

Esri Developer Summit

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Python: Working with Scientific Data

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Deng Ding

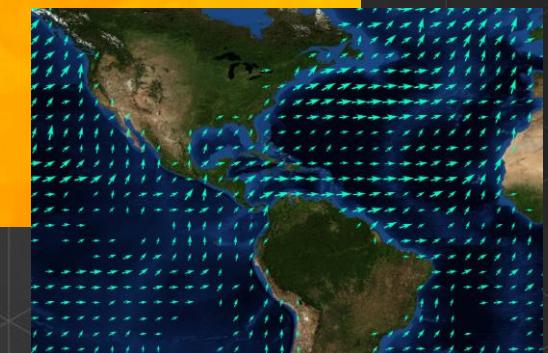
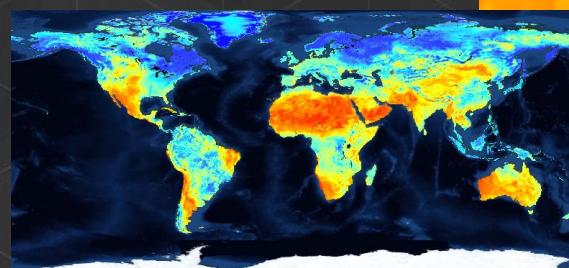
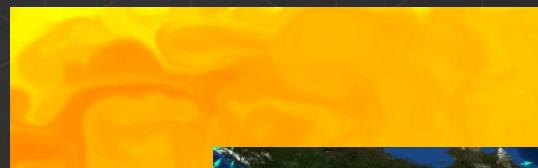
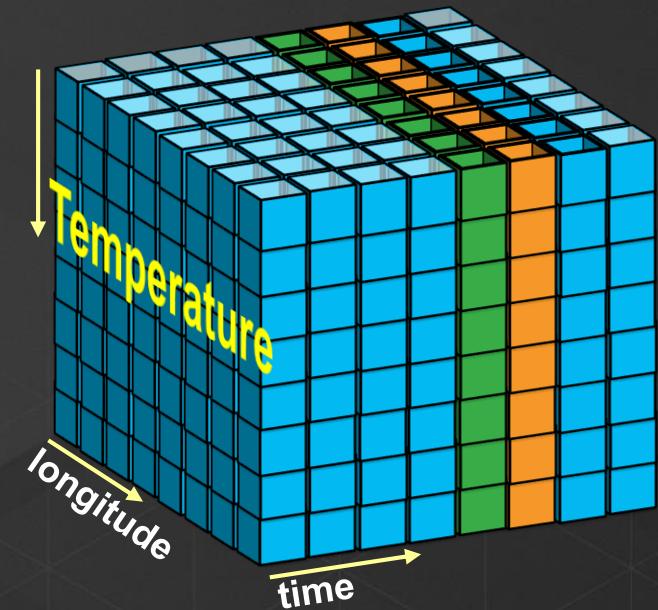
Outline

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

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

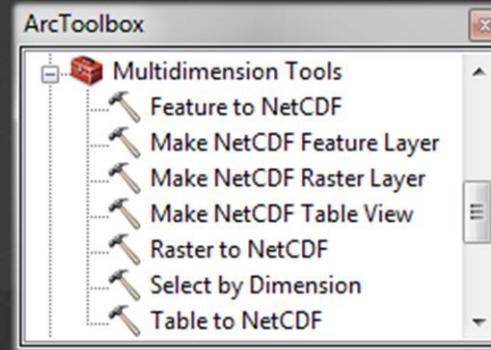


Scientific Data in ArcGIS - Vision



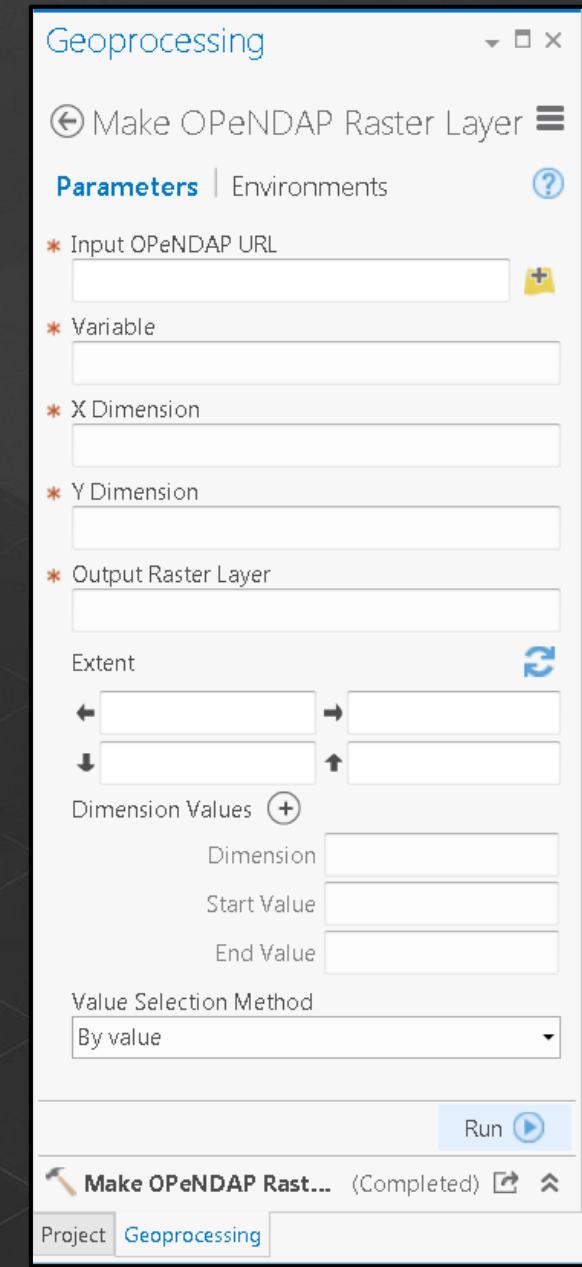
Ingesting Scientific data in ArcGIS

- Directly reads netCDF file using
 - Make NetCDF Raster Layer
 - Make NetCDF Feature Layer
 - Make NetCDF Table View
- Scientific data formats are supported in mosaic dataset
 - netCDF
 - HDF
 - GRIB



Make OPeNDAP Raster Layer

- Ingest OPeNDAP Service
- Output dynamic multidimensional raster
- Support Sub-setting



