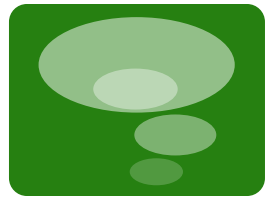
GOVLOOP TRAINING

Simple Ways to do More with Your Scientific Data

June 18th, 2015

Helping you do your job better:

Housekeeping



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- **Take our survey:** Help us, help you! Take our brief evaluation to let us know what you liked about this training.

govloop

Today's Speakers

Dawn Wright
Chief Scientist
Esri

Brian Tisdale
Booz Allen Hamilton

Suresh K.S. Vannan
Manager, DAAC
Oak Ridge National Laboratory

Brett Rose
Solution Engineer
Esri

GovLoop Webinar
June 18, 2015

Location *Matters* in Scientific Discovery

Dawn J. Wright, Ph.D.

Esri Chief Scientist

Esri View of Science

esriurl.com/scicomm

Increasing fundamental scientific understanding

Promoting economic vitality

Protecting life and property

Enabling stewardship of the environment

How the Earth *works*.

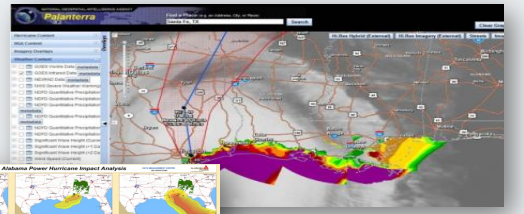
How the Earth should LOOK.

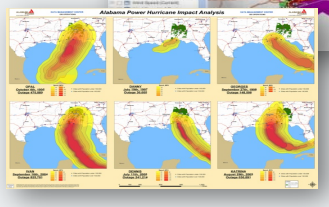
How we should look AT the Earth.

Societal drivers of science are key.

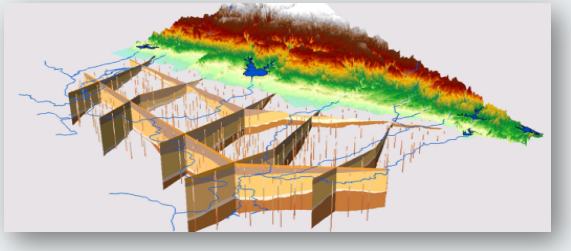
How the Earth works…. How the Earth should *look* ….
How we should look *at* the Earth….

Climate Science





Hydrology

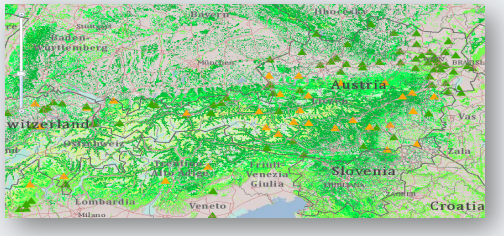


Geology/Geophysics

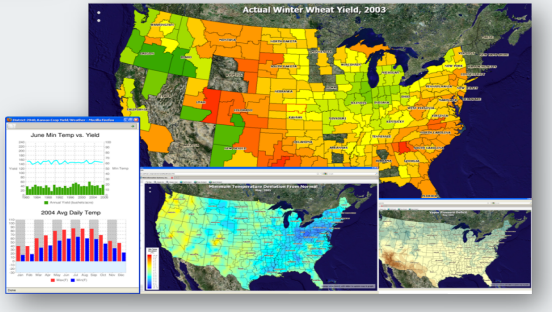
Ecology

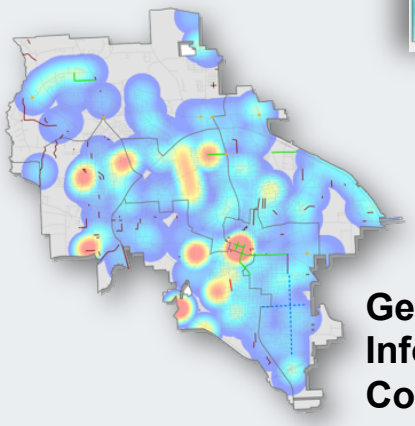
Conservation Biology

Forestry



Agricultural Science

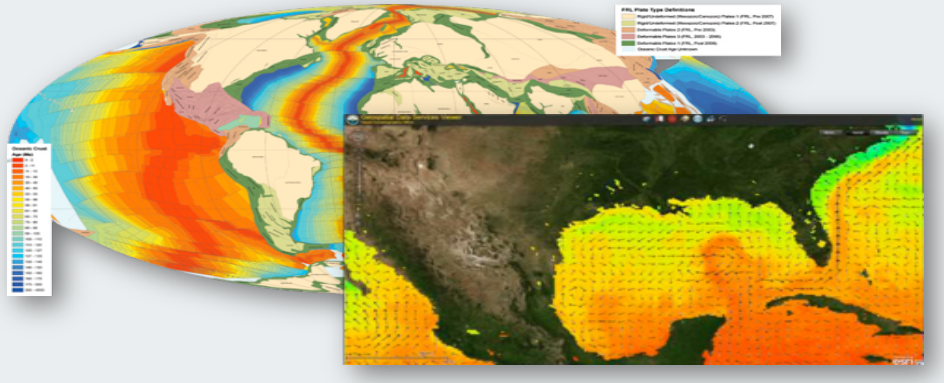




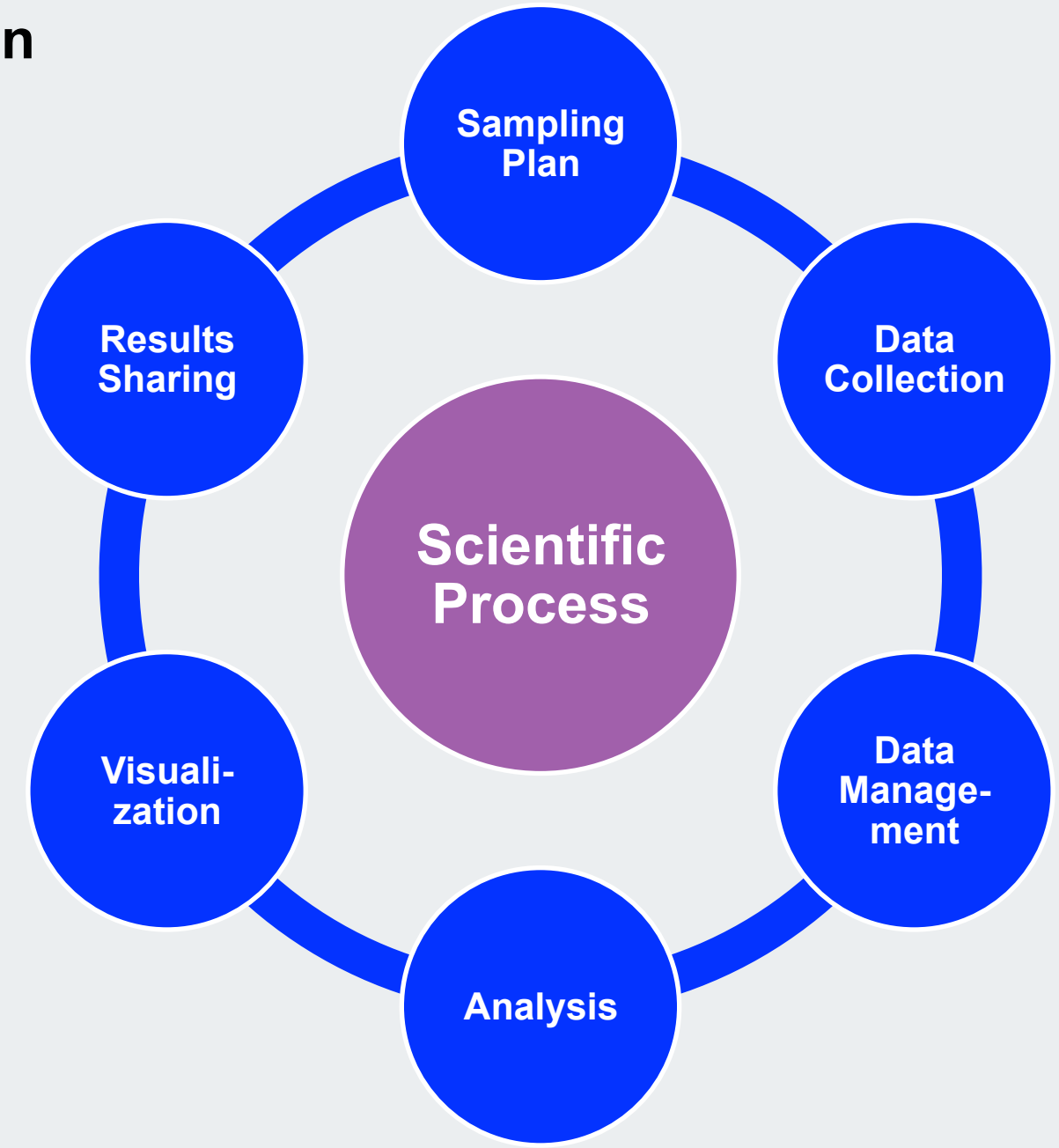
Geographic Information Science / Computer Science

Sustainability Science / Geodesign

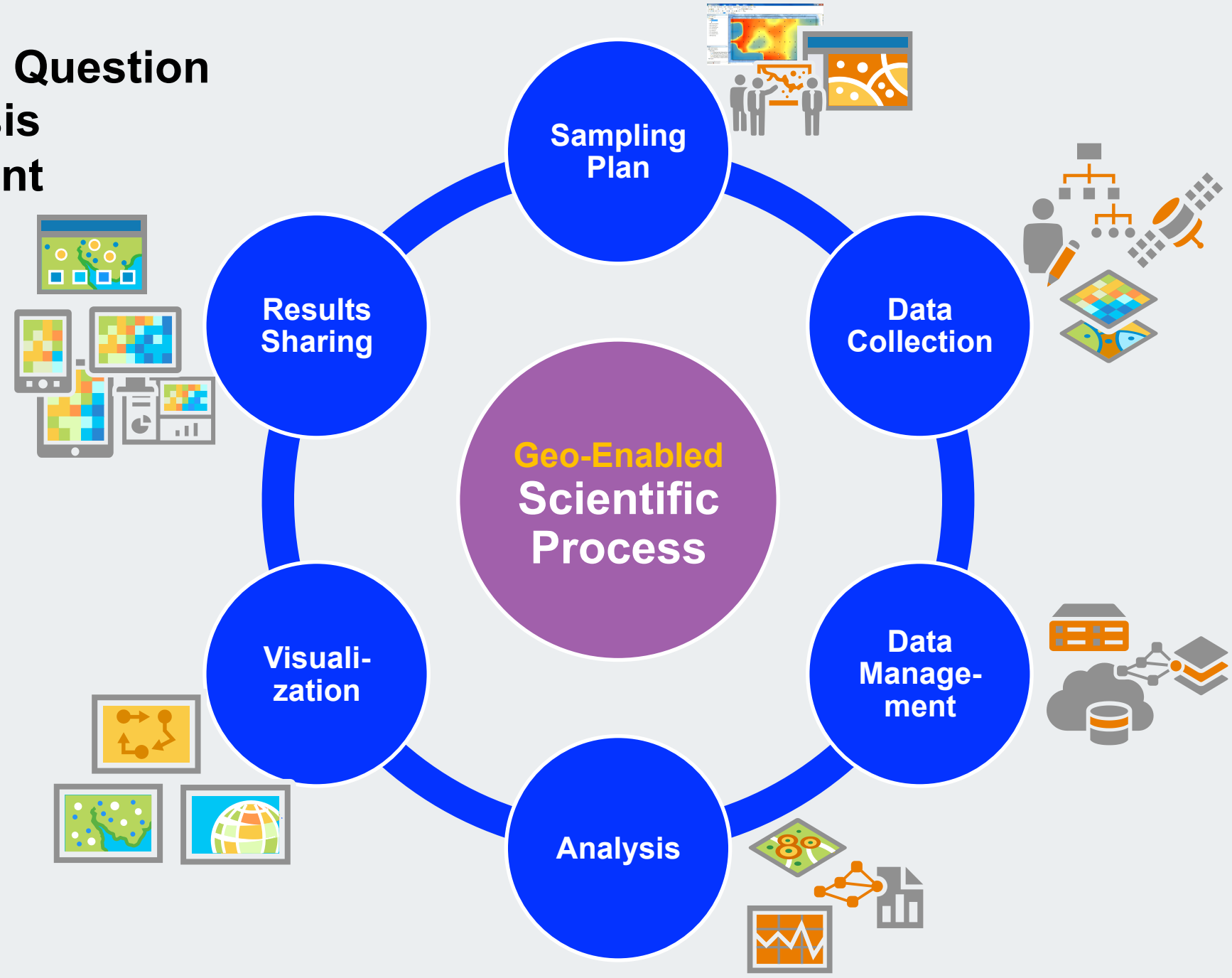
Ocean Science



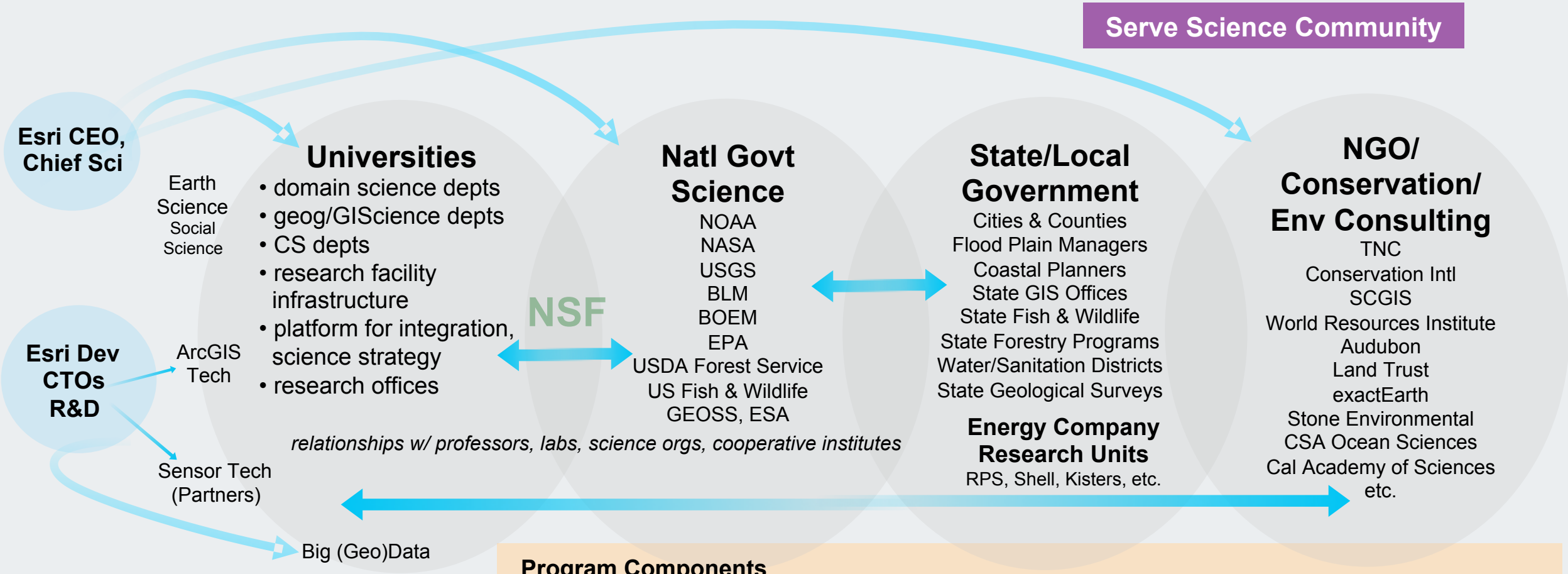
Research Question
Hypothesis
Experiment



Research Question
Hypothesis
Experiment



Esri Science Community Program



Program Components

Chief Scientist, National Government Science Team, Esri Education Team

- **Internships** for students
- **Sabbaticals** for faculty
- **Esri Development Centers** at universities
- **Summits**: Dev, Geodesign, Ocean, Health, etc. (UC Science Symposium coming in 2016)
- **Software stacks** (e.g., MultiD, SciPy, R integration)
- **Data stacks** (e.g., ArcGIS Online content, Living Atlas
- **Resource web sites** (blogs, use cases, webinars)
- **Esri Press** research monographs
- **App challenges**/Design competitlons
- **Informal MOUs** with labs/orgs

Software Stacks for the Scientific Community

- **Python**
- **OPeNDAP** (Open-source Project for a Network Data Access Protocol)
- **R** (the *R* Project for Statistical Computing)

Inclusion of Additional Python Packages

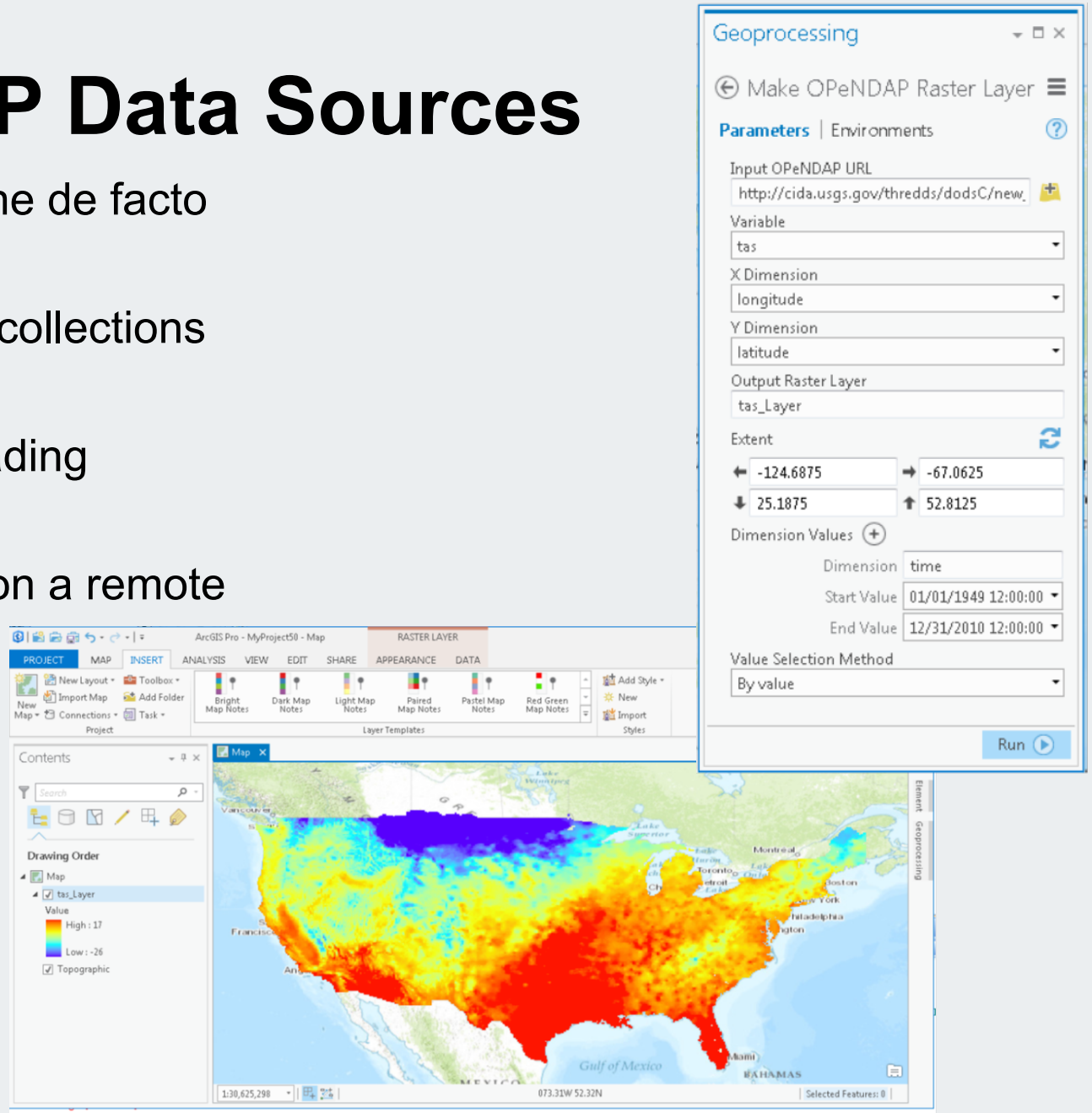
- **Pandas** – provide high-performance, easy-to-use data structures and data analysis tools for working with tables in Python

