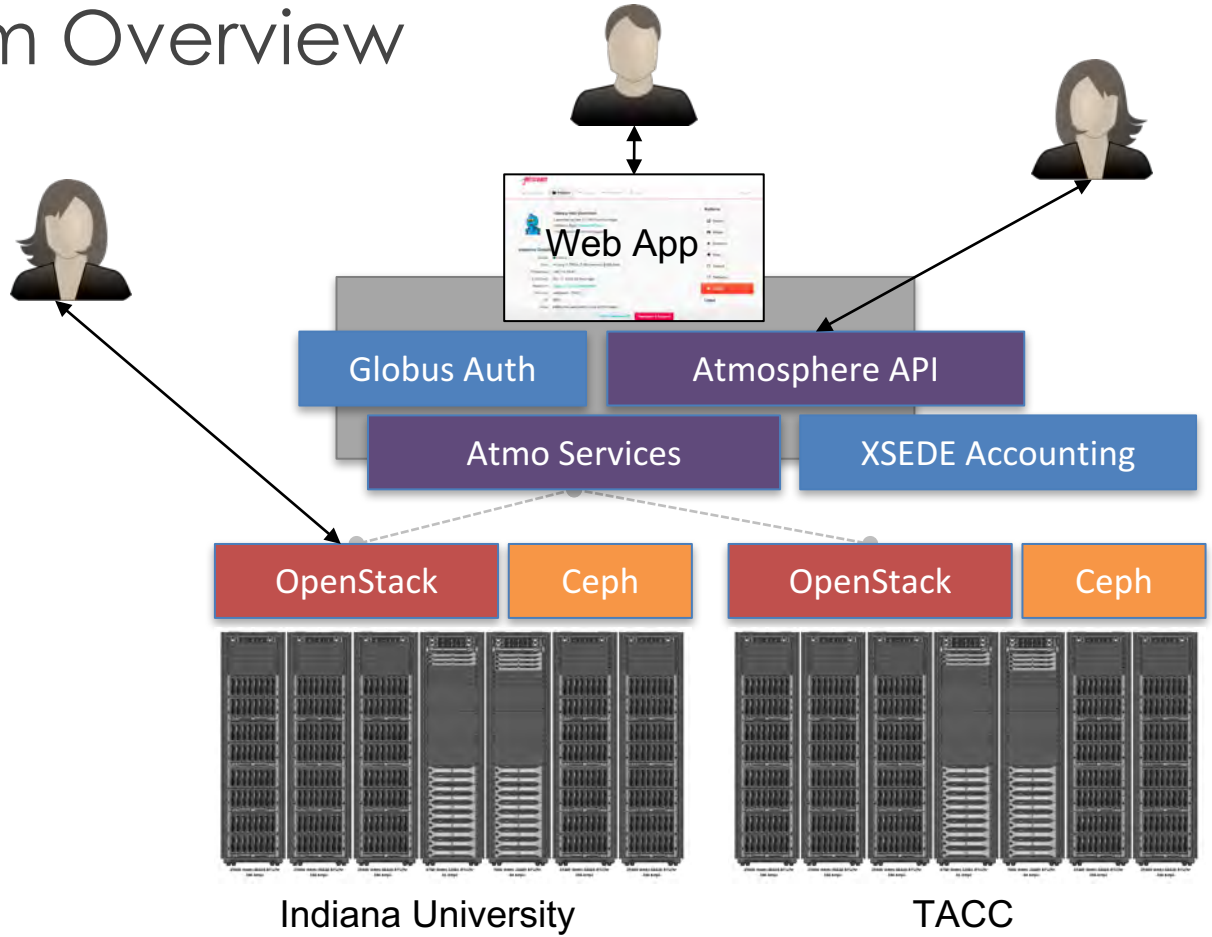
Production cloud hardware (per site)

Hardware	Number	Specifications	Function (IU)
Dell PowerEdge M630 blades	320	2x Intel E5-2680v3 "Haswell" 24 cores @ 2.5 GHz 128 GB RAM 2 TB local disk	Compute hosts OpenStack services
Dell PowerEdge R630 1U server	7	2x Intel E5-2680v3 "Haswell" 24 cores @ 2.5 GHz 128 GB RAM 2 TB local disk	Cluster management High Availability Databases RabbitMQ
Dell PowerEdge R730xd 2U servers	20	2x Intel E5-2680v3 "Haswell" 24 cores @ 2.5 GHz 64 GB RAM 48 TB storage for Ceph pool	~1 PB Ceph storage
Dell S6000-ON network switches	9	32+2 40 Gb/s ports	Top of Rack Spine