CF Convention

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

Initially developed for

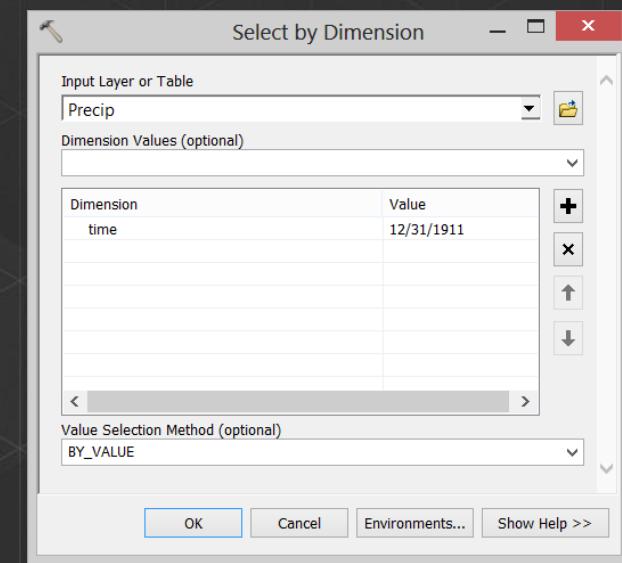
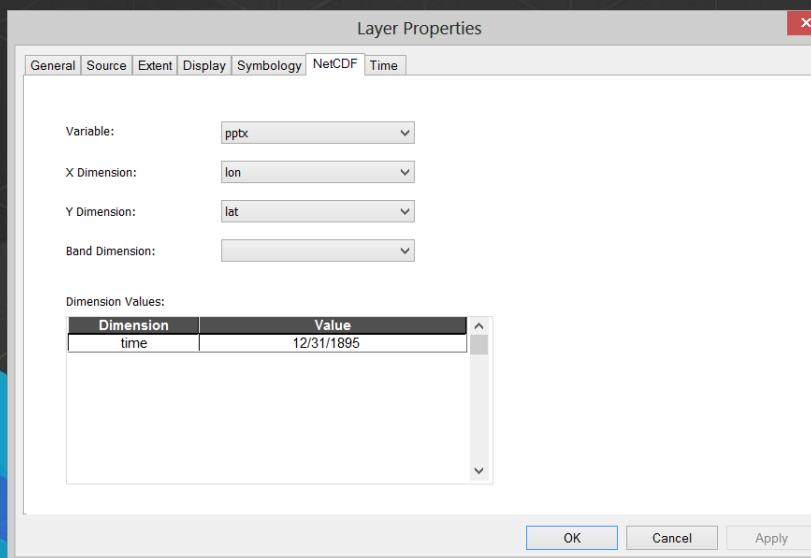
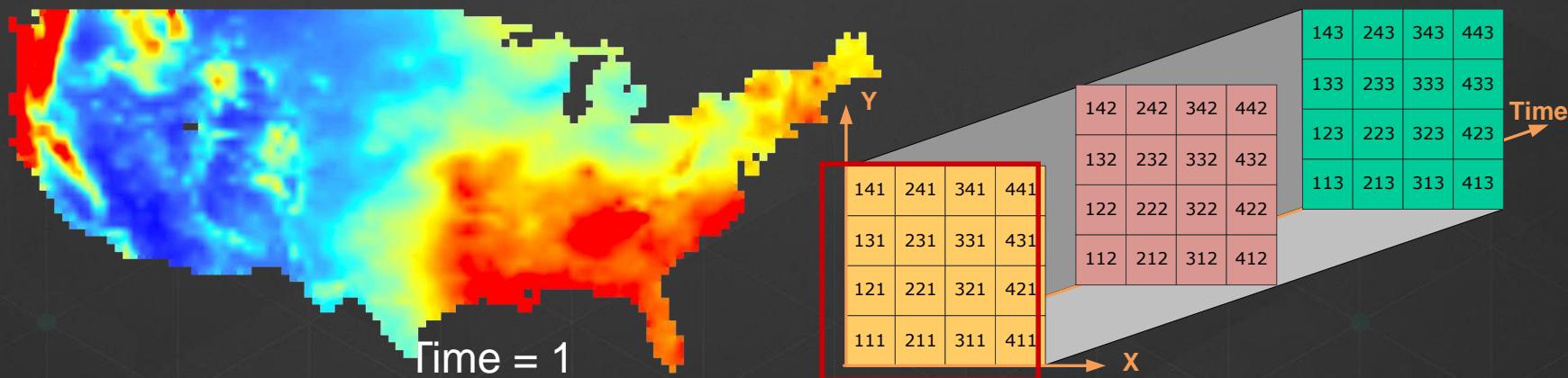
- Climate and forecast data
- Atmosphere, surface and ocean model-generated data
- Also for observational datasets
- CF is now the most widely used conventions for geospatial netCDF data. It has the best coordinate system handling.
- Current version 1.6
- You can use Compliance checker utility to check a netCDF file.

<http://cf-pcmdi.llnl.gov/conformance/compliance-checker/>

NetCDF and Coordinate Systems

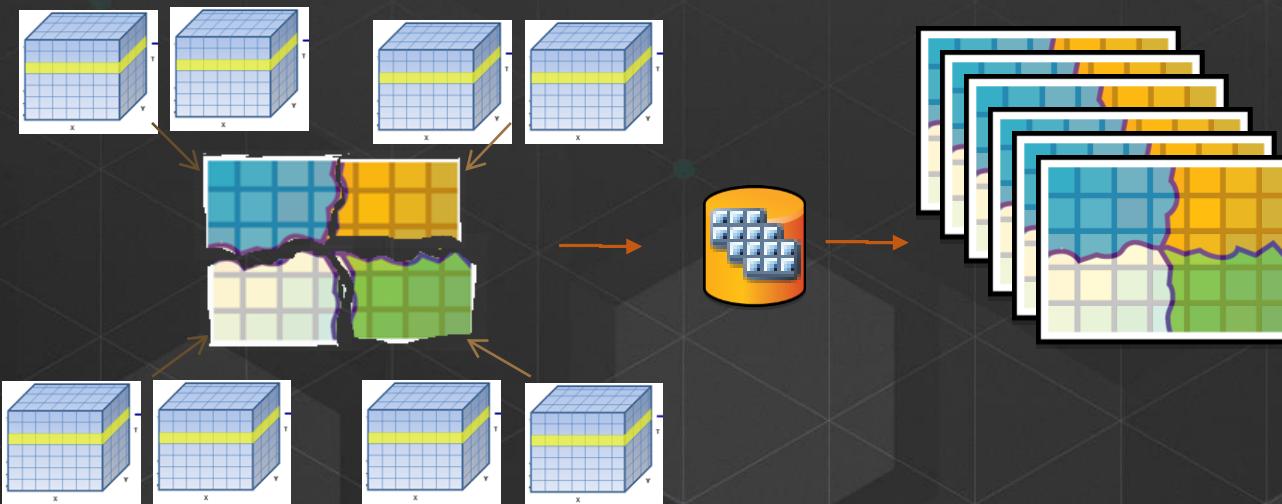
- Geographic Coordinate Systems (GCS)
 - X dimension units: `degrees_east`
 - Y dimension units: `degrees_north`
- Projected Coordinate Systems (PCS)
 - X dimension standard_name: `projection_x_coordinate`
 - Y dimension standard_name: `projection_y_coordinate`
 - Variable has a `grid_mapping` attribute.
 - CF 1.6 conventions currently supports thirteen predefined coordinate systems ([Appendix F: Grid Mappings](#))
- Undefined
 - If not GCS or PCS
- ArcGIS writes (and recognizes) **PE String** as a variable attribute.

Changing Time Slice



What about Aggregation?

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

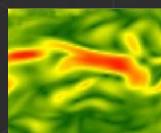


- Mosaic dataset supports multiple files and variables, normalize time and depth

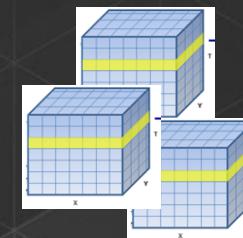
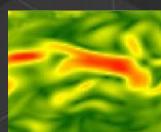
Multidimensional Mosaic Datasets - Storage

Multivariate Cube

- Use geodatabase table to manages multidimensional arrays
 - Do not store pixels but reference it
- Each row is a Raster of 2D array
- Dimensions and variable names are fields in the table

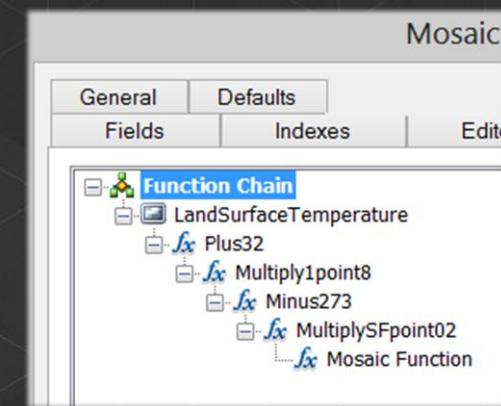
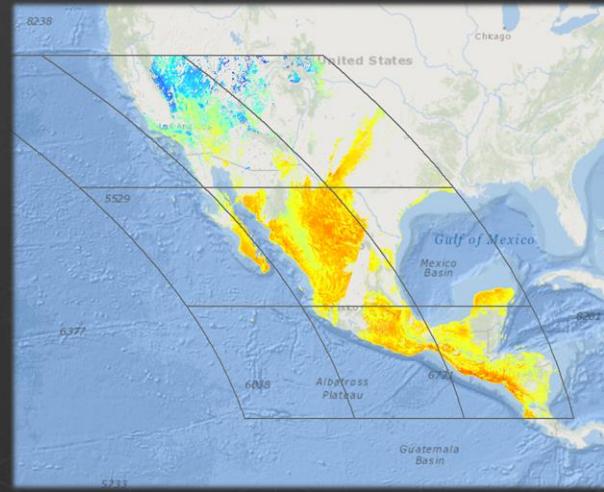


