Scientific Tools for Marine and MetOcean Analysis

ESRI OCEAN GIS FORUM

November 1–3, 2016 | Esri Conference Center, Redlands, California

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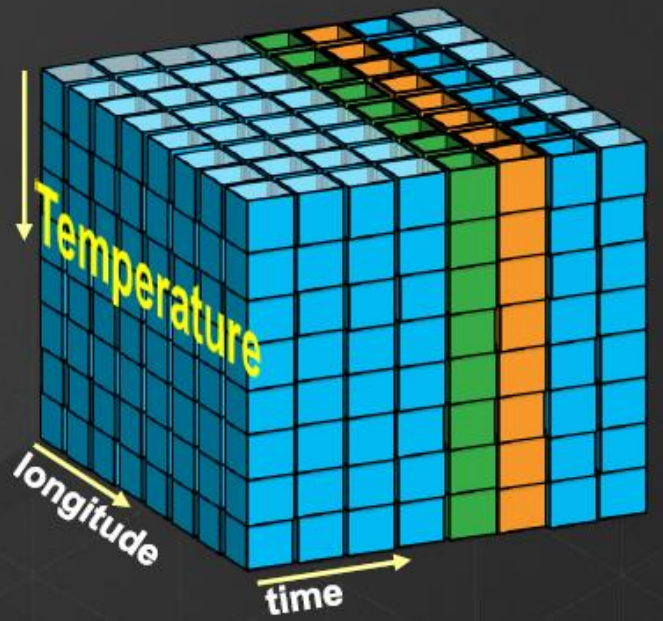
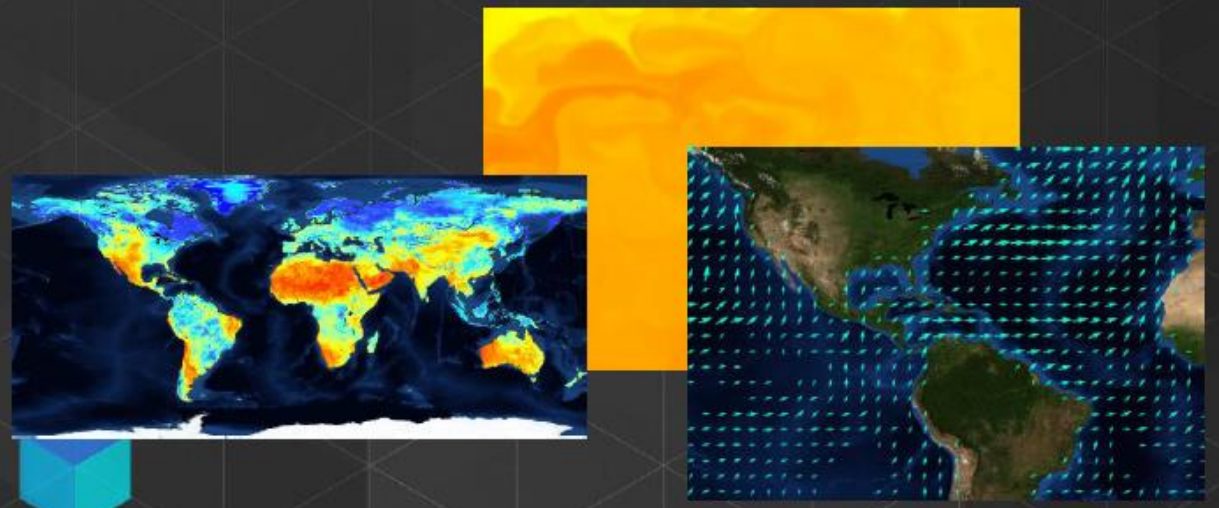
Schedule

- 9:00 – 9:15 Overview
- 9:15 – 9:45 Multidimensional Data and Workflows
- 9:45 – 10:30 Multidimensional hands-on activities
- 10:30 – 10:45 Break
- 10:45 – 11:15 SciPy Overview
- 11:15 – 11:45 SciPy Hand-on activity
- 11:45 – 1:00 Lunch
- 1:00 – 1:30 Conda Overview
- 1:30 – 2:00 Conda Hands-on activity
- 2:00 – 2:15 ModelBuilder Overview
- 2:15 – 2:45 ModelBuilder Hands-on
- 2:45 – 3:00 Break
- 3:00 – 3:15 Spatial Statistics tools Overview
- 3:15 – 4:00 Spatial Statistics Hand-on