Jetstream
http://jetstream-cloud.org/

NSF funded by the National Science Foundation
Award #ACI-1445604

Platform Overview



What is Jetstream, continued…

- **Software layers**
  - **Atmosphere** web interface
    - library of images, generic, domain specific
    - simplify VM administration
  - **OpenStack:** software tools for building and managing cloud computing platforms for public and private clouds.
  - **KVM** hypervisor: what the VMs run on
  - **Ceph**: storage platform that stores data on a single distributed computer cluster, and provides interfaces for **object**-, **block**- and *file-level* storage.
  - **Operating systems**: CentOS, Ubuntu, Windows?
  - **Applications**: e.g. software developed by the domain specialist, gateways, etc.

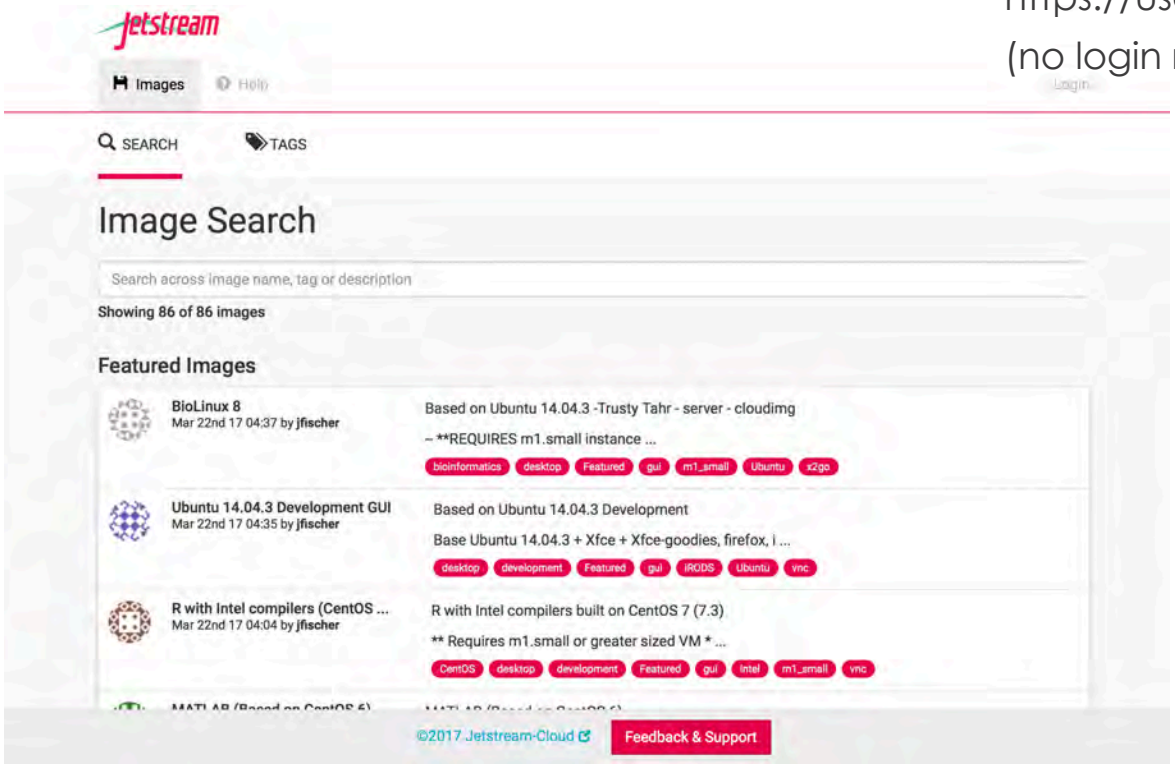
Jetstream
http://jetstream-cloud.org/

NSF funded by the National Science Foundation
Award #ACI-1445604

Jetstream's Atmosphere interface

https://use.jetstream-cloud.org/

(no login required to this point)