OBJ	Raster	Name	Variable *	Standard Time	Standard Z	...
1	<Raster	hycom_glb_regp01.nc:water_temp:0	water_temp	5/17/2013	0	
2	<Raster	hycom_glb_regp01.nc:water_temp:1	water_temp	5/17/2013	-2	
3	<Raster	hycom_glb_regp01.nc:water_temp:2	water_temp	5/17/2013	-4	
4	<Raster	hycom_glb_regp01.nc:water_temp:3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



Scientific data support in Mosaic Dataset

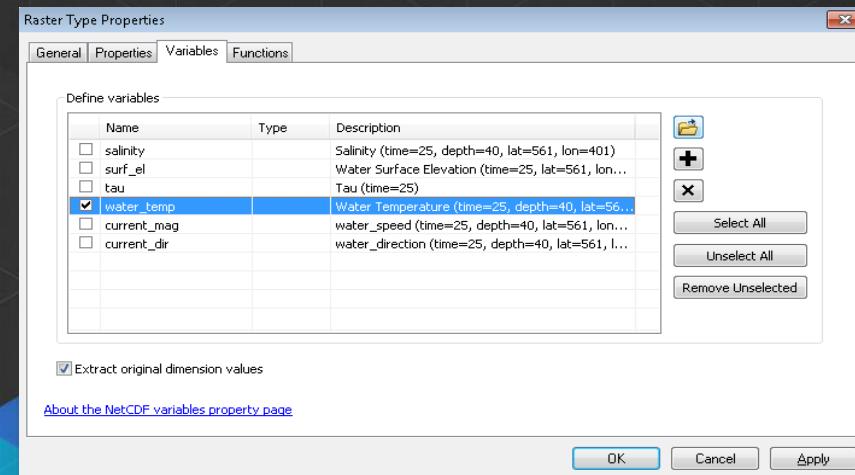
- Supports netCDF, HDF and GRIB
 - Spatial Aggregation
 - Temporal Aggregation
 - On-the-fly analysis
- Serve as Multidimensional
 - Image Service
 - Map Service
 - WMS
- Supports direct ingest
- Eliminates data conversion
- Eliminates data processing
- Improves workflow performance
- Integrates with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



Multidimensional Mosaic Datasets – How to Create

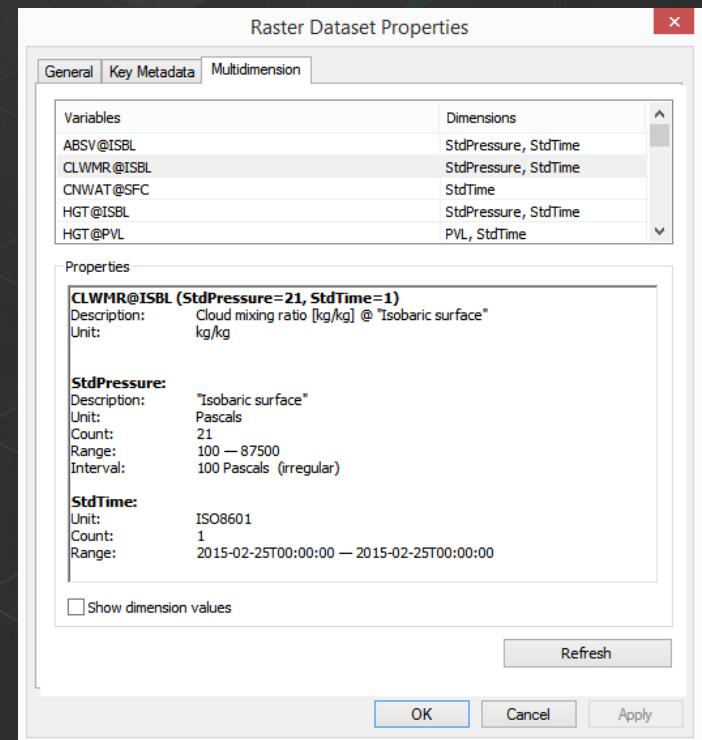
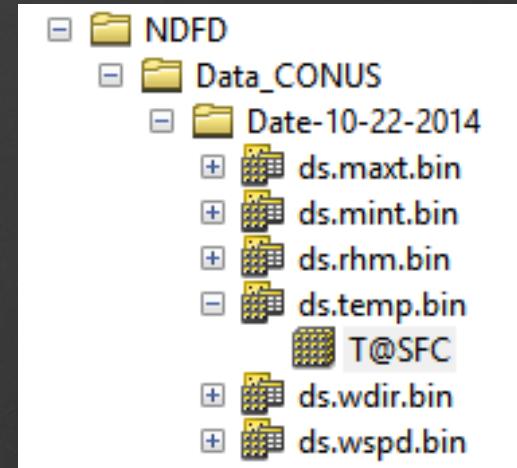
Manage variables and dimensions

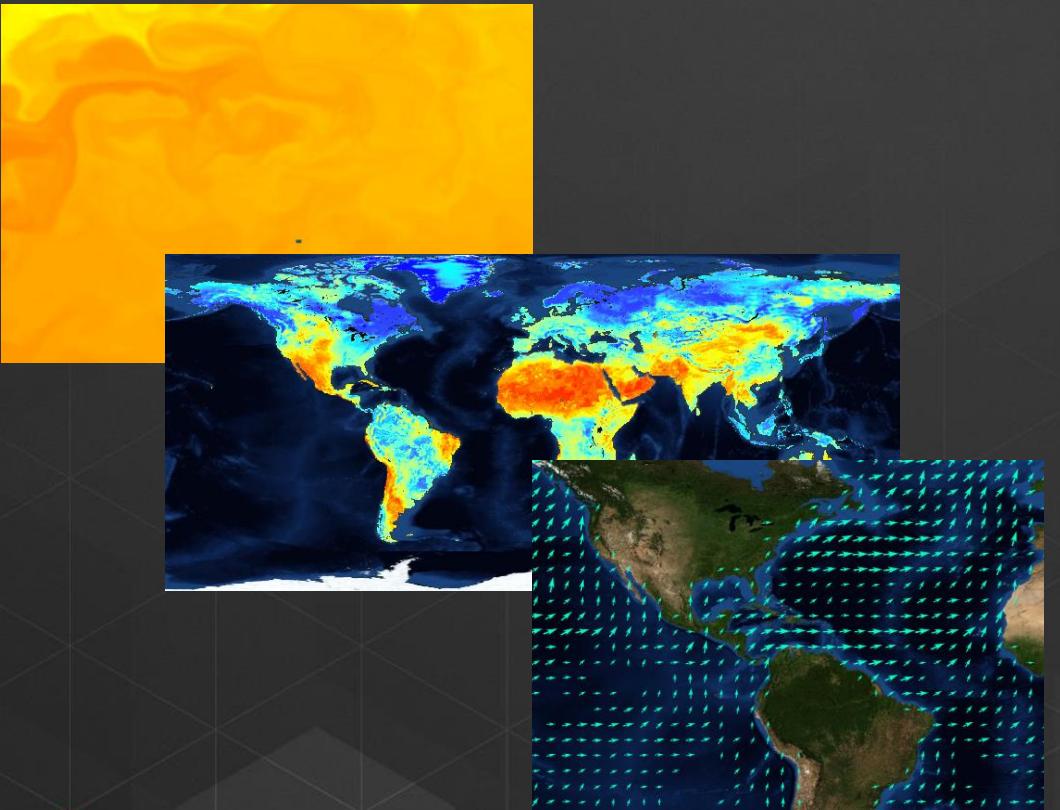
- Raster Types are used to handle various data
 - Landsat, IKONOS, WorldView, etc.
- netCDF, HDF & GRIB raster types
 - Specify the variable (s)
- Define processing template
 - Vector Field
 - Custom: Unit conversion



