Introduction to CyberGIS

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GEOG 479: Advanced Topics in GIS – CyberGIS

- Course Goals
  - Be familiar with the high-performance computing components in CyberGIS
  - Leverage the CyberGIS architecture and resources to facilitate spatial thinking and knowledge discovery from geospatial Big Data.
  - Interact with geospatial Big Data in various forms (e.g., geo-located Twitter data, Taxi trajectory data and national DEM, etc.)
  - Solve geospatial problems with high-performance computing approaches.
- Course Syllabus
  - https://bitbucket.org/geog479/course/downloads/Syllabus.pdf
- Course materials
  - https://bitbucket.org/geog479/

GEOG 479: Advanced Topics in GIS – CyberGIS

- Course Outline
  - Introduction to CyberGIS, Geospatial Big Data and ROGER
  - High performance computing, cyberinfrastructure and GIS
  - Getting started with ROGER
  - Distributed Spatial Databases
  - Taming Big Geospatial Data with Hadoop
  - Advanced Geospatial Data Analytics
  - Mid-term project
  - Terrain analysis: Parallel MapAlgebra for Spatial Analysis
  - Interactive Geo-visualization of Large-scale Movement Data with Spark
  - Final project

What is CyberGIS?

Cyber + GIS ?

What is GIS?

- Systems
- Science
- Services
- Society
- Synthesis
- Spatial is special

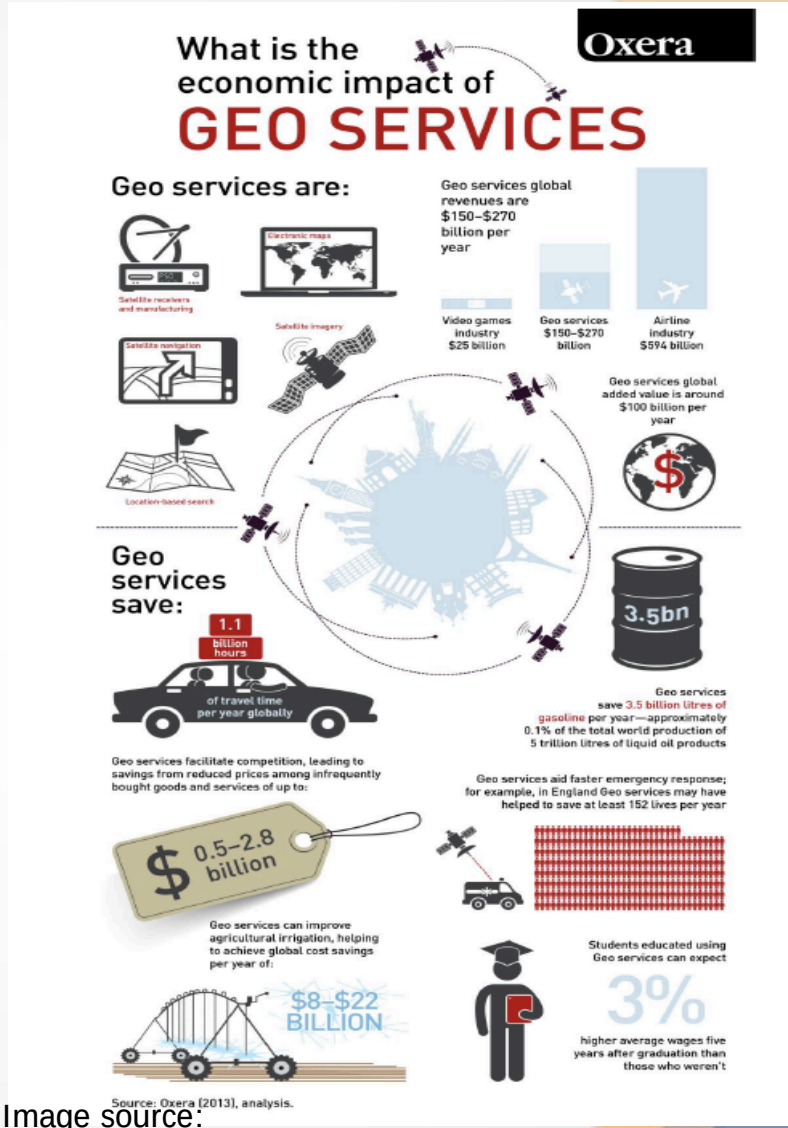


Image source: http://www.oxera.com/Oxera/media/Oxera/downloads/reports/What-is-the-economic-impact-of-Geo-services_1.pdf

What is CyberGIS?

- CyberGIS is the synthesis of cyberinfrastructure, GIS and spatial analysis

- Why CyberGIS?
  - Geospatial discovery and innovation with advanced digital technologies[1]

