NASA AIRS Science Team Meeting

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esri

Addressing Scientific Data Challenges using ArcGIS Platform

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Outline

- ArcGIS Platform
- Scientific Multidimensional Data
- Ingest and Data Management
- Analysis and Visualization
- Extending Analytical Capabilities using Python
- Sharing Services and Web Applications

ArcGIS ▸ An Integrated Web GIS Platform

Web GIS

Providing Mapping, Analysis, Data Management, and Collaboration

Available on the Open Web . . .
. . . and On-Premises

ArcGIS Industries ▸ Connects people with maps, data and apps

- Insurance
- Retail
- Manufacturing
- Real Estate
- Banking
- Media & Entertainment
- Supply Chain

- Federal, State, Local
- Defense
- Intelligence
- Resilient Communities
- Architecture, Engineering, and Construction (AEC)
- Economic Development
- Elections & Redistricting
- Facilities
- Land Administration
- Public Works
- Surveying
- Urban & Regional Planning

- Agriculture
- Climate, Weather, and Atmosphere
- Conservation
- Environmental Management
- Forestry
- Mining
- Oceans
- Petroleum
- Water Resources

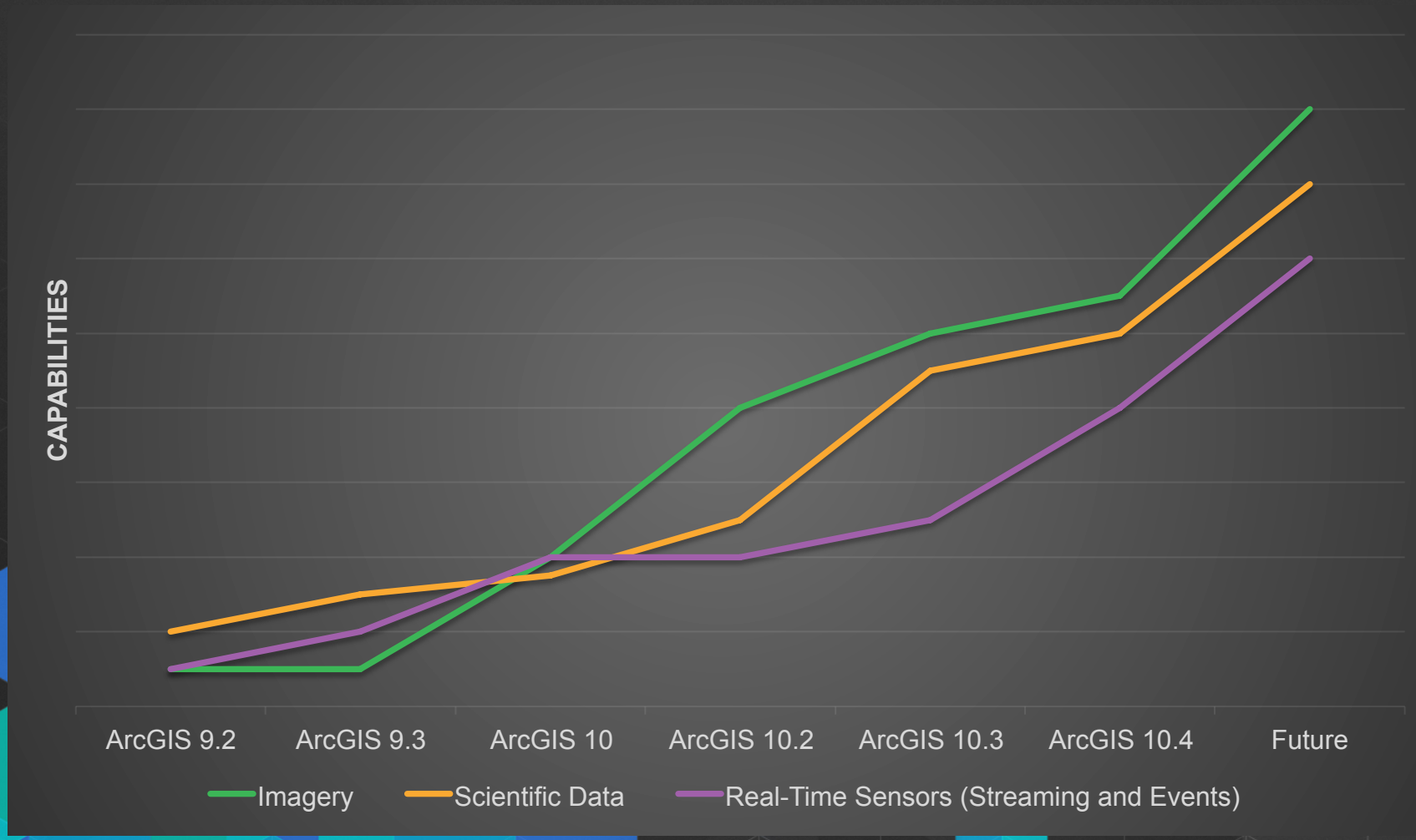
- Emergency Call Taking & Dispatch
- Emergency/Disaster Management
- Fire, Rescue, and EMS
- Homeland/National Security
- Law Enforcement
- Wildland Fire Management

- Airports & Aviation
- Highways
- Railways
- Ports & Maritime
- Public Transit

- Electric
- Gas
- Pipeline
- Telecommunications
- Water/Wastewater

- Education
- Health & Human Services
- Map, Chart, and Data Production
- Sustainable Development

ArcGIS Development ▸ Trends in Capabilities



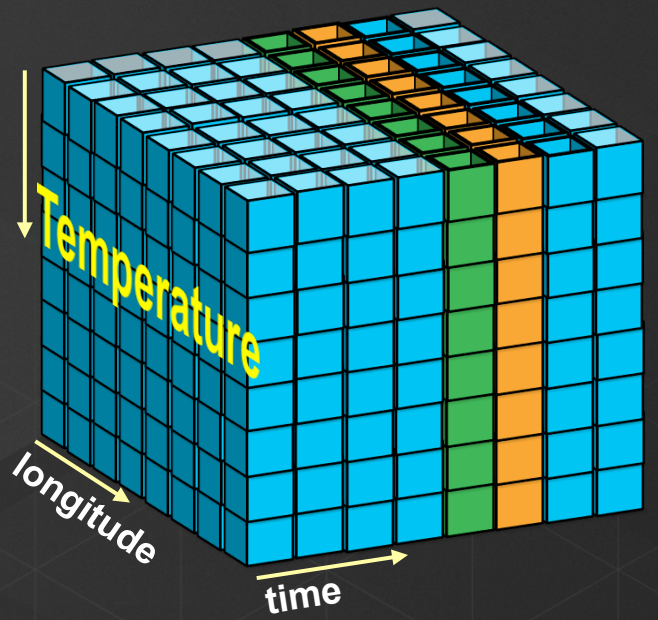
ArcGIS is Evolving as a Remote Sensing Software Platform

- ✓ Sensor Support
  - EO, RADAR, LiDAR, FMV,…
- ✓ > 80 Formats
  - HDF, NetCDF, GRIB, NITF
- ✓ Image Processing
- ✓ Distributed Data & Analytics
- ✓ Management and Dissemination
- ✓ Web Services and Standards
  - WMS, WCS, KML,…

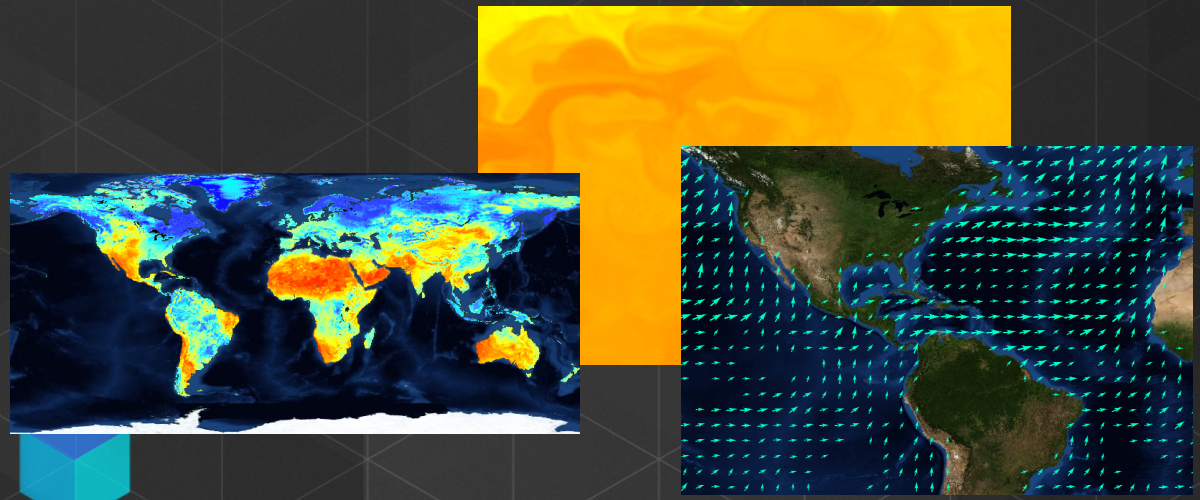
R&D Staff

Scientific Multidimensional Data

- Stored in netCDF, GRIB, and HDF formats
- Multidimensional



  - Ocean data
    Sea temperature, salinity, ocean current
  - Weather data
    Temperature, humidity, wind
  - Land
    Soil moisture, NDVI, land cover



Scientific Data in ArcGIS - Vision

Challenges

variety of formats
volume & velocity
redundancy

portability
scalability
reproducibility

integration
standards
accessibility

Geoinformation Model ▸ Designed for Characteristics of Scientific Data

Variety

- Industry Leading Vector Management & Analytics
- 80+ Raster Formats
  - NetCDF
  - HDF
  - GRIB1,2
- 40+ Commercial Spaceborne & Airborne Sensors
  - +FMV
- Standards & Frameworks
  - OPeNDAP
  - OGC
  - GDAL

Velocity

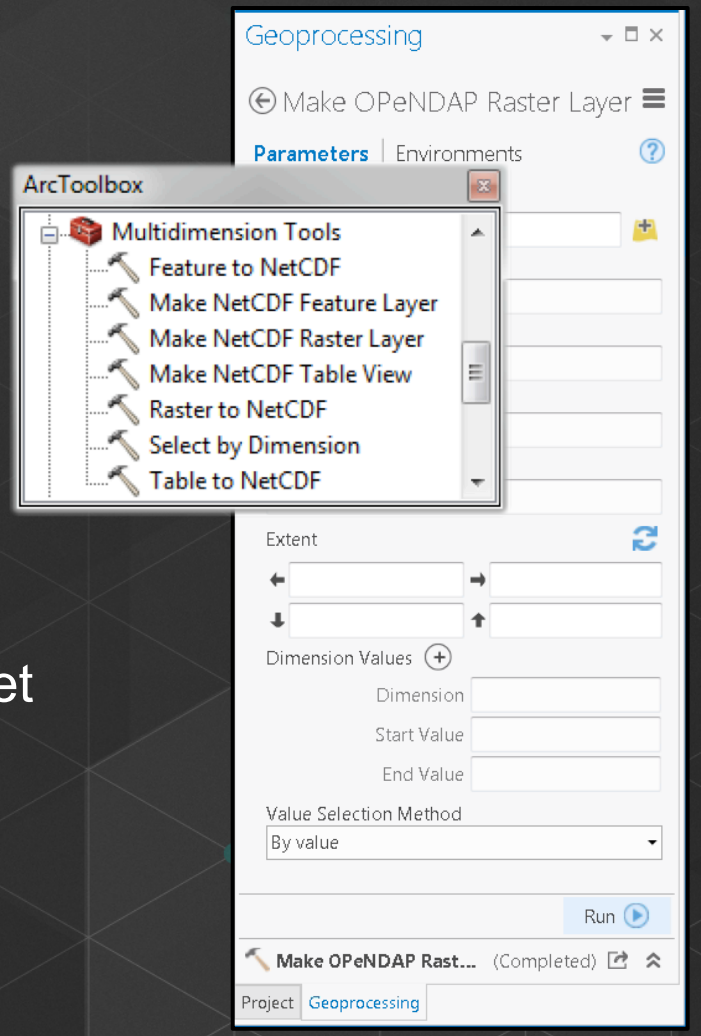
- Data Ingest By Reference
- On-the-Fly Analysis
- Python for Automation
- Streaming Events
- ArcGIS for Server Elasticity

