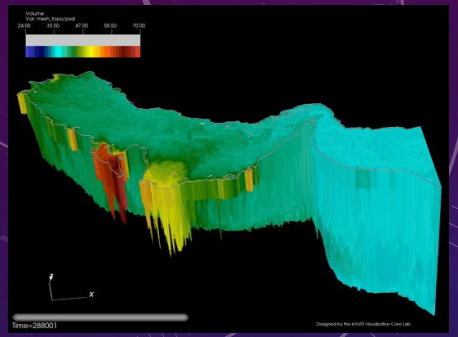
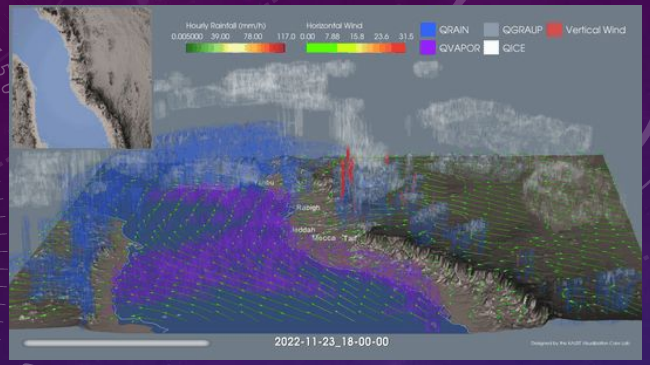
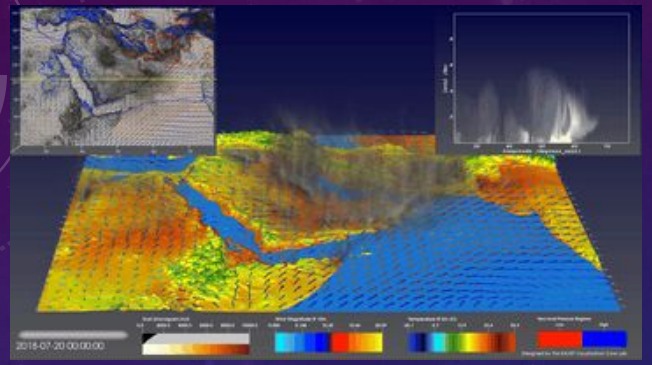
جامعة الملك عبدالله للعلوم والتقنية
King Abdullah University of Science and Technology

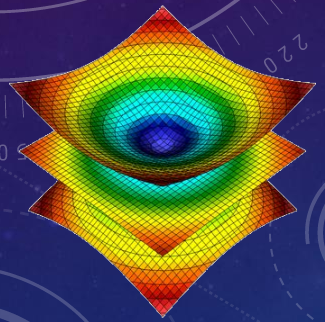






Scientific Visualization 101

VisIt: An Introductory Hands-On Course



KAUST Visualization Core Lab

Dr. James Kress

October 14, 2025

Resources

KVL Contact Information

- KVL Website: wiki.vis.kaust.edu.sa
- General Inquiries: help@vis.kaust.edu.sa

User Resources

- VisIt Downloads: https://visit-dav.github.io/visit-website/releases-as-tables/#latest
- Discussions: https://github.com/visit-dav/visit/discussions
- User Guide: https://visit-sphinx-github-user-manual.readthedocs.io/en/develop/
- Wiki http://www.visitusers.org

Download VisIt now while we go over basic concepts so you are ready for the hands-on portions

The KVL Team

Dr. Sohaib Ghani
(LEAD STAFF SCIENTIST)

- VISUAL ANALYTICS
- INFORMATION VIS
- STATISTICAL ANALYSIS

Dr. James Kress
HPC SCIVIS

- VISUALIZATION SOFTWARE
- HPC INSITU VISUALIZATION
- DISTRIBUTED VISUALIZATION

Dr. Ronell Sicat
SCIVIS, AR/VR

- SCIENTIFIC VISUALIZATION
- SEGMENTATION & 3D ANALYSIS
- AR/VR DEVELOPMENT

Dr. Didier Barradas
Data Scientist

- DATA SCIENCE
- MACHINE LEARNING
- DEEP LEARNING

Dr. Abdelghafour Halimi
Data Scientist

- DATA SCIENCE
- MACHINE LEARNING
- DEEP LEARNING

KVL Core Expertise

Core Services

Training and Workshops

- Scientific Visualization Workshop Series
- Data Science Workshop Series
- AI Tools and Techniques Workshop Series

Data Visualization & Data Science Workflows

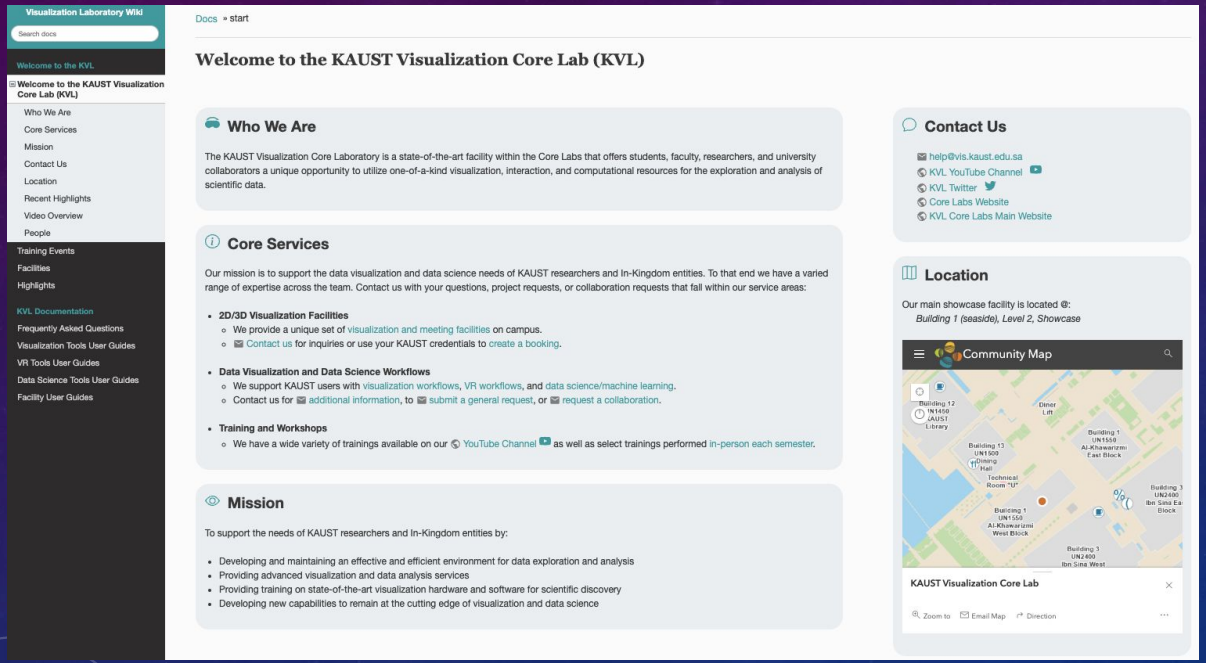
- HPC Visualization
- Image Segmentation & 3D Analysis
- AR/VR
- Large Scale AI & Data Science

Facilities Support

- AR/VR Hub
- Tiled Display Walls

KVL Wiki

--- Find Highlights, Training Info, and More ---



https://wiki.vis.kaust.edu.sa

KVL Training Events

--- Available In-Person and Online ---

- Scientific Visualization Workshop Series
  - ParaView, VisIt, Avizo/Amira
- Data Science Workshop Series
  - Shell, Conda, Python, Git, and more
- Hands-on AI Tools and Techniques Workshop Series
  - Intro to Machine Learning/Deep Learning, Visualization for Data Science

https://www.youtube.com/@kaustvislab

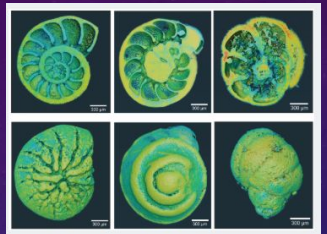
Data Visualization and Science Workflows

KVL Collaborates in areas such as:

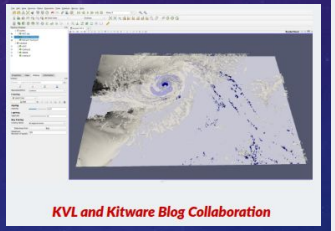
- HPC Visualization
- Scientific and Information Visualization
- AR/VR
- Image Segmentation and 3D Analysis
- Large-scale AI and Data Science

Send us an email if you have a collaborative project that can benefit from our expertise:

help@vis.kaust.edu.sa



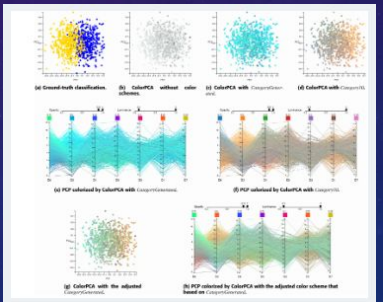
Micro-CT and Holographic Visualization of Late Cretaceous Benthic Foraminifera in Saudi Arabia



KVL and Kitware Blog Collaboration

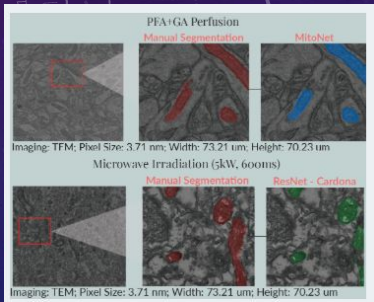
KVL Releases Open Source Software to Visualize Supercomputing Simulations

Mobile AR Visualization of Giant Red Sea Coral

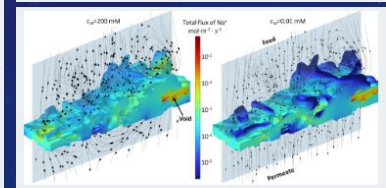


ColorPCA: Scalable Colored Dimensionality Reduction for Unlabeled High-Dimensional Data

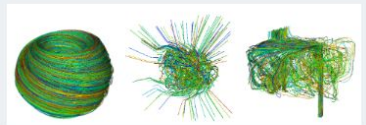
KVL Co-Organized Visualization Workshop



Segmentation and 3D Reconstruction of Glycogen and Mitochondria in Microwave-fixed Brain EM



3D Modeling of Composite Membranes from TEM



Analyzing Particle Advection Performance

Workshop Goals

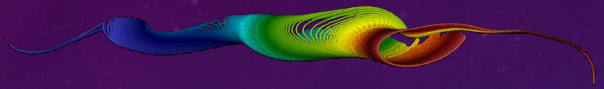
- Hands-on learning with VisIt
  - Introductory course
  - Slides / demonstrations

- Why VisIt @ KAUST
  - Open source, scalable, multi-platform visualization application with users worldwide
  - Available on all major computation resources at KAUST
    - VisIt on Ibex and Shaheen
      - Support for distributed computations to process very large data sets
        - VisIt has been proven on up to 27 billion element meshes

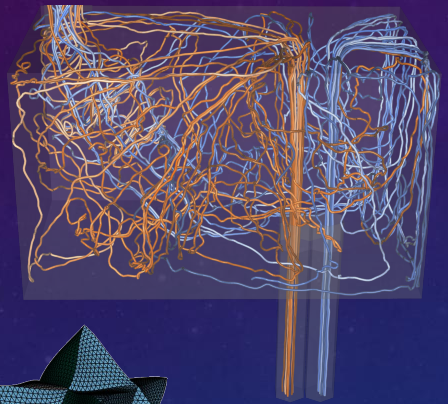
VisIt Basics

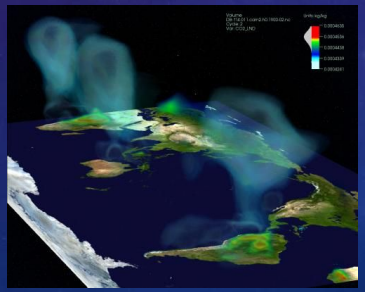
What is VisIt and What can It Do?

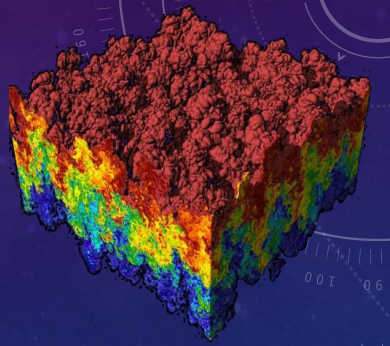
What is VisIt?

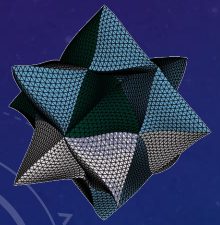


- Open-source application for analysis and visualization of ***mesh-based*** data
- Infrastructure for parallel post-processing that scales from laptops to HPC clusters
- Built-in in situ capabilities





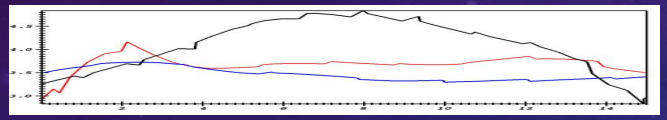




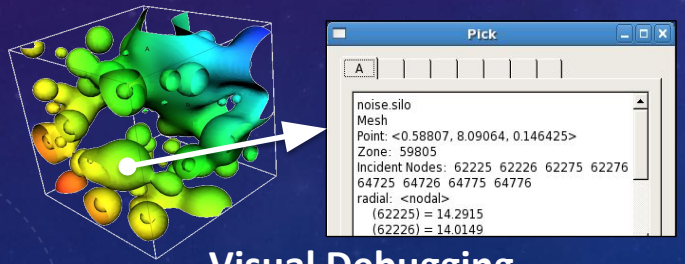
VisIt Supports a Wide Range of Use Cases

Data Exploration

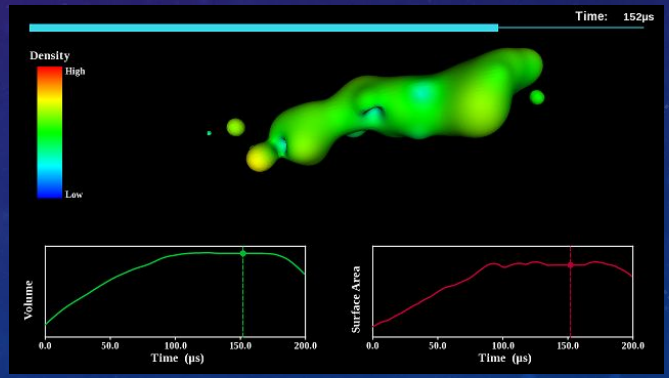
Comparative Analysis



Quantitative Analysis

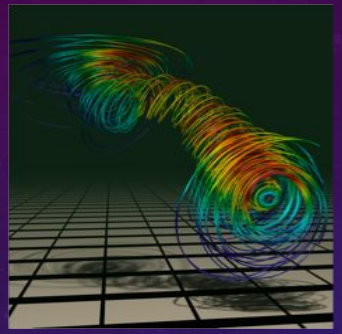


Visual Debugging

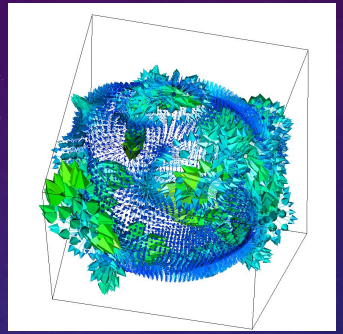


Presentation Graphics

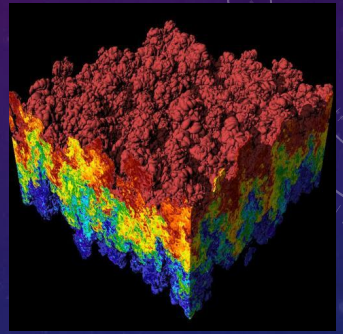
VisIt Supports a Wide Range of Plotting Types



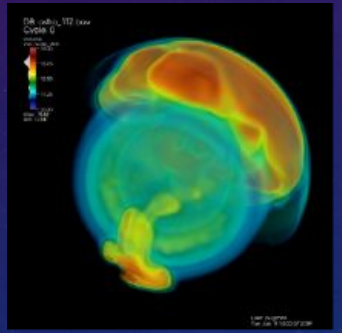
Streamlines / Pathlines



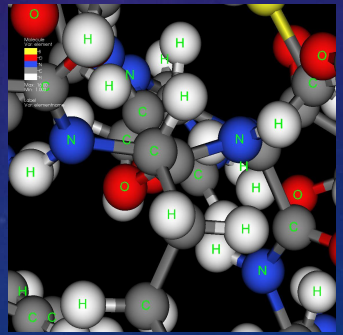
Vector / Tensor Glyphs



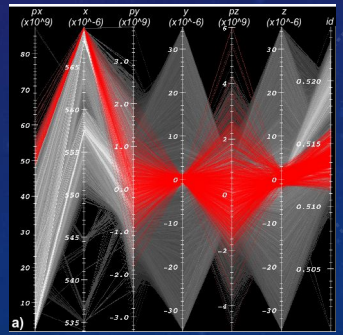
Pseudocolor Rendering



Volume Rendering



Molecular Visualization



Parallel Coordinates

How Do I Obtain VisIt?

