Survey of Scientific Visualization Resources at TACC

Anne Bowen

Scalable Visualization Technologies Group

adb@tacc.utexas.edu

Talk: Summary

- Overview of Scientific Visualization Resources and Applications
- Remote visualization (via vis Portal) quickstart tutorial using VNC
- Visualization strategies/best practices for working with larger data

VIS GROUP AT A GLANCE

We maintain and create HPC software/tools, research novel ways of interacting with data and provide direct support for scientists who use our system.

Projects ranging from optimizing rendering on large systems, data analysis tools for doctors, VR applications for neuroscience, optimizing high resolution tiled display user environments and countless collaborations with scientists across the world (examples at end of slide deck also see sci vis gallery)

TACC SYSTEMS AT A GLANCE

https://www.tacc.utexas.edu/systems/overview

remote vis enabled production system shown in yellow

supported vis systems (with visualization software stack) shown in orange

FRONTERA

HPC, Visualization, Data Analysis Data Intensive Computing

STAMPEDE2

HPC, Visualization, Data Analysis, Data Intensive Computing

LONESTAR 5

HPC, Visualization, Data Analysis

MAVERICK 2

Dedicated deep learning machine

WRANGLER

Data Analysis, Data Management

experimental

FABRIC

Alternate Computer Architectures

DISCOVERY

Testbed Cluster

CATAPULT

A Reconfigurable Architecture for Large Scale Machine Learning

RUSTLER

Data Intensive Computing

VISLAB

Advanced Visualization Resources and Consulting

CHAMELEON

Cloud Computing Testbed

HIKARI

Sustainable Supercomputing

JETSTREAM

Self-Service Cloud System

RODEO

Cloud Computing, Storage

CORRAL

Storage, Data Management

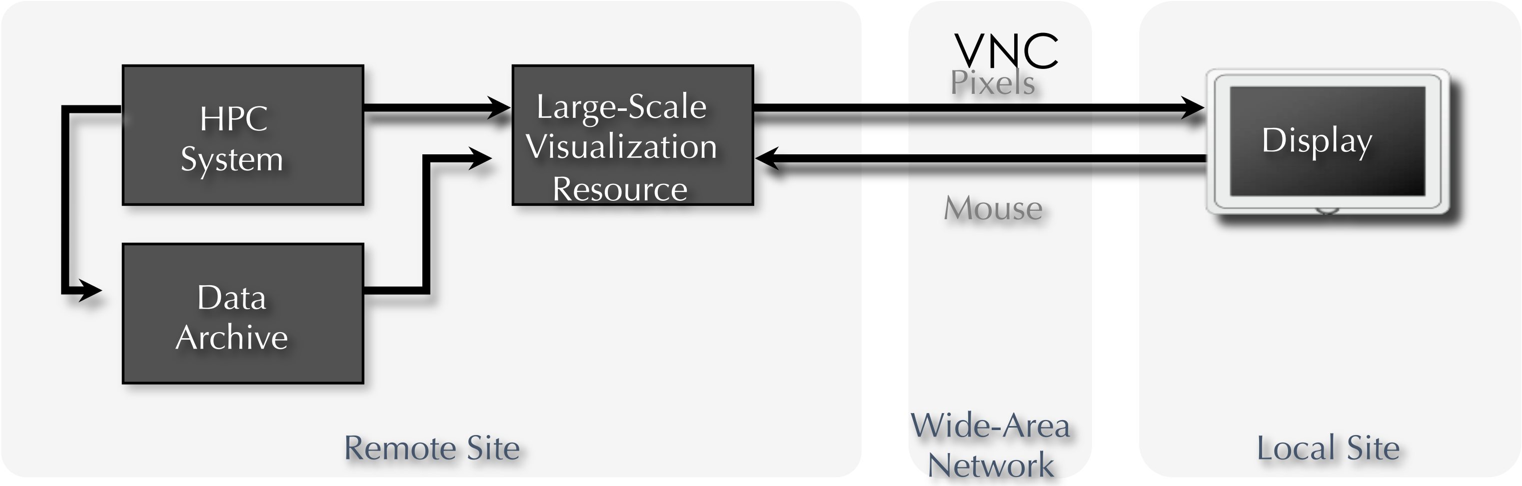
RANCH

Mass Archival Storage

STOCKYARD

Global File System

Old Remote Visualization Model

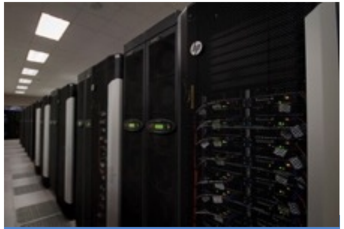


History of Remote Visualization at TACC

Maverick – Sun Fire E25K 3dfx subsystem

Spur – 8 node Sun AMD NVIDIA cluster

Longhorn – 256 node Dell Intel NVIDIA cluster



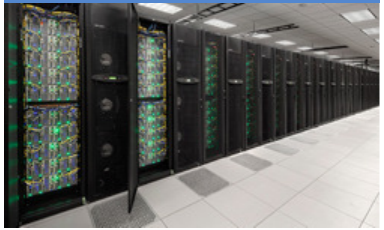
Maverick – 132 node HP Intel NVIDIA cluster

2004 2008 2010 2011 2013 2014

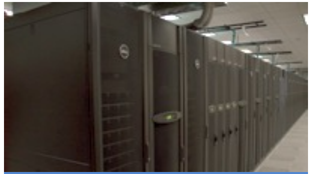
Ranger – 8 node Sun AMD NVIDIA subsystem

Lonestar – 16 node Dell Intel NVIDIA subsystem

Stampede – 128 node Dell Intel NVIDIA subsystem



2015 – present



Stampede2– 5936 node Dell Intel SKX/KNL cluster

FRONTERA

Frontera – 8008 node Dell Intel CLX cluster

TACC

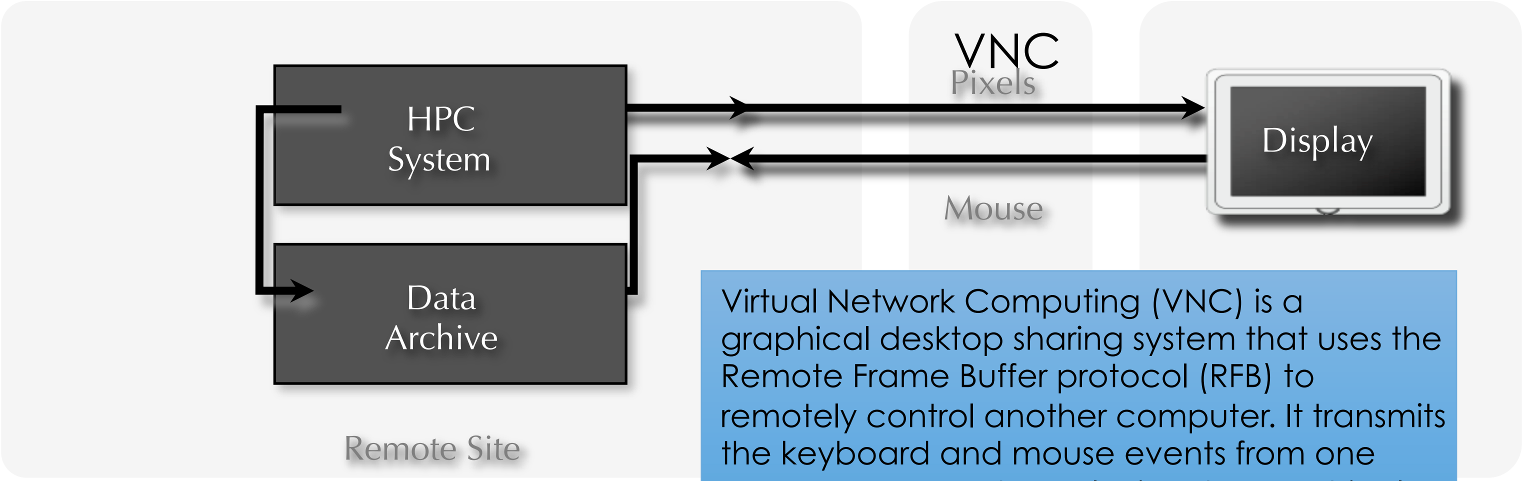
as data set sizes increase…

File Size	100 Gbps	10 Gbps	1 Gbps	300 Mbps	54 Mbps
1 GB	< 1 sec	1 sec	10 sec	35 sec	2.5 min
1 TB	~100 sec	~17 min	~3 hours	~10 hours	~43 hours
1 PB	~1 day	~12 days	~121 days	>1 year	~5 years

TACC

Increasingly Difficult to Move Data from Simulation Machine

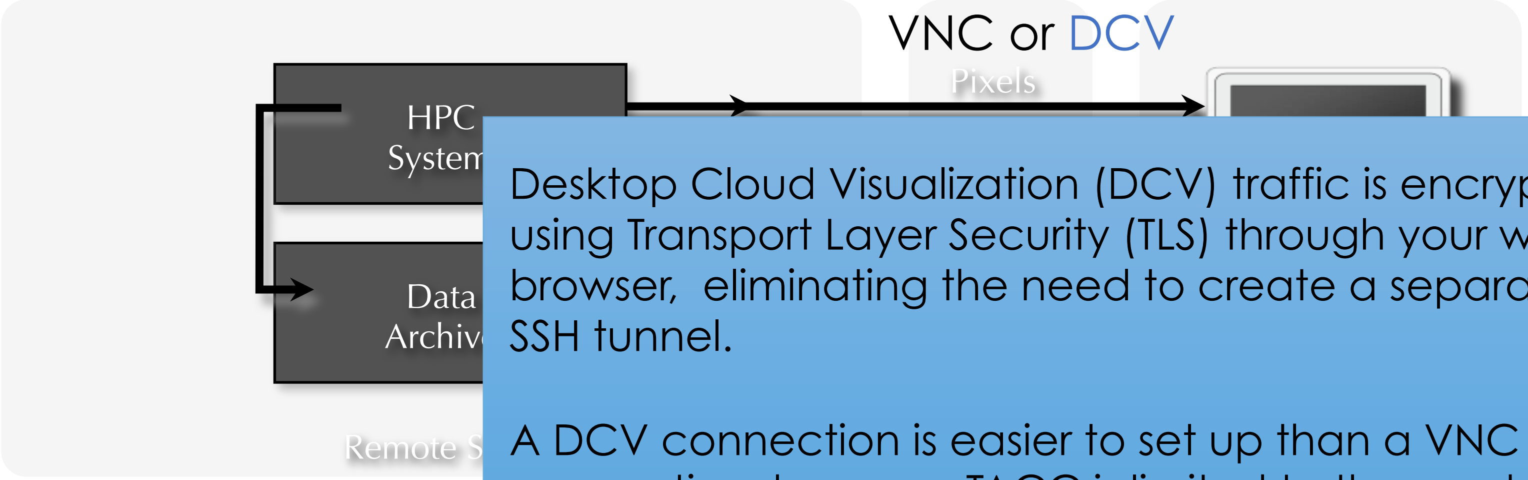
New Remote Visualization Model



Virtual Network Computing (VNC) is a graphical desktop sharing system that uses the Remote Frame Buffer protocol (RFB) to remotely control another computer. It transmits the keyboard and mouse events from one computer to another, relaying the graphical screen updates back in the other direction, over a network

Please use VNC NOT X-forwarding ssh –Y)
VNC (efficiently transmits mouse/keyboard/graphics)

New Remote Visualization Model



Desktop Cloud Visualization (DCV) traffic is encrypted using Transport Layer Security (TLS) through your web browser, eliminating the need to create a separate SSH tunnel.

A DCV connection is easier to set up than a VNC connection, however TACC is limited to the number of concurrent DCV licenses. Stampede2 is currently the only TACC resource allowing DCV connections.

SDVis

http://sdvis.org

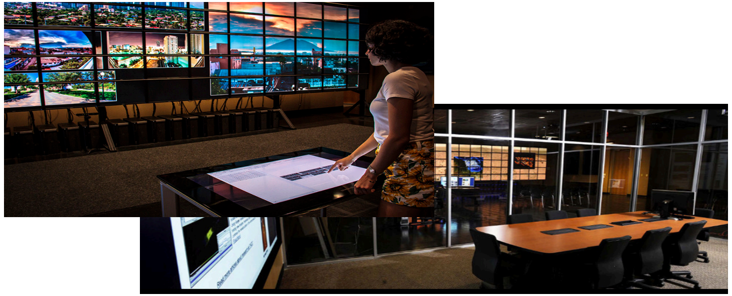
- Software Defined Visualization (SDVis) is an open source initiative to support visualization on workstations through HPC supercomputing clusters without the memory limitations and cost of GPU based solutions.
- Existing applications can be enhanced using the high performing parallel software rendering libraries OpenSWR, Embree, and OSPRay. For example, many major visualization tools such as ParaView, VisIt (binary packages), and VMD adopt our SDVis libraries.

TACC VISUALIZATION RESOURCES

- **Frontera, Stampede2 and Lonestar5** support both interactive and batch visualization on any compute node using the Software-Defined Visualization stack (sdvis.org). **Wrangler and Maverick2** allow remote desktop connections but do not have the full visualization software stack.
- We use the Intel OpenSWR library to render raster graphics with OpenGL, and the Intel OSPRay framework for ray traced images inside visualization software.
- "swr" replaces "vglrun" (e.g. "swr glxgears") and uses similar syntax. OpenSWR can be loaded by executing "module load swr".

TACC VISUALIZATION RESOURCES

https://www.tacc.utexas.edu/vislab



The Vislab serves as a research hub for human-computer interaction, tiled display software development, and visualization consulting. It opportunities to UT faculty, staff and students to use visualization, interaction and computational resources for the exploration and presentation of data.

STALLION
328 Megapixel Tiled-Display system

LASSO
Multi-touch Display

SADDLE
Collaboration Room

SINGLE-USER RESOURCES
Mustang, Horseshoes, zSpace

EXPERIMENTAL TECHNOLOGIES
Leap Motion, Google Glass, Raspberry Pi, Touch Table

OCULUS RIFT
Virtual Reality Head-Mounted Display

BRONCO
Sony 9M Pixel Projection System

TACC VISUALIZATION RESOURCES

Human Data Interaction(HDI) Lab we are experimenting and creating new tools and features for researchers to use so that they can explore their data in different ways to find new discoveries.

- **Rattler** (above)is a multi-configurable display wall that users are able to move about the lab.
- 2 motion capture cameras
- VR/AR devices Oculus Rift, HTC vive and HoloLens
- Multi touch display

Quickstart Tutorial

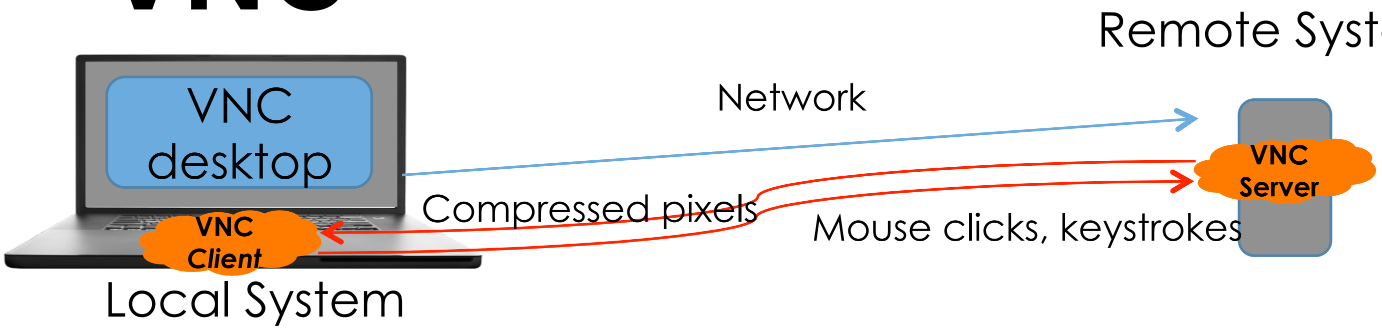
https://portal.tacc.utexas.edu/tutorials/remote-desktop-access

- Start a VNC job on stampede2 (via portal)
- Launch VNC client locally

- Start a VNC job on stampede2 (via ssh)
- Launch VNC client locally

- Start a DCV job
- Launch DCV job (web interface)

VNC



Now any program you run from the VNC desktop on your local system actually runs on the remote system!

VNC protocol is very terse and compact!

1. Connect to remote node
    - SSH from login node or vis portal
    - sbatch job.vnc or request job from vis portal
2. Start VNC Server on remote node
3. Start VNC Client on local system
4. Connect them

Methods of Remote Access for VNC

- Visualization Portal
  - Simplified web-based interface for:
    - Viewing your allocations
    - Submitting jobs
    - Interacting with remote vis sessions (VNC)

- SSH
  - Basic command-line interface, useful for managing files, submitting jobs, etc.

I recommend using a vnc viewer!