Volume

- Manage Millions of Raster Datasets in Mosaic Dataset
- Dissemination
  - Direct Access
  - Web Services
- Aggregation
  - Spatial
  - Temporal
  - Dimensional

Ingesting Scientific data in ArcGIS

- Directly reads netCDF file using
  - Make NetCDF Raster Layer
  - Make NetCDF Feature Layer
  - Make NetCDF Table View
- Ingest OPeNDAP Service
  - Output dynamic multidimensional raster
  - Support Sub-setting
- Scientific data formats are supported in mosaic dataset
  - netCDF
  - HDF
  - GRIB



CF Convention

Climate and Forecast (CF) Convention
http://cf-pcmdi.llnl.gov/

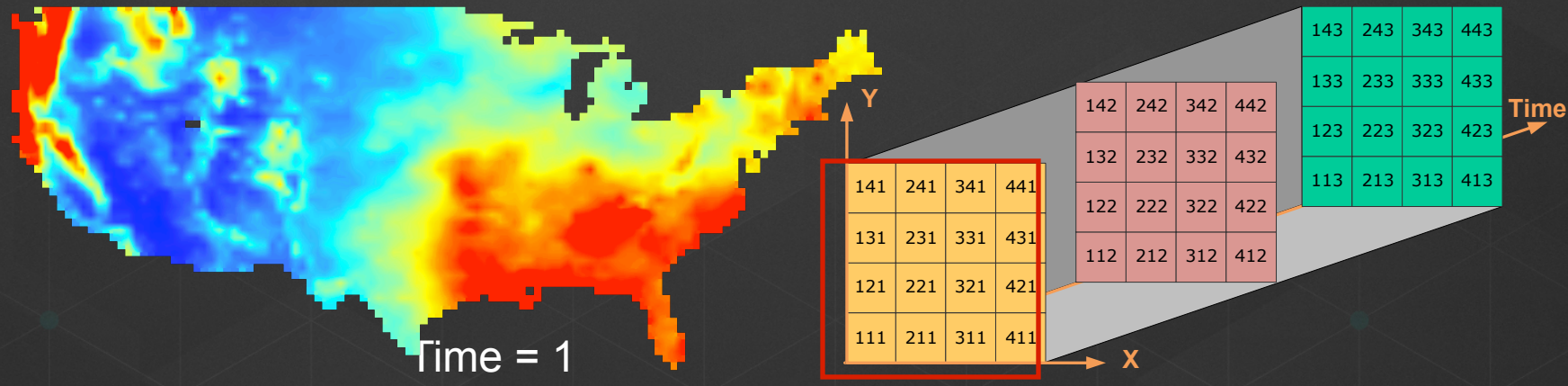
Initially developed for
- Climate and forecast data
- Atmosphere, surface and ocean model-generated data
- Also for observational datasets

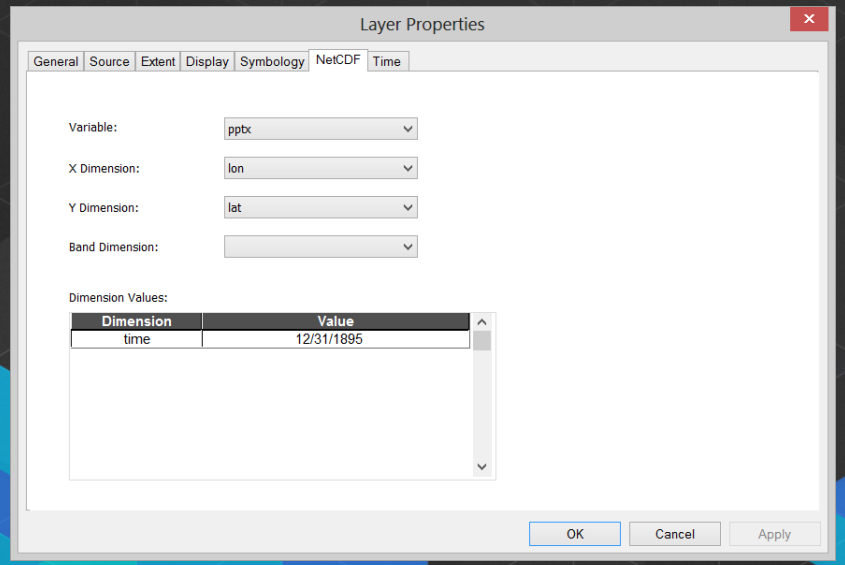
- CF is now the most widely used conventions for geospatial netCDF data. It has the best coordinate system handling.

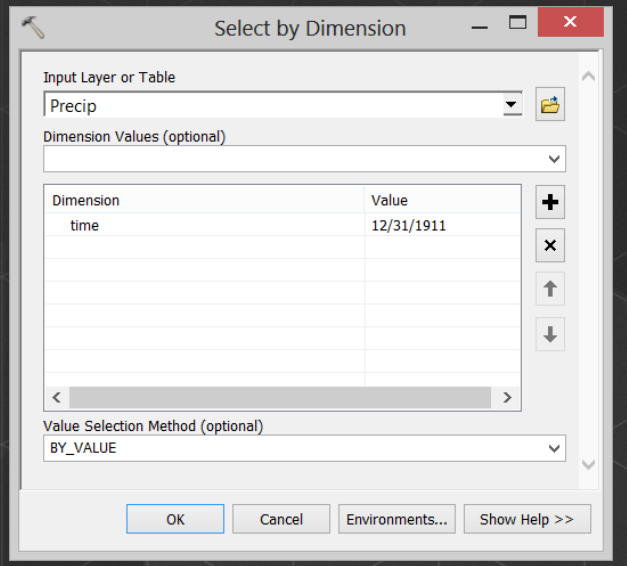
- Current version 1.6

- You can use Compliance checker utility to check a netCDF file.
  http://cf-pcmdi.llnl.gov/conformance/compliance-checker/

Changing Time Slice

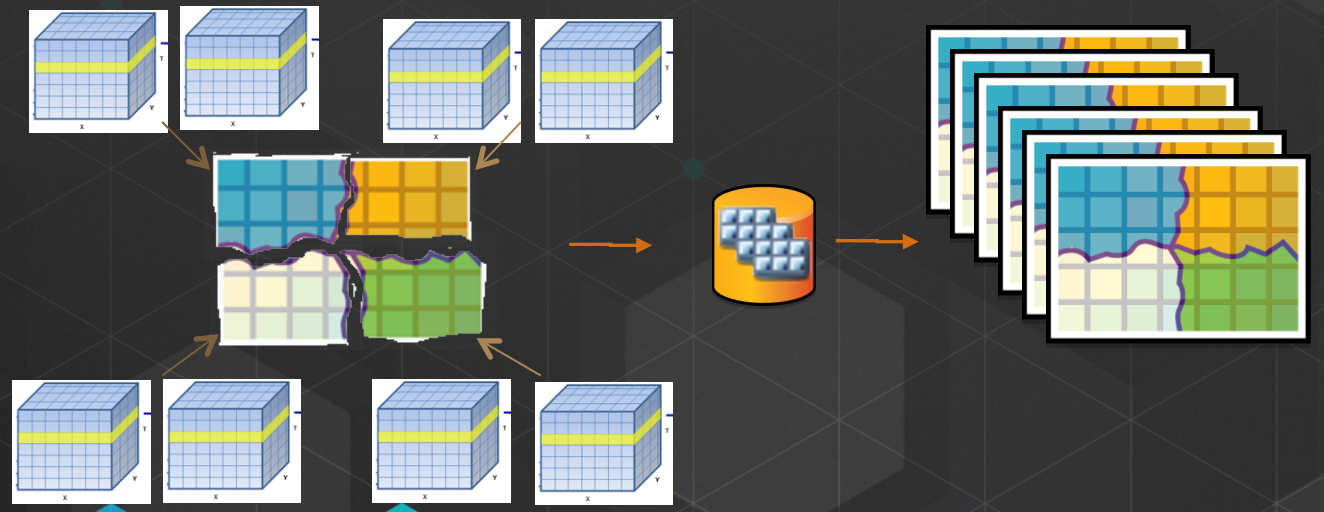






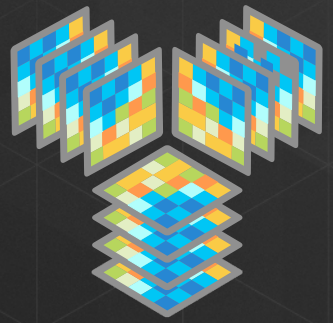
What about Aggregation?

- Create a seamless multi-dimensional cube from
  - files representing different regions
  - files representing different time steps/slices



- Mosaic dataset supports multiple files and variables, normalize time and depth

Multidimensional Mosaic Dataset



HDF

GRIB

netCDF

d-aware rasters

mosaic dataset

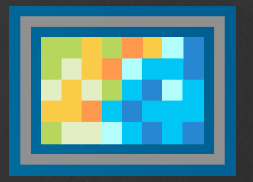
spatially-indexed catalog

multi-resolution, multivariate, multidimensional

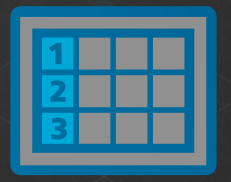
reduce storage redundancy & pixel resampling