- Use an existing build:
  - For your Laptop or Workstation:
    - Binaries for Windows, OSX, and Linux (RHEL + Ubuntu): (https://visit-dav.github.io/visit-website/releases-as-tables/#latest)
  - KVL team manages builds on Ibex and Shaheen
- Build VisIt yourself:
  - "build_visit" is a script that automates the process of building VisIt and its third-party dependencies. (docs: https://visit-sphinx-github-user-manual.readthedocs.io/en/develop/building_visit/index.html)

How Do I Get My Data Into VisIt?

VisIt supports more than 110 file formats

- VTK, Silo, Xdmf, PVTK
- The PlainText database reader can read simple text files (CSV, etc)
  - https://visit-sphinx-github-user-manual.readthedocs.io/en/develop/data_into_visit/PlainTextFormat.html
- visit_writer utility: code to write VTK files from your sim code
  - https://visit-sphinx-github-user-manual.readthedocs.io/en/develop/data_into_visit/VTKFormat.html
- Support for Mesh-based data in Conduit Blueprint:
  - http://llnl-conduit.readthedocs.io/en/latest/blueprint_mesh.html

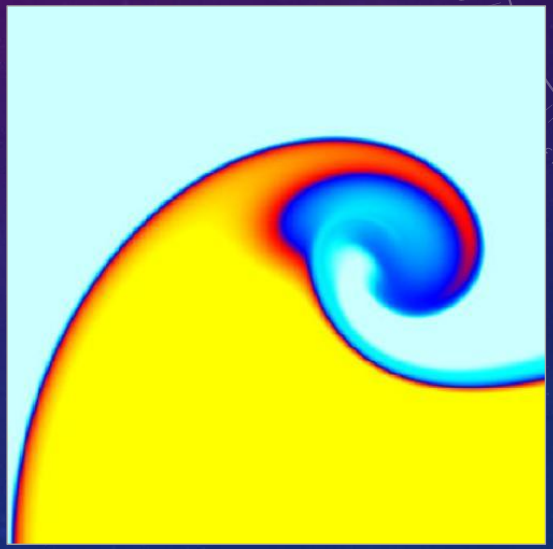
Read the docs: https://visit-sphinx-github-user-manual.readthedocs.io/en/develop/data_into_visit/index.html

Visualization Techniques

For Mesh Based Simulations

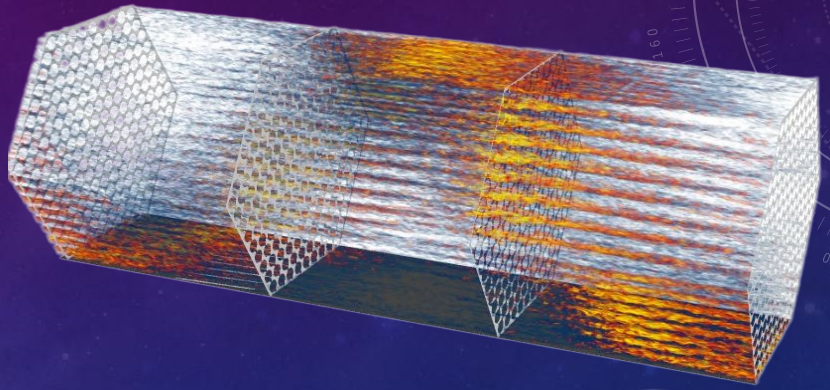
Pseudocolor Rendering
– Maps Scalar Fields to a Range of Colors

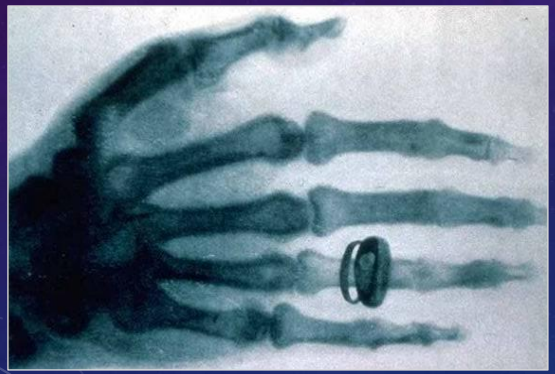
Pseudocolor Rendering of Elevation

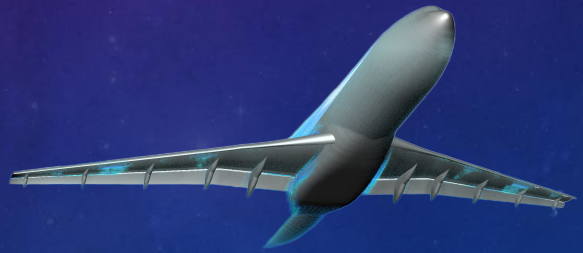


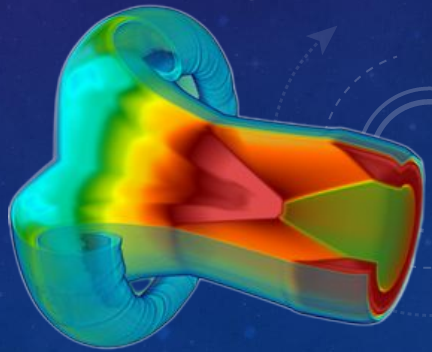
Pseudocolor Rendering of Density

Volume Rendering
– Cast Rays and Applies Transfer Functions



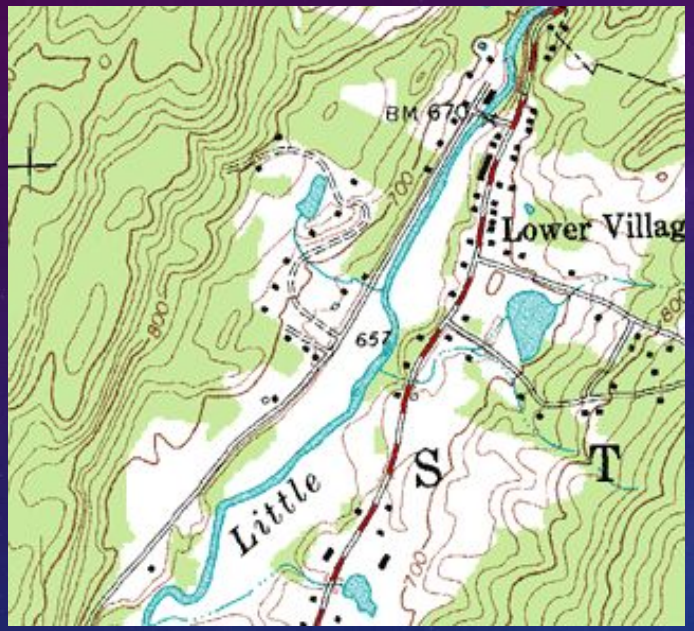






Isosurfacing (Contouring)