- **SciPy -** supports our goal of being a comprehensive geospatial platform for science by expanding the number and type of analytical methods available to the science community

- **netCDF4** - provides programmatic access for a popular scientific data format

Support for OPeNDAP Data Sources

- The OPeNDAP protocol has become the de facto standard for streaming scientific data
- NOAA and NASA have extensive data collections available via OPeNDAP
- New ArcGIS geoprocessing tool for reading OPeNDAP data
- Makes a raster layer from data stored on a remote OPeNDAP server



Mean temperature (C) : 1950-2010

New R – ArcGIS Bridge and Community

- R is the most widely used, fastest growing statistical analysis software
- Many organizations using ArcGIS also use R
- High interest in our existing R integration

- Who is this for?
  - R users who want to work in R with easy, efficient access to ArcGIS data
  - R users who want to provide R analysis capabilities to ArcGIS users
  - ArcGIS users who don't know R

USGS science for a changing world

United States Environmental Protection Agency

NOAA

Shell

bp

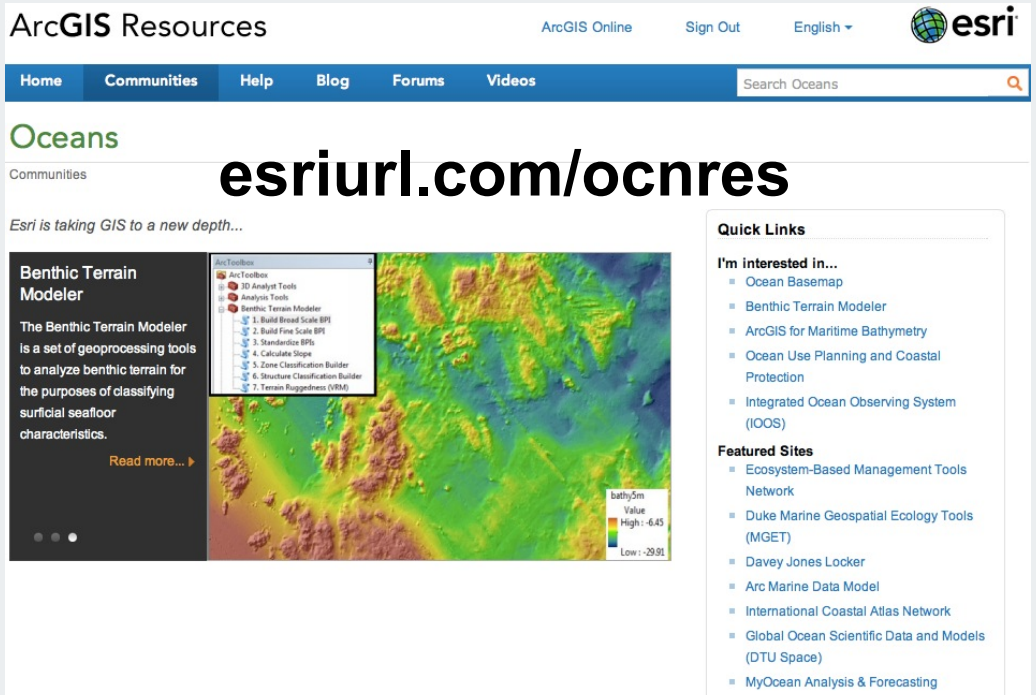
Forest Service U.S. Department of Agriculture

United States Census Bureau

CSIRO Australia

Resource Centers / Case Studies / Blogs

- Analysis from exploration to decision-making demonstrated by example
  - Data and models can be downloaded
  - Analysis and tools are defined by the question - outlined at the start
  - Processes shown, results are interpreted



“Once upon a time …”

esriurl.com/analyticalstories

All Blogs

Esri Insider

Esri visions, strategic initiatives, and trending topics

RSS 2.0 Atom 1.0

Speaking the “Language” of Spatial Analysis via Story Maps

by Dawn Wright on September 15, 2014

Share 192 Tweet 542 Share 1297

The USDA Forest Service’s Restoration Story Map Atlas uses the same format to show the results of analyses for the Pacific Northwest ranging from identifying the percentage of a watershed that could be effectively treated through active forest thinning, prescribed fire, or use of wildfire, to the results of a bivariate rendering of burn probability by conditional flame length.

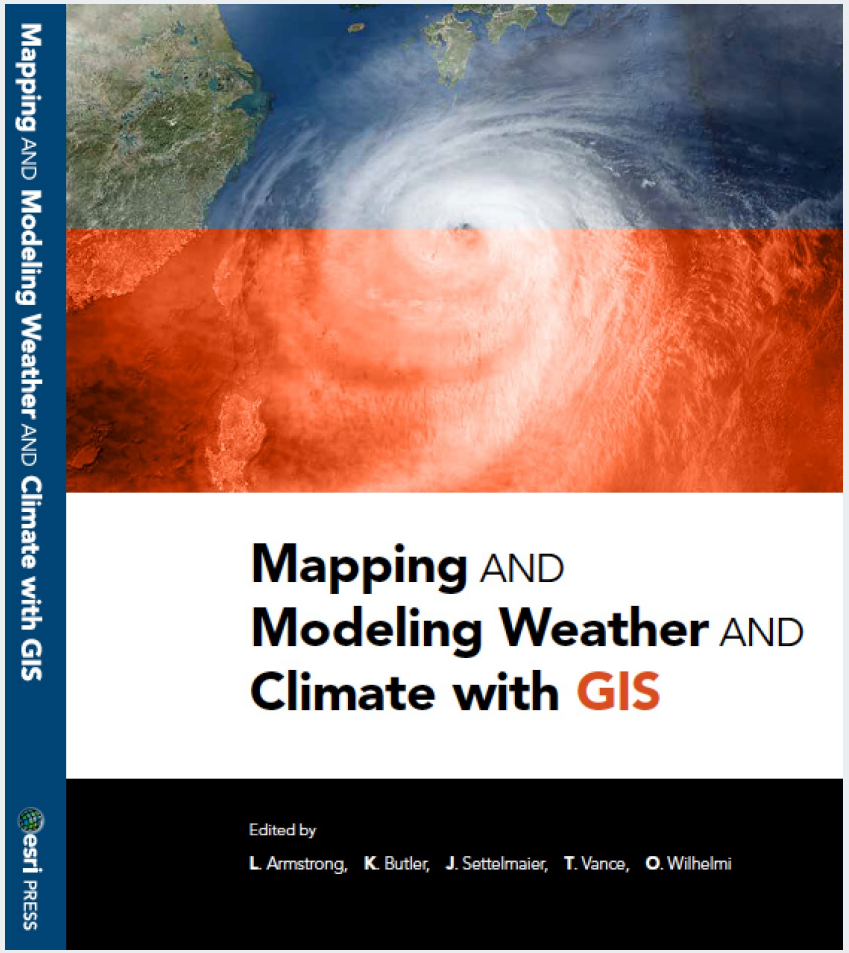
Dawn Wright | Sign out | Site Admin

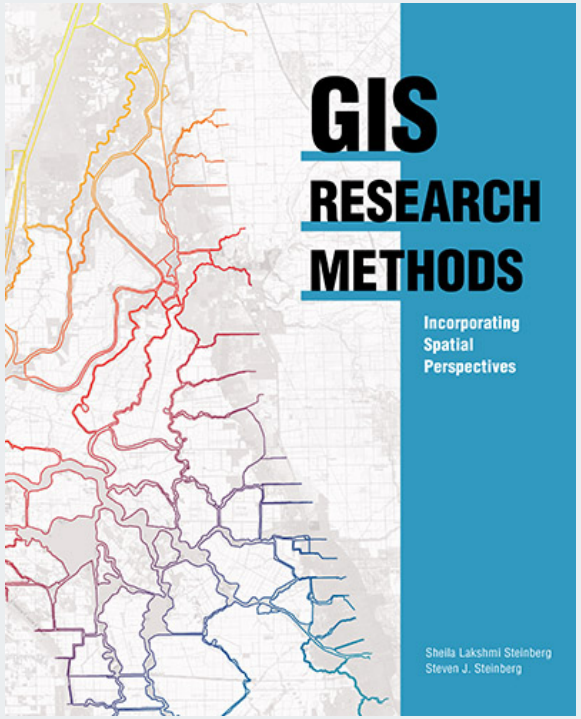
Categories

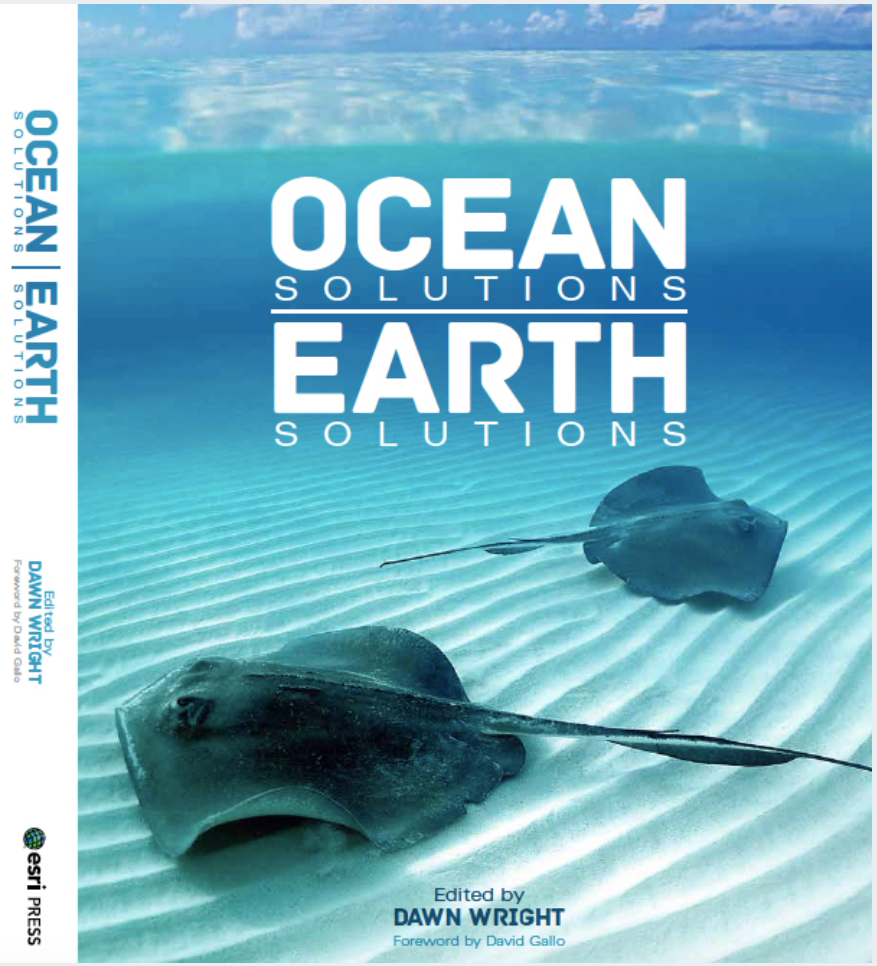
Online big data business citizen engagement climate change Climate Change Adaptation Cloud CyberGIS Dawn Wright demographics education electric Esri geodesign geographic information systems geography GIS GIS Education Gov 2.0 government government accountability government transparency higher education imagery Jack Dangermond location analytics mobile natural resources ocean oceans Oceans & Maritime Public Works remote sensing Retail science spatial analysis spatial thinking story map Story Maps storytelling storytelling with maps user conference utilities

New Esri Press Books for Scientists

esripress.esri.com







Access

Summary Blog Post: esriurl.com/scicomm

2015 Road Map: esriurl.com/sci2015

Personal Web: esriurl.com/dawn

Email: dwright@esri.com

Twitter: @deepseadawn

Elsewhere: road bike, movie theater

Improving the Accessibility and Use of NASA Earth Science Data

Brian Tisdale, Booz Allen Hamilton (BAH), brian.e.tisdale@nasa.gov

NASA Atmospheric Science Data Center (ASDC)

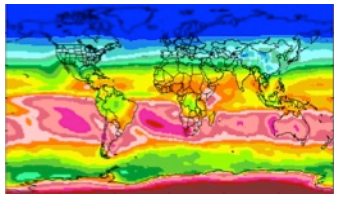
Agenda:

1. The ASDC at a Glance
2. ASDC Geospatial Architecture
3. Use Case - POWER/SSE
4. GDAL Enhancements for ESDIS (GEE)

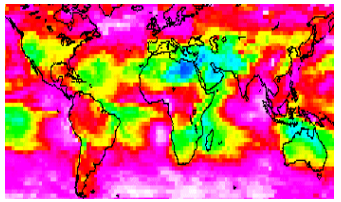
Atmospheric Science Data Center

The ASDC at a Glance

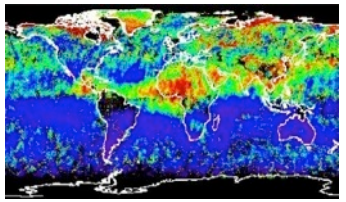
- **Provides data services for over 44 science projects**
- **Primary: CERES, MISR, CALIPSO, ISCCP, SAGE III, MOPITT, TES**
- **Distributes 300+ unique science products**
- **In 2014, 624 Terabytes of data were distributed to over 165,000 customers in 158 countries**
- **3.5 Petabytes of data are in the archive as of January 2015**
- **Over 58 million files (1,537 TB) on high-speed disk for quick access**



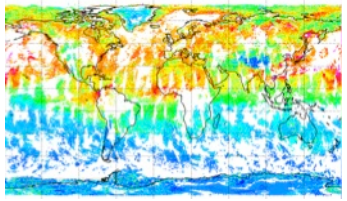
Radiation Budget - The radiation budget takes into account the sum of all radiation, transferred in all directions, through the Earth's atmosphere and to and from space.
Instruments: CERES



Clouds - A visible aggregate of minute water droplets and/or ice crystals in the atmosphere above the Earth's surface.
Instruments: CALIPSO, MISR



Aerosols - Suspension of particles of condensed matter (liquid, solid, or mixed) in a carrier gas (usually air).
Instruments: CALIPSO, MISR, SAGE III



Tropospheric Chemistry - Measurements of chemical constituents in the atmosphere including the major (non-H_2O) greenhouse gases (CO_2, CH_4, O_3, N_2O).
Instruments: MOPITT, TES

Improving the Accessibility and Use of NASA Earth Science Data in Geospatial Applications

- Many of the NASA Langley Atmospheric Science Data Center (ASDC) Distributed Active Archive Center (DAAC) multidimensional tropospheric and atmospheric chemistry data products are stored in HDF4, HDF5 or NetCDF format, which traditionally have been difficult to analyze and visualize with geospatial tools.

- With the rising demand from the diverse end-user communities for geospatial tools to handle multidimensional products, several applications, such as ArcGIS, have refined their software.

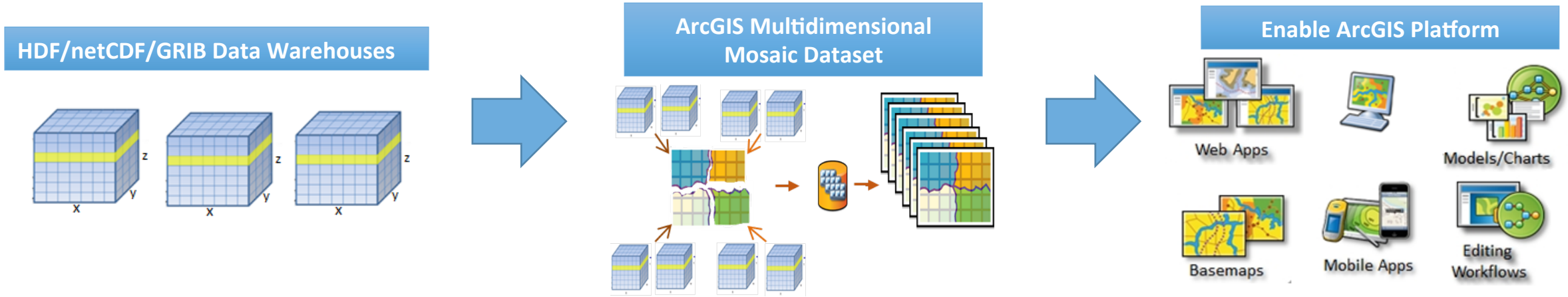
- Many geospatial applications now have new functionalities that enable the end user to:
  - Store, serve, and perform analysis on each individual variable, its time dimension, and vertical dimension.
  - Use NetCDF, GRIB, and HDF raster data formats across applications directly
  - Publish output within REST image services or WMS for time and space enabled web application development.