defines information products

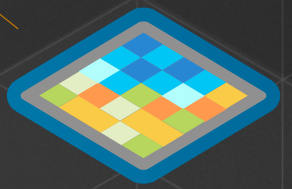
on-demand processing



mosaic



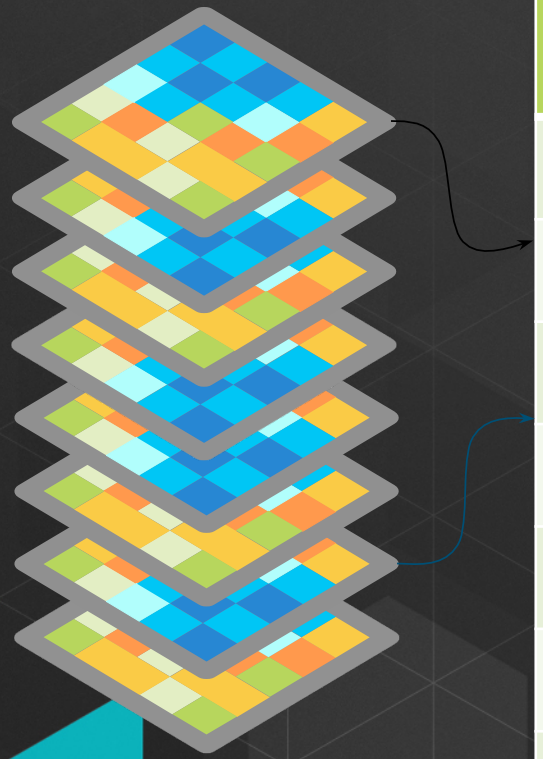
table



raster pixels

Representing multivariate collection of multidimensional rasters in ArcGIS

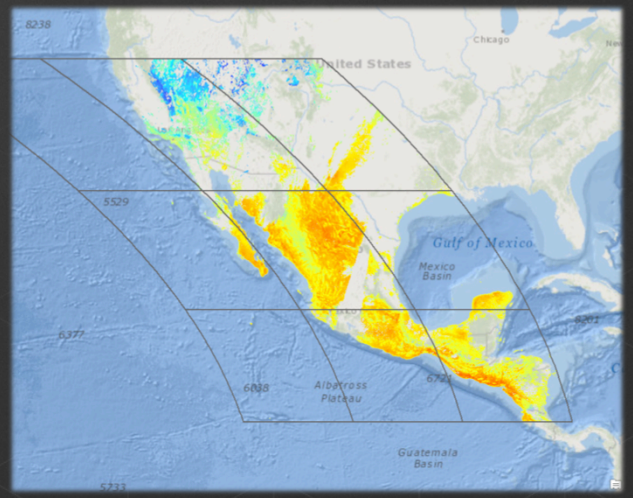
Tabular View

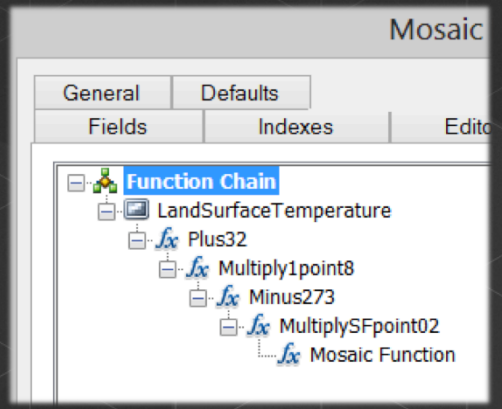


Raster	Shape	Variable	StdTime	StdZ
…	…	Temperature	3/22/2016	-10
…	…	Temperature	3/23/2016	-10
…	…	**Temperature**	**3/24/2016**	**-10**
…	…	Salinity	3/22/2016	-10
…	…	**Salinity**	**3/23/2016**	**-10**
…	…	Salinity	3/24/2016	-10
…	…	Temperature	3/22/2016	-20
…	…	Temperature	3/23/2016	-20
…	…	…	…	…

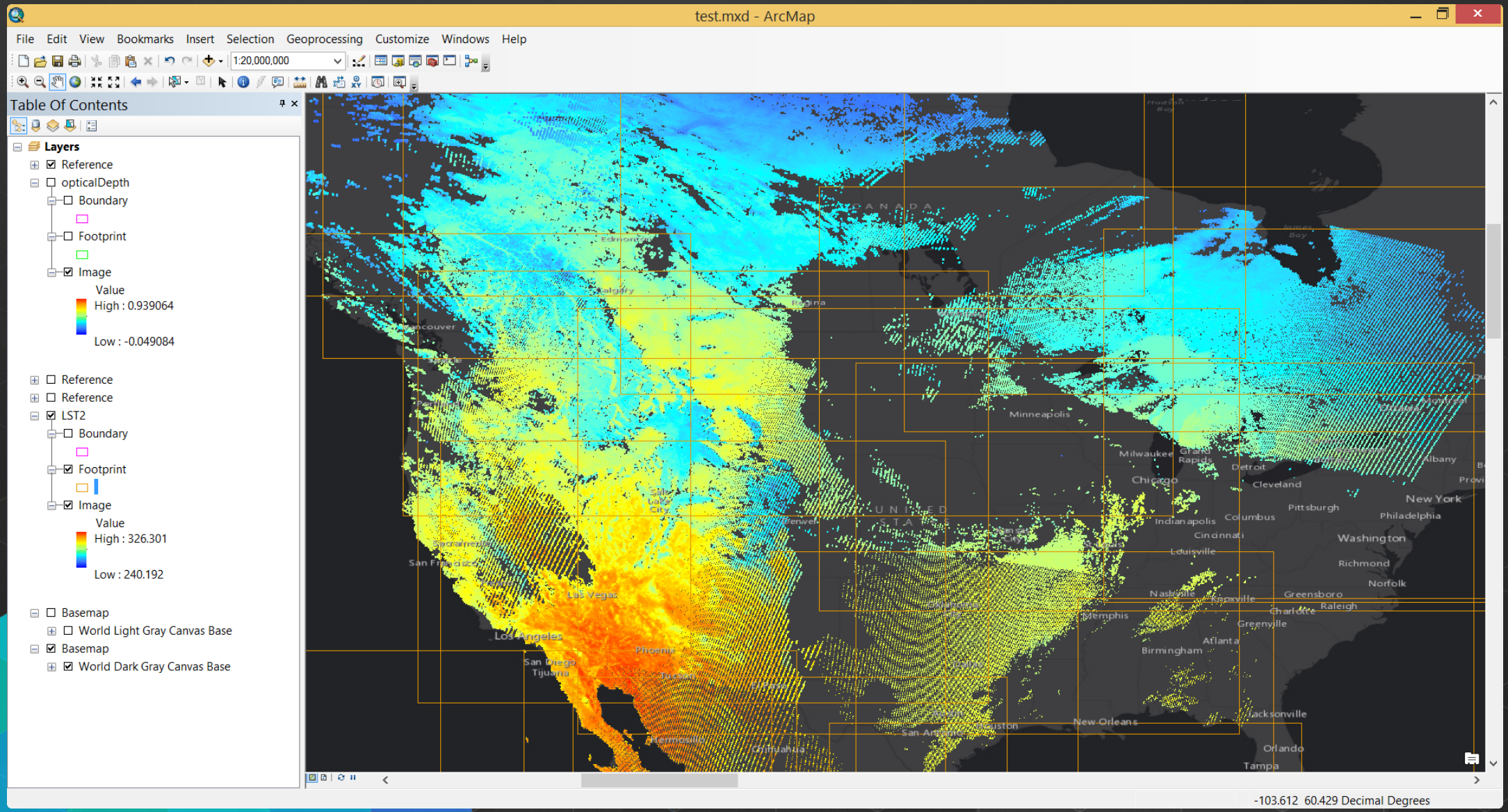
Scientific data support in Mosaic Dataset

- Supports netCDF, HDF and GRIB
  - Spatial Aggregation
  - Temporal Aggregation
  - On-the-fly analysis
- Serve as Multidimensional
  - Image Service
  - Map Service
  - WMS
- Supports direct ingest
- Eliminates data conversion
- Eliminates data processing
- Improves workflow performance
- Integrates with service oriented architecture





MODIS: Land Surface Temperature



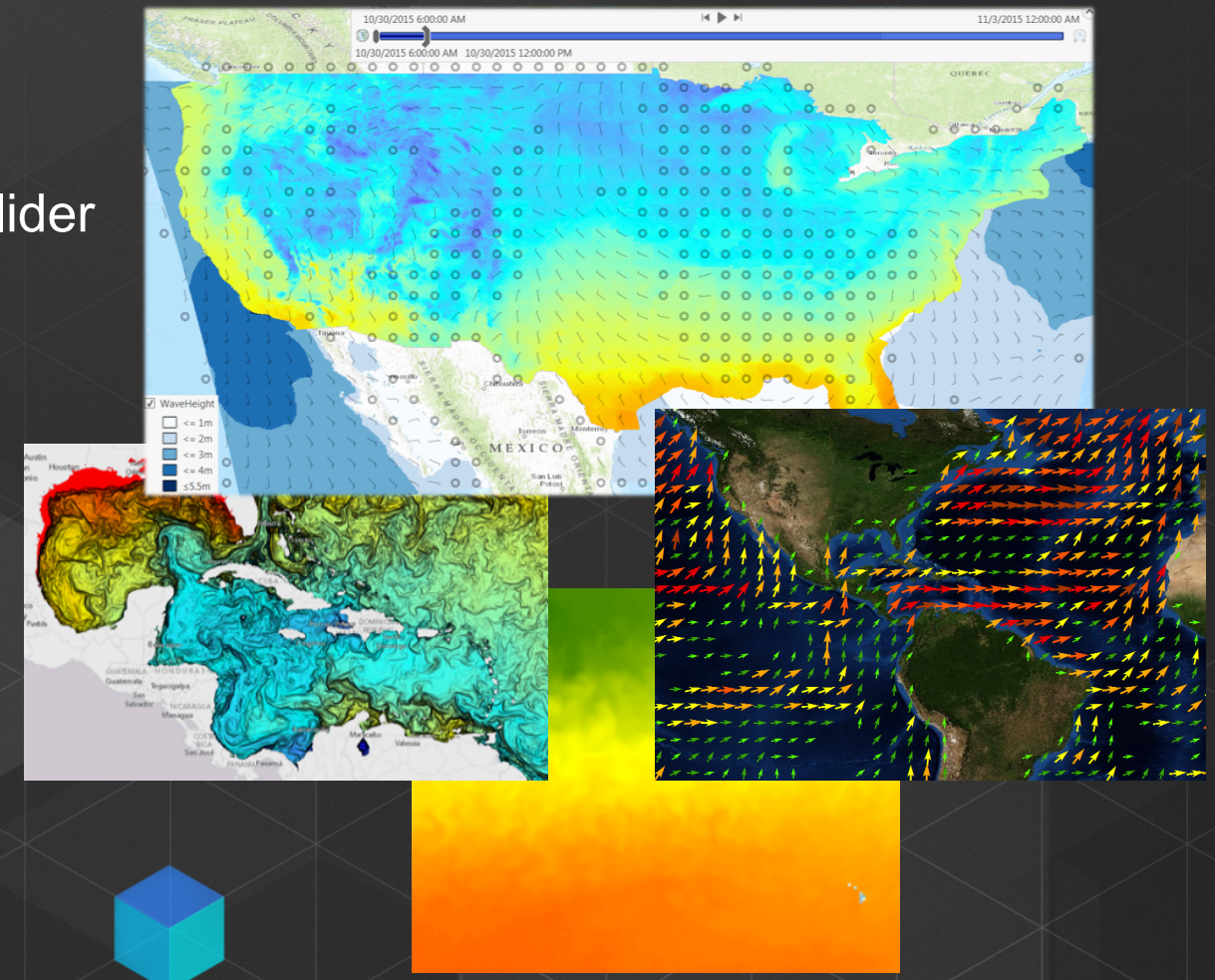
Using Scientific Data in ArcGIS

Behaves the same as any layer or table

- Display
  - Same display tools for raster and feature layers will work on multi-dimensional raster and feature layers.
- Graphing
  - Driven by the table just like any other chart.
- Animation
  - Multi-dimensional data can be animated through time dimension
- Analysis Tools
  - Will work just like any other raster layer, feature layer, or table. (e.g. create buffers around points, reproject rasters, query tables, etc.)