Raster Product

- Provide a uniform user experience for ingesting scientific data in different formats





Demo 1

- Data Ingest
- Data Management

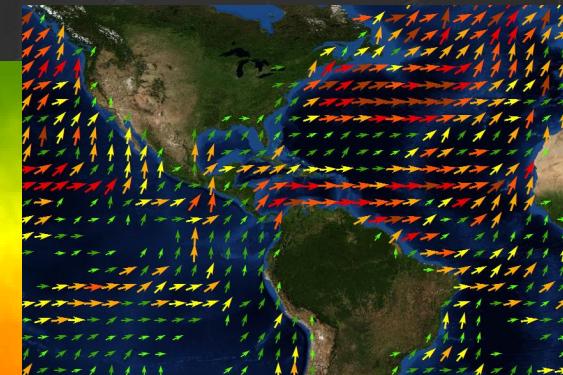
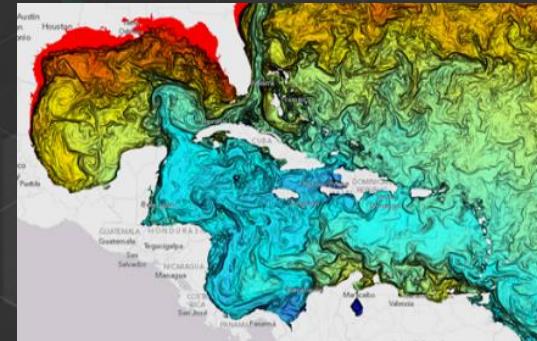
Using Scientific Data in ArcGIS

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

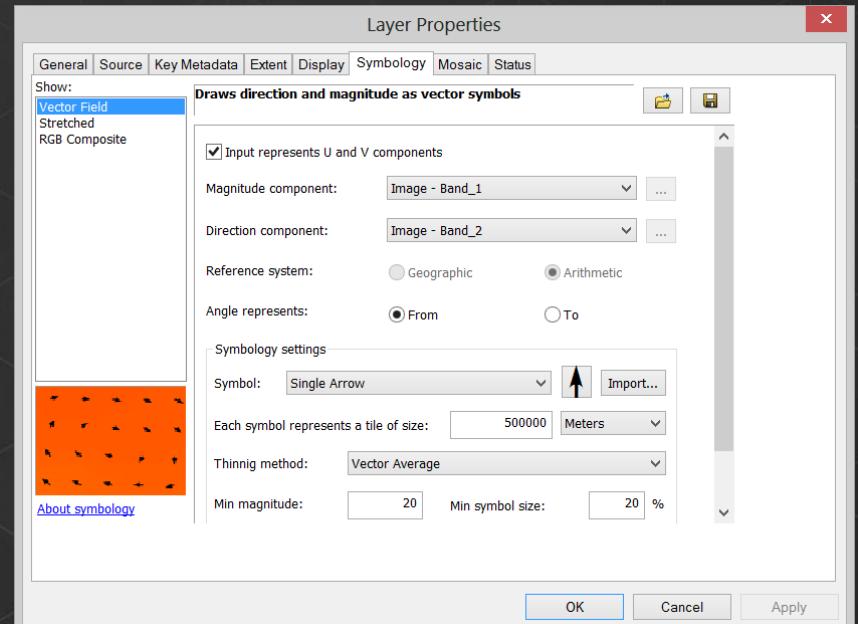
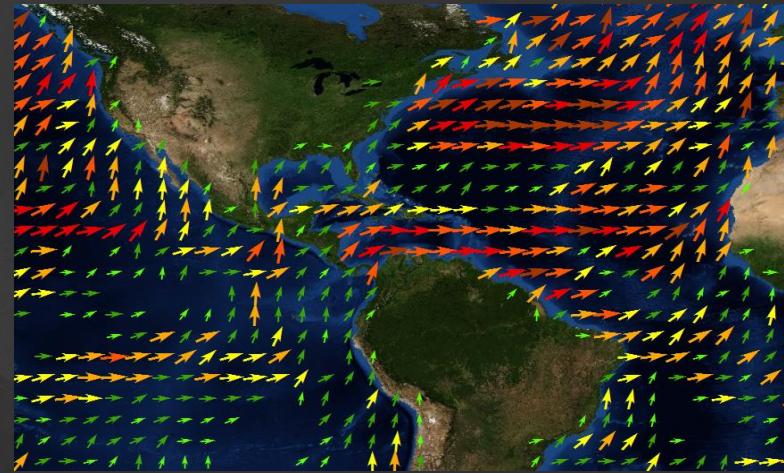
- Slicing
- Temporal animation using Time Slider
- Dimensional animation using Range Slider
- Predefined renderer



Visualization of Raster as Vectors

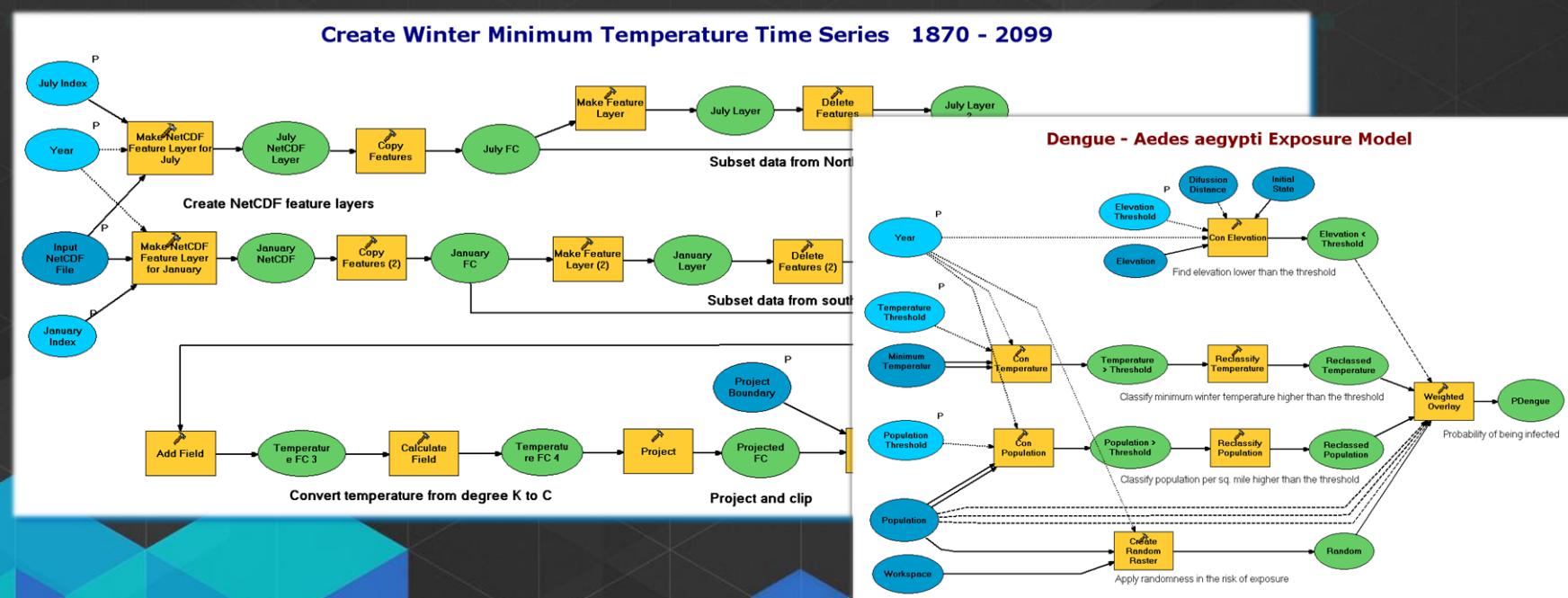
- New Vector Field renderer for raster
 - Supports U-V and Magnitude-direction
 - Dynamic thinning
 - On-the-fly vector calculation