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

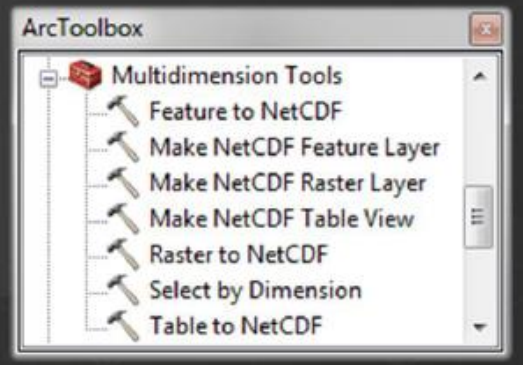




Scientific Data in ArcGIS - Vision

Ingesting Scientific data in ArcGIS

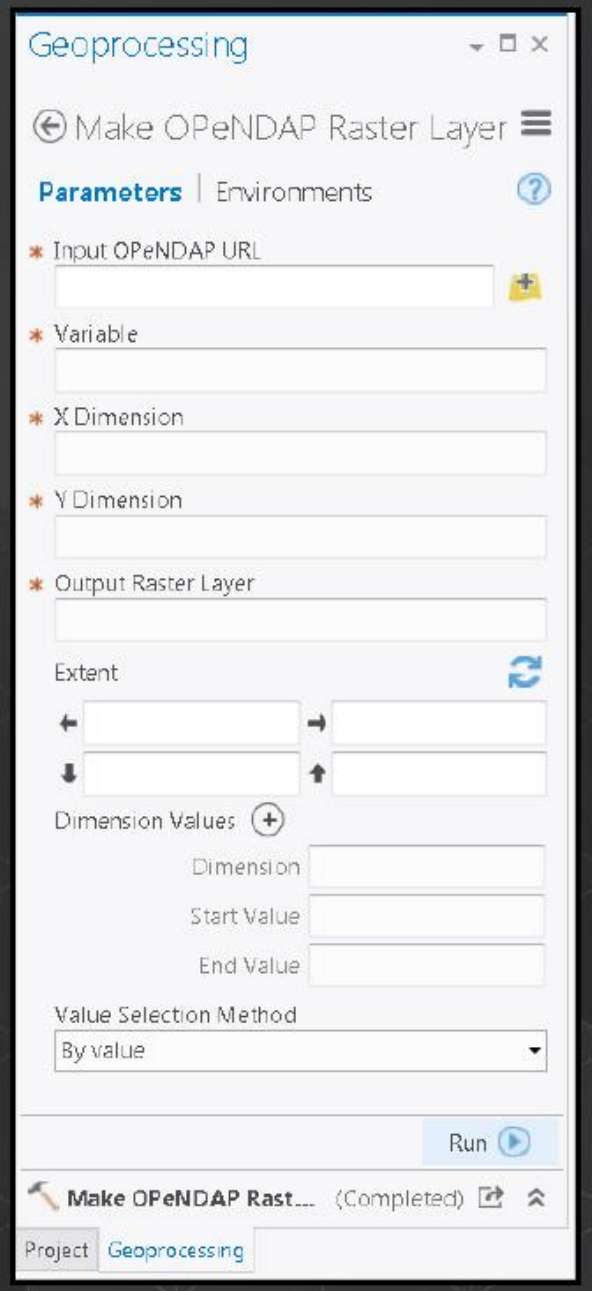
- Directly reads netCDF file using
  - Make NetCDF Raster Layer
  - Make NetCDF Feature Layer
  - Make NetCDF Table View



- 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.

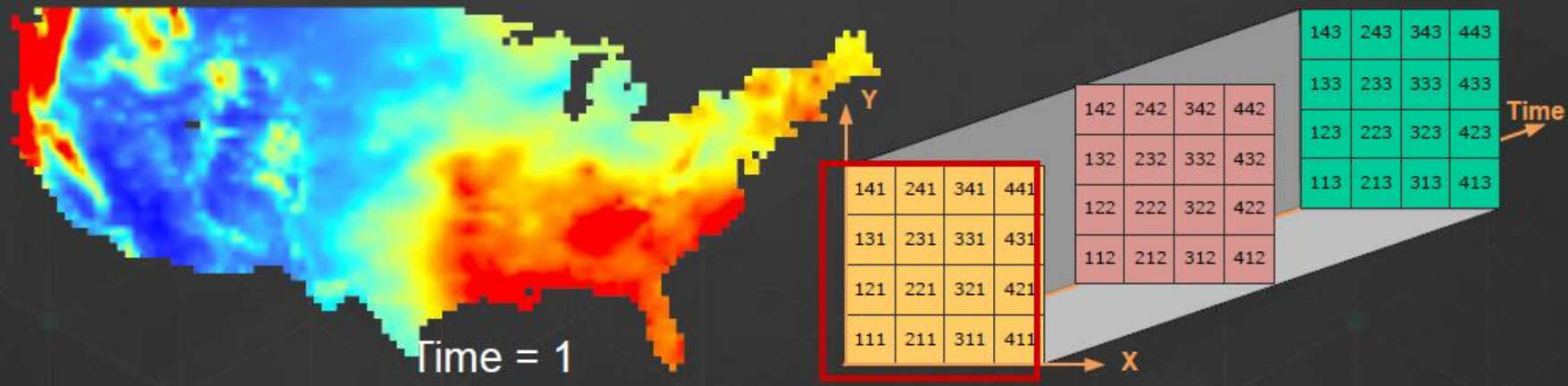
- Current version 1.6

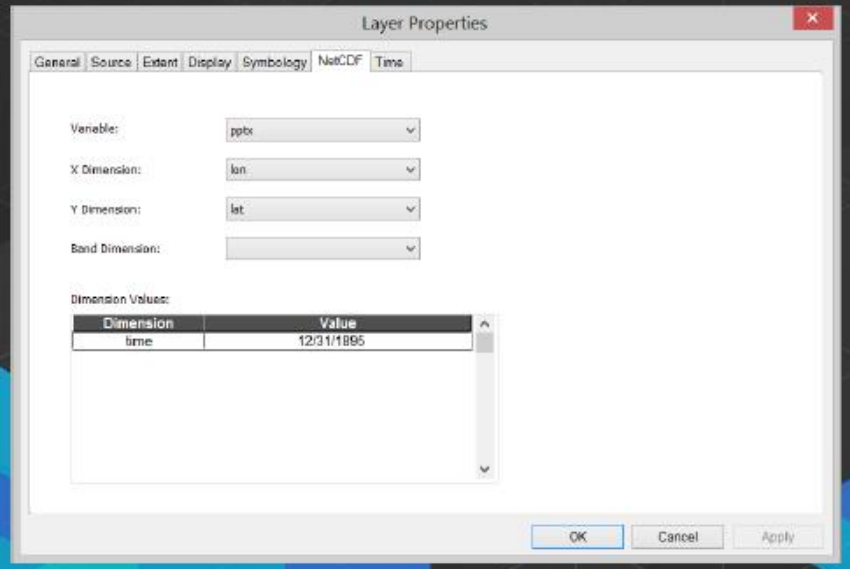
- You can use Compliance checker utility to check a netCDF file.
  http://cf-pcmdi.llnl.gov/conformance/compliance-checker/