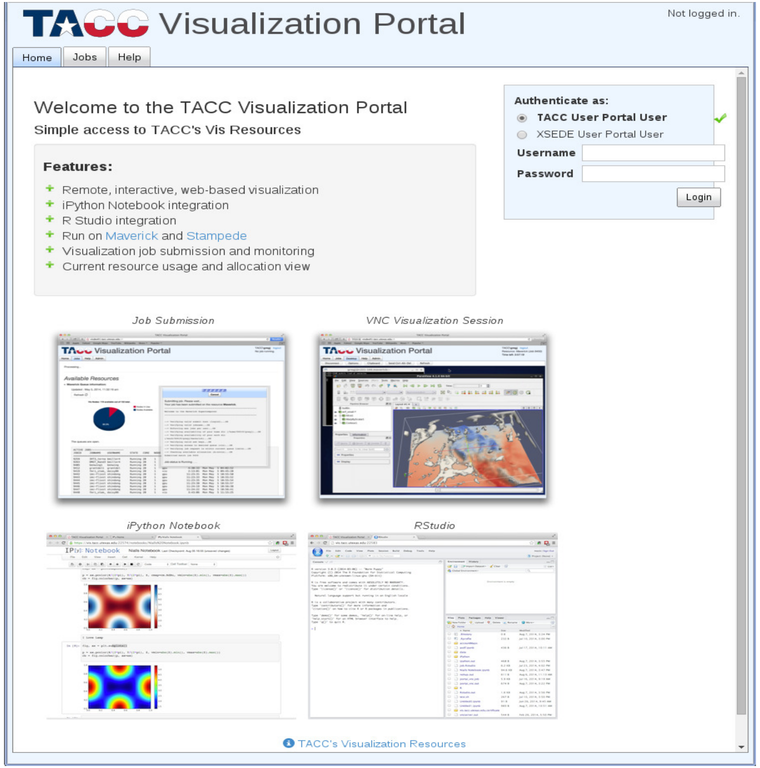
(could run in broswer via portal, but user experience is better with a standalone vnc client)

On Mac, default app "Screen Sharing" works well

Or on other platforms:

https://www.realvnc.com/en/connect/download/viewer/

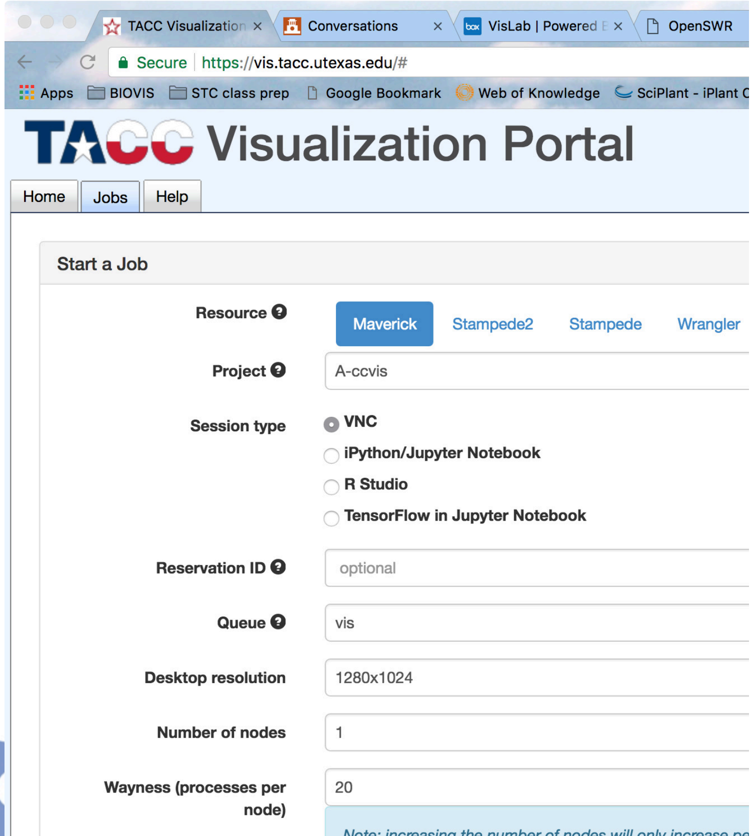
We (try to) Make It Easy – The Vis Portal



- A web-based interface that lets you:
  - View your allocations
  - Submit jobs
  - Interact with remote VNC
  Avoids the hassle and complexity of manually managing your jobs

- http://vis.tacc.utexas.edu

We (try to) Make It Easy – The Vis Portal



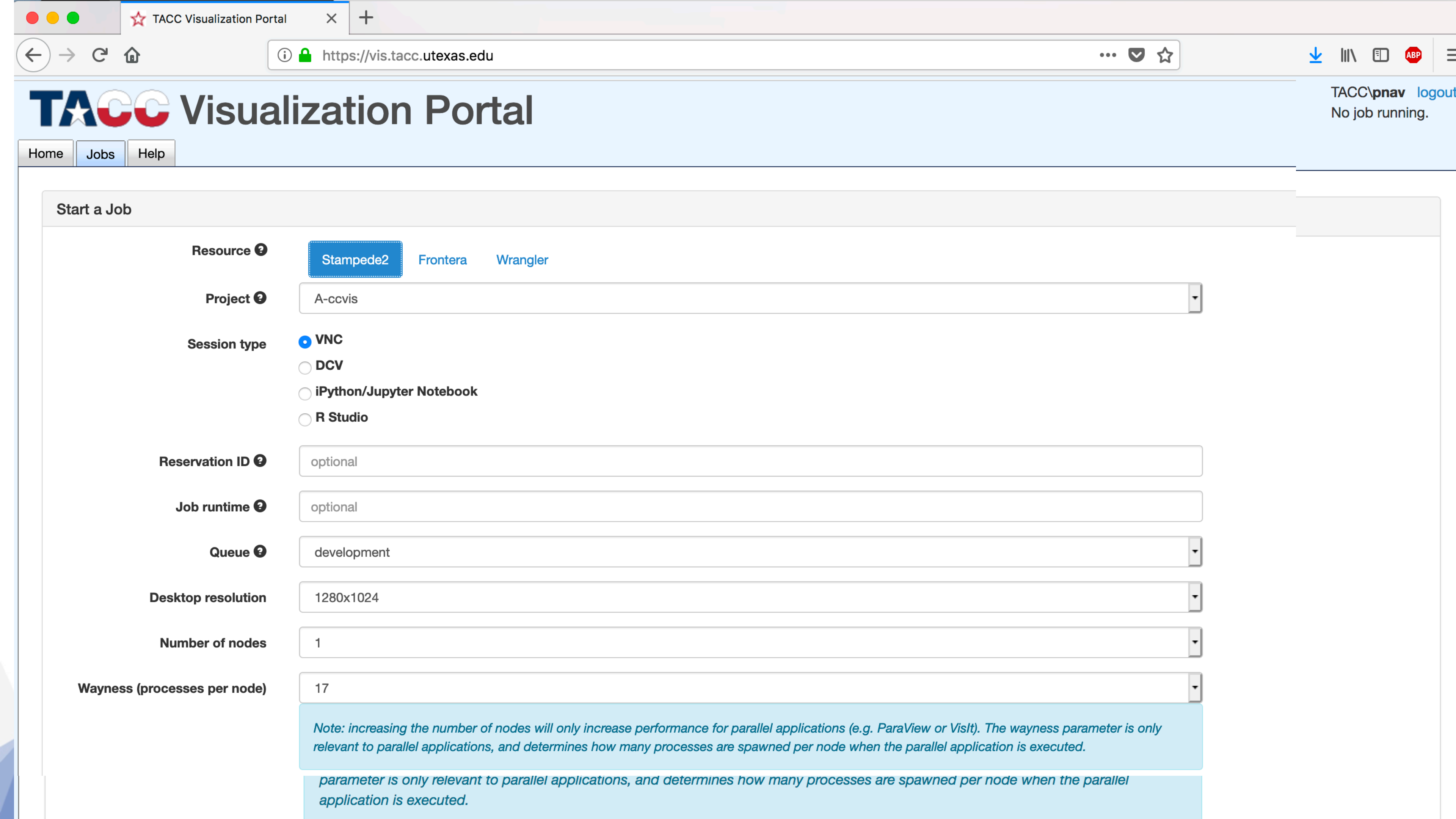
Fill in fields

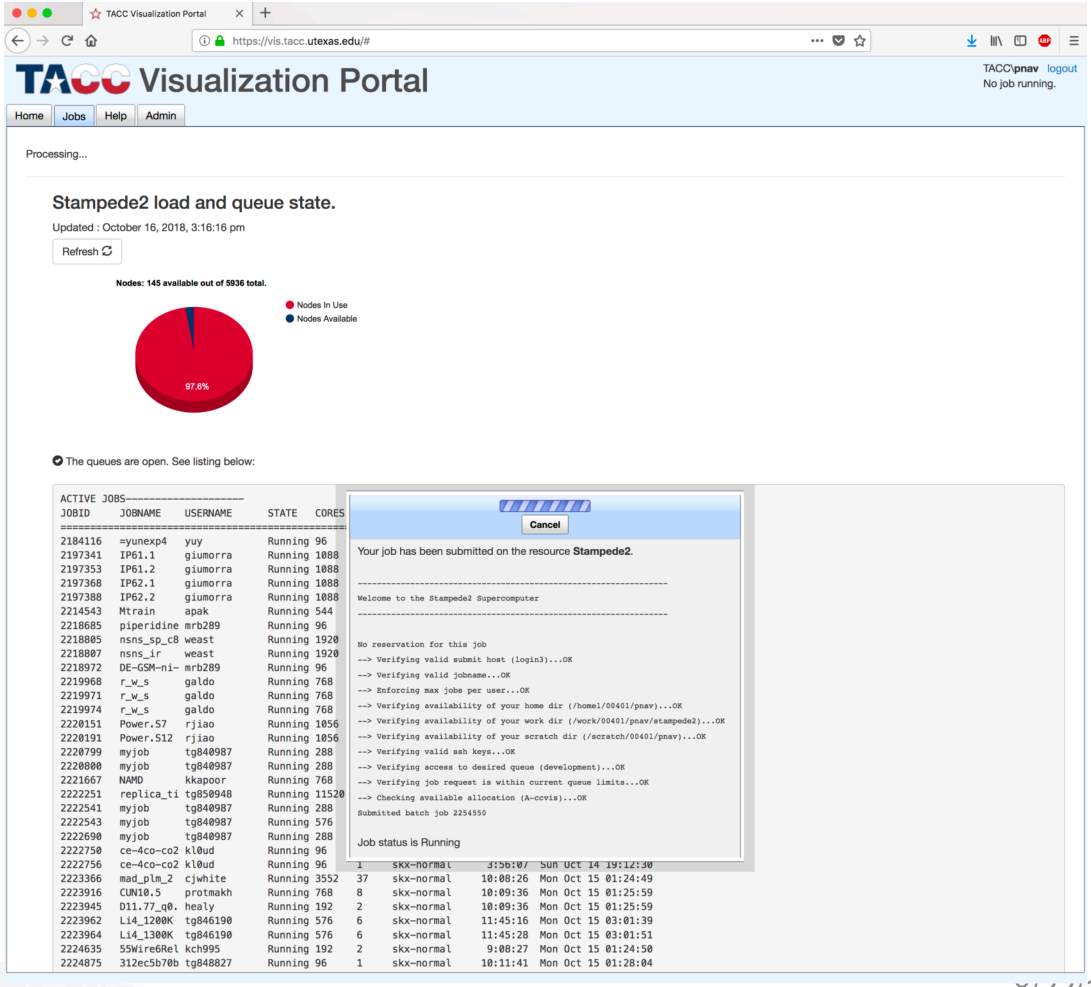
- Which supercomputer
- Project to be billed
- Type
  - VNC
  - iPython/Jupyter Notebook
  - Rstudio
  - TensorFlow/Jupyter Notebook
- Desktop resolution
- Number of nodes
- Number of processes per node

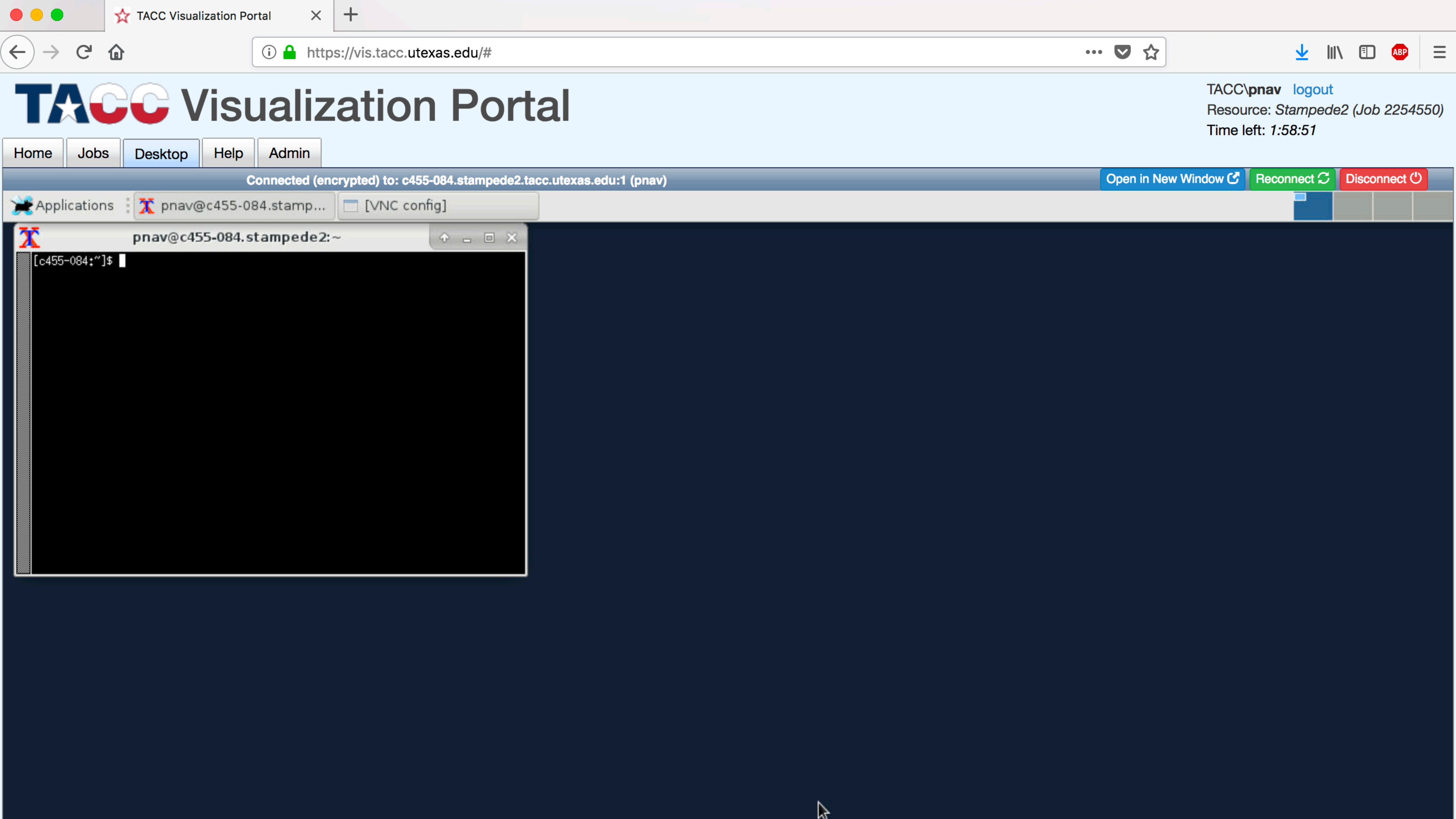
First time – set VNC password

Hit Start Job

Wait for job to run


TACC Visualization Portal
https://vis.tacc.utexas.edu
TACC Visualization Portal
TACC\pnav logout
No job running.
Home
Jobs
Help
Start a Job
Resource
Stampede2
Frontera
Wrangler
Project
A-ccvis
Session type
VNC
DCV
iPython/Jupyter Notebook
R Studio
Reservation ID
optional
Job runtime
optional
Queue
development
Desktop resolution
1280x1024
Number of nodes
1
Wayness (processes per node)
17
Note: increasing the number of nodes will only increase performance for parallel applications (e.g. ParaView or VisIt). The wayness parameter is only relevant to parallel applications, and determines how many processes are spawned per node when the parallel application is executed.
parameter is only relevant to parallel applications, and determines how many processes are spawned per node when the parallel application is executed.