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



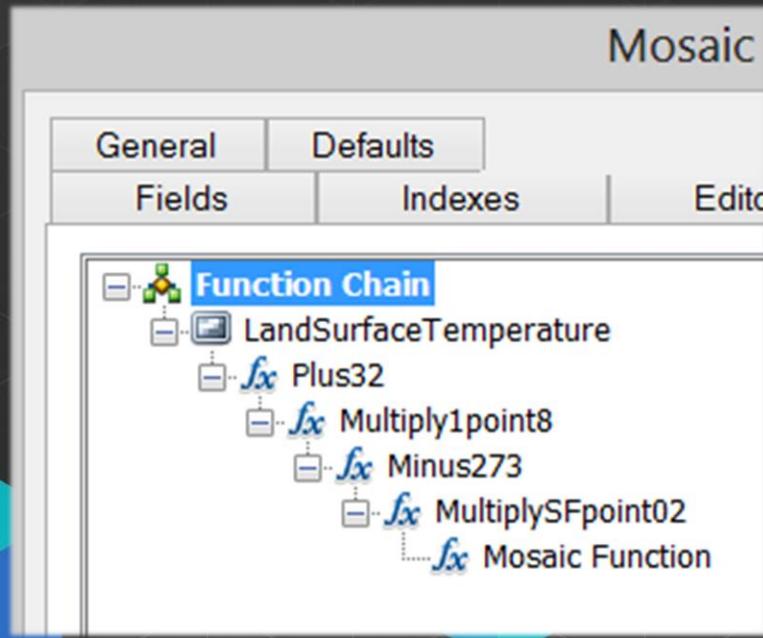
Spatial and Temporal Analysis

- 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

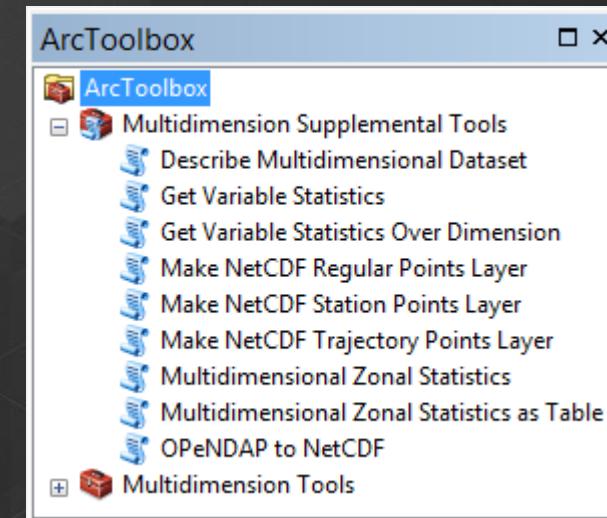


Python – Extending Analytical Capabilities

Supplemental tools

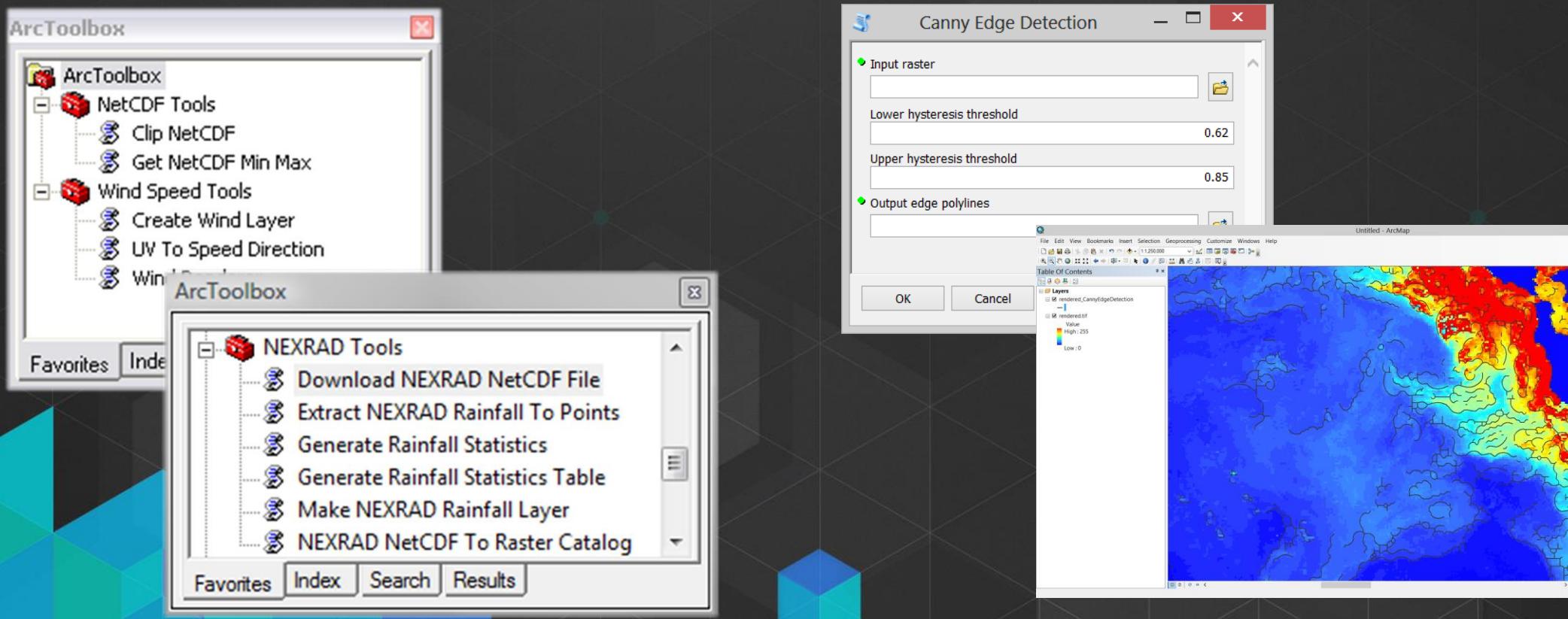
- OPeNDAP to NetCDF
- Make NetCDF Regular Point Layer
- Make NetCDF Station Point Layer
- Make NetCDF Trajectory Point Layer
- Describe Multidimensional Dataset
- Get Variable Statistics
- Get Variable Statistics Over Dimension
- Multidimensional Zonal Statistics
- Multidimensional Zonal Statistics As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

<http://blogs.esri.com/esri/arcgis/2013/05/24/introducing-the-multidimension-supplemental-tools-2/>