– Extracts Surfaces of that Represent Level Sets



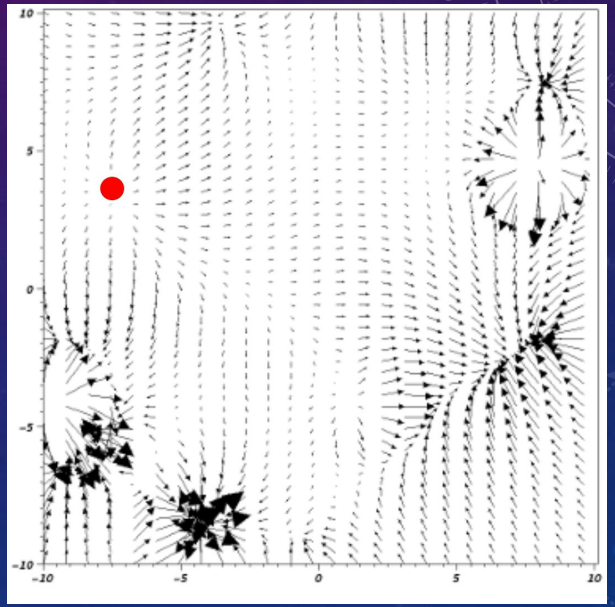
2D Contour (Elevation)

3D Contour (Pressure)

Particle advection – Foundation of Several Flow Vis Techniques

- S(t) = position of particle at time t
- $S(t_0) = p_0$
  - t_0: initial time
  - p_0: initial position
- S'(t) = v(t, S(t))
  - v(t, p): velocity at time 't' and position 'p'
  - S'(t): derivative of the integral curve at time 't'

This is just an ordinary differential equation

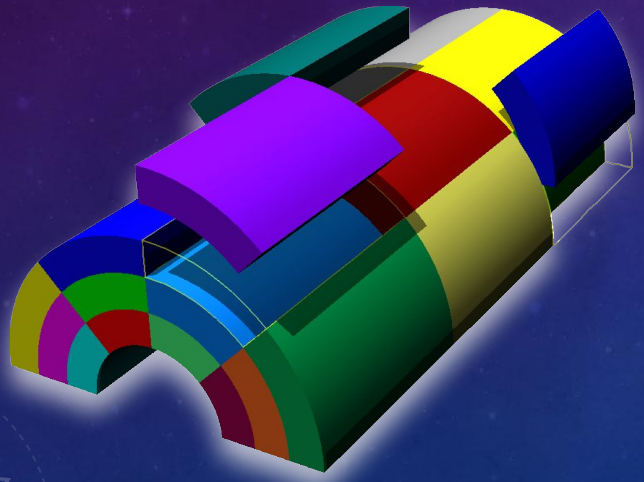


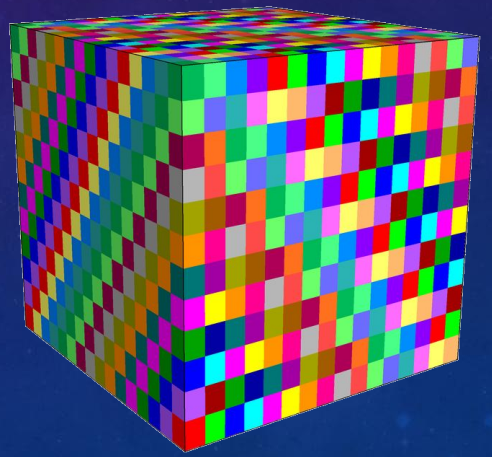
Streamline and Pathline – Built on Particle Advection

- Streamlines:
  Instantaneous paths
- Pathlines:
  Time dependent paths

Domain Decomposed Meshes – Enable scalable parallel visualizations

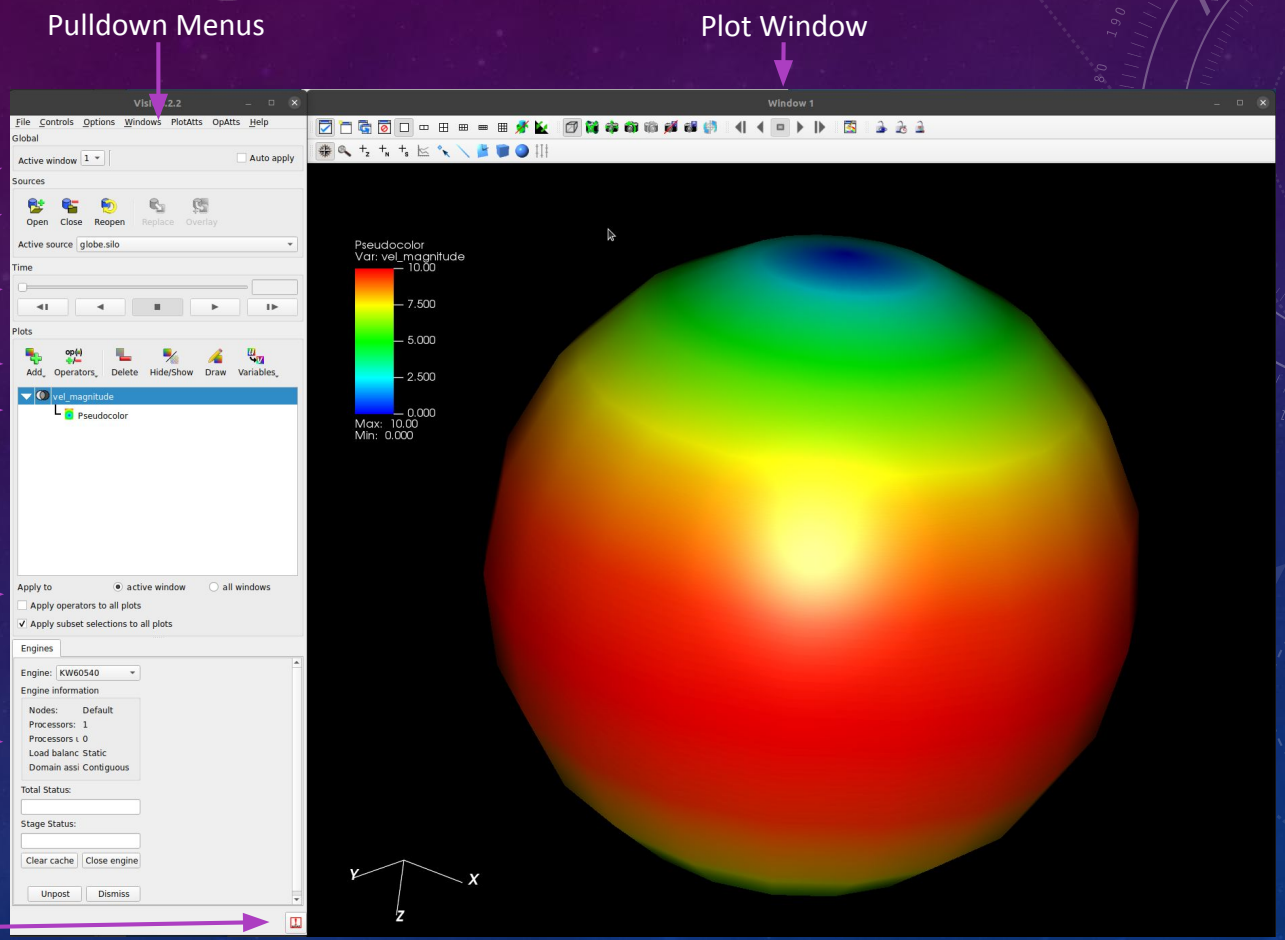
- Simulation meshes may be composed of smaller mesh “blocks” or “domains”
- Domains are partitioned across MPI tasks for processing





VisIt Interface Tour

VisIt GUI


Pulldown Menus
Plot Window
Active Window Selector
Data Sources
Time Slider
Plots & Operators
Pipeline Browser
Apply To
Notepad
Output Indicator
File Controls Options Windows PlotAtts OpAtts Help
Global
Active window 1
Auto apply
Sources
Open Close Reopen Replace Overlay
Active source globe.silo
Time
Plots
Add Operators Delete Hide/Show Draw Variables
vel_magnitude
Pseudocolor
Apply to active window all windows
Apply operators to all plots
Apply subset selections to all plots
Engines
Engine: KW60540
Engine information
Nodes: Default
Processors: 1
Load balanc Static
Domain assi Contiguous
Total Status:
Stage Status:
Clear cache Close engine
Unpost Dismiss
Window 1
Pseudocolor
Var: vel_magnitude
10.00
7.500
5.000
2.500
0.000
Max: 10.00
Min: 0.000
Y
X
Z