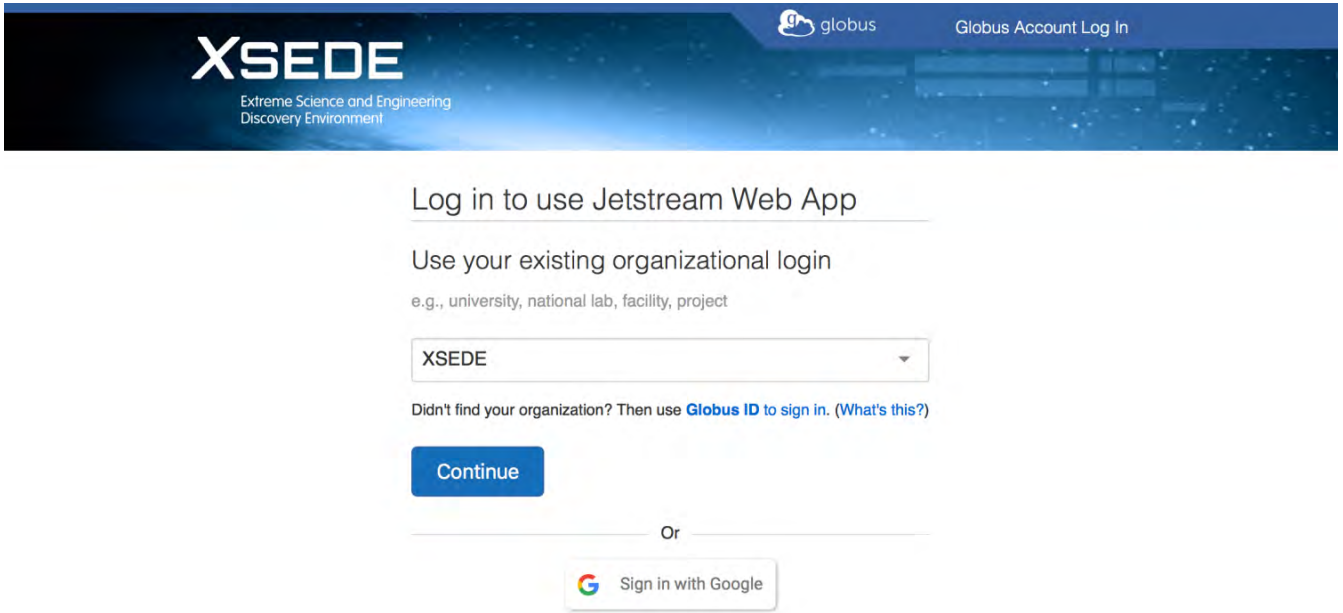


Jetstream
http://jetstream-cloud.org/

funded by the National Science Foundation
Award #ACI-1445604

Jetstream's Atmosphere interface

(Select identity provider)