Application Specific Script Tools

- Python is used to build custom tools for specific tasks or datasets



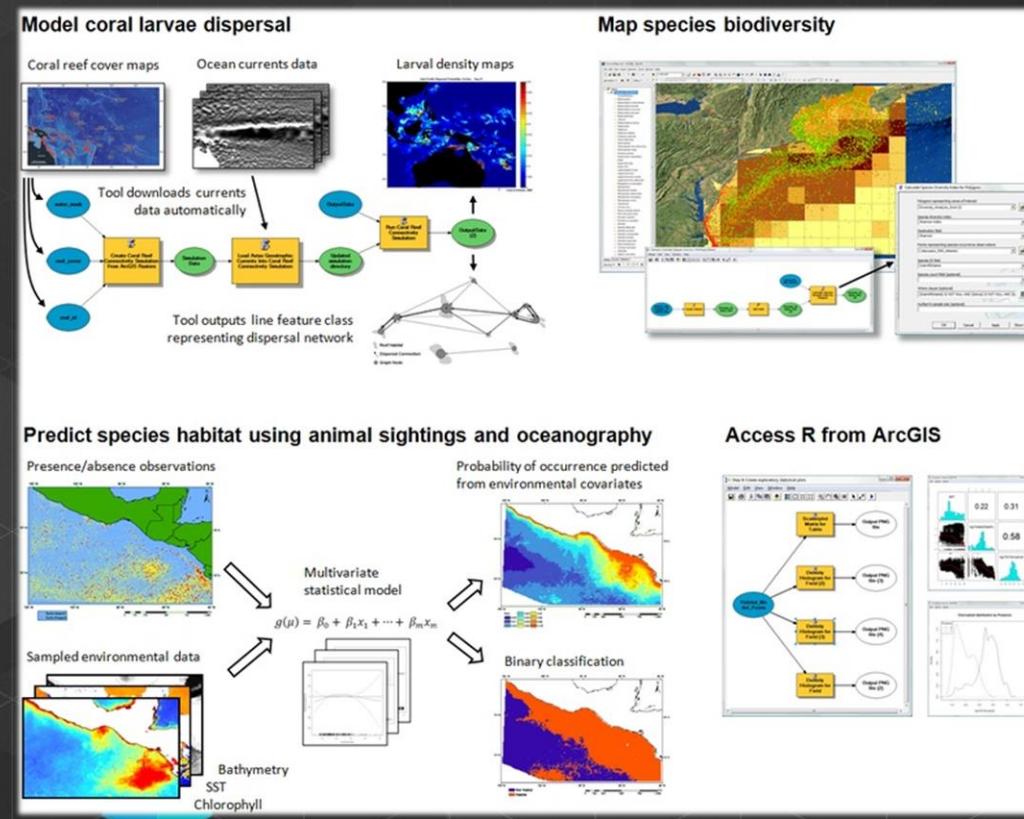
Community Developed Tools

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

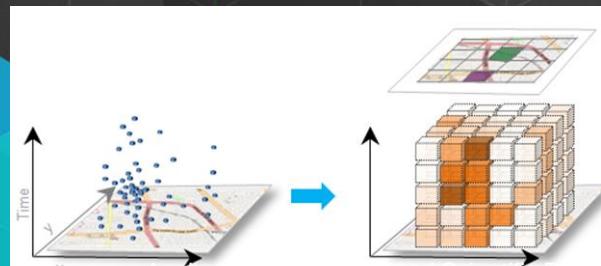
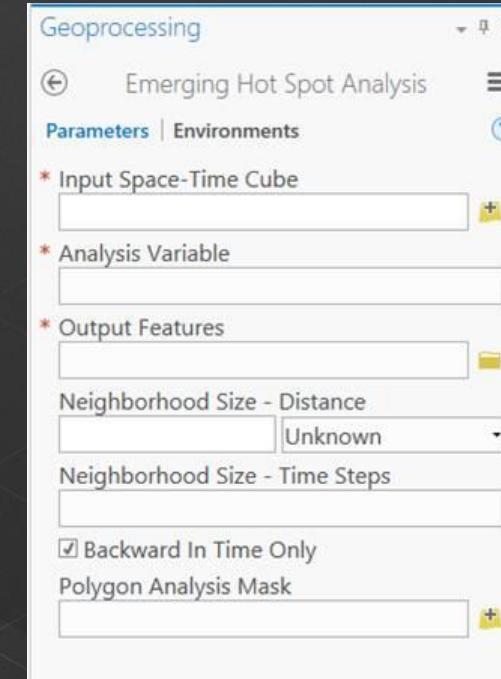
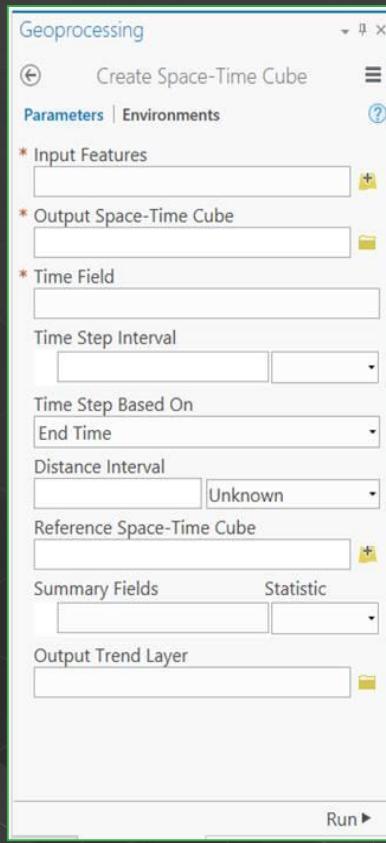
- Marine Geospatial Ecology Tools (MGET)
 - Developed at Duke Univ.
 - Over 180 tools for import management, and analysis of marine data

<http://mget.env.duke.edu/mget>

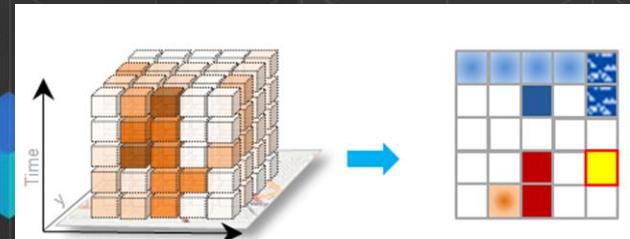
- Australian Navy tools
(not publicly available)



Create Space-Time Cube & Emerging Hot Spot Analysis



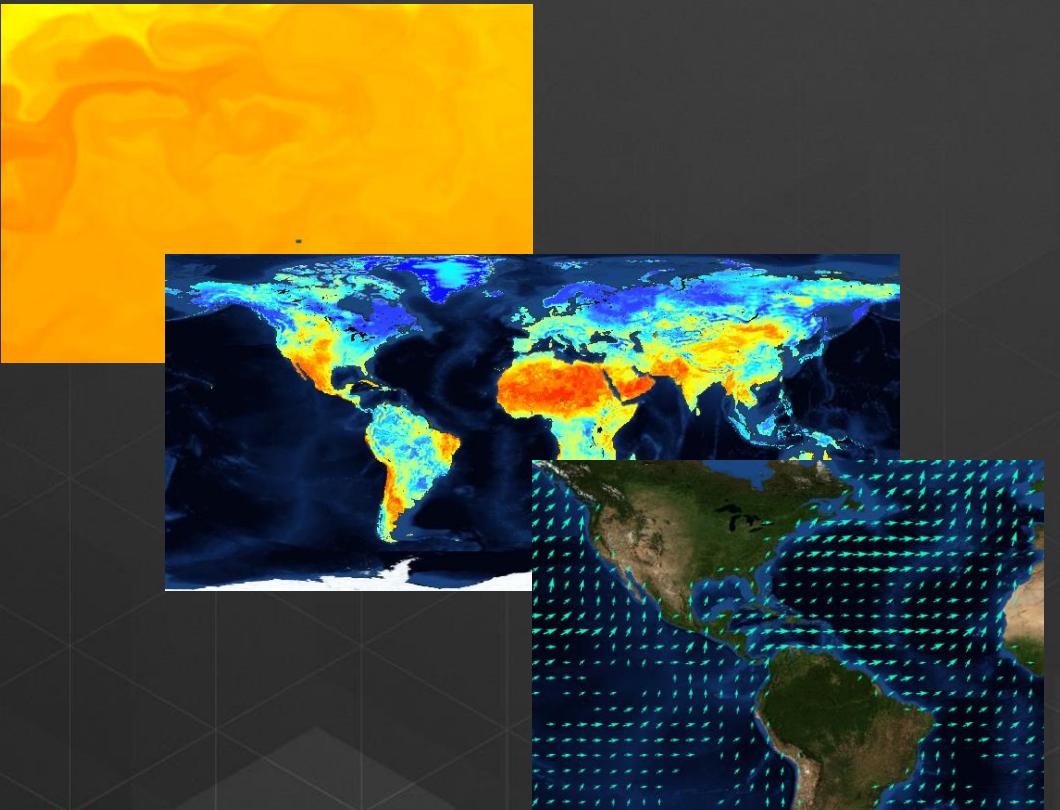
ArcGIS



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 aggregation
 - Compression
- SciPy
- Python Raster Function