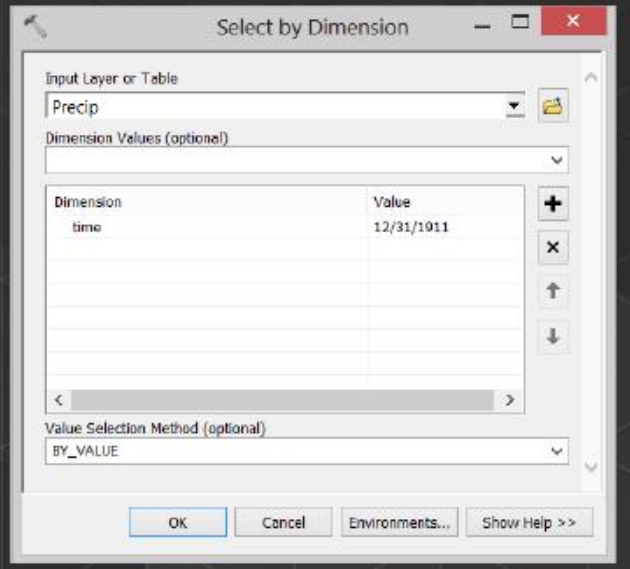
NetCDF and Coordinate Systems

- 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

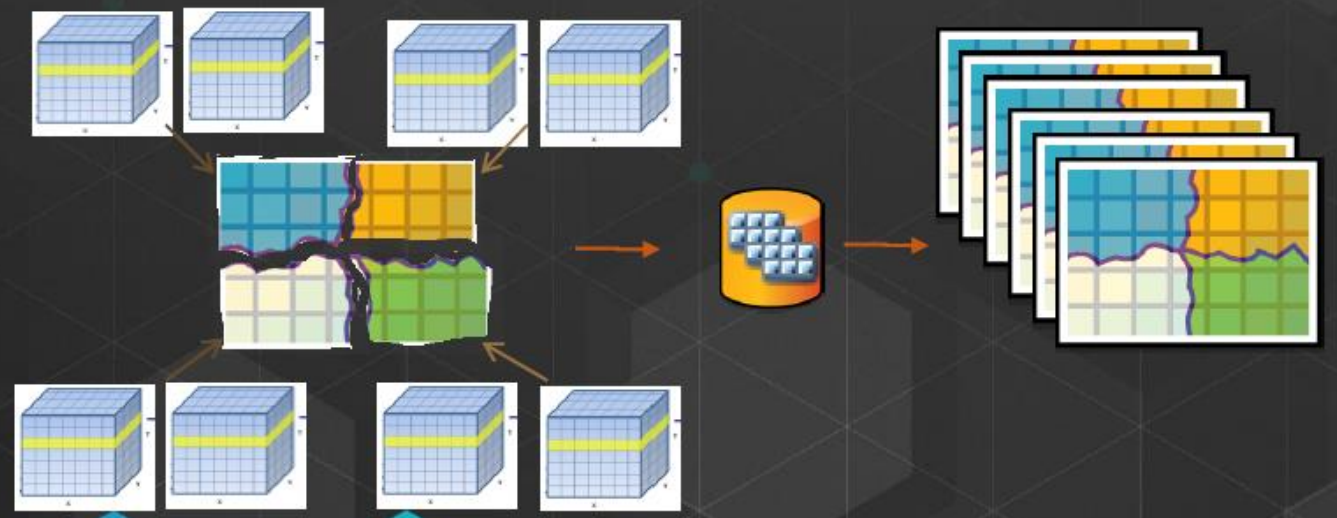






What about Aggregation?

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

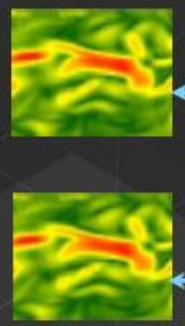


- Mosaic dataset supports multiple files and variables, normalize time and depth

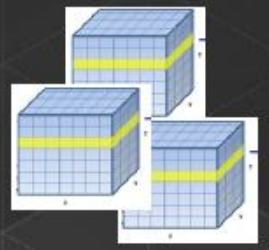
Multidimensional Mosaic Datasets - Storage

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

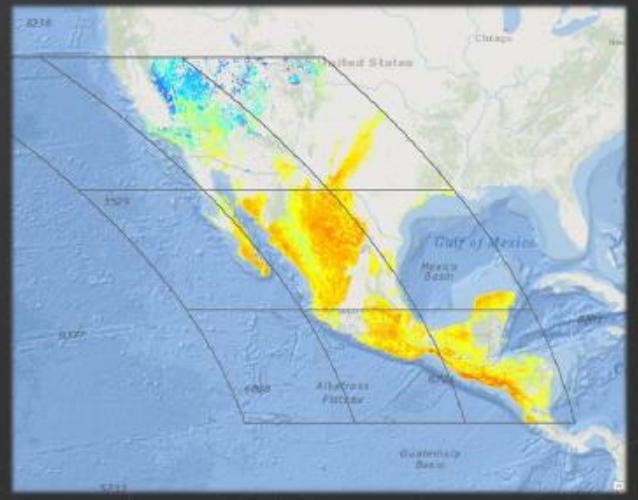


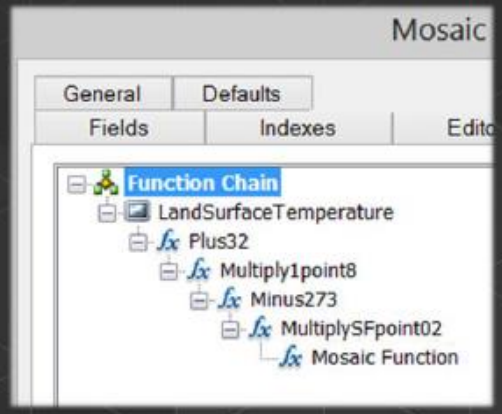
OBJ	Raster	Name	Variable *	Standard Time	Standard Z	...
1	<Raster	hycom_glb_regp01.nc:water_temp:0	water_temp	5/17/2013	0	
2	<Raster	hycom_glb_regp01.nc:water_temp:1	water_temp	5/17/2013	-2	
3	<Raster	hycom_glb_regp01.nc:water_temp:2	water_temp	5/17/2013	-4	
4	<Raster	hycom_glb_regp01.nc:water_temp:3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