TACC Visualization Portal
https://vis.tacc.utexas.edu/#
TACC Visualization Portal
TACC\pnav logout
No job running.
Home
Jobs
Help
Admin
Processing...
Stampede2 load and queue state.
Updated : October 16, 2018, 3:16:16 pm
Refresh
Nodes: 145 available out of 5936 total.
Nodes In Use
Nodes Available
97.6%
The queues are open. See listing below:
ACTIVE JOBS--------------------
JOBID JOBNAME USERNAME STATE CORES
2184116 =yunexp4 yuy Running 96
2197341 IP61.1 giumorra Running 1088
2197353 IP61.2 giumorra Running 1088
2197368 IP62.1 giumorra Running 1088
2197388 IP62.2 giumorra Running 1088
2214543 Mtrain apak Running 544
2218685 piperidine mrb289 Running 96
2218805 nsns_sp_c8 weast Running 1920
2218807 nsns_ir weast Running 1920
2218972 DE-GSM-ni- mrb289 Running 96
2219968 r_w_s galdo Running 768
2219971 r_w_s galdo Running 768
2219974 r_w_s galdo Running 768
2220151 Power.S7 rjiao Running 1056
2220191 Power.S12 rjiao Running 1056
2220799 myjob tg840987 Running 288
2220800 myjob tg840987 Running 288
2221667 NAMD kkapoor Running 768
2222251 replica_ti tg850948 Running 11520
2222541 myjob tg840987 Running 288
2222543 myjob tg840987 Running 576
2222690 myjob tg840987 Running 288
2222750 ce-4co-co2 kl0ud Running 96
2222756 ce-4co-co2 kl0ud Running 96
2223366 mad_plm_2 cjwhite Running 3552 37 skx-normal 10:08:26 Mon Oct 15 01:24:49
2223916 CUN10.5 protmakh Running 768 8 skx-normal 10:09:36 Mon Oct 15 01:25:59
2223945 D11.77_q0. healy Running 192 2 skx-normal 10:09:36 Mon Oct 15 01:25:59
2223962 Li4_1200K tg846190 Running 576 6 skx-normal 11:45:16 Mon Oct 15 03:01:39
2223964 Li4_1300K tg846190 Running 576 6 skx-normal 11:45:28 Mon Oct 15 03:01:51
2224635 55Wire6Rel kch995 Running 192 2 skx-normal 9:08:27 Mon Oct 15 01:24:50
2224875 312ec5b70b tg848827 Running 96 1 skx-normal 10:11:41 Mon Oct 15 01:28:04
Cancel
Your job has been submitted on the resource Stampede2.
Welcome to the Stampede2 Supercomputer
No reservation for this job
--> Verifying valid submit host (login3)...OK
--> Verifying valid jobname...OK
--> Enforcing max jobs per user...OK
--> Verifying availability of your home dir (/home1/00401/pnav)...OK
--> Verifying availability of your work dir (/work/00401/pnav/stampede2)...OK
--> Verifying availability of your scratch dir (/scratch/00401/pnav)...OK
--> Verifying valid ssh keys...OK
--> Verifying access to desired queue (development)...OK
--> Verifying job request is within current queue limits...OK
--> Checking available allocation (A-ccvis)...OK
Submitted batch job 2254550
Job status is Running


TACC Visualization Portal
https://vis.tacc.utexas.edu/#
TACC Visualization Portal
TACC\pnav logout
Resource: Stampede2 (Job 2254550)
Time left: 1:58:51
Home
Jobs
Desktop
Help
Admin
Connected (encrypted) to: c455-084.stampede2.tacc.utexas.edu:1 (pnav)
Open in New Window
Reconnect
Disconnect
Applications
pnav@c455-084.stamp...
[VNC config]
pnav@c455-084.stampede2:~
[c455-084:~]$

TACC Visualization Portal

TACC\pnav logout
Resource: *Stampede2 (Job 4210767)*
Time left: *1:59:40*

Home | Jobs | Help

Your DCV session is running on Stampede2.

Open DCV in Browser

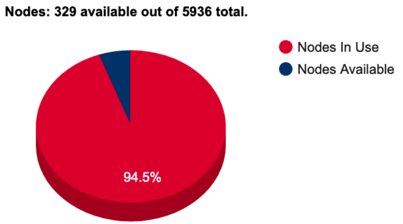
Terminate DCV Session

Session available at: https://stampede2.tacc.utexas.edu:16355

Stampede2 load and queue state.

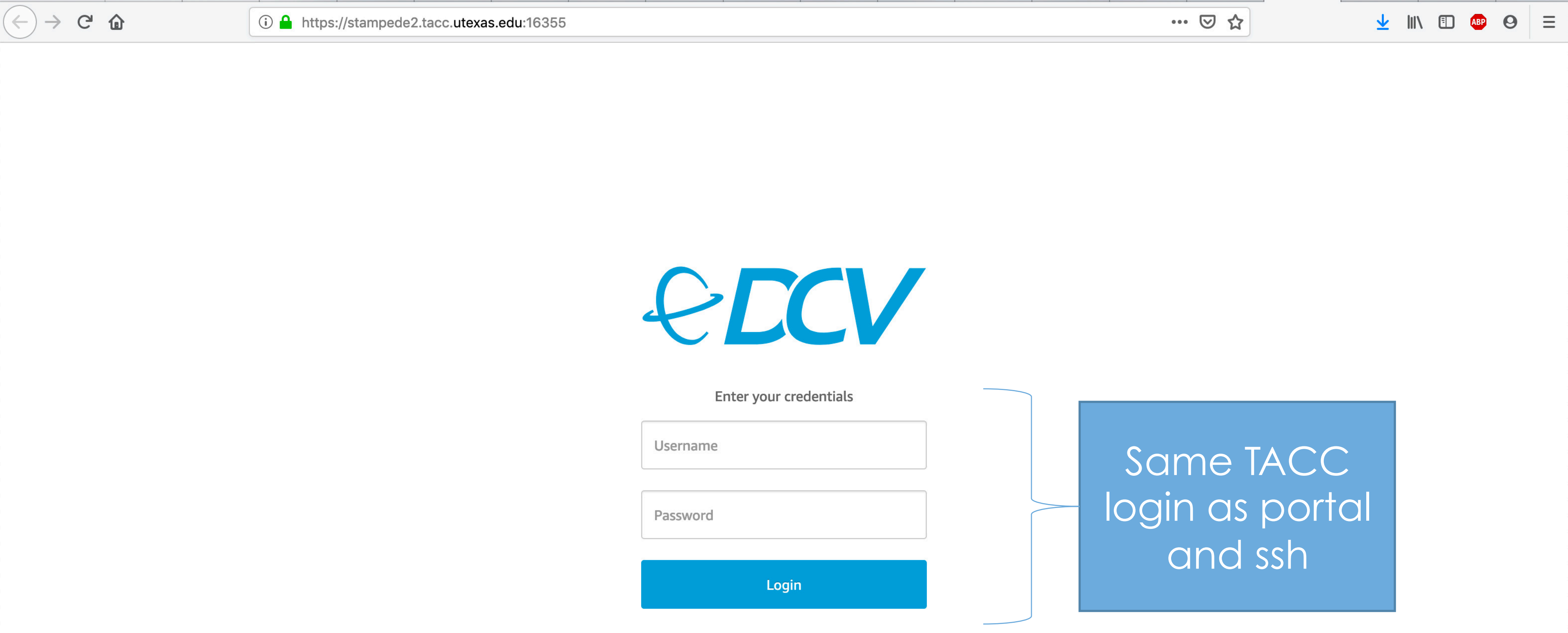
Updated : August 21, 2019, 10:01:04 pm

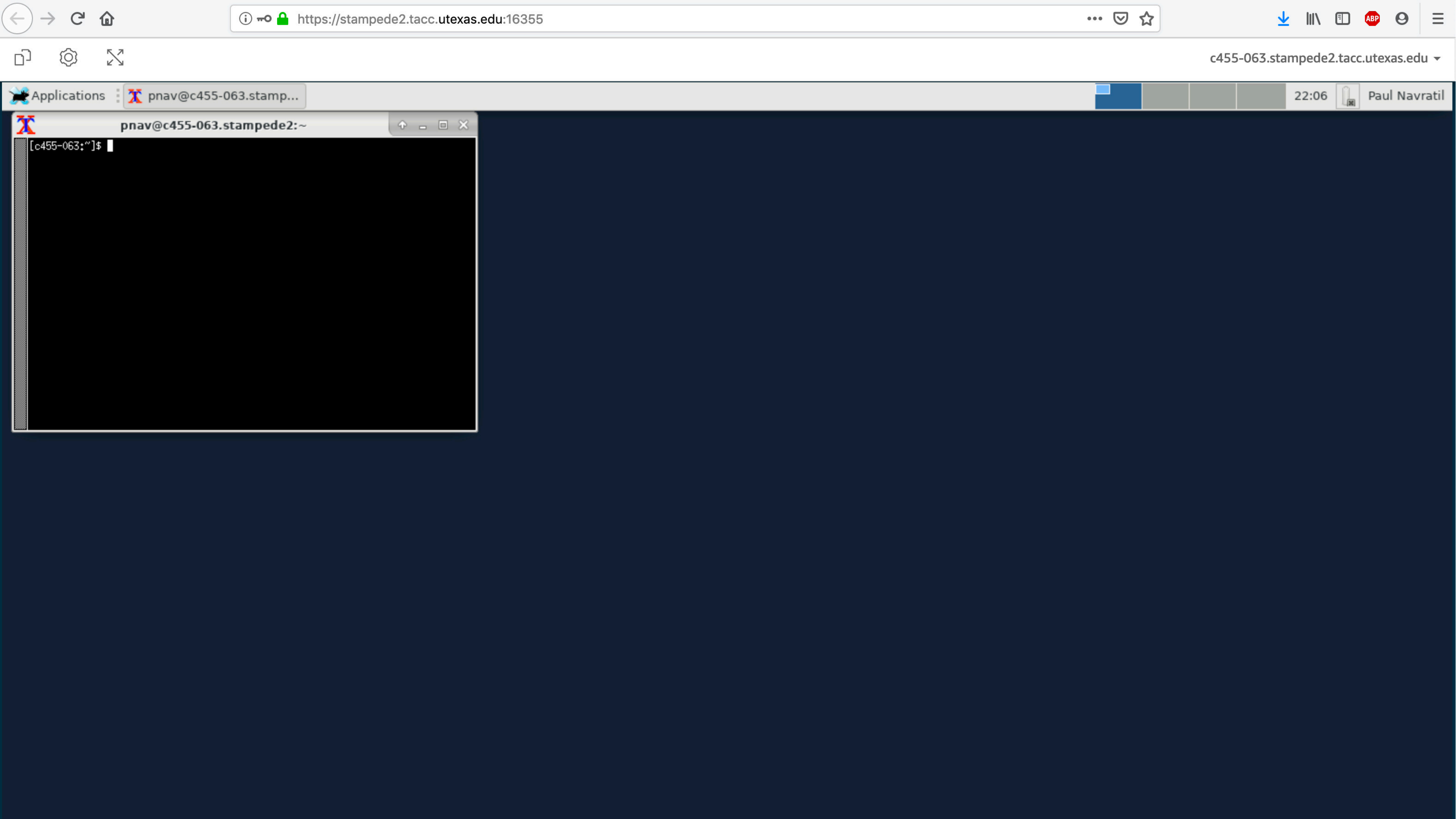
Refresh



The queues are open. See listing below:

```
ACTIVE JOBS--------------------
JOBID     JOBNAME    USERNAME      STATE   CORES  NODES QUEUE         REMAINING STARTTIME
===================================================================================
4102142   YYY        armanf        Running 272    1     normal          6:26:10  Tue Aug 20 04:27:29
4102181   YYY        armanf        Running 272    1     normal          3:36:41  Tue Aug 20 01:38:00
```


https://stampede2.tacc.utexas.edu:16355
DCV
Enter your credentials
Username
Password
Login
Same TACC login as portal and ssh


https://stampede2.tacc.utexas.edu:16355
c455-063.stampede2.tacc.utexas.edu
Applications
pnav@c455-063.stamp...
22:06
Paul Navratil
pnav@c455-063.stampede2:~
[c455-063:~]$

```
[login3:~]$ touch vncserver.out
[login3:~]$ tail -f vncserver.out
using default VNC server /bin/vncserver
memory limit set to 186124209 kilobytes
set wayness to
got VNC display :1
local (compute node) VNC port is 5901
got login node VNC port 23288
Created reverse ports on Frontera logins
Your VNC server is now running!
To connect via VNC client:  SSH tunnel port 23288 to frontera.tacc.utexas.edu:23288
                            Then connect to localhost:23288
```

```
[login3:~]$ touch dcvserver.out
[login3:~]$ tail -f dcvserver.out
TACC: job 33464 execution at: Tue Aug 13 10:42:58 CDT 2019
TACC: running on node c188-114
TACC: local (compute node) DCV port is 8443
TACC: got login node DCV port 21488
TACC: Created reverse ports on Frontera logins
TACC: Your DCV session is now running!
TACC: To connect to your DCV session, please point a modern web browser to:
TACC:          https://frontera.tacc.utexas.edu:21488
```

TACC Visualization Portal

TACC\pnav logout
Resource: *Stampede2 (Job 4213902)*
Time left: *1:57:47*

Home | Jobs | Help

Your iPython Notebook session is running on Stampede2.

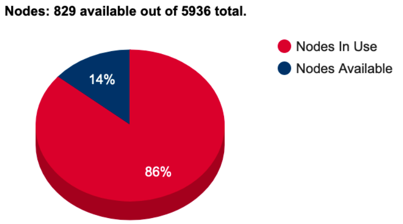
Open Jupyter in Browser

Terminate Jupyter

Stampede2 load and queue state.

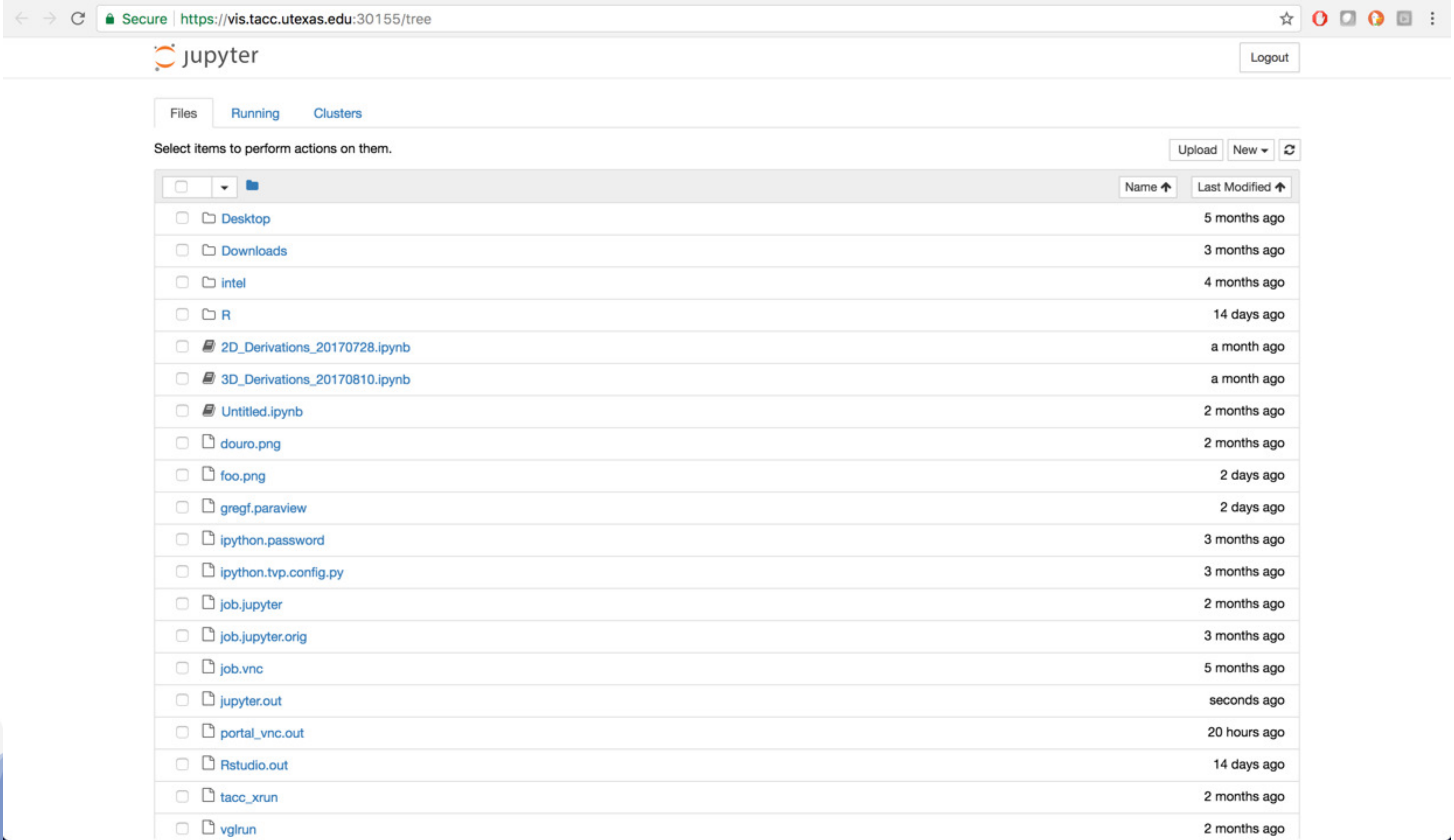
Updated : August 22, 2019, 10:43:51 am

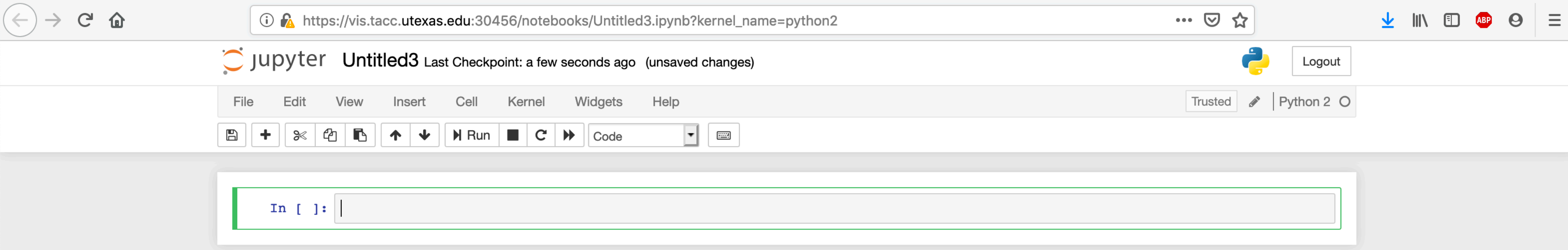
Refresh



The queues are open. See listing below:

```
ACTIVE JOBS--------------------
JOBID     JOBNAME    USERNAME      STATE   CORES  NODES QUEUE         REMAINING STARTTIME
================================================================================
4102143   YYY        armanf        Running 272    1     normal        41:44:12  Thu Aug 22 04:28:15
4102182   YYY        armanf        Running 272    1     normal        38:55:08  Thu Aug 22 01:39:11
4125924   0702L438_3 tg828509      Running 1536   16    skx-normal    33:10:12  Wed Aug 21 19:54:15
4137774   x1y32z4r12 jwalker       Running 2176   8     normal        46:16:57  Thu Aug 22 09:01:00
4139715   x1y32z4r64 jwalker       Running 272    1     normal         3:09:26  Tue Aug 20 13:53:29
4139732   x1y16z8r64 jwalker       Running 272    1     normal         3:13:01  Tue Aug 20 13:57:04
```