1. Wang, S. (2013)

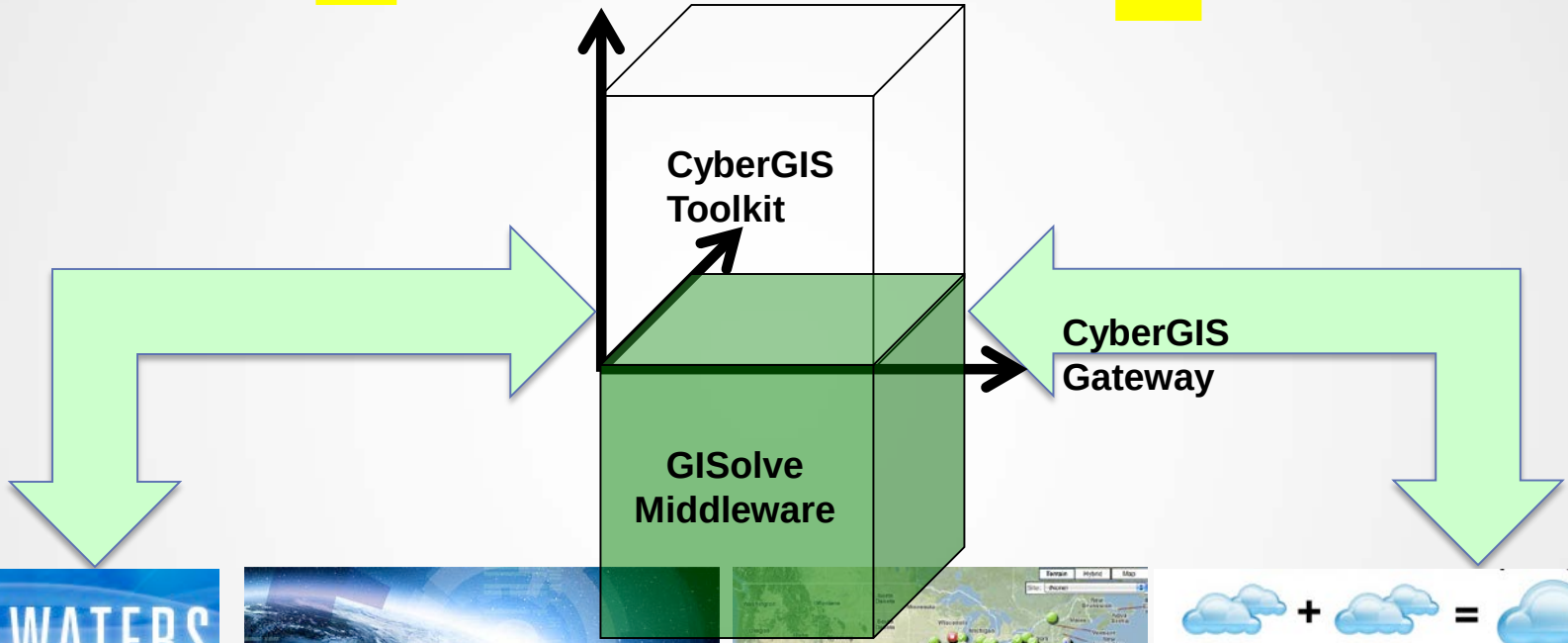
cyberinfrastructure

CyberGIS is Geographic Information Science and Systems based on advanced cyberinfrastructure.

Cyberinfrastructure includes:

- (high performance) computing systems
- data storage systems
- advanced instruments
- data repositories
- visualization environments
- people
- linked by high speed networks