Data Discovery and Access through Web Services

- Web services are used to make the application platform and technology independent by following standards, promoting interoperability
  - Data Access Protocol (DAP) Service
  - WCS (Web Coverage Service)
  - WMS (Web Mapping Service)
  - Webification Science (w10n-sci)
  - **ArcGIS Image Service**
    - NASA's Enterprise License Agreement (ELA) with Esri allows the agency to acquire access to Esri ArcGIS software at no additional cost to programs
- Examples of applications that support standards-based web services
  - NASA Global Imagery Browse Services (GIBS)
  - NASA Earthdata Search
  - Group on Earth Observations (GEOSS) Portal
  - Panoply
  - Integrated Data Viewer (IDV)
  - ArcGIS
  - Quantum GIS (QGIS)

Atmospheric Science Data Center

Utilizing the ArcGIS Platform as an End-to-End Solution for Processing, Analyzing, and Visualizing NASA's Scientific Data



Aggregate (mosaic) spatial, time, and vertical dimensions

- Create a seamless multidimensional cube:
  - from files representing different regions
  - from files representing different time steps/ slices
- Spatial Aggregation
- Temporal Aggregation
- On-the-fly analysis

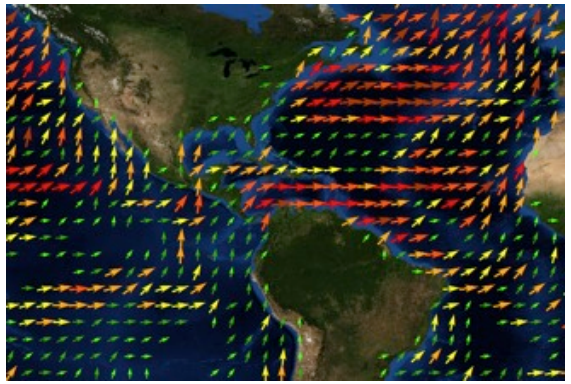
Atmospheric Science Data Center

End-to-End Solution for Processing, Analyzing, and Visualizing Data

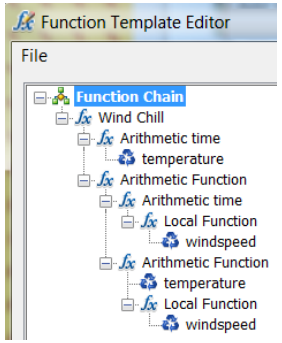
Mosaic Index

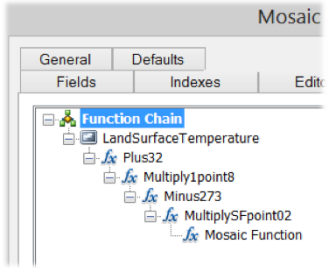
OBJ	Raster	Name	Variable *	Standard Time	Standard Z	...
1	<Raster	hycom_glb_regp01.nc:water_temp:0	water_temp	5/17/2013	0	
2	<Raster	hycom_glb_regp01.nc:water_temp:1	water_temp	5/17/2013	-2	
3	<Raster	hycom_glb_regp01.nc:water_temp:2	water_temp	5/17/2013	-4	
4	<Raster	hycom_glb_regp01.nc:water_temp:3	water_temp	5/17/2013	-6	
5	<Raster	hycom_glb_regp01.nc:water_temp:4	water_temp	5/17/2013	-8	

Visualization

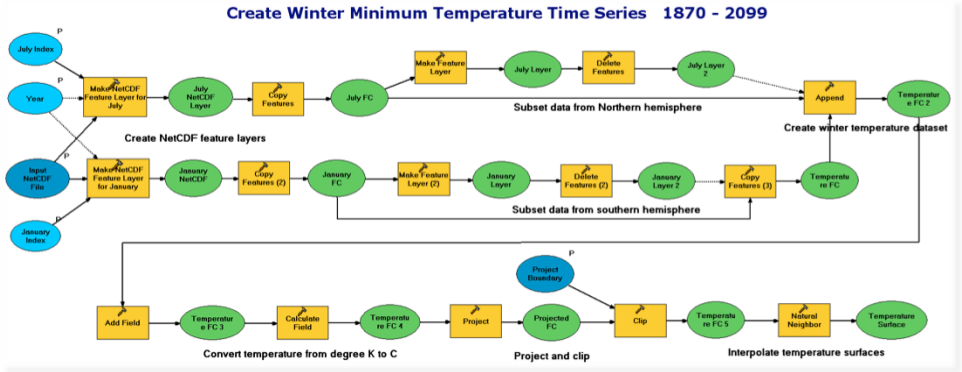


Modeling with Raster function template (RFT)

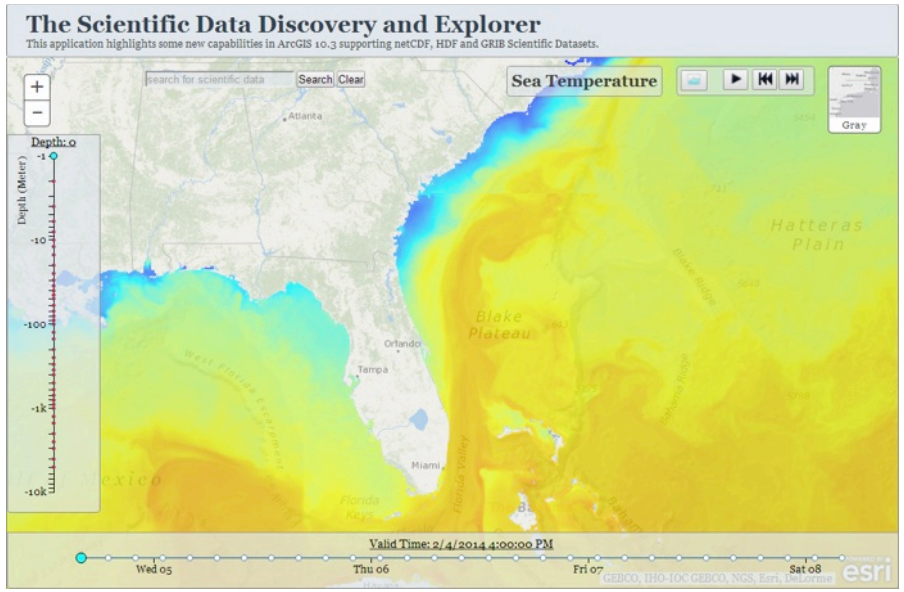




Spatial and Temporal Analysis

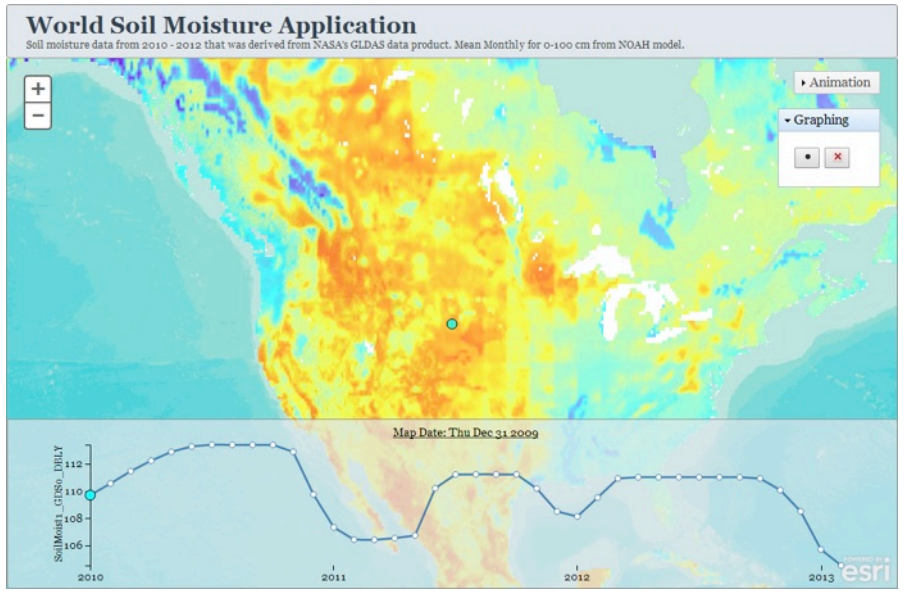


Multidimensional Data in Web Applications

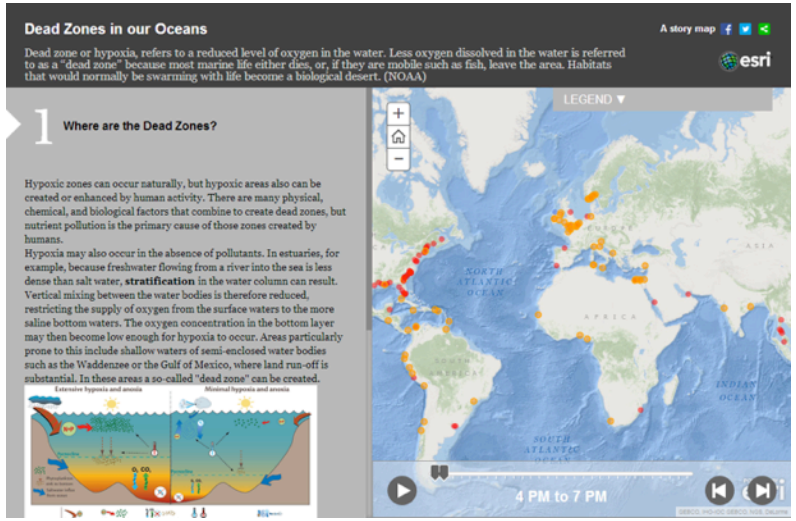


Depth

Time

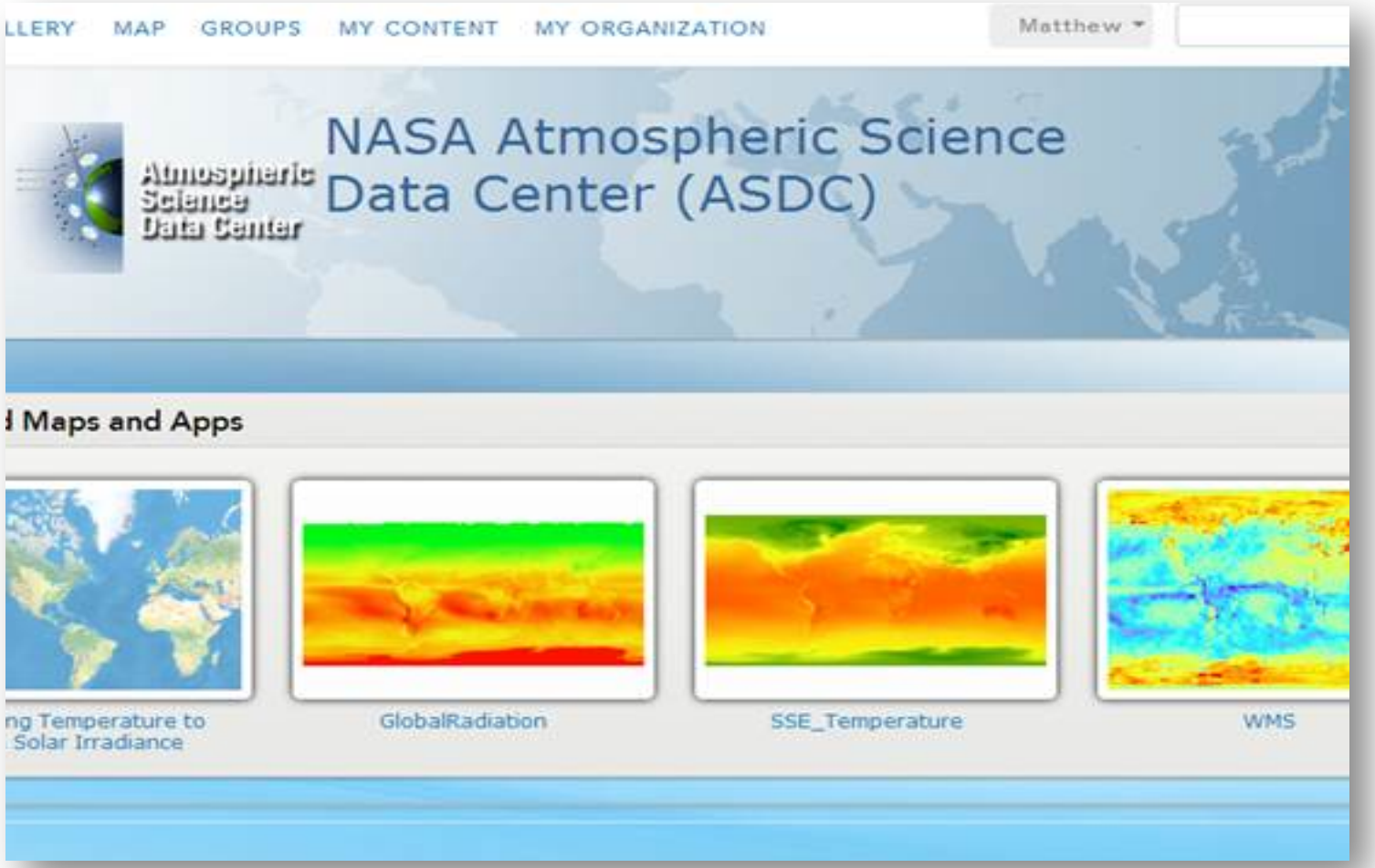


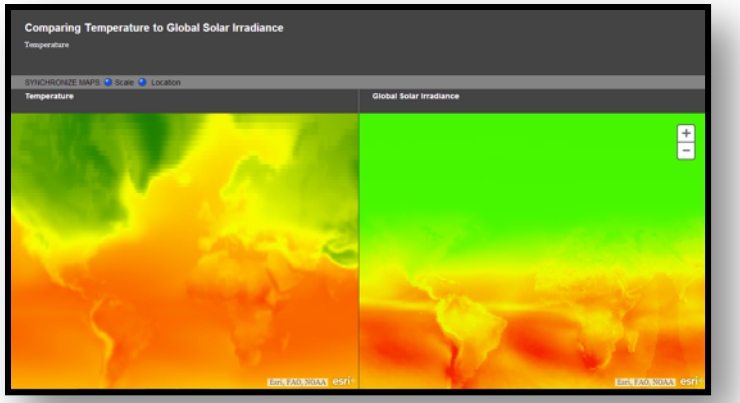
Temporal Graph



Create Story Maps to tell the story of your scientific data

NASA ASDC ArcGIS Portal





GEOPLATFORM.gov

DATA.GOV

Use Case: POWER Surface meteorology and Solar Energy (SSE)

Objective: Integrate improved environmental data, analysis and modeling for enhanced management of energy production and energy efficiency systems.

ATMOSPHERIC SCIENCE DATA CENTER

NASA Surface meteorology and Solar Energy - Choices

Latitude 37 / Longitude -77 was chosen.

Select parameters and press Submit
(Default is ALL types)

Submit | Reset

Geometry	Latitude and longitude (center and boundaries)
Parameters for Solar Cooking	Average insolation Midday insolation Clear sky insolation Clear sky days
Parameters for Sizing and Pointing of Solar Panels and for Solar Thermal Applications	Insolation on horizontal surface (Average, Min, Max) Diffuse radiation on horizontal surface (Average, Min, Max) Direct normal radiation (Average, Min, Max) Insolation at 3-hourly intervals Insolation clearness index, K (Average, Min, Max) Insolation normalized clearness index Clear sky insolation Clear sky insolation clearness index Clear sky insolation normalized clearness index Downward Longwave Radiative Flux
Solar Geometry	Solar Noon Daylight Hours Daylight average of hourly cosine solar zenith angles Cosine solar zenith angle at mid-time between sunrise and solar noon Declination Sunset Hour Angle Maximum solar angle relative to the horizon Hourly solar angles relative to the horizon Hourly solar azimuth angles
Parameters for Tilted Solar Panels	Radiation on equator-pointed tilted surfaces Minimum radiation for equator-pointed tilted surfaces Maximum radiation for equator-pointed tilted surfaces
Parameters for Sizing Battery or other Energy-storage Systems	Minimum available insolation as % of average values over consecutive-day period Horizontal surface deficits below expected values over consecutive-day period Equivalent number of NO-SUN days over consecutive-day period

Parameters for Sizing Battery or other Energy-storage Systems:

Equivalent Number Of NO-SUN Or BLACK Days (days)

Lat 37 Lon -77	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1 day	0.96	0.95	0.95	0.93	0.91	0.92	0.95	0.89	0.92	0.96	0.94	0.96
3 day	2.61	2.38	2.46	2.66	2.47	1.89	2.16	2.39	2.07	2.37	2.46	2.44
7 day	5.08	4.51	4.53	3.95	4.48	3.33	3.53	3.58	3.61	4.43	3.58	4.11
14 day	7.15	6.14	4.08	5.31	6.77	4.35	3.98	4.95	4.57	5.39	4.74	7.12
21 day	6.19	8.35	5.00	5.24	7.35	4.93	5.12	6.02	3.70	7.40	5.82	8.44
Month	4.60	7.63	3.60	5.26	9.01	3.67	4.27	5.24	4.17	6.81	6.49	6.65

Parameter Definition

Meteorology (Temperature):

Monthly Averaged Cooling Degree Days Above 18° C

Lat 37 Lon -77	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Sum
22-year Average	0	0	4	22	86	189	257	224	130	34	5	1	952

Parameter Definition

Meteorology (Wind):

Monthly Averaged Wind Speed At 50 m Above The Surface Of The Earth (m/s)

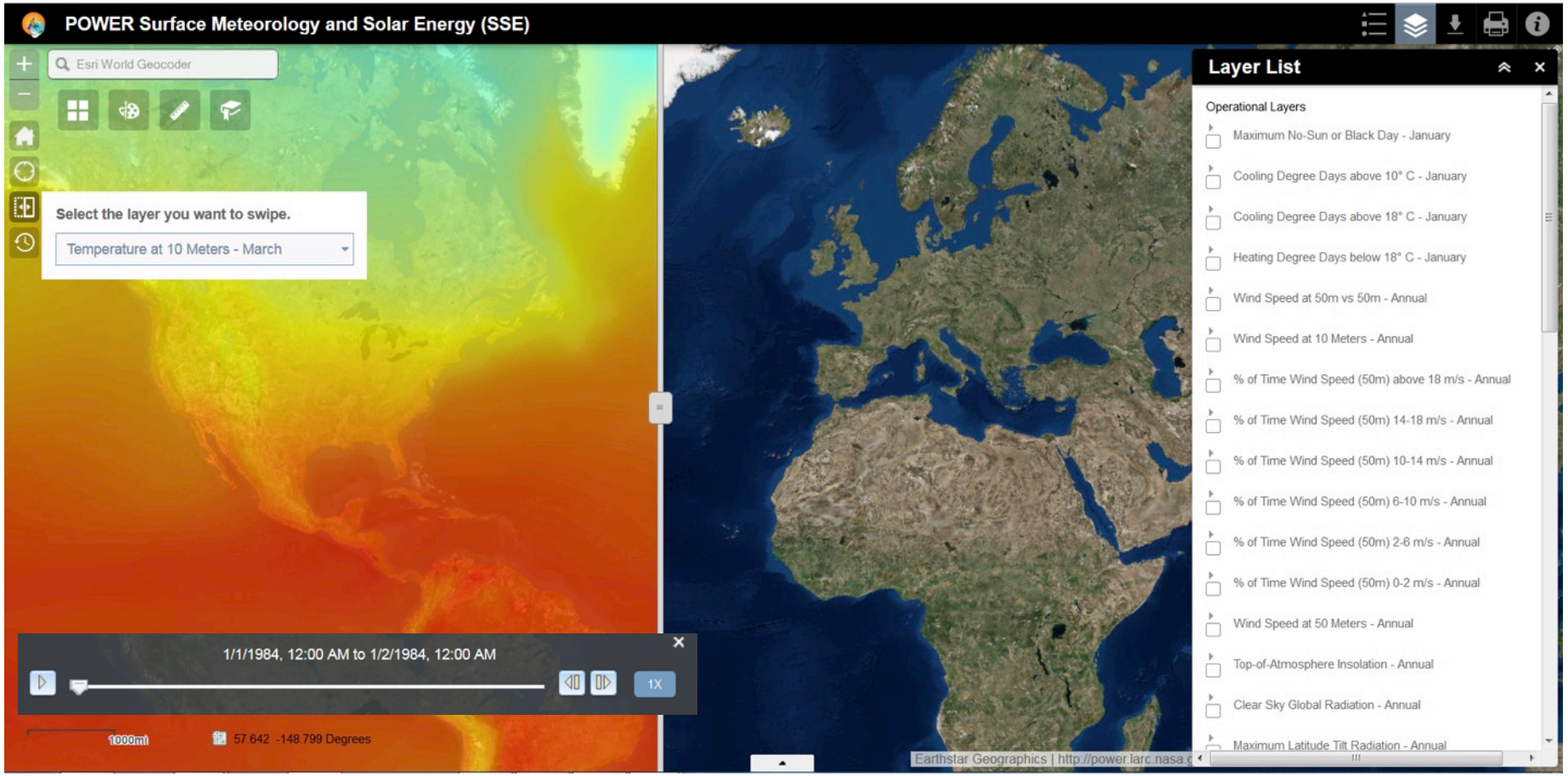
Lat 37 Lon -77	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Average
10-year Average	6.60	6.71	6.67	6.04	5.13	4.88	4.34	4.17	4.80	5.38	6.27	6.65	5.63

Minimum And Maximum Difference From Monthly Averaged Wind Speed At 50 m (%)

Lat 37 Lon -77	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Average
Minimum	-13	-11	-14	-10	-13	-11	-10	-16	-8	-11	-8	-11	-11
Maximum	13	8	9	15	16	9	11	10	11	9	10	7	11