Hands–On Session 1

GUI Tour

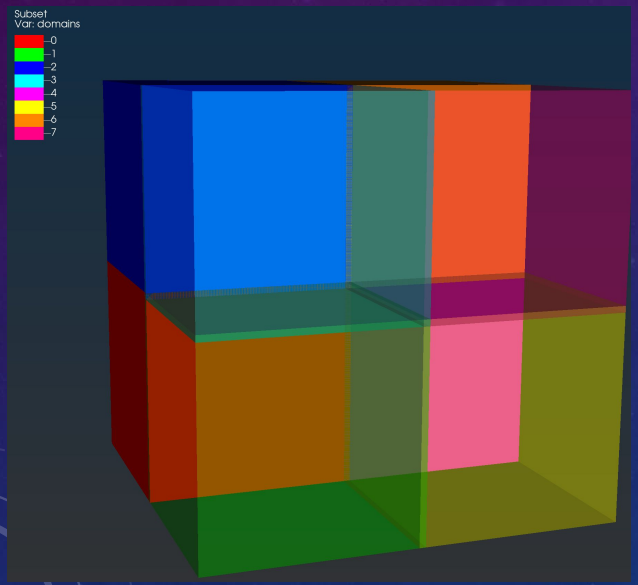
First Data Set

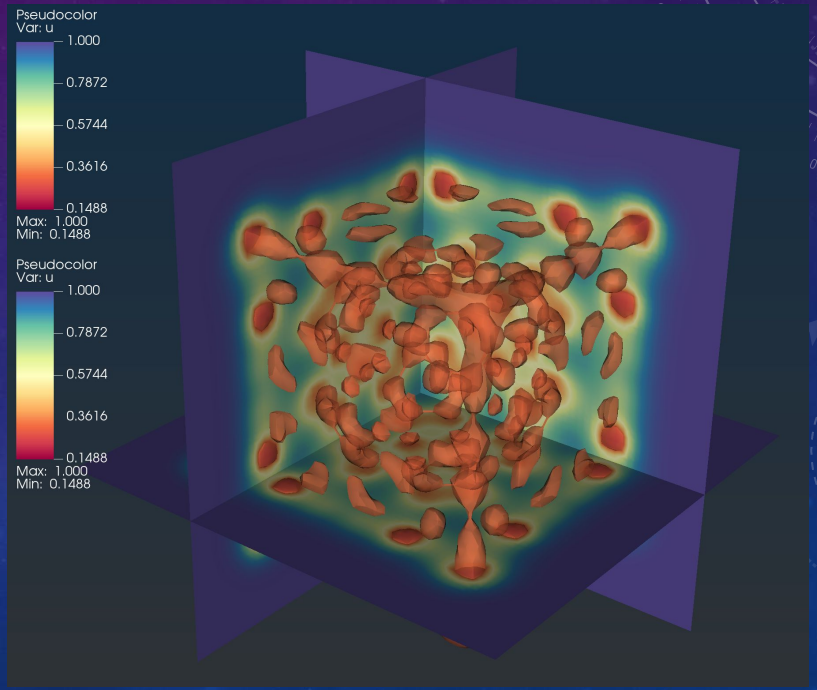
Creation of our data

Miniapp simulation data: Gray-Scott Miniapp

- *This is a 3D 7-point stencil code to simulate the Gray-Scott reaction diffusion model.*
  - *A Reaction-diffusion system is a system in which a dynamical system is attached to a diffusion equation, and it creates various patterns. This is an equation that simulates the chemical reaction between the chemicals 'U' and 'V'. 'U' is called the activator and 'V' is called the repressor.*

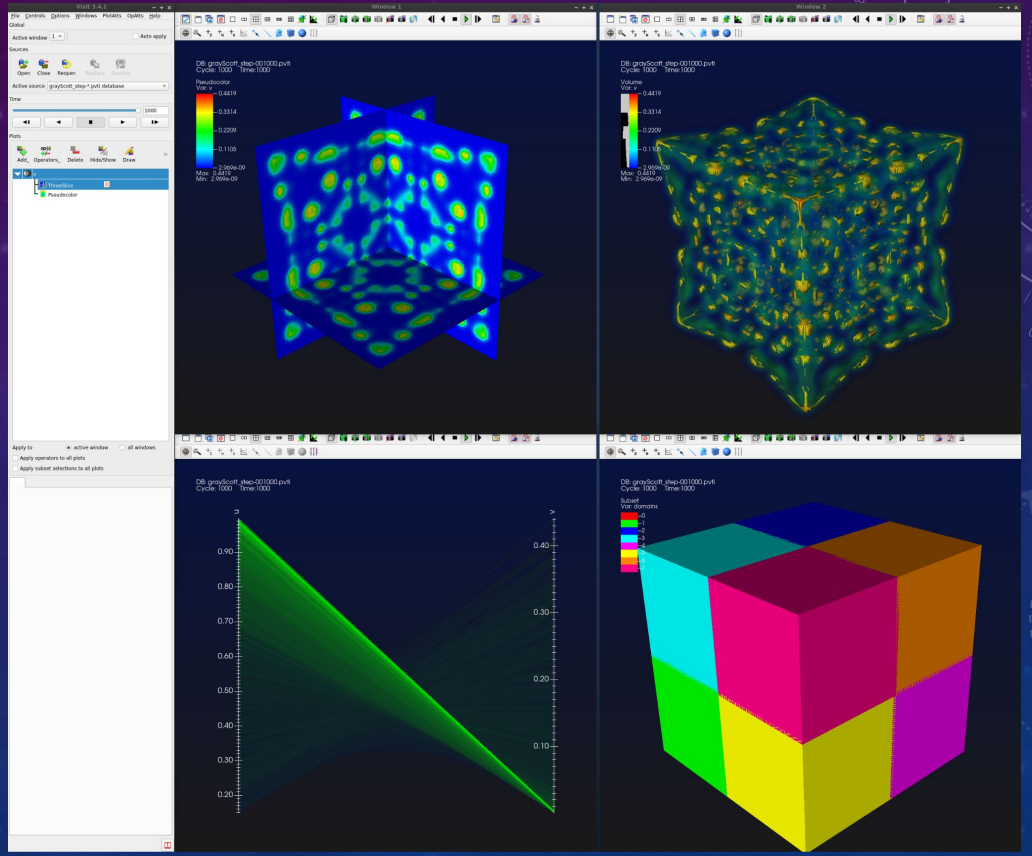
- Gray-Scott Data Set
  - grayScott_step-*.pvti - *Parallel VTK Image File*
    - Multi Time Step / Multi Block Files





VisIt GUI Tour

- Opening files / file types
- View file info
- Navigating views
- Multiple views
- Window tools
- Add plot / add operator
- Change plot / operator attributes
- Selectively applying operators
- Link views