Advanced Digital and Spatial Studies



BLUE WATERS
SUSTAINED PETASCALE COMPUTING

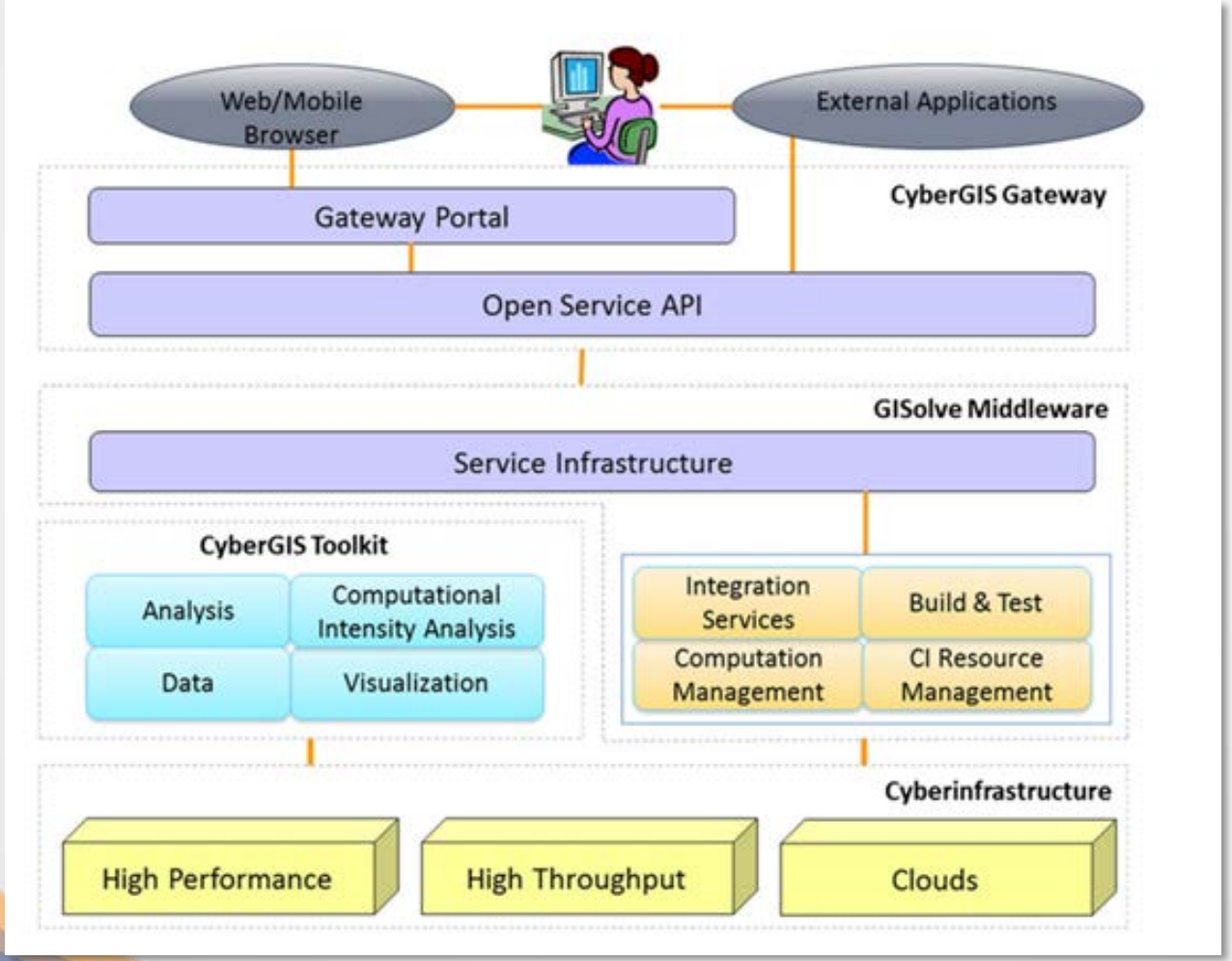
www.ncsa.illinois.edu/BlueWaters/

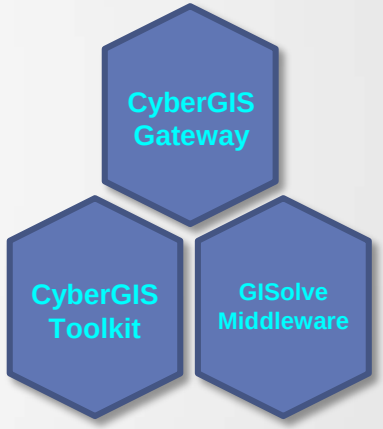
www.xsede.org

www.opensciencegrid.org

http://lakjeewa.blogspot.com/2011/09/what-is-cloud-computing.html

CyberGIS Software Environment





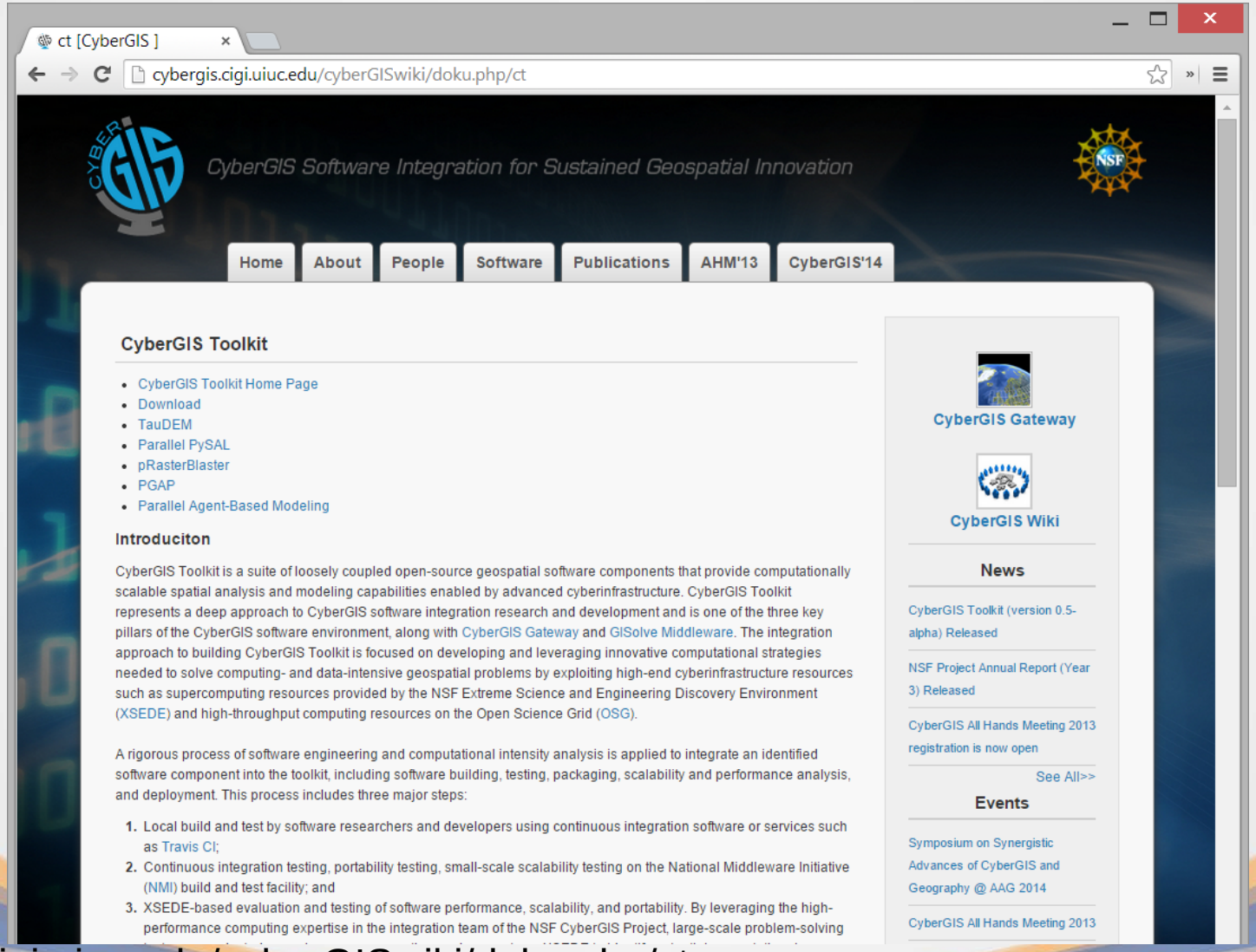
CyberGIS Gateway

GISolve Middleware

GISolve Open Service API

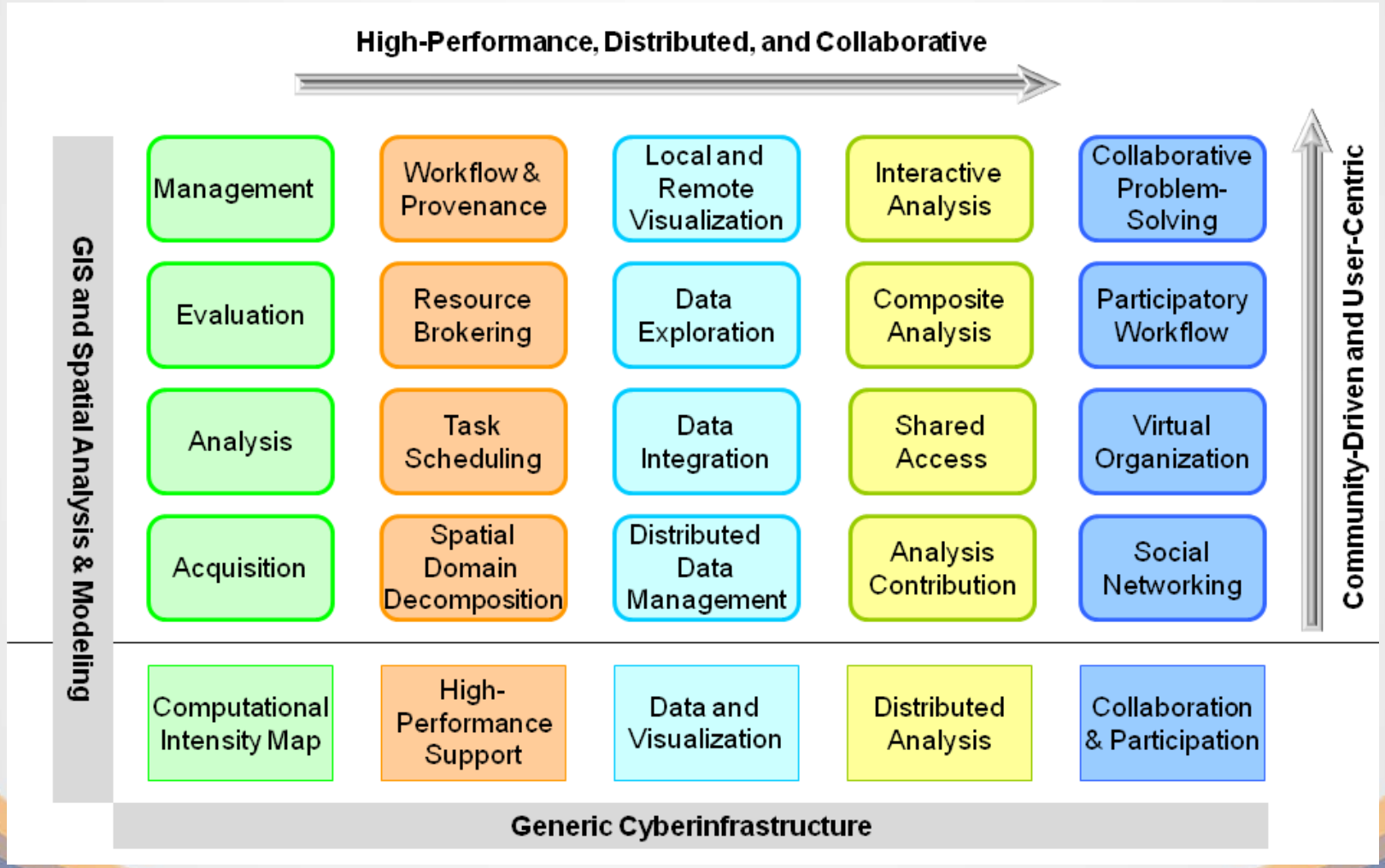
www.cigi.illinois.edu/dokuwiki/doku.php/projects/gisolve/index

CyberGIS Toolkit



cybergis.cigi.uiuc.edu/cyberGISwiki/doku.php/ct

CyberGIS Toolkit



CyberGIS architecture
(source: Wang et al., 2013)

