NetCDF and HDF Data in ArcGIS

Nawajish Noman
Kevin Butler
Outline

• NetCDF and HDF in ArcGIS
  - Demo 1
• Visualization and Analysis
  - Demo 2
• Customization using Python
  - Demo 3
• Future Directions
Scientific Data and Esri

- Direct support - NetCDF and HDF
- THREDDS/OPeNDAP – a framework for scientific data networking, integrated use by our customers
- Examples using Esri technology
  - National Climate Data Center
  - National Weather Service
  - National Center for Atmospheric Research
  - U. S. Navy (NAVO)
  - Air Force Weather
  - Australian Navy
  - Australian Bur. of Met.
  - UK Met Office
**NetCDF Support in ArcGIS**

- ArcGIS reads/writes **netCDF** since version 9.2
- An array based data structure for storing multidimensional data.
- N-dimensional coordinates systems
  - X, Y, Z, time, and other dimensions
- Variables – support for multiple variables
  - Temperature, humidity, pressure, salinity, etc
- Geometry – implicit or explicit
  - Regular grid (implicit)
  - Irregular grid
  - Points
Gridded Data

Regular Grid

Irregular Grid
Reading netCDF data in ArcGIS

- NetCDF data is accessed as
  - Raster
  - Feature
  - Table

- Direct read
- Exports GIS data to netCDF
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

- The CF conventions generalize and extend the COARDS (Cooperative Ocean/Atmosphere Research Data Service) convention.
- CF is now the most widely used conventions for geospatial netCDF data. It has the best coordinate system handling.
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.
NetCDF Tools

Toolbox: Multidimension Tools

- Make NetCDF Raster Layer
- Make NetCDF Feature Layer
- Make NetCDF Table View
- Raster to NetCDF
- Feature to NetCDF
- Table to NetCDF
- Select by Dimension
NetCDF Layer/Table Properties
Changing Time Slice

Time = 1

Esri UC2013 - Technical Workshop - NetCDF and HDF in ArcGIS
Reading HDF in ArcGIS
Raster Concepts

• **Raster Format** (e.g. img, tif, etc.)
  - driver level support / storage format and layout / read/write of pixels and metadata

• **Raster Type** (e.g. GeoEye-1)
  - implies Raster Format support and are format and sensor specific
  - intelligent use of metadata and other sensor specific parameters
  - defines georeferencing and well known processing chains

• **Raster Product** (e.g. Panchromatic, Multispectral, Pansharpened)
  - templates which make it easy to work with well defined end user products
  - multiple per sensor
  - e.g. Panchromatic, Multispectral, Pansharpened

• **Raster Product Definition** (e.g. Natural Color, False Color)
  - defines “how you want your Mosaic Dataset to look” regardless of multiple source sensors and band combinations
  - uses metadata such as wavelength information to map bands
## HDF Raster Support

<table>
<thead>
<tr>
<th>Raster Concept</th>
<th>ArcGIS 10.1 Support</th>
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| Raster Format        | **HDF4**  
|                      | • read: open a HDF subdataset as a Raster Dataset  
|                      | • write: APIs available but not exposed in UI  
|                      | **HDF5**  
|                      | • read: open a HDF subdataset as a Raster Dataset  
|                      | • write: not supported at this time                                                                                                                                                                                                 |
| Raster Type          | **HDF4, HDF5**  
|                      | • direct ingest of one or many HDF subdatasets into a Mosaic Dataset using the Raster Dataset Raster Type or the Table Raster Type                                                                                   |
|                      | * Esri interested in discussing other Raster Types                                                                                                                                                                |
| Raster Product       | * Esri interested in discussing other Raster Products                                                                                                                                                           |
| Raster Product Definition | * Esri interested in discussing other Raster Product Definitions                                                                                                                                               |
HDF Raster Support

10.1 Raster Format and Raster Type support implies:

- **ArcGIS Desktop**
  - direct use as a Raster Dataset or Mosaic Dataset
  - use via conversion (i.e. convert to another format)
  - feature rich use in the applications
    - Visualization and Mapping
    - Geoprocessing

- **ArcGIS Server**
  - publishing as dynamic image services
  - caching and publishing as tile services (i.e. basemaps)
  - OGC (WCS, WMS, WMTS)
Displaying MODIS LST Data

HDFView

ArcGIS
Demo: Reading netCDF and HDF data
Using netCDF Data

Behaves the same as any layer or table

• Display
  • Same display tools for raster and feature layers will work on netCDF raster and netCDF feature layers.

• Graphing
  • Driven by the table just like any other chart.

• Animation
  • Multidimensional data can be animated through a dimension (e.g. time, pressure, elevation)

• Analysis Tools
  • A netCDF layer or table will work just like any other raster layer, feature layer, or table. (e.g. create buffers around netCDF points, reproject rasters, query tables, etc.)
Time in ArcGIS

- Simple Temporal Mapping

- Unified experience for Time
  - Configure time properties on the layer
  - Use Time Slider to visualize temporal data

- Share temporal visualization
  - Time-enabled Map Services
  - Export videos or images
  - Generate temporal map books using ArcPy scripting
  - Layer and map packages
Animation Examples
Spatial and Temporal Analysis

• Several hundreds analytical tools available for raster, features, and table

• Temporal Modeling
  • Looping and iteration in ModelBuilder and Python
Generate Rainfall Statistics

- Calculates specified statistics for all time steps
- Outputs a raster catalog
- Optionally outputs a netCDF file
Generate Rainfall Statistics Table

- Calculates statistics for all time steps
- Outputs a table
- Optionally creates a graph
Demo: Animation and Analysis
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

- Australian Navy tools
  (not publicly available)
Script Tools

- Python is used to build custom tools for specific tasks or datasets
New Multidimension 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
OPeNDAP to NetCDF
Reading Features from a netCDF File
Dependencies on 3rd Party Utilities

- **netcdf4-python**
  - This module can read and write files in both the new netCDF 4 and the old netCDF 3 format, and can create files that are readable by HDF5 clients.

- **Pydap**
  - Pydap is a pure Python library implementing the Data Access Protocol, also known as DODS or OPeNDAP. OWSLib

- **OWSLib (OGC Web Service utility library)**
  - Package for working with OGC map, feature, and coverage services. OWSLib provides a common API for accessing service metadata and wrappers for GetCapabilities, GetMap, and GetFeature requests.
Demo: Workflow and Customization
HDF and Swath
Future Initiatives…

• Ongoing efforts - require close collaboration with all of you

• Some of the future initiatives are:
  • Continue to support netCDF classic and netCDF4
  • Provide better support for HDF5
  • Provide tool to consume data served using THREDDS/OPeNDAP
  • Continue to support the evolving CF convention
  • Support a strong developer experience for netCDF and HDF using Python

• What else?
Things to Consider…

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

• Provide “mechanism” so that we can access scientific data using a single set of APIs….

• and can expect data to be CF complainant

• Make your data “spatial” (by specifying geographic or a projected coordinate system)
• Clearly define workflow and requirements
• Create sample tools where possible
Thank you…

Please fill out the session evaluation

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