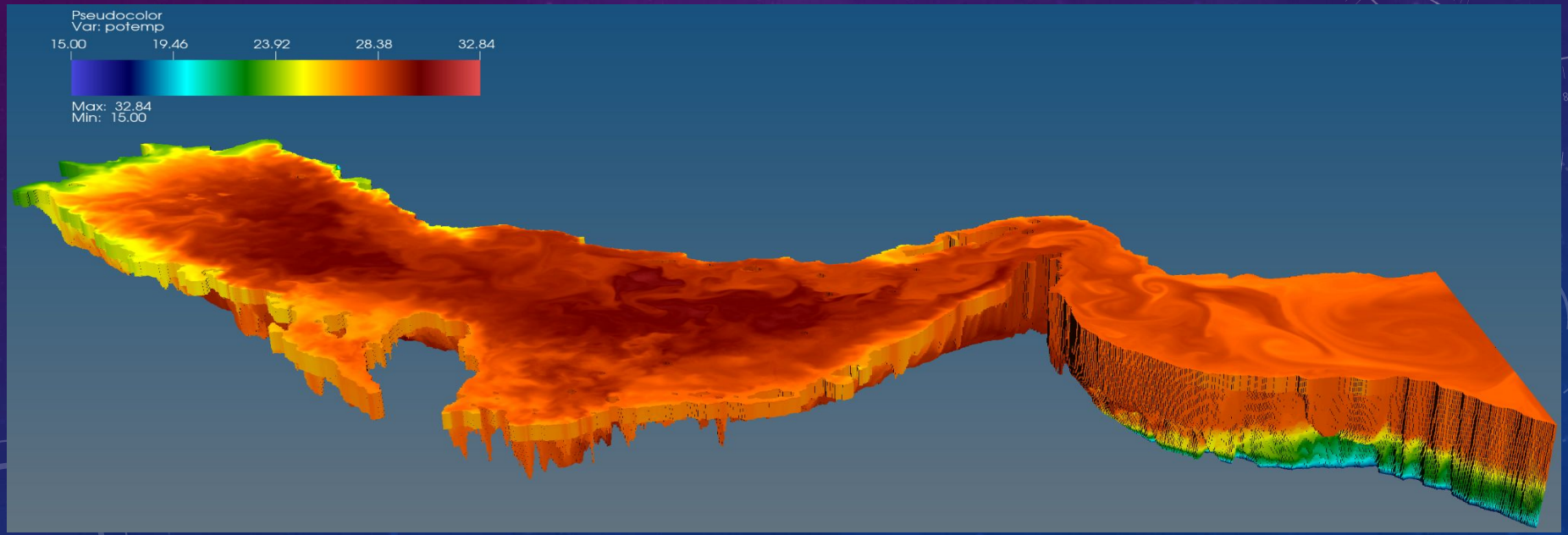
Hands–On Session 2

Basic Plots / Slices / Contours

Second Data Set

- Arabian Gulf Data Set
  - Arabian_gulf.vtu – *VTK binary XML format*

Location of our data



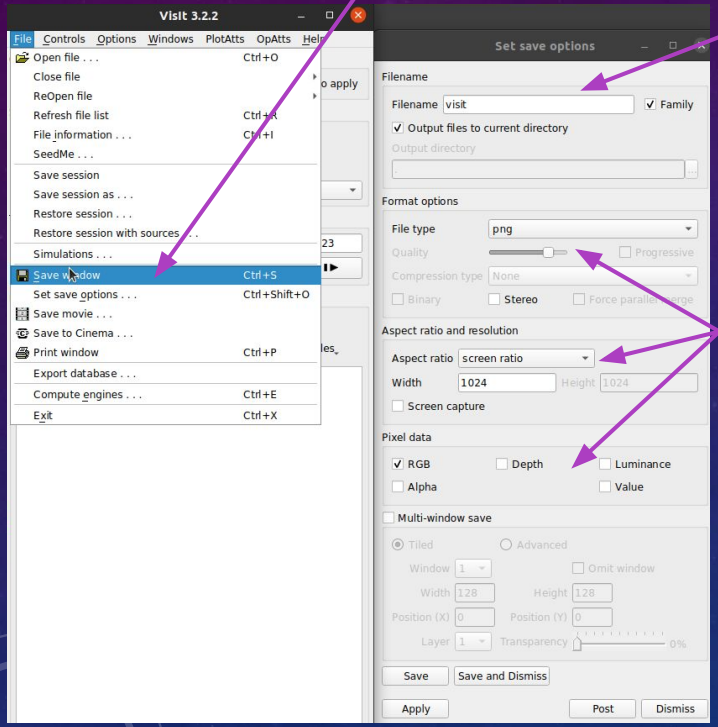
Hands–On Session 3

Screenshots / Movies / Animations / Custom Expressions / Queries / Saving VisIt State