Terminologies

- Cloud computing
- High performance computing
- High-throughput computing
- Distributed computing
  - Hadoop and Spark
  - Non-relational database (NoSQL)
  - Distributed database
- Parallel computing

- Computational geography
- WebGIS

CyberGIS Center for Advanced Digital and Spatial Studies

Empower advanced digital and spatial studies through innovation of CyberGIS technologies and applications

Research Application Focus Areas:

Agriculture and Food
Disaster and Emergency
Earth and Environment
Energy and Water Resources
Health and Wellness

CyberGIS Gateway and ArcGIS Online Integration

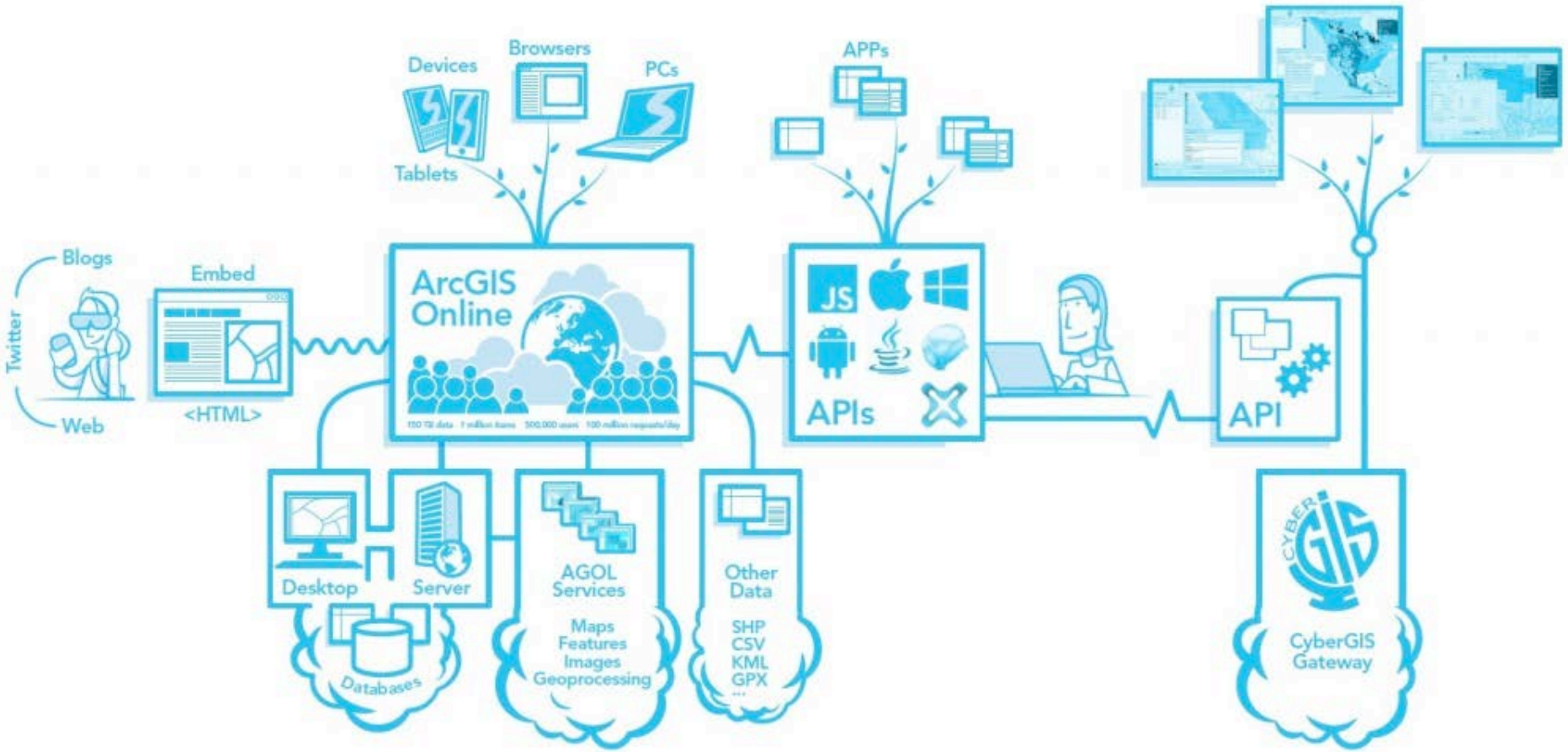
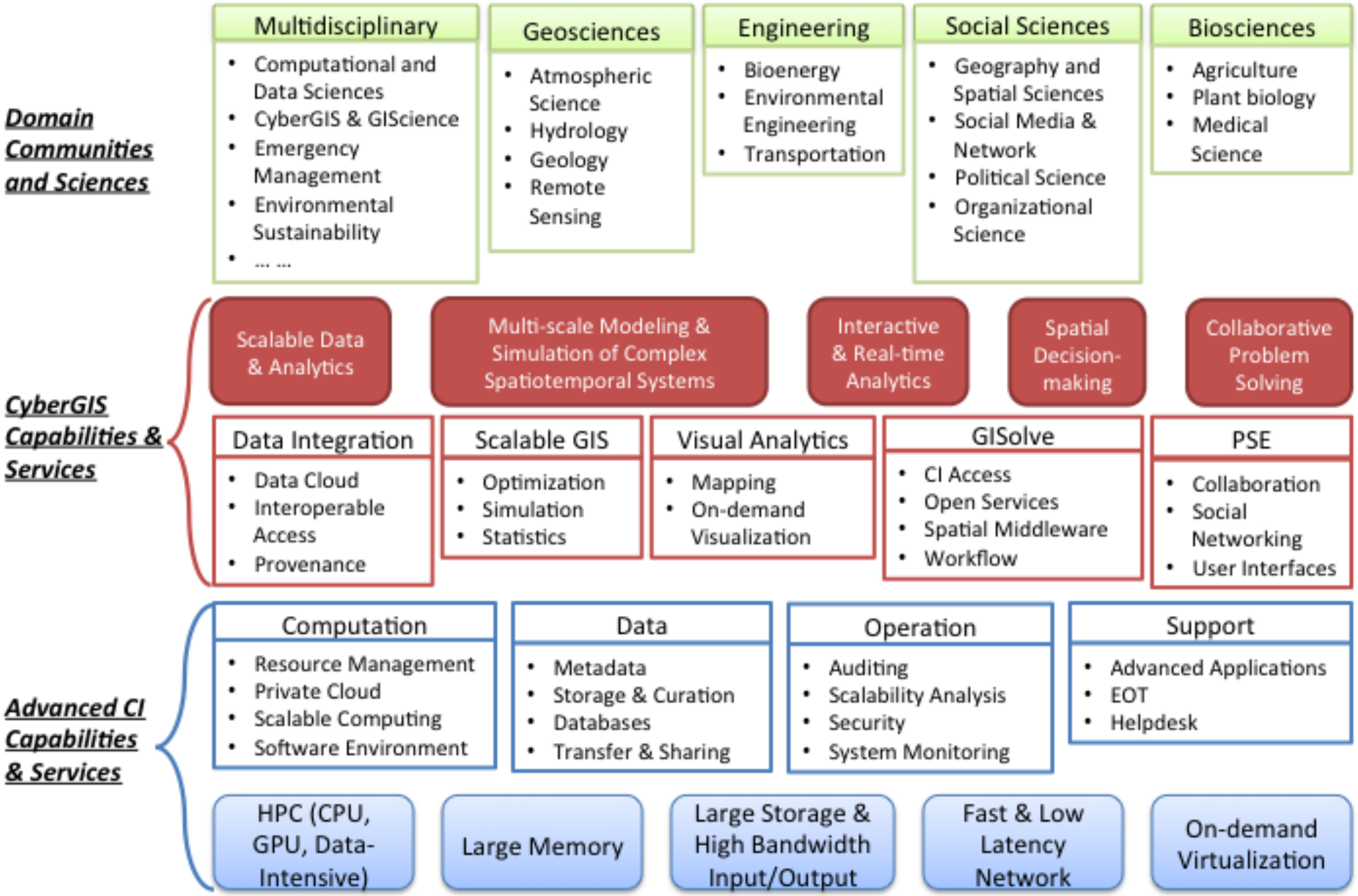