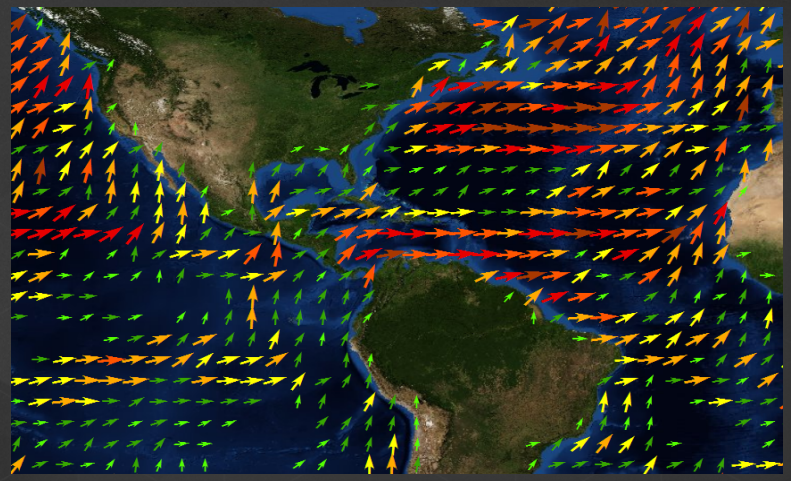
Visualization of Scientific Data

- Slicing
- Temporal animation using Time Slider
- Dimensional animation using Range Slider
- Predefined renderer

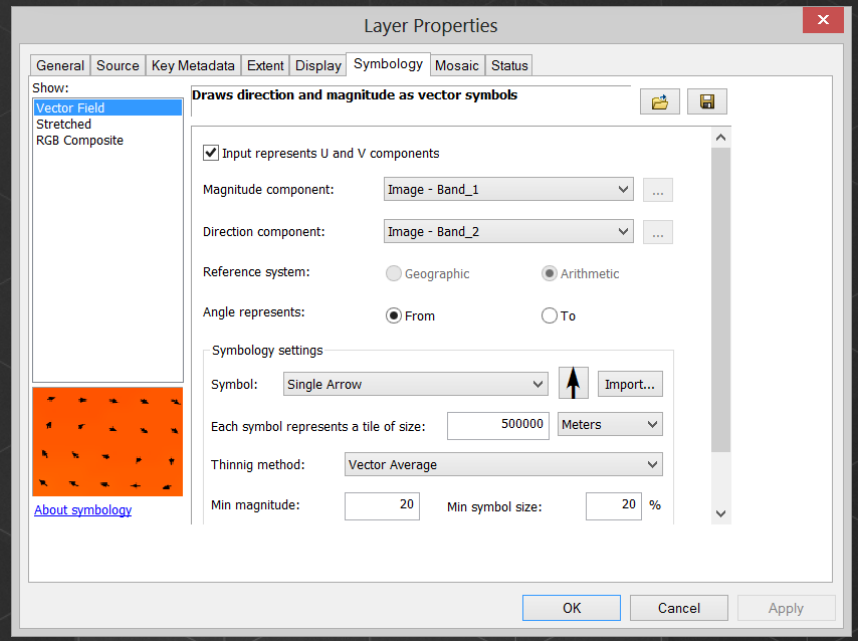


Visualization of Raster as Vectors

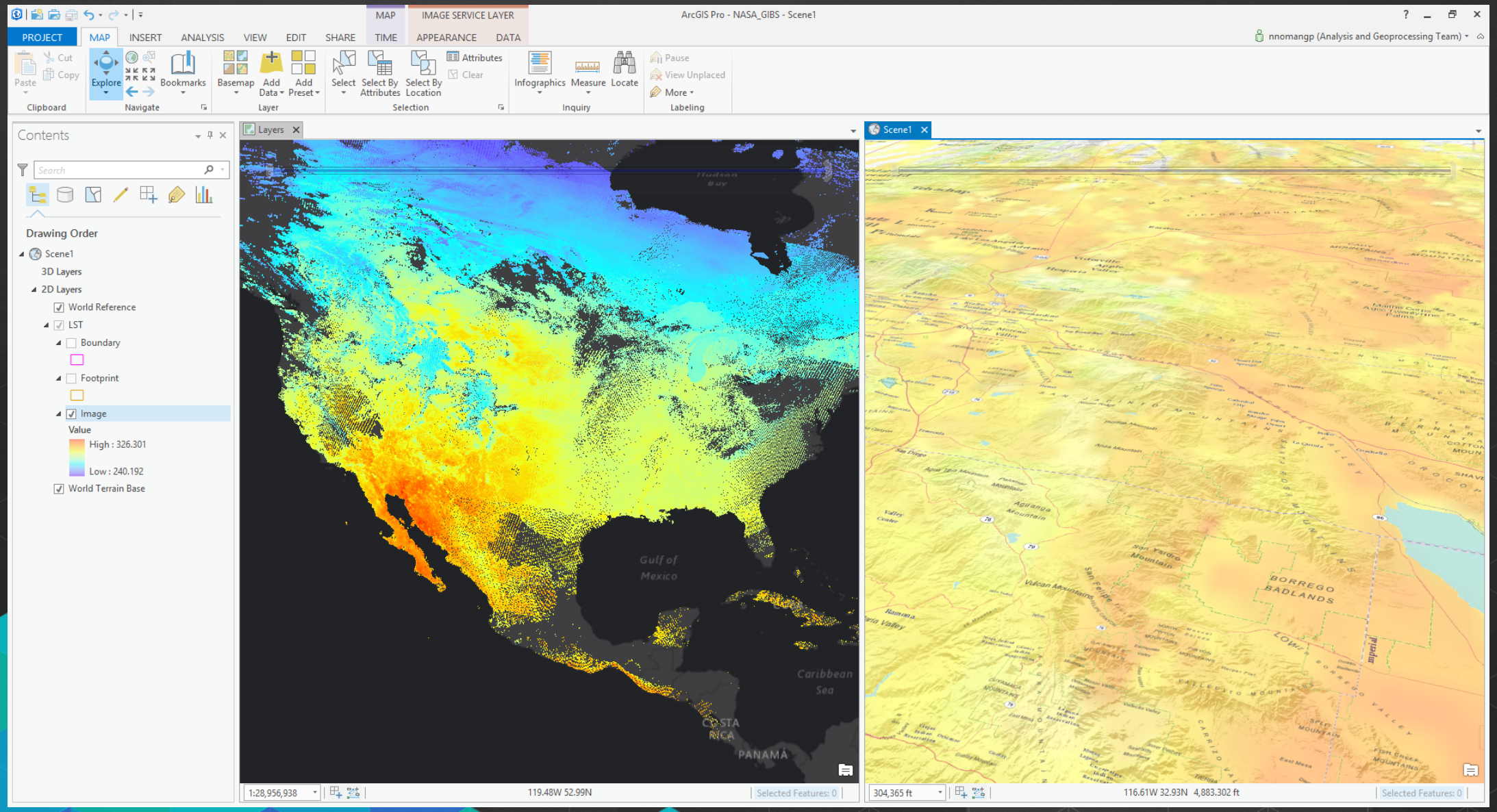
- New Vector Field renderer for raster
  - Supports U-V and Magnitude-direction
  - Dynamic thinning
  - On-the-fly vector calculation



- Eliminates raster to feature conversion
- Eliminates data processing
- Improves workflow performance

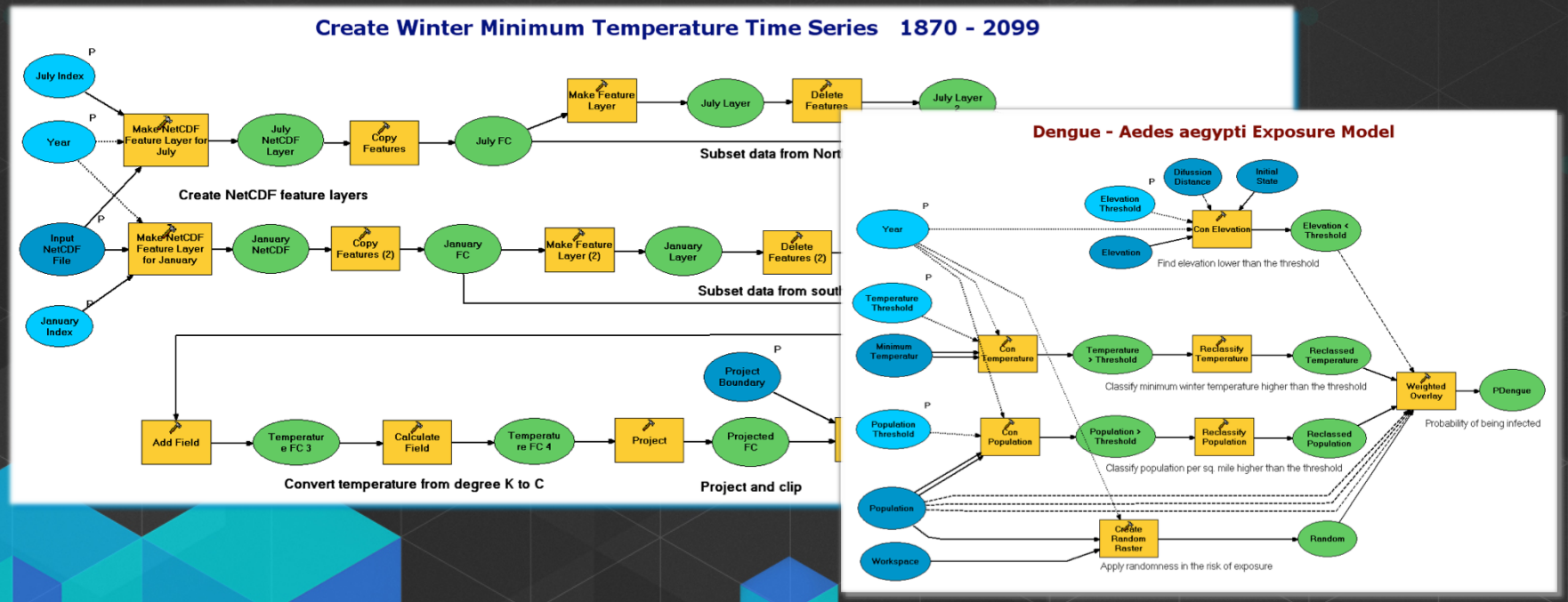


Visualizing Land Surface Temperature in ArcGIS Pro



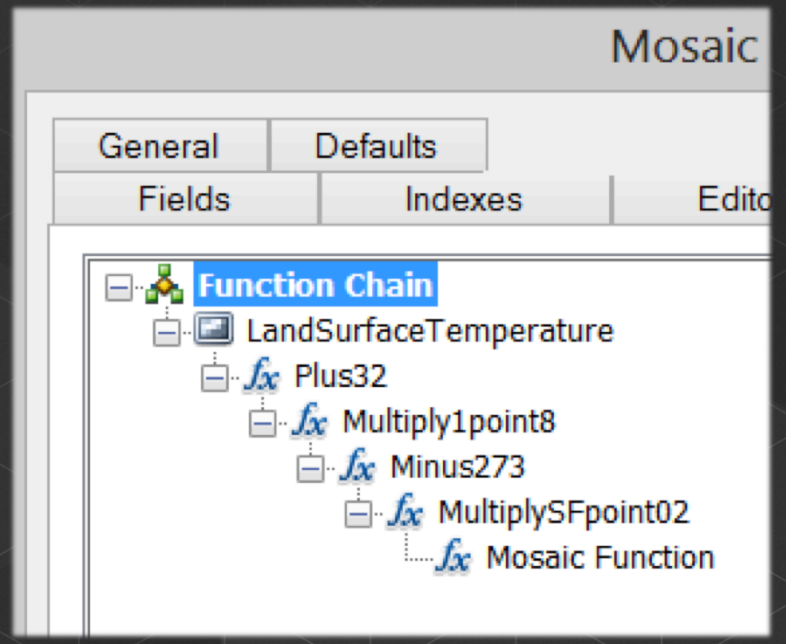
Spatial and Temporal Analysis

- Hundreds of analytical tools available for raster, features, and table
- Temporal Modeling
  - Looping and iteration in ModelBuilder and Python



On-the-Fly Processing using Raster Functions

- Several analytical functions are available out of the box
- Functions are chained together to create complex model
- Used to perform on-the-fly analysis
- Extend analytical capability using Python Raster Function