Demo #1: Ingest

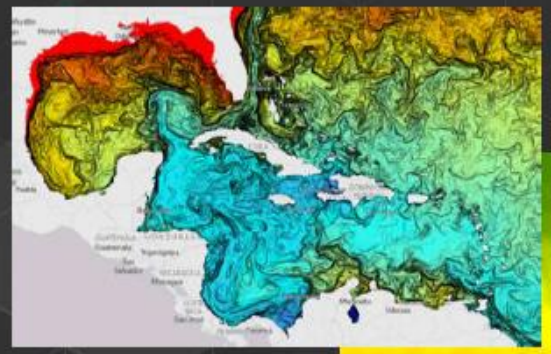
Using Scientific Data in ArcGIS

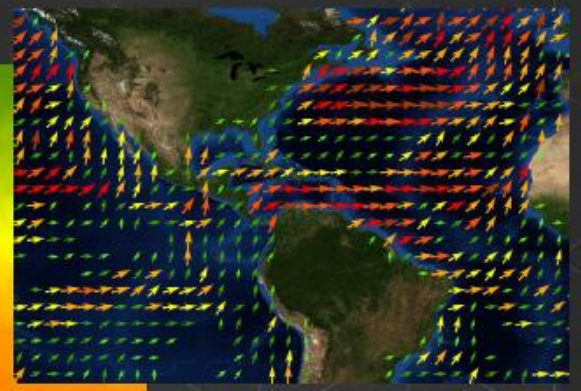
Behaves the same as any layer or table

- 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

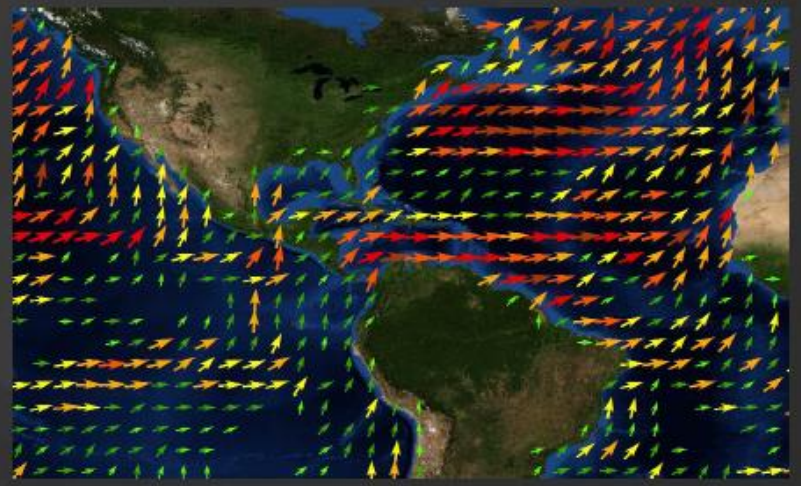
- Slicing
- Temporal animation using Time Slider
- Dimensional animation using Range Slider
- Predefined renderer



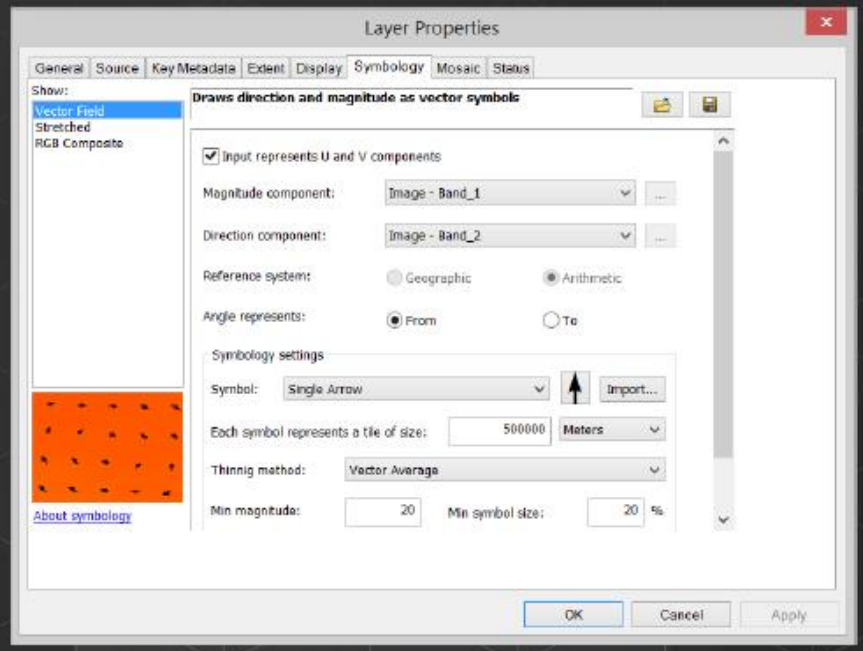


Visualization of Raster as Vectors

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

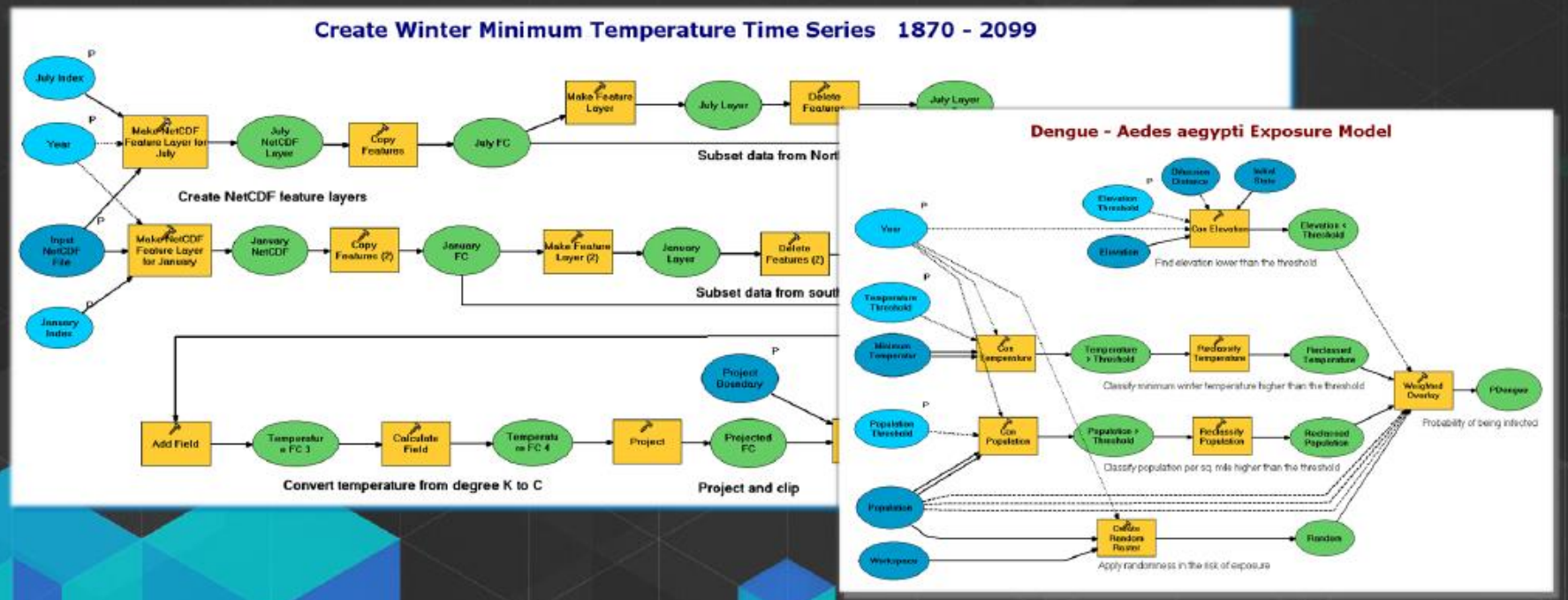


- Eliminates raster to feature conversion
- Eliminates data processing
- Improves workflow performance