Image source: http://blogs.esri.com/esri/arcgis/2013/10/01/what-is-cybergis/



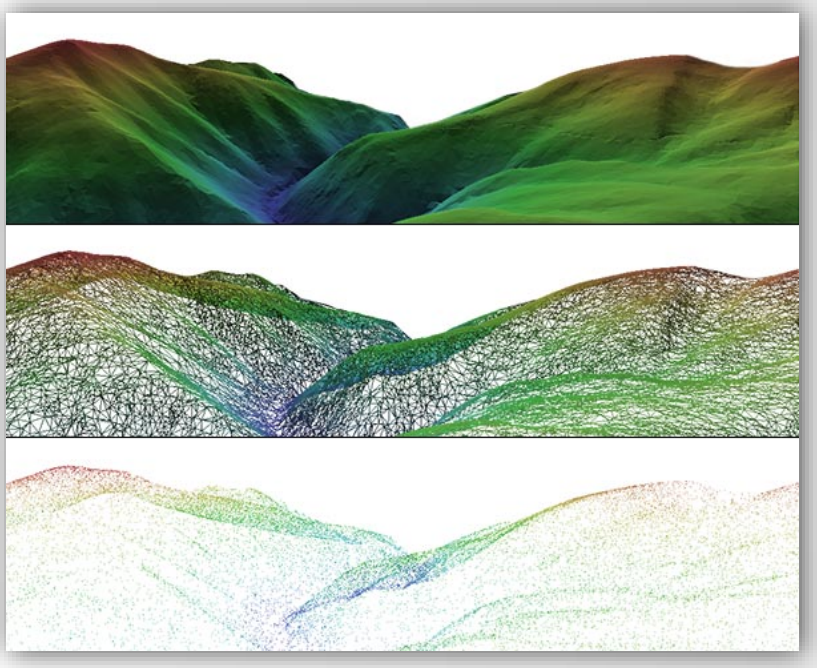
* EOT – Education, Outreach, and Training; HPC – High Performance Computing; PSE – Problem-Solving Environment

Education, Outreach, and Training Activities

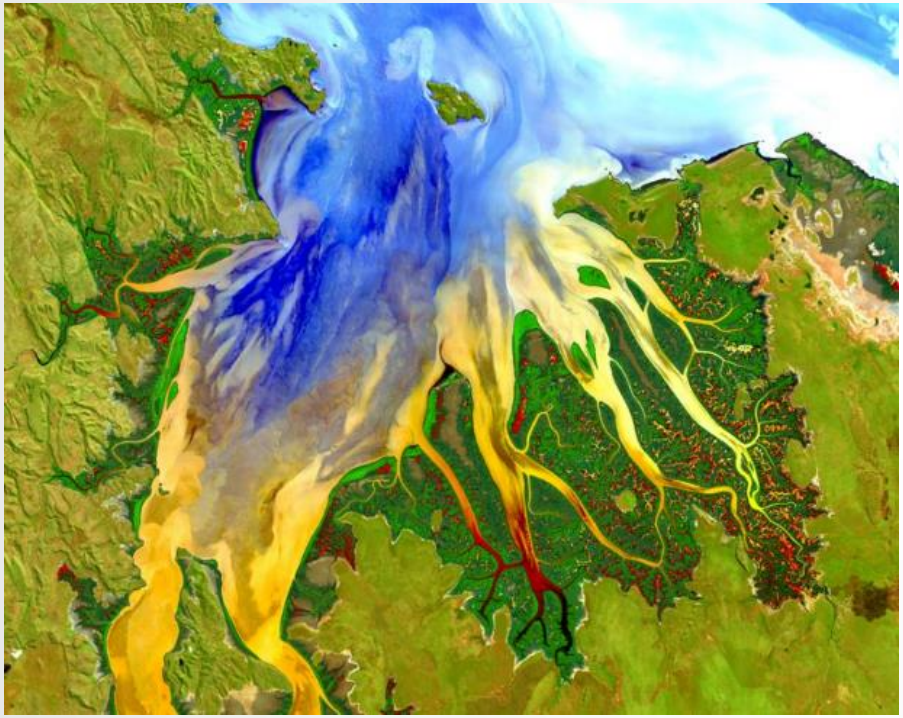
- CyberGIS Commons
  - For hands-on learning and training
- CyberGIS Collaboration Space
  - For groups to develop collaborative research
- CyberGIS Helpdesk
  - For in-depth technical consulting
- CyberGIS Brown Bag Seminars
  - Once every two to three weeks on average
- CyberGIS Distinguished Speaker Series
  - Once every two months on average
- CyberGIS MOOCs
- CyberGIS Webinars

Geospatial Big Data

- Volume
  - USGS NED 30m(175GB), 10m(500GB)
- Variety
  - Forms and formats (Raster and Vector)
  - Shapefile, GeoTiff, GeoJSON, WMS, WFS, NetCDF, HDF5
- Velocity
  - All Geocoded Tweets
    - 2.5kb/tweet
    - 6,000 average tweet per second
    - 3% of tweets are geo-located
    - 38GB per day
  - Landsat 8
    - 650GB per day
- Veracity
  - Uncertainty