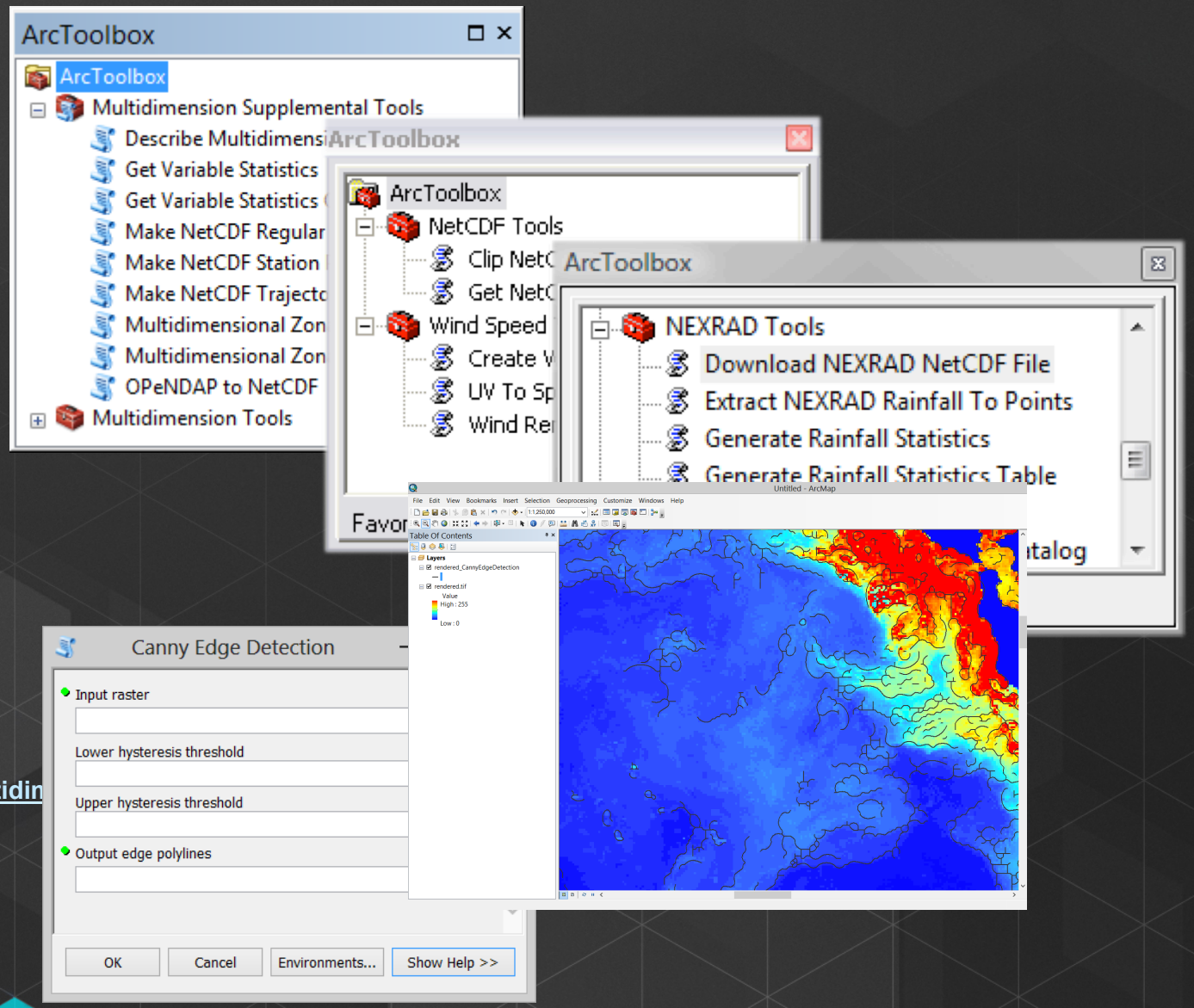


Python – Extending Analytical Capabilities

Supplemental tools

- OPeNDAP to NetCDF
- Make NetCDF Regular Point Layer
- Make NetCDF Station Point Layer
- Make NetCDF Trajectory Point Layer
- Describe Multidimensional Dataset
- Get Variable Statistics
- Get Variable Statistics Over Dimension
- Multidimensional Zonal Statistics
- Multidimensional Zonal Statistics As Table

http://blogs.esri.com/esri/arcgis/2013/05/24/introducing-the-multidin

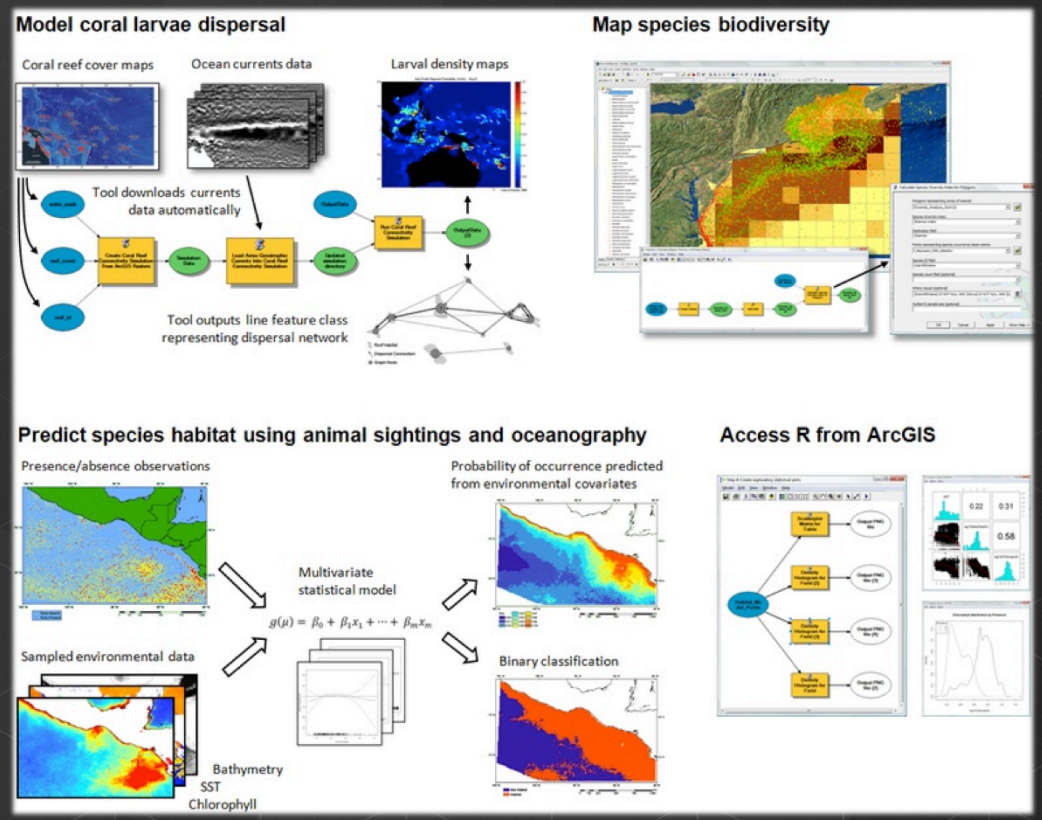


Community Developed Tools

- Geoprocessing Resource Center
  http://resources.arcgis.com/geoprocessing/

- Marine Geospatial Ecology Tools (MGET)
  - Developed at Duke Univ.
  - Over 180 tools for import management, and analysis of marine data
    http://mgel.env.duke.edu/mget

- Australian Navy tools
  (not publicly available)



Python Package: netCDF4-Python, SciPy

- netCDF4-python is included in 10.3/Pro
  - Read and write netCDF file
  - Conversion time values to date
  - Multi-file aggregasion
  - Compression
- SciPy
- Python Raster Function

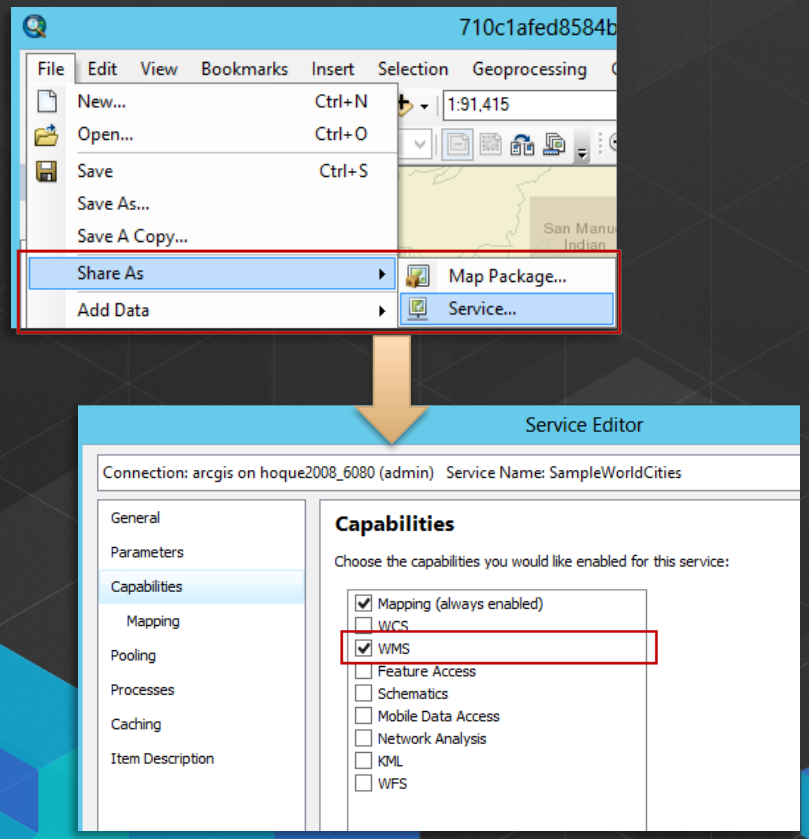
https://www.unidata.ucar.edu/software/netcdf/workshops/2012/netcdf_python/netcdf4python.pdf

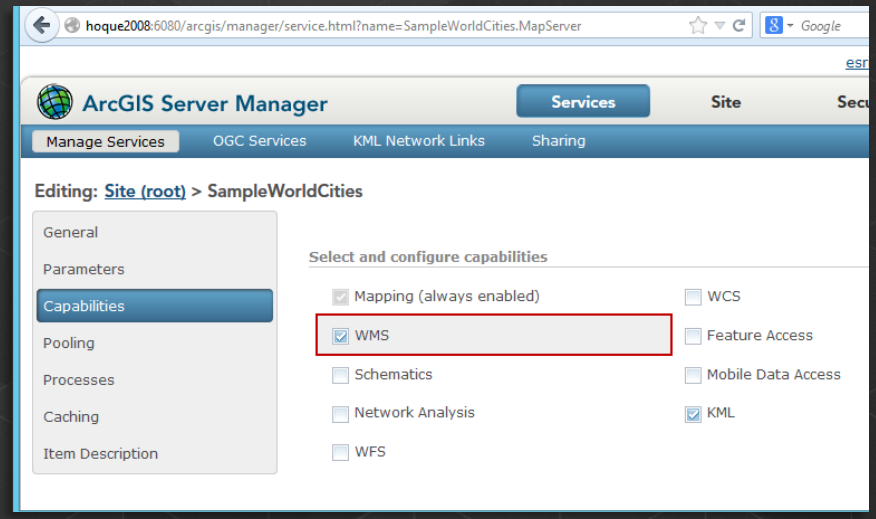
Sharing / WMS Support (for multi-dimensions)

- Map Service (supports WMS)
  - Makes maps available to the web.
- Image Service (supports WMS)
  - Provides access to raster data through a web service.
- Geoprocessing Service
  - Exposes the analytic capability of ArcGIS to the web.