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



Demo 2

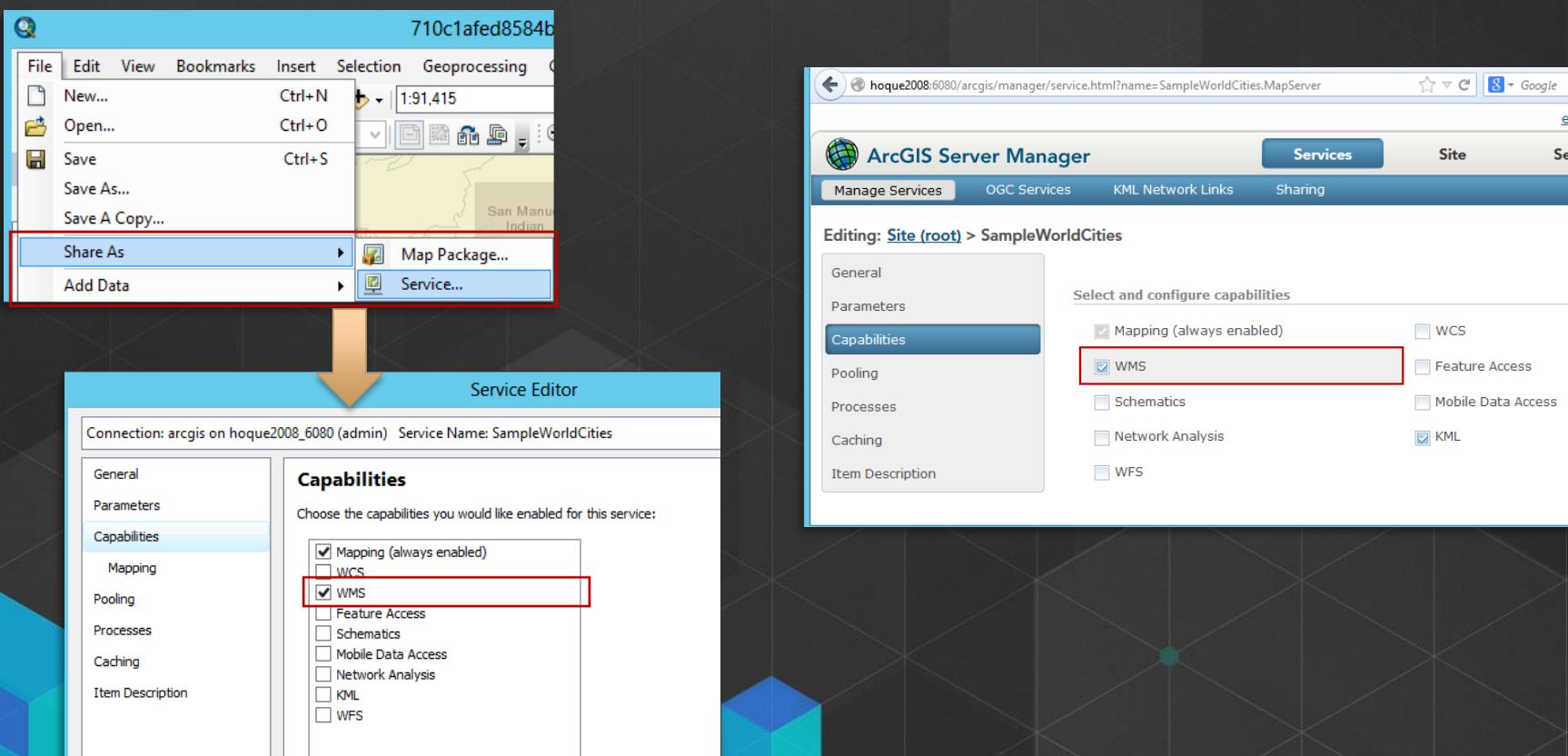
- Analysis
- Visualization

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



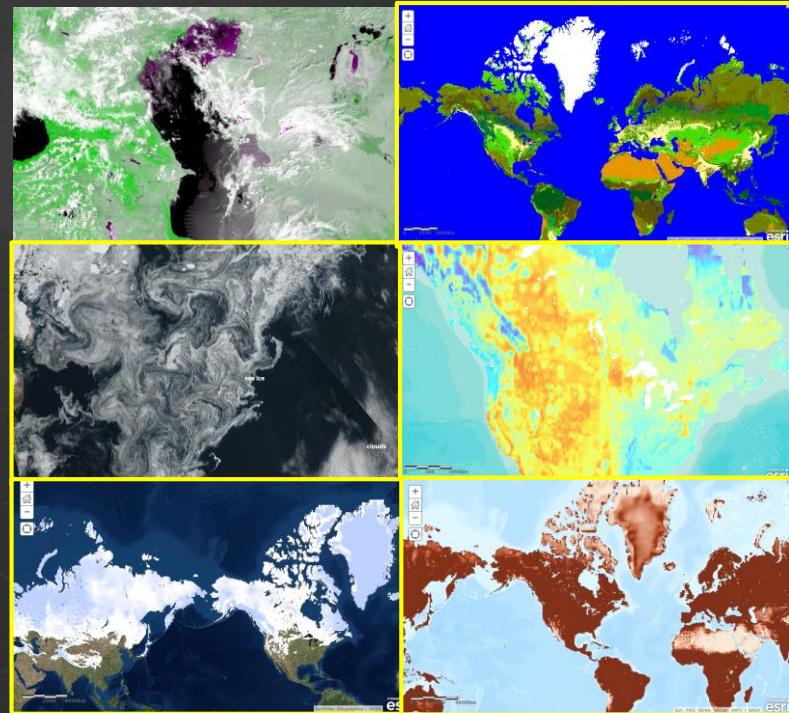
Multi-dimensional data support in WMS

- `getCapabilities`
 - Supports time, elevation and other dimensions (e.g. depth)
- `getMap`
 - Returns map for any dimension value
`&DIM_<dimensionName>=<value>&`
 - Supports CURRENT for time dimension
`&TIME=CURRENT&`
- `getFeatureInfo`
 - Returns information about feature for any dimension value

Services of Scientific Data

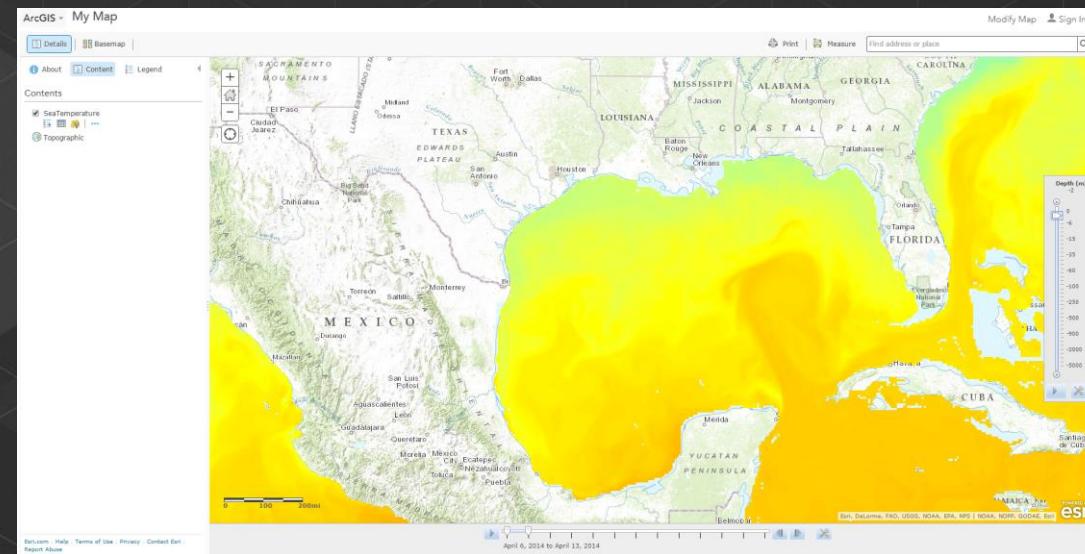
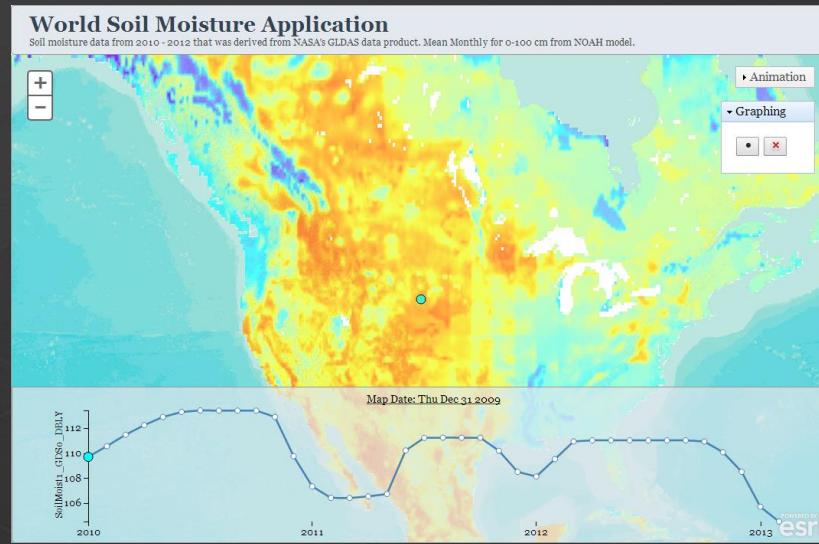
Online Imagery content that can be directly used:

- 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

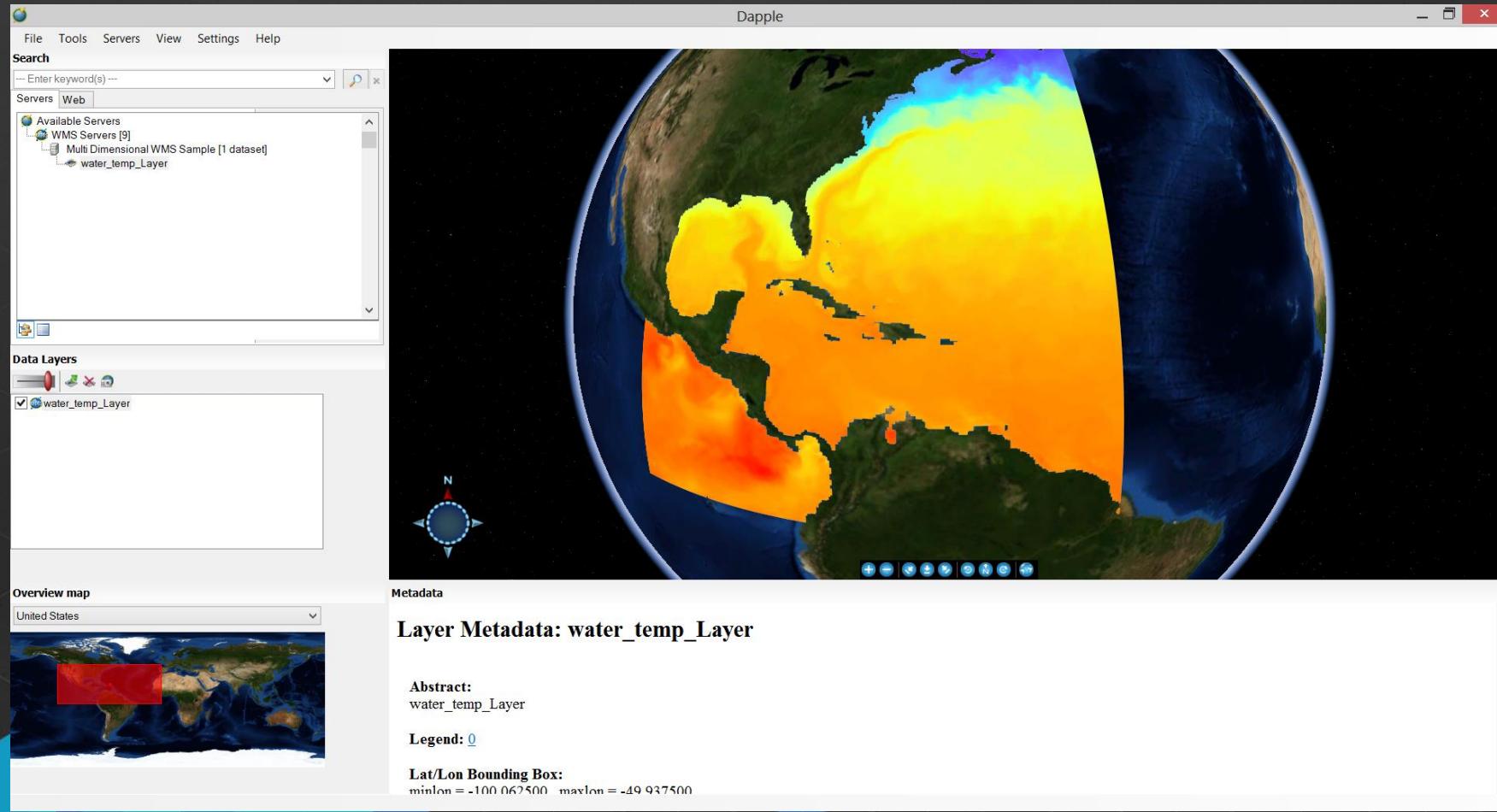


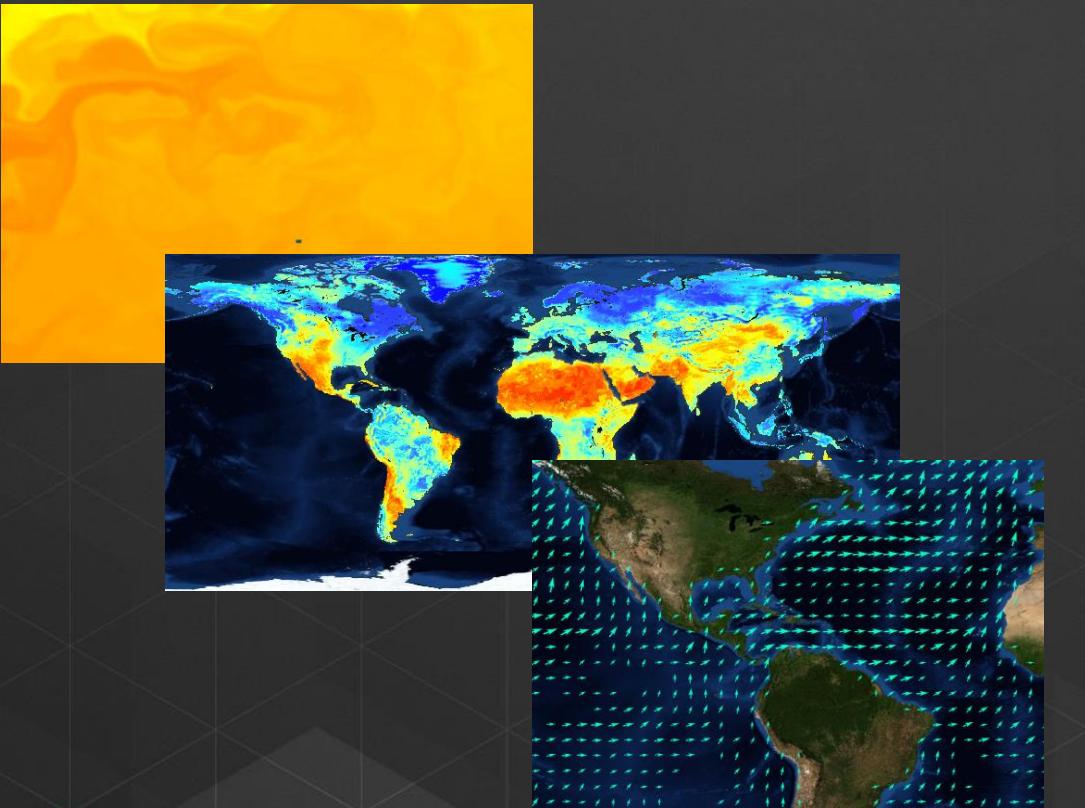
Consuming Scientific Data Services

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



WMS in Dapple Earth Explorer





Demo 3

- Creating Services
- Consuming Services

Things to Consider...

- Embrace the Common Data Model (netCDF, HDF etc.)
- Use Data and metadata standards (OGC, CF etc)
- Produce and use CF compliant data
- Make your data “spatial” (by specifying geographic or a projected coordinate system)
- Create sample tools where possible
- Clearly define workflow and requirements