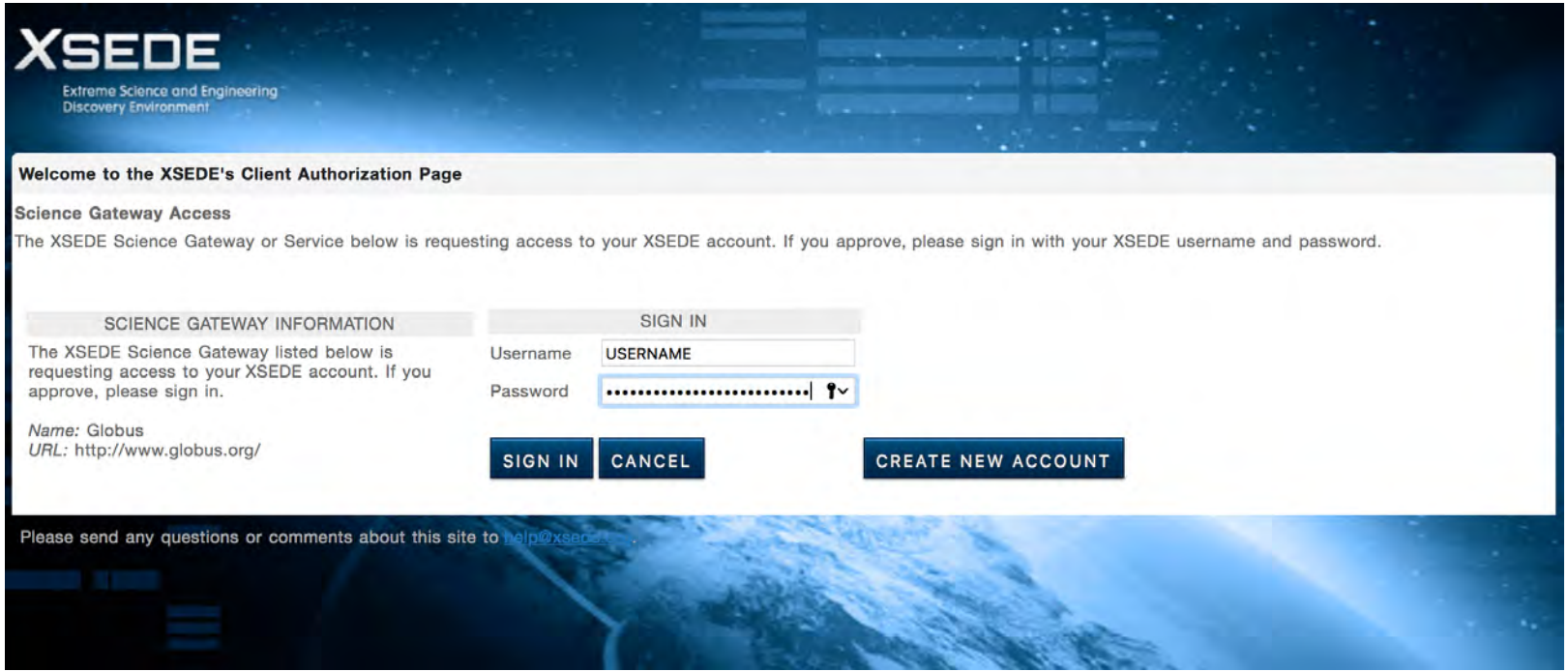


Jetstream
http://jetstream-cloud.org/

funded by the National Science Foundation
Award #ACI-1445604

Jetstream's Atmosphere interface

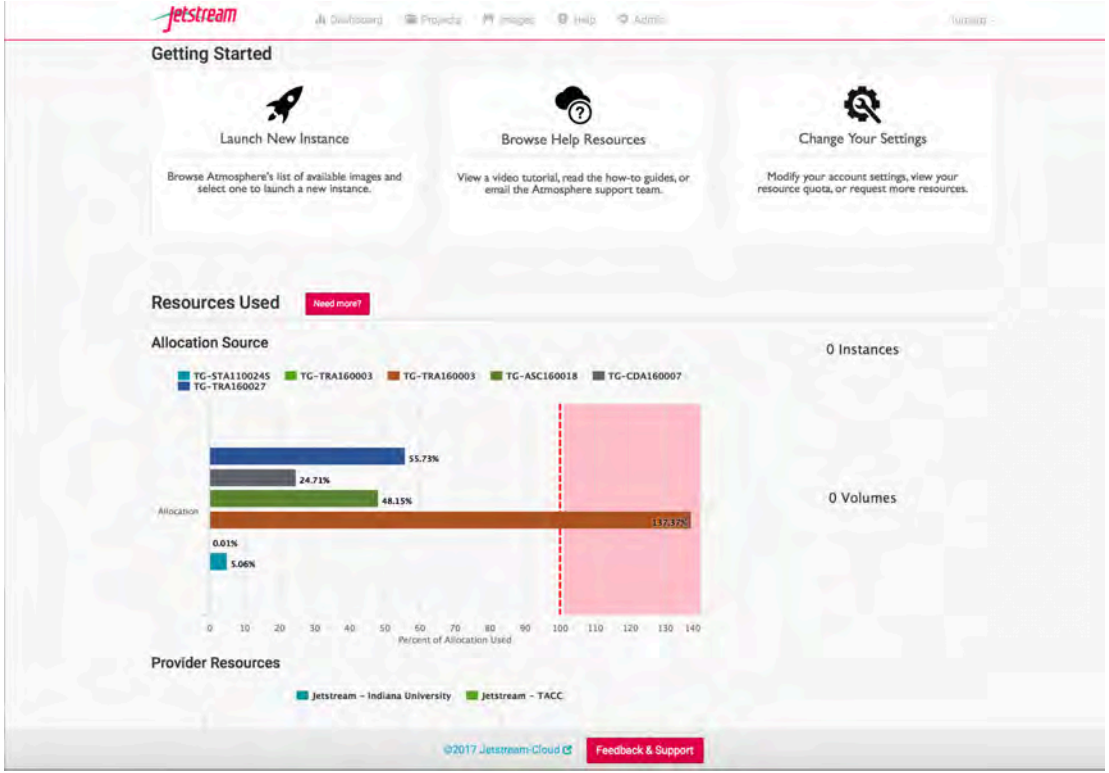
(Authenticate)