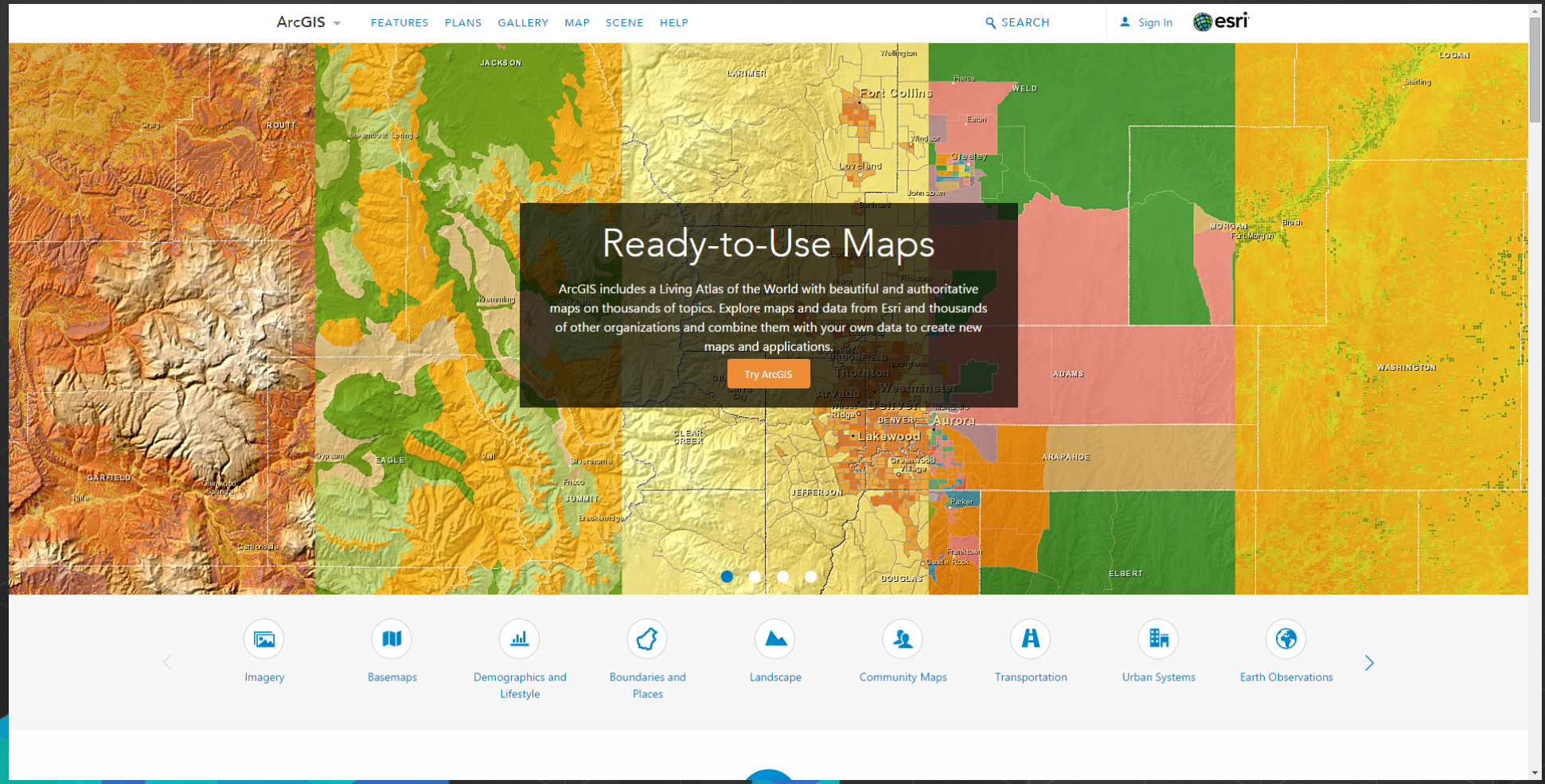
Publishing a WMS on ArcGIS Server

- Enable WMS capabilities on Service Editor or Manager



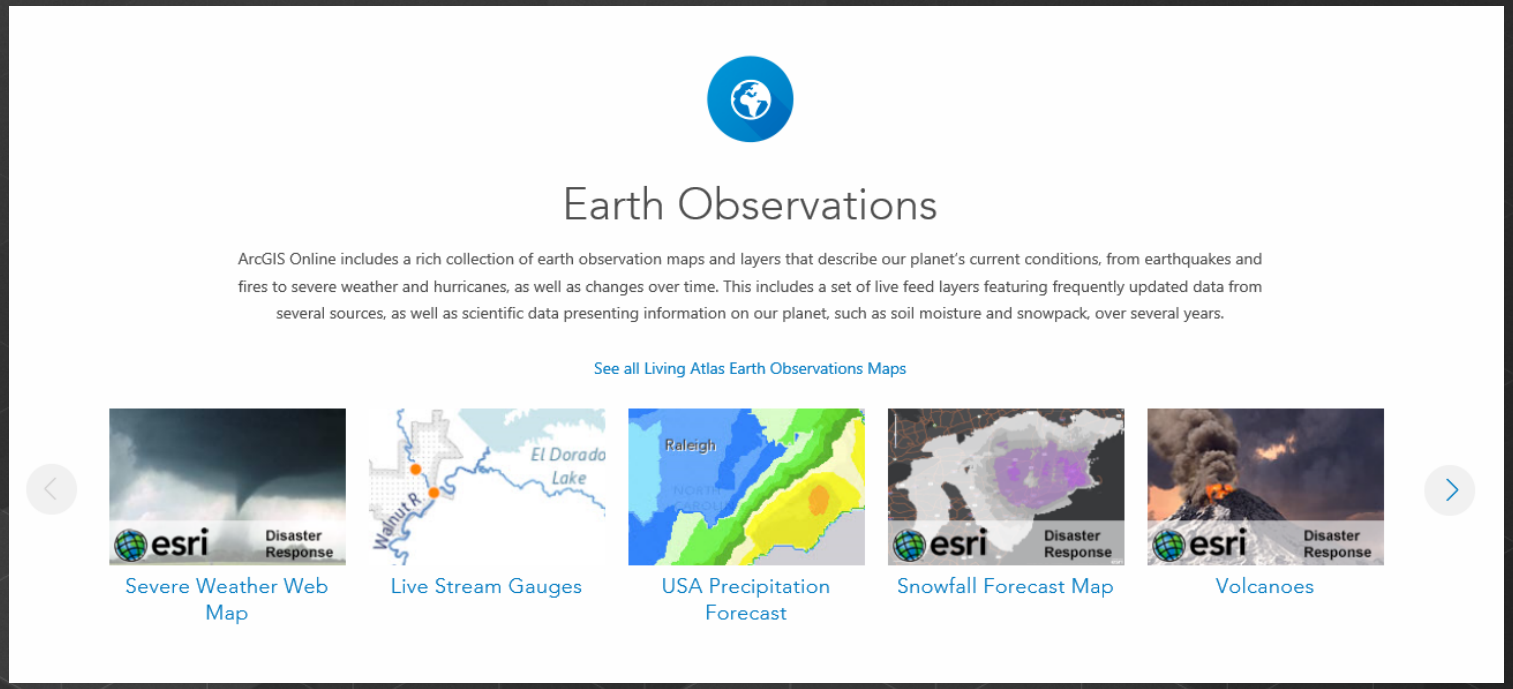


ArcGIS Online: The Living Atlas



The Living Atlas

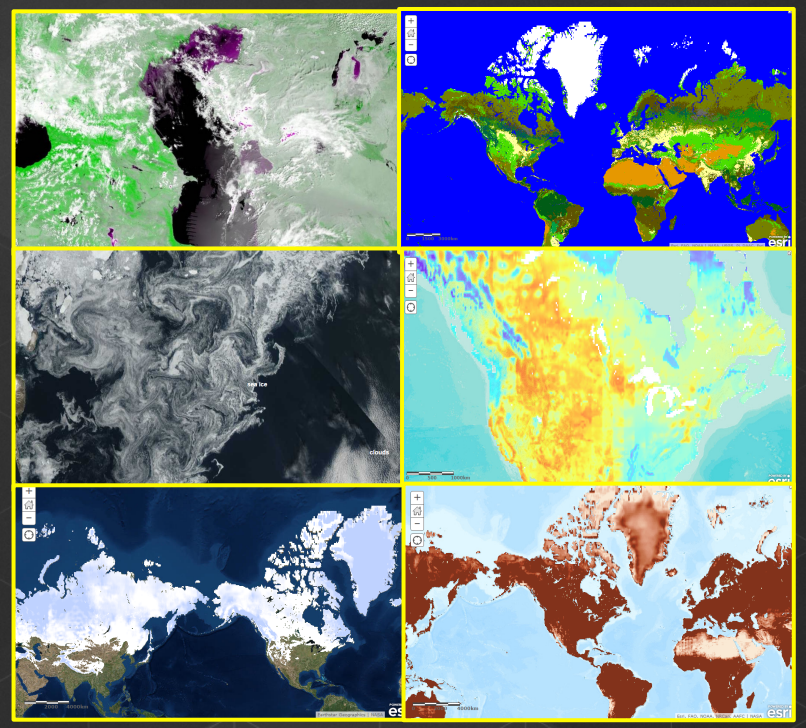
- Imagery
- Basemaps
- Demographics & Lifestyle
- Boundaries & Places
- Landscape
- Community Maps
- Transportation
- Urban Systems
- Earth Observations
- Historic Maps