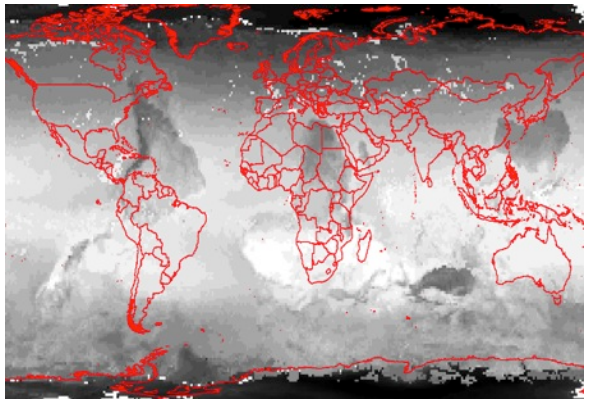
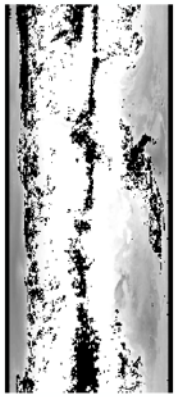
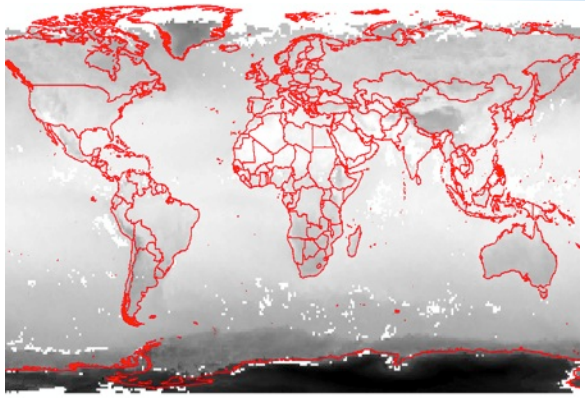
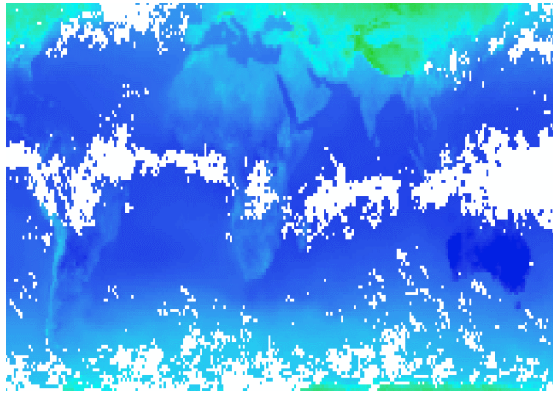
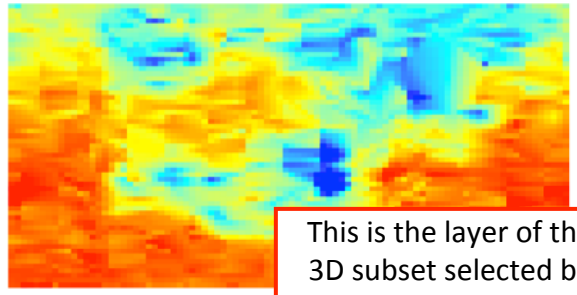
- ***Limited graphical capability***
- ***Requires improvement to better serve customers***

POWER SSE – GIS Web Application Enhancements

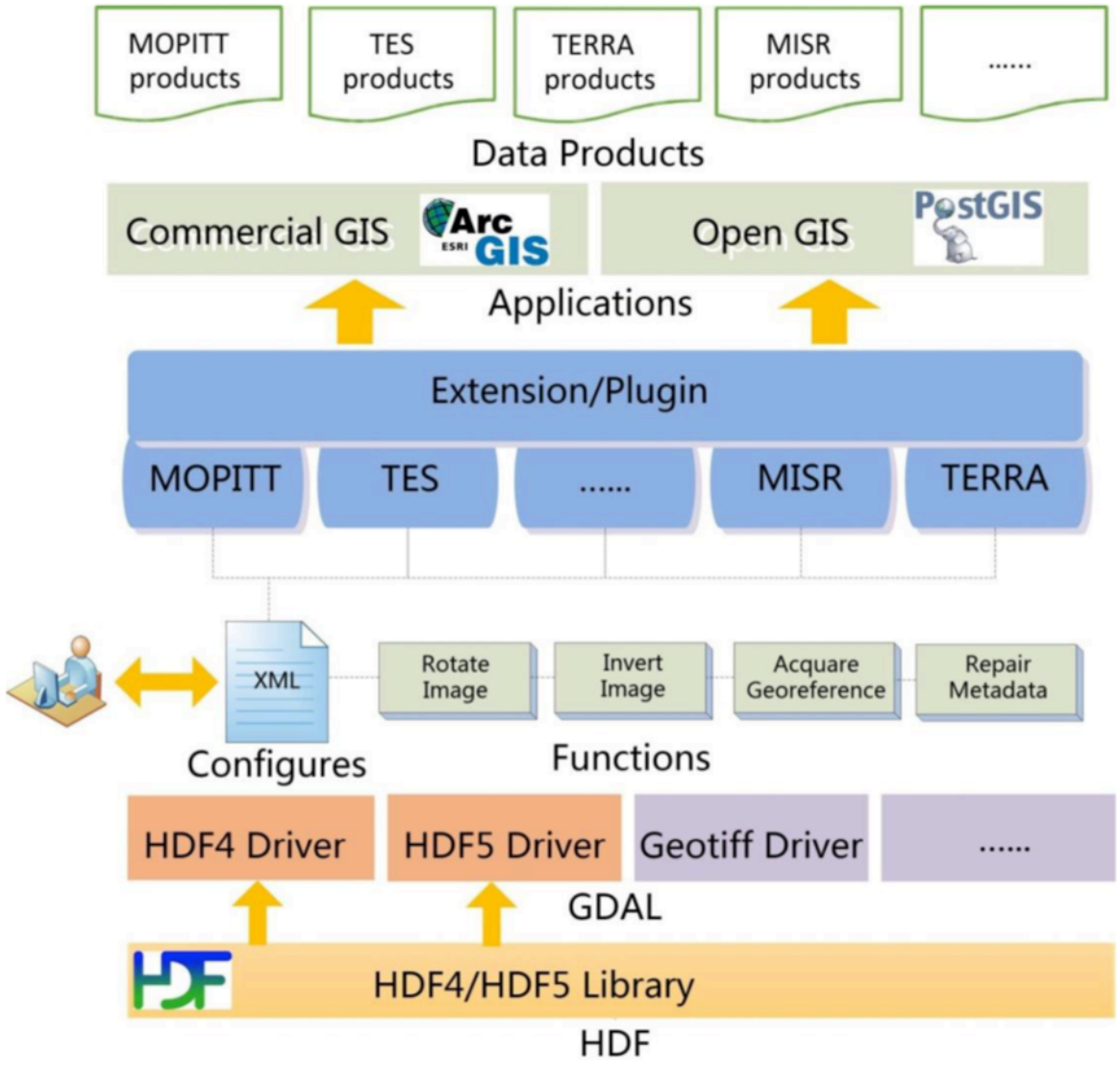


- High quality viewing (Desktop/Mobile) and printing
- Data Extraction and Subsetting
- Simultaneous Dataset Visualization (Swiping)
- Temporal Visualization
- Custom Color Ramps
- Pixel/Attribute Value Identification at Selected Location

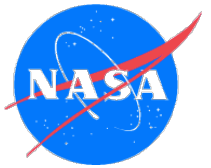
Geospatial Data Abstraction Library (GDAL) Enhancements

	Image Displayed Inverted **<u>MOP03TM.005 (HDF4)</u>:** Retrieved Surface Temperature Night	**Missing Geo-Reference & 90 Degree Rotated** **<u>MOP03TM.006 (HDF5)</u>:** A Priori Surface Temperature Night	**Missing Geo-Reference & Cannot Display the 3D dataset** **<u>TL3COD.001 (HDF5)</u>:** CO
Before Enhancement			
After Enhancement			 This is the layer of the 3D subset selected by users

Geospatial Data Abstraction Library (GDAL) Enhancements



- **Revised GDAL HDF Drivers** to allow for extending and additional functionality.
- Added functions such as **Image rotator, 3D subset reader, geo-reference interpreter, and metadata repairer** to set up the generic algorithm framework.
- Customized **framework** with **Data product plugins** that recognize file name patterns.
- Enabled image rendering and user workflow with an **ArcGIS plugin / extension** for testing of effectiveness of the improved GDAL.



Improving the Accessibility and Use of NASA Earth Science Data

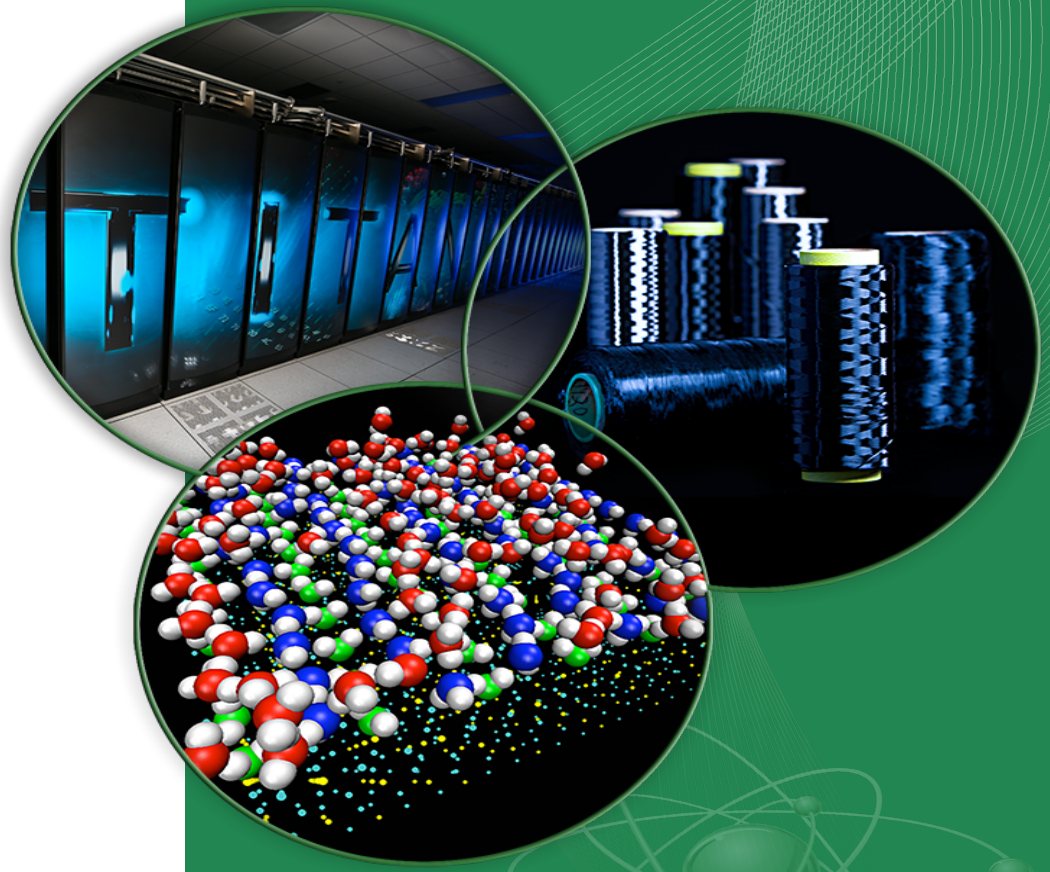
Brian Tisdale, BAH, brian.e.tisdale@nasa.gov

NASA Atmospheric Science Data Center (ASDC)

CONTACT US FOR BETA ACCESS

SIMPLE WAYS TO DO MORE WITH YOUR SCIENTIFIC DATA

June 18th 2015



Tools for Access to Scientific Data – Doing More with Data

Suresh Vannan
ORNL DAAC Manager
Data Theme Lead,
Climate Change Science Institute (CCSI)
Oak Ridge National Laboratory (ORNL)
http://daac.ornl.gov

ORNL is managed by UT-Battelle
for the US Department of Energy

OAK RIDGE National Laboratory

Agenda

- Overview of ORNL
- Tools for scientific data at ORNL
- Overview of ORNL DAAC
- Tools for scientific data at ORNL DAAC

Oak Ridge National Laboratory

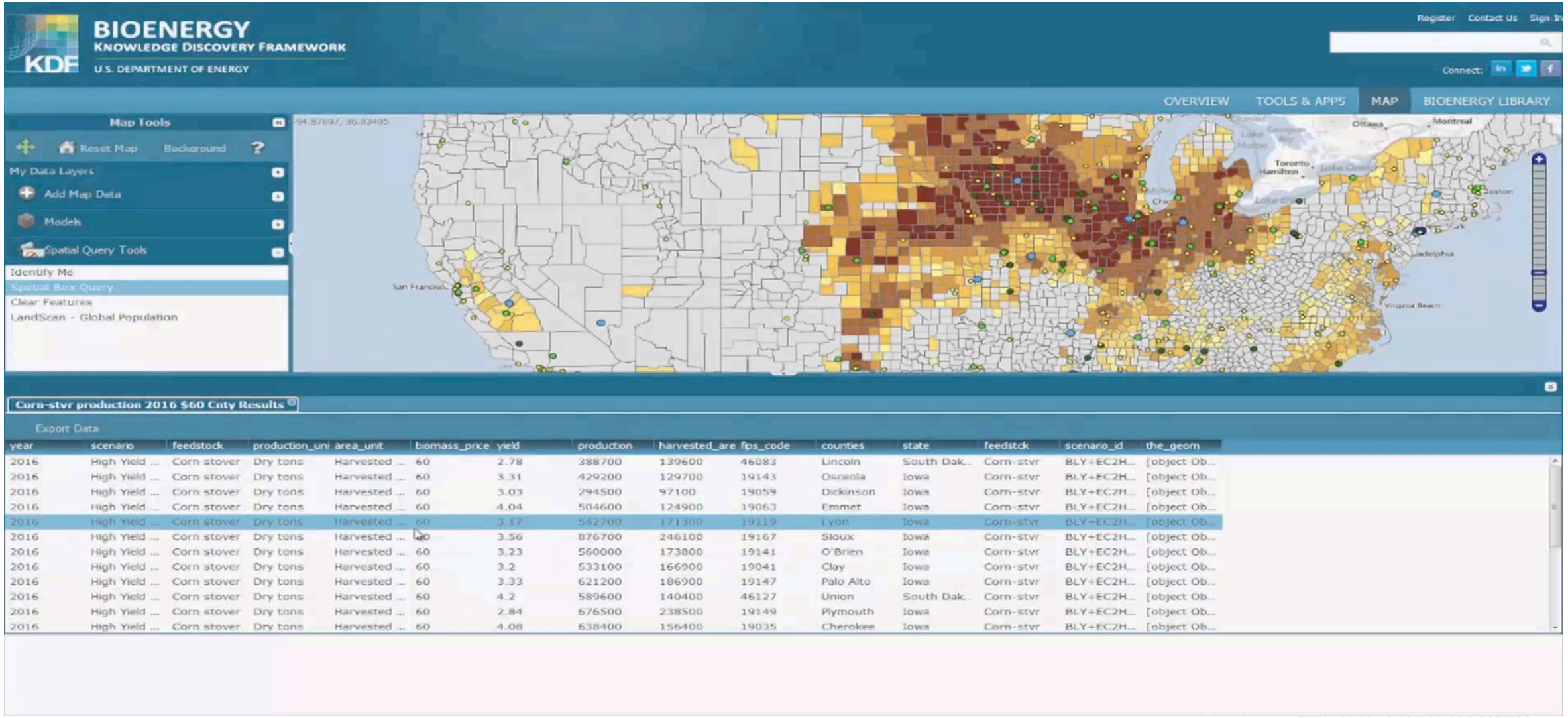
Oak Ridge National Laboratory is the largest US Department of Energy science and energy laboratory, conducting basic and applied research to deliver transformative solutions to compelling problems in energy and security.

ORNL supports these missions through leadership in four major areas of science and technology:

- **Neutrons**
- **Computing**
- **Materials**
- **Nuclear**

ORNL Tools for scientific data -Bioenergy

https://www.bioenergykdf.net/

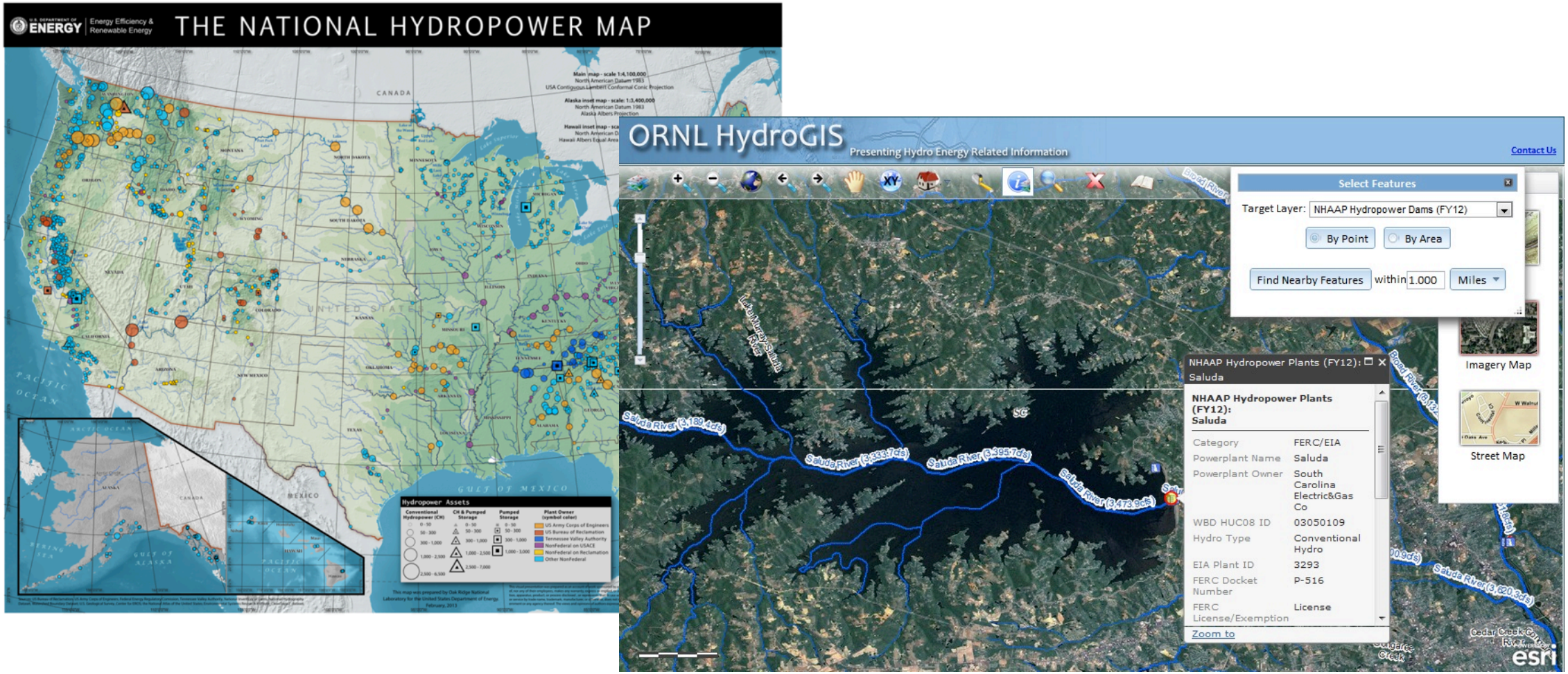


year	scenario	feedstock	production_uni	area_unit	biomass_price	yield	production	harvested_are	fips_code	counties	state	feedstck	scenario_id	the_geom
2016	High Yield ...	Corn stover	Dry tons	Harvested ...	60	2.78	388700	139600	46083	Lincoln	South Dak...	Corn-stvr	BLY+EC2H...	[object Ob...
2016	High Yield ...	Corn stover	Dry tons	Harvested ...	60	3.31	429200	129700	19143	Osceola	Iowa	Corn-stvr	BLY+EC2H...	[object Ob...
2016	High Yield ...	Corn stover	Dry tons	Harvested ...	60	3.03	294500	97100	19059	Dickinson	Iowa	Corn-stvr	BLY+EC2H...	[object Ob...
2016	High Yield ...	Corn stover	Dry tons	Harvested ...	60	4.04	504600	124900	19063	Emmet	Iowa	Corn-stvr	BLY+EC2H...	[object Ob...
2016	High Yield ...	Corn stover	Dry tons	Harvested ...	60	3.17	542700	171300	19119	Lyon	Iowa	Corn-stvr	BLY+EC2H...	[object Ob...
2016	High Yield ...	Corn stover	Dry tons	Harvested ...	60	3.56	876700	246100	19167	Sioux	Iowa	Corn-stvr	BLY+EC2H...	[object Ob...
2016	High Yield ...	Corn stover	Dry tons	Harvested ...	60	3.23	560000	173800	19141	O'Brien	Iowa	Corn-stvr	BLY+EC2H...	[object Ob...
2016	High Yield ...	Corn stover	Dry tons	Harvested ...	60	3.2	533100	166900	19041	Clay	Iowa	Corn-stvr	BLY+EC2H...	[object Ob...
2016	High Yield ...	Corn stover	Dry tons	Harvested ...	60	3.33	621200	186900	19147	Palo Alto	Iowa	Corn-stvr	BLY+EC2H...	[object Ob...
2016	High Yield ...	Corn stover	Dry tons	Harvested ...	60	4.2	589600	140400	46127	Union	South Dak...	Corn-stvr	BLY+EC2H...	[object Ob...
2016	High Yield ...	Corn stover	Dry tons	Harvested ...	60	2.84	676500	238500	19149	Plymouth	Iowa	Corn-stvr	BLY+EC2H...	[object Ob...
2016	High Yield ...	Corn stover	Dry tons	Harvested ...	60	4.08	638400	156400	19035	Cherokee	Iowa	Corn-stvr	BLY+EC2H...	[object Ob...