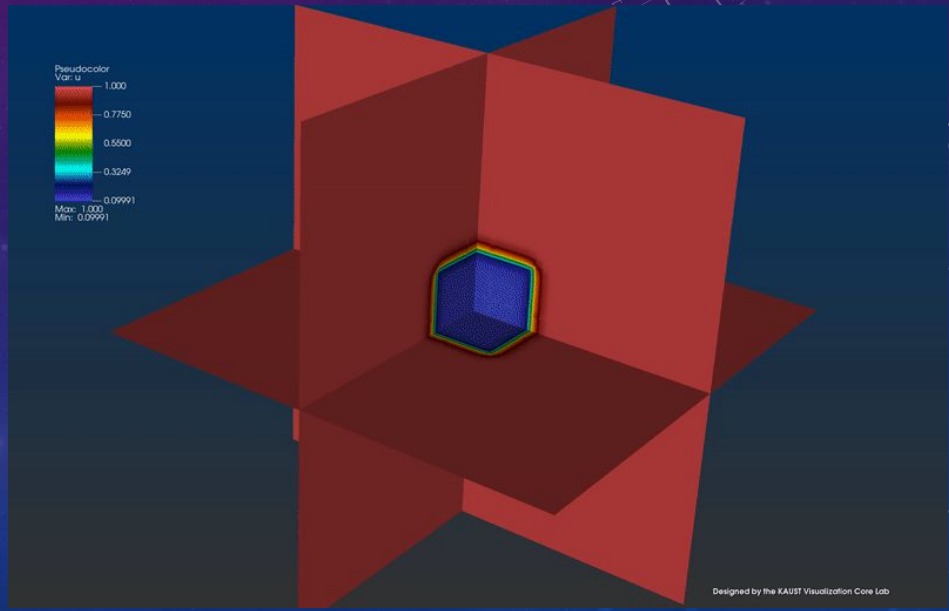
Screenshots / Movies

Save Window / Save Options

Filename & Directory



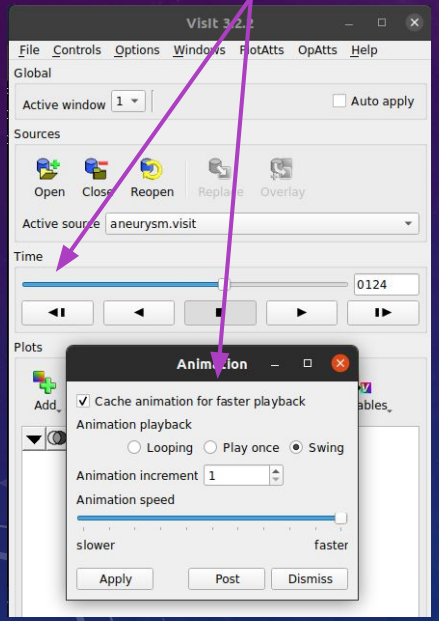
Save Options



Animation / Keyframing

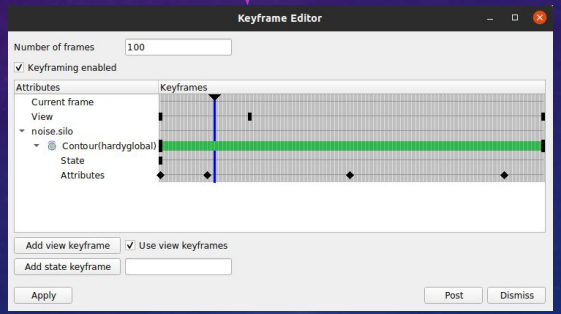
Viewing Animations

Animation Time Slider

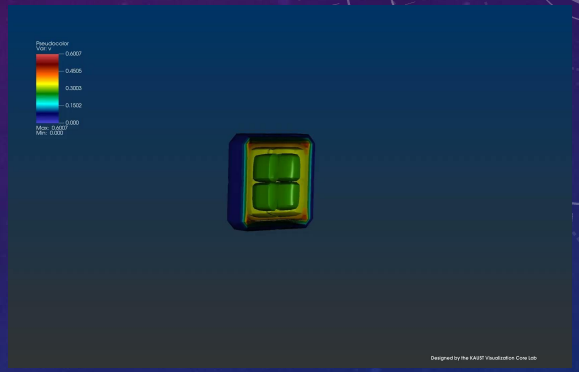


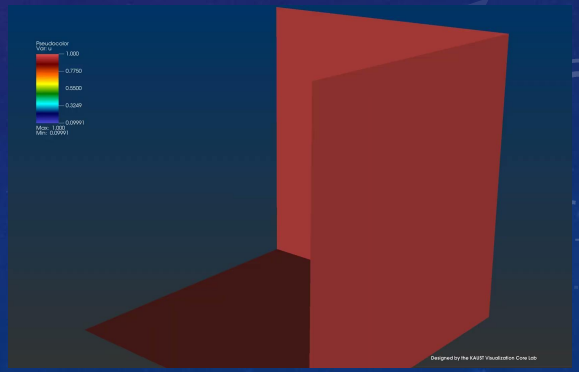
Keyframing

Keyframe editor



Resulting Movies



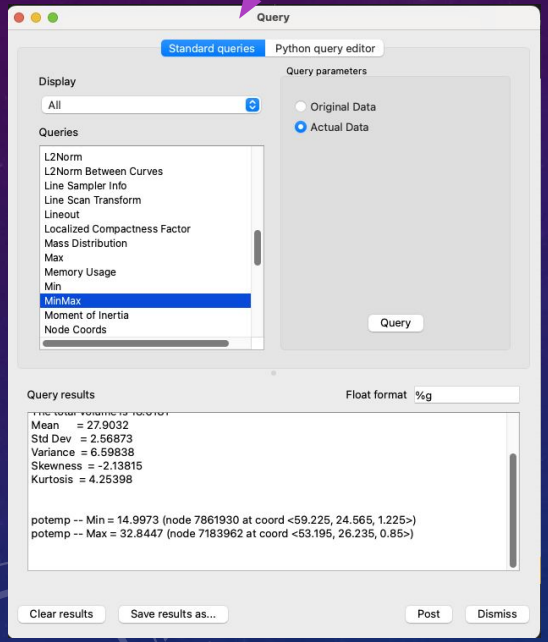


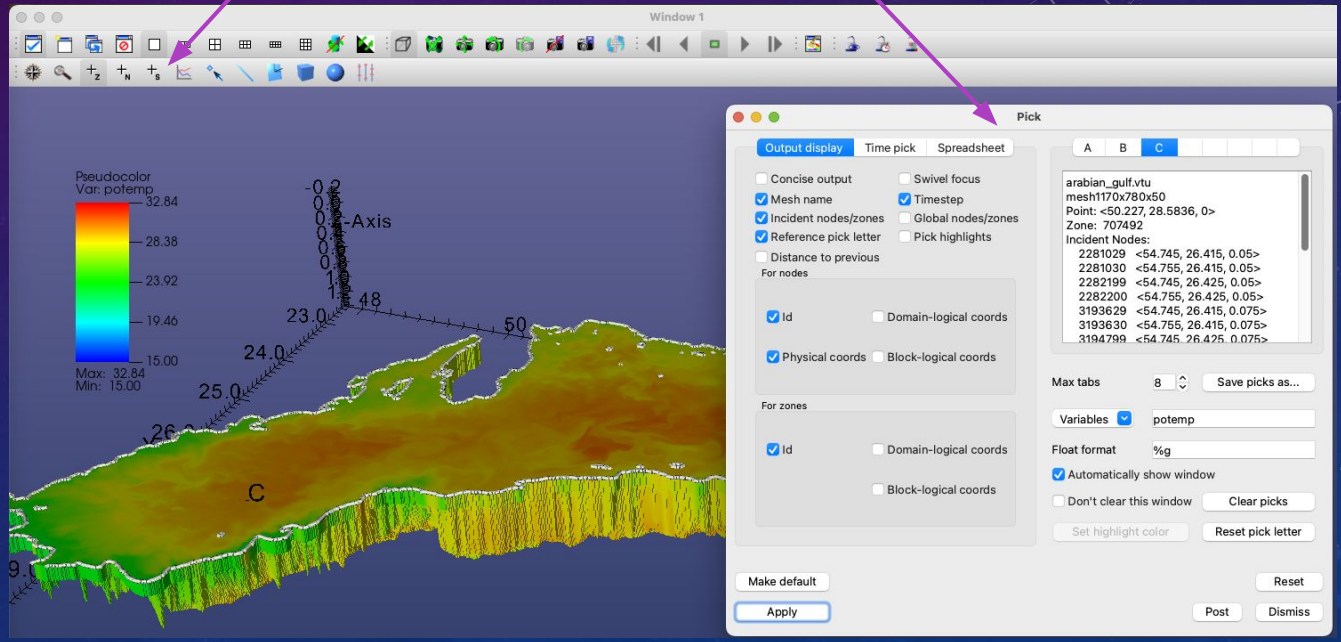
Queries / Pick

Query Window

Pick Options

Output Window



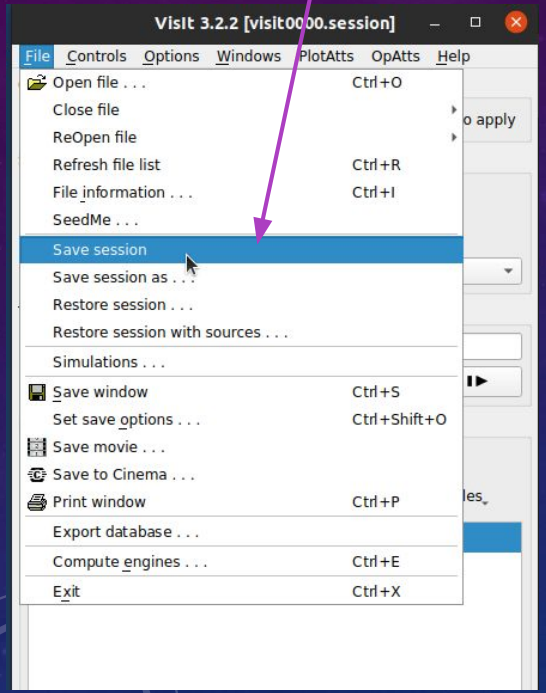


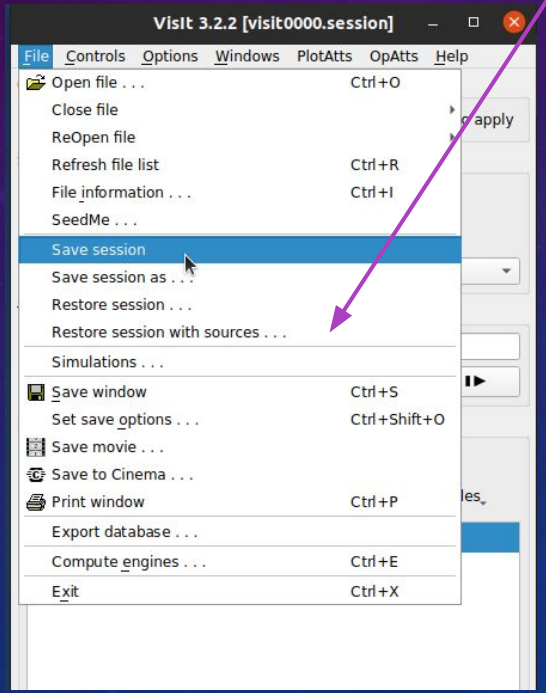
Save Session / Restore Session w/Sources