Secure | https://vis.tacc.utexas.edu:30155/tree
jupyter
Logout
Files
Running
Clusters
Select items to perform actions on them.
Upload
New
Name
Last Modified
Desktop 5 months ago
Downloads 3 months ago
intel 4 months ago
R 14 days ago
2D_Derivations_20170728.ipynb a month ago
3D_Derivations_20170810.ipynb a month ago
Untitled.ipynb 2 months ago
douro.png 2 months ago
foo.png 2 days ago
gregf.paraview 2 days ago
ipython.password 3 months ago
ipython.tvp.config.py 3 months ago
job.jupyter 2 months ago
job.jupyter.orig 3 months ago
job.vnc 5 months ago
jupyter.out seconds ago
portal_vnc.out 20 hours ago
Rstudio.out 14 days ago
tacc_xrun 2 months ago
vglrun 2 months ago



Uses the default python in your environment!

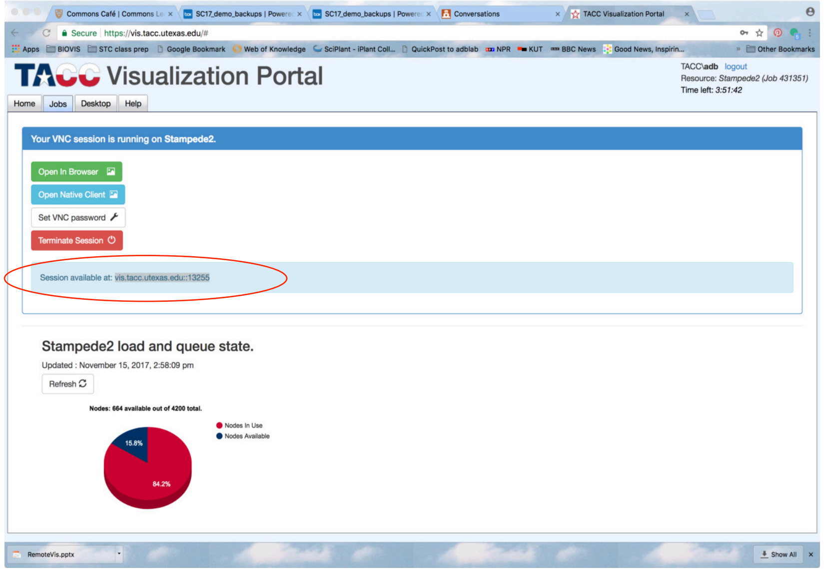
To use python3, edit your environment to include

```
module load python3
alias python=python3
```

To use Conda (if you are *sure* the notebook build works)

```
export TACC_VIS_ALLOW_CONDA=1
```

Accessing your VNC session with a stand-alone viewer

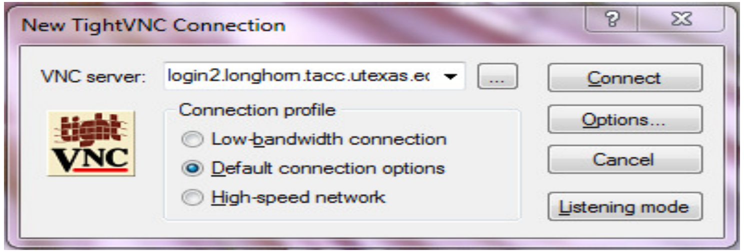


Navigate to the Jobs tab

Copy the server address

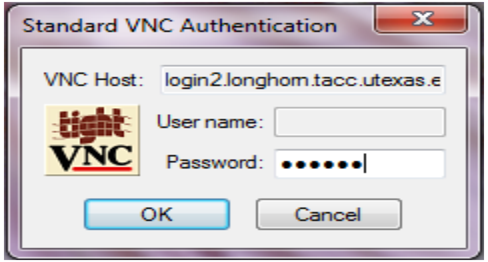
Accessing your VNC session with a stand-alone viewer

Navigate to the Jobs tab
Copy the server address
Paste into Mac "Screen Sharing"



Run YOURFAVORITE_VNC application

- *Enter the server address from the Jobs tab*
- *Click Connect*
- *Enter your VNC password set previously*
- *Click Okay*



TACC

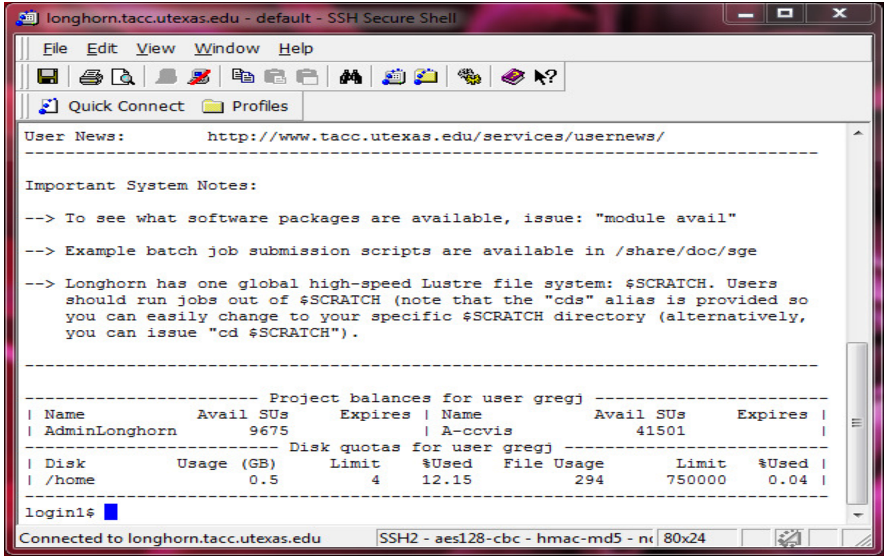
VNC via SSH Access

ssh to stampede2

You're now on a stampede2 login node

Can run usual shell utilities

Manage data, etc.



[please reference user guide!](#)

SSH Access

- Can submit a remote VNC job from remote machine:
  - sbatch /share/doc/slurm/job.vnc
  - tail -f vncserver.out
  - Start a tunnel (for security!)
  - Connect to address in output file with a VNC viewer

```
job 3645 execution at: Wed Jan 27 14:18:16 CST 2010
running on node c201-121
using default VNC server /opt/apps/tightvnc/1.3.10/bin/vncserver
memory limit set to 46960947 kilobytes
set wayness to 8
got VNC display :1
local (compute node) VNC port is 5901
got login node VNC port 10121
Your VNC server is now running!
To connect via VNC client:  SSH tunnel port 10121 to login1.longhorn.tacc.utexas
.edu:10121
                            Then connect to localhost::10121
```

Connected to longhorn.tacc.utexas.edu | SSH2 - aes128-cbc - hmac-md5 - nc | 80x24

What is a ssh tunnel (aka port-forwarding)?
SSH tunneling is a method of transporting networking data over an encrypted SSH connection. It is used to add encryption to applications.

Take a look at `/share/doc/slurm/job.vnc`

can make a copy in a local directory and modify if desired

```
#
# To submit the job, issue: "sbatch /share/doc/slurm/job.vnc"
#
# For more information, please consult the User Guide at:
#
# https://portal.tacc.utexas.edu/user-guides/stampede2
#-----------------------------------------------------------------------------
#
#SBATCH -J vncserver            # Job name
#SBATCH -o vncserver.out              # Name of stdout output file (%j expands to jobId)
#SBATCH -p development                # Queue name
#SBATCH -N 1                          # Total number of nodes requested (68 cores/node)
#SBATCH -n 17                         # Total number of mpi tasks requested
#SBATCH -t 02:00:00             # Run time (hh:mm:ss) - 4 hours

#--------------------------------------------------------------------------
# ---- You normally should not need to edit anything below this point -----
#--------------------------------------------------------------------------
```

Running Vis Applications through VNC

To see available applications:

module avail

To see how to load/run an application;

module spider paraview

To see how to load/run an application;

module spider paraview/5.6.0

Examples:

Run ParaView

```
module load  intel/18.0.0  impi/18.0.0 qt5 swr ospray paraview/5.6.0


The following have been reloaded with a version change:
  1) impi/18.0.2 => impi/18.0.0     2) intel/18.0.2 => intel/18.0.0

swr paraview
```

TACC

COMMON VISUALIZATION APPLICATIONS

Paraview (general purpose parallel Sci Vis)

Visit (general purpose parallel Sci Vis)

VMD (molecular vis)

OpenCV (image analysis)

yt (astrophysics)

VTK (visualization library)

qGIS (geographical vis, via the design safe portal https://www.designsafe-ci.org)

OpenSWR (OpenGL-compatible software renderer)

plus more: xsede portal software search

Services/Training/Help:

- Summer Institutes
- Ask a question via the ticket system
- Reserve the Vislab (POB on main UT campus)

Why do we focus on VisIt and Paraview for our SciVis training/tutorials?

- Open-source, multi-platform **parallel** data analysis and visualization application available on our machines
- Good for general-purpose, rapid visualization
- Built upon the Visualization ToolKit (VTK) library
- The interface looks the same whether you run locally or remotely, serial or in parallel

Note: Works best with data that is (or can be) represented by a grid

Focus on data-sets/visualization tasks that would benefit from HPC resources and HPC tools:

Large data :

- Data cannot (would take to much time or is too large) be moved off system where it is computed
- Visualization requires parallel systems for enough memory and/or compute

Small data:

- Data are small and easily moved
- Office machines and laptops are adequate for visualization

We focus on “scientific” visualization tools/tutorials, what does that mean?

- Scientific Visualization deals with data for which the spatial representation is given or known (primarily gridded data)

- Information Visualization chooses a spatial representation for what is otherwise abstract unstructured data.

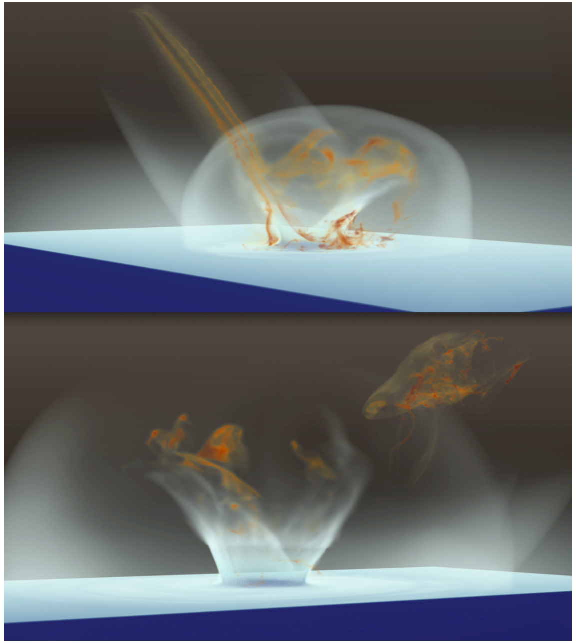
Often quite a bit of overlap!

The Power of Visualization: Allows Us to “See” the Science

*A picture can represent *giga-, tera- and peta-bytes of data that is otherwise incomprehensible*

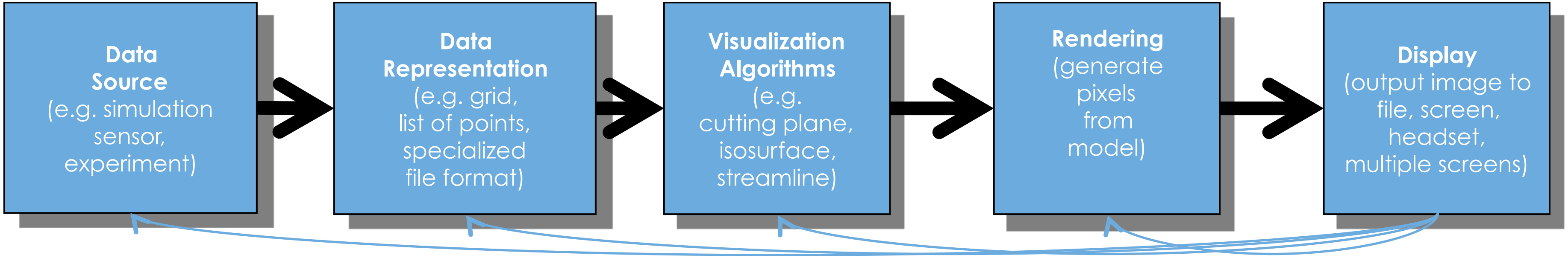
Shown here are two time-steps of a simulation of a 250m asteroid impacting the ocean surface. Water vapor arising from the impact is shown in light blue, asteroid fragments in orange.

[Full Movie Here]



Visualization: Francesca Samsel, Greg Abram, UT Austin Science: G.Gisler, J. Patchett, LANL

Visualization Pipeline



Adjust Simulation Parameters

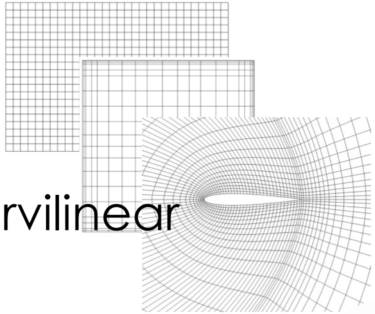
Refinement

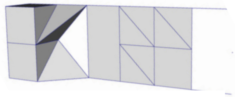
Changing Techniques

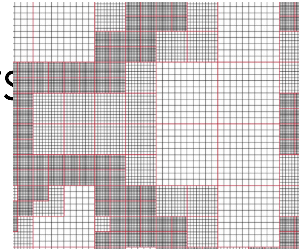
… adjust according to needs/goals

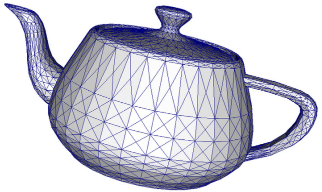
Example Input Data Types: *

- Paraview/VisIT support:
  - Structured grids
    - uniform rectilinear, rectilinear, and curvilinear
  - Unstructured grids
  - Point data
  - Polygonal data (specialized unstructured grid)
  - Adaptive Mesh Refinement
  - Many other specialty formats





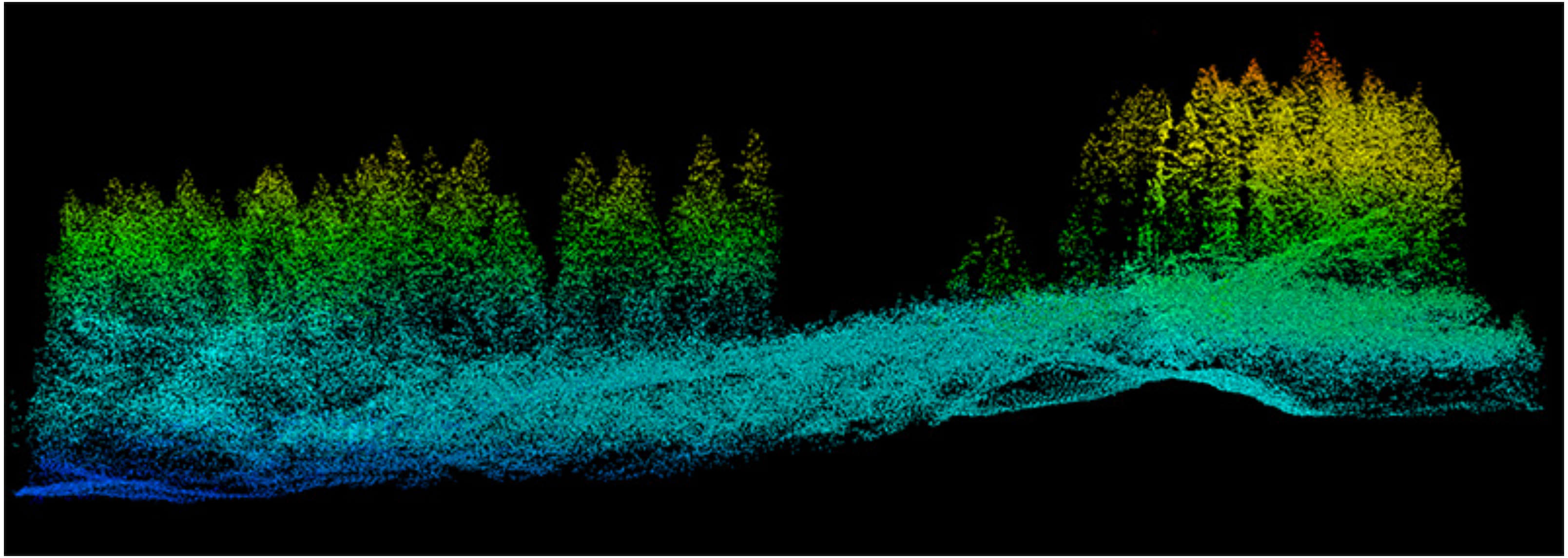




*http://www.paraview.org/Wiki/images/c/c6/ParaViewTutorial312.pdf

Input Data Types (examples)