Contact: Budhendra L. Bhaduri

OAK RIDGE National Laboratory

ORNL Tools for scientific data -HydroPower



Contact:

Shih-Chieh Kao

OAK RIDGE National Laboratory

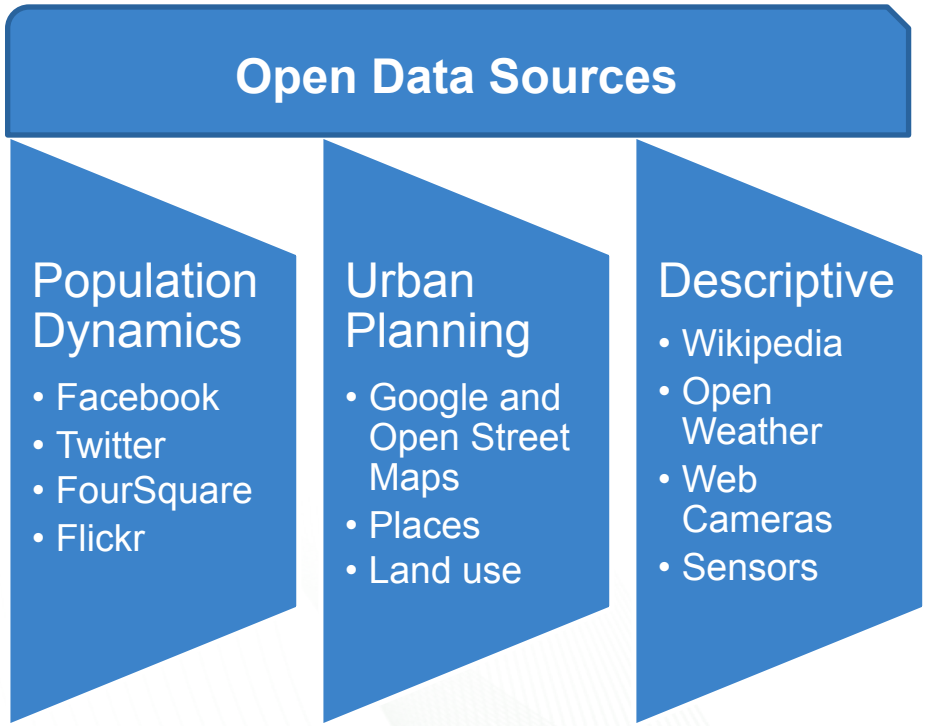
PlanetSense: Utilizing Open Source Data for Geospatial Intelligence

PlanetSense

- Open source data initiative in geospatial research

- Pervasive availability of open source data
  - Social media, volunteered geographic information, public data repository, participatory sensing
  - Real-time, streaming, updated continuously, incomplete

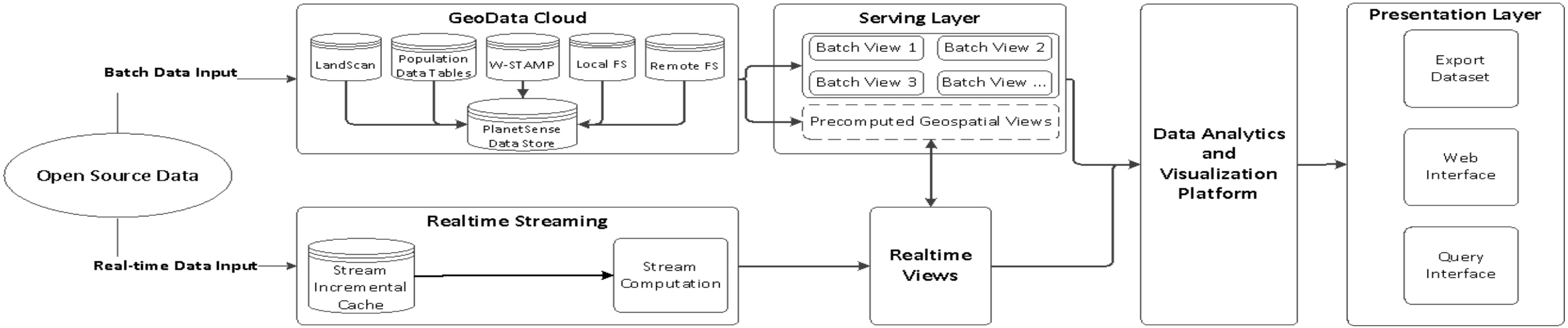
- Contact:
  - Budhendra L. Bhaduri, Gautam S. Thakur



OAK RIDGE National Laboratory

Workflow and applications

PlanetSense



Population Dynamics

- Special event population
- Occupancy analysis
- Mobility

Spatial Research

- Land use (commercial, residential, and mix)
- Urban planning

Transportation

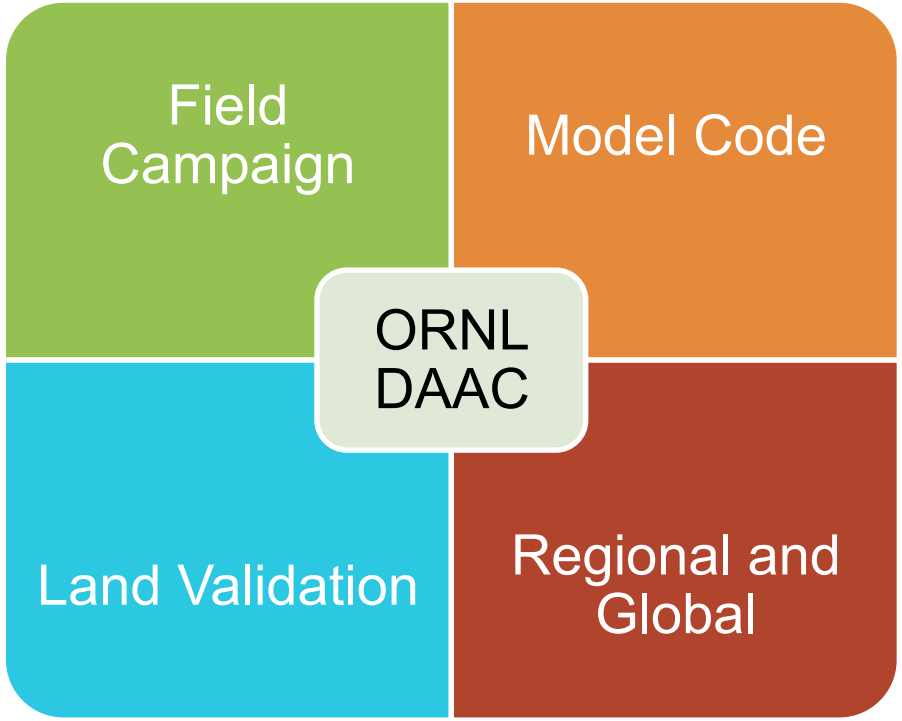
- Urban mobility simulation
- Evacuation
- Traffic optimization

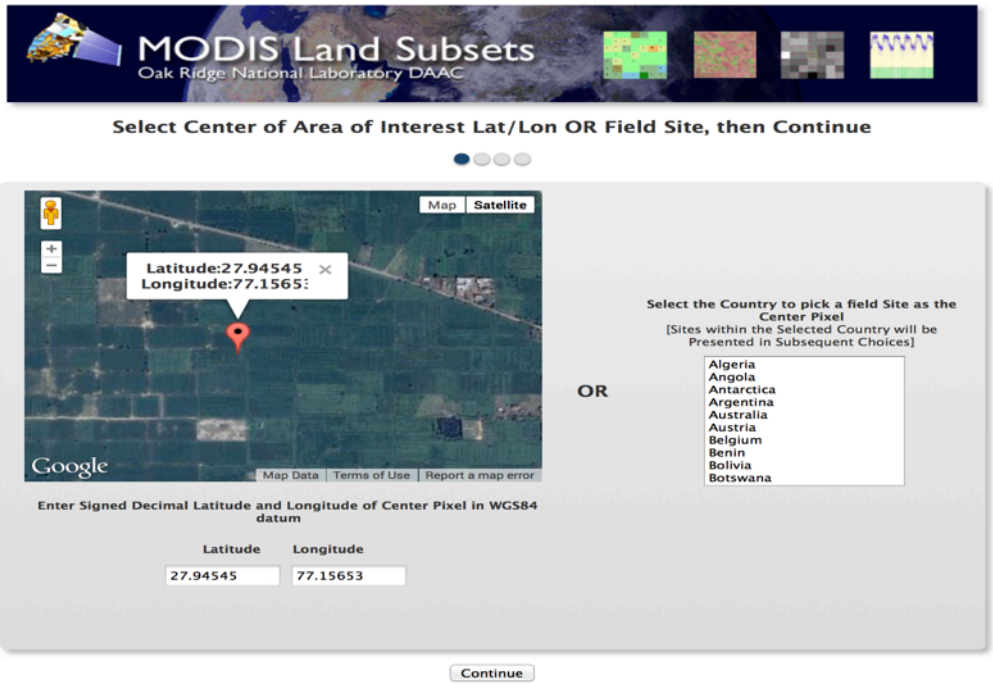
Energy

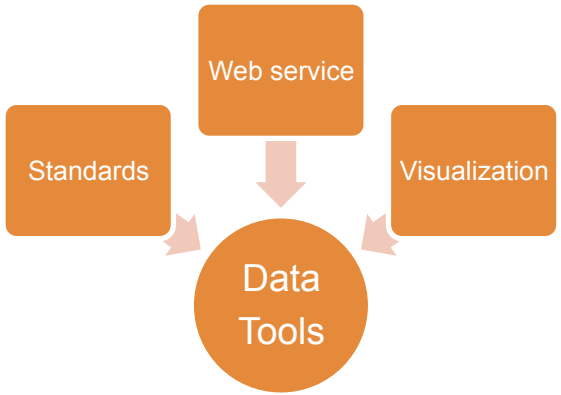
- Energy demand and utilization
- Critical Infrastructure

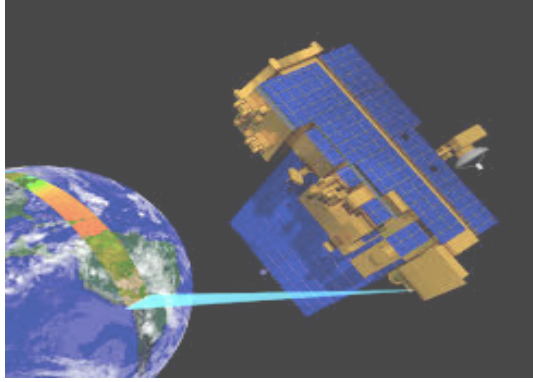
The Oak Ridge National Laboratory Distributed Active Archive Center (ORNL DAAC) archives data produced by NASA's Terrestrial Ecology Program in support of NASA's Carbon Cycle and Ecosystems Focus Area.

- 1118 data sets
- Average data set Size = 485 MB (Range 0.5 KB to > 10GB)
- Average Number of granules per dataset 241 granules (Range 1 to > 6000)
- 5000+ Investigators
- 50+ file formats