Spatial and Temporal Analysis

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

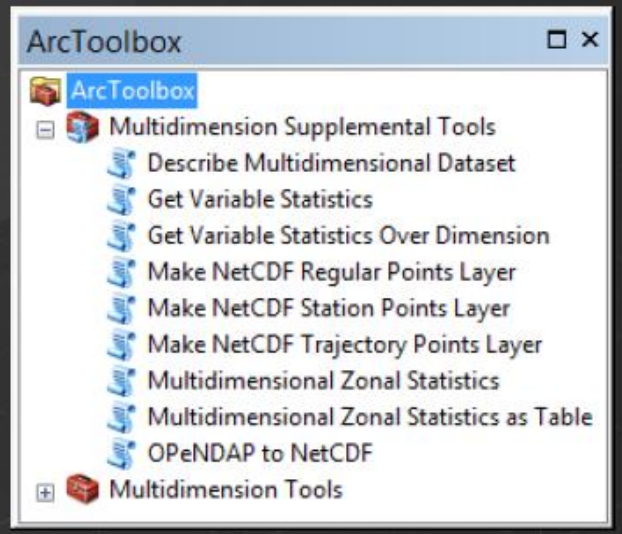


Python – Extending Analytical Capabilities

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/

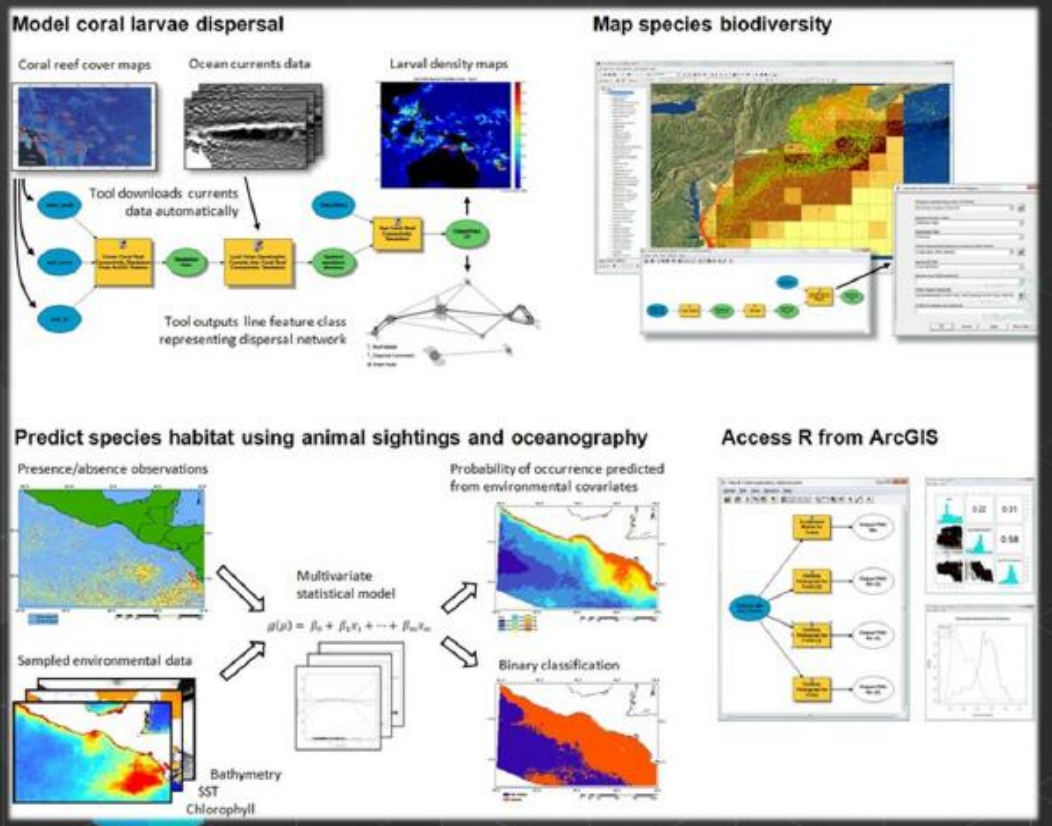


Community Developed Tools

- 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)