Geospatial Big Data



Landsat 8

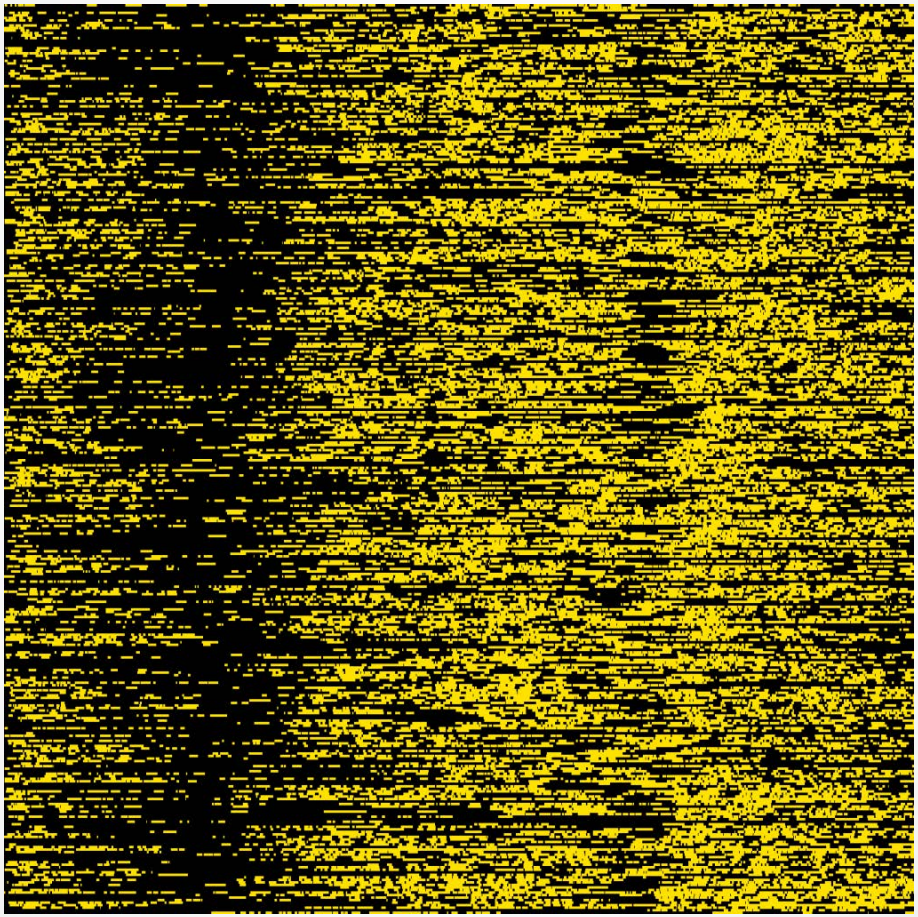
- ~650 images per day
- ~1GB each (compressed)
- ~650gb per day

Twitter Firehose

All Geocoded Tweets

- ~2.5KB / tweet
- ~6,000 average tweet per second
- ~3% of tweets are geolocated
- ~38GB per day

Geospatial Big Data



Visualization of New York taxi data
The black pixel means the taxi did not have fare and yellows means it did
Source: http://chriswhong.com/open-data/my-first-data-art-nyc-taxi-defrag/

CyberInfrastructure Resources

NSF Blue Waters @ UofI
13,300 TFlop/s

NSF XSEDE: SDSC Comet
2,000 TFlop/s

UofI Campus Cluster

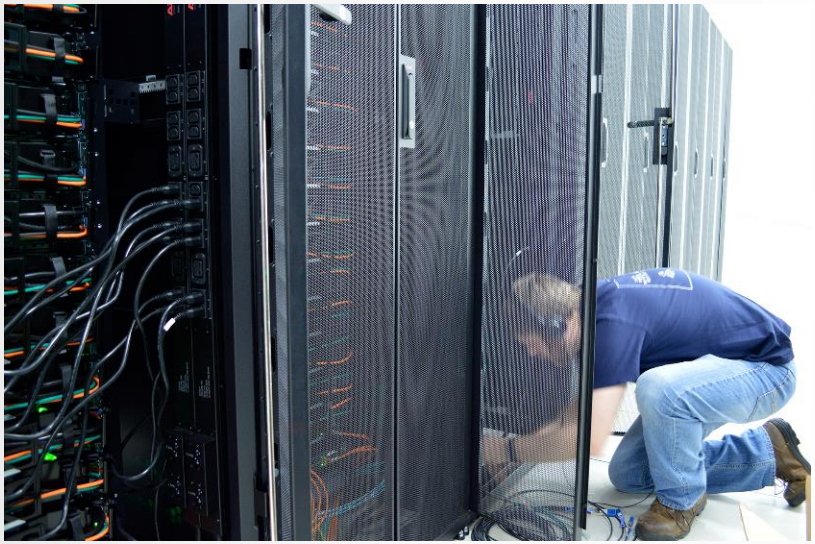
CyberGIS ROGER

CyberGIS ROGER
Resourcing Open Geospatial Education and Research
After Roger Tomlinson
goo.gl/8MpYC9
~60 TFlop/s

Why ROGER?

- Both a research project and a research resource
- Configured to best support geospatial data, with emphases on local memory and shared storage size and speed
- Supports multiple paradigms: traditional batch HPC, Hadoop, and Cloud (OpenStack).
- Integrate the three paradigms and leverage their strengths
- Inform the design of future geospatial supercomputers

ROGER: Overview



- Provides the CyberGIS Center with HPC, Hadoop and OpenStack functionality all on one system
- Managed by Systems Group

  With support from our storage, network, security and services groups

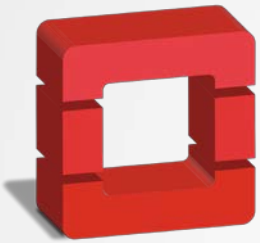
ROGER: File system

- IBM General Parallel File System (GPFS)
- Parallel file system means all of the nodes get fast access to hard drive storage.

ROGER for this class

- Will create ROGER accounts for every student in this class
- Interact with various components in ROGER
  - Job submission
  - Handling and processing massive data with Hadoop, Spark, R, and Python, etc.
  - Getting to know OpenStack
  - Working with Geospatial libraries