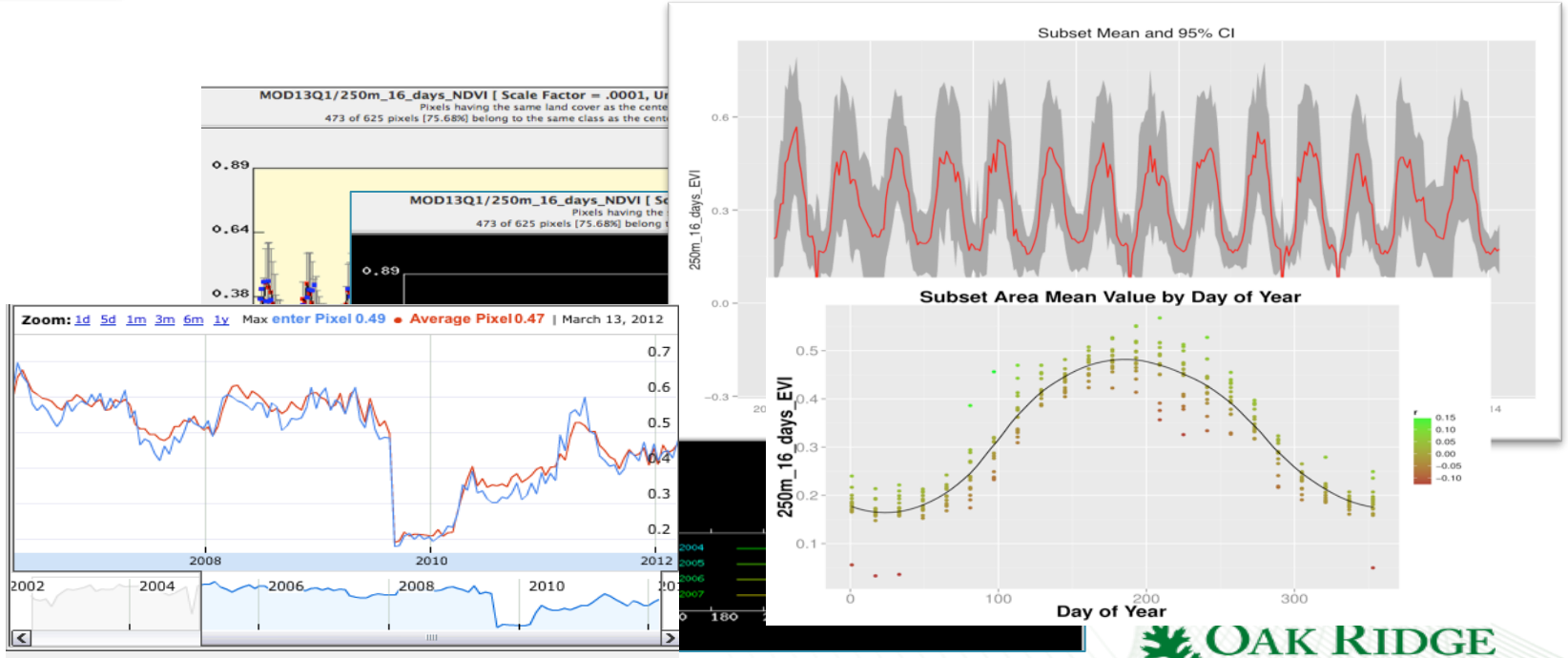






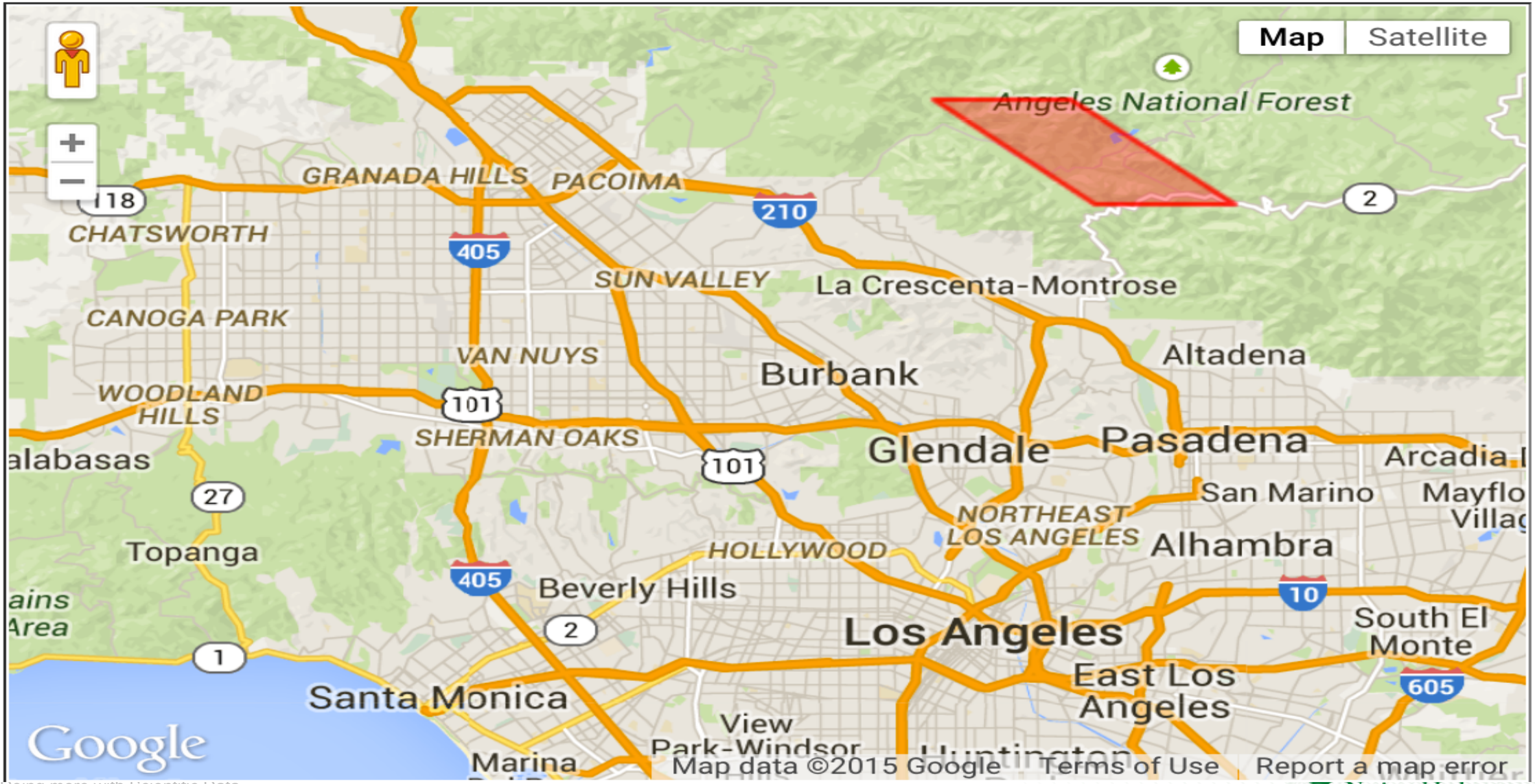
Web based
data order

http://daac.ornl.gov/MODIS



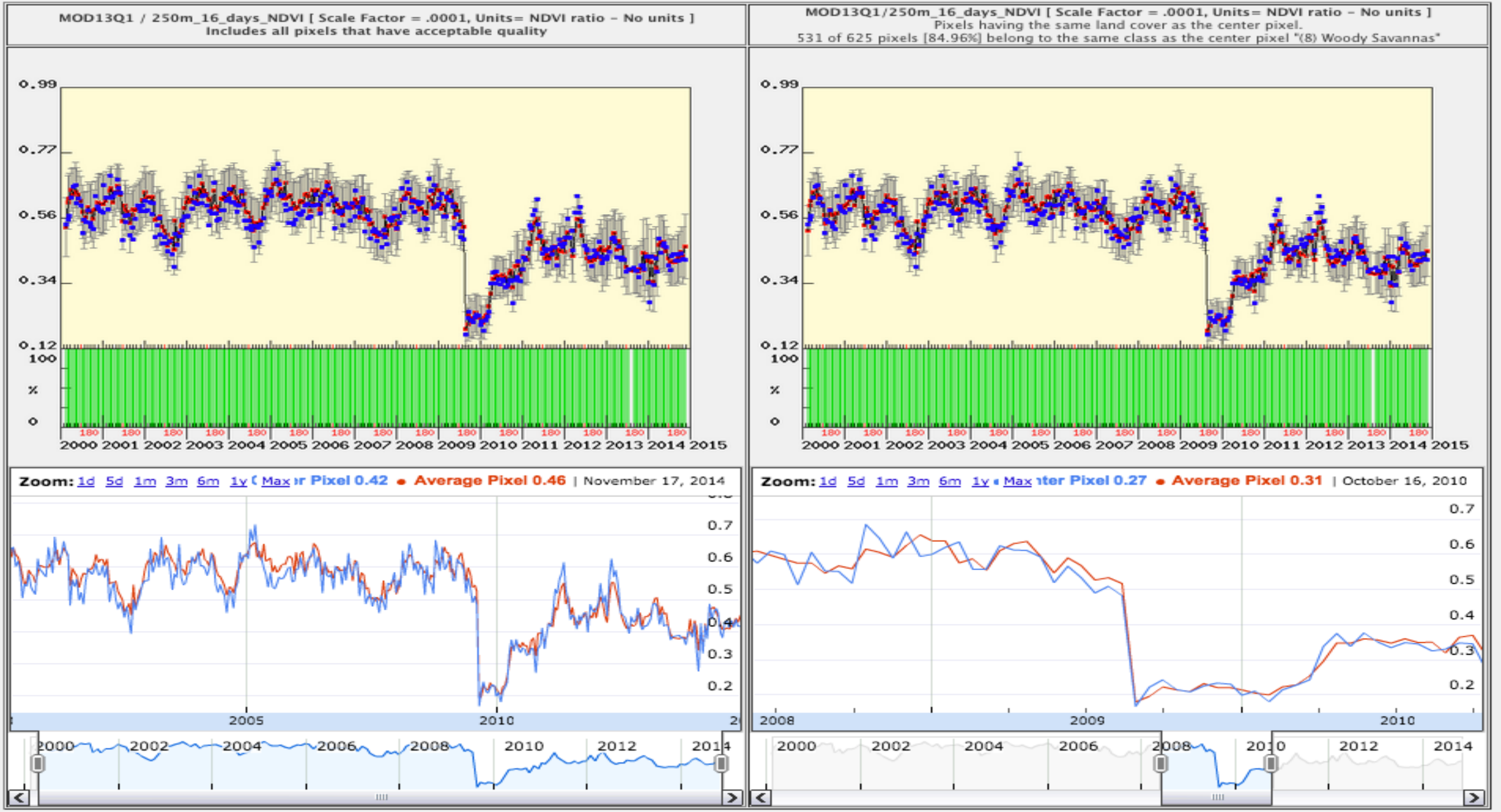
OAK RIDGE National Laboratory

Red Box Marks the Approximate Location of the Subset Area
… Presented For Visual Interest Only …
Image courtesy of Google

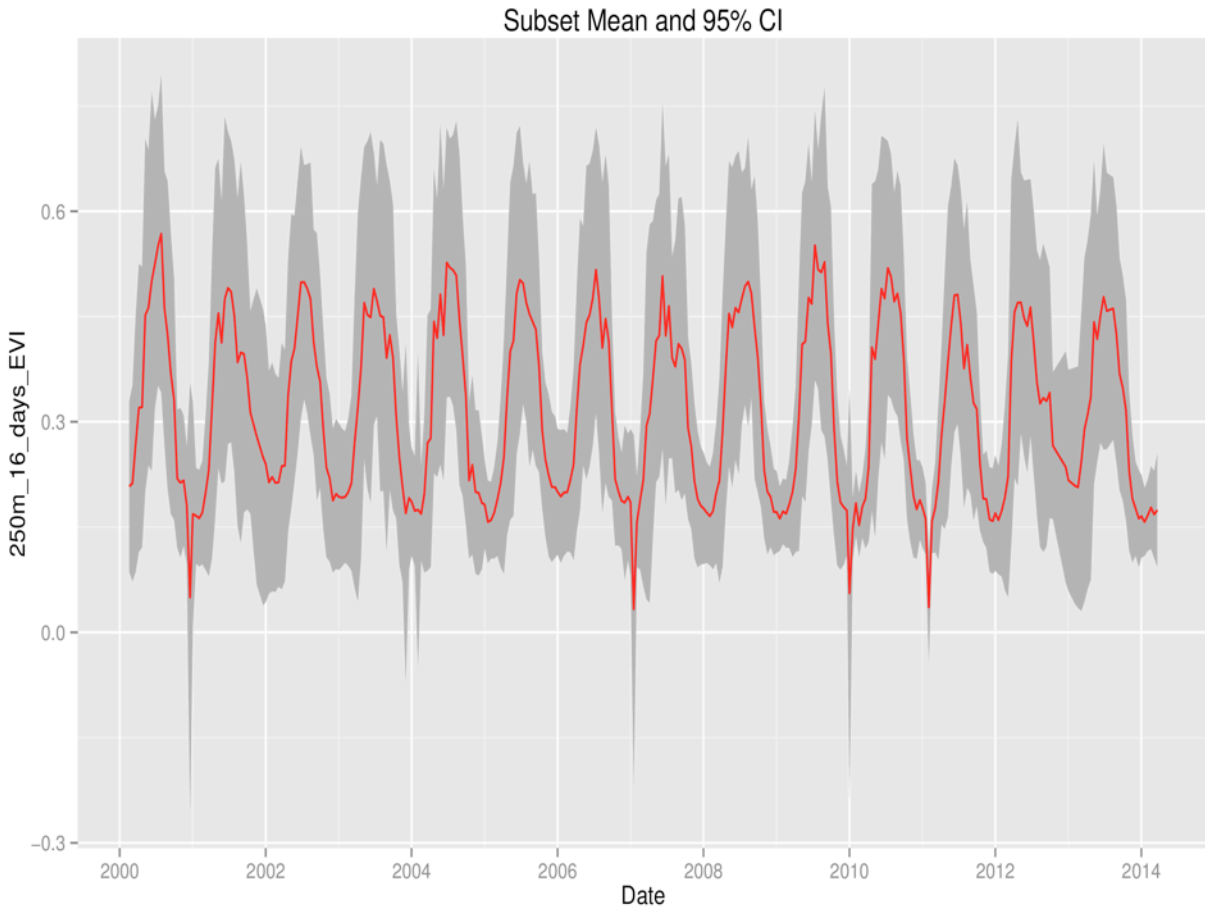


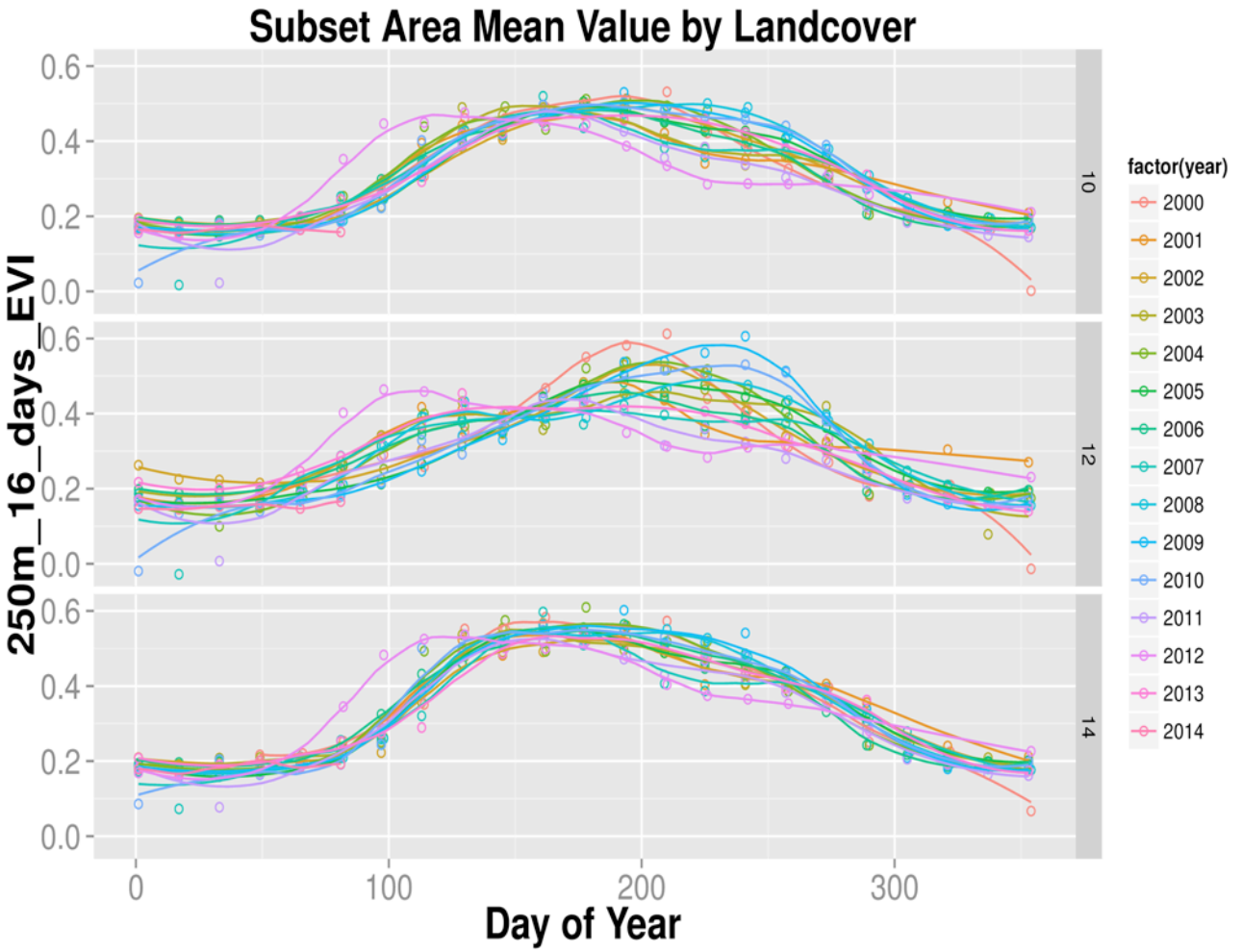
Station Fire, near JPL, California

Station Fire with JPL in the foreground
(photo courtesy of C. Miller, JPL)


MOD13Q1 / 250m_16_days_NDVI [Scale Factor = .0001, Units= NDVI ratio – No units]
Includes all pixels that have acceptable quality
MOD13Q1/250m_16_days_NDVI [Scale Factor = .0001, Units= NDVI ratio – No units]
Pixels having the same land cover as the center pixel.
531 of 625 pixels [84.96%] belong to the same class as the center pixel "(8) Woody Savannas"
0.99
0.77
0.56
0.34
0.12
100
%
0
2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015
Zoom: 1d 5d 1m 3m 6m 1y Max
Average Pixel 0.46 | November 17, 2014
Average Pixel 0.31 | October 16, 2010
0.7
0.6
0.5
0.4
0.3
0.2
2005
2010
2008
2009
2000 2002 2004 2006 2008 2010 2012 2014