Jetstream
http://jetstream-cloud.org/

funded by the National Science Foundation
Award #ACI-1445604

Jetstream's Atmosphere interface



(user's home space)

Jetstream
http://jetstream-cloud.org/

funded by the National Science Foundation
Award #ACI-1445604

Hardware and instance "flavors"

Flavor	vCPUs	RAM	Storage	Per Node
tiny	1	2	8	46
small	2	4	20	23
medium	6	16	60	7
large	10	30	120/60*	4
xlarge	24	60	240/60*	2
xxlarge	44	120	480/60*	1

- Short-term storage comes as part of launched instance
- Long-term storage is XSEDE-allocated
- *Flavors updated March 2017, storage-rich flavors **are not** imaged

Jetstream
http://jetstream-cloud.org/

funded by the National Science Foundation
Award #ACI-1445604

Jetstream usage highlights

As of October 2017:

- 360 active XSEDE projects covering 66 fields of science and **2180 active users** representing **191 institutions**
- **86%** of Jetstream users new to XSEDE (at end of PY1)
- >76 million CPU hours allocated to XSEDE projects since June 2016
- 9 science gateways
- 42 education/teaching allocations serving almost 800 students
- Averaging 816 concurrent VMs
- **100%** system availability, **99.4%** cap availability
- **97.7%** "job" completion (at end PY1)

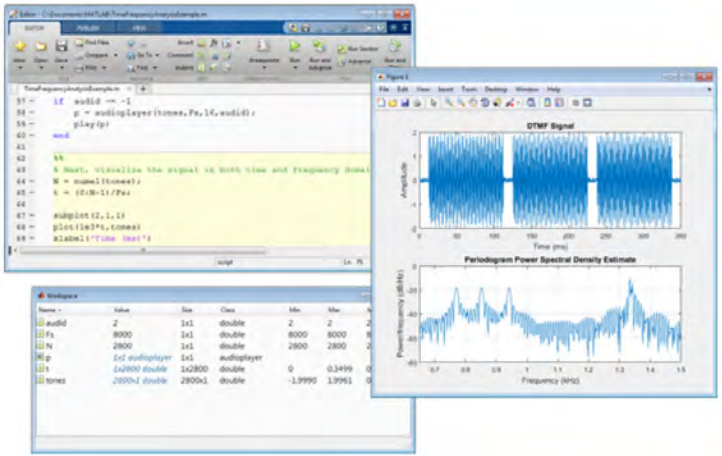
Jetstream
http://jetstream-cloud.org/

NSF funded by the National Science Foundation
Award #ACI-1445604

Not just the usual suspects…

Physics, chemistry, and other "usual" HPC suspects are represented, but Jetstream also is home to projects on:

- Financial analysis / Economics
- Political science
- Humanities / Text analysis
- Network analysis
- Computer Science / Machine learning
- Satellite data analysis



Jetstream
http://jetstream-cloud.org/

funded by the National Science Foundation
Award #ACI-1445604

Discipline or area of interest	#of Jetstream allocations	SUs allocated on Jetstream	% of SUs allocated on Jetstream	% of all SUs allocated on other XSEDE-supported systems
Astronomy	2	1,108,096	3.04%	8.61%
Atmospheric Sciences	4	2,752,400	7.55%	3.73%
Biological Sciences	57	5,199,000	14.27%	4.95%
Campus/Domain Champions	123	6,105,500	16.76%	0.09%
Computational Science	11	1,150,000	3.16%	0.92%
Computer Science	15	4,944,302	13.57%	1.8%
Education Allocations	24	2,847,600	7.82%	0.01%
Engineering	1	100,000	0.27%	3.81%
Geosciences	10	1,978,400	5.43%	2.87%
Humanities/Social Sciences	10	560,000	1.54%	0.45%
Molecular Biosciences	8	4,647,520	12.75%	17.65%
Network Science	3	200,000	0.55%	0.06%
Ocean Science	3	230,000	0.63%	1.30%
Physics	4	2,252,400	6.18%	16.43%
Training & Development	11	2,362,000	6.48%	0.16%