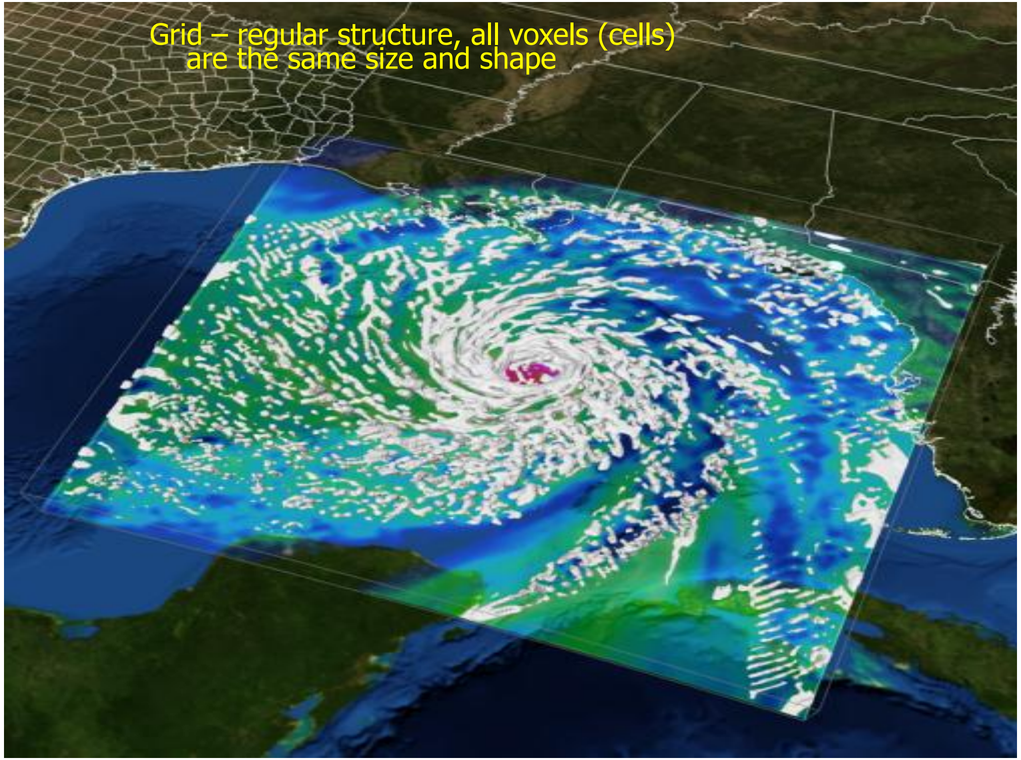
Point – scattered values with no defined structure



lidar point cloud of a forest

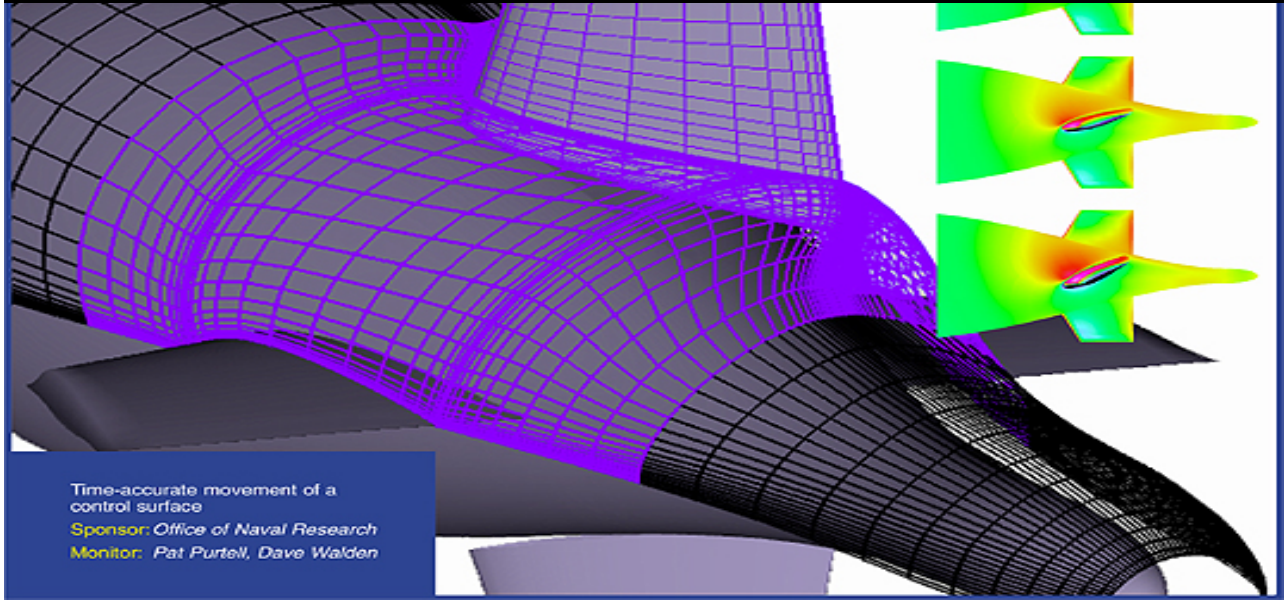
http://gsp.humboldt.edu/OLM/Courses/GSP_216_Online/lesson7-1/data.html

Input Data Types (examples)

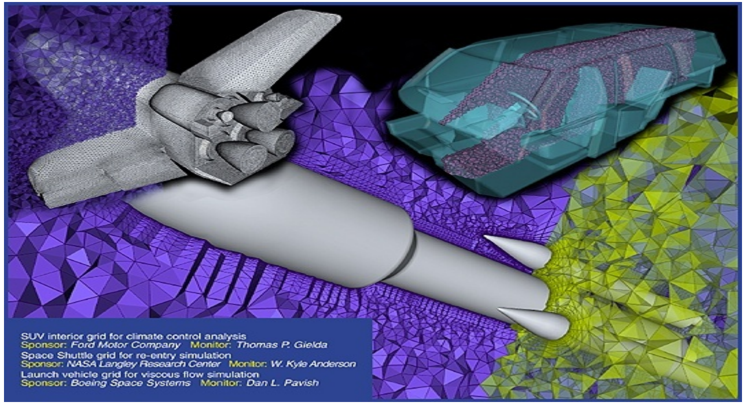


Input Data Types (examples)

Curvilinear – regularly grided mesh
shaping function applied

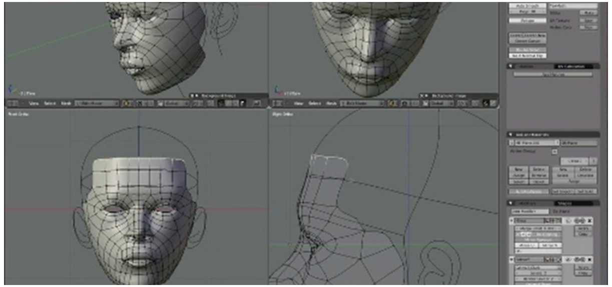


Input Data Types (examples)



Unstructured grid – irregular mesh typically composed of tetrahedra, prisms, pyramids, or hexahedra.

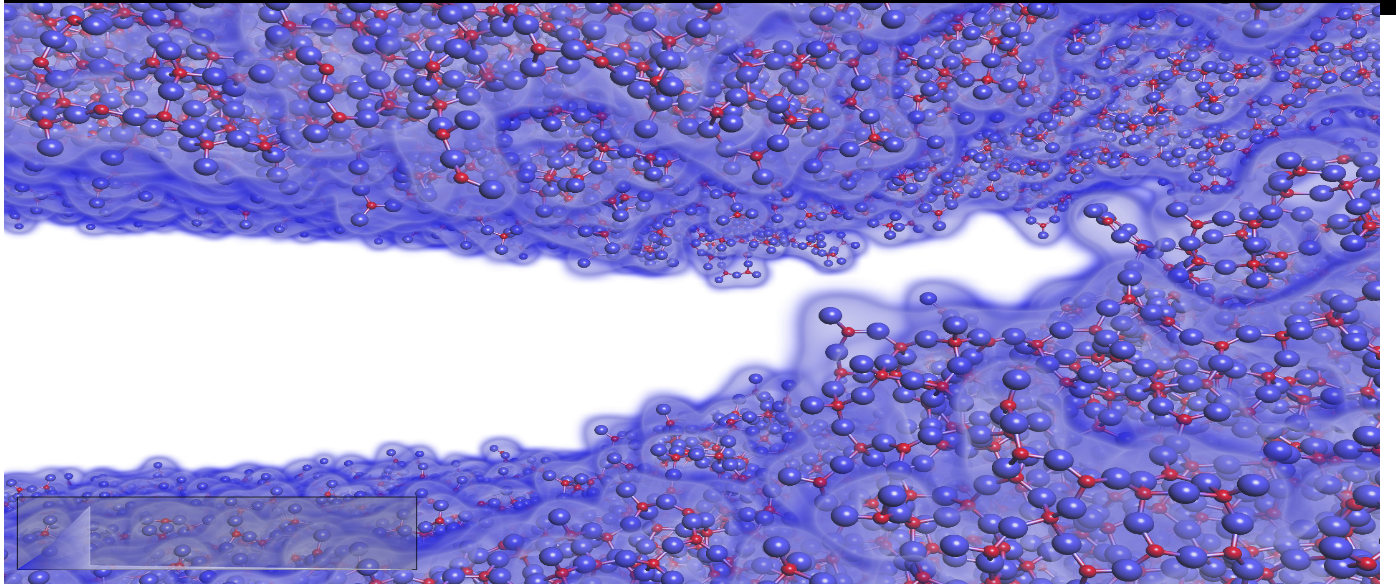
polygonal



3d modeling (blender)

Input Data Types (examples)

Non-mesh connected point data
(e.g. molecular)

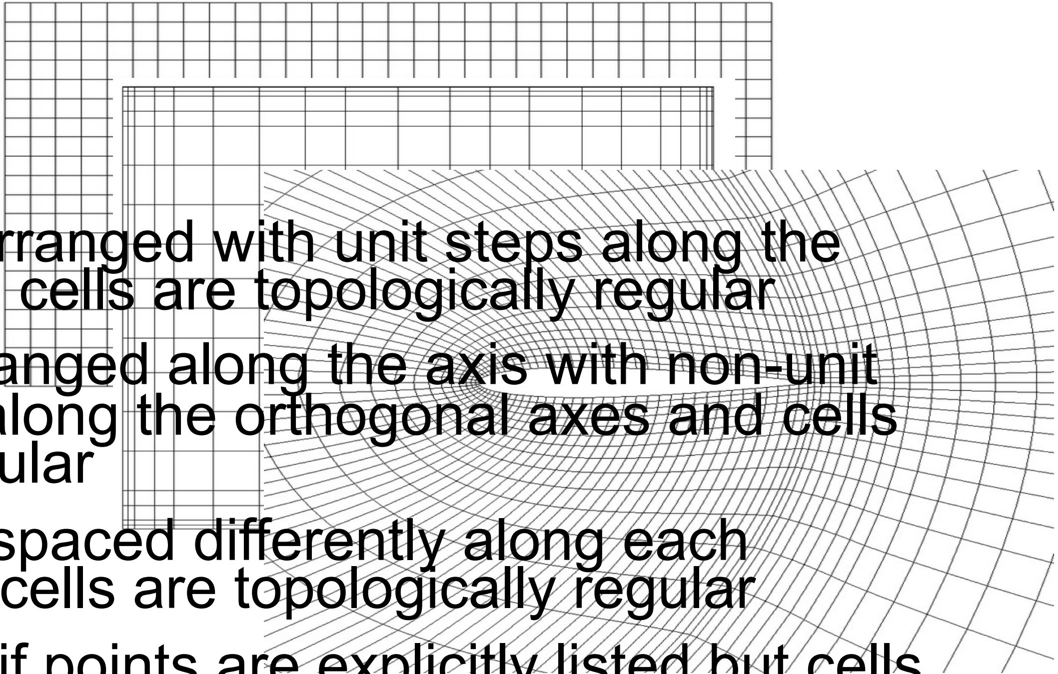


Grid Considerations

Cartesian Regular Rectilinear	<<	Structured	<<	Unstructured

- Structured and unstructured grids use *much, much* more space and compute

Grid Types



Cartesian if points are arranged with unit steps along the orthogonal axes and cells are topologically regular

Regular if points are arranged along the axis with non-unit but equal step size along the orthogonal axes and cells are topologically regular

Rectilinear if points are spaced differently along each orthogonal axis and cells are topologically regular

Structured (Curvilinear) if points are explicitly listed but cells remain topologically regular

Unstructured if both points and cells are explicitly listed

Parallel Visualization

- Often Visualization tasks need more memory than is provided by one node…parallel visualization is only *partly* about upping the compute power available, its also about getting sufficient memory and I/O bandwidth.
- I/O is a *really big* issue. Planning how to write your data for parallel access, and placing it where it can be accessed quickly, is critical.

Parallel Data Formats

To run in parallel, data must be distributed among parallel subprocess' memory space

- ***Unstructured* data formats** are "data-soup" – without additional information, data must be:
  - Read into one process serially, partitioned and distributed
  - Read in entirety into *each* process, relevant parts kept, rest discarded
- ***Structured* data formats** can be decomposed into partitions and read in parallel (up to the limits of the underlying file system)
- ***Parallel* formats** contain information enabling each subprocess to import its own subset of data simultanously
  - *Maximize bandwith into parallel visualization process*
  - *Minimize reshuffling for ghost-zones*

Visualization Algorithms

F(domain) → attributes

- Attributes are physical properties often represented as:
  - Scalars (e.g. temperature)
  - Vectors (e.g. wind direction)
- Lots of ways to visualize attributes (examples follow..)

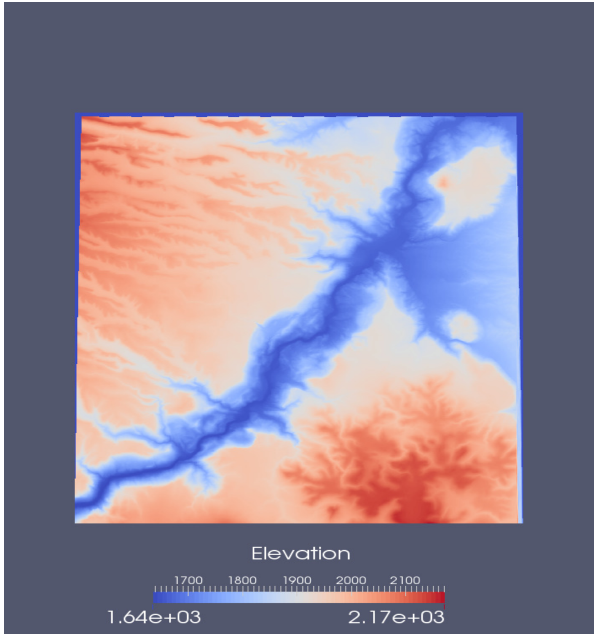
Attribute Visualization

- 2-D Example: The elevation of terrain

- F(lat, lon) → elevation

- Here elevation is interpreted as color

- can you guess the locale?