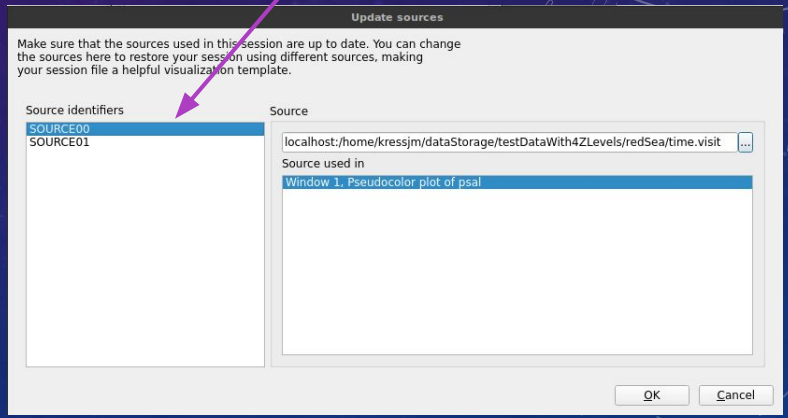
Save Session Dialogue

Restore Session with Sources

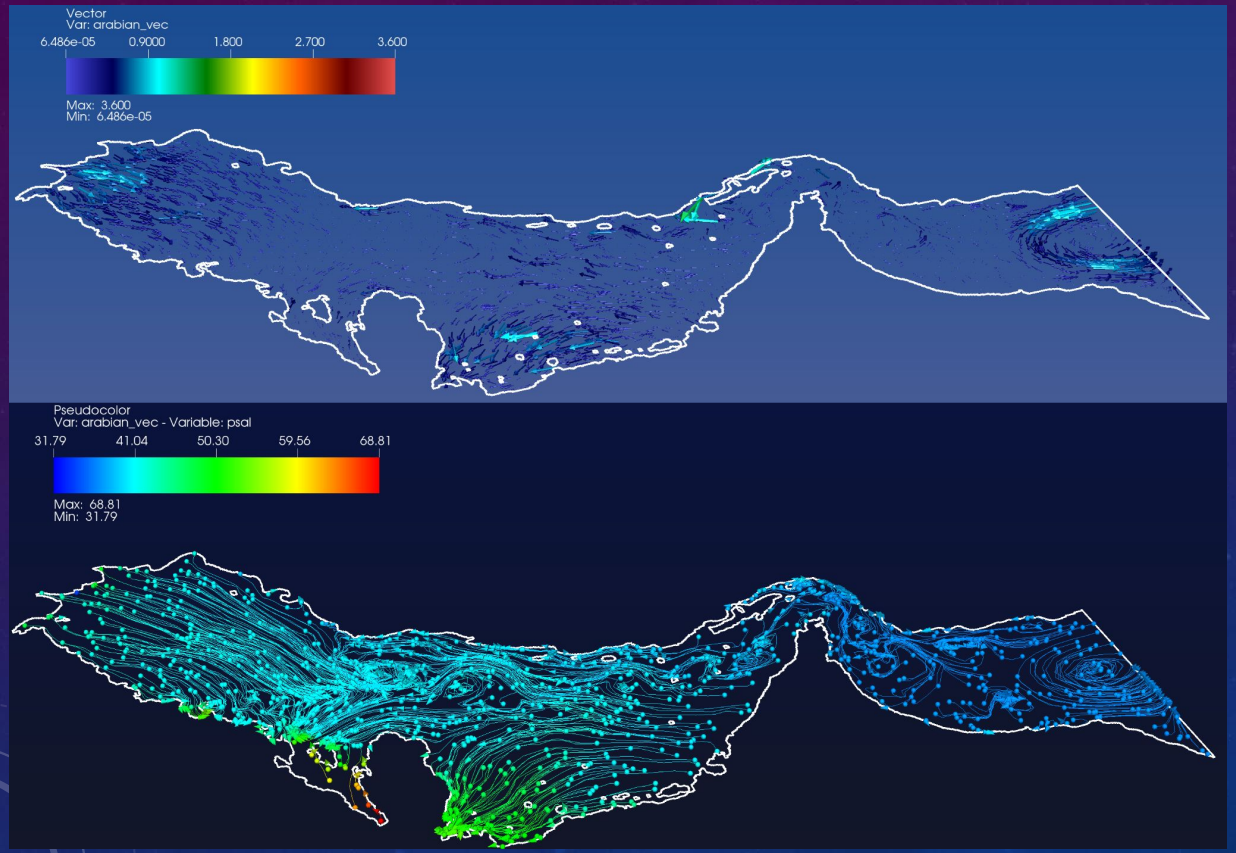
See each source and what plot uses each source







Vector Plots / Streamlines



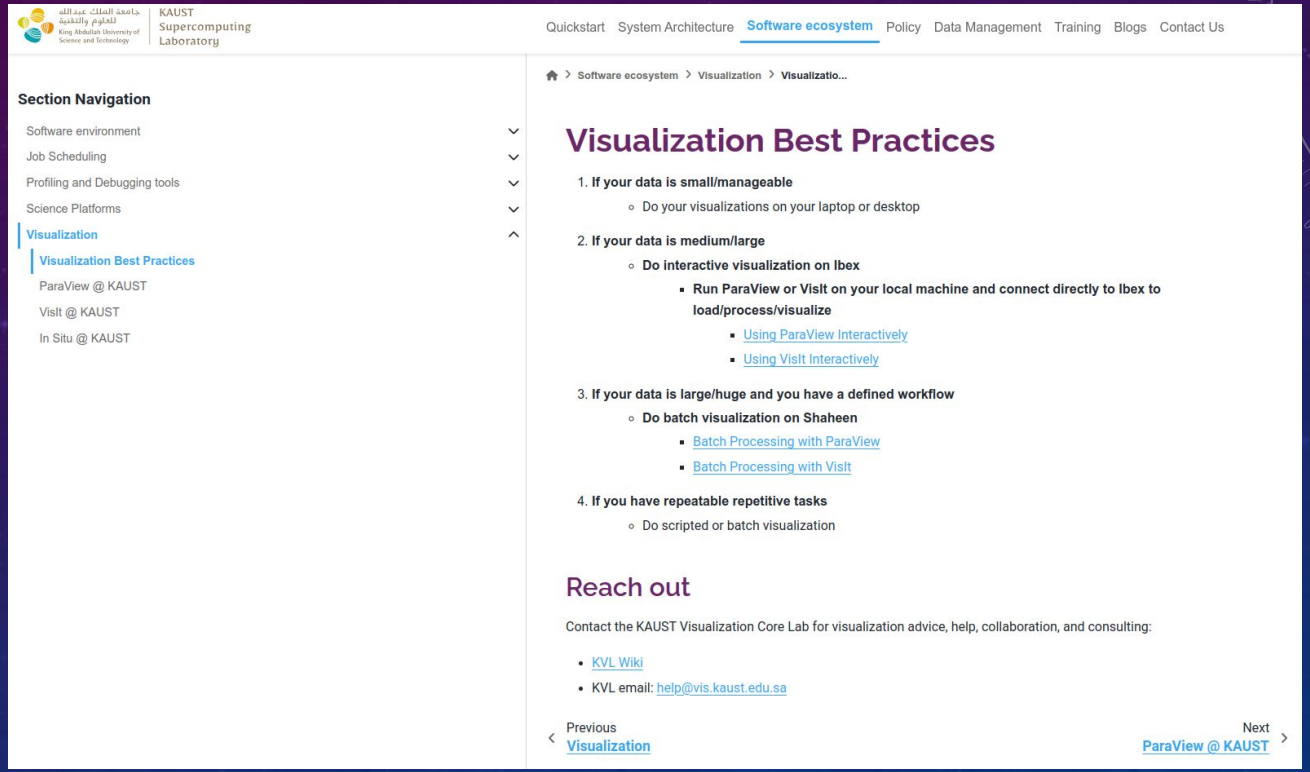
Create a vector expression, then:

1. Create vector plot
   a. Transform coordinates in z-direction
2. Create integral curve plot
   a. Slice in z-direction
   b. Project data to 2D
   c. Integral curve
   d. Elevate data back to 3D

VisIt Wrap-up

Best Practices / Scaling-up Workflows

Visualization Best Practices



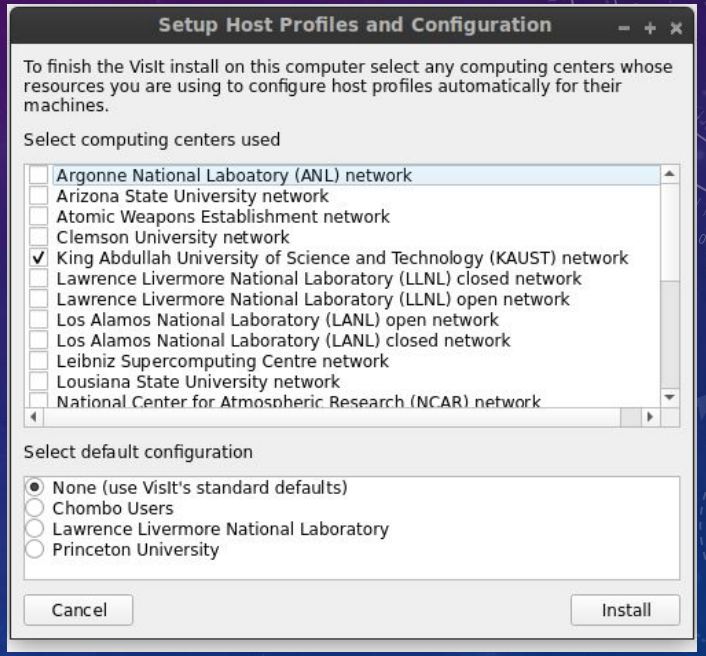
docs.hpc.kaust.edu.sa

Accessing KAUST HPC Resources

- Must have an active/valid user account
- Load the KAUST profile
- Connect & Visualize

For instructions see:

- https://docs.hpc.kaust.edu.sa/soft_env/visualization/visit_overview.html



Thanks!

Contacts:

james.kress@kaust.edu.sa

help@vis.kaust.edu