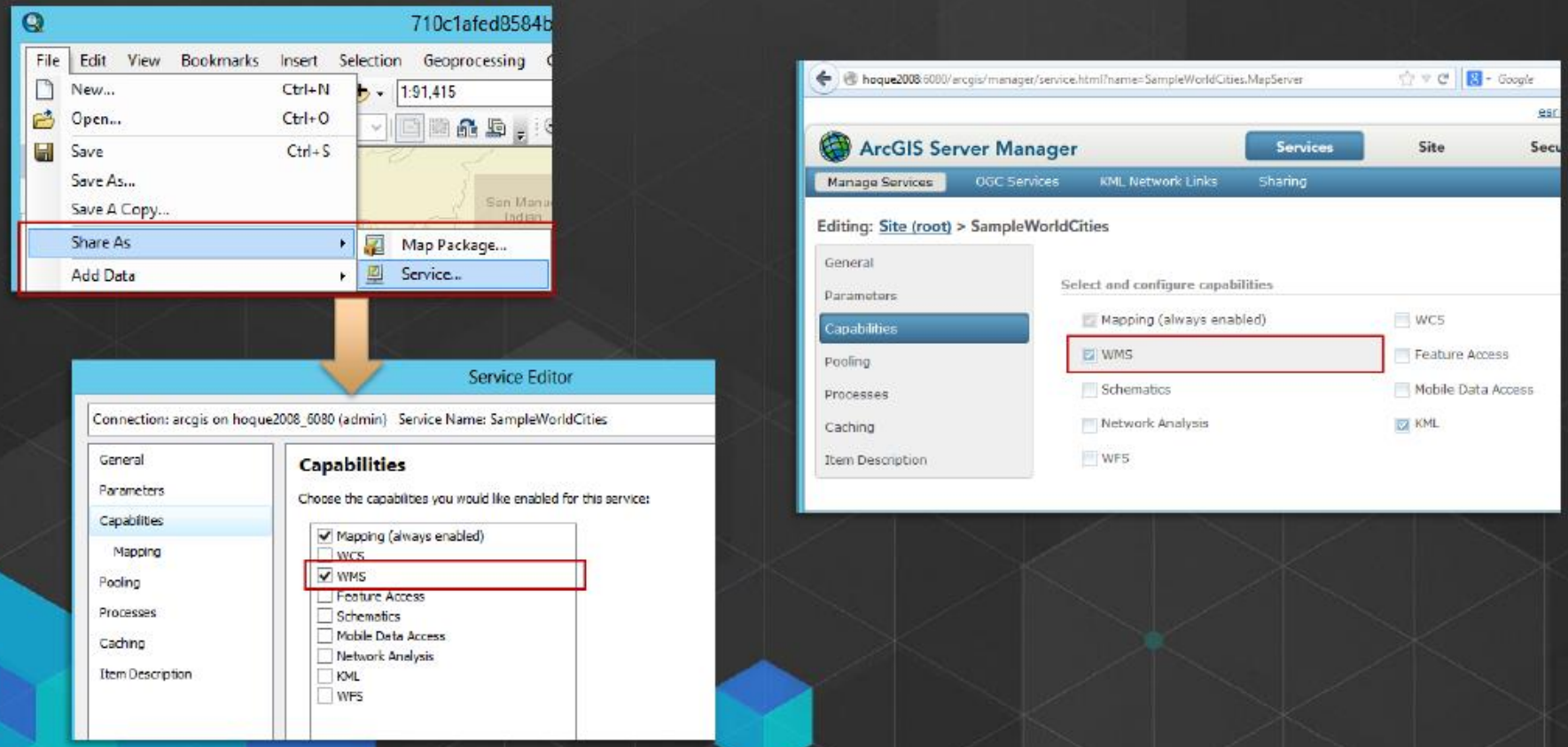
Demo #2: Analysis & Visualization

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

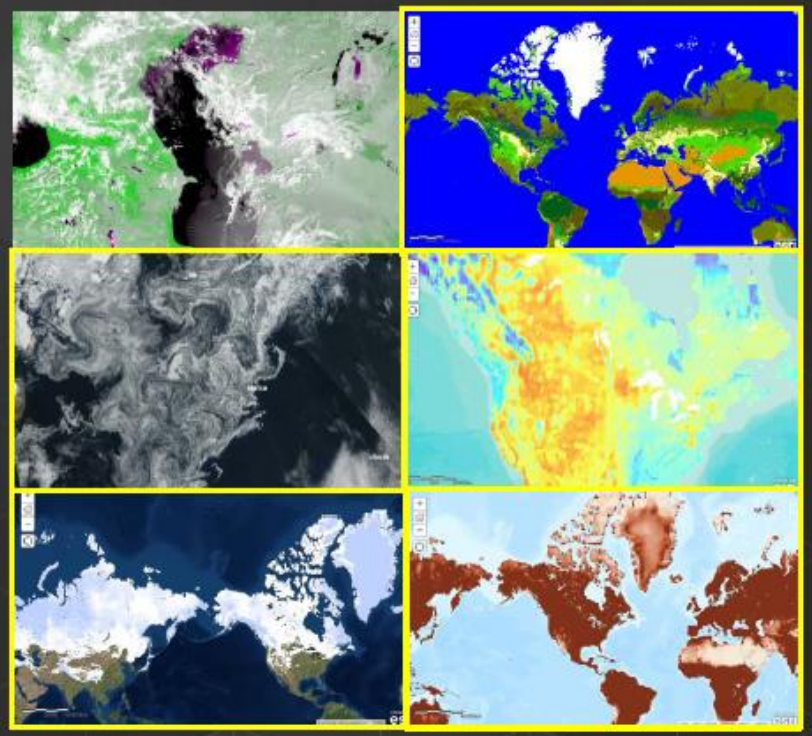
    `&DIM_<dimensionName>=<value>&`
  - Supports CURRENT for time dimension

    `&TIME=CURRENT&`
- getFeatureInfo
  - Returns information about feature for any dimension value

Services of Scientific Data

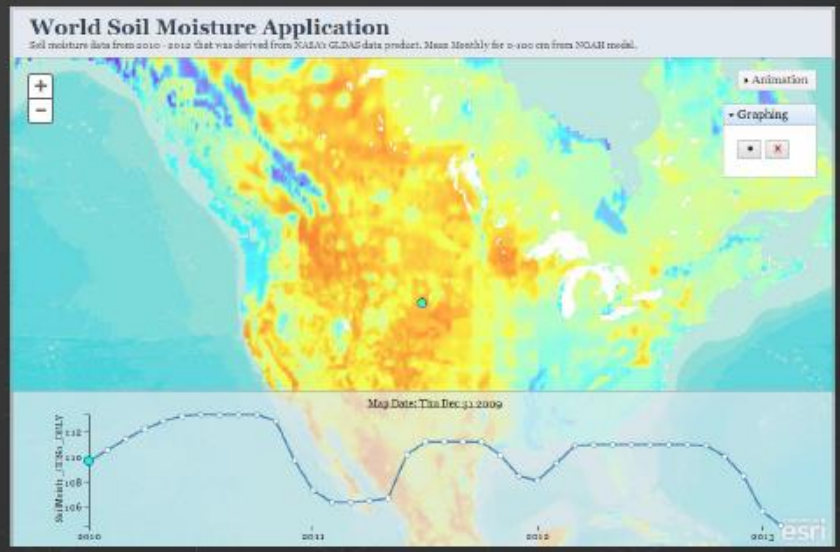
Online Imagery content that can be directly used:

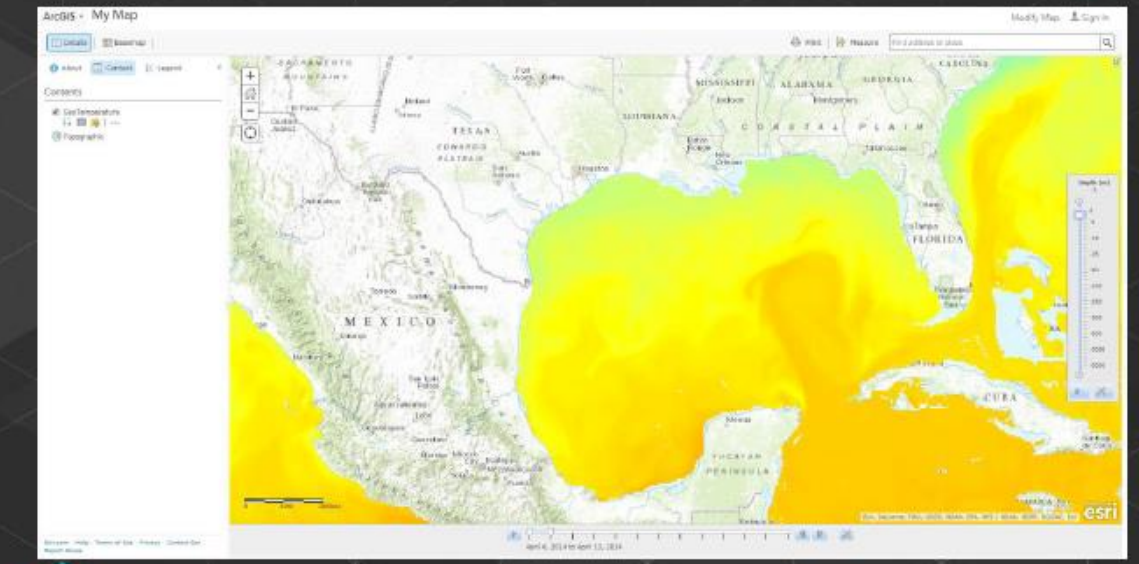
- MODIS data
  - MODIS land cover 2000-2011
  - MODIS Vegetation Analysis
  - MODIS Greenland Sea Ice
- Live NOAA wind service
- NASA Global Land Data Assimilation (GLDS)
  - Soil moisture
  - Evapotranspiration
  - Snow pack
- More



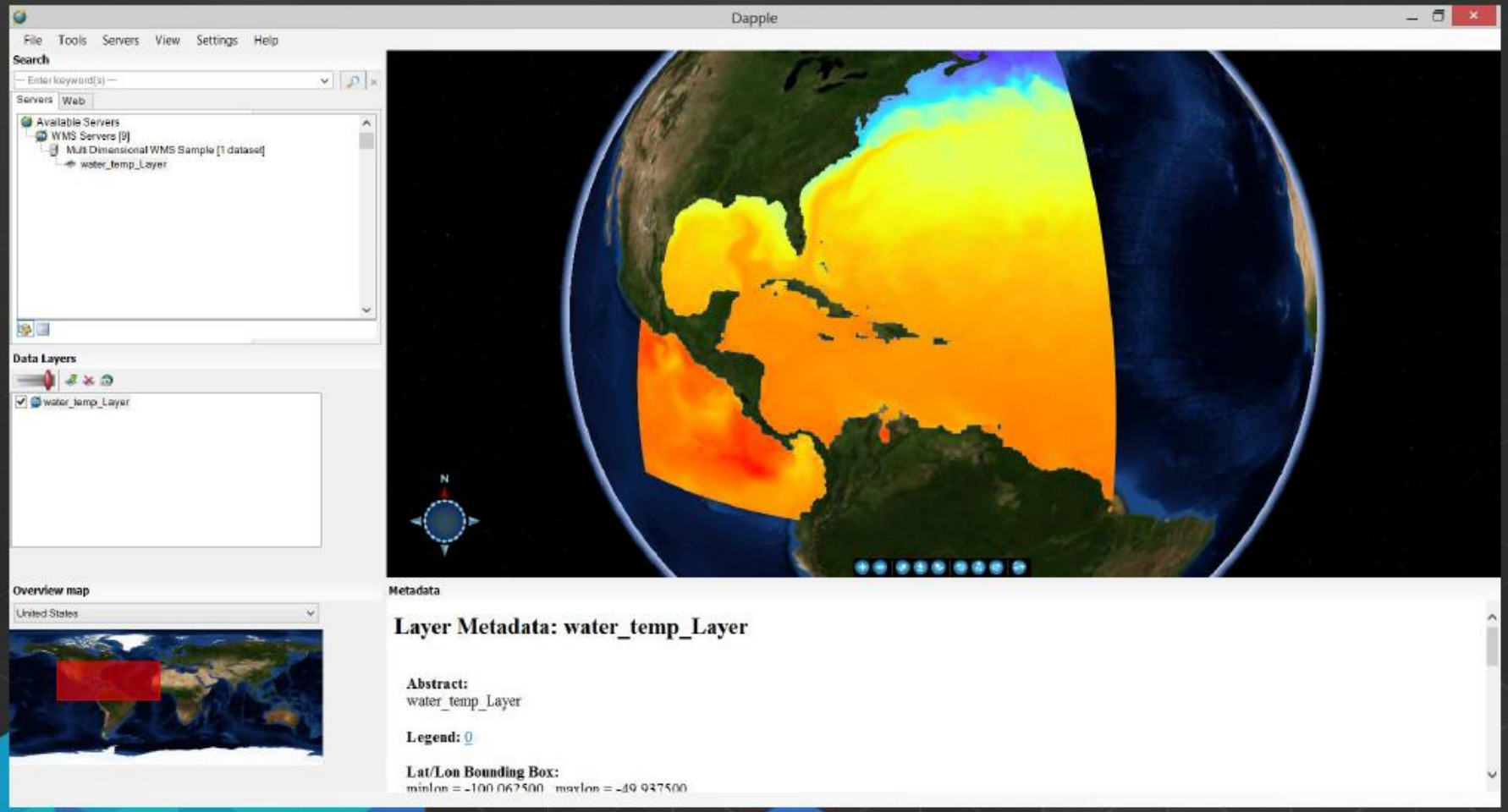
Consuming Scientific Data Services

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





WMS in Dapple Earth Explorer



Things to Consider…

- Embrace the Common Data Model (netCDF, HDF etc.)
- Use Data and metadata standards (OGC, CF etc)