Attribute Visualization

2-D Example: The elevation of terrain

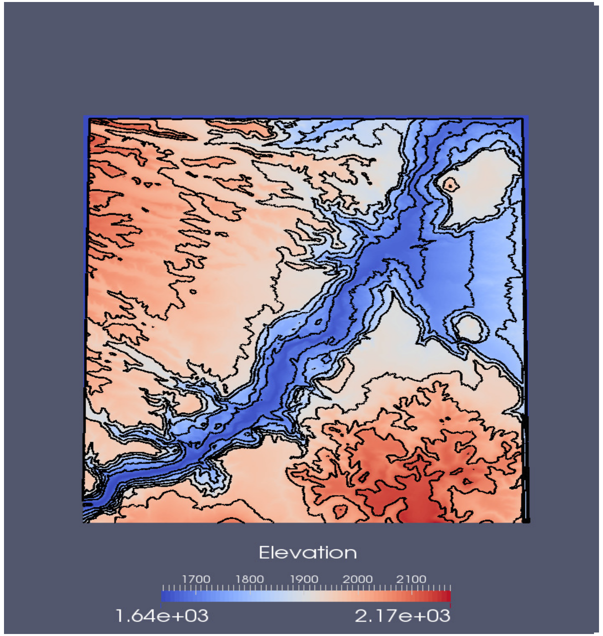
Join points of equal height

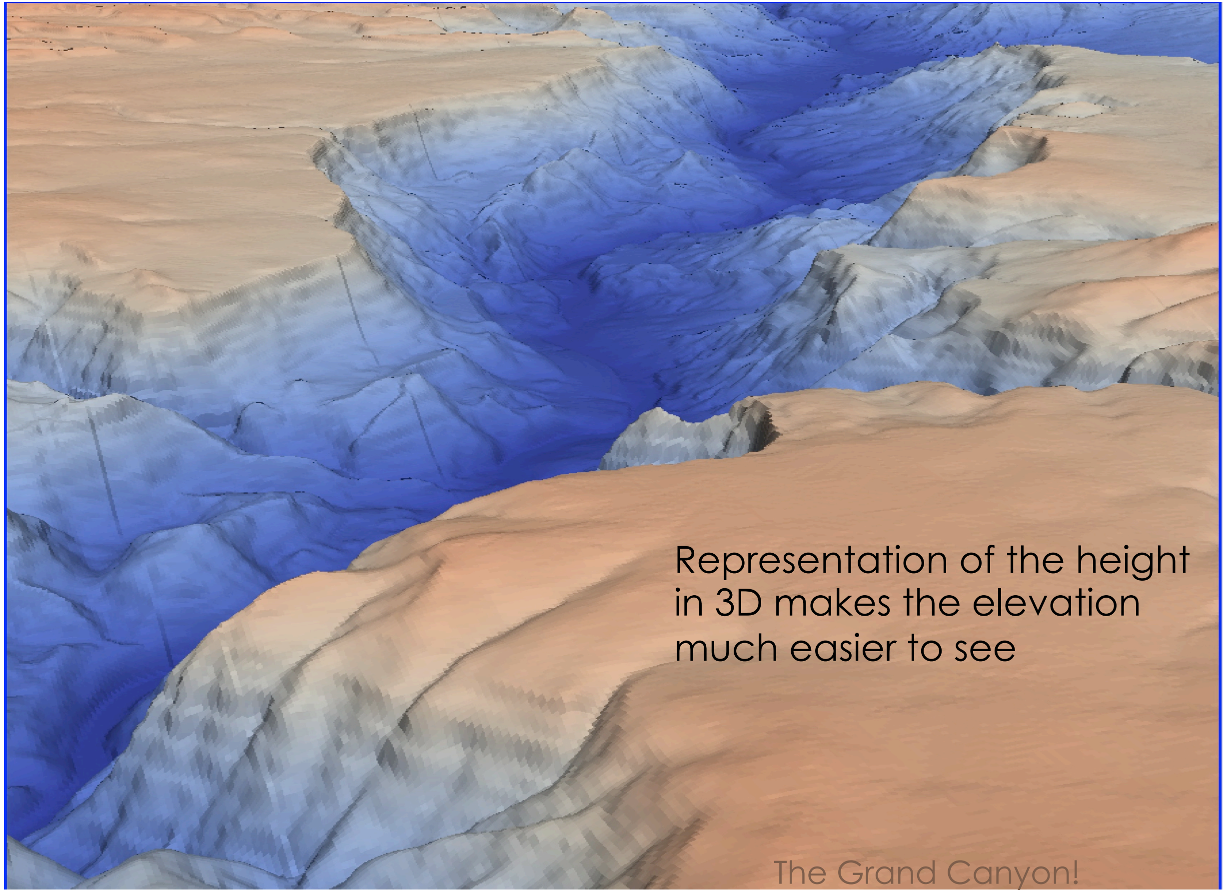
with a line, called a

contour line (or isoline)

F(lat, lon) → elevation

Insert contour lines to create
[a topographic map]



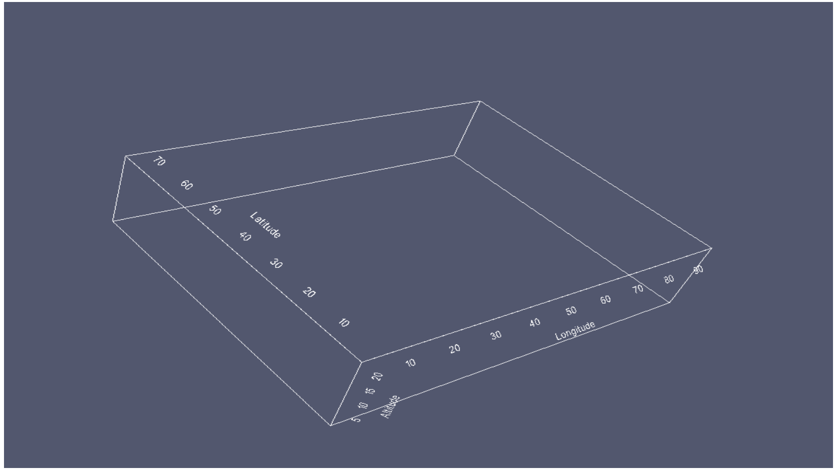

Representation of the height in 3D makes the elevation much easier to see
The Grand Canyon!

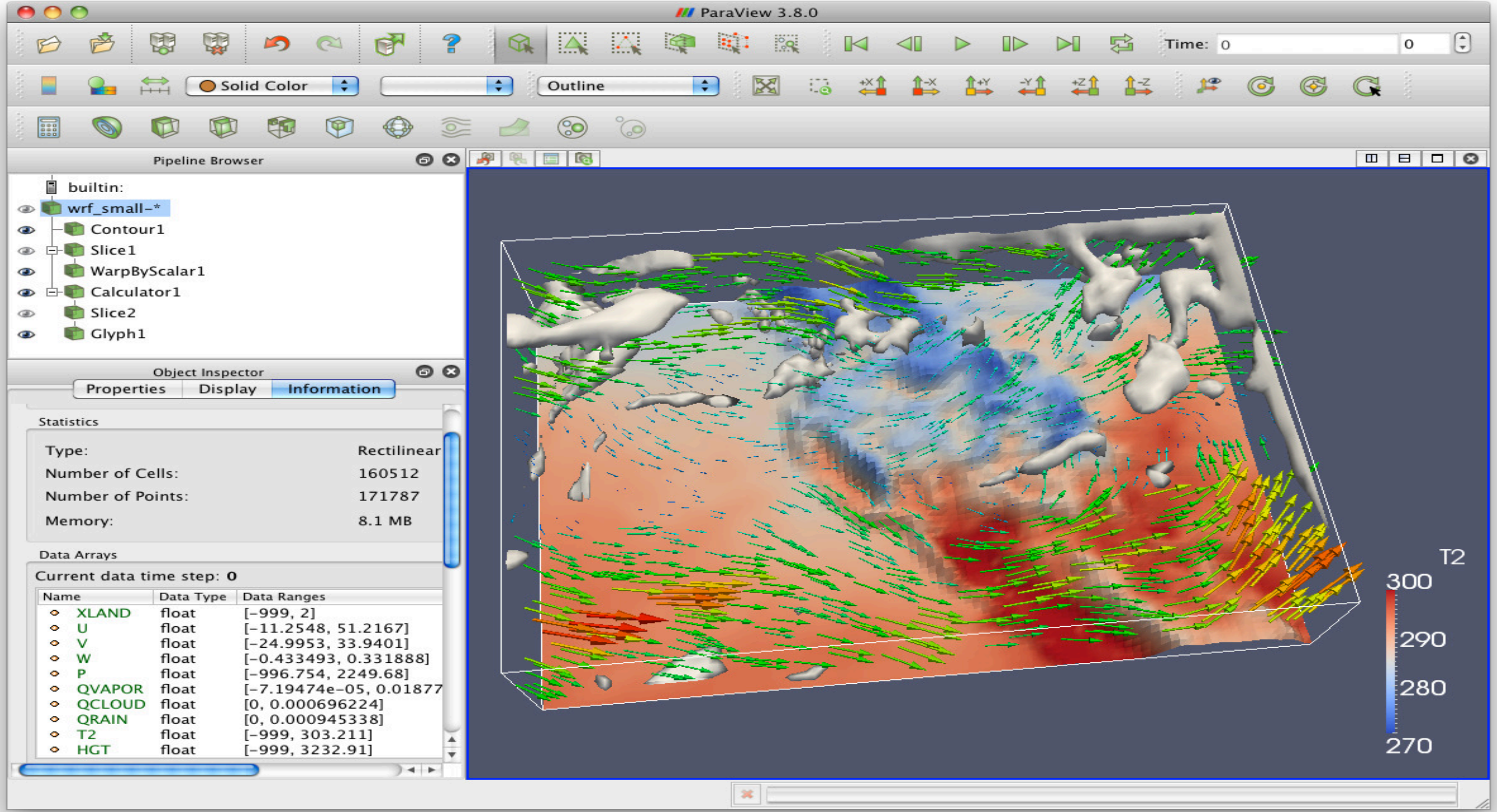
Attribute Visualization

3-D Example: Weather (from our Paraview tutorial)

F(lat, lon, *alt*) →
(temp, pressure, wind…)

temp, pressure are *scalars*
wind is a *vector*

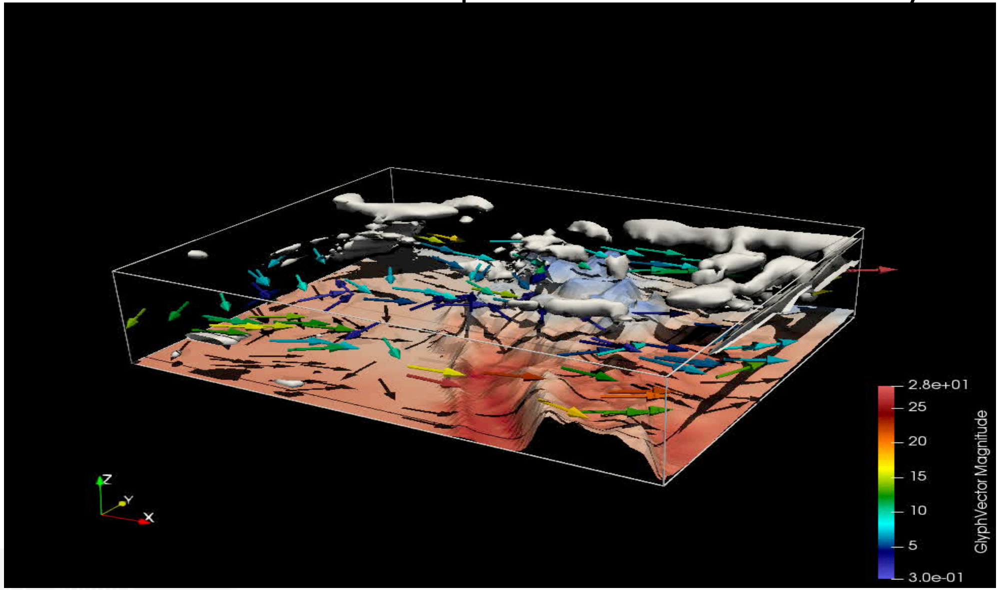




ParaView 3.8.0
Time: 0
0
Solid Color
Outline
Pipeline Browser
builtin:
wrf_small-*
Contour1
Slice1
WarpByScalar1
Calculator1
Slice2
Glyph1
Object Inspector
Properties
Display
Information
Statistics
Type: Rectilinear
Number of Cells: 160512
Number of Points: 171787
Memory: 8.1 MB
Data Arrays
Current data time step: 0
Name Data Type Data Ranges
XLAND float [-999, 2]
U float [-11.2548, 51.2167]
V float [-24.9953, 33.9401]
W float [-0.433493, 0.331888]
P float [-996.754, 2249.68]
QVAPOR float [-7.19474e-05, 0.01877
QCLOUD float [0, 0.000696224]
QRAIN float [0, 0.000945338]
T2 float [-999, 303.211]
HGT float [-999, 3232.91]
T2
300
290
280
270

Time Varying Data

- A sequence of grids with attributes
- Generally not interpolated in time
- Grids may be the same, or change from timestep to timestep
- Vis applications (Paraview/VisiT) recognize time series data but don’t load the entire sequence into memory.

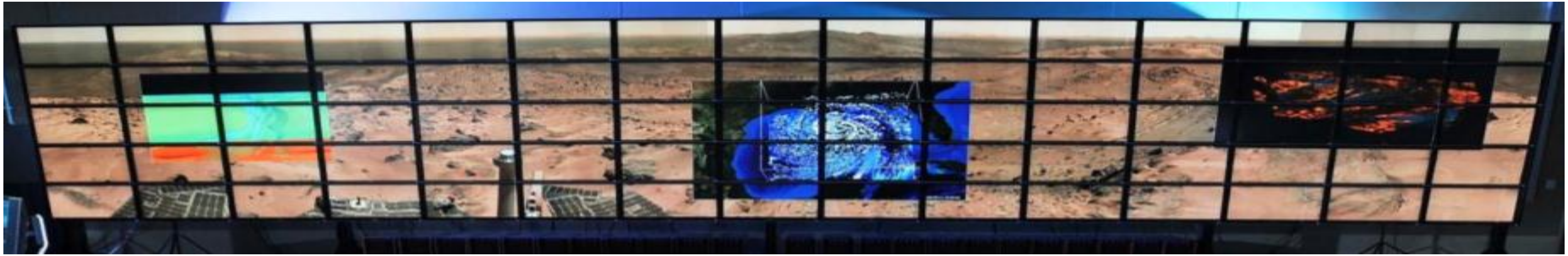


TACC

How to view very large, high resolution data?

- Displays cannot show entire high-resolution images at their native resolution, what are other ways (other than screen/mouse) for exploring data-sets?

Large high resolution displays



Stallion – world's 2nd highest-resolution tiled display

328 Megapixels
40960 x 8000 pixel resolution

Dell 30” LCD
4 Megapixel display
2560 x 1600 resolution

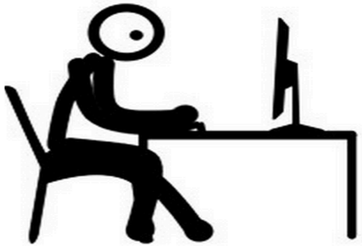
TACC

Virtual-Reality: Head-Mounted Displays

- Head tracked (maybe just orientation)
- Images projected onto viewing surface
- Stereo
- Can be *very* effective
- Cheap!

CONS:

- Resolution
- Some get seasick



Kind of in-between

zSpace

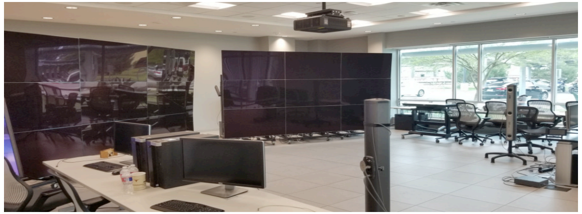
also Augmented Reality solutions like HoloLens

Thank you!

Questions?

Reconfigurable Visualization Spaces

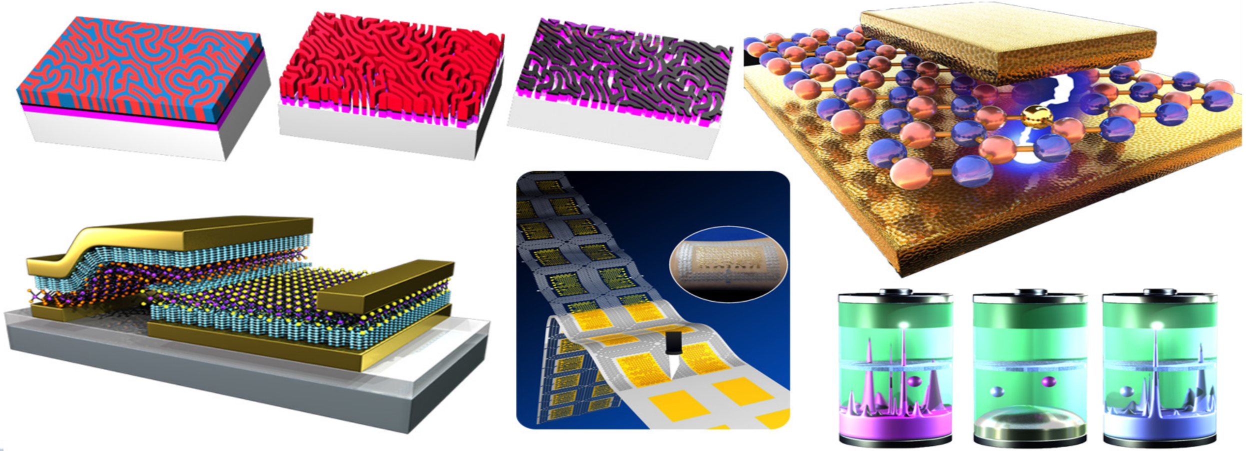
Most vislabs are designed with a permanent configuration in mind and are deployed only once, TACC's Human Data Interaction Lab is designed to be extremely adaptable, and its configuration can be changed on demand.