About those gateways…

- IRIS
  - Serving large scale earthquake and geographical data for analysis
- Unidata
  - Providing distribution and analysis of meteorological data
- OpenMRS
  - Providing medical records systems for the resource-constrained
- SEAGrid
  - Computational chemistry, molecular and fluid dynamics, and structural mechanics gateway
- NAMDRunner
  - Based on the GenApp gateway – over 1 million computing hours used to date for MD
- Coming gateways: CIPRES Gateway, The Neuroscience Gateway, ChemCompute gateway, UltraScan III

Jetstream
http://jetstream-cloud.org/

NSF funded by the National Science Foundation
Award #ACI-1445604

Galaxy riding Jetstream

- Galaxy is a platform for biomedical research, focused on accessibility, transparency and reproducibility
  - The main project instance (usegalaxy.org) has more than **100,000 registered users** executing **300,000+ jobs each month**
  - Many users need more capacity than the public quota, or other customizations (e.g., new tools)

Use Jetstream as a ***bursting*** platform

- From Galaxy Main, offload jobs onto a remote Slurm cluster running on Jetstream instances
- Run Galaxy Interactive Environments (i.e., Dockerized iPython/RStudio containers) in an isolated environment on a Swarm cluster running on Jetstream

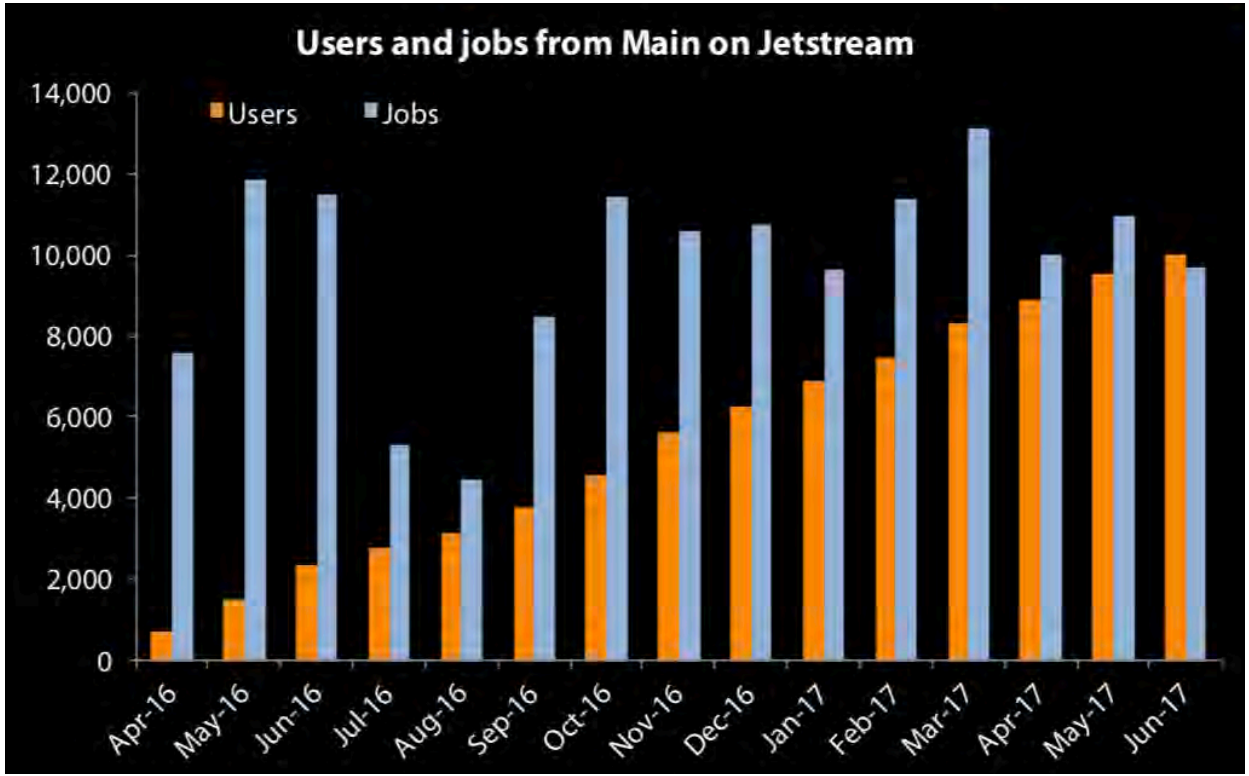
Use Jetstream as a ***self-service*** platform

- Pre-built Galaxy image configured with hundreds of tools and access to TBs of genomic reference data, available via the self-launch model within minutes
- Allows users to acquire (free) resources, and gives them complete control