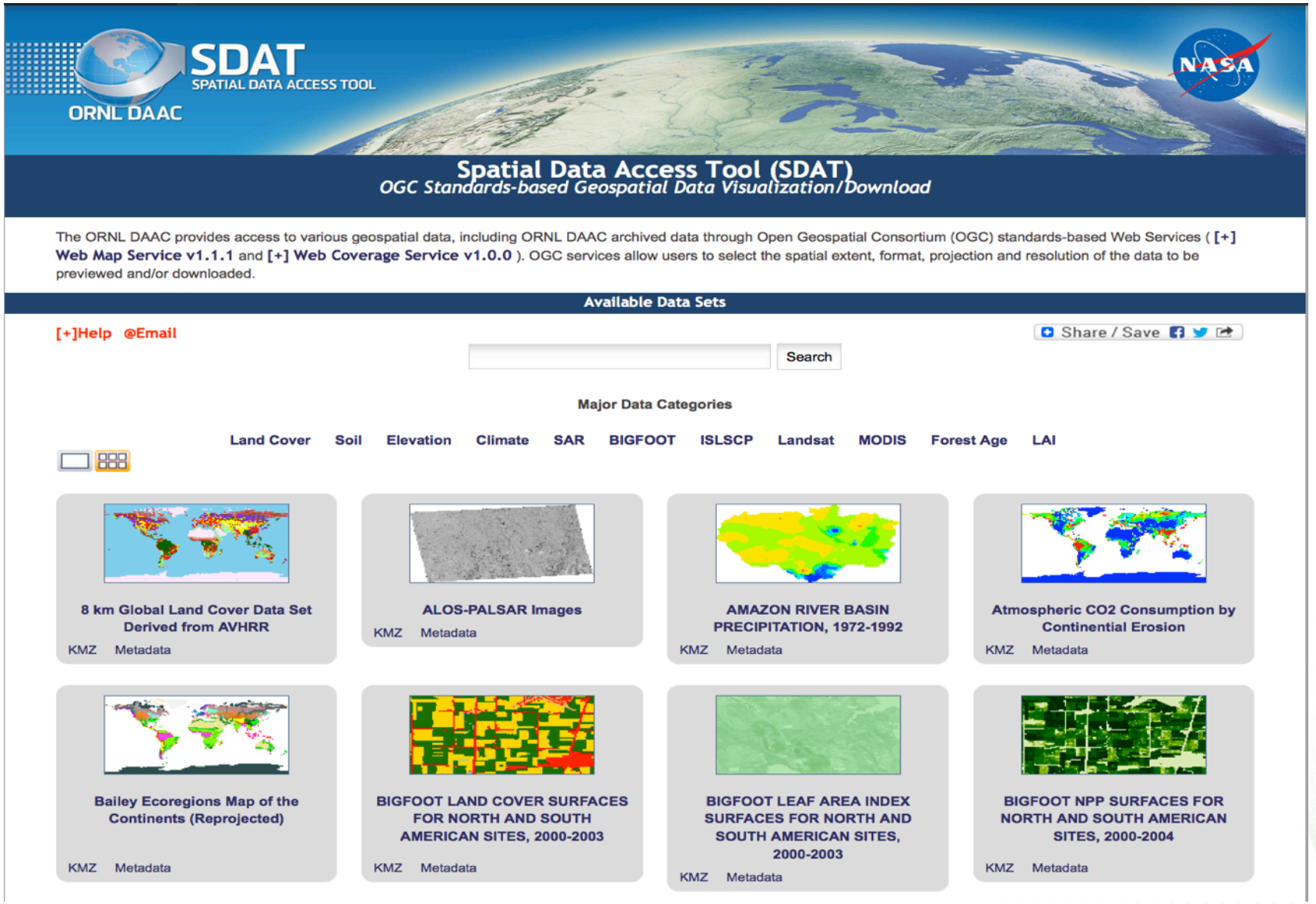
MODIS Subset Visualization using R



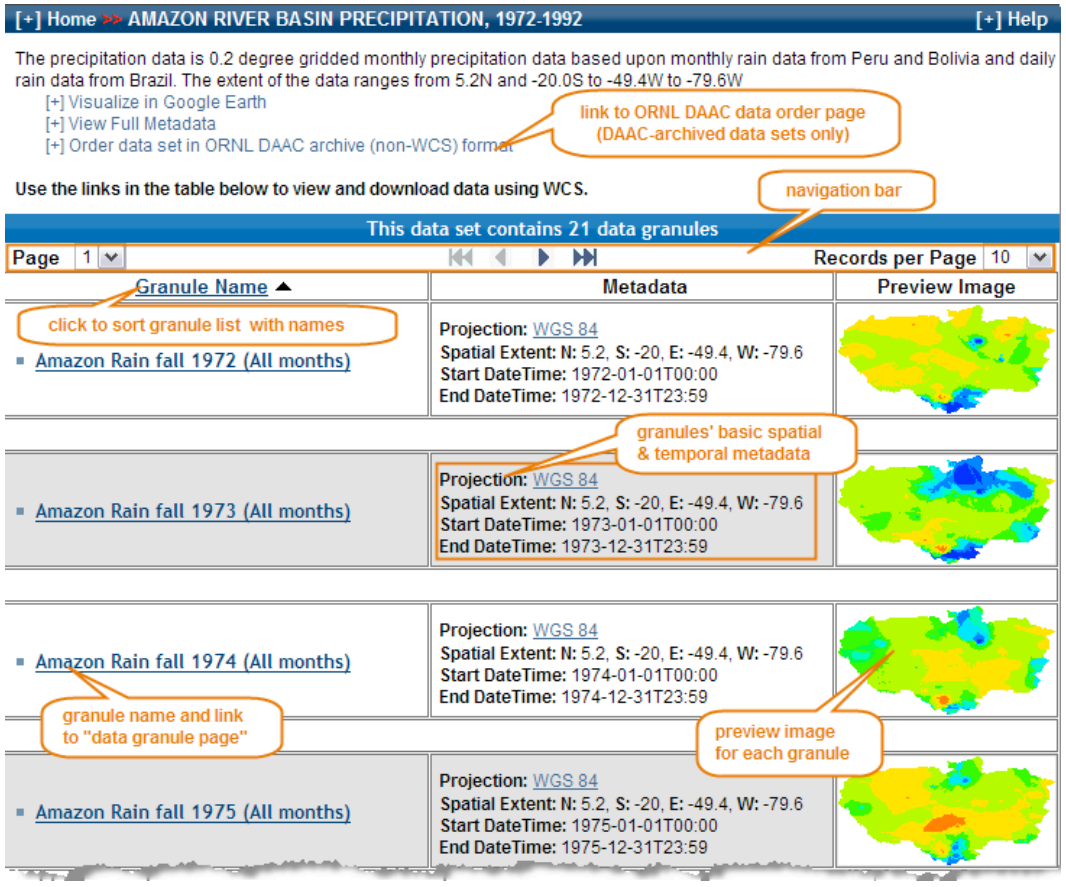


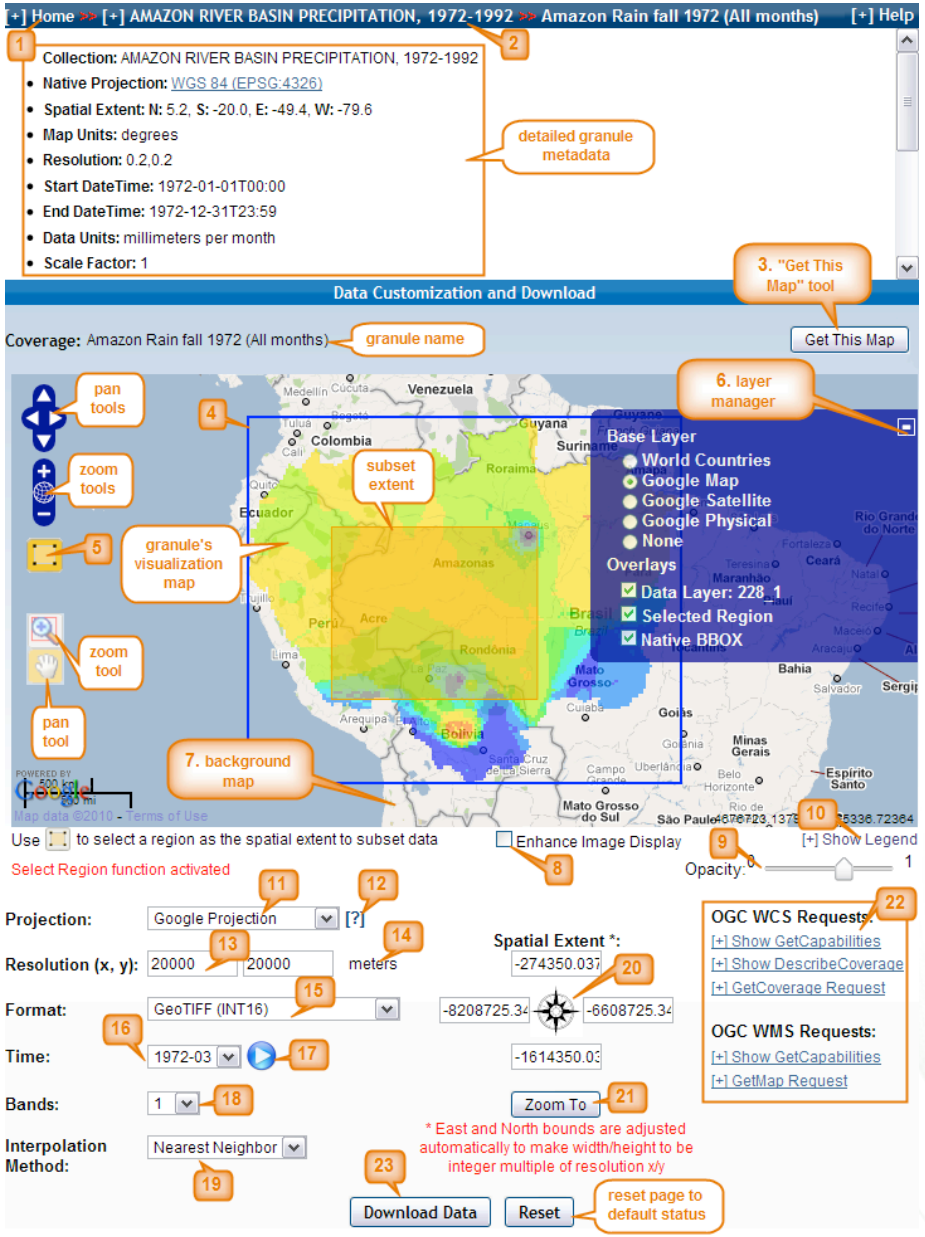
ORNL DAAC

ORNL DAAC Spatial Data Access Tool (SDAT)

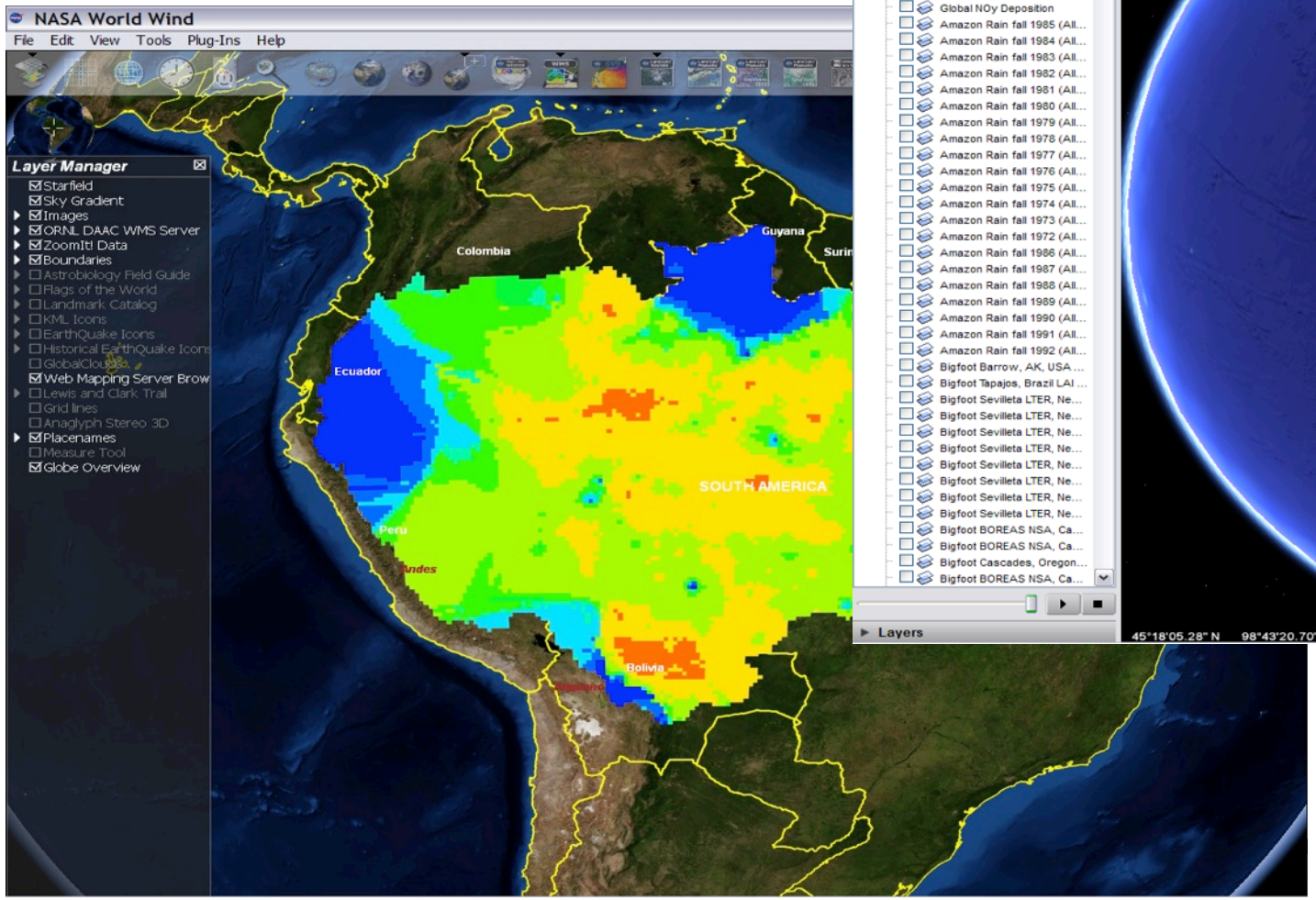


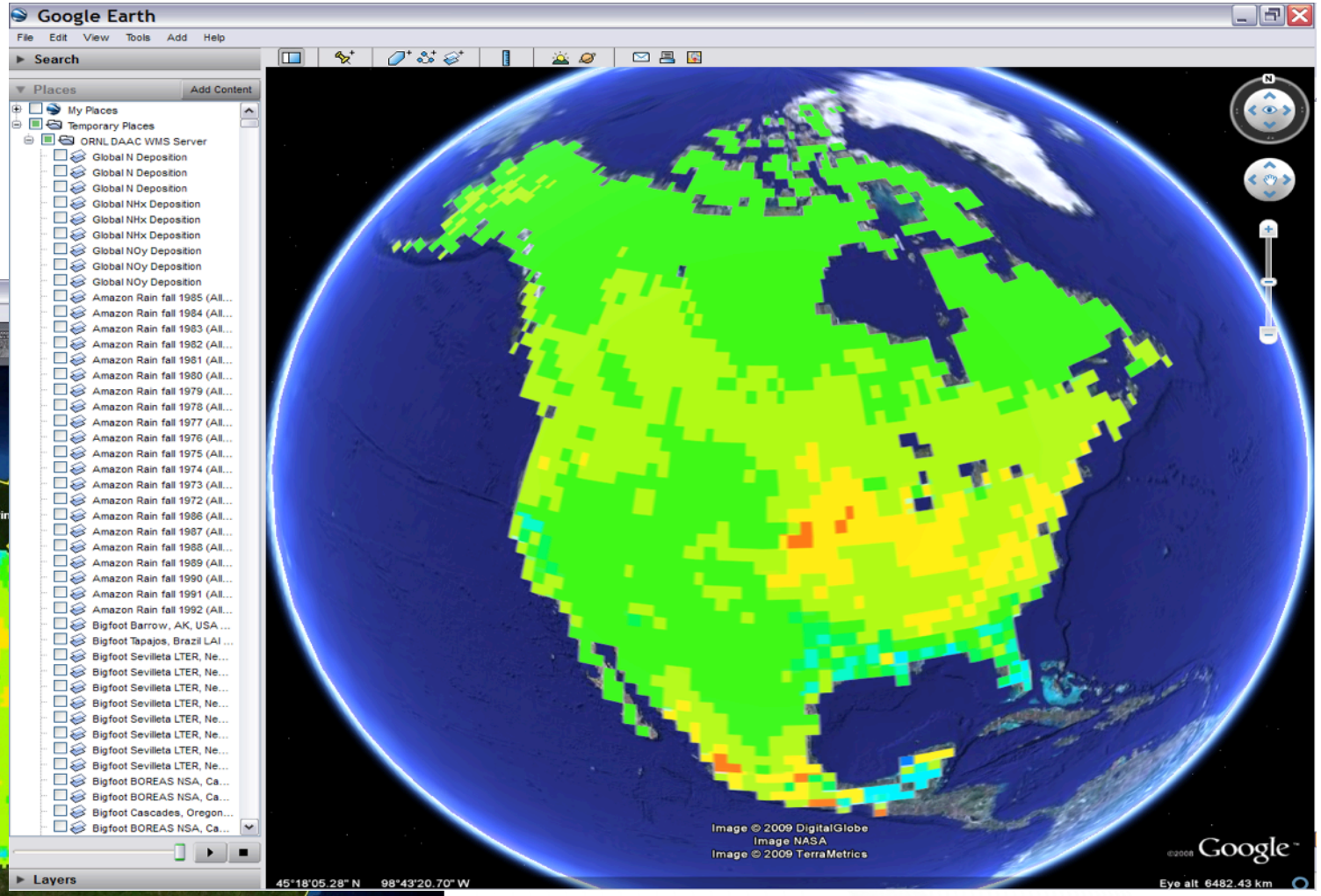
ORNL DAAC Spatial Data Access Tool (SDAT)