This on-demand reconfigurability is a major accomplishment, but flexibility comes at a cost. Reconfiguring the interactive visualization systems requires significant amounts of time, effort and expertise. We are conducting a research program to make it faster and easier to reconfigure

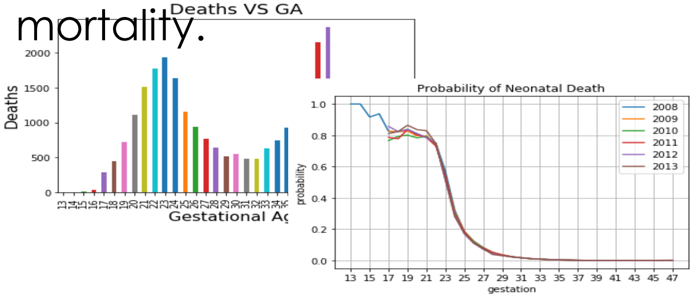
Conceptual Vis

Conceptual vis attempts to show a process or assembly or experiment that is too small to see by the naked eye or even microscope, whether it be trying to build new materials from which to make faster relays and switches to stable batteries to a new method for printing medical devices.



Making sense of Healthcare data

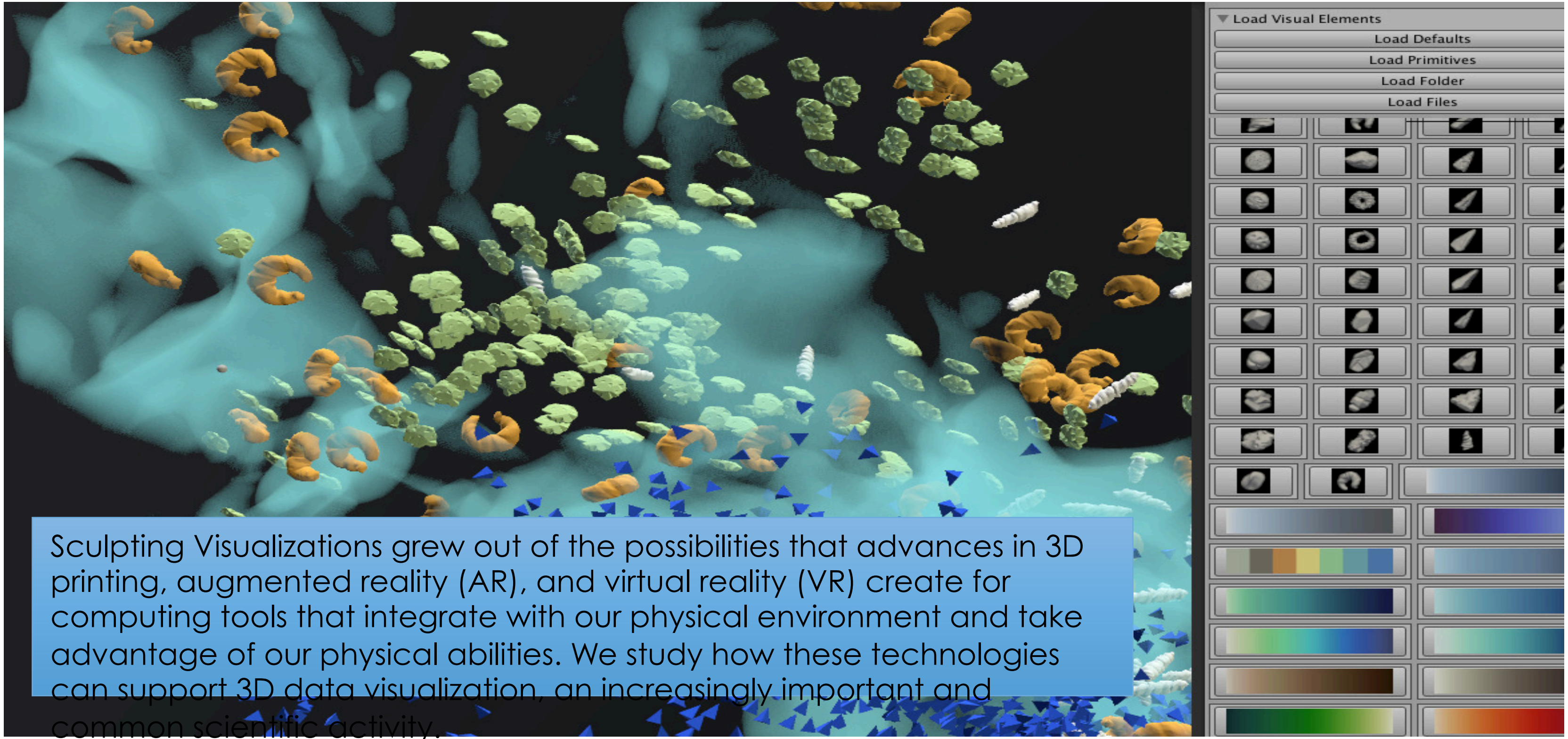
In the current health care environment, many clinicians make decisions that are based on data, but a vast majority of collected data is not used and very often the data may not be optimal, complete, or entirely accurate. Clinicians would benefit from a rigorous data-driven infrastructure that would allow them to make decisions and discover causal factors for a variety of different health-related issues, including stillbirth, preterm birth, and neonatal death. The collaboration as planned would also help lead to new care delivery models and could be applied to other conditions such as maternal mortality.



[full artical introducing paretnership between TACC and Dell Medical School]

Sculpting Vis

https://www.sculpting-vis.org

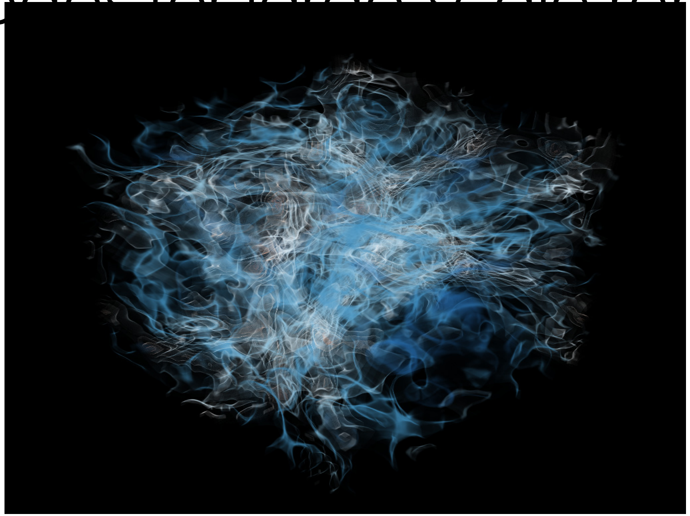


Sculpting Visualizations grew out of the possibilities that advances in 3D printing, augmented reality (AR), and virtual reality (VR) create for computing tools that integrate with our physical environment and take advantage of our physical abilities. We study how these technologies can support 3D data visualization, an increasingly important and common scientific activity.

GraviT

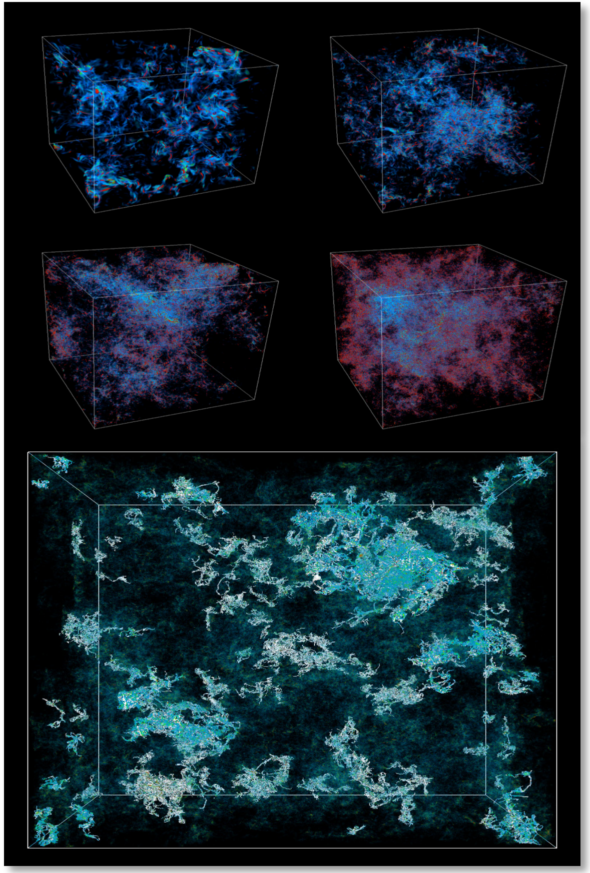
https://github.com/TACC/GraviT

GraviT is a distributed ray tracing framework that enables applications to leverage hardware-optimized ray tracers within a single environment across many nodes for large scale rendering tasks.



Visualization of Large Scale Turbulent Flow

Kelly Gaither, Hank Childs, Greg Johnson, Karl Schulz, Cyrus Harrison, Diego Donzis, Texas A&M; P.K. Yeung, Georgia Tech



Remote interactive visualization of 17 time-steps (34 TB) of the largest turbulent flow simulation computed to date (4096^3).

First time this had been visualized interactively at this scale.

Equal parts data mining and remote interactive visualization – goal was to characterize flow behavior over time.

Gaither, K., Childs, H., Schulz, K., Harrison, C., Barth, W., Donzis, D., and Yeung, P.K., "Using Visualization and Data Analysis to Understand Critical Structures in Massive Time Varying Turbulent Flow Simulations," IEEE Computer Graphics and Applications, 32(4), Jul/Aug 2012.

Stellar Magnetism

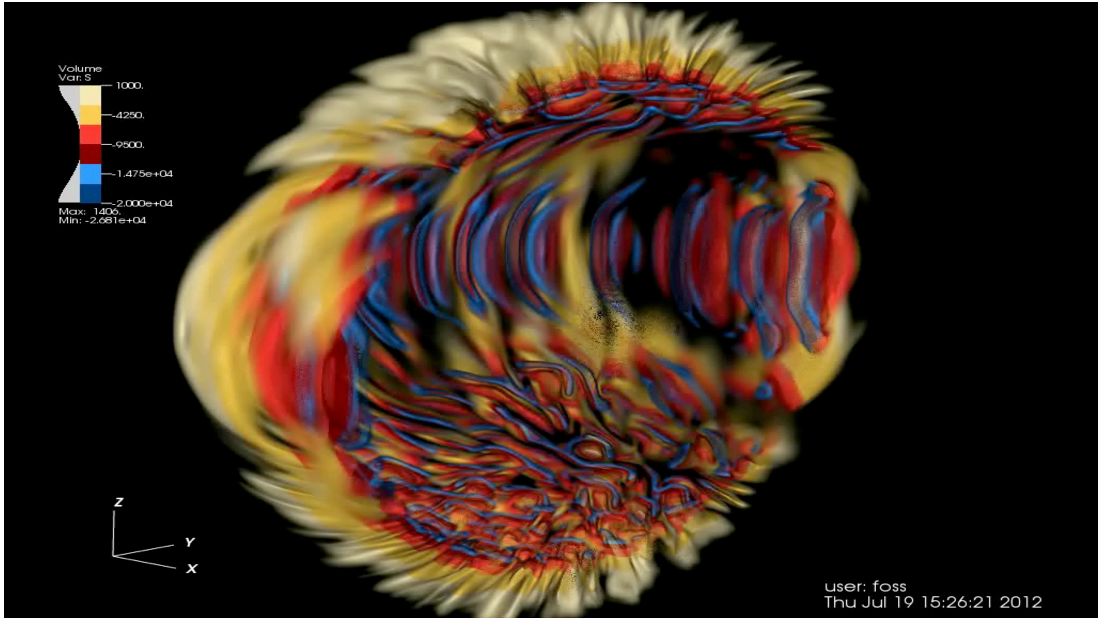
Greg Foss, TACC; Ben Brown, University of Wisconsin, Madison

A Sun-like star undergoes magnetic cyclic reversal shown by field lines.

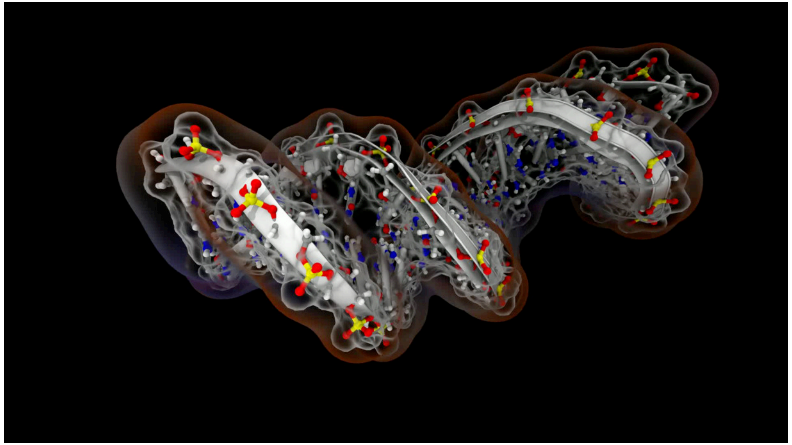
Shifts in positive and negative polarity demonstrate large-scale polarity changes in the star.

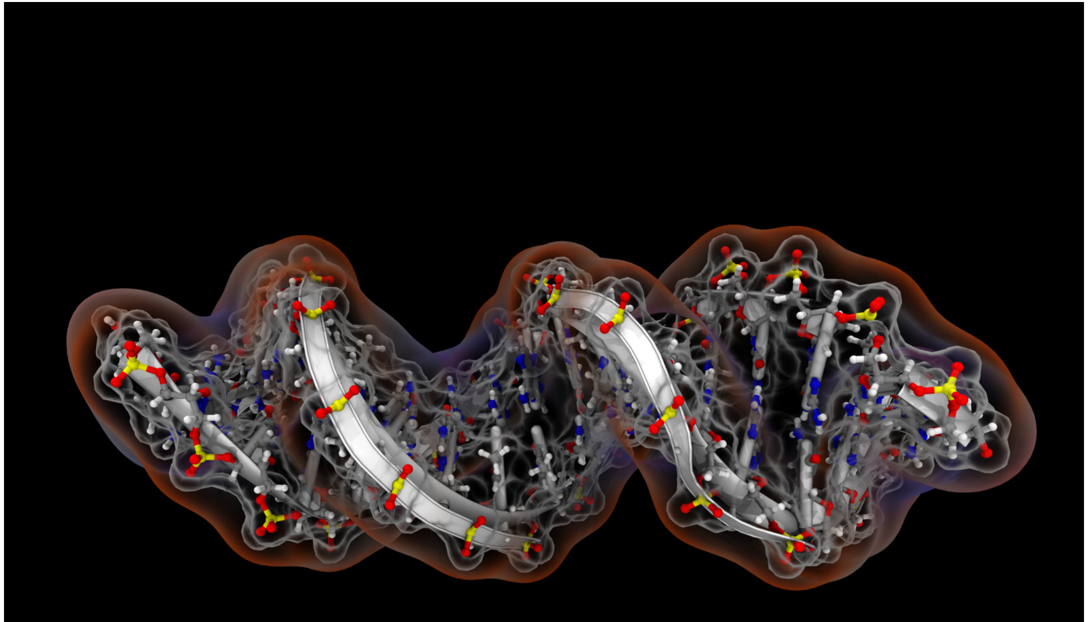
Wreath-like areas in the magnetic field may be the source of Sun spots.

Terabytes of data to mine through and visualize.



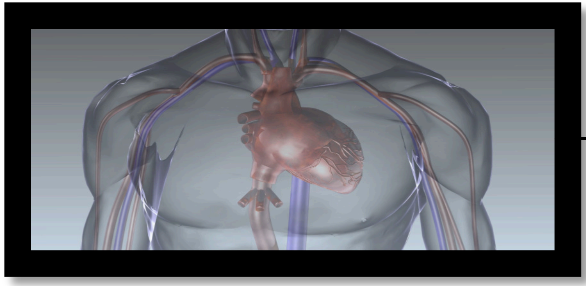
Molecular Dynamics Analysis of Ion Distributions Around a DNA strand.