- Produce and use CF complainant data

- Make your data “spatial” (by specifying geographic or a projected coordinate system)
- Create sample tools where possible

- Clearly define workflow and requirements

Directed Activities

1. Ingest data using Make OPeNDAP Raster Layer

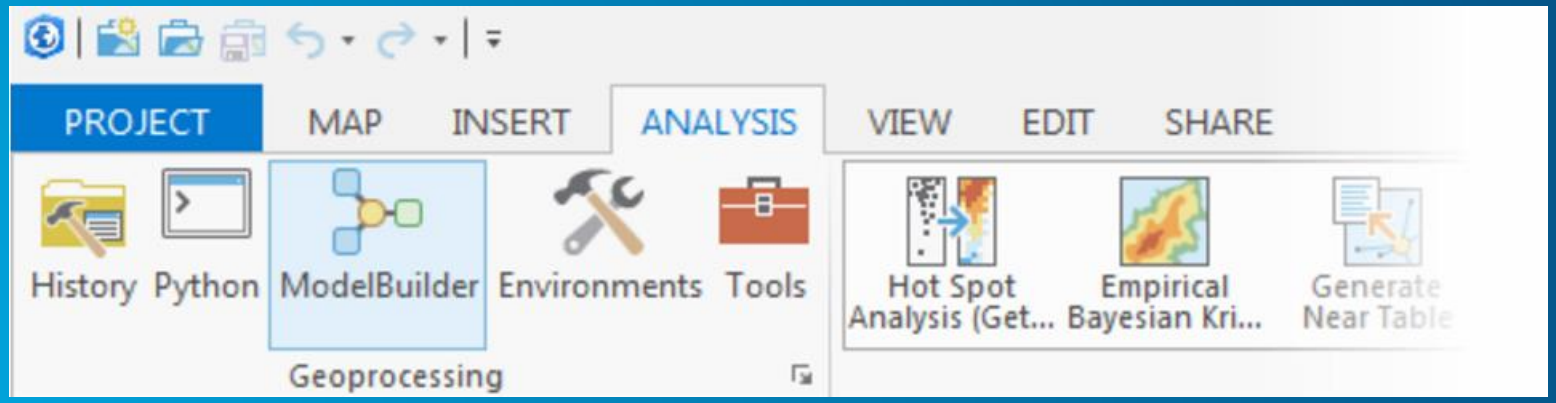
2. Analysis – Create pseudo-climate regions

3. Visualization
    1. Make NetCDF Raster Layer
    2. Choose appropriate symbology
    3. Enable time
    4. Animate
    5. Explore time settings
    6. Range Slider

4. Repeat with your own data as time is available

ModelBuilder

- ModelBuilder is a visual programming language for building geoprocessing workflows.
- Geoprocessing models automate and document your spatial analysis and data management processes.
- A model is represented as a diagram that chains together sequences of processes and geoprocessing tools, using the output of one process as the input to another process.

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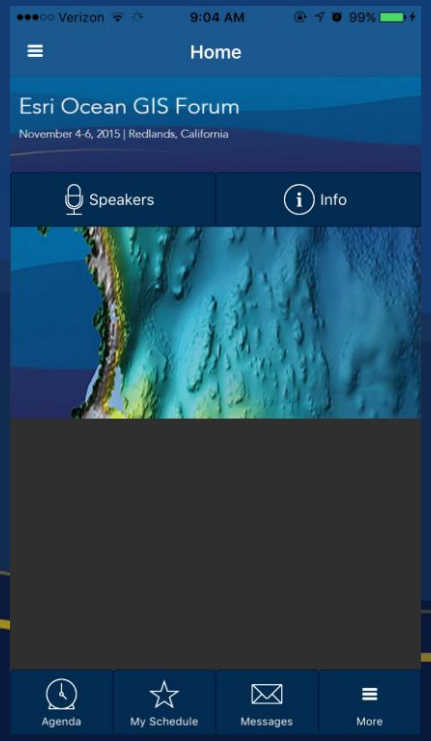
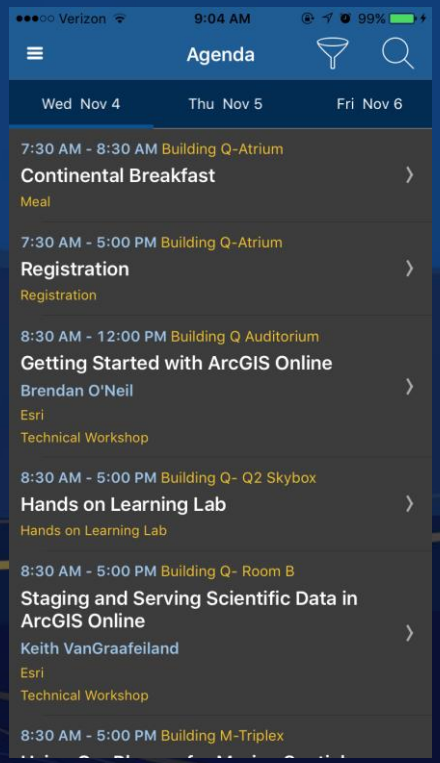
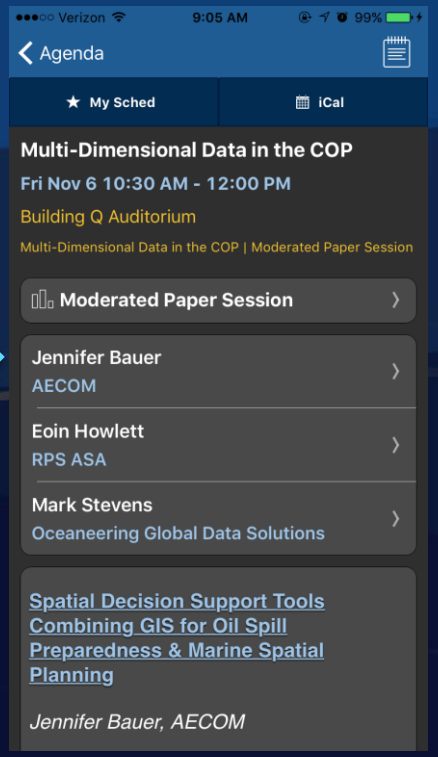


Select the session you attended



Select "Moderated Paper Session" or "Technical Workshop Survey"



Complete Answers and Select "Submit"