ROGER for this class

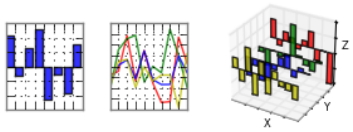


openstack
CLOUD SOFTWARE

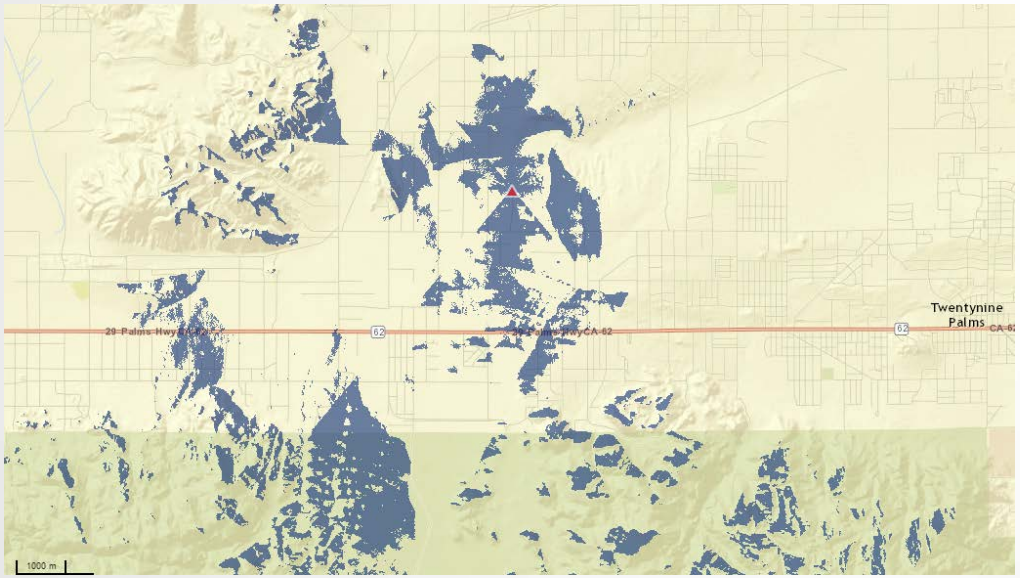
mongoDB

pandas

$$y_{it} = \beta' x_{it} + \mu_i + \epsilon_{it}$$



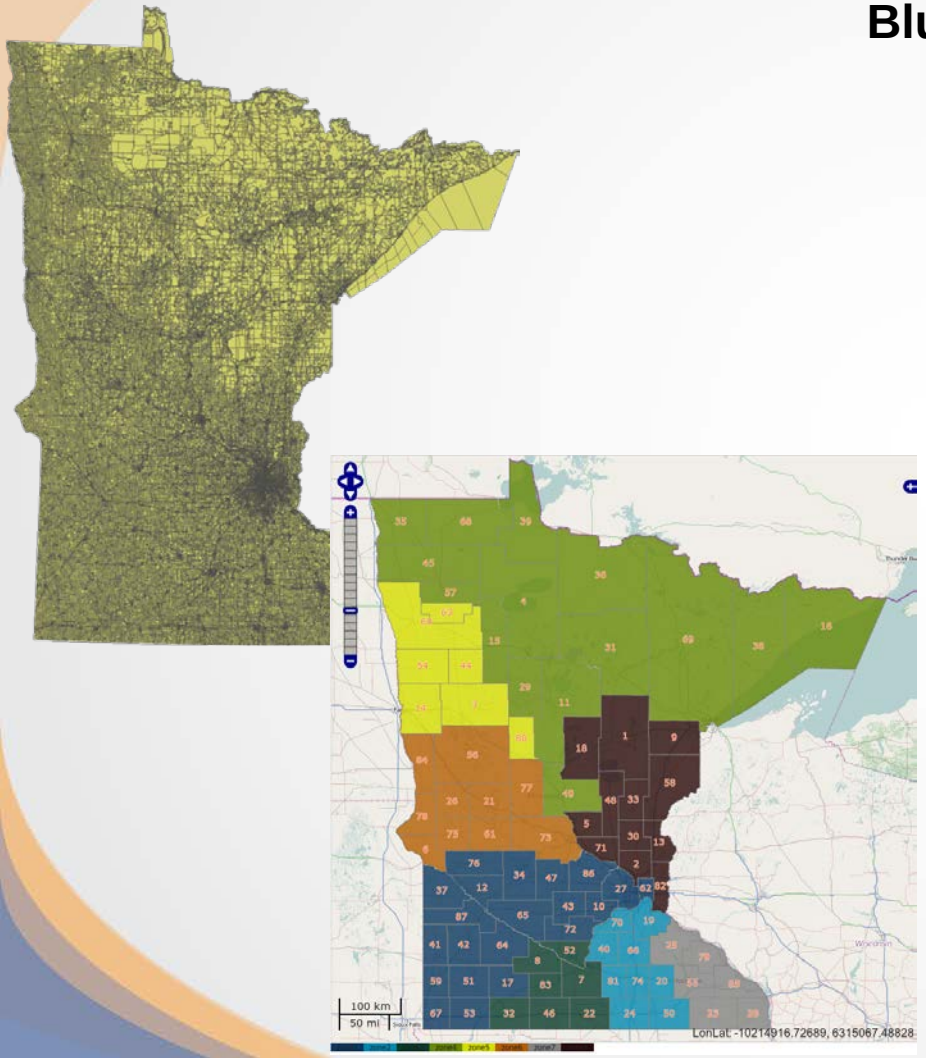
CyberGIS Viewshed App



Viewshed

Uofl Cluster

Parallel Genetic Algorithm for Redistricting Optimization on Blue Waters

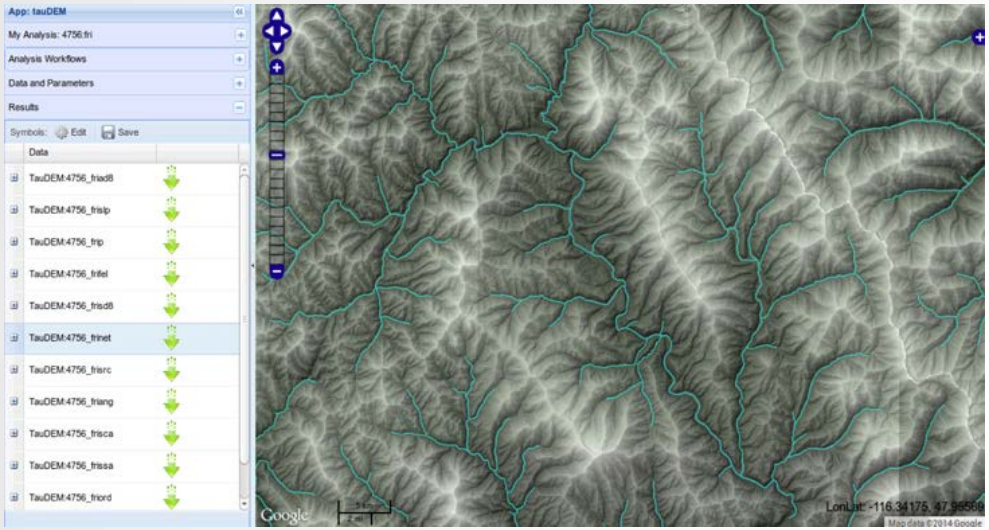


NSF Blue Waters @ UofI

13,300 TFlop/s

Collaborative Work with Wendy K. Tam Cho @ UIUC

CyberGIS TauDEM App



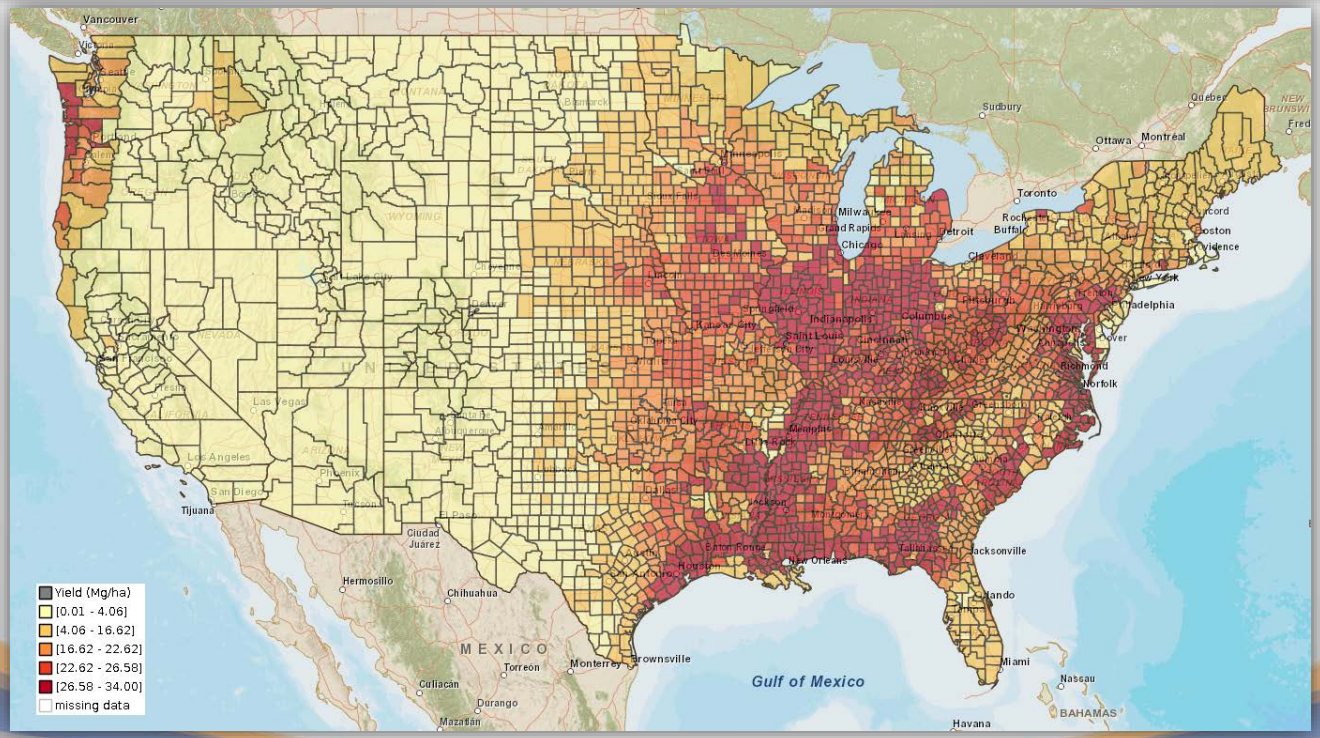
TauDEM

NSF XSEDE: SDSC Trestles

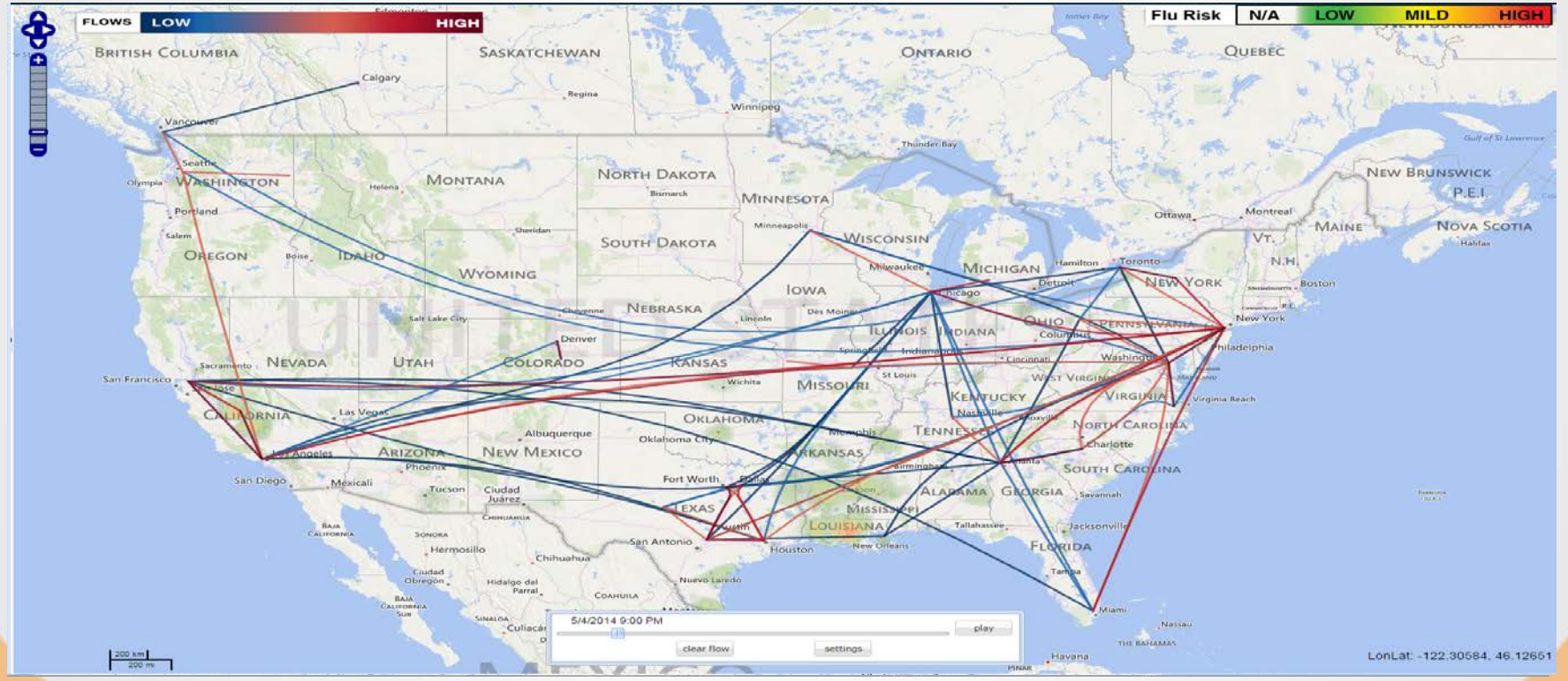
100 TFlop/s

Collaborative Work with David Tarboton @ Utah State University

CyberGIS BioScope App



CyberGIS FluMapper App



Lab

1. FluMapper
   - Social media, point data, streaming data, Hadoop, routing, raster and vector visualization
2. BioScope
   - Agriculture, supply chain optimization, chart generation, reference base maps
3. TauDEM
   - Hydrologic data analysis, digital elevation models, code reuse

Reference

- Wang, S., Anselin, L., Bhaduri, B., Crosby, C., Goodchild, M. F., Liu, Y., and Nyerges, T. L. (2013). Cybergis software: a synthetic review and integration roadmap. *International Journal of Geographical Information Science*, 27(11), 2122–2145.
- Wang, S. (2013) "CyberGIS: Blueprint for Integrated and Scalable Geospatial Software Ecosystems." *International Journal of Geographical Information Science*, 27 (11): 2119-2121