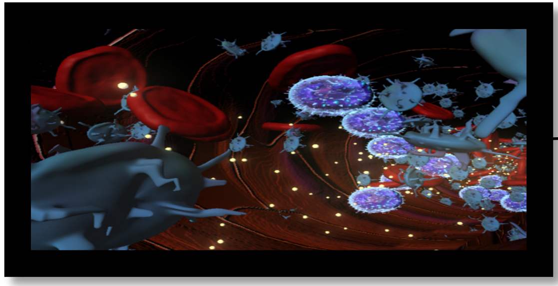


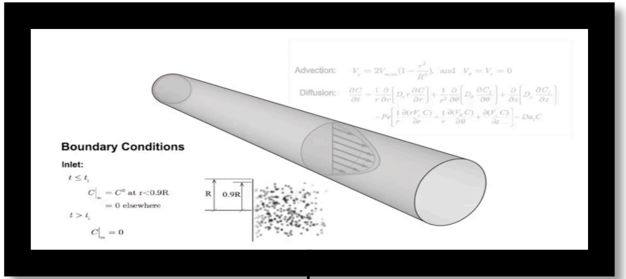


Antonio Gomez (HPC) assisted Daniel Roe (a post-doc that works with the MD package AMBER, one of the most widely used MD codes on our systems) to significantly optimize the parallelization of the trajectory analysis CCPTRAJ subroutine and also the parallel IO

Ben Urick, Jo Wozniak, Karla Vega, TACC; Erik Zumalt, FIC; Shaolie Hossain, Tom Hughes, ICES.



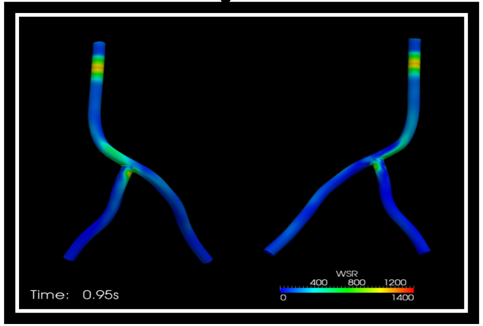




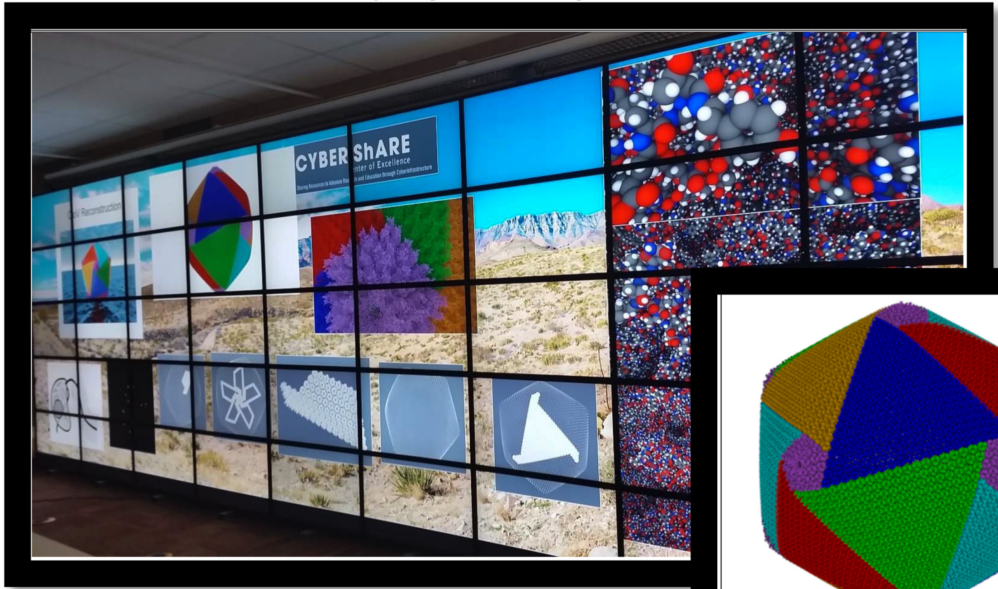
A computational tool-set was developed to support the design and analysis of a catheter-based local drug delivery system that uses nanoparticles as drug carriers to treat vulnerable plaques and diffuse atherosclerosis.

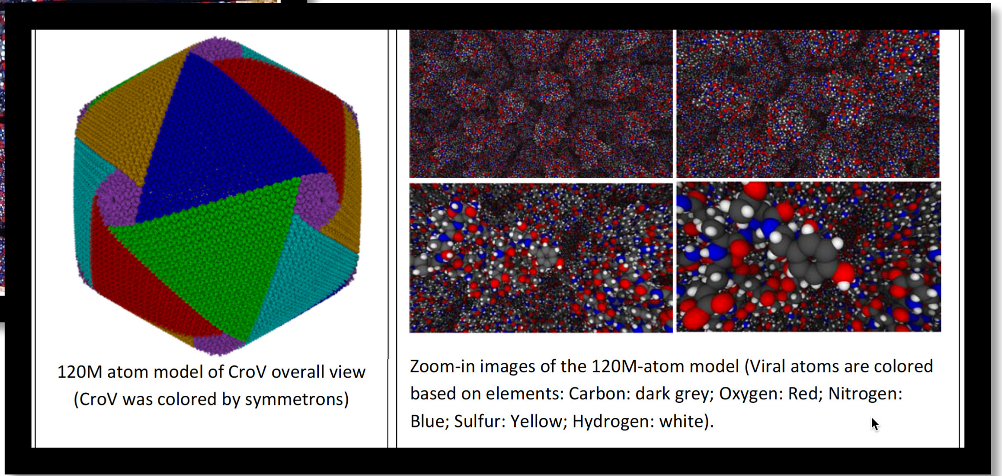
The tool is now poised to be used in medical device industry to address important design questions such as, "given a particular desired drug-tissue concentration in a specific patient, what would be the optimum location, particle release mechanism, drug release rate, drug properties, and so forth, for maximum efficacy?"

The goal of this project is to create a visualization that explains the process of simulating local nanoparticulate drug delivery systems. The visualization makes use of 3DS Max, Maya, EnSight and ParaView.



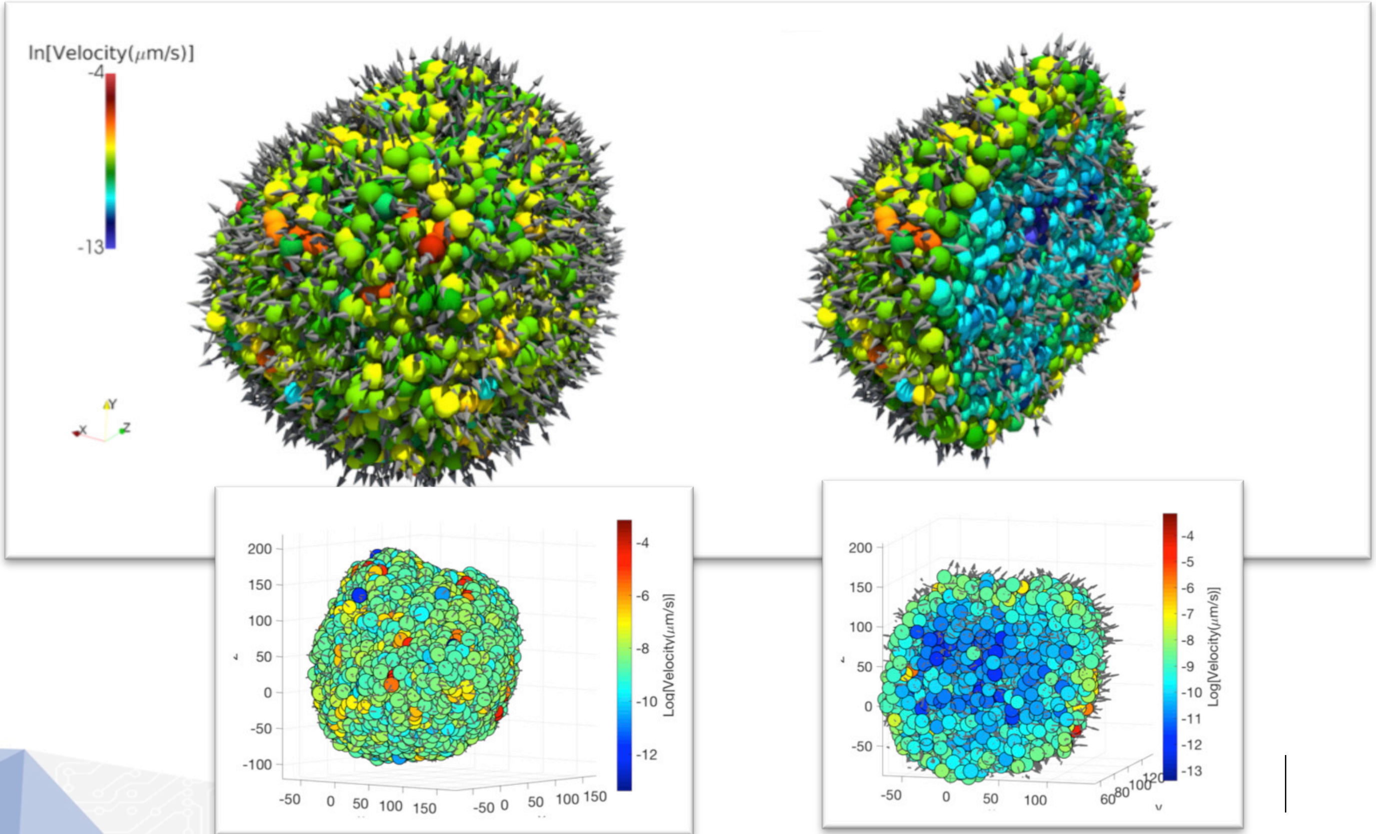
UT El Paso researcher River Xiao used OSPRay visualize and interact with 12M atom “girus” on their CyberShaRE tiled display (2015)





Physical Signatures of Cancer Metastatis

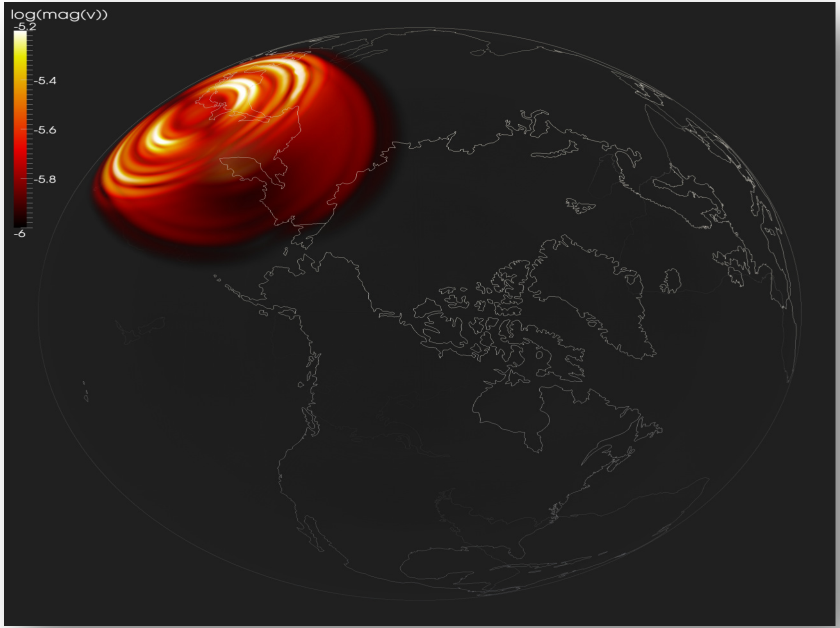
Abdul N Malmi-Kakkada, Thirumalai Lab, Department of Chemistry. UT Austin



Volume Visualization of Tera-Scale Global Seismic Wave Propagation

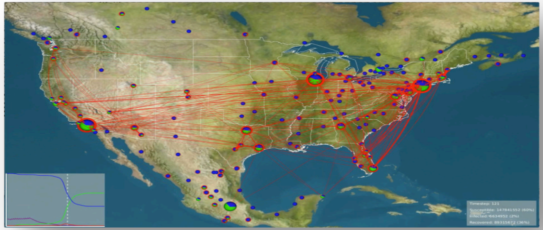
Carsten Burstedde, Omar Ghattas, James Martin, Georg Stadler and Lucas Wilcox, ICES; Greg Abram, TACC

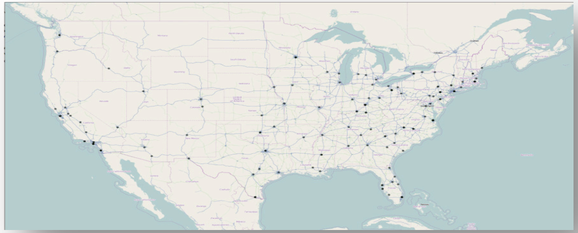
- Modeling propagation of seismic waves through the earth helps assess seismic hazard at regional scales and aids in interpretation of earth's interior structure at global scales.
- Discontinuous Galerkin method used to for numerical solution of the seismic wave propagation partial differential equations.
- Visualization corresponds to a simulation of global wave propagation from a simplified model of the 2011 Tohoku earthquake with a central source frequency of 1/85 Hz, using 93



H1N1 Flu Outbreak Simulation: Integrating Science and Art

Greg Johnson, Brandt Westing, Karla Vega, Kelly Gaither, TACC; Ned Dimitrov, Lauren Meyers, UT Comp. Bio; Francesca Samsel, Austin, TX.



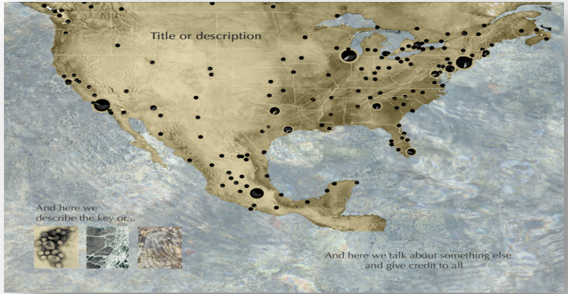


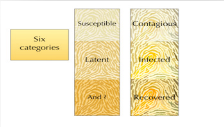
Visualization of a swine flu epidemic spreading throughout North America.

Epidemic begins in Mexico City.

Visualization classifies individuals into three groups: susceptible (blue), infected (red), and recovered (green). Available antivirals are shown in purple.

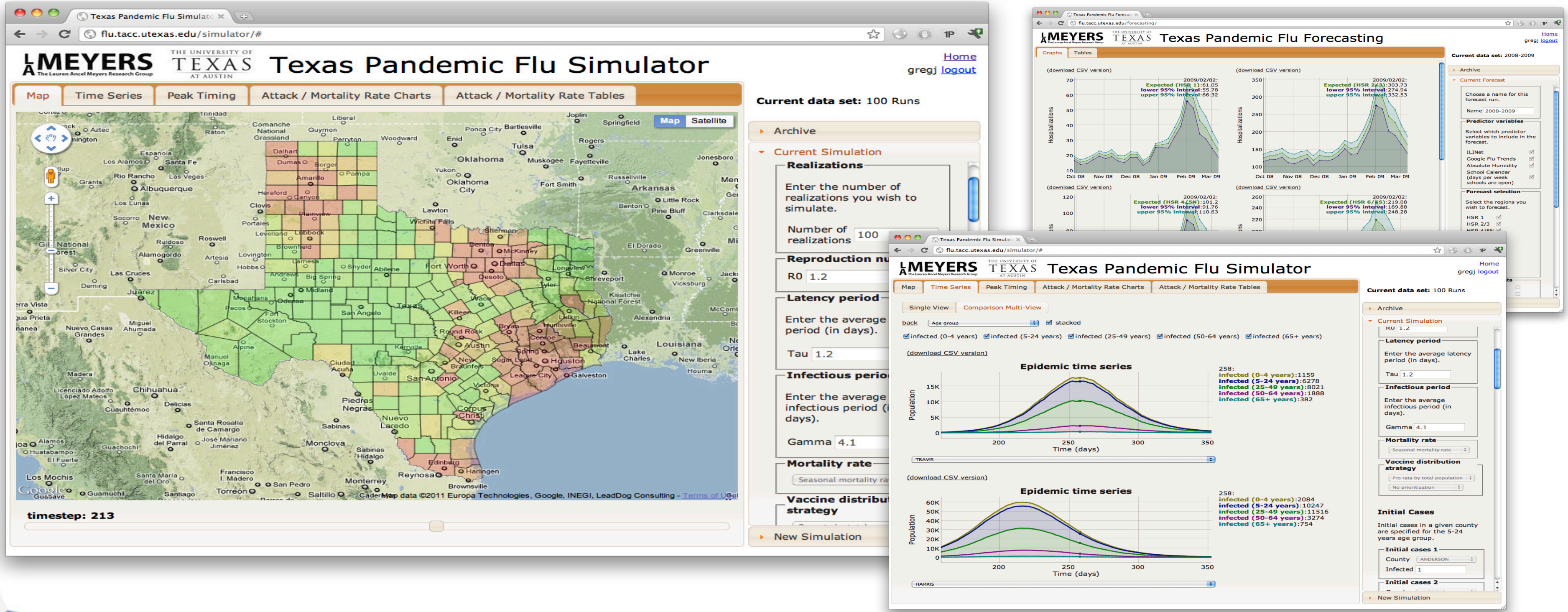
Cities and transportation links are highlighted in red to indicate large numbers of infected individuals and infectious travelers.





Texas Pandemic Flu Toolkit

Greg Johnson, Adam Kubach, TACC; Lauren Meyers & group, UT Biology; David Morton & group, UT ORIE.



TACC

Visualizing Distributed Learning

Weijia Xu, Karla Vega, Makoto Sadahiro

Researchers are conducting studies to compare the effectiveness of virtual and real manipulatives in the support and success of learning

This research explores the use of information and scientific visualization tools for data mining and feature detection