Jetstream
http://jetstream-cloud.org/

NSF funded by the National Science Foundation
Award #ACI-1445604

Jetstream Galaxy bursting: ~10K unique users,115K jobs



< 5% of the Jobs

15–20% of the CPU time

Disk throughput is important

Now leveraging containers and Jupyter Notebooks

Jetstream
http://jetstream-cloud.org/

funded by the National Science Foundation
Award #ACI-1445604

HPC vs Cloud

Flickr user Haz – No Reservation

- Adapting to a different environment:
- No reservations (until now); no queueing
- More interactive use and less/no batch queuing
- What? No parallel filesystem?!?
- Being your own admin – hey, we have root!
- You really can have almost any (Linux) software you want**
- Constantly getting new features
  - ** Here there be dragons…

Flickr user José Silenzi - dragon

Jetstream
http://jetstream-cloud.org/

NSF
funded by the National Science Foundation
Award #ACI-1445604

PY1 Challenges

- Outreach efforts largely funded by IU and partners
- Barriers to XSEDE adoption in general
- XRAC process cumbersome to intended audience
- User support needs are significant
- Can be intimidating to port traditional HPC workflows

Jetstream
http://jetstream-cloud.org/

funded by the National Science Foundation
Award #ACI-1445604

Jetstream REU Program 2017

- NSF Supplement for 4 undergraduates
- Looking to recruit 4-6 students for 2018

- REU student videos on YouTube
  https://www.youtube.com/user/IUPTI

- News release describing their experiences
https://itconnections.iu.edu/2017-august/jetstream.php

Jetstream
http://jetstream-cloud.org/

funded by the National Science Foundation
Award #ACI-1445604

Requesting access to Jetstream

- Trial allocations available **TODAY**
- You can request startup allocations anytime.
- You can request allocations for educational use anytime.
- Next submission period for large allocations is 15 December 2017 – 15 January 2018.
- We are happy to help you prepare a request and create a successful proposal.
- You do **not** have to have prior use of Jetstream to be successful.
- You **do** need a US-based collaborator

Jetstream
http://jetstream-cloud.org/

NSF funded by the National Science Foundation
Award #ACI-1445604

PY2 Plans

- Enabling better Jupyter deployments for training and research
- Continue improving trial allocations
- More videos/training
- Encouraging orchestration for more communities
- Image build repository (proposed to XSEDE for funding)

Jetstream
http://jetstream-cloud.org/

funded by the National Science Foundation
Award #ACI-1445604

PY2 plans continued…

- Partner with XSEDE Campus Champions and ACI-REF Facilitators to do tutorials for interested under-served researchers
- Explore better ways to communicate with the user community and to allow them to communicate with each other
- Develop additional domain science images with input from the Jetstream and XSEDE community
- Begin work on Windows VM adaptation for Jetstream API if licensing can be resolved

Jetstream
http://jetstream-cloud.org/

NSF funded by the National Science Foundation
Award #ACI-1445604

Jetstream partners

Jetstream
http://jetstream-cloud.org/

NSF
funded by the National Science Foundation
Award #ACI-1445604

Help / References

Wiki / Documentation: http://wiki.jetstream-cloud.org

User guides: https://portal.xsede.org/user-guides

XSEDE KB: https://portal.xsede.org/knowledge-base

Email: help@xsede.org

Campus Champions: https://www.xsede.org/campus-champions

Paper describing Jetstream: Jetstream: A self-provisioned, scalable scince and engineering cloud environment

Configuration management: https://github.com/jetstream-cloud/Jetstream-Salt-States

Jetstream
http://jetstream-cloud.org/

NSF funded by the National Science Foundation
Award #ACI-1445604

Questions?

Project website: http://jetstream-cloud.org/
Project email: help@jetstream-cloud.org Direct email: dyh@iu.edu

License Terms

Jetstream
http://jetstream-cloud.org/

funded by the National Science Foundation
Award #ACI-1445604

Things left behind…

Flickr user Oiluj Samall Zeid - Lejos de Yulín

Jetstream
http://jetstream-cloud.org/

funded by the National Science Foundation
Award #ACI-1445604

Just for fun: Happy Cluster – Mad Cluster

ChilledDoor Rack Cooling System by motivair

Jetstream
http://jetstream-cloud.org/

funded by the National Science Foundation
Award #ACI-1445604