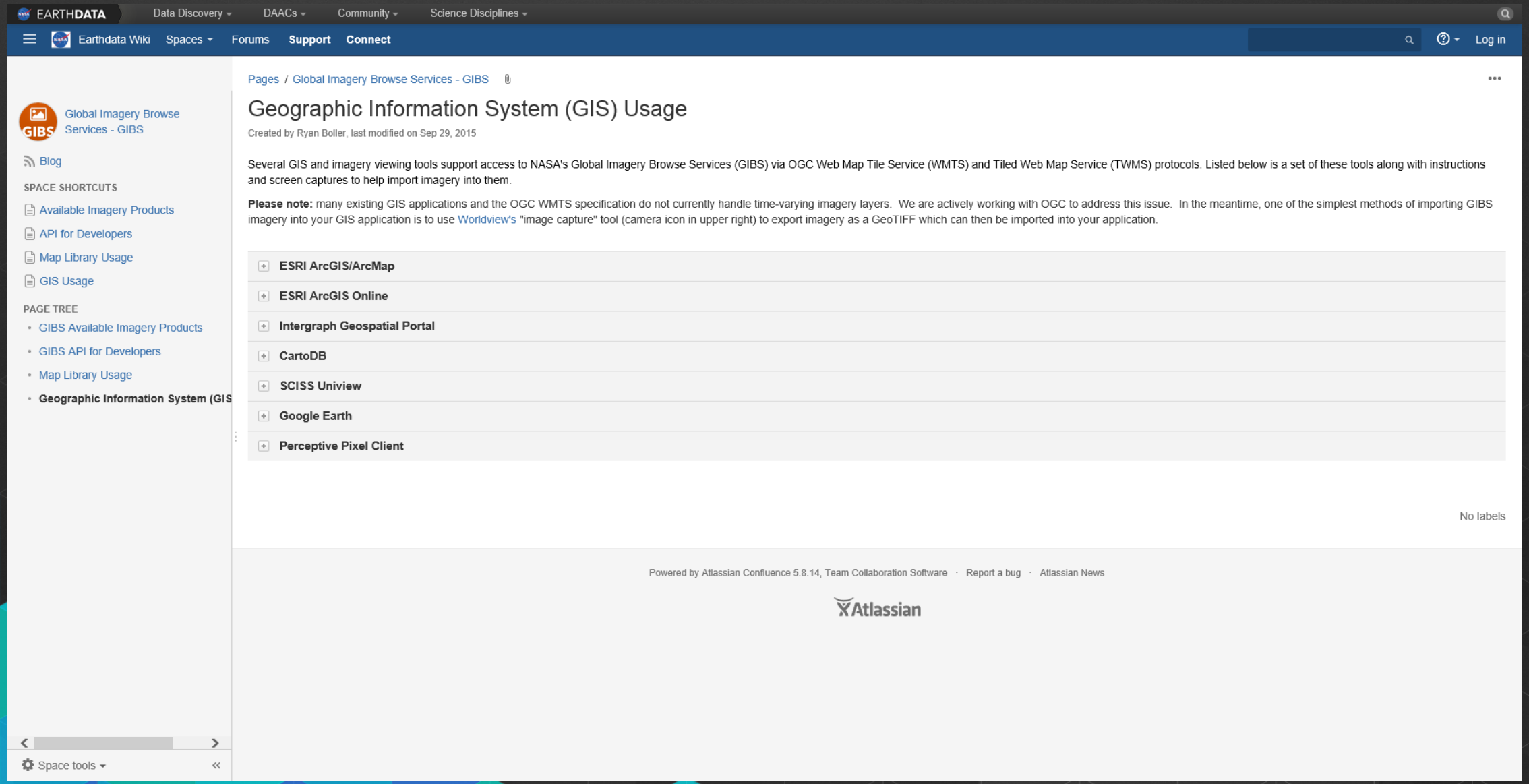
Services of Scientific Data

Online Imagery content that can be directly used:

- MODIS data
  - MODIS land cover 2000-2011
  - MODIS Vegetation Analysis
  - MODIS Greenland Sea Ice
- Live NOAA wind service
- NASA Global Land Data Assimilation (GLDS)
  - Soil moisture
  - Evapotranspiration
  - Snow pack
- More



NASA Global Imagery Browse Services (GIBS)



NASA Global Imagery Browse Services (GIBS)

ArcGIS Features Plans Gallery Map Scene Help Sign In

Daily Planet Imagery

This map shows imagery for the planet that is updated on a daily basis. It features the NASA MODIS imagery True Color band composition (Bands 1 4 3 | Red, Green, Blue) which most accurately shows how we see the earth's surface with our own eyes.

Web Map by esri
Last Modified: August 21, 2015
★★★★★ (9 ratings, 18,293 views)
Sign in to rate this item.
Facebook Twitter

OPEN

Description

This series of products from MODIS represents the only daily global composites available and is suitable for use at global and regional levels. This True Color band composition (Bands 1 4 3 | Red, Green, Blue) most accurately shows how we see the earth's surface with our own eyes. It is a natural looking image that is useful for land surface, oceanic and atmospheric analysis. There are four True Color products in total. For each satellite (Aqua and Terra) there is a 250 meter corrected reflectance product and a 500 meter surface reflectance product. Although the resolution is coarser than other satellites, this allows for a global collection of imagery on a daily basis, which is made available in near real-time. In contrast, Landsat needs 16 days to collect a global composite. Besides the maximum resolution difference, the surface and corrected reflectance products also differ in the algorithm used for atmospheric correction.

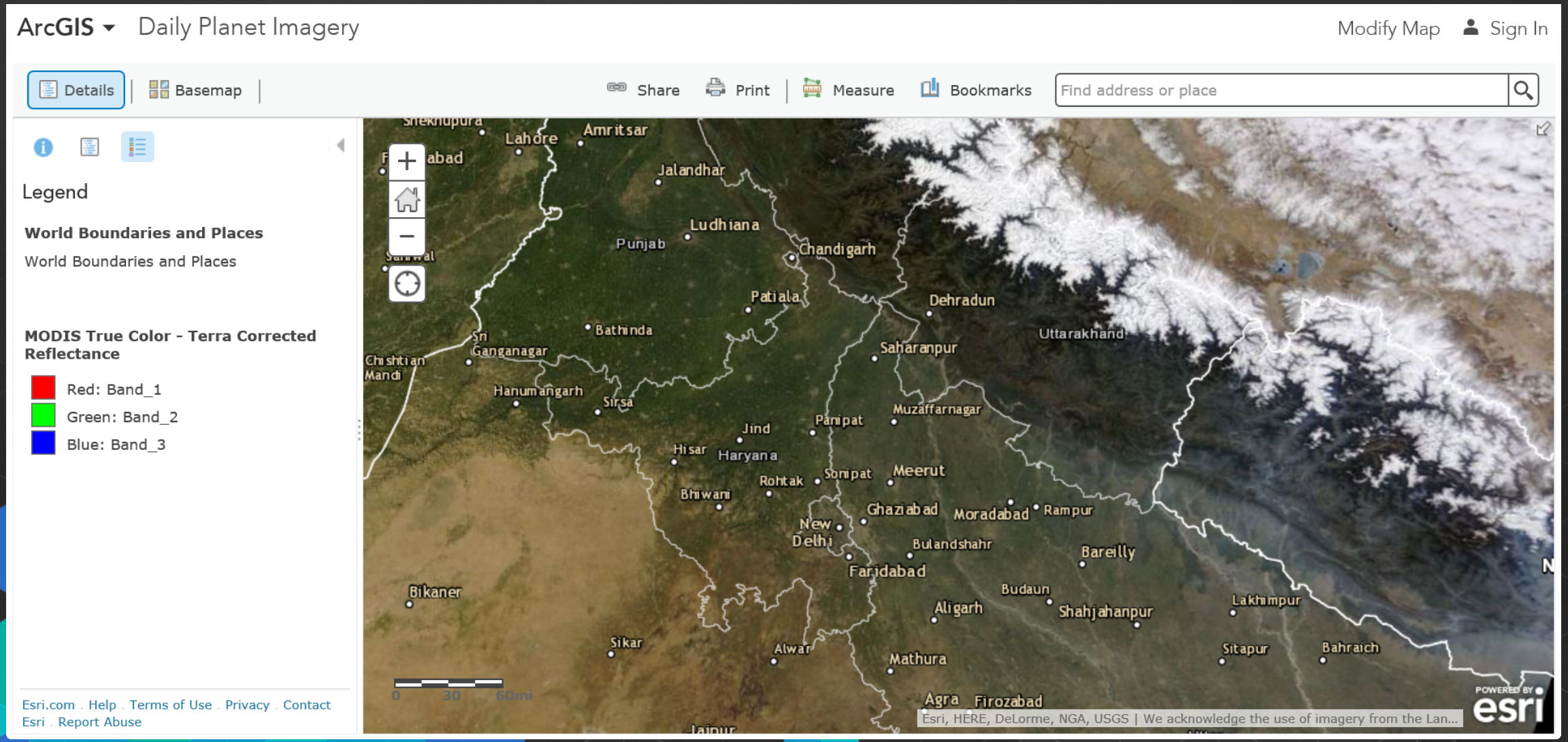
NASA Global Imagery Browse Services (GIBS)
This image layer provides access to a subset of the NASA Global Imagery Browse Services (GIBS), which are a set of standard services to deliver global, full-resolution satellite imagery. The GIBS goal is to enable interactive exploration of NASA's Earth imagery for a broad range of users. The purpose of this image layer, and the other GIBS image services hosted by Esri, is to enable convenient access to this beautiful and useful satellite imagery for users of ArcGIS. The source data used by this image layer is a finished image; it is not recommended for quantitative analysis.

Several full resolution, global imagery products are built and served by GIBS in near real-time (usually within 3.5 hours of observation). These products are built from NASA Earth Observing System satellites data courtesy of LANCE data providers and other sources. The MODIS instrument aboard Terra and Aqua satellites, the AIRS instrument aboard Aqua, and the OMI instrument aboard Aura are used as sources. Several of the MODIS global products are made available on this Esri hosted service.

This image layer hosted by Esri provides direct access to one of the GIBS image products. The Esri servers do not store any of this data itself. Instead, for each received data request, multiple image tiles are retrieved from GIBS, which are then processed and assembled into the proper image for the response. This processing takes place on-the-fly, for each and every request. This ensures that any update to the GIBS data is immediately available in the Esri mosaic service.

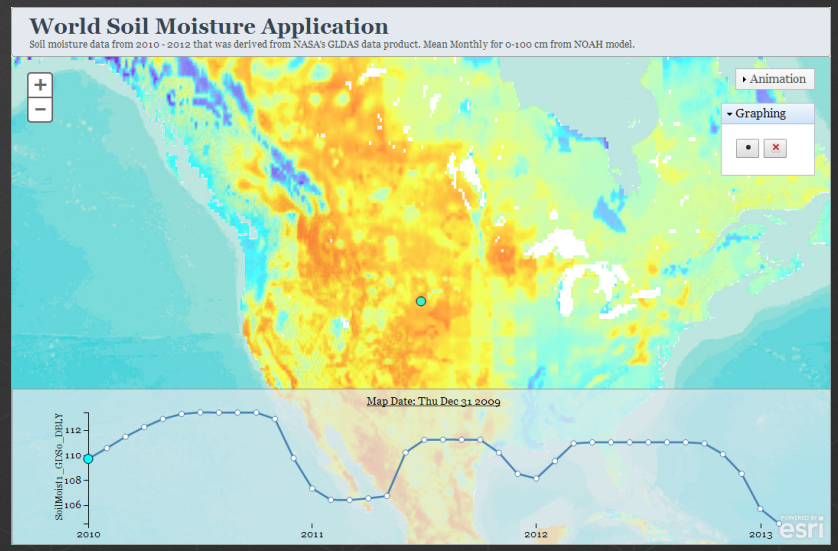
Note on Time: The image service supporting this map is time enabled, but time has been disabled on this image layer so that the most recent imagery displays by default. If you would like to view imagery over time, you can update the layer properties to enable time animation and configure time settings. The results can be saved in a web map to use later or share with others.