OAK RIDGE National Laboratory





OAK RIDGE National Laboratory

GovLoop Webinar

Integration of Tools for Scientific Analysis with GIS

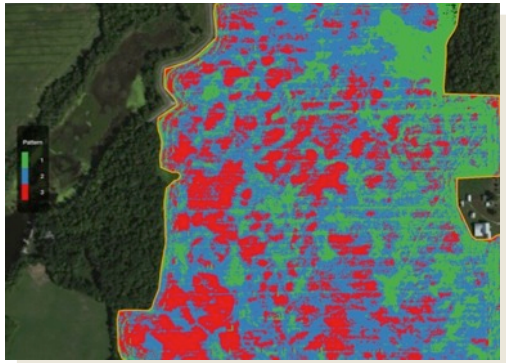
Brett Rose, PhD

brose@esri.com

Science begins with observations

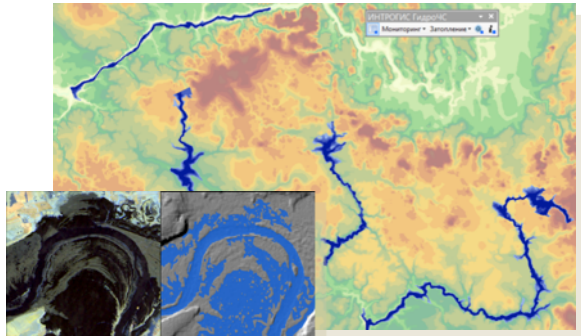
We use science everyday

Crop Health



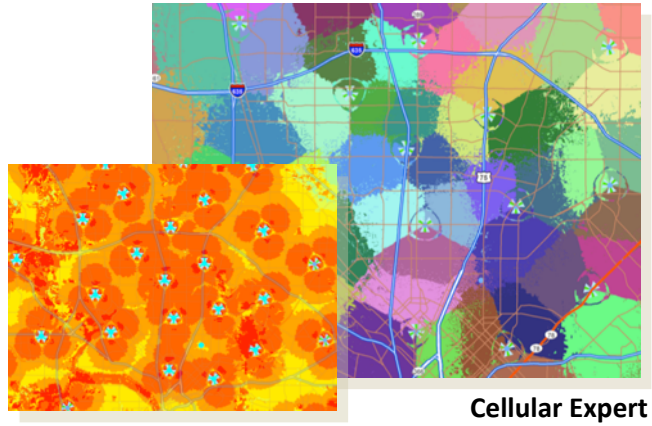
GeoSilos
Indiana

Hydro Analysis



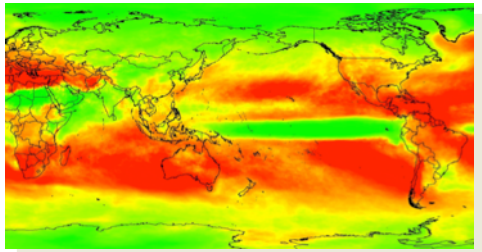
IntroGIS
Russia

Cellular Coverage Analysis



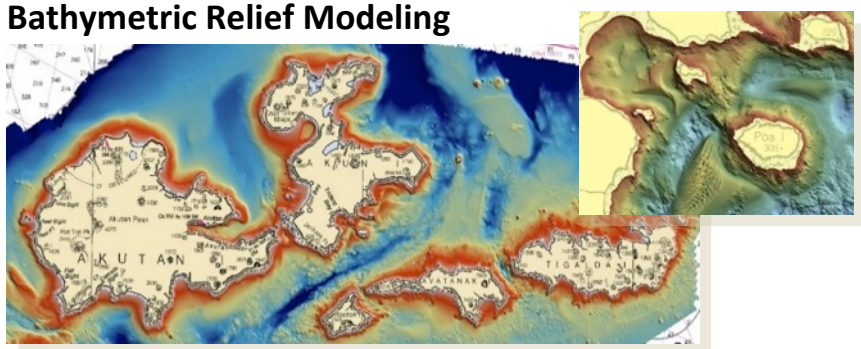
Cellular Expert
Texas

Global Rainfall



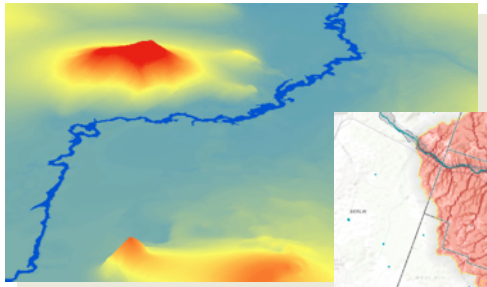
CLIMsystems
Global

Bathymetric Relief Modeling



Fugro Palegos
Alaska

Hydrographic Modeling

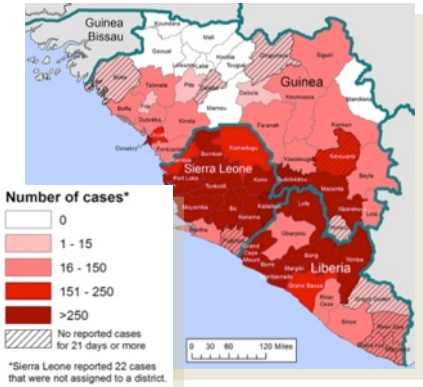


IntroGIS
Russia

Water Runoff Modeling

Stone Environmental
Vermont

Ebola Disease



West Africa

To do science we need to

Understand where things are

Measure size, shape and distribution

Determine how places are related

Find best location and paths

Detect and quantify patterns

Make predictions

We can use Spatial Analysis

Spatial analytics can mean a lot of things

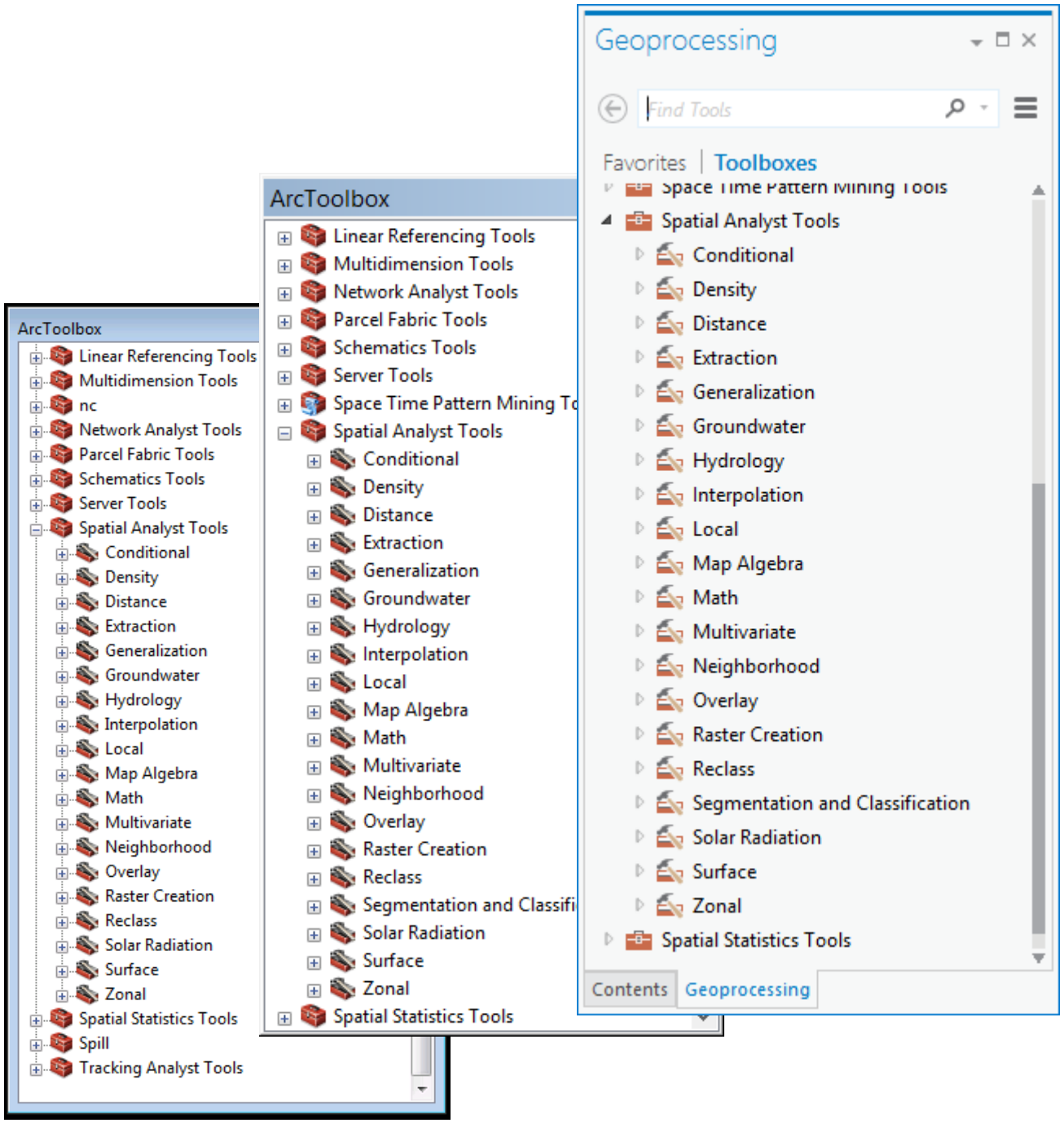
With spatial analytics we

map → to see possible patterns

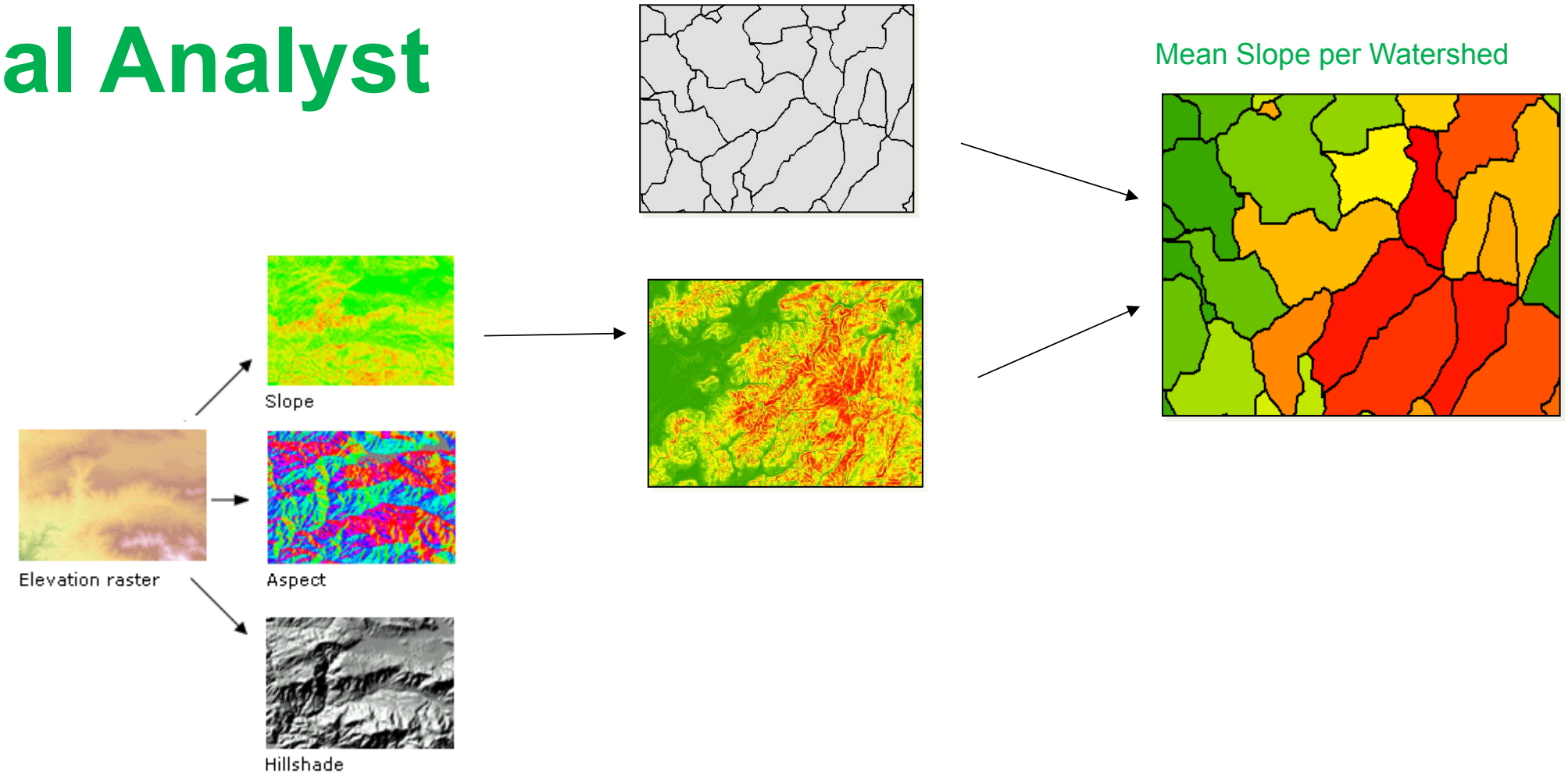
describe → to improve understanding

measure → to minimize subjectivity

Tools in ArcGIS

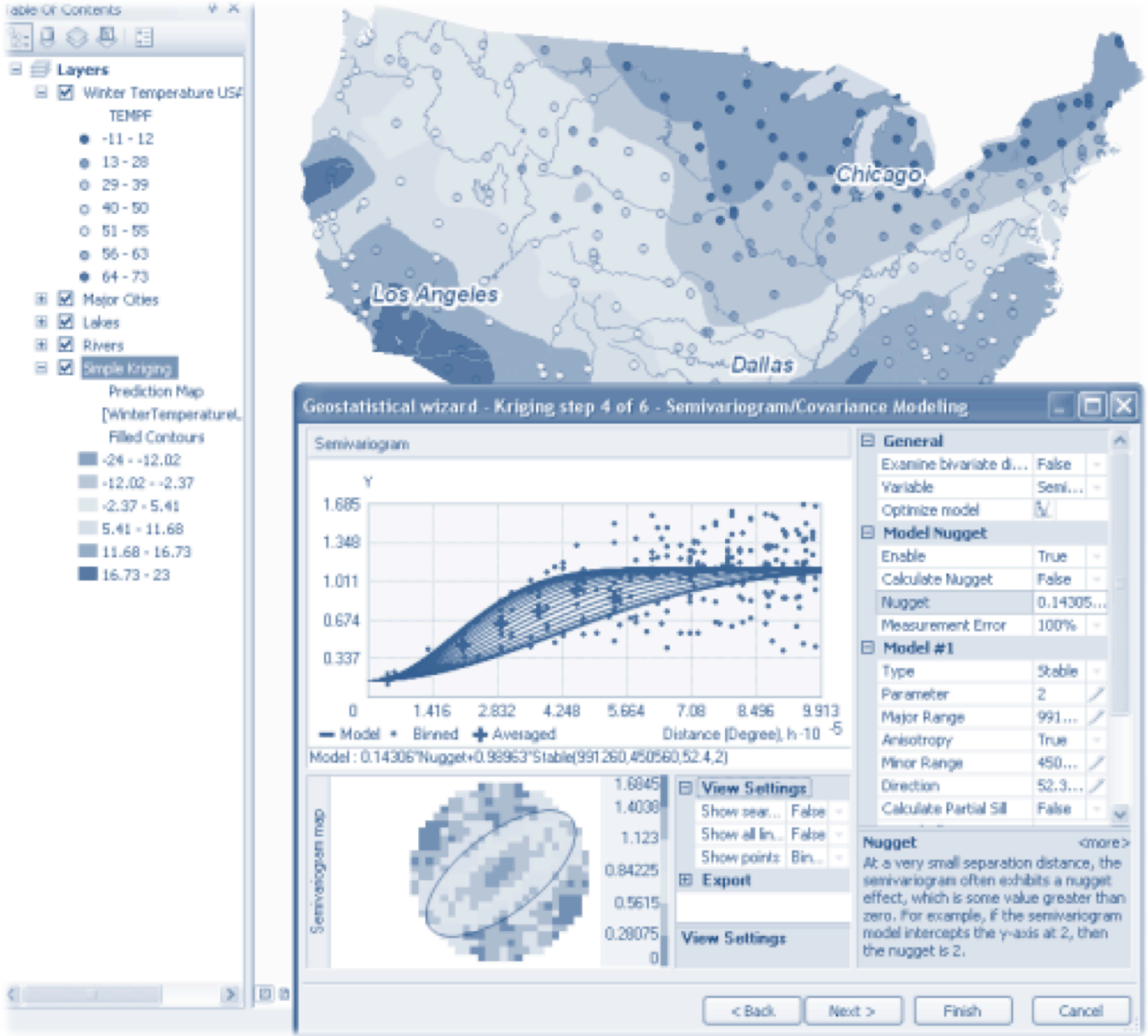


Spatial Analyst

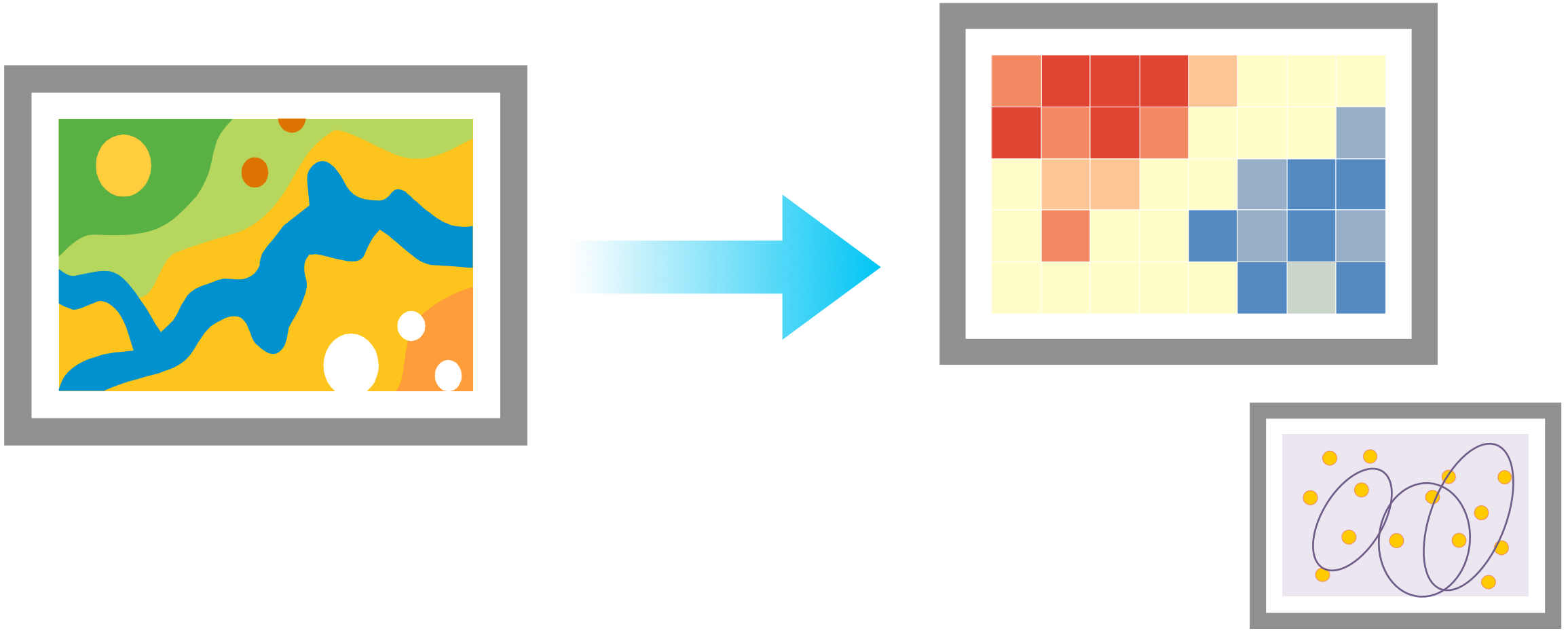



```
# This is map algebra
outRas = Raster("inraster1") + Raster("inraster2")
```

Geostatistics



Spatial Statistics

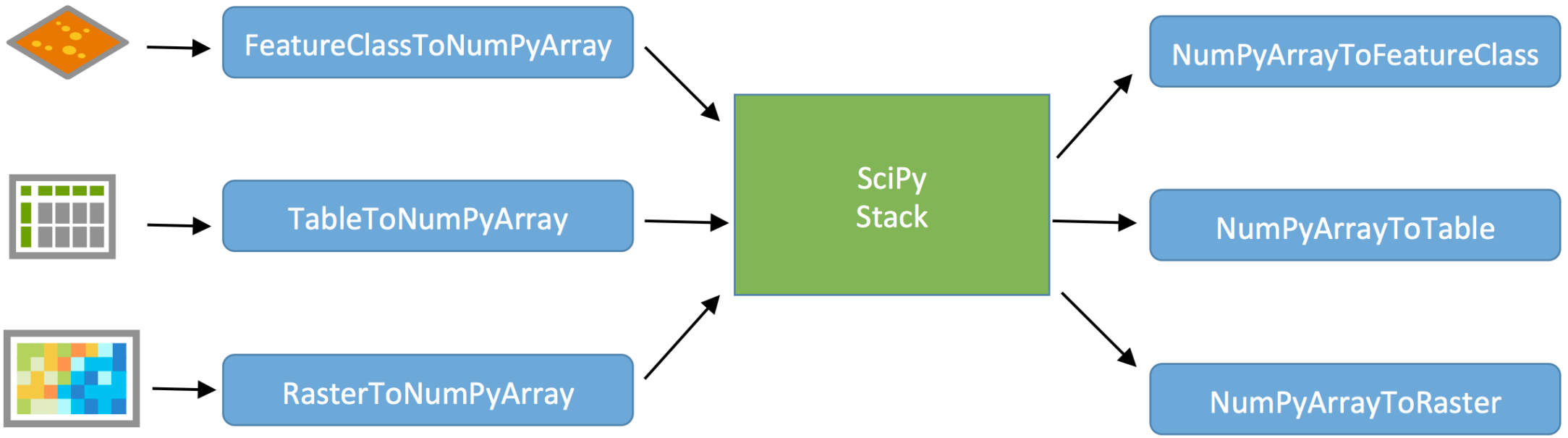


Extend and integrate spatial analytics

python

- Spatial Statistics Tools
  - Analyzing Patterns
    - Average Nearest Neighbor
    - High/Low Clustering (Getis-Ord General G)
    - Incremental Spatial Autocorrelation
    - Multi-Distance Spatial Cluster Analysis (Ripleys K Function)
    - Spatial Autocorrelation (Morans I)
  - Mapping Clusters
    - Cluster and Outlier Analysis (Anselin Local Morans I)
    - Grouping Analysis
    - Hot Spot Analysis (Getis-Ord Gi*)
    - Optimized Hot Spot Analysis
    - Similarity Search
  - Measuring Geographic Distributions
    - Central Feature
    - Directional Distribution (Standard Deviational Ellipse)
    - Linear Directional Mean
    - Mean Center
    - Median Center
    - Standard Distance
  - Modeling Spatial Relationships
    - Exploratory Regression
    - Generate Network Spatial Weights
    - Generate Spatial Weights Matrix
    - Geographically Weighted Regression
    - Ordinary Least Squares

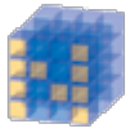
ArcGIS + SciPy

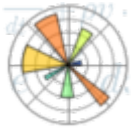


We use SciPy because

- Most languages don't support things useful for science, e.g.:
  - Vector primitives
  - Complex numbers
  - Statistics
- Object oriented programming isn't always the right paradigm for analysis applications, but is the only way to go in many modern languages
- SciPy brings the pieces that matter for scientific problems to Python

SciPy Stack





IP[y]: IPython

nose

NumPy for numerical computation using arrays

SciPy a collection of numerical algorithms

Matplotlib for 2D and 3D plotting

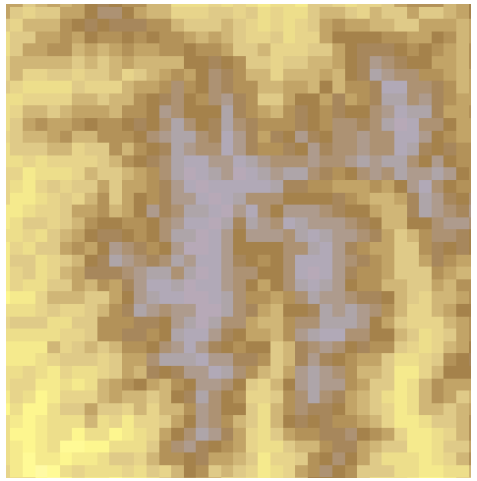
Pandas for high-performance data structures

SymPy for symbolic mathematics and computer algebra

IPython providing an interactive interface for quickly testing scripts and

`nose` which allows you to test your Python code.

Spatial Analyst

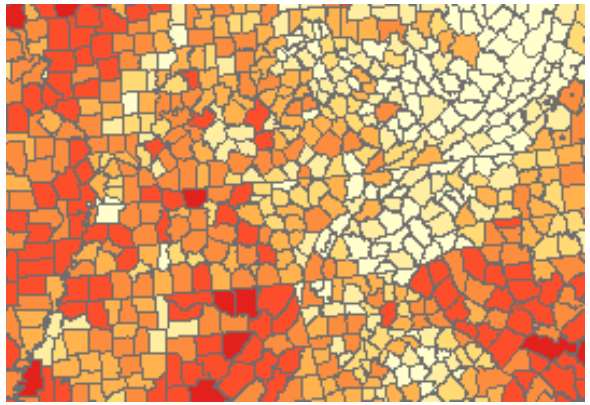


python™

NumPy

Spatial & Geo Stats

Data Access Module



python™

NumPy

Spatial Statistics Data Object and Utilities

matplotlib

NetCDF4

- Fast, HDF5 and NetCDF4 read+write support, OPeNDAP
- Heirarchical data structures
- Widely used in meterology, oceanography, climate communities
- Easier: Multidimensional Toolbox, but can be useful

```
import netCDF4
nc = netCDF4.Dataset('test.nc', 'r', format='NETCDF4')
print nc.file_format
# outputs: NETCDF4
nc.close()
```

Multi-Dimensional data

- Multidimensional formats: HDF, GRIB, NetCDF
- Access via OPeNDAP, vector renderer, Raster Function Chaining
- An example which combines mutli-D with time
- Multi-D supported as WMS, and in Mosaic datasets (10.2.1+)

Other integration

pysal

pysal
Python Spatial Analysis Library

- Open Source Python Library for Spatial Analytical Functions
- ASU GeoDa Center for Geospatial Analysis and Computation
- Luc Anselin
  - PySpace (GeoDaSpace)
- Sergio Rey
  - STARS

BSD License

R

- R (The *R* Project for Statistical Computing)
  - Over 60 CRAN sites across 30+ countries
  - Its Free GNU GENERAL PUBLIC LICENSE
  - Base is powerful Statistics, Linear Algebra, Visualization , etc…
  - Its extendible 1800+ Contributed Extensions
  - splancs, spatstat, spdep, rgdal, maptools, shapefiles

R

- Contains “cutting edge” data analysis techniques from a wide body of academic and applied fields
- Extendible
- Indirectly compatible
  - Direct via RPy/RPy2 and win32com
- GNU
- Revolution
- esri continues to focus on improving the interaction in the future

links

pysal

https://geodacenter.asu.edu/pysal

https://github.com/pysal

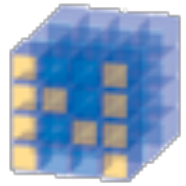
SciPy and **NumPy**

http://www.scipy.org/

R

http://www.r-project.org

IP[y]:
IPython



Try for yourself

http://esri.github.io/

http://esriurl.com/scicomm

http://developers.arcgis.com

Other

Thank you

Ask Us Your Questions

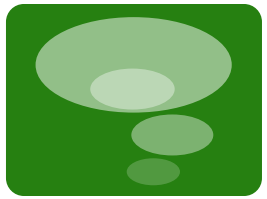
Dawn Wright
Chief Scientist
Esri

Brian Tisdale
Booz Allen Hamilton

Suresh K.S. Vannan
Manager, DAAC
Oak Ridge National Laboratory

Brett Rose
Solution Engineer
Esri

Thanks for Joining



- **Learn more:** Continue learning! Check out the Resources Section for additional information on GIS and smarter communities. All resources are saved on-demand.
- **On-Demand:** We will email you a link to the on-demand version of this training so you can view it again or share with a colleague. Plus your GovLoop training certificate.
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