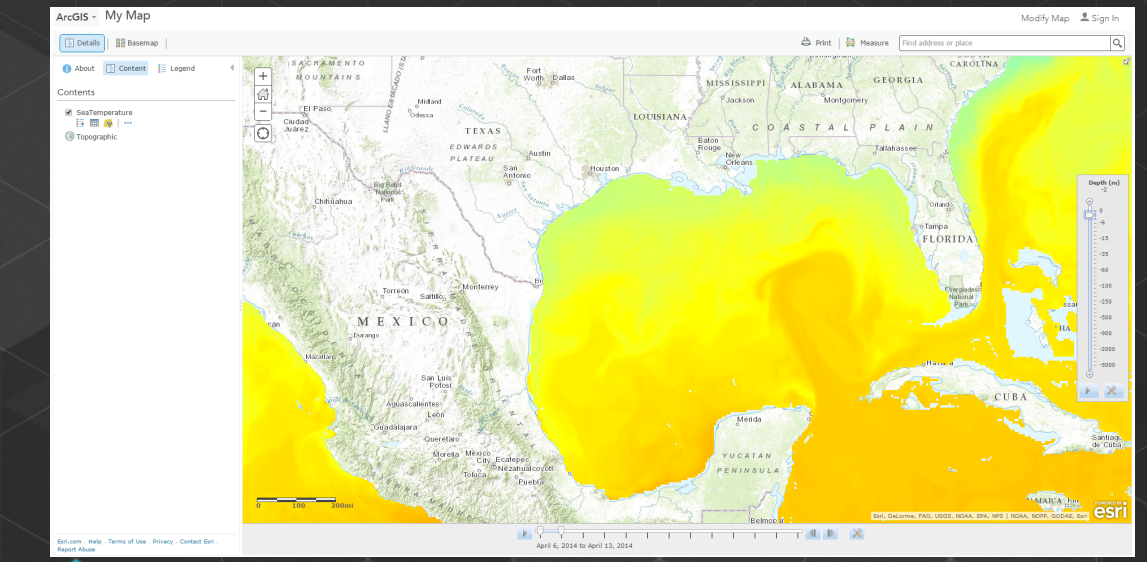
Corrected Reflectance in Map Viewer



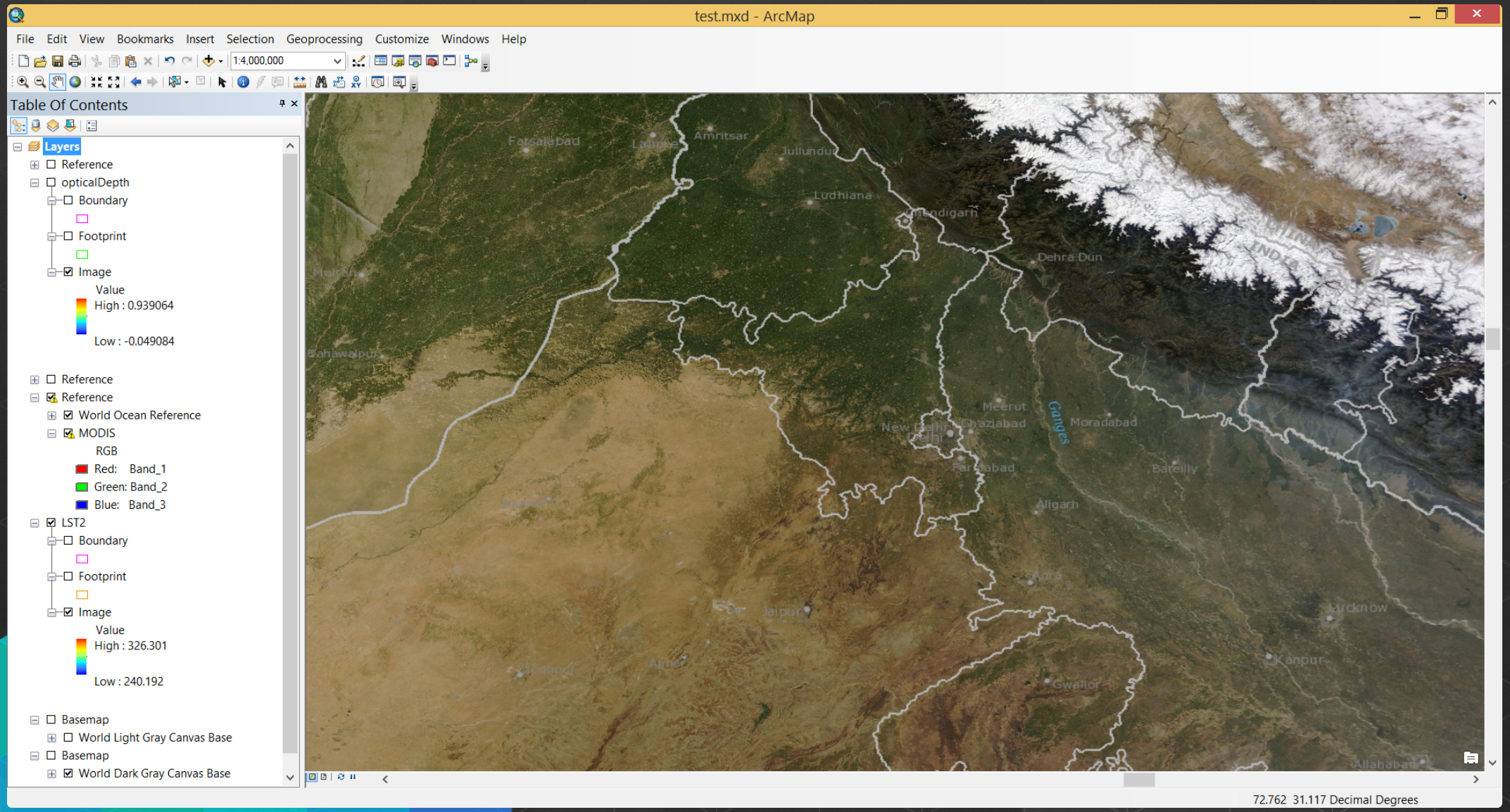
Consuming Scientific Data Services

- ArcGIS Desktop/Pro/Server
- Web Map Viewer
- Web Applications
- Story maps
- Operational Dashboard

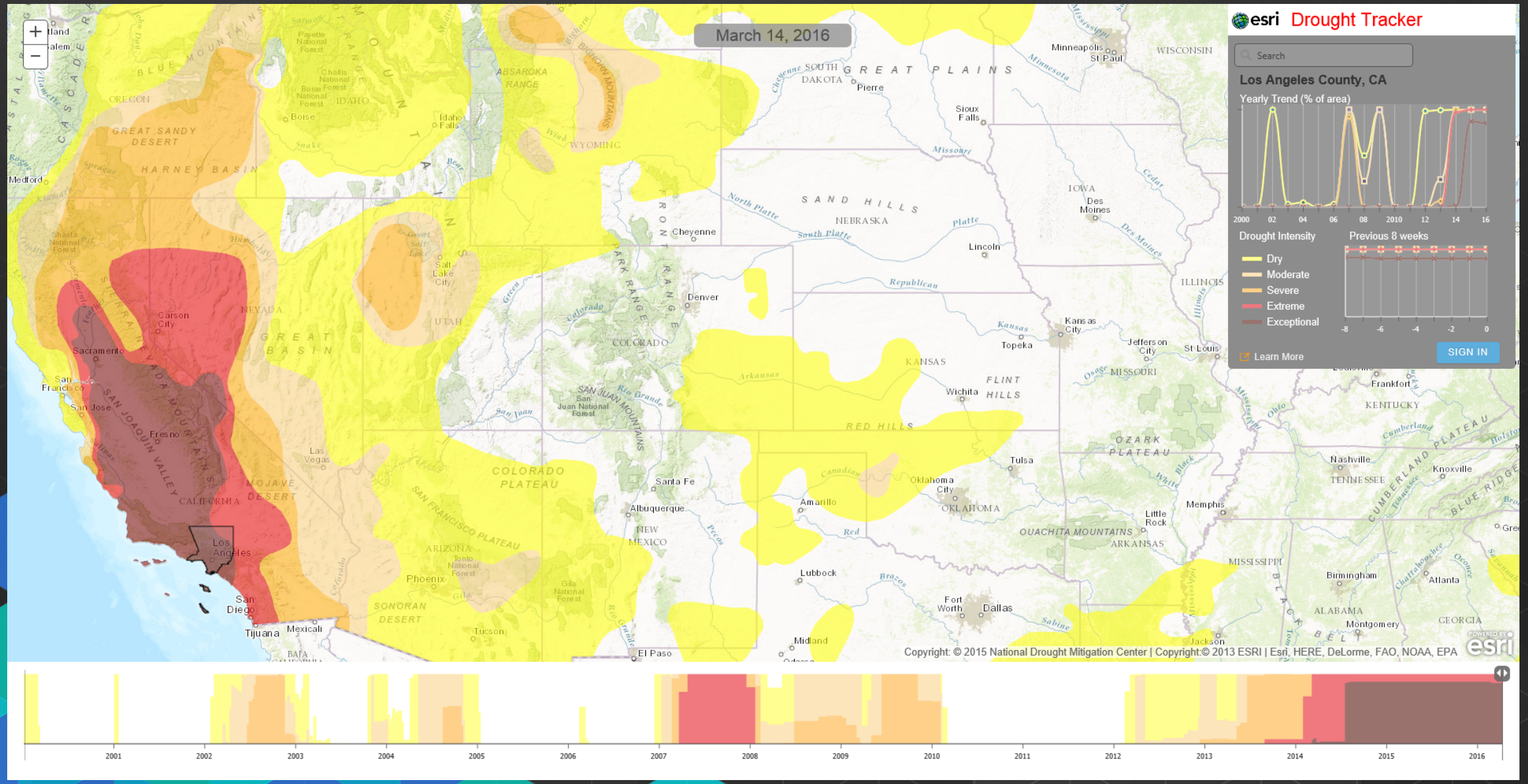




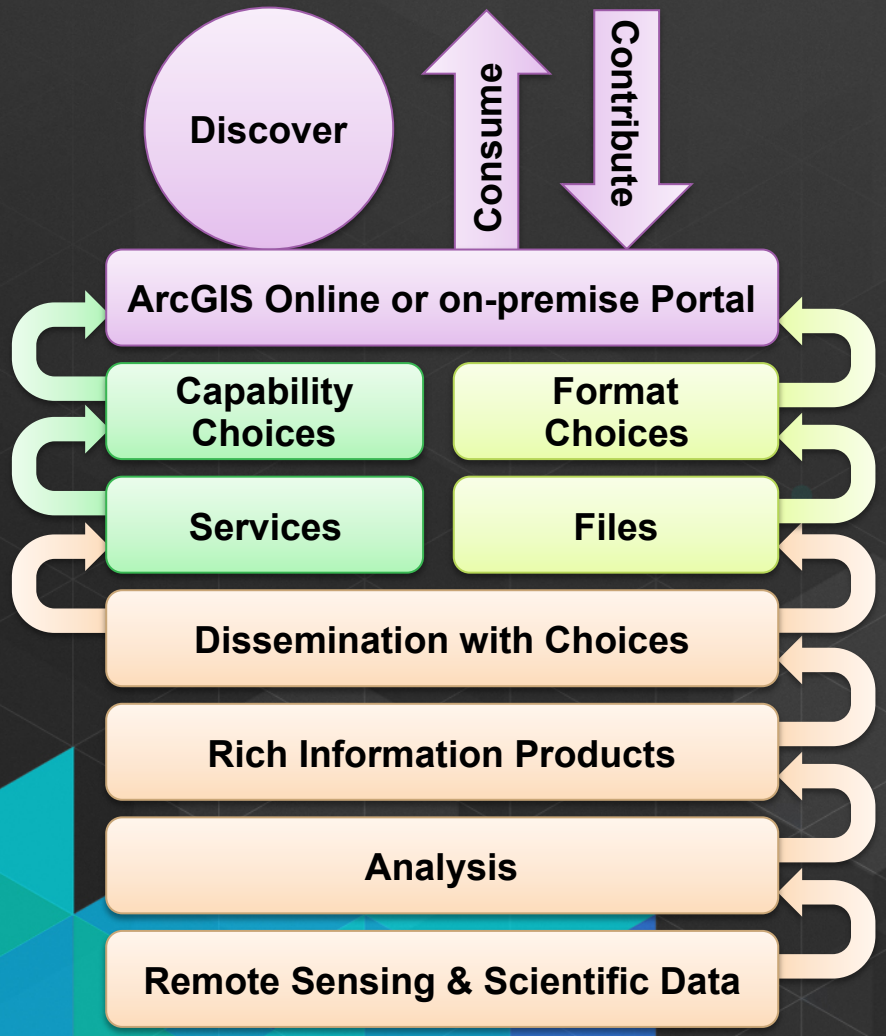
Corrected Reflectance – Consumed in ArcGIS Desktop



Web Application: Drought Tracker



ArcGIS is a Scientific Collaboration Platform



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